Financed under a specific grant agreement no 2018/402-850 from EU IPA II Multi-Beneficiary Programme for Albania, Bosnia and Herzegovina, North Macedonia, Kosovo*, Montenegro and Serbia

Western Balkans Investment Framework Infrastructure Project Facility Technical Assistance 8 (IPF 8)

TA2018148R0 IPA

Mediterranean Corridor, Bosnia and Herzegovina - Croatia CVc Road Interconnection, Subsection: Konjic (Ovcari) - Prenj Tunnel - Mostar North

Gap Analysis & ESIA Disclosure Pack

WB20-BiH-TRA-02 Component 1

Volume 1: Environmental and Social Impact Assessment Report

Chapter 11 Noise

December 2025

COWI | IPF

Western Balkans Investment Framework (WBIF)

Infrastructure Project Facility Technical Assistance 8 (IPF 8)

Infrastructures: Energy, Environment, Social, Transport and Digital Economy

TA2018148 R0 IPA

Volume 1: Environmental and Social Impact Assessment Report

Chapter 11 Noise

December 2025

The Infrastructure Project Facility (IPF) is a technical assistance instrument of the Western Balkans Investment Framework (WBIF) which is a joint initiative of the European Union, International Financial Institutions, bilateral donors and the governments of the Western Balkans which supports socio-economic development and EU accession across the Western Balkans through the provision of finance and technical assistance for strategic infrastructure investments. This technical assistance operation is financed with EU funds.
Disclaimer: *The authors take full responsibility for the contents of this report. The opinions expressed do not necessarily reflect the view of the European Union or the European Investment Bank.*

PROJECT NO.	DOCUMENT NO.
	WB20-BiH-TRA-02

VERSION	DATE OF ISSUE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1	2/09/2021	ESIA Report	Alexandros Galatas	Irem Silajdžić Konstantin Siderovski	Richard Thadani
2	21/11/2022	ESIA Report – Chapter 11 Noise	Alexandros Galatas	Irem Silajdžić	Richard Thadani
3	03/03/2023	ESIA Report – Chapter 11 Noise	Alexandros Galatas	Irem Silajdžić	Richard Thadani
4	10/10/2023	ESIA Report – Chapter 11 Noise	Alexandros Galatas	Irem Silajdžić	Richard Thadani
5	06/01/2025	ESIA Report – Chapter 11 Noise	Alexandros Galatas	Irem Silajdžić	Richard Thadani
6	01/08/2025	ESIA Report – Chapter 11 Noise	Alexandros Galatas	Irem Silajdžić	Richard Thadani
7	31/12/2025	ESIA Report – Chapter 11 Noise	Alexandros Galatas	Irem Silajdžić	Richard Thadani

CONTENTS

List of tables

List of figures

11 Noise

11.1 Introduction

This chapter reports findings of the assessment of the potential noise impacts during both the construction and operational phases.

The chapter includes a brief introduction to road traffic noise, a description of the possible noise mitigation measures for motorways and their efficiency and the outcomes of the analysis for the area under study. Finally, the specific and optimum noise mitigation measures to comply with national, European, and international standards are identified.

All the available Project data needed for the calculation of the noise nuisance have been collected, such as the vehicle circulation for various load scenarios, the detailed designs of the new motorway, the topographical data at the vicinity of the project etc.

This chapter should be read in conjunction with the following chapters:

Chapter 1	Introduction
Chapter 2	About the Project
Chapter 3	Detailed Project description
Chapter 4	Policy, legislative and institutional context
Chapter 5	Assessment methodology
Chapter 17	Cumulative impacts
Chapter 18	Residual impacts
Chapter 19	ESMP.

11.2 Baseline Conditions

The level of noise emissions of the existing road and rail infrastructure is not well known because there aren't strategic noise maps for these objects in BiH. Also, the Municipality of Mostar and Konjic do not have noise maps on which the noise level in the areas of intervention could be observed.

In order to determine baseline noise in the project area the monitoring was performed along the main motorway route, the Konjic bypass and access roads to the Prenj Tunnel.

<u>Main motorway route</u>

Environmental noise measurements were performed along the proposed main alignment at seven locations during March 2021 and seven locations during July 2021. The measurements were carried out by accredited test laboratory ZAGREBINSPEKT Ltd., Mostar. The measurement methodology follows the guidelines of European Directive for Environmental noise 49/2002.

The locations for the measurements have been selected with the criteria to be close to the new motorway and in locations where houses or buildings are nearby i.e., in a distance less than 150 m. More specifically, the measurement points which were selected are shown in the following table and figures.

Table 11-1: Description of measuring points near main motorway route

Ordinal number	Description of the MP	Location
MP 1 – Ovcari	Ovcari settlement at the beginning of the route, to the left of the M17 before entering Konjic	N: 43° 40' 9,75" E: 17° 58' 36,01"
MP 2 – Polje Bijela	Near river Neretva, after the Viaduct No. 4 in Polje Bijela	N: 43° 38' 0,57" E: 17° 58' 37,87"
MP 3 – Bijela	Near the motorway alignment in Bijela settlement	N: 43° 37' 27,77" E: 17° 58' 9,80"
MP 4 – Podgorani	Houses closest to the alignment in the Podgorani settlement	N: 43° 27' 47,24" E: 17° 53' 23,78"
MP 5 – R435a	Next to the road R435a towards Rujiste near the house closest to the alignment	N: 43° 26' 27,66" E: 17° 54' 34,63"
MP 6 – Bijela	Bijela settlement near the houses closest to the alignment	N: 43° 36' 7,81" E: 17° 56' 50,20"
MP 7 – Kutilivac	At the end of the route, just before Mostar North Interchange	N: 43° 23' 33,05" E: 17° 54' 3,59"

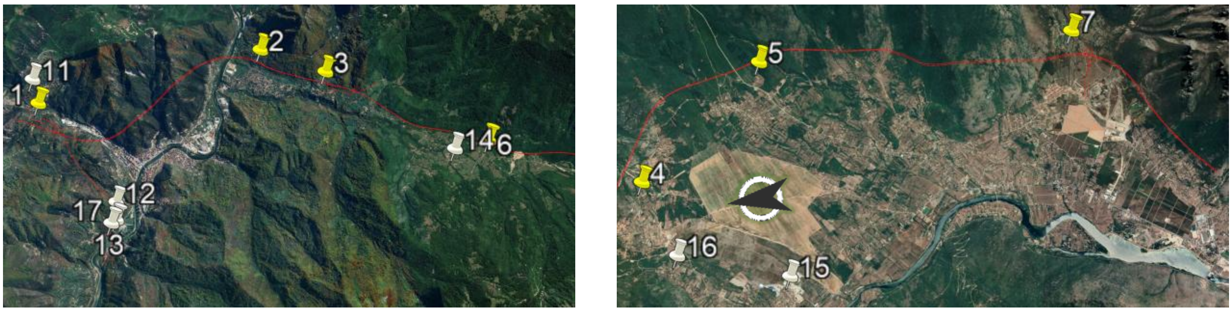


Figure 11-1: Environmental Noise Measurement locations and alignment

The results of outdoor baseline noise measurements are presented in tables below.

Table 11-2: Results of noise measurements in March at the location MP 1

<table>
<tr><th>Measurement point</th><th colspan="4">Description of measuring and working conditions</th><th>Time</th></tr>
<tr><td rowspan="3">MP 1</td><td colspan="4">Ovcari settlement at the beginning of the section, left from M17 before entrance to Konjic
N: 43° 40' 9,75" E: 17° 58' 36,01"</td><td>16.3.-17.3.2021.</td></tr>
<tr><td colspan="4">Noise level and the adjustment in dB(A)</td><td rowspan="2">09:18-09:23</td></tr>
<tr><td>Energy average value</td><td>Adjust ment</td><td>Rating level</td><td>Limit value</td></tr>
</table>

Measurement point	Description of measuring and working conditions									Time
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	60.1	72.5	-	-	60.1	72.5	65.0	80.0	
								60.0	80.0	

Limit values are shown for day and night period

Table 11-3: Detailed representation of acoustic parameters for MP 1

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
60.1	87.2	32.2	72.5	60.4	59.9	45.4	40.4	39.4	37.2

Table 11-4: Results of noise measurements in March at the location MP 2

Measurement point	Description of measuring and working conditions									Time
MP 2	Polje Bijela settlement N: 43° 38' 0,57" E: 17° 58' 37,87"									19.3.-20.3.2021. 09:51-10:08
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	54.8	66.0	-	-	54.8	66.0	60.0	75.0	
								50.0	70.0	

Limit values are shown for day and night period

Table 11-5: Detailed representation of acoustic parameters for MP 2

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
54.8	86.6	39.2	66.0	59.9	56.7	44.6	42.3	41.8	41.0

Table 11-6: Results of noise measurements in March at the location MP 3

Measurement point	Description of measuring and working conditions	Time
MP 3	Near Mladeskovici settlement N: 43° 37' 27,77" E: 17° 58' 9,80"	20.3.-21.3.2021.
	Noise level and the adjustment in dB(A)	

Measurement point	Description of measuring and working conditions									Time
	Energy average value			Adjustment		Rating level		Limit value		11:43-11:43
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	56.8	68.9	-	-	56.8	68.9	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-7: Detailed representation of acoustic parameters for MP 3

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
56.8	84.4	27.9	68.9	61.7	58.0	43.5	32.1	31.3	40.1

Table 11-8: Results of noise measurements in March at the location MP 4 – main motorway route

Measurement point	Description of measuring and working conditions									Time
MP 4	Podgorani settlement N: 43° 27' 47,24" E: 17° 53' 23,78"									23.3.-24.3.2021. 18:42-18:42
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	55.9	63.1	-	-	55.9	63.1	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-9: Detailed representation of acoustic parameters for MP 4 – main motorway route

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
55.9	92.5	21.6	63.1	59.5	57.7	45.0	26.7	25.6	24.3

Table 11-10: Results of noise measurements in March at the location MP 5 – main motorway route

Measurement point	Description of measuring and working conditions	Time
MP 5	Humilisani settlement	

Measurement point	Description of measuring and working conditions									Time
	N: 43° 26' 27,66" E: 17° 54' 34,63"									22.3.-23.3.2021. 17:55-18:07
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	55.3	62.7	-	-	55.3	62.7	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-11: Detailed representation of acoustic parameters for MP 5 – main motorway route

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
55.3	90.3	35.6	62.7	57.8	53.6	43.5	39.0	38.2	37.3

Table 11-12: Results of noise measurements in March at the location MP 6

Measurement point	Description of measuring and working conditions									Time
MP 6	Bijela settlement N: 43° 36' 7,81" E: 17° 56' 50,50"									21.3.-22.3.2021. 14:38-14:38
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	52.3	63.0	-	-	52.3	63.0	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-13: Detailed representation of acoustic parameters for MP 6

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
52.3	81.5	31.0	63.0	58.9	54.8	36.5	32.9	32.6	32.2

Table 11-14: Results of noise measurements in March at the location MP 7

Measurement point	Description of measuring and working conditions									Time
MP 7	Kutilivac settlement N: 43° 23' 33,05" E: 17° 54' 3,59"									24.3.-25.3.2021. 19:55-19:55
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	48.8	59.0	-	-	48.8	59.0	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-15: Detailed representation of acoustic parameters for MP 7

LA$_{eq}$ (dB)	LAF$_{MAX}$ (dB)	LAF$_{MIN}$ (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
48.8	80.0	23.8	59.0	53.6	51.4	36.0	29.2	28.1	26.5

Table 11-16: Results of noise measurements in July at the location MP 1

Measurement point	Description of measuring and working conditions									Time
MP 1	Ovcari settlement at the beginning of the section, left from M17 before entrance to Konjic N: 43° 40' 9,75" E: 17° 58' 36,01"									16.7.-17.7.2021. 08:15-08:15
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	59.7	73.1	-	-	59.7	73.1	65.0	80.0	
								60.0	80.0	

**Limit values are shown for day and night period*

Table 11-17: Detailed representation of acoustic parameters for MP 1

LA$_{eq}$ (dB)	LAF$_{MAX}$ (dB)	LAF$_{MIN}$ (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
59.7	89.2	35.2	73.1	61.5	59.7	49.8	40.3	39.3	37.7

Table 11-18: Results of noise measurements in July at the location MP 2

<table>
<tr><th>Measurement point</th><th colspan="9">Description of measuring and working conditions</th><th>Time</th></tr>
<tr><td rowspan="7">MP 2</td><td colspan="9">Polje Bijela settlement
N: 43° 38' 0,57"
E: 17° 58' 37,87"</td><td rowspan="7">17.7.-
18.7.2021.

09:22-09:22</td></tr>
<tr><td colspan="9">Noise level and the adjustment in dB(A)</td></tr>
<tr><td colspan="3">Energy average value</td><td colspan="2">Adjustment</td><td colspan="2">Rating level</td><td colspan="2">Limit value</td></tr>
<tr><td>L_{rezid}</td><td>L_{eq}</td><td>$L_{1\%}$</td><td>K_T</td><td>K_I</td><td>L_{Req}</td><td>$L_{R1\%}$</td><td>L_{Req}</td><td>$L_{R1\%}$</td></tr>
<tr><td rowspan="2">-</td><td rowspan="2">63.9</td><td rowspan="2">71.5</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">63.9</td><td rowspan="2">71.5</td><td>60.0</td><td>75.0</td></tr>
<tr><td>50.0</td><td>70.0</td></tr>
</table>

**Limit values are shown for day and night period*

Table 11-19: Detailed representation of acoustic parameters for MP 2

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
63.9	104.2	40.0	71.5	63.4	59.6	49.1	45.1	44.0	42.5

Table 11-20: Results of noise measurements in July at the location MP 3

<table>
<tr><th>Measurement point</th><th colspan="9">Description of measuring and working conditions</th><th>Time</th></tr>
<tr><td rowspan="7">MP 3</td><td colspan="9">Near Mladeskovici settlement
N: 43° 37' 27,77"
E: 17° 58' 9,80"</td><td rowspan="7">18.7.-
19.7.2021.

10:01-10:01</td></tr>
<tr><td colspan="9">Noise level and the adjustment in dB(A)</td></tr>
<tr><td colspan="3">Energy average value</td><td colspan="2">Adjustment</td><td colspan="2">Rating level</td><td colspan="2">Limit value</td></tr>
<tr><td>L_{rezid}</td><td>L_{eq}</td><td>$L_{1\%}$</td><td>K_T</td><td>K_I</td><td>L_{Req}</td><td>$L_{R1\%}$</td><td>L_{Req}</td><td>$L_{R1\%}$</td></tr>
<tr><td rowspan="2">-</td><td rowspan="2">59.1</td><td rowspan="2">71.9</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">59.1</td><td rowspan="2">71.9</td><td>60.0</td><td>75.0</td></tr>
<tr><td>50.0</td><td>75.0</td></tr>
</table>

**Limit values are shown for day and night period*

Table 11-21: Detailed representation of acoustic parameters for MP 3

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
59.1	89.6	26.9	71.9	65.0	59.1	42.4	34.6	33.2	30.7

Table 11-22: Results of noise measurements in July at the location MP 4

Measurement point	Description of measuring and working conditions									Time
MP 4	Podgorani settlement N: 43° 27' 47,24" E: 17° 53' 23,78"									26.7.-27.7.2021. 10:30-10:30
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	60.2	65.8	-	-	60.2	65.8	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-23: Detailed representation of acoustic parameters for MP 4

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
60.2	98.6	32.4	65.8	61.0	57.7	42.5	37.2	36.4	34.9

Table 11-24: Results of noise measurements in July at the location MP 5

Measurement point	Description of measuring and working conditions									Time
MP 5	Humilisani settlement N: 43° 26' 27,66" E: 17° 54' 34,63"									25.7.-26.7.2021. 08:25-08:25
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	59.3	66.4	-	-	59.3	66.4	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-25: Detailed representation of acoustic parameters for MP 5

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
59.3	86.0	49.1	66.4	63.2	61.7	57.5	53.6	52.8	51.5

Table 11-26: Results of noise measurements in July at the location MP 6 – main motorway route

Measurement point	Description of measuring and working conditions									Time
MP 6	Bijela settlement N: 43° 36' 7,81" E: 17° 56' 50,50"									23.7.-24.7.2021. 07:19-07:19
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	47.2	58.9	-	-	47.2	58.9	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-27: Detailed representation of acoustic parameters for MP 6

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
47.2	81.5	21.1	58.9	46.9	41.2	32.1	26.1	25.0	23.4

Table 11-28: Results of noise measurements in July at the location MP 7

Measurement point	Description of measuring and working conditions									Time
MP 7	Kutilivac settlement N: 43° 23' 33,05" E: 17° 54' 3,59"									27.7.-28.7.2021. 11:07-11:07
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	58.2	64.7	-	-	58.2	64.7	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-29: Detailed representation of acoustic parameters for MP

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
58.2	79.0	36.5	64.7	62.1	60.8	57.4	47.1	44.2	39.8

Based on the compiled and analysed data from the field during both winter (March) and summer (July) period, it can be stated that the results of measurements correspond to the acoustic requirements defined by the *Law on Noise Protection*[1]. Acoustic parameters LAeq i LA1% are compared with limit values for area V in the settlement Ovcari (MP 1), and with limit values for area IV in the rest of the measuring points in accordance with the *Law on Noise Protection.*

<u>South Connection to the Main Road M17 (Konjic Bypass)</u>

Environmental noise measurements at the planned route of Konjic Bypass were performed along the proposed alignment at three locations during June 2022. The measurements were carried out by accredited test laboratory ZAGREBINSPEKT Ltd., Mostar. The measurement methodology follows the guidelines of European Directive for Environmental noise 49/2002.

The locations for the measurements have been selected with the criteria to be close to the new road and in locations where houses or buildings are nearby i.e., in a distance less than 150 m. More specifically, the measurement points which were selected are shown in the following tables and figures.

Table 11-30: Description of measuring points near Konjic Bypass

Ordinal number	Description of the MP	Location
MP 1 – Ovcari	Ovcari settlement at the beginning of the route	N: 43°40'9.69" E: 17°58'55.07"
MP 2 – Donje Selo	Near houses which are next to the planned Konjic Bypass in Donje Selo settlement	N: 43°39'39.03" E: 17°57'7.38"
MP 3 – Donje Selo	Near river Neretva in Donje Selo settlement	N: 43°39'44.85" E: 17°56'52.27"

[1] Official Gazette of FBiH, No. 110/12

Figure 11-2: Ovcari settlement at the beginning of the route

Figure 11-3: Near houses which are next to the planned Konjic Bypass in Donje Selo settlement

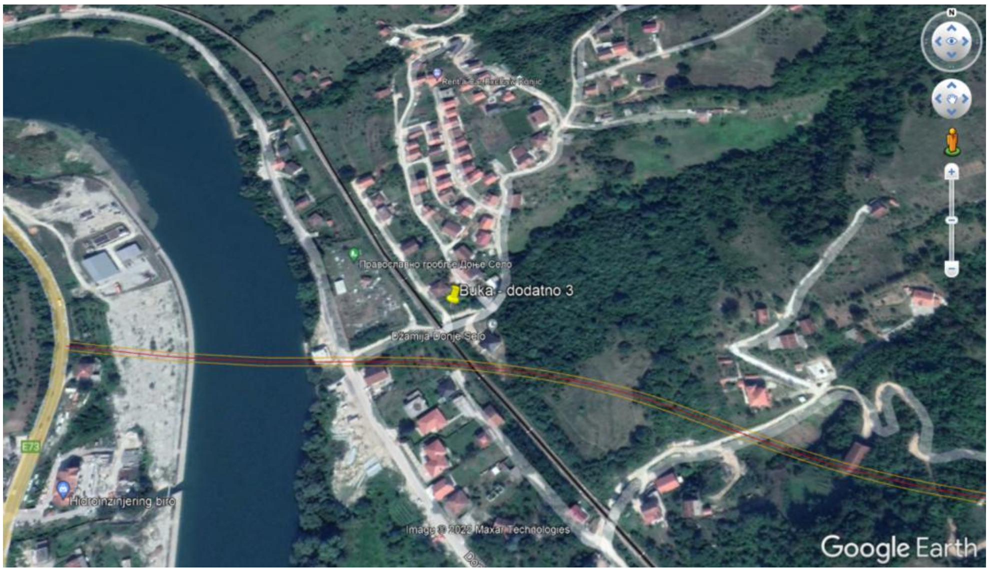


Figure 11-4: Near river Neretva in Donje Selo settlement

The results of outdoor baseline noise measurements are presented in tables below.

Table 11-31: Results of noise measurements at the location MP 1

<table>
<tr><th>Measurement point</th><th colspan="9">Description of measuring and working conditions</th><th>Time</th></tr>
<tr><td rowspan="6">MP 1</td><td colspan="9">Noise emission was recorded near Ovcari settlement
43° 40’ 9,69” N
17° 58’ 55,07” E</td><td rowspan="6">13.6.-14.6.2022.

08:25-08:25</td></tr>
<tr><td colspan="9">Noise level and the adjustment in dB(A)</td></tr>
<tr><td colspan="3">Energy average value</td><td colspan="2">Adjustment</td><td colspan="2">Rating level</td><td colspan="2">Limit value</td></tr>
<tr><td>L_{rezid}</td><td>L_{eq}</td><td>$L_{1\%}$</td><td>K_T</td><td>K_I</td><td>L_{Req}</td><td>$L_{R1\%}$</td><td>L_{Req}</td><td>$L_{R1\%}$</td></tr>
<tr><td rowspan="2">-</td><td rowspan="2">53.6</td><td rowspan="2">63.5</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">53.6</td><td rowspan="2">63.5</td><td>60.0</td><td>75.0</td></tr>
<tr><td>50.0</td><td>75.0</td></tr>
</table>

**Limit values are shown for day and night period*

Table 11-32: Detailed representation of acoustic parameters for MP 1

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
53.6	84.2	23.6	63.5	59.0	57.1	43.4	37.1	35.7	33.6

Table 11-33: Results of noise measurements at the location MP 2

Measurement point	Description of measuring and working conditions									Time
MP 2	Noise emission was recorded near Donje Selo settlement 43° 39' 39,03" N 17° 57' 7,38" E									18.6.-19.6.2022. 08:15-08:15
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	49.7	60.8	-	-	49.7	60.8	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-34: Detailed representation of acoustic parameters for MP 2

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
49.7	77.5	29.4	63.8	56.8	54.6	40.4	35.2	34.3	32.7

Table 11-35: Results of noise measurements at the location MP 3

Measurement point	Description of measuring and working conditions									Time
MP 3	Noise emission was recorded near Donje Selo settlement 43° 39' 44,85" N 17° 56' 52,27" E									19.6.-20.6.2022. 10:04-10:04
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	61.5	67.5	-	-	61.5	67.5	65.0	80.0	
								60.0	80.0	

**Limit values are shown for day and night period*

Table 11-36: Detailed representation of acoustic parameters for MP 3

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
61.5	96.4	34.6	67.5	59.4	57.2	46.3	41.2	40.1	38.3

Based on the compiled and analysed data from the field, it can be stated that the results of measurements correspond to the acoustic requirements defined by the *Law on Noise Protection*[2]. Acoustic parameters LAeq i LA1% are compared with limit values for area V in the settlement Ovcari (MP 1), and with limit values for area IV in the rest of the measuring points in accordance with the *Law on Noise Protection.*

Access roads to the Prenj Tunnel

Environmental noise measurements at the planned access roads were performed along the proposed alignment at three locations during June 2022. The measurements were carried out by accredited test laboratory ZAGREBINSPEKT Ltd., Mostar. The measurement methodology follows the guidelines of European Directive for Environmental noise 49/2002.

The locations for the measurements have been selected with the criteria to be close to the new road and in locations where houses or buildings are nearby i.e., in a distance less than 150 m. More specifically, the measurement points which were selected are shown in the following tables and figures.

Table 11-37: Description of measuring points near access roads to Prenj Tunnel

Ordinal number	Description of the MP	Location
MP 1 - Bijela	Bijela settlement	N: 43°36'27.03" E: 17°56'49.64"
MP 2 – HP Investing	Near HP Investing industrial site in Prigradjani	N: 43°26'38.73" E: 17°51'46.13"
MP 3 – Prigradjani	Houses near the southern access road in Prigradjani	N: 43°27'37.65" E: 17°52'22.04"
MP 4	Near river Neretva at the beginning of southern access road	N: 43°39'41.63" E: 17°56'54.21"

[2] Official Gazette of FBiH, No. 110/12

Figure 11-5: Bijela settlement

Figure 11-6: Near HP Investing industrial site in Prigradjani

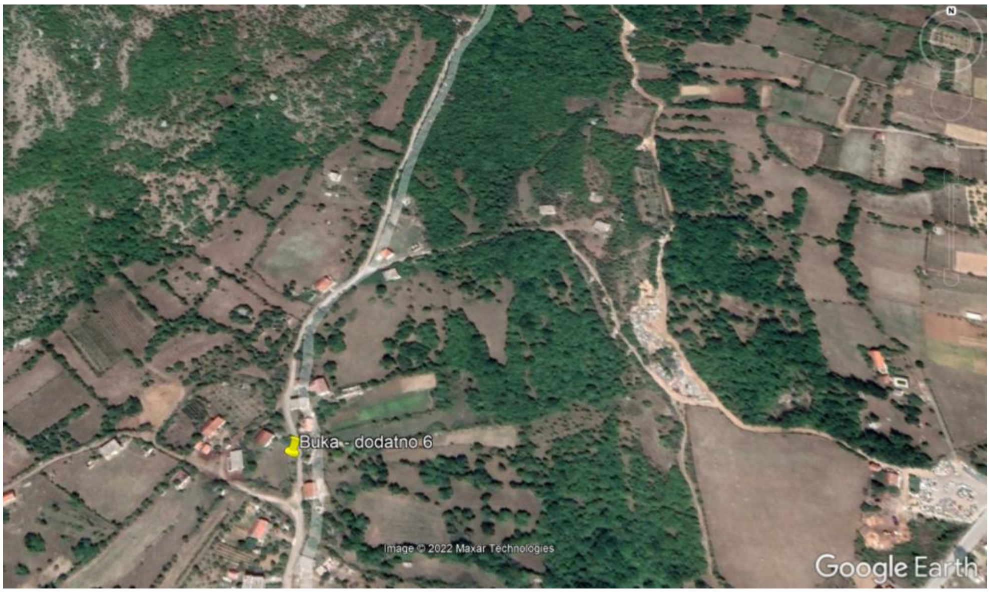


Figure 11-7: Houses near the southern access road in Prigradjani

Figure 11-8: Near river Neretva at the beginning of southern access road

The results of outdoor baseline noise measurements are presented in tables below.

Table 11-38: Results of noise measurements at the location MP 1

<table>
<tr><th>Measurement point</th><th colspan="9">Description of measuring and working conditions</th><th>Time</th></tr>
<tr><td rowspan="6">MP 1</td><td colspan="9">Noise emission was recorded near Bijela settlement
43° 36’ 27,03” N
17° 56’ 49,64” E</td><td rowspan="6">24.6.-25.6.2022.

06:09-06:09</td></tr>
<tr><td colspan="9">Noise level and the adjustment in dB(A)</td></tr>
<tr><td colspan="3">Energy average value</td><td colspan="2">Adjustment</td><td colspan="2">Rating level</td><td colspan="2">Limit value</td></tr>
<tr><td>L_{rezid}</td><td>L_{eq}</td><td>$L_{1\%}$</td><td>K_T</td><td>K_I</td><td>L_{Req}</td><td>$L_{R1\%}$</td><td>L_{Req}</td><td>$L_{R1\%}$</td></tr>
<tr><td rowspan="2">-</td><td rowspan="2">50.3</td><td rowspan="2">63.4</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">50.3</td><td rowspan="2">63.4</td><td>60.0</td><td>75.0</td></tr>
<tr><td>50.0</td><td>75.0</td></tr>
</table>

**Limit values are shown for day and night period*

Table 11-39: Detailed representation of acoustic parameters for MP 1

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
50.3	74.1	33.9	63.4	53.4	50.6	43.0	38.0	37.3	36.2

Table 11-40: Results of noise measurements at the location MP 2

Measurement point	Description of measuring and working conditions									Time
MP 2	Noise emission was recorded near Prigradjani settlement 43° 26′ 38,73″ N 17° 51′ 46,13″ E									26.6.-27.6.2022. 11:00-11:00
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	57.4	66.8	-	-	57.4	66.8	65.0	80.0	
								60.0	80.0	

**Limit values are shown for day and night period*

Table 11-41: Detailed representation of acoustic parameters for MP 2

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
57.4	87.6	39.0	66.8	63.2	58.8	53.1	47.1	45.9	43.4

Table 11-42: Results of noise measurements at the location MP 3

Measurement point	Description of measuring and working conditions									Time
MP 3	Noise emission was recorded near Prigradjani settlement 43° 27′ 37,65″ N 17° 52′ 22,04″ E									25.6.-26.6.2022. 08:10-08:10
	Noise level and the adjustment in dB(A)									
	Energy average value			Adjustment		Rating level		Limit value		
	L_{rezid}	L_{eq}	$L_{1\%}$	K_T	K_I	L_{Req}	$L_{R1\%}$	L_{Req}	$L_{R1\%}$	
	-	57.9	63.5	-	-	57.9	63.5	60.0	75.0	
								50.0	75.0	

**Limit values are shown for day and night period*

Table 11-43: Detailed representation of acoustic parameters for MP 3

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
57.9	93.0	29.7	63.5	60.1	58.5	50.6	38.8	37.3	34.9

Table 11-44: Results of noise measurements at the location MP 4

<table>
<tr><th>Measurement point</th><th colspan="9">Description of measuring and working conditions</th><th>Time</th></tr>
<tr><td rowspan="6">MP 7</td><td colspan="9">Noise emission was recorded near river Neretva
43° 39’ 41,63” N
17° 56’ 54,21” E</td><td rowspan="6">20.6.-21.6.2022.
11:19-11:19</td></tr>
<tr><td colspan="9">Noise level and the adjustment in dB(A)</td></tr>
<tr><td colspan="3">Energy average value</td><td colspan="2">Adjustment</td><td colspan="2">Rating level</td><td colspan="2">Limit value</td></tr>
<tr><td>L_{rezid}</td><td>L_{eq}</td><td>$L_{1\%}$</td><td>K_T</td><td>K_I</td><td>L_{Req}</td><td>$L_{R1\%}$</td><td>L_{Req}</td><td>$L_{R1\%}$</td></tr>
<tr><td rowspan="2">-</td><td rowspan="2">53.3</td><td rowspan="2">62.6</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">53.3</td><td rowspan="2">62.6</td><td>65.0</td><td>80.0</td></tr>
<tr><td>60.0</td><td>80.0</td></tr>
</table>

**Limit values are shown for day and night period*

Table 11-45: Detailed representation of acoustic parameters for MP 4

LA_{eq} (dB)	LAF_{MAX} (dB)	LAF_{MIN} (dB)	LA1% (dB)	LA5% (dB)	LA10% (dB)	LA50% (dB)	LA90% (dB)	LA95% (dB)	LA99% (dB)
53.3	81.5	31.8	62.6	57.1	54.8	42.1	37.4	36.4	34.9

Based on the compiled and analysed data from the field, it can be stated that the results of measurements correspond to the acoustic requirements defined by the *Law on Noise Protection*[3]. Acoustic parameters LAeq and LA1% are compared with the limit values for area V in settlements Prigradjani and Donje Selo (MP 5 and 7). For MP 4 and 6, situated in settlements Bijela and Prigradjani, and due to lower population and less intensive traffic the results are compared with the limit value for the area IV in accordance with the *Law on Noise Protection.*

The results from grouping the measurement time-history graphs in three time periods: day, evening, and night, are given in Table 11-46. The results are compared to the World Bank General EHS Guidelines in Figure 11-9.

Table 11-46: measured noise levels [dB(A)]

Location	L_{day}	$L_{evening}$	L_{night}	L_{DEN}
1.	59.7	62.1	49.0	62.0
2.	55.1	52.3	50.1	57.7
3.	57.3	55.7	39.8	56.9
4.	55.7	45.1	35.5	53.3
5.	56.5	47.4	49.0	57.1

[3] Official Gazette of FBiH, No. 110/12

6.	52.7	49.4	40.2	52.4
7.	48.1	41.7	41.8	49.6
11.	56.4	48.1	52.0	58.9
12.	52.3	50.8	40.2	52.6
13.	65.3	47.2	43.7	62.5
14.	51.0	54.5	41.7	54.2
15.	59.7	47.3	54.6	61.7
16.	59.7	55.1	43.5	58.5
17.	54.8	48.5	45.6	54.9

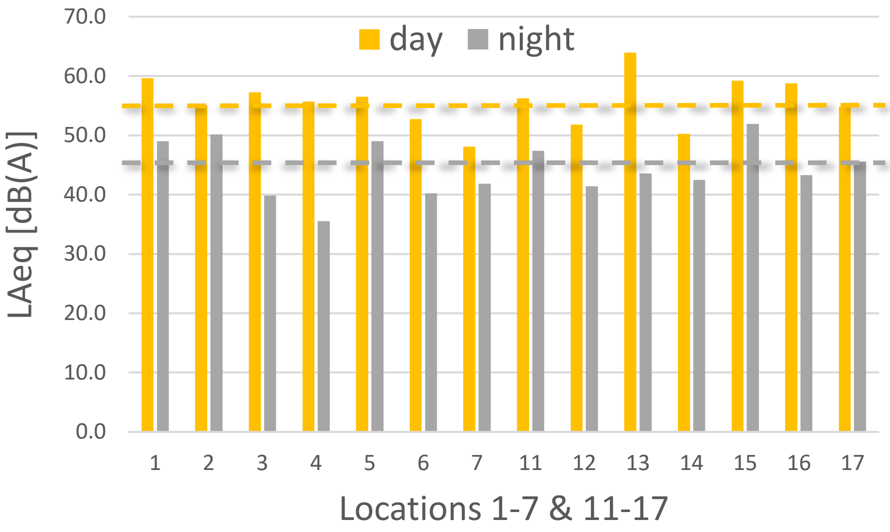


Figure 11-9: Baseline noise measurements – comparison with World Bank limits

The measurement results will be utilised to assess the background noise in the study area.

There are locations where the baseline measurements are above the limits, especially at the beginning of the project which is close to the existing road and in the vicinity of the city of Konjic (#1). Small exceedances are noted in Polje Bijela (#2), in Podgorani (#4), and Lisani (#5).

11.3 Assessment of Potential Impacts

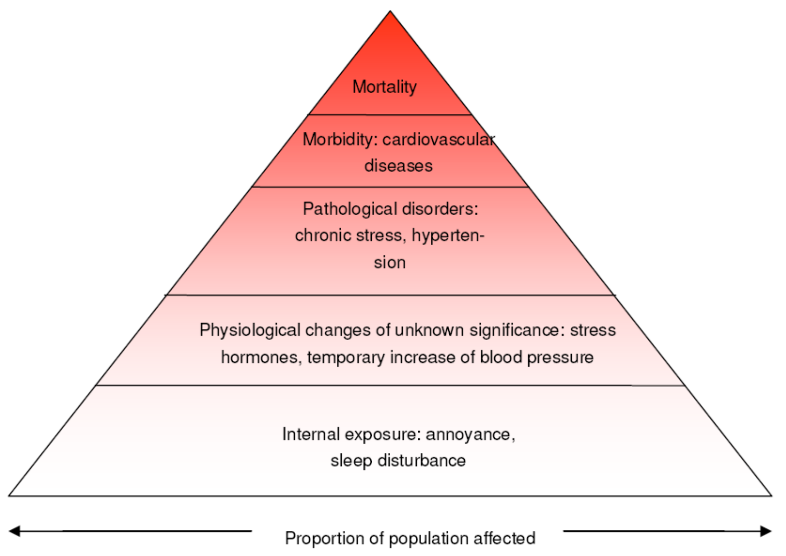
11.3.1 Overview of Potential Impacts

Over recent years, acoustic pollution has become a common problem for developing countries and its treatment one of the new challenges in environmental policy. Furthermore, noise diminishes the quality of life in a more general perspective. According to WHO[4], half of the EU citizens (EU 15) are estimated to live in areas which do not ensure acoustical comfort for residents:

> 40% of the population is exposed to road traffic noise with an equivalent sound pressure level exceeding 55 dB(A) during daytime
> 20% to levels exceeding 65 dB(A)
> At night, more than 30% are exposed to sleep-disturbing sound levels (>55 dB(A))

Often neglected, noise induces a severe impact on humans and on living organisms. Some of the adverse effects are summarised below:

> Annoyance: Noise creates annoyance to the receptors due to sound level fluctuations. The aperiodic sound due to its irregular occurrences causes displeasure to hearing and causes annoyance.
> Physiological effects: The physiological features like breathing amplitude, blood pressure, heart-beat rate, pulse rate, blood cholesterol are effected by noise.
> Loss of hearing: Long exposure to high sound levels cause loss of hearing. This is mostly unnoticed, but it has an adverse impact on hearing function.
> Human performance: The working performance of workers will be affected in noisy environments as they'll be losing their concentration.
> Nervous system: Exposure to high sound levels causes pain, ringing in the ears, feeling of tiredness, thereby effecting the functioning of human system.
> Sleeplessness: Noise affects the sleeping by inducing the people to become restless and loose concentration and presence of mind during their activities.



Source: RIVM (2001).

Figure 11-10: Effects of long-term excessive noise exposure

[4] World Health Organization, "GUIDELINES FOR COMMUNITY NOISE", 1999

11.3.2 Assessment Methodology

11.3.2.1 Regulatory Framework

National regulatory framework

In the area of FBiH, legislation for noise emission is regulated by the Noise Protection Act[5]. The permissible levels of outdoor noise for the planning of new facilities or sources of noise, for different environments and time of the day, are given in Table 11-47.

Table 11-47: National requirements according to Law No. 9774 and its amendments [dB(A)]

Zone	Area Purpose	L_{eq} - day	L_{eq} - night	L1%
I	Hospital, treatment centre	45	40	60
II	Tourist, recreational and rehabilitation centres	50	40	65
III	Clear housing, educational and health institutions, green public and recreational areas	55	45	70
IV	Commercial business, residential and housing along traffic corridors, warehouses without heavy transport	60	50	75
V	Business, administrative, commercial, craft, service (communal service)	65	60	80
VI	Industrial, warehouse, service and traffic area without housing	70	70	85

IFC – World Bank Noise Level Guidelines

The World Bank Group General EHS Guidelines provide limit values for ambient noise levels as presented in the following table.

Table 11-48: World Bank EHS Noise Level Guidelines

Receptor	Daytime $L_{eq,T}$ 07:00 - 22:00 [dB(A)]	Night-time $L_{eq,T}$ 22:00-07:00 [dB(A)]
Residential; Institutional; Educational	55	45
Industrial; Commercial	70	70

The Project area lies in the first category: **Residential; Institutional; Educational**.

[5] Official Gazette of FBiH, No.: 110/12

According to the guideline, noise impacts should not exceed the levels presented in Table 11-48 above or result in a maximum increase of background levels of +3 dB at the nearest receptor location off-site.

World Health Organisation (WHO) Guidelines

The WHO Guidelines provide limit values for ambient noise levels as presented in the following table.

Table 11-49: Permissible Noise Levels in Areas with Different Sensitivity Scales

Designation	Day $L_{eq,T}$ [dB(A)]	Evening $L_{eq,T}$ [dB(A)]	Night $L_{eq,T}$ [dB(A)]
A	50	45	40
B	55	50	45
C	60	55	50

Where the designation means:

- A = Sensitive – These areas are designated quiet areas as they hold value in terms of them being places of worship, important tourist attractions, recreational park land and those areas surrounding hospitals, schools and noise sensitive natural habitats.
- B = Mixed – Areas designated in this category will typically be dominated by Residential Properties and may range from sparse population densities to suburban districts of cities.
- C = Non-sensitive – This designation applies to mixed areas, often within cities where there is a mix of residential and commercial activities. This designation will also apply to retail and financial districts.

The Project area lies in **Designation B**.

In the vicinity of the motorway there is a mixed area with buildings of residential and other uses, mainly farming. The limit values that will be considered are 55 dB(A) for day-time (07:00 – 23:00, combining day and evening ratings, L_{de}) and 45 dB(A) for night-time (23:00 – 07:00, night rating L_{night}).

11.3.2.2 Methodology of Evaluation

Definition, properties and measuring units of sound

Sound is defined as the mechanical disturbance that propagates with certain speed in a medium that can develop internal forces and has such a character that can stimulate the ear (the auditory transducer) and cause auditory sense.

The frequency of the sound, f, is the oscillation frequency of the particles of the elastic medium due to the dissipation of the sound wave, which corresponds to the number of repetitions per second and is measured in Hertz (Hz).

In acoustics the units that are used are usually logarithmic. The main unit of measurement is the decibel (dB). It is a logarithmic unit of measurement of acoustic pressure, intensity and power emitted by a sound source. Instant sound level (Sound Pressure Level) is defined thus as:

$$\mathrm{SPL} = 20 \log \frac{p(t)}{p_{ref}},$$

where $p(t)$ is the sound pressure and $p_{ref} = 2 \times 10^{-5}\, N/m^2$ is the reference value.

The dynamic range that can be perceived by a young person is 0-120 dB, which in linear units corresponds to the range from $20\,\mu\mathrm{Pa}$ to $20{,}000{,}000\,\mu\mathrm{Pa}$! Exposure to sounds above 120 dB is harmful, even if it is short-term.

The human ear works in the frequency range from 16 Hz up to 20 kHz, but its sensitivity is not the same at all frequencies. Specifically, the human ear is more sensitive to frequencies in the range of 1,000-6,000 Hz. For this reason, and in order to adjust the measured noise in the way of the human ear canal, frequency-weighting filters are used. The most common filter is the A-weighting filter.

The sound level resulting from measurements with A-weighting filter is called the A-weighted sound level and is measured in dB(A). In most cases, the noise measurements (acoustic pressure levels) are made using this filter, by using certified portable devices called sound level meters. These instruments are fitted with A-weighting filter and the calculation in dB(A) is done automatically.

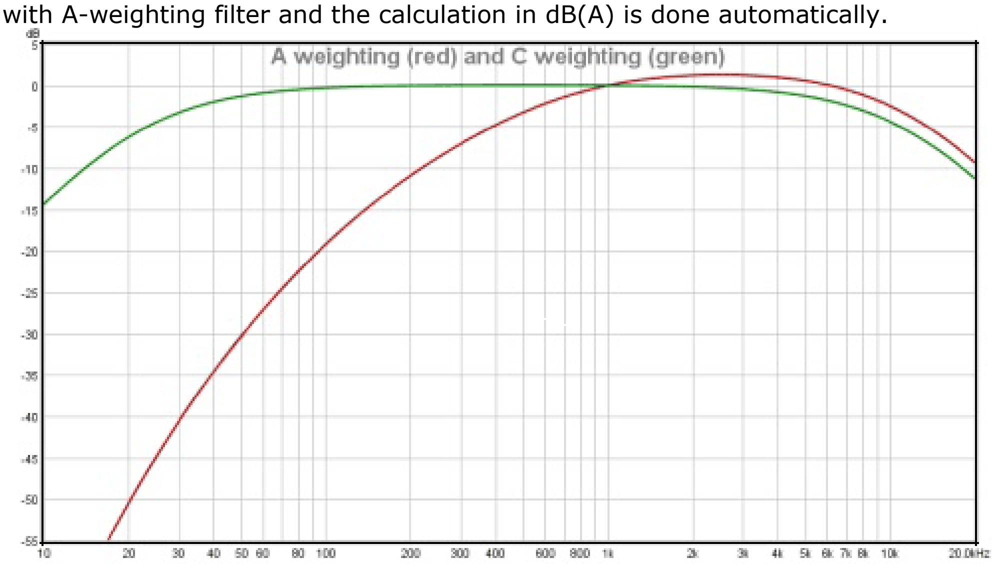


Figure 11-11: A-weighting and C-weighting curves

Indicators for the assessment of environmental noise

All noise sources cause a time-varying sound pressure level. Therefore, the noise cannot be described and evaluated with the use of instant sound level. For this reason, in order to sensibly quantify noise, we use certain single-value indexes/descriptors. Indexes commonly used for the assessment of environmental noise are:

L_{eq}:	The equivalent continuous sound level or equivalent noise level, which expresses the level of a constant sound source that encompasses the same acoustic energy with the actual sound: $L_{eq} = 10\log\frac{\frac{1}{T}\int_0^T p(t)^2dt}{p_{ref}^2}$, where T is the time of observation.
$L_{F,max}/L_{F,min}$:	The maximum/minimum of all the exponential moving average levels recorded during a measurement using the time constant 'Fast' ($T = 125$ ms).
$L_{S,max}/L_{S,min}$:	The maximum/minimum of all the exponential moving average levels recorded during a measurement using the time constant 'Slow' ($T = 1$ s). The 'Slow' filter dampens the reaction to sudden changes in noise level more than the 'Fast' filter, thus $L_{S,max}$ always has lower value than $L_{F,max}$ and $L_{S,min}$ always has higher values than $L_{F,min}$.
$L_{F,5\%}/L_{F,10\%}$:	The level at which $5\%/10\%$ of the exponential moving average levels recorded during a measurement using time constant 'Fast' ($T = 1$ ms) is below it. They are useful for isolating transient noise incidents from background noise, i.e. vehicle pass-by, and they are often used in transport noise analysis.
$L_{F,90\%}/L_{F,95\%}/L_{F,99\%}$:	The level at which $90\%/95\%/99\%$ of the exponential moving average levels recorded during a measurement using time constant 'Fast' ($T = 1$ ms) is below it. They are effective in excluding transient noise incidents from the results; hence they provide an estimate of the ambient background noise of an area whenever no characteristic noise source is dominant.
SEL:	The Sound Exposure Level is the sound level of a transient sound source that emits constant sound for one second and encompasses the same acoustic energy with the actual sound: $SEL = L_{eq} + 10\log T$, where T is the time of observation. It can be used to compare noise events which have different time durations.
$L_{day}/L_{evening}/L_{night}$:	The A-weighted long-term average sound level as defined in ISO 1996-2:2007, determined over all respective periods of a year (day: $T = 07\text{h}00 - 19\text{h}00$, evening: $T = 19h00 - 23h00$, night: $T = 23h00 - 07h00$).
L_{DEN}:	Weighted 24h noise level index defined by L_{day}, $L_{evening}$ and L_{night} using the formula: $L_{DEN} = 10\log(\frac{12}{24}10^{\frac{L_{day}}{10}} + \frac{4}{24}10^{\frac{L_{evening}+5}{10}} + \frac{8}{24}10^{\frac{L_{night}+10}{10}})$.

European environmental noise assessment method

The Environmental Noise Directive (END) is the main EU instrument through which land-based noise emissions are monitored and actions developed. It defines environmental noise as 'unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, road traffic, rail traffic, air traffic, and from sites of industrial activity' (2002/49/EC Directive). It places an obligation on EU Member States to assess noise levels by producing strategic noise maps for all major roads, railways, airports and urban areas. Based on these noise-mapping results, Member States must prepare action plans containing measures that address noise issues and their effects for those areas where the specific END indicator thresholds have been surpassed. The Directive neither sets limit values for noise exposure, nor prescribes measures for inclusion in the action plans.

The END was revised by the EU Directive 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council. The amendment suggests that the Member States will apply the new European Commission developed Common Noise aSSessment methOdS (CNOSSOS-EU) for calculating environmental noise starting 31st December 2018. CNOSSOS-EU aims at improving the consistency and comparability of noise assessment results across the EU Member States which are performed on the basis of the data becoming available through the consecutive rounds of strategic noise mapping in Europe.

To evaluate the noise nuisance from a new motorway, as in the case of this Project, the procedures defined in CNOSSOS-EU road computation method are applied. The method calculates the sound power of the road vehicles based on their type, their frequency and the road surface type and condition. Then the dissipation of the noise level from the motorway to the sensitive receiver is calculated considering the distance, the topology and the sound absorption of the terrain, the environment (temperature, relative moisture, wind) and any obstacle (i.e., noise barrier, other buildings) that comes between the source and the receiver.

The calculated estimate of the noise level at the receiver is then compared to the noise limits applicable to the area under study. If there are areas where the level is over the limits, mitigation measures should be designed.

Sound propagation simulation software

Under the scope of the Environmental Impact Study of the project, in order to quantitatively assess the emitted noise levels by the operation of the railway corridor, a noise simulation model was developed using specialised computer software. The calculations and the resulting noise maps were performed using the specialised noise prediction and noise assessment software IMMI Premium 2021 by Woelfel MebSysteme GmbH. The software fully covers the requirements of European Noise Directive including its 2015 amendment, while it provides through the QSI data Structure (DIN 44687) the possibility of transferring projects and data to and from other noise prediction and evaluation software. In this way, full compatibility with other relevant software is achieved and the data is usable over time.

All input data information was gathered and classified in GIS layers for data management and quality assurance purposes. IMMI provides great interconnectivity between its data structures and GIS software (Figure 11-12).

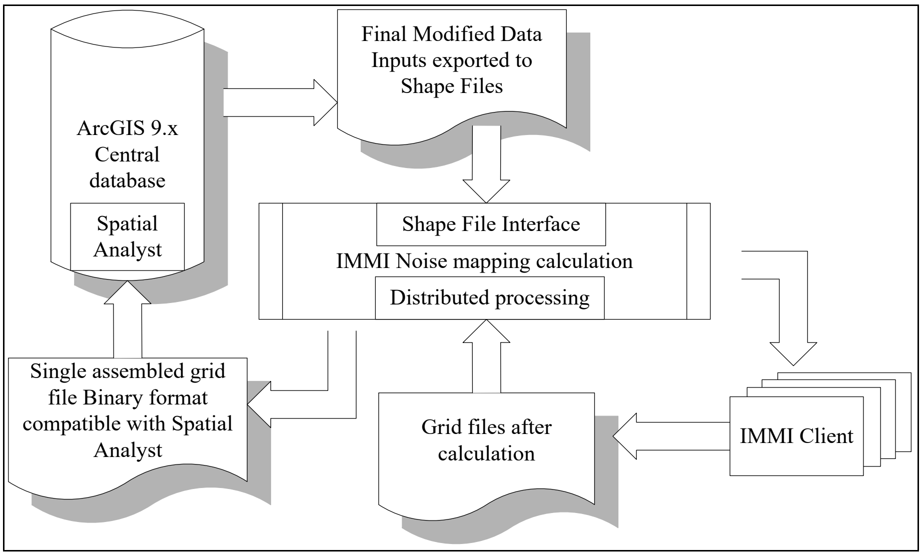


Figure 11-12: IMMI interconnectivity with GIS software

Other IMMI Premium 2021 features that are valuable for the current study include:

- Completeness of the software as to the needs arising from the Environmental Noise Directive (2002/49 EC) and its amendment (EC 2015/996),
- Possibility to perform the calculations as a whole 3D model area of the project by distributing the intensive calculations required to a computer network (Figure 11-13),
- Provides elements as sound screens (straight or cantilevered), green belts, porous asphalt etc. to investigate the efficiency of noise abating measures,
- Automated algorithm for optimal calculation of sound barrier height,
- Acceleration mechanisms to increase the speed of noise mapping calculations,
- Interconnectivity (data input/output) with geographic information Systems (GIS) and design software like AutoCAD,
- Connection to WMS servers for acquiring georeferenced satellite imagery,
- Usability in model changes after importing directly from the software,
- Quality assurance mechanisms and automatic checks of the data quality before starting calculations,
- Simultaneous calculation in each receiver position of all 4 noise indicators (L_{day}, $L_{evening}$, L_{night}, L_{den}) and registration in separate layers,
- Ability to display results in thematic maps (with different sets of receivers or sources or combination of sources/receivers),
- Ability to perform different scenarios for the identification of noise measures with different policies (policy tests) but also with different meteorological and spatial planning data.

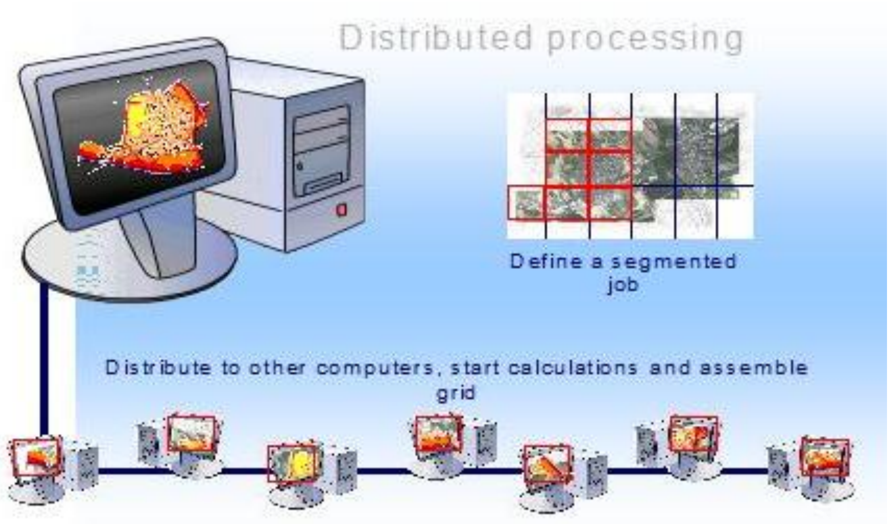


Figure 11-13: IMMI distributed processing schematic

For calculating road transportation noise, the model uses the European Commission developed Common Noise aSSessment methOdS (CNOSSOS-EU). The method calculates the sound power of the vehicles based on their type, their speed, their frequency and the track type and condition. Then the dissipation of the noise level from the railway to the sensitive receiver is calculated considering the distance, the topology and the sound absorption of the terrain, the environment (temperature, relative moisture, wind) and any obstacle (i.e. noise barrier, other buildings) that comes between the source and the receiver.

The new European Commission developed Common Noise aSSessment methOdS (CNOSSOS-EU) for calculating environmental noise requires a substantial amount of input parameters in order to produce a 3D model of the area of the project, such as meteorological parameters, terrain model, screening obstacles, road network geometry and traffic flows distributed over different vehicle types (intercity, regional trains, various types of freight trains, trams, etc.) and over three time periods during one 24h day ('day': 07h00 – 19h00, 'evening': 19h00 – 23h00, 'night': 23h00 – 07h00).

Open road is modeled as a linear sound emitting source, whose level depends on traffic load. In order to have more accurate results for the noise barriers efficiency, the motorway is modeled as two-line sources, one for the left branch and one for the right brunch.

Tunnels are simulated in CNOSSOS-EU as point sources at the portals, which represent the noise coming from inside the tunnel and it is calculated based on traffic load and the dimensions of the portal.

Motorway noise mitigation measures

Noise reduction can be achieved at-source using low noise road surfaces. Low-noise road surfaces, such as thin-layer, double-layer, porous and poroelastic pavements, offer considerable potential to cut road noise dramatically, since tyre-road interaction is the main noise source at high vehicle speeds. Such surface measures have the advantage of bringing immediate benefits, particularly for use in noise hotspots. CNOSSOS-EU models low-noise road surfaces by applying a weighting factor to the sound power of the individual vehicle noise emissions. The weighting factors are given in 1/3-octave bands, and they depend on the type of the road surface and the vehicle category. Generic weighting factors for low-noise road surfaces are provided (1-layer ZOAB, 2-layer ZOAB, 2-layer ZOAB (fine), thin layer A, thin layer B).

If the desired degree of noise reduction cannot be achieved by at-source measures, noise barriers will be helpful in reducing propagation of the noise. The primary function of noise barriers is to shield receivers from excessive noise generated by road traffic. Many factors need to be considered in the detailed design of noise barriers. A proper design of noise barriers would be needed to take into consideration both acoustic and non-acoustic aspects. Acoustical design considerations include barrier material, barrier locations, dimensions and shapes. Non-acoustical design considerations are equally important, such as maintainability, structural integrity, safety and aesthetics.

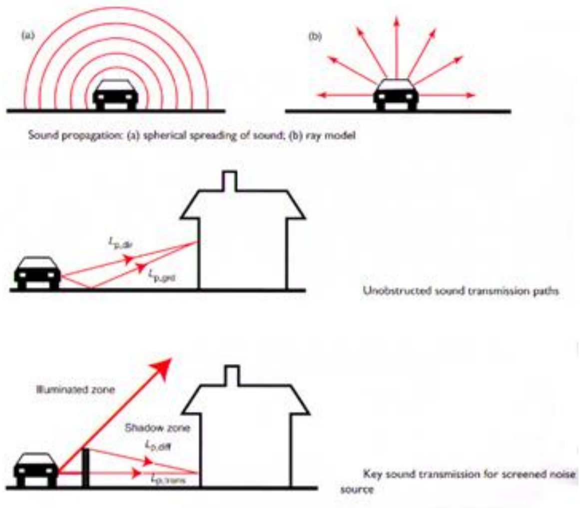
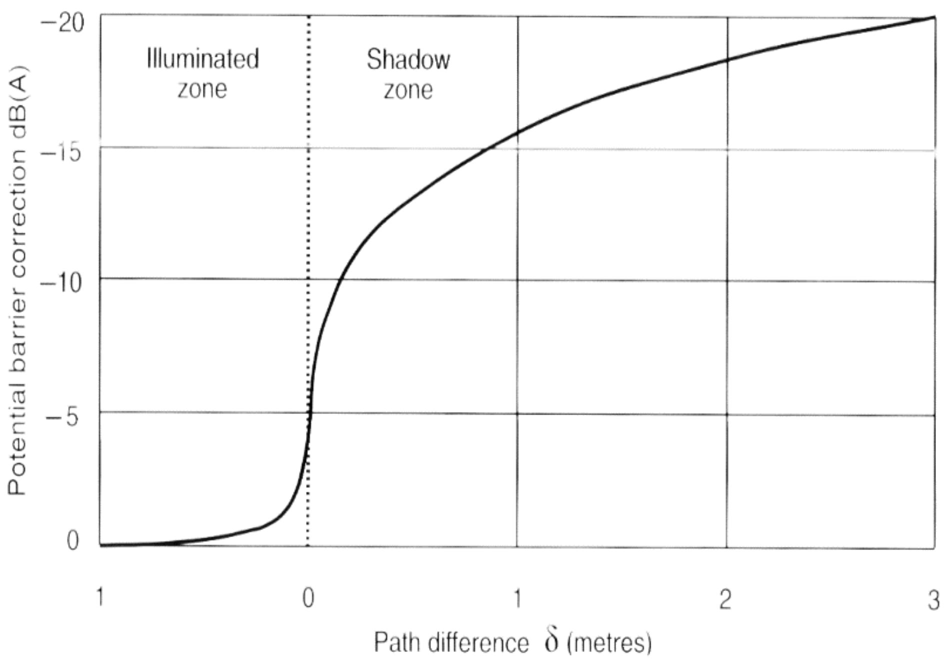


Figure 11-14: Sound propagation and transmission

When introducing a barrier, the critical "acoustic ray" is the ones diffracted above the top edge of the barrier.

The length difference δ (diffracted path length minus direct path length) is the most important parameter on the attenuation the barrier can provide. There is mathematical formula to predict accurately the sound insulation (Figure 11-15).

CNOSSOS-EU models geometrically the attenuation from screening, based on the increase of distance the sound wave has to travel among other factors. Each road lane is divided in several equivalent point sources and the attenuation factor is calculated by tracing rays, in generated vertical and horizontal cross sections, from the discretised point sources to the receiver. The model is also taking into account the negative effects on the actual attenuation from noise barriers that can be caused by downwind propagation and reflections. Reflections reduce the acoustic performance and can be prevented by using sound absorptive barriers (Figure 11-17). The formula is semi-empirical and has a cut-off at 25 dB maximum attenuation in any scenario.



0-5 dB minimal mitigation of noise to receivers, the barrier might not be efficient cost wise

-5-10 dB receivers will understand a noticeable decrease of noise exposure

-10-15 dB the screening of the noise barrier is very noticeable

-15-20 dB very difficult to reach in practice – too high barriers are needed

Figure 11-15: Noise barrier Insertion Loss

The effective height of a barrier can be improved by locating the barrier as close to the source as possible and by angling or curving a cantilevered barrier towards the road (Figure 11-16).

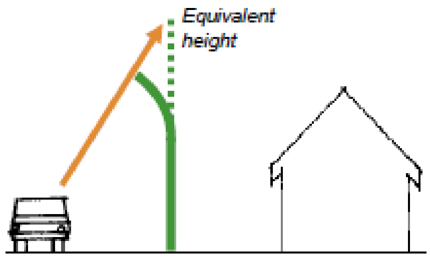


Figure 11-16: A cantilevered barrier angled across the road can increase the noise mitigation achieved by a barrier

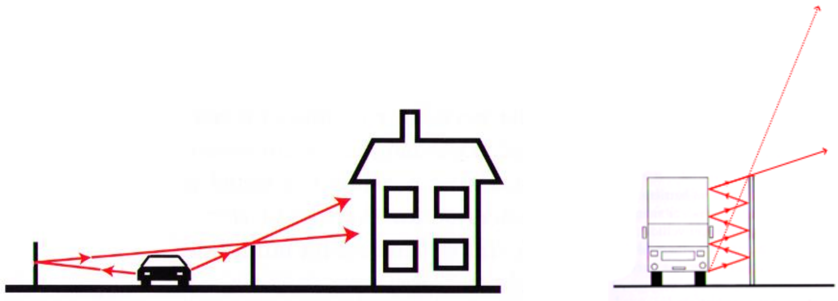


Figure 11-17: Influence of reflections in road traffic noise propagation

11.3.2.3 Input Parameters

Meteorological data

Climate in this area is a modified Mediterranean, characterised by warm and relatively dry summers and mild winters with abundant rainfall in the colder part of the year, which reaches its maximum in the latter part of the autumn. The highest average monthly temperature is usually recorded in July (about 20 – 25 °C). The month with the lowest temperatures is January, with averages in the range of 0.7 to 4.8 °C.

Terrain model

The characteristics of the topography have been defined in the model by importing elevation data from various sources, thus shaping the digital terrain model of the study area. The digital elevation of the noise model is composed of:

> the broader area in a grid resolution of 1'' arc was taken from the USGS SRTM database,
> the contours inside an area of approximately ±50-100m from the alignment's axis from the topographic survey of existing conditions,
> the area modified by the project from the contours of the design.

The model includes land uses of the area regarding housing areas (settlements) and areas covered by vegetation, as they are determined in project's EIA report. In general, the overall absorption coefficient value was taken as 0.5 in the model[6].

Alignment

The geometry of the proposed Project is based on the Preliminary Design (PD) alignment of 2016 that has since been updated to take into account alignment optimisations, detailed topographic ground model and other constraints identified during the design development. Once approved the Main Design / Detailed Design shall commence. The length of the section considered for this assignment is approximately 36 km. The route enters the canyon of Konjic Bijela

[6] minimum value of 0.0 represents hard reflecting ground and maximum value of 1.0 represents absorbing soft ground

and gradually climbs towards the tunnel Prenj which is a straight-line underground crossing of the main mountain. Upon exiting the tunnel, route Prenj develops north of the area above the settlements of Dubrava above Selista and Zelanika and gradually descends into the area of Bijelo Polje.

The section includes tunnels, bridges-viaducts and three interchanges: Konjic North I/C, Konjic South I/C and Mostar North I/C. The basic elements of the cross section include two separate roads, each of which has two driving lanes width of 3.75 m. Marginal strip, which is located along the separating belt, and is included in the green belt is 2x0.50 m (Figure 11-18 – Figure 11-19). Terrain is categorised as hilly-mountain (Figure 11-20) and computational speed is V_r = 120 km/h.

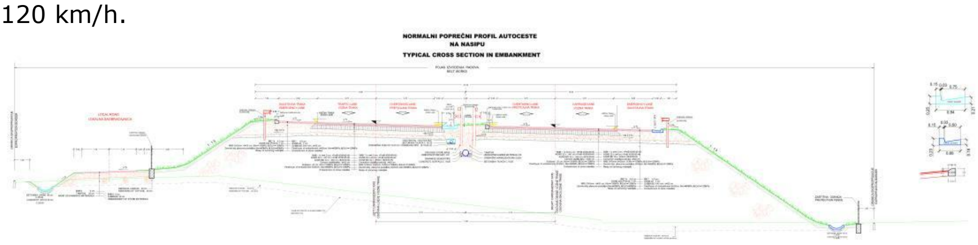


Figure 11-18: Characteristic cross-section (PD) of the motorway in an embankment

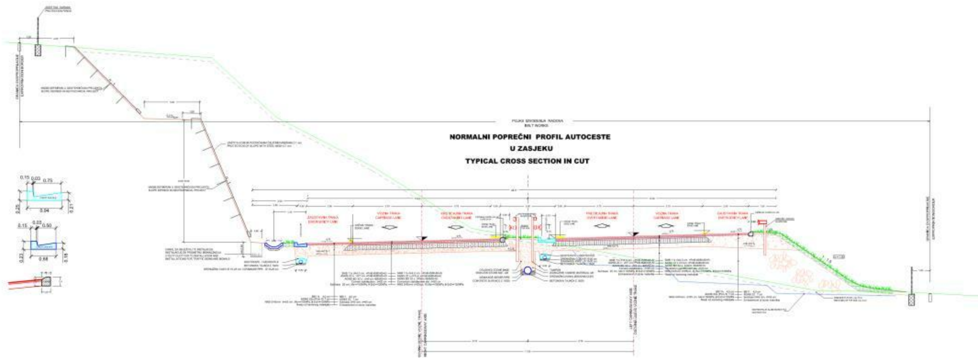


Figure 11-19: Characteristic cross-section (PD) of the motorway in a side cut

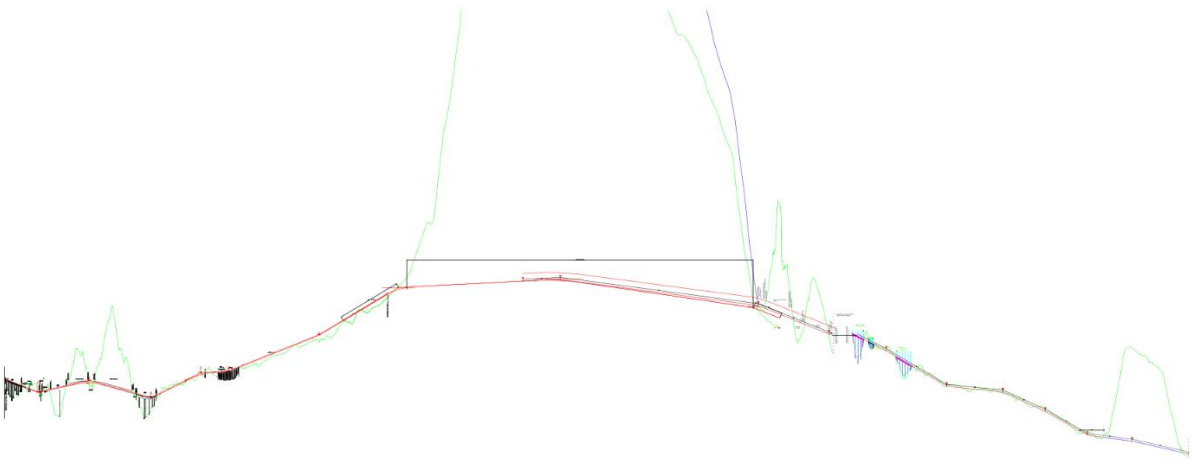


Figure 11-20: Longitudinal profile of the motorway as foreseen in the PD of 2016

Baseline noise data

The level of noise emissions of the existing road and rail infrastructure has been measured for the purpose of this Project. Environmental Noise measurements were performed along the proposed alignment at fourteen locations during two visits in 2021 & 2022. Details are provided in Chapter 11.2 of this report.

Traffic loads

The expected vehicle circulation in the new motorway is given for two scenarios (launch year and horizon year 2060) at per the traffic study of the Project[7]. Table 11-50 summarises the data:

Table 11-50: Estimated Daily Traffic flows for launch year and for horizon year

Type	Description	Launch year	Horizon year
PA	Passenger car	8 328.0	33 167.0
BUS	Autobus	138.0	501.0
LTV	Light truck	133.0	572.0
STV	Moderate truck	160.0	687.0
TTV	Heavy goods vehicle	152.0	652.0
AV	Car-wagon	341.0	1 464.0
Total (AADT)		**9 252.0**	**37 043.0**

For the traffic loads of Konjic bypass, AADT values of 2.838 veh/day and 10.543 veh/day were used for the launch year scenario and the horizon year scenario respectively. These values correspond to the traffic flows of M-17 section 'Konjic – Jablanica' when the new highway will be in operation[8], as presented in the traffic study of the project[9].

For the traffic loads of all other branches at the interchanges, 5% of the above traffic is considered.

Given the lack of data regarding the traffic distributions, for the day-evening-night distribution the percentage 70%-20%-10% is used according to EU position paper on good practice guide for application of END[10].

[7] "TRAFFIC STUDY - MOTORWAY ON CORRIDOR Vc - Section: Konjic (Ovcari Interchange) / Mostar North interchange, L = 36,50 km", INSTITUT ZA GRAĐEVINARSTVO "IG" BANJA LUKA D.O.O., 2016.

[8] Hence the traffic flow used is an unfavorable scenario regarding traffic noise from Konjic bypass, since it includes traffic towards Jablanica generated from Konjic, which is not expected to be serviced by Konjic bypass

[9] "TRAFFIC STUDY - MOTORWAY ON CORRIDOR Vc - Section: Konjic (Ovcari interchange) / Mostar North interchange, L = 36,50 km", INSTITUT ZA GRAĐEVINARSTVO "IG" BANJA LUKA D.O.O., 2016.

[10] European Commission Working Group Assessment of Exposure to Noise (WG-AEN), "Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure, Version 2", 2007

Areas investigated – sensitive receivers

For the assessment of the sensitive areas regarding noise pollution, the following criteria were considered:

- The distance of schools, health institutions, religions institutions and other relevant institutions
- The distance of residential houses, population density and recreation places
- The distance of agricultural farms and plantations with proposed alignment
- The distance of industrial activates with the study area
- HSH stations and facilities were not included in the sensitive receiver list.

Based on the above, buildings and structures are clustered as shown in the following maps.

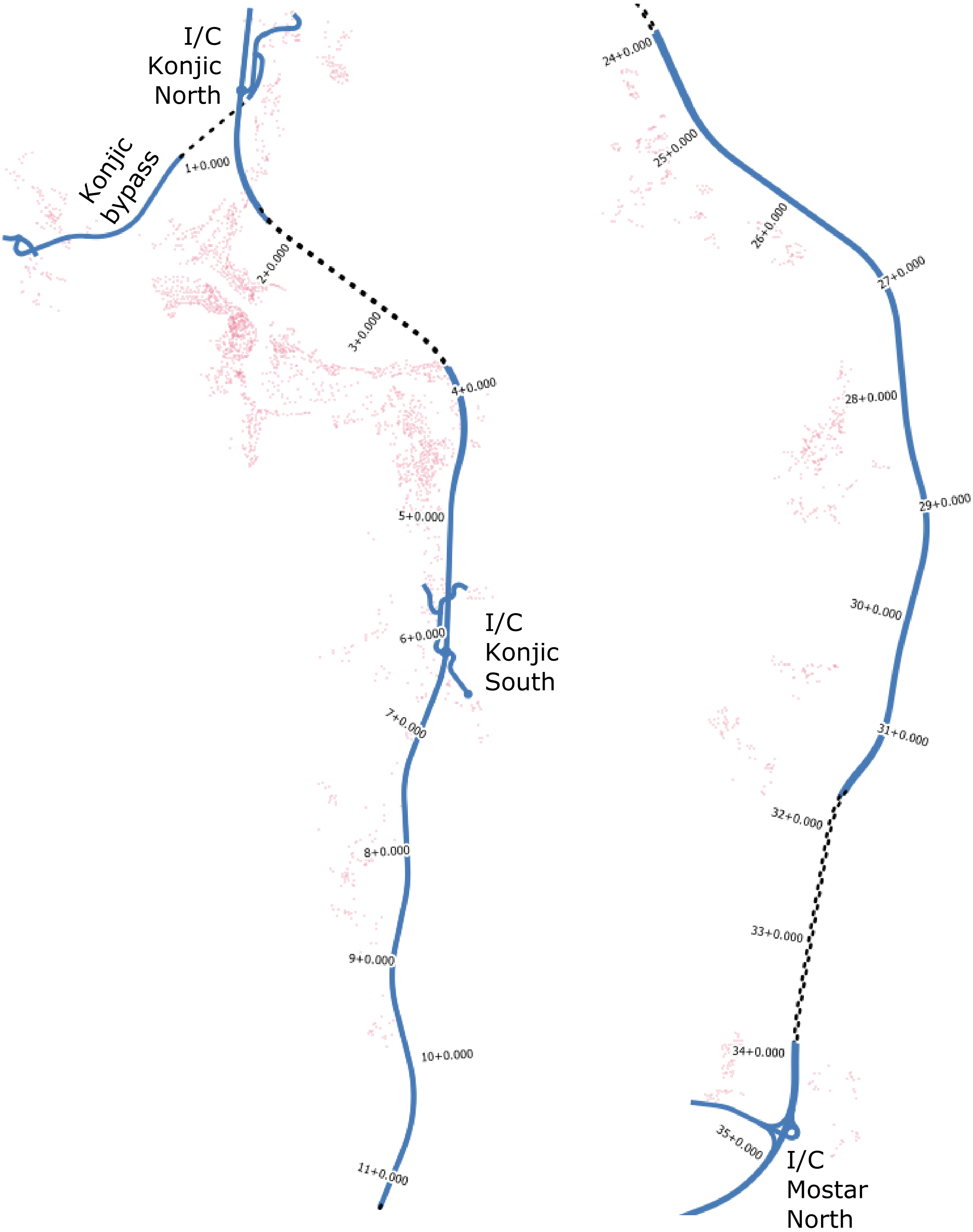


Figure 11-21: Indication of sensitive receivers near the alignment (left: north of Prenj Mountain, right: south of Prenj Mountain)

11.3.3 Identified impacts

11.3.3.1 Construction Phase

In the **construction phase**, the main causes of potential negative impact of noise are:

> Nature of construction works
> Presence of construction machines at the site

On construction sites there are many different noise sources, and these sources exhibit many differing types of noise such as background noise, idling noise, blast noise, impact noise, rotating noise, intermittent noise, howling, screeches and squeals that need to be controlled.

The noise emission intensity depends on types of working machines and motor vehicles that are used during the construction (age of the machine and technical condition of mechanical parts) as well as the organisation of construction sites and activities during construction, which can minimise the number of idle motions of freight vehicles and hours of working machines while awaiting loading. No blasting is foreseen or expected.

The two main receptors of concern are "human receptors" that includes workers on site, local residents and users of surrounding infrastructure, and "ecological receptors" referring to sensitive fauna disturbed by increase in noise and vibrations.

At the construction site itself noise activity can:

> disturb speech communication and communication via devices (noise above 65 dB reduces a possibility to maintain speech communication at a distance shorter than 1 metre, and aggravates telephone communication),
> decrease work ability, productivity, and concentration due to prolonged exposure to intense noise,
> damage hearing.

In the project area of influence, the increased noise can lead to psychic fatigue with a decreased attention span and feeling of unease.

Based on the experience from similar sites, the increase in noise levels at the construction site can be up between L_{eq}80-90dB(A) depending on the number of machines working simultaneously and type of works performed. The sound level at operator can vary from 85db(A) to up to 110db(A) depending on the type of the machine he is operating[11]. Impact equipment (such as pile driver, pneumatic breaker) is the biggest noise hazard to operators and workers nearby while earth moving equipment (such as bulldozer, truck, paver, etc.) exposes a greater number of workers to noise hazards. For the workers on site, it is

[11] Laborers Helath and Safety Fund of North America, Controlling Noise on Construction Sites, Guidance document, available at https://www.lhsfna.org/LHSFNA/assets/File/bpguide%202014.pdf

important to have protective equipment and implement OHS measures (job rotation, activity planning, scheduling of operations, etc.) that will protect them from negative impacts of prolonged exposure to noise.

Concerning the residents in the area, the noise is decreasing with the distance from the source so it is fair to assume that largest impact will be on the houses located in close vicinity to the construction camp. Doubling the distance from the noise source lowers the noise level by 6dB. The scheduling of work, appropriate placement/containment of noisy equipment, as well as appropriate planning of noisy works can reduce the impact on residents in the area.

11.3.3.2 Operation Phase

In the **operation phase**, the main cause of increased noise levels is the motorway traffic. The modelling of noise is performed for the purpose of this study.

Based on the emissions and all other relevant input data presented in Chapter 11.3.2.3, the propagation of acoustic noise is calculated using a 3D model of the surroundings including buildings, obstacles, terrain surface, ground absorption, etc.

Table 11-51: Input data and assumptions for the sound propagation 3D model

No	Input Data	Assumptions - Values
1	**Topography: Primary and secondary contour lines and altitude points**	Contours in project area Rest of study area: from the SRTM (NASA) database
2	**Buildings – obstacles**	From topographic maps provided and satellite imagery
3	**Ground – Sound Absorption**	Average ground sound absorption A = 0.5 (assumption)
4	**Noise Sources – motorway**	Traffic load presented in 11.3.2.3
5	**Noise Sources – other**	Based on existing conditions from baseline noise measurements (2021)
6	**Noise Propagation – wind direction**	Downwind propagation (worst case scenario)
7	**Noise Propagation – meteo data**	Temperature 10°C, Humidity 60%
8	**Calculations – order of reflections**	3
9	**Control Criteria**	$L_{de} \leq 55$ dB(A), $L_{night} \leq 45$ dB(A),
10	**Investigated scenarios**	1. launch year scenario 2. horizon year (2060) scenario

All calculations were done with following software: IMMI Premium 2021. The results are given in dB(A) as A-weighted level of energy equivalent noise (L_{eq}). The calculations are done separate for day-time (07:00 till 23:00) and night-time (23:00 till 07:00).
The resulting noise maps of the sound dissipation are presented in the following figures.

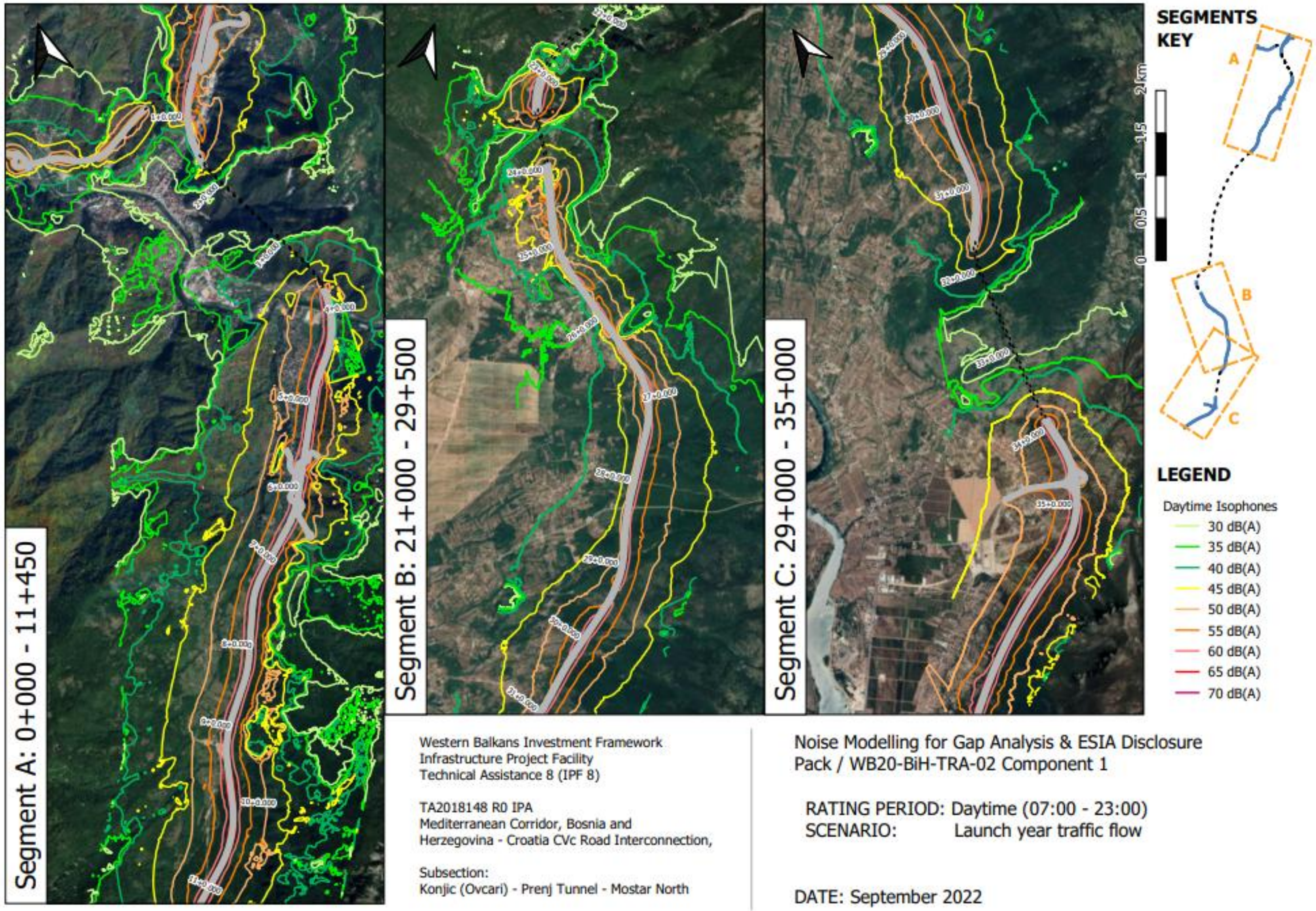


Figure 11-22: Noise maps – Daytime (07:00-23:00), launch year traffic flow

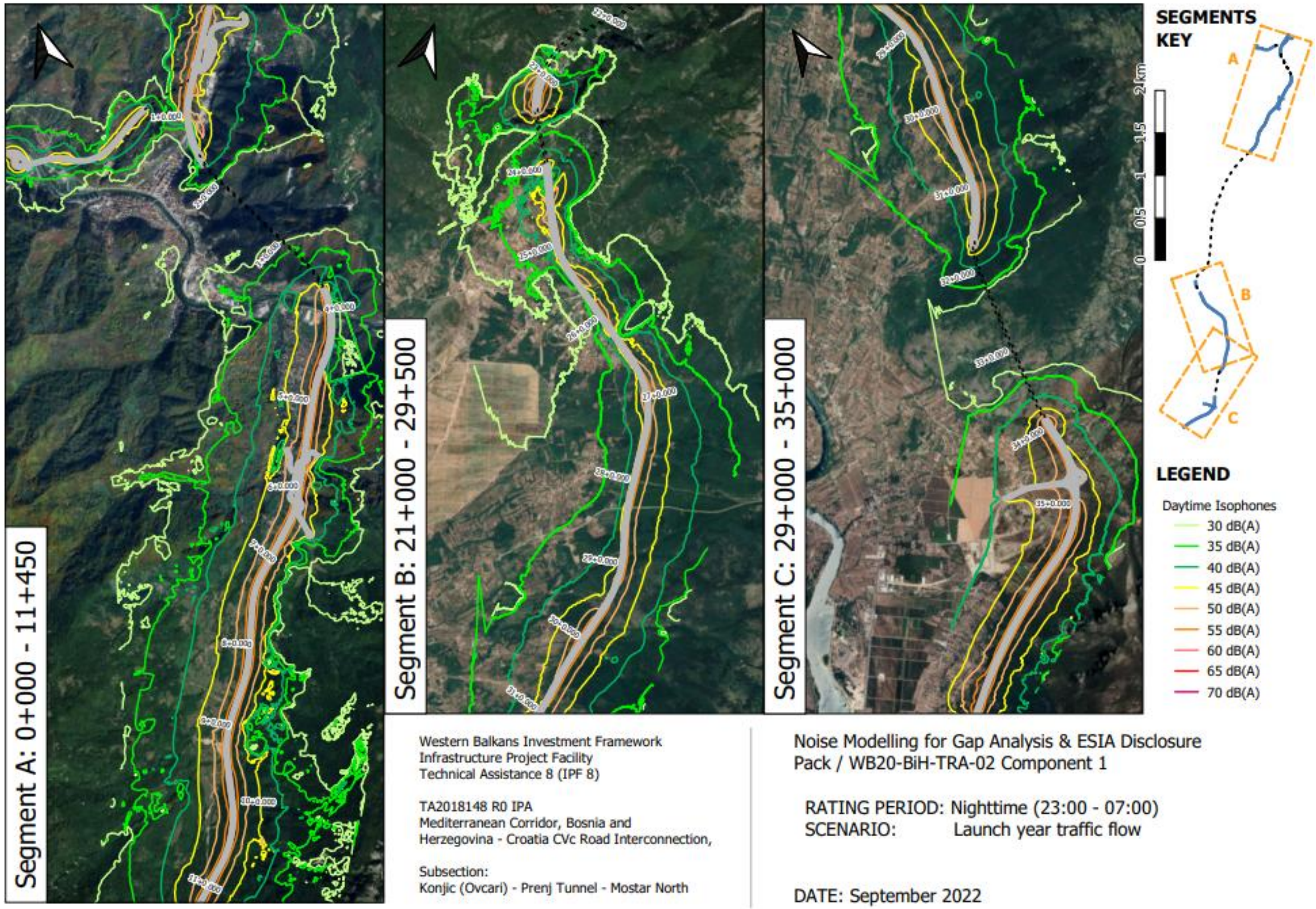


Figure 11-23: Noise maps – Night-time (23:00-07:00), launch year traffic flow

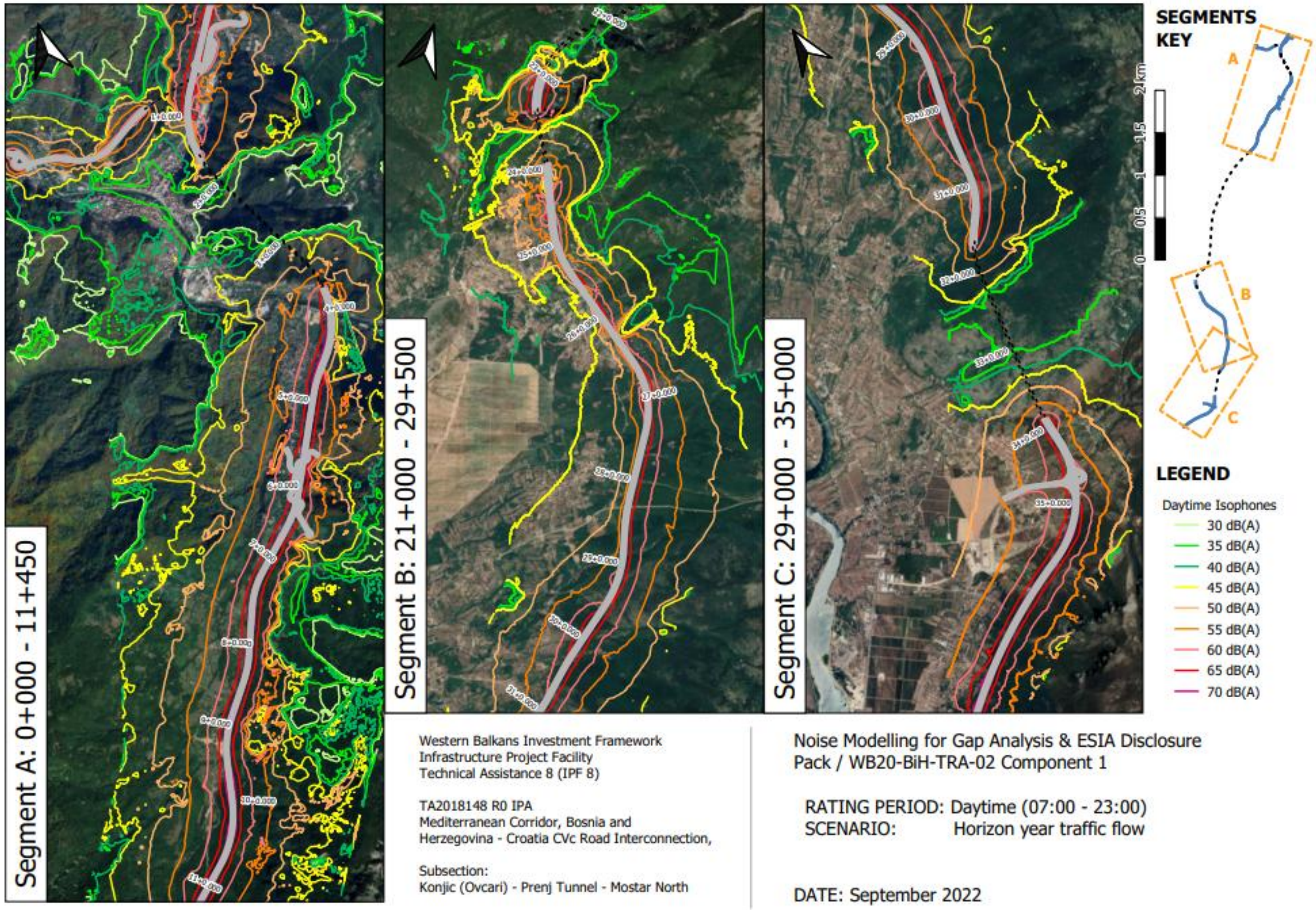


Figure 11-24: Noise maps – Daytime (07:00-23:00), horizon year traffic flow

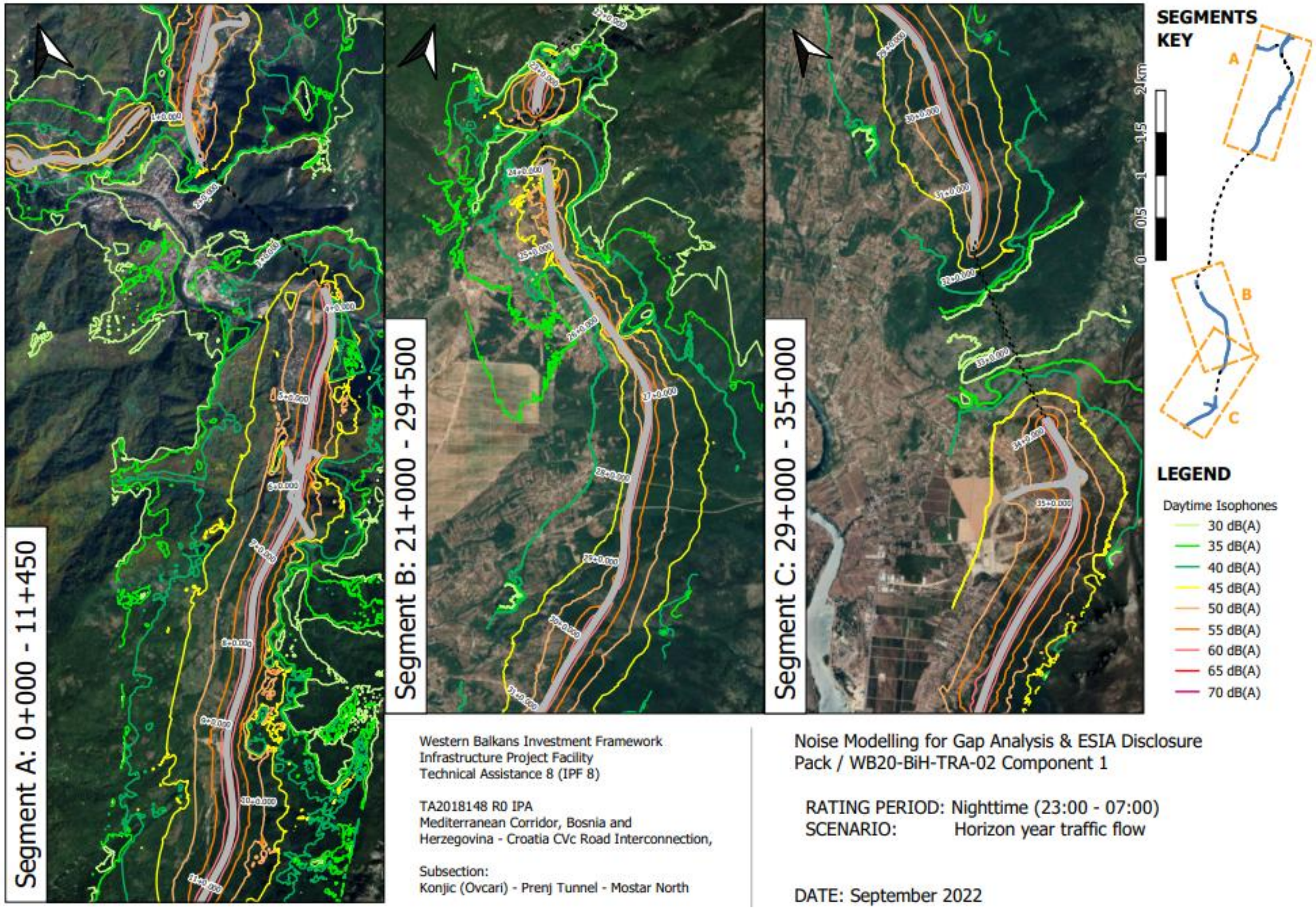


Figure 11-25: Noise maps – Night-time (23:00-07:00), horizon year traffic flow

The results of the noise maps indicate that there are existing buildings that will be exposed to noise over L_{de} = 55 dB(A) and L_{night} = 45 dB(A), as presented in the following tables (Table 11-52 and Table 11-53), where the distribution of noise levels from the new motorway on facades for the buildings of sensitive receivers identified within a ±250m distance from the alignment axis is shown.

In Table 11-52 and Table 11-53, texts with lime colour represent the number of sensitive receivers that are exposed to higher noise levels from noise coming from the operation the motorway than the allowable limit, but the background noise level (BNL) is less than 3 dB lower, hence no annoyance is expected.

In Table 11-52 and Table 11-53, texts with red colour represent the number of sensitive receivers that are exposed to higher noise levels from noise coming from the operation the motorway than the allowable limit AND the background noise level (BNL) is more than 3 dB lower, hence annoyance is expected.

Table 11-52: Distribution of nearby residential buildings according to noise levels exposed, ***launch year scenario***

	>...-35 dB(A)	>35-40 dB(A)	>40-45 dB(A)	>45-50 dB(A)	>50-55 dB(A)	>55-60 dB(A)	>60-... dB(A)	BNL [dB(A)]
				Day-time (07:00-23:00)				
Donje Selo		17	41	45	10	3		51-62
Ovcari	46	26	19	4				59-62
Konjic	1 059	231	70	36	15	3		52-55
Bijela River valley	11	20	300	299	36	19	16	45-57
Podgorani and Humilisani region	152	154	183	26				45-56
Kutilivac			21	69	12	4		42-47
				Night-time (23:00-07:00)				
Donje Selo	24	52	30	8	2			40-43
Ovcari	83	12						49
Konjic	1314	70	19	9	2			50
Bijela River valley	91	317	223	38	21	11		35-39
Podgorani and Humilisani region	393	114	8					35-49
Kutilivac		60	37	8	1			41

Table 11-53: Distribution of nearby residential buildings according to noise levels exposed, ***horizon year scenario***

	>...-35 dB(A)	>35-40 dB(A)	>40-45 dB(A)	>45-50 dB(A)	>50-55 dB(A)	>55-60 dB(A)	>60-... dB(A)	BNL [dB(A)]
Day-time (07:00-23:00)								
Donje Selo			5	37	51	17	6	51-62
Ovcari	34	5	28	21	7			59-62
Konjic	284	706	282	75	46	17	4	52-55
Bijela River valley			27	210	352	78	34	45-57
Podgorani and Humilisani region		113	150	198	53			45-56
Kutilivac				4	83	12	7	42-47
Night-time (23:00-07:00)								
Donje Selo		15	36	51	11	3		40-43
Ovcari	53	27	15					49
Konjic	1 092	212	76	19	12	3		50
Bijela River valley	5	29	358	268	27	14		35-39
Podgorani and Humilisani region	179	168	158	10				35-49
Kutilivac			39	56	8	3		41

Based on the outcome of the calculations from the simulation of the road traffic noise during the operation of the motorway, it comes out that there are regions that exceed the limits of 55 dB for L_{de}, 45 dB for L_{night} and +3 dB from background noise at the facades of some nearby settlements and sensitive receivers, for all two scenarios investigated.

To further analyse the efficiency of noise barriers as a mitigation measure in order to reduce the road traffic noise, several control points to the nearest sensitive receivers were placed. Table 11-54 shows the requirements for the noise barriers needed to reduce the noise within required limits.

Table 11-54: Reduction of noise from road traffic using noise barriers, levels in dB(A) for Horizon year and Launch year

Control point	Chainage	Region	Horizon year				Launch year				Barrier side and height
			Without protection		With noise barriers		Without protection		With noise barriers		
			L_{de}	L_{night}	L_{de}	L_{night}	L_{de}	L_{night}	L_{de}	L_{night}	
IPkt 1211	0+600 KB	Donje Selo	59.8	52.7	54.7	47.6	52.8	45.7	47.7	40.6	left - 5m
IPkt 1293	0+600 KB	Donje Selo	60.1	52.0	54.3	46.2	53.1	45.0	47.3	39.2	right - 3m
IPkt 1371	3+700	Konjic	61.5	54.5	53.7	44.7	55.4	48.4	47.6	38.7	right - 5m
IPkt 1852	4+370	Bijela River valley	62.7	55.7	53.2	46.2	56.7	49.7	47.2	40.2	left - 5m
IPkt 1855	4+400	Bijela River valley	60.2	53.2	53.5	45.6	54.2	47.2	47.5	39.5	left - 5m
IPkt 1861	4+480	Bijela River valley	56.9	50.0	45.3	38.4	50.9	44.0	39.3	32.3	right - 3m
IPkt 1901	5+000	Bijela River valley	53.5	46.8	48.7	41.8	47.5	40.8	42.7	35.7	right - 3m
IPkt 1944	5+420	Bijela River valley	59.3	52.4	53.6	46.6	53.3	46.4	47.6	40.6	right - 3m
IPkt 1953	5+640	Bijela River valley	69.4	62.4	55.0	47.0	63.3	56.4	49.0	41.0	right - 5m
IPkt 1971	5+690	Bijela River valley	64.8	57.9	52.1	45.2	58.8	51.8	46.1	39.1	right - 5m
IPkt 1985	5+870	Bijela River valley	54.8	47.9	45.2	38.2	48.8	41.8	39.2	32.2	right - 5m
IPkt 2020	6+610	Bijela River valley	54.5	47.5	48.8	41.8	48.5	41.5	42.8	35.8	left - 3m
IPkt 2013	6+700	Bijela River valley	54.3	47.4	52.5	45.6	48.3	41.4	46.5	39.5	left - 3m
IPkt 2124	6+910	Bijela River valley	60.0	53.0	50.7	43.4	54.0	47.0	44.7	37.4	left - 3m
IPkt 2259	7+430	Bijela River valley	56.9	50.0	49.2	42.0	50.9	44.0	43.2	35.9	left - 3m
IPkt 2401	10+340	Bijela River valley	56.6	49.8	49.2	42.3	50.6	43.8	43.2	36.2	left - 3m
IPkt 2579	27+750	Podgorani & Humilisani	52.7	45.7	50.4	43.5	46.7	39.7	44.4	37.5	right - 3m

Control point	Chainage	Region	Horizon year				Launch year				Barrier side and height
			Without protection		With noise barriers		Without protection		With noise barriers		
			L_{de}	L_{night}	L_{de}	L_{night}	L_{de}	L_{night}	L_{de}	L_{night}	
IPkt 2480	28+650	Podgorani & Humilisani	52.1	45.1	50.3	43.4	46.0	39.1	44.3	37.4	right - 3m
IPkt 2803	34+150	Kutilivac	53.1	46.1	49.4	42.5	47.0	40.1	43.4	36.4	left - 3m
IPkt 2790	34+200	Kutilivac	57.2	50.2	51.3	44.4	51.2	44.2	45.3	38.3	left - 3m
IPkt 2787	34+300	Kutilivac	60.0	53.0	53.0	44.9	54.0	47.0	47.0	38.9	left - 3m
IPkt 2814	34+550	Kutilivac	52.5	45.5	49.1	42.1	46.4	39.5	43.1	36.1	left - 3m
IPkt 2809	34+750	Kutilivac	52.5	45.6	48.4	41.4	46.5	39.6	42.4	35.4	left - 3m
IPkt 2821	34+900	Kutilivac	52.7	45.8	47.8	40.8	46.7	39.8	41.8	34.8	left - 3m
IPkt 2822	CR1 0+120	Kutilivac	53.1	46.2	49.1	42.2	47.1	40.1	43.1	36.2	left - 4.5m
IPkt 2786	CR1 0+220	Kutilivac	60.3	53.3	49.6	42.7	54.2	47.3	43.6	36.7	left - 4.5m
IPkt 2836	CR1 0+430	Kutilivac	53.2	46.3	52.0	44.9	47.2	40.3	46.0	38.9	left - 4.5m

Table 11-55 below provides a summary of impacts and assessment of their significance.

Table 11-55: Summary of potential noise impacts and assessment of their significance before mitigation

Phase	Type of potential impact	Adverse/ Beneficial	Magnitude	Sensitivity	Impact evaluation	Significance (before mitigation)
Noise						
Pre-construction	Due to the timespan between preparation of this Study and start of construction works, up-to-date information on ambient noise levels in the project area will be needed to determine the baseline conditions	Adverse	Moderate	Medium	**Moderate**	**Significant**
Construction	Impact on workers and residents from increased levels of noise during construction works	Adverse	Moderate	Medium	**Moderate**	**Significant**
Operation	Impact on residents from increased levels of noise from motorway traffic	Adverse	Moderate	Medium	**Moderate**	**Significant**

11.4 Mitigation and Enhancement Measures

11.4.1 Pre-construction Phase

Due to the timespan between preparation of this ESIA and start of construction works, up-to-date information on ambient noise levels in the project area will be needed to determine the baseline conditions. Therefore, it will be necessary to repeat the analysis of ambient noise in the Project area, possibly in two seasons (summer and winter).

On the other hand, inadequate planning of noise barriers may cause impacts on residents from increased levels of noise from motorway traffic. It is proposed to:

- Confirm the noise modelling results and proposal for noise barrier locations given in Chapter 11.4.3 after the Main Design is completed.

- Confirm the technical details of noise barriers considering also the JPAC Technical standards for noise barriers.
- The locations of noise barriers will also be reconsidered in consultation with the local community of Konjic and settlements Tresanica, Gornje Polje, Glavicine, Bijela, Podgorani, Kutilivac and Vrapcici since these settlements are most likely to experience negative impacts of increased level of noise.

11.4.2 Construction Phase

Impact on workers and residents from increased levels of noise during construction works is expected. Therefore, the following mitigation measures should be implemented:

- Include noise control measures in the CESMP to avoid the exceeding of permitted values in accordance with the Law on protection against noise, such as:
    - restriction of works to day-time only (period of day: 06:00 to 22:00, period of night: 22:00 to 06:00),
    - on unpaved roads, maximum speed of vehicles should be restricted to 20 km/h to minimise load-rattle,
    - haul routes should avoid passing dwellings at distances closer than ten metres,
    - equipment and machinery to be shut down when not in use,
    - in case of noise increase complaints by residents, simultaneous use of machines that generate noise over 70 dB should be limited to reduce negative cumulative impacts of noise levels generated during construction works and to ensure that noise levels are within legally defined values, and all noise complaints shall be investigated,
    - all equipment and vehicles will be maintained in good working order - implement a regular equipment maintenance and repair program,
    - machines and vehicles to be used in construction activities must have use/operation permits,
    - noise monitoring to be done at the edge of industrial areas and construction sites,
    - noise monitoring to be done in settlements,
    - monitoring upon complaints during the construction phase of the Project to confirm compliance with legally prescribed values or to identify where additional mitigation is required.
- Installation of noise barriers based on the results of noise modelling and local community consultation done in the pre-construction phase. Read Chapter 11.4.3 for details.

11.4.3 Operation Phase

Based on the outcome of the calculations from the simulation of the road traffic noise during the operation of the motorway for various scenarios, it is estimated that the noise level will exceed the limits of 55 dB for L_{de} and 45 dB for L_{night} in some nearby settlements and sensitive receivers. Therefore, additional noise mitigation measures are suggested apart from the ones for the optimal motorway operation, such as preserving the road and the tarmac in a good condition.

11.4.3.1 Reducing Road Traffic Noise with Noise Barriers

The most applicable measure that can reduce the noise levels is the construction of noise barriers the closest possible to the source, i.e., the traffic lanes. As it is indicated in the Traffic Study, the vehicle circulation is expected to increase over the years while the motorway is in operation.

According to the calculations presented in the previous chapter, for the launch year scenario exceedances of the allowable road traffic noise limits are expected for dwellings in East Konjic, for dwellings in Bijela River valley and for dwellings at Kutilivac (Table 11-54), columns launch year – without protection.

For the horizon year (2060) scenario, even more sensitive receivers are exposed to road traffic noise levels above limits, including dwellings in other additional parts of the alignment.

The table below presents a possible two-step deployment of the noise barriers based in future increase of vehicle circulation, which will be indicated from traffic flow monitoring and from motorway noise monitoring program. Backward calculations indicate that noise levels exceeding the allowable limits are expected when traffic flow gets higher than 25,000 vehicles per day.

Table 11-56: Noise barrier deployment scenarios (refer to Table 11-54)

At the beginning of motorway operation:
N01, at west of motorway, 10 500m of 3-5m high noise barrier
N03, at east of motorway, 878m of 5m high noise barrier
N05, at east of motorway, 1 210 of 3m high noise barrier
When increase of vehicle circulation is identified:
N02, at west of motorway, 2 000m of 3m high noise barrier
N04, at east of motorway, 500 of 3m high noise barrier
N06, at north of Connection Road 1, 540m of 4.5m high noise barrier
N07, both sides of bridge in Konjic Bypass 230m of 5m high noise barrier on left side 130m of 3m high noise barrier on right side

Important remark: Even if noise barriers N02, N04, N06 and NO7 will be decided to be erected in the future, detailed design for bridges and embankments in these areas should consider the space requirements for noise barrier installation, especially

a) for the fixation of the posts to the bridge deck and/or posts' foundation in high embankments, b) for the required distance that the noise barriers will need to have from the road safety barriers and c) for avoiding to place any obstacles along the axis of the noise barrier (such as lighting posts); the trail running along the noise barrier's axis (a 20 cm width band) should be clear up to a height of at least 5-6 meters.

The details of the proposed noise barriers are given below. The noise barriers N01-N06 are shown in the following maps (Figure 11-26-Figure 11-29):

Barriers on the right side of motorway (sensitive receivers WEST of motorway):

N01:
from km 3+710 (end of right tunnel tube T-1) to km 10+500 (start of right tunnel tube T-2), length: 6 790m, height 3-5m, as close to the road surface as allowed

N02:
From km 27+200 (end of overpass 1) to km 29+200 (section P584), length: 2 000m – 25m for spans of overpass 2 and overpass 3, height: 3m, as close to the road surface as allowed

Barriers on the left side of motorway (sensitive receivers EAST of motorway):

N03:
from km 3+733 (end of left tunnel tube T-1) to km 4+611 (section P93), length: 878m, height: 5m, bridge & embankment: as close to the road surface as allowed, cut: top of cut

N04:
from km 6+500 to km 7+000, length: 500m, height: 3m, as close to the road surface as allowed

N05:
from km 33+980 (end of left tunnel tube T-5) to km 34+941 (section P700), length: 961m + 250m overlap at interchange "MOSTAR NORTH", height: 3m, as close to the road surface as allowed

Barriers on north side of Connecting Road 1 (to I/C "Mostar North")

N06:
from km 0+000 to km 0+540 (toll station), length: 540m, height: 4.5m, as close to the road surface as allowed

Barriers on Neretva bridge of Konjic Bypass

N07a (left):

from km 0+330 to km 0+560, length: 230m, height: 5m,

as close to the road surface as allowed

N07b (right):

from km 0+430 to km 0+560 (toll station), length: 130m, height: 3m,

as close to the road surface as allowed

Figure 11-26: Locations of N03 (yellow) and northern part of N01 (light blue)

Figure 11-27: Locations of southern part of proposed noise barriers N01 (light blue)

Figure 11-28: Locations of proposed noise barrier N02 (red)

Figure 11-29: locations of proposed noise barriers N05 (green) and N06 (orange)

Figure 11-30: locations of proposed noise barriers N07a and N07b

11.4.3.2 Acoustic Properties of Noise Barriers

The sound insulation of the noise barrier panel should comply to the below specification:
DL_R > 29 dB acc. to EN 1793-2:2018

There is no need for sound absorption, so either transparent (which cannot provide absorption) either non-transparent (concrete, steel, aluminium, wood, etc.) panels can be used.

Special care should be given in bridges. An application study for the acoustic treatment of expansion joint gap and gap between left and right branch will be needed, in order to prevent any substantial noise leakage from these gaps.

11.4.3.3 Remarks Regarding Applications of Noise Barriers

In general, noise barriers are modular systems consisting of foundation bodies posts and replaceable panels between the posts.

Spacing between posts can be from 2.00 to 4.00m according to the modular system chosen by the contractor. In order to deal with permanent fixtures and installations, the spacing may be reduced where necessary.

Noise barriers on earthworks must not prevent storm water from runoff. Due to the shape of the terrain a solution with a gap between lowest noise barrier panel (reinforced concrete base panel) and ground is preferred. This gap must not be larger than 3.0 cm in height. If a solution without a gap is chosen an aquiferous layer having a thickness of 20.0 cm is to be built. The base panel of the noise barrier is allowed to embed not more than 10.0 cm into this layer.

Rules and guidelines for corrosion protection according to ZTV-Ing, part 4, section 3 together with DIN EN 12944 and TL/TP-KOR-Steel Structures have to be considered. Galvanising, coating etc. are to be applied at the factory, as long as they are for corrosion protection. To apply corrosion protection coating at the site needs to be agreed with the client.

The panels must be constructed in that way that the surface on the top edge is closed, and no water retention is possible. Water penetrating hollow panels must be able to run off quickly and completely. Runoff water is not allowed to be led into panels below. (Drainage towards the post)

If transparent noise barriers are to be used, they must be from PMMA acrylic sheets, minimum thickness of 20mm.

If non-transparent barriers are to be used, they can be from concrete, steel, or aluminium panels. In panels made as hollow bodies sound absorption mats or absorbing plates have to build in with a distance to the outside of front and back wall of at least 10 mm. The same holds for hollow panels with absorbing covers. Mats and plates made of mineral insulating materials are to be covered on the absorbing side (e.g., black glass mat). These mats have to be free of corrosive substances, lightproof and resistant against de-icing salt, weather and rot. (No protection film is allowed.) Even aged the panels have to be dimensionally stable and in position. They must not be positioned in the water bearing part of the panels.

The upper and lower flanges have to be constructed as tongue and groove system (for hollow panels).

The panels must not clatter because of suction and pressure effect caused by passing trucks and wind. A two-sided elastic support is preferred.

For vertical support elastomeric bearings type F according to DIN EN 1337-3 shall be used, which have to be secured against loosening, dismantling and falling out. The panels must not move out of the supports at the posts.

The main supporting structures, panels and associated components of the noise barriers should have a design life of a minimum of 50 years and the whole system has to be burglar-proof.

The dimensioning of the components (foundation, steel posts, panels, etc.) shall be conformed in accordance with applicable European standards (Eurocodes). The structural analysis shall consider the static and dynamic reactions of the components and the whole system. Because of to the frequent stress change due to the pressure-suction load all elements including anchoring and footing are to be tested for fatigue. According to the embodiment the dry weight or, if unfavourable, the wet weight is to be considered. The wind and snow-plow loads have to be considered according to local climate data.

Traffic safety should also be considered when positioning noise barriers, as they must not lie in the buffer zone of crash barriers or reduce visibility.

With respect to the tender documentation, performance requirements (based on the above criteria) will be specified in order to allow for the Contractor to produce the most cost effective and aesthetic solution to the Beneficiary. There will also be a requirement that the Contractor designs such barriers and presents his calculations and solutions to the Engineer/Beneficiary for approval.