HALSTON

Appendix 4.1

Environmental Risk Assessment (ERA)

COMAH SUPPORT FOR PROJECT COOLPOWRA

Project Coolpowra Environmental Risk Assessment

Halston Environmental and Planning Limited

Report No.: 2, Rev. 1
Document No.: 2246099
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Objective:

To carry out an environmental risk assessment of the Project Coolpowra planning application stage

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Table of contents

1 EXECUTIVE SUMMARY

This report presents the Environmental Risk Assessment for the Project Coolpowra planning application stage.

The ERA methodology follows the Source-Pathway-Receptor model outlined in the Chemical and Downstream Oil Industries Forum (CDOIF) Guideline on Environmental Risk Tolerability for COMAH Establishments. The source of environmental risk identified was diesel from three liquid fuel tanks with a capacity of 7333m^3 each.

One Source-Pathway-Receptor trio with MATTE potential was identified as the release of approximately 6196 tonnes of diesel stored in 7333m^3 liquid fuel tank capacity impacting on the Kilcrow River

The overall unmitigated level of risk posed by the establishment from the release of diesel to the Kilcrow River was found to be in the tolerable if ALARP (TifALARP) on the CDOIF risk matrix. Following the identification of the control measures in place and their probability of failure on demand, it was found that the level of mitigated risk posed by the establishment to the Kilcrow River falls into the Broadly Acceptable region.

2 INTRODUCTION

Project Coolpowra is a proposed Reserve Gas-Fired Power Generator, GIS Electrical Substation and Energy Storage System.

Halston Environmental and Planning Limited (Halston) is to produce an environmental risk assessment (ERA) as part of its COMAH HSE submission. The Health and Safety Authority (HSA) can request it to see the ERA. DNV has been subcontracted by Halston Environmental and Planning Limited to carry out the ERA in support of the application.

The Chemicals Act (Control of Major Accident Hazards involving Dangerous Substances) Regulations 2015 (S.I. No. 209 of 2015) (the "COMAH Regulations") (Ref. /1/), implement the Seveso III Directive (2012/18/EU) and aim to prevent and mitigate the effects of major accidents involving dangerous substances which can cause serious harm to people and/or the environment, with the overall objective of providing a high level of protection in a consistent and effective manner. The site development qualifies as a "lower tier" site under the COMAH Regulations 2015 as it holds quantities of dangerous substances above threshold quantities specified in Schedule 1 of the COMAH Regulations 2015 (Ref. /1/).

The ERA outlined in this document has been undertaken in accordance with the Chemical and Downstream Oil Industries Forum (CDOIF) Guideline on Environmental Risk Tolerability for COMAH Establishments (Ref. /2/), the Guide to the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015 (S.I. No. 209 of 2015) (Ref. /3/) and the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Enforcement Regulations, 2008 (Ref. /4/). The CDOIF guideline for carrying out ERAs is an industry wide accepted methodology.

3 RISK ASSESSMENT METHODOLOGY

3.1 What is a Major Accident to the Environment?

It is not possible to provide a scientific definition of changes in the environment caused by an event at an establishment that would constitute a major accident to the environment. However, the more extensive the areas and quantities of natural and semi-natural resource damaged, the longer the effects are likely to last, and the more intense or severe these effects, then the more likely it is that the event will be regarded as a major accident to the environment by the competent authority. Moreover, if the event affects nationally or internationally sites designated for nature conservation purposes then the event is likely to be regarded as a major accident at lower thresholds than those that apply to other designated areas, amenity areas, the wider countryside or the more common types of agricultural land. As a general rule, the specific threshold levels that apply to other designated sites, scarce habitats and more widespread habitats vary in relation to the importance of the particular type of site.

In the most general terms, major accident hazards to the environment will be those where events have the potential to: (i) pose knock-on threats to human health by contamination of food or drinking water or impacts on sewage treatment regimes; (ii) affect large areas of land designated for conservation, amenity or planning purposes. Note that large in an ecological sense may include extensive agglomerations of fragmented habitats; (iii) be long-term or persistent and/or inhibit natural processes of regeneration; (iv) be severe by causing significant permanent or long-term damage to the ecosystem (direct, indirect, or knock-on), such as reduced breeding success of protected species, or reduced biodiversity of protected habitats (including local or national extinctions of protected species), or destruction/reduction in quality of a significant proportion of the area of a rare habitat (Ref. /5/).

3.2 Environmental Risk Assessment Approach

DNV's environmental risk assessment methodology follows the Source-Pathway-Receptor model that is outlined in the CDOIF (Ref. /2/) and DETR Guidelines (Ref. /5/). The assessment involves the following steps which are described below:

1. **Source-pathway-receptor assessment -** The first stage involves a detailed assessment of the materials stored on site, identification of the natural and man-made receptors surrounding the site and the pathways leading from the site to these receptors.

2. **Determination of the severity and duration of harm to receptors –** to determine the consequence level for each unmitigated liquid, gaseous and ignited release event, the severity levels, S1, S2, S3 and S4 for significant, severe, major and catastrophic respectively were established.

Three approaches are used to determine the severity of harm caused by liquid releases. These include an oil slick approach and an LC_{50} approach for releases on water and analysis of a representative pool diameter for releases on land. These are described later in Section 3.2.1. For particular species, the severity of harm is based on an estimate of the proportion of the national population which is affected, if a release impacts the receptor where the species is resident. Once established, these severity levels are then compared with the likely duration of harm D1, D2, D3 and D4 for short term, medium term, long term and very long term respectively to establish a consequence level between A and D as shown in the matrix presented in Figure 3-1. The reference tables from the CDOIF guidelines (Ref. /2/) used to establish the consequence levels and the duration of harm categories associated with each MAH scenario are shown in Appendix A. The method used for predicting the duration of harm caused by the release scenarios to the environmental receptors is presented in Section 3.2.2.

Severity of Harm					
	4		C	D	D
	3		B	C	D
	2		A	B	C
	1	*Sub-MATTE Harm*			
		1	**2**	**3**	**4**
		Harm Duration Category			

Frequency at which the CDOIF consequence level is reached or exceeded	**Frequency per receptor per establishment per year**	
	Intolerable (greater than)	**Broadly Acceptable (less than)**
A	1.0 E-02	1.0 E-04
B	1.0 E-03	1.0 E-05
C	1.0 E-04	1.0 E-06
D	1.0 E-05	1.0 E-07

Figure 3-1: Method and matrix for determining MATTE consequence level and corresponding receptor frequency tolerability thresholds

3. **Quantification of unmitigated risk to receptors –** the frequencies of the unmitigated occurrences of any scenarios qualifying as MATTEs are determined using site specific or generic quantitative risk assessment (QRA) data. This includes similar releases of the material which could follow the same pathway to the receptor. These frequencies are aggregated to determine the total unmitigated risk posed to each receptor by the establishment. A comparison of the unmitigated risk posed to each receptor against the criteria in the risk matrix presented in Figure 3-2 to establish whether the risk is intolerable, tolerable if as low as reasonably practicable (TifALARP) or broadly acceptable.

	Frequency per establishment per receptor per year						
Frequency at which CDOIF Consequence Level is equalled or exceeded	10^{-8} - 10^{-7}	10^{-7} - 10^{-6}	10^{-6} - 10^{-5}	10^{-5} - 10^{-4}	10^{-4} - 10^{-3}	10^{-3} - 10^{-2}	$>10^{-2}$
D- MATTE						Intolerable	
C- MATTE				TifALARP			
B - MATTE	Broadly Acceptable						
A- MATTE							
Sub MATTE	Tolerability not considered by CDOIF						

Figure 3-2: CDOIF Risk Matrix

4. **Quantification of mitigated risk to receptors –** the frequencies of the unmitigated MATTE scenarios are multiplied by the probability of failure on demand (PFD) of any relevant protection layers on the site. These mitigated frequencies are aggregated to determine the total mitigated risk posed to each receptor by the establishment. The mitigated risks posed to each receptor are again compared to the criteria in the risk matrix presented in Figure 3-2 to establish whether the risk is intolerable, TifALARP or broadly acceptable.
5. **ALARP demonstrations if necessary -** Operators may be required to conduct a ALARP demonstration if the mitigated level of risk posed by the establishment to any of the surrounding receptors is found to be intolerable or TifALARP.

3.2.1 Determining Severity of Harm to Receptors

Harm to Water Receptors

Two approaches are used to determine the severity of harm caused by a liquid release to a water based environmental receptor. These are based on a lethal concentration (LC_{50}) of material in the receptor and the critical thickness of an oil slick. The type of approach applied depends on the properties of the material being released. For releases onto land, an approach based on a representative diameter for liquid pool is used.

If a release can reach a receptor where particular species can be found, the severity of harm is assessed using the MATTE tolerability tables in Appendix A.

1. LC_{50} Approach

An LC_{50} approach can be used to determine the severity of harm caused by water soluble substances which can exert toxic effects on aquatic life. The median lethal concentration, LC_{50} (lethal concentration, 50%) is the concentration of a substance required to kill half of the members of a tested population after a specified test duration. The value may be obtained by direct observation or from interpolation. LC_{50} values are a useful indicator of the substance's ecotoxicity with lower values indicative of increased toxicity. LC_{50} values can therefore define maximum allowable toxicant concentrations. As a general rule the longer the exposure time for a particular species, the lower the LC_{50} value. The reason for this observation is that it takes time for the compound to penetrate the bodies of test organisms to affect harm.

The following simple equation is then used to determine the minimum amount of material which could credibly cause a MATTE scenario:

$$\text{Mass of material for MATTE potential} = \text{Area of receptor} \times \text{Water depth} \times LC_{50}\ \text{value} \quad (1)$$

2. Oil Slick Approach

The fate and behaviour of oil in the marine environment depends on many processes including dissolution, emulsification, oxidation and destruction, physical transport and the marine environment. According to "Offshore Environment" (Ref. /6/), it is stated that an oil slick with a thickness of less than 0.1 mm in the marine environment will tend to disintegrate into separate fragments and spread over larger and more distant areas. It is therefore assumed that a critical thickness greater than or equal to 0.1 mm is feasible for an oil slick that has the potential to cause a MATTE.

To calculate the minimum volume of material required to cause a MATTE to a receptor, the critical thickness of 0.1 mm is multiplied by the defined minimum threshold area for a MATTE in the receptor (Ref. /2/).

In addition, the way in which an oil slick breaks up and dissipates depends largely on how persistent the oil is. Light products such as kerosene tend to evaporate, dissipate quickly and naturally and rarely need cleaning up. Such products are termed non-persistent oils. Persistent oils, such as many crude oils, break up and dissipate more slowly and usually require a clean-up response. An oil slick usually drifts in the same direction as the wind, and as it does, it dissipates and thins.

Harm to Land Receptors

Liquid spills on land surfaces will spread to form pools, the extent of which will depend on a number of factors such as the ground surface and topography.

Low viscosity liquids (e.g. light distillates) spilt on concrete are assumed to spread to form pools with a uniform thickness of 5 mm. DNV's Safeti software is used for quantified risk assessment and sets this thickness value as a default for pools. This value is used for releases to areas of made ground within the site area. Liquids with higher viscosities (e.g. middle distillates and crude / heavy oils) that are spilt on concrete are assumed to spread to form pools with a uniform thickness of 20 mm. If liquid hydrocarbons are spilt onto unmade ground that is covered with vegetation they will form pools with significantly greater thicknesses due to the liquid hold-up provided by the vegetation. A value of 50 mm has been assumed in the case where crude oil is spilt onto unmade ground.

Harm to Soil and Groundwater Receptors

Liquids which are released to permeable ground will migrate downwards through the soil and potentially into groundwater layers due to the effect of gravity and capillary forces. For hydrocarbon releases, the depth and size of the plume depends on (Ref. /7/):

1. Properties of the hydrocarbon material – heavier hydrocarbons show lower rates of permeation through the soil due to their higher viscosity and tendency to adsorb to soil particles. On the other hand, BTEX (benzene, toluene, ethylbenzene and xylene) have lowest soil sorption coefficients and move quickly through the soil;
2. Properties of the soil – porosity and permeability are the two most important factors which influence liquid flow through the ground. Soils such as sand with high porosities and permeabilities allow for the fastest rates of permeation.

Hydrocarbons that have been released into the ground break down over time due to vaporisation and the action of bacteria in the soil. The length of time that the hydrocarbons remain in the ground depends on the molecular weight of the compound, with heavier hydrocarbons being more resistant to degradation than lighter ones. Hydrocarbons also degrade more quickly in hot and humid climates. In general, sub-surface hydrocarbon releases tend to degrade quite quickly – a field study of a crude oil spill site in India indicated that up to 75% of the hydrocarbons could be degraded within a year (Ref. /7/).

Accurately predicting the subsurface spread of hydrocarbons is difficult even with complex modelling solutions. DNV will employ a simplified semi-quantitative approach to determine the severity and duration of harm of releases. This approach will involve the following steps:

1. Determine if the released hydrocarbons have the potential to permeate through the soil layer and enter the groundwater layer depending on the properties of the released material and the properties and thickness of the soil layer.
2. If the hydrocarbon release can permeate into the groundwater layer, any BTX components and light hydrocarbons present in the material will be assumed to be able to spread indefinitely in the groundwater until they occupy a volume with a concentration greater than the legal or recommended concentration of the pollutant in question. It will be assumed that middle distillates and heavy hydrocarbons will not be able to spread easily within the groundwater layers due to their higher viscosities. The following simple equation is then used to determine the minimum amount of material which could credibly cause a MATTE scenario:

   Mass of material for MATTE potential = Groundwater area x Groundwater table depth x Legal limit of pollutant (2)

3.2.2 Determining Duration of Harm

The overall receptor tolerability for MATTE, as defined in Figure 3-1, is dependent on the level of harm caused by the incident and also the duration of that harm. A supporting document to the CDOIF guidance has been produced by ENVIRON titled 'Environmental Recovery Guide' - Supporting Guide to the Environmental Risk Tolerability for COMAH Establishments Guideline' (Ref. /8/). This document lays out a straightforward method for determining harm duration for any environmental release based on the chemical and receptor type under analysis. The guidance in the document is based on a review of around 300 case studies of environmental incidents in the CDOIF related industries and a review of monitoring studies of the Exxon Valdez incident.

The environmental recovery guidance document provides two flow charts, which are based on water habitats and land habitats, allowing the assessor to determine the harm duration. The flowcharts contain all 60 of the chemicals listed in the COMAH Regulations and split these substances by their ability to be broken down or dispersed in the natural environment. The flowchart then splits up different habitat (receptor) types by their ability to regenerate and their environmental sensitivity i.e. a river is classed as a different type of habitat to a coral reef. A harm duration category is then selected, for each potential MATTE event, based on the categories of chemical and habitat.

The recovery flowchart for water and land receptors is provided in Figure 3-3 and Figure 3-4 respectively. The method presented in Figure 3-3 is not applicable for firewater, so engineering judgement was used to determine the harm duration category.

The recovery time for each particular species is taken as the breeding lifecycle. The harm duration category is selected based on the relevant water or land habitat flowchart provided in Figure 3-3 or Figure 3-4.

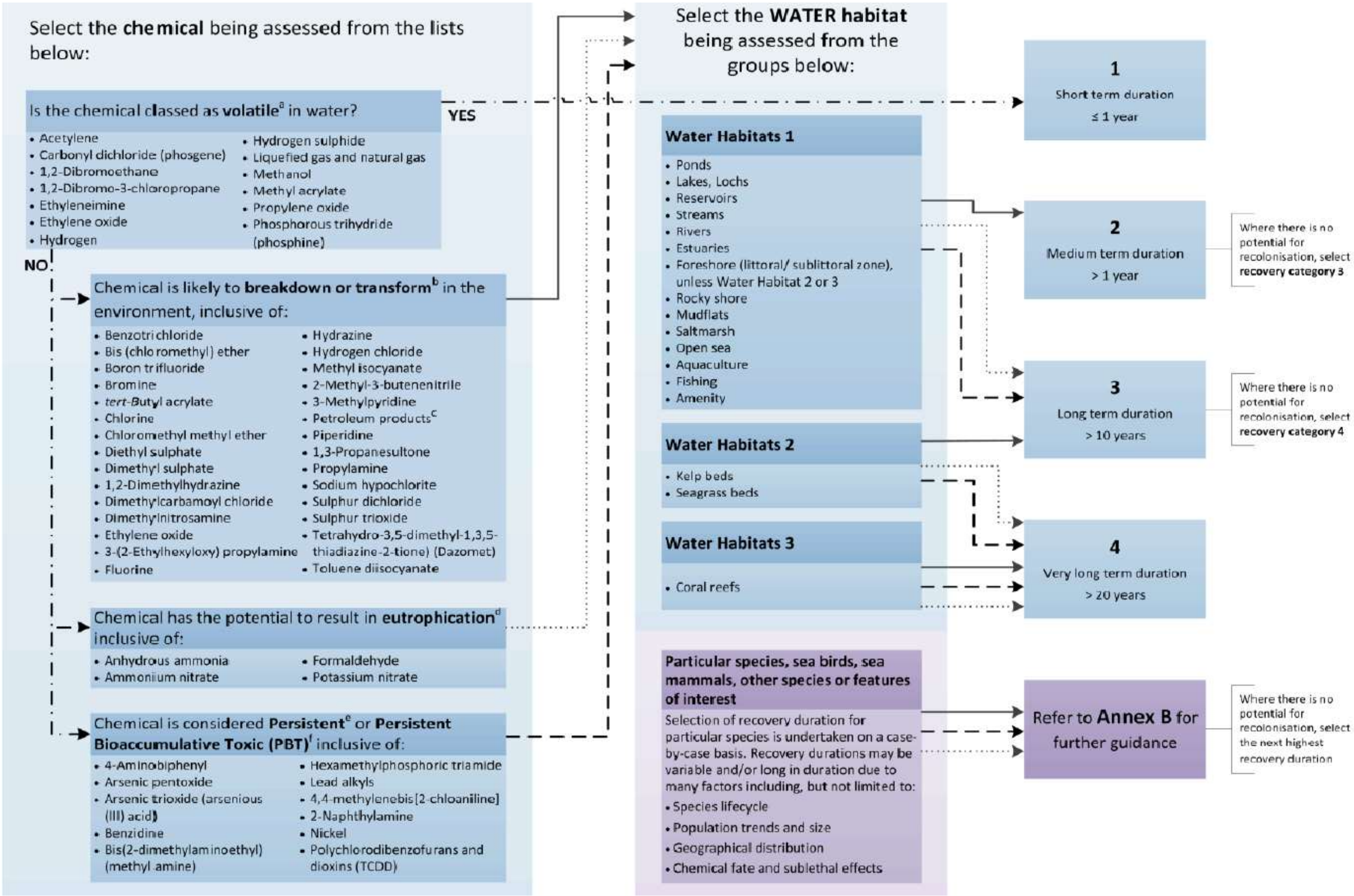

Figure 3-3: Recovery flowchart for water receptors (Ref. /8/)

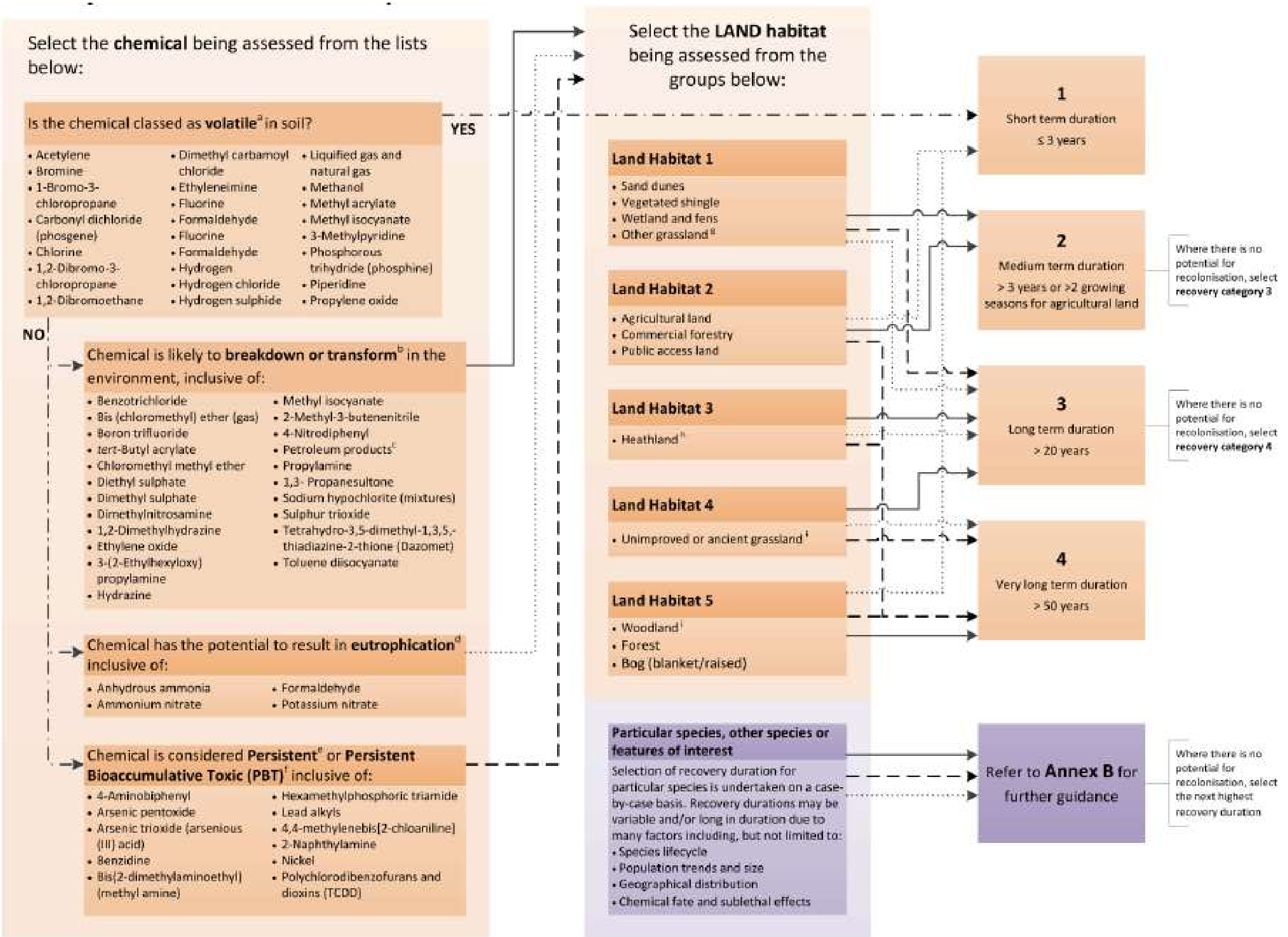

Figure 3-4: Recovery flowchart for land receptors (Ref. /8/)

4 SITE DESCRIPTION

The proposed development is located in the townland of Coolpowra, Ballynaheskeragh, Coolnageeragh and Gortlusky, County Galway, and is located approximately 4km north of Portumna and 3.1km south of Killimor. See Figure 4-1 for site location and Figure 4-2 for site layout plan.

The project includes a Reserve Gas-Fired Generator which comprises three opencycle gas-fired generator (OCGT) units located within a turbine hall, accompanied by auxiliary equipment, with secondary fuel (gas oil) stored in a bunded structure outside the turbine hall, alongside cooling equipment and other electrical plant items (e.g. transformers). The Reserve Gas-Fired Generator will include an above ground installation (AGI) compound.

An underground gas pipeline, designed to operate at pressures of 16bar or higher, will be established by Gas Networks Ireland (GNI) through a separate planning application. This pipeline will be directed to the proposed AGI at the development site from the nearest connection point on the gas transmission network.

The project includes a 400kV Gas Insulated Switchgear (GIS) Substation comprising a two-storey building positioned and secured within a palisade fenced compound. The proposed GIS will upgrade and replace the existing air insulated switchgear (AIS) substation with a new gas GIS substation at Oldstreet. The GIS substation will facilitate connection of the reserve gas fired generator and ESS to the existing node on the transmission network.

Finally, the project includes an energy Storage System which includes: (i) a long duration energy storage (LDES) battery (200MW) positioned in an outdoor compound and (ii) a synchronous condenser (400MVA electrical rating) positioned within a building. The technology is designed to complement and support the reserve gas fired generator by providing zero carbon, instantaneous power and balancing power to the grid.

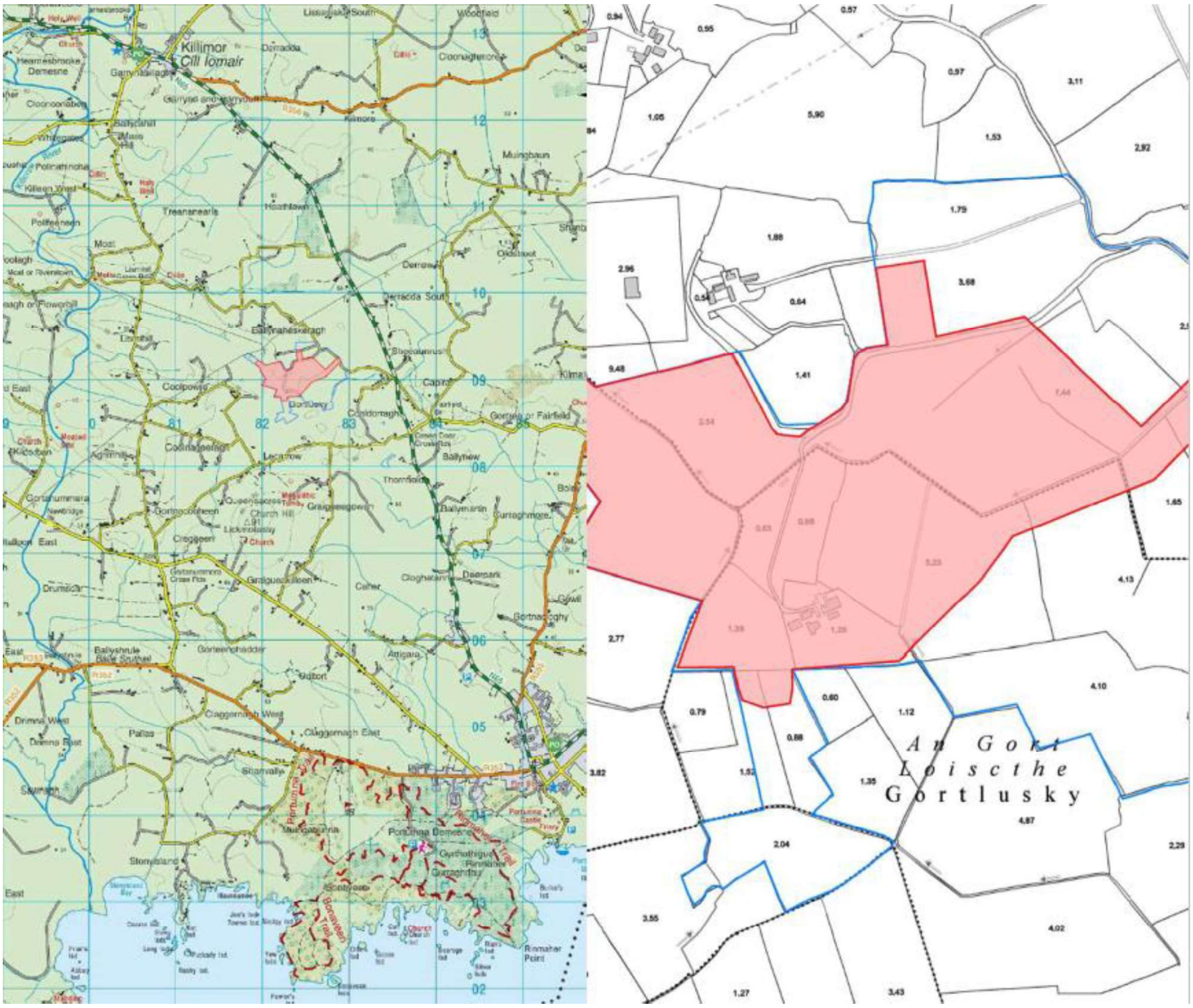

Figure 4-1 Site Location Plan

Figure 4-2 Site Layout Plan

5 BASELINE DESCRIPTION OF THE LOCAL ENVIRONMENT

The site setting descriptions are detailed in the Summary Description of Receiving Environment (Ref. /9/) and summarised in the following sections.

5.1 Topography

Lands within the development site boundary are in agricultural use and include a farmhouse and outbuildings which will be demolished. The proposed lands are situated at an elevation of c. 51-54m.

5.2 Geology

Bedrock Formation Beneath the site is Visean basinal limestone "Calp" described as Dark-grey argillaceous & cherty limestone & shale. Soils on the site are described as Mullabane (Teagasc Code 1100q) and described as mostly Brown Earths and Calcareous Brown Eaths on drift with limestones, associated with Luvisols and some inclusions of Rendzinas and peat.

5.3 Soil and Sediment

The soils are classed as well drained (Type BminSW). The Killimor Esker (Code GY078), a moderate-sized ridge comprised of esker sands and gravels, deposited under the ice sheet and trends east west is located 2.6km north of the site at its nearest point.

5.4 Groundwater

The bedrock aquifer beneath the site is a locally important aquifer with bedrock which is moderately productive only in local zones (Aquifer Category LI). Aquifer vulnerability is classed as moderate mainly with the exemption of the south-western corner of the site where vulnerability is classed as high with some outcropping rock /rock near the surface,

There are no karst features (including Turloughs) within the boundary of the proposed development lands; the closest karst feature being Pollnabreeka Spring, an enclosed depression approximately 2.8km south of the site. There are no known (recorded by GSI) groundwater abstraction wells within 4km of the site.

5.5 Hydrology

The site is within the Lower Shannon Hydrometric Area (River Basin District IEGBNISH), which has an area of 5,032km^2. The application site is primarily within the Lower Shannon catchment (catchment ID 25B) with the western part of the site bordering Lower Shannon catchment ID 25B. Desktop studies show that the proposed development lands are contained in the Gortaha_010 and Kilcrow_070 WFD River subbasins. There are a number of field ditches and streams within the proposed development site. The main watercourse within the development land is the Ballynaheskeragh stream (also known as GORTAHA_010) which is shown (see Figure 5-1) to be flowing generally in a north western and discharges to the Kilcrow River.

The Kilcrow River is located approximately 1.8km west of the development land boundary and it flows generally in a southern direction and through Barroughter Bog SAC approximately 9km downstream of the site, before flowing into Lough Derg (Shannon) SPA (Code 004058) /Lough Derg, North-east Shore SAC (Code 002241) a further 1.1km downstream of Barroughter Bog SAC.

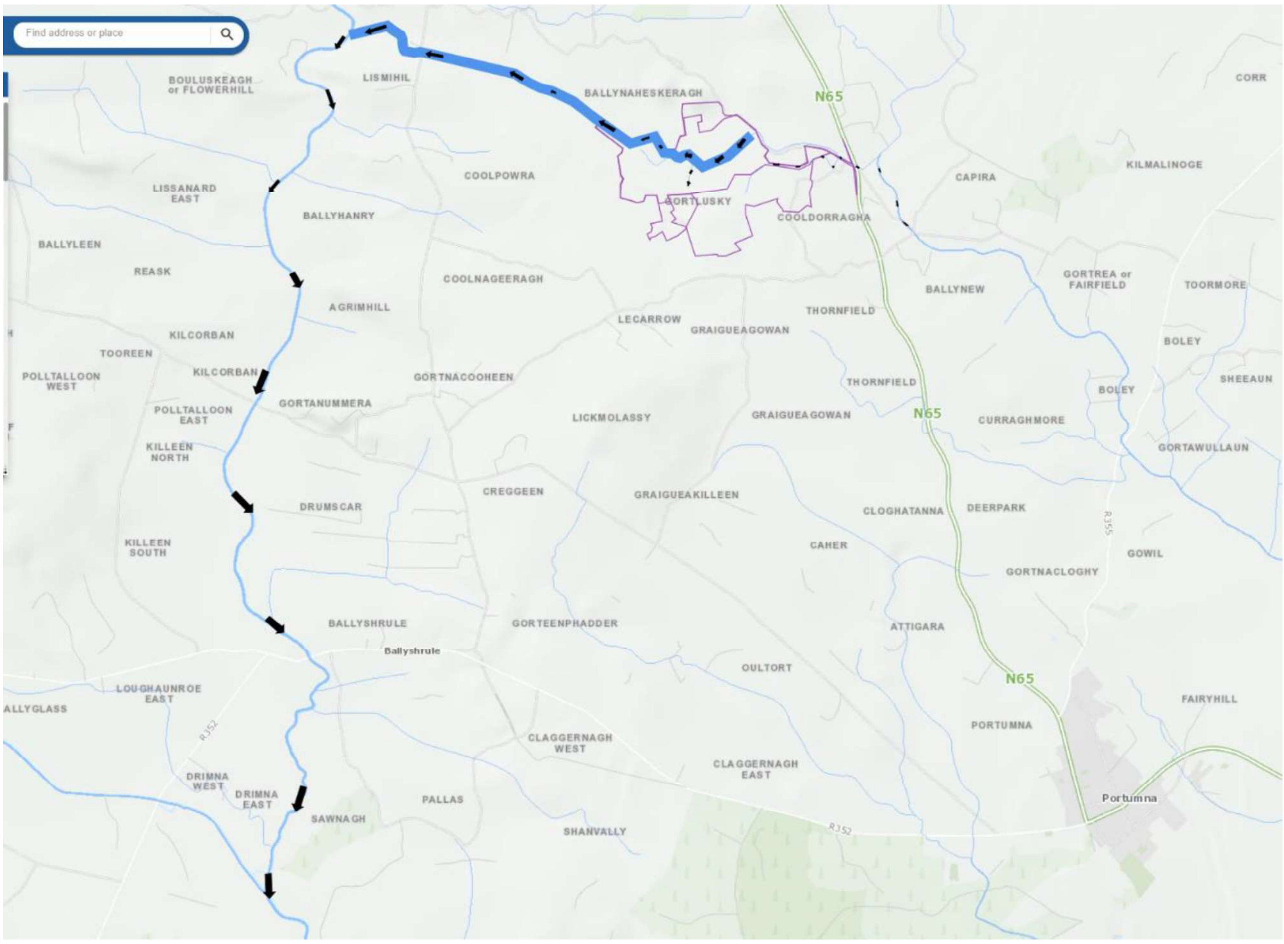

Figure 5-1: Ballynaheskeragh Stream and Kilcrow River Flow Path

5.5.1 Flooding

The application site boundary is located within (fluvial) Flood Zone C (low probability of flooding) as confirmed by a review of Office of Public Works(OPW) available flood mapping. Historical flood events are recorded by OPW. A review of the online historical data indicates that there is no record of past flooding events mapped within a 2km radius of the application site. The application site is located on lands with clear drainage paths away from the site, so the risk of pluvial flooding is categorised as low. There is no groundwater flood risk as identified from a review of Groundwater Flood Probability Maps prepared by Geological Survey Ireland. No Areas of Further Assessment (AFA) are identified at the proposed site in the Strategic Flood Risk Assessment (SFRA) for the Galway CDP 2022-2028.

5.6 Cultural Heritage

There are no listed or known architectural heritage, archaeological monuments or geological heritage sites within the proposed development site.

5.7 Biodiversity, Flora and Fauna

There are no protected sites within the development land. Capira/Derrew Bog NHA (Site code 001240) is 1.3km east of the site and is the closest designed site. Ardgraigue Bog SAC (Site Code 002356)/pNHA (Site Code 01224) is 3.7km northwest of the site and Middle Shannon Callows SPA (Site Code 004096) /River Shannon Callows SAC/pNHA (Site Code 000216) is 5.2km at its closest point southeast of the site.

A map showing the location of European Sites (SAC, SPA) within a 15km radius of the proposed development lands is presented in Figure 5-2.

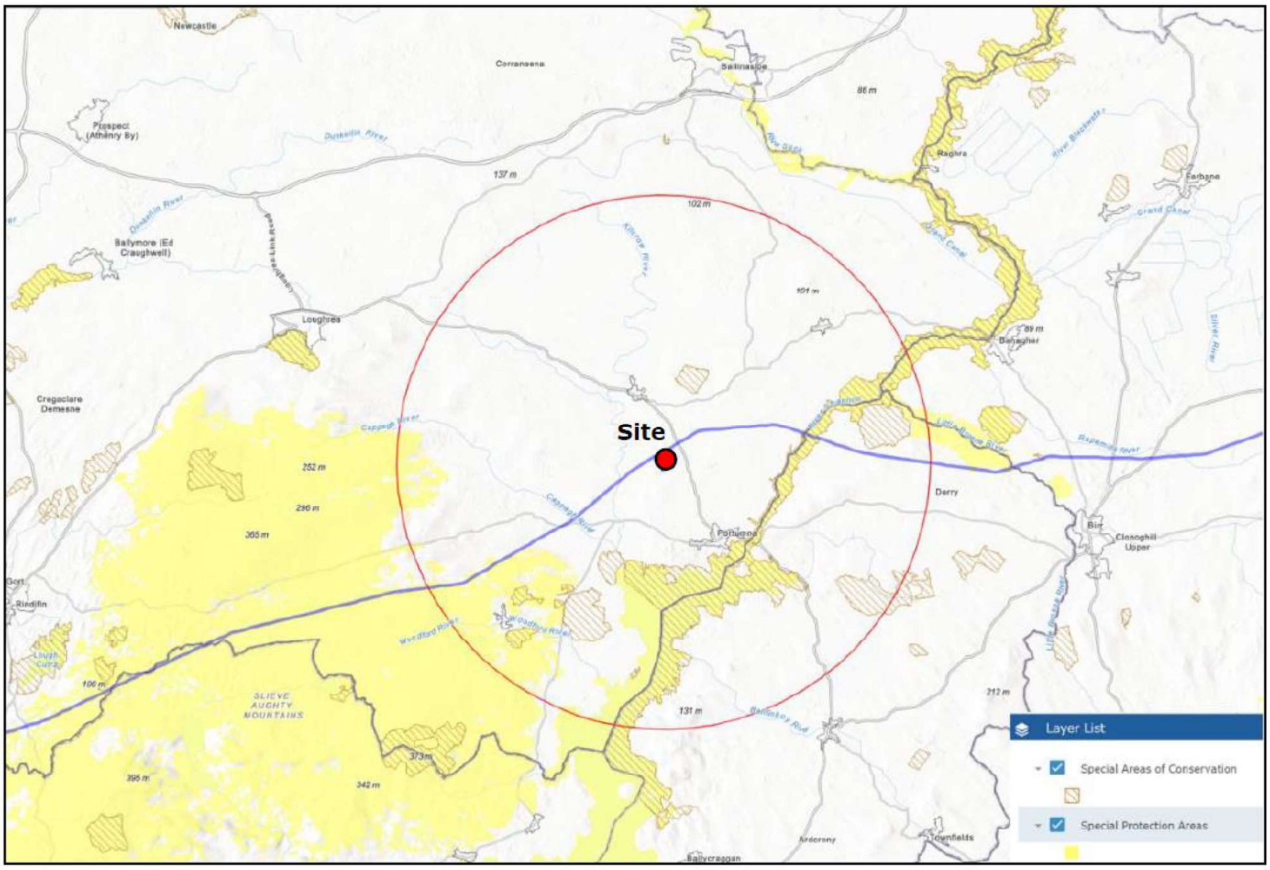

Figure 5-2 European Sites (15km radius from the site presented) along with the 400kV power line

5.8 Landscape and Visual

The proposed development is located within the 'Eastern Plains Region', which 'derives most of its character from the covering blanket of glacial soils that give rise to extensive, level plains of grasslands, with many areas of bog in the north'. Within this landscape region, the site is within the 'Central Galway Complex Landscape' Type, described as 'Level plain of productive grassland containing many settlements and dwellings'. The site sensitivity is classed as 'Low', the lowest degree of sensitivity, and defined as 'unlikely to be adversely affected by change'. Whilst a considerable number of designated scenic routes are located throughout County Galway, according to the Galway CDP 2022-2028 none of these occur within the 2km study area. The area in which the proposed development site is located is typical productive rural landscape that is not considered rare or distinctive at national or regional level.

The proposed development will be located adjacent to, and south of, the existing operational 400kV AIS electricity substation (Oldstreet). The proposed site was chosen as the preferred site following analysis of sites along the two 400kV transmission lines which runs from Moneypoint to the east coast of Ireland. The site adjoins the 400kV line which routes from Moneypoint to Oldstreet (an intermediate substation) and then to Woodland, where there is a connection to the East West Interconnector (EWIC)1. Oldstreet is the only substation along the HV line between Moneypoint and Woodland.

5.9 Air Quality and Climate

The site is located in Air Zone D (rural Ireland, i.e. remainder of the state excluding Zones A, B and C). According to the Environmental Protection Agency (EPA), the Air Quality Index is classed as 3 (Good).

6 SOURCE TERM

All of the materials handled on the site must be identified and assessed in order to determine whether they have the potential to cause a MATTE to any of the environmental receptors surrounding the site. In this section, the identified materials are assessed in a preliminary substance screening step in which materials are screened out if their release quantities or parameters related to their behaviour in the environment (e.g. ecotoxicity, degradability, water solubility, etc.) are deemed insufficient to result in environmental harm.

The only dangerous material present on the site that has been identified is the secondary fuel (diesel). The material parameters are detailed in Table 6-1.

6.1 Preliminary Substance Screening

A preliminary substance screening process is conducted using the following criteria:

1. Where the material does not have any physical, chemical, toxic or eco-toxic properties that could adversely affect the environment following a release, the material is screened out.
2. Where the material does not meet a minimum inventory criterion of 250 litres (equivalent to a single barrel), the material is screened out. The 250 litre minimum inventory criterion has been set based on engineering judgement.

The ERA considers the worst-case unignited catastrophic (full-inventory) failures of the liquid fuel tanks (diesel) stored on site. All releases are assumed to be unignited for the purposes of the preliminary substance screening.

There is the potential for ignited release of natural gas as per Coolpowra Project - Proposed gas-fired generator which will combust natural gas supplied from the GNI transmission system. This is discussed in Sections 9.2 and 9.3.

The proposed 400kV Gas Insulated Switchgear (GIS) Electrical Substation may contain a greenhouse gas such as sulphur hexafluoride which is identified as a non-flammable and non-toxic gas and unlikely to cause a MATTE.

The site has three liquid fuel tanks with a capacity of 7333m^3 each. The calculated tonnage of diesel stored in each tank is calculated as 6196 tonnes based on a diesel density of 845 kg/m^3.

6.2 Summary of Representative MATTE Scenarios

The representative scenario is the release of approximately 6196 tonnes of diesel stored in one of the liquid fuel tanks on the site. This is the worst-case unignited catastrophic (full-inventory) release scenario. The release of diesel representative scenario will be assessed to determine whether it has the potential to cause a MATTE to one of the identified environmental receptors surrounding the site.

Table 6-1 List of Materials Held on Site with Chemical Properties

Material	CAS No.	Composition	Solubility in Water	Other Physical and Chemical Properties	Toxicity	Aquatic Toxicity	Degradability	Bioaccumulation	Comment
Diesel		Mixture of C9-C25 hydrocarbons	Insoluble	State (ambient conditions): liquid Boiling point: 170-390 °C Flash point: 55-75 °C Density: 820-845 kg/m^3 Flammability: flammable	Rat (inhalation): LC_{50} 4.1 mg/L (4 h)	Invertebrates: *Daphnia magna* (water flea): EL_{50} (48 h) 68 mg/l Fish: LL_{50} (96 h) 65 mg/l	Biodegradable	Not expected to bioaccumulate	Spillages may penetrate the soil and accumulate in sediments.

7 PATHWAY TERM

The pathways describe how unignited and ignited releases can potentially make their way offsite and into the surrounding environment via air, water and land pathways. At this stage of the assessment, it is assumed that no mitigation measures (for example bunds and tertiary containment) are in place.

7.1 Releases to Atmosphere

For substances that are released to atmosphere, the pathway of dispersion through air and subsequent deposition is viable. Atmospheric release scenarios include:

1. Transmission of thermal radiation, flame and overpressure through the atmosphere.
2. Dispersion and subsequent deposition of gaseous/vapour releases (including fire plume gases) through the atmosphere.
3. Atmospheric deposition of solids/liquids (for example from boilover events).

7.2 Releases to Water

There is potential for a release to the Ballynaheskeragh stream which flows within the proposed development land. Any release into this water course then has potential to continue to the Kilcrow River

7.3 Releases to Ground

For scenarios that result in releases with the potential for environmental damage that are transported by land, the existence of a complete source-pathway-receptor linkage is more complex and the pathway component of the linkage may be scenario location specific. The following land pathways have been considered:

1. Overland flow of the substance from point of release to receptor. This is more likely to occur where the ground at the point of release is impermeable, either through the presence of made ground or natural conditions.
2. Throughflow of material through the ground – the substance is released onto permeable ground and then flows laterally through the sub-surface over a short distance to surrounding environmental receptors. In this case, the soil layer would be considered to be both a receptor and a pathway.
3. Groundwater flow – the substance is released onto permeable ground and percolates through the surface layers into groundwater. Further dispersion through the groundwater may then occur, potentially leading to the exposure of more distant environmental receptors. In these cases, the groundwater can be both a receptor and a pathway.
4. Flow of released material offsite via the drainage system.

A discussion on whether the abovementioned land pathways present credible pathways that can result in the transportation of released material from specific points of release on site to any of the surrounding environmental receptors is given in the subsections below.

7.3.1 Overland Flow

Released liquids will be able to reach the surrounding environmental receptors via overland flow if the gradient of the land slopes in the direction of the receptors, the flow pathway is not excessively long and there are no significant impediments to flow (e.g. vegetation).

The site development is within agricultural pastures and the overall topography of the site has been considered to be flat. Any liquid releases are therefore expected to spread out form circular pools around their point of release.

7.3.2 Throughflow and Groundwater Flow

The three liquid fuel tanks storing diesel have a bund. Which is designed to contain 150% capacity of a single tank within. Pumping of water from bunds can only be manually initiated by an operator following inspection of the water within the bund. In the event of a spillage from an unloading fuel tanker the liquid will runoff into a central gully. The spill will be detected by a below ground forecourt oil separator which will contain and store the liquid for removal off site. The retention separator will be capable of retaining the maximum spillage likely to occur for road tanker delivery. The below ground separator is designed to accommodate 150% of this volume.

However, there are areas outside of the tank bunds through which liquids can permeate. Where bund overtopping may occur, diesel is not expected to percolate quickly through the ground due to the viscosity dependence on outside temperature.

7.3.3 Releases via Site Drainage System

The structure of the site's drainage system is assessed to determine if there is a potential for collected material to be discharged offsite and into any of the surrounding receptors.

The drainage system is incorporates below-ground oil interceptors, a firewater retention tank, stormwater attenuation pond, silt sumps (at gully positions) and infiltration trenches. Large external areas/compounds at the site will be surfaced with stone /grassed areas to allow rainwater to percolate to the underlying soils (e.g., AIS compound, AGI and areas beyond the main compound areas but within the development site boundary).

The access roads to the site are to be drained utilising filter drains. These are to run longitudinally along the road and allow the stormwater to filter directly to ground /soils via infiltration trenches. Surface water collected from impermeable areas will be delivered to the site stormwater drainage system. Surface water will be routed via the fire wastewater retention tank and an oil/water interceptor prior to entering an attenuation pond. The outfall from the attenuation pond will be controlled using a hydrobrake which will limit the discharge of stormwater to the receiving watercourse to 9.4l/s (4l/s per hectare).

During times when chemicals are handled, isolation valves in the drainage system will be closed. This is to assure that accidently spilled chemicals do not enter the storm water drain. The isolation valves will only be opened again once it has been assured that contamination of the downstream system can be excluded.

Any overwhelming which occurs will follow the flow path discussed in Section 7.3.1 and 7.3.2. It is assumed that a flow pathway from the site to the Kilcrow River via the drainage system therefore exists.

8 RECEPTOR TERM

The receptors which are located nearest to the site development are considered to be at the highest risk of harm from unignited and ignited releases. An overview of the sensitive features that are found in the receptors that have been identified to be at the highest risk of harm from the site are given in the subsections below.

8.1 Kilcrow River

The Kilcrow flows from north to south, before joining the Duniry River which subsequently joins Lough Derg/River Shannon. The River Shannon empties into the Atlantic Ocean through the Shannon Estuary. The Kilcrow River is located approximately 1.8km which then flows for about 9km and meets Duniry River approximately 1km upstream of Lough Derg. Lough Derg is approximately 11km from the site.

8.2 Agricultural Land

The site development is within agricultural pastures and releases from the site may impact the agricultural pastures assumed to 200 ha of land surrounding the site.

8.3 Soil

The soil located below the site area within agricultural pastures is considered as a separate environmental receptor as per the CDOIF Guidelines (Ref./3/). This receptor group refers to the material at the earth's surface to a depth of 1 m.

8.4 Groundwater

The site development is located above an aquifer classed as being of moderate vulnerability and located within a locally important aquifer. The bedrock is moderately productive in local zones.

The flow of groundwater in the area is assumed to be from north to south, in line with the Kilcrow River flow direction. There are no groundwater drinking water protection areas within, or close to, the proposed site development lands.

For the purposes of this assessment, a single groundwater receptor with a depth of 12 m will be considered with properties equivalent to the Dinantian Pure Unbedded Limestone – Waulsortian Limestone aquifer.

8.5 Heritage Sites

There are no listed or known architectural heritage, archaeological monuments or geological heritage sites within the proposed development site.

8.6 Designated Areas

There are no protected sites within the development lands. Capira/Derrew Bog NHA (Site code 001240) is 1.3km east of the site and is the closest designed site. Ardgraigue Bog SAC (Site Code 002356)/pNHA (Site Code 01224) is 3.7km northwest of the site and Middle Shannon Callows SPA (Site Code 004096) /River Shannon Callows SAC/pNHA (Site Code 000216) is 5.2km at its closest point southeast of the site.

8.7 Summary of Receptors at Risk of Harm from Site

The environmental receptors that have been deemed to be at potential risk of harm from operations at the site are listed in Table 8-1 below. Details on the size and CDOIF designation of each receptor are also provided.

Table 8-1: Environmental receptors which may potentially be affected by Site Development

Receptor ID	Receptor Name	Size	CDOIF Designation
R1	Kilcrow River / Lough Derg	Kilcrow River - 22 km length, (9km under consideration) Lough Derg – 118km^2	Fresh and estuarine water habitats
R2	Agricultural Land	200 ha	Widespread Habitat – non-designated Land
R3	Soil	N/A	Soil or sediment
R4	Dinantian Pure Unbedded Limestone – Waulsortian Limestone aquifer	12 m depth	Not a groundwater source of drinking water
R5	Capira/Derrew Bog NHA	119 ha	Designated Area
R6	Ardgraigue Bog SAC	24.3 ha	Designated Area
R7	Middle Shannon Callows SPA	3750 ha	Designated Area
R8	River Shannon Callows SAC	5856 ha	Designated Area

9 DETERMINING MATTE POTENTIAL

The MATTE potentials of the unmitigated liquid and unignited gaseous release scenarios are determined in this section. The first step taken was to establish which of the surrounding receptors can be affected and then it was checked whether the quantity of material that is predicted to reach the receptor is sufficient to cause a MATTE. If the potential for a MATTE exists, the level of harm caused to the affected receptor is determined by establishing the severity of harm caused and the likely duration of harm of the effects of the release on the impacted receptor.

9.1 Unignited Liquid Scenario

The first step taken was to determine whether the released liquid have the potential to affect the surrounding environmental receptors by establishing whether flow pathways exist between the sources and receptors. The severity of harm caused to the affected receptors by the released material was then determined using the approaches described in Section 3.2.1 (LC_{50} approach, oil slick approach, etc.). The duration of harm caused to the affected receptors was then determined using the approach outlined in Section 3.2.2. The severity and duration of harm were then used to establish the MATTE consequence level to each receptor between A and D as shown in the matrix presented in Figure 3-1.

The representative unignited liquid scenario is the release of approximately 6196 tonnes of diesel stored in 7333m^3 liquid fuel tank capacity identified in the preliminary screening stage. The scenario is assessed to determine if there is a potential for a MATTE to any of the surrounding receptors. This scenario examines the release of diesel following a catastrophic failure of a 7333m^3 tank and represents the largest worst case single release of diesel. Details of the maximum releasable inventory and pool radius are presented in Table 9-1 below.

Table 9-1: Scenario of Diesel Release Details

Scenario Description	Release Location	Worst Case Quantity Released		Pool Radius (m)
		m^3	Tonnes	
Catastrophic failure of one diesel tank	Fuel Tank Bund Area	7333	6196	683

The surface of the site is considered to be flat and the release is expected to spread out in a circular pool with an assumed thickness of 20 mm from its point of origin. A conservative assumption has been made for the purposes of simplification that there will be no flash-off of any of the light components in the released material and there will be no reduction in the mass of liquid. The released material may potentially impact the following environmental receptors:

- **R1 Kilcrow River / Lough Derg –** in the absence of containment measures i.e., the bund, the released diesel is expected to either:
  - Spread across the surface until it flows into the Ballynaheskeragh stream which flows within the proposed development land. Any release into this water course then has potential to continue to Kilcrow River. No direct flow of the released material into the Kilcrow River is expected to occur due to the distance of the site to the river itself.
  - Spread across the surface of the site until it is infiltrated to the below ground fire wastewater retention tank or intercepted via upgradient of infiltration. The diesel, if it is not infiltrated into the below ground wastewater retention tank or intercepted there, will be routed into the Ballynaheskeragh stream which flows within the proposed development land. Any release into this water course then has potential to

continue to the Kilcrow River . No direct flow of the released material into the Kilcrow River is expected to occur due to the distance of the site to the river itself.

- **R2 Agricultural Land and R3 Soil –** the released diesel is not expected to flow far enough to impact the agricultural land or its soil. Therefore, no significant environmental harm to these receptors is expected to occur.
- **R4 Groundwater –** some of the released diesel will spread to areas of unmade ground and the well on the site. However, the material is expected to permeate into the ground slowly. This will allow the majority of the spill to be cleaned up before a significant volume can permeate into the ground. A small percentage of the released diesel will enter the sub-surface but this is expected to remain above the groundwater layer due to the low solubility of its components in water. Therefore, no significant environmental harm to this receptor is expected to occur.

The potential environmental harm to the Kilcrow River (R1) is discussed in the following sub-section and the findings are summarised in Table 9-2.

9.1.1 Potential Impacts on R1 – Kilcrow / Lough Derg

A release of diesel into the waters of the Kilcrow River may potentially cause harm via the formation of an oil slick on the surface of the water. Thus, the oil slick approach has been used to assess the potential level of environmental harm. The length of the Kilcrow River that would be covered if a slick of slop oil spread evenly across the width of the river with a thickness of 0.1 mm and an assumed average width of 5m was calculated as:

$$Length\ of\ river\ affected\ (m) = \frac{Volume\ released\ (m^3)}{Slick\ thickness\ (m) \times Width\ of\ River\ (m)} \qquad (9.1)$$

The calculations show that a release of 7333m^3 of diesel will cover the entire 9km length of the Kilcrow River under consideration with a 0.1 mm slick. The slick will therefore continue into Lough Derg where the remain diesel will cover a 14.6km length of Lough Derg. This is the equivalent to approximately 63% of Lough Derg, which constitutes a severity level of 3 (Major) as per Table A-1. It is expected that it will be possible to remove the majority of the released oil from the water in the river/lough within a year. However, it is expected that due to the very high release volume, a significant quantity of the released oil may mix with sediments and vegetation on the banks of the river and create effects which last longer than 1 year. A medium-term duration of harm (>1 year) was therefore selected as per Table A-2. The overall consequence level is therefore a level B MATTE.

Table 9-2: MATTE Assessment results for Release of Diesel Scenario

Receptor	**Minimum Area Required for MATTE**	**Min. Release Quantity Required for MATTE**	**Area Affected by Full Inventory Release**	**Severity Rating**	**Duration Category**	**MATTE Consequence Level**
R1 – Kilcrow River (oil slick approach)	2 km	8.45 te	9km of Kilcrow River 14.6km length of Lough Derg	3	2	B

9.1.2 Releases of Firewater

Firewater systems present on site will provide an immediate response to events that involve fires. The release of firewater will be assumed to only occur following releases of flammable materials or occurrences of fires on the site.

Firewater itself does not have the potential to cause environmental harm. However, firewater run-off from the site can contain combusted and un-combusted forms of the substances involved in the fire. Therefore in the event of a fire, any fire wastewater generated will drain through the system and be held in a below ground tank (fire wastewater holding tank), which will accord with EPA requirements (3,690m3 capacity). An actuated penstock valve will be positioned on the outlet of the below ground tank which will be activated to close upon the activation of the fire alarm within the development. The contaminated water will be subsequently tested and appropriately disposed of. Gaseous extinguishing systems will also be provided for use on electrical systems.

The application of firewater can increase the potential for the release of diesel to reach the surrounding receptors via run-off from the site and it is assumed that the flow pathways will remain the same. It is difficult to estimate exactly how much further release of diesel will spread if firewater is applied simultaneously. It is expected that the spill radii will increase slightly but will not increase in the MATTE levels determined previously.

9.2 Ignited Scenario

Environmental receptors can be harmed by ignited events, either as a result of direct flame engulfment or, outside the flame, by short or long-term exposure to elevated levels of thermal radiation transmitted through the atmosphere. Overpressure generated by an explosion can also result in environmental impacts.

A variety of consequence types are considered including jet fire, flash fire, fireball, pool fire and vapour cloud explosion. The consequence types and the potentially affected receptors are presented in Table 9-3.

The assessment show that the only ignited consequence types that have the potential to impact the surrounding environmental receptors are:

- Flash fires – flash fires may impact the Agricultural Land (R2). However, any land or vegetation which is burnt is expected to recover within a year which will avoid the potential for a MATTE being realised;
- Overpressure events – an overpressure of 0.1 bar is typically strong enough to break glass on buildings but is not strong enough to cause harm to flora and fauna and generally predict that stronger overpressure levels are not expected to extend for significant distances.

It should be noted that diesel is difficult to ignite. In general diesel needs a sustained naked flame with a heat source to ignite. Therefore ignited events from the site are therefore not expected to result in any MATTEs to the surrounding receptors.

Table 9-3: Receptors potentially impacted by ignited events

Consequence Type	Receptors Potentially Affected	Notes
Jet fire	-	Consequence effects not expected to impact any of the surrounding receptors.
Flash fire	R2	Affected receptors are expected to recover in <1 year. No potential for MATTE.
Fireball	-	Consequence effects not expected to impact any of the surrounding receptors.
Pool fire	-	Consequence effects not expected to impact any of the surrounding receptors.

Vapour cloud expansion (0.1 bar)	R2	No harm to flora or fauna expected to be caused by an overpressure of 0.1 bar.

9.3 Combustion Products

Combustion products are the materials produced as a result of the decomposition of the material involved in a fire including intermediate breakdown products, smoke and particulates. The likely fall-out products following a fire or explosion will mainly be limited to CO, CO_2, H_2O and a number of partially oxidised products such as soot and smoke etc. Polycyclic Aromatic Hydrocarbons (PAHs) may also be produced during the combustion of natural gas.

Soot formation is expected to be an issue with fires involving solid or liquid fuels such as crude oil. Soot is generated by the incomplete combustion of hydrocarbons and it can be transported as fine particulates through the air. Particulate matter is also expected to be produced if the fire from an ignited event burns the ground, vegetation or other structures on or off the site.

There is a wide spectrum of particle sizes released during a fire. Smaller sized particles tend to travel further distances than the larger sized particles. In general, within a few kilometres of the site, material with diameters of a few millimetres to even centimetres will settle. Particles with diameters of a few to tens of micrometres may be transported up to ten kilometres away from the source (Ref. /11/). Particles may be deposited directly on to land or surface water sources, or washed out of the atmosphere by precipitation and indirectly deposited. The extent of environmental damage will depend on the meteorological conditions (e.g. the wind direction, wind speed, atmospheric stability and rainfall) and generally decreases non-linearly with distance from the site of the release.

Wind direction will influence the likely environmental receptors; the wind speed will influence the dispersion rate and the extent that a material is carried downwind. Similarly, rainfall can have differing impacts on an atmospheric release. The reactivity and solubility of a material will influence whether it is likely to undergo hydrolysis or deposition through precipitation. Deposition onto land could result in soil contamination or percolation into groundwater causing contamination. The properties of the material, such as its persistence and ecotoxicity will also influence the extent of environmental damage. Soot can also impact surface water receptors either via direct deposition or via land run-off.

Any fall-out, which reaches the surrounding receptors, may result in some short-term impacts but particle degradation is likely to occur relatively quickly. Therefore, a release of combustion products via the atmosphere is unlikely to result in a MATTE.

10 FREQUENCY ASSESSMENT OF UNMITIGATED CONSEQUENCES

The frequency assessment follows the approach defined in Section 6.2 of the CDOIF guidance (Ref. /2/). It is undertaken by assigning an unmitigated event frequency to the release of diesel scenario that has the potential to cause a MATTE to the Kilcrow River/Lough Derg. The unmitigated event frequency for the release of diesel is used to establish the unmitigated risk posed by the establishment to the identified receptor.

10.1 Unmitigated Scenario Frequency and Risk Summary

The unmitigated event frequency for the release of diesel scenario identified to have the potential to cause a MATTE is summarised in Table 10-1. The sources of the frequency data used is also stated in the table.

Table 10-1: Unmitigated event frequencies for each potential MATTE scenario

Scenario Description	Receptor	MATTE Consequence Level	Frequency (event per year)	Source of Frequency data
Release of Diesel	R1 – Kilcrow River / Lough Derg	B	1.5E-04	Calculated using Table 2.2 Atmospheric Storage Tank Fire Frequencies for Large bund fire (full bund area), assuming 25 year tank life (Ref. /12/).

The unmitigated event frequency is the total unmitigated risk posed by the establishment to the receptor identified. The establishment risk to the receptor is plotted against the CDOIF tolerability criteria for event frequency per receptor per year in Figure 10-1 and found to be in the tolerable if ALARP (TifALARP) on the CDOIF risk matrix.

	Frequency per establishment per receptor per year (unmitigated)						
Frequency at which CDOIF Consequence Level is equalised or exceeded (events/year)	10^{-8} - 10^{-7}	10^{-7} - 10^{-6}	10^{-6} - 10^{-5}	10^{-5} - 10^{-4}	10^{-4} - 10^{-3}	10^{-3} - 10^{-2}	$>10^{-2}$
D - MATTE							
C - MATTE							
B - MATTE				**R1**			
A - MATTE							
Sub-MATTE	Tolerability not considered by CDOIF						

Figure 10-1: Unmitigated frequency per establishment per receptor per year

11 MITIGATED FREQUENCIES

The layers of protection in place to prevent the release scenario from reaching the surrounding environmental receptors are considered, in order to determine the mitigated levels of risk from the site. The mitigated frequency of harm caused to the surrounding environmental receptors is calculated by multiplying the unmitigated frequency by the probability of failure on demand (PFD) values of any layers of protection which may potentially stop the release from making its way to the receptor.

A description of the relevant layers of protection in place to prevent the scenario identified as having the potential to cause a MATTE to the surrounding receptor is given below.

11.1 Release Impacting R1 – Kilcrow River/ Lough Derg

The layers of protection relevant to releases from the site which have been identified to have the potential to cause MATTEs to the Kilcrow River / Lough Derg are:

- Tank bund.
- Fire wastewater retention tank.

A description and the PFD values allocated to each of these layers of protection are provided in the table below.

Table 11-1: Layers of protection relevant to preventing releases to the Kilcrow River / Lough Derg

Layer of Protection	Description	PFD
Tank bund	The diesel fuel tanks surrounded by a concrete bund which provide capacity for 110% of the contents of the tanks. Tank releases may breach the containment provided by the bund following a structural failure of the bund walls, overtopping of the bund walls or if the bund drain valve has been left open.	0.01 (Ref. /13/)
Fire wastewater retention tank	The catastrophic failure of one of the diesel fuel tanks will result in the release of a very large volume of diesel which has the potential to spread and form a pool from the release point. Collection and infiltration to the below ground fire wastewater retention tank occurs around the site. In addition, there are a number of interceptors (oil/water separators) upgradient of the infiltration points which are also routed to the fire wastewater retention tank.	0.3 (Ref. /13/)

The event tree which illustrates the layers of protection that are in place to prevent the release of diesel from causing a MATTE in the Lough Derg are shown in Figure 11-1. The event tree is used to calculate the risk reduction factors that the layers of protection expected to provide to reduce the unmitigated frequencies of the scenarios.

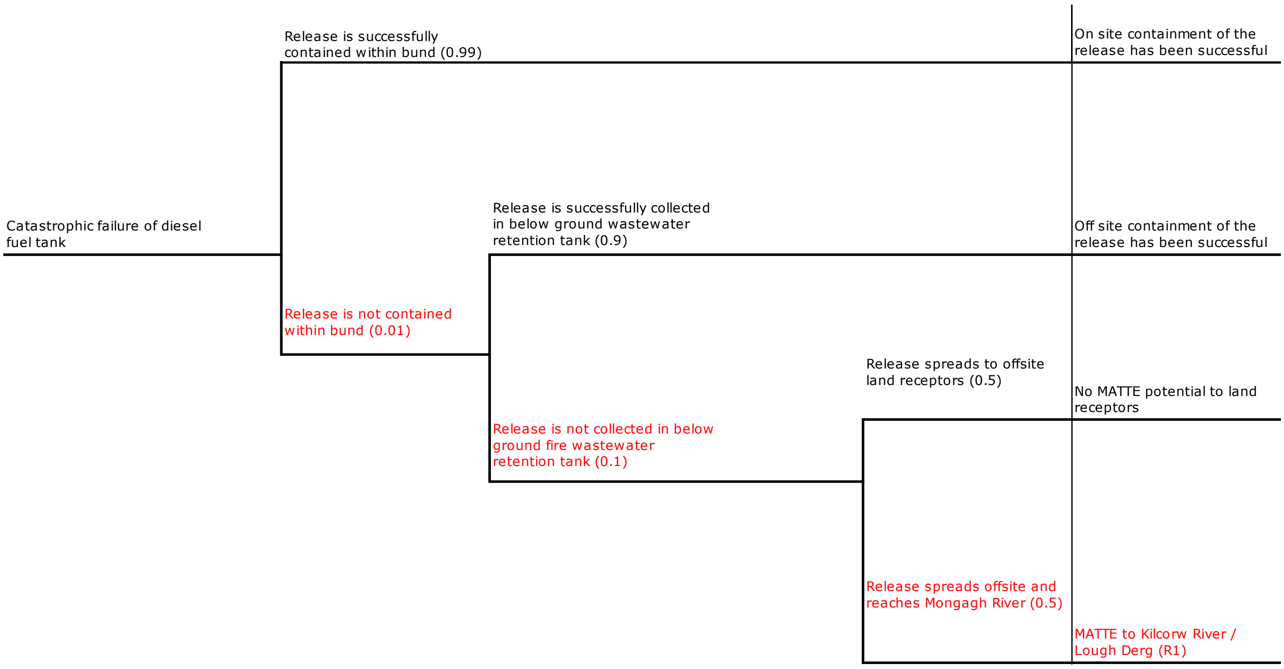

Figure 11-1: Event tree for catastrophic failure of diesel tank in bunded area

11.2 Mitigated Event Frequency Calculations

The mitigated event frequency for the MATTE scenario was calculated by multiplying the unmitigated event frequency by the risk reduction factor associated with the layers of protection in place for the scenario.

Table 11-2: Mitigated event frequencies for each potential MATTE scenario

Receptor	Scenario Description	MATTE Consequence Level	Unmitigated Frequency (per year)	Risk Reduction Factor	Mitigated Frequency (per year)
R1 – Kilcrow River / Lough Derg	Release of Diesel	B	1.5E-04	5.00E-04	7.50E-08

11.3 Mitigated Risk Summary

The mitigated event frequency for release of diesel scenario as reported in Table 11-2 is used to establish the mitigated risk posed by the establishment to the identified receptor.

The mitigated establishment risk per receptor per consequence level is summarised in Table 11-3. The establishment risk to the identified receptor was then plotted against the CDOIF tolerability criteria for event frequency per receptor per year in Figure 11-2 and found to be in the Broadly Acceptable Region of the CDOIF risk matrix.

Table 11-3: Mitigated establishment risk

Receptor	MATTE Consequence Level	Total Mitigated MATTE Frequency (events/year)
R1 – Kilcrow River / Lough Derg	B	2.25E-07

	Frequency per establishment per receptor per year (mitigated)						
Frequency at which CDOIF Consequence Level is equalised or exceeded (events/year)	10^{-8} - 10^{-7}	10^{-7} - 10^{-6}	10^{-6} - 10^{-5}	10^{-5} - 10^{-4}	10^{-4} - 10^{-3}	10^{-3} - 10^{-2}	>10^{-2}
D - MATTE							
C - MATTE							
B - MATTE		**R1**					
A - MATTE							
Sub-MATTE	Tolerability not considered by CDOIF						

Figure 11-2: Mitigated frequency per establishment per receptor per year

12 CONCLUSIONS

One Source-Pathway-Receptor trio with MATTE potential was identified as the release of approximately 6196 tonnes of diesel stored in 7333m^3 liquid fuel tank capacity impacting on the Kilcrow River / Lough Derg

The overall unmitigated level of risk posed by the establishment from the release of diesel to the Kilcrow River / Lough Derg was found to be in the tolerable if ALARP (TifALARP) on the CDOIF risk matrix. Following the identification of the control measures in place and their probability of failure on demand, it was found that the level of mitigated risk posed by the establishment to Kilcrow River / Lough Derg falls into the Broadly Acceptable region.

13 REFERENCES

/1/ The Chemicals Act (Control of Major Accident Hazards involving Dangerous Substances) Regulations 2015 (S.I. No. 209 of 2015) (the "COMAH Regulations"), Health and Safety Authority, 2015

/2/ Guideline – Environmental Risk Tolerability for COMAH Establishments, Version 2.0, Chemical and Downstream Oil Industries Forum.

/3/ A Guide to the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015 (S.I. No. 209 of 2015

/4/ The REACH Enforcement Regulations 2008, European Parliament No. 1906/2006.

/5/ Guidance on the Interpretation of Major Accident to the Environment for the Purpose of the COMAH Regulations 1999, Department of the Environment, Transport and the Region (DETR), 1999.

/6/ Oil Spills in the Sea, Offshore Environment, S. Patin. Available at: http://www.offshore-environment.com/oil.html.

/7/ Behaviour of Hydrocarbons in the Subsurface, Pennsylvania Department of Environmental Protection. Available at: http://files.dep.state.pa.us/EnvironmentalCleanupBrownfields/LandRecyclingProgram/LandRecyclingProgramPortalFiles/CSSAB/2004/fprg_chap3.pdf

/8/ Supporting Guide to the Environmental Risk Tolerability for COMAH Establishments Guideline - Environmental Recovery Guide, ENVIRON, 2015.

/9/ Halston, Environmental Planning, Project Coolpowra Summary Description of Receiving Environment, February 2024

/10/ https://www.epa.ie/our-services/licensing/air/

/11/ Using Science to Create a Better Place – Review of Emission Factors for Incident Fires, Environment Agency, 2009.

/12/ OGP Risk Assessment Data Directory, Storage Incident Frequencies, Report No 434-3, March 2010

/13/ CCPS LOPA guidance by DNV, 2010

APPENDIX A

MATTE Tolerability Tables

Table A-1: Severity of harm criteria for environmental receptors (Ref. /2/)

Row	Receptor Type	Severity of Harm				Reference to	Comments
		Significant *While this level of harm might be significant pollution, it is not considered a MATTE.*	**Severe** *DETR Criteria – the lowest level of harm that might be considered MATTE.*	**Major**	**Catastrophic**	*Corresponding Harm/Duration/ Recovery row in Table A-2*	*The 'Severe' to 'Catastrophic' levels of harm are considered to be included as 'Serious' with respect to the COMAH definition of a major accident.* *Receptors include:*
	Severity Level →	**1**	**2**	**3**	**4**		
1	Designated Land/Water Sites (Nationally important)	<0.5ha or <10%	>0.5ha or 10-50% of site area, associated linear feature or population	>50% of site area, associated linear feature population	*N/A*	Land or Surface Water	NNR, SSSI, MNR
2	Designated Land/Water Sites (Internationally important)	<0.5ha or <5% (<5% LF/Pop)	>0.5ha or 5-25% of site area or 5-25% of associated linear feature or population	25-50% of site area, associated linear feature or population	>50% of site area, associated linear feature or population	Land or Surface Water	SAC, SPA, RAMSAR
3	Other Designated Land	<10ha or <10%	10-100ha or 10-50% of land	>100ha or >50% of land	*N/A*	Land	ESA, AONB, National Park, etc.
4	Scarce Habitat	<2ha or <10%	2-20ha or 10-50% of habitat	>20ha or >50% of habitat	*N/A*	Land or Surface Water	BAP habitats, geological features

Row	Receptor Type	Severity of Harm				Reference to	Comments
		Significant *While this level of harm might be significant pollution, it is not considered a MATTE.*	**Severe** *DETR Criteria – the lowest level of harm that might be considered MATTE.*	**Major**	**Catastrophic**	*Corresponding Harm/Duration/ Recovery row in Table A-2*	*The 'Severe' to 'Catastrophic' levels of harm are considered to be included as 'Serious' with respect to the COMAH definition of a major accident.* *Receptors include:*
	Severity Level →	**1**	**2**	**3**	**4**		
5	Widespread Habitat – Non-designated Land	<10ha	Contamination of 10-100ha of land, preventing growing of crops, grazing of domestic animals or renders the area inaccessible to the public because of possible skin contact with dangerous substances. Alternatively, contamination of 10ha or more of vacant land.	100 – 1000ha (applied as per text under 'Severe')	>1000ha (applied as per text under 'Severe')	Land	Land/water used for agriculture, forestry, fishing or aquaculture
6	Widespread Habitat – Non-designated Water		Contamination of aquatic habitat which prevents fishing or aquaculture or renders is inaccessible to the public.	*N/A*	*N/A*	Surface Water	Land/water used for agriculture, forestry, fishing or aquaculture

Row	Receptor Type	**Severity of Harm**				**Reference to**	**Comments**
		Significant *While this level of harm might be significant pollution, it is not considered a MATTE.*	**Severe** *DETR Criteria – the lowest level of harm that might be considered MATTE.*	**Major**	**Catastrophic**	*Corresponding Harm/Duration/ Recovery row in Table A-2*	*The 'Severe' to 'Catastrophic' levels of harm are considered to be included as 'Serious' with respect to the COMAH definition of a major accident.* *Receptors include:*
	Severity Level →	**1**	**2**	**3**	**4**		
7	Source of Public or Private Drinking Water (Groundwater or Surface Water)	Interruption of drinking water supply <1000 person-hours or For England & Wales only <1ha SPZ	Interruption of drinking water supplied from a ground or surface source (where persons affected x duration in hours [at least 2] >1,000) or For England & Wales only 1-10ha of SPZ where drinking water standards are breached	>1 x 10^7 person-hours interruption of drinking water (a town of ~100,000 people losing supply for month) or For England & Wales only 10-100ha SPZ drinking water standards breached	>1 x 10^9 person-hours interruption of drinking (~1 million people losing supply for 1 month) or For England & Wales only >100ha SPZ drinking water standards breached	Groundwater body or Surface Water Public Drinking Water Source	In England the area of groundwater, used for public drinking water, at risk from pollution is mapped using Source Protection Zones (SPZs). In Scotland, there is not an equivalent mapping of SPZs and only the interruption criteria should be used.

Row	Receptor Type	Severity of Harm				Reference to	Comments
		Significant *While this level of harm might be significant pollution, it is not considered a MATTE.*	**Severe** *DETR Criteria – the lowest level of harm that might be considered MATTE.*	**Major**	**Catastrophic**	*Corresponding Harm/Duration/ Recovery row in Table A-2*	*The 'Severe' to 'Catastrophic' levels of harm are considered to be included as 'Serious' with respect to the COMAH definition of a major accident.* *Receptors include:*
	Severity Level →	**1**	**2**	**3**	**4**		
8	Groundwater Body (non-Drinking Water Source)	<1ha	1-100ha of groundwater body where the WFD status has been lowered	100-10,000ha	>10,000ha	Groundwater body or Surface Water Public Drinking Water Source	UKTAG has determined that to qualify as a body of groundwater, an aquifer must be capable of supplying 10m^3 per day or 50 people (on a continuous basis) and that such aquifers/groundwater bodies have future resource value which must be protected. Groundwater Bodies have been identified and mapped in accordance with guidance under the Water Framework Directive – see 3.2.3 and Appendix 3 for further information
9	Other Groundwater (outside of groundwater bodies)	Groundwater not a pathway to another receptor.	*Where the groundwater is a pathway for another receptor assess against relevant criteria for the receptor.*			*N/A*	

Row	Receptor Type	Severity of Harm				Reference to	Comments
		Significant *While this level of harm might be significant pollution, it is not considered a MATTE.*	**Severe** *DETR Criteria – the lowest level of harm that might be considered MATTE.*	**Major**	**Catastrophic**	*Corresponding Harm/Duration/ Recovery row in Table A-2*	*The 'Severe' to 'Catastrophic' levels of harm are considered to be included as 'Serious' with respect to the COMAH definition of a major accident.* *Receptors include:*
	Severity Level →	**1**	**2**	**3**	**4**		
10	Soil or sediment (i.e. as receptor rather than purely a pathway)	Contamination not leading to environmental damage (as per ELD), or not significantly, affecting overlying water quality.	Contamination of 10-100ha of land etc. as per Widespread Habitat; Contamination sufficient to be deemed environmental damage (Environmental Liability Directive)	Contamination of 100-1000ha of land, as per Widespread Habitat; Contamination rendering the soil immediately hazardous to humans (e.g. skin contact) or the living environment, but remediation available.	Contamination of >1000ha of land, as per Widespread Habitat; Contamination rendering the soil immediately hazardous to humans (e.g. skin contact) or the living environment and remediation difficult or impossible.	Land	
11	Built environment	Damage below a level at which designation of importance would be withdrawn.	Damage sufficient for designation of importance to be withdrawn.	Feature of built environment subject to designation of importance entirely destroyed.	*N/A*	Built environment	This is limited to Grade 1 / Cat A Listed buildings, scheduled ancient monuments, conservation area, etc.
12	Various receptors. Should not be used to identify and assess MATTE.	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	Refer to DETR. Standards relating to continuous emissions, contained in other EU legislation.

Row	Receptor Type	Severity of Harm				Reference to	Comments
		Significant *While this level of harm might be significant pollution, it is not considered a MATTE.*	**Severe** *DETR Criteria – the lowest level of harm that might be considered MATTE.*	**Major**	**Catastrophic**	*Corresponding Harm/Duration/ Recovery row in Table A-2*	*The 'Severe' to 'Catastrophic' levels of harm are considered to be included as 'Serious' with respect to the COMAH definition of a major accident.* *Receptors include:*
	Severity Level →	**1**	**2**	**3**	**4**		
12	Particular species (Note – these criteria apply nationally – i.e. England, Wales, Scotland)	Loss of <1% of animal or <5% of plant ground cover in a habitat.	Loss of 1-10% of animal or 5-50% of plant ground cover.	Loss of 10-90% of animal or 50-90% of plant ground cover.	Total loss (>90%) of animal or plant ground cover.	Land	
14	Marine	<2ha littoral or sub-littoral zone, <100ha of open sea benthic community, <100 dead sea birds (<500 gulls), <5 dead/significantly impaired sea mammals.	2-20ha littoral or sub-littoral zone, 100-1000ha of open sea benthic community, 100-1000 dead sea birds (500-5000 gulls), 5-50 dead/significantly impaired sea mammals.	20-200ha littoral or sub-littoral zone, 100-10,000ha of open sea benthic community, 1000-10,000 dead sea birds (5,000-50,000 gulls), 50-500 dead/significantly impaired sea mammals.	>200ha littoral and sub-littoral zone, >1000ha of open sea benthic community, >10000 dead sea birds (>50000 gulls), >500 dead/significantly impaired sea mammals.	Surface Water	

Row	Receptor Type	Severity of Harm				Reference to	Comments
		Significant *While this level of harm might be significant pollution, it is not considered a MATTE.*	**Severe** *DETR Criteria – the lowest level of harm that might be considered MATTE.*	**Major**	**Catastrophic**	*Corresponding Harm/Duration/ Recovery row in Table A-2*	*The 'Severe' to 'Catastrophic' levels of harm are considered to be included as 'Serious' with respect to the COMAH definition of a major accident.* *Receptors include:*
	Severity Level →	**1**	**2**	**3**	**4**		
15	Fresh and estuarine water habitats	Impact below that of Severity level 2	WFD Chemical or ecological status lowered by one class for 2-10km of watercourse or 2-20ha or 10-50% area of estuaries or ponds. Plus interruption of drinking supplies, as per DETR Table 6.	WFD Chemical ecological status lowered by one class for 10-200km of watercourse or 20-200ha or 50-90% area of estuaries and ponds. Plus interruption of drinking water supplies, as per DETR Table 6.	WFD Chemical or ecological status lowered by one class for >200km of watercourse or >200ha or >90% area of estuaries and ponds. Plus interruption of drinking water supplies, as per DETR Table 6.	Surface Water	

Table A-2: Duration / recovery criteria (based on unmitigated consequence) (Ref. /2/)

Description	Short term	Medium term	Long term	Very long term
	Harm with such short recovery is not considered a MATTE.			
Harm Duration Category →	**1**	**2**	**3**	**4**
LAND	≤ 3 years	> 3 years or > 2 growing seasons for agricultural land	> 20 years	> 50 years
SURFACE WATER (ALL EXCEPT PUBLIC OR PRIVATE DRINKING WATER SOURCE)	≤ 1 year	> 1 year	> 10 years	> 20 years
GROUNDWATER BODY OR SURFACE WATER PUBLIC OF PRIVATE DRINKING WATER SOURCE	*N/A*	Harm affecting non-public drinking water source.	Harm affecting public drinking water source or SPZ.	*N/A*
BUILT ENVIRONMENT	Can be repaired in < 3 years, such that its designation can be reinstated.	Can be repaired in > 3 years, such that its designation can be reinstated.	Feature destroyed, cannot be rebuilt, all features except world heritage site.	Feature destroyed, cannot be rebuilt, world heritage site

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APPENDIX 4.2

CONSEQUENCE STUDY REPORT

COMAH SUPPORT FOR PROJECT COOLPOWRA

Consequence Study Report

Halston Environmental and Planning Limited

Rev. 1
Document no.: 2246462
Date: 2024-05-28

Project name:	COMAH Support for Project Coolpowra	DNV Services UK Limited Energy Systems
Report title:	Consequence Study Report	Aberdeen SHE Risk
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Objective:

Prepared by:	Verified by:	Approved by:
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Table of contents

Abbreviations

AGI	Above Ground Installation
AIS	Air Insulated Switchgear
ALARP	As Low as Reasonably Practicable
CFD	Computational Fluid Dynamics
CIA	Chemical Industries Association
DAL	Dimensioning Accidental Load
FBR	Full Bore Rupture
GIS	Gas Insulated Switchgear
GNI	Gas Networks Ireland
HCRD	Hydrocarbon Leak Frequency Database
HSE	Health and Safety Executive
IOGP	International Association of Oil and Gas Producers
LDES	Long Duration Energy Storage
LFL	Lower Flammability Limit
OCGT	Open Cycle Gas-Fired Generators
PFD	Process Flow Diagram
QRA	Quantitative Risk Assessment
UG	Underground

1 EXECUTIVE SUMMARY

1.1 Background

The aim of Project Coolpowra is to design, develop, and expand Ireland's 400kV transmission system to improve the reliability, resilience, and efficiency of the electricity supply, supporting the transition to greener energy. It facilitates the integration of renewable energy sources, aligning with Ireland's goals to reduce greenhouse gas emissions and combat climate change.

This study has conducted a preliminary consequence modelling, which by its nature, results in typically **worst-case hazard contours**. In order to provide context to the results, a semi-quantitative risk assessment has been carried out based on DNVs experience in assessing similar industrial facilities.

1.2 Conclusions

The consequences derived have been both for small 5 mm releases and full bore/catastrophic releases. There are no notable consequences for any small leak scenario, except for the firewater tanker locations. Given the high flash point of diesel, it is difficult to ignite and this is reflected by the low likelihoods associated with the ignited diesel scenarios in the risk assessment.

The following conclusions are made from this study:

- **Risk**: None of the risks associated with the facility are considered intolerable. A high-level semi-quantitative risk assessment has not highlighted any serious concerns at this point, and given that further risk assessment studies are planned for further stages of the project (detailed design), it is likely that all risks will be demonstrated to be tolerable.
  - **Off-site risk:** No natural gas or diesel hazards have been identified with the potential to impact off-site populations. Given the proposed safeguards and control measures associated with the long duration energy storage (LDES) compound (including fire water application, spacing, and inert gas application), a full scale LDES compound fire, which may have the potential to result in smoke passing the site boundary, is considered unlikely.
- **Consequence Results:** Consequence modelling results are considered representative of worst-case scenarios. Still, no off-site impacts have been identified during the consequence modelling. Furthermore, a full risk-based study (such as a quantitative risk assessment, QRA, to be undertaken in detailed design) is likely to demonstrate that the safety risk from the proposed facility is tolerable both on and off-site.
  - **Pool Fires:** In the highly unlikely event of a catastrophic rupture of a diesel road tanker resulting in a pool fire, the thermal radiation intensity is at levels sufficient to cause multiple fatalities at the administration/control building. Furthermore, there is potential for fuel tank pool fires to escalate to the adjacent tanks, or to cause catastrophic damage to the fire water tanks.
  - **Jet Fires:** There is potential for the 37.5 kW/m^2 contours to extend across a large section of the facility, which suggests that there is potential for escalation due to jet fires associated with the natural gas system on-site. There is also potential for personnel situated outside (e.g. walking between areas of the site) to be fatally injured from natural gas jet fires. There is also potential (based on unmitigated risk) for escalation of jet fires originating in the AGI or on-site pipeline to the LDES compound, however given the protective systems at the LDES compound, a compound-wide fire is considered unlikely.
  - **Fireballs:** The hazard contours associated with fireballs are relatively large, however these are short lived events and therefore do not contribute greatly to escalation, and the likelihood of a fireball has been deemed improbable over the lifetime of the facility.

- **Flash Fires:** Flash fires can have far reaching effects; however, cloud shapes can be seen to be much smaller than the entire cloud envelope. The ½ LFL cloud can impact the majority of the site such that muster points could be considered compromised.
- **LDES System:** The safety risk posed by LDES systems must not be underestimated, and there is potential for very large fires should propagation between containers occur. Should an LDES fire be contained to a single container (as is likely the case given the protective measures proposed for the facility), there is potential for localised asset damage and safety risk to first responders.
- **Off-site impacts:** Natural gas and fuel oil consequence modelling has highlighted no particular concerns to third-party buildings or properties outside of the site boundary. In the unlikely event that a large-scale LDES compound fire occurs, with the fire propagating across multiple containers, there is potential for off-site impacts from smoke and evolved gases.

1.3 Recommendations

The following recommendations are made:

1. Consider fire protection strategies for the tanker unloading and fuel oil storage areas, which could include separate bunds for each storage tank, deluge (sprinkler) systems, and/or foam application on confirmation of a fire. Also consider relocation of the fire water tanks to a location away from all flammable inventories to ensure they are not impacted by fire events.
2. There is currently potential two occupied buildings (security and administration/control building) to be within the 37.5 kW/m^2 hazard ranges associated with jet fires and pool fires. If possible, Halston Lumcloom should consider relocating these buildings to an area outside all hazard contours – which would be considered an inherently safe solution.
3. Ensure any muster points are located outside of the ½ LFL clouds, as shown in Section 5.4.
4. If possible, the spacing between the natural gas-containing systems and the LDES compound should be increased to reduce the likelihood of a natural gas jet fire escalating to a large-scale battery fire, which could potentially have off-site impacts.
5. Undertake further risk assessments in later design stages and review the input data and assumptions. This should primarily address any uncertainties or assumptions in process information, as these will be more accurately defined as the design progresses. Particular attention should be given to fire and explosion risk within the LDES compound - ensuring and demonstrating that all applicable design standards have been followed to minimise the risk associated with stored electrical energy.

Note, these recommendations aim to further reduce any risk associated with Project Coolpowra, however other risk reduction measures may be deemed more appropriate as the design develops

2 INTRODUCTION

Halston Lumcloon Energy is designing, developing, and expanding Ireland's 400kV transmission system to improve the reliability, resilience, and efficiency of the electricity supply, supporting the transition to greener energy. It facilitates the integration of renewable energy sources, aligning with Ireland's goals to reduce greenhouse gas emissions and combat climate change.

Halston have developed a proposal, which consists of units such as reserve gas-fired generators, Gas Insulated Switchgear Substations, long duration energy storage batteries and more. The first site for application of the plant concept is a facility in Ireland, and the modules and components are designed for use with gas oil. Natural gas is present in the underground pipelines and equipment associated with integration into Gas Network Ireland's network.

2.1 Study Scope

The study covers:

- Quantitatively model a set of identified major accident hazards, at a level of detail commensurate with the design data currently available.
- Both full bore pipework ruptures and catastrophic vessel ruptures are modelled, as well as smaller (5mm diameter) leaks, giving an indication as to the likely extent of hazard ranges associated with the project.
- Risk to people and asset in terms of flammable leak major accident hazards (i.e. potential fire and explosion loads to the plant itself and surrounding facilities) will be assessed at a high level to give an early indication of the risk profile of the facility.

The following aspects are excluded from the study scope:

- Risk during construction, commissioning or other phases not representing normal operation of the facilities.
- Risks to the environment and of business interruption / remediation / reputation.

2.2 Study Objectives

The objectives of the report are:

- Conduct a high-level risk study (consequence modelling and semi-quantitative risk assessment) to highlight any preliminary siting or layout concerns for the facility based on the current layout.
- To understand the potential risk exposure of site personnel, key buildings, offsite populations, and other siting aspects.

3 DESCRIPTION AND STUDY BASIS

The assumptions for this study were derived from the project description and discussion with project team members, which are summarised below:

The key inputs defining the design as modelled in this study are:

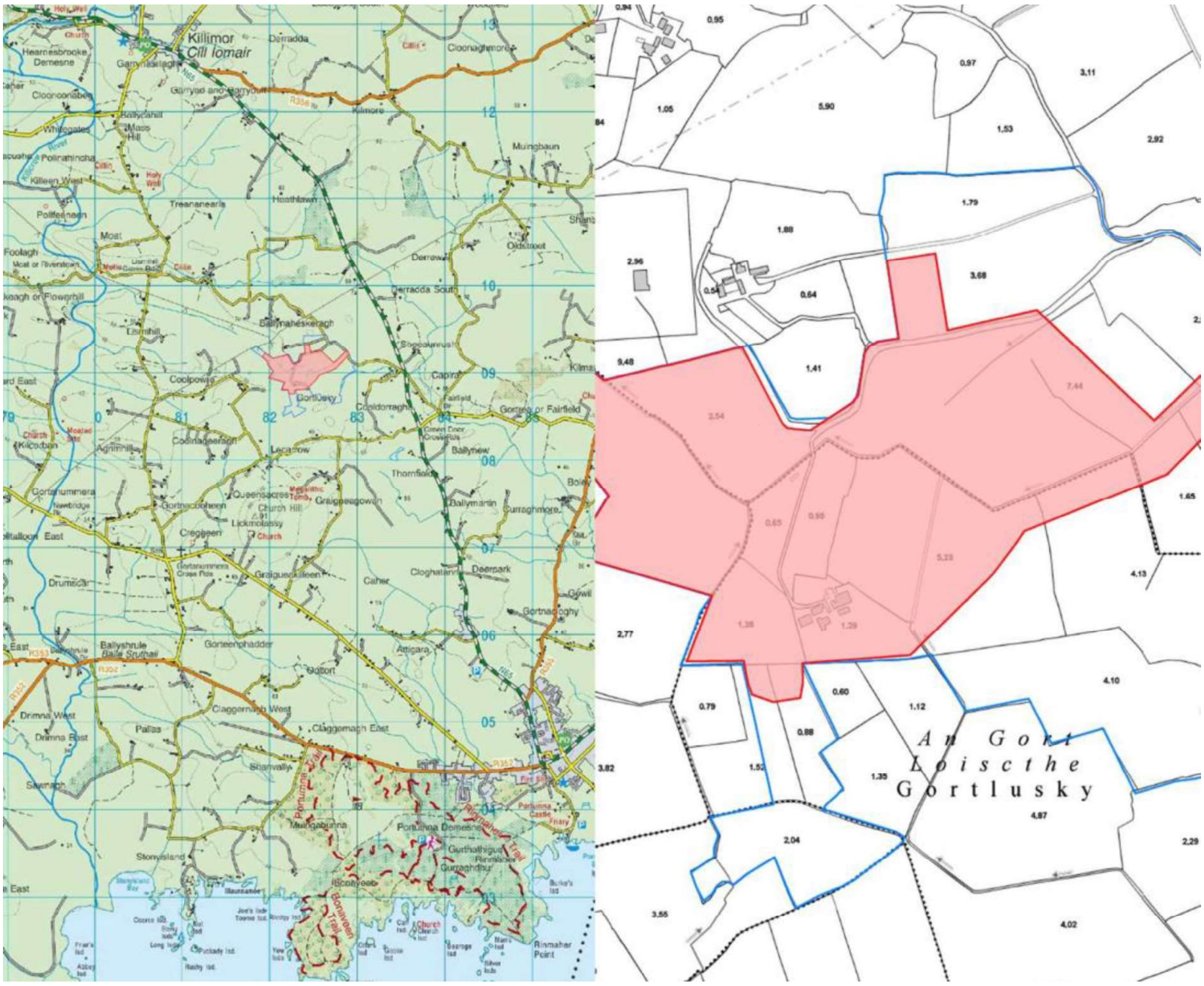
- Process details are given by the Project Description document /1/ and discussion with the project team
- The overall process structure and major equipment items are given by the Project Description /1/.

Other data provided by Halston, and public information sources provide underlying basis for the study modelling as discussed in the remainder of this section.

3.1 Site Location

The proposed development is located approximately 4km north of Portumna and 3.1km south of Killimor. Lands within the development site boundary are in agricultural use and include a farmhouse and outbuildings which will be demolished. The proposed lands are situated at an elevation of c. 51-54m AOD and are accessed by road via the N65 (National Road) and the L8763 (local road). The N65 connects the towns of Loughrea and Portumna. The proposed development will be located adjacent to, and south of, the existing operational 400kV AIS electricity substation (Oldstreet).

Figure 3-1 Location of the Halston Plant



3.2 Site Layout

The facility layout shown in Figure 3-2 is used as the basis for this study.

Figure 3-2 Layout of the Halston Site

3.3 Process Description

The plant processing equipment within the scope of this study is defined within Table 3-1. Note that not all of these items present hazards that form part of the consequence modelling.

Table 3-1 Summary of The Plant Processing Equipment and Systems

System	Description
Reserve Gas-Fired Generator	Three OCGT units, 1,125 MW (3 x 375 MW) Output will connect to the electricity system via the gas insulated switchgear (GIS).
Under Ground Gas Pipeline	Delivers gas to proposed AGI on site. Operating at pressures of 16 bar or higher, established by Gas Networks Ireland (GNI) through separate planning application at the time of this report. Around 400m run-length across the site in zig-zag formation.
Gas Insulated Switchgear (GIS) Substation	Forms part of the Electricity Transmission System. Two-storey building positioned and secured within a palisaded fenced compound. The proposed GIS will upgrade and replace the existing air insulated switchgear (AIS) substation with a new gas GIS substation at Oldstreet. The GIS substation will facilitate connection of the reserve gas fired generator and ESS to the existing node on the transmission network thereby securing energy supply into the future
Energy Storage System Energy – Grid Stability	LDES with 200 MW / 800 MWh Output. Synchronous Condenser with 400 MVA output. Both connect to electricity system via the GIS. The technology is designed to complement and support the reserve gas fired generator by providing zero carbon, instantaneous power and balancing power to the grid.
Diesel Storage Tanks	Three vessels containing gas oil, with a gross maximum inventory of 22,000 m^3.
Diesel Road Tanker	Located between the OCGT units and the diesel storage tanks, assumed to have an internal capacity
Grid Connection AGI	Connects to the main gas pipeline run by Gas Networks Ireland
Diesel Transfer Pumps	For safe delivery of diesel from tanks to process.
Foul Holding Tank	For use with the foul treatment area

3.4 Ambient Conditions

It is necessary to define certain meteorological constants as inputs to the consequence modelling. These values are summarised in Table 3-2, based typical values for facilities located in the United Kingdom.

Table 3-2 Meteorological Parameters

Parameter	Value	Notes and References
Atmospheric Temperature	10°C	Based on average annual temperatures.
Relative Humidity	70%	Typical annual average for Ireland.
Surface Temperature	10°C	Taken to be the same as atmospheric temperature

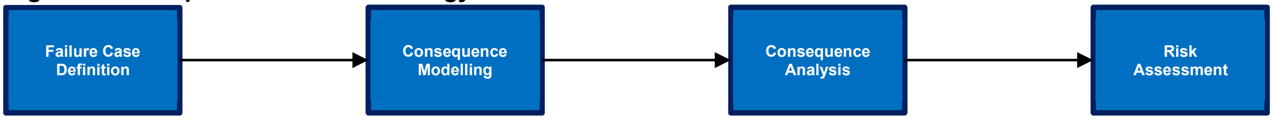
The contribution of solar flux to thermal radiation is not accounted for risks from fires (as is typical for these studies).

Those parameters above which are not based on any available site/ project specific data source are assumed values, selected based on experience or using model defaults, with the intention of providing the most appropriate modelling results whilst still taking a conservative approach so as not to underestimate any of the risk levels.

4 METHODOLOGY

The outline methodology to be adopted for this preliminary consequence modelling shown in Figure 4-1 and is described in more detail in in the following sections.

Figure 4-1 Simplified QRA Methodology Flowchart



4.1 Software

DNV Phast software v9.0 is used to carry out the study. A summary of global modelling parameters to be applied in the study are provided in Table 4-1. Other values not mentioned in this document can be assumed to remain as default settings in the software.

Table 4-1 General Phast Parameters to be Used for Modelling

Parameter	Value	Notes
Software version	V9.0	Latest version
Height of interest	1 m	Population is assumed to be located at ground level with a receptor height of 1 m (equal to release height); this applies to the whole population identified for the study.
Default leak direction for above-ground releases	Horizontal impinged	Releases from any containerised equipment are considered as impinged. Modelling all releases as horizontal is somewhat conservative, however is typical practice for QRA studies.
Default release elevation	1.5 m	Typical standard value representing 'head height'
Surface Type	Concrete	
Surface Roughness	183 mm	Affects the turbulence in the air reaching the release source and is related to effective average obstacle height over the terrain. 183 mm is the Phast default and is suitable for occasional large obstacles, and is selected as the site has neither open, flat terrain (typically assigned a value of 30 mm), nor a significantly built-up area (typically assigned a value of 500 mm or more) in close proximity to the site.
Flammable averaging time	18.75 sec	Phast default value for flammable dispersion.
Flammable vapour cloud extent allowing ignition	Lower Flammability Limit (LFL)	Effects are calculated at effect height rather than the default cloud centreline height (affects buoyant cloud delayed ignition risk)

4.2 Failure Cases

Normal operating conditions for each failure case have been assumed, namely pressure, temperature, and operating flowrate.

Table 4-2 Operating parameters and parameters assumed for modelling.

Vessel/Equipment	Parameter	Value used
Diesel Storage Tanks	Temperature	20 °C
Diesel Storage Tanks	Volume inventory (per tank)	7333.3 m3
Diesel Road Tanker	Pressure	Atmospheric
Diesel Road Tanker	Temperature	20 °C
Diesel Road Tanker	Volume inventory	40 m^3
Diesel Transfer Pumps	Pressure	2 barg
Diesel Transfer Pumps	Temperature	20 °C
Diesel Transfer Pumps	Maximum Diameter	6 inches (full bore)
Diesel Transfer Pumps	Flow Rate	0.5 kg/s
Grid Connection AGI	Pressure	25 barg
Grid Connection AGI	Temperature	20 °C
Grid Connection AGI	Maximum Diameter	6 inches (full bore)
Gas Pipeline	Pressure	16 barg
Gas Pipeline	Temperature	20 °C

4.2.1 Leak Sizes

A range of representative leak sizes has been modelled as shown in Table 4-3.

Table 4-3 Representative Leak Sizes Modelled

Leak Size Name	Representative Hole Diameter (mm)	Hole Size Range for Frequency Analysis (mm)
Medium Leak	5	3-10
Full-Bore Rupture (FBR)	Line Size	Residual from total frequency for component

Additionally, catastrophic rupture of all vessels has been modelled, which is representative of vessel failure e.g. due to vehicle impact of mechanical defects.

4.2.2 Locations

A single representative leak location is defined per failure case, based on the plot plans and information provided.

The gas pipeline was modelled as an extended line source with potential leak locations along the pipeline length, however only the worst-case results are reported in this document.

4.3 Consequence Analysis

This section outlines the approach to be used for consequence modelling analysis.

4.3.1 Process Fluid Compositions

Some key assumptions have been made when defining the process fluid compositions to be modelled:

- The natural gas feed is assumed to be 100% methane.
- Secondary fuel oil (gas oil) is modelled as diesel.

4.3.2 Discharge

The discharge parameters have been determined within Phast on the basis of the defined failure case parameters (pressure, temperature). Where releases occur downstream of equipment such as a pump or compressor, the release rate will typically be driven by the normal flow rate of the section in forward flow. Therefore, the release rates are capped at a maximum of 150% of the inflow rate.

Detection and isolation are not modelled at this stage.

4.3.3 Dispersion

Releases have been modelled with a “horizontal” release direction, accounting for the open nature of the facility, with limited opportunity for direct impingement to adjacent equipment.

A default representative release height of 1.5 m applies for all failure cases, as is typical QRA practice.

4.3.4 Fire Modelling

Standard Phast models for flash fires and fireballs are used.

4.3.5 Explosion Modelling

Explosions are assumed to have the potential to occur where a vapour cloud with concentration within the flammable range is ignited and there is simultaneously a mechanism to accelerate the flame front. Such explosion scenarios require delayed ignition of the vapour cloud.

The potential detonation of natural gas in the open (i.e. outside areas of congestion/confinement) is not considered credible, and therefore a single area of congestion has been defined in the model, this being the Transformers shown by location 20 in Figure 3-2.

The approach to modelling a vapour cloud explosion (VCE) associated with a flammable cloud interacting with these transformers is to calculate the mass of methane associated with filling the transformer area with a stoichiometric mixture of methane in air, in this case approximately 80 kg of methane, and assuming ignition in the centre of this location. All explosion results outlined in this report are based on an explosion in this transformer compound.

4.3.6 Ignition Modelling

For the sake of consequence modelling, it is always assumed that the natural gas and secondary fuel (diesel) are ignited and the worst-case results are presented in Section 5. In reality, diesel is difficult to ignite - having a flash point of between 52 and 96ºC, it is classified as ‘combustible’ rather than ‘flammable’. This means that diesel is not readily ignited with a naked flame and requires sustained energy input (or atomisation) for it to ignite.

As a result, although the consequences of a diesel fire can appear severe, the likelihood of this event occurring can be considered less than for a more readily ignitable fluid (such as petrol or gases such as natural gas). This is reflected in the high-level risk assessment presented in Section 6.

4.3.7 Long Duration Energy Storage Modelling

DNV are currently unable to model fires associated with battery energy storage systems (BESSs), however a qualitative assessment is undertaken for the likely impacts of BESS fires, based on DNVs experience in risk assessment of these systems.

4.4 Vulnerability Criteria

This section covers the integration of the consequence and frequency modelling to provide risk estimates for human receptors. The vulnerability criteria in Table 4-4 are for information only and provide context to the choice of hazard levels reported in this document.

Table 4-4 Vulnerability Criteria

Hazard	Effect Threshold (model ≥ threshold)	Fatality Probability				Notes
		Outdoor	Indoor CIA 4*	Indoor CIA 3*	Indoor CIA 2*	
Flash fire	LFL	100%	50%	20%	20%	DNV internal guidance.
Jet fire	4.7 kW/m²	0%	0%	0%	0%	4.7 kW/m² is considered the 'safe limit' for on-site personnel. 6.3 kW/m² is considered the point at which escape routes are considered impaired. 37.5 kW/m² is considered the point at which process equipment can sustain damage.
	6.3 kW/m²	0%	0%	0%	0%	
	12.5 kW/m²	50%	25%	25%	25%	
	37.5 kW/m²	100%	100%	50%	50%	
Fireball	4 kW/m²	0%	0%	0%	0%	0% at lower radiation thresholds to account for the short exposure duration.
	12.5 kW/m²	0%	0%	0%	0%	
	37.5 kW/m²	100%	100%	50%	50%	
Pool fire	4 kW/m²	0%	0%	0%	0%	4.7 kW/m² is considered the 'safe limit' for on-site personnel. 6.3 kW/m² is considered the point at which escape routes are considered impaired. 37.5 kW/m² is considered the point at which process equipment can sustain damage.
	12.5 kW/m²	50%	25%	25%	25%	
	37.5 kW/m²	100%	100%	50%	50%	
Explosion overpressure (side-on)	0.07 bar	0%	3%	2%	0%	Linearly interpolated between thresholds. 0% below lowest threshold. Outdoors represents people adjacent to buildings. Indoors from IOGP /11/ based on Chemical Industries Association (CIA) guidance.
	0.14 bar	0%	15%	8%	3%	
	0.35 bar	30%	90%	55%	70%	
	0.5 bar	100%	100%	65%	80%	
Toxicity	-	-	-	-	-	No toxic components have been identified for this study.

Note*: CIA4: 'Portacabin' type timber construction, single storey, CIA3: Typical domestic building: two-storey, brick, walls, timber floors, CIA2: Typical office block: four storey, concrete frame and roof, brick block wall panels.

4.5 Tolerability of Risk

The Health and Safety Authority (HSA) in Ireland follow a similar approach to the Health and Safety Executive (HSE) in the United Kingdom in respect to tolerability of risk, and the ALARP principle (Ref /12/). Risks can be designated into one of three categories:

a) **Broadly Acceptable**, whereby the individual risk is calculated to be below $1x10^{-6}$ per year. As long as it can be demonstrated that good practice has been followed in terms of management of these risks, no further action is required.

b) **Tolerable if ALARP.** Individual risk calculated to lie between $1x10^{-6}$ and $1x10^{-3}$ /$1x10^{-4}$ for on-site and off-site populations respectively are considered tolerable if it can be demonstrated that further risk reductions are not practicable. In practice, this would mean demonstrating that further risk mitigation measures could not be justified in terms of cost (monetary or time/effort) against the level of risk reduction gained.

c) **Intolerable**. If the risk is found to exceed $1x10^{-3}$ /$1x10^{-4}$ for on-site and off-site populations respectively, risk reduction measures must be implemented regardless of cost, to bring the risk into the Tolerable if ALARP region before operation can continue.

Note, the quantitative figures outlined above are typically the outcome of a full QRA. This is outside the scope of the scope of this document given the early stage of the project however a QRA is planned for detailed design. The risk ranking matrix used in this semi-quantitative assessment aims to map the identified hazards across the three categories listed above.

5 CONSEQUENCE ASSESSMENT

Note, these results are for consequences only and do not consider the likelihood of the initial release, ignition probability, or any other conditional modifiers such as occupancy. They are necessarily coarse given the relatively early design maturity, and it is likely that any risk results derived during detailed design will give less severe contours.

5.1 Pool Fire Thermal Radiation

The thermal radiation consequence contours representing all diesel pool fires (irrespective of duration) are shown in Figure 5-1 to Figure 5-6. It can be seen from the shape of the contours that:

- The control room is located outside of all pool fire contours for all scenarios except for the catastrophic rupture of the Diesel Road Tanker where it lies within the 6.3 kW/m^2 contour, but this only impairs escape routes and leads to no fatalities.
- The radiative flux of 37.5 kW/m^2 is the key thermal load in terms of escalation and the risk effects. Any pool fire could escalate to any of the adjacent equipment (i.e. a single pool fire from any storage tank would cause all of the other storage tanks, the diesel road tanker and diesel transfer pump, and vice versa).
- Catastrophic rupture of the road tanker with subsequent pool ignition could result in high thermal loads on the OCGT building, however the effects of drainage in mitigating pool formation have not been modelled.
- The fire water retention tanks lay within the pool fire contours at 12.5 kW/m^2 for all catastrophic ruptures of any fuel storage tanks, road tanker and diesel transfer pumps, however this level of thermal flux is unlikely to cause damage to the fire water tanks.
- Given that all three fuel storage tanks currently share a bund, it is possible that catastrophic failure of one vessel could escalate to a large fire resulting in catastrophic damage to all three tanks. Furthermore, the integrity of the firewater tanks could be compromised in such an event which would result in loss of a key protective safeguard.

Recommendation – Assess the potential to relocate the fire water tanks to an area where they are unlikely to sustain damage in the event of a fire.

Figure 5-1: Contours for Pool Fire Radiation at category 5/D for Diesel Storage Tank (Southern) Catastrophic Rupture in kW/m^2

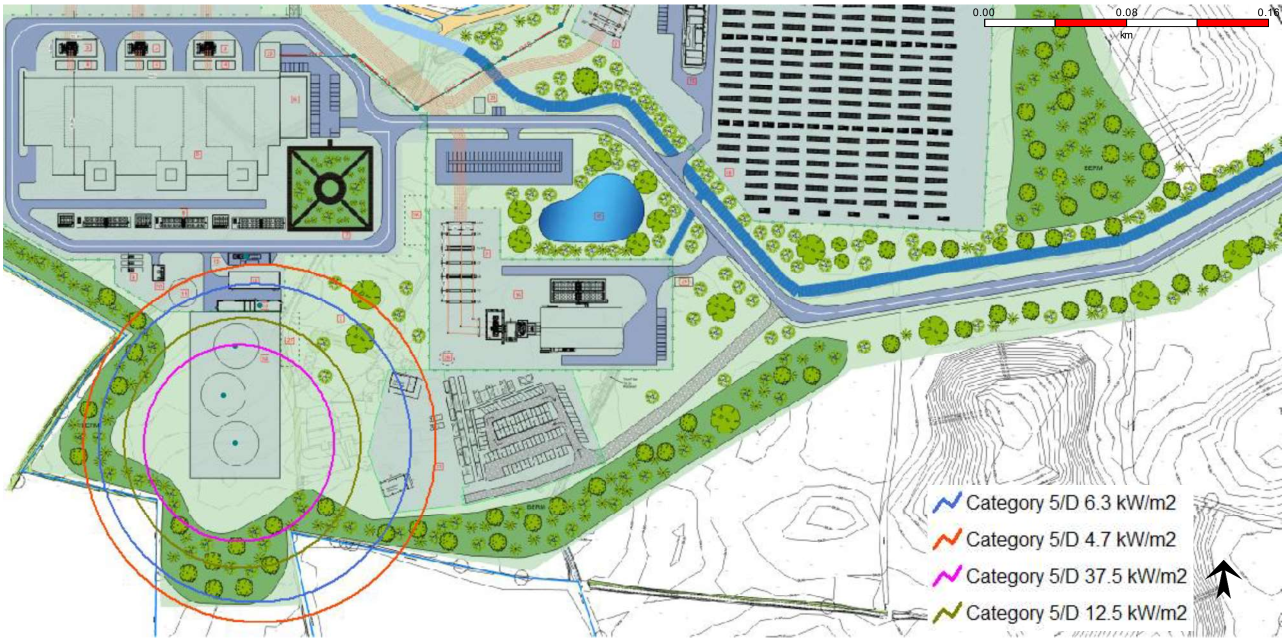


Figure 5-2: Contours for Pool Fire Radiation at category 5/D for Diesel Storage Tank (Central) Catastrophic Rupture in kW/m²

Figure 5-3: Contours for Pool Fire Radiation at category 5/D for Diesel Storage Tank (Northern) Catastrophic Rupture in kW/m²

Figure 5-4: Contours for Pool Fire Radiation at category 5/D for Diesel Storage Tank (Northern) for a small 5mm hole size leak in kW/m2

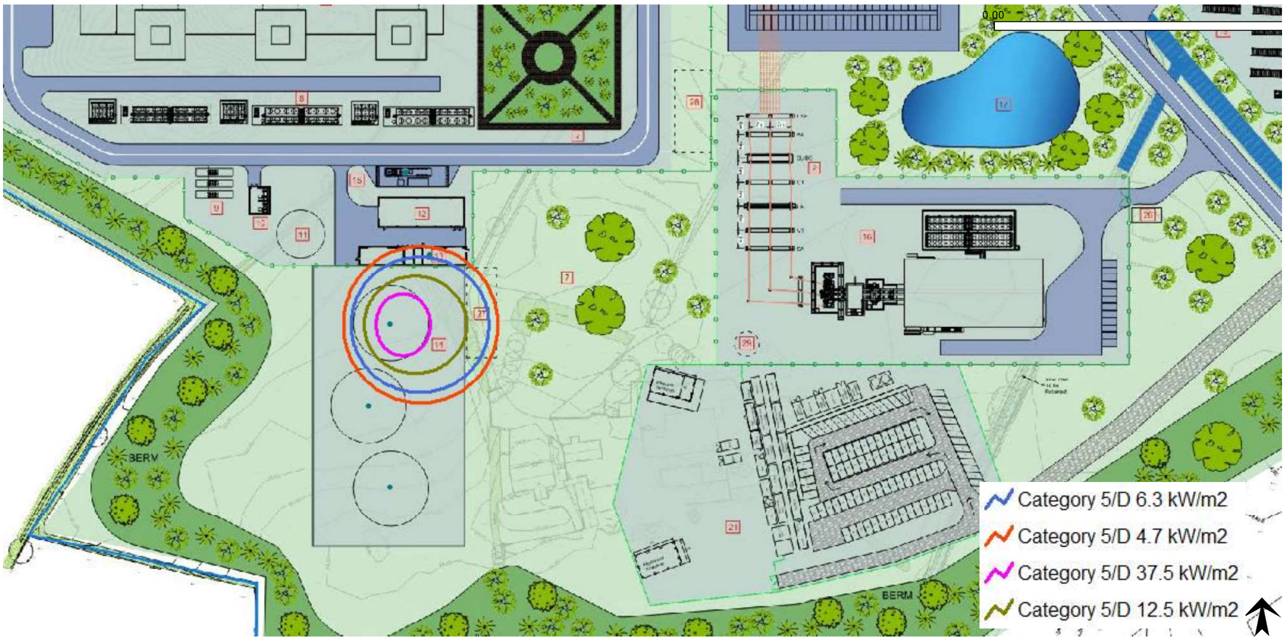


Figure 5-5: Contours for Pool Fire Radiation at category 5/D for Diesel Road Tanker Catastrophic Rupture in kW/m2

Figure 5-6: Contours for Pool Fire Radiation at category 5/D for Diesel Transfer Pump Full Bore Rupture in kW/m²

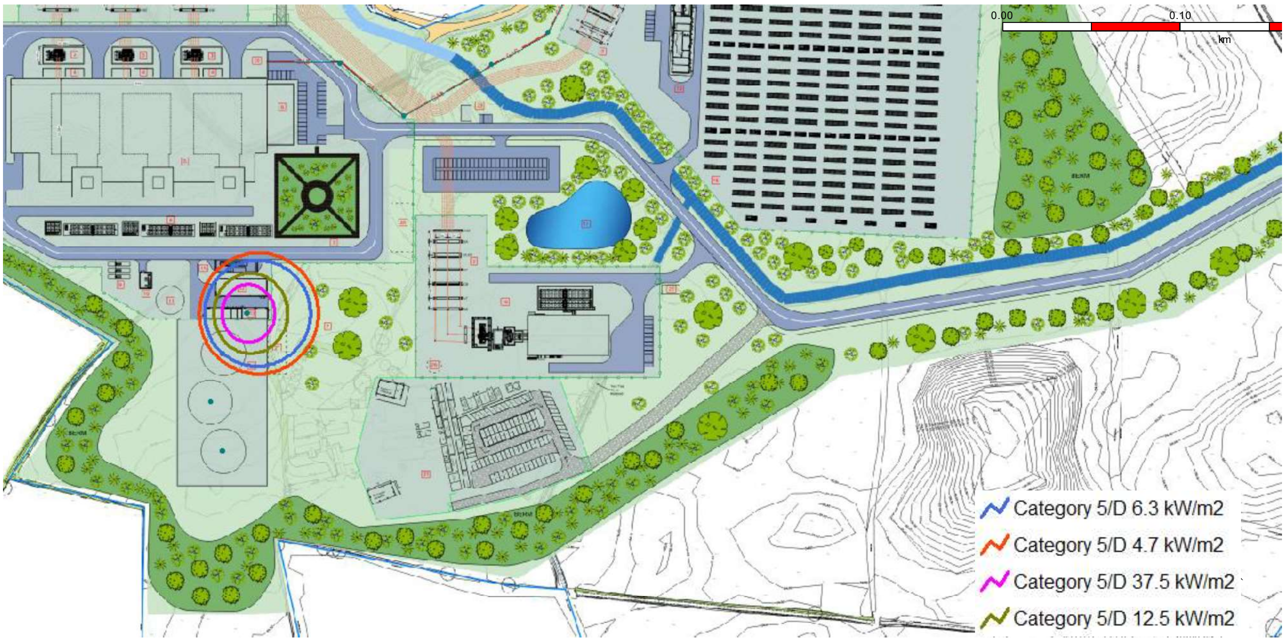
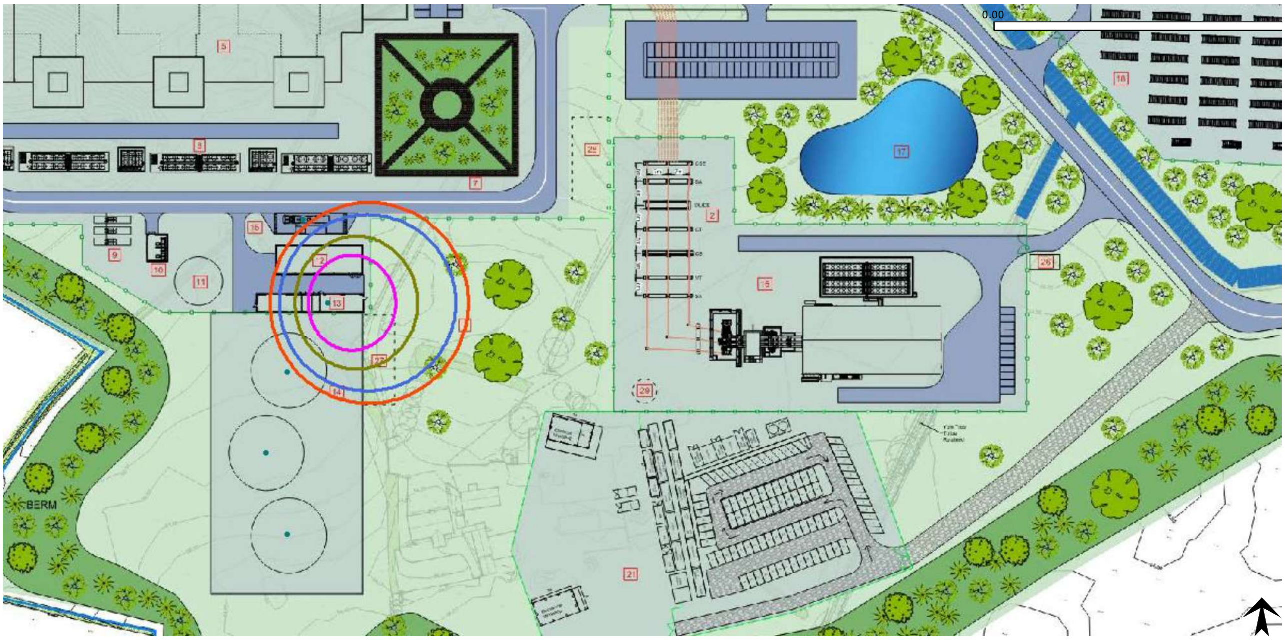


Figure 5-7: Contours for Pool Fire Radiation at category 5/D for Diesel Transfer Pump small 5mm hole leak in kW/m²



5.2 Jet Fire Thermal Radiation

The thermal radiation consequence contours representing all jet fires (irrespective of duration) are shown in Figure 5-8 and Figure 5-9. Jet fires form following ignition of a high momentum natural gas leak, assumed to occur at the facility AGI or on the buried gas pipeline. It can be seen from the shape of the contours that:

- The control room is located outside of all jet fire contours for the AGI.
- The control room is located outside of the long pipeline rupture's 37.5 kW/m^2 hazard frequency contours (corresponding to 100% chance of fatality for occupants for a portakabin style building) and outside the 12.5 kW/m^2 hazard frequency contours (corresponding to 25% chance of fatality for occupants for a portakabin style building). It is within the 6.3 kW/m^2 contour, but this only impairs escape routes and is unlikely to lead to fatalities.
- Security building lies within the 37.5 kW/m^2 contour of the long pipeline rupture and thus if any personnel are present during this event, there could be fatalities.
- There is potential for jet fires to escalate to the adjacent LDES compound, which could result in large fires within the system.

Figure 5-8: Contours for Jet Fire Radiation at category 5/D for Grid Connection AGI in kW/m^2

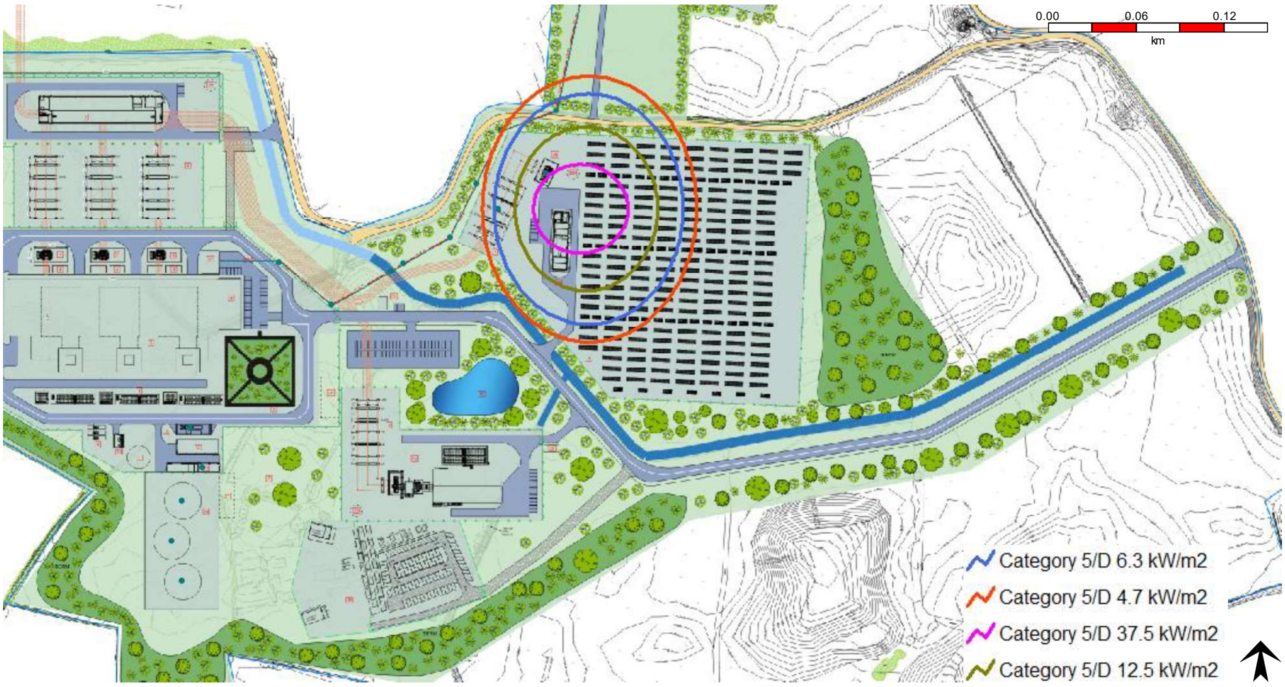
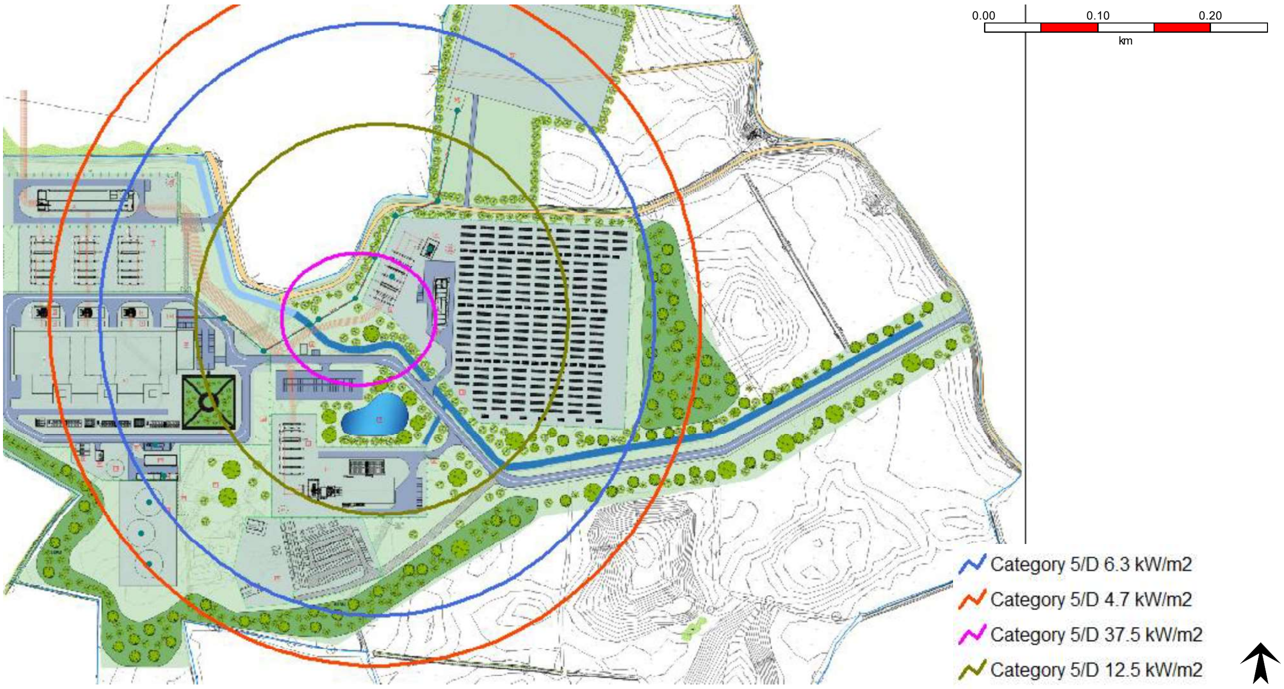


Figure 5-9: Contours for Jet Fire Radiation at category 5/D for Long Pipeline Full Bore in kW/m²

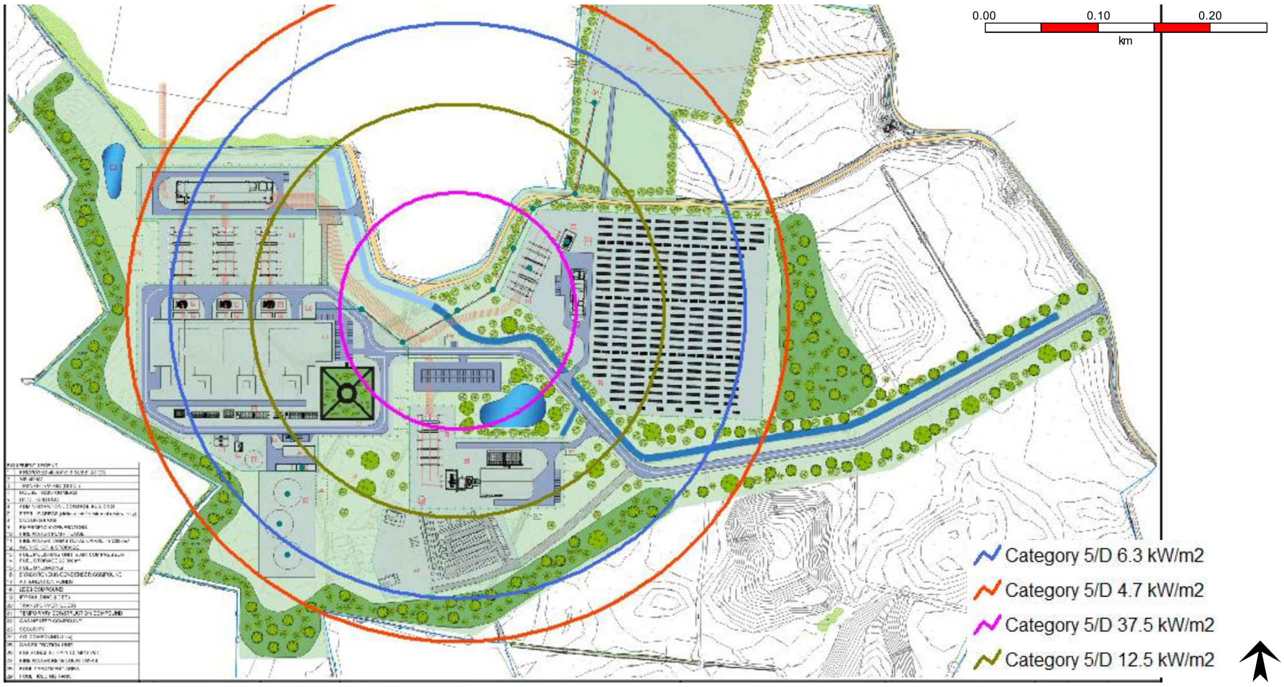


5.3 Fireball Thermal Radiation

The thermal radiation hazard frequency contours representing thermal loading from fireballs is shown in Figure 5-10. Fireballs are typically short duration events associated with catastrophic loss of containment. In the case of the buried pipeline, these are considered highly unlikely.

Security building lies within the 37.5 kW/m^2 and thus if any personnel are present during this event, there could be fatalities. The control room lies within the 12.5 kW/m^2 contour which does not lead to any causalities from fireballs

Figure 5-10: Contours for 5/D Fireball Radiations (kW/m^2) of long pipeline



5.4 Flash Fires

The vapour dispersion / flash fire to LFL hazard contours are shown in Figure 5-11 to Figure 5-16. These provide an indication of the flammable dispersion extents from the plant.

Flash fires associated with the fuel storage systems generally remain very localised, this is due to the fluid being a liquid at ambient temperature with a relatively high flash point. The flash fires associated with releases upstream of the AGI appear to have the potential to engulf the majority of the site within the 1/2LFL envelope, however the shape of the cloud is extremely thin, as shown in Figure 5-15, and the overall risk is consequently reduced.

Figure 5-11: Flash Fire at 5/D for both 3500 and 7000 ppm for catastrophic rupture of Diesel Storage Tank (northern)

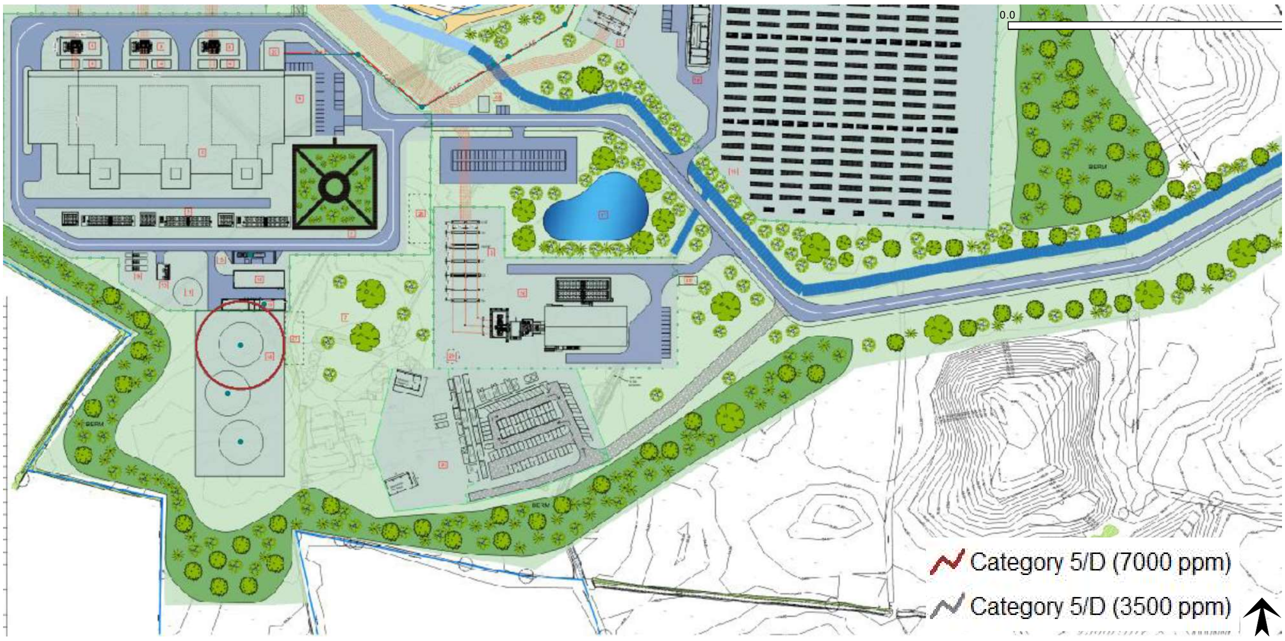


Figure 5-12: Flash Fire at 5/D for both 2500 and 5000 ppm for catastrophic rupture of Diesel Road Tanker

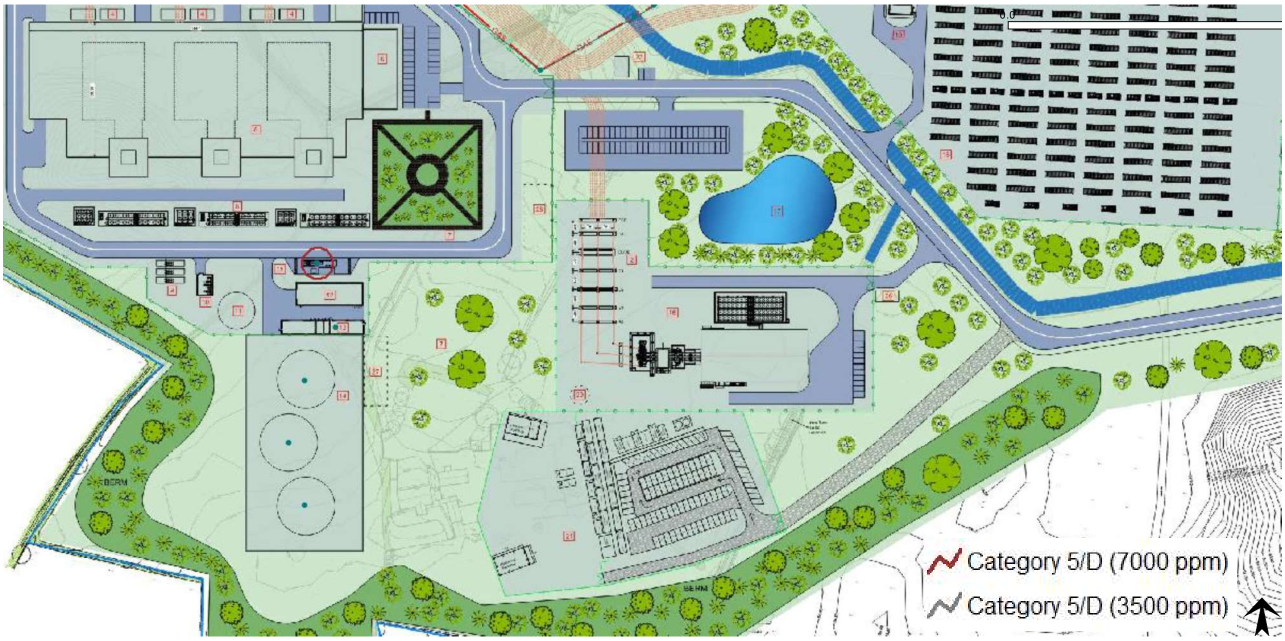


Figure 5-13: Flash Fire at 5/D for both 2500 and 5000 ppm for catastrophic rupture of Diesel Transfer Pump

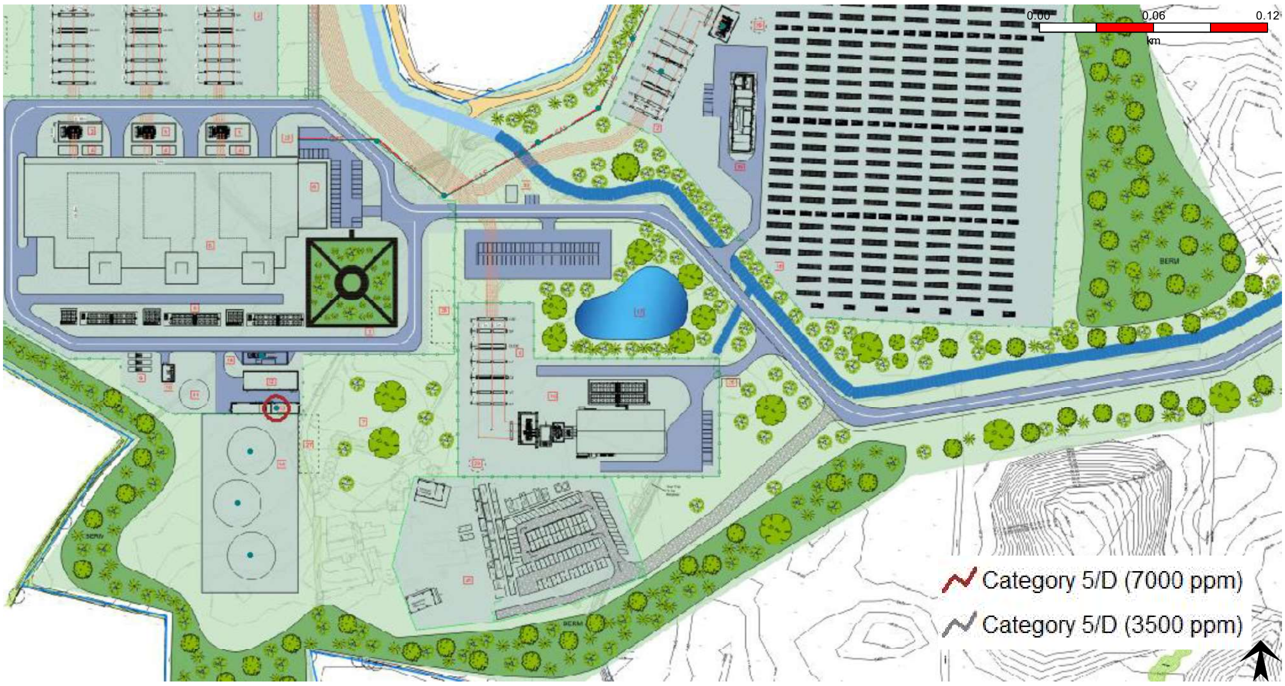


Figure 5-14: Flash Fire at 5/D for both 25000 and 50000 ppm for full bore (6 inch) of AGI grid connection

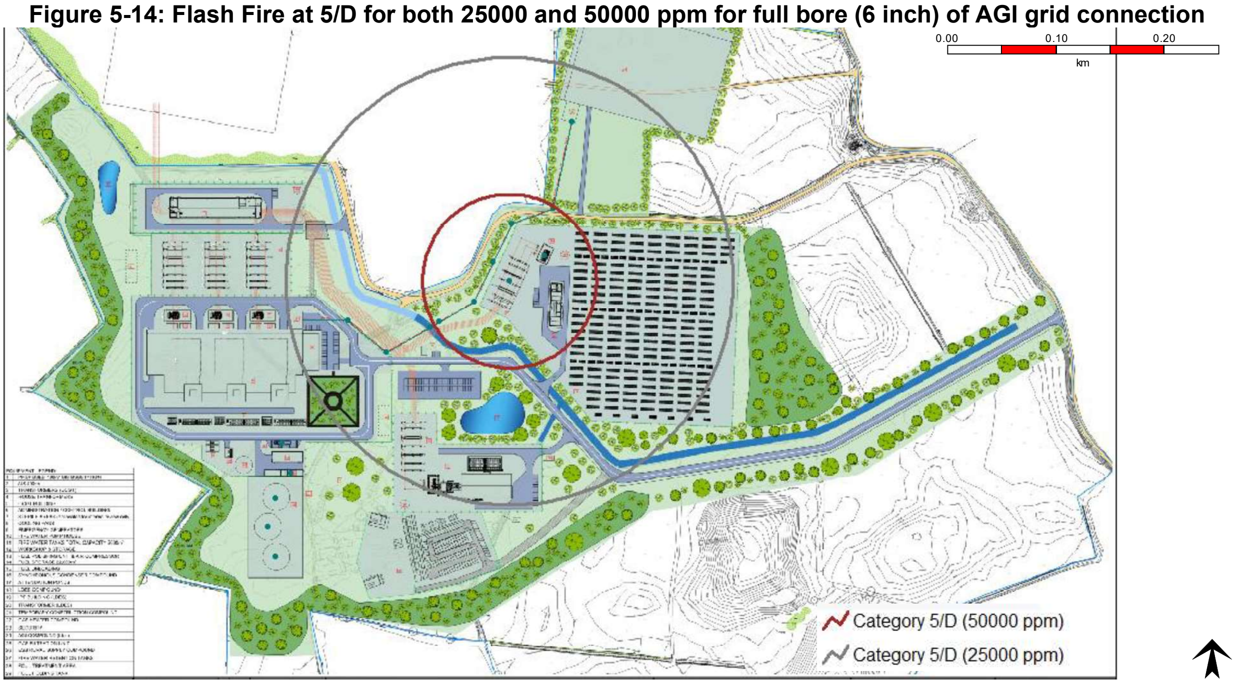
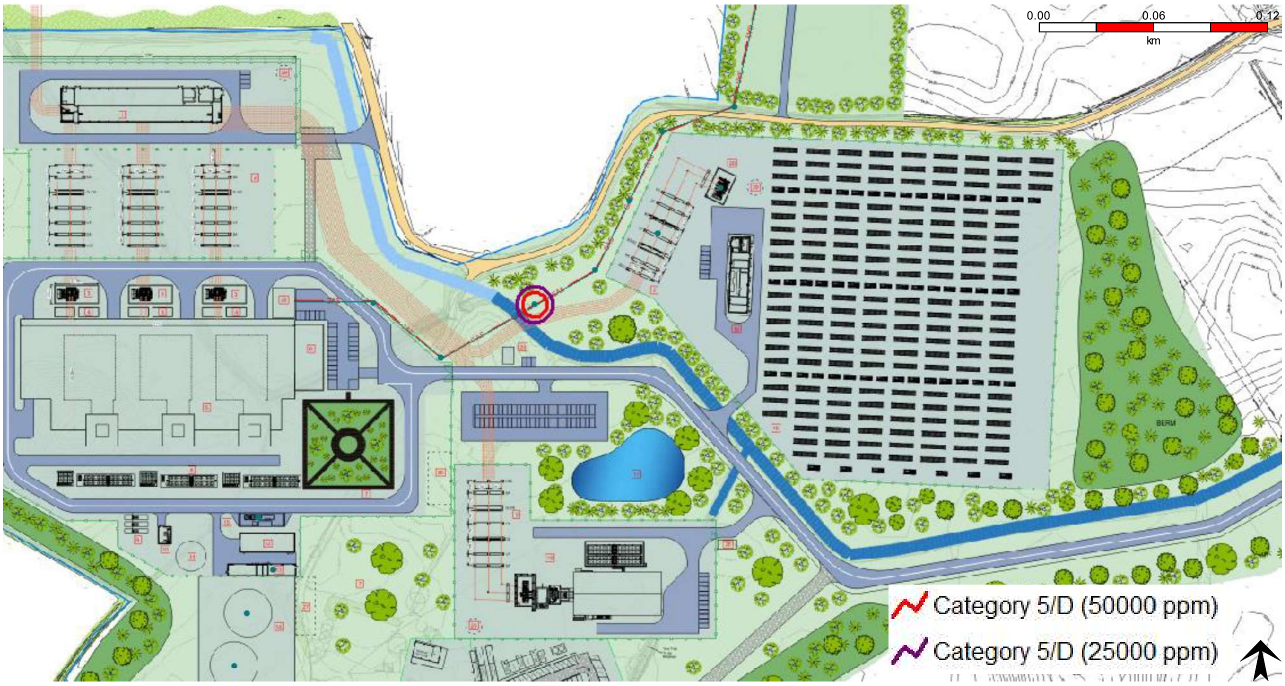


Figure 5-15: Shape of LFL and ½ LFL cloud shown for a release at the AGI.

Figure 5-16   Flash Fire at 5/D for both 25000ppm and 50000 ppm for full bore of long pipeline



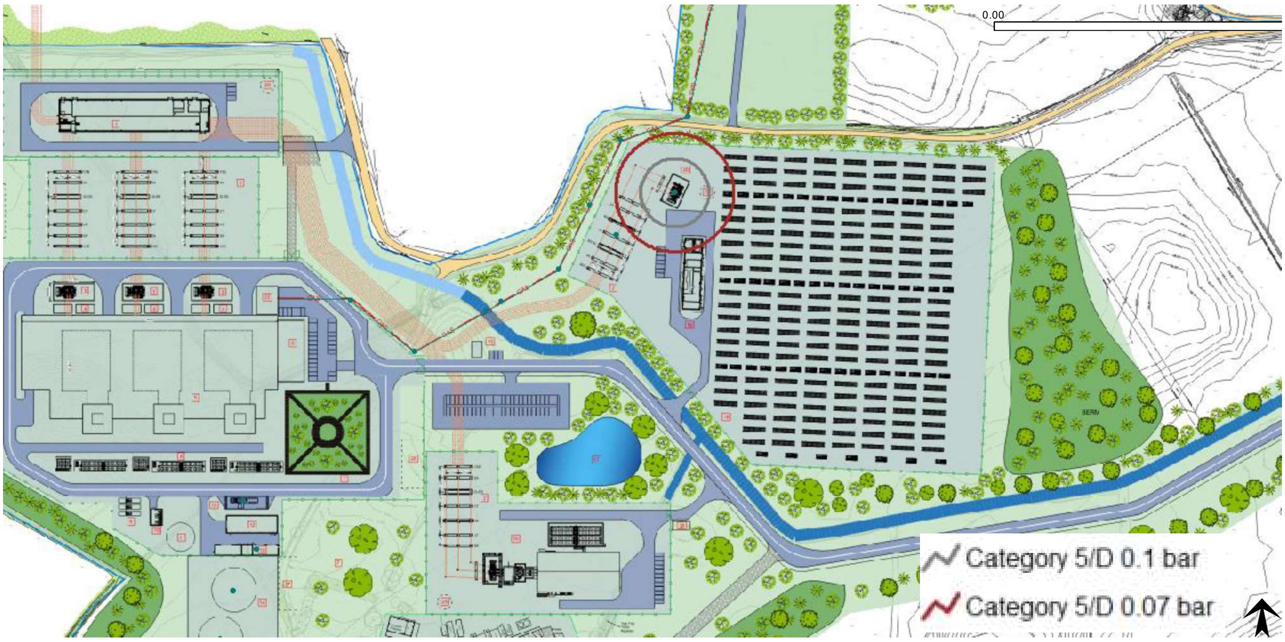
5.5 Explosion Overpressures

The explosion overpressure contours are shown in Figure 5-17 for overpressures of 0.1 bar and 0.07 bar.

The key observations from these contours are:

- The overpressure hazard contours remain localised to the transformer area, however the 0.07 bar contour does reach the IPP building, and there is therefore potential for damage to this building.

Figure 5-17: Contours for Explosion Overpressure of 100 and 70 mbar – Methane VCE Transformer



5.6 Long Duration Energy Storage (LDES) Battery System

Battery Energy Storage Systems (BESS) present significant safety risk through fire and explosion (thermal runaway). In case of the proposed development, the aggregate stored energy will likely exceed 1 GWh (assuming 400 MW with at least 5 hours of capacity); making it one of the largest installations under development globally.

Should a fire occur in one of the LDES battery containers, there is potential that the fire propagates through the entire system, which would have catastrophic consequences in terms of asset loss and potential risk to personnel and first responders. Proper fire management design should be followed during the design of the LDES system such that the potential for a fire to propagate from one container to the next is reduced to ALARP. It is likely that the LDES system will be of particular interest to regulators and insurers, and as such, DNV recommend specific risk assessment for the system when the design is sufficiently mature.

6 PRELIMINARY RISK ASSESSMENT

Given the early stage of this project, and the resulting lack of engineering design detail, a full quantitative risk assessment (QRA) cannot be undertaken. However, based on engineering judgement and experience of assessing other similar industrial facilities, DNV have conducted a preliminary risk assessment using the consequence results reported above.

The following basis is taken for assessing the severity (S) of the modelled scenarios:

Table 6-1: Severity ranking categories.

Severity Category	Criteria
S5	Multiple Fatalities or one off-site fatality
S4	Multiple serious injuries or one fatality
S3	Serious (life altering) Injury
S2	Serious (non-life altering) injury
S1	Minor injury

The following basis is used for assessing the likelihood (L) of the modelled scenarios:

Table 6-2: Likelihood ranking categories.

Likelihood Category	Criteria
L5	Can occur multiple times per year
L4	Can occur once in a year
L3	Can occur once during the lifetime of the facility
L2	Potential to occur once in 100 years
L1	Unlikely to occur once in 100 years

And the following risk matrix is proposed to rank risks at this stage.

Figure 6-1: Proposed risk matrix

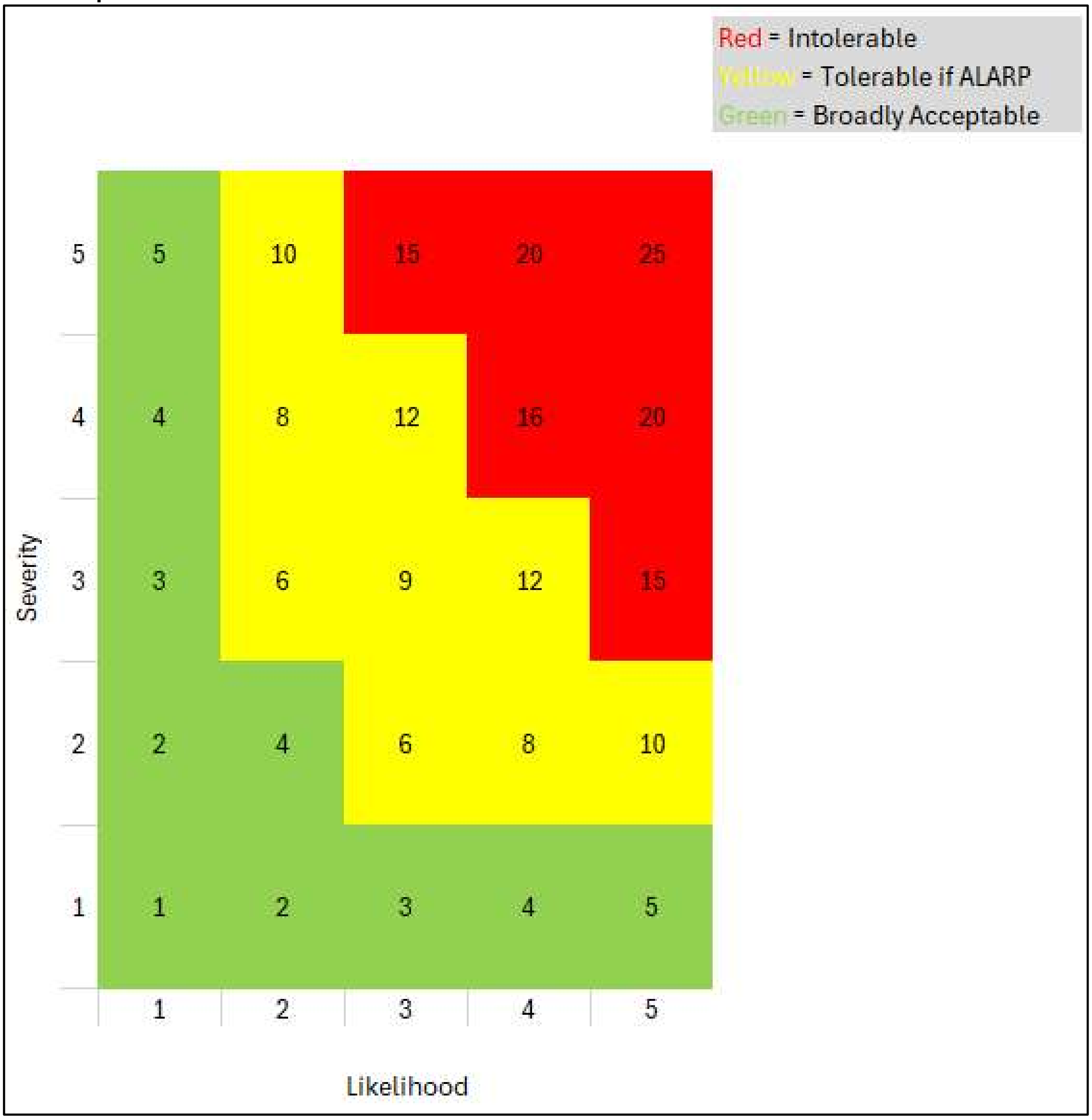


Table 6-3: Semi-quantitative risk assessment of modelled scenarios.

System	Scenario	Severity	Likelihood	Risk
Diesel Storage Tanks	Catastrophic rupture with pool fire	5	1	5
	Small leak with pool fire	3	2	6
Diesel Road Tanker	Catastrophic rupture with pool fire	5	1	5
	Small leak with pool fire	3	2	6
Diesel Transfer Pumps	Small leak with pool fire	3	2	6
	Full bore rupture with pool fire	3	1	3
Grid Connection AGI	Small leak with jet fire/flash fire/VCE	3	3	9
	Full bore rupture with jet fire/flash fire/VCE	5	2	10
Long Pipeline	Small leak with jet fire/flash fire/VCE	3	2	6
	Full bore rupture with jet fire/flash fire/VCE	5	2	10
VCE	Explosion	4	2	8
LDES Battery	Single container fire	4	3	12
	Multi-container fire	5	2	10

At this stage, no intolerable risks have been identified. However, the facility operator will be required to demonstrate that all risks have been managed and that all reasonably practicable measures have been implemented to reduce the risk. The ALARP demonstration principle is a key feature of the Control of Major Accident Hazards (COMAH) regulations, and it is likely that further risk assessments will be required as the design of the facility matures, such that the control of risk can be adequately demonstrated.

7 CONCLUSIONS & RECOMMENDATIONS

7.1 Conclusions

The consequences derived have been both for small 5 mm releases and full bore/catastrophic releases. Despite there being no notable consequences for any small leaks except for the firewater tank locations.

The following conclusions are made from this study:

- **Risk**: All facility risks are, at this point in time, considered tolerable if ALARP. Halston Lumcloom energy will be required to demonstrate that all risks have been controlled as low as reasonably practicable before the facility can be operational.
- **Pool Fire Radiation:** In the event of a catastrophic rupture of a diesel road tanker resulting in a pool fire, the thermal radiation intensity is at levels sufficient to cause multiple fatalities at the administration/control building. Furthermore, there is potential for fuel tank pool fires to escalate to the adjacent tanks, or to cause catastrophic damage to the fire water tanks.
- **Jet Fires:** There is potential for the 37.5 kW/m^2 contours to extend across a large section of the facility, which suggests that there is potential for escalation due to jet fires associated with the natural gas system on-site. There is also potential for personnel situated outside (e.g. walking between areas of the site) to be fatally injured from natural gas jet fires. There is also potential for escalation of jet fires originating in the AGI or on-site pipeline to the LDES compound.
- **Fireballs:** The hazard contours associated with fireballs are relatively large, however these are short lived events and therefore do not contribute greatly to escalation, and the likelihood of a fireball has been deemed improbably over the lifetime of the facility.
- **Flash Fires:** Flash fires can have far reaching effects, as seen in Figure 5-14, however Figure 5-15 provides an indication as to the shape of the flammable cloud which can be seen to be much smaller than the entire cloud envelope. However, the ½ LFL cloud can impact the majority of the site such that any muster points could be considered compromised.
- **LDES System:** The safety risk posed by LDES systems must not be underestimated, and there is potential for very large fires should propagation between containers occur. Should an LDES fire be contained to a single container (as should be the case for properly designed systems), there is potential for localised asset damage and safety risk to first responders.
- **Off-site impacts:** Natural gas and fuel oil consequence modelling has highlighted no particular concerns to third-party buildings or properties outside of the site boundary. In the unlikely event that a large-scale LDES compound fire occurs, with the fire propagating across multiple containers, there is potential for off-site impacts from smoke and evolved gases.

7.2 Recommendations

The following recommendations are made:

1. Consider fire protection strategies for the tanker unloading and fuel oil storage areas, which could include separate bunds for each storage tank, and deluge (sprinkler) systems, and/or foam application on confirmation of a fire. Also consider relocation of the fire water tanks to a location away from all flammable inventories to ensure they are not impacted by fire events.
2. There is currently potential for occupied buildings (security and administration/control building) to be within the 37.5 kW/m^2 hazard ranges associated with jet fires and pool fires. If possible, Halston Lumcloom should

consider relocating these buildings to an area outside all hazard contours – which would be considered an inherently safe solution.

3. Ensure any muster points are located outside of the ½ LFL clouds, as shown in Section 5.4.
4. If possible, the spacing between the natural gas-containing systems and the LDES compound should be increased to reduce the likelihood of a natural gas jet fire escalating to a large-scale battery fire, which could potentially have off-site impacts.
5. Undertake further risk assessments in later design stages and review the input data and assumptions. This should primarily address any uncertainties or assumptions in process information, as these will be more accurately defined as the design progresses. Particular attention should be given to fire and explosion risk within the LDES compound - ensuring that all applicable design standards have been followed to minimise the risk associated with stored electrical energy.

Note, these recommendations aim to further reduce any risk associated with Project Coolpowra, however other risk reduction measures may be deemed more appropriate as the design develops.

8 REFERENCES

/1/ Project Coolpowra, Proposed Reserve Gas-Fired Power Generator, GIS Electrical Substation and Energy Storage System, Project Description SEP-0398, February 2024, Rev 01.

/2/ CPA-HAL-OC-XX-DR-PL-1000, Proposed Site Location, March 2024, Rev P01.

/3/ CPA-HAL-MP-XX-DR-PL-1000,.Master Plan Layout, March 2024, Rev P03

/4/ Summary description of receiving environment, SEP-0398, February 2024, Rev 01

/5/ UK HSE, "Reducing risks, protecting people", ISBN 0 7176 2151 0, 2001.

/6/ UK HSE, "HSE's Land Use Planning Methodology", https://www.hse.gov.uk/landuseplanning/methodology.htm, accessed February 2024.

/7/ IOGP, "Risk Assessment Data Directory – Process Release Frequencies", 434-01, Version 3.0, September 2019.

/8/ TNO, "Guidelines for Quantitative Risk Assessment – 'Purple Book", CPR 18E, 2005.

/9/ UK HSE Failure Rate and Event Data (FRED) report.

/10/ IOGP, "Risk Assessment Data Directory – Ignition Probabilities", 434-06, Version 1.0, September 2019.

/11/ IOGP, "Risk Assessment Data Directory – Vulnerability of Humans", 434-14, Version 1.0, July 2023.

/12/ Guidance to Inspectors on the Assessment of Safety Reports under the COMAH Regulations 2015, HSA, Rev 4, 2017.

APPENDIX A
Flammable Dispersion Results

Scenario	Weather	Hole size (mm)	Distance to LFL fraction (m)	Distance to LFL (m)
Diesel Storage (central) - Catastrophic rupture	Category 1.5/F	Full rupture	22	22
Diesel Storage (central) - Catastrophic rupture	Category 1.5/D	Full rupture	22	22
Diesel Storage (central) - Catastrophic rupture	Category 5/D	Full rupture	25	25
Diesel Storage (central) - leak	Category 1.5/F	5	Not reached at height of interest	Not reached at height of interest
Diesel Storage (central) - leak	Category 1.5/D	5	Not reached at height of interest	Not reached at height of interest
Diesel Storage (central) - leak	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Road tanker - Catastrophic rupture	Category 1.5/F	Full rupture	6	6
Road tanker - Catastrophic rupture	Category 1.5/D	Full rupture	6	6
Road tanker - Catastrophic rupture	Category 5/D	Full rupture	7	7
Road tanker - Leak	Category 1.5/F	5	Not reached at height of interest	Not reached at height of interest
Road tanker - Leak	Category 1.5/D	5	Not reached at height of interest	Not reached at height of interest
Road tanker - Leak	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Leak	Category 1.5/F	5	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Leak	Category 1.5/D	5	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Leak	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Catastrophic rupture	Category 1.5/F	Full rupture	5	5
Diesel Transfer Pumps - Catastrophic rupture	Category 1.5/D	Full rupture	5	5
Diesel Transfer Pumps - Catastrophic rupture	Category 5/D	Full rupture	6	6
Grid Connection AGI - Leak	Category 1.5/F	5	Not reached at height of interest	Not reached at height of interest

Scenario	Weather	Hole size (mm)	Distance to LFL fraction (m)	Distance to LFL (m)
Grid Connection AGI - Leak	Category 1.5/D	5	Not reached at height of interest	Not reached at height of interest
Grid Connection AGI - Leak	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Grid Connection AGI - Full bore rupture	Category 1.5/F	152	187	83
Grid Connection AGI - Full bore rupture	Category 1.5/D	152	182	77
Grid Connection AGI - Full bore rupture	Category 5/D	152	205	80
Long pipeline (single point) - 5mm	Category 1.5/F	5	1	1
Long pipeline (single point) - 5mm	Category 1.5/D	5	1	1
Long pipeline (single point) - 5mm	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Long pipeline (single point) - Full bore	Category 1.5/F	914	Not reached at height of interest	Not reached at height of interest
Long pipeline (single point) - Full bore	Category 1.5/D	914	6	5
Long pipeline (single point) - Full bore	Category 5/D	914	9	6

APPENDIX B
Jet fire results

Scenario	Weather	Hole size (mm)	Flame emissive power (kW/m2)	Distance downwind to intensity level 1 (4.7 kW/m2) (m)	Distance downwind to intensity level 2 (6.3 kW/m2) (m)	Distance downwind to intensity level 3 (12.5 kW/m2) (m)	Distance downwind to intensity level 4 (37.5 kW/m2) (m)	Ellipse area at intensity level 1 (4.7 kW/m2) (m2)
Diesel Storage (central) - leak	Category 1.5/F	5	33	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
Diesel Storage (central) - leak	Category 1.5/D	5	33	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
Diesel Storage (central) - leak	Category 5/D	5	64	1	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	1
Road tanker - Leak	Category 1.5/F	5	21	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
Road tanker - Leak	Category 1.5/D	5	22	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
Road tanker - Leak	Category 5/D	5	50	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Leak	Category 1.5/F	5	39	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Leak	Category 1.5/D	5	40	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Leak	Category 5/D	5	78	1	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	1
Grid Connection AGI - Leak	Category 1.5/F	5	40	4	4	Not reached at height of interest	Not reached at height of interest	3
Grid Connection AGI - Leak	Category 1.5/D	5	40	4	4	Not reached at height of interest	Not reached at height of interest	3
Grid Connection AGI - Leak	Category 5/D	5	37	4	4	Not reached at height of interest	Not reached at height of interest	2
Grid Connection AGI - Full bore rupture	Category 1.5/F	152	350	134	124	106	82	20943
Grid Connection AGI - Full bore rupture	Category 1.5/D	152	350	134	124	106	82	20943
Grid Connection AGI - Full bore rupture	Category 5/D	152	350	135	126	108	88	20639
Long pipeline (single point) - 5mm	Category 1.5/F	5	42	4	4	2	1	29
Long pipeline (single point) - 5mm	Category 1.5/D	5	42	4	4	2	1	29
Long pipeline (single point) - 5mm	Category 5/D	5	70	6	5	4	4	34
Long pipeline (single point) - Full bore	Category 1.5/F	914	184	300	248	132	15	232841
Long pipeline (single point) - Full bore	Category 1.5/D	914	184	300	248	132	15	232841
Long pipeline (single point) - Full bore	Category 5/D	914	286	335	295	219	102	274608

APPENDIX C
Pool fire results

Scenario	Weather	Hole size (mm)	Pool diameter (m)	Distance downwind to intensity level 1 (4.7 kW/m2) (m)	Distance downwind to intensity level 2 (6.3 kW/m2) (m)	Distance downwind to intensity level 3 (12.5 kW/m2) (m)	Distance downwind to intensity level 4 (37.5 kW/m2) (m)
Diesel Storage (central) - Catastrophic rupture	Category 1.5/F	Full rupture	94	104	91	69	54
Diesel Storage (central) - Catastrophic rupture	Category 1.5/D	Full rupture	94	104	91	69	54
Diesel Storage (central) - Catastrophic rupture	Category 5/D	Full rupture	94	112	98	71	55
Diesel Storage (central) - leak	Category 1.5/F	5	14	34	30	22	13
Diesel Storage (central) - leak	Category 1.5/D	5	14	34	30	22	13
Diesel Storage (central) - leak	Category 5/D	5	14	36	33	25	13
Road tanker - Catastrophic rupture	Category 1.5/F	Full rupture	101	107	94	71	57
Road tanker - Catastrophic rupture	Category 1.5/D	Full rupture	101	107	94	72	57
Road tanker - Catastrophic rupture	Category 5/D	Full rupture	101	117	103	74	59
Road tanker - Leak	Category 1.5/F	5	11	28	25	19	10
Road tanker - Leak	Category 1.5/D	5	11	28	25	19	10
Road tanker - Leak	Category 5/D	5	11	30	27	22	10
Diesel Transfer Pumps - Leak	Category 1.5/F	5	17	35	32	23	15
Diesel Transfer Pumps - Leak	Category 1.5/D	5	17	36	32	24	15
Diesel Transfer Pumps - Leak	Category 5/D	5	17	38	35	26	16
Diesel Transfer Pumps - Catastrophic rupture	Category 1.5/F	Full rupture	50	60	53	39	30
Diesel Transfer Pumps - Catastrophic rupture	Category 1.5/D	Full rupture	50	60	53	39	30
Diesel Transfer Pumps - Catastrophic rupture	Category 5/D	Full rupture	50	66	58	40	31

APPENDIX D
Fireball results

Scenario	Weather	Hole size (mm)	Distance downwind to intensity level 1 (4.7 kW/m2) (m)	Distance downwind to intensity level 2 (6.3 kW/m2) (m)	Distance downwind to intensity level 3 (12.5 kW/m2) (m)	Distance downwind to intensity level 4 (37.5 kW/m2) (m)
Long pipeline (single point) - Full bore	Category 1.5/F	914	292	254	182	104
Long pipeline (single point) - Full bore	Category 1.5/D	914	292	254	182	104
Long pipeline (single point) - Full bore	Category 5/D	914	292	254	182	104

APPENDIX E
Explosion results

Scenario	Weather	Material	Distance downwind to overpressure 1 (0.07 bar) (m)	Distance downwind to overpressure 2 (0.1 bar) (m)	Distance downwind to overpressure 3 (0.35 bar) (m)
Methane VCE - Transformer	Category 1.5/F	METHANE	33	19	Not reachable
Methane VCE - Transformer	Category 1.5/D	METHANE	33	19	Not reachable
Methane VCE - Transformer	Category 5/D	METHANE	33	19	Not reachable

About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

Whether assessing a new ship design, optimizing the performance of a wind farm, analysing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

Driven by its purpose, to safeguard life, property, and the environment, DNV helps tackle the challenges and global transformations facing its customers and the world today and is a trusted voice for many of the world's most successful and forward-thinking companies.

HALSTON

Appendix 4.3

Lighting Study

DATE:	**18 May 2024**
DESIGNER:	**Don Kinghan**
PROJECT No:	**DAR24011**
PROJECT NAME:	**Coolpowra Flexgen, Co. Galway R1**

DARAMACK
Exterior Lighting Design

Lighting designed to the recommendations of BS5489-1:2020 and Lighting Class P4 and in conjunction with CIBSE SLL outdoor lighting guides to provide suitable lighting levels for the safe movements of vehicular and personnel movements.

Lighting Class P4
Maintained average illuminance >5.0Lux
Minimum point illuminance >1.0Lux

Outdoor Lighting Report

PREPARED BY: W Don Kinghan
www.daramacklighting.co.uk

Layout Report

General Data

Dimensions in Metres Angles in Degrees

Calculation Grids

ID	Grid Name	X	Y	X' Length	Y' Length	X' Spacing	Y' Spacing
1	Grid 1	582642.99	709081.71	400.00	39.00	1.60	1.50
2	Grid 2	582496.91	708967.80	198.00	90.00	1.50	1.50
3	Grid 3	582332.54	709088.85	159.00	60.00	1.50	1.50
4	Grid 4	582239.67	709062.06	120.00	36.00	1.50	1.50
5	Carpark	582259.09	709033.71	99.00	36.00	1.50	1.50
6	Grid 6	582020.96	708915.96	258.00	180.00	1.50	1.50
7	Grid 7	581978.58	709109.85	207.00	60.00	1.50	1.50
8	Grid 8	582185.90	709045.78	21.00	42.00	1.50	1.50
9	Grid 9	582333.01	709243.54	93.00	129.00	1.50	1.50
10	Grid 10	582326.38	708947.72	150.00	90.00	1.50	1.50
11	Grid 11	582368.61	709077.91	60.00	126.00	1.50	1.50
12	Grid 12	583036.95	709013.61	171.00	42.00	1.50	1.50
13	Grid 13	583197.40	709043.20	120.00	36.00	1.50	1.50

Luminaires

Luminaire A Data

Supplier	Philips
Type	BGP291 DW50 BL2
Lamp(s)	LED-HB 5.2S 730
Lamp Flux (klm)	6.00
File Name	LumiStreet Gen2 Micro_BGP291_DW50 BL 2_6000_20LED_5.2S_CLO_L90_730.ies
Maintenance Factor	0.83
Lum. Int. Class	G3
No. in Project	98

Layout

ID /Mast	Type	X	Y	Height	Angle	Tilt	Cant	Out-reach	Target X	Target Y	Target Z
1	A	583257.80	709142.03	6.00	166.00	0.00	0.00	0.40			
2	A	583249.25	709116.60	6.00	144.00	0.00	0.00	0.40			
3	A	583232.05	709093.77	6.00	147.00	0.00	0.00	0.40			
4	A	583214.09	709070.42	6.00	140.00	0.00	0.00	0.40			
5	A	583194.71	709049.26	6.00	124.00	0.00	0.00	0.40			
6	A	583159.32	709042.48	6.00	299.00	0.00	0.00	0.40			
7	A	583133.07	709030.18	6.00	293.00	0.00	0.00	0.40			
8	A	583105.36	709027.99	6.00	265.00	0.00	0.00	0.40			

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Layout Continued

ID /Mast	Type	X	Y	Height	Angle	Tilt	Cant	Out-reach	Target X	Target Y	Target Z
9	A	583069.27	709031.33	6.00	262.00	0.00	0.00	0.40			
10	A	583037.48	709035.73	6.00	259.00	0.00	0.00	0.40			
11	A	583002.19	709040.61	6.00	261.00	0.00	0.00	0.40			
12	A	582964.42	709045.84	6.00	261.00	0.00	0.00	0.40			
13	A	582930.07	709050.62	6.00	260.00	0.00	0.00	0.40			
14	A	582895.20	709059.90	6.00	252.00	0.00	0.00	0.40			
15	A	582863.87	709070.07	6.00	251.00	0.00	0.00	0.40			
16	A	582834.22	709079.62	6.00	250.00	0.00	0.00	0.40			
17	A	582802.11	709089.92	6.00	250.00	0.00	0.00	0.40			
18	A	582767.80	709093.52	6.00	271.00	0.00	0.00	0.40			
19	A	582733.94	709093.97	6.00	269.00	0.00	0.00	0.40			
20	A	582697.68	709094.71	6.00	271.00	0.00	0.00	0.40			
21	A	582666.04	709094.41	6.00	267.00	0.00	0.00	0.40			
22	A	582634.39	709092.57	6.00	294.00	0.00	0.00	0.40			
23	A	582601.59	709079.03	6.00	293.00	0.00	0.00	0.40			
24	A	582564.66	709063.48	6.00	294.00	0.00	0.00	0.40			
25	A	582531.18	709049.67	6.00	291.00	0.00	0.00	0.40			
26	A	582495.52	709034.83	6.00	292.00	0.00	0.00	0.40			
27	A	582474.84	709014.82	6.00	113.00	0.00	0.00	0.40			
28	A	582455.11	709037.46	6.00	238.00	0.00	0.00	0.40			
29	A	582425.40	709058.35	6.00	234.00	0.00	0.00	0.40			
30	A	582397.69	709077.86	6.00	230.00	0.00	0.00	0.40			
31	A	582372.10	709095.88	6.00	233.00	0.00	0.00	0.40			
32	A	582340.01	709107.09	6.00	279.00	0.00	0.00	0.40			
33	A	582303.53	709098.14	6.00	283.00	0.00	0.00	0.40			
34	A	582267.03	709089.41	6.00	282.00	0.00	0.00	0.40			
35	A	582238.42	709081.86	6.00	270.00	0.00	0.00	0.40			
36/ENC01	A	582272.98	709062.25	6.00	283.00	0.00	0.00	0.90			
37/ENC01	A	582272.98	709062.25	6.00	103.00	0.00	0.00	0.90			
38/ENC03	A	582329.00	709075.89	6.00	283.00	0.00	0.00	0.90			
39/ENC03	A	582329.00	709075.89	6.00	103.00	0.00	0.00	0.90			
40/ENC02	A	582300.97	709068.96	6.00	283.00	0.00	0.00	0.90			
41/ENC02	A	582300.97	709068.96	6.00	103.00	0.00	0.00	0.90			
42	A	582235.80	709054.97	6.00	192.00	0.00	0.00	0.40			
43	A	582210.67	709058.80	6.00	107.00	0.00	0.00	0.40			
44	A	582206.91	709092.40	6.00	238.00	0.00	0.00	0.40			

Layout Continued

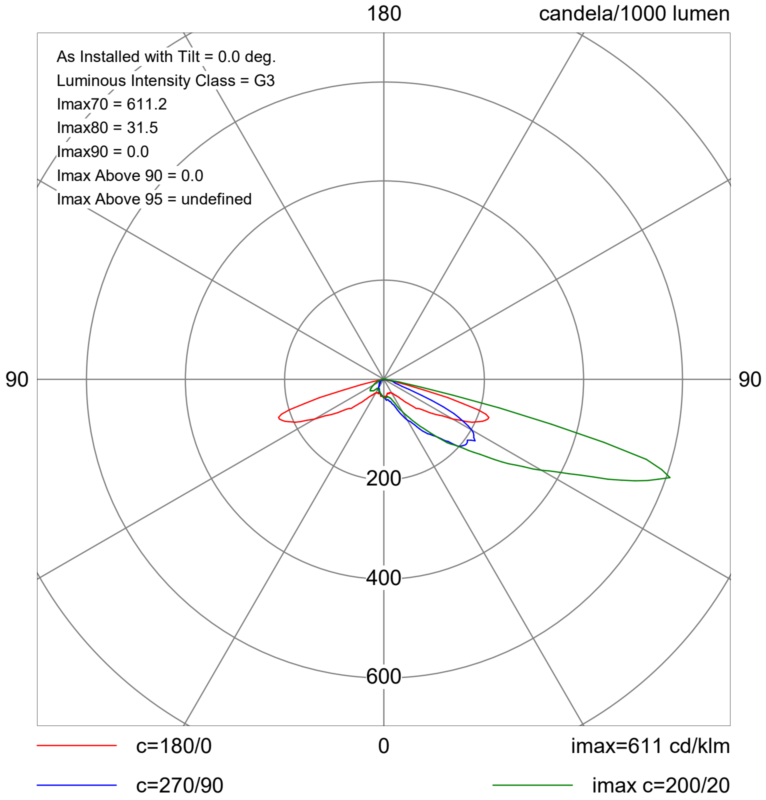
ID /Mast	Type	X	Y	Height	Angle	Tilt	Cant	Out-reach	Target X	Target Y	Target Z
45	A	582162.93	709091.49	6.00	283.00	0.00	0.00	0.40			
46	A	582244.45	709020.15	6.00	193.00	0.00	0.00	0.40			
47	A	582226.88	708989.97	6.00	104.00	0.00	0.00	0.40			
48	A	582191.20	708981.07	6.00	104.00	0.00	0.00	0.40			
49	A	582155.98	708972.74	6.00	104.00	0.00	0.00	0.40			
50	A	582125.05	708965.18	6.00	103.00	0.00	0.00	0.40			
51	A	582097.20	708958.35	6.00	106.00	0.00	0.00	0.40			
52	A	582069.23	708952.62	6.00	88.00	0.00	0.00	0.40			
53	A	582034.22	708964.67	6.00	42.00	0.00	0.00	0.40			
54	A	582022.53	708997.41	6.00	19.00	0.00	0.00	0.40			
55	A	582013.71	709035.66	6.00	15.00	0.00	0.00	0.40			
56	A	582006.93	709063.94	6.00	13.00	0.00	0.00	0.40			
57	A	582031.76	709069.35	6.00	196.00	0.00	0.00	0.40			
58	A	582056.14	709056.39	6.00	104.00	0.00	0.00	0.40			
59	A	582090.74	709065.08	6.00	106.00	0.00	0.00	0.40			
60	A	582067.92	709079.72	6.00	193.00	0.00	0.00	0.40			
61	A	582105.74	709088.47	6.00	198.00	0.00	0.00	0.40			
62	A	582127.35	709073.76	6.00	104.00	0.00	0.00	0.40			
63	A	582143.26	709097.83	6.00	197.00	0.00	0.00	0.40			
64	A	582042.57	708997.26	6.00	200.00	0.00	0.00	0.40			
65	A	582063.93	708976.20	6.00	106.00	0.00	0.00	0.40			
66	A	582098.14	708984.31	6.00	103.00	0.00	0.00	0.40			
67	A	582132.70	708992.67	6.00	104.00	0.00	0.00	0.40			
68	A	582166.63	709000.78	6.00	107.00	0.00	0.00	0.40			
ANC01	A	582158.88	709184.99	6.00	282.00	0.00	0.00	0.40			
ANC03	A	582115.44	709186.56	6.00	280.00	0.00	0.00	0.40			
ANC02	A	582127.90	709161.74	6.00	101.00	0.00	0.00	0.40			
ANC04	A	582095.87	709154.25	6.00	105.00	0.00	0.00	0.40			
ANC05	A	582069.06	709147.67	6.00	102.00	0.00	0.00	0.40			
ANC06	A	582042.56	709141.00	6.00	106.00	0.00	0.00	0.40			
ANC07	A	582013.85	709134.10	6.00	109.00	0.00	0.00	0.40			
ANC08	A	582009.34	709152.71	6.00	279.00	0.00	0.00	0.40			
77	A	582179.13	709079.49	6.00	14.00	0.00	0.00	0.40			
78	A	582200.09	709069.26	6.00	198.00	0.00	0.00	0.40			
79	A	582186.10	709050.31	6.00	24.00	0.00	0.00	0.40			
80	A	582392.40	709265.24	6.00	0.00	0.00	0.00	0.40			

Layout Continued

ID /Mast	Type	X	Y	Height	Angle	Tilt	Cant	Out-reach	Target X	Target Y	Target Z
81	A	582378.90	709268.22	6.00	102.00	0.00	0.00	0.40			
82	A	582387.02	709303.75	6.00	8.00	0.00	0.00	0.40			
83	A	582388.27	709342.48	6.00	188.00	0.00	0.00	0.40			
84	A	582363.11	709342.22	6.00	97.00	0.00	0.00	0.40			
CNC01	A	582440.24	709011.55	6.00	140.00	0.00	0.00	0.40			
CNC02	A	582419.75	708995.92	6.00	104.00	0.00	0.00	0.40			
CNC03	A	582398.62	708981.03	6.00	108.00	0.00	0.00	0.40			
CNC04	A	582366.72	708973.34	6.00	104.00	0.00	0.00	0.40			
CNC05	A	582395.69	709011.68	6.00	332.00	0.00	0.00	0.40			
CNC06	A	582409.18	709031.50	6.00	201.00	0.00	0.00	0.40			
CNC07	A	582372.66	709033.36	6.00	282.00	0.00	0.00	0.40			
CNC08	A	582332.04	709023.69	6.00	283.00	0.00	0.00	0.40			
DNC01	A	582400.84	709100.44	6.00	149.00	0.00	0.00	0.40			
DNC04	A	582396.70	709152.30	6.00	189.00	0.00	0.00	0.40			
DNC03	A	582370.33	709154.98	6.00	16.00	0.00	0.00	0.40			
DNC06	A	582389.49	709189.60	6.00	195.00	0.00	0.00	0.40			
DNC05	A	582360.47	709184.39	6.00	9.00	0.00	0.00	0.40			
DNC02	A	582388.93	709126.28	6.00	59.00	0.00	0.00	0.40			

Polar Diagram

Luminaire A BGP291 DW50 BL2



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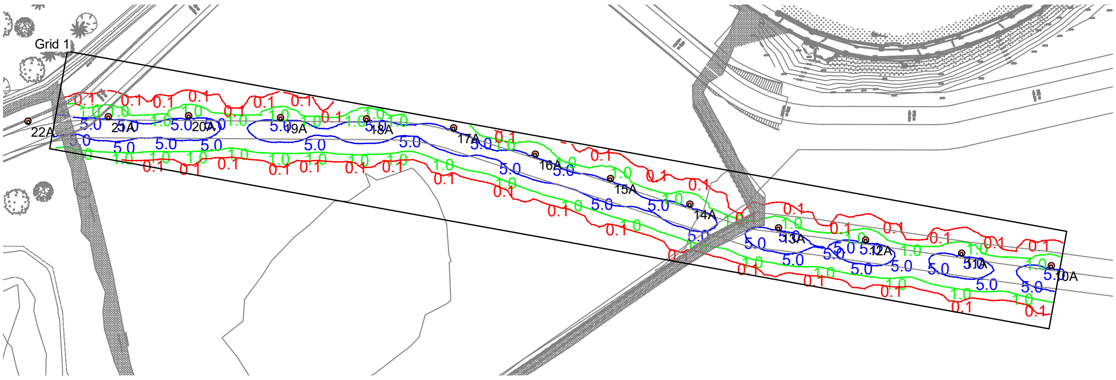
Horizontal Illuminance (lux)

Grid 1

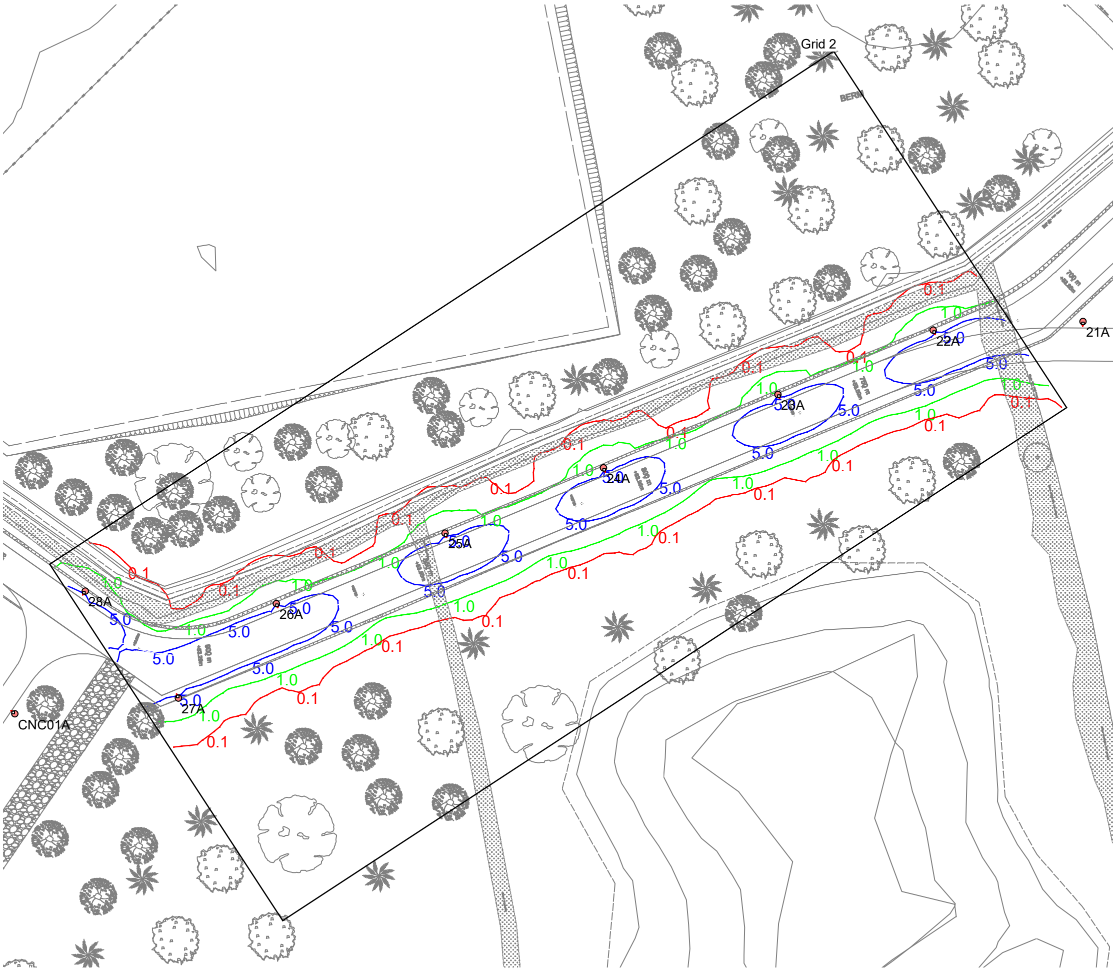


Results

Eav	5.62
Emin	1.14
Emax	10.38
Emin/Emax	0.11
Emin/Eav	0.20

Horizontal Illuminance (lux)

Grid 2



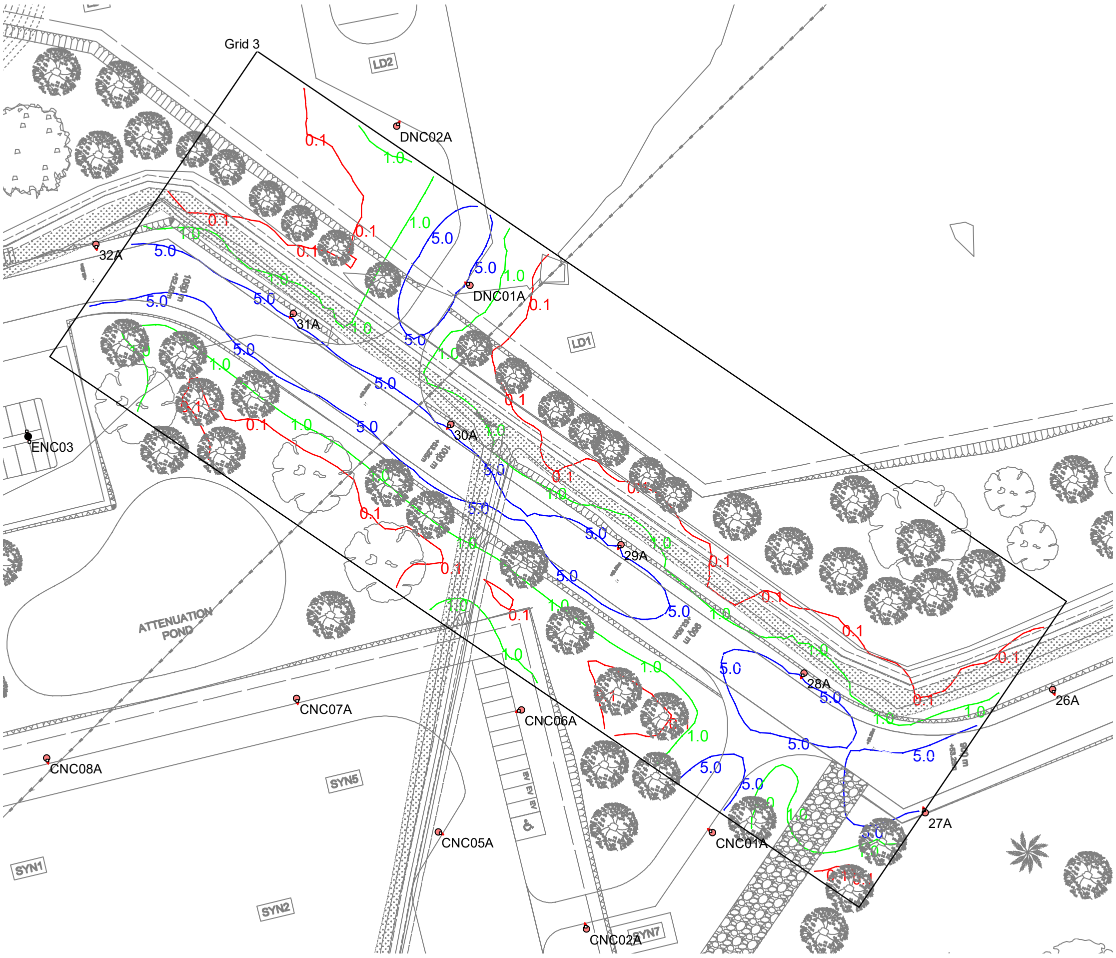
Results

Eav	5.57
Emin	1.12
Emax	10.91
Emin/Emax	0.10
Emin/Eav	0.20

DATE: 18 May 2024	DESIGNER: Don Kinghan	DARAMACK Exterior Lighting Design
PROJECT No: DAR24011	PROJECT NAME: Coolpowra Flexgen, Co. Galway R1	

Horizontal Illuminance (lux)

Grid 3



Results

Eav	5.69
Emin	1.15
Emax	10.30
Emin/Emax	0.11
Emin/Eav	0.20

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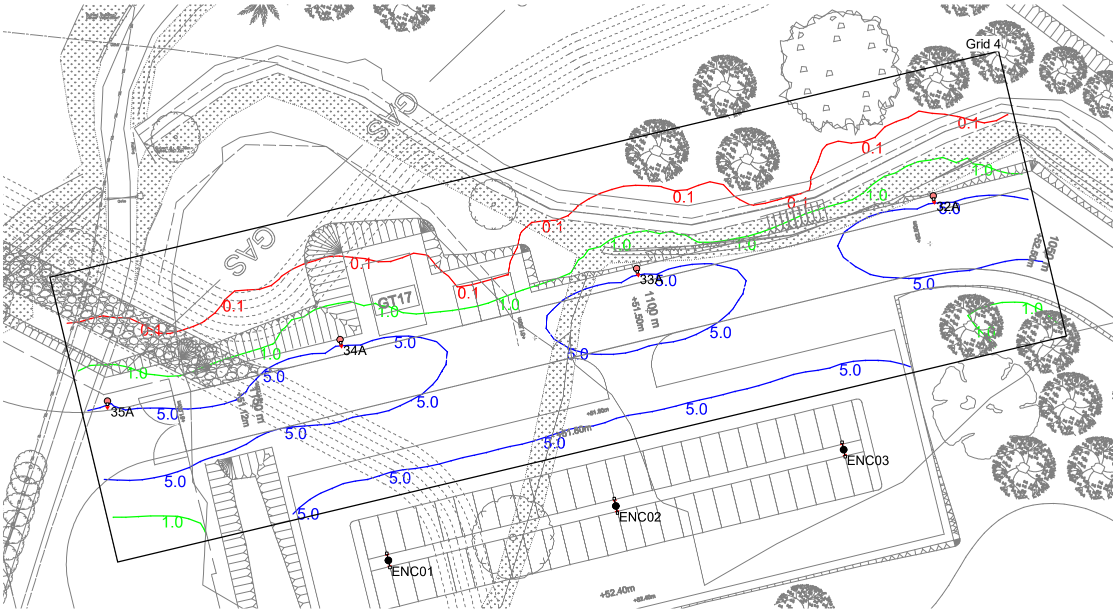
Horizontal Illuminance (lux)

Grid 4

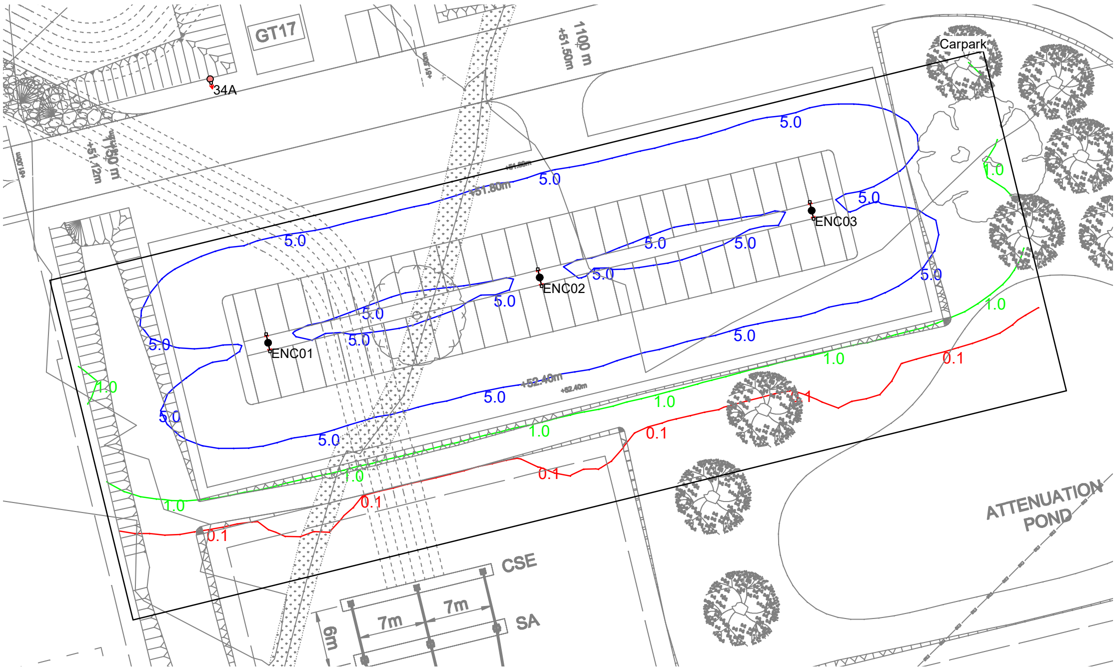


Results

Eav	5.32
Emin	1.07
Emax	10.25
Emin/Emax	0.10
Emin/Eav	0.20

Horizontal Illuminance (lux)

Carpark



Results

Eav	6.97
Emin	2.78
Emax	11.16
Emin/Emax	0.25
Emin/Eav	0.40

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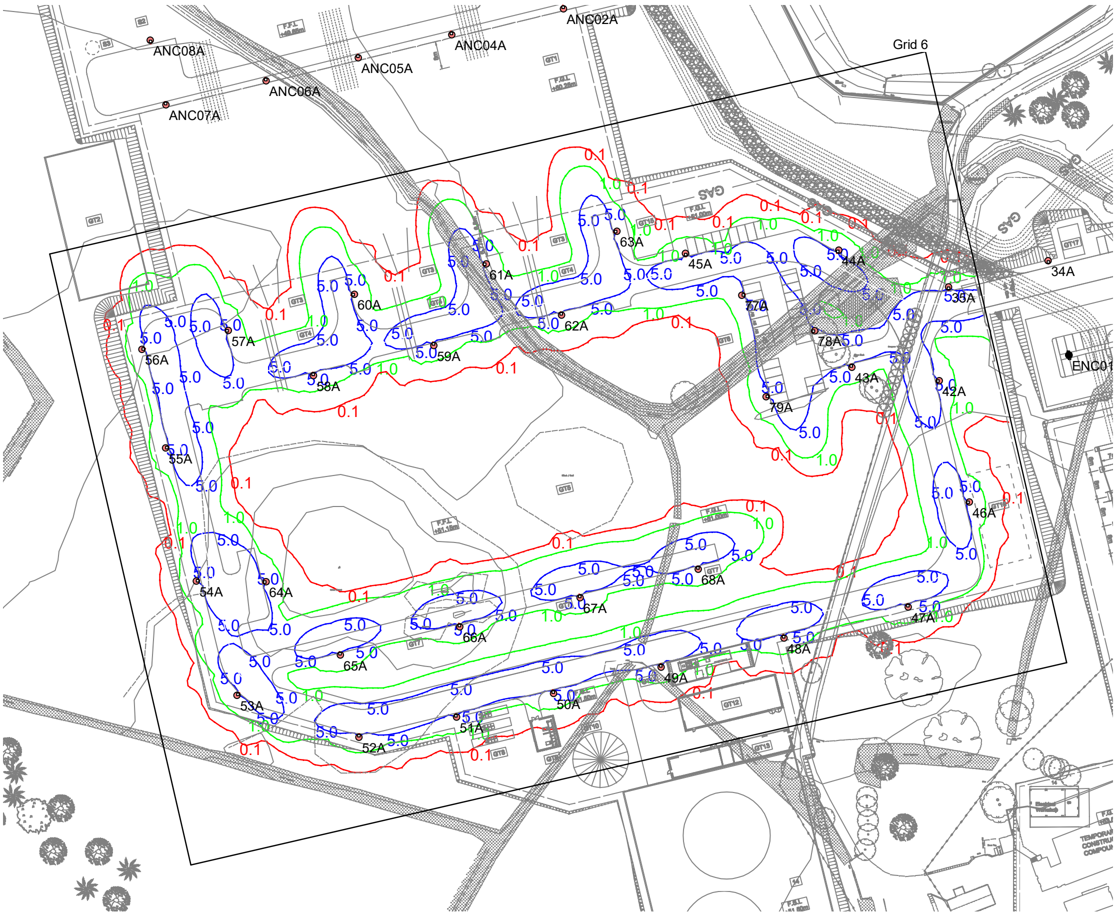
Horizontal Illuminance (lux)

Grid 6

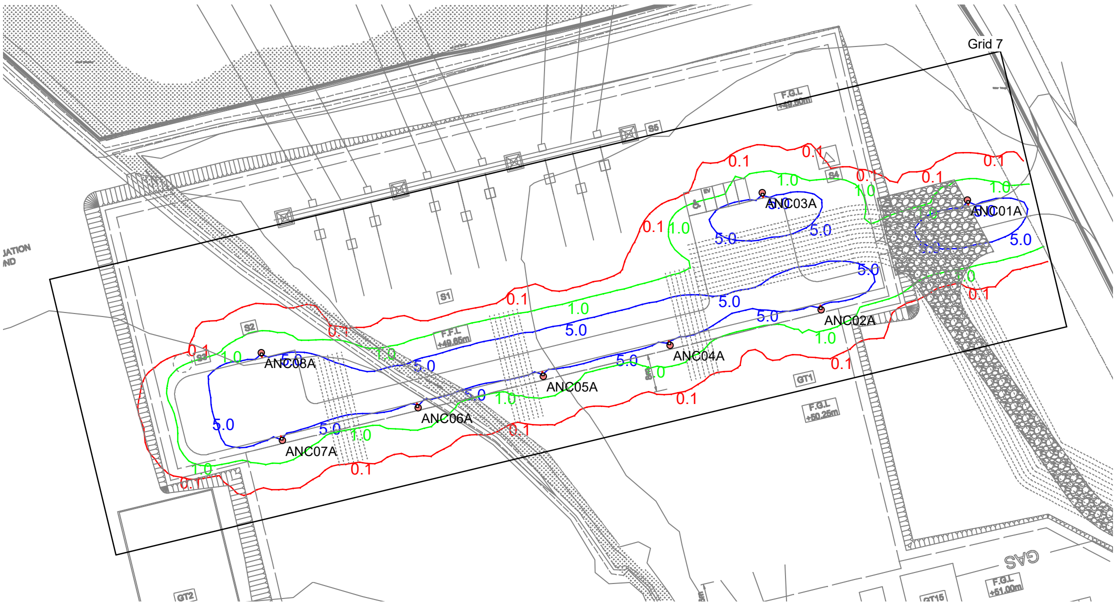


Results

Eav	6.59
Emin	1.29
Emax	11.56
Emin/Emax	0.11
Emin/Eav	0.20

Horizontal Illuminance (lux)

Grid 7



Results

Eav	6.37
Emin	1.33
Emax	11.27
Emin/Emax	0.12
Emin/Eav	0.21

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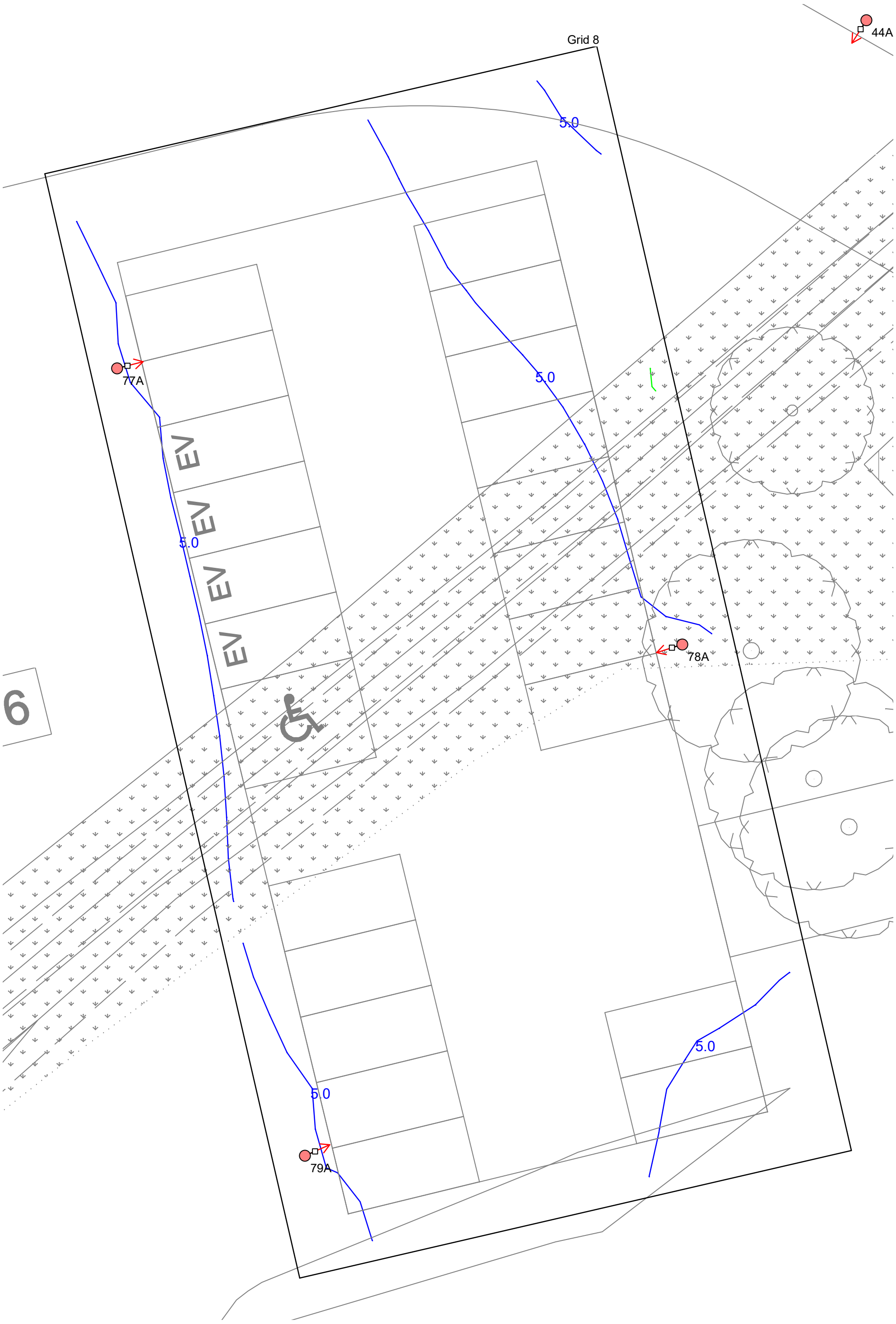
Horizontal Illuminance (lux)

Grid 8



Results

Eav	8.98
Emin	2.85
Emax	14.69
Emin/Emax	0.19
Emin/Eav	0.32

Horizontal Illuminance (lux)

Grid 9

Results

Eav	6.10
Emin	1.19
Emax	10.82
Emin/Emax	0.11
Emin/Eav	0.20

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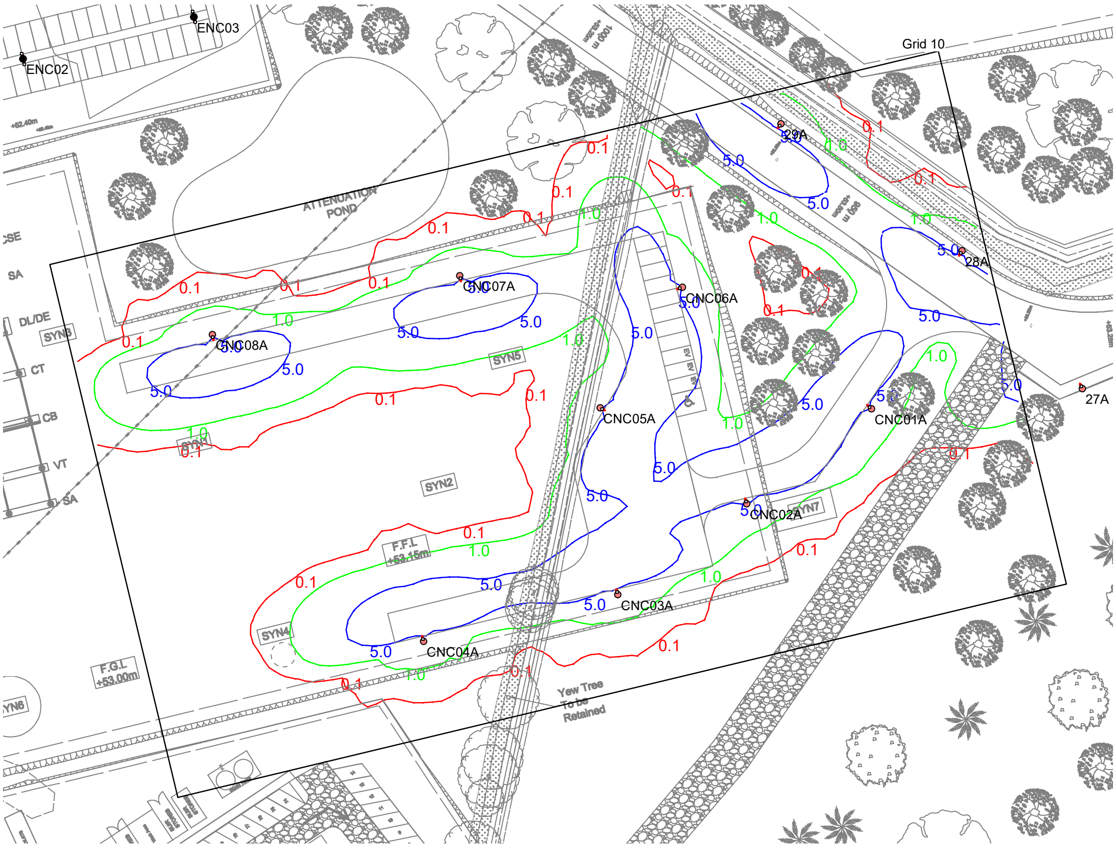
Horizontal Illuminance (lux)

Grid 10



Results

Eav	6.33
Emin	1.24
Emax	11.91
Emin/Emax	0.10
Emin/Eav	0.20

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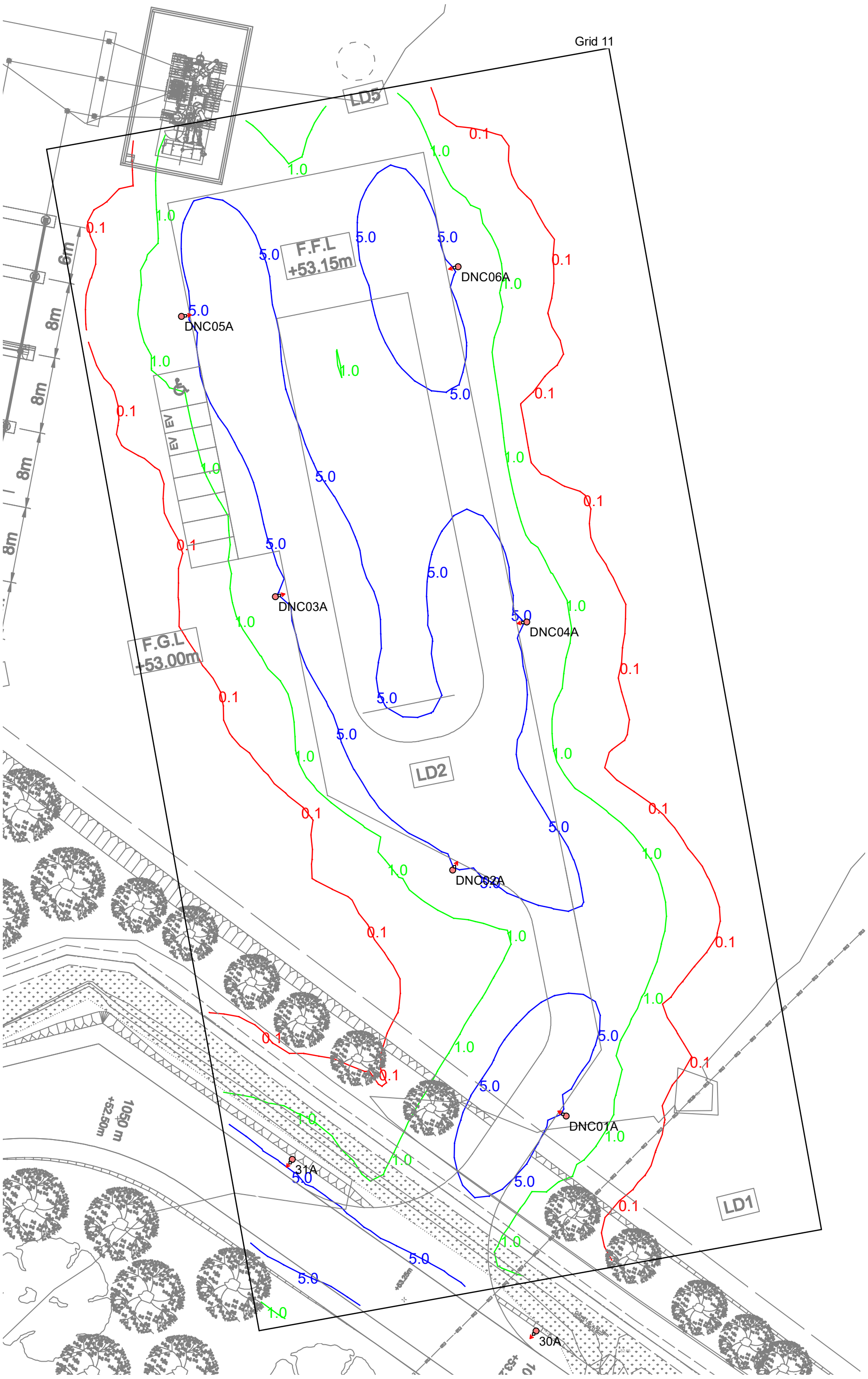
Horizontal Illuminance (lux)

Grid 11



Results

Eav	6.03
Emin	1.18
Emax	10.83
Emin/Emax	0.11
Emin/Eav	0.20

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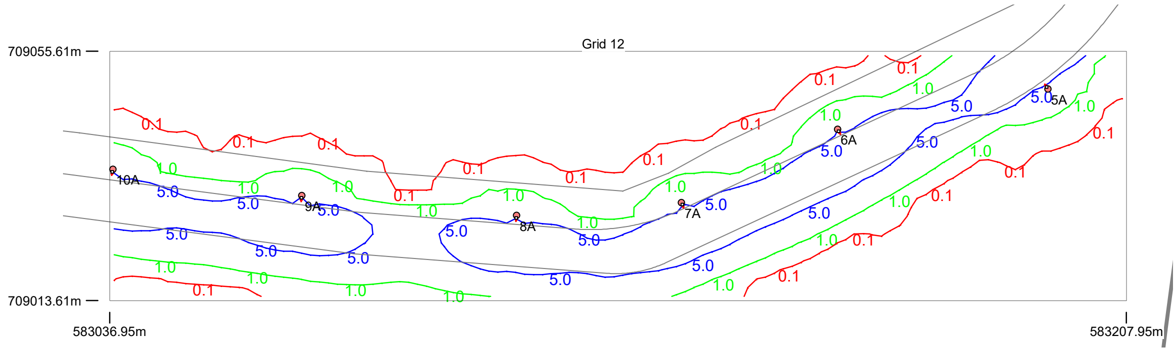
Horizontal Illuminance (lux)

Grid 12



Results

Eav	5.88
Emin	1.22
Emax	10.44
Emin/Emax	0.12
Emin/Eav	0.21

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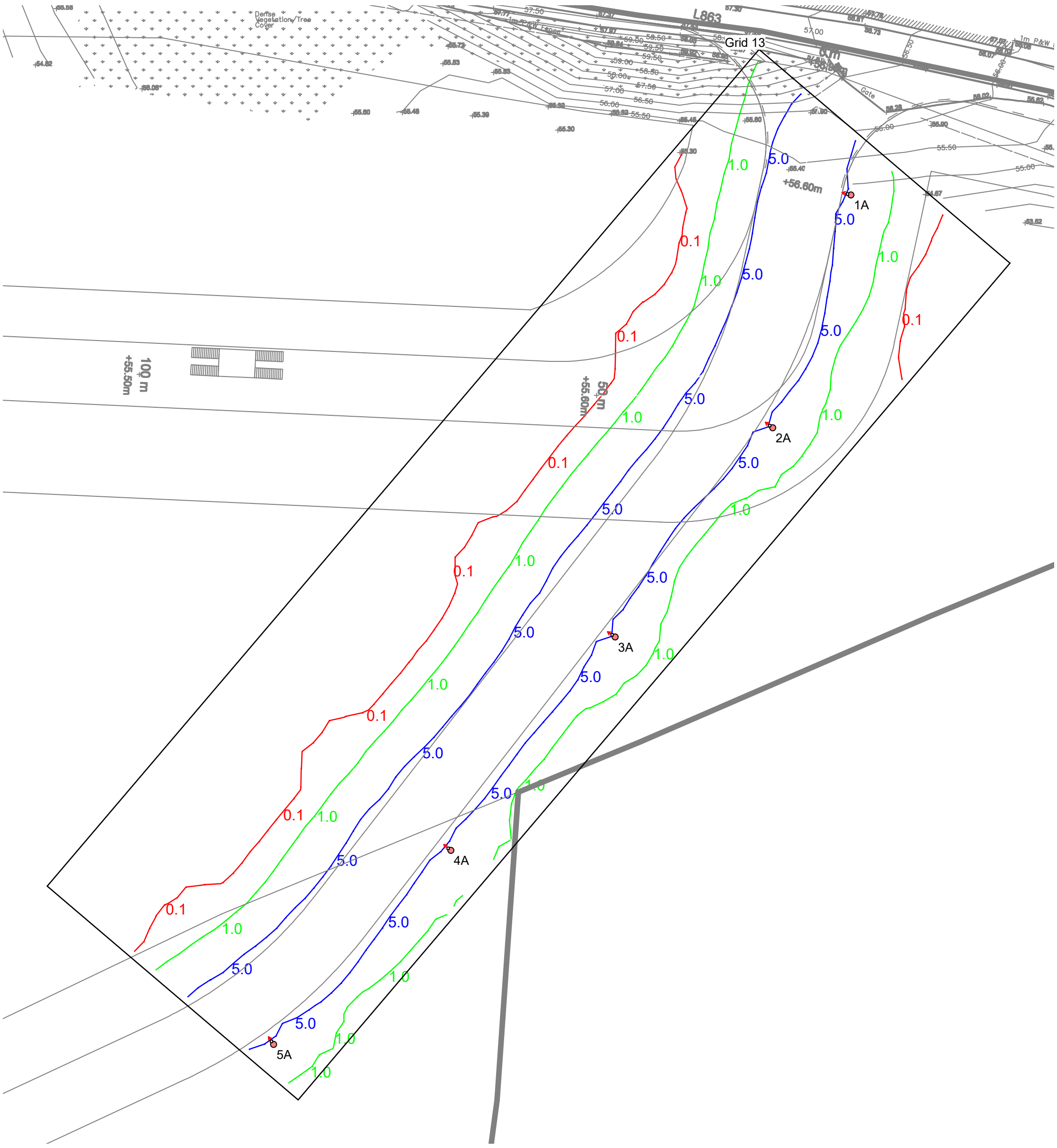
Horizontal Illuminance (lux)

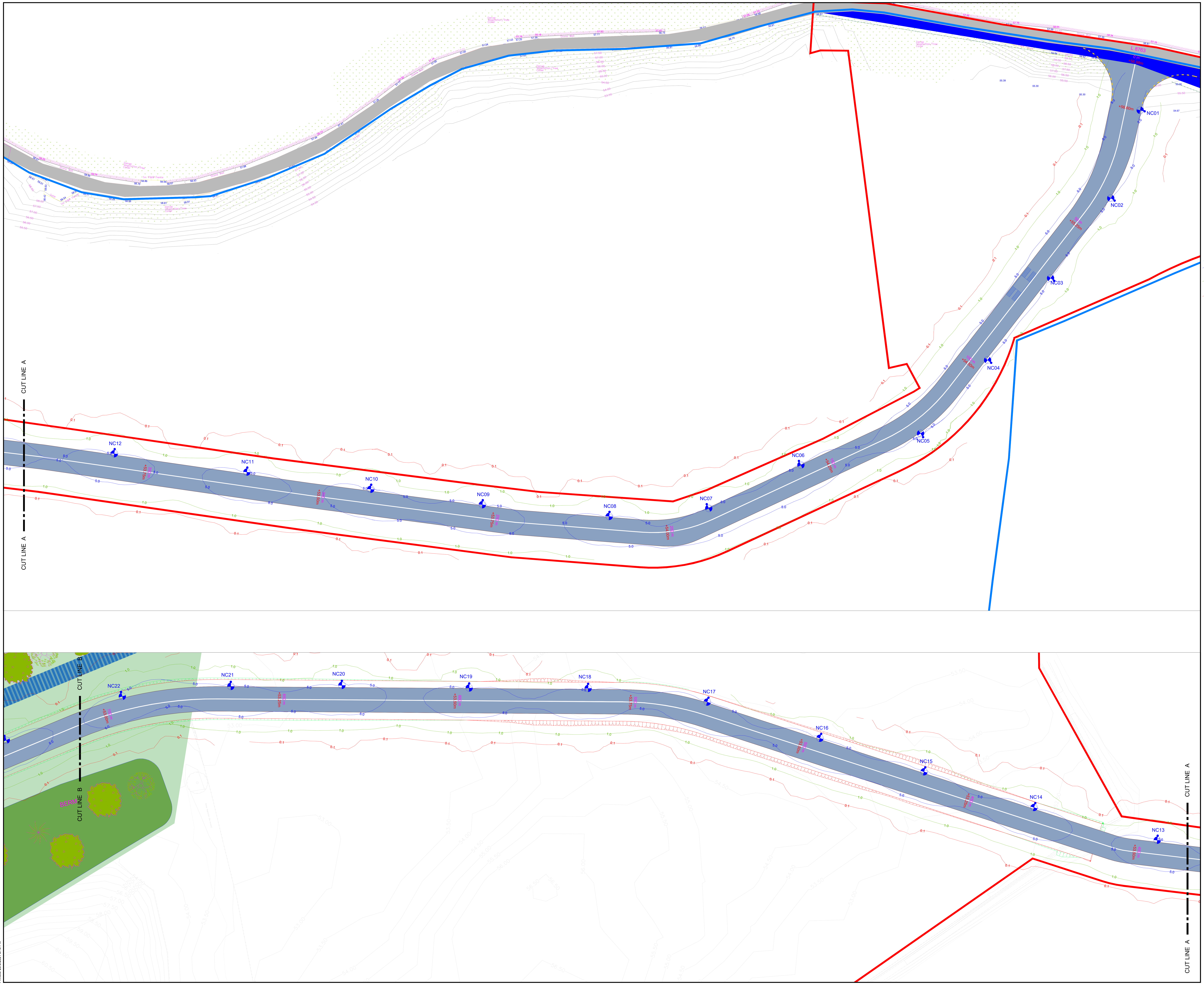
Grid 13



Results

Eav	6.83
Emin	1.38
Emax	11.22
Emin/Emax	0.12
Emin/Eav	0.20

9196878517



CDM RESIDUAL DESIGN RISKS
AND RESIDUAL ENVIRONMENTAL RISKS

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92 — Luminaire as Philips LumiStreet Gen2 Micro BGP291, 6.0klm 20LED 39W DW50 BL2 3000K Warm White CLO post top mounted luminaire complete with factory-fitted integral rear shields at 0° tilt on 6m standard galvanized steel planted lighting columns.

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5.0 — 5.0Lux Contour Line - Target average illuminance

1.0 — 1.0Lux Contour Line - Target minimum illuminance

0.1 — 0.1Lux Contour Line - equivalent to full moon on clear night

DRAWING TO BE READ IN CONJUNCTION WITH DAR24011/002 AND DAR24011/003

LUX RATING CHART

	Condition	Light Level (LUX)	Foot Candles (FC)
Day Time	Sunlight	107,527	10,000
	Daylight	10,752.70	1,000
	Overcast Day	1,075.30	100
	Very Dark Day	107.53	10
	Twilight	10.75	1
Night Time	Deep Twilight	1.08	0.1
	Full Moon	0.108	0.01
	Quarter Moon	0.0108	0.001
	Starlight	0.0011	0.0001
	Overcast Night	0.0001	0.00001

Rev	Date	Description	Drn	Chk'd
R0	14/05/24	FIRST ISSUE	WDK	WDK

Revisions

Site Key Plan

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Drawing Originator

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EXTERIOR LIGHTING DESIGN
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Drawing Status

PRELIMINARY

Project Name

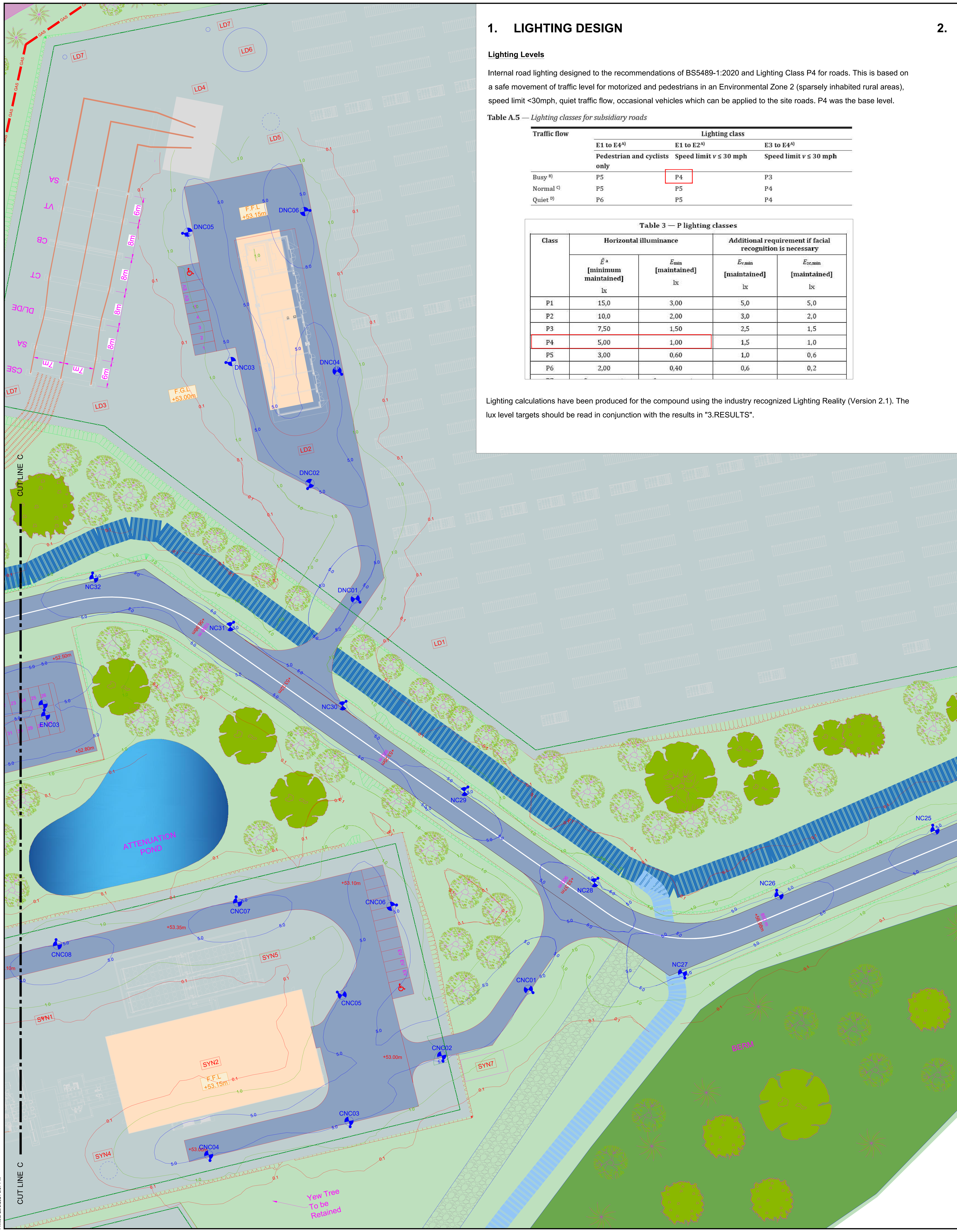
COOLPOWRA FLEXGEN, Co. GALWAY

Drawn by	Drawn Date	Checked by	Checked Date
WDK	10/05/24	WDK	14/05/24
Approved by	Approved Date	Scale 1:500	

Title — Original drawing sheet is A1

EXTERNAL LIGHTING LAYOUT WITH LUX LEVEL CONTOURS SHEET 1 OF 3

Drawing Number	Revision
DAR24011/001	R0



1. LIGHTING DESIGN

Lighting Levels

Internal road lighting designed to the recommendations of BS5489-1:2020 and Lighting Class P4 for roads. This is based on a safe movement of traffic level for motorized and pedestrians in an Environmental Zone 2 (sparsely inhabited rural areas), speed limit <30mph, quiet traffic flow, occasional vehicles which can be applied to the site roads. P4 was the base level.

Table A.5 — *Lighting classes for subsidiary roads*

Traffic flow	Lighting class		
	E1 to E4 A)	E1 to E2 A)	E3 to E4 A)
	Pedestrian and cyclists only	Speed limit $v \leq 30$ mph	Speed limit $v \leq 30$ mph
Busy B)	P5	P4	P3
Normal C)	P5	P5	P4
Quiet D)	P6	P5	P4

Table 3 — P lighting classes

Class	Horizontal illuminance		Additional requirement if facial recognition is necessary	
	$\bar{E}$ a [minimum maintained] lx	E_{min} [maintained] lx	$E_{v,min}$ [maintained] lx	$E_{sc,min}$ [maintained] lx
P1	15,0	3,00	5,0	5,0
P2	10,0	2,00	3,0	2,0
P3	7,50	1,50	2,5	1,5
P4	5,00	1,00	1,5	1,0
P5	3,00	0,60	1,0	0,6
P6	2,00	0,40	0,6	0,2

Lighting calculations have been produced for the compound using the industry recognized Lighting Reality (Version 2.1). The lux level targets should be read in conjunction with the results in "3.RESULTS".

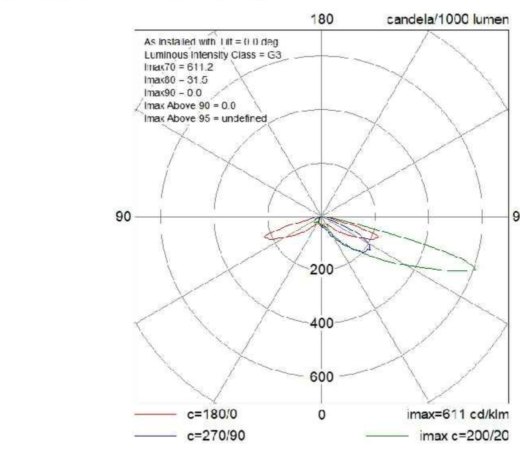
2. LUMINAIRE

Lighting Arrangement

Lighting columns are arranged to achieve the required minimum lighting levels while avoiding excessive light spill onto the site perimeter. These lighting columns are installed with luminaires mounted at 6m, with factory fitted rear shields, a 0° tilt angle and a G3 rating. (This is a rating (G1 - G6) of the control of obtrusive light and upward light output with G6 being the highest.)

The Philips Lighting luminaire range - Philips LumiStreet Gen2 Micro - has been selected to provide the lighting. Philips are a reputable and approved manufacturer which have lighting units installed on Ireland's road networks and many exterior lighting applications. Polar diagram, right, for the G3 rated luminaire right shows the light distribution.

Luminaire A BGP291 DW50 BL2



3. RESULTS

Illuminance results are provided in a separate accompanying lighting calculation report. The site area is broken down into 12No. number of grids to cover the site area. The results show that a light spill is limited to within a few metres behind the lighting column with the use of a low 6m mounting height , 0° tilt, integral back shields to maximize the optical control and minimize the spill light beyond the development perimeter. A warmer 3000K colour temperature LED light source has been selected as opposed to a typical 4000K neutral white light as the warmer colour temperature has a less detrimental effect on flying insects and bats.

Illuminance levels have been exported as lux level contours and overlaid on the site layout.

NOTES:

The electricity storage facility will not be a manned facility. It is anticipated that personnel will only be on site for planned maintenance which would be expected to be carried out in daylight hours.

The chosen lighting level has been selected from the BS5489-1:2020 to provide safe movement of both personnel and vehicular traffic were the risk level is low and with only occasional vehicles.

Light spill has been limited to approximately 1.0Lux where the lighting is next to a site boundary which can be verified by the inclusion of the 1.0Lux contour on the site layout.

LIGHT SPILL MITIGATION MEASURES

The luminaires have been proposed with integral rear shields and a mounting tilt of 0° to reduce back spill lighting and upward light. Additional lighting mitigation measures could be applied such as photocell control to switch lights on and off at dusk and dawn and programmed off at preset times such as the example switching regime below.

Motion sensors could be utilized to activate the lighting only when movement is detected such as the Philips Interact and Multisensor system which can operate as a standalone installation or be locally networked and remotely managed by the Interact software. However, the method of lighting control will be a decision based on the operational requirements of the client.

Example switching regime.
Dusk - 22:00hrs - ON
22:00 - 06:00hrs - OFF
06:00 - Dawn - ON

It is anticipated the buildings within the facility will have perimeter wall-mounted lighting installed which should select fittings with downward optical lighting control. For maintenance purposes portable lighting would be recommended to be carried by the maintenance personnel to provide localized lighting where required which further reduces the amount of permanent site lighting required.

The contour Lux plots show that the light levels will be considerably below the maximum allowed levels as described in the ILP "*Guidance notes for the reduction of obtrusive light*" Table 3 shown below.

Additional guidance has been taken from the Institution of Lighting Professionals (ILP) guidance documents "*Bats and Lighting in the UK*" and "*Dark Sky Ireland - Policy Document*"

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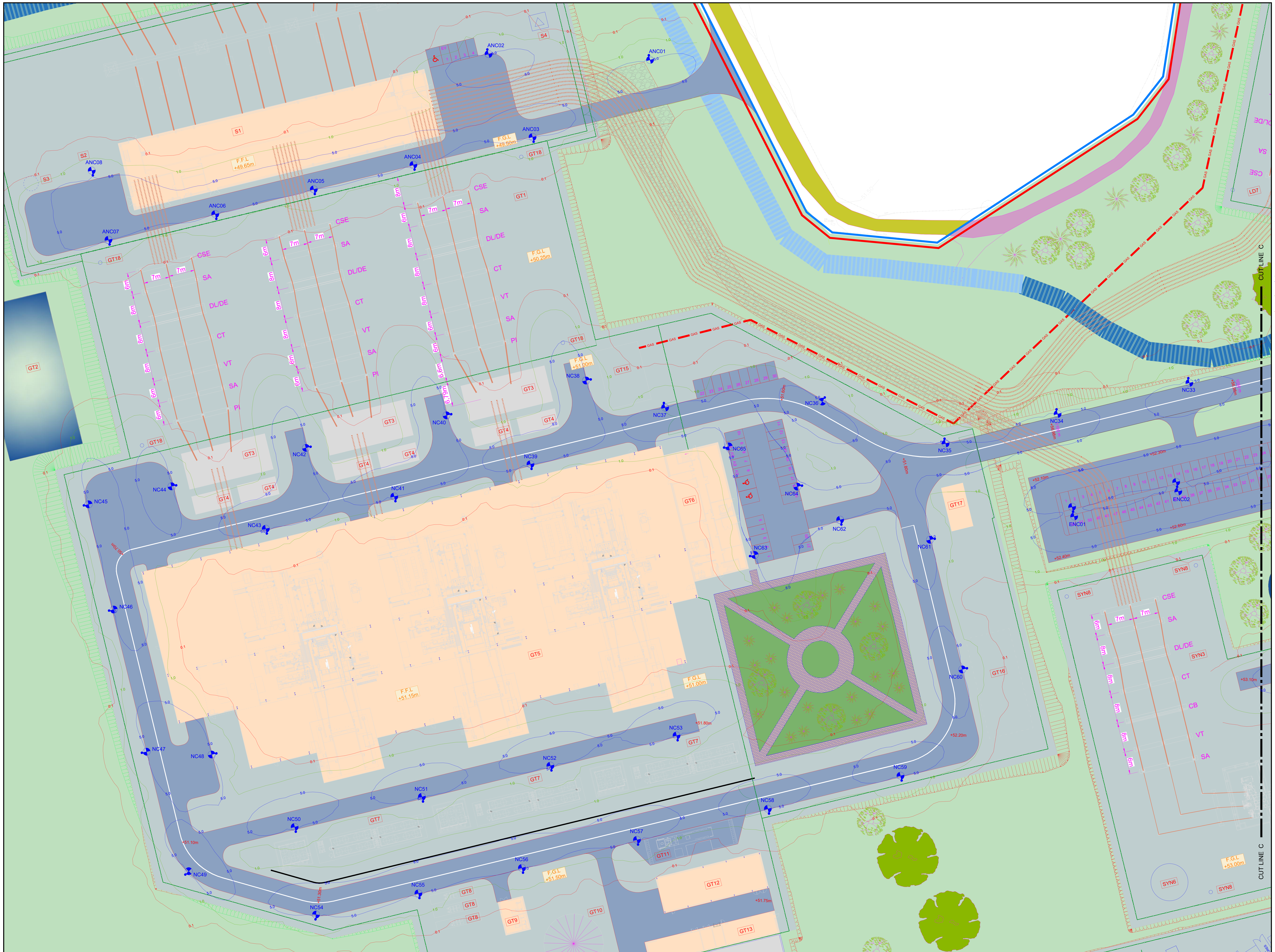
Title — Original drawing sheet is A1

EXTERNAL LIGHTING LAYOUT
WITH LUX LEVEL CONTOURS
SHEET 2 OF 3

Drawing Number	Revision
DAR24011/002	R1



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EXTERNAL LIGHTING LAYOUT
WITH LUX LEVEL CONTOURS
SHEET 3 OF 3

Drawing Number	Revision
DAR24011/003	R1