Ford | energy from waste

FORD ENERGY RECOVERY FACILITY AND WASTE SORTING AND TRANSFER FACILITY, FORD CIRCULAR TECHNOLOGY PARK

ENVIRONMENTAL STATEMENT
TECHNICAL APPENDIX E:
HUMAN HEALTH RISK ASSESSMENT

MARCH 2021

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Ford Energy Recovery Facility and Waste Sorting and Transfer Facility

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Appendix E: Human Health Risk Assessment

ENGINEERING ┼ CONSULTING

Document approval

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Document revision record

Revision no	Date	Details of revisions	Prepared by	Checked by
0	02/02/2021	First Issue.	RDW	RSF
1	02/03/2021	Updated following Client comments	RDW	RSF

Contents

1 Introduction

Fichtner Consulting Engineers Ltd (Fichtner) has been engaged to undertake a Human Health Risk Assessment (HHRA) for the proposed Energy Recovery Facility ("the ERF") which is to constitute part of the Proposed Ford Circular Technology Park (the "Proposed Development").

As the fuel combusted at the ERF will be sourced from waste, the limits on emissions to air will be based on those outlined in Chapter IV and Annex VI of the Industrial Emissions Directive (IED) (2010/75/EU) for waste incineration and co-incineration plants. This will include limits on emissions of dioxins and furans (collectively referred to as "dioxins" for the purpose of this assessment).

The Waste Incineration BREF was published by the European Integrated Pollution Prevention and Control (IPPC) Bureau in December 2019. The BREF has introduced BAT-AELs (BAT Associated Emission Levels) which are more stringent than those currently set out in the IED for some pollutants. The ERF would be designed to meet the requirements of the BREF for a new plant. Therefore, it has been assumed that the emissions from the ERF would comply with the BAT-AELs set out in the BREF for new plants.

The advice from health specialists such as the Health Protection Agency (HPA) (now Public Health England) is 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 ERF have been considered, and are presented in this report. This includes a review of published literature on the health effects of energy recovery facilities, and a quantitative assessment of the effect of the ERF.

For most substances released from the ERF, the most significant effects on human health will arise by inhalation. However, for dioxins and dioxin-like polychlorinated biphenyls (PCBs) which accumulate in the environment, inhalation is only one of the potential exposure routes.

The Air Quality Assessment Levels (AQALs) 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 dioxins and dioxin-like PCBs the health assessment criteria is expressed as the total intake from ingestion and inhalation. Therefore, this assessment considers exposure routes other than just inhalation.

2 Literature review

The HPA, whose role has now been taken over by Public Health England (PHE), published a note RCE-13 "The Impact on Health of Emissions to Air from Municipal Waste Incinerators", in 2009[1]. The summary states:

> "While it is not possible to rule out adverse health effects from modern, well-regulated municipal waste incinerators with complete certainty, any potential damage to the health of those living close-by is likely to be very small, if detectable"

PHE commissioned further research in 2012, while continuing to state that the conclusions of RCE-13 remain applicable. These studies were commissioned from the Small Area Health Statistics Unit, which is based at Imperial College London and Kings College London. The methodology and results of the studies have been published in a series of papers in scientific journals. The two most recent papers, known as Ghosh et al (2018)[2] and Freni-Sterrantino et al (2019)[3], are the most relevant.

These studies considered whether living near a municipal waste incinerator (MWI) is linked with adverse reproductive and infant health outcomes. These outcomes were studied as they are considered more sensitive to the accumulation of pollutants in the environment than other potential markers such as lifetime cancer rates.

Ghosh et al (2018) concluded that:

> "This large national study found no evidence for increased risk of a range of birth outcomes, including birth weight, preterm delivery and infant mortality, in relation to either MWI emissions or living near an MWI operating to the current EU waste incinerator regulations in Great Britain."

Freni-Sterrantino et al (2019) concluded that:

> "we did not find an association between the opening of a new MWI and changes in infant mortality trends or sex ratio at birth for 10 and 4 km buffers, using distance as proxy of exposure, after taking into account temporal trends in comparator areas and potential confounding factors."

These two recent papers consider facilities in the UK, operating under the same regulatory regime which would apply to the ERF and operating to the current standards of the IED. Neither paper found any evidence of an association of waste incineration facilities with the health outcomes considered. Given that the ERF would actually operate to tighter standards, as it would use the reduced emissions limits from the Waste Incineration BREF, the conclusions are directly relevant and support PHE's position statement that "*any potential damage to the health of those living close-by is likely to be very small, if detectable*".

Therefore, it can be concluded that the effect of emissions from the ERF of pollutants that accumulate in the environment would not be significant. Nonetheless, a quantitative assessment of the effect of emissions from the ERF has been undertaken and is presented in the following sections.

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[1] https://www.gov.uk/government/publications/municipal-waste-incinerators-emissions-impact-on-health

[2] Ghosh RE, Freni Sterrantino A, Douglas P, Parkes B, Fecht D, de Hoogh K, Fuller G, Gulliver J, Font A, Smith RB, Blangiardo M, Elliott P, Toledano MB, Hansell AL. (2018) Fetal growth, stillbirth, infant mortality and other birth outcomes near UK municipal waste incinerators; retrospective population based cohort and case-control study. Environment International.

[3] Freni-Sterrantino, A; Ghosh, RE; Fecht, D; Toledano, MB; Elliott, P; Hansell, AL; Blangiardo, M. (2019) Bayesian spatial modelling for quasi-experimental designs: An interrupted time series study of the opening of Municipal Waste Incinerators in relation to infant mortality and sex ratio. Environment International. 128 106-115

3 Issue Identification

3.1 Issue

The key issue for consideration is the release of substances to atmosphere from the ERF which have the potential to harm human health. Details of the dispersion modelling can be found in Appendix C3 [Emissions Modelling]. There are no other existing local sources which include emissions of dioxins or dioxin-like PCBs.

The ERF will be designed to meet the BAT-AELs outlined in the Waste Incineration BREF. 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. An assessment the impact of inhalation of these pollutants on human health is presented in Appendix C3 [Emissions Modelling]. However, dioxins and dioxin-like PCBs can accumulate in the environment, which means that inhalation is only one of the potential exposure routes. The health assessment criteria is expressed as the total intake from ingestion and inhalation. Pathway modelling considering the intake from inhalation and ingestion has been carried out using the software "Industrial Risk Assessment Program-Human Health" (IRAP-h View – Version 5.0, "IRAP"). In addition, a review of published literature on the health effects of energy recovery facilities has been undertaken.

3.2 Chemicals of Potential Concern (COPC)

The following substances have been considered COPCs for the purpose of this assessment:

- PCDD/Fs (individual congeners), i.e., dioxins; and
- Dioxin-like PCBs;

This risk assessment investigates the potential for long term health effect of these COPCs through other routes than just inhalation. The impact of all other pollutants released from the Facility have been assessed against the Air Quality Assessment Levels for the protection of human health which are based on atmospheric concentrations of pollutants as the main pathway is via inhallation.

4 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 United States Environment Protection Agency's (USEPA)'s approach. However, this assessment applies the approach set out in the Environment Agency's document "Human Health Toxicological Assessment of Contaminants in Soil", ref SC050021 (2009).

For the COPCs considered, which have 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 ERF, the predicted intake of a substance due to emissions from the ERF is added to the MDI and compared with the TDI.

The following table outlines the MDIs (the typical intake from existing background sources) and TDIs for dioxins and dioxin-like PCBs. These figures are defined in the "Contaminants in soil: updated collation of toxicology data and intake values for humans: dioxins, furans and dioxin-like PCBs" (Environment Agency 2009).

Table 1:   Intake of Dioxins and Dioxin-Like PCBs

Item	Units	Intake	
		70 kg adult	**20 kg child**
Tolerable Daily Intake (TDI)	pg WHO-TEQ/kg bw/day		2.0
Mean Daily Intake (MDI)	pg WHO-TEQ/kg bw/day	0.7	1.8
	% of TDI	35.00%	90.65%

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 Table 7.

The TDI has been set at a level which can be ingested daily over a lifetime without appreciable health risk. Therefore, if the total exposure is less than the TDI, it can be concluded that the impact of the ERF is not significant.

5 Conceptual Site Model

5.1 Conceptual site model

IRAP, created by Lakes Environmental, is based on the USEPA Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities[4]. This Protocol is a development of the approach defined by Her Majesties Inspectorate on Pollution (HMIP) in the UK in 1996[5], taking account of further research since that date. The exposure pathways included in the IRAP model are shown in Table 2.

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 shown in the table below.

Table 2:   Pathways Considered

Pathway	Residential	Allotment	Agricultural
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 poultry	-	Yes	Yes
Ingestion of home-grown beef	-	-	Yes
Ingestion of home-grown pork	-	-	Yes
Ingestion of home-grown milk	-	-	Yes
Ingestion of breast milk (infants only)	Infants only		

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. Therefore, a modified agricultural receptor has been used where the ingestion of home-grown beef, pork and milk have been excluded.

As shown in Figure 1, the pathway from the ingestion of mother's milk in infants is considered within the assessment. The IRAP model calculates the amount of dioxins entering the mother's milk and being passed on to the infants. IRAP does not include data on individual PCBs, but it does

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

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

include data for take-up and accumulation rates within the food chain for two groups of PCBs, known as Aroclor 1254 and Aroclor 1016. IRAP does not include these when determining the intake via mother's milk. Therefore, a safety factor of 1.5 has been applied to the dioxin and dioxin-like PCBs emission rate when considering the impact of the intake via mother's milk. The impacts are then compared against the TDI.

Figure 1:   Conceptual Site Model – Exposure Pathways
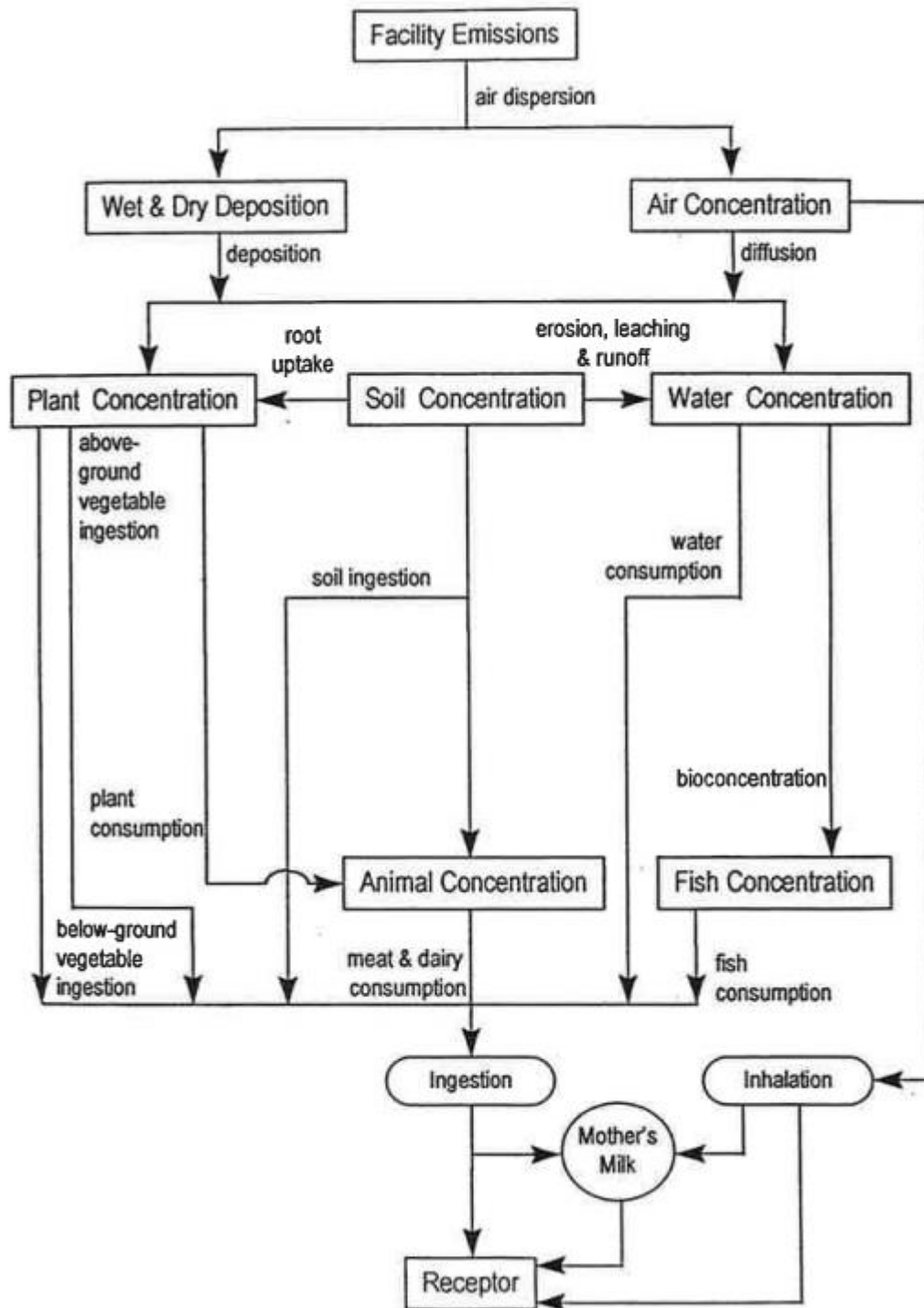
5.2   Pathways excluded from assessment

The intake of dioxins via dermal absorption, groundwater, surface water exposure and fish consumption 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.

5.2.1   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[6] 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[7] provides a screening calculation using conservative assumptions, which states that 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.

5.2.2   Groundwater

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

The USEPA[8] 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.

5.2.3   Surface water

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. Run off to rainwater tanks may not go through the same treatment. However, rainwater 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.

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

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

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

5.2.4 Fish consumption

The consumption of locally caught fish has been excluded from the assessment. Whilst 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 ERF.

A review of the local waterbodies has been undertaken to see if there are any game fishing lakes in the local area[9]. The closest game fishing lake is the Chalk Springs Fishery in Arundel, located approximately 4.6 km north-east of the ERF. Due to the distance from the ERF it is considered that the impact at the fishery will be imperceptible. In addition, the likelihood of persons sourcing a large proportion of their diet from a trout fishery is very low. Game fishing may take place along rivers in the local area. However, the accumulation of pollutants in river systems is not of significant concern, as any pollutants will be washed downstream rather than accumulating. Therefore, the fish consumption pathway has been excluded from this assessment.

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

6 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 ERF, and at the point of maximum impact of annual mean emissions.

For the purposes of this assessment, receptor locations have been categorised as 'residential', 'agricultural' and 'allotment'. 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. Allotment receptors represents land designated for non-commercial growing of food plants. An allotment type receptor has been applied for school to allow for the consumption of any produce as a very conservative approach.

The sensitive receptors assessed are listed in Table 3. A receptor has been assessed at the point of maximum impact. This point is uninhabited but may be cultivated or used for grazing. Reference should be made to Annex B which shows the location of these receptors with respect to the ERF.

Table 3:   Sensitive Receptors

ID	Receptor Name	Location		Type of Receptor
		X	Y	
MAX	Point of maximum impact	500010	103725	Agricultural / Residential/ Allotment
R1	Ford Lane 1	499101	103893	Resident
R2	Ford Lane 2	499246	103908	Resident
R3	Ford Lane 3	499674	103662	Resident
R4	Rodney Crescent	499962	103515	Resident
R5	Ford Road	500100	103236	Resident
R6	Ford Open Prison 1	500137	102865	Resident
R7	Horsemere Green Lane 1	500109	102385	Resident
R8	Horsemere Green Lane 2	499847	102322	Resident
R9	Beagle Drive	499015	102981	Resident
R10	Yapton Primary School	497788	103647	School
R11	Proposed Ford Airfield Residential 1	499218	103340	Resident
R12	Proposed Ford Airfield Residential 2	499319	102906	Resident
R13	Proposed Ford Airfield Residential 3	499249	103576	Resident
R14	Proposed Ford Airfield Residential 4	498952	103288	Resident
R15	Proposed Ford Airfield Residential 5	499156	103056	Resident
R16	Proposed Landings Residential Development 1	499593	103313	Resident
R17	Proposed Landings Residential Development 2	499744	103175	Resident
R18	Proposed Landings Residential Development 3	499660	103040	Resident
R19	Proposed Landings Residential Development 4	499470	103463	Resident
R20	Proposed Allocation of Arun DC Secondary School	498749	103383	Resident

| ID | Receptor Name | Location | | Type of Receptor |
		X	Y	
R21	Proposed Residential Development Climping	499801	102358	Resident
R22	Proposed Residential Development Bilsham Road	497709	102995	Resident
R23	Proposed Residential Development Drove Lane	497575	103238	Resident
R24	Proposed Residential Development Walberton	497446	106017	Resident
R25	Proposed Residential Development Littlehampton	502954	103875	Resident
R26	Cinders Lane Allotment	498233	102704	Allotment
R27	Kingley Gate Allotment	501337	103823	Allotment
R28	Proposed Residential Development Wicks Farm	499090	104019	Resident
R29	Proposed Residential Developments North End Road	498234	103762	Resident
R30	Proposed Residential Developments Burndell Road	498847	102663	Resident

7 IRAP Model Assumptions and Inputs

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

7.1 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 ERF is taken as 25 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.

7.2 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.

7.3 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.

7.4 Concentrations in humans

7.4.1 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 – 20 m³/day; and
- children – 7.2 m³/day.

These are as specified within the Environment Agency's document "Human Health Toxicological Assessment of Contaminants in Soil". The calculation also takes account of time spent outside, since most people spend most of their time indoors.

7.4.2 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.

7.4.3 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.

7.4.4 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	0.688 kg/day
• Safety factor on total dioxin intake to account for PCBs	1.5

7.5 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 2014 to 2018 from the Shoreham/Brighton Airport weather station, as used within the air quality dispersion modelling. This provides the annual

average precipitation which can be used to calculate the general IRAP-h input parameters, as presented in Table 4.

Table 4:   Site-Specific Properties

Input Variable	Assumption	Value (cm/year)
Annual average evapotranspiration	70% of annual average precipitation	52.45
Annual average irrigation	0% of annual average precipitation	0.00
Annual average precipitation	100% of annual average precipitation	74.93
Annual average runoff	10% of annual average precipitation	7.49

The average wind speed was taken as 4.79 m/s, calculated from the average of the five years of weather data from Shoreham.

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

Table 5:   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

These deposition assumptions have been applied to the annual mean concentrations predicted using the dispersion modelling, to generate the inputs needed for the IRAP modelling. For details of the dispersion modelling methodology please refer to Appendix C3 [Emissions Modelling].

7.6   Modelled emissions

For the purpose of this assessment it is assumed that the ERF operates at the BAT-AELs within the Waste Incineration BREF for its entire operational life. In reality, the ERF will be shut down for periods of maintenance and will typically operate below the emission limits prescribed in the permit.

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

Table 6:   COPC Emissions Modelled

COPC	Split of congeners for a release of 1 ng I-TEQ/Nm³[1]	Emission conc. (ng/Nm³)[2]	Emission rate (ng/s)[3]
Sum I-TEQ dioxins[4]	-	0.04 ng I-TEQ/Nm³	-
2,3,7,8-TCDD	0.031	0.0012	0.066
1,2,3,7,8-PeCDD	0.245	0.0098	0.434

COPC	Split of congeners for a release of 1 ng I-TEQ/Nm³[1]	Emission conc. (ng/Nm³)[2]	Emission rate (ng/s) [3]
1,2,3,4,7,8-HxCDD	0.287	0.0115	8.566
1,2,3,6,7,8-HxCDD	0.258	0.0103	3.611
1,2,3,7,8,9-HxCDD	0.205	0.0082	7.557
1,2,3,4,6,7,8-HpCDD	1.704	0.0681	0.608
OCDD	4.042	0.1616	0.519
2,3,7,8-TCDF	0.277	0.0111	0.587
1,2,3,7,8-PCDF	0.277	0.0111	0.909
2,3,4,7,8-PCDF	0.535	0.0214	1.134
1,2,3,4,7,8-HxCDF	2.179	0.0871	0.587
1,2,3,6,7,8-HxCDF	0.807	0.0323	1.710
1,2,3,7,8,9-HxCDF	0.042	0.0017	0.547
2,3,4,6,7,8-HxCDF	0.871	0.0348	1.846
1,2,3,4,6,7,8-HpCDF	4.395	0.1757	9.314
1,2,3,4,7,8,9-HpCDF	0.429	0.0172	4.618
OCDF	3.566	0.1426	0.089
Total	20.150	0.8057	42.704
Dioxin-like PCBs	-	0.0092	0.488

Notes:

(1) Split of the congeners taken from Table 7.2a from the HMIP document.

(2) All emissions are expressed at reference conditions of dry gas, 11% oxygen, 273.15K.

(3) Emission release rate calculated by multiplying the normalised volumetric flow rate by the emission concentration.

(4) The Waste Incineration BREF includes an emission limit for dioxins of 0.04 ng I-TEQ/Nm³, or a combined limit of 0.06 ng I-TEQ/Nm for dioxins when dioxin-like PCBs are included. As this assessment considers dioxin-like PCBs separately, the lower limit of 0.04 ng I-TEQ/Nm³ for dioxins has been used.

A number of points should be noted for the two groups of COPCs:

1. Dioxins

The split of the different dioxins and furans is based on split of congeners for a release of 1 ng I-TEQ/Nm³ as presented in in Table 6. This data is taken from Table 7.2a from the HMIP document "Risk Assessment of Dioxin Releases from Municipal Waste Incineration Processes".

To determine the emission rates, this split of the different dioxins has been multiplied by normalised volumetric flow rate to determine the release rate of each congener.

2. Dioxin-like PCBs

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]/m³

- Mean = 2.6×10^{-3} ng[TEQ]/m³

- Minimum = 5.6×10^{-5} ng[TEQ]/m³

For the purpose of this assessment, the maximum monitored PCB concentration has been used which has been converted to an emission rate using the volumetric flow.

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 Aroclor is based on a fixed composition of PCBs. Since we are not aware of any data on the specification of PCBs within incinerator or co-incinerator emissions, as a worst-case assumption we have assumed that the PCBs are released in each of the two Aroclor compositions.

As shown in Table 1, the MDI and TDI for dioxins and dioxin-like PCBs is given in pg WHO-TEQ/kg bw/day. However, the split of congeners shown in Table 6 which are used to calculate the release rate of each dioxin are based on the I-TEFs listed in Annex VI Part II of the IED. To determine the total intake TEQ for comparison with the TDI, the output of the IRAP model has been multiplied by the relevant WHO-TEFs. The I-TEFs and WHO-TEFs are shown in Table 7.

Table 7: Toxic Equivalency Factors for Dioxins and Furans

Congener	IED I-TEQ Multiplier	2005 WHO-TEF Multiplier
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	0.5	1
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01
OCDD	0.001	0.0003
2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PCDF	0.5	0.03
2,3,4,7,8-PCDF	0.05	0.3
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF	0.001	0.0003

Source: Contaminants in soil: updated collation of toxicological data and intake values for humans, Dioxins, furans and dioxin-like PCBs (Science report: SC050021/TOX 12), Environment Agency, 2009

8 Results

8.1 Assessment against TDI - point of maximum impact

The following tables present the impact of emissions of dioxins and dioxin-like PCBs from the ERF at the point of maximum impact of emissions from the ERF for an 'agricultural' receptor. As explained in section 2, 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 worst-case scenario. Reference should be made to Annex B for the location of the point in relation to the ERF.

Table 8: Impact Analysis – Dioxins and Dioxin-Like PCBs – Point of Maximum Impact

Receptor Type	MDI (% of TDI)	Process Contribution (% of TDI)	Overall (% of TDI)
Adult			
Agricultural	35.00%	2.28%	37.28%
Allotment	35.00%	2.26%	37.26%
Residential	35.00%	0.05%	35.05%
Child			
Agricultural	90.65%	3.22%	93.87%
Allotment	90.65%	3.19%	93.84%
Residential	90.65%	0.16%	90.81%

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 8, at the point of maximum impact the overall impact (including the contribution from existing dietary intake) is less than the TDI for dioxins and dioxin-like PCBs. Therefore, there would not be an appreciable health risk based on the emission of these pollutants.

8.2 Breast milk exposure

The total accumulation of dioxins in an infant resulting from emissions from the ERF, considering the breast milk pathway and based on an adult agricultural receptor at the point of maximum impact of emission from the ERF feeding an infant, is 0.387 pg WHO-TEQ / kg-bw / day which is 12.89% of the TDI. For an allotment and residential type receptor this is only 12.76% and 0.24% of the TDI respectively.

There are no ingestion pathways besides breast milk ingestion for an infant receptor. As the process contribution is less than the TDI, it is considered that the ERF will not increase the health risks from the accumulation of dioxins in infants significantly.

8.3 Maximum impact at a receptor

The following tables outline the impact of emissions from the ERF at the most affected receptor (i.e. the receptor with the greatest impact from ingestion and inhalation of emissions from the

proposed development) (R27 – Kingley Gate Allotment). This receptor has been classified as an agricultural receptor, which is conservative as it assumes that a significant proportion of the diet of the receptor is sourced from the receptor point assessed, including meat and milk products. In reality, people in the UK tend to source their diet from a wide geographical area.

Table 9:   Impact Analysis – Dioxins and Dioxin-Like PCBs – Maximum Impacted Receptor

Receptor Type	MDI (% of TDI)	Process Contribution (% of TDI)	Overall (% of TDI)
Adult			
Agricultural	35.00%	0.65%	35.65%
Child			
Agricultural	90.65%	0.92%	91.57%

As shown, for the most impacted receptor the overall impact (including the contribution from existing dietary intake) is less than the TDI for dioxins and dioxin-like PCBs. Therefore, there would not be an appreciable health risk based on the emission of these pollutants.

In addition, the total accumulation of dioxins in an infant, resulting from emissions from the ERF considering the breast milk pathway and based on an adult allotment receptor at R27 feeding an infant, is 0.111 pg WHO-TEQ / kg-bw / day which is 3.70% of the TDI. Therefore, as the process contribution is less than the TDI, it is considered that the ERF will not increase the health risks from the accumulation of dioxins in infants significantly.

Detailed results for all identified receptor locations are presented in Annex A. As shown, the predicted impact at all other receptor locations is considerably lower than for the maximum impacted receptor. This includes all other farms, allotments, residential properties and schools included in the assessment.

8.4   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, agricultural, allotment and residential 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 ERF.

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 Aroclor is based on a fixed composition of PCBs. Since we are not aware of any data on the specification of PCBs within incinerator or co-incinerator emissions, as a worst-case assumption we have assumed that the PCBs are released in each of the two Aroclor compositions and the impact based on the maximum.

IRAP does not include these Aroclors (which are being used as a proxy for dioxin-like PCBs) when determining the intake via mother's milk. Therefore, a safety factor of 1.5 has been applied to the dioxin and dioxin-like PCBs emission rate when considering the impact of the intake via mother's milk.

8.5 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."

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 ERF 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 850°C 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 ERF 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[10]. 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 ERF.

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

8.6 Cumulative analysis

There are no cumulative schemes that have been identified as having the potential for cumulative effects with the stack emissions from the ERF. However, a number receptor points have been included in the conceptual site model to represent the proposed or allocated residential developments identified as being within the modelling domain. The impact at these receptor points has been assessed within this assessment.

8.7 Fall-back position

In 2015, Grundon Waste Management Ltd secured planning permission for an energy from waste facility and a materials recovery facility (application reference: WSCC/096/13/F). The application was subject to EIA and was accompanied by a Human Health Risk Assessment written in September 2013. The 2013 Human Health Risk Assessment concluded that the impact of emissions of dioxins and dioxin-like PCBs on human health was predicted to be '*not significant*'. Therefore, the conclusions of the extant permission are consistent to those for the proposed development as presented within this assessment.

9 Conclusions

This HHRA has been undertaken based on the following conservative assumptions:

- the ERF will operate continually at the BAT-AELs, i.e. at the maximum concentrations which it is expected that the ERF will be permitted to operate at; and

- the hypothetical maximum impacted receptor (an agricultural receptor at the point of maximum impact) only ingests food and drink sourced from the area with the maximum contribution from the ERF.

The results of the assessment show that, for the hypothetical maximum impacted receptor (an agricultural child receptor at the point of maximum impact of emissions from the ERF), the combined intake from the ERF and the existing MDI intake of dioxins and dioxin-like PBCs via inhalation and ingestion is below the TDI. In addition, the ingestion of dioxins by an infant being breast fed by an agricultural receptor at the point of maximum impact of emissions from the ERF is less than the TDI. The impact at identified receptor locations (considering farms, allotments residential properties and schools in the local area) is even less. Therefore, there would not be an appreciable health risk based on the emission of dioxins and dioxin-like PCBs.

No other significant sources of dioxins or dioxin-like PCBs have been identified in the local area. Therefore, there is no risk of cumulative impacts with other projects.

In conclusion, the impact of emissions of dioxins and dioxin-like PCBs from the ERF on human health is predicted to be not significant.

Annexes

A Detailed Results Tables

Table 10: Comparison with Total Dioxin and Dioxin-Like PCBs 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 TDI)
MDI (% of TDI)				**35.00%**
Point of maximum impact - agricultural	1.31E-04	4.54E-02	4.55E-02	37.277%
Point of maximum impact - allotment	1.30E-04	4.50E-02	4.51E-02	37.257%
Point of maximum impact – residential	1.31E-04	9.06E-04	1.04E-03	35.052%
R1 Ford Lane 1	3.02E-05	2.09E-04	2.40E-04	35.012%
R2 Ford Lane 2	3.43E-05	2.38E-04	2.72E-04	35.014%
R3 Ford Lane 3	9.54E-06	6.61E-05	7.56E-05	35.004%
R4 Rodney Crescent	1.01E-04	7.01E-04	8.03E-04	35.040%
R5 Ford Road	3.08E-05	2.14E-04	2.44E-04	35.012%
R6 Ford Open Prison 1	2.18E-05	1.51E-04	1.73E-04	35.009%
R7 Horsemere Green Lane 1	1.90E-05	1.32E-04	1.51E-04	35.008%
R8 Horsemere Green Lane 2	3.00E-05	2.08E-04	2.38E-04	35.012%
R9 Beagle Drive	1.82E-05	1.26E-04	1.44E-04	35.007%
R10 Yapton Primary School	1.15E-05	3.98E-03	3.99E-03	35.200%
R11 Proposed Ford Airfield Residential 1	6.44E-07	4.50E-06	5.15E-06	35.000%
R12 Proposed Ford Airfield Residential 2	1.28E-05	8.86E-05	1.01E-04	35.005%
R13 Proposed Ford Airfield Residential 3	6.35E-06	4.40E-05	5.04E-05	35.003%
R14 Proposed Ford Airfield Residential 4	6.80E-06	4.72E-05	5.40E-05	35.003%
R15 Proposed Ford Airfield Residential 5	7.47E-06	5.18E-05	5.92E-05	35.003%
R16 Proposed Landings Residential Development 1	9.20E-08	6.29E-07	7.22E-07	35.000%

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 TDI)
R17 Proposed Landings Residential Development 2	2.75E-06	1.91E-05	2.18E-05	35.001%
R18 Proposed Landings Residential Development 3	7.61E-06	5.27E-05	6.03E-05	35.003%
R19 Proposed Landings Residential Development 4	9.97E-08	6.75E-07	7.74E-07	35.000%
R20 Proposed Allocation of Arun DC Secondary School	1.43E-05	9.93E-05	1.14E-04	35.006%
R21 Proposed Residential Development Climping	2.96E-05	2.05E-04	2.35E-04	35.012%
R22 Proposed Residential Development Bilsham Road	7.15E-06	4.95E-05	5.67E-05	35.003%
R23 Proposed Residential Development Drove Lane	5.06E-06	3.51E-05	4.01E-05	35.002%
R24 Proposed Residential Development Walberton	5.38E-06	3.73E-05	4.27E-05	35.002%
R25 Proposed Residential Development Littlehampton	1.81E-05	1.26E-04	1.44E-04	35.007%
R26 Cinders Lane Allotment	1.16E-05	4.03E-03	4.04E-03	35.202%
R27 Kingley Gate Allotment	3.76E-05	1.30E-02	1.31E-02	35.654%
R28 Proposed Residential Development Wicks Farm	3.06E-05	3.06E-05	6.12E-05	35.003%
R29 Proposed Residential Developments North End Road	1.84E-05	1.84E-05	3.68E-05	35.002%

| 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 TDI)
R30 Proposed Residential Developments Burndell Road	2.01E-05	2.01E-05	4.03E-05	35.002%

Table 11: Comparison with Total Dioxin and Dioxin-Like PCBs 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 TDI)
MDI (% of TDI)				**90.65%**
Point of maximum impact - agricultural	1.65E-04	6.41E-02	6.43E-02	93.866%
Point of maximum impact - allotment	1.63E-04	6.36E-02	6.37E-02	93.836%
Point of maximum impact – residential	1.65E-04	3.07E-03	3.23E-03	90.812%
R1 Ford Lane 1	3.81E-05	7.09E-04	7.47E-04	90.687%
R2 Ford Lane 2	4.33E-05	8.05E-04	8.49E-04	90.692%
R3 Ford Lane 3	1.20E-05	2.24E-04	2.36E-04	90.662%
R4 Rodney Crescent	1.28E-04	2.37E-03	2.50E-03	90.775%
R5 Ford Road	3.89E-05	7.23E-04	7.62E-04	90.688%
R6 Ford Open Prison 1	2.75E-05	5.12E-04	5.39E-04	90.677%
R7 Horsemere Green Lane 1	2.40E-05	4.46E-04	4.70E-04	90.673%
R8 Horsemere Green Lane 2	3.78E-05	7.04E-04	7.42E-04	90.687%
R9 Beagle Drive	2.29E-05	4.26E-04	4.49E-04	90.672%
R10 Yapton Primary School	1.44E-05	5.62E-03	5.64E-03	90.932%
R11 Proposed Ford Airfield Residential 1	8.12E-07	1.52E-05	1.60E-05	90.651%
R12 Proposed Ford Airfield Residential 2	1.61E-05	3.00E-04	3.16E-04	90.666%
R13 Proposed Ford Airfield Residential 3	8.00E-06	1.49E-04	1.57E-04	90.658%
R14 Proposed Ford Airfield Residential 4	8.57E-06	1.60E-04	1.68E-04	90.658%
R15 Proposed Ford Airfield Residential 5	9.41E-06	1.75E-04	1.85E-04	90.659%
R16 Proposed Landings Residential Development 1	1.16E-07	2.13E-06	2.25E-06	90.650%

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 TDI)
R17 Proposed Landings Residential Development 2	3.47E-06	6.45E-05	6.80E-05	90.653%
R18 Proposed Landings Residential Development 3	9.59E-06	1.79E-04	1.88E-04	90.659%
R19 Proposed Landings Residential Development 4	1.26E-07	2.28E-06	2.41E-06	90.650%
R20 Proposed Allocation of Arun DC Secondary School	1.81E-05	3.36E-04	3.54E-04	90.668%
R21 Proposed Residential Development Climping	3.73E-05	6.94E-04	7.31E-04	90.687%
R22 Proposed Residential Development Bilsham Road	9.01E-06	1.68E-04	1.77E-04	90.659%
R23 Proposed Residential Development Drove Lane	6.38E-06	1.19E-04	1.25E-04	90.656%
R24 Proposed Residential Development Walberton	6.78E-06	1.26E-04	1.33E-04	90.657%
R25 Proposed Residential Development Littlehampton	2.28E-05	4.25E-04	4.48E-04	90.672%
R26 Cinders Lane Allotment	1.46E-05	5.69E-03	5.70E-03	90.935%
R27 Kingley Gate Allotment	4.73E-05	1.84E-02	1.85E-02	91.573%
R28 Proposed Residential Development Wicks Farm	3.86E-05	3.86E-05	7.71E-05	90.654%
R29 Proposed Residential Developments North End Road	2.32E-05	2.32E-05	4.64E-05	90.652%

| 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 TDI)
R30 Proposed Residential Developments Burndell Road	2.54E-05	2.54E-05	5.07E-05	90.653%

B   Figures
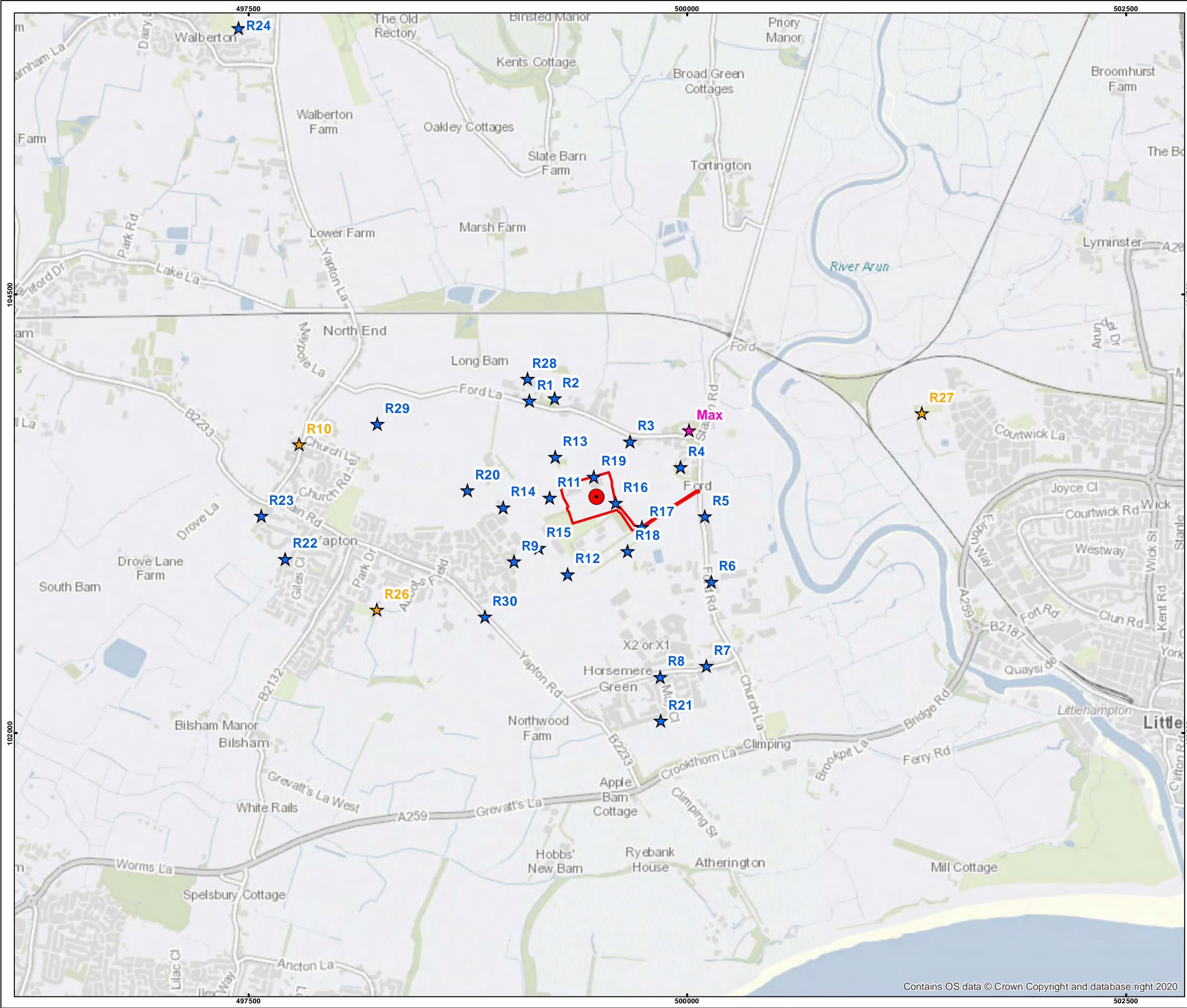
Legend

- ● Stack Locations
- ▭ Site Boundary
- ★ Max Receptor
- ★ Alottment Receptor Locations
- ★ Residential Receptor Locations

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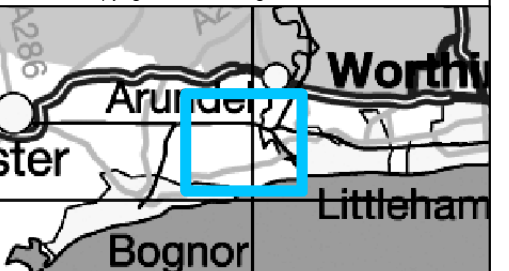
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