APPENDIX 9.1

NOISE PROPAGATION MODEL

THIS PAGE IS INTENTIONALLY BLANK

Appendix 9.1

Noise Propagation Modelling Inputs and Results

OPERATIONAL NOISE MODELLING INPUTS AND ASSUMPTIONS

Prediction of operational noise was carried out using CadnaA noise propagation software. Assumptions and model inputs are detailed below. Further details of noise propagation modelling methodology can be found in EIAR Chapter 9: Noise and Vibration.

CadnaA Noise Model Set Up

CadnaA (Computer Aided Noise Abatement) is a leading proprietary software for environmental noise propagation calculation, presentation and assessment. The CadnaA noise modelling software package was set up to use ISO9613 "Attenuation of Sound during Propagation Outdoors Part 2 General Method of Calculation" prediction methodology along with a range of topographical and ordnance data collected on the surrounding area to build up a picture of the noise environment in the vicinity of noise sources. The ISO 9613-2 propagation model is a light downwind model, which assumes that weather conditions are favourable for sound propagation. Where conditions are less favourable to sound propagation occur, such as when the assessment locations are crosswind or upwind of the Proposed Development, the sound levels would be expected to be lower and the downwind predictions presented would be regarded as conservative i.e. greater than those experienced in practice.

The software was used to build a 3-dimensional model of all features which may affect the generation and propagation of noise in the vicinity of the Proposed Development and to predict the specific sound levels due to the Proposed Development at nearby residential properties (receptors).

The propagation model takes account of sound attenuation due to geometric spreading and atmospheric absorption. The assumed temperature and relative humidity are 10 ˚C and 70 % respectively. Ground effects are also taken into account by the propagation model, with ground effects surrounding noise sources and receptors being of particular significance. CadnaA allows definition of ground absorption across a whole site or with a map of ground absorption. Hard ground is represented by Ground Absorption G=0, G=1 for soft ground and G=0.5 is typically adopted to reflect a mix of hard and porous ground. For this project G=0.5 has been applied within the Proposed Development site boundary to represent the mix of hard and soft ground within the site. For the area surrounding the site, hard ground (G=0) has been applied to larger areas of hard standing, for example the M7 industrial estate and surrounding agricultural lands have been assumed to comprise primarily soft ground and have been assigned G=1.

Where buildings have been included in the model, reflections have been included, with a reflection loss of 0 dB unless otherwise stated.

Noise-sensitive receptors have been included in the model at a height of 1.5m above ground level for daytime predictions and 4m above ground level for night-time predictions.

Unless otherwise stated, noise sources have been assumed to have a 100% 'on-time'.

Sound pressure levels were predicted at all 42 representative noise-sensitive receptors for both daytime (07:00 – 23:00) and night-time (23:00 – 07:00) periods. Receptor height for daytime predictions was 1.5m above ground level, with 4m above ground level assumed for night-time predictions.

Plant and Equipment Noise Source Data

A review of the Proposed Development has identified the following key items of plant and equipment which have the potential for significant noise emissions are:

- Data centre cooling system for each of the 6 buildings;
- Data external plant compound;
- Substation.

Plant and equipment source sound levels have been provided in manufacturer datasheets and acoustic testing reports. Where sound pressure levels have been provided, these have been converted to sound power levels, with dimensions of equipment obtained from manufacturer datasheets and project general arrangement and section drawings. It should be noted that manufacturer datasheets are typical for the type of plant and equipment to be installed and are subject to final equipment selection. Installed plant and equipment will achieve the same noise levels (or lower) than those indicated within this assessment. A summary of the model inputs is shown in the sections that follow.

Data Centre Cooling System

Supply fans will draw fresh air through louvres along the sides of the data centre building. The AHU air intakes are located behind the long facades of each data centre, with large louvered sections sitting within the façade to provide ventilation to the AHUs internally.

These have been modelled as vertical area sources on the outside of the data centre buildings.

The location of the supply air louvred sections are illustrated in the elevation drawings within Volume II: Figures and Drawings. Each long façade has been modelled with four vertical area sources for the louvred areas, each with an overall sound power level representative of 1/8 of the AHU air intake fans within the data centre building.

AHU exhaust noise is generated by the extract fans, which are located within the AHU itself and ducted to the penthouse louvres at roof level. Each duplex AHU comprises 8 extract fans.

Return fans from either 2no. or 4no. duplex AHU units will direct exhaust air to common ‘penthouse louvres’ above roof level.

The general arrangement and section drawings for the data halls can be found in Volume II Figures and Drawings.

Data Centre 4

The data centre cooling system for the Data Centre 4 building comprises 28no. duplex Air Handling Units (AHUs). Each duplex unit has 12no. supply fans and 8 no. return fans, with a total of 336 supply fans and 224 return fans for Data Centre 4.

Return fans from either 2no. or 4no. duplex AHU units will direct exhaust air to one of 16no. common penthouse louvre above roof level.

The Data Centre 4 data hall will have 6 exhaust shafts serving 4no. duplex units and 2 exhaust shafts serving 2no. duplex units. The general arrangement and section drawings for Data Centre 4 can be found in Volume II Figures and Drawings.

All other Data Centres

The data centre cooling system for each of the other data centre buildings comprises 56no. duplex Air Handling Units (AHUs). Each duplex unit has 12no. supply fans and 8no. return fans, with a total of 672 supply fans and 448 return fans per data centre building.

Return fans from either 2no. or 4no. duplex AHU units will direct exhaust air to one of 8no. common penthouse louvres above roof level. For the purposes of the noise model, a height of 3m above roof level has been assumed.

Each data hall will have 12 exhaust shafts serving 4no. duplex units and 4 exhaust shafts serving 2no. duplex units. The general arrangement and section drawings for the data halls can be found in Volume II Figures and Drawings.

Normal and Emergency Operations

During ‘normal’ operation, all AHUs are operational, with a volumetric flow rate of 40.44 m^3/s.

‘Emergency operation’ refers to a situation where 1 in every 7 duplex AHUs (a total of 2no. in Data Centre 4 and 4no. in all other Data Centres) is out of service (e.g. for maintenance) and the duty on the remaining operational AHUs is increased to 43.6 m^3/s to compensate.

The specific AHUs which will be out of service will vary as required, and it has been assumed that the increase in sound power level associated with the remaining fans has been evenly spread across the external vertical area sources on the DC building facades which represent the fresh air supply louvres.

AHU Air Intake Noise Source Levels

A summary of the air intake noise sources under each operating condition is shown in Table 9.1.1 for Data Centre 4 and in Table 9.1.2 for all other Data Centres.

Table 9.1.1: Data Centre 4 Cooling System Air Intake Normal and Emergency Operating Conditions

		No. Duplex AHUs	No. Fans	Fan Volumetric Flow Rate, m^3/s	Total Sound Power Level Sound Power Level, dBA L_W
Normal Operation	Air Intake	28	336	40.44	82
Emergency Operation	Air Intake	26	312	43.6	83

Table 9.1.2: All Other Data Centre Cooling System Air Intake Normal and Emergency Operating Conditions

		No. Duplex AHUs	No. Fans	Fan Volumetric Flow Rate, m^3/s	Total Sound Power Level Sound Power Level, dBA L_W
Normal Operation	Air Intake	56	672	40.44	85
Emergency Operation	Air Intake	52	624	43.6	86

AHU Exhaust Noise Source Levels

A summary of the cooling system exhaust noise sources under each operating condition is shown in Table 9.1.3 for Data Centre 4 and in Table 9.1.4 for all other Data Centres.

Table 9.1.3: Data Centre 4 Cooling System Exhaust Normal and Emergency Operating Conditions

		No. Duplex AHUs	No. Fans	Fan Volumetric Flow Rate, m^3/s	Total Sound Power Level Sound Power Level, dBA L_W	
					4 Duplex Exhaust	2 Duplex Exhaust
Normal Operation	Exhaust	28	224	40.44	77.4	74.4
Emergency Operation	Exhaust	26	208	43.6	79.1	76.1

Table 9.1.4: All Other Data Centre Cooling System Exhaust Normal and Emergency Operating Conditions

		No. Duplex AHUs	No. Fans	Fan Volumetric Flow Rate, m^3/s	Total Sound Power Level Sound Power Level, dBA Lw	
					4 Duplex Exhaust	2 Duplex Exhaust
Normal Operation	Exhaust	56	448	40.44	77.4	74.4
Emergency Operation	Exhaust	52	416	43.6	79.1	76.1

Data Centre External Plant Area

Power generation equipment will be located within the external plant area for each data centre. This equipment will include gas turbine generator packages and ducting and battery energy storage systems (BESS). The noise sources associated with these items of equipment are discussed in the sections that follow.

A combination of open cycle gas turbines (OCGTs) and combined cycle gas turbines (CCGTs) will be used. The energy strategy sets out that the on-site generation of electricity will primarily use CCGTs to provide for 50% of the energy required, supplemented by OCGTs and smaller reciprocating engines.

The number of each gas turbine generator type the number of BESS inverters within each data centre external plant area is shown in Table 9.1.5.

Table 9.1.5: External Plant Area Power Generation

	OCGTs	CCGTs	Inverters
DC4	2	2	28
All Other DCs	4	3	49

Gas Turbine Generators

The Data Centre 4 external plant area contains 4no. gas turbine generators. All other data centres will contain 7no. gas turbine generators.

The primary noise sources associated with the gas turbines and located within the external plant area are:

- Gas turbine enclosure;
- Pipework/ductwork to exhaust, and;
- Heat recovery system (CCGTs only).

These noise sources were input into the acoustic model as contributing noise sources to the reverberant noise level within the external plant area of each data centre.

In addition to the noise sources within the external plant area, each gas turbine will exhaust through the external plant area roof, each represented in the noise model as a point source 1m above the building parapet height.

The proposed turbine types for open cycle gas turbines are Solar Taurus 60 turbines, as included in the noise modelling associated with the submitted EIAR. The combined cycle gas turbines proposed turbine type are Solar Taurus 70 turbines.

Both turbine types will benefit from a bespoke acoustic enclosure which will surround the main turbine casing. The acoustic enclosure will include inspection windows, removable panelling for maintenance and silencers on the ventilation air inlet/outlet and combustion air inlet.

The turbine enclosure for both turbine types will achieve a maximum total sound power level (denoted as L_W) of 94.2 dBA (data confirmed by turbine supplier Solar Turbines). For the combined cycle gas turbines (CCGTs), this includes the heat recovery system which is also located within the gas turbine enclosure within the external plant area.

Exhaust Duct and Stack Tip

Exhaust noise has been considered both in terms of break-out noise from ductwork and noise emission from the stack tip The combustion exhaust will be fitted a silencer which will achieve a sound pressure level of 66 dBA @1m from the exhaust stack ducting and 66 dBA @1m perpendicular to the exhaust stack tip. It is assumed that the exhaust stack will discharge at a height of 20m above external plant room ground level, (1m above the parapet height). These input parameters have been input into the model for both turbine types.

The spectral shape for each noise source was provided by the turbine manufacturer based on measurements and applied to the project-specific sound power level for each element of the turbine package.

Table 9.1.6: Gas Turbine Sound Power Level Model Inputs

Centre Frequency, Hz:	63	125	250	500	1K	2K	4K	8K	Overall L_W, dBA
	Sound Power Level, L_W dBZ								
Enclosure	99.2	96.2	97.2	91.2	88.2	83.2	83.2	77.2	94.3
Chimney Stack/Duct	92.0	87.0	85.0	80.0	80.0	80.0	81.0	77.0	87.3
Stack Tip	83.0	84.0	80.0	74.0	68.0	65.0	67.0	64.0	77.1

Battery Energy Storage System (BESS)

The Battery Energy Storage System (BESS) will generate noise by way of the cooling fans associated with the inverters. There will be 7no. BESS inverters associated with each gas turbine generator.

The worst-case scenario for noise has been considered in order to provide a robust assessment of noise. As such, it is assumed that all gas turbines are in operation for the purposes of the noise modelling. It should be noted that this does not represent a typical power generation scenario, but a worst-case for the purposes of noise impact assessment. All other operating scenarios will have a lower noise impact upon sensitive receptors. Note that the worst-case model scenario assumes that the gas reciprocating engines are not in operation, as these are smaller, quieter units than the gas turbines and are used for load stepping.

Additional Noise Sources

The combined cycle gas turbines (CCGTs) enable additional power generation via a steam turbine through heat recovery. The operation of the steam turbine relies upon air cooled condensers. A single steam turbine and air cooled consider will be installed for each data centre. These items will be located adjacent to each data centre external plant area.

Steam Turbines

The steam turbines will be fully enclosed within bespoke buildings. Each building will achieve an average external sound pressure level of 56.4 dBA at 1m from the enclosure (data confirmed by turbine supplier Solar Turbines). These are new noise sources which were not part of the design assessed in the submitted EIAR.

Air-Cooled Condensers

A bank of air-cooled condensers will be located adjacent to each steam turbine, adjacent to the external plant area of each DC. These are new noise sources which were not part of the design assessed in the submitted EIAR.

Noise from the air-cooled condensers is primarily generated from the fin fan coolers, which have a variable operation speed and therefore variable noise output. It is anticipated that these will operate as required 24/7, with a reduced fan speed during the night-time period.

Low-noise air-cooled condensers will be installed, with a total sound power level of 84 dBA per data centre (data confirmed by turbine supplier Solar Turbines). This sound power level has been assumed for both daytime and night-time scenarios.

Operational Scenarios

Daytime and night-time worst-case power generations scenarios have been considered. These represent the maximum number of operational gas turbines and associated plant that will be operational during this time

The daytime noise model assumes that all BESS inverters, data hall AHUs, substation are also operating with a 100% on time.

The night-time scenario assumes that one gas turbine and associated equipment is offline in all data centres, as shown in Table 9.1.7.

Table 9.1.7: Gas Turbine Sound Power Level Model Inputs

	No of Gas Turbines Operating		No of BESS Inverters Operating per DC Compound	
	DC4	All Other DCs	DC4	All Other DCs
Worst-Case Daytime Power Scenario	4	7	28	49
Worst-Case Night-Time Power Scenario	4	6	28	42

NOISE MODELLING RESULTS

Noise modelling results are shown in Table 9.1.8 for the worst-case daytime and in Table 9.1.9 for night-time operational scenarios.

Daytime predicted sound pressure levels are shown for all 42 noise-sensitive receptors which assume a receptor height of 1.5m above ground height.

Night-time predicted sound pressure levels are shown for all 42 noise-sensitive assuming a receptor height of 4m above ground height, representing the height of a bedroom window.

The modelling results from the submitted EIAR are also shown in each table for comparison. There was no significant difference in the predicted operational daytime or night-time sound pressure levels when comparing the predicted levels in the submitted EIAR and the updated model incorporating the design changes described in the EIAR Addendum.

Table 9.1.8: Worst-Case Daytime Noise Propagation Modelling Results

Receptor Location	Predicted Worst-Case Daytime Sound Pressure Level 1.5 m Receptor Height, dB $L_{Aeq, T}$		
	Submitted EIAR Model	Updated Model	Difference
1	42.7	42.8	0.1
2	39	39.2	0.2
3	38.1	38.2	0.1
4	37.8	37.9	0.1
5	37.3	37.5	0.2
6	36.9	36.9	0
7	36	35.9	-0.1
8	35.6	35.5	-0.1
9	39.1	39.1	0
10	40.4	40.3	-0.1
11	39.3	39.3	0
12	37.4	37.3	-0.1
13	35.8	35.8	0
14	37	36.9	-0.1
15	37.9	37.8	-0.1
16	39	38.9	-0.1
17	39.3	39.2	-0.1
18	39.2	39.1	-0.1
19	38.9	38.7	-0.2
20	39.9	39.8	-0.1
21	40.1	40.1	0
22	37.2	37.1	-0.1
23	32.1	31.6	-0.5
24	33.5	33.3	-0.2
25	34.1	33.8	-0.3
26	34.3	34	-0.3
27	33.6	33.5	-0.1
28	31.7	31.5	-0.2
29	33.4	33.2	-0.2
30	35	34.9	-0.1
31	32.2	32	-0.2
32	32.9	32.8	-0.1
33	32.1	31.9	-0.2
34	35.1	34.9	-0.2
35	35.3	35.1	-0.2
36	35.6	35.6	0
37	35.8	35.8	0
38	35.7	35.8	0.1
39	36	36	0
40	33.5	33.4	-0.1
41	32.4	32.3	-0.1
42	33.3	33.3	0

Table 9.1.9: Worst-Case Night-Time Noise Propagation Modelling Results

Receptor Location	Predicted Worst-Case Night-Time Sound Pressure Level 4 m Receptor Height, dB $L_{Aeq, T}$		
	Submitted EIAR Model	Updated Model	Difference
1	43.6	43.7	0.1
2	39.4	39.1	-0.3
3	38	37.9	-0.1
4	37.7	37.6	-0.1
5	37.1	37.3	0.2
6	36.6	36.6	0
7	35.8	35.7	-0.1
8	36.2	36	-0.2
9	40.1	40.2	0.1
10	40.9	40.9	0
11	40.3	40.3	0
12	37.1	37	-0.1
13	35.6	35.6	0
14	37.4	37.4	0
15	38.2	38.3	0.1
16	39.2	39.3	0.1
17	39.5	39.5	0
18	39.4	39.4	0
19	39.1	39.1	0
20	39.9	39.8	-0.1
21	40	39.8	-0.2
22	37.5	37.4	-0.1
23	32	31.8	-0.2
24	33.8	33.6	-0.2
25	34	33.9	-0.1
26	34.3	34.1	-0.2
27	34	33.9	-0.1
28	32.2	32	-0.2
29	33.8	33.6	-0.2
30	35.4	35.3	-0.1
31	32.1	31.9	-0.2
32	32.8	32.6	-0.2
33	31.9	31.7	-0.2
34	35.8	35.5	-0.3
35	35.5	35.2	-0.3
36	35.6	35.6	0
37	35.8	35.8	0
38	35.6	35.6	0
39	35.7	35.8	0.1
40	33.2	33	-0.2
41	32	31.9	-0.1
42	32.9	33	0.1