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Reference N°

Noise Propagation Study

LD Celulose S.A.

Dissolving Pulp Mill, in Indianópolis and Araguari - Minas Gerais State

Contents

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Rev.	Data/Autor	Data/Verificado	Data/Aprovado	Data/Autorizado	Observações

SUMMARY

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1 INTRODUCTION

This document consists of the Noise Propagation Study from the future dissolving pulp mill of LD CELULOSE in Indianópolis (industrial site) and Araguari (pipelines), in Minas Gerais, Brazil, and aims to evaluate the environmental impact of noise in the vicinity of the installation area of the new mill.

The acceptable noise level for a given environment is usually recommended by standards and legislation (BISTAFA, 2011). In Brazil, environmental noise is regulated, at federal level, by CONAMA Resolution No. 01/1990 and by NBR 10151/2000.

According to Section I of CONAMA Resolution No. 01/1990, "the emission of noise, as a result of any industrial, commercial, social or recreational activities, including those of political propaganda, shall, in the interests of health, enjoy public standards, criteria and guidelines established in this Resolution". In the same Resolution, in Paragraph II, it is established that "noise levels higher than those considered acceptable by Standard NBR 10151 – Noise Assessment in Inhabited Areas, aiming at the comfort of the community, are prejudicial to health and public peace".

The Standard NBR 10151/2000 establishes levels of criterion of evaluation of external noise for different types of areas in the day and night period.

In the State of Minas Gerais, environmental noise is regulated by means of State Law No. 7302/1978 and State Law No. 10100/1990, which provides for protection against noise pollution.

Thus, in accordance with the provisions, the objective of this study is to predict the sound pressure level (SPL) that will be emitted after the implantation of the LD CELULOSE soluble cellulose factory, in comparison with the level of evaluation criterion (NCA) established by Standard NBR 10.151/2000 and also with the maximum limits established by State Law 10.100/1990, through the use of acoustic modeling software called Predictor-LimA (version V10.13).

This study is part of the EIA/RIMA project of dissolving pulp mill of LD CELULOSE.

This Study is comprised by following chapters:

- Introduction
- Project Information
- Noise Propagation Model
- Simulation of the Noise Propagation
- Conclusions
- References

2 PROJECT INFORMATION

2.1 General Description

The LD CELULOSE mill will have the capacity to produce 540,000 t/y of dissolving pulp, which will be exported and used as raw material for the production of viscose yarns and others. In addition, a cogeneration unit with a nominal capacity of 132 MW.

The dissolving pulp mill will be located in the municipality of Indianópolis and Araguari (MG), along Highway BR 365, 35 km away from Uberlândia.

The operating regime of the dissolving pulp mill will be 24 hours a day, 7 days a week and 12 months a year. The actual production period will be approximately 352 days, considering the annual general maintenance stoppage of the equipment.

The total workforce, considering own employees and third parties, necessary for the operation of the dissolving pulp mill will be approximately 500 people.

Regard to environmental control systems, the implementation of the industrial plant will adopt the Best Available Technologies (BAT), aiming at reducing, controlling and monitoring liquid effluent emissions, atmospheric emissions and solid waste generated.

2.2 Location

The dissolving pulp mill will be located in the municipality of Indianópolis and Araguari (MG), along Highway BR 365, 35 km away from Uberlândia.

The mill will be accessed through a 5-kilometer highway that is part of this licensing, and will be connected to the MG-748 state highway.

The following figure shows the location and the access of the project.

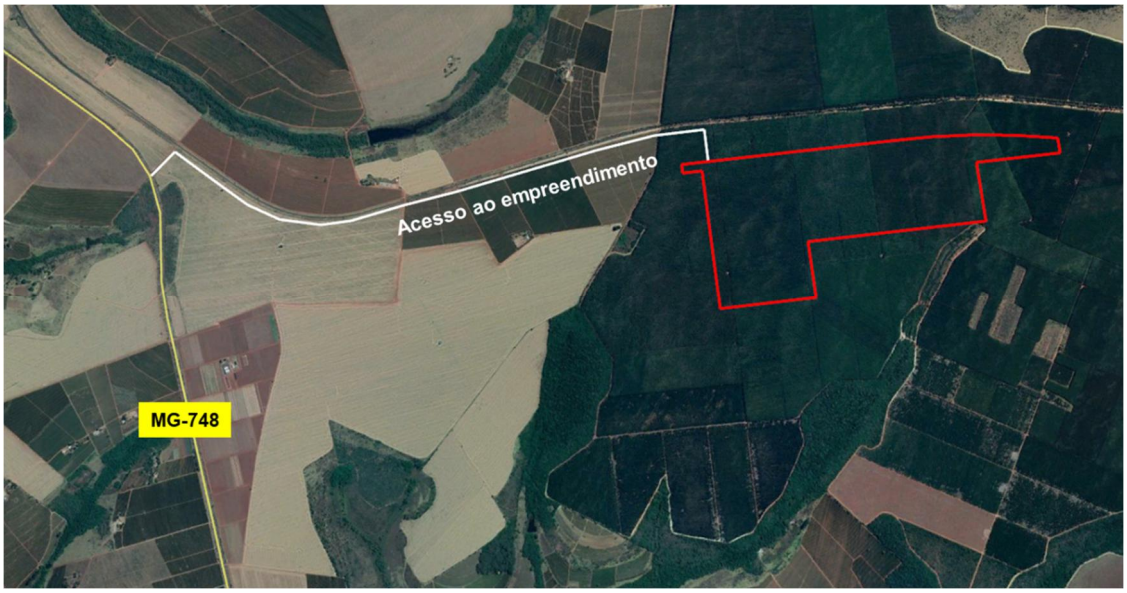

Figure 1 – Mill location. Source: *Google Earth* (2018).

2.3 Characteristics of the Environment

2.3.1 Land Use and Occupation

Around of the place foreseen for the implantation of the enterprise there is predominance of agricultural activities and forestry. To the south, to the north and east of this site are eucalyptus plantations of the company Duratex Florestal. To the west there are plantations of corn and coffee, and also plantations of eucalyptus company Duratex Florestal. To the south, tangent to the future venture, there is also the Ferrovia Centro Atlântica (FCA).

The population agglomeration closest to the development, which consists of the urban area of the municipality of Indianópolis-MG, is located approximately 20 km south-west.

It is important to point out that the area planned for the implementation of the LD CELULOSE plant is located within Fazenda Nova Monte Carmelo, leased to Duratex Florestal.

The following figures show the land use in the surroundings of the project and the location of the future plant within the Fazenda Nova Monte Carmelo area.

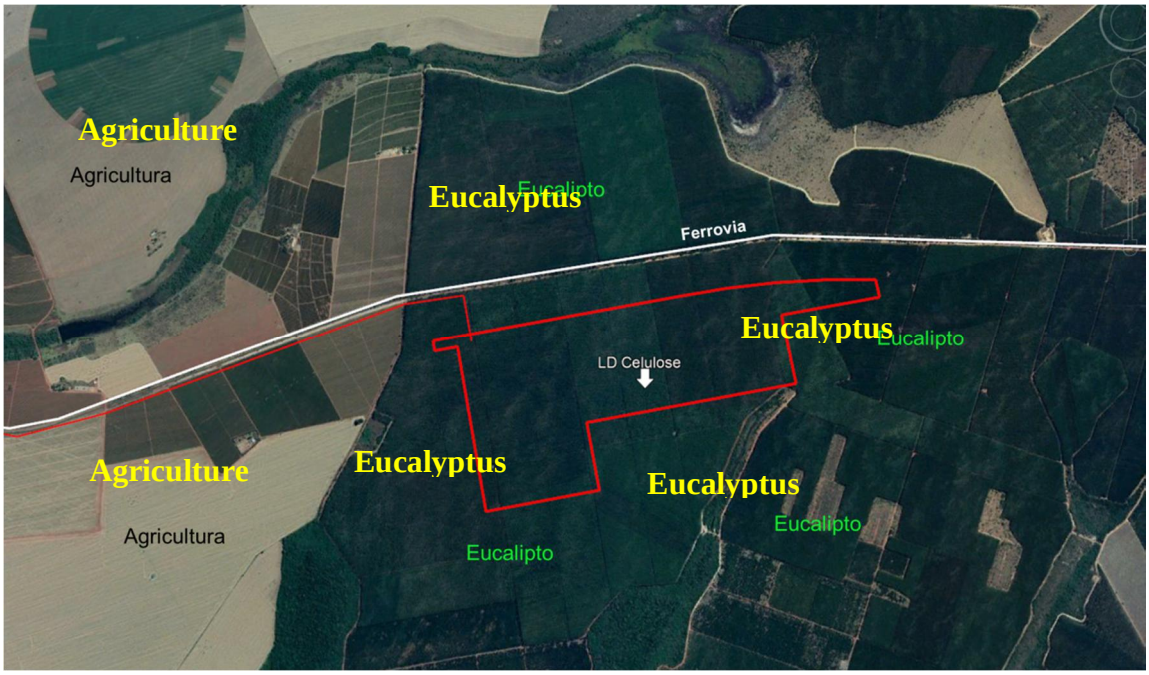

Figure 2 – Land Use and Occupation in the location of the project. Source: *Google Earth* (2018).

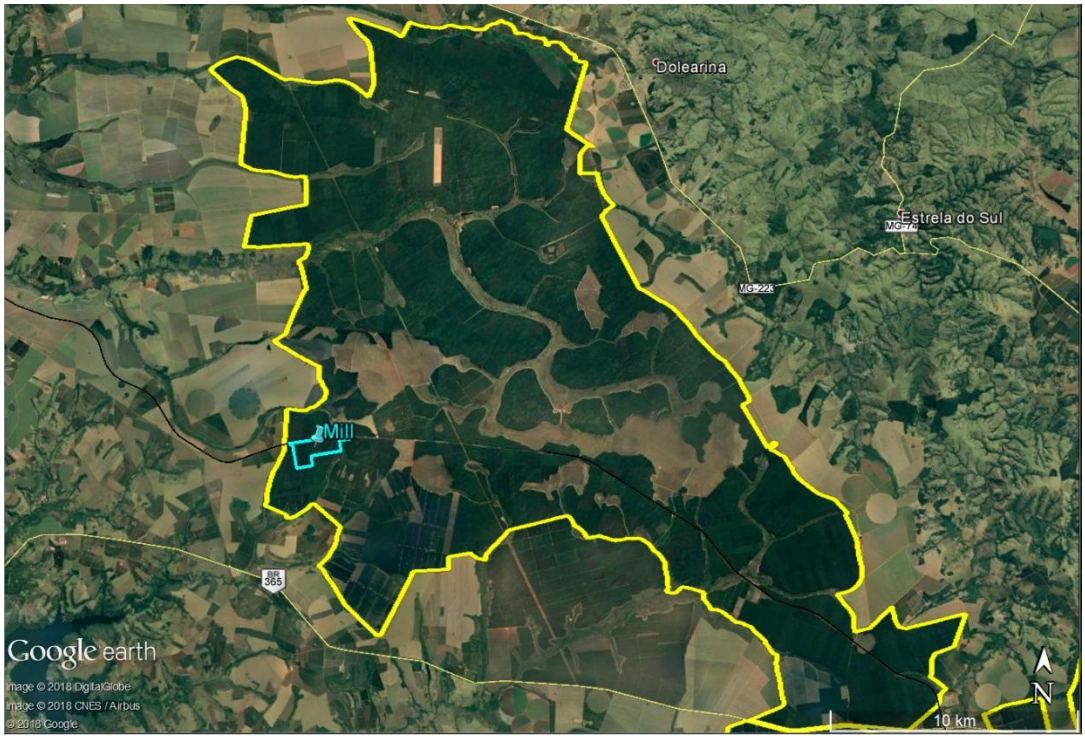

Figure 3 – Location of the future factory within the area of Fazenda Nova Monte Carmelo (outline in yellow). Source: *Google Earth* (2018).

2.3.2 Environmental Noise

In the EIA/RIMA of the LD CELULOSE dissolving pulp project, the ambient sound pressure level (ambient noise) was monitored at 8 different points during the day and night periods.

The results of ambient sound pressure level around area of the dissolving pulp mill ranged between 34.4 dB(A) e 40.1 dB(A) in day period, and between 40.9 dB(A) e 46.6 dB(A) in night period.

The highest results in the night period occurred mainly due to the sounds of insects.

2.4 Layout of the Mill

The layout of the plant is shown in the following figure and detailed in **ANNEX I**.

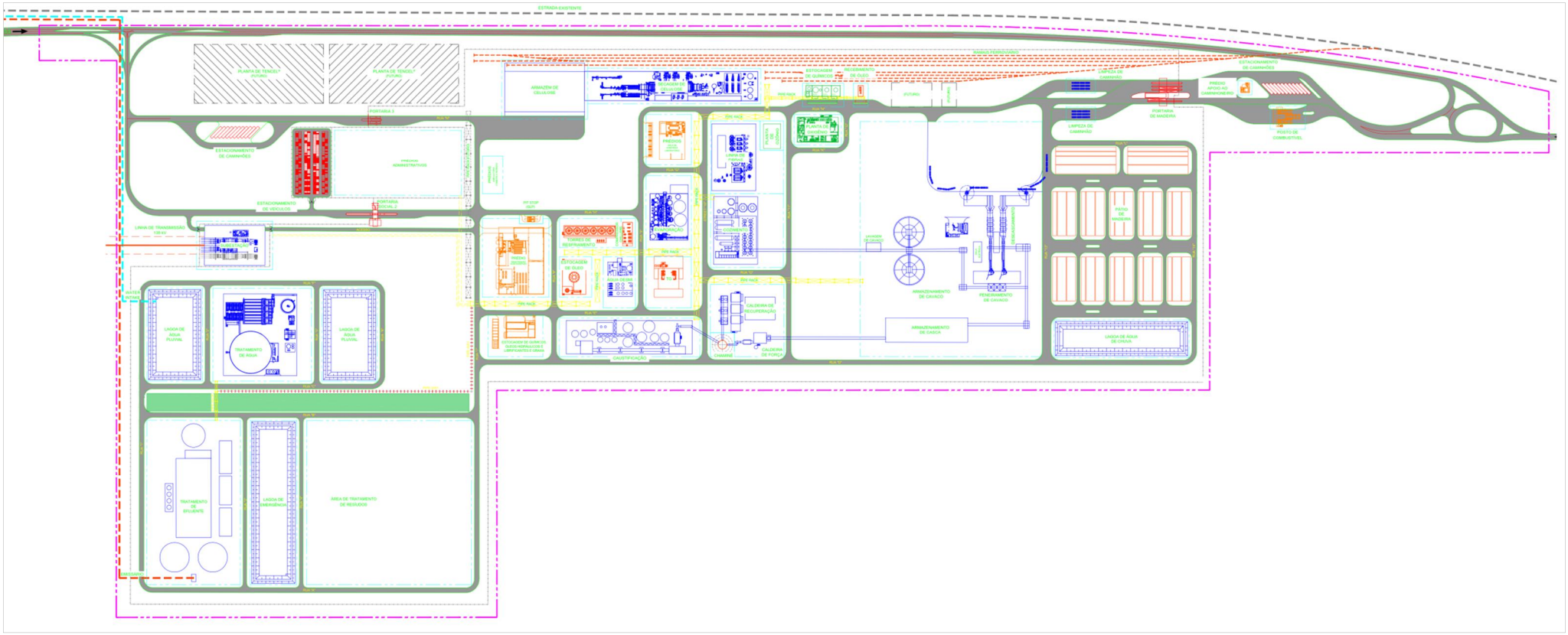

Figure 4 – Layout of the mill.

2.5 Noise Sources Characterization

The sources of noise in the dissolving pulp mill will come from industrial activity. In addition, LD CELULOSE will adopt rail transportation for the disposal of pulp production. In this way, there will be arrival and departure of iron composition in the factory. The following are the noise generating areas of the future factory:

- Wood yard
- Cooking
- Fiber Line
- Drying of pulp
- Pulp Warehouse
- Evaporation
- Recovery boiler
- Caustification and lime kiln
- Chemicals area
- Water treatment
- Water treatment for boilers
- Cooling towers
- Compressed air plant (compressor)
- Plant for oxygen production
- Ozone production plant
- Power boiler (biomass)
- Turbogenerator
- Wastewater treatment
- Waste treatment area
- Shunting yard

3 NOISE PROPAGATION MODEL

3.1 Noise Propagation Concept

Outdoor sound propagation is usually studied in terms of 3 components: the sound source, the transmission path and the receiver.

SOUND SOURCE → TRANSMISSION TRAJECTORY → RECEIVER

First, the source (machines, equipment, etc.) emits a certain sound power, generating a sound level that can be measured in the vicinity of the source. From there, the sound level is attenuated as the sound propagates, between the source and the receiver, along a certain trajectory.

The sound level decreases with distance, as the sound diverges from the source, which may be directional. The sound absorption of the atmospheric air attenuates the sound along its trajectory. Ground reflections interfere with direct sound, causing attenuation or, less frequently, amplification. Densely wooded areas, natural and artificial barriers give natural attenuation to sound. Spreading sound in the tree canopy can reduce the effectiveness of barriers. Vertical gradients of wind and temperature refract (curve) the sound trajectories up and down, generating regions of acoustic shadow, altering the interference with the soil and modifying the effectiveness of the barriers.

The attenuation, as the sound propagates from the source, depends on the frequency. Thus, the reduction of the A-weighted total sound level depends on the composition of the sound spectrum.

3.2 Predictor-LimA Software

Predictor-LimA is software for projects and analysis of environmental noise of Brüel & Kjaer. Predictor software was acquired by Brüel & Kjaer in 1997 and software Lim-A was purchased in 2001. Since 2002, Brüel & Kjaer has integrated the intuitive features of Predictor and the flexibility of Lim-A into a single software called Predictor -Lime.

The Predictor-LimA software is a comprehensive acoustic modelling system. It allows you to manipulate and see the effect of changing the physical environment before costly real measurements or contingencies are taken.

The program calculates the noise level on specific locations from specified sources, propagated via intermediate obstacles and media, based on national and international standards. Consequences of noise reduction measures can be rapidly assessed and it is possible to compare calculated, measured and permitted values. Typical uses of Predictor are:

- If a noise source cannot be measured at the preferred distance.
- Prediction of sound pressure levels in the course of new developments.
- Evaluating the impact over time.
- Evaluating alternative plans.

Predictor is a forecast system. The results it produces can only be as good as the environmental noise calculation method that is used. However, Predictor allows you to specify the acoustic properties of model entities (items) to a high degree, thus giving realistic results.

Predictor-LimA is an important tool to assist in assessing noise levels over a wide area and for predicting changes in noise levels due to changes in use. Noise prediction is widely used in all stages of planning of large industrial enterprises, as well as other types of enterprises, such as wind farms. Noise prediction enables the assessment and reporting of changes in noise impact and constitutes an important part of environmental impact evaluation.

From this software it is possible to create noise maps, a fundamental tool for planning actions related to this subject.

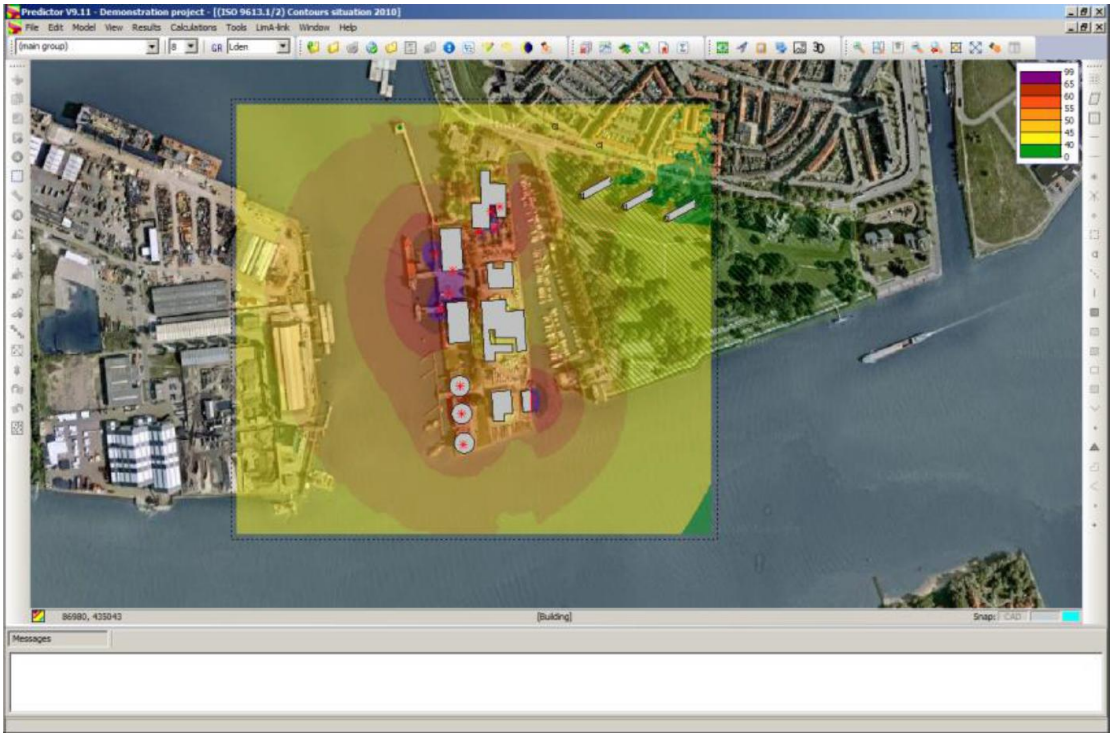

Figure 5 – Screen of the Predictor-LimA software. Source: Brüel & Kjaer (2015).

3.2.1 Calculation Method

The method for calculating outdoor noise attenuation used by the Predictor LimA software is based on the international standards ISO 9613-1 and ISO 9613-2.

ISO 9613-1:1993 – *Attenuation of sound during propagation outdoors - Part 1: Calculation of the absorption of sound by the atmosphere.*

ISO 9613-2:1996 –*Attenuation of sound during propagation outdoors - Part 2: General method of calculation.*

Based on ISO 9613 - 1/2, Predictor calculates the noise level as follows:

$$L_{lt,per} = L_{dw} - C_{m,per} - C_{t,per} \quad (1)$$

$$L_{dw} = L_W + D_c - A \quad (2)$$

$L_{lt,per}$	Long-term average octave (or 1/3-octave) SPL during the evaluation period in dB
L_{dw}	Equivalent continuous downwind octave (or 1/3-octave) SPL in dB
$C_{m,per}$	Meteorological correction during the evaluation period in dB
$C_{t,per}$	Correction for the active time of the source during the evaluation period in dB
L_W	Sound power level in dB(A) per octave (or 1/3-octave)
D_c	Directivity correction in dB
A	Attenuation (octave-band) in dB per octave (or 1/3-octave)

The attenuation A is calculated as follows:

$$A = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{fol} + A_{site} + A_{hous} \quad (3)$$

A_{div}	Geometrical divergence in dB
A_{atm}	Atmospheric absorption in dB/octave (or 1/3-octave)
A_{gr}	Ground effect in dB/octave (or 1/3-octave)
A_{bar}	Screening in dB/octave (or 1/3-octave)
A_{fol}	Attenuation due to foliage in dB/octave (or 1/3-octave)
A_{site}	Attenuation due to installations on an industrial site in dB/octave (or 1/3-octave)
A_{hous}	Attenuation due to housing in dB

3.2.2 Types of Noise Sources

In Predictor LimA software there are 4 different types of noise sources available, as detailed below.

Point or Line Source

A point source is an item used for modelling the sound pressure level emission of various sound sources. This represents the sources of noise whose dimensions are negligible within the scale of the model, having its acoustic power concentrated in a point located in the geometric center of the source, as shown in the following figure.

Figure 6 – Example of point sources (red points).

A line source is an item used for modelling the sound power of industrial line sources with a specific sound power per meter. Line sources use the shape of a polynomial line where each point has its own height. In the following figure is demonstrated this type of source.

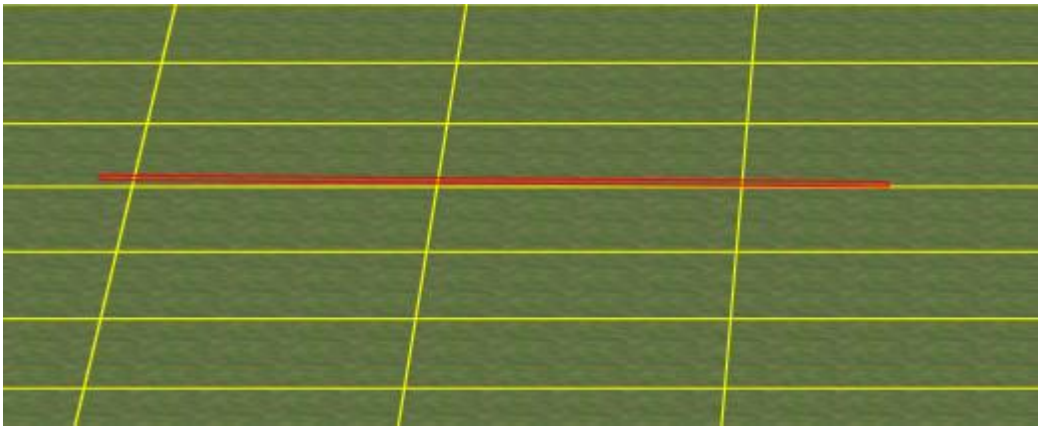

Figure 7 – Example of line source (red line).

Area Source

An area source is an item used for modelling the industrial area sources with a specific sound power per m². An area source is devided into a grid of point sources with equal distances in X- and Y-direction. Area sources are simulated in a combination of emitting source and buildings.

A building is an object, with the shape of a rectangle or a polygon, used for modelling the screening and reflection effects of physical objects like houses and screens. In the following figure is demonstrated this type of source.

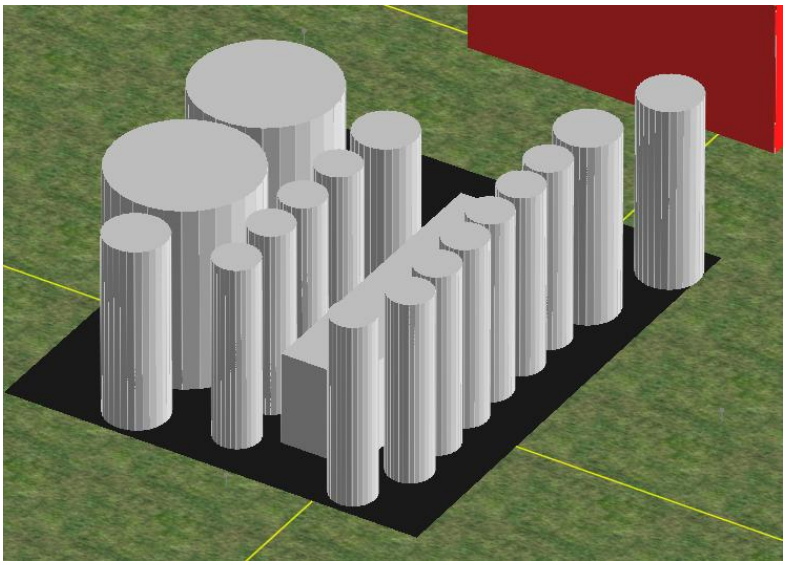

Figure 8 – Example of area source (black line).

Emitting Facade and/or Roof

An emitting roof and an emitting facade are sources which model the noise emitted from industrial buildings. An emitting roof has the shape of a polygon. It is located on top of a building item. An emitting facade use the shape of a line part with two points where each point has its own height. It is located outside a building item, parallel to

one of the sides of the building item. In the following figure is demonstrated this type of source.

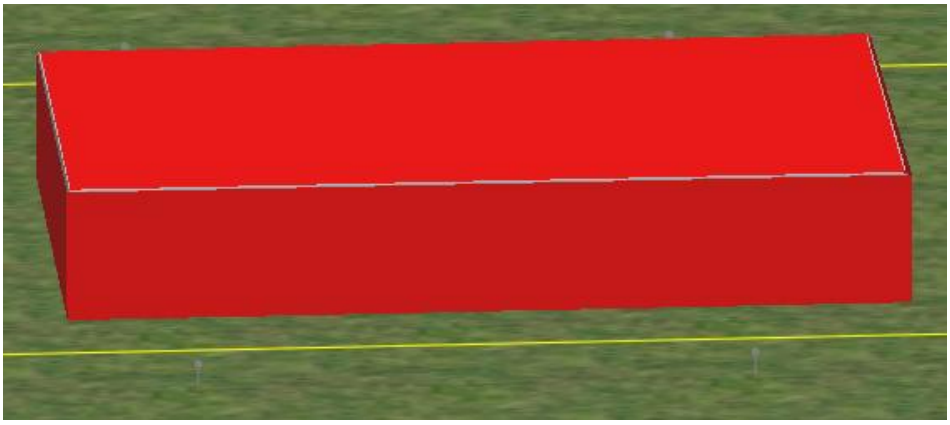

Figure 9 – Example of emitting facade and roof (red areas).

Moving Source

A moving source is used to model the path of mobile sources (e.g. truck routes). A moving source is a polyline, with 2 or more points. Each point can have a different height above ground. In the following figure is demonstrated this type of source.

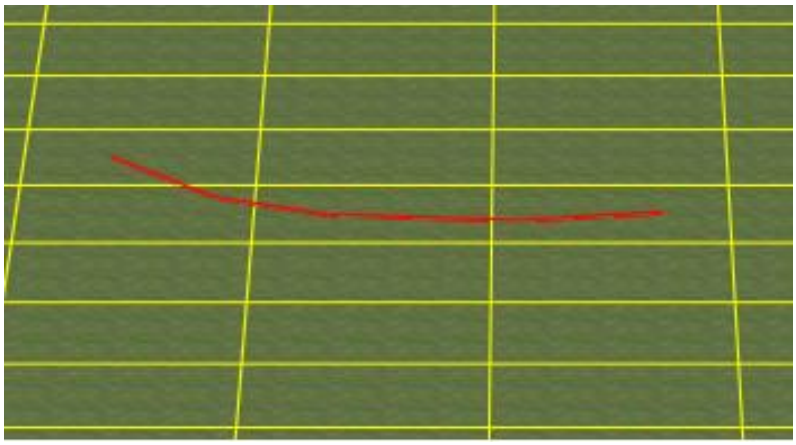

Figure 10 – Example of moving source (red line).

3.2.3 Noise Sources Database

SourceDB + is software for the maintenance of databases with 1/3 octave sound power levels for industrial sources. This software includes image database of machines and equipment as well as linear and area sources. In addition, there is information of the type of industry and the type of fuel for each machine and equipment. The following figures show some screens of the SourceDB + software.

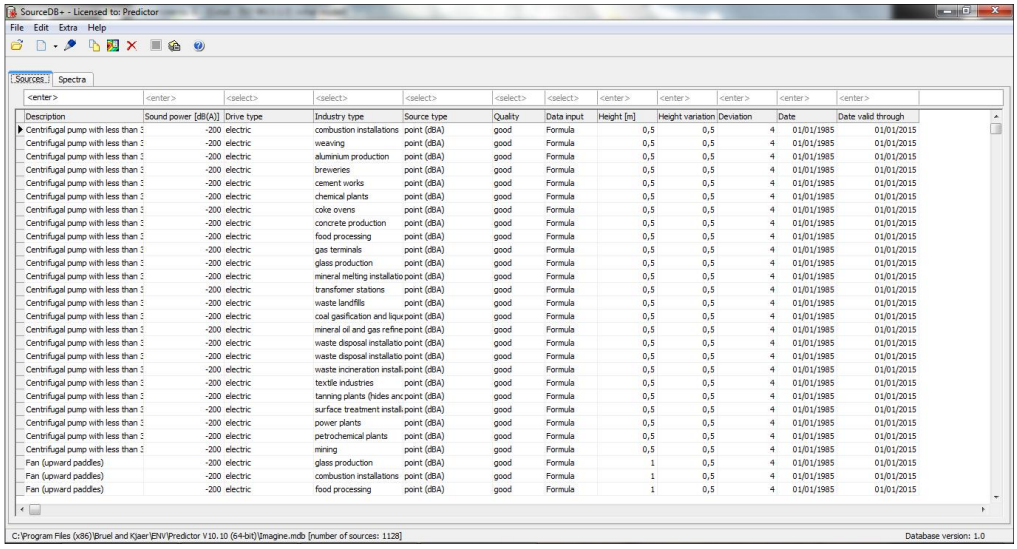

Figure 11 – SourceDB + interface with list of available sources of noise.

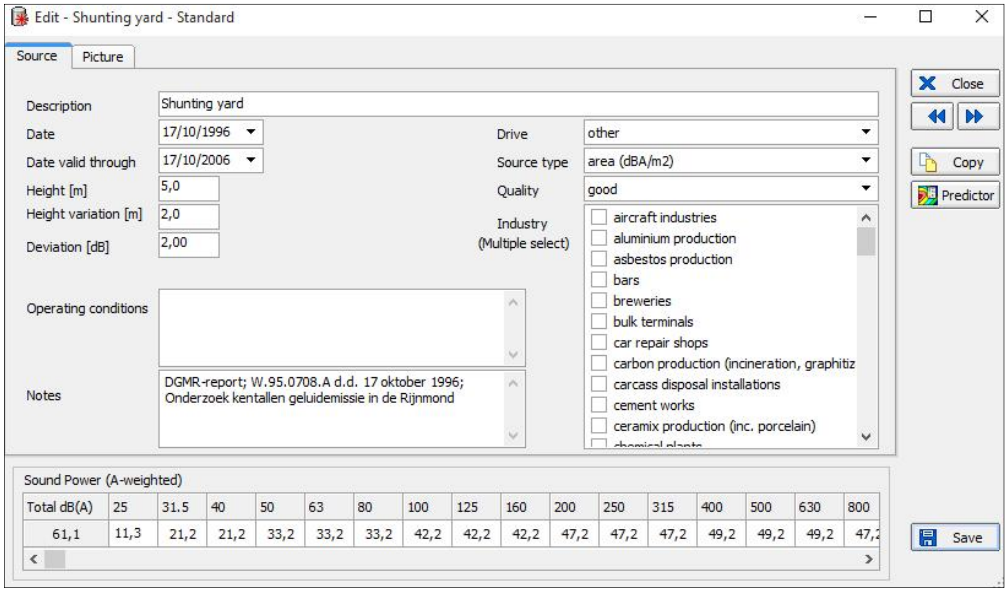

Figure 12 – Data from a selected noise source in SourceDB +.

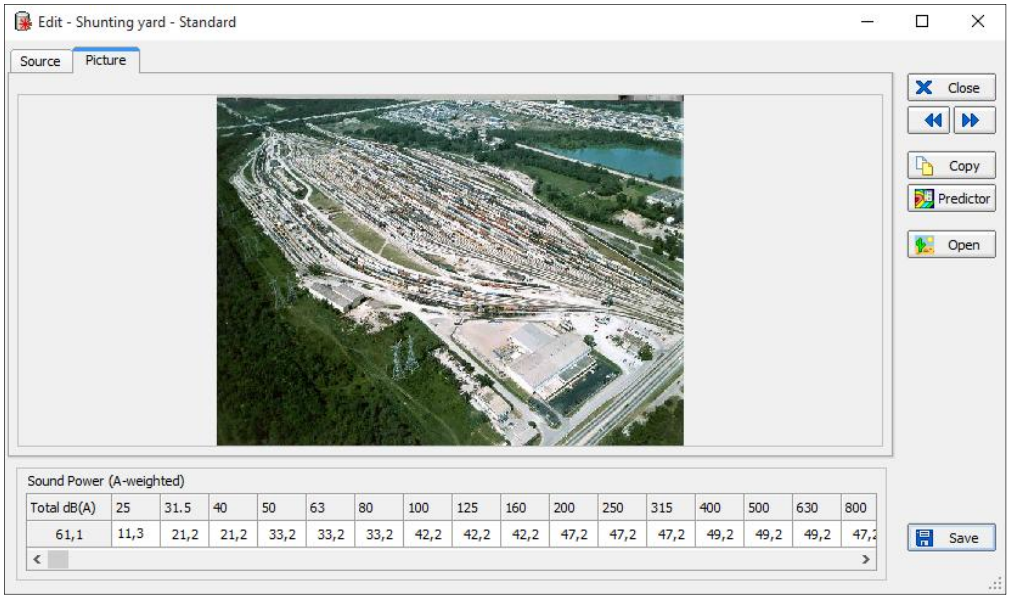

Figure 13 – Picture of a noise source selected in SourceDB +.

3.2.4 Cartesian Grid

The Cartesian grid (point grid) of the Predictor-LimA is called a grid. The grid is a region, in the shape of a rectangle, circle or polygon, used as the basis for the presentation of the isolines (contours) of the simulated sound pressure levels.

All points on a grid will be simulated as an individual point of sound pressure reception (noise).

The grid size (number of simulated points) varies according to the extent of the grid coverage area and the distance between grid points.

The larger the grid size (number of simulated points), the longer the processing time (calculation) of the simulation.

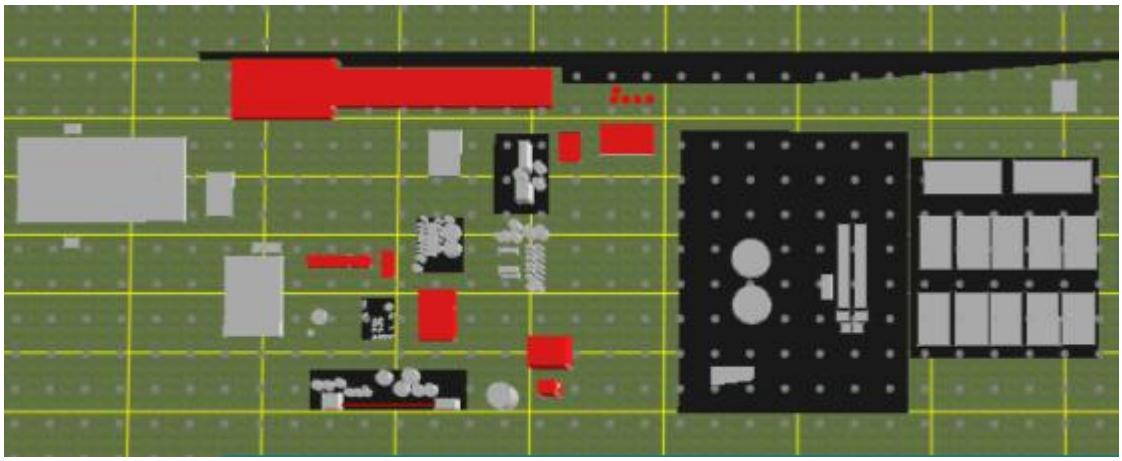

Figure 14 – Example of grid of the *software* Predictor-LimA (gray points).

3.2.5 Periods

In the Predictor-LimA the periods are time intervals within a 24 hour day, starting from hour 0 till hour 23. Usually periods will be based on the evaluation periods as defined by law. Predictor calculates the equivalent sound level for each period. You can define up to four parts of a day as a period, for example: Day, Evening and Night. You have to set the start and end times for each period. In addition a compound period can be defined. This compound period is a calculated value derived from the already specified periods. For each model you can set different periods.

When calculating prediction results for a specific period, only sources that are active during that period are taken into account. If a source is partly active during a period, Predictor will automatically calculate a time reduction for this source. Modifying periods can affect the results.

4 SIMULATION OF THE NOISE PROPAGATION

4.1 Premises

The version of the Predictor LimA software used in this simulation was version V10.13.

The method of calculating the noise attenuation in the open air used by the software Predictor LimA is based on the international standards ISO 9613-1/2.

The version of the SourceDB + software used in this simulation was version V2.02.

The operating regime of the LD CELULOSE soluble cellulose plant will be 24 hours a day, 7 days a week and 12 months a year. The actual production period will be approximately 352 days, considering the annual general maintenance stoppage of the equipment.

Regarding the periods, in this simulation the day and night periods were considered. The time of the daytime period was defined between 06:00 and 22:00 and the time of the night period was defined between 22:00 and 06:00, according to State Law No. 10.100/1990.

As the factory will operate 24 hours a day, it was considered that there will be no significant differences between the daytime and nighttime periods.

In the simulation, a rectangular Cartesian mesh (grid) was considered, centered in the area of the LD CELLULOSE factory.

For this study, 2 scenarios were considered, varying the presence or absence of the shunting yard operation in the area of the factory to run the pulp production.

The simulation was based on 3 types of noise sources available in the model:

- Point or linear source
- Area Source
- Facade and/or roof source

4.2 Dados de Entrada

The input data from the Predictor software are related to meteorological data (humidity, temperature and pressure), Cartesian grid data (size, distance between points and total number of points), to building data, barriers or non-vegetation data. (description and height), data on noise emission sources (description, type, height and sound pressure level in decibels).

In the noise simulation of the present study, the data presented in the following tables were used.

Table 1 – Meteorological conditions

Variable	Unit	Value
Humidity	%	60
Temperature	°C	22,30
Pressure	kPa	92

Table 2 – Cartesian Grid

Variable	Unit	Value
Grid size	km	2,46 x 1,51
Distance between grid points	m	30 x 30
Points in the grid	-	4.233

Table 3 – Buildings, barriers or vegetation (non-noise emitting)

Description	Height
Substation	4 m
Administration buildings	8 m
Maintenance and warehouse building	15 m
Ambulatory and fire protection building	8 m
Oil storage	15m
Diesel oil storage	3m
Laboratory and control room building	8 m
Stack	90 m
Debarking	8 m
Bark storage	36 m
Chip storage	36 m

Description	Height
Chip screening	12 m
Chippers	10 m
Electrical room	4 m
Support truck building	8 m
Wood gate	4 m
Social Gate 2	4 m
Gate 3	4 m
Eucalyptus plantations	18 m

Table 4 – Noise sources

Description	Type de source	Height of the edification	Sound pressure level[1]
Wood yard	Area source	6 m	77,5 dB(A)
Cooking	Area source	60 m	74 dB(A)
Fiber line	Area source	60 m	74 dB(A)
Drying of pulp	Façade and roof source	25 m	74 dB(A)
Pulp Warehouse	Façade and roof source	25 m	58 dB(A)
Evaporation	Area source	30 m	74 dB(A)
Recovery boiler	Façade and roof source	90 m	74 dB(A)
Caustification	Area source	40 m	74 dB(A)
Caustification (lime kiln)	Line source	4 m	99 dB(A)
Chemicals area (pumps)	Point source	-	72,7 dB(A)
Water treatment	Area source	10 m	78 dB(A)
Water treatment for boilers	Area source	8 m	78 dB(A)
Cooling towers	Façade and roof source	20 m	72,7 dB(A)
Compressed air plant (compressor)	Façade and roof source	8 m	74 dB(A)
Plant for oxygen production	Façade and roof source	12 m	74 dB(A)
Ozone production plant	Façade and roof source	12 m	74 dB(A)

Description	Type de source	Height of the edification	Sound pressure level[1]
Power boiler (biomass)	Façade and roof source	90 m	74 dB(A)
Turbogenerator	Façade and roof source	25 m	74 dB(A)
Wastewater treatment	Area source	8 m	78 dB(A)
Waste treatment area	Area source	3 m	74 dB(A)
Shunting yard	Area source	-	65,1 dB(A)

[1] Source: SourceDB + software database.

For this study, 2 scenarios were considered, varying the presence or absence of the shunting yard operation in the area of the factory to run the pulp production.

Table 5 - Scenarios evaluated in the present study

Table 5 – Scenarios evaluated in the present study

Scenario nº	Shunting Yard operation in the mill area
1	Absent
2	Present

4.3 Results of Evaluated Scenarios

4.3.1 Scenario 1 (No Shunting Yard Operation)

In this scenario, the sound pressure levels predicted in the future operation of the project were evaluated without the shunting yard operation in the area of the mill to transport the pulp production.

The simulation results showed that the sound pressure levels reached maximum values in the range between 80 and 90 dB (A). Some sound pressure levels, outside the site boundaries of the LD CELULOSE plant, reached values close to 70 dB (A). However, the vast majority of sound pressure levels outside the site are below 60 dB (A), as shown in the figures below.

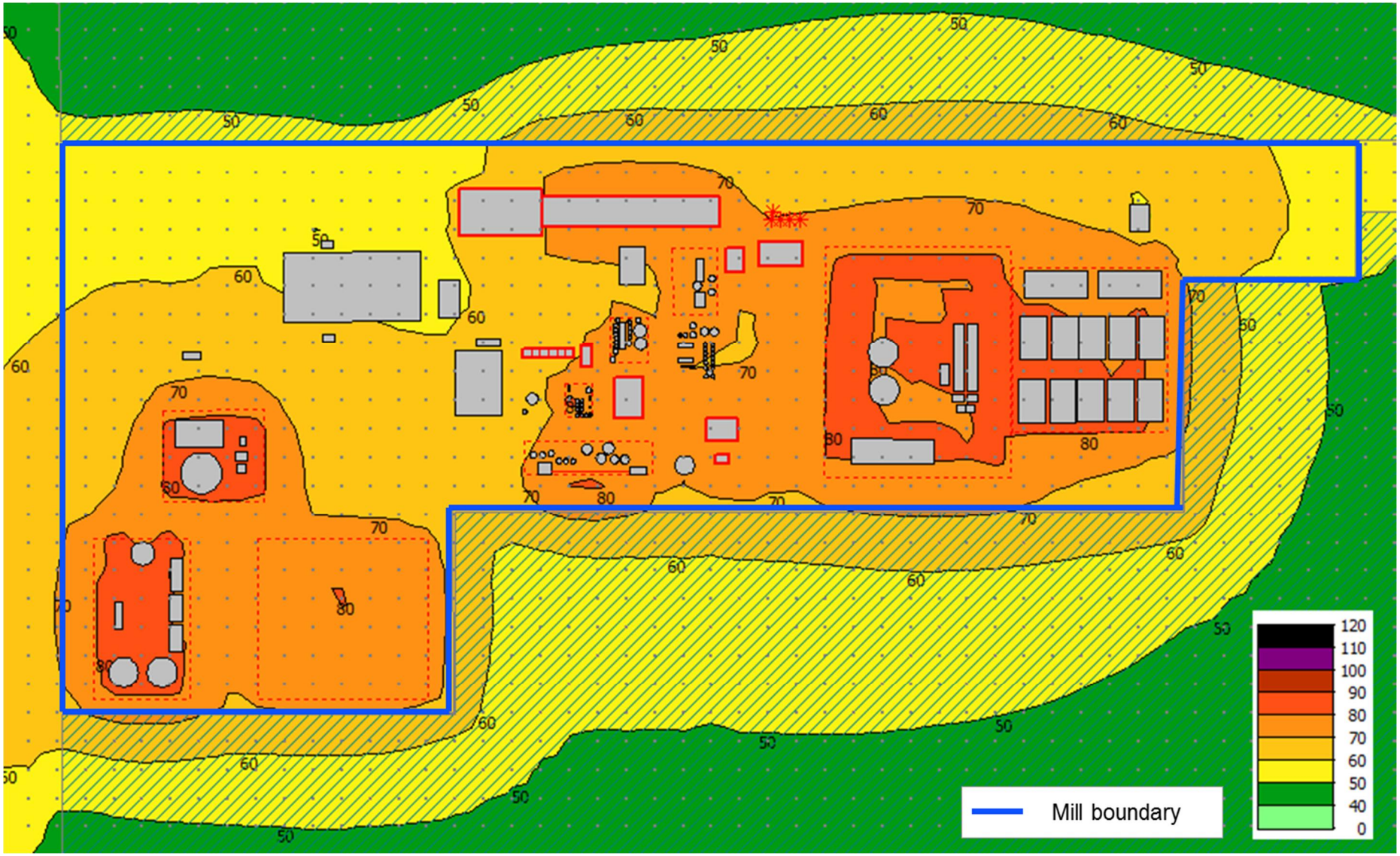

Figure 15 – Results of the scenario 1 (No Shunting Yard Operation).

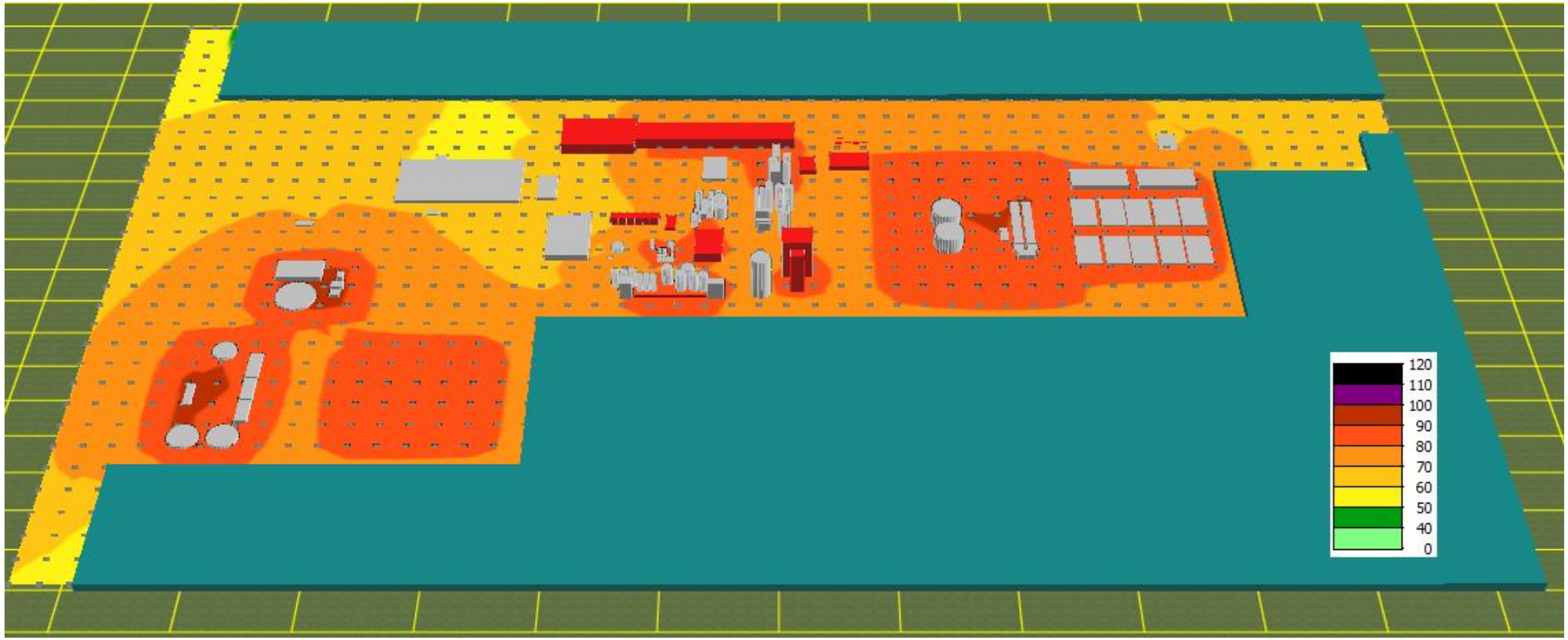

Figure 16 – Results of the scenario 1 – 3D vision.

4.3.2 Scenario 2 (Included Shunting Yard Operation)

In this scenario, the sound pressure levels predicted in the future operation of the project were evaluated with the shunting yard operation in the area of the mill to transport the pulp production.

The simulation results showed that the sound pressure levels reached maximum values in the range between 80 and 90 dB (A). Some sound pressure levels, outside the site boundaries of the LD CELULOSE plant, reached values close to 70 dB (A). However, the vast majority of sound pressure levels outside the site are below 60 dB (A), as shown in the figures below.

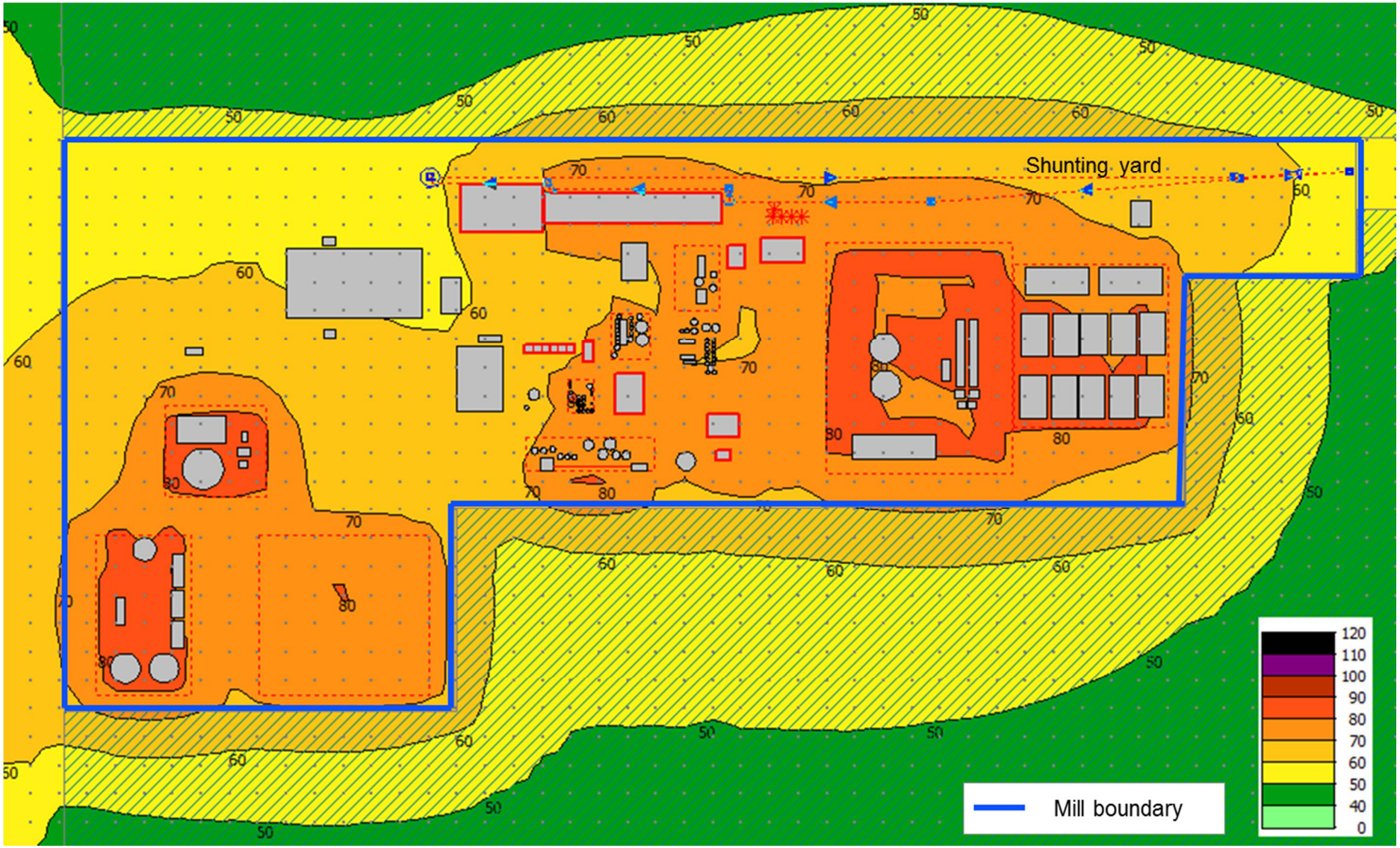

Figure 17 – Results of the scenario 2 (Included Shunting Yard Operation).

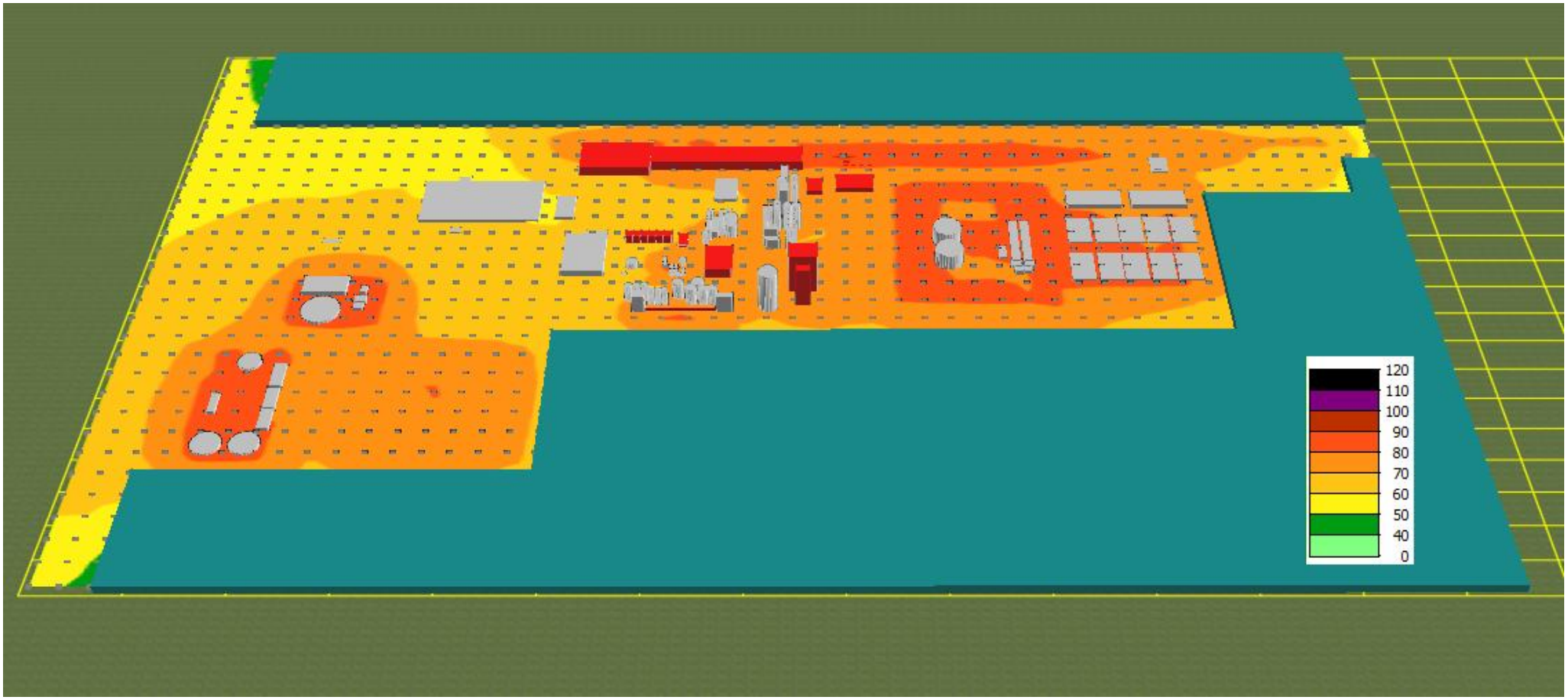

Figure 18 – Results of the scenario 2 – 3D vision.

5 CONCLUSIONS

For this study, 2 scenarios were considered, varying the presence or absence of the shunting yard operation in the area of the factory to transport the pulp production.

In this study, the prediction of the sound pressure levels (noise) to be emitted in the operation of the future dissolving pulp mill of LD CELULOSE was verified, compared to the level of the evaluation criterion (NCA) established by Standard NBR 10.151/2000 and the standards established by State Law No. 7302/1978 and its amendments.

In Scenario 1, which does not include the rail operation in the plant area, it was found that some sound pressure levels, outside the limits of the site boundaries of the LD CELULOSE plant, reached values close to 70 dB (A). However, the vast majority of sound pressure levels outside the limits of the site are below 60 dB (A).

In Scenario 2, which contemplates the shunting yard operation in the plant area for the disposal of pulp production, considered the most critical scenario, it was also verified that some sound pressure levels, outside the limits of the site boundaries of the LD CELULOSE plant, reached values close to 70 dB (A). However, the vast majority sound pressure levels outside the limits of the site are below 60 dB (A).

Overall, in both Scenario 1 (without rail operation) and Scenario 2 (with rail operation), the values of the sound pressure levels in the outside the site boundaries are slightly above that established by Standard NBR 10.151/2000 and by State Law No. 7302/1978 and its amendments, that is, 70 dB (A) for the daytime period and 60 dB (A) for the night period.

It is noted that in the vicinity of the site there is no population agglomeration, being the nearest (urban area of the municipality of Indianópolis-MG) located approximately 20 km. In the area surrounding the site, the land occupation refers mainly to the agricultural and forestry plantations of Duratex Florestal.

It is important to note that the site of the LD CELULOSE plant is located inside the Fazenda Nova Monte Carmelo, leased to Duratex Florestal.

Regarding to the shunting yard operation in the area of the mill, it is noted that in the region there is the Ferrovia Centro Atlântica (FCA), which runs alongside the site. In this way, the noise related to the shunting yard operation is already part of the environmental noise of the region. The arrival of train composition at the mill will take place at most once a day.

It can be concluded from the simulations carried out in the present study that the sound pressure levels related to the operation of the dissolving pulp mill of LD CELULOSE will not cause any inconvenience, since there is no population agglomeration around the enterprise.

The use of software for noise simulation of a future enterprise is an important tool to assist in the evaluation of possible impacts, but it is always important to emphasize that it is a forecast, which must be evaluated later by means of environmental noise monitoring.

6 REFERENCES

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MINAS GERAIS. State Law No. 10100/1990 – Provisions on protection against noise pollution in the State of Minas Gerais.

MINAS GERAIS. State Law No. 7302/1978 – Provides for protection against noise pollution in the state of Minas Gerais.

MMA. CONAMA Resolution No. 01/1990 – Provides criteria for noise emission standards arising from any industrial activities.

ANNEX I
MILL LAYOUT

REVISION TABLE

CODE:
PR -PRELIMINARY
PA -FOR APPROVAL
PI -FOR INFORMATION
PC -FOR QUOTATION
CO-FOR COMMENTS
LE -RELEASED FOR CONSTRUCTION
LD -RELEASED FOR DETAILING
CC -AS BUILT
CA -CANCELED

REV.	DATE	PROJ.	VERIF.	APPROV.	AUTHOR.	CODE	DESCRIPTION
0							

NOTAS:

LEGENDA:
- ÁREAS DE PROCESSO
- UTILIDADES E BALANÇO DA PLANTA
- QUÍMICOS
- PRÉDIOS NÃO PROCESSOS
- FUTURO
- LIMITE DO SITE

ITEM PENDENTE:

REFERENCE DOCUMENTS

TITLE	NUMBER

DISTRIBUTION

TO	REVISION 0	a	b	c	d	e	f
AMADEUS	E						
PÖYRY	E						

N- PRINT/PLOT (HARD COPY) E- ELECTRONIC FILE

PRELIMINARY

PÖYRY

PROJETO AMADEUS
Fábrica de celulose solúvel
Minas Gerais - Brazil

RESP./TITLE/CREA NUMBER | CUSTOMER NUMBER | REV.

TITLE
LAYOUT GERAL DA FÁBRICA

SCALE 1:2000 | UNIT mm | PROJECTION | PÖYRY NUMBER | REV.