Cottam Solar Project

Environmental Statement Addendum:

Air Quality Impact Assessment of Battery Energy Storage Systems (BESS) Fire

Revision A

Prepared by: Tetra Tech Limited

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Cottam
SOLAR PROJECT

Island Green Power Limited

Cottam Solar Project

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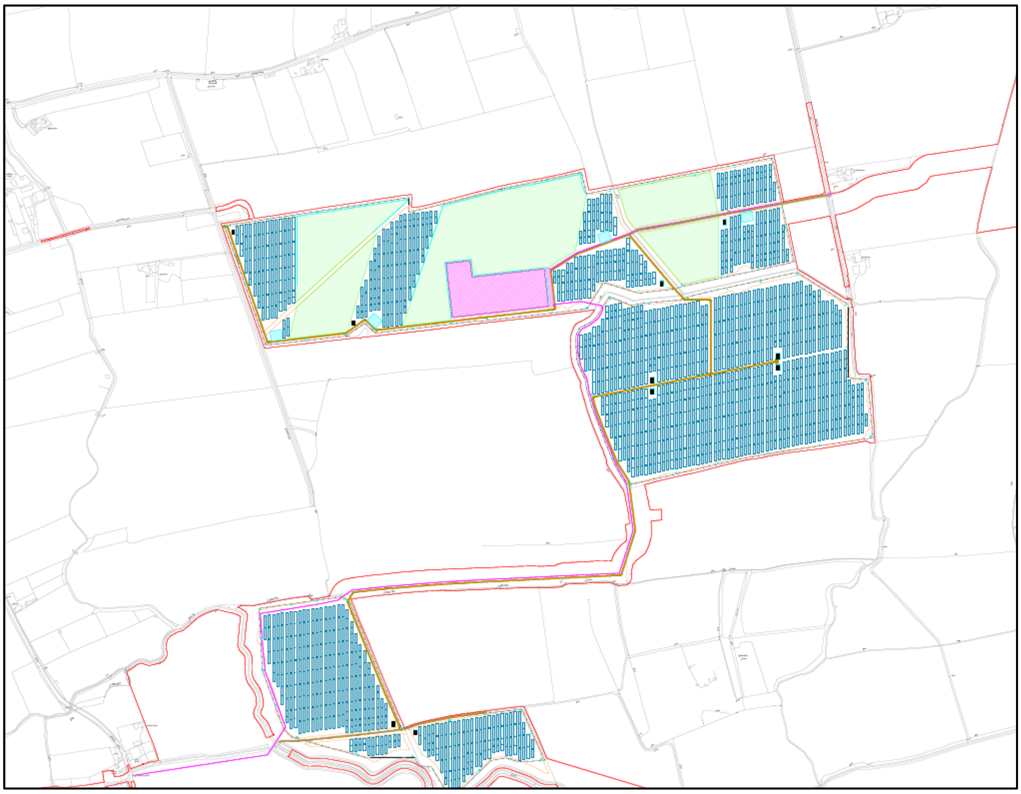

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Issue	Date	Status
1	7th July 2023	First Issue
2	2nd August 2023	Second Issue
3	20th November 2023	Third Issue – the assessment has been revised using burn test emission data from LFP battery modules that are typically integrated into BESS systems.
4		
5		

Contents Page

List of Tables

Figures & Appendices

Non-Technical Summary

This report presents the findings of a fire impact assessment from a battery energy storage system (BESS). Potential battery fire impacts have been assessed using dispersion modelling tools to ensure the protection of human health and the health of workers. The predicted BESS fire pollutant concentrations at relevant sensitive receptor locations have been assessed and compared against relevant UK Air Quality Standards for the protection of human health and relevant British occupational exposure limits for the protection of the health of works.

Baseline air quality conditions have been defined following reviews of Local Planning Authority air quality monitoring, and background concentrations published by DEFRA, as well as undertaking detailed modelling.

The detailed modelling results have been presented in this report in terms of the emitted pollutant Process Contribution (PC) and Predicted Environmental concentration (PEC) (PEC = PC + Background Concentration). AERMOD modelling has been undertaken using the most representative meteorological dataset. The worst-case and highest predicted long-term and short-term PECs were compared to the appropriate Air Quality Objectives (AQOs) / Environmental Assessment Levels (EALs) or relevant impact assessment criteria.

The pollutants which were assessed are based on the latest LFP BESS fire test data and information (available in October 2023).

BESS Fire Impact Assessment Results

The short-term predicted environmental concentrations of Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO) at the residential receptor locations from a BESS fire incident are all below the relevant air quality objectives for the protection of human health.

All receptors will have a 'low' air pollution level on the DAQI based on the short-term NO_2 pollution index.

The predicted ground level 8-Hour mean and 15-min mean of ~~Hydrogen Chloride (HCl) and~~ Hydrogen Fluoride (HF) concentrations at the residential receptor locations are all below the relevant British occupational exposure limits. The short-term ~~HCL and~~ HF impact of a BESS fire at the receptors is sufficiently 'small'. The effect of a BESS fire on the receptors is insignificant.

~~The assessment results show that two receptors would potentially experience 'moderate' or 'high' air pollution levels on the UK Daily Air Quality Index (DAQI) as a result of a BESS fire at the site. All other nearby sensitive receptors will have 'low' air pollution levels on the DAQI.~~

~~It should be noted that whilst it is not expected that a BESS fire would last for a long period time, the assessment has utilised worst-case scenario of Particulate Matter (PM_{10}) to determine the potential impact by assuming that a BESS fire would last up to 24 hours, as the air quality standard of short-term averaging period for PM_{10} is measured as 24-hour mean. Therefore, a fire which lasted for a short period of time, for example 1-hour, would result in lower levels of air pollution at sensitive receptors than those predicted for the worst-case assessment undertaken.~~

~~The action plans for the protection of human health will be implemented in case a BESS fire.~~

The predicted maximum short-term HF concentrations are below the AEGL-1 (Acute Exposure Guideline Level 1). In addition, the sensitivity study assessment results of HF impact under a windy condition demonstrate that the predicted HF concentrations are also below the AEGL-1.

BESS Fire Action Plan

The assessment concludes that there is a low risk of adverse effects at the closest sensitive receptor location as a result of a potential BESS fire. Good practice safety measures which are detailed in the document 'Outline Battery Storage Safety Management Plan, PINS reference: EN010133, Document reference APP/C7.9; APFP regulation 5(2)(q)' will be implemented immediately in the case of a fire.

Substation Fire Action Plan

Good practice safety measures have been identified to be implemented in the case of a substation fire. Those measures include:

> *"The site manager/fire safety representative will need to assess the fire location(s), wind directions and surrounding receptors. The site manager/fire safety representative will take appropriate actions accordingly. The actions to be taken include:*
>
> *(1) to inform any potentially affected residents, especially those that are located at downwind locations to the substation fire;*
>
> *(2) to cancel outdoor events and keep windows closed for any potentially affected residents, especially those that are located at downwind locations to the substation fire; and*

(3) to stop any farming activities and to move any farmers/workers within Good practice safety measures have been identified in the case of a BESS fire and those measures include:

> *"The site manager/fire safety representative will need to assess the fire location(s), wind directions and surrounding receptors. The site manager/fire safety representative will take appropriate actions accordingly. The actions to be taken include:*
>
> *(1) to inform any potentially affected residents, especially those that are located at downwind locations to the BESS fire;*
>
> *(2) to cancel outdoor events and keep windows closed for any potentially affected residents, especially those that are located at downwind locations to the BESS fire; and*
>
> *(3) to stop any farming activities and to move any farmers/workers within 500300 m of the BESSsubstation fire to a cleaner air location."*

A cleaner air location can be defined as beingwould preferably not be downwind, and be at a distance greater than 500300 m from the BESS fire in any direction. At this distance there will be no adverse effects due to pollutants from the fire.substation fire.

1.0 Introduction

Tetra Tech have prepared a potential air quality impact assessment from a fire incident in support of a planning application for Cottam Solar Project (the 'Scheme').

- The Cottam Solar Project consists of three land parcels (the 'Site" or 'Sites) described as Cottam 1, 2, 3a and 3b for a proposed solar project.

The Scheme comprises the installation of solar photovoltaic (PV) generating panels and on-site energy storage facilities across proposed sites in Lincolnshire and Nottinghamshire together with grid connection infrastructure. The proposed development would allow for the generation, storage and export of up to around 600 megawatts (MW) renewable energy.

A fire accident can be considered to be an occurrence involving fire on the battery cells or thermal runaway of the battery cells within the BESS storage cabinets.

The battery fire impact has been assessed to determine the potential impact on human health.

The pollutant emissions used in the assessment have been carefully considered with selection based on robust battery fire testing results from scientific studies undertaken by accredited laboratories and the published national and international BESS fire testing reports.

The air quality impact assessment uses dispersion modelling tools to predict absolute air quality impacts at specific receptor locations, and predicted pollutant concentrations at receptor locations have been assessed against UK Air Quality Standards.

1.1 Previous Versions of (i) Solar Panel Fire Incident Impact Assessment Report and (ii) BESS Fire Incident Assessment Technical Note

Tetra Tech previously issued the following two reports:

- **(i) Solar Panel Fire Incident Impact Assessment Report**

  Tetra Tech has undertaken a **solar panel fire incident impact assessment** and produced a report titled '*Potential Air Quality Impact Assessment from a Fire Incident*' (dated 9th August 2022).

- **(ii) BESS Fire Incident Assessment Technical Note**

  A **BESS fire incident impact assessment** was undertaken and technical note produced titled '*Air Quality Assessment on Emission Impact from the Battery Energy Storage Systems (BESS) Fire*' (dated 14th December 2022).

  The technical note was produced based on results of assessment undertaken by Tetra Tech to determine the potential impact of a solar panel fire incident at the proposed development. The potential impact of a BESS fire incident on surrounding sensitive receptors was assessed using an 'Air Quality

Category' approach, with categories classified as 'good', 'moderate', 'unhealthy', 'very unhealthy' or 'hazardous'.

The assessment concluded that there is low risk of adverse effects at the closest receptors. However, an action plan with good practice safety measures ~~has been~~will be developed and ~~will be~~ implemented in the case of a BESS fire.

1.2 UK Health Security Agency Comment Letters

The UK Health Security Agency (UKHSA) has issued two letters with comments which are relevant to (i) the solar panel fire incident impact assessment report, and (ii) the BESS fire incident impact report.

The sections of UKHSA's letters which are relevant to the fire risk assessments, are summarised as follows:

The UKHSA's **first letter** was dated 21st July 2022, reference no. CIRIS59631. UKHSA's comments stated the following:

> *"**Environmental Public Health***
>
> *We have assessed the submitted documentation and wish to make the following comments in relation to the air quality chapter.*
>
> *Table 17.2 describes smoke levels from particulate matter concentrations. In addition to the information in table 17.2, the applicant should compare modelled outputs for their fire scenario to relevant UK air quality standards which are protective of health. We also recommend that, in addition to particulate matter, the applicant considers emissions of other substances associated with the development in the event of an accident or fire. i.e. what substances could be released from the batteries in the event of a failure and what products of combustion might be produced that would be different for this type of installation compared to other fires."*

The UKHSA's **second letter** was dated 21st March 2023, reference no. CIRIS63064, regarding the battery energy storage system fire risk assessment. UKHSA's comments stated the following:

> *"The battery energy storage system fire risk assessment has not used UK Air Quality Standards to consider potential impacts from a fire on site. We (the UKHSA) recommended at the Section 42 stage (21st July 2022) that health protective standards from the UK were considered in their assessment. This does not appear to have been addressed in the application."*

1.3 Communications and Meetings with the UK Health Security Agency

Tetra Tech sent an email to the UKHSA on 13th March 2023 in response to their comments on the fire impact assessments undertaken. The UKHSA responded to Tetra Tech with a letter dated 19th May 2023, reference: CIRIS63514. The letter from the UKHSA stated the following (the request for information from Tetra Tech is presented in **Blue**):

"Thank you for your consultation regarding the above development. You (Tetra Tech) asked:

"We (Tetra Tech) are planning to undertake an additional fire risk assessment on behalf of Cottam Solar Project Limited in response to your above comments. Our proposal includes:

> *(a) Undertaking additional solar panel fire modelling assessment using ADMS software. The predicted pollutant levels of NO_2, PM_{10}, $PM_{2.5}$ and hydrogen fluoride at sensitive receptors will be assessed using UK Air Quality Standards; and*
>
> *(b) Undertaking a detailed battery energy storage systems (BESS) fire impact assessment using AERMOD dispersion model software. The predicted pollutant levels of NO_2, benzene, HCl, and HF will be assessed at sensitive receptors using UK Air Quality Standards.*

I (Tetra Tech) appreciate if you (the UKHSA) could review and advise whether you agree it is a suitable approach."

The UK Health Security Agency (the UKHSA) welcomes the opportunity to comment on your (Tetra Tech's) proposals at this stage of the project. Your (Tetra Tech's) proposed approach will provide assurance, but we (the UKHSA) note that you (Tetra Tech) could consider particulate matter (PM_{10} and $PM_{2.5}$) emissions for the BESS fire impact assessment. Within the assessments we (the UKHSA) suggest justification of the selection of pollutants considered, and the models used is provided."

Further discussion was undertaken with the UKHSA in a meeting held on 8th June 2023. During the meeting it was agreed that (1) there is currently no policy, legislation, or guidance which provides clarity on the methodology for undertaking a Battery Energy Storage System (BESS) Fire Risk Assessment, and (2) there is currently no policy, legislation, or guidance which provides clarity on the methodology for undertaking a Solar Panel Fire Modelling Assessment.

However, it was agreed that the following approach is considered appropriate:

- Undertake an additional Solar Panel Fire Modelling Assessment using ADMS software to determine predicted pollutant levels of Particulate Matter (PM_{10} and $PM_{2.5}$) and Hydrogen Fluoride at sensitive receptors. The report will include details of the justification of the assessment methodologies. The predicted pollutant concentrations at receptor locations will be assessed and compared against UK Air Quality Standards; and
- Undertake a BESS Fire Risk Assessment using AERMOD dispersion model software to determine pollutant levels of NO_2, Benzene, HCl, HF, and Particulate Matter (PM_{10} and $PM_{2.5}$). The report will include details of the justification of the assessment methodologies. The predicted pollutant concentrations at receptor locations will be assessed and compared against UK Air Quality Standards.

Subsequently, after the above approach was agreed it was determined from the latest LFP BESS fire test emissions data (made available in October 2023) that NO_2, HCL, PM_{10} and Benzene are not present in high enough volumes in fire gases to require inclusion in the assessment. As such, HCL, PM_{10} and Benzene have not been included in the assessment, and only NO_2 is included for completeness.

This report presents the BESS fire risk assessment results.

The Solar Panel Fire Risk Assessment results have been presented in a separate stand-alone report (Report titled *'Updated Air Quality Impact Assessment of a Solar Panel Fire Incident'*, by Tetra Tech, Ref: 784-B031438, Dated: 31 July 2023).

1.4 BESS Fire Risk Assessment Update Using LFP Battery Modules Test Data

This report presents the BESS fire risk assessment outcomes using burn test emission data from LFP battery modules that are typically integrated into BESS systems.

The BESS fire risk assessment has been revised to determine pollutant impact of NO_2, HF, CO and CH_4 on the surrounding environment.

~~1.4~~1.5 Scheme Location

The development (the Scheme) consists of 3 areas named Cottam 1, Cottam 2 and Cottam 3 (sub-divided into 3a and 3b), and the associated substation areas. The details of the locations are presented in **Figure 1-1**~~**Figure 1-1**~~, **Figure 1-2**~~**Figure 1-2**~~ and **Figure 1-3**~~**Figure 1-3**~~**,** below.

- Cottam 1 is located approximately 10 km northwest of Lincoln;
- Cottam 2 is located approximately 20 km northwest of Lincoln and approximately 6 km of northeast of Gainsborough; and
- Cottam 3 is located approximately 24 km northwest of Lincoln and approximately 8 km of northeast of Gainsborough;

The proposed development sites are mainly surrounded by agriculture areas.

This report is focused on the assessment of the potential impacts at surrounding sensitive receptor locations from dust and smoke generated by a BESS fire within the proposed development.

Figure 1-1. Site Locations

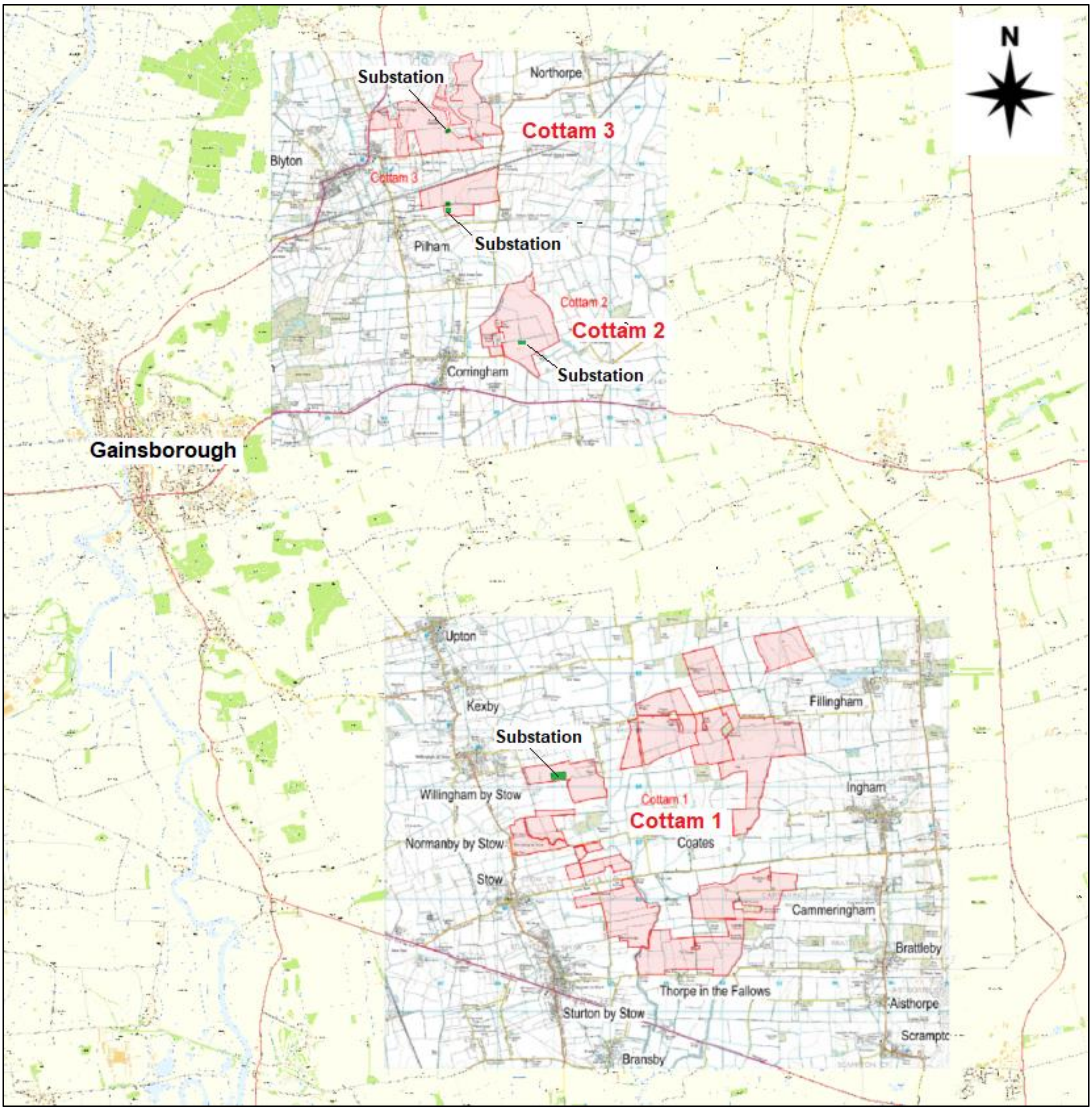


Figure 1-2. Cottam 1

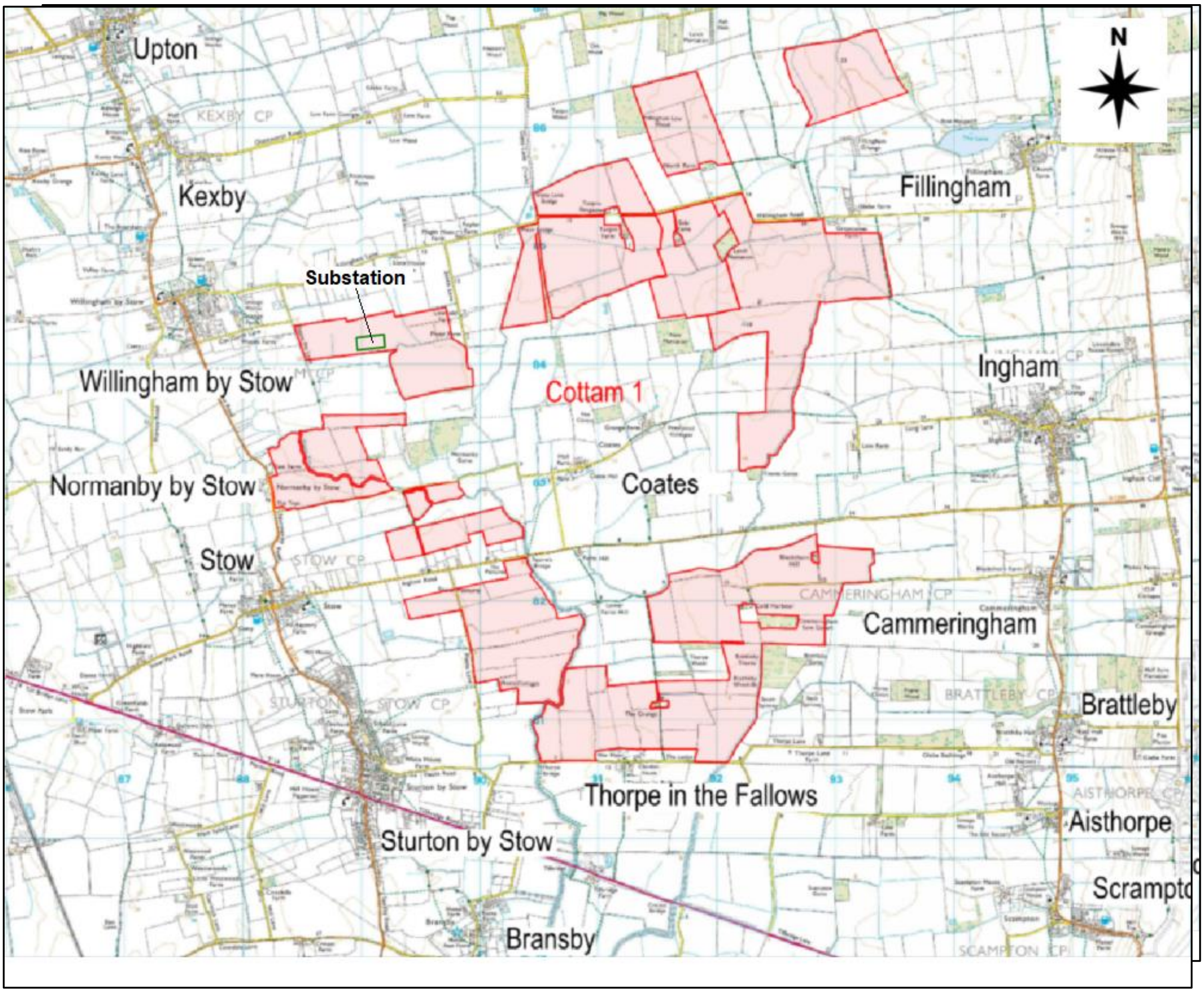
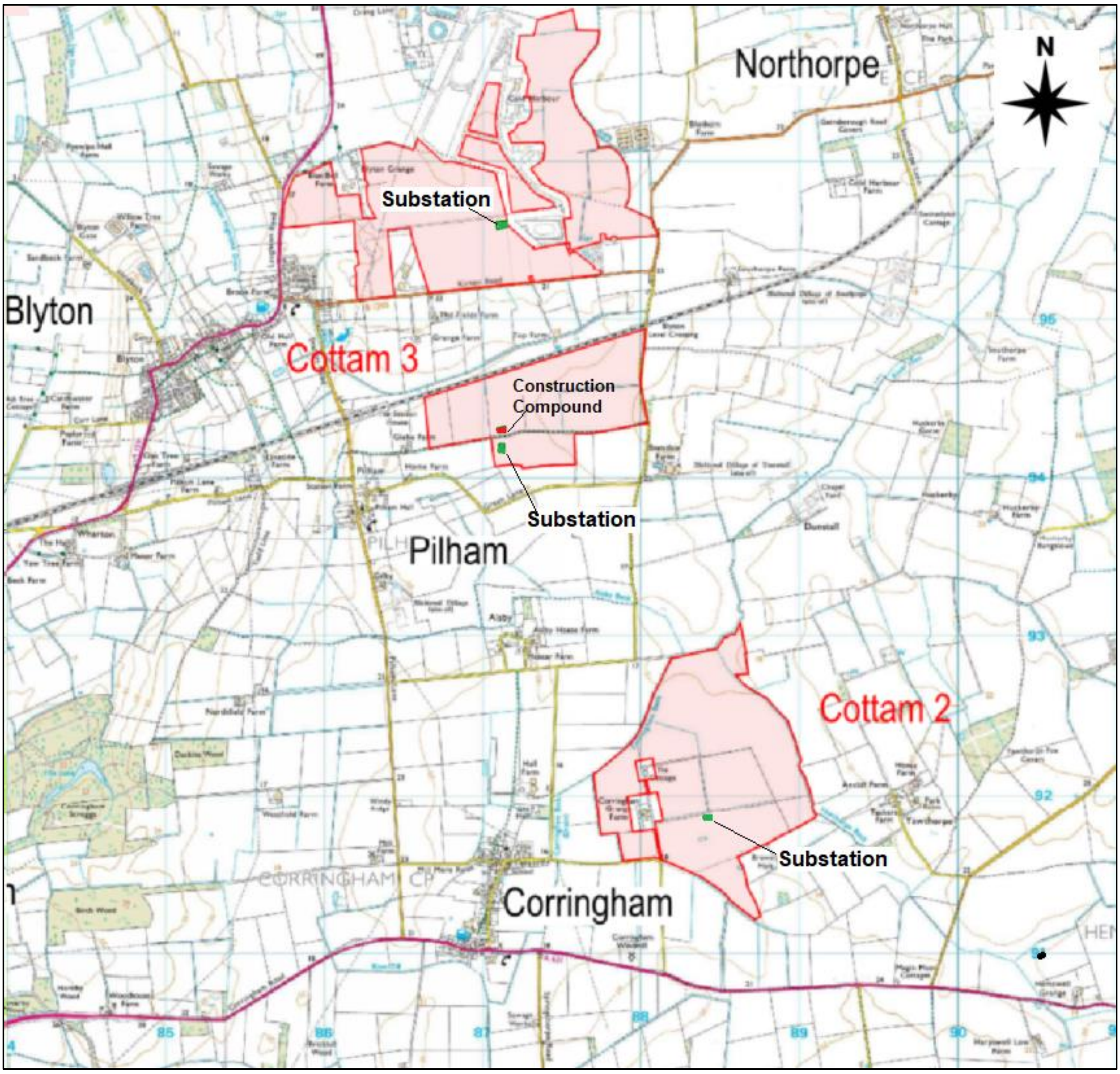


Figure 1-3. Cottam 2 & 3



~~1.5~~1.6 The BESS Site Location

The BESS is located in Cottam 1 area. Two site layout plan options have been proposed, named 'Cottam 1 West A' and 'Cottam 1 West B'. Cottam 1 West B has a larger Energy Storage Area than Cottam 1 West A. The plans for the two options are presented in Figure 1-4~~Figure 1-4~~ and Figure 1-5~~Figure 1-5~~.

Figure 1-4. BESS Site Layout Plan – Cottam 1 West A

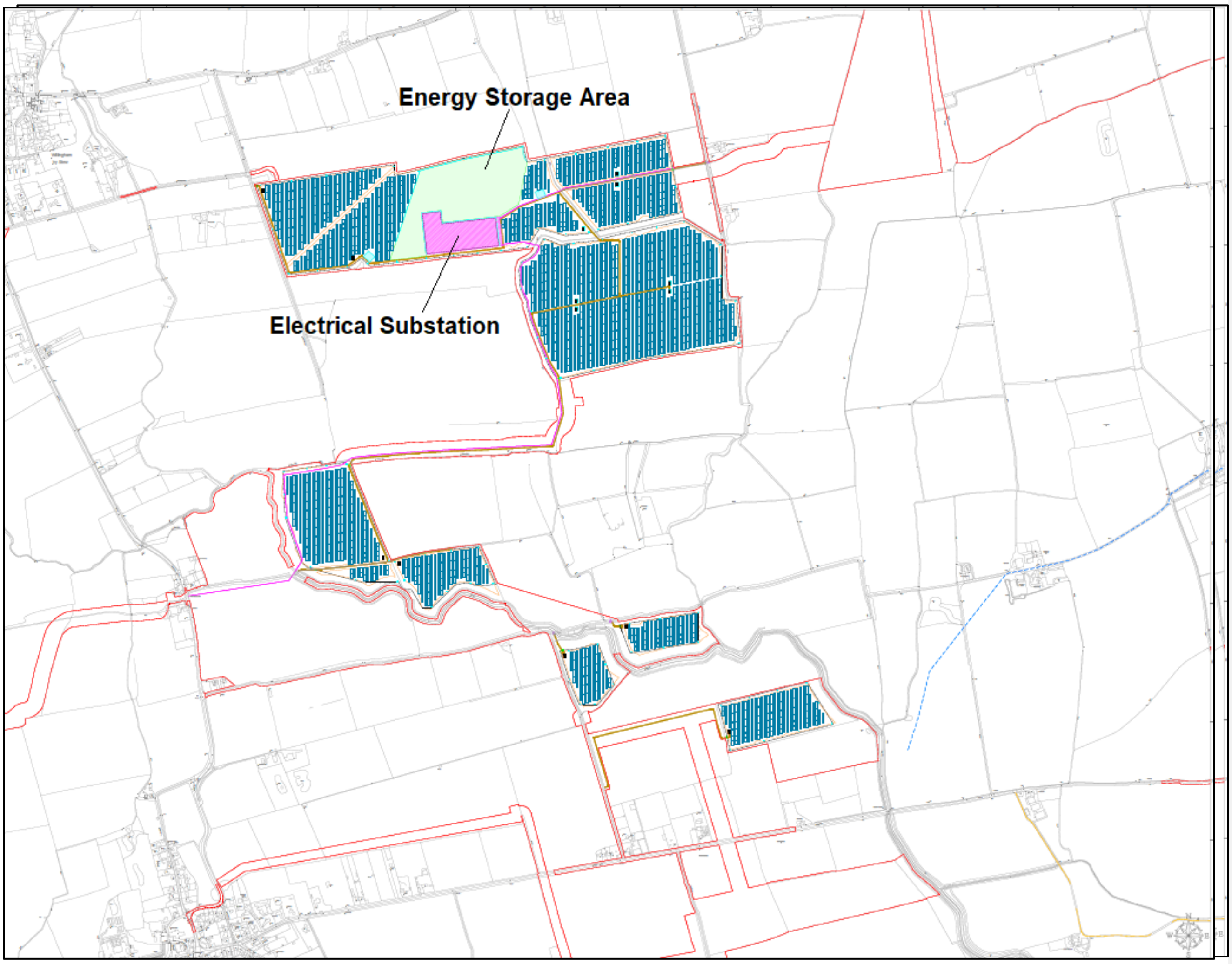
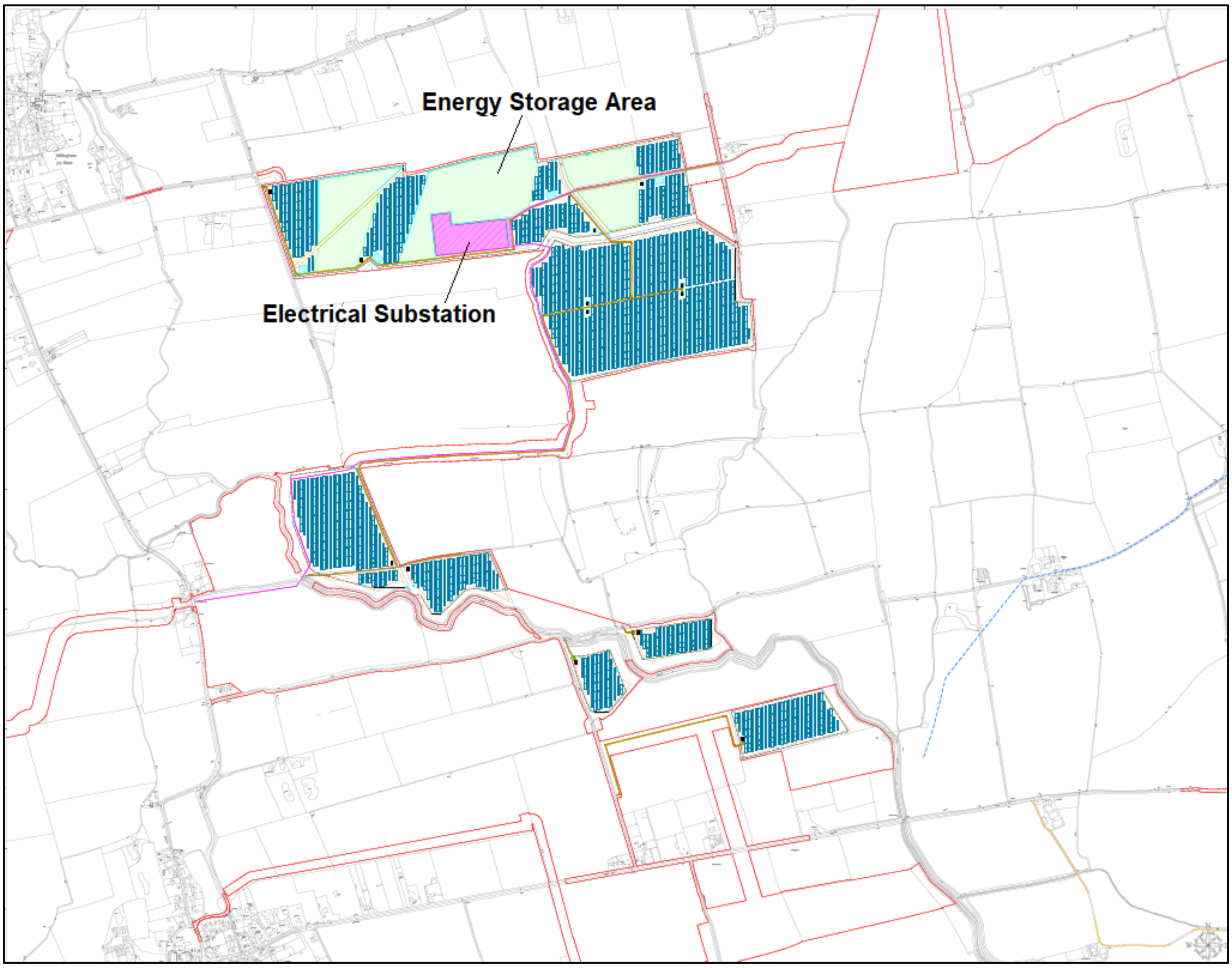


Figure 1-5. BESS Site Layout Plan – Cottam 1 West B



2.0 Extant Policy, Legislation and Relevant Agencies

2.1 Documents Consulted

The following documents were consulted during the undertaking of this assessment:

Legislation and Best Practice Guidance

- National Planning Policy Framework, Ministry for Housing, Communities and Local Government, Revised July 2021;
- Planning Practice Guidance: Air Quality, Ministry for Housing, Communities and Local Government, November 2019;
- The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2007;
- The Environment Act 1995;
- The Environment Act 2021;
- The Environmental Targets (Fine Particulate Matter) (England) Regulations 2023;
- Local Air Quality Management Technical Guidance LAQM.TG(22), Defra, 2022Design Manual for Roads and Bridges, Volume 11, Section 3, Part 1, LA 105 Air quality, Highways England, November 2019;
- Land-Use Planning & Development Control: Planning for Air Quality, EPUK & IAQM, 2017;
- Guidance on the Assessment of Dust from Demolition and Construction, IAQM, 2014;
- A Guide to the Assessment of Air Quality Impacts on Designated Nature Conservation Sites (Version 1.1), IAQM, May 2020;
- Ecological Assessment of Air Quality Impacts, CIEEM, January 2021.
- Development Control: Planning for Air Quality (2010 Update),Updated guidance from Environmental Protection UK on dealing with air quality concerns within the development control process, April 2010;
- Guidance on air emissions risk assessment for your environmental permit, Defra and Environment Agency, last updated 5 July 2022;
- The Air Quality (Scotland) Regulations 2016; and
- Local air quality management: policy guidance, updated guidance for local authorities to take account of changes to industrial emissions legislation and requirements, 20 April 2018.

Websites Consulted

- Google maps (maps.google.co.uk);
- The UK National Air Quality Archive (www.airquality.co.uk);
- Department for Transport Matrix (www.dft.go.uk/matrix);
- emapsite.com;
- Multi-Agency Geographic Information for the Countryside (http://magic.defra.gov.uk/);

- Planning Practice Guidance (http://planningguidance.planningportal.gov.uk/);
- West Lindsey District Council (https://www.west-lindsey.gov.uk/); and
- Bassetlaw District Council (https://www.bassetlaw.gov.uk/).

Site Specific Reference Documents

- Annual Status Report (ASR) 2021, West Lindsey District Council, June 2021;
- Central Lincolnshire Local Plan 2012 – 2036, adopted April 2017. Central Lincolnshire covers the combined area of the City Of Lincoln, North Kesteven, and West Lindsey;
- 2020 Air Quality Annual Status Report (ASR) for Bassetlaw District Council, August 2020;
- Bassetlaw Draft Worksop Central Development Plan Document (DPD), June 2021; and
- Bassetlaw Local Plan 2020 – 2037, publication version, August 2021.

2.2 Air Quality Legislative Framework

European Legislation

European air quality legislation is consolidated under Directive 2008/50/EC, which came into force on 11th June 2008. This Directive consolidated and replaced previous legislation which was designed to deal with specific pollutants in a consistent manner and provides new air quality objectives for fine particulates. The consolidated Directives include:

- **Directive 1999/30/EC** – the First Air Quality "Daughter" Directive – sets ambient air limit values for nitrogen dioxide and oxides of nitrogen, sulphur dioxide, lead and particulate matter;
- **Directive 2000/69/EC** – the Second Air Quality "Daughter" Directive – sets ambient air limit values for benzene and carbon monoxide;
- **Directive 2002/3/EC** – the Third Air Quality "Daughter" Directive – seeks to establish long-term objectives, target values, an alert threshold and an information threshold for concentrations of ozone in ambient air;
- **The 2008 Ambient Air Quality Directive (2008/50/EC)** - The Directive sets limits for key pollutants in the air we breathe outdoors. These legally binding limit values are for concentrations of major air pollutants that impact public health, such as particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (NO_2). The directive also sets limit values for a range of other pollutants, such as ozone, sulphur dioxide and carbon monoxide; and
- **The 4th air quality daughter directive (2004/107/EC)** – the Directive sets targets for levels in outdoor air of certain toxic heavy metals and polycyclic aromatic hydrocarbons. Both directives are introduced into the UK through the Air Quality Standards Regulations 2010.

The European Commission (EC) Directive Limits, outlined above, have been transposed in the UK through the Air Quality Standards Regulations 2010. In the UK responsibility for meeting ambient air quality limit values is devolved to the national administrations in Scotland, Wales and Northern Ireland.

National Legislation

Air Quality Standards Regulations 2010 (as amended)

The consolidated EU directive referred to above is implemented into domestic law by the Air Quality Standards Regulations 2016i. The limit values (re ambient air quality) defined within those Regulations are legally-binding and apply across England, with the exception of the carriageway and central reservation of roads where the public does not normally have access, on factory premises or at industrial locations (where health and safety provisions apply) and any locations where the public does not have access and there is no fixed habitation.

The Air Quality Standards Regulations 2010 (as amended) set legally binding limits for concentrations of certain air pollutants (i.e. “limit values”). This is with the intention of avoiding, preventing or reducing harmful effects on human health and the environment as a whole. To the extent that any concentrations exceed limit values, the Secretary of State is required to prepare an “air quality plan” with measures so as to achieve the limit value.

Environmental Protection Act 1990

The Environmental Protection Act 1990 prescribes a statutory nuisance as air quality pollutants emitted from premises (including land), through smoke, fumes or gases, dust, steam or smell that is prejudicial to health or a nuisance.

Local Authorities are required to investigate any public complaints regarding air quality, and if they are satisfied that a statutory nuisance exists, or is likely to occur or recur, they must serve an abatement notice. A notice is served on the person responsible for the nuisance. It requires either simply the abatement of the nuisance or works to abate the nuisance to be carried out, or it prohibits or restricts the activity.

The UK Air Quality Strategy

The UK Air Quality Strategy is the method for implementation of the air quality limit values in England, Scotland, Wales and Northern Ireland and provides a framework for improving air quality and protecting human health from the effects of pollution.

For each nominated pollutant, the Air Quality Strategy sets clear, measurable, outdoor air quality standards and target dates which should be aimed for; the combined standard and target date is referred to as the Air Quality Objective (AQO) for that pollutant. Adopted national standards are based on the recommendations of the Expert Panel on Air Quality Standards (EPAQS) and have been translated into a set of Statutory Objectives within the Air Quality (England) Regulations 2000.

The AQOs for pollutants included within the Air Quality Strategy and assessed as part of the scope of this report are presented in Table 2-1~~Table 2-1~~ along with European Commission (EC) Directive Limits.

Table 2-1. Air Quality Standards, Objectives and Limit Values

Pollutant	Applies	Objective	Concentration Measured as	Date to be achieved and maintained thereafter	European Obligations	Date to be achieved and maintained thereafter	New or existing
NO_2	UK	200µg/m³ not to be exceeded more than 18 times a year	1-Hour Mean	31st December 2005	200µg/m³ not to be exceeded more than 18 times a year	1st January 2010	Retain Existing
	UK	40µg/m³	Annual Mean	31st December 2005	40µg/m³	1st January 2010	
CO	UK	10mg/m³	Maximum daily 8 Hour Mean	31st December 2004	10mg/m³ Maximum daily 8 hour mean	1st January 2005	Retain Existing

British Occupational Exposure Limits

Workplace exposure limits (WELs) are British occupational exposure limits and are set in order to help protect the health of workers. WELs are concentrations of hazardous substances in the air, averaged over a specified period of time, referred to as a time-weighted average (TWA). Two time periods are generally used:

- Long-term (8-Hours); and
- Short-term (15-Minutes).

Short-term exposure limits (STELs) are set to help prevent effects such as eye irritation, which may occur following exposure for a few minutes.

Section 79 of Part III of the Environmental Protection Act (1990) defines nuisance as:

> *"…any dust, steam, smell or other effluvia arising on industrial trade or business premises and being prejudicial to health or a nuisance."*

The assessment considers the likely 'hazardous substances' associated with a BESS fire and identifies the potential risks of these substances referencing Indicative Occupational Exposure Limit Values and Workplace Exposure Limits within 'EH40/2005 Workplace exposure limits.

~~HCl,~~ HF and Respirable Dust Workplace Exposure Limits

The HSE document "EH40/2005 Workplace exposure limits" for ~~HCl,~~ HF and respirable dust (smaller than 10 µm) are presented in Table 2-2~~Table 2-2~~.

Table 2-2. Work Exposure Limits for ~~HCl,~~ HF ~~and Respirable Dust~~

Substance	Workplace Exposure Limit	
	Long-term exposure limit (8-hr TWA Reference Period)	Short-term exposure limit (15-minute TWA Reference Period)
	$mg.m^{-3}$	$mg.m^{-3}$
Hydrogen fluoride	1.5	2.5

CO Workplace Exposure Limits

The workplace exposure limits for CO as detailed within the HSE document 'EH40/2005 Workplace exposure limit' are presented in Table 2-3~~Table 2-3~~.

Table 2-3. Work Exposure Limits for CO

Substance	Workplace Exposure Limit	
	Long-term exposure limit (8-hr TWA Reference Period)	Short-term exposure limit (15-minute TWA Reference Period)
	mg/m^3	mg/m^3
Carbon monoxide	23	117

Methane Explosive Limits

Methane is a flammable gas. Methane forms explosive mixtures with air and the explosions may occur. Public Health England (www.gov.uk/phe) published the methane explosive limits as below:

- Lower explosive limit: 5.53%;
- Upper explosive limit: 15%.

Acute Exposure Guideline Levels (AEGLs)

Public Health England (PHE) publish Incident Management guidance for specific air pollutants including hydrogen fluoride (PHE publications gateway number 2014790, Published: November 2017). This document summarises the physical and chemical properties of the substance and the hazard they pose to human health. Internationally recognised best practice emergency response guidelines are reported by PHE.

AEGLs estimate the concentrations at which most people—including sensitive individuals such as old, sick, or very young people—will begin to experience health effects if they are exposed to a hazardous chemical for a specific length of time (duration). For a given exposure duration, a chemical may have up to three AEGL values, each of which corresponds to a specific tier of health effects. The three AEGL tiers are defined as follows:

- AEGL-3 is the airborne concentration, expressed as parts per million (ppm) or milligrams per cubic meter (mg/m3), of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

- AEGL-2 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- AEGL-1 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

All three tiers (AEGL-1, AEGL-2, and AEGL-3) are developed for five exposure periods: 10 minutes, 30 minutes, 60 minutes, 4 hours, and 8 hours. The table below shows how the chlorine AEGL values vary with exposure duration.

Emergency Response Planning Guidelines (ERPGs)

ERPGs estimate the concentrations at which most people will begin to experience health effects if they are exposed to a hazardous airborne chemical for 1 hour. (Sensitive members of the public—such as old, sick, or very young people—aren't covered by these guidelines and they may experience adverse effects at concentrations below the ERPG values.) A chemical may have up to three ERPG values, each of which corresponds to a specific tier of health effects. The three ERPG tiers are defined as follows:

- ERPG-3 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.
- ERPG-2 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.
- ERPG-1 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odour.

Emergency response planning guideline (ERPG) values and Acute exposure guideline levels (AEGLs) of HF used in this assessment are listed in Table **2-4**.

Table 2-4. ERPG Values and AEGLs Values

Substance	EPRG-1 Value [a]	Time period for EPRG	AEGL-1 [b]	Time period for AEGL
HF	2 ppm 1.64 mg/m^3	10 minutes & up to 1 hour	1 ppm 0.82 mg/m^3	10 minutes & up to 1 hour

Note:

(a) *The ERPG value is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odour.*

(b) *The AEGL value is Level of the chemical in air at or above which the general population could experience notable discomfort.*

For the purposes of this assessment they represent a maximum concentration value in a 10-minute period. These concentration values are also valid at an averaging time of 1 hour, which is the resolution of the meteorological data used in this assessment.

Local Air Quality Management

Under Section 82 of the Environment Act (1995) (Part IV) Local Authorities (LAs) are required to periodically review and assess air quality within their area of jurisdiction under the system of Local Air Quality Management (LAQM). This review and assessment of air quality involves assessing present and likely future air quality against the AQOs. If it is predicted that levels at the façade of buildings where members of the public are regularly present (normally residential properties) are likely to be exceeded, the LA is required to declare an Air Quality Management Area (AQMA).

~~Environment Act 2021~~

~~The Environment Act (2021) introduces a commitment to create a legally binding duty on government to reduce the concentrations of fine particulate matter ($PM_{2.5}$) in ambient air and the targets have been detailed in 'The Environmental Targets (Fine Particulate Matter) (England) Regulations 2023', which is discussed more details in next section.~~

~~The Environmental Targets (Fine Particulate Matter) (England) Regulations 2023~~

~~The Environmental Targets (Fine Particulate Matter) (England) Regulations 2023 was published on 31st January 2023, and came into force the following day. The 2023 Regulations introduce a reduced long-term annual average Air Quality Objective for $PM_{2.5}$ of 10 µg/m^3, a reduction from the current Air Quality objective of 20 µg/m^3 set out within the Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020. Additionally, the 2023 Regulations introduce a population exposure target for $PM_{2.5}$ where there is at least a 35% reduction in population exposure by the end of 31st December 2040, as compared with the average population exposure in the three-year period from 1st January 2016 to 31st December 2018.~~

~~The Air Quality Standards / Objectives are based on average exposure during a 1-year (long-term) period, a 24-hour period, an 8-hour period, or a 1-hour period. It should be noted that a fire would be expected to last for a short period of time before it is extinguished and, therefore, it is not likely that a BESS fire would result in a breach of the long-term Air Quality Standards / Objectives. An exceedance of the Air Quality Standards / Objectives would be more likely to occur for the short-term (24-hour period or less) objectives and, as such, the short-term air quality standards and relevant workplace exposure limits have been used within this assessment. Additionally, fire-generated particulate matter ($PM_{2.5}$) levels and their associated air quality category ('good' to 'hazardous' levels) have also been used within this assessment.~~

3.0 Potential Pollutant Release in a BESS Fire

3.1 Pollutant Emissions from a BESS Fire

There is limited information publicly available on a real BESS fire and the associated pollutant emissions data. In addition, a standardised set of emission factors for BESS is not currently available from the Environment Agency and, therefore, equivalent fire development and thermal runaway, smoke and heat release pollutant emissions data must be sourced from the research literature, BESS fire testing reports and Tetra Tech's project experiences on air quality impact assessment on battery fire / thermal runaway testing. , as below:

In 2016 a U.S. based organisation, the Fire Protection Research Foundation (FPRF), published a report of '*Hazard Assessment of Lithium-Ion Battery Energy Storage Systems, February 26, 2016'* that included gas sample measurements from batteries subjected to external and internal ignition tests for a BESS at 100 kWh size.

1. Tetra Tech has completed an air quality impact assessment of pollution emissions from a battery testing facility. The battery testing facility has tested different types and sizes of batteries.
   a. The battery types include Lithium Iron Phosphate (LFP), Lithium Nickel Manganese Cobalt (NMC) and Lithium Ion; and
   b. The battery sizes range from 2.2 Ah to 63280 Ah.

   The heat release, gas temperature, gas volumes produced, gas species generated, for example, H_2, CO_2, CO, NO_2, HCL, HF during the battery fire / thermal runaway tests have been recorded.;
2. BESS fire test emission data from LFP battery modules that are typically integrated into BESS systems; and

The BESS fire testing data published in a report of '*Hazard Assessment of Lithium-Ion Battery Energy Storage Systems, February 26, 2016'* by the Fire Protection Research Foundation (FPRF) have been also studied. The test data included gas sample measurements from batteries subjected to external and internal ignition tests for a BESS at 100 kWh size.

Based on the testing results using a LFP battery at the battery testing facility, the generated pollutants/species dangerous to human health are identified as HF, NO_2, CO, HCL and HF.

3.2 Fire Smoke Composition

The smoke released by any type of fire (forest, brush, crop, structure, tires, waste or wood burning) is a mixture of particles and chemicals produced by incomplete burning of carbon-containing materials. All smoke contains carbon monoxide, carbon dioxide and particulate matter (PM or soot). Smoke can contain many different

~~chemicals, including aldehydes, acid gases, sulphur dioxide, nitrogen oxides, polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, styrene, metals and dioxins. The type and number of particles and chemicals in smoke varies depending on what is burning, how much oxygen is available, and the burn temperature (Department of Health of New York State).~~ CH_4.

~~3.3 Particulates from a Fire~~

~~Particle levels are a principal concern in fire smoke. The size of particles in the air we breathe affects their potential to cause health problems. Particle pollution may contain substances like carbon, sulphur and nitrogen compounds, metals and organic chemicals. Particle size is usually measured in microns, which are units of one millionth of a metre. Coarse particles range from 2.5-10 microns in diameter (Smoke Exposure from Wildland fires, interim Guidelines for Protecting community Health and wellbeing, Manitob Health January 26, 2021).~~

~~Fine particles, with diameters less than 2.5 microns are often linked to health effects. Particles in this size range are slow to clear from the lungs when they are inhaled.~~

~~Particles from smoke tend to be extremely small, with a size range near the wavelength of visible light (0.4 to 0.7 microns). At this size range, smoke particles efficiently scatter light and make it difficult to see, explaining why people often become disoriented in smoke. It also explains why some smoke particles can be inhaled deeply into the lungs and why these are a greater health concern than larger particles.~~

~~3.4 Health Effects of Fire Smoke~~

~~Particulate matter exposure is the principle public health threat from short-term smoke exposure. The health effects of smoke from wildland fires range from eye, nose or throat irritation to serious problems such as reduced lung function, bronchitis, exacerbation of asthma and even a risk of death. People who are otherwise healthy may have irritated eyes, increased mucus production in the nose or throat, and/or coughing or difficulty breathing, especially during exercise. People with existing respiratory or cardiovascular conditions may experience aggravation of existing conditions.~~

~~Exposure to high levels of smoke should be avoided. Individuals are advised to limit their physical exertion if exposure to high levels of smoke cannot be avoided. Individuals with cardiovascular or respiratory conditions (e.g. asthma), fetuses, infants, young children, and the elderly may be more vulnerable to the health effects of smoke exposure (Department of Health of New York State).~~

4.0 Assessment Methodology

4.1 Fire Incident Impact Assessment

In general, major accident, as they relate to the Scheme, fall into three categories:

- Events that could not realistically occur, due to the nature of the Scheme or its location;
- Events that could realistically occur, but for which the Scheme, and associated receptors, are no more vulnerable than any other development; and
- Events that could occur, and to which the Scheme is particularly vulnerable, or which the Scheme has a particular capacity to exacerbate.

'Accidents' are considered to be an occurrence resulting from uncontrolled developments in the course of construction and operation of a development (e.g. major emission or fire). As such, the potential impacts on local residents from a fire accident, such as battery storage and substation fire, are considered within this assessment.

Chapter 5 to Chapter 8 ~~presents~~present the BESS fire incident impact assessment methodologies and assessment results~~ and the fire action plans~~.

Chapter 9 details the substation fire incident impact assessment results and the fire action plans.

Air pollutant exposure from a fire incident is the principal public health threat from short-term exposures. Therefore, detailed air dispersion modelling of pollutant impact from a fire has been undertaken to predict the short-term pollutant concentrations at residential receptors most likely to be affected.

4.2 Determining Impact Description of the Air Quality Effects

The potential environmental effects from ~~the operations of the proposed CHP engines~~a BESS fire will be assessed according to the UK air quality regulations and the latest guidance produced by EPUK and IAQM.

The impact description of the effects during the operational phase of the development is based on the latest guidance produced by EPUK and IAQM in January 2017. The guidance provides a basis for a consistent approach that could be used by all parties associated with the planning process to professionally judge the overall impact description of the air quality effects based on severity of air quality impacts.

The following rationale is used in determining the severity of the air quality effects at individual receptors:

~~2.~~3. The change in concentration of air pollutants, air quality effects, are quantified and evaluated in the context of AQOs. The effects are provided as a percentage of the Air Quality Objective (AQO), which may be an AQO, EU limit or target value, or an Environment Agency 'Environmental Assessment Level (EAL)';

3.4. The absolute concentrations are also considered in terms of the AQO and are divided into categories for long term concentration. The categories are based on the sensitivity of the individual receptor in terms of harm potential. The degree of harm potential to change increases as absolute concentrations are close to or above the AQO;

4.5. Severity of the effect is described as qualitative descriptors; negligible, slight, moderate or substantial, by taking into account in combination the harm potential and air quality effect. This means that a small increase at a receptor which is already close to or above the AQO will have higher severity compared to a relatively large change at a receptor which is significantly below the AQO;

5.6. The effects can be adverse when pollutant concentrations increase or beneficial when concentrations decrease as a result of development;

6.7. The judgement of overall impact description of the effects is then based on severity of effects on all the individual receptors considered; and,

7.8. Where a development is not resulting in any change in emissions itself, the impact description of effect is based on the effect of surrounding sources on new residents or users of the development, i.e., will they be exposed to levels above the AQO.

Table 4-1. Impact Descriptors for Individual Receptors

Long term average concentration at receptor in assessment year	% Change in concentration relative to AQO			
	1	2-5	6-10	>10
≤75% of AQO	Negligible	Negligible	Slight	Moderate
76-94% of AQO	Negligible	Slight	Moderate	Moderate
95-102% of AQO	Slight	Moderate	Moderate	Substantial
103-109 of AQO	Moderate	Moderate	Substantial	Substantial
≥110 of AQO	Moderate	Substantial	Substantial	Substantial

In accordance with explanation Note 2 of Table 6.3 of the EPUK & IAQM guidance, the Table is intended to be used by rounding the change in percentage pollutant concentration to whole numbers, which then makes it clearer which cell the impact falls within. The user is encouraged to treat the numbers with recognition of their likely accuracy and not assume a false level of precision. Changes of 0%, i.e. less than 0.5%, will be described as Negligible.

4.3 Particulate Matter ($PM_{2.5}$) Concentrations and Smoke Exposure Levels

Health effects from particulate matter (Equivalent approximately $PM_{2.5}$ 1 – 3 hour average in µg/m^3) levels and fire smoke exposures on residents and public has been also assessed.

The guidance within '*Smoke Exposure from Wildland Fires, Interim Guidelines for Protecting Community Health and Wellbeing, Manitob Health January 26, 2021*', has been used in estimation of the smoke levels and air quality category (good to hazardous level) based on the predicted particulate matter levels from a fire.

Air quality is a measure of how clean or polluted the air is. In this assessment air quality has been divided into 5 categories from good (healthy) to hazardous based on the particulate matter levels in air in **Table 4-2.**

Table 4-2. Estimating Smoke Levels from Particulate Matter Concentrations

Note: Adapted from *Wildfire Smoke: a guide for public health officials: http://www.arb.ca.gov/smp/progdev/pubeduc/wfgv8.pdf*

4.44.3 UK Daily Air Quality Index

UK Department for Environment Food & Rural Affairs applies the Daily Air Quality Index (DAQI) to its air quality forecasts to tell public what pollution levels are predicted to be the next day. The forecasts are provided to allow public to plan ahead and where relevant, take the recommended action to reduce the effects of air pollution.

The Daily Air Quality Index (DAQI) details levels of air pollution and provides recommended actions and health advice. The index is numbered 1-10 and divided into four bands, low (1) to very high (10), to provide detail about air pollution levels in a simple way, similar to the sun index or pollen index.

The overall air pollution index for a site or region is determined by the highest concentration of five pollutants:

- Nitrogen Dioxide
- Sulphur Dioxide
- Ozone
- Particles < 2.5µm ($PM_{2.5}$)
- Particles < 10µm (PM_{10})

In case of a BESS fire incident, the fire generated pollutant of particlesNO_2 has been used in the assessment as the gases of nitrogen dioxide and sulphur dioxide were not detectable in the smoke gases during the laboratory test of a BESS fire (discussed in Chapter 3). .

The boundaries between index points for NO_2~~, $PM_{2.5}$ and PM_{10}~~ are presented in ~~**Table 4-3, Table 4-4** and **Table 4-5**. It is assumed that a BESS fire generated particles are all $PM_{2.5}$ for a worst-case assessment.~~Table 4-1.

Form

Nitrogen Dioxide

Based on the hourly mean concentration.

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very Hig
µg/m³	0-67	68-134	135-200	201-267	268-334	335-400	401-467	468-534	535-600	601 or mor

Table 4-2~~3~~. NO_2 DAQI

Nitrogen Dioxide

Based on the hourly mean concentration.

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very Hig
µg/m³	0-67	68-134	135-200	201-267	268-334	335-400	401-467	468-534	535-600	601 or mor

~~**Table 4-4.** $PM_{2.5}$ Particles DAQI~~

$PM_{2.5}$ Particles

Based on the daily mean concentration for historical data, latest 24 hour running mean for the current day.

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
μgm^{-3}	0-11	12-23	24-35	36-41	42-47	48-53	54-58	59-64	65-70	71 or more

~~**Table 4-5.** PM_{10} Particles DAQI~~

PM_{10} Particles

Based on the daily mean concentration for historical data, latest 24 hour running mean for the current day.

Index	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
µg/m³	0-16	17-33	34-50	51-58	59-66	67-75	76-83	84-91	92-100	101 or more

5.0 Baseline Conditions

This section provides a review of the existing baseline air quality, specifically $PM_{2.5}$, in the vicinity of the sites in order to provide a criterion against which to assess potential fire impact on the surrounding residents and public. Baseline air quality in the vicinity of the site has been defined from a number of sources, as described in the following sections.

5.1 Air Quality Review and Assessment

Air Quality Review

As required under section 82 of the Environment Act 1995, Bassetlaw District Council (BDC) and West Lindsey District Council (WLDC) has conducted an ongoing exercise to review and assess air quality within its area of jurisdiction.

5.1.1 Air Quality Monitoring

Monitoring of air quality within BDC and WLDC has been undertaken through both automatic and non-automatic monitoring methods.

Automatic Monitoring

Automatic methods consists of Automatic analysers continuously draw in ambient (outdoor) air and measure the concentration of the pollutant in the sampled air.

Bassetlaw does not have any automatic monitoring sites.

West Lindsey District Council undertook automatic (continuous) monitoring at 1 site during 2020.

Non-automatic monitoring

Non-automatic Networks measure less frequently compared to automatic networks - either daily, weekly or monthly - and samples are collected by some physical means (such as diffusion tube or filter). These samples are then subjected to chemical analysis, and final pollutant concentrations calculated from these results. Non-automatic monitoring method is typically used to measure the NO_2 concentrations.

BDC and WLDC do not monitor for Particulate Matter ($PM_{2.5}$) and (PM_{10}).

5.1.2 Air Quality Management Areas (AQMA)

Bassetlaw District Council currently does not have any AQMAs.

West Lindsey currently does not have any declared AQMAs.

5.1.3 Background Pollutant Mapping

Background pollutant concentration data on a 1km x 1km spatial resolution is provided by the UK National Air Quality Archive[1] and is routinely used to support LAQM and Air Quality Assessments where local pollutant monitoring has not been undertaken.

The relevant background concentrations for this assessment are obtained from the UK National Air Quality Information Archive database based on the National Grid Co-ordinates of 1 x 1 km grid squares nearest to the application site.

The CO background concentrations are derived from the Defra background maps 2001, which are the latest available datasets.

The mapped background concentrations adjacent to the site are summarised in Table 5-1~~Table 5-1~~ below.

Table 5-1. Defra Predicted Background Concentrations

UK NGR (m)		2021 Predicted Background Concentration - Annual Mean (µg/m^3)		
X	Y	NO_x	NO_2	CO
489500	384500	8.77	6.84	107

Table 5-1~~Table 5-1~~ indicates that there were no background exceedances of the relevant AQOs within the vicinity of the sites during 2021.

Acid Gases

The UK Acid Gases and Aerosols Monitoring Network has been in operation since September 1999, providing monthly measurement data of acid gases and aerosols as part of the UK Eutrophying and Acidifying Atmospheric Pollutants (UKEAP) project.

~~Concentrations of particulate chloride are measured throughout the UK as part of the Nitric Acid Monitoring Network (UKEAP). The closest site to the development is Gaenby (UK-AIR ID: UKA00492; EU Site ID: GB0067R; Easting/Northing: 499346, 390042), which is located approximately 12km north-east of the BESS site. Monitoring results between 2020 and 2022, the most recent year with data available, is detailed within Table 5-2.~~

~~**Table 5-2.** Monitored Background Data for Hydrogen Chloride (HCl), 2020 to 2022~~

HF is not routinely monitored within the UK. However, based on ambient measurements taken in the vicinity of industrial sites, the Expert Panel on Air Quality Standards (EPAQS) suggests that background levels have been in the range 0.034 µg/m^3 to 2.35 µg/m^3 [2].

1 www.airquality.co.uk.
2 EPAQS. Guidelines for Halogens and Hydrocarbon Halides in Ambient Air for Protecting Human Health against Acute Irritancy Effects

5.2 Background Data used in the Assessment

As the site is located in a rural area, the NO_2 background concentration of 6.84 µg/m³, which was derived from Defra background mapping data, has been used in the assessment.

The background concentrations of 107 µg/m³ for CO; 2.77 µg/m³ for HCl and 2.35 µg/m³ for HF have been used for the purposes of the assessment.

6.0 Detailed Modelling Methodology

In order to consider the potential air quality impacts from a BESS fire, a quantitative assessment using the third generation Breeze AERMOD dispersion model has been undertaken. AERMOD is a development from the ISC3 dispersion model and incorporates improved dispersion algorithms and pre-processors to integrate the impact of meteorology and topography within the modelling output.

The model utilises hourly meteorological data to define conditions for fire plume rise, transport, diffusion and deposition. It estimates the concentrations at receptor locations for each hour of input meteorology and calculates user-selected hourly short-term averages.

6.1 Modelling Parameter and Averaging Period

Short-term pollutant concentrations (hourly or 8-hourly) have been used to compare to the UK air quality standards for the protecting of human health.

6.2 BESS Fire Modelling Using AERMOD

In order to consider the potential air quality impacts from a BESS fire, a quantitative assessment using the third generation AERMOD (American Meteorological Society / Environmental Protection Agency Regulatory Model) modelling software. AERMOD is a US EPA regulatory model and it is an Environment Agency approved model for the prediction of pollutant concentrations from a wide range of sources that are present at typical industrial facilities.

The AERMOD model accepts hourly meteorological data to define the conditions for plume rise, transport, diffusion and deposition. It estimates the concentration or deposition value for each source and receptor combination for each hour of input meteorology and calculates annual and user-selected short-term averages. The model also takes into account the local terrain surrounding the facility. Since most air quality standards are stipulated as averages or percentiles, AERMOD allows further analysis of the results for comparison purposes.

6.3 Proposed BESS System

A BESS system typically consists of battery energy storage unit, conversion unit and electrical substations.

The details of the proposed battery energy storage unit parameters are presented as below:

- Battery Chemistry: Lithium Iron Phosphate (LFP);
- LFP 280Ah cell;
- Cell Configuration: 1P52S (46,592 kWh);
- Rack Configuration: 8 ~~Racks~~Modules (372,736 kWh);

- System Configuration: 10P416S (10 Racks);
- Number of racks in one cabinet: 2 (746,427 kWh);
- Dimension (D*H*W – mm): 2664 * 2896 * 1457; and
- The outer material of the cabinet: steel.

6.4 Pollutant Emission Rate Calculations

A battery energy storage unit/cabinet has a capacity to hold 2 racks. Racks are separated by thermal barriers, therefore creating a delay in heat transfer between racks in the event of a fire and it is likely that the first modules or racks to catch fire would burn out before racks further away within the container would catch fire. It is assumed that a steady or rapid propagation will occur and 2 racks in one cabinet will be on fire at one time.

It is assumed that one rack would catch fire at one time and a total of 416 cells on fire.

There is limited information publicly available on a real BESS fire and the associated pollutant emissions data. In addition, a standardised set of emission factors for BESS is not currently available from the Environment Agency and, therefore, equivalent fire development and thermal runaway, smoke and heat releases, pollutant emissions data must be sourced from the research literature, BESS fire testing reportstest emission data from LFP battery modules that are typically integrated into BESS systems and Tetra Tech's project experiences on air quality impact assessment on battery fire / thermal runaway testing.

In 2016 a U.S. based organisation, the Fire Protection Research Foundation (FPRF), published a report of '*Hazard Assessment of Lithium-Ion Battery Energy Storage Systems, February 26, 2016*' that included gas sample measurements from batteries subjected to external and internal ignition tests for a BESS at 100 kWh size.

Tetra Tech has completed an air quality impact assessment of pollution emissions from a battery testing facility. The battery testing facility has tested different types and sizes of batteries.

- The battery types include Lithium Iron Phosphate (LFP), Lithium Nickel Manganese Cobalt (NMC) and Lithium Ion; and
- The battery sizes range from 2.2 Ah to 63 Ah.

The heat release, gas temperature, gas volumes produced, gas species generated, for example, H_2, CO_2, CO, NO_2, HCL, HF during the battery fire / thermal runaway tests have been recorded.

BESS fire test emission data from several recent full scale burn tests incorporating LFP battery modules demonstrated that a '2 Rack BESS cabinet system (750 kWh)' would generally burn out in 2 – 8 hours.

Based on the testing results using a LFP battery at the battery testing facility, the generated pollutants/species dangerous to human health are HF, NO_2, CO, HCL and HFCH_4.

Tetra Tech have reviewed and studied available battery testing and BESS fire test reports. A number of assumptions have been made in building a conceptual model to simulate a BESS fire.

~~1. One rack on fire at one time (due to inbuilt fire suppression systems and safety spacing between battery units);~~

~~2. A total of 416 cells in one rack;~~

~~3. LFP cell capacity of 280 Ah;~~

~~4.~~1. A fire/thermal runaway being taking place inside ~~the container~~one cabinet which ~~is similar to an "internal ignition testing" reported in 2016 USA Fire Protection Research Foundation (FPRF) testing report~~consists of 2 racks of battery modules;

~~5. BESS fire will last for 180 minutes which is deriving from the "internal ignition testing" results reported in 2016 USA Fire Protection Research Foundation (FPRF) testing report;~~

2. ~~Exhaust~~BESS fire will last for 2 hours to produce a worst-case assessment;

3. Two different fire plume gas temperatures of 800°C and 1000°C have been assessed; and

~~6.~~ Two different gas volumes associated with the different plume gas temperatures, one at gas temperature ~~60 °C which is deriving~~of 800°C and other at gas temperature of 1000°C, from the ~~"internal ignition~~ testing~~"~~ results ~~reported in 2016 USA Fire Protection Research Foundation (FPRF) testing report;~~

~~7. Gas volume generations being derived from the~~using a LFP battery ~~testing facility testing results;~~

~~8. Pollutants/species generations being derived from~~at the battery testing facility ~~testing results; and~~

~~9.~~4. ~~A Leclanché system container size of 6.058m x 2.896m x 2.438m~~.

The fire gas volumes, pollutant mass emissions and modelling parameters are presented in **Table 6-1**~~**Table 6-1**~~.

Form

Table 6-1. Mass Emissions and Emission Source Parameters for Fire Modelling

Parameter	One Rack on Fire	Unit
No. of Rack will be on Fire	2	-
Total No. of Cells per Rack	416	cells
Total Energy Capacity per Rack	375	kWh
Fire Gas Volume Temperature	800 or 1,000	°C
Gas volume generated at gas temperature of 800 °C [a]	0.56	Litter/Wh
Gas volume generated at gas temperature of 1,000 °C [a]	0.78	Litter/Wh
BESS System Fire Duration [a]	2	hours
Carbon Monoxide (CO) Gas Concentrations	3370	ppm
Hydrogen Fluoride (HF) Gas Concentrations	635	ppm
Methane (CH_4) Gas Concentrations	535	ppm
Nitrogen Oxides (NO_x) Gas Concentrations	67	ppm
Gas Mass Emission Rate at gas temperature of 800 °C		
CO Mass Emission Rate during the Fire	0.246	g/s
HF Mass Emission Rate during the Fire	0.0395	g/s
CH4 Mass Emission Rate during the Fire	0.0225	g/s
NO_x Mass Emission Rate during the Fire	0.00801	g/s
Gas Mass Emission Rate at gas temperature of 1,000 °C		
CO Mass Emission Rate during the Fire	0.342	g/s
HF Mass Emission Rate during the Fire	0.055	g/s
CH4 Mass Emission Rate during the Fire	0.0313	g/s
NO_x Mass Emission Rate during the Fire	0.0313	g/s
Fire gas upward velocity	2.5	m/s
Gas Escaping Area at gas temperature of 800 °C	0.172	m^2
Gas Escaping Area at gas temperature of 1,000 °C	0.203	m^2
Fire gas Escaping Height	2.8	m

Note:

a. *Derived from the testing results using a LFP battery at the battery testing facility ~~results;~~.*

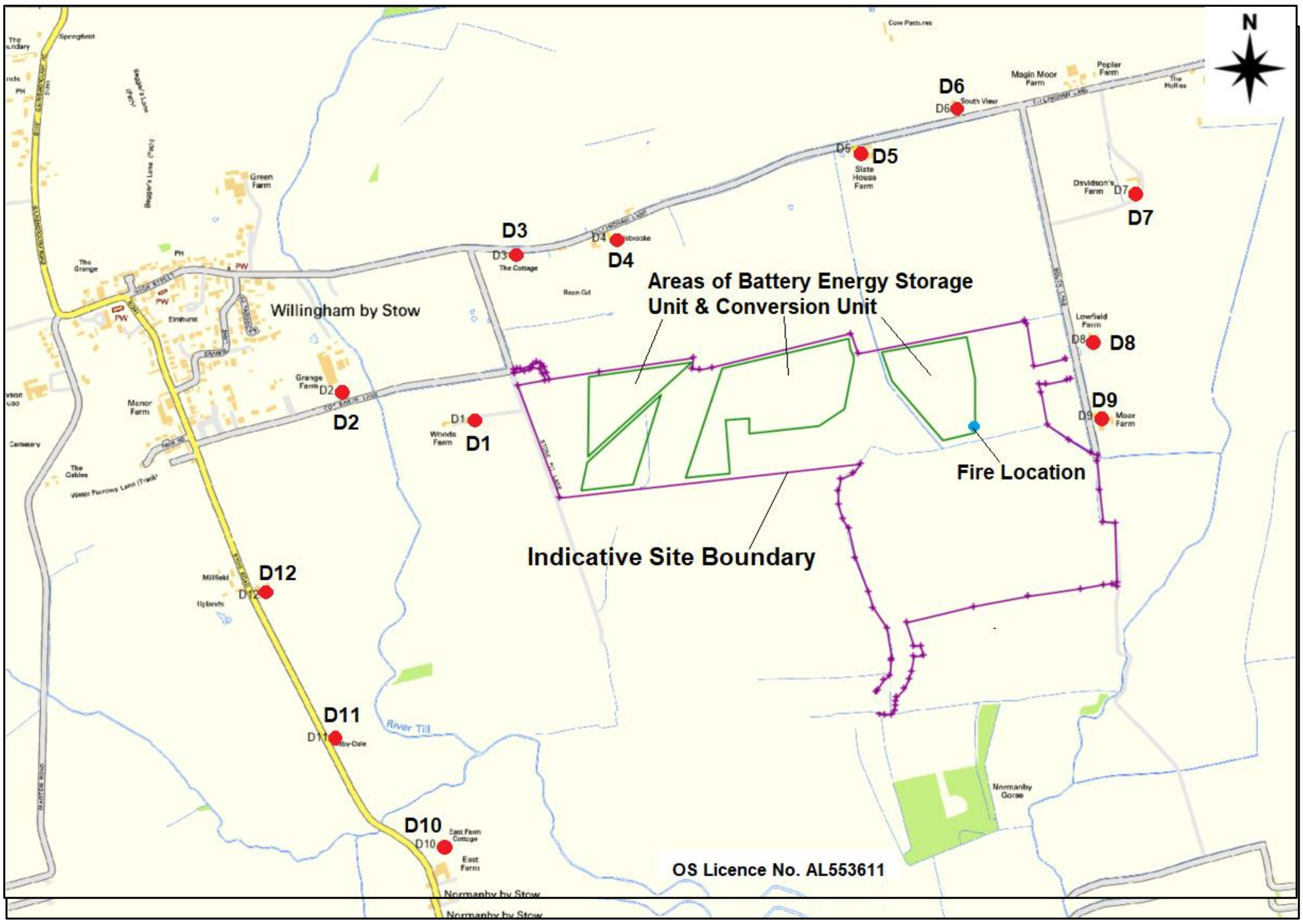
~~*b. Derived from the USA Fire Protection Research Foundation (FPRF) report of 'Hazard Assessment of Lithium-Ion Battery Energy Storage Systems, February 26, 2016, and*~~

~~*c. Using the CO/PM emission ratio of 5 which has been derived from the published data in the EA's report of "Review of emission factors for incident fires", Innovation for efficiency science programme, Science report: SC060037/SR3, August 2009.*~~

The location of the modelled fire is illustrated in ~~**Figure 6-1**~~Figure 6-1.

The selected fire location is within the site layout plant of 'Cottam 1 West B' where the battery energy storage unit is located, as near as possible the closest receptor to represent worst-case.

Figure 6-1. Modelled Fire location



6.5 Emission Impact Assessment Scenarios

Three different emission impact assessment scenarios have been undertaken:

- Scenario 1 – Assessment of a fire plume at temperatures of 800°C and the associated gas volume generation under this temperature;
- Scenario 2 – Assessment of a fire plume at temperatures of 1,000°C and the associated gas volume generation under this temperature; and

- Scenario 3 – A sensitivity study of pollutant impacts under a high wind weather condition – a wind speed of 38 miles per hour (17m/s).

~~6.5~~6.6 Receptors

~~6.5.1~~6.6.1 Discrete Receptors

The residential receptors surrounding the BESS site boundary will be incorporated into the modelling. The selected residential receptors are presented in Table 6-2~~Table 6-2~~ and shown in Figure 6-2~~Figure 6-2~~.

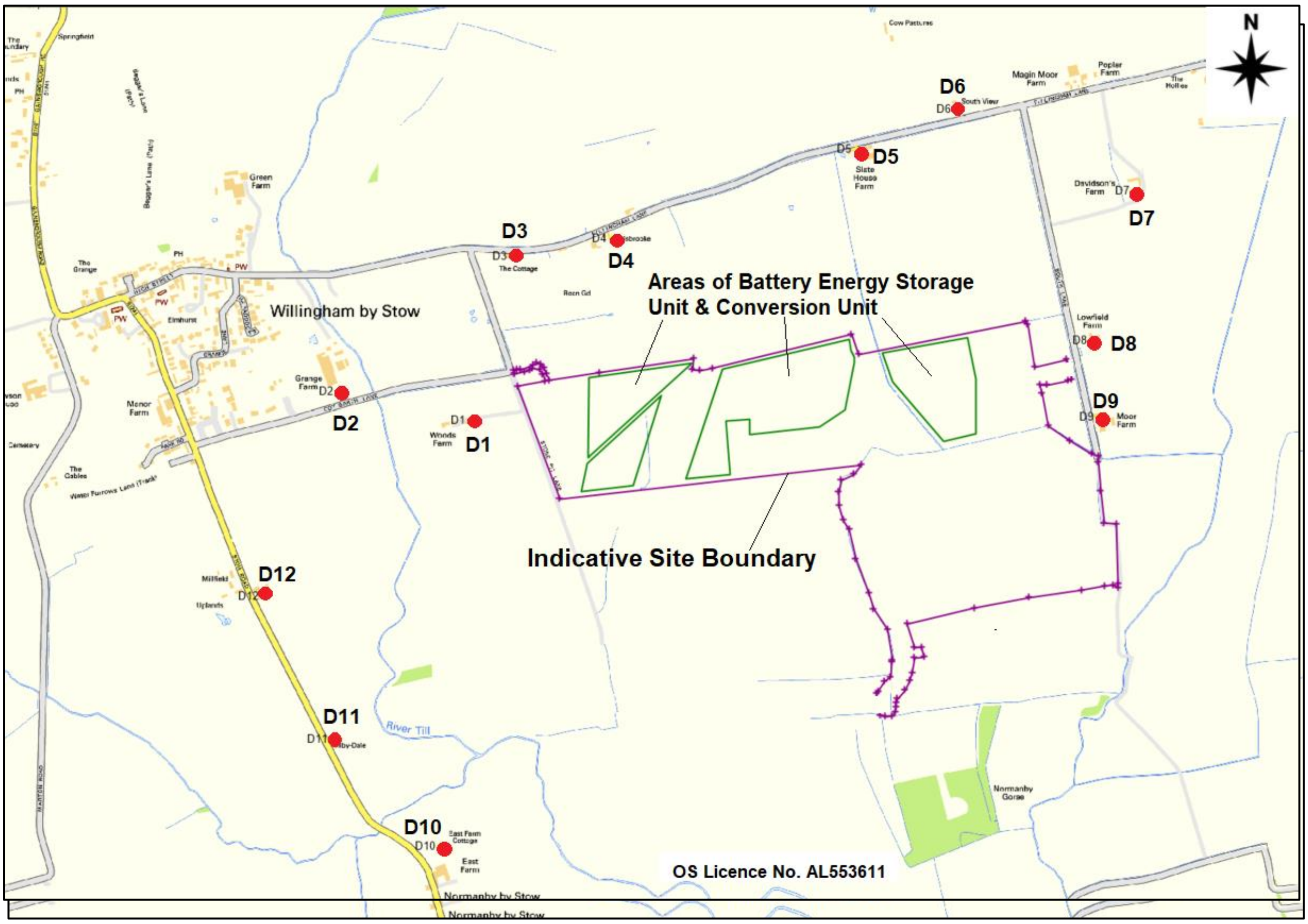
Table 6-2. Modelled Sensitive Receptors

Discrete Sensitive Receptor		UK NGR (m)		Bearing from Site	Approx. Distance from Site Redline Boundary (m)	Approx. Distance from the Boundary of area of Battery Energy Storage Unit (m)
		X	Y			
D1	Woods Farm	488310	384232	W	150	310
D2	Grange Farm	487979	384307	W	440	620
D3	The Cottage (residential)	488414	384647	N	270	360
D4	Carisbrooke Farm	488664	384691	N	340	340
D5	Slate House Farm	489282	384915	N	470	470
D6	South View (Residential)	489532	385015	N	580	580
D7	Davidson's Farm	489979	384811	NE	420	570
D8	Lowfield Farm	489873	384434	E	140	300
D9	Moor Farm	489891	384243	E	120	295
D10	East Farm Cottage	488234	383163	SW	940	960
D11	Tilby-Dale (Residential)	487962	383431	SW	840	880
D12	The Haven (residential	487790	383791	SW	780	850

It should be noted that approximate distance from the boundary of area of Battery Energy Storage Unit has been measured as a worst-case from the boundary of the Energy Storage Area to each individual residential property boundary, using the Cottam 1 West B option plan. The closest residential property boundary is located approximately 295 m away from the closest energy storage area boundary. However, it should be noted that the closest residential receptor will be approximately 320 m away from the closest BESS cabinet.

A shorter distance of 295 m has been used in the study to produce a worst-case assessment.

Figure 6-2. Modelled Sensitive Receptor Locations



~~6.5.2~~6.6.2 Ecological Receptors

The Nature Conservation (Scotland) Act 2004 received Royal Assent in June 2004, with the majority of its provisions coming into force on 29 November 2004. Containing five Parts and seven Schedules, the Act places duties on public bodies in relation to the conservation of biodiversity, increases protection for Sites of Special Scientific Interest (SSSI), amends legislation on Nature Conservation Orders, provides for Land Management Orders for SSSIs and associated land, strengthens wildlife enforcement legislation, and requires the preparation of a Scottish Fossil Code. The Act is compliant with the provisions of the European Convention on Human Rights, requiring consultation where the rights of the individual may be affected by these measures.

According to guidance within *'Air emissions risk assessment for your environmental permit'* (Defra and Environment Agency, 2 August 2016), assessments should consider the impact on the conservation areas as follows:

> Examining if there are any of the following within 10 km of the site (or within 15 km for coal or oil-fired power stations):
>
> - Special Protection Areas (SPAs);
> - Special Areas of Conservation (SACs); and
> - Ramsar sites (protected wetlands).
>
> Examining if there are any of the following within 2 km of the site:
>
> - Sites of Special Scientific Interest (SSSIs); and
> - Local Nature Sites (ancient woods, local wildlife sites and national and local nature reserves)

There are a number of deciduous woodlands within a 2 km radius of the BESS site, ranging from 800 to 1100 meters to the battery energy storage unit areas.

Given the factors of (1) a BESS fire incident would only last a short period, e.g., up to a couple of hours and (2) the identified designated sites are located a considerable distance away the proposed development site, it is unlikely that there will be long-term significant air quality impacts in case of a battery fire. Therefore, those designated sites are not included in the assessment.

~~6.5.3~~6.6.3 Cartesian Grid Receptors

A Cartesian receptor grid was used in the model in order to produce the concentration contour lines. The Cartesian receptor grid consists of receptors identified by their x (east-west) and y (north-south) coordinates.

The grid was constructed with grid spacing (x, y) of ~~50~~25 m x ~~50~~25 m over an area covering ~~3000~~1500 m by ~~3000~~1500 m with south-west corner UK NGR (m) of ~~487600, 382600~~488780, 383550.

~~6.6~~6.7 Meteorological Data

The meteorological data (~~2019 - 2021~~2018 – 2022 inclusive) used in the assessment are derived from Scampton weather station, which is considered representative of conditions within the vicinity of the site, with all the complete parameters necessary for the AERMOD model. Reference should be made to Figure 6-3~~Figure 6-3~~ for an illustration of the prevalent wind conditions at the weather station.

Form

~~6.7~~6.8 Surface Characteristics

The land uses surrounding the Site are currently being used for agricultural purposes in arable production. A surface roughness value of 0.3 (agricultural areas (max)) has been used in the modelling for a worst-case assessment.

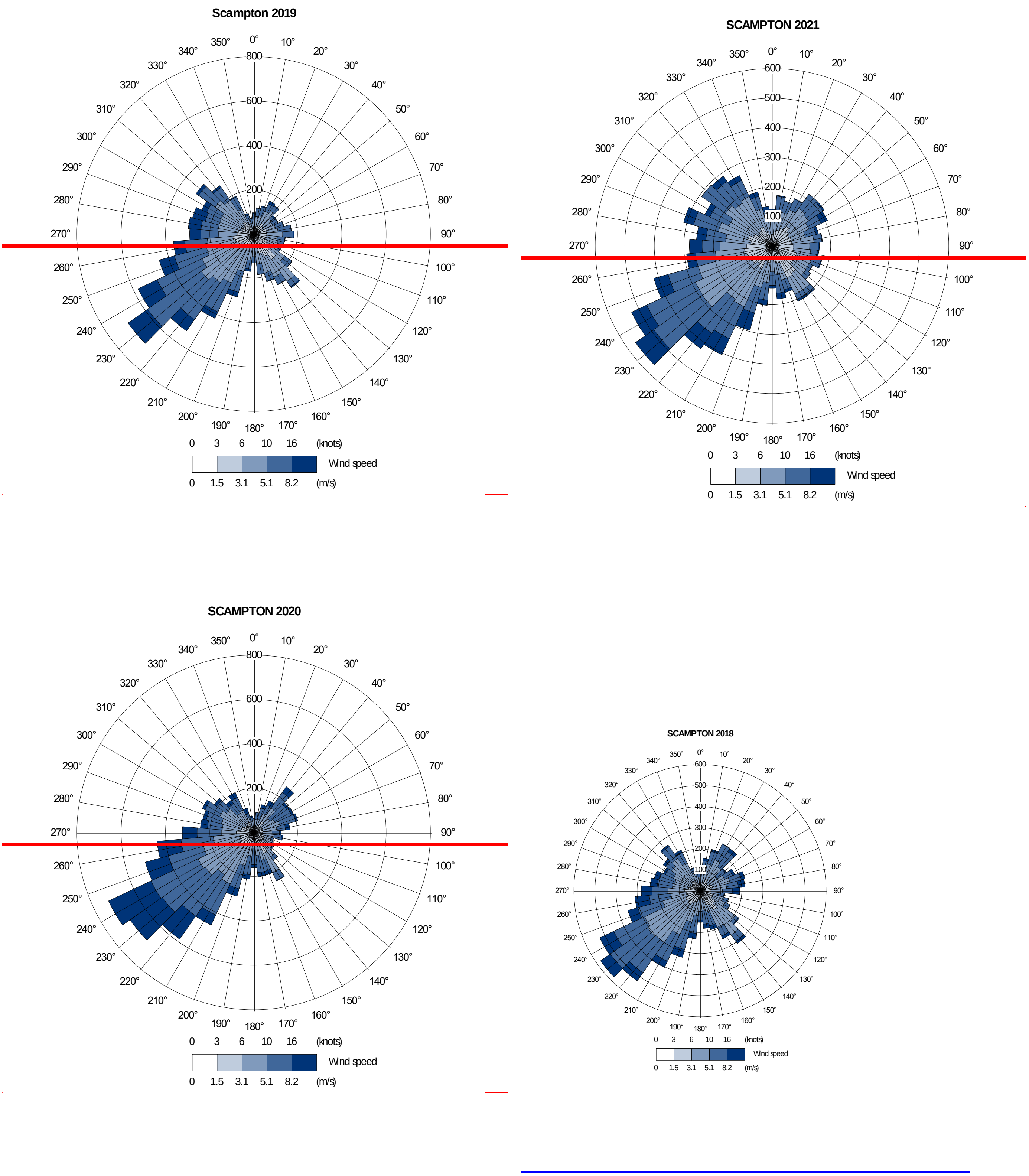
~~6.8~~6.9 Buildings in the Modelling Assessment

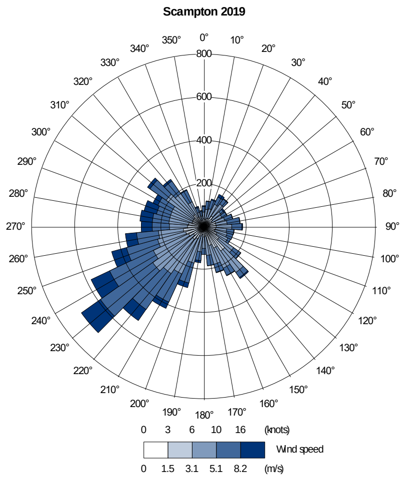
Buildings nearby or immediately adjacent to the fire location could potentially cause building downwash effects on emission sources. There would be no large buildings located adjacent to the battery energy storage unit area and therefore, no buildings have been included in the model for the assessment.

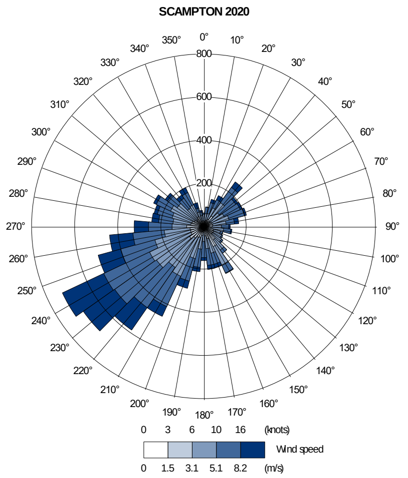
~~6.9~~6.10 Treatment of Terrain

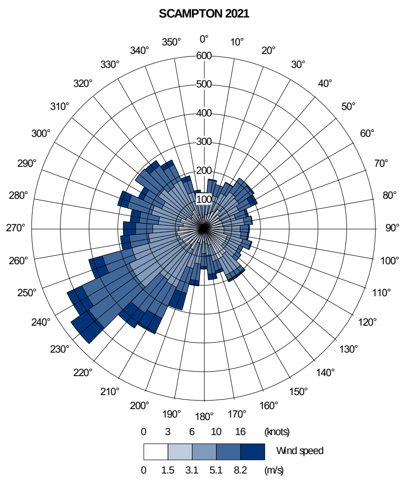
The presence of steep terrain can influence the dispersion of emissions and the resulting pollutant concentrations. USEPA guidance indicates that terrain effects should be considered if the gradient exceeds 1:10. As the land is relatively flat, digital terrain data have not been used in the assessment.

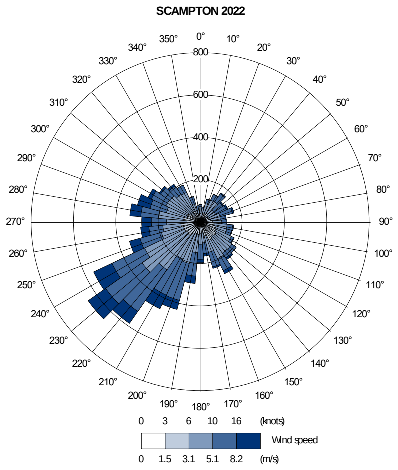
Figure 6-3. Meteorological Station Wind Rose




Scampton 2019
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


SCAMPTON 2020
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


SCAMPTON 2021
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


SCAMPTON 2022
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)

~~6.10~~6.11 Modelling Uncertainty

Uncertainty in dispersion modelling predictions can be associated with a variety of factors, including:

- Model uncertainty - due to model limitations;
- Data uncertainty - including emissions estimates, background estimates and meteorology; and
- Variability - randomness of measurements used.

However, potential uncertainties in model results have been minimised as far as practicable and worst-case inputs considered in order to provide a robust assessment. This included the following:

- Choice of model – ~~ADMS-Roads~~AERMOD is a commonly used atmospheric dispersion model and results have been verified through a number of studies to ensure predictions are as accurate as possible;
- Emission rates - Emissions were based on the ~~number of~~testing results using a LFP battery ~~cells could be on fire~~ at ~~a time~~the battery testing facility;
- Background concentrations - Background pollutant concentrations were obtained from a number of recognised sources in order to consider baseline levels in the vicinity of the site, as detailed within the main report text; and,
- Variability - All model inputs are as accurate as possible and worst-case conditions have been considered where necessary in order to ensure a robust assessment of potential pollutant concentrations.

7.0 Detailed Modelling Assessment Results

7.1 Scenario 1 – BESS Fire Gas Temperature of 800 °C

~~7.1~~ Nitrogen Dioxide (NO_2)

7.1.1 - Short-Term (1- Hour Mean) ~~NO_2~~

The short-term emissions of NO_2 from the fire emissions were assessed for all ~~3~~5 years of meteorological data. The maximum predicted PECs for the ~~3~~5 years of meteorological data assessed are compared against the relevant AQS, in **Table 7-1**~~**Table 7-1**~~.

Table 7-1. The Maximum Short-Term (1-Hour Mean, 99.79th Percentile) Concentrations of NO_2 – Scenario 1

Pollutant	Year	Process Contribution (PC)	PC as %age of AQO	PEC[(a)] (PC +Background)	Easting (m)	Northing (m)
NO_2	2018	0.435	0.22	14.12	489880	384243
NO_2	2019	0.789	0.39	14.47	489880	384243
NO_2	2020	0.760	0.38	14.44	489880	384243
NO_2	2021	0.791	0.40	14.47	489880	384243
NO_2	2022	0.772	0.39	14.45	489880	384243
AQOs	200					

Note:

~~(a)~~(c) Inclusive of Background concentration of 13.7 µg/m³.

From the meteorological dataset, the year resulting in maximum short-term NO_2 concentration was identified as ~~2019~~2021. The highest long-term PEC of NO_2 when using ~~2019~~2021 meteorological data is ~~120.24~~14.47 µg/m³, which is below the relevant short-term AQS of 200 µg/m³ for the protection of human health.

The short-term NO_2 PEC concentrations have been calculated at each of the discrete receptors for the worst meteorological year of 2019 and these results are detailed in **Table 7-2**~~**Table 7-2**~~.

Table 7-2. Summary of the Predicted NO_2 Concentrations at Discrete Receptors – When a Fire Takes Place at a Worst-Case Distance to a Receptor – Scenario 1

Receptor	Predicted 1-hour Mean (99.79th Percentile) Concentration (µg/m³)– 2021 Met Data			
	Process Contribution (PC)	PC as %age of AQO	PEC[(a)] (PC +Background)	PEC as %age of AQO
D1	0.14	0.07	13.82	6.9%
D2	0.10	0.05	13.78	6.9%
D3	0.16	0.08	13.84	6.9%
D4	0.20	0.10	13.88	6.9%
D5	0.30	0.15	13.98	7.0%
D6	0.20	0.10	13.88	6.9%
D7	0.29	0.15	13.97	7.0%
D8	0.62	0.31	14.30	7.1%
D9	0.79	0.40	14.47	7.2%
D10	0.09	0.05	13.77	6.9%
D11	0.08	0.04	13.76	6.9%
D12	0.07	0.04	13.75	6.9%
AQOs	200			

Note:

(a) Inclusive of Background concentration of 13.7 µg/m³.

From Table 7-2Table 7-2, it can be seen that there are no exceedances of the short-term NO_2 AQS of 200 µg/m³ at any of the identified discrete receptors.

Therefore, the predicted short-term NO_2 concentrations from the Site are considered acceptable for the protection of human health.

~~The contour plots of~~As the predicted short-term (1-hour mean) ground level PCs of NO_2 ~~for all receptors, including discrete and grid receptors are presented in **Figure 7-1**.~~

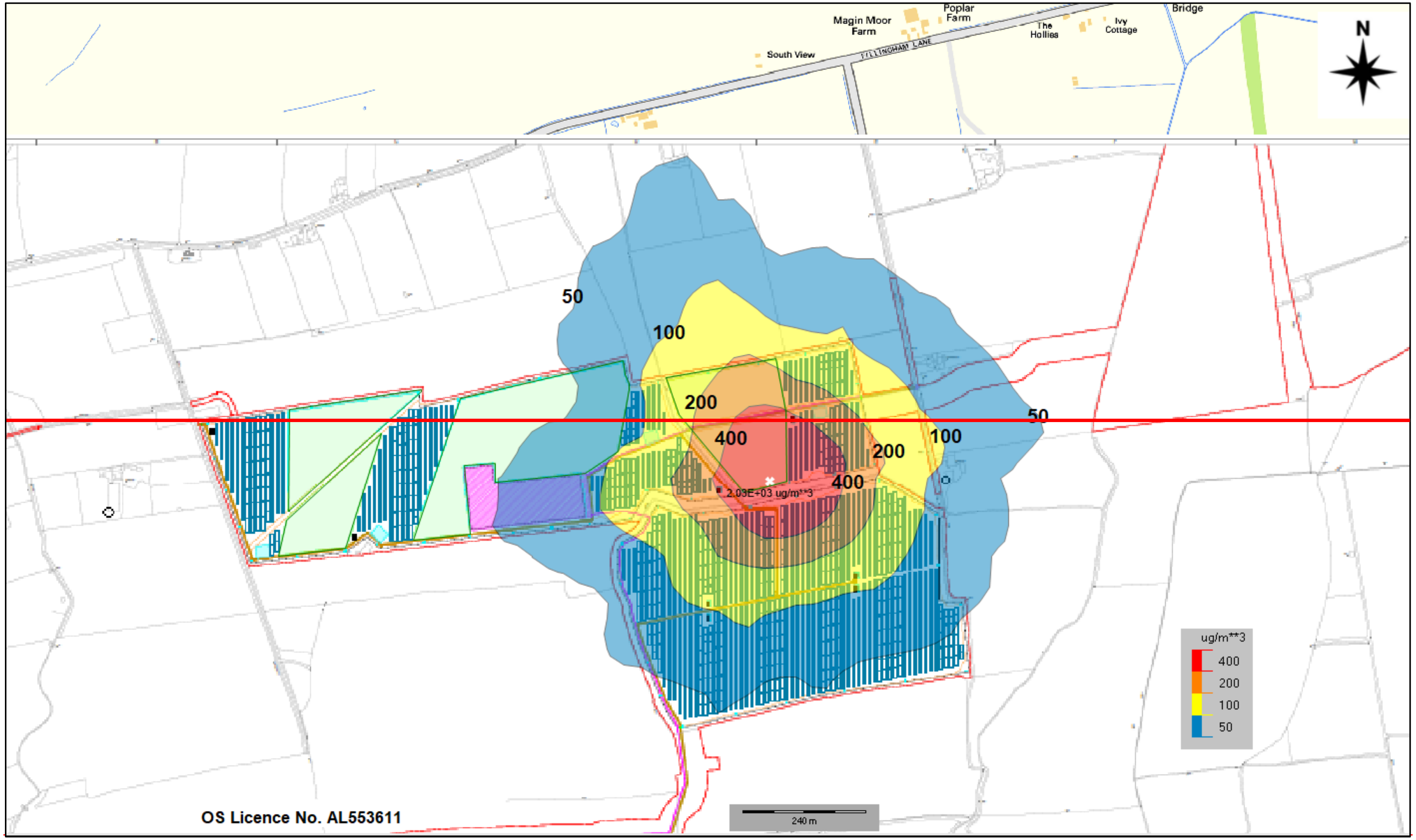
~~The contour plots show that~~is well below the ~~predicted maximum concentrations occur adjacent to the BESS fire location, with a predicted decrease in concentration with the increased distance from the fire location.~~

~~The 200 µg/m³ contour line of the short-term NO_2 concentrations is 200 m to 220 m away from the BESS fire location.~~

~~The 100 µg/m³ contour line of the short-term NO_2 concentrations, which is 50~~1% of the short-term NO_2 AQS, ~~is 300 m to 415 m away from the BESS fire location.~~the contour plots of the short-term PCs are not presented.

Form

Figure 7-1. ~~NO_2 Short-Term (1-Hour Mean, 99.79th Percentile) PC Concentrations of NO_2 – 2019 Met Data~~



~~Short-Term (24-~~Short-Term (1-hr mean) NO_2 – ~~Worst-Case~~ Assessment ~~by Assuming a BESS Fire Being lasting for up to 24 Hours~~against DAQI

~~A worst-case scenario assessment has been undertaken by assuming a BESS fire lasting for up to 24 hours. The predicted 24-hour mean NO_2 concentrations at 100%ile are compared to the UK daily air quality index.~~

~~The predicted 24~~The predicted 1-hour mean NO_2 concentrations at 100%ile at each discrete receptor, inclusive of background, are assessed against the DAQI and summarised in **Table 7-3**~~**Table 7-3**. The predicted NO_2 concentrations represent the maximum concentrations at a worst-case distance to the receptor, and the concentrations at other locations within the battery site will be lower than those presented in **Table 7-3**~~

Table 7-3. ~~The modelled fire location was selected at the nearest possible position to the sensitive receptor.~~

~~**Table 7-3.**~~ The Short-Term (~~24~~1-Hour Mean, 100th Percentile) Concentrations of NO_2 at Key Receptors – Scenario 1

Receptor	Predicted 1-hour Mean (100th Percentile) Concentration (µg/m³) of NO_2			
	Process Contribution (PC)	PEC	PEC(a) (PC +Background)	NO_2 DAQI
D1	0.26	13.68	13.94	Low
D2	0.19	13.68	13.87	Low
D3	0.27	13.68	13.95	Low
D4	0.32	13.68	14.00	Low
D5	0.51	13.68	14.19	Low
D6	0.42	13.68	14.10	Low
D7	0.51	13.68	14.19	Low
D8	1.12	13.68	14.80	Low
D9	1.37	13.68	15.05	Low
D10	0.18	13.68	13.86	Low
D11	0.16	13.68	13.84	Low
D12	0.15	13.68	13.83	Low

As shown in **Table 7-3**~~**Table 7-3**~~, ~~receptors D8 and D9 will have 'high' air pollution levels on the UK Daily Air Quality Index (DAQI) in the case of a BESS fire which lasts up to 24 hours. All remaining receptors~~all receptors will have a 'low' air pollution level on the DAQI.

~~Therefore, the action plans for the protection of human health in Chapter 8 will be implemented in the case of a BESS fire.~~

7.1.2 Carbon Monoxide (CO)

Predicted ground level short-term (8-hour running mean) CO concentrations were assessed against the relevant AQO using 20192021 met data (the year resulting in maximum short-term PC concentration). The results of the model predictions at each discrete receptor, inclusive of background, are summarised in Table 7-4Table 7-4.

Forma

Table 7-4. Summary of Predicted CO Concentrations – Scenario 1

Receptor	Predicted Maximum 8-hour Running Mean Concentration (µg/m³)			
	Process Contribution (PC)	PC as %age of AQO	PEC(a) (PC +Background)	PEC as %age of AQO
D1	5.86	0.06	155.7	1.56%
D2	5.11	0.05	154.9	1.55%
D3	3.50	0.03	153.3	1.53%
D4	6.44	0.06	156.2	1.56%
D5	14.95	0.15	164.8	1.65%
D6	13.03	0.13	162.8	1.63%
D7	9.16	0.09	159.0	1.59%
D8	33.41	0.33	183.2	1.83%
D9	40.35	0.40	190.1	1.90%
D10	3.28	0.03	153.1	1.53%
D11	3.55	0.04	153.3	1.53%
D12	5.23	0.05	155.0	1.55%
AQOs	10,000			

Note: *(a) Inclusive of Background concentration of 149.8 µg/m³.*

As indicated in Table 7-4Table 7-4, the maximum predicted 8-hour running mean CO process contributions (PC) at receptors is 422.31µg40.35 µg/m³ when using 20192021 met data. The predicted 8-hour running mean PCs of CO at the modelled discrete receptors are well below 0.4.22% of the short-term AQO, which are considered insignificant.

Forma

The maximum PEC of 8-hour running mean CO emissions is 572190.1 µg/m³, which does not exceed the relevant short-term AQS of 10,000 µg/m³.

The percentage of short-term PEC relative to the AQAL as a result of the plant operations at all receptor locations, with respect to CO exposure, are determined to be less than 5.721.90%. The significance is determined to be 'negligible'.

Therefore, the short-term PECs of CO at all receptors are below the relevant short-term AQS of 10,000 µg/m³ for the protection of human health.

7.1.3 Hydrogen Chloride (HCLFluoride (HF)

8-Hour Mean for the Protection of Workers

British Occupational Exposure Limits have been used in the assessment.

8-Hour Mean for the Protection of Workers

Predicted ground level 8-hour mean HClHF concentrations using 20192021 met data (the year resulting in maximum short-term PC concentration) were assessed against the WSLs. The results of the model predictions at each discrete receptor, inclusive of background, are summarised in **Table 7-5Table 7-5**.

Table 7-5. Summary of Predicted HClHF Concentrations (8-Hour Mean) for the Protection of Workers – Scenario 1

ID	Name	Predicted 8-hour Mean Concentration HF (µg/m³)			
		Process Contribution (PC)	PC as %age of AQO	PEC [a] (PC+Background)	PEC % of WSLs
D1	Woods Farm	1.88	0.13	5.17	0.34%
D2	Grange Farm	1.64	0.11	4.93	0.33%
D3	The Cottage (residential)	1.12	0.07	4.41	0.29%
D4	Carisbrooke Farm	2.07	0.14	5.36	0.36%
D5	Slate House Farm	4.80	0.32	8.09	0.54%
D6	South View (Residential)	4.18	0.28	7.47	0.50%
D7	Davidson's Farm	2.94	0.20	6.23	0.42%
D8	Lowfield Farm	10.73	0.72	14.02	0.93%
D9	Moor Farm	12.96	0.86	16.25	1.08%
D10	East Farm Cottage	1.05	0.07	4.34	0.29%
D11	Tilby-Dale (Residential)	1.14	0.08	4.43	0.30%
D12	The Haven (residential	1.68	0.11	4.97	0.33%
WSLs		1,500			

Note:
[(a)] *Inclusive of Background concentration of 3.29 µg/m³.*

15-Minute Mean for the Protection of Workers

Predicted ground level 15-min mean HClHF concentrations using 20192021 met data (the year resulting in maximum short-term PC concentration) were assessed against the WSLs. The results of the model predictions at each discrete receptor, inclusive of background, are summarised in **Table 7-6Table 7-6**.

Table 7-6. Summary of Predicted ~~HCl~~HF Concentrations (15-Min Mean) for the Protection of Workers – Scenario 1

ID	Name	Predicted 15-Min Mean Concentration HF (µg/m³)			
		Process Contribution (PC)	PC as %age of AQO	PEC [a] (PC+Background)	PEC % of WSLs
D1	Woods Farm	4.78	0.14	11.1	0.44%
D2	Grange Farm	3.30	0.10	9.6	0.38%
D3	The Cottage (residential)	4.22	0.13	10.5	0.42%
D4	Carisbrooke Farm	6.34	0.19	12.6	0.51%
D5	Slate House Farm	9.38	0.28	15.7	0.63%
D6	South View (Residential)	7.90	0.24	14.2	0.57%
D7	Davidson's Farm	9.22	0.28	15.5	0.62%
D8	Lowfield Farm	20.45	0.61	26.7	1.07%
D9	Moor Farm	26.05	0.78	32.3	1.29%
D10	East Farm Cottage	3.28	0.10	9.6	0.38%
D11	Tilby-Dale (Residential)	2.64	0.08	8.9	0.36%
D12	The Haven (residential	2.90	0.09	9.2	0.37%
WSLs		2,500			

Note:

[(a)] *Inclusive of Background concentration of ~~8.82~~6.30 µg/m³*

From the table above, assessment results indicated that:

(1) The predicted ~~HCl~~HF Concentrations (8-hour Mean) at the selected receptor locations are below 8-hr workplace exposure limit of ~~2~~1.5 mg/m³;

(2) The predicted ~~HCl~~HF Concentrations (15-Min Mean) at the selected receptor locations are below 15-min workplace exposure limit of ~~8~~2.5 mg/m³; and

(3) The short-term HCL impact of a BESS fire on the selected receptors is sufficiently 'small'. The effect of a BESS fire on the receptors is considered to be insignificant.

~~7.2 Hydrogen Fluoride (HF)~~

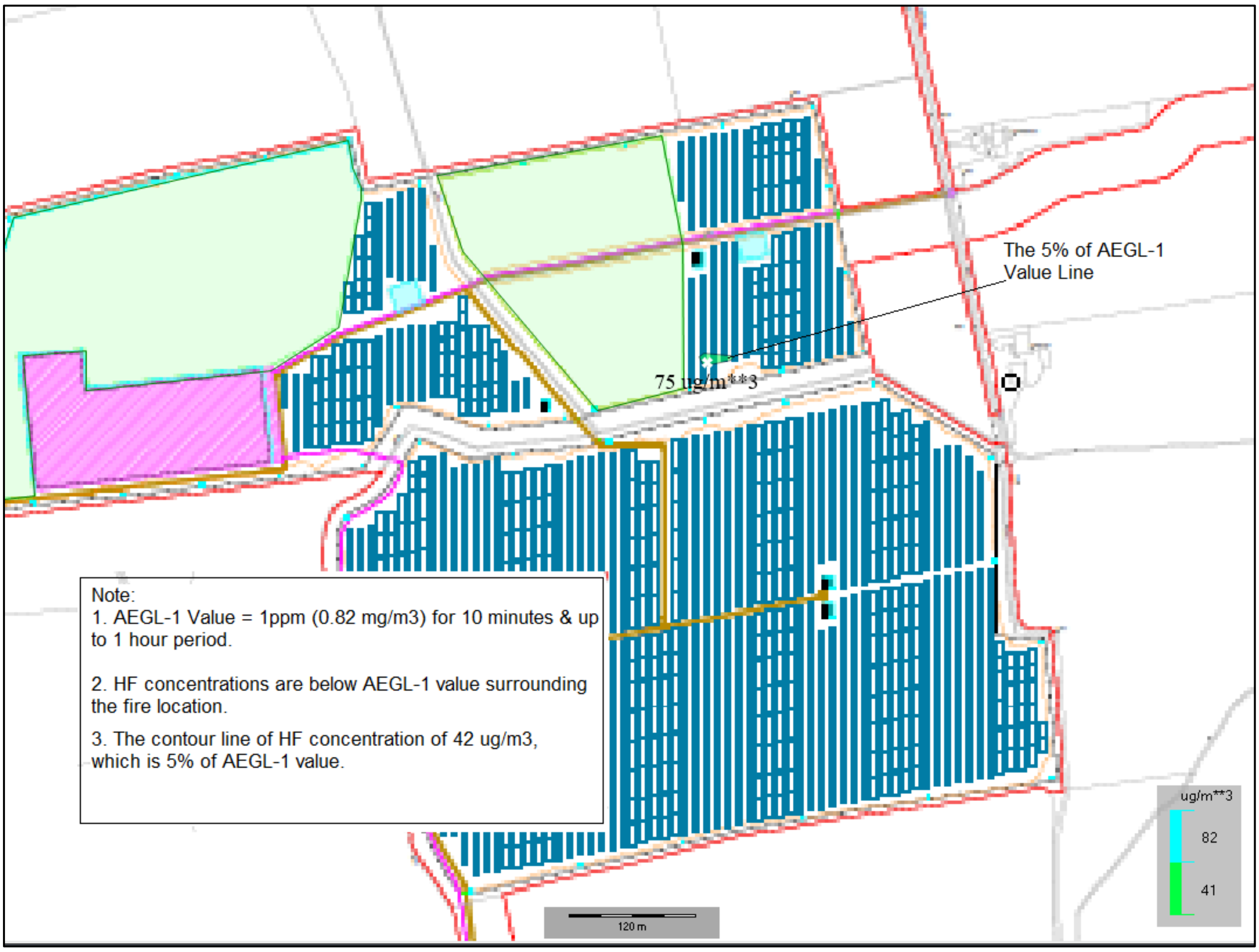
~~8-Hour Mean for the Protection~~HF Concentration Assessed against AEGL-1 Value

The contour plots of ~~**Workers**~~

~~Predicted~~the predicted ground level ~~8-hour mean~~15-minute HF concentrations using 2021 met data are shown in **Figure 7-1.**

Forma

Figure 7-1. Predicted ground level 15-minute HF concentrations using 2021 met data – Scenario 1



From 2019 met data (Figure 7-1 it can be seen that:

(1) The predicted maximum HF concentrations (15-minute Mean) is below the AEGL-1 Value = 1 ppm (0.82 mg/m^3) for 10 minutes & up to 1 hour period;

(2) The contour line of HF concentration of 41 µg/m^3, which is 10% of AEGL-1 value, is approximately 20 m away from the fire location; and

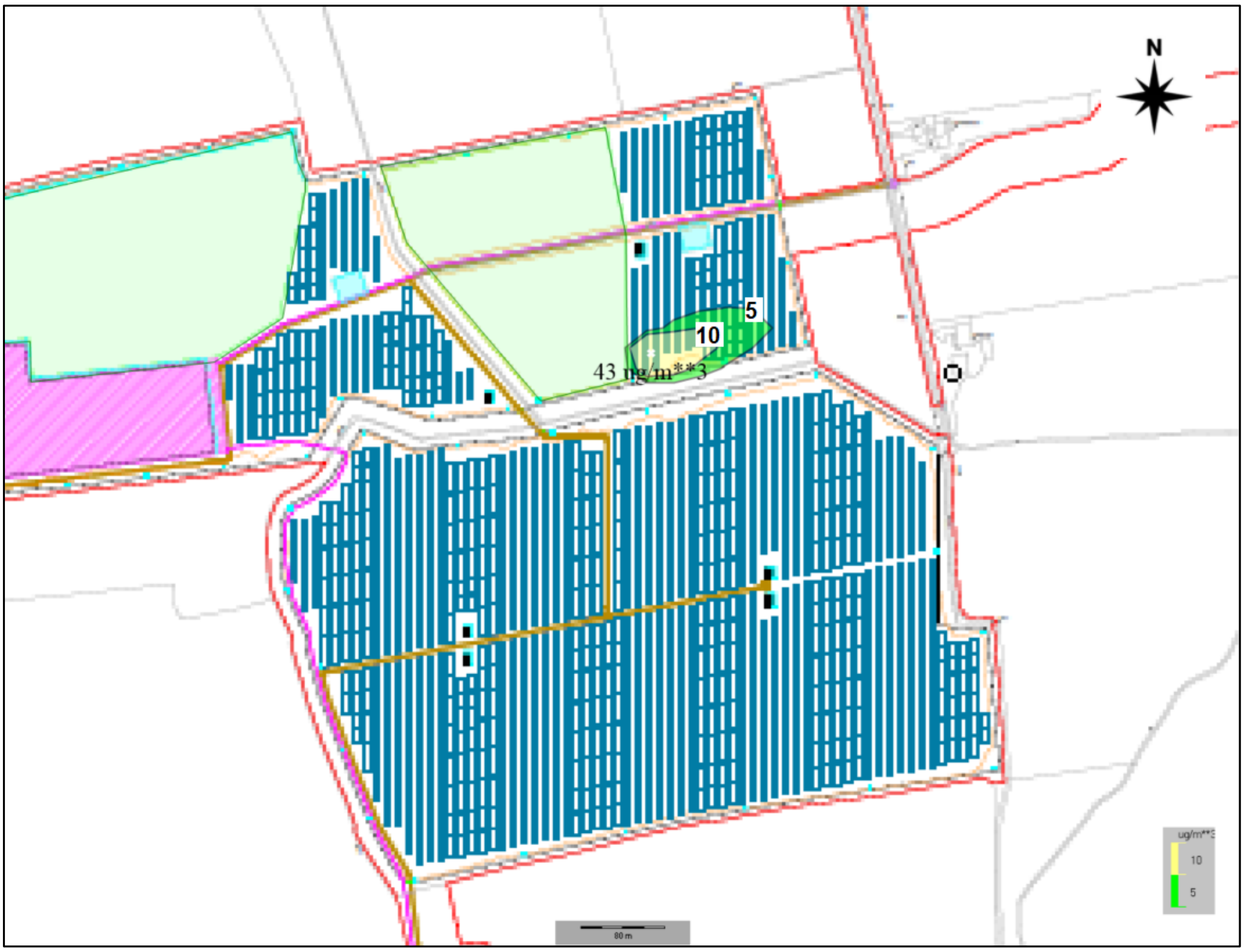
(3) It is considered that nearly all individuals can be exposed for up to 1 hour without experiencing other than mild transient adverse health effects.

7.1.4 Methane (CH_4)

The contour plots of the predicted ground level short-term (15-Min Mean) CH4 concentrations surrounding the fire location were shown in **Figure 7-2** and assessed against the lower/upper explosive limits.

Forma

Figure 7-2 Predicted ground level short-term (15-Min Mean) CH4 concentrations – Scenario 1



From Figure 7-2 it can be seen that:

(1) The predicted maximum CH4 concentrations (15-minute Mean) is below the lower explosive limit of 5.33% CH_4 in air; and

(2) It is considered that it is unlikely that there is potential methane explosive risk surrounding the fire location if the BESS system is visibly burning, if a venting thermal runaway event occurs i.e. smoke and no flames then there is likely to be a significant localised explosive risk.

7.2 Scenario 2 – BESS Fire Gas Temperature of 1000 °C

7.2.1 Nitrogen Dioxide (NO_2) - Short-Term (1- Hour Mean)

The short-term emissions of NO_2 from the fire emissions were assessed for all 5 years of meteorological data. The maximum predicted PECs for the 3 years of meteorological data assessed are compared against the relevant AQS, in **Table 7-7.**

Table 7-7. The Maximum Short-Term (1-Hour Mean, 99.79th Percentile) Concentrations of NO_2 – Scenario 2

Pollutant	Year	Process Contribution (PC)	PC as %age of AQO	PEC[(a)] (PC +Background)	Easting (m)	Northing (m)
NO_2	2018	0.613	0.31	14.29	489880	384243
NO_2	2019	1.014	0.51	14.69	489880	384243
NO_2	2020	0.976	0.49	14.66	489880	384243
NO_2	2021	1.031	0.52	14.71	489880	384243
NO_2	2022	0.948	0.47	14.63	489880	384243
AQOs	200					

Note:

(d) Inclusive of Background concentration of 13.7 µg/m³.

From the meteorological dataset, the year resulting in maximum short-term NO_2 concentration was identified as 2021. The highest long-term PEC of NO_2 when using 2021 meteorological data is 14.71 µg/m³, which is below the relevant short-term AQS of 200 µg/m³ for the protection of human health.

The short-term NO_2 PEC concentrations have been calculated at each of the discrete receptors for the worst meteorological year of 20121 and these results are detailed in **Table 7-8.**

Table 7-8. Summary of the Predicted NO_2 Concentrations at Discrete Receptors – When a Fire Takes Place at a Worst-Case Distance to a Receptor – Scenario 2

Receptor	Predicted 1-hour Mean (99.79th Percentile) Concentration (µg/m³)– 2021 Met Data			
	Process Contribution (PC)	PC as %age of AQO	PEC[(a)] (PC +Background)	PEC as %age of AQO
D1	0.21	0.10	13.89	6.9%
D2	0.14	0.07	13.82	6.9%
D3	0.22	0.11	13.90	7.0%
D4	0.28	0.14	13.96	7.0%
D5	0.40	0.20	14.08	7.0%
D6	0.27	0.14	13.95	7.0%
D7	0.40	0.20	14.08	7.0%
D8	0.79	0.39	14.47	7.2%
D9	1.03	0.52	14.71	7.4%
D10	0.13	0.06	13.81	6.9%
D11	0.12	0.06	13.80	6.9%
D12	0.10	0.05	13.78	6.9%
AQOs	200			

Note: ~~PC concentration) were assessed against the WSLs. The results of the model predictions~~

(b) Inclusive of Background concentration of 13.7 µg/m³.

From **Table 7-8** it can be seen that there are no exceedances of the short-term NO_2 AQS of 200 µg/m³ at any of the identified discrete receptors.

Therefore, the predicted short-term NO_2 concentrations from the Site are considered acceptable for the protection of human health.

As the predicted short-term (1-hour mean) ground level PCs of NO_2 is well below the 1% of the short-term NO_2 AQS, the contour plots of the short-term PCs are not presented.

Short-Term (1-hr mean) NO_2 – Assessment against DAQI

The predicted 1-hour mean NO_2 concentrations at 100%ile at each discrete receptor, inclusive of background, are assessed against the DAQI and summarised in **Table 7-9Table 7-7**.

Forma

Table 7-7. Summary of Predicted HF Concentrations (8-Hour Mean) for the Protection of Workers

Note:
[(a)] *Inclusive of Background concentration of 3.29 µg/m³*

15-Minute Mean for the Protection of Workers

Table 7-9. The Short-Term (1-Hour Mean, 100th Percentile) Concentrations of NO_2 at Key Receptors – Scenario 2

Receptor	Predicted 1-hour Mean (100th Percentile) Concentration (µg/m³) of NO_2			
	Process Contribution (PC)	PEC	PEC(a) (PC +Background)	NO_2 DAQI
D1	0.36	14.04	7.0%	Low
D2	0.27	13.95	7.0%	Low
D3	0.36	14.04	7.0%	Low
D4	0.44	14.12	7.1%	Low
D5	0.66	14.34	7.2%	Low
D6	0.57	14.25	7.1%	Low
D7	0.66	14.34	7.2%	Low
D8	1.43	15.11	7.6%	Low
D9	1.70	15.38	7.7%	Low
D10	0.25	13.93	7.0%	Low
D11	0.23	13.91	7.0%	Low
D12	0.20	13.88	6.9%	Low

As shown in **Table 7-3**, all receptors will have a 'low' air pollution level on the DAQI.

Forma

7.2.2 Carbon Monoxide (CO)

Predicted ground level 15-minshort-term (8-hour running mean HF) CO concentrations were assessed against the relevant AQO using 20192021 met data (the year resulting in maximum short-term PC concentration) were assessed against the WSLs.). The results of the model predictions at each discrete receptor, inclusive of background, are summarised in **Table 7-10Table 7-8**.

Forma

Table 7-10. Summary of Predicted CO Concentrations – Scenario 2

Receptor	Predicted Maximum 8-hour Running Mean Concentration (µg/m^3)			
	Process Contribution (PC)	PC as %age of AQO	PEC$_{(a)}$ (PC +Background)	PEC as %age of AQO
D1	8.05	0.08	157.8	1.58%
D2	7.11	0.07	156.9	1.57%
D3	4.73	0.05	154.5	1.55%
D4	8.78	0.09	158.6	1.59%
D5	19.80	0.20	169.6	1.70%
D6	17.29	0.17	167.1	1.67%
D7	12.39	0.12	162.2	1.62%
D8	45.82	0.46	195.6	1.96%
D9	53.66	0.54	203.5	2.03%
D10	4.63	0.05	154.4	1.54%
D11	4.92	0.05	154.7	1.55%
D12	7.30	0.07	157.1	1.57%
AQOs	10,000			

Note: *(a) Inclusive of Background concentration of 149.8 µg/m^3.*

As indicated in **Table 7-10** the maximum predicted 8-hour running mean CO process contributions (PC) at receptors is 53.66 µg/m^3 when using 2021 met data. The predicted 8-hour running mean PCs of CO at the modelled discrete receptors are well below 0.6% of the short-term AQO, which are considered insignificant.

The maximum PEC of 8-hour running mean CO emissions is 203.5 µg/m^3, which does not exceed the relevant short-term AQS of 10,000 µg/m^3.

The percentage of short-term PEC relative to the AQAL as a result of the plant operations at all receptor locations, with respect to CO exposure, are determined to be less than 2.03%. The significance is determined to be 'negligible'.

Therefore, the short-term PECs of CO at all receptors are below the relevant short-term AQS of 10,000 µg/m^3 for the protection of human health.

7.2.3 Hydrogen Fluoride (HF)

8-Hour Mean for the Protection of Workers

Predicted ground level 8-hour mean HF concentrations using 2021 met data (the year resulting in maximum short-term PC concentration) were assessed against the WSLs. The results of the model predictions at each discrete receptor, inclusive of background, are summarised in **Table 7-11.**

Table 7-11. Summary of Predicted HF Concentrations (8-Hour Mean) for the Protection of Workers – Scenario 2

ID	Name	Predicted 8-hour Mean Concentration HF (µg/m³)			
		Process Contribution (PC)	PC as %age of AQO	PEC [a] (PC+Background)	PEC % of WSLs
D1	Woods Farm	2.29	0.15	5.58	0.37
D2	Grange Farm	1.52	0.10	4.81	0.32
D3	The Cottage (residential)	2.82	0.19	6.11	0.41
D4	Carisbrooke Farm	6.37	0.42	9.66	0.64
D5	Slate House Farm	5.56	0.37	8.85	0.59
D6	South View (Residential)	3.99	0.27	7.28	0.49
D7	Davidson's Farm	14.74	0.98	18.03	1.20
D8	Lowfield Farm	17.26	1.15	20.55	1.37
D9	Moor Farm	1.49	0.10	4.78	0.32
D10	East Farm Cottage	1.58	0.11	4.87	0.32
D11	Tilby-Dale (Residential)	2.35	0.16	5.64	0.38
D12	The Haven (residential	2.34	0.16	5.63	0.38
WSLs		1,500			

Note:
(a) *Inclusive of Background concentration of 3.29 µg/m³.*

15-Minute Mean for the Protection of Workers

~~8.~~Predicted ground level 15-min mean HF concentrations using 2021 met data (the year resulting in maximum short-term PC concentration) were assessed against the WSLs. The results of the model predictions at each discrete receptor, inclusive of background, are summarised in **Table 7-12.**

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Table 7-12. Summary of Predicted HF Concentrations (15-Min Mean) for the Protection of Workers – Scenario 2

ID	Name	Predicted 15-Min Mean Concentration HF (µg/m³)			
		Process Contribution (PC)	PC as %age of AQO	PEC [a] (PC+Background)	PEC % of WSLs
D1	Woods Farm	13.12	0.39	19.4	0.78%
D2	Grange Farm	9.21	0.27	15.5	0.62%
D3	The Cottage (residential)	11.71	0.35	18.0	0.72%
D4	Carisbrooke Farm	17.10	0.51	23.4	0.94%
D5	Slate House Farm	24.46	0.73	30.8	1.23%
D6	South View (Residential)	21.58	0.64	27.9	1.12%
D7	Davidson's Farm	23.89	0.71	30.2	1.21%
D8	Lowfield Farm	52.31	1.56	58.6	2.34%
D9	Moor Farm	64.99	1.94	71.3	2.85%
D10	East Farm Cottage	9.19	0.27	15.5	0.62%
D11	Tilby-Dale (Residential)	7.39	0.22	13.7	0.55%
D12	The Haven (residential	8.14	0.24	14.4	0.58%
WSLs		2,500			

Note:

[a] *Inclusive of Background concentration of 6.30 µg/m³*

From the table above, assessment results indicated that:

(1) The predicted HF Concentrations (8-hour Mean) at the selected receptor locations are below 8-hr workplace exposure limit of 1.5 mg/m³;

(2) The predicted HF Concentrations (15-Min Mean) at the selected receptor locations are below 15-min workplace exposure limit of 2.5 mg/m³; and

(3) The short-term HCL impact of a BESS fire on the selected receptors is sufficiently 'small'. The effect of a BESS fire on the receptors is considered to be insignificant.

~~7.3 Particulate Matter ($PM_{2.5}$)~~

~~There are no short-term (1-hour mean or 24-hour mean) air quality standards for $PM_{2.5}$.~~

~~The particulate matter emission impact has been assessed against (1) Particles (PM_{10}) 24-hour mean air quality standard of 50 µg/m³ and the WEL of 8-hour Mean for the Protection of Workers.~~

~~Short-Term (24-hr mean) Particulate Matter (PM_{10})~~

Predicted short-term (24-hour mean) PM_{10} concentrations were assessed against the relevant AQO using 2019 met data (the year resulting in maximum short-term PC concentration). The results of the model predictions at each discrete receptor, inclusive of background, are summarised in **Table 7-9**.

Table 7-9. The Short-Term (24-Hour Mean, 90.41th Percentile) Concentrations of PM_{10} at Key Receptors

Note: *(a) Inclusive of Background concentration of 15.42 µg/m³.*

As shown in **Table 7-9**, there are no exceedances of the short-term NO_2 AQO at any of the identified sensitive receptors. The predicted cumulative impacts are significantly below the AQO of 50 µg/m³.

Therefore, the predicted cumulative short-term PM_{10} concentrations from all source emissions are considered acceptable for the protection of human health.

8-Hour Mean for the Protection of Workers

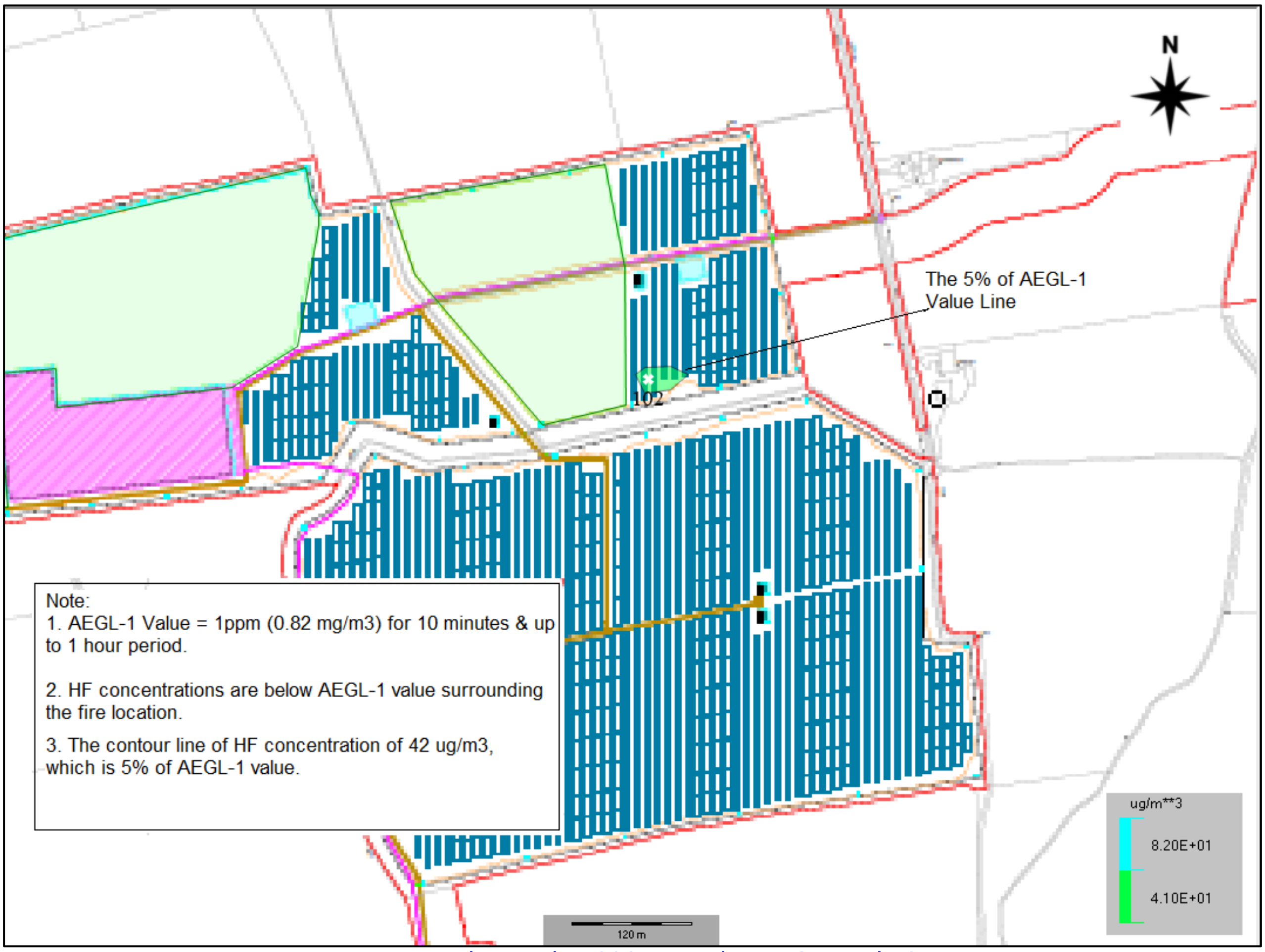
Predicted**HF Concentration Assessed against AEGL-1 Value**

The contour plots of the predicted ground level 8-hour mean PM_{10}15-minute HF concentrations using 20192021 met data (the year resulting in maximum short-term PC concentration) were assessed against the WSLs. The results of the model predictions at each discrete receptor, inclusive of background, are summarisedshown in **Figure 7-3Table 7-10**.

Table

Forma

Figure 7-10. Summary of **3.** Predicted PM_{10} Concentrations (8-Hourground level 15-minute HF



concentrations using 2021 met data – Scenario 2

From **Figure 7-3** it can be seen that.

Forma

(1) The predicted maximum HF concentrations (15-minute Mean) foris below the Protection of WorkersAEGL-1 Value = 1 ppm (0.82 mg/m^3) for 10 minutes & up to 1 hour period.

Note:

[a] *Inclusive of Background*The contour line of HF concentration of *15.42*41 µg/m^3, which is 5% of AEGL-1 value, is approximately 20 m away from

(2) From the table above, assessment results indicated that:fire location.

(1) The predicted PM_{10} Concentrations (8-hour Mean) at the selected receptor locations are below 8-hr workplace exposure limit of 4 mg/m^3;

(2) The short-term PM_{10} impact of a BESS fire on the selected receptors is sufficiently 'small'. The effect of a BESS fire on the receptors is It is considered tothat nearly all individuals can be insignificant.

(3) **Short-Term (24-hr mean) Particulate Matter (PM_{10}) – Worst-Case Assessment by Assuming a BESS Fire Being lasting**exposed for up to **24 Hours**1 hour without experiencing other than mild transient adverse health effects.

7.2.4 A worst-case scenario assessment has been undertaken by assuming a BESS fire being lasting for up to 24 hours. The predicted 24-hour mean PM_{10}Methane (CH_4)

The contour plots of the predicted ground level short-term (15-Min Mean) CH4 concentrations at 100%ile are compared to the UK daily air quality index. It is also assumed that the predicted PM_{10}surrounding the fire location were shown in **Figure 7-4** and assessed against the lower/upper explosive limits.

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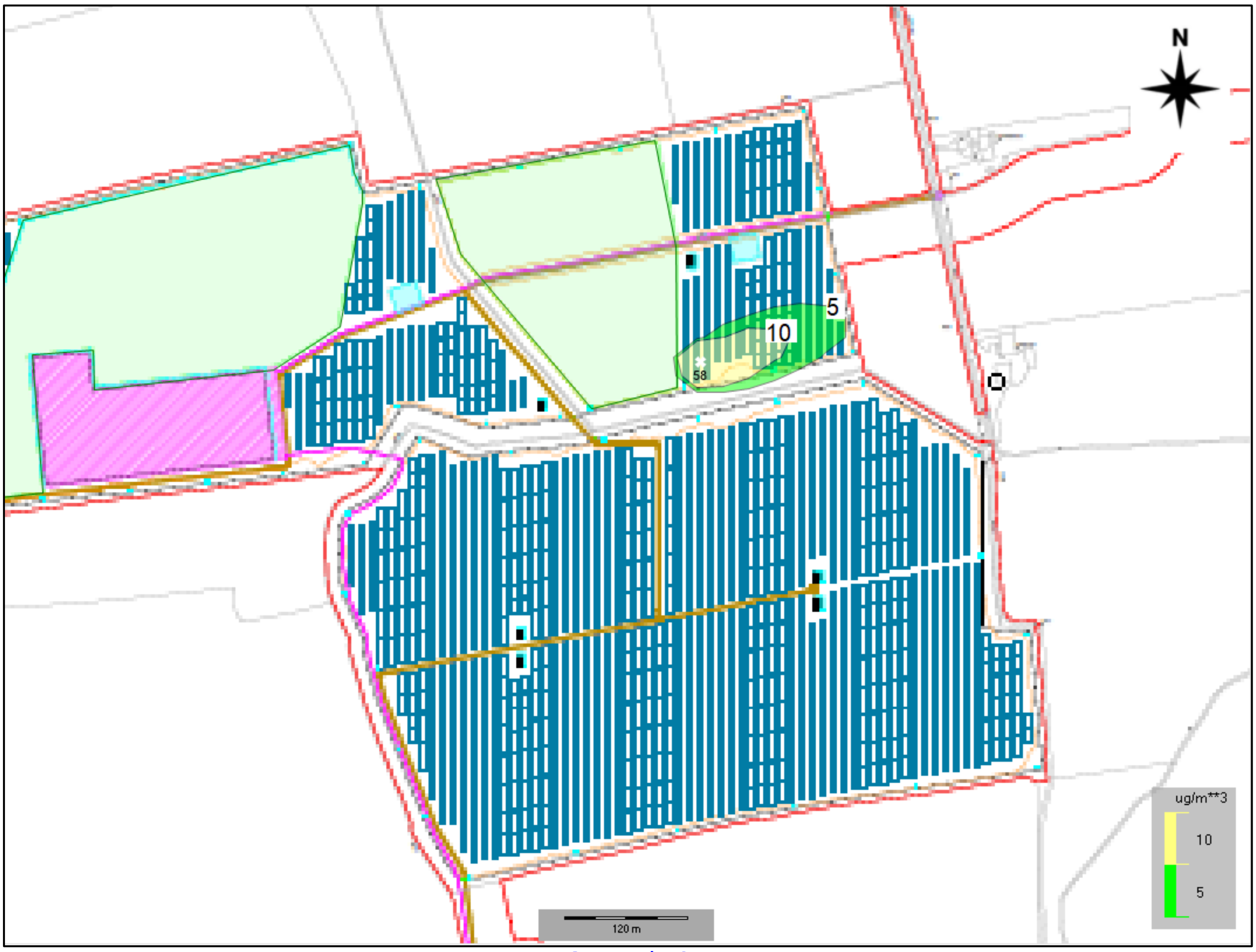
Figure 7-4. Predicted ground level short-term (15-Min Mean) CH4 concentrations ~~are 100% of $PM_{2.5}$~~



Scenario 2

From Figure 7-4 it can be seen that:

(1) The predicted maximum CH4 concentrations (15-minute Mean) is below the lower explosive limit of 5.33% CH_4 in air; and

(2) It is considered that it is unlikely that there is potential methane explosive risk surrounding the fire location if the BESS system is visibly burning, if a venting thermal runaway event occurs i.e. smoke and no flames then there is likely to be a significant localised explosive risk.

7.3 Sensitivity Study of BESS Fire at a Windy Condition

A sensitivity study has been undertaken to assess the HF pollutant impact under a high wind weather condition, for example, with a wind speed of 38 miles per hour (17m/s).

It is assumed that the wind is blowing from SW at the time of a fire, with a wind speed of 17 m/s.

Details of the main meteorological parameters used in the model are as below:

- Ground Surface temperature in degrees Celsius: 20 °C;
- Wind speed: 17 m/s
- Wind direction in degree: 225° (blow from SW) ;
- Precipitation in mm: 0;
- Cloud cover in Oktas: 2;
- Relative humidity in %: 95.

A series of 20 receptors, which were spaced at 10 m intervals has been defined at downwind locations from the fire location.

Two different receptor heights has been assessed: (1) impacts on the ground level receptors and (2) impacts on the receptor locations of 2 meters above the ground level.

The flume gas temperature used in the assessment is 1.000 °C to produce a worst-case assessment.

Table 7-13 presents the predicted ~~24-hour mean PM_{10}~~HF concentrations ~~at 100%ile at each discrete receptor, inclusive of background, are summarised in **Table 7-11**.~~both at ground level and at 2 metres above ground level and HF concentrations has been assessed against AEGL-1 Value of 0.82 mg/m^3

Table 7-13~~11.~~ ~~The Short-Term (24-Hour Mean, 100th Percentile)~~ Predicted HF Concentrations ~~of PM_{10} Assessed as $PM_{2.5}$ at Key Receptors~~under the High Wind Weather Condition

Receptor		Predicted 15-Min Mean Concentration HF (µg/m^3)			
		Concentrations at the Ground Level		Concentrations at 2 m above the Ground Level	
ID	Location	PEC [a] (PC+Background)	AEGL-1 Value of 0.82 mg/m^3 (820 µg/m^3)	PEC [a] (PC+Background)	AEGL-1 Value of 0.82 mg/m^3 (820 µg/m^3)
D1	5 m to Fire	33.05	< AEGL-1 Value	452.81	< AEGL-1 Value
D2	10 m to Fire	104.85	< AEGL-1 Value	127.56	< AEGL-1 Value
D3	20 m to Fire	76.07	< AEGL-1 Value	70.77	< AEGL-1 Value
D4	30 m to Fire	51.94	< AEGL-1 Value	48.11	< AEGL-1 Value
D5	40 m to Fire	37.95	< AEGL-1 Value	35.81	< AEGL-1 Value
D6	50 m to Fire	29.07	< AEGL-1 Value	27.88	< AEGL-1 Value
D7	60 m to Fire	23.48	< AEGL-1 Value	22.78	< AEGL-1 Value
D8	70 m to Fire	19.71	< AEGL-1 Value	19.28	< AEGL-1 Value
D9	80 m to Fire	17.05	< AEGL-1 Value	16.77	< AEGL-1 Value
D10	90 m to Fire	33.05	< AEGL-1 Value	14.90	< AEGL-1 Value

~~As shown in **Table 7-11**, the receptors of D8 and D9 will have 'moderate' UK Daily Air Quality Index in case of a BESS fire lasts up to 24 hours. All remaining receptors will have a 'low' DAQI.~~

~~Therefore, the action plans for the protecting human health in Chapter 8 will be implemented in the case a BESS fire.~~

The sensitivity study assessment results demonstrate that the predicted HF concentrations both at ground level and at 2 metres above ground level are all below the AEGL-1 Value of 0.82 mg/m^3. It is considered that nearly all individuals can be exposed for up to 1 hour without experiencing other than mild transient adverse health effects.

8.0 Action Plan for Protecting Human Health from a BESS Fire Smoke

8.1 BESS Fire Modelling Assessment Results

As discussed in Section 6.1, the 200 µg/m³ contour line of the short-term NO_2 concentrations is 200 m to 220 m away the BESS fire location and the 100 µg/m³ contour line of the short-term NO_2 concentrations, which is 50% of the short-term NO_2 AQS, is 300 m to 415 m away the BESS fire location.

8.2 National Operational Guidance: Control Measure – Cordon Control: Hazardous Materials

The 'National Operational Guidance: Control measure – Cordon controls: Hazardous materials' guidance is developed and maintained by the National Fire Chiefs Council (NFCC). The guidance provides emergency action codes in case of a fire which releases gases, vapours or dust.

The guidance is available on: https://www.ukfrs.com/guidance/search/cordon-controls-hazardous-materials.

The emergency action codes states the following:

> *"The Dangerous Goods Emergency Action Code List (EAC) gives the following information on public safety hazards. An 'E' following the first two characters of an EAC indicates that there may be a public safety hazard outside the immediate area of the incident, and that the following actions should be considered by first responders:*
>
> - *People should be told to stay indoors, with all doors and windows closed, preferably in upstairs rooms facing away from the incident. They should eliminate all ignition sources and stop any ventilation;*
> - *Effects may spread beyond the immediate vicinity. All non-essential personnel should be instructed to move at least 250m away from the incident;*
> - *Police and fire and rescue service incident commanders should consult with each other and with a product expert or a source of product expertise; and*
> - *The possible need for subsequent public evacuation should be considered, but it should be remembered that in most cases it will be safer to shelter-in-place than to evacuate".*

A key piece of information from the guidance which is used in considering the level of risk from a BESS fire at the proposed development states that "*All non-essential personnel should be instructed to move at least 250m away from the incident*".

~~8.3 Bess Fire Action Plan~~

~~Following factors have been considered and used in producing a BESS fire action plan for the protection of human health for surrounding residential receptors:~~

~~(1) The closest residential property boundary is located approximately 295 m away from the closest energy storage area boundary and the closest residential receptor is located approximately 320 m away from the closest BESS cabinet.~~

~~(2) A BESS fire would only produce a short-term impact in terms of surrounding environment;~~

~~(3) The National Fire Chiefs Council states that the effects (in case of a fire) may spread beyond the immediate vicinity and that all non-essential personnel should be instructed to move at least 250m away from the incident; and~~

~~(4) BESS fire modelling assessment results discussed in Section 6.1.~~

Whilst there is a low risk of adverse effects at the closest sensitive receptor location as a result of a potential BESS fire, ~~the following~~ good practice safety measures which are detailed in the document of "Outline Battery Storage Safety Management Plan, PINS reference: EN010133, Document reference APP/C7.9; APFP regulation 5(2)(q) " will be implemented immediately in the case of a fire~~:~~.

~~"The site manager/fire safety representative will need to assess the fire location(s), wind directions and surrounding receptors. The site manager/fire safety representative will take appropriate actions accordingly. The actions to be taken include:~~

~~(1) to inform any potentially affected residents, especially those that are located at downwind locations to the BESS fire;~~

~~(2) to cancel outdoor events and keep windows closed for any potentially affected residents, especially those that are located at downwind locations to the BESS fire; and~~

~~(3) to stop any farming activities and to move any farmers/workers within 500 m of the BESS fire to a cleaner air location."~~

~~A cleaner air location would preferably not be downwind, and be at a distance greater than 500 m from the BESS fire.~~

9.0 Substation Fire Impact Assessment and Fire Safety Procedures

9.1 Substation Fire Types

The risk of fire in substations has been proven historically to be low. However, the type of fire depends on the equipment and systems used in the stations, which can vary. Fires may involve the combustion of components including directional control valves, oil-insulated equipment and cables, transformer oil or PCB equipment.

9.2 National Grid Fire Safety Procedures

National Grid provide the following safety procedures in case of a substation fire (source: https://firstresponder.ngridsafety.com/substation-fires/):

- **Let it burn**. Burning electrical equipment is already ruined and will be replaced. Contact National Grid and wait for them to arrive. Under no circumstances should you enter the substation before National Grid personnel arrive.
- **Isolate the area** at least 300 feet in all directions. Keep unauthorised persons away.
- **Be alert** to the risk of transformer explosions, smoke hazards and oil releases. Stay upwind and consider initial downwind evacuation for at least 1,000 feet.
- **Monitor for oil runoff**; direct it away from catch basins or surface waters.
- **If an equipment fire must be suppressed**, utility personnel and your incident commander will tell you how to proceed.

9.3 Air Quality Impacts from a Substation Fire

Among the types of substation fire, a transformer oil fire may spread to form a pool of fire and may produce damage to the surrounding structures and impact on the surrounding environment.

In the case of a transformer oil fire, the fire may become intense/explosive and reach a fully developed stage in a relatively short period. Conversely, a transformer oil fire also quickly reaches a decay stage when the temperature/heat release decreases and intensity reduces. According to the published article '*Full scale experimental and numerical simulation of outside transformer fire'* (Y.H. Hu, et al, Journal of Physics: conference Series, 2387 (2002) 012012), the heat flux will begin decreasing within 5 minutes of the onset of the fire. This demonstrates that, although a transformer oil fire may be intense, it will last a relatively short period of time at a fully developed stage and, as such, it is highly unlikely that the 1-hour or 24-hour air quality standards will be breached, due to duration alone. In addition, the short-term nature of any substation fire would mean that the long-term air quality impact on surrounding receptors from a transformer fire will not be significant. On this basis, it is considered that a more detailed assessment of substation fires is not required.

9.4 Substation Fire Action Plan

In addition to following the National Grid's safety procedures, the substation fire safety procedures (which are same as BESS safety procedures) will be implemented in the case of a substation fire.

Substation Fire Action Plan

Good practice safety measures have been identified to be implemented in the case of a substation fire. Those measures include:

> *"The site manager/fire safety representative will need to assess the fire location(s), wind directions and surrounding receptors. The site manager/fire safety representative will take appropriate actions accordingly. The actions to be taken include:*
>
> *(1) to inform any potentially affected residents, especially those that are located at downwind locations to the substation fire;*
>
> *(2) to cancel outdoor events and keep windows closed for any potentially affected residents, especially those that are located at downwind locations to the substation fire; and*

(3) to stop any farming activities and to move any farmers/workers within **Substation Fire Action Plan**

Good practice safety measures have been identified to be implemented in the case of a substation fire. Those measures include:

> *"The site manager/fire safety representative will need to assess the fire location(s), wind directions and surrounding receptors. The site manager/fire safety representative will take appropriate actions accordingly. The actions to be taken include:*
>
> *(1) to inform any potentially affected residents, especially those that are located at downwind locations to the 500substation fire;*
>
> *(2) to cancel outdoor events and keep windows closed for any potentially affected residents, especially those that are located at downwind locations to the substation fire; and*
>
> *(3) to stop any farming activities and to move any farmers/workers within 300 m of the substation fire to a cleaner air location."*

A cleaner air location would preferably not be downwind, and be at a distance greater than 500300 m from the substation fire.

10.0 Conclusions

Tetra Tech have undertaken a potential air quality impact assessment from a BESS fire incident in support of a planning application for the Cottam Solar Project (the 'Scheme').

The objective of the BESS fire impact assessment is to determine whether the impacts from a panel fire meet the required air quality standards (AQSs) or workplace exposure limit (WELs) for the protection of human health or worker's health.

The detailed modelling results have been presented in terms of the emitted pollutant PC and PEC. AERMOD modelling was undertaken for the most representative meteorological dataset and the worst-case, highest predicted long-term and short-term PECs were compared to the appropriate AQOs / EALs or relevant impact assessment criteria.

Three impact assessment scenarios have been undertaken:

- Scenario 1 – Assessment of a fire plume at temperatures of 800°C and the associated gas volume generation under this temperature;
- Scenario 2 – Assessment of a fire plume at temperatures of 1,000°C and the associated gas volume generation under this temperature; and
- Scenario 3 – A sensitivity study of pollutant impacts under a high wind weather condition – a wind speed of 38 miles per hour (17m/s).

Air Quality Impact Assessment Results for a BESS Fire

The pollutants assessed have been selected based on a U.S. organisation, the Fire Protection Research Foundation (FPRF), published a report of '*Hazard Assessment of Lithium-Ion Battery Energy Storage Systems, February 26, 2016*' and the sampled pollution emissions from a UK battery testing facility. The assessment of impacts from the PM_{10} and $PM_{2.5}$ emissions was undertaken in accordance with UKHSA's recommendations.

The predicted short-term environmental concentrations of NO_2 at the residential receptor locations from a BESS fire incident are all below the relevant UK air quality objective for the protection of human health for both Scenario 1 and Scenario 2.

A worst-case scenario NO_2 impact assessment has been undertaken by assuming that a BESS fire would last for up to 24 hours. It should be noted that a fire which lasted for a short period of time, for example 1-hour, would result in lower levels of air pollution at sensitive receptors than those predicted for the worst-case assessment undertaken. The worst-case assessment results show that two receptors would experience a 'High' air pollution level on the UK Daily Air Quality Index (DAQI) should a fire keep going for up to 24 hours, whilst all other receptors will have 'low' air pollution level on the DAQI. Therefore, the action plans for the protection of human health will be implemented in the case of a BESS fire to move people away from these receptor locations.

All receptors will have a 'low' air pollution level on the DAQI based on short-term NO_2 pollution index for both Scenario 1 and Scenario 2.

The short-term predicted environmental concentrations of CO at the residential receptor locations from a BESS fire incident are below the relevant air quality objectives for the protection of human health for both Scenario 1 and Scenario 2.

The predicted ground level 8-Hour mean and 15-min mean of HCl and HF concentrations at the residential receptor locations are all below the relevant British occupational exposure limits. The short-term HCL and HF impact of a BESS fire at the receptors is sufficiently 'small'. The effect of a BESS fire on the receptors is insignificant for both Scenario 1 and Scenario 2.

The predicted short-term (24-hour mean) environmentalmaximum HF concentrations of PM_{10} at the residential receptor locations from a (15-minute Mean) is below the AEGL-1 Value for 10 minutes & up to 1 hour period for both Scenario 1 and Scenario 2.
It is considered that it is unlikely that there is potential methane explosive risk surrounding the fire location if the BESS fire incidentsystem is visibly burning, if a venting thermal runaway event occurs i.e. smoke and no flames then there is likely to be a significant localised explosive risk.
The sensitivity study assessment results of HF impact under a windy condition demonstrate that the predicted HF concentrations are all below the relevant air quality objectives for the protection of human health.

A worst-case scenario PM_{10} impact assessment has been undertaken by assuming that a BESS fire would last up to 24 hours, as the air quality standard of short-term averaging period for PM_{10} is measured as 24-hour mean. It should be noted that a fire which lasted for a short period of time, for example 1-hour, would result in lower levels of air pollution at sensitive receptors than those predicted for the worst-case assessment undertaken. The worst-case assessment results show that two receptors would experience a 'moderate' air pollution level on the UK DAQI should a fire keep going for up to 24 hours, while all other receptors will have 'low' air pollution level on the DAQI. However, the action plans for the protecting human health will be implemented immediately in all cases of a BESS fire incident.

BESS Fire Action Plan

AEGL-1 (Acute Exposure Guideline Level 1).

BESS Fire Action Plan

The assessment concludes that there is a low risk of adverse effects at the closest sensitive receptor location as a result of a potential BESS fire. Good practice safety measures which are detailed in the document 'Outline Battery Storage Safety Management Plan, PINS reference: EN010133, Document reference APP/C7.9; APFP regulation 5(2)(q)' will be implemented immediately in the case of a fire.

Substation Fire Action Plan

Good practice safety measures have been identified to be implemented in the case of a BESSsubstation fire. Those measures include:

> *"The site manager/fire safety representative will need to assess the fire location(s), wind directions and surrounding receptors. The site manager/fire safety representative will take appropriate actions accordingly. The actions to be taken include:*
>
> *(1) to inform any potentially affected residents, especially those that are located at downwind locations to the BESS fire;*
>
> *(2) to cancel outdoor events and keep windows closed for any potentially affected residents, especially those that are located at downwind locations to the BESS fire; and*
>
> *(3) to stop any farming activities and to move any farmers/workers within 500 m of the BESS fire to a cleaner air location."*

A cleaner air location would preferably not be downwind, and be at a distance greater than 500 m from the BESS fire.

Units and Abbreviations Used

ADMS	An advanced distribution management system
ASR	Annual Status Report
AQAP	Air Quality Action Plan
AQO	Air Quality Objectives
AQMA	Air Quality Management Area
~~CHP~~	~~Combined Heat and Power~~
CLJSPC	The Central Lincolnshire Joint Strategic Planning Committee
DEFRA	Department for Environment, Food and Rural Affairs
DPD	Development Plan Document
EA	Environment Agency
EAL	Environmental Assessment Level
EC	European Commission
EPAQS	Expert Panel on Air Quality Standards
EPUK	Environmental Protection UK
ES	Environment Statement
EU	European Union
g/s	Gram per second
°C	Temperature (in Celsius)
IAQM	Institute of Air Quality Management
LA	Local Authority
LAQM	Local Air Quality Management
MHCLG	The Ministry for Housing, Communities and Local Government
m/s	Velocity (in metres per second)
µg/m^3	Concentration (in micrograms per cubic metre)
m^3/s	Volumetric flow rate (in cubic meters of air per second)
mg/Nm^3	Concentration (in milligrams per cubic metre at standard conditions)
mg/s	Emission rate (in milligrams per second)
MW	Megawatts
UK NGR	UK National Grid Reference
NO_2	Nitrogen dioxide
NO_X	Total oxides of nitrogen
NPPF	National Planning Policy Framework
PAHs	polycyclic Aromatic Hydrocarbons
PC	the process contribution

PEC	the predicted environmental concentration
PM	Particulate Matter
PM_{10}	Particulate matter with a mean hydraulic diameter less then 10µm
$PM_{2.5}$	Particulate matter with a mean hydraulic diameter less then 2.5µm
PPG	Planning Policy Guidance
PPS	Planning Policy Statements
PV	Photovoltaic
%ile	Percentile
%(v/v)	Percentage (volume per volume)
TETRA TECH	Tetra Tech Limited
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

Appendix A – Terms & Conditions

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