Air Emissions Risk Assessment and Dispersion Modelling

Olefins 6 Plant Shutdown Temporary Boilers

SABIC UK Petrochemicals Ltd

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PROJECT 215000-00036 - Air Emissions Risk Assessment and Dispersion Modelling - Olefins 6 Plant Shutdown Temporary Boilers

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Glossary

APIS	UK Air Pollution Information System
CO	Carbon Monoxide
EA	UK Environment Agency
GLC	Ground Level Concentration
NO_X	Nitrogen Oxides (Nitrogen Monoxide + Nitrogen Dioxide)
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
O_3	Ozone
PC	Process Contribution
PEC	Predicted Environmental Concentration (Process Contribution + Background Levels)
PM_{10}	Particulate Matter with particle diameter equal or lower than 10 micrometers (µm)
$PM_{2.5}$	Particulate Matter with particle diameter equal or lower than 2.5 µm (fine PM)
SO_2	Sulphur Dioxide
SPA	Special Protection Areas
SSSI	Site of Special Scientific Interest
US EPA	United States Environmental Protection Agency

Executive summary

SABIC UK Petrochemicals Ltd (SABIC) is planning to shut down their Olefins 6 Plant in Wilton. During the shutdown, two temporary boilers will be required to supply steam for a period of 4 weeks (2 weeks at the start and 2 weeks at the end).

This report summarises the assessment of the potential impacts from the air emissions of the temporary boilers, which was completed following the procedures established by the UK Environment Agency in two parts:

1. **Air Emissions Risk Assessment (H1)**

   The methodology described by the UK Environment Agency for air emissions risk assessments was followed to 1) identify the emissions of air pollutants from the temporary boilers that may pose a risk to human health and protected areas; and 2) disregard the emissions that may have negligible impact.

   The results of the Air Emissions Risk Assessment found that the emissions of nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) were considered relevant and required detailed dispersion modelling.

2. **Dispersion Modelling Assessment**

   The dispersion of pollutants deemed relevant based on the H1 Assessment was modelled using the dispersion model AERMOD. The objective of the modelling assessment was to quantify potential impacts from the Project emissions on human health and nearby protected areas.

The results of the dispersion modelling found that the maximum impacts from project emissions (“process contributions” - PCs) were encountered northeast nearby the emission sources, within SABIC facilities boundary limits. Process contributions to impacts on sensitive locations for human health and protected areas are minor.

Cumulative impact (“predicted environmental concentration” - PEC) does not exceed any of the UK Air Quality Standards in the sensitive locations for human health. The PEC in Seal Sands Peninsula (protected area) exceeds the 24-hr NO_2 Environment Agency Target for Protected Areas due to the already high background NO_2 levels in that location. Process contribution to PECs in all the protected areas assessed is negligible.

1 Introduction

1.1 Project Description and Location

The SABIC UK Petrochemicals Ltd (SABIC) Olefins 6 Plant is undertaking a shutdown process. The plant is located at Sembcorp Wilton International site, approximately 5 km south of the Teesmouth and Cleveland Coast, a Site of Special Scientific Interest (SSIA), Special Protection Area (SPA) and Ramsar site. The plant location is outlined in blue and white in Figure 1-1.

Figure 1-1. Project location (blue and white)

During the shutdown process, two temporary boilers will be installed in the plant to supply steam. The two boilers will each operate at 50% load and will use Low NO_X light fuel oil. Each of the boilers will have a dedicated stack and will be mounted above an articulated lorry trailer, making the effective stack height 9.65 metres.

The emissions data for each of the two boilers operating at 50% load, as provided by the vendor, are summarised in Table 1-1.

Table 1-1. Temporary boiler emissions vendor data (per unit)

Parameter	Units	IPPC Data (50% load)
Boiler Output (Actual)	kg/hr	3,244
Fuel		Low NO_X Light Fuel Oil
Efficiency (Gross)	%	88
Fuel Input	kg/s	0.052
Flue Gas Temperature	°C	205
Flue Diameter (Internal)	mm	529
Flue Gas Volume (Dry Basis)	Nm^3/hr	2,308.36
Efflux Velocity at 205°C	m/s	5.68
NO_X Emissions		
Concentration	mg/m^3 (dry)	200
Rate	g/s	0.128
SO_X Emissions		
Concentration	mg/m^3 (dry)	162
Rate	g/s	0.1104
CO Emissions	g/s	0.019
Concentration	mg/m^3 (dry)	30
Rate	g/s	0.019
PM_{10} Emissions		
Concentration	mg/m^3 (dry)	11.349
Rate	g/s	0.0073
$PM_{2.5}$ Emissions		
Concentration	mg/m^3 (dry)	2.432
Rate	g/s	0.0016

1.2 Objective and Scope of Work

The main objectives of this assessment are to identify and quantify the potential impacts to human health and protected areas due to the emissions of air pollutants from the temporary boilers to be operative during the Olefins 6 Plant shutdown.

The boilers are planned to operate for 4 weeks only; therefore, only short-term impacts were assessed. Considering that all the combustion sources that normally operate in the plant will be shut down, it is expected that potential impacts from the temporary boilers will be lower than those currently generated during the normal operation of the plant.

The potential impacts from the Project air emissions were identified and quantified following the procedures set by the UK Environment Agency (UK EA, 2016), summarised below:

- **Air Emissions Risk Assessment (H1).** Identify the emissions of air pollutants from the temporary boilers that may pose a risk to human health and protected areas; and 2) disregard the emissions that may have negligible impact (described in detail in Section 5 and Appendix A).
- **Dispersion Modelling Assessment.** The air dispersion of pollutants deemed relevant based on the Air Emissions Risk Assessment was modelled using the dispersion model AERMOD. The objective of the modelling assessment was to quantify potential impacts from the Project emissions on human health and nearby protected areas. The modelling methodology and results are described in detail in Sections 7 and 8. The modelling was prepared in compliance with the requirements of the UK Environment Agency for air dispersion modelling reports (UK EA, 2019).

These assessments focused only on the potential air emission impacts from the two temporary boilers. Emissions from other facilities in the Project area were not considered; however, background air quality levels were consulted to assess current air quality levels in the area. As the background air quality levels include normal process emissions from the SABIC plant, this makes the assessment very conservative.

2 Air Quality Standards

2.1 Human Health Protection Limits

The ambient air quality standards and objectives established in the UK for human health protection are summarised in the UK Air Quality Standards Regulations and the Air Quality Strategy. These are summarised in Table 2-1 for the main pollutants emitted by the project.

Table 2-1. UK Air Quality Standards and Objectives for Human Health Protection

Pollutant	Average Period	Limit (μg/m³)	Allowed Exceedances
NO_2	1 h	200	Not to be exceeded more than 18 times a year
	Annual	40	None
SO_2	15 min	266	Not to be exceeded more than 35 times a year
	1 h	350	Not to be exceeded more than 24 times a year
	24 h	125	Not to be exceeded more than 3 times a year
CO	8 h	10,000	None
PM_{10}	24 h	50	Not to be exceeded more than 35 times a year
	Annual	40	None
$PM_{2.5}$	Annual	25	None

2.2 Protected Areas Limits

Additionally, the UK establishes air quality standards for the protection of conservation areas with additional non-statutory environmental assessment levels (EALs) set by the Environment Agency. These are summarised in Table 2-2 for the pollutants emitted in the project.

Table 2-2. UK Standards and Environment Agency EALs for Protected Areas

Pollutant	Average Period	Limit (μg/m³)	Allowed Exceedances
NO_2	24 h	75	None
	Annual	30	None
SO_2	Annual	10 / 20[(1)]	None

(1) 10 $\mu g/m^3$ where lichens or bryophytes are present, 20 $\mu g/m^3$ where they are not present

3 Receptors of Special Interest

A set of locations of special interest were identified near the Project site, as indicated in Figure 3-1. These locations, considered receptors, were selected to assess the potential impact due to the Project emissions on:

- Protected areas. Relevant protected areas include the Teesmouth and Cleveland Coast and the River Tees. Ecosystems in these areas, as well as wildlife (i.e, feeding birds), are sensitive to air pollution.
- Sensitive locations for human health, such as schools, hospitals and leisure areas.

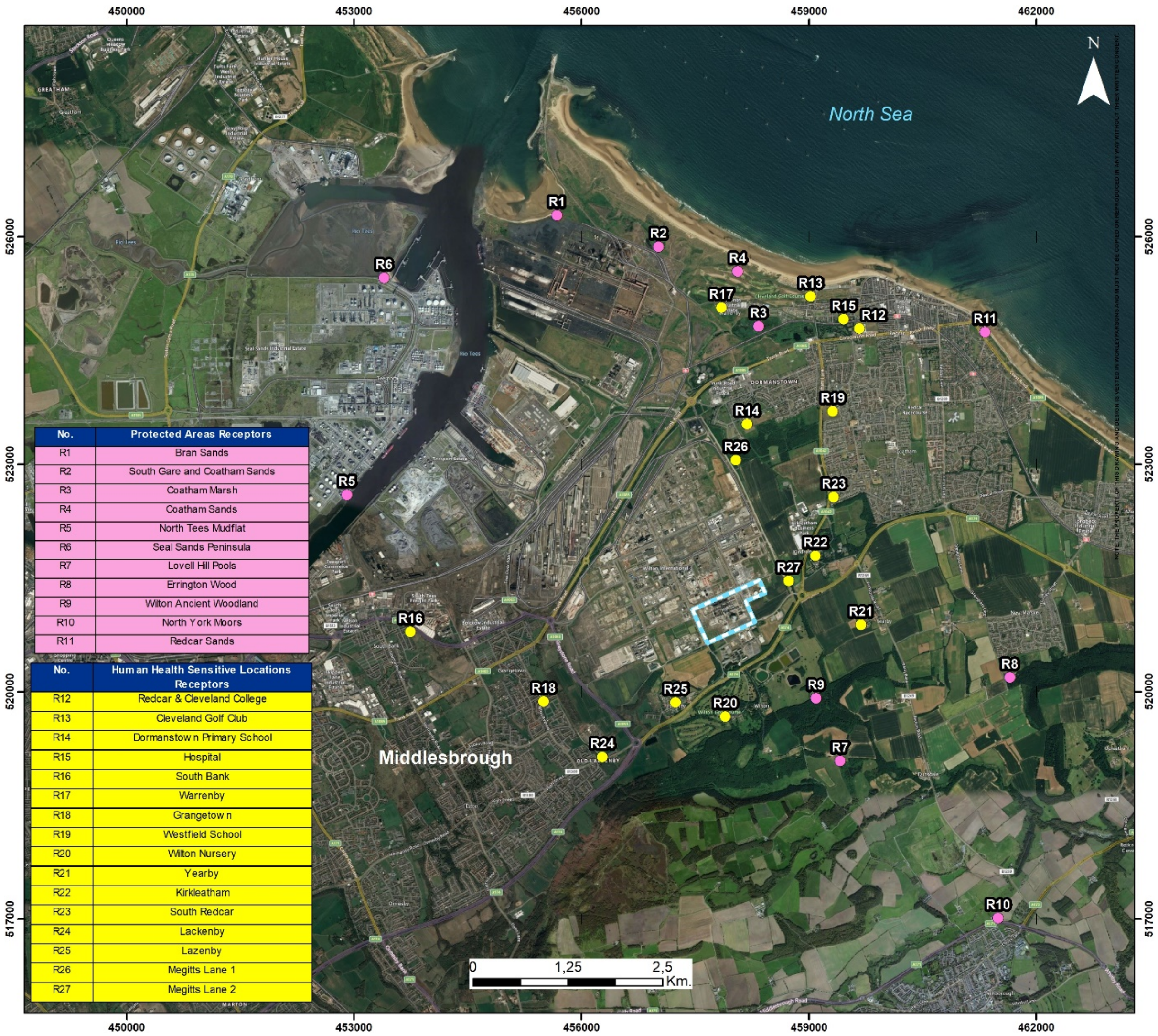

Figure 3-1. Locations of Receptors of Special Interest

4 Background Air Quality

The nearest ambient air quality monitoring station to the Project site is in Dormanstown, approximately 2.5 km north of the plant. This station, which is operated by the Redcar and Cleveland Borough Council and has been active since 2012, monitors NO_X, PM_{10}, $PM_{2.5}$, SO_2 and O_3. The station location is classed as suburban with a focus on industrial and road traffic emissions. The station is positioned in school grounds in an area of relevant public exposure. Traffic is relatively light in the area, and the station is within 4 km of the main industrial chemical and steel complexes in the Borough. It is a key site for monitoring industrial source pollution and coastal ozone levels.

Data for the period 2014-2018 presented in the 2019 Air Quality Annual Status Report (Redcar and Cleveland Borough Council, 2019) were used to assess the background air quality levels for human health purposes, as summarised in Table 4-1.

Table 4-1. Dormanstown Background Air Quality Levels (2014-2018)

Pollutant	Standard and Averaging Period	Air Quality Level (µg/m^3)						UK AQ Standard
		2014	2015	2016	2017	2018	Max	
NO_2	1-h mean (99.79th percentile) (Exceedances)	59 (0)	55 (0)	NR (0)	NR (0)	NR (0)	**59**	**200**
	Annual mean	12.8	12.7	11	12	10	**12.8**	**40**
PM_{10}	24-h mean (90.41th percentile) (Exceedances)	27 (3)	26 (4)	NR (0)	NR (1)	NR (0)	**27**	**50**
	Annual mean	15.7	15.7	12.7	12	12	**15.7**	**40**
$PM_{2.5}$	Annual mean	11	11	8.9	8.4	8.4	**11**	**20**
SO_2	15-min mean (99.90th percentile) (Exceedances)	67 (0)	43 (0)	NR (0)	NR (0)	NR (0)	**67**	**266**
	1-h mean (99.73th percentile) (Exceedances)	45 (0)	27 (0)	NR (0)	NR (0)	NR (0)	**45**	**350**
	24-h mean (99.18th percentile) (Exceedances)	16 (0)	11 (0)	NR (0)	NR (0)	NR (0)	**16**	**125**

NR = Not reported

It is important to highlight that, although the short-term levels of pollutants have not been reported within the last three years of these records (2016 to 2018) and are therefore not listed in Table 4-1, the 2019 Air Quality Annual Status Report shows decreasing trends of all ambient levels of air pollutants from 1998 to 2018. Therefore, short-term levels of air pollutants for 2014 and 2015 can be considered as conservative references of current air quality levels.

In general, it can be stated that data collected for the 2014-2018 period and presented in Table 4-1 generally represent good air quality, with only some exceedances of the PM_{10} 24-hr Air Quality Standard.

Road traffic emissions are the major source of pollutants. There are no Air Quality Management Areas in the Borough.

In addition to data recorded by the Dormanstown station, long-term NO_X and NO_2 ambient concentrations for the conservation areas close to the Project site (see Section 3) were obtained from the UK Air Pollution Information System (APIS) website[1] for the most recent available reporting years of 2016 to 2018. These data are calculated from emission source data on the basis of a grid with a resolution of 1 km, and only available long-term annual averages of NO_X and SO_2 are available, as listed in Table 4-2.

Table 4-2. Long-term Background Air Quality Levels in Protected Areas close to the Project

Protected Area Receptor	NO_X as NO_2, Annual Average 2016 – 2018, µg/m^3	SO_2, Annual Average 2016 – 2018, µg/m^3
Bran Sands (R1)	26	0
South Gare and Coatham Sands (R2)	19.5	0
Coatham Marsh (R3)	21.3	3.9
Coatham Sands (R4)	19.43	0
North Tees Mudflat (R5)	23.59	2.05
Seal Sands Peninsula (R6)	44.67	3.07
Lovell Hill Pools (R7)	13.93	1.21
Errington Wood (R8)	12.98	1.56
Wilton Ancient Woodland (R9)	13.93	1.21
North York Moors (R10)	11.41	1.12
Redcar Sands (R11)	19.97	1.56
Average Protected Areas	20.61	1.43
UK Protected Conservation Area Target	**30**	**10 / 20[(1)]**

(1) *10 µg/m^3 where lichens or bryophytes are present, 20 µg/m^3 where they are not present*

Data from the APIS database show significant annual NO_2 levels at most of the receptor locations in the Teesmouth and Cleveland Coastal SSSI, SPA and Ramsar site, with one record exceeding the UK Target for Protected Conservation Areas (44.67 µg/m^3 in Seal Sands Peninsula, compared to the 30 µg/m^3 target). It is important to note that these receptors are close to several industrial areas where NO_X emissions are expected to be significant. Conversely, annual SO_2 levels are very low compared to the UK Target.

[1] *UK Air Pollution Information System (APIS). Available online: www.apis.ac.uk*

5 Screening out of Pollutants (H1 Assessment)

The H1 Air Emissions Risk Assessment is based on the following two steps:

Step 1: Quantification of the Process Contribution (PC) of air pollutants

The environmental concentration of each substance released to air, known as the process contribution (PC), were calculated following this step based on:

- Effective height of release of pollutants (m): Zero metres (0 m) because structures at short distances are taller than the stacks of the boilers [2];
- Operating time of the sources (% of year): The two boilers will operate during 4 weeks total, representing 7.7% of the year (4 weeks/52 total weeks of the year); and
- Release rates of pollutants (g/s): Based on the pollutants emissions concentrations (mg/m^3) and exhaust flow rate (m^3/s), these rates were provided by the vendor (see Table 1-1).

Pollutants were screened out if:

– The short-term PC is less than 10% of the short-term environmental standard; and
– The long-term PC is less than 1% of the long-term environmental standard.

Step 2: Quantification of Predicted Environmental Concentrations (PEC) of air pollutants

For those pollutants not screened out in Step1, the predicted environmental concentration (PEC) is calculated as the PC plus the background concentration of the air pollutant. Background concentrations of air pollutants monitored by the Dormanstown station (see Table 4-1, Section 4) were used for calculating PEC.

Pollutants were screened out if:

– The short-term PC is less than 20% of the short-term environmental standards minus twice the long-term background concentration; and
– The long-term PEC is less than 70% of the long-term environmental standards.

Those pollutants not screened out in Step 2 required detailed air dispersion modelling to assess their potential impact on air quality. The H1 Air Emissions Risk Assessment was carried out with the Environment Agency's H1 Risk Assessment Tool, as recommended by the Environment Agency (UK EA, 2016). The full assessment is presented in Appendix A.

Results of the H1 assessment indicate that Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) emissions from the temporary boilers are significant and cannot be screened out (PC > 20% of the short-term standard). Therefore, detailed dispersion modelling for these pollutants was completed to assess project compliance.

[2] Olefins 6 cooling tower (60 metres high, L) is located at approximately 130 metres southwest of the boilers (less than 5*L)

6 Pollutants of Concern

Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) were determined to be the pollutants of concern to be modelled, as per the result of the H1 Air Emissions Assessment (see Section 5).

- **Nitrogen Dioxide (NO_2):** NO_2 is a component of nitrogen oxides (NO_X) comprising nitrogen monoxide (NO) and NO_2. Although NO is the main component of NO_X released to atmosphere, it reacts with atmospheric oxygen to form NO_2 as the NO_X is transported in the atmosphere; therefore, the relative composition of NO_2 increases at farther distances from the emitting source. According to Public Health England, *"Short-term exposure to NO_2, particularly at high concentrations, is a respiratory irritant that can cause inflammation of the airways leading to - for example - cough, production of mucus and shortness of breath. Studies have shown associations of NO_2 in outdoor air with reduced lung development, and respiratory infections in early childhood and effects on lung function in adulthood".*[3]
- **Sulphur Dioxide (SO_2):** SO_2 is a pollutant generated during the combustion of sulphur-containing fuels. SO_2 has an irritant effect on the lining of the nose, throat and airways, and the effects are often felt very quickly.[3]

The two temporary boilers will operate for a planned period of 4 weeks; therefore, only short-term NO_2 and SO_2 impacts were modelled. Based on the short-term targets established in the UK Air Quality Standards, the time averaging periods listed in Table 6-1 were modelled for each pollutant.

Table 6-1. Summary of averaging periods of pollutants modelled

Pollutant of Concern	Averaging Period	Standard for Assessment
NO_2	1-hour	200 $\mu g/m^3$ (UK Air Quality Objectives)
	24-hour	75 $\mu g/m^3$ (UK Target for Protected Conservation Areas)
SO_2	15-min	266 $\mu g/m^3$ (UK Air Quality Objectives)
	1-hour	350 $\mu g/m^3$ (UK Air Quality Objectives)
	24-hour	125 $\mu g/m^3$ (UK Air Quality Objectives)

Deposition impacts on ecosystems, being also a long-term impact, is excluded from this assessment.

[3] *Public Health England. Guidance. Health Matters: air pollution*
https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution

7 Dispersion Modelling Methodology

7.1 Model Description

The steady-state Gaussian plume model AERMOD is a comprehensive multi-level air dispersion modelling system that simulates essential atmospheric physical processes and provides refined concentration estimates over a wide range of meteorological conditions and modelling scenarios (US EPA, 2004). AERMOD is currently the most widely used air quality modelling tool.

AERMOD assumes the pollutant concentration distribution to be Gaussian in both vertical and horizontal directions. In this distribution, the pollutant concentration profile assumes that maximum concentrations are encountered in the centre of the plume, with concentrations decreasing toward the edge following the shape of a bell curve.

AERMOD comprises two pre-processors AERMET and AERMAP. The AERMET pre-processor combines meteorological data (e.g., wind speed and direction, temperature and cloud cover) with surface characteristics (e.g., albedo, surface roughness and Bowen ratio). Terrain influences are accounted for in the AERMAP pre-processor. Other variables, such as emission source parameters (stack height and diameter, exit temperatures and velocities, and pollutants emission rates) and the receptors that will define the modelling domain are required as inputs by AERMOD.

Ground concentrations of pollutants (PC) are calculated for each specified averaging period over the full modelling period at each receptor in the model domain. Maximum modelled ground level concentrations (GLCs) are then graphically mapped as contours across the grid or as discrete points at each sensitive receptor, and they represent the 'worst-case' meteorological conditions for atmospheric emissions.

The AERMOD modelling methodology is shown schematically in Figure 7-1.

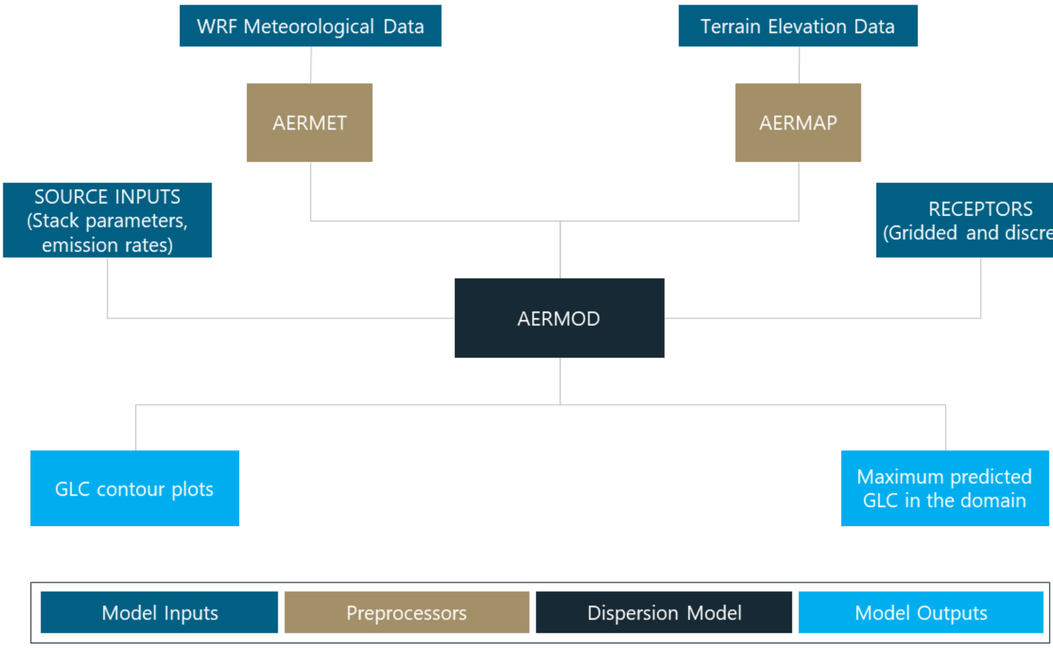

Figure 7-1. AERMOD Methodology Schematic Diagram

7.2 Model Assumptions and Limitations

The inherent assumptions and limitations of the AERMOD air dispersion model are summarised below:

- The model is based on a three-year meteorological dataset collected from the nearest meteorological stations and prepared with a prognostic model, which is built with data provided by a vast network of meteorological stations. As such, the meteorological data are not collected at the specific facility location under study.
- The model assumes steady-state meteorological conditions that are invariant over the entire model space for each hour modelled, and as such, is not highly accurate in areas where significant variations in meteorological conditions exist. For instance, AERMOD cannot be used to incorporate highly variable wind patterns caused by changes in terrain elevations, and modelling across complex terrains may result in over-predictions.
- The model assumes a straight-line plume. In combination with the previous limitation, the plume cannot change direction in the model from the source to the receptors.
- AERMOD is the Gaussian model recommended by the US EPA for short-range transport of pollutants, up to 50 km from the source. At distances beyond 50 km, steady-state Gaussian plume models like AERMOD tend to over-estimate pollutant ground concentrations, because the model maintains constant wind patterns that are unlikely to persist over long distances.
- The model cannot account for or be used to model reactive pollutants (e.g., ozone).

Because of the specific topographic conditions of the Project area, the pollutants of concern and the distance range within which the maximum PCs from the Project are expected, the limitations described above did not restrict the applicability of the model.

7.3 Model Inputs Definition

7.3.1 Emission Data

All input data used in the modelling assessment were provided by SABIC and by the boiler package vendor. These inputs represent the planned operation mode of each of the two boilers (50% load each) and were introduced as presented in Table 7-1 into the AERMOD tool.

Table 7-1. AERMOD modelling inputs

Source	Coordinates (British National Grid)		Height (m)	Internal Diameter (m)	Exit Velocity (m/s)	Exit Temperature (°C)	NO_X rate (g/s)	SO_2 rate (g/s)
	X (m)	Y (m)						
Stack 1	458234.7	521078.9	9.65	0.529	5.68	205	0.128	0.104
Stack 2	458225.0	521100.0	9.65	0.529	5.68	205	0.128	0.104

Given that these boilers are identical, the emission parameters for modelling are identical.

7.3.2 Meteorology

A meteorological file was prepared using the Weather Research and Forecasting (WRF) prognostic model, which uses data provided by the National Centres for Environmental Prediction (NCEP) Global Reanalysis. The WRF Model is a next-generation mesoscale numerical weather prediction system designed to serve both atmospheric research and operational forecasting needs. The model serves a wide range of meteorological applications across scales from tens of metres to thousands of kilometres. Since WRF is a regional model, it requires an initial condition as well as lateral boundary conditions to run. Obtaining meteorological data for a specific location requires that meteorological records from as many surface meteorological stations as possible are considered, and a large model run is required to set the boundary conditions.

The meteorological file used for this study is the complete series of hourly values of surface and upper soundings meteorological variables for the period covering the years 2017 to 2019.

The surface dataset includes wind speed, wind direction, dry bulb temperature, cloud cover, and ceiling height. Upper soundings include wind speed, dew point, atmospheric pressure and measurement height. Surface observations, upper soundings and land use parameters (albedo, Bowen ratio and surface roughness) were used as input data in the meteorological pre-processor AERMET to calculate the boundary layer parameters, which include friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, mixing height and surface heat flux. The behaviour of the plume was estimated based on these output parameters, and the two-file output of the AERMET pre-processor was used as input for the AERMOD air dispersion model.

The windrose of the 2017-2019 meteorological data, provided in Figure 7-2, demonstrates the main wind directions during the three-year period, which were mostly from the southwest (SW, 21.7% of total hours), followed by the south-southwest (SSW, 14.3% of total hours) and the west-southwest (WSW, 11.9% of total hours).

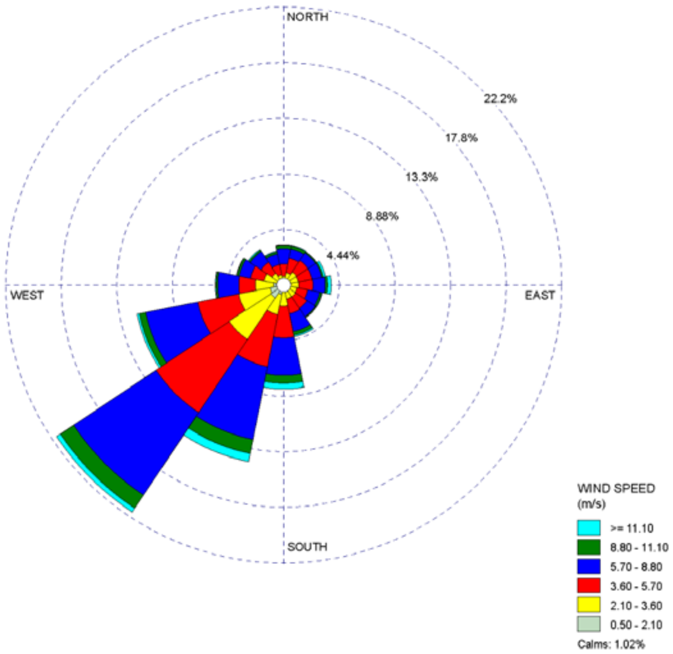

Figure 7-2. WRF Pre-processed Data Windrose for the Project Area (2017-2019)

7.3.3 Modelling Domain

Two nested uniform grids, centred in the Olefins 6 Plant location, were used in the modelling:

- A coarse grid of 11 km x 11 km of 12,321 receptors (111 x 111 receptors with a spacing of 100 meters) was used to cover the whole study area
- A fine grid of 2.5 km x 2.5 km of 2,601 receptors (51 x 51 receptors with a spacing of 50 meters) was used for the Project location to better characterise the zones where the maximum predicted air quality impact from the Project emissions are expected.

In addition to this Cartesian grid, the receptors described in Section 3 to characterise protected areas and sensitive locations for human health were included in the model as discrete receptors.

The Cartesian grids representing the modelling domain (blue) and the discrete receptors (pink for protected areas and yellow for sensitive locations for human health) are indicated on the map of the area in Figure 7-3. The location of the Olefins 6 plant is outlined in red.

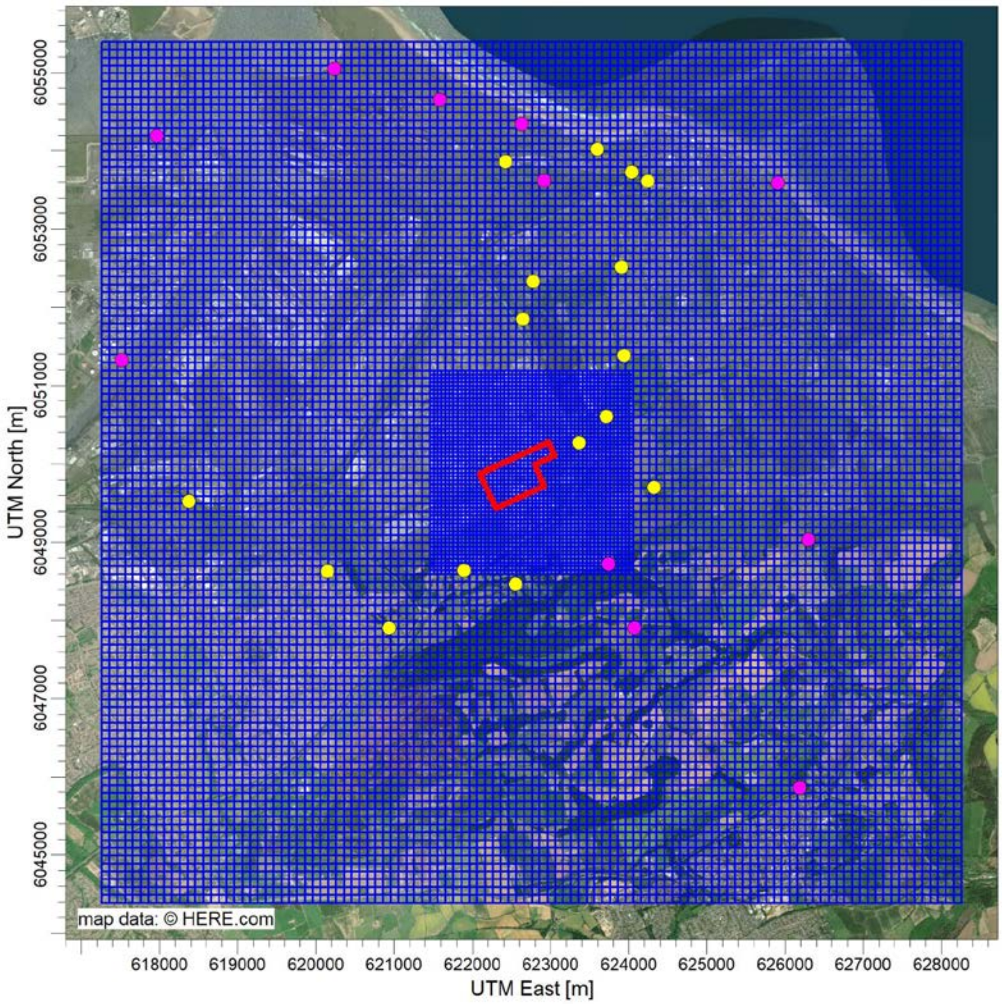

Figure 7-3. AERMOD modelling grids (blue), discrete receptors (pink and yellow) and Olefins 6 Plant (red)

AERMOD was used to predict PCs of air pollutants at each receptor location on the grid. From these results, contours with equal PCs were calculated using the model to plot the PC contour maps provided in Appendix B.

7.3.4 Topography and buildings

The area of study was assumed to be flat, which most closely approximates the actual topography, and variations in receptor elevations were not considered.

Several high buildings located near the boilers may affect the dispersion of pollutants from the stacks. Buildings can have a relevant effect on pollutant dispersion by entraining pollutants into the cavity region in the immediate leeward side of the building, making the pollutants go rapidly to the ground. Consequently, pollutant PCs are increased near buildings and decrease at farther distances.

Buildings with a relevant height (>10 metres) near the temporary boilers were introduced into the model to identify their potential effects on air pollutant dispersion. The effects of these buildings were determined through model sensitivity analysis, as described in Section 7.4.

7.4 Model Sensitivity Analysis: Effect of Nearby Buildings

Prior to modelling, a sensitivity analysis of the AERMOD results was carried out to identify the potential effect of nearby buildings and structures on pollutant dispersion from the temporary stacks (building downwash). Buildings with a relevant height (>10 metres) near the temporary boilers were introduced into the model to identify their potential effects on air pollutant dispersion. The dimensions and locations of these buildings were provided by SABIC and are presented in Table 7-2 and Figure 7-4.

Table 7-2. Summary of Buildings near the Temporary Boilers

Building	Shape	Centre Location		Height (m)	Length (m)	Width (m)	Angle (°)
		X (m)	Y (m)				
Olefins 6 cooling tower	Circular	458123	520959	60	52	52	0
Olefins 6 cooling tower basin	Circular	458123	520959	12	110	110	0
Butadiene house	Rectangular	458197	521015	12	40	4	65
F1962 tank1	Circular	458404	521283	18	46	46	0
F1962 tank2	Circular	458474	521314	18	46	46	0
Filling facilities - tallest tank	Circular	458113	521226	13.5	10	10	0
Furnace structure	Rectangular	457944	521148	30	230	35	65
Lotte silos	Circular	457768	521256	42	11	11	0
Pipe rack 1	Rectangular	457958	521096	14	215	18	65
Pipe rack 2	Rectangular	457989	521025	15	280	10	65
Compressor house 1 (combined)	Rectangular	457998	521071	24	54.5	40.6	65
Compressor house 2	Rectangular	458094	521096	20	41.5	13.8	65

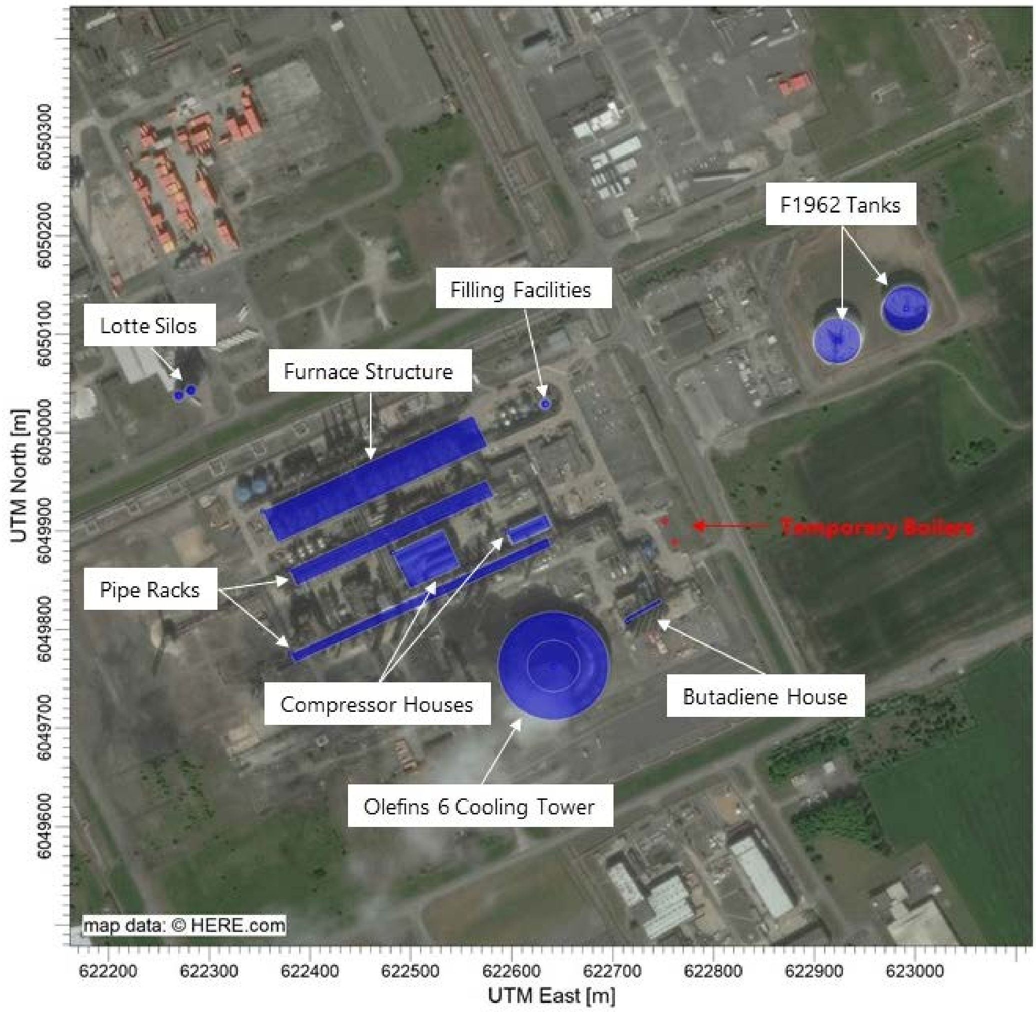

Figure 7-4. Locations of relevant buildings near the temporary boilers (red)

The downwash that these buildings could induce on the pollutant dispersion was analysed. For the sensitivity analysis, planned emissions of NO_X from the two temporary boilers (see Table 7-1) were employed. The three years of meteorological data available for the modelling were employed (2017-2019), and the total modelling domain covered an area of 2.5 km x 2.5 km with 50-m receptor spacing. The results of this sensitivity analysis are presented in Table 7-3.

Table 7-3. Modelling results for the building effects analysis

Model run	Maximum modelled NO_2 PC ($\mu g/m^3$)		Change (%) (1)	
	1-hr	24-hr	1-hr	24-hr
No Buildings	91.5	30.1		
Buildings	91.5	30.1	0%	0%

(1) The change (%) represents the increase in the maximum model results for the Buildings model run compared to the 'No Buildings' model run.

These results indicate that the presence of the buildings does not affect the maximum predicted PC for either the 1-hr or the 24-hr mean levels. Graphical contours for the predicted NO_2 PC for these averaging periods, presented in Figure 7-5, show no variation with or without the modelled buildings.

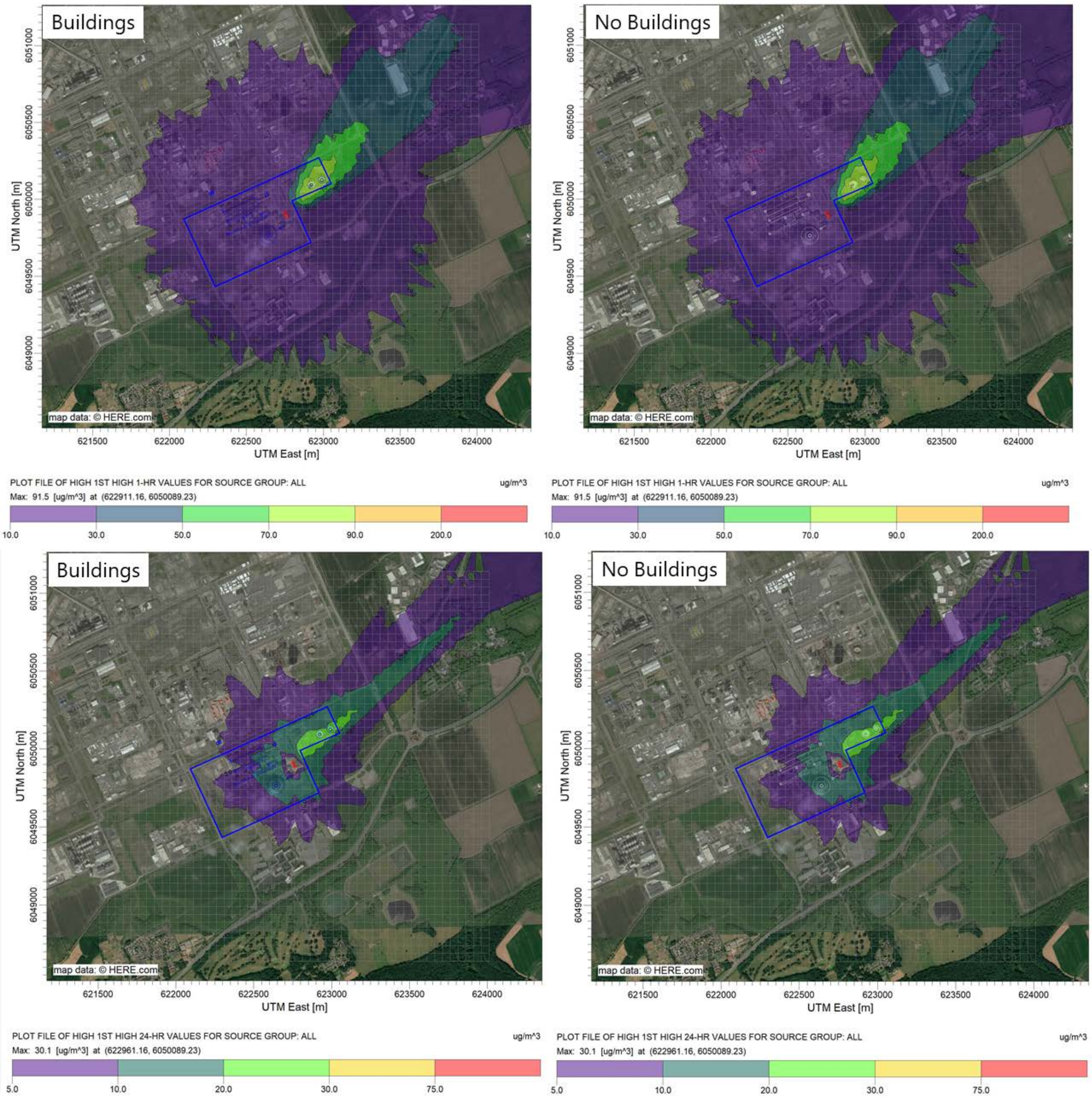

Figure 7-5. Building effect sensitivity test on AERMOD predictions for NO_2 PCs: 1-hr mean average (top) and 24-hr mean average (bottom)

Based on these results from the sensitivity analysis, buildings were excluded from the modelling.

8 Modelling Results

Results from the dispersion modelling of air pollutants with AERMOD, presented in this section, are divided into two main categories:

- **Air Quality Impact on Human Health.** The modelled impacts from the Project on local air quality and the subsequent impact on human health are described in Section 8.1.
- **Impacts on Protected Areas.** The potential impacts derived from the Project emissions on the protected areas close to the Project site are described in Section 8.2.

8.1 Air Quality Impact on Human Health

8.1.1 Maximum Project Impact – Process Contributions (PCs)

The maximum PCs of air pollutants emitted by the two temporary boilers over the entire modelling period, as modelled using AERMOD, are listed in Table 8-1. The contour maps of the maximum PCs of each pollutant at each receptor in the domain modelled using AERMOD are provided in Appendix B. These contours represent the maximum predicted PCs at each receptor on the Cartesian grid during the three-year modelling period under worst-case conditions at each point (i.e., meteorological conditions that lead to the highest predicted PCs of pollutants at each point).

Table 8-1. Maximum predicted PCs of air pollutants compared with UK Air Quality Limits (expressed as μg/m³)

Pollutant	Average Period	Maximum PC	UK Air Quality Limit	PC as % of the Limit
NO_2	1-hr	91.5	200	46%
SO_2	15-min	99.7	266	37%
	1-hr	74.4	350	21%
	24-hr	24.5	125	20%

These results indicate that the operation of the two temporary boilers at 50% load each during the Plant shutdown is not predicted to exceed the Air Quality Limits. As seen in the contour plots (see Appendix B), the maximum PCs listed in Table 8-1 are encountered within 300 metres northeast of the stacks, within the SABIC complex boundaries. At farther distances from the sources, maximum predicted PCs decay significantly.

It is important to note that the modelling results represent the maximum predicted PCs for NO_2 and SO_2 during the entire 3-year modelling period. Therefore, these represent conservative values and actual air quality impact from the boilers is expected to be lower than the maximum values listed in Table 8-1.

Nitrogen Dioxide (NO_2)

The maximum predicted contribution from the Project, 91.5 $\mu g/m^3$, represents approximately 46% of the 1-hr NO_2 standard (200 $\mu g/m^3$).

The modelled dispersion of nitrogen oxides (NO_X) emitted by the stacks is a mixture of nitrogen dioxide (NO_2) and nitrogen monoxide (NO). The PCs of NO_X predicted by the model cannot be directly compared with the UK limits, which are established for NO_2. Full conversion of NO_X to NO_2 was assumed in this assessment. This approach is more conservative than the guidance provided by the Environment Agency to model NO_2 (i.e, assuming NO_2 as 50% of total NOx, UK EA 2016) and therefore overestimation of the NO_2 impacts from the project shall be expected. Even considering this conservative approach, the maximum listed in Table 8-1 for the maximum predicted level of NO_2 is below the 1-hr limits for NO_2 as set by the UK Ambient Air Quality Standards Regulations.

Sulphur Dioxide (SO_2)

Maximum predicted SO_2 PCs represents approximately 37% of the 15-min SO_2 objective (99.7 $\mu g/m^3$ compared to the objective 266 $\mu g/m^3$), 21% of the 1-hr SO_2 standard (74.4 $\mu g/m^3$ compared to the standard 350 $\mu g/m^3$), and 20% of the 24-hr SO_2 standard (24.4 $\mu g/m^3$ compared to the standard 125 $\mu g/m^3$).

Although these maximum PCs cannot be disregarded as insignificant, it is important to note that the two temporary boilers will only operate during a 4 weeks period during the shutdown of the plant. The combustion sources that operate in the plant during normal conditions (e.g., furnaces, boilers and heaters) will be shut down. In the case of NO_2, a main pollutant from combustion activities, this indicates that the potential impacts from the two temporary boilers on local air quality will be potentially lower than those generated by the plant under normal conditions, producing an overall positive impact in the area (e.g., lower PCs from the plant during the shutdown).

On the other hand, this positive impact should not be expected in the case of SO_2, as the plant is using gas as fuel during normal operation and therefore SO_2 emissions are negligible. Nevertheless, as seen in Table 8-1, maximum SO_2 PCs derived from the temporary boilers are predicted to be well below the standards.

As indicated previously, the maximum PCs are predicted to occur within the SABIC facilities and will decrease rapidly at farther distances; therefore, the air pollutant PCs derived from the Project emissions are not expected to generate significant impacts on human health in populated areas located in the study area. The maximum predicted PCs on the sensitive locations for human health (see Section 3) are listed in Table 8-2 (1-hr NO_2 PC), Table 8-3 (15-min SO_2 PC), Table 8-4 (1-hr SO_2 PC), and Table 8-5 (24-hr SO_2 PC).

Table 8-2. Maximum predicted NO_2 1-hr PC at sensitive locations for human health compared with UK Limits (expressed as $\mu g/m^3$)

Location	Description	NO_2 1-hr PC	UK Air Quality Limit	PC as % of the Limit
Redcar & Cleveland College (R12)	College	5.30	200	2.7%
Cleveland Golf Club (R13)	Golf club	4.98		2.5%
Dormanstown Primary School (R14)	School	6.75		3.4%
Hospital (R15)	Hospital	5.15		2.6%
South Bank (R16)	Residential	4.65		2.3%
Warrenby (R17)	Residential	5.04		2.5%
Grangetown (R18)	Residential	4.91		2.5%
Westfield School (R19)	School	12.36		6.2%
Wilton Nursery (R20)	Nursery	8.59		4.3%
Yearby (R21)	Residential	7.68		3.8%
Kirkleatham (R22)	Residential	30.62		15.3%
South Redcar (R23)	Residential	27.01		13.5%
Lackenby (R24)	Residential	5.68		2.8%
Lazenby (R25)	Residential	7.24		3.6%
Megitts Lane 1 (R26)	Leisure	7.09		3.5%
Megitts Lane 2 (R27)	**Leisure**	**32.40**		**16.2%**

Table 8-3. Maximum predicted SO_2 15-min PC at sensitive locations for human health compared with UK Limits (expressed as $\mu g/m^3$)

Location	Description	SO_2 15-min PC	UK Air Quality Limit	PC as % of the Limit
Redcar & Cleveland College (R12)	College	5.77	266	2.2%
Cleveland Golf Club (R13)	Golf club	5.43		2.0%
Dormanstown Primary School (R14)	School	7.35		2.8%
Hospital (R15)	Hospital	5.61		2.1%
South Bank (R16)	Residential	5.06		1.9%
Warrenby (R17)	Residential	5.49		2.1%
Grangetown (R18)	Residential	5.35		2.0%
Westfield School (R19)	School	13.46		5.1%
Wilton Nursery (R20)	Nursery	9.35		3.5%
Yearby (R21)	Residential	8.36		3.1%
Kirkleatham (R22)	Residential	33.34		12.5%
South Redcar (R23)	Residential	29.41		11.1%
Lackenby (R24)	Residential	6.19		2.3%
Lazenby (R25)	Residential	7.88		3.0%
Megitts Lane 1 (R26)	Leisure	7.72		2.9%
Megitts Lane 2 (R27)	**Leisure**	**35.28**		**13.3%**

Table 8-4. Maximum predicted SO_2 1-hr PC at human health sensitive locations compared with UK Limits (expressed as $\mu g/m^3$)

Location	Description	SO_2 1-hr PC	UK Air Quality Limit	PC as % of the Limit
Redcar & Cleveland College (R12)	College	4.31	350	1.2%
Cleveland Golf Club (R13)	Golf club	4.05		1.2%
Dormanstown Primary School (R14)	School	5.48		1.6%
Hospital (R15)	Hospital	4.18		1.2%
South Bank (R16)	Residential	3.78		1.1%
Warrenby (R17)	Residential	4.09		1.2%
Grangetown (R18)	Residential	3.99		1.1%
Westfield School (R19)	School	10.04		2.9%
Wilton Nursery (R20)	Nursery	6.98		2.0%
Yearby (R21)	Residential	6.24		1.8%
Kirkleatham (R22)	Residential	24.88		7.1%
South Redcar (R23)	Residential	21.95		6.3%
Lackenby (R24)	Residential	4.62		1.3%
Lazenby (R25)	Residential	5.88		1.7%
Megitts Lane 1 (R26)	Leisure	5.76		1.6%
Megitts Lane 2 (R27)	**Leisure**	**26.33**		**7.5%**

Table 8-5. Maximum predicted SO_2 24-hr PC at human health sensitive locations compared with UK Limits (expressed as µg/m^3)

Location	Description	SO_2 24-hr PC	UK Air Quality Limit	PC as % of the Limit
Redcar & Cleveland College (R12)	College	0.71	125	0.6%
Cleveland Golf Club (R13)	Golf club	0.53		0.4%
Dormanstown Primary School (R14)	School	0.86		0.7%
Hospital (R15)	Hospital	0.66		0.5%
South Bank (R16)	Residential	0.37		0.3%
Warrenby (R17)	Residential	0.49		0.4%
Grangetown (R18)	Residential	0.50		0.4%
Westfield School (R19)	School	0.73		0.6%
Wilton Nursery (R20)	Nursery	0.94		0.7%
Yearby (R21)	Residential	0.93		0.7%
Kirkleatham (R22)	Residential	3.89		3.1%
South Redcar (R23)	Residential	4.09		3.3%
Lackenby (R24)	Residential	0.74		0.6%
Lazenby (R25)	Residential	0.76		0.6%
Megitts Lane 1 (R26)	Leisure	0.98		0.8%
Megitts Lane 2 (R27)	**Leisure**	**4.13**		**3.3%**

These results show that the receptor that could be impacted the most is Megitts Lane 2 (located at the south part of Megitts Lane). At this receptor, the maximum predicted NO_2 PC represents 16.6% of thestandard, while the maximum predicted SO_2 PCs represents 13.3%, 7.5 % and 3.3% of the limits for the 15-min, 1-hr, and 24-hr averaging periods, respectively. At the remaining sensitive receptors, the maximum predicted PCs represent lower percentages of the respective UK Air Quality Standards, confirming the minor contribution of the project emissions on local air quality.

8.1.2 Cumulative Impact – Predicted Environmental Concentrations (PECs)

Cumulative air quality impact (PEC) was calculated considering the maximum background air pollution levels recorded by the Dormanstown station (see Table 4-1, Section 4). These levels are 59 μg/m³ for NO_2 1 hr, 67 μg/m³ for SO_2 15-min, 45 μg/m³ for SO_2 1-hr, and 16 μg/m³ for SO_2 24-hr.

This cumulative assessment is as an approximation for the following reasons:

- Ambient air pollution levels recorded by the Dormanstown station are considered representative of the air quality throughout the study domain.
- The background levels recorded at the Dormanstown station include contributions from the Olefins 6 Plant during normal operation. Therefore, this cumulative assessment considers the contribution of the plant during the shutdown in addition to the contribution of the plant emissions during normal operation.

Maximum modelled PECs, calculated as the maximum predicted PCs over the modelling domain (see Table 8-1) and the background levels of pollutants monitored by the Dormanstown station, are listed in Table 8-6.

Table 8-6. Maximum modelled PEC of air pollutants compared to the UK Air Quality Limits (expressed in μg/m³)

Pollutant	Average Period	Maximum PC	Background	Maximum PEC	UK Air Quality Objective	PC as % PEC
NO_2	1-hr	91.5	59	150.5	200	75%
SO_2	15-min	99.7	67	166.7	266	63%
	1-hr	74.4	45	119.4	350	34%
	24-hr	24.5	16	40.5	125	32%

These estimates indicate that 1-hr NO_2 PECs could be up to 75% of the UK Air Quality Objective and SO_2 PECs could be up to 63% of the Objective (for the 15-min average). As discussed previously in Section 8.1.1, these maximum PECs shall be expected under the worst-case dispersion conditions and will be encountered in the vicinities of the emission sources (within the SABIC facilities). Additionally, these PECs could be considered an over-estimation because the PECs during the shutdown will be lower than expected under normal operational conditions of the plant when multiple combustion sources are emitting air pollutants simultaneously.

The maximum predicted PECs in the sensitive locations for human health are listed in Table 8-7 (NO_2 1-hr PEC), Table 8-8 (SO_2 15-min PEC), Table 8-9 (SO_2 1-hr PEC), and Table 8-10 (SO_2 24-hr PEC).

As in the case of PCs, the maximum PECs are encountered at Megitts Lane south (Megitts Lane 2). PECs at this receptor could be up to 45.7% of the standard in the 1-hr NO_2, while maximum predicted SO_2 PECs represent 38.5%, 20.4 % and 16.1% of the standards for the 15-min, 1-hr and 24-hr averaging periods, respectively. At the remaining sensitive receptors, the maximum predicted PECs represent lower percentages of the respective UK Ambient Air Quality Objectives.

Table 8-7. Maximum predicted NO_2 1-hr PEC at human health sensitive locations compared with UK Limits (expressed as $\mu g/m^3$)

Location	Description	NO_2 1-hr PEC	UK Air Quality Limit	PEC as % of the Limit
Redcar & Cleveland College (R12)	College	64.3	200	32.2%
Cleveland Golf Club (R13)	Golf club	63.98		32.0%
Dormanstown Primary School (R14)	School	65.75		32.9%
Hospital (R15)	Hospital	64.15		32.1%
South Bank (R16)	Residential	63.65		31.8%
Warrenby (R17)	Residential	64.04		32.0%
Grangetown (R18)	Residential	63.91		32.0%
Westfield School (R19)	School	71.36		35.7%
Wilton Nursery (R20)	Nursery	67.59		33.8%
Yearby (R21)	Residential	66.68		33.3%
Kirkleatham (R22)	Residential	89.62		44.8%
South Redcar (R23)	Residential	86.01		43.0%
Lackenby (R24)	Residential	64.68		32.3%
Lazenby (R25)	Residential	66.24		33.1%
Megitts Lane 1 (R26)	Leisure	66.09		33.0%
Megitts Lane 2 (R27)	**Leisure**	**91.4**		**45.7%**

Table 8-8. Maximum predicted SO_2 15-min PEC at human health sensitive locations compared with UK Limits (expressed as $\mu g/m^3$)

Location	Description	SO_2 15-min PEC	UK Air Quality Limit	PEC as % of the Limit
Redcar & Cleveland College (R12)	College	72.77	266	27.4%
Cleveland Golf Club (R13)	Golf club	72.43		27.2%
Dormanstown Primary School (R14)	School	74.35		28.0%
Hospital (R15)	Hospital	72.61		27.3%
South Bank (R16)	Residential	72.06		27.1%
Warrenby (R17)	Residential	72.49		27.3%
Grangetown (R18)	Residential	72.35		27.2%
Westfield School (R19)	School	80.46		30.2%
Wilton Nursery (R20)	Nursery	76.35		28.7%
Yearby (R21)	Residential	75.36		28.3%
Kirkleatham (R22)	Residential	100.34		37.7%
South Redcar (R23)	Residential	96.41		36.2%
Lackenby (R24)	Residential	73.19		27.5%
Lazenby (R25)	Residential	74.88		28.2%
Megitts Lane 1 (R26)	Leisure	74.72		28.1%
Megitts Lane 2 (R27)	**Leisure**	**102.28**		**38.5%**

Table 8-9. Maximum predicted SO_2 1-hr PEC at human health sensitive locations compared with UK Limits (expressed as $\mu g/m^3$)

Location	Description	SO_2 1-hr PEC	UK Air Quality Limit	PEC as % of the Limit
Redcar & Cleveland College (R12)	College	49.31	350	14.1%
Cleveland Golf Club (R13)	Golf club	49.05		14.0%
Dormanstown Primary School (R14)	School	50.48		14.4%
Hospital (R15)	Hospital	49.18		14.1%
South Bank (R16)	Residential	48.78		13.9%
Warrenby (R17)	Residential	49.09		14.0%
Grangetown (R18)	Residential	48.99		14.0%
Westfield School (R19)	School	55.04		15.7%
Wilton Nursery (R20)	Nursery	51.98		14.9%
Yearby (R21)	Residential	51.24		14.6%
Kirkleatham (R22)	Residential	69.88		20.0%
South Redcar (R23)	Residential	66.95		19.1%
Lackenby (R24)	Residential	49.62		14.2%
Lazenby (R25)	Residential	50.88		14.5%
Megitts Lane 1 (R26)	Leisure	50.76		14.5%
Megitts Lane 2 (R27)	**Leisure**	**71.33**		**20.4%**

Table 8-10. Maximum predicted SO_2 24-hr PEC at human health sensitive locations compared with UK Limits (expressed as $\mu g/m^3$)

Location	Description	SO_2 24-hr PEC	UK Air Quality Limit	PEC as % of the Limit
Redcar & Cleveland College (R12)	College	16.71	125	13.4%
Cleveland Golf Club (R13)	Golf club	16.53		13.2%
Dormanstown Primary School (R14)	School	16.86		13.5%
Hospital (R15)	Hospital	16.66		13.3%
South Bank (R16)	Residential	16.37		13.1%
Warrenby (R17)	Residential	16.49		13.2%
Grangetown (R18)	Residential	16.5		13.2%
Westfield School (R19)	School	16.73		13.4%
Wilton Nursery (R20)	Nursery	16.94		13.6%
Yearby (R21)	Residential	16.93		13.5%
Kirkleatham (R22)	Residential	19.89		15.9%
South Redcar (R23)	Residential	20.09		16.1%
Lackenby (R24)	Residential	16.74		13.4%
Lazenby (R25)	Residential	16.76		13.4%
Megitts Lane 1 (R26)	Leisure	16.98		13.6%
Megitts Lane 2 (R27)	**Leisure**	**20.13**		**16.1%**

8.2 Impacts on Protected Areas

The potential impacts from the Project emissions on protected areas nearby were quantified through the assessment of the predicted daily NO_2 levels at the protected area receptors identified in the study area (see Section 3).

The contour plot of the 24-hr NO_2 PCs, as modelled with AERMOD and provided in Figure B.2 in Appendix B, shows that the maximum PC, 30.1 $\mu g/m^3$, is predicted within the boundary of SABIC facilities, northeast of the emission sources, in an unprotected area. The PCs are predicted to decay rapidly at farther distances.

The maximum 24-hr NO_2 impacts on protected areas, both PC and PEC, are summarised in Table 8-11. The cumulative impacts (PEC) were calculated by estimating the short-term background NO_2 levels based on the long-term levels listed in Table 4-2 (Section 4), by assuming the short-term concentration doubles the long-term levels (UK EA, 2016).

Table 8-11. Maximum predicted NO_2 24-hr Impact, PC and PEC, on Protected Areas receptors and comparison with the Environment Agency EAL (expressed as $\mu g/m^3$)

Location	PC	Background (1)	Max PEC	EAL	PC as % of PEC
Bran Sands (R1)	0.29	52	52.29	75	0.6%
South Gare and Coatham Sands (R2)	0.41	39	39.41		1.0%
Coatham Marsh (R3)	0.68	42.6	43.28		1.6%
Coatham Sands (R4)	0.74	38.86	39.60		1.9%
North Tees Mudflat (R5)	0.44	47.18	47.62		0.9%
Seal Sands Peninsula (R6)	0.58	89.34	89.92		0.6%
Lovell Hill Pools (R7)	0.51	27.86	28.37		1.8%
Errington Wood (R8)	0.59	25.96	26.55		2.2%
Wilton Ancient Woodland (R9)	1.05	27.86	28.91		3.6%
North York Moors (R10)	0.37	22.82	23.19		1.6%
Redcar Sands (R11)	1.46	39.94	41.40		3.5%

(1) Background 24-hr NO_2 levels calculated from the long-term annual levels (Table 4-2) following the procedure recommended by the EA: "When you calculate background concentration, you can assume that the short-term background concentration of a substance is twice its long-term concentration." (UK EA, 2016)

These results indicate the following:

- The maximum PC from the project emissions (1.46 $\mu g/m^3$) is encountered at Redcar Sands. The maximum PCs at all protected area receptors are negligible when compared with the Environment Agency environmental assessment level (75 $\mu g/m^3$).
- PEC levels are below the Environment Agency EAL at all receptors except at the Seal Sands Peninsula (89.92 $\mu g/m^3$), where the 75 $\mu g/m^3$ EAL is exceeded. As indicated in Section 4, background levels at this receptor already exceeded the EAL. The maximum PC from the project at Seal Sands Peninsula represents only 0.6% of the total PEC. At Redcar Sands, the PC represents 3.5% of the PEC.

These results indicate that the project emissions will not significantly contribute to the ecosystems degradation of the protected areas nearby.

9 Conclusions

The potential impacts due to the air emissions from the two temporary boilers to be installed during the Olefins 6 Plant shutdown process were assessed following the procedures indicated by the UK Environment Agency. The impacts assessed included potential human health impacts and degradation of ecosystems in the nearby protected areas.

Screening Out of Pollutants (H1 Assessment)

An air emissions risk assessment (H1) was completed to screen out those emissions from the boilers deemed insignificant before proceeding with the air dispersion modelling. The assessment, carried out with the Environment Agency H1 Risk Assessment Tool, is provided in Appendix A. Outcomes of the assessment indicate that NO_2 and SO_2 emissions from the boilers are sufficiently significant to require detailed dispersion modelling.

Air Dispersion Modelling Assessment

The dispersion of pollutants deemed relevant by the H1 Assessment was modelled using the AERMOD air dispersion modelling tool. The objective of this modelling assessment was to quantify potential impacts due to the Project emissions on human health and on protected areas. The assessment included the quantification of the project contribution to air quality (PC) and the cumulative air quality impact (PEC).

The modelling assessment covered a modelling domain of 11 km x 11 km and three (3) years of meteorological data generated by the prognostic model WRF. Emissions data provided by the vendor for the boilers operating at 50% were used to characterize emission inputs to the model. Due to the short duration of the activity assessed (the boilers will operate for 4 weeks), only short-term impacts were modelled.

The dispersion modelling results show that the maximum impacts from the project emissions (PCs) will be encountered northeast nearby the emission sources, within SABIC facilities boundary limits. These PCs are predicted to be 91.5 $\mu g/m^3$ and 30.1 $\mu g/m^3$ for the 1-hr and 24-hr NO_2 averages, and 99.7 $\mu g/m^3$, 74.4 $\mu g/m^3$ and 24.5 $\mu g/m^3$ for the 15-min, 1-hr and 24-hr SO_2 averages under the worst-case conditions. These maximum PCs are below the human health and protected areas standards established by the UK Environment Agency.

At farther distances, PCs from the Project emissions will decay rapidly, and contributions to impacts on sensitive locations for human health and on protected areas will be minor.

The cumulative impact (PEC) is not predicted to exceed any of the UK Air Quality limits at the sensitive locations for human health. The PEC at the Seal Sands Peninsula (protected area) is predicted to exceed the 24-hr NO_2 Environment Agency environmental assessment level due to the already high background NO_2 levels that exceed currently the target at that location. The Project contribution to PECs at all protected areas assessed will be minor.

Final Considerations

This assessment was focused on the potential air emission impacts from the temporary boilers. Emissions from other facilities in the Project area were not considered. Background air quality levels obtained from nearby monitoring stations and recommended databases were consulted to assess current air quality levels in the area.

Although the maximum impacts due to the emissions of the boilers cannot be disregarded as insignificant, it is important to note that:

- Maximum impacts are encountered within 300 metres northeast of the stacks, within the SABIC complex boundaries. At farther distances from the sources, maximum predicted PCs decay significantly.
- The modelling results represent the maximum predicted PCs for NO_2 and SO_2 during the entire 3-year modelling period. Therefore, these represent conservative values and actual air quality impact from the boilers is expected to be lower than the maximum values.

10 References

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Appendix A
H1 Air Emissions Risk Assessment

H1

Welcome to the H1 Software

Version 2.7.8 - January 2017

If you find the screen fonts in the H1Tool too small to read you can use the Windows zoom feature at any time to magnify the screen by holding down the 'Windows' key and '+' key. To cancel the feature hold down the 'Windows' key and 'Esc' key.

Introduction

This version of the tool accompanies the Horizontal Guidance Note H1 and the eleven supporting technical annexes.

Important Notes:

With the exception of Annex I (Landfill) and Annex J (Groundwater) this software tool can be used to complete risk assessments within the technical annexes which support H1. However, further information may need to be provided in the following areas:

- detailed assessment of fate and effects, where required
- decision-making trails for the comparison and ranking of options

This software provides a general structure for assessing costs and environmental impacts. You may need to decide the best way to apply this structure to fit the nature and pattern of your operation, in particular:

- where load is variable, such as seasonal or demand-led operations
- where a number of processes are conducted at the same time, such as integrated operations
- where a number of products are made, with possible differences in unit operations and release points employed
- where fugitive or potential emergency releases are of particular interest

Information in this database will be used to determine your EPR permit, therefore to get the most from this software tool, you should:

- read the H1 Overview document, to understand the basic principles, module structure and methods
- use the HELP boxes and refer to the H1 guidance as you progress to ensure that the data you input is representative and accurate
- use the comments boxes to clarify assumptions and data sources

This software will also output annual emissions data to an OPRA profile(s), which you can select on the Summary Tables page.

On line instructions on using this tool and on the H1 Methodology itself are available on Gov.UK (click here)

Environment Agency

In conjunction with:
www.ability-software.co.uk

Facility Reference Information

Please complete the following information:

Company Name:	SABIC UK
Location:	Wilton Olefins 6 Plant
Permit Number:	

If you have data already stored in a previous version of the H1 software you may import it by pressing the button to the right.

Import Utility

Please note that before the import can take place any data that already exists in this copy of the tool will be removed. Please also note that any 'Operating Mode' information you had entered in your Air and Water inventories will defer to the default of 100% on data import

NOTE ON MICROSOFT ACCESS SECURITY WARNING
Depending on your security settings, you may get a security notice appearing each time the import routine connects to a table in your source database. You need to click 'Open' on this message for the Import routine to be successful. There are 18 tables to connect to in total but if you place your cursor over the 'Open' button you will be able to repeatedly click your mouse to make this process execute quickly and without too much frustration. We apologise for this inconvenience but it is an aspect of Microsoft Security provisions that are beyond our control.

Step 1

Introduction to Step 1

Step 1: Describe the Scope and Options

The aim of this step is to:

- state the OBJECTIVES of the assessment

- in the case of ENVIRONMENTAL ASSESSMENT of the whole facility, describe the scope of the activities to be included in the assessment;

- in the case of OPTIONS APPRAISALS, identify candidate options for BAT by considering all relevant techniques to prevent and minimise pollution and the scope of activities covered by the techniques.

Depending on the reason for the assessment, you will need to complete different modules of the guidance. The software will automatically select the required modules according to the responses you enter.

NOTE: If you are going to complete more than one assessment or appraisal, make sure that you create a copy of the H1 file for each new assessment BEFORE you begin to input data. This is because Microsoft Access automatically saves changes to the current file you are using, rather than allowing you to save your changes at the end of your work.

TO CONTINUE WITH STEP 1, PRESS "NEXT".

Describe the Objectives

Depending on the reason for the assessment you will need to complete different parts of the tool.

Select the type of assessment:

(●) a)	to carry out an ENVIRONMENTAL ASSESSMENT of the releases resulting from the facility as a whole	Do Steps 1, 2 and 3 only
( ) b)	to conduct a costs/benefits OPTIONS APPRAISAL to determine BAT or support the case for derogation under the Industrial Emission Directive.	Do Steps 1,2, 3 and 4 and continue with 5 and 6 if necessary

1.1 Briefly summarise the objectives and reason for the assessment in terms of the main environmental impacts or emissions to be controlled:

Assessment of the air emissions released from two temporary boilers to operate for 4 weeks during the Olefins 6 Plant shutdown

Scope of Environmental Assessment

List the activities included in the assessment

Number	Activity

Use the 'Add' button at the bottom left to create a new activity

1	Release of combustion gases (Nox, SO2 and CO) and particulate matter (PM10 and PM2.5) during the operation of the two boilers

Comments

Describe the Candidate Options

Identify all reasonably applicable options of techniques

You should include:

a) a brief description of individual control measures or configurations of control measures seleted for each option, and the activities with which they are associated (the existing base-case may conveniently be the first option).

b) justification why any techniques generally applicable to the regulated facility have not been selected for assessment. (see relevant H1 annex) (This should be based on regulated facility-specific technical, not economic reasons).

c) for new projects, whether any initial environmental assessment that was done at the project evaluation stage, or any screening of technology or process routes prior to this assessment, particularly where this has a bearing on environmental performance. (see H1)

In the case of b) or c)
please enter your Comments here:

Option Number	Title	Description
1	Base-Case	The two boilers operate at 50% load during 4 weeks

Once a series of options have been generated for the proposed project, it is recommended that the Operator discuss these with the local Regulator to check both parties agree that the options are satisfactory. This may save the Operator from spending resources on assessment of options which are unlikely to meet the required environmental performance.

List the main activity or activities to which the release control options are applicable and any other activities that will be affected by the candidate control option on the main activity:

Step 2

Introduction to Step 2

Step 2: Emissions Inventory

The aim of this Step is to produce an inventory of sources and releases of polluting substances from each option. This is used as the basis for the subsequent evaluation of environmental impacts.

For this Step you will require information on:

- release points and sources of emissions to air, water (inc. sewer) or land

- concentration and mass rate of released substances

- frequency and duration of releases and how these relate to long term and short term effects

IMPORTANT NOTES

- you may need to consider a suitable method for assessment of groups of pollutants, such as VOCs, heavy metals, uncharacterised liquid effluents, etc (see "Grouping air emissions" in Annex F).

TO CONTINUE WITH STEP 2, PRESS "NEXT".

Air Release Points

Please define your Release Points for Releases to Air

Are there any Air emissions? Yes

Number	Description	Location or Grid Reference	Activity or Activities	Effective Height (metres)	Efflux Velocity (m/s)	Total Flow (m3/hr)
1	Temporary Boiler Stack 1	NZ582210	Steam raising boiler	0	5.68	2308.36
2	Temporary Boiler Stack 2	NZ582210	Steam raising boiler	0	5.68	2308.36

Comments: Effective height is zero. Olefins 6 cooling tower (60 meters high, L) is located at approximately 130 meters southwest the boilers (less than 5*L).

Total flow rate normalized to STP conditions as provided in Vendor Data.

Air Emissions Inventory

Please list all Substances released to Air for each Release Point identified in the previous page.

Number	Substance	Meas'ment Method	Operating Mode (% of	Data relating to Long Term effects			Data relating to Short Term effects			Annual Rate	ELV Conc.
				Conc. mg/m3	Release Rate g/s	Meas'ment Basis	Conc. mg/m3	Release Rate g/s	Meas'ment Basis	tonne/yr	mg/m3
1	Sulphur Dioxide (15 Min Mean)	Estimated*	7.7%				162.0	0.103876	Vendor data		
2	Sulphur Dioxide (1 Hour Mean)	Estimated*	7.7%				162.0	0.103876	Vendor data		
3	Sulphur Dioxide (24 Hour Mean)	Estimated*	7.7%				162.0	0.103876	Vendor data		
4	Nitrogen Dioxide	Estimated*	7.7%				200.0	0.128242	Vendor data		
5	Carbon monoxide	Estimated*	7.7%				30.0	0.019236	Vendor data		
6	Particulates (PM10) (24 hr Mean)	Estimated*	7.7%				11.3	0.007277	Vendor data		
7	Particulates (PM2.5)	Estimated*	7.7%				2.4	0.001559	Vendor data		
8	Nitrogen Dioxide (Ecological - Daily Mean)	Estimated*	7.7%				200.0	0.128242	Vendor data		

Measurement method: * provide detail in comments box

Comments: Only Short Term effects expected. Each boiler operates at 50% load during a total period of 4 weeks. This represents 7.7% of the year (4 weeks out of 52 total weeks of the year)

Air Emissions Inventory

Please list all Substances released to Air for each Release Point identified in the previous page.

Number	Substance	Meas'ment Method	Operating Mode (% of	Data relating to Long Term effects: Conc. mg/m3	Long Term: Release Rate g/s	Long Term: Meas'ment Basis	Data relating to Short Term effects: Conc. mg/m3	Short Term: Release Rate g/s	Short Term: Meas'ment Basis	Annual Rate tonne/yr	ELV Conc. mg/m3
1	Sulphur Dioxide (15 Min Mean)	Estimated*	7.7%				162.0	0.103876	Vendor data		
2	Sulphur Dioxide (1 Hour Mean)	Estimated*	7.7%				162.0	0.103876	Vendor data		
3	Sulphur Dioxide (24 Hour Mean)	Estimated*	7.7%				162.0	0.103876	Vendor data		
4	Nitrogen Dioxide	Estimated*	7.7%				200.0	0.128242	Vendor data		
5	Carbon monoxide	Estimated*	7.7%				30.0	0.019236	Vendor data		
6	Particulates (PM10) (24 hr Mean)	Estimated*	7.7%				11.3	0.007277	Vendor data		
7	Particulates (PM2.5)	Estimated*	7.7%				2.4	0.001559	Vendor data		
8	Nitrogen Dioxide (Ecological - Daily Mean)	Estimated*	7.7%				200.0	0.128242	Vendor data		

Measurement method: * provide detail in comments box

Comments: Only Short Term effects expected. Each boiler operates at 50% load during a total period of 4 weeks. This represents 7.7% of the year (4 weeks out of 52 total weeks of the year)

Step 3

Introduction to Step 3

Step 3: Quantify Impacts

The aim of this Step is to quantify the effects on the environment of the releases listed in the inventory in Step 2. The guidance provides methods for assessing the eight main environmental considerations of most relevance to the EPR regime. Your releases may not result in effects to all eight of these considerations, and this tool allows you to screen out any that are not relevant.

The emissions you entered in Step 2 are automatically brought forward for assessment into each environmental consideration that is relevant for that type of release (e.g. a release may have more than one type of effect).

This part of the tool allows you to screen out any releases that are insignificant, and to identify those releases where further, detailed assessment of the potential environmental impact may be required.

IMPORTANT NOTE

This software tool only completes part of the requirements for Step 3, as described above. Depending upon the degree of risk to the environment presented by the releases, the operator may need to do further, detailed assessment of the potential effects using methodologies that are not provided here. This information should be submitted separately, as indicated within this part of the tool.

TO CONTINUE WITH STEP 3, PRESS "NEXT".

Identify Relevant Impacts

Identify any environmental impacts that are not relevant to this assessment by deselecting from the list below:

Releases in Part 2?	Selected	Impact	Justification for omission
Yes	☑	Air	
Yes	☐	Deposition from Air to Land	N/A
No	☐	Water	N/A
No	☐	Waste	N/A
Yes	☐	Visual	N/A
Yes	☐	Ozone Creation	N/A
Yes	☐	Global Warming	N/A

If you have deselected an environmental impact as not relevant to this assessment,
no further assessment of this impact will be carried out

Local Environmental Quality

Describe the Quality of the Environment:

Provide a brief description of the main local factors that may influence the importance of the impact of emissions in the surrounding environment

Air Quality

Are there any Environmental Quality Standards relating to substances released from the activities, which may be at risk due to additional contribution from the activity ? (Environmental Quality Standards for air and water are described in EPR Technical Guidance Notes)	No
Are there any Local Air Quality Management Plans applicable to releases from the activity?	No

Water Quality & Resources

Are there any Environmental Quality Standards relating to substances released from the activities, which may be at risk due to additional contribution from the activity?

Are proposals to abstract water satisfactory in order to obtain an abstraction licence?

Is the activity located in a groundwater vulnerable zone (for activities with direct releases to land only)?

Proximity to Sensitive Receptors

Is public annoyance likely to be an issue for noise, odour or plume visibility ?	No
Are there any wildlife habitats, eg Special Areas of Conservation,or Special Protection Areas, likely to be affected by releases from the activity? (Description of requirements of Habitats Directive is provided in EPR Technical Guidance Notes)	Critical N deposition loads are currently exceeded in some SSSIs local areas

Air Impacts

Calculate Process Contributions of Emissions to Air

This table estimates the Process Contribution (PC), calculated as the maximum ground level concentration for each emission listed in the inventory, according to the release point parameters input earlier. If you have more accurate data obtained through dispersion modelling, this may be entered as indicated and will be used instead of the estimated PC.

		Long Term			Short Term		
Number	Substance	EAL µg/m3	PC µg/m3	* Modelled PC µg/m3	EAL µg/m3	PC µg/m3	Modelled PC µg/m3
1	Sulphur Dioxide (15 Min Mean)		-		266	810	
2	Sulphur Dioxide (1 Hour Mean)		-		350	810	62
3	Sulphur Dioxide (24 Hour Mean)		-		125	810	
4	Nitrogen Dioxide	40	-		200	1,000	76
5	Carbon monoxide		-		10000	150	
6	Particulates (PM10) (24 hr Mean)		-		50	56.8	
7	Particulates (PM2.5)	25	-			12.2	
8	Nitrogen Dioxide (Ecological - Daily Mean)	30	-		75	1,000	

Note that the Process Contribution shown for each substance is the sum of the individual process contributions of each point from which the substance is emitted. Process Contributions obtained from modelling data should incorporate all relevant release points and flow conditions.

* State the location of any detailed air dispersion modelling and also the main assumptions:

Comments: Dispersion modelling carried out with AERMOD in screening mode for the preliminary estimation of conservative air quality impacts (maximum 1-hr average impacts only)

Air Impact Screening Stage One

Screen out Insignificant Emissions to Air

This page displays the Process Contribution as a proportion of the EAL or EQS. Emissions with PCs that are less than the criteria indicated may be screened from further assessment as they are likely to have an insignificant impact.

Number	Substance	Long Term EAL	Short Term EAL	Long Term PC	Long Term % PC of EAL	> 1% of EAL?	Short Term PC	Short Term % PC of EAL	> 10% of EAL?
		µg/m3	µg/m3	µg/m3	%		µg/m3	%	
1	Sulphur Dioxide (15 Min Mean)	-	266	-	-		810	305	**Yes**
2	Sulphur Dioxide (1 Hour Mean)	-	350	-	-		62.0	17.8	**Yes**
3	Sulphur Dioxide (24 Hour Mean)	-	125	-	-		810	648	**Yes**
4	Nitrogen Dioxide	40.0	200	-	-		76.0	38.0	**Yes**
5	Carbon monoxide	-	10,000	-	-		150	1.51	**No**
6	Particulates (PM10) (24 hr Mean)	-	50.0	-	-		56.8	114	**Yes**
7	Particulates (PM2.5)	25.0	-	-	-		12.2	-	
8	Nitrogen Dioxide (Ecological - Daily Mean)	30.0	75.0	-	-		1,000	1,334	**Yes**

Air Impact Modelling Stage Two Screening

Identify need for Detailed Modelling of Emissions to Air

This page displays the Process Contributions in relation to the backgound pollutant levels and the EAL or EQS. You should use this information to decide whether to conduct detailed modelling. Note that releases that are insignificant are not shown as they are screened from further assessment. Also complete this page if you have already done detailed modelling.

Number	Substance	Air Bkgrnd Conc.	Long Term					Short Term		
		Air Bkgrnd Conc.	PC	% PC of headroom (EAL -	PEC	% PEC of EAL	% PEC of EAL >=70?	PC	% PC of headroom (EAL - Bkgrnd)	% PC of headroom >=20?
		µg/m3	µg/m3		mg/m3	%		µg/m3		
1	Sulphur Dioxide (15 Min Mean)	67	-	-	0	-		810	614	**Yes**
2	Sulphur Dioxide (1 Hour Mean)	45	-	-	0	-		62.0	23.9	**Yes**
3	Sulphur Dioxide (24 Hour Mean)	16	-	-	0	-		810	871	**Yes**
4	Nitrogen Dioxide	59	-	-	0	0	**No**	76.0	92.7	**Yes**
6	Particulates (PM10) (24 hr Mean)	27	-	-	0	-		56.8	-1,419	**No**
8	Nitrogen Dioxide (Ecological - Daily Mean)	35	-	-	0	0	**No**	1,000	20,006	**Yes**

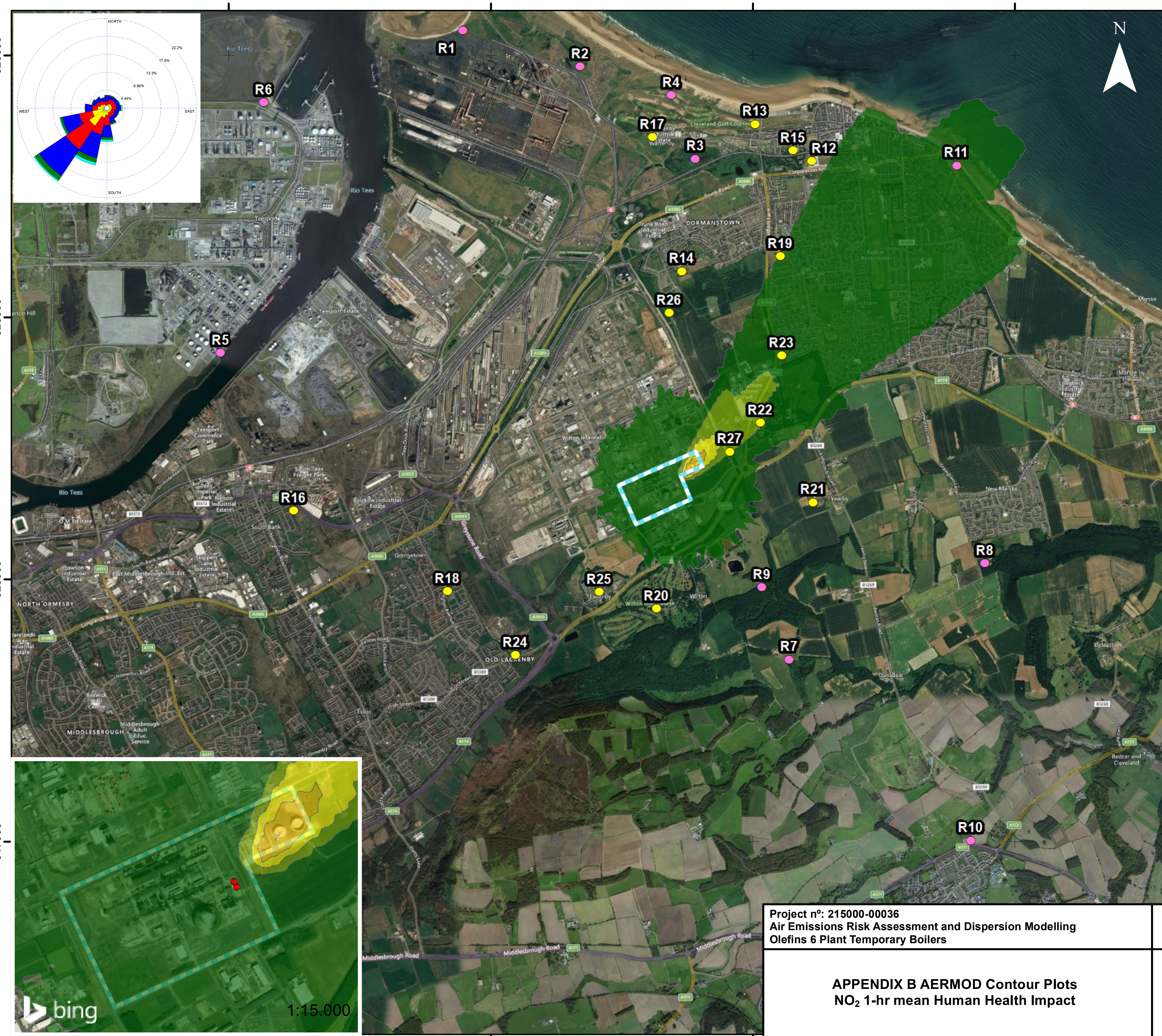
Air Impact Modelling Assessment

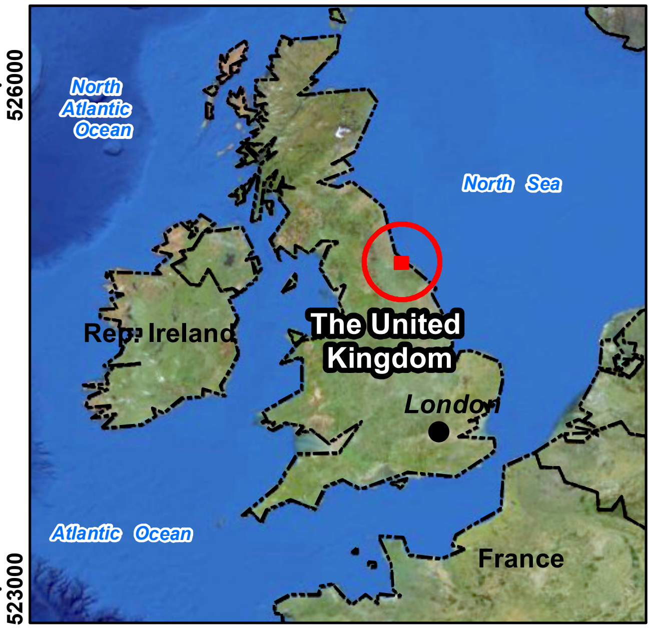
See guidelines in H1 Annex F section entitled "Decide if you need detailed air modelling.

Describe here the justification for whether detailed modelling is, or is not required for any of the releases. Refer to the guidelines in H1 Annex F	NO2 and SO2 contributions shall be considered as significant.The short term NO2 and SO2 process contribution is >20% of the short term environmental standard.
Describe source of background information:	Redcar and Cleveland Borough Council; 2019 Air Quality Annual Status Report; June 2019 (and preceding years)
Document Reference of detailed modelling work:	Air Emissions Risk Assessment and Dispersion Modelling. SABIC Olefins 6 Plant Shutdown Temporary Boilers. July 2020. 215000-00036

Appendix B
AERMOD Contour Plots

LIST OF PLOTS





Legend

- Plant
- Stacks

Receptors

- Protected Areas
- Human Health Sensitive Locations

NO_2 1-hr (ug/m^3)

- 10 - 30
- 30 - 50
- 50 - 70
- 70 - 90
- > 90

Maximum PC = 91.5 ug/m^3
UK Air Quality Objective = 200 ug/m^3

British National Grid
Source:
Basemap licensed by ESRI- Bing Maps for ArcGIS Desktop Users
Service Agreement. See http://www.esri.com/legal/licensing/third-party-data.html

0 1,25 2,5 Km.

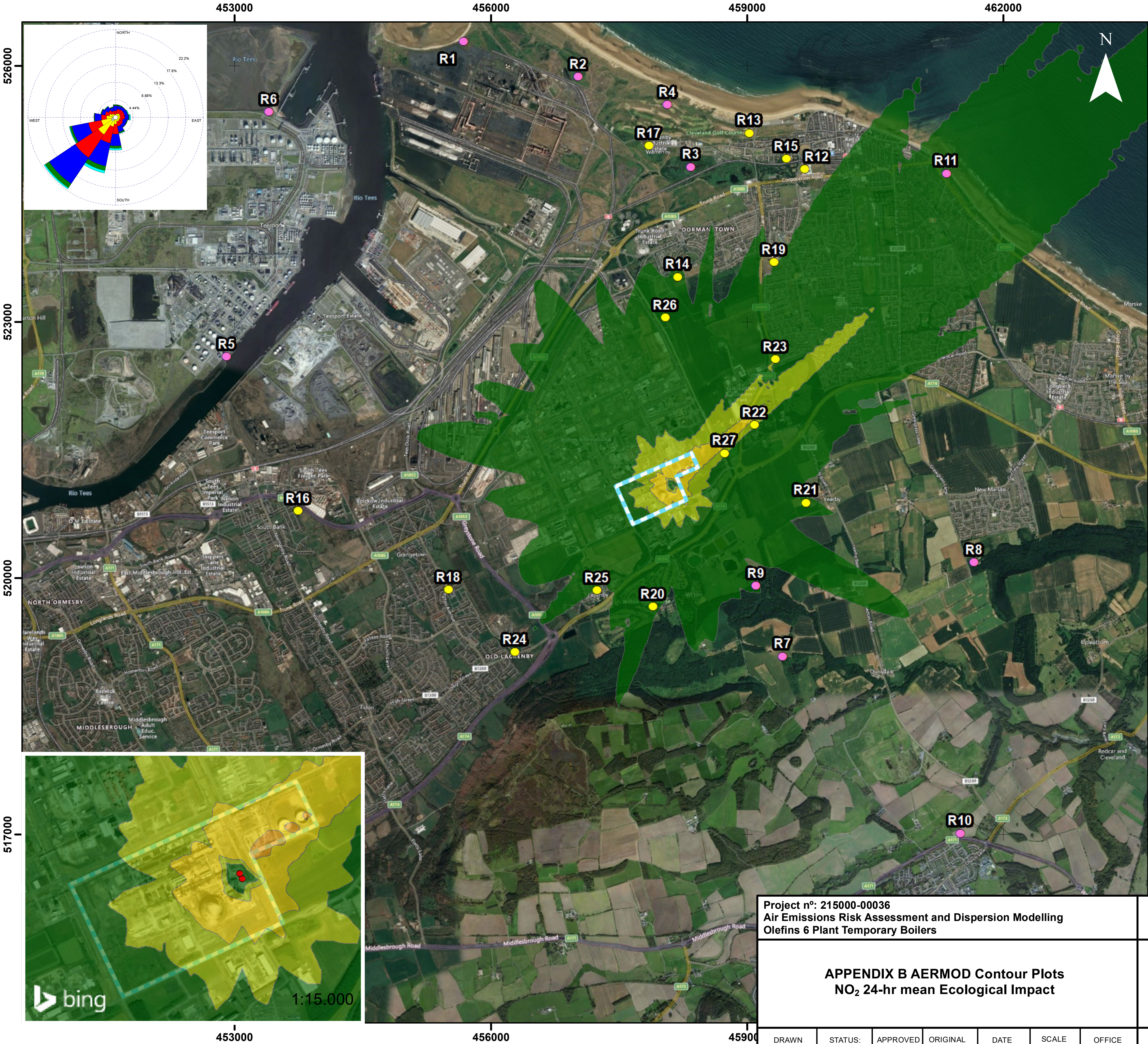
Project nº: 215000-00036
Air Emissions Risk Assessment and Dispersion Modelling
Olefins 6 Plant Temporary Boilers

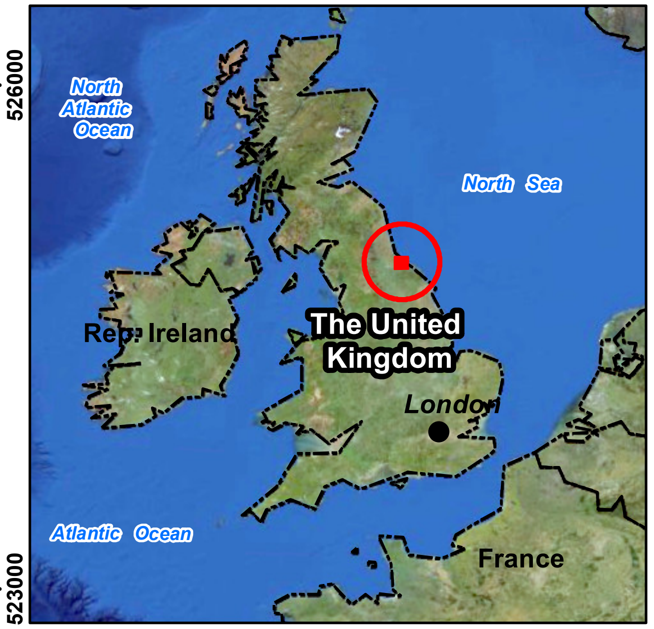
sabic

APPENDIX B AERMOD Contour Plots
NO_2 1-hr mean Human Health Impact

Advisian
Worley Group

DRAWN	STATUS:	APPROVED	ORIGINAL	DATE	SCALE	OFFICE	CODE		
FJPA	DRAFT	MSA	A3	24/06/2020	1:45.000	MADRID		**FIGURE B.1**	Rev.0





Legend

Plant

Stacks

Receptors

Protected Areas

Human Health Sensitive Locations

NO_2 24-hr (ug/m^3)

- 1 - 5
- 5 - 10
- 10 - 25
- > 25

Maximum PC = 30.1 ug/m^3
UK Target for Protected Areas = 75 ug/m^3

British National Grid
Source:
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0 1,25 2,5 Km.

Project nº: 215000-00036
Air Emissions Risk Assessment and Dispersion Modelling
Olefins 6 Plant Temporary Boilers

sabic

APPENDIX B AERMOD Contour Plots
NO_2 24-hr mean Ecological Impact

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DRAWN	STATUS:	APPROVED	ORIGINAL	DATE	SCALE	OFFICE	CODE	FIGURE B.2	Rev.0
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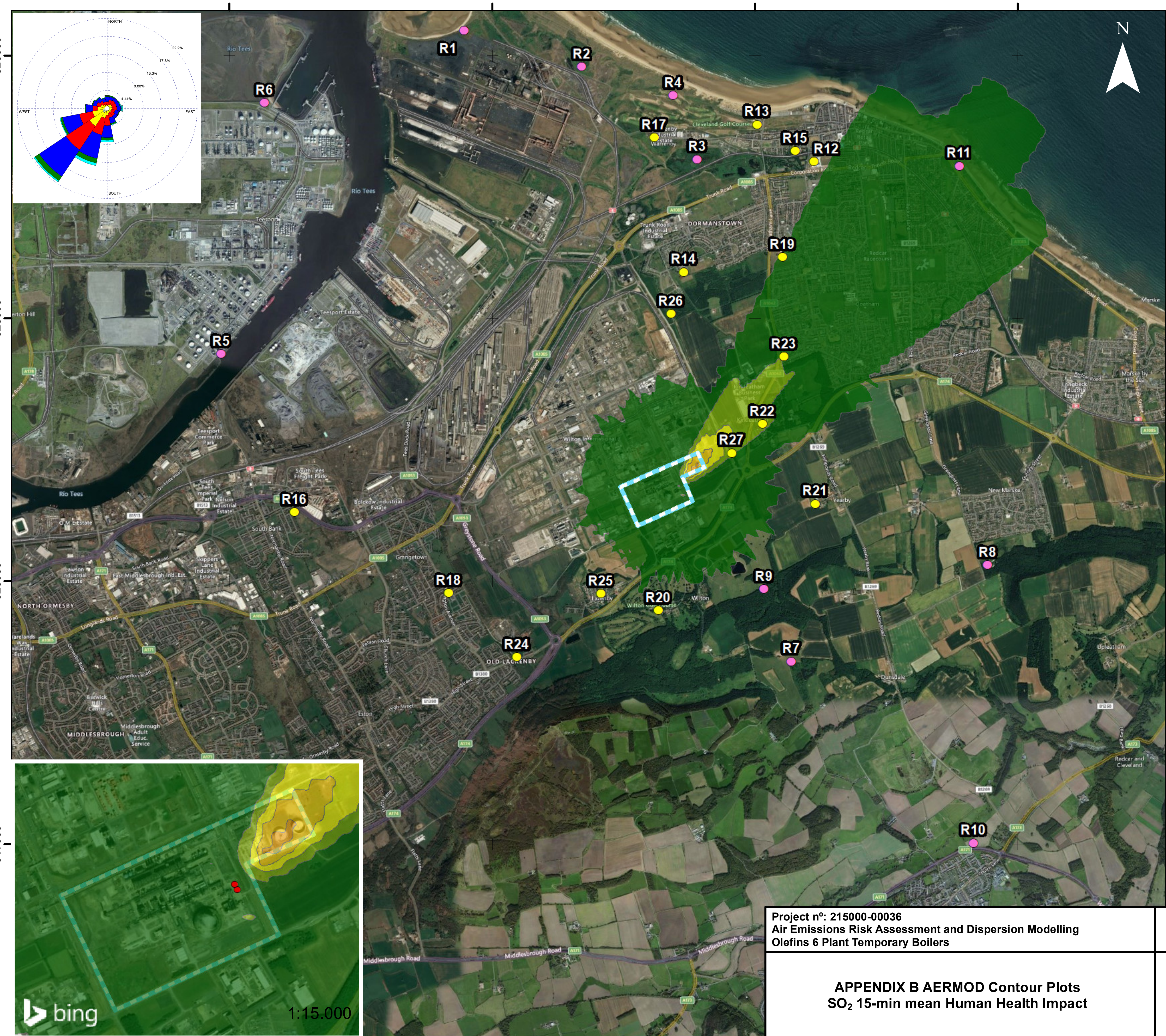

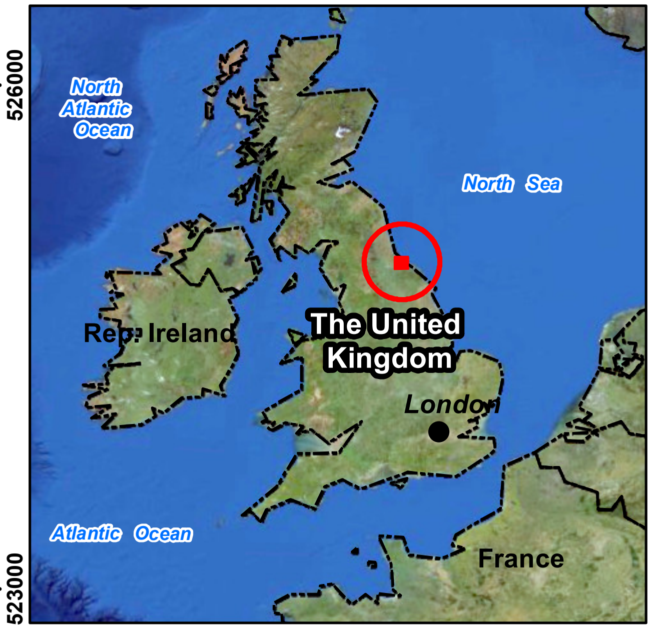

Legend

Plant

Stacks

Receptors

Protected Areas

Human Health Sensitive Locations

SO_2 15-min (ug/m^3)

- 10 - 30
- 30 - 50
- 50 - 70
- 70 - 90
- > 90

Maximum PC = 99.7 ug/m^3
UK Air Quality Objective = 266 ug/m^3

British National Grid
Source:
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Service Agreement. See http://www.esri.com/legal/licensing/third-party-data.html

0 1,25 2,5 Km.

Project nº: 215000-00036
Air Emissions Risk Assessment and Dispersion Modelling
Olefins 6 Plant Temporary Boilers

sabic

APPENDIX B AERMOD Contour Plots
SO_2 15-min mean Human Health Impact

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DRAWN	STATUS:	APPROVED	ORIGINAL	DATE	SCALE	OFFICE	CODE		
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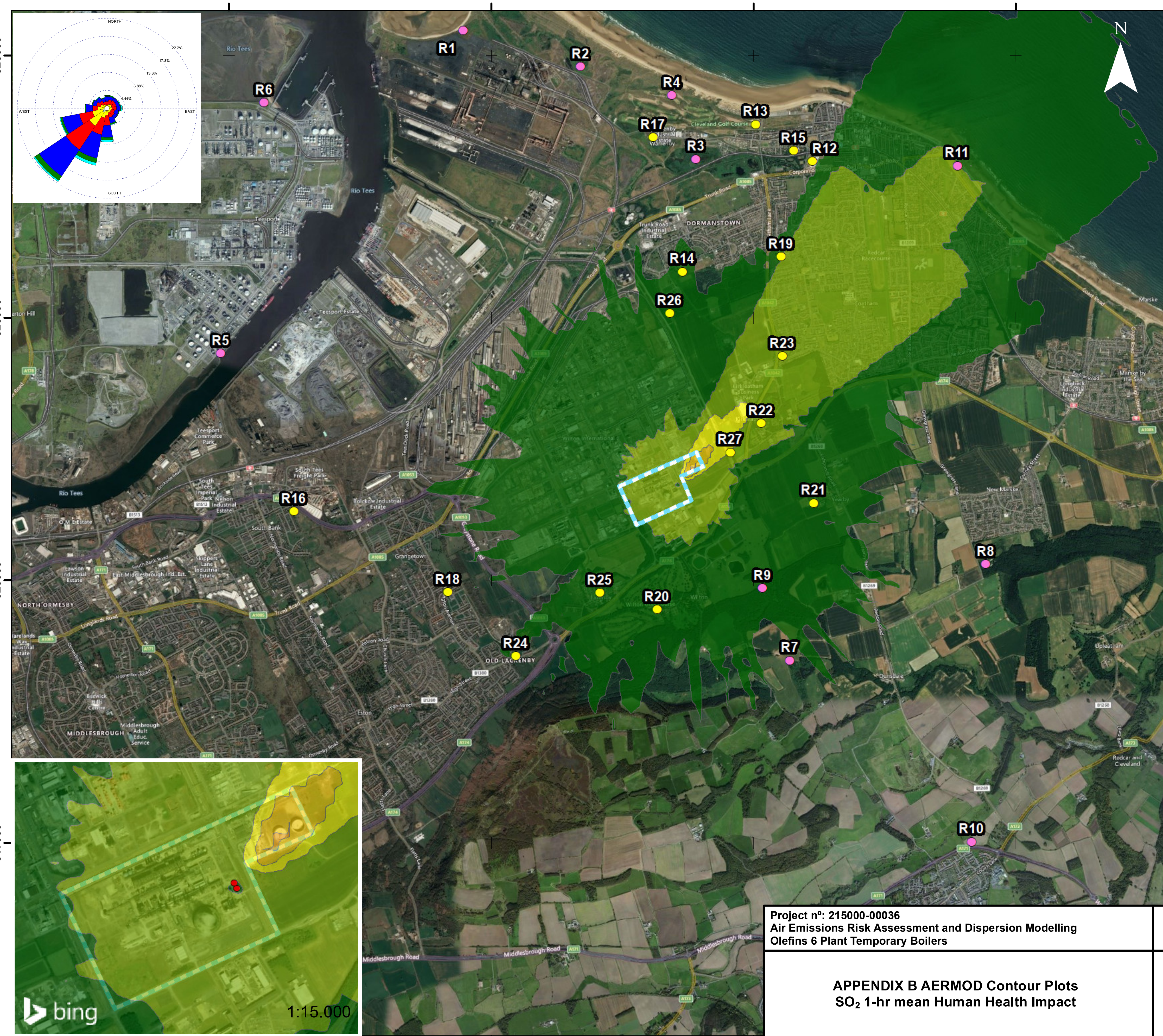

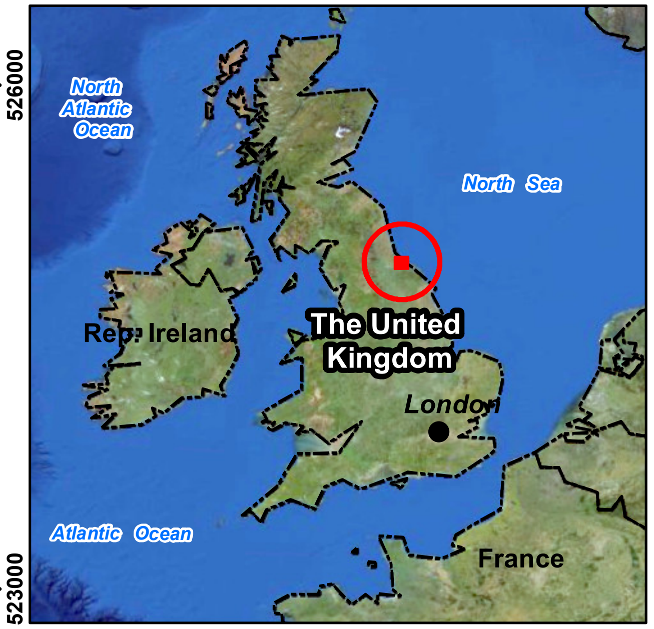

Legend

- Plant
- Stacks

Receptors

- Protected Areas
- Human Health Sensitive Locations

SO_2 1-hr (ug/m^3)

- 5 - 10
- 10 - 30
- 30 - 50
- 50 - 70
- > 70

Maximum PC = 74.4 ug/m^3
UK Air Quality Objective = 350 ug/m^3

British National Grid
Source:
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Service Agreement. See http://www.esri.com/legal/licensing/third-party-data.html

0 1,25 2,5 Km.

Project nº: 215000-00036
Air Emissions Risk Assessment and Dispersion Modelling
Olefins 6 Plant Temporary Boilers

sabic

APPENDIX B AERMOD Contour Plots
SO_2 1-hr mean Human Health Impact

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Worley Group

DRAWN	STATUS:	APPROVED	ORIGINAL	DATE	SCALE	OFFICE	CODE	FIGURE B.4	Rev.0
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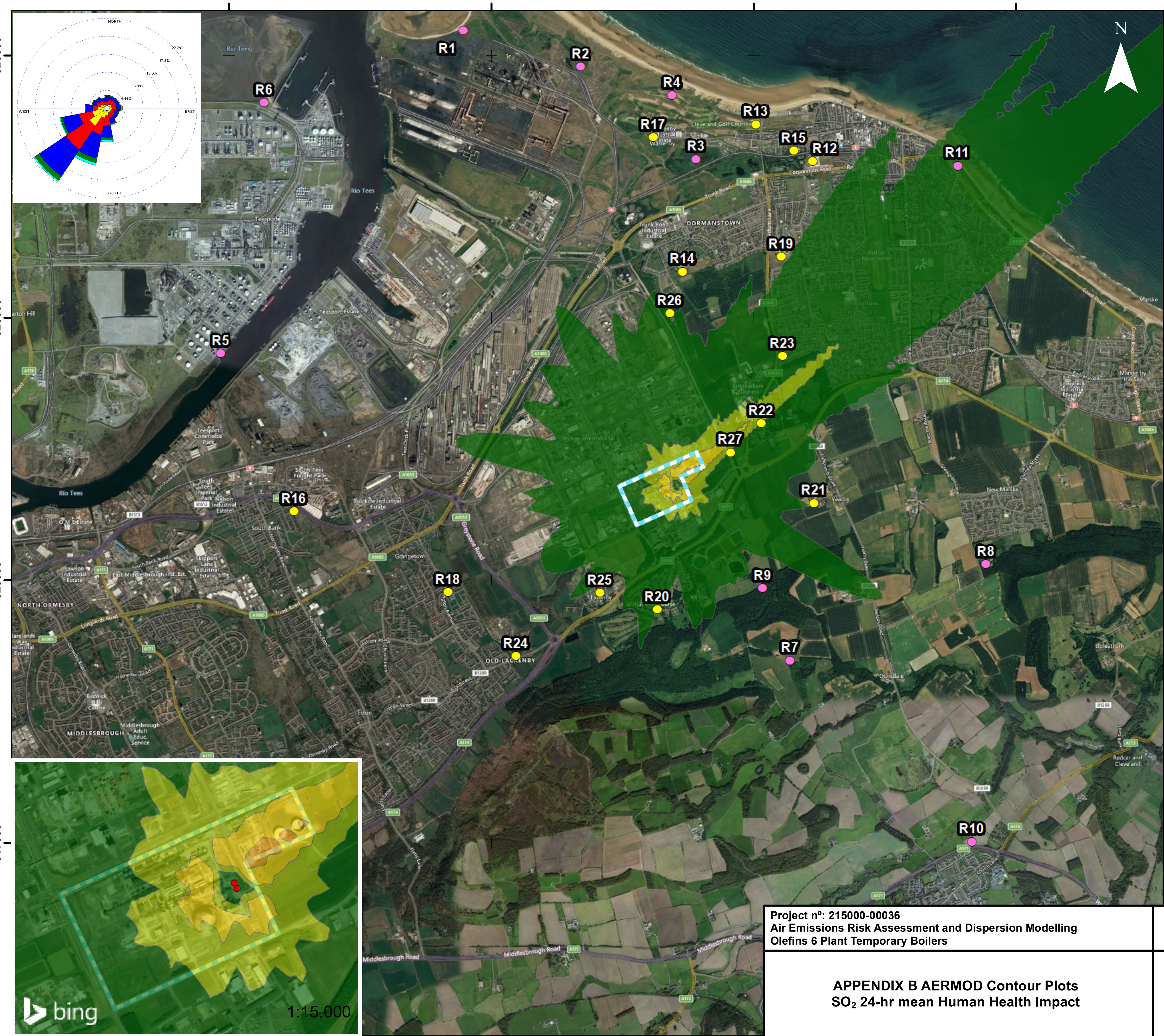

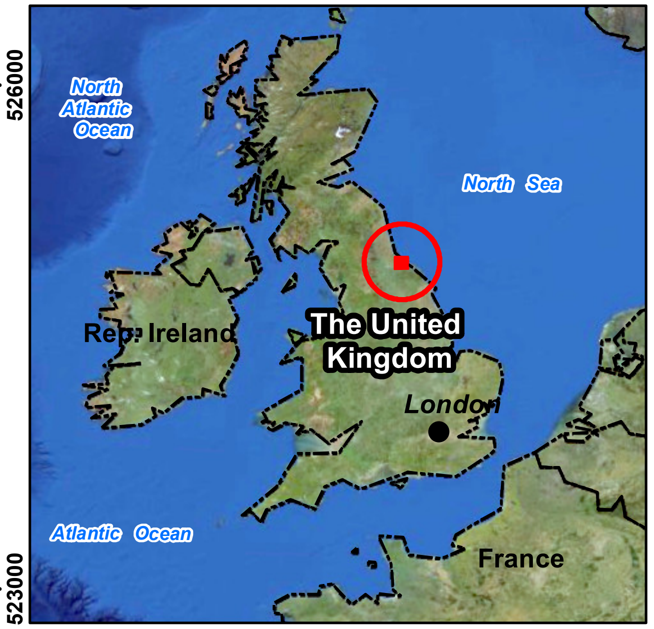

Legend

- Plant
- Stacks

Receptors

- Protected Areas
- Human Health Sensitive Locations

SO_2 24-hr (ug/m^3)

- 1 - 5
- 5 - 10
- 10 - 20
- > 20

Maximum PC = 24.5 ug/m^3
UK Air Quality Objective = 125 ug/m^3

British National Grid
Source:
Basemap licensed by ESRI- Bing Maps for ArcGIS Desktop Users
Service Agreement. See http://www.esri.com/legal/licensing/third-party-data.html

0 1,25 2,5 Km.

Project nº: 215000-00036
Air Emissions Risk Assessment and Dispersion Modelling
Olefins 6 Plant Temporary Boilers

sabic

APPENDIX B AERMOD Contour Plots
SO_2 24-hr mean Human Health Impact

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Worley Group

DRAWN	STATUS:	APPROVED	ORIGINAL	DATE	SCALE	OFFICE	CODE		
FJPA	DRAFT	MSA	A3	25/06/2020	1:45.000	MADRID		**FIGURE B.5**	Rev.0