DELIVERABLE 1.2.1[1]

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Work Package WP1	Acoustically green city areas – Q-Zones		
1.2	Embedded parks in Q-Zones		
	Boundary conditions and noise gains for parks embedded in Q-Zones		
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PU	Public	✓
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restrictec to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for the members of the consortium (including the Commission Services)	

Nature of Deliverable

R	Report	✓
P	Prototype	
D	Demonstrator	
O	Other	

SEVENTH FRAMEWORK PROGRAMME

1 see List of Deliverables, DoW – Annex I to the contract, p.32 (document 233655_CITYHUSH_AnnexI_DoW_2010-01-31_Corrections.pdf - available on the ftp-server)

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Annex

0 EXECUTIVE SUMMARY

0.1 OBJECTIVE OF THE DELIVERABLE

Identification of boundary conditions and maximum noise gains for parks embedded in Q-Zones.

Work Package 1.2 (WP1.2) has two key aims: the identification of potential maximum noise gains (in a park embedded within a Q-Zone) by increasing the quietness of an area surrounding a park and the identification of the influential parameters when determining the boundary of a Q-Zone.

0.2 DESCRIPTION OF THE WORK PERFORMED SINCE THE BEGINNING OF THE PROJECT

Numerous site inspections have been carried out in each of the cities that are addressed in this work. Contact has also been made with the relevant city administrations/authorities in order to identify potential sites to be considered for a Q-Zone and to discuss possible local issues.

Five different European cities have been chosen to evaluate the effects of establishing prospective Q-Zones. The evaluation was based on geographical data, traffic data, population data and assumptions on population behavior. Traffic models were created and these were then used to simulate noise distributions for various hypothetical Q-Zone scenarios. The difference in the noise situation of these scenarios with the current situation was compared and will be presented.

0.3 MAIN RESULTS ACHIEVED SO FAR

- Simulation/forecast of the maximum noise gains expected from embedment of chosen parks in the appropriate Q-Zones.
- Improvements of the noise situation in the Q-Zone and the corresponding park were achieved in many cases.
- Capacity increases were achieved in many cases.
- Negative impacts on areas outside the Q-Zone were identified.
- Approach for individual adaption of standard Q-Zone configurations has been suggested, to reduce negative effects in the areas outside the Q-Zone.

0.4 EXPECTED FINAL RESULTS

- Presentation of methods to reduce noise levels inside parks.
- Description of the boundary conditions (scenario configurations) and their impact on the respective test sites

0.5 POTENTIAL IMPACT AND USE[2]

Support of city administrations in the production and implementation of noise action plans according to the directive 2002/49/EC.

0.6 PARTNERS INVOLVED AND THEIR CONTRIBUTION

ACC has been responsible for the deliverable and has also contributed with the noise modeling parts within the test-sites Bratislava, Bristol and Essen.
ACL has contributed with noise model parts related to Gothenburg and Stockholm.
KTH has been responsible for all traffic modeling for all test-sites.

0.7 CONCLUSIONS

- Noise situation in parks can be improved by embedding the park in a Q-Zone
- Possible negative effects outside the Q-Zone need to be mitigated by measures that need to be assessed and defined for each individual case
- An approach is shown that gives reason to believe that negative effects can be minimized by individual modification of the standard Q-Zone configurations

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2 *including the socio-economic impact and the wider societal implications of the project so far*

1. INTRODUCTION

1.1. PURPOSE

Identification of boundary conditions and maximum noise gains for parks embedded in Q-Zones.

1.2. BACKGROUND

The CITYHUSH project will support city administrations in the production and implementation of noise action plans according to the directive 2002/49/EC.
The identified hot spots and noise action plans made with the existing technology suffer from major shortcomings:

a. poor correlation between hot spots with annoyance and complaints;
b. most measures lead to increased emissions;
c. only indoor noise comfort is addressed.

Step change solutions are proposed to reduce noise in the city environment. The project deals with developing suitable problem identification and evaluation tools, with designing and developing solutions for hot spots, which show high correlation with annoyance and complaints.
The following innovative solutions and tools will be developed:

1. concept of Q-Zones (zones in inner city where only quiet low emission vehicles are tolerated),
2. concept of parks embedded in Q-Zones,
3. improved indoor noise score rating models by integrating low frequency noise and the occurrence of high noise single events,
4. noise score rating models for outdoors,
5. objective and psychoacoustic evaluation tool for low noise low emission vehicles,
6. mathematical synthesis tool for noise from low noise and low emission vehicles,
7. general performance noise specifications for low noise low emission vehicles,
8. novel concepts for low noise roads based upon dense elastic road surfaces,
9. novel concepts for low noise roads based upon grinding of asphalt top layers,
10. novel concepts for tires for low noise vehicles, including heavy vehicles,
11. criteria for use of low noise motorcycles,
12. active and passive noise attenuation measures within the tyre hood,
13. solutions for high low frequency absorption at facades of buildings,
14. solutions for high low frequency isolation in the propagation path.

All the above solutions and tools will be designed, prototyped and validated. They will result in obtaining the anticipated noise impacts.

1.3. WHAT THE REPORT COVERS

The following report concentrates on item 2 listed above 'Concept of Parks Embedded in Q-Zones'. The possibility of increasing the quietness in a park by surrounding it by a Q-Zone area will be studied. We will also analyze and display how quiet areas in city cores can be created and preserved e.g. by "Q-Zone embedded- parks". This is a concept where a park in the city core will be surrounded by a "Q-Zone" area so that the park will be a genuine calm area for the benefit of the visitors. The following studies will be described:

- determination of the maximum noise gains expected from embedment of the park in a Q-Zone; and
- determination of the influence of local parameters

The following deliverable was required as part of this project, 'D1.2.1-Boundary conditions and noise gains for embedded parks in Q-Zones'.

2. MAXIMUM NOISE GAINS FROM EMBEDMENT OF THE PARK IN A Q-ZONE

One of the key aims is determining the maximum noise gains expected from embedment of the park in a Q-Zone: This has been done by evaluating the existing noise levels in different parks of European cities (test sites). The information will be extracted by using the city- and source-models from noise mapping which is available from the Strategic Noise Mapping carried out by different member states for the 1st round noise mapping of agglomerations (available through partner ACCON and Acoustic Control). A pre-selection of 5 situations in 5 reference cities were made all over Europe. The test sites are described in Deliverable D1.1.1 [1].

The detailed information and area specific results for the 5 finally chosen test sites, where embedded parks in Q-Zones are being considered, are shown in Chapter 7, (7.1-7.5).

3. BOUNDARY CONDITIONS FOR A PARK IN A Q-ZONE

The determination of the influence of local parameters, such as: the size of park areas, the range of noise sources, the size of the projected surrounding Q-Zone, the nature of the surrounding areas and the methods of accessing the area are necessary to enable ease of implementation across member states. In this respect, it was appropriate to understand that the environment of an embedded park potentially related more to the differential between the noise levels within other surrounding areas than to any single absolute noise descriptor.

Among experts the view is shared, that an area can be defined as quiet when the noise level is around 6 dB lower than the surroundings. The absolute level seems less important. A similar approach could fit well with the definition of boundary conditions for Q-Zones as well as providing a potential route for defining a noise descriptor.

3.1. DEFINING BOUNDARY CONDITIONS

The boundary conditions for all of the test sites being used for the purposes of the CityHush project vary according to the city and the location of the Q-Zone and park. However, there are a number of concepts, which need to be considered at all sites when defining the boundary conditions of a park embedded in a Q-Zone.

3.2. SIZE OF PARKS

There does not appear to be a maximum or minimum size limit in terms of defining the boundary conditions of an embedded park. The area surrounding the embedded park is the defining factor, as the size of a park is constrained by the roads and transport links surrounding it, which includes the traffic flows and movements of an area. The aim is to achieve noise reduction gains by controlling and managing the traffic flow around embedded parks, i.e. within the Q-Zone, which surrounds the park. If a park is too small the scope of reducing the noise levels within the park may potentially be reduced due to the limited traffic movements, hence any change in vehicle type will also have limited positive effects for noise gains.

3.3. RANGE OF NOISE SOURCES

The noise sources and characteristics will vary considerably for each park embedded in a Q-Zone, some will be surrounded by residential and some will have a more commercial characteristic. Transport sources will also vary for each site, based on the characteristics of the surrounding area, distances to nearby rail, tramlines, tube lines, bus lanes, public transport, aircraft and private vehicles such as cars, motorcycles and scooters. However, for the purposes of defining boundary conditions of an embedded park this report will only consider cars.

Noise from within the embedded park will also be a contributing factor to the overall noise characteristics of the embedded park and the surrounding Q-Zone. These are not considered within the findings of this study, however they may warrant further consideration later, as the variation between parks and the activities that take place in a park will differ considerably between parks and countries. The activities within parks may be best reviewed by the Local Authority and be considered at a local level.

3.4. Size of projected surrounding Q-Zone

The work being undertaken as part of WP2.1 has found that 400 m may be a suitable cut off point in terms of distance to travel to a park, stating the following:

The distance of the green area (embedded park) from the dwelling of an inhabitant may be crucial for its relevance to residents, with previous studies indicating that urban green areas within a maximum distance of 400 m (5 minute walk) from the home encourage outdoor recreation and health-promoting activities (Kaplan (1985) [2], Takano et al., (2002); [3], Humpel et al., (2004), [4]; Jim and Chen and (2006), [5]. On the other hand, van den Berg et al. [6] found that the amount of green space in a 3 km radius, but not in a 1 km radius, moderated the relationship between stressful life events and number of health complaints.

Defining the size of Q-Zone is a complex issue, as many different factors need to be considered when doing so:

- the usage and facilities within the embedded park
- access to other green spaces (embedded parks) in the area
- ease of access
- characteristics of the Q-Zone surrounding the embedded park
- attitudes of park visitors, variations between cities and nationalities.

Defining the size of the projected Q-Zone by application of a specific distance in certain circumstances may be difficult to apply based on the embedded parks size and location. A park in the centre of a largely commercial area would potentially need far more management than an equivalently sized park surrounded by residential streets, where levels would predominantly be lower.

Also by using a specified distance, it will be difficult to mitigate against a particularly noisy road or premises which falls within the Q-Zone, a better option would be the use of contours radiating out from the boundary of the park, the boundary of the Q-Zone could be defined by specific contour bands. Once an increase of say 10 dB (or 2 x 5 dB) is reached that becomes the boundary of the Q-Zone, applying contours in this way will also allow other noise sources in the future to be evaluated more easily and will provide an easy evaluation criteria. This process also fits with the strategic maps already produced. This will also allow for variations in areas type, so that each area can be tailored to the specific needs of the authority or the area.

3.5. Nature of surrounding area

The characteristics of a Q-Zone surrounding an embedded park can vary in nature, whether industrial, commercial or residential. The usage of the embedded park within the Q-Zone effectively defines whether or not the area can be considered as a Q-Zone. The fact that local residents with their children use a park or if employees of local business only use it during their lunch break, should not be a defining factor of an embedded park. Both parks should be considered, but the emphasis in terms of importance may need additional consideration based on the number of park visitors, percentage of usage during an average week. Such matters may be best discussed at a local level.

3.6. Noise descriptors

Boundary conditions could be defined using differences in noise level contours, from inside to outside of the park, the size of park will affect the way in which contours work, as larger parks may be covered by a range of noise level contours.

Depending on park size, a varying percentage of the park space may have to meet a defined noise level or the park as a whole will have to meet a minimum noise level. The local authority controlling such an area may best determine the designation of parks by contours or absolute noise level. Various classifications of parks may be an option and a potential way of dealing with varying levels of noise, based on different surroundings/environment. Different classes could also act as a potential methodology for determining whether a park needs additional mitigation/active noise management.

4. INFORMATION COLLECTED

4.1. TRAFFIC DATA

The areas identified in each city as potential Q-Zone were surveyed for the purpose of identifying traffic flows and to define the noise characteristics of the areas in question.

Therefore for each test site a detailed traffic model had to be built-up, which also covers besides the Q-Zone with its embedded park the surrounding area influenced by traffic re-distribution caused by restriction (e.g. only hybrid cars allowed) and other measures.

For validation of the created traffic models ACCON carried out additional survey work concentrating specifically on traffic movements and other noise relevant traffic parameters.

The traffic models used are described in Deliverable D1.1.2 [7] and in Chapter 7.1 to 7.5 for each test site.

4.2. NOISE MODEL DATA

Based on the size of the traffic model for each test site a noise model was built up (created), which allows considering the noise distribution in the environment and the noise levels at buildings. Therefore, the available 3-dimensional digital terrain and building data, the digital road network, barriers and other noise relevant parameters from the 1st round of Strategic Noise Mappings were updated.

For each test site an interface between the traffic model and the noise model was created, which allows a systematic and automated investigation of different traffic scenarios.

4.3. RESIDENT DATA

For all test sites “resident data” for each building was incorporated into the noise model. This allows considering the “number of residents in walking distance” as a describing parameter. Also the influence of the implementation of a Q-Zone and its embedded park on the annoyance of the affected residents can be investigated.

5. PARAMETERS AND CHARACTERISTIC VALUES FOR DETERMINATION OF NOISE GAINS

5.1. PARAMETERS FOR EVALUATION OF EXISTING NOISE LEVELS IN PARKS

The noise situation within a park can be described by different parameters. Beside average daytime noise levels, also the number and height of noise peaks in a park are criteria, which can influence the use of a park. In dependence of the use of a park (e.g. recreation, sports, children play ground) the noise distribution within the park is also an influencing parameter. Large size parks offer recreation areas in the centre of a park and sport activities, gastronomy or children playgrounds in more noisy areas of a park. Small sized parks often allow only one exclusive use, as the noise caused by the more noisy use of the park itself exempts recreation use.

For evaluation of the existing noise levels in parks, we decided to determine the following parameters:

- Average day/evening-time noise level (L_{de}) in the park, based on grid calculations (10 x 10 m²)
- Noise distribution within a park (area [m²] affected by noise [1 dB classes]), based on L_{de}.

5.2. PARAMETERS FOR EVALUATION OF NOISE GAINS ON RESIDENTIAL AREAS

The size of the Q-Zone and the size of the embedded park influence the traffic distribution inside and outside the Q-Zone. Analogical effects on environmental noise of residential buildings around the embedded park or Q-Zone can be expected. For identification and evaluation of the noise situation around a Q-Zone we decided to determine the following parameters:

- L_{den} at the most exposed facade of each residential building
- L_{den} at the “quietest” facade of each residential building
- Number of people per building affected in 1 dB classes
- Noise score per building based on “Improved noise score model for indoors” published in Deliverable D2.2.2 (WP 2.2) [8]

5.3. PARAMETER FOR THE EVALUATION OF THE BEHAVIOR OF RESIDENTS TO VISIT LOCAL PARKS

The “Ambient noise” around residential buildings could influence the behavior of the residents, to visit local parks. The effect of noise in the outdoor urban environment will be investigated in the CityHush project within WP2.1 (see Deliverable 2.1.2 “Validated noise score model for noise outdoors” [9]).

Remark:

The “nature of the surrounding area” could also be an influencing parameter for evaluation of embedded parks in Q-Zones. TNO (see Deliverable 2.1.1 [10] and 2.1.2 [9]) based its preliminary dose-response relation on research in natural parks and urban parks. There was a clear difference between these two functions, with much higher annoyance in the natural parks, probably due to expectations concerning the acoustical quality. Annoyance at a given noise level in urban streets may be lower than in urban parks, but so far there are no research results available to confirm such an assumption.

Based on preliminary project results the “Ambient noise” of residential buildings are linked with the residents’ practice of visiting parks. We therefore consider the following parameters:

- average ambient noise level (L_{de}) within a 400 m radius of the location of the considered residential buildings and
- average noise level (L_{de}) at the building façade.

Because the “Ambient noise” of a residential building also influences the degree of annoyance and thereby the “% highly annoyed people”, we decided to consider that influence by calculating the % HAP based on the L_{den}´, as described in D.2.2.2 [11].

6. EVALUATION OF NOISE SITUATION WITHIN DIFFERENT SCENARIOS AND TEST SITES

For further analysis of the influence of noise relevant parameters the following characteristic values will be determined for each test site and for each scenario (variation of size of park, size of Q-Zone, percentage electric cars,...):

Characteristic values for the embedded park:

- average noise level ($L_{de,av}$) within the park based on 10 m x 10 m-grid-calculations
- noise distribution within a park (area [m²] affected by noise [5 dB classes])
- "capacity" of embedded park ("capacity" is defined as size of area with an average L_{de} which is 10 dB lower than that of its "surrounding" (surrounding is defined as the area, that's residents can reach the park within a 5 min walk/ within a distance of 400 m)
- number of visitors calculated on number of residents within a 5-min-walk-distance (400 m) to the park

Characteristic values for the Q-Zone including embedded park:

- average noise level ($L_{de,av}$) within the Q-Zone based on 10 m x 10 m-grid-calculation
- number of residents within the Q-Zone
- L_{den} (at the most exposed facade) and L_{den} (at the quietest facade) of each residential building within the Q-Zone
- annoyance of residents (single number value) calculated on the number of residents and the building specific average noise level L'_{den}. We will refer to this value as "highly annoyed people"(HAP) (see D2.2.2 [8])

Characteristic values for the Q-Zone affected area (test site without the Q-Zone):

- average noise level ($L_{de,av}$) within the test site based on 10 m x 10 m-grid-calculation
- number of residents outside the Q-Zone
- annoyance of residents (single number value) calculated on the number of residents and the building specific average noise level based on the L'_{den} (see D2.2.1 Improved noise score model for the Q-Zone).

7. APPLICATION OF DEVELOPED STUDIES IN TEST SITES

7.1. BRATISLAVA TEST SITE

Bratislava is situated in southwestern Slovakia, within the Bratislava Region. The city has a total area of 367 km^2. Bratislava straddles the Danube River, which crosses the city from the west to the southeast. The city location is shown in the Figure 7.1.1 below.

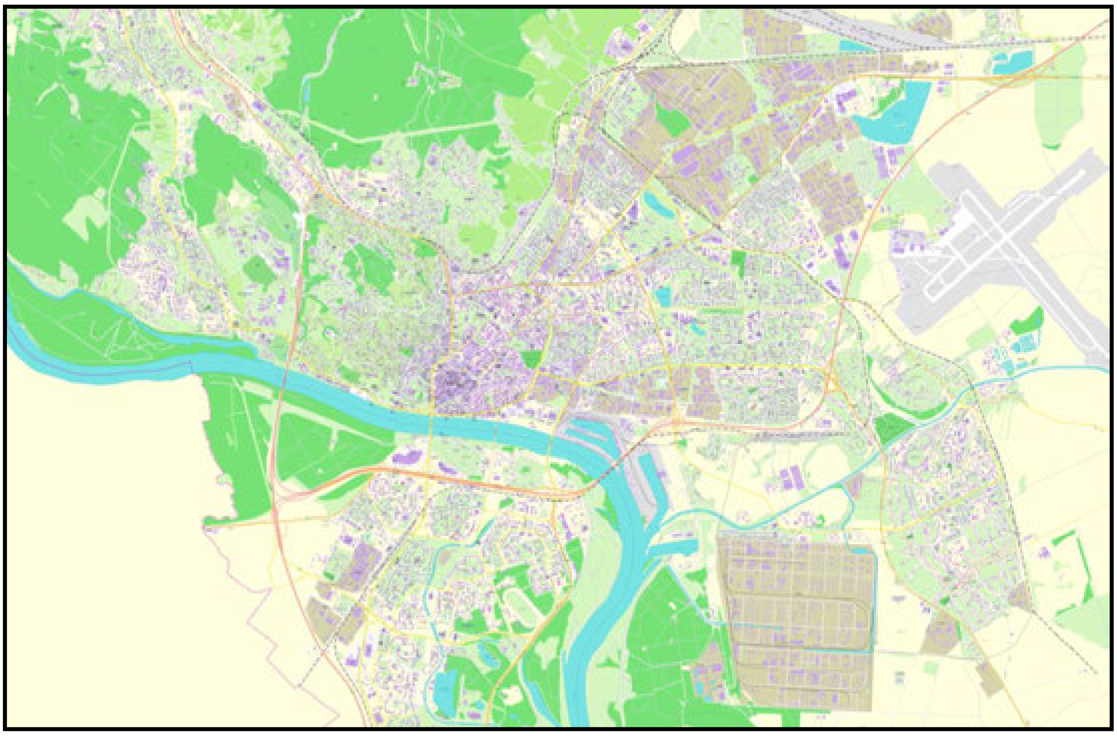

Figure 7.1.1: Overview map of Bratislava

7.1.1 Description of the Q-Zone and its embedded park in Bratislava

The City of Bratislava is already planning and developing areas along the Danube River. The Danube embankment offers excellent possibilities to create an enjoyable recreational environment, and reshaping dockland areas to a mix of commercial and residential land use is under way. Such developments are located east and west of the area south of the old town.

The prospective Q-Zone straddles the Danube, the identified park is located south of the river. This is shown in the Figure 7.1.2 below.

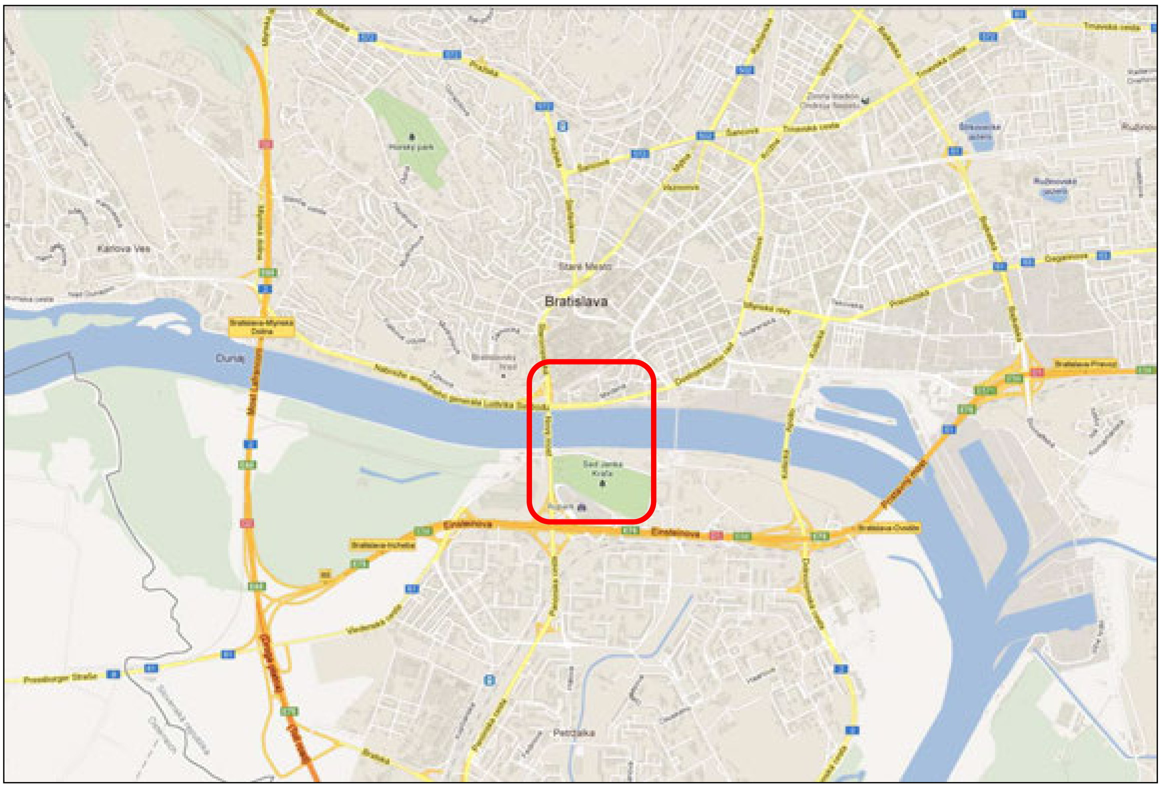

Figure 7.1.2: Prospective area in Bratislava for establishing a Q-Zone

In Figure 7.1.3 we have highlighted the park area by the shaded area and the outlines of the two prospective Q-Zones. A small Q-Zone which is limited to the northern side of the river and a large Q-Zone which also includes the park on the southern side.

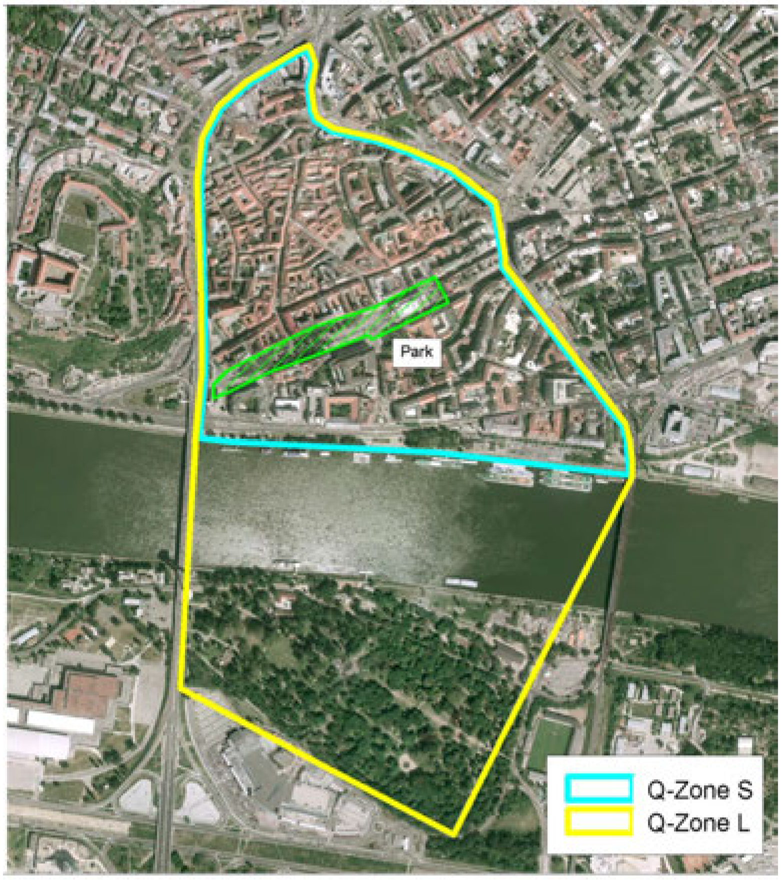

Figure 7.1.3 Embedded park with two Q-Zones

The attributes characterizing the park, the Q-Zone and the test site are compiled in Table 7.4.1. Area sizes are given each for the test site, the Q-Zone and the park respectively. Further attributes refer to the park's number of visitor, who reside in the park-surrounding and the number of residents in the various zones. Additionally we have also specified the population density for the Q-Zone and the test site outside the Q-Zone.

Table 7.1.1: Test-site-describing attributes for Bratislava

Area test site		6.46 km²
Area Q-Zone	**Small S**	0.51 km²
	Large L	1.05 km²
Area embedded park		0.03 km²
Number of residents with access to the park (within a 5 min-walk-distance to the park)		6 807
Number of residents within the Q-Zone	**Small S**	4 421
	Large L	4 424
Density Q-Zone L (inhabitants / km²)		4 216
Number of residents within the test site (outside Q-Zone L)		24 064
Density test site (outside Q-Zone L) (inhabitants / km²)		4 449

7.1.1.1 Noise map and noise distribution on the test site

In Figure 7.1.4 a noise map of the test site in Bratislava is shown. This is a map where the distribution of noise levels $L_{de,av}$ are illustrated by an overlaid color grid. A legend is included where the various colors are mapped with noise level classes. Also the outline of the large Q-Zone is depicted. The noise distribution in Figure 7.1.4 reflects the current situation (i.e. the base case scenario) on the test site in Bratislava. Main roads can be identified as major sources of noise and noise levels are relatively high in the park on southern side of the river.

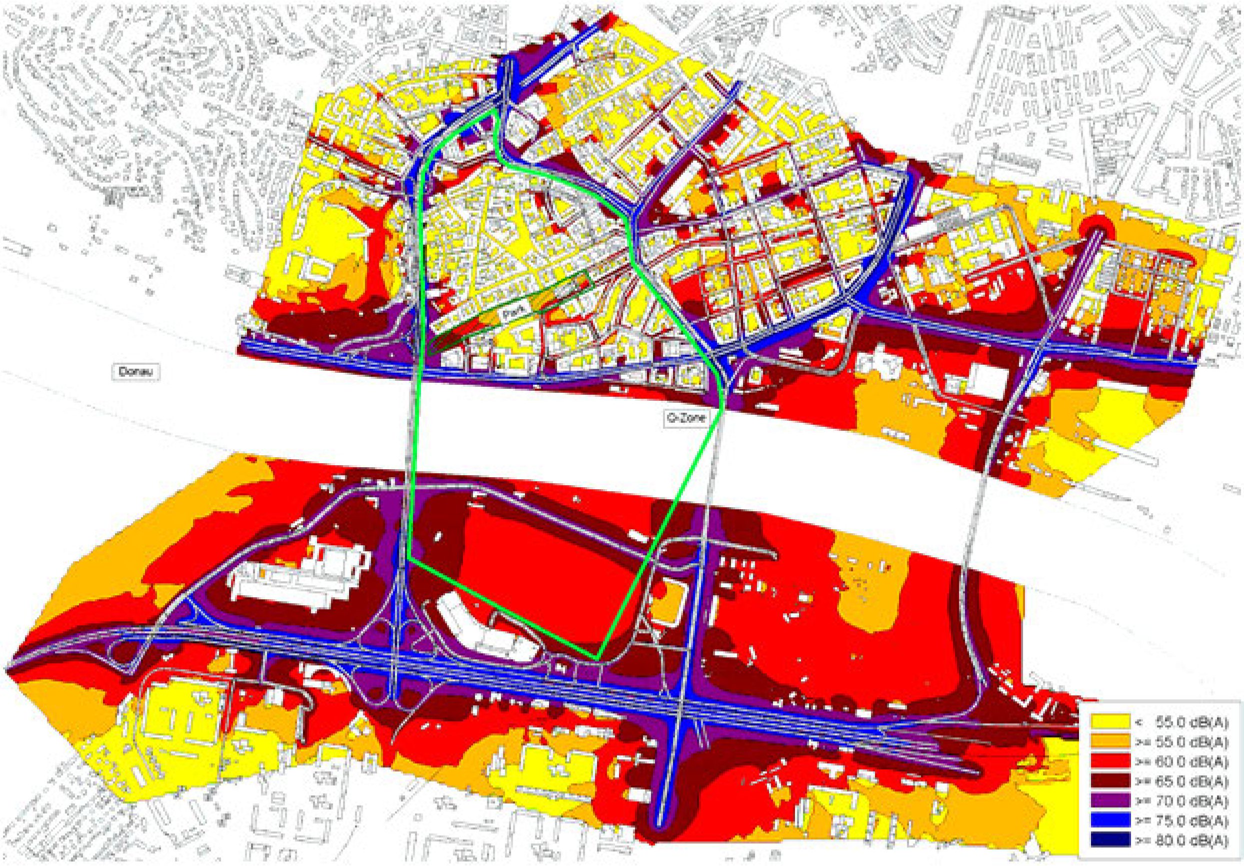

Figure 7.1.4: Noise map of Bratislava ($L_{de,av}$) – in the base case scenario(S16). The boundary of the larger of the two Q-Zones is also outlined.

In Table 7.1.2 the noise distribution in the park area, the two different Q-Zones and the test site (area [m²] affected by noise [5 dB classes]), based on the L_{de} is shown. It catches the eye that the park does not include any areas with average noise levels below 50 dB(A), which reflects the situation already observed on the noise map in Figure 7.1.4. The defined Q-Zones do contain areas of 1 000 m² that fall in to the noise class in the range of 40-45 dB(A).

Table 7.1.2 Noise distributions for the different areas that have been defined for Bratislava test site. Noise levels (based on the L_{de}) are given in 5 dB classes for each of the Q-Zone configurations and for the test sites in the base case scenario. The test site areas exclude the area of the corresponding Q-Zone and the Q-Zone areas exclude the park area.

Noise level [5 dB classes]	Park area [m²]	Q-Zone S area [m²]	Q-Zone L area [m²]	Test site (S Q-Zone) area [m²]	Test site (L Q-Zone) area [m²]
< 40	0	0	0	33 700	33 700
40 - 45	0	1 000	1 000	144 200	144 200
45 - 50	0	147 000	147 000	319 500	319 500
50 - 55	5 900	62 900	629 00	528 000	528 000
55 - 60	9 400	35 900	36 100	959 300	959 100
60 - 65	6 700	51 800	397 600	1 714 900	1 369 100
65 - 70	5 700	61 700	219 600	1 076 500	918 600
70 - 75	1 000	53 800	79 300	578 700	553 200
> 75	0	45 500	53 200	490 200	482 500
Total area size	28 700	459 600	996 700	5 845 000	5 307 900

7.1.1.2 Noise reduction potential

To estimate the park's noise reduction potential, we computed the average noise levels $L_{de,av}$ by assuming a hypothetical, completely noiseless Q-Zone. We exempted all noise sources in the simulation software in two different Q-Zone configurations. We will refer to this as the "background-noise-level-scenario", a model in which all contributing factors to the park's noise levels lie outside the Q-Zone. By this, we can estimate the possible noise reduction that can be expected by installing a specific Q-Zone. The results of these estimations are shown in Table 7.1.3. The noise reduction potential for the park in Bratislava is predicted with 5.1 dB for both Q-Zone sizes.

Table 7.1.3: Noise reduction potential of the Q-Zone on the test site in Essen estimated with the background-noise-level-scenario"

Test site Essen	Base case $L_{de,av}$ [dB(A)]	Background noise level $L_{de,av}$ [dB(A)]	Potential of noise reduction $L_{de,av}$ [dB]
park area, small Q-Zone	60.0	54.9	5.1
park area, large Q-Zone	60.0	54.9	5.1
small Q-Zone area with park	59.2	54.0	5.2
large Q-Zone area with park	62.0	58.4	3.6

7.1.2 Traffic data and investigated traffic scenarios on Bratislava test site

The traffic simulations for Bratislava were built on traffic data from a Bratislava traffic model application that was generously made available to the Cityhush project by local authorities. This application only allowed for traffic simulations concerning cars in our case. No effects with respect to changes of modes, destinations or travel frequency are therefore included. Only route choice effects are simulated. Traffic reductions within the Quiet Zone may therefore be somewhat underestimated, and redistribution effects somewhat overestimated. A major enhancement of the traffic model in the Cityhush project was to allow for the fact that different travellers have different cost sensitivity, which is necessary to take into account when simulating traffic effects of different noise fees. More details concerning the traffic model application can be found in Deliverable D1.1.2 [7].

To be able to establish boundary conditions for Q-Zones, four defining parameters were systematically varied in the traffic simulations. These were

- zone size
- type/degree of constrained access to the Q-Znoe
- low noise vehicle ownership inside and outside the Q-Zone.

The following traffic scenarios shown in Table 7.1.4 were simulated for the Bratislava case:

Table 7.1.4: Table of the Q-Zone scenario configurations for Bratislava

Scenario	Zone	Fee, Euros/passage	Inside LNVO percentage	External LNVO percentage
S1	none	none	1	1
S2	large	ban	1	1
S3	large	1	1	1
S4	large	2	1	1
S5	small	ban	1	1
S6	small	1	1	1
S7	small	2	1	1
S8	none	none	5	5
S9	large	ban	20	5
S10	large	1	20	5
S11	large	2	20	5
S12	none	none	20	20
S13	large	ban	100	20
S14	large	1	100	20
S15	large	2	100	20

The Zone sizes are described in 7.5.1. The fees are to be paid on entry and exit, thereby penalizing through traffic relatively harder than traffic with origin or destination in the zone. The ban is assumed not to be applied to zone residents.

7.1.3 Noise situation for different traffic scenarios on the test site in Bratislava

Here we will discuss the results for the various scenarios in terms of their impact on the park, the Q-Zone and the test site. We will be looking at the noise differences ($L_{de,av}$) between the base case and the forecasted scenarios. We will draw an overall comparison of the effects of the various scenarios and highlight prominent results. To recall the properties of the individual scenarios, we summarized them in Table 7.1.1. During the work it has established itself that the fifteen different scenarios are numbered starting with the index 16 through 30. Here S16 refers to the initial, base case scenario S30 is the fifteenth scenario.

The effects on the average noise levels of the different Q-Zone configurations can be evaluated by studying the noise levels and their distribution on a noise map, or by studying the differences compared to the base case scenario on a noise difference map. We can also evaluate the average noise level $L_{de,av}$ calculated from the grid noise levels L_{de} over an entire zone (e.g. Q-Zone or the test site). Such average levels will be presented at a later stage in this chapter. Correspondingly, the average difference values can also be calculated.

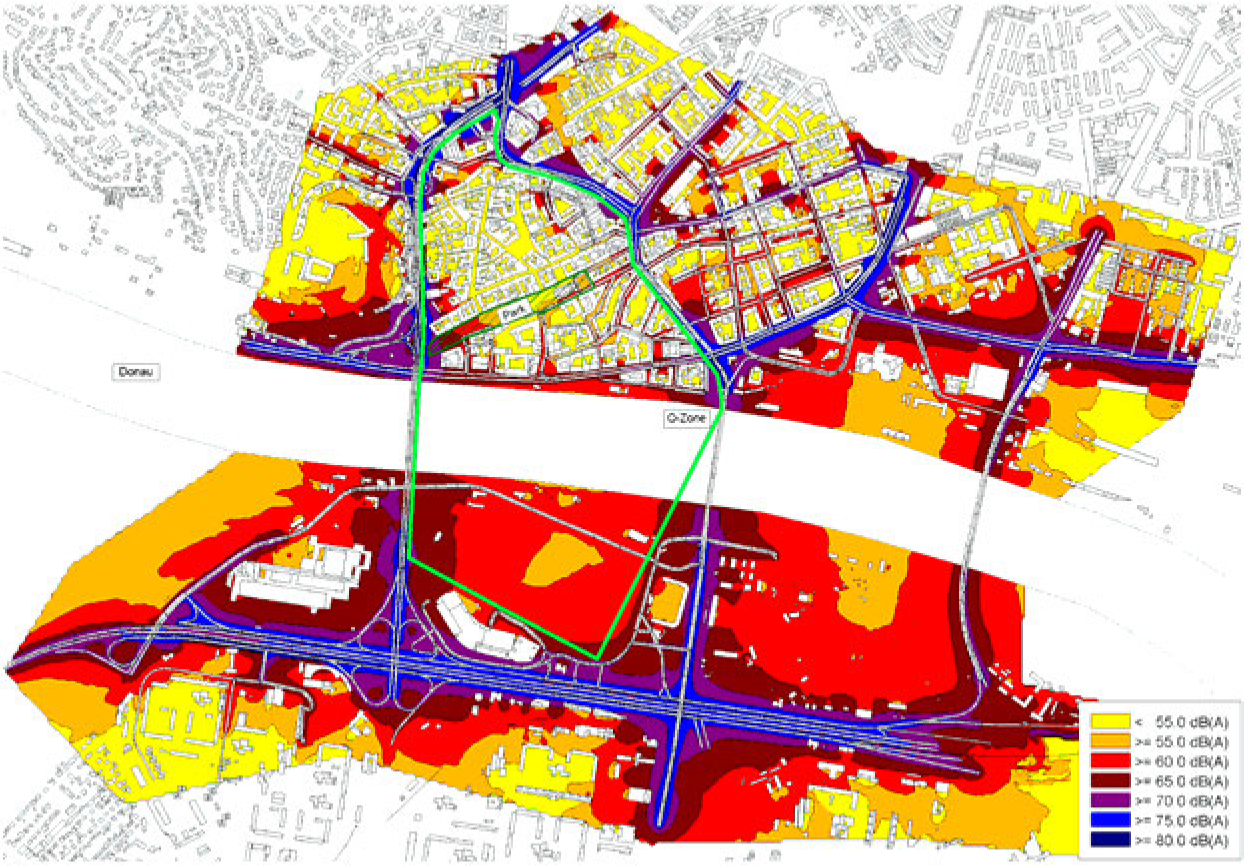

Figure 7.1.5: Noise map of Bratislava with scenario S25

Figure 7.1.5 depicts the noise map of scenario S25, as it is defined in Table 7.1.4 Compared to the base case in Figure 7.1.4 we can identify reduced noise levels at various points on the map. This is quite obvious in the park area, where the formally red surface now includes an orange area. The visual analysis is made easier by illustrating changes in the noise situation with a noise difference map, which is shown in Figure 7.1.6. Here we can observe wide spread ranges of green and pastel-greenish-yellow color tones which indicate noise improvements in the corresponding regions. We can also identify regions with a degraded noise situations, which are highlighted in orange, red and purple color tones. Obviously, other scenarios will produce different pictures. A complete set of noise maps and noise difference maps for the various scenarios is compiled in a separate appendix.

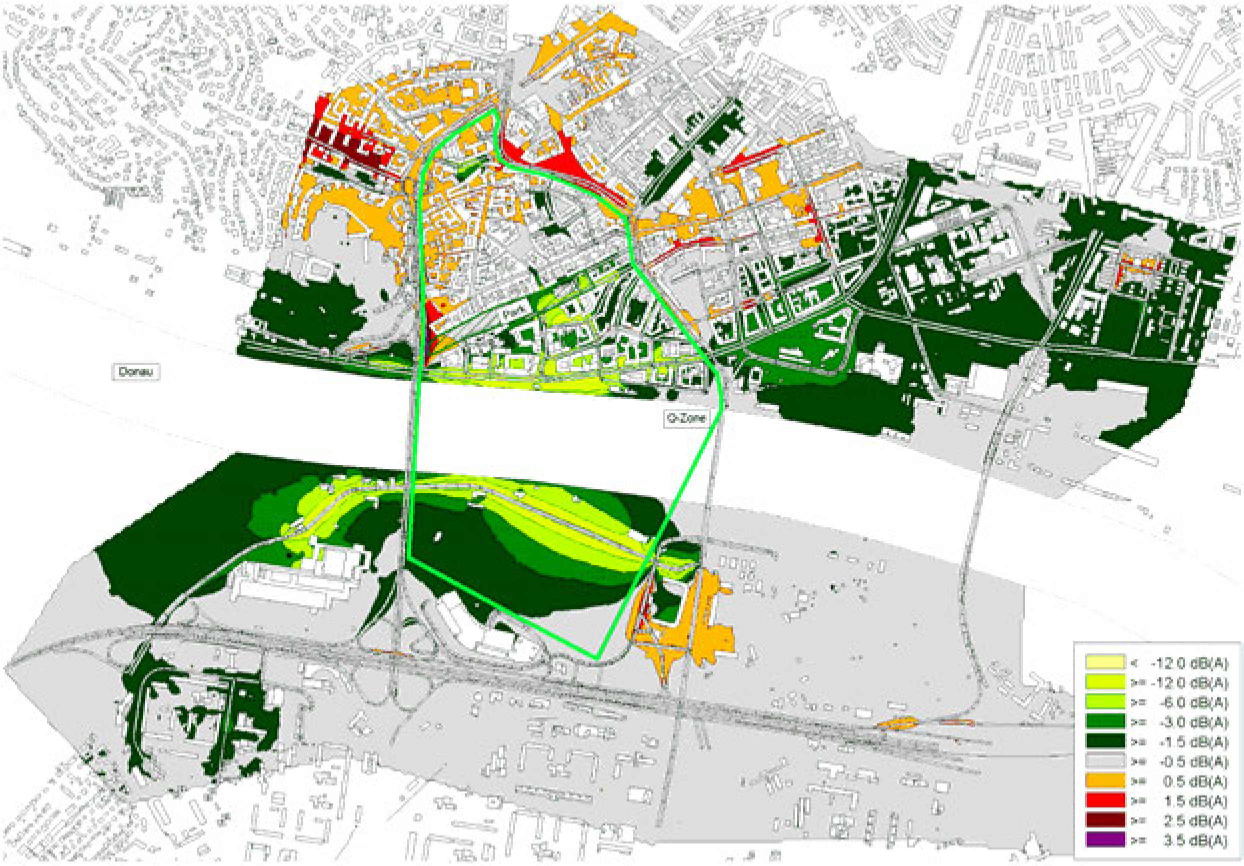

Figure 7.1.6: Noise difference map for the scenario S25

In Table 7.1.5 we have compiled the park areas that fall into noise classes with a 5 dB range for all scenarios. Compared to Table 7.1.2 there are several scenarios which include park areas with noise levels in the 45-50 dB(A) class. This suggests an improvement in the park compared to the base case scenario.

Table 7.1.5: Noise distribution in the various scenarios for the park area. Noise levels are given in 5 dB noise classes. The values in the table specify m^2 of the park area.

Noise level / Scenario	< 45	45 - 50	50 - 55	55 - 60	60 - 65	65 - 70	70 - 75	> 75
S16	0	0	5 900	9 400	6 700	5 700	1 000	0
S17	0	0	9 500	7 700	7 100	2 800	1 600	0
S18	0	100	9 300	7 900	6 900	2 900	1 600	0
S19	0	100	9 200	7 800	7 100	2 900	1 600	0
S20	0	100	9 400	8 000	6 800	2 800	1 600	0
S21	0	100	9 300	7 700	7 100	2 900	1 600	0
S22	0	100	9 000	7 900	7 200	2 900	1 600	0
S23	0	0	6 400	9 100	6 600	5 700	900	0
S24	0	100	10 600	7 600	6 100	2 800	1 500	0
S25	0	100	10 100	7 900	6 300	2 800	1 500	0
S26	0	100	10 100	7 500	6 700	2 800	1 500	0
S27	0	400	8 000	8 200	6 700	4 600	800	0
S28	0	1 000	14 300	6 500	3 600	2 200	1 100	0
S29	0	1 000	13 400	7 300	3 700	2 200	1 100	0
S30	0	900	13 200	7 600	3 700	2 200	1 100	0

The values of Table 7.1.5 are illustrated in Figure 7.1.7 as a bar chart. In this form the most prevailing noise class can easily be identified. We can determine the 50-55 dB class where the largest areas fall into for most scenarios except for scenarios S16, S23 and S27, where the largest areas lie within the 55-60 dB class. These scenarios are characterized by having no Q-Zone configured and only different amounts of LNVO in the test site population are investigated.

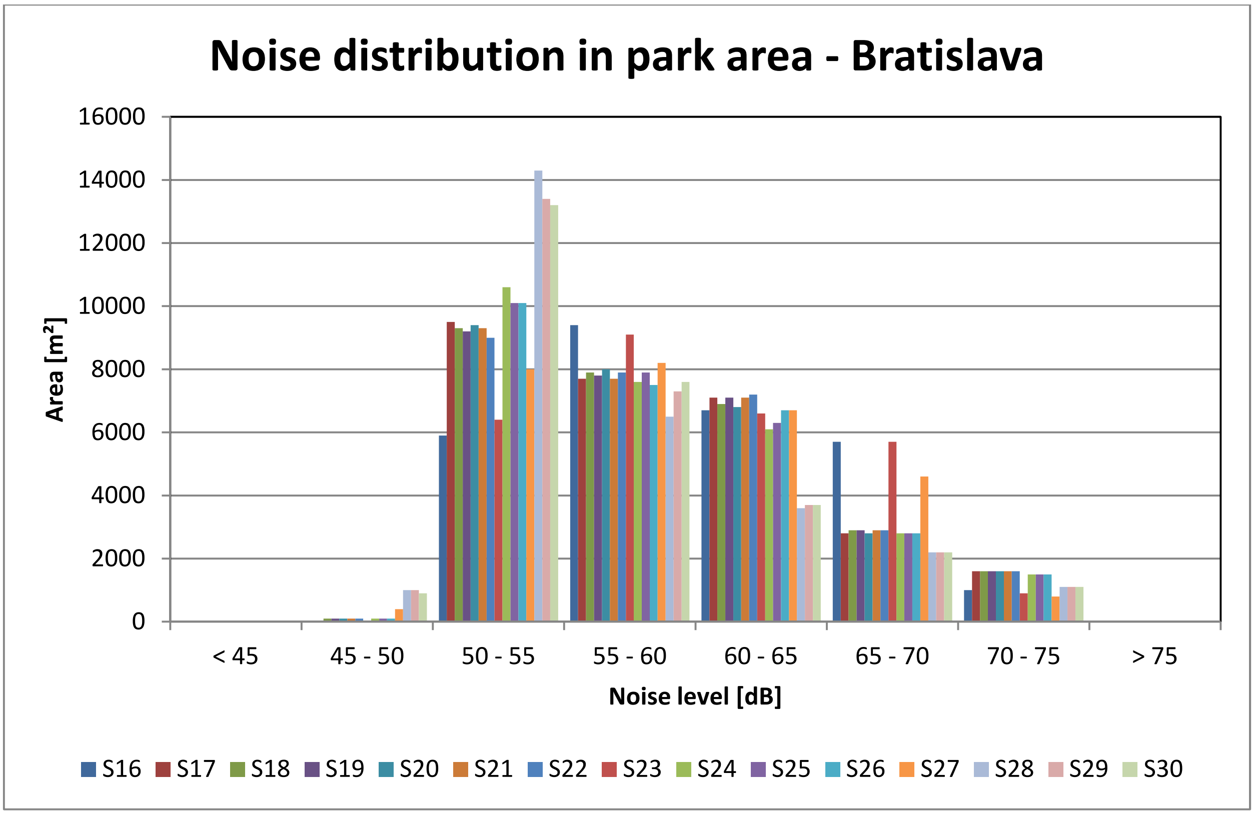

Figure 7.1.7: Noise distribution in the Bratislava park for the various simulation scenarios

7.1.4 Potential noise gains on the test site in Bratislava

In the following we will be looking at some key indicators for assessing the effects of the various Q-Zone scenarios. A summary of these key indicators are presented in Table 7.1.6 and we will be referring to this table throughout the rest of this section. The indicators are the change of the average day / evening noise level $L_{de,av}$ in the park, the change in the "capacity" and we also consider the changes of the number of HAP.

By the term "change" we refer to the differences between the base case and each of the scenarios in regard to the values of the considered measures.

When determining the number of HAP we specify the values in various parts of the test site: in the Q-Zone, outside the Q-Zone (i.e. the test site region without the area of the Q-Zone) and the complete test site. We will also present absolute values of the $L_{de,av}$ in various tables throughout this section.

Table 7.1.6: Potential noise gains on the test site in Bratislava

Scenario	Change $L_{de,av}$ (park) [dB]	Change $L_{de,av}$ (surround.) [dB]	Change of "Capacity"	Change of number HAP within Q-Zone	Change of number HAP outside Q-Zone within affected area	Change of number HAP (Test-site including Q-Zone)
S16						
S17	-1.1	-1	1 320	-49	26	-22
S18	-1.1	-1	1 320	-49	6	-43
S19	-1.0	-1	1 119	-50	8	-42
S20	-1.2	-0.6	1 406	-49	33	-16
S21	-1.0	-0.6	1 320	-49	19	-30
S22	-1.0	-0.6	1 119	-50	21	-28
S23	-0.2	-0.2	115	-5	-25	-30
S24	-1.6	-1.2	1 923	-55	-17	-72
S25	-1.4	-1.2	1 837	-55	-22	-78
S26	-1.4	-1.2	1 866	-56	-21	-77
S27	-0.8	-0.8	804	-29	-121	-150
S28	-3.5	-2.2	8 180	-96	-134	-230
S29	-3.3	-2.2	7 606	-92	-138	-230
S30	-3.2	-2.2	7 204	-92	-139	-231

7.1.4.1 Noise and capacity indicators for the park, the Q-Zone and the test site.

We can also obtain a fair gain in the parks capacity with most scenarios from Table 7.1.6. The scenarios, which are potentially realizable in the short term (i.e. minimum LNVO) do show negative effects outside the Q-Zone in terms of a rise in the number of HAP. We find a rising improvement for the capacity values and the reduction in the number of HAP with a rise in LNVO throughout the test site.

From Table 7.1.6 we can observe a moderate but general reduction in the park's average noise levels for all scenarios. The highest noise gains were achieved in those cases with the highest LNVO.

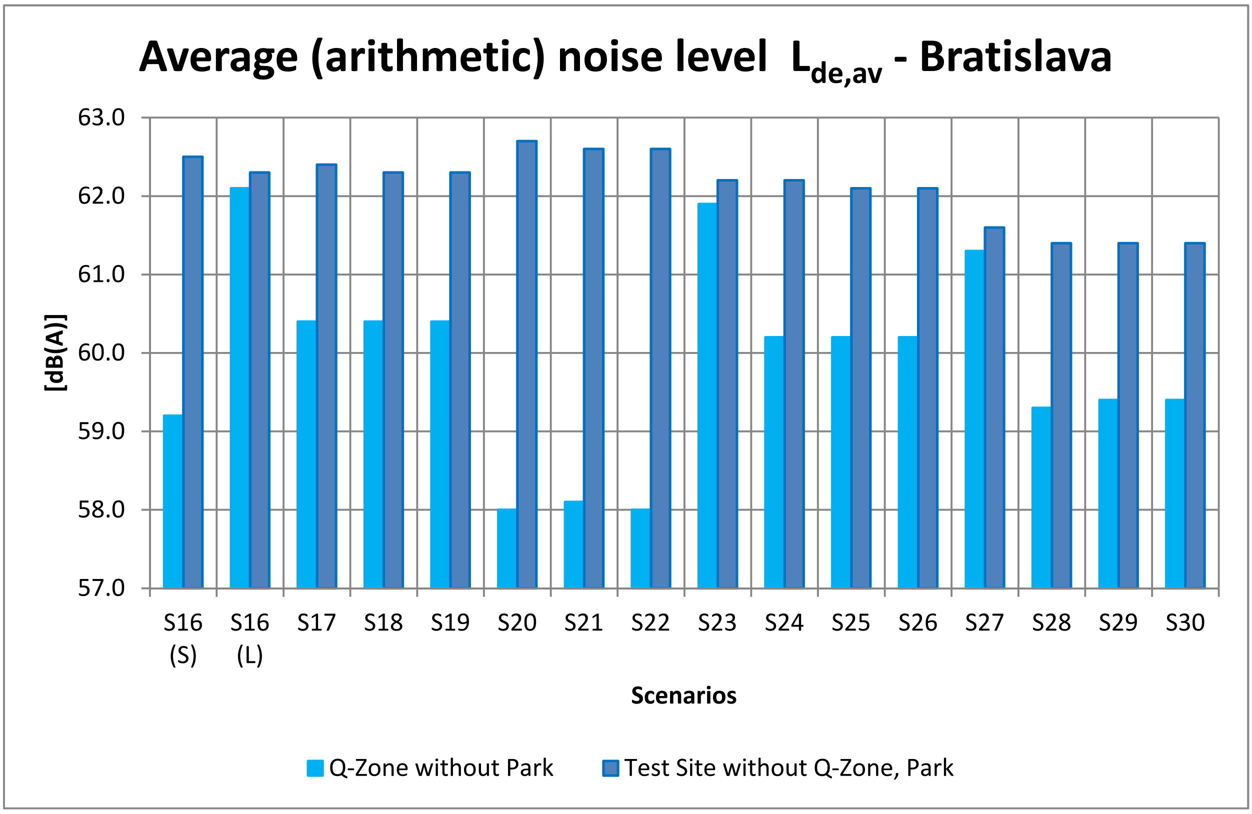

Figure 7.1.8: The noise situation in the Q-Zone and the Test site without the Park

The average noise levels for the test site (excluding the Q-Zone and the park) and Q-Zone (excluding the park), are presented as a bar chart in Figure 7.1.8.

Absolute values for the park, the park's surrounding and for the capacity are presented in Table 7.1.7. In Figure 7.1.9 the average noise levels in the park and the capacity values are depicted as a bar chart. Again we observe a moderate reduction in noise levels and a capacity increase in all scenarios. The most prominent results are obtained by raising the LNVO in the test site.

Table 7.1.7: Characteristic values for the embedded park in Bratislava

Scenario		**S16**	**S17**	**S18**	**S19**	**S20**	**S21**	**S22**	**S23**	**S24**
$L_{de,av}$ (park)	[dB(A)]	60.0	58.9	58.9	59.0	58.8	59.0	59.0	59.9	58.5
$L_{de,av}$ (surrounding)	[dB(A)]	62.5	61.5	61.5	61.5	61.9	61.9	61.9	62.3	61.3
"Capacity" of park	[m²]	1 091	2 411	2 411	2 210	2 497	2 411	2 210	1 205	3 014
Scenario		**S25**	**S26**	**S27**	**S28**	**S29**	**S30**			
$L_{de,av}$ (park)	[dB(A)]	58.6	58.6	59.2	56.5	56.7	56.8			
$L_{de,av}$ (surrounding)	[dB(A)]	61.3	61.3	61.7	60.3	60.3	60.3			
"Capacity" of park	[m²]	2 927	2 956	1 894	9 270	8 696	8 294			

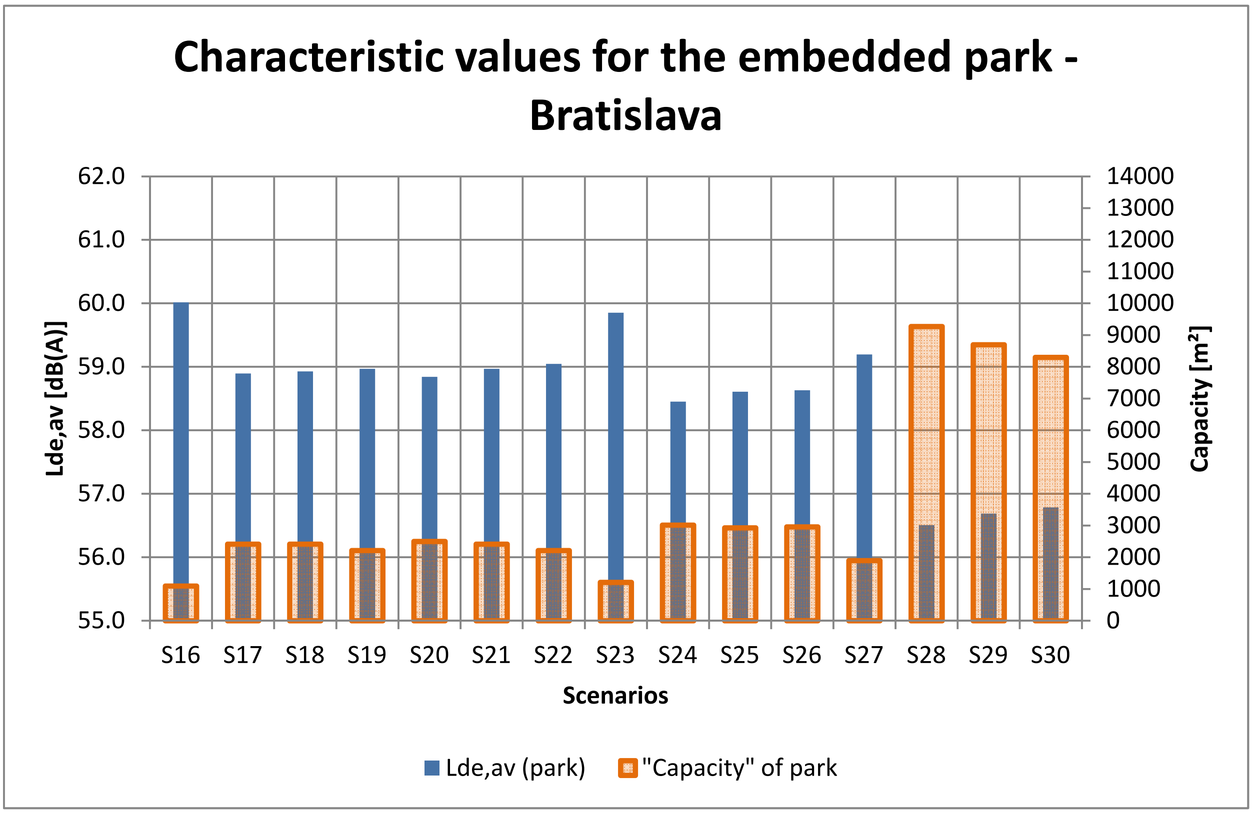

Figure 7.1.9: Bar chart of the noise and capacity values for the park in Bratislava

7.1.4.2 Highly annoyed people in the Q-Zone and the test site excluding the Q-Zone

The indicator "*number of highly annoyed people* (HAP)" can be used as a single number value for a comparative evaluation of noise effects from various Q-Zone configurations. Changes in the number of HAP within the Q-Zone and the test site are shown in Table 7.1.6 and in relation to the number of inhabitants in Figure 7.1.10. A decrease in the number of HAP inside the Q-Zone can be recognized for all scenarios. The situation is different for the test site (excluding the Q-Zone and the park). Here we find a slight rise in the number of HAP in the scenarios S17 through S22. The rest of the scenarios show a slight decrease in the number of HAPs for these regions.

Table 7.1.8: Characteristic values for the Q-Zone in Bratislava

Scenario		**S16**	**S17**	**S18**	**S19**	**S20**	**S21**	**S22**	**S23**	**S24**
$L_{de,av}$	[dB(A)]	62.1	60.4	60.4	60.4	58.0	58.1	58.0	61.9	60.2
No. residents		4 424	4 424	4 424	4 424	4 421	4 421	4 421	4 424	4 424
HAP		420	371	371	370	371	371	370	415	365
Scenario		**S25**	**S26**	**S27**	**S28**	**S29**	**S30**			
$L_{de,av}$	[dB(A)]	60.2	60.2	61.3	59.3	59.4	59.4			
No. residents		4 424	4 424	4 424	4 424	4 424	4 424			
HAP		365	364	391	324	329	328			

Again the most noticeable improvements in the number of HAP were forecasted for those scenarios with high shares of LNVs.

Table 7.1.9: Characteristic values for the test site in Bratislava

Scenario		S16	S17	S18	S19	S20	S21	S22	S23
$L_{de,av}$	[dB(A)]	62.3	62.4	62.3	62.3	62.7	62.6	62.6	62.2
No. residents		240 64	24 064	24 064	24 064	24 067	24 067	24 067	24 064
HAP		1 979	2 005	1 984	1 986	2 012	1 998	2 000	1 954
Scenario		**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**	
$L_{de,av}$	[dB(A)]	62.2	62.1	62.1	61.6	61.4	61.4	61.4	
No. residents		240 64	24 064	24 064	24 064	24 064	24 064	24 064	
HAP		1 962	1 956	1 957	1 858	1 844	1 840	1 840	

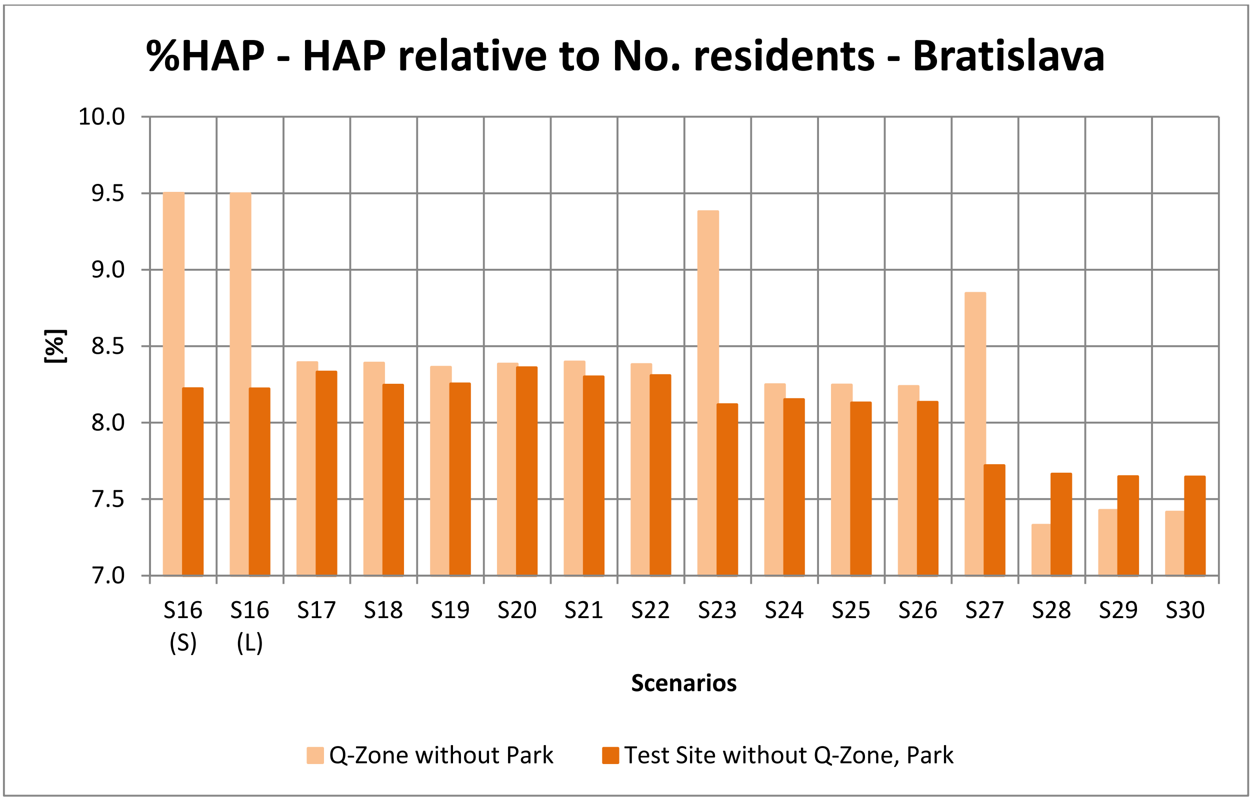

Figure 7.1.10: Percentage of HAP related to the number of inhabitants in the corresponding zone

7.1.5 Summary for Bratislava test site

Moderate improvements were found for the average noise levels inside the park by embedding it in a Q-Zone for most scenarios. Some scenarios showed negative effects for some outside regions caused by redistribution effects. These are noticeable by an increase in the number of HAP in the corresponding area. Accordingly care needs to be taken when measures are taken to implement a Q-Zone, to reduce negative impacts on the population in other parts of the city.

7.2. BRISTOL TEST SITE

Bristol is the largest city in South West England. The city covers a total area of 332 square kilometers, and has a population of about 421 000. The population density is 1 268 persons/km². Figure 7.2.1 shows Bristol and the surrounding area. The city is located close to the mouth of the river Severn.

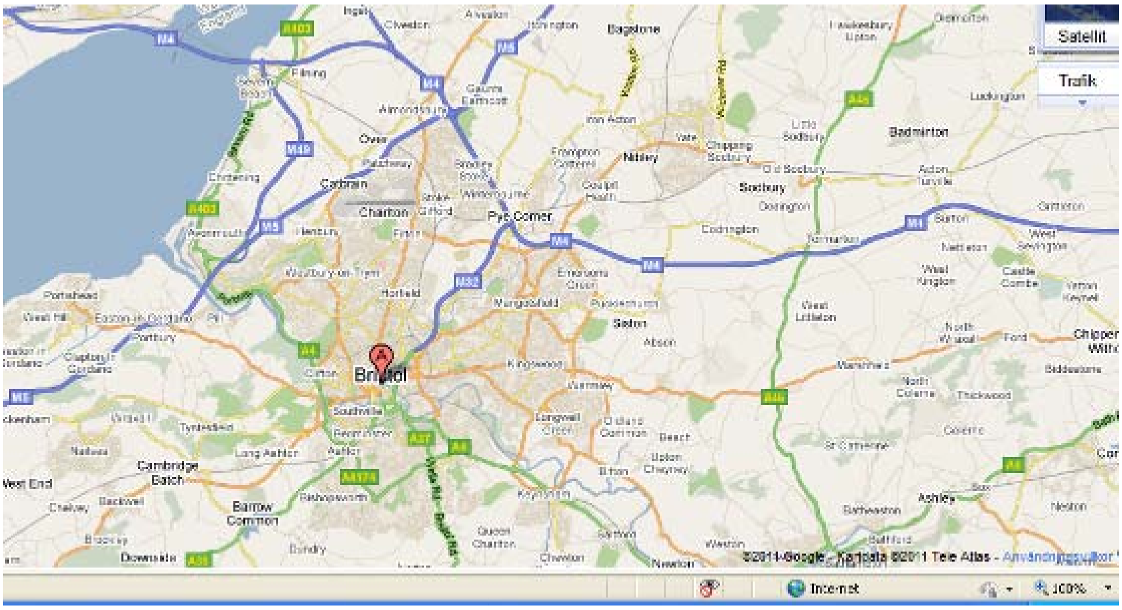

Figure 7.2.1 Overview map of Bristol

7.2.1 Description of the Q-Zone and its embedded park in Bristol

After discussions with local representatives of the City Council and a site visit, transforming the area around Castle Park (and the opposite side of the river) into a Q-Zone appeared to provide an interesting opportunity in Bristol. This is particularly the case, as there are plans to turn the former commercial and industrial site on the opposite side of the river into a residential area. The area also includes a park-like avenue, bordering the pedestrian zone of the old town. The arterial route that runs along the riverbank presents a major challenge, and different ways and options of handling this will be analyzed. The park is mainly expected to be frequented by shoppers and employees /workers from nearby businesses/shops. Castle Park with the surrounding regions, and the river Avon that runs through the central parts of Bristol are shown in Figure 7.2.2. The blue circle roughly marks the area of interest. The exact Q-Zone boundaries are shown in and Figure 7.2.3.

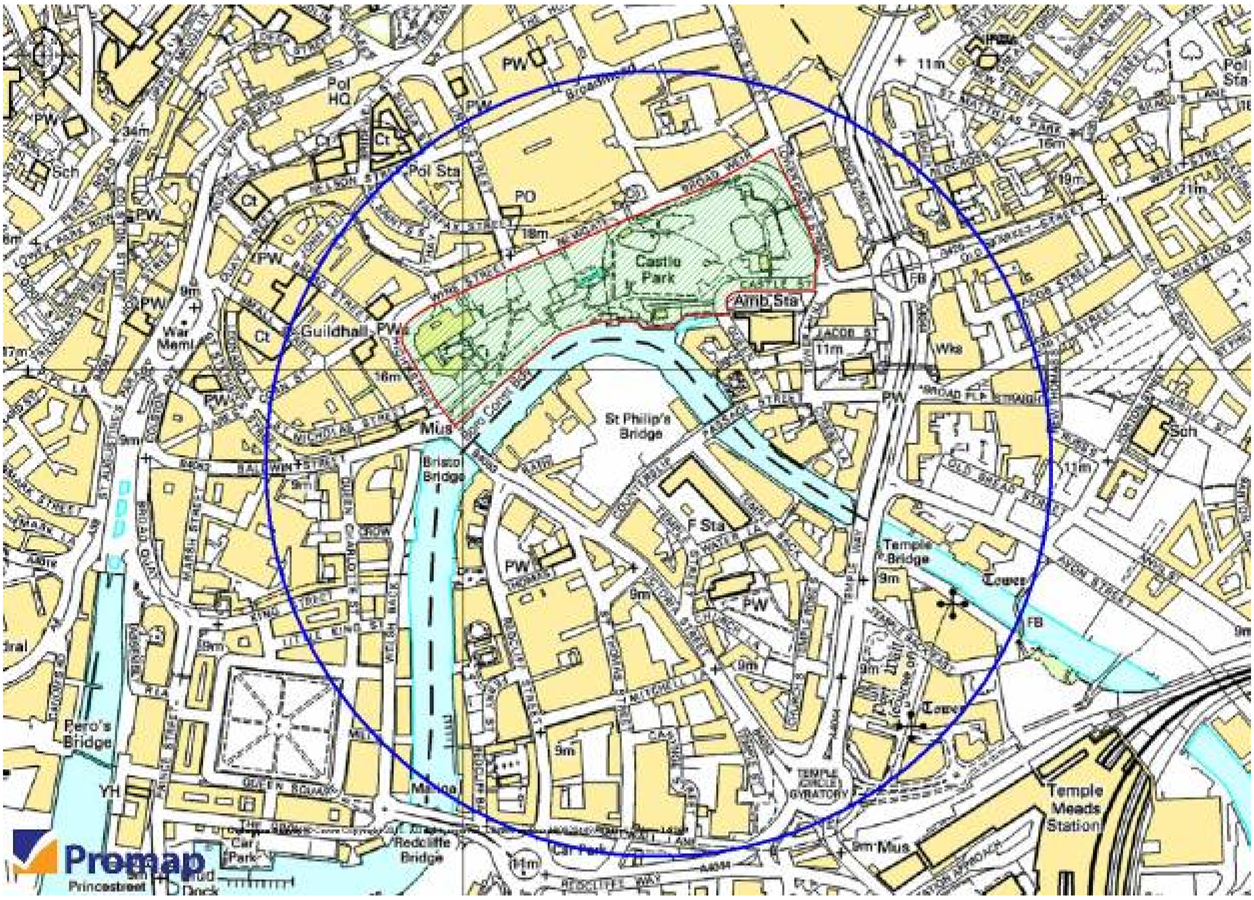

Figure 7.2.2 Location of the designated park to be embedded in a Q-Zone and its test area in Bristol

For Bristol only one Q-Zone was defined, in terms of its size and the setting of its boundary line.

Figure 7.2.3 Castel Park (shaded green) in Bristol embedded in the Q-Zone

The attributes characterizing the park, the Q-Zone and the test site are compiled in Table 7.2.1. Area sizes are each given for the test site, the Q-Zone and the park respectively. Further attributes refer to the park's number of visitor, who reside in the park-surrounding and the number of residents in the various zones. Additionally we have also specified the population density for the Q-Zone and the test site outside the Q-Zone.

Table 7.2.1: Test-site-describing attributes in Bristol

Area test site	5.63 km²
Area Q-Zone	0.14 km²
Area embedded park	0.07 km²
Number of residents with access to the park (within a 5 min-walk-distance to the park)	8 795
Number of residents within the Q-Zone	3 492
Density Q-Zone (inhabitants / km²)	24 991
Number of residents within the test site (outside Q-Zone)	20 478
Density test site (outside Q-Zone) (inhabitants / km²)	3 732

7.2.1.1 Noise map and noise distribution on the test site

Figure 7.2.4 depicts a noise map of the test site. This is a map where the distribution of noise levels $L_{de,av}$ is illustrated by an overlaid color grid. A legend is included in which the various colors are mapped to noise level classes. Also the outline of the Q-Zone is depicted. The noise distribution in the figure reflects the current situation (i.e. the base case scenario) on the test site in Bristol. As with the previous case in Essen, main roads can be identified as major sources of noise.

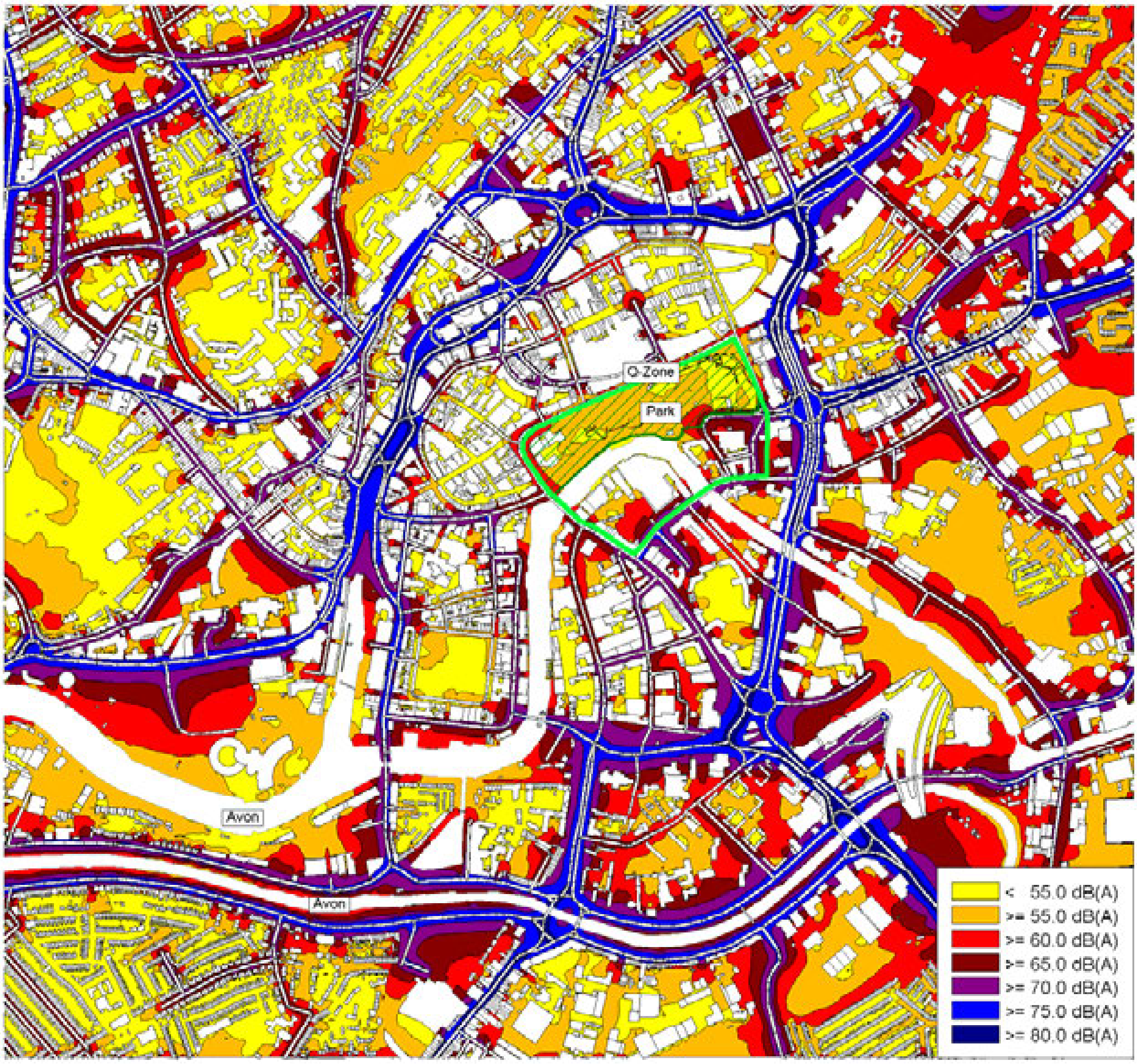

Figure 7.2.4: Base case noise situation (L_{de}) in castle park its surrounding areas in Bristol

In Table 7.2.2 the noise distribution within castle park, the Q-Zone and the test site (area [m²] affected by noise [5 dB classes]), based on the L_{de}, is shown. We notice that there are no areas inside the park and the designated Q-Zone that fall in and below the 40-45 dB(A) noise class. In fact the lowest noise class observed in the park is the

50-55 dB(A) range, which covers an area of 7 900 m^2. The lowest noise class in the Q-Zone comprises a total area of 1 200 m^2 where an average noise level in the range of 45-50 dB(A) is found. It is noteworthy that the test site contains a total area of 6 800 m^2 that falls into the noise class of 40-45 dB and 16800 m^2 that show noise levels smaller than 40 dB(A). This implies, that the test site contains quieter regions, than the Q-Zone and the park in the base case scenario.

Table 7.2.2: Noise distribution L_{de} on the test site in Bristol in the base case

Noise level [5 dB classes]	Park area [m²]	Q-Zone area [m²]	Test site area [m²]
< 40	0	0	16 800
40 - 45	0	0	6 800
45 - 50	0	1 200	310 900
50 - 55	7 900	8 600	871 600
55 - 60	25 200	16 600	1 235 500
60 - 65	16 300	15 200	939 000
65 - 70	9 000	13 100	709 400
70 - 75	7 500	10 400	630 600
> 75	300	2 200	633 600
Total area size	66 200	67 300	5 354 200

7.2.1.2 Noise reduction potential

To estimate the park's noise reduction potential, we computed the average noise levels $L_{de,av}$ by assuming a hypothetical, completely noiseless Q-Zone. We exempted all noise sources in the simulation software in the various Q-Zone configurations. We will refer to this as the "background-noise-level-scenario", a model in which all contributing factors to the park's noise levels lie outside the Q-Zone. By this, we can estimate the possible noise reduction to be expected by installing a specific Q-Zone. The results of these estimations are shown in Table 7.2.3. The noise reduction potential of castle park in Bristol with the defined Q-Zone is estimated with 7.6 dB.

Table 7.2.3: Noise reduction potential of the Q-Zone on the test site in Essen estimated with the background-noise-level-scenario"

Test site Essen	Base case $L_{de,av}$ [dB(A)]	Background noise level $L_{de,av}$ [dB(A)]	Potential of noise reduction $L_{de,av}$ [dB]
park area	61.5	53.9	7.6
Q-Zone area with park	62.2	54.7	7.5

7.2.2 Traffic data and investigated traffic scenarios on Bristol test site

The traffic simulations for Bristol were built on traffic data from a Bristol traffic model application that was generously made available to the CityHush project by local authorities. This application only allowed for traffic simulations concerning cars in our case. No effects with respect to changes of modes, destinations or travel frequency are therefore included. Only route choice effects are simulated. Traffic reductions within the Quiet Zone may therefore be somewhat underestimated, and redistribution effects somewhat overestimated. A major enhancement of the traffic model in the CityHush project was to allow for the fact that different travellers have different cost sensitivity, which is necessary to take into account when simulating traffic effects of different noise fees. More details concerning the traffic model application can be found in Deliverable D1.1.2 [7].

To be able to establish boundary conditions for Q-Zones, four defining parameters were systematically varied in the traffic simulations. These were

- type/degree of constrained access to the Q-Zone
- low noise vehicle ownership inside and outside the Q-Zone.
-

The traffic scenarios shown in Table 7.2.4 were simulated for the Bristol case.

Table 7.2.4: Table of Q-Zone scenario configurations in Bristol

Scenario	Q-Zone	Fee [€]	Inside LNVO	External LNVO
S1	none	none	0.01	0.01
S2	large	ban		
S3		1		
S4		0.5		
S8	none	none	0.05	0.05
S9	large	ban	0.2	
S10		1		
S11		0.5		
S12	none	none		0.2
S13	large	ban	1	
S14		1		
S15		0.5		

The fees are to be paid on entry and exit, thereby penalizing through traffic relatively harder than traffic with origin or destination in the zone. The ban is assumed not to be applied to zone residents.

7.2.3 Noise situation for different traffic scenarios on the test site in Bristol

In analogy to the procedure described in section 7.3.3 the effects of different Q-Zone configurations (traffic scenarios) on the average noise levels can be studied with noise maps and noise difference maps. For Bristol these maps are included in a separate Annex. The corresponding Q-Zone scenarios for Bristol are described in Table 7.2.4.

We can see from Table 7.2.4 that in the case of Bristol all scenarios result in a reduction of $L_{de,av}$ noise levels inside and outside the park. There is also a general reduction in the number of HAP and an increase in the park's capacity. We do find the most noticeable improvements in those cases where we assume a high amount of LNV.

Table 7.2.5: Noise distribution in the various scenarios for the park area. Noise levels are given in 5 dB noise classes. The values in the table specify m^2 of the park area.

Noise level / Scenario	< 45	45 - 50	50 - 55	55 - 60	60 - 65	65 - 70	70 - 75	> 75
S1	0	0	7 900	25 200	16 300	9 000	7 500	300
S2	0	1 400	16 100	41 500	6 000	600	600	0
S3	0	800	15 500	38 000	8 700	2 600	600	0
S4	0	800	15 500	38 000	8 700	2 600	600	0
S8	0	200	8 000	25 700	15 600	9 400	7 100	200
S9	0	1 400	19 000	36 300	8 200	800	500	0
S10	0	900	17 200	36 500	8 400	2 600	600	0
S11	0	900	17 200	36 500	8 400	2 600	600	0
S12	0	300	9 300	28 000	12 900	9 600	6 100	0
S13	0	2 600	25 100	29 700	7 600	1 200	0	0
S14	0	2 200	23 300	30 500	7 600	2 600	0	0
S15	0	2 200	23 300	30 500	7 600	2 600	0	0

Table 7.2.5 shows the forecasted noise distribution in 5 dB classes in the park for our various simulation scenarios. Results for all scenarios exhibit park areas that fall into the 45-50 dB class, which is an improvement to the base case. With the exception of scenario S8 we also find that the scenario forecasts do not produce any park areas with noise levels higher than 75 dB. In Figure 7.2.5 the values from Table 7.2.5 are illustrated as a bar chart where it can be seen that the largest cumulated park area falls into the 55-60 dB class for virtually all scenarios.

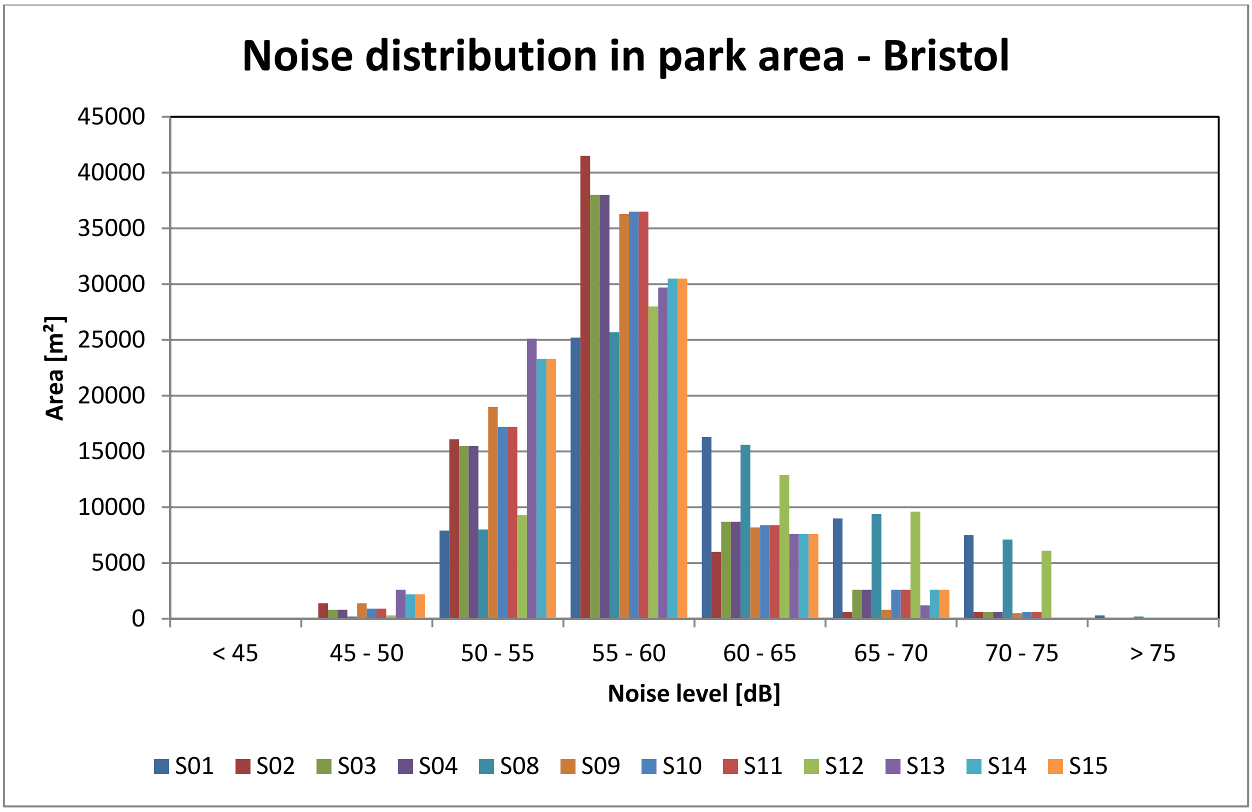

Figure 7.2.5: Noise distribution in the park in Bristol for the various simulation scenarios

7.2.4 Potential noise gains on the test site in Bristol

In the following we will be looking at some key indicators for assessing the effects of the various Q-Zone scenarios. A summary of these key indicators are presented in Table 7.2.6 and we will be referring to this table throughout the rest of this section. The indicators are the change of the average day / evening noise level $L_{de,av}$ in the park, the change in the “capacity” and we also consider the changes of the number of HAP.

By the term “change” we refer to the differences between the base case and each of the scenarios in regard to the values of the considered measures.

When determining the number of HAP we specify the values in various parts of the test site: in the Q-Zone, outside the Q-Zone (i.e. the test site region without the area of the Q-Zone) and the complete test site. We will also present absolute values of the $L_{de,av}$ in various tables throughout this section.

Table 7.2.6: Potential noise gains on the test site in Bristol (key indicators)

scenario	Change $L_{de,av}$ (park) [dB]	Change $L_{de,av}$ (surround.) [dB]	Change of "Capacity"	Change of number HAP within Q-Zone	Change of number HAP outside Q-Zone within affected area	Change of number HAP (Test-site including Q-Zone)
S1						
S2	-5.0	-0.7	9 599	-49	-16	-66
S3	-4.3	-0.8	8 142	-51	-42	-93
S4	-4.2	-0.8	8 142	-51	-42	-93
S5	-0.1	-0.2	331	-10	-21	-31
S6	-5.0	-1.0	11 320	-53	-71	-124
S7	-4.4	-1.0	9 003	-55	-69	-124
S8	-4.4	-1.0	9 003	-55	-69	-124
S9	-0.7	-0.8	1 986	-32	-105	-137
S10	-5.6	-2.0	17 543	-96	-175	-271
S11	-5.2	-2.0	16 285	-96	-175	-271
S12	-5.2	-2.0	16 285	-96	-175	-271

7.2.4.1 Noise and capacity indicators for the park, the Q-Zone and the test site

From the difference values (i.e. changes) listed in Table 7.2.6, we can observe reductions in noise level in the park and in the number of HAP across the test site. An increase in the capacity is also forecasted in all scenarios. It seems obvious, that the highest impact can be precipitated when imposing traffic bans or by increasing the amount of LNVs. Both the traffic ban (with a 1 % LNVO, S2) and an increase of the LNVO (S12) will reduce the $L_{de,av}$ inside the park by 5 dB or up to 5.6 dB respectively. The absolute values of the $L_{de,av}$ in the Q-Zone(without the park) and the test site (without the Q-Zone and the park) are presented in Table 7.2.7. Also the absolute values of the park's $L_{de,av}$ and capacity are presented as a bar chart in Figure 7.2.7.

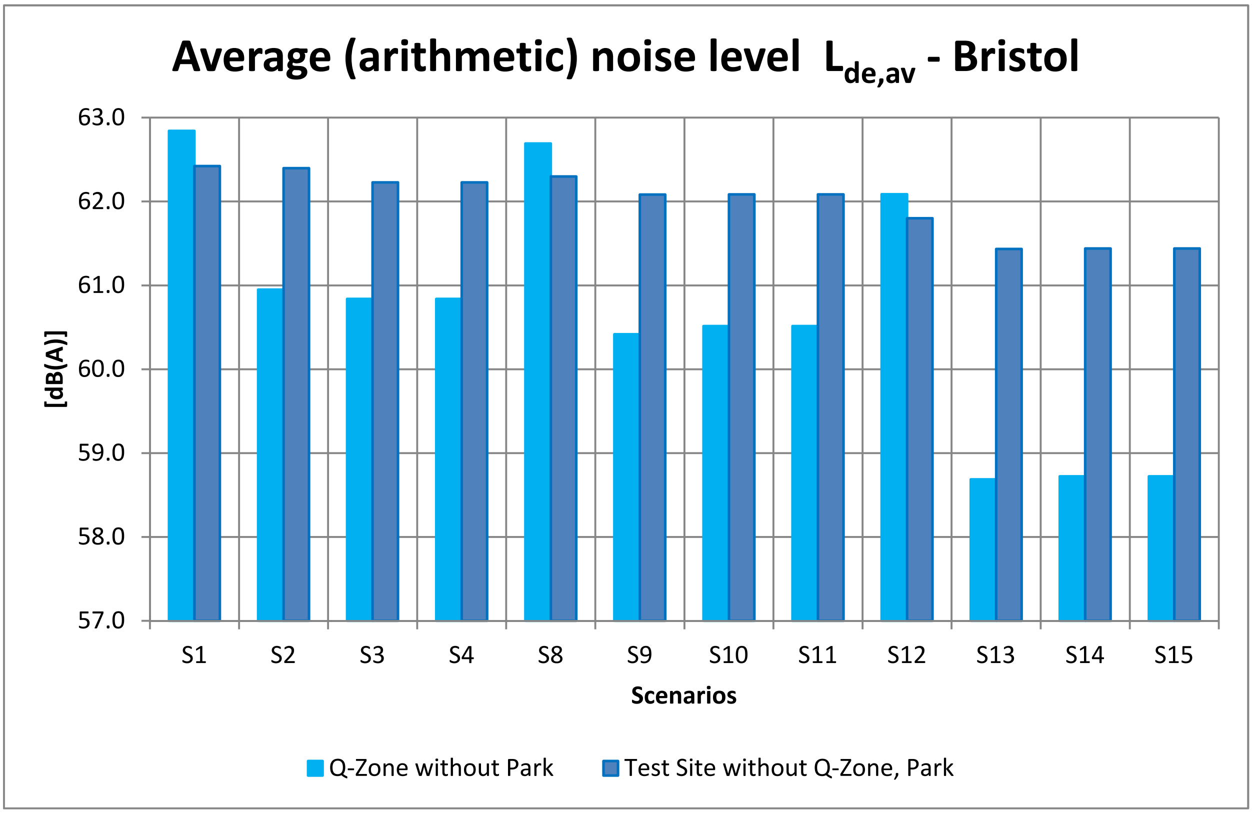

Figure 7.2.6: Arithmetic average of the $L_{de,av}$ in the test site excluding the Q-Zone and park, as well as for the Q-Zone excluding the park

The capacity gain can be quantified by an increase of 9 599 m² in the traffic ban scenario with 1 % LNVO (S2) and up to 17 543 m² in the highest LNVO scenario (S10). The absolute values for the park's capacity are presented in Table 7.2.7 and also as a bar chart in Figure 7.2.7.

Table 7.2.7: Characteristic values for the embedded park in Bristol

Scenario		**S1**	**S2**	**S3**	**S4**	**S8**	**S9**	**S10**	**S11**	**S12**
$L_{de,av}$ (park)	[dB(A)]	61.5	56.5	57.2	57.2	61.3	56.5	57.0	57.0	60.7
$L_{de,av}$ (surrounding)	[dB(A)]	64.8	64.1	64.0	64.0	64.6	63.8	63.8	63.8	64.0
"Capacity" of park[4]	[m²]	6 885	16 484	15 027	15 027	7 216	18 205	15 888	15 888	8 871
Scenario		**S13**	**S14**	**S15**						
$L_{de,av}$ (park)	[dB(A)]	55.8	56.2	56.2						
$L_{de,av}$ (surrounding)	[dB(A)]	62.8	62.8	62.8						
"Capacity" of park[4]	[m²]	24 428	23 170	23 170						

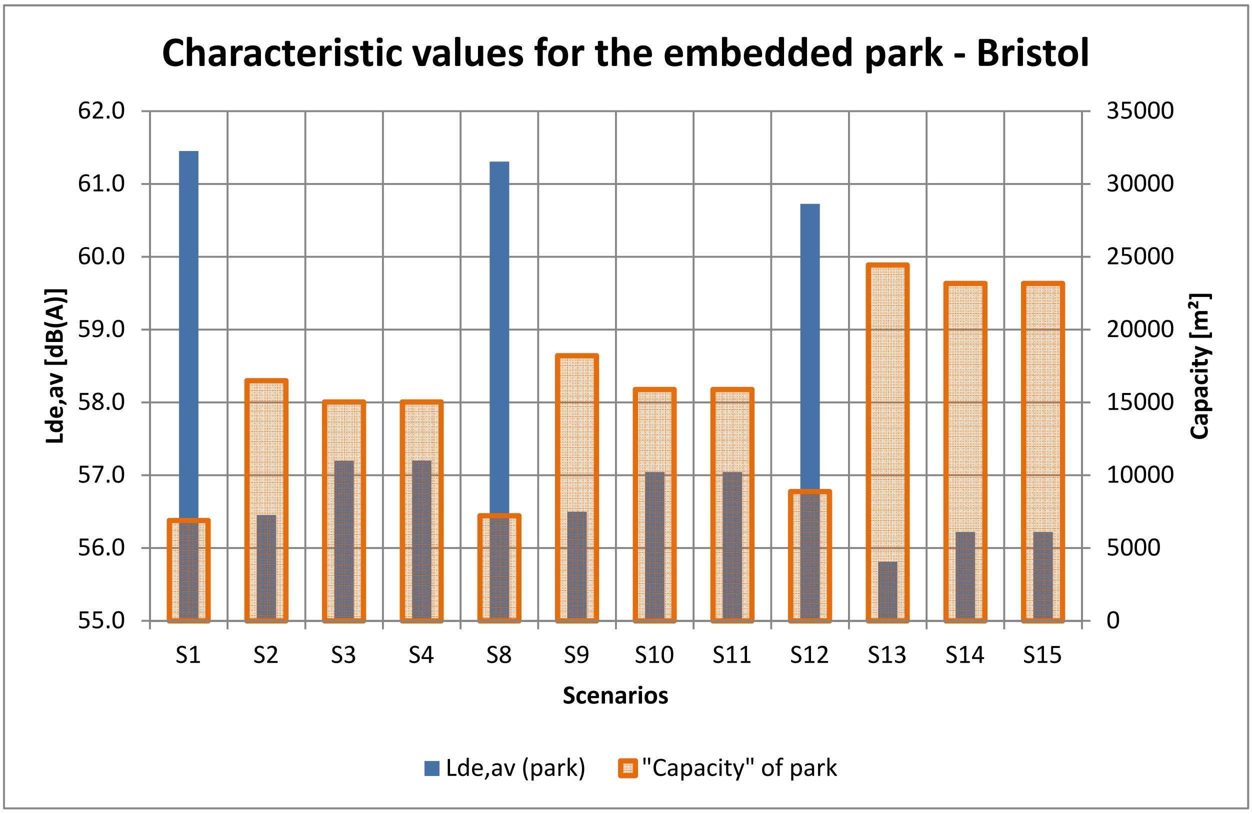

Figure 7.2.7: Bar chart of the noise and capacity values for the embedded park in Bristol

7.2.4.2 Highly annoyed people in the Q-Zone and the test site excluding the Q-Zone

A reduction in the number of HAP can be quantified with -271 across the test site (including the Q-Zone) for those scenarios with the highest LNVO (S10 – S12). The number of HAP can be reduced e.g. by 93 in scenario S3 and S4, where we assumed a Q-Zone with a minimal exit / entry fee of 1 Euro or 0.5 Euros respectively and a minimally assumed LNVO of 1 % in- and outside the Q-Zone. With this example we can see, that a change in the fee (within the investigated range) does not have an impact on the noise indicators in this example, as the impact on the traffic distribution is minimal.

Table 7.2.8: Characteristic values for the Q-Zone in Bristol

Scenario		**S1**	**S2**	**S3**	**S4**	**S8**	**S9**	**S10**	**S11**	**S12**
$L_{de,av}$	[dB(A)]	62.8	61.0	60.8	60.8	62.7	60.4	60.5	60.5	62.1
No. residents		3 476	3 476	3 476	3 476	3 476	3 476	3 476	3 476	3 476
HAP		432	382	380	380	421	379	376	376	399
Scenario		**S13**	**S14**	**S15**						
$L_{de,av}$	[dB(A)]	58.7	58.7	58.7						
No. residents		3 476	3 476	3 476						
HAP		336	336	336						

The absolute number of HAP residing in the Q-Zone is given in Table 7.2.8 together with the total number of residents. Corresponding values for the test site are given in Table 7.2.9 and in Figure 7.2.8 shows the number of HAP in relation to the number of residents in the test site excluding the Q-Zone and park, as well as for the Q-Zone excluding the park. It is quite clear that the number of HAP relative to the population number is reduced in every scenario compared to the base case.

Table 7.2.9: Characteristic values for the test site without the Q-Zone, Park in Bristol

Scenario		**S1**	**S2**	**S3**	**S4**	**S8**	**S9**	**S10**	**S11**
$L_{de,av}$	[dB(A)]	62.4	62.4	62.2	62.2	62.3	62.1	62.1	62.1
No. residents		18 931	18 931	18 931	18 931	18 931	18 931	18 931	18 931
HAP		2 417	2 400	2 375	2 375	2 396	2 346	2 348	2 348
Scenario		**S12**	**S13**	**S14**	**S15**				
$L_{de,av}$	[dB(A)]	61.8	61.4	61.4	61.4				
No. residents		18 931	18 931	18 931	18 931				
HAP		2 312	2 241	2 242	2 242				

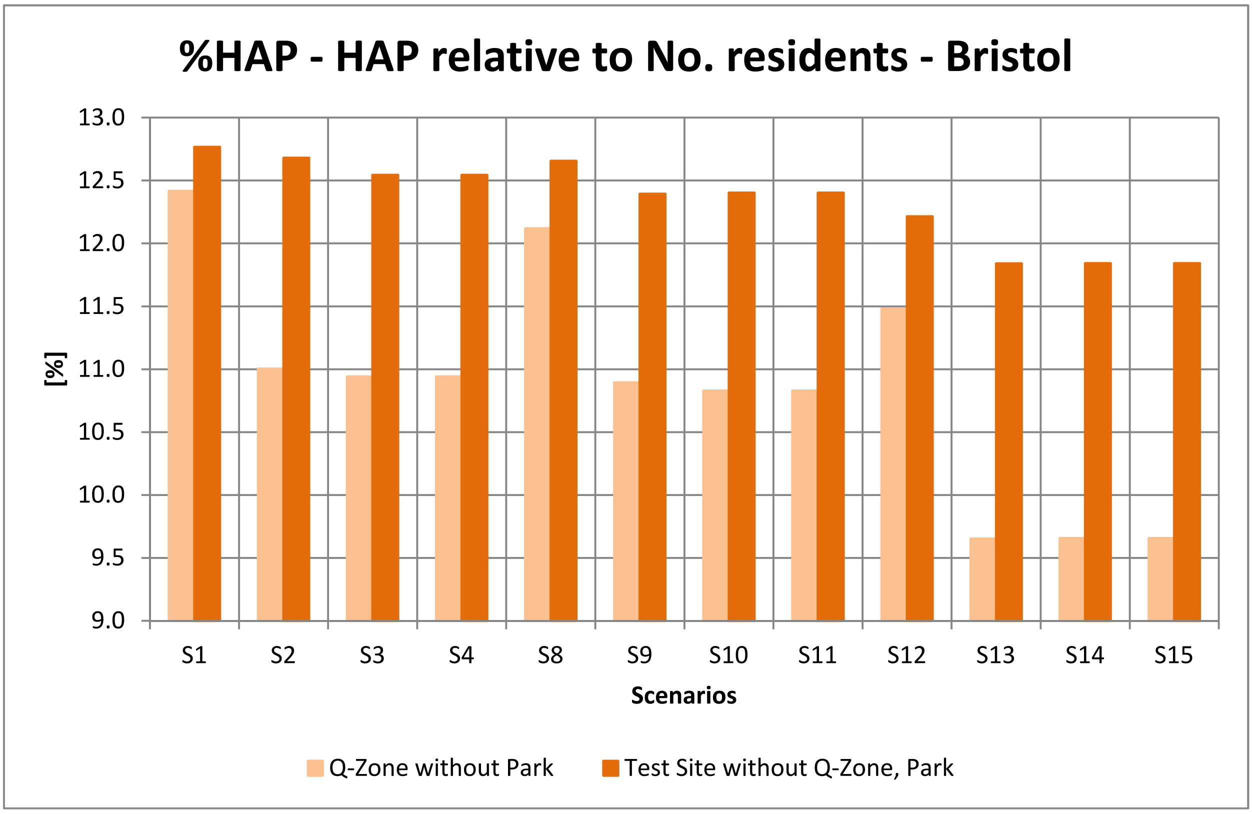

Figure 7.2.8: Number of HAP in relation to the number of residents in the test site excluding the Q-Zone and park as well as for the Q-Zone excluding the park

7.2.5 Summary for Bristol test site

For the test site in Bristol all scenarios show a reduction of the average noise levels in the park, an increase in the capacity and an overall reduction of the number of HAP throughout the test site. In two scenarios these effect were marginal but in most scenarios they were distinct.

7.3. ESSEN TEST SITE

Essen is a city in western Germany and is part of the Ruhr area in the federal state of North Rhine-Westphalia. The Ruhr area was formerly Germany's centre for heavy industry and a major coal and steel producer.

The total area of investigation covers 210 km² and has a population density of 2 750 inhabitants per km².

7.3.1 Description of the Q-Zone and its embedded park in Essen

The central parts of Essen contain relatively few parks. The most obvious candidate for an embedded park is the Stadtgarten shown in Figure 7.3.1. The park is surrounded by commercial and residential areas. A railway line runs along the northern side of the park.

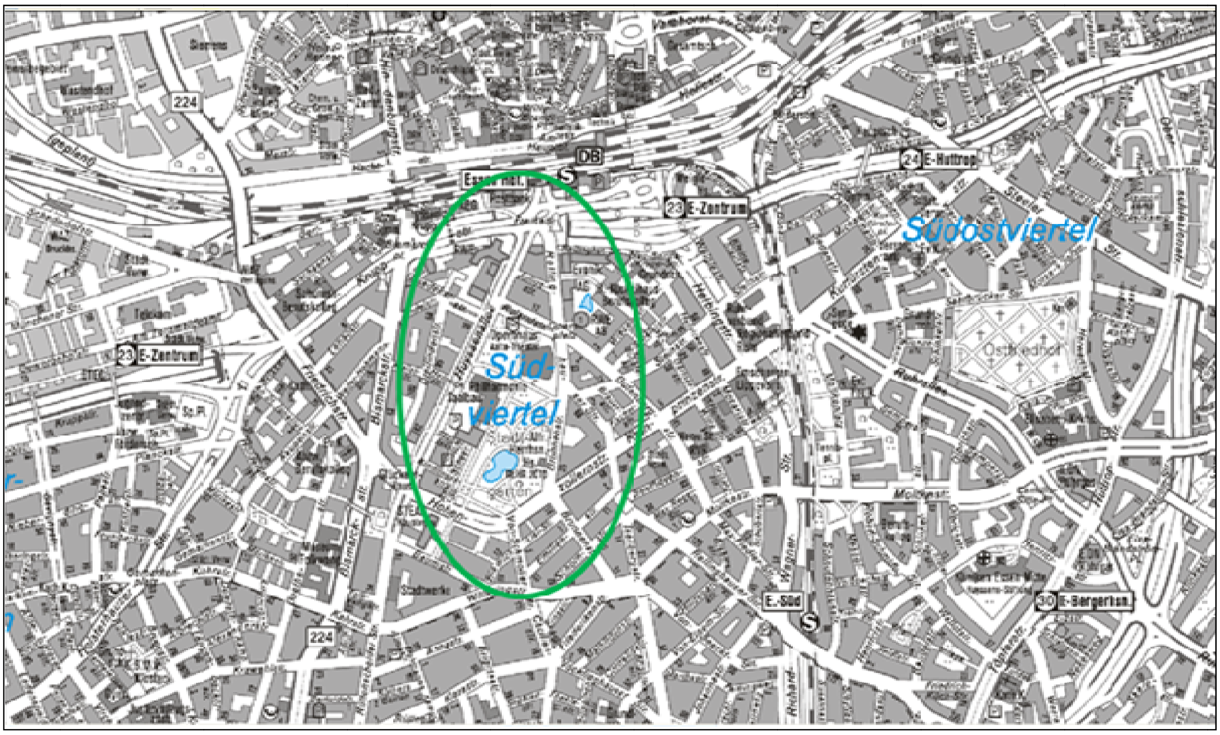

Figure 7.3.1: Stadtgarten park in central Essen

Four variants of Q-Zone were defined that enclose a small, large, extra large and a super large area around the park respectively. The boundaries of these Q-Zones are outlined in different colors in Figure 7.3.2. The two large sized Q-Zones (red and blue) enclose a major road at their southern end.

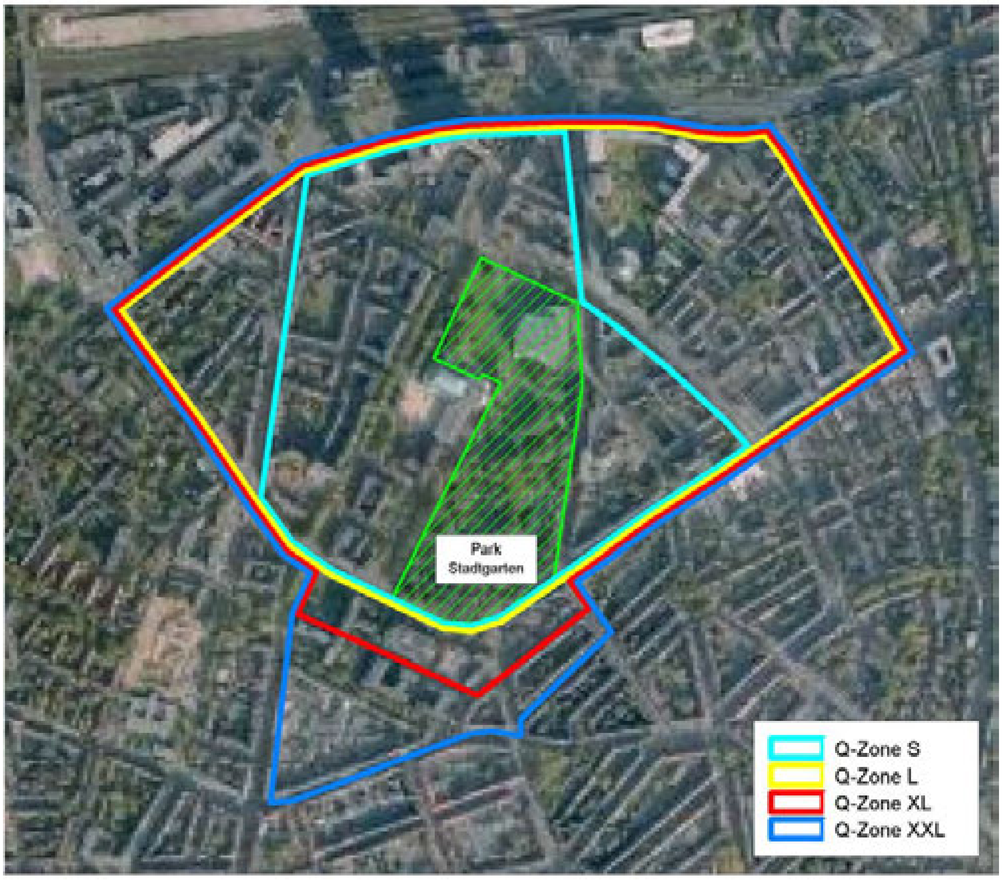

Figure 7.3.2: Embedded park with Q-Zones

The attributes characterizing the test site are listed in Table 7.3.1. We have specified the area of the test site, the various Q-Zones and the park respectively. The other attributes refer to the number of park visitors who reside in the park-surrounding and the number of residents in the various zones. Additionally we also specify the population density for the Q-Zone and the test site outside of the Q-Zone.

Table 7.3.1: Test-site-describing attributes for Essen

Area test site		13.10 km²
Area Q-Zone	**Small S**	0.38 km²
	Large L	0.60 km²
	X-Large XL	0.64 km²
	XX-Large XXL	0.71 km²
Area embedded park		0.11 km²
Number of residents with access to the park (within a 5 min-walk-distance to the park)		10 583
Number of residents within the Q-Zone	**Small S**	1 754
	Large L	4 152
	X-Large XL	4 267
	XX-Large XXL	5 012
Density Q-Zone L (inhabitants / km²)		6 935
Number of residents within the test site (outside Q-Zone L)		90 455
Density test site (outside Q-Zone L) (inhabitants / km²)		7 233

7.3.1.1 Noise map and noise distribution on the test site

Figure 7.3.1 shows a noise map of the test site. This is a map where the distribution of levels $L_{de,av}$ are illustrated by an overlaid color grid. A legend that maps the colors to noise level classes is shown in the bottom right-hand corner (the outline of the large Q-Zone is also depicted). The noise distribution in Figure 7.3.1 reflects the current situation on the test site, which we will refer to as the base case. Here we can see that road traffic is the dominant source of noise.

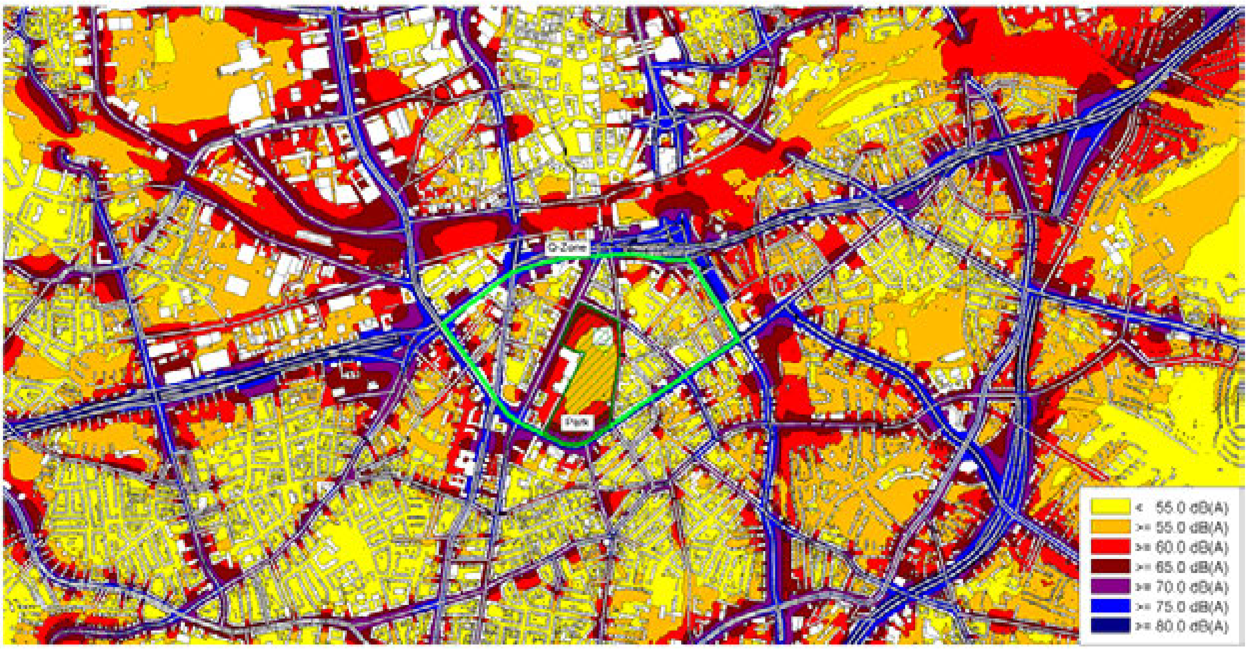

Figure 7.3.1: Noise map (L_{de}) of the park and its surrounding in central Essen in the base case

In Table 7.3.2 the noise distribution in the Stadtgarten park, in the various Q-Zones and in the test site are shown. The noise distribution describes the cumulated areas [m²] that have average noise levels based on the L_{de} that fall into a given noise class with a 5 dB range. We can observe from Table 7.3.2 that there are no areas inside the park and the designated Q-Zones that fall in classes with noise levels below 45 dB(A). In fact the lowest noise class which is found in the park is the 50-55 dB(A) range with an area of 2600 m². The 45-50 dB(A) range is the lowest noise class that can be found in any of Q-Zones. In the case of the small Q-Zone we find 14300 m² and for the XXL-Q-Zone we find 36 600 m² in this class. It is noteworthy that the test site contains an area of 32 800 m² of the 40-45 dB(A) noise class. This implies that in the base case the test site contains quieter regions, than the Q-Zones and the park.

Table 7.3.2: Noise distribution for the various defined areas. Noise levels (based on the L_{de}) are given in 5 dB classes for each of the Q-Zone configurations and for the test sites in the base case scenario. The test site areas exclude the area of the corresponding Q-Zone and the Q-Zone areas exclude the park area.

Noise level [5 dB classes]	Park area [m²]	Q-Zone S area [m²]	Q-Zone L area [m²]	Q-Zone XL area [m²]	Q-Zone XXL area [m²]	Test site (S Q-Zone) area [m²]	Test site (L Q-Zone) area [m²]	Test site (XL Q-Zone) area [m²]	Test site (XXL Q-Zone) area [m²]
< 40	0	0	0	0	0	32 800	32 800	32 800	32 800
40 - 45	0	0	0	0	0	49 700	49 700	49 700	49 700
45 - 50	0	140 300	21 800	22 800	36 600	1 016 600	1 009 100	1 008 100	994 300
50 - 55	2600	64 200	116 600	118 800	140 500	2 393 700	2 341 300	2 339100	2 317 400
55 - 60	45 900	44 800	92 500	94 700	109 100	3 225 100	3 177 400	3 175 200	3 160 800
60 - 65	28 000	41 400	74 300	80 300	88 700	2 138 700	2 105 800	2 099 800	2 091 400
65 - 70	17 700	29 200	54 300	60 000	65 200	1 380 600	1 355 500	1 349 800	1 344 600
70 - 75	7 500	47 500	71 700	83 000	86 800	1 098 000	1 073 800	1 062 500	1 058 700
> 75	2 600	28 000	55 800	64 400	66 500	1 294 000	1 266 200	1 257 600	1 255 500
Total area size	10 4300	269 400	487 000	524 000	593 400	12 629 200	1 2411 600	1 237 4600	12 305 200

7.3.1.2 Noise reduction potential

To estimate the park's noise reduction potential, we computed the average noise levels $L_{de,av}$ by assuming a hypothetical, completely noiseless Q-Zone. For this, we exempted all noise sources in the simulation software in the various Q-Zone configurations. We will refer to this as the "background-noise-level-scenario", a model in which all contributing factors to the park's noise levels lie outside the Q-Zone. By this, we can estimate the possible noise reduction to be expected by installing a specific Q-Zone. The results of these estimations are shown in Table 7.3.3.

Table 7.3.3: Noise reduction potential of the Q-Zone on the test site in Essen estimated with the background-noise-level-scenario"

Test site Essen	Base case $L_{de,av}$ [dB(A)]	Background noise level $L_{de,av}$ [dB(A)]	Potential of noise reduction $L_{de,av}$ [dB]
park area, Q-Zone S	62.1	59.1	3.0
park area, Q-Zone L	62.1	58.1	4.0
park area, Q-Zone XL	62.1	52.6	9.5
Q-Zone S area with park	62.3	58.0	4.3
Q-Zone L area with park	62.2	57.6	4.6
Q-Zone XL area with park	62.6	56.4	6.2

7.3.2 Traffic data and investigated traffic scenarios on Essen test site

The traffic simulations for Essen were built on traffic data from an Essen traffic model application that was generously made available to the CityHush project by local authorities. This application only allowed for traffic simulations concerning cars in our case. No effects with respect to changes of modes, destinations or travel frequency are therefore included. Only route choice effects are simulated. Traffic reductions within the Quiet Zone may therefore be somewhat underestimated, and redistribution effects somewhat overestimated. A major enhancement of the traffic model in the CityHush project was to allow for the fact that different travellers have different cost sensitivity, which is necessary to take into account when simulating traffic effects of different noise fees. More details concerning the traffic model application can be found in Deliverable D1.1.2 [7].

To be able to establish boundary conditions for Q-Zones, four defining parameters were systematically varied in the traffic simulations. These were

- zone size
- type/degree of constrained access to the Q-Zone
- low noise vehicle ownership inside and outside the Q-Zone .

The traffic scenarios shown in Table 7.3.4 were simulated for the Essen case.

Table 7.3.4: Table of Q-Zone scenario configurations in Essen

<table>
<tr><th></th><th>Q-Zone</th><th>Fee [€]</th><th>Inside LNVO*</th><th>External LNVO</th></tr>
<tr><td>S1</td><td>none</td><td>none</td><td rowspan="7">0.01</td><td rowspan="7">0.01</td></tr>
<tr><td>S2</td><td rowspan="3">large</td><td>ban</td></tr>
<tr><td>S3</td><td>1</td></tr>
<tr><td>S4</td><td>0.5</td></tr>
<tr><td>S5</td><td rowspan="3">small</td><td>ban</td></tr>
<tr><td>S6</td><td>1</td></tr>
<tr><td>S7</td><td>0.5</td></tr>
<tr><td>S8</td><td>none</td><td>none</td><td>0.05</td><td rowspan="2">0.05</td></tr>
<tr><td>S9</td><td>large</td><td rowspan="3">ban</td><td>0.2</td></tr>
<tr><td>S10</td><td>XL</td><td rowspan="2">0.01</td><td rowspan="2">0.01</td></tr>
<tr><td>S11</td><td>XXL</td></tr>
<tr><td>S12</td><td>none</td><td>none</td><td>0.2</td><td rowspan="4">0.2</td></tr>
<tr><td>S13</td><td>large</td><td rowspan="2">ban</td><td rowspan="3">1</td></tr>
<tr><td>S14</td><td>XXL</td></tr>
<tr><td>S15</td><td>large</td><td>0.5</td></tr>
</table>

(*LNVO: Low noise vehicle ownership)

The different zone sizes are described in section 7.3.1. The fees are to be paid on entry and exit, therefore through traffic is penalized harder in relation to traffic with its origin or destination in the zone. The ban is assumed not to be applied to zone residents.

7.3.3 Noise situation for different traffic scenarios on the test site in Essen

Here we will discuss the results for the various scenarios in terms of their impact on the park, the Q-Zone and the test site. We will be looking at the noise differences ($L_{de,av}$) between base case and the forecasted scenarios. We will draw an overall comparison of the effects of the various scenarios and highlight prominent results.

The effects on the average noise levels of the different Q-Zone configurations (i.e. traffic scenarios) can be evaluated by studying the noise levels and their distribution on a noise map or by studying the differences compared to the base case scenario on a noise difference map. We can also evaluate the average noise level $L_{de,av}$ calculated from the grid noise levels L_{de} over an entire zone (e.g. Q-Zone or the test site). Correspondingly, the average difference values can also be calculated.

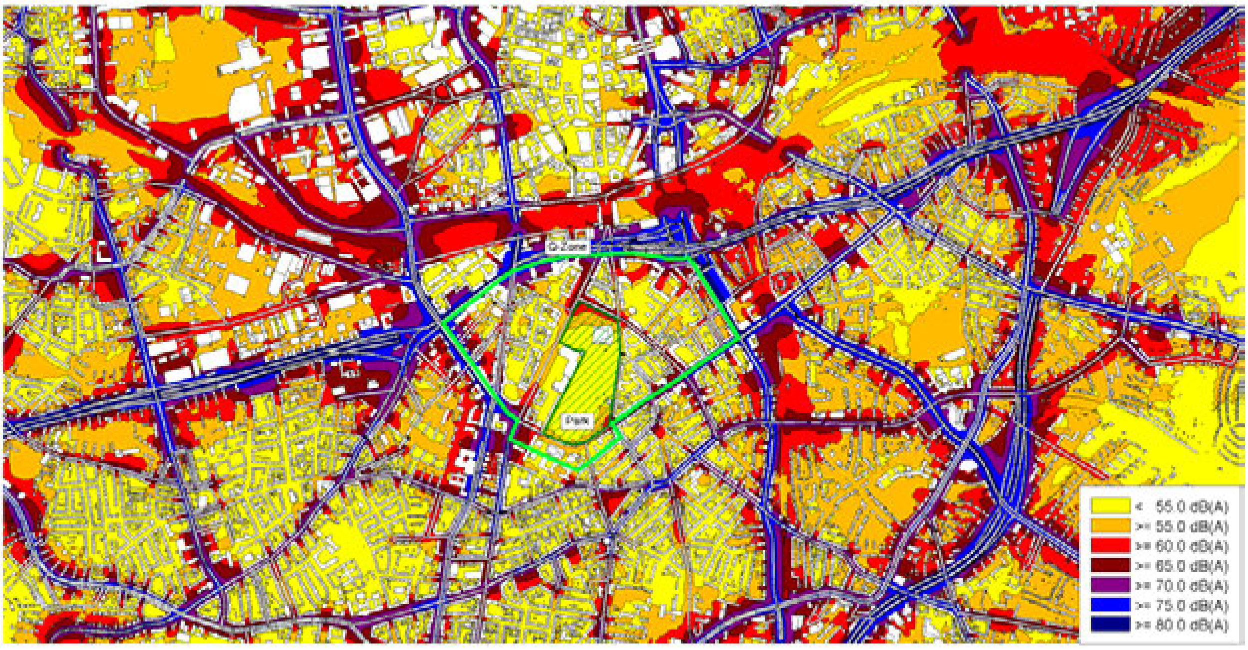

Figure 7.3.2: Noise map for the Scenario S10. The major impact on the noise situation is due the character of its Q-Zone.

Figure 7.3.2 depicts the noise map of scenario S10, as it is defined in table 7.3.4 Compared to the base case in Figure 7.3.1 we can identify reduced noise levels at various points on the map. The visual analysis is improved by illustrating changes in the noise situation with a noise difference map, which is shown in Figure 7.3.3. Obviously, other scenarios will produce different pictures. A complete set of noise maps and noise difference maps for the various scenarios is compiled in a separate appendix.

Figure 7.3.3: Noise difference map of scenario S10

In Table 7.3.5 we can see the noise distribution inside the park for the various scenarios. In some scenarios we can now find areas with noise levels in the 45-50 dB range, which indicates an improvement inside the park. Almost all scenarios have remaining areas with noise levels above 75 dB(A) except for scenario 10, which contains no area with noise levels above the 65-70 dB range.

Table 7.3.5: Noise distribution in the various scenarios for the park area. Noise levels are given in 5 dB noise classes. The values in the table specify m² of the park area.

Noise level / Scenario	< 45	45 - 50	50 - 55	55 - 60	60 - 65	65 - 70	70 - 75	> 75
S1	0	0	2 600	45 900	28 000	17 700	7 500	2 600
S2	0	0	22 400	42 000	19 100	10 200	7 200	3 400
S3	0	0	22 400	42 000	19 100	10 200	7 200	3 400
S4	0	0	21 000	43 100	19 400	10 200	7 200	3 400
S5	0	300	28 300	37 800	17 400	10 000	7 100	3 400
S6	0	300	28 300	37 800	17 400	10 000	7 100	3 400
S7	0	300	28 300	37 800	17 400	10 000	7 100	3 400
S8	0	0	2 700	47 300	27 500	17 200	7 000	2 600
S9	0	0	22 700	43 100	18 200	10 200	7 000	3 100
S10	0	12 400	69 300	17 200	5 000	400	0	0
S11	0	700	34 200	40 000	15 700	8 800	4 200	700
S12	0	0	5 300	48 200	27 000	15 400	6 400	2 000
S13	0	100	28 700	42 200	15 100	9 500	6 300	2 400
S14	0	2 800	44 600	34 100	11 800	7 600	3 300	100
S15	0	100	28 500	42 400	15 100	9 500	6 300	2 400

In Figure 7.3.4 the values of Table 7.3.5 are illustrated as a bar chart. In this form the most prevailing noise class can easily be identified. The 55-60 dB range is found in the majority of areas in most scenarios except for scenario 10 and scenario 14, where by far the largest area lie within the 50-55 dB class.

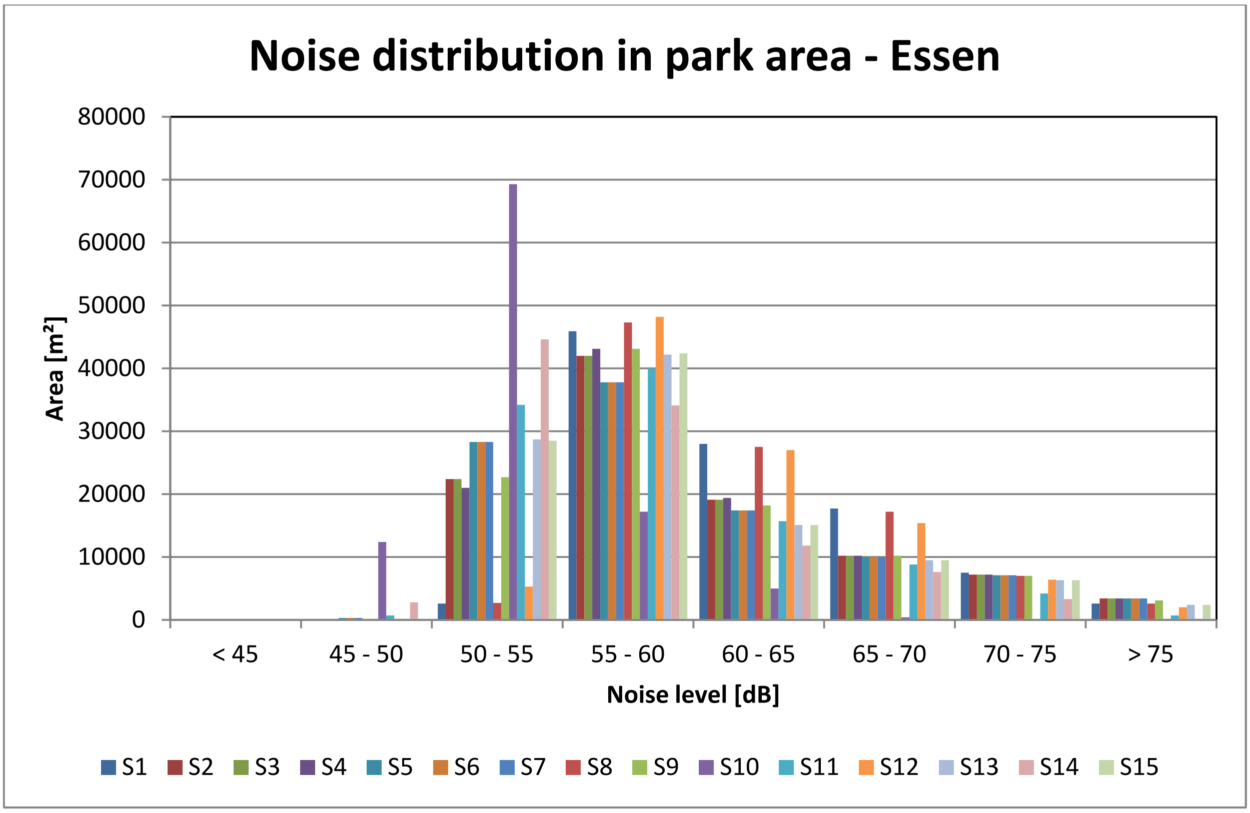

Figure 7.3.4: Noise distribution in the park in Essen for the various simulation scenarios

7.3.4 Potential noise gains on the test site in Essen

In the following we will be looking at some key indicators for assessing the effects of the various Q-Zone scenarios. A summary of these key indicators are presented in Table 7.3.6 and we will be referring to this table throughout the rest of this section. The indicators are the change of the average day / evening noise level $L_{de,av}$ in the park, the change in the “capacity” and we also consider the changes of the number of HAP.

By the term “change” we refer to the differences between the base case and each of the scenarios as regards to the values of the considered measures.

When determining the number of HAP we specify the values in various parts of the test site: in the Q-Zone, outside the Q-Zone (i.e. the test site region without the area of the Q-Zone) and the complete test site. We will also present absolute values of the $L_{de,av}$ in various tables throughout this section.

Table 7.3.6: Forecasted changes in noise, capacity and HAP

Scenario	Change $L_{de,av}$ (park) [dB]	Change $L_{de,av}$ (surround.) [dB]	Change of "Capacity"	Change of number HAP within Q-Zone	Change of number HAP outside Q-Zone within affected area	Change of number HAP (Test-site including Q-Zone)
S1						
S2	-1.9	-1	9 491	-39	135	96
S3	-1.9	-1	9 595	-40	135	95
S4	-1.9	-1	7 196	-40	135	95
S5	-2.4	-0.7	13 246	-7	9	2
S6	-2.4	-0.7	13 246	-7	9	2
S7	-2.4	-0.7	13 350	-7	9	2
S8	-0.1	-0.1	104	-6	-93	-99
S9	-2.1	-1.2	9 908	-42	12	-30
S10	-8.9	-1.7	65 291	-70	102	32
S11	-4.1	-1.3	21 694	-53	117	64
S12	-0.8	-0.8	521	-27	-467	-494
S13	-2.9	-2	13 767	-68	-467	-535
S14	-5.3	-2.4	29 412	-101	-527	-627
S15	-2.8	-2	13 559	-68	-467	-536

7.3.4.1 Noise and capacity indicators for the park, the Q-Zone and the test site

From Table 7.3.6 we discern that scenario S10 reveals an outstanding reduction of the average noise level in the park compared to the other scenarios. Scenario S10 comprises the XL-Q-Zone. This Q-Zone design has a pronounced effect on the traffic distribution inside the test site, as it encloses a major road on its southern end. An average improvement of 8.9 dB is forecasted for the park. Scenarios 11 and 14 constitute a special case, and we will discuss this at a later stage.

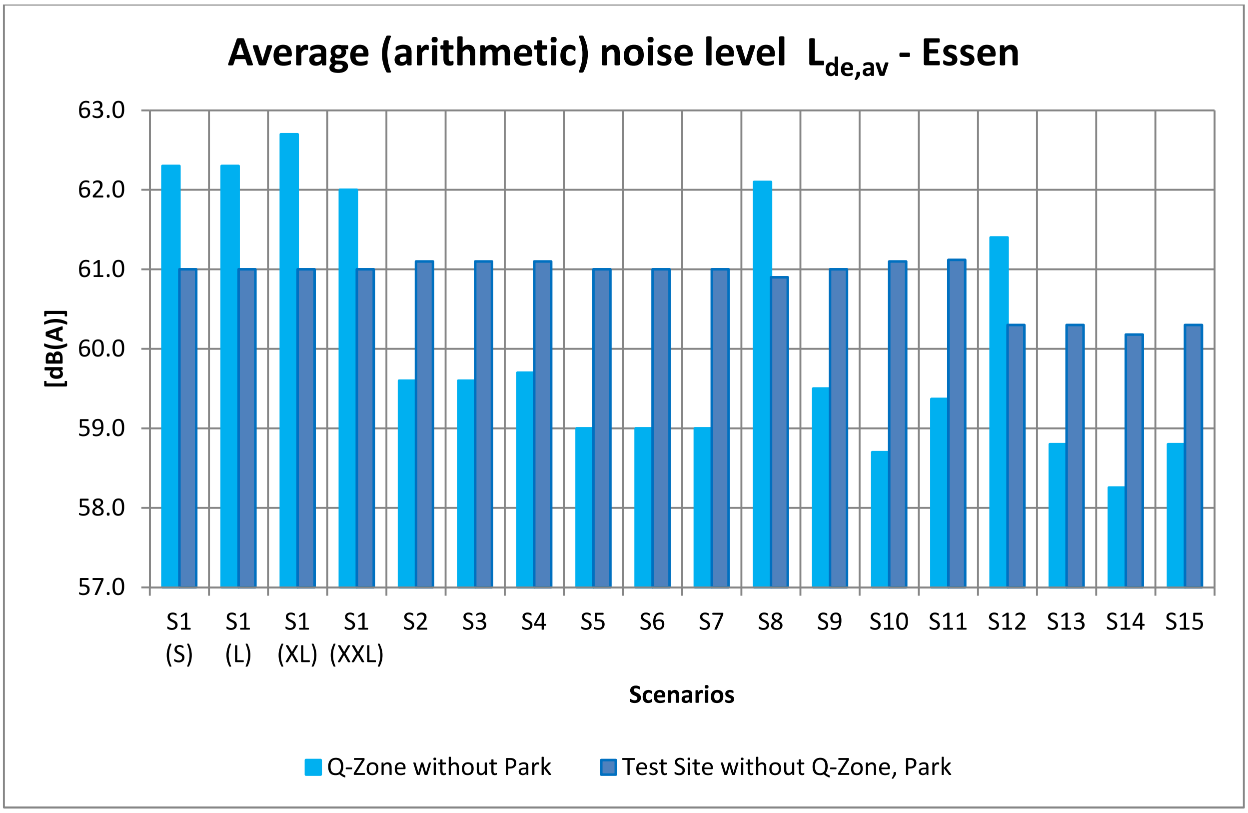

Figure 7.3.5: The noise situation in the Q-Zone and the test site without the Park

A similar picture as that of the changes in the park's average day/evening noise levels ($L_{de,av}$), can also be drawn for the park's capacity. Our investigated scenarios show a capacity gain between 104 m² in scenario 8 and 65 291m² in scenario 10 with the XL-Q-Zone. The latter gain is the 312-fold capacity of the base case, which is a remarkable gain. In Table 7.3.7 the absolute capacity values and Table 7.3.6 the capacity gains are shown for all scenarios. Again scenarios S11 and S14 pose a special case, which we will discuss later.

Table 7.3.7: Noise and capacity values for the various scenarios in the embedded park in Essen

Scenario		S1	S2	S3	S4	S5	S6	S7	S8	S9
$L_{de,av}$ (park)	[dB(A)]	62.1	60.2	60.2	60.2	59.7	59.7	59.7	62.0	60.0
"Capacity" of park[4]	[m²]	209	9 700	9 804	7 405	13 455	13 455	13 559	313	10 117
Scenario		**S10**	**S11**	**S12**	**S13**	**S14**	**S15**			
$L_{de,av}$ (park)	[dB(A)]	53.2	58.0	61.3	59.2	56.8	59.3			
"Capacity" of park[4]	[m²]	65 500	21 903	730	13 976	29 621	13 768			

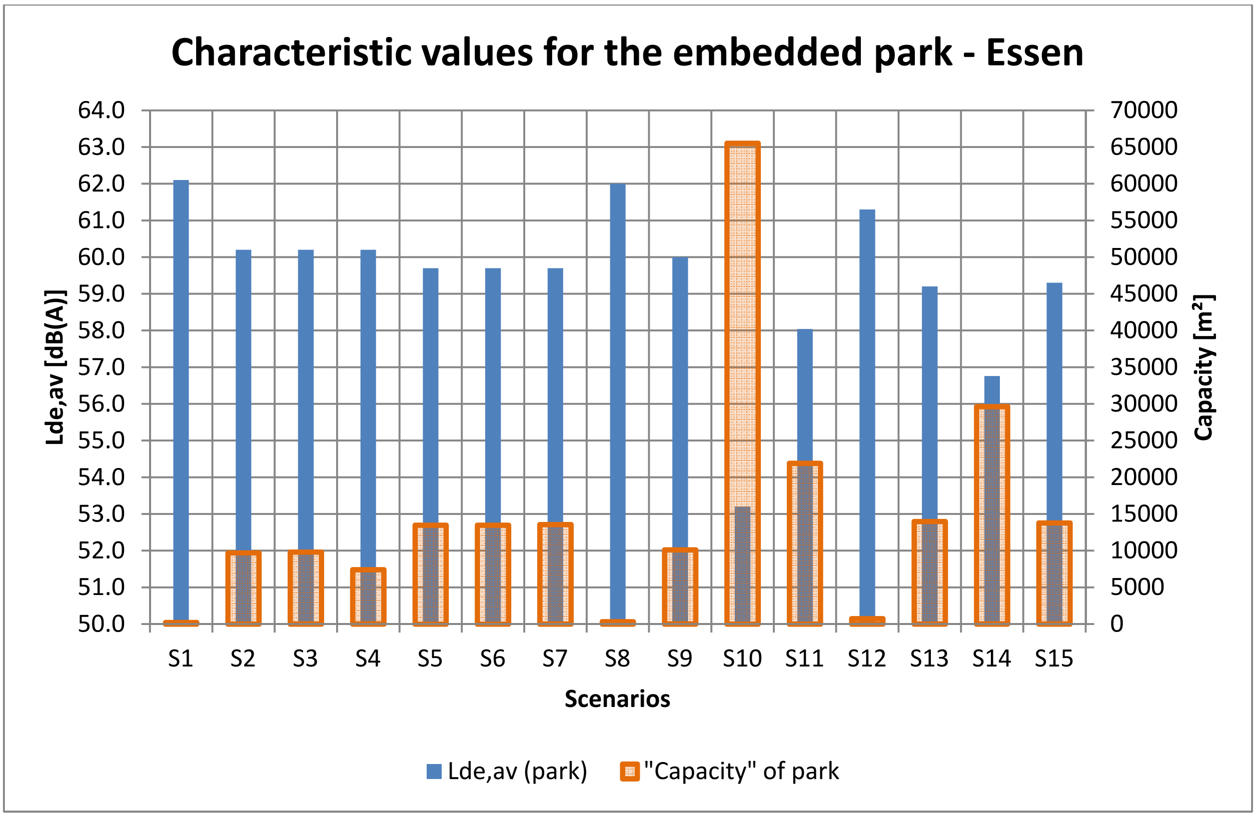

Figure 7.3.6: Bar chart of the noise and capacity values of the embedded park in Essen

7.3.4.2 Highly annoyed people in the Q-Zone and the test site excluding the Q-Zone

As we have previously mentioned, the indicator "*number of highly annoyed people* (HAP)" can be used as a single number value for a comparative evaluation of noise effects from various Q-Zone configurations. Changes in the number of HAP within the Q-Zone and the test site are shown in Table 7.3.6. A decrease in the number of HAP inside the Q-Zone can be recognized for all scenarios, which corresponds with the values given in Table 7.3.6. All scenarios show minor to moderate improvements in the number of HAP inside the Q-Zone.

Table 7.3.8: Characteristic values for the Q-Zone in Essen

Scenario		**S1** small	**S1** large	**S1** XL	**S1** XXL	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
$L_{de,av}$	[dB(A)]	62.3	62.3	62.7	62.0	59.6	59.6	59.7	59.0	59.0	59.0
No. residents		1 754	4 152	4 267	5 012	4 152	4 152	4 152	1 754	1 754	1 754
HAP		158	425	440	507	386	385	385	151	151	151
Scenario		**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**		
$L_{de,av}$	[dB(A)]	62.1	59.5	58.7	59.4	61.4	58.8	58.3	58.8		
No. residents		4 152	4 152	4 267	5 012	4 152	4 152	5 012	4 152		
HAP		419	383	369	454	398	356	406	357		

The most noticeable improvements for the Q-Zone was forecasted for scenarios S14 which comprises a super large (XXL-Q-Zone) and for scenario S10. These situations also show a high increase of the number of HAP outside the Q-Zone, i.e. the conditions for some parts of the population deteriorate. This is actually the case for most scenarios, except for those where we find a significant rise in LNVO.

Table 7.3.9 Characteristic values for the test site without the Q-Zone

Scenario		S1 (small)	S1 (large)	S1 (XL)	S1 (XXL)	S2	S3	S4	S5	S6
$L_{de,av}$	[dB(A)]	61.0	61.0	61.0	61.0	61.1	61.1	61.1	61.0	61.0
No. residents		92 851	90 453	90 338	89 593	90 453	90 453	90 453	92 851	92 851
HAP		8 156	7 889	7 875	7 807	8 024	8 024	8 024	8 165	8 165
Scenario		**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**
$L_{de,av}$	[dB(A)]	61.0	60.9	61.0	61.1	61.1	60.3	60.3	60.2	60.3
No. residents		92 851	90 453	90 453	90 338	89 593	90 453	9 0453	89 593	90 453
HAP		8 165	7 796	7 902	7 976	7 924	7 422	7 422	7 281	7 422

Self-evidently we need to recognize that a judgment which is based only on the average noise levels in the various zones is insufficient for determining overall improvements across the test site. By considering the differences in the HAP value for the complete test site (including the Q-Zone) we actually find a slight increase of the total number of HAP which does suggest a worsening for the overall population throughout the test site. This is attributed to the fact that the original traffic from the major road that's section is enclosed by the Q-Zone is re-directed into other parts of the test site. As a result the proximate surrounding is traffic-calmed but at the expense of increasing traffic density and noise in peripheral regions.

The focus in this report lies on noise improvements in the park, which is generally achievable with the presented methods, but it is important to realize the consequences for other areas. Therefore appropriate mediation measures are required in those areas that are negatively affected by any actions taken as regards a Q-Zone implementation.

The HAP values for the various areas are presented together with the number of residents in Table 7.3.8 and Table 7.3.9 respectively. In Figure 7.3.7 the percentage of the number of HAP are given in relation the inhabitants for the Q-Zone and the test site respectively.

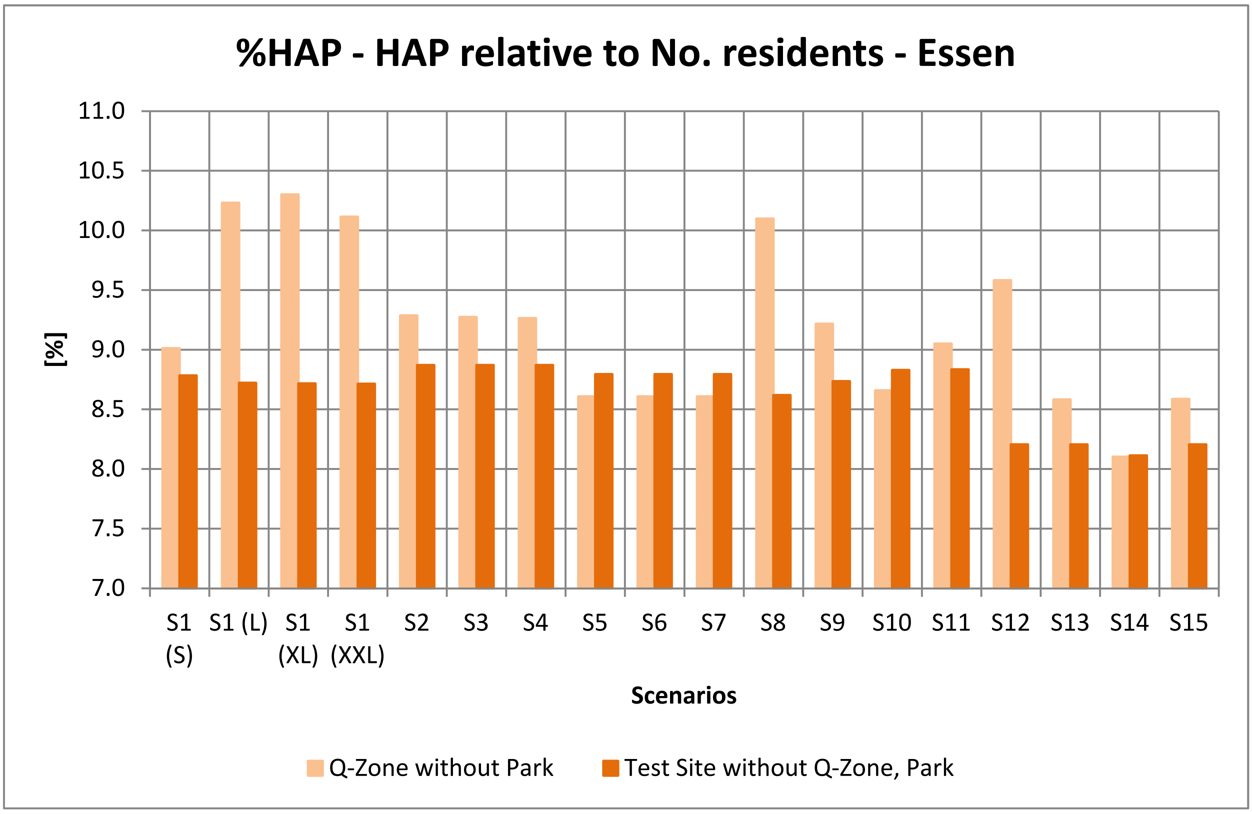

Figure 7.3.7: Percentage of HAP related to the number of inhabitants in the corresponding zone

7.3.5 Summary for Essen test site

Depending on the scenario which is observed, average day/evening-time noise level (L_{de}) in the park could be reduced by a maximum of 8.9 dB. The "capacity" of the embedded park could be increase from 0 m² in the base case to a maximum 65 291 m² (59.4 % of the park area). The scenario with the maximum reduction of the number of HAP was forecasted with 627 in the complete test site or by 7 %. Improvements in the park's noise level are possible by embedding it in a Q-Zone. It needs to be considered that the improvements in the park and the Q-Zone have negative consequences in other regions of the city caused by redistribution effects and is revealed by a rise in the number of HAP in the effected regions. Therefore, an implementation is only reasonable in conjunction with mitigation measures in those areas outside the Q-Zone that are negatively affected by any actions taken.

7.4. GOTHENBURG TEST SITE

7.4.1 Description of the Q-Zone and its embedded park in Gothenburg

The central parts of Gothenburg contain several parks that are affected by noise disturbance. Parks have been subject to investigations with respect to use and environmental status. The Cityhush Gothenburg municipality partner suggested three main alternatives for a park surrounded by a Q-Zone as shown in Figure 7.4.1.

Figure 7.4.1: Parks in central Gothenburg

The Trädgårdsföreningen is the largest park and a more detailed overview is shown in Figure 7.4.2 in which also noise levels are included (shorter intervals).

Figure 7.4.2: Noise levels in the Trädgårdsföreningen park (dB(A))

According to the investigation, the park is used for a number of different recreational purposes like resting, walking, playing, experiencing water and flowers and also for cultural events. The two other parks are smaller and not as much used as the Trädgårdsföreningen.

After discussions with the Gothenburg municipality partners, the Trädgårdsföreningen park appeared to have the highest potential to be embedded in a Q-Zone. The two potential Q-Zone areas are shown in Figure 7.4.3.

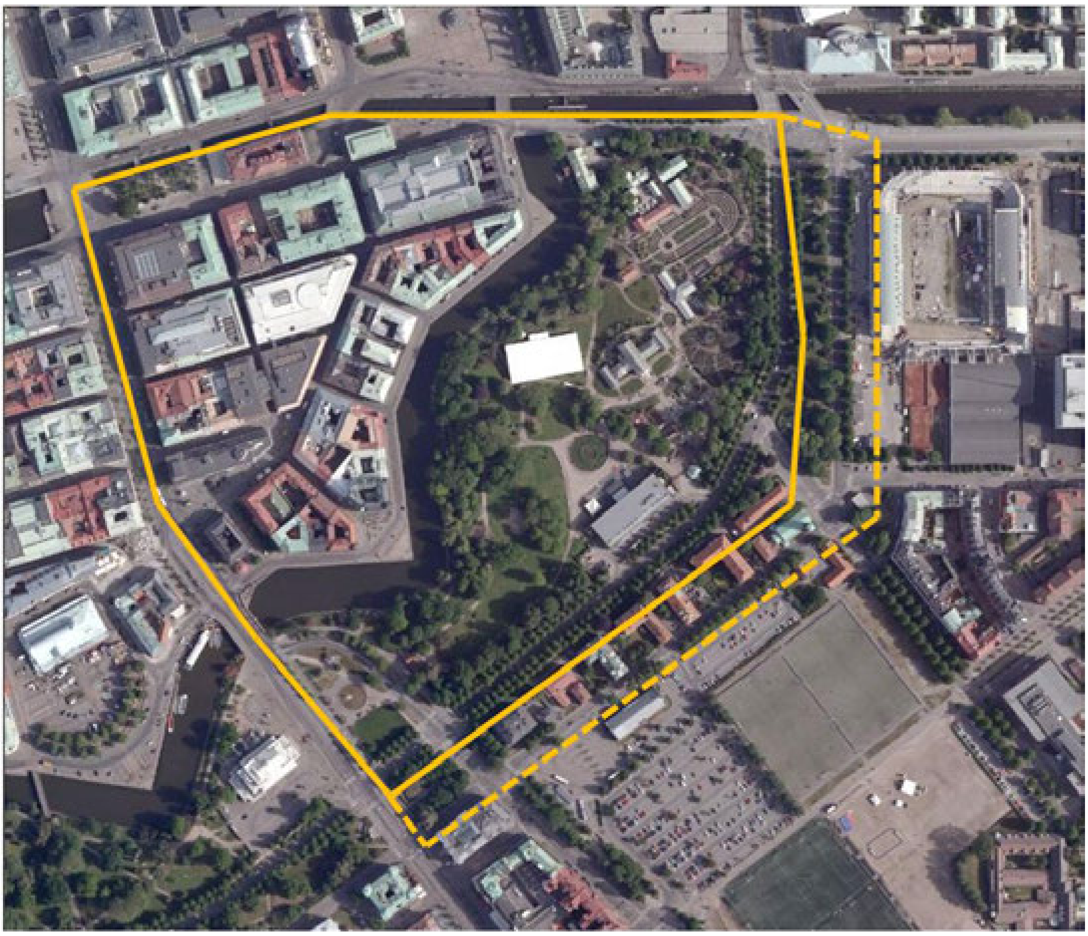

Figure 7.4.3: Intended Q-Zone area

The attributes characterizing the park, the Q-Zone and the test site are compiled in Table 7.4.4. Area sizes are each given for the test site, the Q-Zone and the park respectively. Further attributes refer to the park's number of visitors, who reside in the park-surrounding and the number of residents in the various zones. Additionally we have also specified the population density for the Q-Zone and the test site outside the Q-Zone.

Table 7.4.1: Test-site-describing attributes in Gothenburg

Area test site		2.4 km^2
Area Q-Zone	**Large L**	0.28 km^2
	Medium M	0.25 km^2
Area embedded park		0.8 km^2
Number of visitors calculated on number of residents within a 5 min-walk distance to the park		13 292
Number of residents within the Q-Zone	**Large L**	212
	Medium M	109
Density [inhabitants/km^2] Q-Zone	**Large L**	757
	Medium M	436
Number of residents within the test site (outside Q-Zone Large)		28 159
Number of residents within the test site (outside Q-Zone Medium)		28 262
Density [inhabitants/km^2] within test site (outside Q-Zone Large)		13 282
Density [inhabitants/km^2] within test site (outside Q-Zone)		13 314

7.4.1.1 Noise map and noise distribution on the test site

Figure 7.4.4 depicts a noise map of the Q-Zone and its surrounding area. On this map the distribution of noise levels $L_{de,av}$ is illustrated by an overlaid color grid. A legend is included in which the various colors are mapped to noise level classes. The noise distribution in the figure reflects the current situation (i.e. the base case scenario) on the test site in Bristol. As with the previous case in Essen, main roads can be identified as major sources of noise.

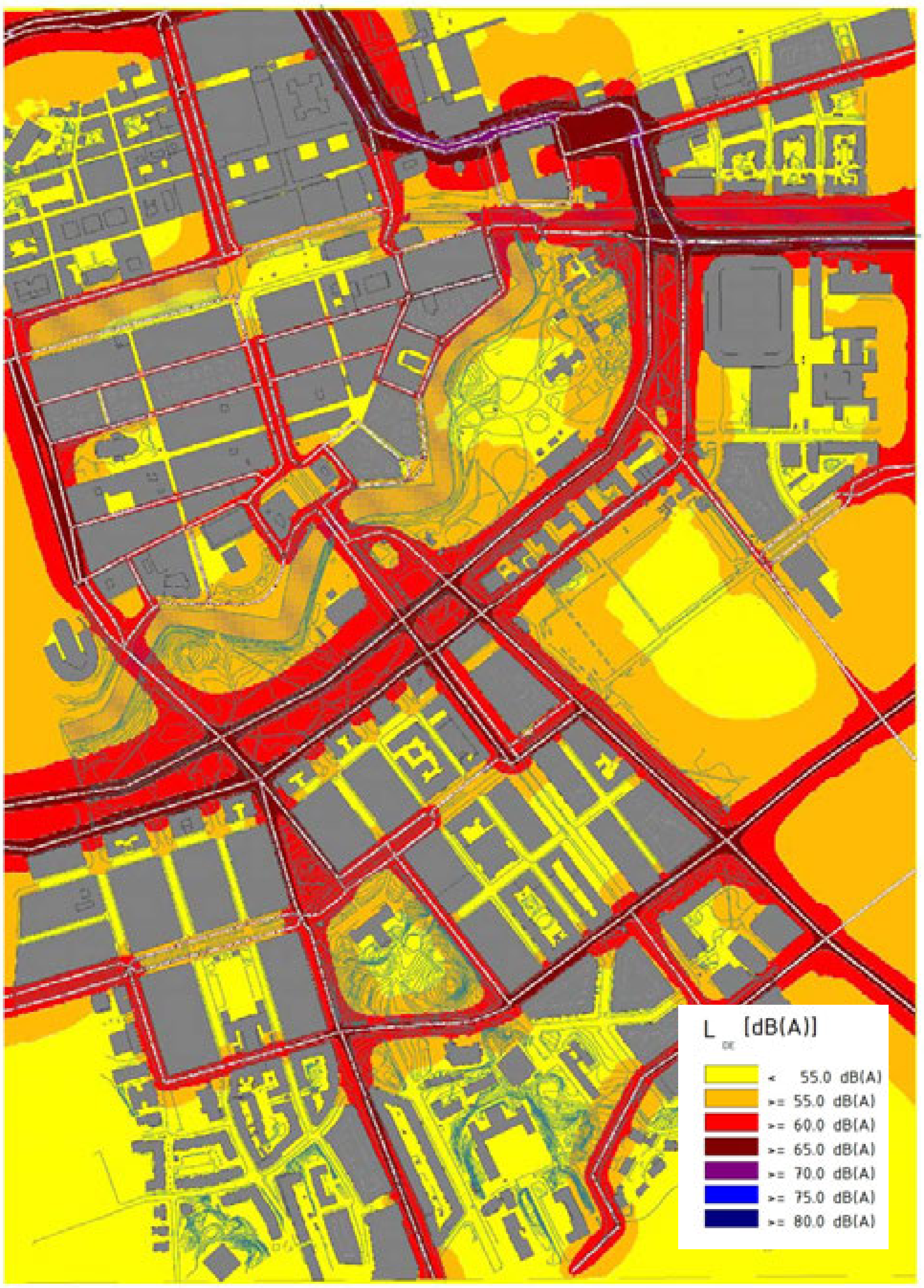

Figure 7.4.4: Noise map of the test site, with the Q-Zone and the park

In table 7.4.2 the noise distribution within Trädgårdsföreningen park, the surrounding Q-Zone and the test site (area [m²] affected by noise [5 dB classes]), based on the L_{de} is shown. There are no areas inside the park that fall in and below the 40-45 dB(A) noise class. The lowest noise class observed in the park is the 45-50 dB(A) range, which covers an area of 92 m^2, which is the lowest noise class in the Q-Zone. It is again noteworthy that the test site contains a total area of 75276 m^2 that falls into the noise class of 40-45. This implies, that the test site contains quieter regions, than the Q-Zone and the park in the base case scenario.

Table 7.4.2: Noise distribution in the test site in Gothenburg

Noise level [5 dB classes]	Park area [m²]	Q-Zone area [m²]	Test site area [m²]
40-45	0	2 532	75 276
45-50	92	3 920	183 236
50-55	24 172	35 712	288 132
55-60	42 660	76 644	504 300
60-65	11 360	56 524	409 764
65-70	16	13 284	158 520
>70	0	20	11 040
Total area size	77 836	184 860	1 682 748

7.4.1.2 Noise reduction potential

To estimate the park's noise reduction potential, we computed the average noise levels $L_{de,av}$ by assuming a hypothetical, completely noiseless Q-Zone. We exempted all noise sources in the simulation software in the various Q-Zone configurations. We will refer to this as the "background-noise-level-scenario", a model in which all contributing factors to the park's noise levels lie outside the Q-Zone. By this, we can estimate the possible noise reduction to be expected by installing a specific Q-Zone. The results of these estimations are shown in Table 7.4.3.

Table 7.4.3 Noise reduction potential of the Q-Zone on the test site in Essen Gothenburg estimated with the "background-noise-level-scenario"

Test site Göteborg	Base case $L_{de,av}$	Background noise level $L_{de,av}$	Potential of noise reduction $L_{de,av}$
Park area	56.9	56.9	0
Small Q-Zone area incl. park	58.3	56.8	1.5
Large Q-Zone area incl. park	59.1	57.7	1.4

7.4.2 Traffic data and investigated traffic scenarios on Gothenburg test site

The traffic simulations for Gothenburg were made by applying the national Swedish forecasting model Sampers, which was generously made available to the CityHush project by national authorities. This application allowed for traffic simulations concerning all modes used for local and regional travel. Effects with respect to changes of modes, destinations or travel frequency were also included, in addition tp. route choice effects. The model also allowed for the fact that different travellers have different cost sensitivity, which is necessary to take into account when simulating traffic effects of different noise fees. More details concerning the traffic model application can be found in Deliverable D1.1.2 [7].

To be able to establish boundary conditions for Q-Zones, four defining parameters were systematically varied in the traffic simulations. These were

- zone size
- type/degree of constrained access to the Q-Zone
- low noise vehicle ownership inside and outside the Q-Zone.

The following traffic scenarios shown in Table 7.4.4 were simulated for the Gothenburg case:

Table 7.4.4: Table of Q-Zone scenario configurations in Gothenburg

Scenario	Zone	Fee, Euros/passage	Inside LNVO percentage	External LNVO percentage
S0	-	none	1	1
S1	small	Low noise vehicles only	1	1
S3	large	Low noise vehicles only	1	1
S5	small	Noise fee 0.5 Euro	1	1
S7	large	Noise fee 0.5 Euro	1	1
S13	large	Noise fee 0.5 Euro	100	20
S15	-	none	20	20
S16	small	Low noise vehicles only	100	20

The different zone sizes are described in 7.3.1. The fees are to be paid on entry and exit, thereby penalizing through traffic relatively harder than traffic with origin or destination in the zone. The ban is assumed not to be applied to zone residents.

7.4.3 Noise situation for different traffic scenarios on the test site in Gothenburg

In Table 7.4.4 we provided an overview of the different Q-Zone configurations. We will be presenting the results for seven different Q-Zone configurations, where different access policies for entering and exiting the Q-Zone and various percentage shares of LNVO are assumed. The current noise situation (base case) is described by the G0 scenario in the various tables throughout this section.

In Table 7.4.5 we can see the noise distribution inside the park for the various scenarios.

Table 7.4.5: Noise distribution in the various scenarios for the park area. Noise levels are given in 5 dB noise classes. The values in the table specify m² of the park area.

Noise level / Scenario	40-45	45 - 50	50 - 55	55 - 60	60 - 65	65 - 70	>70
G0	0	92	24120	42 568	11 292	4	0
G1	0	404	47 480	26 692	3 008	0	0
G3	16	884	54 328	19 620	2 608	0	0
G5	0	296	40 892	31 936	3 140	0	0
G7	0	536	47 496	26 400	3 168	0	0
G13	0	800	53 624	20 712	2 208	0	0
G15	0	136	29 116	39 080	8 192	0	0
G16	16	552	52 572	22 312	1 872	0	0
G16b	32	664	56 460	18 468	1 624	0	0

7.4.4 Potential noise gains on the test site in Gothenburg

In the following we will be looking at some key indicators for assessing the effects of the various Q-Zone scenarios. A summary of these key indicators are presented in Table 7.4.6 and we will be referring to this table throughout the rest of this section. The indicators are the change of the average day / evening noise level $L_{de,av}$ in the park, the change in the “capacity” and we also consider the changes of the number of HAP.

By the term “change” we refer to the differences between the base case and each of the scenarios in regard to the values of the considered measures.

When determining the number of HAP we specify the values in various parts of the test site: in the Q-Zone, outside the Q-Zone (i.e. the test site region without the area of the Q-Zone) and the complete test site. We will also present absolute values of the $L_{de,av}$ in various tables throughout this section.

Table 7.4.6: Potential noise gains on test site Gothenburg

Scenario	Change $L_{de,av}$ (park) [dB]	Change $L_{de,av}$ (surround.) [dB]	Change of "Capacity"	Change of number HAP within Q-Zone	Change of number HAP outside Q-Zone within affected area	Change of number HAP (Test-site including Q-Zone)
Base Case	0	0	0	0	0	0
G1	-2.2	-0.7	300	4	485	489
G3	-2.8	-1.1	1 332	-10	20	22
G5	-1.7	-0.6	172	5	280	285
G7	-2.2	-0.9	716	-9	-7	-4
G13	-2.9	-1.4	800	-10	-49	-48
G15	-0.4	-0.4	-12	5	217	223
G16	-2.9	-1.2	384	-3	-9	-12

7.4.4.1 Noise and capacity indicators of the park, Q-Zone and test site

From Table 7.4.8 and Figure 7.4.6 we observe, that we have slightly falling average noise levels in the park for all scenarios. The highest reductions we find for scenarios G3 and G13 of 2.7 dB and 2.8 dB respectively. Both scenarios are characterizes by the large Q-Zone configuration and an exclusive access policy to the Q-Zone for LNVs in scenario G3 and a 20 % outside / 100 % inside LNVO in scenario G13 with an imposed access fee of 0.5 Euros for other vehicles. Also scenario G3 shows the highest park's capacity increase by 387 %. All other scenarios except for scenario G15 also show a capacity gain. Scenario G15 is characterized by no Q-Zone but a 20 % LNVO.

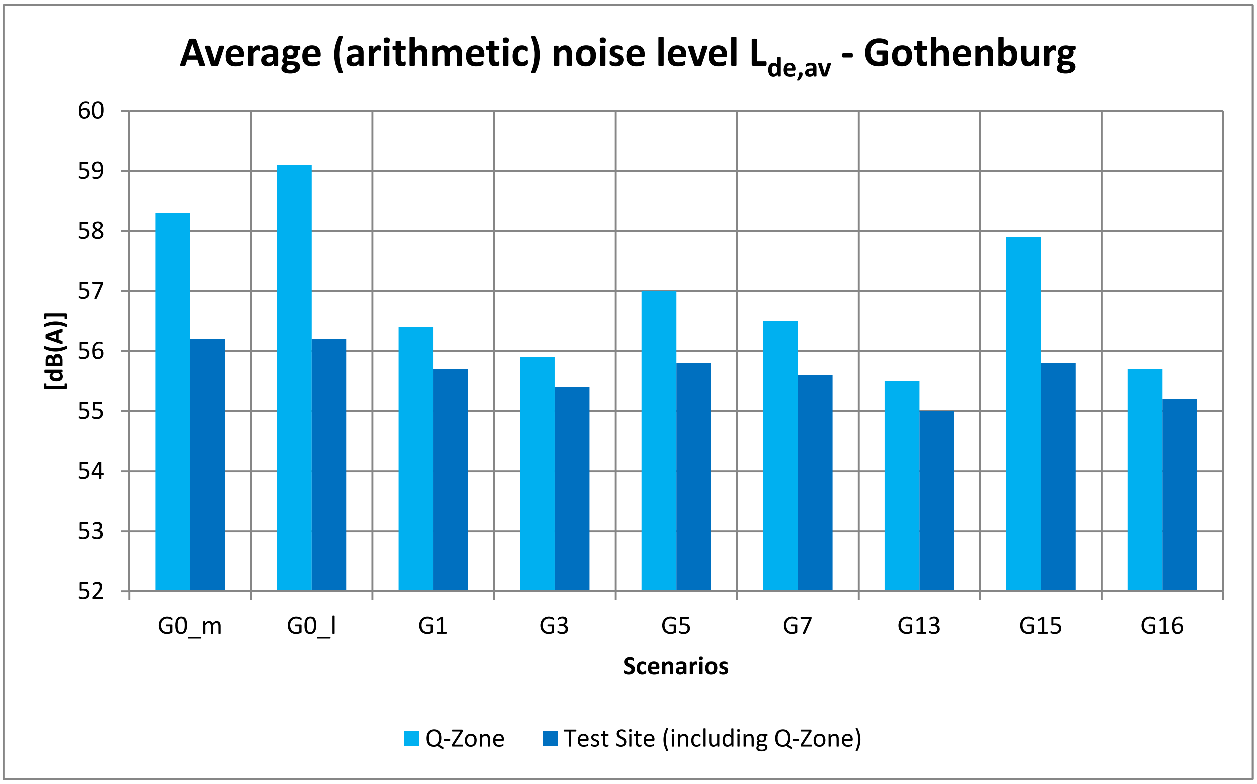

Figure 7.4.5: Average noise situation in the Q-Zone and the test site

Table 7.4.7 Characteristic values for the embedded park in Gothenburg

	Unit	G0	G1	G3	G5	G7	G13	G15	G16
$L_{de,av}$ (park)	dB(A)	57.8	55.5	55.0	56.1	55.6	54.9	57.4	54.9
$L_{de,av}$ (surrounding)	dB(A)	61.9	61.1	60.8	61.2	61.0	60.5	61.5	60.7
"Capacity" of embedded park	[m^2]	464	764	1 796	636	1 180	1 264	452	848

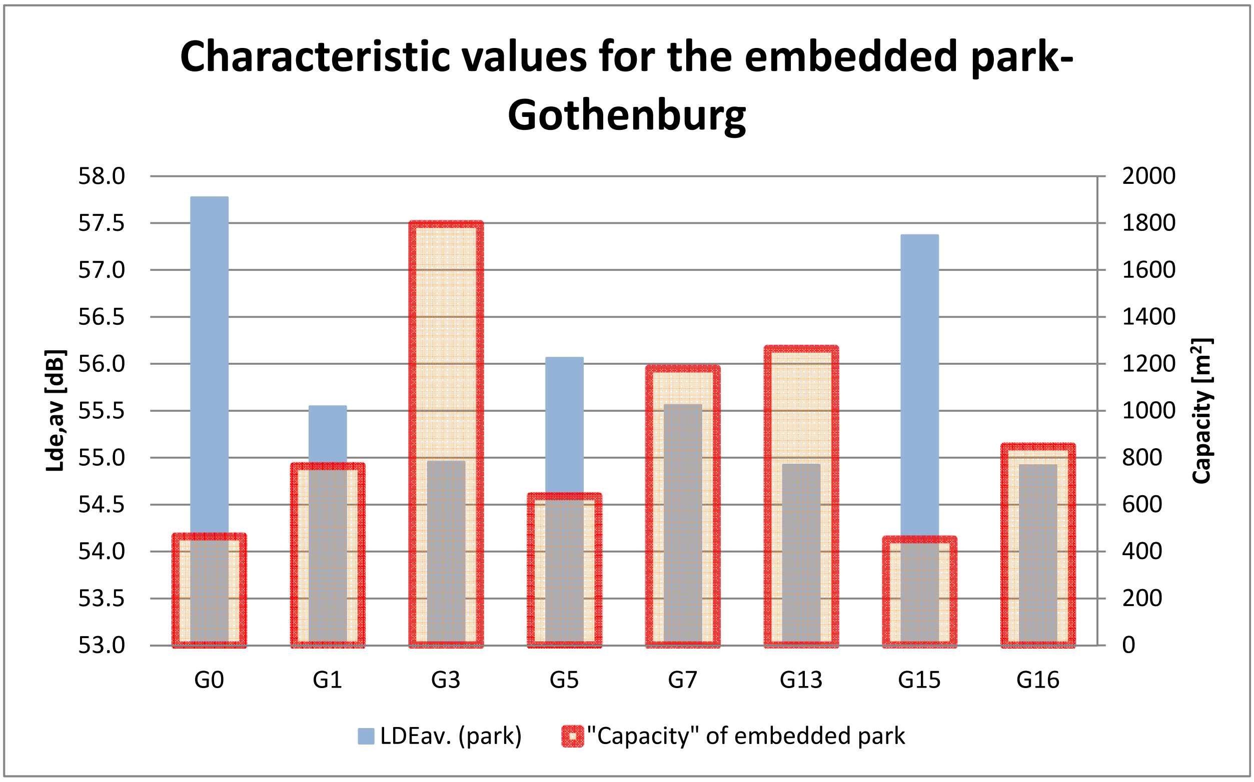

Figure 7.4.6: Characteristic values for the embedded park in Gothenburg

7.4.4.2 Highly annoyed people in the Q-Zone and the test site (with Q-Zone)

From Table 7.4.8 and Table 7.4.9 we can determine the change of the number of HAP in the various scenarios compared to the base case. In Table 7.4.8 we distinguish between scenarios for the medium sized Q-Zone and the large Q-Zone. For the medium sized Q-Zone only scenario G16 results in a reduction of the number of HAP in the Q-Zone and the test site. For the large Q-Zone scenarios G7, G13 and G15 show a reduction in the Q-Zone area but only G7 and G13 show a reduction for the complete test site.

Table 7.4.8: Characteristic values for the Q-Zone in Gothenburg

	Unit	G0_m	G0_L	G1	G3	G5	G7	G13	G15	G16
$L_{de,av}$ [dB(A)]	dB(A)	58.3	59.1	56.4	55.9	57.0	56.5	55.5	57.9	55.7
No. residents	dB(A)	109	212	109	212	109	212	212	109	109
HAP		20	32	24	22	25	23	22	25	17

In both tables we used different background colours for a better distinction the scenario association with the two different Q-Zones.

Table 7.4.9: Characteristic values for the test site (including the Q-Zone) in Gothenburg

	Unit	G0	G1	G3	G5	G7	G13	G15	G16
$L_{de,av}$ [dB(A)]	dB(A)	56,2	55,7	55,4	55,8	55,6	55,0	55,8	55,2
No. residents	dB(A)	2 8371	2 8371	28 371	28 371	28 371	28 371	28 371	28 371
HAP		1 072	1 562	1 095	1 357	1 069	1 025	1 295	1 061

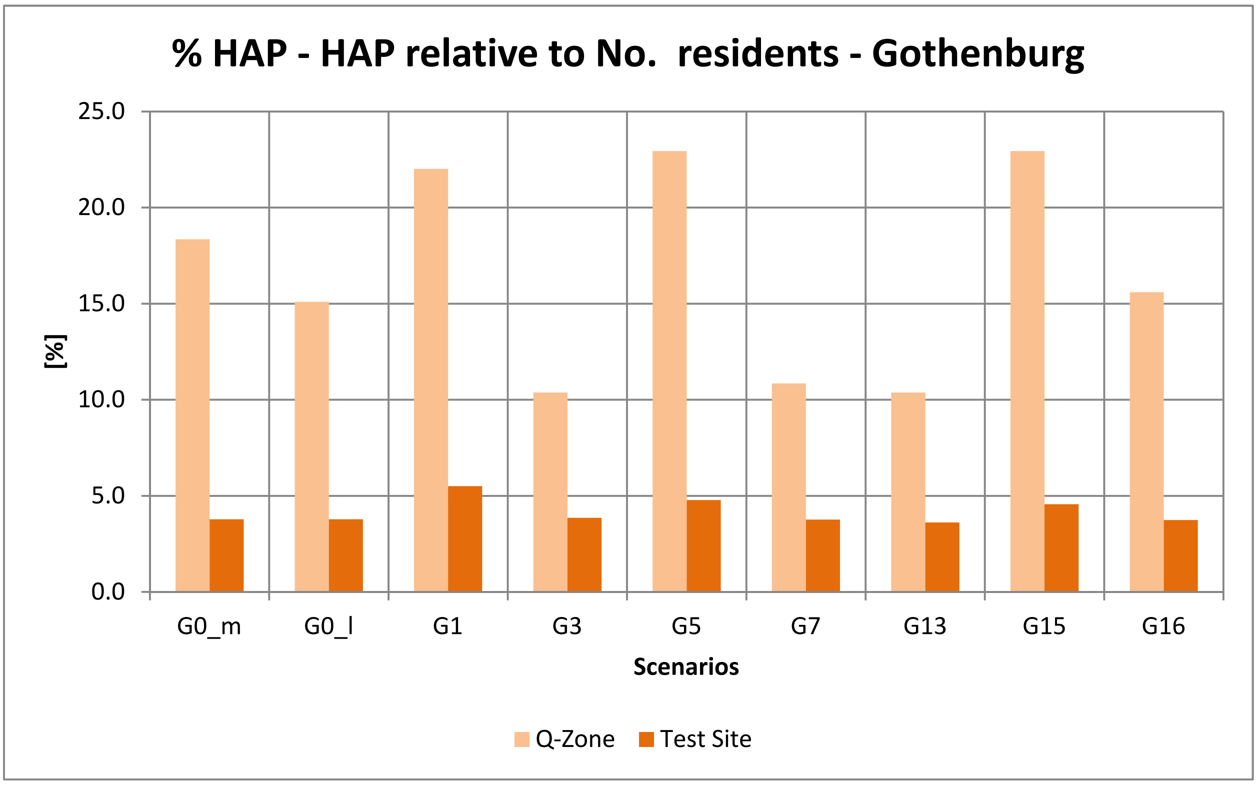

Figure 7.4.7: Percentage of HAP related to the number of inhabitants in the corresponding zone

7.4.5 Summary for Gothenburg test site

Marginal to moderate improvements were found for the average noise levels inside the park by embedding it in a Q-Zone for all scenarios. In one scenario these improvements come at the cost of a reduced capacity. Most scenarios do show an increase in the number of HAP outside the Q-Zone which is not desirable. Therefore, an implementation is only reasonable in conjunction with mitigation measures in those areas outside the Q-Zone that are negatively affected by any actions taken.

7.5. STOCKHOLM TEST SITE

Stockholm is the capital of Sweden and its largest city.

7.5.1 Description of Q-Zone and its embedded park in Stockholm

After discussion with the Stockholm Municipality partner, it was decided to choose the area indicated in Figure 7.51 (red and yellow lines). The area is not only disturbed by car traffic – a railway line also crosses part of the area. The area contains several parks, and is also suitable for testing smaller Q-Zone sizes. In Figure 7.5.1 Stockholm Q-Zone borders (park in blue, small zone size in yellow, medium zone size in solid red, large zone size in solid and dashed red) are shown.

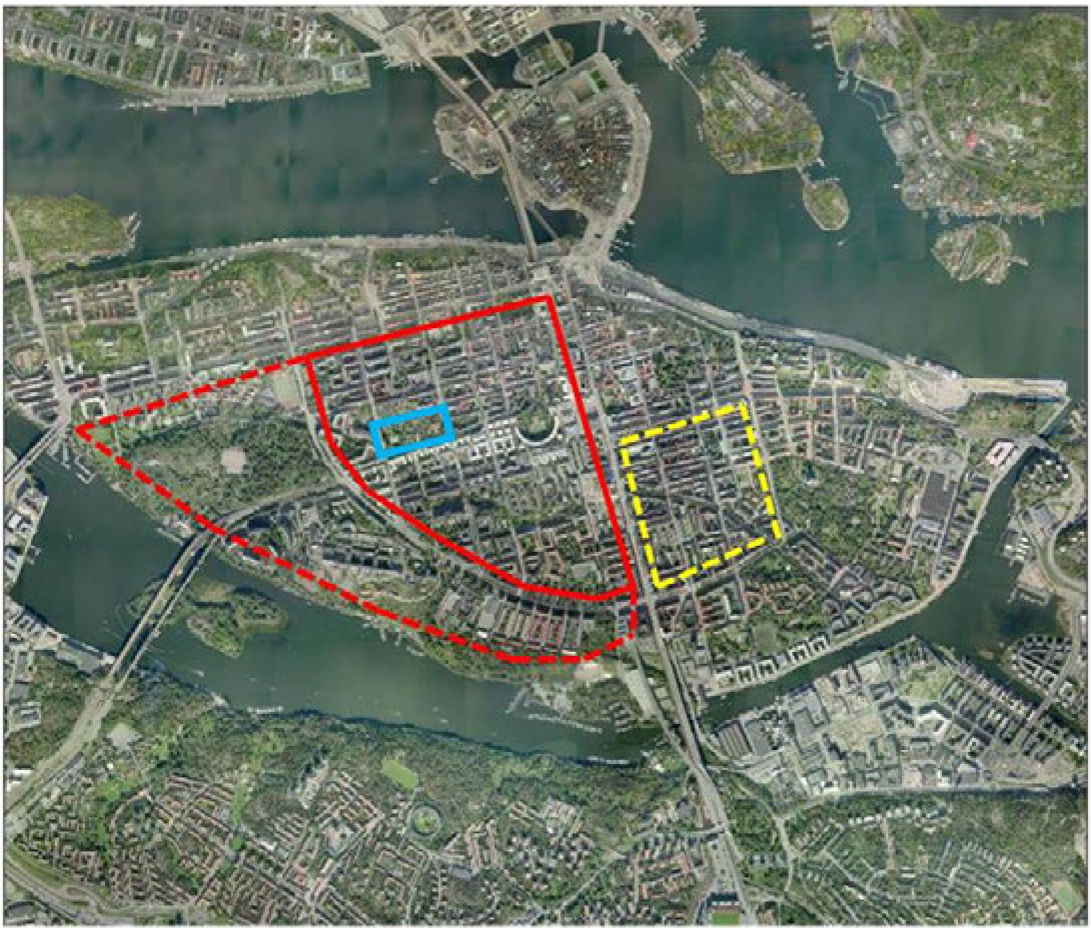

Figure 7.5.1: Intended Q-Zone area

The attributes characterizing the park, the Q-Zone and the test site are compiled in Table 7.5.1. Area sizes are given for the test site, the various Q-Zones and the park respectively. Further attributes refer to the park's number of visitors, who reside in the park-surrounding and the number of residents in the various zones. Additionally we have also specified the population density for the Q-Zone and the test site outside the Q-Zone.

Table 7.5.1: Test-site-describing attributes (Stockholm)

Area Test site		4,97 km²
Area Q-Zones	**Large**	2,34 km²
	Medium	1,27 km²
	Small	0.42 km²
Area embedded park		0.03 km²
Number of visitors calculated on number of residents within a 5 min-walk-distance to the park		24562
Number of residents within each Q-Zone	**Large**	32 412
	Medium	25 776
	Small	15 903
Density [inhabitants/km²] for each Q-Zone	**Large**	13 851
	Medium	20 296
	Small	37 864
Number of residents within the test site (outside each Q-Zones)	**Large**	76 103
	Medium	82 739
	Small	92 612
Density [inhabitants/km²] within test site (outside each Q-Zones)	**Large**	28 937
	Medium	22 362
	Small	20 354

7.5.1.1 Noise map and noise distribution on the test site

Figure 7.5.2: Noise map of the test site in Stockholm

Figure 7.5.2 depicts a noise map of the Q-Zone and its surrounding area. On this map the distribution of noise levels $L_{de,av}$ is illustrated by an overlaid color grid. A legend is included in which the various colors are mapped to noise level classes. The noise distribution in the figure reflects the current situation (i.e. the base case scenario) on the test site in Stockholm. As with the previous cases, main roads can again be identified as major sources of noise.

Table 7.5.2: Noise distribution at test site Stockholm

Noise level [5 dB classes]	Park area [m²]	Small Q-Zone area [m²]	Medium Q-Zone area [m²]	Large Q-Zone area [m²]	Test site area [m²]
40-45	1 350	4 640	23 990	53 710	92 110
45-50	590	6 460	18 100	34 310	69 650
50-55	280	7 570	15 200	26 190	59 290
55-60	170	7 420	14 160	21 650	54 410
60-65	10	2 890	8 370	15 380	40 230
65-70	0	360	1 240	4 670	13 020
>70	0	0	0	60	500
Total area size	3 340	40 710	123 660	228 860	491 340

In Table 7.5.2 the noise distribution within park, the various surrounding Q-Zone areas and the test site (area [m²] affected by noise [5 dB classes]), based on the L_{de} is shown. In Stockholm the park already seems to be relatively quiet (compared to other city parks) as it shows 1350 m² of park area that falls into the noise class with the range of 40-45 dB(A) in the base case. Neither do we find noise levels above 65 dB(A) in the park.

7.5.1.2 Noise reduction potential

To estimate the park's noise reduction potential, we computed the average noise levels $L_{de,av}$ by assuming a hypothetical, completely noiseless Q-Zone. We exempted all noise sources in the simulation software in the various Q-Zone configurations. We will refer to this as the "background-noise-level-scenario", a model in which all contributing factors to the park's noise levels lie outside the Q-Zone. By this, we can estimate the possible noise reduction to be expected by installing a specific Q-Zone. The results of these estimations are shown in Table 7.5.3. It is remarkable that for the park alone we do not find any noise reduction potential. Though for the different Q-Zone scenarios quite a significant reduction potential between 8.2 dB and 14.1 dB is estimated.

Table 7.5.3 Noise reduction potential of the Q-Zone on the test site in Stockholm estimated with the background-noise-level-scenario"

Test site Stockholm	Base case $L_{de,av}$	Background noise level $L_{de,av}$	Potential of noise reduction $L_{de,av}$
Park area	43.3	43.3	0.0
Small Q-Zone area incl. park	47.1	38.9	8.2
Medium Q-Zone area incl. park	45.0	36.3	8.7
Large Q-Zone area incl. park	45.0	30.9	14.1

7.5.2 Traffic data and investigated traffic scenarios on Stockholm test site

The traffic simulations for Stockholm were made by applying the national Swedish forecasting model Sampers, which was generously made available to the CityHush project by national authorities. This application allowed for traffic simulations concerning all modes used for local and regional travel. Effects with respect to changes of modes, destinations or travel frequency were also included, in addition tp. route choice effects. The model also allowed for the fact that different travelers have different cost sensitivity, which is necessary to take into account when simulating traffic effects of different noise fees. More details concerning the traffic model application can be found in Deliverable D1.1.2 [7].

To be able to establish boundary conditions for Q-Zones, four defining parameters were systematically varied in the traffic simulations. These were

- zone size
- type/degree of constrained access to the Q-Zone
- low noise vehicle ownership inside and outside the Q-Zone.

The following traffic scenarios shown in Table 7.5.4 were simulated for the Stockholm case:

Table 7.5.4 Table of Q-Zone scenario configurations in Stockholm

Scenario	Zone	Fee, Euros/passage	Inside LNVO percentage	External LNVO percentage
S0	-	none	1	1
S1	small	Low noise vehicles only	1	1
S2	medium	Low noise vehicles only	1	1
S3	large	Low noise vehicles only	1	1
S4	large	Noise fee 1 Euro	1	1
S5	large	Noise fee 0.5 Euro	1	1
S6	medium	Noise fee 1 Euro	1	1
S7	medium	Noise fee 0.5 Euro	1	1
S8	small	Noise fee 1 Euro	1	1
S9	small	Noise fee 0.5 Euro	1	1
S10	large	Low noise vehicles only	20	5
S11	large	Noise fee 0.5 Euro	20	5
S12	large	Low noise vehicles only	100	20
S13	large	Noise fee 0.5 Euro	100	20
S14	-	none	5	5
S15	-	none	20	20
S16	medium	Low noise vehicles only	100	20

The fees are to be paid on entry and exit, thereby penalizing through traffic relatively harder than traffic with origin or destination in the zone. The ban is assumed not to be applied to zone residents.

7.5.3 Noise situation for different traffic scenarios at the test site in Stockholm

We will be presenting the results for twelve different scenarios, where different access policies for entering and exiting the Q-Zone and various percentage shares of LNVO are assumed. Each of the scenarios is associated with a specific Q-Zone dimension. The current noise situation (base case) is described by the S0 or as the base case scenario in the various tables throughout this section.

In Table 7.5.5 we can see the noise distribution inside the park for the various scenarios.

Table 7.5.5: Noise distribution in the various scenarios for the park area. Noise levels are given in 5 dB noise classes. The values in the table specify m² of the park area.

Noise level / Scenario	40-45	45 - 50	50 - 55	55 - 60	60 - 65	65 - 70	>70
S0	2 700	1 180	112	340	20	0	0
S1	2 680	1 140	116	340	20	0	0
S2	1 620	700	84	140	0	0	0
S3	2 000	920	104	280	0	0	0
S4	2 360	1 080	108	320	0	0	0
S5	2 380	1 100	108	320	0	0	0
S6	1 840	820	88	200	0	0	0
S7	1 940	880	92	220	0	0	0
S8	2 680	1 160	116	340	20	0	0
S9	2 640	1 160	116	340	20	0	0
S10	2 020	920	108	280	0	0	0
S11	2 280	1 040	104	320	0	0	0
S12	1 200	660	60	80	0	0	0
S13	1 800	820	88	200	0	0	0
S14	2 620	1 160	116	340	20	0	0
S15	2 420	1 080	108	320	0	0	0
S16	9 80	520	72	0	0	0	0

7.5.4 Potential noise gains on the test site in Stockholm

In the following we will be looking at some key indicators for assessing the effects of the various Q-Zone scenarios. A summary of these key indicators are presented in Table 7.5.6 and we will be referring to this table throughout the rest of this section. The indicators are the change of the average day / evening noise level $L_{de,av}$ in the park, the change in the "capacity" and we also consider the changes of the number of HAP.

By the term "change" we refer to the differences between the base case and each of the scenarios in regard to the values of the considered measures.

When determining the number of HAP we specify the values in various parts of the test site: in the Q-Zone, outside the Q-Zone (i.e. the test site region without the area of the Q-Zone) and the complete test site. We will also present absolute values of the $L_{de,av}$ in various tables throughout this section.

Table 7.5.6: Potential noise gains on test site Stockholm

Scenario	Change $L_{de,av}$ (park) [dB]	Change $L_{de,av}$ (surround.) [dB]	Change of "Capacity"	Change of number HAP within Q-Zone	Change of number HAP outside Q-Zone within affected area	Change of number HAP (Test-site including Q-Zone)
Base Case	0	0	0	0	0	0
S1	-0.1	0.1	20	-504	170	-76
S2	-3.1	-1.3	180	-309	411	-156
S3	-1.4	-2.2	-70	-1 035	97	-939
S4	-0.7	-0.8	-20	-769	531	-238
S5	-0.5	-0.6	-20	-797	407	-391
S6	-2.1	-0.6	180	-542	562	20
S7	-1.9	-0.5	170	-541	570	29
S8	-0.1	0.1	100	-231	248	17
S9	-0.1	0.1	20	-226	236	9
S10	-1.4	-2.0	-70	-644	1 223	579
S11	-0.8	-0.8	-20	-769	520	-249
S12	-4.6	-4.4	-30	-1 312	-176	-1 488
S13	-2.3	-1.9	20	-1 020	-31	-1 051
S14	-0.1	0.1	100	-512	574	62
S15	-0.5	-0.3	20	-514	300	-214
S16	-5.7	20.9	340	-598	-292	-891

7.5.4.1 Noise and capacity indicators of the park, Q-Zone and test site

From Figure 7.5.3 we can observe, that we have a reduction of the average noise level in the Q-Zone in virtually all scenarios compared to corresponding base case scenario (matching Q-Zone sizes cf. values in Table 7.5.8).

It needs to be considered that the three different base case scenarios (s, m, l) are only relevant for the Q-Zone noise levels. The values in the base case are identical for all three Q-Zones when looking at the test site which includes the Q-Zone here. We also see a slight reduction in average noise levels in the test site except for scenarios S8, S9 and S14, where the values are unchanged compared to the base case (cf. Table 7.5.9).

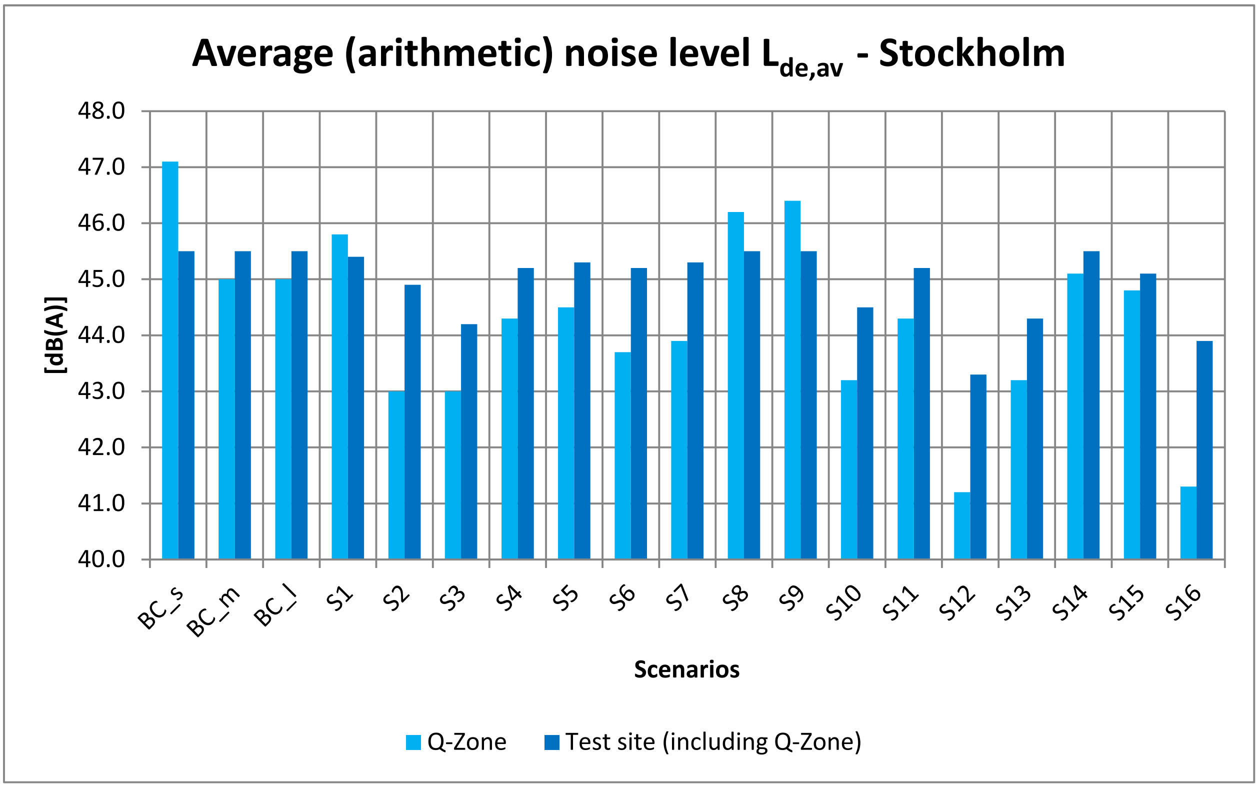

Figure 7.5.3: Average noise situation in the Q-Zone and the test site

Table 7.5.7: Characteristic values for the embedded park in Stockholm

	$L_{de,av}$ (park)	$L_{de,av}$ (surrounding)	"Capacity" of embedded park
Unit	dB(A)	dB(A)	[m²]
BC	43.3	45.2	160
S1	43.2	45.3	180
S2	40.2	43.9	340
S3	41.9	43.0	90
S4	42.6	44.4	140
S5	42.8	44.6	140
S6	41.2	44.6	340
S7	41.4	44.7	330
S8	43.2	45.3	260
S9	43.2	45.3	180
S10	41.9	43.2	90
S11	42.5	44.4	140
S12	38.8	40.8	130
S13	41.0	43.3	180
S14	43.2	45.3	260
S15	42.8	45.0	180
S16	37.6	88.1	500

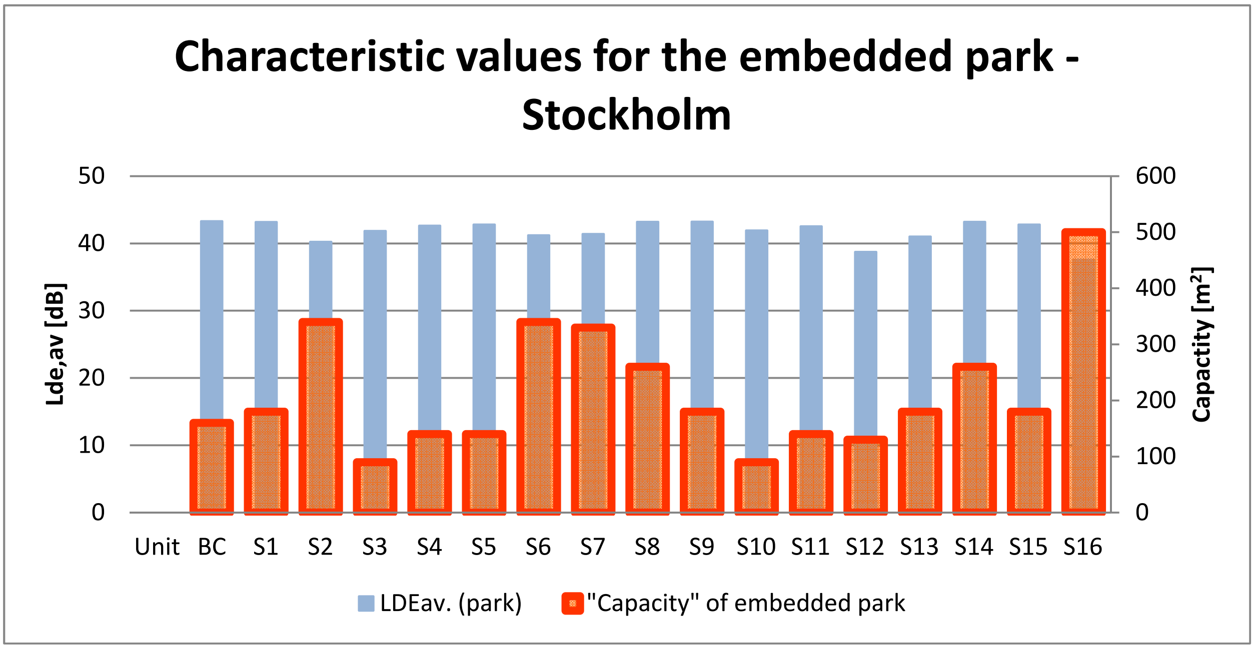

Figure 7.5.4: Characteristic values for the embedded park in Stockholm

7.5.4.2 Highly annoyed people in the Q-Zone and the test site

From Table 7.5.8 and Table 7.5.9 we can determine the change of the number of HAP in the various scenarios compared to the base case. In Table 7.5.8 we distinguish between scenarios for the small, medium and the large sized Q-Zone. When comparing the results within each of the Q-Zone sizes, we find decreasing average noise levels in the Q-Zone. Scenarios S14 and S15 have been calculated with no dedicated Q-Zone but with a LNVO assumption throughout the test site.

Table 7.5.8: Characteristic values for the Q-Zone in Stockholm

Scenario	BC_s	BC_m	BC_l	S1	S2	S3	S4	S5	S6	S7
$L_{de,av}$ [dB(A)]	47.1	45.0	45.0	45.8	43.0	43.0	44.3	44.5	43.7	43.9
No. Residents	15 903	25 776	32 412	15 903	25 776	32 412	32 412	32 412	25 776	25 776
HAP	437	695	2 536	190	128	1501	1767	1739	153	154
Scenario	S8	S9	S10	S11	S12	S13	S14	S15	S16	
$L_{de,av}$ [dB(A)]	46.2	46.4	43.2	44.3	41.2	43.2	45.1	44.8	41.3	
No. Residents	15 903	15 903	32 412	32 412	32 412	32 412	25 776	25 776	25 776	
HAP	205	210	1 892	1 767	1 224	1 516	183	181	96	

Table 7.5.9: Characteristic values for the test site in Stockholm

Scenario	BC	S1	S2	S3	S4	S5	S6	S7	S8
$L_{de,av}$ [dB(A)]	45.5	45.4	44.9	44.2	45.2	45.3	45.2	45.3	45.5
No. Residents	108 515	108 515	108 515	108 515	108 515	108 515	108 515	108 515	108515
HAP 5	7 742	7 665	7 586	6 803	7 504	7 351	7 762	7 771	7 759
Scenario	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	
$L_{de,av}$ [dB(A)]	45.5	44.5	45.2	43.3	44.3	45.5	45.1	43.9	
No. Residents	108 515	108 515	108 515	108 515	108 515	108 515	108 515	108 515	
HAP	7 751	8 321	7 493	6 254	6 690	7 804	7 528	6 851	

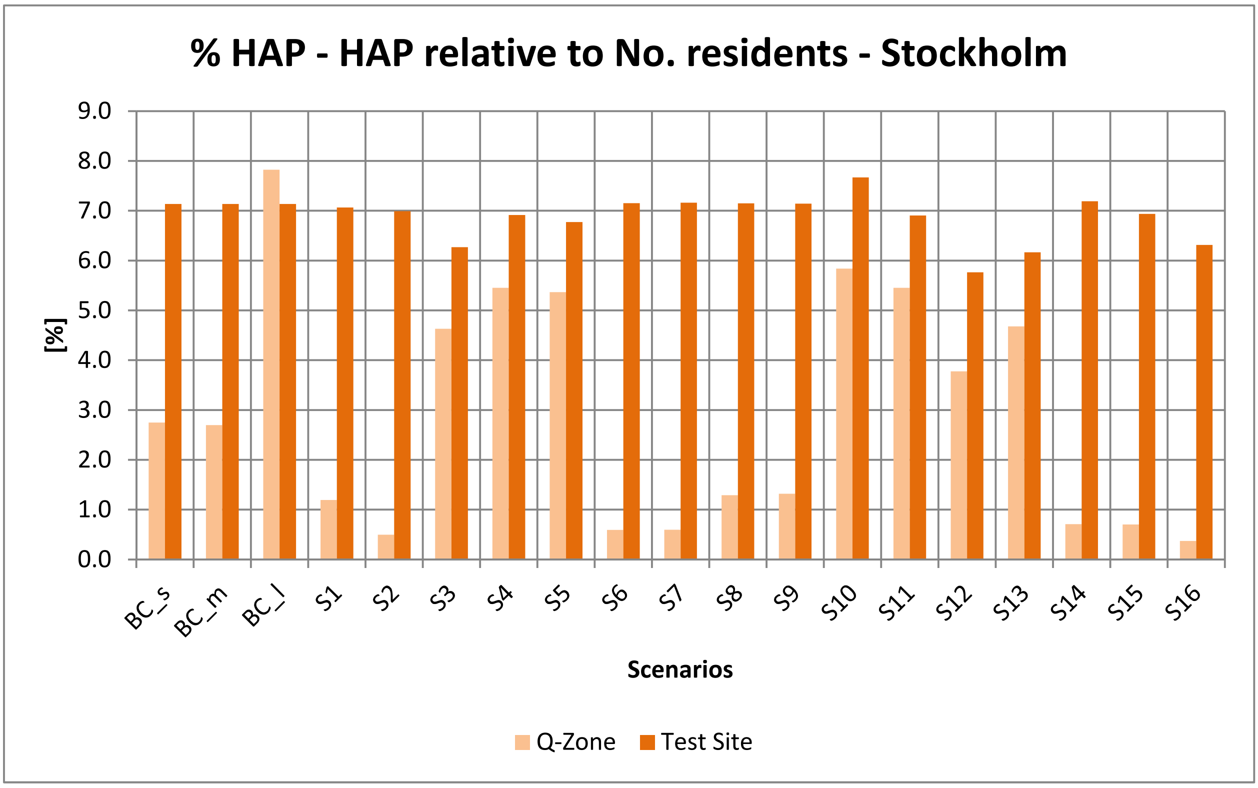

Figure 7.5.5: Percentage of HAP related to the number of inhabitants in the corresponding zone

7.5.5 Summary for Stockholm test site

Marginal to moderate improvements were found for the average noise levels inside the park by embedding it in a Q-Zone for all scenarios. It must be noted that in some scenarios these improvement come at the cost of a reduced capacity. Most scenarios do show an increase in the number of HAP outside the Q-Zone which is not desirable. Therefore, an implementation is only reasonable in conjunction with mitigation measures in those areas outside the Q-Zone that are negatively affected by any actions taken.

8. FURTHER ANALYSIS

8.1. ANALYSIS OF TWO SPECIAL CASES IN ESSEN

As we have shown, improvements of average noise levels and of the capacity inside parks embedded in Q-Zones can be produced. This was shown with parks in five different cities. We simulated various Q-Zone configurations (i.e. boundary conditions) and investigated the effects of various sizes of Q-Zone, different access policies and various percentages in LNVO. In quite a few cases the accomplished improvements for the park came at the expense of a growing number of HAP outside the Q-Zone. Thus the potential quality gain in the considered park is often combined with an increase in annoyance for some parts of the population that reside in outlying areas. There is a range of possibilities for mitigation that can additionally be applied in these negatively affected regions.

Here we will present two further scenario configurations, which we applied to the simulations on the test site in Essen only. Namely, these scenarios are 11 and 14. They were created with the aim to investigate the effects of implementing “softer” traffic restrictions in the Q-Zone. All other scenarios have “hard” traffic restrictions, i.e. there are no exceptions in the form that some parts of the Q-Zone may be exempt from the generally applied policies. This is different for the scenarios 11 and 14. These were defined with the main road at the southern boundary of the Q-Zone not to be included in the general Q-Zone policy, although it lies within the common Q-Zone area. General traffic is still permitted on this main road with an imposed speed limit of 30 km/h. The road surface is assumed of the low noise type which in itself is assumed to provide a noise reduction of 3 dB.

We will compare both scenarios with the scenario 10, which showed the best noise reduction values in the park but also showed an overall increase in the number of HAP in the test site.

Figure 8.1.1: Noise difference map Essen scenario S11 – S1

By comparing the noise difference maps in Figure 8.1.1 and Figure 8.1.2 we can observe that in scenario 11 we do not achieve as high a noise reduction in the park as it is forecasted in scenario 10 (-4.1 dB vs. -8.9 dB, cf. Table 7.3.6). This can be recognized by the darker green color at the southern side of the park and be accounted to the main road at that end of the park, which is open to general traffic in scenario 11 opposed to scenario 10. To the west and the south west of the Q-Zone there are two roads, that show noise reductions in scenario 10 which are not present in scenario 11. The reason for this is that the traffic ban in scenario 10 reduces the through traffic on the main road in south of the Q-Zone and therefore traffic and thus noise is also reduced on the connecting road. The situation is different in scenario 11 where traffic is permitted through the Q-Zones southern main road and therefore through traffic and noise is not reduced on the connecting roads outside the Q-Zone. On the other hand, we can identify a ring road to the west of the Q-Zone, which shows a slight increase of noise level along its length. The total amount of areas along the ring road affected by this increase is larger for scenario 10 than for scenario 11. This effect is accounted for a greater traffic displacement from the Q-Zone to the periphery in scenario 10. In total both scenarios show an overall increase in the number of HAP in the test site, where the increase in scenario 10 is not as high as in scenario 11 (+32 vs. +64, cf. Table 7.3.6).

Figure 8.1.2: Noise difference map Essen scenario S10 – S1

Scenario S14 shows an improvement in noise levels across most areas of the test site (most areas shaded green). Only a small amount of areas remain with noise increases. The overall noise reduction is accounted to the fact of a high ownership of LNV (100 % inside the Q-Zone and 20 % outside the Q-Zone). It is though remarkable that the total average reduction in the park area does not reach the high mark that was achieved in scenario 10 (-5.3 dB vs. -8.9 dB), cf. Table 7.3.6). Out of all, scenario 14 shows the highest overall decrease of HAP (-627, cf. Table 7.3.6). This is a vast improvement compared to scenario 10 (HAP: +32, cf. Table 7.3.6). The reason for this is seen in the fact that most areas do show a decrease in noise level, so that a high fraction of residential areas benefit from this. Because of the high proportion of LNV, scenario 14 describes a future scenario.

In summary the extension of the size of the Q-Zone does not necessarily imply an improvement of the noise situation in the park and the surrounding city areas. This is indicated by comparing the results of the scenarios S10 with S11 (it needs to be mentioned that S11 implements softer restrictions). Although S11 has a larger Q-Zone defined results show lesser noise level improvements in the park (which is our key-issue), but also a higher amount of HAP outside the Q-Zone. The number of HAP are again reduced by a higher proportion of LNV in the population, which can be seen from the results of scenario S14. Interesting indications can be gained by comparing the scenarios S10, S11, S14 with S12. Scenario S12 stipulates no Q-Zone, but a proportion of 20% LNV in and outside the Q-Zone. The forecasts show slight improvements in the park (-0.8 dB) and relatively high reductions of the amount of HAP in the test site (-494). Whilst on the one hand we observe a reduction in the park's noise levels with the establishment of some sort of Q-Zone (S10, S11, S14), we can on the other hand observe a forecasted reduction of the amount of HAP with an increase in the LNVO (S12 and

S14). This may be an indication that the high increase of HAP in the test site seen in S10 will probably be reduced, when the proportion of LNVO in the population rises.

Figure 8.1.3: Noise difference map Essen scenario S14 – S1

8.2. SUMMARY FOR TWO SPECIAL CASES IN ESSEN

With the scenarios S11 and S14 it was shown that noise increases in outlying regions caused by traffic redistribution in the Q-Zone due to "hard" Q-Zone configurations are not compensated by just applying "softer" Q-Zone policies. Regions that are negatively affected require careful analysis and in consequence solutions specifically adapted to the individual characteristics of the site in question. It has though been shown that by a future increase in LNVO the overall noise situation in urban areas can be improved. In consequence the number HAP can be reduced.

The above findings suggest, that the Q-Zone seems necessary to establish parks with a significant noise reduction compared to the rest of the city. Negative effects for periphery city areas may be compensated over time with an increasing proportion of LNVOs in the population.

9. CONCLUSION

All test sites have their individual character and therefore show very different initial conditions. As an example, the site in Essen is located centrally in the city and a main road with a high amount of traffic flanks the park. In comparison, the test site in Stockholm is located on an island and is not influenced by background noise from the surrounded traffic network. In consequence, we will find that any territorial setting and the available traffic infrastructure will set constraints on the appropriate configuration of a quieted zone. As a result, one should expect that the same set of rules applied to the configuration of one Q-Zone would show very different results in other locations. Thus, we will not be able to expect one universal rule for establishing parks embedded in quiet zones. The establishment of such quieted areas is expected to be subject to individual examination. Despite these differences throughout the test sites of the various cities, we were able to apply the same overall testing schematics.

In summary we have developed the methodology for analyzing a site that is intended to be quieted by establishing a Q-Zone. An evaluation procedure is available to forecast and determine positive and negative effects that the establishment of a Q-Zone will imply. Additional measures can be implemented for the compensation of unwanted effects. These measures are subject to careful individual analysis and measures could be, but are not limited to installing modern noise absorbing windows, noise barriers, redistributing traffic from residential to commercial areas, switching residential areas to commercial areas and vice versa, implementing speed restrictions.

To successfully install a park embedded in a Q-Zone city planners require a highly detailed traffic and noise prediction model of the area under investigation. To be able to find a solution that is fully adapted to the local situation and task, city planners are required to perform a combined analysis of the above models to enable them to make optimal planning decisions.

We have shown that the noise situation in parks can be improved by embedding the park in a Q-Zone. Possible negative effects outside the Q-Zone should be compensated by mitigation measures that need to be assessed and defined in each individual case.

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Annex

Table of contents

A 1. ADDITIONAL FIGURES FOR THE CITY OF BRATISLAVA

A 1.1 Simulated scenarios for the city of Bratislava

To provide a better overview we included the definition of the scenarios once again at this point. For Bratislava, the following set of traffic scenarios was simulated:

Scenario nr	Zone	Fee, Euros/passage	Inside LNVO percentage	External LNVO percentage
1	none	none	1	1
2	large	ban	1	1
3	large	1	1	1
4	large	2	1	1
5	small	ban	1	1
6	small	1	1	1
7	small	2	1	1
8	none	none	5	5
9	large	ban	20	5
10	large	1	20	5
11	large	2	20	5
12	none	none	20	20
13	large	ban	100	20
14	large	1	100	20
15	large	2	100	20

A 1.2 Noise maps for the city of Bratislava - 15 scenarios

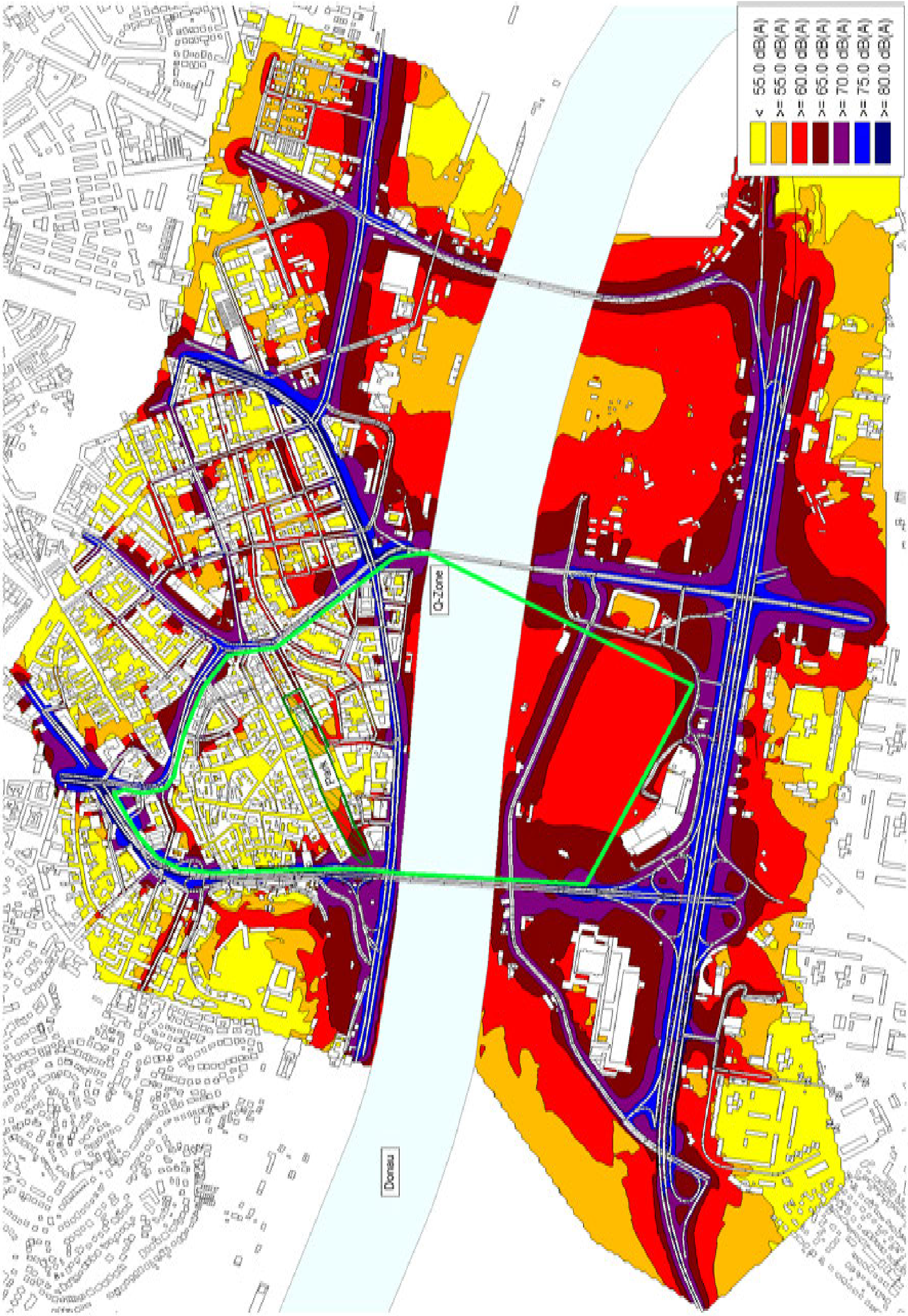

Figure 1: Scenario 1 (S16) - L_{de}

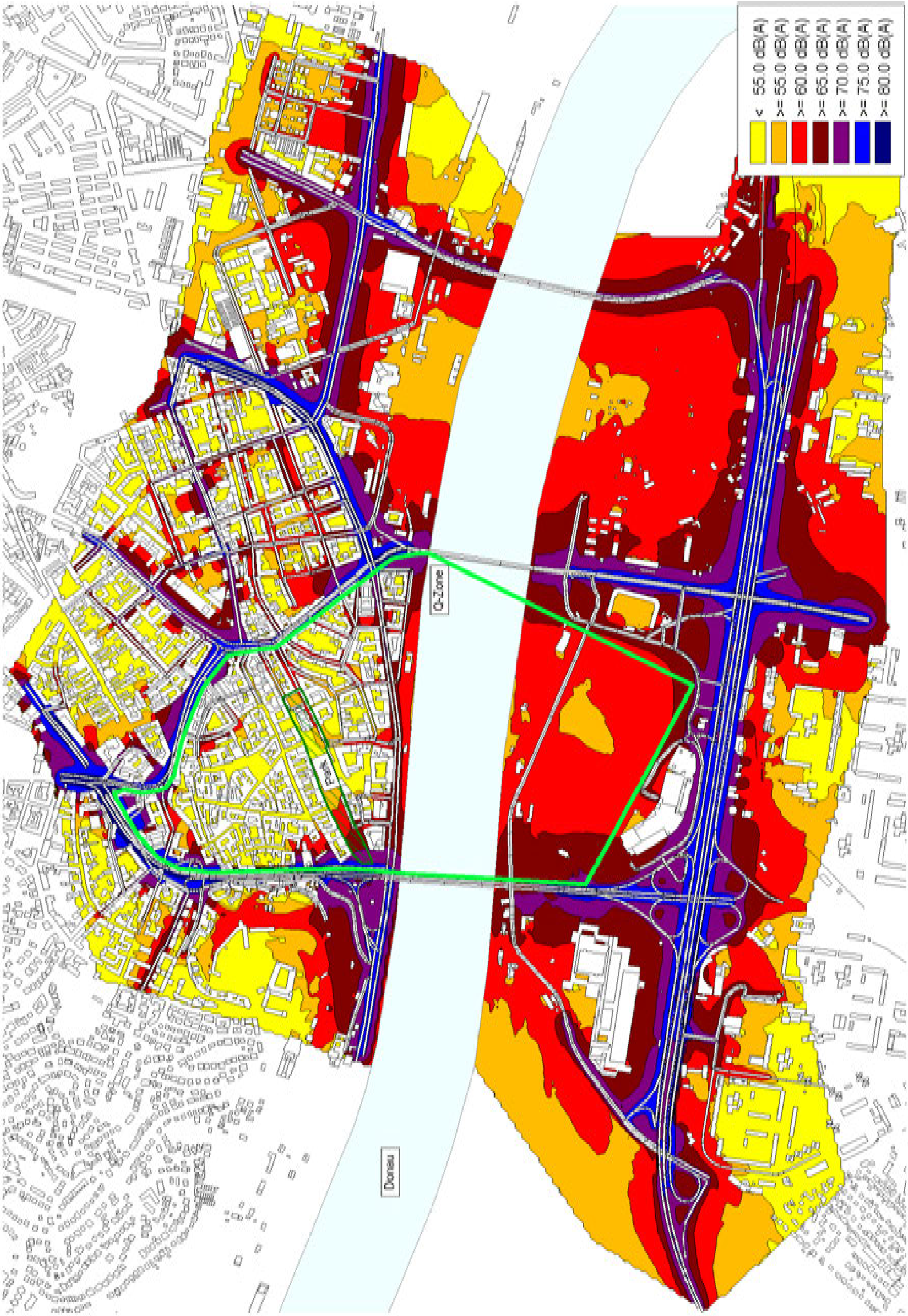

Figure 2: Scenario 2 (S17) - L_{de}

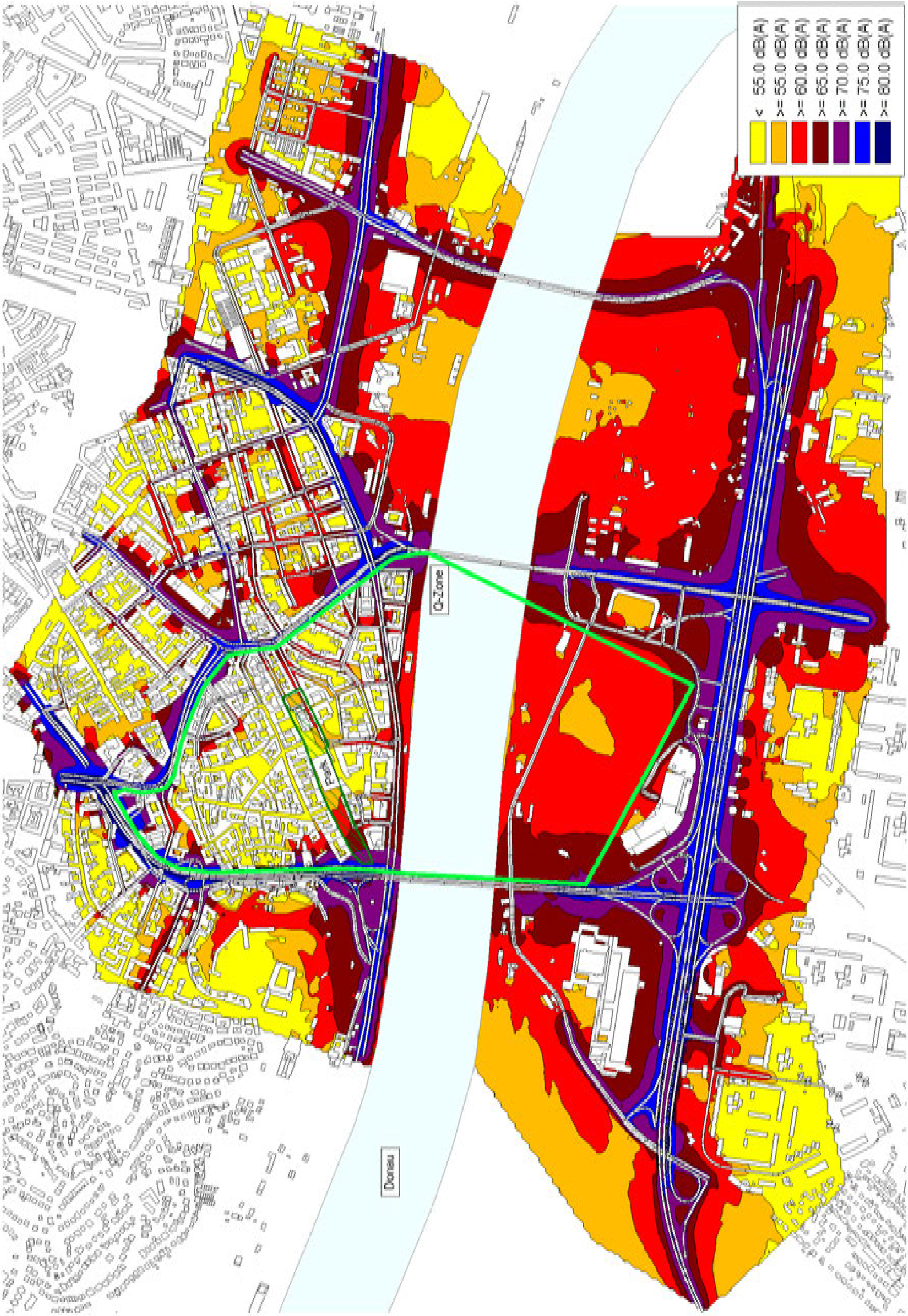

Figure 3: Scenario 3 (S18) - L_{de}

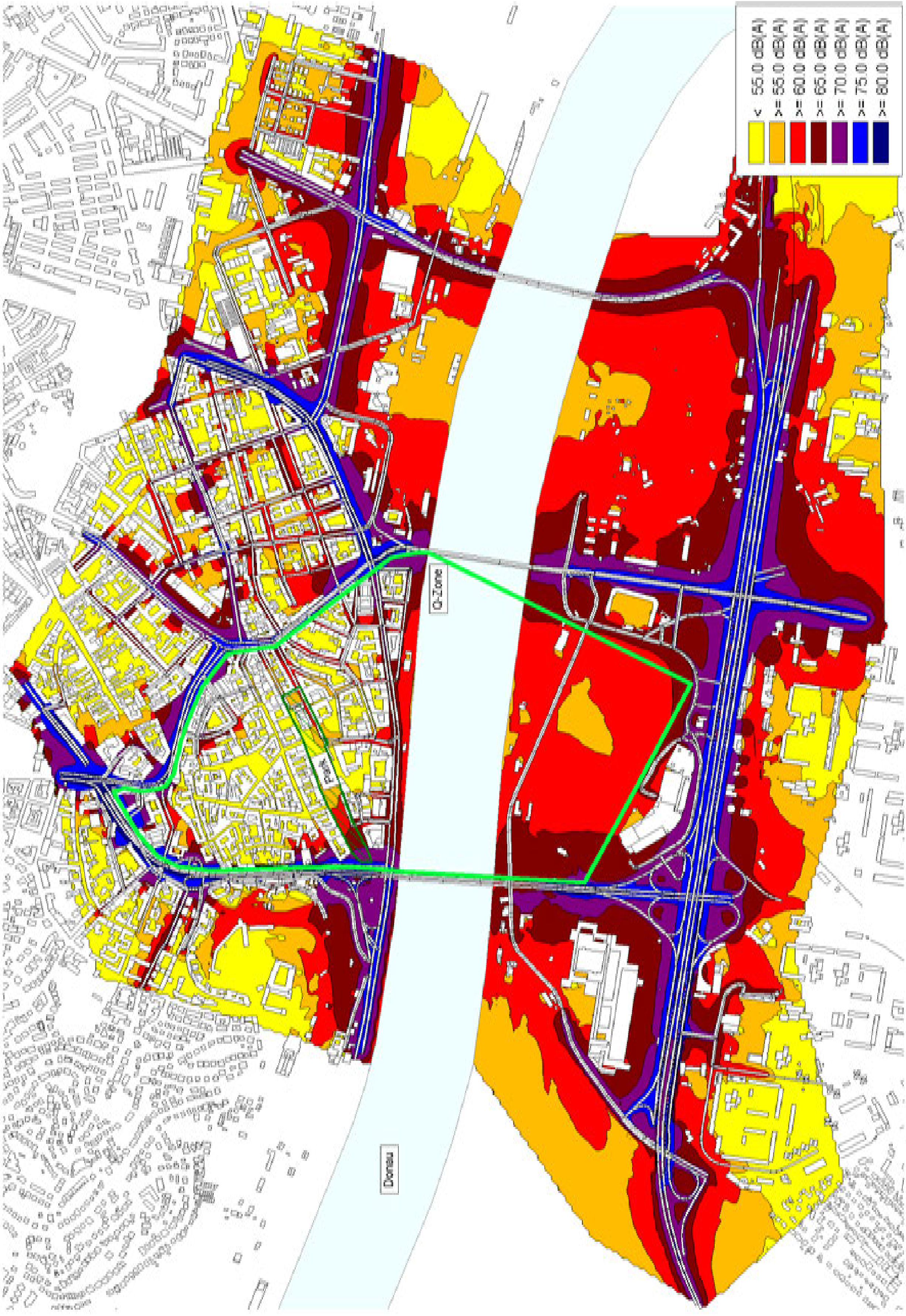

Figure 4: Scenario 4 (S19) – L_{de}

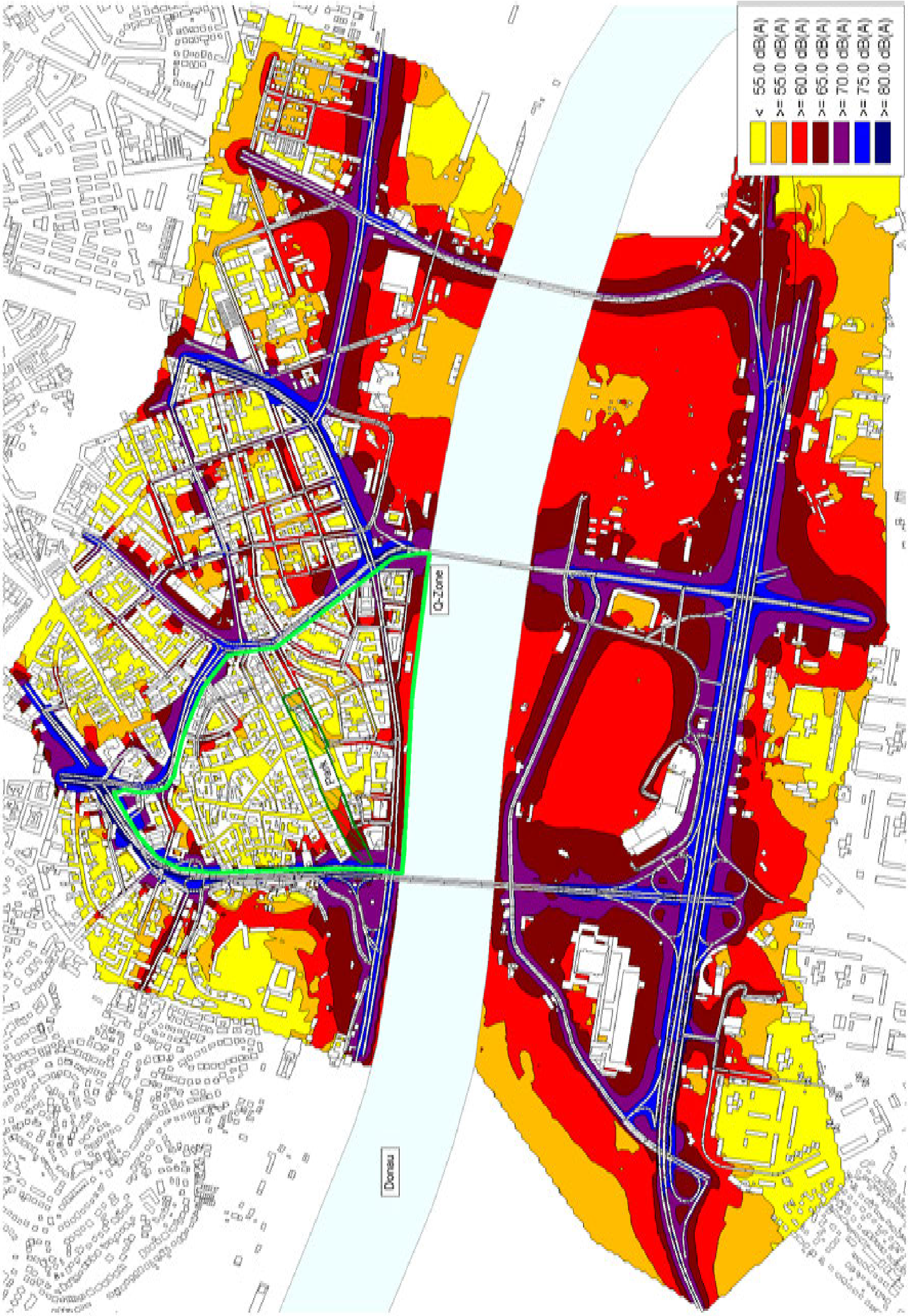

Figure 5: Scenario 5 (S20) – L_{de}

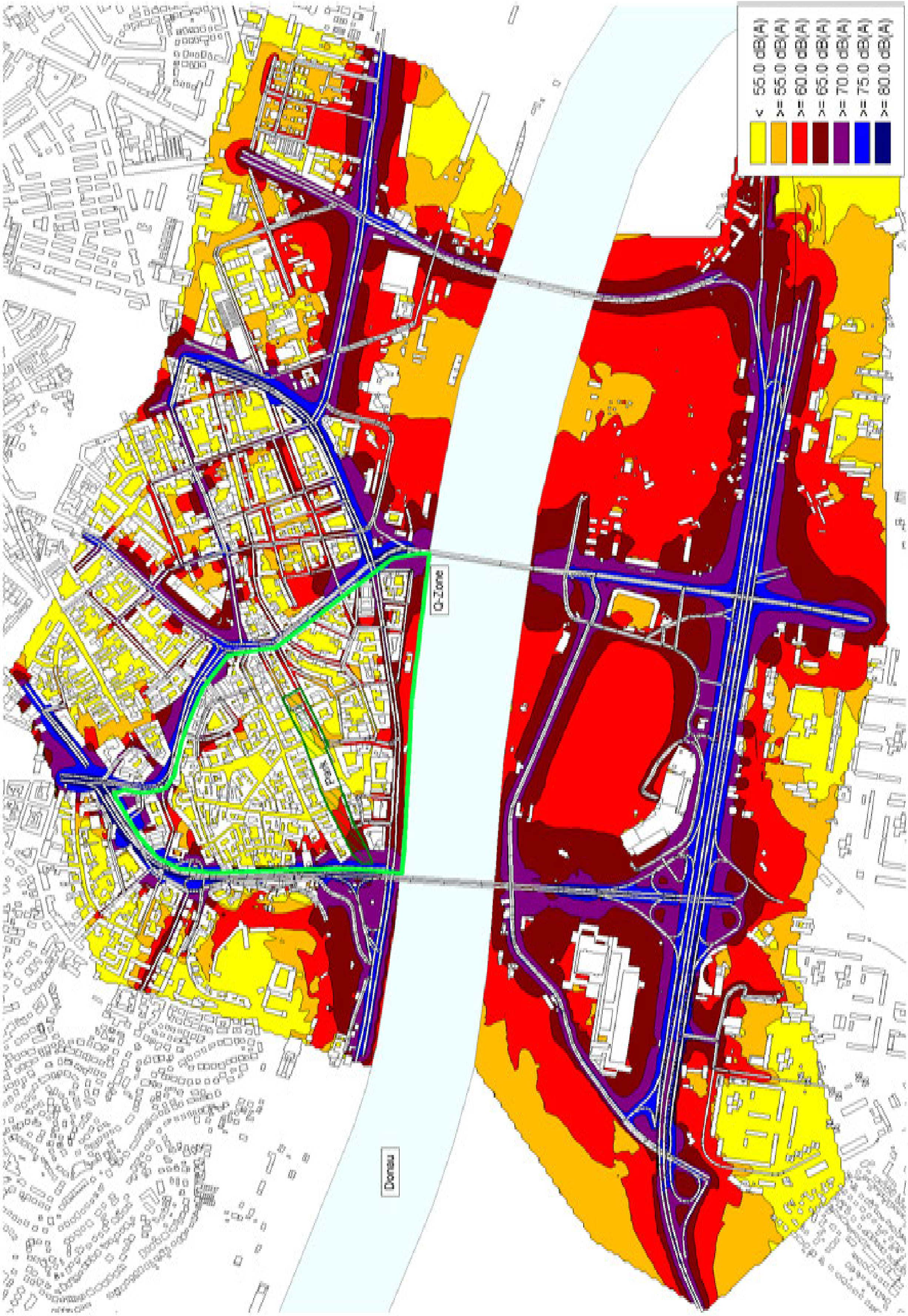

Figure 6: Scenario 6 (S21) – L_{de}

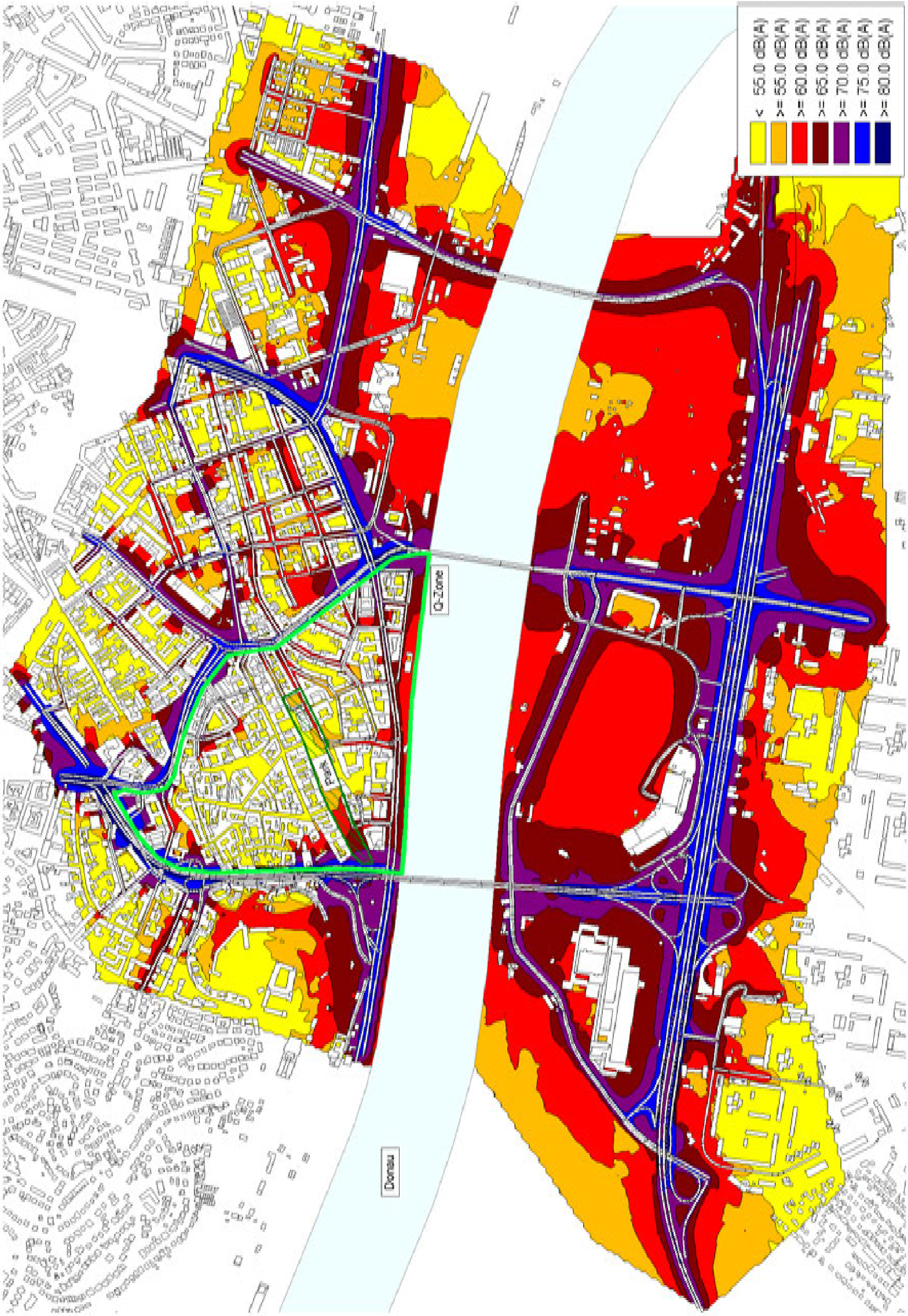

Figure 7: Scenario 7 (S22) – L_{de}

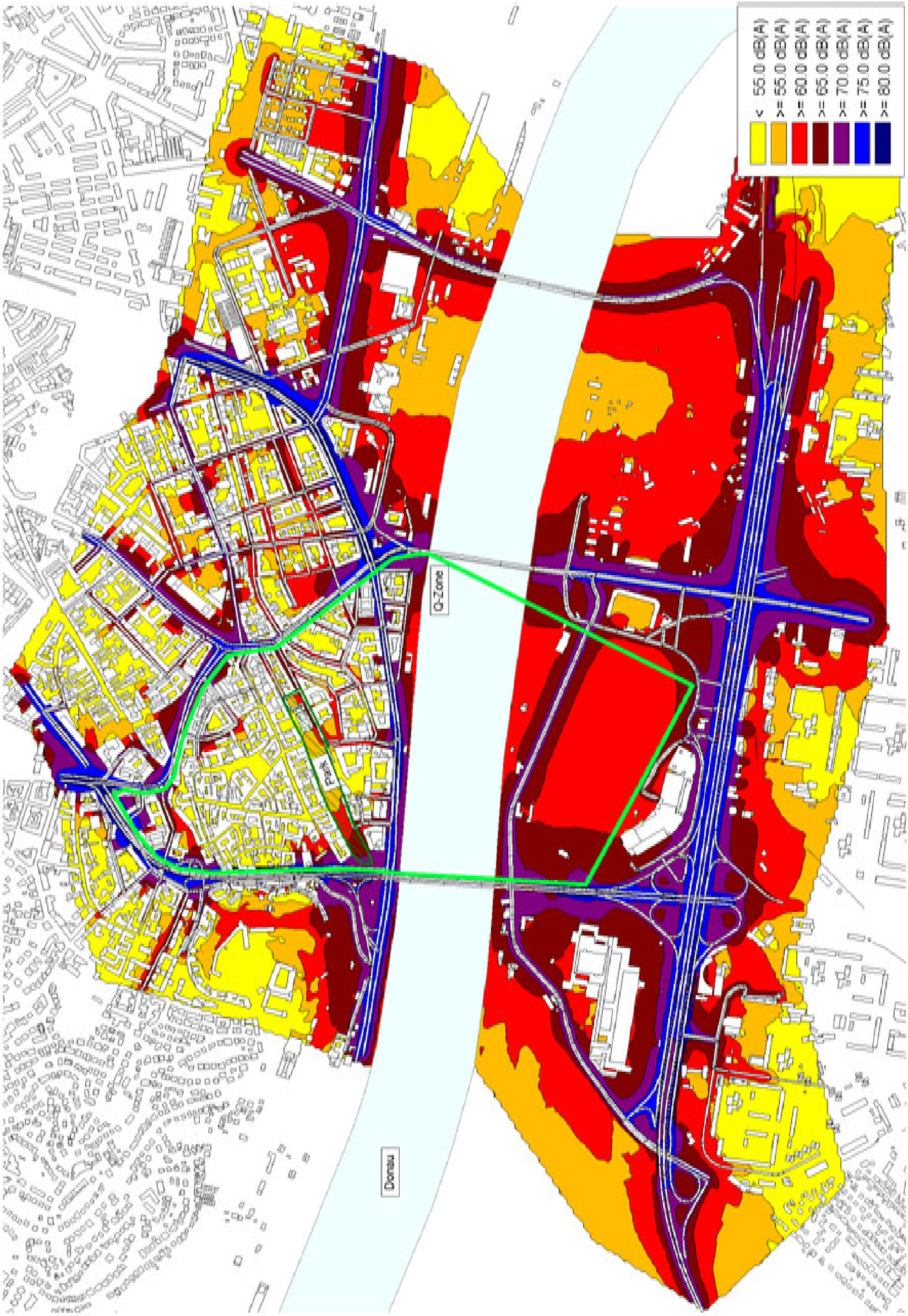

Figure 8: Scenario 8 (S23) - L_{de}

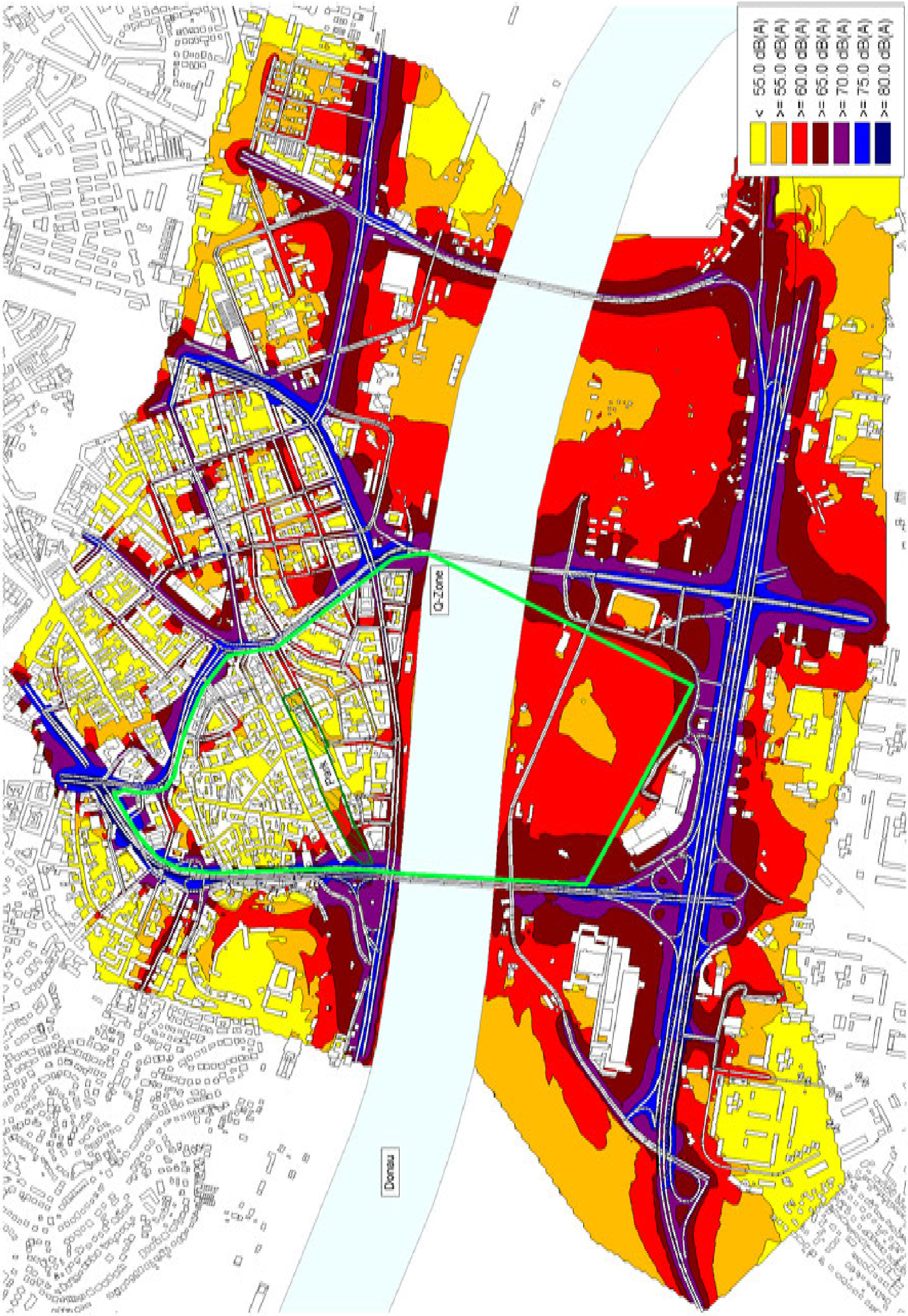

Figure 9: Scenario 9 (S24) - L_{de}

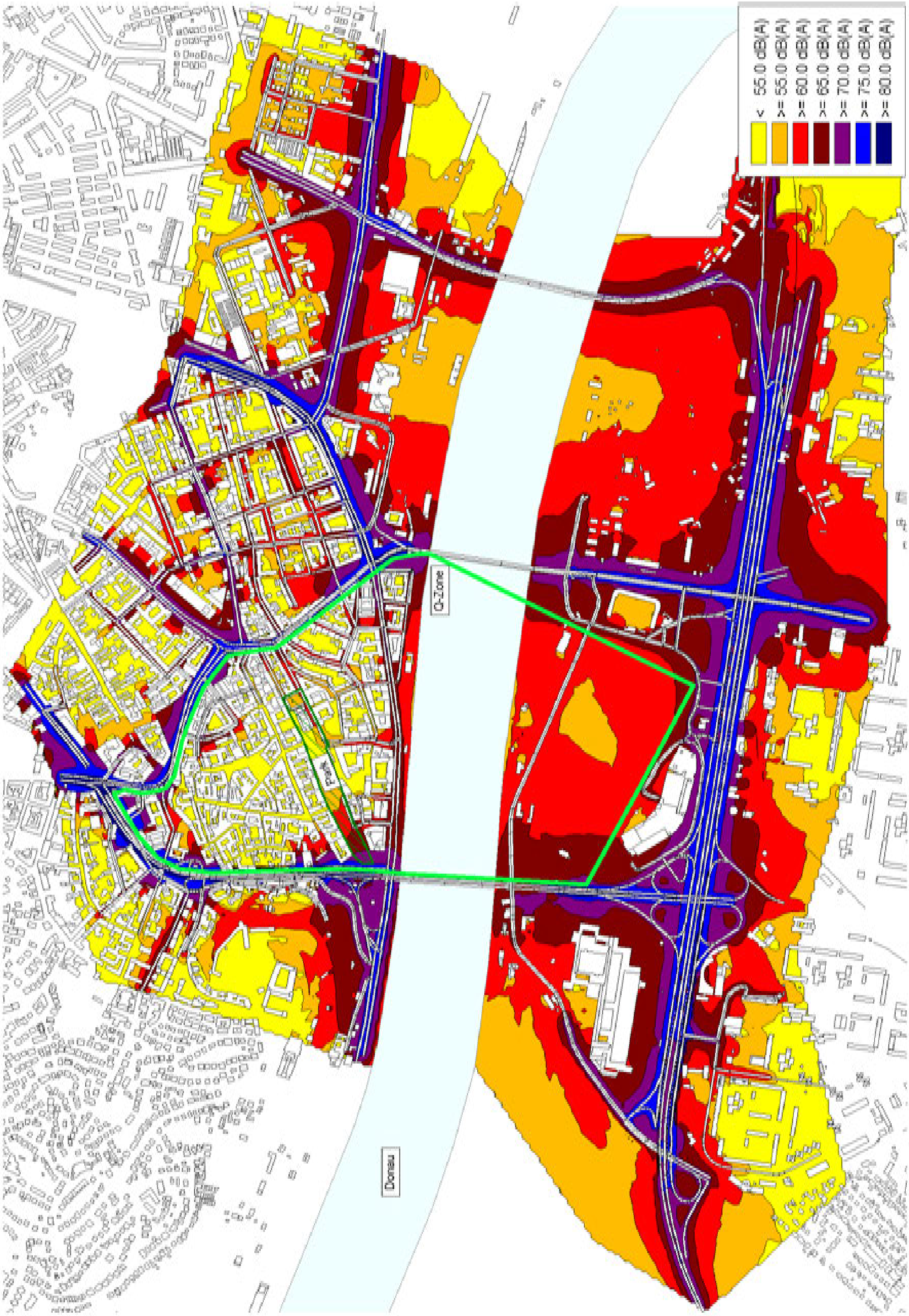

Figure 10: Scenario 10 (S25) - L_{de}

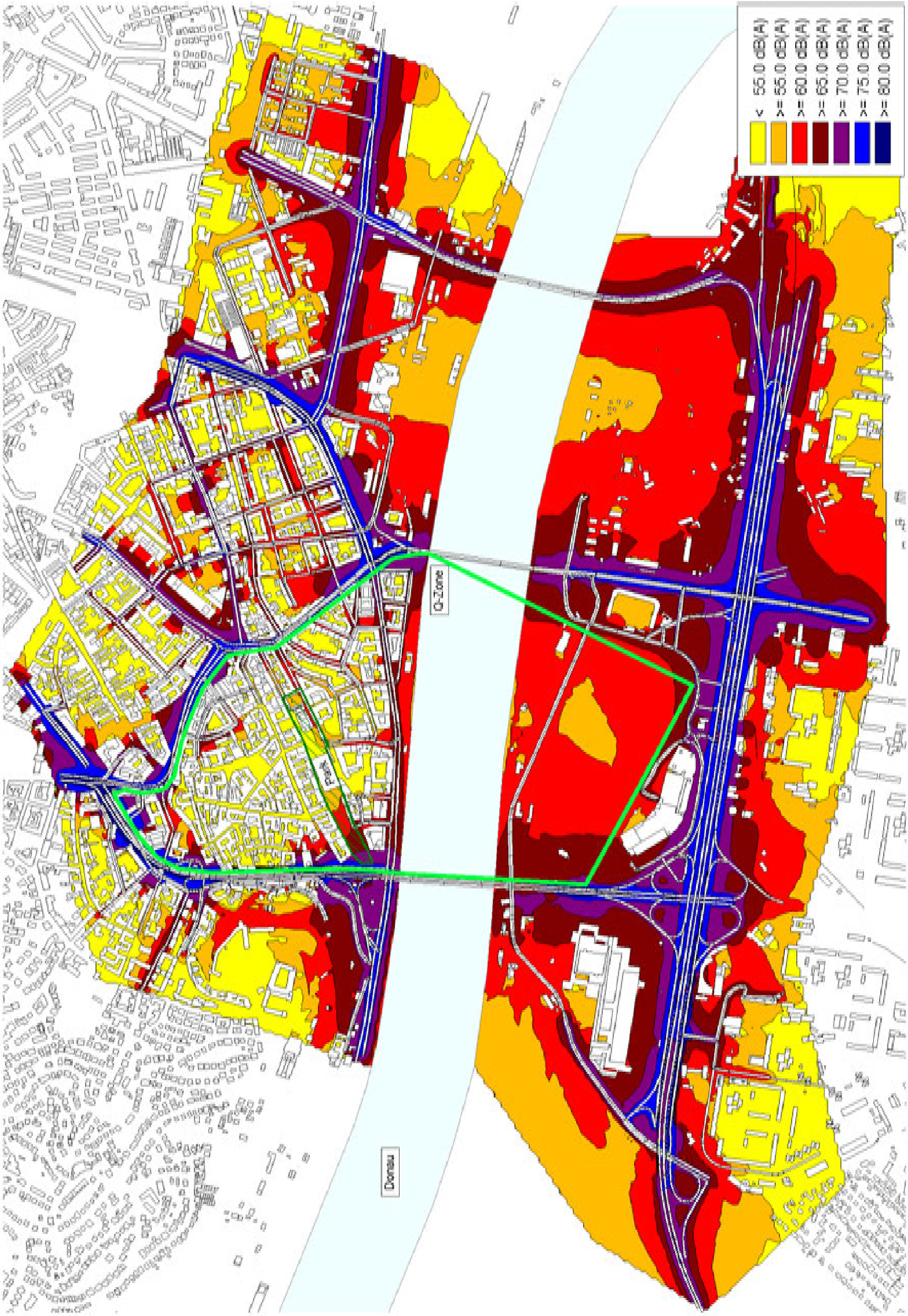

Figure 11: Scenario 11 (S26) - L_{de}

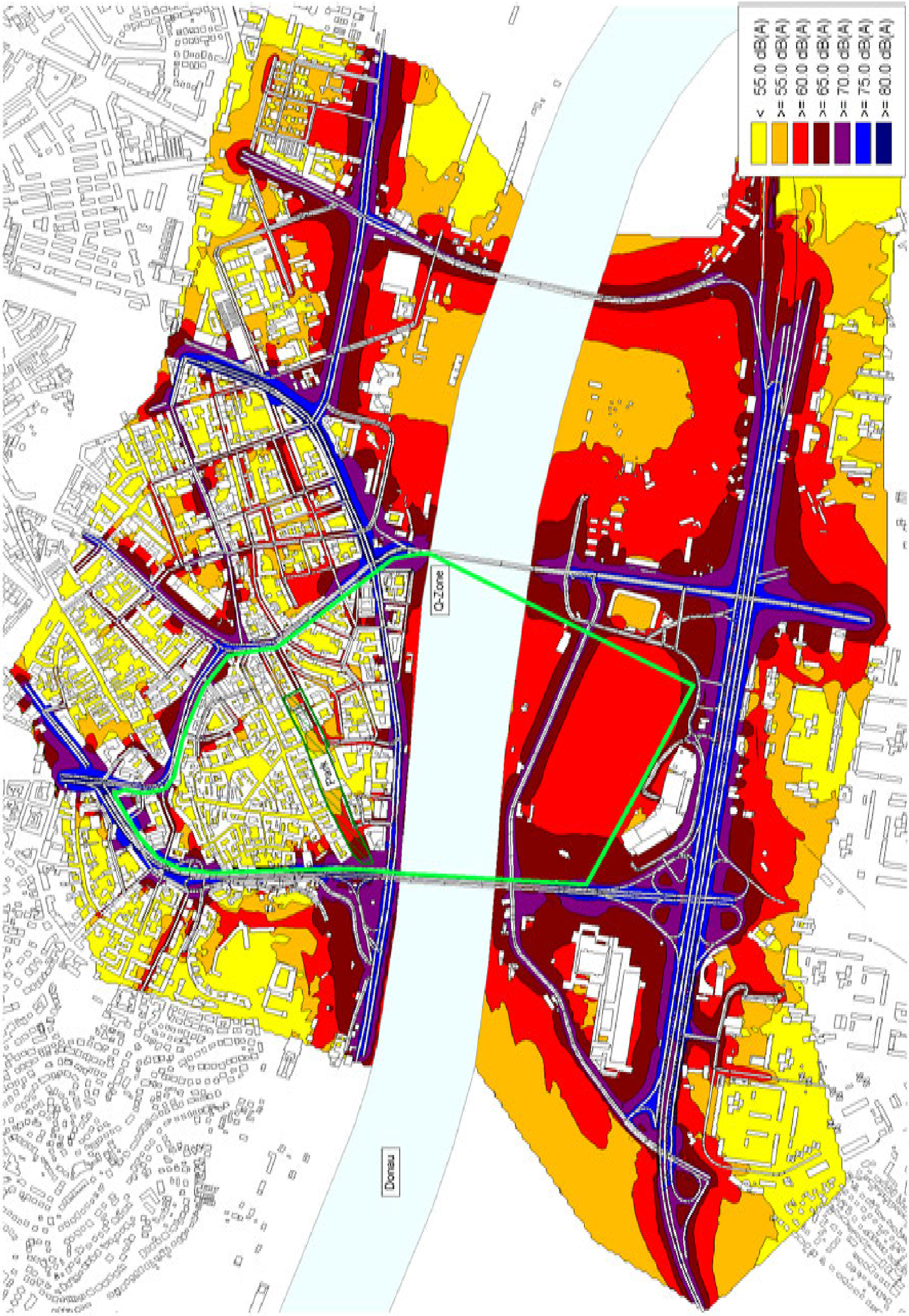

Figure 12: Scenario 12 (S27) – L_{de}

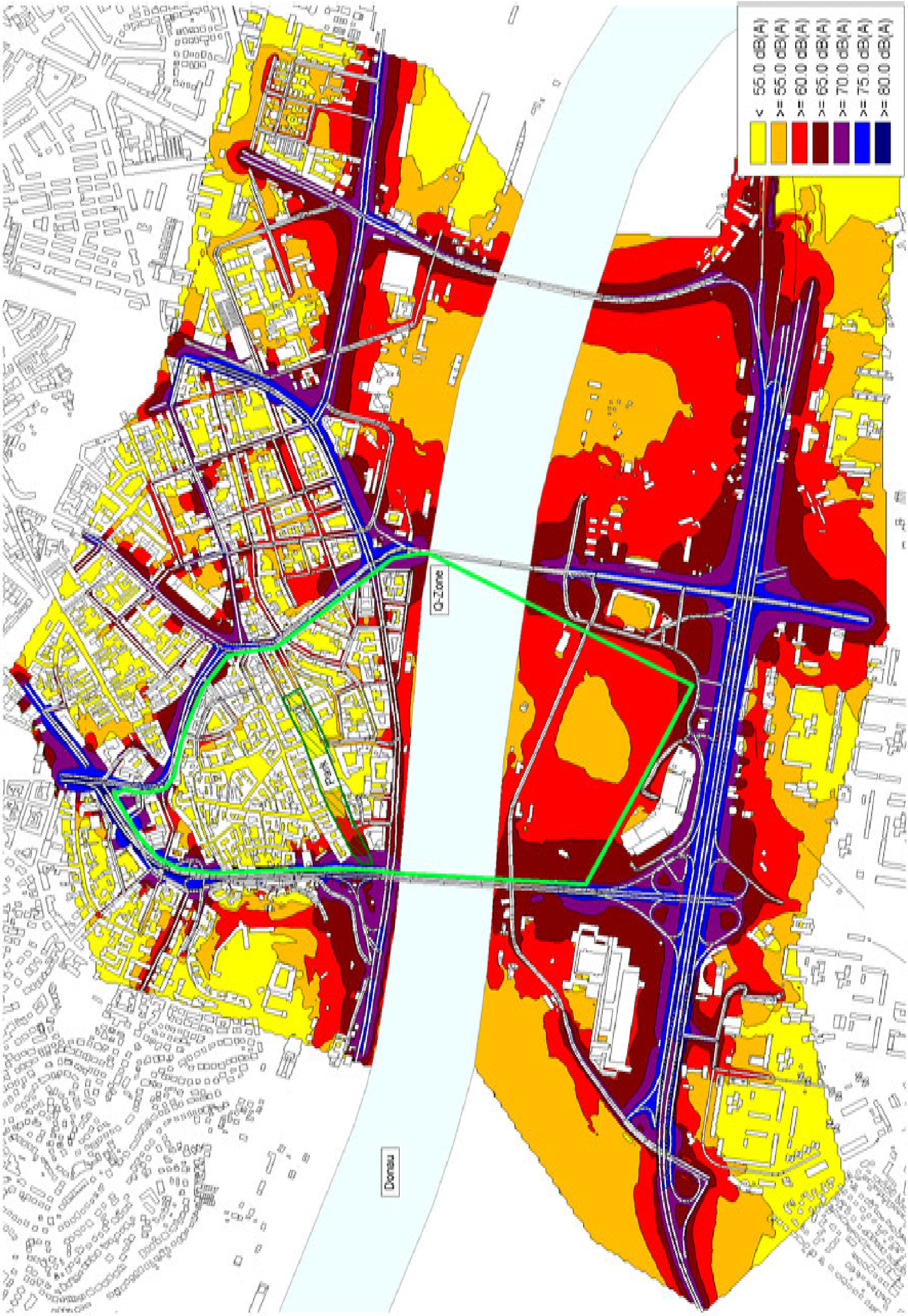

Figure 13: Scenario 13 (S28) - L_{de}

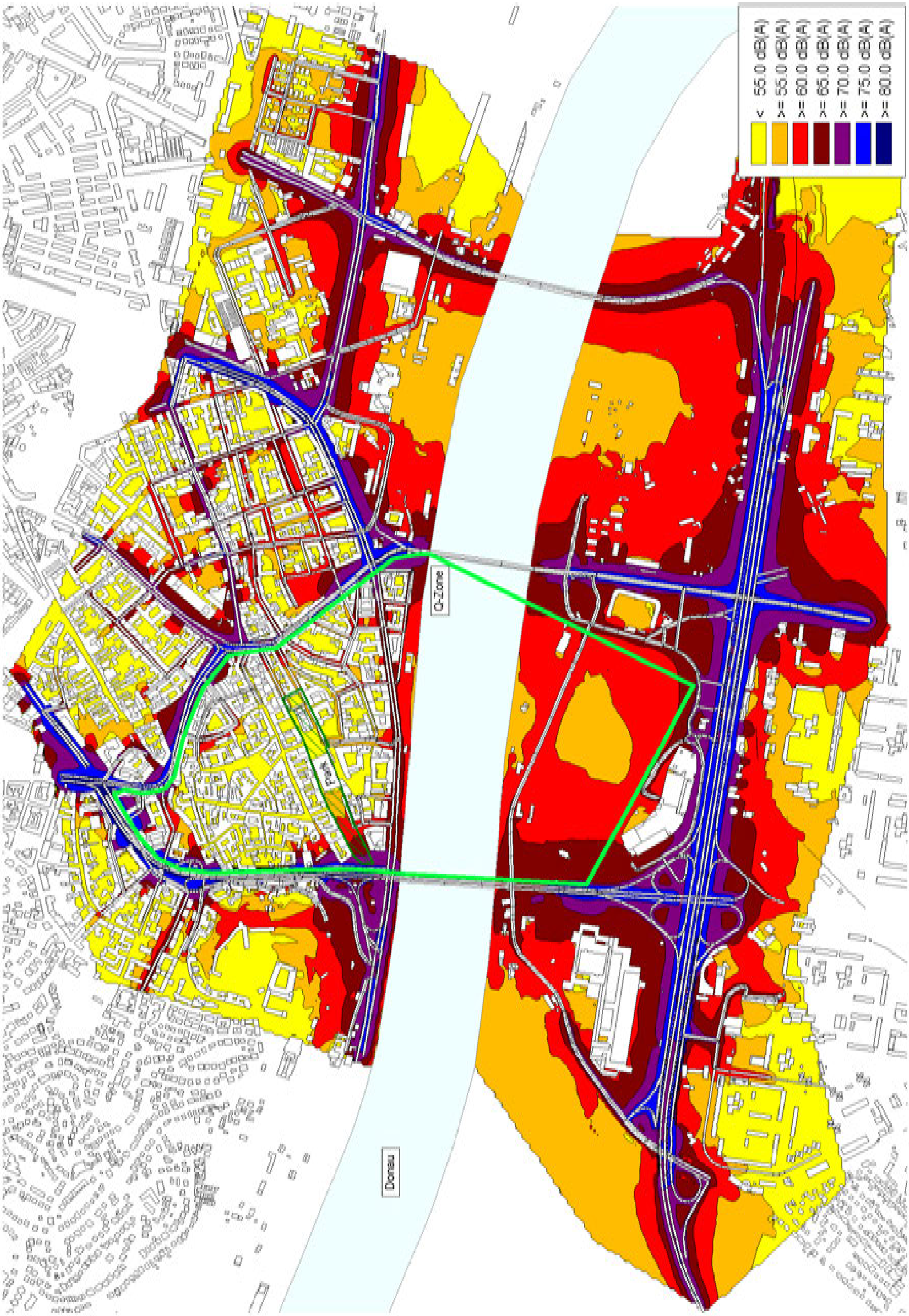

Figure 14: Scenario 14 (S29) - L_{de}

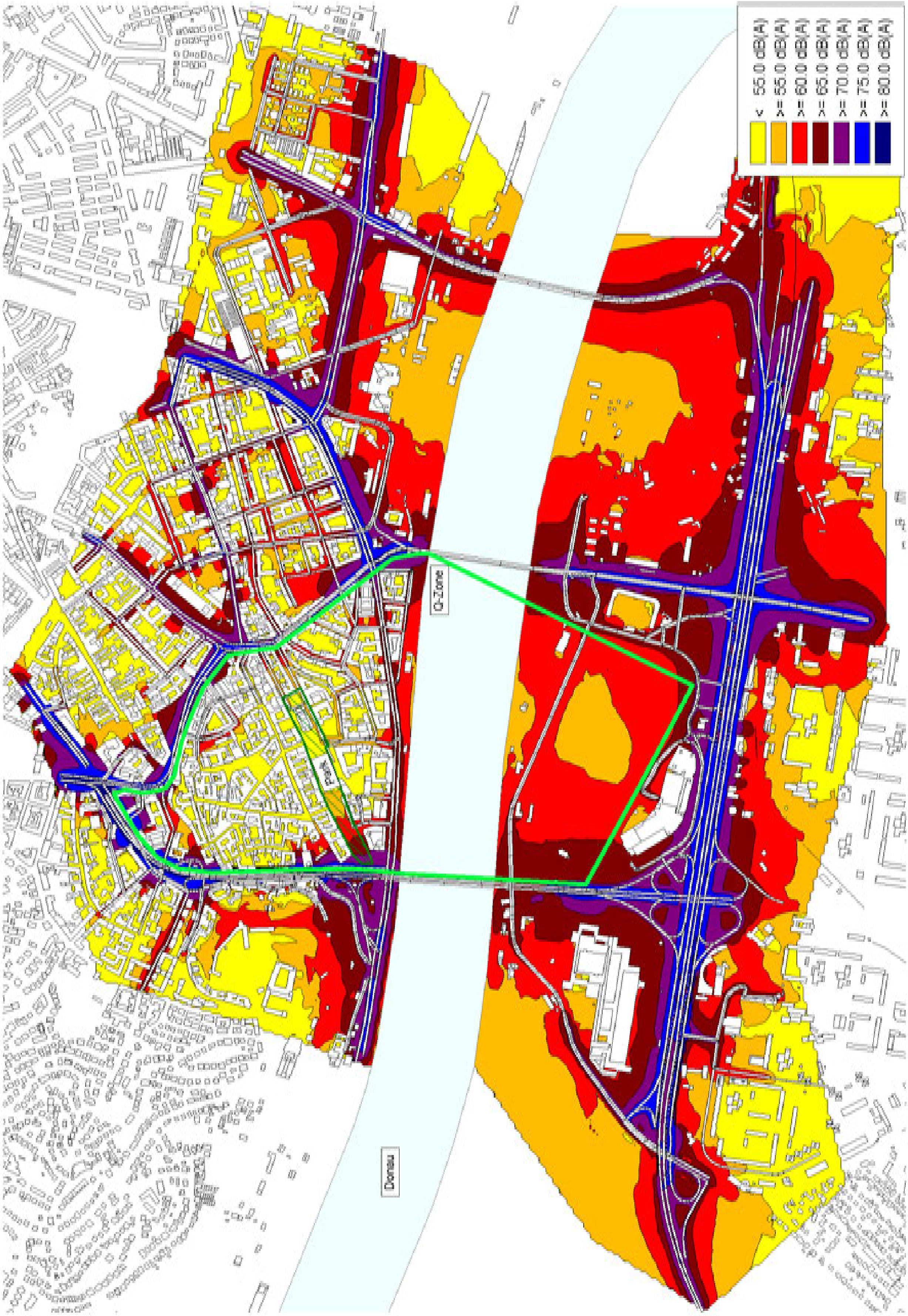

Figure 15: Scenario 15 (S30) - L_{de}

A 1.3 Noise difference maps for the city of Bratislava

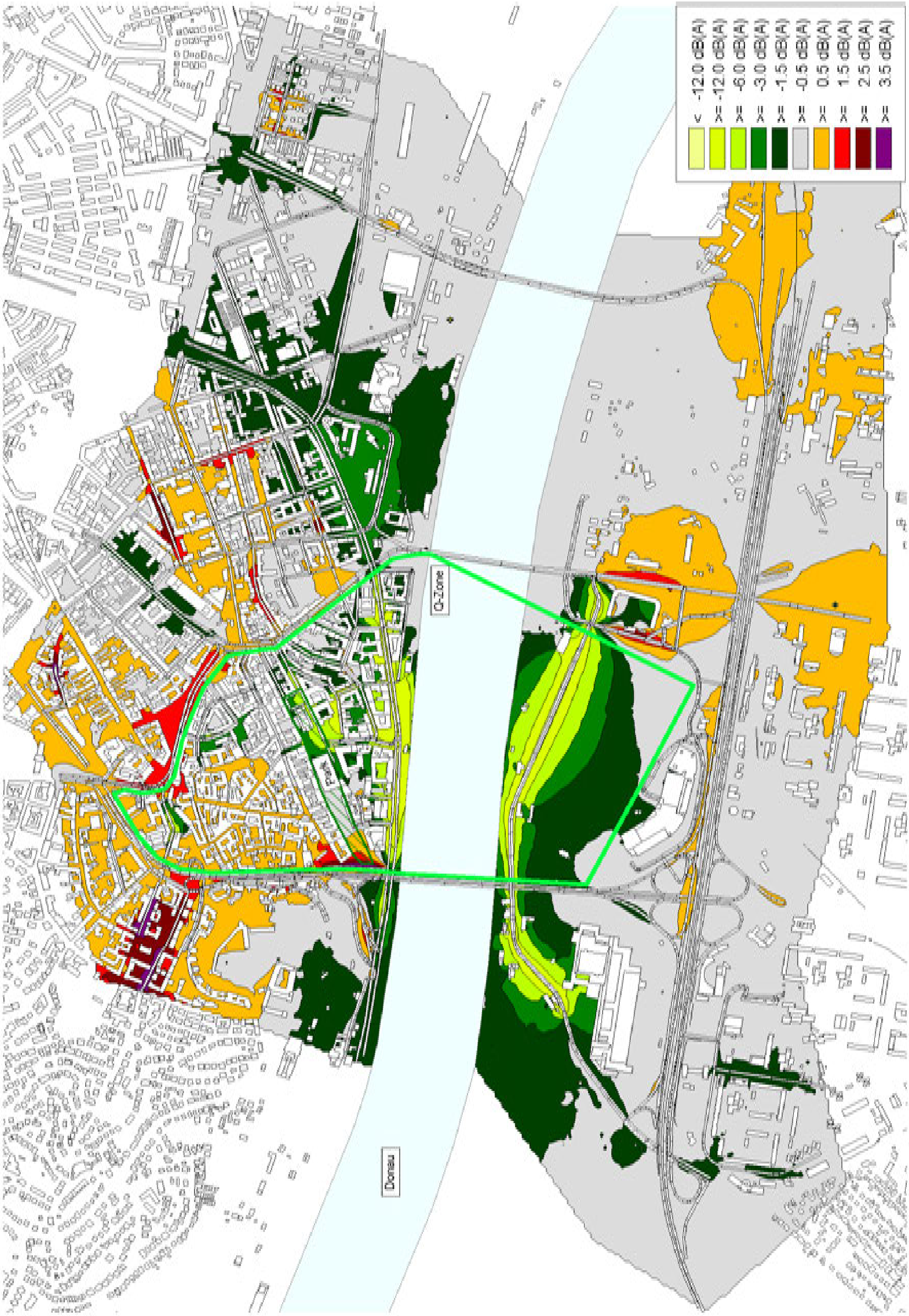

Figure 16: Scenario 2 (S17) – difference to base case – L_{de}

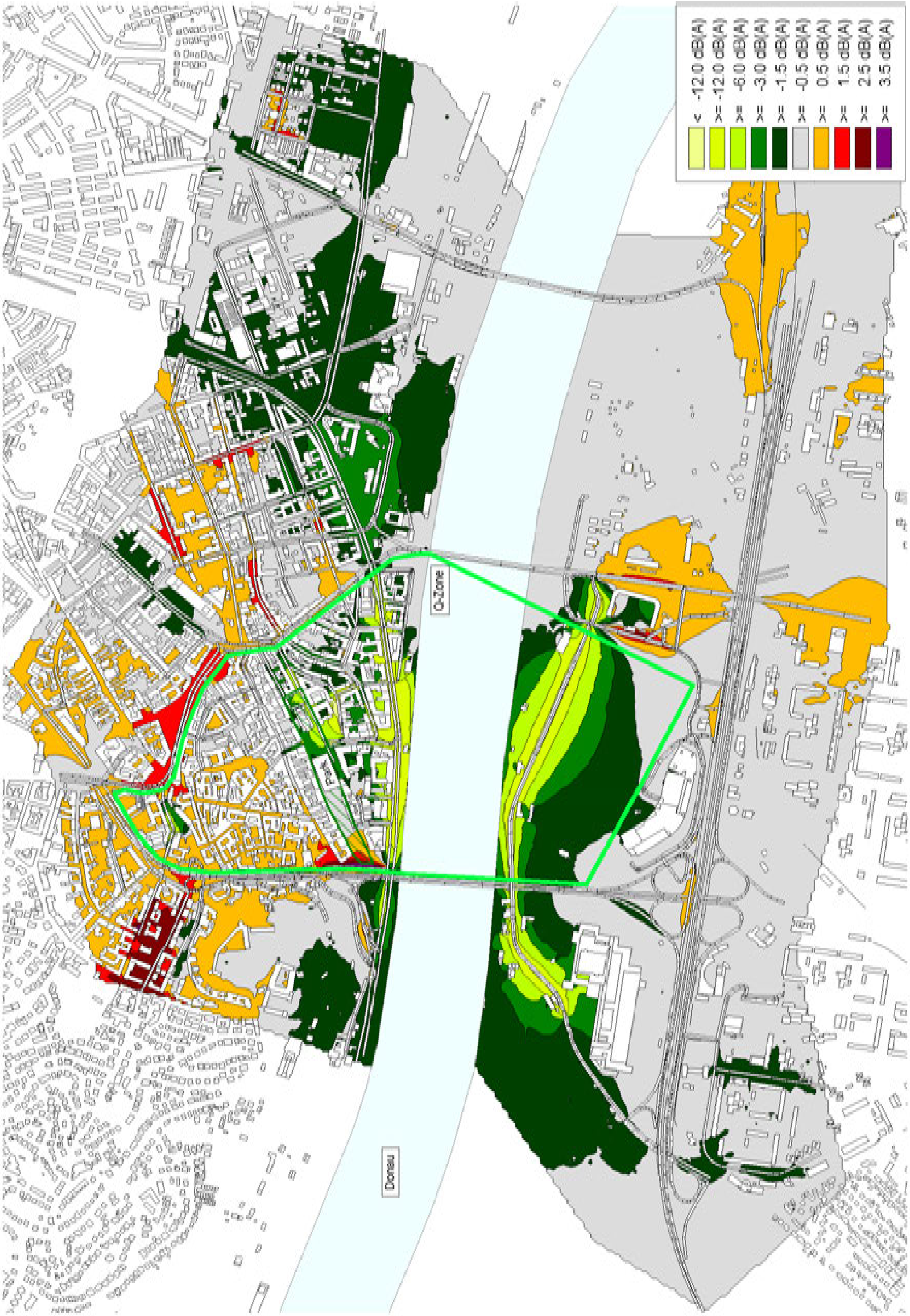

Figure 17: Scenario 3 (S18) – difference to base case- L_{de}

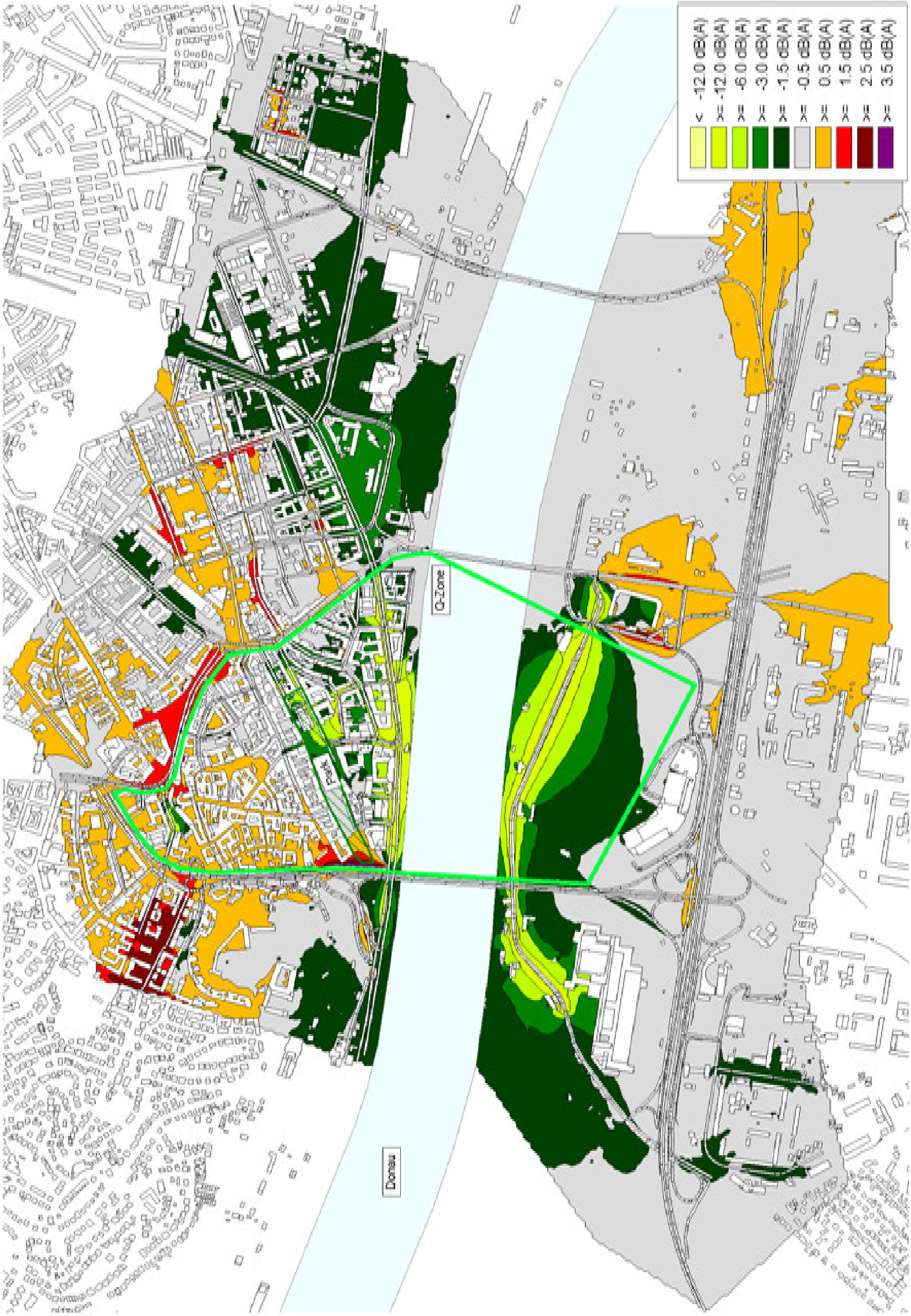

Figure 18: Scenario 4 (S19) - difference to base case – L_{de}

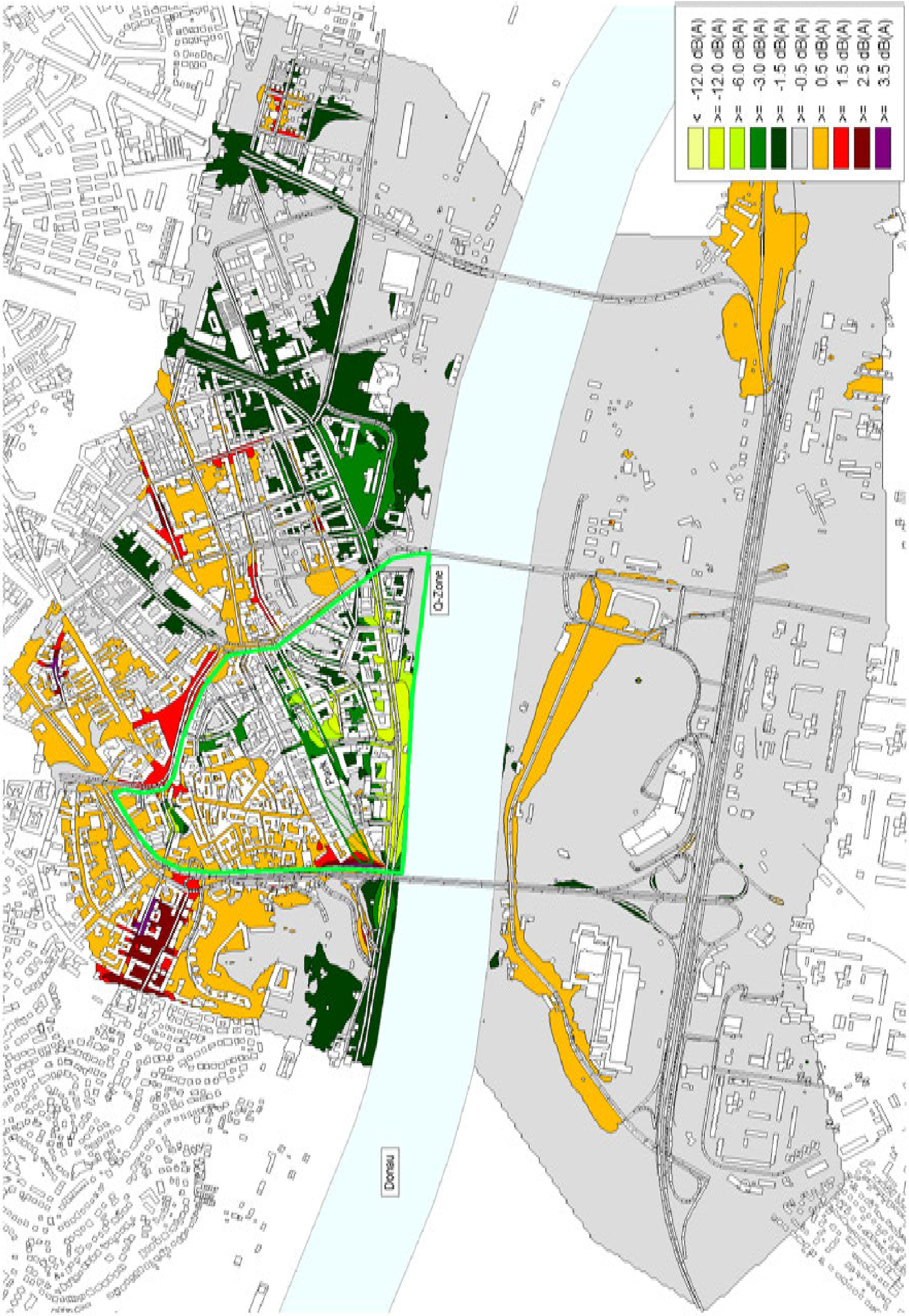

Figure 19: Scenario 5 (S20) - difference to base case - L_{de}

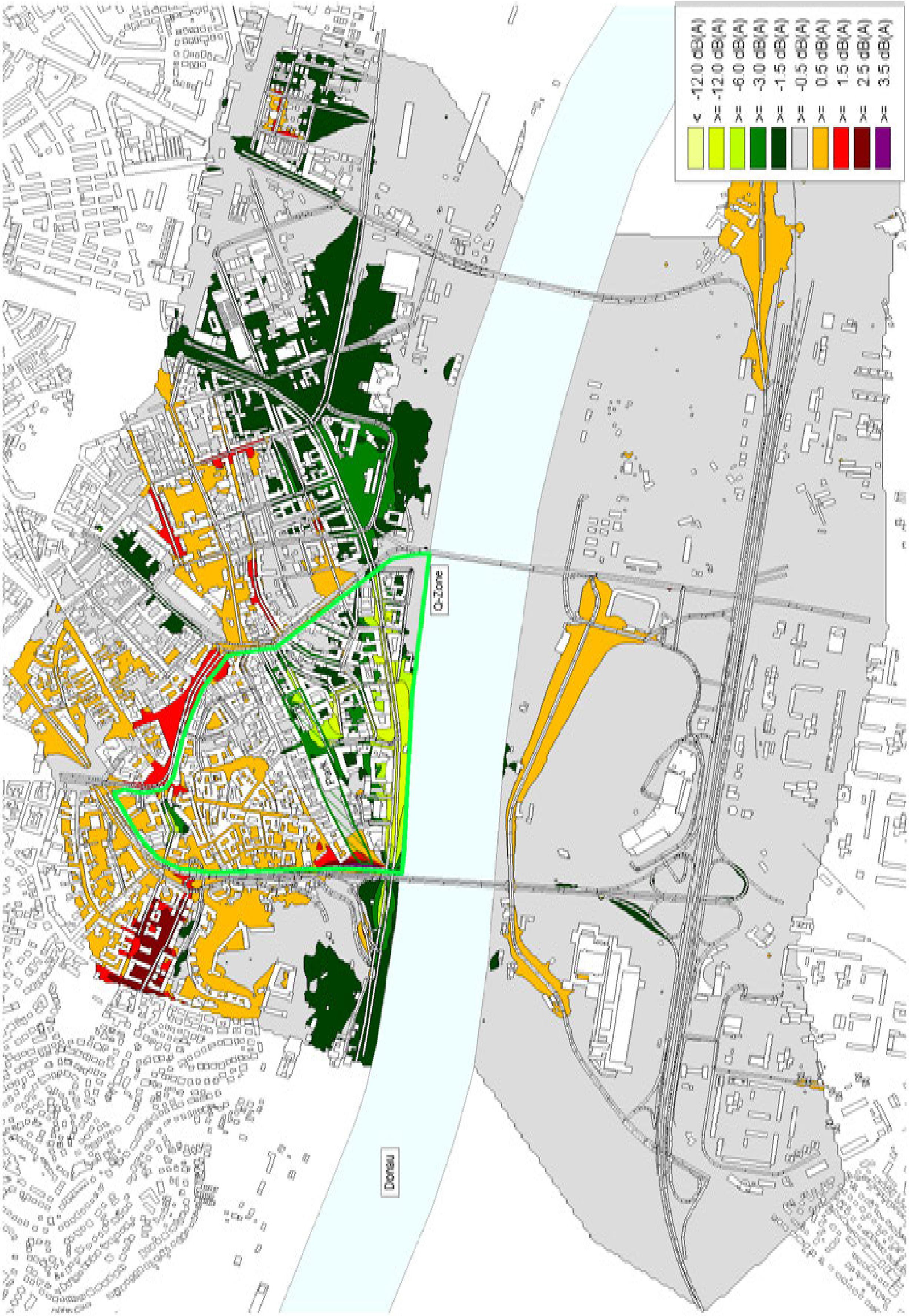

Figure 20: Scenario 6 (S21) - difference to base case – L_{de}

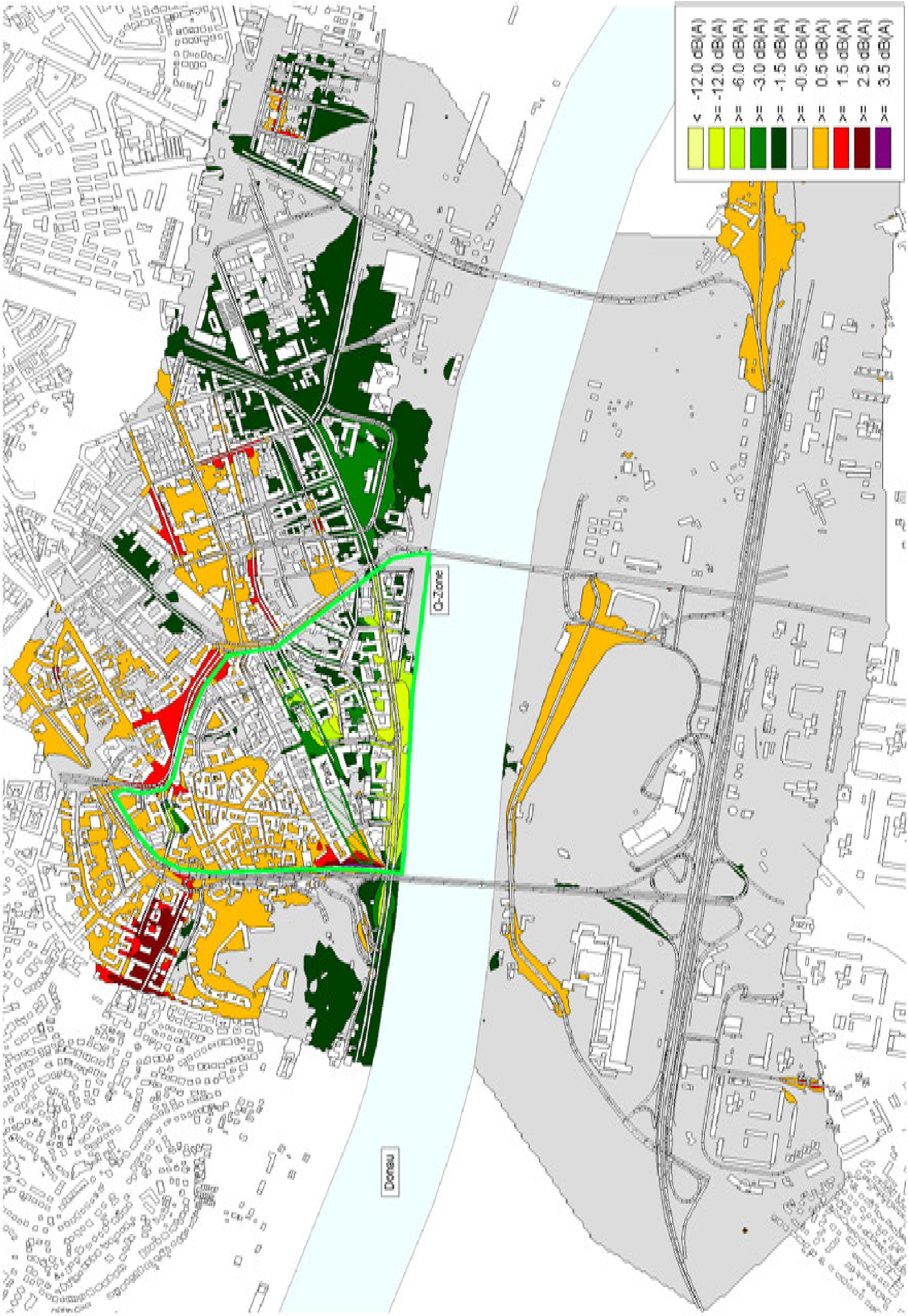

Figure 21: Scenario 7 (S22) - difference to base case – L_{de}

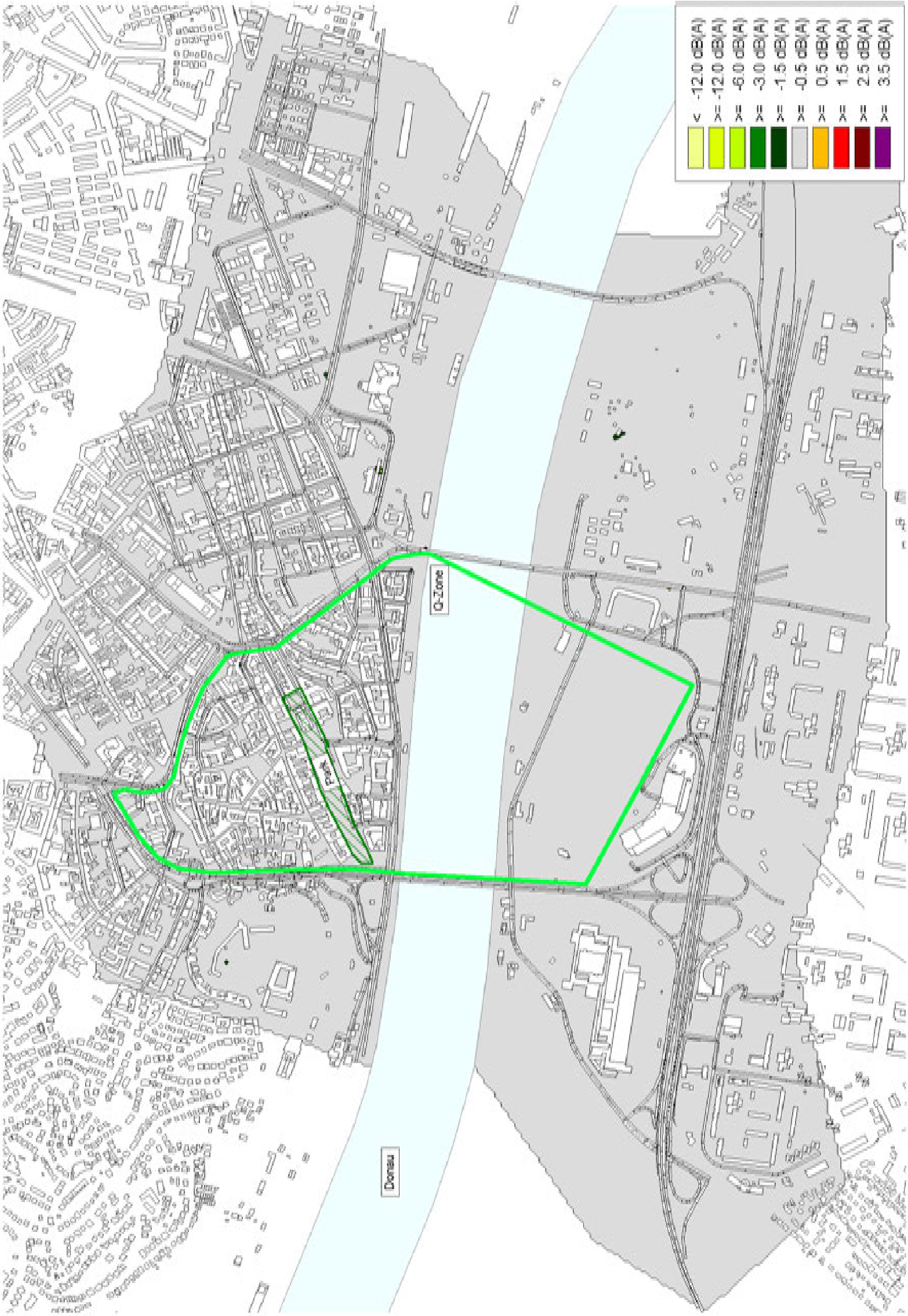

Figure 22: Scenario 8 (S23) – difference to base case – L_{de}

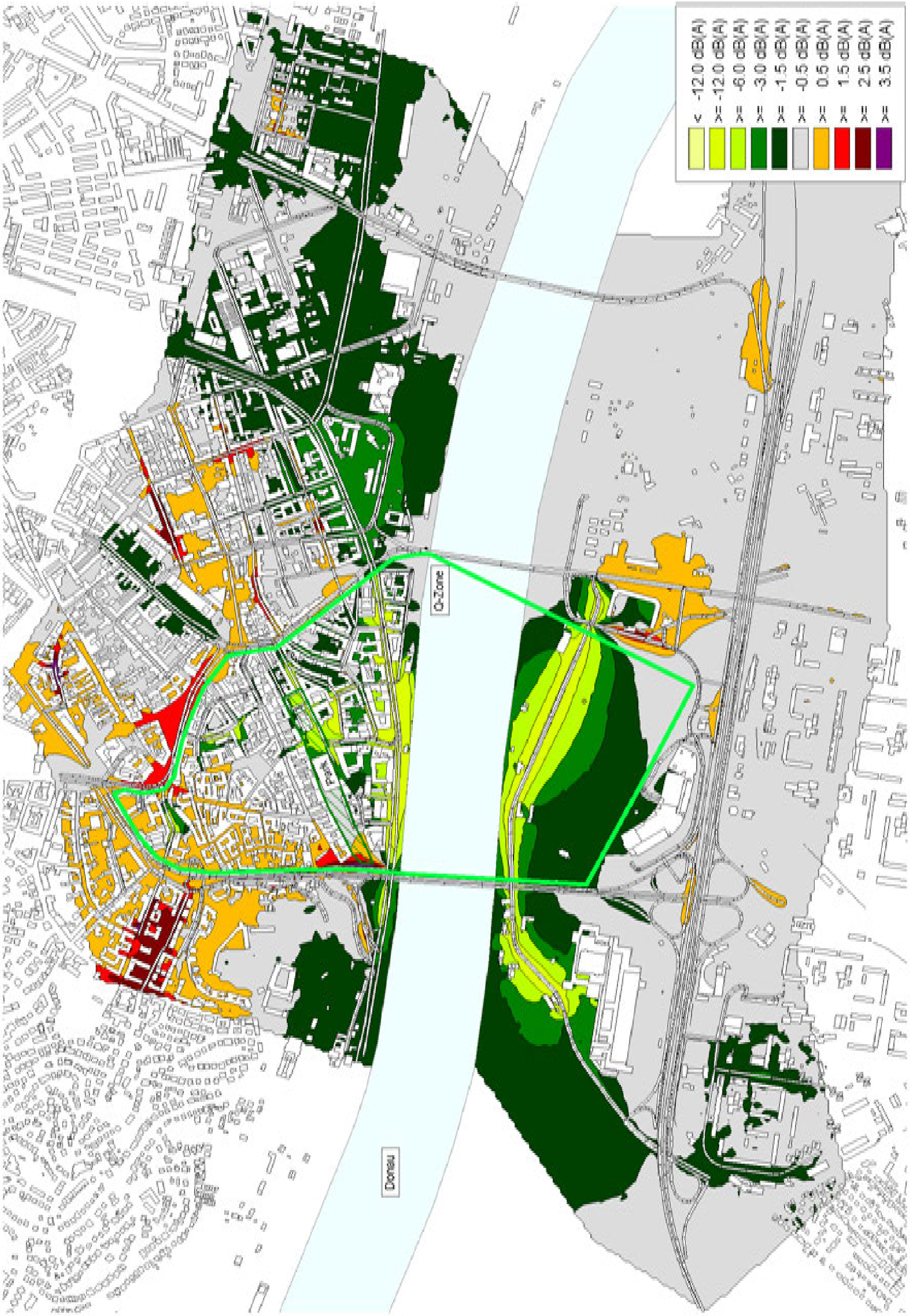

Figure 23: Scenario 9 (S24) – difference to base case – L_{de}

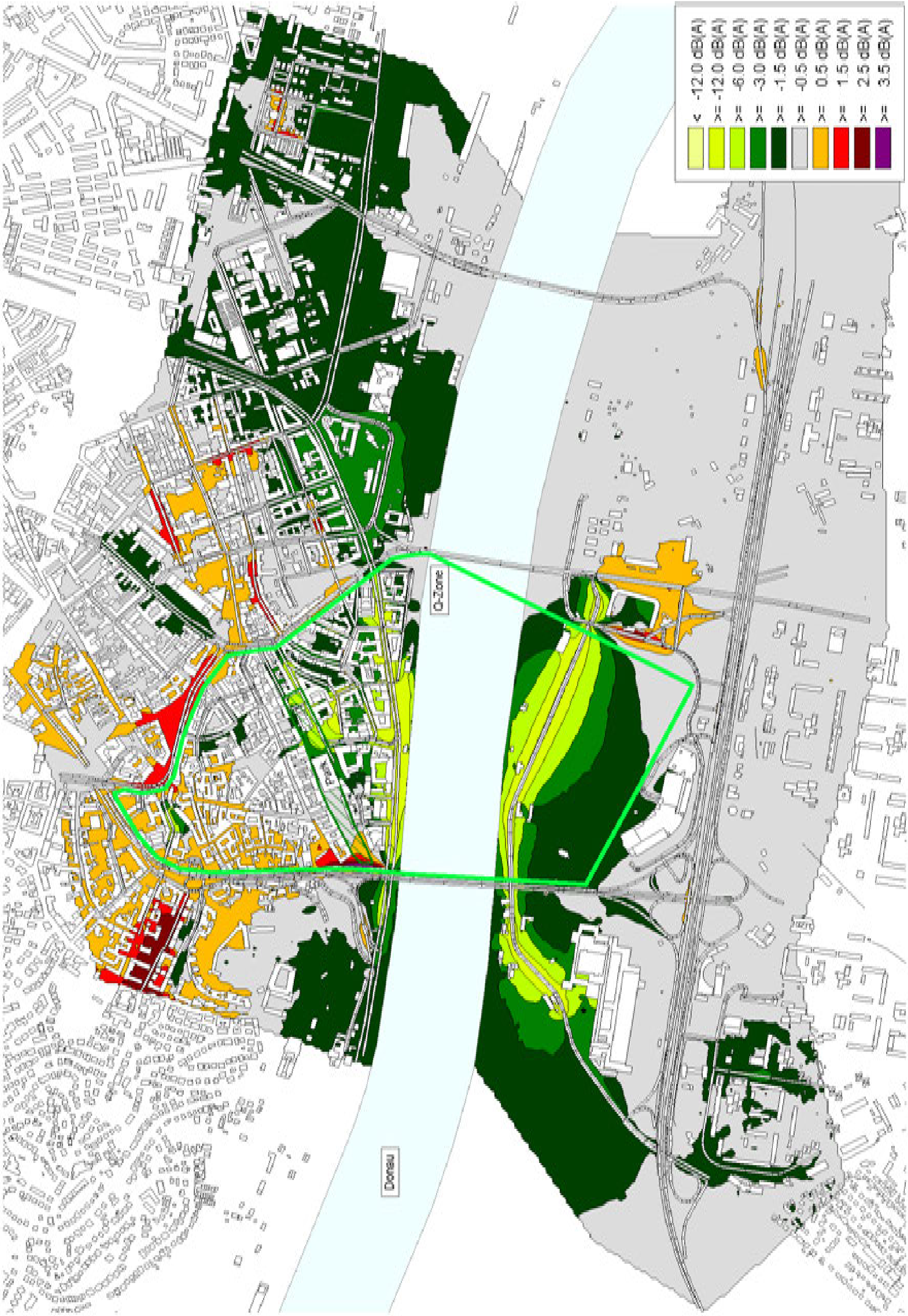

Figure 24: Scenario 10 (S25) – difference to base case – L_{de}

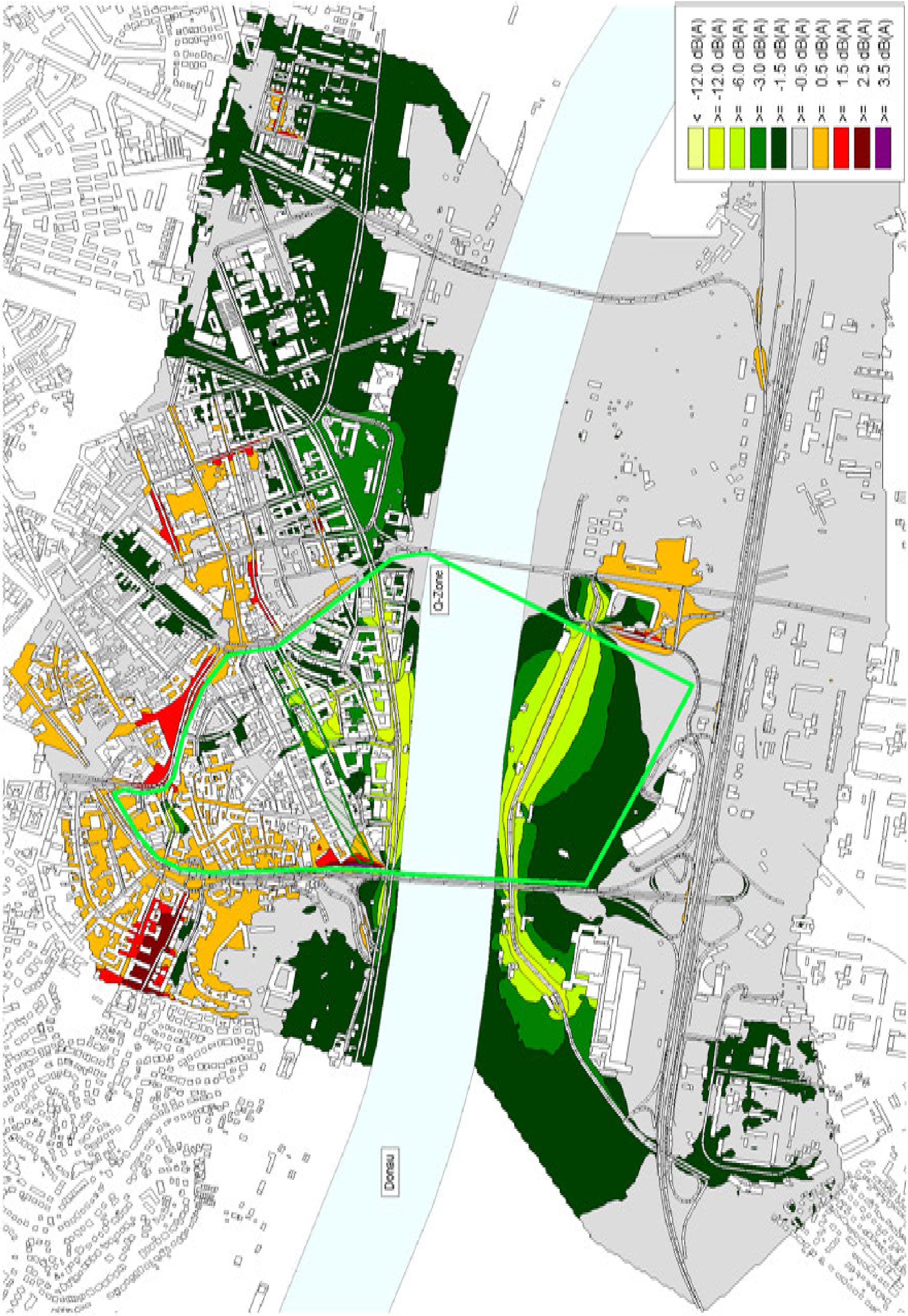

Figure 25: Scenario 11 (S26) – difference to base case – L_{de}

Figure 26: Scenario 12 (S27) – difference to base case – L_{de}

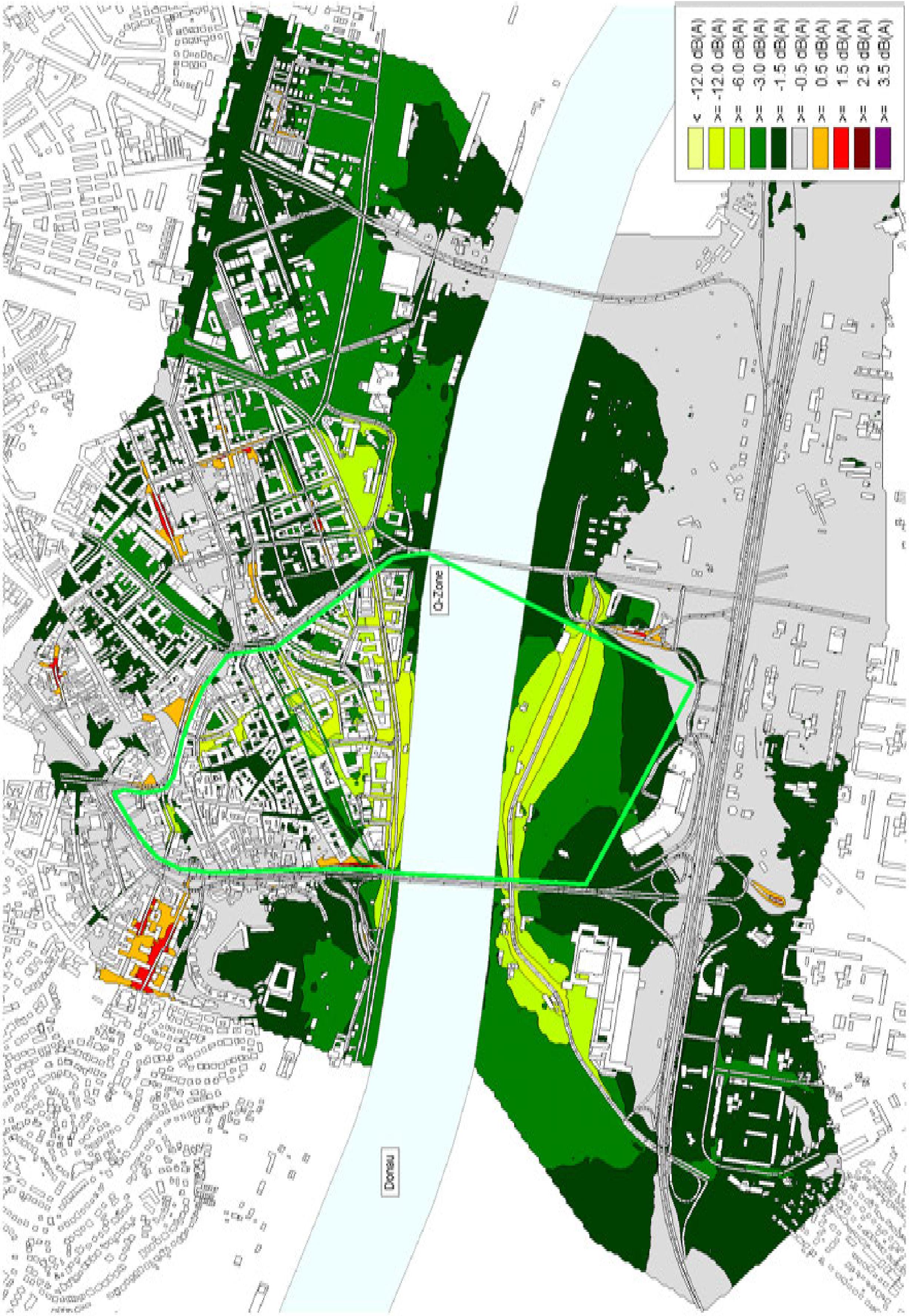

Figure 27: Scenario 13 (S28) – difference to base case – L_{de}

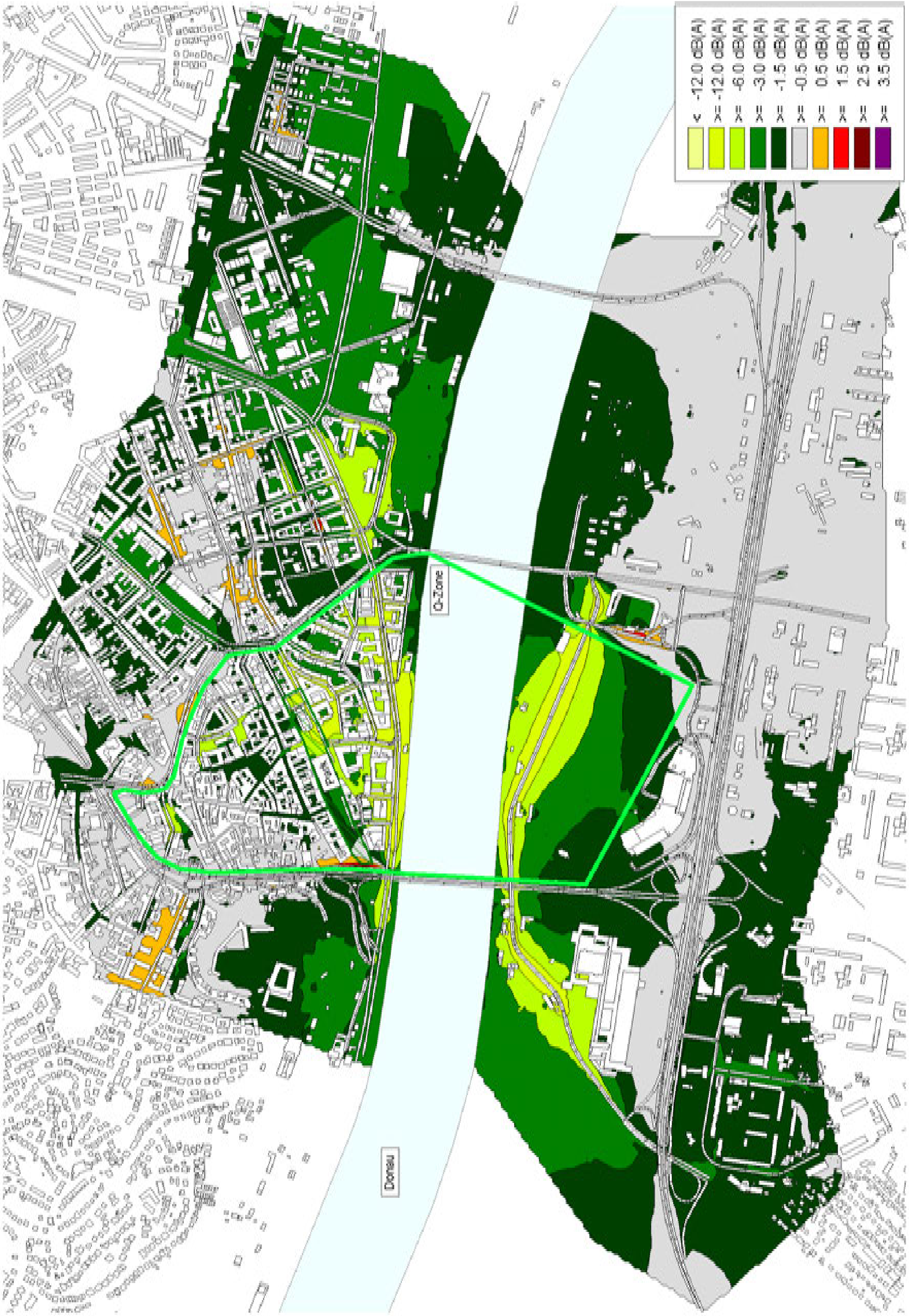

Figure 28: Scenario 14 (S29) – difference to base case – L_{de}

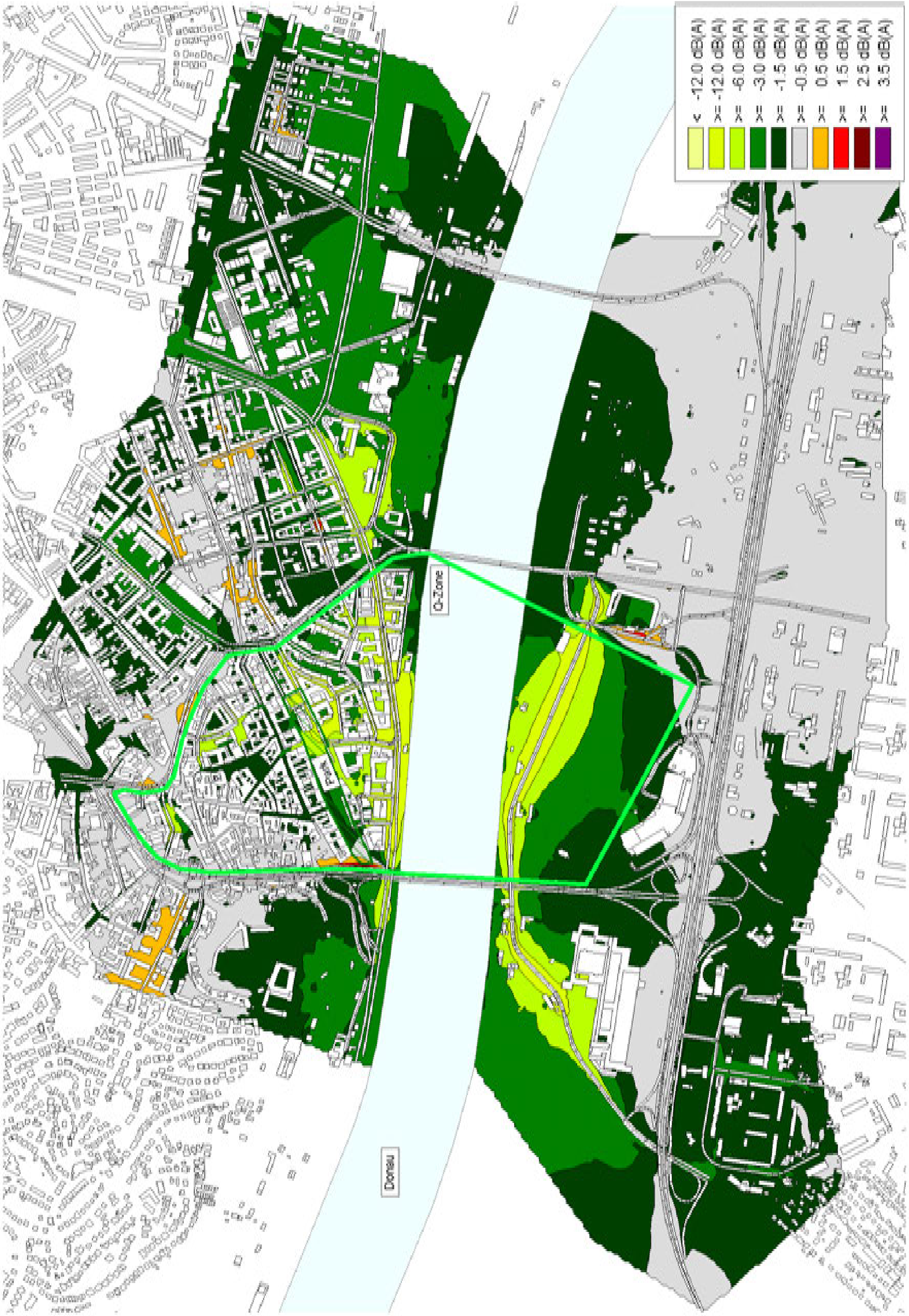

Figure 29: Scenario 15 (S30) – difference to base case - L_{de}

A 2. ADDITIONAL FIGURES FOR THE CITY OF BRISTOL

A 2.1 Simulated scenarios for the city of Bristol

To provide a better overview we included the definition of the scenarios once again at this point. For Bristol, the following set of traffic scenarios was simulated:

Scenario nr	Zone	Fee, Euros/passage	Inside LNVO percentage	External LNVO percentage
1	none	none	1	1
2	QZ	ban	1	1
3	QZ	1	1	1
4	QZ	0.5	1	1
8	none	none	5	5
9	QZ	ban	20	5
10	QZ	1	20	5
11	QZ	0.5	20	5
12	none	none	20	20
13	QZ	ban	100	20
14	QZ	1	100	20
15	QZ	0.5	100	20

A 2.2 Noise maps for the city of Bristol

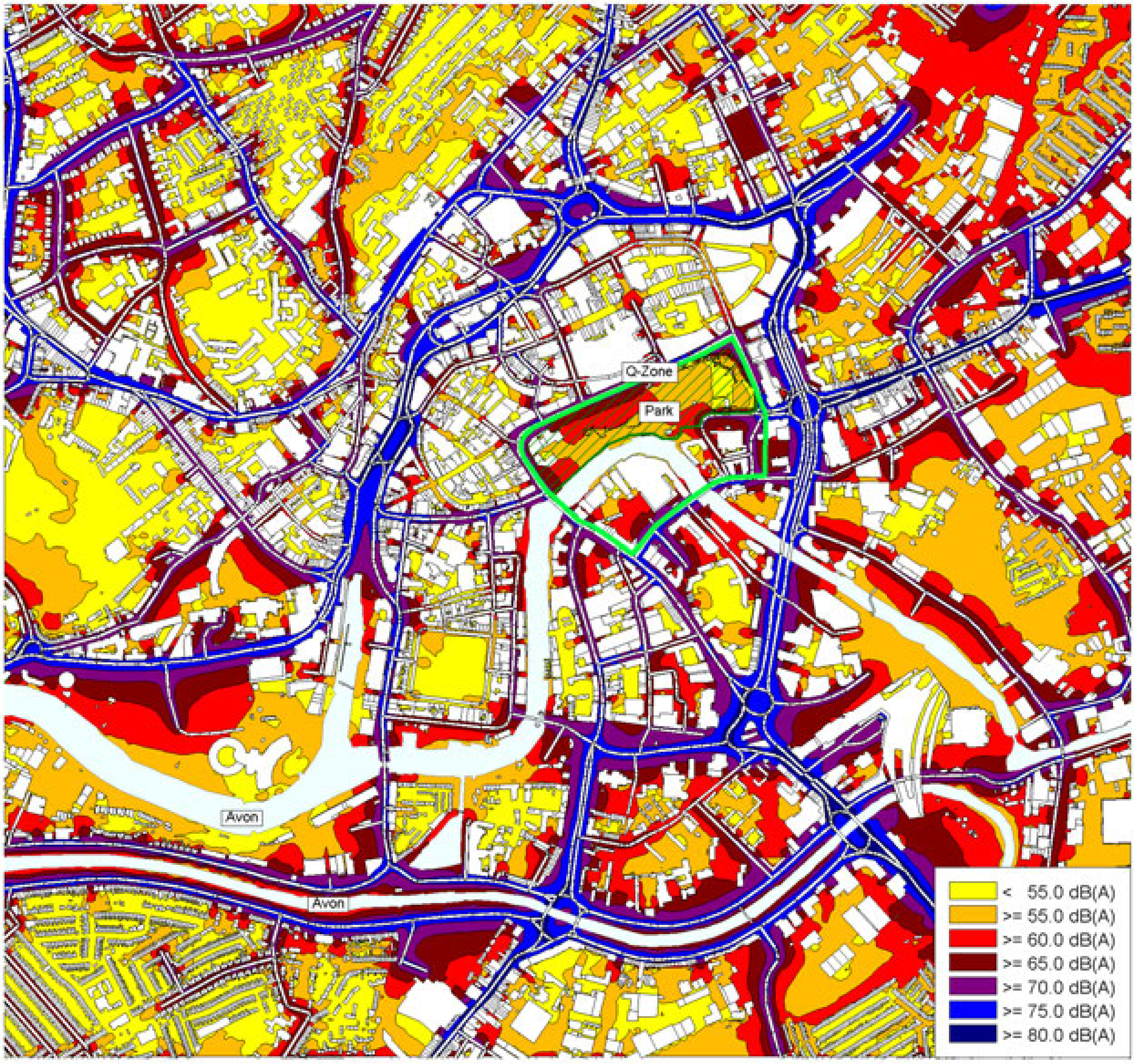

Figure 30: Bristol Scenario 1 (Base Case) - L_{de}

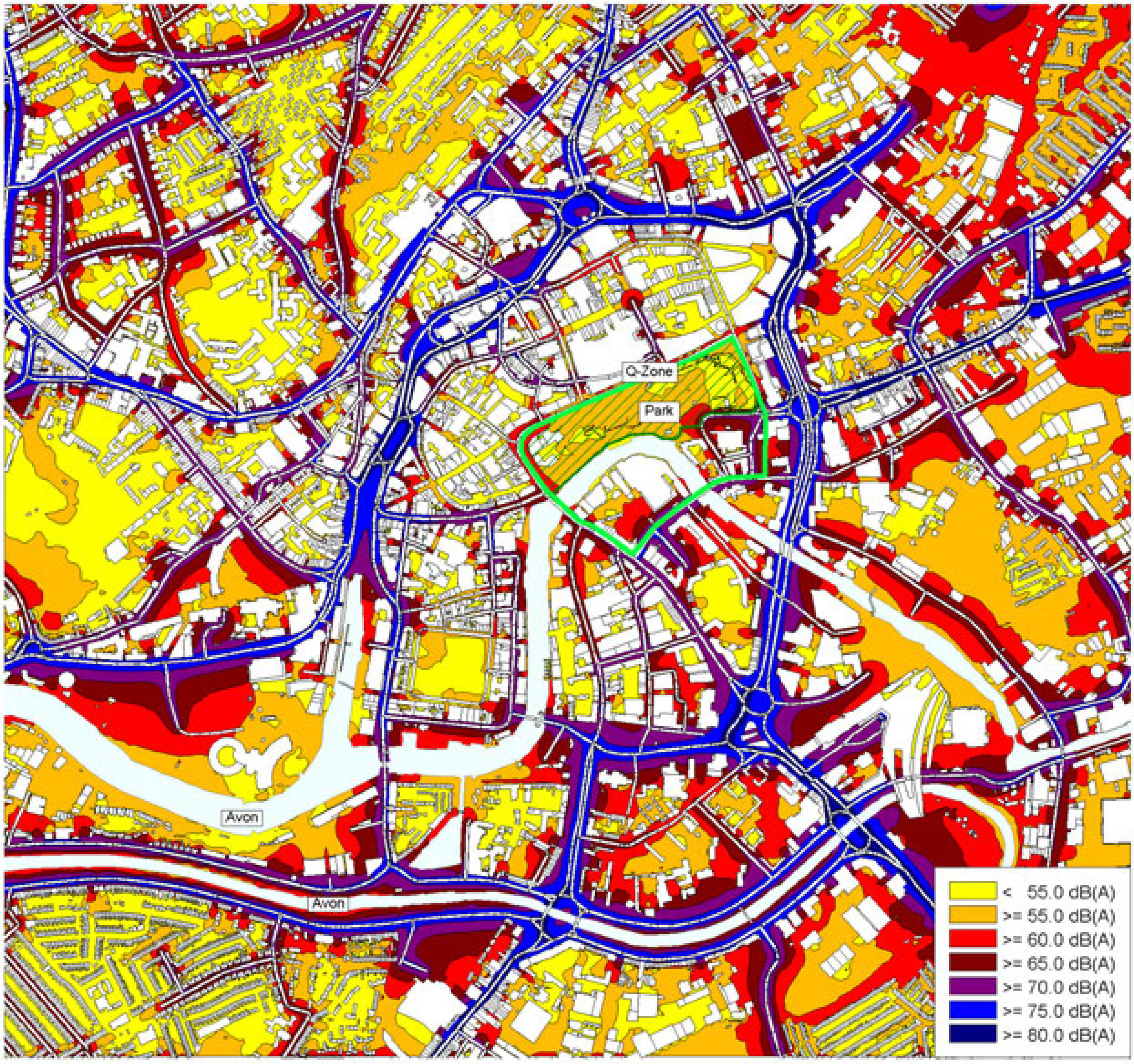

Figure 31: Bristol Scenario 2 - L_{de}

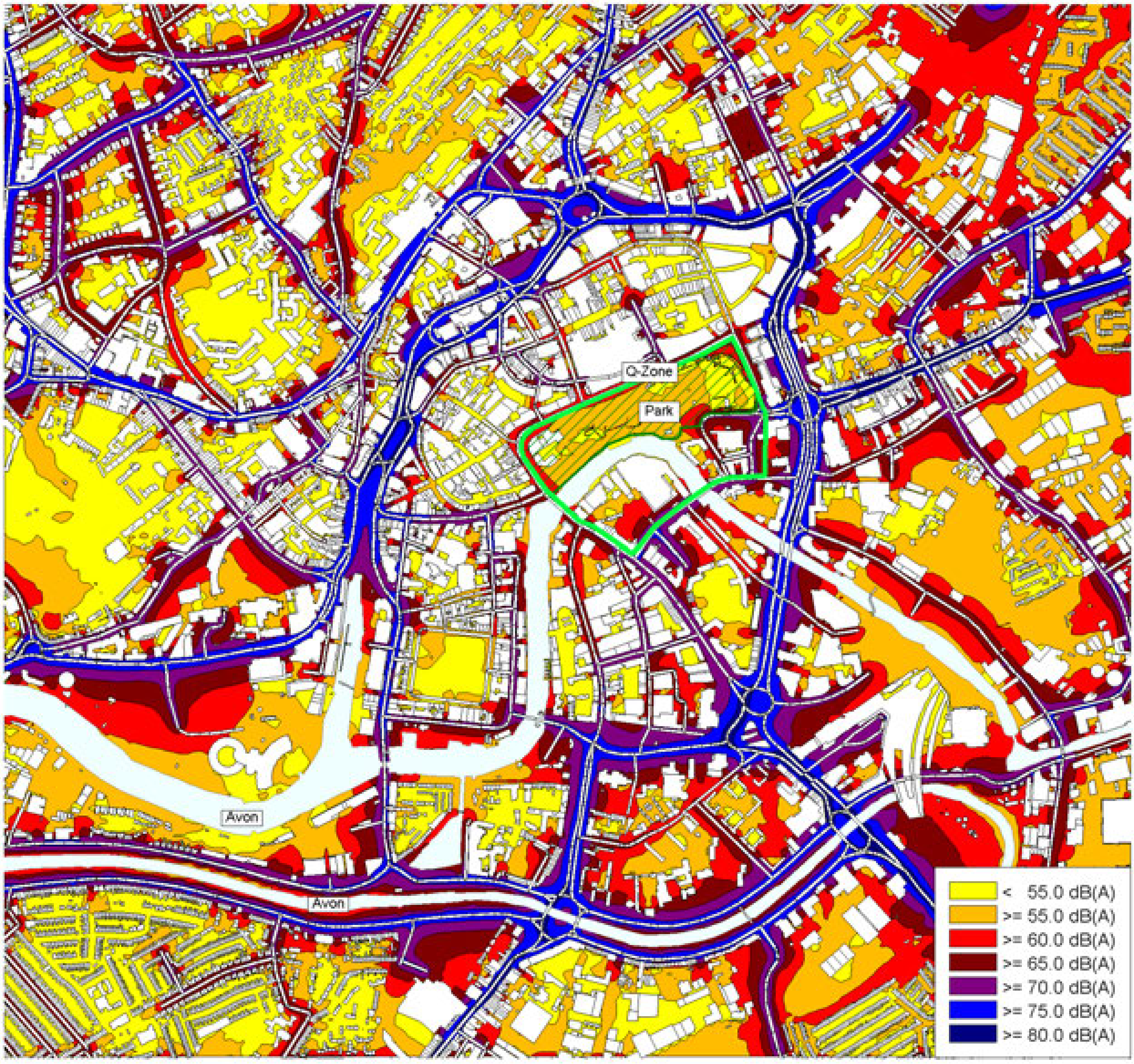

Figure 32: Bristol Scenario 3 - L_{de}

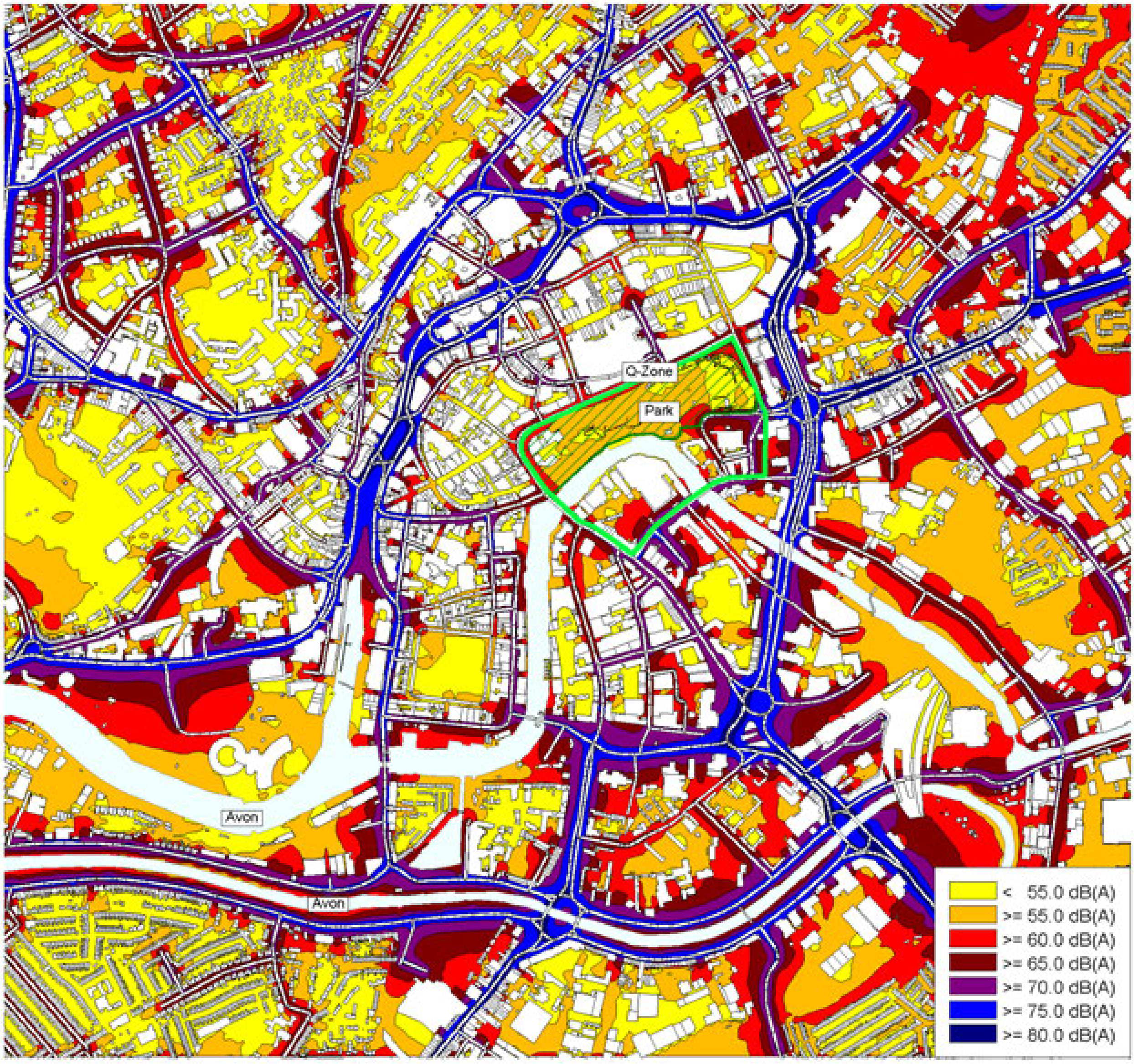

Figure 33: Bristol Scenario 4 - L_{de}

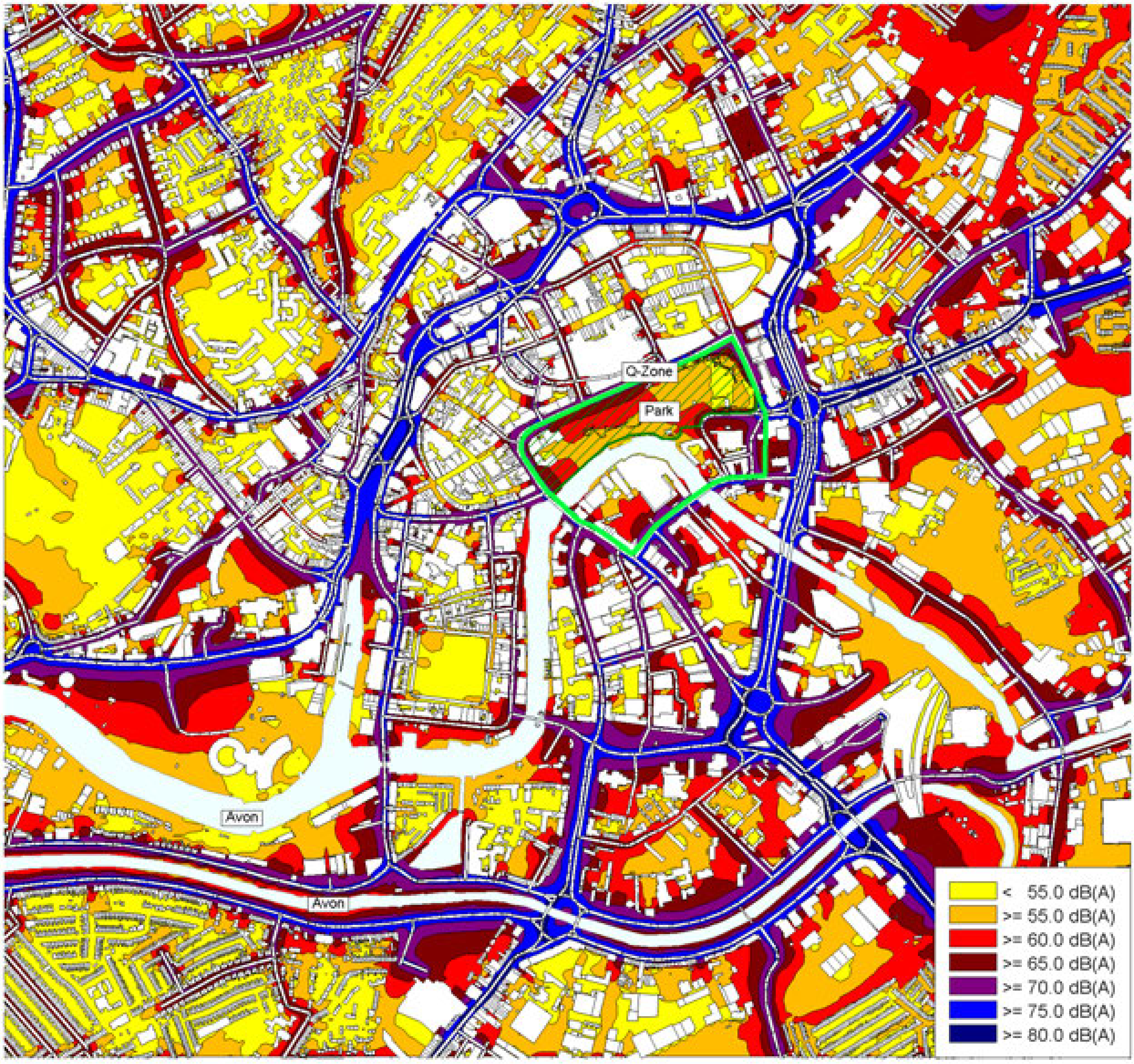

Figure 34: Bristol Scenario 8 - L_{de}

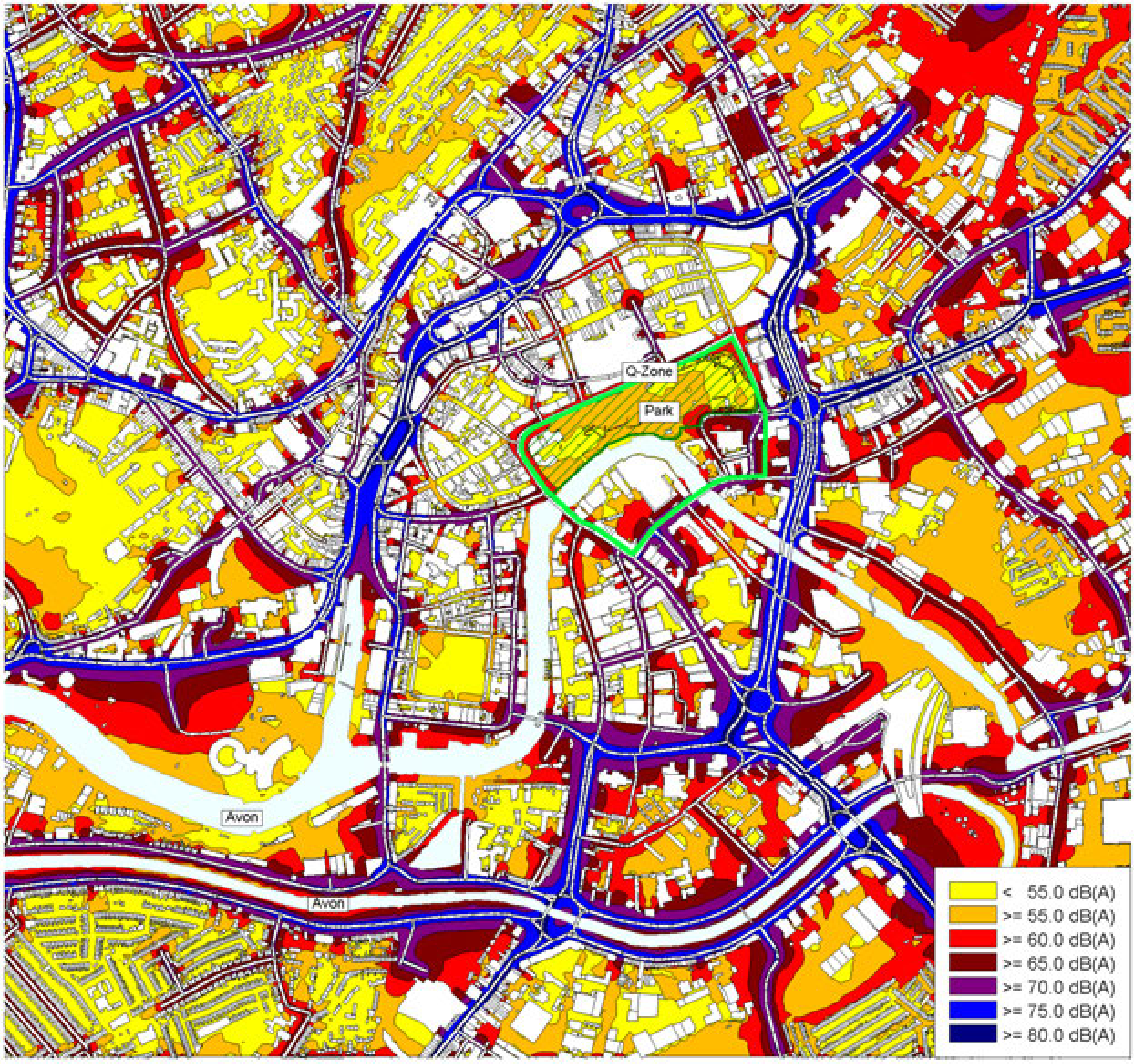

Figure 35: Bristol Scenario 9 - L_{de}

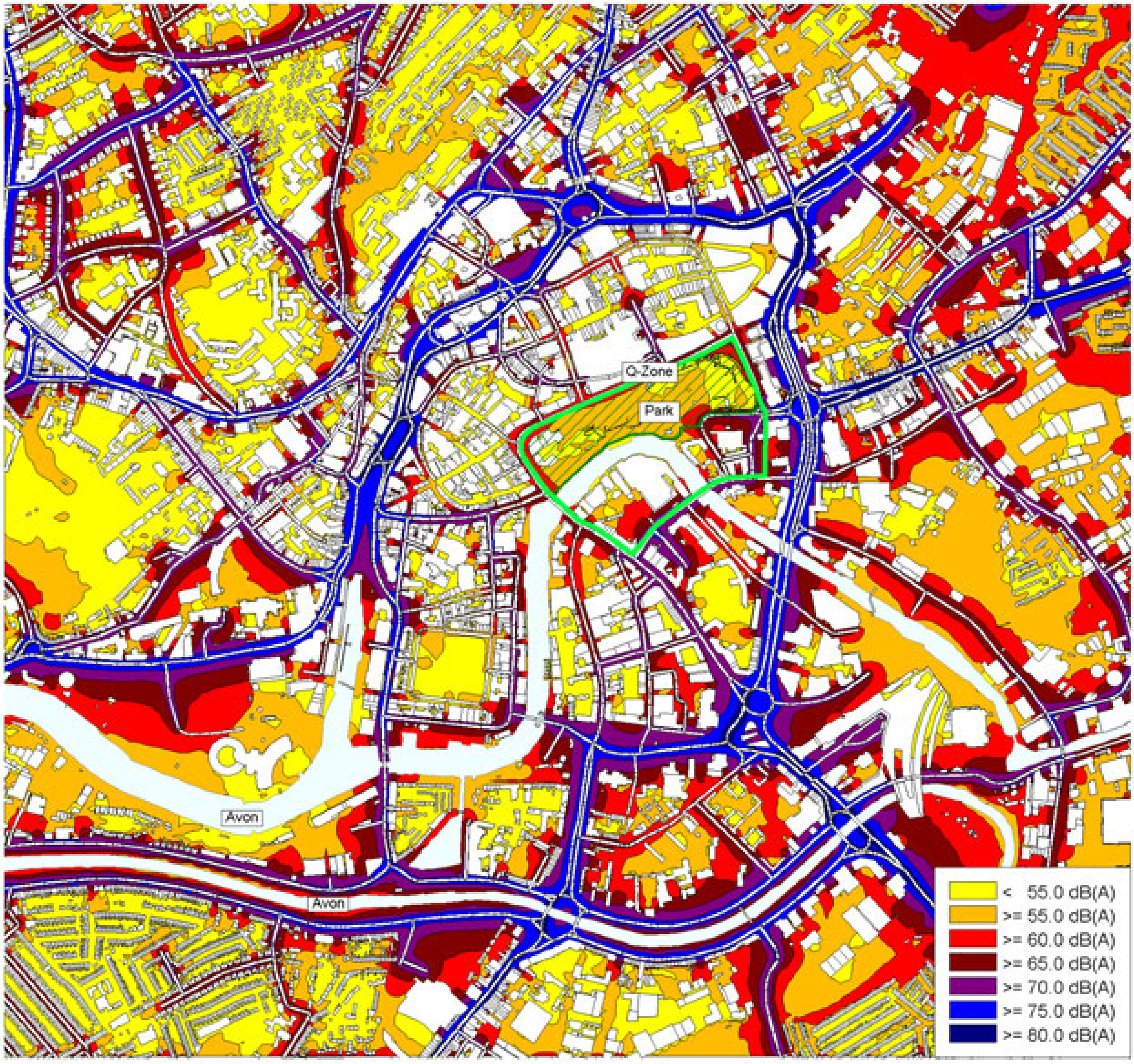

Figure 36: Bristol Scenario 10 - L_{de}

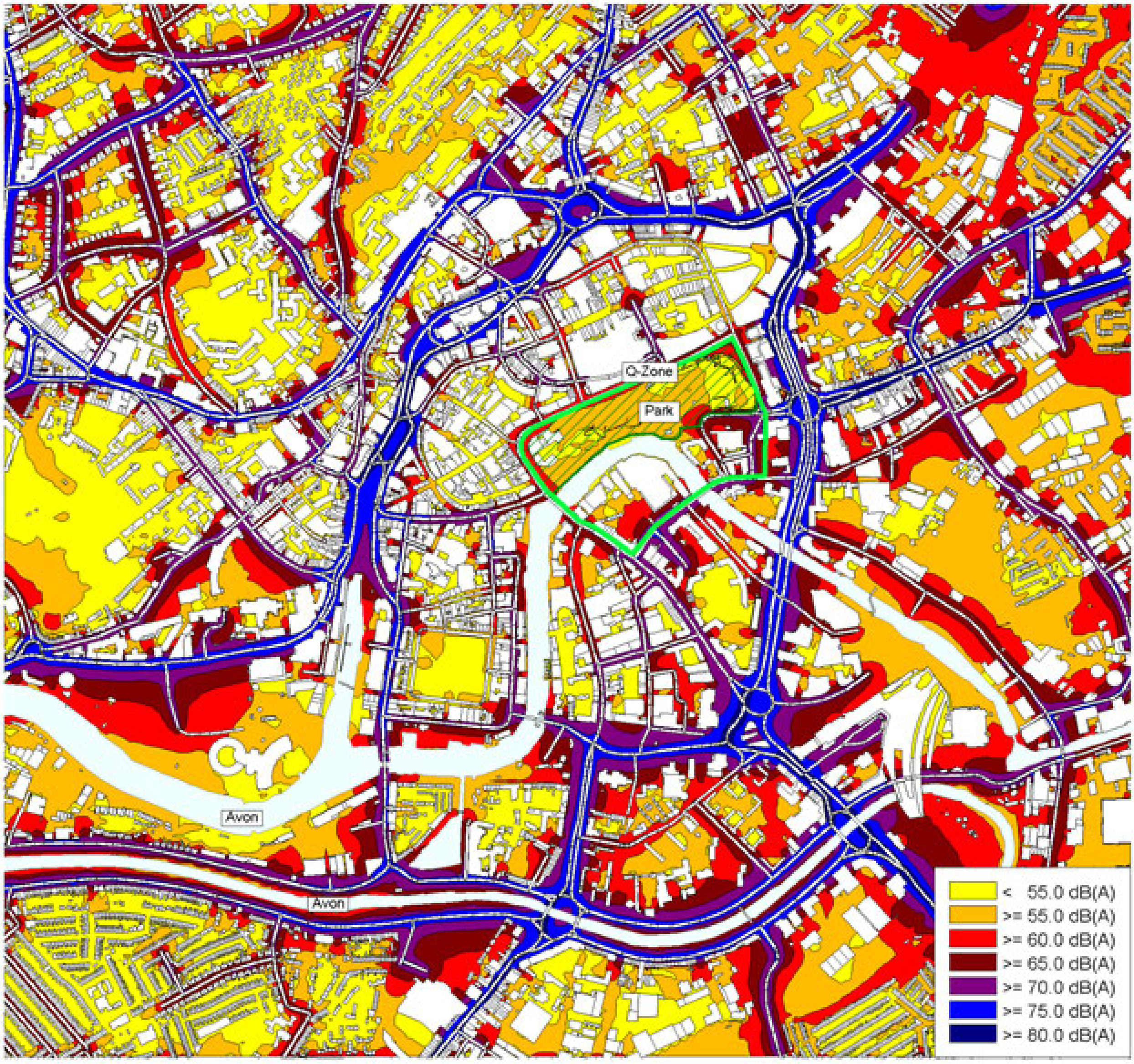

Figure 37: Bristol Scenario 11 - L_{de}

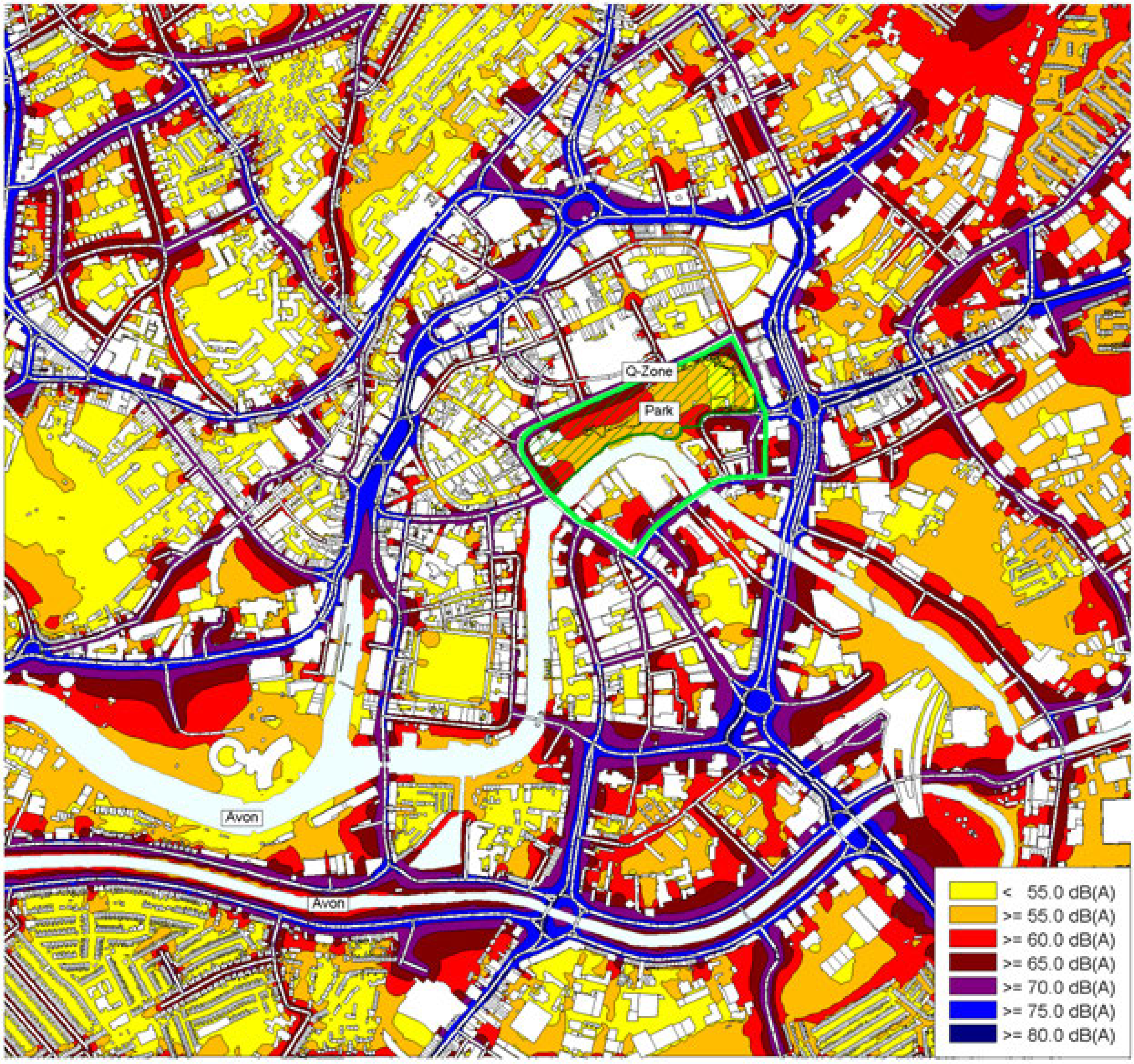

Figure 38: Bristol Scenario 12 - L_{de}

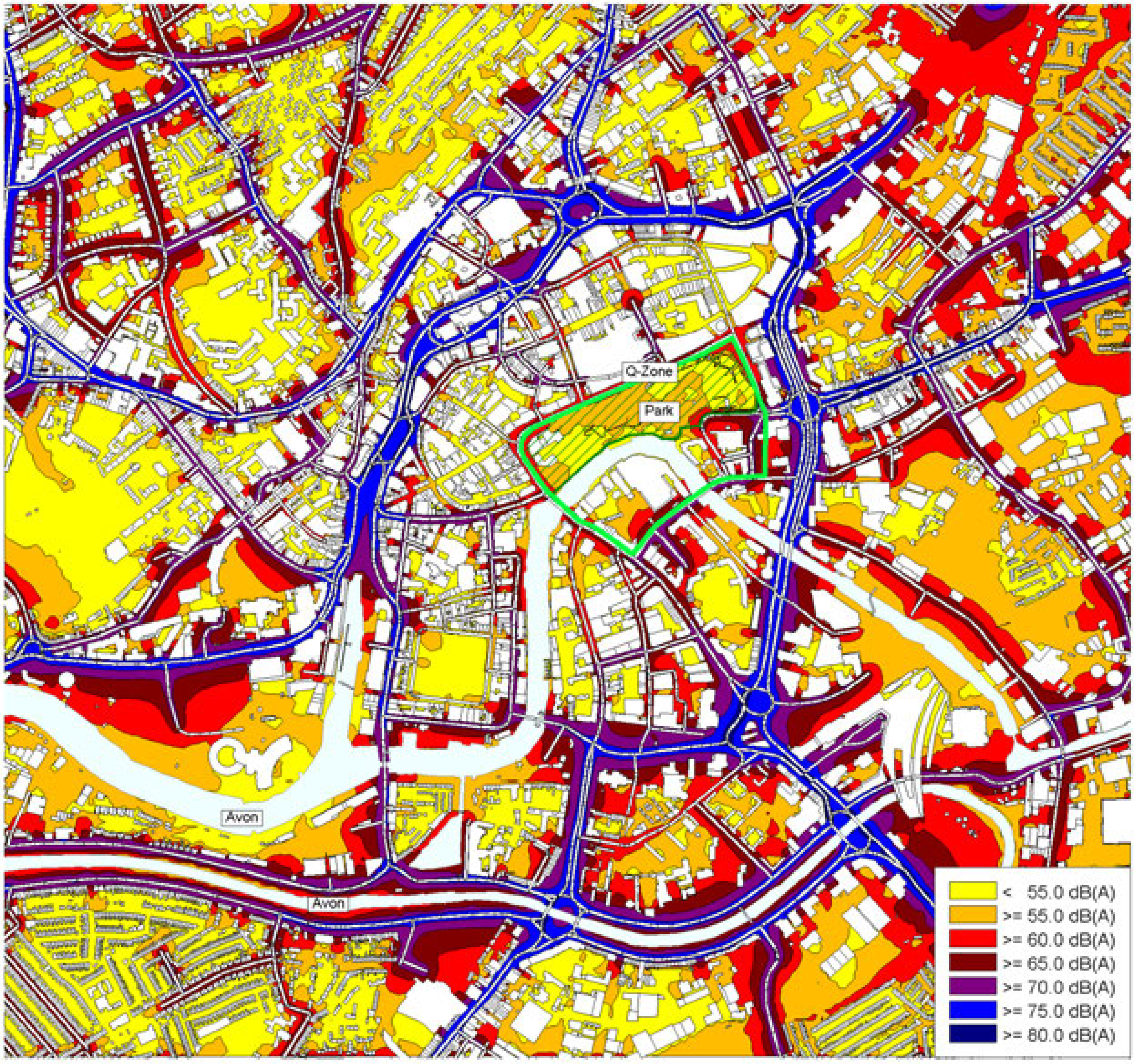

Figure 39: Bristol Scenario 13 - L_{de}

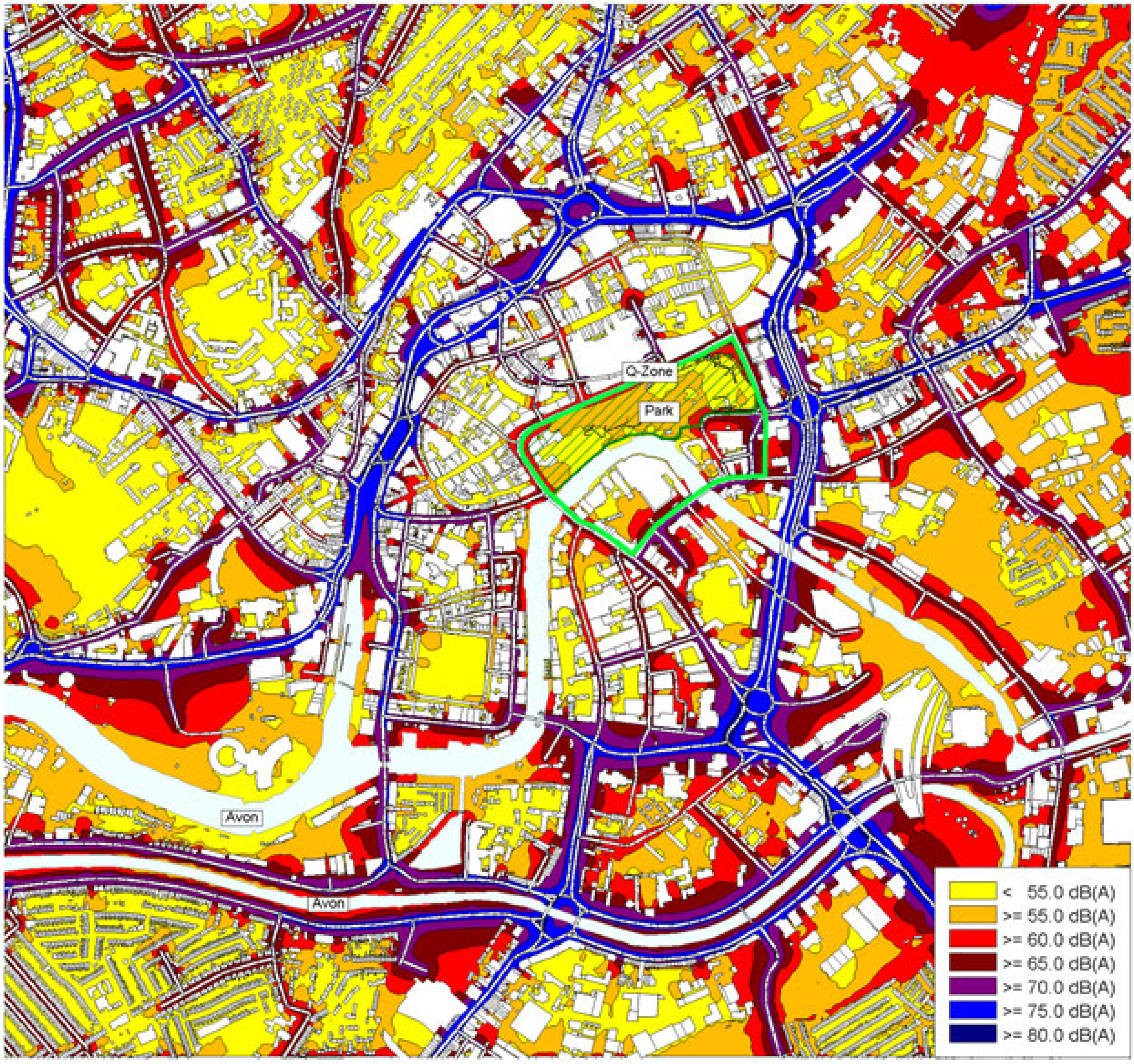

Figure 40: Bristol Scenario 14 - L_{de}

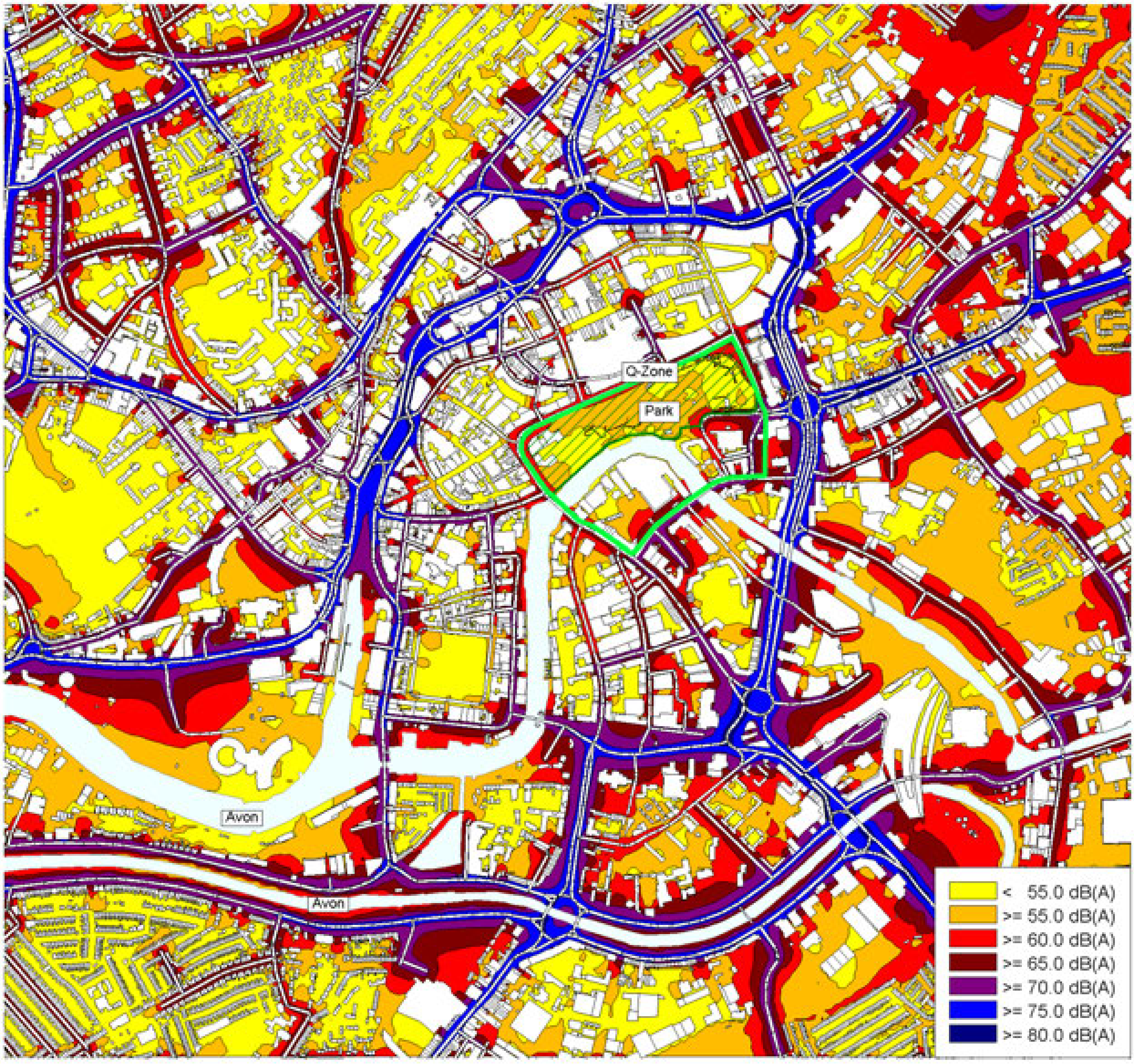

Figure 41: Bristol Scenario 15 - L_{de}

A 2.3 Noise difference maps for the city of Bristol

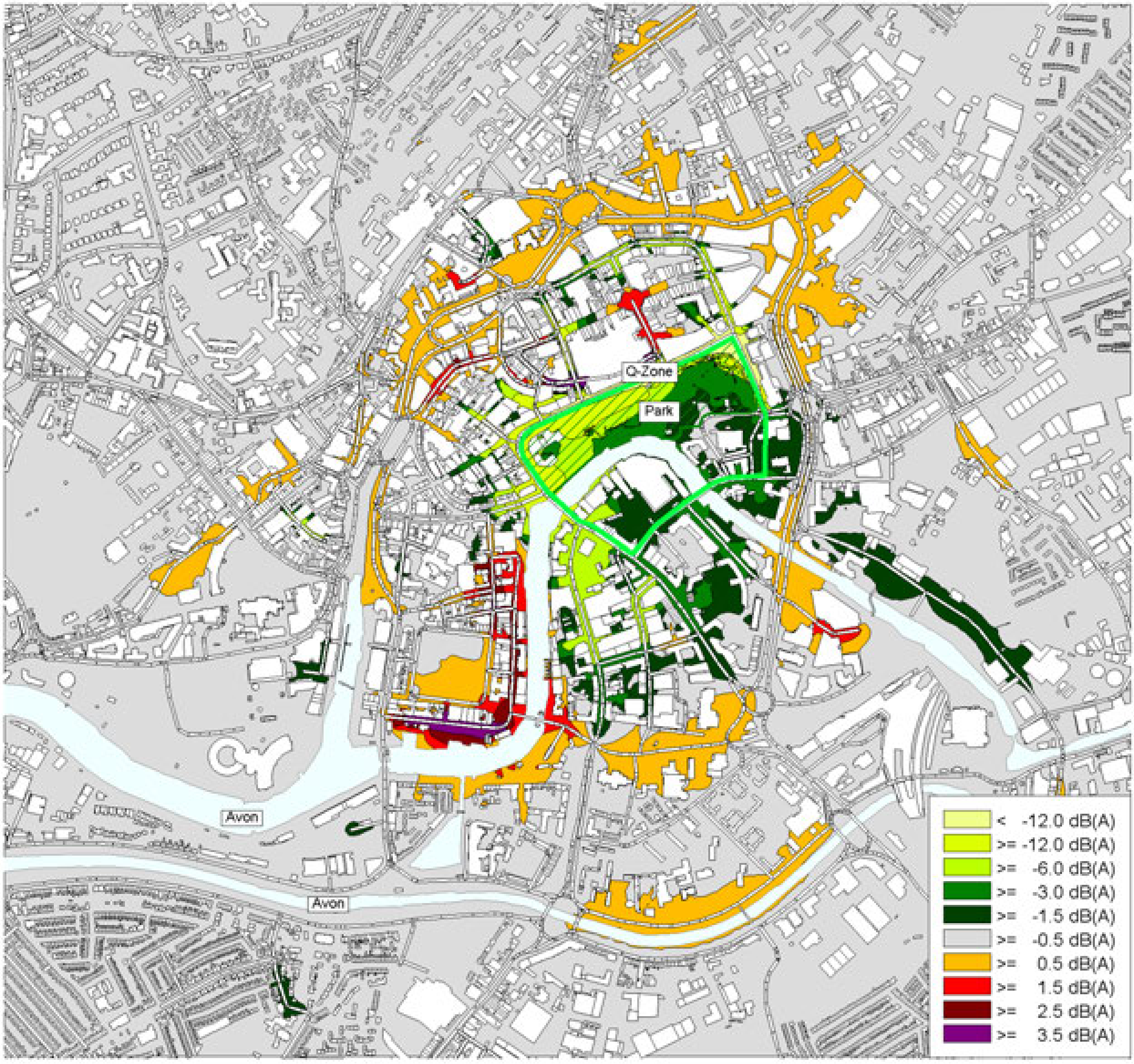

Figure 42: Bristol Scenario 2 – difference to base case - L_{de}

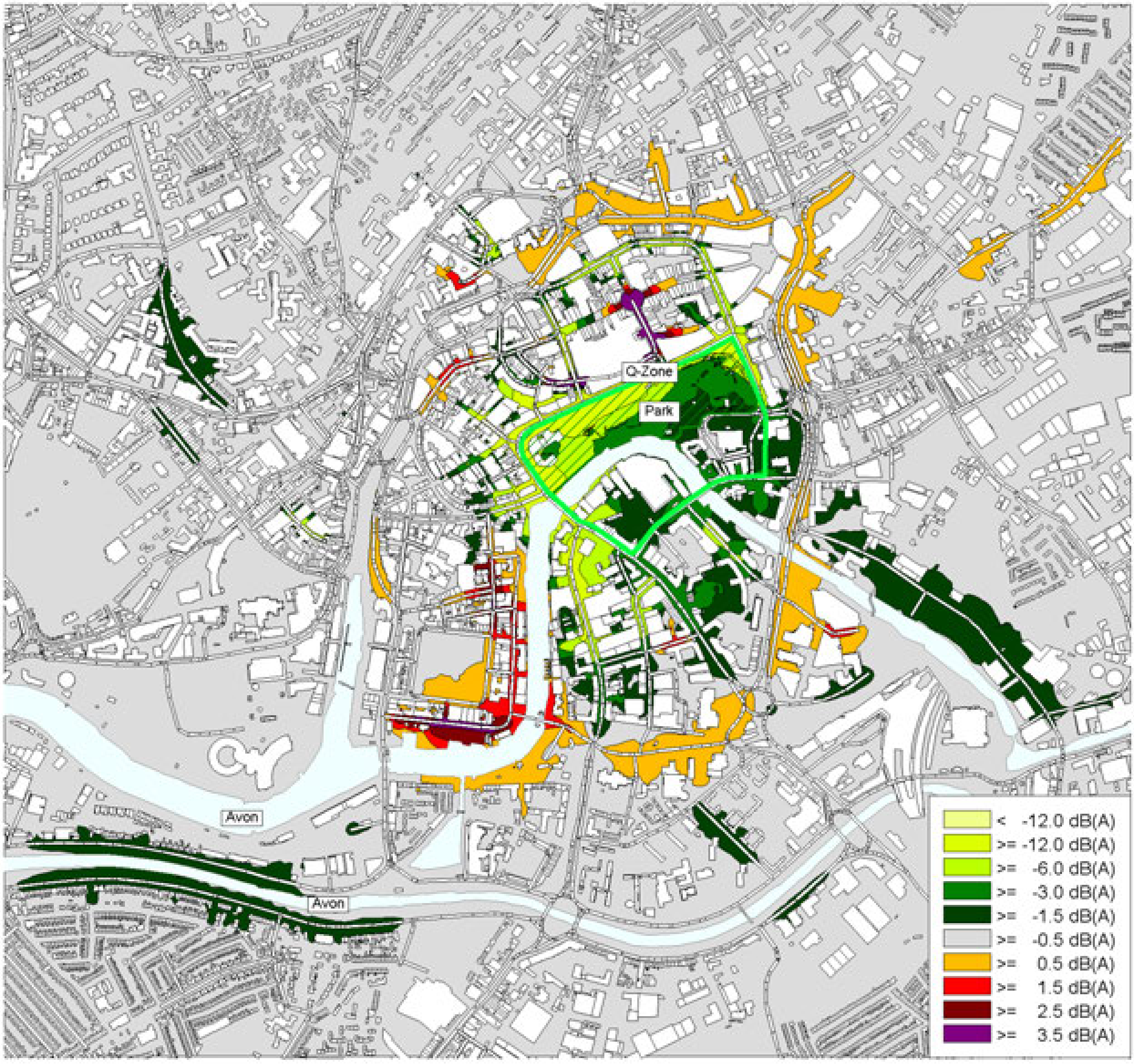

Figure 43: Bristol Scenario 3 – difference to base case - L_{de}

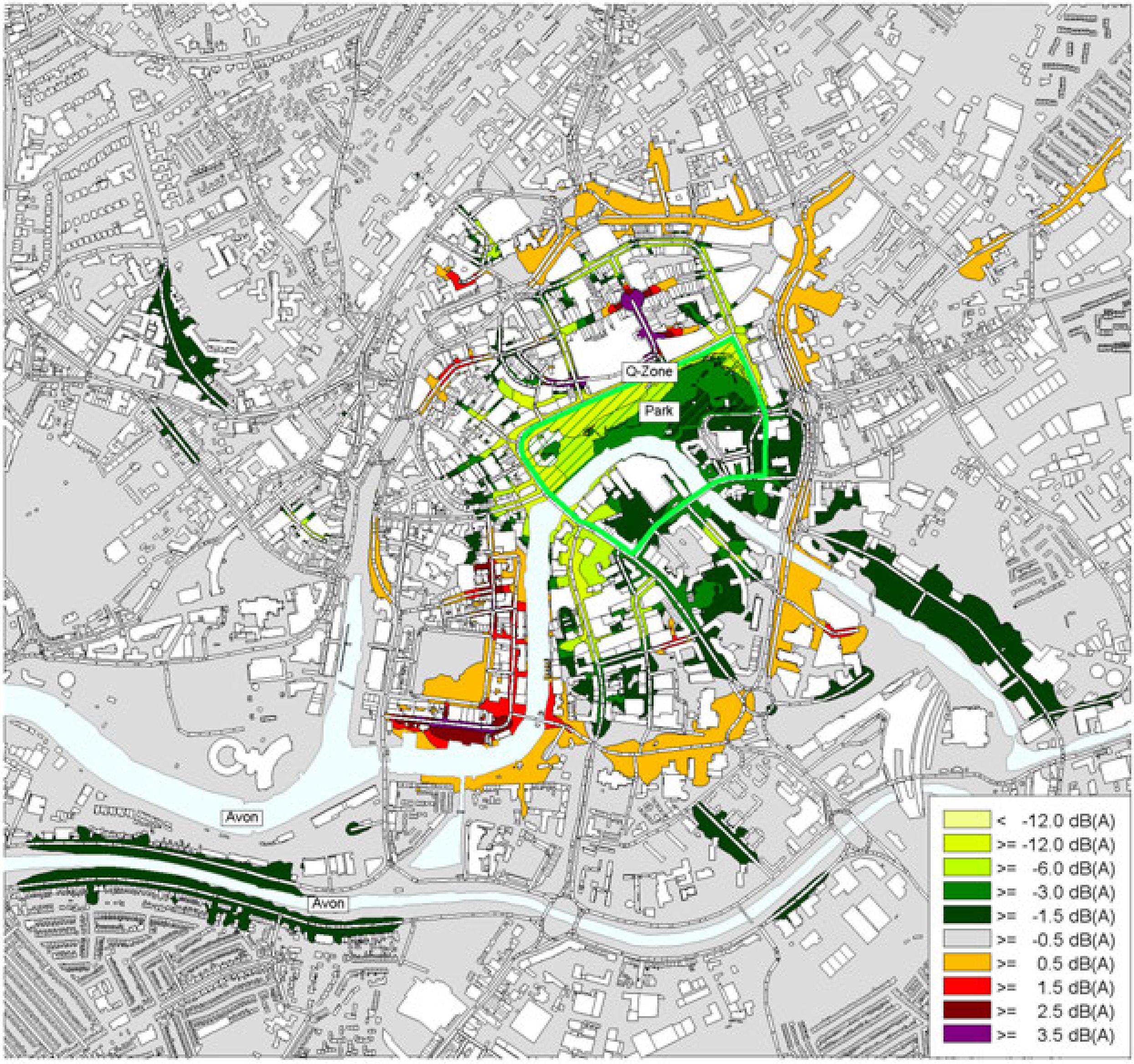

Figure 44 Bristol Scenario 4 - difference to base case - L_{de}

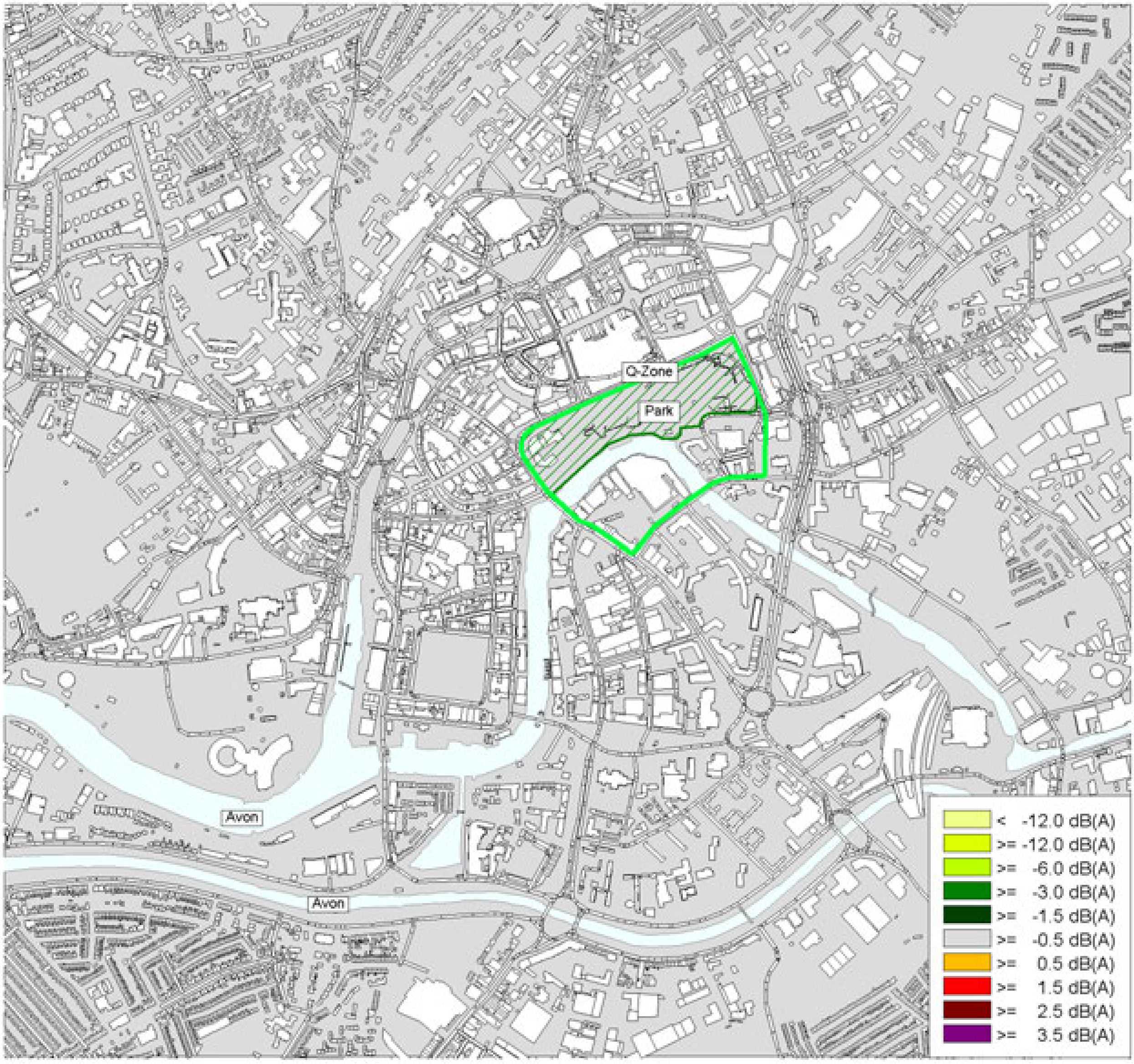

Figure 45 Bristol Scenario 8 - difference to base case - L_{de}

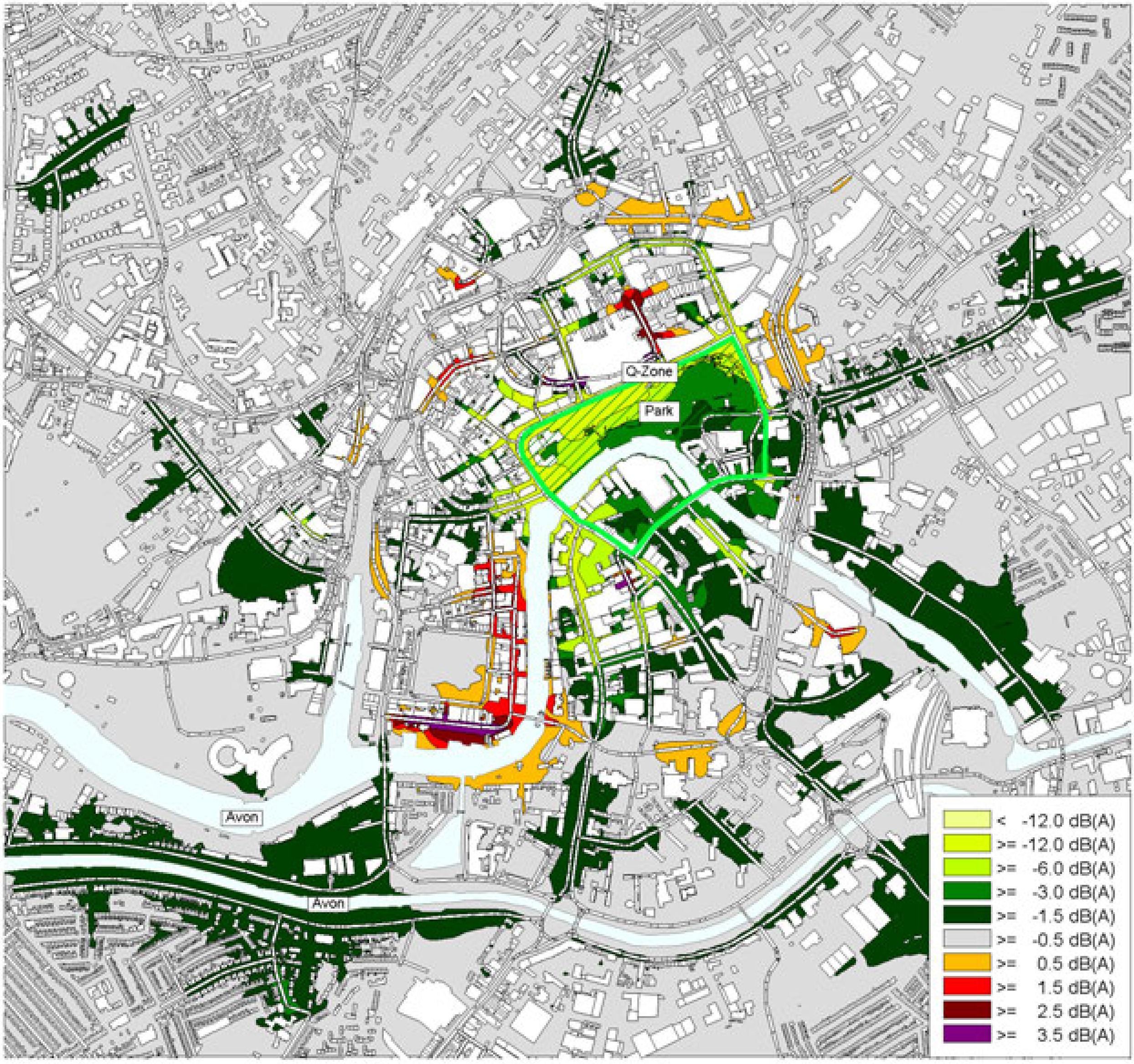

Figure 46: Bristol Scenario 9 – difference to base case - L_{de}

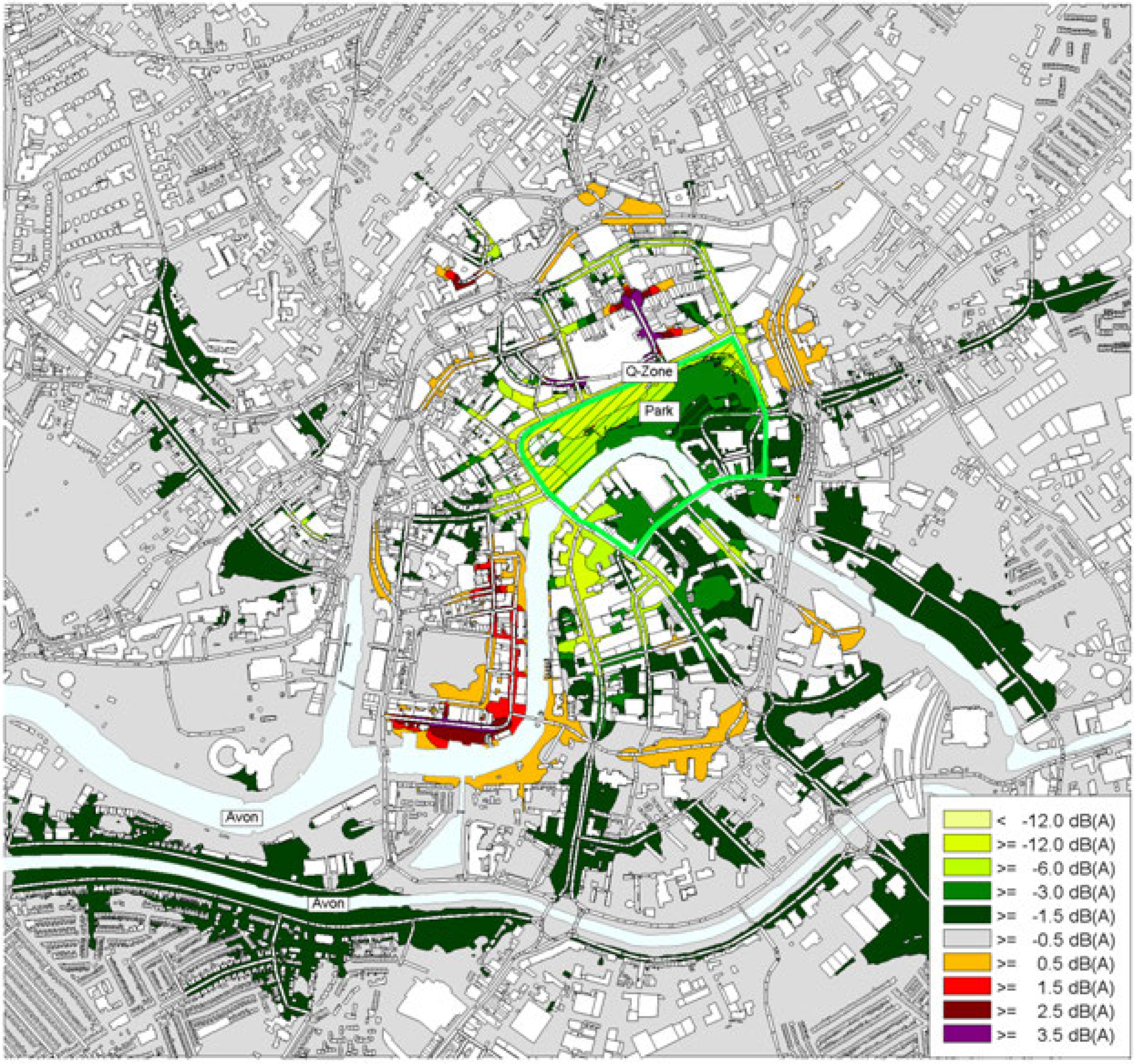

Figure 47: Bristol Scenario 10 – difference to base case - L_{de}

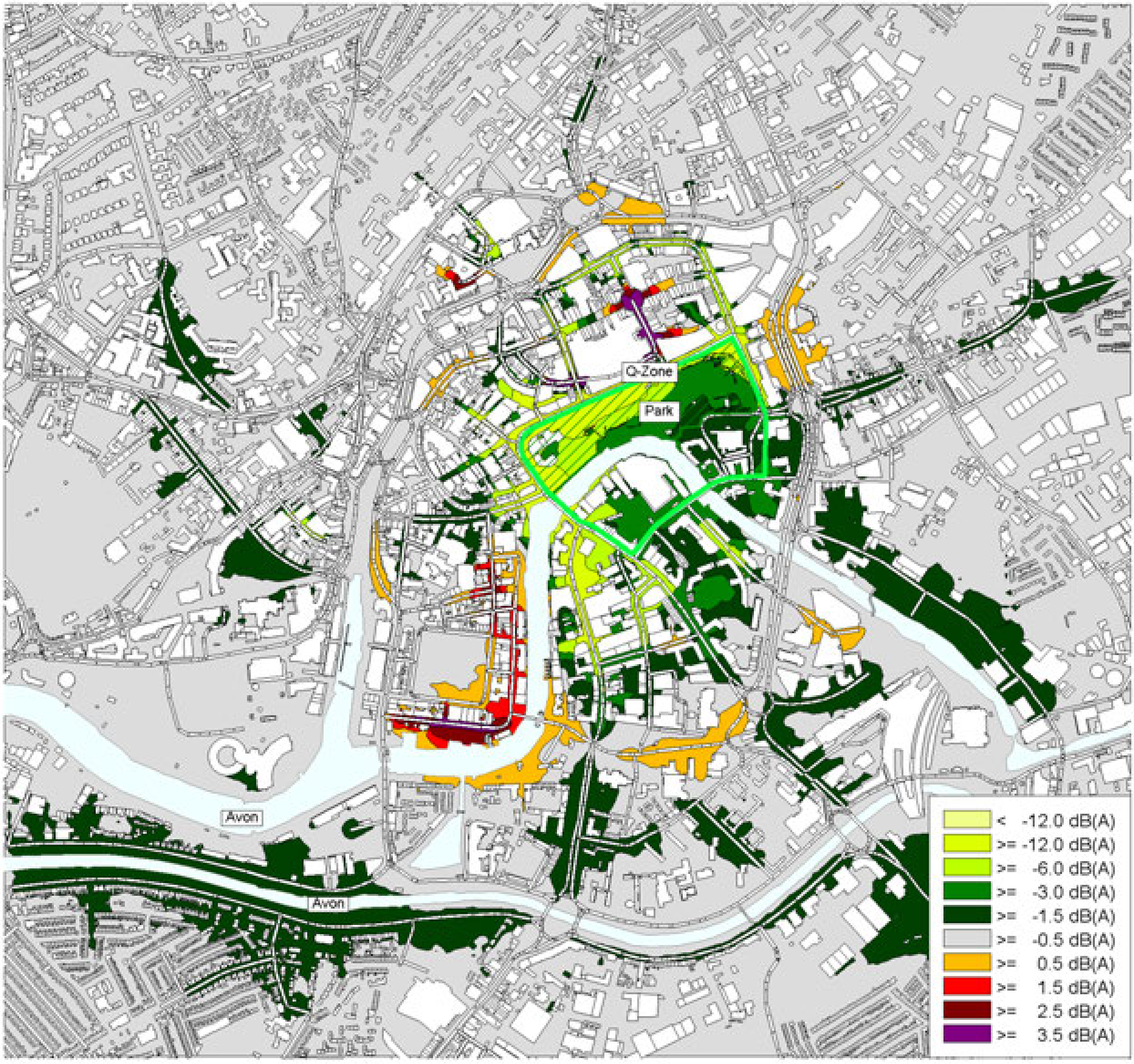

Figure 48: Bristol Scenario 11 – difference to base case - L_{de}

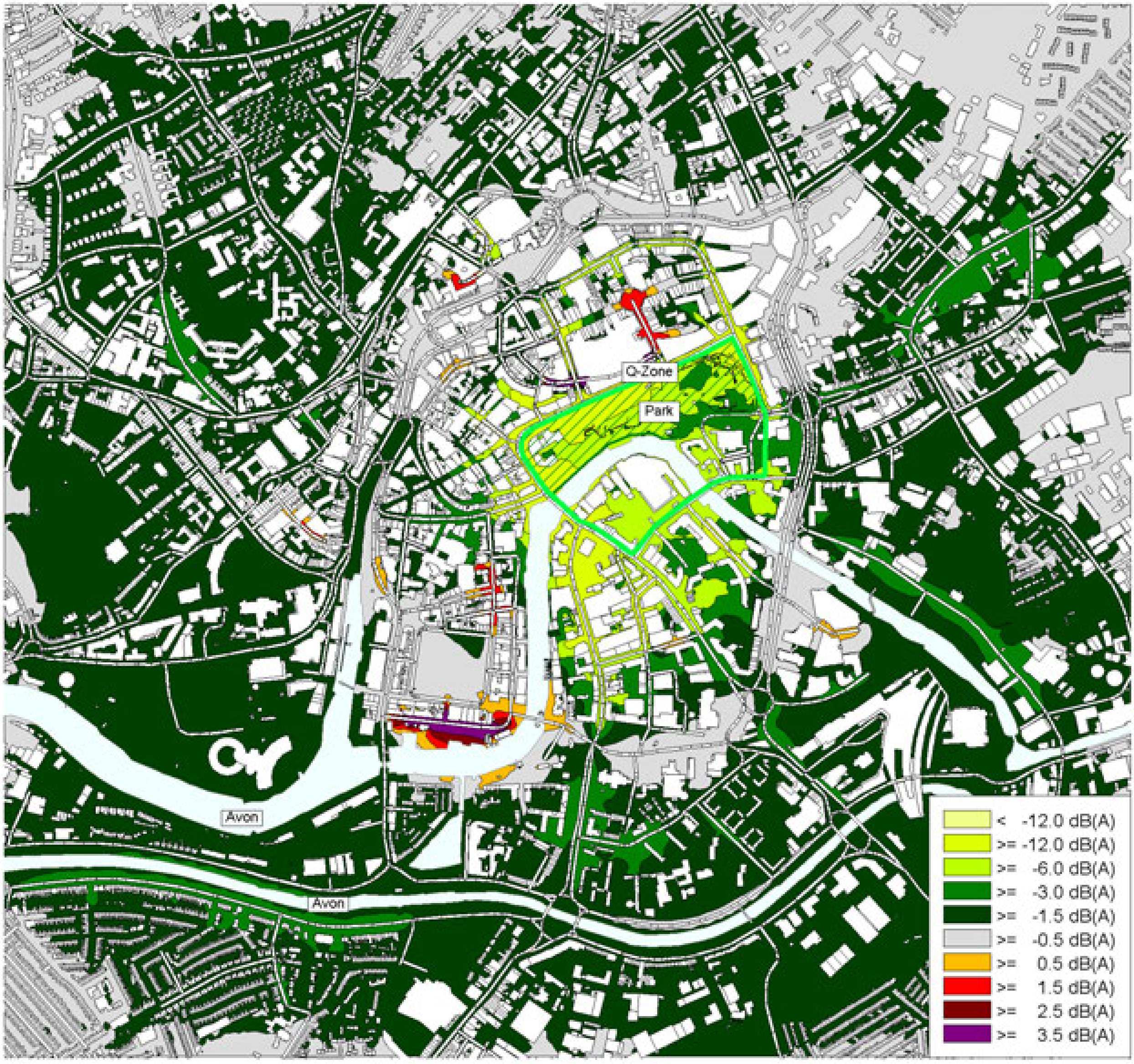

Figure 49: Bristol Scenario 12 – difference to base case - L_{de}

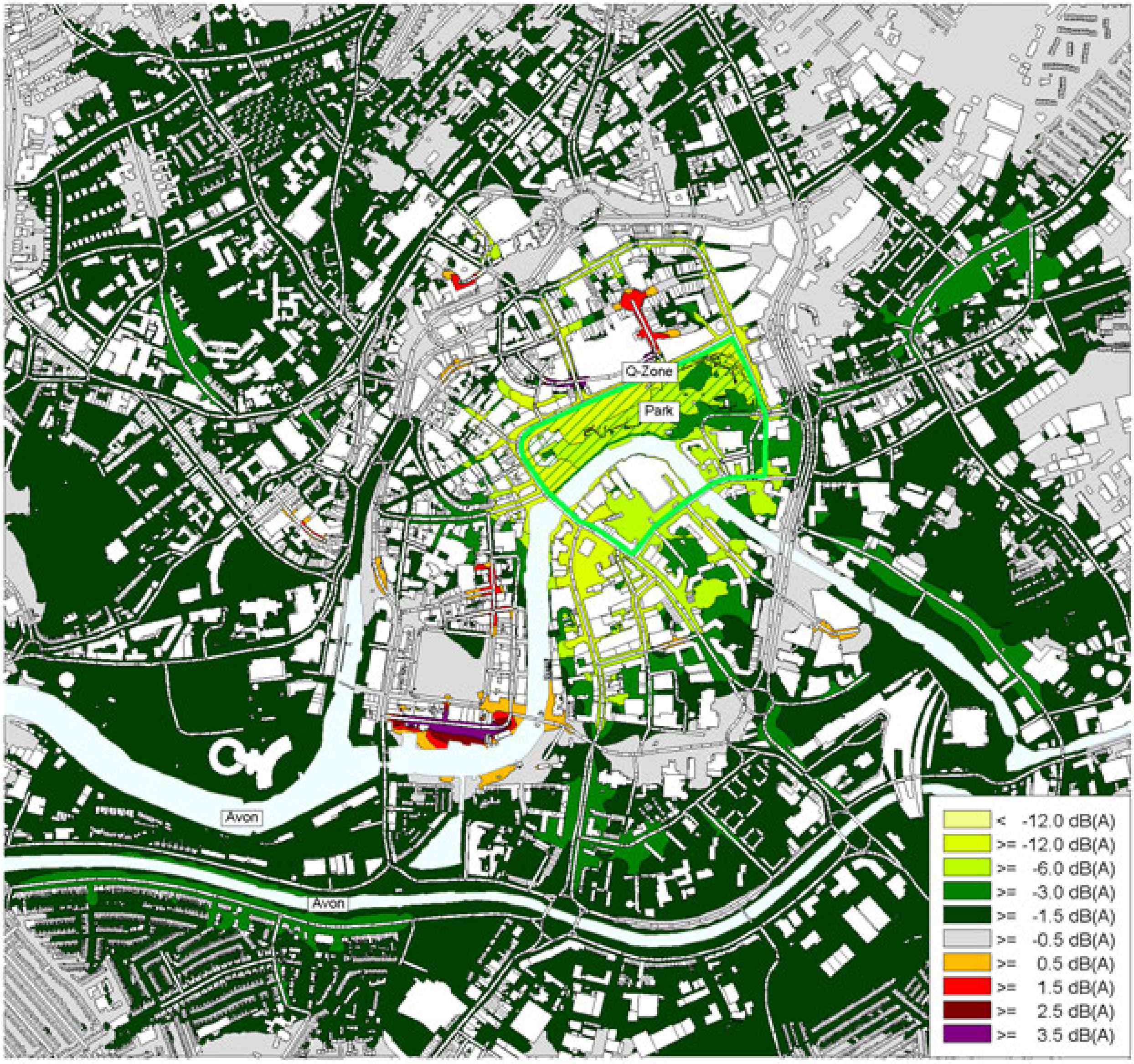

Figure 50: Bristol Scenario 13 – difference to base case - L_{de}

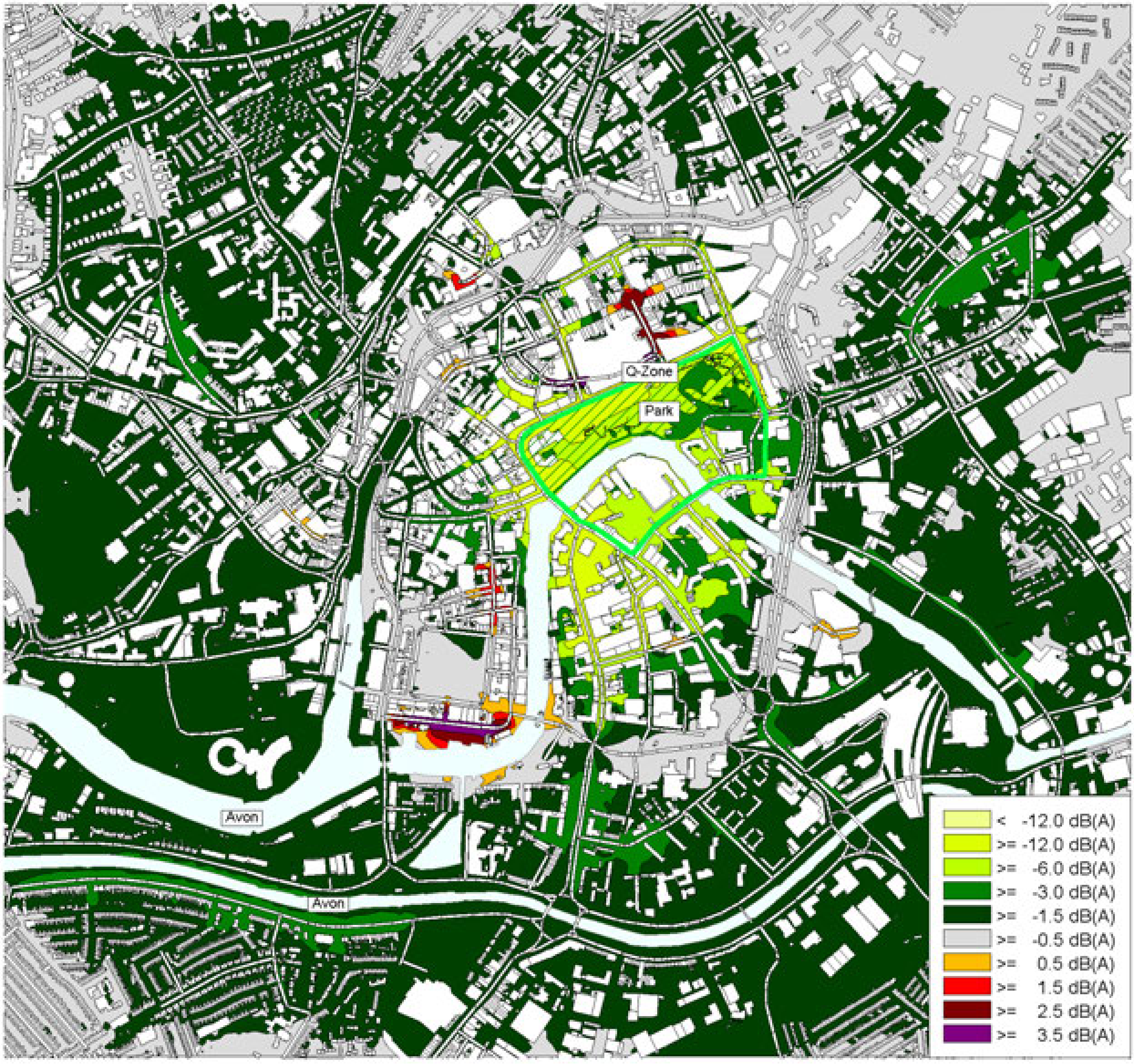

Figure 51: Bristol Scenario 14 – difference to base case - L_{de}

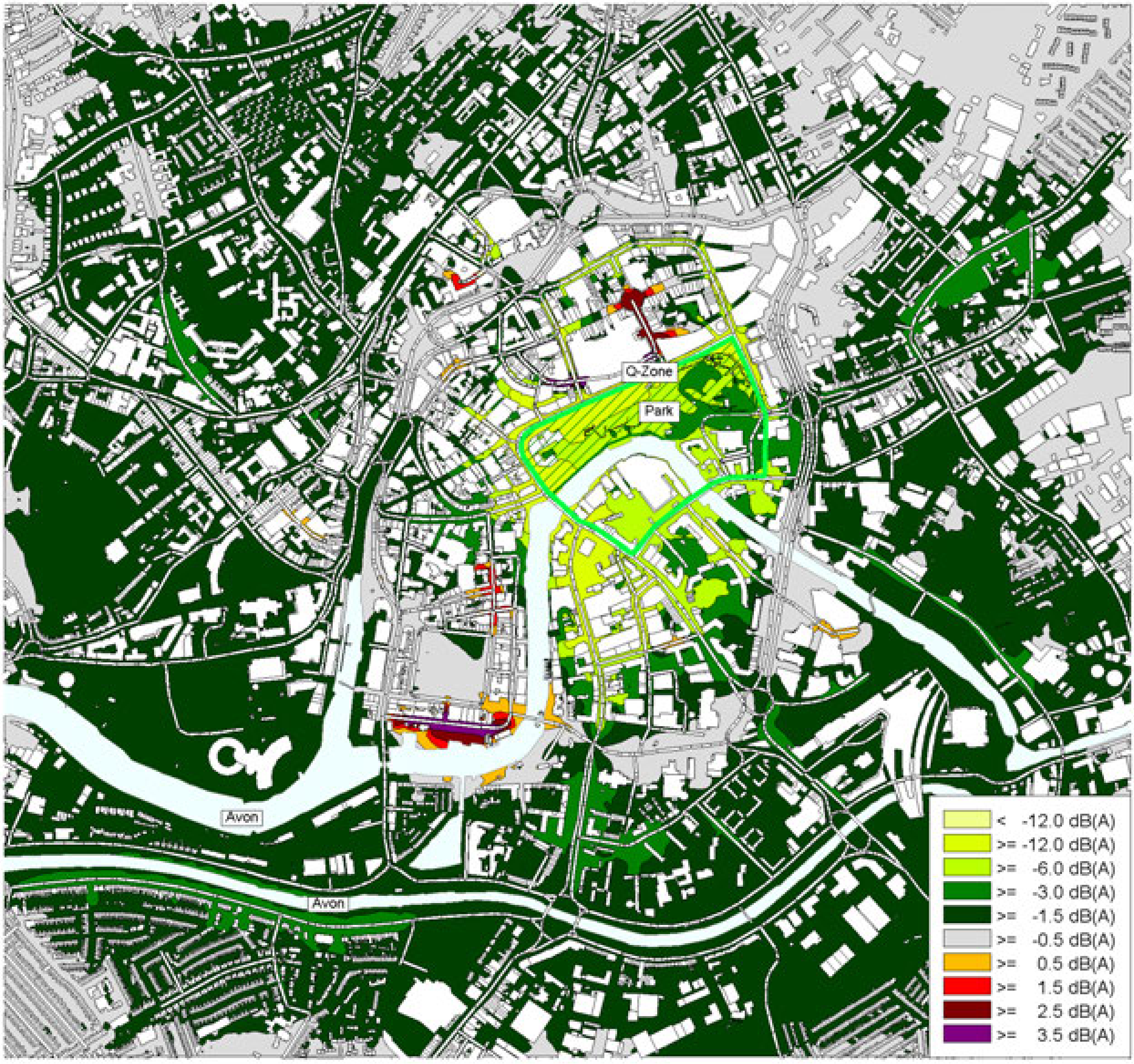

Figure 52: Bristol Scenario 15 – difference to base case - L_{de}

A 3. ADDITIONAL FIGURES FOR THE CITY OF ESSEN

A 3.1 Simulated scenarios for the city of Essen

To provide a better overview we included the definition of the scenarios once again at this point. For Bratislava, the following set of traffic scenarios was simulated:

Scenario nr	Zone	Fee, Euros/passage	Inside LNVO percentage	External LNVO percentage
1	none	none	1	1
2	large	ban	1	1
3	large	1	1	1
4	large	0.5	1	1
5	small	ban	1	1
6	small	1	1	1
7	small	0.5	1	1
8	none	none	5	5
9	large	ban	20	5
10	XL	ban	1	1
11	XXL	ban	1	1
12	none	none	20	20
13	large	ban	100	20
14	XXL	ban	100	20
15	large	0.5	100	20

A 3.2 Noise maps for the city of Essen - 15 scenarios

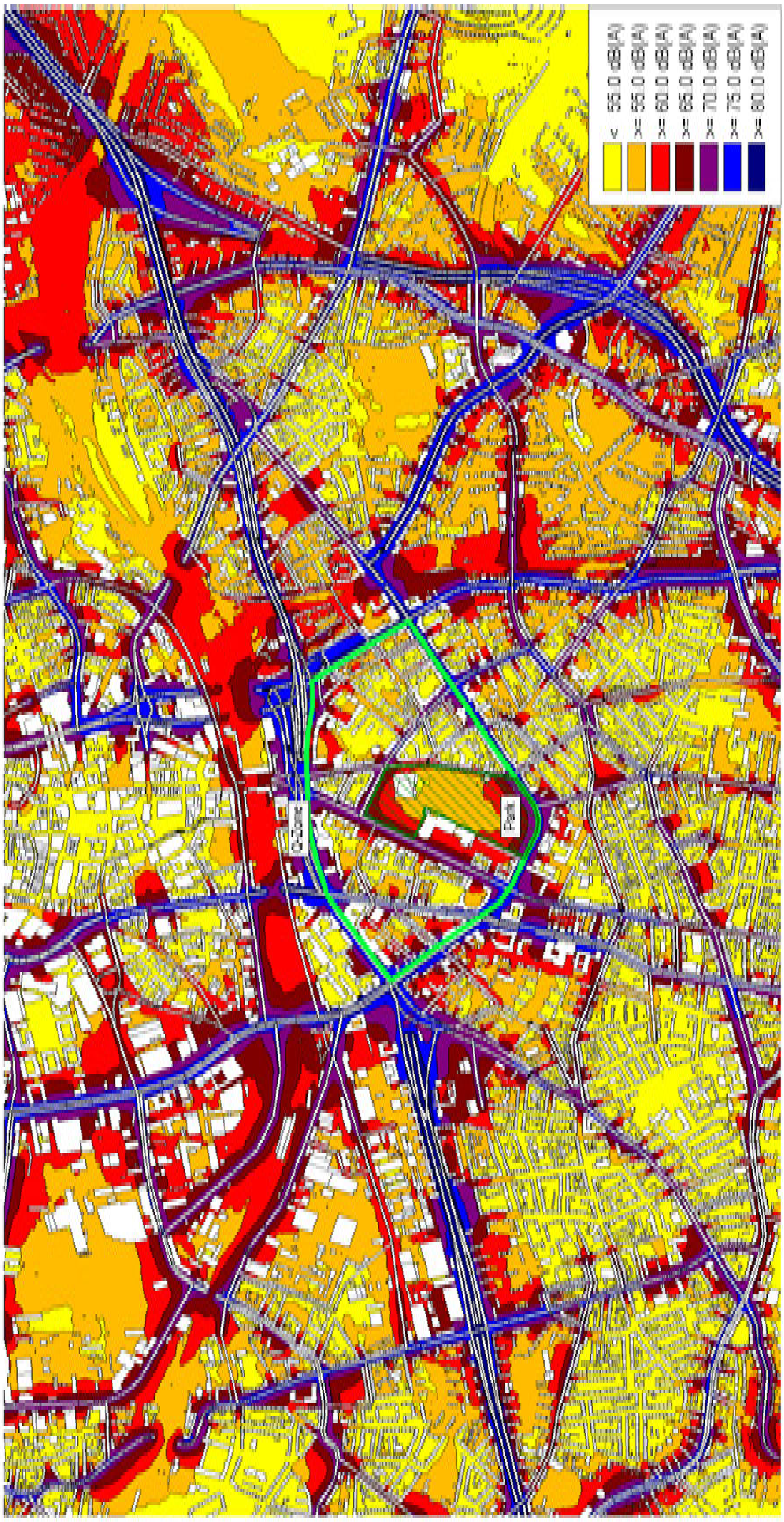

Figure 53: Essen Scenario 1 (Base Case) - L_{de}

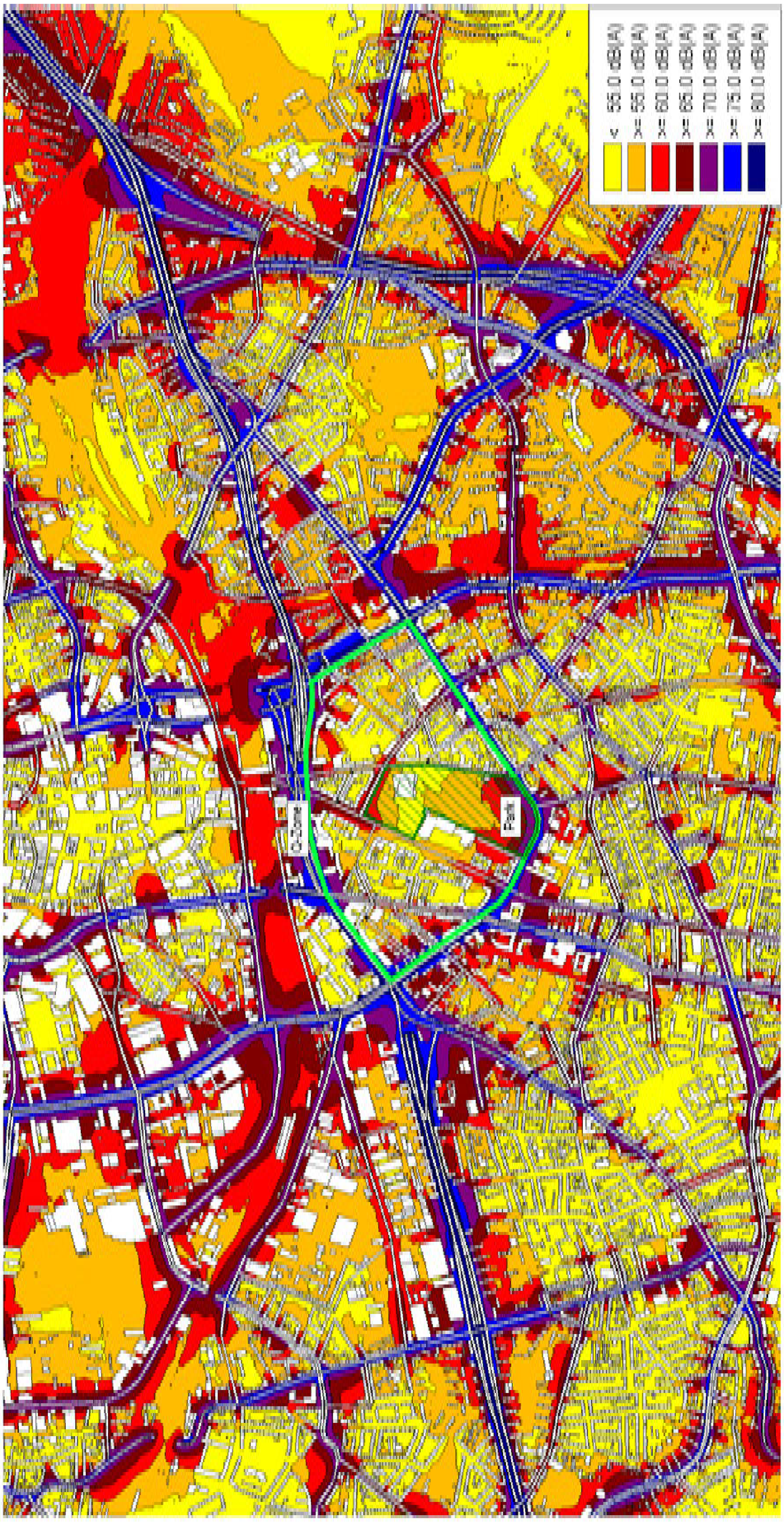

Figure 54: Essen Scenario 2 - L_{de}

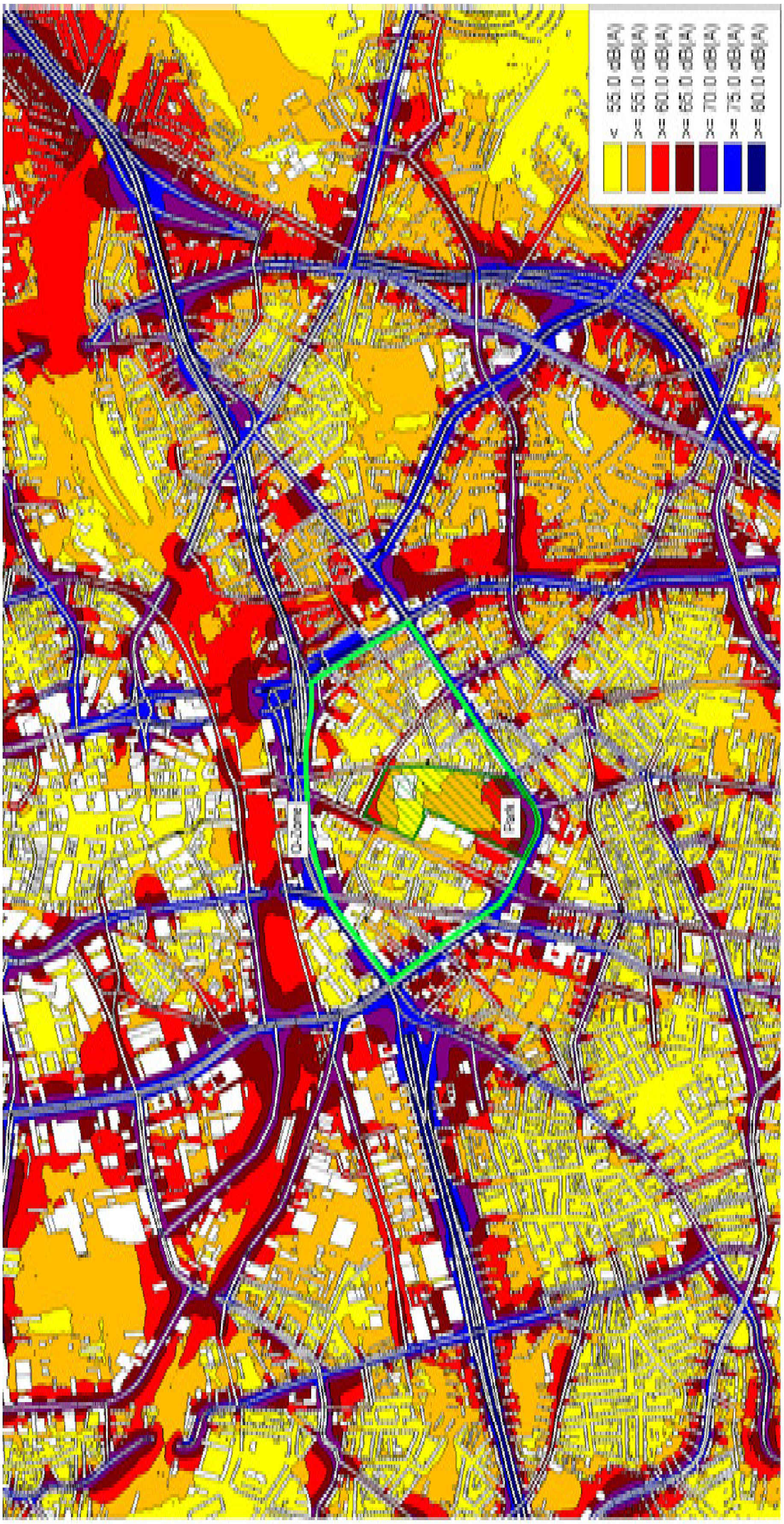

Figure 55: Essen Scenario 3 - L_{de}

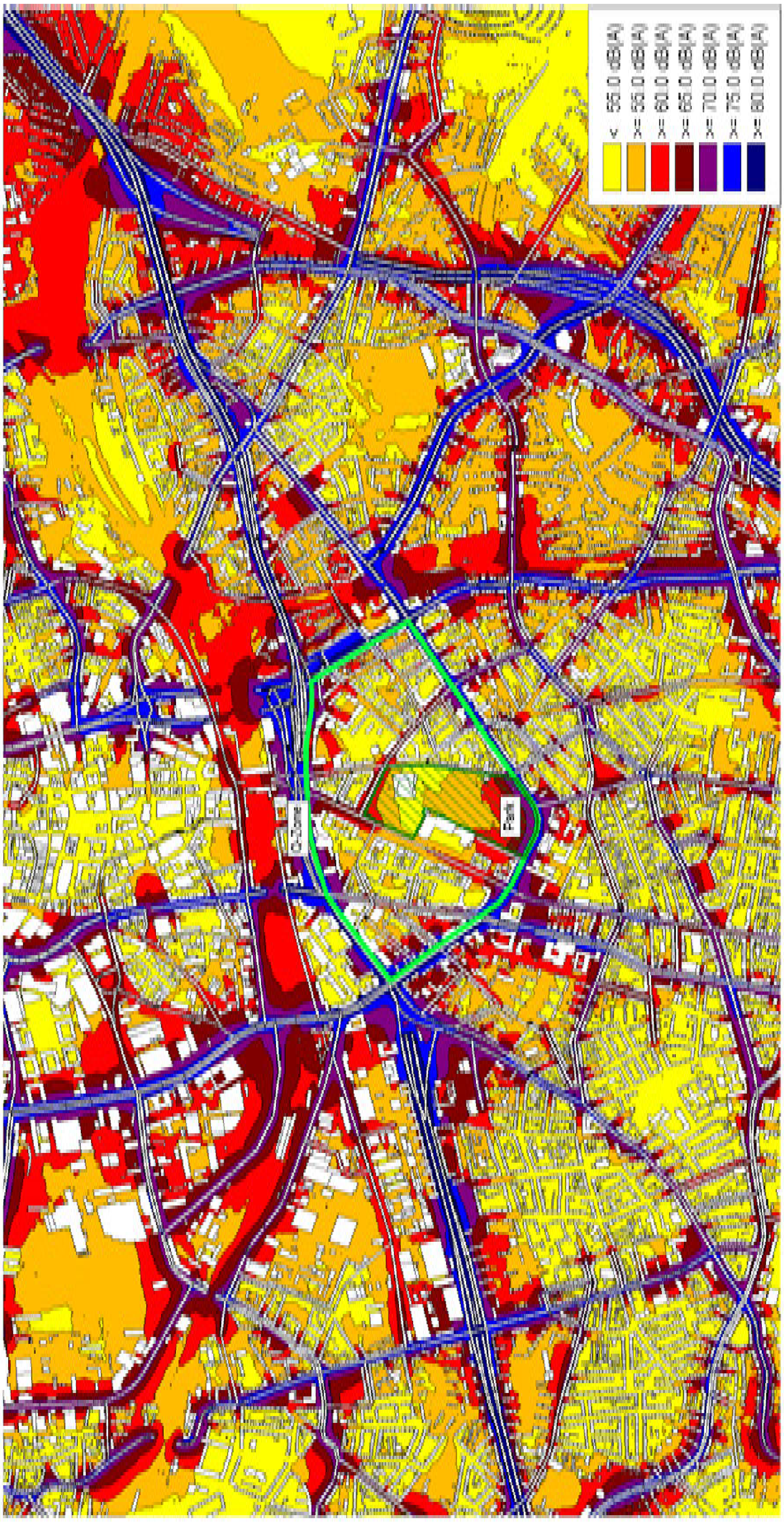

Figure 56: Essen Scenario 4 - L_{de}

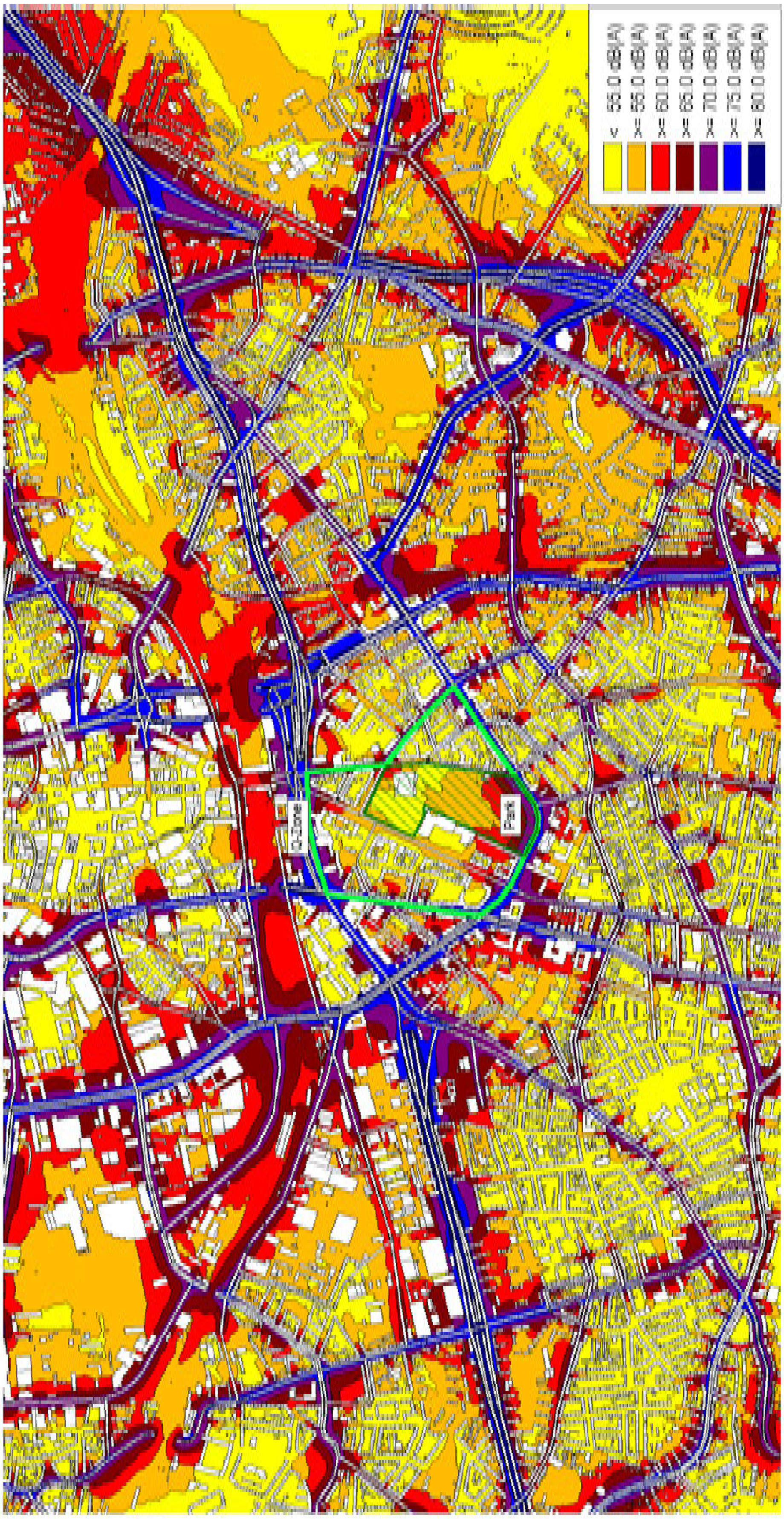

Figure 57: Essen Scenario 5 - L_{de}

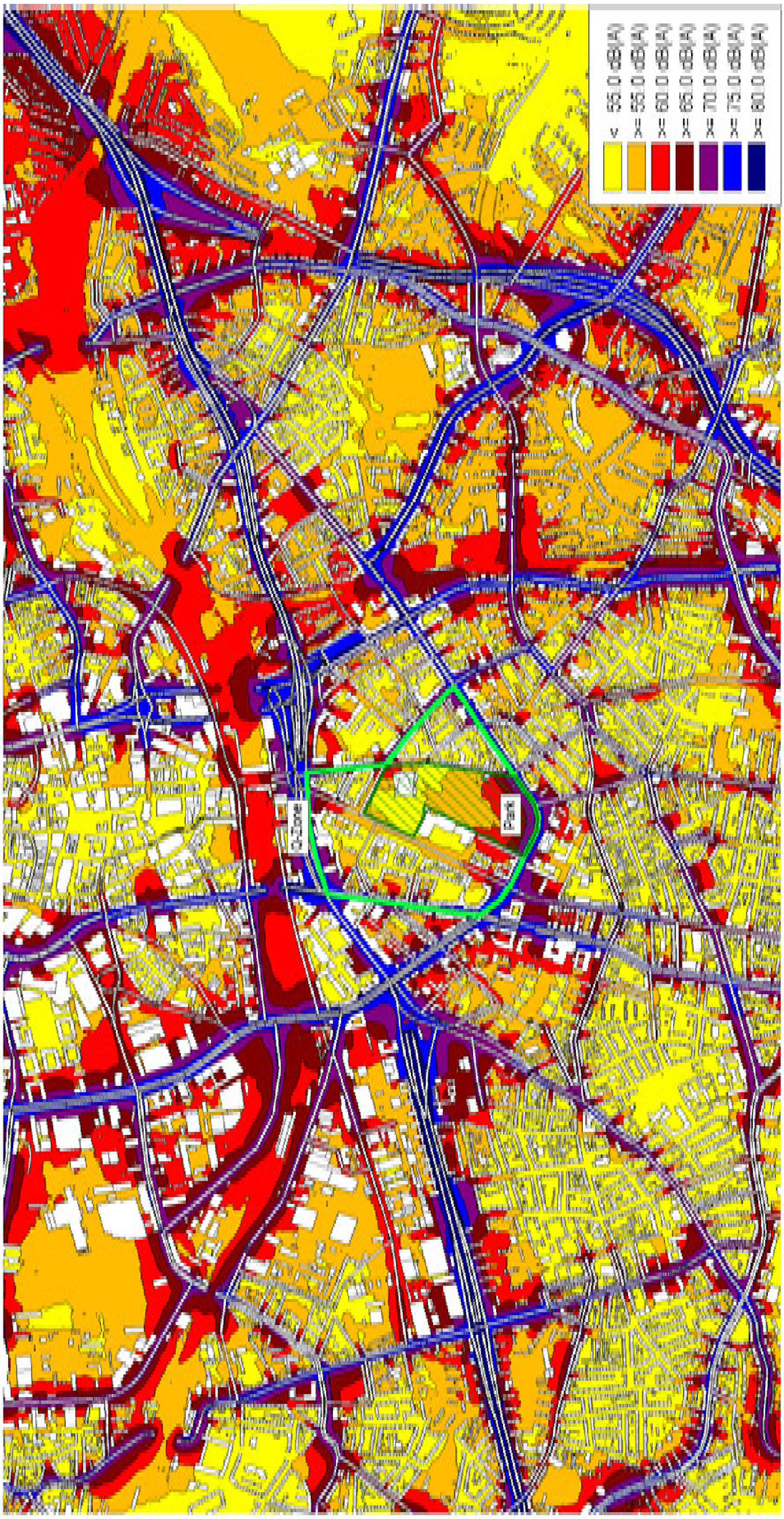

Figure 58: Essen Scenario 6 - L_{de}

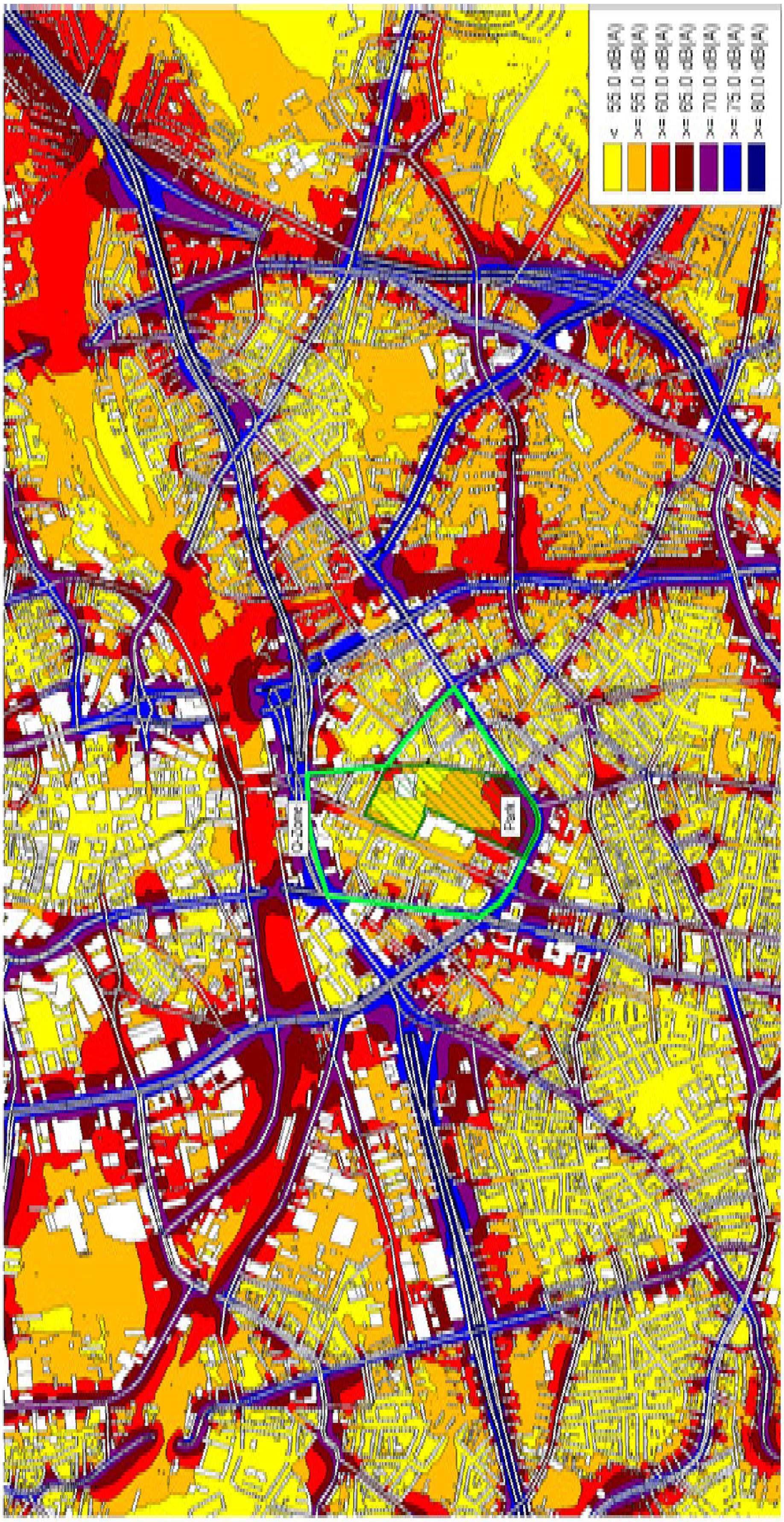

Figure 59: Essen Scenario 7 - L_{de}

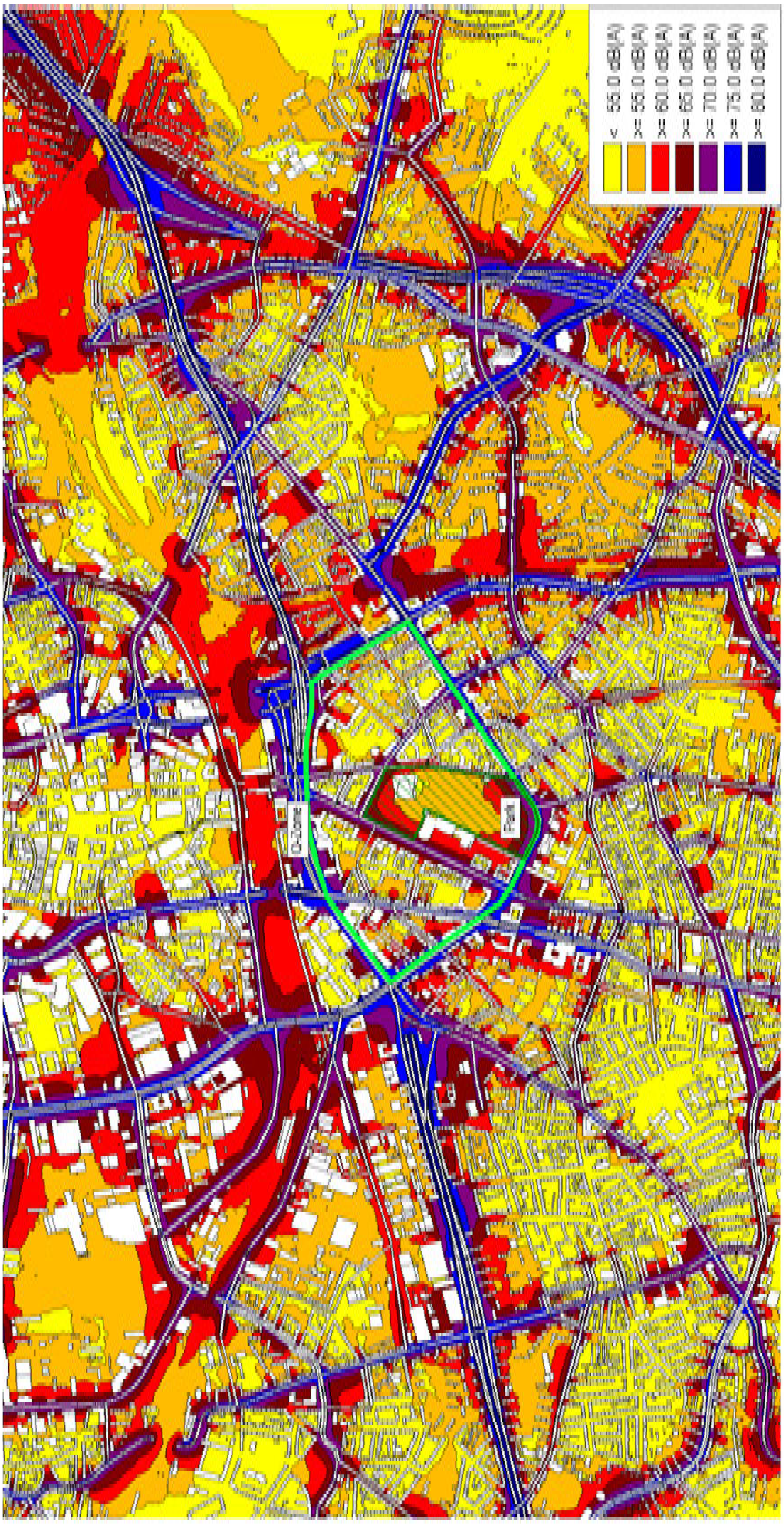

Figure 60: Essen Scenario 8 - L_{de}

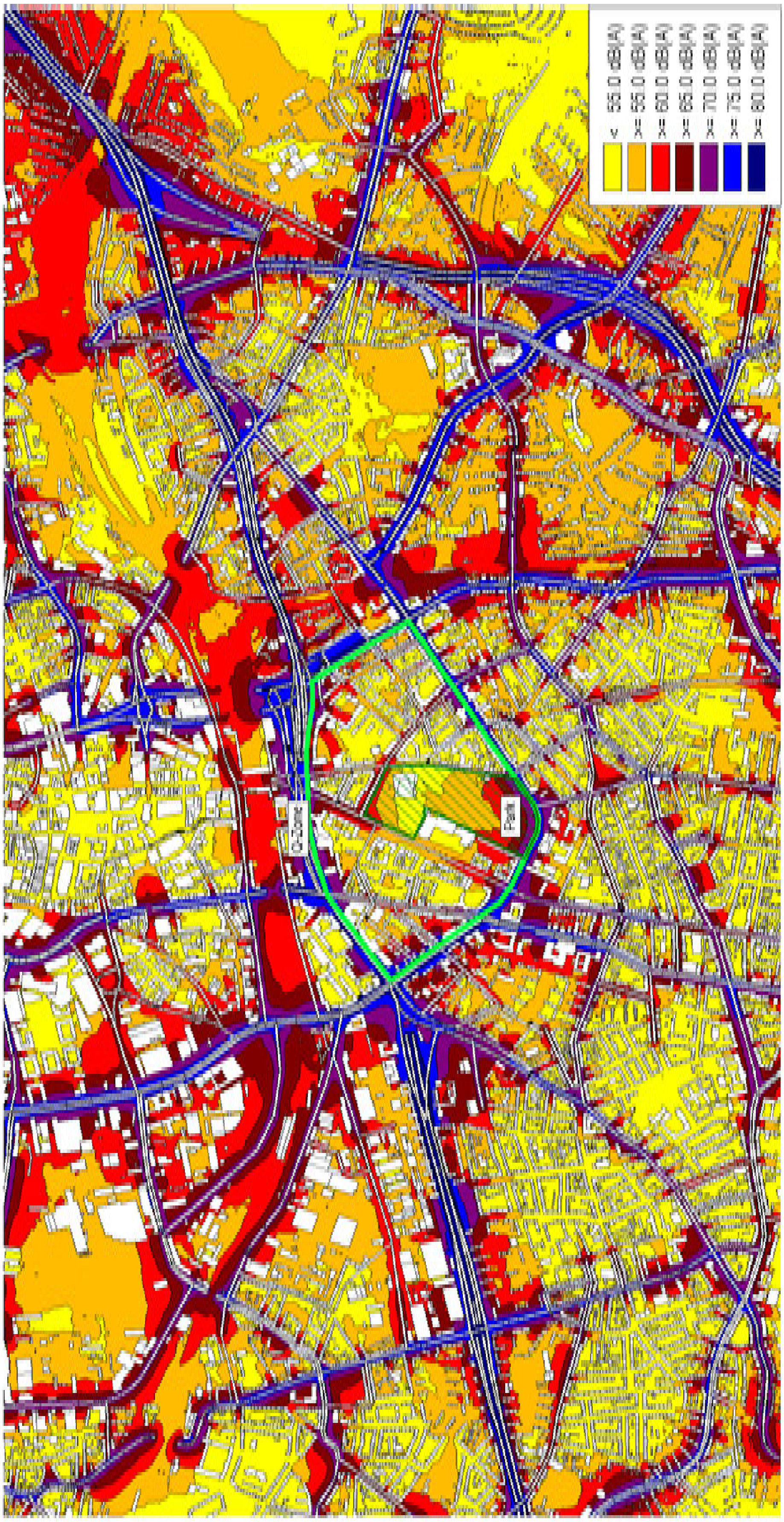

Figure 61: Essen Scenario 9 - L_{de}

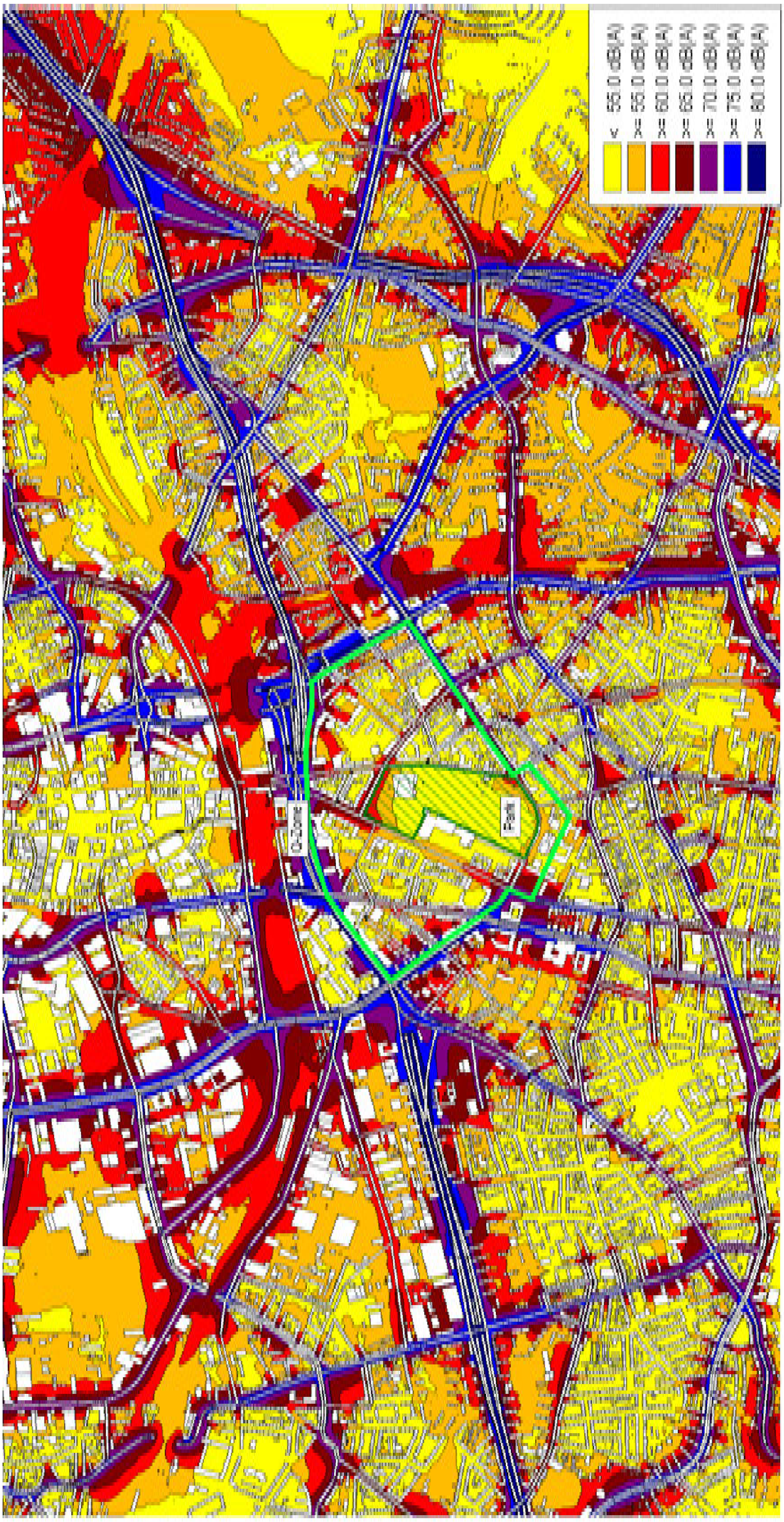

Figure 62: Essen Scenario 10 - L_{de}

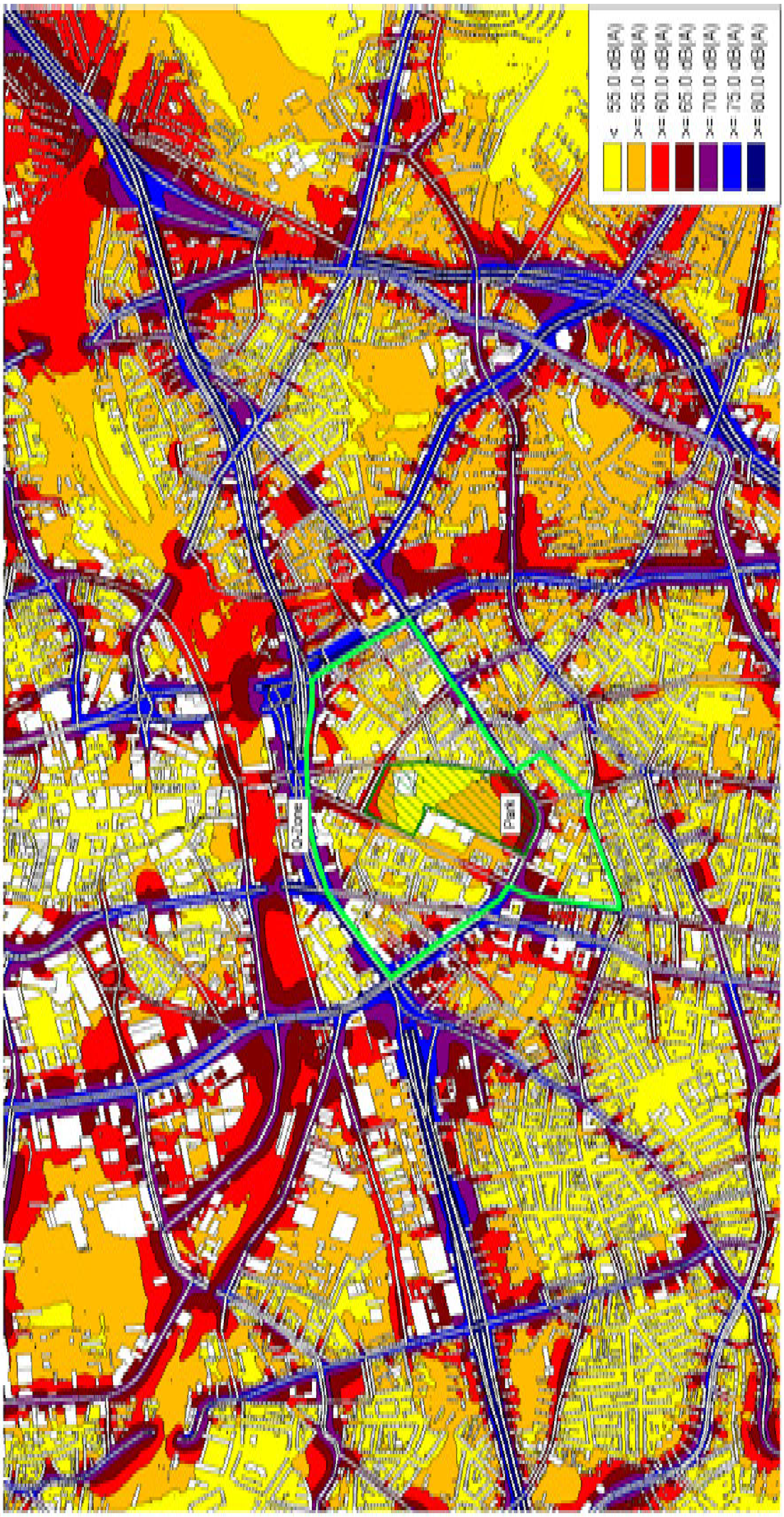

Figure 63: Essen Scenario 11 - L_{de}

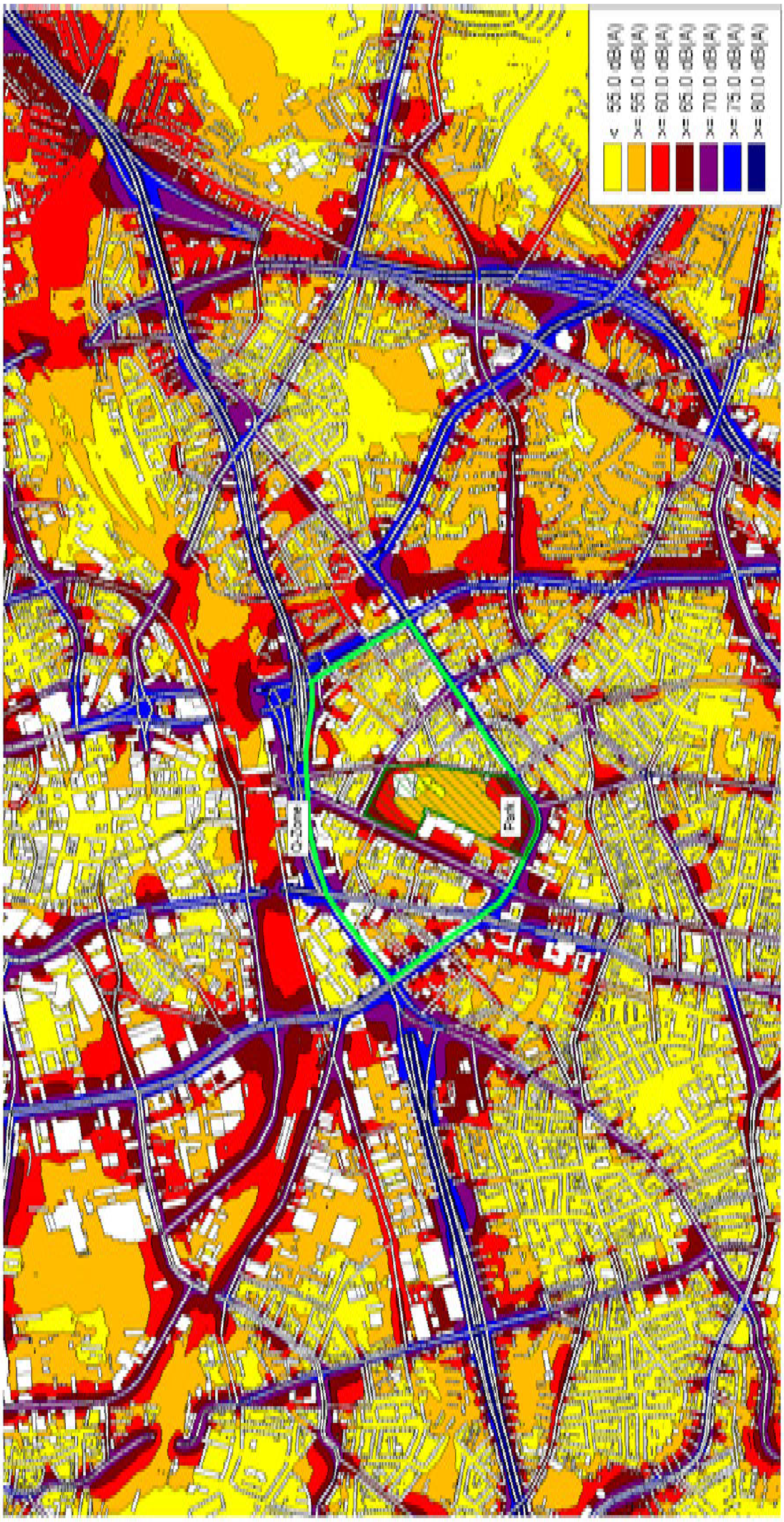

Figure 64: Essen Scenario 12 - L_{de}

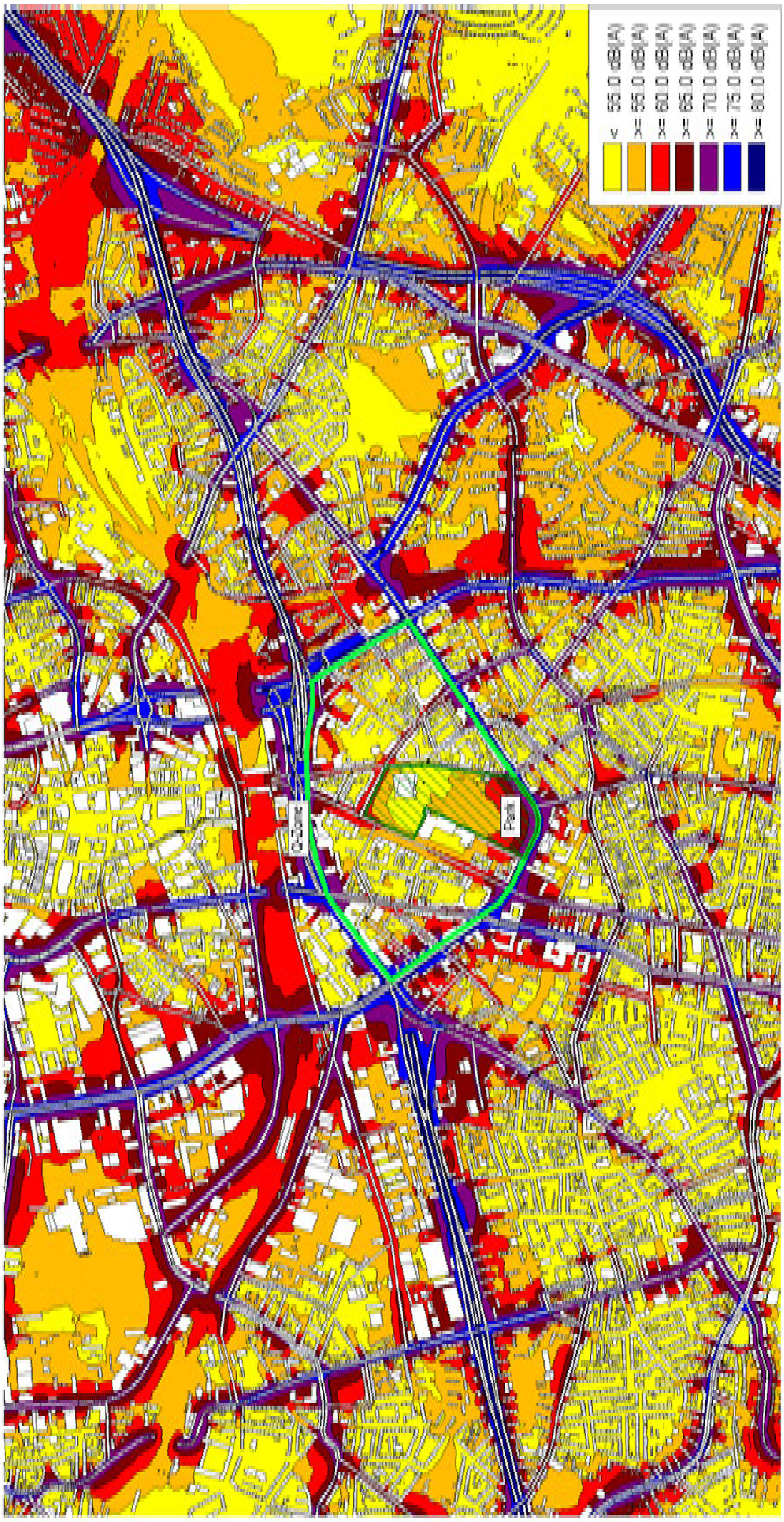

Figure 65: Essen Scenario 13 - L_{de}

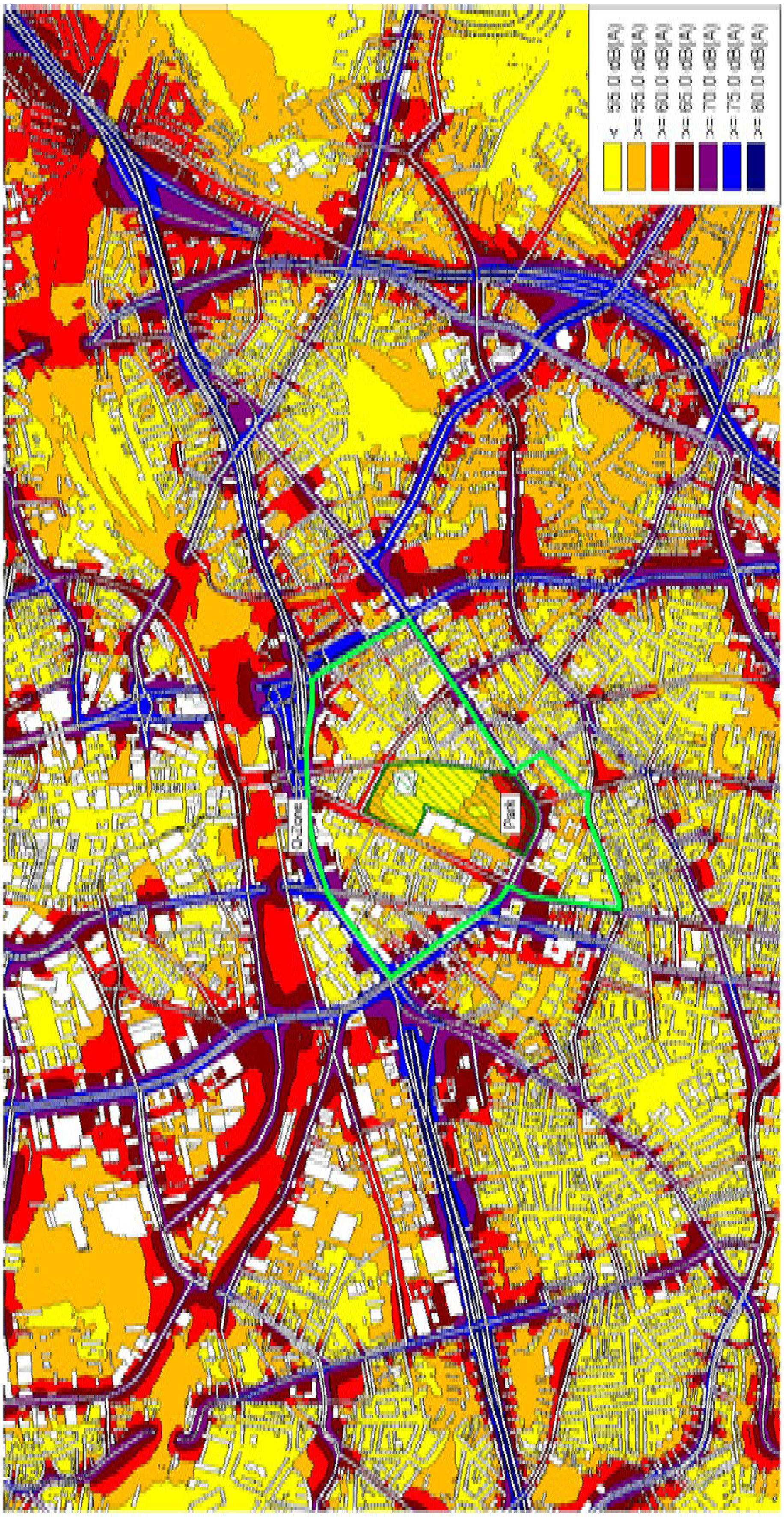

Figure 66: Essen Scenario 14 - L_{de}

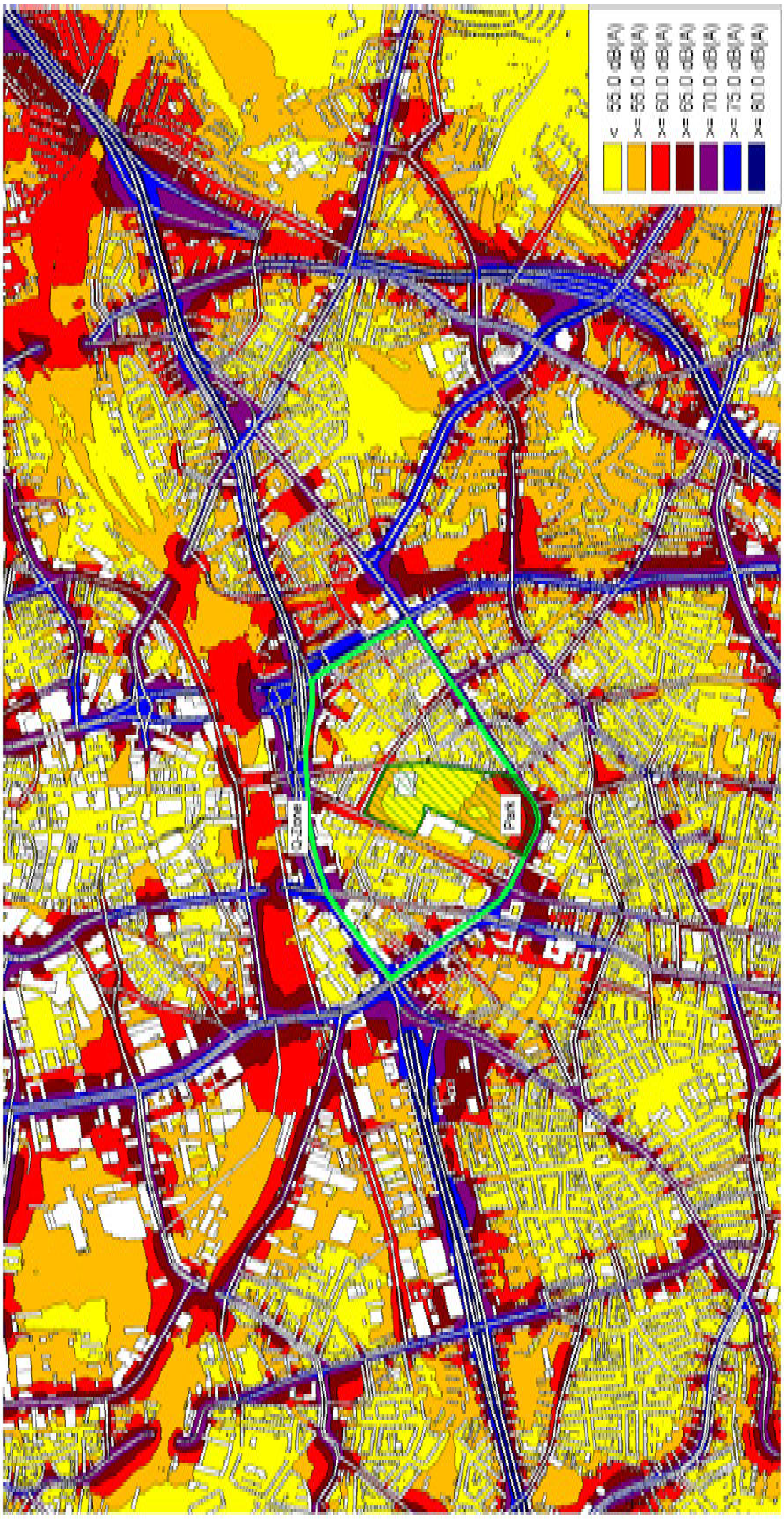

Figure 67: Essen Scenario 15 - L_{de}

A 3.3 Noise difference maps for the city of Essen

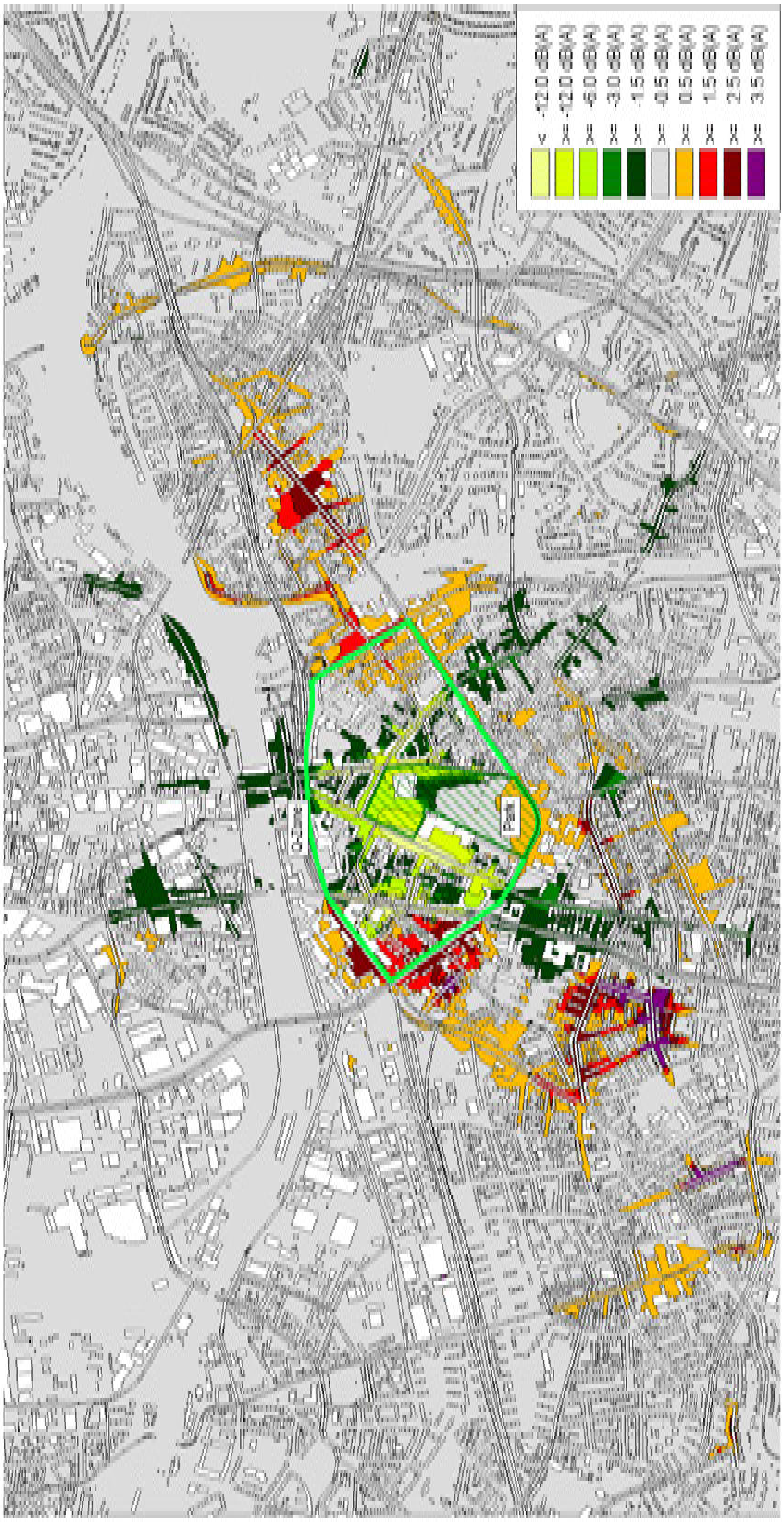

Figure 68: Essen Scenario 2 – difference to base case - L_{de}

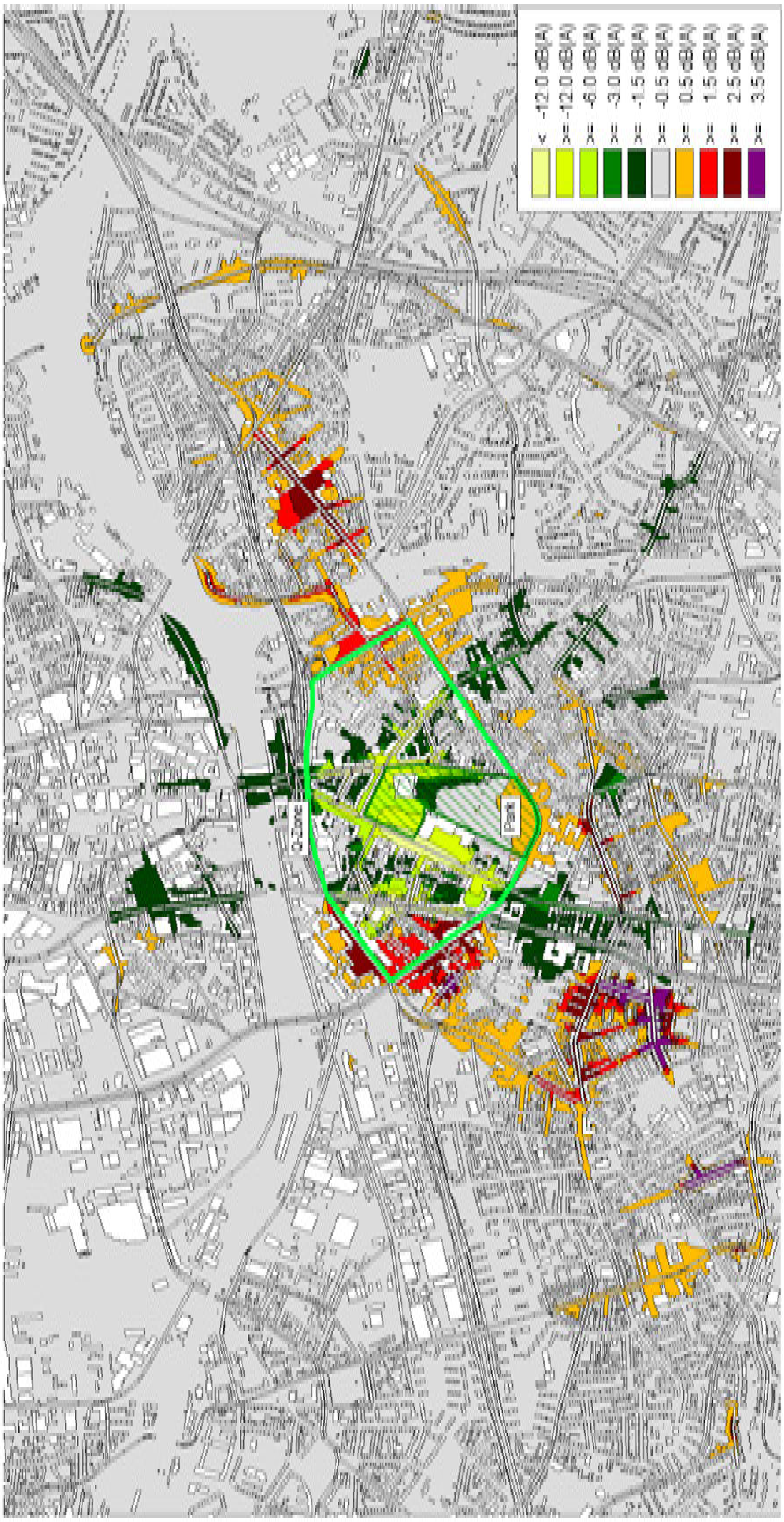

Figure 69: Essen Scenario 3 – difference to base case - L_{de}

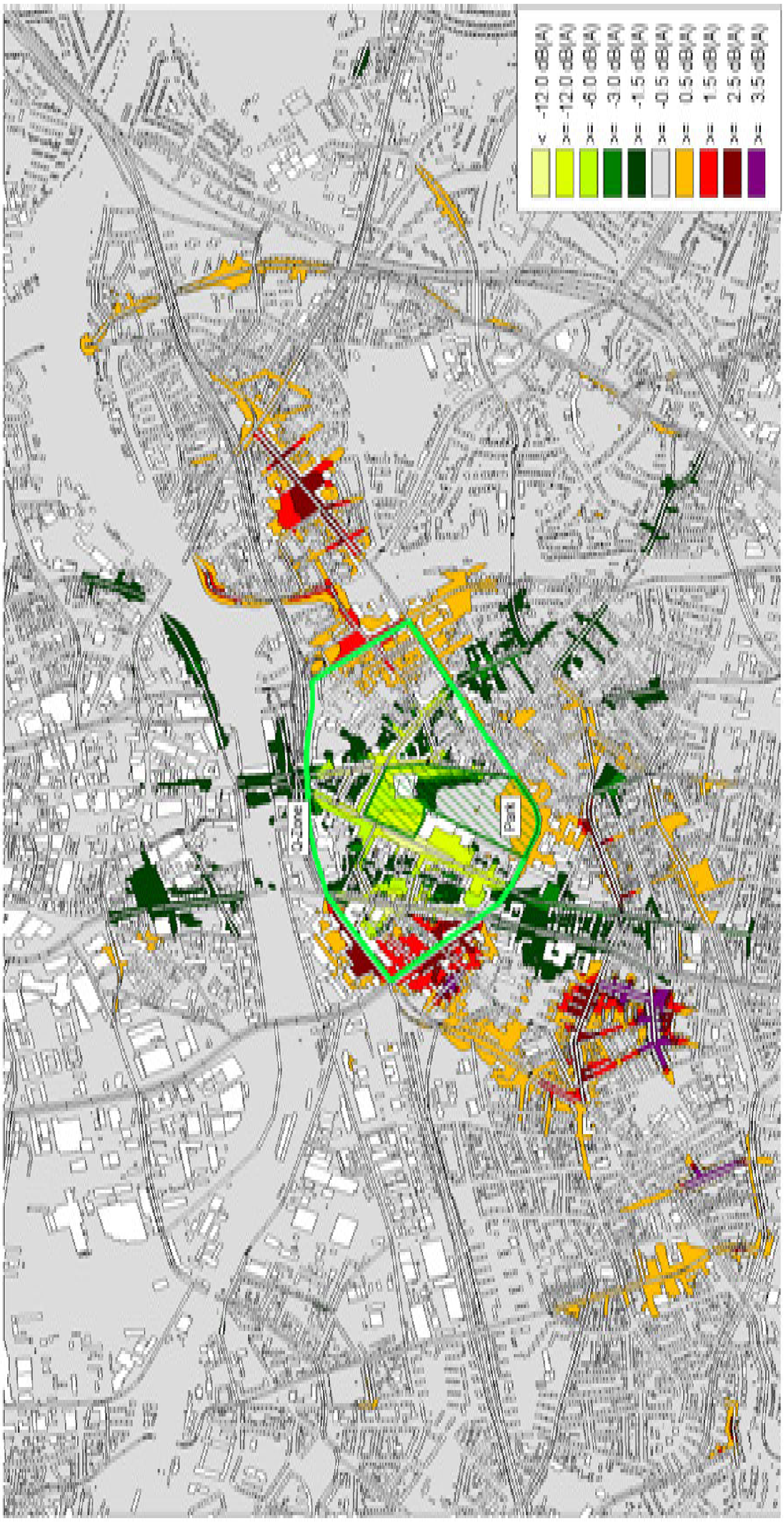

Figure 70: Essen Scenario 4 – difference to base case - L_{de}

Figure 71: Essen Scenario 5 – difference to base case - L_{de}

Figure 72: Essen Scenario 6 – difference to base case - L_{de}

Figure 73: Essen Scenario 7 – difference to base case - L_{de}

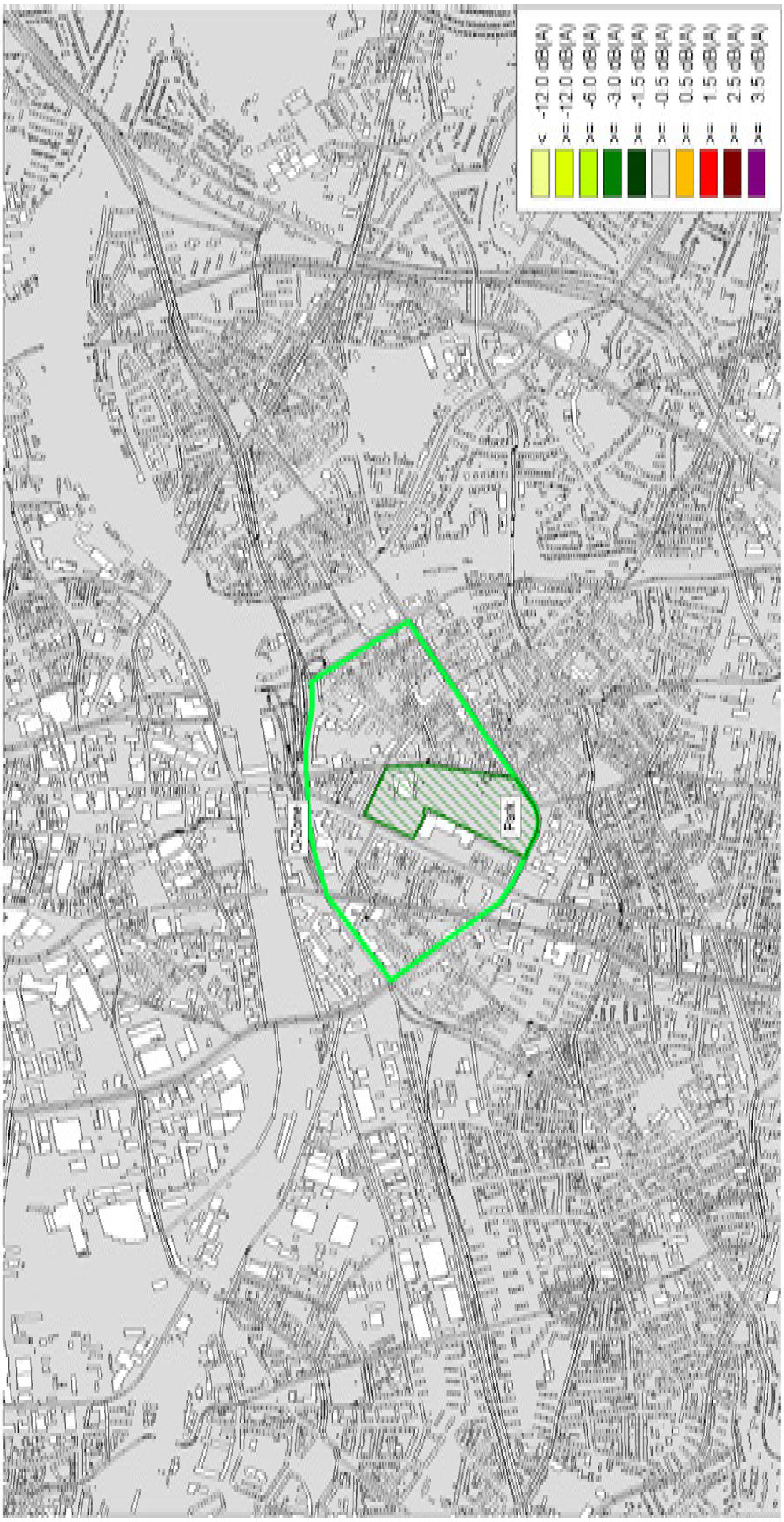

Figure 74: Essen Scenario 8 – difference to base case - L_{de}

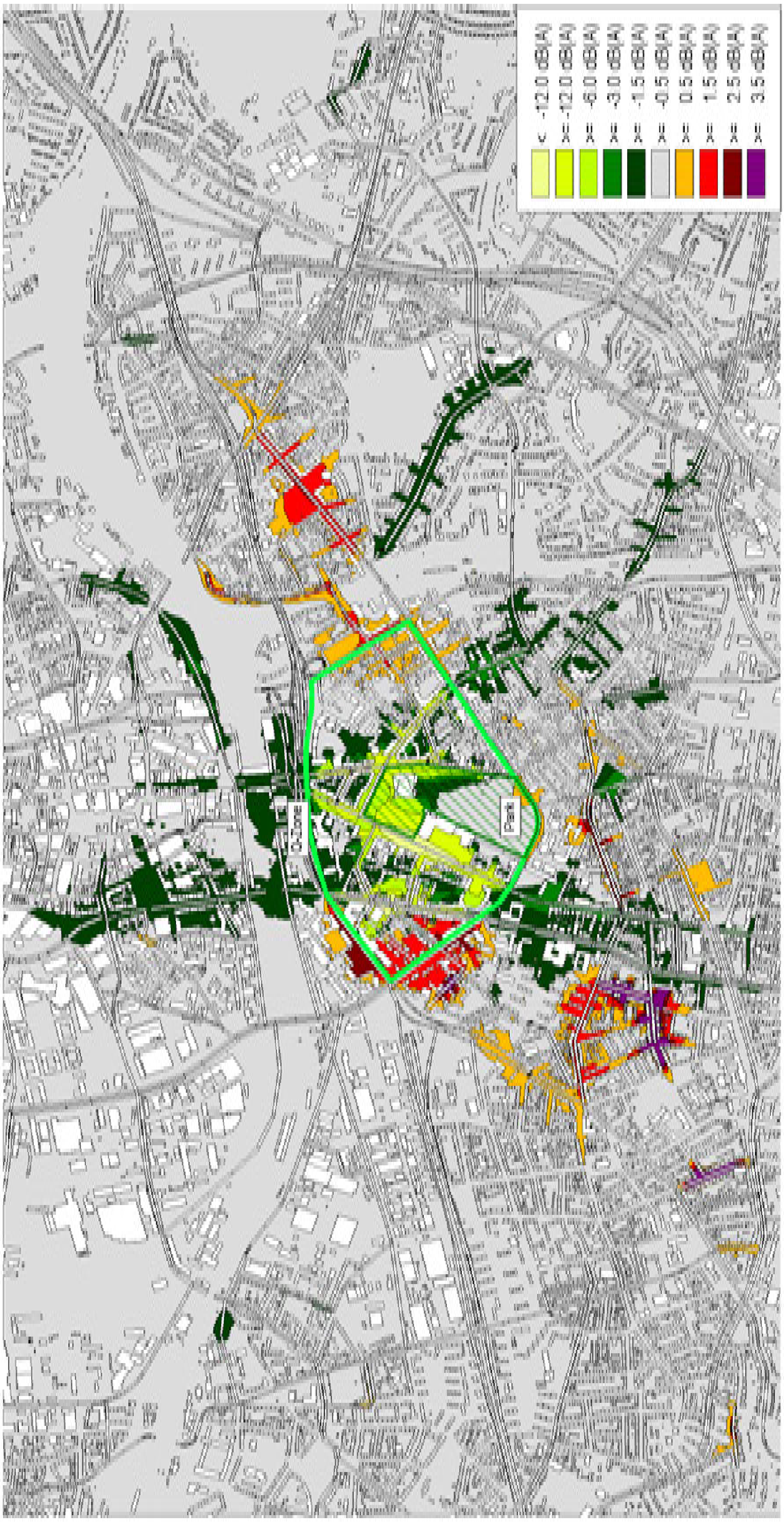

Figure 75: Essen Scenario 9 – difference to base case - L_{de}

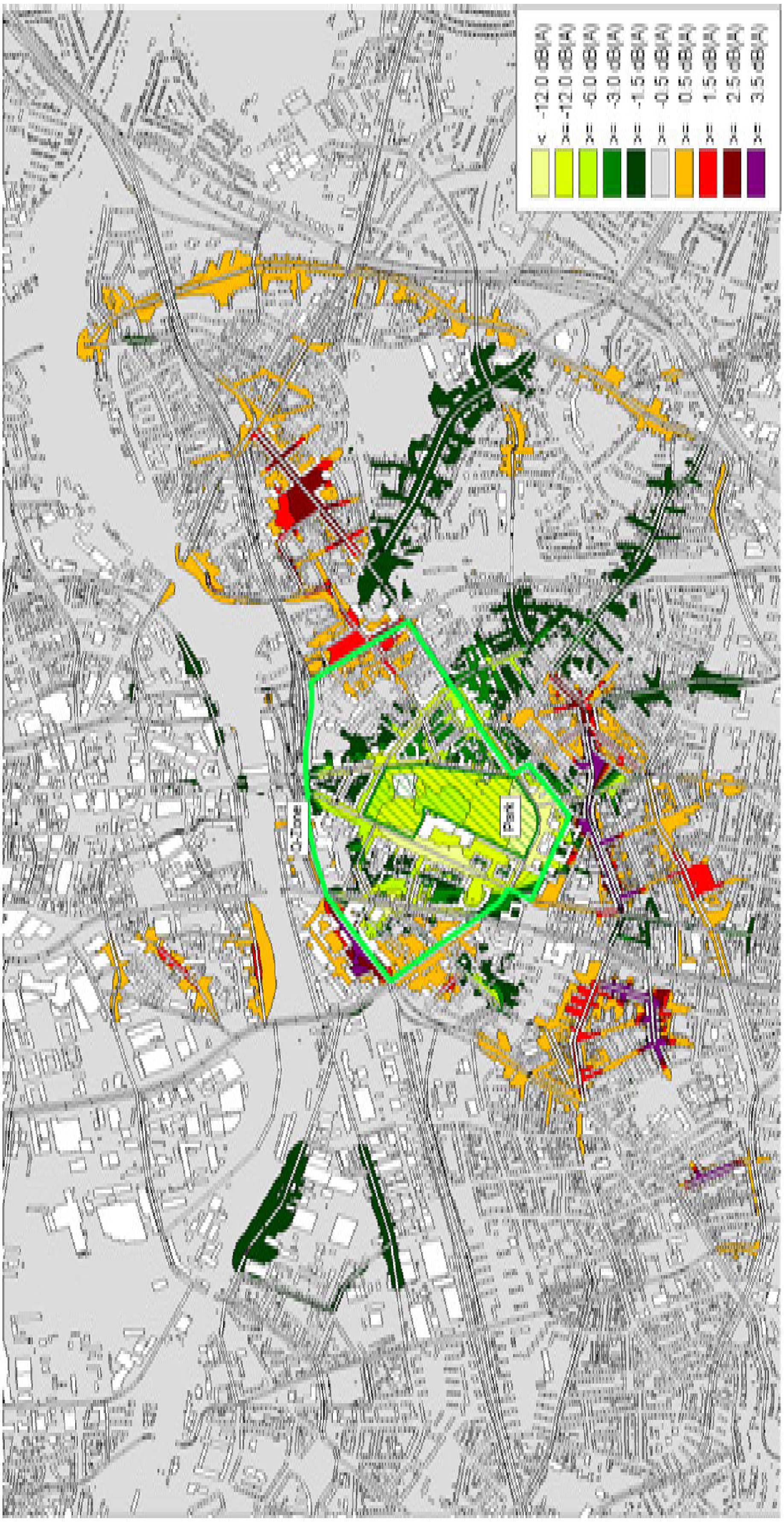

Figure 76: Essen Scenario 10 – difference to base case - L_{de}

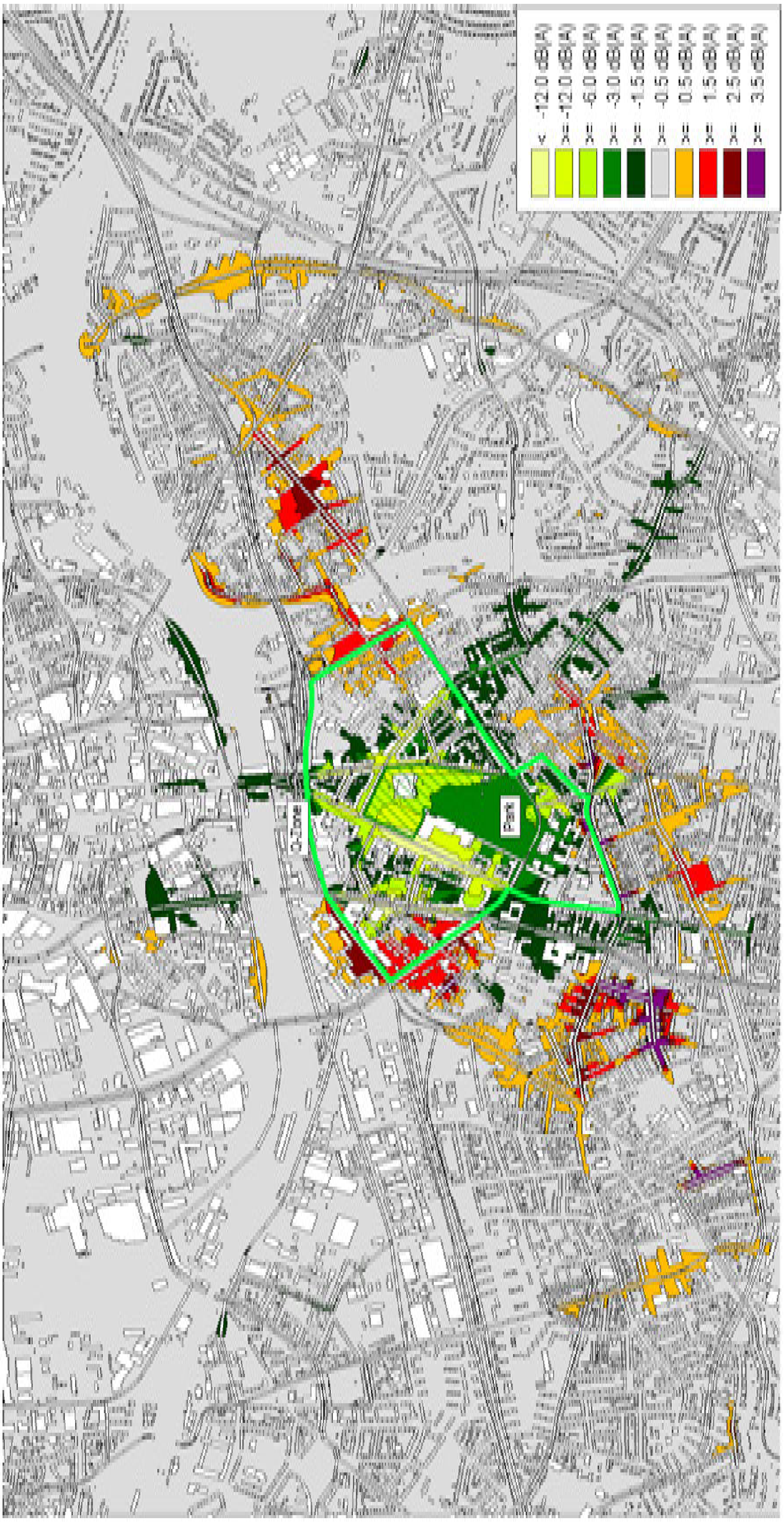

Figure 77: Essen Scenario 11 – difference to base case - L_{de}

Figure 78: Essen Scenario 12 – difference to base case - L_{de}

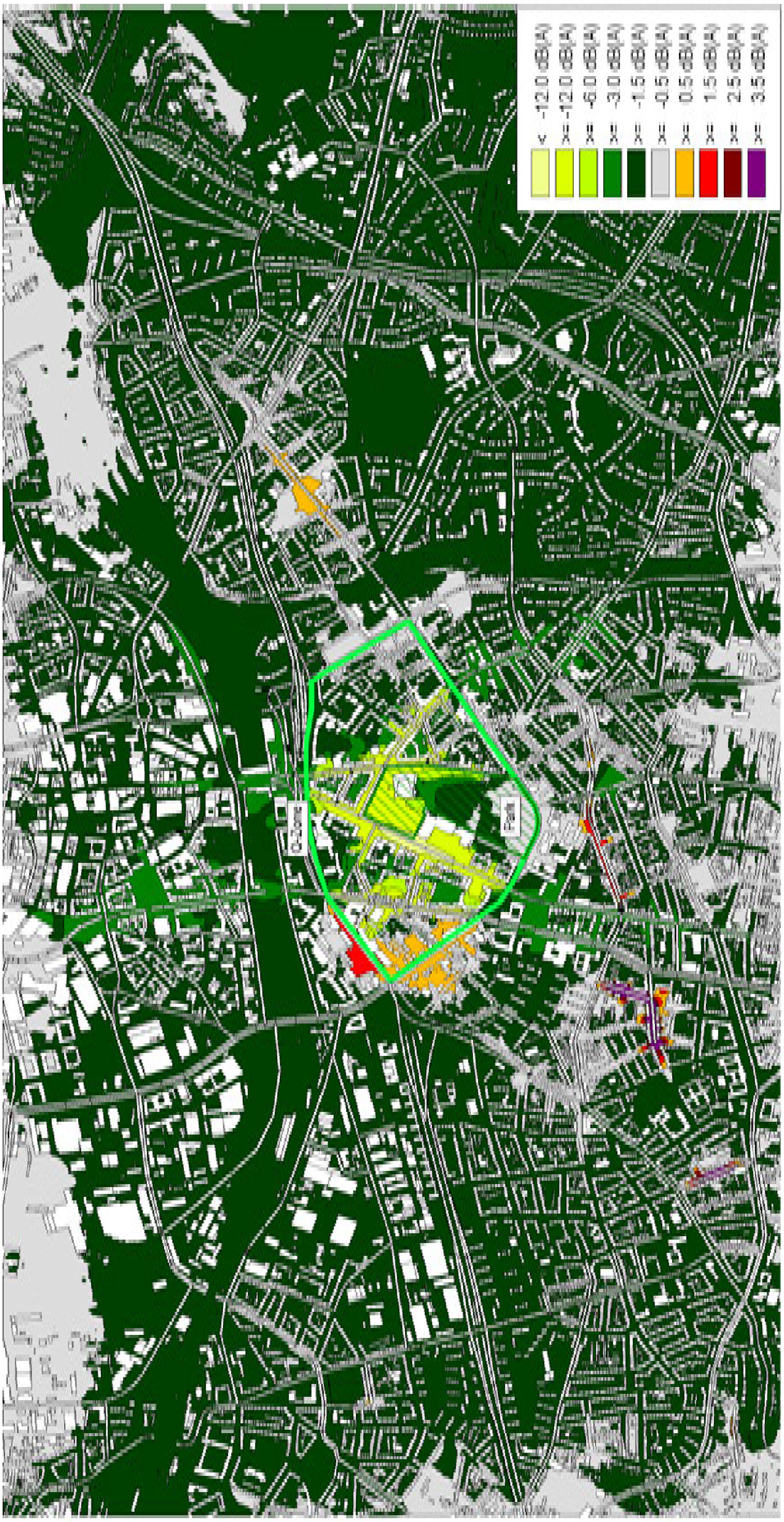

Figure 79: Essen Scenario 13 – difference to base case - L_{de}

Figure 80: Essen Scenario 14 – difference to base case - L_{de}

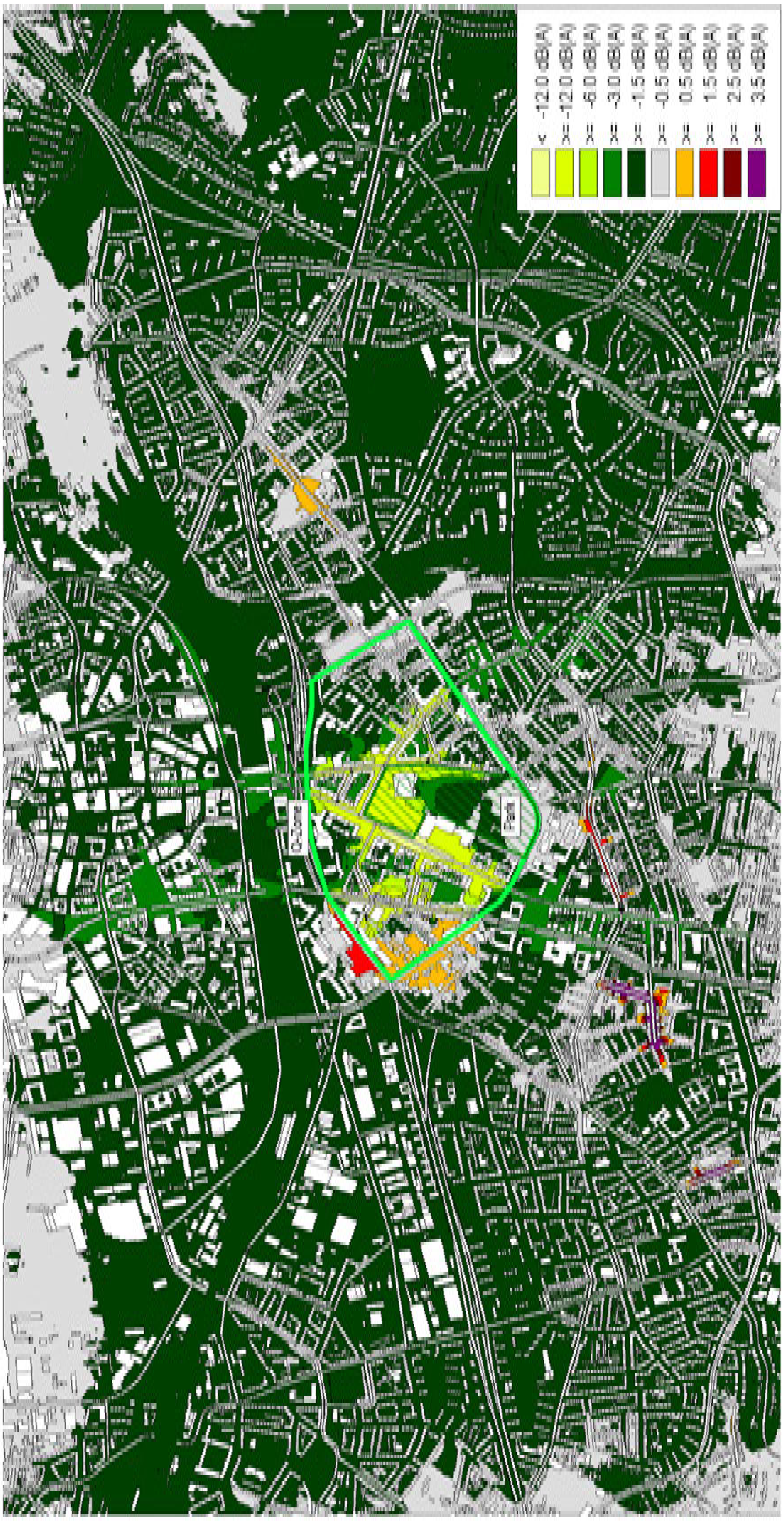

Figure 81: Essen Scenario 15 – difference to base case - L_{de}

A 4. ADDITIONAL FIGURES FOR THE CITY OF GOTHENBURG

A 4.4 Simulated scenarios for the city of Gothenburg

To provide a better overview we included the definition of the scenarios once again at this point. For Gothenburg, the following set of traffic scenarios was simulated:

Scenario nr	Zone	Fee, Euros/passage	Inside LNVO percentage	External LNVO percentage
BC	none	none	1	1
G1	medium	ban	1	1
G3	large	ban	1	1
G5	medium	1	1	1
G7	large	1	1	1
G13	large	1	100	20
G15	medium	none	20	20
G16	medium	ban	100	20

A 4.5 Noise maps for the city of Gothenburg

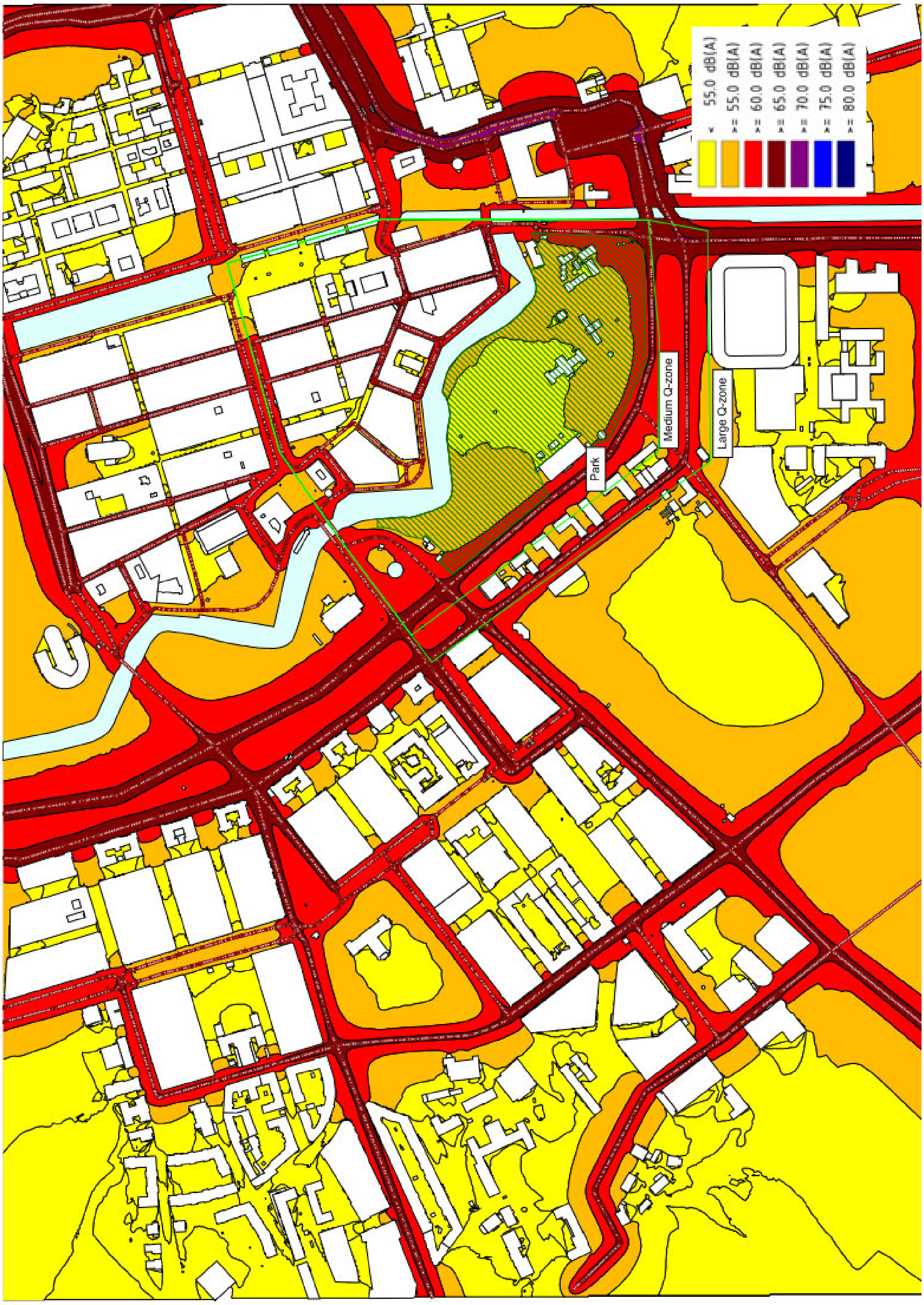

Figure 82: Scenario 1 (BC) - L_{de}

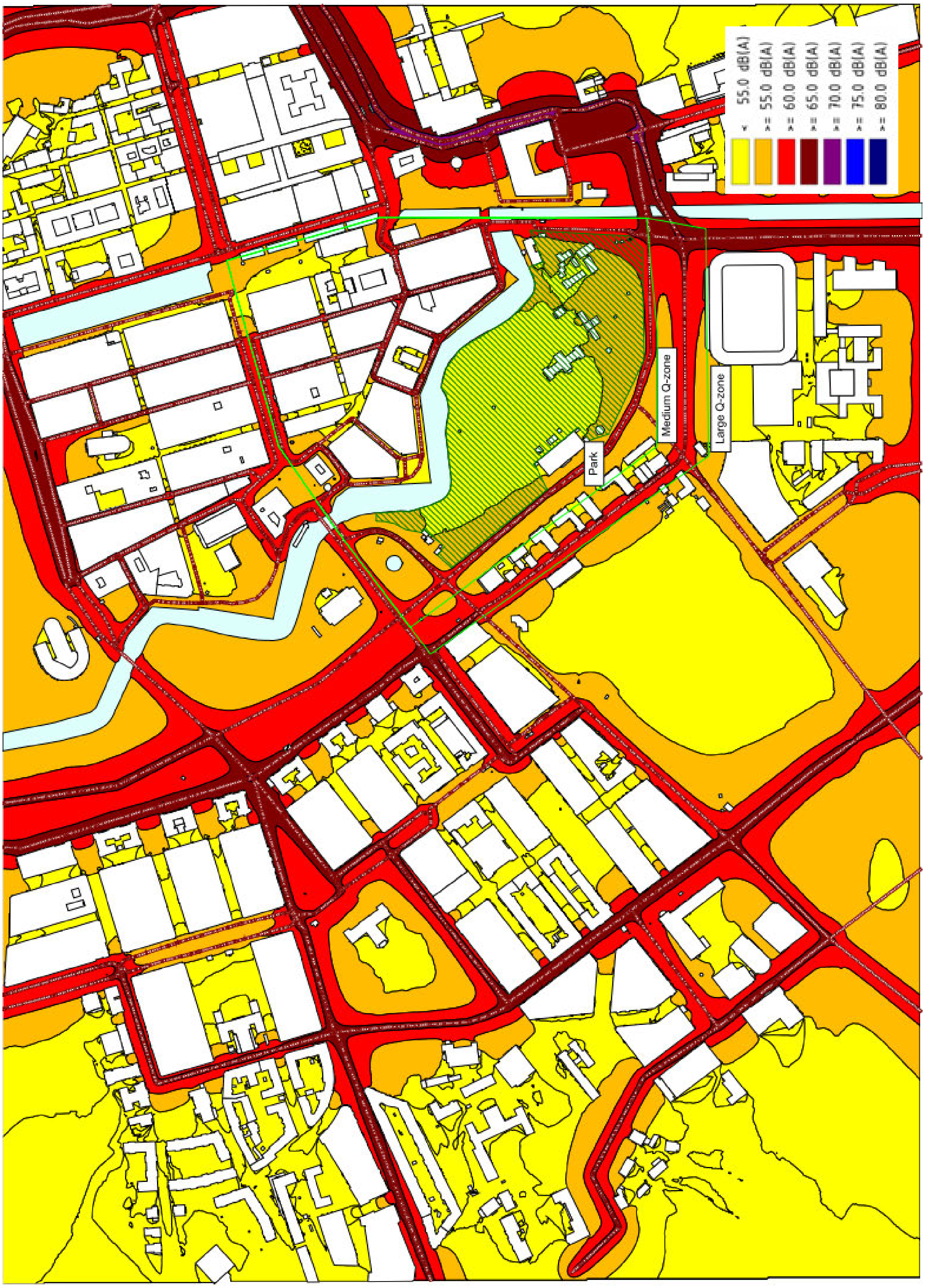

Figure 83: Scenario 2 (G1) - L_{de}

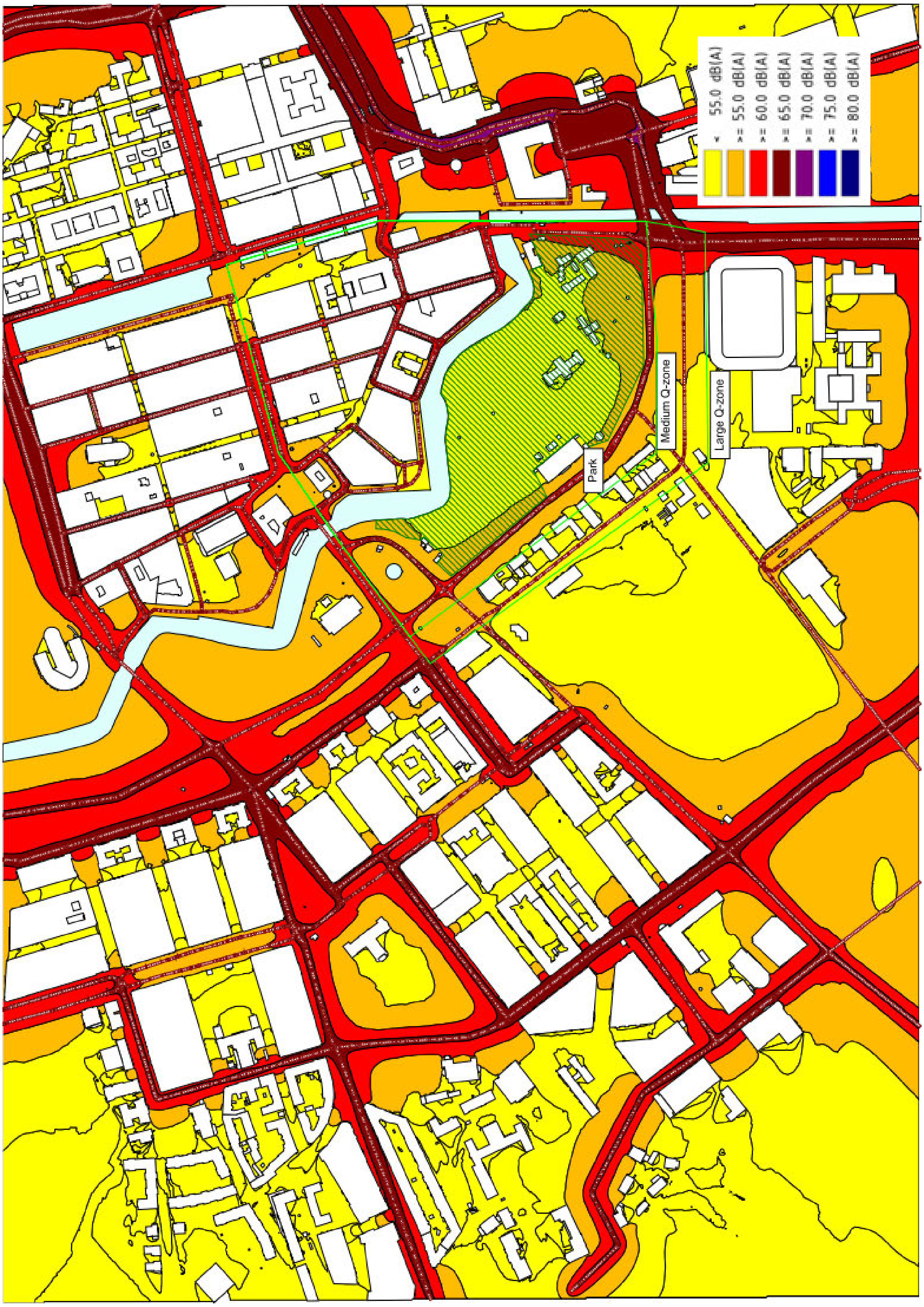

Figure 84: Scenario 3 (G3) - L_{de}

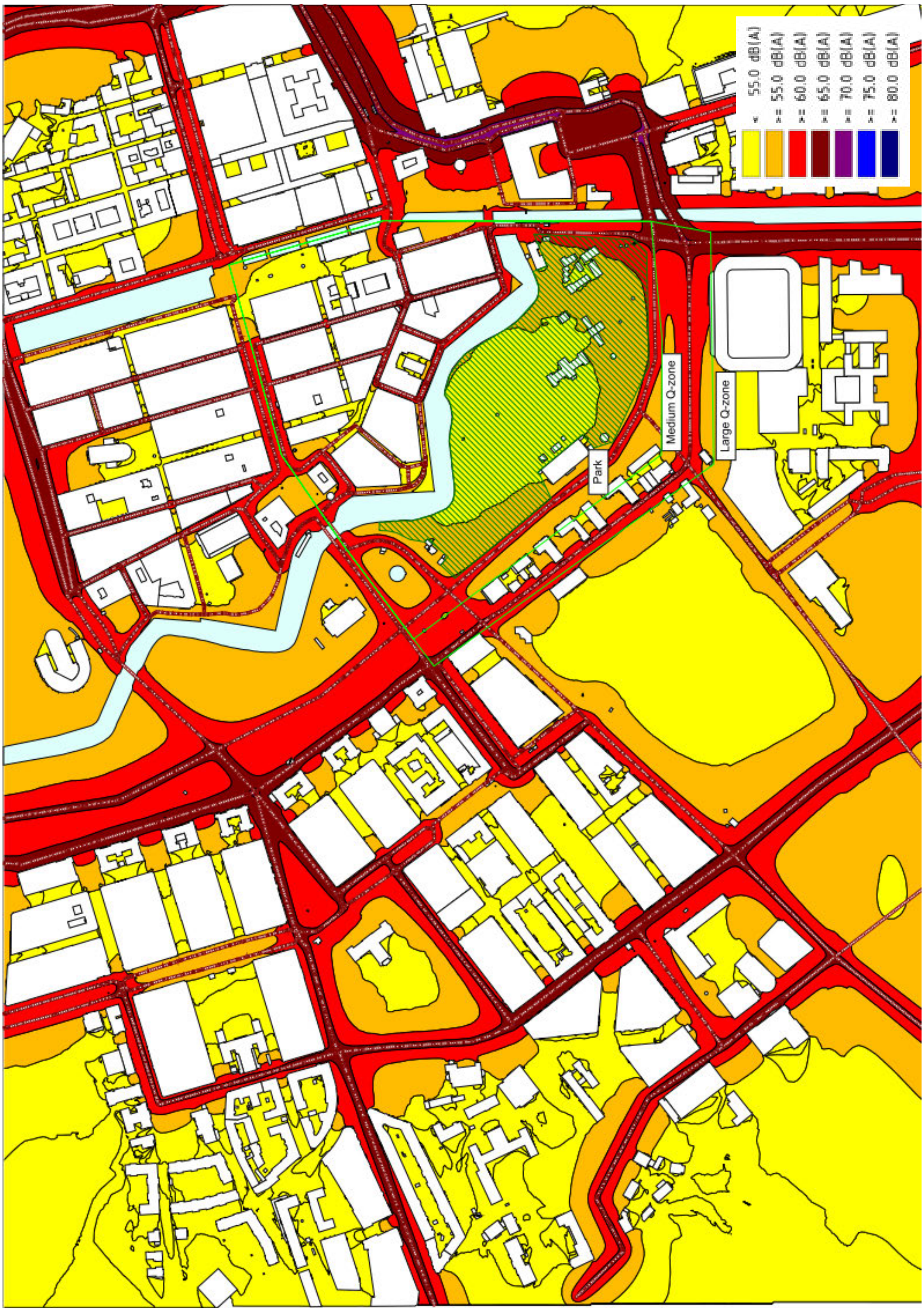

Figure 85: Scenario 4 (G5) – L_{de}

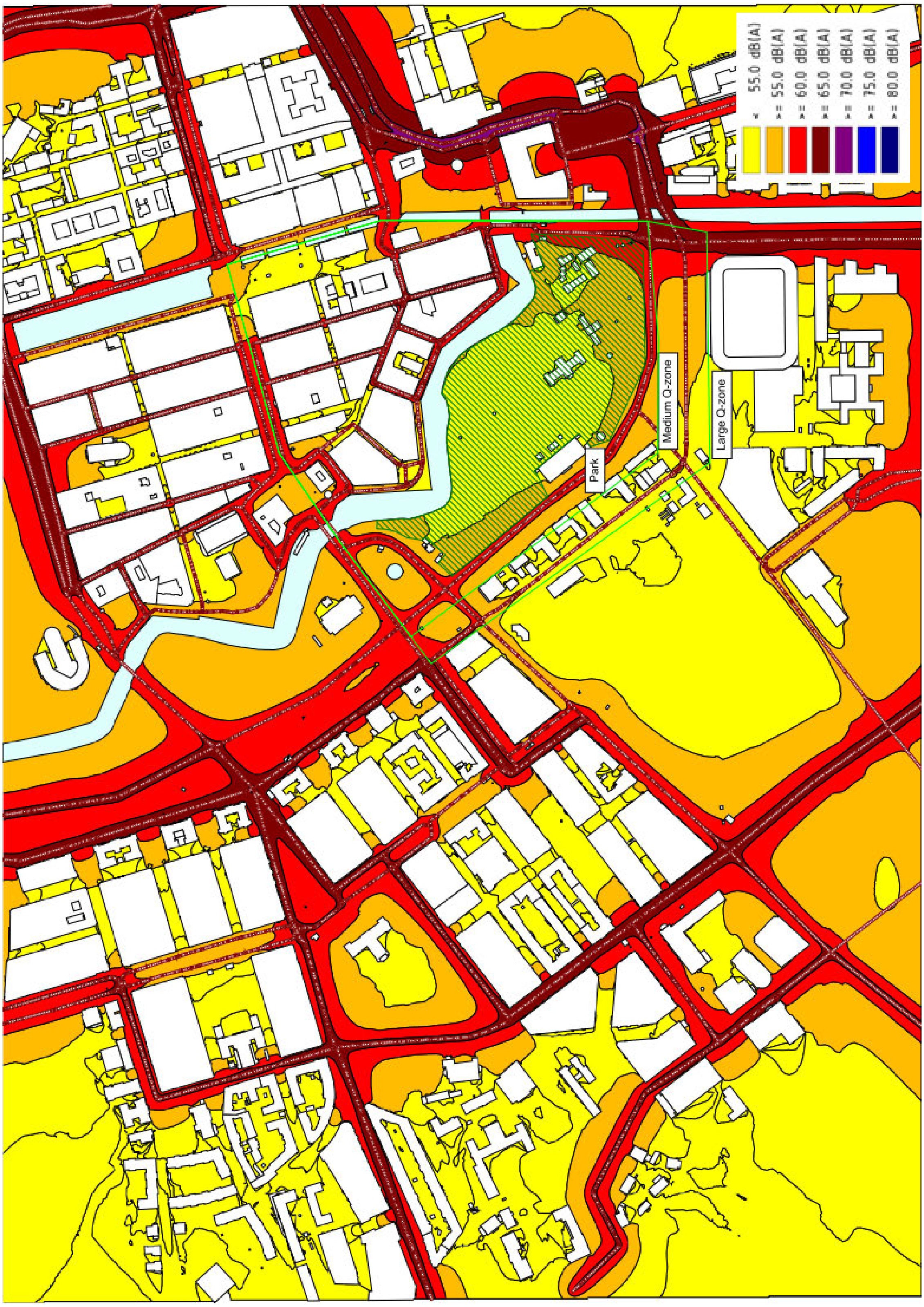

Figure 86: Scenario 5 (G7) – L_{de}

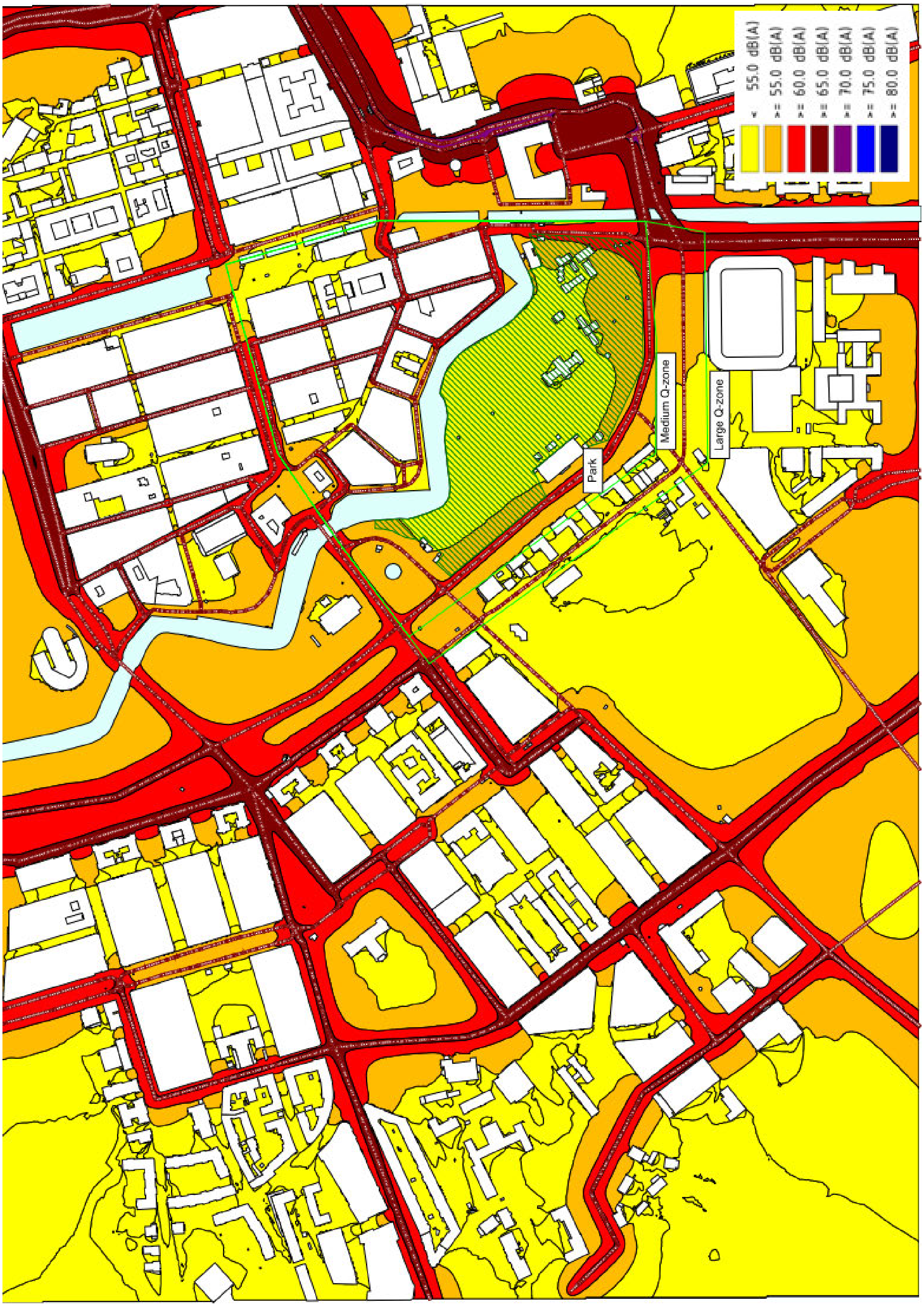

Figure 87: Scenario 6 (G13) – L_{de}

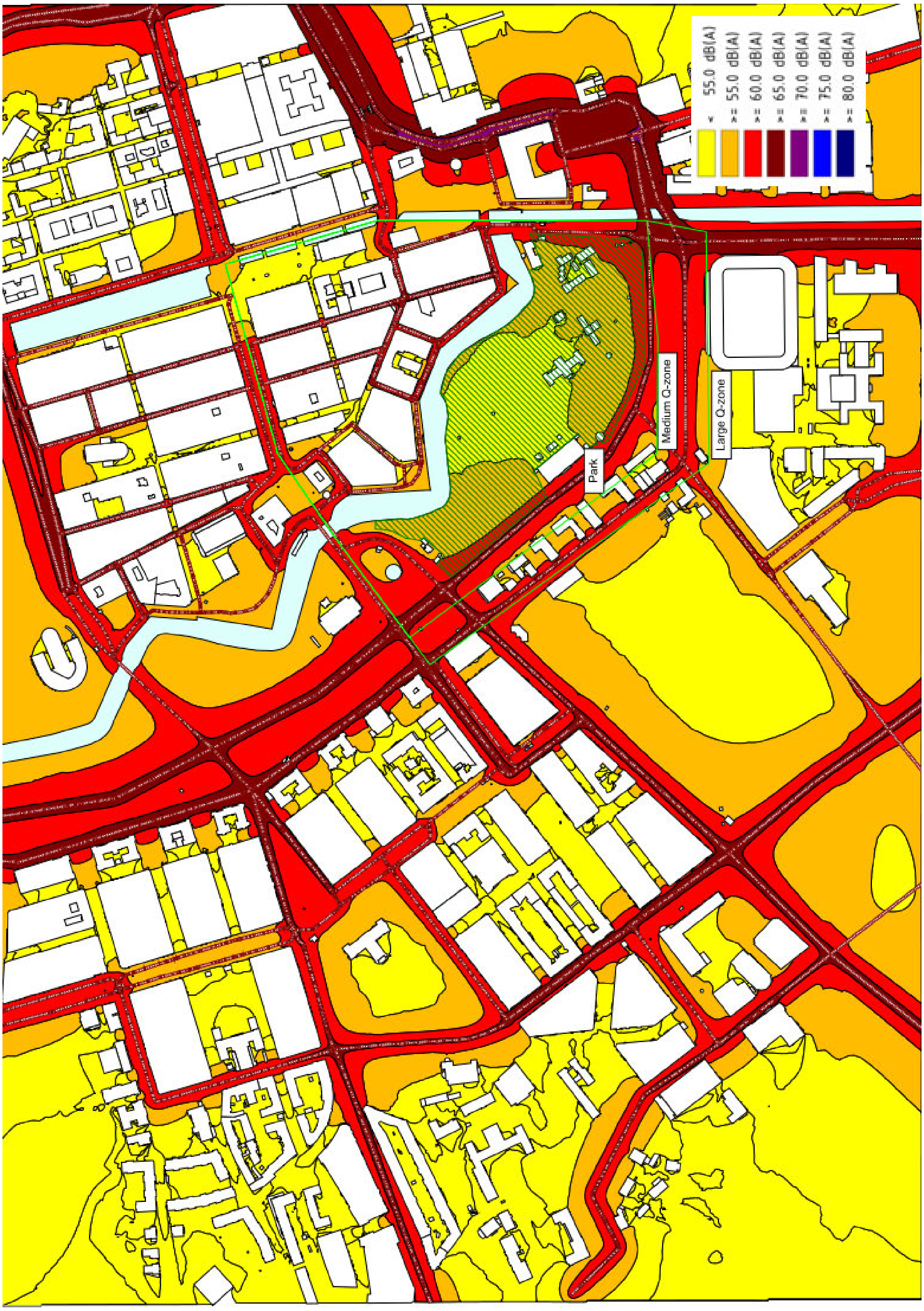

Figure 88: Scenario 7 (G15) – L_{de}

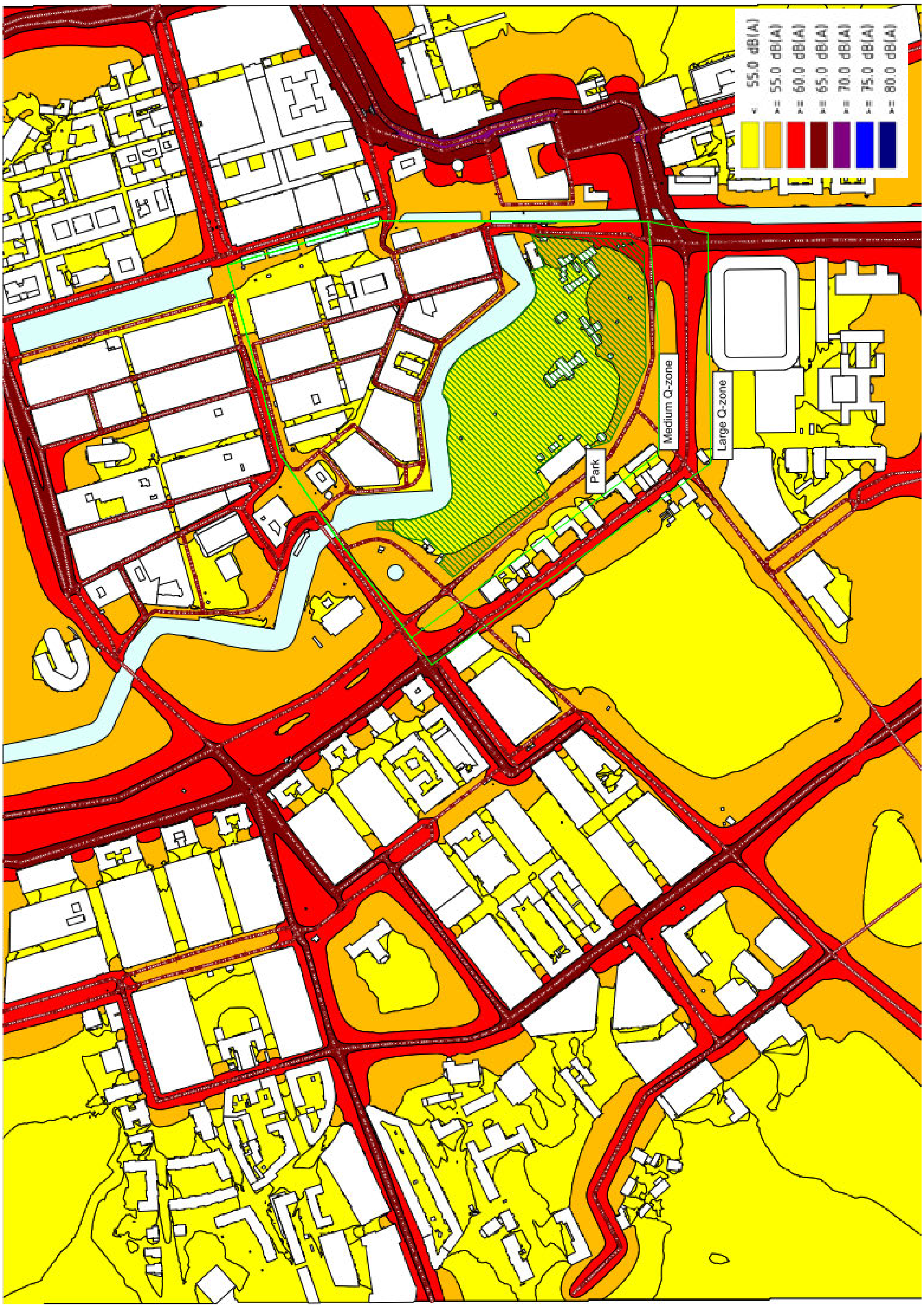

Figure 89: Scenario 8 (G16) - L_{de}

A 4.6 Noise difference maps for the city of Gothenburg

Figure 90: Scenario 2 (G1) – difference to base case – L_{de}

Figure 91: Scenario 3 (G3) – difference to base case- L_{de}

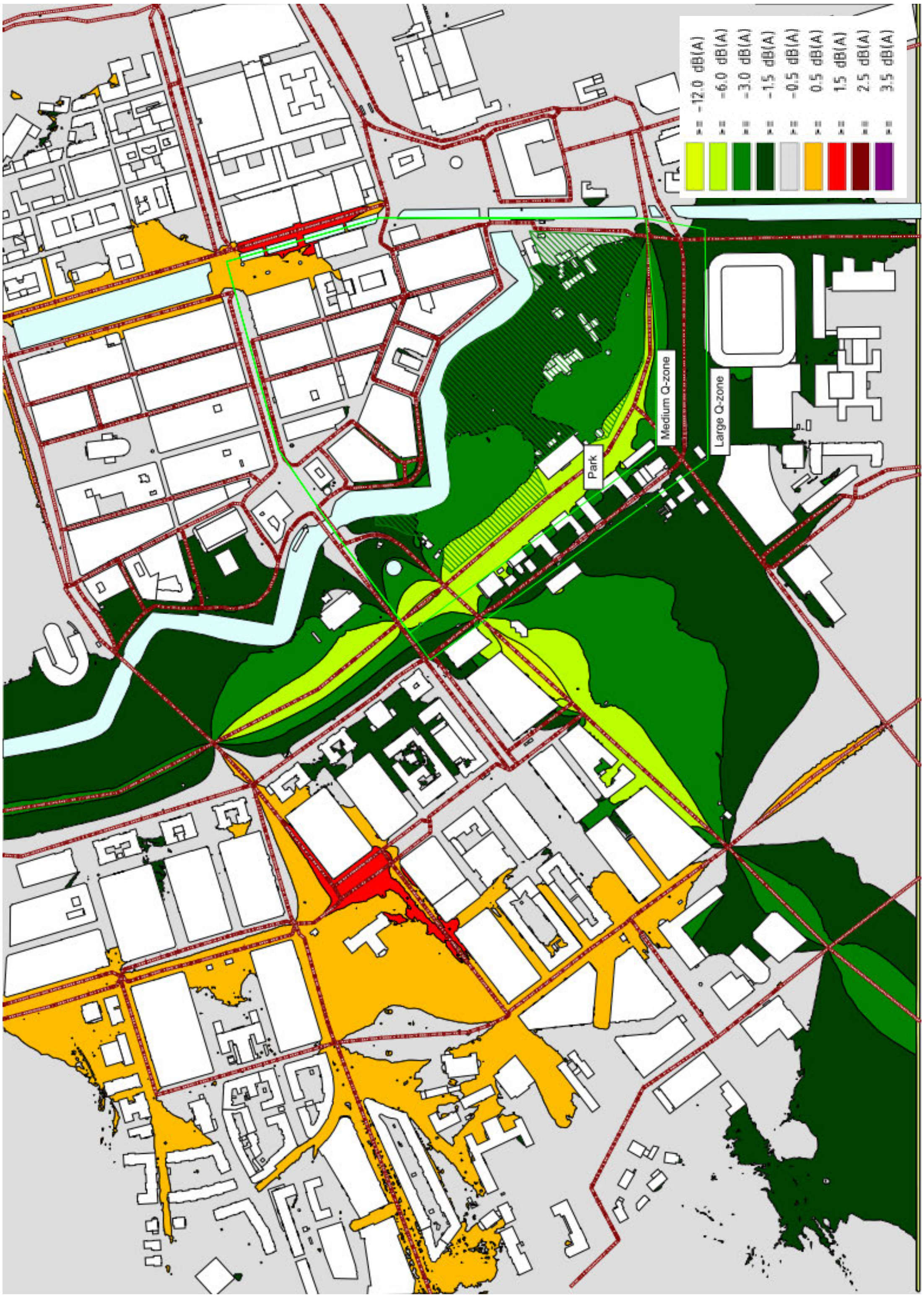

Figure 92: Scenario 4 (G5) - difference to base case – L_{de}

Figure 93: Scenario 5 (G7) - difference to base case – L_{de}

Figure 94: Scenario 6 (G13) - difference to base case – L_{de}

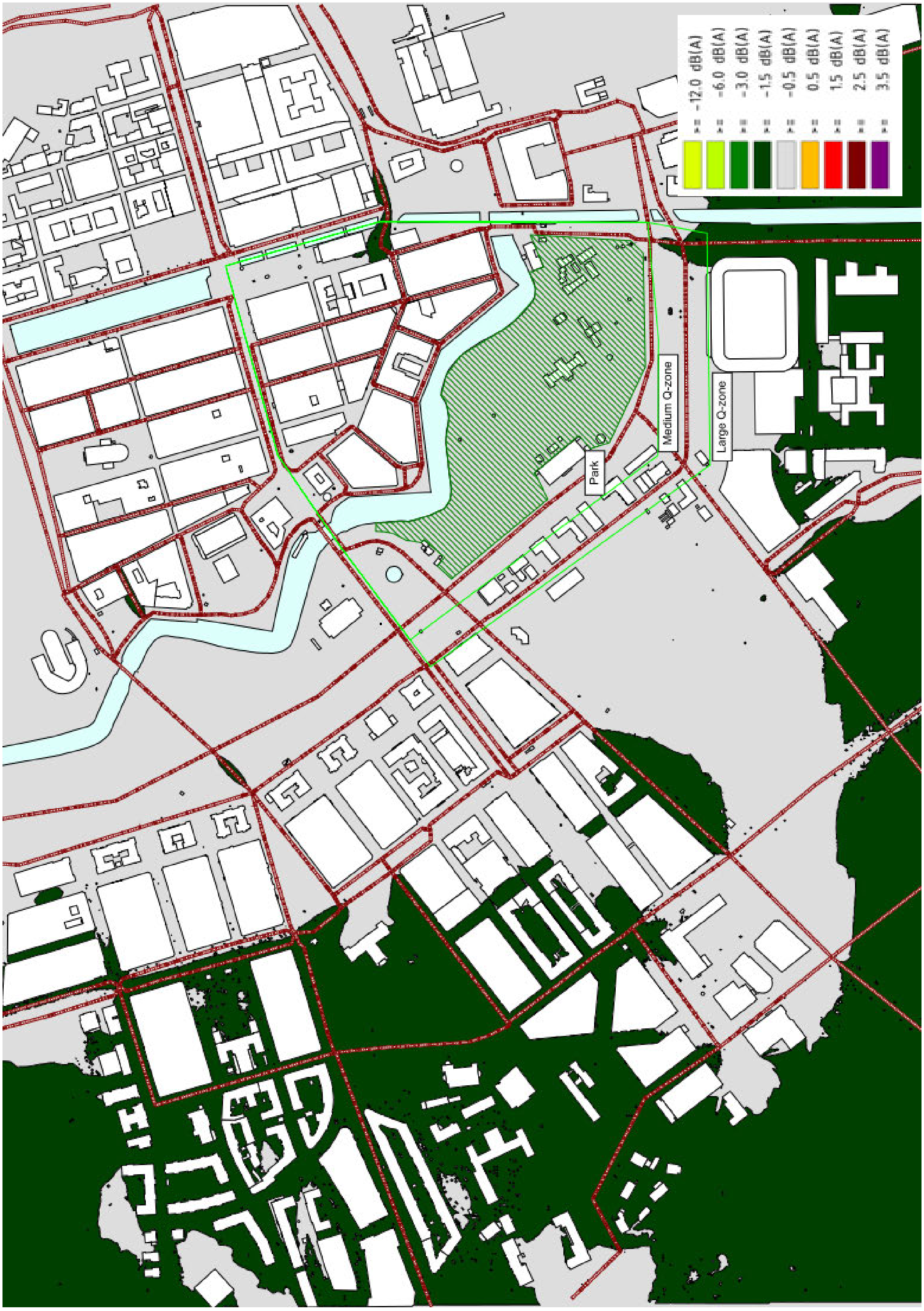

Figure 95: Scenario 7 (G15) - difference to base case – L_{de}

Figure 96: Scenario 8 (G16) – difference to base case – L_{de}

A 5. ADDITIONAL FIGURES FOR THE CITY OF STOCKHOLM

A 5.7 Simulated scenarios for the city of Stockholm

To provide a better overview we included the definition of the scenarios once again at this point. For Stockholm, the following set of traffic scenarios was simulated:

Scenario nr	Zone	Fee, Euros/passage	Inside LNVO percentage	External LNVO percentage
BC	medium	none	1	1
S1	small	ban	1	1
S2	medium	ban	1	1
S3	large	ban	1	1
S4	large	1	1	1
S5	large	0.5	1	1
S6	medium	1	1	1
S7	medium	0.5	1	1
S8	small	1	1	1
S9	small	0.5	1	1
S10	large	ban	20	5
S11	large	0.5	20	5
S12	large	ban	100	20
S13	large	0.5	100	20
S14	medium	none	5	5
S15	medium	none	20	20
S16	Medium	ban	100	20

A 5.8 Noise maps for the city of Stockholm

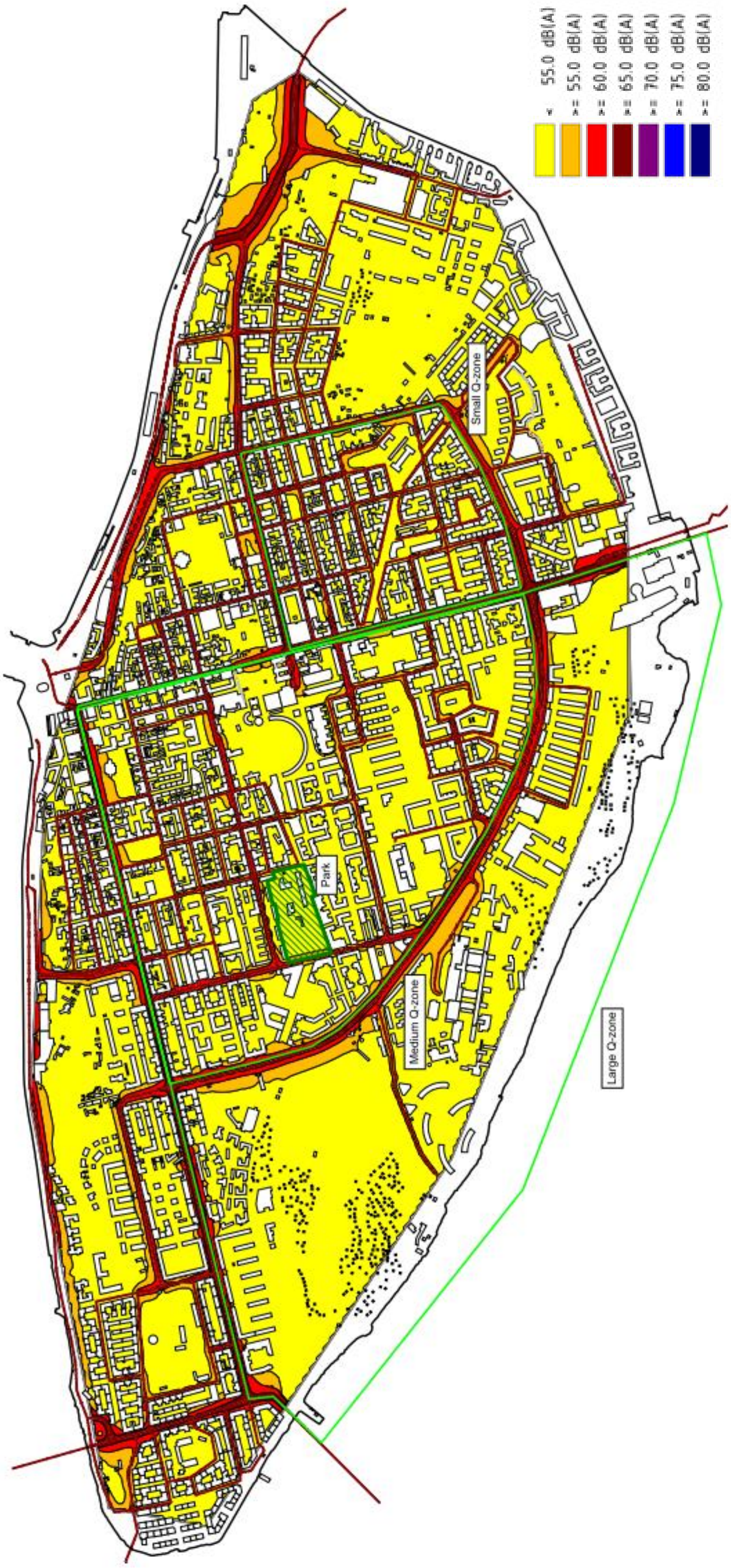

Figure 97: Scenario BC (Base Case) - L_{de}

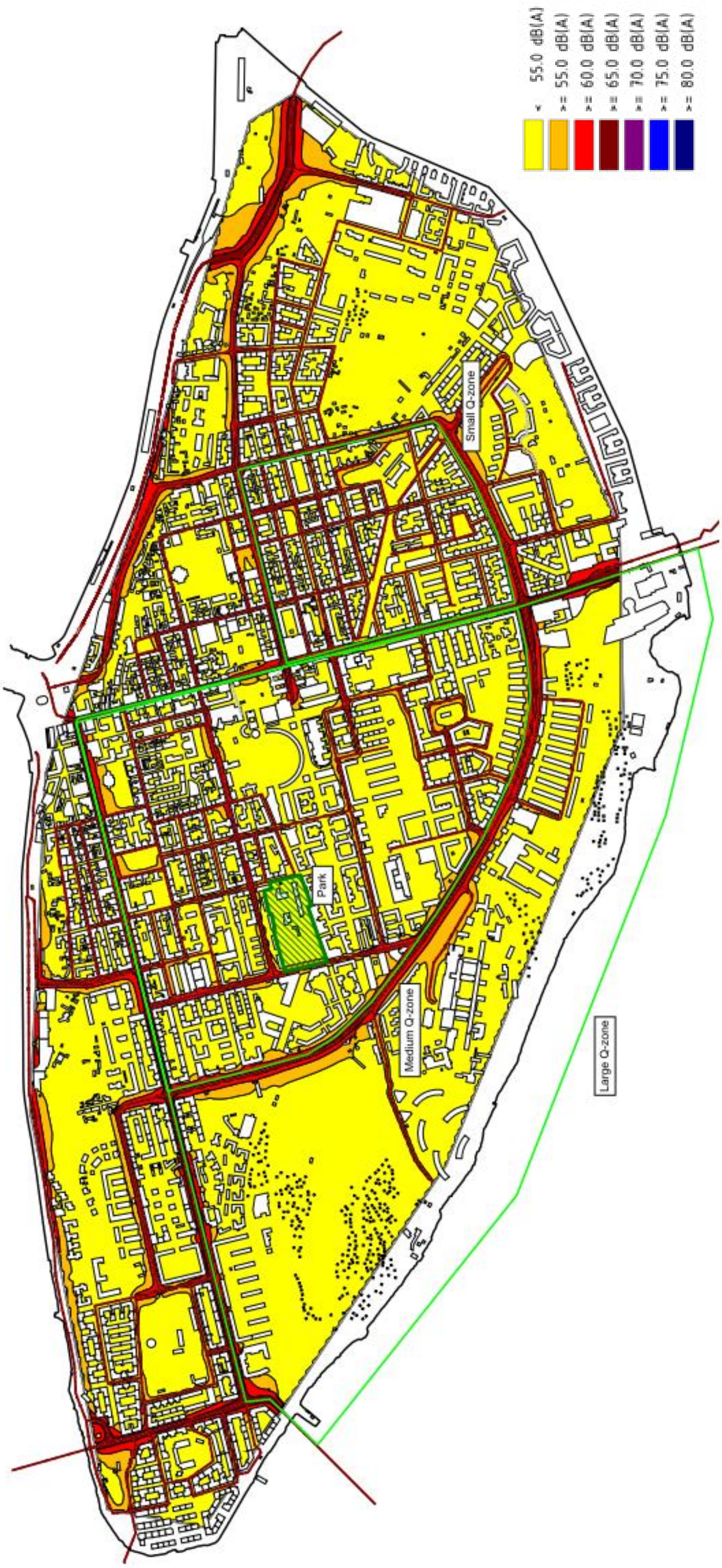

Figure 98: Scenario 1 (S1) - L_{de}

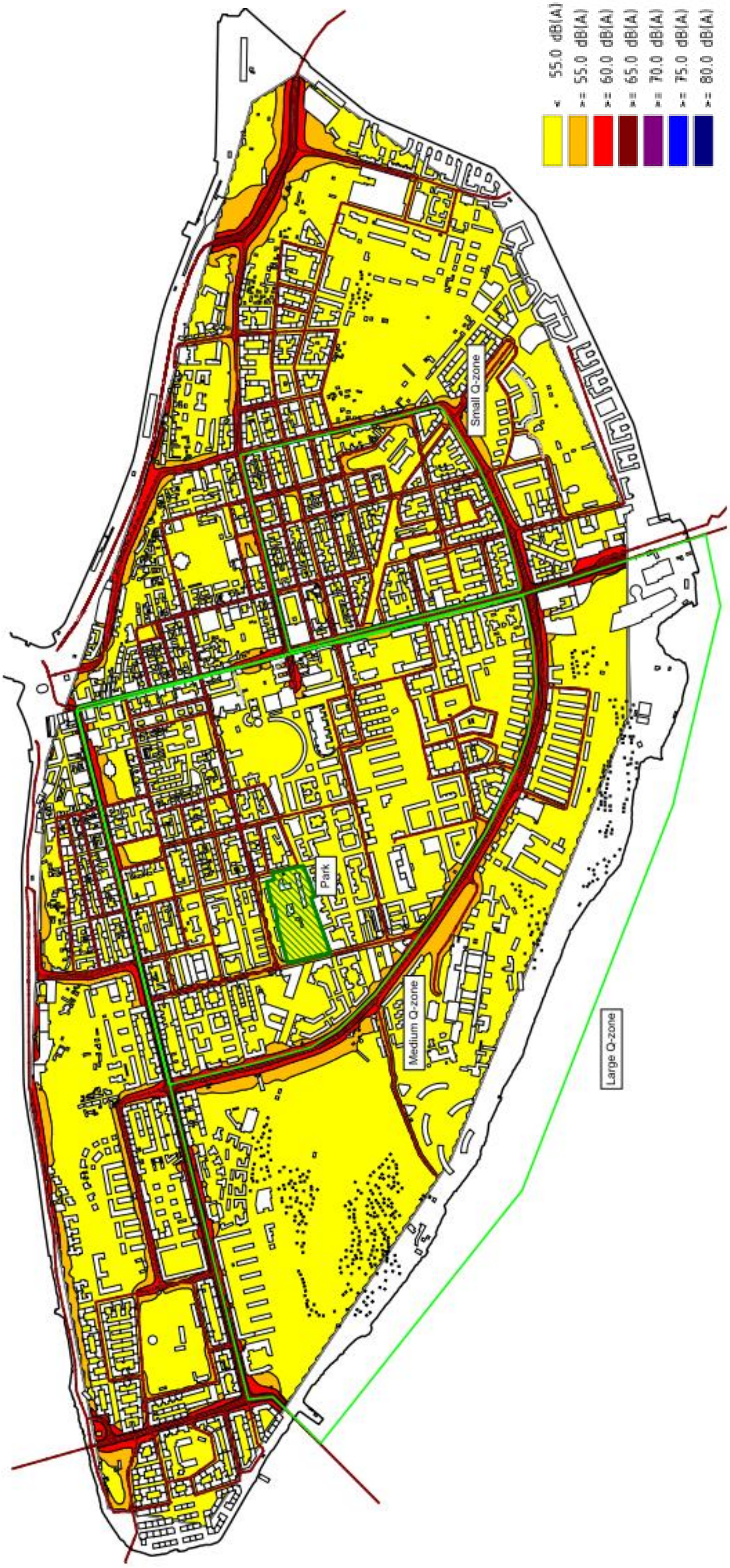

Figure 99: Scenario 2 (S2)- L_{de}

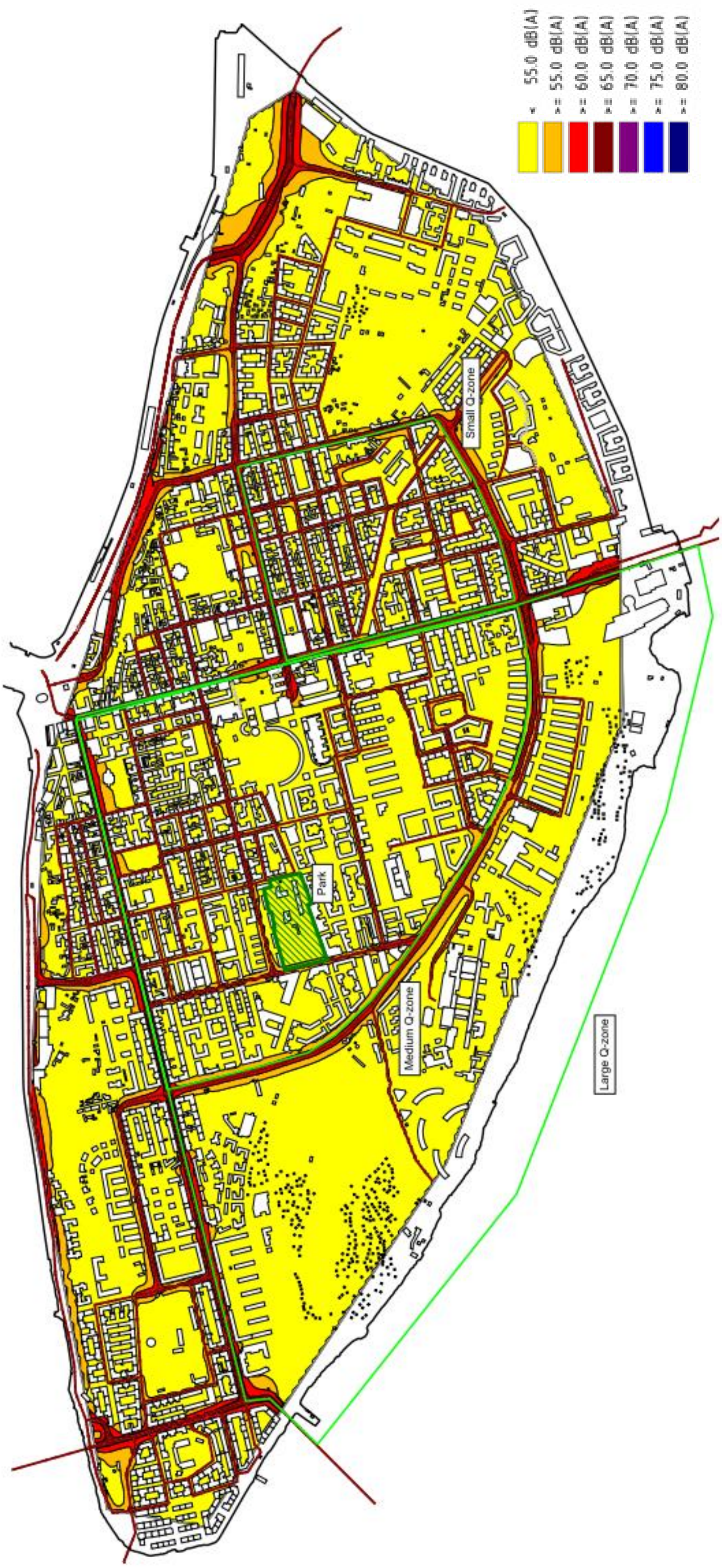

Figure 100: Scenario 3 (S3)- L_{de}

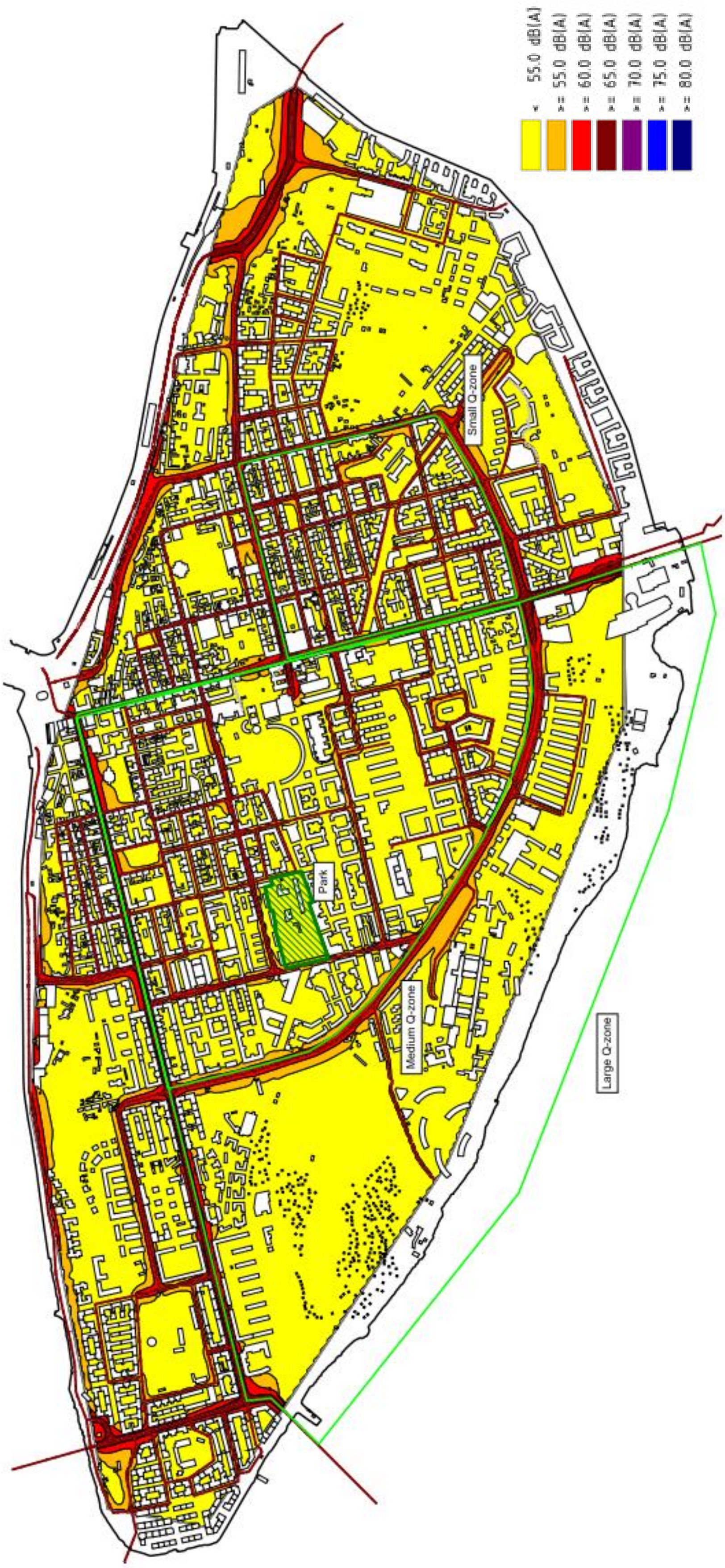

Figure 101: Scenario 4 (S4)- L_{de}

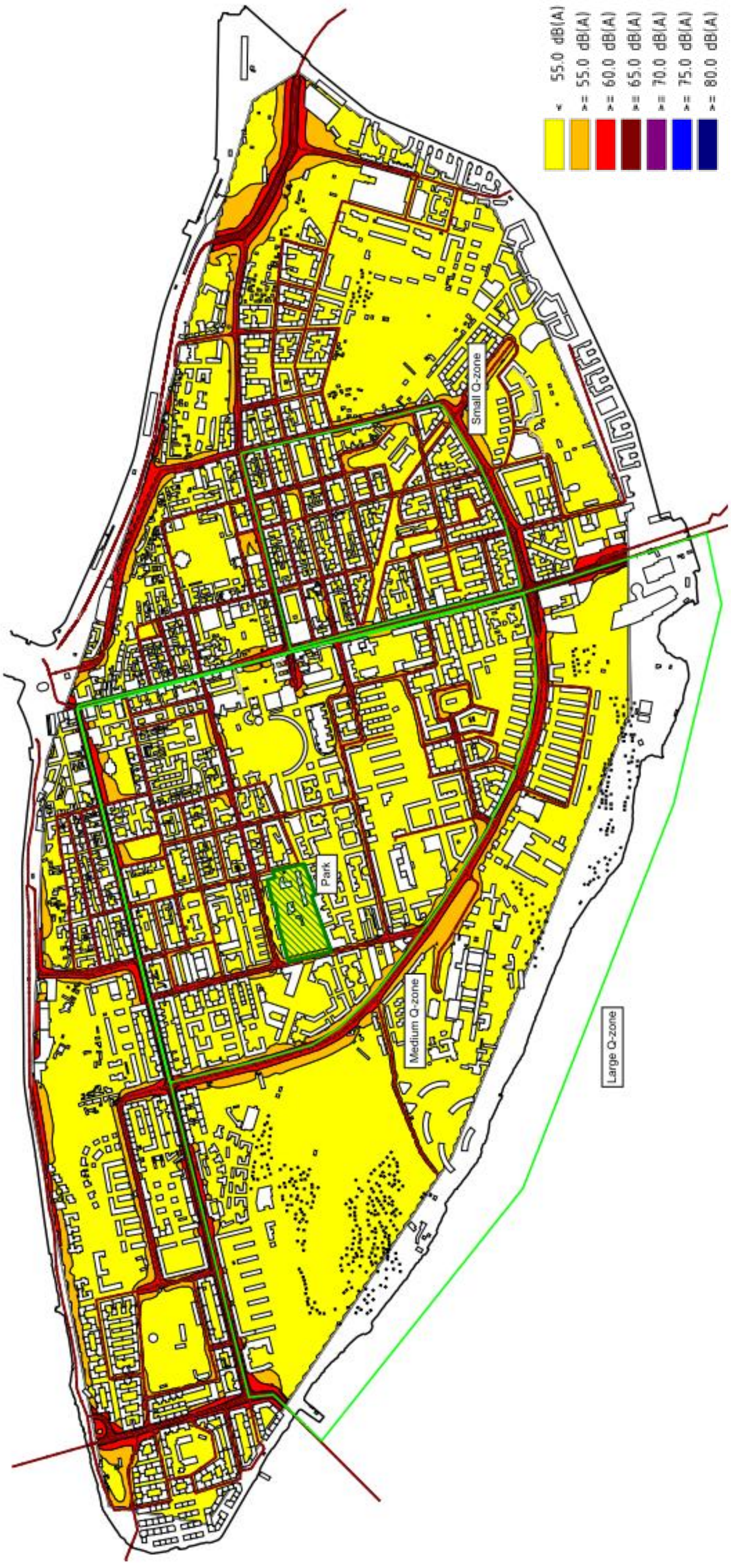

Figure 102: Scenario 5 (S5)- L_{de}

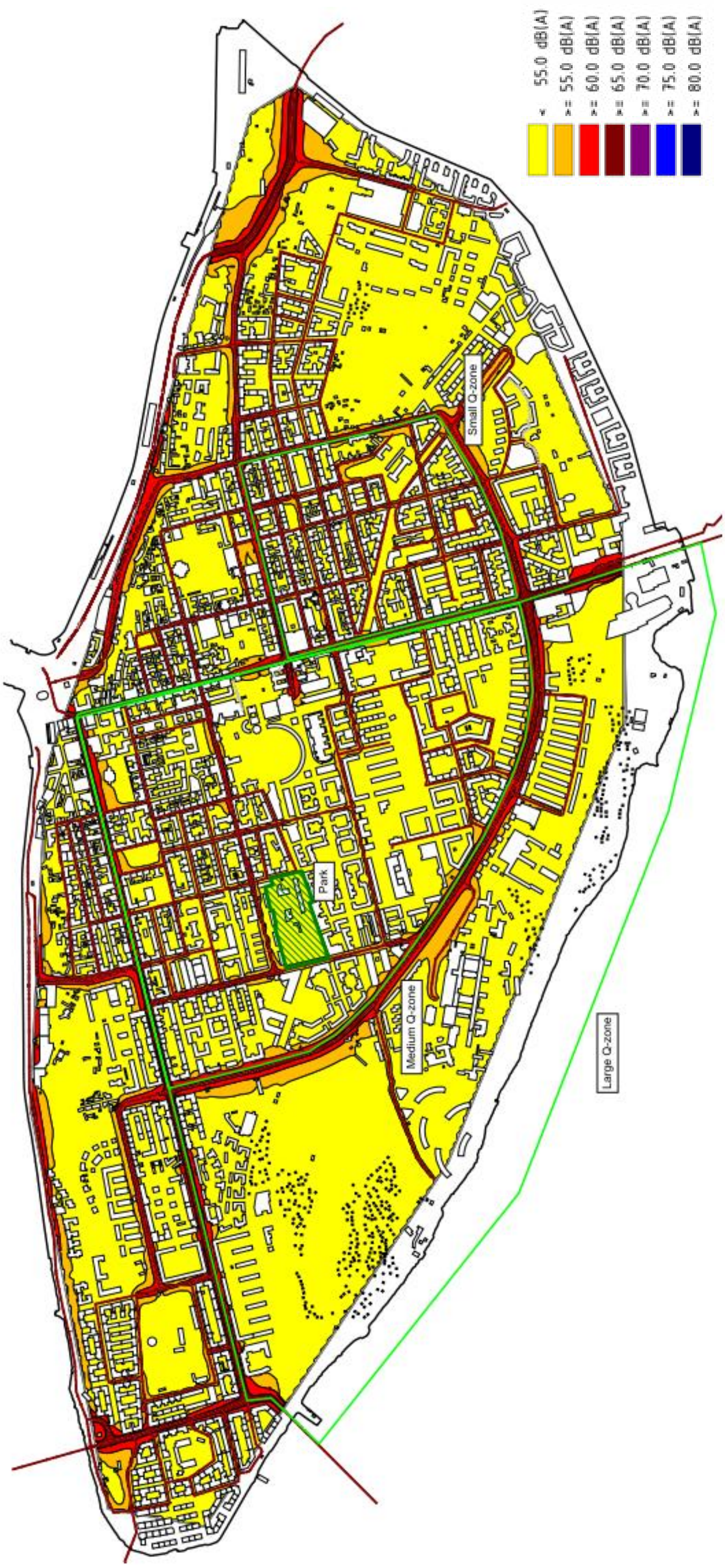

Figure 103: Scenario 6 (S6)- L_{de}

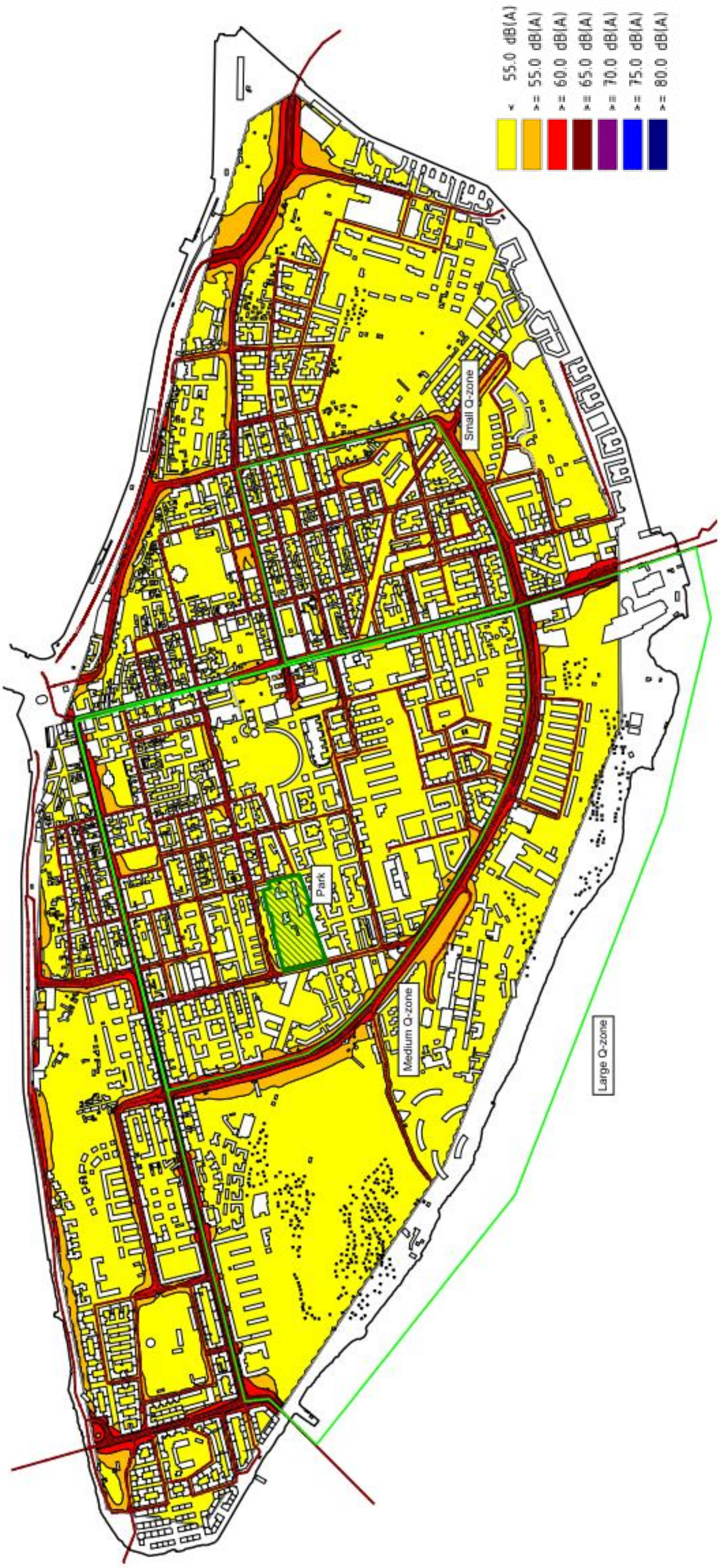

Figure 104: Scenario 7 (S7)- L_{de}

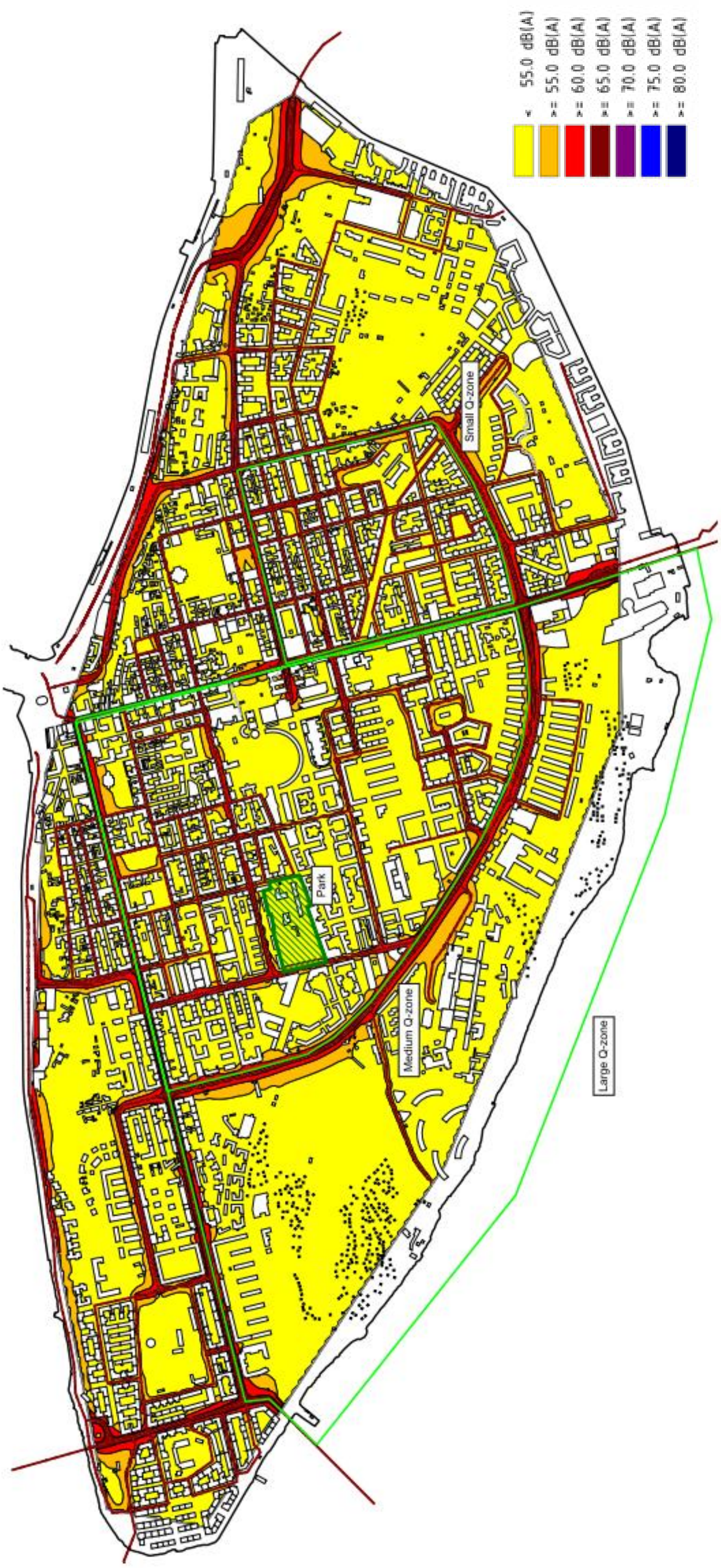

Figure 105: Scenario 8 (S8)- L_{de}

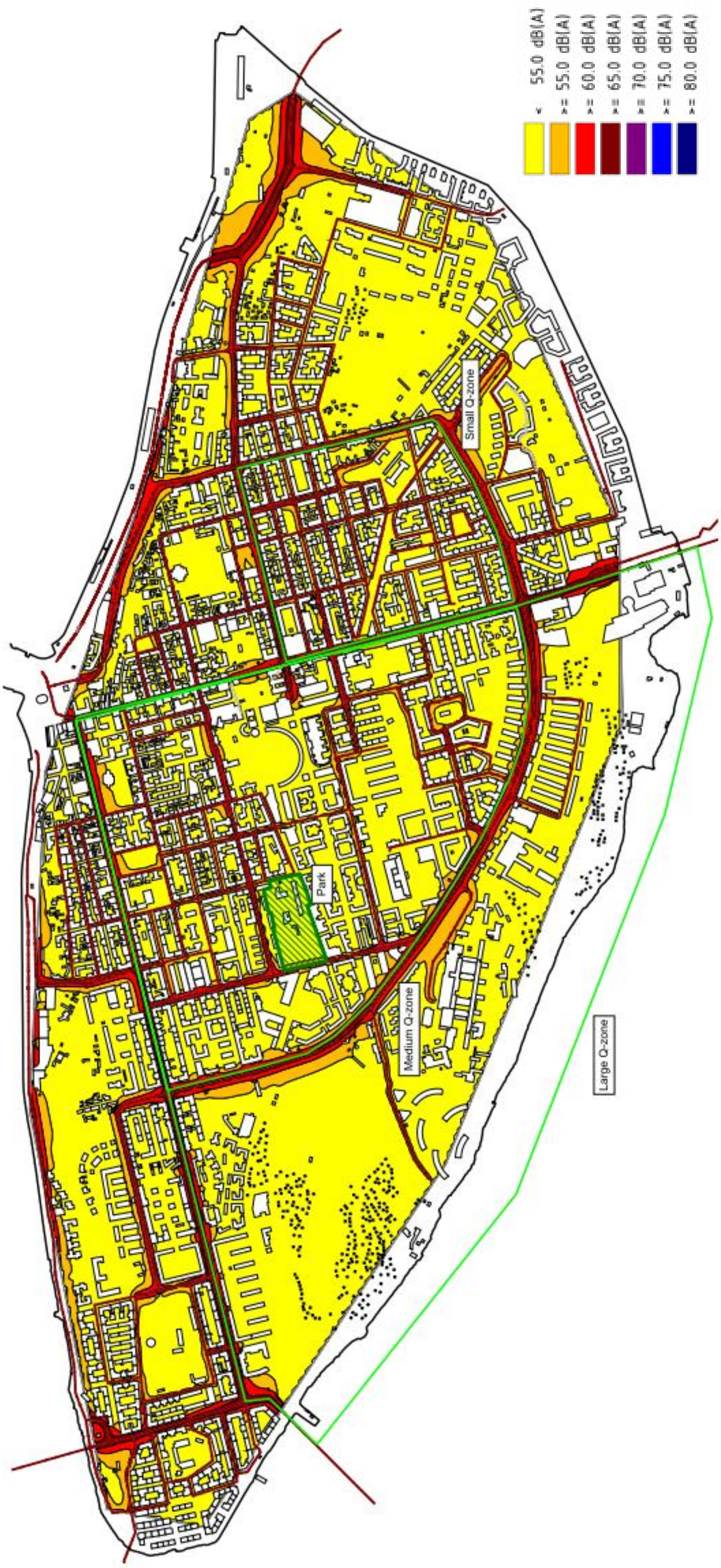

Figure 106: Scenario 9 (S9)- L_{de}

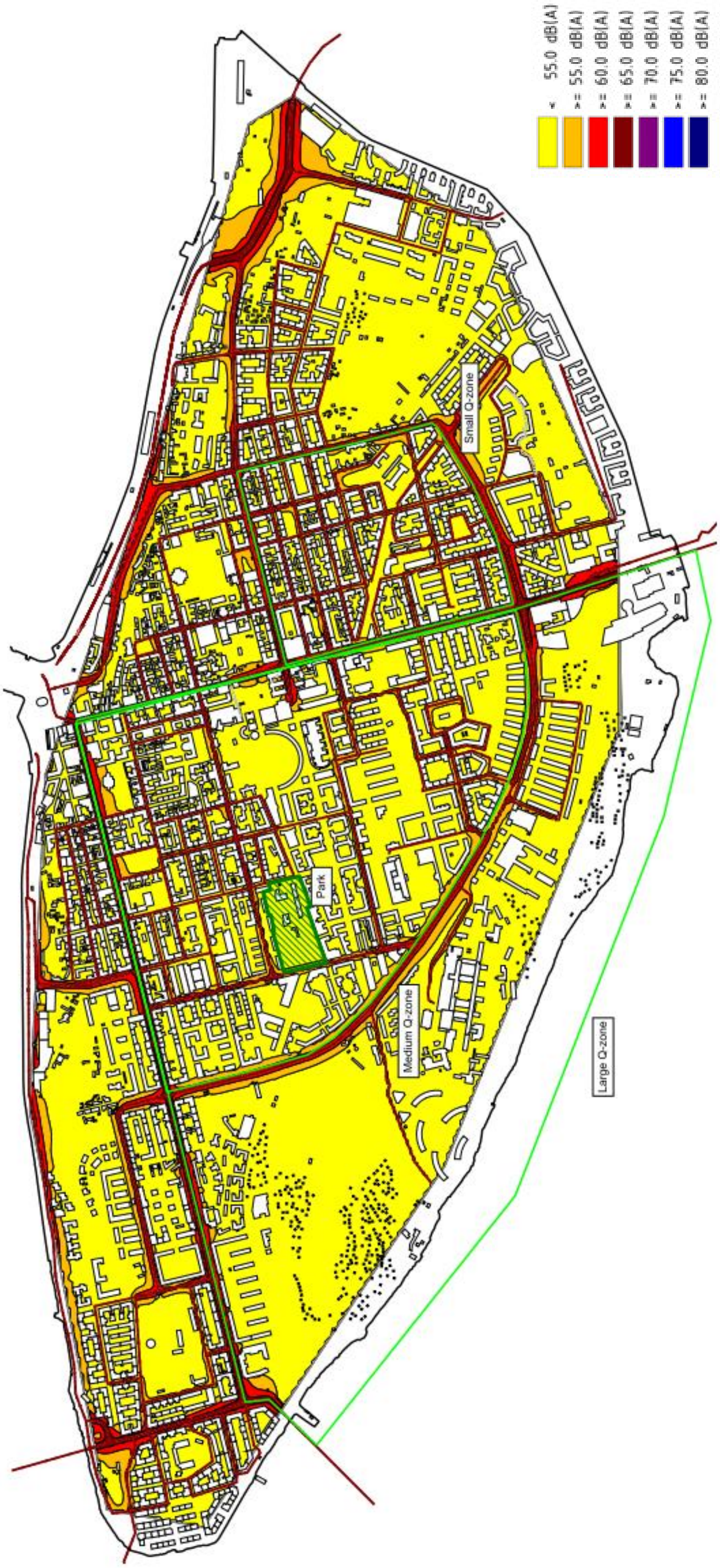

Figure 107: Scenario 10 (S10)- L_{de}

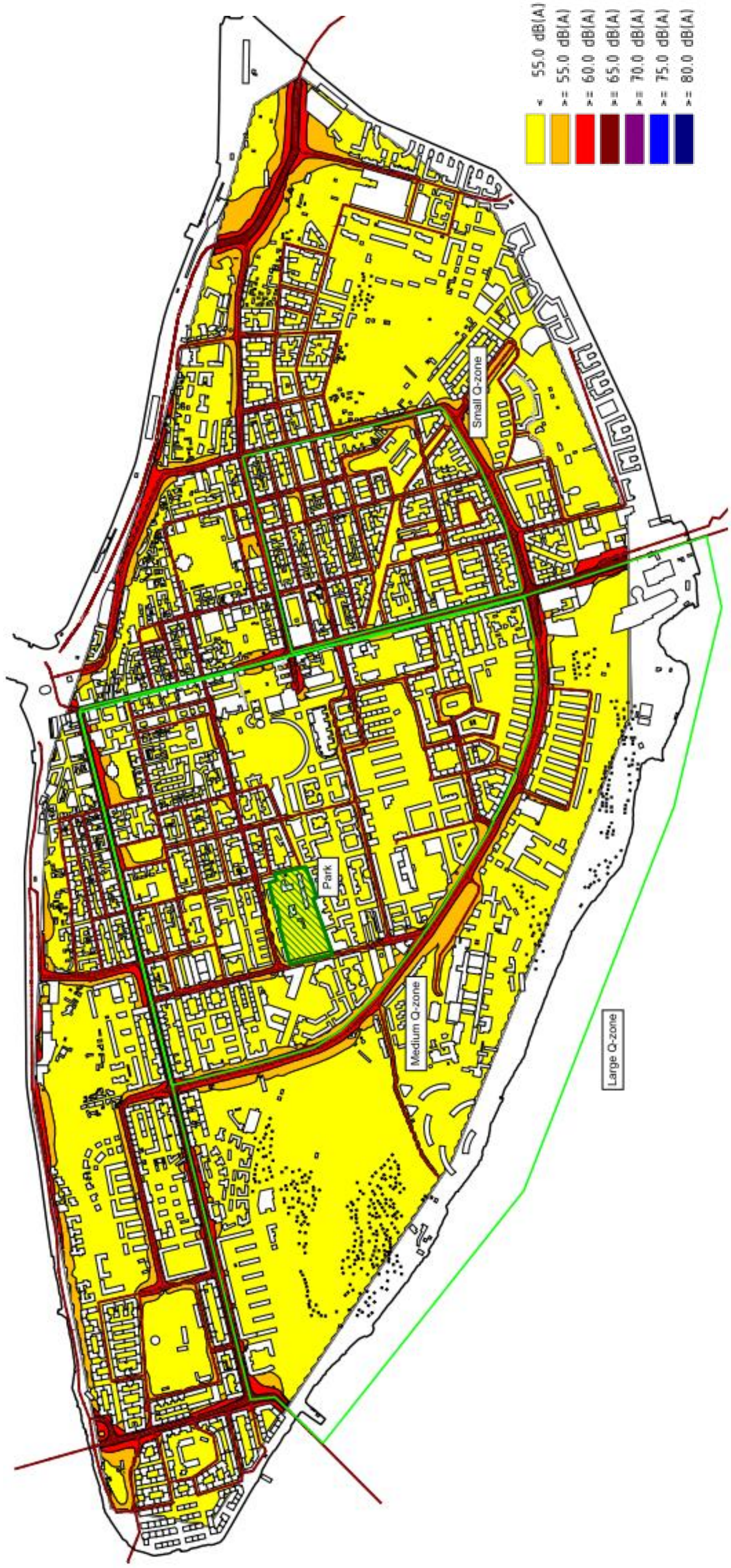

Figure 108: Scenario 11 (S11)- L_{de}

Figure 109: Scenario 12 (S12) - L_{de}

Figure 110: Scenario 13 (S13)- L_{de}

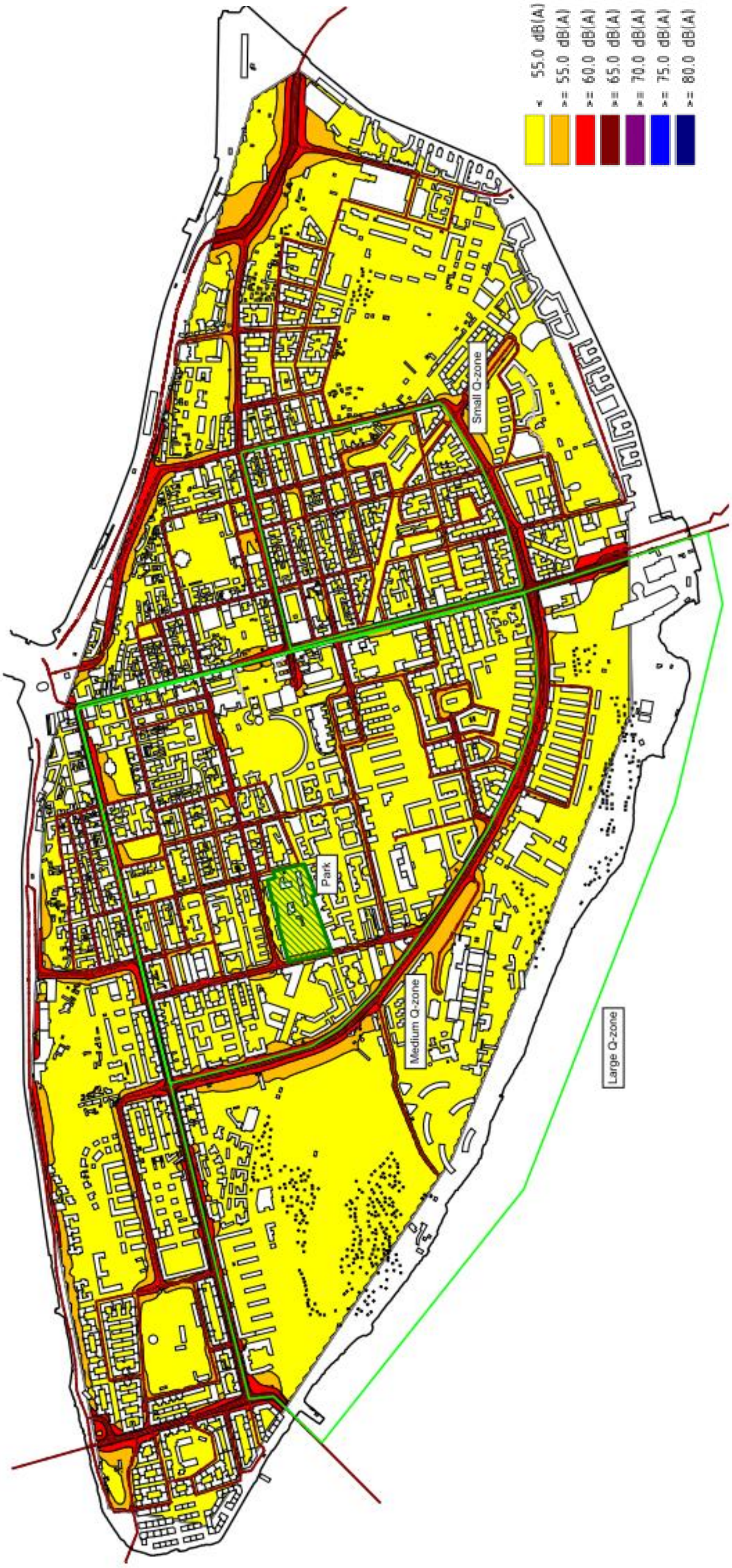

Figure 111: Scenario 14 (S14)- L_{de}

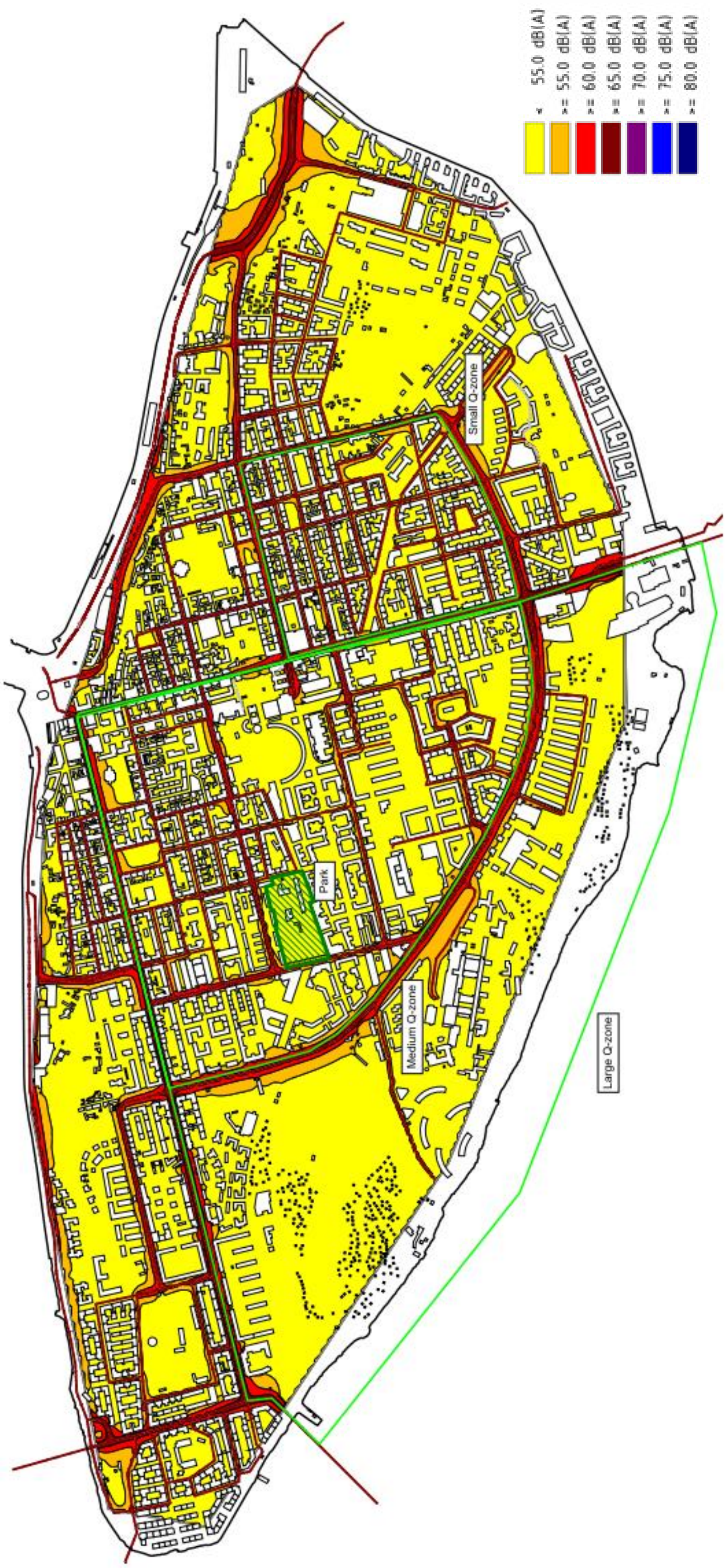

Figure 112: Scenario 15 (S15)- L_{de}

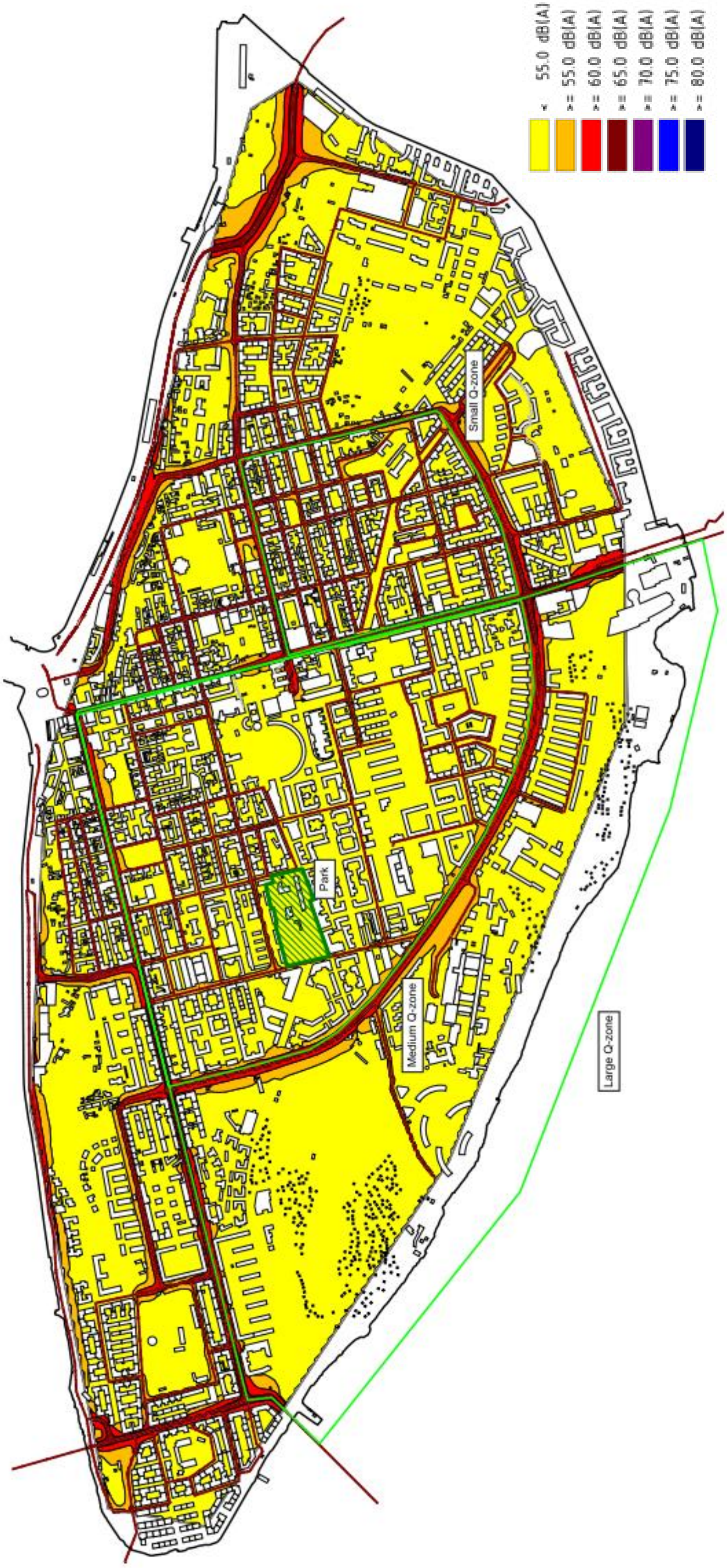

Figure 113: Scenario 16 (S16)- L_{de}

A 5.9 Noise difference maps for the city of Stockholm

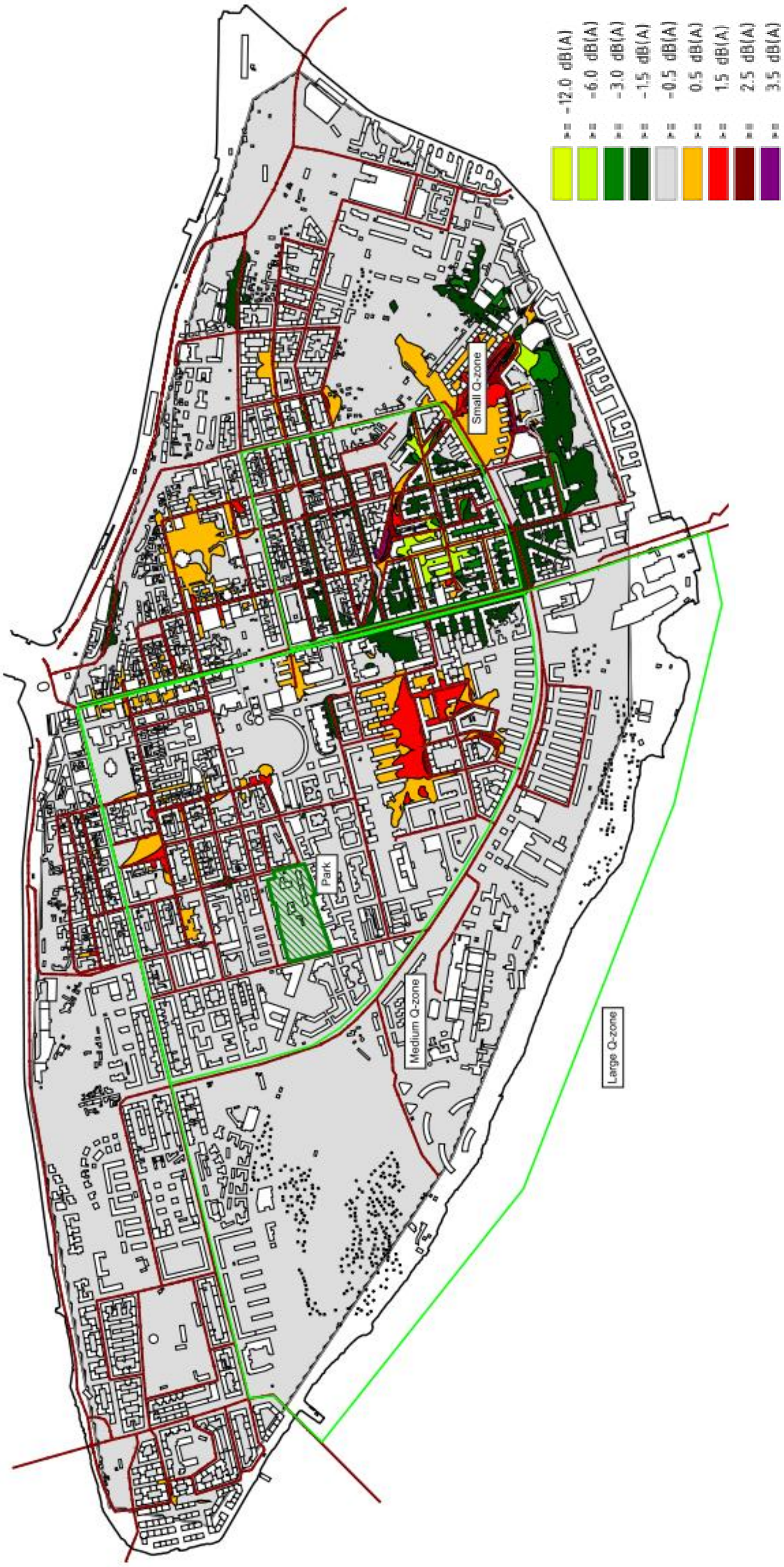

Figure 114: Scenario 1 (S1) – difference to base case – L_{de}

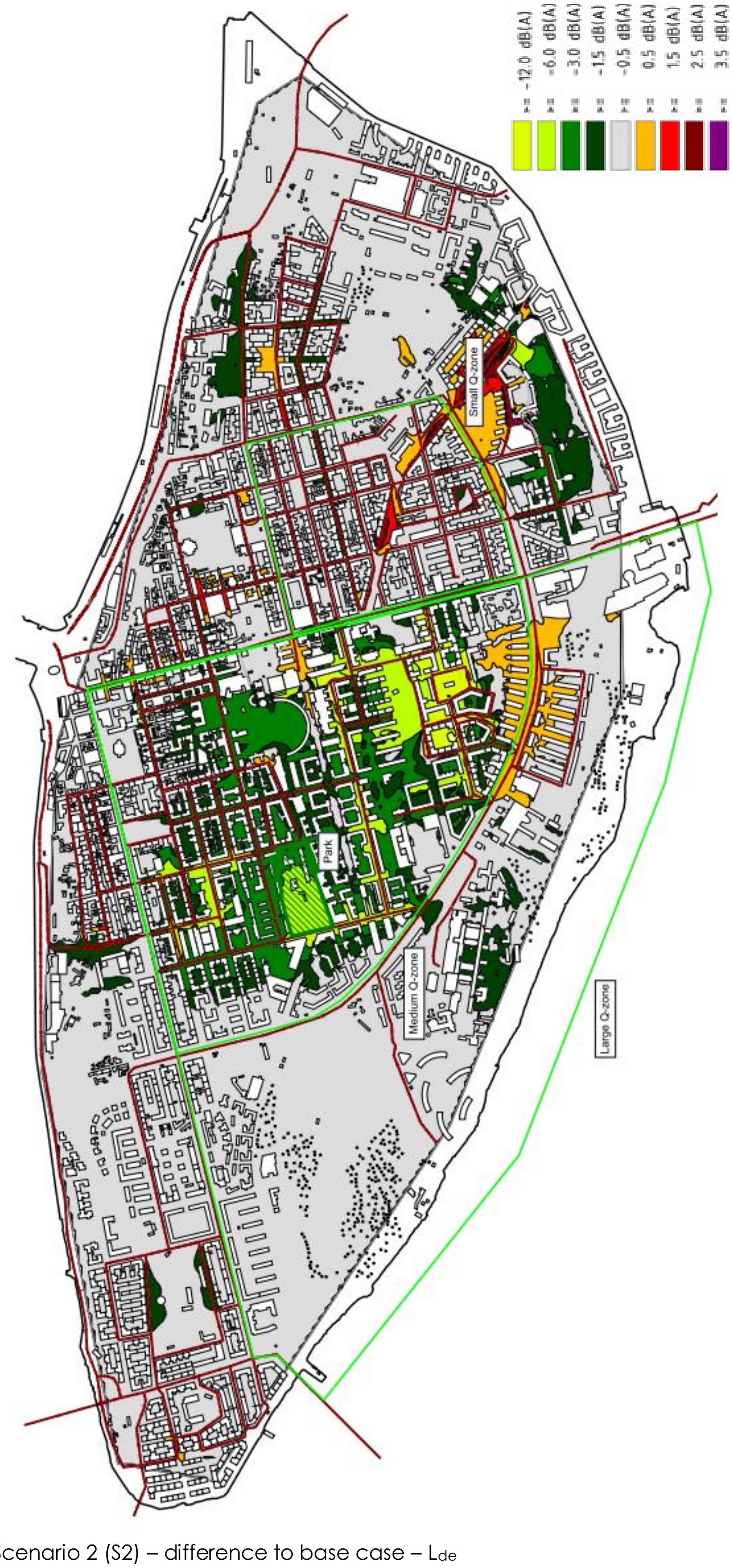

Figure 115: Scenario 2 (S2) – difference to base case – L_{de}

Figure 116: Scenario 3 (S3) – difference to base case – L_{de}

Figure 117: Scenario 4 (S4) – difference to base case – L_{de}

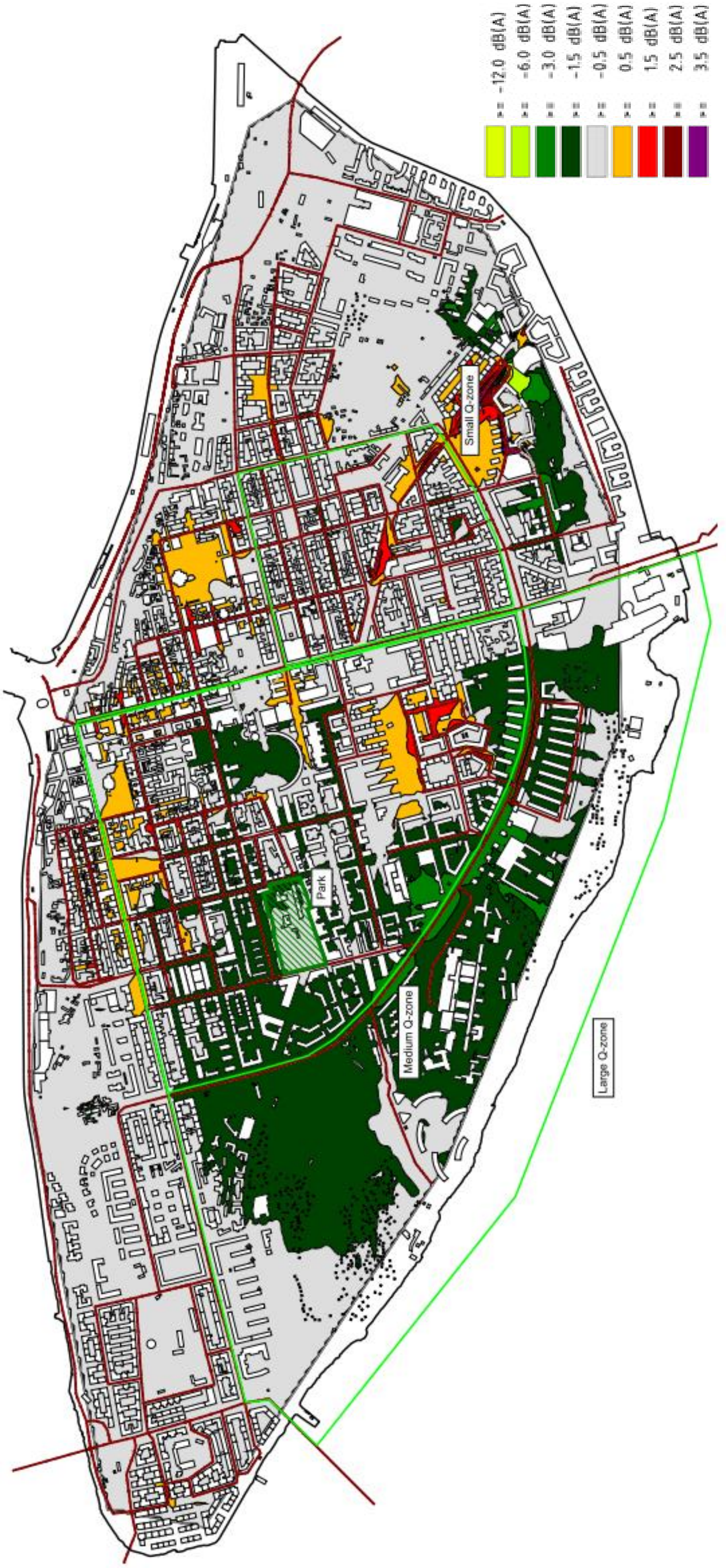

Figure 118: Scenario 5 (S5) – difference to base case – L_{de}

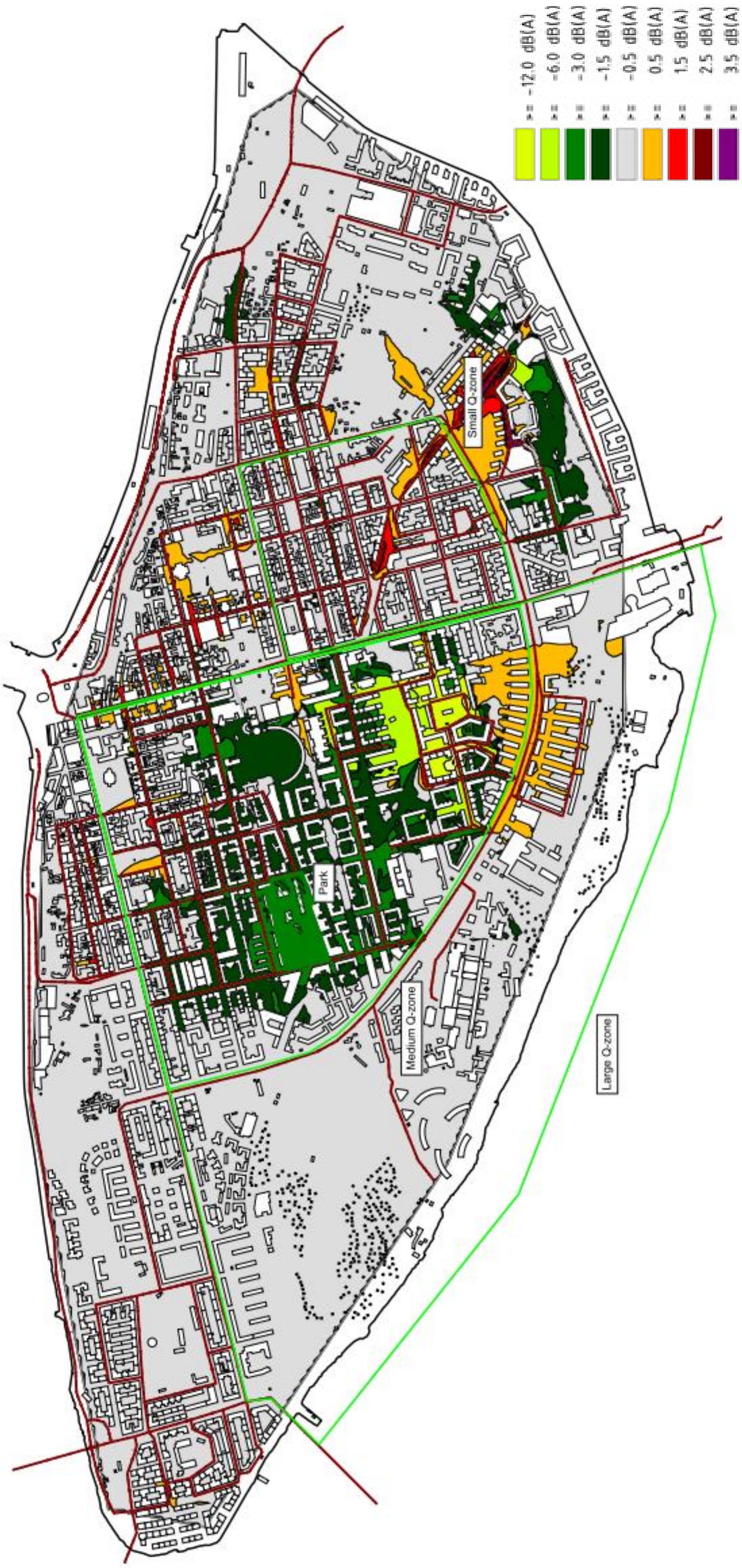

Figure 119: Scenario 6 (S6) – difference to base case – L_{de}

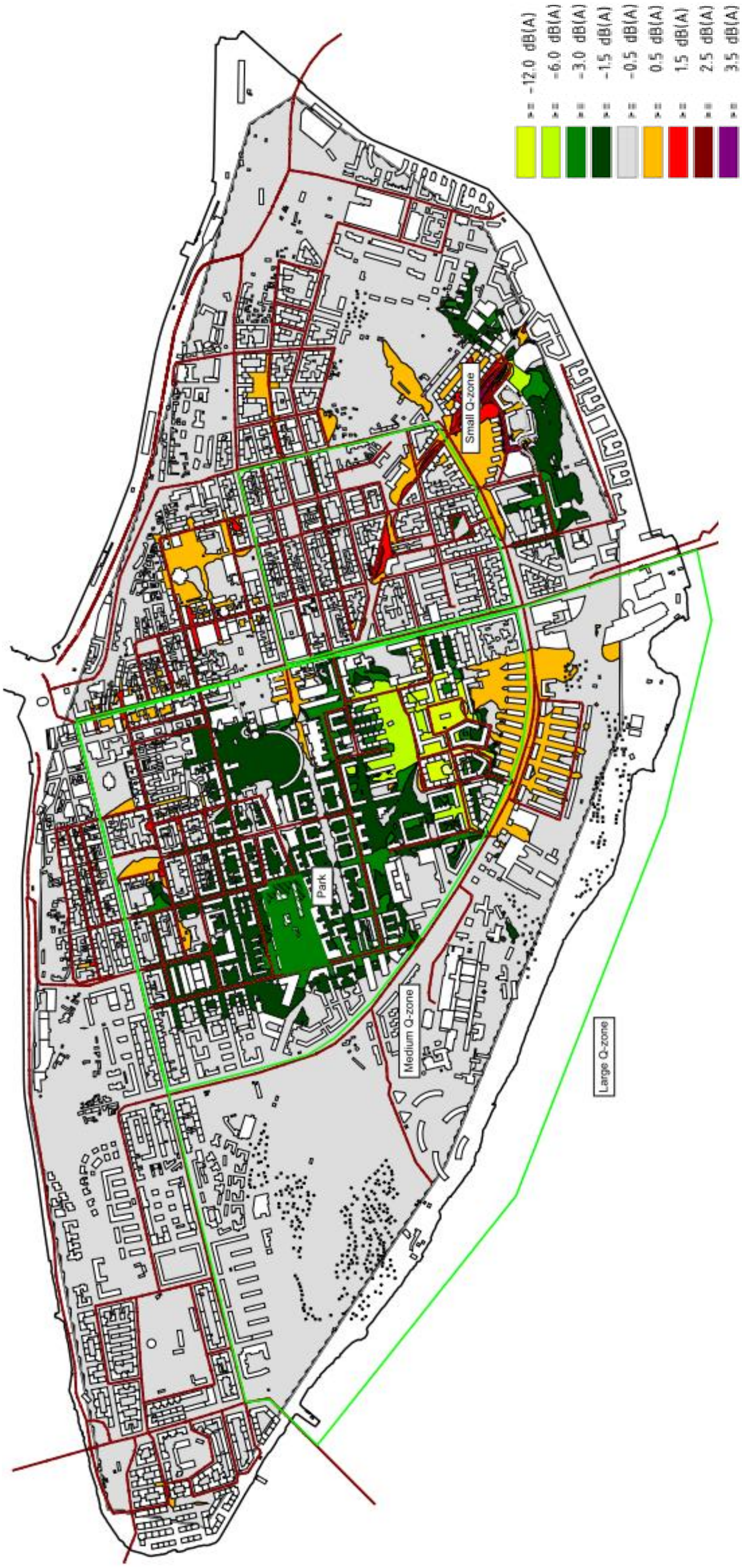

Figure 120: Scenario 7 (S7) – difference to base case – L_{de}

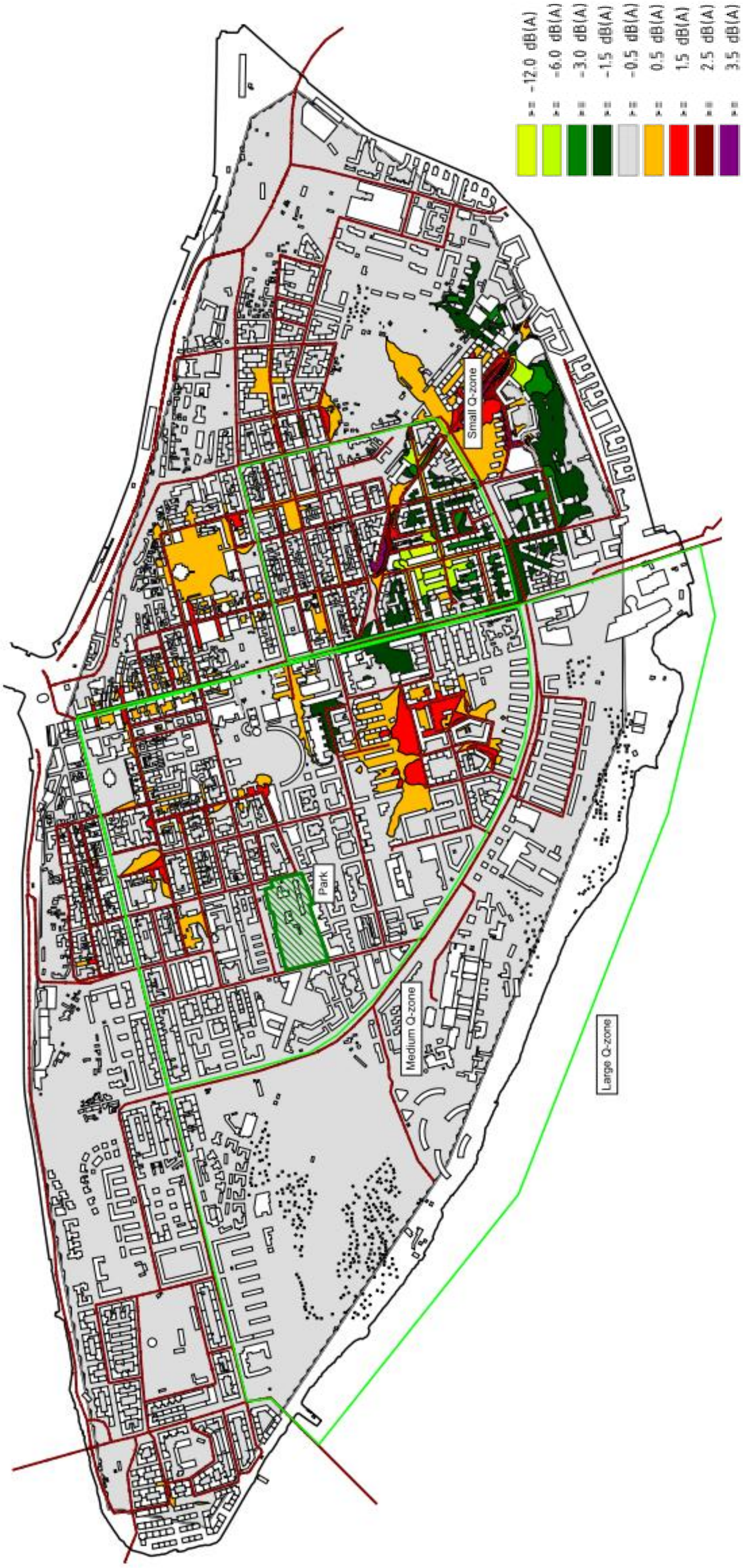

Figure 121: Scenario 8 (S8) – difference to base case – L_{de}

Figure 122: Scenario 9 (S9) – difference to base case – L_{de}

Figure 123: Scenario 10 (S10) – difference to base case – L_{de}

Figure 124: Scenario 11 (S11) – difference to base case – L_{de}

Figure 125: Scenario 12 (S12) – difference to base case – L_{de}

Figure 126: Scenario 13 (S13) – difference to base case – L_{de}

Figure 127: Scenario 14 (S14) – difference to base case – L_{de}

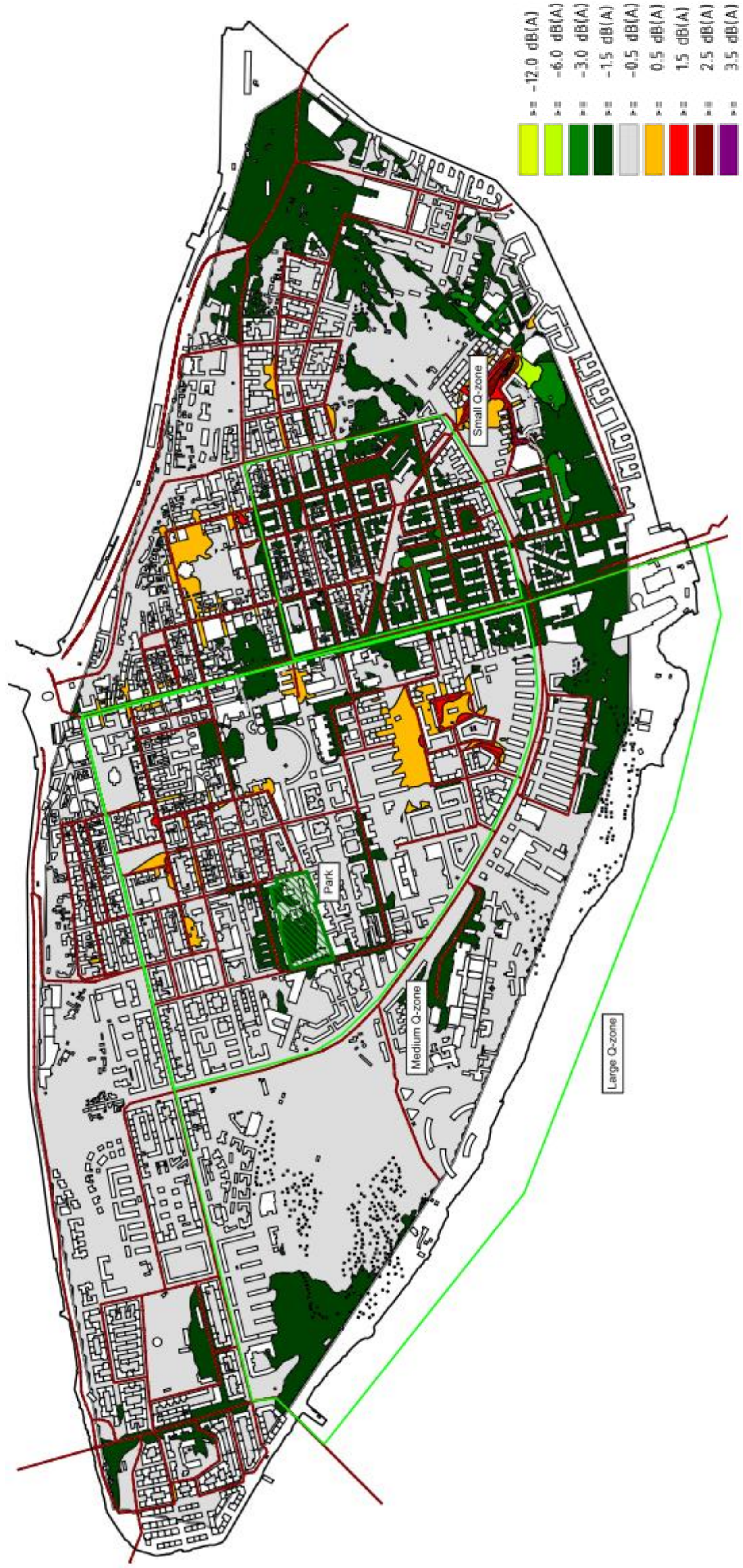

Figure 128: Scenario 15 (S15) – difference to base case – L_{de}

Figure 129: Scenario 16 (S16) – difference to base case – L_{de}