# Lamu Coal Power Plant

# Noise Impact Assessment Report

**Prepared for: Kurrent Technologies Ltd**

**Report Ref: J3092**

**Date: May 2015**

# Report Approval & Revision Record

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# Acronyms

| | |
|---|---|
| BRE | Building Research Establishment |
| BS | British Standard |
| CEMP | Construction Environmental Management Plan |
| dB | decibels |
| dB(A) | decibels 'A' weighted |
| DEFRA | Department of Environment, Food and Rural Affairs (UK) |
| EHS | Environmental, Health and Safety |
| ESIA | Environmental and Social Impact Assessment |
| GIIP | Good International Industry Practice |
| HSE | Health, Safety and Environment |
| IEMA | Institute of Environmental Management and Assessment |
| IFC | International Finance Corporation |
| IoA | Institute of Acoustics |
| ISO | International Standards Organisation |
| KTL | Kurrent Technologies Ltd. |
| kV | Kilovolts |
| mm / m / km | millimetres / metres / kilometres |
| MW | Megawatts |
| NIA | Noise Impact Assessment |
| NSR | Noise Sensitive Receptor |
| SWRO | Salt Water Reverse Osmosis |
| tph | Tonnes per hour |
| USGS | United States Geological Survey |
| WHO | World Health Organisation |
| WKC | WardKarlson Consulting Pty Ltd |

# 1 Introduction

## 1.1 Project Background

WardKarlson Consulting Ltd (WKC) has been commissioned by Kurrent Technologies Limited (KTL) to conduct a noise impact assessment (NIA) for the proposed Lamu Coal Power Plant (hereafter referred to as the 'Project'), located within the Lamu region of northern Kenya.

## 1.2 Aims and Objectives

This report, forming part of the Environmental and Social Impact Assessment (ESIA) focuses on the noise associated with Project, using design data specifications and experience of similar projects. The key objective of this assessment is to evaluate the potential impact of the project activities on the local noise climate from:

- Construction noise associated with the Project;
- Normal operating conditions of the Project; and,
- Emergency operating conditions of the Project.

Potential impacts from the Project have been modelled using SoundPLAN Version 7.3 and compared against International Finance Corporation (IFC) General Environmental, Health and Safety (EHS) Guidelines [1], whilst construction noise impacts have been assessed using British Standard BS5228 [2].

## 2 Project Description

The proposed Lamu Coal Power Plant will be located on the north side of the New Lamu Port area, Manda Bay situated in Lamu County, northern Kenya (Figure 2-1 and Figure 2-2).

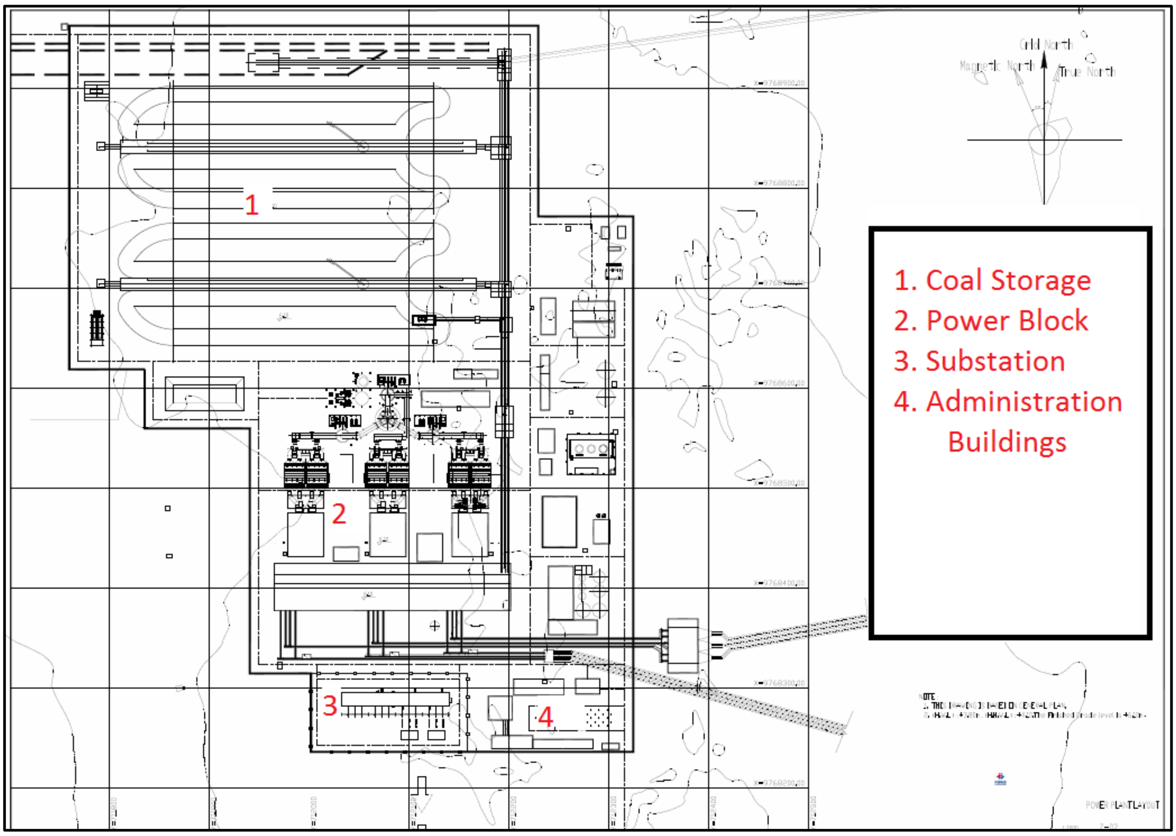
**Figure 2-1 - Project location (regional context)**

**Figure 2-2 - Project Location (local context)**


The project will consist of 3x350 MW coal units to be built on a tract of land identified and reserved for its construction by the Government of Kenya. The general arrangement plan of the plant is divided into four main areas (Figure 2-3).

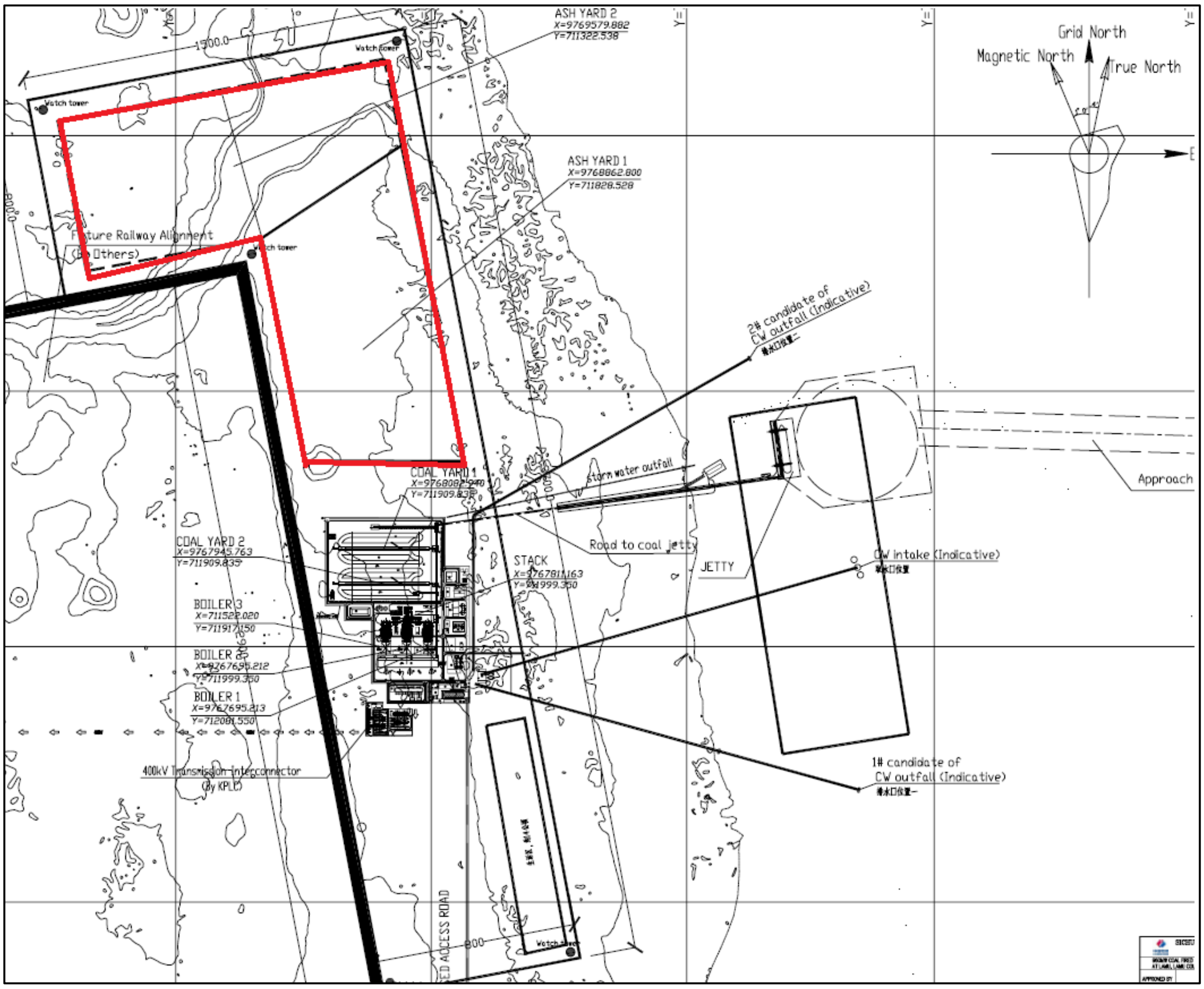
1) Coal yard and coal handling facilities;
2) The main power block;
3) 400 kV substation; and,
4) The administration buildings and canteen, and construction/ operating quarters.

**Figure 2-3 - General Plant Layout**




The ash storage areas are shown in Figure 2-4.

## Figure 2-4 – Ash Yards in Relation to Main Areas



# 3 Project Noise Standards and Impact Significance

This section presents the relevant international standards and guidelines, and project specifications applicable to this assessment.

## 3.1 Project Standards

### 3.1.1 International Standards

The international standards/guidelines that have been applied to the Project in the noise impact assessment are the IFC General EHS Guidelines [1]. The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in specific industry sectors.

IFC refers to guidance from the World Health Organisation (WHO) on establishing community noise levels. The guidance indicate that noise levels at receptors should not exceed the levels presented in Table 3-1, or result in a maximum increase in background levels of 3 dB(A) at the nearest receptor location off-site [1].

**Table 3-1 - Maximum Permissible Noise Levels for General Environment (IFC, 2007)**

| Classification of Receptor | Noise level Guidelines ($L_{Aeq}$ one hour (dB(A)) | |
|---|---|---|
| | Day (7 a.m. – 10 p.m.) | Night (10 p.m. – 7 a.m.) |
| Residential, Institutional or Educational | 55 | 45 |
| Industrial or Commercial | 70 | 70 |

In the case of exceedances in allowable noise levels at the external façade of a building, internal noise levels are semi-quantitatively assessed by applying typical noise mitigation reductions from windows. Windows are identified as the least sound-insulating component of typical building façades. The resulting internal noise levels are assessed against BS8233:2014 'Guidance on Sound Insulation and Noise Reduction for Buildings' [3] which is based on existing guidelines issued by the WHO and assume normal diurnal fluctuations in external noise. These recommended indoor ambient noise levels are detailed in Table 3-2 below.

**Table 3-2 - Indoor Ambient Noise Levels for Dwellings (Table 4: BS8233: 2014)**

| Activity | Location | **Noise level Guidelines** ($L_{Aeq}$ over the time period under assessment (dB(A)) | |
|---|---|---|---|
| | | **Daytime (07:00 to 23:00)** | **Night time (23:00 to 07:00)** |
| Resting | Living room | 35 | - |
| Dining | Dining room /area | 40 | - |
| Sleeping (Daytime resting) | Bedroom | 35 | 30 |

Although the definition of the time periods for day and night time do not correlate with the IFC Guidelines, BS8233:2014 is used to semi-quantitatively assess the impacts at residential dwellings [3].

## 3.2 Calculation of Construction Noise

British Standard BS5228:2008 'Noise and Vibration Control on Construction and Open Sites' [2] provides a calculation method, practical information on noise reduction measures, and promotes 'Best Practice Means' approach to control noise emissions during construction.

The noise emission data presented in BS5228 [2] does not reflect the latest advancements in plant noise emissions control. Therefore, whilst the calculations in this assessment have been carried out according to the BS5228 methodology, several of the input data for construction plant noise levels have been taken from the United Kingdom's Department for Environment, Food and Rural Affairs (DEFRA) report 'Update of Noise Database for Prediction of Noise on Construction and Open Sites' [4].

Due to the temporary and transient nature of construction noise, a Project threshold value has been set at 10 dB(A) higher than the IFC limit (i.e. 55 dB(A) + 10 dB(A) = 65 dB(A)). This margin has been applied on the basis of typical assessment criteria outlined in BS5228 [2]. The criteria indicates that a 10 dB(A) exceedance of statutory background noise limits as being the point at which the project is liable for costs of temporary relocation of inhabitants affected by the construction noise.

A conservative approach has been taken for this assessment and only maximum levels are assessed. Therefore, even if the assessment should indicate an exceedance of the 65 dB(A) construction noise threshold, it is expected that this noise level will be temporary and transient and therefore not classified as background noise.

## 3.3 Significance Criteria for Impact Assessment

The criteria for the assessment of noise changes arising at noise sensitive receptors (NSRs) from the operation of the power plant have been adapted from the joint Institute of Environmental Management and Assessment (IEMA) and the Institute of Acoustics (IoA) guidelines for noise and vibration impact assessment categories and are given in Table 3-3 [5].

**Table 3-3 - Noise Impact Assessment Criteria [5]**

| Impact Category | Noise Change Band | Description |
|---|---|---|
| No Effect | 0 dB(A) | Not discernible |
| Negligible | 0.1 – 2.9 dB(A) | Not discernible – Marginal changes in noise levels of less than 3 dB(A) in residential areas, or outdoor recreational areas in close proximity to main roads. |
| Minor Negative | 3 to 4.9 dB(A) | Noticeable adverse – Noise levels of 3-5 dB(A) in residential areas, or at outdoor recreational areas. |
| Moderate Negative | 5 to <10 dB(A) | Considerable adverse – Noise levels warrant mitigation of residential properties on a widespread basis in a community, or for outdoor recreation areas close to main roads. |

| Impact Category | Noise Change Band | Description |
|---|---|---|
| Major Negative | 10 dB(A) or more | Major adverse – Noise increases to a level where continued residential use of individual properties is inappropriate, or where the use of a community building could be inappropriate. |

# 4 Existing Noise Conditions

## 4.1 Baseline Noise Survey

An ambient noise survey was conducted for the Project for period of 6 days from 10th January 2015 to the 15th of January 2015. A total of 11 daytime noise measurements were taken at locations along the Project boundary and various locations extending more than 1.5 km from the Project boundary.

The selected sound level meter automatically logs environmental noise measurement parameters including $L_{Aeq}$, $L_{Amax}$, $L_{A10}$ and $L_{A90}$, definitions of which are presented in the Glossary. A summary of the measurement locations are detailed in Noise Sensitive Receptors

## 4.2 Noise Sensitive Receptors

Eleven (11) locations were included in the baseline survey carried in January 2015. These locations and receptors are detailed in Figure 4-1, Figure 4-2 and Table 4-1 below:

**Figure 4-1 - Locations of Ambient Noise Monitoring Locations (All Locations)**

**Figure 4-2- Locations of Ambient Noise Monitoring Locations (up to 1.5 km from Project Boundary)**


**Table 4-1 - Baseline Noise Levels and Receptor Descriptions**

| No. | Description | Coordinates | Noise Level $L_{Aeq}$ (dB(A)) | | | | Ambient Noise Description |
|---|---|---|---|---|---|---|---|
| | | | $L_{Aeq}$ | $L_{A90}$ | $L_{A10}$ | $L_{Amax}$ | |
| 1 | Near beam AP4 (homestead) | S02°05'19.6" E040°53'30.0" | 53.0 | 31.9 | 54.2 | 85.8 | (No record) |
| 2 | Near beam AP1 (homestead) | S02°05'09.3" E040°54'25.0" | 47.3 | 39.0 | 50.9 | 68.6 | (No record) |
| 3 | Between beam AP1 & AP4 | S02°05'26.4" E040°54'41.0" | 43.8 | 39.8 | 46.3 | 58.8 | Waves from the ocean |
| 4 | Between beam AP1 & AP2 | S02°04'52.8" E040°54'02.4" | 49.4 | 44.2 | 51.7 | 66.9 | General domestic noise |
| 5 | Between beam AP1 & AP3 | S02°05'15.5" E040°53'18.3" | 44.1 | 31.9 | 43.8 | 60.2 | Birds |
| 6 | Bargoni village | S02°02'49.6" E040°47'10.0" | 42.2 | 35.0 | 42.6 | 64.5 | Noise from the mosque, traffic and domestic noise |

| No. | Description | Coordinates | Noise Level $L_{Aeq}$ (dB(A)) | | | | Ambient Noise Description |
|---|---|---|---|---|---|---|---|
| | | | $L_{Aeq}$ | $L_{A90}$ | $L_{A10}$ | $L_{Amax}$ | |
| 7 | Village between Bargoni & Bobo | S02°05'05.6" E040°46'51.4" | 43.2 | 37.3 | 46.9 | 54.2 | General public noise |
| 8 | Patte Jetty | S02°06'38.0" E040°58'21.0" | 58.9 | 55.4 | 61.0 | 71.2 | Traffic (motor vehicles and motorcycles), boats, ocean waves and general public noise |
| 9 | Resort (beach area) | S02°04'24.8" E040°58'30.1" | 46.9 | 44.3 | 48.9 | 52.1 | Ocean breeze |
| 10 | Hindi Mosque | S02°10'47.8" E040°48'59.1" | 51.0 | 46.4 | 53.2 | 65.1 | Traffic along Hindi road |
| 11 | Jipe (homestead) | S02°11'14.9" E040°49'57.4" | 47.5 | 43.0 | 50.2 | 59.5 | Domestic noise from chicken/ hens and dog barking |

The measurement of baseline noise is used to determine the ambient noise climate of the Project area. Due to the assessment criteria adopted for this study which rely on the incremental change between ambient noise and modelled cumulative noise levels, it is considered most conservative to adopt the lowest $L_{Aeq}$ value measured on the site boundary (record No. 3 - Between beam AP1 & AP4) for use as the baseline noise level for any other locations on the boundary for which no measurement was collected, which in this case is equal to 43.8 dB(A).

In addition, a number of key locations within the worker camp and accommodation area have been considered and are shown in Figure 4-3 and Table 4-2 below:

**Figure 4-3 - Locations of Accommodation Areas in Close Proximity to the Plant**

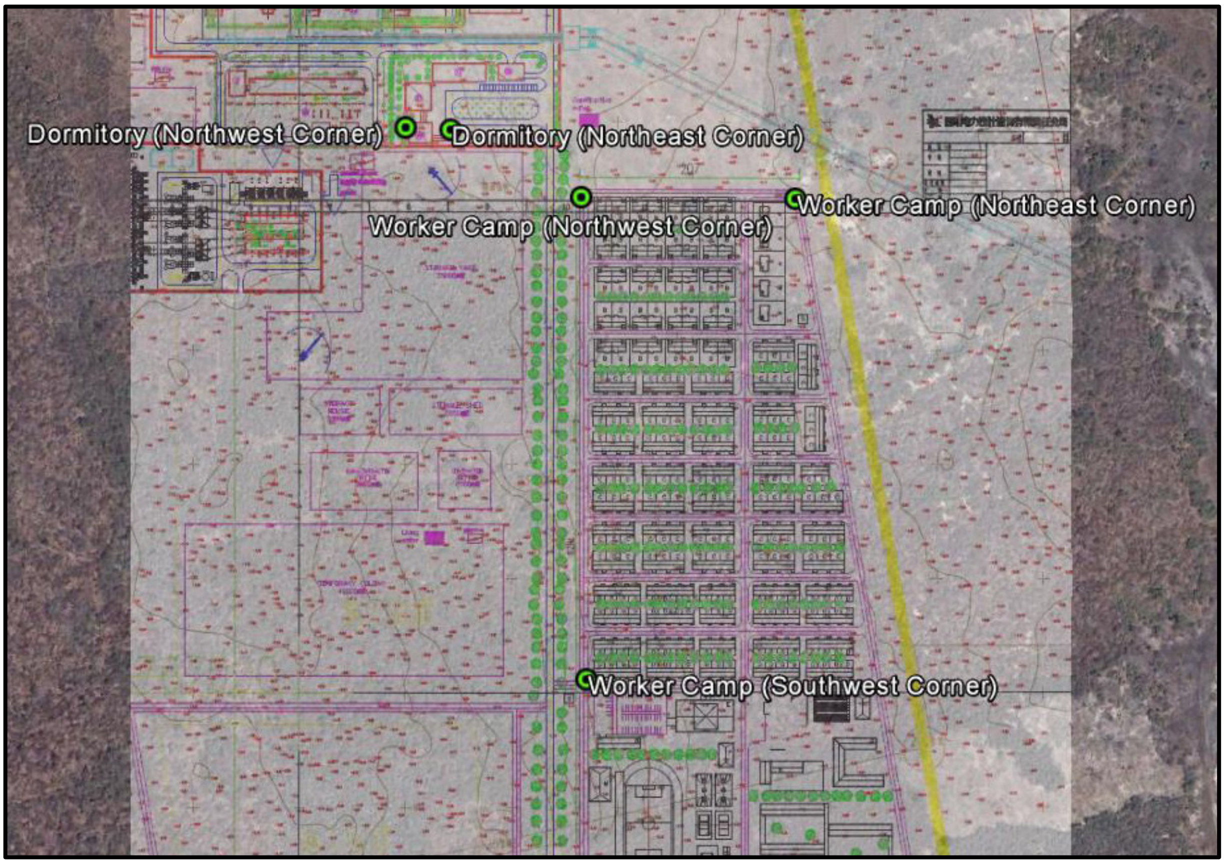



**Table 4-2 - Receptor Descriptions of Accommodation Area Receptors**

| No. | Description | Coordinates |
|---|---|---|
| 1 | Dormitory (Northwest corner) | S02°06'8.15"<br>E040°54'26.10" |
| 2 | Dormitory (Northeast corner) | S02°06'8.15"<br>E040°54'27.31" |
| 3 | Worker Camp (Northwest corner) | S02°06'10.10"<br>E040°54'30.97" |
| 4 | Worker Camp (Northeast corner) | S02°06'10.12"<br>E040°54'36.10" |
| 5 | Worker Camp (Southwest corner) | S02°06'23.61"<br>E040°54'31.11" |

Based on initial screening, a number of NSRs were selected for assessment in this study as shown in Figure 4-4 and Table 4-3. This selection has been based on the location/receptors proximity to the Project facility, and sensitivity to the construction and operational phases of the Project.

**Figure 4-4 - Locations of Selected Receptors for Assessment**


**Table 4-3 - Selected NSRs for Noise Impact Assessment**

| Noise Sensitive Receptor and Description | | IFC receptor classification | Ambient Day/Night time Noise Limits[1] dB(A) | Baseline Day Time Ambient Noise dB(A) |
|---|---|---|---|---|
| NSR1 [2] | Near beam AP4 (homestead) | Residential | 55 / 45 | 53.0 |

| Noise Sensitive Receptor and Description | | IFC receptor classification | Ambient Day/Night time Noise Limits[1] dB(A) | Baseline Day Time Ambient Noise dB(A) |
|---|---|---|---|---|
| NSR2 [2] | Near beam AP1 (homestead) | Residential | 55 / 45 | 47.3 |
| NSR3 [2] | Between beam AP1 & AP4 | Residential | 55 / 45 | 43.8 |
| NSR4 [2] | Between beam AP1 & AP2 | Residential | 55 / 45 | 49.4 |
| NSR5 [2] | Between beam AP1 & AP3 | Residential | 55 / 45 | 44.1 |
| NSR6 [3] | Dormitory (Northwest corner) | Residential | 55 / 45 | 43.8 |
| NSR7 [3] | Dormitory (Northeast corner) | Residential | 55 / 45 | 43.8 |
| NSR8 [3] | Worker Camp (Northwest corner) | Residential | 55 / 45 | 43.8 |
| NSR9 [3] | Worker Camp (Northeast corner) | Residential | 55 / 45 | 43.8 |
| NSR10 [3] | Worker Camp (Southwest corner) | Residential | 55 / 45 | 43.8 |

**Note 1:** Standards in accordance with IFC EHS guidelines noise limits [1]
**Note 2:** NSRs 1 to 5 are classified as existing receptors
**Note 3:** NSRs 6 to 10 are classified as new receptors associated with worker accommodation areas

NSRs 1 to 5 are existing receptors and are representative of the impact to the existing community. NSRs 6 to 10 are considered representative of locations which will be constructed for the purpose of accommodation of workers. As these NSRs fall within the boundary of the Project site, the land use classification is technically industrial, however, given that they are designed to accommodate workers, they have been classified as residential receptors under the IFC guidelines [1]. Note however, that due to the change in land-use from being unoccupied, the impact assessment criteria outline in Table 3-3 is not used. In the case of new NSRs, assessment is done using a direct comparison against the IFC standard, and not the change in noise from the existing ambient noise levels.

# 5 Construction Noise Impact Assessment

An assessment of predicted noise emissions from construction activities at the sensitive receptor points associated with the Project (Table 4-3) was carried out in accordance with BS5228 [2]. As stated in Section 3.3, a construction noise threshold of 65 dB(A) was applied at all receptors.

## 5.1 Equipment Numbers

Precise details of the construction schedule or equipment requirements are not yet finalised; however, the assessment was conducted based on assumed impact durations and equipment numbers for the construction of the Project Facilities.

BS5228 [2] gives reference noise levels for typical construction equipment items. The noise levels are defined as the equivalent sound pressure level (Lp) at a distance of 10m from the item in question.

Using the sound pressure levels of the various items of equipment it is possible to calculate the cumulative noise level of all the various units running simultaneously (by logarithmic addition) and then to determine the resultant noise level at any distance from the construction, based on the principles of the inverse square law for noise propagation over distance.

The inverse square law:

$$L_{P2} = L_{P1} - 20\log\left({}^{R_2}/_{R_1}\right)$$

Where $L_{P1}$ is the sound pressure level at the reference distance from the construction equipment (in this case 10 m);

$L_{P2}$ is the sound pressure level at the sensitive receptor;

$R_1$ is the reference distance of where the sound pressure level of the equipment item(s) was referenced (in this case 10 m); and,

$R_2$ is the distance between the construction activities and the sensitive receptor.

The assumed construction equipment list for the various phases of construction is detailed in Table 5-1.

**Table 5-1 - Assumed Construction Equipment Inventory**

| Plant/Activity | Number of units | Lp @ 10m | Reference [1] |
|---|---|---|---|
| **I. Earth Work Equipment** | | | |
| Backhoe Excavator | 6 | 78 | C.2 No. 3 |
| Dozer | 4 | 79 | C.2 No. 11 |
| Loader | 10 | 68 | C.2 No. 8 |
| **II. Transportation Equipment** | | | |
| Autodumper (Large) | 20 | 76 | C.4 No. 4 |

| Plant/Activity | Number of units | Lp @ 10m | Reference [1] |
|---|---|---|---|
| Autodumper (Small) | 10 | 78 | C.4 No. 7 |
| Water Tank Truck | 4 | 76 | C.4 No. 76 |
| **III. Concrete and mortar Equipment** | | | |
| Concrete Mixing Plant | 2 | 80 | C.4 No. 20 |
| Concrete batching machine | 2 | N/A | N/A |
| Material loader (a) | 4 | 68 | C.2 No. 8 |
| Material loader (b) | 2 | 68 | C.2 No. 8 |
| Concrete mixing transportation cart | 10 | 76 | C.4 No. 22 |
| Concrete pump truck | 2 | 77 | C.4 No.21 |
| Concrete transport pump | 4 | 67 | C.4 No. 24 |
| Mortar mixer | 8 | 61 | C.4 No. 23 |
| **IV. Lifting Equipment** | | | |
| Track type crane (a) | 1 | 67 | C.3 No. 28 |
| Track type crane (b) | 1 | 67 | C.4 No. 46 |
| Truck crane | 2 | 70 | C.4 No. 43 |
| **V. Special Equipment** | | | |
| Piling machine | 10 | 82 | C.3 No. 15 |
| Construction elevator | 1 | 66 | C.4 No. 62 |
| Diesel generator | 2 | 74 | C.4 No. 84 |
| Water purification equipment | 3 | N/A | N/A |
| **VI. Other Equipment** | | | |
| Steel processing equipment | 6 | N/A | N/A |
| Woodwork equipment | 4 | N/A | N/A |
| Electric slag pressure welding machine | 6 | 73 | C.3 No. 31 |
| Flash butt-welding machine | 4 | 73 | C.3 No. 31 |
| Electric welder | 10 | 73 | C.3 No. 31 |
| Electric winch (a) | 4 | N/A | N/A |
| Electric winch (b) | 4 | N/A | N/A |
| Impact hammer | 6 | 82 | C.3 No. 15 |
| Hand drill | 10 | 76 | CONCAWE CNP 064 [6] |
| Sand-wheel grinder | 6 | 75 | C.4 No. 94 |
| Angle abrader | 10 | 75 | C.4 No. 94 |
| Bench grinder | 4 | 80 | C.4 No. 93 |
| Electrohydraulic pipe bender | 2 | N/A | N/A |
| Pneumatic drill(including hammer) | 20 | 82 | C.3 No. 15 |

| Plant/Activity | Number of units | Lp @ 10m | Reference [1] |
|---|---|---|---|
| Submerged pump | 20 | 62 | C.8 No. 23 |
| Sewage pump | 8 | 68 | C.4 No.88 |
| Vertical tamping machine | 2 | 82 | C.3 No. 15 |
| Frog hammer | 6 | 82 | C.3 No. 15 |

**Note 1:** Noise levels of construction equipment as per BS5228 estimates, DEFRA update and vendor data for equipment of similar capacity and size (Tables C.1 to C.12) unless stated otherwise [2] [4].

## 5.2 Impact Assessment Summary

Noise emissions from construction activities have been estimated for the 6 groupings of equipment items outlined in Table 5-1 in accordance with the methodology presented in BS5228:2008 [2]. Due to the scale of the construction site, it is not possible to identify an exact location from which to measure the edge of the construction site. As a result, construction noise is assessed in terms of a general noise contour and reported as such in Table 5-2 below.

In addition, NSRs 1 to 6 have been assessed for cumulative construction noise impacts based on the measured baseline noise levels at these locations as well as the measured distances between the NSRs and the edge of the nearest edge of the main plant area.

To represent a reasonable worst case scenario, each single incidence of each item in the construction equipment detailed in Table 5-1 has been assumed to be operating concurrently at a single location. It is assumed that construction activity will only take place during the day and thus no assessment is made against a night time standard. For details of the Construction assessment, see Appendix A for sample tables.

The assessment is divided into the various stages of construction as defined by the construction equipment inventory in Table 5-1.

The construction noise threshold (due to its temporary nature) is assessed as 65 dB(A) as per Section 3.2.

### 5.2.1 Expected Construction Noise Levels

**Table 5-2 - Construction Noise Levels as a function of Distance (Project in Isolation)**

| Distance (m) | Construction Noise Level (dB(A)) | | | | | |
|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI |
| 10 | 81.7 | 81.5 | 81.8 | 73.0 | 82.7 | 89.5 |
| 20 | 75.7 | 75.5 | 75.8 | 67.0 | 76.7 | 83.5 |
| 30 | 72.2 | 72.0 | 72.3 | 63.5 | 73.2 | 80.0 |
| 40 | 69.7 | 69.5 | 69.8 | 61.0 | 70.7 | 77.5 |
| 50 | 62.7 | 62.6 | 62.9 | 54.0 | 63.8 | 70.6 |
| 75 | 59.2 | 59.0 | 59.3 | 50.5 | 60.2 | 67.0 |
| 100 | 56.7 | 56.5 | 56.8 | 48.0 | 57.7 | 64.5 |
| 150 | 53.2 | 53.0 | 53.3 | 44.5 | 54.2 | 61.0 |

| Distance (m) | Construction Noise Level (dB(A)) | | | | | |
|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI |
| 200 | 50.7 | 50.5 | 50.8 | 42.0 | 51.7 | 58.5 |
| 300 | 47.2 | 47.0 | 47.3 | 38.5 | 48.2 | 55.0 |

When the project is considered in isolation, the construction noise limit of 65 dB(A) is expected to be exceeded for all types of construction activity. It should be noted however, that in all cases, the exceedance of the limit is expected to be limited to within a radius of approximately 50 - 75 m from the edge of the construction site. A review of aerial photographs (Google Earth) of the Project area reveal no identifiable receptors within this radius and it is thus considered unlikely that significant negative impacts will be experienced as a result of construction noise.

### 5.2.2 Cumulative Impact Assessment

The cumulative noise contribution due to construction activity (only Group VI which is considered as 'worst case') at the identified NSRs (NSR 1 to 5) is detailed in Table 5-3 below and evaluated against the impact criteria detailed in Table 3-3. This includes the addition of baseline data to the predicted construction noise levels.

The distances from the edge of the construction site to each of the receptors has been measured using Google Earth and is measured as the shortest possible distance between them. The resultant maximum noise level caused by construction noise at each receptor is then calculated based on the methodology outlined in BS5228 [2].

**Table 5-3 - Construction Noise Levels at Sensitive Receptors**

| Receptor | Distance from boundary (m) | Construction Noise Contribution (Group IV) (dB(A)) | Baseline Noise Level (dB(A)) | Total Noise Level (dB(A)) | Maximum Change in Noise Level at NSR (dB(A)) | Exceedance of Construction Noise Limit? | Impact Severity |
|---|---|---|---|---|---|---|---|
| NSR1 | 1 550 | 40.7 | 53.0 | 53.2 | 0.2 | No | Negligible |
| NSR2 | 1 100 | 43.7 | 47.3 | 48.9 | 1.6 | No | Negligible |
| NSR3 | 710 | 47.5 | 43.8 | 49.0 | 5.2 | No | Moderate |
| NSR4 | 1 640 | 40.3 | 49.4 | 49.9 | 0.5 | No | Negligible |
| NSR5 | 1 940 | 38.8 | 44.1 | 45.2 | 1.1 | No | Negligible |

When considering construction noise, moderate negative impacts are expected at NSR3 as per the assessment criteria outlined in Table 3-3 [5]. Other NSR's around the Project site are not expected to be impacted by construction noise, as the predicted levels are well below the construction noise threshold of 65 dB(A). In addition the construction phase will include the construction of a 2.5 m perimeter wall, which will act as additional screening during the later construction phases.

The construction worker camp locations are not known at this stage of the design process but can be expected to experience negative impacts (noise levels between 65 and 75 dB(A)) during day time construction activity. During these times (day time hours) however, the residents of the worker camps will be involved in the construction activities and are not likely to be significantly impacted by the noise experienced at the worker camps.

## 5.3 Mitigation of Construction Noise

The noise predictions presented in Table 5-3 are for activities with all assumed construction equipment (Table 5-1) operating concurrently with no site hoarding acting as a noise control measure, therefore this can be considered a 'worst case' scenario.

Noise and vibration from construction activities can be controlled through the Health, Safety and Environmental (HSE) Management Plans, such as the Construction Environmental Management Plan (CEMP). The following mitigation measures are proposed for the subject construction works:

- Prioritise building the perimeter walls around the facility;
- Where reasonable and feasible, the proponent will apply best practice noise mitigation measures including:
    - Maximising the offset distance between noisy equipment items and residential receptors;
    - Avoiding the coincidence of noisy equipment working simultaneously close together when adjacent to sensitive receptors;
    - Orienting equipment away from noise sensitive receptors; and,
    - Carrying out loading and unloading away from noise sensitive areas.
- Site inductions should cover the importance of noise control and available noise reduction measures;
- Construction contractors should be required to use equipment that is in good working order and that meets current best practice noise emission levels. This should be achieved by making it a component of contractual agreements with the construction contractions;
- Community liaison would form a critical element in the management of the impacts. If provided with adequate warning, affected sensitive receptors are sometimes willing to accept excessive noise for a short period of time. Designation of a community liaison officer who will be able to deal with the concerns of residents and establishment of a

complaint response programme can enable the identification and resolution of any noise related concerns at an early stage;

- Noise monitoring should be undertaken in order to determine the construction noise emission levels and to aid the selection of additional noise controls where necessary. Additional noise controls such as portable screening would be employed if monitoring indicates the need or in response to concerns;
- Where limit values are exceeded immediate appropriate action will be undertaken for example reducing hours of heavy construction works or replacing tooling techniques;
- As far reasonably practicable sources of significant noise should be enclosed. The extent to which this can be done depends on the nature of the machines to be enclosed and their ventilations requirements;
- Minimise reversing of equipment to prevent nuisance caused by reversing alarms;
- Driver practices when approaching and leaving the site should minimise noise emissions created through activities such as unnecessary acceleration and breaking squeal;
- All mobile or fixed noise-producing equipment used on the project, where regulated for noise output by a local, state, or federal agency, shall comply with such regulation while in the course of project activity;
- Electrically-powered equipment instead of pneumatic or internal combustion powered equipment shall be used, where feasible;
- Material stockpiles and mobile equipment staging, parking, and maintenance areas shall be located as far as practicable from noise-sensitive receptors;
- Construction site and haul-road speed limits shall be established and enforced during the construction period;
- The use of noise-producing signals, including horns, whistles, alarms, and bells shall be for safety warning purposes only;
- The on-site construction supervisor shall have the responsibility and authority to receive and resolve noise complaints. A clear appeal process to the Owner shall be established prior to construction commencement that will allow for resolution of noise problems that cannot be immediately solved by the site supervisor;
- The contractor shall develop a project noise control plan, which shall have been approved and implemented prior to commencement of any construction activity;
- Contract incentives may be offered to the construction contractor to minimise or eliminate noise complaints resulting from project activities where project construction would result in significant noise impacts;

- The emplacement of berms or erection of temporary sound wall barriers (site hoarding) will be considered where project activity is unavoidably close to noise-sensitive receptors; and,
- Planting of trees and shrubbery while useful for visual screening is not an effective noise control mechanism and is not considered a noise control or mitigation measure for noise impacts.

# 6 Project Facilities Operational Noise Impact Assessment

## 6.1 Noise Model

In order to estimate the operational noise levels, the internationally recognised noise modelling software SoundPLAN 7.3 has been utilised.

The propagation methodology adopted within the SoundPLAN model was the International Organisation for Standardisation (ISO) 9613 'Acoustics – Attenuation of Sound during Propagation Outdoors' (ISO, 1996) [7]. This document can be referred to for an in depth description of the methodology SoundPLAN utilises for attenuation of sound and propagation outdoors.

ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources [7]. The method predicts the equivalent continuous A-weighted sound pressure level ($L_{Aeq}$) under meteorological conditions favourable to propagation from sources of known sound emission. The source (or sources) may be moving or stationary and takes account of the following physical effects:

- Geometrical divergence;
- Atmospheric absorption;
- Ground effect;
- Reflection from surfaces; and,
- Screening by obstacles.

This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning: industrial noise sources, road or rail traffic, construction activities, and many other ground-based noise sources.

## 6.2 Propagation of Sound

The variables which affect sound propagation over ground away from a source have been the subject of much detailed investigation over the years. The principal factors influencing sound attenuation with distance from the source are:

- Geometrical spreading (this is the standard spherical wave divergence term which gives 6 dB reduction in noise level for each doubling of distance from point source e.g. small motor, 3 dB for a line source e.g. piping) [8];
- Source directivity;
- Atmospheric (molecular) absorption;
- Ground effects (different for hard/soft ground, and type of ground cover);

- Atmospheric wind temperature gradients (refraction);
- Source height;
- Atmospheric turbulence; and,
- Barrier effects (diffraction).

The total attenuation due to all these factors except geometrical spreading and directivity is generally referred to as 'excess attenuation', and will vary with frequency. Because of these effects, a significant noise source may not be significant at, and beyond, the boundary and vice-versa. For example a noise source dominated by low frequency noise (with a long wave length) is likely to travel a greater distance under the same excess attenuation factors to that of a noise source dominated with high frequency noise (with a shorter wavelength).

## 6.3 Meteorological and Ground Conditions

The most influential environmental condition on noise propagation is distance, the greater the distance between the noise source and the receiver the greater the noise reduction achieved. Typically for stationary sources (such as those associated with a coal power station), a reduction of 6 dB(A) per doubling of distance is considered the norm [8].

The type of ground cover also influences noise propagation. Soft ground such as sand or agricultural land absorbs sound energy shortening the propagation path whereas hard ground such as compact soil or tarmac reflects the sound energy and thereby noise travels further. It has been assumed for this assessment that the ground cover will be relatively hard with an associated absorption coefficient of 0.2.

For noise propagation over short distances climatic conditions do not have a significant effect, however over longer distance over 50 m wind becomes more influential. Downwind the level may increase by a few dB, depending on wind speed whereas on the upwind or side-wind the level can drop by 10 dB.

Temperature gradients create effects similar to those of wind gradients, except that they are uniform in all directions from the source. On a sunny day with no wind, temperature decreases with altitude, giving a noise shadow. (The result is the noise is taken up and away from the source and the ground). On a clear night temperature may increase with altitude (temperature inversion) focusing sound towards the ground surface.

## 6.4 Modelled Equipment

In the absence of detailed design data, equipment has been integrated into the noise model as either a point, area or block source, depending on the size and function of the item of equipment. In the absence of vendor noise data, all equipment has been modelled at the occupational noise threshold sound pressure level (Lp) of 85 dB(A) at a distance of 1 metre from any equipment façade.

The sound power level data has been estimated based on the sound pressure level data and approximate equipment sizes estimated from data provided by the project engineers or based on approximate dimensions illustrated on Project plot plans and facility layout drawings.

Full details of equipment modelled is detailed in Appendix B.

**Table 6-1 - Project Facilities and Associated Equipment**

| Noisy Equipment | No. of Identical Equipment Items | $L_P$ (dB(A)) @ 1m | Operating Conditions (Normal / Emergency) |
|---|---|---|---|
| Turbine | 3 | 85 | Normal |
| Motor driven variable speed feed water pump | 3 | 85 | Emergency |
| Condensate pump | 6 | 85 | Emergency |
| Turbine driven feed water pump | 6 | 85 | Normal |
| Turbine driven feed water booster pump | 6 | 85 | Normal |
| Feed water pump turbine | 6 | 85 | Normal |
| Closed cycle cooling water pump | 6 | 85 | Normal |
| Vacuum pump | 6 | 85 | Normal |
| Lube oil transportation pump | 3 | 85 | Normal |
| Boiler [1] | 3 | 85 | Normal |
| Primary air fan [1] | 6 | 85 | Normal |
| Forced draft fan [1] | 6 | 85 | Normal |
| Sealing air fan [1] | 6 | 85 | Normal |
| Scan air cooling fan [1] | 6 | 85 | Normal |
| Slag crusher [1] | 3 | 85 | Normal |
| Fluidising Air Blower [1] | 4 | 85 | Emergency |
| Air Preheater | 6 | 85 | Normal |
| LDO supplying pump | 5 | 85 | Emergency |
| LDO unloading pump | 2 | 85 | Normal |
| Bulldozer | 3 | 85 | Normal |
| Loader | 2 | 85 | Normal |
| Vibrating feeder | 2 | 85 | Normal |
| Shaking-striking device | 20 | 85 | Normal |
| Roller screen | 2 | 85 | Normal |
| Ring hammer crusher | 2 | 85 | Normal |
| Blowdown pump | 6 | 85 | Normal |
| Induced drift fan | 6 | 85 | Normal |
| Pulveriser | 15 | 85 | Normal |
| Waste water pump | 6 | 85 | Normal |
| Screw air compressor | 9 | 85 | Normal |
| Fluidising air blower of ash silo | 4 | 85 | Normal |

| Noisy Equipment | No. of Identical Equipment Items | $L_P$ (dB(A)) @ 1m | Operating Conditions (Normal / Emergency) |
|---|---|---|---|
| Fluidising air blower of ash hopper | 4 | 85 | Normal |
| UF produced water pump | 3 | 85 | Normal |
| HP feed water pump of SWRO | 3 | 85 | Normal |
| Feed up pump of RO | 2 | 85 | Normal |
| HP feed pump of RO | 2 | 85 | Normal |
| Feed up pump of ion-exchange system | 2 | 85 | Normal |
| Demineralized water pump | 3 | 85 | Emergency |
| Roots blower | 4 | 85 | Normal |
| Waste water pump | 2 | 85 | Emergency |
| Circulating water pump (CWP) | 6 | 85 | Normal |
| Washing pump for traveling screen | 2 | 85 | Normal |
| Drainage pump | 2 | 85 | Normal |
| Seawater booster pump | 3 | 85 | Normal |
| Cooling water pump for CWP motors | 2 | 85 | Normal |
| Make up water pump for D.M plant | 4 | 85 | Normal |
| Potable water pump for power plant | 2 | 85 | Normal |
| Reuse water pump | 2 | 85 | Emergency |
| Reuse water pump | 2 | 85 | Normal |
| Coal wastewater booster pump | 2 | 85 | Normal |
| Electric motor driven main pump | 1 | 85 | Normal |
| Diesel engine driven pump | 1 | 85 | Normal |
| Low-voltage dry-type transformer | 31 | 85 | Normal |

**Note 1:** Due to limited detail of the locations of these equipment items within the boiler halls, all items indicated have been included as a single block source with dimensions as per the plot plan and a height of 8 metres.

## 6.5 Modelling Assumptions

The following assumptions have been made for the modelling assessment, and wherever possible, a conservative approach has been taken:

- It has been assumed that all continuous noise sources operate 24 hours per day;
- There is a 2,5m perimeter wall around the entire project site;
- Equipment height has been based upon the plant layout plot plans and knowledge of similar projects;
- Noise sources have been modelled as point, area or blocks (as described earlier);

- The model does not incorporate features which might provide partial screening (e.g., columns, pipe racks, structural steelwork, and small equipment);
- Ground absorption has been modelled as relatively hard ground (having an absorption coefficient of 0.2) to maintain a conservative assessment; and,
- Reasonable worst case meteorological conditions have been applied, i.e. steady wind conditions blowing in each direction.
- The model does not include noise from pipework or valves.
- A digital ground map was generated using terrain data received from the United States Geological Survey (USGS) Global Data Explorer [9] on a resolution of approximately 30 m.

## 6.6 Predicted Noise Levels

### 6.6.1 Boundary Noise Levels

Equipment has been assumed to be designed to comply with the work area noise limits, however an assessment of the noise impact at the site boundary and beyond has been conducted to determine if the Project facilities will meet the specified daytime boundary noise level of 70 dB(A).

Table 6-2 presents the predicted cumulative noise levels under normal operating conditions at the site boundary. Similarly, Table 6-3 shows the cumulative noise levels under emergency operating conditions at the site boundaries.

Under normal conditions equipment noise is predicted to be localised to the work areas. The cumulative noise (based on the logarithmic addition of baseline ambient and project noise levels) generated by the Project facilities is expected to diminish towards the site boundary with maximum noise levels predicted to range from 45.3 dB(A) on the northern boundary to 55.5 dB(A) on the eastern boundary.

**Table 6-2 - Predicted Project Site Boundary Noise Levels – Normal Operation**

| Boundary | Maximum Cumulative Boundary Noise Level under Normal Operating Conditions (dB(A)) | Boundary Noise Limit: IFC Guidelines | |
|---|---|---|---|
| | | Daytime Noise Limit (dB(A)) | Night Time Noise Limit (dB(A)) |
| North | 45.3 | 70 | 70 |
| East | 55.5 | 70 | 70 |
| West | 54.4 | 70 | 70 |
| South | 48.9 | 70 | 70 |

Based on the assessment results, the boundary noise levels are not anticipated to exceed the IFC daytime and night time guideline noise limit [1].

Table 6-3 shows the cumulative noise levels under emergency operating conditions at the site boundaries.

**Table 6-3 - Predicted Project Site Boundary Noise Levels – Emergency Scenario**

| Boundary | Maximum Cumulative Boundary Noise Level under Emergency Operating Conditions (dB(A)) |
|---|---|
| North | 45.4 |
| East | 55.8 |
| West | 54.6 |
| South | 49.1 |

### 6.6.2 Existing Noise Sensitive Receptors

Noise emissions from normal and emergency operational activities have been estimated for the five existing NSRs identified in the area of the Project facilities as shown in Section 0.

According to the IFC standards, the daytime and night time noise limits at the residential NSRs are 55 dB(A) and 45 dB(A) respectively.

The cumulative noise level at each receptor is calculated by logarithmic addition of the Project noise (modelled noise level) to the ambient (measured baseline) noise level at each location.

The noise levels at NSRs due to normal operation of the Project in isolation at the five sensitive receptors are detailed in Table 6-4 and assessed against the IFC daytime and night time noise standards. Similarly, Table 6-5 shows the assessment of noise levels under emergency operating conditions at each of the five existing NSRs.

**Table 6-4 - Assessment of Noise Levels at Existing NSRs under Normal Operating Conditions**

| Receptor | Project Noise Contribution at Receptor (dB(A)) | Baseline Noise Level at Receptor (dB(A)) | Cumulative Noise Level at Receptor (dB(A)) | Change in Noise Level at Receptor (dB(A)) | Applicable IFC Noise Limit (dB(A)) | | Impact Rating |
|---|---|---|---|---|---|---|---|
| | | | | | Day | Night | |
| NSR1 | 40.7 | 53.0 | 53.2 | 0.2 | 55 | 45 | Negligible |
| NSR2 | 44.3 | 47.3 | 49.1 | 1.8 | 55 | 45 | Negligible |
| NSR3 | 47.4 | 43.8 | 49.0 | 5.2 | 55 | 45 | Moderate |
| NSR4 | 40.7 | 49.4 | 49.9 | 0.5 | 55 | 45 | Negligible |
| NSR5 | 38.6 | 44.1 | 45.2 | 1.1 | 55 | 45 | Negligible |

**Table 6-5 - Assessment of Noise Levels at Existing NSRs under Emergency Operating Conditions**

| Receptor | Project Noise Contribution at Receptor (dB(A)) | Baseline Noise Level at Receptor (dB(A)) | Cumulative Noise Level at Receptor (dB(A)) | Change in Noise Level at Receptor (dB(A)) | Applicable IFC Noise Limit (dB(A)) | | Impact Rating |
|---|---|---|---|---|---|---|---|
| | | | | | Day | Night | |
| NSR1 | 40.9 | 53.0 | 53.3 | 0.3 | 55 | 45 | Negligible |
| NSR2 | 44.4 | 47.3 | 49.1 | 1.8 | 55 | 45 | Negligible |
| NSR3 | 47.5 | 43.8 | 49.0 | 5.2 | 55 | 45 | Moderate |
| NSR4 | 41.0 | 49.4 | 50.0 | 0.6 | 55 | 45 | Negligible |
| NSR5 | 38.8 | 44.1 | 45.2 | 1.1 | 55 | 45 | Negligible |

As detailed in Table 6-4 and Table 6-5, the cumulative noise levels (Project noise contribution with ambient noise) have been compared against the IFC noise limits for daytime and night time periods [1]. The results indicate no exceedances of daytime noise limits for any of the NSRs, however all five NSRs are expected to experience exceedances of the night time limit of 45 dB(A).

It should be noted that it is arguable that the noise limits are conservative with regards to the existing ambient noise levels, as most ambient noise levels already exceed the applicable night time limit.

In terms of contextualising background noise levels in excess of the standards, the IFC Guidelines [1] states that the contribution of operational noise should not result in an increase of background noise levels by more than 3 dB(A). Based on this requirement, the cumulative noise level should not be 3 dB(A) greater than the ambient noise level.

Although NSR 3 does experience an increase in noise level of more than 3 dB(A), the ambient measured noise level is below the day and night time IFC noise limit [1] and therefore the Project does not cause violation of this guideline. It should be noted at this point that the Project contribution to this exceedance is below the daytime noise limit and only 2.5 dB(A) above the night time IFC limit.

### 6.6.3 New Noise Sensitive Receptors

Noise emissions from normal and emergency operational activities have been estimated for the five new NSRs identified in the area of the Project facilities as shown in Section 0.

According to the IFC standards, the daytime and night time noise limits at the residential NSRs are 55 dB(A) and 45 dB(A) respectively.

The noise levels at NSRs due to normal operation of the Project in isolation at the five sensitive receptors are detailed in Table 6-6 and assessed against the IFC daytime and night time noise standards [1]. Similarly, Table 6-7 shows the assessment of noise levels under emergency operating conditions at each of the five new NSRs.

**Table 6-6 - Assessment of Noise Levels at New NSRs under Normal Operating Conditions**

| Receptor | Project Noise Level at Receptor (dB(A)) | Applicable IFC Noise Limit (dB(A)) | | Exceedance of Applicable IFC Noise Limit (dB(A)) | |
|---|---|---|---|---|---|
| | | Day | Night | Day | Night |
| NSR6 | 65.5 | 55 | 45 | 10.5 | 20.5 |
| NSR7 | 64.1 | 55 | 45 | 9.1 | 19.1 |
| NSR8 | 60.2 | 55 | 45 | 5.2 | 15.2 |
| NSR9 | 52.1 | 55 | 45 | N/A | 7.1 |
| NSR10 | 53.2 | 55 | 45 | N/A | 8.2 |

**Table 6-7 - Assessment of Noise Levels at New NSRs under Emergency Operating Conditions**

| Receptor | Project Noise Level at Receptor (dB(A)) | Applicable IFC Noise Limit (dB(A)) | | Exceedance of Applicable IFC Noise Limit (dB(A)) | |
|---|---|---|---|---|---|
| | | Day | Night | Day | Night |
| NSR6 | 65.9 | 55 | 45 | 10.9 | 20.9 |
| NSR7 | 64.6 | 55 | 45 | 9.6 | 19.6 |
| NSR8 | 60.5 | 55 | 45 | 5.5 | 15.5 |
| NSR9 | 52.2 | 55 | 45 | N/A | 7.2 |
| NSR10 | 53.6 | 55 | 45 | N/A | 8.6 |

As detailed in Table 6-6 and Table 6-7, the Project noise levels have been compared against the IFC noise limits for daytime and night time periods. The results indicate exceedances of daytime noise limits for NSR 6, 7 and 8; while all five NSRs are expected to experience exceedances of the night time limit of 45 dB(A).

It should be noted that it is arguable that the noise limits are conservative with regards to the fact that the classification of the NSRs is technically an industrial area; however, given that these areas are designed to accommodate workers, it was considered more conservative to assess the noise levels at these locations against the residential standards.

Noise contour maps have been generated from the modelling assessment and are shown in Appendix C. Various mitigation measures to address these exceedances are outlined in Section 6.7.

## 6.7 Mitigation of Operational Noise

### 6.7.1 Boundary Noise Levels and Existing Noise Sensitive Receptors

Noise levels at the boundary and existing NSRs can be partially controlled through proper maintenance of continuous noise sources such as pumps, fans, compressors and turbines. It is essential that equipment is built to comply with the specification of 85 dB(A) at 1 m.

However, as this assessment conservatively assumes 85 dB(A) noise levels at 1 m from the façade of all sources, the noise levels at various receptors (NSRs and boundary) around the Project site are considered a worst case scenario and may change based on the final design.

Further mitigation measures for the noise levels produced by each equipment item should be investigated based on the final design of the complete facility.

### 6.7.2 New Noise Sensitive Receptors

The elevated noise levels expected to occur at NSRs 6 to 10 are likely unavoidable due to the relatively close proximity of the worker accommodation areas (receptors) to the power block (noisiest part of the plant). Of primary concern at these receptors is the indoor noise level in order to allow for adequate sleeping conditions in accordance with the BS8233:2014 as outlined in Table 3-2 [3].

The Building Research Establishment (BRE) Digest 379 (1993) [10] outlines typical noise insulation rating for different types of windows as shown in Table 6-8.

**Table 6-8 - Typical Noise Insulation Factors for Different Types of Window (BRE Digest 379 (1993) [10])**

| Type of Window | Single Number Insulation Rating $R_w$ (dB) | Description |
|---|---|---|
| Open Window | ± 10 | Small casement window open to 45° for ventilation |
| Single Glazing | 22 – 30 | 4 mm single glazed window |
| Thermal Glazing | 33 – 35 | Thermal 6-12-6 mm in a PVC-U frame |
| Secondary Glazing | 40 – 45 | Open-able 4-200-4 mm system with absorbent reveals |
| Note that the descriptions provided are examples of the typical window types and are not specific recommendations for mitigation. | | |

The $R_w$ insulation factor is derived as an overall average noise reduction factor but can be calculated individually for every window based on its size and location on the façade. For the purposes of assessing internal noise levels, it will be conservatively assumed that all windows provide the lower end of the noise reduction range specified in Table 6-8.

On the basis of the modelled results above, and the assumption that Project operational noise levels are consistent for both day and night time periods, the following mitigation measures are recommended to be included in the design of the accommodation areas:

**Table 6-9 - Proposed Mitigation Measures for Inclusion in Design of Accommodation Areas**

| Receptor | Project Noise Level at Receptor (dB(A)) | Exceedance of BS8233 Noise Limit for Sleeping (dB(A)) | Recommended Window Specification for Accommodation Area | Single Number Insulation Rating |
|---|---|---|---|---|
| | | | | $R_w$ (dB) |
| NSR6 | 65.9 | 35.9 | Secondary Glazing | 40 – 45 |
| NSR7 | 64.6 | 34.6 | Secondary Glazing | 40 – 45 |
| NSR8 | 60.5 | 30.5 | Thermal Glazing | 33 – 35 |
| NSR9 | 52.2 | 22.2 | Thermal Glazing | 33 – 35 |
| NSR10 | 53.6 | 23.6 | Thermal Glazing | 33 – 35 |

# 7 Conclusion

A noise impact assessment for the proposed Lamu Coal Power Station Project has been conducted to determine the significance and degree of impact at various types of receptor in the vicinity of the Project for both the construction and operational phases.

## 7.1 Construction Phase

Calculation of noise impacts due to construction equipment at the identified existing NSRs was calculated based on the methodology outlined in BS5228 [2]. The impact significance at these NSRs was then assessed based on the joint IEMA and IoA guidelines for noise and vibration impact assessment given in Table 3-3 [4].

It is expected that the construction noise threshold of 65 dB(A) will be met within a radius of approximately 50 - 75 m from the edge of the construction site.

Five NSRs were selected for assessment purposes. A moderate negative impact due to construction noise is expected at NSR3. It should be noted that despite the moderate impact predicted, the cumulative noise level at NSR3 is still below the 65 dB(A) construction noise threshold adopted for the assessment. At each of the other existing NSRs, a negligible increase in ambient noise level is expected and does not constitute a significant impact.

In conclusion, it is not expected that construction noise will pose significant impacts to any of the identified existing NSRs in the vicinity of the Project.

A variety of possible noise mitigation measures have been suggested, which if implemented effectively, could lead to reduction in impacts for the onsite receptors which are affected by construction noise (such as worker camps), and therefore should be implemented through HSE management plans.

## 7.2 Operational Noise Impact Assessment

In order to estimate the operational noise level, the internationally recognised noise modelling software SoundPLAN 7.3 has been utilised.

Potentially noisy items of plant at the Project facilities that include pumps, compressors, turbines, generators and air coolers (fans) were included in the noise model and an overall site noise contour map produced (See Appendix C).

### 7.2.1 Boundary Noise Levels

Under normal conditions, noise-producing equipment is predicted to be localised to the work areas within the boundary of the plant. The noise generated by the Project is expected to diminish towards the site boundary with maximum noise levels predicted to range from 45.3 dB(A) on the northern boundary to 55.5 dB(A) on the eastern boundary.

Based on the model results, the boundary noise levels are not anticipated to exceed the IFC daytime and night time guideline noise limit [1]. With the added mitigation created by trees, grasses and various other naturally occurring screening measures, it is expected that boundary noise levels will be lower than those predicted in this assessment.

### 7.2.2 Existing Noise Sensitive Receptors

An initial screening of Project area and baseline data resulted in the selection of five existing NSRs for the purposes of this assessment. A detailed impact assessment was carried out for these NSRs by comparing Project operations noise (with the inclusion of baseline data) at the NSRs to the national standards and international guidelines as detailed in Section 3.

The assessment indicated that the Project operational noise levels are not expected to cause any exceedance of the daytime IFC noise limits, however the night time noise limit of 45 dB(A) is expected to be exceeded at all five of the existing NSRs.

It is noted that the baseline noise level at each NSR is included in the assessment and in the case of NSR 1, 2 and 4 is already in exceedance of the night time IFC noise standard [1].

### 7.2.3 New Noise Sensitive Receptors

The assessment indicated that all of the five new NSRs designed to accommodate workers at the Project site are predicted to experience noise levels that exceed the IFC night time noise limit of 45 dB(A) [1]. Similarly NSR 6, 7 and 8 are expected to experience daytime noise levels in exceedance of the relevant IFC limit. However, it should be acknowledged that these locations are all within the boundary of the Project site and it is thus expected that these exceedances are unavoidable.

A semi-quantitative assessment of the indoor noise levels at these receptors was carried out in order to determine the appropriate noise mitigation measures (with regards to design of windows in the accommodation area) to recommend so as to achieve compliance with the standards outlined in BS8233:2014 [3]. Of primary concern is compliance with the standard for adequate sleeping conditions within the accommodation buildings.

It was determined that secondary and thermal glazing should be incorporated in the design of the dormitory and worker camp accommodation buildings respectively (see Table 6-8 for details of window design).

Further mitigation measures should be investigated upon completion of the final design of the Project facilities and equipment in order to ensure compliance with IFC noise limits as well as WHO and BS8233 standards.

# 8 References

1. The International Finance Corporation (IFC) Environment, Health, and Safety (EHS) Guidelines: Noise Management

2. British Standards Institute (BSi), 2008, ‘BS5228 – Noise and Vibration Control on Construction and Open Sites’. BSi, London

3. British Standards Institute (BSi), 2014, ‘BS8233 – Guidance on Sound Insulation and Noise Reduction for Buildings’. BSi, London

4. Department for Environment, Food and Rural Affairs (DEFRA), 2005, ‘Update of Noise Database for Prediction of Noise on Construction and Open Sites’. Norwich, United Kingdom

5. Institute of Acoustics (IoA)/Institute of Environmental Management and Assessment (IEMA) Joint Working Party on Noise Impact Assessment (2002) draft Guidelines for Noise Impact Assessment

6. CONCAWE, Technical Memorandum on Noise from Construction Work (Other than percussive piling), Table 3, CNP064. (Accessed on 21/05/2015)

   [http://www.epd.gov.hk/epd/english/environmentinhk/noise/guide_ref/tm_nonpp_4_3.html]

7. International Organisation for Standardisation (ISO) ISO9613-2 ‘Acoustics – Attenuation of Sound During Propagation Outdoors’ (1993)

8. Sharland, Ian. Woods Practical Guide to Noise Control. Woods of Colchester Limited (1979)

9. United States Geological Survey, Global Data Explorer. (accessed on 08/05/2015)

   [http://gdex.cr.usgs.gov/gdex/]

10. The Building Research Establishment (BRE), Digest 379 (1993).

# 9 Glossary

**LAeq T**: This is the continuous equivalent sound level. It is a widely used noise parameter that calculates a constant level of noise with the same energy content as the varying acoustic noise signal being measured. The letter "A" denotes that the A-weighting has been included and "eq" indicates that an equivalent level has been calculated. Hence, $L_{Aeq}$ is the A-weighted equivalent continuous noise level. A-weighting is a filter incorporated into a sound level meter which when measuring noise replicates the sensitivity of human hearing.

**LASN, T percentile levels:** The level of A-weighted noise exceeded for N% of the measurement time. $L_{AS90}$, T is often used as a measure of background noise in many standards and guidelines. The $L_{AS90}$, T parameter would therefore represent the level exceeded for 90% of the measurement period, T. Likewise the $L_{AS10}$, T would indicate the level exceeded for 10% of the measurement period, T indicating the higher noise levels measured.

$L_{Amax}$: The maximum A-weighted sound pressure level occurring in a specified time period.

$L_{A10}$: The A-weighted sound pressure level that is exceeded 10% of the measurement period.

$L_{A90}$: The A-weighted sound pressure level that is exceeded 90% of the measurement period.

**Octave Band Analysis**: To identify frequency components of a sound, there is octave band analysis in which frequencies are segmented into proportionate widths (octave bands) and analysed. The sound pressure level of a single octave band is called the "octave band level", while that analysed for $^1/_3$ of the octave band is called a "$^1/_3$ octave band level". The frequency band in the octave band and $^1/_3$ octave band is expressed as the centre frequency of that band. Using $f_1$ and $f_2$ as the upper and lower end frequencies of the band.

**Sound Pressure Level (Lp):** An acoustic measurement for the ratios of sound energy. Rated in decibels.

**Sound Power Level (Lw):** The Lw is a measure of the total airborne acoustic power generated by a noise source, expressed on a decibel scale referenced to a common standard (10-12 watts).

**Decibel (dB):** dB is a logarithmic unit of measurement that expresses the magnitude of a physical quantity (usually power or intensity) relative to a specified or implied reference level. Since it expresses a ratio of two quantities with the same unit, it is a dimensionless unit.

**dB(A):** The 'A' weighting network is very similar to the way in which the human ear responds to variations in sound pressure level as it places higher attenuation on the lower frequencies than on the mid to upper frequencies. It is applied to the decibel scale in order to account for how the human ear responds to changes in sound levels.

# Appendix A: Sample Construction Noise Impact Assessment Tables

## Sample Construction Assessment Tables

### Construction Assessment at NSR 5

**1. Earth Work Equipment**

| Unit Type | *Noise Emission* Leq 10m dB | Receptor distance (m) | Distance Correction | *Adjustments* Screening dB | Reflection dB | Res. Laeq dB | *Numbers Adjustments* Duration (% of total hours) | No. of plant | dB Correction | ACTIVITY LAeq dB |
|---|---|---|---|---|---|---|---|---|---|---|
| Backhoe Excavator | 78.00 | 1 940 | -45.76 | 5.00 | - | 27.24 | 100.00 | 1.00 | - | 27.24 |
| Dozer | 79.00 | 1 940 | -45.76 | 5.00 | - | 28.24 | 100.00 | 1.00 | - | 28.24 |
| Loader | 68.00 | 1 940 | -45.76 | 5.00 | - | 17.24 | 100.00 | 1.00 | - | 17.24 |
| | | | | | | | | | **SUBTOTAL** | **30.97** |

**2. Transportation Equipment**

| Unit Type | *Noise Emission* Leq 10m dB | Receptor distance (m) | Distance Correction | *Adjustments* Screening dB | Reflection dB | Res. Laeq dB | *Numbers Adjustments* Duration (% of total hours) | No. of plant | dB Correction | ACTIVITY LAeq dB |
|---|---|---|---|---|---|---|---|---|---|---|
| Autodumper (Large) | 76.00 | 1 940 | -45.76 | 5.00 | - | 25.24 | 100.00 | 1.00 | - | 25.24 |
| Autodumper (Small) | 78.00 | 1 940 | -45.76 | 5.00 | - | 27.24 | 100.00 | 1.00 | - | 27.24 |
| Water Tank Truck | 76.00 | 1 940 | -45.76 | 5.00 | - | 25.24 | 100.00 | 1.00 | - | 25.24 |
| | | | | | | | | | **SUBTOTAL** | **30.79** |

**3. Concrete and mortar Equipment**

| Unit Type | *Noise Emission* Leq 10m dB | Receptor distance (m) | Distance Correction | *Adjustments* Screening dB | Reflection dB | Res. Laeq dB | *Numbers Adjustments* Duration (% of total hours) | No. of plant | dB Correction | ACTIVITY LAeq dB |
|---|---|---|---|---|---|---|---|---|---|---|
| Concrete Mixing Plant | 76.40 | 1 940 | -45.76 | 5.00 | - | 25.64 | 100.00 | 1.00 | - | 25.64 |
| Concrete batching machine | - | 1 940 | -45.76 | 5.00 | - | N/A | 100.00 | 1.00 | - | N/A |
| Material loader (a) | 68.00 | 1 940 | -45.76 | 5.00 | - | 17.24 | 100.00 | 1.00 | - | 17.24 |
| Material loader (b) | 68.00 | 1 940 | -45.76 | 5.00 | - | 17.24 | 100.00 | 1.00 | - | 17.24 |
| Concrete mixing transportation cart | 76.00 | 1 940 | -45.76 | 5.00 | - | 25.24 | 100.00 | 1.00 | - | 25.24 |
| Concrete pump truck | 77.00 | 1 940 | -45.76 | 5.00 | - | 26.24 | 100.00 | 1.00 | - | 26.24 |
| Concrete transport pump | 67.00 | 1 940 | -45.76 | 5.00 | - | 16.24 | 100.00 | 1.00 | - | 16.24 |
| Mortar mixer | 61.00 | 1 940 | -45.76 | 5.00 | - | 10.24 | 100.00 | 1.00 | - | 10.24 |
| | | | | | | | | | **SUBTOTAL** | **31.08** |

**4. Lifting Equipment**

| Unit Type | *Noise Emission* Leq 10m dB | Receptor distance (m) | *Adjustments* Distance Correction | Screening dB | Reflection dB | Res. Laeq dB | *Numbers Adjustments* Duration (% of total hours) | No. of plant | dB Correction | **ACTIVITY LAeq dB** |
|---|---|---|---|---|---|---|---|---|---|---|
| Track type crane (a) | 67.00 | 1 940 | -45.76 | 5.00 | - | 16.24 | 100.00 | 1.00 | - | 16.24 |
| Track type crane (b) | 67.00 | 1 940 | -45.76 | 5.00 | - | 16.24 | 100.00 | 1.00 | - | 16.24 |
| Truck crane | 70.00 | 1 940 | -45.76 | 5.00 | - | 19.24 | 100.00 | 1.00 | - | 19.24 |
| | | | | | | | | | **SUBTOTAL** | **22.26** |

**5. Special Equipment**

| Unit Type | *Noise Emission* Leq 10m dB | Receptor distance (m) | *Adjustments* Distance Correction | Screening dB | Reflection dB | Res. Laeq dB | *Numbers Adjustments* Duration (% of total hours) | No. of plant | dB Correction | **ACTIVITY LAeq dB** |
|---|---|---|---|---|---|---|---|---|---|---|
| Piling machine | 82.00 | 1 940 | -45.76 | 5.00 | - | 31.24 | 100.00 | 1.00 | - | 31.24 |
| Construction elevator | 66.00 | 1 940 | -45.76 | 5.00 | - | 15.24 | 100.00 | 1.00 | - | 15.24 |
| Diesel generator | 74.00 | 1 940 | -45.76 | 5.00 | - | 23.24 | 100.00 | 1.00 | - | 23.24 |
| Water purification equipment | - | 1 940 | -45.76 | 5.00 | - | N/A | 100.00 | 1.00 | - | N/A |
| | | | | | | | | | **SUBTOTAL** | **31.98** |

**6. Other Equipment**

| Unit Type | *Noise Emission* Leq 10m dB | Receptor distance (m) | *Adjustments* Distance Correction | Screening dB | Reflection dB | Res. Laeq dB | *Numbers Adjustments* Duration (% of total hours) | No. of plant | dB Correction | **ACTIVITY LAeq dB** |
|---|---|---|---|---|---|---|---|---|---|---|
| Steel processing equipment | - | 1 940 | -45.76 | 5.00 | - | N/A | 100.00 | 1.00 | - | N/A |
| Woodwork equipment | - | 1 940 | -45.76 | 5.00 | - | N/A | 100.00 | 1.00 | - | N/A |
| Electric slag pressure welding machine | 73.00 | 1 940 | -45.76 | 5.00 | - | 22.24 | 100.00 | 1.00 | - | 22.24 |
| Flash butt-welding machine | 73.00 | 1 940 | -45.76 | 5.00 | - | 22.24 | 100.00 | 1.00 | - | 22.24 |
| Electric welder | 73.00 | 1 940 | -45.76 | 5.00 | - | 22.24 | 100.00 | 1.00 | - | 22.24 |
| Electric winch (a) | - | 1 940 | -45.76 | 5.00 | - | N/A | 100.00 | 1.00 | - | N/A |
| Electric winch (b) | - | 1 940 | -45.76 | 5.00 | - | N/A | 100.00 | 1.00 | - | N/A |
| Impact hammer | 82.00 | 1 940 | -45.76 | 5.00 | - | 31.24 | 100.00 | 1.00 | - | 31.24 |
| Hand drill | 75.50 | 1 940 | -45.76 | 5.00 | - | 24.74 | 100.00 | 1.00 | - | 24.74 |
| Sand-wheel grinder | 75.00 | 1 940 | -45.76 | 5.00 | - | 24.24 | 100.00 | 1.00 | - | 24.24 |
| Angle abrader | 75.00 | 1 940 | -45.76 | 5.00 | - | 24.24 | 100.00 | 1.00 | - | 24.24 |
| Bench grinder | 80.00 | 1 940 | -45.76 | 5.00 | - | 29.24 | 100.00 | 1.00 | - | 29.24 |
| Electrohydraulic pipe bender | - | 1 940 | -45.76 | 5.00 | - | N/A | 100.00 | 1.00 | - | N/A |
| Pneumatic drill(including hammer) | 82.00 | 1 940 | -45.76 | 5.00 | - | 31.24 | 100.00 | 1.00 | - | 31.24 |
| Submerged pump | 62.00 | 1 940 | -45.76 | 5.00 | - | 11.24 | 100.00 | 1.00 | - | 11.24 |
| Sewage pump | 68.00 | 1 940 | -45.76 | 5.00 | - | 17.24 | 100.00 | 1.00 | - | 17.24 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vertical tamping machine | 82.00 | 1 940 | -45.76 | 5.00 | - | 31.24 | 100.00 | 1.00 | - | 31.24 |
| Frog hammer | 82.00 | 1 940 | -45.76 | 5.00 | - | 31.24 | 100.00 | 1.00 | - | 31.24 |
| | | | | | | | | | **SUBTOTAL** | **38.79** |

# Appendix B: Assumed Facilities Noise Equipment Log

## Table A1: Project Facilities Equipment Noise Log

| Equipment Tag | Equipment Description | LP (dB(A)) @ 1 m | Data Reference | |
|---|---|---|---|---|
| | | | m N | m E |
| **Continuous Pumps** | | | | |
| N_P_CW_1 | Circulating water pump | 85.0 | 712 295 | 9 767 609 |
| N_P_CW_2 | Circulating water pump | 85.0 | 712 294 | 9 767 604 |
| N_P_CW_3 | Circulating water pump | 85.0 | 712 292 | 9 767 598 |
| N_P_CW_4 | Circulating water pump | 85.0 | 712 292 | 9 767 592 |
| N_P_CW_5 | Circulating water pump | 85.0 | 712 292 | 9 767 586 |
| N_P_CW_6 | Circulating water pump | 85.0 | 712 292 | 9 767 580 |
| N_P_EM_1 | Electric motor driven main pump | 85.0 | 711 924 | 9 767 649 |
| N_P_CP_1a | Condensate pump | 85.0 | 711 984 | 9 767 650 |
| N_P_CP_2a | Condensate pump | 85.0 | 712 055 | 9 767 647 |
| N_P_CP_3a | Condensate pump | 85.0 | 712 125 | 9 767 643 |
| N_P_TFW_1 | Turbine driven feed water pump | 85.0 | 711 978 | 9 767 659 |
| N_P_TFW_2 | Turbine driven feed water pump | 85.0 | 711 978 | 9 767 648 |
| N_P_TFW_3 | Turbine driven feed water pump | 85.0 | 712 048 | 9 767 655 |
| N_P_TFW_4 | Turbine driven feed water pump | 85.0 | 712 048 | 9 767 645 |
| N_P_TFW_5 | Turbine driven feed water pump | 85.0 | 712 118 | 9 767 652 |
| N_P_TFW_6 | Turbine driven feed water pump | 85.0 | 712 118 | 9 767 641 |
| N_P_TFW_1 | Turbine driven feed water booster pump | 85.0 | 711 990 | 9 767 662 |
| N_P_TFW_2 | Turbine driven feed water booster pump | 85.0 | 711 989 | 9 767 656 |
| N_P_TFW_3 | Turbine driven feed water booster pump | 85.0 | 712 060 | 9 767 659 |
| N_P_TFW_4 | Turbine driven feed water booster pump | 85.0 | 712 060 | 9 767 652 |
| N_P_TFW_5 | Turbine driven feed water booster pump | 85.0 | 712 130 | 9 767 655 |
| N_P_TFW_6 | Turbine driven feed water booster pump | 85.0 | 712 129 | 9 767 650 |
| N_P_CCCW_1 | Closed cycle cooling water pump | 85.0 | 711 994 | 9 767 662 |
| N_P_CCCW_2 | Closed cycle cooling water pump | 85.0 | 711 994 | 9 767 656 |
| N_P_CCCW_3 | Closed cycle cooling water pump | 85.0 | 712 064 | 9 767 658 |

| Equipment Tag | Equipment Description | LP (dB(A)) @ 1 m | Data Reference | |
|---|---|---|---|---|
| | | | m N | m E |
| N_P_CCCW_4 | Closed cycle cooling water pump | 85.0 | 712 064 | 9 767 652 |
| N_P_CCCW_5 | Closed cycle cooling water pump | 85.0 | 712 134 | 9 767 655 |
| N_P_CCCW_6 | Closed cycle cooling water pump | 85.0 | 712 133 | 9 767 649 |
| N_P_VP_1 | Vacuum Pump | 85.0 | 711 989 | 9 767 650 |
| N_P_VP_2 | Vacuum Pump | 85.0 | 711 993 | 9 767 650 |
| N_P_VP_3 | Vacuum Pump | 85.0 | 712 059 | 9 767 646 |
| N_P_VP_4 | Vacuum Pump | 85.0 | 712 064 | 9 767 646 |
| N_P_VP_5 | Vacuum Pump | 85.0 | 712 129 | 9 767 643 |
| N_P_VP_6 | Vacuum Pump | 85.0 | 712 133 | 9 767 643 |
| N_P_LOP_1 | Lube Oil Transport Pump | 85.0 | 711 984 | 9 767 645 |
| N_P_LOP_2 | Lube Oil Transport Pump | 85.0 | 712 055 | 9 767 642 |
| N_P_LOP_3 | Lube Oil Transport Pump | 85.0 | 712 125 | 9 767 639 |
| N_P_LDOS_1 | LDO Supply Pump | 85.0 | 712 217 | 9 767 782 |
| N_P_LDOS_2 | LDO Supply Pump | 85.0 | 712 220 | 9 767 782 |
| N_P_LDOS_3 | LDO Supply Pump | 85.0 | 712 223 | 9 767 781 |
| N_P_LDOS_4 | LDO Supply Pump | 85.0 | 712 226 | 9 767 781 |
| N_P_LDOU_1 | LDO Unloading Pump | 85.0 | 712 218 | 9 767 779 |
| N_P_LDOU_2 | LDO Unloading Pump | 85.0 | 712 224 | 9 767 779 |
| N_P_WWP_1 | Waste Water Pump | 85.0 | 712 214 | 9 767 918 |
| N_P_WWP_2 | Waste Water Pump | 85.0 | 712 218 | 9 767 918 |
| N_P_WWP_3 | Waste Water Pump | 85.0 | 712 223 | 9 767 918 |
| N_P_WWP_4 | Waste Water Pump | 85.0 | 712 227 | 9 767 917 |
| N_P_WWP_5 | Waste Water Pump | 85.0 | 712 231 | 9 767 917 |
| N_P_WWP_6 | Waste Water Pump | 85.0 | 712 235 | 9 767 917 |
| N_P_UFP_1 | UF Produced Water Pump | 85.0 | 712 196 | 9 767 671 |
| N_P_UFP_2 | UF Produced Water Pump | 85.0 | 712 196 | 9 767 664 |
| N_P_UFP_3 | UF Produced Water Pump | 85.0 | 712 195 | 9 767 657 |
| N_P_HPF_1 | HP Feed water pump of SWRO | 85.0 | 712 195 | 9 767 649 |
| N_P_HPF_2 | HP Feed water pump of SWRO | 85.0 | 712 195 | 9 767 642 |

| Equipment Tag | Equipment Description | LP (dB(A)) @ 1 m | Data Reference | |
|---|---|---|---|---|
| | | | m N | m E |
| N_P_HPF_3 | HP Feed water pump of SWRO | 85.0 | 712 189 | 9 767 671 |
| N_P_FP_1 | Feed up Pump of RO | 85.0 | 712 188 | 9 767 664 |
| N_P_FP_2 | Feed up Pump of RO | 85.0 | 712 188 | 9 767 657 |
| N_P_HPFP_1 | HP Feed pump of RO | 85.0 | 712 188 | 9 767 649 |
| N_P_HPFP_2 | HP Feed pump of RO | 85.0 | 712 187 | 9 767 642 |
| N_P_FIOX_1 | Feed up pump of Ion-exchanging system | 85.0 | 712 181 | 9 767 671 |
| N_P_FIOX_2 | Feed up pump of Ion-exchanging system | 85.0 | 712 180 | 9 767 664 |
| N_P_DWP_1 | Demineralised Water Pump | 85.0 | 712 180 | 9 767 657 |
| N_P_DWP_2 | Demineralised Water Pump | 85.0 | 712 180 | 9 767 650 |
| N_P_WPT_1 | Washing pump for traveling screen | 85.0 | 712 298 | 9 767 600 |
| N_P_WPT_2 | Washing pump for traveling screen | 85.0 | 712 297 | 9 767 595 |
| N_P_DP_1 | Drainage pump | 85.0 | 712 297 | 9 767 589 |
| N_P_DP_2 | Drainage pump | 85.0 | 712 298 | 9 767 606 |
| N_P_SWBP_1 | Seawater booster pump | 85.0 | 712 302 | 9 767 603 |
| N_P_SWBP_2 | Seawater booster pump | 85.0 | 712 301 | 9 767 597 |
| N_P_SWBP_3 | Seawater booster pump | 85.0 | 712 301 | 9 767 591 |
| N_P_CWPM_1 | Cooling water pump for CWP motors | 85.0 | 712 296 | 9 767 583 |
| N_P_CWPM_2 | Cooling water pump for CWP motors | 85.0 | 712 301 | 9 767 586 |
| N_P_MWDM_1 | Make-up water pump for D.M. Plant | 85.0 | 712 209 | 9 767 872 |
| N_P_MWDM_2 | Make-up water pump for D.M. Plant | 85.0 | 712 213 | 9 767 872 |
| N_P_MWDM_3 | Make-up water pump for D.M. Plant | 85.0 | 712 216 | 9 767 872 |
| N_P_MWDM_4 | Make-up water pump for D.M. Plant | 85.0 | 712 220 | 9 767 872 |
| N_P_PWP_1 | Potable water pump | 85.0 | 712 211 | 9 767 868 |
| N_P_PWP_2 | Potable water pump | 85.0 | 712 215 | 9 767 868 |
| N_P_RWP_1 | Reuse water pump | 85.0 | 712 245 | 9 767 995 |
| N_P_RWP_2 | Reuse water pump | 85.0 | 712 245 | 9 767 993 |
| N_P_CWWP_1 | Coal waste water pump | 85.0 | 711 753 | 9 767 909 |
| N_P_CWWP_1 | Coal waste water pump | 85.0 | 711 759 | 9 767 909 |
| N_P_BDP_1 | Blow Down Pump | 85.0 | 712 156 | 9 768 152 |

| Equipment Tag | Equipment Description | LP (dB(A)) @ 1 m | Data Reference | |
|---|---|---|---|---|
| | | | m N | m E |
| N_P_BDP_2 | Blow Down Pump | 85.0 | 712 151 | 9 768 073 |
| N_P_BDP_3 | Blow Down Pump | 85.0 | 712 146 | 9 767 942 |
| N_P_BDP_4 | Blow Down Pump | 85.0 | 712 146 | 9 767 905 |
| N_P_BDP_5 | Blow Down Pump | 85.0 | 712 140 | 9 767 808 |
| N_P_BDP_6 | Blow Down Pump | 85.0 | 711 916 | 9 767 686 |
| **Emergency Pumps** | | | | |
| E_P_FW_1 | Motor driven variable speed feed water pump | 85.0 | 711 985 | 9 767 662 |
| E_P_FW_2 | Motor driven variable speed feed water pump | 85.0 | 712 055 | 9 767 659 |
| E_P_FW_3 | Motor driven variable speed feed water pump | 85.0 | 712 125 | 9 767 656 |
| E_P_CP_1b | Condensate pump | 85.0 | 711 985 | 9 767 656 |
| E_P_CP_2b | Condensate pump | 85.0 | 712 055 | 9 767 653 |
| E_P_CP_3b | Condensate pump | 85.0 | 712 125 | 9 767 649 |
| E_P_LDOS_1 | LDO Supply Pump | 85.0 | 712 218 | 9 767 781 |
| E_P_LDOS_2 | LDO Supply Pump | 85.0 | 712 224 | 9 767 780 |
| E_P_DWP_1 | Demineralised Water Pump | 85.0 | 712 179 | 9 767 642 |
| E_P_WWP_1 | Waste Water Pump | 85.0 | 712 238 | 9 767 917 |
| E_P_WWP_2 | Waste Water Pump | 85.0 | 712 242 | 9 767 917 |
| E_P_RWP_1 | Reuse water pump | 85.0 | 712 245 | 9 767 990 |
| E_P_RWP_2 | Reuse water pump | 85.0 | 712 245 | 9 767 988 |
| E_P_EFF_1 | Electric Driven firefighting pump | 85.0 | 712 261 | 9 767 994 |
| E_P_DFF_1 | Diesel Driven firefighting pump | 85.0 | 712 261 | 9 767 988 |
| **Other Point Sources** | | | | |
| N_C_RH_1 | Ring-type hammer crusher | 85.0 | 712 140 | 9 767 822 |
| N_O_BD_1 | Bulldozer | 85.0 | 711 913 | 9 768 025 |
| N_O_BD_2 | Bulldozer | 85.0 | 711 977 | 9 768 023 |
| N_O_BD_3 | Bulldozer | 85.0 | 712 044 | 9 768 018 |
| N_O_L_1 | Loader | 85.0 | 711 937 | 9 767 903 |
| N_O_L_2 | Loader | 85.0 | 712 014 | 9 767 900 |

| Equipment Tag | Equipment Description | LP (dB(A)) @ 1 m | Data Reference | |
|---|---|---|---|---|
| | | | m N | m E |
| N_H_VF_1 | Vibrating Feeder | 85.0 | 712 134 | 9 767 677 |
| N_H_VF_2 | Vibrating Feeder | 85.0 | 712 134 | 9 767 674 |
| N_O_SD_1 | Striking Motor | 85.0 | 711 924 | 9 767 676 |
| N_O_SD_2 | Striking Motor | 85.0 | 711 934 | 9 767 675 |
| N_O_SD_3 | Striking Motor | 85.0 | 711 944 | 9 767 675 |
| N_O_SD_4 | Striking Motor | 85.0 | 711 954 | 9 767 674 |
| N_O_SD_5 | Striking Motor | 85.0 | 711 965 | 9 767 674 |
| N_O_SD_6 | Striking Motor | 85.0 | 711 975 | 9 767 673 |
| N_O_SD_7 | Striking Motor | 85.0 | 711 984 | 9 767 673 |
| N_O_SD_8 | Striking Motor | 85.0 | 711 995 | 9 767 672 |
| N_O_SD_9 | Striking Motor | 85.0 | 712 005 | 9 767 672 |
| N_O_SD_10 | Striking Motor | 85.0 | 712 015 | 9 767 671 |
| N_O_SD_11 | Striking Motor | 85.0 | 712 025 | 9 767 671 |
| N_O_SD_12 | Striking Motor | 85.0 | 712 035 | 9 767 670 |
| N_O_SD_13 | Striking Motor | 85.0 | 712 045 | 9 767 670 |
| N_O_SD_14 | Striking Motor | 85.0 | 712 055 | 9 767 669 |
| N_O_SD_15 | Striking Motor | 85.0 | 712 065 | 9 767 669 |
| N_O_SD_16 | Striking Motor | 85.0 | 712 075 | 9 767 669 |
| N_O_SD_17 | Striking Motor | 85.0 | 712 084 | 9 767 668 |
| N_O_SD_18 | Striking Motor | 85.0 | 712 094 | 9 767 668 |
| N_O_SD_19 | Striking Motor | 85.0 | 712 104 | 9 767 667 |
| N_O_SD_20 | Striking Motor | 85.0 | 712 114 | 9 767 667 |
| N_F_RB_1 | Roots Blower | 85.0 | 712 222 | 9 767 900 |
| N_F_RB_2 | Roots Blower | 85.0 | 712 227 | 9 767 900 |
| N_F_RB_3 | Roots Blower | 85.0 | 712 232 | 9 767 900 |
| N_F_RB_4 | Roots Blower | 85.0 | 712 237 | 9 767 899 |
| N_T_LVDT_1 | Low-voltage Dry-type Transformer (4.6) | 85.0 | 712 186 | 9 767 617 |
| N_T_LVDT_2 | Low-voltage Dry-type Transformer (4.6) | 85.0 | 712 192 | 9 767 617 |
| N_T_LVDT_3 | Low-voltage Dry-type Transformer (4.6) | 85.0 | 712 199 | 9 767 617 |

| Equipment Tag | Equipment Description | LP (dB(A)) @ 1 m | Data Reference | |
|---|---|---|---|---|
| | | | m N | m E |
| N_T_LVDT_4 | Low-voltage Dry-type Transformer (4.6) | 85.0 | 712 206 | 9 767 616 |
| N_T_LVDT_5 | Low-voltage Dry-type Transformer (4.4) | 85.0 | 711 988 | 9 767 786 |
| N_T_LVDT_6 | Low-voltage Dry-type Transformer (4.4) | 85.0 | 711 987 | 9 767 778 |
| N_T_LVDT_7 | Low-voltage Dry-type Transformer (4.4) | 85.0 | 711 987 | 9 767 771 |
| N_T_LVDT_8 | Low-voltage Dry-type Transformer (4.4) | 85.0 | 712 067 | 9 767 783 |
| N_T_LVDT_9 | Low-voltage Dry-type Transformer (4.4) | 85.0 | 712 066 | 9 767 775 |
| N_T_LVDT_10 | Low-voltage Dry-type Transformer (4.4) | 85.0 | 712 066 | 9 767 768 |
| N_T_LVDT_11 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 058 | 9 767 709 |
| N_T_LVDT_12 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 064 | 9 767 709 |
| N_T_LVDT_13 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 070 | 9 767 708 |
| N_T_LVDT_14 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 058 | 9 767 703 |
| N_T_LVDT_15 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 064 | 9 767 703 |
| N_T_LVDT_16 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 070 | 9 767 703 |
| N_T_LVDT_17 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 058 | 9 767 696 |
| N_T_LVDT_18 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 064 | 9 767 696 |
| N_T_LVDT_19 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 069 | 9 767 695 |
| N_T_LVDT_20 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 057 | 9 767 690 |
| N_T_LVDT_21 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 063 | 9 767 690 |
| N_T_LVDT_22 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 069 | 9 767 690 |
| N_T_LVDT_23 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 098 | 9 767 865 |
| N_T_LVDT_24 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 108 | 9 767 865 |
| N_T_LVDT_25 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 098 | 9 767 861 |
| N_T_LVDT_26 | Low-voltage Dry-type Transformer (4.5) | 85.0 | 712 108 | 9 767 861 |
| N_T_LVDT_27 | Low-voltage Dry-type Transformer (4.7) | 85.0 | 711 938 | 9 767 665 |
| N_T_LVDT_28 | Low-voltage Dry-type Transformer (4.7) | 85.0 | 711 938 | 9 767 659 |
| N_T_LVDT_29 | Low-voltage Dry-type Transformer (4.7) | 85.0 | 711 938 | 9 767 654 |
| N_T_LVDT_30 | Low-voltage Dry-type Transformer (4.8) | 85.0 | 711 942 | 9 767 662 |
| N_T_LVDT_31 | Low-voltage Dry-type Transformer (4.8) | 85.0 | 711 941 | 9 767 657 |
| N_F_FBAH_1 | Fluidising Air Blower for Ash Hopper | 85.0 | 712 000 | 9 767 863 |

| Equipment Tag | Equipment Description | LP (dB(A)) @ 1 m | Data Reference | |
|---|---|---|---|---|
| | | | m N | m E |
| N_F_FBAH_2 | Fluidising Air Blower for Ash Hopper | 85.0 | 712 000 | 9 767 861 |
| N_F_FBAH_3 | Fluidising Air Blower for Ash Hopper | 85.0 | 712 000 | 9 767 860 |
| N_F_FBAH_4 | Fluidising Air Blower for Ash Hopper | 85.0 | 712 000 | 9 767 859 |
| N_F_FBAS_1 | Fluidising Air Blower for Ash Silo | 85.0 | 711 928 | 9 767 853 |
| N_F_FBAS_2 | Fluidising Air Blower for Ash Silo | 85.0 | 711 933 | 9 767 853 |
| N_F_FBAS_3 | Fluidising Air Blower for Ash Silo | 85.0 | 711 938 | 9 767 853 |
| N_F_FBAS_4 | Fluidising Air Blower for Ash Silo | 85.0 | 711 942 | 9 767 853 |
| **Block Sources** | | | | |
| N_H_1 | Air Preheater | 85.0 | N/A | N/A |
| N_C_1 | Air Compressor | 85.0 | N/A | N/A |
| N_C_2 | Air Compressor | 85.0 | N/A | N/A |
| N_C_3 | Air Compressor | 85.0 | N/A | N/A |
| N_C_4 | Air Compressor | 85.0 | N/A | N/A |
| N_C_5 | Air Compressor | 85.0 | N/A | N/A |
| N_C_6 | Air Compressor | 85.0 | N/A | N/A |
| N_C_7 | Air Compressor | 85.0 | N/A | N/A |
| N_ST_1 | Steam Turbine | 85.0 | N/A | N/A |
| N_ST_2 | Steam Turbine | 85.0 | N/A | N/A |
| N_ST_3 | Steam Turbine | 85.0 | N/A | N/A |
| N_FT_1 | Feed water pump turbine | 85.0 | N/A | N/A |
| N_FT_2 | Feed water pump turbine | 85.0 | N/A | N/A |
| N_FT_3 | Feed water pump turbine | 85.0 | N/A | N/A |
| N_FT_4 | Feed water pump turbine | 85.0 | N/A | N/A |
| N_FT_5 | Feed water pump turbine | 85.0 | N/A | N/A |
| N_FT_6 | Feed water pump turbine | 85.0 | N/A | N/A |
| N_M_1 | Coal Mill | 85.0 | N/A | N/A |
| N_M_2 | Coal Mill | 85.0 | N/A | N/A |
| N_M_3 | Coal Mill | 85.0 | N/A | N/A |
| N_M_4 | Coal Mill | 85.0 | N/A | N/A |

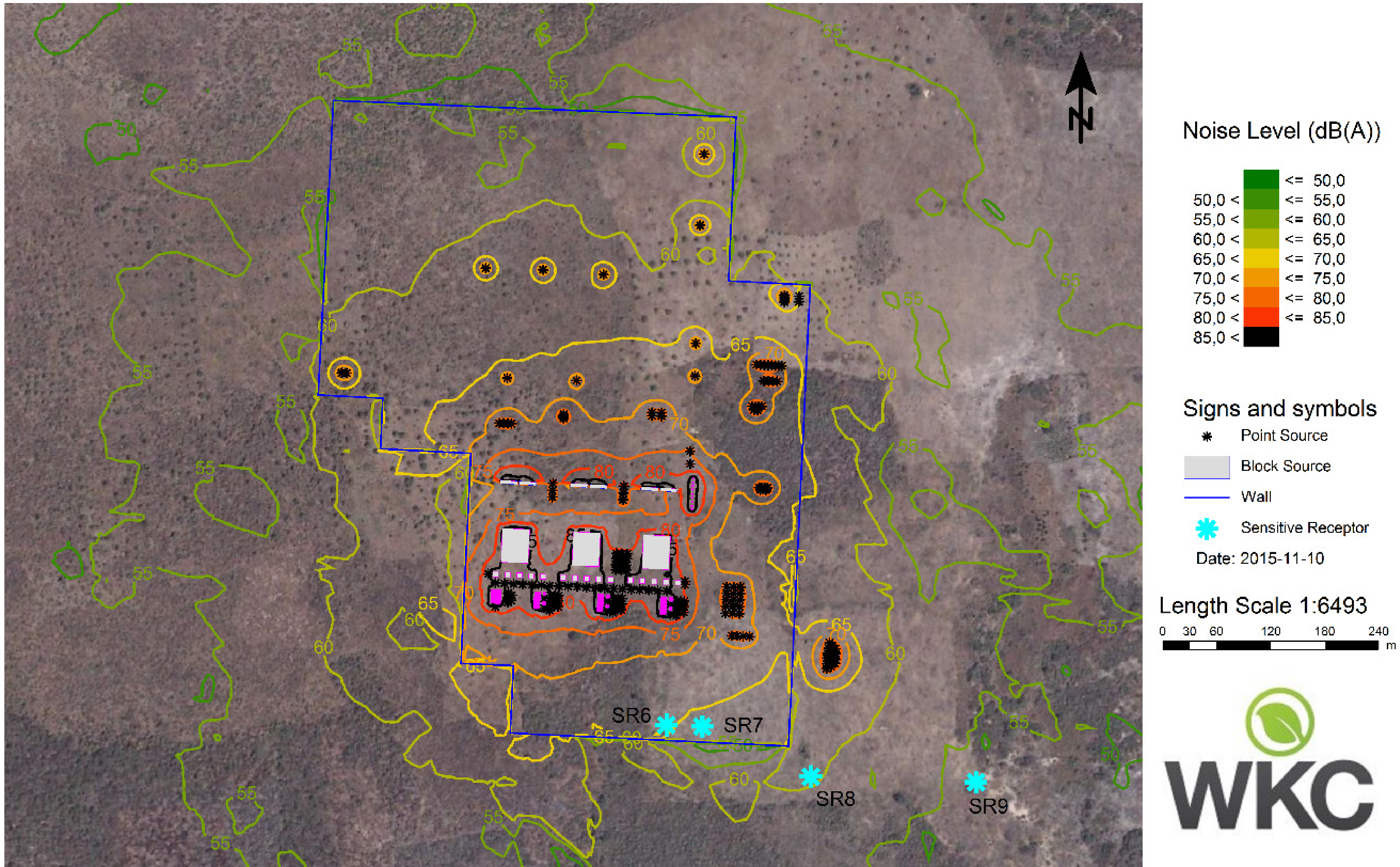
| Equipment Tag | Equipment Description | LP (dB(A)) @ 1 m | Data Reference | |
|---|---|---|---|---|
| | | | m N | m E |
| N_M_5 | Coal Mill | 85.0 | N/A | N/A |
| N_M_6 | Coal Mill | 85.0 | N/A | N/A |
| N_M_7 | Coal Mill | 85.0 | N/A | N/A |
| N_M_8 | Coal Mill | 85.0 | N/A | N/A |
| N_M_9 | Coal Mill | 85.0 | N/A | N/A |
| N_M_10 | Coal Mill | 85.0 | N/A | N/A |
| N_M_11 | Coal Mill | 85.0 | N/A | N/A |
| N_M_12 | Coal Mill | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (Boiler) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (Boiler) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (Boiler) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (P.A. Fans) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (P.A. Fans) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (P.A. Fans) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (P.A. Fans) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (P.A. Fans) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (P.A. Fans) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (F.D. Fans) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (F.D. Fans) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (F.D. Fans) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (F.D. Fans) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (F.D. Fans) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (F.D. Fans) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (Fluidising Air Blowers) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (Fluidising Air Blowers) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (Fluidising Air Blowers) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (Fluidising Air Blowers) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (Fluidising Air Blowers) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (Fluidising Air Blowers) | 85.0 | N/A | N/A |

| Equipment Tag | Equipment Description | LP (dB(A)) @ 1 m | Data Reference | |
|---|---|---|---|---|
| | | | m N | m E |
| N_BH_1 | Boiler Hall (Sealing Air Fans) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (Sealing Air Fans) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (Sealing Air Fans) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (Sealing Air Fans) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (Sealing Air Fans) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (Sealing Air Fans) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (Scan Air Cooling Fans) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (Scan Air Cooling Fans) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (Scan Air Cooling Fans) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (Scan Air Cooling Fans) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (Scan Air Cooling Fans) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (Scan Air Cooling Fans) | 85.0 | N/A | N/A |
| N_BH_1 | Boiler Hall (Slag Crusher) | 85.0 | N/A | N/A |
| N_BH_2 | Boiler Hall (Slag Crusher) | 85.0 | N/A | N/A |
| N_BH_3 | Boiler Hall (Slag Crusher) | 85.0 | N/A | N/A |
| **Area Sources** | | | | |
| N_IDF_1 | I.D fans | 85.0 | N/A | N/A |
| N_IDF_2 | I.D fans | 85.0 | N/A | N/A |
| N_IDF_3 | I.D fans | 85.0 | N/A | N/A |
| N_IDF_4 | I.D fans | 85.0 | N/A | N/A |
| N_IDF_5 | I.D fans | 85.0 | N/A | N/A |
| N_IDF_6 | I.D fans | 85.0 | N/A | N/A |

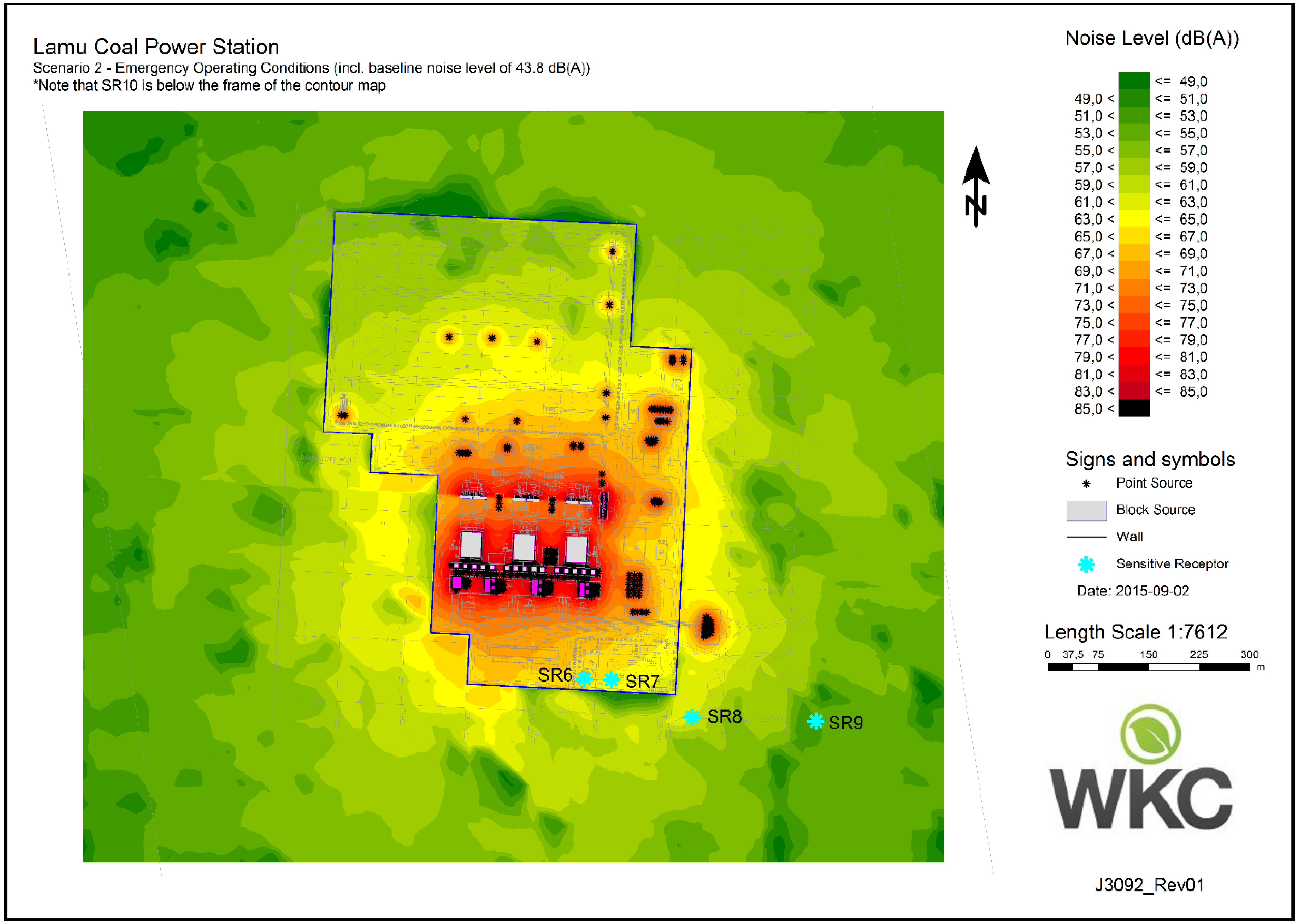
# Appendix C: Noise Contour Maps

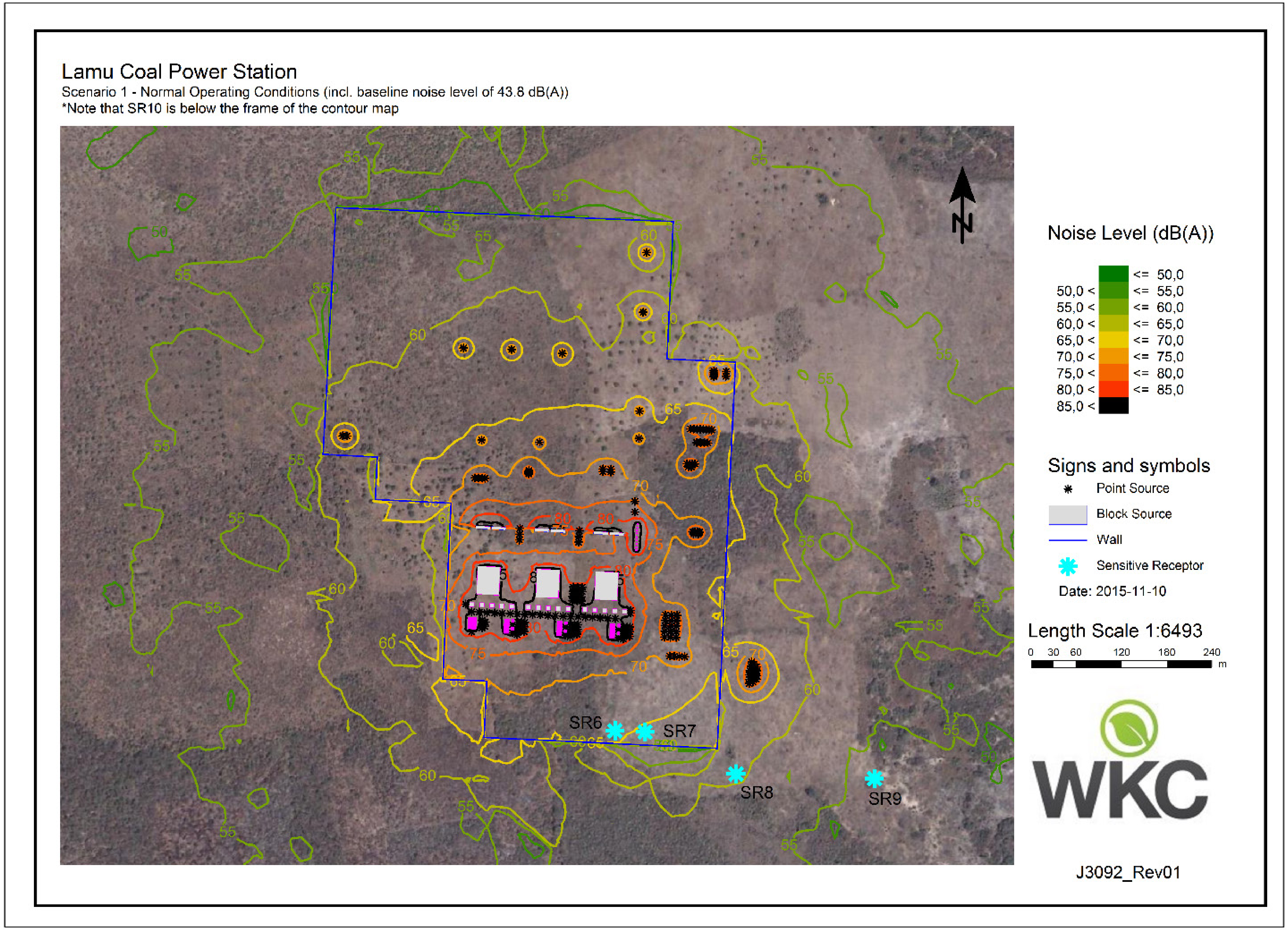
# Lamu Coal Power Station

Scenario 1 - Normal Operating Conditions (incl. baseline noise level of 43.8 dB(A))
*Note that SR10 is below the frame of the contour map




J3092_Rev01


Lamu Coal Power Station
Scenario 2 - Emergency Operating Conditions (incl. baseline noise level of 43.8 dB(A))
*Note that SR10 is below the frame of the contour map
SR6
SR7
SR8
SR9
N
Noise Level (dB(A))
<= 49,0
49,0 < <= 51,0
51,0 < <= 53,0
53,0 < <= 55,0
55,0 < <= 57,0
57,0 < <= 59,0
59,0 < <= 61,0
61,0 < <= 63,0
63,0 < <= 65,0
65,0 < <= 67,0
67,0 < <= 69,0
69,0 < <= 71,0
71,0 < <= 73,0
73,0 < <= 75,0
75,0 < <= 77,0
77,0 < <= 79,0
79,0 < <= 81,0
81,0 < <= 83,0
83,0 < <= 85,0
85,0 <
Signs and symbols
Point Source
Block Source
Wall
Sensitive Receptor
Date: 2015-09-02
Length Scale 1:7612
0 37,5 75 150 225 300 m
J3092_Rev01


Lamu Coal Power Station
Scenario 1 - Normal Operating Conditions (incl. baseline noise level of 43.8 dB(A))
*Note that SR10 is below the frame of the contour map
SR6
SR7
SR8
SR9
Noise Level (dB(A))
<= 50,0
50,0 < <= 55,0
55,0 < <= 60,0
60,0 < <= 65,0
65,0 < <= 70,0
70,0 < <= 75,0
75,0 < <= 80,0
80,0 < <= 85,0
85,0 <
Signs and symbols
Point Source
Block Source
Wall
Sensitive Receptor
Date: 2015-11-10
Length Scale 1:6493
0 30 60 120 180 240 m
WKC
J3092_Rev01