An Assessment using Dispersion Modelling of the Impact of Emissions from the Existing Biomass Boiler at the Wicks Waste Management & Recycling facility, Sowerby Wood Business Park, Barrow in Furness, Cumbria

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1. Introduction

AS Modelling & Data Ltd. has been instructed by David Baldwin, of Recogen Ltd., on behalf of the applicant, to use computer modelling to assess the impact of emissions of nitrogen oxides, sulphur dioxide, particulate matter and carbon monoxide from a existing biomass boiler at the Wicks Waste Management & Recycling facility, Sowerby Wood Business Park, Barrow in Furness, Cumbria. LA14 4QR.

Emissions of nitrogen oxides (NO_X), sulphur dioxide (SO_2), particulate matter (PM_{10}) and carbon monoxide (CO) from the stack serving the existing biomass boiler have been assessed and quantified based upon data supplied to AS Modelling & Data Ltd. by the manufacturers of the biomass boilers (Ariterm). The NO_x, SO_2, PM_{10} and CO emission rates have then been used as the basis of inputs to an atmospheric dispersion model which calculates nitrogen oxides NO_x, SO_2, PM_{10} and CO exposure levels in the surrounding area.

This report is arranged in the following manner:

- Section 2 provides relevant details of the proposed development and potentially sensitive receptors in the area.

- Section 3 provides some general information on NO_x, SO_2, PM_{10} and CO and details of the method used to determine emission rates; relevant guidelines and legislation on exposure limits and where relevant, details of likely background levels of the pollutants.

- Section 4 provides some information about ADMS, the dispersion model used for this study and details the modelling procedure.

- Section 5 contains the results of the modelling.

- Section 6 provides a discussion of the results and conclusions.

2. Background Details

The Wicks Waste Management & Recycling facility is located on Sowerby Business Park, on the periphery of the town of Barrow in Furness. In close proximity to the site there are industrial or commercial properties, while beyond there are rural areas, which comprise some arable and pasture, a golf course and there are further industrial or commercial properties. The suburbs of Barrow in Furness lie from approximately 1 km to the south and the site is close to the Morecambe Bay coastline, which is 750 m to the west of the site, with the land rising to the east.

There is a 999 KW biomass boiler installed at the Wicks facility. Emissions from the biomass boiler are discharged through a single stack.

There are potential human health receptors in the surrounding area, including residences and commercial properties. There are a number of businesses on the Sowerby Business Park which are very close to the proposed biomass boiler, the nearest being: Booker Wholesale, which is approximately 100 m to the north-north-east; an unnamed business located approximately 100 m to the east and P & W Business Services approximately 100 m to the north-east of the biomass boiler stack.

The closest residences to the biomass boiler stack are at Sowerby Cottages, which are approximately 270 m to the south. There are further residences at Rakesmoor Farm, which is approximately 1 km to the south-east, Sinkfall, which is approximately 1.2 km to the east and Booth Wood, which is approximately 1 km to the north-east of the site. The denser residential areas of the town of Barrow in Furness extend from approximately 1 km to the south of the biomass boiler stack.

A map of the surrounding area is provided in Figure 1a; in this figure, the location of the Wicks Waste & Recycling facility is outlined in blue and the positions of key human health receptors are marked by orange crosses.

There are four areas that are designated as Ancient Woodlands (AWs) within 2 km of the biomass boiler at the site. Additionally, there are three areas that are designated as Sites of Special Scientific Interest (SSSIs) within 5 km of the site, namely Elliscales Quarry SSSI to the north-east and Duddon Estuary SSSI to the west, which is also designated as a Ramsar site and is part of Morecambe Bay Special Area of Conservation (SAC)/Specially Protected Area (SPA). There is also South Walney & Piel Channel Flats SSSI to the south, which also designated as part of Morecambe Bay SAC/SPA/Ramsar.

A map of the surrounding area showing the positions of the wildlife sites is provided in Figure 1b; in this figure, the AWs are shaded olive, the SSSIs are shaded green, the Ramsar is shaded blue, the SPA is shaded orange, the SAC is shaded purple and the site of the Wicks Waste & Recycling facility is marked by a blue rectangle.

Figure 1a. The area surrounding the Wicks Waste & Recycling facility

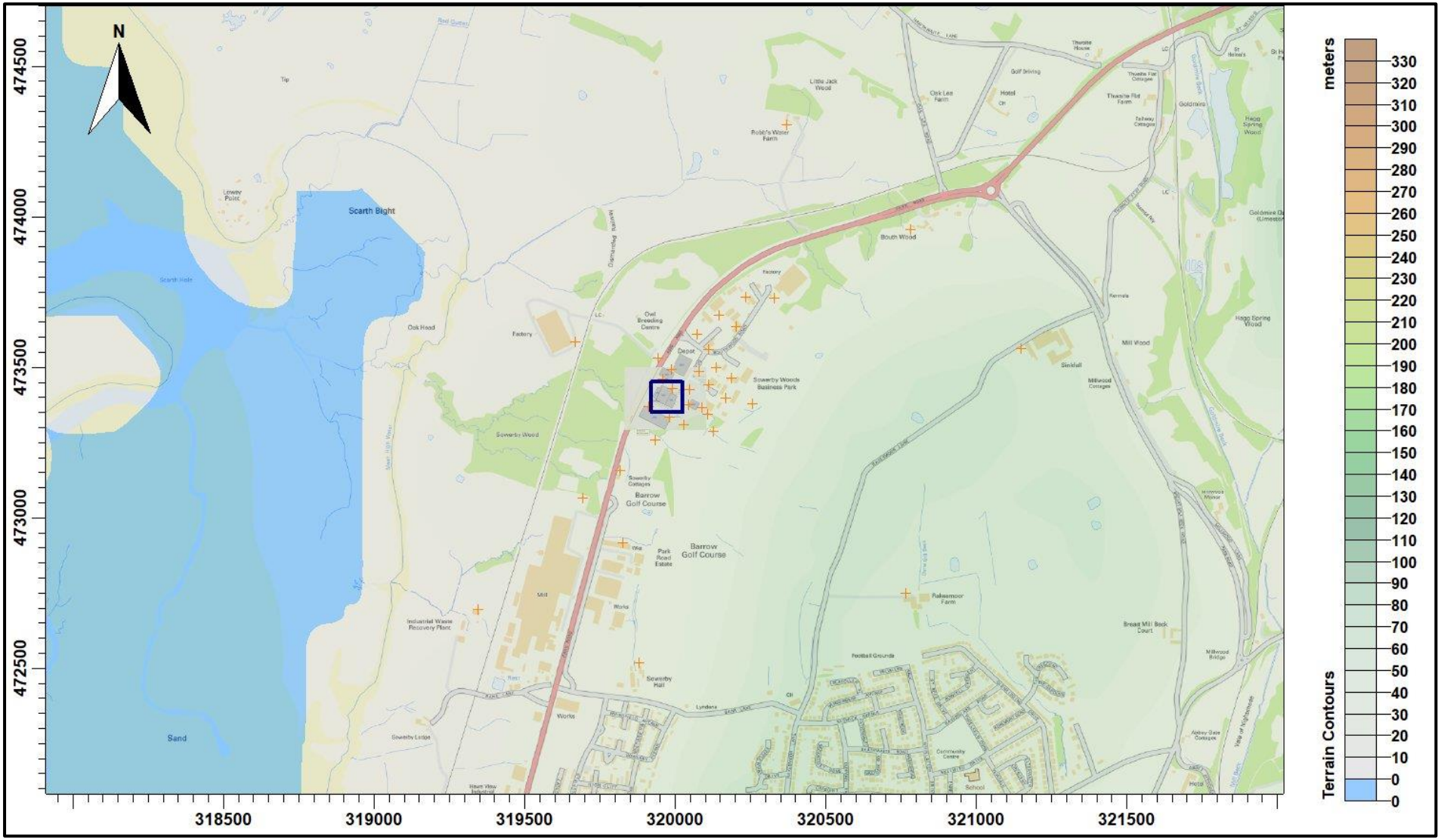
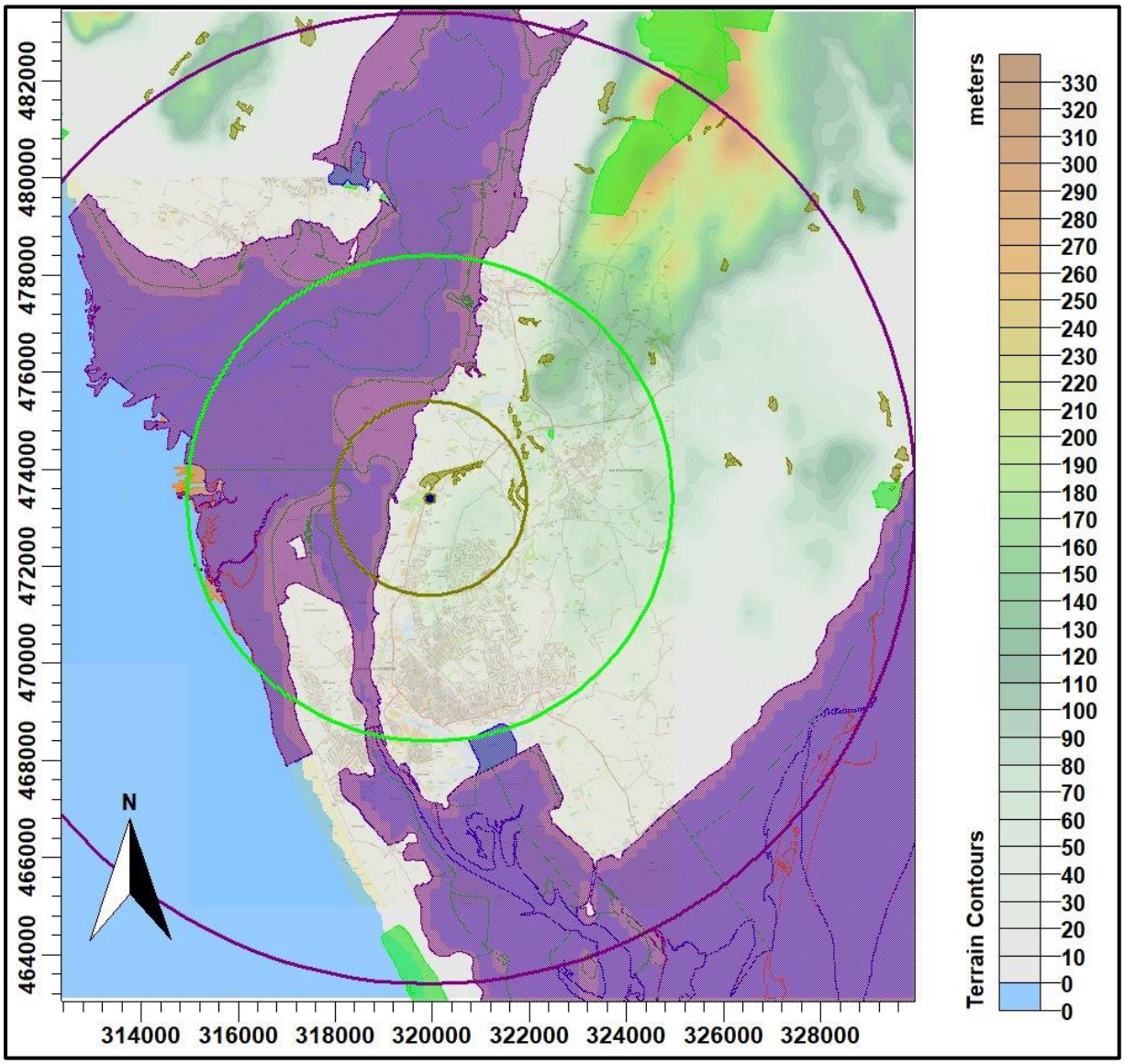


Figure 1b. Wildlife sites in the area surrounding the Wicks Waste & Recycling facility – concentric circles radii 2 km (olive), 5 km (green) and 10 km (purple)



3. Air Quality Legislation, Regulation, Background Levels & Emission Rates

3.1 Air Quality Strategy and Air Quality Standards Regulations

The current UK Air Quality Strategy (AQS) was published in July 2007 and set out objectives for local authorities in undertaking their local air quality management duties. The AQS establishes the framework for air quality improvements. The strategy is based upon measures agreed at the national and international level. The role of the local authority review and assessment process is to identify all those areas where the air quality objectives are being, or are likely to be, exceeded.

For the purposes of this assessment, the limit values set out in the Air Quality Standards Regulations 2010 and the objective levels specified under the current UK AQS have been used. The Air Quality Standards Regulations 2010 transpose into English law the requirements of the European Directives 2008/50/EC and 2004/107/EC on ambient air quality.

The Air Quality Standards Regulations 2010 objectives levels are shown in Table 1a.

Table 1a. Air Quality Standards Regulations 2010 - objectives levels

Pollutant	Air Quality Objective Concentration	Averaging period
Benzene (VOC)	16.25 µg/m^3	Running annual mean
	5.00 µg/m^3	Annual mean
1,3-Butadiene (VOC)	2.25 µg/m^3	Running annual mean
Carbon Monoxide (CO)	**10.0 mg/m^3**	**Maximum daily running 8-hour mean**
Lead	0.25 µg/m^3	Annual mean
Nitrogen Dioxide (NO_2)	**200 µg/m^3 not to be exceeded more than 18 times a year**	**1-hour mean**
	40 µg/m^3	**Annual mean**
Sulphur dioxide (SO_2)	**350 µg/m^3, not to be exceeded more than 24 times a year**	**1-hour mean**
	125 µg/m^3, not to be exceeded more than 3 times a year	**24-hour mean**
	266 µg/m^3, not to be exceeded more than 35 times a year	**15-minute mean**
Particle Matter (PM_{10})	**50 µg/m^3, not to be exceeded more than 35 times a year**	**Daily mean**
	40 µg/m^3	**Annual mean**

3.2 Guidance on the Significance of the Impact of Emissions

Where comment on the significance of the impact of emissions is made in this report, it is based upon guidance contained in an Environmental Protection UK publication titled Land Use Planning & Development Control: Planning For Air Quality (January 2017). It should be noted, however, that the final judgment on significance is made by the local authority's air quality specialist. The definitions of impact of magnitude for changes in pollutant concentration as a percentage of the assessment level and predicted concentration for an annual mean are provided in Table 1b.

Table 1b. Air quality impact descriptors for changes to annual mean concentrations

Average concentration (as percentage of Predicted Environmental Concentration)	Change in concentration (Process Contribution as percentage of Environmental Assessment Level)			
	<1	>=1 and <5	>=5 and <10	>10
<75	Negligible	Negligible	**Slight**	**Moderate**
>=75 to <95	Negligible	**Slight**	**Moderate**	**Moderate**
>=95 to <103	**Slight**	**Moderate**	**Moderate**	**Substantial**
>=103 to <110	**Moderate**	**Moderate**	**Substantial**	**Substantial**
>=110	**Moderate**	**Substantial**	**Substantial**	**Substantial**

3.3 Background NO_2, SO_2, Benzene (VOC) and CO Levels

The background concentrations used in this report are obtained from the Defra website, Local Air Quality Management (LAQM) support pages. Details of the methods used to drive these background concentrations are described in the AEA report titled "UK modelling under the Air Quality Directive (2008/50/EC) for 2010 covering the following air quality pollutants: SO_2, NO_x, NO_2, PM_{10}, $PM_{2.5}$, lead, benzene, CO, and ozone".

The background concentrations of NO_2, SO_2, PM_{10} and CO are provided in Tables 2a, 2b, 2c and 2d. The tables contain the concentration for the centroid of the 1 km Ordnance Survey grid square around the site and the centroid of the adjacent 1 km Ordnance Survey grid squares.

Table 2a. Background NO_2 concentrations

NO_2 concentration 2017 (µg/m^3)					
OS easting & OS northing	317500	318500	319500	320500	321500
471500	5.080	6.725	8.496	7.580	7.168
472500	4.871	6.079	7.625	7.081	6.507
473500	4.852	5.244	6.791	6.886	6.185
474500	-	4.863	5.249	5.893	7.789
475500	-	4.578	4.758	5.149	5.673

Table 2b. Background SO_2 concentrations

SO_2 concentration 2001 (µg/m^3)					
OS easting & OS northing	317500	318500	319500	320500	321500
471500	1.580	-	1.990	2.060	2.200
472500	1.550	-	2.500	1.830	1.780
473500	-	-	1.730	1.700	1.640
474500	-	-	1.550	1.650	1.610
475500	-	-	1.510	1.530	1.560

Table 2c. Background PM_{10} concentrations

PM_{10} concentration 2017 (µg/m^3)					
OS easting & OS northing	317500	318500	319500	320500	321500
471500	9.190	9.834	11.173	10.320	10.320
472500	8.973	9.378	10.726	10.313	10.796
473500	8.998	9.183	10.612	11.610	11.981
474500	-	9.067	10.102	10.904	11.901
475500	-	8.979	9.494	11.576	11.697

Table 2d. Background CO concentrations

CO concentration 2001 (mg/m^3)					
OS easting & OS northing	317500	318500	319500	320500	321500
471500	0.177	-	0.202	0.206	0.208
472500	0.166	-	0.185	0.190	0.195
473500	-	-	0.177	0.182	0.187
474500	-	-	0.171	0.176	0.181
475500	-	0.164	0.169	0.173	0.178

3.4 Quantification of Emissions of NO_2, SO_2, PM_{10} and CO

Emissions of NO_x, PM_{10} and CO from the proposed biomass boiler are obtained from data supplied by the manufacturers of the biomass boilers (Ariterm). The emission rates used for the modelling are provided in Table 3.

Table 3. NO_x, NO_2, SO_2, PM_{10} and CO emission rates

Source	NO_x emission rate (g/s)	NO_2 emission rate (assuming NO_X is 100% NO and all is converted to NO_2) (g/s)	SO_2 emission rate (g/s)	PM_{10} emission rate (g/s)	CO emission rate (g/s)
Biomass boiler	0.112396	0.172340	0.009028	0.022840	0.073576

3.5 Choice of Receptors

Predicted pollutant levels are calculated at discrete receptor points by the dispersion model. The choice of where these receptors are defined is usually based upon guidance from the Environment Agency's H1: Environmental risk assessment for permits and its technical annexes, specifically Annex A - Amenity & accident risk from installations and waste activities.

More specific guidance on the choice of receptors is available in the Environmental Protection UK publication titled Development Control: Planning For Air Quality (2010 Update). The descriptions from Development Control: Planning For Air Quality are reproduced in Table 4.

Table 4. Choice of receptors (Development Control: Planning For Air Quality)

Averaging period of objective	Where the objective should apply	Where the objective should not generally apply
Annual	All locations where members of the public might be regularly exposed. Building facades, residential properties, schools hospitals care homes etc.	Building facades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
8 hours to 24 hours	All locations where the annual mean objectives would apply. Gardens of residential properties.	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
1 hour	All locations where the annual mean and 24 and 8-hour mean objectives would apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where the public might reasonably be expected to spend one hour or more. Any outdoor locations at which the public may be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.
15 minutes	All locations where members of the public might reasonably be expected to spend a period of 15 minutes or longer.	

4. The Atmospheric Dispersion Modelling System (ADMS) and Model Parameters

4.1 ADMS

The Atmospheric Dispersion Modelling System (ADMS) ADMS 5 is a new generation Gaussian plume air dispersion model, which means that the atmospheric boundary layer properties are characterised by two parameters, the boundary layer depth and the Monin-Obukhov length rather than in terms of the single parameter Pasquill-Gifford class.

Dispersion under convective meteorological conditions uses a skewed Gaussian concentration distribution (shown by validation studies to be a better representation than a symmetrical Gaussian expression).

ADMS has a number of model options including: dry and wet deposition; NO_x chemistry; impacts of hills, variable roughness, buildings and coastlines; puffs; fluctuations; odours; radioactivity decay (and γ-ray dose); condensed plume visibility; time varying sources and inclusion of background concentrations.

ADMS has an in-built meteorological pre-processor that allows flexible input of meteorological data both standard and more specialist. Hourly sequential and statistical data can be processed and all input and output meteorological variables are written to a file after processing.

The user defines the pollutant, the averaging time (which may be an annual average or a shorter period), which percentiles and exceedance values to calculate, whether a rolling average is required or not and the output units. The output options are designed to be flexible to cater for the variety of air quality limits, which can vary from country to country and are subject to revision.

4.2 Meteorological Data

Computer modelling of dispersion requires hourly sequential meteorological data and to provide robust statistics the record should be of a suitable length; preferably four years or longer.

The meteorological data used in this study is obtained from assimilation and short term forecast fields of the Numerical Weather Prediction (NWP) system known as the Global Forecast System (GFS). The GFS is a spectral model and data are archived at a horizontal resolution of 0.25 degrees, which is approximately 25 km over the UK (formerly 0.5 degrees, or approximately 50 km). The GFS resolution adequately captures major topographical features and the broad-scale characteristics of the weather over the UK. Smaller scale topological features may be included in the dispersion modelling by using the flow field module of ADMS (FLOWSTAR). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional observational records may be over represented, this is because the instrumentation used may not record wind speeds below approximately 0.5 m/s and start up wind speeds may be greater than 1.0 m/s. In NWP data, the wind speed is continuous down to 0.0 m/s, allowing the calms module of ADMS to function correctly.

- Traditional records may include very local deviations from the broad-scale wind flow that would not necessarily be representative of the site being modelled; these deviations are difficult to identify and remove from a meteorological record. Conversely, local effects at the site being modelled are relatively easy to impose on the broad-scale flow and provided horizontal resolution is not too great, the meteorological records from NWP data may be expected to represent well the broad-scale flow.

- Information on the state of the atmosphere above ground level which would otherwise be estimated by the meteorological pre-processor may be included explicitly.

The wind rose for the raw GFS data at the site of the Wicks Waste & Recycling facility near Barrow in Furness is shown in Figure 2a.

Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the location of the Wicks Waste & Recycling facility near Barrow in Furness is shown in Figure 2b. Note that elsewhere in the modelling domain the modified wind roses may differ more, or less, markedly and that the resolution of the wind field is approximately 300 m.

Figure 2a. The wind rose. Raw GFS derived data, for 52.766 N, 3.067 W, 2013-2016

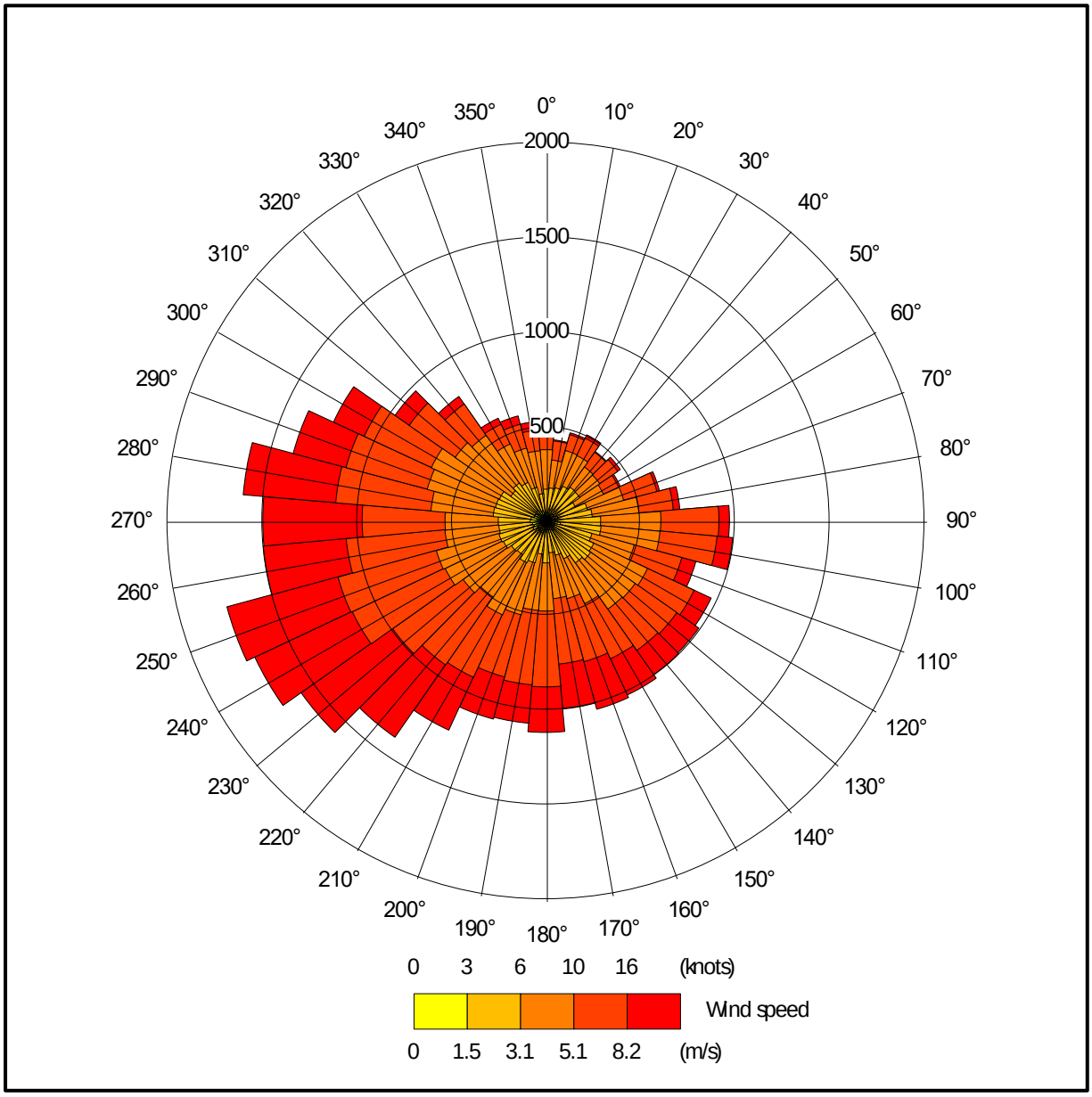
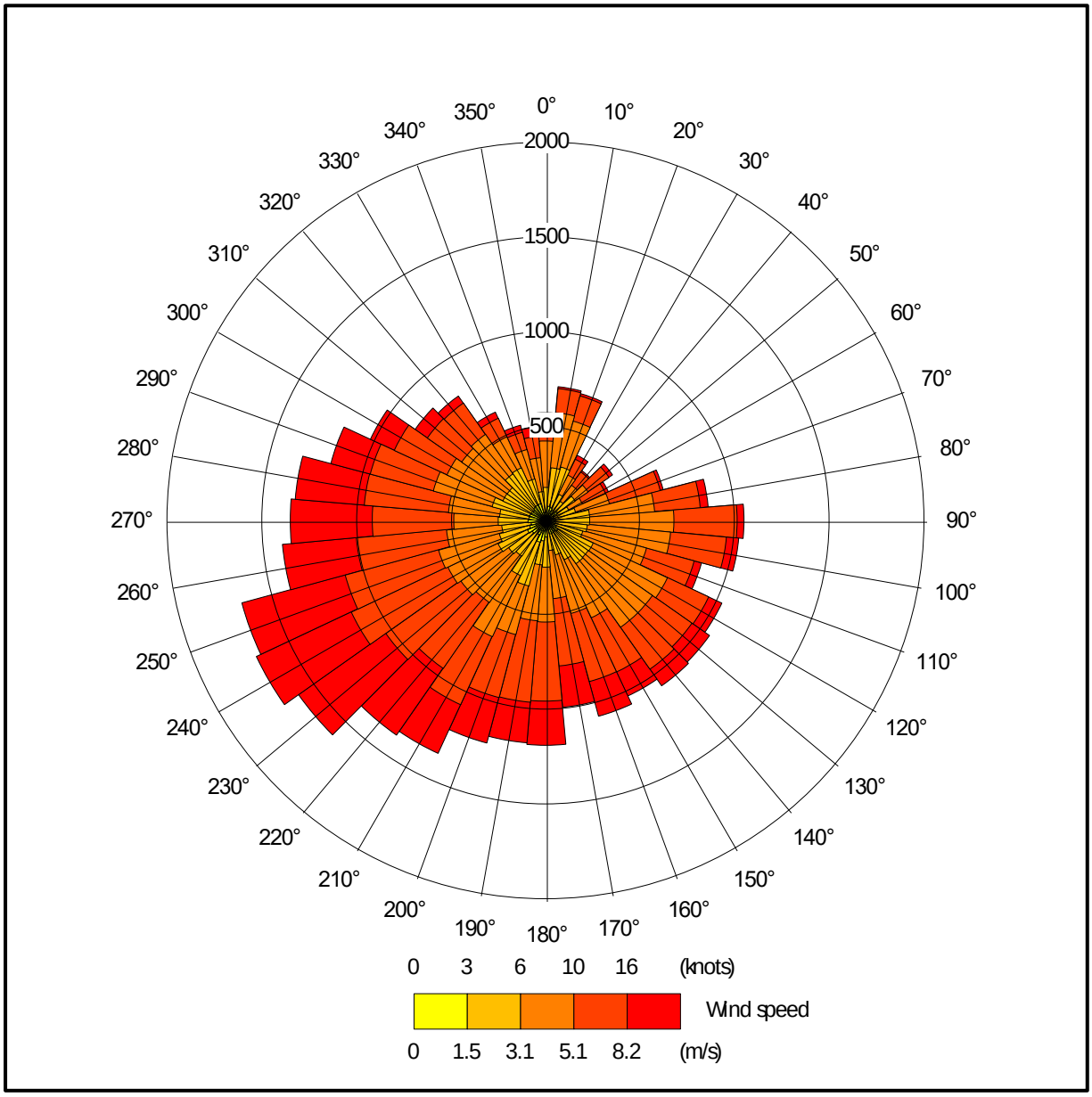


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 319975, 473400



4.3 Emission Sources

Emissions of NO_x, SO_2, PM_{10} and CO from the stack serving the biomass boiler are modelled using a single point source. The stack is assumed to operate constantly.

NO_x chemistry is modelled as described by the Environment Agency Guidance note "CONVERSION RATIOS FOR NOX AND NO2". The NO_x emitted from combustion sources is a mixture of nitrogen oxides, primarily NO and conversion to NO_2 occurs in the atmosphere at various rates, dependant on a variety of factors. Whilst this process can be modelled by ADMS, the uncertainties involved are considered too great for robust results to be obtained. Therefore, in this case and as per the Environment Agency guidance, for modelling purposes, the NO_x is assumed to be all NO which is converted to NO_2 at source. For short term objectives (less than 24 hours) it is assumed that 35% of the NO is converted to NO_2. For long term objectives (greater than 24 hours) it is assumed that 70% of the NO is converted to NO_2. For ecological receptors, it is assumed that 100% of the NO is converted to NO_2.

Details of the modelled stack parameters are provided in Table 5. The position of the biomass boiler stack may be seen in Figure 3, where it is marked by a red star symbol.

Table 5. Point source emission parameters

Stack ID	X (m)	Y (m)	Height (m)	Diameter (m)	Efflux velocity (m/s)	Efflux temp-erature (°C)	100% NO_2 (g/s)	70% NO_2 (g/s)	35% NO_2 (g/s)	SO_2 (g/s)	PM_{10} (g/s)	CO g/s)
BW1s	319939	473394	15.0	0.28	11.28	117.0	0.17234	0.12064	0.06032	0.00903	0.02284	0.07358

4.4 Modelled Buildings

The structure of the various buildings at and around the site may affect the plumes from the point source. Therefore, the major buildings are modelled within ADMS. The positions of the modelled buildings may be seen in Figure 3, where they are marked by blue rectangles.

4.5 Discrete receptors

4.5.1 Human health receptors

Thirty-five discrete receptors have been defined at a selection of nearby residences, commercial and industrial premises and amenity areas. The receptors are defined at 1.5 m above ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4a and Figure 4b, a closer view near to the Sowerby Wood Business Park, where they are marked by enumerated pink rectangles.

4.5.2 Ecological Receptors

Thirty-eight discrete receptors have been defined: fourteen at the AWs (1 to 14); one at the SSSI (15) and twenty-three at the Ramsar/SACs/SPAs (16 to 38). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4c, where they are marked by enumerated pink rectangles.

4.6 The Nested Cartesian Grid

To produce the contour plots presented in this report and to obtain the maximum predicted concentrations, a nested Cartesian grid has been defined within ADMS. The individual grid receptors are defined at a height of 1.5 m above ground level within ADMS. The position of the individual grid points of the nested Cartesian grid may be seen in Figure 4a, where they are marked by green crosses.

4.7 Terrain Data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 20.0 km x 20.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS in the modelling. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 300 m. Note that FLOWSTAR is used to resolve the local wind flows and that the default minimum turbulence in ADMS when modelling complex terrain has been reduced towards the flat terrain value, this is because although desirable to resolve the local wind flow the default minimum turbulence in ADMS is intended to account for additional orographic roughness over mountains and lee slopes, neither of which are present in this case.

4.8 Roughness Length

A fixed surface roughness length of 0.275 m has been applied over the entire modelling domain. As a precautionary measure, the GFS meteorological data is assumed to have a roughness length of 0.25 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and the stability and therefore increases predicted ground level concentrations.

4.9 Deposition

In this case, it proves unnecessary to model deposition explicitly and where deposition figures are quoted, these are obtained by multiplying the predicted NO_2 or SO_2 concentration by an appropriate deposition velocity, a factor of 315.576 to convert units and a factor of 14/46 to convert NO_2 to N and 32/64 to convert SO_2 to S. Acid deposition assumes that the H+ deposition is $1/14^{th}$ of the N deposition plus $1/16^{th}$ of the S deposition. Please note that, because deposition of NO_2 or SO_2 and the consequent plume depletion are not accounted for, this is a precautionary approach. Therefore, predicted concentrations (and nitrogen and acid deposition rates) are always higher than if deposition were modelled explicitly, particularly where there is some distance between the source and a receptor.

Figure 3. The positions of modelled point sources and buildings

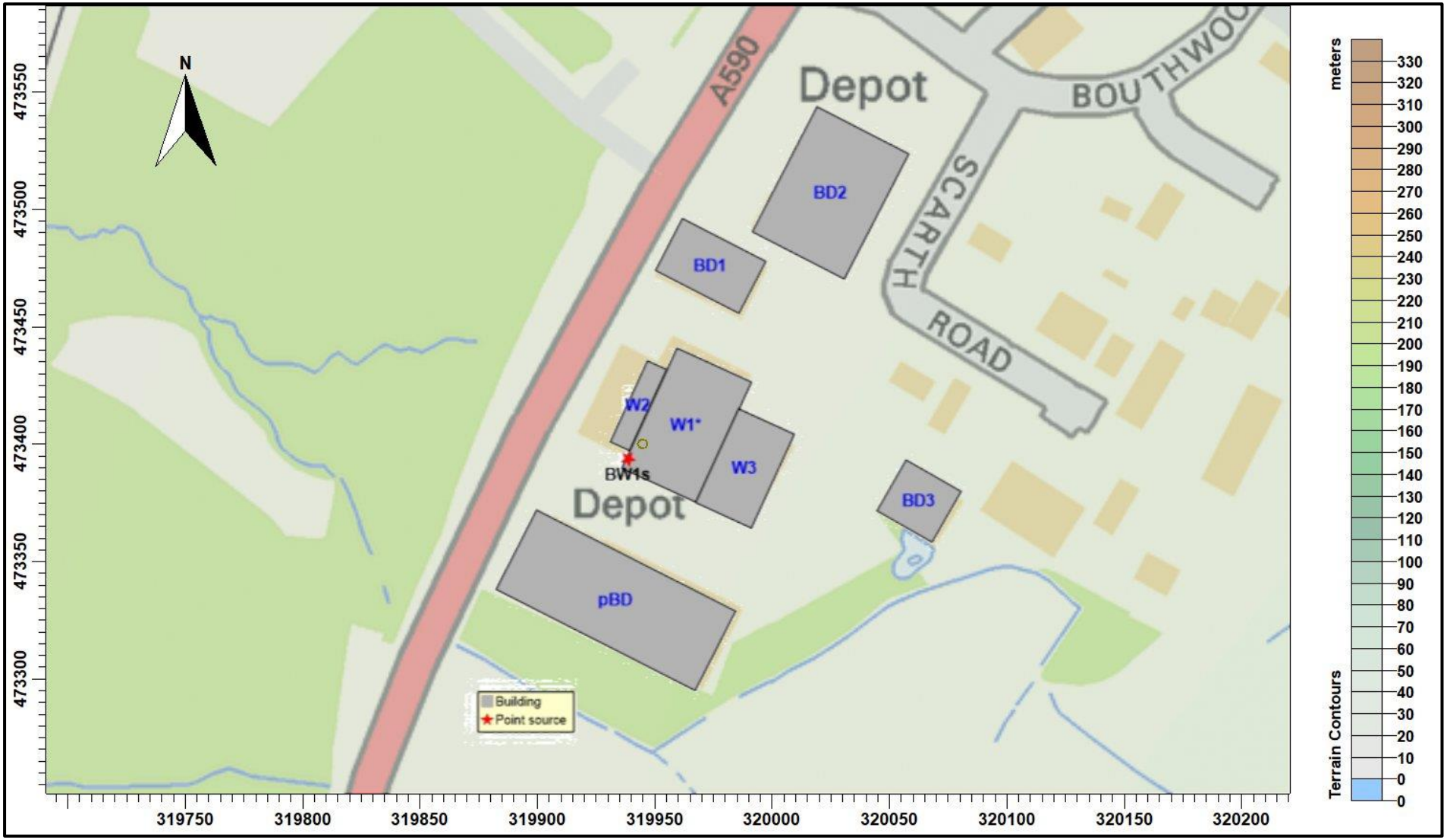


Figure 4a. The nested Cartesian grid and human health discrete receptors

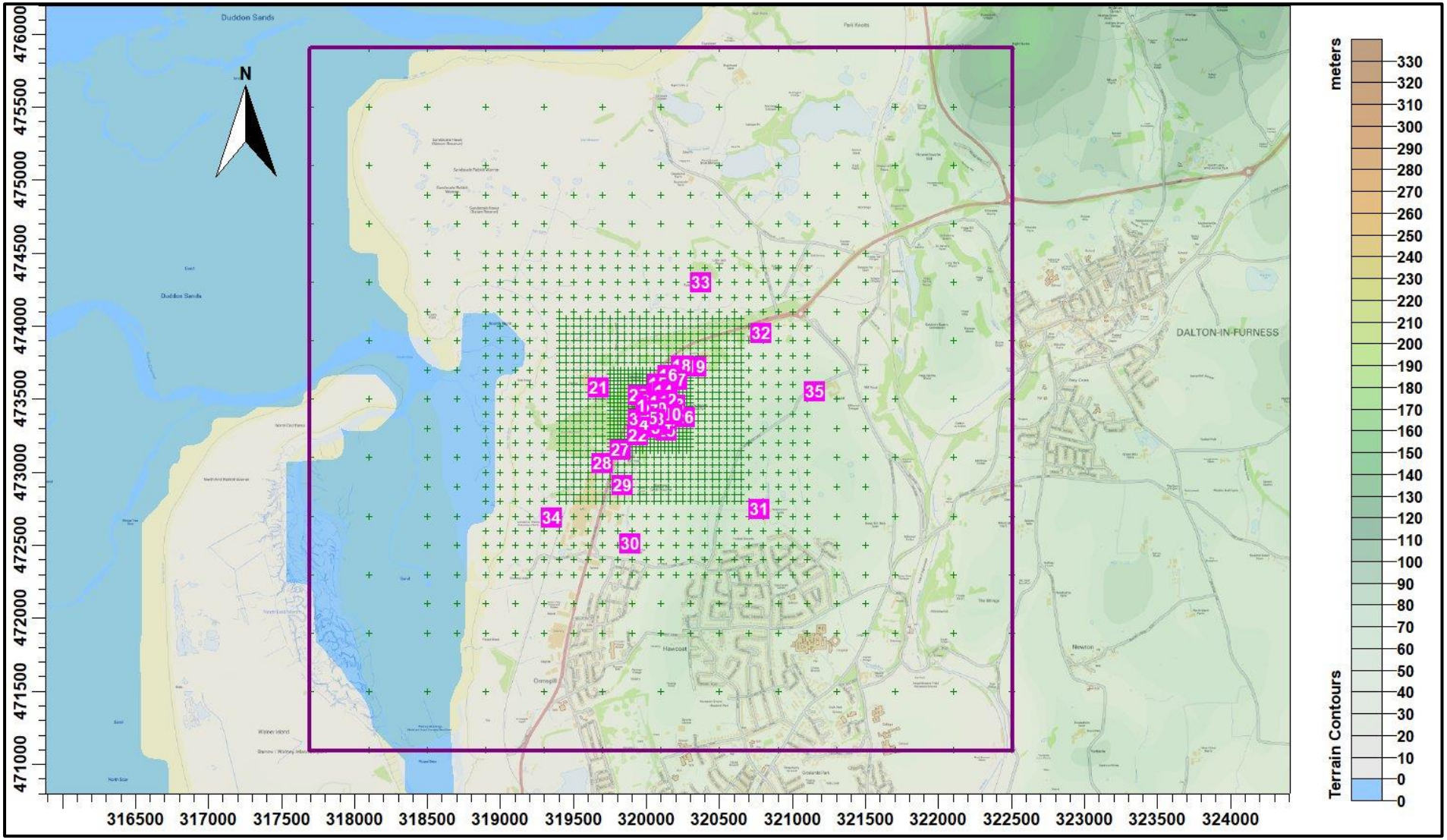


Figure 4b. The human health discrete receptors, a closer view

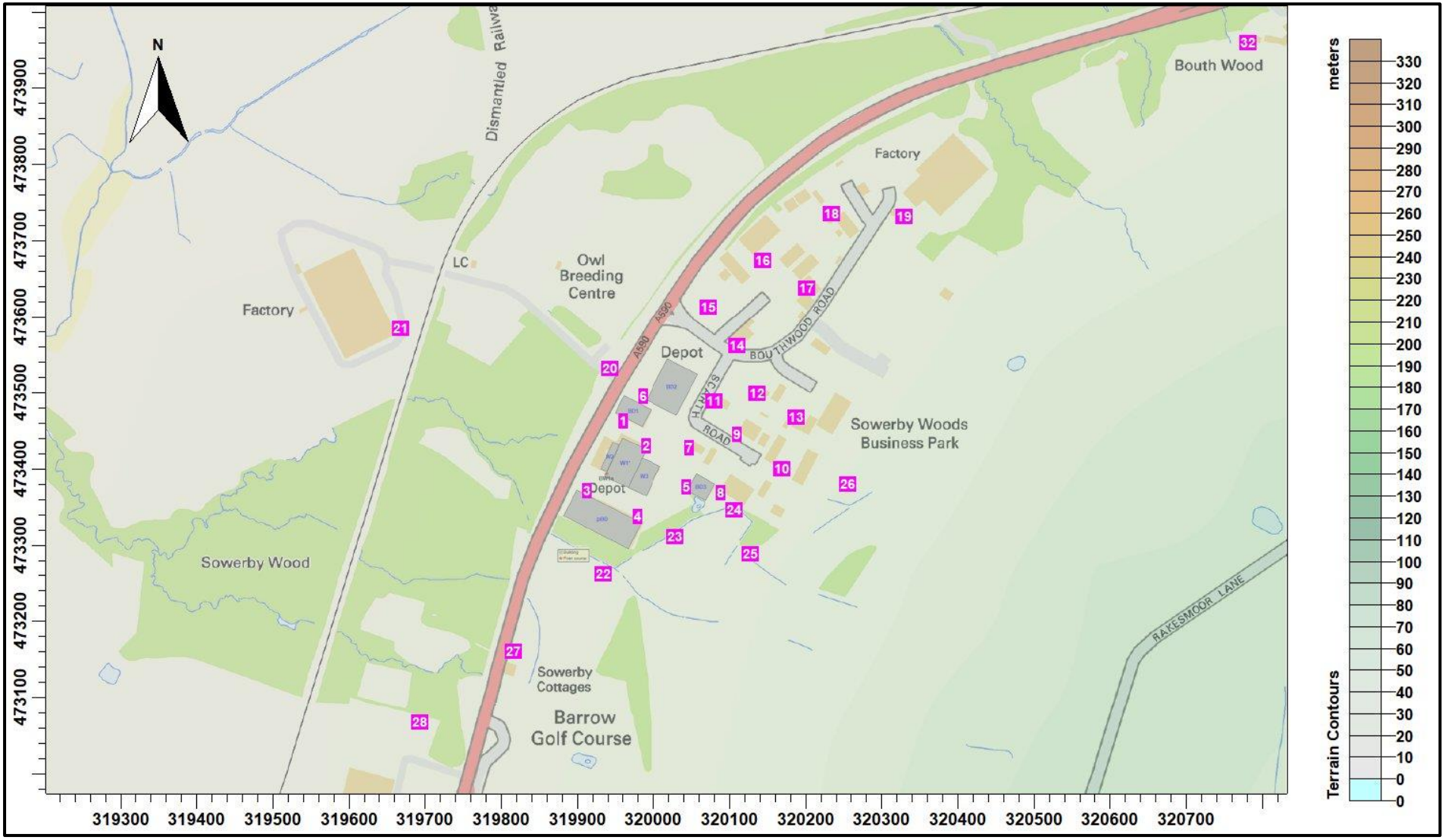
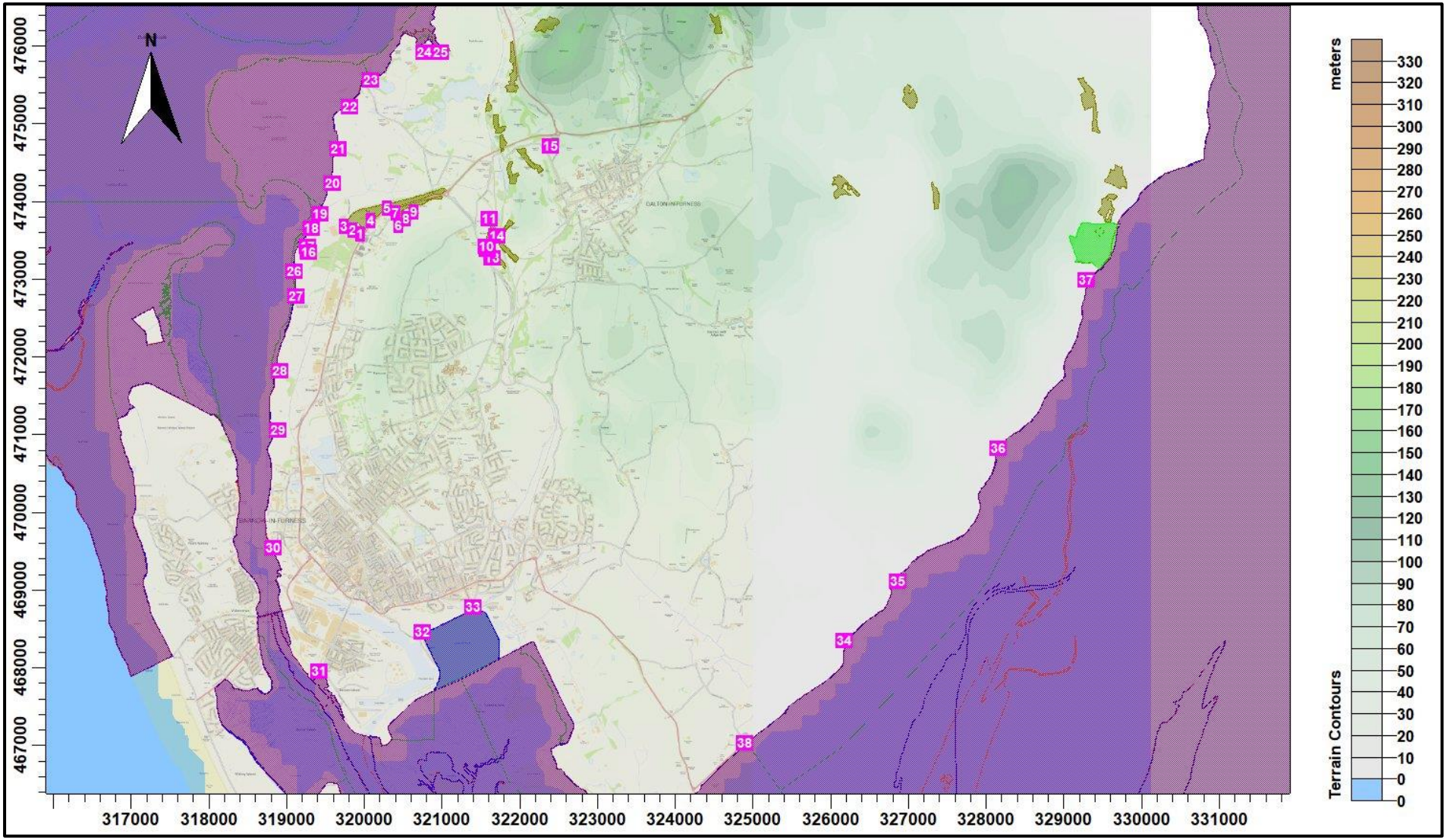


Figure 4c. The discrete receptors at the local wildlife sites



5. Details of the Model Runs and Results

ADMS was run four times, once for each year of the meteorological dataset, using the calms and terrain modules of ADMS.

From the model output, the following statistics for each grid point (discrete and nested Cartesian) were calculated:

- Maximum annual mean NO_2 concentration.
- Maximum 1 hour mean NO_2 concentration.
- Maximum 24 hour mean SO_2 concentration.
- Maximum 1 hour mean SO_2 concentration.
- Maximum 15 minute mean SO_2 concentration.
- Maximum annual mean PM_{10} concentration.
- Maximum 24 hour mean PM_{10} concentration.
- Maximum running 8 hour mean CO concentration.

Summaries of the maximum predicted concentrations for each of these statistics for the human health receptors (at any receptor point, discrete or nested Cartesian) are presented in Table 6. Further details of the predicted concentration for each pollutant and averaging period at each of the discrete receptors, assuming constant emission from the biomass boiler stack, are shown in Annex 1 of this report in Tables A1a through to A1h.

Contour plots of the predicted concentration for each pollutant and averaging period in the surrounding area, assuming constant emission from the biomass boiler, are shown in Annex 2 of this report in Figures A2a through to A2i.

The results of the modelling for the ecological receptors are provided in Table 7.

Table 6. Maximum predicted concentrations of NO_2, SO_2, PM_{10} and CO – constant emissions – 15.0 m stack

Statistic	Maximum Point		PC	Background	EAL	PEC	PC as %age of EAL	%age change from background levels	Air quality impact descriptors	Exceedances of EAL predicted
	X(m)	Y(m)								
Maximum annual mean NO_2 concentration ($\mu g/m^3$)	319938	473388	3.82	6.79	40.00	10.61	9.54	56.22	Slight	No
Maximum 1 hour mean NO_2 concentration ($\mu g/m^3$)	319900	473438	51.40	13.58	200.00	64.98	25.70	378.46	-	0.00
Maximum 24 hour mean SO_2 concentration ($\mu g/m^3$)	319875	473400	1.28	3.46	125.00	4.74	1.03	37.12	-	0.00
Maximum 1 hour mean SO_2 concentration ($\mu g/m^3$)	319900	473438	7.69	3.46	350.00	11.15	2.20	222.34	-	0.00
Maximum 15 minute mean SO_2 concentration ($\mu g/m^3$)	319900	473438	7.83	3.46	266.00	11.29	2.94	226.16	-	0.00
Maximum annual mean PM_{10} concentration ($\mu g/m^3$)	319938	473388	0.72	10.61	40.00	11.33	1.81	6.81	Negligible	No
Maximum 24 hour mean PM_{10} concentration ($\mu g/m^3$)	319875	473400	3.25	21.22	50.00	24.47	6.50	15.31	-	0.00
Maximum running 8 hour mean CO concentration (mg/m^3)	320025	473363	0.02	0.36	10.00	0.39	0.21	5.83	-	0.00

Table 7. Maximum predicted concentrations of NO_2, SO_2 N deposition and H+ deposition at the ecological receptors – 15.0 m stack

Receptor Number	X (m)	Y (m)	Nitrogen Dioxide							Sulphur Dioxide					Acid Deposition		
			Max ann conc. (µg/m³)	Cle (µg/m³)	%of Cle	depv (m/s)	N depo (kg/ha/y)	Clo (kg/ha/y)	% of Clo	Max ann conc. (µg/m³)	Cle (µg/m³)	%of Cle	depv (m/s)	S depo (kg/ha/y)	H+ depo (keq/ha/y)	Clo (keq/ha/y)	% of Clo
1	319955	473567	1.029	30.0	**3.43**	0.0015	0.148	10.0	**1.48**	0.054	20.0	0.27	0.012	0.102	0.017	2.0	0.85
2	319845	473614	0.545	30.0	**1.82**	0.0015	0.079	10.0	0.79	0.029	20.0	0.14	0.012	0.054	0.009	2.0	0.45
3	319735	473662	0.300	30.0	**1.00**	0.0015	0.043	10.0	0.43	0.016	20.0	0.08	0.012	0.030	0.005	2.0	0.25
4	320081	473732	0.345	30.0	**1.15**	0.0015	0.050	10.0	0.50	0.018	20.0	0.09	0.012	0.034	0.006	2.0	0.28
5	320288	473892	0.162	30.0	0.54	0.0015	0.023	10.0	0.23	0.008	20.0	0.04	0.012	0.016	0.003	2.0	0.13
6	320444	473681	0.187	30.0	0.62	0.0015	0.027	10.0	0.27	0.010	20.0	0.05	0.012	0.019	0.003	2.0	0.15
7	320404	473841	0.153	30.0	0.51	0.0015	0.022	10.0	0.22	0.008	20.0	0.04	0.012	0.015	0.003	2.0	0.13
8	320545	473757	0.134	30.0	0.45	0.0015	0.019	10.0	0.19	0.007	20.0	0.04	0.012	0.013	0.002	2.0	0.11
9	320634	473850	0.101	30.0	0.34	0.0015	0.015	10.0	0.15	0.005	20.0	0.03	0.012	0.010	0.002	2.0	0.08
10	321569	473406	0.034	30.0	0.11	0.0015	0.005	10.0	0.05	0.002	20.0	0.01	0.012	0.003	0.001	2.0	0.03
11	321616	473758	0.031	30.0	0.10	0.0015	0.004	10.0	0.04	0.002	20.0	0.01	0.012	0.003	0.001	2.0	0.03
12	321583	473368	0.033	30.0	0.11	0.0015	0.005	10.0	0.05	0.002	20.0	0.01	0.012	0.003	0.001	2.0	0.03
13	321645	473259	0.032	30.0	0.11	0.0015	0.005	10.0	0.05	0.002	20.0	0.01	0.012	0.003	0.001	2.0	0.03
14	321706	473534	0.030	30.0	0.10	0.0015	0.004	10.0	0.04	0.002	20.0	0.01	0.012	0.003	0.000	2.0	0.02
15	322393	474701	0.016	30.0	0.05	0.0015	0.002	10.0	0.02	0.001	20.0	0.00	0.012	0.002	0.000	1.0	0.03
16	319289	473327	0.115	30.0	0.38	0.0015	0.017	10.0	0.17	0.006	20.0	0.03	0.012	0.011	0.002	0.2	0.95
17	319269	473411	0.113	30.0	0.38	0.0015	0.016	10.0	0.16	0.006	20.0	0.03	0.012	0.011	0.002	0.2	0.93
18	319317	473639	0.099	30.0	0.33	0.0015	0.014	10.0	0.14	0.005	20.0	0.03	0.012	0.010	0.002	0.2	0.82
19	319437	473828	0.105	30.0	0.35	0.0015	0.015	10.0	0.15	0.005	20.0	0.03	0.012	0.010	0.002	0.2	0.87
20	319590	474216	0.062	30.0	0.21	0.0015	0.009	10.0	0.09	0.003	20.0	0.02	0.012	0.006	0.001	0.2	0.51
21	319662	474657	0.036	30.0	0.12	0.0015	0.005	10.0	0.05	0.002	20.0	0.01	0.012	0.004	0.001	0.2	0.30
22	319814	475202	0.024	30.0	0.08	0.0015	0.004	10.0	0.04	0.001	20.0	0.01	0.012	0.002	0.000	0.2	0.20
23	320078	475546	0.020	30.0	0.07	0.0015	0.003	10.0	0.03	0.001	20.0	0.01	0.012	0.002	0.000	0.2	0.17
24	320775	475899	0.018	30.0	0.06	0.0015	0.003	10.0	0.03	0.001	20.0	0.00	0.012	0.002	0.000	0.2	0.15
25	320983	475907	0.017	30.0	0.06	0.0015	0.002	10.0	0.02	0.001	20.0	0.00	0.012	0.002	0.000	0.2	0.14
26	319101	473091	0.058	30.0	0.19	0.0015	0.008	10.0	0.08	0.003	20.0	0.02	0.012	0.006	0.001	0.2	0.48
27	319121	472766	0.031	30.0	0.10	0.0015	0.004	10.0	0.04	0.002	20.0	0.01	0.012	0.003	0.001	0.2	0.26
28	318921	471805	0.014	30.0	0.05	0.0015	0.002	10.0	0.02	0.001	20.0	0.00	0.012	0.001	0.000	0.2	0.12
29	318885	471036	0.019	30.0	0.06	0.0015	0.003	10.0	0.03	0.001	20.0	0.00	0.012	0.002	0.000	0.2	0.15
30	318832	469530	0.017	30.0	0.06	0.0015	0.002	10.0	0.02	0.001	20.0	0.00	0.012	0.002	0.000	0.2	0.14

Receptor Number	X (m)	Y (m)	Nitrogen Dioxide							Sulphur Dioxide					Acid Deposition		
			Max ann conc. (µg/m³)	Cle (µg/m³)	%of Cle	depv (m/s)	N depo (kg/ha/y)	Clo (kg/ha/y)	% of Clo	Max ann conc. (µg/m³)	Cle (µg/m³)	%of Cle	depv (m/s)	S depo (kg/ha/y)	H+ depo (keq/ha/y)	Clo (keq/ha/y)	% of Clo
31	319423	467940	0.011	30.0	0.04	0.0015	0.002	10.0	0.02	0.001	20.0	0.00	0.012	0.001	0.000	0.2	0.09
32	320748	468441	0.007	30.0	0.02	0.0015	0.001	10.0	0.01	0.000	20.0	0.00	0.012	0.001	0.000	0.2	0.06
33	321397	468765	0.006	30.0	0.02	0.0015	0.001	10.0	0.01	0.000	20.0	0.00	0.012	0.001	0.000	0.2	0.05
34	326182	468333	0.005	30.0	0.02	0.0015	0.001	10.0	0.01	0.000	20.0	0.00	0.012	0.000	0.000	0.2	0.04
35	326872	469103	0.004	30.0	0.01	0.0015	0.001	10.0	0.01	0.000	20.0	0.00	0.012	0.000	0.000	0.2	0.04
36	328156	470807	0.004	30.0	0.01	0.0015	0.001	10.0	0.01	0.000	20.0	0.00	0.012	0.000	0.000	0.2	0.03
37	329292	472970	0.003	30.0	0.01	0.0015	0.000	10.0	0.00	0.000	20.0	0.00	0.012	0.000	0.000	0.2	0.02
38	324898	467021	0.004	30.0	0.01	0.0015	0.001	10.0	0.01	0.000	20.0	0.00	0.012	0.000	0.000	0.2	0.04

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6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by David Baldwin, of Recogen Ltd., on behalf of the applicant, to use computer modelling to assess the impact of emissions of nitrogen oxides, sulphur dioxide, particulate matter and carbon monoxide from a existing biomass boiler at the Wicks Waste Management & Recycling facility, Sowerby Wood Business Park, Barrow in Furness, Cumbria. LA14 4QR.

Emissions of nitrogen oxides (NO_X), sulphur dioxide (SO_2), particulate matter (PM_{10}) and carbon monoxide (CO) from the stack serving the biomass boiler have been assessed and quantified based upon data supplied to AS Modelling & Data Ltd. by the manufacturers of the biomass boilers (Ariterm). The NO_x, SO_2, PM_{10} and CO emission rates have then been used as the basis of inputs to an atmospheric dispersion model which calculates nitrogen oxides NO_x, SO_2, PM_{10} and CO exposure levels in the surrounding area.

6.1 Results

6.1.1 NO_2

There are no predicted exceedances of the EAL of 40 µg/m^3 for NO_2 as an annual mean. Assuming continuous emissions, at the maximum point, the magnitude of the PC is 9.5% of the EAL; the change is less than 10% of the EAL and the PEC is less than 75% of the EAL; therefore, at the maximum point, the impact would be described as Slight using the Land Use Planning & Development Control: Planning For Air Quality criteria. At all of the discrete receptors the impact would be described as Negligible using the Land Use Planning & Development Control: Planning For Air Quality criteria.

There are no predicted exceedances of the EAL of 200 µg/m^3, for 1 hour mean NO_2.

6.1.2 SO_2

There are no predicted exceedances of the EAL of 125 µg/m^3, for 24 hour mean SO_2.

There are no predicted exceedances of the EAL of 350 µg/m^3, for 1 hour mean SO_2.

There are no predicted exceedances of the EAL of 266 µg/m^3, for 15 minute mean SO_2.

6.1.3 PM_{10}

There are no predicted exceedances of the EAL of 40 µg/m^3 as an annual mean. Assuming continuous emissions, at the maximum point the magnitude of the PC is 1.8% of the EAL; the change is less than 10% of the EAL and the PEC is below 75 % of the EAL; therefore, the impact would be described as Negligible using the Land Use Planning & Development Control: Planning For Air Quality criteria.

There are no predicted exceedances of the EAL of 150 µg/m^3, for 24 hour mean PM_{10}.

6.1.4 CO

There are no predicted exceedances of the EAL of 10mg/m^3, for 8 hour running mean CO.

6.2 Ecological Receptors

At the closest Ancient Woodland, there are four receptors where the predicted process contribution to NO_2 concentrations exceed 1% of the Critical Level of 30.0 µg/m^3 and one receptor where the predicted process contributions to nitrogen deposition exceed 1% of the Critical Load of 10.0 kg/ha/yr. Therefore, the process contributions of the proposed biomass boiler stack to NO_2 concentrations and nitrogen deposition at this AW would not normally be deemed insignificant but may, or may not, be deemed acceptable.

At all other receptors considered, SO_2 concentration, N deposition and H+ deposition, are below 1% of the relevant Critical Level or Critical Load and therefore would normally be deemed insignificant for these pollutants.

7. References

Cambridge Environmental Research Consultants (CERC) (website).
http://www.cerc.co.uk/environmental-software/ADMS-model.html

Environment Agency H1 Risk Assessment (website).
http://www.environment-agency.gov.uk/business/topics/permitting/36414.aspx

Environment Agency. CONVERSION RATIOS FOR NOX AND NO2
http://www.environment-agency.gov.uk/static/documents/Conversion_ratios_for__NOx_and_NO2_.pdf

Environmental Protection UK. Development Control: Planning For Air Quality (2010 Update)

Environmental Protection UK. Land Use Planning & Development Control: Planning For Air Quality (2017 Update)

UK Air Pollution Information System (APIS) (website).
http://www.apis.ac.uk/

Annex 1 – Predicted concentrations at the discrete receptors – 12 m stack

Table A1a. Maximum annual mean NO_2 concentration

Receptor Number	X(m)	Y(m)	Maximum annual NO_2 concentration							
			PC	Background	EAL	PEC	PC as %age of EAL	%age change from background levels	Air quality impact descriptors	Exceedances of EAL predicted
Maximum	319937.5	473387.5	3.8	6.79	40.0	10.6	9.5	56.2	Slight	None
Max Exceedances	-	-	-	-	-	-	-	-	-	-
1	319960	473462	0.9	6.79	40.0	7.7	2.2	13.2	Negligible	None
2	319990	473429	1.3	6.79	40.0	8.1	3.3	19.6	Negligible	None
3	319913	473369	1.6	6.79	40.0	8.4	4.0	23.3	Negligible	None
4	319980	473335	1.0	6.79	40.0	7.8	2.5	14.8	Negligible	None
5	320044	473375	1.3	6.89	40.0	8.2	3.3	19.0	Negligible	None
6	319988	473494	0.9	6.79	40.0	7.7	2.2	13.1	Negligible	None
7	320047	473426	1.4	6.89	40.0	8.3	3.6	20.7	Negligible	None
8	320089	473367	1.0	6.89	40.0	7.8	2.4	13.8	Negligible	None
9	320110	473444	0.9	6.89	40.0	7.8	2.3	13.1	Negligible	None
10	320168	473399	0.6	6.89	40.0	7.5	1.4	8.3	Negligible	None
11	320080	473488	0.9	6.89	40.0	7.8	2.2	12.8	Negligible	None
12	320137	473498	0.6	6.89	40.0	7.5	1.5	9.0	Negligible	None
13	320188	473466	0.5	6.89	40.0	7.4	1.3	7.3	Negligible	None
14	320110	473560	0.5	6.89	40.0	7.4	1.3	7.4	Negligible	None
15	320073	473611	0.4	6.89	40.0	7.3	1.1	6.4	Negligible	None
16	320145	473672	0.3	6.89	40.0	7.2	0.7	4.1	Negligible	None
17	320202	473636	0.3	6.89	40.0	7.2	0.7	4.0	Negligible	None
18	320234	473733	0.2	6.89	40.0	7.1	0.5	2.7	Negligible	None
19	320330	473730	0.2	6.89	40.0	7.0	0.4	2.2	Negligible	None
20	319943	473531	0.9	6.79	40.0	7.7	2.4	13.9	Negligible	None
21	319668	473583	0.2	6.79	40.0	7.0	0.5	3.1	Negligible	None
22	319935	473260	0.6	6.79	40.0	7.4	1.5	8.6	Negligible	None
23	320028	473310	0.7	6.89	40.0	7.6	1.7	10.0	Negligible	None
24	320106	473345	0.7	6.89	40.0	7.6	1.8	10.7	Negligible	None
25	320127	473287	0.5	6.89	40.0	7.3	1.1	6.6	Negligible	None
26	320255	473379	0.3	6.89	40.0	7.2	0.8	4.6	Negligible	None
27	319816	473159	0.2	6.79	40.0	7.0	0.4	2.6	Negligible	None
28	319693	473066	0.1	6.79	40.0	6.9	0.2	1.2	Negligible	None
29	319826	472917	0.1	7.62	40.0	7.7	0.3	1.5	Negligible	None
30	319880	472520	0.1	7.62	40.0	7.7	0.1	0.7	Negligible	None
31	320765	472750	0.0	7.08	40.0	7.1	0.1	0.5	Negligible	None
32	320781	473959	0.1	6.89	40.0	6.9	0.1	0.7	Negligible	None
33	320369	474306	0.0	5.89	40.0	5.9	0.1	0.8	Negligible	None
34	319345	472694	0.0	7.62	40.0	7.7	0.1	0.3	Negligible	None
35	321148	473561	0.0	6.19	40.0	6.2	0.1	0.6	Negligible	None

Table A1b. Maximum 1 hour mean NO_2 concentration

Receptor Number	X(m)	Y(m)	Maximum 1hr NO_2 concentration							
			PC	Background	EAL	PEC	PC as %age of EAL	%age change from background levels	Air quality impact descriptors	Exceedances of EAL predicted
Maximum	319900	473437.5	51.4	13.6	200.0	65.0	25.7	378.5		0.0
Max Exceedances	319960	473462	14.58	13.6	200.0	28.2	7.3	107.3	-	0.0
1	319960	473462	14.6	13.6	200.0	28.2	7.3	107.3		0.0
2	319990	473429	14.2	13.6	200.0	27.8	7.1	104.3		0.0
3	319913	473369	45.0	13.6	200.0	58.6	22.5	331.4		0.0
4	319980	473335	16.9	13.6	200.0	30.5	8.4	124.3		0.0
5	320044	473375	13.6	13.8	200.0	27.4	6.8	99.0		0.0
6	319988	473494	11.5	13.6	200.0	25.1	5.7	84.6		0.0
7	320047	473426	12.4	13.8	200.0	26.1	6.2	89.8		0.0
8	320089	473367	7.7	13.8	200.0	21.4	3.8	55.7		0.0
9	320110	473444	6.3	13.8	200.0	20.1	3.2	45.9		0.0
10	320168	473399	6.3	13.8	200.0	20.1	3.2	45.9		0.0
11	320080	473488	5.9	13.8	200.0	19.7	3.0	43.1		0.0
12	320137	473498	5.2	13.8	200.0	19.0	2.6	38.1		0.0
13	320188	473466	4.7	13.8	200.0	18.5	2.4	34.4		0.0
14	320110	473560	5.0	13.8	200.0	18.7	2.5	36.1		0.0
15	320073	473611	4.3	13.8	200.0	18.0	2.1	31.0		0.0
16	320145	473672	3.5	13.8	200.0	17.2	1.7	25.2		0.0
17	320202	473636	3.3	13.8	200.0	17.1	1.7	24.1		0.0
18	320234	473733	2.7	13.8	200.0	16.4	1.3	19.3		0.0
19	320330	473730	2.4	13.8	200.0	16.1	1.2	17.2		0.0
20	319943	473531	12.3	13.6	200.0	25.9	6.2	90.9		0.0
21	319668	473583	2.8	13.6	200.0	16.4	1.4	20.5		0.0
22	319935	473260	8.5	13.6	200.0	22.1	4.2	62.4		0.0
23	320028	473310	26.0	13.8	200.0	39.8	13.0	189.1		0.0
24	320106	473345	6.4	13.8	200.0	20.2	3.2	46.6		0.0
25	320127	473287	5.8	13.8	200.0	19.6	2.9	42.4		0.0
26	320255	473379	4.5	13.8	200.0	18.2	2.2	32.3		0.0
27	319816	473159	4.3	13.6	200.0	17.9	2.1	31.6		0.0
28	319693	473066	5.2	13.6	200.0	18.8	2.6	38.2		0.0
29	319826	472917	3.2	15.2	200.0	18.5	1.6	21.1		0.0
30	319880	472520	10.1	15.2	200.0	25.3	5.0	66.0		0.0
31	320765	472750	1.2	14.2	200.0	15.3	0.6	8.3		0.0
32	320781	473959	1.1	13.8	200.0	14.9	0.6	8.2		0.0
33	320369	474306	2.3	11.8	200.0	14.1	1.1	19.4		0.0
34	319345	472694	2.5	15.2	200.0	17.8	1.3	16.5		0.0
35	321148	473561	1.0	12.4	200.0	13.4	0.5	8.1		0.0

Table A1c. Maximum 24 hour mean SO_2 concentration

Receptor Number	X(m)	Y(m)	Maximum 24hr SO_2 concentration							
			PC	Background	EAL	PEC	PC as %age of EAL	%age change from background levels	Air quality impact descriptors	Exceedances of EAL predicted
Maximum	319875	473400	1.3	3.5	125.0	4.7	1.0	37.1		0.0
Max Exceedances	-	-	-	-	-	-	-	-	-	-
1	319960	473462	0.5	3.5	125.0	4.0	0.4	15.8		0.0
2	319990	473429	0.7	3.5	125.0	4.2	0.6	20.3		0.0
3	319913	473369	0.7	3.5	125.0	4.2	0.6	21.1		0.0
4	319980	473335	0.6	3.5	125.0	4.1	0.5	18.4		0.0
5	320044	473375	0.7	3.4	125.0	4.1	0.6	20.7		0.0
6	319988	473494	0.7	3.5	125.0	4.1	0.5	19.7		0.0
7	320047	473426	0.7	3.4	125.0	4.1	0.6	21.9		0.0
8	320089	473367	0.5	3.4	125.0	3.9	0.4	15.8		0.0
9	320110	473444	0.5	3.4	125.0	3.9	0.4	13.5		0.0
10	320168	473399	0.4	3.4	125.0	3.8	0.3	10.9		0.0
11	320080	473488	0.4	3.4	125.0	3.8	0.4	13.1		0.0
12	320137	473498	0.3	3.4	125.0	3.7	0.2	9.1		0.0
13	320188	473466	0.3	3.4	125.0	3.7	0.2	8.3		0.0
14	320110	473560	0.3	3.4	125.0	3.7	0.3	9.3		0.0
15	320073	473611	0.3	3.4	125.0	3.7	0.2	9.0		0.0
16	320145	473672	0.2	3.4	125.0	3.6	0.2	6.6		0.0
17	320202	473636	0.2	3.4	125.0	3.6	0.1	5.3		0.0
18	320234	473733	0.2	3.4	125.0	3.6	0.1	4.5		0.0
19	320330	473730	0.1	3.4	125.0	3.5	0.1	2.9		0.0
20	319943	473531	0.5	3.5	125.0	4.0	0.4	15.6		0.0
21	319668	473583	0.2	3.5	125.0	3.7	0.2	6.5		0.0
22	319935	473260	0.7	3.5	125.0	4.2	0.6	21.2		0.0
23	320028	473310	0.6	3.4	125.0	4.0	0.5	18.7		0.0
24	320106	473345	0.5	3.4	125.0	3.9	0.4	15.7		0.0
25	320127	473287	0.3	3.4	125.0	3.7	0.2	9.0		0.0
26	320255	473379	0.2	3.4	125.0	3.6	0.2	7.0		0.0
27	319816	473159	0.3	3.5	125.0	3.8	0.2	8.8		0.0
28	319693	473066	0.2	3.5	125.0	3.6	0.1	5.4		0.0
29	319826	472917	0.2	5.0	125.0	5.2	0.2	4.0		0.0
30	319880	472520	0.1	5.0	125.0	5.1	0.1	1.5		0.0
31	320765	472750	0.0	3.7	125.0	3.7	0.0	1.0		0.0
32	320781	473959	0.0	3.4	125.0	3.4	0.0	0.9		0.0
33	320369	474306	0.0	3.3	125.0	3.3	0.0	1.3		0.0
34	319345	472694	0.1	5.0	125.0	5.1	0.0	1.2		0.0
35	321148	473561	0.0	3.3	125.0	3.3	0.0	0.7		0.0

Table A1d. Maximum 1 hour mean SO_2 concentration

Receptor Number	X(m)	Y(m)	Maximum 1hr SO_2 concentration							
			PC	Background	EAL	PEC	PC as %age of EAL	%age change from background levels	Air quality impact descriptors	Exceedances of EAL predicted
Maximum	319900	473437.5	7.7	3.5	350.0	11.2	2.2	222.3		0.0
Max Exceedances	-	-	-	-	-	-	-	-	-	-
1	319960	473462	2.2	3.5	350.0	5.6	0.6	63.1		0.0
2	319990	473429	2.1	3.5	350.0	5.6	0.6	61.3		0.0
3	319913	473369	6.7	3.5	350.0	10.2	1.9	194.7		0.0
4	319980	473335	2.5	3.5	350.0	6.0	0.7	73.0		0.0
5	320044	473375	2.0	3.4	350.0	5.4	0.6	60.0		0.0
6	319988	473494	1.7	3.5	350.0	5.2	0.5	49.7		0.0
7	320047	473426	1.9	3.4	350.0	5.3	0.5	54.4		0.0
8	320089	473367	1.1	3.4	350.0	4.5	0.3	33.8		0.0
9	320110	473444	0.9	3.4	350.0	4.3	0.3	27.8		0.0
10	320168	473399	0.9	3.4	350.0	4.3	0.3	27.8		0.0
11	320080	473488	0.9	3.4	350.0	4.3	0.3	26.1		0.0
12	320137	473498	0.8	3.4	350.0	4.2	0.2	23.1		0.0
13	320188	473466	0.7	3.4	350.0	4.1	0.2	20.8		0.0
14	320110	473560	0.7	3.4	350.0	4.1	0.2	21.9		0.0
15	320073	473611	0.6	3.4	350.0	4.0	0.2	18.8		0.0
16	320145	473672	0.5	3.4	350.0	3.9	0.1	15.3		0.0
17	320202	473636	0.5	3.4	350.0	3.9	0.1	14.6		0.0
18	320234	473733	0.4	3.4	350.0	3.8	0.1	11.7		0.0
19	320330	473730	0.4	3.4	350.0	3.8	0.1	10.4		0.0
20	319943	473531	1.8	3.5	350.0	5.3	0.5	53.4		0.0
21	319668	473583	0.4	3.5	350.0	3.9	0.1	12.1		0.0
22	319935	473260	1.3	3.5	350.0	4.7	0.4	36.7		0.0
23	320028	473310	3.9	3.4	350.0	7.3	1.1	114.6		0.0
24	320106	473345	1.0	3.4	350.0	4.4	0.3	28.2		0.0
25	320127	473287	0.9	3.4	350.0	4.3	0.2	25.7		0.0
26	320255	473379	0.7	3.4	350.0	4.1	0.2	19.6		0.0
27	319816	473159	0.6	3.5	350.0	4.1	0.2	18.5		0.0
28	319693	473066	0.8	3.5	350.0	4.2	0.2	22.4		0.0
29	319826	472917	0.5	5.0	350.0	5.5	0.1	9.6		0.0
30	319880	472520	1.5	5.0	350.0	6.5	0.4	30.1		0.0
31	320765	472750	0.2	3.7	350.0	3.8	0.1	4.8		0.0
32	320781	473959	0.2	3.4	350.0	3.6	0.0	5.0		0.0
33	320369	474306	0.3	3.3	350.0	3.6	0.1	10.4		0.0
34	319345	472694	0.4	5.0	350.0	5.4	0.1	7.5		0.0
35	321148	473561	0.1	3.3	350.0	3.4	0.0	4.5		0.0

Table A1e. Maximum 15 minute mean SO_2 concentration

Receptor Number	X(m)	Y(m)	Maximum 15 min SO2 concentration							
			PC	Background	EAL	PEC	PC as %age of EAL	%age change from background levels	Air quality impact descriptors	Exceedances of EAL predicted
Maximum	319900	473437.5	7.8	3.5	266.0	11.3	2.9	226.2		0.0
Max Exceedances	-	-	-	-	-	-	-	-	-	-
1	319960	473462	2.3	3.5	266.0	5.7	0.9	65.7		0.0
2	319990	473429	2.2	3.5	266.0	5.7	0.8	64.4		0.0
3	319913	473369	6.8	3.5	266.0	10.3	2.6	197.6		0.0
4	319980	473335	2.6	3.5	266.0	6.1	1.0	75.6		0.0
5	320044	473375	2.2	3.4	266.0	5.6	0.8	65.3		0.0
6	319988	473494	1.7	3.5	266.0	5.2	0.7	50.4		0.0
7	320047	473426	2.0	3.4	266.0	5.4	0.7	57.9		0.0
8	320089	473367	1.3	3.4	266.0	4.7	0.5	38.3		0.0
9	320110	473444	1.2	3.4	266.0	4.6	0.4	33.9		0.0
10	320168	473399	1.1	3.4	266.0	4.5	0.4	33.6		0.0
11	320080	473488	1.0	3.4	266.0	4.4	0.4	30.2		0.0
12	320137	473498	1.0	3.4	266.0	4.4	0.4	28.7		0.0
13	320188	473466	0.9	3.4	266.0	4.3	0.3	26.4		0.0
14	320110	473560	0.8	3.4	266.0	4.2	0.3	24.3		0.0
15	320073	473611	0.8	3.4	266.0	4.2	0.3	22.8		0.0
16	320145	473672	0.7	3.4	266.0	4.1	0.3	20.2		0.0
17	320202	473636	0.6	3.4	266.0	4.0	0.2	19.0		0.0
18	320234	473733	0.6	3.4	266.0	4.0	0.2	16.2		0.0
19	320330	473730	0.5	3.4	266.0	3.9	0.2	15.6		0.0
20	319943	473531	2.0	3.5	266.0	5.4	0.7	57.2		0.0
21	319668	473583	0.6	3.5	266.0	4.0	0.2	16.6		0.0
22	319935	473260	1.5	3.5	266.0	5.0	0.6	43.5		0.0
23	320028	473310	4.1	3.4	266.0	7.5	1.5	120.5		0.0
24	320106	473345	1.1	3.4	266.0	4.5	0.4	32.9		0.0
25	320127	473287	1.0	3.4	266.0	4.4	0.4	29.4		0.0
26	320255	473379	0.9	3.4	266.0	4.3	0.3	27.3		0.0
27	319816	473159	0.8	3.5	266.0	4.3	0.3	24.5		0.0
28	319693	473066	0.9	3.5	266.0	4.4	0.3	26.3		0.0
29	319826	472917	0.8	5.0	266.0	5.8	0.3	16.0		0.0
30	319880	472520	2.8	5.0	266.0	7.8	1.0	55.6		0.0
31	320765	472750	0.3	3.7	266.0	3.9	0.1	7.7		0.0
32	320781	473959	0.3	3.4	266.0	3.7	0.1	7.6		0.0
33	320369	474306	0.5	3.3	266.0	3.8	0.2	14.5		0.0
34	319345	472694	0.5	5.0	266.0	5.5	0.2	9.9		0.0
35	321148	473561	0.2	3.3	266.0	3.5	0.1	7.1		0.0

Table A1f. Maximum annual mean PM_{10} concentration

Receptor Number	X(m)	Y(m)	Maximum annual mean PM_{10} concentration							
			PC	Background	EAL	PEC	PC as %age of EAL	%age change from background levels	Air quality impact descriptors	Exceedances of EAL predicted
Maximum	319937.5	473387.5	0.7	10.6	40.0	11.3	1.8	6.8	Negligible	No
Max Exceedances	-	-	-	-	-	-	-	-	-	-
1	319960	473462	0.2	10.6	40.0	10.8	0.4	1.6	Negligible	None
2	319990	473429	0.3	10.6	40.0	10.9	0.6	2.4	Negligible	None
3	319913	473369	0.3	10.6	40.0	10.9	0.7	2.8	Negligible	None
4	319980	473335	0.2	10.6	40.0	10.8	0.5	1.8	Negligible	None
5	320044	473375	0.2	11.6	40.0	11.9	0.6	2.1	Negligible	None
6	319988	473494	0.2	10.6	40.0	10.8	0.4	1.6	Negligible	None
7	320047	473426	0.3	11.6	40.0	11.9	0.7	2.3	Negligible	None
8	320089	473367	0.2	11.6	40.0	11.8	0.4	1.6	Negligible	None
9	320110	473444	0.2	11.6	40.0	11.8	0.4	1.5	Negligible	None
10	320168	473399	0.1	11.6	40.0	11.7	0.3	0.9	Negligible	None
11	320080	473488	0.2	11.6	40.0	11.8	0.4	1.4	Negligible	None
12	320137	473498	0.1	11.6	40.0	11.7	0.3	1.0	Negligible	None
13	320188	473466	0.1	11.6	40.0	11.7	0.2	0.8	Negligible	None
14	320110	473560	0.1	11.6	40.0	11.7	0.2	0.8	Negligible	None
15	320073	473611	0.1	11.6	40.0	11.7	0.2	0.7	Negligible	None
16	320145	473672	0.1	11.6	40.0	11.7	0.1	0.5	Negligible	None
17	320202	473636	0.1	11.6	40.0	11.7	0.1	0.4	Negligible	None
18	320234	473733	0.0	11.6	40.0	11.6	0.1	0.3	Negligible	None
19	320330	473730	0.0	11.6	40.0	11.6	0.1	0.3	Negligible	None
20	319943	473531	0.2	10.6	40.0	10.8	0.4	1.7	Negligible	None
21	319668	473583	0.0	10.6	40.0	10.7	0.1	0.4	Negligible	None
22	319935	473260	0.1	10.6	40.0	10.7	0.3	1.0	Negligible	None
23	320028	473310	0.1	11.6	40.0	11.7	0.3	1.1	Negligible	None
24	320106	473345	0.1	11.6	40.0	11.7	0.3	1.2	Negligible	None
25	320127	473287	0.1	11.6	40.0	11.7	0.2	0.7	Negligible	None
26	320255	473379	0.1	11.6	40.0	11.7	0.2	0.5	Negligible	None
27	319816	473159	0.0	10.6	40.0	10.6	0.1	0.3	Negligible	None
28	319693	473066	0.0	10.6	40.0	10.6	0.0	0.1	Negligible	None
29	319826	472917	0.0	10.7	40.0	10.7	0.1	0.2	Negligible	None
30	319880	472520	0.0	10.7	40.0	10.7	0.0	0.1	Negligible	None
31	320765	472750	0.0	10.3	40.0	10.3	0.0	0.1	Negligible	None
32	320781	473959	0.0	11.6	40.0	11.6	0.0	0.1	Negligible	None
33	320369	474306	0.0	10.9	40.0	10.9	0.0	0.1	Negligible	None
34	319345	472694	0.0	10.7	40.0	10.7	0.0	0.0	Negligible	None
35	321148	473561	0.0	12.0	40.0	12.0	0.0	0.1	Negligible	None

Table A1g. Maximum 24 hour mean PM_{10} concentration

Receptor Number	X(m)	Y(m)	Maximum 24hr mean PM_{10} concentration							
			PC	Background	EAL	PEC	PC as %age of EAL	%age change from background levels	Air quality impact descriptors	Exceedances of EAL predicted
Maximum	319875	473400	3.2	21.2	50.0	24.5	6.5	15.3		0.0
Max Exceedances	319960	473462	1.39	21.2	50.0	22.6	2.8	6.5		0.0
1	319960	473462	1.4	21.2	50.0	22.6	2.8	6.5		0.0
2	319990	473429	1.8	21.2	50.0	23.0	3.5	8.4		0.0
3	319913	473369	1.8	21.2	50.0	23.1	3.7	8.7		0.0
4	319980	473335	1.6	21.2	50.0	22.8	3.2	7.6		0.0
5	320044	473375	1.8	23.2	50.0	25.0	3.6	7.7		0.0
6	319988	473494	1.7	21.2	50.0	23.0	3.5	8.1		0.0
7	320047	473426	1.9	23.2	50.0	25.1	3.8	8.1		0.0
8	320089	473367	1.4	23.2	50.0	24.6	2.7	5.8		0.0
9	320110	473444	1.2	23.2	50.0	24.4	2.3	5.0		0.0
10	320168	473399	0.9	23.2	50.0	24.2	1.9	4.0		0.0
11	320080	473488	1.1	23.2	50.0	24.3	2.2	4.8		0.0
12	320137	473498	0.8	23.2	50.0	24.0	1.6	3.4		0.0
13	320188	473466	0.7	23.2	50.0	23.9	1.4	3.1		0.0
14	320110	473560	0.8	23.2	50.0	24.0	1.6	3.5		0.0
15	320073	473611	0.8	23.2	50.0	24.0	1.5	3.3		0.0
16	320145	473672	0.6	23.2	50.0	23.8	1.1	2.5		0.0
17	320202	473636	0.5	23.2	50.0	23.7	0.9	2.0		0.0
18	320234	473733	0.4	23.2	50.0	23.6	0.8	1.7		0.0
19	320330	473730	0.2	23.2	50.0	23.5	0.5	1.1		0.0
20	319943	473531	1.4	21.2	50.0	22.6	2.7	6.4		0.0
21	319668	473583	0.6	21.2	50.0	21.8	1.1	2.7		0.0
22	319935	473260	1.9	21.2	50.0	23.1	3.7	8.7		0.0
23	320028	473310	1.6	23.2	50.0	24.8	3.2	6.9		0.0
24	320106	473345	1.4	23.2	50.0	24.6	2.7	5.8		0.0
25	320127	473287	0.8	23.2	50.0	24.0	1.6	3.4		0.0
26	320255	473379	0.6	23.2	50.0	23.8	1.2	2.6		0.0
27	319816	473159	0.8	21.2	50.0	22.0	1.5	3.6		0.0
28	319693	473066	0.5	21.2	50.0	21.7	0.9	2.2		0.0
29	319826	472917	0.5	21.5	50.0	22.0	1.0	2.4		0.0
30	319880	472520	0.2	21.5	50.0	21.6	0.4	0.9		0.0
31	320765	472750	0.1	20.6	50.0	20.7	0.2	0.4		0.0
32	320781	473959	0.1	23.2	50.0	23.3	0.2	0.3		0.0
33	320369	474306	0.1	21.8	50.0	21.9	0.2	0.5		0.0
34	319345	472694	0.2	21.5	50.0	21.6	0.3	0.7		0.0
35	321148	473561	0.1	24.0	50.0	24.0	0.1	0.2		0.0

Table A1h. Maximum running 8 hour mean CO concentration

Receptor Number	X(m)	Y(m)	Maximum running 8hr CO concentration							
			PC	Background	EAL	PEC	PC as %age of EAL	%age change from background levels	Air quality impact descriptors	Exceedances of EAL predicted
Maximum	320025	473362.5	0.021	0.364	10.000	0.385	0.2	5.8		0.0
Max Exceedances	-	-	-	-	-	-	-	-	-	-
1	319960	473462	0.009	0.354	10.000	0.363	0.1	2.7		0.0
2	319990	473429	0.011	0.354	10.000	0.365	0.1	3.0		0.0
3	319913	473369	0.011	0.354	10.000	0.365	0.1	3.0		0.0
4	319980	473335	0.011	0.354	10.000	0.365	0.1	3.0		0.0
5	320044	473375	0.012	0.364	10.000	0.376	0.1	3.3		0.0
6	319988	473494	0.007	0.354	10.000	0.361	0.1	2.1		0.0
7	320047	473426	0.011	0.364	10.000	0.375	0.1	3.1		0.0
8	320089	473367	0.007	0.364	10.000	0.371	0.1	1.8		0.0
9	320110	473444	0.006	0.364	10.000	0.370	0.1	1.6		0.0
10	320168	473399	0.005	0.364	10.000	0.369	0.0	1.3		0.0
11	320080	473488	0.006	0.364	10.000	0.370	0.1	1.7		0.0
12	320137	473498	0.004	0.364	10.000	0.368	0.0	1.1		0.0
13	320188	473466	0.004	0.364	10.000	0.368	0.0	1.0		0.0
14	320110	473560	0.004	0.364	10.000	0.368	0.0	1.0		0.0
15	320073	473611	0.004	0.364	10.000	0.368	0.0	1.2		0.0
16	320145	473672	0.003	0.364	10.000	0.367	0.0	0.8		0.0
17	320202	473636	0.002	0.364	10.000	0.366	0.0	0.7		0.0
18	320234	473733	0.002	0.364	10.000	0.366	0.0	0.6		0.0
19	320330	473730	0.002	0.364	10.000	0.366	0.0	0.4		0.0
20	319943	473531	0.009	0.354	10.000	0.363	0.1	2.7		0.0
21	319668	473583	0.003	0.354	10.000	0.357	0.0	0.8		0.0
22	319935	473260	0.008	0.354	10.000	0.362	0.1	2.3		0.0
23	320028	473310	0.009	0.364	10.000	0.373	0.1	2.5		0.0
24	320106	473345	0.006	0.364	10.000	0.370	0.1	1.6		0.0
25	320127	473287	0.005	0.364	10.000	0.369	0.0	1.3		0.0
26	320255	473379	0.003	0.364	10.000	0.367	0.0	0.9		0.0
27	319816	473159	0.005	0.354	10.000	0.359	0.0	1.3		0.0
28	319693	473066	0.003	0.354	10.000	0.357	0.0	0.7		0.0
29	319826	472917	0.003	0.370	10.000	0.373	0.0	0.7		0.0
30	319880	472520	0.002	0.370	10.000	0.372	0.0	0.5		0.0
31	320765	472750	0.001	0.380	10.000	0.381	0.0	0.2		0.0
32	320781	473959	0.001	0.364	10.000	0.365	0.0	0.2		0.0
33	320369	474306	0.001	0.352	10.000	0.353	0.0	0.3		0.0
34	319345	472694	0.001	0.370	10.000	0.371	0.0	0.3		0.0
35	321148	473561	0.001	0.374	10.000	0.375	0.0	0.2		0.0

Annex 2 – Contour plots of predicted concentrations in the area surrounding the farm

Figure A2a. Maximum annual mean NO_2 concentration (process contribution)

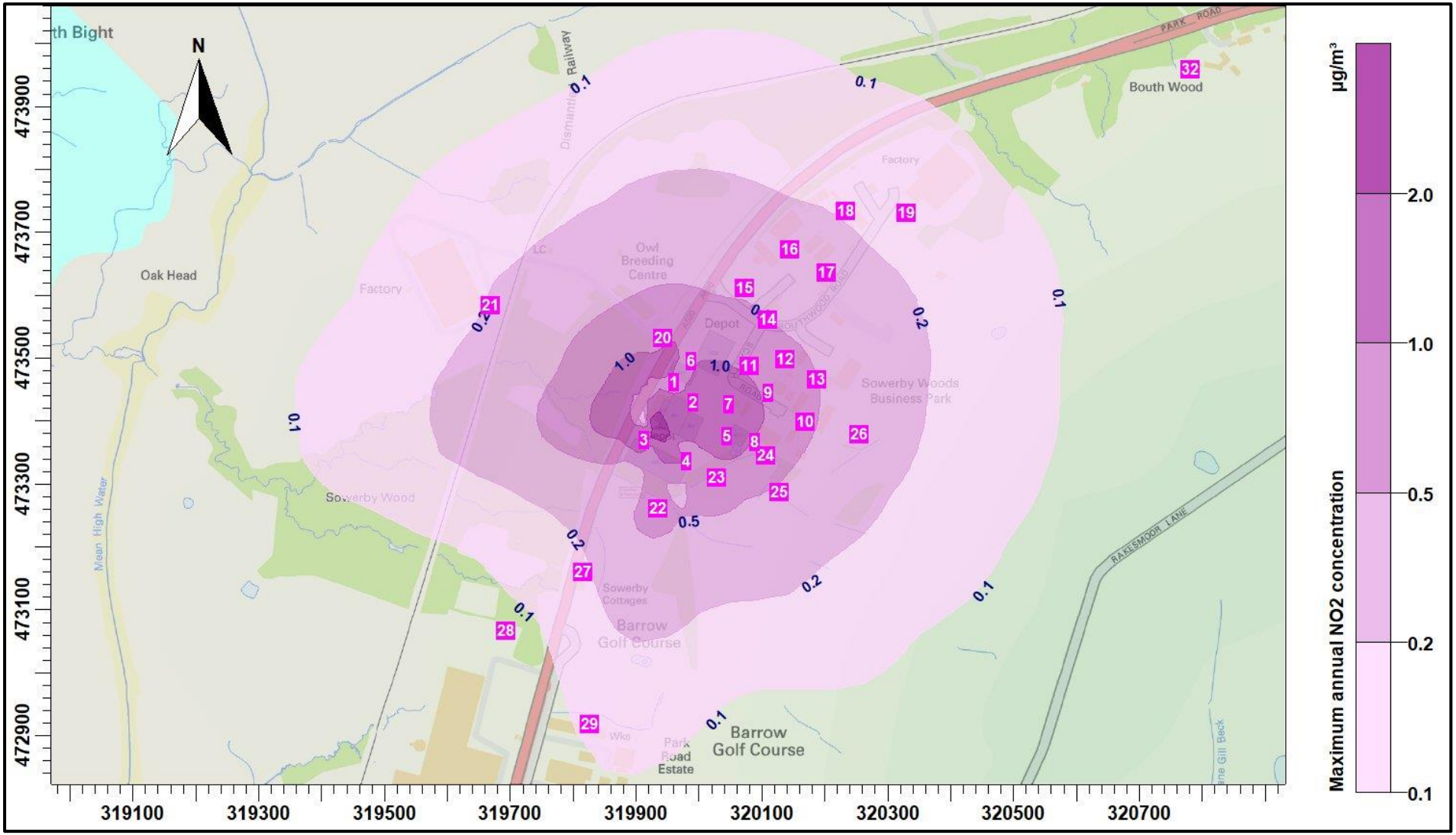

Figure A2b. Maximum 1 hour mean NO_2 concentration (process contribution)

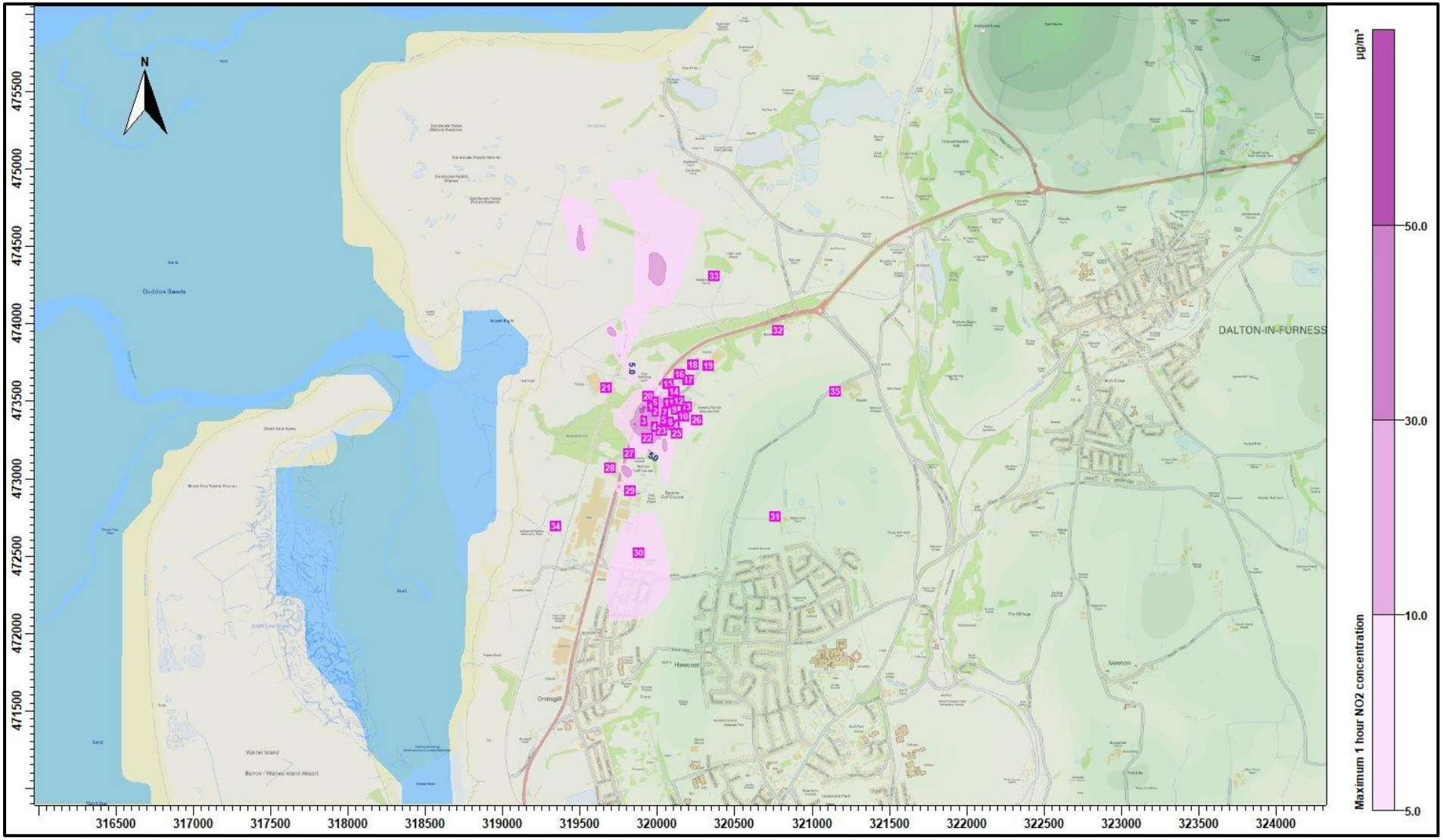

Figure A2c. Maximum 1 hour mean NO_2 concentration (process contribution) – a closer view

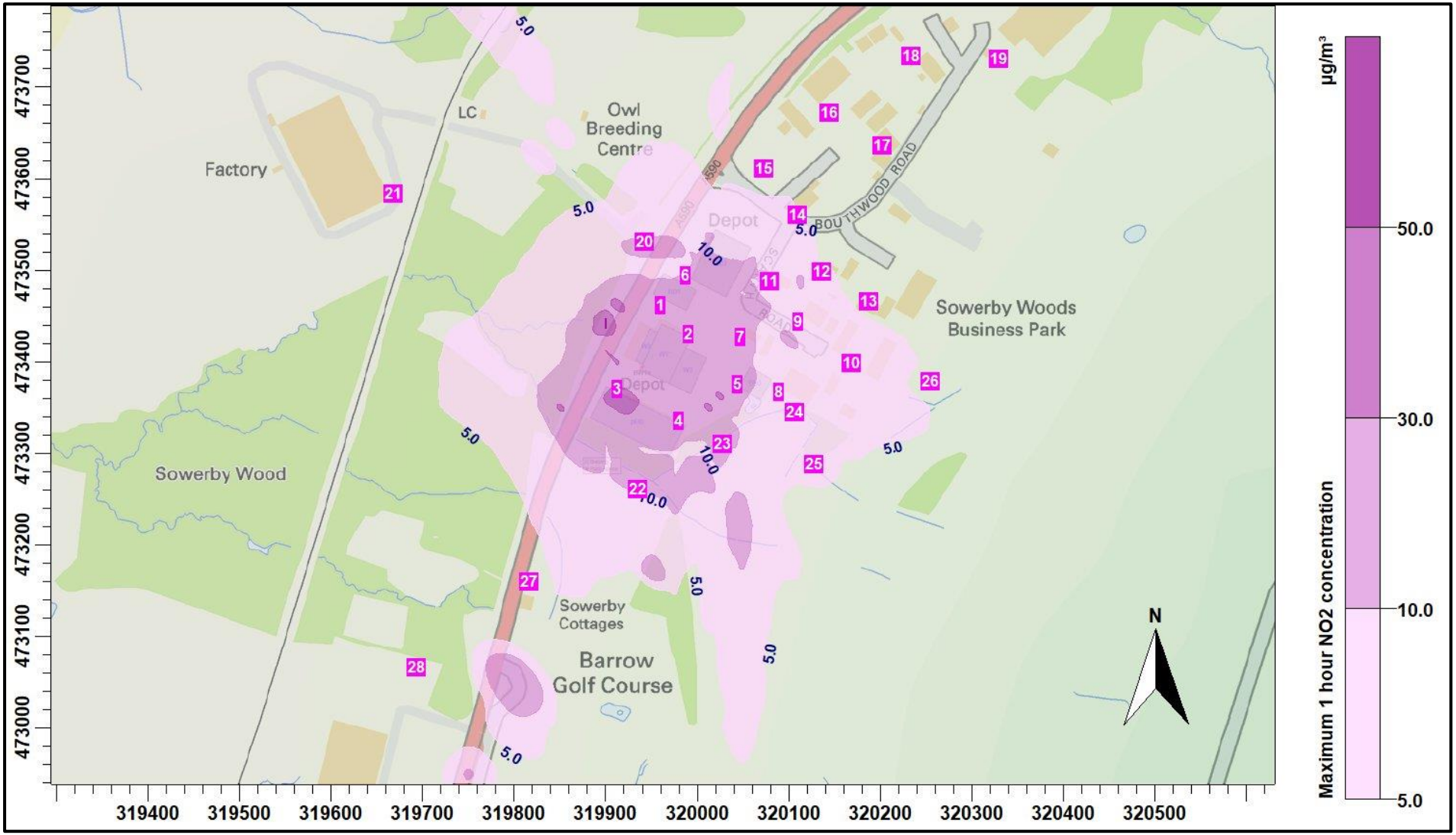

Figure A2d. Maximum 24 hour mean SO_2 concentration (process contribution)

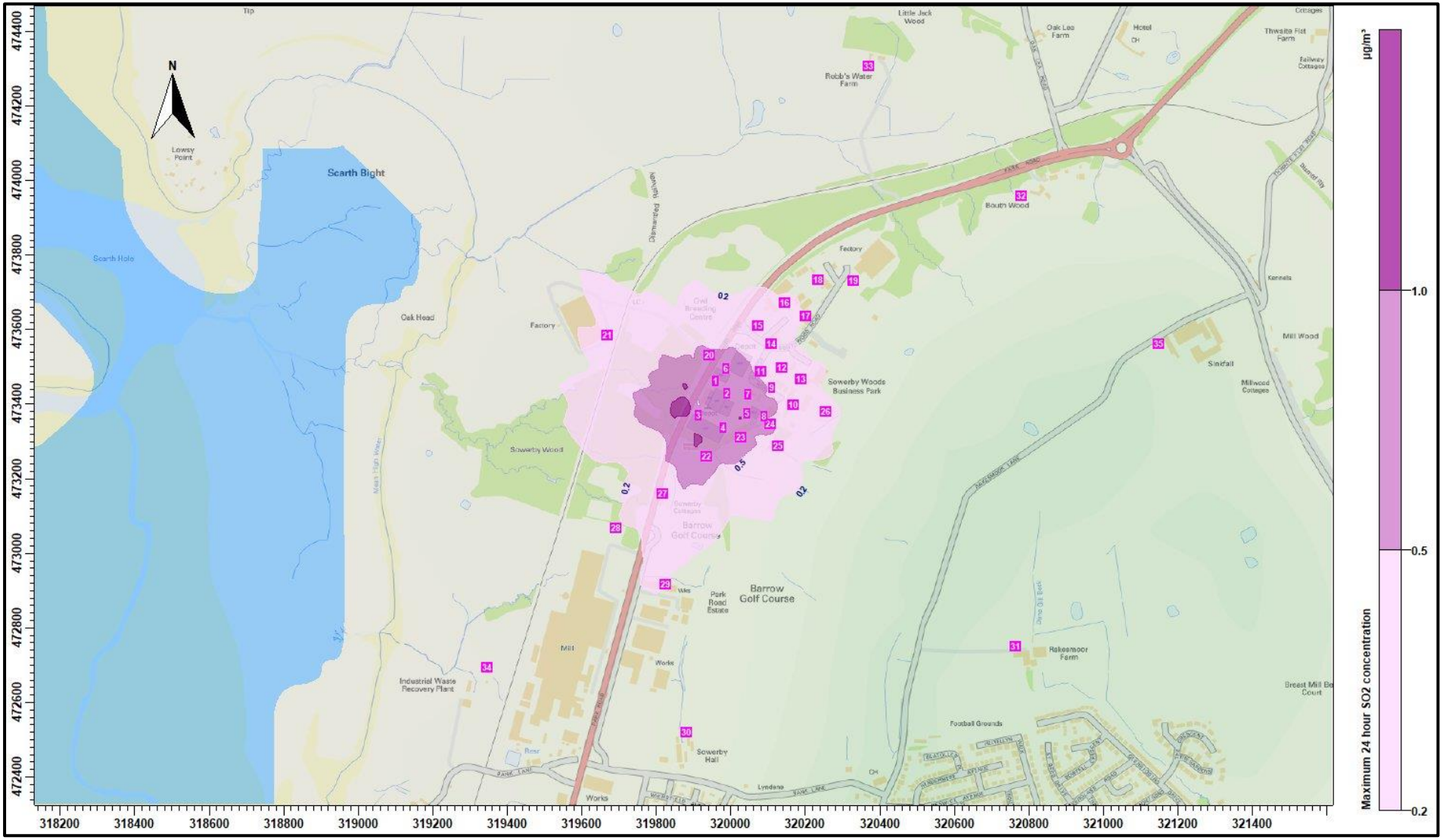

Figure A2e. Maximum 1 hour mean SO_2 concentration (process contribution)

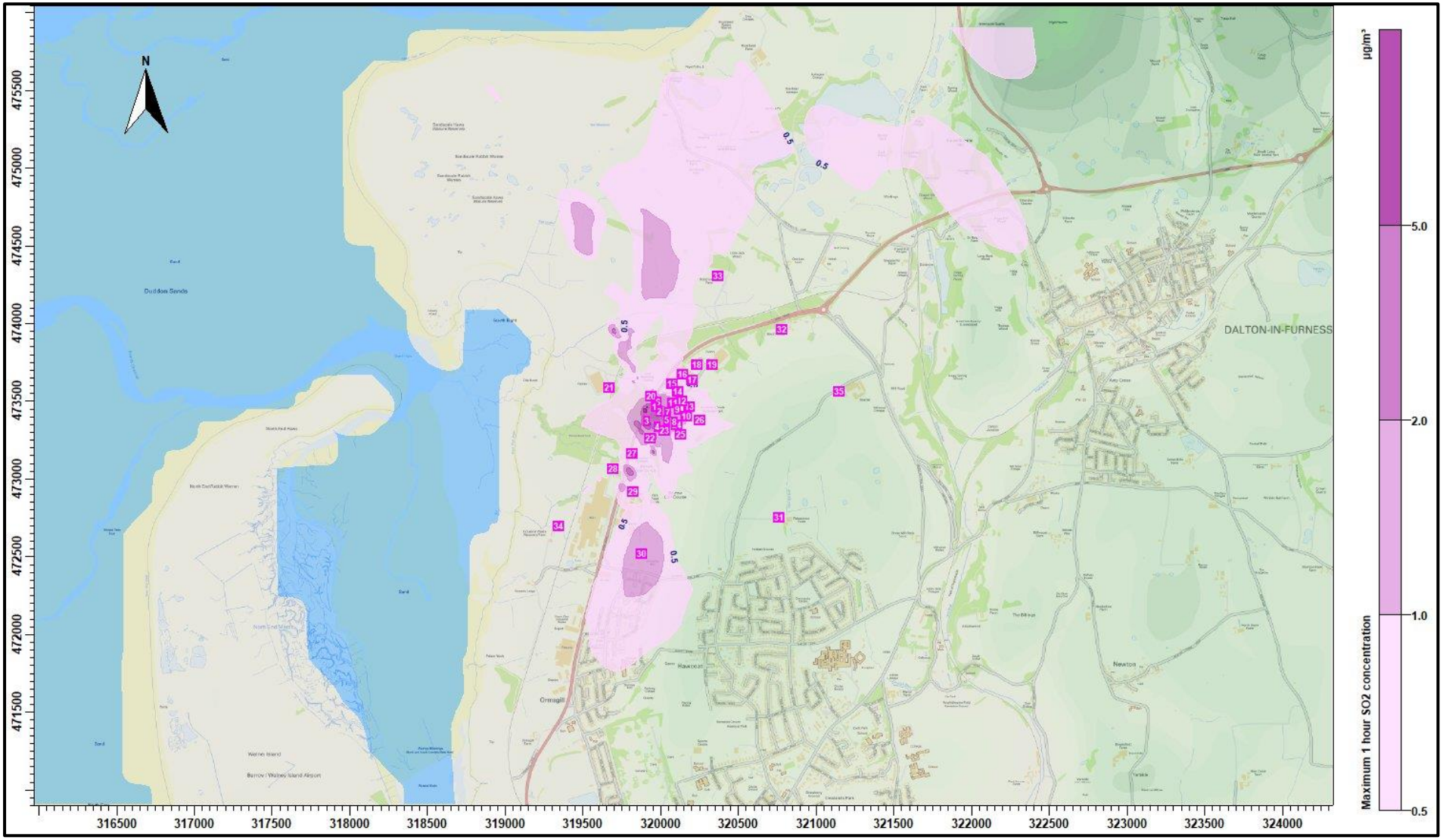

Figure A2f. Maximum 15 minute mean SO_2 concentration (process contribution)

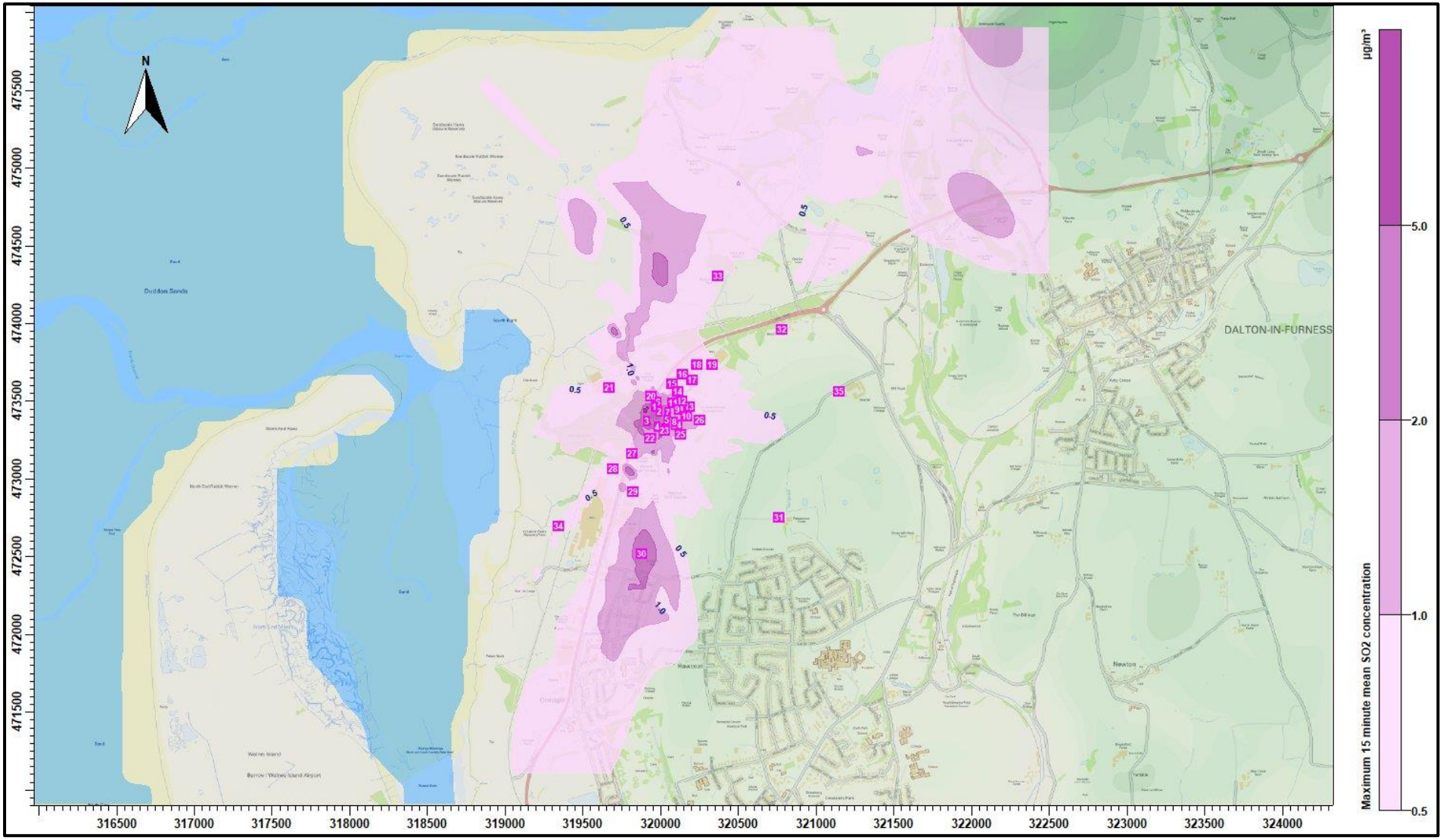

Figure A2g. Maximum annual mean PM_{10} concentration (process contribution)

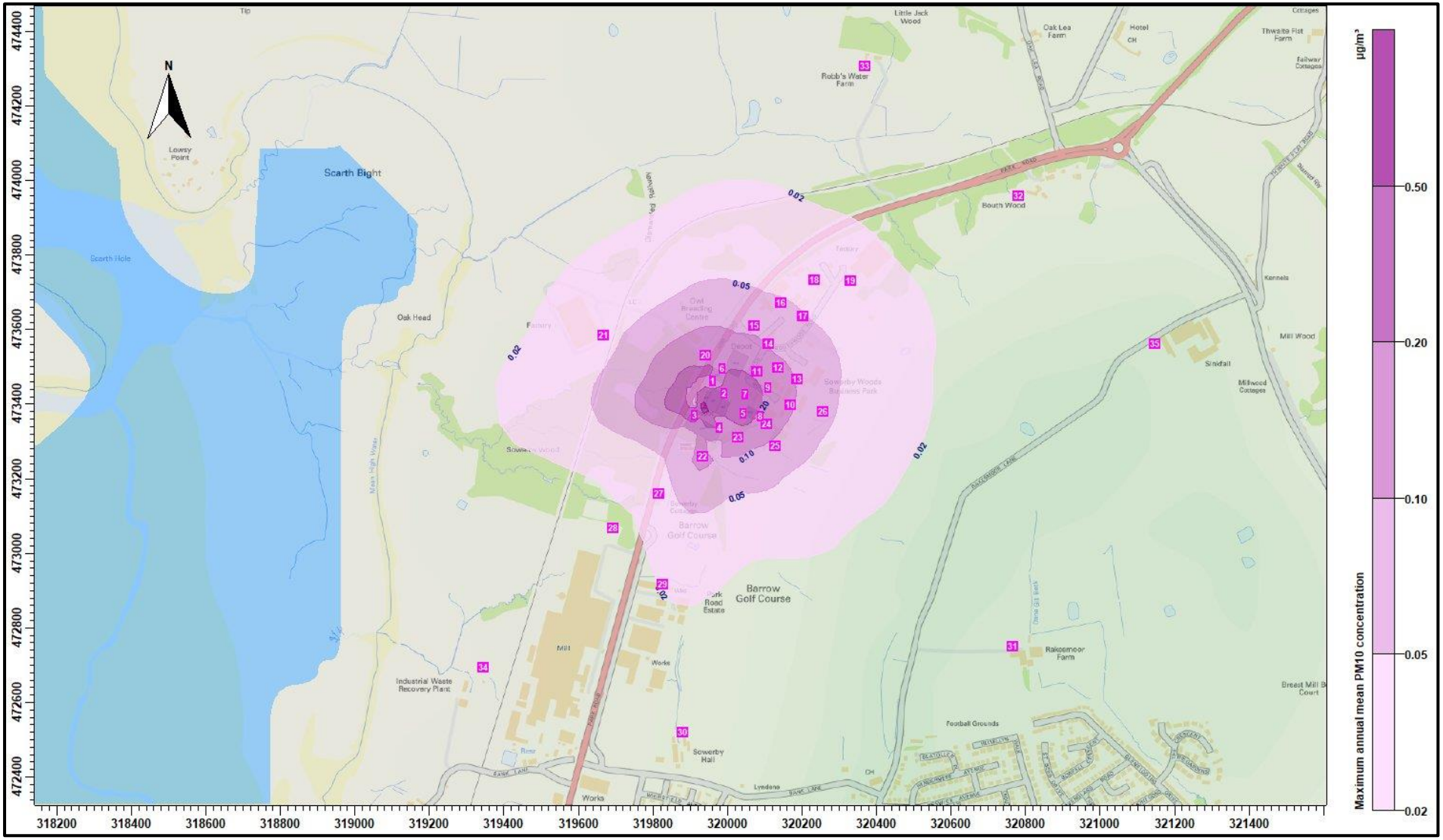

Figure A2h. Maximum 24 hour mean PM_{10} concentration (process contribution)

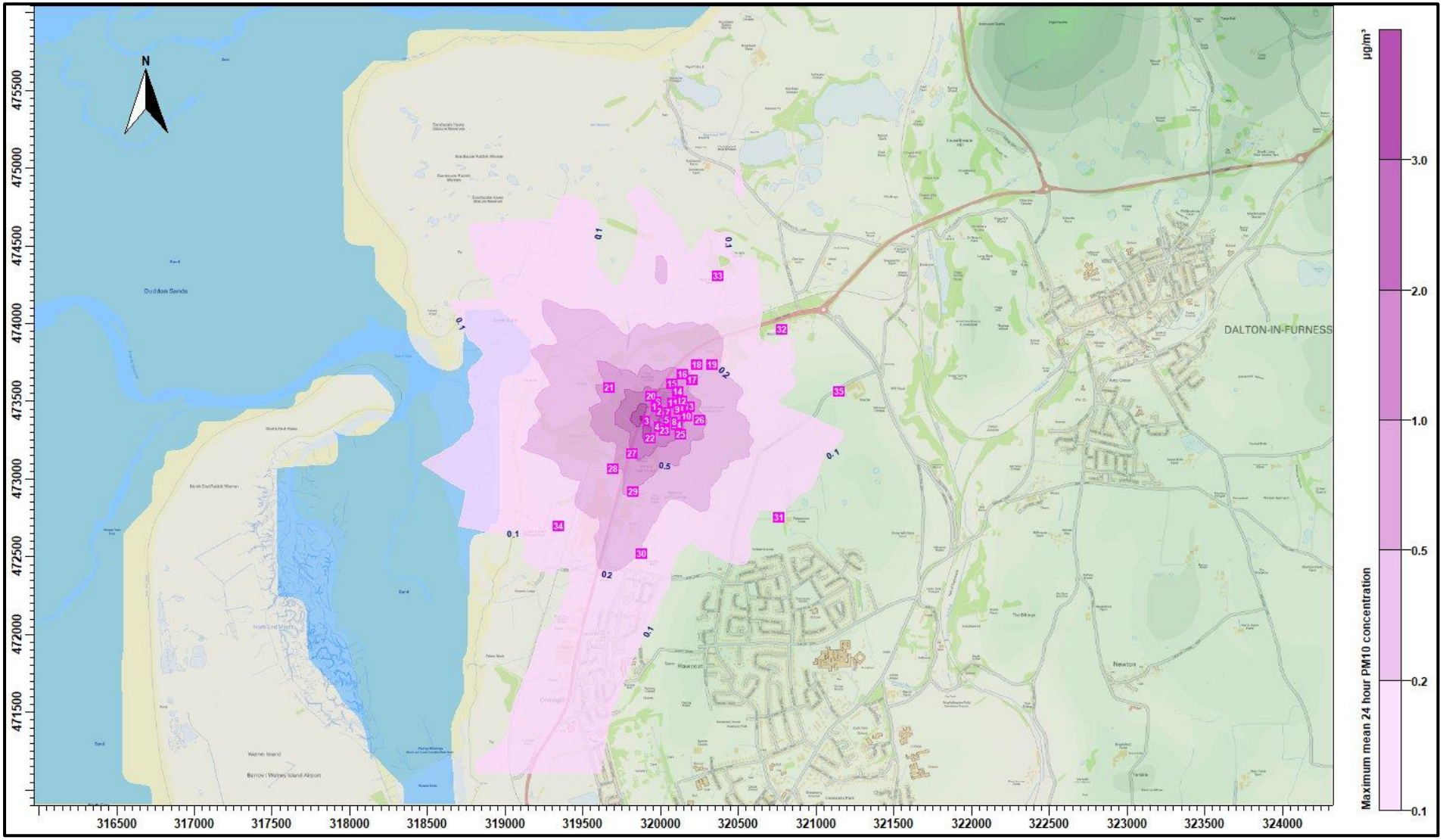

Figure A2i. Maximum 8 hour mean rolling CO concentration (process contribution)