
NOISE AND VIBRATION IMPACT ASSESSMENT STUDY
FOR THE
BEN SCHOEMAN DOCK DEEPENING

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Executive Summary

The National Ports Authority of S.A. (NPA), a division of Transnet Limited, is planning the dredging of Ben Schoeman Dock in order to increase the available water depth of the port, as well as the extension of Berths 601-604, in order to accommodate the new generation container vessels.

The present study estimates the noise emissions and vibration from the proposed construction operations and assesses the noise and vibration impacts in the adjacent areas and communities (see Figure 1 below).

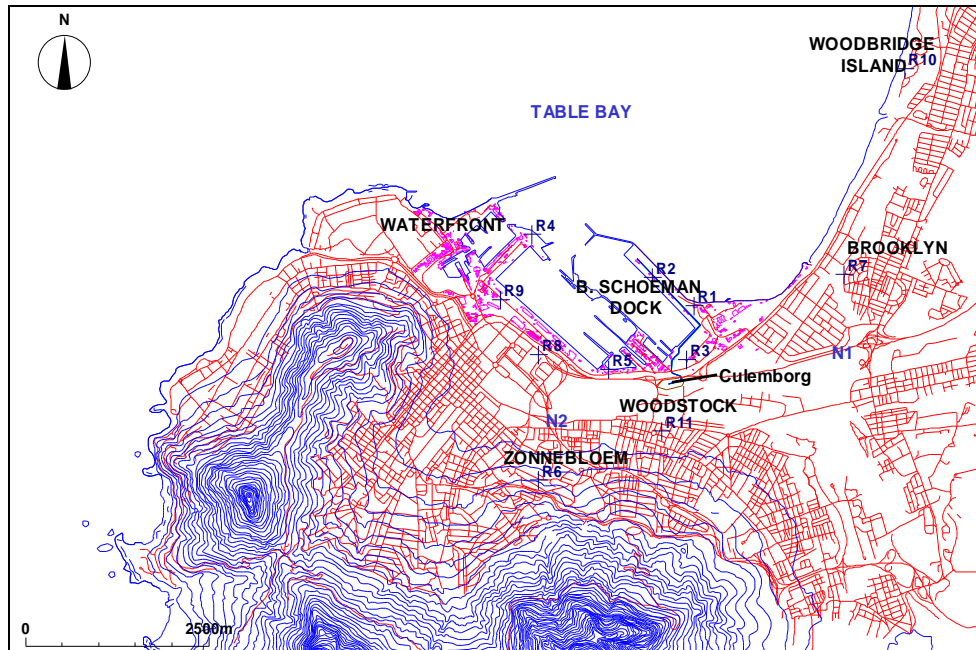


Figure 1: Location of Residential Areas and Noise Monitoring Locations R1-R6.

1. NOISE

The study approach incorporated daytime and night-time ambient noise measurements at six locations, five within the perimeter of the port and one in an adjacent residential area. The noise levels were calculated with the MITHRA noise model and the expected impacts assessed by utilising SANS 10103 “The measurement and rating of environmental noise with respect to annoyance and to speech communication”.

The establishment of the sound power levels for the various equipment to be used during the construction operations were based on two resources. Firstly, on the latest update of the equipment database included in the British Standard 5228: Part 1: 1984 “Noise Control on Construction and Open Sites Part 1: Code of Practice for Basic Information and Procedures for Noise Control” and secondly, on measurements taken by the consultants at various construction sites.

As a worst-case scenario, it was assumed that equipment utilised for the quay wall extension and berth deepening and the dredging of the container basin will operate simultaneously. In addition to the main construction operations, the noise from the materials handling at the Culemborg site was also taken into consideration.

1.1. Noise Measurements and Baseline Conditions

The following Table 1 shows the details of the selected monitoring points, as well as their coordinates.

Table 1: Noise Monitoring Points

No	Location	Zoning	Coordinates (dd°mm.mmm')	
			S	E
R1	Port administration building, east of BSD	Industrial	S33°54.781	E18°27.320
R2	Ben Schoeman Dock (BSD), main quay	Industrial	S33°54.571	E18°26.922
R3	Eastern side of BSD, on weighing bridge tower	Industrial	S33°55.161	E18°27.213
R4	Western side of BSD, in the NPA building area	Industrial	S33°54.271	E18°25.849
R5	South of BSD, next to yacht club	Industrial	S33°55.230	E18°26.521
R6	Zonneloem area, along Constitution Road	Residential	S33°56.004	E18°25.908

Table 2 shows the averaged values of the noise measurements at the different locations for representative daytime and night-time periods. The detailed measurement parameters can be found in Appendix A.

It can be seen that the daytime and night-time noise levels within the BSD quay area were in excess of the SANS guidelines of 70 dBA and 60 dBA respectively. Noise levels in locations outside the BSD quay area, such as R4 and R5, fell within the guidelines.

The existing noise levels in the Zonneloem area were also higher than the guidelines, primarily due to traffic in the local road network, on the N1 and N2 highways, as well as the existing port operations.

The existing noise environment in the general port area is dominated by:

- The loading and offloading operations at the Duncan and Ben Schoeman Docks.
- Traffic along Duncan Road and Marine Drive.
- Traffic along the N1 and N2 highways.
- Commercial activities in the Central Business District (CBD).

Table 2: Measured Noise Levels

Monitoring Point	Daytime	Night-time	District	SANS Guideline	
	dBA	DBA		Daytime	Night-time
R1	71	67	Industrial	70	60
R2	77	75	Industrial	70	60
R3	77	71	Industrial	70	60
R4	60	52	Industrial	70	60
R5	68	55	Industrial	70	60
R6	59	57	Residential	55	45

1.2. Noise Modelling Results

The noise contours around the proposed construction sites were calculated for the daytime and night-time conditions. From these contour maps it was evident that for the daytime conditions, the 70 dBA noise contour, which represents the industrial district guideline, was found to be contained within the site's boundaries for the BSD deepening and the Culemborg site. The 45 dBA zone extended approximately 900 m from the main construction area and to the south reached the northern section of Woodstock. Areas such as Brooklyn, Zonnebloem and the Waterfront were found outside of the 40 dBA zone. This means that based on the measured and adopted guideline noise levels in these areas, the difference between the construction generated noise and the existing ambient noise is greater than 9 dBA. Therefore, the noise contribution from the construction activities will be well below 1 dBA.

For the night-time, it was evident that these conditions favoured sound propagation from the source to the receptor and produced noise zones that extended further away from the construction area. The 60 dBA contour, which represents the night-time guideline for industrial districts, was found to be contained within the port's area and the 45 dBA zone reached half way towards Brooklyn. The Culemborg site under night-time conditions generated a 60 dBA zone that reached beyond its boundaries. It was, however, contained within the surrounding industrial area. The 50 dBA contour just reached the Woodstock area.

Several discrete receptors were positioned at the locations of the noise monitoring points R1 to R6, and the noise contribution of the proposed construction activities were calculated. In addition, several receptors were placed in the different residential areas around the site. Table 3 shows the noise levels at these receptors. As can be seen, the noise levels were well below the district's guideline for the day, as well as the night-time periods (i.e. lower than the guideline by approximately 6 dBA or more). The only exceptions were at the BSD quay (R1, R2 and R3) and in the Woodstock area (R11), where the noise level exceeded the night-time guideline (R1) or was marginally lower (R2, R3 and R11).

From the noise measurements it was found that the existing levels at the BSD quay range between 70 dBA and 77 dBA and are currently well above the SANS guideline for industrial areas. This means that the expected noise increase in these locations attributed to the construction operations would be approximately 1 dBA.

In the Woodstock area the likely night-time noise contribution of the construction activities was found to be approximately 1 dBA or less, since the area's existing noise level is higher than the district's guideline.

Table 3: Calculated Noise Levels at Discrete Receptors.

Receptor	Location	SANS District	Modelled	District	Modelled	District
			Day DBA	Guideline dBA	Night dBA	Guideline DBA
R1	Port Admin building	Industrial	64.4	70	64.8	60
R2	BSD quay	Industrial	56.1	70	59.1	60
R3	Weighing bridge	Industrial	55.8	70	57.3	60
R4	NPA building area	Industrial	34.3	70	38.2	60
R5	Yacht club	Industrial	43.2	70	47.2	60
R6	Zonnebloem	Urban	36.4	55	39.3	45
R7	Brooklyn	Urban	34.4	55	38.8	45
R8	Central	CBD	36.7	65	41.1	55
R9	Waterfront	Urban with business	34.0	60	38.7	50
R10	Woodbridge Isl.	Urban	23.6	55	26.7	45
R11	Woodstock	Urban with business	46.7	60	49.2	50

1.3. Impact Assessment and Recommendations

Based on the estimations of the noise during the construction phase, the following main conclusions can be drawn:

- During construction the noise impact will be area-specific and will last for approximately three years.
- The 70 dBA daytime guideline for industrial districts will not be exceeded outside the site's boundaries. The same applies to the 60 dBA night-time guideline.
- The constructions at the BSD will have a negligible effect on the existing noise levels in the nearby residential areas, i.e. well below 1 dBA.
- The community in the closest residential area of Woodstock is expected to have no observed reaction since the noise increase will not be noticeable. The same applies to Zonnebloem and Woodbridge Island.

It should be noted that there are no additional mitigation measures necessary to be implemented other than to adhere to good practice guidelines outlined in the recommendations section.

The construction noise impact rating can be summarised as follows:

Table 1.4: Noise Impact Assessment Table.

<i>Extent</i>	<i>Intensity</i>	<i>Duration</i>	<i>Consequence</i>	<i>Probability</i>	<i>Significance</i>	<i>Status</i>	<i>Confidence</i>
Local	Low	Short-term	Very Low	Definite	Very Low	- ve	High

It is recommended that noise monitoring should be performed biannually along the site's boundaries in order to ensure conformity with the regulations and indicate relevant corrective measures to be implemented.

2. VIBRATION

In order to provide the required increase in depth throughout the full extent of the basin, a volume of approximately 280,000 m³ of hard rock must be removed from the eastern end of the basin where it rises toward the land side. The initial specialist report on the removal of this rock bench recommended that its removal be carried out by drilling and controlled underwater blasting. Other mechanical methods, not involving the use of blasting, were eliminated as being inappropriate to the volume, integrity, and hardness of the rock to be removed and the logistics of alternative operations.

In addition, the rock surface to be blasted is at least 8m below the water surface. There will therefore be no air blast, as there is no surface blasting required, which is normally the other limiting factor associated with blasting, along with ground-transmitted vibration.

The remaining issues are the transfer of shock energy from the water into the air and into the dock structure from where it is radiated, significantly attenuated, as sound, and where it will cause vibration of the dock structure and buildings thereon.

The rock removal specialist report (Szendrei et al., 2006) presents sets of calculations and other tables of data predicting ground vibration levels at positions remote from the blast site which have been checked and verified and subsequently used as the basis for this environmental assessment. These assumptions and the values of empirical constants used in these calculations must be verified by test blasts on site before major work begins in order to give confidence to the predictions and enable the appropriate blasting parameters to be chosen to avoid exceedance of acceptable levels of vibration.

The recommended drilling and blasting regime of the rock removal specialist report allows adjustment of a number of the relevant parameters, including the drill-hole layout, firing timing, and charge size to ensure that pre-defined acceptable levels of vibration at sensitive structures are not exceeded.

This process in itself is tantamount to de facto mitigation of the blast-generated vibration, as the proposed initial test blasts to determine the geotechnical parameters will enable a safe blasting regime to be designed right from the beginning, and also because the regime will be continuously adjusted in the light of knowledge gained progressively during the blasting operation.

It is recommended that identified sensitive structures, including the closest section of the dock itself to the likely blast sites, should be instrumented with triaxial vibration monitoring instrumentation capable of time signal capture as well as the peak particle velocity values used for comparison with established limit values. This will enable post-event analysis of the signal to obtain the frequency content and other parameters which may be necessary for structural dynamic analysis of sensitive structures as well as providing feedback to the blasting manager for further optimising the blasting regime.

Seals and birds are to be lured out of the Ben Schoeman dock to sea during blasting periods. This means that all animals should be at least 1500 m away from the blasting area. It is therefore highly unlikely that seals or birds will be affected.

Under these conditions of continuous monitoring and blast optimisation using these measured results, it is considered that accepted limit values can be met at sensitive receptors and buildings.

It should be noted that mitigation measures other than the blasting procedures that will normally be followed were not found to be necessary.

Table 1.5: Vibration Impact Assessment Table.

<i>Extent</i>	<i>Intensity</i>	<i>Duration</i>	<i>Consequence</i>	<i>Probability</i>	<i>Significance</i>	<i>Status</i>	<i>Confidence</i>
Local	Low	Short-term	Very Low	Definite	Very Low	- ve	High

Contents

Executive Summary.....	ii
1 INTRODUCTION	1
1.1 Scope of the Noise and Vibration Study.....	1
2 INVESTIGATIVE METHODOLOGY	2
2.1 NOISE	2
2.1.1 Noise Measurements.....	2
2.1.2 Noise Sources during the Construction Operations	3
2.1.3 Noise Calculations for the Construction Operations	7
2.1.4 Noise Impact Assessment Methodology	7
2.2 VIBRATION	10
2.2.1 Effects of Vibration on Humans	10
2.2.2 Effect of Vibration on Structures.....	10
3 THE AFFECTED BASELINE ENVIRONMENT.....	12
3.1 NOISE MEASUREMENTS AND BASELINE LEVELS	12
3.2 BASELINE ENVIRONMENT WITH REGARD TO VIBRATION.....	15
4 PREDICTED NOISE LEVELS DURING CONSTRUCTION	15
4.1 NOISE MODELLING RESULTS	16
5 IMPACT ASSESSMENT AND RECOMMENDATIONS	19
5.1 NOISE IMPACT ASSESSMENT DURING CONSTRUCTION.....	19
5.1.1 Recommendations for Noise Minimisation During Construction	20
5.1.2 Monitoring	20
5.2 VIBRATION IMPACT ASSESSMENT DURING CONSTRUCTION	20
5.2.1 Effects of Vibration on Humans	21
5.2.2 Effect of Vibration on Structures.....	21
5.2.3 Effects on Marine Ecology	21
5.2.4 Recommendations for Vibration Minimisation During Construction	21
5.2.5 Monitoring	22
REFERENCES	23

FIGURES

FIGURE 1: LOCATION OF RESIDENTIAL AREAS AND NOISE MONITORING LOCATIONS R1-R6.....	II
FIGURE 1.1: PROPOSED BASIN DEEPENING AND BERTHS 601-604.....	1
FIGURE 3.1: LOCATION OF RESIDENTIAL AREAS AND NOISE MONITORING LOCATIONS R1-R6.....	13

FIGURE 4.1: THREE-DIMENSIONAL REPRESENTATION OF THE STUDY AREA	16
FIGURE 4.2: DAYTIME NOISE CONTOURS DURING CONSTRUCTION	17
FIGURE 4.3: NIGHT-TIME NOISE CONTOURS DURING CONSTRUCTION	18
FIGURE B.1: NOISE MONITORING LOCATIONS AND MODELLING DISCRETE RECEPTORS	33

TABLES

TABLE 1: NOISE MONITORING POINTS	III
TABLE 2: MEASURED NOISE LEVELS	IV
TABLE 3: CALCULATED NOISE LEVELS AT DISCRETE RECEPTORS	V
TABLE 1.4: NOISE IMPACT ASSESSMENT TABLE	VI
TABLE 1.5: VIBRATION IMPACT ASSESSMENT TABLE	VII
TABLE 2.1: NOISE MONITORING POINTS' COORDINATES	3
TABLE 2.2: SOUND LEVEL MEASUREMENT INSTRUMENTATION	3
TABLE 2.3: CONSTRUCTION EQUIPMENT SOUND POWER EMISSION LEVELS	5
TABLE 2.4: INTERNAL TRAFFIC FLOWS	6
TABLE 2.5: ADDING AND SUBTRACTING NOISE LEVELS	8
TABLE 2.5: TYPICAL RATING LEVELS FOR AMBIENT NOISE	9
TABLE 2.6: CATEGORIES OF COMMUNITY/GROUP RESPONSE	9
TABLE 2.7: NOISE IMPACT MAGNITUDE ASSESSMENT CRITERIA	10
TABLE 2.8: RECOMMENDED MAXIMUM THRESHOLD VALUES OF PEAK PARTICLE VELOCITY FOR DIFFERENT TYPES OF STRUCTURE	11
TABLE 3.1: MEASURED NOISE LEVELS	12
TABLE 3.2: RESIDENTIAL AREAS DISTANCES FROM THE BSD CONSTRUCTION OPERATIONS	13
TABLE 4.1: CALCULATED NOISE LEVELS AT DISCRETE RECEPTORS	19
TABLE 5.1: NOISE IMPACT ASSESSMENT TABLE	20
TABLE 5.2: VIBRATION IMPACT ASSESSMENT TABLE	21

APPENDICES

APPENDIX A NOISE MONITORING RESULTS	25
APPENDIX B MAPS	32

Glossary of Acoustic Terms

A-weighted sound level:	A measure of sound pressure level designed to reflect the acuity of the human ear, which does not respond equally to all frequencies.
Decibel (dB)	A measure of sound. It is equal to 10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference sound pressure. The reference sound pressure used is 20 micropascals, which is the lowest audible sound.
dB(A):	Unit of sound level. The weighted sound pressure level by the use of the A

	metering characteristic and weighting specified in ANSI Specifications for Sound Level Meter.
Equivalent A-weighted sound level (L_{Aeq}):	Is the value of A-weighted sound pressure level in decibels of continuous steady sound that within a specified interval has the same sound pressure as a sound that varies with time. This is an average sound level that would produce the same energy equivalence as the fluctuating sound level actually occurring.
Impulse Time Weighting Integrating Averaging Sound Level Meter	A standard time weighting applied by the Sound Level Meter.
L_{A10}	A Sound Level Meter which accumulates the total sound energy over a measurement period and calculates an average. The noise level exceeded 10% of the measurement period with 'A' frequency weighting calculated by statistical analysis. It represents the higher noise levels during the measurement interval. It is generally utilized for traffic noise impacts.
L_{A50}	The noise level exceeded 50% of the measurement period with 'A' frequency weighting calculated by statistical analysis.
L_{A90}	The noise level exceeded 90% of the measurement period with 'A' frequency weighting calculated by statistical analysis. It gives an indication of the underlying noise level, or the level that is almost always there in between intermittent noisy events. It is generally utilized for the determination of background noise, i.e. the noise levels without the influence of the main sources.

1 INTRODUCTION

The development of the Port of Cape Town by the National Ports Authority of S.A. (NPA), a division of Transnet Limited, requires that Ben Schoeman Dock be dredged to increase available water depth of the port. In addition, Berths 601-604 need to be altered, in order to accommodate the new generation container vessels.

SRK Consulting (SRK) has been appointed by Transnet to conduct the Environmental Impact Assessment (EIA) phase of the EIA of the proposed deepening of the Ben Schoeman Dock (BSD) and alteration of Berths 601-604. Demos Dracoulides and Associates (DDA) were appointed by SRK to undertake the noise and vibration impact assessment study for the project's EIA.

The extent of the basin deepening and the berth alterations can be seen in Figure 1.1.



Figure 1.1: Proposed Basin Deepening and Berths 601-604

1.1 Scope of the Noise and Vibration Study

The purpose of the study was the following:

- Identify the most significant sources of noise vibration and shock during the construction and operation of the proposed project (including frequency and nature of these noises);
- Identify the main receptors for noise impacts (e.g. surrounding communities and businesses);
- Analyse noise impacts on the ambient (current) noise environment;

- Assess the impacts of vibration and shock on existing port infrastructure;
- Assess the cumulative impacts of noise associated with simultaneous construction activities from the BSD and berth alterations;
- Where required, provide general recommendations for the mitigation of the noise and vibration impacts.

2 INVESTIGATIVE METHODOLOGY

The study approach incorporated daytime and night-time ambient noise measurements at six locations, five within the perimeter of the port and one in an adjacent residential area. The noise and vibration levels were calculated and the expected impacts assessed by utilising the methodologies outlined below.

2.1 NOISE

2.1.1 Noise Measurements

In order to establish the existing baseline noise levels at the Port of Cape Town, noise measurements were performed over several days in September and October 2006. It should be noted that the above-mentioned period is not the busiest time of year at the port, such that the ambient noise levels could be higher than the ones measured.

Five noise monitoring points were situated within the port's perimeter. One additional measurement point was positioned in the Zonnebloem residential area, since it has a direct line of sight with the BSD, where the construction activities will take place.

The locations of the monitoring points can be seen in Figure B.1 of Appendix B. These locations were chosen for the following reasons:

- Representative of the areas' current noise levels.
- Area's line of sight with the proposed construction activities.
- Easy accessibility under the current conditions.
- Likelihood of continuing to exist after the development of the site and therefore be used for future comparison purposes.

Table 2.1 below shows the Global Positioning System (GPS) coordinates for the monitoring points utilised in the study.

Table 2.1: Noise Monitoring Points' Coordinates

No	Location	Zoning	Coordinates (dd°mm.mmm')	
			S	E
R1	Port administration building, east of BSD	Industrial	S33°54.781	E18°27.320
R2	Ben Schoeman Dock (BSD), main quay	Industrial	S33°54.571	E18°26.922
R3	Eastern side of BSD, on weighing bridge tower	Industrial	S33°55.161	E18°27.213
R4	Western side of BSD, in the NPA building area	Industrial	S33°54.271	E18°25.849
R5	South of BSD, next to yacht club	Industrial	S33°55.230	E18°26.521
R6	Zonnebloem area, along Constitution Road	Residential	S33°56.004	E18°25.908

The measurements were performed in accordance with procedures stipulated in the South African National Standard (SANS) Code of Practice: SANS 10103:2004, as well as the requirements of the Department of Environmental Affairs and Tourism (DEAT) Noise Control Regulations in Terms of Section 25 of the Environmental Conservation Act 73 of 1989.

The sound level meter instrumentation utilised complied with the accuracy requirements for a Type 1 instrumentation and calibrator specified in International Electrotechnical Committee (IEC) Publication 651, IEC 804 and IEC 942 (see Table 2.2). In accordance with the SANS 10103 Code, a calibration was performed before and after the series of sound measurements. All equipment is accompanied with valid calibration certificates from the De Beers testing laboratories.

Table 2.2: Sound Level Measurement Instrumentation

Instrument	Type	Serial No
1. Precision Integrating Sound Level Meter	01dB SIP 95	10741
1a. Microphone	01dB MK 250	3857
1b. 1/3 rd Octave Band Filter	01dB Real Time Digital Filter	10741
2. Field Calibrator	01bB CAL 01 S	990640

For the identification of the coordinates of each monitoring point, the GARMIN iQue 3600 was utilised (Serial Number: 90266767). For the localised weather parameters the following instrumentation was used:

- SPEEDTECH instruments SKYMATE SM-18 wind speed and temperature meter, Serial Number 8525.

2.1.2 Noise Sources during the Construction Operations

The establishment of the sound power levels for the various equipment to be used during the construction operations were based on two resources. Firstly, on the latest update of the equipment database included in the British Standard 5228: Part 1: 1984 "Noise Control on Construction and Open Sites Part 1: Code of Practice for Basic Information and Procedures for Noise Control" and secondly, on measurements taken by the consultants at various construction sites.

The selected typical mix of equipment such as dredgers, tug boats, excavators, bulldozers, front-end loaders, cement mixers, compressors, pneumatic drills and trucks were based on the construction operations described in the following sections.

Quay Wall Extension

Alteration of the berths will be carried out by construction of a 10m reinforced concrete deck extension of the existing quay wall, which will be supported on piled foundations installed approximately 7 m from the existing cope line.

Prior to the pile installation a scour protection trench adjacent to the quay wall is to be dredged. This will require drilling and blasting of rock at the eastern end of the basin where it rises toward the land side. Dredging of the coarse and fractured blast material will be accomplished using dredging equipment, although some soft material could be dredged using a land based grab. Spoiled material will be deposited at an offshore disposal site utilising barges.

Dredging of Ben Schoeman Dock

Deepening of the berths, together with the scour protection trench, requires the dredging of approximately 1.23 million m³ of material.

It is anticipated that dredging of the trench adjacent to the quay wall will be phased but that dredging of the basin area will be more or less continuous. The contractor will aim to and plan his dredging activities to make sure they are continuous for each equipment item with no standing time. Therefore, with one piece of dredging equipment for the full duration or 2 pieces of dredging equipment mobilised to undertake certain sections of work, each operating on a continuous basis for their particular section. As a worst-case scenario, it was assumed that the dredger and a land based excavator would be simultaneously utilised during the construction period.

The equipment assumed to be utilised during the basin deepening and quay extension for the purposes of this study is:

- Dredging equipment
- Barge
- Tug Boat
- Long Reach Tracked Excavator
- Crane
- Welding equipment
- Pile Driver
- Pneumatic Drill

- Concrete truck offloading
- Concrete Pump
- Truck offloading
- Front-end Loader

Culemborg Site

In addition to the main construction operations, the materials to be utilised for the berth construction and deepening will be delivered and stored at the Culemborg site. The site's area is approximately 1.8 ha in size and is situated east of Lower Church Road, between Woodstock and the port.

The potential uses for the Culemborg site are:

- Storage of construction materials.
- Concrete batching plant.
- Utilisation for activities such as pre-casting of concrete, rebar cages, welding of steel piles, etc.

The equipment assumed to be operating at the Culemborg site was:

- Concrete Mixing Truck
- Concrete Batching Plant
- Truck offloading
- Front-end loader
- Welding

The following table shows the noise sources associated with the construction equipment and their sound power levels utilised in the noise modelling. It was assumed, as a worst-case scenario, that all the equipment would be operated simultaneously. The sound power levels of the construction equipment for standard frequencies is shown in the following Table 2.3.

Table 2.3: Construction Equipment Sound Power Emission Levels.

Equipment	Octave Band (Hz)					
	125	250	500	1000	2000	4000
	Sound Power Level (dB), re 1 pW					
Dredger	113.6	106.0	105.0	100.1	101.1	93.3
Barge	76.1	107.1	106.2	107.4	105.9	103.1
Tug Boat	76.1	107.1	106.2	107.4	105.9	103.1
Long Reach Tracked Excavator	109.2	105.6	108.7	106.9	104.1	96.4
Crane	109.2	104	108.4	106	104.3	102.7
Welding equipment	86.3	80.2	78.8	79.2	76	70.5
Pile Driver	111.5	107	120	114.3	118.8	113.1
Pneumatic Drill	92.4	96.3	100.7	102.8	101.1	96.5

Equipment	Octave Band (Hz)					
	125	250	500	1000	2000	4000
	Sound Power Level (dB), re 1 pW					
Concrete offloading	101	103.1	97.5	95.1	92.2	87.4
Concrete Pump	106	109.1	103.5	101.1	98.2	93.4
Concrete Mixing Truck	106.8	100.9	101.2	99	94.1	87.3
Concrete Batching Plant	109.3	103.4	104.2	102.0	97.2	91.1
Truck offloading	113.2	116.9	114.4	110.6	106.8	100.2
Front-end Loader	114.6	113.0	107.0	106.0	104.1	101.2

The following parameters and assumptions were used in the calculations:

- Construction operating hours 24 hr.
- Typical construction section of 50 m.
- No noise barriers in place.

The internal traffic on the route between the Culemborg site and the work face at the quay was also taken into consideration. The expected truck movements were obtained from the Traffic Impact Assessment study (HHO, 2006). Table 2.4 below summarises the data utilised in the noise modelling of the internal traffic. The following assumptions were adopted from the Traffic Impact Assessment report:

- A 30% increase was assumed for peak delivery days, as it is unlikely that a uniform delivery rate will apply.
- A peak hourly flow of 20% of daily demand was assumed.
- Internal heavy vehicle movements will consist of concrete mixers travelling between the Culemborg site and the construction area, and heavy vehicles transporting the materials (e.g. rebars, formwork components) between the Culemborg site and the construction area. An estimated number of 20 vehicles were assumed to travel between the Culemborg site and the construction site.

Table 2.4: Internal Traffic Flows.

Items	Units	Quantities		Vehicle Types	Capacity (tonnes)	Daily Trucks	
		Total	Daily			Average	Peak
Berth Deepening							
Concrete	m ³	34,010	43.44	Concrete Mixers	5.5	7.9	10
Other	-	-	-	-	-	-	20
				TOTAL DAILY (internal)			30
				Hourly Total Trucks (20%)			7

2.1.3 Noise Calculations for the Construction Operations

The noise levels within and around the port area, due to all the construction equipment and operations, were estimated with the use of the internationally accepted prediction software package MITHRA. MITHRA was developed by CSTB (Centre for the Science and Technology of Buildings), and has been fully functional as a software program since 1987, utilised in many countries in the European Union (EU) and USA for the modelling of environmental noise and noise planning.

The MITHRA model has been extensively verified in numerous case studies, as well as validated worldwide and is currently recommended by the EU Directive relating to the assessment and management of environmental noise (Commission of the European Communities, 2000).

The model can take into account several parameters as input, including:

- Site three-dimensional topography and ground types.
- Existing and future building layout and noise barriers.
- Meteorological effects.
- The introduction of road, rail, as well as industrial area and point noise sources.
- The incorporation of noise measurements to assist in the determination of noise emissions from existing noise sources.
- Noise prediction analysis utilising source sound power spectra in octave bands, as recommended by the model or taken from actual measurements.
- Providing an integrated environment for noise predictions under different scenarios of operation.

For the noise propagation, the ground contours as well as the wind direction frequencies were taken into consideration. The main assumptions adopted in the noise modelling for the construction phase were:

- Daytime temperature and humidity 25°C and 40% respectively.
- Night-time temperature and humidity 15°C and 80% respectively.
- The ground was considered to be highly reflective.

2.1.4 Noise Impact Assessment Methodology

Sound and noise are measured in units of decibels (dB). The dB scale is not linear but logarithmic. This means that adding and subtracting noise levels is different than in the linear scale. For example, if two identical noise sources each producing 60 dB operate simultaneously they will generate 63 dB. Similarly, a 10-decibel increase in sound levels represents ten times as much sound energy.

The human ear can accommodate a wide range of sound energy levels, including pressure fluctuations that increase by more than a million times. It is, however, not equally receptive to all frequencies of sound. The A-weighting of sound levels is a method used to approximate how the human ear would perceive a sound, mostly by reducing the contribution from lower frequencies by a specified amount. The unit for the A-weighted sound levels is dBA.

Table 2.5 below provides an approximation of the resulting noise levels if the difference between the levels of two sources is 1 to 10 or more decibels. For example, by removing a noise source that individually generates 6 dBA below the ambient noise level, the resulting noise level reduction would be 1 dB.

Table 2.5: Adding and Subtracting Noise Levels.

Difference between the two sound levels	Quantity to be added to or subtracted from the higher level
0	3
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
6	1
7	0.8
8	0.6
9	0.5
10 or more	0

Small changes in ambient sound levels will not be able to be detected by the human ear. Most people will not notice a difference in loudness of sound levels of less than 3 dBA, which is a two-fold change in the sound energy. A 10-dBA change in sound levels would be perceived as doubling of sound loudness.

The noise impact in the site's surrounding areas was determined in terms of the difference between the existing measured or typical noise levels in that area and the predicted levels for the construction activities.

This difference was assessed in accordance with the guidelines provided in the SANS Code of Practice 10103:2004, as well as the noise regulations applicable to the Western Cape (DEAT, 1998). The latter regulations define noise as 'disturbing' if it causes the ambient noise level to increase by 7 dBA or more over an area's typical noise level, as designated in SANS 10103 or as otherwise designated by the local authority.

The typical rating levels, L_r , of noise within each of the areas surrounding the proposed development sites were measured or selected in accordance with the following table from the SANS 10103 Code.

Table 2.6: Typical Rating Levels for Ambient Noise

Type of District	Outdoors Rating Level L_r ^{1,2} dBA	
	Day-time	Night-time
Residential Districts		
Rural districts	45	35
Suburban districts with little road traffic	50	40
Urban districts	55	45
Non Residential Districts		
Urban districts with workshops, business premises and main roads	60	50
Central business districts	65	55
Industrial districts	70	60
¹ A-weighted sound pressure levels, which include corrections for total character and impulsiveness of the noise.		
² Day-time: 06:00 – 22:00, Night-time: 22:00 – 06:00		

The expected community response due to L_r excess in the different areas according to the SANS Code is given in the Table 2.7 below.

Table 2.7: Categories of Community/Group Response

Excess of L_r ¹ dBA	Estimated Response	
	Response Category	Description
0	None	No observed reaction
$0 < \Delta L_r \leq 3$	None to Little	Change slightly noticeable
$0 < \Delta L_r \leq 10$	Little	Sporadic complaints
$5 < \Delta L_r \leq 15$	Medium	Widespread complaints
$10 < \Delta L_r \leq 20$	Strong	Threats of community/group action
¹ Expected increase of ambient noise in an area due to a proposed development		

The assessment of the noise impact magnitude or severity of the proposed plant was based on the L_r excess (ΔL_r) in the different areas according to the following table.

Table 2.8: Noise Impact Magnitude Assessment Criteria

Increase in L_r dBA	Impact
$\Delta L_r \leq 3$	Very low
$3 < \Delta L_r \leq 5$	Low
$5 < \Delta L_r \leq 10$	Medium
$10 < \Delta L_r \leq 15$	High
$15 < \Delta L_r$	Very High

2.2 VIBRATION

2.2.1 Effects of Vibration on Humans

Humans are extremely sensitive to low levels of vibration and can detect levels of ground vibration of less than 0.1 mm/s, which is less than 1/100th of the levels which could cause even minor cosmetic damage to a normal building. Complaints and annoyance regarding ground vibration are therefore much more likely to be determined by human perception than by noticing minor structural damage. However, these effects, and the startling effect of sudden impulses of both sound and vibration are often perceived as intrusion of privacy and could be a source of considerable annoyance to the local community. For this reason, and because of the absence of information on either the likely community response to vibration or the likely levels of impact should be considered moderate. However, previous notification of blasting activities at predetermined times on stated days, and careful design of the blasting regime to reduce the levels of ground borne vibration will contribute significantly to the minimisation of the overall impact of blasting on the surrounding community.

However, both an acoustic pulse transferred to the air from the water and ground surfaces, and ground vibration can give rise to secondary noise in a building, such as the rattling of windows and other loose objects which are in a state of neutral equilibrium, and this is often interpreted as a far more serious occurrence than it really is. An additional complication is that the blast will in general contain frequencies below those which can be heard by the human ear i.e. below 20Hz.. These low frequencies also contain sufficient energy to give rise to secondary noise, just as with ground vibration, making it characteristically difficult to differentiate between the effects and the perception of airborne sound and ground-borne vibration.

2.2.2 Effect of Vibration on Structures

There is wide agreement in the industry that the Peak Particle Velocity (PPV) is the parameter which best correlates with observed damage to structures caused by vibration, and is widely applied in assessments. The first observable damage to structures, the forming of hairline cracks in plaster,

begins at a PPV of about 25mm/s. The US Bureau of Mines recommends twice this value, 50mm/s, as the limit for residential property. Minor structural damage can occur at values in excess of 100mm/s, and serious damage occurs at values in excess of 200mm/s, according to a range of authors (Lear, 1992). Effects on temporary structures are likely to occur at values which are lower than for masonry structures, though the high variability in the type and construction quality of such structures renders reliable prediction of these values difficult.

The maximum threshold values of peak particle velocity for different types of structures, as recommended by African Explosives Limited (AEL) are presented in Table 2.8.

Table 2.9: Recommended maximum threshold values of peak particle velocity for different types of structure.

Blasting Situation	Recommended maximum level (mm/s)
Heavily reinforced concrete structures	120
Property owned by the concern performing blasting operations where minor plaster cracks are acceptable	84
Private property in reasonable repair where public concern is not an important consideration	50
Private property if public concern is important or if blasting is conducted on a regular and frequent basis	10

For a ground blast, the relationship between the Peak Particle Velocity (**C**), the distance from the charge (**R**), and the mass of the explosive (**W**), can be simply expressed (Beeslaar et al., 2001) as follows:

$$C = a \frac{[R]^{-b}}{[\sqrt{W}]}$$

where

- C** is the PPV in mm/s
- R** is the distance of the monitoring position from the explosion site in meters.
- W** is the mass of the explosive charge in Kg.
- a** is a site-specific constant expressing the efficiency of excitation of the ground by a given charge, and depends on local geology, explosive coupling efficiency, resonance effects, ground condition and water content. Tentatively, an empirical value of 4282 was used in the rock removal specialist report and in this assessment.
- b** is a site-specific constant expressing the attenuation of the PPV with distance. Tentatively, an empirical value 1.6 was used in the rock removal specialist report and in this assessment.

The above equation enables the size of the charge to be determined so that the PPV at a specified distance can be kept below a predefined limit. The constants **a** and **b** are determined empirically by a small number of test blasts before the commencement of operational blasting and the original assumptions modified when this information becomes available. Vibration levels at a sensitive engineering structure have been successfully managed by using this technique at Speekfontein opencast colliery, (Beeslaar et al., 2001) close to a power station. It is recommended in the first instance that a set of test blasts should be considered before operations begin to determine the constants **a** and **b** specifically for the site, and calculate actual PPVs at sensitive buildings, so that levels can be controlled by competent blast design.

2.2.3. Effect on Marine Ecology

Seals and birds are to be lured out of the Ben Schoeman dock to sea during blasting periods. This means that all animals should be at least 1500 m away from the blasting area. It is therefore highly unlikely that seals or birds will be affected

3 THE AFFECTED BASELINE ENVIRONMENT

3.1 NOISE MEASUREMENTS AND BASELINE LEVELS

Table 3.1 below shows the averaged values of the noise measurements at the different locations for representative daytime and night-time periods. The detailed measurement parameters can be found in Appendix A.

Table 3.1: Measured Noise Levels

Monitoring Point	Daytime	Night-time	District	SANS Guideline	
	dBA	DBA		Daytime	Night-time
R1	71	67	Industrial	70	60
R2	77	75	Industrial	70	60
R3	77	71	Industrial	70	60
R4	60	52	Industrial	70	60
R5	68	55	Industrial	70	60
R6	59	57	Residential	55	45

The potential receptors and closest residential areas to the port are Woodstock, Brooklyn, Milnerton, Zonnebloem and the Waterfront hotels. The following figure depicts the nearest residential areas around the port and the locations of the noise monitoring points R1 to R6. Table 3.2 shows the

approximate distances from the BSD deepening operations and the Culemborg site to the various areas and noise receptors.

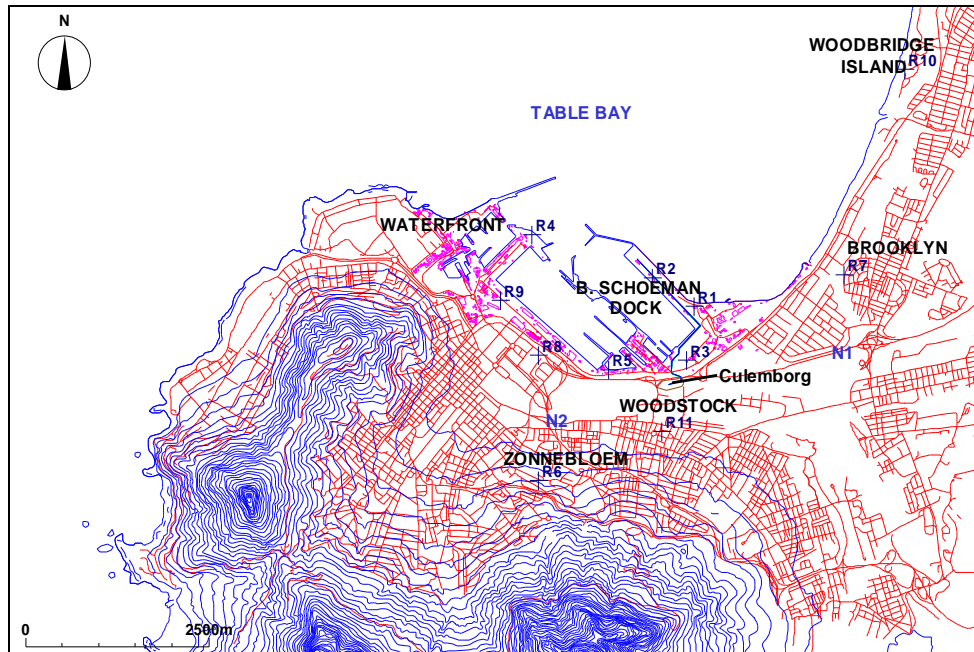


Figure 3.1: Location of Residential Areas and Noise Monitoring Locations R1-R6.

Table 3.2: Residential Areas Distances from the BSD Construction Operations

Area/Receptor	Type of Area,	Distance from (m)		SANS Guideline	
		BSD	Culemborg	Daytime	Night-time
Woodstock	Commercial / Residential	1,500	700	60	50
Brooklyn	Residential	2,500	2,700	55	45
Zonnebloem	Residential	2,550	2,250	55	45
Milnerton	Residential	4,000	4,750	55	45
Woodbridge I.	Residential	4,500	5,200	55	45
Waterfront	Commercial / Residential	1,500	3,200	60	50

To the south of the port is the commercial and residential area of Woodstock. The distances from the BSD and Culemborg site are 1,500 m and 700 m respectively. There are a variety of industries in the area. The noise environment is dominated by local traffic on the main road network, rail traffic as well as by industrial and commercial sources. The area can be characterised as ‘Urban district with some workshops, with business premises, and with main roads’. In accordance with SANS, the typical recommended ambient noise levels during the daytime and night-time are 60 dBA and 50 dBA respectively.

The residential area of Brooklyn is situated approximately 2,500 m east of the port's proposed construction operations. Brooklyn is shielded off from the construction operations by the Paardeneiland industrial area. It is expected that the industrial buildings in Paardeneiland will shield off most of the noise from the dredging operations. The current noise environment in this area is dominated by the N1 highway, Koeberg Road and Marine Drive traffic. According to the procedures specified in SABS 10103, the Brooklyn area can be described as an 'Urban' district, with typical daytime and night-time noise levels of 55 dBA and 45 dBA respectively.

The Zonnebloem residential area has a direct line of sight with the BSD area. This means that the construction operations could potentially have a negative impact on the area's noise levels under certain meteorological conditions. The area, however, is situated quite far from the port (approximately 2,500 m) and the current noise levels in Zonnebloem are quite high, i.e. exceeding the SANS guideline for an 'Urban' district (see position R6 in Table 3.1). The noise levels in this area are consistently around 58 dBA throughout the day- and night-time. The main contributors to these high noise levels are local traffic, as well as traffic along the N1 and N2 highways and the existing port operations.

Milnerton and Woodbridge Island residential areas are situated more than 4,000 m north-east of the port. The present ambient noise climate is dominated by the waves breaking on the beach, as well as traffic on Milner Drive and the local road network. The current noise levels are expected to exceed the SANS guideline for an 'Urban' district.

The distance between the Waterfront and the northern section of the BSD is approximately 1,500 m. There are a number of port buildings that could shield off most of the Waterfront area from the noise emissions of the dredging operations. Noise emissions from the current port activities, the central business district and traffic on the local road network dominate the noise environment. The area can be characterised as 'Urban district with some workshops, with business premises, and with main roads', and is expected to have noise levels of 60 dBA and 50 dBA during day-time and night-time respectively. This is also confirmed by the noise measurements performed at Point 4, in front of the NPA building (see Table 3.1).

From Table 3.1 it can also be seen that the highest noise levels were recorded in close proximity to the current operations around the BSD, i.e. points R1 to R3.

The existing noise environment in the general port area is dominated by:

- The loading and offloading operations at the Duncan and Ben Schoeman Docks.
- Traffic along Duncan Road and Marine Drive.

- Traffic along the N1 and N2 highways.
- Commercial activities in the Central Business District (CBD).

3.2 BASELINE ENVIRONMENT WITH REGARD TO VIBRATION

The characteristics of blasting vibration, which is highly transient, its manner of propagation, and the assessment of the response of a community and building structures to it, is completely different from the assessment of the associated construction and equipment noise, which is mainly continuous or at least intermittent. The assessment of noise from construction noise relies on the comparison of the sound level of the construction noise with the sound level measured before the introduction of that noise, which is a relative parameter.

In the case of vibration, however, the baseline level is almost always zero, or so small as to be insignificant, and generally immeasurable, and the assessment is made on the actual predicted or measured absolute vibration value, which is the parameter which causes disturbance to humans or potential damage to buildings, which is our primary concern, and marine animals. The baseline environment is therefore assumed to be pristine, i.e. completely free of shock and vibration before construction and/or blasting commences, and carrying out baseline measurements is not necessary or usual. Vibration from natural and normal activities, including container offloading, crane and ship movements, are small compared to the energy of blasting.

4 PREDICTED NOISE LEVELS DURING CONSTRUCTION

The noise levels around and within the perimeter of the port were predicted using the methodology outlined in Section 2.1.

The following figure shows the three-dimensional representation of the Ben Schoeman Dock and the extended Cape Town Harbour area, as well as the residential areas and the Central Business District.

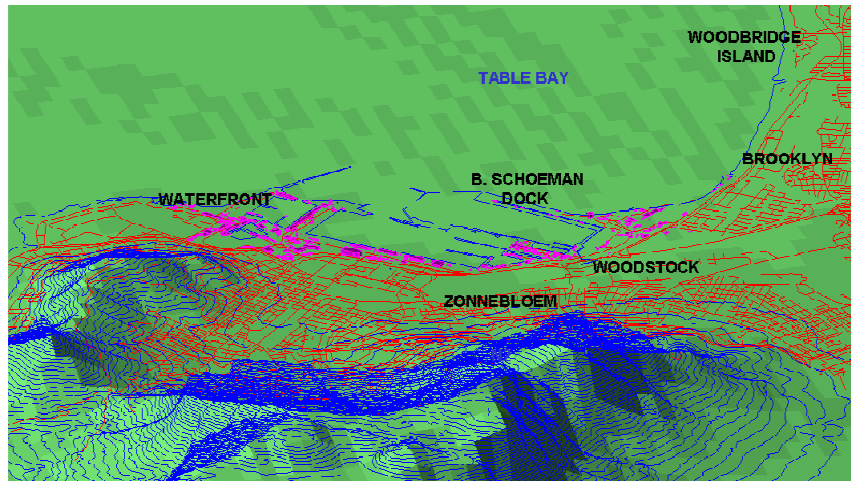


Figure 4.1: Three-dimensional Representation of the Study Area

4.1 NOISE MODELLING RESULTS

The following figures show the noise contours during construction around the proposed site locations during daytime and night-time conditions, representative of the entire construction period.

As can be seen from Figure 4.2 for the daytime conditions, the 70 dBA noise contour, which represents the industrial district guideline, was found to be contained within the site's boundaries for the BSD deepening and the Culemborg site. The 45 dBA zone extended approximately 900 m from the main construction area and to the south reached the northern section of Woodstock. Areas such as Brooklyn, Zonnebloem and the Waterfront were found outside of the 40 dBA zone. This means that based on the measured and adopted guideline noise levels in these areas, the difference between the construction generated noise and the existing ambient noise is greater than 9 dBA. Therefore, the noise contribution from the construction activities will be well below 1 dBA.

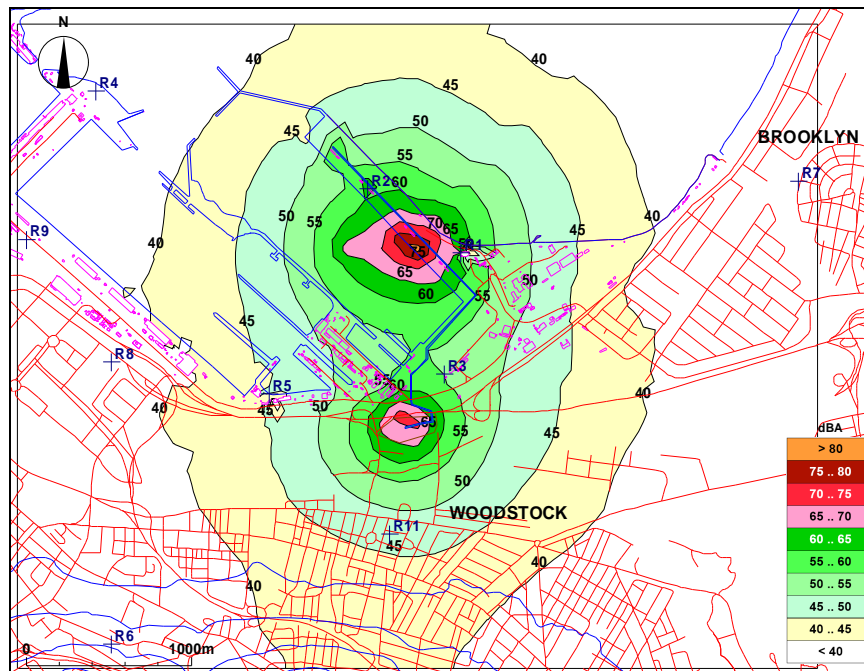


Figure 4.2: Daytime Noise Contours During Construction

Figure 4.3 shows the relevant noise contours for the night-time conditions. It can be seen that these conditions favour sound propagation from the source to the receptor, thus producing noise zones that extend further away from the construction area. In addition, there are more stringent guidelines regarding the night-time period.

The 60 dBA contour, which represents the night-time guideline for industrial districts, was found to be contained within the port's area and the 45 dBA zone reached half way towards Brooklyn. The Culemborg site under night-time conditions generated a 60 dBA zone that reached beyond its boundaries. It was, however, contained within the surrounding industrial area. The 50 dBA contour just reached the Woodstock area.

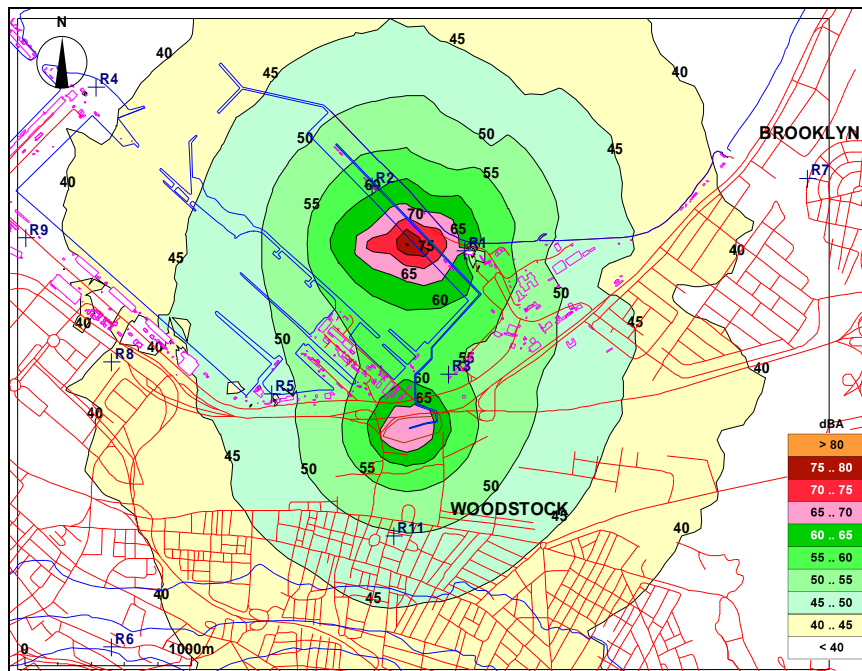


Figure 4.3: Night-time Noise Contours During Construction

Several discrete receptors were positioned at the locations of the noise monitoring points R1 to R6 and the noise contribution of the proposed construction activities were calculated. In addition, several receptors were placed in the different residential areas around the site. These receptor locations can be seen in Appendix B. Table 4.1 shows the noise levels at these receptors. As can be seen, the noise levels were well below the district's guideline for the day, as well as the night-time periods (i.e. lower than the guideline by approximately 6 dBA or more). The only exceptions were at the BSD quay (R1, R2 and R3) and in the Woodstock area (R11), where the noise level exceeded the night-time guideline (R1) or was marginally lower (R2, R3 and R11).

As indicated by the noise measurements (see Table 3.1, point R2), the existing levels at the BSD quay range between 70 dBA and 77 dBA and are currently well above the SANS guideline. This means that the expected noise increase in these locations attributed to the construction operations would be approximately 1 dBA.

In the Woodstock area the night-time noise contribution of the construction activities is expected to be 3 dBA if the noise level in the area is around the SANS guideline of 50 dBA, and 1 dBA or less if the area's existing noise level is higher than the district's guideline. The second scenario is considered to be most probable, since the existing noise environment in the area is currently impacted by heavy traffic, commercial and industrial activities.

Table 4.1: Calculated Noise Levels at Discrete Receptors.

			Modelled	District	Modelled	District
	Location	SANS	Day	Guideline	Night	Guideline
Receptor		District	DBA	dBA	dBA	DBA
R1	Port Admin building	Industrial	64.4	70	64.8	60
R2	BSD quay	Industrial	56.1	70	59.1	60
R3	Weighing bridge	Industrial	55.8	70	57.3	60
R4	NPA building area	Industrial	34.3	70	38.2	60
R5	Yacht club	Industrial	43.2	70	47.2	60
R6	Zonnebloem	Urban	36.4	55	39.3	45
R7	Brooklyn	Urban	34.4	55	38.8	45
R8	Central	CBD	36.7	65	41.1	55
R9	Waterfront	Urban with business	34.0	60	38.7	50
R10	Woodbridge Isl.	Urban	23.6	55	26.7	45
R11	Woodstock	Urban with business	46.7	60	49.2	50

5 IMPACT ASSESSMENT AND RECOMMENDATIONS

5.1 NOISE IMPACT ASSESSMENT DURING CONSTRUCTION

Based on the estimations of the noise during the construction phase, the following conclusions can be drawn:

- During construction the noise impact will be area-specific and will last for approximately three years (in the worst case scenario).
- The 70 dBA daytime guideline for industrial districts will not be exceeded outside the site's boundaries. The same applies to the 60 dBA night-time guideline.
- The constructions at the BSD will have a negligible effect on the existing noise levels in the nearby residential areas, i.e. well below 1 dBA.
- The community in the closest residential area of Woodstock is expected to have no observed reaction since the noise increase will not be noticeable. The same applies to Zonnebloem and Woodbridge Island.
- There are no additional mitigation measures necessary to be implemented other than to adhere to good practice guidelines outlined in the recommendations section.

The construction impact rating can be summarised as follows:

Table 5.1: Noise Impact Assessment Table.

<i>Extent</i>	<i>Intensity</i>	<i>Duration</i>	<i>Consequence</i>	<i>Probability</i>	<i>Significance</i>	<i>Status</i>	<i>Confidence</i>
Local	Low	Short-term	Very Low	Definite	Very Low	- ve	High

As no specific mitigation measures are required, an impact rating with mitigation was not provided.

5.1.1 Recommendations for Noise Minimisation During Construction

For the construction operations of the BSD deepening, the following recommendations can be made:

- The construction equipment should be properly maintained, accompanied by a maintenance track record and have their silencer systems properly functioning at all times.
- The movement and operation of the construction equipment should be kept as far as possible from the site's boundaries.
- The stockpile materials should be positioned so as to provide screening and protect the site's boundaries from noise during specific construction operations.

5.1.2 Monitoring

It is recommended that noise monitoring should be performed biannually along the site's boundaries in order to ensure conformity with the regulations and indicate relevant corrective measures to be implemented. The measurements should be performed by an independent third party, in accordance with procedures stipulated in the South African National Standard (SANS) Code of Practice: SANS 10103:2004.

5.2 VIBRATION IMPACT ASSESSMENT DURING CONSTRUCTION

Blasting operations are very different from the majority of other construction activities, which are continuous, or at least intermittent with a significant on-time. Blasting is an infrequent event which affects the environment for only a very short time, usually seconds only. For that reason the impact of blasting is usually low even if the instantaneous vibration level is significant either from the point of view of human reaction, or building response.

Vibration from pile driving operations, which may be far longer in duration, are not significant at distances of 50m or more, even if the piles are large and impact driving methods are used.

Table 5.2: Vibration Impact Assessment Table.

<i>Extent</i>	<i>Intensity</i>	<i>Duration</i>	<i>Consequence</i>	<i>Probability</i>	<i>Significance</i>	<i>Status</i>	<i>Confidence</i>
Local	Low	Short-term	Very Low	Definite	Very Low	- ve	High

5.2.1 Effects of Vibration on Humans

Blasting operations are not likely, according to the blasting report to have any damaging effect on humans, if these blasting operations are designed and carried out with due regard to good blasting practice. However, both an acoustic pulse transferred to the air from the water and ground surfaces, and ground vibration can give rise to secondary noise in a building, such as the rattling of windows and other loose objects which are in a state of neutral equilibrium, and this is often interpreted as a far more serious occurrence than it really is. An additional complication is that the blast will in general contain frequencies below those which can be heard by the human ear i.e. below 20Hz.. These low frequencies also contain sufficient energy to give rise to secondary noise, just as with ground vibration, making it characteristically difficult to differentiate between the effects and the perception of airborne blast and ground borne vibration.

5.2.2 Effect of Vibration on Structures

The nature and magnitude of the response to vibration from underwater blasting operations will depend critically on the blasting regime chosen, the nature of the rock to be blasted, the size and depth of the charge, the type of explosive, the local topography, the local geology, and the detonation sequence. The closest dwellings around the site are at distances of approximately 1.5 km from the nearest point of blasting and are therefore too distant to be affected in any way by the vibration from blasting operations. Neither is ground vibration from blasting operations likely to have any damaging effect on humans or buildings on the dock, if these blasting operations are designed and carried out with due regard to good blasting practice and with the desire to obtain cost-effective results in operational terms.

5.2.3 Effects on Marine Ecology

The Blasting report recommends that all seals and birds be lured out of the Ben Schoeman dock to sea during blasting periods. This means that all seals should be at least 1500 m away from the blast, as the location of the rock to be removed is at the land end of the dock. It is therefore highly unlikely that seals or birds will be affected.

5.2.4 Recommendations for Vibration Minimisation During Construction

It is recommended in the first instance that a set of test blasts should be carried out before operations begin to determine the constants **a** and **b** specifically for the site, (see section 2.2.2) and

calculate actual PPVs at sensitive buildings, so that levels can be controlled by competent blast design.

It should be noted that the below-mentioned mitigation measures are not considered additional but part of the blasting procedures that will be normally followed.

1. Calculating the charge size and timing delay to keep ground vibration levels below pre-determined acceptable values.
2. Pre-notification of affected persons, all office premises on the dock property should be notified of the intention to blast and the time of blast, preferably at the same time of day to remove the element of surprise.
3. Correct stemming of blast holes to reduce noise and vibration generation and improve blasting efficiency.
4. Monitoring of ground vibration and human response should be undertaken by an independent third party entity to ensure that agreed levels are in fact acceptable and are being adhered to, and to modify the blasting design as required.

5.2.5 Monitoring

It is recommended that identified sensitive structures, including the closest section of the dock itself to the likely blast sites, should be instrumented with triaxial vibration monitoring instrumentation capable of time signal capture as well as the peak particle velocity values used for comparison with established limit values. This will enable post-event analysis of the signal to obtain the frequency content and other parameters which may be necessary for structural dynamic analysis of sensitive structures as well as providing feedback to the blasting manager for optimising the blasting regime. In addition, similar 3-axis underwater monitoring should be carried out in the basin to quantify the underwater pressures.

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Appendix A

Noise Monitoring Results

No	Location	Zoning	Coordinates (dd°mm.mmm')	
			S	E
R1	Port administration building, east of BSD	Industrial	S33°54.781	E18°27.320

Record Sheet Position R1, on the 14th floor of the Port Administration building, overlooking the Ben Schoeman Dock and the current operations on the quay. Noise mainly due to loading and offloading of containers.



Time	T (C°)	RH (%)	W (m/s)	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L90 (dBA)	L50 (dBA)	L10 (dBA)	L1 (dBA)	Comments
11:21	24.6		2.5	68.7	64.8	77.9	65.5	67	71.3	75.4	
12:05	26.9		2.7	72.8	63	85.7	65.3	70	75.8	82.6	
16:04	19.6	42.1	1.1	70.3	64.4	79.1	66.4	68.6	72.9	77.5	
16:27	23.2		4	71.8	62.8	86	64.1	68	75.2	80.4	
23:09	19.9		0.9	69.3	63.8	81.1	64.4	66.1	72.5	77.8	
23:32	22.9		0	65.1	63.5	74.1	63.9	64.6	66.1	68	

No	Location	Zoning	Coordinates (dd°mm.mmm')	
			S	E
R2	Ben Schoeman Dock (BSD), main quay	Industrial	S33°54.571	E18°26.922



Time	T (C°)	RH (%)	W (m/s)	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L90 (dBA)	L50 (dBA)	L10 (dBA)	L1 (dBA)	Comments
00:02	22		0.6	76.1	56.2	93.9	57.9	63.1	78	88.4	
12:02	29.4	45.3	1.1	79.2	72	98.3	72.6	74.5	81.1	90.4	
12:30	25.5		4.5	76.7	67.6	94.5	69.3	71.7	78.5	88.5	
16:54	19.6	50.2	2.3	76.8	57.1	94.2	59.5	68.4	80.7	87.9	
17:09	26.5		1.4	75.5	68.5	92.8	69.1	70.5	78.1	86	
23:52	23.7	81.2	0	74.6	67.1	85.9	68.8	72.1	77.6	83.2	

No	Location	Zoning	Coordinates (dd°mm.mmm')	
			S	E
R3	Eastern side of BSD, on weighing bridge tower	Industrial	S33°55.161	E18°27.213



Time	T (C°)	RH (%)	W (m/s)	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L90 (dBA)	L50 (dBA)	L10 (dBA)	L1 (dBA)	Comments
11:35	23.5	55.3	1.7	78.8	61.6	95.1	67.5	72.5	81.5	90.3	
11:44	25.6		2.4	73.1	61.4	86.6	64.2	69.5	76.8	81.9	
16:33	20.7	46.7	2.1	79.8	66.6	101.1	69.2	73.7	81.2	87	
16:49	26.4		0.7	77.6	66.7	93.9	69.9	73.4	80.1	88.9	
22:27	19.3		3.5	81	55.4	100.9	62.2	69.2	80.6	93.9	
23:33	20.3	78.4	1.5	61.5	47.9	79.6	50	54.7	65.2	72.8	

No	Location	Zoning	Coordinates (dd°mm.mmm')	
			S	E
R4	Western side of BSD, in the NPA building area	Industrial	S33°54.271	E18°25.849



Time	T (C°)	RH (%)	W (m/s)	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L90 (dBA)	L50 (dBA)	L10 (dBA)	L1 (dBA)	Comments
10:26	24.6	46.9	3.5	62.2	55.7	76.9	56.8	59.3	64.2	71.1	
11:01	22.7		4.8	60.4	54.9	69.1	56.4	57.6	64.1	67.4	
14:20	22.9	45.5	2.9	57.5	53.4	66.1	54.3	55.8	60	64.5	
15:30	26.5		1.2	58.5	52.9	71.2	54.1	56.2	61	66.6	
22:15	17.9		1.5	51.2	47.2	66.3	48	48.9	53.4	58.7	
22:27	20.7	69.7	0	53	48.9	66.8	49.6	51.1	54.5	62.4	

No	Location	Zoning	Coordinates (dd°mm.mmm')	
			S	E
R5	South of BSD, next to yacht club	Industrial	S33°55.230	E18°26.521



Time	T (C°)	RH (%)	W (m/s)	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L90 (dBA)	L50 (dBA)	L10 (dBA)	L1 (dBA)	Comments
10:54	29.7	51.7	0.7	66.1	57.9	78.9	60.6	63.9	68.7	74.8	
11:32	24.9		2.7	68.8	54.3	83.5	57.2	63.2	71.8	80.3	
15:07	24.5	41.7	2.4	71.8	55.4	86.4	59	64.3	75	84.4	
16:05	28.2		2.7	63.3	58	76.4	59.7	61.8	65.4	70.3	
22:41	23.8		0	56.9	55.4	62.3	56.1	56.8	57.4	58.6	
22:52	21.2	88.3	0	52.5	48.8	63.5	49.7	50.8	53.7	61.3	

No	Location	Zoning	Coordinates (dd°mm.mmm')	
			S	E
R6	Zonnebloem area, along Constitution Road	Residential	S33°56.004	E18°25.908



Time	T (C°)	RH (%)	W (m/s)	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L90 (dBA)	L50 (dBA)	L10 (dBA)	L1 (dBA)	Comments
10:04	25.6	40.2	2.2	62	46.9	78.9	48.3	50.8	65	74.4	
10:37	24.1		4.5	60.2	46.7	73.7	48.4	51.5	64.6	70.8	
14:50	23.5	43.9	1.1	56.2	50.8	72.8	53.2	54.8	56.5	62.6	
15:05	24.9		4.6	57.6	46.3	73.8	47.4	49.7	60.4	69.4	
22:03	18.9		0	58.7	49.1	72.9	57	57.7	59.2	66.7	
22:05	18.2	71.7	0	55.4	51.5	72.8	52.1	52.8	55.4	64.4	

Appendix B

MAPS

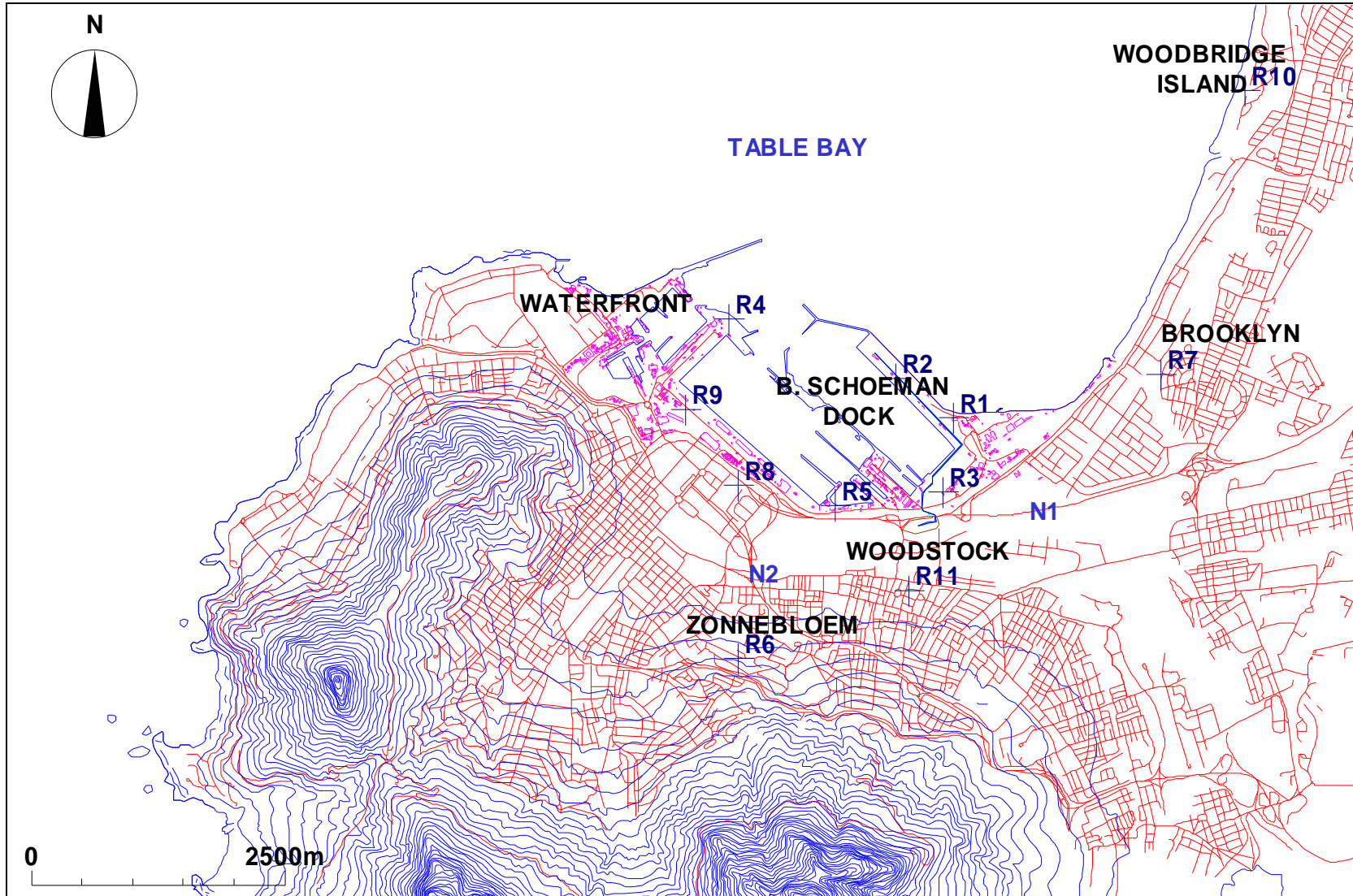


Figure B.1: Noise Monitoring Locations and Modelling Discrete Receptors