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GENT FAIRHEAD & CO LIMITED
RIVENHALL IWMF
STACK HEIGHT ASSESSMENT

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1 Introduction

It is proposed that the Rivenhall IWMF (the Facility) will have a stack height of 58 metres (above surrounding ground level) which is equivalent to 108 metres Above Ordnance Datum (AOD).

In the absence of published Environment Agency guidance that relates directly to BAT for stack height, this report is intended to assess the stack height in a comparable manner to other technology BAT assessments, via an approach discussed with the EA during pre-application discussions, and is intended to address any concerns raised by local stakeholders regarding the height of the stack.

Within this report we will:

(1) Provide a cost-benefit analysis assessment of alternative stack heights against the proposed stack height and NOx emission limit of 150mg/Nm^3;

(2) Explain the influence of building height and location on stack height; and

(3) Consider the proposed stack height in relation to other energy from waste (EfW) facilities which have been permitted by the Environment Agency.

1.1 The Facility

In determining the suitable stack height for the Facility, it is necessary to understand the topography of the site and the surrounding ground and how the Facility has been incorporated into the local environment.

The Facility will be located in a former quarry, the base of which will be located below the current ground level following the removal of in-fill from the quarry. The base of the stack will be located approximately 20m below the current ground level and the stack height above is proposed to be 58 metres above the surrounding terrain. Therefore, the total stack height proposed is 78 metres from its base.

In this report, stack heights are stated relative to the surrounding ground level, unless otherwise stated.

The relative vertical dimensions of the surrounding land, the quarry, the Facility building and the stack are presented graphically in Figure 1 below:

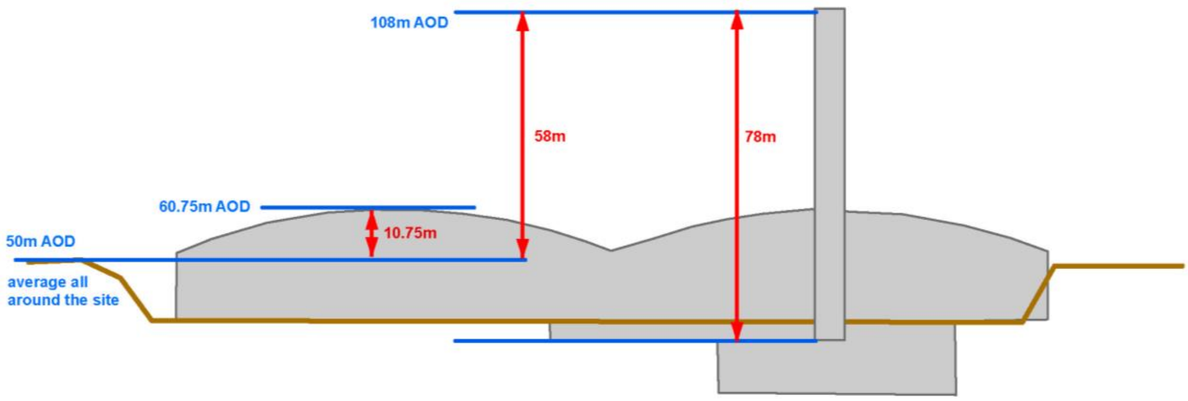

Figure 1 – The topography of the Facility

2 Cost Benefit Analysis

The Cost Benefit Analysis presented in this report will follow the principles and structure of Technical Guidance Note EPR-H1 and provide commentary, where appropriate on the environmental parameters mentioned within EPR-H1.

For the purposes of this Cost Benefit Analysis, cost data has been obtained from the contractor responsible for the design and construction of the stack.

2.1 Options Considered

The air quality impact associated with a range of stack heights of between 25m and 95m (above surrounding ground level) have been calculated using the conservative air quality model used to predict the air quality impacts within the Dispersion Modelling Assessment (Annex 5). It should be noted that the actual emission concentrations resulting from operation of the Facility will be below those used in the modelling. The evaluation is therefore considered to be conservative.

The stack height in the extant planning consent is 35m above surrounding ground level, at 85m AOD. At the request of the EA, this report considers capital costs for shorter stacks and as a result data for stack heights of 25m and 30m has been included.

For convenience in presentation, the stack heights analysed increase in 5m increments initially, expanding to 10m for taller stacks.

2.2 Environmental Performance

2.2.1 Emissions to Air

As identified in the Dispersion Modelling Assessment (Annex 5), emissions of all pollutants have been screened as insignificant at the point of maximum impact, except for 15-minute sulphur dioxide; annual mean nitrogen dioxide; annual mean VOC's (expressed as benzene and 1,3-butadiene; and annual mean cadmium). However, in relation to these pollutants, these are unlikely to give rise to significant pollution in that the PEC is less than 70% (taking expected modelling uncertainties into account) of both the long term and short term ES. Hence, for the purposes of determining the most appropriate stack height, only emissions of NOx have been considered as it is acknowledged by the EA as the most sensitive pollutant of those pollutants which cannot be screened out as insignificant.

The impact of emissions to air is considered in the Air Dispersion Assessment, presented in Annex 5 to the Environmental Permit application, and reference should be made to this Annex for all details of the modelling. Furthermore, an assessment to justify the selection of the proposed technologies for the abatement of NOx has been undertaken, and is presented in Annex 6. This assessment justifies that the use of SNCR to abate emissions of NOx is considered to represent BAT for the IWMF.

The following Table 2-1 presents the predicted ground level concentrations at the point of maximum concentration for the different stack heights considered, and assuming that the emissions from the CHP Plant are released at the proposed emission limit for NOx of 150 mg/Nm^3 for the whole year. These are both conservative assumptions when considering impact at receptors, as that impact will be lower than at the point of maximum impact, the plant will typically operate below the emission limit and the plant will not operate for the whole year as it will be offline for maintenance. It should be noted that the stack exit emission is one of the lowest NOx emission limits for a waste incineration plant in the UK. The short term impacts assume that the emissions are released at the proposed half-hourly emission limit for NOx (400 mg/Nm^3) during the worst-case weather conditions for dispersion, which is also a very conservative assumption.

As well as increasing the stack height, the technology provider has indicated that it would be possible to further reduce the emission limit for NOx from 150mg/Nm^3 to 100mg/Nm^3 using the proposed NOx abatement technology (SNCR). Whilst GFC understands that this emission limit may have been achieved on only two other facilities in Europe, it is unproven in any other EfW facility using this technology in the UK. Furthermore, limited data sets relating to maximum daily emissions indicate potential difficulties in agreeing with the EA that this is an available emission limit at this time. However, at an emission limit of 150 mg/Nm^3, data from other EfW facilities using SNCR NOx abatement systems confirm that the daily maximum can be guaranteed not to be exceeded and, under normal operations, daily emission limits will be lower. Therefore, GFC considers that the lower limit of 100 mg/Nm^3 cannot be justified as being 'available' until there is sufficient data demonstrating that it can be achieved on a long-term basis.

Table 2-1 – Air Emissions – Process Contributions at Point of Maximum Impact with an emission limit of NOx of 150 mg/Nm³

Stack Heights (above surrounding ground level)		25m	30m	35m	40m	45m	50m	55m	60m	65m	75m	85m	95m
Long Term													
Process Contribution (PC)	µg/m³	3.11	2.42	1.94	1.59	1.33	1.12	0.96	0.83	0.72	0.56	0.45	0.36
Background	µg/m³	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6
Predicted Environmental Contribution (PEC)	µg/m³	21.71	21.02	20.54	20.19	19.93	19.72	19.56	19.43	19.32	19.16	19.05	18.96
Air Quality Objective (AQAL)	µg/m³	40	40	40	40	40	40	40	40	40	40	40	40
PC as % of AQAL	%	7.78%	6.05%	4.85%	3.97%	3.31%	2.80%	2.40%	2.07%	1.81%	1.40%	1.12%	0.91%
PEC as % of AQAL	%	54.27%	52.55%	51.35%	50.47%	49.81%	49.30%	48.90%	48.57%	48.31%	47.90%	47.62%	47.41%
Short Term													
Process Contribution (PC)	µg/m³	65.46	47.02	32.76	26.48	22.07	19.00	17.12	15.62	14.28	12.24	10.70	9.24
Background	µg/m³	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6
Predicted Environmental Contribution (PEC)	µg/m³	102.66	84.22	69.96	63.68	59.27	56.20	54.32	52.82	51.48	49.44	47.90	46.44
Air Quality Objective (AQAL)	µg/m³	200	200	200	200	200	200	200	200	200	200	200	200
PC as % of AQAL	%	32.73%	23.51%	16.38%	13.24%	11.04%	9.50%	8.56%	7.81%	7.14%	6.12%	5.35%	4.62%
PEC as % of AQAL	%	51.33%	42.11%	34.98%	31.84%	29.64%	28.10%	27.16%	26.41%	25.74%	24.72%	23.95%	23.22%

It can be seen that there are no predicted exceedances of AQALs for any of the stack heights. Increasing the stack height reduces the PC and the PEC. Whilst it is not possible to screen out the long-term impact as insignificant at any of the proposed stack heights except at a stack height of 95m (i.e. 145m AOD), significant pollution will not arise as the background concentrations are low. The long term PEC is around 50% of the AQAL at all stack heights and so the impact can be described as "not significant". Applying the IAQM (2017) guidance[1], which is used to describe impacts in the planning regime, the impact at all stack heights above 35m above surrounding ground level would be described as '*negligible*'.

It should be noted that the short term impact can be screened out as insignificant for stack heights of 50m or more above surrounding ground level, and that there is a significant increase in short term impacts for stack heights of less than 35m.

As the long term impact cannot be screened out as insignificant, notwithstanding that the impact will not be significant, the impact at residential receptors and sensitive ecological areas has also been considered.

2.2.1.1 Residential Receptors

The table below shows the impact of annual mean emissions of nitrogen dioxide at residential receptors. The second column shows the highest predicted annual average impact at any receptor using any of the five years of weather data. The third column shows the number of residential receptors where, for at least one year of weather data, the impact cannot be screened out as insignificant.

Table 2-2 – Impact on Sensitive Receptors

Stack Height Above Surrounding Ground Level (m)	Highest annual average contribution of nitrogen dioxide at a residential receptor (% of AQAL)	Number of residential receptors not screened out as insignificant
25	3.77%	>300
30	3.47%	>250
35	3.18%	111
40	2.90%	26
45	2.64%	5
50	2.39%	3
55	2.16%	3
60	1.95%	3
65	1.75%	2
75	1.40%	1
85	1.11%	1
95	0.86%	0

[1] "Land-Use Planning & Development Control: Planning For Air Quality", Institute of Air Quality Management, January 2017.

Data from Table 2-2 is supported by Figure 2, which shows the area where the annual PC of nitrogen dioxide is greater than 1% of the AQAL in any year for varying stack heights from 35m (85m AOD). At stack heights below 35m, the number of residential receptors which are affected in Coggeshall becomes harder to identify, so this has not been shown graphically on the diagram.

Figure 2 shows that the most noticeable marginal benefits from increasing the stack height relate to a stack height of 40m and 45m above surrounding ground level. Above this height, the change in number of receptors which cannot be screened out as insignificant becomes small. As explained in the Dispersion Modelling Assessment (Annex 5 to the EP application), even when the impact cannot be screened out, the impact on these receptors is still '*not significant*' as the PEC is less than 50%. Under the IAQM (2017) guidance for planning applications, the impact at all receptors would be described as '*negligible'* at all stack heights considered.

Taking Table 2-2 above into consideration, it is concluded that:

- the impact of annual mean nitrogen dioxide cannot be screened out as insignificant at all sensitive receptors until the stack height reaches around 95m;
- increasing the stack height from 35m to 55m above surrounding ground level (i.e. to 105mAOD) would enable the impact on an additional 108 residential receptors to be screened as 'insignificant' for annual mean emissions of nitrogen dioxide, whilst reducing the predicted impact on the most impacted receptor by 1.02% of the AQAL.

Notwithstanding this, it should be stressed that the impact is not significant at any receptors at any of the stack heights considered.

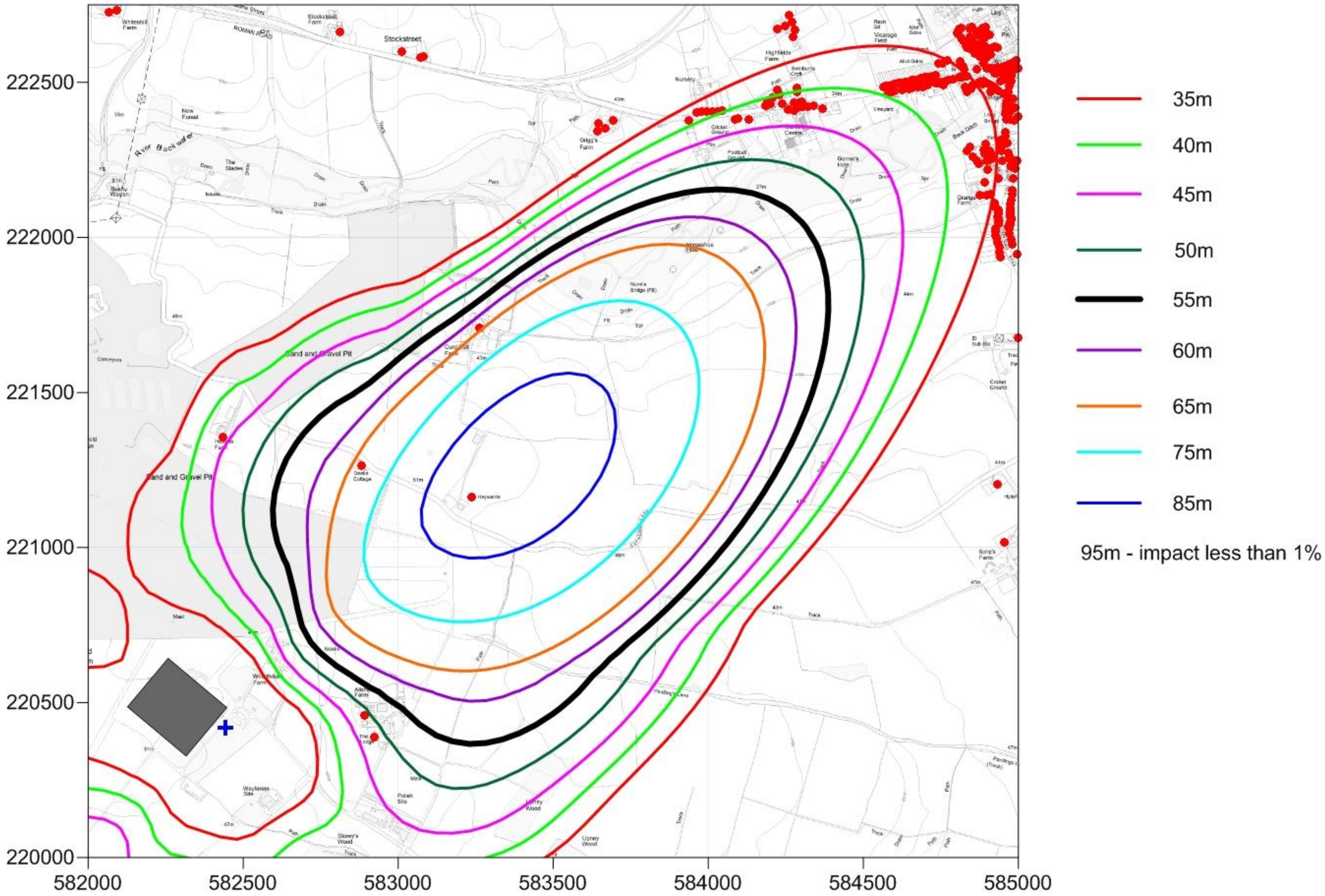

Figure 2 – Area where annual Average NO_2 concentrations are greater than 1% of AQAL with varying stack heights above surrounding ground level

2.2.1.2 Sensitive Ecological Receptors

As shown in the Air Dispersion Modelling Assessment, the impact of emissions to air from the Facility are screened as insignificant for all sensitive ecological receptors. Therefore, the impact of emissions upon ecological receptors has not been considered within this assessment.

2.2.2 Emissions to Water

There are no emissions to water associated with any of the stack heights considered.

2.2.3 Photochemical Ozone Creation Potential

Nitrogen dioxide has a photochemical ozone creation potential (POCP) value relative to Ethylene of 2.8 and nitrogen oxide has a POCP value relative to Ethylene of -42.7. The POCP associated with the SNCR system used to abate emissions of NOx from the CHP Plant will be the same for the alternative stack heights. The POCP associated with emissions from the Facility is -17,200 independent of the stack height. This is negative, as the abatement of NOx has a negative impact on POCP.

2.2.4 Global Warming Potential

The direct emissions of greenhouse gases are the same for each of the stack heights being considered. The energy consumption will be slightly different for each stack height due to the pressure drop along the chimney increasing with height and thereby causing an increase in power consumption of the ID (Induced Draft) fan associated with the increases in stack height. Notwithstanding this, the additional power consumption is considered to be insignificant (<1kW) compared to the overall power consumption of the Facility.

2.2.5 Raw Materials

The estimated consumption of raw materials associated with each stack height will be the same, as this is determined by the NOx abatement system.

2.2.6 Waste Streams

There are no waste streams associated with any of the options.

2.3 Costs

The estimated costs associated with each option are presented below. To enable direct comparisons to be made, the costs are presented as annualised costs, with the capital investment and financing costs spread over a 30-year lifetime with a rate of return of 3.5%, consistent with Treasury Green Book guidance, as instructed by the Environment Agency. The capital costs for the different stack heights are extracted from quotations from the contractor who will construct the Facility, should it receive an Environmental Permit. Some of these costs are based on a Euro:£ exchange rate of 1.2.

The contractor did not provide quotations for shorter stacks. However, as costs for 25m and 30m stacks have been requested by the EA and are needed for the marginal cost assessment in section 2.4 below, these costs have been extrapolated from the costs provided by the contractor. The maintenance costs for these shorter stacks are shown as negative figures as they are being compared with the planning consent height of 35m.

Table 2-3 – Costs

Stack Height Above Surrounding Ground Level (m)	Capital Cost of Stack and Foundations (£)	Annualised Cost (£/yr)	Additional Maintenance Cost (£/yr)	Total Annualised Cost (£/yr)
25	1,475,000	80,198	-20,000	60,198
30	1,754,167	95,376	-10,000	85,376
35	2,033,333	110,555	-	110,555
40	2,312,500	125,734	10,000	135,734
45	2,591,667	140,912	20,000	160,912
50	2,854,167	155,185	30,000	185,185
55	3,116,667	169,457	40,000	209,457
60	3,400,000	184,863	50,000	234,863
65	3,683,333	200,268	60,000	260,268
75	4,258,333	231,531	80,000	311,531
85	4,808,333	261,435	100,000	361,435
95	5,366,667	291,793	120,000	411,793

2.4 Analysis

The table below compares the results for the various stack heights. The table also shows the marginal annualised cost for each increase in stack height and the marginal cost per 1% reduction in process contribution to annual mean nitrogen dioxide for each increase in stack height. This shows that the marginal cost to achieve the same benefit increases as the stack height increases.

Table 2-4 – Comparison Table, Stack Height options with an emission limit of NOx of 150 mg/Nm^3

Parameter	Units	Stack height (above surrounding ground level)											
		25	30	35	40	45	50	55	60	65	75	85	95
Impact of Long Term emissions of NO_2 at Point of Maximum Impact	% PC of AQAL	7.78%	6.05%	4.85%	3.97%	3.31%	2.80%	2.40%	2.07%	1.81%	1.40%	1.12%	0.91%
No. of residential properties which NO2 impact cannot be screened as '*insignificant*'		>300	>250	111	26	5	3	3	3	2	1	1	0
Total Annualised Cost	£ p.a.	£60,198	£85,376	£110,555	£135,734	£160,912	£185,185	£209,457	£234,863	£260,268	£311,531	£361,435	£411,793
Marginal Annualised Cost	£ p.a.	-	£25,179	£25,179	£25,179	£25,179	£24,272	£24,272	£25,405	25,405	51,264	49,904	50,357
Marginal cost per reduction in impact (% PC of AQAL)	£ p.a.	-	£14,512	£20,963	£28,884	£38,107	£47,280	£60,459	£78,345	£95,596	£126,763	£174,461	£239,268

It should be noted that there is a step change in the total annualised cost at 75m due to the need to increase the strength of the stack foundations and provide the stability required.

Using the information presented in Table 2-4, the marginal abatement costs associated with increasing the stack height are compared with the environmental impact in Figure 3 and Figure 4 below.

Whilst the cost benefit analysis focusses on the environmental emission impacts which are considered within EPR-H1, it is important to note that this does not take account of the visual impact of the stack, as this is a concern for the planning regime. (This is also discussed in section 3.4.) The Facility would be located in an area of open, flat countryside and the visual impact of the stack was considered to have some detrimental effect on the landscape character by the Planning Inspector at the Public Inquiry into the Facility. We are aware that the potential for change to visual impact is the primary consideration in the scoping opinion from the local authority on the proposed planning application for a taller stack.

Given this additional issue, the objective of the marginal abatement cost assessment is to identify the point at which the additional costs associated with increasing the stack height are less proportionate to the environmental benefits gained. This is a recognised form of analysis when considering environmental benefits versus marginal cost increases and was discussed with the EA during pre-application discussions. The graphs have been extended down to a stack height above surrounding ground level of 30m to illustrate the benefits already achieved with a stack height of 35m as per the current planning permission.

Figure 3 and Figure 4 below show two ways of identifying the point at which the additional costs associated with increasing the stack height are less proportionate to the environmental benefits gained. Both figures show the relationship between the marginal annualised cost and the process contribution for all of the assessed stack heights.

- Figure 3 shows a line between each of the points and illustrates that there are two parts of the line where the slope is consistent. This shows that there is a change in slope between the first part of the line and the latter part, with the two slopes intercepting at around 50 metres and this change from one slope to the other occurs within the range of stack heights between about 45 and 60m. Hence, this identifies the point at which there is a clear change between the marginal costs associated with increasing the stack height against the environmental benefits from reducing the process contribution.
- Figure 4 shows a more analytical approach. A line drawn from the top left hand corner of the graph to the bottom right hand corner that encompases all of the datapoints would have an angle of 45° if the graph were drawn as a square, so it is referred to below as “the 45° line”. This line joins all the points where the fractional change in the quantity being measured on the x axis is the same as the fractional change in the quantity being measured on the y axis. If the line is at any other angle then one of the two quantities changes more than the other, so a steeper slope means the PC as a percentage of the AQAL is dropping faster than the marginal cost is increasing and a shallower line means the reverse.

  The aim is to find the point at which the marginal cost starts to increase faster than the PC as a percentage of the AQAL is decreasing. This is the point at which a line with the same slope as the 45° line makes a tangent with the line of best fit shown on the graph. This is a power curve, which means that it has an equation of the form $y=Ax^B$. The slope of this curve is the first derivative, which is $ABx^{(B-1)}$. Hence, the point at which the slope of this curve is the same as the slope of the 45° line can be calculated and is 57.4m.

Both of the figures suggest that the cost effectiveness of increases in stack height begin to reduce noticeably around 50-60 m above surrounding ground level.

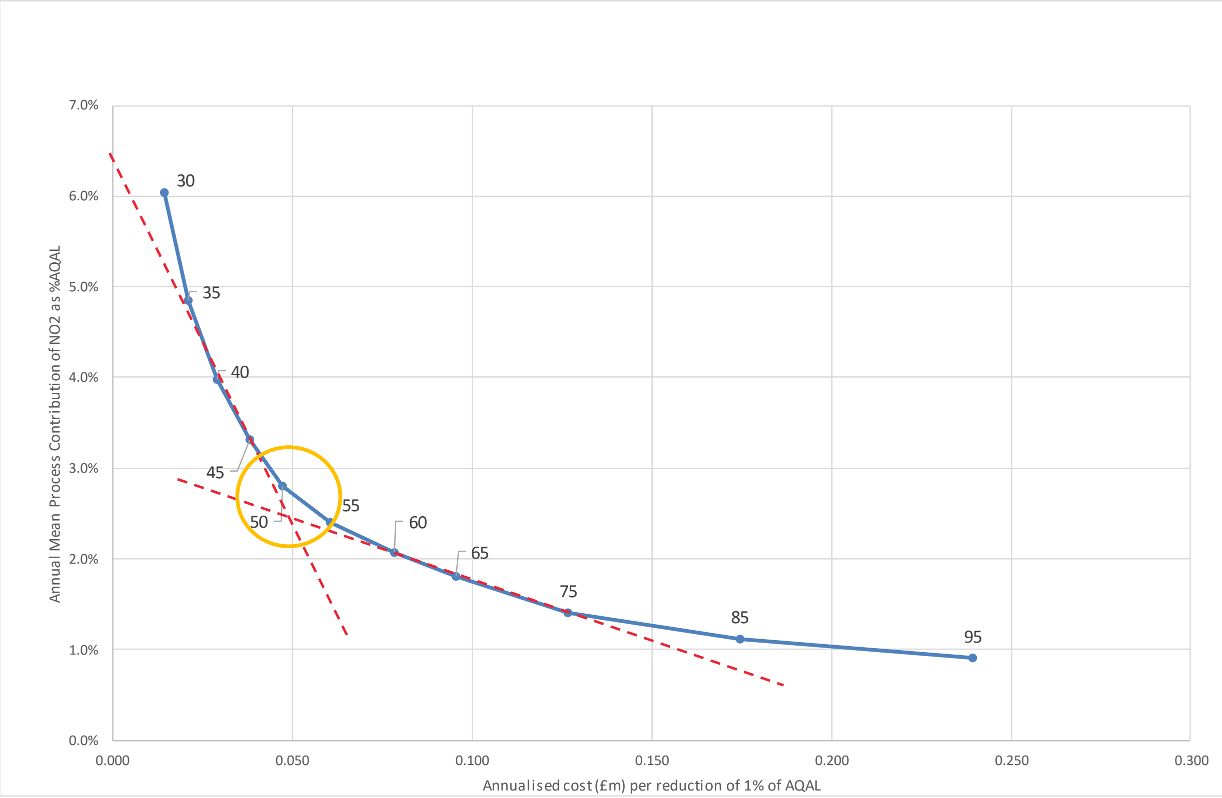

Figure 3 – Annual mean PC against Marginal Annualised Cost, showing change in slope

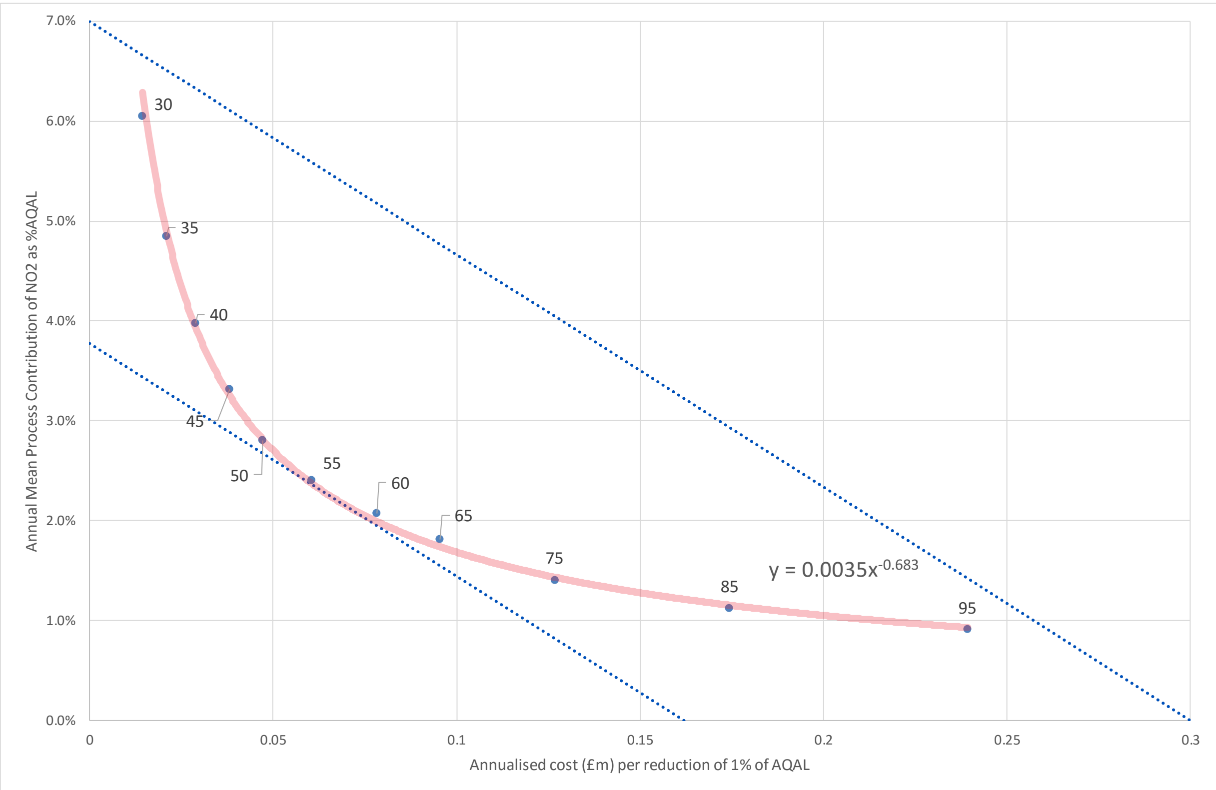

Figure 4 – Annual mean PC against Marginal Annualised Cost, showing interception with 45° line

The information in Table 2-4 also shows that the number of receptors which cannot be screened out as insignificant in all weather years drops to 3 at a stack height of 50m above surrounding ground level and that the stack height would need to increase to 65m before an additional receptor is also screened out. This also supports a stack height of 50 to 60m above surrounding ground level.

A stack height of 58m above surrounding ground level has been selected as this is within the indicated range from all methods and is the height calculated from the analytical method, rounded up to the nearest metre.

As can be seen from the information presented above, with some interpolation between the data points, increasing the stack from 35m to 58m above surrounding ground level will:

- enable short term impacts for nitrogen dioxide to be screened out as insignificant;
- reduce the maximum long-term process contribution for nitrogen dioxide from 4.85% to about 2.2% of the AQAL;
- reduce the number of residential properties at which the impact of long term emissions of nitrogen dioxide cannot be screened as 'insignificant' under all weather conditions, assuming that the Facility operates at the emission limit for the entire year, from 111 to 3; and
- increase the annualised costs associated with the stack by approximately £114,000.

Increasing the stack height further would have limited benefits for increased marginal costs. This is particularly the case as the impact on the limited number of receptors that cannot be screened is in any event not significant. The environmental benefits of increasing the stack height above 58m are considerably less than the benefits associated with increasing from 35m to 58m, even acknowledging that the actual long term impact at all stack heights above 35m is not significant, and would be described as "negligible" under the IAQM (2017) guidance.

Taking all of the above into consideration, it is concluded that a stack of height 58m (above surrounding ground level) (108m AOD) with a long term emission-limit for NOx of 150mg/m^3 represents BAT for the Rivenhall IWMF.

3 Stack Height Comparisons

This section of the report examines the stack heights of other similar energy-from-waste plants constructed in the UK.

It is not appropriate to compare the stack heights of energy from waste plants – or any other large combustion process - simply by considering plant capacity. The height chosen for the stack depends on a number of other factors. These include the following:

(1) the age of the plant

(2) the adjacent building height; and

(3) the sensitivity of the surrounding environment.

In this section of this report, we have explained these different factors in order to demonstrate that the proposed stack height of 58m above surrounding ground level for the Rivenhall IWMF, as selected following the above assessment related to BAT, is not inconsistent with other similar facilities in the UK.

3.1 Age of the Plant

The regulations regarding determination of stack height have changed over the years. The 1956 Memorandum on Chimney Heights provided a "design by rule" for combustion processes that gave rise to SO_2 and NOx. The Memorandum was adapted and expanded to cover a wide range of pollutants and discharge conditions and issued by HMIP as Technical Guidance Note D1, and incorporated into Part 1 of the Environmental Protection Act 1990. The D1 Guidance Note provided a method of calculating minimum stack height by use of a formula.

By the end of the 1990s/early 2000s, various air modelling software had become established and progressively validated. The D1 Guidance Note was subsumed into the Environment Agency's H1 assessment and then withdrawn in 2016, by which time computer-based air quality modelling was the preferred method for air quality assessment and stack height determination.

This means that the basis on which a number of the energy from waste plant stack heights were determined is now out of date and different to that used for Rivenhall. The D1 calculation gave a stack height to ensure adequate dispersion of sulphur dioxide. The concentration of SO_2 produced by waste is relatively low compared to fossil fuels, but the chimney height determination was the same for energy from waste plants as for fossil fuel burning plants. It is not possible to generalise across all plants designed during the late 1990s/ early 2000, but is possible that some of the plants designed during the period may have stacks that are actually higher than would otherwise have been the case based upon current modelling. Whatever the case, it is a fact that the determination of the stack height at this time was on a different set of criteria to that of today.

3.2 Building Height

A major determining factor for stack height is the height of any nearby buildings. This is because buildings have a significant effect on air flows. If the stack is not tall enough to ensure that the emissions are released outside of the influence of buildings, then emissions will be brought rapidly to ground level, leading to high ground level concentrations. This has been recognised for many years, starting with the old rule-of-thumb that stacks should be at least 3 metres taller than the building they are on and moving through Technical Guidance Note D1 (referred to above), where the height and length of the building were key inputs in determining appropriate stack heights. It continues to be recognised in atmospheric dispersion modelling, as any buildings which are less than a third of the stack height are excluded from a model.

The figures in later sections of this assessment show the significance of buildings. As presented in Annex 5 to the EP application, the graphs showing the process contribution with different stack heights indicate dramatic reductions as the stack height increases from 25m to 35m and then smaller decreases with taller stack heights.

3.3 Plant Capacity

The capacity of the plant may have an effect on stack height, but this is more complex and is not inevitable. There are three different effects, some of which compete with each other.

(1) A larger plant will release a greater mass of pollutants, assuming that it runs at the same emission limit, and so it has the potential to lead to higher ground level concentrations.

(2) However, a larger plant releases a greater volume of total flue gases. These have an increased buoyancy effect, which improves the dispersion of pollutants.

(3) A larger plant will need a larger building. However, this is not necessarily a taller building. The height of the building for an incineration plant is primarily determined by the height of the boiler, and the height of the boiler is related to the capacity of each stream. For example, a plant which has a single stream with a capacity of 150,000 tpa would have the same building height as a 300,000 tpa plant which has two streams, both with a capacity of 150,000 tpa. The building would be larger, but not taller. It should be noted that the Rivenhall CHP Plant has two streams.

The relationship between capacity and building height is further complicated by the addition of architectural features, which can serve to improve the appearance of a building but almost always lead to an increase in its height, or, as is the case at Rivenhall, by lowering parts of the plant, such as the boiler, into the ground.

3.4 Surrounding Environment

The third main influence on stack height is the surrounding environment. Again, this can have a number of different effects.

(1) If the surrounding environment includes particularly sensitive habitats, it can be necessary to increase the height of the stack to improve dispersion and reduce the impact of the plant. An example of this is the Cornwall EfW plant, where the stack height was increased to protect a sensitive habitat close to the plant.

(2) Air Quality Management Areas (AQMA). Since 1997 the local air quality in progressively more areas of the country (mostly urban), is managed under an AQMA. In many of these areas, the background levels are already exceeding the AQAL and so it is necessary for any new emission sources to be controlled to have an insignificant impact. In these areas, the stack height needs to be set such that all pollutants are screened out as insignificant. An example of this is Beddington EfW plant, where the stack height was increased to protect the local AQMA.

(3) Conversely, if the surrounding environment is not sensitive or does not include many receptors or residential properties, a shorter stack can be acceptable.

(4) Finally, the surrounding environment might be sensitive to visual impacts. This can lead to the building being buried underground and to the height of the stack being reduced, in order to reduce the visual impact of the plant. This is the case at Rivenhall and was also the case at Newhaven, East Sussex and Hartlebury, Worcestershire.

3.5 Stack Heights of other plants

Permit applications and decision documents for a number of other incineration and co-incineration plants have been reviewed. All of this information is in the public domain.

Figure 5 below compares the total stack height (i.e. the physical length of the stack from its base to the emissions point) with the plant throughput for 34 waste and waste wood plants with throughputs above 100,000 tonnes per annum. It can be seen that the relationship between throughput and stack effective length is quite weak (i.e. there is a low correlation between the two) with a lot of spread. The red square shows the Rivenhall IWMF with a total stack height (physical length from the base) of 78m, for consistency with the other data.

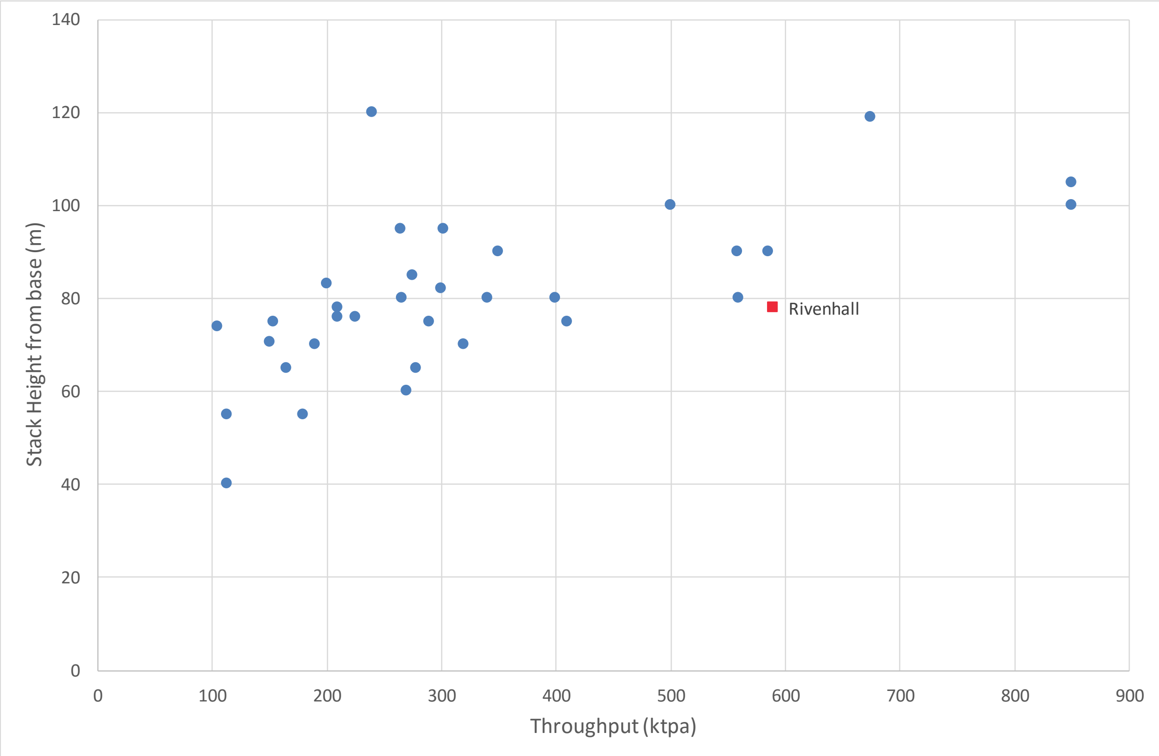

Figure 5 – Total Stack Height (physical length) against Throughput

Figure 6 below compares the stack height above surrounding ground level with capacity for the same 34 plants. The purple diamonds show the other plants which are lowered - in Hartlebury, Newhaven and Allington – and the red square shows the Rivenhall IWMF with a stack height of 58m above surrounding ground level (i.e. at 108m AOD). It can be seen that the spread is slightly increased and the correlation between stack height and plant capacity remains low.

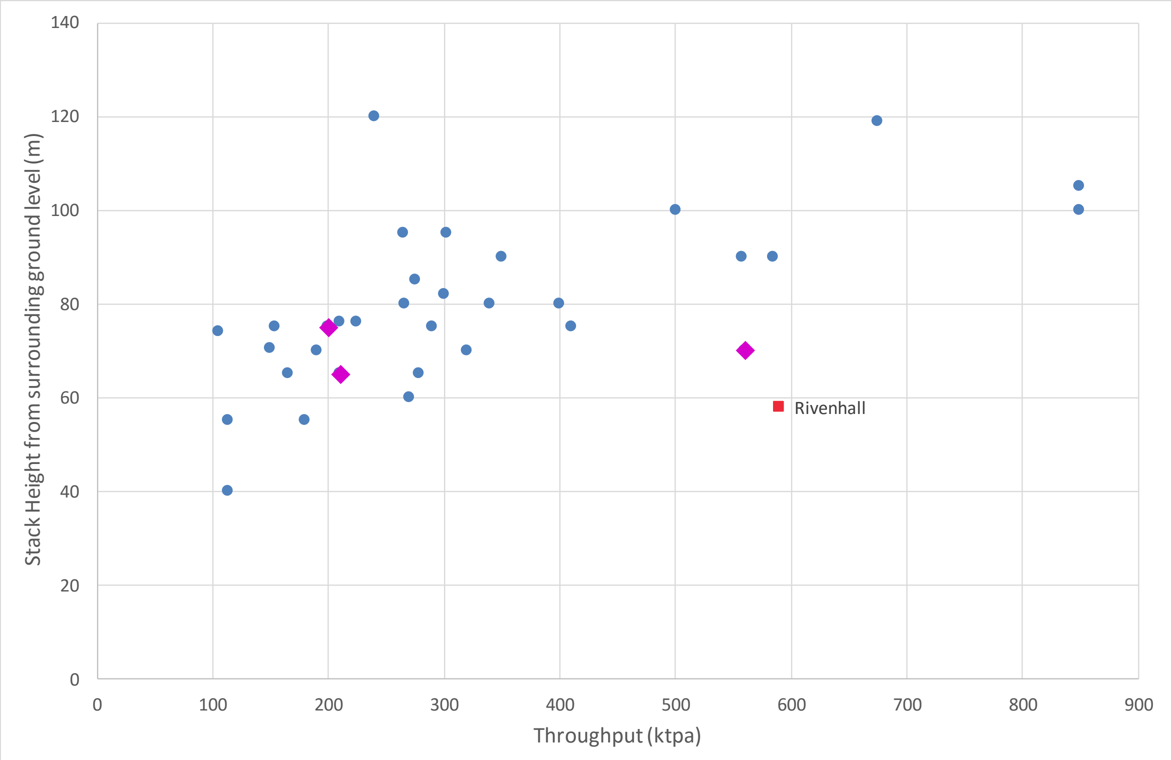

Figure 6 –Stack Height (above surrounding ground level) against Throughput

The reason that these two figures do not show a strong relationship between capacity and stack height is that it is not a direct relationship for the reasons discussed above.

Figure 7 and Figure 8 below show the relationship between stack height and building height for the 29 plants for which we have building height data. The red squares show the Rivenhall IWMF.

(1) Figure 7 shows stack heights and building heights above surrounding ground level. This shows the Rivenhall IWMF with a stack height of 58m above surrounding ground level and a building height of 10 m, also above surrounding ground level, to compare the height of emission points relative to the surroundings. The heights for the other plants are also shown above surrounding ground level.

(2) Figure 8 shows the Rivenhall IWMF with a total stack height of 78m from the base (i.e. physical length of stack) and a building height of approximately 30m from the base of the CHP Plant to offer a direct comparison of its total stack height with other plants. In this figure, we have adjusted the relevant heights for the three other UK plants which are partly buried – Hartlebury, Newhaven and Allington – for consistency. These are shown as purple diamonds.

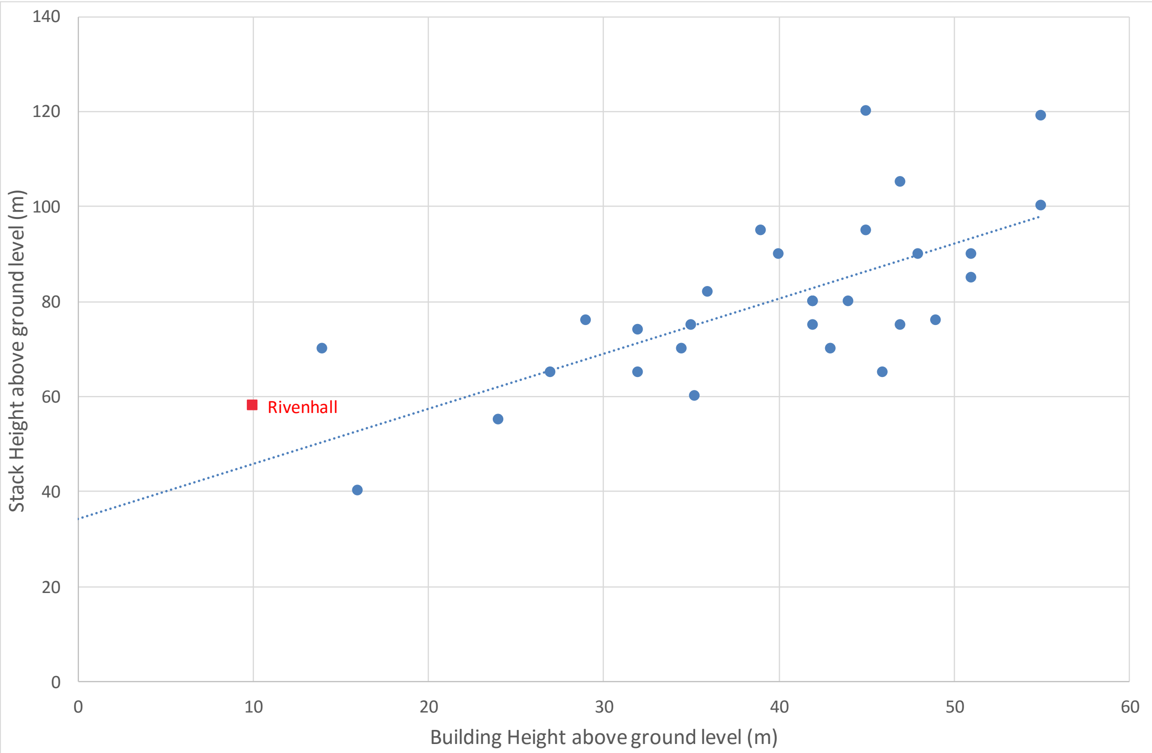

Figure 7 – Stack Height against Building Height above ground level

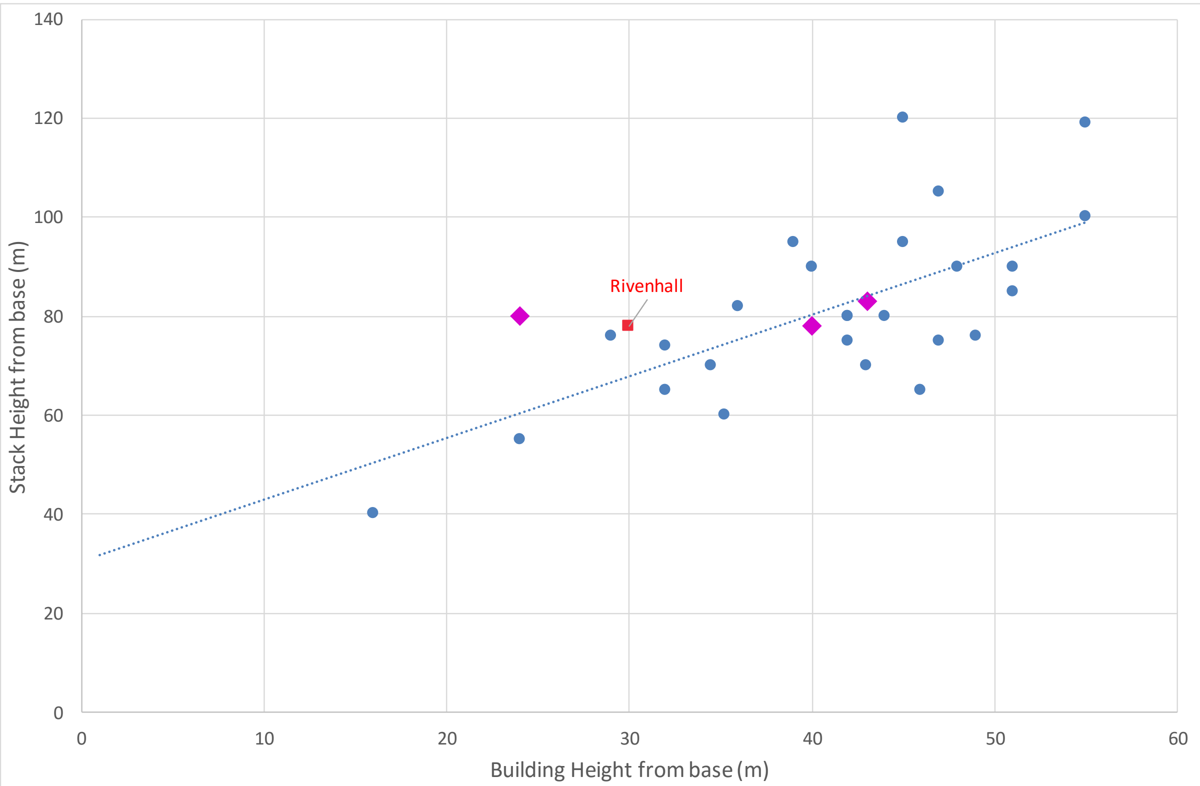

Figure 8 – Stack Height against Building Height above base level

As shown in both Figures 7 and 8, there is a clearer relationship between stack height and building height than there is between total stack height and throughput (Figure 5 and Figure 6). It can also be seen that the proposed stack height for the Rivenhall IWMF is above the line of best fit in both cases. This confirms that building height is the more important factor.

As the Rivenhall plant is below the surrounding ground level and the roof contour virtually follows that of the surrounding land, the influence of the building on the stack plume is reduced, and this enhances the effectiveness of the stack in dispersing the pollutants. This means that the dispersion of pollutants from the Rivenhall stack, with a height of 58m above surrounding ground level, is significantly better than it would be if the building were not partially buried.

Finally, Figure 9 illustrates the effect of the fourth factor, the surrounding environment. This is a copy of Figure 7, except that we have labelled five further plants. Runcorn has a tall stack because there are existing buildings in the close vicinity which are taller than the boiler house. Cornwall, Beddington and Ferrybridge Multifuel 2 have taller stacks than would be expected from the building height in order to protect statutory sensitive receptors nearby – a protected habitat for Cornwall and an AQMA for the other sites. We have also labelled Ferrybridge Multifuel 1 for comparison. This has a shorter stack than the stack height for Ferrybridge 2 because it is around 300 m further away from the receptor in the AQMA which influenced the stack height for Ferrybridge 2.

If we remove the four plants with unexpectedly high stacks from the dataset and calculate a new line of best fit, we can see that the other plants have less spread around the line and that Rivenhall IWMF is even closer to the line. This emphasises the importance of the surrounding environment and also confirms that building height is one of the most important influences on stack height. The continued spread around the line of best fit confirms that building height is not the only factor, with the age of the plant and the plant capacity also being relevant.

Overall, we consider that the figures demonstrate that the proposed stack height, when properly compared with the building height and the immediate surroundings of the Rivenhall IWMF, is not inconsistent with other similar facilities in the UK.

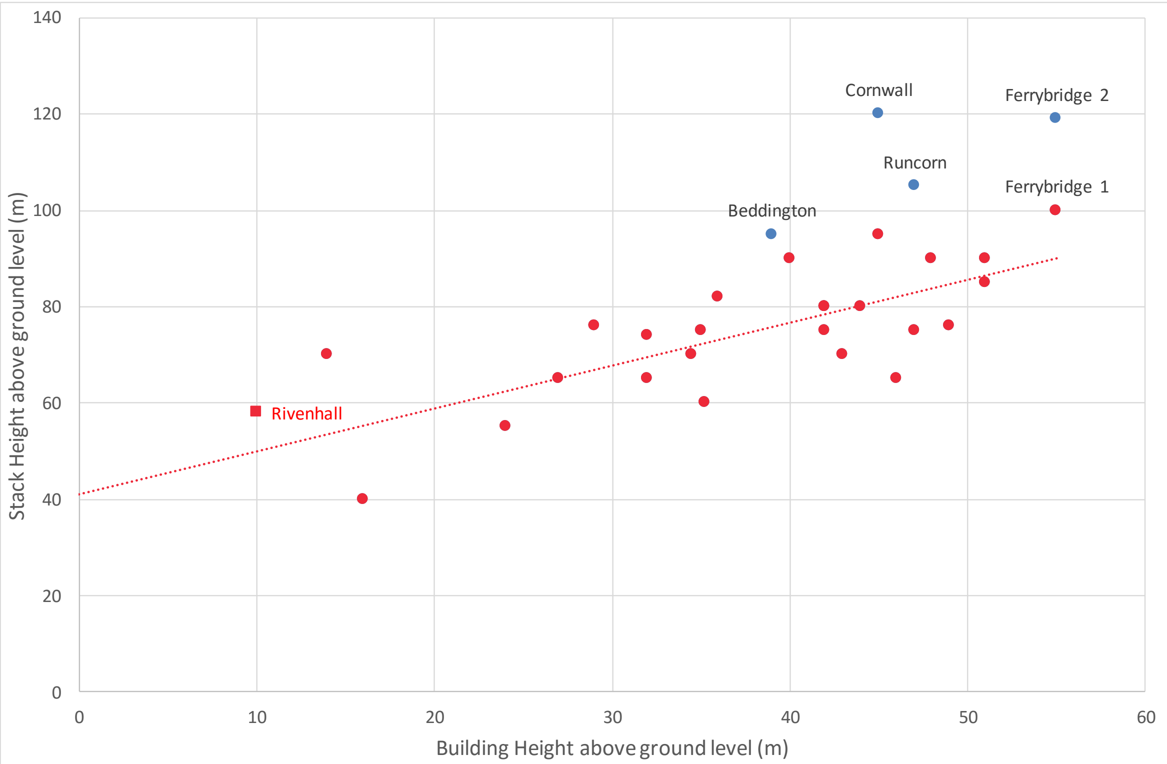

Figure 9 – Stack Height against Building Height above ground level, labelled

4 Conclusions

This Stack Height Assessment has assessed the stack height in a comparable manner to other technology BAT assessments, via an approach agreed with the EA during pre-application discussions. It also compares the proposed stack height in relation to other EfW facilities which have been approved by the Environment Agency. This assessment draws the following conclusions.

4.1 Stack Height BAT Assessment

An evaluation of stack heights from 25m above surrounding ground level (75mAOD) to 95m above surrounding ground level (145mAOD) has been made. This assessment found that the environmental benefits of increasing the stack height above 58m are considerably less than the benefits associated with increasing from 35m to 58m, even acknowledging that the actual long term impact at all stack heights above 35m is not significant, and would be described as "negligible" under the IAQM (2017) guidance.

It is concluded that a stack of height 58m (above surrounding ground level) (108m AOD) with a long term emission limit for NOx of $150mg/m^3$ represents BAT for the Rivenhall IWMF.

4.2 Stack Height comparisons

The stack heights of 34 different energy-from-waste plants have been compared to the Rivenhall IWMF 58m stack. The analysis considers a number of factors that influence the height of stacks at EfW plants. The analysis demonstrates that the proposed stack height for Rivenhall, when properly compared with the dominant factors of building height and the immediate surroundings, is not inconsistent with other similar facilities in the UK.

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