West Burton Solar Project

Environmental Statement Addendum:

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

Prepared by: Tetra Tech Limited

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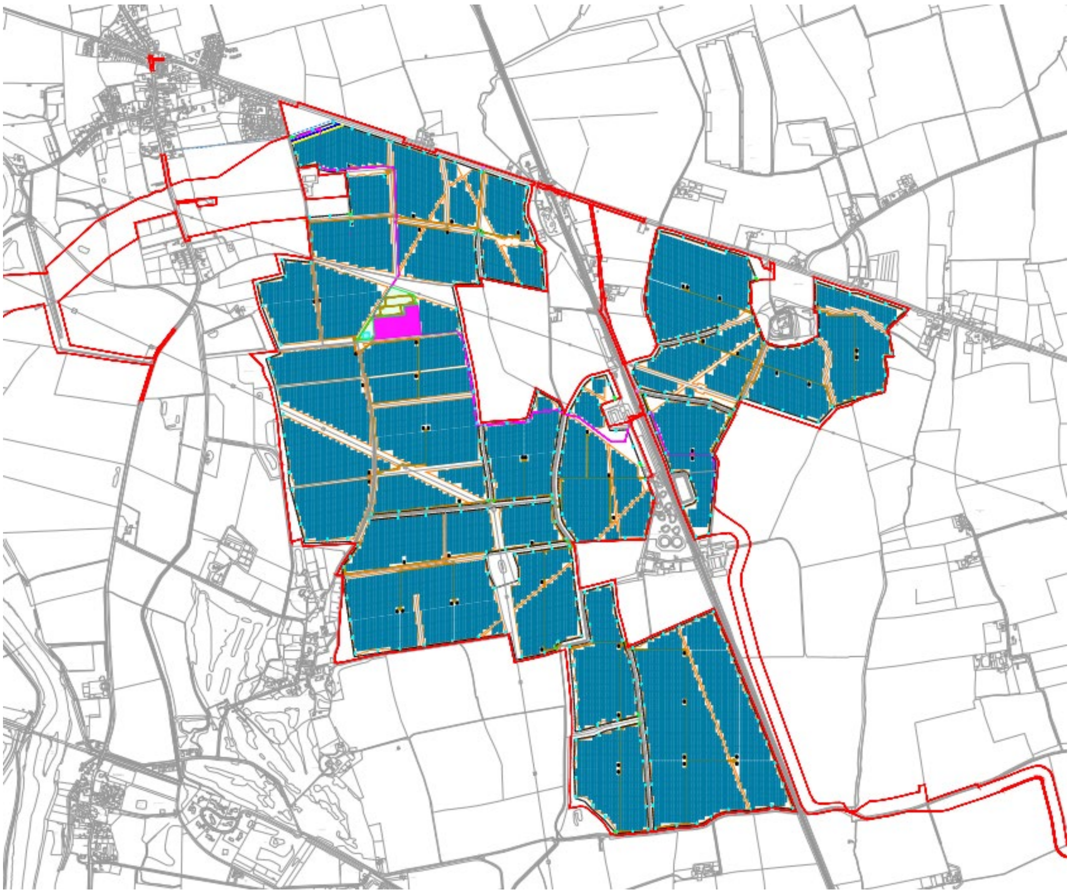
APFP Regulation 5(2)(q)

West Burton
SOLAR PROJECT

Island Green Power Limited

West Burton Solar Project

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



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Issue	Date	Status
1	14th December 2022	First Issue of a Technical Note – The Technical Note was titled as "*Air Quality Assessment on Emission Impact from the Battery Energy Storage Systems (BESS) Fire*"
2	8th December 2023	Second Issue – The technical note was updated using burn test emission data from LFP battery modules that are typically integrated into BESS systems
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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 workers.

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 Fluoride (HF) concentrations at the residential receptor locations are all below the relevant British occupational exposure limits. The short-term HF impact of a BESS fire at the receptors is sufficiently ‘small’. The effect of a BESS fire on the receptors is insignificant.

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 all below the AEGL-1 (Acute Exposure Guideline Level 1) with the exception of the HF concentrations being above the AEGL-1 at 2 metres above ground level and close to fire, for example, 5 metres away from the fire location.

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: EN010132, Document reference EX3/WB7.9_A; 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 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 300 m from the substation fire.

1.0 Introduction

Tetra Tech Limited have prepared a potential air quality impact assessment from a BESS fire incident in support of the application for development consent for the West Burton Solar Project (the 'Scheme').This assessment has been prepared to support the updated **7.9_A Outline Battery Safety Management Plan Revision A [EN010132/EX3/WB7.9_A]** and to provide consistency with submissions made into the Examination for the Cottam Solar Project PINS reference EN010133. The Applicant considered that this would be helpful to the Examining Authority and Interested Parties in their understanding of the Battery Energy Storage System (BESS).

- The West Burton Solar Project consists of three land parcels (the 'Site" or "Sites") described as West Burton 1, 2, and 3, 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 480 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 BESS Fire Incident Assessment Technical Note

Tetra Tech previously issued the following report, which was submitted as part of the DCO application:

- **BESS Fire Technical Note**

  Tetra Tech has undertaken a fire incident impact assessment and produced a report titled '*Potential Air Quality Impact Assessment from a Fire Incident*' (dated 1st February 2023), which was submitted as **ES Appendix 17.4 BESS Fire Technical Note [APP-136]**.

  The technical note was produced based on results of assessment undertaken by Tetra Tech to determine the potential impact of a 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 will be developed and implemented in the case of a BESS fire.

1.2 UK Health Security Agency Comment Letters

While undertaking the fire risk assessment for West Burton Solar Project, Tetra Tech were conducting the fire risk assessment for Cottam Solar Project [PINS reference EN010133] at the same time. Both projects are being developed by Island Green Power. The BESS on the West Burton Solar Project is proposed to have a maximum footprint of 1.75ha, the Cottam Solar Project BESS will have a maximum footprint of 15.2ha. Therefore the West Burton BESS is significantly smaller than the Cottam BESS.

To date the only formal comments that have been submitted by the UK Health Security Agency on the West Burton Solar Project into the examination was as a Relevant Representation **[RR-341**] and raised no issues. Their comments stated that "*We can confirm that: With respect to Registration of Interest documentation, we are reassured that earlier comments raised by us on 08 January 2023 have been addressed. In addition, we acknowledge that the Environmental Statement (ES) has not identified any issues which could significantly affect public health. UKHSA/OHID is satisfied with the methodology used to undertake the environmental assessment. Following our review of the submitted documentation we are satisfied that the proposed development should not result in any significant adverse impact on public health. On that basis, we have no additional comments to make at this stage and can confirm that we have chosen NOT to register an interest with the Planning Inspectorate on this occasion.*"

After reviewing the Cottam Solar Project ES chapter on air quality [EN010133/ APP-052], the UKHSA issued two letters with comments relevant to the Cottam project. The sections of UKHSA's letters which are relevant, 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 have undertaken further consultation with the UK Health Security Agency on behalf of the Cottam Solar Project in response to the letters referred to above. Whilst the following correspondence relates to Cottam Solar Project, the Applicant considers that it provides useful background and context to the updates made to this document for the Scheme as many of the comments apply to both projects.

Tetra Tech sent an email on the Cottam Solar Project 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 to discuss Cottam Solar Project. 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, HCI, 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 were not included in the assessment, and only NO_2 was included for completeness.

The Air Quality Impact Assessment of Battery Energy Storage Systems (BESS) Fire report for the Cottam Solar Project presents the BESS fire risk assessment results and was submitted into the Cottam Solar Project examination at deadline 1 [EN010133/REP-079].

The Solar Panel Fire Risk Assessment results for Cottam Solar Project were 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 and this report was also submitted in to the Cottam Solar Project examination at deadline 1. [EN010133/REP-078]).

The UK Health Security Agency (UKHSA) reviewed the two fire risk assessment reports produced for Cottam Solar Project: (i) the solar panel fire incident impact assessment report, and (ii) the BESS fire incident impact report and confirmed in a letter dated 23rd August 2023 that for Cottam Solar Project there were no outstanding issues between the UK HSA and the Applicant and therefore there was no need for a Statement of Common Ground for the Cottam Solar Project.

As no issues were raised by the UK HSA in respect of the Scheme, it was not considered necessary to progress a Statement of Common Ground with the UK HSA for the Scheme.

As the UK HSA did not request any additional solar panel fire risk assessment in respect of the Scheme, the Applicant has only prepared this BESS fire risk assessment for the Scheme.

1.4 BESS Fire Risk Assessment Update for West Burton Solar Project Using LFP Battery Modules Test Data

Building upon the fire risk assessment works for Cottam Solar Project, this BESS fire risk assessment note includes BESS burn test emission data from LFP battery modules compared to the latest version submitted for the Cottam Solar Project.

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

1.5 Scheme Location

The development (the Scheme) consists of 3 areas named West Burton 1, West Burton 2 and West Burton 3. The details of the locations are presented below and in **Figure 1-1**.

- West Burton 1 – which is located approximately 7 km northwest of Lincoln;
- West Burton 2 – which is located approximately 8 km northwest of Lincoln; and
- West Burton 3 – which is located approximately 12 km northwest of Lincoln.

The proposed development sites are mainly surrounded by agriculture areas.

The electrical substation location within the West Burton 1 area is shown in **Figure 1-2.**

The electrical substation location within the West Burton 2 area is shown in **Figure 1-3.**

The energy storage area and the electrical substation location within the West Burton 3 area are shown in **Figure 1-4.**

The detailed layout plan of the energy storage area and the electrical substation within the West Burton 3 area is shown in **Figure 1-5.**

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

Figure 1-1. Site Locations

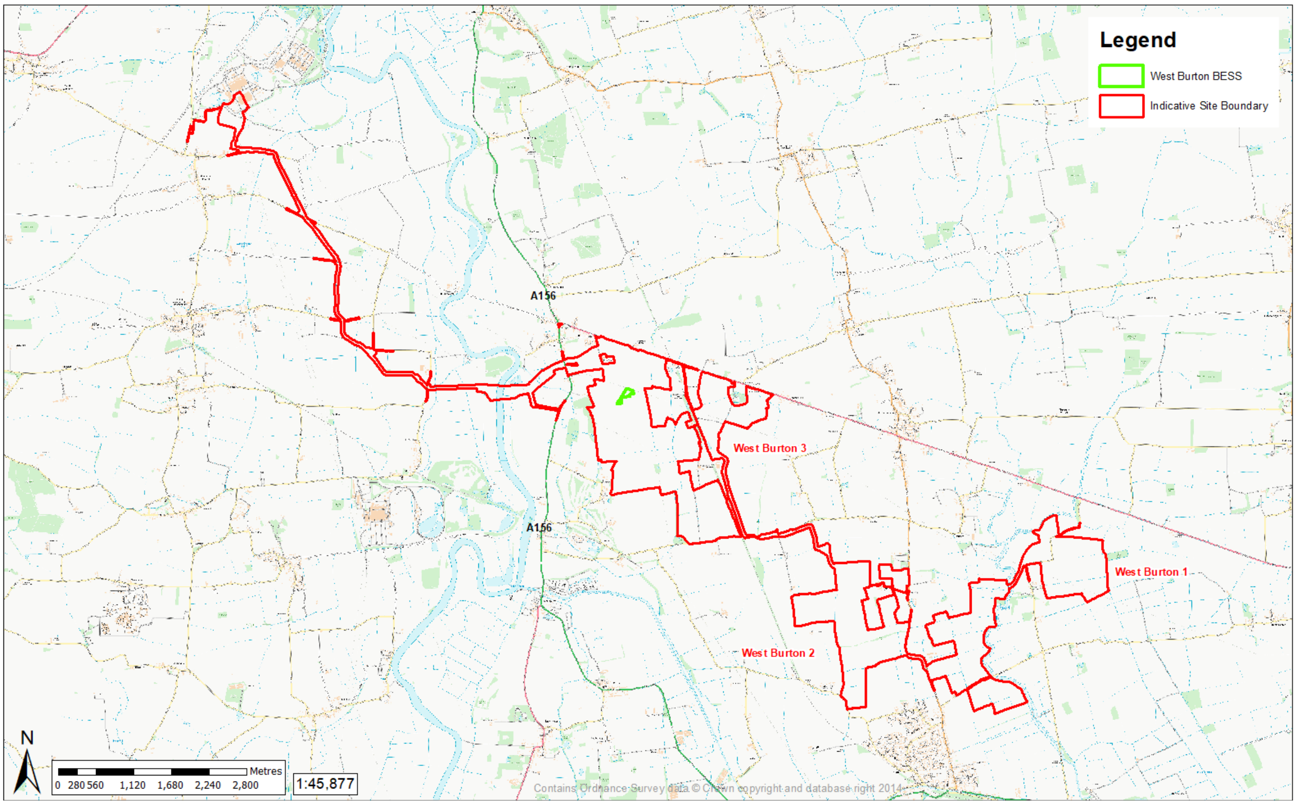


Figure 1-2. West Burton 1 – Electrical Substation

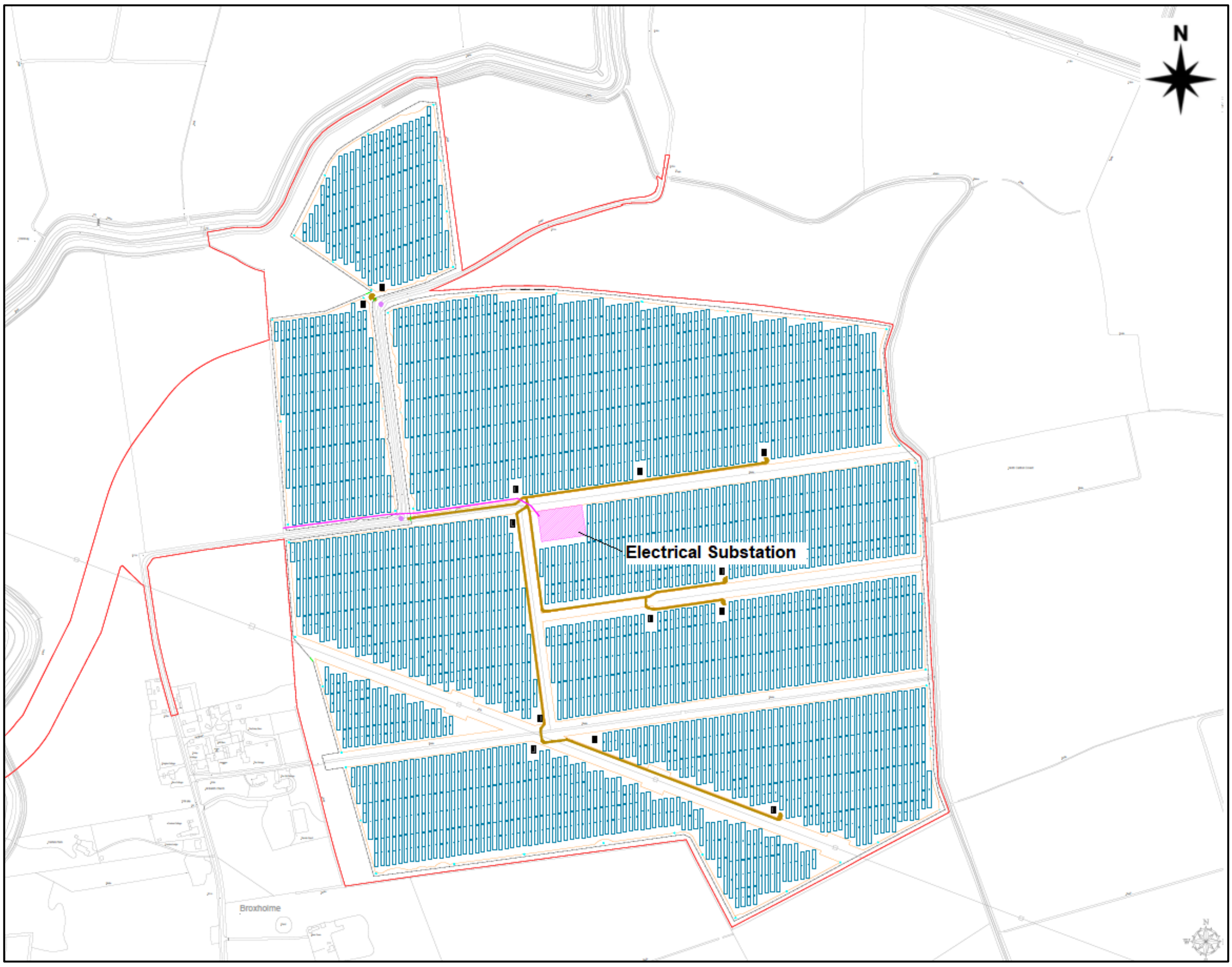


Figure 1-3. West Burton 2 – Electrical Substation

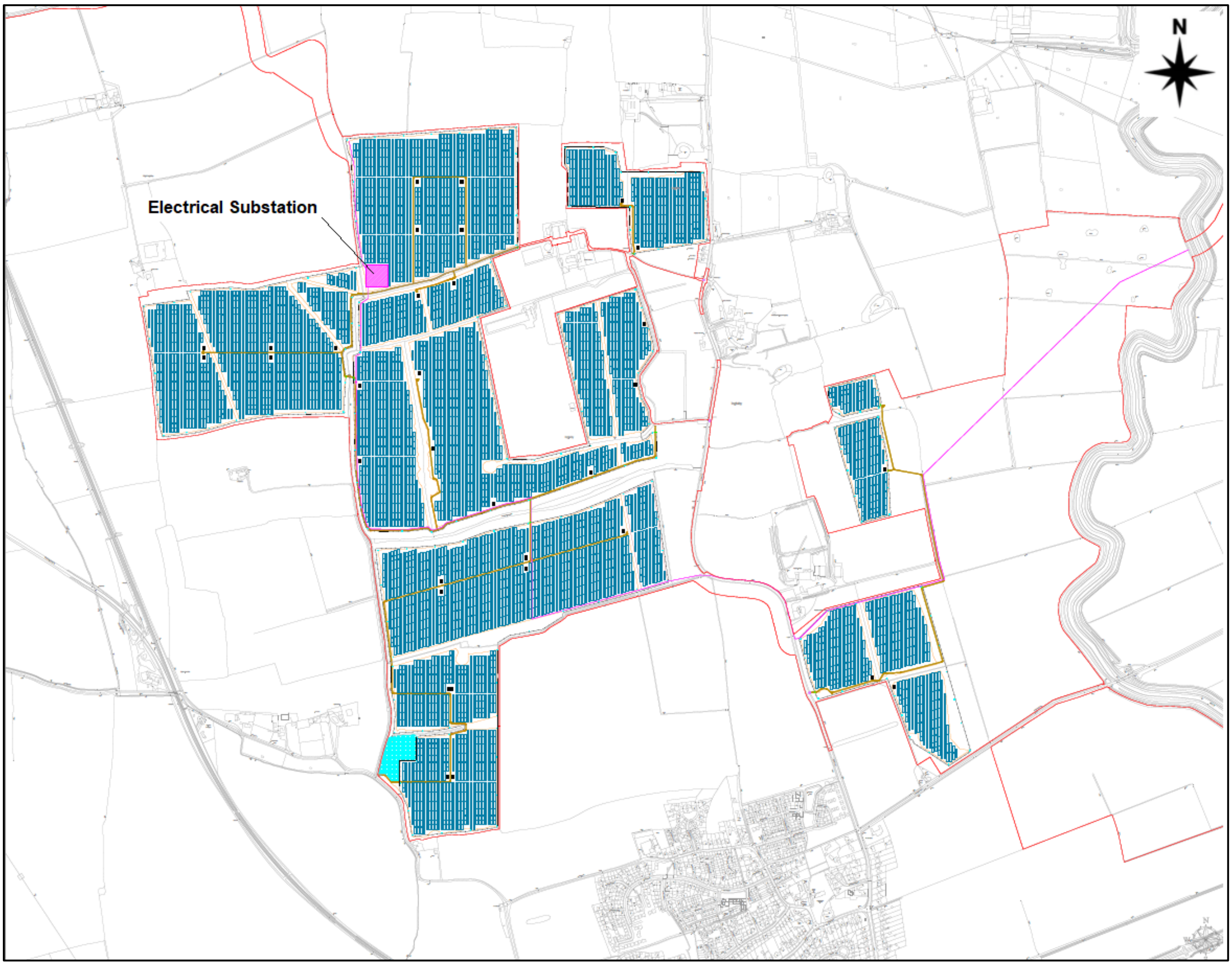
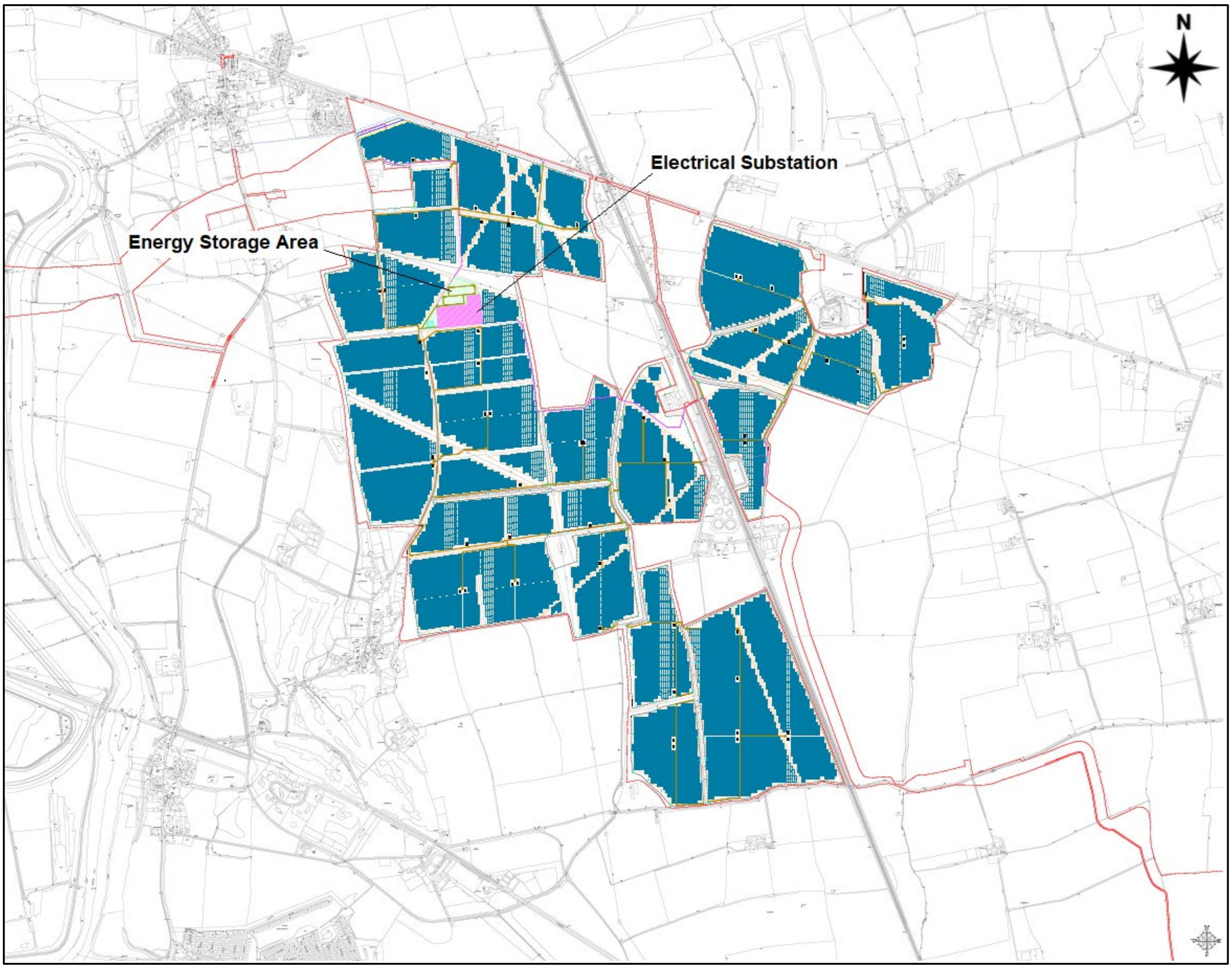


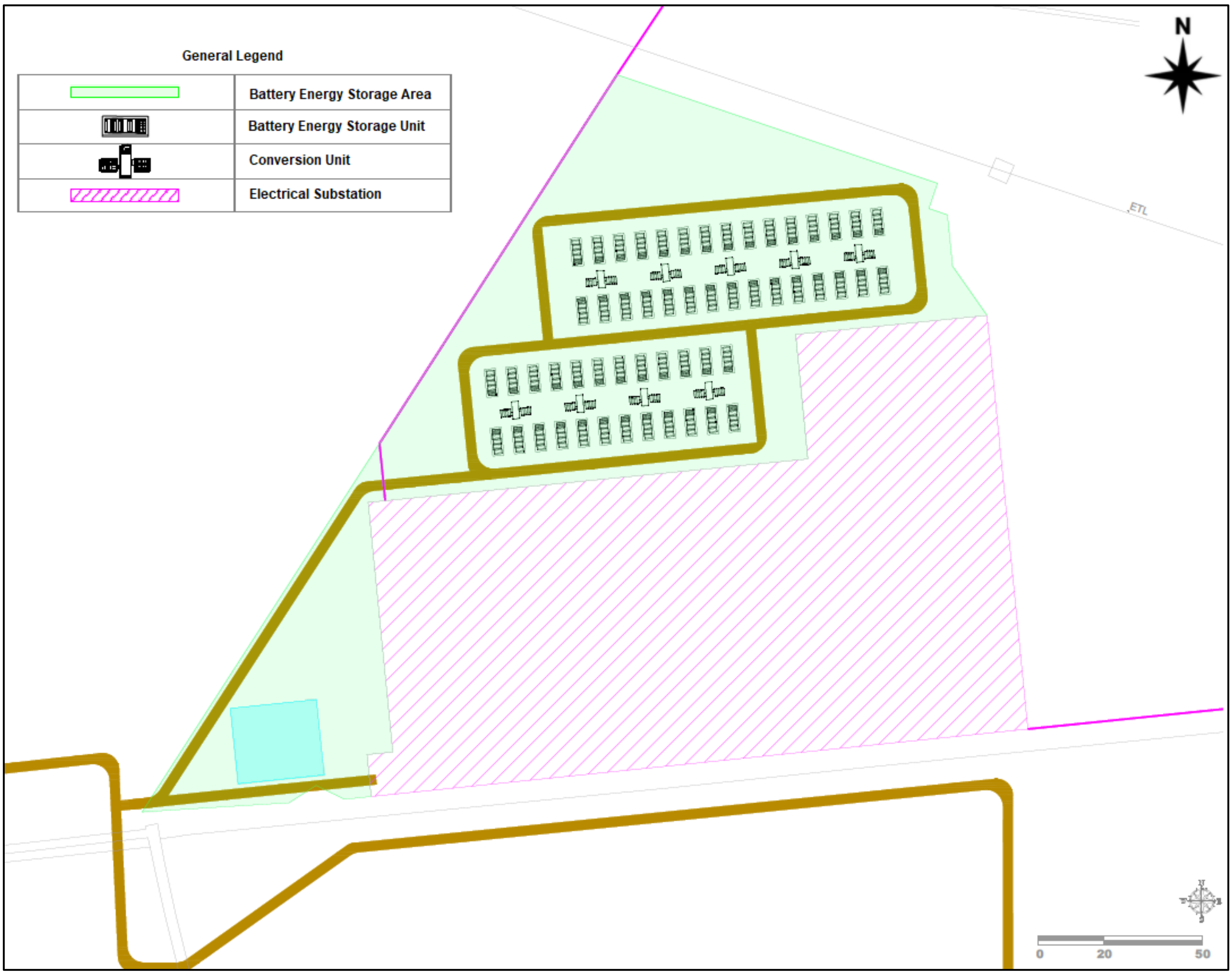
Figure 1-4. West Burton 3 – Energy Storage Area & Electrical Substation



1.6 The BESS Site Location

The BESS is located in the West Burton 3 area. The battery energy storage and electrical substation area are located next to each other, as presented in **Figure 1-5**.

Figure 1-5. BESS and Substation Layout Plan – West Burton 3



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** 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/m^3 not to be exceeded more than 18 times a year	1-Hour Mean	31st December 2005	200µg/m^3 not to be exceeded more than 18 times a year	1st January 2010	Retain Existing
	UK	40µg/m^3	Annual Mean	31st December 2005	40µg/m^3	1st January 2010	
CO	UK	10mg/m^3	Maximum daily 8 Hour Mean	31st December 2004	10mg/m^3 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.

HF and Respirable Dust Workplace Exposure Limits

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

Table 2-2. Work Exposure Limits for HF

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. 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%; and
- 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	10 minutes & up to 1 hour	1 ppm	10 minutes & up to 1 hour
	1.64 mg/m^3		0.82 mg/m^3	

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).

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:

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 280 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 and CH_4.

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 present the BESS fire incident impact assessment methodologies and assessment results.

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 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:

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)';

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;
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;
6. The effects can be adverse when pollutant concentrations increase or beneficial when concentrations decrease as a result of development;
7. The judgement of overall impact description of the effects is then based on severity of effects on all the individual receptors considered; and,
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 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 NO_2 has been used in the assessment.

The boundaries between index points for NO_2 are presented in **Table 4-2.**

Table 4-2. 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

5.0 Baseline Conditions

This section provides a review of the existing baseline air quality 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 consist 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.

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** below.

Table 5-1. Defra Predicted Background Concentrations

Council	Area	UK NGR (m)		2021 Predicted Background Concentration - Annual Mean (µg/m^3)		
		X	Y	NO_x	NO_2	CO
West Lindsey District	West Burton 3	485500	380500	9.31	7.34	109

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.

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].

5.2 Background Data used in the Assessment

As the site is located in a rural area, the NO_2 background concentration of 7.34 µg/m^3, which was derived from Defra background mapping data, has been used in the assessment.

The background concentrations of 109 µg/m^3 for CO and 2.35 µg/m^3 for HF have been used for the purposes of the assessment.

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

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 Modules (372,736 kWh);

- Number of racks in one cabinet: 2 (746,427 kWh); 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. It is assumed that a steady or rapid propagation will occur and 2 racks in one cabinet will be on fire at one time.

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 test 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.

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 and CH_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. A fire/thermal runaway being taking place inside one cabinet which consists of 2 racks of battery modules;
2. 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
4. Two different gas volumes associated with the different plume gas temperatures, one at gas temperature of 800°C and other at gas temperature of 1000°C, from the testing results using a LFP battery at the battery testing facility.

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

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 (diameter)	0.172	m
Gas Escaping Area at gas temperature of 1,000 °C (diameter)	0.203	m
Fire gas Escaping Height	2.8	m

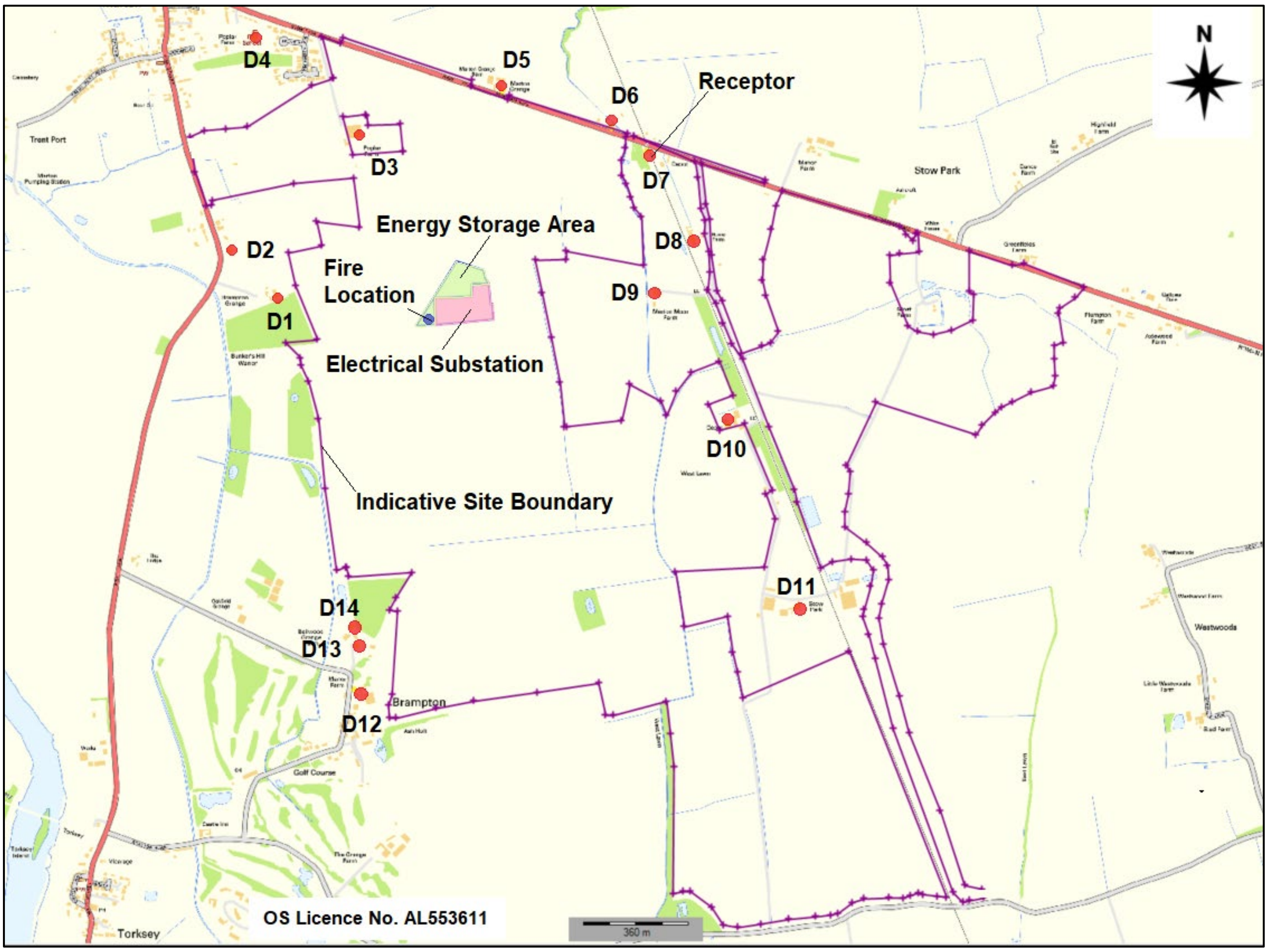
Note:

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

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

The selected fire location is within the 6.4.4.4 West Burton Energy Storage, Illustrative Layout Plan [APP-145] where the battery energy storage unit is located, as near as possible to 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).

6.6 Receptors

6.6.1 Discrete Receptors

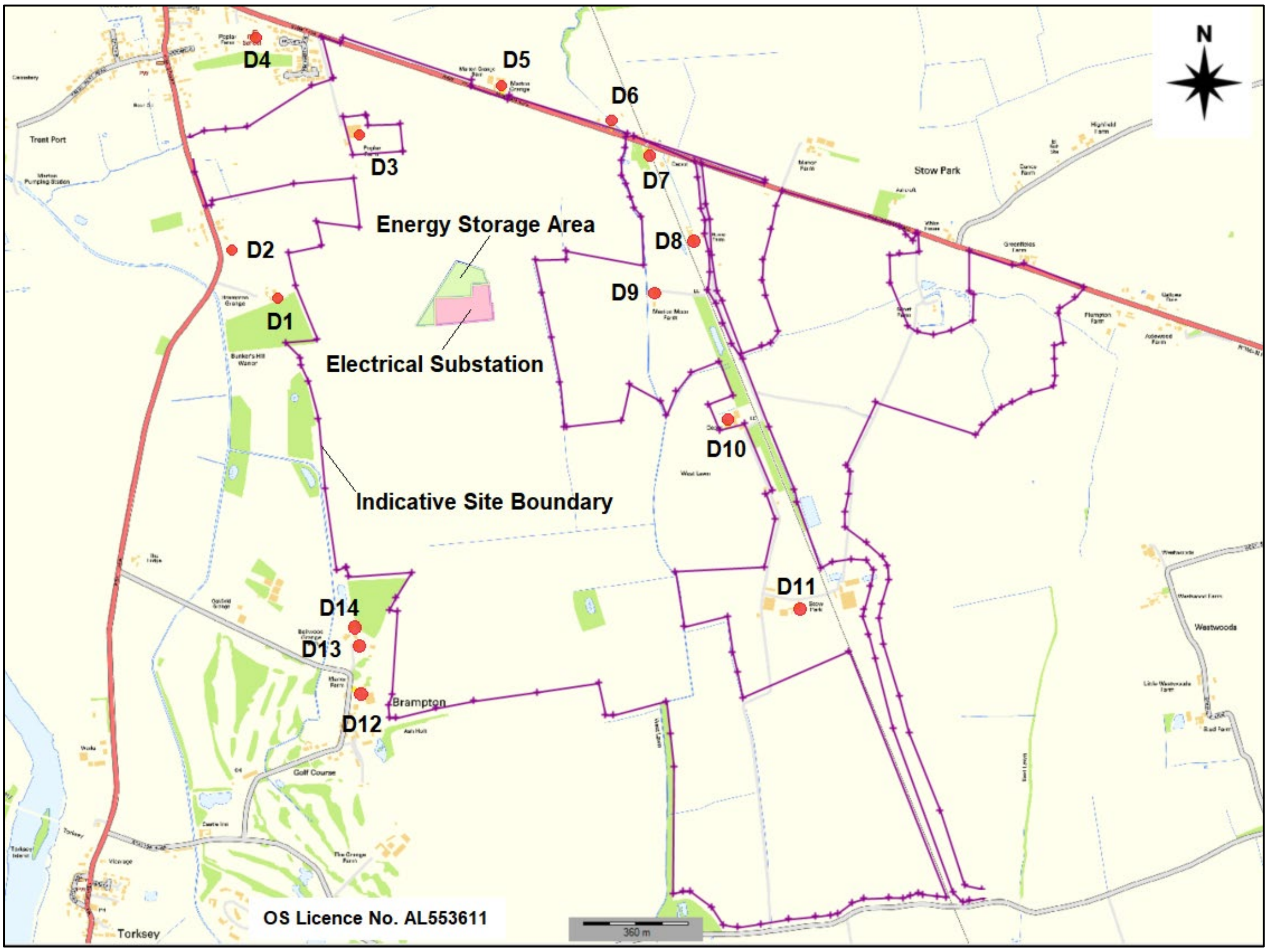
The residential receptors surrounding the BESS site boundary will be incorporated into the modelling. The selected residential receptors are presented in **Table 6-2** and shown in **Figure 6-2**.

Table 6-2. Modelled Sensitive Receptors

Discrete Sensitive Receptor		UK NGR (m)		Bearing from Site	Approx. Distance from Solar Farm Site Redline Boundary (m)	Approx. Distance from the Receptor location (m)
		X	Y			
D1	Brampton Grange, High Street	484374	380954	W	80	510
D2	67 High Street Marton	484213	381113	NW	180	740
D3	Poplar Farm	484650	381509	NNW	50	670
D4	The Marton Academy, Stow Park Road	484294	381842	NW	250	1150
D5	Marton Grange	485150	381664	N	20	840
D6	South View, Stow Park	485524	381534	NE	20	910
D7	Station House, Stow Park	485649	381456	NE	50	940
D8	Home Farm	485804	381149	ENE	50	950
D9	Marton Moor Farm	485675	380969	E	110	780
D10	Depot	485926	380511	SE	5	1070
D11	Stow Park (Farm)	486164	379887	SE	170	1600
D12	Manor Farm	484640	379602	S	120	1300
D13	Bellwood Cottage, Brampton	484648	379753	S	160	1150
D14	Bellwood Grange Farm	484630	379819	S	150	1080

It should be noted that the approximate distance between the modelled fire location and receptor location has been measured as a worst-case from the boundary of the Energy Storage Area to each individual residential property boundary. The closest residential property boundary is located approximately 510 m away from the closest energy storage area boundary.

Figure 6-2. Modelled Sensitive Receptor Locations



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).

Burton Wood Ancient & Semi-Natural Woodland is located to the north of the site and approximately 1200m to the solar farm redline boundary at its closest point but is more than 2 km away from the BESS area boundary.

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.

6.6.3 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 25 m x 25 m over an area covering 1000 m by 1000 m with south-west corner UK NGR (m) of 484400, 380400.

6.7 Meteorological Data

The meteorological data (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** for an illustration of the prevalent wind conditions at the weather station.

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.

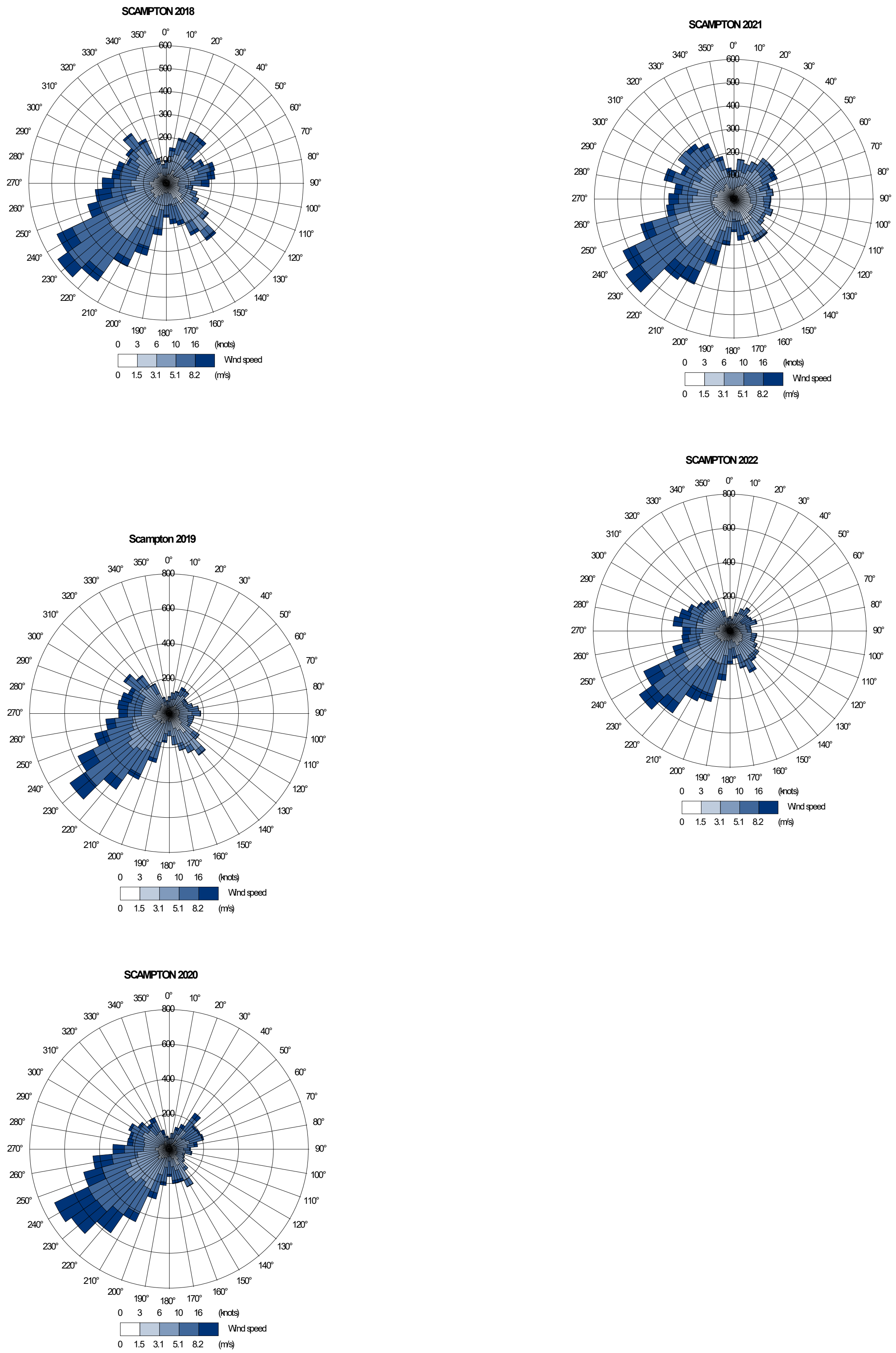
6.9 Buildings in the Modelling Assessment

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.

6.10 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



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 – 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 testing results using a LFP battery at 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

7.1.1 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 5 years of meteorological data assessed are compared against the relevant AQS, in **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	0.226	0.11	14.91	484374	380954
NO_2	2019	0.415	0.21	15.10	484650	381509
NO_2	2020	0.334	0.17	15.01	484374	380954
NO_2	2021	0.528	0.26	15.21	484374	380954
NO_2	2022	0.482	0.24	15.16	484374	380954
AQOs	200					

Note:

(c) Inclusive of Background concentration of 147 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 15.21 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. 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 ($\mu g/m^3$)– 2021 Met Data			
	Process Contribution (PC)	PC as %age of AQO	PEC[(a)] (PC +Background)	PEC as %age of AQO
D1	0.53	0.26	15.21	7.6%
D2	0.32	0.16	15.00	7.5%
D3	0.36	0.18	15.04	7.5%
D4	0.14	0.07	14.82	7.4%
D5	0.23	0.12	14.91	7.5%
D6	0.20	0.10	14.88	7.4%
D7	0.17	0.09	14.85	7.4%
D8	0.17	0.09	14.85	7.4%
D9	0.23	0.11	14.91	7.5%
D10	0.16	0.08	14.84	7.4%
D11	0.07	0.04	14.75	7.4%
D12	0.09	0.05	14.77	7.4%
D13	0.11	0.06	14.79	7.4%
D14	0.12	0.06	14.80	7.4%
AQOs	200			

Note:

(a) Inclusive of Background concentration of 14.7 $\mu g/m^3$.

From **Table 7-2**, it can be seen that there are no exceedances of the short-term NO_2 AQS of 200 $\mu g/m^3$ 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 7-3.**

Table 7-3. The Short-Term (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	0.76	15.44	7.7%	Low
D2	0.53	15.21	7.6%	Low
D3	0.55	15.23	7.6%	Low
D4	0.30	14.98	7.5%	Low
D5	0.42	15.10	7.5%	Low
D6	0.41	15.09	7.5%	Low
D7	0.35	15.03	7.5%	Low
D8	0.37	15.05	7.5%	Low
D9	0.42	15.10	7.6%	Low
D10	0.31	14.99	7.5%	Low
D11	0.20	14.88	7.4%	Low
D12	0.26	14.94	7.5%	Low
D13	0.30	14.98	7.5%	Low
D14	0.33	15.01	7.5%	Low

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

7.1.2 Carbon Monoxide (CO)

Predicted ground level short-term (8-hour running mean) CO concentrations were assessed against the relevant AQO using 2021 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 7-4**.

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

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	35.78	0.36	188.4	1.88%
D2	21.48	0.21	174.1	1.74%
D3	12.10	0.12	164.7	1.65%
D4	6.61	0.07	159.2	1.59%
D5	8.87	0.09	161.5	1.61%
D6	12.28	0.12	164.9	1.65%
D7	8.67	0.09	161.3	1.61%
D8	6.00	0.06	158.6	1.59%
D9	9.44	0.09	162.0	1.62%
D10	5.80	0.06	158.4	1.58%
D11	6.29	0.06	158.9	1.59%
D12	4.48	0.04	157.1	1.57%
D13	5.45	0.05	158.1	1.58%
D14	6.77	0.07	159.4	1.59%
AQOs	10,000			

Note: *(a) Inclusive of Background concentration of 152.6 µg/m^3.*

As indicated in **Table 7-4**, the maximum predicted 8-hour running mean CO process contributions (PC) at receptors is 35.78 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 0.36% of the short-term AQO, which are considered insignificant.

The maximum PEC of 8-hour running mean CO emissions is 188.4 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 1.88%. 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.

7.1.3 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 7-5.**

Table 7-5. Summary of Predicted HF 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	Brampton Grange, High Street	11.49	0.77	14.78	0.99%
D2	67 High Street Marton	6.90	0.46	10.19	0.68%
D3	Poplar Farm	3.88	0.26	7.17	0.48%
D4	The Marton Academy, Stow Park Road	2.12	0.14	5.41	0.36%
D5	Marton Grange	2.85	0.19	6.14	0.41%
D6	South View, Stow Park	3.94	0.26	7.23	0.48%
D7	Station House, Stow Park	2.78	0.19	6.07	0.40%
D8	Home Farm	1.93	0.13	5.22	0.35%
D9	Marton Moor Farm	3.03	0.20	6.32	0.42%
D10	Depot	1.86	0.12	5.15	0.34%
D11	Stow Park (Farm)	2.02	0.13	5.31	0.35%
D12	Manor Farm	1.44	0.10	4.73	0.32%
D13	Bellwood Cottage, Brampton	1.75	0.12	5.04	0.34%
D14	Bellwood Grange Farm	2.17	0.14	5.46	0.36%
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 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 7-6.**

Table 7-6. Summary of Predicted 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	Brampton Grange, High Street	15.40	0.46	21.7	0.87%
D2	67 High Street Marton	9.24	0.28	15.5	0.62%
D3	Poplar Farm	5.21	0.16	11.5	0.46%
D4	The Marton Academy, Stow Park Road	2.85	0.08	9.1	0.37%
D5	Marton Grange	3.82	0.11	10.1	0.40%
D6	South View, Stow Park	5.29	0.16	11.6	0.46%
D7	Station House, Stow Park	3.73	0.11	10.0	0.40%
D8	Home Farm	2.58	0.08	8.9	0.36%
D9	Marton Moor Farm	4.06	0.12	10.4	0.41%
D10	Depot	2.50	0.07	8.8	0.35%
D11	Stow Park (Farm)	2.71	0.08	9.0	0.36%
D12	Manor Farm	1.93	0.06	8.2	0.33%
D13	Bellwood Cottage, Brampton	2.35	0.07	8.6	0.35%
D14	Bellwood Grange Farm	2.91	0.09	9.2	0.37%
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;

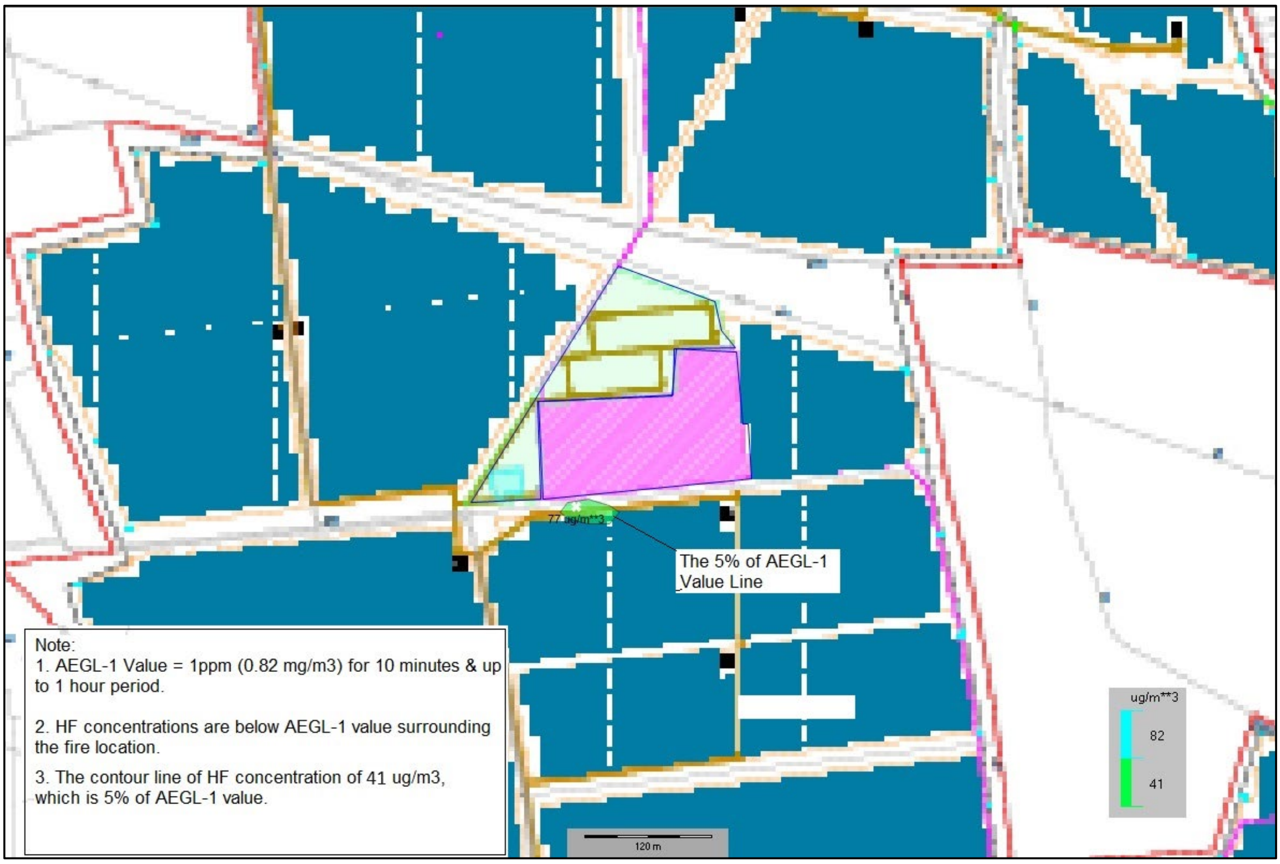
(2) The predicted HF Concentrations (15-Min Mean) at the selected receptor locations are below 15-min workplace exposure limit of 2.5 mg/m³; and

(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.

HF Concentration Assessed against AEGL-1 Value

The contour plots of the predicted ground level 15-minute HF concentrations using 2021 met data are shown in **Figure 7-1.**

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



From **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;

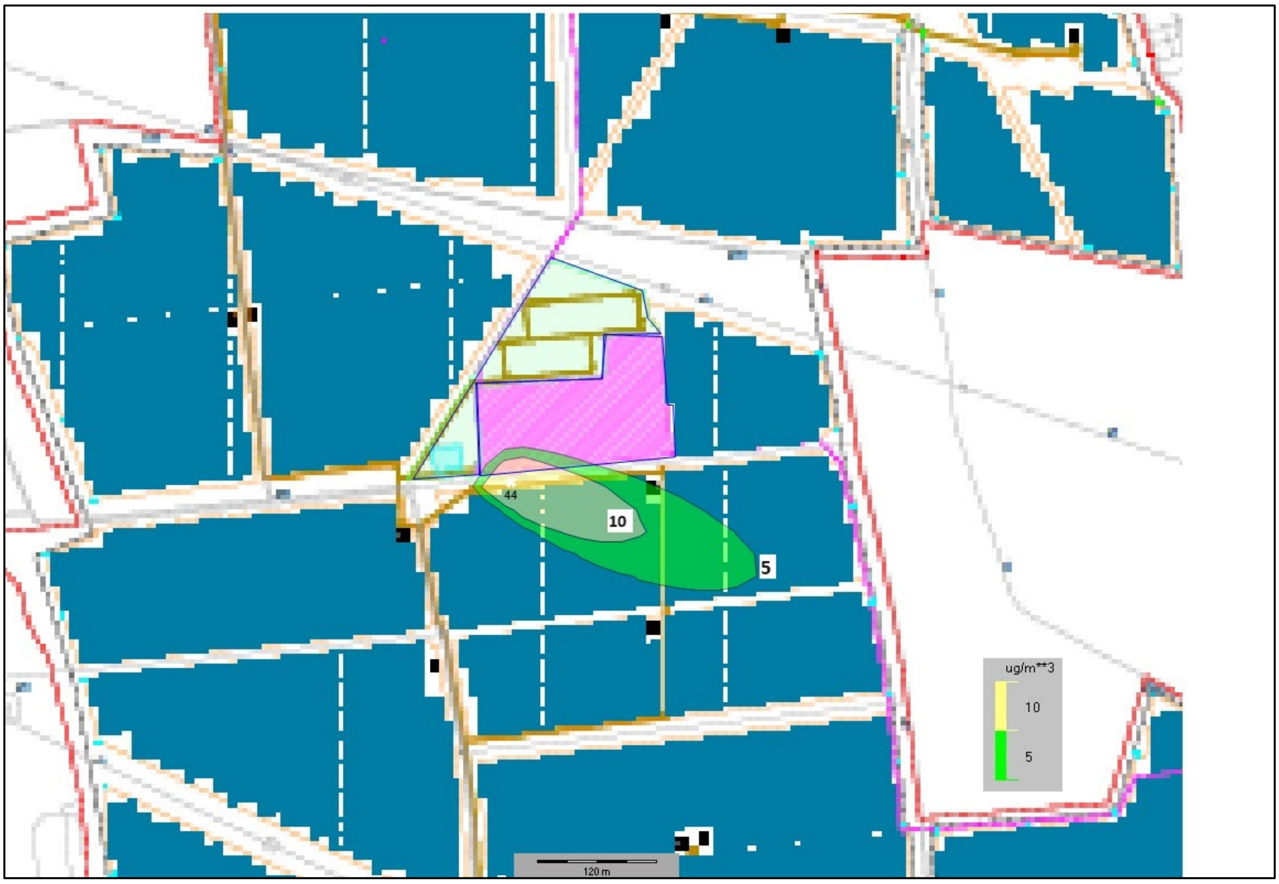
(2) The contour line of HF concentration of 41 µg/m^3, which is 10% of AEGL-1 value, is approximately 40 m away from the fire location; and

(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.

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	0.303	0.15	14.98	484374	380954
NO_2	2019	0.566	0.28	15.25	484650	381509
NO_2	2020	0.440	0.22	15.12	484374	380954
NO_2	2021	0.646	0.32	15.33	484374	380954
NO_2	2022	0.591	0.30	15.27	484374	380954
AQOs	200					

Note:

(d) Inclusive of Background concentration of 14.7 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 15.33 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	0.65	0.32	15.33	7.7%
D2	0.44	0.22	15.12	7.6%
D3	0.47	0.24	15.15	7.6%
D4	0.19	0.09	14.87	7.4%
D5	0.31	0.16	14.99	7.5%
D6	0.27	0.14	14.95	7.5%
D7	0.24	0.12	14.92	7.5%
D8	0.24	0.12	14.92	7.5%
D9	0.31	0.16	14.99	7.5%
D10	0.22	0.11	14.90	7.4%
D11	0.10	0.05	14.78	7.4%
D12	0.13	0.06	14.81	7.4%
D13	0.16	0.08	14.84	7.4%
D14	0.17	0.09	14.85	7.4%
AQOs	200			

Note:

(b) Inclusive of Background concentration of 14.7 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/m^3 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 7-9.**

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/m^3) of NO_2			
	Process Contribution (PC)	PEC	$PEC_{(a)}$ (PC +Background)	NO_2 DAQI
D1	0.96	15.64	7.8%	Low
D2	0.69	15.37	7.7%	Low
D3	0.70	15.38	7.7%	Low
D4	0.41	15.09	7.5%	Low
D5	0.55	15.23	7.6%	Low
D6	0.55	15.23	7.6%	Low
D7	0.47	15.15	7.6%	Low
D8	0.50	15.18	7.6%	Low
D9	0.58	15.26	7.6%	Low
D10	0.42	15.10	7.5%	Low
D11	0.28	14.96	7.5%	Low
D12	0.35	15.03	7.5%	Low
D13	0.41	15.09	7.5%	Low
D14	0.45	15.13	7.6%	Low

As shown in **Table 7-9**, all receptors will have a 'low' air pollution level on the DAQI.

7.2.2 Carbon Monoxide (CO)

Predicted ground level short-term (8-hour running mean) CO concentrations were assessed against the relevant AQO using 2021 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 7-10.**

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

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	45.83	0.46	198.4	1.98%
D2	28.12	0.28	180.7	1.81%
D3	16.58	0.17	169.2	1.69%
D4	9.10	0.09	161.7	1.62%
D5	12.34	0.12	164.9	1.65%
D6	16.72	0.17	169.3	1.69%
D7	11.76	0.12	164.4	1.64%
D8	8.21	0.08	160.8	1.61%
D9	13.10	0.13	165.7	1.66%
D10	7.91	0.08	160.5	1.61%
D11	8.75	0.09	161.3	1.61%
D12	6.23	0.06	158.8	1.59%
D13	7.57	0.08	160.2	1.60%
D14	9.21	0.09	161.8	1.62%
AQOs	10,000			

Note: *(a) Inclusive of Background concentration of 152.6 μg/m³.*

As indicated in **Table 7-10** the maximum predicted 8-hour running mean CO process contributions (PC) at receptors is 45.83 μg/m³ when using 2021 met data. The predicted 8-hour running mean PCs of CO at the modelled discrete receptors are well below 0.46% of the short-term AQO, which are considered insignificant.

The maximum PEC of 8-hour running mean CO emissions is 198.4 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 1.98%. 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.

7.2.3 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	Brampton Grange, High Street	14.74	0.98	18.03	1.20%
D2	67 High Street Marton	9.04	0.60	12.33	0.82%
D3	Poplar Farm	5.33	0.36	8.62	0.57%
D4	The Marton Academy, Stow Park Road	2.93	0.20	6.22	0.41%
D5	Marton Grange	3.97	0.26	7.26	0.48%
D6	South View, Stow Park	5.38	0.36	8.67	0.58%
D7	Station House, Stow Park	3.78	0.25	7.07	0.47%
D8	Home Farm	2.64	0.18	5.93	0.40%
D9	Marton Moor Farm	4.21	0.28	7.50	0.50%
D10	Depot	2.54	0.17	5.83	0.39%
D11	Stow Park (Farm)	2.81	0.19	6.10	0.41%
D12	Manor Farm	2.00	0.13	5.29	0.35%
D13	Bellwood Cottage, Brampton	2.43	0.16	5.72	0.38%
D14	Bellwood Grange Farm	2.96	0.20	6.25	0.42%
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 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.**

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 ($\mu g/m^3$)			
		Process Contribution (PC)	PC as %age of AQO	PEC [a] (PC+Background)	PEC % of WSLs
D1	Brampton Grange, High Street	19.75	0.59	26.0	1.04%
D2	67 Hight Street Marton	12.12	0.36	18.4	0.74%
D3	Poplar Farm	7.15	0.21	13.4	0.54%
D4	The Marton Academy, Stow Park Road	3.92	0.12	10.2	0.41%
D5	Marton Grange	5.32	0.16	11.6	0.46%
D6	South View, Stow Park	7.21	0.22	13.5	0.54%
D7	Station House, Stow Park	5.07	0.15	11.4	0.45%
D8	Home Farm	3.54	0.11	9.8	0.39%
D9	Marton Moor Farm	5.64	0.17	11.9	0.48%
D10	Depot	3.41	0.10	9.7	0.39%
D11	Stow Park (Farm)	3.77	0.11	10.1	0.40%
D12	Manor Farm	2.68	0.08	9.0	0.36%
D13	Bellwood Cottage, Brampton	3.26	0.10	9.6	0.38%
D14	Bellwood Grange Farm	3.97	0.12	10.3	0.41%
WSLs		2,500			

Note:

[(a)] *Inclusive of Background concentration of 6.30 $\mu g/m^3$*

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/m^3;

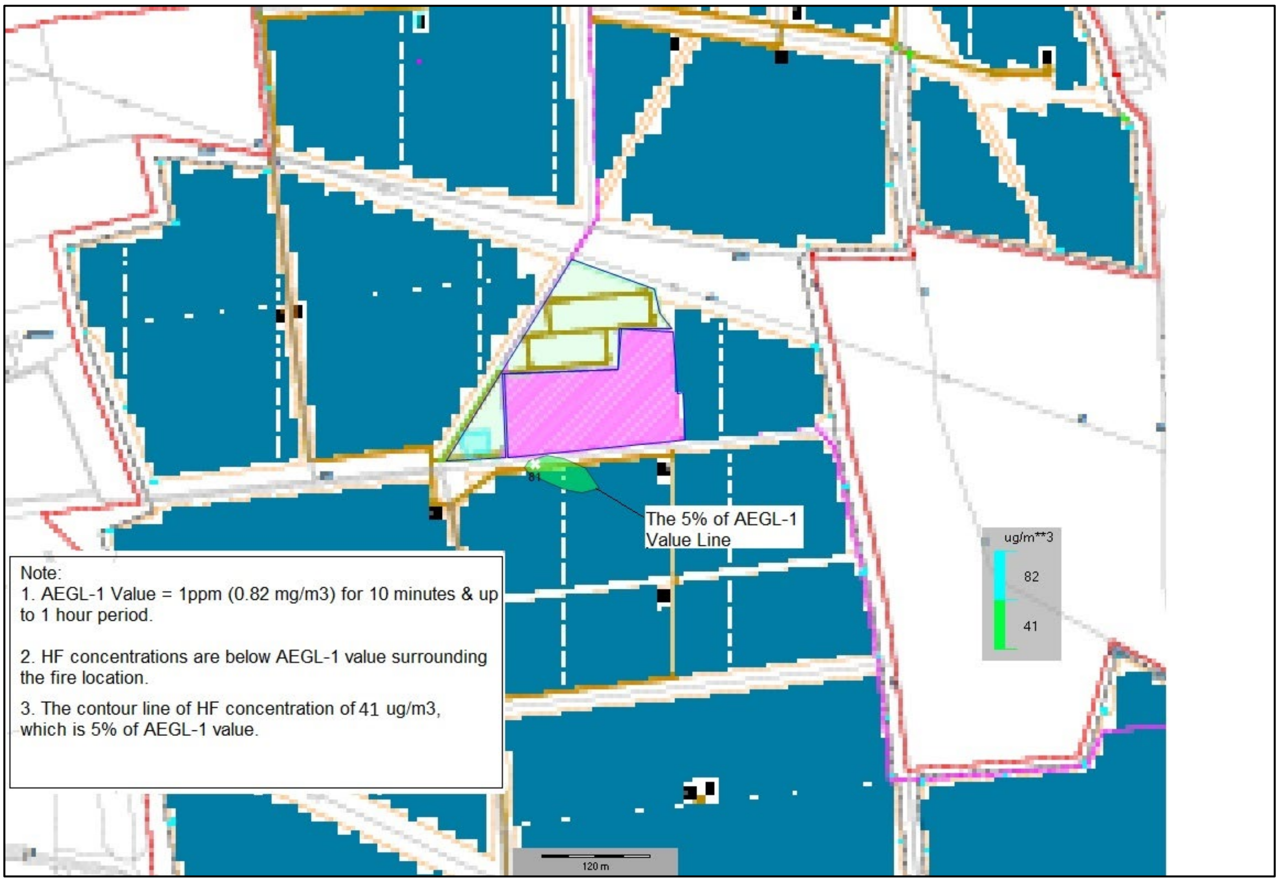
(2) The predicted HF Concentrations (15-Min Mean) at the selected receptor locations are below 15-min workplace exposure limit of 2.5 mg/m^3; and

(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.

HF Concentration Assessed against AEGL-1 Value

The contour plots of the predicted ground level 15-minute HF concentrations using 2021 met data are shown in **Figure 7-3.**

Figure 7-3. Predicted ground level 15-minute HF concentrations using 2021 met data – Scenario 2



From **Figure 7-3** 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.

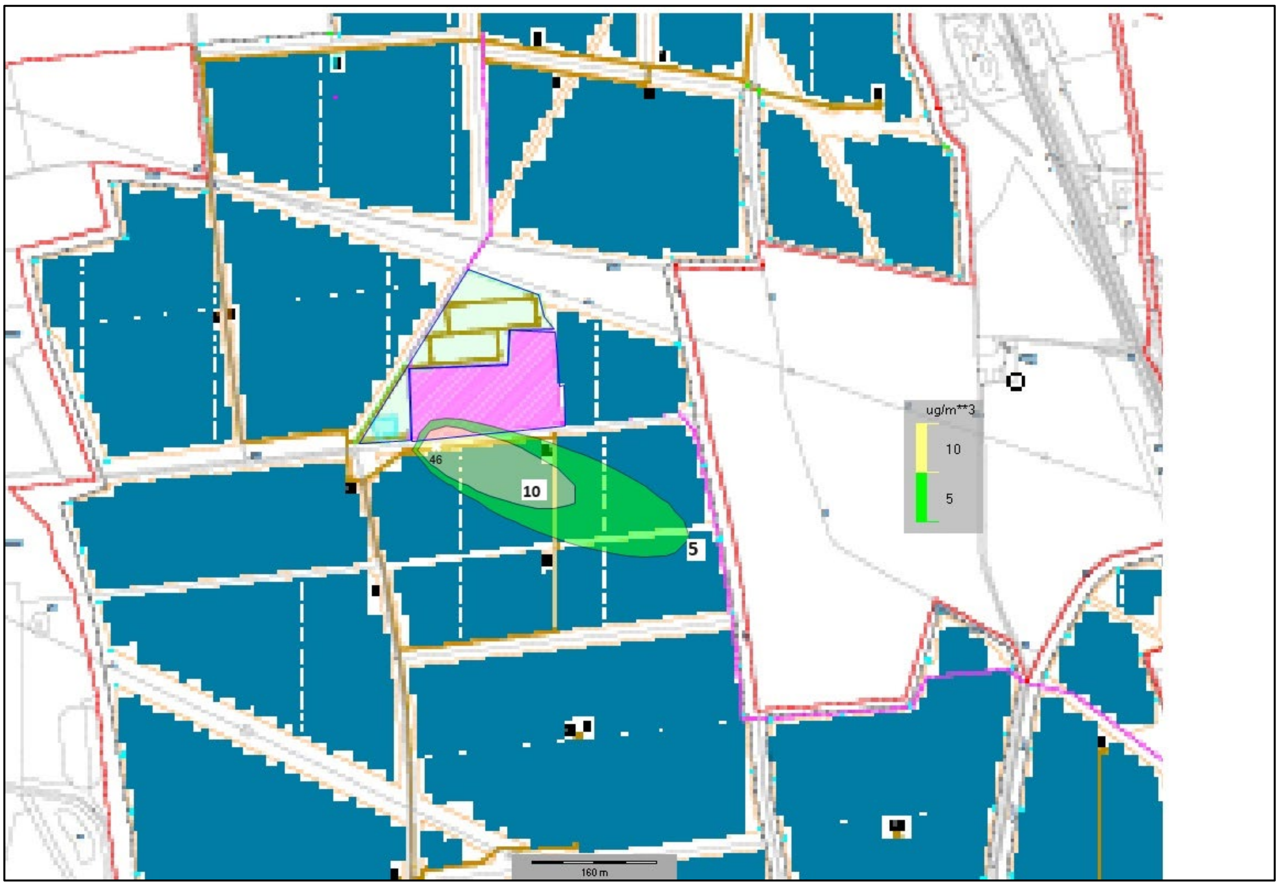
(2) The contour line of HF concentration of 41 µg/m^3, which is 5% of AEGL-1 value, is approximately 20 m away from the fire location.

(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.

7.2.4 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 7-4** and assessed against the lower/upper explosive limits.

Figure 7-4. Predicted ground level short-term (15-Min Mean) CH4 concentrations – 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 have 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 HF concentrations 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 Predicted HF Concentrations under 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	6.31	< AEGL-1 Value	1259.9	> AEGL-1 Value
D2	10 m to Fire	39.05	< AEGL-1 Value	412.9	< AEGL-1 Value
D3	20 m to Fire	96.31	< AEGL-1 Value	194.4	< AEGL-1 Value
D4	30 m to Fire	102.35	< AEGL-1 Value	120.7	< AEGL-1 Value
D5	40 m to Fire	88.45	< AEGL-1 Value	88.0	< AEGL-1 Value
D6	50 m to Fire	73.14	< AEGL-1 Value	69.4	< AEGL-1 Value
D7	60 m to Fire	60.23	< AEGL-1 Value	56.7	< AEGL-1 Value
D8	70 m to Fire	50.65	< AEGL-1 Value	47.9	< AEGL-1 Value
D9	80 m to Fire	42.68	< AEGL-1 Value	40.7	< AEGL-1 Value
D10	90 m to Fire	36.82	< AEGL-1 Value	35.4	< AEGL-1 Value

The sensitivity study assessment results demonstrate that:

- The predicted HF concentrations at 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.
- The predicted HF concentration at 2 metres above ground level and 5 metres away from the fire location is above the AEGL-1 Value of 0.82 mg/m^3. However, the concentrations will fall under the AEGL-1 Value of 0.82 mg/m^3 from 10 m away from a fire. It is considered that

nearly all individuals 10 meters away from a fire 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

Whilst 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 WB7.9_A Outline Battery Storage Safety Management Plan Revision A **[EN010132/EX3/WB7.9_A]** (to be submitted at Deadline 3) will be implemented immediately in the case of a 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 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 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 300 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 West Burton 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 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.

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 HF concentrations at the residential receptor locations are all below the relevant British occupational exposure limits. The short-term 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 maximum HF concentrations (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 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.

The sensitivity study assessment results of HF impact under a windy condition demonstrate that the predicted HF concentrations are all below the AEGL-1 (Acute Exposure Guideline Level 1) with exception of the HF concentrations being above the AEGL-1 at 2 metres above ground level and close to fire, for example, 5 metres away from the fire location.

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: EN010132, Document reference **EX3/WB7.9_A**; 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.

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
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)
$\mu g/m^3$	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

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