# Cottam Solar Project

# Environmental Statement Addendum:

## Updated Air Quality Impact Assessment of a Solar Panel Fire Incident

Prepared by: Tetra Tech Limited
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Cottam
SOLAR PROJECT

# Island Green Power Limited

# Cottam Solar Project

# Updated Air Quality Impact Assessment of a Solar Panel Fire Incident

**2nd August 2023**

**784-B031438**

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| 1 | 9th August 2022 | First Issue |
| 2 | 2nd August 2023 | Second Issue – Updated assessment with additional modelling |
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## Non-Technical Summary

This report presents the findings of a fire accident impact assessment, which forms one of Technical Appendices of ES Volume 3. ES Volume 3 consists of a set of appendices in support of ES Volume 1, Chapter 15: other Environmental Topics.

This second issue of the updated report includes the additional fire risk assessment results for a solar panel fire incident. The battery energy storage system (BESS) fire risk assessment has been undertaken and presented in a separate stand-alone BESS fire risk assessment report.

The solar panel fire risk assessment results show that he short-term predicted environmental concentrations of carbon monoxide, arsenic, lead, cadmium and selenium at the selected receptor locations from a solar panel fire incident are all below the relevant UK air quality objectives for the protection of human health or UK Health and Safety Executive workplace exposure limits for the protection of workers.

Potential effects of a fire incident on the surrounding residents and public have been assessed further using the ‘air quality category’ which is classified as ‘good’, ‘moderate’, ‘unhealthy’, ‘very unhealthy’ or ‘hazardous’. Each category corresponds to a different level of health concern. The air quality category in this assessment is classified using the values of fire-generated particulate matter (equivalent to $PM_{2.5}$) concentrations in air. Furthermore, air quality category zones have been determined according to the air quality category to make it easy for public/site manager/fire safety representative to quickly to take appropriate actions in case of a fire.

Four air quality category zones have been identified as below:

- Hazardous Zone – within 10 m from a fire;
- Unhealthy Zone – 11 to 20 m from a fire;
- Moderate/Unhealthy for Sensitive Groups Zone – 21 to 200 m from a fire; and
- Good Air Quality Zone – more than 200 m from a fire.

The daily mean (24-hour average) $PM_{2.5}$ concentrations at downwind locations of a fire outside of a 200 m fire zone (the receptors are located more than 200 m away from the fire) will be below the level of air pollution of UK air quality index value 3 and the zone can be classified as a ‘low’ air pollution banding.

As a fire could occur at any location within the development during the site construction, operational and decommissioning phases, generic receptor locations have been used in the assessment. In case of a fire, the site manager/fire safety representative will need to assess the fire locations, 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 potential affected residents within the zones and to advise public about health effects of smoke, related symptoms, and ways to reduce exposure; (2) to cancel outdoor events; and/or (3) to move affected residents to a cleaner air location.

# 1.0 Introduction

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

- The Cottam Solar Project consists of three land parcels (the 'Site" or 'Sites) described as Cottam 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 600 megawatts (MW) renewable energy.

A fire accident can be considered to be an occurrence involving smoke, heat, and flames causing property damage, such as solar panels and substations.

A fire impact assessment considered the smoke impact on the surrounding residents/population when a fire break out at one selected location within the Scheme. Fire affected zones/areas have been identified and those predicted fire impact zones/areas can be applied to or overlaid over any locations within the Scheme since it is not practical to model every location as a fire source and a fire could occur anywhere within a Site at Scheme.

## 1.1 First Issue of the Report

The first issue of the report was dated 9th August 2022. In this report, the effect of a solar panel fire incident was assessed using the 'Air Quality Category' which is classified as 'good', 'moderate', 'unhealthy', 'very unhealthy' or 'hazardous'. The 'Air Quality Category' was defined according to the fire-generated particulate matter (equivalent to $PM_{2.5}$) concentrations in air.

A solar panel fire action plan for protecting human health from fire smoke was discussed.

This report was produced to form one of Technical Appendices of ES Volume 3. ES Volume 3 consists of a set of appendices in support of ES Volume 1, Chapter 15: Other Environmental Topics.

## 1.2 Previous Versions of the Battery Energy Storage System (BESS) Fire Incident Assessment Technical Note

Tetra Tech previously issued a BESS fire risk assessment note/report in December 2022.

- **BESS Fire Incident Assessment Technical Note**

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

The technical note was produced based on result of assessment undertaken by Tetra Tech to determine the potential impact of a solar panel fire incident at the proposed development. The potential impact of a BESS fire incident on surrounding sensitive receptors was assessed using an 'Air Quality Category' approach, with categories classified as 'good', 'moderate', 'unhealthy', 'very unhealthy' or 'hazardous'.

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

## 1.3 UK Health Security Agency Comment Letters

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

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

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

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

The UKHSA's **second letter** was dated 21st March 2023, reference no. CIRIS63064, regarding a 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 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."*

## 1.4 Communications and Meetings with the UK Health Security Agency

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

> *"Thank you for your consultation regarding the above development. You (Tetra Tech) asked:*
>
> *"We (Tetra Tech) are planning to undertake an additional fire risk assessment on behalf of Cottam Solar Project Limited in response to your above comments. Our proposal includes:*
>
> > *(a) Undertaking additional solar panel fire modelling assessment using ADMS software. The predicted pollutant levels of $NO_2$, $PM_{10}$, $PM_{2.5}$ and hydrogen fluoride at sensitive receptors will be assessed using UK Air Quality Standards; and*
> >
> > *(b) Undertaking a detailed battery energy storage systems (BESS) fire impact assessment using AERMOD dispersion model software. The predicted pollutant levels of $NO_2$, benzene, HCl, and HF will be assessed at sensitive receptors using UK Air Quality Standards.*
>
> *I (Tetra Tech) appreciate if you (the UKHSA) could review and advise whether you agree it is a suitable approach."*
>
> *The UK Health Security Agency (the UKHSA) welcomes the opportunity to comment on your (Tetra Tech's) proposals at this stage of the project. Your (Tetra Tech's) proposed approach will provide assurance, but we (the UKHSA) note that you (Tetra Tech) could consider particulate matter ($PM_{10}$ and $PM_{2.5}$) emissions for the BESS fire impact assessment. Within the assessments we (the UKHSA) suggest justification of the selection of pollutants considered, and the models used is provided."*

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

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

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

concentrations at receptor locations will be assessed and compared against UK Air Quality Standards.

This updated report presents the solar panel fire risk assessment results.

The BESS Fire Risk Assessment results have been presented in a separate stand-alone report (Report titled '*Updated Air Quality Impact Assessment of Battery Energy Storage Systems (BESS) Fire*', by Tetra Tech, Ref: 784-B031438, Dated: 2$^{nd}$ August 2023).

## 1.5 Site Location

The development (the Scheme) consists of 3 areas of Cottam 1, Cottam 2, Cottam 3 and the associated substation areas. The details of the locations are presented in **Figure 1-1** to **Figure 1-3**, below.

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

The proposed development sites are predominantly surrounded by agricultural areas.

This report is focused on the assessment of the potential impacts from solar panels or substation equipment fire generated dust and smoke on surrounding sensitive receptor locations.

**Figure 1-1**. Site Locations

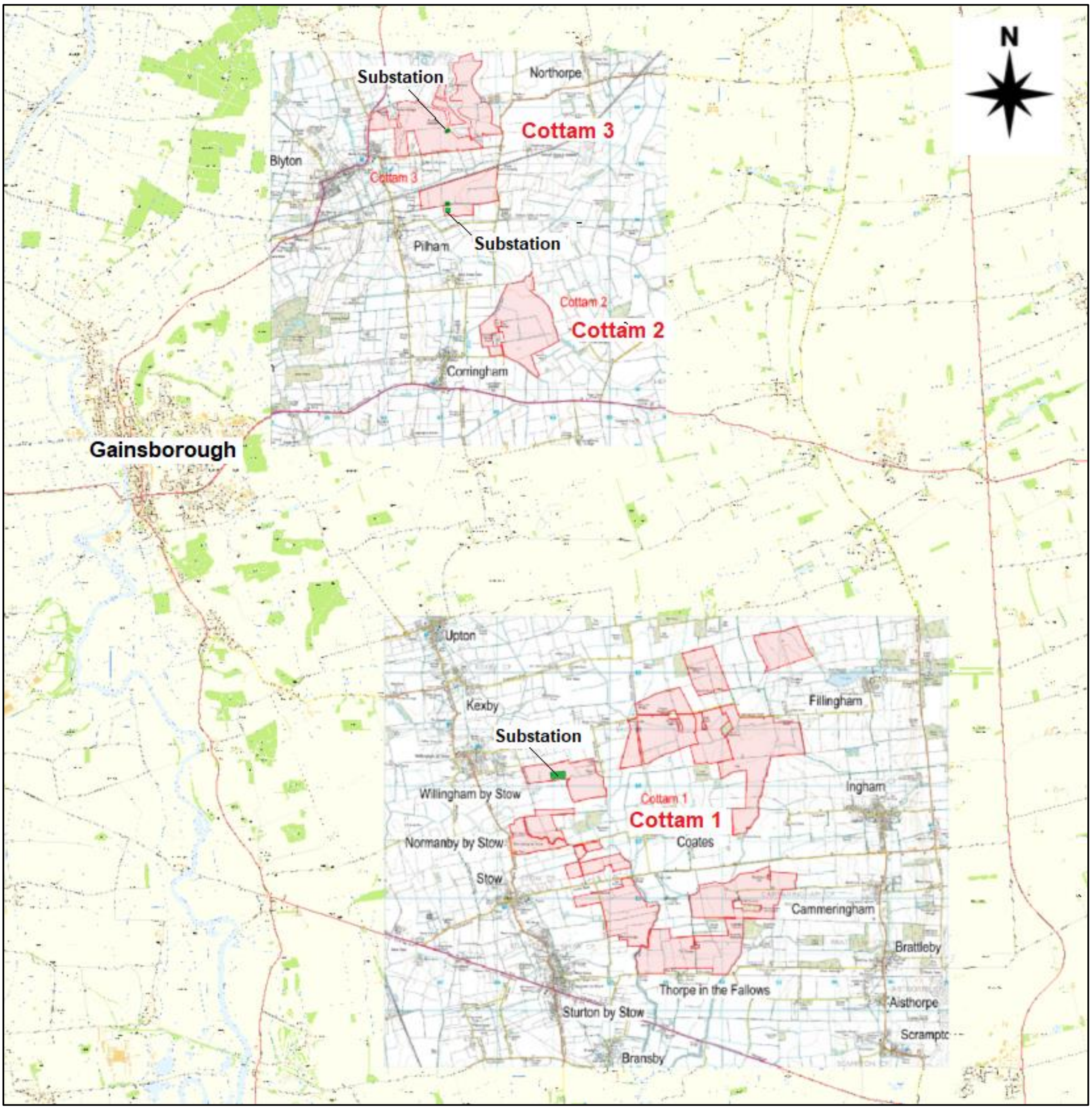


**Figure 1-2.** Cottam 1

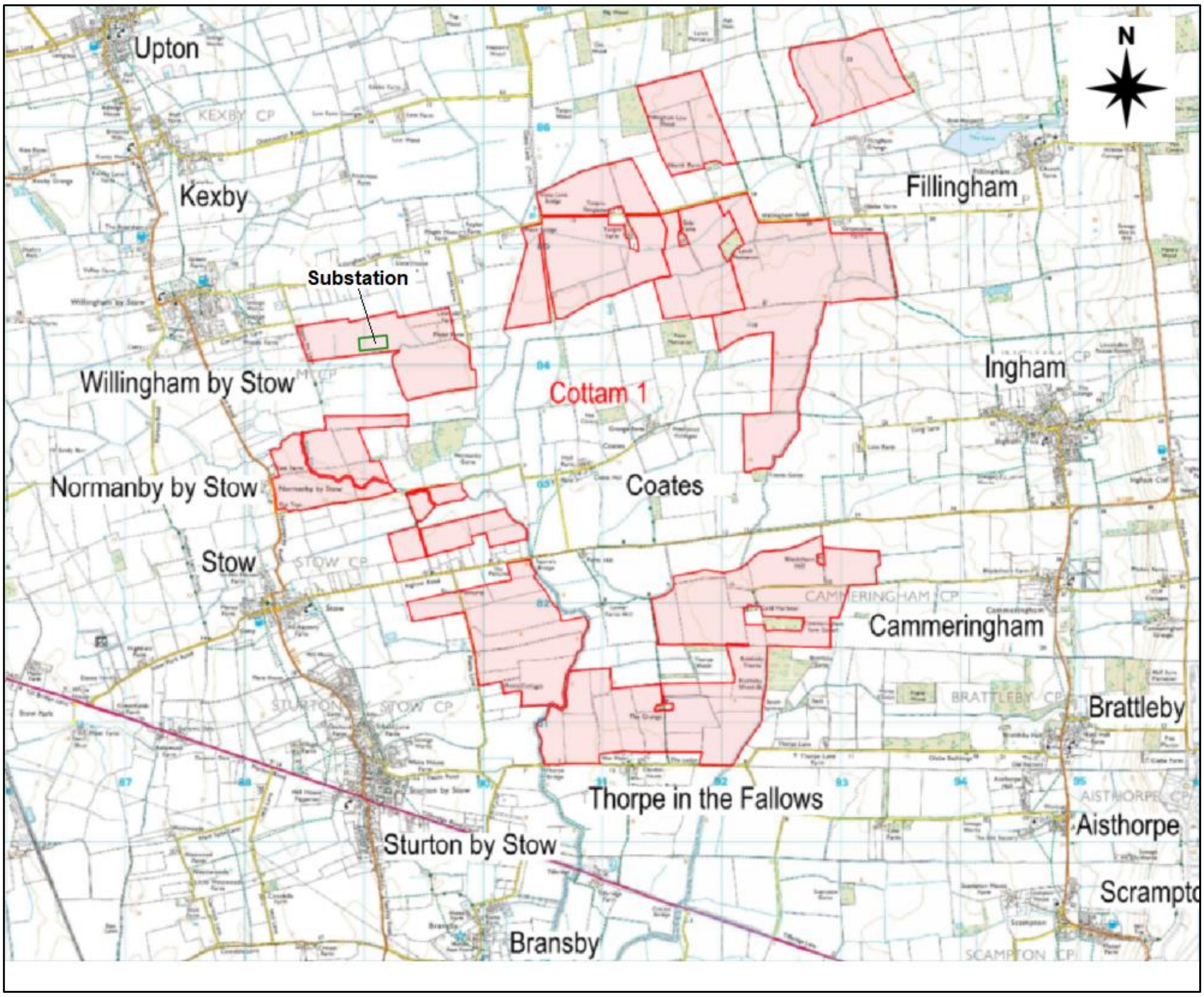
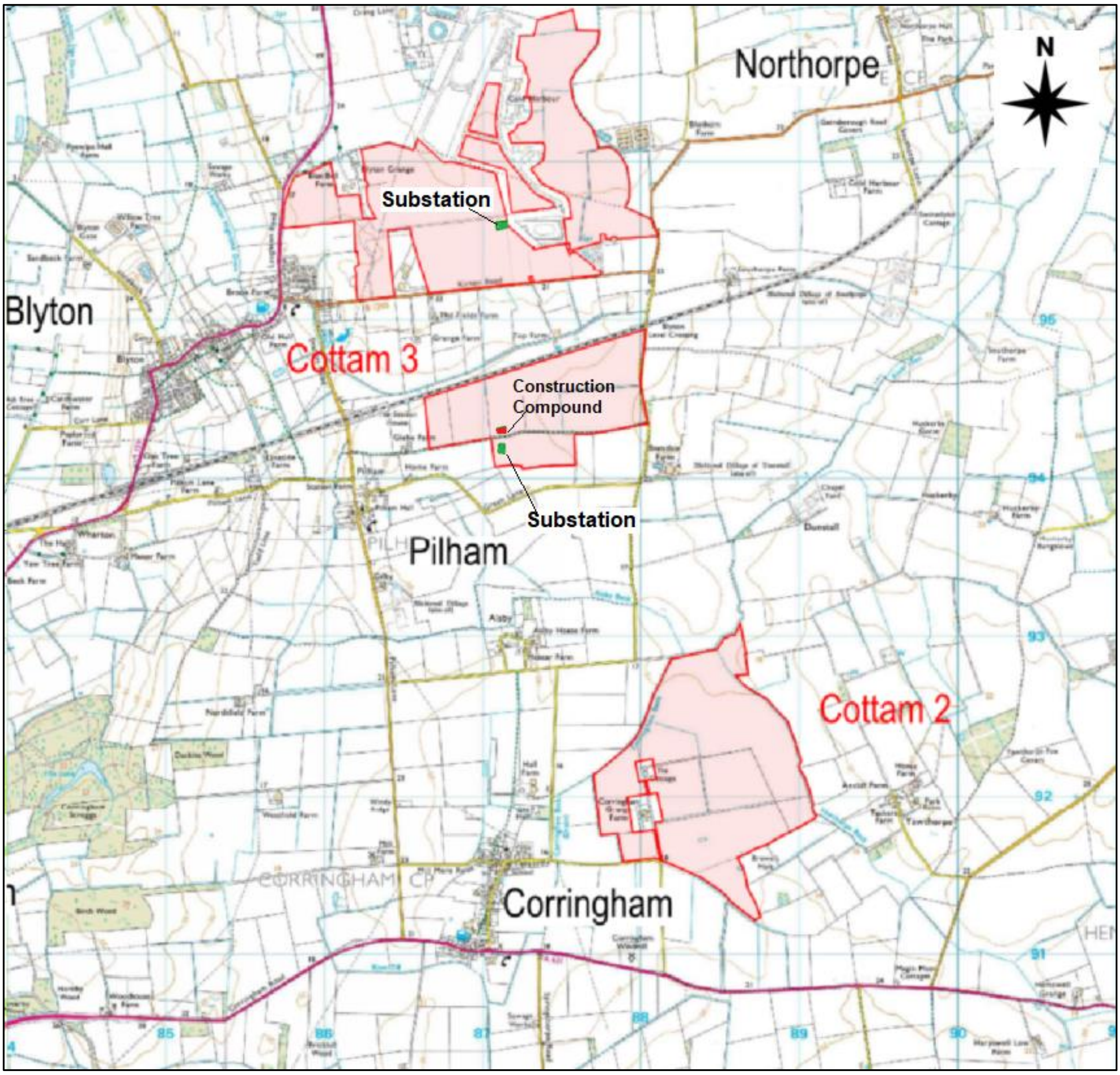


**Figure 1-3.** Cottam 2 & 3



# 2.0 Extant Policy, Legislation and Relevant Agencies

The health effects of a fire on public health has been assessed against the fire-generated particulate matter levels and their associated air quality category (good to hazardous levels).

## 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 Standards Regulations (Amendments), 2016;
- The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, Defra, 2007;
- The Environment Act, 1995;
- Local Air Quality Management Technical Guidance LAQM.TG16, Defra, 2021;
- Design Manual for Roads and Bridges, Volume 11, Section 3, Part 1, LA 105 Air quality, 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; and
- A Guide to the Assessment of Air Quality Impacts on Designated Nature Conservation Sites (Version 1.0), IAQM, May 2020.

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.
- **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 and World Health Organisation (WHO) Guidelines. The workplace exposure limits (WELs) are presented in **Table 2-2**.

**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 |
|---|---|---|---|---|---|---|---|
| Particles ($PM_{10}$) | UK | 50 µg/m$^3$ by end of 2004 (max 35 exceedances a year) | 24-hour Mean | 1st January 2005 | 50 µg/m$^3$ by end of 2004 (max 35 exceedances a year) | 1st January 2005 | Retain Existing |
| | UK | 40 µg/m$^3$ by end of 2004 | Annual Mean | 1st January 2005 | 40 µg/m$^3$ | 1st January 2005 | |
| $PM_{2.5}$ | UK | 10 µg/m$^3$ | Annual Mean | 31st December 2040 | - | - | New |
| 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 |
| Lead | UK | 0.5 µg/m$^3$ | Annual Mean | 1st January 2005 | 0.5 µg/m$^3$ | 1st January 2005 | Retain Existing |
| | UK | 0.25 µg/m$^3$ | Annual Mean | 31 December 2008 | - | - | - |

**Table 2-2.** Target Values in the Air Quality Standards Regulations 2010

| Pollutant | Target value for the total content in the PM10 fraction averaged over a calendar year | Date by which target value should be met |
|---|---|---|
| Arsenic | 6 ng/m$^3$ | 31st December 2012 |
| Cadmium | 5 ng/m$^3$ | 31st December 2012 |

**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 solar panel 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.

**CO and Heavy Metal Workplace Exposure Limits**

The HSE document 'EH40/2005 Workplace exposure limits' for CO and heavy metal are presented in **Table 2-3**.

**Table 2-3.** Work Exposure Limits for CO and Heavy Metal

| 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 |
| Arsenic (AS) | 0.1 | - |
| Lead (Pb) | 0.15 | - |
| Cadmium (Cd) | 0.025 | - |
| Selenium (Se) | 0.1 | - |

**Local Air Quality Management**

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

Environment Act 2021

The Environment Act (2021) introduces a commitment to create a legally binding duty on government to reduce the concentrations of fine particulate matter ($PM_{2.5}$) in ambient air, and to set a long-term target expected to be 10 $\mu g/m^3$, a reduction from the current Air Quality objective of 20 $\mu g/m^3$ set out within the Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020. A draft of a statutory instrument (or drafts of statutory instruments) containing regulations setting the $PM_{2.5}$ air quality target must be laid before Parliament on or before 31st October 2022 and is expected to come into force thereafter.

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

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

It can be seen that the air quality standards/objectives are based on the average exposure during 1-year or 24-hour period. As a fire would last for a short period of time before it is extinguished, it is considered that the short-term air quality standards or relevant workplace exposure limits are the most appropriate to be used for this assessment. In addition, fire-generated particulate matter ($PM_{2.5}$) levels and their associated air quality category (good to hazardous levels) have also been used in the assessment.

# 3.0 Potential Pollutant Release in a Solar Panel Fire

A solar photovoltaic (PV) generating panel system operates with zero emissions and no toxic substances are released into the environment under the normal operating conditions. However, there is a potential release of gaseous toxic substances under the effect of heat in a fire.

This section includes an examination of typical solar panel installation components and, therefore, possible pollutants being released in case of a fire.

The results of a laboratory test, which was conducted at the fire testing centre of Currenta during June 2014 with the aim of characterizing the release of harmful substances by photovoltaic modules in case of fire, have been studied. The test was conducted by BMU (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany)).

This section also examines the smoke composition, particulates from a fire and health effects of fire smoke.

## 3.1 Composition of Solar Panels and Potential Pollutant Releases in a Fire

Solar PV panels include one or more PV modules assembled as a pre-wired, field-installable unit. PV modules consist of PV cell circuits sealed in an environmentally protective laminate and are the fundamental building block of PV systems.

For estimating theoretically possible releases of pollutants, typically used materials are analysed. Basic compositions of PV components are presented in **Table 3-1** (Source: German Guideline on Assessing Fire Risks in Photovoltaic Systems and Developing Safety Concepts for Risk Minimization, June 2018).

**Table 3-1.** Basic Compositions of PV Components

| Solar Module Component | Composition |
|---|---|
| Frames | Metals, plastics |
| Carrier material | Glass, plastic film, metallic foil |
| Back rails | Metals, plastics |
| Solar cells | Depending on the technology: Silicon, plastic films, metallic foil, dyes, various (heavy) metals |
| Embedding | Cast resin, plastic films |
| Sealing compound | Rubber, silicone |
| Cell connectors | Metals, alloys |
| Junction boxes | Plastics, metals, diodes |
| Cables, plugs | Plastics, metals |
| Substructure | Metals, plastics |
| DC junction boxes | Metals, glass, plastics |
| Inverters | Metals, glass, plastics |

In a fully developed fire with high temperatures and oxygen supply, the materials of glass aluminium will remain in an inert state. Other metals, such as copper, cadmium and arsenic, will be converted to oxidic products or toxic heavy metals in air. The plastics and organic materials are largely converted through combustion to the oxidation products of the pollutants including carbon monoxide, hydrogen chloride, benzene, hydrogen cyanide, formaldehyde, styrene and hydrogen fluoride from polymers.

## 3.2 Gas Pollutant Release from a Laboratory Test on a Solar Panel

In association with the BMU research project, BMU's experimental studies were conducted at the fire testing centre of Currenta during June 2014 with the aim of characterizing the release of harmful substances by photovoltaic modules in case of fire.

The experimental program covered three different module types of commercially available modules at the time: (a) polycrystalline (Crystalline Silica), (b) thin-film (copper indium – gallium selenium) and (c) thin-film (Cadmium telluride). The modules had an aluminium frame with a size of 1.2 – 1.65 metres in length and 0.6 – 1.0 metres in width.

For each module, a flame was applied to the backs of the inclined modules with a gas burner. Pollution analyses were conducted on the smoke gas produced.

The pollutant concentrations were measured in a fully developed fire for each of the tested modules. The measured maximum concentrations among the models over the test period are presented in **Table 3-2.**

Based on the results of the solar panel fire test undertaken by BMU, the sampled pollutants/substances generated from the tests have been considered for the purposes of this solar panel fire impact assessment.

**Table 3-2.** The Maximum Pollutant Concentrations within the Tested Modules

| Pollutant | Concentration | Unit |
|---|---|---|
| Arsenic (AS) | 1.6 | µg/m$^3$ |
| Lead (Pb) | 1330 | µg/m$^3$ |
| Cadmium (Cd) | 77 | µg/m$^3$ |
| Selenium (Se) | 40 | µg/m$^3$ |
| Carbon dioxide | 5,817 | mg/m$^3$ |
| Carbon monoxide | 382 | mg/m$^3$ |

## 3.3 Fire Smoke Composition

The smoke released by any type of fire (forest, brush, crop, structure, tires, waste or wood burning) is a mixture of particles and chemicals produced by incomplete burning of carbon-containing materials. All smoke contains carbon monoxide, carbon dioxide and particulate matter (PM or soot). Smoke can contain many different chemicals, including aldehydes, acid gases, sulphur dioxide, nitrogen oxides, polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, styrene, metals and dioxins. The type and number of particles and chemicals in smoke varies depending on what is burning, how much oxygen is available, and the burn temperature (Department of Health of New York State).

## 3.4 Particulates from a Fire

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

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

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

## 3.5 Health Effects of Fire Smoke

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

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

# 4.0 Assessment Methodology

## 4.1 Fire Incident Impact Assessment

In general, major accidents or disasters, 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 solar panel, battery storage and sub-stations fire, are considered and assessed. Particulate matter exposure is the key principle public health threat from short-term smoke exposure, therefore, detailed air dispersion modelling of particulate matter impact from smoke has been undertaken to predict the short-term concentrations $PM_{2.5}$ at residential receptors at downwind locations likely to be affected by incidents including fire.

An approved atmospheric dispersion modelling package (ADMS-Roads) has been used in the Air Quality Impact Assessment of a Major Fire Accident, where, smoke levels and their associated air quality category (good to hazardous level) will be estimated using the modelled predicted particulate matter levels, and the potential smoke effects on residential and other sensitive receptors are assessed and mitigation measures are discussed where appropriate.

## 4.2 Determining Impact Description of the Air Quality Effects

The potential environmental effects from the operations of the proposed CHP engines 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:

1. 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)';

2. 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;
3. 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;
4. The effects can be adverse when pollutant concentrations increase or beneficial when concentrations decrease as a result of development;
5. The judgement of overall impact description of the effects is then based on severity of effects on all the individual receptors considered; and,
6. Where a development is not resulting in any change in emissions itself, the impact description of effect is based on the effect of surrounding sources on new residents or users of the development, i.e., will they be exposed to levels above the AQO.

**Table 4-1.** Impact Descriptors for Individual Receptors

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

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

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

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

Guidance within '*Smoke Exposure from Wildland fires, interim Guidelines for Protecting community Health and wellbeing, Manitob Health January 26, 2021*', has been used in estimation of the smoke levels and air quality category ('good' to 'hazardous' level) based on the predicted particulate matter levels from a fire.

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

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

| Air Quality Category | Equivalent Approximately $PM_{2.5}$ 1-3-hour average in µg/m$^3$ | Visibility in km |
|---|---|---|
| Good | 0-40 | 15 kms and up |
| Moderate/Unhealthy for Sensitive Groups | 41-175 | 5-14 kms |
| Unhealthy | 176-300 | 2.5-4 kms |
| Very Unhealthy | 301-500 | 1.5-2 kms |
| Hazardous | over 500 | Less than 1 km |

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

## 4.4 UK Daily Air Quality Index

The UK Department for Environment Food & Rural Affairs applies the Daily Air Quality Index (DAQI) to its air quality forecasts to inform the public as to what the air pollution levels are predicted to be the next day. The forecasts are provided to allow the 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 UV 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 solar panel fire incident, the fire generated pollutant of particles has been used in the assessment as the gases of nitrogen dioxide and sulphur dioxide were not detectable in the smoke gases during the laboratory test of solar panel fire (discussed in Chapter 3).

The boundaries between index points for $PM_{2.5}$ and $PM_{10}$ are presented in **Table 4-3** and **Table 4-4**. It is assumed that a solar panel file generated particles are all $PM_{2.5}$ for a worst-case assessment.

**Table 4-3.** $PM_{2.5}$ Particles DAQI

## $PM_{2.5}$ Particles

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

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

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

## $PM_{10}$ Particles

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

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

# 5.0 Baseline Conditions

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

## 5.1 Air Quality Review and Assessment

**Air Quality Review**

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

### 5.1.1 Air Quality Monitoring

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

**Automatic monitoring**

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

Bassetlaw does not have any automatic monitoring sites.

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

**Non-automatic monitoring**

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

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

### 5.1.2 Air Quality Management Areas (AQMA)

Bassetlaw District Council currently does not have any AQMAs.

West Lindsey currently does not have any declared AQMAs.

### 5.1.3 Background Pollutant Mapping

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

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

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

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

**Table 5-1.** Defra Predicted Background Concentrations

| Council | Area | UK NGR (m) | | 2021 Predicted Background Concentration - Annual Mean (µg/m$^3$) | | |
|---|---|---|---|---|---|---|
| | | X | Y | $PM_{10}$ | $PM_{2.5}$ | CO |
| West Lindsey District | Cottam 1 | 491500 | 383500 | 15.50 | 8.41 | 107 |
| West Lindsey District | Cottam 2 & 3 | 487500 | 393500 | 15.58 | 8.44 | 107 |

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

Furthermore, the maximum annual mean concentrations in the table, for example, 15.58 µg/m$^3$ for $PM_{10}$, 8.44 µg/m$^3$ for $PM_{2.5}$ and 107 µg/m$^3$ for CO have been used in the assessment to produce a worst-case assessment.

#### Heavy Metals

Monitoring of heavy metals is carried out by DEFRA at 24 urban and industrial sites throughout the UK in 2008. The closest monitoring location to the proposed development is ‘Scunthorpe Town’, located approximately 26 km north of the BESS site. The monitoring data from this site for 2022 is included in **Table 5-2**.

[1] www.airquality.co.uk.

**Table 5-2.** Monitored Background Data for Metals at Scunthorpe Town, 2022

| Station Name | Measured Concentration | 2022 Monitored Concentration (ng/m³) | | | |
|---|---|---|---|---|---|
| | | As | Cd | Pb | Se |
| Scunthorpe Town | Average | 0.75 | 0.26 | 10.38 | 1.03 |
| Scunthorpe Town | Minimum | 0.47 | 0.09 | 3.53 | 0.74 |
| Scunthorpe Town | Maximum | 1.32 | 0.78 | 31.09 | 1.38 |
| The monitoring data between 01/01/2022 and 07/12/2022 and a total of 14 measurements for each metal have been analysed. | | | | | |

## 5.2 Sensitive Receptors

### 5.2.1 Discrete (Individual) Receptors

Considering the nature of a fire incident, a fire could take place anywhere within the Site and it would last only a short period of time before being extinguished, a set of generic receptors located downwind of a fire has been selected. Four sets of receptors affected by southerly, northerly, easterly and westerly winds are defined as below:

- Receptor Set 1: Receptor locations affected by westerly wind (coming from the west and blowing toward the east), A series of 20 receptors, which were spaced at 10 m intervals, are defined eastward from a fire.
- Receptor Set 2: Receptor locations affected by easterly wind (coming from the east and blowing toward the west), A series of 20 receptors, which were spaced at 10 m intervals, are defined westward from a fire.
- Receptor Set 3: Receptor locations affected by southerly wind (coming from the south and blowing toward the north), A series of 20 receptors, which were spaced at 10 m intervals, are defined northward from a fire.
- Receptor Set 4: Receptor locations affected by northerly wind (coming from the north and blowing toward the south), A series of 20 receptors, which were spaced at 10 m intervals, are defined southward from a fire.

As a fire could occur at any location within the development during the site construction, operational and decommissioning phases, a set of generic receptor locations at the Cottam 1 site has been selected to represent potential receptors at Cottam 1, 2, 3, and the substations.

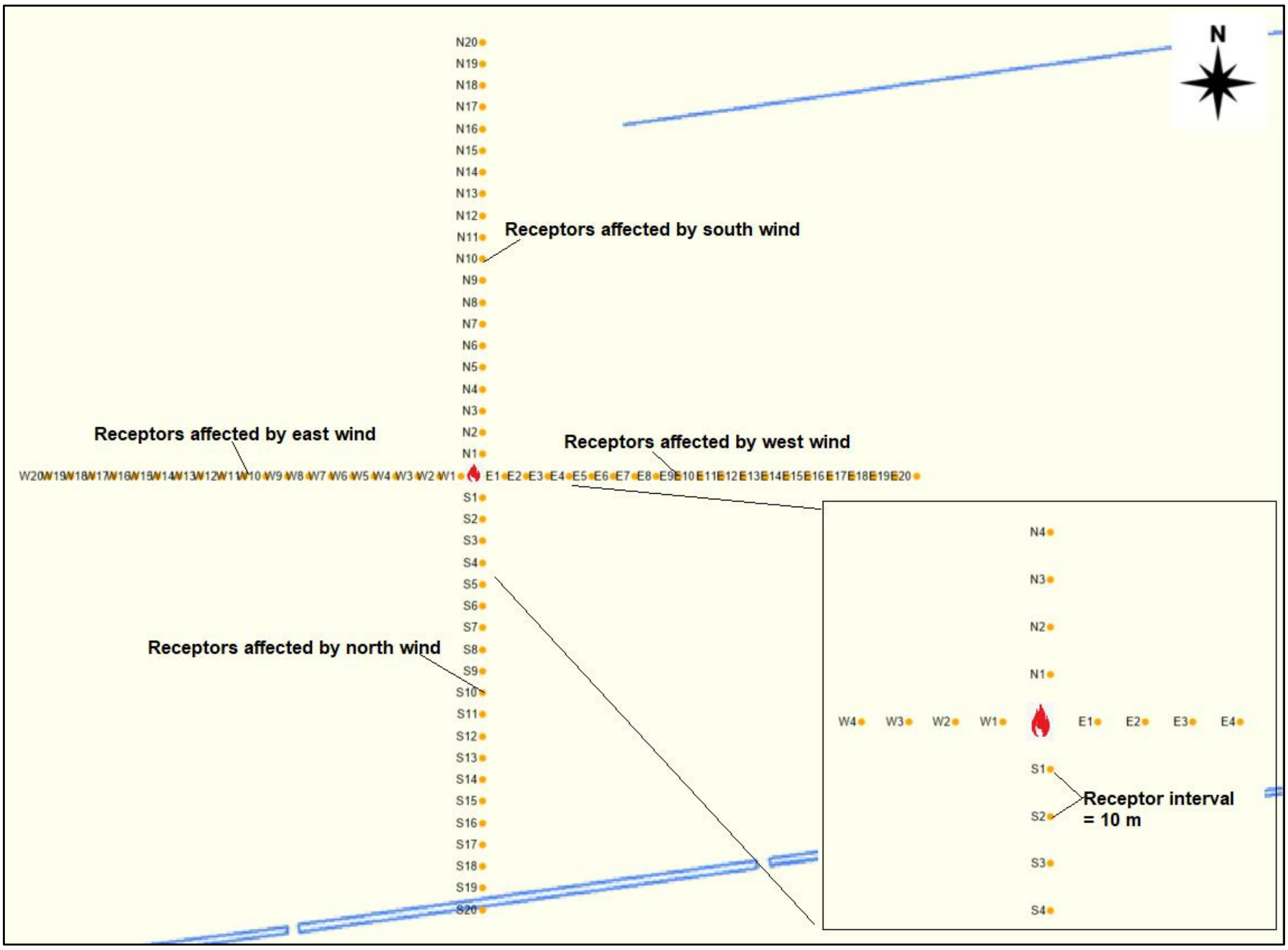
The selected generic receptor locations are presented in **Table 5-3** and are illustrated in **Figure 5-1**.

**Table 5-3.** Selected Sensitive Receptor Locations

| Discrete Sensitive Receptor | | UK NGR (m) | |
|---|---|---|---|
| | | X | Y |
| E1 | E1 (Affected by west winds that blow from west to east) | 488310 | 382900 |
| E2 | E2 | 488320 | 382900 |
| E3 | E3 | 488330 | 382900 |
| E4 | E4 | 488340 | 382900 |
| E5 | E5 | 488350 | 382900 |
| E6 | E6 | 488360 | 382900 |
| E7 | E7 | 488370 | 382900 |
| E8 | E8 | 488380 | 382900 |
| E9 | E9 | 488390 | 382900 |
| E10 | E10 | 488400 | 382900 |
| E11 | E11 | 488410 | 382900 |
| E12 | E12 | 488420 | 382900 |
| E13 | E13 | 488430 | 382900 |
| E14 | E14 | 488440 | 382900 |
| E15 | E15 | 488450 | 382900 |
| E16 | E16 | 488460 | 382900 |
| E17 | E17 | 488470 | 382900 |
| E18 | E18 | 488480 | 382900 |
| E19 | E19 | 488490 | 382900 |
| E20 | E20 | 488500 | 382900 |
| W1 | W1 (Affected by east winds that blow from east to west) | 488290 | 382900 |
| W2 | W2 | 488280 | 382900 |
| W3 | W3 | 488270 | 382900 |
| W4 | W4 | 488260 | 382900 |
| W5 | W5 | 488250 | 382900 |
| W6 | W6 | 488240 | 382900 |
| W7 | W7 | 488230 | 382900 |
| W8 | W8 | 488220 | 382900 |
| W9 | W9 | 488210 | 382900 |
| W10 | W10 | 488200 | 382900 |
| W11 | W11 | 488190 | 382900 |
| W12 | W12 | 488180 | 382900 |
| W13 | W13 | 488170 | 382900 |
| W14 | W14 | 488160 | 382900 |
| W15 | W15 | 488150 | 382900 |
| W16 | W16 | 488140 | 382900 |
| W17 | W17 | 488130 | 382900 |
| W18 | W18 | 488120 | 382900 |
| W19 | W19 | 488110 | 382900 |
| W20 | W20 | 488100 | 382900 |
| N1 | N1 (Affected by south winds that blow from south to north) | 488300 | 382910 |
| N2 | N2 | 488300 | 382920 |

| Discrete Sensitive Receptor | | UK NGR (m) | |
|---|---|---|---|
| | | X | Y |
| N3 | N3 | 488300 | 382930 |
| N4 | N4 | 488300 | 382940 |
| N5 | N5 | 488300 | 382950 |
| N6 | N6 | 488300 | 382960 |
| N7 | N7 | 488300 | 382970 |
| N8 | N8 | 488300 | 382980 |
| N9 | N9 | 488300 | 382990 |
| N10 | N10 | 488300 | 383000 |
| N11 | N11 | 488300 | 383010 |
| N12 | N12 | 488300 | 383020 |
| N13 | N13 | 488300 | 383030 |
| N14 | N14 | 488300 | 383040 |
| N15 | N15 | 488300 | 383050 |
| N16 | N16 | 488300 | 383060 |
| N17 | N17 | 488300 | 383070 |
| N18 | N18 | 488300 | 383080 |
| N19 | N19 | 488300 | 383090 |
| N20 | N20 | 488300 | 383100 |
| S1 | S1 (Affected by north winds that blow from north to south) | 488300 | 382890 |
| S2 | S2 | 488300 | 382880 |
| S3 | S3 | 488300 | 382870 |
| S4 | S4 | 488300 | 382860 |
| S5 | S5 | 488300 | 382850 |
| S6 | S6 | 488300 | 382840 |
| S7 | S7 | 488300 | 382830 |
| S8 | S8 | 488300 | 382820 |
| S9 | S9 | 488300 | 382810 |
| S10 | S10 | 488300 | 382800 |
| S11 | S11 | 488300 | 382790 |
| S12 | S12 | 488300 | 382780 |
| S13 | S13 | 488300 | 382770 |
| S14 | S14 | 488300 | 382760 |
| S15 | S15 | 488300 | 382750 |
| S16 | S16 | 488300 | 382740 |
| S17 | S17 | 488300 | 382730 |
| S18 | S18 | 488300 | 382720 |
| S19 | S19 | 488300 | 382710 |
| S20 | S20 | 488300 | 382700 |

**Figure 5-1.** Selected Sensitive Receptor Locations



# 6.0 Detailed Modelling Methodology

In order to consider the potential air quality impacts from a fire, a quantitative assessment using the third generation ADMS-Roads dispersion model has been undertaken. ADMS stands for '*Atmospheric Dispersion Modelling System*'.

The ADMS-Roads pollution model is a comprehensive tool for investigating air pollution problems due to networks of roads that may be in combination with industrial sites (for example, point source). A fire, for example, a solar panel fire, has been modelled as an industrial emission source.

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

Hourly (short-term) particulate matter ($PM_{2.5}$) concentrations have been used to define air quality categories and fire smoke exposure levels for protecting human health.

## 6.2 Modelling of Fire Using ADMS-Roads

In ADMS-Roads Modelling, a fire is assumed to consist of a flaming region directly above the fuel source, for example, solar panels. Above the flaming region is a hot region, which is referred to as the buoyant plume. In the buoyant plume the combustion products from the fire are carried upwards in the strong buoyant flow generated by the heat released. The combination of the fire and associated buoyant plume is referred to as the fire plume.

ADMS-Roads has been used to model the dispersion of combustion products from the top point of the buoyant plume. The modelled release height H = fuel height + flame height.

## 6.3 Particulate Matter ($PM_{2.5}$) Emission Rates from a Fire

Tetra Tech have reviewed and studied few solar panels fire incident videos available on the internet. A number of assumptions have been made in building a conceptual model to simulate a solar panel file.

1. A solar panel is between 0.8 m (the front edge) and 2.5 m (the back of the panel) above ground level. A solar panel fuel height of 1 m is assumed;
2. Fire flame height 1 m;
3. Single solar panel size (L x W): 1680 mm x 966 mm;
4. Single solar panel weight: 18 to 20 kg;
5. Assuming 9 panel on fire with flame at same time;

6. Solar panel combustible percentage: assuming 100%;
7. Time for a solar panel to be burn out: 30 minutes; and
8. The mass emission calculations of carbon monoxide and heavy metals have been derived from the testing results of German Guideline on Assessing Fire Risks in Photovoltaic Systems and Developing Safety Concepts for Risk Minimization, June 2018. The gases of nitrogen dioxide, sulphur dioxide, hydrogen chloride and hydrogen fluoride were not detectable in the smoke gases.

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

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

| Parameter | 9 Single Solar Panels on Fire | Unit |
|---|---|---|
| No. of solar panels on fire | 9 | - |
| Single solar panel weight | 20 | kg |
| Total combustible weight | 180 | kg |
| Fire exhaust gas volume at 20 °C and 101.325 Pa | 1031.7 [a] | $Nm^3$ |
| Heat release from a fire, using hard PVC as material | 20 | MJ/kg |
| Time for a solar panel to be burn out: 30 minutes | 30 | minutes |
| Fire gas volume at reference condition of 273 K, 101.3kPa, dry gas | 0.57 | $Nm^3/s$ |
| Fire gas temperature | 304 [b] | °C |
| Fire gas volume at fire gas temperature | 1.13 | $Am^3/s$ |
| Particulate emission rate ($PM_{2.5}$) | 19 [c] | Kg/tonne of panel |
| | 4.01 | g/s |
| Panel area on fire | 15.06 | $m^2$ |
| Arsenic (AS) | 0.0000082 | g/s |
| Lead (Pb) | 0.00682 | g/s |
| Cadmium (Cd) | 0.00040 | g/s |
| Selenium (Se) | 0.00021 | g/s |
| Carbon monoxide | 1.96 | g/s |
| Fire gas upward velocity | 10 | m/s |
| Flame height + fuel height | 2 | m |

Note:

a. *Derived from the wood dry flue gas of 4.892 $Nm^3$/kg and Wood heat release of 17MJ/kg.*
b. *Derived from the peak temperature from a car fire; and*
c. Particulate emission rates from 4.8 kg/ton (green waste to 19 kg/tonne (agricultural leaves). The maximum being used.

## 6.4 Meteorological Data

The meteorological data (2019) used in the assessment is 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 ADMS-Roads model. Reference should be made to **Figure 6-1** for an illustration of the prevalent wind conditions at the weather station.

The met data have been modified/adjusted to have the wind blowing constantly at one direction, for example, wind always blow from the south, north, east or west. The adjustment is necessary for assessing fire impact at downwind locations for a certain short period. The wind roses of 2019 met (not adjusted) and the adjusted wind conditions from the south, north, east and west are presented in **Figure 6-1** (next page).

## 6.5 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.

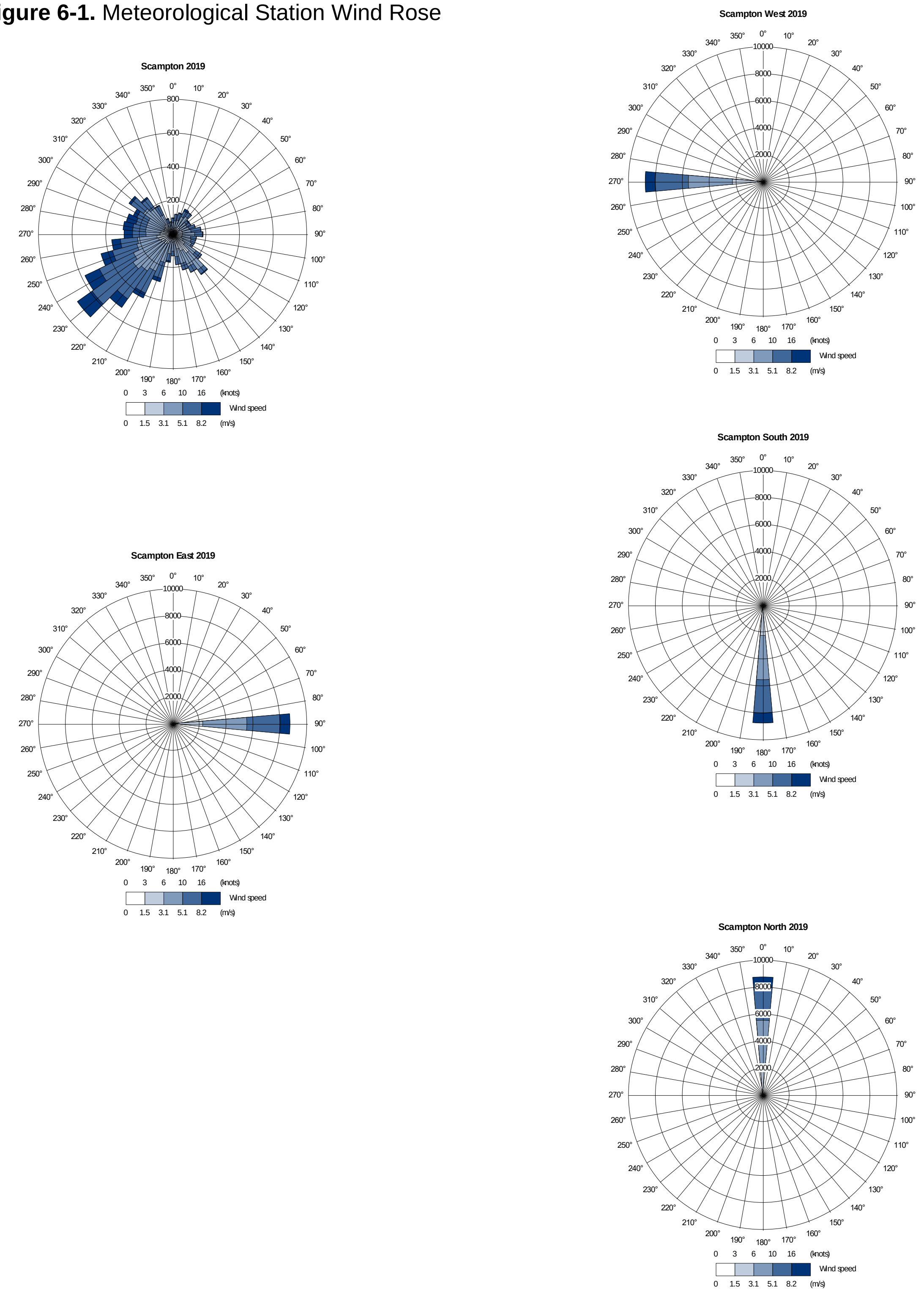
## 6.6 Buildings in the Modelling Assessment

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 solar panels and therefore, no buildings have been included in the model for the assessment.

## 6.7 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 6-1.** Meteorological Station Wind Rose



## 6.8 Modelling Uncertainty

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

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

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

- Choice of model – ADMS-Roads is a commonly used atmospheric dispersion model and results have been verified through a number of studies to ensure predictions are as accurate as possible;
- Emission rates - Emissions were based on the number of solar panels could be on fire at a time;
- 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

The detailed computational modelling assessment of process emissions of particulate matter ($PM_{2.5}$) was undertaken using the input parameters detailed in Section 6.

## 7.1 Particulate Matter ($PM_{2.5}$)

Predicted $PM_{2.5}$ concentrations have been used to determine the air quality category levels of the health concern.

**Short-Term (1-hr mean) Particulate Matter ($PM_{2.5}$)**

The short-term emissions of particulate matter ($PM_{2.5}$) from a fire incident were assessed using the adjusted met data which assumes the wind would blow constantly in one direction during the fire, resulting in the worst impact on the receptors at downwind locations. A total of 4 wind directions of easterly, westerly, southerly and northerly wind have been assessed.

The model results show that the maximum predicted particulate matter concentration at the modelled receptor locations was predicted when wind is blowing from the north. The model results also demonstrate that there is very little difference (less than 0.01% of differences) between the predicted concentrations when using the east, south or west wind met data. The predicted concentrations when wind is blowing from the north are presented in **Table 7-1** for the assessment.

**Table 7-1.** The Short-Term (1-Hour Mean) Concentrations of $PM_{2.5}$ at Different Receptor Locations

| Receptors at Down Wind Locations of a Fire | | The Maximum Predicted 1-Hour Mean (µg/m³) | |
|---|---|---|---|
| **Name** | **Wind Blows from North to South** | **PC [a] (µg/m³)** | **PEC [b] (PC + Background [c]) (µg/m³)** |
| 10 m from the Fire | S1 | 588.71 | 603.0 |
| 20 m from the fire | S2 | 244.20 | 258.5 |
| 30 m from the Fire | S3 | 155.77 | 170.1 |
| 40 m from the Fire | S4 | 116.55 | 130.9 |
| 50 m from the Fire | S5 | 94.15 | 108.5 |
| 60 m from the Fire | S6 | 79.45 | 93.8 |
| 70 m from the Fire | S7 | 68.98 | 83.3 |
| 80 m from the Fire | S8 | 61.06 | 75.4 |
| 90 m from the Fire | S9 | 54.84 | 69.1 |
| 100 m from the Fire | S10 | 49.80 | 64.1 |
| 110 m from the Fire | S11 | 45.62 | 59.9 |
| 120 m from the Fire | S12 | 42.11 | 56.4 |
| 130 m from the Fire | S13 | 39.09 | 53.4 |
| 140 m from the Fire | S14 | 36.48 | 50.8 |
| 150 m from the Fire | S15 | 34.18 | 48.5 |
| 160 m from the Fire | S16 | 32.15 | 46.5 |
| 170 m from the Fire | S17 | 30.34 | 44.6 |
| 180 m from the Fire | S18 | 28.72 | 43.0 |
| 190 m from the Fire | S19 | 27.25 | 41.6 |
| 200 m from the Fire | S20 | 25.92 | 40.2 |

*Note:*
*(a) PC – the process contribution/the concentration contributed by fire;*
*(b) PEC the predicted environmental concentration (PC + background); and*
*(c) 1-hour $PM_{2.5}$ background concentration of 14.31µg/m³.*

There is no short-term $PM_{2.5}$ air quality standard.

Any residential receptors within 200 m of the fire location, however, will be notified and going to cleaner air area if the smoke event is projected to be prolonged. It is unlikely that a solar panel fire will last over 24 hours. The daily mean (24-hour average) $PM_{2.5}$ concentrations outside of 200 m fire zone (the receptors being located more than 200 m away from the fire) will be less than 35 µg/m³ (or less than a value of the UK air quality index 3) and the zones being 200 m away a fire can be classified as a 'low' air pollution banding according to UK Air 'Daily Air Quality Index'.

The $PM_{2.5}$ concentrations determined in **Table 7-1** have been combined with the smoke levels from particulate matter concentrations shown in **Table 4-2** to determine the air quality category at each of the receptor locations, as shown in **Table 7-2.**

**Table 7-2.** Predicted $PM_{2.5}$ Concentrations and Associated Air Quality Category

| Receptors at Down Wind Locations of a Fire | | The Maximum Predicted 1-Hour Mean (µg/m³) | Air Quality Category |
|---|---|---|---|
| Name | Wind Blows from North to Sough | PEC (PC + Background) (µg/m³) | |
| 10 m from the Fire | S1 | 603.0 | Hazardous |
| 20 m from the Fire | S2 | 258.5 | Unhealthy |
| 30 m from the Fire | S3 | 170.1 | Moderate/Unhealthy for Sensitive Groups |
| 40 m from the Fire | S4 | 130.9 | |
| 50 m from the Fire | S5 | 108.5 | |
| 60 m from the Fire | S6 | 93.8 | |
| 70 m from the Fire | S7 | 83.3 | |
| 80 m from the Fire | S8 | 75.4 | |
| 90 m from the Fire | S9 | 69.1 | |
| 100 m from the Fire | S10 | 64.1 | |
| 110 m from the Fire | S11 | 59.9 | |
| 120 m from the Fire | S12 | 56.4 | |
| 130 m from the Fire | S13 | 53.4 | |
| 140 m from the Fire | S14 | 50.8 | |
| 150 m from the Fire | S15 | 48.5 | |
| 160 m from the Fire | S16 | 46.5 | |
| 170 m from the Fire | S17 | 44.6 | |
| 180 m from the Fire | S18 | 43.0 | |
| 190 m from the Fire | S19 | 41.6 | |
| 200 m from the Fire | S20 | 40.2 | |
| >200 m from the Fire | - | <40 | Good |

**Table 7-3** illustrates 4 identified air quality category zones and the zones are summarised as below:

**Table 7-3.** Air Quality Category Zones

| Air Quality Category Zones | Distance to a Fire (m) |
|---|---|
| Hazardous Zone | Within 10 m from the Fire |
| Unhealthy Zone | 11 to 20 m from the Fire |
| Moderate/Unhealthy for Sensitive Groups Zone | 21 to 200 m from the Fire |
| Good air quality Zone | More than 200 m from fire |

## 7.2 Carbon monoxide (CO)

The predicted short-term (8-hour running mean) CO concentrations from a fire incident at downwind receptor locations when wind is blowing from the north are presented in **Table 7-4.**

**Table 7-4.** Predicted Short-Term Concentrations of CO at Downwind Receptor Locations

| Receptors at Down Wind Locations of a Fire | | The Maximum Predicted 8-Hour Mean (µg/m$^3$) | | |
|---|---|---|---|---|
| Name | Wind Blows from North to Sough | PC | Background | PEC (PC + Background) |
| 10 m from the Fire | S1 | 201.42 | 107 | 308.42 |
| 20 m from the Fire | S2 | 83.55 | 107 | 190.55 |
| 30 m from the Fire | S3 | 53.30 | 107 | 160.30 |
| 40 m from the Fire | S4 | 39.88 | 107 | 146.88 |
| 50 m from the Fire | S5 | 32.21 | 107 | 139.21 |
| 60 m from the Fire | S6 | 27.18 | 107 | 134.18 |
| 70 m from the Fire | S7 | 23.60 | 107 | 130.60 |
| 80 m from the Fire | S8 | 20.89 | 107 | 127.89 |
| 90 m from the Fire | S9 | 18.76 | 107 | 125.76 |
| 100 m from the Fire | S10 | 17.04 | 107 | 124.04 |
| 110 m from the Fire | S11 | 15.61 | 107 | 122.61 |
| 120 m from the Fire | S12 | 14.41 | 107 | 121.41 |
| 130 m from the Fire | S13 | 13.37 | 107 | 120.37 |
| 140 m from the Fire | S14 | 12.48 | 107 | 119.48 |
| 150 m from the Fire | S15 | 11.70 | 107 | 118.70 |
| 160 m from the Fire | S16 | 11.00 | 107 | 118.00 |
| 170 m from the Fire | S17 | 10.38 | 107 | 117.38 |
| 180 m from the Fire | S18 | 9.83 | 107 | 116.83 |
| 190 m from the Fire | S19 | 9.33 | 107 | 116.33 |
| 200 m from the Fire | S20 | 8.87 | 107 | 115.87 |
| AQOs | 10,000 | | | |

As indicated in **Table 7-4**, the maximum predicted 8-hour running mean CO process contributions (PC) at receptors is 201.42 µg/m$^3$. The predicted 8-hour running mean PCs of CO at the modelled discrete receptors are well below 2.01% of the short-term AQO, which are considered insignificant.

The maximum PEC of 8-hour running mean CO emissions is 308.42 µg /m$^3$, which does not exceed the relevant short-term AQS of 10,000 µg/m$^3$. 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.

## 7.3 Arsenic (As)

British Occupational Exposure Limits have been used in the assessment.

**8-Hour Mean for the Protection of Workers**

Predicted ground level 8-hour mean As concentrations from a fire incident at downwind receptor locations when wind is blowing from the north were assessed against the WELs. The results of the model predictions at each discrete receptor, inclusive of background, are summarised in Table **7-5**.

**Table 7-5.** Predicted Short-Term Concentrations of As at Downwind Receptor Locations

| Receptors at Down Wind Locations of a Fire | | The Maximum Predicted 8-Hour Mean (µg/m³) | | |
|---|---|---|---|---|
| Name | Wind Blows from North to Sough | PC | Background | PEC (PC + Background) |
| 10 m from the Fire | S1 | 8.43E-04 | 1.32E-03 | 2.16E-03 |
| 20 m from the Fire | S2 | 3.50E-04 | 1.32E-03 | 1.67E-03 |
| 30 m from the Fire | S3 | 2.23E-04 | 1.32E-03 | 1.54E-03 |
| 40 m from the Fire | S4 | 1.67E-04 | 1.32E-03 | 1.49E-03 |
| 50 m from the Fire | S5 | 1.35E-04 | 1.32E-03 | 1.45E-03 |
| 60 m from the Fire | S6 | 1.14E-04 | 1.32E-03 | 1.43E-03 |
| 70 m from the Fire | S7 | 9.87E-05 | 1.32E-03 | 1.42E-03 |
| 80 m from the Fire | S8 | 8.74E-05 | 1.32E-03 | 1.41E-03 |
| 90 m from the Fire | S9 | 7.85E-05 | 1.32E-03 | 1.40E-03 |
| 100 m from the Fire | S10 | 7.13E-05 | 1.32E-03 | 1.39E-03 |
| 110 m from the Fire | S11 | 6.53E-05 | 1.32E-03 | 1.39E-03 |
| 120 m from the Fire | S12 | 6.03E-05 | 1.32E-03 | 1.38E-03 |
| 130 m from the Fire | S13 | 5.60E-05 | 1.32E-03 | 1.38E-03 |
| 140 m from the Fire | S14 | 5.22E-05 | 1.32E-03 | 1.37E-03 |
| 150 m from the Fire | S15 | 4.89E-05 | 1.32E-03 | 1.37E-03 |
| 160 m from the Fire | S16 | 4.60E-05 | 1.32E-03 | 1.37E-03 |
| 170 m from the Fire | S17 | 4.34E-05 | 1.32E-03 | 1.36E-03 |
| 180 m from the Fire | S18 | 4.11E-05 | 1.32E-03 | 1.36E-03 |
| 190 m from the Fire | S19 | 3.90E-05 | 1.32E-03 | 1.36E-03 |
| 200 m from the Fire | S20 | 3.71E-05 | 1.32E-03 | 1.36E-03 |
| WEL | 100 | | | |

As indicated in **Table 7-5,** the maximum predicted 8-hour running mean As process contributions (PC) at receptors is $8.43\times10^{-4}$ µg/m³. The predicted 8-hour mean PCs of As at the modelled discrete receptors are well below $8.43\times10^{-4}$ % of the WEL, which are considered insignificant.

The maximum PEC of 8-hour mean As emissions is $2.16\times10^{-3}$ µg/m³, which does not exceed the relevant short-term WEL of 100 µg/m³.

## 7.4 Lead (Pb)

British Occupational Exposure Limits have been used in the assessment.

**8-Hour Mean for the Protection of Workers**

Predicted ground level 8-hour mean Pb concentrations from a fire incident at downwind receptor locations when wind is blowing from the north were assessed against the WELs. The results of the model predictions at each discrete receptor, inclusive of background, are summarised in **Table 7-6**.

**Table 7-6.** Predicted Short-Term Concentrations of Pb at Downwind Receptor Locations

| Receptors at Down Wind Locations of a Fire | | The Maximum Predicted 8-Hour Mean (µg/m$^3$) | | |
|---|---|---|---|---|
| Name | Wind Blows from North to Sough | PC | Background | PEC (PC + Background) |
| 10 m from the Fire | S1 | 0.70 | 0.031 | 0.73 |
| 20 m from the Fire | S2 | 0.29 | 0.031 | 0.32 |
| 30 m from the Fire | S3 | 0.19 | 0.031 | 0.22 |
| 40 m from the Fire | S4 | 0.14 | 0.031 | 0.17 |
| 50 m from the Fire | S5 | 0.11 | 0.031 | 0.14 |
| 60 m from the Fire | S6 | 0.09 | 0.031 | 0.13 |
| 70 m from the Fire | S7 | 0.08 | 0.031 | 0.11 |
| 80 m from the Fire | S8 | 0.07 | 0.031 | 0.10 |
| 90 m from the Fire | S9 | 0.07 | 0.031 | 0.10 |
| 100 m from the Fire | S10 | 0.06 | 0.031 | 0.09 |
| 110 m from the Fire | S11 | 0.05 | 0.031 | 0.09 |
| 120 m from the Fire | S12 | 0.05 | 0.031 | 0.08 |
| 130 m from the Fire | S13 | 0.05 | 0.031 | 0.08 |
| 140 m from the Fire | S14 | 0.04 | 0.031 | 0.07 |
| 150 m from the Fire | S15 | 0.04 | 0.031 | 0.07 |
| 160 m from the Fire | S16 | 0.04 | 0.031 | 0.07 |
| 170 m from the Fire | S17 | 0.04 | 0.031 | 0.07 |
| 180 m from the Fire | S18 | 0.03 | 0.031 | 0.07 |
| 190 m from the Fire | S19 | 0.03 | 0.031 | 0.06 |
| 200 m from the Fire | S20 | 0.03 | 0.031 | 0.06 |
| WEL | 150 | | | |

As indicated in **Table 7-6,** the maximum predicted 8-hour running mean As process contributions (PC) at receptors is 0.7 µg/m$^3$. The predicted 8-hour mean PCs of As at the modelled discrete receptors are well below 0.47 % of the WEL, which are considered insignificant.

The maximum PEC of 8-hour mean As emissions is 0.73 µg/m$^3$, which does not exceed the relevant short-term WEL of 500 µg/m$^3$.

## 7.5 Cadmium (Cd)

British Occupational Exposure Limits have been used in the assessment.

**8-Hour Mean for the Protection of Workers**

Predicted ground level 8-hour mean Cd concentrations from a fire incident at downwind receptor locations when wind is blowing from the north were assessed against the WELs. The results of the model predictions at each discrete receptor, inclusive of background, are summarised in **Table 7-7**.

**Table 7-7.** Predicted Short-Term Concentrations of Cd at Downwind Receptor Locations

| Receptors at Down Wind Locations of a Fire | | The Maximum Predicted 8-Hour Mean (µg/m$^3$) | | |
|---|---|---|---|---|
| Name | Wind Blows from North to Sough | PC | Background | PEC (PC + Background) |
| 10 m from the Fire | S1 | 4.11E-02 | 7.80E-04 | 4.19E-02 |
| 20 m from the Fire | S2 | 1.71E-02 | 7.80E-04 | 1.78E-02 |
| 30 m from the Fire | S3 | 1.09E-02 | 7.80E-04 | 1.17E-02 |
| 40 m from the Fire | S4 | 8.14E-03 | 7.80E-04 | 8.92E-03 |
| 50 m from the Fire | S5 | 6.57E-03 | 7.80E-04 | 7.35E-03 |
| 60 m from the Fire | S6 | 5.55E-03 | 7.80E-04 | 6.33E-03 |
| 70 m from the Fire | S7 | 4.82E-03 | 7.80E-04 | 5.60E-03 |
| 80 m from the Fire | S8 | 4.26E-03 | 7.80E-04 | 5.04E-03 |
| 90 m from the Fire | S9 | 3.83E-03 | 7.80E-04 | 4.61E-03 |
| 100 m from the Fire | S10 | 3.48E-03 | 7.80E-04 | 4.26E-03 |
| 110 m from the Fire | S11 | 3.19E-03 | 7.80E-04 | 3.97E-03 |
| 120 m from the Fire | S12 | 2.94E-03 | 7.80E-04 | 3.72E-03 |
| 130 m from the Fire | S13 | 2.73E-03 | 7.80E-04 | 3.51E-03 |
| 140 m from the Fire | S14 | 2.55E-03 | 7.80E-04 | 3.33E-03 |
| 150 m from the Fire | S15 | 2.39E-03 | 7.80E-04 | 3.17E-03 |
| 160 m from the Fire | S16 | 2.25E-03 | 7.80E-04 | 3.03E-03 |
| 170 m from the Fire | S17 | 2.12E-03 | 7.80E-04 | 2.90E-03 |
| 180 m from the Fire | S18 | 2.01E-03 | 7.80E-04 | 2.79E-03 |
| 190 m from the Fire | S19 | 1.90E-03 | 7.80E-04 | 2.68E-03 |
| 200 m from the Fire | S20 | 4.11E-02 | 7.80E-04 | 4.19E-02 |
| WEL | 25 | | | |

As indicated in **Table 7-7,** the maximum predicted 8-hour running mean As process contributions (PC) at receptors is $4.11\times10^{-2}$ µg/m$^3$. The predicted 8-hour mean PCs of As at the modelled discrete receptors are well below 0.16 % of the WEL, which are considered insignificant.

The maximum PEC of 8-hour mean As emissions is $4.19\times10^{-2}$ µg/m$^3$, which does not exceed the relevant short-term WEL of 25 µg/m$^3$.

## 7.6 Selenium (Se)

British Occupational Exposure Limits have been used in the assessment.

**8-Hour Mean for the Protection of Workers**

Predicted ground level 8-hour mean Se concentrations from a fire incident at downwind receptor locations when wind is blowing from the north were assessed against the WELs. The results of the model predictions at each discrete receptor, inclusive of background, are summarised in **Table 7-8.**

**Table 7-8.** Predicted Short-Term Concentrations of Se at Downwind Receptor Locations

| Receptors at Down Wind Locations of a Fire | | The Maximum Predicted 8-Hour Mean (μg/m³) | | |
|---|---|---|---|---|
| Name | Wind Blows from North to Sough | PC | Background | PEC (PC + Background) |
| 10 m from the Fire | S1 | 2.16E-02 | 1.38E-03 | 2.30E-02 |
| 20 m from the Fire | S2 | 8.95E-03 | 1.38E-03 | 1.03E-02 |
| 30 m from the Fire | S3 | 5.71E-03 | 1.38E-03 | 7.09E-03 |
| 40 m from the Fire | S4 | 4.27E-03 | 1.38E-03 | 5.65E-03 |
| 50 m from the Fire | S5 | 3.45E-03 | 1.38E-03 | 4.83E-03 |
| 60 m from the Fire | S6 | 2.91E-03 | 1.38E-03 | 4.29E-03 |
| 70 m from the Fire | S7 | 2.53E-03 | 1.38E-03 | 3.91E-03 |
| 80 m from the Fire | S8 | 2.24E-03 | 1.38E-03 | 3.62E-03 |
| 90 m from the Fire | S9 | 2.01E-03 | 1.38E-03 | 3.39E-03 |
| 100 m from the Fire | S10 | 1.83E-03 | 1.38E-03 | 3.21E-03 |
| 110 m from the Fire | S11 | 1.67E-03 | 1.38E-03 | 3.05E-03 |
| 120 m from the Fire | S12 | 1.54E-03 | 1.38E-03 | 2.92E-03 |
| 130 m from the Fire | S13 | 1.43E-03 | 1.38E-03 | 2.81E-03 |
| 140 m from the Fire | S14 | 1.34E-03 | 1.38E-03 | 2.72E-03 |
| 150 m from the Fire | S15 | 1.25E-03 | 1.38E-03 | 2.63E-03 |
| 160 m from the Fire | S16 | 1.18E-03 | 1.38E-03 | 2.56E-03 |
| 170 m from the Fire | S17 | 1.11E-03 | 1.38E-03 | 2.49E-03 |
| 180 m from the Fire | S18 | 1.05E-03 | 1.38E-03 | 2.43E-03 |
| 190 m from the Fire | S19 | 9.99E-04 | 1.38E-03 | 2.38E-03 |
| 200 m from the Fire | S20 | 9.50E-04 | 1.38E-03 | 2.33E-03 |
| WEL | 100 | | | |

As indicated in **Table 7-8,** the maximum predicted 8-hour running mean As process contributions (PC) at receptors is $3.16 \times 10^{-2}$ μg/m³. The predicted 8-hour mean PCs of As at the modelled discrete receptors are well below $3.16 \times 10^{-2}$ % of the WEL, which are considered insignificant.

The maximum PEC of 8-hour mean As emissions is $2.30 \times 10^{-2}$ μg/m³, which does not exceed the relevant short-term WEL of 100 μg/m³.

# 8.0 Action Plan for Protecting Human Health from Fire Smoke

The following table details actions to be taken for the protection of human health during a fire within the identified air quality category zones.

**Table 8-1.** Recommended Actions in Case of a Fire

| Air Quality Category | Air Quality Category Zones | Health Messages At-Risk (Sensitive*) Populations | Health Messages General Populations | Actions for Site Manager/fire safety representative at Island Green Power Limited |
|---|---|---|---|---|
| >200 m from the fire | Good | Enjoy your usual outdoor activities | Ideal air quality for outdoor activities | N/A |
| 21 - 200 m from a fire | Moderate/Unhealthy for Sensitive Groups | Reduce or reschedule prolonged strenuous activities and limit time spent outdoors | Be aware of health effects of smoke and related symptoms. | Inform any residents/public within the zone.<br>Advise the public about: health effects of smoke, related symptoms, and ways to reduce exposure. If the smoke event is projected to be prolonged, evaluate and notify possible cleaner air location and prepare evacuation plans for At-Risk Populations. |
| 21 – 20 m from a fire | **Unhealthy** | Avoid prolonged strenuous activities and stay indoors if possible. | Reduce or reschedule prolonged strenuous activities outdoors, especially if you experience symptoms. | Inform any residents/public within the zone and Consider having populations go to cleaner air area. |
| 10 m from a fire | **Hazardous** | Avoid all strenuous activities and stay indoors. | Avoid all strenuous activities and stay indoors. | Inform any residents/public within the zone to cancel outdoor events.<br><br>Consider having populations go to cleaner air area. |

*Note: *Sensitive: People with existing respiratory and cardiovascular conditions, infants and young children, the elderly, pregnant women and possibly other groups (diabetics, smokers and people participating in sports or strenuous work outdoors).*

# 9.0 Conclusions

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

The objective of the solar panel 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.

Baseline air quality conditions have been defined.

The detailed modelling results have been presented in terms of the emitted pollutant PC and PEC. ADMS modelling has been undertaken for the most representative meteorological dataset and the worst-case, highest predicted short-term PECs have been compared to the appropriate AQOs/WELs.

**Air Quality Impact Assessment Results for a Solar Panel Fire**

The pollutants assessed have been selected based on the research and testing of solar panel fires undertaken by BMU. BMU is an abbreviation of 'Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany)'.

The short-term predicted environmental concentrations of carbon monoxide, arsenic, lead, cadmium, selenium the selected receptor locations from a solar panel fire incident are all below the relevant air quality objectives for the protection of human health or workplace exposure limits for the protection of workers.

The daily mean (24-hour average) $PM_{2.5}$ concentrations outside of 200 metre fire zone (the receptors are located more than 200 m away from the fire location) will be below the level of air pollution of UK air quality index value 3 and the zone can be classified as a 'low' air pollution banding.

Four air quality category zones have been identified based on the predicted short-term $PM_{2.5}$ concentrations.

The effect of a fire incident has been assessed using the 'Air Quality Category' which is classified as 'good', 'moderate', 'unhealthy', 'very unhealthy' or 'hazardous'. The 'Air Quality Category' and air quality category zones have been defined according to the fire-generated particulate matter (equivalent to $PM_{2.5}$) concentrations in air.

Four air quality category zones have been identified:

- Hazardous Zone – within 10 m from a fire;
- Unhealthy Zone – 11 to 20 m from a fire;
- Moderate/Unhealthy for Sensitive Groups Zone – 21 to 200 m from a fire; and
- Good Air Quality Zone – more than 200 m from a fire.

### Solar Panel Fire Action Plan

A fire could occur at any location within the development during the site construction, operational and decommissioning phases, therefore, generic receptor locations have been used in the assessment. In the case of a fire occurring, the site manager/fire safety representative will need to assess the fire locations, 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 within the affected zones and to advise public about health effects of smoke, related symptoms, and ways to reduce exposure; (2) to cancel outdoor events; and/or (3) to move affected residents to a cleaner air location.

# Units and Abbreviations Used

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

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

# Appendix A – Terms & Conditions

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