Safran Landing Systems Services (UK) Limited

Air quality impact assessment of an abnormal release of hydrogen cyanide

Meteor Business Park, Gloucester

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AIR QUALITY IMPACT ASSESSMENT OF AN ABNORMAL RELEASE OF HYDROGEN CYANIDE

METEOR BUSINESS PARK, GLOUCESTER

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0 SUMMARY

Safran Landing Systems GLS placed a contract with Environmental Scientifics Group Limited (ESG) to undertake an assessment of the impact on local air quality of an abnormal release of hydrogen cyanide from the metal finishing operations at its Meteor Business Park site. Two hydrogen cyanide generation scenarios (A & B) and three release scenarios (1, 2 and 3) were considered.

The absolute worst case hydrogen cyanide generation scenario (A) was considered where a failure of all vats and bund containments resulted in the mixing of the total vat inventory of sodium cyanide and sulphuric acid associated with chromium and cadmium plating with total reaction to produce hydrogen cyanide limited only by the presence of sodium hydroxide and sodium carbonate. A more realistic worst case (B) involving a limited failure of vats and bunds was also considered.

Assuming that the Metal Finishing Facility is evacuated and the air within extracted to atmosphere via the existing ventilation systems serving the vats, the resulting dispersion of hydrogen cyanide releases is predicted to have maximum impact beyond the site boundary, but within the Meteor Business Park. A maximum concentration of 8 times the workplace exposure limit is expected to occur on site. Beyond the site boundary process contributions exceed the Environmental Assessment Level for human health for hydrogen cyanide at all neighbouring commercial premises and residential locations within 1 km.

For the scenario where the release was confined within the Hangar 4 building and the extraction system shutdown with only fugitive releases to atmosphere, concentrations within the site boundary were predicted to be reduced to below the WEL at all ground level locations and to drop considerably at locations beyond the site boundary. This appears to be a somewhat more effective control measure for the protection of site workers following a release than the continued use of the extraction systems.

In the case of a complete failure of the containment of the Hangar 4 building the highest on site concentrations are experienced with the main affect being around the immediate vicinity of Hangar 4. Resulting concentrations beyond the site boundary are above the EAL at neighbouring commercial premises and residential locations, although at lower concentrations that for an extractive release.

The hydrogen cyanide generation scenario A reflects the maximum possible release and is considered highly unlikely. Scenario B is the more likely worst case scenario involving limited vat mixing which has been considered in previous assessments at Safran. For all release scenarios this provides a much lower ambient hydrogen cyanide impact than the corresponding scenario A with most concentrations being within the WEL on site and within the EAL at nearby residential locations. Although the concentrations at the nearest commercial neighbours exceed the EAL for exposure over an hour, this is much reduced and manageable with appropriate evacuation or containment procedures.

The assessment indicates that containment of the release within the Hangar 4 building and subsequent gradual release by fugitive means is likely to provide the least ambient impact and will generally ensure concentrations remain within the WEL and EAL for the most likely scenarios. The use of the existing extraction system to remove any hydrogen cyanide generated will result in higher concentrations beyond the site boundary. A full failure of containment is the worst case release scenario and tends to result in very high concentrations of hydrogen cyanide local to the release point.

In the event of a release from the Metals Finishes Facility it would be most appropriate to muster and evacuate towards the east of the site and to avoid the immediate areas around Hangar 4 and the main gate.

It is considered that the more probable worst case generation scenario with limited vat mixing is unlikely to cause environmental benchmark exceedence either on site or on nearby commercial or residential locations, if suitable precautions are taken. Remaining within premises with doors and window closed will allow time for external concentrations to drop to a safe level by dispersion. Alternatively evacuation will reduce the time exposed to the release with exposure unlikely to be in excess of the 15 minute workplace exposure level.

Necessary assumptions made to undertake the modelling are considered to have the effect of overestimating the process contribution to ambient concentrations of hydrogen cyanide. It is therefore considered that the predicted process impact on ambient concentrations reported herein is a conservative assessment and the conclusions reached therefore incorporate a reasonable margin of comfort in spite of the inevitable uncertainty of such modelling studies.

1 INTRODUCTION

Safran Landing Systems (UK) Limited (Safran) placed a contract with Environmental Scientifics Group Limited (ESG) to undertake an assessment of the impact on local air quality of an abnormal release of hydrogen cyanide from the metal finishing operations at its Meteor Business Park site.

1.1 Scope of study

Safran Landing Systems' metal finishing operations at its Meteor Business Park site employ a range of materials which could theoretically combine to cause a release of hydrogen cyanide. The potential for releases of hydrogen cyanide and the subsequent impact has been assessed using atmospheric dispersion modelling within the site's Major Accident Prevention Policy (MAPP). Safran Landing Systems consider that the assessment, undertaken in 2001, needs to be reviewed.

Within the metal finishing operations the principal route to production of hydrogen cyanide is the combination of sodium cyanide, used in cadmium plating, with sulphuric acid employed in chromium plating. The purpose of this study is to examine the potential release of hydrogen cyanide, its dispersion and the subsequent impact on ambient air quality both within the Safran site and further afield in the vicinity of the site. The significance of the resulting ambient air quality impact is assessed in the context of applicable workplace and ambient air quality guidelines.

1.2 General approach

The approach taken in this assessment comprised the following main stages:

- Determine a suitable modelling tool for the assessment.
- Collect appropriate representative process operational data for input to the model.
- Establish the location of the release relative to existing buildings (including nearby public and commercial buildings and residential properties).
- Obtain information on local background concentrations of hydrogen cyanide.
- Obtain 5 years' recent meteorological data from a measurement station appropriate to the location.
- Model the dispersion of potential releases of hydrogen cyanide from the Metal Finishing Facility to determine the process contribution to ambient concentrations of hydrogen cyanide over the Safran site and the neighbouring area with particular attention to locations of human exposure.
- Assess the predicted process contributions and established background concentrations with reference to applicable workplace and air quality standards to determine compliance.

Further details of the approach taken and model input information are provided in the following sections.

1.3 Structure of the report

This report provides an assessment of the impact of releases of hydrogen cyanide from abnormal operations on air quality within and in the vicinity of Safran's Meteor Business Park site. The approach to the assessment has been described above. The following sections provide a detailed commentary on the assessment and conclusions:

Section 2	Air quality standards and assessment criteria
Section 3	The model methodology employed and important input data
Section 4	The results of the assessment including sensitivity analysis
Section 5	Conclusions of the assessment

2 POLICY CONTEXT AND ASSESSMENT CRITERIA

Safran's metal finishing operations at their Meteor Business Park site employ materials which if combined have the potential to release hydrogen cyanide gas to the atmosphere. As part of the review of the Major Accident Prevention Policy, Safran have identified the need to update their assessment of the impact of abnormal operating scenarios which may result in the release of hydrogen cyanide.

2.1 Context of assessment

Many people are exposed to a variety of substances at work which can, under some circumstances, have a harmful effect on their health. Hydrogen cyanide is recognised as a hazardous substance in this regard with a specified workplace exposure limit (WEL) set in order to help protect the health of workers. Substances that have been assigned a WEL are subject to the requirements of Control of Substances Hazardous to Health (COSHH) regulations which require employers to prevent or control exposure to hazardous substances

The Environment Agency play an important role in relation to local air quality management by ensuring that processes under their regulatory control do not contribute significantly to any threat to the attainment of air quality standards. It is in this context that, as part of the environmental permitting process operated by the Environment Agency, it is necessary to demonstrate the impact of site operations on local air quality in the context of the Environment Agency's published guidance[1].

It is necessary to examine the impact of potential hydrogen cyanide releases both within the general workplace, as regulated under COSHH, and in the wider area beyond the site boundary where environmental standards relevant to human health apply.

2.2 Hydrogen cyanide releases from metal finishing operations

The metal finishing operations at Safran's Meteor Business Park site include both chromium plating using sulphuric acid and cadmium plating employing sodium cyanide. While stringent measures are in place to prevent the combination of these materials, there are abnormal circumstances where accidental mixing could occur.

On mixing the following reaction can occur:

$2NaCN$	+	H_2SO_4	→	$2HCN$	+	Na_2SO_4
Sodium cyanide		Sulphuric acid		Hydrogen cyanide		Sodium sulphate

2.3 Environmental Standards

The UK's air quality strategy is based on meeting obligations within the European Union (EU) Ambient Air Quality Directive (2008/50/EC, 21 May 2008)[2] and the Fourth Daughter Directive (relating to metals and hydrocarbons)[3]. These Directives specify legally binding limit values and target values. Limit values are set for individual pollutants and are made up of a concentration value, an averaging time over which it is to be measured, the number of exceedences allowed per year, if any, and a date by which it must be achieved. Some pollutants have more than one limit value covering different endpoints or averaging times. Target values and are set out in the same way as limit values and are to be attained where possible by taking all necessary measures not entailing disproportionate costs.

The Air Quality (Standards) Regulations 2010[4] transpose into English law the requirements of Directives 2008/50/EC and 2004/107/EC on ambient air quality. Equivalent regulations have been made by the devolved administrations in Scotland, Wales and Northern Ireland. Schedules 2 and 3 of the Regulations specify limit and target values respectively.

There are no air quality standards which are specific to the ambient concentration of hydrogen cyanide, however for the purposes of assessing the significance of pollutants in the ambient atmosphere the Environment Agency publish Environmental Assessment Levels (EALs) for the protection of human health[1]. The EAL relevant to this study is summarised in Table 2.1.

Table 2.1 Environmental Assessment Level

Pollutant	Basis	Concentration
Hydrogen cyanide	hourly mean	220 $\mu g/m^3$

The Air Quality Standards Regulations 2010[4] define ambient air as;

"…outdoor air in the troposphere, excluding workplaces where members of the public do not have regular access."

Compliance with limit values for the protection of human health does not need to be assessed (Schedule 1, Part 1) at the following locations:

a) any location situated within areas where members of the public do not have access and there is no fixed habitation;
b) on factory premises or at industrial locations to which all relevant provisions concerning health and safety at work apply;
c) on the carriageway of roads and on the central reservation of roads except where there is normally pedestrian access to the central reservation."

In this case it is considered that beyond the site boundary the EAL is likely to be applicable in areas where there is human exposure of an hour or more on a regular basis (e.g. commercial and residential premises). Within the site boundary it would be expected that regulations specific to the workplace would be applicable.

Hydrogen cyanide has a specified workplace exposure limit as summarised in Table 2.2[5].

Table 2.2 Workplace Exposure Limit

Pollutant	Basis	Concentration
Hydrogen cyanide	15 minute reference period	11000 $\mu g/m^3$

The WEL is on a short term basis which is generally set to help prevent effects such as eye irritation, which may occur following exposure for a few minutes. Hydrogen cyanide is noted as a substance which can be absorbed through the skin.

2.4 Background hydrogen cyanide concentrations

In considering the overall impact of a process release, such as this herein, on local air quality and compliance with environmental benchmarks, it is necessary not only to consider the contribution from the source but also the existing level of the substance of interest. There are no readily available data on ambient concentrations of hydrogen cyanide in the vicinity of the Safran site.

General assessments indicate a concentration in the non-urban troposphere of around 180-190 ng/m^3 (c. 0.2 µg/m^3)[6]. This is equivalent to around 0.1% of the EAL and 0.002% of the WEL. In the context of the current study it is considered that the background level of hydrogen cyanide is unlikely to have any influence on attainment of environmental or workplace standards.

2.5 Assessment criteria

The Environment Agency[1] provides a methodology for assessing the impact and determining the acceptability of emissions to atmosphere on ambient air quality for human health

The contribution of the process (PC) to the ambient concentration of a given pollutant is considered insignificant, and requiring no further assessment, if both of the following conditions are met:

- the long term PC is less than 1% of the long term environmental standard
- the short term PC is less than 10% of the short term environmental standard

If these conditions are not met then the corresponding predicted environmental concentration ((PEC) i.e. PC + background concentration) should be assessed. The process contribution is considered insignificant and requiring no further assessment, if both of the following conditions are met:

- the short-term PC is less than 20% of the short term standard minus twice the long term background concentration
- the long-term PEC is less than 70% of the long-term environmental standard

3 MODELLING METHODOLOGY

The process contributions to ambient concentrations of hydrogen cyanide from the abnormal operating scenarios considered have been modelled using the Atmospheric Dispersion Modelling System (ADMS) version 5.2. The use of this modelling tool is widely accepted by UK Local Authorities and the Environment Agency.

ADMS and the United States Environmental Protection Agency's (US EPA) AERMOD modelling systems are the two most widely used air dispersion models for regulatory purposes worldwide. Both are based on broadly similar principles. In this case ADMS 5.2 has been employed for the assessment

ADMS 5.2 requires a range of information in order to perform the modelling. The primary information required is discussed below.

3.1 Assessment area

Two assessment areas were considered, each with the Metal Finishing Facility (MFF) located approximately at the centre. Figure 3.1 illustrates the location of the site within the local area, while Figure 3.2 details the Safran site arrangement and neighbouring commericial premises on the Meteor Business Park.

Figure 3.1 Location of the Safran Landing Systems site

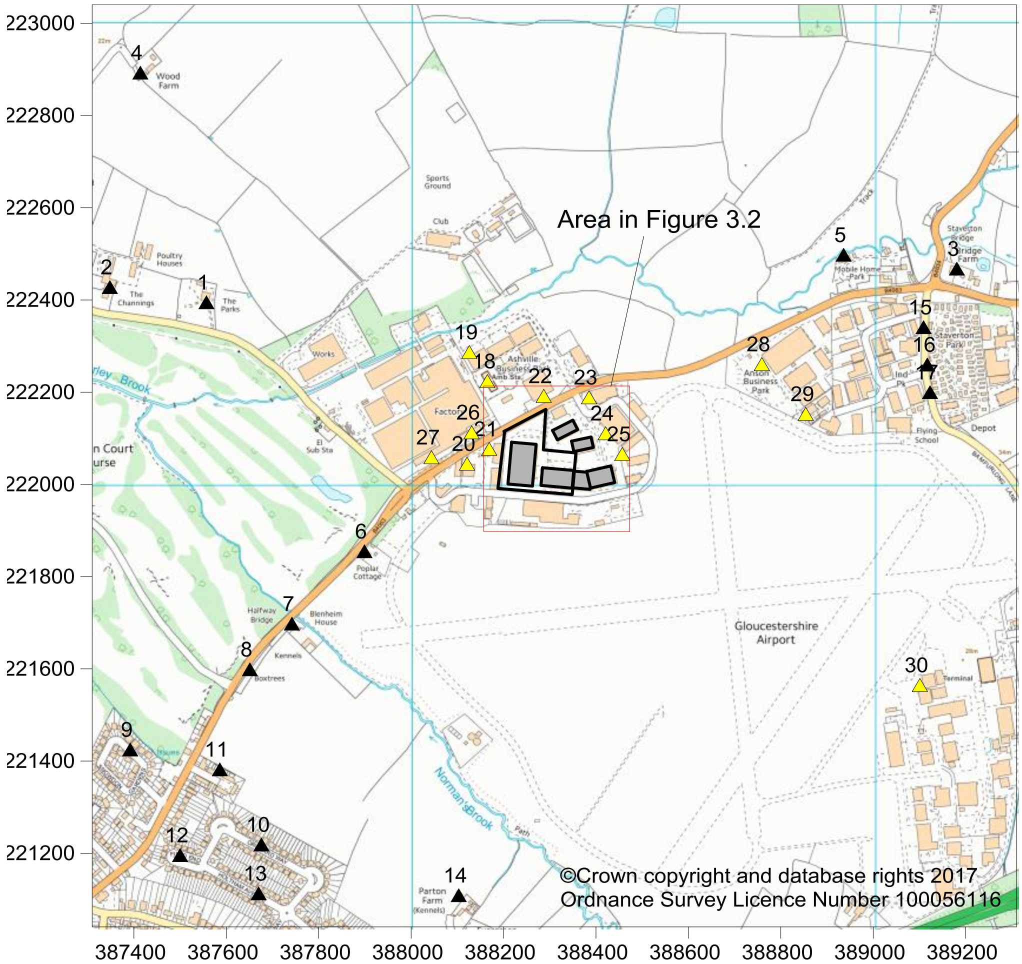
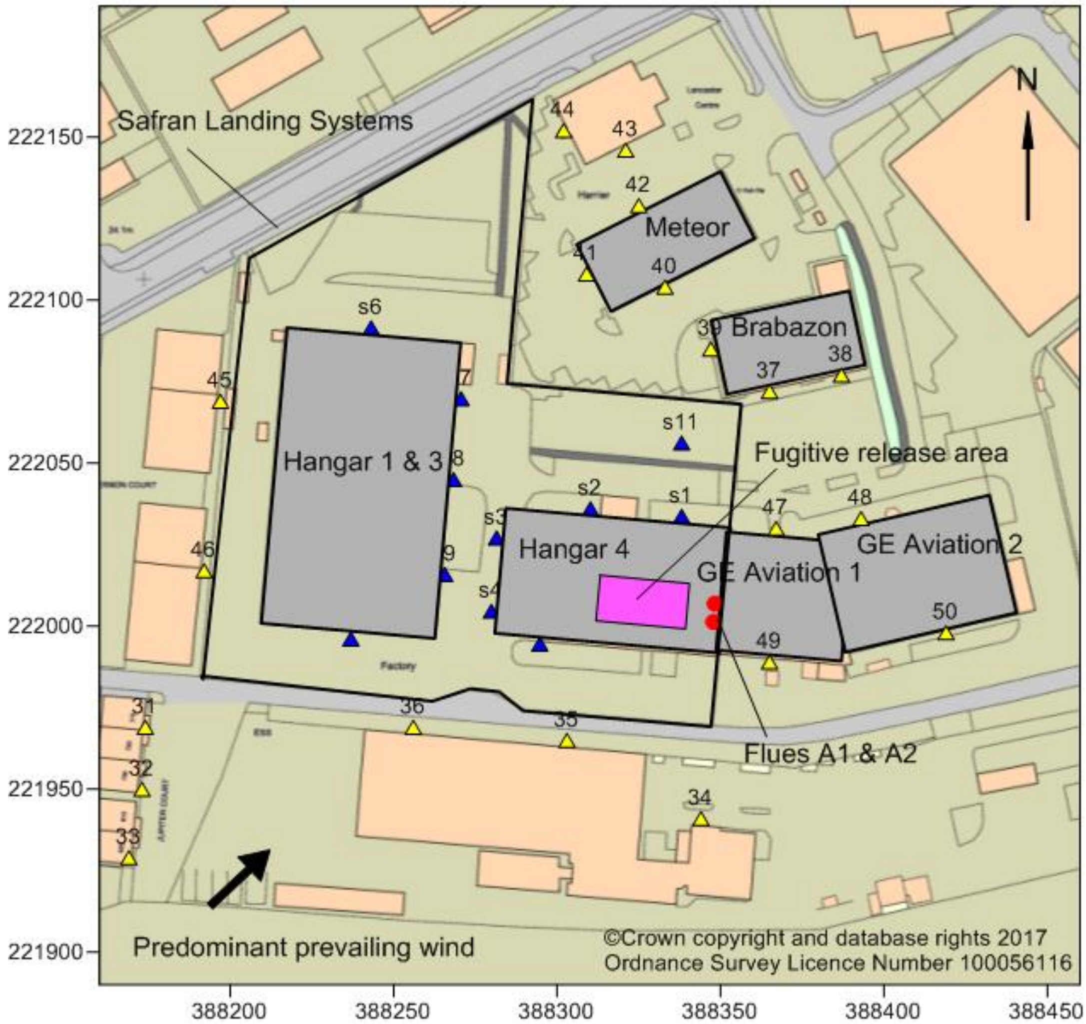


Figure 3.2 Safran Landing Systems site arrangement



A general grid (300 m x 300 m) with receptors spaced at 3 m intervals (i.e. 10201 points for a 101 x 101 grid) was used to assess the process contribution to ground level concentrations over the area in Figure 3.2, which primarily encompassed the Safran site where the WEL might be expected to apply and also near commercial neighbours on the Meteor Business Park, who are more likely to be subject to the EAL.

The wider dispersion pattern, covering other commercial operations beyond the Cheltenham Road and the nearest residential locations was also considered over the larger 2 km x 2 km area shown in Figure 3.1 (10201 points at 20 m intervals). These locations are more likely to be subject to the EAL.

Both grids were considered at an elevation of 1.5 m above local ground level which is considered to be appropriate to an average height of human exposure.

In addition to the receptor grid, 11 receptors (S1 to S11 in Figure 3.2 (blue)) were located around the main site buildings and areas of frequent use on the Safran Landing Systems site and were at a level appropriate to the ground floor and first floor window heights as described in Table 3.1.

Table 3.1 Locations of receptors on the Safran Landing Systems' site

Receptor (see Figure 3.2)		Height m	Easting	Northing
S1	Hangar 4 North face	1.5 & 9.0	388338.1	222033.7
S2	Hangar 4 North face	1.5 & 9.0	388310.2	222036.0
S3	Hangar 4 West face	1.5 & 9.0	388281.5	222027.1
S4	Hangar 4 West face	1.5 & 9.0	388279.9	222004.6
S5	Hangar 4 South face	1.5 & 9.0	388294.7	221994.5
S6	Hangar 1 North face	1.5 & 9.0	388243.1	222091.5
S7	Hangar 1 East face	1.5 & 9.0	388270.6	222069.8
S8	Annex East face	1.5	388268.3	222045.0
S9	Hangar 3 East face	1.5 & 9.0	388265.6	222015.9
S10	Hangar 3 South face	1.5 & 9.0	388236.9	221996.1
S11	Reception	1.5	388338.1	222056.2

17 receptors (1 to 17 in Figure 3.1 (black)) were placed around the residential locations within about 1 km of the MFF and are summarised in Table 3.2. A further 20 receptors (31 to 50 in Figure 3.2 (yellow)) were placed around the commercial and industrial locations, generally within the Meteor Business Park, neighbouring Safran's site. In addition, 13 receptors (18 to 30 in Figure 3.1 (yellow)) were positioned at other commercial locations, generally outside of the Meteor Business Park, beyond 100 m of the MFF. These are described in Table 3.3. All residential and commercial receptors considered receptors were at an elevation of 1.5 m above local ground level.

It is also necessary to consider the impact of releases on any local statutory designated sites. In this case no local sites met the Environment Agency criteria for assessment and as such impact at nature conservation sites is not included in this assessment.

Table 3.2 Locations of residential receptors

Receptor (see Figure 3.1)		Position[a]	Easting	Northing
1	Terncourt	884 m NW	387557	222395
2	The Channings	1087 m NW	387348	222428
3	Bridge Farm	955 m NE	389181	222468
4	Wood Farm	1292 m NW	387414	222893
5	Mobile Home Park	770 m NE	388936	222498
6	Poplar Cottage	472 m W	387899	221855
7	Blenheim House	678 m SW	387742	221698
8	Boxtrees	805 m SW	387651	221599
9	Snowdon Gardens	1116 m SW	387392	221425
10	Orchard Way	1031 m SW	387676	221219
11	Westover Court	982 m SW	387586	221382
12	Field End	1169 m SW	387500	221196
13	Holtham Avenue	1117 m SW	387670	221113
14	Parton Farm	925 m S	388103	221109
15	Bamfurlong Lane 1	833 m NE	389109	222341
16	Bamfurlong Lane 2	811 m E	389117	222260
17	Bamfurlong Lane 3	800 m E	389123	222200

a. Location of the receptor relative to the A2 flue.

Table 3.3 Locations of commercial receptors

Receptor (see Figures 3.1 & 3.2)		Position[a]	Easting	Northing
18	Ambulance station	288 m NW	388165	222224
19	Ashville Business Park	362 m NW	388126	222287
20	Mitsubishi	231 m W	388121	222045
21	Completely Motoring	194 m NW	388169	222077
22	Mercedes Benz	201 m N	388287	222192
23	Actemium	192 m N	388385	222189
24	Safran 1 (other division)	132 m NE	388421	222111
25	Clarkson Evans	127 m NE	388457	222066
26	Safran 2 (other division)	244 m NW	388131	222113
27	Safran 2 (other division)	309 m W	388044	222059
28	Anson Business Park 1	486 m NE	388759	222261
29	Anson Business park 2	528 m E	388854	222153
30	Airport terminal	870 m SE	389101	221565
31	710-720 Jupiter Court	177 m W	388174	221969
32	730-810 Jupiter Court	182 m W	388173	221950
33	820 Jupiter Court	193 m W	388169	221929
34	Severn Trent Water 1	60 m S	388344	221941
35	Severn Trent Water 2	58 m SW	388303	221965
36	Severn Trent Water 3	97 m W	388256	221969
37	Brabazon 1	73 m N	388365	222072
38	Brabazon 2	85 m NE	388387	222077
39	Brabazon 3	84 m N	388347	222085
40	Harrier 1	104 m N	388333	222104

Table 3.3 (continued)

Receptor (see Figures 3.1 & 3.2)	Position[a]	Easting	Northing
41 Harrier 2	114 m N	388309	222108
42 Harrier 3	130 m N	388325	222129
43 Lancaster Centre 1	147 m N	388321	222146
44 Lancaster Centre 2	110 m SE	388441	221942
45 Vernon Court 1	166 m NW	388197	222069
46 Vernon Court 2	157 m W	388192	222017
47 GE Aviation 1	35 m NE	388367	222030
48 GE Aviation 2	55 m NE	388393	222033
49 GE Aviation 3	21 m SE	388365	221989
50 GE Aviation 4	71 m E	388419	221998

a. Location of the receptor relative to the A2 flue.

3.2 Buildings

The presence of buildings close to discharge flues can influence the dispersion of releases. The most significant impact can be the downwash of a plume around a building causing increased concentrations in the immediate area around the building. Buildings can also disturb the wind flow causing a turbulent wake downwind which can also affect dispersion. It is normally considered that buildings within 5 times the height of release should be considered in any modelling.

It is normally considered that buildings within 5 times the height of release should be considered in any modelling. In this case the adjacent Hangar 4 building and Hangars 1 and 3 on the site were considered. Beyond the site it was also necessary to consider the GE Aviation building adjacent to Hangar 4 and the Brabazon and Harrier office blocks. ADMS 5.2 models buildings as either rectangular or circular structures. As shown in Figure 3.2 all buildings were estimated as rectangular blocks. Based on the drawings provided by Safran [7] the defining parameters for these buildings, as summarised in Table 3.4, were estimated and used within the modelling.

Table 3.4 Building parameters

Building (see Figure 3.2)	Building centre grid reference		Height (m)		Length (m)	Width (m)
	Easting	Northing	Eaves	Ridge		
Hangar 4	388317	222014	9.4	10.4	69.0	38.5
Hangars 1 and 3	388240	222044	9.4	10.4	53.3	91.0
GE Aviation 1	388369	222009	9.4	10.4	38.5	36.4
GE Aviation 2	388410	222016	9.4	10.4	53.7	37.0
Harrier	388333	222118	10.4		49.3	23.0
Brabazon	388371	222087	10.4		43.1	23.2

The heights of buildings in Table 3.4 are referenced to the base of the north west corner of Hangar 4.

The sensitivity of predicted HCN concentrations at the location of maximum and at the commercial receptors on the Meteor Business Park (31 to 50 in Table 3.3) to selection of the main building was examined as below.

Main building	Change (%) in predicted concentration from base case with GE Aviation 1 as main building			
	At location of maximum		Mean over receptors 31 to 50	
	15 min mean	1 hour mean	15 min mean	1 hour mean
Hangar 4	-4.6	-4.7	-5.3	-5.3
Hangars 1 and 3	-4.6	-4.7	0	0
GE Aviation 1	0	0	0	0
GE Aviation 2	0	0	-0.1	-0.1

GE Aviation 1 was selected as the main building having the most influence on dispersion of releases based on this sensitivity analysis.

In this case it is assumed that the ambient atmosphere from within the Metal Finishing Facility, and in particular around the cadmium and chromium plating operation, is vented to atmosphere via the local exhaust ventilation systems exhaust to flues A1 and A2 (see Figure 3.2). Table 3.5 summarises the main characteristics of these flues.

Table 3.5 Exhaust flue characteristics

Flue	Height (m)	Internal diameter at exit (m)	Easting	Northing
A1	10.9	0.85	388347.9	222001.3
A2	14.4	1.50	388348.3	222006.9

3.3 Meteorology

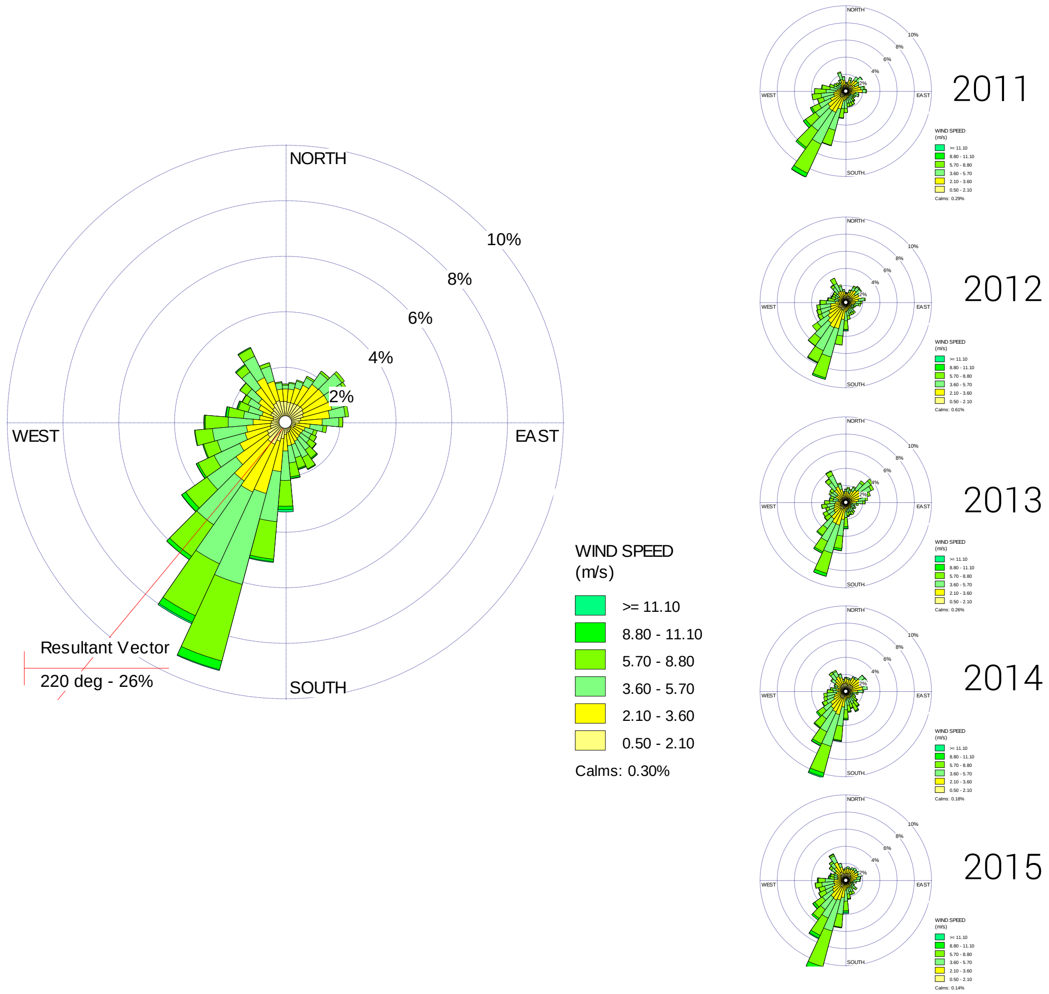
For this modelling assessment hourly sequential meteorological data from the nearest suitable meteorological station to the area was obtained. The data, provided by the UK Met Office, was from the Pershore station and covered the 5-year period 2011 to 2015. The Pershore station is around 23 km north east of the Safran site at an elevation of 35 m, compared with the site elevation of around 22 m. There are three other stations in the area which were also considered as possible sources of meteorological data:

Winchcombe (Sudeley Castle)	15 km E, elevation 112 m (incomplete data set)
Pershore College	22 km NE, elevation 22 m (incomplete data set)
Little Rissington	30 km E, elevation 210 m (complete data set)

On the basis of the general location and surface characteristics, the Pershore station was considered to provide measurements most representative of the conditions around the Safran Landing Systems site area.

The data included, among other parameters, hourly measurements of wind speed and direction. Figure 3.3 illustrates a composite wind rose for the Pershore station for the period considered within this modelling (2011 to 2015). It may be seen that the wind is predominantly from the south west.

Figure 3.3 Composite windrose for the Pershore station (2011 to 2015)



3.4 Surface characteristics

The characteristics of the surrounding surfaces and the land use within the assessment area have an important influence in determining turbulent fluxes and hence the stability of the boundary layer and atmospheric dispersion. In ADMS it is necessary to consider the following parameters which describe land use and surface properties:

Surface roughness
Surface aldebo
Minimum Monin Obukhov length
Priestley Taylor parameter

3.4.1 Surface roughness

The roughness length represents the aerodynamic effects of surface friction and is physically defined as the height at which the extrapolated surface layer wind profile tends to zero. This value is an important parameter used by meteorological pre-processors to interpret the vertical profile of wind speed and estimate friction velocities which are, in turn, used to define heat and momentum fluxes and, consequently, the degree of turbulent mixing.

The surface roughness length is related to the height of surface elements. Typically, the surface roughness length is approximately 10% of the height of the main surface features. Surface roughness is higher in built up areas than in rural locations.

A range of typical roughness values for common land use types are provided within ADMS:

Land use	Surface roughness (m)
Ice	0.00001
Snow	0.00005
Sea	0.0001
Short grass	0.005
Open grassland	0.02
Root crops	0.1
Agricultural areas	0.2-0.3
Parkland, open suburbia	0.5
Cities, woodland	1.0
Large urban areas	1.5

The site is located in a rural/small industrial area with warehousing and light industrial units in the immediate vicinity and with open fields beyond. The nearest medium density housing is around 1 km to the south west, although there are individual residential properties within 500 m. The general area is considered to fall into the category of cities and woodland reflecting the density of buildings in the area surrounding the Metals Finishing Facility. The sensitivity of predicted ambient HCN concentrations to surface roughness at the location of maximum and at the commercial receptors on the Meteor Business Park (31 to 50 in Table 3.3) was examined as below.

Surface roughness (m)	Change (%) in predicted concentration from base case with surface roughness of 1.0 m			
	At location of maximum		Mean over receptors 31 to 50	
	15 min mean	1 hour mean	15 min mean	1 hour mean
0.5	-13.5	-13.6	+2.2	-1.9
1.0	0	0	0	0
1.5	+13.5	+13.8	+6.7	+6.3

Variations in surface roughness of between 0.5 and 1.5 m resulted in a relatively small change in the predicted ambient HCN concentration which is not considered significant in the context of the conclusions reached in section 4.

3.4.2 Surface aldebo

The surface aldebo is the ratio of reflected to incident shortwave solar radiation at the surface of the earth and lies in the range 0 to 1. This parameter is dependent upon surface characteristics and varies throughout the year. Surface aldebo is higher (higher proportion of reflected radiation) when the ground is snow covered. Based on the recommendations of Oke (1987), ADMS provides default values of 0.6 for snow-covered ground and 0.23 for non-snow covered ground, respectively.

In this case a value for surface aldebo of 0.23 has been employed.

3.4.3 Monin Obukhov length

The Monin Obukhov length provides a measure of the stability of the atmosphere and allows for the effect of heat production in cities which may not be represented by the meteorological data. In urban areas heat generated from buildings and traffic warms the air above which has the effect of preventing the atmosphere from becoming very stable. Generally the larger the area the greater the effect. In stable conditions the Monin Obukhov length will not fall below a minimum value with the value becoming larger depending on the size of the city. The minimum value of the Monin Obukhov length generally lies between 1 and 200 m with 1 corresponding to a rural area. ADMS provides the following guidance on minimum Obukhov length:

Population size	Minimum Obukhov length (m)
Large conurbations (>1 million)	100
Cities and large towns	30
Mixed urban/industrial	30
Small towns	10
Rural area	1

In this case the area is considered to be typical of a mixed urban and industrial area and a minimum Monin Obukhov length of 30 has been employed. The sensitivity of predicted ambient HCN concentrations to minimum Monin Obukhov length at the location of maximum and at the commercial receptors on the Meteor Business Park (31 to 50 in Table 3.3) was examined as below.

Minimum Monin Obukhov Length (m)	Change (%) in predicted concentration from base case with Minimum Monin Obukhov Length of 30 m			
	At location of maximum		Mean over receptors 31 to 50	
	15 min mean	1 hour mean	15 min mean	1 hour mean
10	0	0	+0.6	0
30	0	0	0	0
100	0	0	-0.2	+0.4

Variations in the minimum Monin Obukhov Length of between 10 and 100 resulted in negligible changes in the predicted ambient HCN concentration. This is not considered significant in the context of the conclusions reached in section 4.

3.4.4 Priestley Taylor parameter

The Priestly Taylor parameter represents the surface moisture available for evaporation. Areas where moisture availability is greater will experience a greater proportion of incoming solar radiation released back to atmosphere in the form of latent heat, leaving less available in the form of sensible heat and, thus, decreasing convective turbulence. The Priestley Taylor parameter lies between 0 and 3. Based on suggestions by Holstag and van Ulden, ADMS provides default values of:

Land type	Priestley Taylor parameter
Dry bare earth	0
Dry grassland	0.45
Moist grassland	1

In this case the area is considered to be representative of moist grassland and a value of 1.0 for the Priestley Taylor parameter has been employed. The sensitivity of predicted ambient HCN concentrations to the Priestley Taylor parameter at the location of maximum and at the commercial receptors on the Meteor Business Park (31 to 50 in Table 3.3) was examined as below.

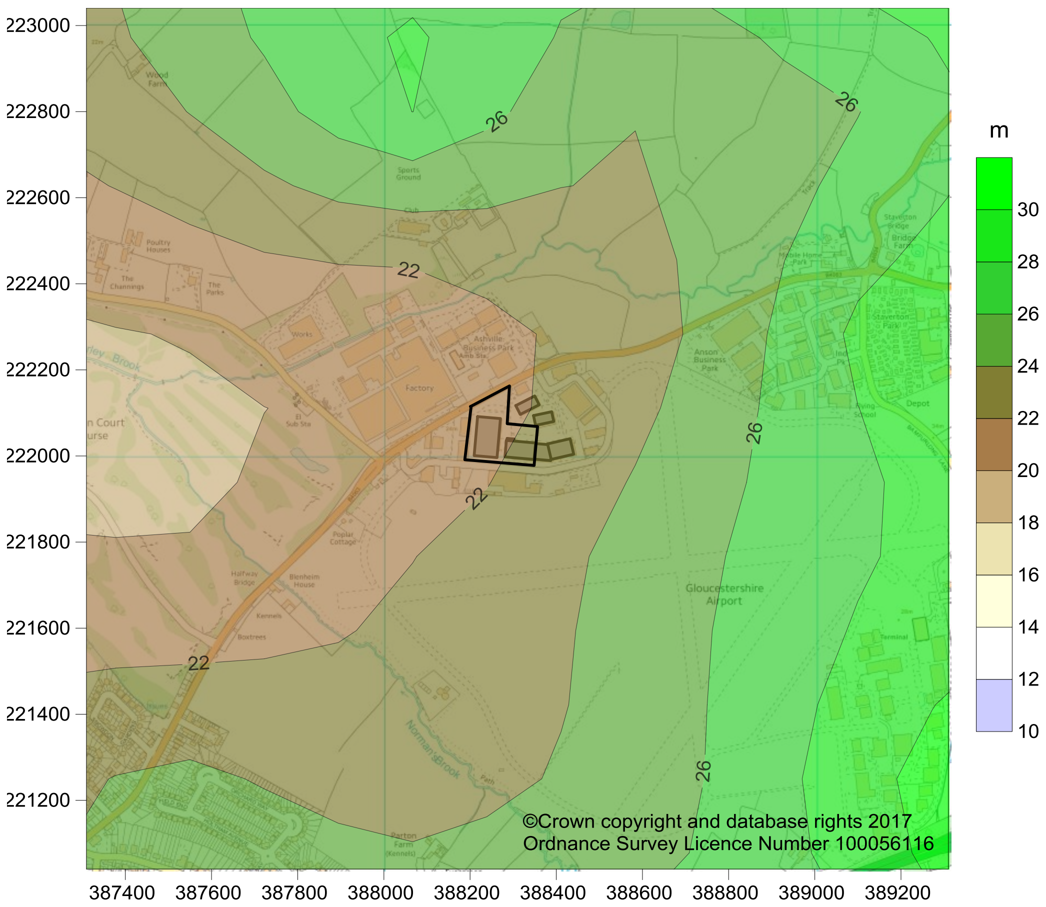
Priestley Taylor parameter	Change (%) in predicted concentration from base case with Priestley Taylor parameter of 1.0			
	At location of maximum		Mean over receptors 31 to 50	
	15 min mean	1 hour mean	15 min mean	1 hour mean
0	+44.3	+46.7	+10.0	+11.0
0.5	+21.1	+22.2	+9.7	+8.6
1.0	0	0	0	0

Variations in the Priestley Taylor parameter of between 0 and 1 resulted in substantial changes in the predicted ambient HCN concentration, although the value selected is considered to be most appropriate for this environment. Although the potential variations are substantial these are unlikely to impact on the conclusions reached in section 4.

3.4.5 Terrain

Terrain data was obtained for the assessment area from the Ordnance Survey Land-form Panorama DTM data base. There is little change in ground elevation across the large assessment area (Figure 3.1). The site lies in a relatively flat area with the ground slightly rising to the east (rising 5 m over a distance of around 2 km) as shown in Figure 3.4.

Figure 3.4 Ground elevation within assessment area



Sensitivity analyses indicated that consideration of ground elevation had the following influence on predicted ambient HCN concentrations.

Terrain	Change (%) in predicted concentration from base case with Terrain considered			
	At location of maximum		Mean over receptors 31 to 50	
	15 min mean	1 hour mean	15 min mean	1 hour mean
Yes	0	0	0	0
No	-21.1	-21.8	-8.4	-8.7

For avoidance of doubt, terrain has been considered in the current assessment.

3.5 Releases of hydrogen cyanide

The generation of hydrogen cyanide is considered to arise from the combination of sulphuric acid and sodium cyanide in the various parts of the plating process in the Metal Finishes Facility.

3.5.1 Material inventories

Based on the information provided by Safran[7] the following inventories of sodium cyanide and sulphuric acid have been determined.

Table 3.6 Inventory of vats containing sulphuric acid

Vat		1	3	4	12	55
		Chromium plating	Chromium plating	Chromium plating	Sulphuric acid etch	Cadmium passivation
Working volume	l	8483	8483	8483	4746	4746
Sulphuric acid	g/l	2.25-2.75	2.25-2.75	2.25-2.75	375-525	3-7
	kg	21.2	21.2	21.2	2136	23.7
	kgmol	0.22	0.22	0.22	21.80	0.24

a.It is assumed that sulphuric acid is present at the middle of its control range.

Table 3.7 Inventory of vats containing sodium cyanide

Vat		45	57	BC3
		Cadmium plating	Reactivation	Bronze plating
Working volume	l	6954	4746	612
Sodium cyanide	g/l	90-120	30-37	20-25
	kg	661	159	14
	kgmol	13.49	3.24	0.29
Sodium hydroxide	g/l	7.5-24	8-15	8-12
	kg	110	55	6
	kgmol	2.75	1.38	0.15
Sodium carbonate	g/l	50	-	-
	kg	348	-	-
	kgmol	3.28	-	-

a.It is assumed that substances are present at the middle of their control range.

Table 3.8 summarises the total sodium cyanide and sulphuric acid present:

Table 3.8 Summary of sulphuric acid and sodium cyanide inventories

Vat	Sulphuric acid		Sodium cyanide	
	kg	kg mol	kg	kgmol
1	21.2	0.22		
3	21.2	0.22		
4	21.2	0.22		
12	2136	21.80		
55	23.7	0.24		
45			661	13.49
57			159	3.24
BC3			14	0.29
Total	2223.3	22.70	834	17.02

3.5.2 Generation of hydrogen cyanide

The reaction between sulphuric acid and sodium hydroxide to produce hydrogen cyanide is:

2NaCN	+	H_2SO_4	→	2HCN	+	Na_2SO_4
Sodium cyanide		Sulphuric acid		Hydrogen cyanide		Sodium sulphate
(2 x 49 = 98 kg/mol)		98 kg/mol		(2 x 27 = 54 kg/mol)		142 kg/mol

2 moles of sodium cyanide reacts with 1 mole of sulphuric acid to produce 2 moles of hydrogen cyanide.

The presence of sodium hydroxide and sodium carbonate in the vats 45, 57 and BC3 will utilise some of the sulphuric acid present according to the following reactions:

2NaOH	+	H_2SO_4	→	$2H_2O$	+	Na_2SO_4
Sodium hydroxide		Sulphuric acid		Water		Sodium sulphate
(2 x 40 = 80 kg/mol)		98 kg/mol		(2 x 18 = 36 kg/mol)		142 kg/mol

Na_2CO_3	+	H_2SO_4	→	H_2O	+	CO_2	+	Na_2SO_4
Sodium carbonate		Sulphuric acid		Water		Carbon dioxide		Sodium sulphate
106 kg/mol		98 kg/mol		18 kg/mol		44 kg/mol		142 kg/mol

Two potential generation scenarios are considered:

Scenario A The total inventory of sodium cyanide and sulphuric acid mix and react

Scenario A	kg	kg mol
H_2SO_4 in vats 1, 3, 4, 12 & 55	2223	22.70
NaCN in vats 45, 57 & BC3	834	17.02
Theoretical HCN produced	460	17.02
H_2SO_4 utilised in reaction	834	8.51
NaOH present in vats 45, 57 & BC3	171	4.28
Na_2CO_3 present in vats 45, 57 & BC3	348	3.28
H_2SO_4 utilised in neutralisation reactions	531	5.42

Sulphuric acid is in excess and the amount of hydrogen cyanide generated is limited by the amount of sodium cyanide present. From the above inventory 17.02 kg mol of sodium cyanide requires 8.51 kg mol (834 kg) of sulphuric acid to produce 17.02 kg mol (460 kg) of hydrogen cyanide.

	2NaCN	+	H_2SO_4	→	2HCN	+	Na_2SO_4
kg mol	17.02		8.51		17.02		8.51
kg	834		834		460		1208

4.28 kg mol of sodium hydroxide utilises 2.14 kg mol of sulphuric acid and 3.28 kg mol sodium carbonate utilises 3.28 kg mol sulphuric acid. The total sulphuric acid utilised by the presence of sodium carbonate and sodium hydroxide is 5.42 kg mol equivalent to 531 kg.

	2NaOH	+	H_2SO_4	→	$2H_2O$	+	Na_2SO_4
kg mol	4.28		2.14		4.28		2.14
kg	171		210		77		304

	Na_2CO_3	+	H_2SO_4	→	H_2O	+	CO_2	+	Na_2SO_4
kg mol	3.28		3.28		3.28		3.28		3.28
kg	348		321		59		144		466

The total sulphuric acid utilised in the reactions is 1365 kg, which can be compared with an original inventory of 2223 kg.

Scenario B Vats 1, 3 and 4 react with the contents of vat 45

Scenario B	kg	kg mol
H_2SO_4 in vats 1, 3 & 4	63.6	0.66
NaCN in vat 45	661	13.49
Theoretical HCN produced	35.1	1.30
H_2SO_4 utilised in reaction	63.6	0.66
NaOH present in vat 45	110	2.75
Na_2CO_3 present in vat 45	348	3.28
H_2SO_4 utilised in neutralisation reactions	456	4.66

The reaction is limited by the amount of sulphuric acid present. 0.65 kg mol of sulphuric acid will react with 1.30 kg mol of sodium cyanide to produce 1.30 kg mol (35.1 kg) of hydrogen cyanide.

	2NaCN	+	H_2SO_4	→	2HCN	+	Na_2SO_4
kg mol	1.30		0.65		1.30		0.65
kg	63.6		63.6		35.1		92.1

If the reaction was governed by the amount of sodium cyanide present, the demand for sulphuric acid would be 6.55 kg mol (661 kg).

	2NaCN	+	H_2SO_4	→	2HCN	+	Na_2SO_4
kg mol	13.49		6.75		13.49		6.75
kg	661		661		364		958

There is also the potential for some sulphuric acid to react with any sodium hydroxide or sodium carbonate present. In this case 2.75 kg mol of sodium hydroxide utilises1.38 kg mol of sulphuric acid and 3.28 kg mol sodium carbonate utilises 3.28 kg mol sulphuric acid.

	$2NaOH$	+	H_2SO_4	→	$2H_2O$	+	Na_2SO_4
kg mol	2.75		1.38		2.75		1.38
kg	110		135		50		195

	Na_2CO_3	+	H_2SO_4	→	H_2O	+	CO_2	+	Na_2SO_4
kg mol	3.28		3.28		3.28		3.28		3.28
kg	348		321		59		144		466

The total sulphuric acid demand for these neutralisation reactions is therefore 456 kg.

The overall potential utilisation of sulphuric acid is 1117 kg. If it is assumed that the reactions proceed in proportion to their respective demand for sulphuric acid, then the generation of hydrogen cyanide will be 59% complete (661/1117) with 0.38 kg mol sulphuric acid reacting with 0.76 kg mol sodium cyanide to produce 0.76 kg mol (20.5 kg) hydrogen cyanide.

	$2NaCN$	+	H_2SO_4	→	$2HCN$	+	Na_2SO_4
kg mol	0.76		0.38		0.76		0.38
kg	37.2		37.2		20.5		53.9

3.5.3 Concentration of hydrogen cyanide in the workplace

Three scenarios are assumed for the dispersion of any hydrogen cyanide generated within Metal Finishes Facility:

1. The building remains intact and the spillages are confined to the bunded area beneath the plating area and the hydrogen cyanide generated is removed by the local extraction system without spreading throughout the entire building.
2. The building remains intact and the plating area is sealed and the extraction system shutdown so that the hydrogen cyanide generated fills the entire plating area building.
3. The building is severely damaged and unable to confine the hydrogen cyanide generated.

The dimensions and volumes associated with above scenarios are determined in Table 3.9.

Table 3.9 Dimensions of release areas

Scenario		1	2	3
Area	m^2	334	392	392
Volume	m^3	1470	3802	not applicable

a.Based on drawings provided by Safran[7]. Height of extraction hoods is 4.4 m. Height of the building is 8.5 m at the eaves and 10.9 m at the ridge.

For the release and dispersion scenarios the workplace concentrations in Table 3,10 estimated.

Table 3.10 Workplace concentrations

Release scenario		A	B
Mass of HCN released	kg	460	20.5
HCN concentration in scenario A	mg/m^3	312925	13946
HCN concentration in scenario B	mg/m^3	120989	5392
HCN concentration in scenario C	mg/m^3	not applicable	

The above concentrations assume that the total release is dispersed into the air volume before any extraction or fugitive losses. This will therefore be a maximum concentration as the reaction will proceed concurrently with any extraction or losses. For scenario C it is assumed that the entire mass generated will be released over the benchmark averaging period.

3.5.4 Ventilation extraction rates

The plating area has three extraction systems which exhaust to atmosphere through two flues. Two of the individual systems serving the cadmium and nickel plating operations combine to exhaust through one flue (A2) with the remaining flue (A1) serving the chromium plating extraction system. Periodic measurements are made in the roof level flues. The extraction rates determined from these measurements over the past 18 months are summarised in Table 3.11.

Table 3.11 Measured extraction rates

<table>
<tr><th colspan="2">Flue</th><th colspan="2">A1</th><th>A2</th></tr>
<tr><td>Diameter at release point</td><td>m</td><td colspan="2">0.86</td><td>1.50</td></tr>
<tr><td>Area at release point</td><td>m^2</td><td colspan="2">0.58</td><td>1.77</td></tr>
<tr><td>Height</td><td>m</td><td colspan="2">10.9</td><td>14.4</td></tr>
<tr><td>Easting</td><td>m</td><td colspan="2">388347.9</td><td>388348.3</td></tr>
<tr><td>Northing</td><td>m</td><td colspan="2">222001.3</td><td>222006.9</td></tr>
<tr><td colspan="5">A1 – Chromium plating extraction</td></tr>
<tr><td rowspan="2">Test date and report</td><td>Temperature</td><td colspan="2">Volume flow rate actual</td><td>Velocity at flue exit</td></tr>
<tr><td>°C</td><td>m^3/h</td><td>m^3/s</td><td>m/s</td></tr>
<tr><td>30.6.16 (LSO 160632, 27.7.16)</td><td>20</td><td>17881</td><td>4.97</td><td>8.6</td></tr>
<tr><td>6.12.16 (LSO161212, 8.1.17)</td><td>13</td><td>16199</td><td>4.50</td><td>7.8</td></tr>
<tr><td>9.3.16 (LSO170324, 24.3.17)</td><td>12</td><td>15974</td><td>4.44</td><td>7.7</td></tr>
<tr><td>Mean</td><td>15</td><td>16685</td><td>4.63</td><td>8.0</td></tr>
<tr><td colspan="5">A2 – Cadmium and nickel plating extraction</td></tr>
<tr><td>30.6.16 (LSO 160632, 27.7.16)</td><td>23</td><td>88206</td><td>24.50</td><td>13.8</td></tr>
<tr><td>6.12.16 (LSO161212, 8.1.17)</td><td>20</td><td>101516</td><td>28.20</td><td>15.9</td></tr>
<tr><td>9.3.16 (LSO170324, 24.3.17)</td><td>5</td><td>99582</td><td>27.66</td><td>15.6</td></tr>
<tr><td>Mean</td><td>16</td><td>96435</td><td>26.79</td><td>15.1</td></tr>
</table>

The total air extraction from the plating shop based on the measured volume flow rates is 31.42 m^3/s. This is equivalent to the extraction of all air within the bunded area (scenario 1) in 47 seconds. The release rates of hydrogen cyanide on this basis for scenarios 1A and 1B are 9787 g/s and 449 g/s respectively.

3.5.5 Fugitive releases

For Scenario 2 it is assumed that the prior to any leakage to atmosphere the total release occupies and is confined to the volume of the Plating area (3802 m^3) and then leaks to atmosphere over an area equivalent to the roof area (392 m^2) at the height of the eaves (8.5 m). It is also assumed that the building leaks at a rate equivalent to a complete air change in 2 hours (i.e. 1901 m^3/h or 0.5 m^3/s) which equates to release of 63.9 g/s and 2.9 g/s for Scenarios 2A and 2B respectively.

For Scenario 3 it is assumed that the entire mass of hydrogen cyanide generated is released to air at a height of 1 m over the area of the equivalent to the roof area (392 m^2). As this release is unconfined, it is further that assumed that the mass of hydrogen cyanide generated in Scenarios A and B is released to atmosphere entirely over the averaging period of the benchmark of interest.

3.5.6 HCN release rates

Based on the above assumptions the following release rates are expected.

Table 3.12 Extractive release rates (Scenarios 1A and 1B)

Extraction flue		A1	A2	A1	A2
Scenario		1A		1B	
Total HCN release	kg	460		20.5	
Volume occupied	m^3	1470		1470	
Concentration before extraction	mg/m^3	312925		13946	
Air extraction rate	m^3/s	4.63	26.79	4.63	26.79
Extraction time	s	47		47	
Total release rate	g/s	9787		436	
Release rate per flue[a]	g/s	1442	8345	64	372
	g/s (15 min mean)	75	436	3.3	19.4
	g/s (1 h mean)	18.8	109	0.8	4.9

a. In order to assess the release on the basis of the 15 minute and one hour means required by environmental benchmarks the average release, based on total extraction over these periods is considered.

Table 3.13 Fugitive release rates (Scenarios 2A, 2B, 3A and 3B)

Scenario		2A	2B	3A	3B
Total HCN release	kg	460	20.5	460	20.5
Volume occupied	m^3	3802	3802	not applicable	
Concentration before extraction	mg/m^3	120989	5392	not applicable	
Fugitive leak rate	m^3/s	0.5	0.5	not applicable	
Time for building air change	s	7200	7200	not applicable	
Area of release	m^2	392	392	392	392
HCN release rate[a]	g/s (15 min mean)	63.9	2.85	511	22.8
	g/s (1 h mean)	63.9	2.85	128	5.69
	g/s/m^2 (15 min mean)	0.163	0.0073	1.304	0.058
	g/s/m^2 (1 h mean)	0.163	0.0073	0.326	0.015

a. The total fugitive release time in Scenario 2 exceeds 1 hour and as such the actual fugitive release is consistent with determining compliance with both the 15 minute and 1 hour benchmarks.

3.6 Modelling scenarios

ADMS 5.2 has been employed to estimate process contributions to ambient concentrations of hydrogen cyanide based on the six release scenarios specified above. For the assessment the model has been run using meteorological data for each of five years (2011 to 2015).

4 MODELLING RESULTS

ADMS 5.2 has been used to model the release scenarios described in Section 3. The results of the modelling are discussed below. In this section results are presented in tabular form, whilst in Annex A contour plots are provided which illustrate the estimated process contribution to ambient concentrations of hydrogen cyanide over the assessment areas.

It is considered that over the area of the Safran site workplace exposure limits will be applicable, while beyond the site boundary it is more likely that Environmental Assessment Levels relevant to human health will need to be considered.

The hydrogen cyanide generation scenarios A and B vary only in their overall release of hydrogen cyanide. In the current MAPP scenario B is considered as an unlikely but practical worst case incident. Scenario A considered herein is the absolute worst case situation where all available sulphuric acid mixes and reacts with all available sodium cyanide. This is considered highly improbable even in the case of a catastrophic incident such as a light aircraft impact.

For release scenario 1, the releases are vented to atmosphere via the extraction system which operates at fixed conditions. The dispersion pattern is the same for 1A and 1B with only the magnitude of the impact varying. For scenarios 2 and 3 the discharges are fugitive and the dispersion pattern is somewhat different to scenario 1 with a more localised impact.

At each location considered the maximum hydrogen cyanide concentration resulting from the releases considered is determined based on a 15 minute or 1 hour averaging period. The maximum concentrations represent the maximum determined for the averaging period over the five meteorological years considered.

Figures A.1 to A.12 provide detailed dispersion contour plots of the impact of all six scenarios.

4.1 Impact of releases within the site boundary

As shown in Figure 4.1 (expressed as a multiple of the exceedence of the WEL) the location of maximum process contribution to ambient hydrogen cyanide concentrations for release scenario A, where the release is passed through the ventilation system, is beyond the site boundary, although largely within the Meteor Business Park, in an arc from the south to north east. The fugitive release scenarios in 2 and 3 have a release with little momentum and as such the higher concentrations tend to occur closer to the release point and generally around the immediate area of Hangar 4 and mostly within the site boundary.

At the locations considered in Figure 3.2 the maximum hydrogen cyanide concentrations determined are summarised in Table 4.1 in terms of the workplace exposure limit.

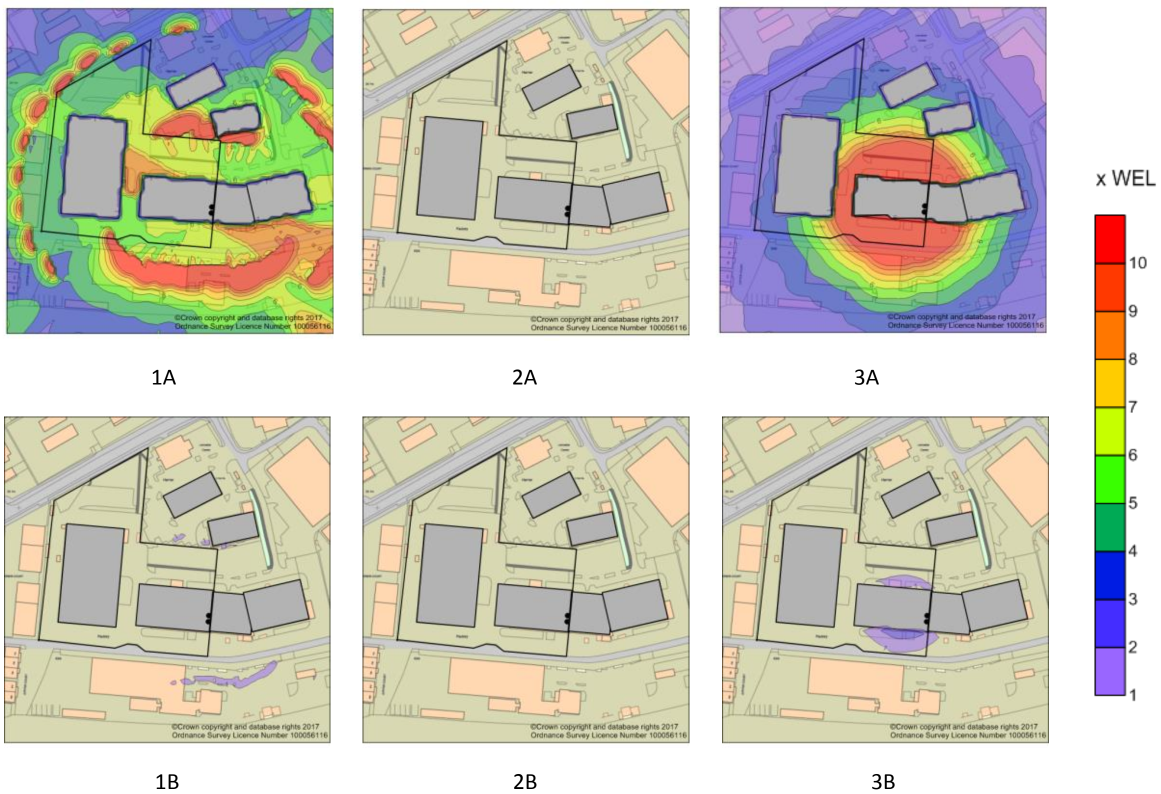
For scenario A, which is considered a highly improbable worse case condition, the maximum concentration at ground level within the site boundary occurs when the release is not confined (3A) and is equivalent to around 6300% of the WEL and while concentrations are highest around the Hangar 4 building the WEL across all of the site is exceeded. Lower concentrations are found where the release is confined and the extraction system is employed (1A), although concentrations across the entire site still exceed the WEL. The most effective means of limiting ambient exposure is to confine the release and allow a gradual fugitive release to atmosphere (2A). In this case there is some exceedence of the WEL around first floor window level of Hangar 4, but concentrations around the remainder of the site are within the WEL.

Table 4.1 Process contributions of hydrogen cyanide at on site locations

Location (see Figure 3.2)	Maximum process contribution of hydrogen cyanide (% WEL[a])					
	1A	2A	3A	1B	2B	3B
Maximum (ground level)	887	52	6300	39	2	290
s1	679	27	3162	30	1	148
s2	814	38	2660	36	2	125
s3	887	51	1532	39	2	72
s4	534	49	1562	24	2	73
s5	642	38	2656	28	2	125
s6	423	32	340	19	1	16
s7	671	45	596	30	2	28
s8	887	49	838	39	2	39
s9	534	49	931	24	2	44
s10	531	39	515	24	2	24
s11	679	49	1296	30	2	61
1s1	679	209	3246	30	10	152
1s2	814	195	2840	36	9	133
1s3	887	113	1578	39	5	74
1s4	534	131	1641	24	6	77
1s5	642	199	3025	28	9	142
1s6	423	35	336	19	2	16
1s7	671	56	590	30	3	28
1s9	534	84	995	24	4	47
1s10	531	50	548	24	2	26

a. The short term WEL for hydrogen cyanide is 11000 µg/m^3 averaged over a 15 minute period.
b. s and 1s indicates ground floor (1.5 m) and high level window (9.0 m) levels.

Figure 4.1 Dispersion pattern of releases over the site



For scenario B which is considered a more likely worst case, only the unconfined release scenario (3B) results in an exceedence of the WEL on site and then just in the immediate surroundings of Hangar 4. For release scenarios 1 and 2 there is compliance with the WEL within the site boundary.

In the event of a release from the Metals Finishes Facility it would be most appropriate to muster and evacuate towards the east and to avoid the immediate areas around Hangar 4 and the main gate

4.2 Impact of releases beyond the site boundary

The pattern of dispersion of release beyond the site boundary (expressed as a multiple of the EAL) is shown in Figure 4.2 for all scenarios. As might be expected the higher releases associated with HCN generation scenario A result in significantly higher concentrations than the corresponding scenario B, where releases are much lower. The predicted process contribution of HCN at the selected near commercial and residential receptors (see Tables 3.2 and 3.3) are summarised in Table 4.2.

Residential properties to the north east of the site around Bamfurlong Lane and nearby properties to the south west along the B4063 are the generally the most affected residential locations beyond the site boundary regardless of the release scenario. For generation scenario A there is exceedance of the EAL at all residential locations whether the release is by extractive or fugitive means. Process contributions tend to be higher when the release is extracted through flues A1 and A2 (scenario 1) as the release has more momentum and travels further. Process contributions are lower with the fugitive release mechanisms (2 and 3) as the release has less momentum and concentrates close to the point of release.

Figure 4.2 Dispersion pattern of releases beyond the site boundary

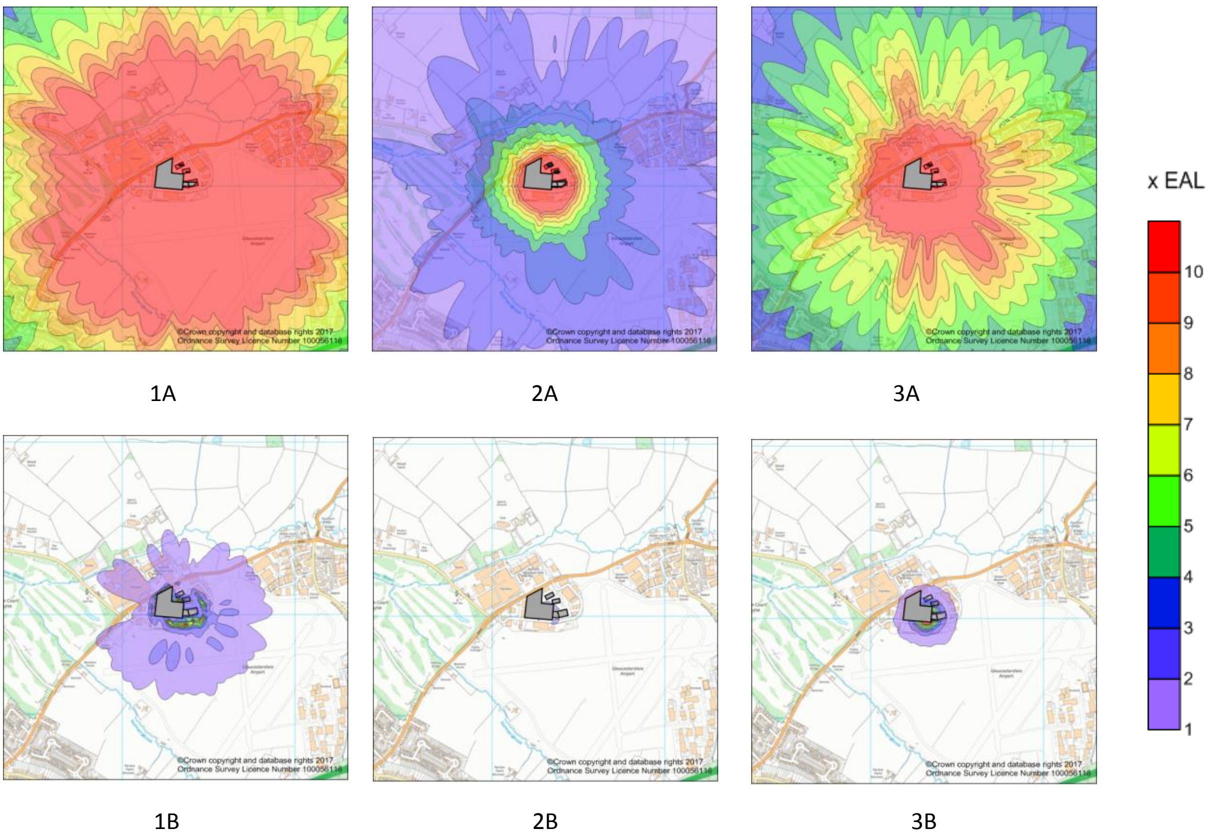


Table 4.2 Process contributions of hydrogen cyanide at off site locations

Location (see Figure 3.1)		Maximum process contribution of hydrogen cyanide (% EAL[a])					
		1A	2A	3A	1B	2B	3B
1	Terncourt	1070	216	478	48	10	22
2	The Channings	810	193	458	36	9	22
3	Bridge Farm	912	290	577	41	13	27
4	Wood Farm	483	150	291	22	7	14
5	Mobile Home Park	1305	313	627	58	14	29
6	Poplar Cottage	2729	340	776	122	16	36
7	Blenheim House	1478	253	766	66	12	36
8	Boxtrees	1192	263	648	53	12	30
9	Snowdon Gardens	705	201	433	31	9	20
10	Orchard Way	835	258	517	37	12	24
11	Westover Court	898	253	508	40	12	24
12	Field End	586	173	400	26	8	19
13	Holtham Avenue	661	245	490	29	11	23
14	Parton Farm	902	254	570	40	12	27
15	Bamfurlong Lane 1	1174	318	629	52	15	30
16	Bamfurlong Lane 2	1072	248	594	48	11	28
17	Bamfurlong Lane 3	1118	278	655	50	13	31
18	Ambulance station	2818	634	1374	125	29	64
19	Ashville Business Park	2471	449	1033	110	21	48
20	Mitsubishi	4588	775	1866	202	36	88
21	Completely Motoring	6268	947	2387	280	44	112
22	Mercedes Benz	3676	966	2190	163	45	103
23	Actemium	3579	872	2075	157	40	97
24	Safran 1 (other division)	5918	1251	3129	263	58	147
25	Clarkson Evans	28789	1180	2905	1278	55	136
26	Safran 2 (other division)	3805	724	1745	169	33	82
27	Safran 2 (other division)	4997	534	1195	222	25	56
28	Anson Business Park 1	2668	374	768	119	17	36
29	Anson Business park 2	1963	289	856	88	13	40
30	Airport terminal	1027	261	575	46	12	27
31	710-720 Jupiter Court	7115	1081	2728	317	50	128
32	730-810 Jupiter Court	4083	1070	2679	182	49	126
33	820 Jupiter Court	3655	957	2334	162	44	110
34	Severn Trent Water 1	15053	2167	8531	660	100	400
35	Severn Trent Water 2	7869	2186	15680	348	101	736
36	Severn Trent Water 3	12233	2065	7327	542	95	344
37	Brabazon 1	24379	2171	8435	1074	100	396
38	Brabazon 2	11023	1843	6047	485	85	284
39	Brabazon 3	11637	2114	7519	515	98	353
40	Harrier 1	7097	1865	5664	315	86	266
41	Harrier 2	5851	1760	4991	260	81	234

Table 4.2 (continued)

Location (see Figure 3.1)		Maximum process contribution of hydrogen cyanide (% EAL[a])					
		1A	2A	3A	1B	2B	3B
42	Harrier 3	4343	1509	3851	192	70	181
43	Lancaster Centre 1	4343	1286	3188	192	59	150
44	Lancaster Centre 2	23228	1323	3306	1029	61	155
45	Vernon Court 1	4915	1199	3036	217	55	142
46	Vernon Court 2	5012	1254	3313	222	58	155
47	GE Aviation 1	7146	2367	18732	316	109	879
48	GE Aviation 2	7146	2207	9180	316	102	431
49	GE Aviation 3	10248	2427	21395	453	112	1004
50	GE Aviation 4	6367	1819	5950	282	84	279

a. The short term EAL for hydrogen cyanide is 220 μg/m^3 averaged over a one hour period.

For generation scenario B the EAL is met comfortably at most residential locations with the confined fugitive release mechanism (2B) providing the lowest process contributions.

Commercial locations neighbouring the Safran site on the Meteor Business Park are more greatly affected than residential locations. Large exceedances of the EAL are predicted for release scenarios 1A to 3A with the Severn Trent site to the south and the Lancaster Centre to the north being particularly affected. Exceedences are greatest with Scenario A, although there is general exceedance of EAL with all scenarios considered. Scenario 2B provides the lowest impact, again demonstrating the effectiveness of confining the HCN generated and allowing a gradual release.

On the basis of Environmental Agency assessment criteria the process contribution of hydrogen cyanide would be considered significant at all residential and commercial locations considered in all scenarios. It is considered that the more probable worst case generation scenario (B) is unlikely to have significant impacts on either nearby commercial or residential locations, if suitable precautions are taken. Remaining within premises with doors and window closed will allow time for external concentrations to drop to a safe level by dispersion. Alternatively evacuation will reduce exposure times and, as shown in Figure 4.1, concentrations beyond the site boundary are generally less than the 15 minute WEL.

4.3 Influence of meteorological conditions

Table 4.3 summarises the influence of meteorological conditions on maximum process contributions at all residential receptors for the six scenarios considered.

The annual variations in meteorological conditions did not have a significant influence on maximum process contributions in most cases. As such it would not be expected that the conclusions of this assessment would be significantly changed by normal variations in meteorological conditions. It should be noted that this assessment is based on the maximum process contribution at each receptor for each 15 minute and hour period in each of the five years considered and as such will be an over estimate for the vast majority of the time.

Table 4.3 Influence of meteorological conditions on maximum process contribution of hydrogen cyanide

Location (see Figure 3.1)		Process contribution of hydrogen cyanide ratio of maximum to minimum (2011 to 2015) 15 minutes averaging (WEL)					
		1A	1B	2A	2B	3A	3B
1	Terncourt	1.4	1.4	1.4	1.4	1.6	1.6
2	The Channings	1.3	1.3	1.4	1.4	1.3	1.3
3	Bridge Farm	1.2	1.2	1.9	1.9	1.6	1.6
4	Wood Farm	1.1	1.1	1.8	1.8	1.6	1.6
5	Mobile Home Park	1.2	1.2	1.4	1.4	1.1	1.1
6	Poplar Cottage	1.8	1.8	1.1	1.1	1.1	1.1
7	Blenheim House	1.2	1.2	1.3	1.3	1.3	1.3
8	Boxtrees	1.2	1.2	1.2	1.2	1.1	1.1
9	Snowdon Gardens	1.1	1.1	1.1	1.1	1.1	1.1
10	Orchard Way	1.1	1.1	1.6	1.6	1.2	1.2
11	Westover Court	1.2	1.2	1.4	1.4	1.1	1.1
12	Field End	1.1	1.1	1.1	1.1	1.0	1.0
13	Holtham Avenue	1.1	1.1	1.7	1.7	1.4	1.4
14	Parton Farm	1.2	1.2	1.5	1.5	1.2	1.2
15	Bamfurlong Lane 1	1.2	1.2	1.3	1.3	1.1	1.1
16	Bamfurlong Lane 2	1.1	1.1	1.2	1.2	1.1	1.1
17	Bamfurlong Lane 3	1.2	1.2	1.1	1.1	1.0	1.0

4.4 Modelling uncertainty

The use of models to predict the dispersion of releases has associated uncertainties. The main uncertainties in this assessment result from:

- The dispersion of hydrogen cyanide within the Metal Finishing Facility is assumed to be confined to the cadmium and chromium plating area served by the ventilation systems exhausting to A1 and A2. Further dispersion throughout the building and release via other systems present, including by fugitive means, would lead to a different dispersion pattern and an extended extraction period. This is judged to have a beneficial effect on maximum process contributions.

- The hydrogen cyanide release determined for each scenario is based on all sulphuric acid available reacting with sodium cyanide and only limited by the presence of sodium hydroxide and sodium carbonate. This assumes all vats to be operating at capacity at the middle point of the chemical control range. In practice it is unlikely that all vats will be in this condition.

- In Scenario 2A and 2B a fugitive release rate equivalent to an air change every 2 hours has been assumed. This is considered to be reasonable for the building, although if the building were better sealed resulting in discharges over a longer period, then ambient impact would be reduced in proportion to the ventilation rate.

- The meteorological conditions upon which the assessment was based vary from hour to hour and year to year and influence ambient impact. A sensitivity analysis has shown the differences expected due to changes in meteorological conditions for a five year period. This assessment is based on the 15 minute or one hour period during each of the five years considered providing the maximum impact and as such is likely to be an overestimate for the vast majority of the time.

- The necessary assumptions made regarding surface characteristics (section 3.4) can have either a negative or positive impact on modelling outcomes. Sensitivity analyses indicates that a precautionary approach has generally been adopted in the assumptions made which tends towards an over estimate of ambient impact in most cases. The likely effects of modelling assumptions are not considered significant in terms of the conclusions of the assessment.

There are inherent uncertainties associated with the use of air dispersion models to predict the ambient impact of releases. With this in mind the assessment herein has been undertaken using conservative assumptions which tend towards an over estimation of the ambient impact. It is therefore considered that the assessment has taken a conservative approach and the conclusions reached therefore incorporate a reasonable margin of comfort in spite of the inevitable uncertainty of such modelling studies.

5 CONCLUSIONS

Safran Landing Systems GLS placed a contract with Environmental Scientifics Group Limited (ESG) to undertake an assessment of the impact on local air quality of an abnormal release of hydrogen cyanide from the metal finishing operations at its Meteor Business Park site. Two hydrogen cyanide generation scenarios (A & B) and three release scenarios (1, 2 and 3) were considered.

The absolute worst case hydrogen cyanide generation scenario (A) was considered where a failure of all vats and bund containments resulted in the mixing of the total vat inventory of sodium cyanide and sulphuric acid associated with chromium and cadmium plating with total reaction to produce hydrogen cyanide limited only by the presence of sodium hydroxide and sodium carbonate. A more realistic worst case (B) involving a limited failure of vats and bunds was also considered.

Assuming that the Metal Finishing Facility is evacuated and the air within extracted to atmosphere via the existing ventilation systems serving the vats, the resulting dispersion of hydrogen cyanide releases is predicted to have maximum impact beyond the site boundary, but within the Meteor Business Park. A maximum concentration of 8 times the workplace exposure limit is expected to occur on site. Beyond the site boundary process contributions exceed the Environmental Assessment Level for human health for hydrogen cyanide at all neighbouring commercial premises and residential locations within 1 km.

For the scenario where the release was confined within the Hangar 4 building and the extraction system shutdown with only fugitive releases to atmosphere, concentrations within the site boundary were predicted to be reduced to below the WEL at all ground level locations and to drop considerably at locations beyond the site boundary. This appears to be a somewhat more effective control measure for the protection of site workers following a release than the continued use of the extraction systems.

In the case of a complete failure of the containment of the Hangar 4 building the highest on site concentrations are experienced with the main affect being around the immediate vicinity of Hangar 4. Resulting concentrations beyond the site boundary are above the EAL at neighbouring commercial premises and residential locations, although at lower concentrations that for an extractive release.

The hydrogen cyanide generation scenario A reflects the maximum possible release and is considered highly unlikely. Scenario B is the more likely worst case scenario involving limited vat mixing which has been considered in previous assessments at Safran. For all release scenarios this provides a much lower ambient hydrogen cyanide impact than the corresponding scenario A with most concentrations being within the WEL on site and within the EAL at nearby residential locations. Although the concentrations at the nearest commercial neighbours exceed the EAL for exposure over an hour, this is much reduced and manageable with appropriate evacuation or containment procedures.

The assessment indicates that containment of the release within the Hangar 4 building and subsequent gradual release by fugitive means is likely to provide the least ambient impact and will generally ensure concentrations remain within the WEL and EAL for the most likely scenarios. The use of the existing extraction system to remove any hydrogen cyanide generated will result in higher concentrations beyond the site boundary. A full failure of containment is the worst case release scenario and tends to result in very high concentrations of hydrogen cyanide local to the release point.

In the event of a release from the Metals Finishes Facility it would be most appropriate to muster and evacuate towards the east of the site and to avoid the immediate areas around Hangar 4 and the main gate.

It is considered that the more probable worst case generation scenario with limited vat mixing is unlikely to cause environmental benchmark exceedence either on site or on nearby commercial or residential locations, if suitable precautions are taken. Remaining within premises with doors and window closed will allow time for external concentrations to drop to a safe level by dispersion. Alternatively evacuation will reduce the time exposed to the release with exposure unlikely to be in excess of the 15 minute workplace exposure level.

Necessary assumptions made to undertake the modelling are considered to have the effect of overestimating the process contribution to ambient concentrations of hydrogen cyanide. It is therefore considered that the predicted process impact on ambient concentrations reported herein is a conservative assessment and the conclusions reached therefore incorporate a reasonable margin of comfort in spite of the inevitable uncertainty of such modelling studies.

6 REFERENCES

1. Environment Agency and Department for Environment Food and Rural Affairs, Risk assessment for specific activities, environmental permits, Environmental Management guidance: Air emissions risk assessment for your environmental permit, 2 August 2016 (www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#environmental-standards-for-air).

2. Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

3. Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.

4. SI 2010:1001, Environmental Protection, The Air Quality Standards Regulations 2010.

5. Health and Safety Executive, EH240/2005 Workplace exposure limits, March 2013.

6. Hydrogen cyanide and Cyanides: human health aspects, Concise International Chemical Assessment, WHO, 2004.

7. Personal communication, email, G Brain (Safran Landing Systems GLS) to N Ford, 29 March 2017.

Annex A Dispersion modelling contour plots

The results of the modelling of the impact of hydrogen cyanide releases on ambient ground level concentrations are presented in tabular form in Section 4. In Annex A the results are presented as contour plots of the process contribution to ambient concentrations. All results are presented as the maximum contribution of the process (excluding existing background concentrations), expressed as a multiple of the applicable environmental benchmark. All plots are based on the maximum ambient concentration over the receptor grid for the five years (2011 to 2015) considered in the assessment.

The plots are considered over an area of 300 m x 300 m (see Figure 3.2) which essentially covers the immediate site where the workplace exposure limit (WEL) for hydrogen cyanide is considered to apply. Plots are also provided for a wider area (2 km x 2 km, see Figure 3.1) which covers the area in the immediate vicinity of the site and includes the closest commercial/industrial neighbours on the Meteor Business Park and residential locations. In this area, excluding the Safran site, the Environmental Assessment Level (EAL) for human health is considered to apply.

Contour plots are scaled between 1 and 10 times the environmental benchmark. An area with no colouring indicates a concentration below the applicable environmental benchmark. An area in red indicates a concentration equivalent to 10 or more times the environmental benchmark.

The figures presented consider both generation scenarios A and B.

The following figures are presented:

Generation Scenario A

Maximum possible generation of hydrogen cyanide by combination of all vat inventories

Release scenario 1

Extraction by ventilation systems through flues A1 and A2

Figure A.1 Scenario 1A - Predicted concentrations of hydrogen cyanide (maximum 15 minutes mean - WEL) at 1.5 m

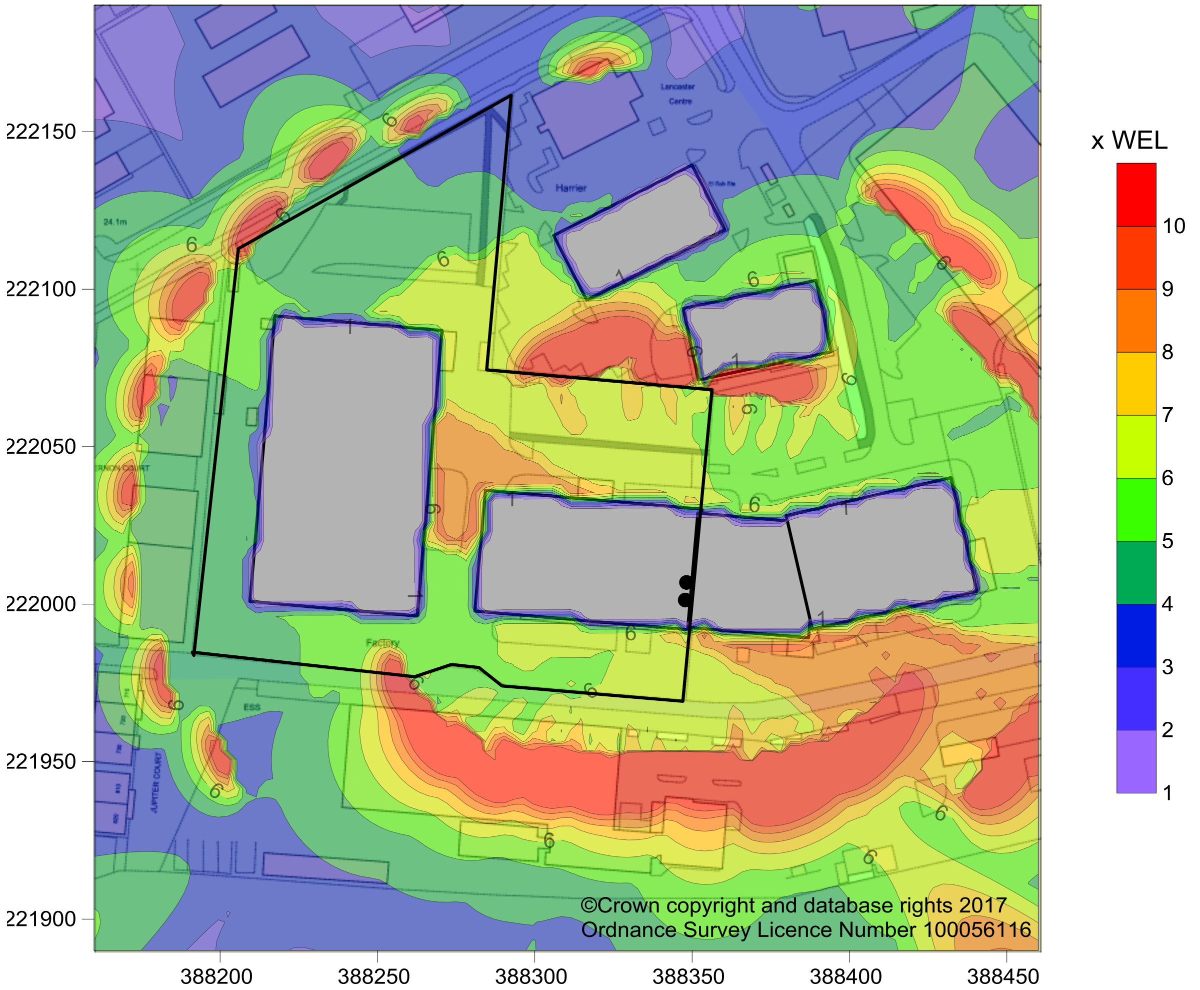
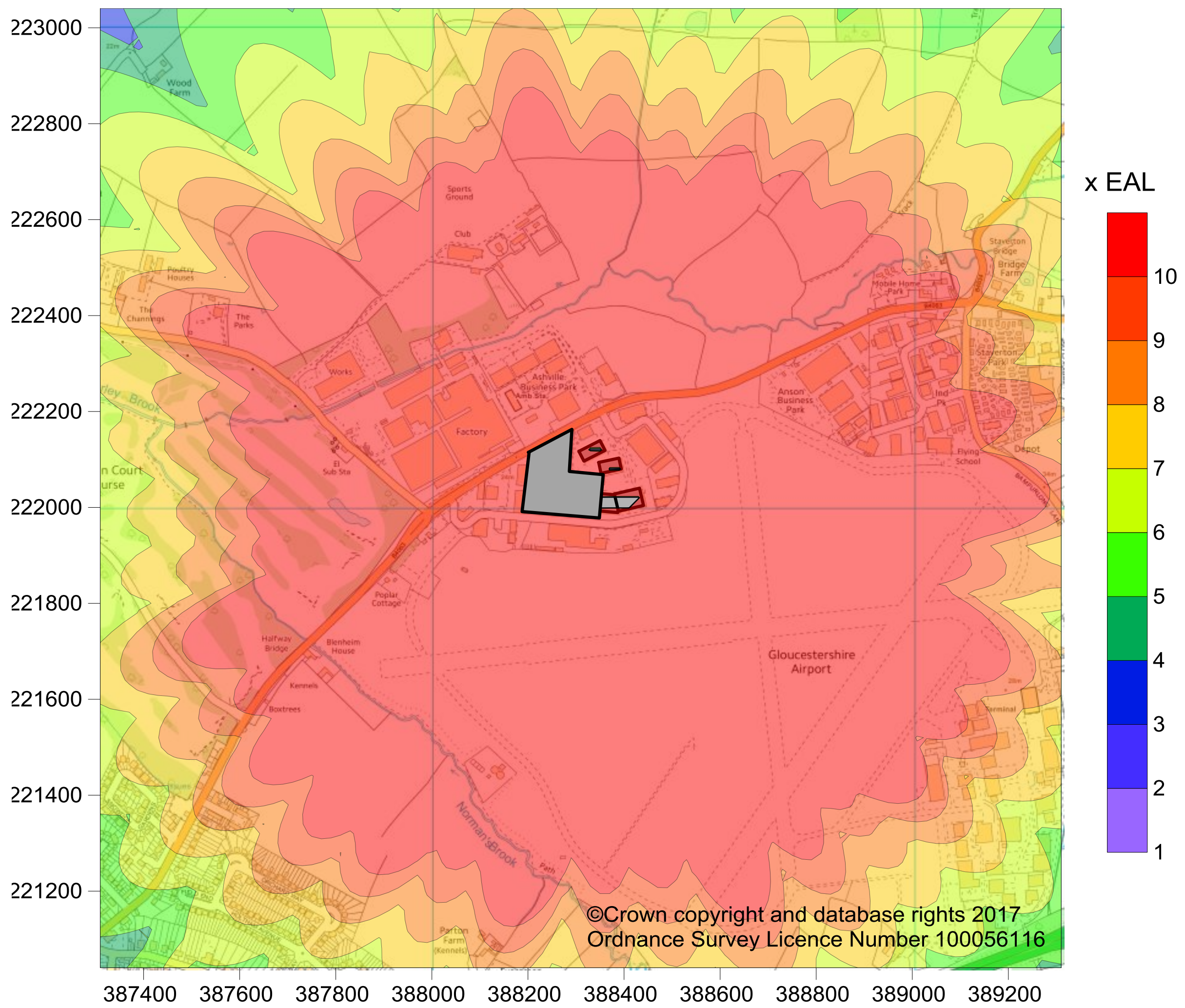


Figure A.2 Scenario 1A - Predicted concentrations of hydrogen cyanide (maximum 1 hour mean - EAL) at 1.5 m



Release scenario 2

Hangar 4 building sealed and release by fugitive leakage only

Figure A.3 Scenario 2A - Predicted concentrations of hydrogen cyanide (maximum 15 minutes mean - WEL) at 1.5 m

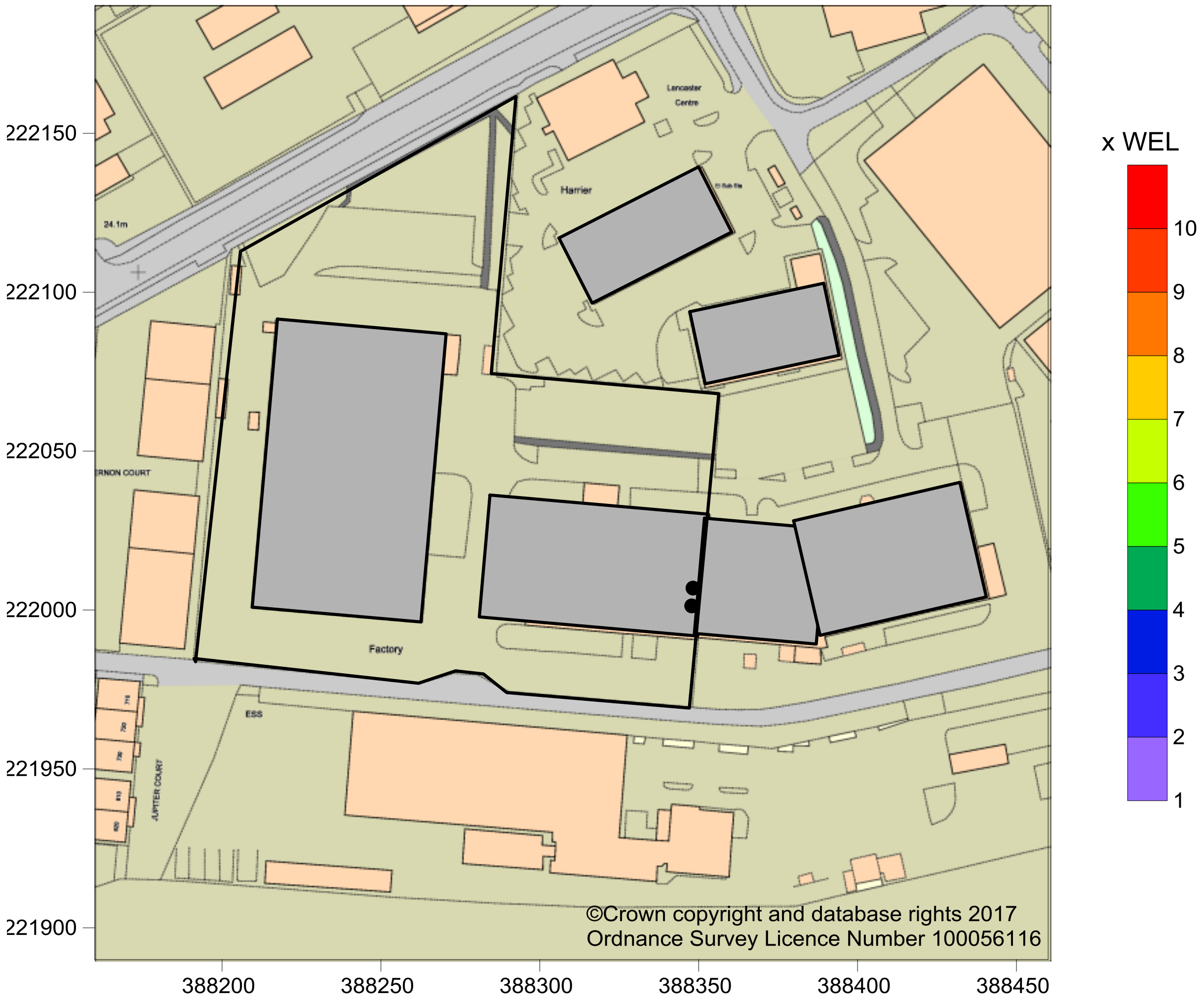
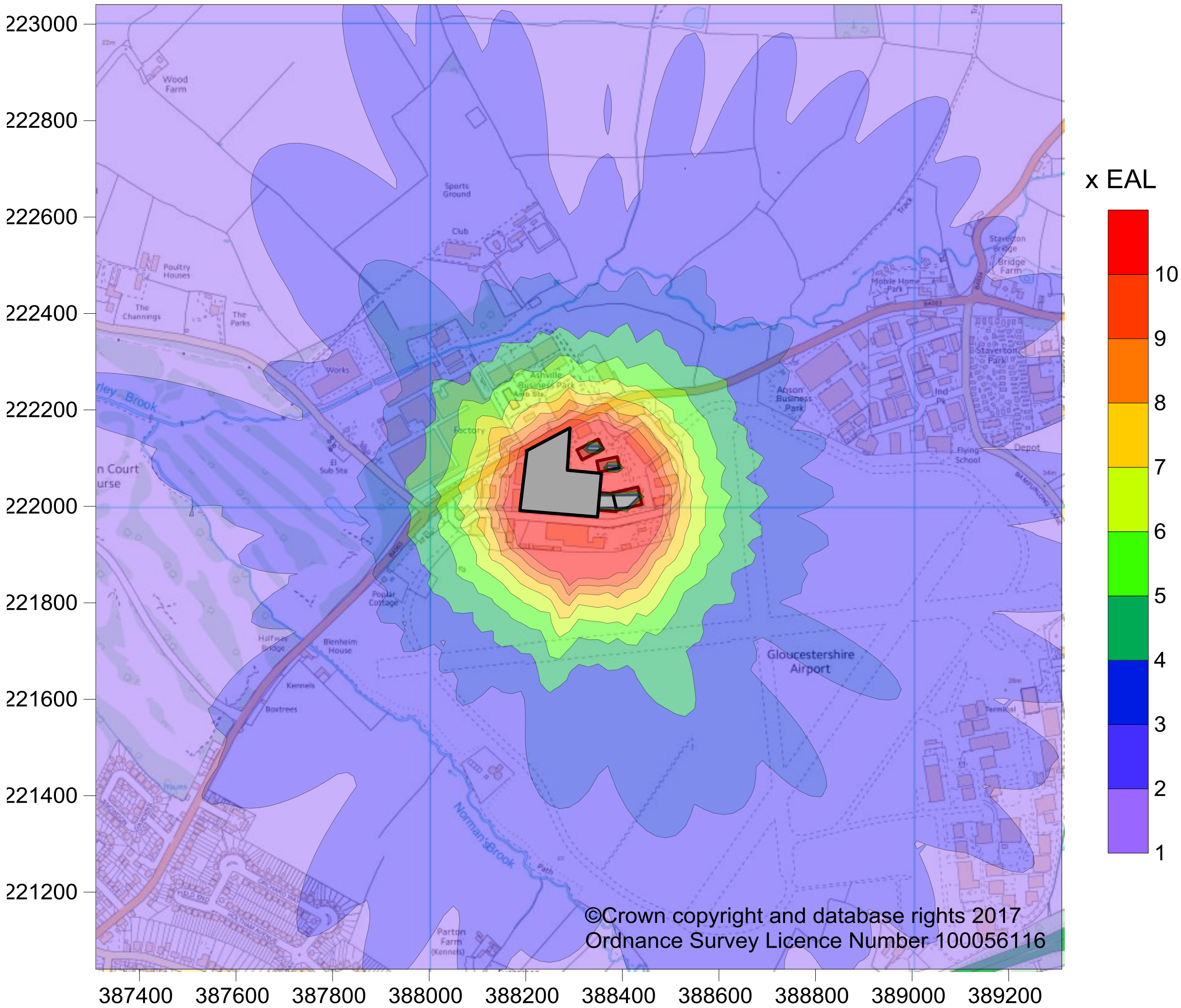


Figure A.4 Scenario 2A - Predicted concentrations of hydrogen cyanide (maximum 1 hour mean - EAL) at 1.5 m



Release scenario 3

Hangar 4 building containment breeched with unconfined release

Figure A.5 Scenario 3A - Predicted concentrations of hydrogen cyanide (maximum 15 minutes mean - WEL) at 1.5 m

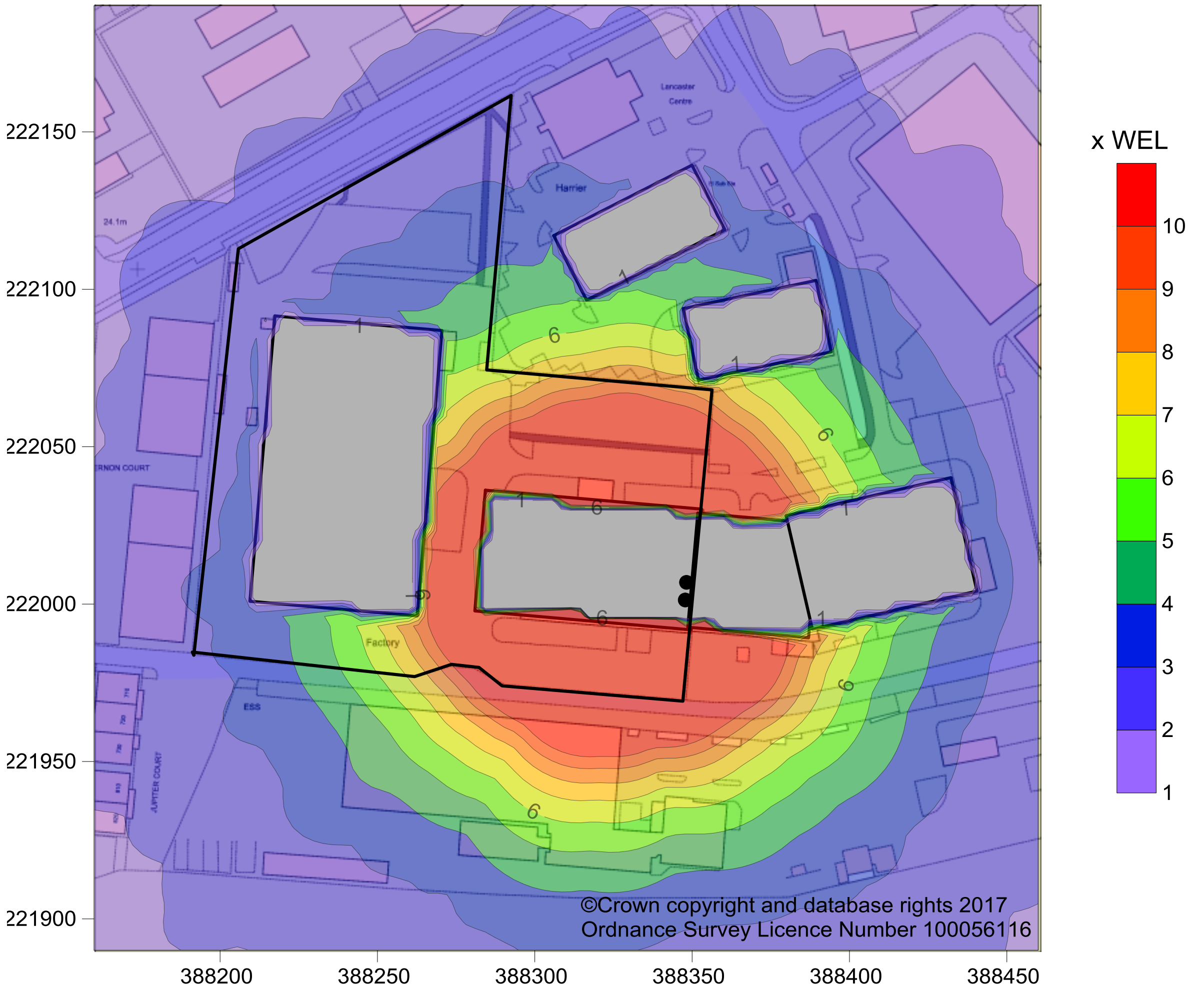
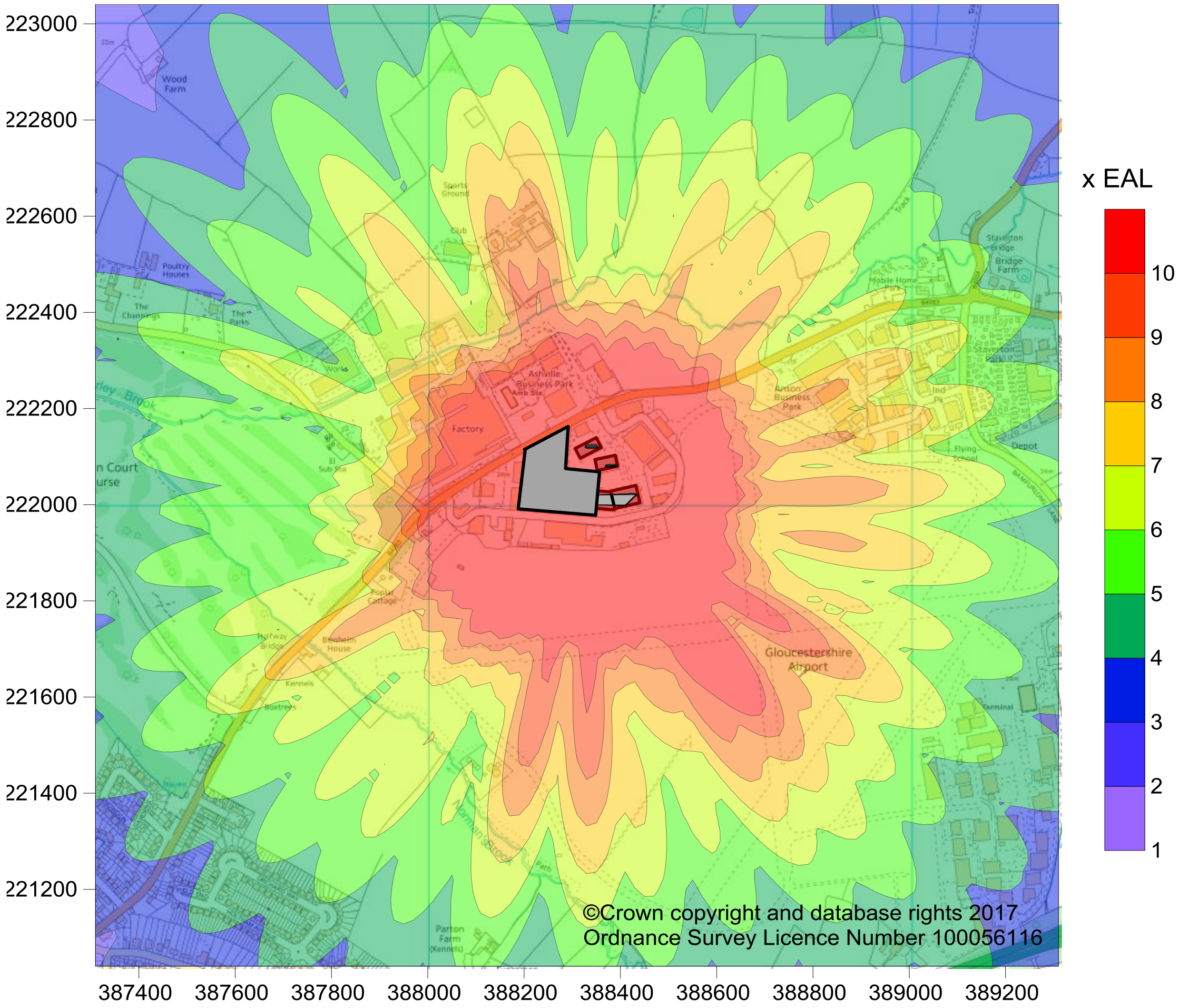


Figure A.6 Scenario 3A - Predicted concentrations of hydrogen cyanide (maximum 1 hour mean - EAL) at 1.5 m



Generation Scenario B

Hydrogen cyanide produced from mixing of Vats 1, 3 and 4 react with the contents of vat 45

Release scenario 1

Extraction by ventilation systems through flues A1 and A2

Figure A.7 Scenario 1B - Predicted concentrations of hydrogen cyanide (maximum 15 minutes mean - WEL) at 1.5 m

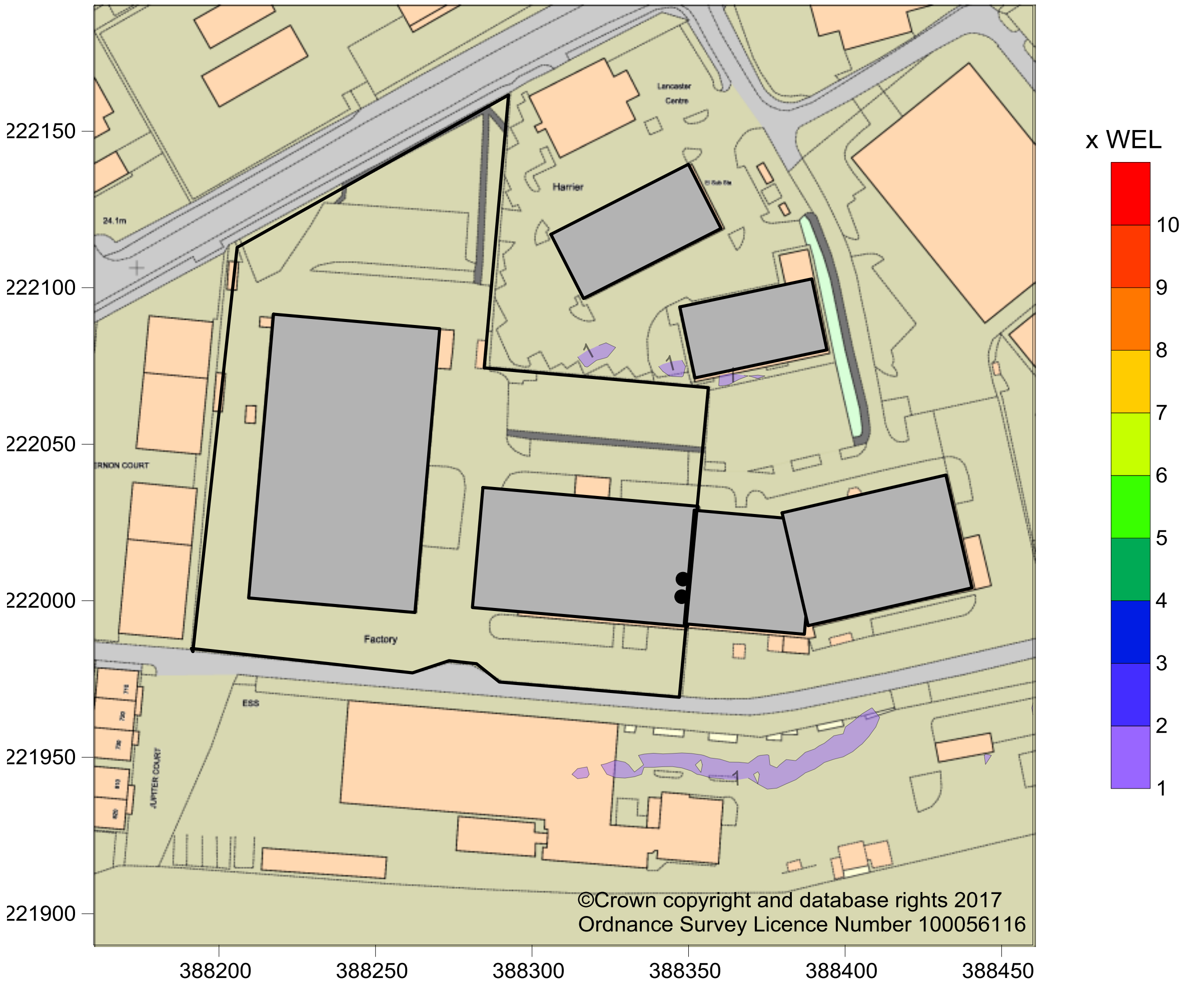
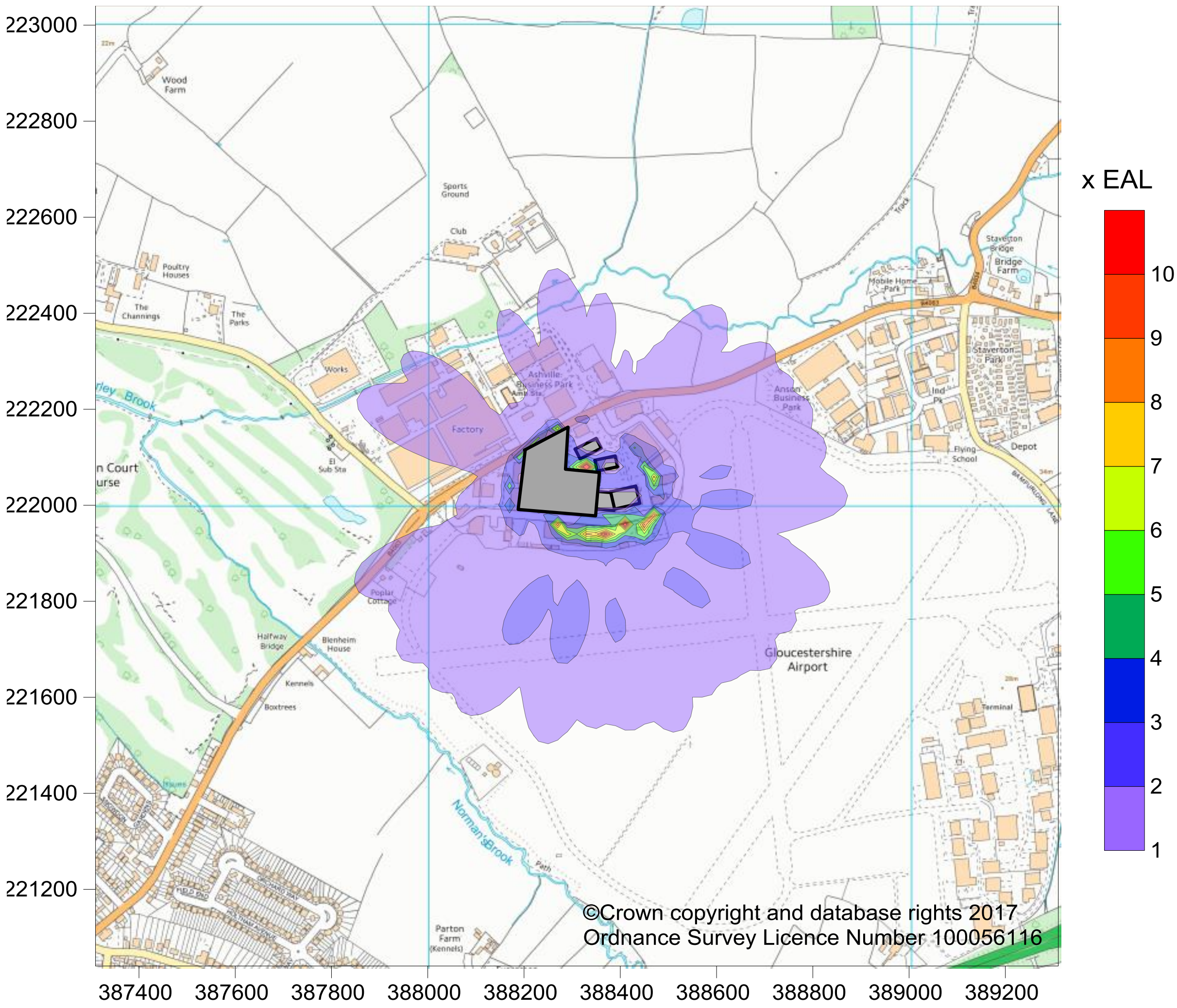


Figure A.8 Scenario 1B - Predicted concentrations of hydrogen cyanide (maximum 1 hour mean - EAL) at 1.5 m



Release scenario 2

Hangar 4 building sealed and release by fugitive leakage only

Figure A.9 Scenario 2B - Predicted concentrations of hydrogen cyanide (maximum 15 minutes mean - WEL) at 1.5 m

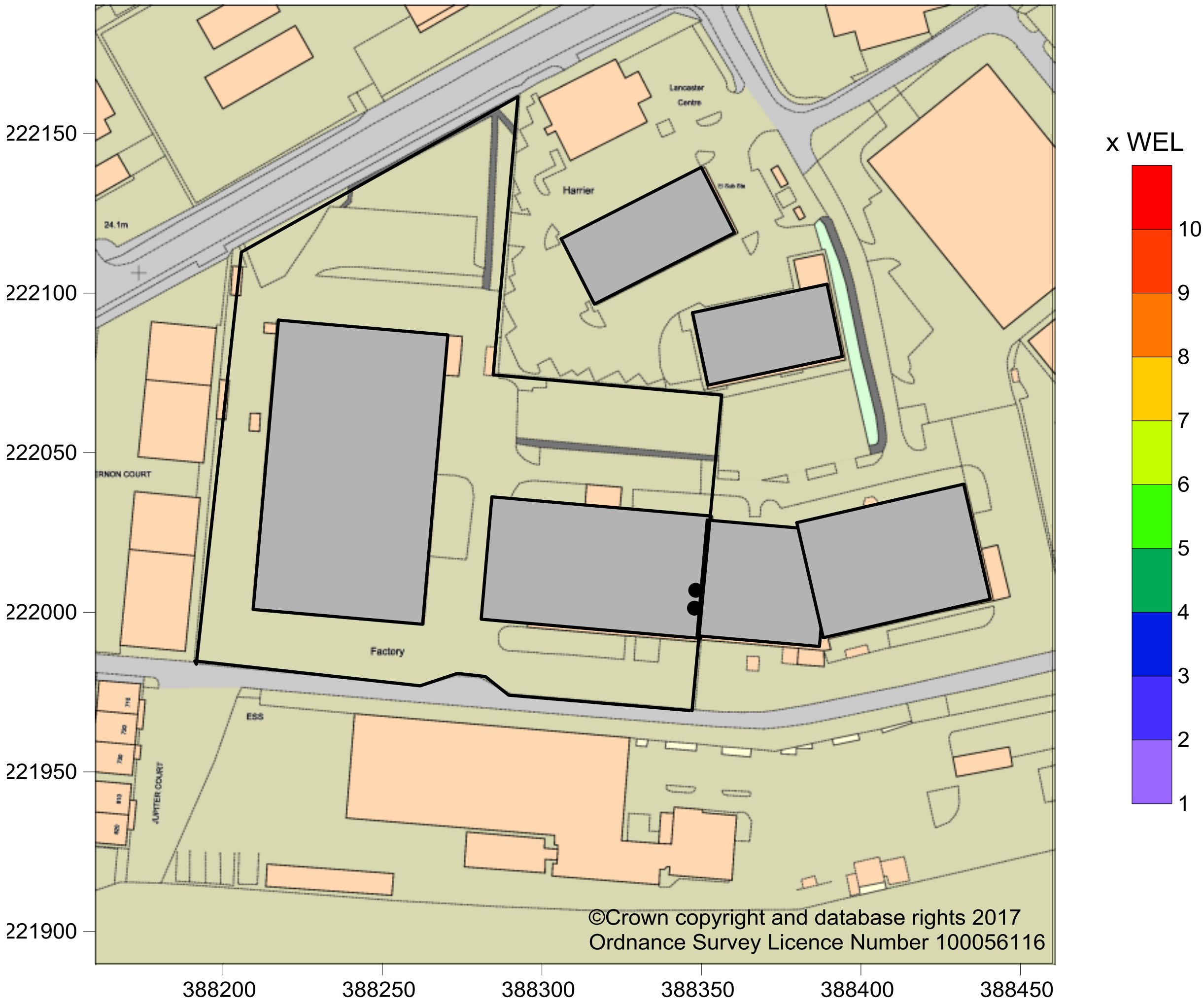
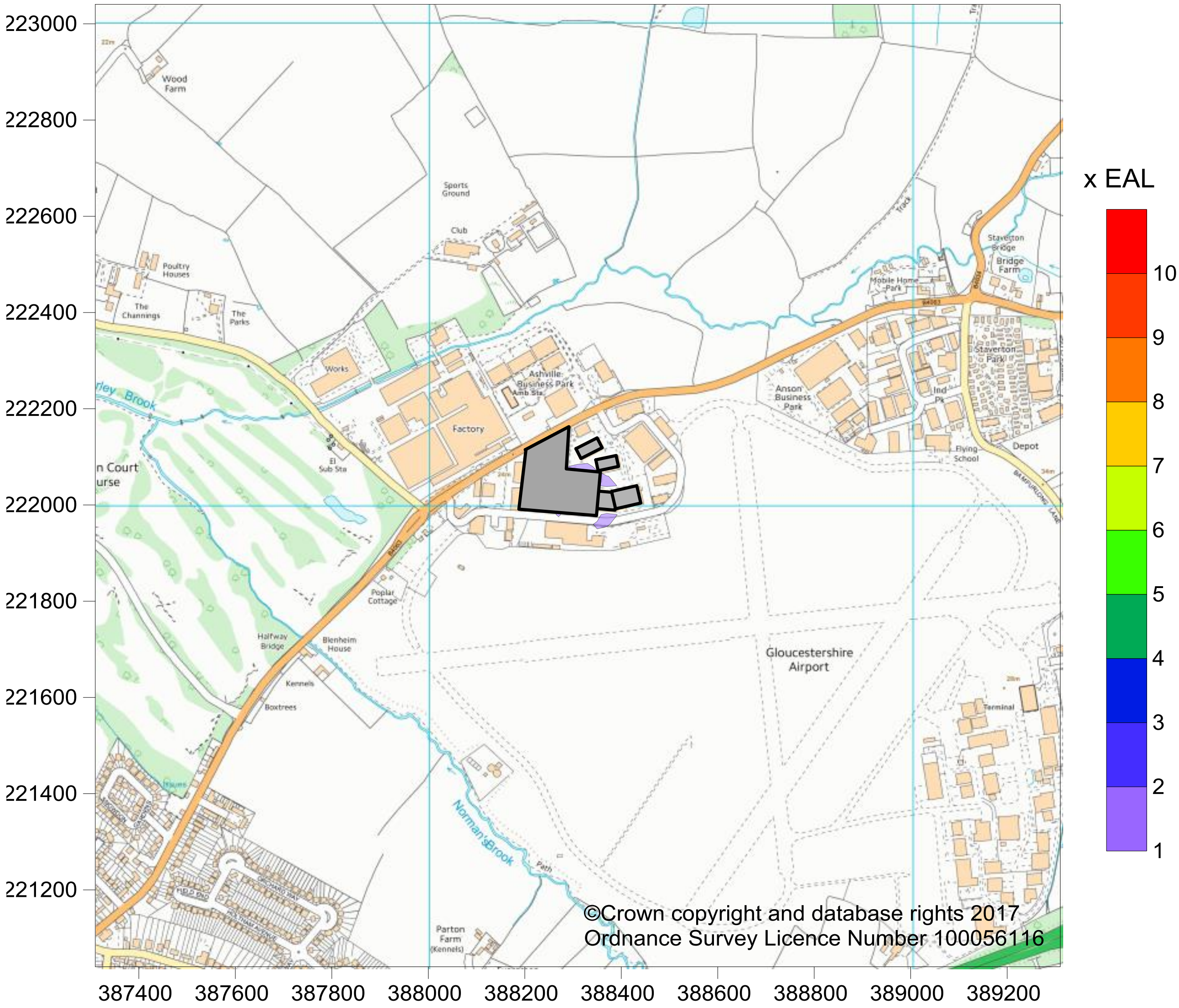


Figure A.10 Scenario 2B - Predicted concentrations of hydrogen cyanide (maximum 1 hour mean - EAL) at 1.5 m



Release scenario 3

Hangar 4 building containment breeched with unconfined release

Figure A.11 Scenario 3B - Predicted concentrations of hydrogen cyanide (maximum 15 minutes mean - WEL) at 1.5 m

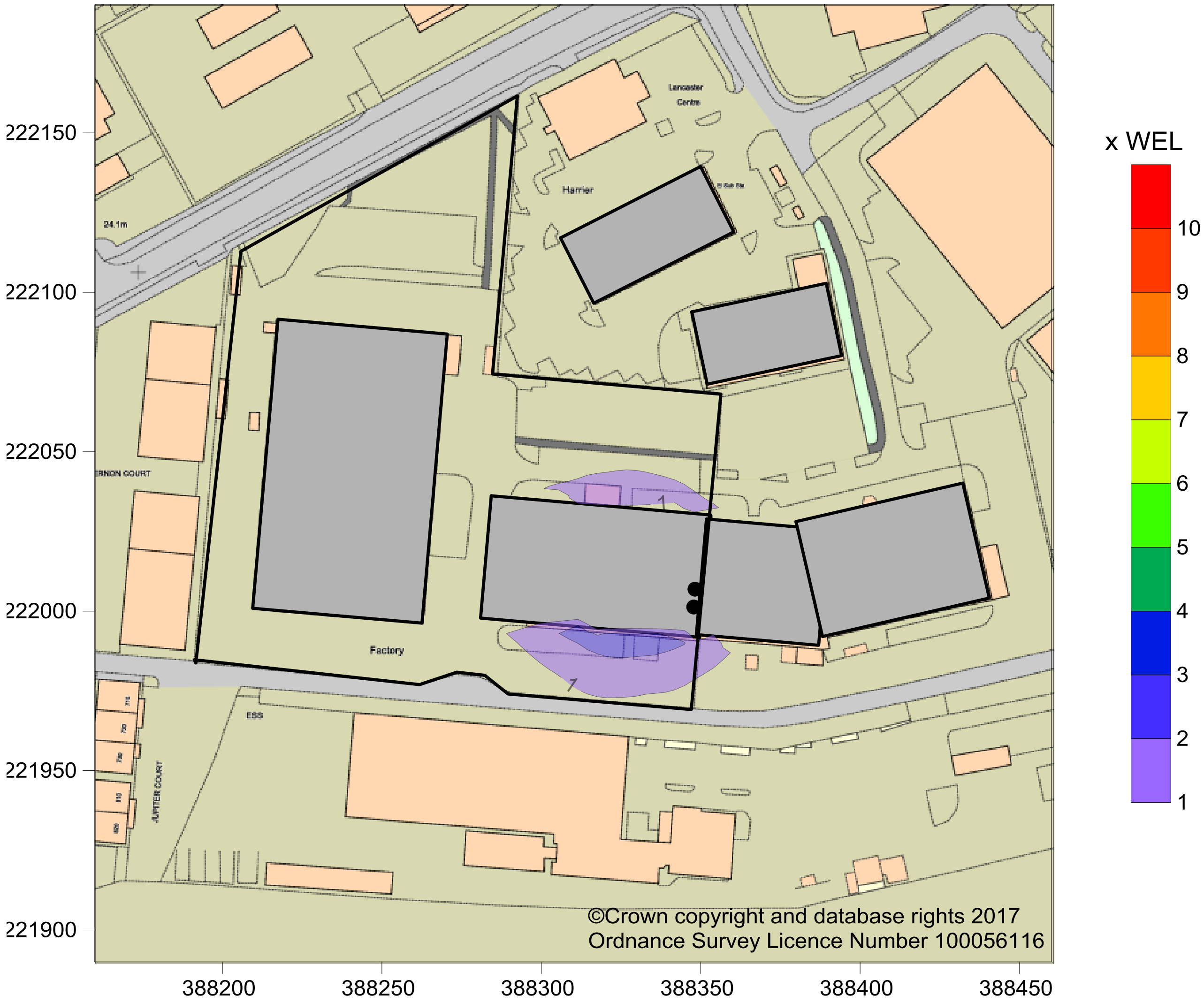
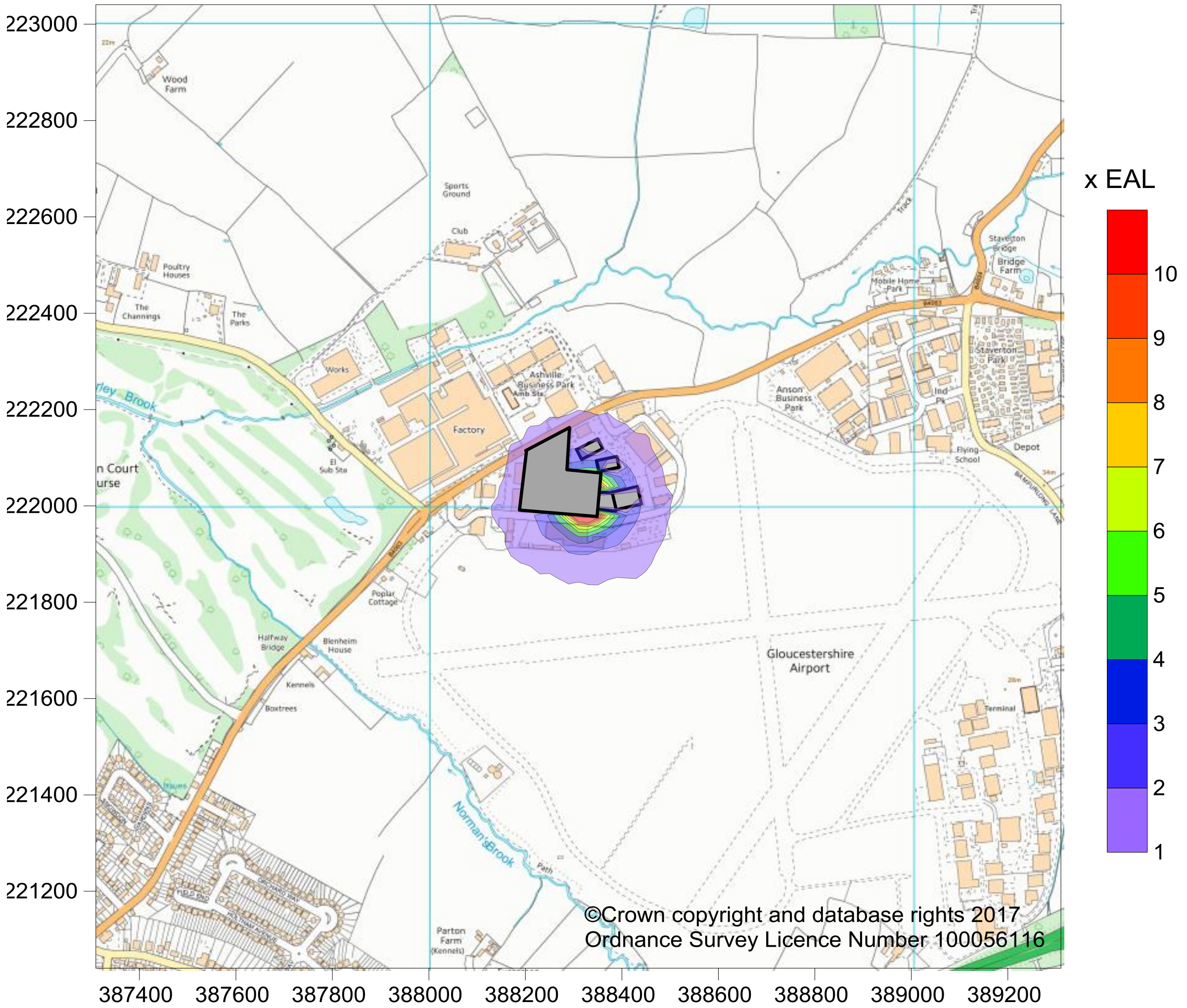


Figure A.12 Scenario 3B - Predicted concentrations of hydrogen cyanide (maximum 1 hour mean - EAL) at 1.5 m



ANNEX B Model input data

The input data used in the current assessment have been provided under separate cover. Electronic files containing the input data used in the modelling of the maximum process contributions have been provided as detailed below:

Scenarios 1A and 1 B

Hydrogen cyanide (1 hour)	SAF 1A S 2014.APL
Hydrogen cyanide (15 minutes)	SAF 1A L 2014.APL

Scenarios 2A & 2B

Hydrogen cyanide (1 hour)	SAF 1A S 2015.APL
Hydrogen cyanide (15 minutes)	SAF 1A L 2015.APL

Scenarios 3A & 3B

Hydrogen cyanide (1 hour)	SAF 1A S 2013.APL
Hydrogen cyanide (15 minutes)	SAF 1A L 2013.APL

END OF REPORT

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