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KRONOSPAN

CHIRK WOOD BASED PANEL PRODUCTION FACILITY

HUMAN HEALTH RISK ASSESSMENT

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1 Introduction

Kronospan Limited (Kronospan) operates a panel board manufacturing facility at their site in Chirk, North Wales (the Facility). The panel board manufacturing process is operated in accordance with an Environmental Permit (EP) which was granted by Wrexham Borough Council (WCBC) (Ref: WCBC/IPPC/03/KR(V2)). In addition to the EP granted by WCBC, the Formalin plant and combustion processes which supply power and heat to support the manufacturing process is operated in accordance with an EP which is regulated by Natural Resources Wales (NRW) (Ref: EA/EPR/BW9999IG/V004).

The application is seeking to transfer all WCBC EP to be regulated by NRW. In addition to this it is proposed to apply for a new Chip Plant and Orientated Strand Board (OSB) line. A full detailed explanation of the agreed process of applying for the EP application is detailed within the Supporting Information report.

The K8 biomass plant currently permitted by WCBC, is a co-incineration plant. As such the plant is required to comply with the Industrial Emissions Directive (IED). The IED includes limits on emissions of heavy metals and dioxins and furans which will be transposed into the NRW permit.

The advice from health specialists such as the Health Protection Agency that the damage to health from emissions from incineration and co-incineration plants is likely to be very small, and probably not detectable. Nevertheless, the specific effects on human health of the proposed plant have been considered, and are presented in this report.

For most substances released from the Facility, the most significant effects on human health will arise by inhalation. The Air Quality Assessment Levels (AQALs) outlined within the Dispersion Modelling Assessment have been set by the various authorities at a level which is considered to present minimum or zero risk to human health. It is widely accepted that, if the concentrations in the atmosphere are less than the AQALs, then the pollutant is unlikely to have an adverse effect on human health.

For some pollutants which accumulate in the environment, inhalation is only one of the potential exposure routes. Therefore, other exposure routes are considered in this assessment.

2 Issue Identification

2.1 Issue

The key issue for consideration is the release of substances from the Facility to atmosphere which have the potential to harm human health. No other sources will include emissions of either metals or dioxins. The Facility is located on the Kronospan site in Chirk.

The Facility will be designed to meet the emission limits outlined in the IED (2010/75/EU). Limits have been set for pollutants known to be produced during the combustion of municipal waste which have the potential to impact upon the local environment either on human health or ecological receptors. These pollutants include:

- nitrogen dioxide, sulphur dioxide, particulate matter, carbon monoxide, ammonia;
- acid gases - hydrogen chloride, and hydrogen fluoride;
- total organic carbon;
- metals - mercury, cadmium, thallium, antimony, arsenic, lead, cobalt, copper, manganese, nickel and vanadium;
- dioxin and furans;
- dioxin like PCBs; and
- polycyclic aromatic hydrocarbons (PAHs).

For most substances released from the Facility, the most significant effects on human health will arise by inhalation. A Dispersion Modelling Assessment has been undertaken to determine the impact of atmospheric concentrations of the pollutants listed above based on the levels transposed under UK Law in the UK Air Quality Strategy and those set by the Environment Agency. These levels have been set at a level which is considered to present minimum or zero risk to human health.

Some pollutants, including dioxins, furans, dioxin-like polychlorinated biphenyls (PCBs) and heavy metals, accumulate in the environment, which means that inhalation is only one of the potential exposure routes. Therefore, impacts cannot be evaluated in terms of their effects on human health by simply reference to ambient air quality standards. An assessment needs to be made of the overall human exposure to the substances by the local population and the risk that this exposure causes.

2.2 Chemicals of Potential Concern (COPC)

The substances which have been considered within this assessment are those which are authorised (as listed above) and for which Tolerable Daily Intake (TDI) or Index Doses (IDs) have been set by the Environment Agency. Although Emission Limit Values (ELVs) for PAHs are not currently set from installations, monitoring is required by legislation in the UK. Therefore, benzo(a)pyrene has been included in the assessment to represent PAH emissions. The following have been considered COPCs for the purpose of this assessment:

- PCDD/Fs (individual congeners) and dioxin like PCBs;
- Benzene;
- Benzo(a)pyrene;
- Mercury (Hg);
- Mercuric chloride;
- Cadmium (Cd);
- Arsenic (As);
- Chromium (Cr), trivalent and hexavalent; and
- Nickel (Ni).

This risk assessment investigates the potential for long term health effect of these COPCs through other routes than just inhalation.

3 Assessment Criteria

IRAP calculates the total exposure through each of the different pathways so that a dose from inhalation and ingestion can be calculated for each receptor. By default, these doses are then used to calculate a cancer risk, using the USEPA's approach. However, the Environment Agency recommends that the results be assessed using the UK's approach, which is explained in the Environment Agency's document "Human Health Toxicological Assessment of Contaminants in Soil", ref SC050021. This approach involves two types of assessment:

- For substances with a threshold level for toxicity, a Tolerable Daily Intake (TDI) is defined. This is "an estimate of the amount of a contaminant, expressed on a bodyweight basis, which can be ingested daily over a lifetime without appreciable health risk." A Mean Daily Intake (MDI) is also defined, which is the typical intake from background sources (including dietary intake) across the UK. In order to assess the impact of the Facility, the predicted intake of a substance due to emissions from the Facility is added to the MDI and compared with the TDI.
- For substances without a threshold level for toxicity, an Index Dose (ID) is defined. This is a level of exposure which is associated with a negligible risk to human health. The predicted intake of a substance due to emissions from the Facility is compared directly with the ID without taking account of background levels.

Substances can reach the body either through inhalation or through ingestion (oral exposure) and the body handles chemicals differently depending on the route of exposure. For this reason, different TDI and IDs are defined for inhalation and oral exposure.

The following table outlines the MDIs (the typical intake from existing background sources) for the pollutants released from the Facility. These figures are defined in the "Contaminants in soil: updated collation of toxicology data and intake values for humans" series of toxicological reports, available from the Environment Agency's website. The values for Nickel have been taken from the Environment Agency's August 2015 document following the publication of the new expert opinion by the European Food Safety Authority.

Table 3.1: Mean Daily Intake of Each Substance

Substance	Mean Daily Intake, 70 kg adult (µg/kg bw/day)		Mean Daily Intake, 20 kg child (µg/kg bw/day)	
	Intake Ingestion	Intake, Inhalation	Intake Ingestion	Intake, Inhalation
Arsenic	0.07	0.0002	0.19	0.0005
Benzene	0.04	2.9	0.11	7.4
Benzene(a)pyrene	-	-	-	-
Cadmium	0.19	0.0003	0.5	0.0007
Chromium	1.81	0.0009	4.70	0.002
Chromium (VI)	0.18	-	0.47	-
Methyl mercury	0.007	-	0.019	-
Mercuric chloride	0.014	-	0.037	-
Nickel	1.9	0.0037	4.96	0.0096
Dioxins and dioxin like PCBs	0.7 pg WHO-TEQ/kg bw/day		1.8 pg WHO-TEQ/kg bw/day	

Table 3.2: Tolerable Daily Intake of Each Substance (µg/kg bw/day)				
Substance	Index dose, Ingestion	Index dose, Inhalation	TDI, Ingestion	TDI, Inhalation
Arsenic	0.3	0.002	-	-
Benzene	0.29	1.4	-	-
Benzene(a)pyrene	0.02	0.00007	-	-
Cadmium	-	-	0.36	0.0014
Chromium	-	0.001	3	-
Chromium (VI)	-	-	3	-
Methyl mercury	-	-	0.23	0.23
Mercuric chloride	-	-	2	0.06
Elemental mercury			-	0.06
Nickel	-	-	2.8	0.006
Dioxins and dioxin like PCBs	-	-	2 pg WHO-TEQ/kg bw/day	

To allow comparison with the TDI for dioxins, intake values for each dioxin are multiplied by a factor known as the WHO-TEF. A full list of the WHO-TEF values for each dioxin is provided in Appendix A.

The following table presents the MDI for an adult and child as a proportion of the TDI.

Table 3.3: Mean Daily Intake of Each Substance as a % of the TDI				
Substance	Mean Daily Intake, 70 kg adult (µg/kg bw/day)		Mean Daily Intake, 20 kg child (µg/kg bw/day)	
	Intake Ingestion	Intake, Inhalation	Intake Ingestion	Intake, Inhalation
Cadmium	53.2%	20.4%	137.7%	52.9%
Chromium	60.5%	-	156.6%	-
Chromium (VI)	6.0%	-	15.7%	-
Methyl mercury	3.1%	-	8.0%	-
Mercuric chloride	0.7%	-	1.9%	-
Elemental mercury	-	1.2%	-	3.1%
Nickel (screening)	68.4%	61.7%	177.1%	159.7%
Nickel (based on monitoring data)	-	6.5%	-	16.9%
Dioxins and dioxin like PCBs	35.00%		90.00%	

As shown, the MDI of cadmium, chromium and nickel from existing sources exceeds the TDI for children.

The MDI for **chromium** is set for chromium III and taken from the DEFRA report "Contaminants in Soil: Collation of Toxicological Data and Intake Values for Humans. Chromium". This states that there are no published reports on the adverse effects in humans resulting from ingested chromium III. Almost all toxicological opinion is that chromium III compounds are of low oral toxicity, and indeed the UK Committee on Medial Aspects of Food Policy recommends chromium III in the diet. The World Health Organisation (WHO) have reviewed the daily intake of chromium from foods and found that existing levels do not represent a toxicity problem. The WHO conclude that "in the form of trivalent compounds, chromium is an essential nutrient and is relatively non-toxic for man and other mammalian species".

The DEFRA report explains that the TDI has been derived from the USEPA's Reference Dose of 3µg/kg bw/day for chromium (VI). This is the only explicitly derived safety limit for oral exposures of chromium. DEFRA recommends that the USEPA Reference Dose is applied to all the chromium content as a starting point. Therefore, the TDI presented in Table 3.2 is actually the TDI for chromium VI not chromium. Assessing the total dietary intake of chromium against this TDI is highly conservative.

The key determinant of **cadmium**'s toxicity potential is its chronic accumulation in the kidney. The Environment Agency in their toxicology report "SC050021/TOx 3) explain that chronic exposure to levels in excess of the TDI might be associated with an increase in kidney disease in a proportion of those exposed, but (small) exceedances lasting for shorter periods are of less consequence. Therefore, assessing a lifetime exposure is appropriate. If we assess the exposure of a receptor over a lifetime (i.e. a period as a child and adult) the lifetime MDI is below the TDI.

The MDI and TDI (oral) for **nickel** has been revised following the publication by the European Food Safety Authority of new expert opinion relating to the reproductive and developmental effects in experimental animals. The MDI exceeds the TDI for children for both inhalation and ingestion. The updated MDI for inhalation is 0.259µg/day for an adult which, assuming an inhalation rate of 20m^3/day, equates to an atmospheric concentration of 13.0ng/m^3. A review of monitoring undertaken across the UK shows that the annual average at rural background sites has ranged from 0.55 to 1.37ng/m^3. The rural background locations are considered representative of conditions in the vicinity of the Facility.

Applying the maximum background concentration of 1.37ng/m^3, the MDI would be 0.03µg/day or 6.5% of the inhalation TDI for an adult and 16.9% of the TDI for a child. This has been used as the value of the MDI for the remainder of this analysis.

4 Conceptual Site Model

4.1 Conceptual site model

A detailed Human Health Risk Assessment has been carried out using the Industrial Risk Assessment Program-Human Health (IRAP-h View – Version 4.0). The programme, created by Lakes Environmental, is based on the United States Environment Protection Agency (USEPA) Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities[1]. This Protocol is a development of the approach defined by Her Majesties Inspectorate on Pollution (HMIP) in the UK in 1996[2], taking account of further research since that date. The exposure pathways included in the IRAP model are shown in Figure 1.

Exposure to gaseous contaminants has the potential to occur by direct inhalation or vapour phase transfer to plants. In addition, exposure to particulate phase contaminants may occur via indirect pathways following the deposition of particles to soil. These pathways include:

- ingestion of soil and dust;
- uptake of contaminants from soil into the food-chain (through home-grown produce and crops); and
- direct deposition of particles onto above ground crops.

The pathways through which inhalation and ingestion occur and the receptors that have been considered to be impacted via each pathway are:

Table 4.1: Pathways Considered

Pathway	Residential	Agricultural	Allotment
Direct inhalation	Yes	Yes	Yes
Ingestion of soil	Yes	Yes	Yes
Ingestion of home-grown produce	Yes	Yes	Yes
Ingestion of drinking water	Yes	Yes	Yes
Ingestion of eggs from home-grown chickens	-	Yes	Yes
Ingestion of home-grown beef	-	Yes	-
Ingestion of home-grown port	-	Yes	-
Ingestion of home-grown milk	-	Yes	-
Ingestion of breast milk (infants only)	Infants only		

It is noted that some households may keep chickens and consume eggs and potentially the birds. The impact on these households is considered to be between the impact at an agricultural receptor and a standard resident receptor. In addition some properties may include allotments where residents may consume a greater amount of home-grown produce than a standard household. Therefore a modified agricultural receptor has been considered (the allotment type receptor) which has the same consumption rates as a agricultural receptor but excludes the ingestion of home-grown beef, pork and milk products.

1 USEPA (2005) Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities.

2 HMIP (1996) Risk Assessment of Dioxin Releases from Municipal Waste Incineration Processes.

As shown in Figure 1, the pathway from the ingestion of mother's milk in infants is considered within the assessment. This considers all dioxins and dioxin-like PCBs. The IRAP model calculates the amount of these COPCs entering the mother's milk and being passed on to the infants. The impacts are then compared against the TDI.

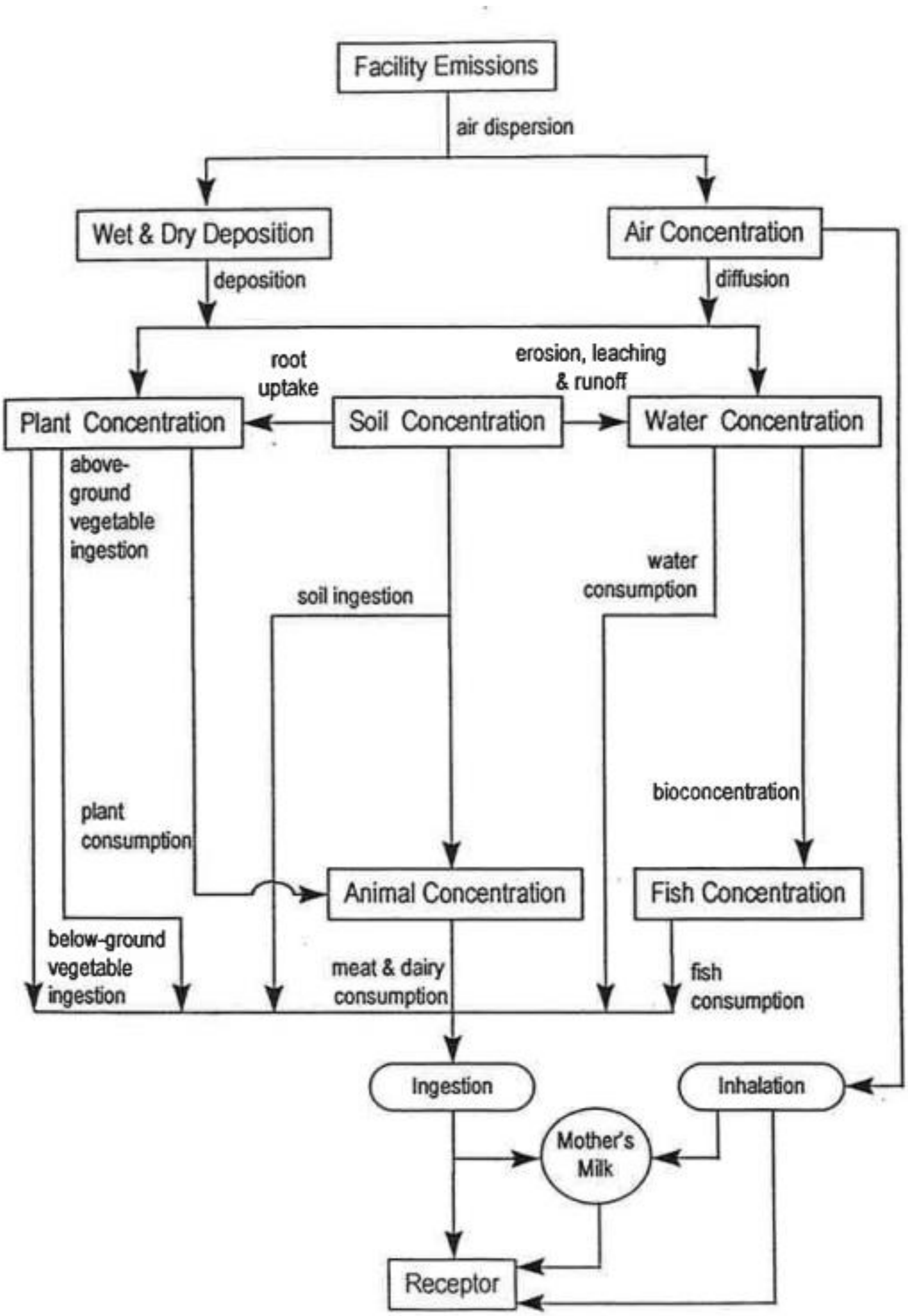

Figure 1: Conceptual Site Model – Exposure Pathways

4.2 Pathways excluded from assessment

The intake of dioxins via dermal absorption, groundwater and surface water exposure pathways is very limited and as such these pathways are excluded from the HHRA. The justification for excluding these pathways is highlighted in the following sections.

4.2.1 Dermal absorption

Both the HMIP and the USEPA note that the contribution from dermal exposure to soils impacted from thermal treatment facilities is typically a very minor pathway and is typically very small relative to contributions resulting from exposures via the food chain.

The USEPA[3] provide an example from the risk assessment conducted for the Waste Technologies, Inc. hazardous thermal treatment in East Liverpool, Ohio. This indicated that for an adult subsidence farmer in a subarea with high exposures, the risk resulting from soil ingestion and dermal contact was 50-fold less than the risk from any other pathway and 300-fold less than the total estimated risk.

The HMIP document[4] provides a screening calculation using conservative assumptions, which states for a 1pg I-TEQ/m^3 the intake via dermal absorption is 30 times lower than the intake via inhalation, which is itself a minor contributor to the total risk.

As such the pathway from dermal absorption is deemed to be an insignificant risk and has been excluded from this assessment.

4.2.2 Groundwater

Exposure via groundwater can only occur if the groundwater is contaminated and consumed untreated by an individual.

The USEPA[5] have concluded that the build-up of dioxins in the aquifer over realistic travel times relevant to human exposure was predicted to be so small as to be essentially zero.

As such the pathway from groundwater is deemed to be an insignificant risk and has been excluded from this assessment.

4.2.3 Surface water

It is noted that a possible pathway is via deposition of emissions directly onto surface water – i.e. local drinking water supplies or rainwater storage tanks.

Surface water generally goes through several treatment steps and as such any contaminants would be removed from the water before consumption. It is noted that run off to rainwater tanks may not go through the same treatment. However, rain water tanks have a very small surface area and as such the potential for deposition and build up of COPCs is limited. As such the pathway from contaminated surface water is deemed to be an insignificant risk and has been excluded from this assessment.

4.2.4 Fish consumption

The consumption of locally caught fish has been excluded from the assessment. Whilst it is noted that fish makes up a proportion of the UK diet, it is not likely that this would be sourced wide-scale from close proximity to the Facility.

[3] USEPA (2005) Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities.

[4] HMIP (1996) Risk Assessment of Dioxin Releases from Municipal Waste Incineration Processes.

[5] USEPA (2005) Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities.

A review of the local waterbodies has been undertaken to see if there are any game fishing lakes in the local area[6]. The closest game fishing lake is the Chirk Fisheries approximately 1.6km to the south west of the Facility. Whilst emissions from the Facility may have an impact at this location, it is considered highly unlikely that fish caught at this location would make up a significant proportion of the diet of a single individual. As such, the total contribution from the Facility would be very small and this pathway has been excluded from this assessment.

[6] Locations Map, http://www.fisharound.net/where-to-fish/locations-map

5 Sensitive Receptors

This assessment considers the possible effects on human health at key receptors, where humans are likely to be exposed to the greatest impact from the Facility, and at the point of maximum impact of annual mean emissions.

For the purposes of this assessment, receptor locations have been categorised as 'residential', 'allotment' or 'agricultural'. Residential receptors represent a known place of residence that is occupied within the study area. Agricultural receptors represent a farm holding or area land of horticultural interest, whereas allotment receptors represent areas of horticultural interest which do not consume home grown meat products with the exception of poultry. The emissions from the Facility are expected to be significant only in the locality of the plant. The specific receptors have been considered in this Assessment. In addition, a receptor has been assessed at the point of maximum impact, although it should be noted that this point is actually within the site boundary and is uninhabited. These sensitive receptors are listed in Table 5.1. Reference should be made to Appendix B which shows the location of these receptors with respect to the Facility.

An impact at an agricultural or allotment receptor is typically predicted to be greater than a residential receptor due to the additional pathways considered. Therefore, as a conservative assessment the allotment receptor has been applied at the sensitive receptors identified as schools. This is highly conservative as it assumes that produce is grown and consumed at the school.

Table 5.1: Sensitive Receptors

ID	Receptor Name	Location		Type of Receptor
		X	Y	
MAX	Point of maximum impact	328962	338433	Agricultural / Allotment / Residential
R1	Brynkinallt Home Farm	329717	338038	Agricultural
R2	Highfield Farm	329767	338684	Agricultural
R3	Chirk Green Farm	329513	338537	Agricultural
R4	Ley Farm	329867	339214	Agricultural
R5	Lodge Farm	329227	339568	Agricultural
R6	Afon-Bradley Farm	328687	339451	Agricultural
R7	New Hall Farm	327543	338884	Agricultural
R8	Pontfaen Farm	328380	336965	Agricultural
R9	Chirk Infant School	329166	338427	Allotment
R10	Ysgol y Waun Primary School	329338	338327	Allotment
R11	Chirk Green Road Allotments	329778	338571	Allotment
R12	Holyhead Road	329023	338452	Residential
R13	20 Ewart Street	329074	338766	Residential
R14	4 Crogen	328979	339008	Residential
R15	102 Crogen	329194	339065	Residential
R16	2 Maes Yr Ysgol	329130	338229	Residential

6 IRAP Model Assumptions and Inputs

The following section details the user defined assumptions used within the IRAP model and provides justifications where appropriate.

6.1 Concentrations in soil

The concentration of each chemical in the soil is calculated from the deposition results of the air quality modelling for vapour phase and particle phase deposition. The critical variables in calculating the accumulation of pollutants in the soil are as follows:

- the lifetime of the Facility is taken as 30 years; and
- the soil mixing depth is taken as 2 cm in general and 30 cm for produce.

The split between the solid and vapour phase for the substance considered depends on the specific physical properties of each chemical.

In order to assess the amount of substance which is lost from the soil each year through volatilisation, leaching and surface run-off, a soil loss constant is calculated. The rates for leaching and surface runoff are taken as constant, while the rate for volatilisation is calculated from the physical properties of each substance.

6.2 Concentrations in plants

The concentrations in plants are determined by considering direct deposition and air-to-plant transfer for above ground produce, and root uptake for above ground and below ground produce.

The calculation takes account of the different types of plant. For example, uptake of substances through the roots will differ for below ground and above ground vegetables, and deposition onto plants will be more significant for above ground vegetables.

6.3 Concentrations in animals

The concentrations in animals are calculated from the concentrations in plants, assumed consumption rates and bio-concentration factors. These vary for different animals and different substances, since the transfer of chemicals between the plants consumed and animal tissue varies.

It is also assumed that 100% of the plant materials eaten by animals is grown on soil contaminated by emission sources. This is likely to be a highly pessimistic assumption for UK farming practice.

6.4 Concentrations in humans

6.4.1 Intake via inhalation

This is calculated from inhalation rates of typical adults and children and atmospheric concentrations. The inhalation rates used for adults and children are:

- adults - 20m^3/day; and
- children – 7.2m^3/day.

These are as specified within the Environment Agency series of reports: "Contaminants in soil: updated collation of toxicology data and intake values for humans". The calculation also takes account of time spent outside, since most people spend most of their time indoors.

6.4.2 Intake via soil ingestion

This calculation allows for the ingestion of soil and takes account of different exposure frequencies. It allows for ingestion of soil attached to unwashed vegetables, unintended ingestion when farming or gardening and, for children, ingestion of soil when playing.

6.4.3 Ingestion of food

The calculation of exposure due to ingestion of food draws on the calculations of concentrations in animals and plants and takes account of different ingestion rates for the various food groups by different age groups.

For most people, locally-produced food is only a fraction of their diet and so exposure factors are applied to allow for this.

6.4.4 Breast milk ingestion

For infants, the primary route of exposure is through breast milk. The calculation draws on the exposure calculation for adults and then allows for the transfer of chemicals in breast milk to an infant who is exclusively breast-fed.

The only pathway considered for dioxins for a breast feeding infant is through breast milk. The modelled scenario consists of the accumulation of pollutants in the food chain up to an adult receptor, the accumulation of pollutants in breast milk and finally the consumption of breast milk by an infant.

The assumptions used were:

- Exposure duration of infant to breast milk — 1 year
- Proportion of ingested dioxin that is stored in fat — 0.9
- Proportion of mother's weight that is stored in fat — 0.3
- Fraction of fat in breast milk — 0.04
- Fraction of ingested contaminant that is absorbed — 0.9
- Half-life of dioxins in adults — 2,555 days
- Ingestion rate of breast milk — 0.688kg/day

6.5 Estimation of COPC concentration in media

The IRAP-h model uses a database of physical and chemical parameters to calculate the COPC concentrations through each of the different pathways identified. The base physical and chemical parameters have been used in this assessment.

In order to calculate the COPC concentrations, a number of site specific pieces of information are required.

Weather data was obtained for the period 2013 to 2017 from the Shawbury weather station, as used within the Dispersion Modelling Assessment. This provides the annual average precipitation which can be used to calculate the general IRAP-h input parameters, as presented in Table 6.1.

Table 6.1: Ground Type Dependent Properties		
Input Variable	**Assumption**	**Value (cm/year)**
Annual average evapotranspiration	70% of annual average precipitation	44.17
Annual average irrigation	0% of annual average precipitation	0.00
Annual average precipitation	100% of annual average precipitation	63.10
Annual average runoff	10% of annual average precipitation	6.31

The average wind speed was taken as 4.19 m/s, calculated from the average of the five years of weather data for the period 2013 to 2017 from the Shawbury weather station.

A number of assumptions have been made with regard to the deposition of the different phases. These are summarised in the following table.

Table 6.2: Deposition Assumptions			
Deposition Phase	**Dry Deposition Velocities (m/s)**	**Ratio Dry deposition to Wet deposition**	
		Dry Deposition	**Wet Deposition**
Vapour	0.005	1.0	2.0
Particle	0.010	1.0	2.0
Bound particle	0.010	1.0	2.0
Mercury vapour	0.029	1.0	0.0
Note: the above deposition velocities have been agreed with the UK Environment Agency for all IRAP based assessments where modelling of specific deposition of pollutants is not undertaken. These are considered to be conservative.			

These deposition assumptions have been applied to the annual mean concentrations predicted using the dispersion modelling which was undertaken as part of the Dispersion Modelling Assessment, to generate the inputs needed for the IRAP modelling. For details of the dispersion modelling methodology please refer to the Dispersion Modelling Assessment.

6.6 Modelled emissions

For the purpose of this assessment it is assumed that the Facility operates at the IED ELVs for its entire operational life. In reality the Facility will be shut down for periods of maintenance and monitoring of similar facilities in the UK shows that they operate below the ELVs.

The following tables present the emissions rates of each COPC modelled and the associated ELVs which have been used to derive the emission rate.

Table 6.3: COPC Emissions Modelled		
COPC	**Emission Limit Value (mg/Nm^3)**	**Emission rate (mg/s)**
Benzene	15	136.8
PAHs (Benzo(a)pyrene)	0.0003	0.0028728
Mercury	0.0001	0.000912
Mercuric chloride	0.024	0.21888
Cadmium	0.025	0.228
Arsenic	0.025	0.228
Chromium	0.092	0.83904
Chromium (VI)	0.00013	0.0011856
Nickel	0.220	2.0064

Table 6.4: COPC Emissions Modelled		
COPC	**Emission Limit Value (ng I-TEQ/Nm^3)**	**Emission rate (ng/s)**
TetraCDD,2,3,7,8	0.1	0.028
HexaCDD,1,2,3,7,8,9		0.187
OctaCDD,1,2,3,4,6,7,8,9		3.685
HeptaCDD,1,2,3,4,6,7,8		1.554
OctaCDF,1,2,3,4,6,7,8,9		3.251
HexaCDD,1,2,3,4,7,8		0.262
PentaCDD,1,2,3,7,8		0.223
TetraCDF,2,3,7,8		0.253
HeptaCDF,1,2,3,4,7,8,9		0.391
PentaCDF,2,3,4,7,8		0.488
PentaCDF,1,2,3,7,8		0.253
HexaCDF,1,2,3,6,7,8		0.736
HexaCDD,1,2,3,6,7,8		0.235
HexaCDF,2,3,4,6,7,8		0.794
HeptaCDF,1,2,3,4,6,7,8		4.007
HexaCDF,1,2,3,4,7,8		1.987
HexaCDF,1,2,3,7,8,9		0.038
Dioxin like PCBs	0.0138	0.126

A number of points should be noted for each group of COPCs:

(1) Benzene (Table 6.3).

a) It has been assumed that the entire TOC emissions consist of only benzene.

b) It has been assumed that TOC emissions are emitted at the daily ELV.

(2) PAHs (Table 6.3).

a) It has been assumed that the entire PAH emissions consist of only benzo(a)pyrene.

b) Benzo(a)pyrene is not a regulated pollutant within the IED. The highest recorded emission concentration of Benzo(a)pyrene from the UK Environment Agency's public register was 0.105ug/m³, or 0.000105mg/m³ (dry, 11% oxygen, 273K). As this is not a regulated pollutant and only monitored periodically we have applied a safety factor of 2 and converted to 6% reference oxygen content.

(3) Group 1 metals - mercury and compounds (Table 6.3).

a) It has been assumed that the ELV of total mercury is 0.05mg/Nm³.

b) The concentration of elemental mercury has been taken as 0.2% of the total mercury and compounds ELV.

c) The concentration of mercury chloride has been taken as 48% of the total mercury and compounds ELV.

d) The losses to the global cycle have been taken as 51.8% of the total mercury and compounds ELV.

(4) Group 2 metals - cadmium (Table 6.3).

a) The assessment is based on the IED ELV of 0.05mg/Nm³ for cadmium, thallium and compounds.

b) It is assumed that the emissions of cadmium are half of the combined ELV for cadmium and thallium.

(5) Group 3 metals – antimony, arsenic, chromium, lead and nickel (Table 6.3).

a) The assessment is based on the IED ELV of 0.5mg/Nm³ for "other metals".

b) The emissions of each of the nine "other metals" in the third group have been taken as no worse than a currently operating facility as detailed in Table A1 of the Environment Agency "Guidance on assessing group 3 metals stack emissions from incinerators – v4", which is reproduced in Table 6.5. This data is based on monitoring at 18 MWI and Waste Wood Co-Incinerators between 2007 and 2015 operating und the IED in the UK.

(6) Dioxins and furans (Table 6.4).

These are a group of similar halogenated organic compounds, which are generally found as a complex mixture. The toxicity of each compound is different and is generally expressed as a Toxic Equivalent Factor (TEF), which relates the toxicity of each individual compound to the toxicity of 2,3,7,8-TCDD, the most toxic dioxin. A full list of the TEF values for each dioxin is provided in Appendix A. The total concentration is then expressed as a Toxic Equivalent (TEQ). Exposure to each congener has been modelled separately and the TEFS applied at this point of considering human exposure to each conger. This approach ensure that the way each congener transfers through the food chain is accounted for.

The split of the different dioxins and furans is based on split of congeners for a release of 0.1ng I-TEQ/Nm³ as presented in Table A.7.

To determine the Emission Rate, the split of the different dioxins for a 0.1ng I-TEQ/Nm³ has been multiplied by normalised volumetric flow rate to determine the release rate of each congener as shown in Table 6.6. The output of the IRAP model is then multiplied by the TEFs set out in Table A.7 to determine the total intake TEQ for comparison with the TDI.

(7) Dioxin like PCBs (Table 6.4).

There are a total of 209 PCBs, which act in a similar manner to dioxins, are generally found in complex mixtures and also have TEFs.

The UK Environment Agency has advised that 44 measurements of dioxin like PCBs have been taken at 24 MWIs between 2008 and 2010. The following data summarises the measurements, all at 11% reference oxygen content:

- Maximum = 9.2×10^{-3} ng[TEQ]/m^3
- Mean = 2.6×10^{-3} ng[TEQ]/m^3
- Minimum = 5.6×10^{-5} ng[TEQ]/m^3

For the purpose of this assessment, as a conservative assumption, the maximum monitored PCB concentration has been used which has been converted to an emission rate using the volumetric flow rate at reference conditions.

The IRAP software, and the HHRAP database which underpins it, does not include any data on individual PCBs, but it does include data for take-up and accumulation rates within the food chain for two groups of PCBs, known as Aroclor 1254 and Aroclor 1016. Each Arocolor is based on a fixed composition of PCBs. Since we are not aware of any data on the specification of PCBs within incinerator emissions, as a worst-case assumption we have assumed that the PCBs are released in each of the two Aroclor compositions.

Table 6.5: Monitoring Data from Municipal Waste Incinerators

Pollutant	Measured Concentration as % of IED Group 3 Limit		
	Mean	Max	Min
Arsenic	0.20%	5.00%	0.04%
Chromium	1.68%	18.40%	0.04%
Chromium (VI)	0.007%	0.026%	0.00046%
Nickel	3.00%	44.00%	0.50%

Note:

The two highest nickel concentrations are outliers being 44%, as above, and 27% of the ELV. The third highest concentration is 0.53 mg/Nm³ or 11% of the ELV.

Table 6.6: Basis for the Emission Rate of Dioxins and Furans			
Dioxin / furan	**Split of Congeners for a release of 1 ng I-TEQ/Nm³**	**Total (I-TEQ) (ng/Nm³)**	**Emission rate (ng/s)**
2,3,7,8-TCDD	0.031	0.0283	0.028
1,2,3,7,8-PeCDD	0.245	0.2234	0.223
1,2,3,4,7,8-HxCDD	0.287	0.2617	0.262
1,2,3,6,7,8-HxCDD	0.258	0.2352	0.235
1,2,3,7,8,9-HxCDD	0.205	0.1869	0.187
1,2,3,4,6,7,8-HpCDD	1.704	1.5535	1.554
1,2,3,4,6,7,8,9-OctaCDD	4.042	3.6851	3.685
2,3,7,8-TCDF	0.277	0.2525	0.253
1,2,3,7,8-PCDF	0.277	0.2525	0.253
2,3,4,7,8-PCDF	0.535	0.4878	0.488
1,2,3,4,7,8-HxCDD	2.179	1.9866	1.987
1,2,3,6,7,8-HxCDF	0.807	0.7357	0.736
1,2,3,7,8,9-HxCDF	0.042	0.0383	0.038
2,3,4,6,7,8-HxCDF	0.871	0.7941	0.794
1,2,3,4,6,7,8-HpCDF	4.395	4.0069	4.007
1,2,3,4,7,8,9-HpCDF	0.429	0.3911	0.391
1,2,3,4,6,7,8,9-OctaCDF	3.566	3.2511	3.251
Total (I-TEQ)	20.150	18.3706	-

NOTES:

Split of the Congener taken from Table 7.2a from the HMIP document and factored by the ELV to determine the split for the proposed ELV. This has then been multiplied by the Normalised Volumetric Flow rate to determine the release rate in g/s.

7 Results

7.1 At point of maximum impact

The following tables present the impact of emissions from the Facility at the point of maximum impact for an 'Agricultural' receptor. As explained in section 4, this receptor type assumes the direct inhalation, and ingestion from soil, drinking water, and home-grown eggs and meat, beef, pork, and milk. This assumes that the person lives at the point of maximum impact and consumes home-grown produce etc. This is considered to be a very worst-case scenario, especially given that the area where this impact is predicted to occur is within the site boundary and is uninhabited. Reference should be made to Appendix B for the location of the point in relation to the Facility. Where appropriate a comparison has been made to the TDI or ID.

The TDI is an estimate of the amount of a contaminant, expressed on a bodyweight basis, which can be ingested daily over a lifetime without appreciable health risk. As shown in Table 7.1, for a worst-case receptor at the point of maximum impact, the overall impact (including the contribution from existing dietary intakes) is less than the TDI for chromium, chromium VI, methyl mercury, mercuric chloride, mercury, nickel and dioxins. Therefore, there would not be an appreciable health risk based on the emission of these pollutants.

For a child receptor the cadmium, chromium and nickel MDI (that sourced from existing dietary intake) exceeds the TDI. However, the process contribution is exceptionally small and the exceedance is a reflection of the fact the MDI is over 100% of the TDI. On this basis it is not considered that the Facility would increase the health risks from cadmium, chromium or nickel for children significantly.

As noted in Section 3, the key determinant of cadmium's toxicity potential is its chronic accumulation in the kidney. The Environment Agency explains that chronic exposure to levels in excess of either the TDI might be associated with an increase in kidney disease in a proportion of those exposed, but (small) exceedances lasting for shorter periods are of less consequence. If we assess the lifetime exposure (i.e. a period being a child and an adult) the overall impact is well below the TDI. Therefore, there would not be an appreciable health risk based on the emission of cadmium over a lifetime of an individual.

As explained in Section 3, almost all toxicological opinion is that chromium III compounds are of low oral toxicity and the WHO state that "in the form of trivalent compounds, chromium is an essential nutrient and is relatively non-toxic for man and other mammalian species". Although the TDI for chromium is predicted to be exceeded, this is due to existing dietary intake. The WHO have reviewed the daily intake of chromium from foods and found that existing levels do not represent a toxicity problem, and state that "in the form of trivalent compounds, chromium is an essential nutrient and is relatively non-toxic for man and other mammalian species". The TDI is based on the USEPA's Reference Dose for chromium IV. Assessing the total dietary intake of chromium against this TDI is highly conservative. As the process contribution is small, the existing levels of chromium do not represent a toxicity problem, and the TDI is highly conservative there would not be an appreciable health risk based on the emission of chromium over a lifetime of an individual. When comparing the chromium VI to the TDI for ingestion the contribution from the Facility is exceptionally small (0.00004% of the TDI for a child receptor).

For nickel, the MDI for ingestion exceeds the TDI for the child receptor. However, the exceedance is a reflection of the fact the MDI is over 100% of the TDI. In addition, this is based on the conservative assumption that the process contribution is based on emissions of nickel at 44% of the group ELV. As outlined in Table 6.5, this is the maximum of the monitoring data and is an outlier. Even with this highly conservative assumption, the process contribution is 0.05% of the ingestion TDI at the point of maximum impact for the agricultural child receptor. On this basis, it is not considered that the Facility would increase the health risks from nickel for children significantly.

Table 7.1: Impact Analysis – TDI – Point of Maximum Impact - Adult						
Substance	**MDI (% of TDI)**		**Process Contribution (% of TDI)**		**Overall (% of TDI)**	
	Inhalation	**Ingestion**	**Inhalation**	**Ingestion**	**Inhalation**	**Ingestion**
Agricultural						
Cadmium	20.41%	53.17%	0.17%	0.005%	20.57%	53.18%
Chromium	-	60.48%	-	0.02%	-	60.50%
Chromium VI	-	6.05%	-	0.00003%	-	6.05%
Methyl mercury	-	3.11%	-	0.002%	-	3.11%
Mercuric chloride	-	0.71%	-	0.01%	-	0.72%
Mercury	1.19%	-	0.0000%	-	1.19%	-
Nickel	8.10%	68.37%	0.34%	0.04%	6.87%	68.40%
Dioxins and dioxin like PCBs	35.00%		0.20%		35.20%	
Allotment						
Cadmium	20.41%	53.17%	0.17%	0.004%	20.57%	53.18%
Chromium	-	60.48%	-	0.002%	-	60.48%
Chromium VI	-	6.05%	-	0.000003%	-	6.05%
Methyl mercury	-	3.11%	-	0.001%	-	3.11%
Mercuric chloride	-	0.71%	-	0.001%	-	0.72%
Mercury	1.19%	-	0.0000%	-	1.19%	-
Nickel	8.10%	68.37%	0.34%	0.005%	6.87%	68.37%
Dioxins and dioxin like PCBs	35.00%		0.01%		35.01%	
Residential						
Cadmium	20.41%	53.17%	0.17%	0.003%	20.57%	53.18%
Chromium	-	60.48%	-	0.002%	-	60.48%
Chromium VI	-	6.05%	-	0.000002%	-	6.05%
Methyl mercury	-	3.11%	-	0.001%	-	3.11%
Mercuric chloride	-	0.71%	-	0.001%	-	0.71%
Mercury	1.19%	-	0.0000%	-	1.19%	-
Nickel	8.10%	68.37%	0.34%	0.003%	6.87%	68.37%
Dioxins and dioxin like PCBs	35.00%		0.005%		35.00%	

Table 7.2: Impact Analysis – TDI – Point of Maximum Impact - Child						
Substance	**MDI (% of TDI)**		**Process Contribution (% of TDI)**		**Overall (% of TDI)**	
	Inhalation	**Ingestion**	**Inhalation**	**Ingestion**	**Inhalation**	**Ingestion**
Agricultural						
Cadmium	52.86%	137.72%	0.21%	0.01%	53.07%	137.73%
Chromium	-	156.63%	-	0.03%	-	156.66%
Chromium VI	-	15.66%	-	0.00004%	-	15.66%
Methyl mercury	-	8.04%	-	0.004%	-	8.05%
Mercuric chloride	-	1.85%	-	0.01%	-	1.86%
Mercury	3.08%	-	0.00002%	-	3.08%	-
Nickel	20.97%	177.07%	0.43%	0.05%	17.33%	177.13%
Dioxins and dioxin like PCBs	90.65%		0.29%		90.94%	
Allotment						
Cadmium	52.86%	137.72%	0.21%	0.01%	53.07%	137.73%
Chromium	-	156.63%	-	0.01%	-	156.64%
Chromium VI	-	15.66%	-	0.00001%	-	15.66%
Methyl mercury	-	8.04%	-	0.002%	-	8.05%
Mercuric chloride	-	1.85%	-	0.003%	-	1.85%
Mercury	3.08%	-	0.00002%	-	3.08%	-
Nickel	20.97%	177.07%	0.43%	0.01%	17.33%	177.08%
Dioxins and dioxin like PCBs	90.65%		0.02%		90.67%	
Residential						
Cadmium	52.86%	137.72%	0.21%	0.01%	53.07%	137.73%
Chromium	-	156.63%	-	0.004%	-	156.64%
Chromium VI	-	15.66%	-	0.00001%	-	15.66%
Methyl mercury	-	8.04%	-	0.002%	-	8.05%
Mercuric chloride	-	1.85%	-	0.003%	-	1.85%
Mercury	3.08%	-	0.00002%	-	3.08%	-
Nickel	20.97%	177.07%	0.43%	0.01%	17.33%	177.08%
Dioxins and dioxin like PCBs	90.65%		0.01%		90.66%	

The ID is the level of exposure which is associated with a negligible risk to human health. As shown, for this worst-case receptor the process contribution is well below the ID. Therefore, emissions from the Facility are considered to have a negligible impact on human health.

Table 7.3: Impact Analysis – ID – Point of Maximum Impact - Adult		
Substance	**Inhalation (% of ID)**	**Ingestion (% of ID)**
Agricultural		
Arsenic	0.12%	0.01%
Benzene	0.10%	0.02%
Benzo[a]pyrene	0.04%	0.09%
Chromium (VI)	0.86%	-
Allotment		
Arsenic	0.01%	0.01%
Benzene	0.10%	0.02%
Benzo[a]pyrene	0.04%	0.001%
Chromium (VI)	0.86%	-
Residential		
Arsenic	0.12%	0.003%
Benzene	0.10%	0.02%
Benzo[a]pyrene	0.04%	0.001%
Chromium (VI)	0.86%	-

Table 7.4: Impact Analysis – ID – Point of Maximum Impact - Child		
Substance	**Inhalation (% of ID)**	**Ingestion (% of ID)**
Agricultural		
Arsenic	0.15%	0.02%
Benzene	0.13%	0.05%
Benzo[a]pyrene	0.05%	0.13%
Chromium (VI)	1.08%	-
Allotment		
Arsenic	0.15%	0.01%
Benzene	0.13%	0.05%
Benzo[a]pyrene	0.05%	0.003%
Chromium (VI)	1.08%	-
Residential		
Arsenic	0.15%	0.01%
Benzene	0.13%	0.04%
Benzo[a]pyrene	0.05%	0.002%
Chromium (VI)	1.08%	-

The total accumulation of dioxins in an infant, considering the breast milk pathway and based on an adult agricultural receptor at the point of maximum impact feeding an infant, is 0.032 pg WHO-TEQ / kg-bw / day which is 1.62% of the TDI. For a residential and allotment type receptor this is 0.043% and 0.030% respectively.

7.2 Maximum impact at a receptor

The following tables outline the impact of emissions from the Facility at the most affected receptor (i.e the receptor with the greatest impact from ingestion and inhalation of emissions) (R3 – Chirk Green Farm, agricultural type receptor). Where appropriate a comparison has been made to the TDI or ID.

Table 7.5: Impact Analysis – TDI –Maximum Impacted Receptor (R3)

Substance	MDI (% of TDI)		Process Contribution (% of TDI)		Overall (% of TDI)	
	Inhalation	Ingestion	Inhalation	Ingestion	Inhalation	Ingestion
Adult						
Cadmium	20.41%	53.17%	0.16%	0.004%	20.57%	53.18%
Chromium	-	60.48%	-	0.012%	-	60.49%
Chromium VI	-	6.05%	-	0.00002%	-	6.05%
Methyl mercury	-	3.11%	-	0.001%	-	3.11%
Mercuric chloride	-	0.71%	-	0.004%	-	0.72%
Mercury	1.19%	-	0.00002%	-	1.19%	-
Nickel	8.10%	68.37%	0.34%	0.02%	6.86%	68.39%
Dioxins and dioxin like PCBs	35.00%		0.13%		35.13%	
Child						
Cadmium	52.86%	137.72%	0.21%	0.01%	53.06%	137.73%
Chromium	-	156.63%	-	0.02%	-	156.65%
Chromium VI	-	15.66%	-	0.00003%	-	15.66%
Methyl mercury	-	8.04%	-	0.002%	-	8.05%
Mercuric chloride	-	1.85%	-	0.01%	-	1.86%
Mercury	3.08%	-	0.00002%	-	3.08%	-
Nickel	20.97%	177.07%	0.42%	0.03%	17.32%	177.11%
Dioxins and dioxin like PCBs	90.65%		0.18%		90.83%	

As shown, for the most impacted receptor the overall impact (including the contribution from existing dietary intakes) is less than the TDI for chromium VI, methyl mercury, mercuric chloride and dioxins. Therefore, there would not be an appreciable health risk based on the emission of these pollutants.

For a child receptor the cadmium, chromium and nickel MDI (that sourced from existing dietary intake) exceeds the TDI for ingestion. However, the process contribution is exceptionally small and the exceedance is a reflection of the fact the MDI is over 100% of the TDI. On this basis, it is not considered that emissions from the Facility would increase the health risks from cadmium, chromium or nickel for children significantly.

The total accumulation of dioxins in an infant, considering the breast milk pathway and based on the adult agricultural receptor at R3 feeding an infant, is 0.020 pg WHO-TEQ / kg bw / day which is 1.02% of the TDI.

Table 7.6: Impact Analysis – ID – Maximum Impacted Receptor (R3)

Substance	Inhalation (% of ID)	Ingestion (% of ID)
Adult – Agricultural		
Arsenic	0.11%	0.01%
Benzene	0.10%	0.02%
Benzo[a]pyrene	0.04%	0.06%
Chromium (VI)	0.84%	-
Child – Agricultural		
Arsenic	0.14%	0.01%
Benzene	0.12%	0.05%
Benzo[a]pyrene	0.05%	0.08%
Chromium (VI)	1.06%	-

As shown, for this worst-case receptor the process contribution is well below the ID. Therefore, emissions from the Facility are considered to have a negligible impact on human health.

7.3 Uncertainty and sensitivity analysis

To account for uncertainty in the modelling the impact on human health was assessed for a receptor at the point of maximum impact.

To account for uncertainty in the dietary intake of a person, both residential and agricultural receptors have been assessed. The agricultural receptor is assumed to consume a greater proportion of home grown produce, which has the potential to be contaminated by the COPCs released, than for a residential receptor. In addition, the agricultural receptor includes the pathway from consuming animals grazed on land contaminated by the emission source. This assumes that 100% of the plant materials eaten by the animals is grown on soil contaminated by emission sources.

The agricultural receptor at the point of maximum impact is considered the upper maximum of the impact of the Facility.

7.4 Upset process conditions

Article 46(6) of the IED (Directive 2010/75/EU) states that:

> *"… the waste incineration plant … shall under no circumstances continue to incinerate waste for a period of more than 4 hours uninterrupted where emission limit values are exceeded.*
>
> *The cumulative duration or operation in such conditions over 1 year shall not exceed 60 hours."*

Article 47 continues with:

> *"In the case of a breakdown, the operator shall reduce or close down operations as soon as practicable until normal operations can be restored."*

In addition Annex VI, Part 3, 2 of the IED states the emission limit values applicable in the circumstances described in Article 46(6) and Article 47:

"The total dust concentration in the emissions into the air of a waste incineration plant shall under no circumstances exceed 150 mg/Nm^3 expressed as a half-hourly average. The air emission limit values for TOC and CO set out in points 1.2 and 1.5(b) shall not be exceeded."

The conditions detailed in Article 46(6) are considered to be "Upset Operating Conditions". As identified these periods are short term events which can only occur for a maximum of 60 hours per year.

Start-up of the K8 biomass plant from cold will be conducted with clean support fuel (low sulphur light fuel oil). During start-up waste will not be introduced onto the grate unless the temperature within the oxidation zone is above the 850ºC as required by Article 50, paragraph 4(a) of the IED. During start-up, the flue gas treatment plant will be operational as will be the combustion control systems and emissions monitoring equipment.

The same is true during plant shutdown where waste will cease to be introduced to the grate. The waste remaining on the grate will be combusted, the temperature not being permitted to drop below 850ºC through the combustion of clean support auxiliary fuel. During this period the flue gas treatment equipment is fully operational, as will be the control systems and monitoring equipment. After complete combustion of the waste, the auxiliary burners will be turned off and the plant will be allowed to cool.

Start-up and shutdown are infrequent events. The Facility is designed to operate continuously, and ideally only shutdown for its annual maintenance programme.

In relation to the magnitude of dioxin emissions during plant start-up and shutdown, research has been undertaken by AEA Technology on behalf of the Environment Agency[7]. Whilst elevated emissions of dioxins (within one order of magnitude) were found during shutdown and start-up phases where the fuel was not fully established in the combustion chamber, the report concluded that:

"The mass of dioxin emitted during start-up and shutdown for a 4-5 day planned outage was similar to the emission which would have occurred during normal operation in the same period. The emission during the shutdown and restart is equivalent to less than 1 % of the estimated annual emission (if operating normally all year)."

There is therefore no reason why such start-up and shutdown operations or upset operating conditions will affect the long term impact of the Facility.

[7] AEA Technology (2012) Review of research into health effects of Energy from Waste facilities.

8 Conclusions

Of all the pollutants considered with a Tolerable Daily Intake (TDI), nickel is the pollutant that results in the highest level of existing exposure (MDI). The combined impact of nickel from existing background sources and contributions from the proposed Facility at the point of maximum impact is 177.13% of the ingestion TDI for agricultural children. However, the process contribution from the Facility for nickel is small, being only 0.05% of the TDI at the point of maximum impact, and 0.03% or less at receptors.

Similarly, the ingestion of cadmium and chromium from existing background sources and contributions from the Facility also exceeds the ingestion TDI for children. However, the process contribution from the proposed Facility for cadmium is again small, being only 0.01% of the TDI at the point of maximum impact for an agricultural receptor, and less than 0.01% or less at actual receptors. The process contribution for chromium is also small, being only 0.03% of the TDI at the point of maximum impact, and 0.2% or less at receptors.

The TDI is set at a level "that can be ingested daily over a lifetime without appreciable health risk". The ingestion of cadmium and chromium by children as a result of background sources, based on UK-wide data, is already above the TDI. On the basis that the process contribution of these substances is exceptionally small it is not considered that the Facility would increase the health risks from these pollutants significantly.

For all other pollutants, the combined impact from the Facility plus the existing MDI is below the TDI, so there would not be an appreciable health risk based on the emission of these pollutants.

Although the MDI exceeds the cadmium TDI for children, the Environment Agency explains that chronic exposure to levels in excess of either the TDI might be associated with an increase in kidney disease in a proportion of those exposed, but (small) exceedances lasting for shorter periods are of less consequence. Therefore, assessing a lifetime exposure is appropriate. If we assess the exposure over the lifetime (i.e. a period as a child and adult) the overall impact is well below the TDI, so there would not be an appreciable health risk based on the emission of cadmium.

Again the TDI for chromium for children is predicted to be exceeded due to existing dietary intake. Toxicological opinion is that chromium III is of low oral toxicity and is needed as part of a healthy diet. The UK Committee on Medial Aspects of Food Policy recommend a minimum safe and adequate intake, but do not restrict an upper limit. The WHO have analysed human intake for chromium through food and conclude that existing levels do not represent a toxicity problem. The TDI is based on the USEPA's Reference Dose for chromium IV. Assessing the total dietary intake of chromium against this TDI is highly conservative. Therefore, it is concluded that as the process contribution is so small and the TDI is set at a highly conservative level there would not be an appreciable health risk based on the emission of chromium.

For pollutants which do not have a TDI, a comparison has been made against an Index Dose (ID). The ID is a threshold below which there are considered to be negligible risks to human health. The greatest contribution from the Facility is from chromium VI, which is only 1.08% of the Index Dose for children at the point of maximum impact. Therefore, emissions from the Facility of chromium VI and all other pollutants are considered to have a negligible impact on human health.

In conclusion, the impact of the Facility will not result in appreciable health risks from its operation.

Appendix A - Detailed Results Tables

Table A.1: Comparison with ID Limits for Adult Receptors							
Receptor	Ingestion (% of ID)			Inhalation (% of ID)			
	Arsenic	Benzene	Benzo(a)pyrene	Arsenic	Benzene	Benzo(a)pyrene	Chromium (VI)
Point of maximum impact - agricultural	0.009%	0.023%	0.088%	0.117%	0.100%	0.042%	0.859%
Point of maximum impact - allotment	0.005%	0.022%	0.001%	0.005%	0.100%	0.042%	0.859%
Point of maximum impact - residential	0.003%	0.024%	0.001%	0.117%	0.100%	0.042%	0.859%
R1 Brynkinallt Home Farm	0.002%	0.006%	0.023%	0.030%	0.026%	0.011%	0.222%
R2 Highfield Farm	0.005%	0.012%	0.045%	0.060%	0.052%	0.022%	0.442%
R3 Chirk Green Farm	0.006%	0.014%	0.055%	0.073%	0.063%	0.026%	0.540%
R4 Ley Farm	0.003%	0.008%	0.030%	0.040%	0.034%	0.014%	0.293%
R5 Lodge Farm	0.003%	0.007%	0.028%	0.037%	0.031%	0.013%	0.270%
R6 Afon-Bradley Farm	0.003%	0.007%	0.027%	0.036%	0.031%	0.013%	0.266%
R7 New Hall Farm	0.002%	0.005%	0.017%	0.023%	0.020%	0.008%	0.169%
R8 Pontfaen Farm	0.001%	0.003%	0.010%	0.014%	0.012%	0.005%	0.102%
R9 Chirk Infant School	0.005%	0.019%	0.001%	0.103%	0.088%	0.037%	0.754%
R10 Ysgol y Waun Primary School	0.003%	0.014%	0.001%	0.074%	0.064%	0.027%	0.548%
R11 Chirk Green Road Allotments	0.003%	0.011%	0.001%	0.058%	0.050%	0.021%	0.426%
R12 Holyhead Road	0.003%	0.024%	0.001%	0.115%	0.098%	0.041%	0.845%
R13 20 Ewart Street	0.002%	0.017%	0.001%	0.082%	0.070%	0.030%	0.603%
R14 4 Crogen	0.002%	0.014%	0.000%	0.066%	0.056%	0.024%	0.483%
R15 102 Crogen	0.002%	0.012%	0.000%	0.058%	0.049%	0.021%	0.424%

Table A.1: Comparison with ID Limits for Adult Receptors							
Receptor	Ingestion (% of ID)			Inhalation (% of ID)			
	Arsenic	Benzene	Benzo(a)pyrene	Arsenic	Benzene	Benzo(a)pyrene	Chromium (VI)
R16 2 Maes Yr Ysgol	0.002%	0.015%	0.001%	0.074%	0.063%	0.026%	0.541%

Table A.2: Comparison with ID Limits for Child Receptors							
Receptor	Ingestion (% of ID)			Inhalation (% of ID)			
	Arsenic	Benzene	Benzo(a)pyrene	Arsenic	Benzene	Benzo(a)pyrene	Chromium (VI)
Point of maximum impact - agricultural	0.016%	0.054%	0.127%	0.147%	0.126%	0.053%	1.082%
Point of maximum impact - allotment	0.012%	0.052%	0.003%	0.147%	0.126%	0.053%	1.082%
Point of maximum impact - residential	0.008%	0.043%	0.002%	0.147%	0.126%	0.053%	1.082%
R1 Brynkinallt Home Farm	0.004%	0.014%	0.033%	0.038%	0.033%	0.014%	0.280%
R2 Highfield Farm	0.008%	0.028%	0.066%	0.076%	0.065%	0.027%	0.557%
R3 Chirk Green Farm	0.010%	0.034%	0.080%	0.093%	0.079%	0.033%	0.681%
R4 Ley Farm	0.006%	0.018%	0.043%	0.050%	0.043%	0.018%	0.369%
R5 Lodge Farm	0.005%	0.017%	0.040%	0.046%	0.040%	0.017%	0.340%
R6 Afon-Bradley Farm	0.005%	0.017%	0.039%	0.046%	0.039%	0.016%	0.336%
R7 New Hall Farm	0.003%	0.011%	0.025%	0.029%	0.025%	0.010%	0.213%
R8 Pontfaen Farm	0.002%	0.006%	0.015%	0.017%	0.015%	0.006%	0.129%
R9 Chirk Infant School	0.011%	0.046%	0.003%	0.129%	0.111%	0.046%	0.951%
R10 Ysgol y Waun Primary School	0.008%	0.033%	0.002%	0.094%	0.080%	0.034%	0.691%
R11 Chirk Green Road Allotments	0.006%	0.026%	0.002%	0.073%	0.063%	0.026%	0.537%
R12 Holyhead Road	0.008%	0.043%	0.002%	0.145%	0.124%	0.052%	1.064%
R13 20 Ewart Street	0.006%	0.030%	0.002%	0.103%	0.089%	0.037%	0.760%
R14 4 Crogen	0.005%	0.024%	0.001%	0.083%	0.071%	0.030%	0.608%
R15 102 Crogen	0.004%	0.021%	0.001%	0.073%	0.062%	0.026%	0.534%

Table A.2: Comparison with ID Limits for Child Receptors							
Receptor	Ingestion (% of ID)			Inhalation (% of ID)			
	Arsenic	Benzene	Benzo(a)pyrene	Arsenic	Benzene	Benzo(a)pyrene	Chromium (VI)
R16 2 Maes Yr Ysgol	0.005%	0.027%	0.001%	0.093%	0.079%	0.033%	0.682%

Table A.3: Comparison with TDI Limits for Adult Receptors									
Receptor	Ingestion (% of ID)						Inhalation (% of ID)		
	Cadmium	Chromium	Chromium VI	Methyl Mercury	Mercuric Chloride	Nickel	Cadmium	Mercury	Nickel
MDI of TDI (%)	**53.17%**	**60.48%**	**6.05%**	**3.11%**	**0.71%**	**68.37%**	**20.41%**	**1.19%**	**6.52%**
Point of maximum impact - agricultural	53.179%	60.495%	6.0476%	3.107%	0.721%	68.403%	20.575%	1.190%	6.866%
Point of maximum impact - allotment	53.179%	60.478%	6.0476%	3.107%	0.715%	68.372%	20.575%	1.190%	6.866%
Point of maximum impact - residential	53.178%	60.478%	6.0476%	3.106%	0.715%	68.371%	20.575%	1.190%	6.866%
R1 Brynkinallt Home Farm	53.176%	60.481%	6.0476%	3.106%	0.716%	68.377%	20.451%	1.190%	6.612%
R2 Highfield Farm	53.177%	60.486%	6.0476%	3.106%	0.718%	68.386%	20.494%	1.190%	6.700%
R3 Chirk Green Farm	53.178%	60.488%	6.0476%	3.107%	0.718%	68.390%	20.513%	1.190%	6.739%
R4 Ley Farm	53.176%	60.483%	6.0476%	3.106%	0.716%	68.379%	20.465%	1.190%	6.641%
R5 Lodge Farm	53.176%	60.482%	6.0476%	3.106%	0.716%	68.379%	20.461%	1.190%	6.631%
R6 Afon-Bradley Farm	53.176%	60.482%	6.0476%	3.106%	0.716%	68.378%	20.460%	1.190%	6.630%
R7 New Hall Farm	53.176%	60.480%	6.0476%	3.106%	0.716%	68.374%	20.441%	1.190%	6.591%
R8 Pontfaen Farm	53.175%	60.478%	6.0476%	3.106%	0.715%	68.372%	20.428%	1.190%	6.565%
R9 Chirk Infant School	53.178%	60.478%	6.0476%	3.106%	0.715%	68.372%	20.555%	1.190%	6.824%
R10 Ysgol y Waun Primary School	53.177%	60.478%	6.0476%	3.106%	0.715%	68.370%	20.515%	1.190%	6.742%
R11 Chirk Green Road Allotments	53.177%	60.477%	6.0476%	3.106%	0.715%	68.370%	20.491%	1.190%	6.694%
R12 Holyhead Road	53.178%	60.478%	6.0476%	3.106%	0.715%	68.371%	20.572%	1.190%	6.861%
R13 20 Ewart Street	53.177%	60.477%	6.0476%	3.106%	0.715%	68.370%	20.525%	1.190%	6.764%

Table A.3: Comparison with TDI Limits for Adult Receptors									
Receptor	**Ingestion (% of ID)**						**Inhalation (% of ID)**		
	Cadmium	**Chromium**	**Chromium VI**	**Methyl Mercury**	**Mercuric Chloride**	**Nickel**	**Cadmium**	**Mercury**	**Nickel**
MDI of TDI (%)	**53.17%**	**60.48%**	**6.05%**	**3.11%**	**0.71%**	**68.37%**	**20.41%**	**1.19%**	**6.52%**
R14 4 Crogen	53.176%	60.477%	6.0476%	3.106%	0.715%	68.369%	20.502%	1.190%	6.716%
R15 102 Crogen	53.176%	60.477%	6.0476%	3.106%	0.715%	68.369%	20.490%	1.190%	6.693%
R16 2 Maes Yr Ysgol	53.176%	60.477%	6.0476%	3.106%	0.715%	68.369%	20.513%	1.190%	6.739%

Table A.4: Comparison with TDI Limits for Child Receptors									
Receptor	Ingestion (% of ID)						Inhalation (% of ID)		
	Cadmium	Chromium	Chromium VI	Methyl Mercury	Mercuric Chloride	Nickel	Cadmium	Mercury	Nickel
MDI of TDI (%)	**137.72%**	**156.63%**	**15.66%**	**8.04%**	**1.85%**	**177.07%**	**52.86%**	**3.08%**	**16.90%**
Point of maximum impact - agricultural	137.733%	156.664%	15.663%	8.047%	1.860%	177.126%	53.067%	3.083%	17.328%
Point of maximum impact - allotment	137.733%	156.639%	15.663%	8.046%	1.853%	177.083%	53.067%	3.083%	17.328%
Point of maximum impact - residential	137.729%	156.638%	15.663%	8.045%	1.853%	177.079%	53.067%	3.083%	17.328%
R1 Brynkinallt Home Farm	137.725%	156.641%	15.663%	8.044%	1.853%	177.085%	52.911%	3.083%	17.008%
R2 Highfield Farm	137.728%	156.649%	15.663%	8.045%	1.855%	177.099%	52.965%	3.083%	17.119%
R3 Chirk Green Farm	137.729%	156.653%	15.663%	8.046%	1.856%	177.105%	52.989%	3.083%	17.168%
R4 Ley Farm	137.726%	156.644%	15.663%	8.045%	1.853%	177.090%	52.929%	3.083%	17.044%
R5 Lodge Farm	137.726%	156.643%	15.663%	8.045%	1.853%	177.088%	52.923%	3.083%	17.032%
R6 Afon-Bradley Farm	137.726%	156.643%	15.663%	8.045%	1.853%	177.088%	52.922%	3.083%	17.030%
R7 New Hall Farm	137.724%	156.639%	15.663%	8.044%	1.852%	177.082%	52.898%	3.083%	16.981%
R8 Pontfaen Farm	137.724%	156.637%	15.663%	8.044%	1.851%	177.078%	52.882%	3.083%	16.948%
R9 Chirk Infant School	137.731%	156.638%	15.663%	8.046%	1.853%	177.082%	53.042%	3.083%	17.276%
R10 Ysgol y Waun Primary School	137.729%	156.637%	15.663%	8.045%	1.852%	177.079%	52.991%	3.083%	17.172%
R11 Chirk Green Road Allotments	137.727%	156.636%	15.663%	8.045%	1.852%	177.077%	52.961%	3.083%	17.111%
R12 Holyhead Road	137.729%	156.638%	15.663%	8.045%	1.853%	177.079%	53.064%	3.083%	17.321%
R13 20 Ewart Street	137.727%	156.636%	15.663%	8.045%	1.852%	177.077%	53.005%	3.083%	17.200%

Table A.4: Comparison with TDI Limits for Child Receptors									
Receptor	Ingestion (% of ID)						Inhalation (% of ID)		
	Cadmium	Chromium	Chromium VI	Methyl Mercury	Mercuric Chloride	Nickel	Cadmium	Mercury	Nickel
MDI of TDI (%)	**137.72%**	**156.63%**	**15.66%**	**8.04%**	**1.85%**	**177.07%**	**52.86%**	**3.08%**	**16.90%**
R14 4 Crogen	137.726%	156.636%	15.663%	8.044%	1.852%	177.076%	52.975%	3.083%	17.139%
R15 102 Crogen	137.726%	156.635%	15.663%	8.044%	1.851%	177.075%	52.961%	3.083%	17.109%
R16 2 Maes Yr Ysgol	137.727%	156.636%	15.663%	8.045%	1.852%	177.076%	52.989%	3.083%	17.168%

Table A.5: Comparison with Total Dioxin TDI Limits for Adult Receptors				
Receptor	**Total Inhalation, (pg WHO-TEQ kg^{-1} bw day $^{-1}$)**	**Total Ingestion, (pg WHO-TEQ kg^{-1} bw day $^{-1}$)**	**Total uptake, (pg WHO-TEQ kg^{-1} bw day $^{-1}$)**	**Comparison (% of limit)**
MDI (% of TDI)				**35.00%**
Point of maximum impact - agricultural	0.001%	0.403%	0.404%	35.202%
Point of maximum impact - allotment	0.001%	0.012%	0.013%	35.006%
Point of maximum impact - residential	0.001%	0.008%	0.009%	35.005%
R1 Brynkinallt Home Farm	0.000%	0.104%	0.104%	35.052%
R2 Highfield Farm	0.001%	0.208%	0.208%	35.104%
R3 Chirk Green Farm	0.001%	0.254%	0.254%	35.127%
R4 Ley Farm	0.0004%	0.137%	0.138%	35.069%
R5 Lodge Farm	0.0003%	0.127%	0.127%	35.063%
R6 Afon-Bradley Farm	0.0003%	0.125%	0.125%	35.063%
R7 New Hall Farm	0.0002%	0.079%	0.079%	35.040%
R8 Pontfaen Farm	0.0001%	0.048%	0.048%	35.024%
R9 Chirk Infant School	0.001%	0.010%	0.011%	35.006%
R10 Ysgol y Waun Primary School	0.001%	0.007%	0.008%	35.004%
R11 Chirk Green Road Allotments	0.001%	0.006%	0.006%	35.003%
R12 Holyhead Road	0.001%	0.008%	0.009%	35.004%
R13 20 Ewart Street	0.001%	0.006%	0.006%	35.003%
R14 4 Crogen	0.001%	0.004%	0.005%	35.003%

Table A.5: Comparison with Total Dioxin TDI Limits for Adult Receptors				
Receptor	**Total Inhalation, (pg WHO-TEQ kg^{-1} bw day^{-1})**	**Total Ingestion, (pg WHO-TEQ kg^{-1} bw day^{-1})**	**Total uptake, (pg WHO-TEQ kg^{-1} bw day^{-1})**	**Comparison (% of limit)**
MDI (% of TDI)				**35.00%**
R15 102 Crogen	0.001%	0.004%	0.004%	35.002%
R16 2 Maes Yr Ysgol	0.001%	0.005%	0.006%	35.003%

Table A.6: Comparison with Total Dioxin TDI Limits for Child Receptors				
Receptor	**Total Inhalation, (pg WHO-TEQ kg^{-1} bw day $^{-1}$)**	**Total Ingestion, (pg WHO-TEQ kg^{-1} bw day $^{-1}$)**	**Total uptake, (pg WHO-TEQ kg^{-1} bw day $^{-1}$)**	**Comparison (% of limit)**
MDI (% of TDI)				**90.65%**
Point of maximum impact - agricultural	0.001%	0.570%	0.572%	90.936%
Point of maximum impact - allotment	0.001%	0.034%	0.035%	90.668%
Point of maximum impact - residential	0.001%	0.027%	0.028%	90.664%
R1 Brynkinallt Home Farm	0.000%	0.147%	0.148%	90.724%
R2 Highfield Farm	0.001%	0.294%	0.294%	90.797%
R3 Chirk Green Farm	0.001%	0.359%	0.360%	90.830%
R4 Ley Farm	0.0005%	0.194%	0.195%	90.747%
R5 Lodge Farm	0.0004%	0.179%	0.179%	90.740%
R6 Afon-Bradley Farm	0.0004%	0.178%	0.178%	90.739%
R7 New Hall Farm	0.0003%	0.112%	0.112%	90.706%
R8 Pontfaen Farm	0.0002%	0.068%	0.068%	90.684%
R9 Chirk Infant School	0.001%	0.030%	0.031%	90.665%
R10 Ysgol y Waun Primary School	0.001%	0.022%	0.022%	90.661%
R11 Chirk Green Road Allotments	0.001%	0.017%	0.017%	90.659%
R12 Holyhead Road	0.001%	0.026%	0.028%	90.664%
R13 20 Ewart Street	0.001%	0.019%	0.020%	90.660%
R14 4 Crogen	0.001%	0.015%	0.016%	90.658%
R15 102 Crogen	0.001%	0.013%	0.014%	90.657%

Table A.6: Comparison with Total Dioxin TDI Limits for Child Receptors				
Receptor	**Total Inhalation, (pg WHO-TEQ kg^{-1} bw day $^{-1}$)**	**Total Ingestion, (pg WHO-TEQ kg^{-1} bw day $^{-1}$)**	**Total uptake, (pg WHO-TEQ kg^{-1} bw day $^{-1}$)**	**Comparison (% of limit)**
MDI (% of TDI)				**90.65%**
R16 2 Maes Yr Ysgol	0.001%	0.017%	0.018%	90.659%

Table A.7: Toxicity Equivalence Factors (TEF)	
Compound	**WHO-TEF Multiplier**
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	0.5
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PCDF	0.05
2,3,4,7,8-PCDF	0.5
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01

NOTES:
Van den Berg et al, 2006 – as set out in the Industrial Emissions Directive Annex VI Part 2.

Appendix B – Location of Sensitive Receptors