FICHTNER

Consulting Engineers Limited

Rivenhall IWMF EP Variation

Gent Fairhead

Schedule 5 Notice #2 - Response

ENGINEERING CONSULTING

Document approval

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Contents

1 Damage Costs for NOx emissions

1. **Submit an air quality damage cost assessment which compares the calculated NOx damage cost for the currently permitted stack height arrangement against the calculated NOx damage cost for the proposed stack height and advanced abatement arrangement.**

1.1 Calculation

The question refers to the DEFRA document "Air quality damage cost guidance", published in January 2019 ("The DEFRA Guidance"). This provides a step-by-step approach to calculating and applying the damage costs for air pollutants. As requested by the Environment Agency, as set out below we have applied this step-by-step approach.

We note that the DEFRA guidance states that the impact-pathway approach is the best practice approach to value changes in air quality but that the damage costs approach can be used for relatively small impacts on air quality. We agree that the impact-pathway approach would give a more representative answer, particularly given the lower population density in the areas affected by emissions from the CHP Plant. However, as requested by the Environment Agency, we have applied the simpler damage costs approach as the air quality impacts are low. As explained in the analysis below, we would expect this approach to be very conservative for the CHP Plant.

The calculations set out below have been carried out in a spreadsheet, which is attached to this document. A printout of the main page is included in Appendix A. We note that DEFRA provides a spreadsheet tool, but some of the data included in this tool is out of date.

1.1.1 Step 1 – Identify and quantify reductions in emissions

As stated in section 3.1 of the supporting information, the permitted NOx emission rate from the CHP Plant is currently 7.734 g/s per line and it would be reduced to 5.156 g/s per line. At 8,150 hours of operation, this gives an annual emission rate of 453.831 tonnes in the current permit, reducing to 302.554 tonnes if the variation is granted.

1.1.2 Step 2 – Identify which damage cost values to use

Table 2 (reproduced below) in the DEFRA Guidance identifies different categories of Part A processes depending on the stack height and the local population density. The category from Table 2 should then be used in Table 3 to identify the appropriate damage cost.

Table 2 - Part A categories

Average population density (persons per km^2)	Stack Height <= 50 m and all small points	Stack Height > 50, <= 100 m	Stack Height > 100 m
<= 250	1	4	7
> 250, <= 1000	2	5	8
> 1000	3	6	9

The IWMF is located in Braintree District. Data on the district is available on the council's website[1]. For the whole district, the population is estimated at 151,677 and the area is 611.68 km^2, which gives a population density of 248 persons/km^2. However, this will overstate the population density in the area affected by emissions from the CHP Plant, as the prevailing wind means that the highest concentrations are in the Coggeshall ward, which has a population of 6,085, an area of about 43 km^2 and hence a population density of 141 people/km^2. Therefore, the appropriate population density to use is "<=250" as this will be more representative of the local area than ">250, <=1000".

For the current permit, the stack height is 58m above ground level and so the appropriate category is 4. Moving on to Table 3 in the DEFRA Guidance, this means that the Central Damage Cost is £1,625 per tonne, with a sensitivity range of £282 to £5,119.

For the proposed variation, the stack height is 35m above ground level and so the appropriate category is 1. This means that the Central Damage Cost is £1,690 per tonne, with a sensitivity range of £287 to £5,375 per tonne.

1.1.3 Step 3 – convert to base year prices

The damage costs are in 2017 prices whereas the anticipated opening year for the CHP Plant is 2023. Therefore, the damage costs need to be adjusted to the base year of 2023, using GDP deflators from the WebTAG Data Book[2] according to the worked example in the DEFRA Guidance. The value for 2017 is 112.36 and the value for 2023 is 126.02, so all damage costs should be increased by 126.02 ÷ 112.36 = 1.1216.

(This is the data which is out of date in the DEFRA tool, as the WebTAG data is from the May 2018 edition, rather than the more recent November 2018 edition.)

1.1.4 Step 4 – Uplift damage costs each year

According to the DEFRA Guidance, the damage costs should be increased by 2% each year from 2017, to reflect an increased willingness to pay for health outcomes as GDP increases. For example, the value for 2025 should be multiplied by 1.02 raised to the eighth power, or 1.1717.

[1] https://www.braintree.gov.uk/info/200136/access_to_information/123/district_statistics

[2] https://www.gov.uk/government/publications/tag-data-book

1.1.5 Step 5 – Calculate benefits for each year

In this step, the tonnage from step 1 is multiplied by the base year damage costs from step 3 and the uplift factor from step 4 to give the costs for each year for both cases.

Taking 2025 as an example year, the damage costs for the current permitted facility would be:

$$453.831 \times 1625 \times \frac{126.02}{112.36} \times 1.02^8 = £969{,}118$$

Through the proposed variation, the damage costs for the facility would be:

$$302.554 \times 1690 \times \frac{126.02}{112.36} \times 1.02^8 = £671{,}922$$

Hence, the benefit would be £297,196.

It should be recalled that the CHP Plant would process about 600,000 tonnes of waste per year, so these damages costs drop from £1.615 per tonne to £1.12 per tonne.

1.1.6 Step 6 – Calculate net present value

The figures for each year are then converted to a net present value by applying a discount factor of 3.5%. We have assumed a plant life of 25 years.

As shown in Appendix A, the NPV for the current permit is £19,653,421 and the NPV for the varied permit is £13,626,372, giving a saving of £6,027,049. As the CHP plant would have processed about 15 million tonnes of waste over 25 years, this gives a NPV of £1.31 per tonne for the permitted plant and £0.91 per tonne for the varied permit.

1.1.7 Step 7 – Sensitivity analysis

The calculations above can be repeated for the high and low sensitivity values. The results of this calculation are shown below.

Table 1: NPV of Damage Costs (£)

Case	Current Permit	Varied Permit	Benefit
Central	19,653,421	13,626,372	6,027,049
Low	3,410,624	2,314,064	1,096,560
High	61,911,299	43,338,312	18,572,986

Hence, it can be seen that the proposed variation will reduce the estimated damage costs for oxides of nitrogen, using DEFRA Guidance, by £6 million as a net present value over 25 years, with a sensitivity range of £1.1 million to £18.6 million. Expressed per tonne of waste, the reduction would be £0.40 per tonne, with a sensitivity range of £0.073 to £1.24 per tonne.

1.2 Commentary

We consider that these damages costs are considerable over-estimates of the actual damage costs associated with NOx emissions from the CHP plant. This is because all of the damage costs are associated with health outcomes linked to atmospheric concentrations of NOx. As illustrated in the original air quality assessment (Appendix D to the variation application, particularly Figure 6) and in the air quality assessment for the variation itself, emissions from the proposed CHP Plant primarily land in uninhabited areas to the north-east of the site. By the time that emissions reach the closest centres of population (Coggeshall and Silver End), the concentration of pollutants is well below the peak concentration, and the concentrations in more major towns, like Braintree, are even lower.

This means that the actual pathway for health impacts is very limited and certainly more limited than will have been assumed for the derivation of the simple damage costs. Therefore, while the Applicant agrees that there will be a reduction in damage costs, the Applicant would expect this to be at the lower end of the sensitivity range.

2 Group 3 metals

2. **Propose an emissions limit value (ELV) for category three metals and demonstrate why it represents the lowest achievable for the proposed plant, with an indication of any measures that may need to be taken to achieve it.**

The Applicant would propose that the ELV for category three metals is reduced to 0.3 mg/Nm^3, which is the upper end of the BAT-AEL range in the draft waste incineration BREF. The measures to be taken to achieve this; the expected emissions resulting from such a limit; and a revised environmental assessment are presented below.

2.1 Measures to be taken

BAT25 in the draft Waste Incineration BREF relates to emissions of dust, metals and metalloids. It includes a BAT-AEL for category 3 metals of 0.01 to 0.3 mg/Nm^3. It lists five possible techniques associated with BAT.

1. **Bag Filter**

   This is already included in the proposed plant and is used at all operational UK EfW plants to abate metals in the solid phase. Lead has the lowest melting point of 327^{o}C, with many of the other category three metals having melting points above 1000^{o}C, so all of the metals would be expected to be in the solid phase.

   In the original permit application, bag filters were considered to be BAT for dust removal.

2. **Electro-static precipitator**

   ESPs are generally considered to be an alternative to bag filters and to achieve less good abatement. Table 4.12 in the draft BREF suggests that ESPs achieve dust levels of <5-20 mg/Nm^3 whereas bag filters achieve <5 mg/Nm^3.

3. **Dry sorbent injection**

   While dry sorbent injection using activated carbon is already included in the design of the CHP Plant, this is primarily to adsorb mercury and the more volatile dioxins and furans. It does not contribute significantly to the abatement of dust, and the BREF specifically states that it is "not relevant for the reduction of dust emissions."

4. **Wet scrubber**

   The BREF notes that wet scrubbers can be used after bag filters to further reduce emissions of dust, metal and metalloids. However, a wet scrubber would lead to saturated flue gases and a visible plume, which is not permitted under the terms of the planning consent. Therefore, a wet scrubber is not considered an 'available' technique.

5. **Fixed or moving bed adsorption**

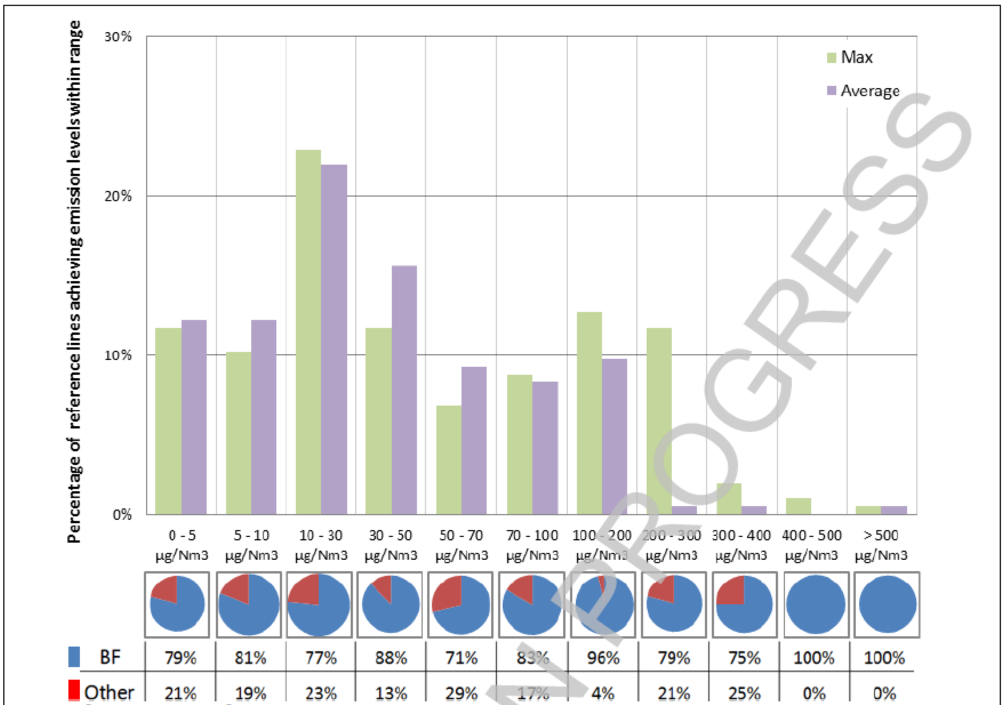
   The BREF notes that this is mainly for adsorption, which will be less effective for metals in the solid phase, but notes that it also acts as a polishing filter for dust. It is noticeable that the description of the technique appears in the sections on abatement of mercury and dioxins, not dust. It introduces a large pressure drop and the fixed bed would need to be replaced periodically.

Hence, the Applicant considers that BAT for dust removal, and for category 3 metal abatement, remains the use of bag filters.

2.2 Performance of bag filters

All UK EfW plants are fitting with bag filters and operate with an emission limit for category 3 metals of 0.5 mg/Nm^3. It is reasonable to assume that the proposed CHP Plant will perform at least as well as current plants.

1. Tolvik has published a report entitled "UK Energy from Waste – Statistics 2018"[3]. This draws on data from the Environment Agency's public registers to show that the average emission concentration for category 3 metals was 14% of the limit, or 0.07 mg/Nm^3. All of these plants are equipped with bag filters.
2. Data submitted by UK plants to the waste incineration BREF questionnaire included 105 measurements of category 3 metals. The average measured value was 0.084 mg/Nm^3, which is fairly consistent with the Tolvik data. The maximum reading was 0.3 mg/Nm^3 and only about 10% of the readings were between 0.2-0.3 mg/Nm^3. Again, all of these plants are equipped with bag filters.
3. The data published in the draft waste incineration BREF and displayed in Figure 3.3.1 (reproduced below) shows that the vast majority of the readings were well below 0.3 mg/Nm^3. About 90% of the average readings for each incineration line were below 0.1 mg/Nm^3 and about 85% of the maximum readings for each incineration line were below 0.2 mg/Nm^3. Most of these plants are equipped with bag filters but not all, and some of them have bag filters combined with other abatement options.



Source: [81, TWG 2016]

Figure 3.31: Periodically monitored Sb+As+Cr+Co+Cu+Pb+Mn+Ni+V emissions to air from reference lines incinerating predominantly MSW

This analysis confirms that current plants operating to an emission limit of 0.5 mg/Nm^3 are achieving actual emissions well below this. It is likely that the CHP Plant would operate with average emissions below 0.2 mg/Nm^3, although some individual readings might be up to 0.3 mg/Nm^3.

[3] Available from https://www.tolvik.com/published-reports/

2.3 Revised environmental assessment

The air quality assessment for category 3 metals has been repeated with the proposed revised ELV of 0.3 mg/Nm^3. This gives a reduced emission rate of 15.467 mg/Nm^3 per line. As explained previously, this is expected to be conservative as actual emissions are expected to be well below this figure.

In preparing the revised assessment, we noticed that that figures reported for category 3 metals in Table 3.1 of the supporting information were incorrect. This was purely a transcription error – the detailed metals assessment in section 3.2.3 of the supporting information was correct. The correct figures with the proposed reduced ELV are shown in Table 2.

Table 2: Process contributions for category 3 metals (for Table 3.1 of supporting information)

Pollutant	Quantity	Unit	Process Contribution					
			2009	2010	2011	2012	2013	Max
Cat. 3 metals	Annual	ng/m^3	3.77	2.71	5.39	4.09	3.70	5.39
	Hourly	ng/m^3	82.38	78.75	81.61	86.03	86.60	86.60

The detailed metals assessment, using the screening methodology outlined in the Environment Agency guidance document "Guidance on assessing group 3 metals stack emissions from incinerators – v4", has also been repeated.

The first stage (worst-case screening) is to assume that each metal is emitted at 100% of the emission level. Where the process contribution (PC) of any metals exceeds 1% of a long term or 10% of a short term AQAL the Environment Agency consider this a potential for significant pollution. Under these circumstances the Predicted Environmental Concentration (PEC) should be compared to the AQAL. If the PEC is greater than 100% of the AQAL, the assessment should proceed to stage 2.

Stage 2 (case specific screening) is to use the maximum emissions data listed in Appendix A of the guidance to revise the predictions. Again, where the PC of any metals exceeds 1% of a long term or 10% of a short term AQAL the PEC should be compared to the AQAL. This can be screened out where the PEC is less than the AQAL.

Table 3 (Long term results) and Table 4 (Short term results) outline the PC and PEC for each metal assuming the worst-case screening and case specific screening, replacing Tables 3.4 and 3.5 in the original supporting information for the variation application. The "case specific screening" assumes the emissions are no worse than the highest measured concentrations from a currently operating plant, as outlined in the EA Guidance.

Table 3: Long term metals results (replacing Table 3.4)

Metal	AQAL (ng/m^3)	Background conc. (ng/m^3)	Metals emitted at combined metal limit		Metal as % of ELV (2)	Metals emitted no worse than a currently permitted Facility		
			PC as % AQAL(1)	PEC as % AQAL		PC (ng/m^3)	PC as % AQAL	PEC as % AQAL
Annual mean								
Arsenic	3	0.47	179.76%	195.43%	5.00%	0.27	8.99%	24.65%
Antimony	5,000	0.83	0.11%	0.12%	2.30%	0.12	0.002%	0.02%
Chromium	5,000	3.43	0.11%	0.18%	18.40%	0.99	0.02%	0.09%
Chromium (VI)	0.2	0.69	2696.46%	3039.46%	0.026%	0.0014	0.70%	343.70%
Cobalt	-	0.08	-	-	1.12%	0.06	-	-
Copper	10,000	2.57	0.05%	0.08%	5.80%	0.31	0.0031%	0.03%
Lead	250	4.40	2.16%	3.92%	10.06%	0.54	0.22%	1.98%
Manganese	150	2.25	3.60%	5.10%	12.00%	0.65	0.43%	1.93%
Nickel	20	1.37	26.96%	33.81%	44.00%	2.37	11.86%	18.71%
Vanadium	5,000	1.11	0.11%	0.13%	1.20%	0.06	0.0013%	0.02%

Note:

(1) The long-term process contribution is 5.39 ng/m^3 for each metal.

(2) Metal as maximum percentage of the IED group 3 ELV, as detailed in Environment Agency metals guidance document (V.4) Table A1.

(3) Chromium (VI) concentrations are based on stack measurements of total chromium and measurements of the proportion of chromium (VI) to total chromium in Air Pollution Control (APC) residuals collected at the same plant.

(4) Nickel concentration is greater than 11% is due to two measurement outliers. The average is around 3% of the Group ELV.

Table 4: Short term metals results (replacing Table 3.5)

Metal	AQAL (ng/m^3)	Background conc. (ng/m^3)	Metals emitted at combined metal limit		Metal as % of ELV [(2)]	Metals emitted no worse than a currently permitted Facility		
			PC as % AQAL[(1)]	PEC as % AQAL		PC (ng/m^3)	PC as % AQAL	PEC as % AQAL
Annual mean								
Arsenic	-	0.94	-	-	5.00%	4.33	-	-
Antimony	150000	1.66	0.06%	0.06%	2.30%	1.99	0.0013%	0.002%
Chromium	150000	6.86	0.06%	0.06%	18.40%	15.93	0.011%	0.015%
Chromium (VI)	-	1.37	-	-	0.03%	0.02	-	-
Cobalt	-	0.16	-	-	1.12%	0.97	-	-
Copper	200000	5.14	0.04%	0.05%	5.80%	5.02	0.003%	0.005%
Lead	-	8.80	-	-	10.06%	8.71	-	-
Manganese	1500000	4.50	0.01%	0.01%	12.00%	10.39	0.0007%	0.001%
Nickel	-	2.74	-	-	44.00%	38.10	-	-
Vanadium	1000	2.22	8.66%	8.88%	1.20%	1.04	0.10%	0.33%

Note:

(1) The long-term process contribution is 86.60 ng/m^3 for each metal.

(2) Metal as maximum percentage of the IED group 3 ELV, as detailed in Environment Agency metals guidance document (V.4) Table A1.

(3) Chromium (VI) concentrations are based on stack measurements of total chromium and measurements of the proportion of chromium (VI) to total chromium in Air Pollution Control (APC) residuals collected at the same plant.

2.3.1 Long-term results

As shown in Table 3, if it is assumed that the entire emissions of metals consist of only one metal, the annual process contributions of arsenic, chromium (VI), lead, manganese and nickel are predicted to be greater than 1% of the long-term AQAL. However, only the PECs for arsenic and chromium (VI) are predicted to be greater than 100% of the AQAL under this worst-case screening assumption.

If it is assumed that the CHP Plant will perform no worse than a currently permitted Energy-from-waste plant, the predicted process contribution is below 1% of the AQAL for all pollutants with the exception of arsenic and nickel. The PECs for arsenic and nickel under this assumption are less than the AQAL, and so the impacts can be screened out. Therefore, under the EA guidance criteria, it can be concluded that there is no risk of exceeding the long-term AQAL for any metals and there is no potential for significant pollution. This is consistent with the conclusions reached in the original air quality assessment.

However, the assumption that the concentrations of nickel and arsenic will be the same as the highest monitored value across all UK EfW facilities is very conservative.

For nickel, the EA notes in its guidance that the highest value is an outlier. Of the 34 measured values considered, the highest is 44% of the ELV, the second highest is 27% and the third highest is 11%, with the average being 3%. Given that the Applicant is committing to a lower ELV for category 3 metals than is currently in force, it would be reasonable to consider a lower nickel concentration.

- Using the third highest measured concentration, the process contribution would be only 2.97% of the EAL.
- Using the average measured concentration, the process contribution would be only 0.81% of the EAL and so could be screened out.

Similarly, the maximum concentration for arsenic of 5% of the ELV is much higher than the average concentration of 0.2% of the ELV. Using this average measured concentration, the process contribution would be only 0.36% of the EAL and so could be screened out.

2.3.2 Short-term results

As shown in Table 4, if it is assumed that the entire emissions of metals consist of only one metal, the maximum 1-hour process contribution of all metals except vanadium is predicted to be less than 10% of the short-term AQAL.

If it is assumed that the CHP Plant will perform no worse than a currently permitted energy-from-waste plant, the predicted process contribution is well below 10% of the AQAL for vanadium, because very little vanadium is released from EfW plants.

Therefore, it can be concluded that there is no risk of exceeding the short-term AQAL for any metal and there is no potential for significant pollution. Again, this is consistent with the conclusions reached in the original air quality assessment.

2.3.3 Comparison with permitted facility

We have compared the annual mean process contribution for category 3 metals as whole for the consented and proposed facilities in Table 5 below. The locations of the receptors are described in the original air quality assessment, which was Appendix D to the supporting information for the variation application.

Table 5: Category 3 metal process contributions at receptors

Receptor		Consented PC ng/m³	Proposed PC ng/m³	Proposed as % of Consented
	Point of Maximum Impact	**4.07**	**5.39**	**132%**
D1	Sheepcotes Farm (Hanger No.1)	0.86	0.88	103%
D3	Allshot's Farm (Scrap Yard)	1.12	2.30	206%
D4	Haywards	3.77	3.54	94%
D5	Herons Farm	1.32	1.36	103%
D6	Gosling's Farm	0.79	0.70	89%
D7	Curd Hall Farm	2.02	1.67	82%
D8	Church (adjacent to Bradwell Hall)	0.63	0.54	86%
D9	Bradwell Hall	0.59	0.50	85%
D10	Rolphs Farmhouse	0.50	0.40	80%
D11	Silver End / Bower Hall / Fossil Hall	1.07	0.90	85%
D12	Rivenhall Pl/Hall	0.95	0.80	84%
D13	Parkgate Farm / Watchpall Cottages	1.05	0.94	90%
D14	Ford Farm / Rivenhall Cottage	0.73	0.62	85%
D15	Porter's Farm	0.96	0.82	85%
D16	Unknown Building 1	1.17	1.08	92%
D17	Bumby Hall / The Lodge / Polish Site	1.12	1.48	133%
D37	Green Pastures Bungalow	0.86	0.76	88%
D38	Deeks Cottage	2.33	2.32	100%
D40	Gosling Cottage / Barn	0.83	0.76	91%
D41	Felix Hall / The Clock House / Park Farm	0.67	0.51	76%
D42	Glazenwood House	0.46	0.40	86%
D43	Bradwell Hall	0.37	0.33	88%
D44	Perry Green Farm	0.52	0.44	86%
D45	The Granary / Porter Farm / Rook Hall	0.63	0.52	83%
D46	Grange Farm	1.43	1.13	79%
D47	Coggeshall	1.26	0.99	79%
	MAX AT A RECEPTOR	**3.77**	**3.54**	**94%**

The table shows that the process contribution at the point of maximum impact is predicted to increase with the variation. However, the process contribution at most receptors is predicted to decrease. In particular, the impact at the most-impacted receptor (Haywards, D4) and in the main centres of population (Coggeshall, D47 and Silver End, D11) is lower with the proposed variation.

It is also important to recall that there is no potential for significant pollution from emissions of category three metals at the point of maximum impact, so this is also the case at all receptors.

2.4 Conclusion

The Applicant proposes a new emission limit for category 3 metals of 0.3 mg/Nm^3. This is proposed for the following reasons:

1. This is the upper end of the BAT-AEL in the draft waste incineration BREF.
2. It can be achieved using bag filters, which are considered to be BAT for abatement of category 3 metals.
3. Actual emissions are expected to be below the emission limit, as demonstrated by monitoring data from UK and European plants.
4. With this reduced emission limit, there is no potential for significant pollution following the variation, which is the same conclusion reached for the current permit.
5. With this reduced emission limit, the process contribution at the most affected receptor and in the two main centres of population is reduced compared to the current permit.

Appendices

A Damage Cost calculation

		g/s	tpa
NOx emissions, current permit		15.468	453.8311
NOx emissions, variation		10.312	302.5541
Reduction in NOx emissions			151.277
		Cat 1	Cat 4
Damage Cost - Central	£/t	1690	1625
Damage Cost - Low	£/t	287	282
Damage Cost - High	£/t	5375	5119
GDP Deflator value 2017		112.36	
GDP Deflator value 2023		126.02	
Uplift factor		2%	
Discount factor		3.50%	

Current Permit	Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
NOx emissions	tpa	454	454	454	454	454	454	454	454	454	454
Damage Cost	£/te	1,625	1,625	1,625	1,625	1,625	1,625	1,625	1,625	1,625	1,625
Rebased damage cost	£/te	1,823	1,823	1,823	1,823	1,823	1,823	1,823	1,823	1,823	1,823
Uplifted damage cost	£/te	2,052	2,094	2,135	2,178	2,222	2,266	2,311	2,358	2,405	2,453
Damage cost per year	£	931,486	950,116	969,118	988,501	1,008,271	1,028,436	1,049,005	1,069,985	1,091,385	1,113,212
PV of damage cost per year	£	931,486	917,986	904,682	891,571	878,650	865,916	853,366	840,998	828,810	816,798

Net Present value of costs		
- Central	£	19,653,421
- Low	£	3,410,624
- High	£	61,911,299

Varied Permit	Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
NOx emissions	tpa	303	303	303	303	303	303	303	303	303	303
Damage Cost	£/te	1,690	1,690	1,690	1,690	1,690	1,690	1,690	1,690	1,690	1,690
Rebased damage cost	£/te	1,895	1,895	1,895	1,895	1,895	1,895	1,895	1,895	1,895	1,895
Uplifted damage cost	£/te	2,135	2,177	2,221	2,265	2,311	2,357	2,404	2,452	2,501	2,551
Damage cost	£	645,830	658,747	671,922	685,360	699,068	713,049	727,310	741,856	756,693	771,827
PV of damage cost per year	£	645,830	636,471	627,246	618,156	609,197	600,368	591,667	583,092	574,642	566,313

Net Present value of costs		
- Central	£	13,626,372
- Low	£	2,314,064
- High	£	43,338,312

NPV of benefit		
- Central	£	6,027,049
- Low	£	1,096,560
- High	£	18,572,986

NOx emissions, current permit	
NOx emissions, variation	
Reduction in NOx emissions	
Damage Cost - Central	£/t
Damage Cost - Low	£/t
Damage Cost - High	£/t
GDP Deflator value 2017	
GDP Deflator value 2023	
Uplift factor	
Discount factor	

Current Permit	Year	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
NOx emissions	tpa	454	454	454	454	454	454	454	454	454	454
Damage Cost	£/te	1,625	1,625	1,625	1,625	1,625	1,625	1,625	1,625	1,625	1,625
Rebased damage cost	£/te	1,823	1,823	1,823	1,823	1,823	1,823	1,823	1,823	1,823	1,823
Uplifted damage cost	£/te	2,502	2,552	2,603	2,655	2,708	2,762	2,818	2,874	2,931	2,990
Damage cost per year	£	1,135,476	1,158,186	1,181,350	1,204,977	1,229,076	1,253,658	1,278,731	1,304,306	1,330,392	1,356,999
PV of damage cost per year	£	804,961	793,295	781,797	770,467	759,301	748,297	737,452	726,764	716,231	705,851

Net Present value of costs	
- Central	£
- Low	£
- High	£

Varied Permit	Year	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
NOx emissions	tpa	303	303	303	303	303	303	303	303	303	303
Damage Cost	£/te	1,690	1,690	1,690	1,690	1,690	1,690	1,690	1,690	1,690	1,690
Rebased damage cost	£/te	1,895	1,895	1,895	1,895	1,895	1,895	1,895	1,895	1,895	1,895
Uplifted damage cost	£/te	2,602	2,654	2,707	2,761	2,817	2,873	2,930	2,989	3,049	3,110
Damage cost	£	787,264	803,009	819,069	835,451	852,160	869,203	886,587	904,318	922,405	940,853
PV of damage cost per year	£	558,106	550,018	542,046	534,191	526,449	518,819	511,300	503,890	496,587	489,390

Net Present value of costs	
- Central	£
- Low	£
- High	£

NPV of benefit	
- Central	£
- Low	£
- High	£

NOx emissions, current permit							
NOx emissions, variation							
Reduction in NOx emissions							
Damage Cost - Central	£/t						
Damage Cost - Low	£/t						
Damage Cost - High	£/t						
GDP Deflator value 2017							
GDP Deflator value 2023							
Uplift factor							
Discount factor							
Current Permit	Year	2043	2044	2045	2046	2047
NOx emissions	tpa	454	454	454	454	454
Damage Cost	£/te	1,625	1,625	1,625	1,625	1,625
Rebased damage cost	£/te	1,823	1,823	1,823	1,823	1,823
Uplifted damage cost	£/te	3,050	3,111	3,173	3,237	3,301
Damage cost per year	£	1,384,139	1,411,822	1,440,059	1,468,860	1,498,237
PV of damage cost per year	£	695,621	685,540	675,604	665,813	656,164
Net Present value of costs						
- Central	£					
- Low	£					
- High	£					

Varied Permit	Year	2043	2044	2045	2046	2047
NOx emissions	tpa	303	303	303	303	303
Damage Cost	£/te	1,690	1,690	1,690	1,690	1,690
Rebased damage cost	£/te	1,895	1,895	1,895	1,895	1,895
Uplifted damage cost	£/te	3,172	3,235	3,300	3,366	3,433
Damage cost	£	959,670	978,863	998,441	1,018,410	1,038,778
PV of damage cost per year	£	482,297	475,308	468,419	461,630	454,940
Net Present value of costs						
- Central	£					
- Low	£					
- High	£					

NPV of benefit	
- Central	£
- Low	£
- High	£

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