



COMAH Land Use Planning Assessment

Project Title: Powerstown Bioenergy

CLIENT

Greengate Biogas
001 Ltd.

DOCUMENT REFERENCE

257501.0316RR01

DATE

25/06/2026

DOCUMENT CONTROL SHEET

Document Control Sheet		
Our Reference	257501.0316RR01	
Original Issue Date	25 th June 2026	
Client:	Greengate Biogas 001 Ltd.	
Client Address:		
Revision	Revision Date	Description
Rev.01	25 th June 2026	First issue of report

Details	Written by	Approved by
Signature		
Name	Maeve McKenna	James Close
Qualifications	BEng MEngSc CEng MIEI	MEng, CEng MChemE
Title	Associate	Principal Risk Consultant
Date	24 th June 2026	

Disclaimer

This report has been prepared by AWN Consulting Ltd. with the reasonable skill, care and diligence to be expected of a competent consulting practice experienced in environmental and engineering disciplines. All analyses and conclusions have been produced and reviewed by suitably qualified and competent experts. Any use of software tools, including artificial intelligence, has been subject to appropriate professional oversight and validation. This report has been prepared and validated by the above-named consultants. The contents are based on the information available at the time of preparation and are intended for the sole use of the named client in accordance with the agreed scope of work. The contents of this report are not intended for third-party use or reliance, and no responsibility is accepted for any third party unless expressly agreed. The provisions in this report apply solely to this project and should not be assumed applicable to other developments.



TABLE OF CONTENTS

1. INTRODUCTION	1
2. DESCRIPTION OF PROPOSED DEVELOPMENT AND SITE LOCATION	2
2.1 Development Description	2
2.1.1 Overview	2
2.1.2 Feedstock	7
2.1.3 Solids Reception Building	7
2.1.4 Liquids Reception Building	7
2.1.5 Solid Digestate Building	7
2.1.6 Bunded Tank Farm	8
2.1.7 Biogas Collection and Treatment	11
2.1.8 Biomethane Network Entry Facility (BNEF)	15
2.1.9 Gas Network Connection	17
2.1.10 Gas Flare(s)	17
2.1.11 Odour Abatement System	18
2.1.12 Heating Centre	18
2.1.13 Administration Building	19
2.1.14 Drainage Infrastructure	19
2.1.15 Ancillary Infrastructure	20
2.1.16 Operating Hours	22
2.2 Surrounding Area and Identified COMAH Receptors	23
2.3 Properties of Dangerous Substances	26
2.3.1 Untreated Biogas	26
2.3.2 Treated Biogas – Renewable Natural Gas	26
2.3.3 Chemicals	26
2.4 COMAH Status Determination	30
3. INTRODUCTION TO RISK ASSESSMENT	33
3.1 Risk Assessment – An Introduction	33
3.2 Land Use Planning and Risk Assessment	33
3.3 Individual Risk Criteria	34
3.4 Environment and Land Use Planning	34
3.5 Societal Risk Assessment Methodology	35
4. LAND USE PLANNING ASSESSMENT METHODOLOGY AND CRITERIA	36
4.1 Assessment Methodology	36
4.1.1 Physical Effects Modelling	36
4.1.2 Risk Assessment Methodology	36
4.2 Thermal Radiation Criteria	36
4.3 Overpressure Criteria	38
4.4 Flash Fire Criteria	41
4.5 Modelling Parameters	41
4.5.1 Weather Conditions	41
4.5.2 Surface Roughness	42
5. IDENTIFICATION OF MAJOR ACCIDENT HAZARDS	43
5.1 Major Accident Hazards	43
5.1.1 Major Accident Scenarios	43
5.1.2 Major Accidents to the Environment (MATTE)	44
6. LAND USE PLANNING ASSESSMENT OF MAJOR ACCIDENT HAZARDS	45
6.1 Vessels Containing Untreated Biogas	45

6.1.1	Biogas Release from Tank: Model Inputs.....	45
6.1.2	Biogas Release from Tank and Fireball	46
6.1.3	Biogas Release from Tank: VCE Results.....	50
6.1.4	Biogas Release from Tank and Jet Fire	54
6.1.5	Biogas Release from Tank and Flash Fire.....	56
6.1.6	Biogas Tank Release Frequencies	59
6.2	Biogas Pipeline Release	59
6.2.1	Biogas Pipeline Release Model Inputs.....	59
6.2.2	Biogas Pipeline Release Discharge Model Outputs.....	62
6.2.3	Biogas Pipeline Release and Jet Fire.....	62
6.2.4	Biogas Pipeline Release: Fireball Results.....	65
6.2.5	Biogas Pipeline Release: VCE Results	70
6.2.6	Biogas Pipeline Release: Flash Fire Results	73
6.2.7	Event Frequencies.....	73
6.3	Indoor Equipment	75
6.3.1	Confined VCE Model Inputs.....	75
6.3.2	Confined VCE Model Outputs.....	76
6.3.3	Confined VCE Frequency	78
7.	INDIVIDUAL RISK CONTOURS	80
8.	SOCIETAL RISK ASSESSMENT	83
9.	CONCLUSION	84
10.	REFERENCES	88
APPENDIX A.	DRAWINGS	89
APPENDIX B.	BIOGAS INVENTORY CALCULATIONS	90
APPENDIX C.	CONSEQUENCE MODELLING CURVES	94
APPENDIX D.	BIOGAS VCE FLAMMABLE MASS CALCUALTION	144

LIST OF TABLES

Table 2-1 Tank Farm Schedule of Tanks Containing Biogas	8
Table 2-2 GNI RNG Grid Entry Quality Requirements	11
Table 2-3 Inventory of Chemicals	20
Table 2-4 Operational Hours	22
Table 2-5 Chemical Quantities and Classification	27
Table 2-6 Quantities of Hazardous Substances at the Proposed Development	31
Table 2-7 Calculation of COMAH Status at the Proposed Development	31
Table 3-1 Land Use Planning Matrix	34
Table 4-1 Heat Flux Consequences	36
Table 4-2 Heat Flux Consequences Indoors	37
Table 4-3 Conversion from Probit to Percentage	38
Table 4-4 Blast Damage	39
Table 4-5 Blast Overpressure Consequences Indoors	41
Table 5-1 Major Accident Scenarios at the Proposed Development	43
Table 6-1 Operating Conditions of Tanks Containing Untreated Biogas	45
Table 6-2 Biogas Release from Tank: Model Inputs	45
Table 6-3 Rupture of Tank Containing Untreated Biogas and Fireball: Model Outputs	46
Table 6-4 Rupture of Tank Containing Untreated Biogas and Fireball: Distances to Specified Thermal Dose Levels	47
Table 6-5 Biogas Release from Tank: Vapour Cloud Explosion Ignition Location and Flammable Mass	50
Table 6-6 Release of Biogas from Storage Tank and VCE: Distances to Specified Overpressure Endpoints	51
Table 6-7 Biogas Release from Tank and Jet Fire: Distances to Specified Thermal Radiation Levels at a Receptor Height of 57 mO.D.	54
Table 6-8 Release of Biogas from Tank and Flash Fire: Distance to Flash Fire Envelope	56
Table 6-9 Event Frequencies for Tanks Containing Biogas	59
Table 6-10 Biogas Pipeline Rupture or Leak: Discharge Model Inputs	60

Table 6-11 Above Ground Biogas Pipeline Release and Jet Fire: Calculated Distances at Specified Thermal Radiation Levels (receptor height 1.0m)	63
Table 6-12 Below Ground Biogas Pipeline Release and Jet Fire: Calculated Distances at Specified Thermal Radiation Levels (receptor height 1.0m)	63
Table 6-13 Above Ground Biogas Pipeline Release and Fireball: Fireball Model Outputs	66
Table 6-14 Below Ground Biogas Pipeline Release and Fireball: Fireball Model Outputs	66
Table 6-15 Above Ground Biogas Pipeline Rupture and Fireball: Distances to Specified Thermal Dose Levels (Receptor Height 1.0 metres)	66
Table 6-16 Below Ground Biogas Pipeline Rupture and Fireball: Distances to Specified Thermal Dose Levels (Receptor Height 1.0 metres)	67
Table 6-17 Biogas Pipeline Rupture or Leak: Vapour Cloud Explosion Ignition Location and Flammable Mass	70
Table 6-18 Biogas Pipeline Release and VCE: Distances to Specified Overpressure Endpoints	71
Table 6-19 Biogas Pipeline Loss of Containment and Flash Fire: Distance to Flash Fire Envelope	73
Table 6-20 Biogas Pipeline Schedule	74
Table 6-21 Biogas Pipeline Event Frequencies	75
Table 6-22 Confined VCE Model Inputs	76
Table 6-23 Confined VCE: Distances to Specified Overpressure Endpoints	76
Table 6-24 Blower Station Biogas Release and VCE: Event Frequency	79
Table 6-25 BNEF Gas Room Biogas Release and VCE: Event Frequency	79
Table 9-1 Summary of Major Accident Scenarios	84

LIST OF FIGURES

Figure 2-1 Site Map with Red Line Planning Boundary for the Proposed Development	4
Figure 2-2 Proposed Development Layout Plan	5
Figure 2-3 Flow Diagram of Anaerobic Digestion Process	6
Figure 2-4 Amine Separator Illustration	14
Figure 2-5 BNEF Container Example	17
Figure 2-6 Typical Enclosed Flare (Himmel)	18
Figure 2-7 Surrounding Area and COMAH Receptors	25
Figure 4-1 API Probability of Occupant Vulnerability	40
Figure 4-2 Wind Rose Oak Park Synoptic Station	42
Figure 6-1 Secondary Digester Rupture and Fireball: Outdoor Lethality Contours	48
Figure 6-2 Secondary Digester Rupture and Fireball: 12.7 kW/m ² and 25.6 kW/m ² Contours	48
Figure 6-3 Post Digestion Storage Tank Rupture and Fireball: Outdoor Lethality Contours	49
Figure 6-4 Post Digestion Storage Tank Rupture and Fireball: 12.7 kW/m ² and 25.6 kW/m ² Contours	49
Figure 6-5 Secondary Digester Rupture and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours	53
Figure 6-6 Post Digestion Storage Tank Rupture and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours	53
Figure 6-7 Liquid Pre-Storage Tank Release and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Lethality Outdoors	55
Figure 6-8 Liquid Pre-Storage Tank Release and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Lethality Outdoors	56
Figure 6-9 Secondary Digester Rupture: Flash Fire Footprint	58
Figure 6-10 Post Digestion Storage Tank Rupture: Flash Fire Footprint	58
Figure 6-11 Above Ground Biogas Pipeline Leak and Jet Fire Downstream of Biogas Upgrade Plant: Thermal Radiation Contours	64
Figure 6-12 Below Ground Biogas Pipeline Leak and Jet Fire Downstream of BNEF: Thermal Radiation Contours	65
Figure 6-13 Above Ground Biogas Pipeline Rupture and Fireball: Outdoor Lethality Contours	68
Figure 6-14 Above Ground Biogas Pipeline Rupture and Fireball: 12.7 kW/m ² and 25.6 kW/m ² Contours	68

Figure 6-15 Below Ground Biogas Pipeline Rupture and Fireball: Outdoor Lethality Contours	69
Figure 6-16 Below Ground Biogas Pipeline Rupture and Fireball: 12.7 kW/m ² and 25.6 kW/m ² Contours	69
Figure 6-17 Above Ground Biogas Pipeline Rupture (Horizontal) and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours	72
Figure 6-18 Below Ground Biogas Pipeline Rupture (Horizontal) and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours	72
Figure 6-19 Confined VCE in Blower Station Room: Overpressure Contours Corresponding to 1% Lethality Outdoors and Indoors in CIA Cat. 3 Buildings	77
Figure 6-20 Confined VCE in BNEF Gas Room: Overpressure Contours Corresponding to 1% Lethality Outdoors and Indoors in CIA Cat. 3 Buildings	77
Figure 7-1 Individual Location-based Risk Contours for New Establishments	81
Figure 7-2 Individual Risk Based Land Use Planning Contours	81
Figure 7-3 Proposed Consultation Distance (1 x 10 ⁻⁹ per year Individual Risk of Fatality Contour)	82
Figure 9-1 Individual Location-based Risk Contours for New Establishments	85
Figure 9-2 Individual Risk Based Land Use Planning Contours	86
Figure 9-3 Proposed Consultation Distance (1 x 10 ⁻⁹ per year Individual Risk of Fatality Contour)	86

GLOSSARY OF TERMS

AGI	Above Ground Installation
API	American Petroleum Institute
BNEF	Biomethane Network Entry Facility
CAS	Chemical Abstracts Service
CCPS	Centre for Chemical Process Safety
CIA	Chemical Industries Association
COMAH	Control of Major Accident Hazards
EIGA	European Industrial Gases Association
EPA	Environmental Protection Agency
ESD	Emergency Shutdown Device
EV	Expectation Value
GNI	Gas Networks Ireland
HSE	Health and Safety Executive (UK Authority)
HSA	Health and Safety Authority
LEL	Lower Explosion Limit
LFL	Lower Flammability Limit (synonymous with LEL)
LOC	Loss of Containment
LPG	Liquefied Petroleum Gas
LUP	Land Use Planning
MATTE	Major Accident to the Environment
O.D.	Ordnance Datum
RNG	Renewable Natural Gas
SEP	Surface Emissive Power
TLUP	Technical Land Use Planning
VCE	Vapour Cloud Explosion

1. INTRODUCTION

AWN Consulting, a Trinity Consultants Team, has been commissioned by Greengate Biogas 001 Ltd. ('Greengate Biogas') to complete a COMAH land use planning assessment in respect of Powerstown Bioenergy project which comprises a proposed Anaerobic Digestion (AD) facility at Powerstown, Co. Carlow for the production of 250GWh per annum of renewable natural gas (RNG) and biogenic liquified carbon dioxide (biogenic CO₂) from agricultural residues including liquid farmyard manures (LFYM) and Solid Farmyard Manures (SFYM) collectively referred to as "feedstocks".

The assessment was prepared by Maeve McKenna, BEng (Chemical Engineering), MEngSc, CEng, MIEI. Maeve has 20 years' experience in environmental and process safety assessment and management projects, including hazard identification studies at notified COMAH establishments, and consequence and risk modelling of major accident hazards, including COMAH land use planning quantitative risk assessments.

The COMAH status is assessed in accordance with the criteria set out in Schedule 1 of the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015 (S.I. 209 of 2015) (COMAH Regulations 2015).

The proposed development will be classified as a "lower tier" COMAH establishment and as such will be subject to the provisions of the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015.

This report maps risk-based land use planning contours and assesses societal risk associated with the proposed development. The individual risk contours are based on consequence assessment and risk modelling of major accident scenarios identified for the proposed development. The assessment has been completed in accordance with the Health and Safety Authority's *Guidance on technical land-use planning advice for planning authorities and COMAH establishment operators* (HSA, 2023).

This report details the following:

- ▶ Description of development and site location
- ▶ Introduction to risk assessment
- ▶ Land Use Planning assessment methodology and criteria
- ▶ Identification of Major Accident Hazards
- ▶ Land Use Planning Assessment of Major Accident Scenarios
- ▶ Individual Risk Contours
- ▶ Societal Risk Assessment
- ▶ Conclusion

2. DESCRIPTION OF PROPOSED DEVELOPMENT AND SITE LOCATION

2.1 Development Description

2.1.1 Overview

Greengate Biogas intends to apply for consent for the Powerstown Bioenergy project; a commercial anaerobic digestion (AD) plant at Powerstown, County Carlow, referred to as the proposed development. The proposed development is designed to process up to 663,000 tonnes per annum (tpa) of agricultural residues, including cattle and pig slurries, farmyard straw manures (e.g. cattle and horse) and poultry manure to produce biomethane, biogenic carbon dioxide (biogenic CO₂) and solid and liquid digestate (digestate).

The proposed development is located on the site of a former quarry in Powerstown, Milford, Co. Carlow, under the name Powerstown Biogas. A proposed gas pipeline will connect Powerstown Biogas to the Gas Network Ireland (GNI) grid at Clogrennan, Co. Carlow. The Biomethane Network Entry Facility (BNEF) and pipeline will be outside of the operational site COMAH boundary.

The proposed development is an anaerobic digestion (AD) facility for the production of 250 GW of renewable natural gas (RNG) and biogenic liquified carbon dioxide (biogenic CO₂) from agricultural residues including liquid farmyard manures (LFYM) and Solid Farmyard Manures (SFYM) collectively referred to as "feedstocks". All of the feedstocks will be compliant with Annex IX of the Renewable Energy Directive (RED) (European Union, 2023).

Feedstock having passed through the digestion process produces a product known as digestate. It is estimated that the proposed development will generate approximately 628,278 tonnes per annum of liquid digestate and 46,405 tonnes per annum of solid digestate, which will be returned to farmers as fertiliser. The proposed site is located on the site of a former quarry; Figure 2-1 shows the red line planning boundary, with the proposed site layout in Figure 2-2 and a process flow diagram of the AD process in Figure 2-3

The proposed anaerobic digestion facility (9 hectares) will include:

- ▶ Site Entrance and Access
- ▶ Weighbridge and Weighbridge Office
- ▶ Circulation Yard
- ▶ Liquids Reception Building
 - Liquids Reception Area
 - Welfare Facility
 - Laboratory and Sample Store
 - Mechanical Room
- ▶ Solids Reception Building
 - Solids Reception Hall
 - Solids Storage Bunker
 - Solids Pretreatment Area
 - Electrical and Control Room
 - Welfare Facility
- ▶ Solid Digestate Building
 - Digestate Loading Area
 - Digestate Separation Loft
 - Digestate Storage Area
 - Mechanical and Electrical Room
- ▶ Bunded Tank Farm

- Primary Digesters (6 No.)
- Secondary Digesters (3 No.)
- Tertiary Digester (1 No.)
- Post Digestion Storage Tank (1 No)
- Liquid Pre-Storage Tank (1 No.)
- Digestate Storage Tank (1 No.)
- Pasteurisation Tanks (3 No.)
- Digestate Loading Tank (1 No.)
- Buffer Storage Tanks (2 No.)
- Tank Farm Building
- Pump Houses
- ▶ Odour Abatement System including stack
- ▶ Heating Centre with exhaust stack
- ▶ Desulphurisation Plant
- ▶ Gas Upgrade Plant
- ▶ CO₂ Liquefaction plant
- ▶ Biomethane Network Entry Facility (BNEF)
- ▶ Gas Flares
- ▶ Administration Building
- ▶ Drainage Infrastructure
 - Storm and Rainwater Collection
 - Wash Water and Process Water Collection Areas
 - Foul Water
 - Storm Water Lagoon
- ▶ Process And Fire Water Storage Tanks
- ▶ Ancillary Infrastructure
 - Storage of Chemicals
 - Fire Water Supply
 - Site Security
 - Lighting
 - Landscaping
 - Solar panels, roof-mounted; heating centre, administration building, liquid and solids reception buildings (2,200 sqm, 480,000 kWh per annum)

Figure 2-1 Site Map with Red Line Planning Boundary for the Proposed Development

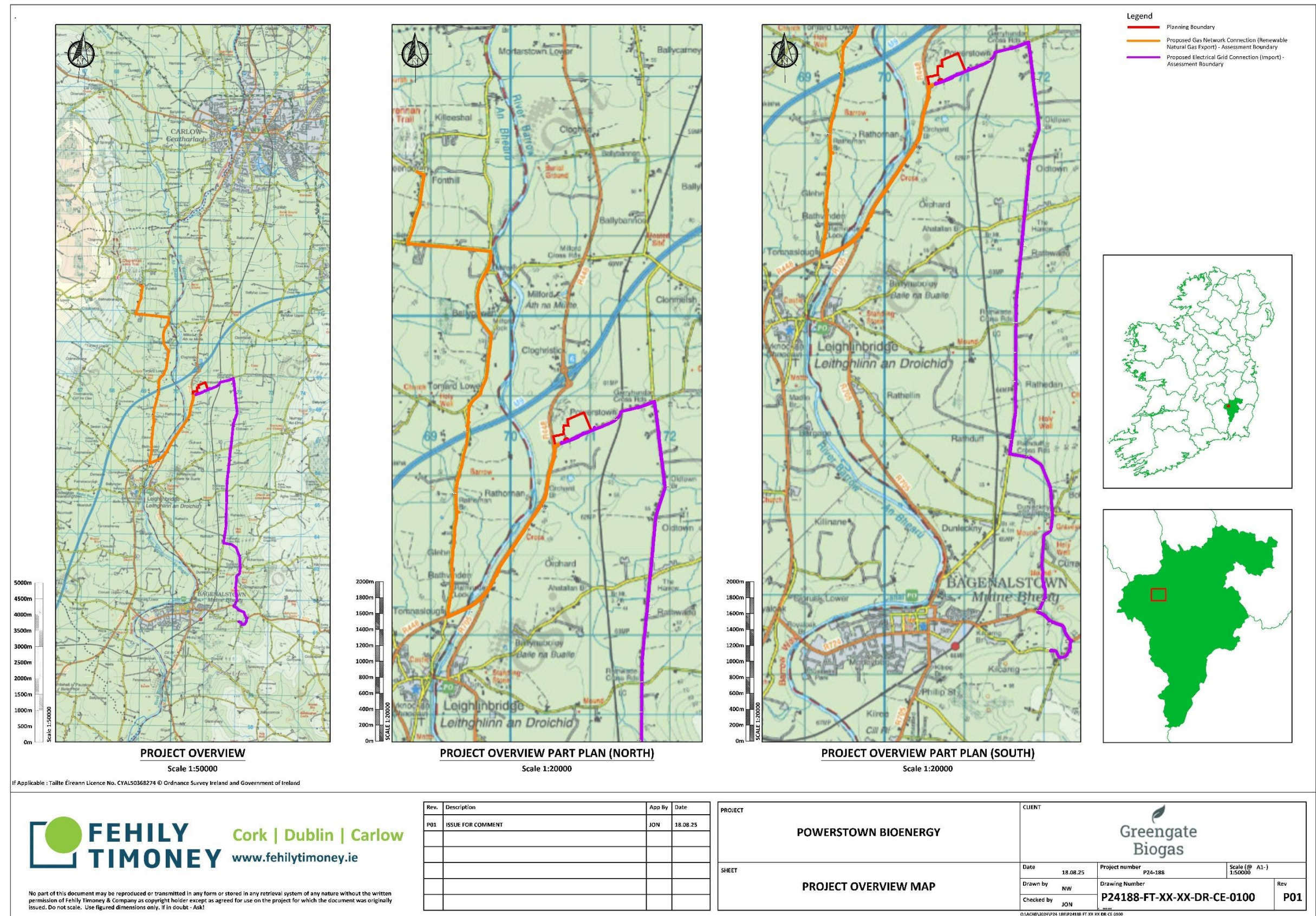
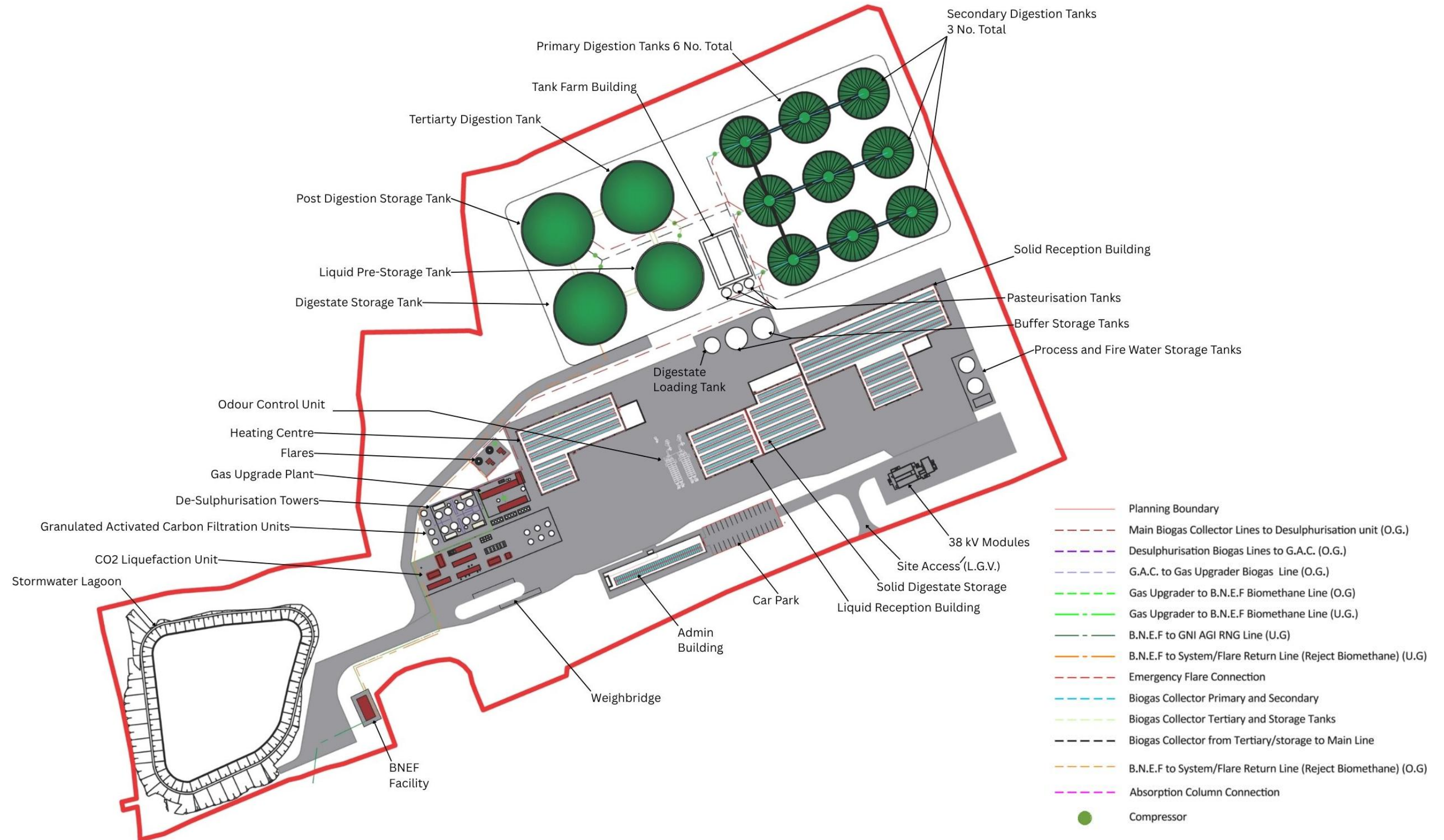


Figure 2-2 Proposed Development Layout Plan



The diagram illustrates a complex biogas production system. It begins with the intake of three types of biomass: Liquid Biomass, Surface Water, and Solid Biomass. These are processed through various stages including storage, disruption, and digestion. The system features multiple heat exchange loops and a final hygienization stage. The resulting biogas is then conditioned and upgraded to produce CH4, while CO2 is captured and sent to a flare. The process also includes a wood chip boiler for additional heat and a system for handling digestate and separated fibers.

Tegningen er intellektuel ejendom tilhørende PlanEnergi og må ikke kopieres eller distribueres, hverken helt eller delvist, uden direkte samtykke fra PlanEnergi. Brud på dette vil blive retsforfulgt.		The drawing is intellectual property of PlanEnergi and may not be copied or distributed, whole or in part, without direct consent from PlanEnergi. Violation of this will be prosecuted.		Die Zeichnung ist geistiges Eigentum von PlanEnergi und darf ohne ausdrückliche Zustimmung von PlanEnergi weder ganz noch teilweise kopiert oder verbreitet werden. Zuwiderhandlungen werden strafrechtlich verfolgt.	
Designed by	Checked by	Approved by	Date	Sheet Size	Scale
SSL	JRM	JRM		A3	

PlanEnergi

Block Flow Diagram

22-094-02-800-100

Edition B

Sheet 1 / 1

2.1.2 Feedstock

The transport of feedstock and digestate will be controlled by Greengate Biogas 001 Ltd. A fleet of 12 bulk haulers and tankers will transport feedstock and digestate from and to farms under contract to supply and receive materials. Starting at opening time, the vehicles will leave the facility via the weighbridge with loads of digestate, drive to farms, unload the digestate and refill with feedstock.

Feedstock will be transferred to the primary digesters via heat exchangers, raising the liquid feedstock temperature from its ambient temperature to just above the thermophilic process temperature range (48-55°C).

2.1.3 Solids Reception Building

The solids reception building is for receiving of solid feedstocks. It is located at the eastern end of the site. The Solids Reception Building will be a portal frame building surrounded by a concrete circulation yard to facilitate access and egress of incoming and outgoing solid farm yard manure (FYM) delivery vehicles. The roof will accommodate solar panels.

There are five elements to the building:

- ▶ Solids Reception Hall
- ▶ Solids Material Bunker
- ▶ Solids Infeed Area
- ▶ Solids Pretreatment Shredding Area
- ▶ Electrical and Control Area

2.1.4 Liquids Reception Building

Liquid feedstocks will be delivered to the site in sealed tankers to the liquid reception building. It is located in the centre of the site. The liquids reception building has 4 no. lanes each separated by raised kerbing. Each lane contains:

- ▶ two spigot valve connection points, one to unload feedstocks and one to load digestate
- ▶ pump system to assist in the loading of digestate
- ▶ pipework for the transfer of digestate or LFYM between the specialist liquid tankers and their respective storage tanks
- ▶ an odour abstraction hood in each lane, immediately above the tanker venting system to control point source emissions
- ▶ steel stairs and gangways to allow driver access to the tanker for cleaning operations

Within the liquids reception building, there is a separate enclosed area with concrete walls and a hollowcore concrete roof. This enclosed area is divided into the following three sections:

- ▶ Laboratory and Sample store
- ▶ Mechanical room
- ▶ Electrical room

2.1.5 Solid Digestate Building

The Solid Digestate Building will be used to separate digestate into solid and liquid fractions following the anaerobic digestion process. Post separation, all solids digestate will be stored and transferred offsite from within the solid digestate building. The facility is in an enclosed steel-frame building with insulated wall and roof panelling. Translucent wall panelling is included to allow daylight to enter. The solid digestate building is divided into four main areas:

- ▶ Solid Digestate Loading Bay
- ▶ Solid Digestate Storage Area
- ▶ Separator Loft
- ▶ Mechanical and Electrical Area

2.1.6 Bunded Tank Farm

The proposed bunded tank farm will comprise a large concrete bund area, locally lower than the surroundings, fully encircled by a reinforced concrete wall. The bund will be accessed via a ramp that forms part of the overall bund structure. The concrete bund will be designed and constructed in accordance with the requirements of:

- ▶ EPA Guidance on the Storage and Transfer of Materials for Scheduled Activities (EPA, 2004)
- ▶ BS 8007 Code of practice for design of concrete structures for retaining aqueous liquids (BSI, 1987)
- ▶ CIRIA C736 Containment systems for the prevention of pollution (CIRIA, 2014)

The bunded area will be capable of retaining 110% of the largest tank volume or 25% of the total installed tank volumes (whichever is greater) with an appropriate freeboard depth. The bund will undergo to integrity testing prior to commissioning. The bund will provide impermeable secondary containment in the highly unlikely event of a tank failure or leakage.

The tank farm will comprise 16 no. tanks required for the anaerobic digestion process, these include 6 no. Primary digester tanks, 3 no. Secondary digester tanks and 1 no. Tertiary digester tanks. Additionally, there will be 1 no. Post Digestion Liquid Digestate Storage Tank, 1 no. Liquid Pre-Storage Tank and 3 no. Pasteurisation tanks located in the tank farm. A list of tanks is included in Table 2-1.

The tanks are shown on the tank farm layout, tank farm details and elevations drawings in Appendix A herein.

Biogas will be collected from each digestion tank via gas piping. Sloping of the pipes and condensate wells will be installed at different areas of the plant as required. The condensate will be discharged to the plant's digestate storage.

Table 2-1 Tank Farm Schedule of Tanks Containing Biogas

Tank	Number of Tanks	Diameter (m)	Height (m)
Primary Digester	6	23.9	28.3
Secondary Digester	3	23.9	28.3
Tertiary Digester	1	33	10* ¹
Post Digestion Liquid Digestate Storage Tanks	1	35	9.6 * ²
Liquid Pre-Storage Tank	1	35	9.6 * ²
Pasteurisation Tank	3	5	10.7
Digestate Storage Tank	1	35	9.6 * ²

*¹ Tank Wall height; Total Height including Gas Balloon 18m

*² Tank Wall height; Total Height including Gas Balloon 17.6m

2.1.6.1 Primary Digesters

There are 6 no. Primary digester tanks. Primary digesters will be constructed in steel. The steel digesters are constructed using coated (painted C2) steel plates for the liquid zone and stainless steel (AISI316) for the top gas zone (top ring and roof). The digesters will feature a reinforced concrete flat bottom. Insulation will be installed on the outside tank and appropriately painted. The roof will be made of stainless steel, clad with insulation and painted.

The primary digestion phase will be undertaken in the six primary digestion tanks. Primary digestion tanks will operate in two parallel groups of three tanks in series. Primary digesters will operate in the thermophilic process temperature range at 48-55°C. The digesters will operate as continuously stirred tank reactors (CSTRs). Mixing of the digesters will be done by one top mounted agitator on the tank's roof.

Digestate discharge from each primary digester to the secondary digester will be facilitated by a cavity pump via a pipe at the bottom of the digester.

Tanks will be equipped with over/under pressure valves for safety. The valves will be dimensioned according to the gas production for the respective tank +100%. To prevent liquid overflow from the tanks, multiple level measurements will be installed in the tanks.

2.1.6.2 Secondary Digesters

The secondary digestion phase will be undertaken in the 3 No. secondary digestion tanks. Secondary digestion uses the same type of tank and follows the same process as outlined for primary digestion, operating in the same thermophilic environment at 48-55°C. Digestate discharge from secondary digesters to the tertiary digester will be facilitated by a cavity pump through a pipe situated at the digester's bottom.

2.1.6.3 Tertiary Digesters

There is 1 no. tertiary digester tank. The tertiary digester tank will be constructed in concrete with a twin-layered gas membrane domed roof. The tertiary digester will be externally heated via an externally mounted heat exchanger to maintain the thermophilic process temperature range. Paddle mixers or submerged agitators will continually mix feedstocks within the tertiary digestion tank. A twin-layered gas membrane domed roof will be used to cover the tank. The concrete tank will be clad with insulation and painted.

The total retention time for the entire digestion process (i.e. primary, secondary and tertiary) will average 58-60 days.

2.1.6.4 Post Digestion Liquid Digestate Storage Tank

Liquid digestate will be stored in a reinforced concrete tank with several submerged mixers to ensure that the digestate can be mixed prior to pasteurisation. A twin-layered gas membrane domed roof will be used to cover the tank. The concrete tank will be clad with insulation and painted. Paddle mixers or submerged agitators will continually mix feedstocks within the post digestion liquid storage tank. The tank will be insulated to maintain digestate temperature pre-pasteurisation.

2.1.6.5 Pasteurisation Tanks

Post digestion, all digestate will be pasteurised in accordance with Animal By-Products Regulations. Digestate will be pumped into one of three pasteurisation tanks, where it will be retained for >1 hour at a temperature >70 °C.

The three tanks will operate on a rotational/batch basis, each serving a specific function: one for receiving the digestate, one for holding it, and one for pumping it to the downstream digestate storage. This rotation cycle shifts hourly. Pasteurisation tanks will be mixed by a centrally mounted vertical mixer.

Similar to the digesters, these pasteurisation tanks are heated reactors, maintaining a temperature of $>70^{\circ}\text{C}$ via overheating ($\geq 2^{\circ}\text{C}$) of the incoming stream in external heat exchangers. Internal heating coils will heat the digestate. Each pasteurisation tank will be equipped with at least three temperature transmitters installed at different levels to continuously monitor that the required minimum temperature (above 70°C) is maintained throughout the tank. If the temperature at any sensor falls below 70°C at any point during the required minimum 1-hour pasteurisation cycle, an alarm will be triggered and the event will be recorded. In such cases, the pasteurisation process will automatically restart to ensure full compliance with regulatory requirements.

The tanks will be installed with SCADA systems that ensure tank material is released only when the temperature is met at all temperature transmitters. The SCADA system will be non by-passable, meaning it cannot be accessed and changed by operating personnel.

Pasteurisation tanks will be constructed in stainless steel and externally insulated.

After the pasteurisation tanks, the digestate will be separated into a solid and liquid fraction in the loft of the solid digestion storage building.

2.1.6.6 Digestate Storage Tank

Pasteurised digestate will be stored in a reinforced concrete tank with several submerged mixers to ensure that the digestate can be mixed prior to collection by trucks. The digestate storage tank will be uninsulated. The roof will be a twin-layer gas membrane domed roof with gas collection to the gas system. Digestate storage capacity will be minimum of 4 days at full production.

2.1.6.7 Buffer Storage Tanks

Two buffer storage tanks will be provided to allow for efficient site operation for the transfer of liquid feedstocks. Liquid feedstock will, if required, be pumped to buffer storage in advance of the Liquid Pre Storage Tank. The buffer storage tanks will be constructed in reinforced concrete with submerged mixers. The buffer storage will be uninsulated. Buffer storage capacity will be approximately $1,000\text{m}^3$ ($2 \times 500\text{m}^3$).

2.1.6.8 Digestate Loading Tank

A digestate loading tank will be provided to allow for efficient pumping and transfer of digestate. Pasteurised digestate will be pumped from the digestate storage tank and the digestate loading tank. The digestate loading tank will be constructed in reinforced concrete with submerged mixers to ensure that digestate is mixed prior to collection by trucks. The digestate tank will be uninsulated. The roof will be flat with a connection to the Odour Abatement system. Digestate storage capacity will be approximately 150m^3 , 6-7 liquid vacuum tankers loads.

2.1.6.9 Tank Farm Bund

The tank farm bund is designed in accordance with Guidance to Storage and Transfer of Materials for Scheduled Activities (EPA, 2004). The tank farm will be bunded in its entirety to ensure adequate containment is provided in the unlikely event of a leak at the facility.

Rainwater falling within the bunded area will drain to a collection sump, from which the bund water will be pumped to the process water tanks or storm water storage lagoon. Pumping from the bunded area will be automatically controlled via level sensors. Water pumps will activate

whenever collected rainwater exceeds a predetermined "high level" in the collection sump, and will continue pumping until the predetermined "low level" is reached.

To maintain the integrity of the bunded area and prevent pumping during unlikely events such as fire and/or a tank leakage, the following control measures will be employed. The rainwater pumps will be programmed (via the site SCADA system) to automatically disable in the event of a site alarm e.g. fire alarm, leakage alarm.

In addition to this system, it is proposed that a Continuous Emissions Monitor (CEM) will be installed within the bunded area rainwater collection sump.

The CEM will monitor a set parameter or number of parameters (e.g. electroconductivity, pH) on a continuous basis. The default automatic pump control status will be OFF. Only if all sensors are measuring within preset operational criteria (i.e. those expected for rainwater) will the CEM allow the installed pumps to switch to ON status and start pumping.

2.1.7 Biogas Collection and Treatment

Raw biogas will be collected from all primary digestion, secondary digestion, tertiary digestion and post storage tanks for upgrading to biomethane and biogenic CO₂. The facility is designed to ensure that RNG to grid delivers $\geq 99\%$ of methane produced by the feedstock in the anaerobic digestion process. The proposed RNG quality requirements are set out in Table 2-2.

Table 2-2 GNI RNG Grid Entry Quality Requirements

Parameter	Entry Requirements	Units
Total Sulphur	< 50 mg/m ³ (including H ₂ S)	mg/m ³ (including H ₂ S)
Oxygen	≤ 1.0 mol% (see RNG note 1)	mol%
Carbon Dioxide	≤ 2.5 mol% (See note 1)	mol% (See note 1)
Hydrogen Sulphide	≤ 5 mg/m ³	mg/m ³
Water Content	≤ 50 mg/m ³	mg/m ³
Gross Calorific Value (Real Gross Dry)	36.9 – 42.3	MJ/m ³
Wobbe Index (Real Gross Dry)	47.2 – 51.41	MJ/m ³
Contaminants and Odor	See Note 2 and 3	-
Incomplete combustion factor	< 0.48	-
Delivery Temperature	1- 38	°C
Hydrogen	< 0.1 mol%	mol%
Soot Index	< 0.60	
Organo Halides	< 1.5 mg/m ³	mg/m ³
Radioactivity	< 5 Becquerels/g	Becquerels/g
Ethane	< 12 mol%	mol%
Nitrogen	≤ 5 mol%	mol%
Hydrocarbon Dewpoint	$\leq -2^{\circ}\text{C}$ up to 85 barg	

Reference Conditions

All measurements at 15° Celsius and 101.325kPa

Note 1 The CO₂ limit of 2.5% will not be considered breached if the total inerts (including CO₂) in the gas is less than 8% where:

"inerts" in natural gas means carbon dioxide (CO₂), nitrogen (N₂), helium (He), argon (Ar), and oxygen (O₂).

Note 2 Natural Gas will not contain solid liquid or gaseous material which may interfere with the integrity or operation of pipes or any Natural Gas appliance which a consumer or transporter could reasonably be expected to operate. With respect to Mist, Dust,

Liquid, gas delivered will be technically free in accordance with BS3156 11.0 [1998].

Note 3 Natural Gas will have no odour that might contravene the obligation of the Transporter to transmit gas which possesses a distinctive and characteristic odour. Where the Transporter requires gas to be odourised, the gas will be odourised in accordance with the following specification:

- Odour intensity of 2 olfactory degrees on the SALES Scale (Ref-IGE/SR/16/1989), or
- such other specification determined by the Transporter acting as an RPO

Emergency Gas Quality Specification In the event of an Emergency, and at the sole discretion of the National Gas Emergency Manager, gas outside of the Entry Specification may be admitted to the system. Without prejudice to the generality of this, the emergency limits as outlined in the Natural Gas Emergency Plan NGEP may be adopted by the Transporter.

Renewable Natural Gas Notes

1. Oxygen content for gas derived from Renewable Natural Gas at an RNG Entry Point connected to the Distribution System will be up to **1 mol%** where there is provision for automatic discontinuation of gas flows for non-compliance with the applicable Entry Specification. Such automatic discontinuation will comprise of the discontinuation of gas flow based on preprogrammed criteria, such criteria determined by the Transporter and embodied in an automated process, all as outlined in the applicable CSA.
2. The CSA in respect of any RNG Delivery Facility may subject to the approval of the Commission specify additional gas quality parameters (which may for avoidance of doubt be subsets of the parameters set out above) and associated limits in respect of such parameters to apply at the individual RNG Entry Point or category of RNG Entry Point in which case the gas quality parameters so specified will (subject to Renewable Natural Gas Note 1 above) apply at such RNG Entry Point(s) in addition to the parameters set out above.

Raw biogas first undergoes gas conditioning, where it is compressed and chilled. Cooling causes a liquid condensate to form, which is pumped to the Liquid Pre-Storage Tank.

2.1.7.1 Liquid Pre-Storage Tank

There is 1 no. liquid pre-storage tank with 4 no. days storage. The tank is constructed from reinforced concrete and is sealed to prevent odour emissions. It is located in the tank farm bunded area, connected via pipework. The tank will have several submerged mixers to keep particulate matter suspended in the slurry. The tanks are covered with a membrane gas cover and will be connected to the gas system for collection of gas. These tanks will not be heated or insulated.

2.1.7.2 Desulphurisation Plant

The biogas will go through a two-step desulphurisation process to remove hydrogen sulphide within the desulphurisation plant. The first step will be a biological process. Biogas passes upwards through a vertical column while a mixture of process water and NPK fertiliser trickles downwards. Sulphur-oxidising bacteria within the column consume the hydrogen sulphide; the downward liquid flow sustains the bacteria and flushes out their by-products as condensate. Condensate will be

pumped from the base of the gas column to the digestate tank. This biological stage typically removes the bulk of the H₂S load, with residual H₂S removed downstream by GAC (Section 2.1.7.3). The desulphurisation plant is located to the west of the site, and west of the gas upgrade plant. It consists of a series of 8 no. hydrogen sulphide filtration towers which are constructed using insulated cladding material. The towers are 3.6m diameter and 10m high. Each roof has a manhole and an inspection hole. Near the base of each tower there is a manhole and a gas outlet. There are 4 no. control units, each one servicing 2 no. hydrogen sulphide filtration towers and 1 no. activated carbon filter unit. All the towers and containers are built on reinforced concrete foundations.

2.1.7.3 Granulated Activated Carbon Filtration

Post-desulphurisation, the biogas is drawn through a tower packed with granular activated carbon (GAC). The high internal surface area of the carbon adsorbs residual hydrogen sulphide (H₂S), volatile organic compounds (VOCs) and other trace contaminants from the gas stream. Carbon media is replaced or regenerated once its adsorption capacity is exhausted.

2.1.7.4 Gas Upgrade Plant

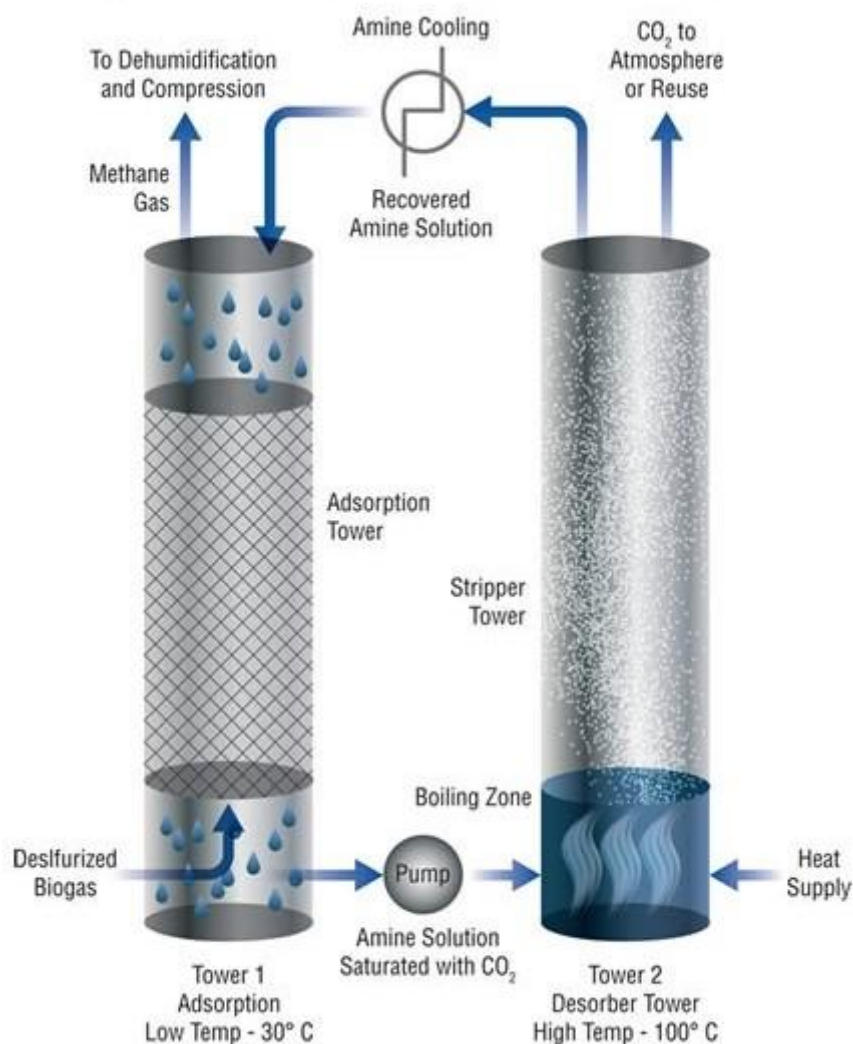
The upgrading process will separate the desulphurised raw biogas mixture into biomethane (CH₄) and biogenic carbon dioxide (biogenic CO₂).

Biogenic CO₂ is CO₂ derived and captured for utilisation from carbon previously absorbed and stored within organic matter.

The desulphurised raw biogas is passed through an amine solution within an absorber tower. Acidic gases (e.g. CO₂ and trace H₂S) are physically absorbed into the amine solution in the absorber tower forming an amine solution. Methane being a non-acidic hydrocarbon does not react with the amine solution and thus remains in the gas phase allowing for its collection as a purified biomethane product. The rich amine is transferred to a stripper tower and heated to its boiling point to regenerate the lean amine and release the absorbed gases. Operating conditions depend on the stripper pressure design (105 °C at ~70 mbarg, or 84 °C at ~-500 mbarg). The released biogenic CO₂ and residual H₂S are collected separately for downstream treatment. The regenerated amine is then recycled via a cooling chamber back to the absorber. Heat is provided by means of hot water or steam generated at the Heating Centre.

Typical amine solutions are Diethanolamine (DEA), Monoethanolamine (MEA) or Methyldiethanolamine (MDEA), or a mix.

Figure 2-4 Amine Separator Illustration



Source: <https://www.biogaspurifier.com/an-overview-of-biogas-upgrading-technologies/>

2.1.7.5 CO₂ Liquefaction Plant

Biogenic CO₂ then undergoes CO₂ liquefaction. It is compressed and cooled, forming liquid CO₂. This liquid CO₂ is stored in insulated tanks for transport offsite as a food grade CO₂ product.

The raw biogenic CO₂ (separated by the Biogas Upgrading Plant) will contain impurities such as moisture, sulphur compounds, and trace hydrocarbons. The raw gas will first undergo purification using molecular sieves, activated carbon filters, and chemical scrubbers.

Next, the purified biogenic CO₂ gas will be compressed in multistage compressors, raising its pressure to around 15–25 bar. Intercoolers between each compression stage will remove excess heat. The compressed gas is then pre-cooled to near 0°C using chillers or heat exchangers. The core liquefaction phase involves cooling the biogenic CO₂ below its critical temperature (around -20°C) under pressure using cryogenic heat exchangers and refrigerants (ammonia). This condenses the gas into a dense liquid.

The final liquid CO₂ will be stored in vacuum-insulated pressure vessels. Specialist trucks will then be used to transport the liquefied biogenic CO₂ offsite for sale as a product in Ireland and abroad. Trucks will be filled using one of two dedicated CO₂ filling points.

The CO₂ liquefaction plant is located directly south and adjacent to the desulphurisation plant and the gas upgrade plant. It will liquefy the carbon dioxide generated in the AD process so that it can be transported off site as a renewable source of biogenic CO₂. The plant is built on reinforced concrete foundations, and it consists of equipment to compress and cool CO₂ to convert it from a gaseous state into a liquefied state. The equipment includes:

- ▶ Liquid CO₂ Tanks
- ▶ Air Cooler Units
- ▶ Compressor Containers
- ▶ Process Containers
- ▶ Refrigeration Container
- ▶ H₂S adsorber
- ▶ CO₂ scrubber
- ▶ CO₂ distiller
- ▶ Deodouriser
- ▶ Gas Dryer
- ▶ Dust filters
- ▶ Gas Cooler Unit
- ▶ Superheater

2.1.8 Biomethane Network Entry Facility (BNEF)

Biomethane will enter the BNEF from the Gas Upgrade Plant. The BNEF will be constructed onsite in accordance with Gas Networks Ireland (GNI) specifications and requirements. The BNEF will comprise a single container unit within a secure fence compound. The unit will be sized to manage 3,400 Sm³/hr of RNG. Average gas flow through this unit will be 2,600 Sm³/hr. The BNEF will continually monitor the biomethane produced against GNI network standards.

Biomethane meeting the required quality parameter will be metered and allowed entry into the gas network as Renewable Natural Gas.

In the event that the biomethane produced fails to meet the required standard, the gas transmission network valve will close and the rejected biomethane will be returned to the digestion plant via an internal gas return loop. The rejected biomethane will then either be reprocessed (re-entering as raw biogas, i.e. to the desulphurisation plant) or flared until such time that the GNI quality parameters are met and the network valve "reopens".

.

The BNEF will also facilitate the addition of odour to the treated biogas.

The following information was provided by Gas Networks Ireland:

- ▶ The BNEF Enclosure and equipment therein will be designed in accordance with EN 17928 ¹
- ▶ The enclosure will be sub-divided into separate room compartments with all internal dividing walls sealed gas tight so that hazardous area zoning is maintained, and specifically safe areas are not compromised.

¹ EN 17928-1:2024 - Gas infrastructure: Injection stations - Part 1: General requirements (CEN) defines the functional and safety principles for stations that inject biomethane, substitute natural gas (SNG) and hydrogen into gas transmission and distribution systems.

- ▶ Compartments will be fitted with thermostatically controlled electrical heating and /or forced ventilation to maintain the interior temperature in the range required by any equipment housed within. Any ventilation to a compartment will be directly to the outside of the enclosure and not to another compartment.
- ▶ The BNEF enclosure will have a gas tight E&I room that will house electrical distribution and control equipment.
- ▶ The enclosure roof will be of fixed construction above safe area compartments and relieving construction above hazardous area compartments, as per guidelines in IGEM/TD/13. All hazardous areas will be classified in line with IGEM/SR/25.
- ▶ Suitable natural ventilation will be installed to ensure suitable ventilation to match the required ATEX rating. High level vents will be installed to prevent the occurrence of gas pockets.
- ▶ The building walls, roof and doors will have a 1-hour fire resistance, ceiling / roof to have ½-hour fire resistance in accordance with the Building Regulations 2006-Technical Guidance Document B-Fire Safety. Any transects between rooms will have a 1-hour fire resistance.
- ▶ The enclosure will be in full compliance with the building regulations. The enclosure designer will be required to provide a certificate of design in accordance with the building regulations to allow GNI to comply with the Building Control Amendment Regulations (2014).
- ▶ Gas detection to be included in the BNEF enclosure with fire and smoke detection in the instrument room.
- ▶ Electrical system design of the BNEF to I.S. EN 10101
- ▶ TN Earthing, derived from an isolating transformer located within the E&I room
- ▶ The electricity supply meter and associated incomer switchgear will be located in a separate dedicated incomer kiosk located outside the BNEF fence line.
- ▶ Earthing and bonding throughout the site will be required to maintain the integrity of electrical protection and hazardous area equipment.
- ▶ Gas detectors will be installed in all indoor areas equipped with pipework containing gas, essentially all hazardous zoned area rooms.

Gas detection will initiate gas supply shut off from the AD plant and emergency ventilation. Figure 2-5 illustrates an example of a BNEF unit².

² www.thyson.com

Figure 2-5 BNEF Container Example



2.1.9 Gas Network Connection

Renewable natural gas (RNG) will be exported from the site via a gas pipeline. The proposed gas pipeline route is subject to a separate statutory consent.

The gas network connection to the national gas grid is located outside of the planning application and COMAH operational boundary.

The proposed gas pipeline will be laid in the road network. The pipeline will be laid in the L3045 for 100 metres, then turning onto the R448 road travelling, south from the site for c. 2.65 km to the intersection of the R448 and the L3038. The gas pipeline will then follow the L3038 / L3039 road northwards for c. 4.75 km before turning westerly along Milford Park Road.

The pipeline will travel along Milford Park Road for c. 1 km before turning north along the L3043 road for c.1 km. The gas pipeline will connect to the Clogrennan AGI, located just off the L7031 road (c. 100m). The route of the proposed pipeline will cross the River Barrow and the M7 motorway.

GNI is the Statutory Undertaker responsible for obtaining development consent for the proposed gas pipeline from the Commission for Regulation of Utilities (CRU).

2.1.10 Gas Flare(s)

Two emergency gas flares, each with its own stack, will be located to the west of the bunded tank farm.

Each flare is an enclosed unit with a stack and a treatment capacity of 3,000 m³/hr. Gas is combusted at over 850 °C with a 5-second retention time to ensure complete conversion of methane to carbon dioxide and destruction of trace compounds, including odours. The flares are electrically powered and controlled via the site SCADA system.

Total flare operation is estimated at approximately 200 hours per year, comprising routine functional testing and abnormal-condition operation (see below).

Flaring will only occur during abnormal operating conditions such as system breakdown, rejection of gas by the BNEF, or extended maintenance periods. Under normal operating conditions, off-spec gas is recycled back into the system, re-upgraded, and stored for 3–4 hours before re-entry to the BNEF, avoiding the need to flare. Flare operation and emissions during abnormal conditions will be regulated under the Industrial Emissions (IE) Licence issued by the EPA.

Flare operation is continuously monitored, with records of methane, carbon dioxide, oxygen and hydrogen sulphide concentrations, along with flow, temperature and pressure. A typical enclosed gas flare is shown in Figure 2-6.

Figure 2-6 Typical Enclosed Flare (Himmel)



2.1.11 Odour Abatement System

The solids reception, liquid reception and solid digestate building will be maintained under continuous negative air pressure, via connection to the odour abatement system.

The abatement system includes a combination of Ammonia (NH₃) Scrubbing, High Intensity Ultraviolet (UV), Photo Chemical Oxidation, and Activated Carbon Filtration technologies enabling the system to achieve high levels of odour removal for all odorous species that could be generated from the onsite activities. Selected air streams will also be subject to advanced Hydrogen Sulphide Pre-Filtration

2.1.12 Heating Centre

The heating centre will provide renewable heat for use within the biogas upgrading and anaerobic digestion process. Heat will be generated by 2 No. 4 MW wood biomass boilers. Approximately 13,000 tpa of biomass will be required to produce the heat demand of the proposed development. The biomass boiler will utilise indigenously sourced virgin wood chips, RED III compliant for heat generation.

The principal consumer of heat generated at the heat centre will be the biogas upgrading plant for the regeneration of amine. It also provides heat for the digestion and pasteurisation processes. The heating centre will contain the following:

- ▶ Biomass Delivery Bunkers
- ▶ Biomass Storage Bunker
- ▶ Biomass Boilers
- ▶ Biomass Boiler Exhaust Air Treatment System
- ▶ Heating Centre Exhaust Stack
- ▶ Ash Handling System

The proposed heating centre will have a reinforced concrete substructure and a cladded steel portal frame. The roof will accommodate solar panels.

2.1.13 Administration Building

A dedicated administration building will provide for all site operations and administrative staff. The building will include the following.

- ▶ IT/server room
- ▶ 4 No. Management offices
- ▶ 2 No. open plan offices (capable of seating 20 people collectively)
- ▶ Reception office
- ▶ Reception Area/ Foyer
- ▶ Conference Room
- ▶ 2 No. W.C.'s inc. 1 No. accessible
- ▶ Canteen
- ▶ Storeroom
- ▶ Changing rooms
- ▶ Open-air viewing platform accessed from an internal staircase.

The building is orientated and glazed so staff can view the entire site. The roof will accommodate solar panels. The open-air viewing platform is designed for visitor access.

2.1.14 Drainage Infrastructure

The proposed development includes the installation of a comprehensive, segregated drainage network for the facility. The infrastructure consists of collection, control, and storage systems for:

- ▶ storm water/rainwater
- ▶ wash water
- ▶ process water
- ▶ foul water

The proposed development has a fully separated storm water drainage system for clean storm and rain water, comprising three distinct hydraulic networks, including:

- ▶ a drainage network serving the yard and circulation areas;
- ▶ a drainage network serving the bunded tank farm;
- ▶ a roof water drainage network collecting rainwater runoff from building roofs; and
- ▶ an interceptor drainage network collecting clean overland flows from surrounding lands and quarry cut areas.

All storm and rainwater is collected in the proposed stormwater lagoon.

Water collected from the yard and circulation areas is collected via a network of linear drainage channels and gulleys. No feedstock or digestate handling activities will be conducted externally, as all unloading and loading will take place indoors. Collected yard area water is gravity fed via a Class 1 Full Retention Oil interceptor to the main collection chamber. The interceptor is included to separate any potential minor hydraulic oil spills or leaks from rainwater draining across the yard area.

Water collected in the tank farm bund drains to one of two sumps in the bund and if it is determined that the bund water is clean the collected water is pumped directly to the storm water lagoon.

Water collected from the roof areas is gravity fed to the main collection chamber.

The proposed facility is located in a local depression due to past quarrying. Overland water flows from the surrounding higher areas and quarry cuts are collected in an interceptor drain and flow via gravity to the main collection chamber, which is located east of the storm water lagoon.

The proposed development has a significant daily water demand; most of this demand will be supplied from the stormwater lagoon. An outlet pump chamber controls the flow of water from the storm water lagoon back to the AD process water tanks under normal operating conditions. There is an automated valve in the outlet pump chamber that allows discharge to the external drainage network under specific conditions.

The proposed stormwater lagoon will be located in the southwest of the site at the entrance. The storm water lagoon will be constructed with an earthen embankment i.e. a raised embankment made from compacted soil.

The effective lagoon depth is 3.0 m, with a total depth of 3.6 m. This includes a 0.30 m freeboard and a 0.30 m sump for particle sedimentation. The lagoon inlet level is fixed at the lowest level of 44.00 m. Since the gravity discharge system is approximately 1 m above this level, an overflow pump and pressure pipes are required to transfer excess water into the lagoon when the water level rises from 1 m up to 3 m. The gravity outfall will also be fitted with a flap valve to prevent reverse flow.

2.1.15 Ancillary Infrastructure

2.1.15.1 Storage of Chemicals

Table 2-3 lists the inventory of chemicals expected to be used on site at the proposed development.

Table 2-3 Inventory of Chemicals

Chemical	Inventory	Location
Polyamine-liquid to boiler water	200 litres	Bunded pallet in Boiler building
Hydrocarbon cooling agent (R290 Refrigerant Grade Propane) Or CO2 cooling agent (R744)	3000 litres	IBC CO2 liquefaction unit and heating area
Inhibited Sulphuric acid	2000 litres	IBC Feedstock building
Sodium hydroxide	1000 litres	IBC Feedstock building
Ferric powder	2000 kg	Bunded pallet Feedstock building
Inhibited hydrochloric acid	2000 litres	IBC Feedstock building

Chemical	Inventory	Location
NPK fertilizer for biofilters	3000 litres	IBC Gas cleaner, upgrading area, air treatment area
Anti-foam (rape seed oil)	100 litres	Bunded pallet Upgrading area
Glycol cooling liquid	2500 litres	IBC Upgrading area or boiler room
Drying agent (Sorbead)	2000 kg	Bunded pallet Upgrading area or boiler room
Amine-liquid (Methyldiethanolamine MDEA)	12000 litres	Bunded pallet Upgrading area, inside container
Gearoil, hydraulic oil, motor oil (synthetic hydrocarbon oil e.g. LCG-100)	2000 litres	Bunded pallets in Workshop
Windshield wiper fluid (methanol)	100 litres	Bunded pallets in Workshop
Adblue®	1000 litres	Bunded pallets in Workshop
Diesel for wheel loader and vehicles	5000 litres	Bunded Diesel Tank
H ₂ SO ₄ , Sulphuric acid 96%	79 m ³	Bunded Tank at Odour Control Unit
NaOH, Sodium Hydroxide 50%	280 m ³	Bunded Tank at Odour Control Unit
H ₂ O ₂ , Hydrogen Peroxide	114 m ³	Bunded Tank at Odour Control Unit
Activated Carbon	23 tonnes	Bunded Pallet in Workshop
Sulphared	1.5 tonnes	Bunded Pallet in Workshop

2.1.15.2 Fire Water Supply

Fire water supply will be provided from the Process Water Tanks. Process Water Tanks will be controlled to at all times maintain the minimum fire water supply design volume (240 m³). The process water tanks will supply a series of fire hydrants located about the site. Hydrants will be supplied by a 150mm rising main by means of an electrical pump operating at 3-4 bar operating pressure³. Additional water supply can be provided by the surface water lagoon or groundwater pump supply. Emergency diesel power electrical generation will be used to power the groundwater and fire hydrant pumps in the event of power failure.

2.1.15.3 Firewater Retention

Firewater retention will be provided in accordance with the Guidance on Retention Requirements for Fire Water Runoff (EPA, 2019). In accordance with the FireWater Risk Assessment (see Appendix 3.2 of Volume 3 of this EIAR) undertaken for the proposed development the worst-case scenario, the overall amount of firewater retention capacity required at the proposed facility is 2,101 m³.

Fire water retention will be provided within the storm water lagoon. In the event of a fire, the automated drainage control system will pump firewater to the surface water lagoon for retention. Post event the storm lagoon would be emptied and transferred off site by an authorised contractor for treatment at an appropriately authorised facility. In that case, the storm water lagoon would be cleaned before refilling with groundwater or stormwater. The storm water lagoon provides 2,385 m³ of firewater storage.

³ Fire Water Volume and Hydrant Supply requirements as per the requirements of the Carlow Fire and Rescue Service.

2.1.15.4 Site Security

The proposed development will be fenced in its entirety by a 2.4m high palisade type perimeter fence. A fully lockable entrance gate will be installed at both entrances.

Internal areas will also be fenced internally for safety and security reasons, preventing unauthorised access to these areas from within the site.

The proposed facility will include CCTV across all site areas internally and externally, including the site access route and boundaries. It is proposed that CCTV will be monitored by site staff during operational hours and supported by a remote monitoring service outside operational hours.

2.1.15.5 ESB Substation and Transformer

The ESB substation will be located in the south of the site. The ESB substation will be constructed in accordance ESB Specifications.

2.1.15.6 SCADA

A supervisory control and data acquisition (SCADA) system is a system of software and hardware elements that allows the following:

- ▶ control industrial processes locally or at remote locations
- ▶ monitor, gather, and process real-time data
- ▶ directly interact with devices such as sensors, valves, pumps, motors etc. through human-machine interface software
- ▶ record events into a log file system
- ▶ provide warning and system alarms

SCADA will be used to monitor and control the anaerobic digestion process, biogas upgrade, heating centre, grid entry unit, process water control, flares and continuous emissions monitoring devices.

2.1.15.7 Solar Panels

Solar panels covering a total area of 2,200 m² or approx. 1,300 panels will be supplied and installed across all available roof areas at the site. The proposed solar panels will be connected to the site "behind the meter" and will supply part of the overall site electrical demand during daytime hours. Solar power export from the site is not expected during standard operations.

The total estimated solar energy will be 430,000 kWh per annum.

2.1.16 Operating Hours

The proposed hours of operation are shown in the following table. It is proposed that no import or export of feedstocks or products would take place on Sundays or Bank Holidays.

Table 2-4 Operational Hours

Operations	Start Time	Finish Time
Plant operation including solid feedstock feeding, liquid feedstock feeding, odour management system and heating centre	Continuous	-
Feedstock acceptance i.e. traffic movements	07:00 Monday-Saturday	19:00 Monday to Friday 14:00 Saturdays

Export of digestate	07:00 Monday-Saturday	19:00 Monday to Friday 14:00 Saturdays
Export of liquefied CO2	07:00 Monday-Saturday	19:00 Monday to Friday 14:00 Saturdays
Export of biomethane	Continuous	-

2.2 Surrounding Area and Identified COMAH Receptors

The proposed development site, known as Mary Kelly's Pit, is located in Powerstown, Milford, County Carlow. The site is situated 2.5 kilometres north of Leighlinbridge, 6 kilometres north of Bagenalstown, approximately 2.5 kilometres northwest of Nurney village, 8.6 kilometres south of Carlow town, and 15 kilometres southwest of Tullow. A site location map is provided in Figure 2-1 in Section 2.1.1.

The site is operated as a quarry by Kilcarrig Quarries Ltd. and has undergone partial restoration. It currently functions as a quarry and a soil recovery facility to facilitate restoration. In May 2025, planning permission was granted (Ref: 23/60263/ABP3201080-24) for restoration to agricultural land over an eight-year period. This permission allows for infilling of less than 25,000 tonnes per annum and completion of remaining quarrying activities, estimated at approximately 7,500 tonnes, over a 24-month period. The site contains one small building and a groundwater well, with no other permanent infrastructure.

The site is located within a mixed-use landscape comprising industrial, infrastructural, and agricultural activities. Powerstown Landfill is located directly north of the site, while the Powerstown Recycling Centre is situated to the east. Both facilities are co-located and are operated under EPA Waste Licence No. W0025-04 BY Carlow County Council. The landfill is closed and has been capped and restored in accordance with the EPA licence. The recycling centre is open to the public.

To the south, the land is primarily used for mineral extraction, with active quarrying operations by Kilcarrig Quarries Ltd. and further north by Dan Morrissey & Co. within one kilometre of the site. A railway line (Dublin–Waterford route) is located to the east, and the R448 Regional Road is located immediately to the west. The River Barrow and agricultural land sits between the R448 Regional Road and the M9 Dublin Waterford motorway.

The wider area surrounding the site is characterised by extensive pastureland and non-irrigated arable fields in all directions.

The site is adjacent to EPA-licensed facilities including the Powerstown Landfill and Recycling Centre (Waste Licence No. W0025-04) and is subject to planning and waste facility permit authorisations. The waste acceptance building is the closest receptor to the tank farm at the proposed development. It is located 68 metres east of the site boundary and 80 m from the closest secondary digester. There are up to two operatives in this building. The general public does not have access to this building.

There is a number of residential properties along the L3045 and the R448 which are identified as COMAH receptors in the COMAH land use planning study.

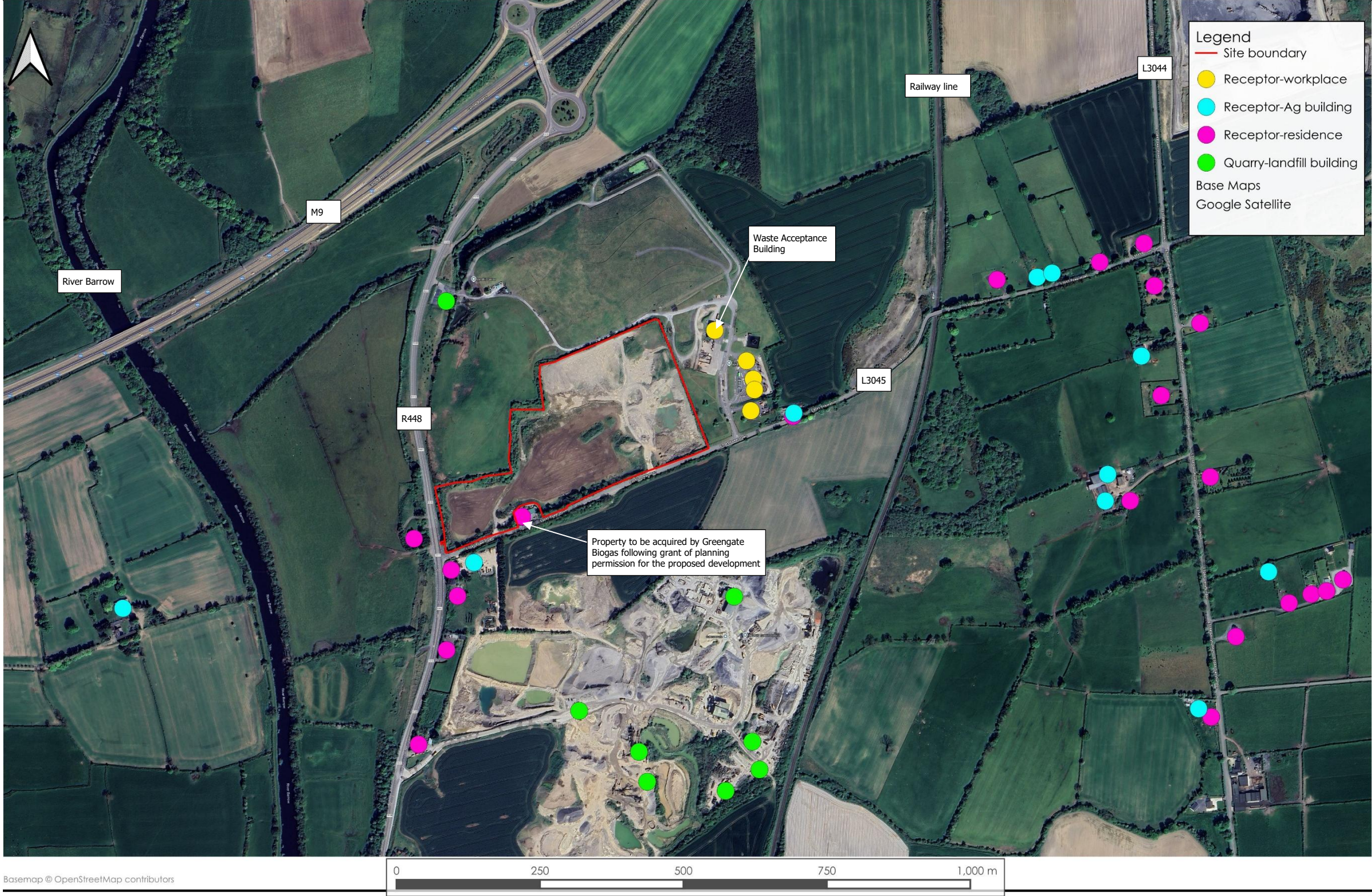
The residential property along the L3045 that is enclosed by the proposed development to the east, north and west is currently occupied. On grant of planning permission an agreement is in

place whereby Greengate Biogas will acquire the site as a vacant property for future commercial use. The residential dwelling is 25 metres from the BNEF container. The residential dwelling on the R448 at the south western site boundary is approx. 15 metres from the site boundary and 115 metres from the BNEF container.

The River Barrow and River Nore Special Area of Conservation (SAC) boundary lies approximately 20 meters west of the site, and the River Barrow itself is located approximately 300 metres west.

Figure 2-7 illustrates the built environment in the vicinity of the proposed development site and identified COMAH Receptors.

Figure 2-7 Surrounding Area and COMAH Receptors



Basemap © OpenStreetMap contributors



Powerstown Anaerobic Digestion Facility COMAH Receptor Map

Generated: 03-06-2026
Drawn By: MMCK
Revision: 0

Source: Google, 2025

2.3 Properties of Dangerous Substances

2.3.1 Untreated Biogas

Untreated biogas is the raw gas produced by the anaerobic digestion process. It is a mixture of methane (CH_4) and carbon dioxide (CO_2), with trace amounts of hydrogen sulphide (H_2S) and water vapour. It is classified as a Flammable Gas Category 1 with hazard statement H220 extremely flammable gas.

Untreated biogas is a mixture of methane (56 – 58 % v/v) and carbon dioxide (42 – 44 % v/v), with trace hydrogen sulphide (H_2S) and water vapour. It is classified as a Flammable Gas Category 1 with hazard statement H220: Extremely flammable gas. Operating conditions on site are:

- Storage temperature: 48 – 55 °C (digesters, post-storage and pasteurisation tanks); ambient (liquid pre-storage and digestate storage tanks)
- Operating pressure: 5 – 15 mbarg
- Vapour density: 0.86 – 0.98 kg/m³ (DNV PHAST Mixtures)

For consequence modelling (Section 6), the flammability properties of pure methane (Section 2.3.2) are applied as a conservative assumption.

2.3.2 Treated Biogas – Renewable Natural Gas

Renewable Natural Gas (methane) (CAS number 74-82-8) is classified as a Flammable Gas Category 1 with hazard statement H220 extremely flammable gas.

The DIPPR© Database that is referenced in DNV PHAST proprietary consequence modelling software gives the following flammable properties for methane:

- ▶ Lower flammability limit 50,000 ppm (5% v/v)
- ▶ Upper flammability limit 150,000 ppm (15% v/v)
- ▶ Maximum surface emissive power 220 kW/m²
- ▶ Heat of combustion 802,620 kJ/kmol

2.3.3 Chemicals

Table 2-5 details the maximum inventory of chemicals that will be stored on site, the chemical classification and identifies those chemicals to which the provisions of the COMAH Regulations 2015 apply.

Table 2-5 Chemical Quantities and Classification

Chemical	CAS #	Inventory	Location	Inventory litres	Density tonnes/m3	Inventory tonnes	Hazard Statements	CLP Classification (Note 1)	COMAH Dangerous Substance (Note 2)	COMAH Named (Note 2)	COMAH Category (Note 3)	Reference
Polyamine-liquid to boiler water	105-59-9 <80% 110-85-0 < 25%	200 litres	Bunded pallet in Boiler building	200	1.05	0.21	H314 Causes severe skin burns and eye damage H318 Causes serious eye damage H334 May cause allergy or asthma symptoms or breathing difficulties if inhaled. H317 May cause an allergic skin reaction. H361fd Suspected of damaging fertility. Suspected of damaging the unborn child.	Skin Corr. 1B Eye Dam. 1 Resp. Sens.1 Skin Sens. 1 Repr. Tox. 2	No	-	-	Dow Safety Data Sheet, UCARSOL TM Ap Solv 814 E, Version 1.0, 3030-09-17
Hydrocarbon cooling agent (R290 Refrigerant Grade Propane) or CO2 cooling agent (R744)	1309-37-1	3000 litres	IBC CO2 liquefaction unit and heating area	3000	0.5	1.5	H220 Extremely Flammable gas H280 Contains gas under pressure; may explode if heated	Flam Gas 1 Press. Gas	Yes			NRL Safety Data Sheet, R290, Rev. 1. 2017-02-17
	124-38-9	3000 litres		3000	-	-	H280 Contains gas under pressure; may explode if heated.	Gases under pressure: liquefied gas	No	-	-	Air Liquide Safety Data Sheet, R744, Version 6.0, 2022-07-01
Inhibited Sulphuric acid	7664-93-9	2000 litres	IBC Feedstock building	2000	1.84	3.68	H290 May be corrosive to metals H314 Causes severe skin burns and eye damage H318 Causes serious eye damage	Met. Corr. 1 Skin Corr. 1 Eye Dam. 1	No	-	-	CHEMSOS Safety Data Sheet, Sufuric Acid 96%, Version GHS 1.0, 2020-11-02
Sodium hydroxide	1310-73-2 (>=40 - <=55 % w/w)	1000 litres	IBC Feedstock building	1000	1.5289	1.5289	H290 May be corrosive to metals H314 Causes severe skin burns and eye damage	Met. Corr. 1 Skin Corr. 1	No	-	-	BASF Safety Data Sheet, Sodium Hydroxide Solution 50%, Version 6.0, 2026-04-27
Ferric powder	1309-37-1	2000 kg	Bunded pallet Feedstock building	-	-	2	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	-	No	-	-	ROTH Safety Data Sheet, Iron(III) oxide, Ver.1, 2025-06-12
Inhibited hydrochloric acid	7647-01-0 (6 - 35%)	2000 litres	IBC Feedstock building	2000	1.18	2.36	H290 May be corrosive to metals. H302 Harmful if swallowed. H314 Causes severe skin burns and eye damage. H332 Harmful if inhaled. H335 May cause respiratory irritation.	Met. Corr. 1 Acute Tox. 4 (inhalation/oral) Skin Corr. 1B Eye Dam. 1 STOT SE 3	No	-	-	ClearTech Safety Data Sheet, Hydrochloric Acid, Inhibited, Revision Date 2020-09-22
NPK fertilizer for biofilters	6484-52-2 (>=10 - <=45% w/w) 14025-15-1 (<=0.5% w/w)	3000 litres	IBC Gas cleaner, upgrading area, air treatment area	3000	0.86	2.58	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	-	No	-	-	Compo Expert Safety Data Sheet, NPK Originale Gold® 15-9-15, Version 1.6, 2023-04-06
Anti-foam (rape seed oil)	8002-13-9	100 litres	Bunded pallet Upgrading area	100	0.92	0.092	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	-	No	-	-	ROTH Safety Data Sheet, Rapeseed oil, Ver. 2, 2024-09-17
Glycol cooling liquid	57-55-6 (35 - 96% w/w) 7732-18-5 (< 65% w/w)	2500 litres	IBC Upgrading area or boiler room	2500	1.05	2.625	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	-	No	-	-	NC Safety Data Sheet, Propylene Glycol (inhibited solution), 2021-01-04

Chemical	CAS #	Inventory	Location	Inventory litres	Density tonnes/m3	Inventory tonnes	Hazard Statements	CLP Classification (Note 1)	COMAH Dangerous Substance (Note 2)	COMAH Named (Note 2)	COMAH Category (Note 3)	Reference
	7758-11-4 (< 5% w/w)											
Drying agent (Sorbead)	1327-36-2	2000 kg	Bunded pallet Upgrading area or boiler room	-	-	2	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	-	No	-	-	BASF Safety Data Sheet, Sorbead R 2860, Version 9.1, 2026-04-27
Amine-liquid (Methyldiethanolamine MDEA)	105-59-9	12000 litres	Bunded pallet Upgrading area, inside container	12000	1.04	12.48	H319 Causes Serious Eye Irritation	Eye Dam. 2	No	-	-	REDOX Safety Data Sheet, Methyldiethanolamine, Revision 4, 2023-05-23
Gearoil, hydraulic oil, motor oil (synthetic hydrocarbon oil e.g. LCG-100)	-	2000 litres	Bunded pallets in Workshop	2700	0.84	2.268	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	-	No	-	-	
Windshield wiper fluid (methanol)	67-56-1	100 litres	Bunded pallets in Workshop	100	0.8143	0.08143	H225 Highly flammable liquid and vapour H301 + H311 + H331 Toxic if swallowed, in contact with skin or if inhaled H370 Causes damage to organs	Flam Liq. 2 Acute Tox. 3 STOT SE 1	Yes	Yes	H2, P5c	Recechem Safety Data Sheet, Windshield Washer Concentration Vers. 2.0, 2025-05-02
Adblue®	57-13-6 (32.5% w/w)	1000 litres	Bunded pallets in Workshop	1000	1.093	1.093	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	-	No	-	-	Greenchem Safety Data Sheet, Adblue®, Rev. 5, 2024-04-05
Diesel for wheel loader and vehicles	64742-46-7	5000 litres	Bunded Diesel Tank	5000	0.9	4.5	H226 Flammable liquid and vapour H411 Toxic to aquatic life with long lasting effects	Flam. Liq. 2 Aquatic Chronic 2	Yes	Yes	P5c, E2	CONCAWE
H2SO4, Sulphuric acid 96%	7664-93-9	79 m3	Bunded Tank at Odour Control Unit	79000	1.84	145.36	H290 May be corrosive to metals H314 Causes severe skin burns and eye damage H318 Causes serious eye damage	Met. Corr. 1 Skin Corr. 1 Eye Dam. 1	No	-	-	CHEMSOS Safety Data Sheet, Sufuric Acid 96%, Version GHS 1.0, 2020-11-02
NaOH, Sodium Hydroxide 50%	1310-73-2 (>=40 - <=55 % w/w)	280 m3	Bunded Tank at Odour Control Unit	280000	1.5289	428.092	H290 May be corrosive to metals H314 Causes severe skin burns and eye damage	Met. Corr. 1 Skin Corr. 1	No	-	-	BASF Safety Data Sheet, Sodium Hydroxide Solution 50%, Version 6.0, 2026-04-27
H2O2, Hydrogen Peroxide	7722-84-1 (20 - 35% w/w)	114 m3	Bunded Tank at Odour Control Unit	114000	1.11	126.54	H315 Causes skin irritation H318 Causes serious eye damage H335 May cause respiratory irritation	Skin Irr. 2 Eye Dam. 1 STOT SE 3	No	-	-	Classification from CLP Regulation Annex vi (23 rd ATP, 20 June 2025)
Activated Carbon	7440-44-0	23 tonnes	Bunded Pallet in Workshop	-	-	23	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	-	-	-	-	NECATEC AG Safety Data Sheet, NECA active® gc , Version 1.5, 2025-06-25 NECATEC AG Safety Data Sheet, NECA active® sulfo ,

Chemical	CAS #	Inventory	Location	Inventory litres	Density tonnes/m3	Inventory tonnes	Hazard Statements	CLP Classification (Note 1)	COMAH Dangerous Substance (Note 2)	COMAH Named (Note 2)	COMAH Category (Note 3)	Reference
												Version 1.5, 2025-06-25
Sulphared	-	1.5 tonnes	Bunded Pallet in Workshop	-	-	1.5	Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008	-	-	-	-	HeGo Biotec, Safety Data Sheet, Sulphared, Version 8.0, 2024-03-26

Note 1 Classification according to the Classification, Labelling and Packing Regulation (EC) no. 1272/2008

Note 2 Dangerous substance is classification is included in Part 1, Schedule 1 of the COMAH Regulations 2015 (S.I. 209 of 2015) or dangerous substance is named is Part 2, Schedule 1 of the COMAH Regulations 2015

Note 3 Category as per Part 1, Schedule 1 of the COMAH Regulations 2015 (S.I. 209 of 2015)

2.4 COMAH Status Determination

Schedule 1 to the COMAH Regulations 2015 describes the application of the regulations. Part 2 of Schedule 1 specifies the qualifying quantities of named dangerous substances to which lower tier status and upper tier status apply.

Untreated biogas will be contained in the vapour space of a number of tanks on site in the tank farm (as detailed in Table 2-1 in Section 2.1.6) as well as in pipework. Upgrade biogas will be contained in pipework from the gas upgrading equipment to the BNEF and in the underground gas line from the BNEF that is then routed off site.

Appendix B contains calculations to determine the quantity of untreated (raw) biogas in vessels and pipework at the proposed development and upgraded biogas (RNG) in pipework on site as follows:

- ▶ Untreated biogas: 28.508 tonnes
- ▶ Upgraded biogas (RNG): 0.1372 tonnes.

Upgraded biogas (RNG) is a named substance in Part 2 of Schedule 1 of the COMAH Regulations 2015 (liquefied flammable gases, Category 1 or 2 (including LPG) and natural gas including RNG).

Chemicals stored and processed on site are detailed in Table 2-5 (inventory and classification) which also identifies dangerous substances included in Schedule 1 of the COMAH Regulations 2015. The following chemicals are included in the COMAH status calculation for the proposed development:

- ▶ Refrigerant grade propane (LPG): 1.5 tonnes
- ▶ Windshield wiper fluid (methanol): 0.081 tonnes
- ▶ Diesel: 4.5 tonnes
- ▶ Hydrogen peroxide (20 – 35% w/w): 126.54 tonnes

Refrigerant grade propane (LPG) is a named substance in in Part 2 of Schedule 1 of the COMAH Regulations 2015 (liquefied flammable gases, Category 1 or 2 (including LPG) and natural gas including RNG).

Methanol is a named substance in Part 2 of Schedule 1 of the COMA Regulations 2015.

Diesel is a named substance in Part 2 of Schedule 1 of the COMA Regulations 2015 (petroleum products).

The Application of the COMAH Regulations 2015 is detailed in Table 2-6 and the factorisation calculation to determine COMAH status is detailed in Table 2-7.

Table 2-6 Quantities of Hazardous Substances at the Proposed Development

Dangerous substance	COMAH Classification	q. Quantity	Q1 Lower tier threshold (Column 2, Part 1, Schedule 1, S.I. 209 of 2015) (tonnes)	Q2 Upper tier threshold (Column 3, Part 1, Schedule 1, S.I. 209 of 2015) (tonnes)	q/Q1 Fraction of Lower tier threshold	q/Q2 Fraction of Upper tier threshold
		tonnes				
Named Substances						
Upgraded Biogas and Propane Coolant (18.Liquefied flammable gases, Category 1 or 2 (including LPG) and natural gas including Renewable Natural Gas)	P2 – Flammable gases	1.6372	50	200	0.033	0.008
Methanol	H2 – Acute Toxic H3 – STOT P5c – Flammable liquid	0.0814	500	5000	0.00016	0.000016
Petroleum products – Diesel	E2 - Aquatic Chronic 2 P5c – Flammable Liquid Cat. 3	4.5	2500	25000	0.0018	0.00018
P2 Flammable gases, Category 1 or 2						
Untreated biogas	P2 – Flammable gases	28.508	10	50	2.851	0.570

Table 2-7 Calculation of COMAH Status at the Proposed Development

Group	COMAH Categories	Rule	Lower Tier Fraction	Upper Tier Fraction
H (Health)	Part 1: H1, H2, H3 and Part 2: Acute Category 1, 2 or 3 (inhalation route), STOT SE Category 1	>1	0.00016	0.000016
P (Physical)	Part 1: P1 to P8 and Part 2: Explosives, flammable gases, flammable aerosols, oxidising gases, flammable liquids, self-reactive substances and mixtures, organic peroxides, pyrophoric liquids and solids, oxidising liquids and solids	>1	2.884	0.578
E (Environment)	Part 1: E1 and E2 and Part 2: hazardous to the aquatic environment acute category 1, chronic category 1 or chronic category 2	>1	0.0018	0.00018

The proposed development will store hazardous substances in excess of the Lower Tier threshold; therefore, the site will be classified as a **Lower Tier COMAH establishment**.

3. INTRODUCTION TO RISK ASSESSMENT

3.1 Risk Assessment – An Introduction

The Centre for Chemical Process Safety (CCPS) has defined risk as (CCPS 2000): "Risk is a measure of human injury, environmental damage, or economic loss in terms of both the incident likelihood and the magnitude of the loss or injury."

Risk is a function of the consequences of an undesired event and how likely it is to occur. It is often expressed as the product of the likelihood and the consequences:

$$\text{Risk} = \text{consequence} \times \text{likelihood}$$

In this form, risk has the units of losses per year.

Risk assessment in the chemical process sector seeks answers to the following questions:

- ▶ What are the hazards?
- ▶ What can go wrong (scenario)?
- ▶ How severe could it be (consequence)?
- ▶ How likely is it to happen (frequency)?
- ▶ How do consequence and frequency combine (risk)?
- ▶ Is the current level of risk tolerable, considering existing safeguards?
- ▶ If not, what needs to be done to reduce and manage the risk?

Risk assessment may be qualitative, semi-quantitative or quantitative, with the level of detail and analysis increasing from qualitative through to quantitative approaches. For COMAH establishments, the HSA Safety Report Assessment Guidelines (HSA, 2017) indicate that the depth of analysis should be proportionate to:

- ▶ the scale and nature of the major accident hazards presented by the establishment
- ▶ the risk posed to neighbouring populations and the environment

3.2 Land Use Planning and Risk Assessment

This land use planning assessment has been carried out in accordance with the HSA's *Guidance on technical land-use planning advice* (HSA, 2023). This approach involves defining three zones for land use planning guidance purposes, based on the potential risk of fatality from major accident scenarios. The HSA has defined the boundaries of the Inner, Middle and Outer Land Use Planning (LUP) zones as:

1E-05/year	Risk of fatality for Inner Zone (Zone 1) boundary
1E-06/year	Risk of fatality for Middle Zone (Zone 2) boundary
1E-07/year	Risk of fatality for Outer Zone (Zone 3) boundary

The process for determining the distances to the boundaries of the inner, middle and outer zones is outlined as follows:

- ▶ Determine the consequences of major accident scenarios using the modelling methodologies described in the HSA's *Guidance on technical land-use planning advice* (HSA, 2023).
- ▶ Determine the severity (probability of fatality) using the Probit functions specified by the HSA.
- ▶ Determine the frequency of the accident (probability of event) using data specified by the HSA.
- ▶ Determine the individual risk of fatality as follows:

Risk = Frequency x Severity

(Equation 1)

The HSA's Guidance on technical land-use planning advice (HSA, 2023) document provides guidance on the type of development appropriate to the inner, middle and outer LUP zones. The methodology sets four levels of sensitivity, with sensitivity increasing from 1 to 4, to describe the development types in the vicinity of a COMAH establishment.

The Sensitivity Levels used in the Land Use Planning Methodology are based on a rationale which allows progressively more severe restrictions to be imposed as the sensitivity of the surrounding area increases. The sensitivity levels are:

- Level 1 Based on normal working population;
- Level 2 Based on the general public – at home and involved in normal activities;
- Level 3 Based on vulnerable members of the public (children, those with mobility difficulties or those unable to recognise physical danger); and
- Level 4 Large examples of Level 3 and large outdoor examples of Level 2 and Institutional Accommodation.

Table 3-1 details the matrix that is used by the HSA to advise on suitable development for technical LUP purposes (HSA, 2023).

Table 3-1 Land Use Planning Matrix

Level of Sensitivity	Inner Zone (Zone 1)	Middle Zone (Zone 2)	Outer Zone (Zone 3)
Level 1	✓	✓	✓
Level 2	✗	✓	✓
Level 3	✗	✗	✓
Level 4	✗	✗	✗

3.3 Individual Risk Criteria

The TLUP guidelines (HSA, 2023) state the maximum tolerable risk to a member of the public is 1E-06 per year and the maximum tolerable risk to a person at an off-site work location is 5E-06 per year.

It is noted that these criteria apply to the total risk from all major accident hazards at an establishment.

3.4 Environment and Land Use Planning

The HSA's Generic TLUP Guidelines (HSA, 2023) outlined that the prevention of Major Accidents to the Environment (MATTEs) is the primary objective, and it is expected that accident pathways will be prevented. Where this is not practicable, the assessment of major accidents to the environment focuses on the specific risks to sensitive receptors within the local environment, the extent of consequences to such receptors and the ability of such receptors to recover.

Assessment is based on a Source-Pathway-Receptor model. For new establishments, the Competent Authority will focus on the removal of accident pathways to receptors (through the use of additional technical measures: appropriate containment, within the confines of current good practice and As Low as Reasonably Practicable (ALARP), for example).

3.5 Societal Risk Assessment Methodology

Where a large population is potentially exposed to the consequences of a major accident, and there is the potential for multiple fatalities from a single event, societal risk is taken into account.

To take account of societal risk, the HSA will initially obtain an estimate of the expectation value.

Expectation Value and FN Curve

The Expectation Value (EV) is the average number of persons receiving a specified level of harm. Hirst and Carter (Hirst et al., 2000) shows that:

$$EV = F \times N \quad \text{(Equation 2)}$$

Where F is the cumulative frequency of all events leading to N fatalities

HSE (2001) provides an upper limit value for an intolerable societal risk criterion: for a predicted accident occurring no more frequently than once in 5,000 years, there should be no more than 50 fatalities. This has gained international acceptance as an anchor point for a line (of slope -1) to create an intolerable societal risk criterion for single accidents. HSA Guidance on Technical Land Use Planning recommended using points at 200 cpm / 50 fatalities and 1000 cpm/10 fatalities to create that line. An acceptable societal risk single risk criterion line can then be drawn at frequencies that are two orders of magnitude below the intolerable line (so a frequency of 1×10^{-4} on the intolerable line becomes 1×10^{-6} on the acceptable line).

Some establishments will have the potential for fatalities to arise from a multiplicity of accident scenarios (or there may be other establishments in the vicinity, adding to the EV). In such situations, the total off-site EV should not exceed the criterion upper limit EV of 10,000. Between EVs of 100 and 10,000, it should be demonstrated that all practicable efforts have been made to reduce the risk to a level that is as low as reasonably practicable (above a developmental EV level of 450, an FN curve will be required as part of the demonstration).

4. LAND USE PLANNING ASSESSMENT METHODOLOGY AND CRITERIA

This COMAH land use planning assessment has been completed in accordance with risk-based approach set out in the HSA's *Guidance on technical land-use planning advice* (HSA, 2023). LUP assessments are completed in the following steps:

- ▶ Identify major accident scenarios with reference to the HSA guidance document (HSA, 2023).
- ▶ Consequence modelling of major accident scenarios with physical consequences.
- ▶ Assign frequencies to major accident scenarios with reference to frequency values outlined in the HSA's Guidance document (HSA, 2023).
- ▶ Assessment of individual risk and generation of individual risk contours.
- ▶ Where necessary, assessment of societal risk using societal risk indices.
- ▶ Source-pathway-receptor model for major accident scenarios with environmental consequences, environmental receptor categorisation, assessment of MATTE harm and duration, compare MATTE frequency with tolerability criteria.

4.1 Assessment Methodology

4.1.1 Physical Effects Modelling

The impacts of physical and health effects on workers and the general public outside of the proposed development were determined by modelling accident scenarios using Gexcon Effects version 12.5.1 and DNV Phast Version 9.1 modelling software.

4.1.2 Risk Assessment Methodology

Gexcon Riskcurves version 13.0.2 modelling software is used in this assessment to calculate individual risk of fatality contours and risk-based land use planning zones associated with major accident scenarios.

4.2 Thermal Radiation Criteria

Fire scenarios have the potential to create hazardous heat fluxes. Therefore, thermal radiation on exposed skin poses a risk of fatality.

Potential consequences of damaging radiant heat flux and direct flame impingement are categorised in Table 4-1 (HSA, 2023).

Table 4-1 Heat Flux Consequences

Thermal Flux (kW/m ²)	Consequences
1 – 1.5	Sunburn
5 – 6	Personnel injured (burns) if they are wearing normal clothing and do not escape quickly
8 – 12	Fire escalation if long exposure and no protection
32 – 37.5	Fire escalation if no protection (consider flame impingement)
31.5	US DHUD, limit value to which buildings can be exposed
37.5	Process equipment can be impacted, AIChE/CCPS
Up to 350	In flame. Steel structures can fail within several minutes if unprotected or not cooled.

In relation to persons indoors, the HSA have specified the thermal radiation consequence criteria (from an outdoor fire) detailed in Table 4-2 (HSA, 2023).

Table 4-2 Heat Flux Consequences Indoors

Thermal Flux (kW/m ²)	Consequences
> 25.6	Building conservatively assumed to catch fire quickly and so 100% fatality probability
< 25.6	People are assumed to escape outdoors, and so have a risk of fatality corresponding to that of people outdoors
< 12.7	People are assumed to be protected, and therefore there is a 0% fatality probability

Thermal Dose Unit (TDU) is used to measure exposure to thermal radiation. It is a function of intensity (power per unit area) and exposure time:

$$\text{Thermal Dose} = I^{1.33} t \quad (\text{Equation 3})$$

where the Thermal Dose Units (TDUs) are (kW/m²)^{4/3}.s, I is thermal radiation intensity (kW/m²), and t is exposure duration (s).

The HSA recommends that the Eisenberg Probit function (HSA, 2023) is used to determine probability of fatality to persons outdoors from thermal radiation as follows:

$$\text{Probit} = -14.9 + 2.56 \ln (I^{1.33} t) \quad (\text{Equation 4})$$

I Thermal radiation intensity (kW/m²)

t exposure duration (s)

Probit (Probability Unit) functions are used to convert the probability of an event occurring to percentage certainty that an event will occur. The Probit variable is related to probability as follows (CCPS, 2000):

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y-5} \exp\left(-\frac{u^2}{2}\right) du \quad (\text{Equation 5})$$

where P is the probability of percentage, Y is the Probit variable, and u is an integration variable. The Probit variable is normally distributed and has a mean value of 5 and a standard deviation of 1.

The Probit to percentage conversion equation is (CCPS, 2000):

$$P = 50 \left[1 + \frac{Y-5}{|Y-5|} \operatorname{erf}\left(\frac{|Y-5|}{\sqrt{2}}\right) \right] \quad (\text{Equation 6})$$

The relationship between Probit and percentage certainty is presented in Table 4-3 (CCPS, 2000).

Table 4-3 Conversion from Probit to Percentage

%	0	1	2	3	4	5	6	7	8	9
0	–	2.67	2.95	3.12	3.25	3.36	3.45	3.52	3.59	3.66
10	3.72	3.77	3.82	3.87	3.92	3.96	4.01	4.05	4.08	4.12
20	4.16	4.19	4.23	4.26	4.29	4.33	4.36	4.39	4.42	4.45
30	4.48	4.50	4.53	4.56	4.59	4.61	4.64	4.67	4.69	4.72
40	4.75	4.77	4.80	4.82	4.85	4.87	4.90	4.92	4.95	4.97
50	5.00	5.03	5.05	5.08	5.10	5.13	5.15	5.18	5.20	5.23
60	5.25	5.28	5.31	5.33	5.36	5.39	5.41	5.44	5.47	5.50
70	5.52	5.55	5.58	5.61	5.64	5.67	5.71	5.74	5.77	5.81
80	5.84	5.88	5.92	5.95	5.99	6.04	6.08	6.13	6.18	6.23
90	6.28	6.34	6.41	6.48	6.55	6.64	6.75	6.88	7.05	7.33
%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
99	7.33	7.37	7.41	7.46	7.51	7.58	7.65	7.75	7.88	8.09

For long duration fires, such as pool fires, it is generally reasonable to assume an effective exposure duration of 60 seconds to take account of the time required to escape (HSA, 2023). It is noted that this is a conservative estimation of the time taken to escape and is used in consequence assessment as the maximum exposure duration for heat radiation.

With respect to exposure to thermal radiation outdoors, the Eisenberg Probit relationship implies:

- ▶ 1% fatality – 963 TDUs (8.02 kW/m² for 60 s exposure duration)
- ▶ 10% fatality – 1450 TDUs (10.9 kW/m² for 60 s exposure duration)
- ▶ 50% fatality – 2399 TDUs (15.9 kW/m² for 60 s exposure duration)

4.3 Overpressure Criteria

Explosions scenarios can result in damaging overpressures, especially when flammable vapour/air mixtures are ignited in a congested area.

Combustion of a flammable gas-air mixture will occur if the composition of the mixture lies in the flammable range and if an ignition source is available. When ignition occurs in a flammable region of the cloud, the flame will start to propagate away from the ignition source. The combustion products expand causing flow ahead of the flame. Initially this flow will be laminar. Under laminar or near laminar conditions the flame speeds for normal hydrocarbons are in the order of 5 to 30 m/s which is too low to produce any significant blast over-pressure. Under these conditions, the vapour cloud will simply burn, causing a flash fire. In order for a vapour cloud explosion to occur, the vapour cloud must be in a turbulent condition.

Turbulence may arise in a vapour cloud in various ways:

- ▶ By the release of the flammable material itself, for instance a jet release from a high-pressure vessel.
- ▶ By the interaction of the expansion flow ahead of the flame with obstacles present in a congested area.

Table 4-4 describes blast damage for various overpressure levels (HSA, 2023).

Table 4-4 Blast Damage

Side-on Overpressure (mbar)	Description of Damage
1.5	Annoying noise
2	Occasional breaking of large windowpanes already under strain
3	Loud noise; sonic boom glass failure
7	Breakage of small windows under strain
10	Threshold for glass breakage
20	"Safe distance", probability of 0.95 of no serious damage beyond this value; some damage to house ceilings; 10% window glass broken
30	Limited minor structural damage
35 – 70	Large and small windows usually shattered; occasional damage to window frames
>35	Damage level for "Light Damage"
50	Minor damage to house structures
80	Partial demolition of houses, made uninhabitable
70 - 150	Corrugated asbestos shattered. Corrugated steel or aluminium panels fastenings fail, followed by buckling; wood panel (standard housing) fastenings fail; panels blown in
100	Steel frame of clad building slightly distorted
150	Partial collapse of walls and roofs of houses
150-200	Concrete or cinderblock walls, not reinforced, shattered
>170	Damage level for "Moderate Damage"
180	Lower limit of serious structural damage 50% destruction of brickwork of houses
200	Heavy machines in industrial buildings suffered little damage; steel frame building distorted and pulled away from foundations
200 – 280	Frameless, self-framing steel panel building demolished; rupture of oil storage tanks
300	Cladding of light industrial buildings ruptured
350	Wooden utility poles snapped; tall hydraulic press in building slightly damaged
350 – 500	Nearly complete destruction of houses
>350	Damage level for "Severe Damage"
500	Loaded tank car overturned
500 – 550	Unreinforced brick panels, 25 - 35 cm thick, fail by shearing or flexure
600	Loaded train boxcars completely demolished
700	Probable total destruction of buildings; heavy machine tools moved and badly damaged
830	Damage level for 'total destruction'

The HSA recommends that the Hurst, Nussey and Pape Probit function (HSA, 2023) is used to determine probability of fatality to persons outdoors from overpressure as follows:

$$\text{Probit} = 1.47 + 1.35 \ln P$$

P Blast overpressure (psi)

The Hurst, Nussey and Pape Probit relationship implies:

- ▶ 1% fatality – 168 mbar
- ▶ 10% fatality – 365 mbar
- ▶ 50% fatality – 942 mbar

The HSA uses relationships published by the Chemical Industries Association (CIA) and the American Petroleum Institute (API) to determine the probability of fatality for building occupants exposed to blast overpressure. The CIA has developed relationships for 4 categories of buildings (CIA, 2020):

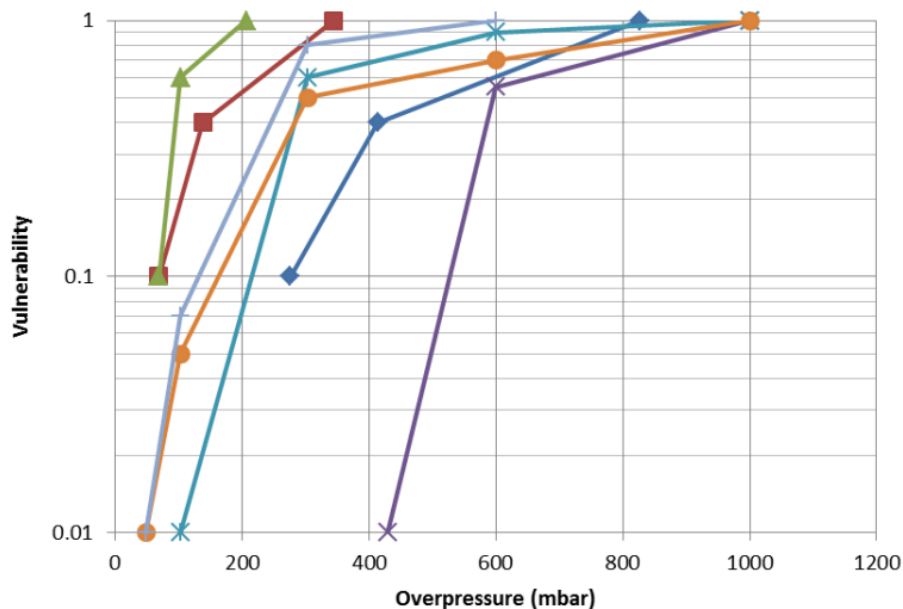
- ▶ CIA 1: hardened structure building (special construction, no windows).
- ▶ CIA 2: typical office block (four storey, concrete frame and roof, brick block wall panels).
- ▶ CIA 3: typical domestic dwelling (two storey, brick walls, timber floors); and
- ▶ CIA 4: 'portacabin' type timber construction, single storey.

The API has developed relationships for 5 categories of buildings (EIGA, 2014):

- ▶ API B1: Wood frame trailer or shack
- ▶ API B2: Steel frame/metal siding or pre-engineered building
- ▶ API B3: Unreinforced masonry bearing wall building
- ▶ API B4: Steel or concrete reinforced masonry infill or cladding
- ▶ API B5: Reinforced concrete or reinforced masonry shear wall building

Figure 4-1 illustrates the probability of occupant vulnerability to overpressure in CIA building categories CIA 1 – 4 and in API building types B1 – B5.

Figure 4-1 API Probability of Occupant Vulnerability



Graph Key:	
	CIA 1: Hardened structure building: special construction, no windows
	CIA 2: Typical office block: four story, concrete frame and roof, brick block wall panels
	CIA 3: Typical domestic buildings: two story, brick walls, timber floors
	CIA 4: Portacabin: timber construction, single story
	API B5: Reinforced concrete or reinforced masonry shear wall building
	API B3: Unreinforced masonry bearing wall building
	API B1, B2, B4: Wood frame trailer or shack, steel-frame/metal siding or pre-engineered building, steel or concrete reinforced masonry infill or cladding
NOTE—Building key items 1 - 4 are defined by CIA; items B1 - B5 are defined by API RP 752 (2003) [5, 3].	

The CIA and API relationships imply the overpressure levels corresponding to probabilities of fatality of 1%, 10% and 50% detailed in Table 4-5 below.

Table 4-5 Blast Overpressure Consequences Indoors

Probability of fatality	Overpressure Level, mbar						
	CIA 1	CIA 2	CIA 3	CIA 4	API B1 B2 and B4	API B3	API B5
1% fatality	435	100	50	50	-	-	-
10% fatality	519	183	139	115	69	69	276
50% fatality	590	284	300	242	172	97	483

For the purposes of this assessment, it is assumed that the vulnerability of building occupants to side-on overpressure, as a result of a MAH at the proposed development, is CIA Category 3 type structures, representing residential buildings in the vicinity of the proposed development.

4.4 Flash Fire Criteria

A flash fire comprises the combustion of a flammable vapour and air mixture in which the flame passes through that mixture at less than sonic velocity, such that negligible damaging overpressure is generated.

The flash fire envelope is the lower flammable limit (LFL) concentration, determined using the unified dispersion model in PHAST Version 9.1 consequence modelling software.

Outdoor fatality levels of 100% are assumed inside the lower flammable limit (LFL) envelope, with 0% fatalities outside that envelope. Indoor fatality levels are conservatively assumed to be 10% within the flash fire envelope. (HSA, 2023)

4.5 Modelling Parameters

4.5.1 Weather Conditions

Weather conditions at the time of a major accident have a significant impact on the consequences of the event. Typically, high wind speeds increase the impact of fires, particularly pool fires, while the associated turbulence dilutes vapour clouds, reducing the impact of toxic and flammable gas releases.

Atmospheric Stability Class and Wind Speed

The following Pasquill stability/wind speed pairs are specified by the HSA in Ireland for dispersion modelling (HSA, 2023):

- ▶ Average weather conditions are represented by stability category D and a wind speed of 5 m/s, i.e., Category D5.
- ▶ Worst case conditions for toxic dispersion are represented by stability category F and a wind speed of 2 m/s, i.e., Category F2.

D5 conditions are assumed to occur 80% of the time, with F2 occurring for the remaining 20% (HSA, 2023).

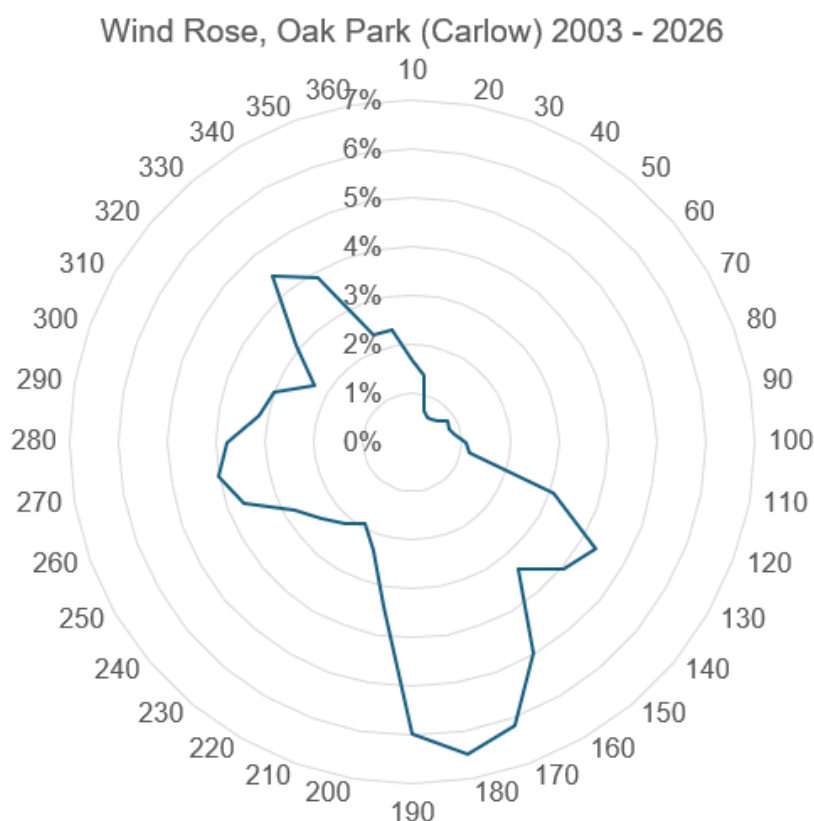
Stability Class D represents neutral conditions with little sun and high wind or overcast night. Stability Class F represents very stable conditions at night with moderate clouds and light/moderate winds.

Wind Direction and Ambient Temperature

The nearest synoptic metrological station to the proposed development area for which long term meteorological data is available is at Oak Park, Carlow.

Figure 4-2 illustrates a wind rose for Oak Park Meteorological Station. It can be seen that the prevailing wind direction is from 180 °.

Figure 4-2 Wind Rose Oak Park Synoptic Station



Ambient Temperature

The TLUP guidance states that a temperature of 15 °C is to be used for D5 conditions and 10 °C for F2 conditions.

Ambient Humidity

For this assessment, a representative ambient humidity of 60% has been assumed.

4.5.2 Surface Roughness

For TLUP purposes, a surface roughness of 0.1 m was used in this assessment.

5. IDENTIFICATION OF MAJOR ACCIDENT HAZARDS

A major accident is defined in the 2015 COMAH Regulations as:

“an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by these Regulations, and leading to serious danger to human health or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances”.

5.1 Major Accident Hazards

5.1.1 Major Accident Scenarios

Table 5-1 details the major accident scenarios arising from the proposed development:

Table 5-1 Major Accident Scenarios at the Proposed Development

Installation	Loss Of Containment scenario	Consequence/Event	Reference
Vessels containing biogas: Primary digesters, secondary digesters, tertiary digester, post digestion liquid digestate storage tank, digestate storage tank, liquid pre-storage tank and pasteurisation tanks	Instantaneous failure	Fireball	Table 34, HSA TLUP Guidance Document, HSA, 2023
		Vapour Cloud Explosion (VCE)	
		Flash fire	
	Continuous leak over 10 minutes	Jet fire	
		VCE	
		Flash fire	
Untreated biogas and treated biogas pipelines	Rupture of Pipeline	Fireball/Jet fire	Table 40/41 and Table 42, HSA TLUP Guidance Document, HSA, 2023
		VCE	
		Flash fire	
	Pipeline Leak of 0.1D	Fireball/Jet fire	
		VCE	
		Flash fire	
Indoor equipment: Blowers at blower station (in biogas upgrade building)	Instantaneous release	VCE	Table 64, HSA TLUP Guidance Document, HSA, 2023
	Release over 10 minutes	VCE	
	Release through 10 mm pipe	VCE	
Indoor equipment: pipework in BNEF	Rupture of Pipeline	VCE	Table 40 and Table 42, HSA TLUP Guidance Document, HSA, 2023
	Pipeline Leak of 0.1D	VCE	

5.1.2 Major Accidents to the Environment (MATTE)

As per Table 2-5, diesel is the only substance that will be present on site that is classified as hazardous to the aquatic environment (categories E1 and E2 in Part 1, Schedule 1 of the COMAH Regulations 2015). The maximum inventory that will be on site is 5000 litres (4.5 tonnes). The drainage system will have the capacity to contain a spill of diesel. Therefore, a major accident to the environment is not considered in the study.

6. LAND USE PLANNING ASSESSMENT OF MAJOR ACCIDENT HAZARDS

6.1 Vessels Containing Untreated Biogas

6.1.1 Biogas Release from Tank: Model Inputs

Untreated biogas will be contained within the vapour space of tanks in the tank farm and within pipework. Tank volumes, storage temperatures and pressures are detailed in Table 6-1.

Table 6-1 Operating Conditions of Tanks Containing Untreated Biogas

Installation	Dangerous substance	% CH ₄	% CO ₂	Volume per tank m ³ (Note 1)	Temperature °C	Pressure
Primary Digesters (6 No.)	Untreated biogas	56 - 58	42 - 44	1,289.44	48 - 55	5 - 15 mbarg
Secondary Digesters (3 No.)	Untreated biogas	56 - 58	42 - 44	1,289.44	48 - 55	5 - 15 mbarg
Tertiary Digester (1 No.)	Untreated biogas	56 - 58	42 - 44	4,852.53	48 - 55	5 mbarg
Post Storage Tank (1 No.)	Untreated biogas	56 - 58	42 - 44	4,852.53	48 - 55	5 - 15 mbarg
Liquid Pre Storage Tank (1 No.)	Untreated biogas	56 - 58	42 - 44	4,852.53	Ambient	5 - 15 mbarg
Digestate Storage Tank (1 No.)	Untreated biogas	56 - 58	42 - 44	5,523.18	Ambient	5 mbarg
Pasteurisation Tank (3 No.)	Untreated biogas	56 - 58	42 - 44	37.59	48 - 55	15 mbarg

Note 1: See Appendix B – Biogas Inventory Calculations.

DNV Phast 9.1 was used to model a release from a tank containing untreated biogas. Model inputs are detailed in Table 6-2. The consequences of loss of containment scenarios from the liquid pre-storage tank are conservatively assessed as the digestate storage tank, both of which operate at ambient temperature.

Table 6-2 Biogas Release from Tank: Model Inputs

Parameter	Instantaneous Release	Release Over 10 Minutes	Source/Assumption
Scenario	Instantaneous Release	Continuous leak over 10 minutes involving the entire inventory	-
Material	Methane	Methane	Conservative assumption — pure methane has a higher heat of combustion and wider flammable range than the actual biogas mixture.
Averaging time	Flammable – 18.75 s	Flammable – 18.75 s	DNV Phast
Exposure duration for long duration fire scenarios	60 s	60 s	HSA recommended (HSA, 2023)

Parameter	Instantaneous Release	Release Over 10 Minutes	Source/Assumption
Time for short duration flammable effects	30 s	30 s	Conservative assumption-modelled exposure duration significantly exceeds the actual physical duration of short-duration flammable events
Release height	Top of tank wall as per Appendix A	Top of tank wall as per Appendix A	-
Effect height	57 m OD which is receptor height (1 m above ground level) at the civic amenity site to the east	57 m OD which is receptor height (1 m above ground level) at the civic amenity site to the east	-
Wind speed	5 m/s (daytime), 2 m/s (nighttime)	5 m/s (daytime), 2 m/s (nighttime)	Recommended by HSA as representative modelling conditions
Pasquill Stability Factor	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	
Ambient Temperature	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	HSA guidance (HSA 2023)

6.1.2 Biogas Release from Tank and Fireball

The HSE static fireball model is used in this study, with the fireball conservatively assumed to be located at ground level with no lift-off. Fireball model outputs are summarised in Table 6-3, with consequence decay curves provided in Appendix C.

Table 6-3 Rupture of Tank Containing Untreated Biogas and Fireball: Model Outputs

Output	Primary or Secondary Digester Rupture		Tertiary Digester, Post Storage Tank		Digestate Storage Liquid Pre-Storage Tank		Pasteurisation Tanks	
	D5	F2	D5	F2	D5	F2	D5	F2
Flammable Mass (kg)	788	788	2964	2964	3940	4010	7.65	7.65
Duration of Fireball (s)	4.15	4.15	6.45	6.45	7.08	7.13	0.89	0.89
Fireball Radius (m)	26.73	26.73	41.55	41.55	45.68	45.95	5.71	5.71

Table 6-4 details the distances to thermal dose levels associated with specified levels of probability of fatality based on the Eisenberg Probit equation described in Section 4.2.

The secondary digesters are the closest tanks containing biogas to an off-site receptor (waste acceptance building at the civic amenity site to east, 80 m east). Figure 6-1 illustrates the thermal radiation contours corresponding to 1% lethality and 100 % lethality outdoors and Figure 6-2 illustrates the thermal radiation contours corresponding to 12.7 kW/m² and 25.6 kW/m² following rupture of a secondary digester.

Figure 6-3 and Figure 6-4 illustrate lethality and thermal radiation contours in the event of a fireball following rupture of the post digestion storage tank which has a larger hazard range and is near to the site boundary.

Table 6-4 Rupture of Tank Containing Untreated Biogas and Fireball: Distances to Specified Thermal Dose Levels

Criterion	Thermal Dose Level	Thermal Radiation	Distance (metres)							
			Primary or Secondary Digester Rupture		Tertiary Digester, Post Storage Tank		Digestate Storage Liquid Pre-Storage Tank		Pasteurisation Tanks	
			D5	F2	D5	F2	D5	F2	D5	F2
1% fatality outdoors (based on fireball duration)	963	-	55.0	56.0	109.6	109.6	112.3	114.8	6.7	6.7
100% fatality outdoors	Fireball radius	-	26.73	26.73	41.55	41.55	45.68	45.95	5.71	5.71
Building protected below this level, 0% fatality probability	-	12.7	123.9	125.5	187.8	190.6	205.5	209.8	28.5	28.8
Building will catch fire quickly, 100% fatality probability	-	25.6	87.3	88.4	132.5	134.3	145.1	148.0	20.2	20.3

Figure 6-1 Secondary Digester Rupture and Fireball: Outdoor Lethality Contours

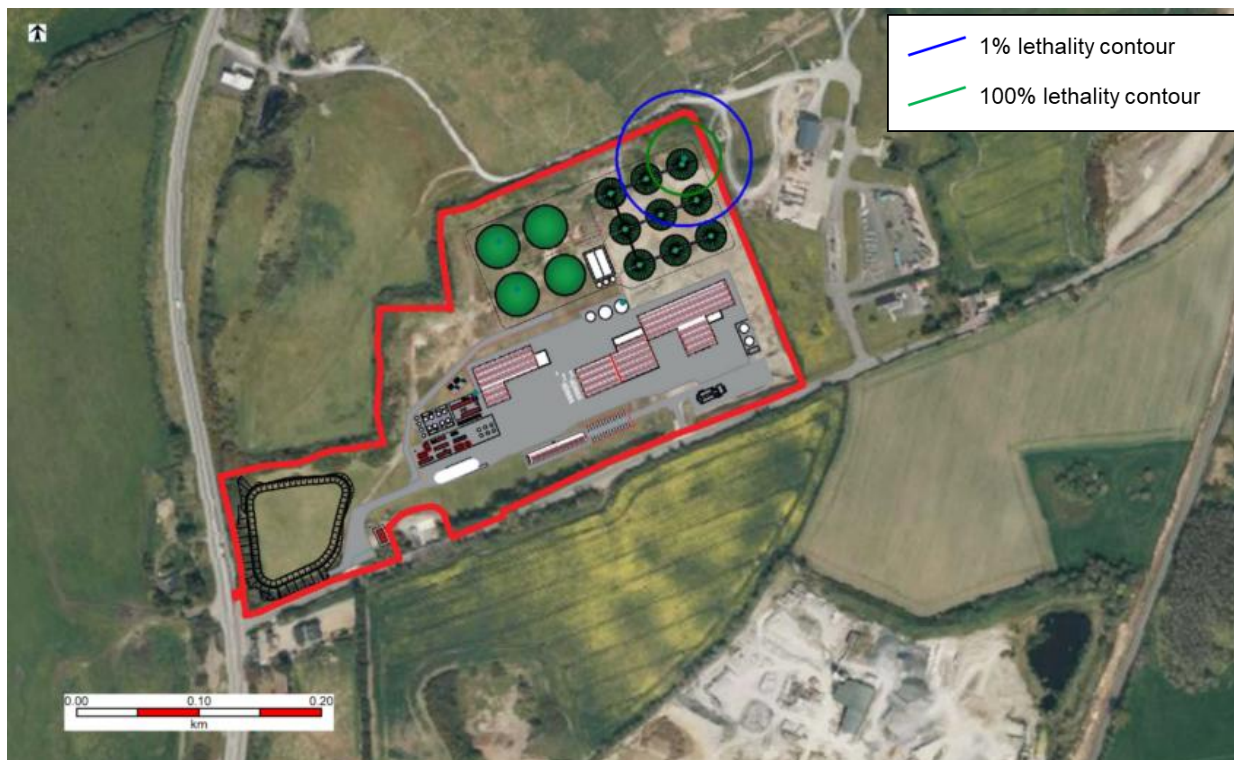


Figure 6-2 Secondary Digester Rupture and Fireball: 12.7 kW/m² and 25.6 kW/m² Contours

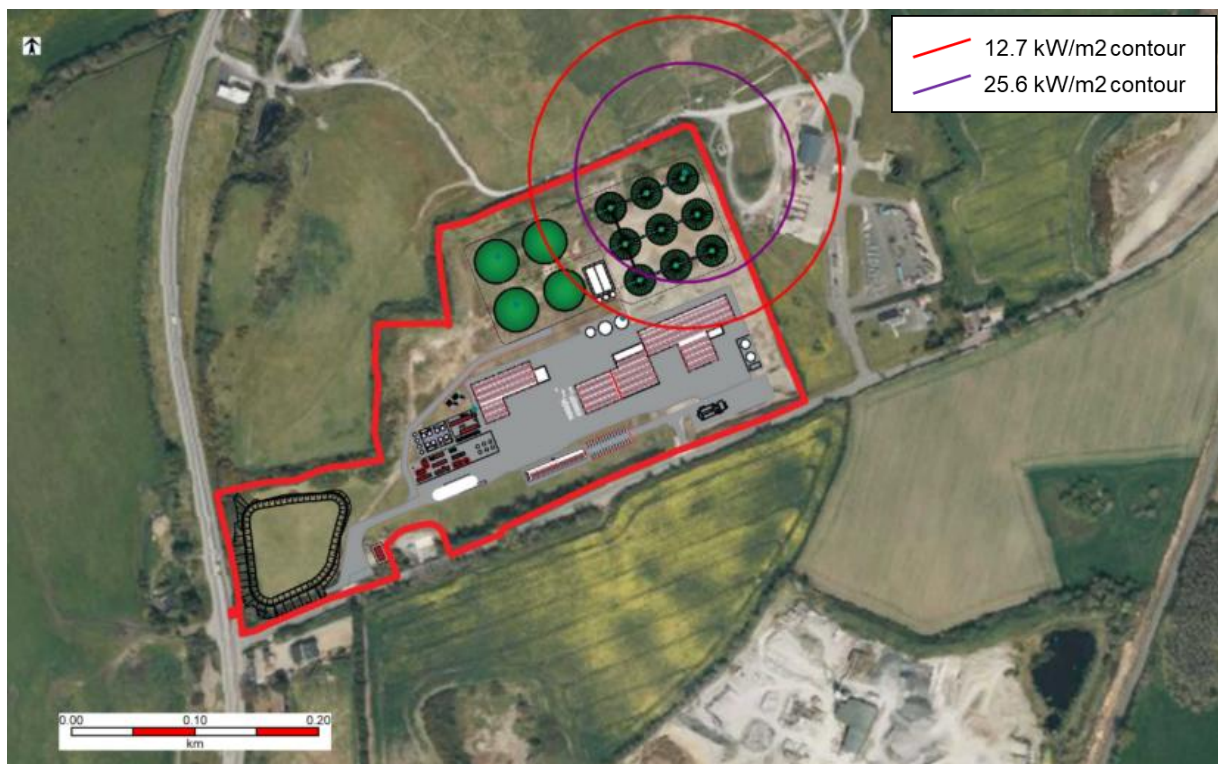


Figure 6-3 Post Digestion Storage Tank Rupture and Fireball: Outdoor Lethality Contours

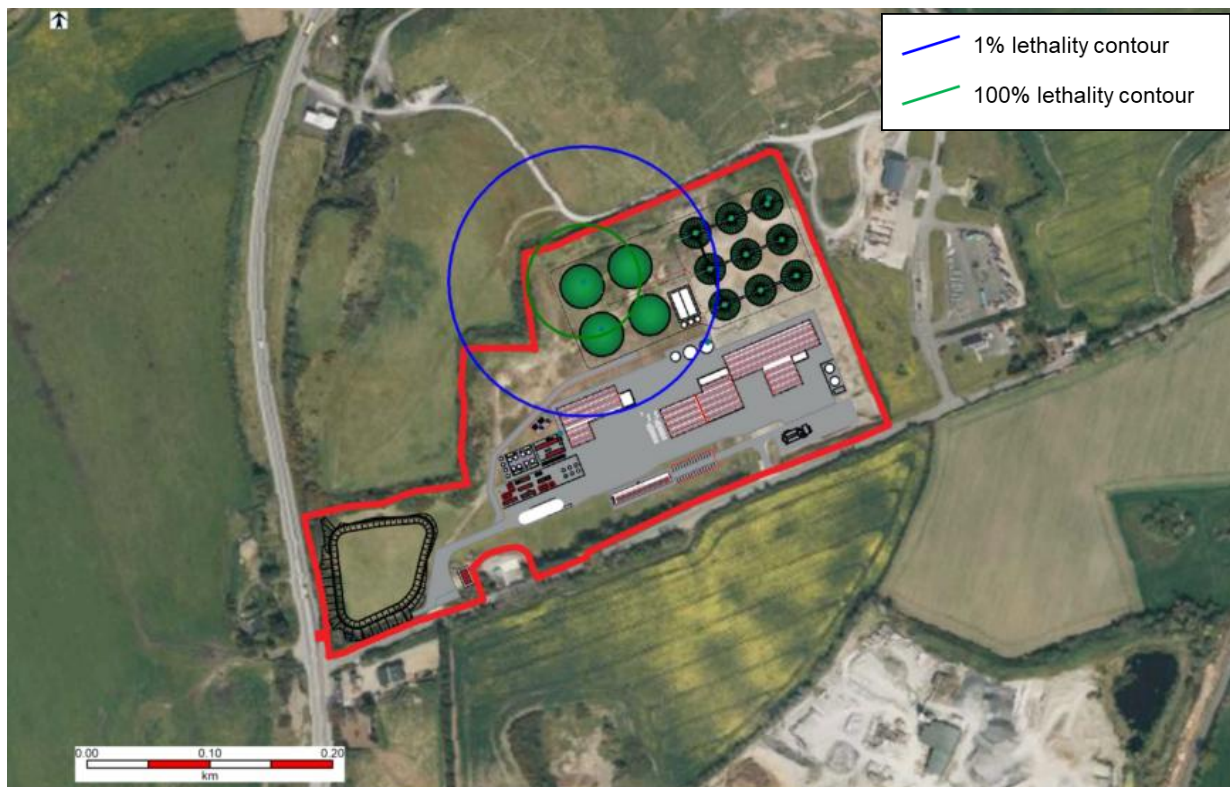
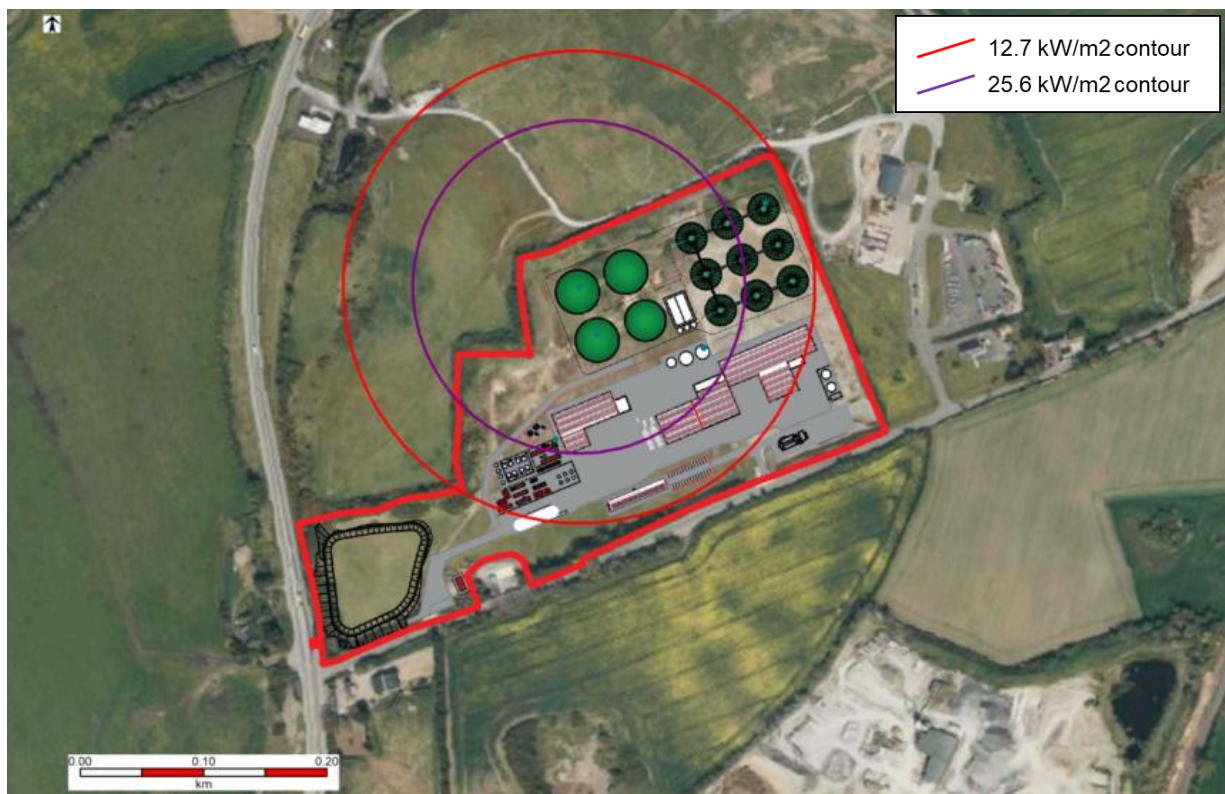


Figure 6-4 Post Digestion Storage Tank Rupture and Fireball: 12.7 kW/m² and 25.6 kW/m² Contours



In the event of rupture of a secondary digester tank the thermal dose corresponding to 1% fatality outdoors extends beyond the COMAH boundary to the east but does not extend to any off site receptor locations.

The 12.7 kW/m² thermal radiation level (0% lethality indoors below this level) is exceeded at the waste acceptance building at the civic amenity centre. The 25.6 kW/m² thermal radiation contour extends over the COMAH boundary to the civic amenity centre but does not extend to any buildings. The fireball is of short duration (4.15 seconds) and the fireball flame does not extend to any off site buildings. Therefore no fatalities are predicted to arise at this location.

It is concluded that in the event of rupture of the post digestion storage tank, the thermal dose corresponding to 1% fatality outdoors extends beyond the site to the north/west of the tank farm but does not extend to any off site receptors. The 12.7 and 25.6 kW/m² thermal radiation contours extend over the site boundary but do not extend to any COMAH receptors. No off site injuries or fatalities are predicted to arise.

6.1.3 Biogas Release from Tank: VCE Results

The DNV PHAST unified dispersion model was used to predict the flammable mass that would arise in the event of rupture of a tank containing untreated biogas or a leak from a tank containing untreated biogas. Ignition location and flammable mass are summarised in Table 6-5.

Table 6-5 Biogas Release from Tank: Vapour Cloud Explosion Ignition Location and Flammable Mass

Loss of containment scenario description	Ignition location	Flammable Mass (kg)	
		Category D5	Category F2
Primary or secondary digester rupture	Confined area is close to source, ignition location at source	134.3	130.7
Primary or secondary digester continuous release over 10 minutes, horizontal release	Confined area is close to source, ignition location at source	0.59	0.68
Primary or secondary digester continuous release over 10 minutes, vertical release	Confined area is close to source, ignition location at source	0.30	0.44
Tertiary digester or post storage tank rupture	Confined area is close to source, ignition location at source	483.7	476.9
Tertiary digester or post storage tank continuous release over 10 minutes, horizontal release	Confined area is close to source, ignition location at source	3.17	3.37
Tertiary digester or post storage tank continuous release over 10 minutes, vertical release	Confined area is close to source, ignition location at source	1.96	2.90
Digestate storage or liquid pre-storage tank rupture	Confined area is close to source, ignition location at source	643.9	645.9
Digestate storage or liquid pre-storage tank continuous release over 10 minutes, vertical release	Confined area is close to source, ignition location at source	4.23	4.49

Loss of containment scenario description	Ignition location	Flammable Mass (kg)	
		Category D5	Category F2
Digestate storage or liquid pre-storage tank continuous release over 10 minutes, horizontal release	Confined area is close to source, ignition location at source	2.03	3.53
Pasteurisation tank rupture	Confined area is close to source, ignition location at source	1.3	1.2
Pasteurisation tank continuous release over 10 minutes, vertical release	Confined area is close to source, ignition location at source	0.005	0.006
Pasteurisation tank continuous release over 10 minutes, horizontal release	Confined area is close to source, ignition location at source	7E-05	No VCE hazard

The TNO Multi Energy model was used to model the overpressure consequences in the event a VCE following the loss of containment of untreated biogas from a bulk storage tank. An explosion strength of 7 was applied to 20% of the stoichiometric cloud volume. Distances to specified overpressure endpoints are summarised in Table 6-6, with consequence decay curves provided in Appendix C.

Figure 6-5 illustrates the overpressure contour corresponding to 1% fatality outdoors and 1% fatality indoors CIA Cat. 3 structures (residential dwellings) following rupture of the secondary digester that is nearest to the waste acceptance building at the civic amenity site to the east.

Figure 6-6 illustrates the overpressure contour corresponding to 1% fatality outdoors and 1% fatality indoors CIA Cat. 3 structure (residential dwellings) following rupture of the post digestion storage tank which has the largest overpressure hazard for this scenario.

Table 6-6 Release of Biogas from Storage Tank and VCE: Distances to Specified Overpressure Endpoints

Scenario description	Distance to 50 mbar Overpressure Level (1% lethality indoors in CIA 3 Buildings) (metres)		Distance to 168 mbar (1% lethality outdoors) (metres)	
	Category D5	Category F2	Category D5	Category F2
Primary or secondary digester rupture and VCE	121.2	120.1	45.3	44.9
Primary or secondary digester continuous release over 10 minutes, horizontal release and VCE	19.8	20.8	7.4	7.8
Primary or secondary digester continuous release over 10 minutes, vertical release and VCE	15.8	18.1	5.9	6.7
Tertiary digester or post storage tank rupture and VCE	185.7	184.9	69.4	69.1
Tertiary digester or post storage tank continuous	34.8	13.0	35.5	13.3

Scenario description	Distance to 50 mbar Overpressure Level (1% lethality indoors in CIA 3 Buildings) (metres)		Distance to 168 mbar (1% lethality outdoors) (metres)	
	Category D5	Category F2	Category D5	Category F2
release over 10 minutes, horizontal release and VCE				
Tertiary digester or post storage tank continuous release over 10 minutes, vertical release and VCE	29.6	33.7	1.1	12.6
Digestate storage or liquid pre- storage tank rupture and VCE	204.3	204.5	76.3	76.4
Digestate storage or liquid pre- storage tank continuous release over 10 minutes, vertical release and VCE	38.3	39.0	14.3	14.6
Digestate storage or liquid pre- storage tank continuous release over 10 minutes, horizontal release and VCE	30.0	36.0	11.2	13.5
Pasteurisation tank rupture and VCE	25.8	25.4	9.6	9.5
Pasteurisation tank continuous release over 10 minutes, vertical release and VCE	4.1	4.4	1.5	1.6
Pasteurisation tank continuous release over 10 minutes, horizontal release and VCE	1.0	No VCE hazard	0.4	No VCE hazard

Figure 6-5 Secondary Digester Rupture and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours

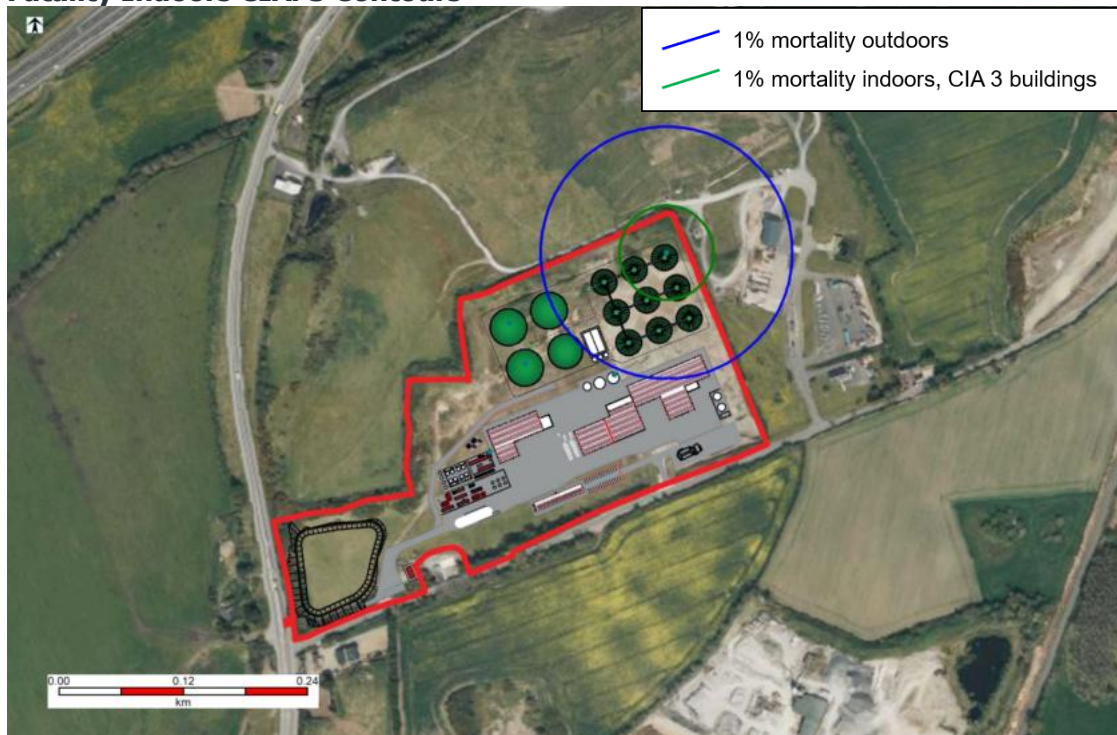
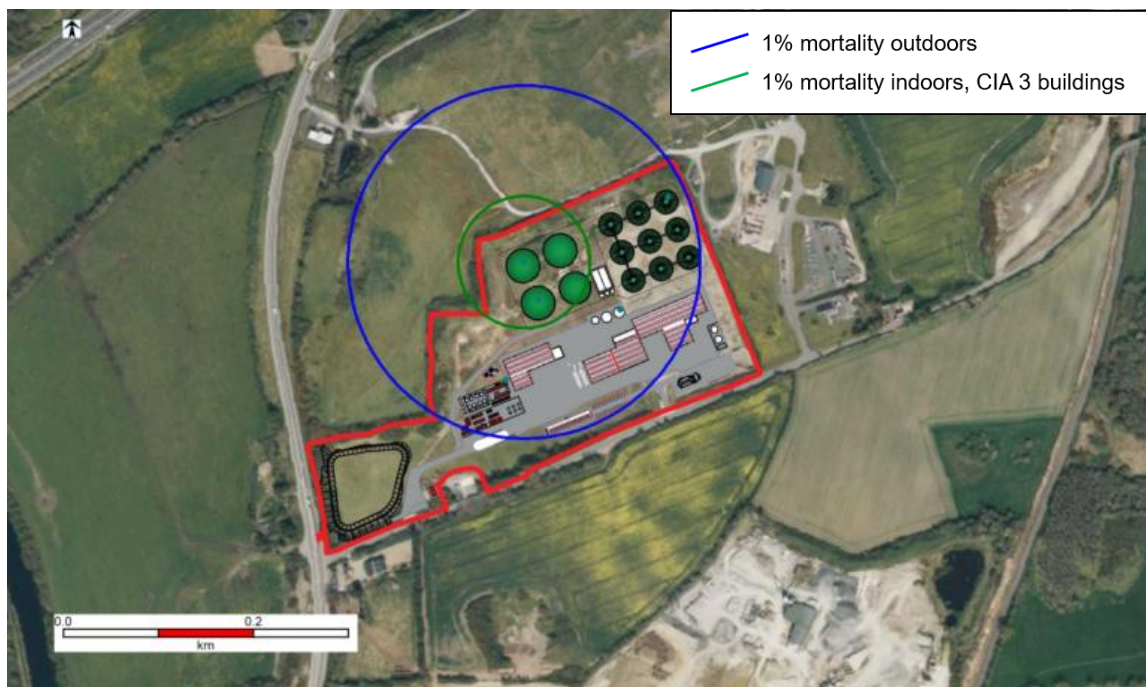


Figure 6-6 Post Digestion Storage Tank Rupture and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours



In the event of a VCE following rupture of a secondary digester, the overpressure consequences corresponding to 1% fatality outdoors extend over the COMAH boundary but does not reach any off site receptor. The building occupants are more vulnerable, the indoor criterion produces a larger contour; the 50 mbar contour corresponding to 1% lethality indoors in CIA3 structures

(residential dwellings) extends to the waste acceptance building at the civic amenity centre, which is occupied by up to 2 operatives. The incident overpressure at the building façade is estimated as 70 mbar. Assuming that CIA3 represents the overpressure vulnerability of this building, the probability of fatality is 2%. The worst case consequences are estimated as injuries.

In the event of a VCE following rupture of the post digestion storage tank, the overpressure level corresponding to 1% lethality outdoors and 1% lethality indoors in CIA3 structures do not extend to any off site receptors.

6.1.4 Biogas Release from Tank and Jet Fire

The (DNV Recommended and best practice) jet fire cone model was used to calculate the thermal radiation consequences following the release of untreated biogas from the tank at the tank farm. The decay curves for this consequence are presented in Appendix C for further information. Table 6-7 details the distances to thermal radiation levels associated with specified probabilities of fatality from a jet fire, reported at a receptor height of 57 m O.D., which is representative of receptors at the civic amenity centre 80 m to the east.

Table 6-7 Biogas Release from Tank and Jet Fire: Distances to Specified Thermal Radiation Levels at a Receptor Height of 57 m O.D.

Scenario description	Distance to 8.02 kW/m ² (1% lethality outdoors) (metres)		Distance to 12.7 kW/m ² (0% lethality indoors) (metres)		Distance to 25.6 kW/m ² (100% lethality indoors) (metres)	
	Category D5	Category F2	Category D5	Category F2	Category D5	Category F2
Primary or secondary digester continuous release over 10 minutes, horizontal release and jet fire	Not reached	Not reached	Not reached	Not reached	Not reached	Not reached
Primary or secondary digester continuous release over 10 minutes, vertical release and jet fire	Not reached	Not reached	Not reached	Not reached	Not reached	Not reached
Tertiary digester or post storage tank continuous release over 10 minutes, horizontal release and jet fire	45.8	35.8	44.7	34.6	43.4	33.1
Tertiary digester or post storage tank continuous release over 10 minutes, vertical release and jet fire	28.9	19.9	23.9	7.6	13.6	Not reached
Digestate storage or liquid pre-storage tank continuous release over 10 minutes, horizontal release and jet fire	48.6	38.0	47.3	36.7	46.0	35.1
Digestate storage or liquid pre-storage tank continuous release over 10 minutes, vertical release and jet fire	30.7	21.4	25.4	8.4	14.4	Not reached

Scenario description	Distance to 8.02 kW/m ² (1% lethality outdoors) (metres)		Distance to 12.7 kW/m ² (0% lethality indoors) (metres)		Distance to 25.6 kW/m ² (100% lethality indoors) (metres)	
	Category D5	Category F2	Category D5	Category F2	Category D5	Category F2
Pasteurisation tank continuous release over 10 minutes, vertical release and jet fire	Not reached	2.9	Not reached	2.8	Not reached	Not reached
Pasteurisation tank continuous release over 10 minutes, horizontal release and jet fire	2.3	Not reached	2.0	Not reached	1.6	Not reached

Figure 6-7 illustrates the thermal radiation contour and effect areas corresponding to 1% fatality outdoors for a jet fire for the worst case jet fire scenario, which occurs following a continuous horizontal, release over 10 minutes from the digestate storage tank.

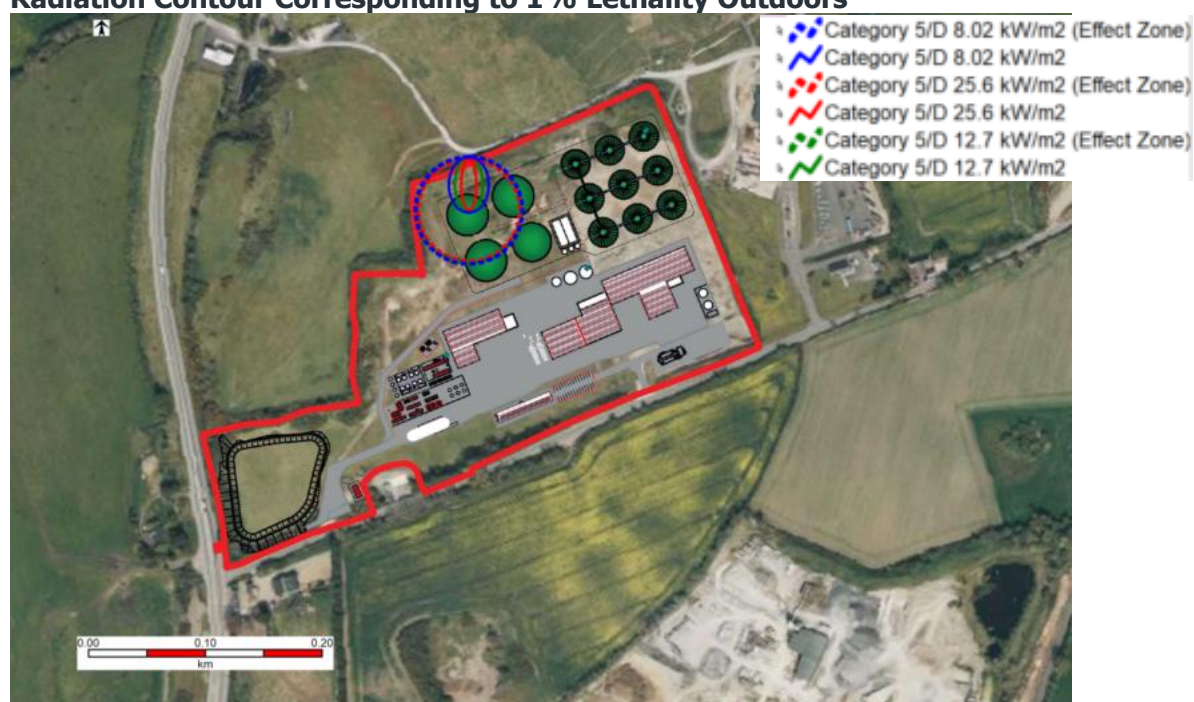
Figure 6-8 illustrates the thermal radiation contour and effect areas corresponding to 1% fatality outdoors for a jet fire following a continuous release over 10 minutes from the post digestion storage tank which is located nearer to the site boundary.

Thermal radiation contours are illustrated for the prevailing wind direction (180 degrees, see Figure 4-2) and the effect areas take account of all possible wind directions.

Figure 6-7 Liquid Pre-Storage Tank Release and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Lethality Outdoors



Figure 6-8 Liquid Pre-Storage Tank Release and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Lethality Outdoors



In the event of a jet fire following a continuous release over 10 minutes of the biogas from a tank at the tank farm, the thermal radiation level corresponding to 1% lethality outdoors does may extend slightly over the COMAH site boundary but will not extend to any off site receptor locations. No off site effects are predicted to arise.

6.1.5 Biogas Release from Tank and Flash Fire

The DNV PHAST Version 9.1 unified dispersion model predicts the flash fire footprints, at a receiver height of 1.5m.

Flash Fire consequence graphs are provided in Appendix C.

Table 6-8 summarises flash fire results following a loss of containment of biogas from a tank at the tank farm. The flash fire distance at a receptor height of 57 m O.D. is reported as representative of a receptor at the civic amenity site to the east. Where a larger flash fire envelope may arise at a different receptor height, this is also reported in Table 6-8.

Table 6-8 Release of Biogas from Tank and Flash Fire: Distance to Flash Fire Envelope

Loss of containment scenario description	Flash Fire Envelope Distance (metres)	
	Category D5	Category F2
Primary or secondary digester rupture	8.7 metres at receptor height of 57 m O.D. Maximum 15.9 metres at 12.3 m above ground level	6.6 metres at receptor height of 57 m O.D. Maximum 13.7 metres at 12.5 m above ground level
Primary or secondary digester continuous release over 10 minutes, horizontal release	Not reached at receptor height of 57 m O.D. 14.3 metres at release height (top of tank wall)	Not reached at receptor height of 57 m O.D. 13.3 metres at release height (top of tank wall)

Loss of containment scenario description	Flash Fire Envelope Distance (metres)	
	Category D5	Category F2
Primary or secondary digester continuous release over 10 minutes, vertical release	Not reached at receptor height of 57 m O.D. 4.3 metres at release height (top of tank wall)	Not reached at receptor height of 57 m O.D. 2.5 metres at release height (top of tank wall)
Tertiary digester or post digestion storage tank rupture	34 metres at receptor height of 57 m O.D.	34 metres at receptor height of 57 m O.D.
Tertiary digester or post digestion storage tank continuous release over 10 minutes, horizontal release	18.9 m at receptor height of 57 m O.D. 22 metres at 2.7 metres above ground level	17.7 m at receptor height of 57 m O.D. 20.5 metres at 2.6 metres above ground level
Tertiary digester or post digestion storage tank continuous release over 10 minutes, vertical release	0.33 m at receptor height of 57 m O.D. 6.5 metres at 8.3 metres above ground level	0.3 m at receptor height of 57 m O.D. 4 metres at 12 metres above ground level
Digestate storage or liquid pre-storage tank rupture	47 m at receptor height of 57 m O.D.	30m at receptor height of 57 m O.D.
Digestate storage or liquid pre-storage tank continuous release over 10 minutes, vertical release	27 m at receptor height of 57 m O.D. 30 metres at 2.4 metres above ground level	26 m at receptor height of 57 m O.D. 28.6 metres at 2.4 metres above ground level
Digestate storage or liquid pre-storage tank continuous release over 10 minutes, horizontal release	0.3 m at receptor height of 57 m O.D. 5 metres at 9.7 metres above ground level	0.25 m at receptor height of 57 m O.D. 3.4 metres at 13.5 metres above ground level
Pasteurisation tank rupture	17 m at receptor height of 57 m O.D.	4.6 m at receptor height of 57 mOD
Pasteurisation tank continuous release over 10 minutes, vertical release	1.3 m at receptor height of 57 m O.D.	1.6 m at receptor height of 57 m O.D.
Pasteurisation tank continuous release over 10 minutes, horizontal release	0.017 m at receptor height of 57 m O.D.	0.015 m at receptor height of 57 m O.D.

Figure 6-9 illustrates the flash fire footprint at a secondary digester (closest tank to site boundary) at a receptor height of 57 m O.D. Figure 6-10 illustrates the flash fire footprint following rupture of the digestate storage tank, which results in the largest flash fire footprint at the tank farm in the event of the loss of containment of biogas.

Figure 6-9 Secondary Digester Rupture: Flash Fire Footprint

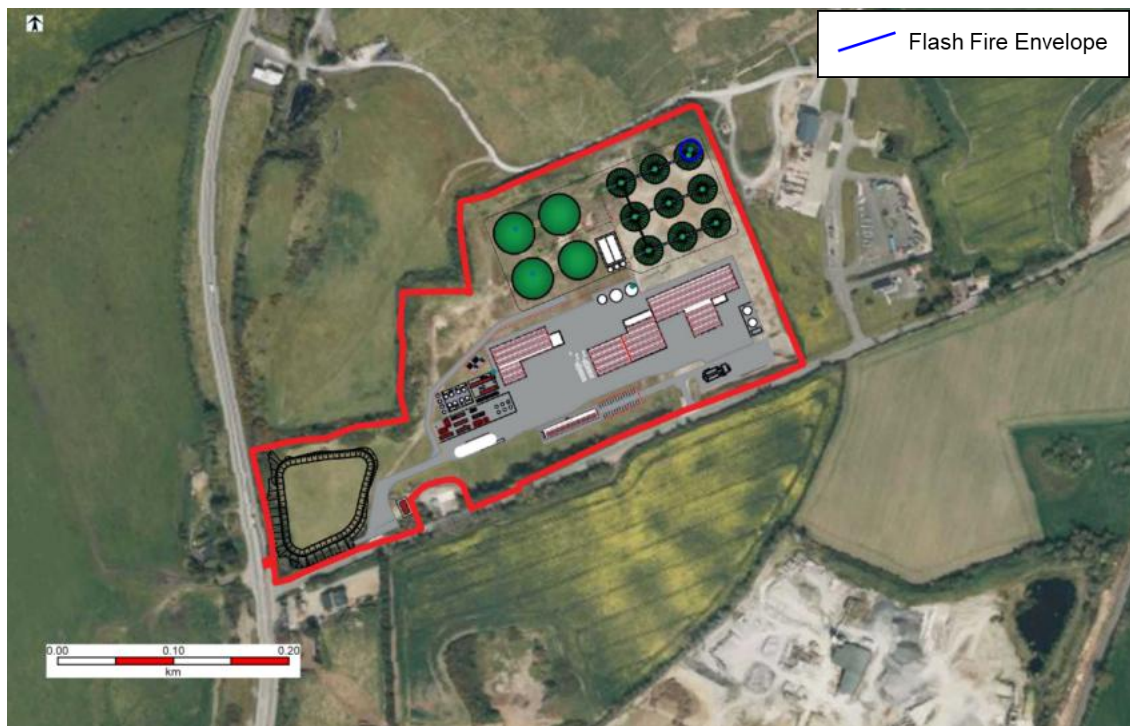


Figure 6-10 Digestate Storage Tank Rupture: Flash Fire Footprint



In the event of the loss of containment of biogas from a tank at the tank farm, the flash fire envelope will not extend over the COMAH boundary and no off site injuries or fatalities are predicted to arise.

6.1.6 Biogas Tank Release Frequencies

Table 23 of the HSA's TLUP guidelines (HSA, 2023) gives release and event frequencies for LPG tank loss of containment scenarios. See Table 6-9 as follows.

Table 6-9 Event Frequencies for Tanks Containing Biogas

Installation	LOC scenario	LOC frequency		Consequence	Event freq. (per year)
Primary / Secondary / Tertiary Digester / Post Digestion Storage Tank / Liquid Pre Storage Tank / Digestate Storage Tank / Pasteurisation Tank	Instantaneous failure and release of untreated biogas	5.00E-06	/yr per tank	Fireball	4.50E-07
				VCE	1.64E-06
				Flash fire	2.46E-06
	Continuous leak over 10 minutes and release of untreated biogas	5.00E-06	/yr per tank	Jet Fire	4.50E-07
				VCE	1.64E-06
				Flash fire	2.46E-06

6.2 Biogas Pipeline Release

6.2.1 Biogas Pipeline Release Model Inputs

Appendix B includes a schedule of untreated (raw) biogas and upgraded biogas (renewable natural gas) pipelines on site at the proposed development. Two representative loss-of-containment scenarios are assessed: the 4 barg pipeline from the gas upgrade plant to the BNEF (partly above ground) and the underground 4 barg pipeline routed off site from the BNEF to the gas network connection. As these operate at higher pressure than the low-pressure (5–15 mbarg) raw-biogas collection pipework, they are taken to conservatively bound the on-site pipeline releases. The DNV PHAST Version 9.1 long-pipeline model is used to assess a rupture or a leak (10% of pipeline diameter), with the gas conservatively modelled as methane (Section 6.1.1). The modelling does not credit valve/Emergency Shutdown Device (ESD) closure. Pipeline release model inputs are detailed in Table 6-10. The above ground biogas pipeline breach is assumed to occur west of the biogas treatment area at the closet point to the site boundary.

The below ground biogas pipeline breach is assumed to occur on the discharge line from the BNEF, nearest to off-site receptors.

Table 6-10 Biogas Pipeline Rupture or Leak: Discharge Model Inputs

Parameter	Representative Above Ground 4 barg Pipeline		Representative Below Ground 4 barg Pipeline		Source/ Assumption
	Pipeline rupture	Pipeline leak, 10% diameter	Pipeline rupture	Pipeline leak, 10% diameter	
Scenario	Pipeline rupture	Pipeline leak, 10% diameter	Pipeline rupture	Pipeline leak, 10% diameter	-
Material	Methane	Methane	Methane	Methane	-
Pipeline diameter			250 mm	250 mm	-
Hole Size			250 mm	25 mm	-
Pipe inflow	3400 Sm ³ /hr or 0.64 kg/s	3400 Sm ³ /hr or 0.64 kg/s	3400 Sm ³ /hr or 0.64 kg/s	3400 Sm ³ /hr or 0.64 kg/s	Maximum plant capacity
Length of pipeline	162 metres on site (a portion of this is above ground)	162 metres on site (a portion of this is above ground)	50 metres on site + 500 metres off site	50 metres on site + 500 metres off site	Conservative assumption
Pressure	4 barg	4 barg	4 barg	4 barg	Pipeline pressure
Temperature	20 degC	20 degC	20 degC	20 degC	Gas Networks Ireland specification
Averaging time	Flammable – 18.75 s	Flammable – 18.75 s	Flammable – 18.75 s	Flammable – 18.75 s	DNV PHAST
Short Duration Effects	30 second cut off time for flammable effects	30 second cut off time for flammable effects	30 second cut off time for flammable effects	30 second cut off time for flammable effects	Assumed
Exposure duration	60 s	60 s	60 s	60 s	HSA recommended (HSA, 2023)
Release height	1 m	1 m	0 m	0 m	Above ground pipeline Below ground pipeline
Release direction	Vertical Horizontal (above ground only)	Vertical Horizontal (above ground only)	Vertical	Vertical	HSA TLUP (HSA 2023)
Effect height	1.0 m	1.0 m	1.0 m	1.0 m	Average height of person in a range of postures

Parameter	Representative Above Ground 4 barg Pipeline		Representative Below Ground 4 barg Pipeline		Source/ Assumption
	Pipeline rupture	Pipeline leak, 10% diameter	Pipeline rupture	Pipeline leak, 10% diameter	
Wind speed	5 m/s 2 m/s	5 m/s 2 m/s	5 m/s 2 m/s	5 m/s 2 m/s	Recommended by HSA as representative modelling conditions
Pasquill Stability Factor	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	
Atmospheric Temperature	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	HSA TLUP (HSA 2023)

6.2.2 Biogas Pipeline Release Discharge Model Outputs

For a biogas pipeline release, the long pipeline discharge model, in Phast Version 9.1, is used with a time varying release. Appendix C contains graphs showing the release rate of biogas vs. time following a biogas pipeline rupture or leak scenarios.

6.2.3 Biogas Pipeline Release and Jet Fire

The (DNV Recommended) jet fire cone model was used to calculate the thermal radiation consequences from biogas jet fire scenarios at the proposed development.

As per HSA TLUP guidelines (HSA, 2023), jet fire results are presented for vertical releases from pipelines. Jet fire results are also presented for horizontal releases for loss of containment scenarios from above ground biogas pipelines. Release rate vs. time graphs for each scenario are provided in Appendix C.

Table 6-11 details distances to specified thermal radiation levels, at a receiver height of 1.5m, associated with

- ▶ 8.02 kW/m² — 1% fatality outdoors
- ▶ 12.7 kW/m² — 0% fatality indoors
- ▶ 25.6 kW/m² — 100% fatality indoors

Table 6-11 Above Ground Biogas Pipeline Release and Jet Fire: Calculated Distances at Specified Thermal Radiation Levels (receptor height 1.0m)

Consequence	Thermal Radiation (kW/m ²)	Distance to Consequence/Thermal Radiation Level (metres)							
		Above Ground Pipeline Rupture and Jet Fire Horizontal Release		Above Ground Pipeline leak, 10% diameter and Jet Fire Horizontal Release		Above Ground Pipeline Rupture and Jet Fire Vertical Release		Above Ground Pipeline leak, 10% diameter and Jet Fire Vertical Release	
		D5	F2	D5	F2	D5	F2	D5	F2
1% lethality outdoors	8.02	28.4	22.5	8.2	8.3	18.2	11.7	4.5	Not reached
0% lethality indoors	12.7	27.9	22.0	7.9	8.0	15.2	3.4	2.3	Not reached
100% lethality indoors	25.6	27.3	21.4	7.3	7.3	8.5	Not reached	Not reached	Not reached

Table 6-12 Below Ground Biogas Pipeline Release and Jet Fire: Calculated Distances at Specified Thermal Radiation Levels (receptor height 1.0m)

Consequence	Thermal Radiation (kW/m ²)	Distance to Consequence/Thermal Radiation Level (metres)			
		Below Ground 4 barg Pipeline Rupture and Jet Fire Vertical Release		Below Ground 4 barg Pipeline leak, 10% diameter and Jet Fire Vertical Release	
		D5	F2	D5	F2
1% lethality outdoors	8.02	31.2	26.7	10.4	7.8
0% lethality indoors	12.7	26.7	17.3	8.6	4.7
100% lethality indoors	25.6	19.1	6.9	7.2	1.8

Figure 6-11 and Figure 6-12 illustrate the thermal radiation contours and effect areas for the worst-case jet fire from an above-ground and a below-ground biogas pipeline respectively. Contours corresponding to 1% fatality outdoors (8.02 kW/m^2), 0% fatality indoors (12.7 kW/m^2) and 100% fatality indoors (25.6 kW/m^2) are shown, at a receptor height of 1.0 m and weather category D5. Contours are shown for the prevailing wind direction (see Figure 4-2; effect areas account for all wind directions).

Figure 6-11 Above Ground Biogas Pipeline Leak and Jet Fire Downstream of Biogas Upgrade Plant: Thermal Radiation Contours

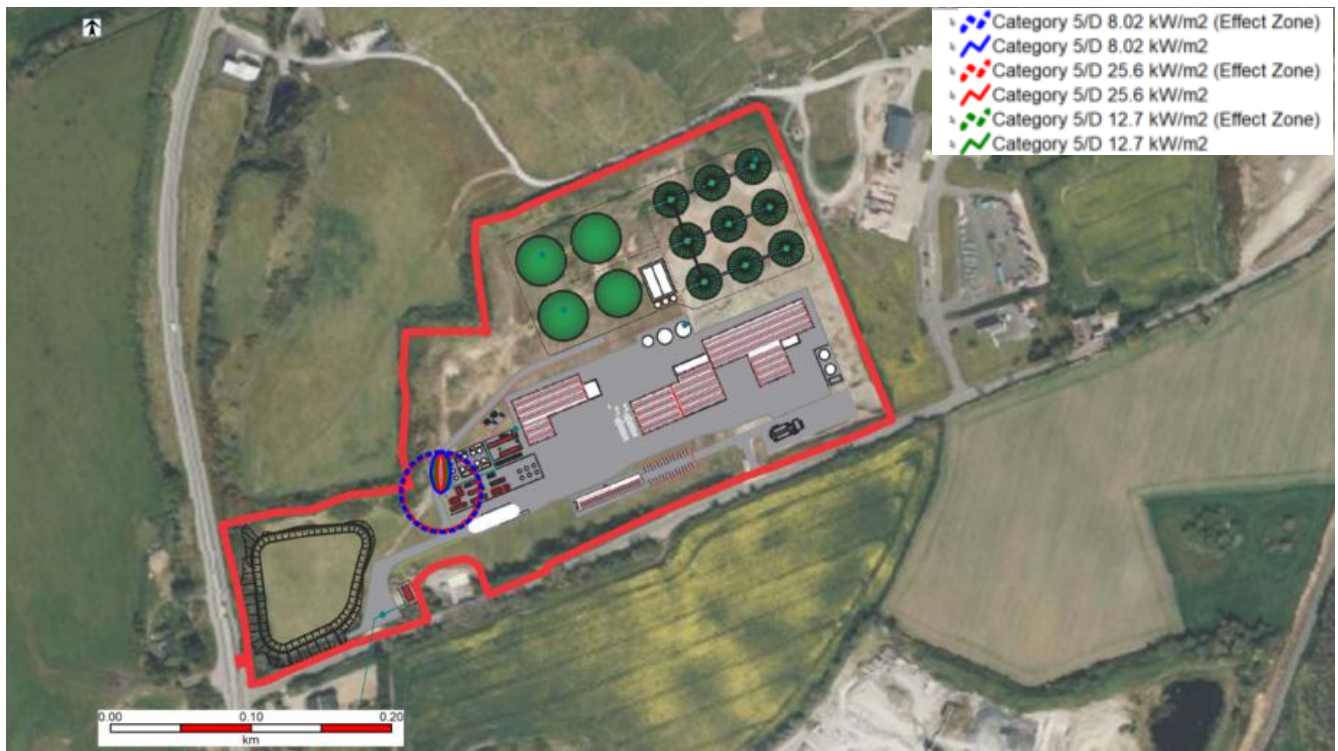
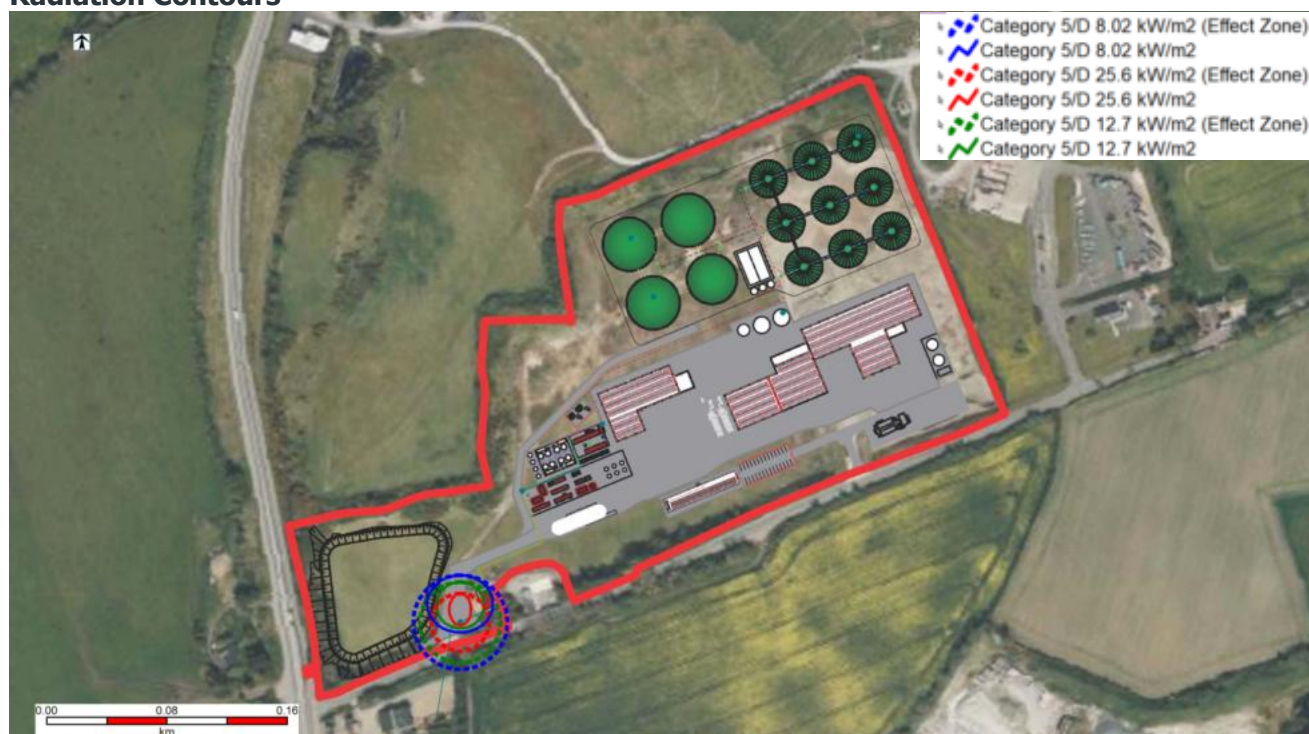


Figure 6-12 Below Ground Biogas Pipeline Leak and Jet Fire Downstream of BNEF: Thermal Radiation Contours



In the event of a jet fire following a release from the 4 barg above-ground biogas pipeline downstream of the gas upgrade plant, the thermal radiation levels corresponding to 1% fatality outdoors and 0% fatality indoors extend beyond the COMAH site boundary but not to any off-site receptor.

In the event of a jet fire following a release from the 4 barg below-ground biogas pipeline downstream of the BNEF, the thermal radiation levels corresponding to 1% fatality outdoors and 100% fatality indoors extend beyond the COMAH site boundary but not to any off-site receptor. It is concluded that no off-site injuries or fatalities are predicted.

6.2.4 Biogas Pipeline Release: Fireball Results

The HSE fireball model is used in this study. This is a static fireball model and assumes that the fireball is located on the ground with no lift-off. For short duration, flammable effects, the mass released within the first 30 seconds contributes to a fireball event. Fireball model outputs are summarised in Tables 6-13 (above ground) and 6-14 (below ground), with consequence decay curves in Appendix C. Tables 6-15 and 6-16 detail the distances to thermal dose levels for specified probabilities of fatality, based on the Eisenberg probit (Section 4.2) and assuming 100% fatality within the fireball radius.

Table 6-13 Above Ground Biogas Pipeline Release and Fireball: Fireball Model Outputs

Output	Pipeline Rupture Horizontal Release		Pipeline leak, 10% diameter Horizontal Release		Pipeline Rupture Vertical Release		Pipeline leak, 10% diameter Vertical Release	
	D5	F2	D5	F2	D5	F2	D5	F2
Flammable Mass (kg)	40.4	40.4	10.8	10.8	40.4	40.4	10.8	10.8
Duration of Fireball (s)	1.54	1.54	1.0	1.0	1.54	1.54	1.0	1.0
Fireball Radius (m)	9.9	9.9	6.4	6.4	9.9	9.9	6.4	6.4

Table 6-14 Below Ground Biogas Pipeline Release and Fireball: Fireball Model Outputs

Output	Below Ground 4 barg Pipeline Rupture Vertical Release		Below Ground 4 barg Pipeline leak, 10% diameter Vertical Release	
	D5	F2	D5	F2
Flammable Mass (kg)	91	91	11	11
Duration of Fireball (s)	2.0	2.0	1.0	1.0
Fireball Radius (m)	13.0	13.0	6.4	6.4

Table 6-15 Above Ground Biogas Pipeline Rupture and Fireball: Distances to Specified Thermal Dose Levels (Receptor Height 1.0 metres)

Criterion	Thermal Dose Level	Thermal Radiation	Distance to Thermal Dose/Radiation Level (metres)							
			Pipeline Rupture Horizontal Release		Pipeline leak, 10% diameter Horizontal Release		Pipeline Rupture Vertical Release		Pipeline leak, 10% diameter Vertical Release	
	TDUs	kW/m2	D5	F2	D5	F2	D5	F2	D5	F2
1% fatality outdoors (based on fireball duration)	963	-	14.2	14.3	7.7	7.8	15.9	14.3	7.7	7.8
100% fatality outdoors	Fireball radius	-	9.9	9.9	6.4	6.4	9.9	9.9	6.4	6.4
Building protected below this level, 0% fatality probability	-	12.7	48.4	48.9	31.8	32.1	48.4	48.9	31.8	32.1
Building will catch fire quickly, 100% fatality probability	-	25.6	34.2	34.5	22.5	22.7	34.2	34.5	22.5	22.7

Table 6-16 Below Ground Biogas Pipeline Rupture and Fireball: Distances to Specified Thermal Dose Levels (Receptor Height 1.0 metres)

Criterion	Thermal Dose Level	Thermal Radiation	Distance to Thermal Dose/Radiation Level (metres)			
			4 barg Pipeline Rupture Vertical Release		4 barg Pipeline leak, 10% diameter Vertical Release	
	TDUs	kW/m2	D5	F2	D5	F2
1% fatality outdoors (based on fireball duration)	963	-	20.8	20.9	7.7	7.8
100% fatality outdoors	Fireball radius	-	13.0	13.0	6.4	6.4
Building protected below this level, 0% fatality probability	-	12.7	62.7	63.4	31.8	32.1
Building will catch fire quickly, 100% fatality probability	-	25.6	44.2	44.7	22.5	22.6

Figure 6-13 illustrates the thermal radiation contours corresponding to 1% lethality and 100 % lethality outdoors in the event of a fireball following rupture of the above ground biogas pipeline downstream of the gas upgrader plant and Figure 6-14 illustrates the thermal radiation contours corresponding to 12.7 kW/m² and 25.6 kW/m².

Figure 6-15 illustrates the thermal radiation contours corresponding to 1% lethality and 100 % lethality outdoors in the event of a fireball following rupture of the above ground biogas pipeline downstream of the BNEF container and Figure 6-16 illustrates the thermal radiation contours corresponding to 12.7 kW/m² and 25.6 kW/m².

Figure 6-13 Above Ground Biogas Pipeline Rupture and Fireball: Outdoor Lethality Contours

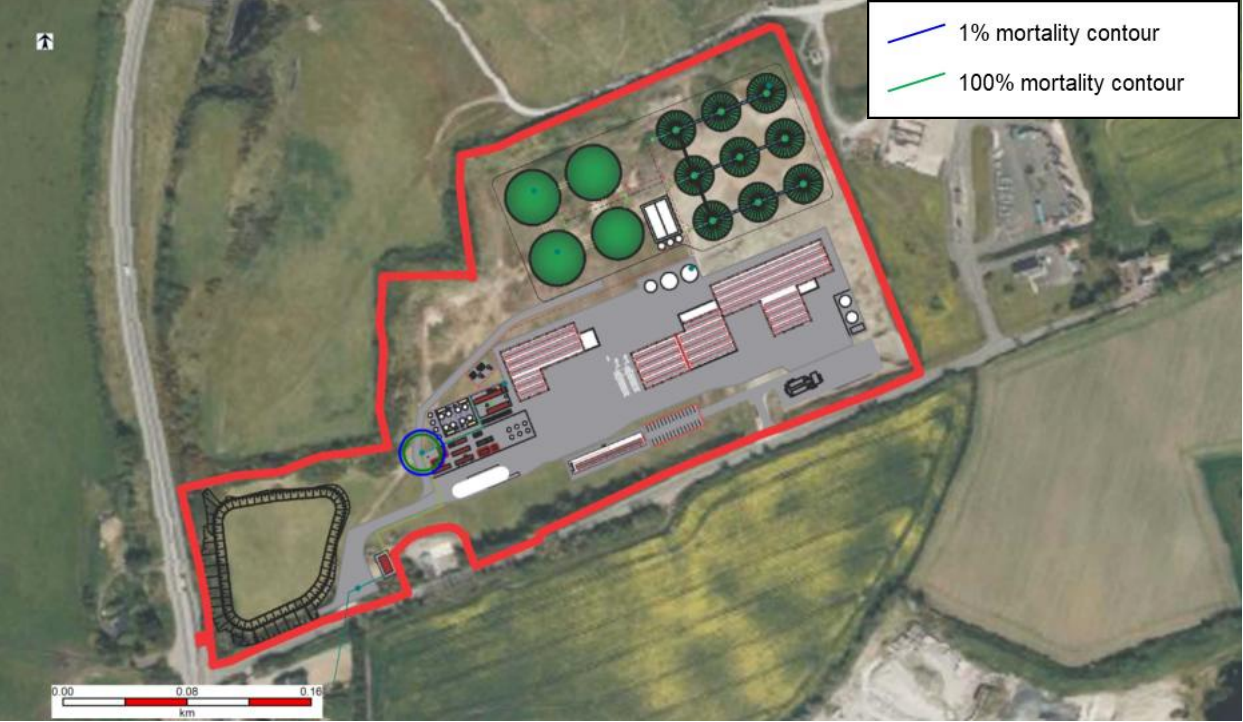


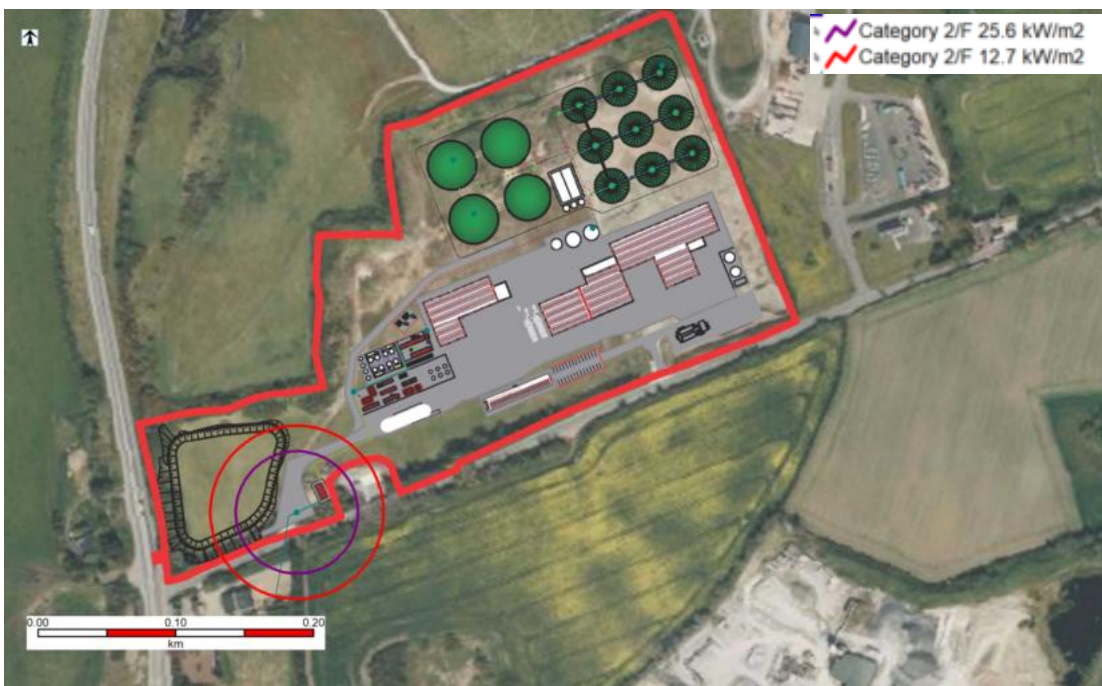
Figure 6-14 Above Ground Biogas Pipeline Rupture and Fireball: 12.7 kW/m² and 25.6 kW/m² Contours



Figure 6-15 Below Ground Biogas Pipeline Rupture and Fireball: Outdoor Lethality Contours



Figure 6-16 Below Ground Biogas Pipeline Rupture and Fireball: 12.7 kW/m² and 25.6 kW/m² Contours



In the event of a fireball following rupture of the above ground biogas pipeline downstream of the gas upgrade plant, the thermal dose contours corresponding to 1% and 100% lethality outdoors do not extend outside of the site boundary. The 1% lethality contour (outdoors) extends to the residential dwelling east of the BNEF. This property will be acquired by the developer of the Powerstown

The 12.7 kW/m² and 25 kW/m² thermal radiation contours extend outside of the site boundary but do not extend to any off site receptors.

In the event of a fireball following rupture of the below ground biogas pipeline downstream of the BNEF, the thermal dose contours corresponding to 1% and 100% lethality outdoors may extend outside of the site boundary to the south (depending on the location of the breach). These contours do not extend to any off site receptors. The 12.7 kW/m² thermal radiation contour extends to the façade of an agricultural building to the rear of a residential dwelling on the R448 south of the proposed development. The fireball is of short duration (2.0 seconds) and limited damage to the building is anticipated.

No off site injuries or fatalities are predicted to arise.

6.2.5 Biogas Pipeline Release: VCE Results

The DNV PHAST unified dispersion model was used to predict the flammable mass that would arise in the event of a biogas pipeline rupture or leak. A VCE hazard is not predicted to arise in the event of a vertical release from an underground biogas pipeline. Ignition location and flammable mass for horizontal pipeline release are summarised in Table 6-17. The TNO Multi-Energy model is used to assess the resulting overpressure, applying an explosion strength of 7 to 20% of the stoichiometric cloud volume. Consequence decay curves are provided in Appendix C, and distances to the specified overpressure endpoints are detailed in Table 6-18.

Table 6-17 Biogas Pipeline Rupture or Leak: Vapour Cloud Explosion Ignition Location and Flammable Mass

Loss of containment scenario description	Ignition location	Flammable Mass	
		Category D5	Category F2
Above Ground 4 barg biogas pipeline rupture, horizontal release	Confined area is close to source, ignition location at source	0.91 kg	1.13 kg
Above Ground 4 barg biogas pipeline leak, 0.1D, horizontal release		0.013 kg	0.011 kg
Above Ground 4 barg biogas pipeline rupture, vertical release	Confined area is close to source, ignition location at source	0.48 kg	0.84 kg
Above Ground 4 barg biogas pipeline leak, 0.1D, vertical release		0.008 kg	0.011 kg
Below ground 4 barg biogas pipeline rupture, vertical release	Confined area is close to source, ignition location at source	2.2 kg	2.0 kg
Below ground 4 barg biogas pipeline leak, 0.1D, vertical release		No VCE Hazard	No VCE Hazard

Table 6-18 Biogas Pipeline Release and VCE: Distances to Specified Overpressure Endpoints

Scenario description	Distance to 50 mbar Overpressure Level (1% lethality indoors in CIA 3 Buildings) (metres)		Distance to 168 mbar (1% lethality outdoors) (metres)	
	Category D5	Category F2	Category D5	Category F2
Above Ground 4 barg biogas pipeline rupture, horizontal release	22.9	24.6	8.6	9.2
Above Ground 4 barg biogas pipeline leak, 0.1D, horizontal release	5.3	5.6	2.0	2.1
Above Ground 4 barg biogas pipeline rupture, vertical release	18.5	22.3	6.9	8.3
Above Ground 4 barg biogas pipeline leak, 0.1D, vertical release	4.7	5.63	1.8	2.0
Below ground 4 barg biogas pipeline rupture, vertical release	31.0	30.0	11.6	11.2
Below ground 4 barg biogas pipeline leak, 0.1D, vertical release	No VCE Hazard	No VCE Hazard	No VCE Hazard	No VCE Hazard

Figure 6-17 illustrates the overpressure contour and effect zone corresponding to 1% fatality outdoors and 1% fatality indoors CIA Cat. 3 following an above ground biogas pipeline rupture (horizontal release) and VCE downstream of the gas upgrade plant. The shape of the contour is shown for the prevailing wind direction (see Figure 4-2) as well as the effect area which takes account of all possible wind directions.

Figure 6-18 illustrates the overpressure contour and effect zone corresponding to 1% fatality outdoors and 1% fatality indoors CIA Cat. 3 following a below ground biogas pipeline rupture (vertical release) and VCE downstream of the BNEF. The shape of the contour is shown for the prevailing wind direction (see Figure 4-2) as well as the effect area which takes account of all possible wind directions.

Figure 6-17 Above Ground Biogas Pipeline Rupture (Horizontal) and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours



Figure 6-18 Below Ground Biogas Pipeline Rupture (Horizontal) and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours



In the event of a VCE following rupture of the above ground biogas pipeline downstream of the gas upgrader plant, the overpressure contours corresponding to 1% fatality outdoors and 1% lethality indoors in CIA Cat. 3 buildings do not extend outside of the site boundary.

In the event of a VCE following rupture of the below ground biogas pipeline downstream of the BNEF, the overpressure contour corresponding to 1% lethality outdoors does not extend outside of the site boundary and the overpressure contour corresponding to 1% lethality indoors in CIA Cat. 3 extends outside of the site boundary to the south but does not extend to any off site receptors.

6.2.6 Biogas Pipeline Release: Flash Fire Results

The DNV PHAST Version 9.1 unified dispersion model is used to predict the flash fire footprints at a receptor height of 1.0 m. Flash fire consequence graphs are provided in Appendix C. Table 6-19 summarises the flash fire results following a loss of containment of biogas from the pipelines.

Table 6-19 Biogas Pipeline Loss of Containment and Flash Fire: Distance to Flash Fire Envelope

Loss of containment scenario description	Flash Fire Envelope	
	Category D5	Category F2
Above Ground 4 barg biogas pipeline rupture, horizontal release	12.1 metres at 1 m receptor height Max. 12.8 metres at 1.5 metres above ground level	12.6 metres at 1 m receptor height Max. 13.6 metres at 1.8 metres above ground level
Above Ground 4 barg biogas pipeline leak, 0.1D, horizontal release	Max. 3.7 metres at 1 m receptor height	Max. 3.8 metres at 1 m receptor height
Above Ground 4 barg biogas pipeline rupture, vertical release	0.2 metres at 1 m receptor height Max. 4 metres at 5.4 metres above ground level	0.18 metres at 1 m receptor height Max. 2.5 metres at 7.7 metres above ground level
Above Ground 4 barg biogas pipeline leak, 0.1D, vertical release	0.024 metres at 1 m receptor height Max. 0.27 metres at 3 metres above ground level	0.022 metres at 1 m receptor height Max. 0.24 metres at 2.5 metres above ground level
Below ground 4 barg biogas pipeline rupture, vertical release	1.25 metres at 1 m receptor height Max. 9.5 metres at 5.7 metres above ground level	1.18 metres at 1 m receptor height Max. 6.4 metres at 10.4 metres above ground level
Below ground 4 barg biogas pipeline leak, 0.1D, vertical release	0.42 metres at 1 m receptor height Max. 1.2 metres at 2.2 metres above ground level	0.27 metres at 1 m receptor height Max. 6.4 metres at 3.4 metres above ground level

The shortest distance between the above ground 4 barg biogas pipeline downstream of the gas upgrade plant and the site boundary is 22 metres. No off site flash fire effects off site are anticipated to arise from a flash fire event following rupture of the biogas pipeline at this location.

The below ground 4 barg biogas pipeline downstream of the BNEF is routed off site. The closest property to the proposed development is along the R448 south of the development boundary. The pipeline route (on site) is 15 metres from the property boundary and 75 metres from the residential dwelling at the property. It is concluded that no injuries or fatalities are anticipated to arise at an off site location in the event of a flash fire at the proposed development following rupture of the underground biogas pipeline downstream of the BNEF.

6.2.7 Event Frequencies

Table 40 of the HSA's TLUP guidelines (HSA, 2023) gives the following pipeline loss of containment frequencies for above ground biogas pipelines within an establishment of diameter > 150 mm:

- Pipeline rupture frequency: 1E-07 per m per year

- ▶ Pipeline leak (10% diameter) frequency: 5E-07 per m per year

Table 41 of the HSA's TLUP guidelines (HSA, 2023) gives the following pipeline loss of containment frequencies for below ground biogas pipelines within an establishment of diameter > 150 mm:

- ▶ Pipeline rupture frequency: 1E-08 per m per year
- ▶ Pipeline leak (10% diameter) frequency: 5E-08 per m per year

The following ignition probabilities are specified in Table 42 of the HSA's TLUP guidelines (HSA, 2023):

- ▶ Fireball/Jet fire: 0.1
- ▶ Flash fire: $0.9 \times 0.6 = 0.54$
- ▶ VCE: $0.9 \times 0.4 = 0.36$

Table 6-20 provides a schedule of biogas pipelines on site at the proposed development. Table 6-21 summarises the event frequencies for a major accident at a biogas pipeline.

Table 6-20 Biogas Pipeline Schedule

Pipeline	Length m	Above/Below Ground	Dangerous substance	Diameter mm
Pipes from primary and secondary digesters	252	Above ground	Untreated (raw) biogas	250
Pipes between gas storage in tertiary and storage tanks	72	Above ground	Untreated (raw) biogas	300
Pipes from tertiary digesters and storage tanks to main gas line	159	Above ground	Untreated (raw) biogas	400
Main gas line to desulphurisation columns (from digesters)	498	Above ground	Untreated (raw) biogas	400
Line to flare	30	Above ground	Untreated (raw) biogas	400
Desulphurisation to GAC lines	92	Above ground	Untreated (raw) biogas	250
GAC to Gas Upgrader	68	Above ground	Untreated (raw) biogas	250
Gas Upgrader to BNEF	83	Above ground	Upgraded biogas (RNG)	250
	79	Below ground		
BNEF to flare (reject biomethane)	170	Above ground	Upgraded biogas (RNG)	400
	91	Below ground		
BNEF to gas network connection (portion within COMAH boundary)	45	Below ground	Upgraded biogas (RNG)	250

Table 6-21 Biogas Pipeline Event Frequencies

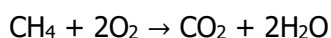
LOC scenario	Loss of containment frequency		Consequence	Conditional probability	Event frequency /m/year
Above ground pipeline rupture	1.00E-07	/m/yr	Jet fire/Fireball	0.1	1.00E-09
			Flash fire	0.54	5.40E-09
			VCE	0.36	3.60E-09
Above ground pipeline leak (10% diameter)	5.00E-07	/m/yr	Jet fire/Fireball	0.1	5.00E-09
			Flash fire	0.54	2.70E-08
			VCE	0.36	1.80E-08
Below ground pipeline rupture	1.00E-08	/m/yr	Jet fire/Fireball	0.1	1.00E-09
			Flash fire	0.54	5.40E-09
			VCE	0.36	3.60E-09
Below ground pipeline leak (10% pipeline)	5.00E-08	/m/yr	Jet fire/Fireball	0.1	5.00E-09
			Flash fire	0.54	2.70E-08
			VCE	0.36	1.80E-08

6.3 Indoor Equipment

6.3.1 Confined VCE Model Inputs

DNV PHAST Version 9.1 consequence modelling software was used to calculate the Multi Energy model overpressures resulting from a VCE in the blower station or in the BNEF gas room.

It is assumed that an accidental release of biogas occurs indoors. In order for a vapour cloud explosion to occur, the concentration of biogas (conservatively represented by methane) must lie between the lower and upper flammable limits. It is assumed that the concentration within the turbine enclosure is a stoichiometric mixture of air and flammable gas. The complete combustion equation for methane is:



The volume of the blower station room in the gas upgrade building is 56.9 m³.

The volume of the gas room in the BNEF container is 78.9 m³.

The mass fraction of methane within stoichiometric mixture in the blower station room/gas room was calculated as 0.056 and the total flammable mass was calculated as 3.77 kg in the blower station room and 5.23 kg in the BNEF gas room (see Appendix D for calculations).

The VCE model inputs are detailed in Table 6-22.

Table 6-22 Confined VCE Model Inputs

Parameter	Units	Blower Station Room	BNEF Gas Room	Source
Chemical name		methane	Methane	-
Flammable mass	kg	3.77	5.23	See Appendix D for calculation
Fraction of flammable cloud confined	-	1	1	Confined VCE within room
Curve number	-	7	7	Very Strong Deflagration: Confined conditions and low ignition energy

6.3.2 Confined VCE Model Outputs

Consequence decay curves are provided in Appendix C.

Table 6-23 details the distances to specified overpressure endpoints. Figure 6-19 illustrates the overpressure contours for the confined VCE in the Blower Station Room, and Figure 6-20 illustrates the equivalent contours for the BNEF Gas Room, in each case corresponding to 1% fatality outdoors and 1% fatality indoors in CIA Cat. 3 buildings.

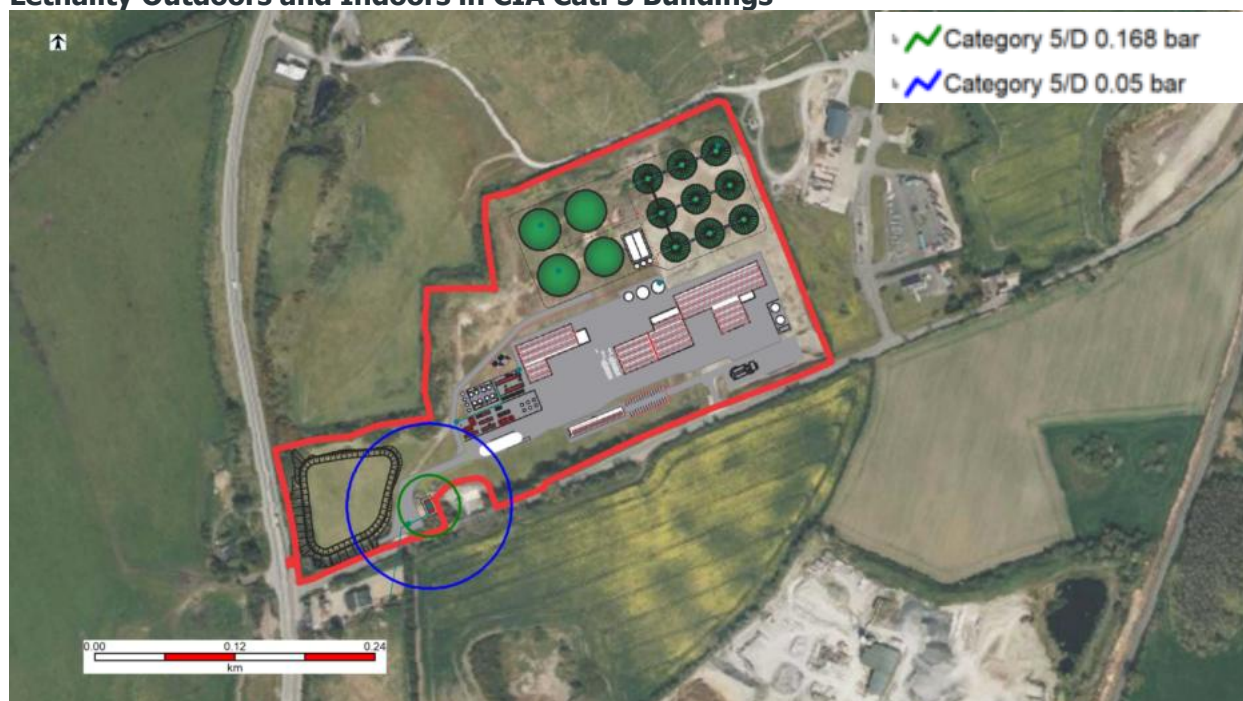
Table 6-23 Confined VCE: Distances to Specified Overpressure Endpoints

Scenario description	Distance to 50 mbar Overpressure Level (1% lethality indoors in CIA 3 Buildings) (metres)	Distance to 168 mbar (1% lethality outdoors) (metres)
	Category D5	Category D5
Confined VCE in Blower Station Room	63.3	24.9
Confined VCE in BNEF Gas Room	70.2	27.5

Figure 6-19 Confined VCE in Blower Station Room: Overpressure Contours Corresponding to 1% Lethality Outdoors and Indoors in CIA Cat. 3 Buildings



Figure 6-20 Confined VCE in BNEF Gas Room: Overpressure Contours Corresponding to 1% Lethality Outdoors and Indoors in CIA Cat. 3 Buildings



The following is concluded for a VCE in at the blower station:

- The overpressure contour corresponding to 1% lethality outdoors (168 mbar) does not extend over the COMAH site boundary

- ▶ The overpressure contour corresponding to 1% fatality indoors in CIA Cat. 3/4 buildings (representative of residential dwellings) does not extend over the COMAH site boundary.
- ▶ No off site fatalities are predicted to arise.

The following is concluded for a VCE in at the BNEF gas room:

- ▶ The overpressure contour corresponding to 1% lethality outdoors (168 mbar) does not extend over the COMAH site boundary
- ▶ The overpressure contour corresponding to 1% fatality indoors in CIA Cat. 3/4 buildings (representative of residential dwellings) does not extend over the COMAH site boundary.
- ▶ No off site fatalities are predicted to arise.

6.3.3 Confined VCE Frequency

The blower station in the gas upgrade building will contain 3 no. compressors. The BNEF gas room will contain approximately 10 metres of biogas pipeline.

Table 64 of the HSA's TLUP guidelines (HSA, 2023) gives the following pipeline loss of containment frequencies for process vessels:

- ▶ Instantaneous release: 5E-06 per year
- ▶ Release over 10 minutes: 1E-05 per year
- ▶ Release through 10 mm pipe: 5E-04 per year

These data are applied to the compressors in the blower room at gas upgrade building.

Table 40 of the HSA's TLUP guidelines (HSA, 2023) gives the following pipeline loss of containment frequencies for above ground biogas pipelines within an establishment where $75 \text{ mm} \leq \text{Diameter} \leq 150 \text{ mm}$:

- ▶ Pipeline rupture frequency: 3E-07 per m per year
- ▶ Pipeline leak (10% diameter) frequency: 2E-06 per m per year

In order for there to be a build-up of biogas indoors in the blower station of in the BNEF gas room, the leak detection and blocking system has to fail. This system has flammable gas sensors and is designed to stop gas supply when gas is detected at a fraction of the LEL (to be determined at detailed design stage). The purple book (Committee for Prevention of Disasters, 2005) states that the failure on demand of a blocking system, such as the one proposed, is 0.01 per demand. This will be applied to the 'release through a 10mm pipe scenario as a mitigation measure for a release in the blower station.

Table 6-24 details the events and corresponding frequencies that could lead to a confined VCE indoors in the blower station.

Table 6-25 details the events and corresponding frequencies that could lead to a confined VCE indoors in the BNEF gas room.

Table 6-24 Blower Station Biogas Release and VCE: Event Frequency

LOC scenario	LOC frequency		Modifier 1 (no. of items of equipment)	Modifier 2 (leak detection, gas supply shutoff, emergency ventilation)	Consequence	Event freq. (per year)
Equipment rupture in blower station	5E-06	/yr	3 No. compressors in gas room	1	VCE	1.5E-05
Equipment failure over 10 minutes in blower station	1E-05	/yr	3 No. compressors in gas room	1	VCE	3.0E-05
Release through 10mm pipe in blower station	5E-04	/yr	3 No. compressors in gas room	0.01	VCE	1.5E-05
Total						6.0E-05

Table 6-25 BNEF Gas Room Biogas Release and VCE: Event Frequency

LOC scenario	LOC frequency		Modifier 1 (no. of items of equipment)	Modifier 2 (leak detection, gas supply shutoff, emergency ventilation)	Consequence	Event freq. (per year)
Pipeline rupture in gas room, 75 mm diameter	3E-07	/m/yr	10 m of pipeline in gas room	1	VCE	3.0E-06
Pipeline leak in gas room, 0.1D, 75 mm diameter	2E-06	/m/yr	10 m of pipeline in gas room	1	VCE	2.0E-07
Total						3.2E-06

7. INDIVIDUAL RISK CONTOURS

Gexcon Riskcurves Version 13.0.2 modelling software is used to calculate the cumulative individual risk of fatality contours and the risk-based land-use planning zones for the proposed development. The model inputs are as follows:

- ▶ The consequences arising from major accident scenarios (Appendix C)
- ▶ Event frequencies (Table 6-9, Table 6-21, Table 6-24 and Table 6-25)
- ▶ Oak Park meteorological station wind speed and frequency data (see Section 4.5)
- ▶ Thermal radiation vulnerability relationships for persons outdoors and indoors described in Section 4.2
- ▶ Overpressure vulnerability relationships for persons outdoors (Hurst Nusey Pape Probit) and indoors (CIA Category 3 – see Section 4.3)
- ▶ Outdoor fatality levels of 100% are assumed inside the lower flammable limit (LFL) envelope, with 0% fatalities outside that envelope. Indoor fatality levels are conservatively assumed to be 10% within the flash fire envelope
- ▶ The HSA TLUP guidance document (HSA, 2023) specifies D5 conditions for 80% of the time, with F2 occurring for the remaining 20%.
- ▶ The HSA TLUP guidance document (HSA, 2023) states that persons are assumed to be indoors 90% of the time and outdoors 10% of the time.
- ▶ Below ground pipeline rupture/leak – fraction vertical direction of 1.
- ▶ Above ground pipeline rupture/leak – fraction vertical direction of 0.5 and horizontal direction 0.5.

Figure 7-1 illustrates individual risk of fatality contours corresponding to tolerability levels for new COMAH establishments based on a hypothetical residential population indoors in buildings of CIA Category 3 overpressure vulnerability (typical residential dwelling) for 90% of the time and outdoors for 10% of the time. Figure 7-2 illustrates individual risk of fatality contours corresponding to the boundaries of COMAH land use planning zones as described in Section 3. Figure 7-3 illustrates the proposed Consultation Distance for the proposed development.

Figure 7-1 Individual Location-based Risk Contours for New Establishments

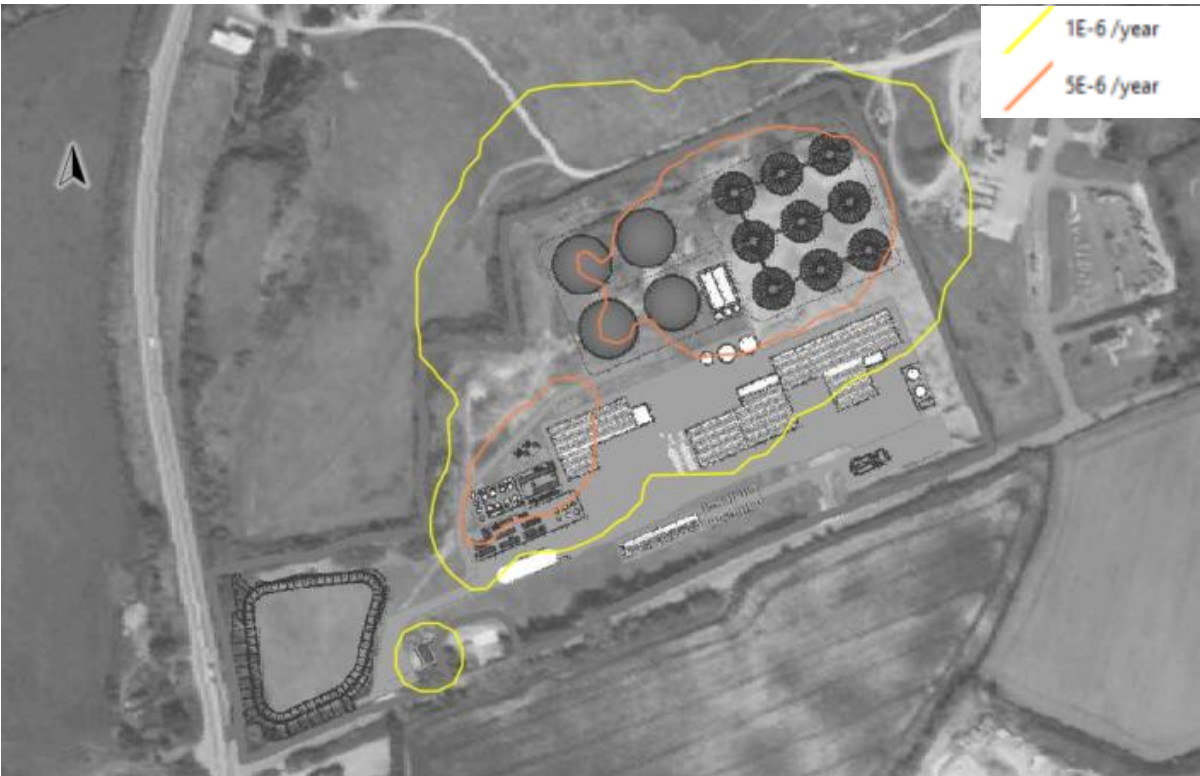


Figure 7-2 Individual Risk Based Land Use Planning Contours

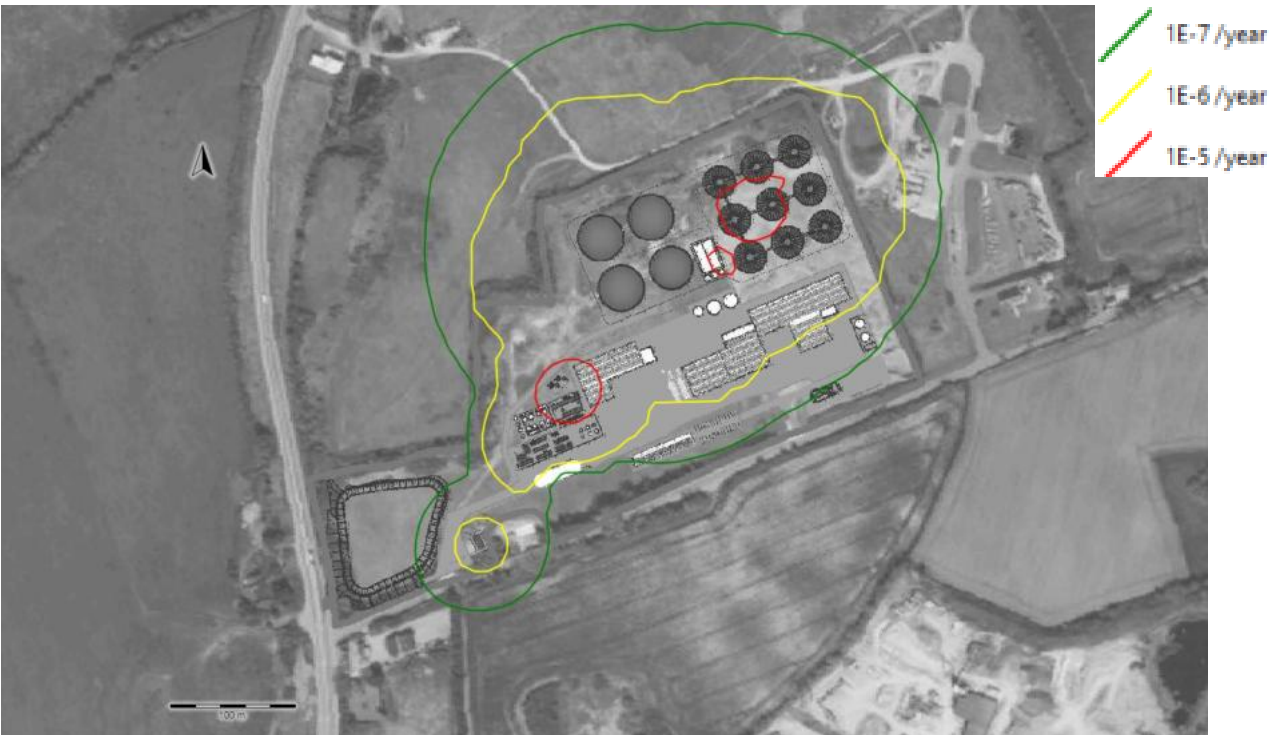
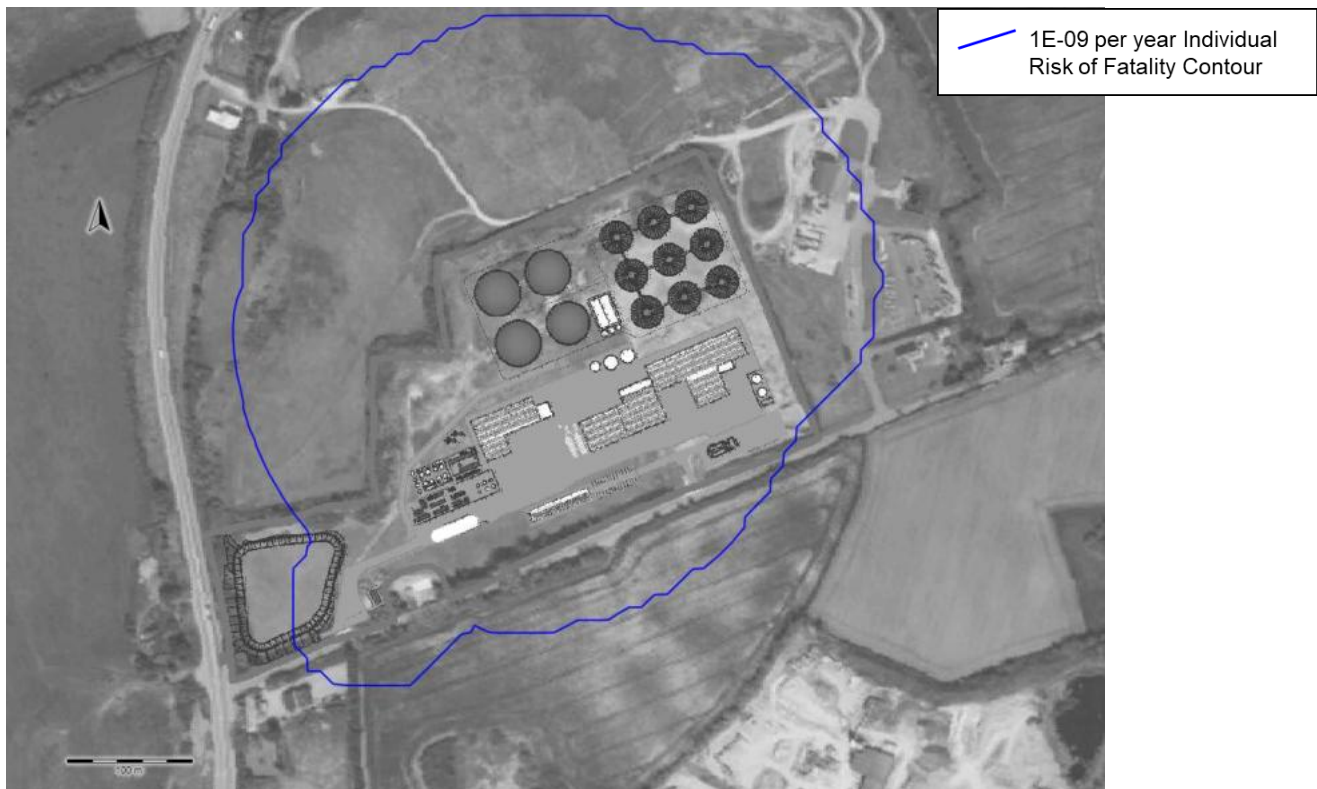


Figure 7-3 Proposed Consultation Distance (1×10^{-9} per year Individual Risk of Fatality Contour)



The individual location-based risk contours corresponding to tolerable levels for new COMAH establishments do not extend to an off-site work location and the 1×10^{-6} per year risk contour extends to the property east of the BNEF container where the public are present. On grant of planning permission an agreement is in place whereby Greengate Biogas will acquire the site as a vacant property for future commercial use. Any future use will comply with the HSA's land use matrix in Table 3-1 in Section 3.2. Therefore, it is concluded that the criteria in Table 1 of the *Guidance on Technical Land Use Planning advice (HSA, 2023)* are met, and level of off-site risk at the proposed development is acceptable.

8. SOCIETAL RISK ASSESSMENT

The purpose of this societal risk study is to generate advice on the types/nature and scale of development that is likely to be acceptable to the HSA.

The Expectation Value (EV) is the average number of persons receiving a specified level of harm. Hirst and Carter (Hirst et al., 2000) shows that:

$$EV = F \times N$$

Where F is the cumulative frequency of all events leading to N fatalities

No major accident scenarios were identified at the proposed development that would result in off site fatalities. Therefore the EV is 0 and further risk reduction is not required.

9. CONCLUSION

AWN Consulting, a Trinity Consultants Team, has been commissioned by Greengate Biogas to complete a COMAH land use planning assessment in respect of Powerstown Bioenergy project at Powerstown, Co. Carlow.

The proposed development will be classified as a "lower tier" COMAH establishment and as such will be subject to the provisions of the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015.

The Land Use Planning assessment was completed in accordance with guidance published by the HSA (HSA, 2023). The following major accident scenarios were assessed:

Table 9-1 Summary of Major Accident Scenarios

Installation	Loss Of Containment scenario	Consequence/Event	Reference
Vessels containing biogas: Primary digesters, secondary digesters, tertiary digester, post digestion liquid digestate storage tank, digestate storage tank, liquid pre-storage tank and pasteurisation tanks	Instantaneous failure	Fireball	Table 34, HSA TLUP Guidance Document, HSA, 2023
		VCE	
		Flash fire	
	Continuous leak over 10 minutes	Jet fire	
		VCE	
		Flash fire	
Untreated biogas and treated biogas pipelines	Rupture of Pipeline	Fireball/Jet fire	Table 40/41 and Table 42, HSA TLUP Guidance Document, HSA, 2023
		VCE	
		Flash fire	
	Pipeline Leak of 0.1D	Fireball/Jet fire	
		VCE	
		Flash fire	
Indoor equipment: Blowers at blower station (in biogas upgrade building)	Instantaneous release	VCE	Table 64, HSA TLUP Guidance Document, HSA, 2023
	Release over 10 minutes	VCE	
	Release through 10 mm pipe	VCE	
Indoor equipment: pipework in BNEF	Rupture of Pipeline	VCE	Table 40 and Table 42, HSA TLUP Guidance Document, HSA, 2023
	Pipeline Leak of 0.1D	VCE	

Figure 9-1 illustrates individual risk of fatality contours corresponding to tolerability levels for new COMAH establishments based on a hypothetical residential population indoors in buildings of CIA Category 3 overpressure vulnerability (typical residential dwelling) for 90% of the time and outdoors for 10% of the time.

Figure 9-2 illustrates individual risk of fatality contours corresponding to the boundaries of COMAH land use planning zones.

Figure 9-3 illustrates the proposed Consultation Distance for the proposed development.

Figure 9-1 Individual Location-based Risk Contours for New Establishments

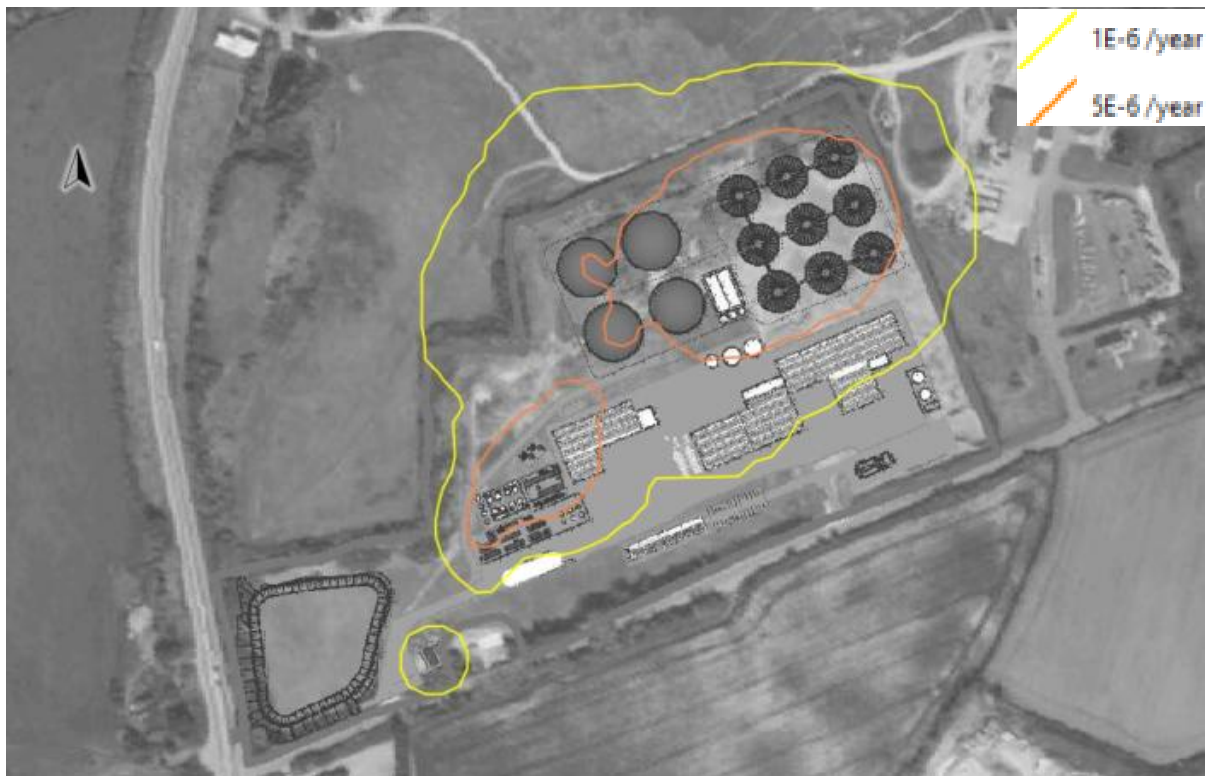
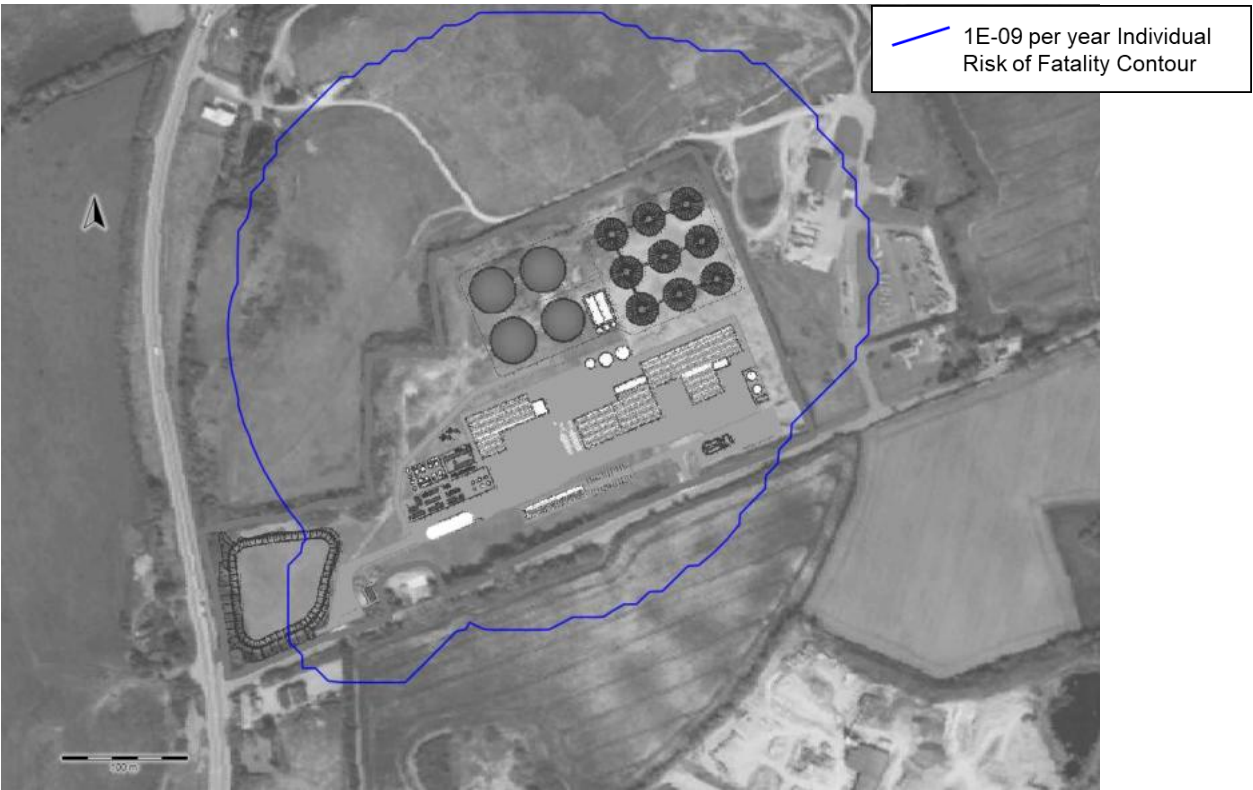


Figure 9-2 Individual Risk Based Land Use Planning Contours



Figure 9-3 Proposed Consultation Distance (1×10^{-9} per year Individual Risk of Fatality Contour)



It is concluded that the individual location-based risk contours corresponding to the tolerable levels for new COMAH establishments do not extend to any off-site work location and the 1×10^{-6} per year risk contour extends to the property east of the BNEF container where the public are present. On grant of planning permission an agreement is in place whereby Greengate Biogas will acquire the site as a vacant property for future commercial use. Any future use will comply with the HSA's land use matrix in Table 3-1 in Section 3.2. The criteria in Table 1 of the HSA's *Guidance on Technical Land Use Planning advice* (HSA, 2023) are therefore met, and the level of off-site risk at the proposed development is acceptable.

No major accident scenarios were identified that would result in off-site fatalities. The societal risk Expectation Value (EV) is therefore 0, which is below the developmental threshold of 100 above which further risk reduction would need to be demonstrated. Accordingly, no further risk reduction is required.

10. REFERENCES

BSI (1987) BS 8007 Code of Practice for design of concrete structures for retaining aqueous liquids

Centre for Chemical Process Safety (CCPS) (2000), Guidelines for Chemical Process Quantitative Risk Analysis, 2nd Edition, AIChE

Chemical Industries Association (CIA) (2020), Guidance for the location and design of occupied buildings on chemical manufacturing and similar major accident sites, 4th Edition

CIRIA (2014), CIRIA C736 Containment systems for the prevention of pollution. Secondary, tertiary and other measures for industrial and commercial premises

Committee for Prevention of Disasters (2005), Guidelines for Quantitative Risk Assessment, CPR 18E, Second Edition, The Hague ("Purple Book")

CONCAWE (1996), Gas Oils (diesel fuels/heating oils) Product Dossier 95/107, Brussels

DNV, PHAST Supporting Documentation, DNV Phast Version 9.1 Technical Documentation, 2024

Environmental Protection Agency (EPA) (2004), Guidance to Storage and Transfer of Materials for Scheduled Activities

Environmental Protection Agency (EPA) (2019), A Guidance on Retention Requirements for Firewater Run-off . s.l. :

https://www.epa.ie/publications/licensing--permitting/industrial/ied/EPA_Guidance_Retention_Firewater_Runoff.pdf

Health and Safety Authority (HSA) (2017) Guidance to Inspectors on the Assessment of Safety Reports under the COMAH Regulations 2015

Health and Safety Authority (HSA) (2023) Guidance on Technical Land-Use Planning Advice, for planning authorities and COMAH establishment operators

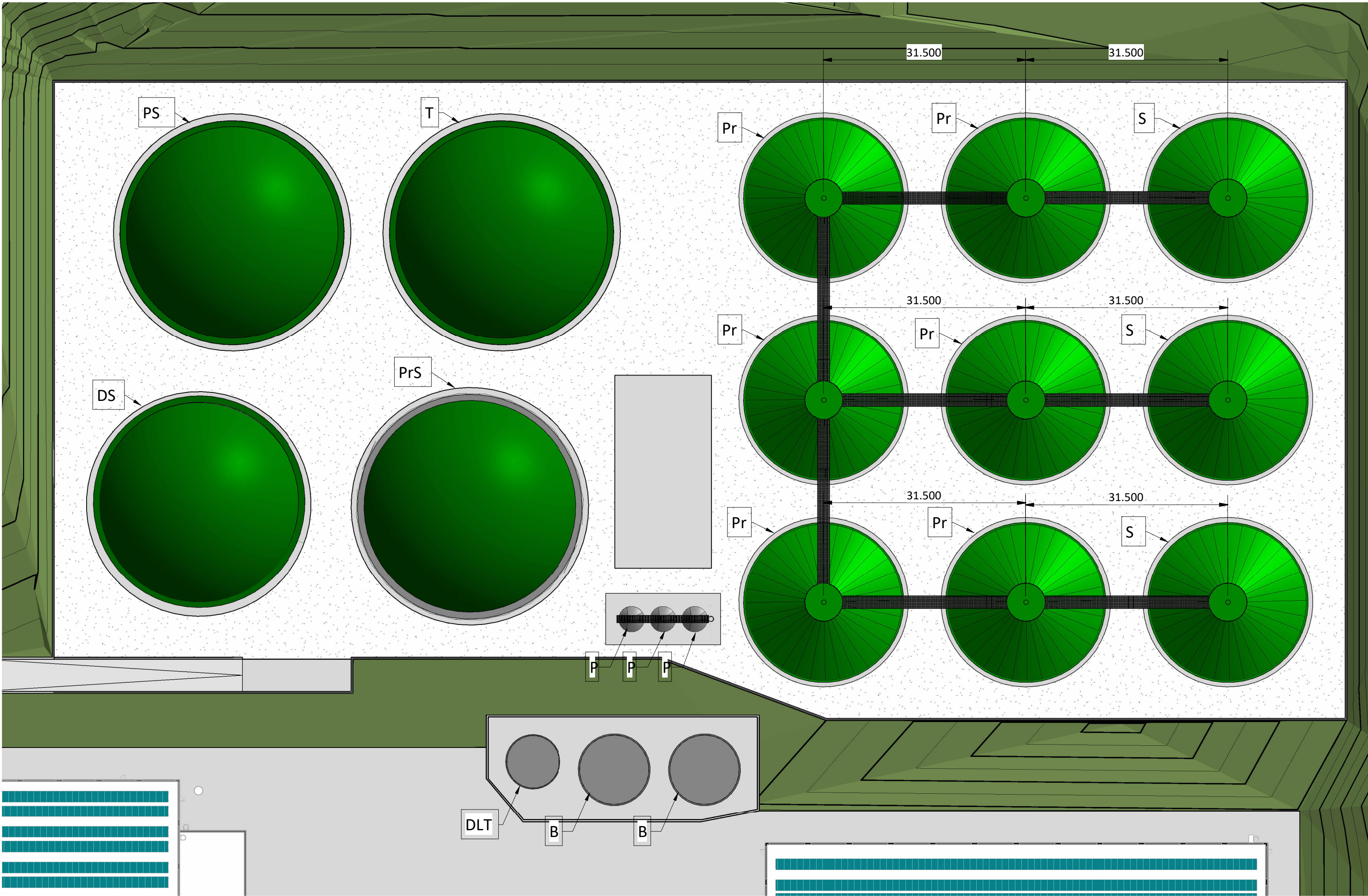
APPENDIX A. DRAWINGS

List of drawings

P24188-FT-XX-XX-DR-CE-1725	Tank Farm Layout - Plan
P24188-FT-XX-XX-DR-CE-1726	Tank Farm Layout - Primary Digestion Tanks Details and Elevations
P24188-FT-XX-XX-DR-CE-1727	Tank Farm Layout - Post Digestion Digestate Storage Tanks Details and Elevations
P24188-FT-XX-XX-DR-CE-1728	Tank Farm Layout - Tertiary Digestion Tanks Details and Elevations
P24188-FT-XX-XX-DR-CE-1729	Pastuerisation Tanks
P24188-FT-XX-XX-DR-CE-1730	Process & Fire Water Storage Tanks - Plans and Elevations
P24188-FT-XX-XX-DR-CE-1735	Gas Flaring Compound Plans Elevations and Details
P24188-FT-XX-XX-DR-CE-1740	Administration Building Plans
P24188-FT-XX-XX-DR-CE-1741	Administration Building Elevations
P24188-FT-XX-XX-DR-CE-1742	Administration Building Sections
P24188-FT-XX-XX-DR-CE-1745	Heating Centre Plans
P24188-FT-XX-XX-DR-CE-1746	Heating Centre Elevations Sheet 1 of 2
P24188-FT-XX-XX-DR-CE-1747	Heating Centre Elevations Sheet 2 of 2
P24188-FT-XX-XX-DR-CE-1748	Heating Centre Sections and Details
P24188-FT-XX-XX-DR-CE-1750	Gas Upgrade Plant - Plan
P24188-FT-XX-XX-DR-CE-1751	Gas Upgrade Plant - Elevations, Sections and Details
P24188-FT-XX-XX-DR-CE-1752	Gas Upgrade Plant - Elevations, Sections and Details
P24188-FT-XX-XX-DR-CE-1755	CO2 Liquefaction Plant: Typical Plan and Elevations
1760s	
P24188-FT-XX-XX-DR-CE-1760	Desulphurisation Plant: Typical Plan and Elevations

APPENDIX B. BIOGAS INVENTORY CALCULATIONS

- Raw biogas tank volume calculations
- Untreated (raw) biogas and upgraded biogas (renewable natural gas, RNG) mass inventory calculations



PROPOSED TANK FARM
Scale 1 : 500

Notes:

Drawings for Planning Purposes Only.

Subject to Detailed Mechanical, Electrical and Process Design.

Process pipework omitted for clarity

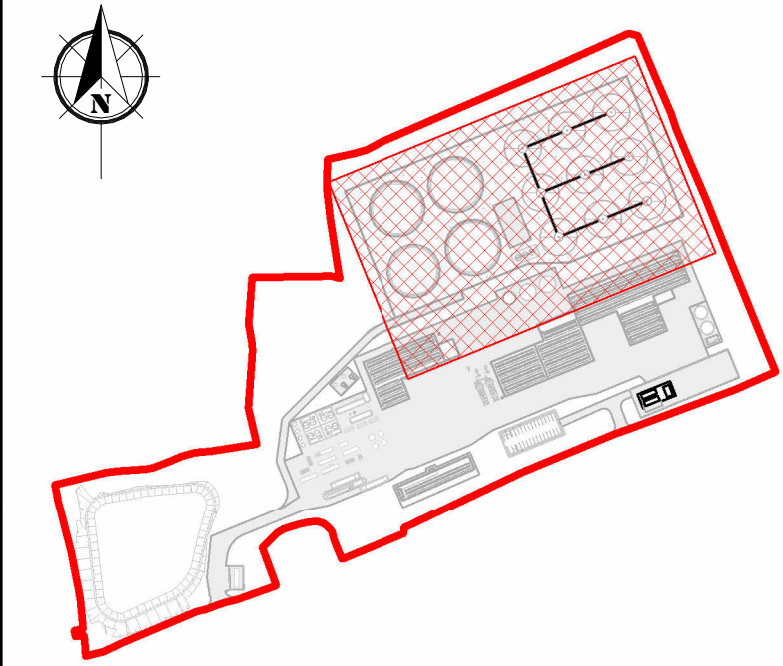
Tank Farm Bund to be designed and constructed in accordance with the requirements of

IPC Guidance Note on Storage and Transfer of Materials for Scheduled Activities (EPA, 2004)

BS 8007 Code of practice for design of concrete structures for retaining aqueous liquids (BSI, 1987)

CIRIA C736 Containment systems for the prevention of pollution (CIRIA, 2014)

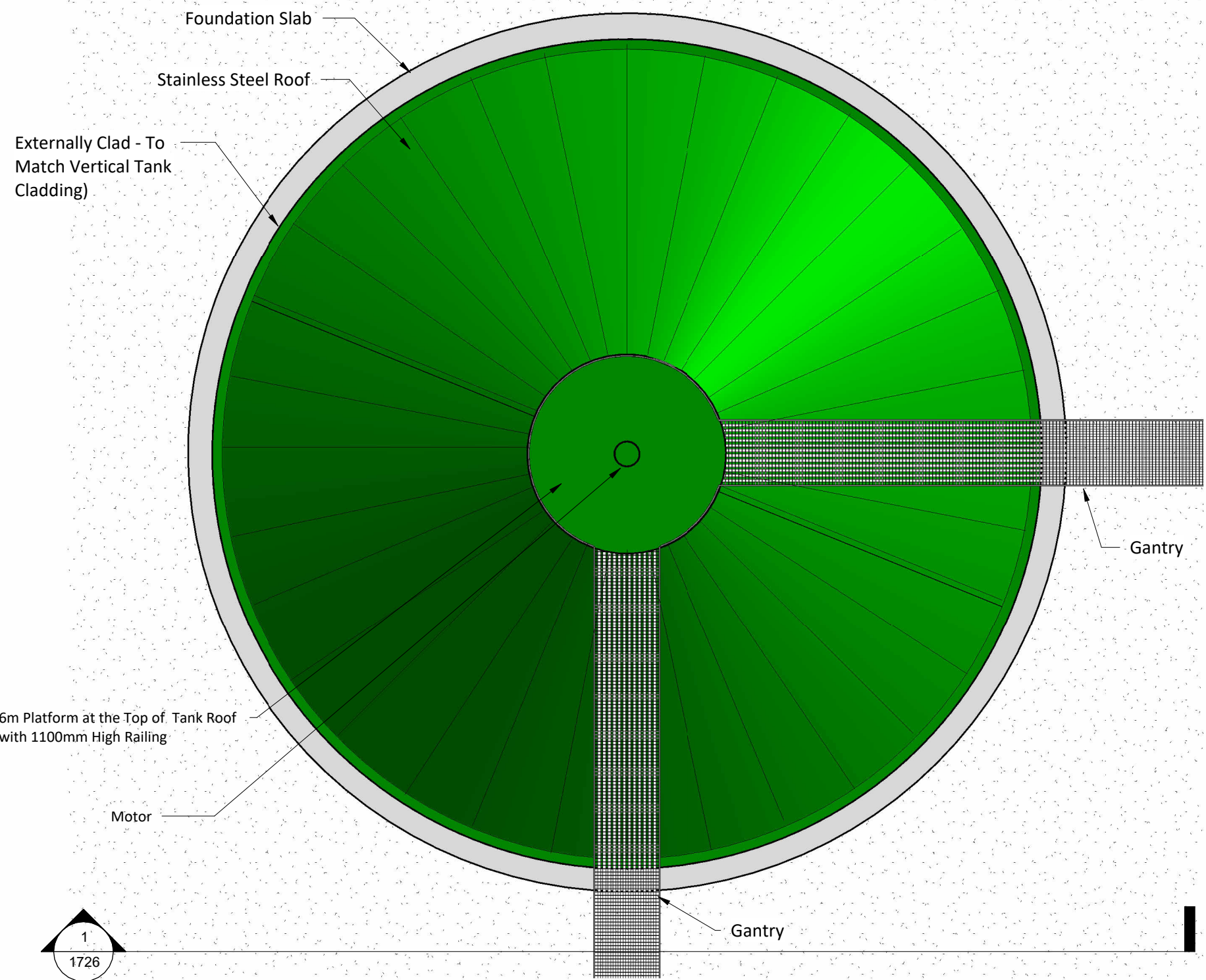
Tank Farm Schedule					
Ref.	Tank Type	Dia (m)	Volume (m³)	No. Of	Dwg Ref.
Pr	Primary Digester	23.9	10,408	6	P24188-FT-XX-XX-DR-CE-1726
S	Secondary Digester	23.9	10,408	3	P24188-FT-XX-XX-DR-CE-1726
PS	Post Storage Tank	35	12,026	1	P24188-FT-XX-XX-DR-CE-1728
T	Tertiary Digester	33	7,356	1	P24188-FT-XX-XX-DR-CE-1728
PrS	Liquid Pre Storage Tank	35	12,026	1	P24188-FT-XX-XX-DR-CE-1728
DS	Digestate Storage	35	8,274	1	P24188-FT-XX-XX-DR-CE-1727
P	Pastuerisation	5	183	3	P24188-FT-XX-XX-DR-CE-1729
B	Buffer Storage	11	500	2	P24188-FT-XX-XX-DR-CE-1731
DLT	Digestate Storage Load-In	8	150	1	P24188-FT-XX-XX-DR-CE-1731



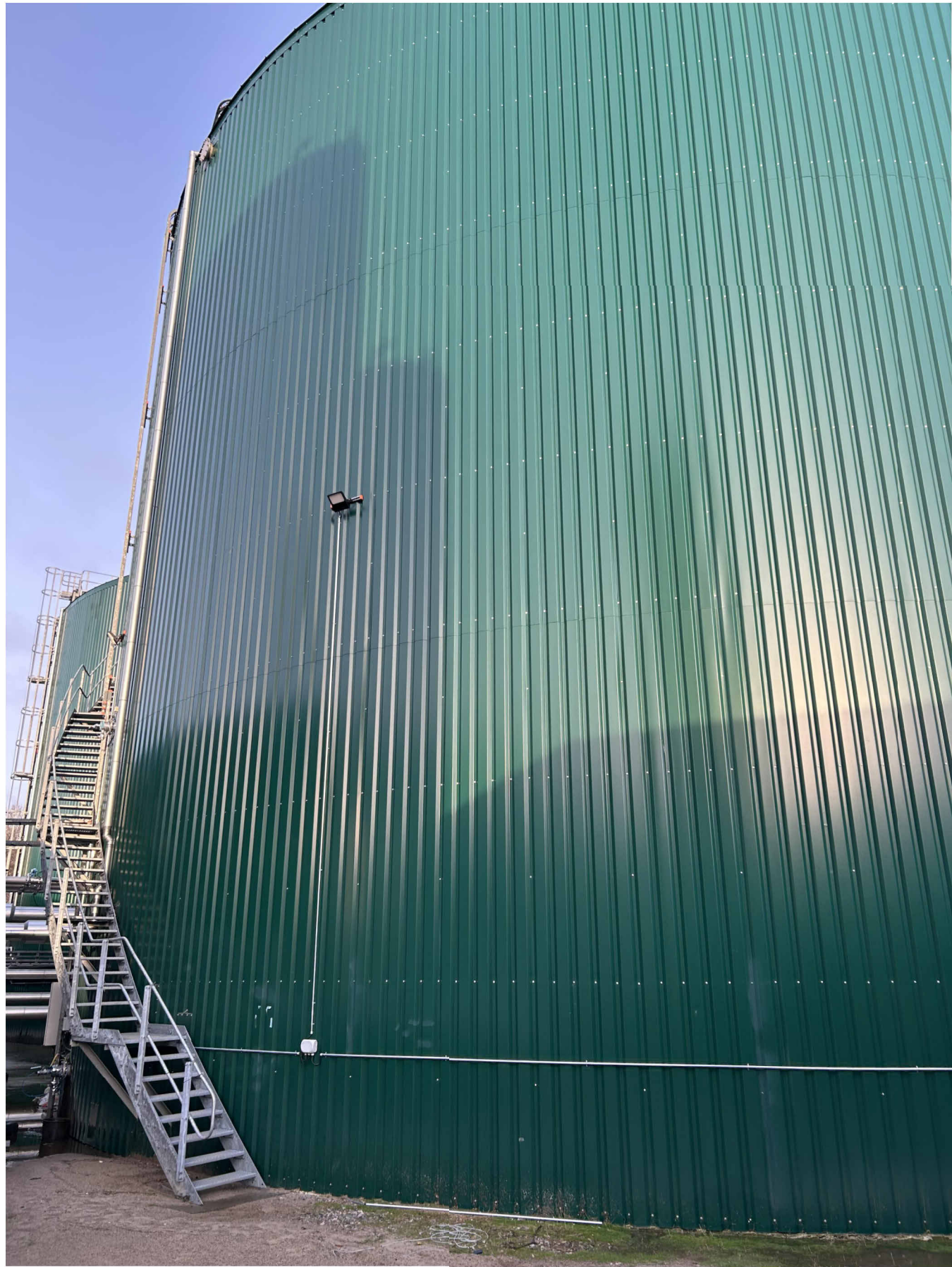
KEYPLAN
Scale 1 : 5000

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

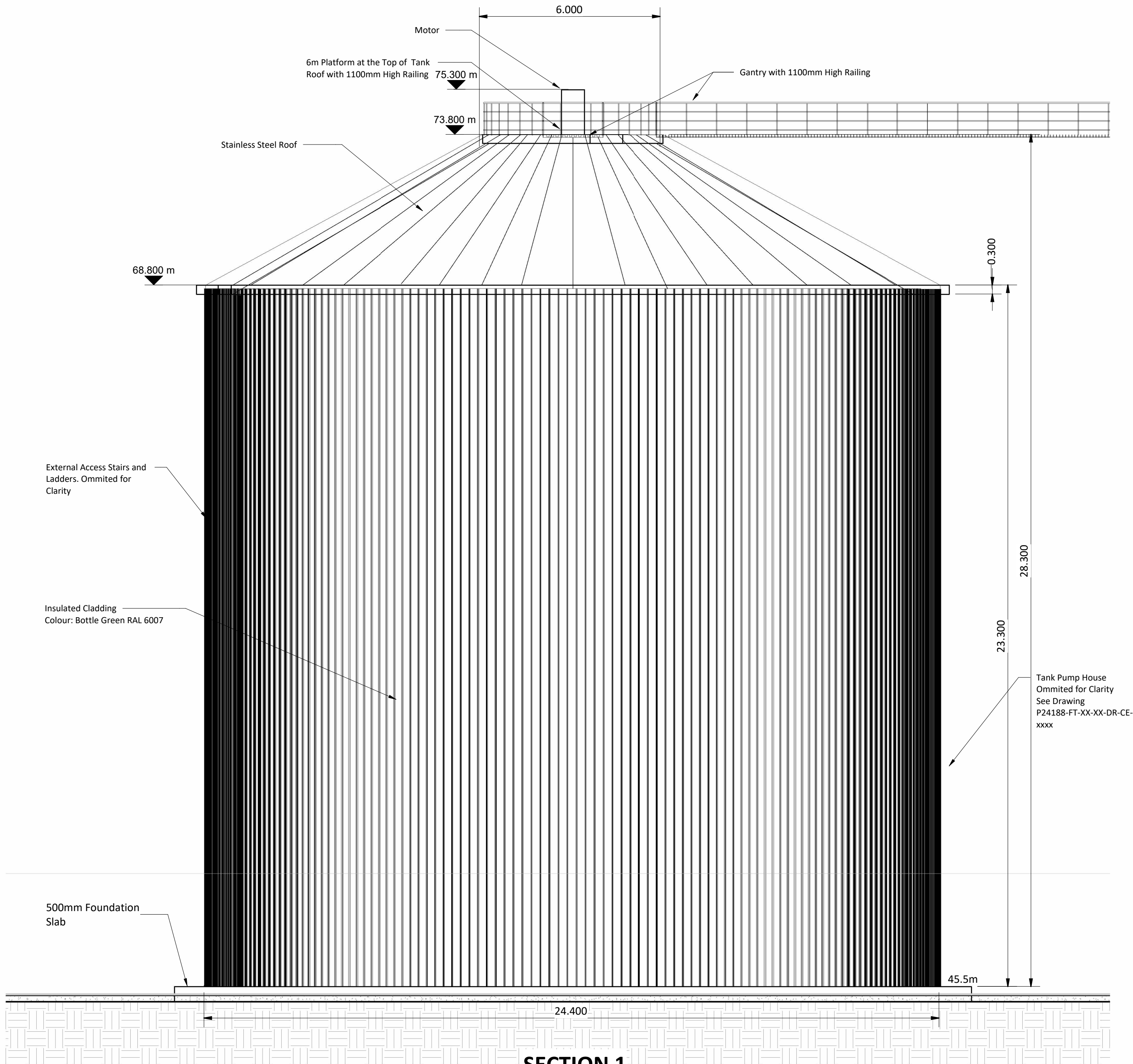
PROJECT		CLIENT					
POWERSTOWN BIOENERGY							
SHEET	TANK FARM LAYOUT - PLAN	Date	22.06.26	Project Number	P24188	Scale (at A1)	As indicated
		Drawn by	NW	Drawing Number			Rev
		Checked by	JON	P24188-FT-XX-XX-DR-CE-1725			P01



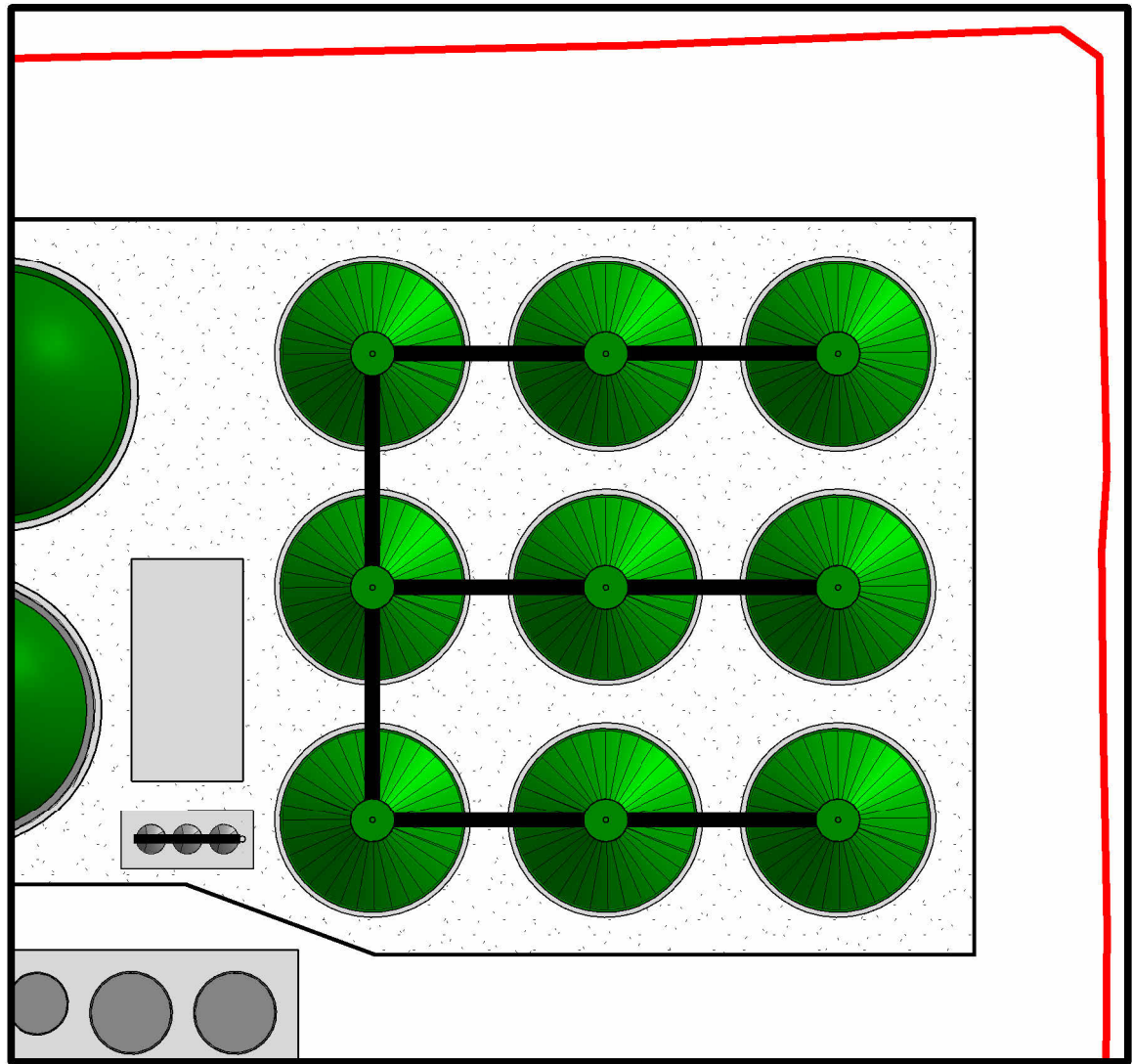
PRIMARY AND SECONDARY DIGESTION TANK - PLAN
Scale 1 : 150



PRIMARY DIGESTOR (N.T.S.)



SECTION 1
Scale 1 : 100



PRIMARY AND SECONDARY DIGESTION TANKS
Scale 1 : 1000

Notes:
Drawings for Planning Purposes Only.
Subject to Detailed Mechanical, Electrical and
Process Design.

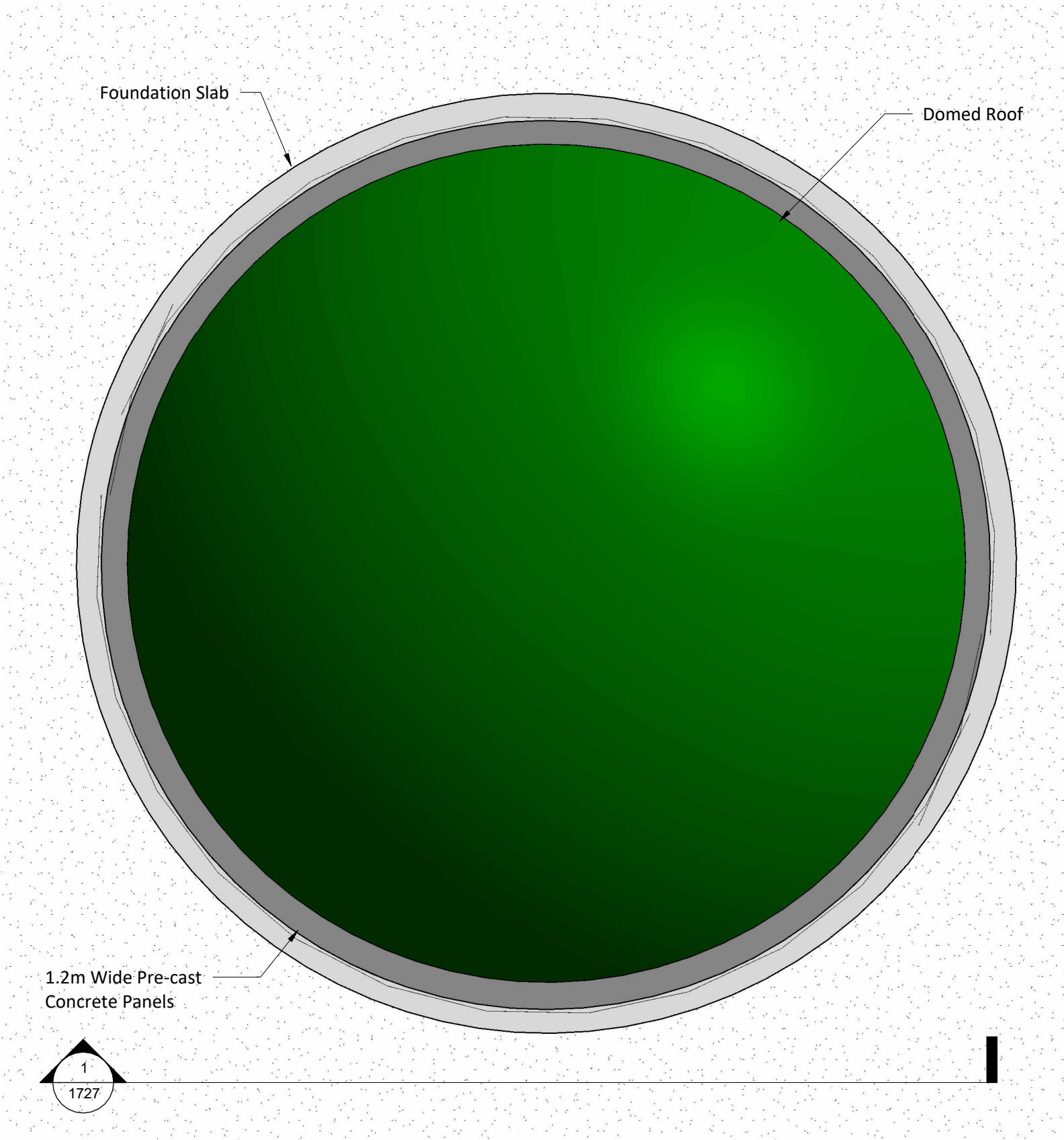
Rev.	Description	App By	Date
A	ISSUE FOR PLANNING	JON	22.06.26

PROJECT	CLIENT			
SHEET	POWERSTOWN BIOENERGY			
	Greengate Biogas			
	Date	TBC	Project Number	Scale (at A1)
	Drawn by	NW	Drawing Number	Rev
Checked by		JON	P24188-FT-XX-XX-DR-CE-1726	A

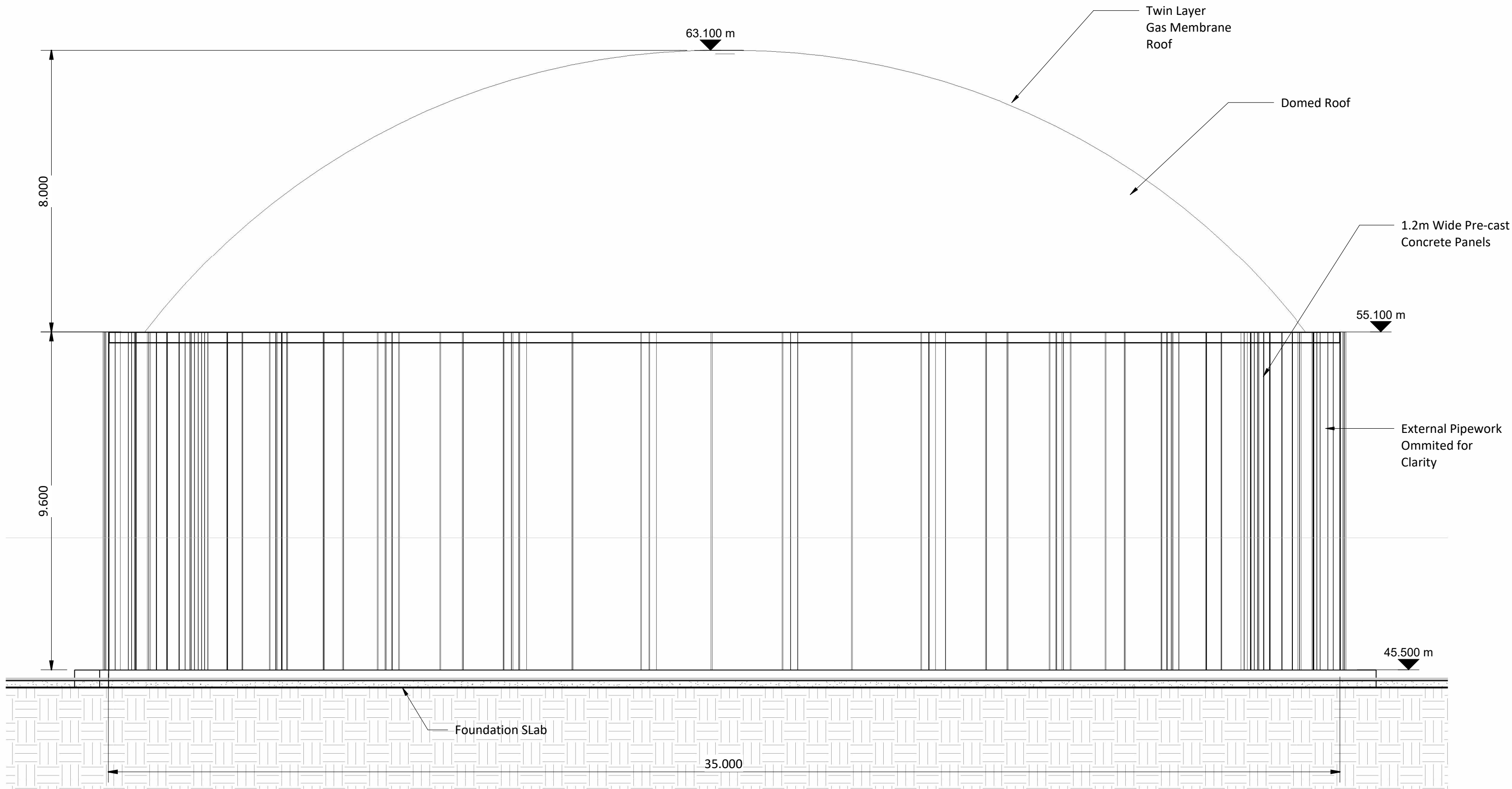
Notes:
Drawings for Planning Purposes Only.
Subject to Detailed Mechanical, Electrical and Process Design.



POST DIGESTION DIGESTATE STORAGE TANK (N.T.S)



POST DIGESTION DIGESTATE STORAGE TANK PLAN
Scale 1 : 200



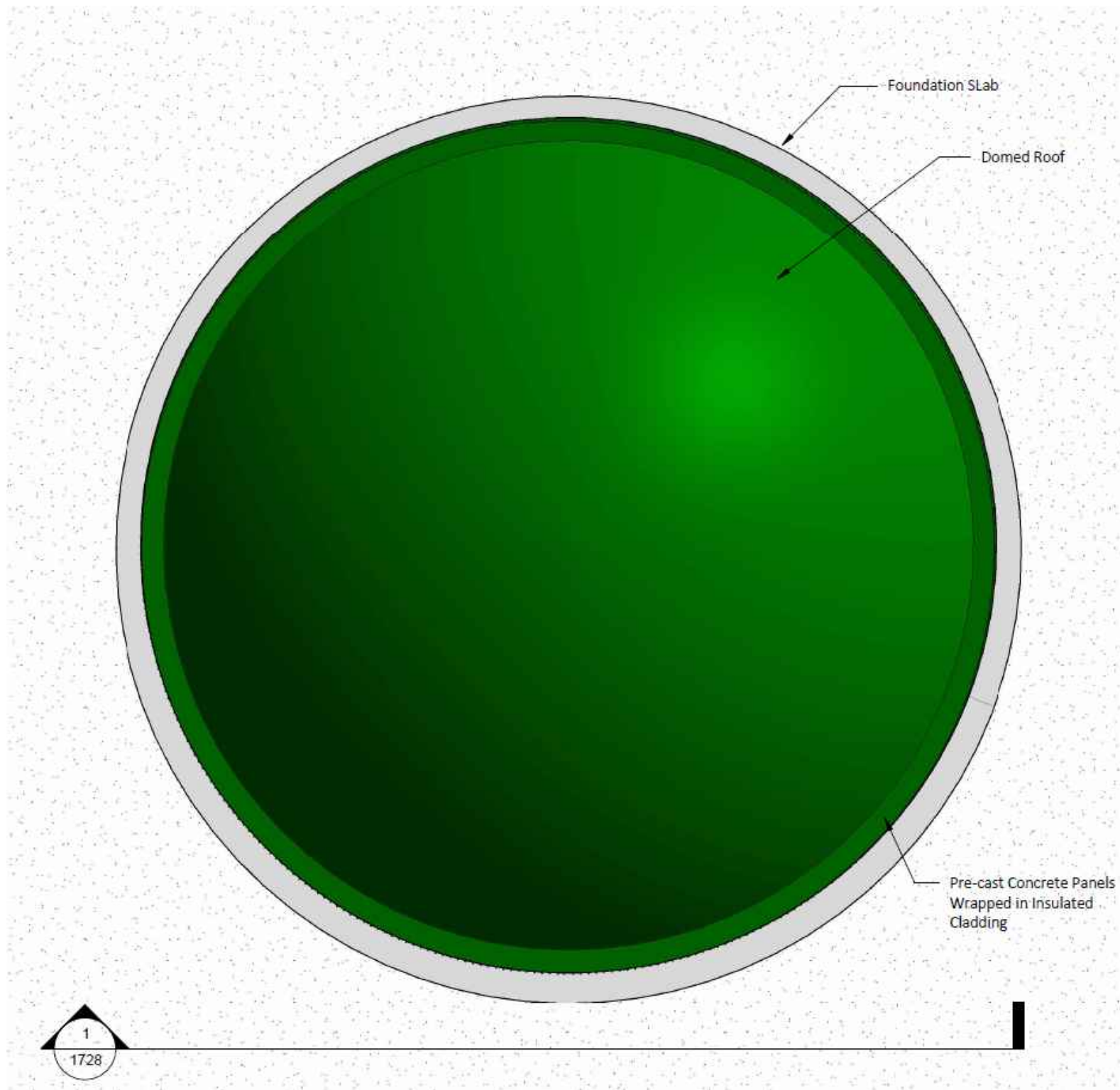
SECTION 1
Scale 1 : 100

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

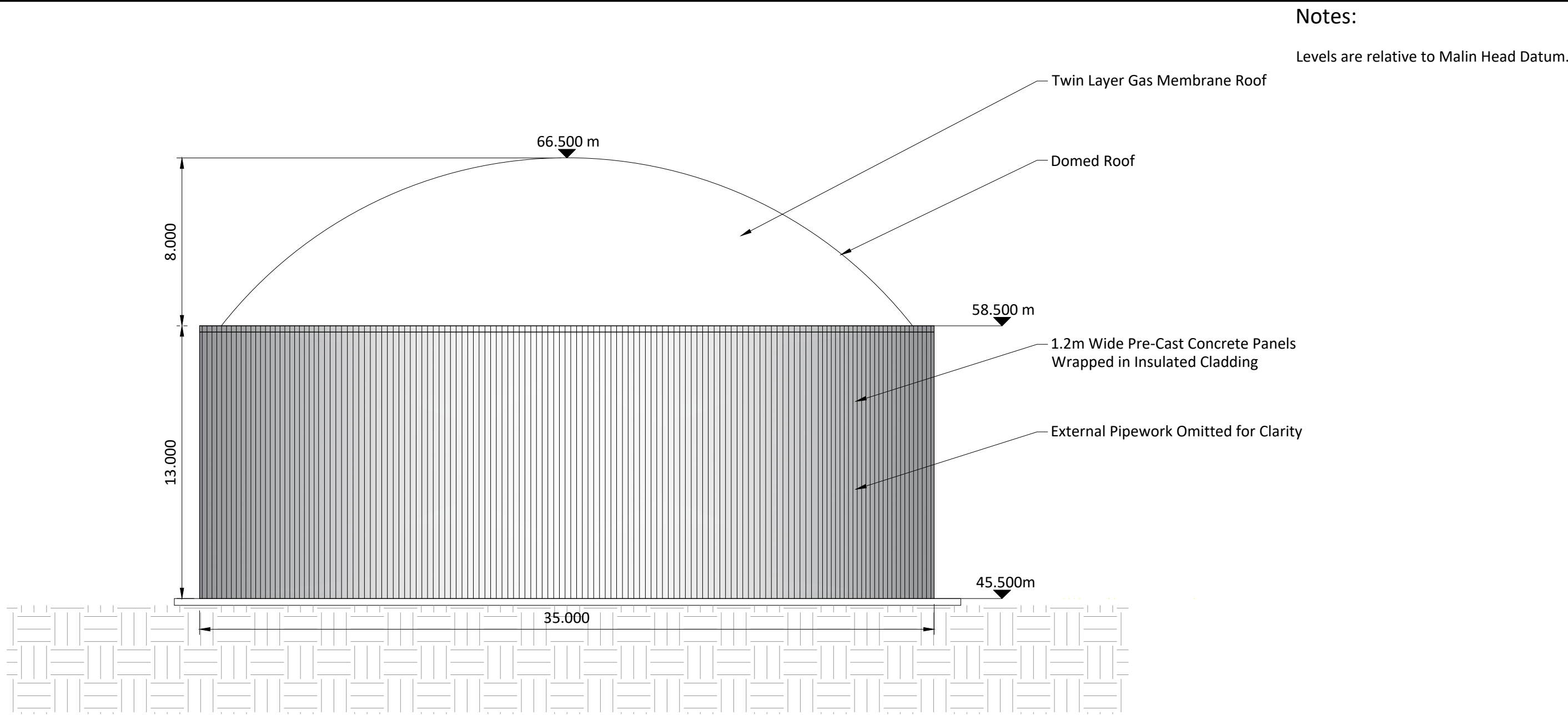
PROJECT	CLIENT			
SHEET	POWERSTOWN BIOENERGY			
				
	Date	18.06.26	Project Number	P24188
	Drawn by	NW	Drawing Number	P24188-FT-XX-XX-DR-CE-1727
Checked by		JON	Scale (at A1) As indicated	Rev P01



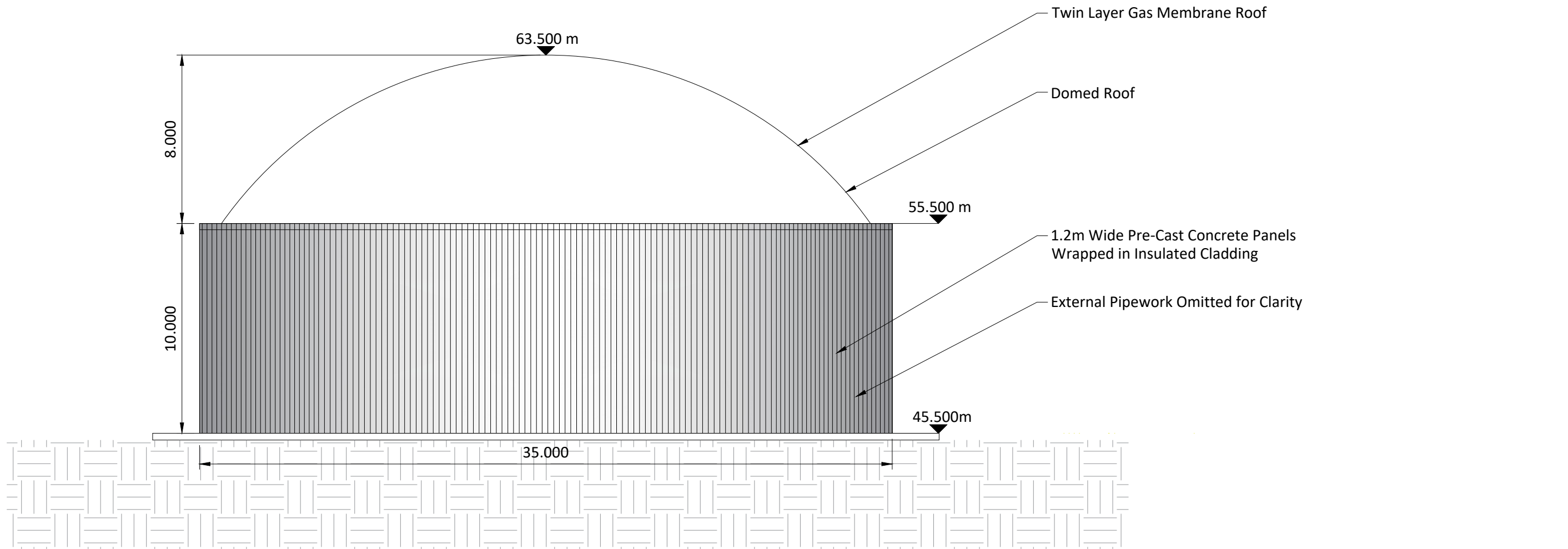
POST STORAGE, LIQUID PRE STORAGE AND TERTIARY DIGESTIONS TANKS
(N.T.S)



POST STORAGE, LIQUID PRESTORAGE AND TERTIARY DIGESTION TANKS: TYPICAL PLAN
(N.T.S)



POST STORAGE AND
LIQUID PRE STORAGE ELEVATION
Scale: 1:200

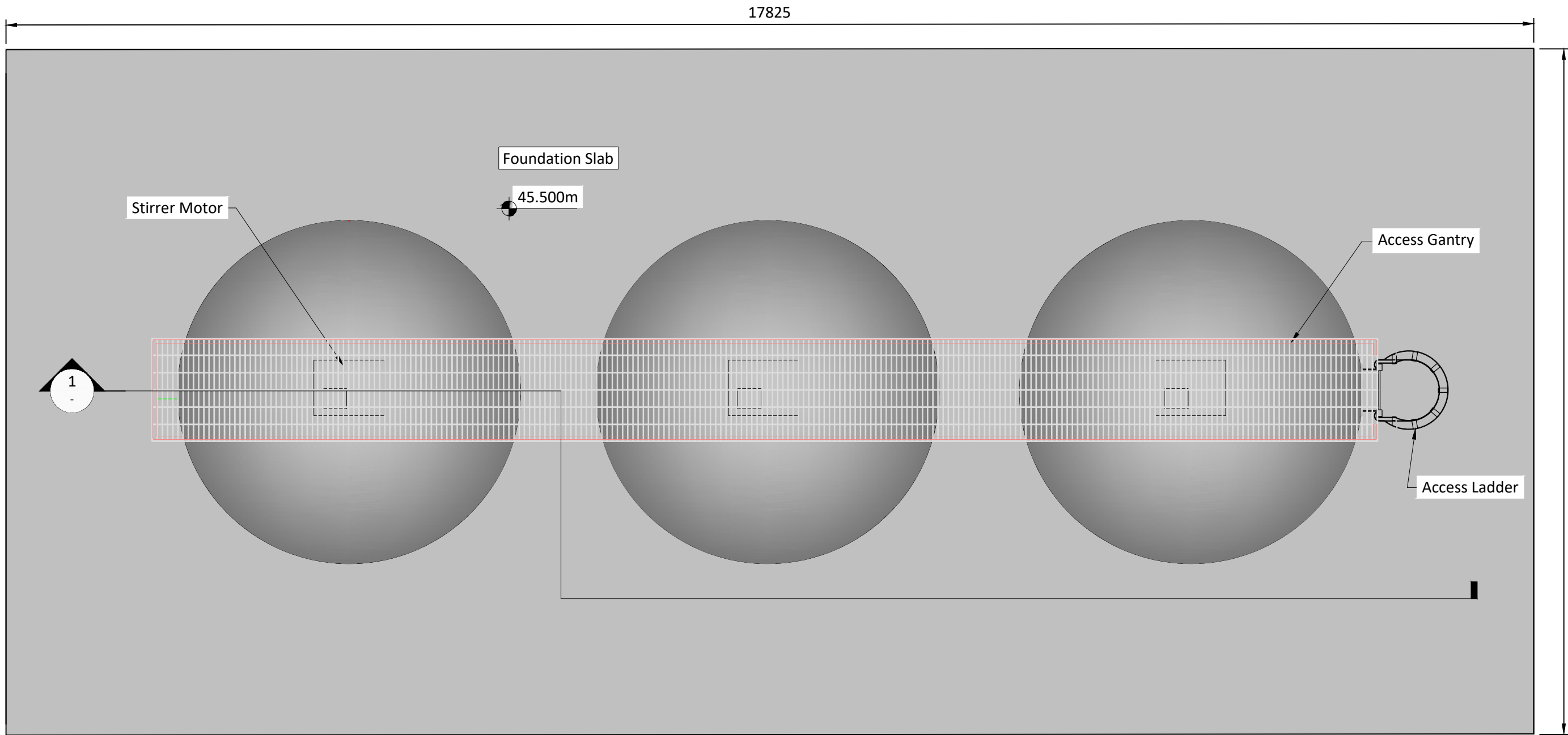


TERTIARY DIGESTION TANK ELEVATION
Scale: 1:200

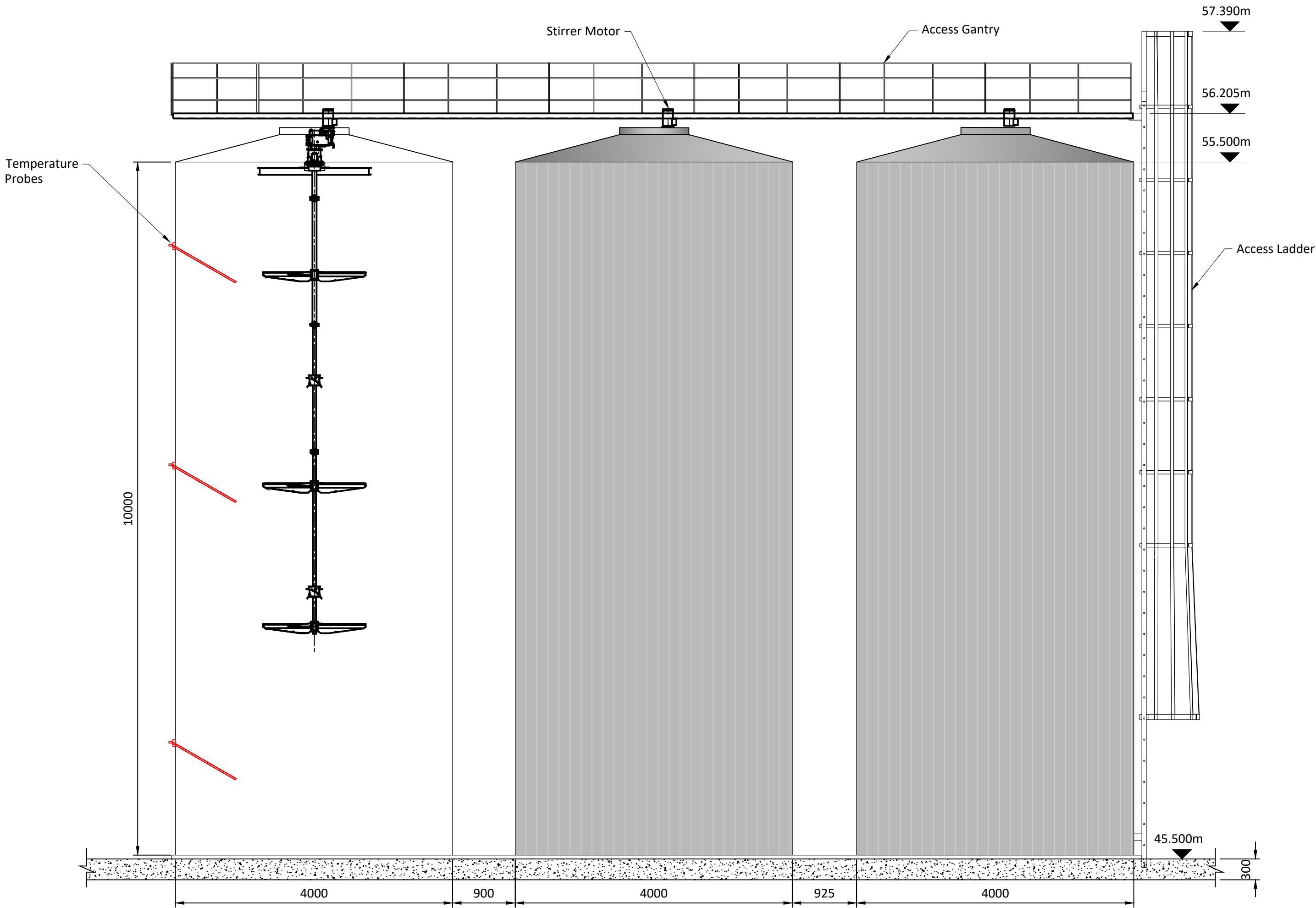
If Applicable : Tailte Éireann Licence No. CYAL50368274 © Ordnance Survey Ireland and Government of Ireland

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT	CLIENT			
SHEET	POWERSTOWN BIOENERGY			
	Date	19.06.26	Project number	P24-188
	Drawn by	NW	Drawing Number	P24188-FT-XX-XX-DR-CE-1728
	Checked by	JON	Scale (@ A1)	1:200
			Rev	P01



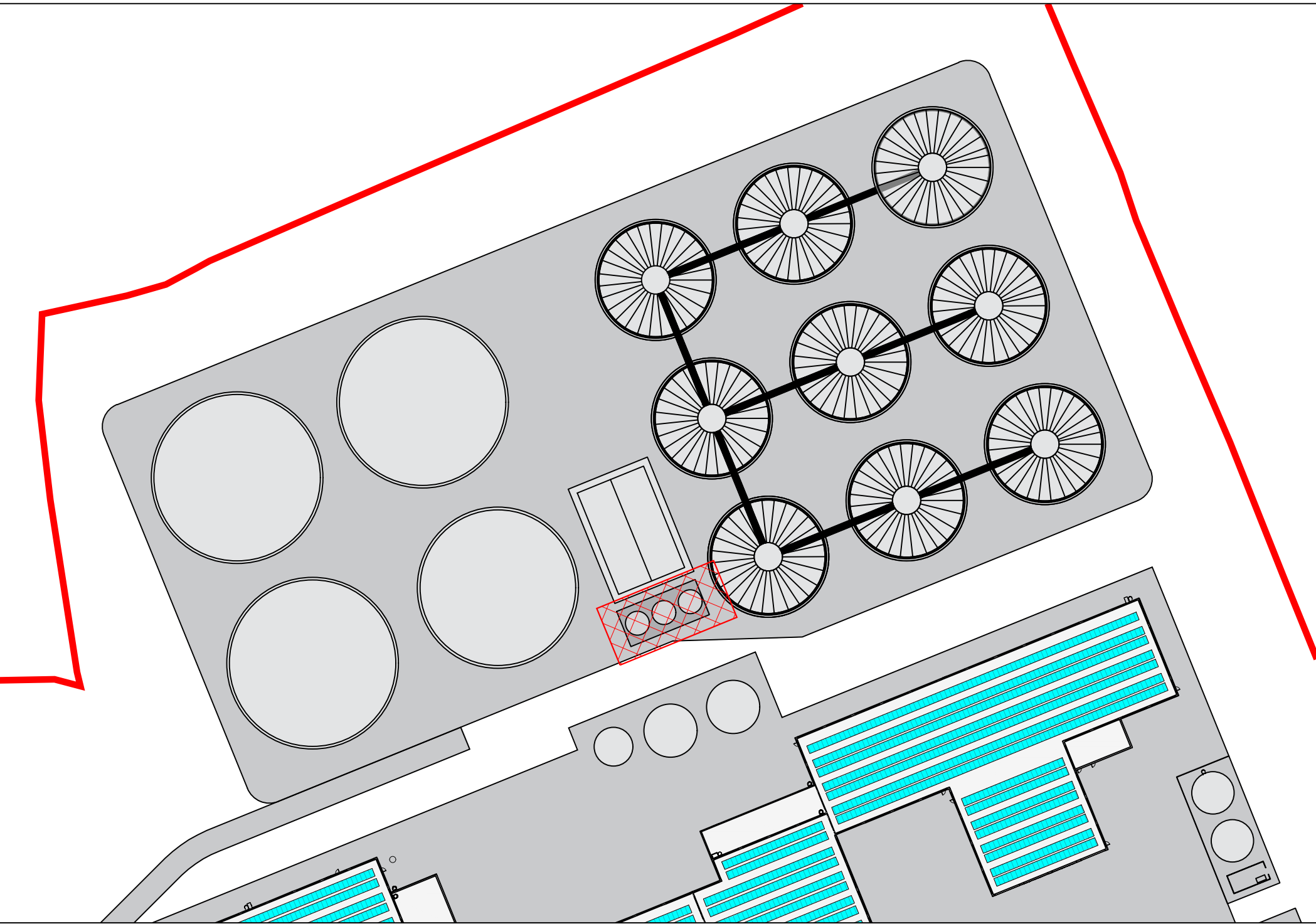
PASTEURISATION TANK LAYOUT
Scale 1:50



TANK ELEVATION
Scale 1:50



TYPICAL PASTEURISATION TANKS (N.T.S.)
(FOREGROUND)



KEYPLAN
Scale 1:2500

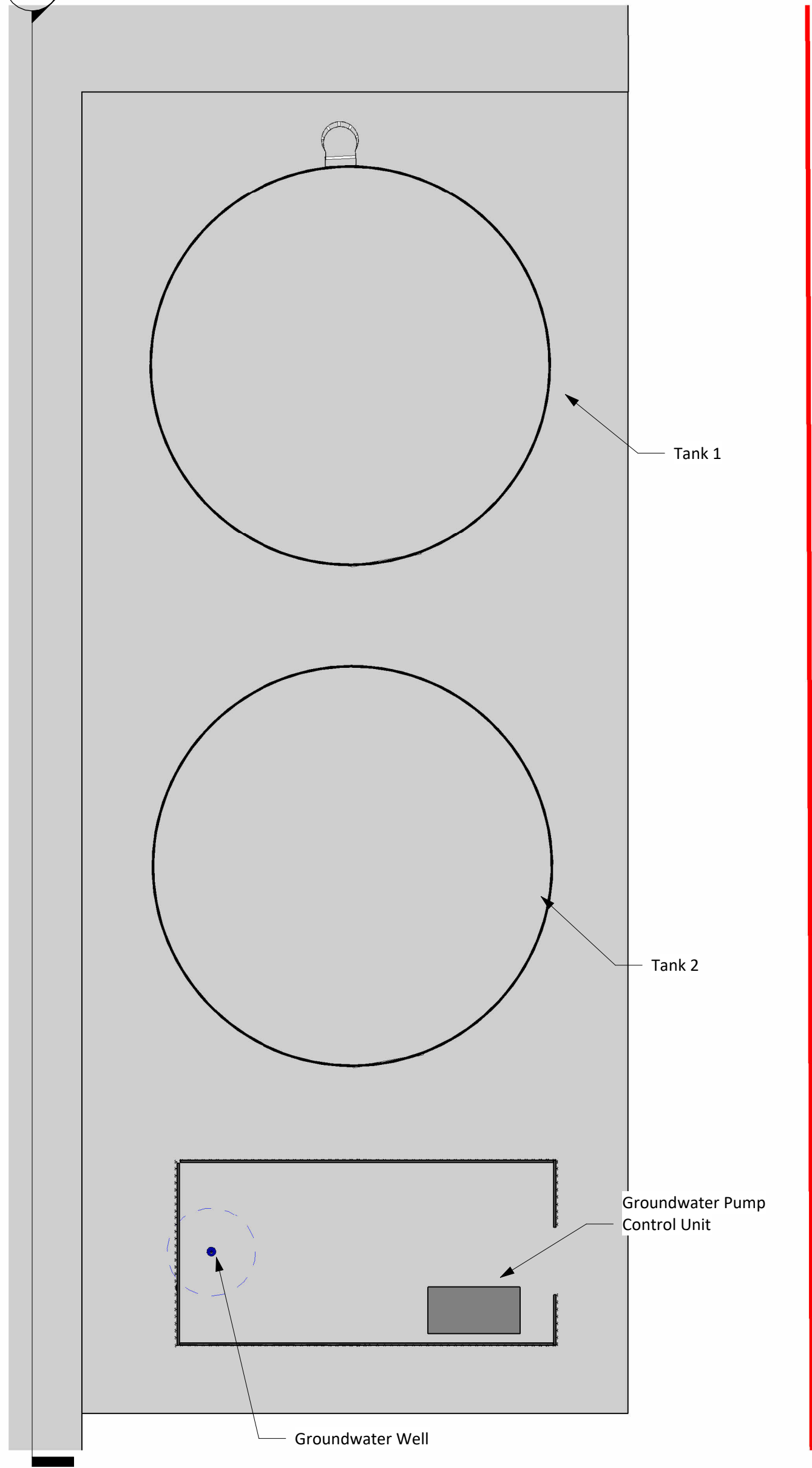
Legend
Planning Boundary

Notes:
Drawings for Planning Purposes Only.
Pasteurisation Tanks to be Externally Insulated.
Internal Mechanism Shown for Illustrative Purposes Only.
Minimum 3No. Temperature Probes to be Provided.
Pasteurisation to Operate on Batch Process -> Fill - Heat - Empty.
Min 70°C - 60 minutes.
Process Subject to Automatic SCADA Control.
Photographs for Illustrative Purposes Only.

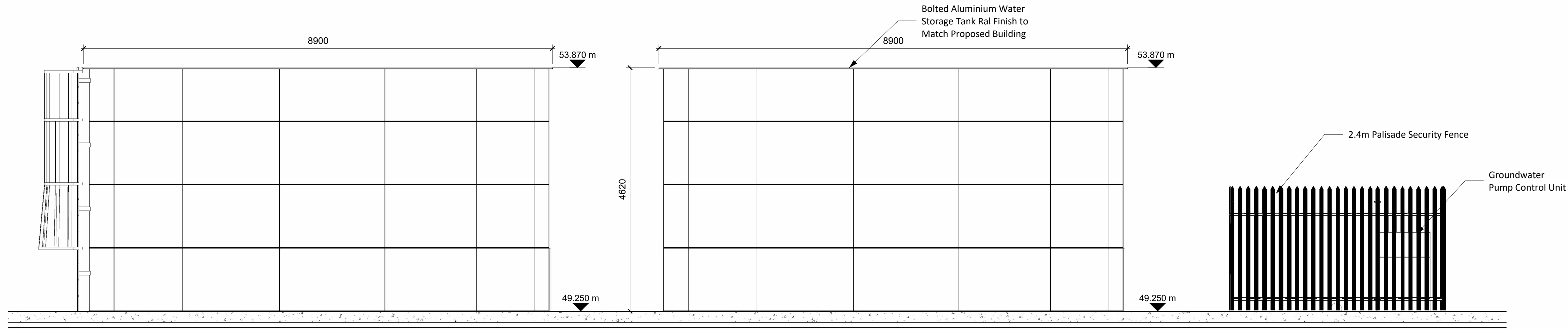
If Applicable : Tailte Éireann Licence No. CYAL50368274 © Ordnance Survey Ireland and Government of Ireland

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT		CLIENT					
POWERSTOWN BIOENERGY		 Greengate Biogas					
SHEET		Date	29.08.25	Project number	P24-188	Scale (@ A1)	As Shown
PASTEURISATION TANKS		Drawn by	NW	Drawing Number			Rev
		Checked by	JON	P24188-FT-XX-XX-DR-CE-1729			P01
		(Sheet set subject 1700)					



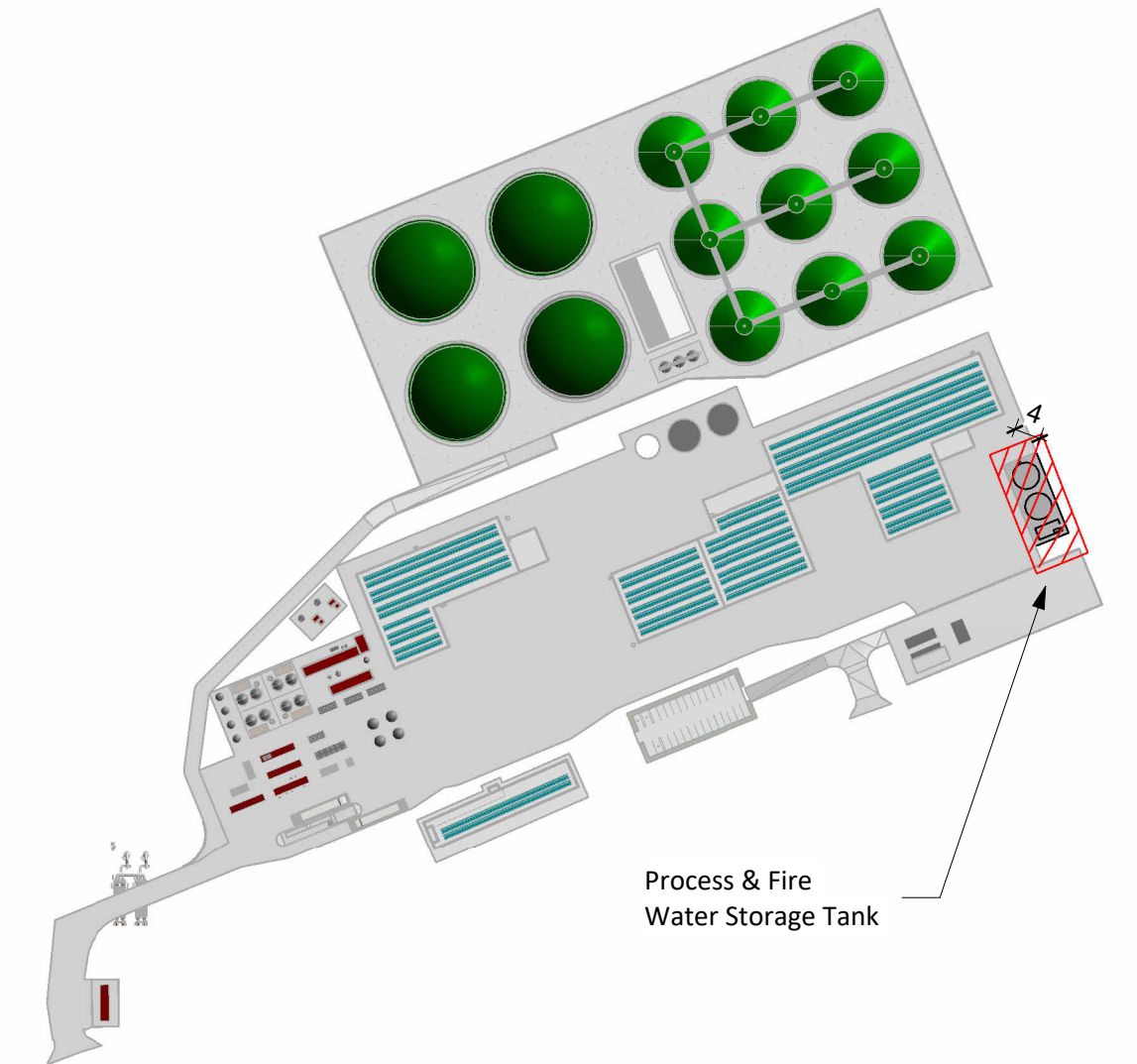
PROCESS & FIRE WATER STORAGE TANKS - PLAN
Scale 1:50



SECTION 1
Scale 1 : 50



TYPICAL PROCESS & FIRE WATER STORAGE TANKS (N.T.S.)



KEYPLAN
Scale 1:2500

Notes:

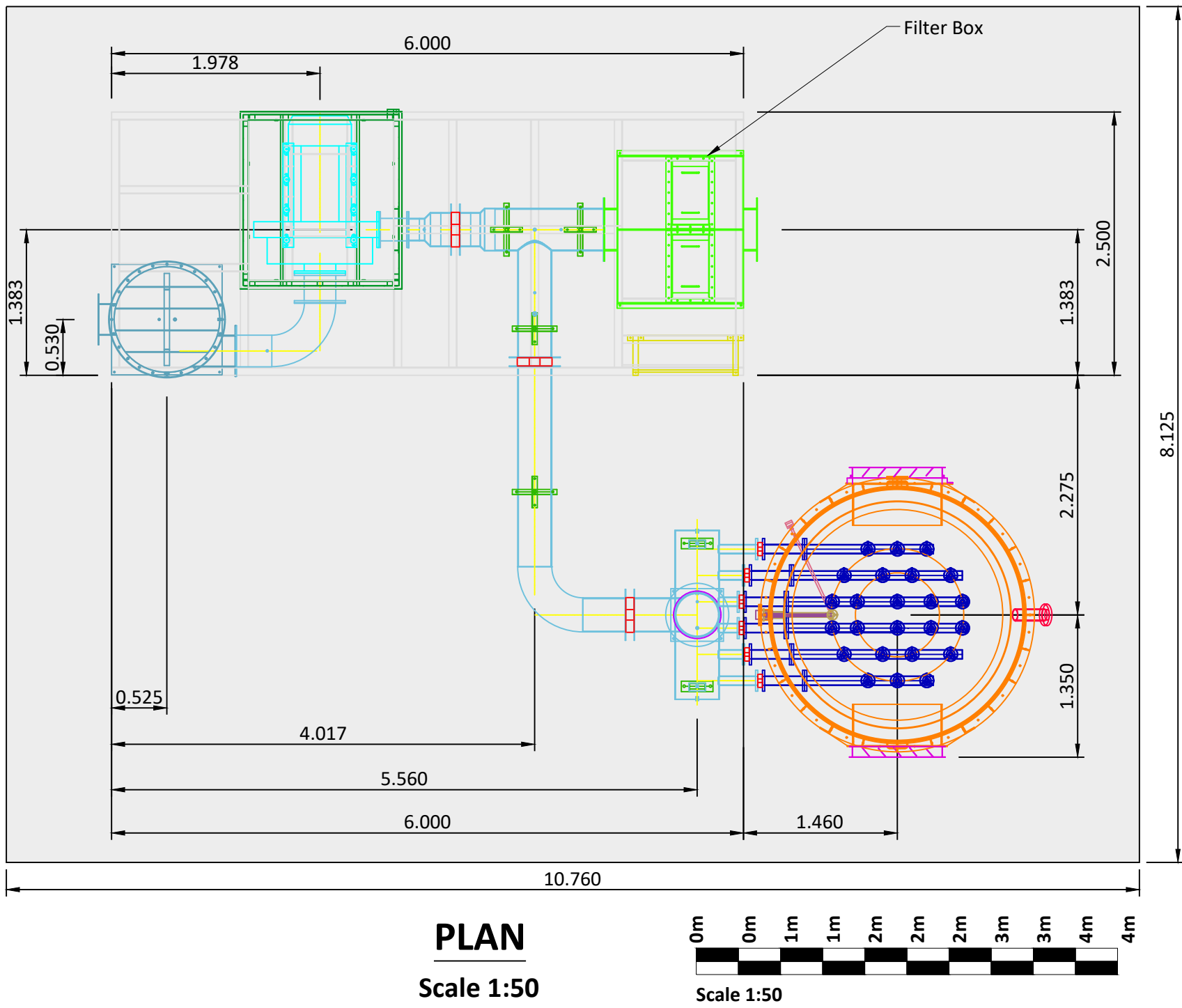
Drawings for Planning Purposes Only.

Subject to Detailed Mechanical, Electrical and Process Design.

Levels are relative to Malin Head Datum.

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT	POWERSTOWN BIOENERGY		CLIENT				
SHEET	PROCESS & FIRE WATER STORAGE TANKS - PLANS AND ELEVATIONS		Date	18.06.26	Project Number	P24188	Scale (at A1) As indicated
			Drawn by	EB	Drawing Number		Rev
			Checked by	JON	P24188-FT-XX-XX-DR-CE-1730		P01



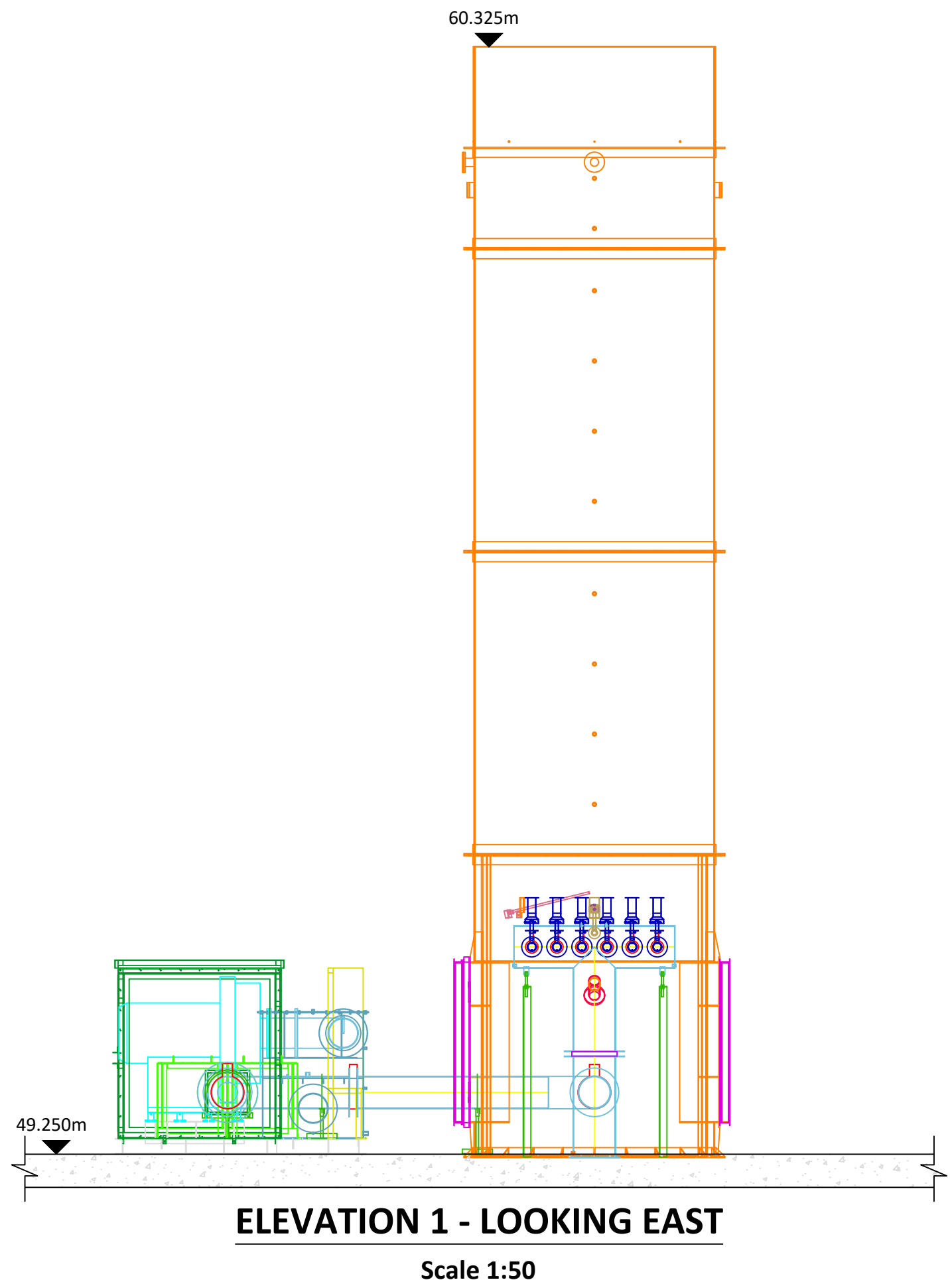
PLAN
Scale 1:50



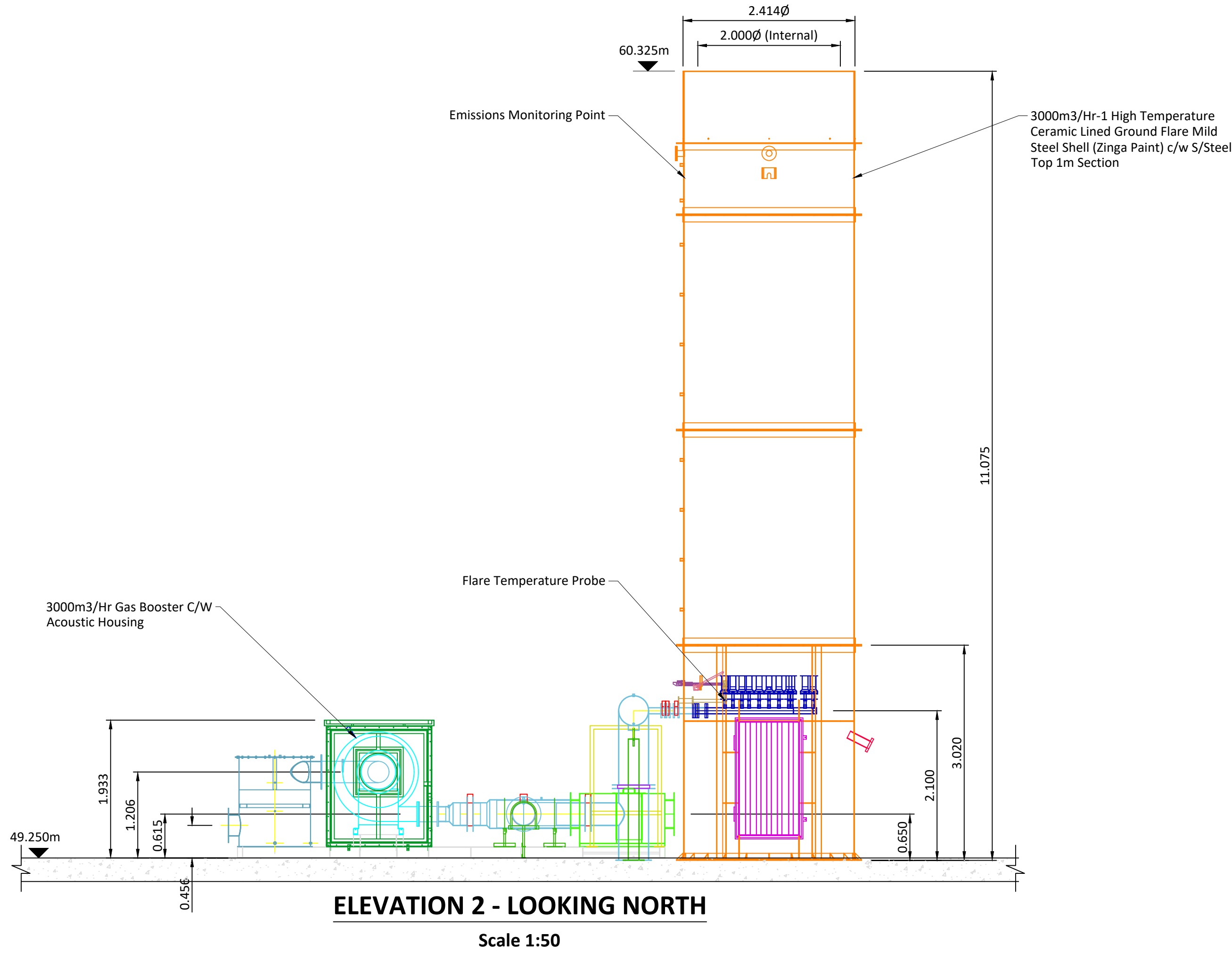
TYPICAL GAS FLARE (N.T.S.)

Legend
Planning Boundary

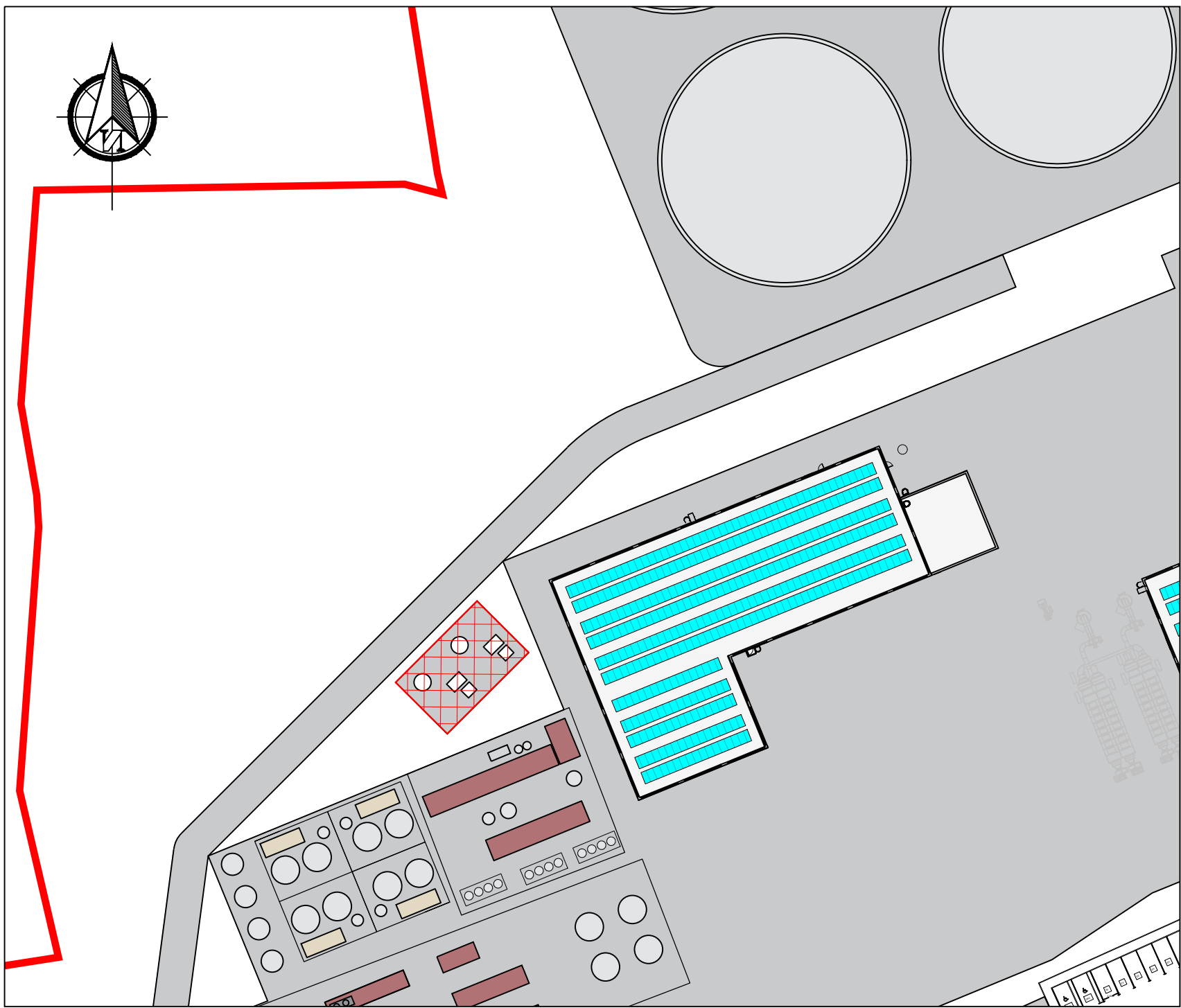
Notes:
Drawings for Planning Purposes Only.
Subject to Detailed Mechanical, Electrical and Process Design.
2 No. 3,000 m³/hr Flares to be Installed (Duty and Standby).
Gas Collection Pipework Omitted for Clarity.
Flares to be Connected to Critical Systems Emergency Electrical Supply.
Fixed Emissions Monitoring Points to be Installed.
Photographs For Illustrative Purposes Only.
Levels are relative to Malin Head Datum.



ELEVATION 1 - LOOKING EAST
Scale 1:50



ELEVATION 2 - LOOKING NORTH
Scale 1:50



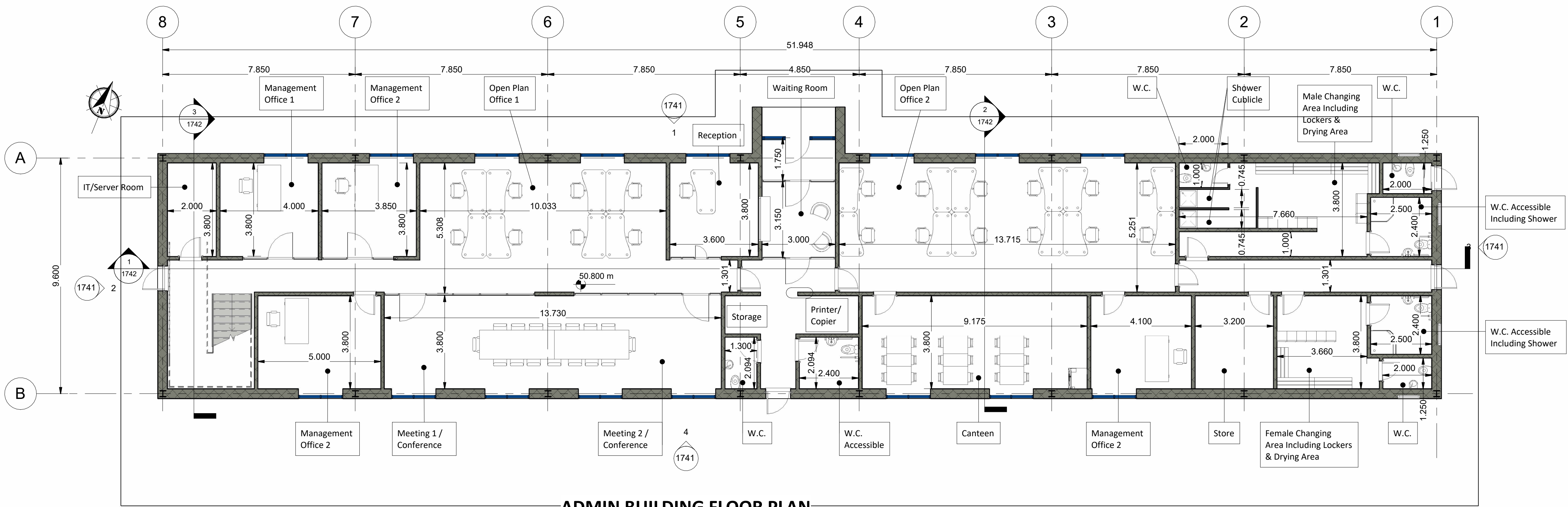
KEYPLAN
Scale 1:750

If Applicable : Tailte Éireann Licence No. CYAL50368274 © Ordnance Survey Ireland and Government of Ireland

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

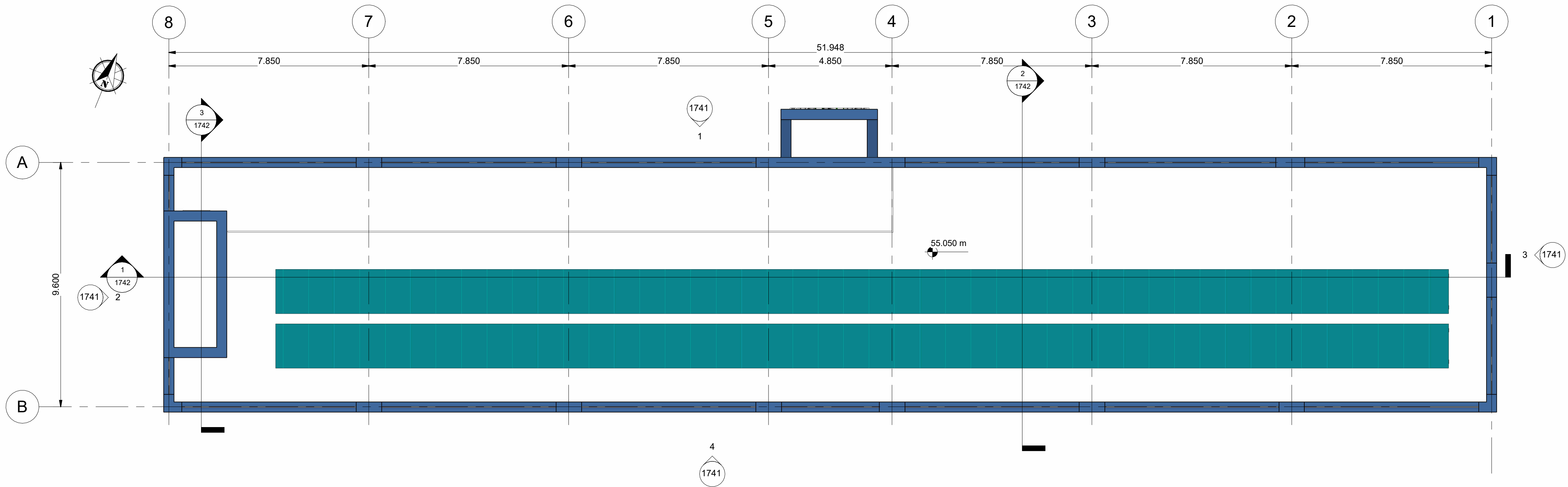
PROJECT		CLIENT		
POWERSTOWN BIOENERGY		Greengate Biogas		
SHEET		Date	29.08.25	Project number
GAS FLARING COMPOUND PLANS ELEVATIONS AND DETAILS		Drawn by	NW	P24-188
		Checked by	JON	Drawing Number
				P24188-FT-XX-XX-DR-CE-1735
				Scale (@ A1) As Shown
				Rev
				P01

O:\ACAD\2024\P24-188\P24188-FT-XX-XX-DR-CE-1735

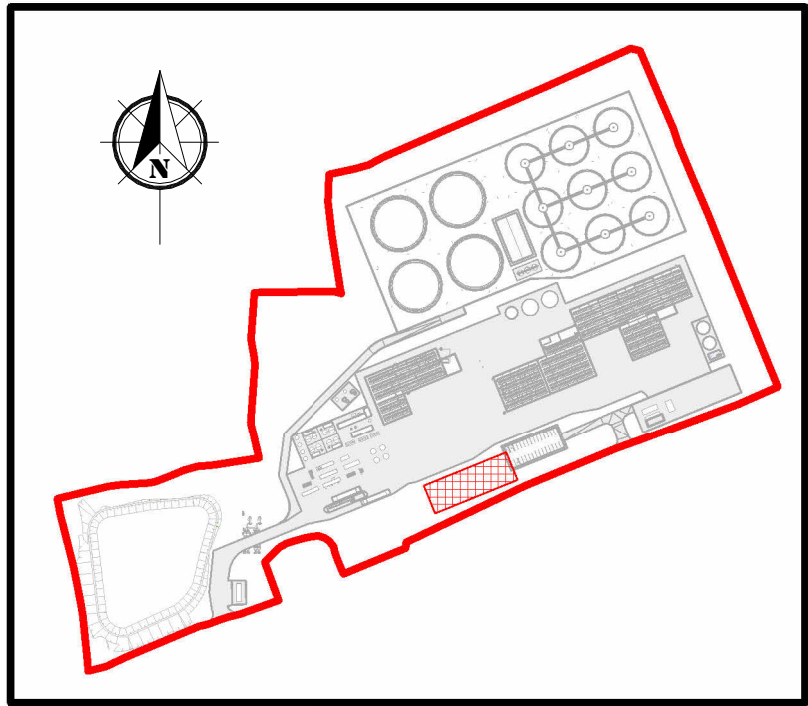


ADMIN BUILDING FLOOR PLAN
Scale 1 : 100

Notes:
For Planning Application purposes only.
Gross Floor Area - 459.35 m2



ADMIN BUILDING ROOF PLAN
Scale 1 : 100



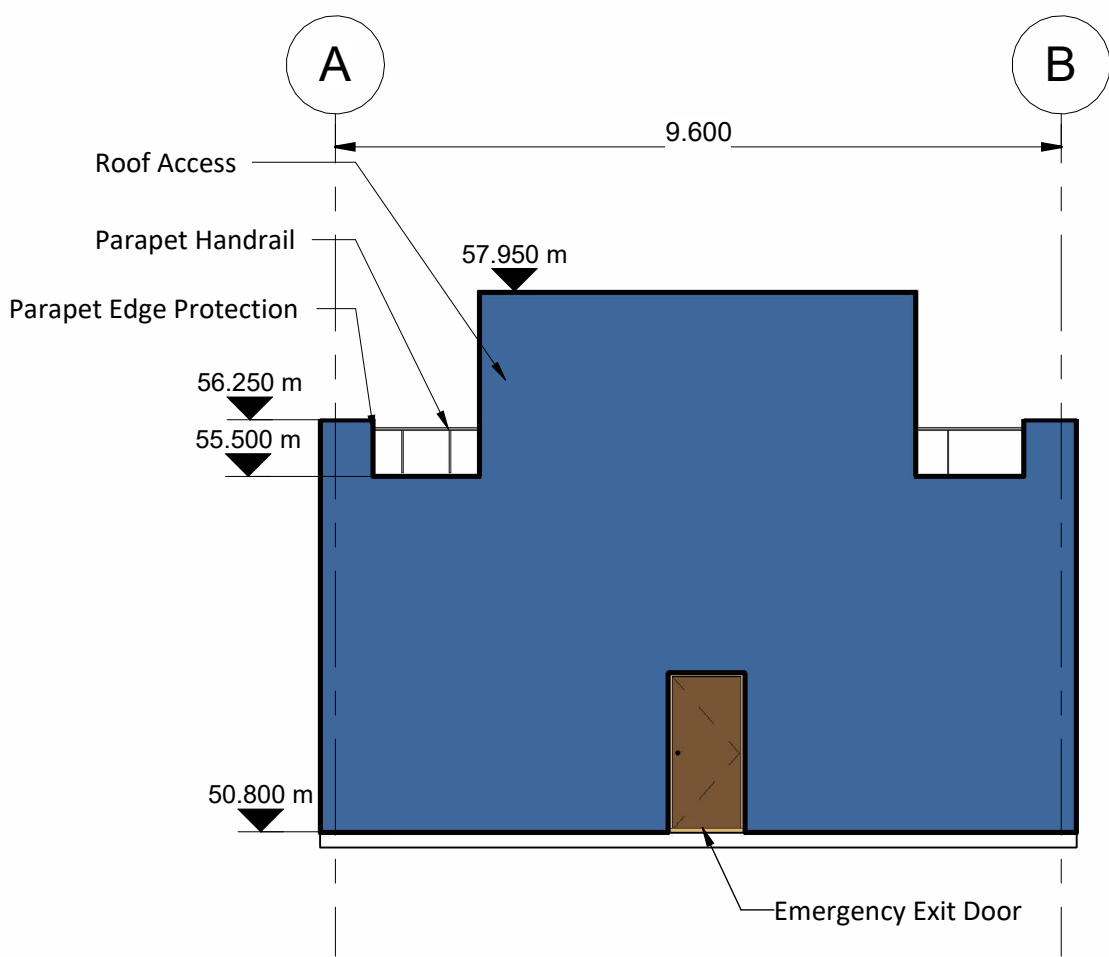
KEYPLAN
Scale 1 : 5000

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT		CLIENT		
POWERSTOWN BIOENERGY		Greengate Biogas		
SHEET		Date	Project Number	Scale (at A1)
ADMINISTRATION BUILDING PLANS		18.08.25	P24188	As indicated
		Drawn by	Drawing Number	Rev
		NW	P24188-FT-XX-XX-DR-CE-1740	P01
		Checked by	JON	

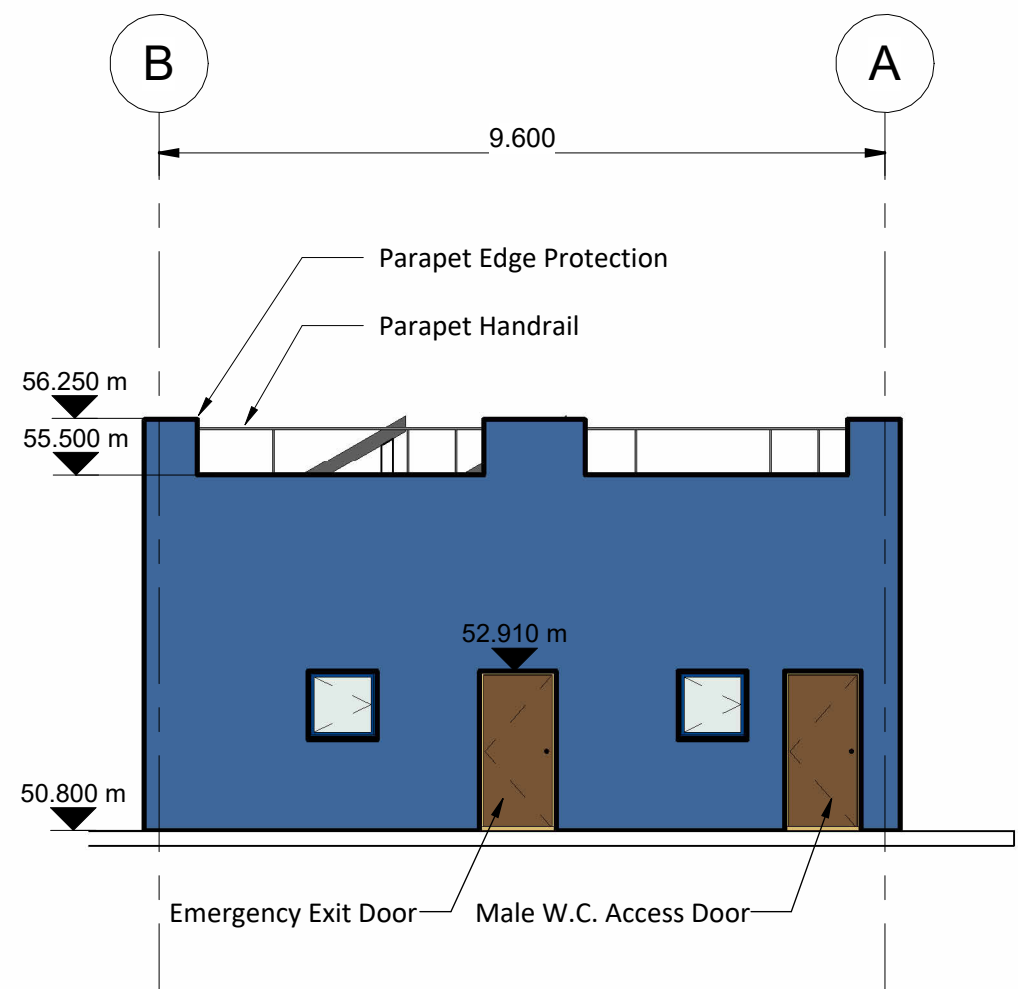


ELEVATION 1 - ADMIN BUILDING - LOOKING SOUTH
Scale 1 : 100

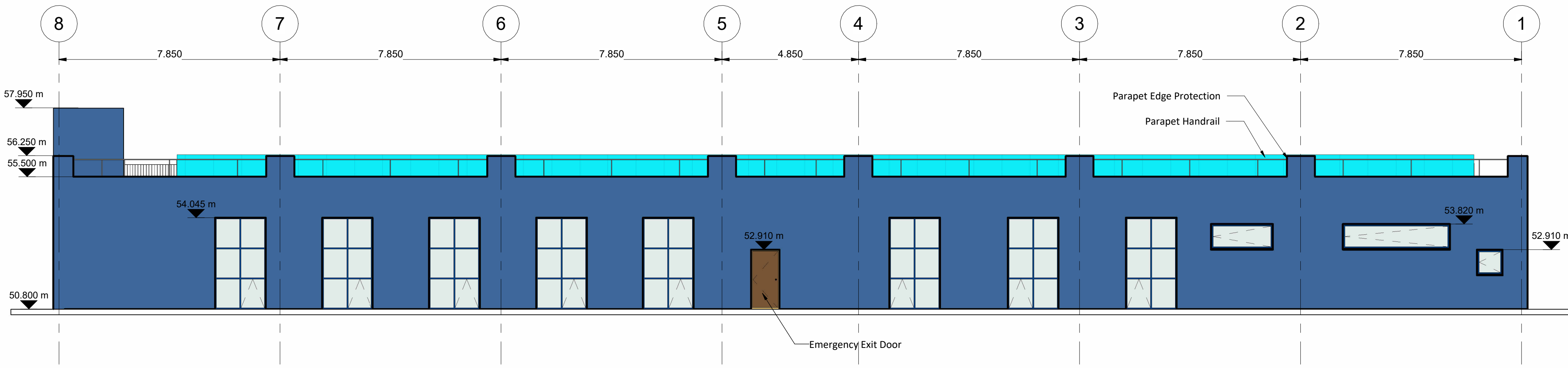


ELEVATION 2 - ADMIN BUILDING - LOOKING WEST
Scale 1 : 100

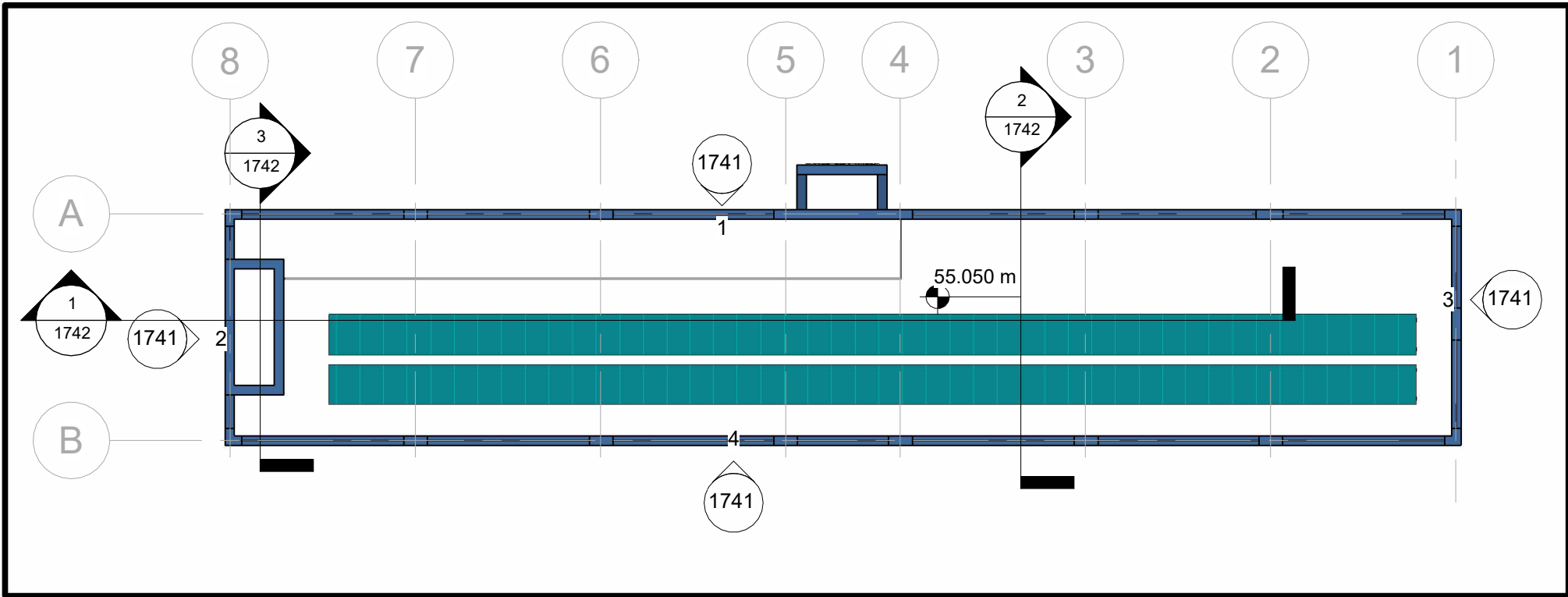
Notes:
Levels are relative to Malin Head Datum.



ELEVATION 3 - ADMIN BUILDING - LOOKING EAST
Scale 1 : 100



ELEVATION 4 - ADMIN BUILDING - LOOKING NORTH
Scale 1 : 100

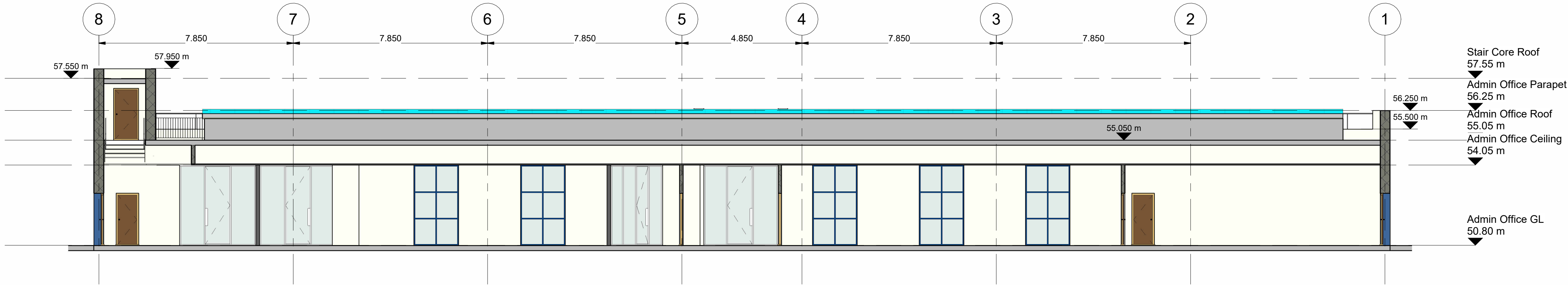


KEYPLAN
Scale 1 : 250

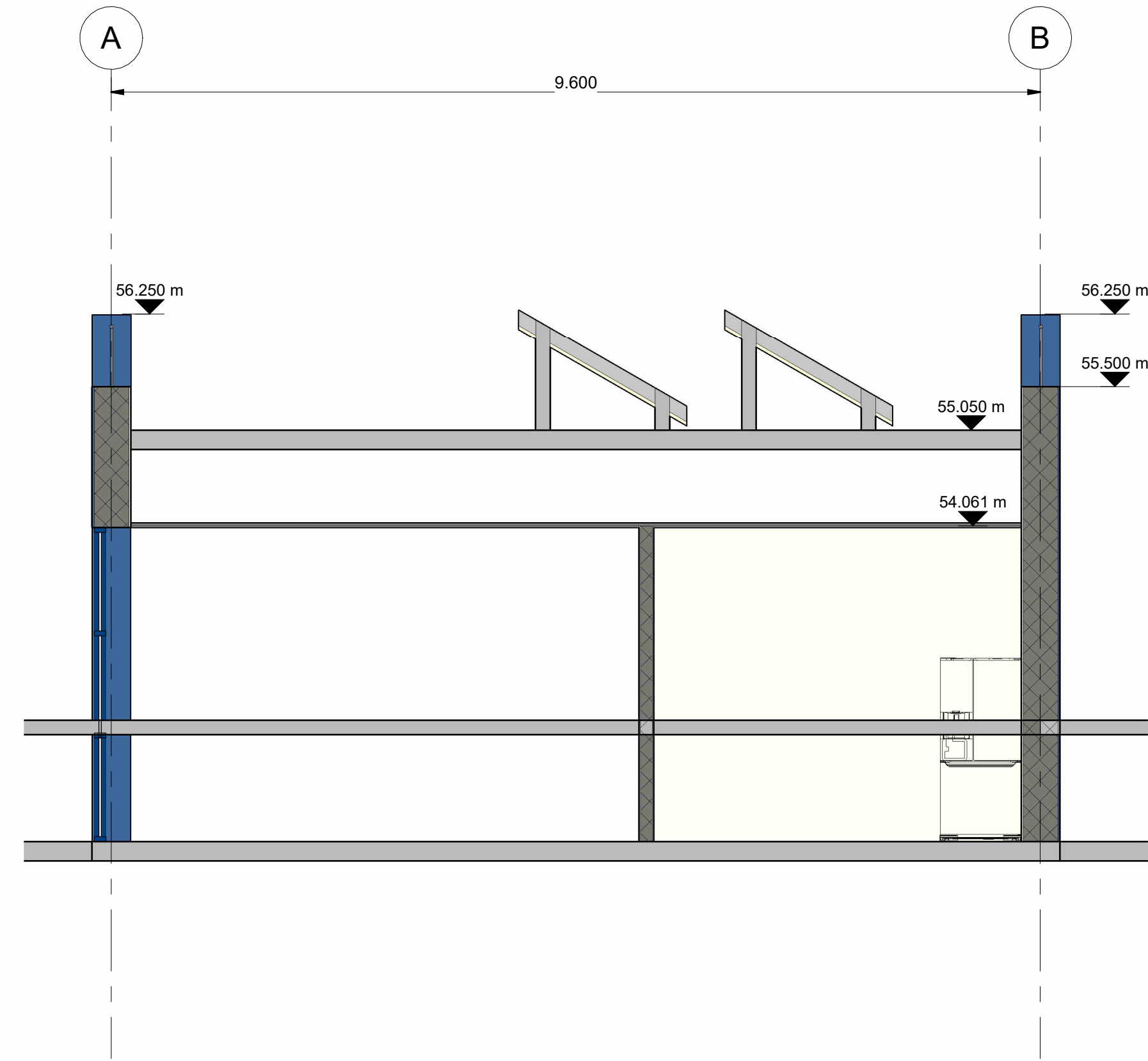
Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT	POWERSTOWN BIOENERGY		CLIENT					
SHEET	ADMINISTRATION BUILDING ELEVATIONS		Date	18.08.25	Project Number	P24188	Scale (at A1) As indicated	
			Drawn by	NW	Drawing Number		P24188-FT-XX-XX-DR-CE-1741	Rev P01
			Checked by	JON				

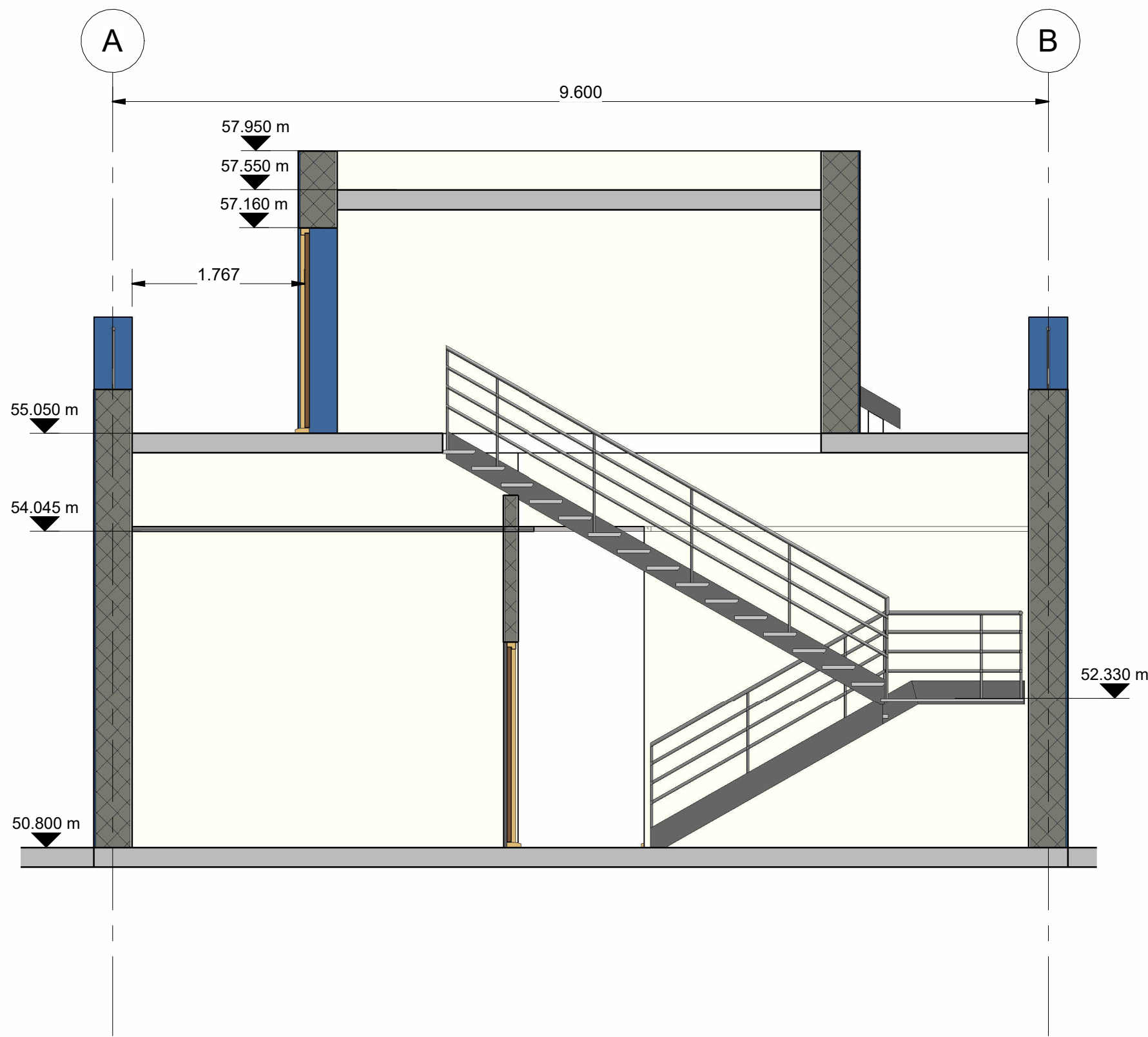
Notes:
Levels are relative to Malin Head Datum.



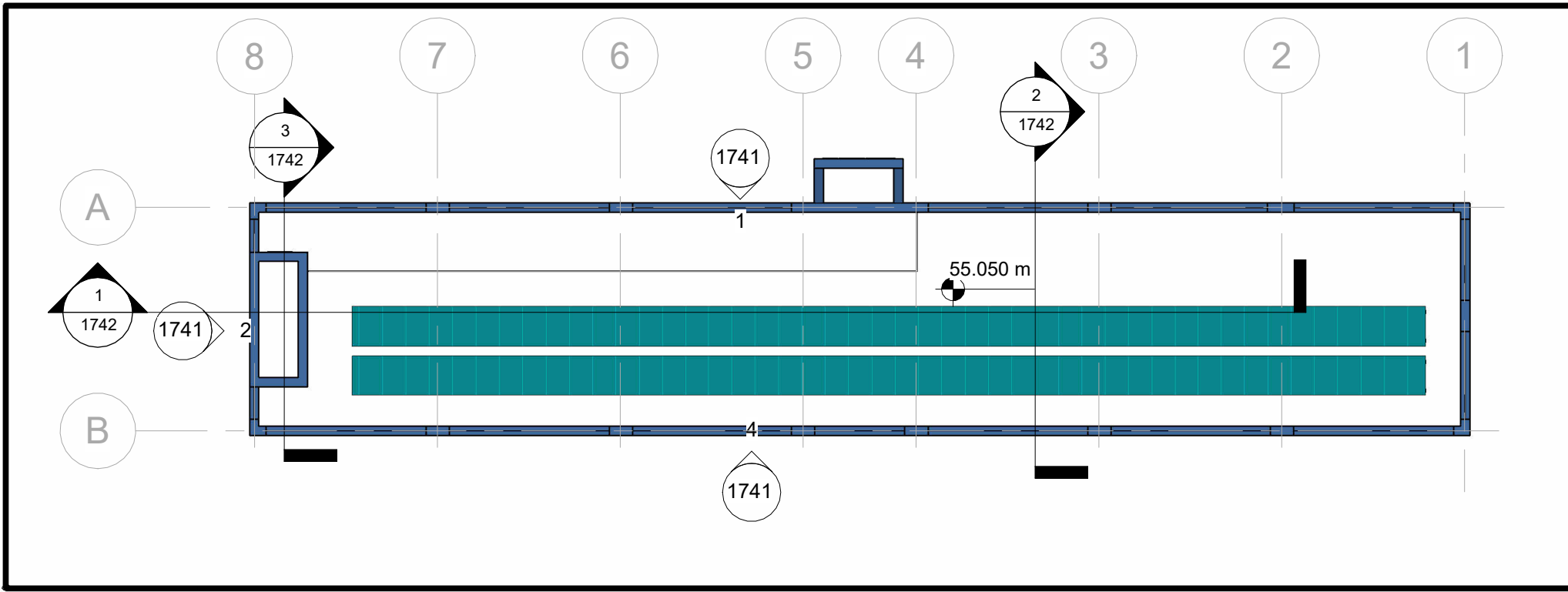
SECTION 1
Scale 1 : 100



SECTION 2
Scale 1 : 50



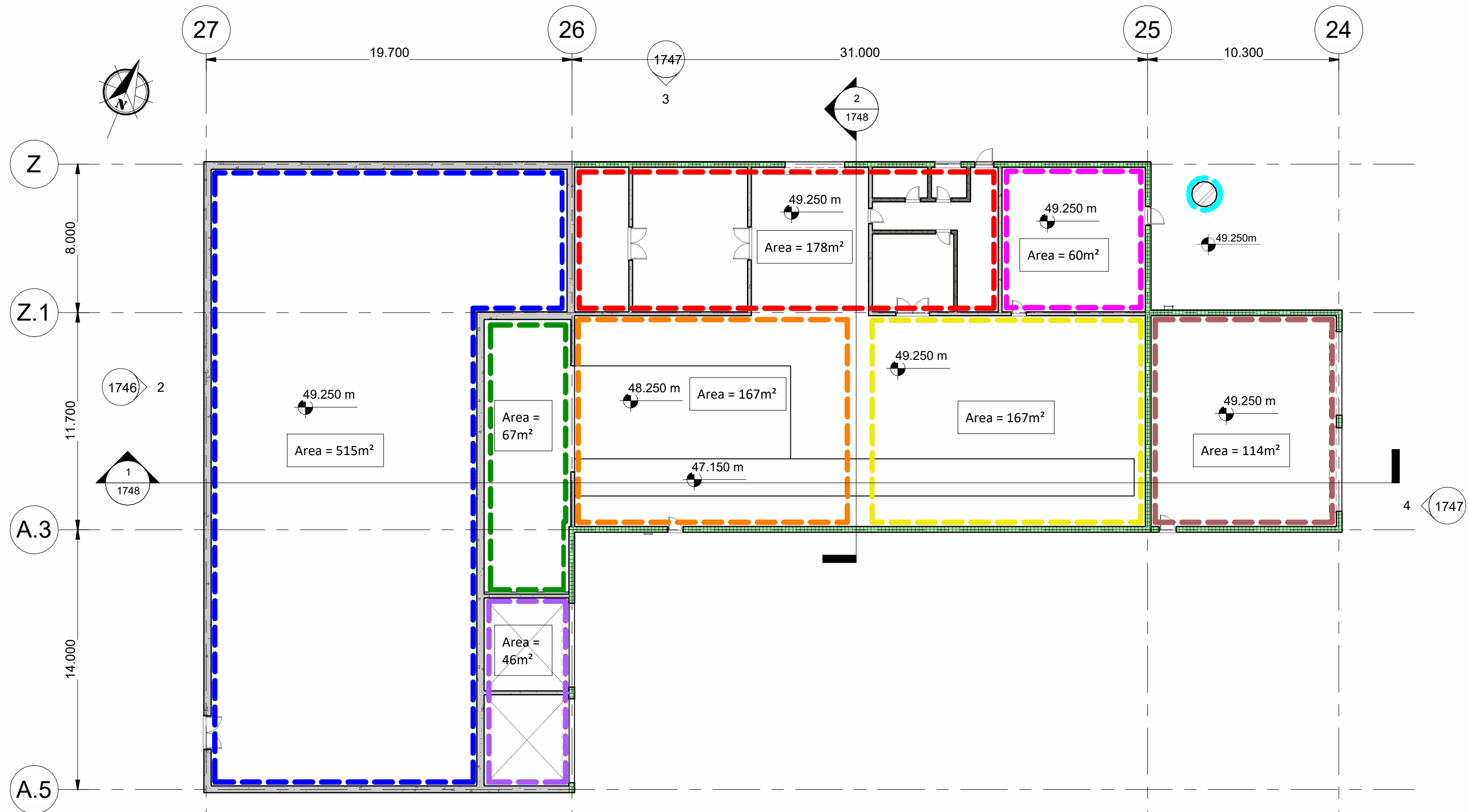
SECTION 3
Scale 1 : 50



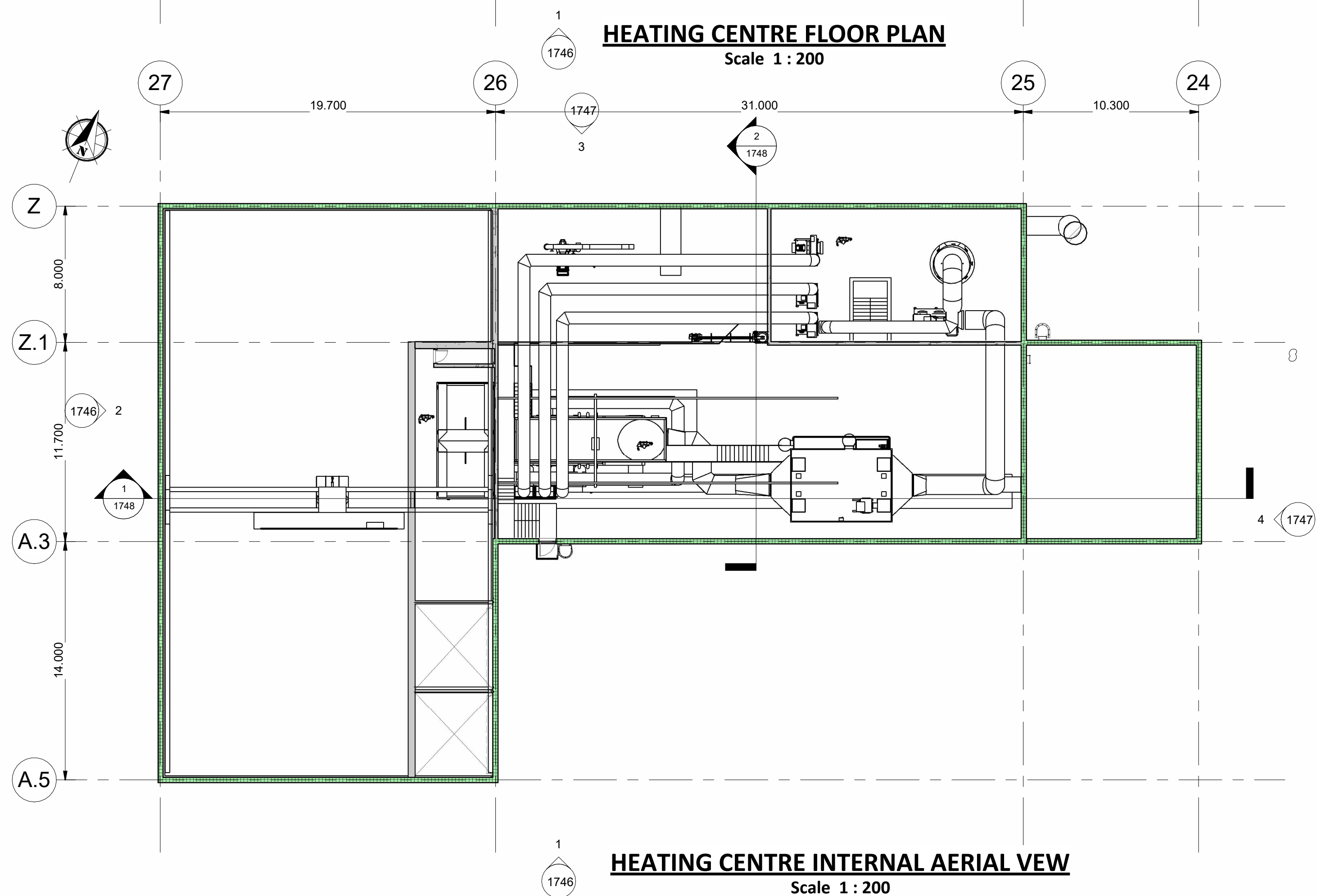
KEYPLAN
Scale 1 : 250

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT	CLIENT		
POWERSTOWN BIOENERGY	Greengate Biogas		
SHEET	Date	Project Number	Scale (at A1)
ADMINISTRATION BUILDING SECTIONS	18.08.25	P24188	As indicated
	Drawn by	Drawing Number	Rev
	NW	P24188-FT-XX-XX-DR-CE-1742	P01
	Checked by	JON	



HEATING CENTRE FLOOR PLAN
Scale 1 : 200



HEATING CENTRE INTERNAL AERIAL VIEW
Scale 1 : 200

NOTES
Drawings for planning purposes only.

Solar panel layout for illustrative purposes only, subject to detailed design.

Internal Mechanical and Electrical Plant shown for illustrative purposes only, subject to detailed mechanical and electrical design.

Access

Permanent Access Walkways

Permanent Access Walkways to be provided to roof areas for solar panel service and maintenance.

Roof Access Ladders

Permanent Roof Access Ladders to be provided. Roof Access Ladders the requirements of DIN 18799-1&3 Fixed ladders for construction works; Fire Escape Ladders to the requirements of DIN 14094-1, Fixed fire-escape ladders as applicable.

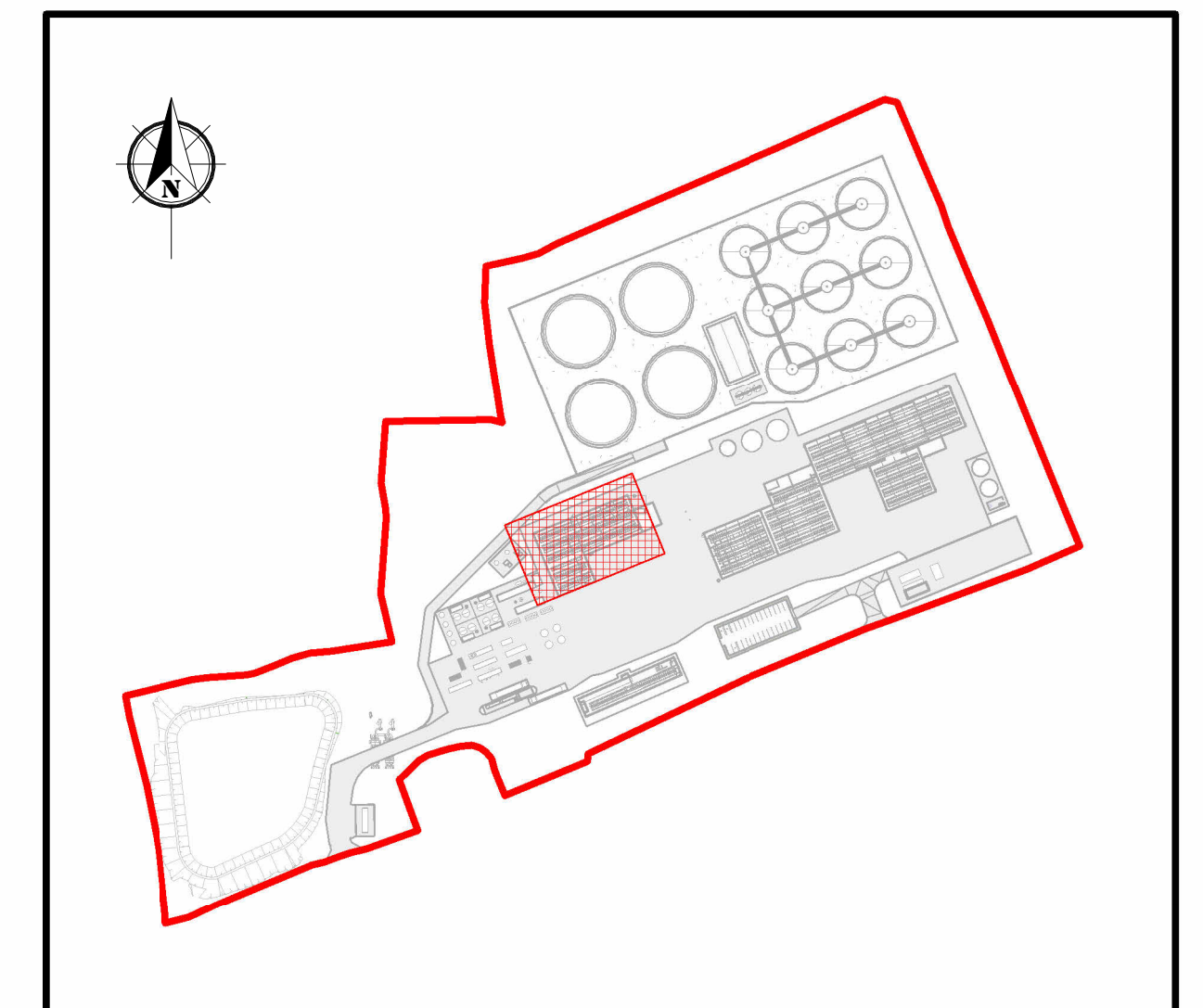
Safety

Parapet edge protection provided, provision of additional protective measures subject to detailed design.

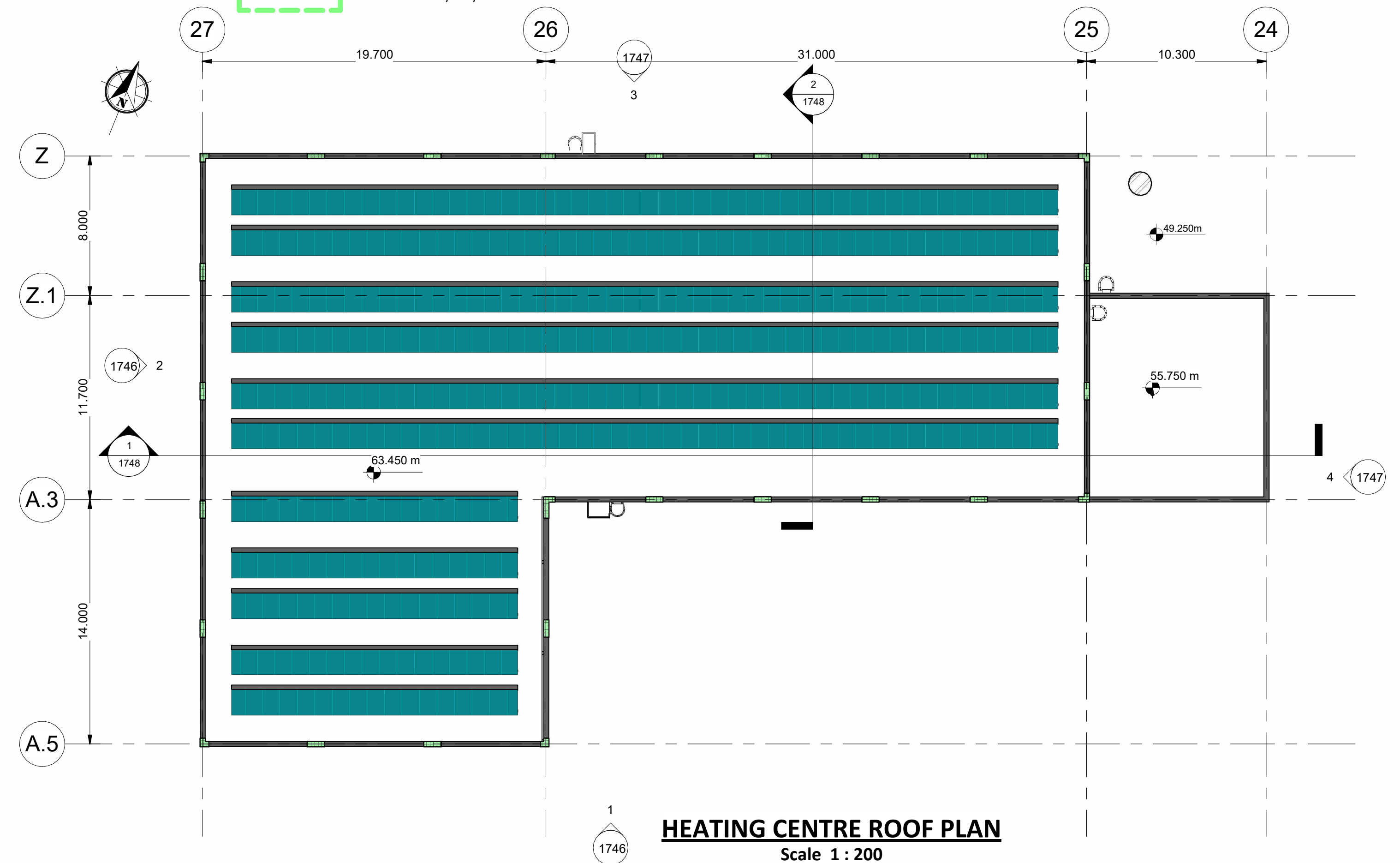
Gross Floor Area = 1,314 m2

Legend

- Proposed RC Wall
- Proposed Kingspan Cladding
- Biomass Reception Pit
- Biomass Storage Bunker
- Biomass Infeed
- Biomass Boiler
- Exhaust Air Treatment System Filter
- Exhaust Air Treatment System Scrubber
- Exhaust Stack
- Operations, Access M&E and Welfare
- Ash Container Hall
- Ash Conveyor System



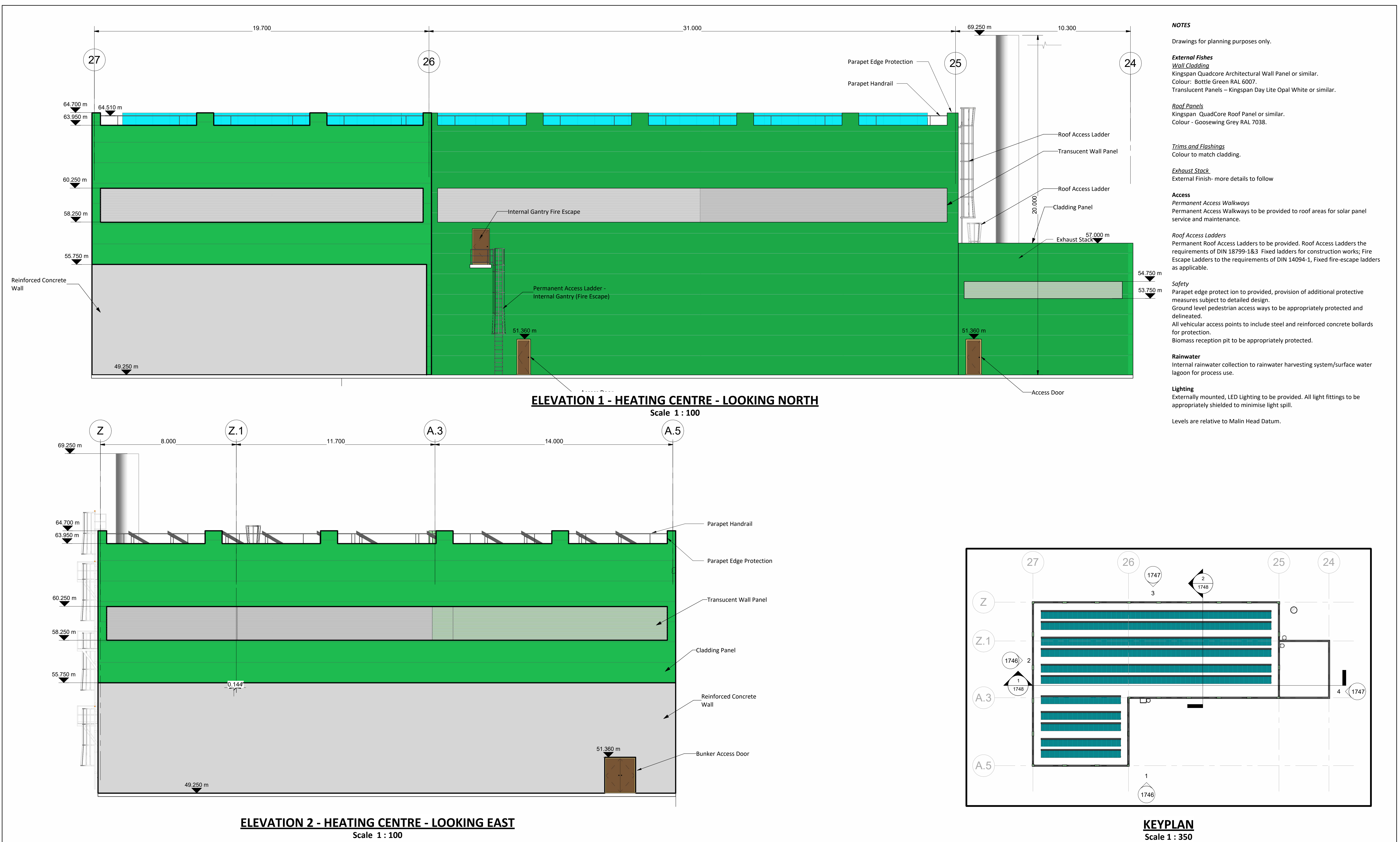
KEYPLAN
Scale 1 : 3500



HEATING CENTRE ROOF PLAN
Scale 1 : 200

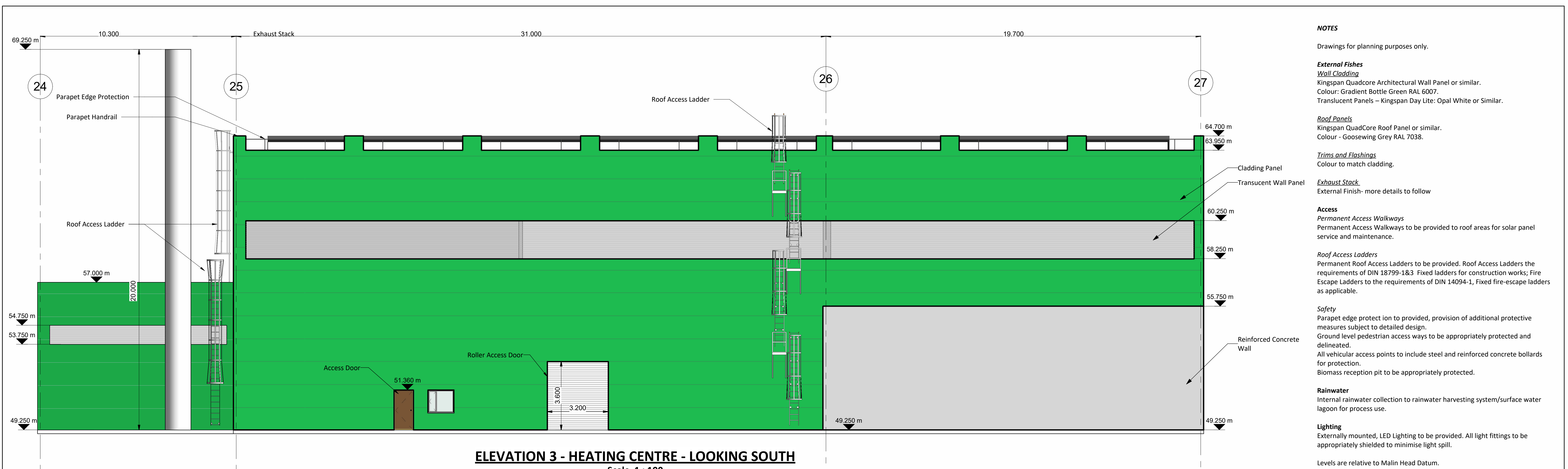
Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT		CLIENT		
POWERSTOWN BIOENERGY		Greengate Biogas		
SHEET		Date	Project Number	Scale (at A1)
HEATING CENTRE PLANS		18.06.26	P24188	As indicated
		Drawn by	Drawing Number	Rev
		NW	P24188-FT-XX-XX-DR-CE-1745	P01
		Checked by	Checker	



Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT		CLIENT		
POWERSTOWN BIOENERGY				
SHEET	Date		Project Number	Scale (at A1)
	18.08.25		P24188	As indicated
	Drawn by	NW	Drawing Number	Rev
Checked by		Checker	P24188-FT-XX-XX-DR-CE-1746	P01



NOTES

Drawings for planning purposes only.

External Fishes
Wall Cladding
Kingspan Quadcore Architectural Wall Panel or similar.
Colour: Gradient Bottle Green RAL 6007.
Translucent Panels – Kingspan Day Lite: Opal White or Similar.

Roof Panels
Kingspan QuadCore Roof Panel or similar.
Colour - Goosewing Grey RAL 7038.

Trims and Flashings
Colour to match cladding.

Exhaust Stack
External Finish- more details to follow

Access
Permanent Access Walkways
Permanent Access Walkways to be provided to roof areas for solar panel service and maintenance.

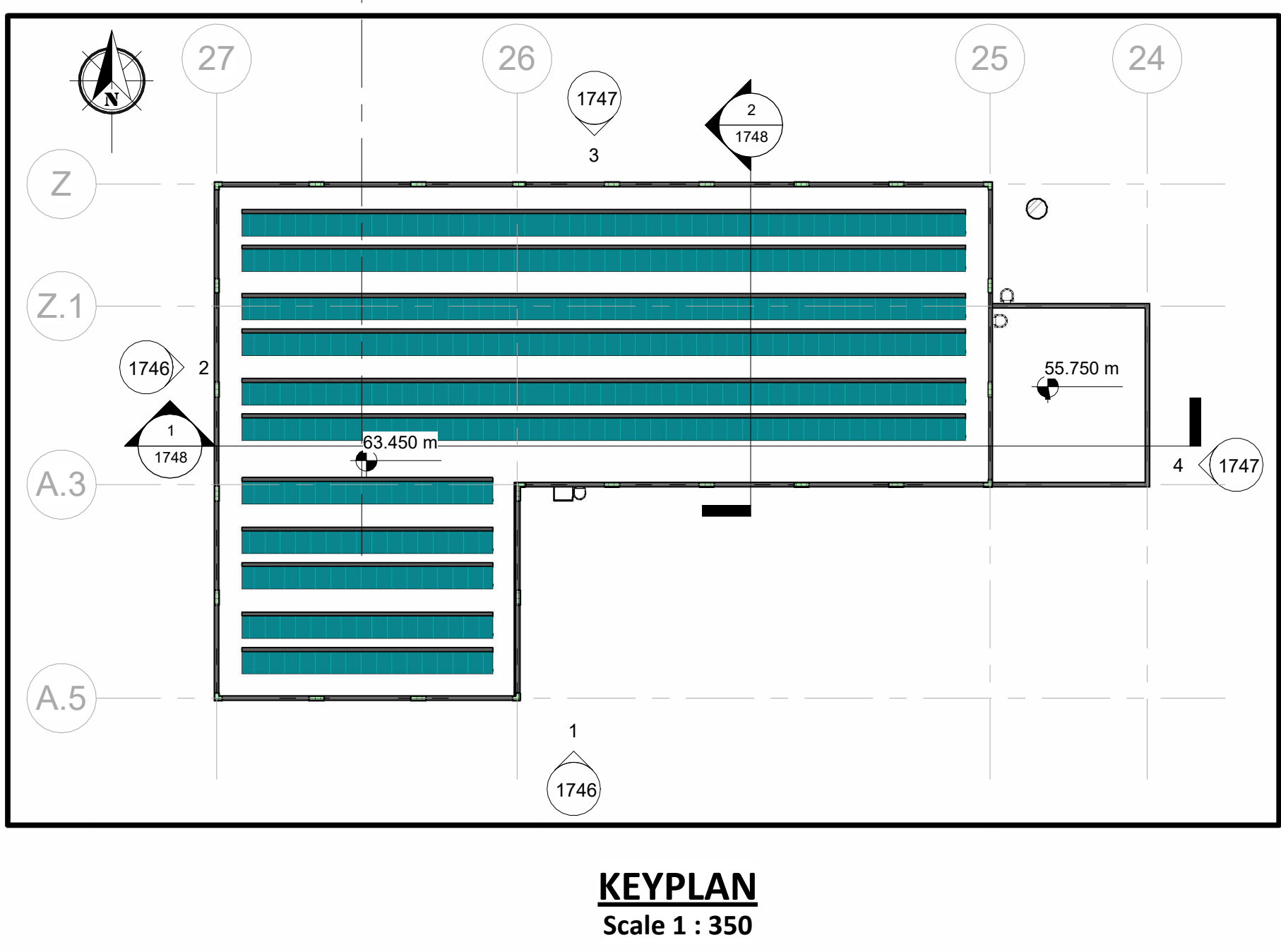
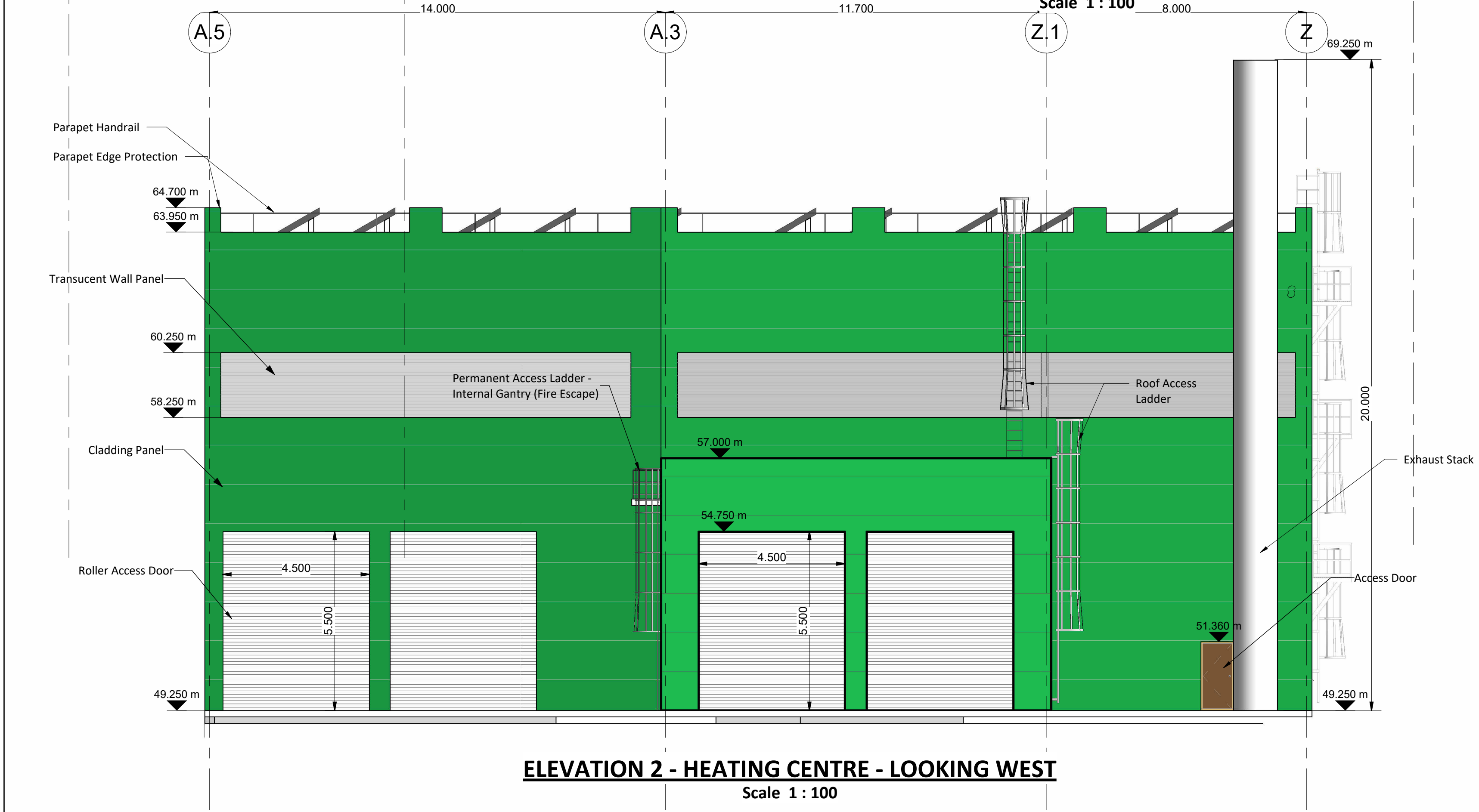
Roof Access Ladders
Permanent Roof Access Ladders to be provided. Roof Access Ladders the requirements of DIN 18799-1&3 Fixed ladders for construction works; Fire Escape Ladders to the requirements of DIN 14094-1, Fixed fire-escape ladders as applicable.

Safety
Parapet edge protect ion to provided, provision of additional protective measures subject to detailed design.
Ground level pedestrian access ways to be appropriately protected and delineated.
All vehicular access points to include steel and reinforced concrete bollards for protection.
Biomass reception pit to be appropriately protected.

Rainwater
Internal rainwater collection to rainwater harvesting system/surface water lagoon for process use.

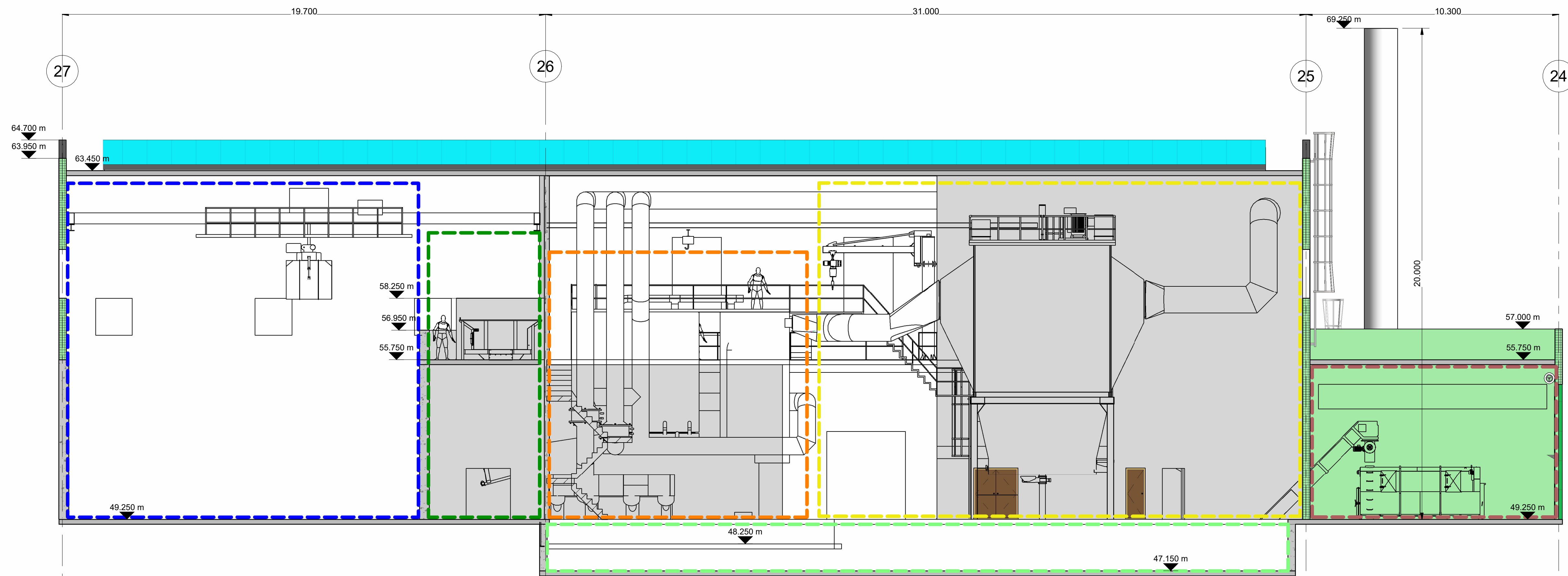
Lighting
Externally mounted, LED Lighting to be provided. All light fittings to be appropriately shielded to minimise light spill.

Levels are relative to Malin Head Datum.

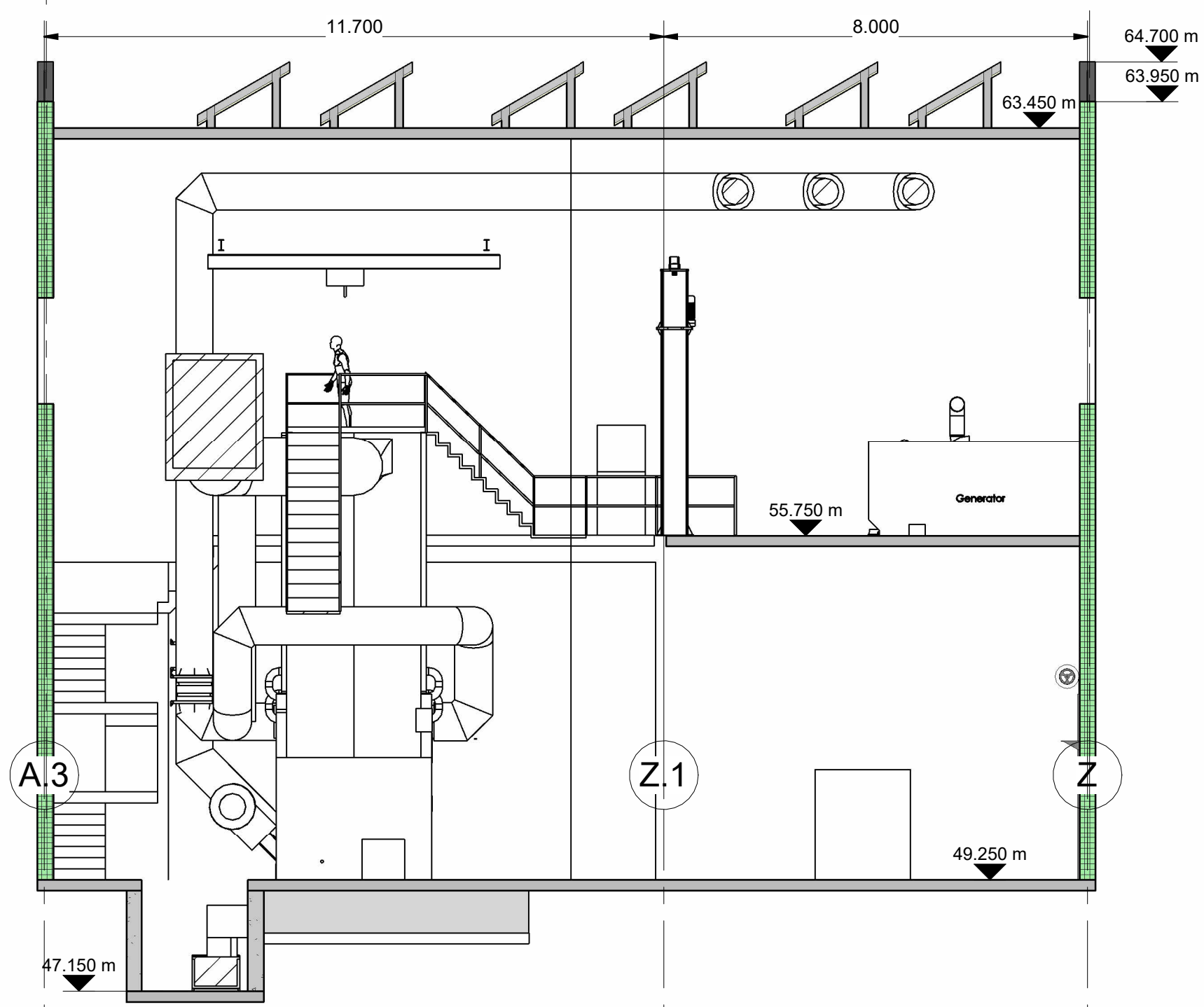


Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

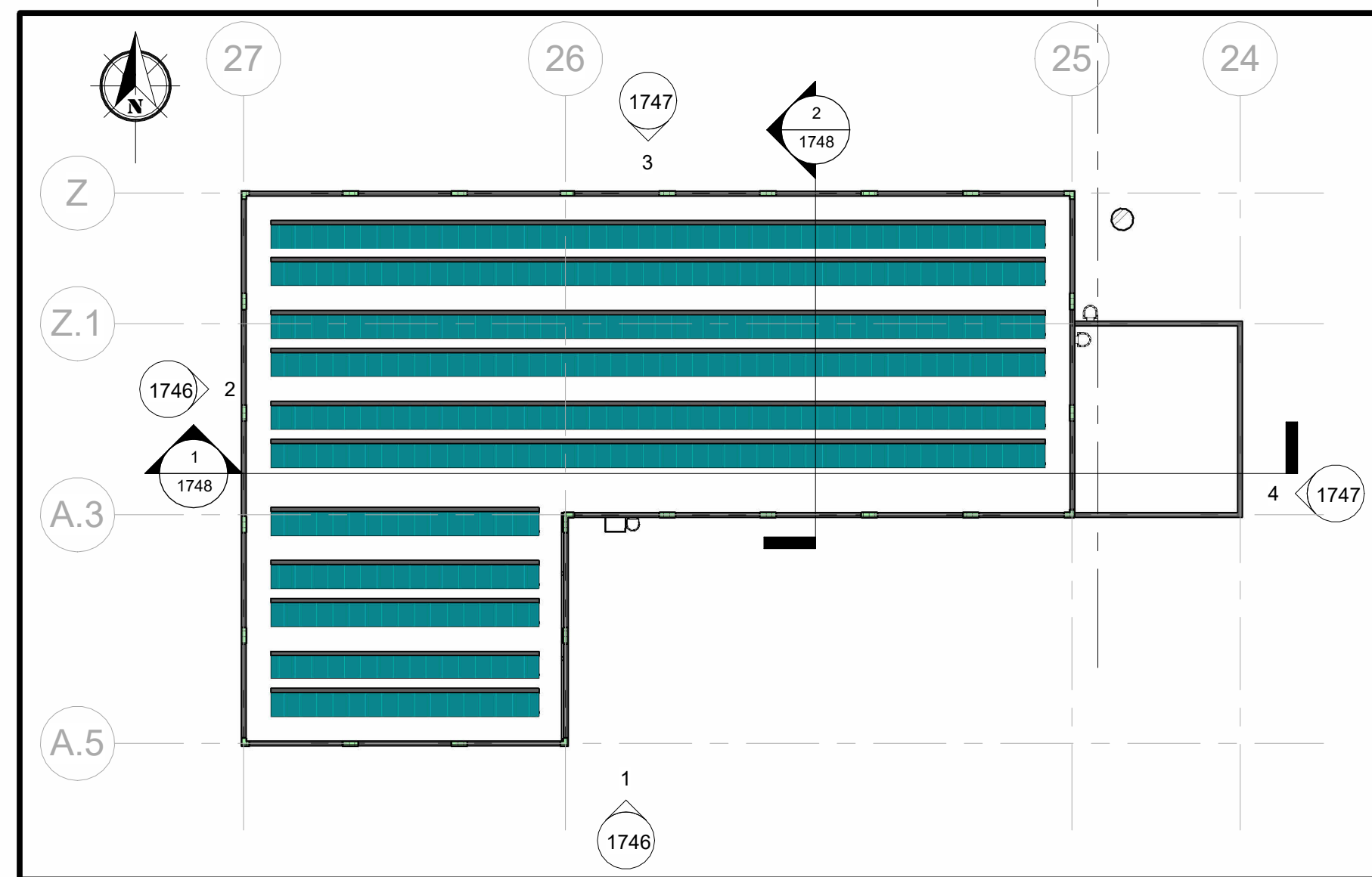
PROJECT	POWERSTOWN BIOENERGY			CLIENT						
SHEET	HEATING CENTRE ELEVATIONS SHEET 2 OF 2			Date	18.08.25	Project Number	P24188		Scale (at A1)	As indicated
				Drawn by	NW	Drawing Number P24188-FT-XX-XX-DR-CE-1747				Rev P01
				Checked by	Checker					



SECTION 1
Scale 1 : 100



SECTION 2
Scale 1 : 100



KEYPLAN
Scale 1 : 350

Legend

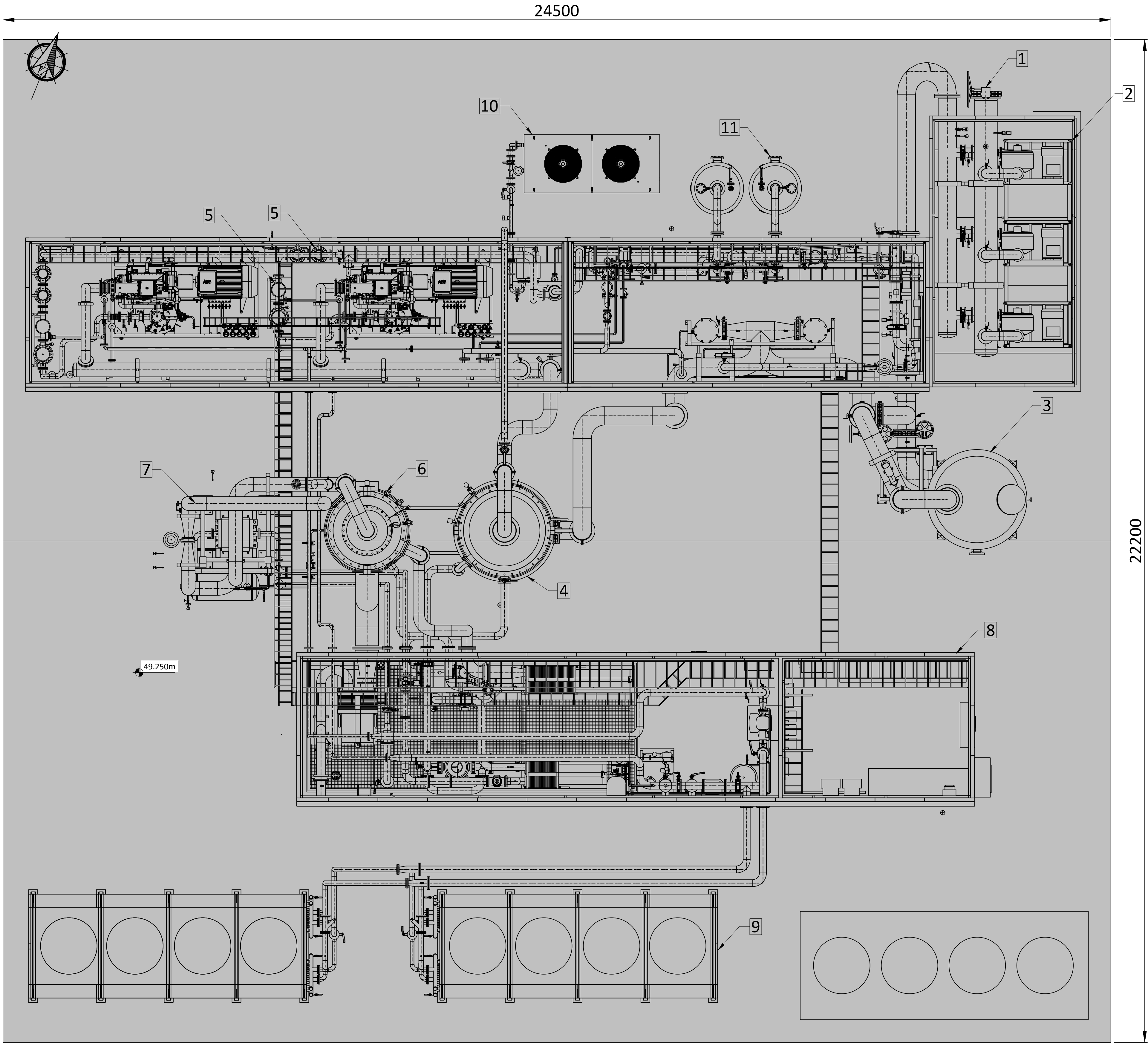
- Proposed RC Wall
- Proposed Kingspan Cladding
- Biomass Reception Pit
- Biomass Storage Bunker
- Biomass Infeed
- Biomass Boiler
- Exhaust Air Treatment System Filter
- Exhaust Air Treatment System Scrubber
- Exhaust Stack
- Operations, Access M&E and Welfare
- Ash Container Hall
- Ash Conveyor System

NOTES

- Drawings for planning purposes only.
- Internal Mechanical and Electrical Plant for illustrative purposes only, subject to detailed design and specification.
- Levels are relative to Malin Head Datum.

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT		CLIENT					
POWERSTOWN BIOENERGY							
SHEET		Date		Project Number		Scale (at A1)	
		18.08.25		P24188		As indicated	
		Drawn by		Drawing Number			Rev
HEATING CENTRE SECTIONS AND DETAILS		Checked by		P24188-FT-XX-XX-DR-CE-1748			P01
		JON					



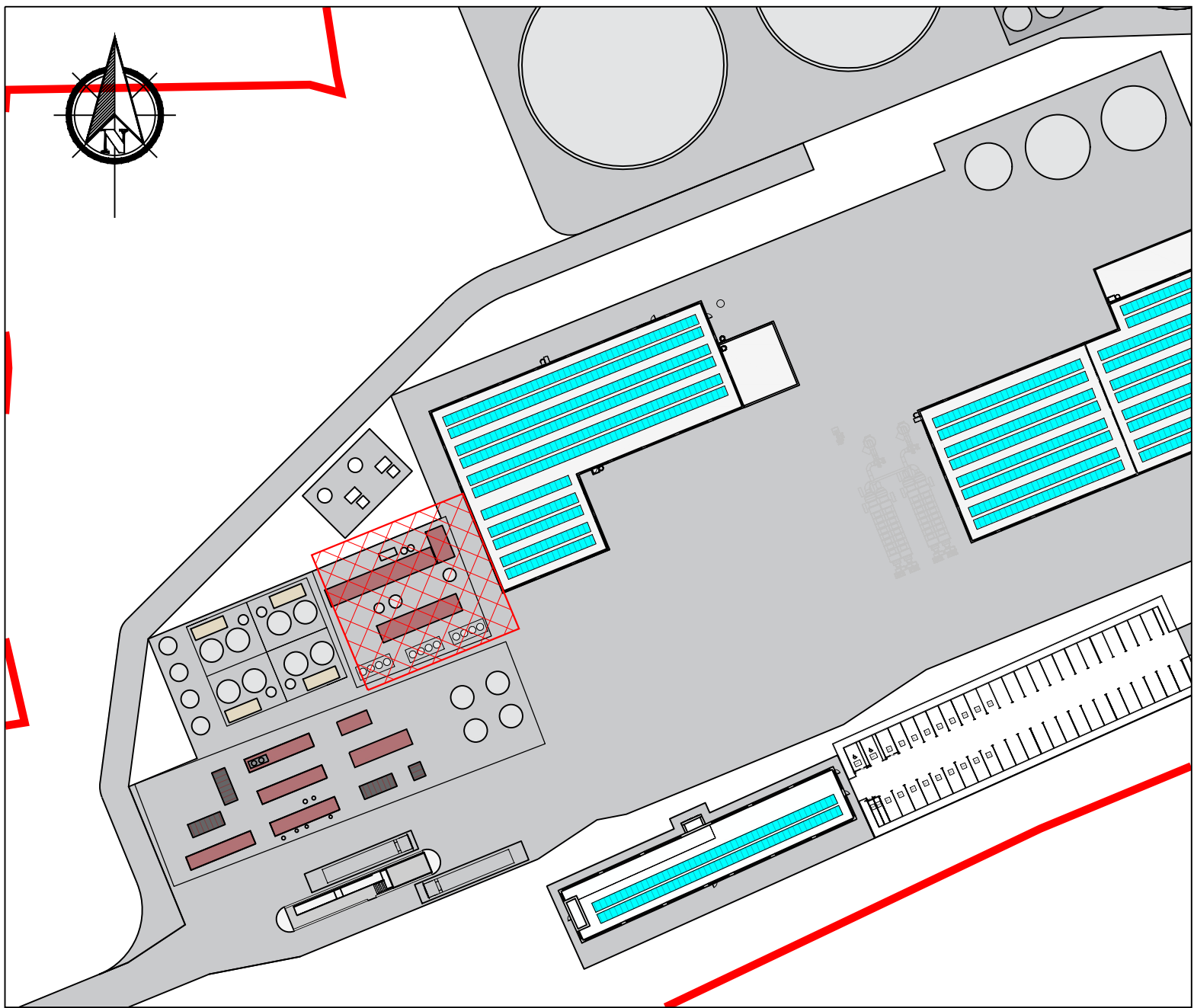
GAS UPGRADE PLANT KEYNOTES	
1	Raw Biogas Inlet
2	Blower Units
3	Granular Activated Carbon Filter. (H ₂ S Removal)
4	Absorption Column (CO ₂ Separation) by Amine Liquid
5	Methane to Renewable Natural Gas Container (Odourisation and Conditioning [Drying])
6	Stripper Column. (CO ₂ Removal From Enriched Amine Liquid Stream by Heating
7	Process Heat Exchanger
8	Process Heating Control Container
9	Process Cooling
10	Process Cooling
11	Granulated Carbon Filters

Notes:
Drawings for Planning Purposes Only.

Subject to Detailed Mechanical, Electrical and Process Design.

Biogas Separation by Amine Based Technology.

Heat to be Provided by Biomass Boiler. For Heating Centre Details Refer to P24188-FT-XX-XX-DR-CE-1745

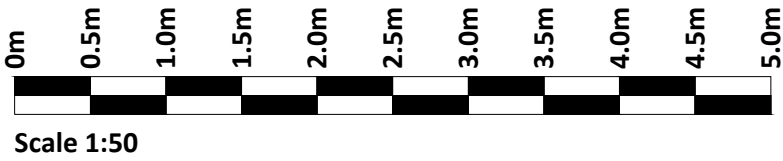


GAS UPGRADE PLANT PLAN

Scale 1:50

KEYPLAN

Scale 1:1000

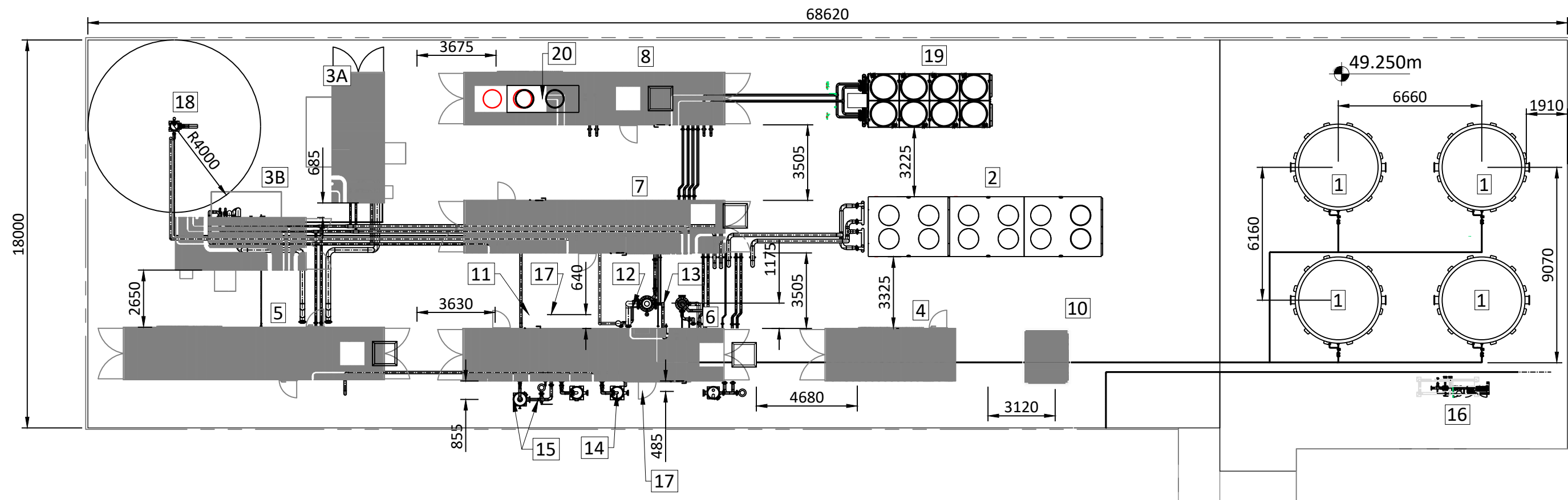
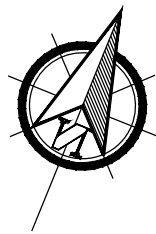


If Applicable : Tailte Éireann Licence No. CYAL50368274 © Ordnance Survey Ireland and Government of Ireland

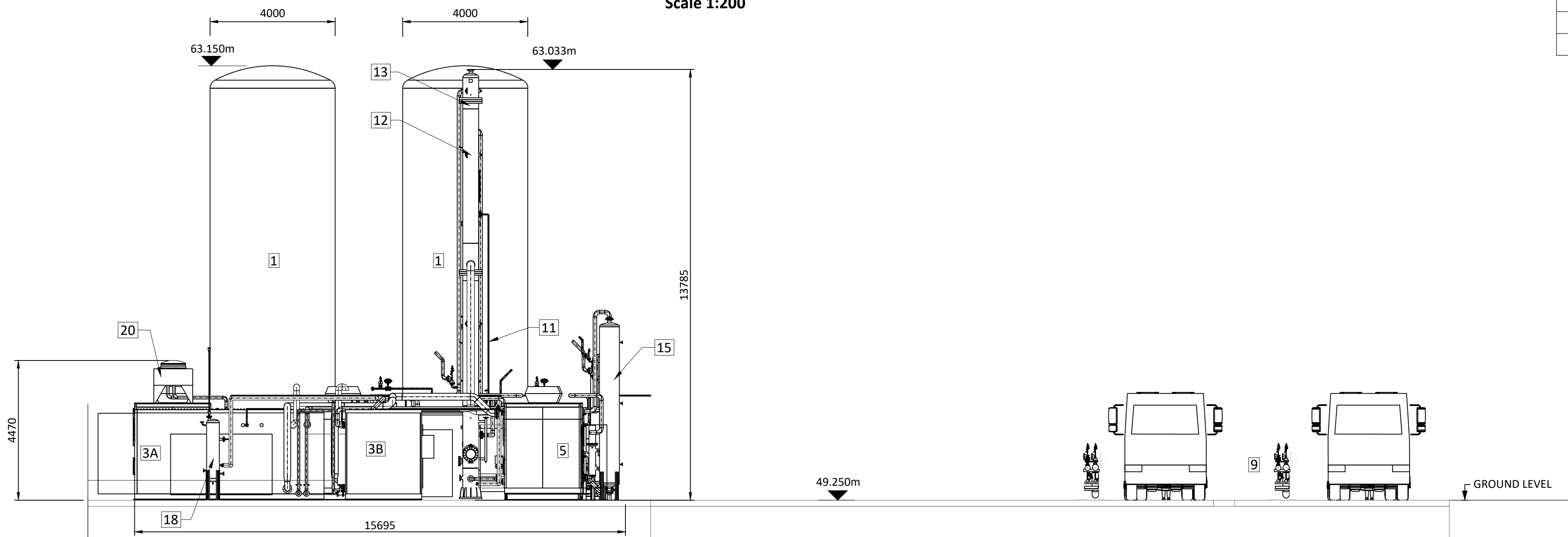
Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT	POWERSTOWN BIOENERGY		CLIENT  Greengate Biogas			
	SHEET	GAS UPGRADE PLANT - PLAN		Date 28.08.25	Project number P24-188	Scale (@ A1) 1:50
		Drawn by NW	Drawing Number P24188-FT-XX-XX-DR-CE-1750		Rev	
		Checked by JON			P01	

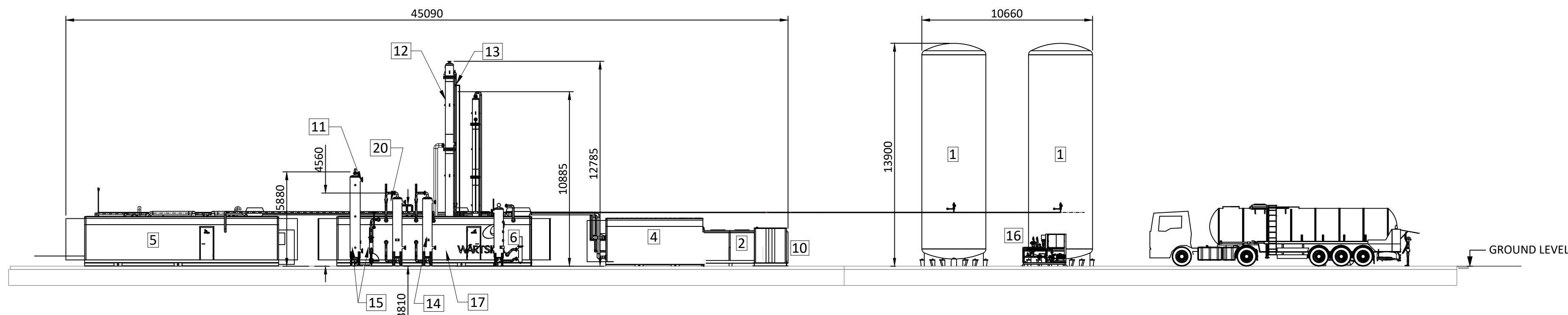
O:\ACAD\2024\P24-188\P24188-FT-XX-XX-DR-CE-1750



PLAN
Scale 1:200



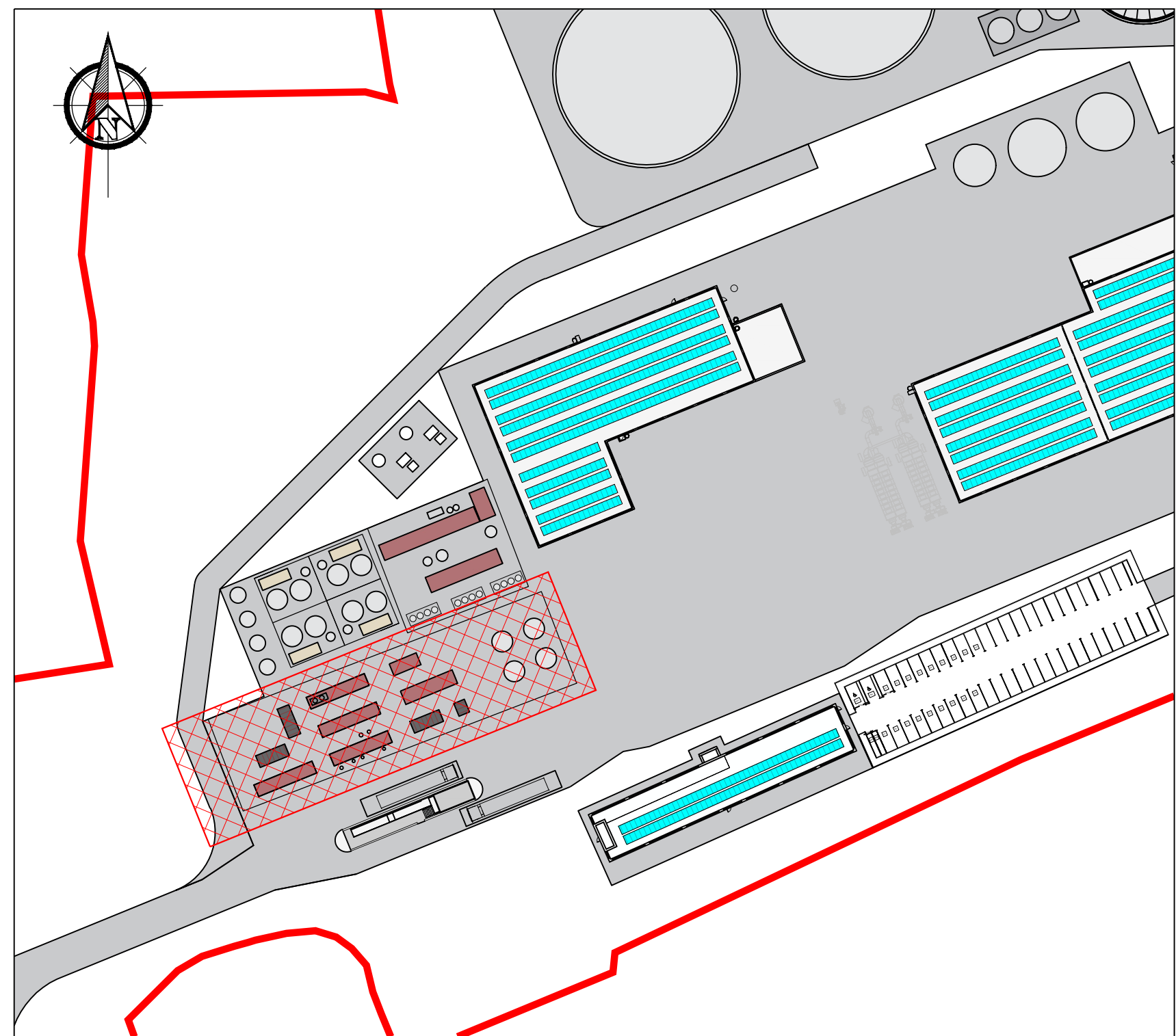
ELEVATION 1 - LOOKING EAST
Scale 1:100



ELEVATION 2 - LOOKING NORTH
Scale 1:200

LCO ₂ PLANT KEYNOTES	
1	LCO ₂ STORAGE TANK
2	Air Cooler
3A	Compressor Container 1
3B	Compressor Container 2
4	Control & MCC Container
5	Process Container 1
6	Process Container 2
7	Process Container 3
8	Refrigeration Container
9	Export Station
10	Analysis Container
11	H ₂ S ADSORBER
12	CO ₂ SCRUBBER
13	CO ₂ DISTILLER
14	Deodouriser
15	Gas Dryer
16	Export Pump Skid
17	Dust Filters
18	Vent Drum
19	Gas Cooler
20	Superheater

Notes:
Drawings for Planning Purposes Only.
Subject to Detailed Mechanical, Electrical and Process Design.
Levels are relative to Malin Head Datum.

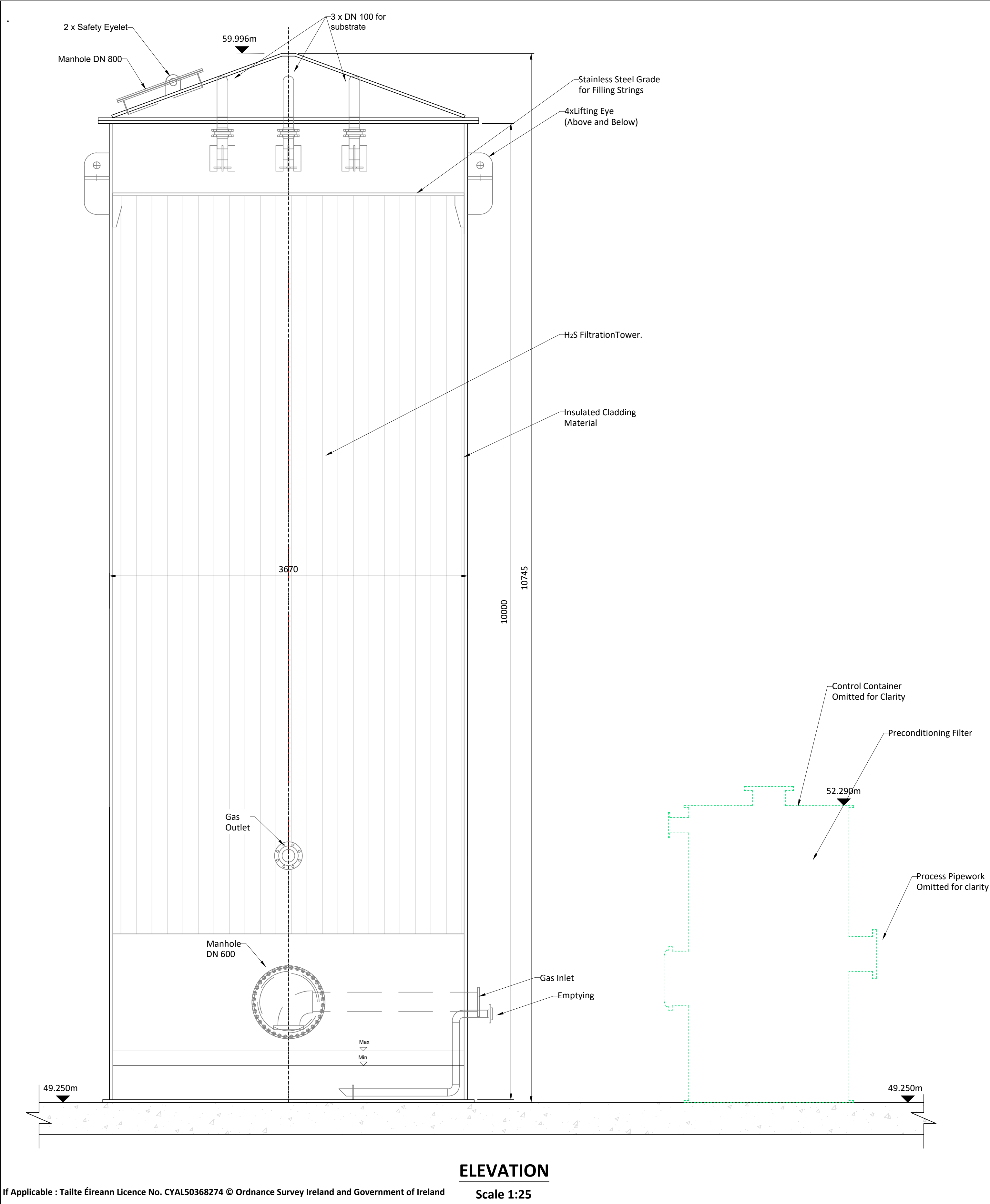


KEYPLAN
Scale 1:1000

If Applicable : Tailte Éireann Licence No. CYAL50368274 © Ordnance Survey Ireland and Government of Ireland

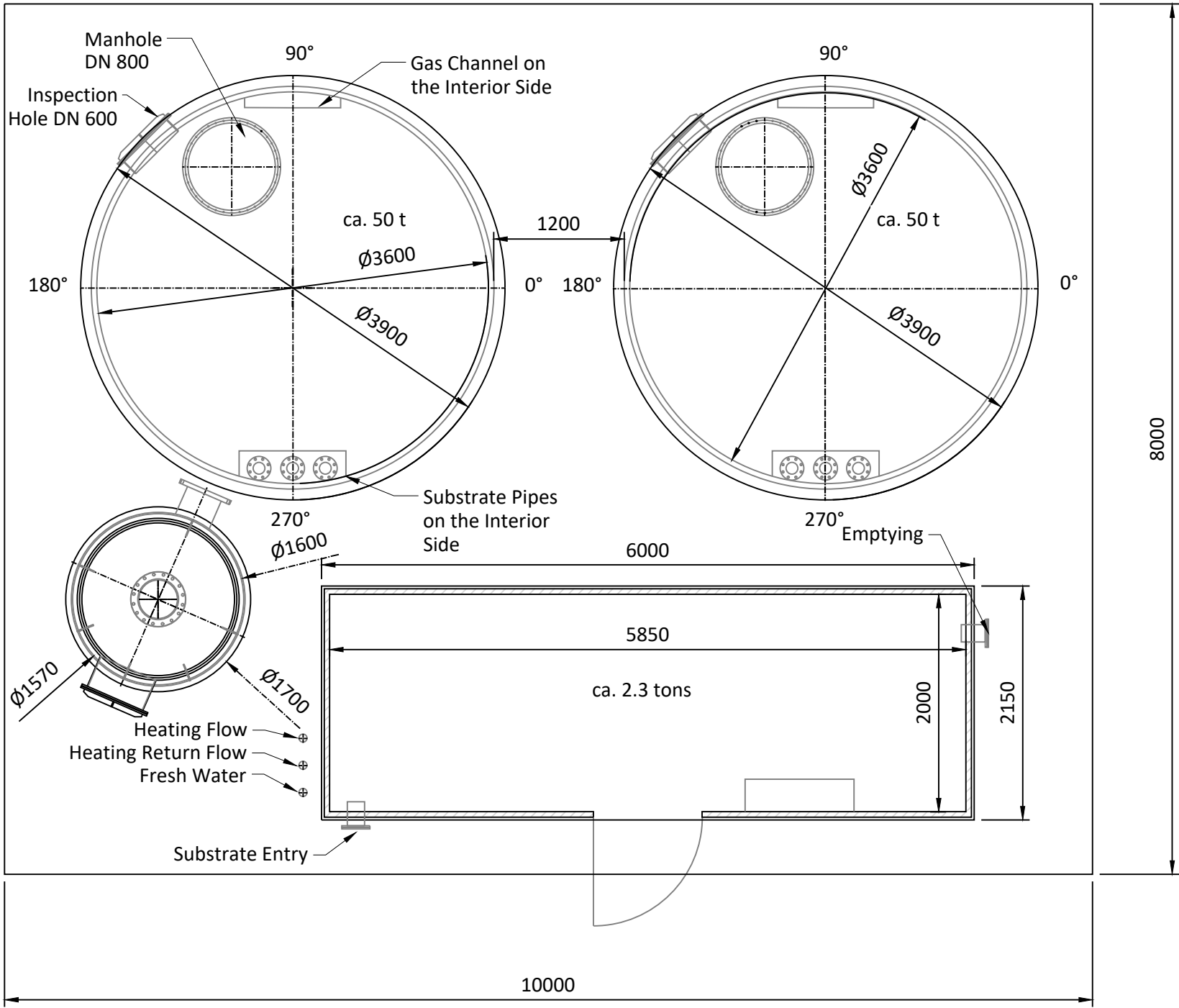
Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT		CLIENT		
POWERSTOWN BIOENERGY				
SHEET		Date	28.08.25	Project number
C02 LIQUEFACTION PLANT: TYPICAL PLAN AND ELEVATIONS		Drawn by	NW	P24-188
		Checked by	JON	Drawing Number
				P24188-FT-XX-XX-DR-CE-1755
				Scale (@ A1) As Shown
				Rev
				P01

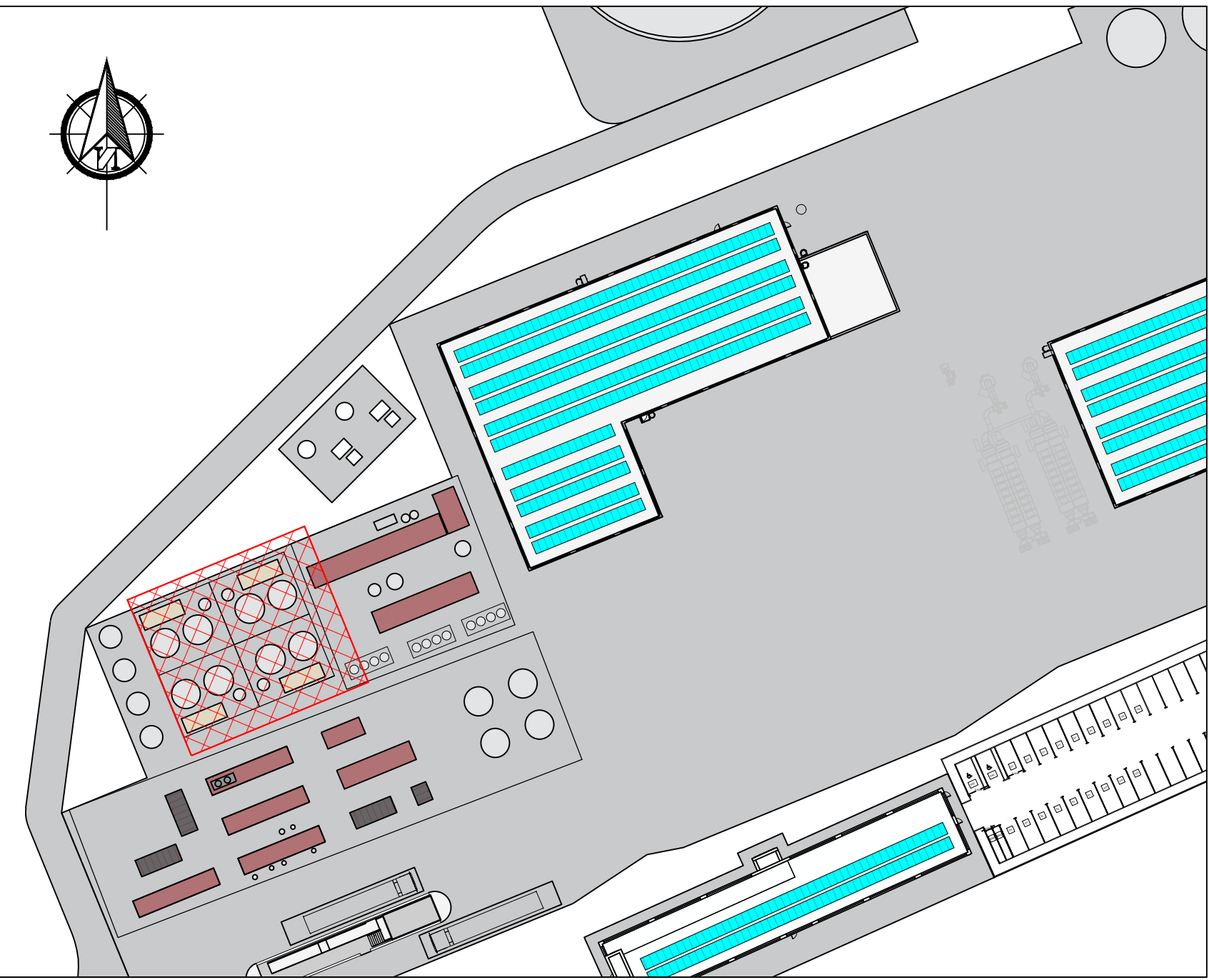
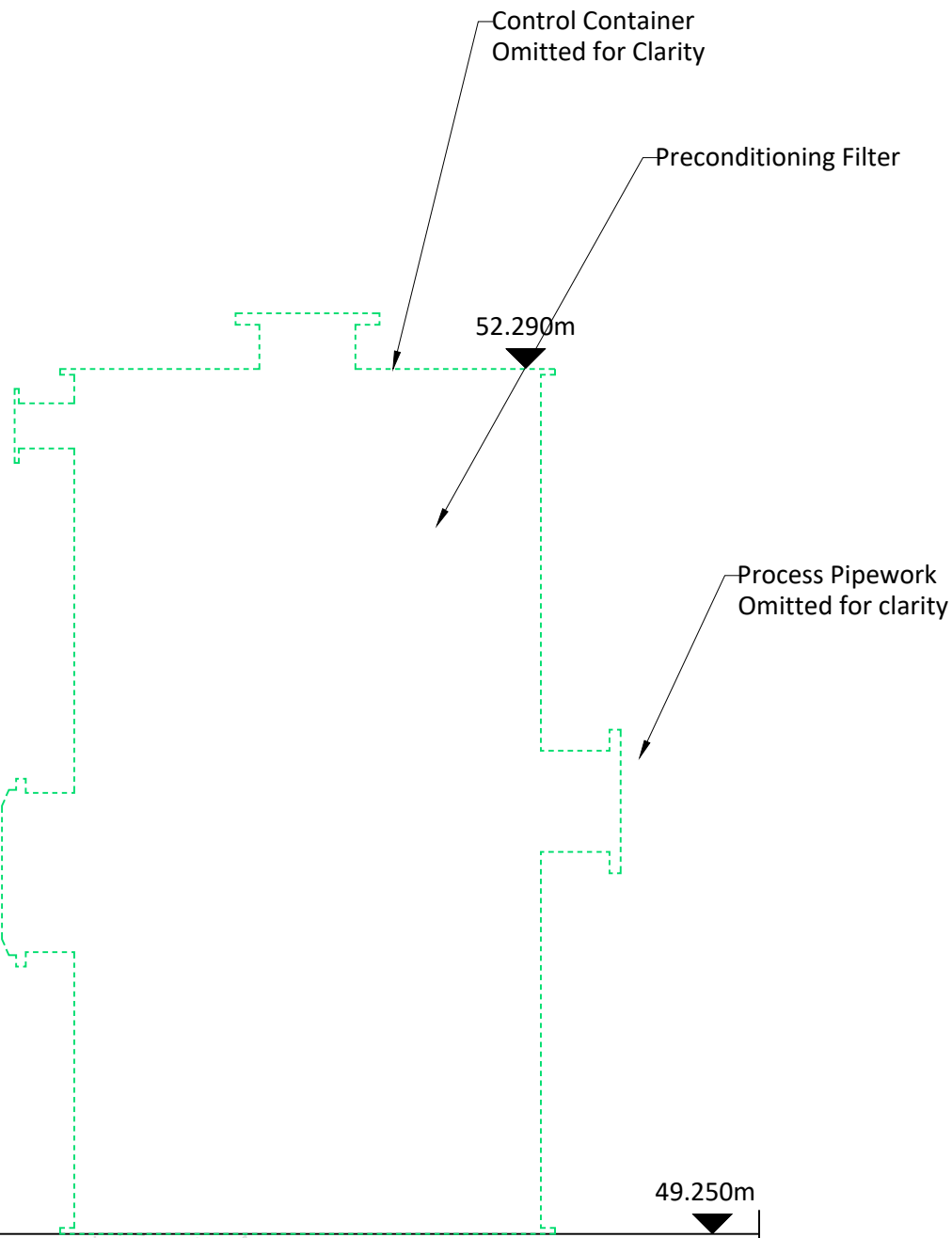


ELEVATION
Scale 1:25

If Applicable : Tailte Éireann Licence No. CYAL50368274 © Ordnance Survey Ireland and Government of Ireland



PLAN
Scale 1:50



KEYPLAN
Scale 1:750

Notes:
Drawings for Planning Purposes Only.
Subject to Detailed Mechanical, Electrical and Process Design.
H₂S Biofilter Towers Typically HDPE with External Insulation Metal Cladding.
Cladding Finish to Match All Other Proposed.
4 No. Sets (2 x Towers) Proposed Plus Control Container.
Levels are relative to Malin Head Datum.

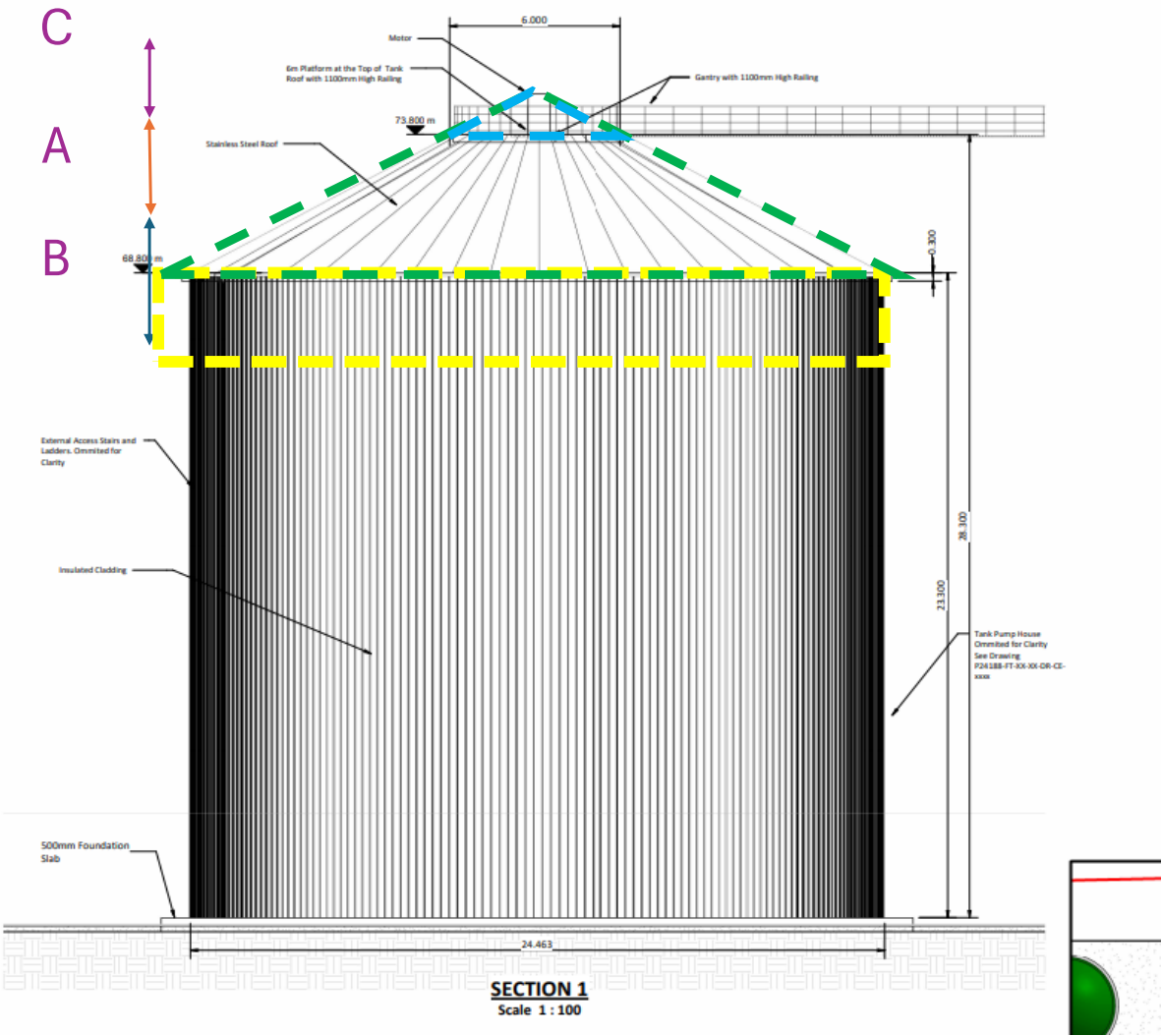


**TYPICAL DE-SULPHURISATION TANKS (N.T.S.)
(CONTROL CONTAINER FOREGROUND,
2 No. HDPE FILTRATION TOWERS)**

Rev.	Description	App By	Date
P01	ISSUE FOR PLANNING	JON	18.06.26

PROJECT	CLIENT		
POWERSTOWN BIOENERGY	Greengate Biogas		
SHEET	Date 28.08.25	Project number P24-188	Scale (@ A1) 1:50
DESULPHURISATION PLANT: TYPICAL PLAN AND ELEVATIONS	Drawn by NW	Drawing Number P24188-FT-XX-XX-DR-CE-1760	Rev P01
	Checked by JON		

Primary and Secondary Digesters



Heights	m
A	5.00
B - Assumed Freeboard Height	0.70
C	1.625

Widths	m
Tank bottom width	24.500
Tank top width	6.00
Wall Width	0.30
Radius of cylinder	11.95

Volume	m³	Calculation method
Yellow	314.04	Cylinder
Blue Cone	15.32	
Green Cone	990.72	
Tip Volume	975.40	Green cone - Blue cone
Total	1,289.44	Tank + Tip

	Number of tanks	Total Volume Untreated Biogas
Primary Digesters	6.00	7,736.65
Secondary Digesters	3.00	3,868.33

Calculation Sheet

a) The free height (height above the liquid) in the cylinder body of the digester (m).

0.7 m

b) Internal cap radius (m).

12.23 m

c) Cap Type

Truncated solid cone cap

d) Dome height (m)

5 m

Volume of cone cap

$h_1 = 6.625$ m

$r_1 = 11.95$ m

$V_1 = 990.72$ m³

$$V = (1/3)\pi hr^2$$

$h_2 = 1.625$ m

$r_2 = 3$ m

$V_2 = 15.32$ m³

$V = V_1 - V_2 = 1,022.63$ m³

Volume of cylindrical freeboard

$h = 0.75$ m

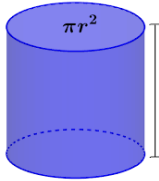
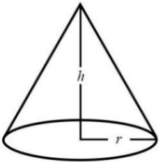
$r = 11.95$ m

$V = 314.04$ m³

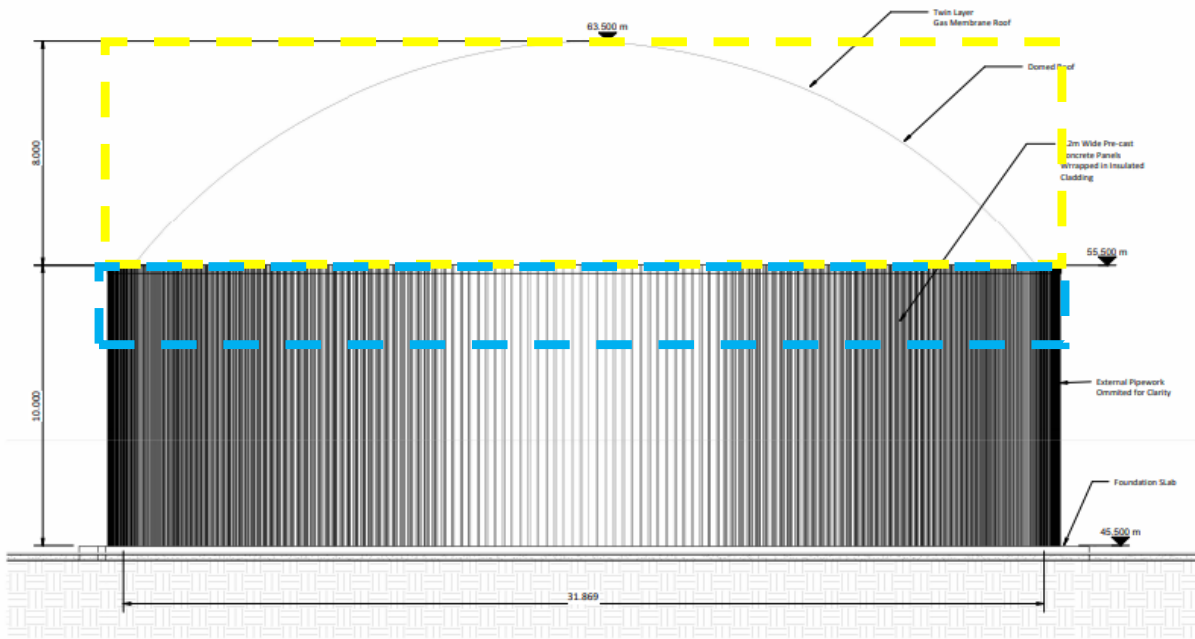
$$V = \pi r^2 \times h$$

Total Volume

$V = 1,289.44$ m³



Tertiary Tank



SECTION 1
Scale 1 : 100

Heights	m
Tank freeboard	0.75
Dome Height	8.00

Widths	m
Tank bottom width	32.87
Wall Width	0.50
Radius	15.935

Volume	m³	Calculation method
Yellow	4,254.27	1/2 ellipsoid
Blue	598.26	Cylinder
Total Volume	4,852.53	

	Number of tanks	Total Volume Untreated Biogas
Tertiary Digesters	1.00	4,852.53
Post Storage Tank	1.00	4,852.53
Liquid Pre Storage Tank	1.00	4,852.53

Calculation Sheet

a) The free height (height above the liquid) in the cylinder body of the digester (m).

0.75 m

b) Internal dome radius (m).

15.935 m

c) Cap Type

Ellipsoid

d) Dome height (m)

8 m

Volume of ellipsoid cap

$$V = \frac{4}{3} \times \pi \times a \times b \times c$$

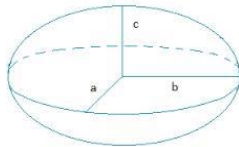
It's half of this so the formula by 0.5

a= 15.935 m

b= 15.935 m

c = 8 m

V = 4,254.27 m³



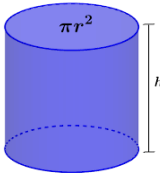
Volume of cylindrical freeboard

h = 0.75 m

r = 15.935 m

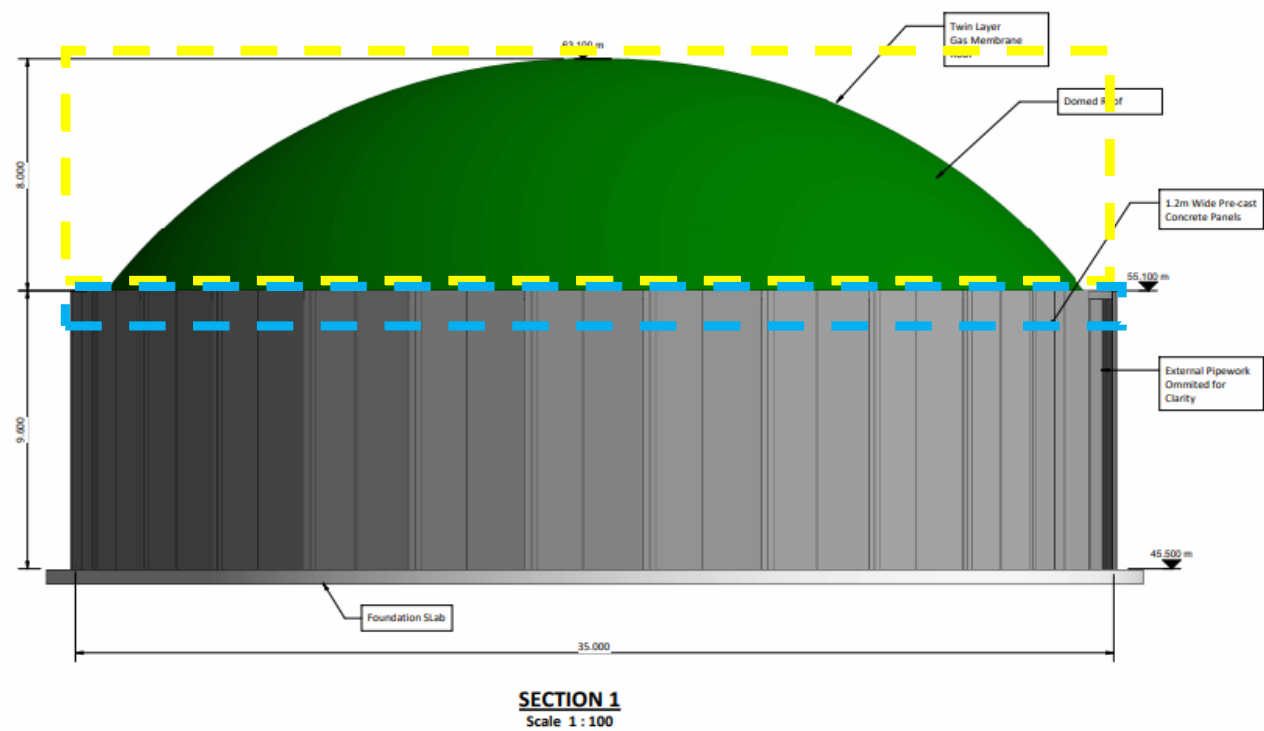
V = 598.26 m³

$$V = \pi r^2 \times h$$



Total Volume

Digestate Storage Tank



Heights	m
Tank freeboard	0.75
Dome	8.00

Widths	m
Internal tank diameter	35.00
Dome Base	34.00
Wall	0.50
Tank Base Radius	17.00
Dome Base Radius	17.00

Volume	m³	Calculation method
Yellow	4,842.24	1/2 Ellipsoid
Blue	680.94	Cylinder
Total Volume	5,523.18	

	Number of tanks	Total Volume Untreated Biogas
Digestate Storage Tank	1.00	5,523.18

Calculation Sheet

a) The free height (height above the liquid) in the cylinder body of the digester (m).

0.75 m

b) Internal dome radius (m).

17 m

c) Cap Type

Ellipsoid

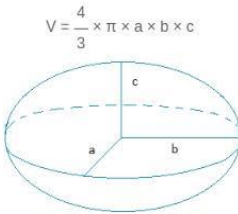
d) Dome height (m)

8 m

Volume of ellipsoid cap

It's half of this so the formula by 0.5

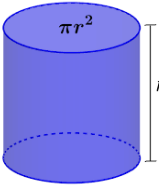
a= 17 m
b= 17 m
c = 8 m
V = 4,842.24 m³



Volume of cylindrical freeboard

h = 0.75 m
r = 17 m
V = 680.94 m³

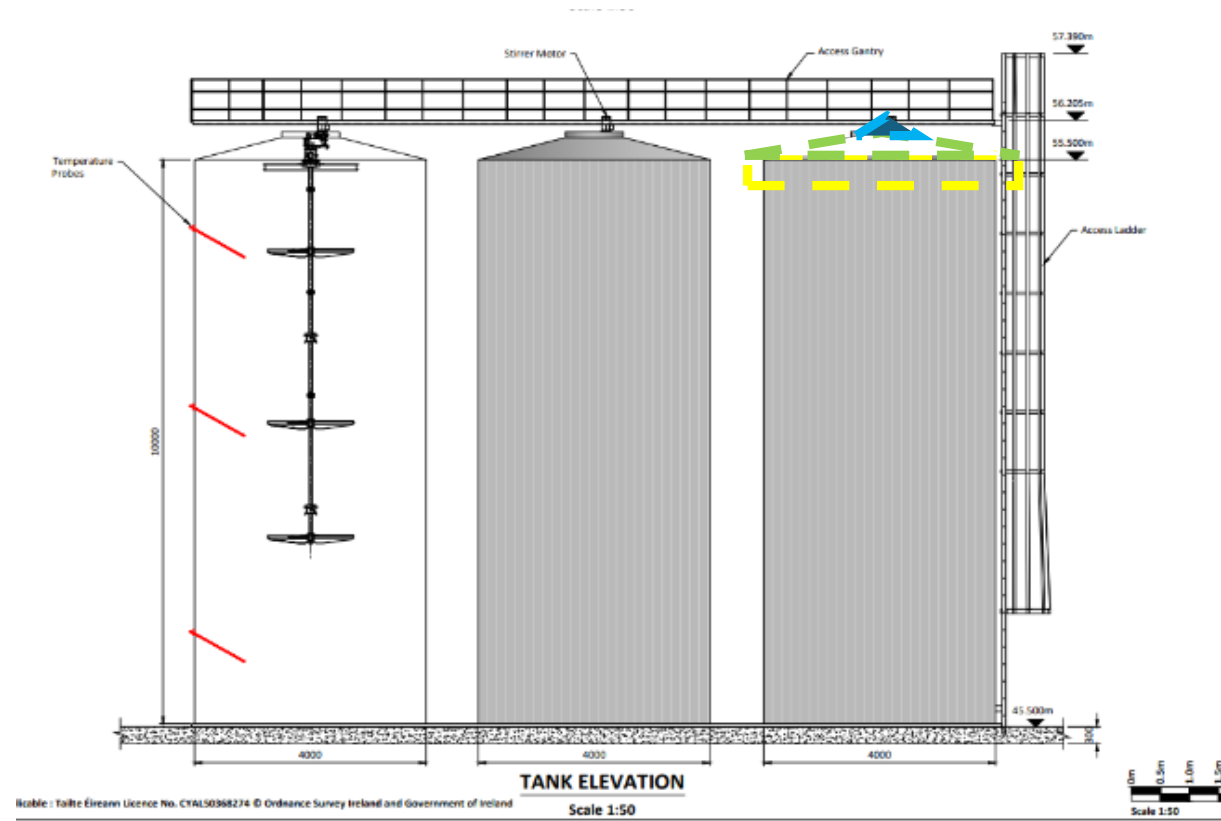
$$V = \pi r^2 \times h$$



Total Volume

V = 5,523.18 m³

Pastuerisation Tanks



Heights	m
Roof	0.70
Tank Freeboard	1.00
Height of Blue Cone	0.175

Widths	m
Tank bottom	4.000
Tank top	1.00
Wall	0.25
Radius of cylinder	2.00

Volume	m³	Calculation method
Yellow	9.62	Cylinder
Blue Cone	0.05	
Green Cone	2.95	Assumed wall thickness is negligible
Tip Volume	2.91	Green cone - Blue cone
Total	12.53	Tank + Tip

	Number of tanks	Total Volume Untreated Biogas
Pastuerisation	3.00	37.59

Calculation Sheet

a) The free height (height above the liquid) in the cylinder body of the digester (m).

1 m

b) Internal cap radius (m).

2 m

c) Cap Type

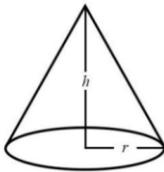
Truncated solid cone cap

d) Dome height (m)

0.7 m

Volume of cone cap

$$h_1 = 0.175 \text{ m}$$
$$r_1 = 0.5 \text{ m}$$
$$V_1 = 0.05 \text{ m}^3$$
$$V = (1/3)\pi hr^2$$

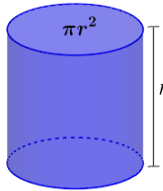


$$h_2 = 0.7 \text{ m}$$
$$r_2 = 2 \text{ m}$$
$$V_2 = 2.95 \text{ m}^3$$

$$V = V_1 - V_2 = 12.53 \text{ m}^3$$

Volume of cylindrical freeboard

$$h = 1 \text{ m}$$
$$r = 1.75 \text{ m}$$
$$V = 9.62 \text{ m}^3$$
$$V = \pi r^2 \times h$$



Total Volume

$$V = 12.53 \text{ m}^3$$

Installation	Dangerous substance	No.	% methane	% CO2	Maximum Volume m3	Temperature oC	Pressure	Density, kg/m ³ (Note 1)	Mass, kg	Mass, tonnes
Primary Digesters	Untreated biogas	6	56 - 58	42 - 44	7,736.65	48 - 55 Assume 48 degC	5 - 15 mbarg Assume 15 mbarg	0.859	6,646.54	6.647
Secondary Digesters	Untreated biogas	3	56 - 58	42 - 44	3,868.33	48 - 55 Assume 48 degC	5 - 15 mbarg Assume 15 mbarg	0.859	3,323.27	3.323
Tertiary Digesters	Untreated biogas	1	56 - 58	42 - 44	4,852.53	48 - 55 Assume 48 degC	5 mbarg	0.859	4,168.80	4.169
Post Storage Tank	Untreated biogas	1	56 - 58	42 - 44	4,852.53	48 - 55 Assume 48 degC	5 - 15 mbarg Assume 15 mbarg	0.859	4,168.80	4.169
Liquid Pre Storage Tank	Untreated biogas	1	56 - 58	42 - 44	4,852.53	Ambient Assume 10 degC	5 - 15 mbarg Assume 15 mbarg	0.975	4,733.33	4.733
Digestate Storage Tank	Untreated biogas	1	56 - 58	42 - 44	5,523.18	Ambient Assume 10 degC	5 mbarg	0.966	5,334.96	5.335
Pastuerisation	Untreated biogas	3	56 - 58	42 - 44	37.59	48 - 55 Assume 48 degC	Assume 15 mbar	0.859	32.29	0.032

Total Untreated biogas in vessels		28.4080
-----------------------------------	--	---------

Pipeline	Dangerous substance	Diameter mm	Diameter m	Length m	Volume m3	Temperature °C	Pressure mbar	Density, kg/m ³ (Note 1)	Mass, kg	Mass, tonnes
Pipes from primary and secondary digesters	Untreated biogas	250	0.25	252	12.370	48 - 55 Assume 48	20	0.863	10.679	0.0107
Pipes between gas storage in tertiary and storage tanks	Untreated biogas	300	0.3	72	5.089	48 - 55 Assume 48	20	0.863	4.394	0.0044
Pipes from tertiary digestors and storage tanks to main gas line	Untreated biogas	400	0.4	159	19.981	48 - 55 Assume 48	20	0.863	17.249	0.0172
Main gas line to desulphurisation columns	Untreated biogas	400	0.4	498	62.581	Cooling to 30 degC in this line	150	1.030	64.480	0.0645
Line to flare	Untreated biogas	400	0.4	30	3.770	30	100	0.986	3.717	0.0037
Desulphurisation to GAC lines	Untreated biogas	250	0.25	92	4.516	30	100	0.986	4.453	0.0045
GAC to Gas Upgrader	Untreated biogas	250	0.25	68	3.338	30	100	0.986	3.291	0.0033
Gas Upgrader to BNEF	Upgraded biogas (methane)	250	0.25	162	3.878	20	4000	3.330	12.913	0.0129
BNEF to flare (reject biomethane)	Upgraded biogas (methane)	400	0.4	261	32.798	20	4000	3.330	109.213	0.1092

Pipeline	Dangerous substance	Diameter mm	Diameter m	Length m	Volume m3	Temperature °C	Pressure mbar	Density, kg/m ³ (Note 1)	Mass, kg	Mass, tonnes
BNEF to gas network connection (portion within COMAH boundary)	Upgraded biogas (methane)	250	0.25	45	2.209	20	4000	3.330	7.355	0.0074

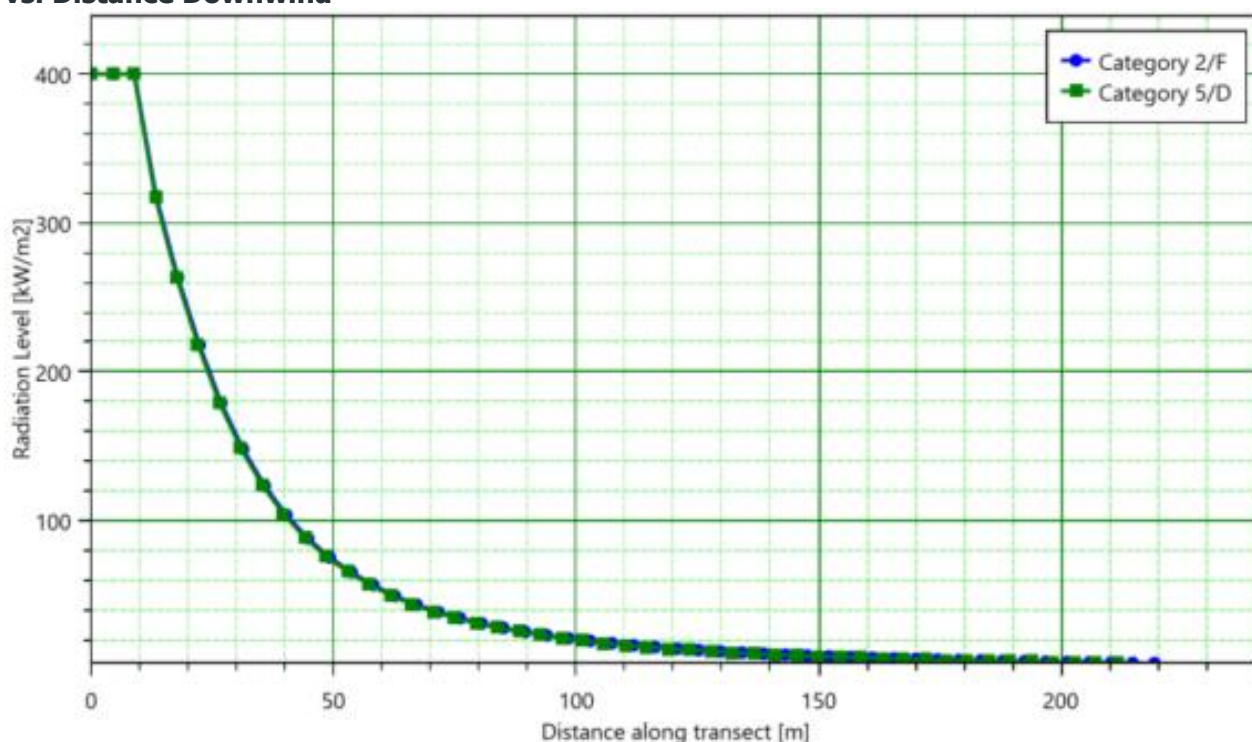
Total untreated (raw) biogas in pipelines	0.1005
Total upgraded biogas (renewable natural gas) in pipelines	0.1372
Total untreated (raw) biogas on site	28.508
Total upgraded biogas (renewable natural gas) on site	0.1372

Note 1. Density calculated using DNV PHAST materials calculator tool

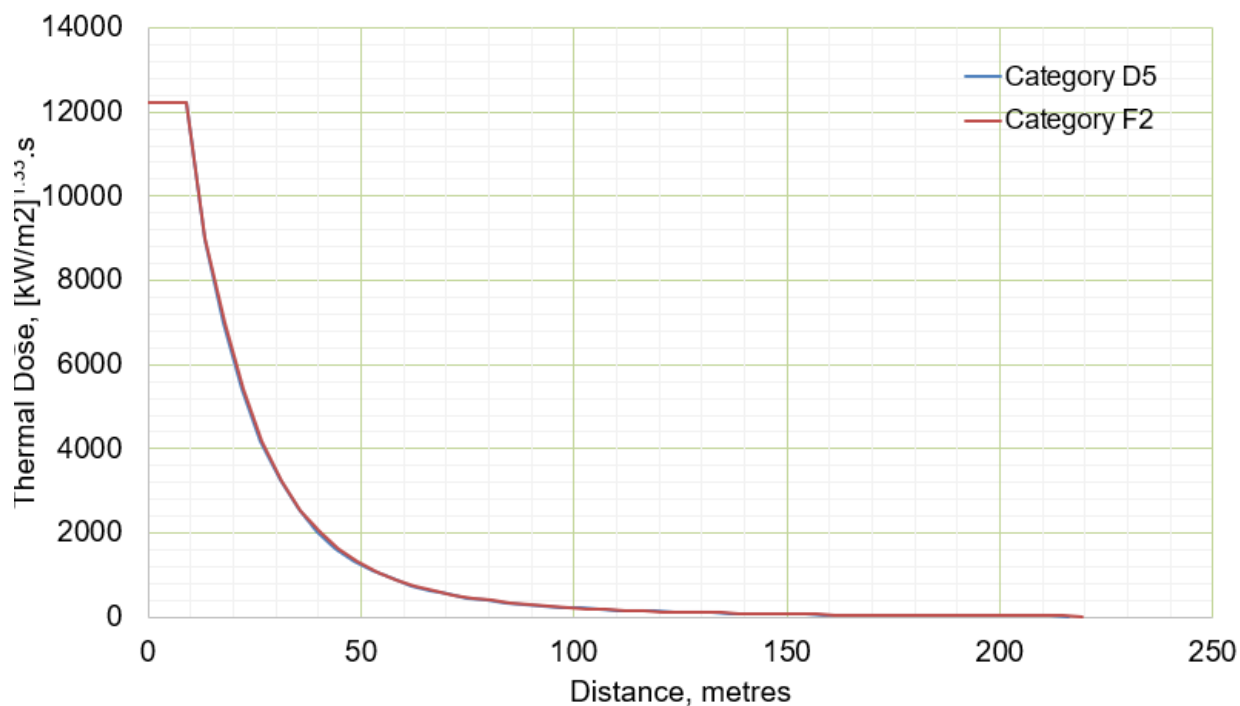
APPENDIX C. CONSEQUENCE MODELLING CURVES

Installation	Primary/Secondary Digester
Scenario	Untreated Biogas Instantaneous Release
Software/model	DNV PHAST Version 9.1 Catastrophic rupture and Unified Dispersion Models Fireball Static (HSE) Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	1,289.44 m ³ of methane at 15 mbarg and 55 degC 26.7 metre fireball radius (D5/F2), 4.15 second duration (D5/F2) Release height is at top of tank wall, 23.3 m above local ground level or 68.8 mOD Receptor height is 57 m OD, or 1 m above ground level at the civic amenity site to the east
Vapour cloud explosion source term	Flammable mass 134.3/130.7 kg at source of release (confined region), Category D5/F2

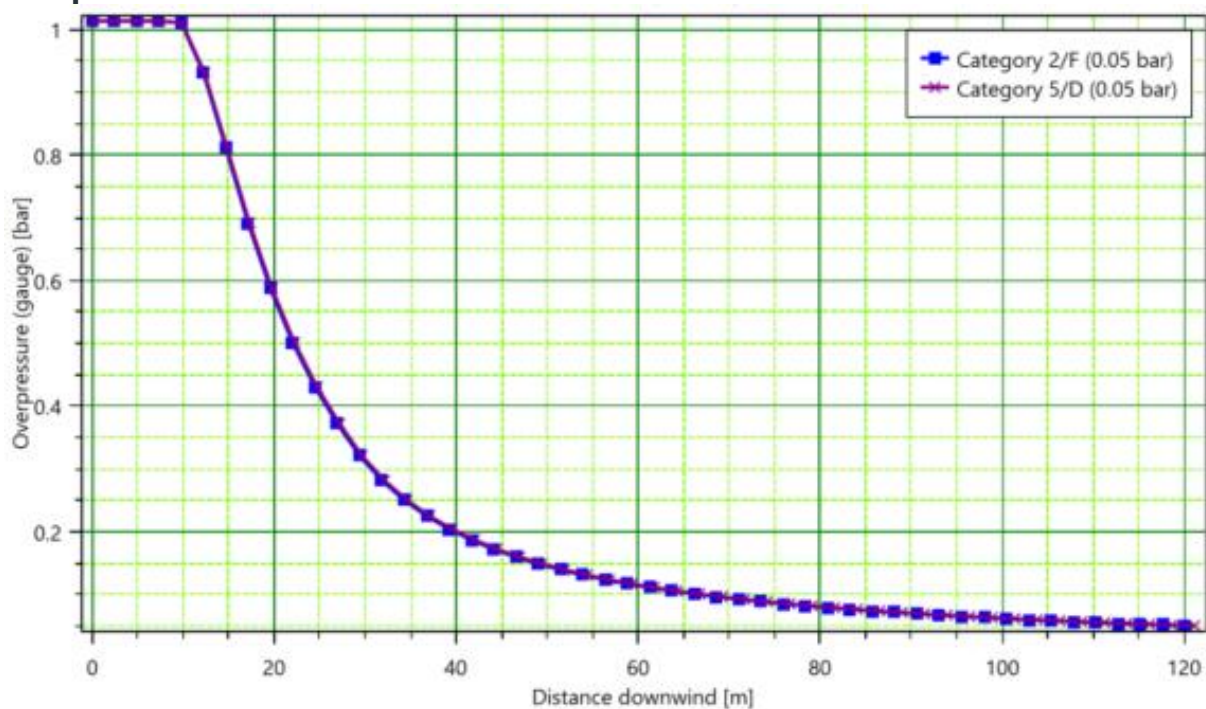
Appendix Figure C-1. Primary/Secondary Digester Rupture and Fireball: Thermal Radiation vs. Distance Downwind



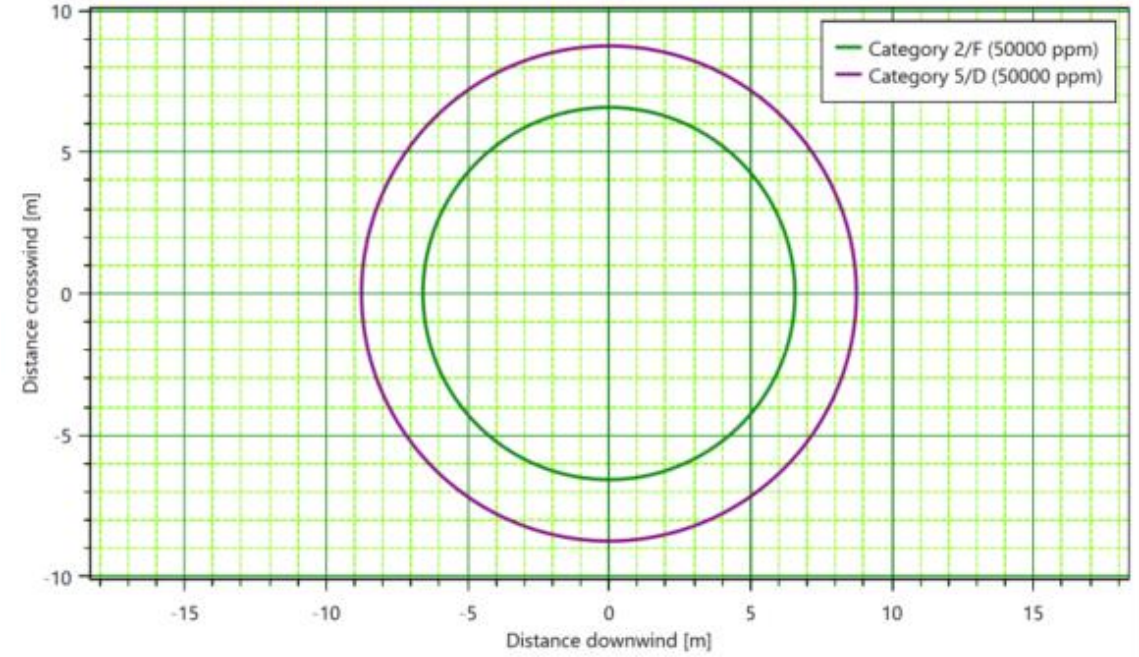
Appendix Figure C-2. Primary/Secondary Digester Rupture and Fireball: Thermal Dose vs. Distance Downwind



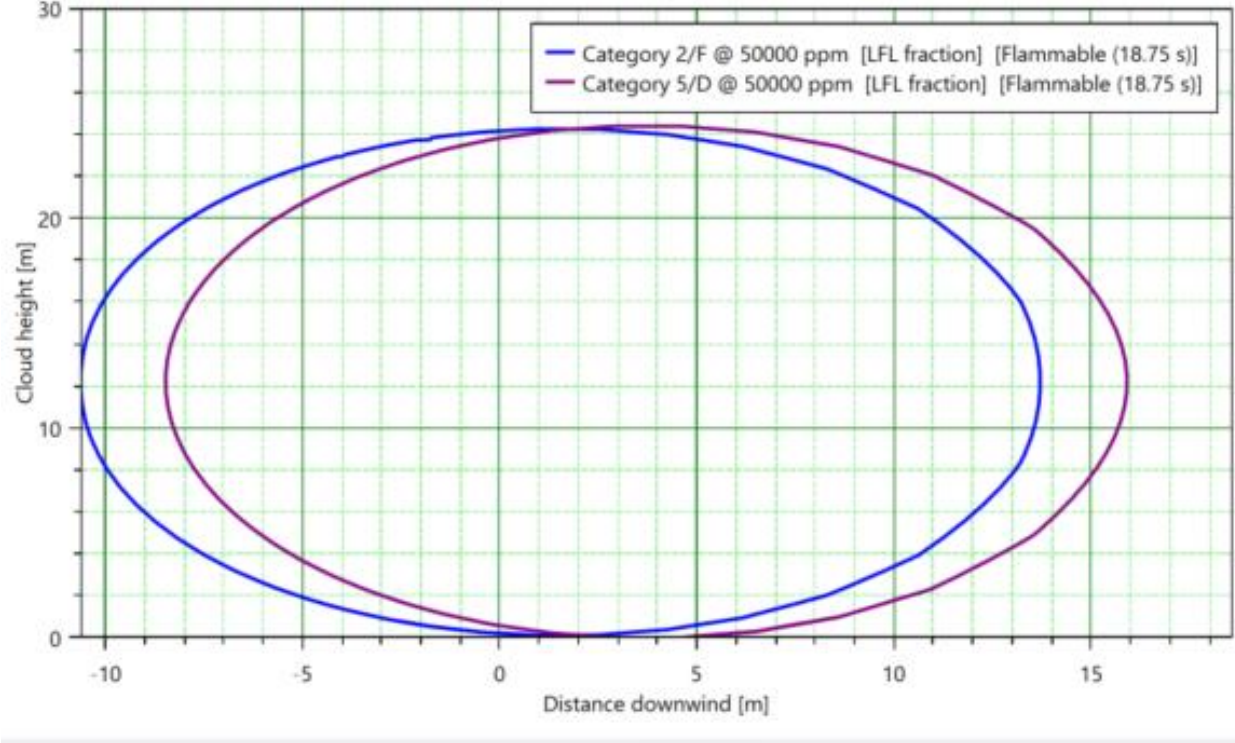
Appendix Figure C-3. Primary/Secondary Digester Rupture and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



Appendix Figure C-4. Primary/Secondary Digester Rupture and Flash Fire: Flash Fire Envelope at receptor height of 57 m O.D.

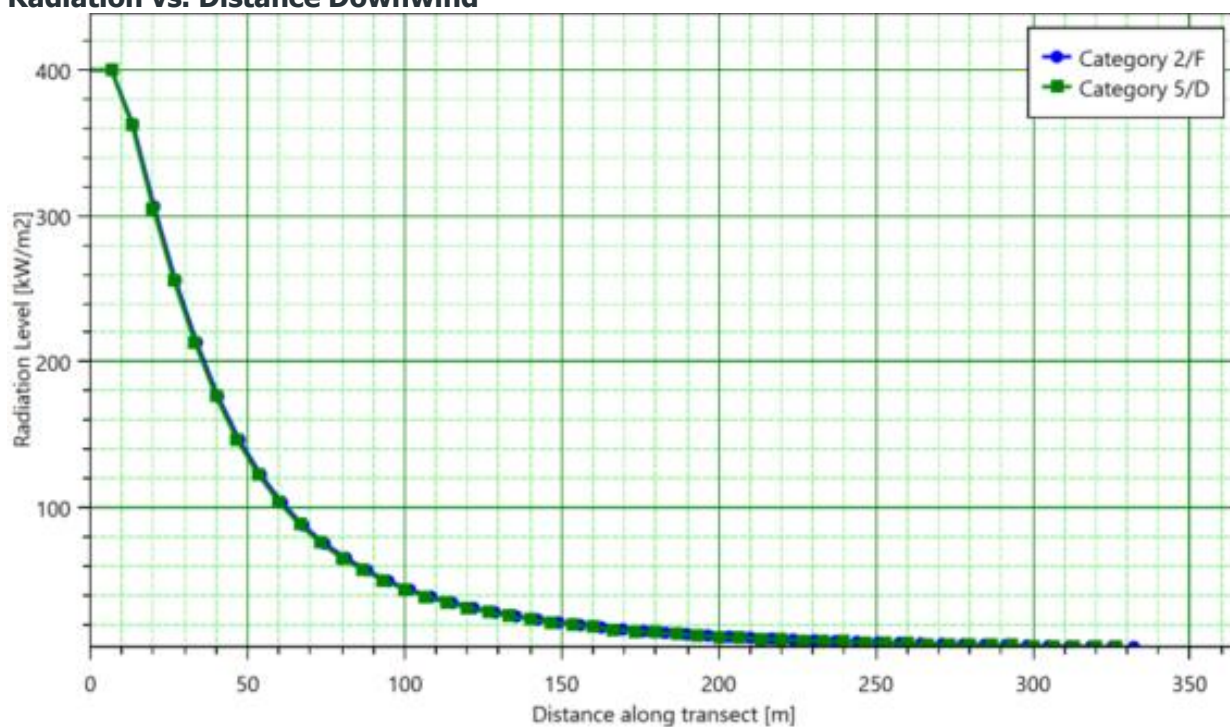


Appendix Figure C-5. Primary/Secondary Digester Rupture and Flash Fire: Dispersion Side View

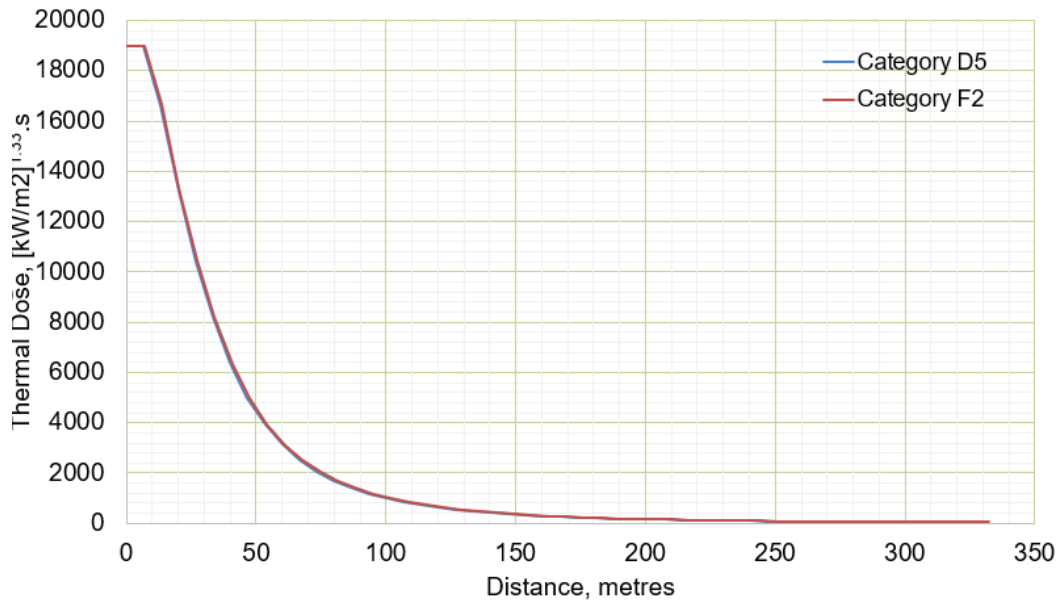


Installation	Tertiary Digester/Post Digestate Storage Tank
Scenario	Untreated Biogas Instantaneous Release
Software/model	DNV PHAST Version 9.1 Catastrophic rupture and Unified Dispersion Models Fireball Static (HSE) Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	4,852.53 m ³ of methane at 15 mbarg and 55 degC 41.5 metre fireball radius (D5/F2), 6.4 second duration (D5/F2) Release height is at top of tank wall, 10 m above local ground level or 55.5 mOD Receptor height is 57 m OD, or 1 m above ground level at the civic amenity site to the east
Vapour cloud explosion source term	Flammable mass 483.7/476.9 kg at source of release (confined region), Category D5/F2

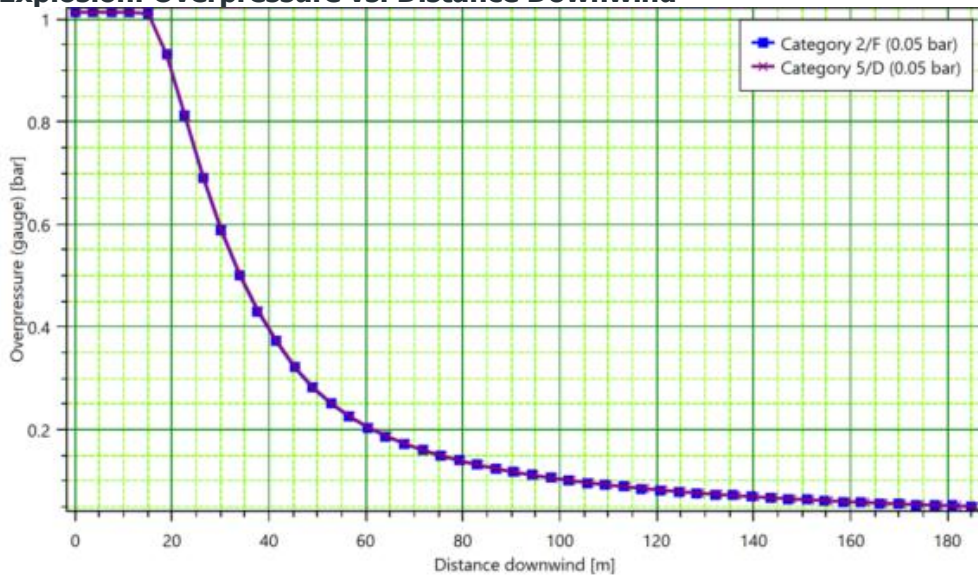
Appendix Figure C-6. Tertiary Digester/Post Digestate Tank Rupture and Fireball: Thermal Radiation vs. Distance Downwind



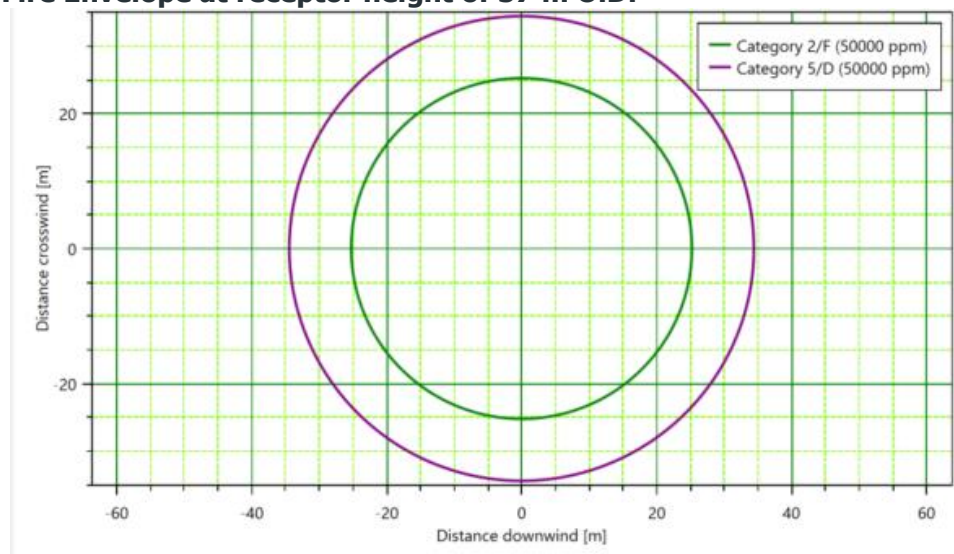
Appendix Figure C-7. Tertiary Digester/Post Digestate Tank Rupture and Fireball: Thermal Dose vs. Distance Downwind



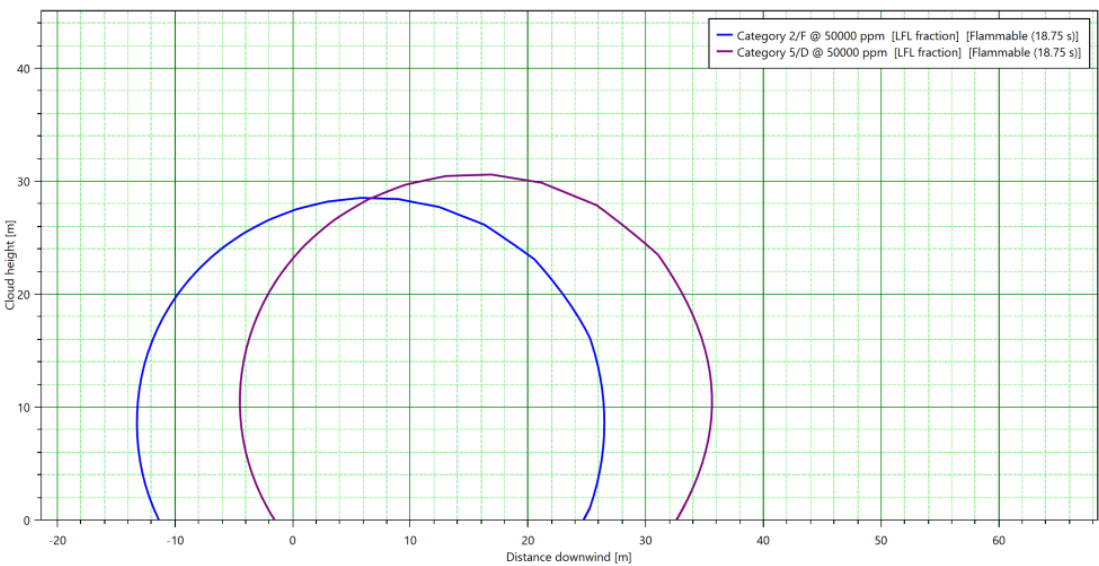
Appendix Figure C-8. Tertiary Digester/Post Digestate Tank Rupture and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



Appendix Figure C-9. Tertiary Digester/Post Digestate Tank Rupture and Flash Fire: Flash Fire Envelope at receptor height of 57 m O.D.

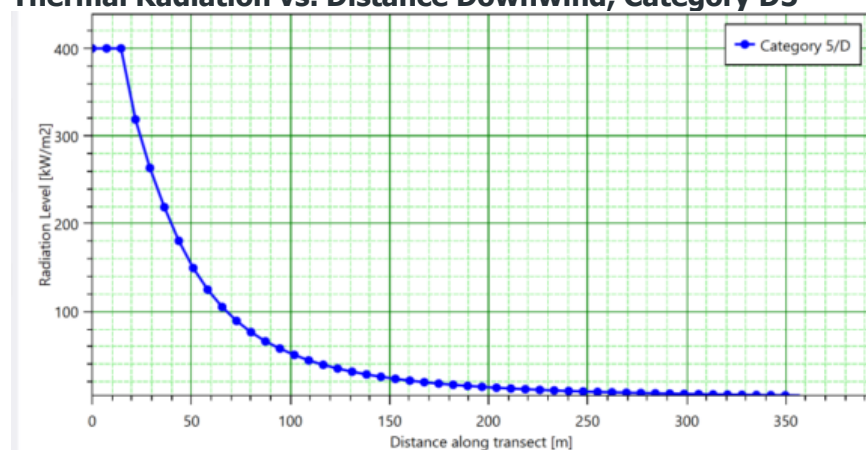


Appendix Figure C-10. Tertiary Digester/Post Digestate Tank Rupture and Flash Fire: Dispersion Side View

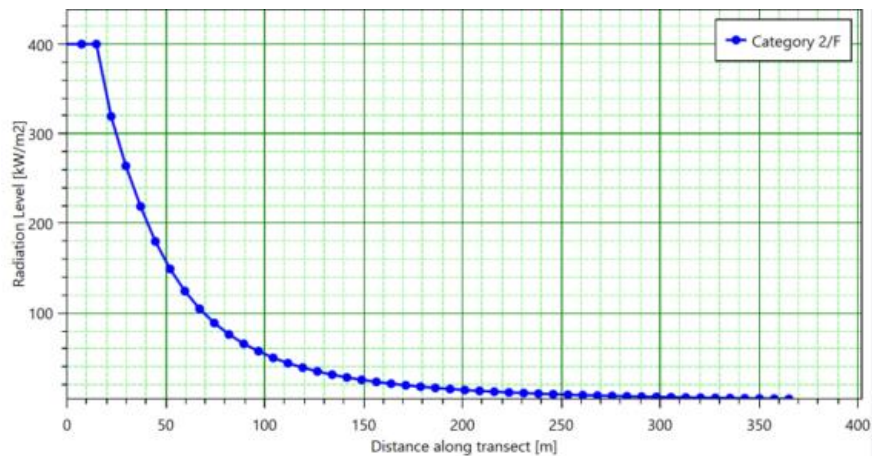


Installation	Digestate Storage/Liquid Pre Storage Tank
Scenario	Untreated Biogas Instantaneous Release
Software/model	DNV PHAST Version 9.1 Catastrophic rupture and Unified Dispersion Models Fireball Static (HSE) Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	5,523.18 m ³ of methane at 5 mbarg and ambient temperature 5.7 metre fireball radius (D5/F2), 0.9 second duration (D5/F2) Release height is at top of tank wall, 9.6 m above local ground level or 55.1 mOD Receptor height is 57 m OD, or 1 m above ground level at the civic amenity site to the east
Vapour cloud explosion source term	Flammable mass 1.3/1.2 kg at source of release (confined region), Category D5/F2

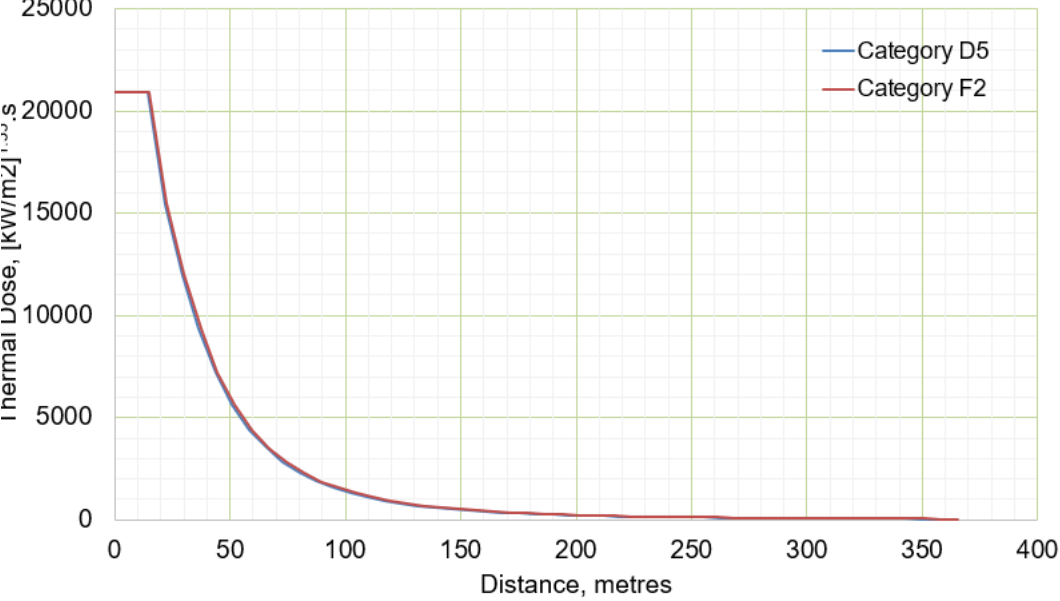
Appendix Figure C-11. Digestate Storage/Liquid Pre Storage Tank Rupture and Fireball: Thermal Radiation vs. Distance Downwind, Category D5



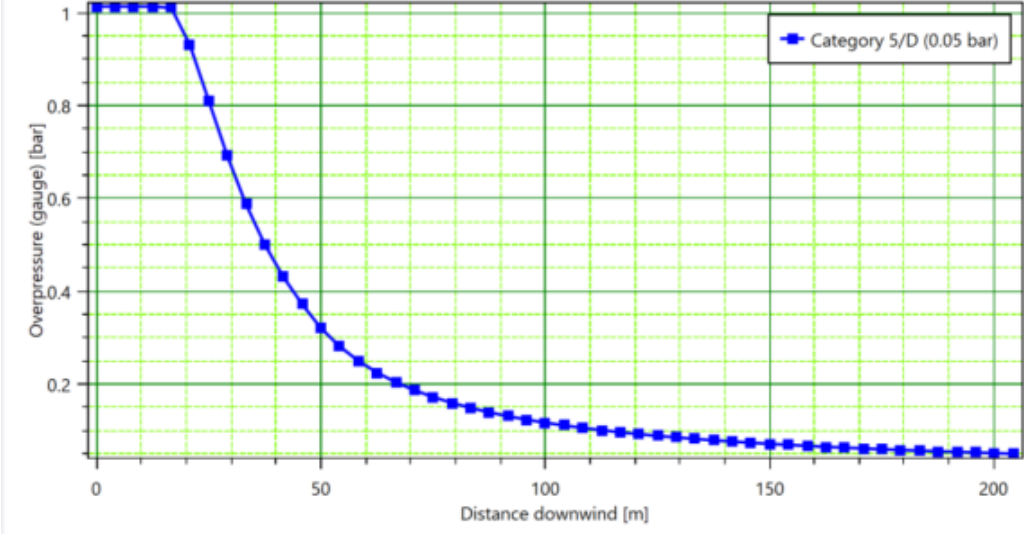
Appendix Figure C-12. Digestate Storage/Liquid Pre Storage Tank Rupture and Fireball: Thermal Radiation vs. Distance Downwind, Category F2



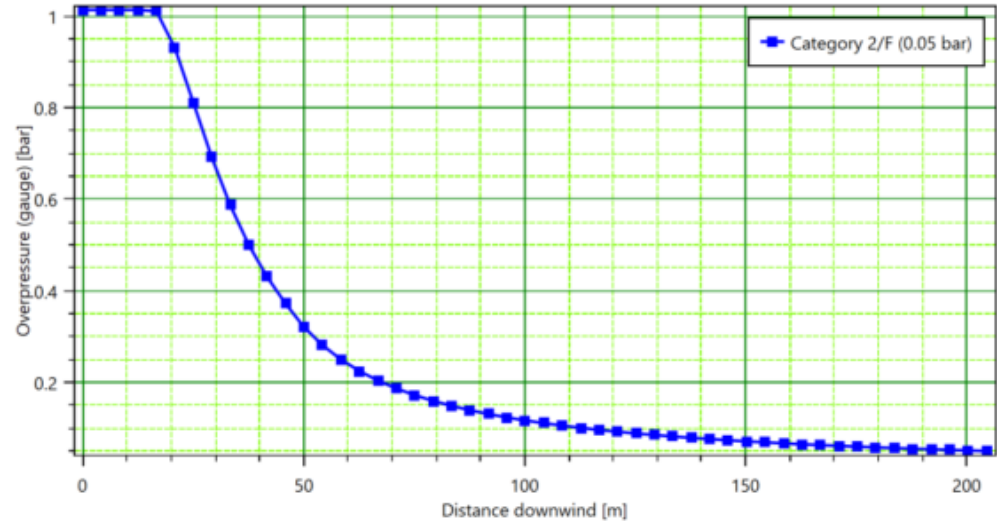
Appendix Figure C-13. Digestate Storage/Liquid Pre Storage Tank Rupture and Fireball: Thermal Dose vs. Distance Downwind



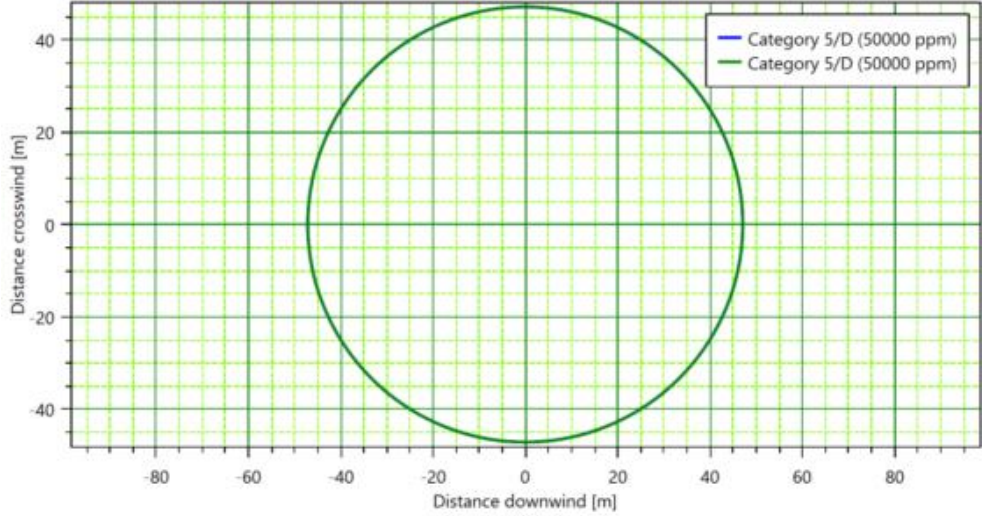
Appendix Figure C-14. Digestate Storage/Liquid Pre Storage Tank Rupture and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



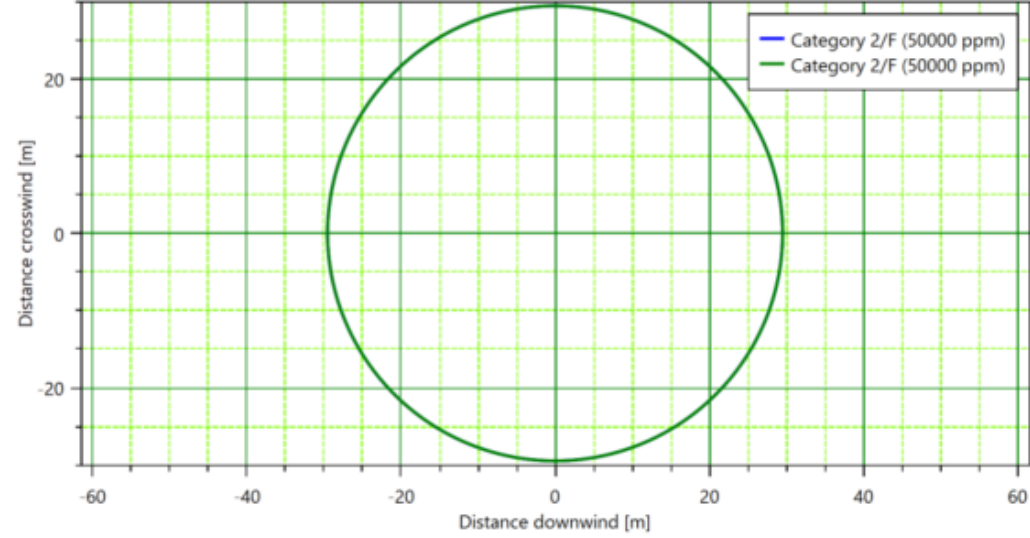
Appendix Figure C-15. Digestate Storage/Liquid Pre Storage Tank Rupture and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



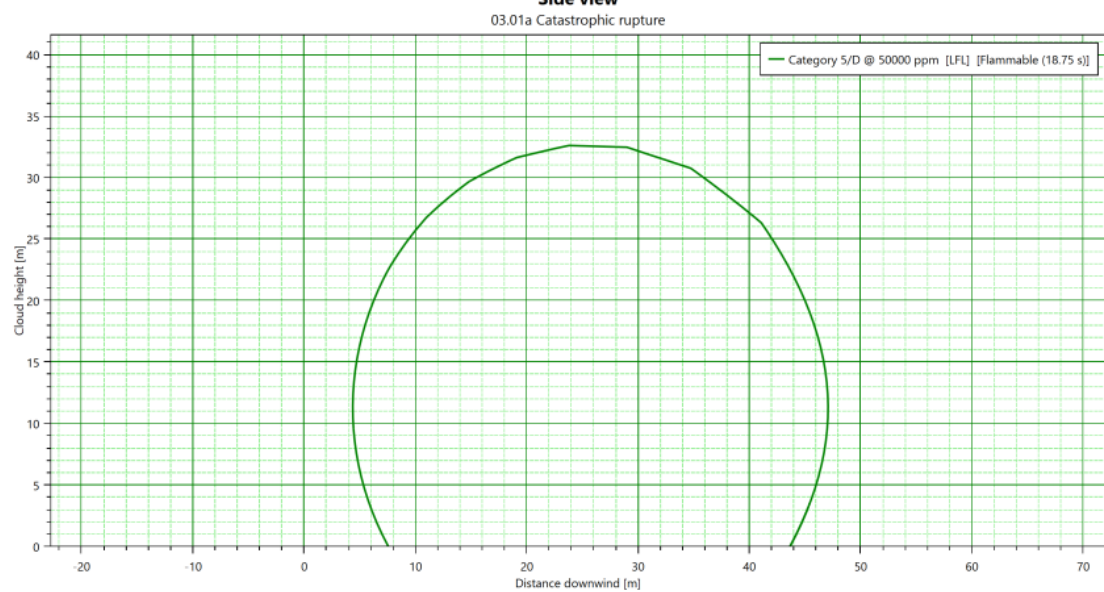
Appendix Figure C-16. Digestate Storage/Liquid Pre Storage Tank Rupture and Flash Fire: Flash Fire Envelope at receptor height of 57 m O.D., Category D5



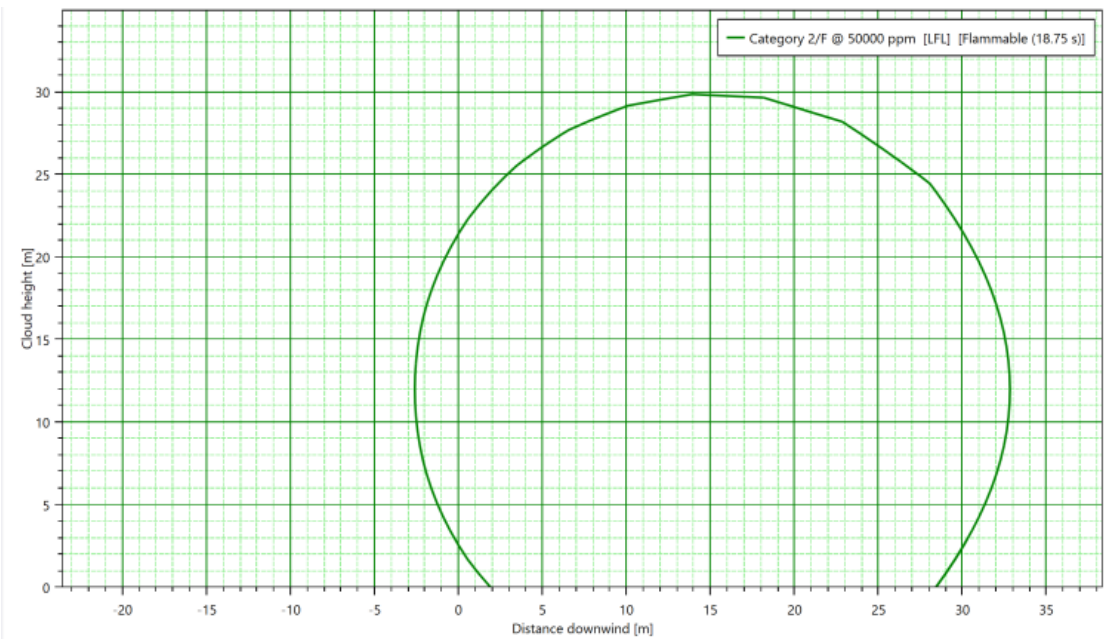
Appendix Figure C-17. Digestate Storage/Liquid Pre Storage Tank Rupture and Flash Fire: Flash Fire Envelope at receptor height of 57 m O.D., Category F2



Appendix Figure C-18. Digestate Storage/Liquid Pre Storage Tank Rupture and Flash Fire: Dispersion Side View, Category D5

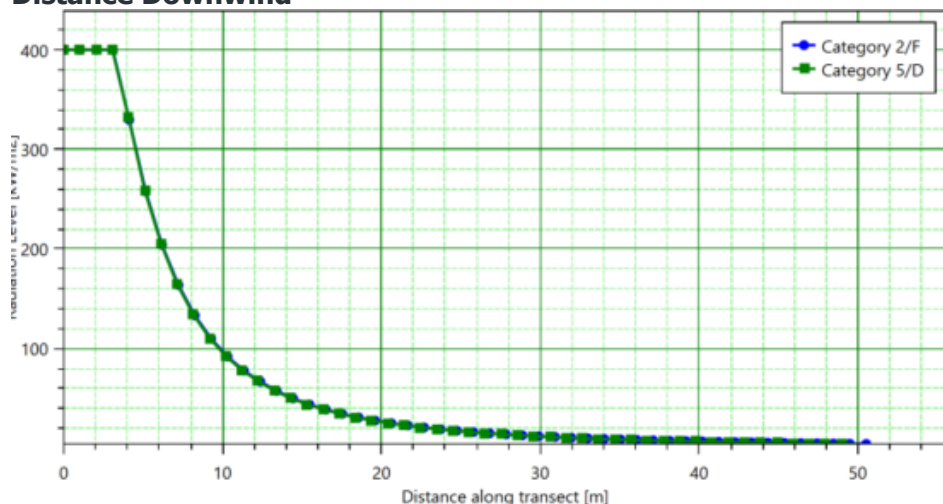


Appendix Figure C-19. Digestate Storage/Liquid Pre Storage Tank Rupture and Flash Fire: Dispersion Side View, Category F2

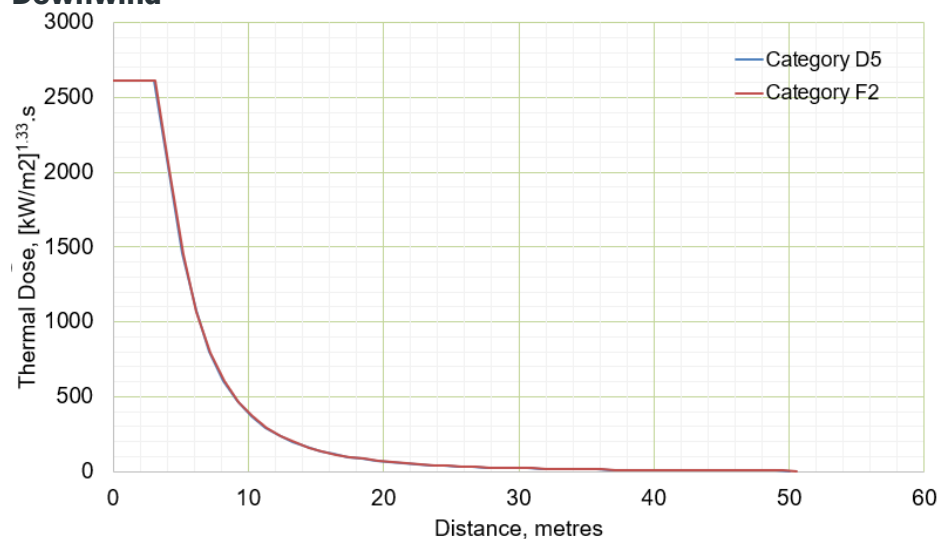


Installation	Pasteurisation Tank
Scenario	Untreated Biogas Instantaneous Release
Software/model	DNV PHAST Version 9.1 Catastrophic rupture and Unified Dispersion Models Fireball Static (HSE) Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	12.53 m ³ of methane at 15 mbarg and 55 degC 41.5 metre fireball radius (D5/F2), 6.4 second duration (D5/F2) Release height is at top of tank wall, 10 m above local ground level or 55.5 mOD Receptor height is 57 m OD, or 1 m above ground level at the civic amenity site to the east
Vapour cloud explosion source term	Flammable mass 483.7/476.9 kg at source of release (confined region), Category D5/F2

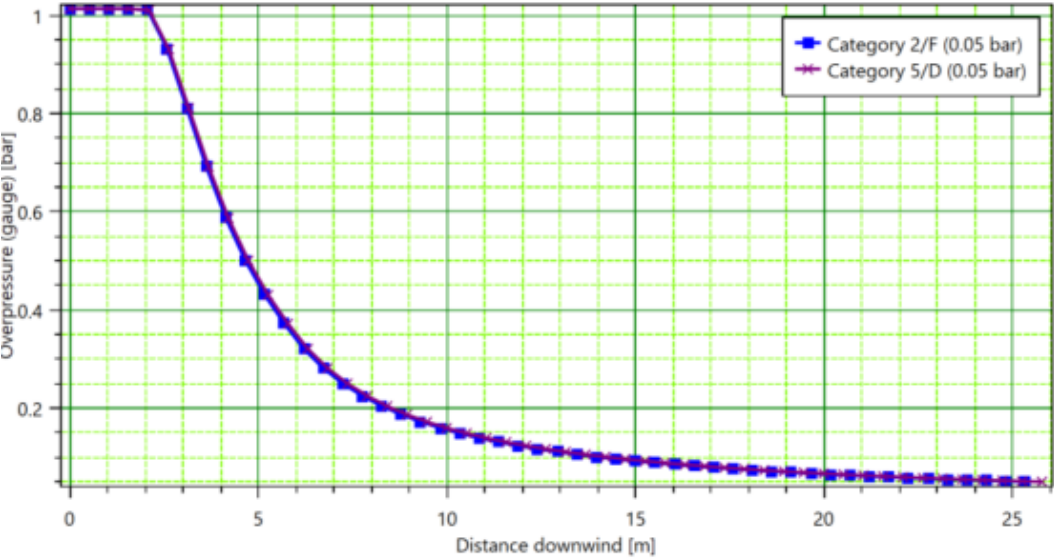
Appendix Figure C-20. Pasteurisation Tank Rupture and Fireball: Thermal Radiation vs. Distance Downwind



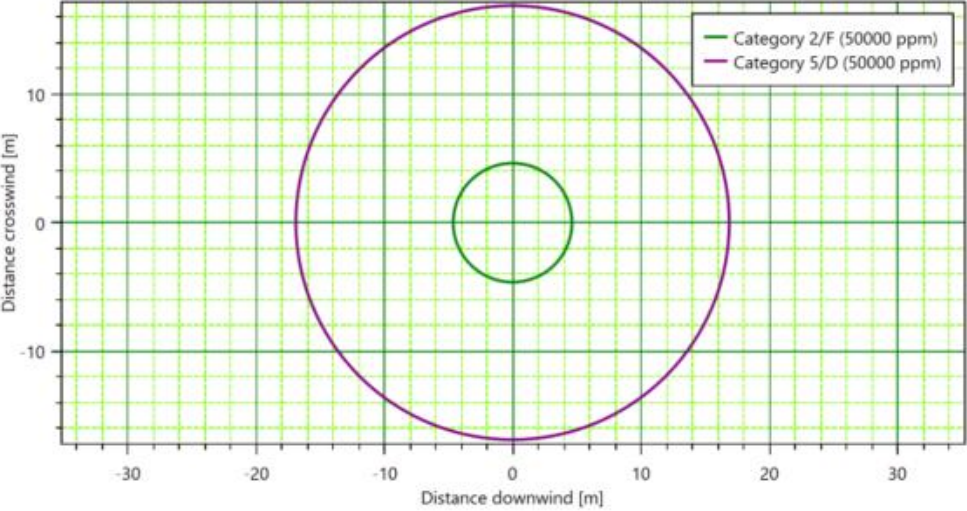
Appendix Figure C-21. Pasteurisation Tank Rupture and Fireball: Thermal Dose vs. Distance Downwind



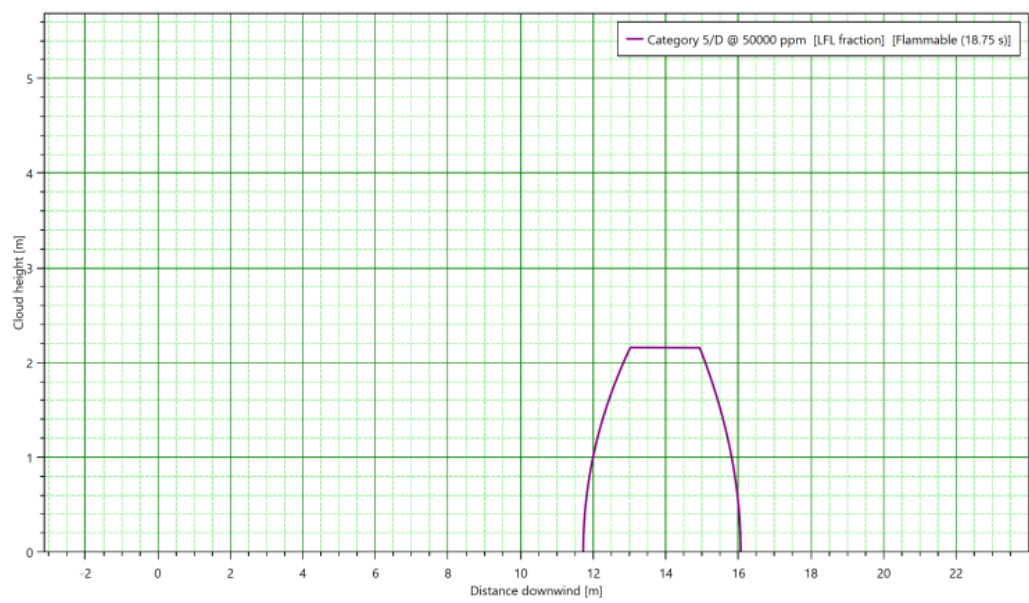
Appendix Figure C-22. Pasteurisation Tank Rupture and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



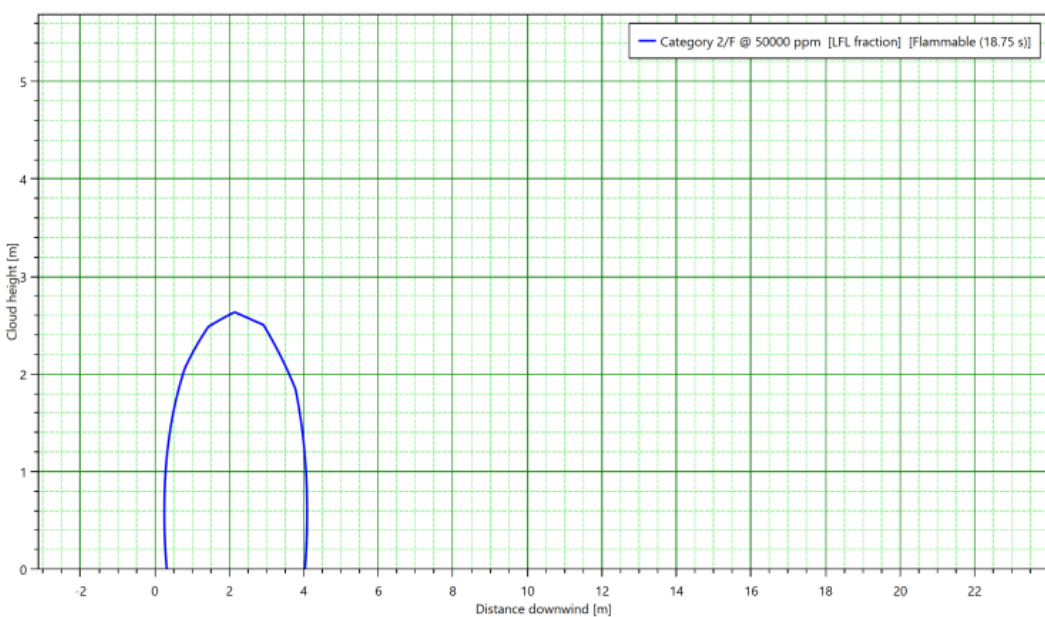
Appendix Figure C-23. Pasteurisation Tank Rupture and Flash Fire: Flash Fire Envelope at receptor height of 57 m O.D.



Appendix Figure C-24. Pasteurisation Tank Rupture and Flash Fire: Dispersion Side View, Category D5

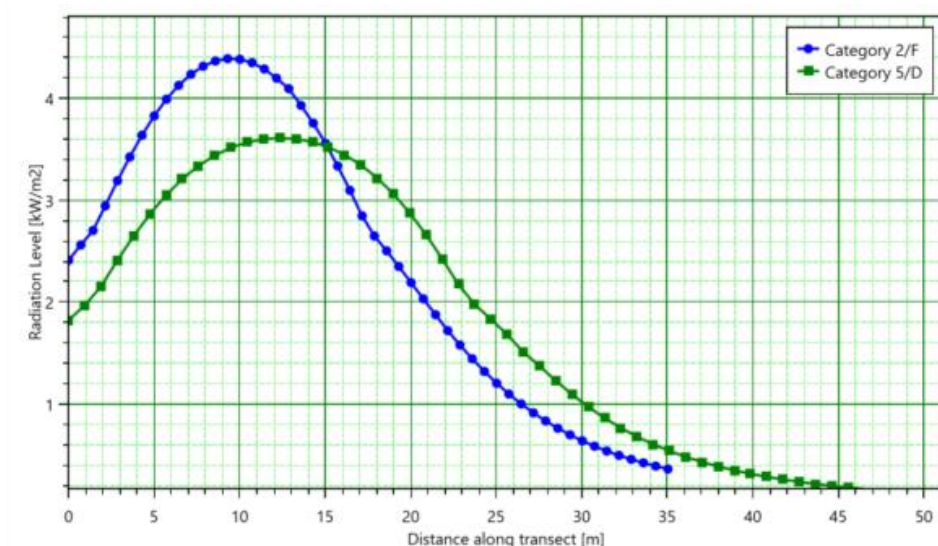


Appendix Figure C-25. Pasteurisation Tank Rupture and Flash Fire: Dispersion Side View, Category F2

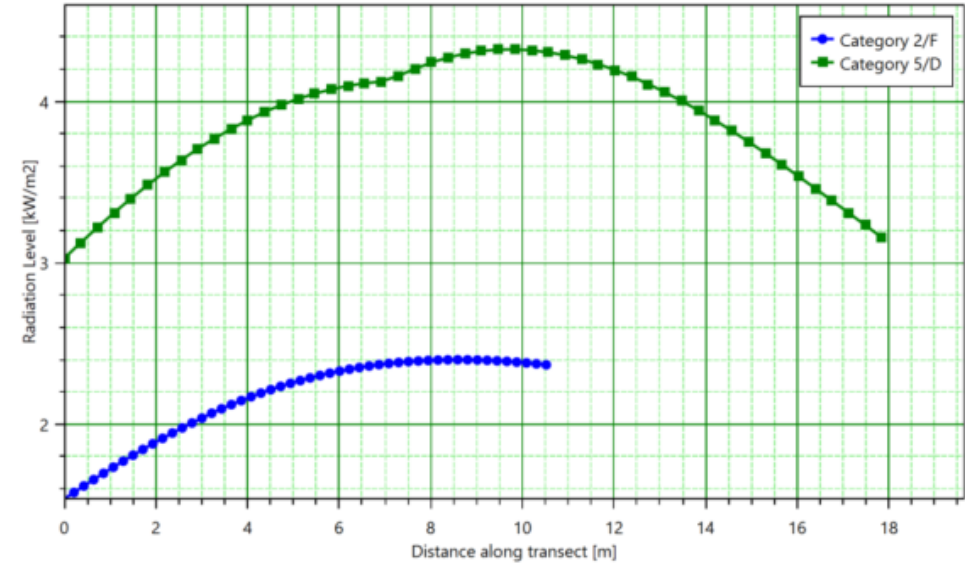


Installation	Primary/Secondary Digester
Scenario	Continuous Release (Entire Contents) Over 10 Minutes
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Jet Fire Cone Model TNO Multi Energy Model
Discharge/ Jet Fire /Dispersion Model Source Term	1,289.44 m ³ of methane at 15 mbarg and 55 degC Release height is at top of tank wall, 23.3 m above local ground level or 68.8 mOD Receptor height is 57 m OD, or 1 m above ground level at the civic amenity site to the east
Vapour cloud explosion source term	Flammable mass 0.59/0.68 kg at source of horizontal release (confined region), Category D5/F2 Flammable mass 0.30/0.44 kg at source of vertical release (confined region), Category D5/F2

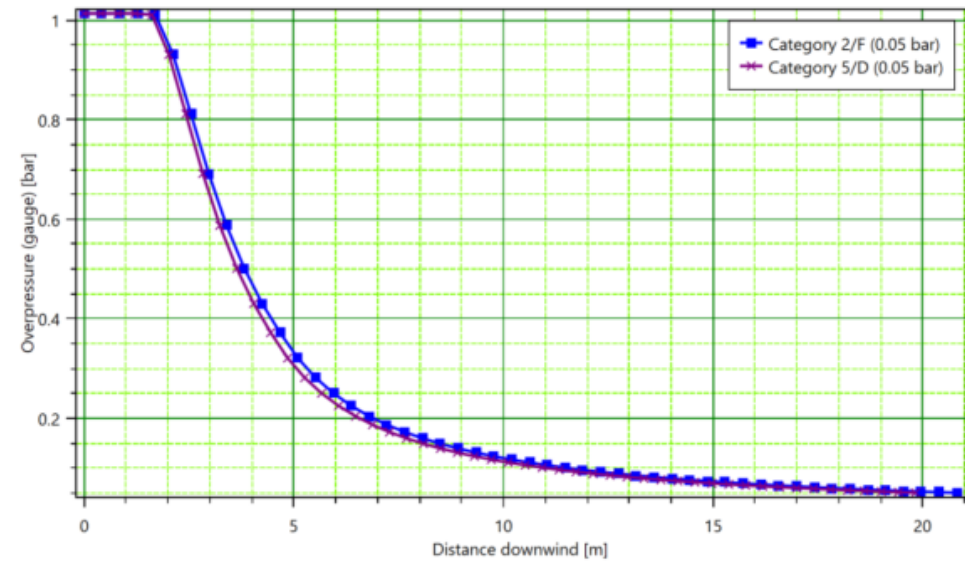
Appendix Figure C-26. Primary/Secondary Digester Continuous Release (Horizontal) Over 10 Minutes and Jet Fire: Thermal Radiation vs. Distance Downwind



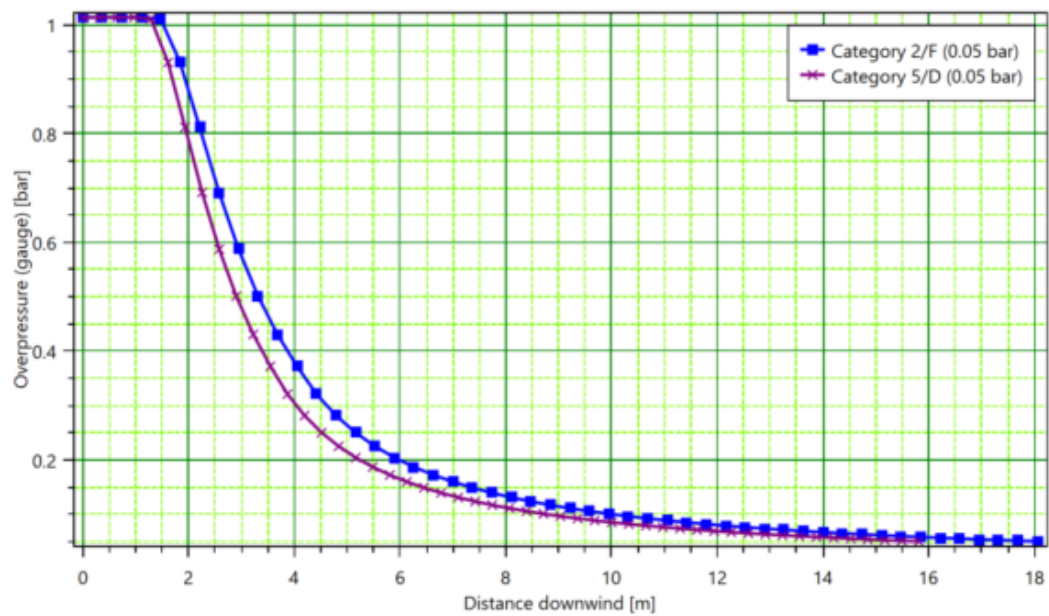
Appendix Figure C-27. Primary/Secondary Digester Continuous Release (Vertical) Over 10 Minutes and Jet Fire: Thermal Radiation vs. Distance Downwind



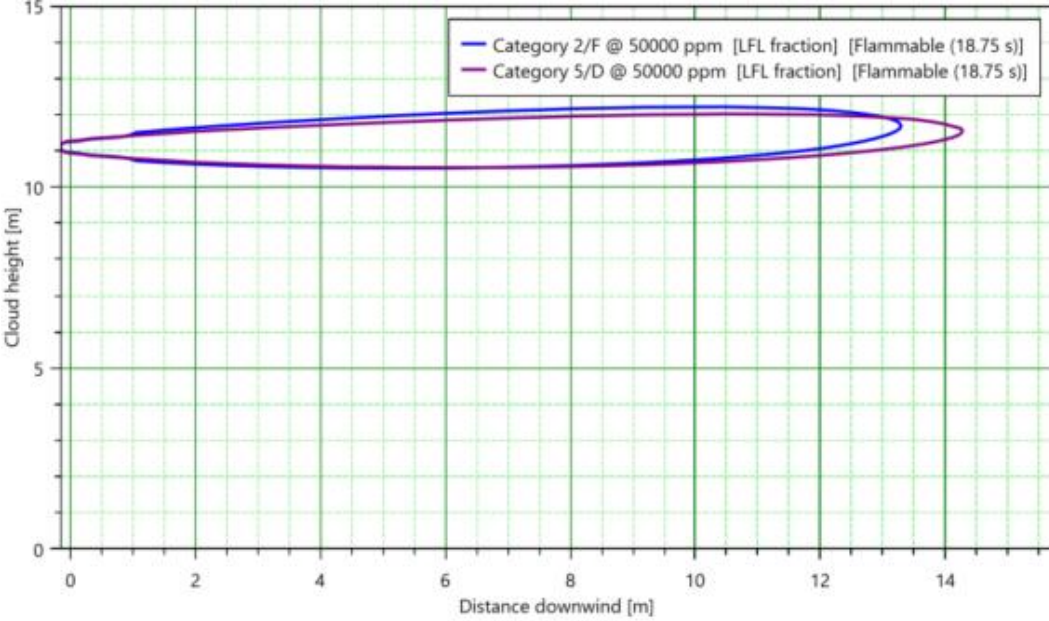
Appendix Figure C-28 Primary/Secondary Digester Continuous (Horizontal) Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



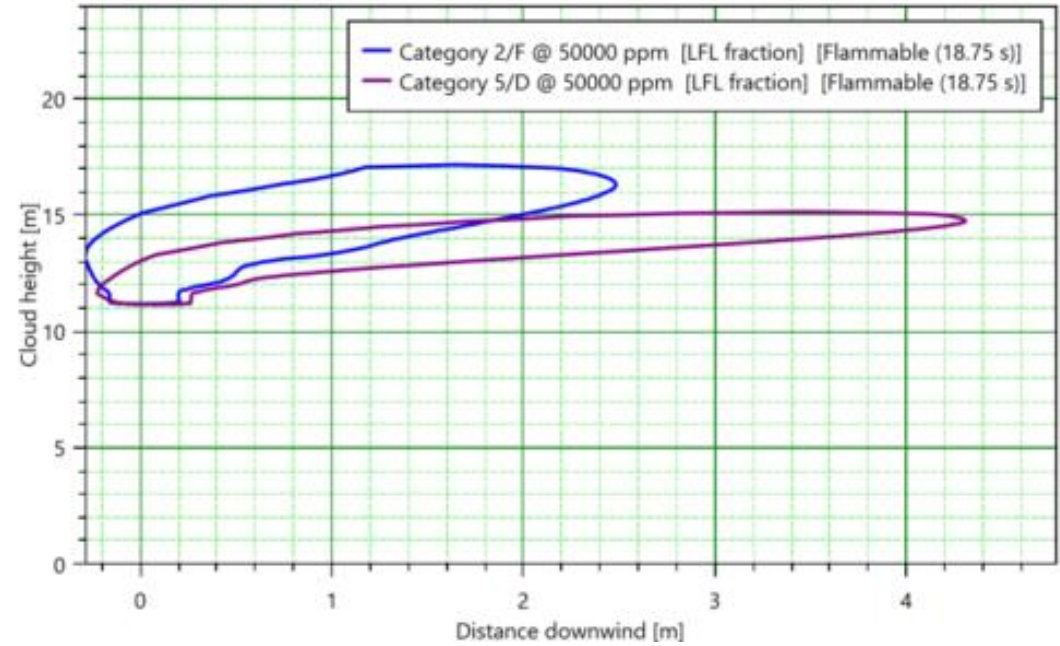
Appendix Figure C-29. Primary/Secondary Digester Continuous (Vertical) Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



Appendix Figure C-30. Primary/Secondary Digester Continuous (Horizontal) Release Over 10 Minutes and Flash Fire: Dispersion Side View

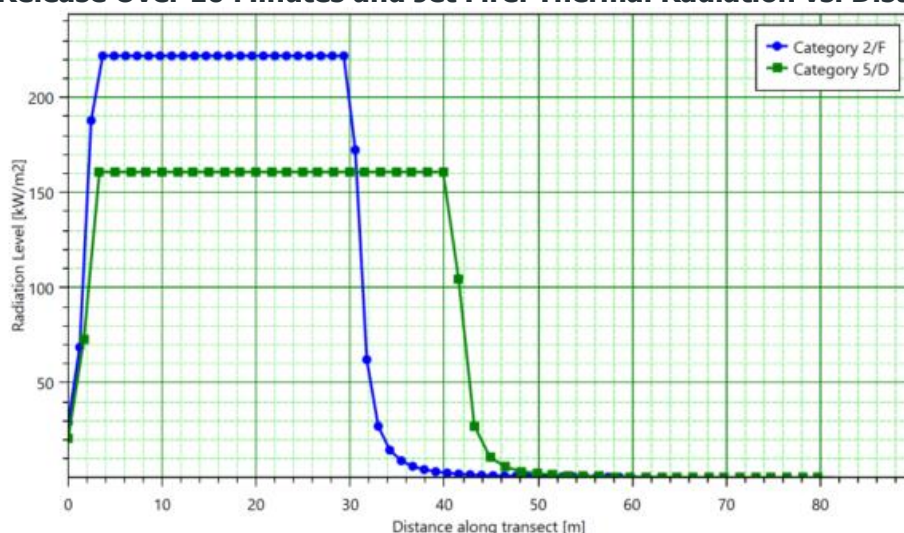


Appendix Figure C-31. Primary/Secondary Digester Continuous Release Over 10 Minutes (Vertical) and Flash Fire: Dispersion Side View,

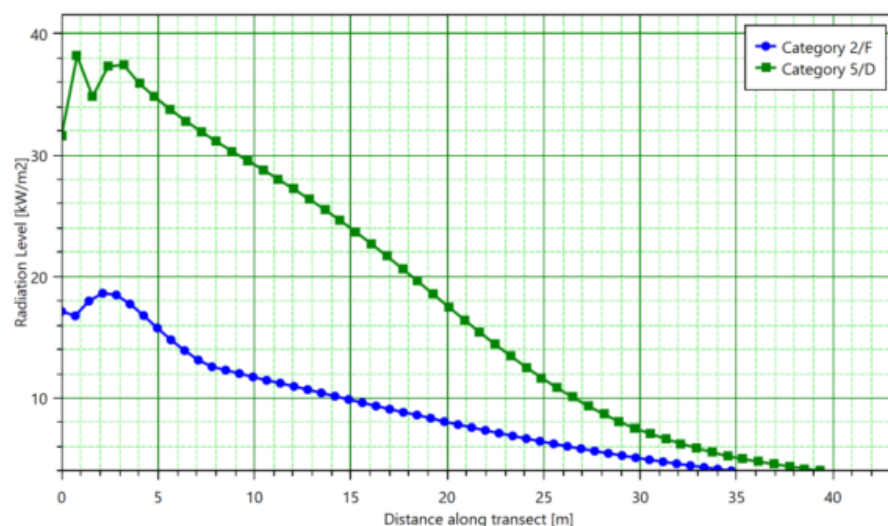


Installation	Tertiary Digester/Post Digestate Storage Tank
Scenario	Continuous Release (Entire Contents) Over 10 Minutes
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Jet Fire Cone Model TNO Multi Energy Model
Discharge/Fireball/ Dispersion Model Source Term	4,852.53 m ³ of methane at 15 mbarg and 55 degC Release height is at top of tank wall, 10 m above local ground level or 55.5 m O.D. Receptor height is 57 m OD, or 1 m above ground level at the civic amenity site to the east
Vapour cloud explosion source term	Flammable mass 3.17/3.37 kg at source of horizontal release (confined region), Category D5/F2 Flammable mass 1.96/2.90 kg at source of vertical release (confined region), Category D5/F2

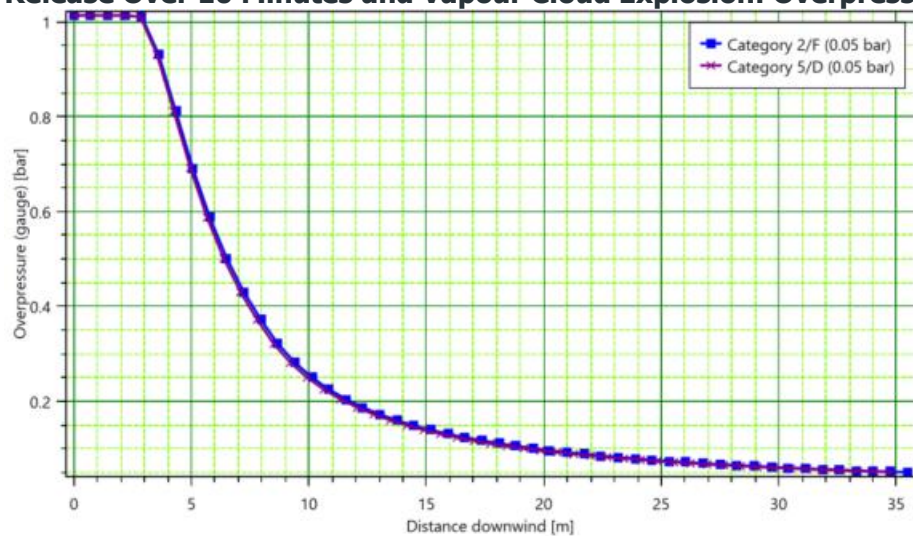
Appendix Figure C-32. Tertiary Digester/Post Digestate Storage Tank Continuous Horizontal Release Over 10 Minutes and Jet Fire: Thermal Radiation vs. Distance Downwind



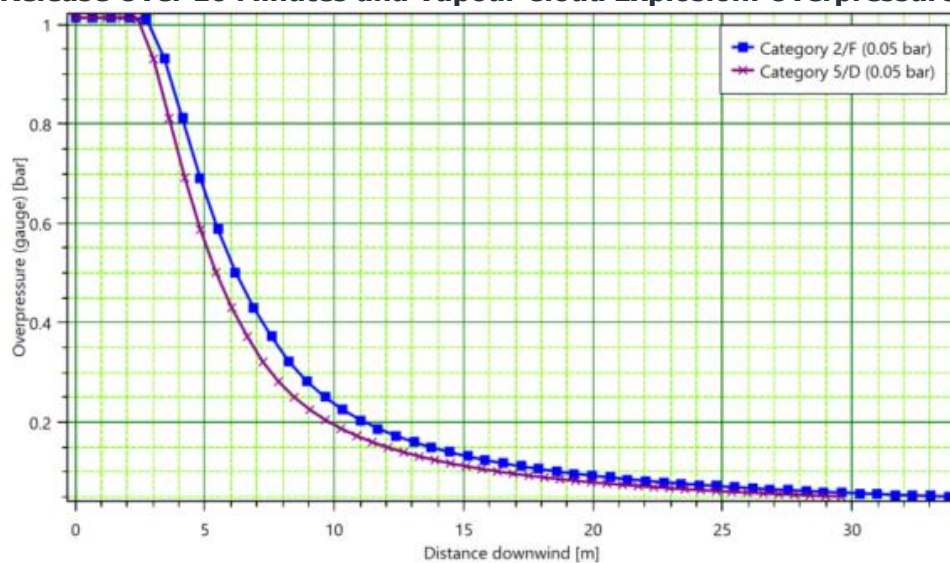
Appendix Figure C-33. Tertiary Digester/Post Digestate Storage Tank Continuous Vertical Release Over 10 Minutes and Jet Fire: Thermal Radiation vs. Distance Downwind



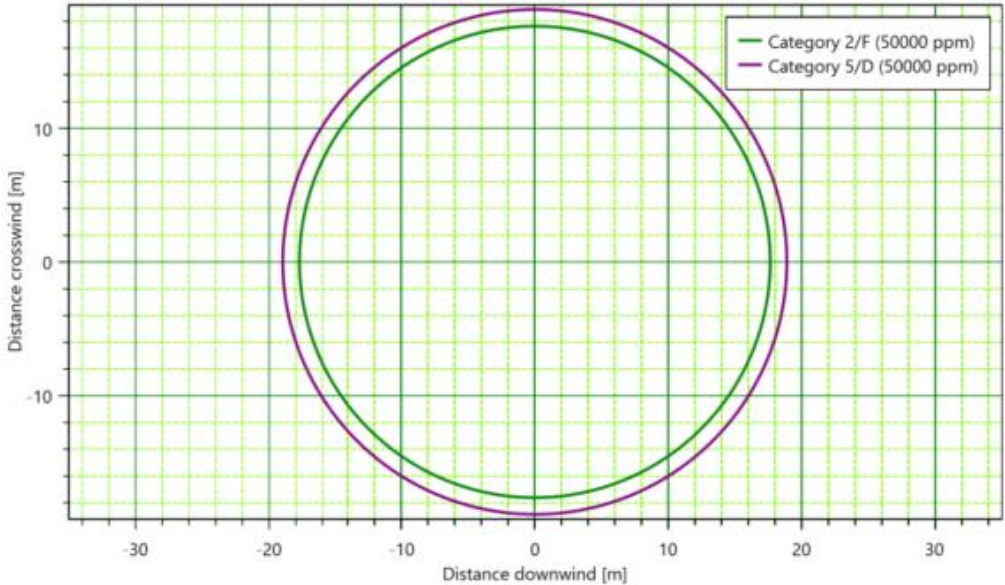
Appendix Figure C-34. Tertiary Digester/Post Digestate Storage Tank Continuous Horizontal Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



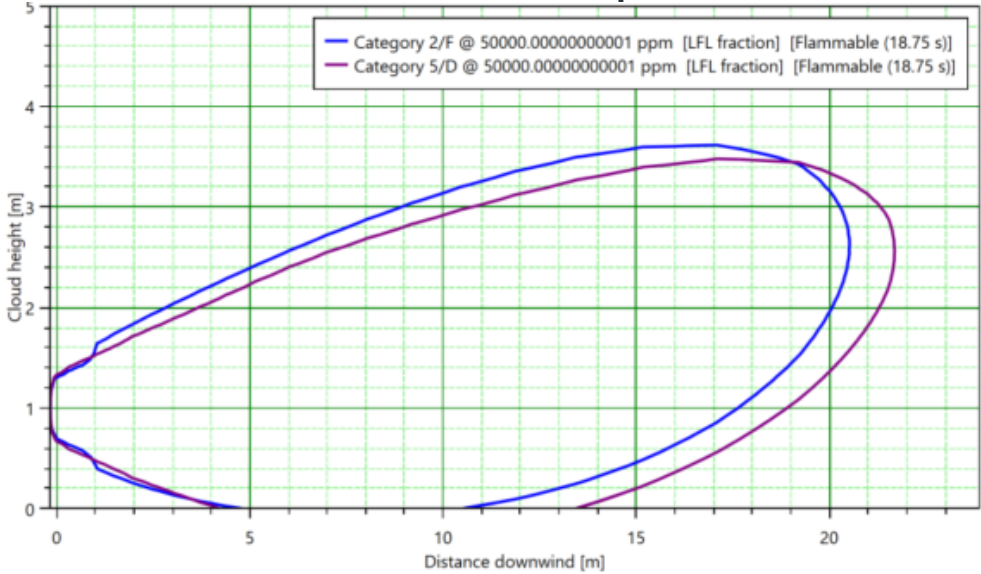
Appendix Figure C-35. Tertiary Digester/Post Digestate Storage Tank Continuous Vertical Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



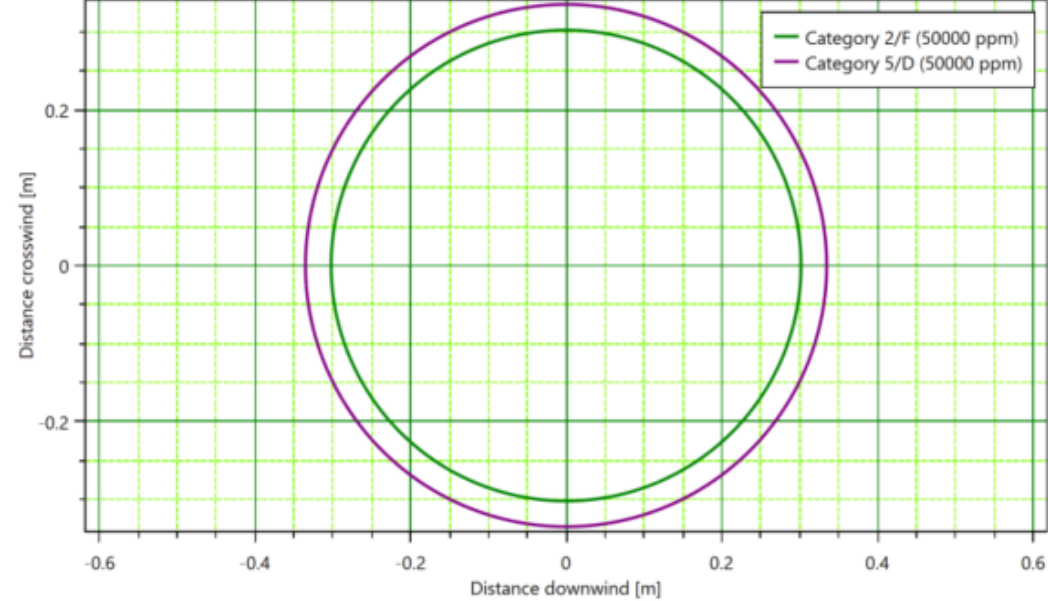
Appendix Figure C-36. Tertiary Digester/Post Digestate Storage Tank Continuous Horizontal Release Over 10 Minutes and Flash Fire: Flash Fire Envelope, at receptor height of 57 m O.D.



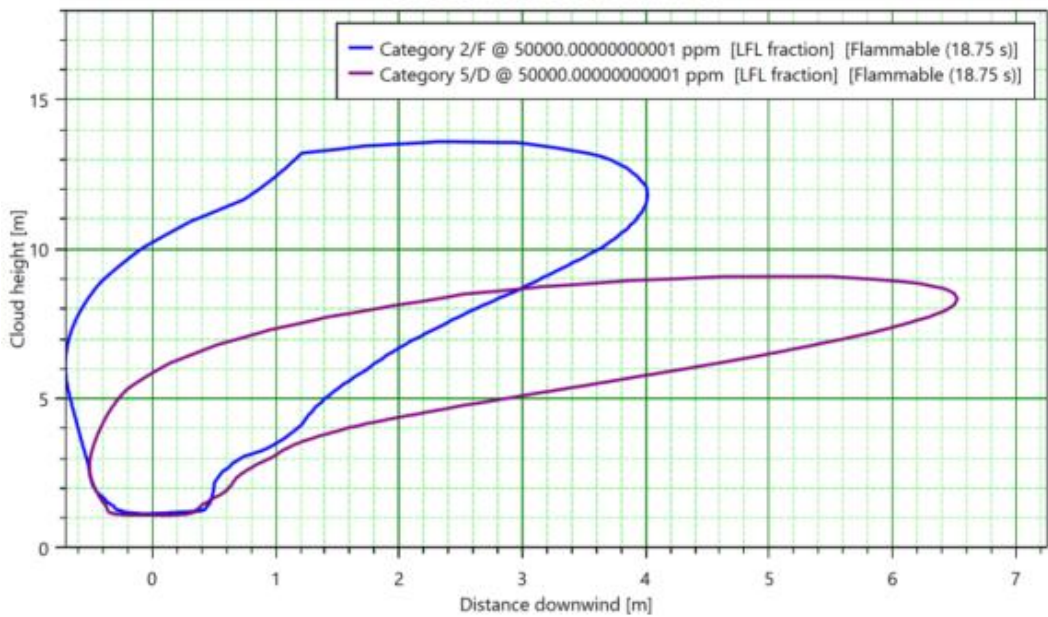
Appendix Figure C-37. Tertiary Digester/Post Digestate Storage Tank Continuous Horizontal Release Over 10 Minutes and Flash Fire: Dispersion Side View



Appendix Figure C-38. Tertiary Digester/Post Digestate Storage Tank Continuous Vertical Release Over 10 Minutes and Flash Fire: Flash Fire Envelope at receptor height of 57 m O.D. t

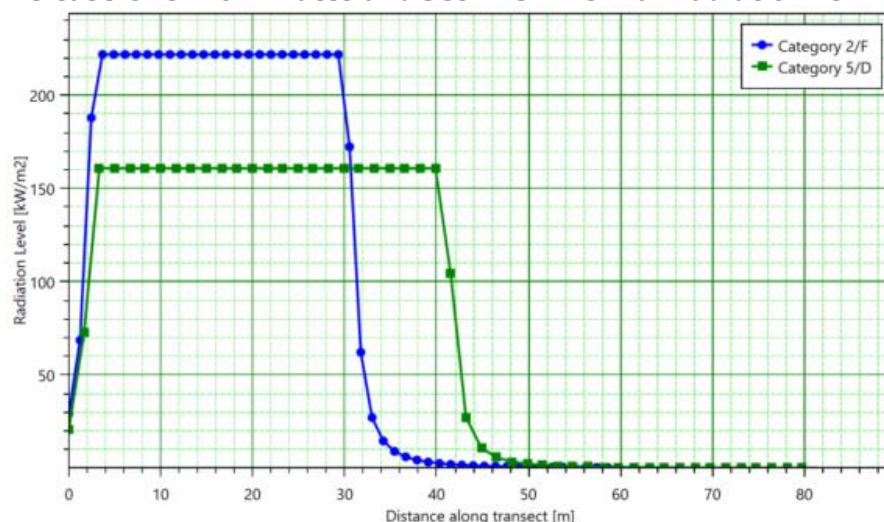


Appendix Figure C-39. Tertiary Digester/Post Digestate Storage Tank Continuous Vertical Release Over 10 Minutes and Flash Fire: Dispersion Side View

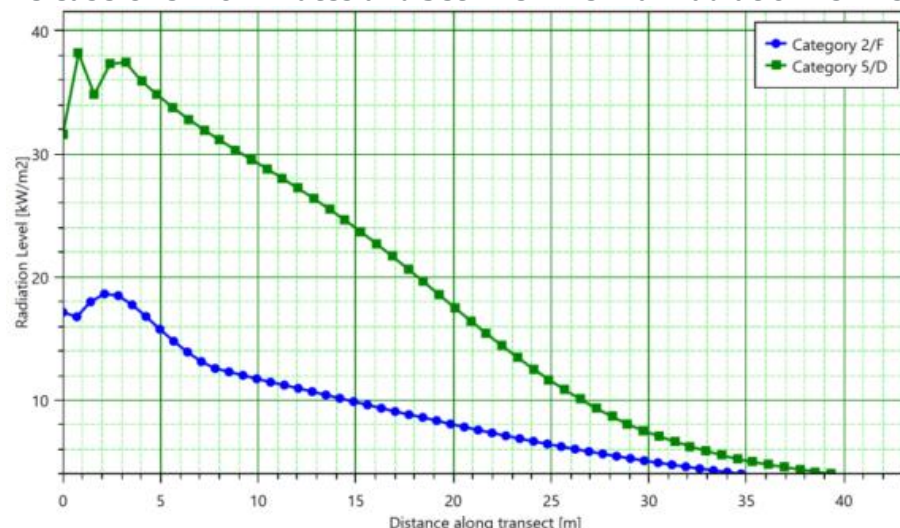


Installation	Digestate Storage/Liquid Pre Storage Tank
Scenario	Continuous Release (Entire Contents) Over 10 Minutes
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Jet Fire Cone Model TNO Multi Energy Model
Discharge/Fireball/ Dispersion Model Source Term	5,523.18 m ³ of methane at 5 mbarg and ambient temperature Release height is at top of tank wall, 9.6 m above local ground level or 55.1 m O.D. Receptor height is 57 m OD, or 1 m above ground level at the civic amenity site to the east
Vapour cloud explosion source term	Flammable mass 4.23/4.49 kg at source of horizontal release (confined region), Category D5/F2 Flammable mass 2.03/3.53 kg at source of vertical release (confined region), Category D5/F2

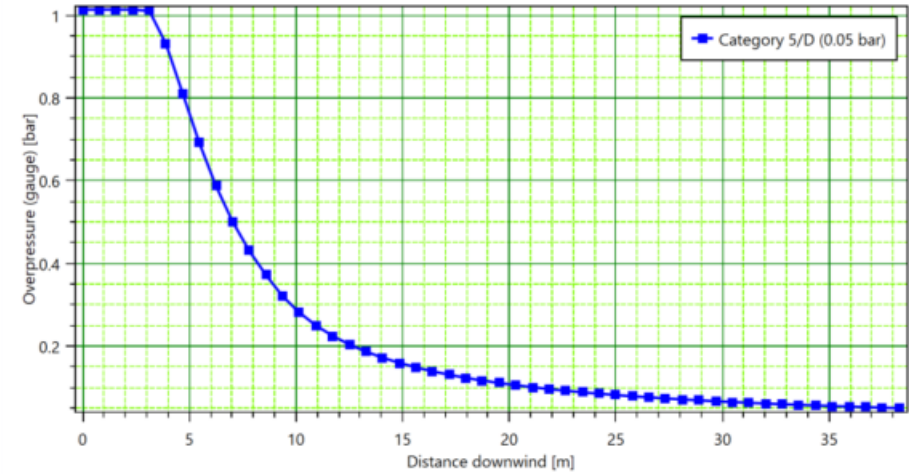
Appendix Figure C-40. Digestate Storage/Liquid Pre Storage Tank Continuous Horizontal Release Over 10 Minutes and Jet Fire: Thermal Radiation vs. Distance Downwind



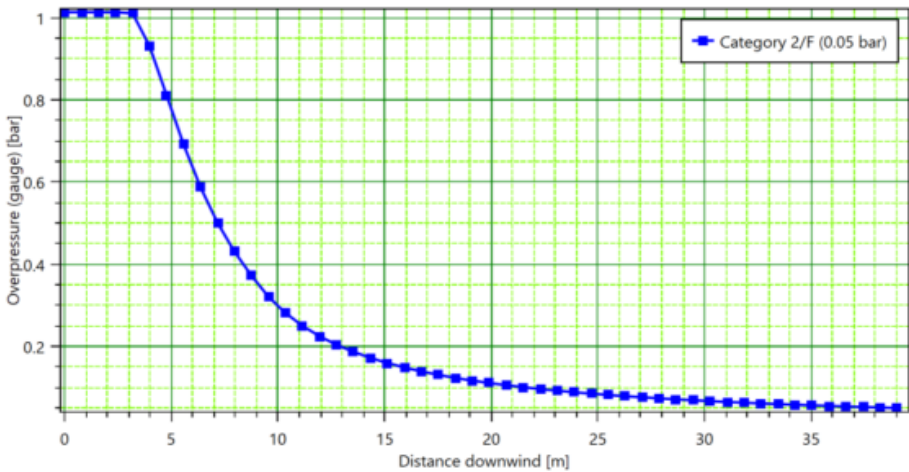
Appendix Figure C-41. Digestate Storage/Liquid Pre Storage Tank Continuous Vertical Release Over 10 Minutes and Jet Fire: Thermal Radiation vs. Distance Downwind



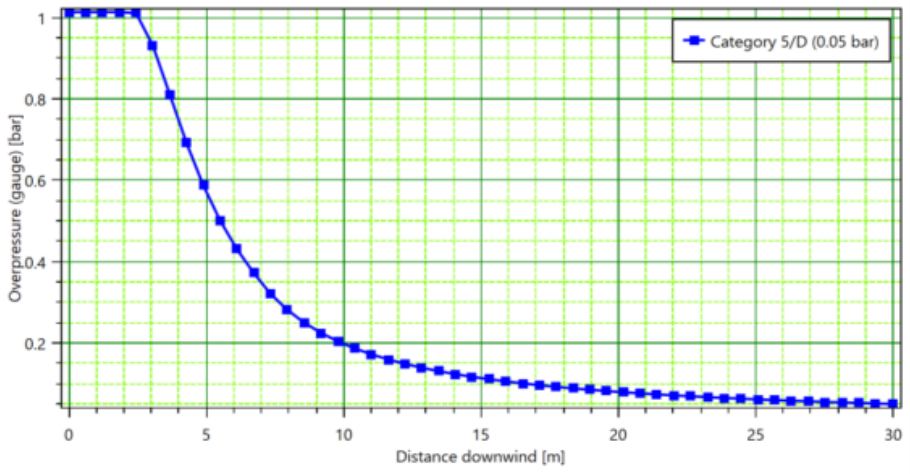
Appendix Figure C-42. Digestate Storage/Liquid Pre Storage Tank Continuous Horizontal Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



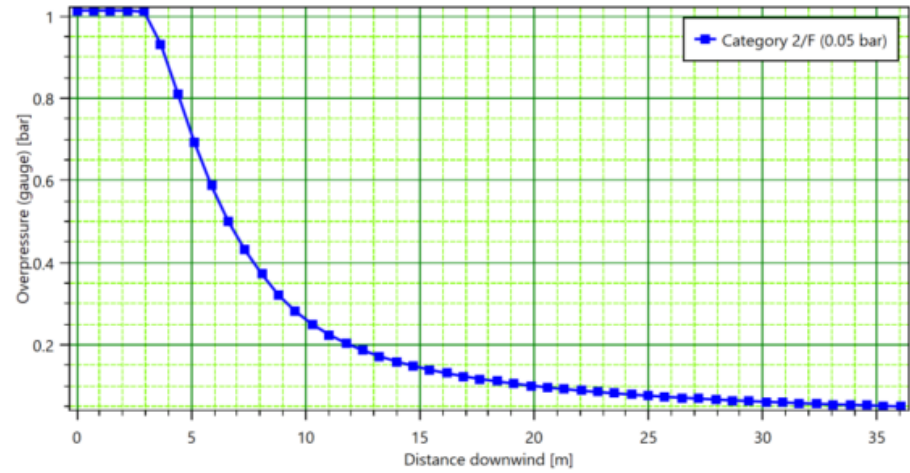
Appendix Figure C-43. Digestate Storage/Liquid Pre Storage Tank Continuous Horizontal Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



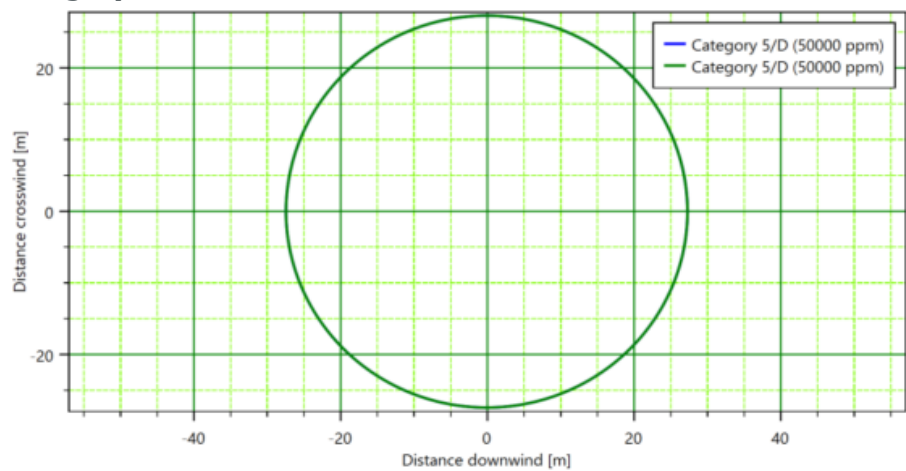
Appendix Figure C-44. Digestate Storage/Liquid Pre Storage Tank Continuous Vertical Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



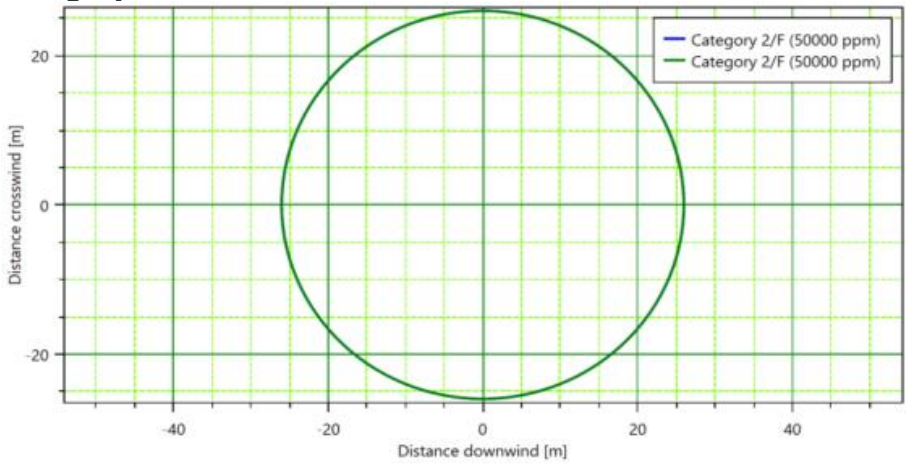
Appendix Figure C-45. Digestate Storage/Liquid Pre Storage Tank Continuous Vertical Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



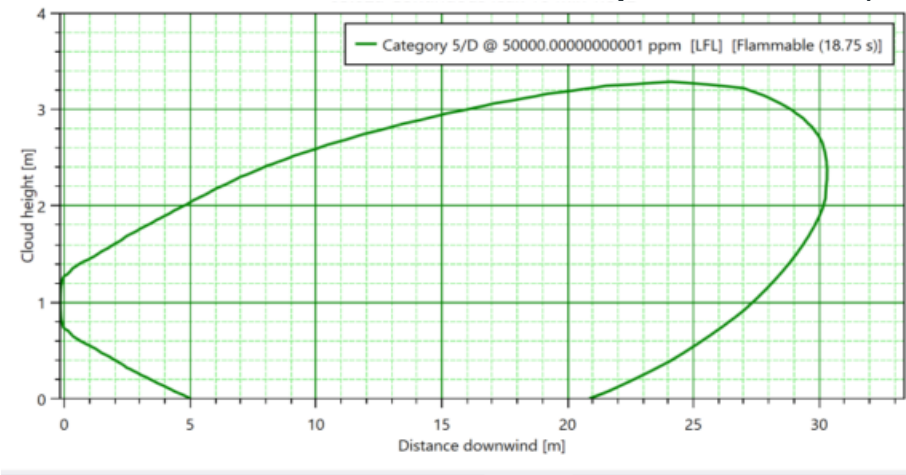
Appendix Figure C-46. Digestate Storage/Liquid Pre Storage Tank Continuous Horizontal Release Over 10 Minutes and Flash Fire: Flash Fire Envelope, at receptor height of 57 m O.D., Category D5



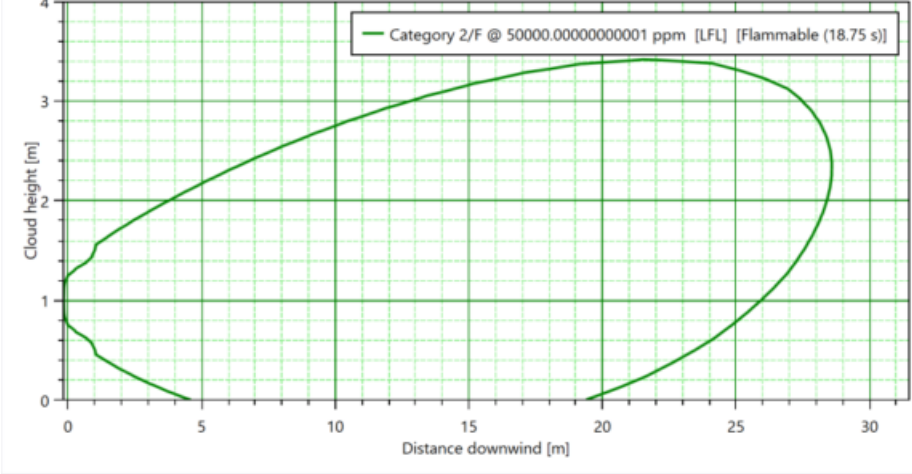
Appendix Figure C-47. Digestate Storage/Liquid Pre Storage Tank Continuous Horizontal Release Over 10 Minutes and Flash Fire: Flash Fire Envelope, at receptor height of 57 m O.D., Category F2



Appendix Figure C-48. Digestate Storage/Liquid Pre Storage Tank Continuous Horizontal Release Over 10 Minutes and Flash Fire: Dispersion Side View, Category D5

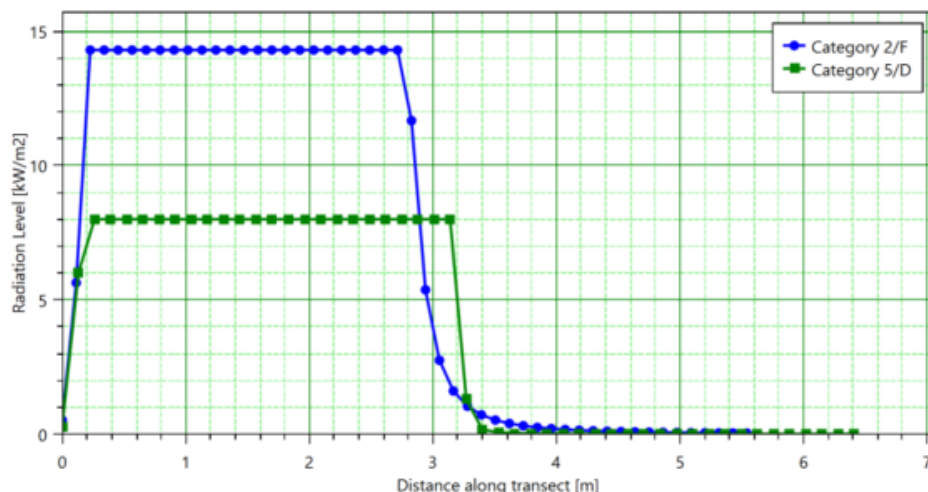


Appendix Figure C-49. Digestate Storage/Liquid Pre Storage Tank Continuous Horizontal Release Over 10 Minutes and Flash Fire: Dispersion Side View, Category F2

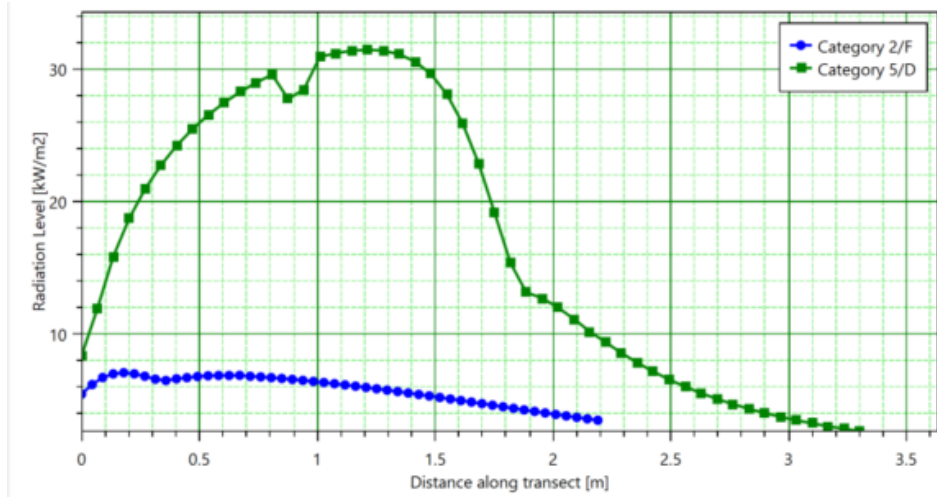


Installation	Pasteurisation Tank
Scenario	Continuous Release (Entire Contents) Over 10 Minutes
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Jet Fire Cone Model TNO Multi Energy Model
Discharge/Fireball/ Dispersion Model Source Term	12.53 m ³ of methane at 15 mbarg and 55 degC Release height is at top of tank wall, 10 m above local ground level or 55.5 m O.D. Receptor height is 57 m OD, or 1 m above ground level at the civic amenity site to the east
Vapour cloud explosion source term	Flammable mass 0.005/0.006 kg at source of horizontal release (confined region), Category D5/F2 Flammable mass 0.00007/0 kg at source of vertical release (confined region), Category D5/F2

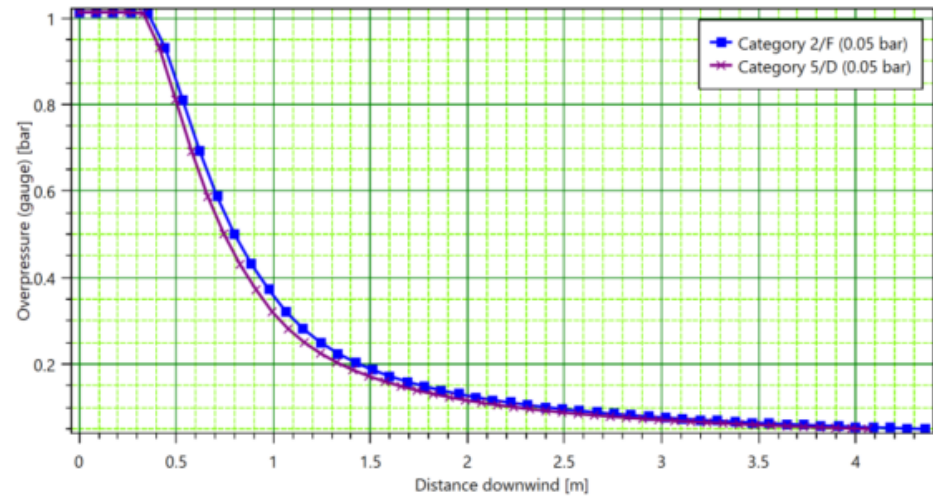
Appendix Figure C-50. Pasteurisation Tank Continuous Horizontal Release Over 10 Minutes and Jet Fire: Thermal Radiation vs. Distance Downwind



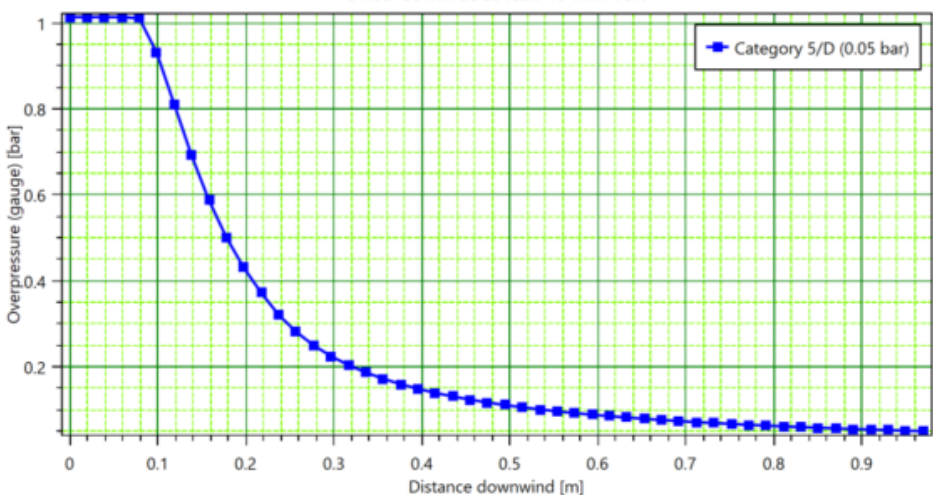
Appendix Figure C-51. Pasteurisation Tank Continuous Vertical Release Over 10 Minutes and Jet Fire: Thermal Radiation vs. Distance Downwind



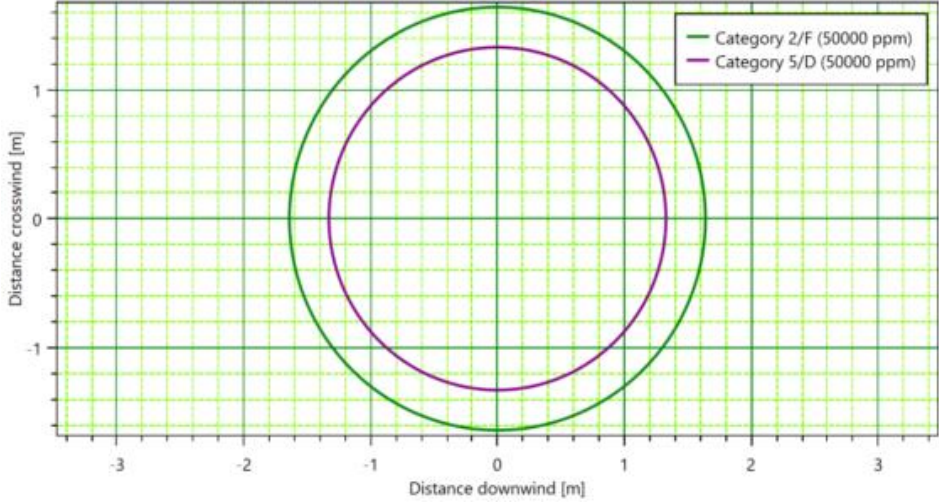
Appendix Figure C-52. Pasteurisation Tank Continuous Horizontal Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



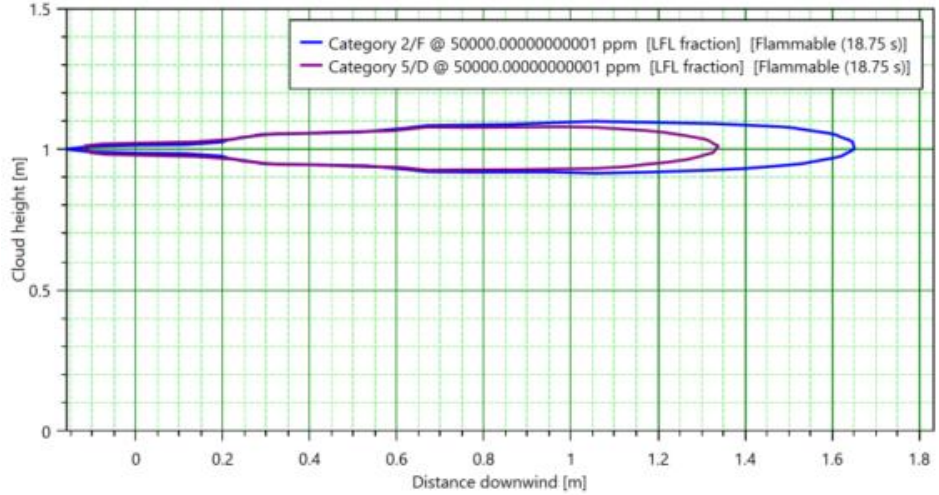
Appendix Figure C-53. Pasteurisation Tank Continuous Vertical Release Over 10 Minutes and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



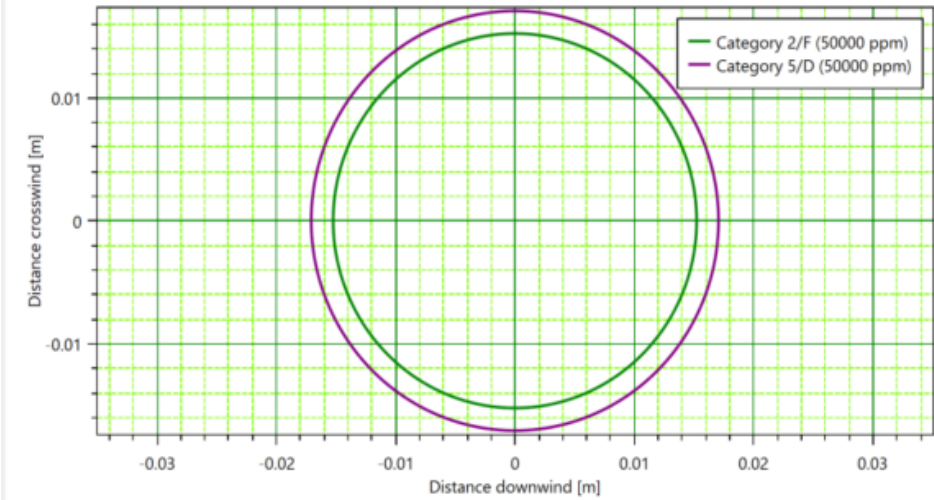
Appendix Figure C-54. Pasteurisation Tank Continuous Horizontal Release Over 10 Minutes and Flash Fire: Flash Fire Envelope, at receptor height of 57 m O.D.



Appendix Figure C-55. Pasteurisation Tank Continuous Horizontal Release Over 10 Minutes and Flash Fire: Dispersion Side View

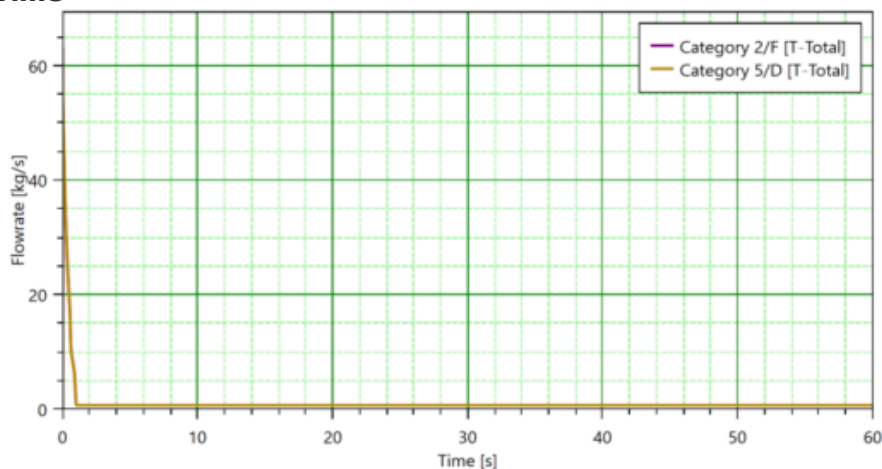


Appendix Figure C-56. Pasteurisation Tank Continuous Vertical Release Over 10 Minutes and Flash Fire: Flash Fire Envelope, at receptor height of 57 m O.D

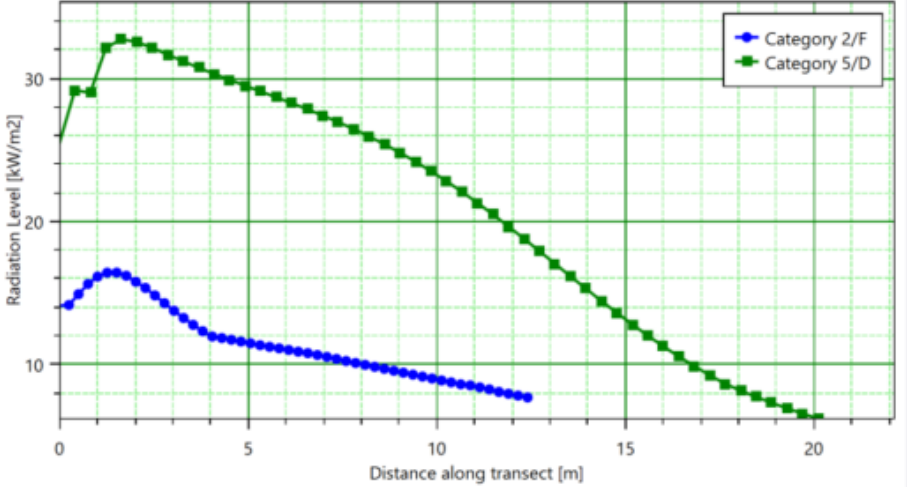


Installation	Biogas Pipeline 4 barg above ground pipeline
Scenario	Above Ground Outdoor Pipeline rupture, Jet Fire/Fireball, Vapour Cloud Explosion or Flash Fire
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Fireball Static (HSE) Model Jet Fire Cone Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	0.64 kg/s (D5/F2) biogas at 4 barg and 20 degC, 250 mm diameter (D) pipeline, hole 250 mm size 9.9 metre fireball radius (D5/F2), 1.54 second duration
Jet Fire Model Source Term	1.7 kg/s (D5/F2) Biogas 63 m/s velocity D5 / F2
Vapour cloud explosion source term	Horizontal release: 0.91/1.13 kg flammable mass Vertical release: 0.48/0.84 kg flammable mass

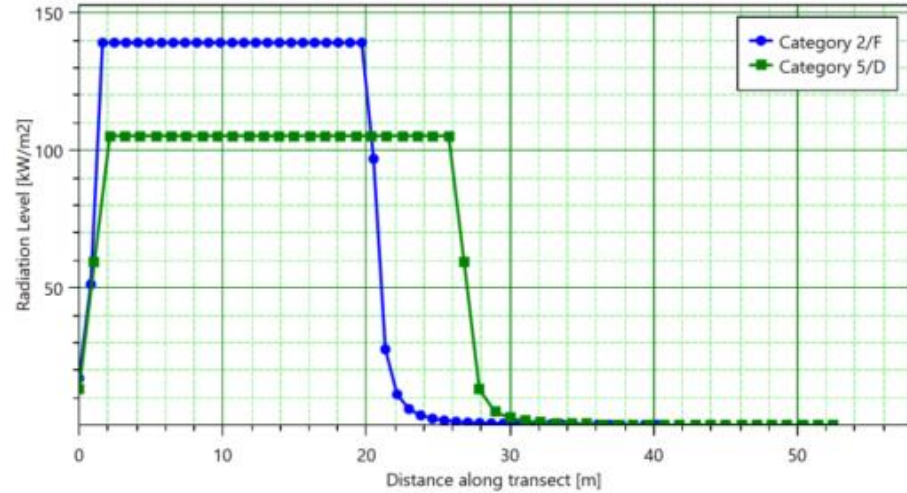
Appendix Figure C-57. Above Ground 4 barg Biogas Pipeline Rupture: Mass Flow Rate vs. Time



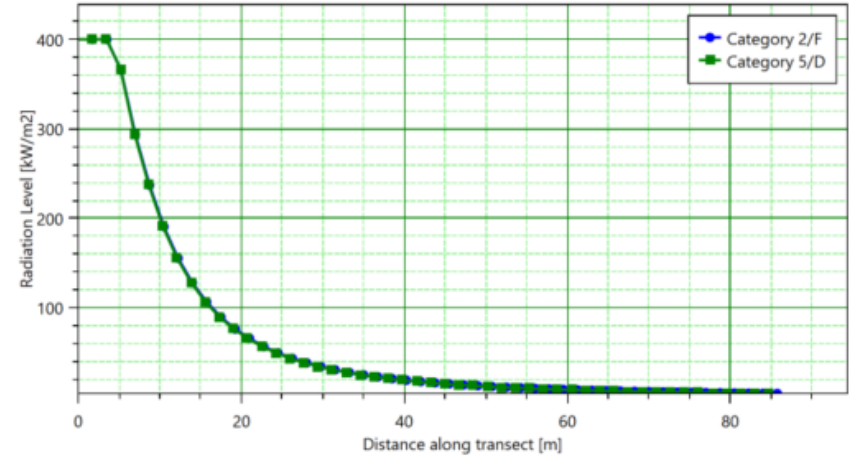
Appendix Figure C-58. Above Ground 4 barg Biogas Pipeline Rupture and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind



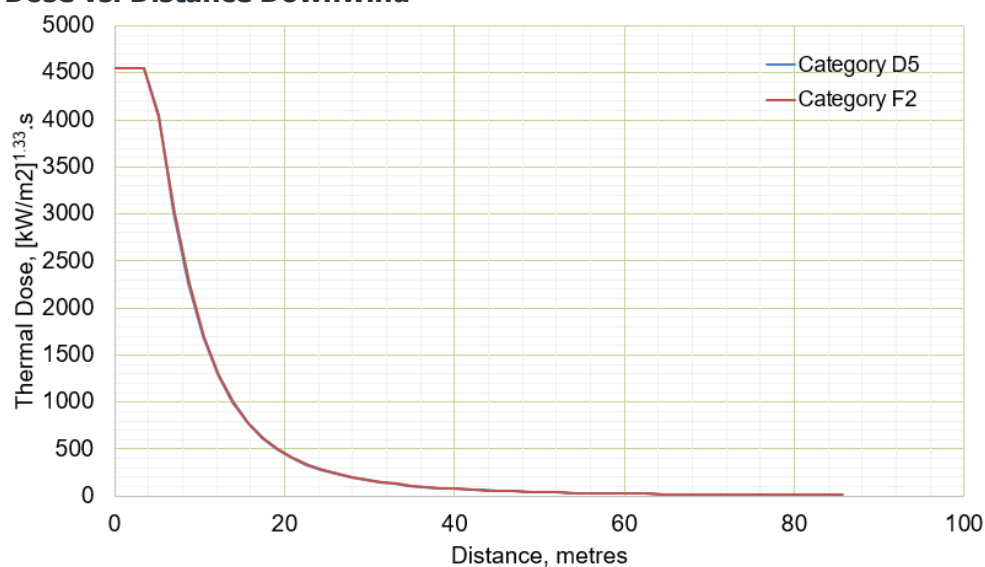
Appendix Figure C-59. Above Ground 4 barg Biogas Pipeline Rupture and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind



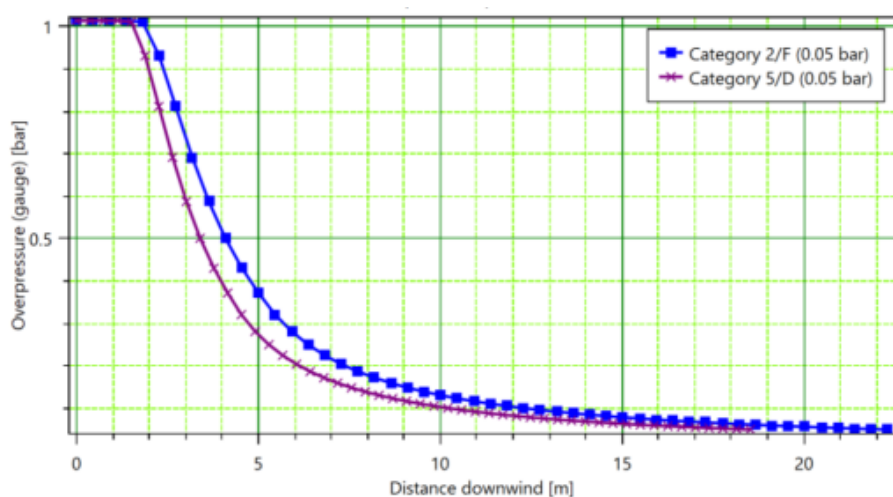
Appendix Figure C-60. Above Ground 4 barg Biogas Pipeline Rupture and Fireball: Thermal Radiation vs. Distance Downwind



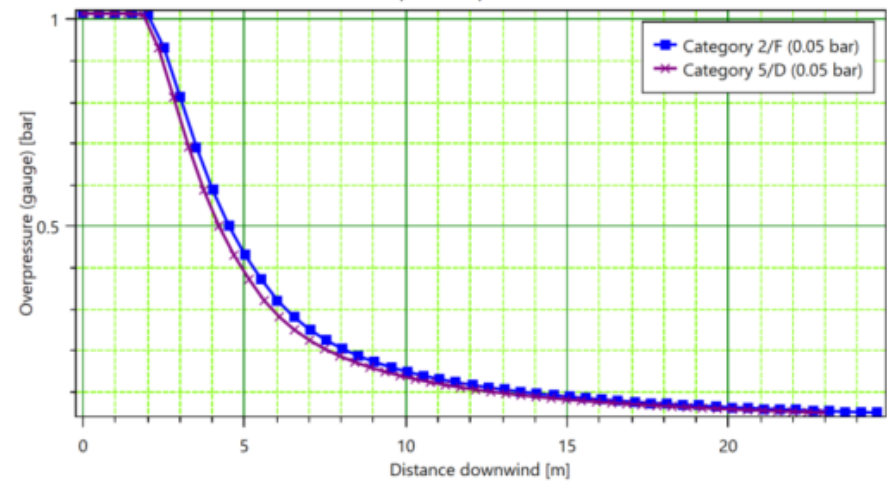
Appendix Figure C-61. Above Ground 4 barg Biogas Pipeline Rupture and Fireball: Thermal Dose vs. Distance Downwind



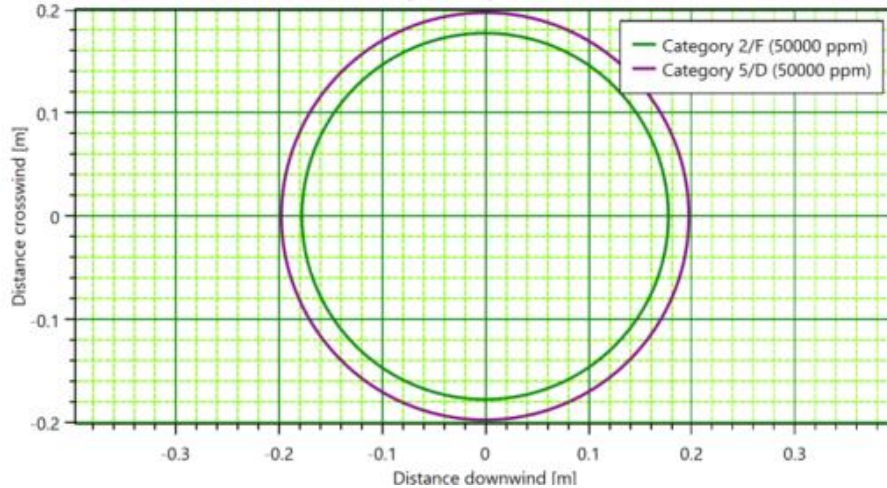
Appendix Figure C-62. Above Ground 4barg Biogas Pipeline Rupture, Vertical Release and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



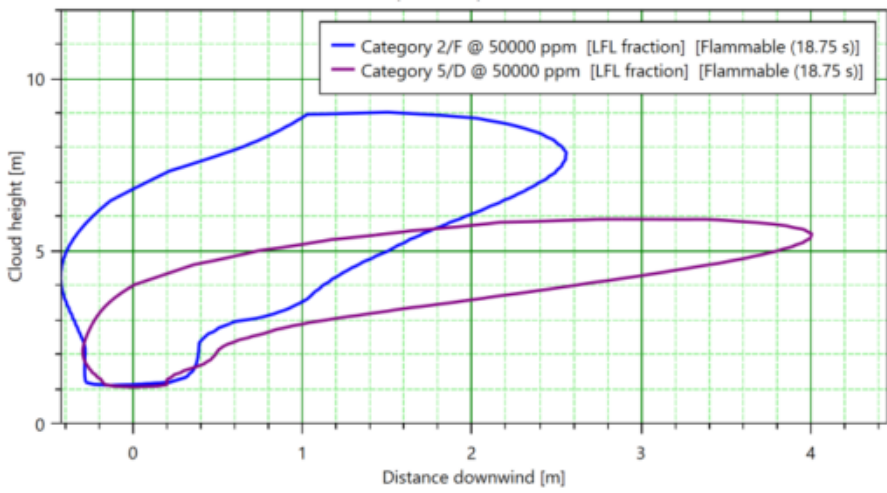
Appendix Figure C-63. Above Ground 4 barg Biogas Pipeline Rupture, Horizontal Release and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



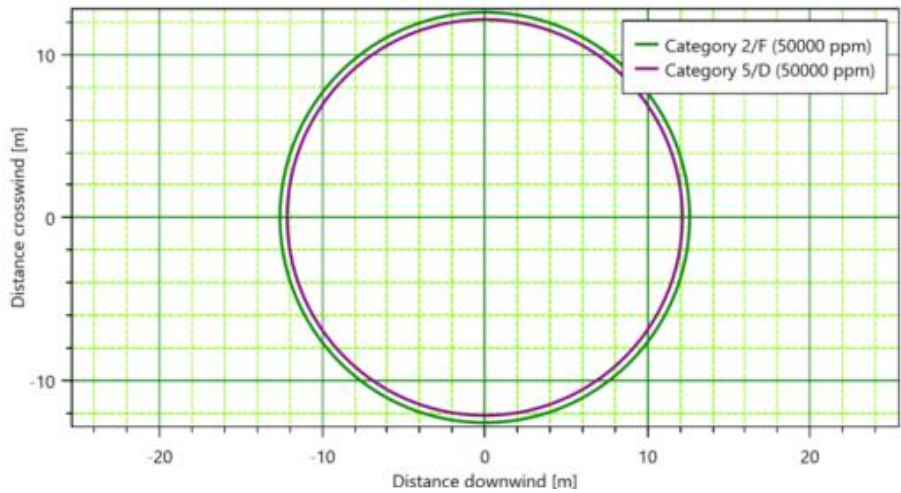
Appendix Figure C-64. Above Ground 4 barg Biogas Pipeline Rupture, Vertical Release and Flash Fire: Flash Fire Envelope at 1.0 metre receptor height



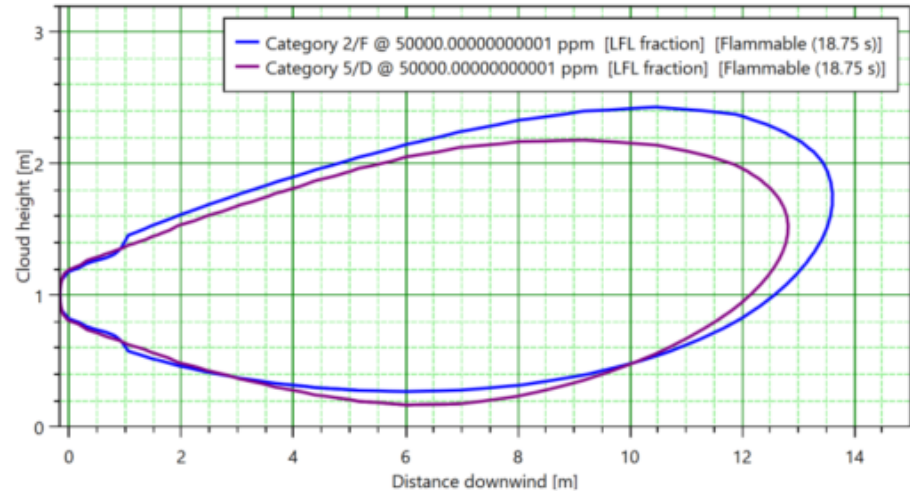
Appendix Figure C-65. Above Ground 4 barg Biogas Pipeline Rupture Vertical Release and Flash Fire: Dispersion Side View



Appendix Figure C-66. Above Ground 4 barg Biogas Pipeline Rupture, Horizontal Release and Flash Fire: Flash Fire Envelope at 1.0 metre receptor height

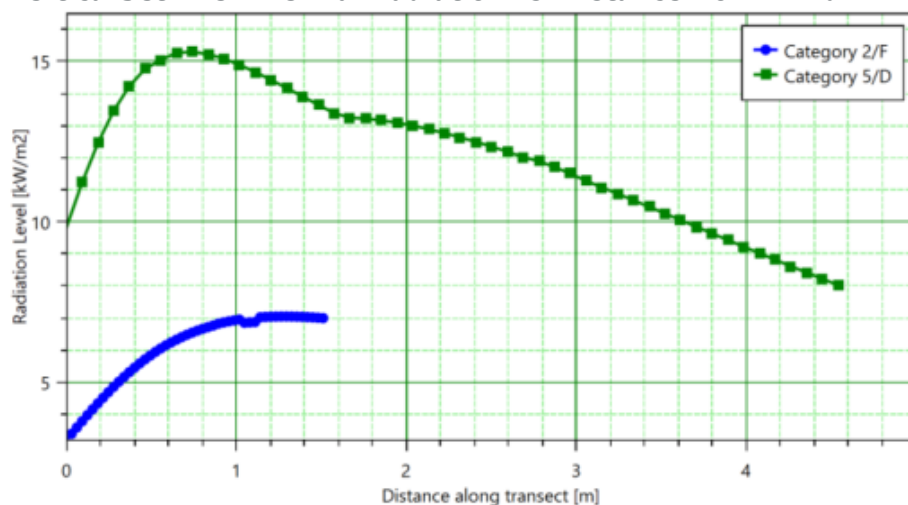


Appendix Figure C-67. Above Ground 4 barg Biogas Pipeline Rupture Horizontal Release and Flash Fire: Dispersion Side View

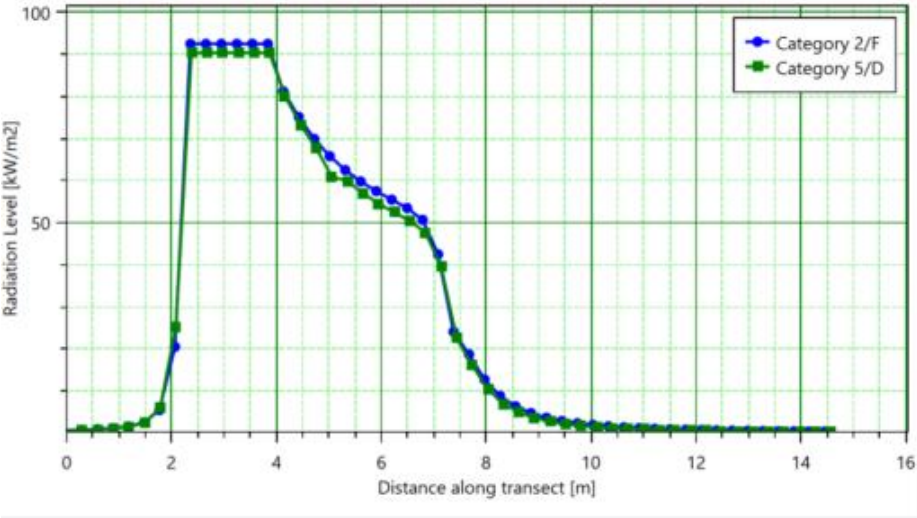


Installation	Biogas Pipeline 4 barg above ground pipeline
Scenario	Above Ground Outdoor Pipeline leak (10% of diameter), Jet Fire/Fireball, Vapour Cloud Explosion or Flash Fire
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Fireball Static (HSE) Model Jet Fire Cone Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	0.64 kg/s (D5/F2) biogas at 4 barg and ambient temperature, 250 mm diameter (D) pipeline, hole 25 mm size 6.4 metre fireball radius (D5/F2), 1.0 second duration
Jet Fire Model Source Term	0.36 kg/s (D5/F2) biogas 611 m/s velocity D5 / F2
Vapour cloud explosion source term	Horizontal release: 0.013/0.011 kg flammable mass Category D5/F2 Vertical release: 0.008/0.011 kg flammable mass Category D5/F2

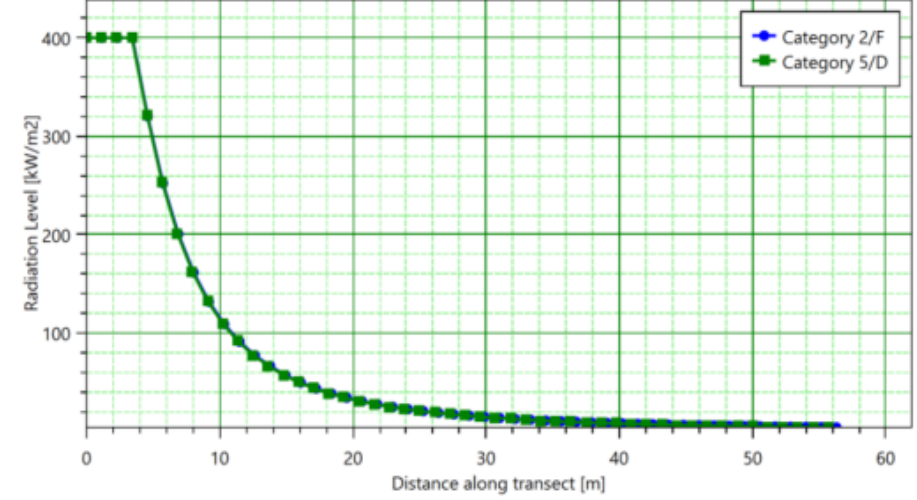
Appendix Figure C-68. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter) and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind



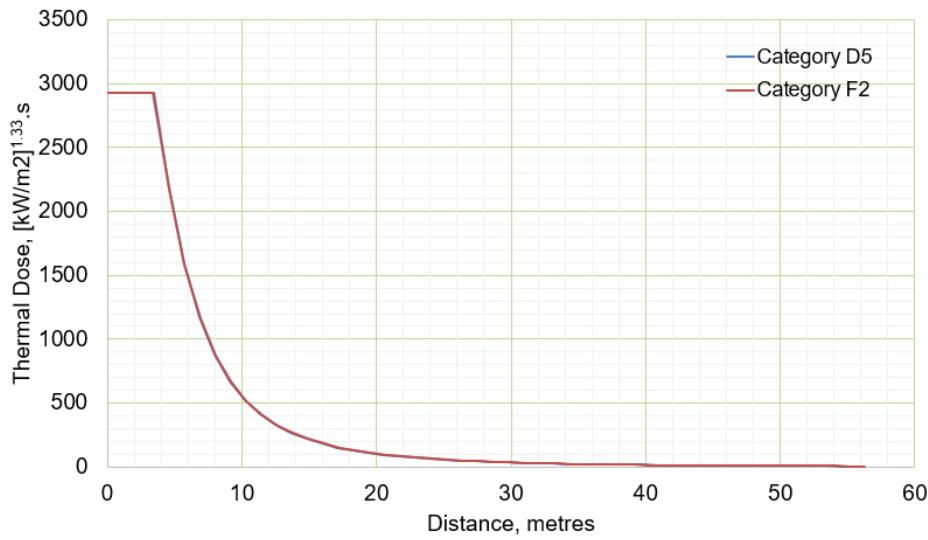
Appendix Figure C-69. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter) and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind



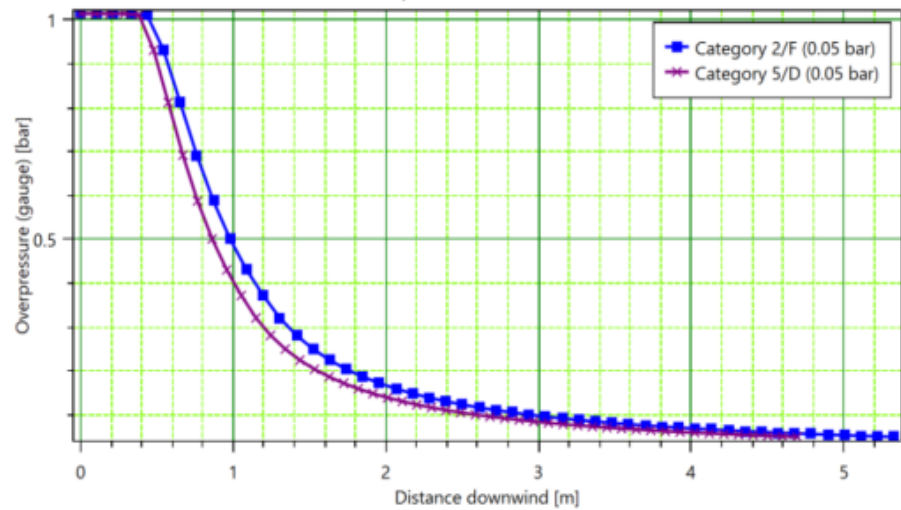
Appendix Figure C-70. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter) and Fireball: Thermal Radiation vs. Distance Downwind



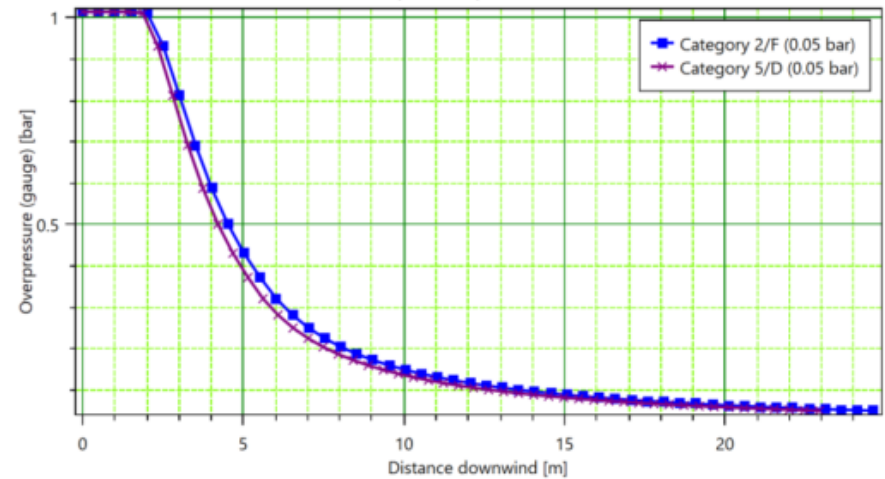
Appendix Figure C-71. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter) and Fireball: Thermal Dose vs. Distance Downwind



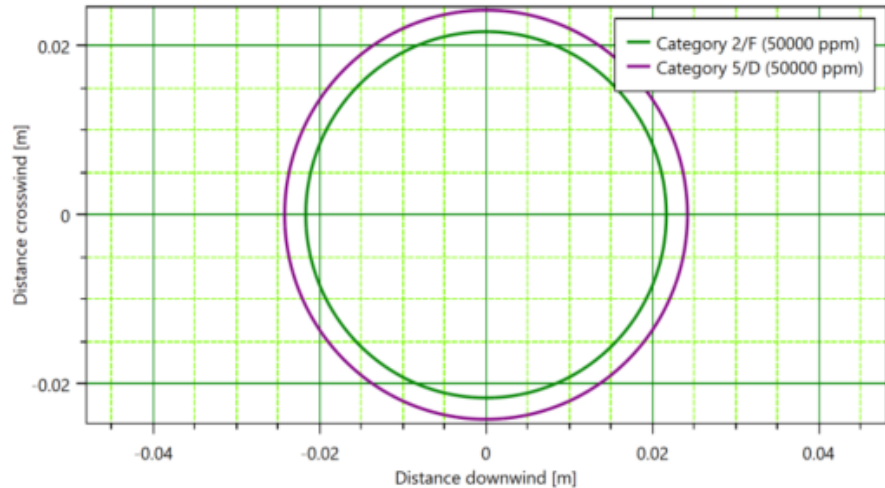
Appendix Figure C-72. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter), Vertical Release and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



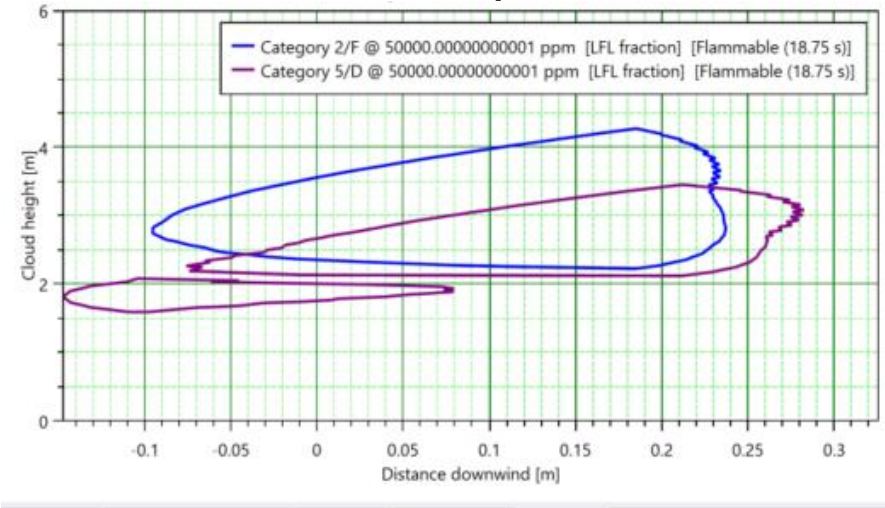
Appendix Figure C-73. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter), Horizontal Release and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



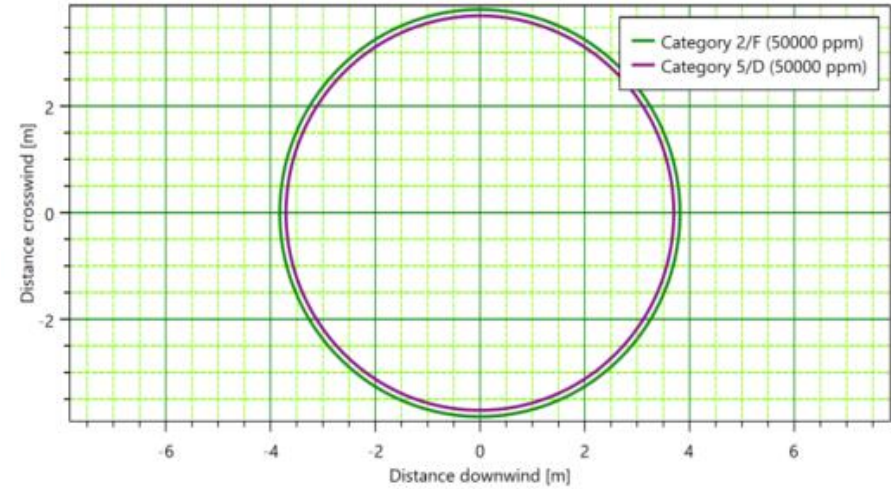
Appendix Figure C-74. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter), Vertical Release and Flash Fire: Flash Fire Envelope at 1.0 metre receptor height



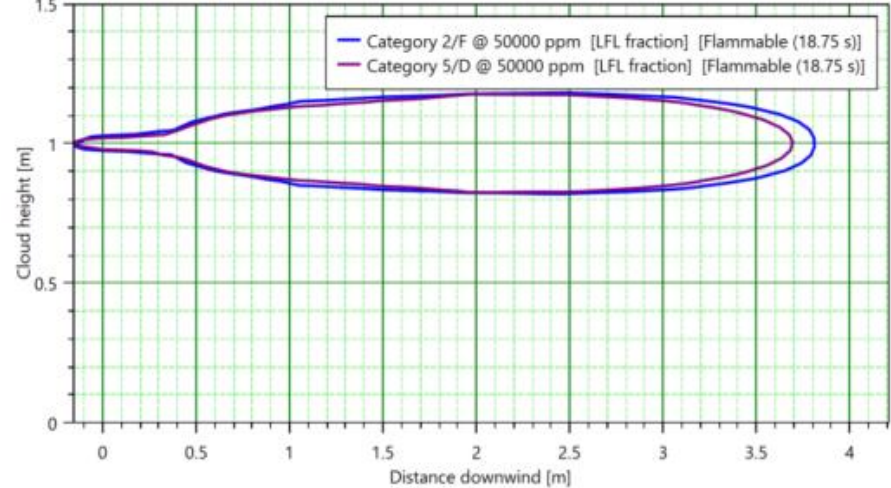
Appendix Figure C-75. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter), Vertical Release and Flash Fire: Dispersion Side View



Appendix Figure C-76. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter), Horizontal Release and Flash Fire: Flash Fire Envelope at 1.0 metre receptor height

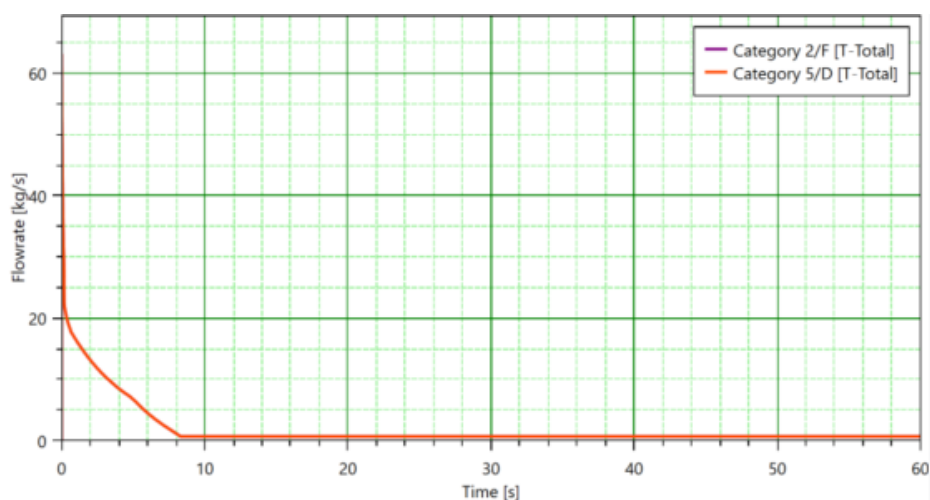


Appendix Figure C-77. Above Ground 4 barg Biogas Pipeline Leak (10% of Diameter), Horizontal Release and Flash Fire: Dispersion Side View

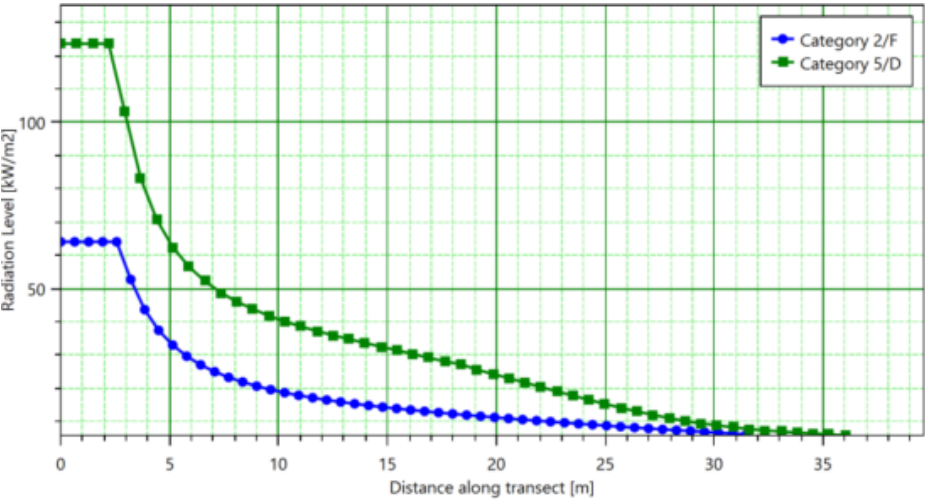


Installation	Biogas Pipeline 4 barg below ground pipeline
Scenario	Below Ground Outdoor Pipeline rupture, vertical release, Jet Fire/Fireball, Vapour Cloud Explosion or Flash Fire
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Fireball Static (HSE) Model Jet Fire Cone Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	0.64 kg/s (D5/F2) biogas at 4 barg and 20 degC, 250 mm diameter (D) pipeline, hole 250 mm size 13.0 metre fireball radius (D5/F2), 2.0 second duration
Jet Fire Model Source Term	4.2 kg/s (D5/F2) biogas 12.7 m/s velocity D5 / F2
Vapour cloud explosion source term	2.2/2.0kg flammable mass

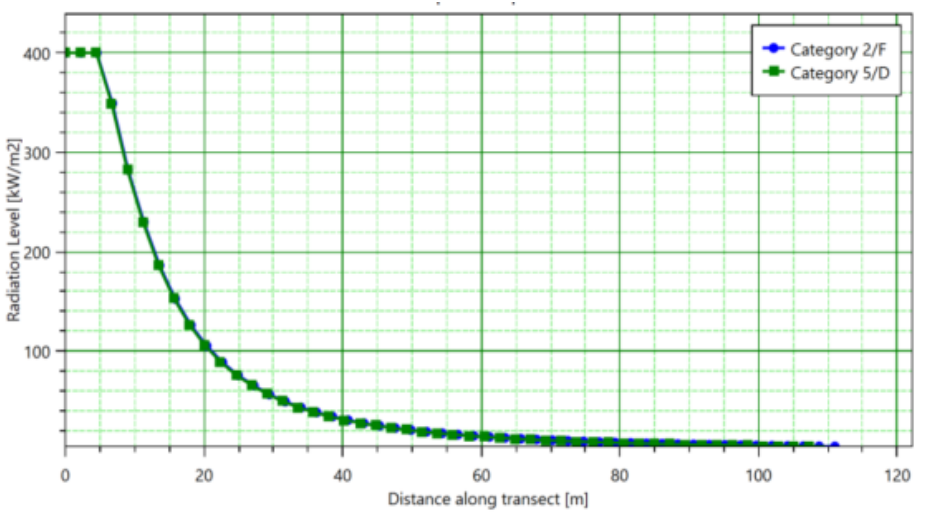
Appendix Figure C-78. Below Ground 4 barg Biogas Pipeline Rupture: Mass Flow Rate vs. Time



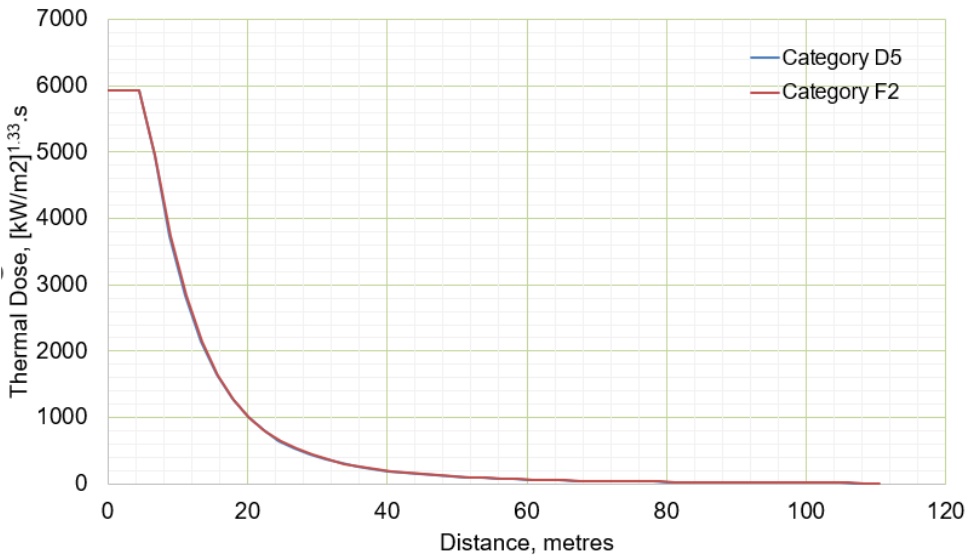
Appendix Figure C-79. Below Ground 4 barg Biogas Pipeline Rupture and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind



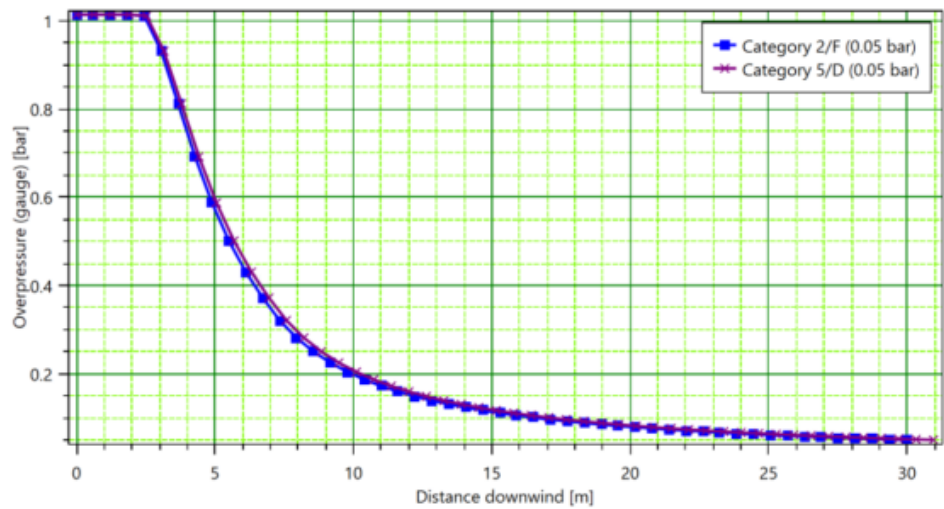
Appendix Figure C-80. Below Ground 4 barg Biogas Pipeline Rupture and Fireball: Thermal Radiation vs. Distance Downwind



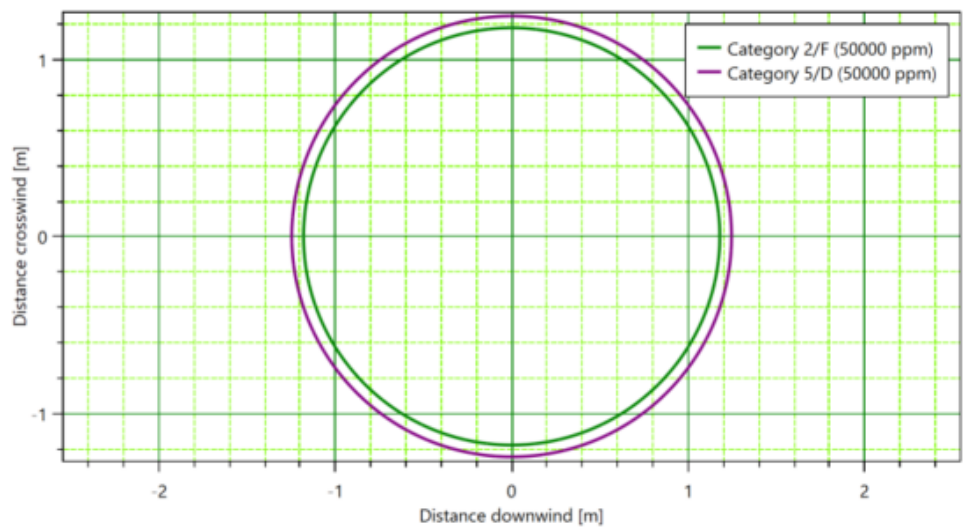
Appendix Figure C-81. Below Ground 4 barg Biogas Pipeline Rupture and Fireball: Thermal Dose vs. Distance Downwind



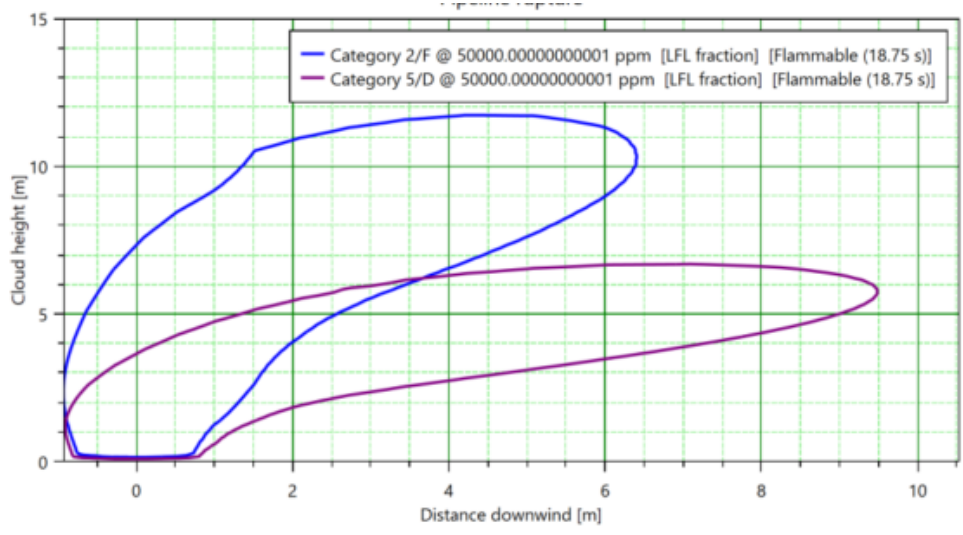
Appendix Figure C-82. Below Ground 4 barg Biogas Pipeline Rupture (Vertical Release) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind



Appendix Figure C-83. Below Ground 4 barg Biogas Pipeline Rupture (Vertical Release) and Flash Fire: Flash Fire Envelope, at1 m AGL

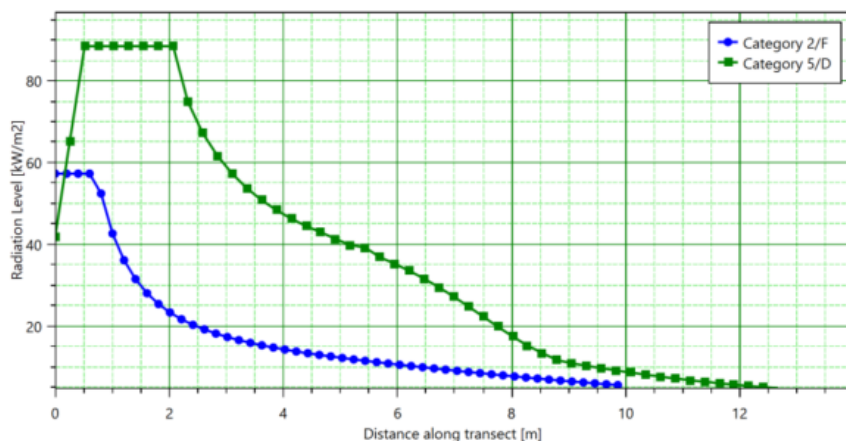


Appendix Figure C-84. Below Ground 4 barg Biogas Pipeline Rupture (Vertical Release) and Flash Fire: Dispersion Side View

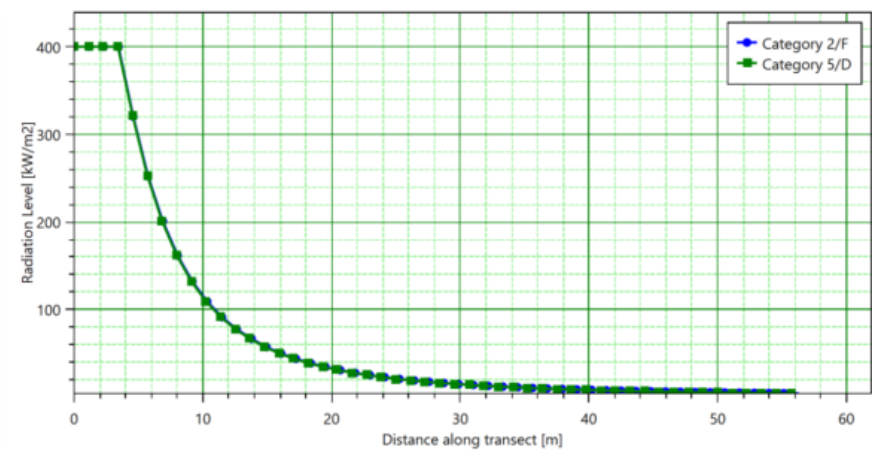


Installation	Biogas Pipeline 4 barg below ground pipeline
Scenario	Below Ground Outdoor Pipeline leak (10% of diameter), Jet Fire/Fireball, Vapour Cloud Explosion or Flash Fire
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Fireball Static (HSE) Model Jet Fire Cone Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	0.64 kg/s (D5/F2) at 4 bar and 20 degC, 250 mm diameter (D) pipeline, hole 25 mm size 6.4 metre fireball radius (D5/F2), 1.0 second duration
Jet Fire Model Source Term	2.8 kg/s (D5/F2) biogas 682 / 674 m/s velocity D5 / F2
Vapour cloud explosion source term	Horizontal release: 0.25 kg flammable mass Category F2, no VCE hazard for Category D5 Vertical release: No vapour cloud explosion hazard is predicted for a vertical release

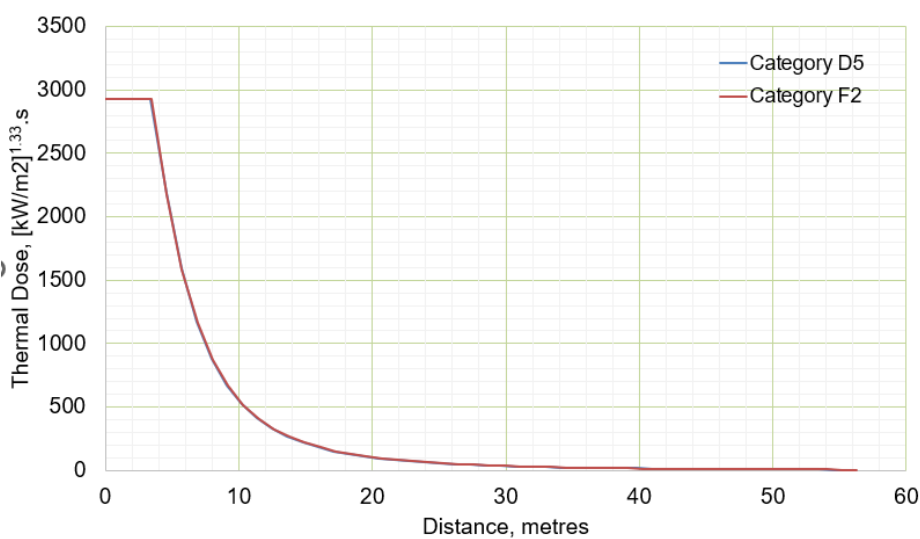
Appendix Figure C-85. Below Ground 4 barg Biogas Pipeline Rupture and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind



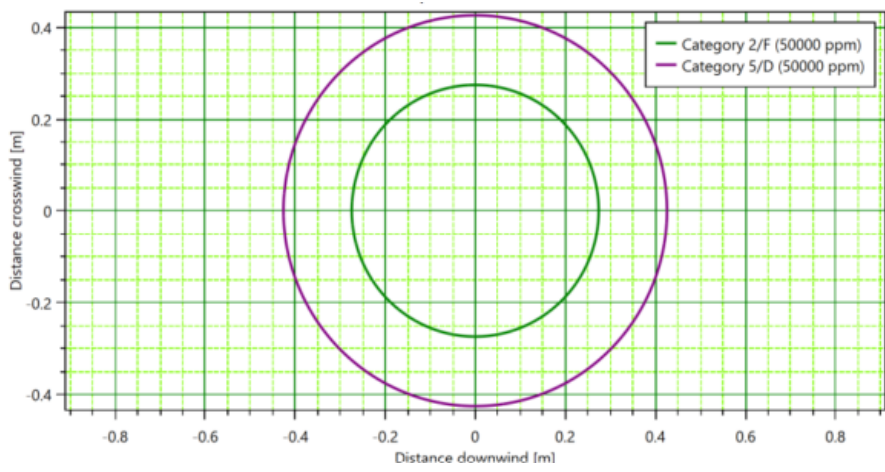
Appendix Figure C-86. Below Ground 4 barg Biogas Pipeline Rupture and Fireball: Thermal Radiation vs. Distance Downwind



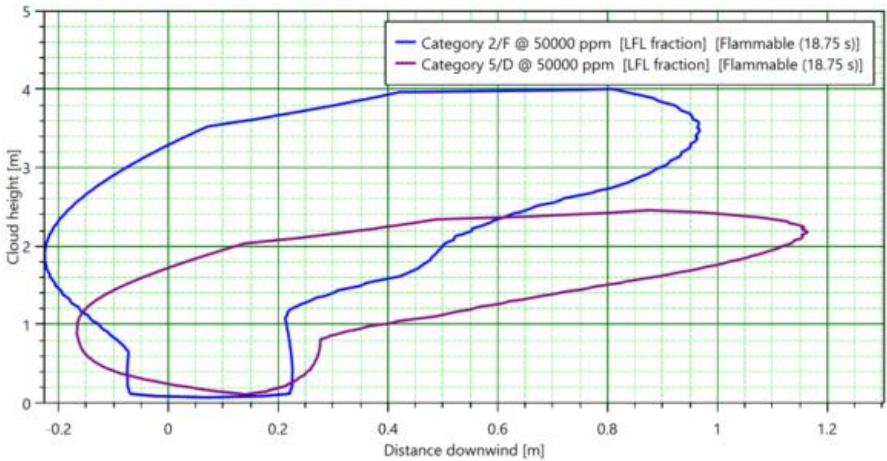
Appendix Figure C-87. Below Ground 4 barg Biogas Pipeline Rupture and Fireball: Thermal Dose vs. Distance Downwind



Appendix Figure C-88. Below Ground 4 barg Biogas Pipeline Rupture (Vertical Release) and Flash Fire: Flash Fire Envelope, at1 m AGL

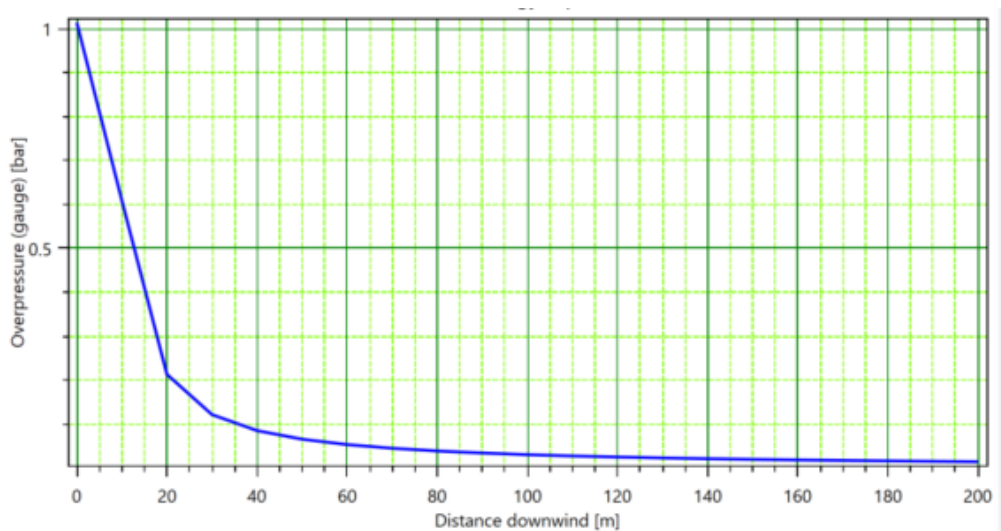


Appendix Figure C-89. Below Ground 4 barg Biogas Pipeline Rupture (Vertical Release) and Flash Fire: Dispersion Side View



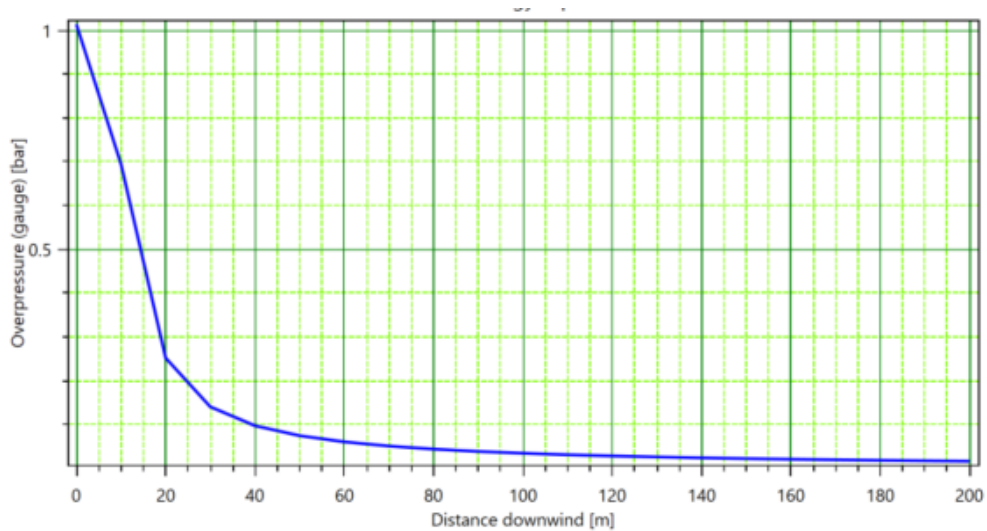
Installation	Blower Station
Scenario	Vapour Cloud Explosion within Blower Station Room
Software/model	DNV PHAST Version 9.1 TNO Multi Energy Model
Source Term	3.77 kg flammable mass (biogas) Explosion strength of 7 100% confinement

Appendix Figure C-90. Confined VCE in Blower Station Room: Overpressure Decay Curve



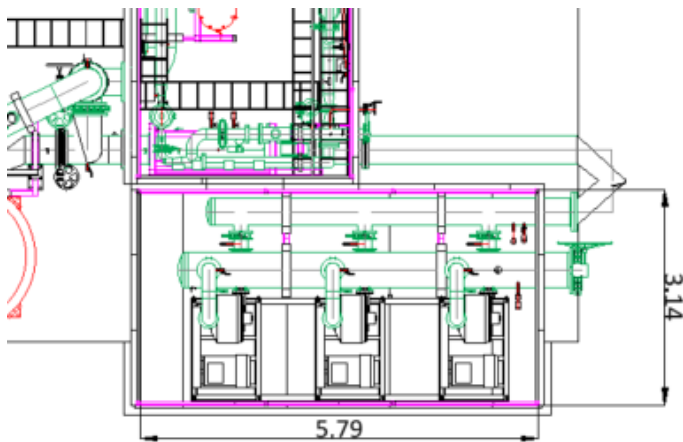
Installation	BNEF
Scenario	Vapour Cloud Explosion within Gas Room
Software/model	DNV PHAST Version 9.1 TNO Multi Energy Model
Source Term	5.23 kg flammable mass (biogas) Explosion strength of 7 100% confinement

Appendix Figure C-91. Confined VCE in BNEF Gas Room: Overpressure Decay Curve



APPENDIX D. BIOGAS VCE FLAMMABLE MASS CALCUALTION

Blower Station Room



Blower Station room length 5.79 metres

Blower Station room width 3.14 metres

Blower Station room height 3.13 metres

Blower Station room volume 56.9 cubic metres (length x width x height)

Complete combustion equation for Methane: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

Stoichiometric Mass Fraction Calculation:

Compound	Mol	Mol fraction	Molecular weight (kg/kmol)	Mass (kg)	Mass fraction
CH ₄	1	0.096	16.040	1.54	0.056
O ₂	2	0.192	31.999	6.13	0.222
N ₂	7.44	0.713	28.014	19.96	0.723
Total	10.44	1		27.63	1.000

Volume of Blower Station room: 56.9 m³

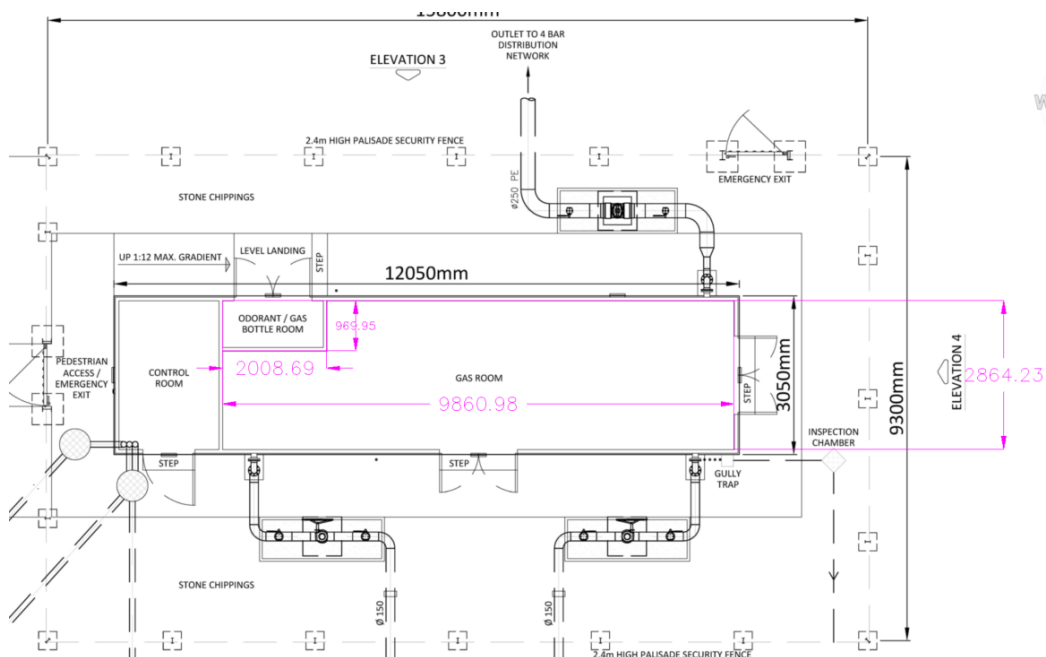
Density of Methane/Air Mixture at 10°C (conservative temperature assumption) (calculated from DNV PHAST 9.1): 1.193 kg/m³

Mass of Flammable Mixture in the Blower station room: 67.88 kg (56.9 m³ x 1.193 kg/m³)

Compound	Mass (kg)
CH ₄	3.77
O ₂	15.06
N ₂	49.05

Flammable Mass of Methane in Blower Station room: **3.77 kg**

BNEF Gas Room



Gas room plus odorant room length 9.86 metres

Gas room width 2.864 metres

Gas room height 3.000 metres

Volume of gas room + odorant room 84.717 cubic metres (length x width x height)

Odorant room length 2.009 metres

Odorant room width 0.970 metres

Odorant room height 3.000 metres

Volume of odorant room 5.843 cubic metres (length x width x height)

Volume of gas room 78.874 cubic metres

Mass of Flammable Mixture in gas room: 94.13 kg ($78.874 \text{ m}^3 \times 1.193 \text{ kg/m}^3$)

Compound	Mass (kg)
CH ₄	5.23
O ₂	20.88
N ₂	68.01

Flammable Mass of Methane in BNEF gas room: **5.23 kg**

END OF REPORT