DELIVERABLE 2.11

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Work Package 2.3	Evaluate Noise Mitigation Measures	
	Small Prototypes for "Traffic Control Measures for Vehicles"	
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This deliverable has been quality checked and approved by QCITY Coordinator
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0 EXECUTIVE SUMMARY

0.1 OBJECTIVE OF THE DELIVERABLE

The objective of deliverable D2.11 is to evaluate noise mitigation measures related to traffic control, such as prohibition against through traffic on specific links, reduction of speed limits and restrictions on noisy vehicles.

This document should be seen as including an updated version of deliverable D2.4 “Traffic control measures for vehicles: Basic Concepts”.

0.2 STRATEGY USED AND/OR A DESCRIPTION OF THE METHODS (TECHNIQUES) USED WITH THE JUSTIFICATION THEREOF

Studies were made using the transport forecasting system Sampers (Beser and Algers 2002) modelling travel demand and the transport system in Stockholm County. The most detailed results are vehicle flows per link for different time periods and transit loads for the same periods. Changes in flows and speed that occur for different traffic control strategies were used as input to create related noise maps. Noise calculations were made using the noise mapping software CadnaA (Datakustik GmbH, Munich). To handle differences in geographic representation and traffic data aggregation between the two modules an interface was developed and applied. (We have only studied traffic and noise levels for daytime conditions.) Two study areas were selected, Järva and Södermalm in Stockholm. In these areas, scenarios were studied in form of speed restrictions, prohibition against through traffic and restrictions on noisy vehicles as a possible way to create quiet areas.

As traffic control policies not only have noise effects we additionally studied effects on travelled kilometres, person hours and change in travel pattern. However, effects of a noise mitigation measure related to traffic management will always be network dependent and site specific. Here, we therefore present effects and cost less precise than for physical noise mitigation devices studied in QCity. In additions, it is important to understand that the relative changes presented are depending on the size of the modelled network.

0.3 BACKGROUND INFO AVAILABLE AND THE INNOVATIVE ELEMENTS WHICH WERE DEVELOPED

Based on the work with setting up the Stockholm test site model environment and to develop necessary interfaces between the Stockholm forecasting model and the CadnaA noise mapping software, we have demonstrated the importance of considering redistribution effects when using traffic control measures for noise abatement. We have also demonstrated the viability of quiet areas, using restrictions on noisy vehicles.

0.4 PROBLEMS ENCOUNTERED

During our work we did not encountered any major problems that made us reconsider the overall approach of the studies.

0.5 PARTNERS INVOLVED AND THEIR CONTRIBUTION

Partners involved in WP 2.3.2 were the Royal Institute of Technology (KTH) and Acoustic Control (ACL). KTH handled the traffic modelling whereas Acoustic Control created noise maps with traffic data obtained from simulations. Moreover the interface between the two modules was developed using experience and expertise of both partners.

0.6 CONCLUSIONS

The QCity project is mainly related to noise mitigation measures on vehicles or along the road, reducing noise but not affecting traffic itself. In this work package we in addition study measures affecting the noise source directly, i.e. traffic. The nature of such measures is different in two important ways. The first is that they impact not only noise, but also accessibility, other emissions and accidents etc. The second is that traffic management measures, undertaken to obtain an effect at some desired site, also will have redistribution effects, i.e. diverted traffic will cause noise (and other) effects elsewhere. These effects need to be considered to avoid sub optimization. Here we studied examples of measures related to **traffic control** using a traffic forecasting system and a noise mapping software. **Noise reduction** and **noise redistribution** is considered as well as impacts on accessibility.

Differences in speed due to traffic management measures are important, as it affects noise levels as well as travel times. Ability to forecast speed changes is therefore essential and should be considered if any measure related to traffic management measure is to be applied. A sensitivity analysis made on speed data in the study area Järva shows that using speed limits instead of modelled flow dependent speed gives up to 3 dB higher noise levels. This is because high traffic volumes give lower speed due to congestion.

Our study examples and calculations of daytime noise levels show that closing off through traffic can give a large noise reduction, up to – 14 dB(A). This causes less people being exposed to high noise levels in the range 55 to 75 dB(A). In our cases diverted traffic gives noise increases up to 4 dB(A). But if traffic can be diverted to roads with no close by dwellings the negative effects would be reduced. The implementation cost of this measure is relatively low but one should consider overall effects in a cost-benefit analysis.

Reduced speed gives a noise reduction of approximately –4 dB(A). Redistribution effects are much smaller than in the case of closing a road and noise increases are also less, approximately 2 dB(A). Additionally our study with reduced speed on a road in the study area Järva show that the share of inhabitants exposed to levels around 55 dB(A) are decreased almost to the same extent as for closing the same stretch of road for through traffic. Moreover reduced speed also generally has a positive impact on traffic safety aspects and air quality. Implementation costs are relatively low and it is an easy measure to implement. We consider it being a very efficient measure to reduce noise.

Further, a first study shows that a potential way to create quiet areas is to apply restrictions on noisy vehicles entering or leaving an area. With road barriers the noise reduction within a generalized study area averages 10 dB(A). With a 2-euro charge the reduction is approximately 7 dB(A). On boundary roads the noise increase is around 2 to 3 dB(A) but noise leakage into the restricted area is small. Revenues should be used to finance the system but possibly also to pay for measures to reduce negative noise boundary effects. The feasibility of this measure depends however also on the provision of adjacent parking space and quiet vehicles. The concept shows a great noise reduction potential and further research is needed.

All modelled policies show low impacts on accessibility in terms of travel time and person hours travelled. These results are however relative to the total network; locally the effects can be much larger.

Acceptance of applying any of the measures studied is related to the number of people affected. We believe that reduced speed has higher acceptance than closing off trough traffic as it generally impacts the driver less and is also related to positive traffic safety effects. Creation of quiet areas using restrictions on noisy vehicles will most likely have a low level of acceptance. But for people living inside the area and for owners of quiet vehicles the level of acceptance would possibly be much higher.

0.7 RELATION WITH THE OTHER DELIVERABLES (INPUT/OUTPUT/TIMING)

The Data Terrain Model used when calculating noise maps has been developed in SP1.

The interface method used was an output from deliverable D2.4 “Traffic control measures for vehicles: Basic Concepts”. In deliverable D2.12 “Small prototypes for Car ownership measures for vehicles” scenarios are studied how to reach the levels of car ownership of quiet vehicles which are applied in the analyses of creating quiet areas.

Noise mitigation measures developed in this sub work package are additionally evaluated in WP 2.3.6 where all measures studied in WP 2.3 are ranked considering performance/cost, general applicability and general acceptance, resulting in D2.15 “Ranking of different noise source mitigation measures”. Results are also presented in deliverable D6.2 “Technical consolidation report on all conceptual designs: source, propagation, receiver”. In addition, models developed are used in SP5 in relation to the Stockholm test site study.

1 INTRODUCTION

The objective in work package 2.3.2 is to evaluate noise mitigation measures related to traffic control. This document presents methods and results of studies carried out by KTH in collaboration with acousticians at Acoustic Control. Chapter 1 and 2 are mainly based on texts in deliverable D2.4 "Traffic control measures for vehicles: Basic Concepts". Thus this document can be read without reading deliverable D2.4 in advance and is considered to be an updated version.

1.1 BACKGROUND

QCity is a project in EU's sixth framework programme. The aim is to develop an integrated technology infrastructure for efficient control of road and rail ambient noise by considering the attenuation of noise creation at source at both vehicle/infrastructure levels. The project will support European noise policy to eliminate harmful effects of noise exposure and decrease levels of transport noise creation, especially in urban areas. A major objective is to provide municipalities with tools to establish noise maps and action plans (Directive 2002/49/EC) and to provide them with a broad range of validated technical solutions for the specific "hot spot" problems they encounter in their specific city.

Noise and traffic management has been treated in other EU projects. In SMILE ('Guidelines for Road Traffic Noise Abatement') an objective is to give guidelines directed to decision makers regarding organisational and strategic approaches. Different possible measures are presented and exemplified but noise effects are not calculated. However, references are given on noise abatement measures applied in European towns and cities, in most cases only qualitatively described. In the report 'Traffic management and noise reducing pavements – Recommendations on additional noise reducing measures' (Danish Road Institute, 2004) produced as Deliverable 12 in the SILVIA project, prediction models are applied to show noise effects due to reduced speed, different shares of heavy vehicles and calmer driver behaviour. A European literature survey of experiences related to these issues is also presented. However, only local effects are described, not considering redistribution effects in the traffic network. In the QCity project, we show examples of traffic control measures using area wide traffic forecasts and noise mapping. We therefore analyse noise effects area wide and not only at the source, also considering noise redistribution and impacts on accessibility.

1.2 TASK DESCRIPTION

Noise reduction action plans need to take into account a wide range of different options to reduce noise. In order to relate technical improvements investigated in the QCity project to other means of noise reduction, some effort will be put in calculation of such effects. This work package looks into the impact of traffic control measures in this respect. Different scenarios are analysed and compared using traffic forecasting models and acoustic models. Changes in flows and speed that occur for different traffic control strategies are used as input to create related noise maps. Restricting car traffic to specific links, restricting speed and restrictions on noisy vehicles are scenarios studied and presented in this report.

Although the project has a focus on "hot spots" and "quiet areas", attention has also been paid to the whole urban area as traffic control policies often have system wide effects. We use the Sampers transportation modelling system (Beser and Algers 2002) and its existing model modelling trips in an area including Stockholm County (illustrated in Figure 1 and Figure 2). Traffic control measures are applied in sub areas of the model network and noise level impacts in these areas are calculated using the noise mapping software CadnaA (Datakustik GmbH, Munich). In addition, we look at regional effects such as change in travel pattern and travelled kilometres.

Two study areas in Stockholm municipality have been selected, Järva and Södermalm. The first area represents a suburban region with road types varying from local streets to European highways and different forms of public transport such as bus and commuter train. The second area represents an urban environment in the centre of Stockholm**.** Figure 3 shows a map of Stockholm municipality and the study areas encircled in blue.

Figure 1: Sweden and the location of model area coloured in blue.

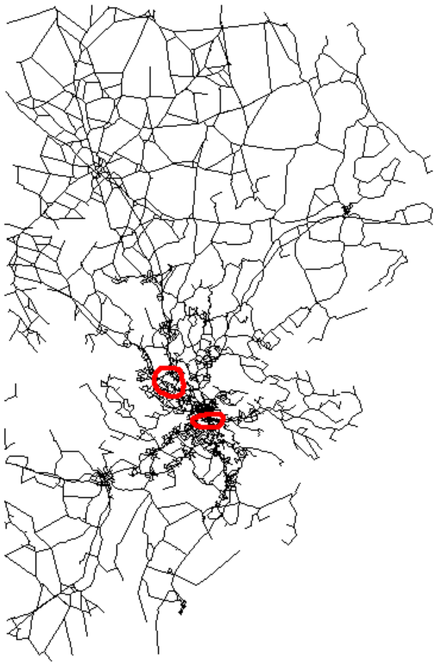

Figure 2: The model network shown with study areas encircled in red.

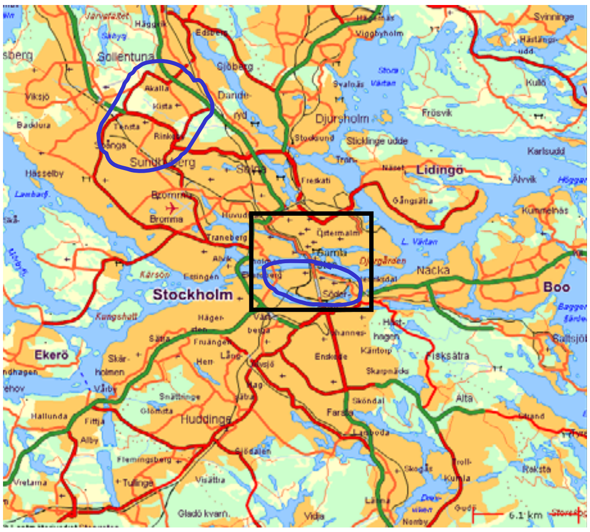

Figure 3: City map of the Stockholm region with study areas encircled in blue and inner city marked by black square. (Map taken from http://www.enrio.se)

2 METHOD

This chapter gives a short introduction to the concept of traffic forecasting and describes the transportation modelling system and noise map software used in our studies. An important issue to handle is the interface between the two modules described in 2.3. Note that most of the text in this chapter is taken from deliverable 2.4 ‘Traffic control measures for vehicles: Basic Concepts’. This document should be seen as including an updated version of D2.4

In the EU-project IMAGINE (Improved Methods for the Assessment of the Generic Impact of Noise in the Environment), the suitability of traffic models for noise modelling was considered (Report 2.2 Suitability of traffic models for noise modelling). The conclusions were in short that “There is no superior type of traffic model to deliver input for traffic noise models. Depending on the study area (e.g. major roads, or agglomerations), several traffic model types are capable to deliver the required output.” Each model has its own strengths and weaknesses, and in the QCITY project therefore different types of traffic models are used in different applications. In each case, the practical situation in terms of data and model availability needs to be taken into account.

2.1 TRAFFIC FORECASTING

Traffic is a result of people’s choices. Where to travel, in what kind of mode, on which route and at what time, are all choices we make for a journey. These choices depend on the characteristics of different modes, routes, etc, and how the individuals value the characteristics. With traffic models we try to simulate these choices using people’s values derived from actual behaviour in traffic. To evaluate effects of a change in the traffic system like a new road or introduction of tolls, traffic models are helpful tools. Consequently traffic forecasts are often used to support decision-makers when evaluating different solutions of current traffic problems or future scenarios.

Traffic models are based on two important components, traffic demand and traffic supply. The individuals that travel through the network in different modes constitute traffic demand whereas traffic supply is defined by the traffic network and the public transport system the travellers can use making their trip.

Depending on the sort of traffic scenario to be studied different traffic simulation models to model supply are used. There are three main types of models, macroscopic, microscopic and mesoscopic. A macro simulation model describes the traffic at a high level of aggregation based on flows. It is a static model that takes a “snapshot” of traffic flows, and the network is simplified to a representation of links and nodes. Micro simulation models are dynamic models where each vehicle is simulated individually. The network is built in detail and traffic controls such as traffic signals and yield signs are modelled. Both macroscopic and microscopic models apply behavioural models to simulate how vehicles interact in the system, though micro simulation models model driver behaviour at a higher level of detail. Mesoscopic models typically model individual car movements along a road link less extensively.

2.1.1 The Sampers forecasting system

When studying traffic control measures in QCity we use the transportation modelling system Sampers (Beser and Algers 2002) which contains a multimodal travel demand model system and which is integrated with the analysis package Emme/2 (Inro, Canada). Demand is calculated as a function of socioeconomic variables describing travellers, attraction variables describing destinations and traffic network variables describing the transport system. The demand is assigned to the traffic network by the network analysis package. The latter is a macroscopic model where a region to be analysed is described by zones, links and nodes. Zones are areas that generate or attract trips representing e.g. dwellings and working sites, whereas links and nodes make up the traffic network. The most detailed results are vehicle flows per category per link for different time periods, and transit loads per line for the same periods. Figure 12 on page 17 illustrates the structure of the model, and the next two paragraphs give a more detailed description.

2.1.1.1 Basic model structure

The Sampers system is built on a four-dimensional model, reflecting choices people make in the dimensions of trip generation, trip distribution, mode choice and route choice.

The three first dimensions are modelled simultaneously using discrete choice models of the nested logit type (Ben-Akiva, Lerman 1985). This implies that the probability to choose each possible combination of alternatives in the three dimensions (to travel or not, to what destination, by what mode) is calculated for each person in the area. The results are then aggregated to a level describing the total traffic demand between each origin and destination zone pair for each mode. For route choice, a network assignment procedure is used to be able to consider congestion effects of travellers' route choice.

Different variables are used to describe the alternatives in the different dimensions. The nested structure of the model allows factors affecting one dimension to also affect choices in other dimensions (a change in parking costs in one area will not only affect mode choice, but also destination choice and the choice to make a trip at all). Below, some examples of variables used to describe different choice dimensions are given:

Trip generation: Trip generation, i.e. in the choice to make a trip, varies often by socioeconomic category, and variables like age, gender, income and car-ownership are often used.

Trip distribution: This relates to the choice of destination (i.e. destination zone). An individual makes her choice based on the attraction of the destinations as well as the generalised cost (time and money) to reach different destinations. The attraction variables are different depending on the trip purpose. For work trips a part of the attraction can be the number of working sites, while for shopping trips the attraction may be described by the size of stores and the number of stores in an area.

Mode split: Mode split is a consequence of people's mode choice, which is influenced by travel cost and travel time components like wait time, in vehicle time and access time. Also, socioeconomic variables can have an influence – it is often the case that men are more likely to use the family car than women.

Network assignment: In order to make it possible to consider peoples route choice with respect to congestion, a network assignment procedure is used that achieves consistency between route choice and network congestion. This is modelled in Emme/2 by the concept of network equilibrium (Ortúzar, Willumsen 1990). Each link is associated with a volume-delay function describing how travel time varies with traffic volumes based on the capacity of the link; see the general characteristics in Figure 4. Turning vehicles can also get so called turn penalties in the nodes (road junctions) to account for delays due to signals etc. An iterative algorithm is used to obtain the equilibrium situation. The final solution describes flows in accordance with Wardrop's user optimum principle where no traveller can decrease his or her travel time by changing route. For public transport, route choice of public transport submodes is modelled by the so-called Optimum Strategy approach (Spiess and Florian 1990). Here a passenger will pick the transit line or combination of transit lines that minimizes his or her travel time considering travel time in the vehicle, connection times and waiting times. For slow modes walk and bike people are modelled to use the shortest path.

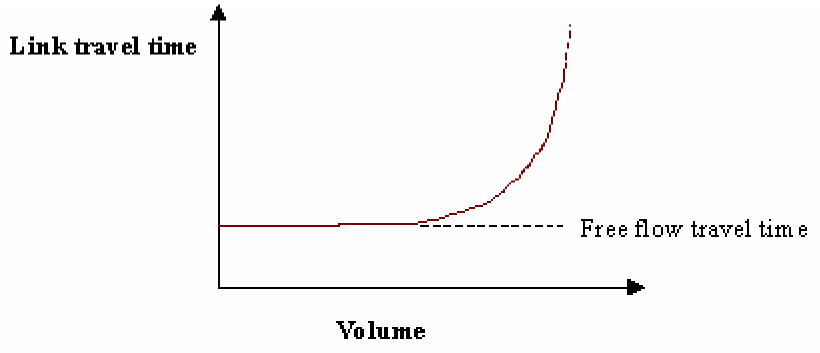

Figure 4: Characteristics of a volume delay function.

Finally, in situations with congested networks, it is necessary to recalculate the travel demand and redo the network assignment in an iterative process. As the generalised cost of a link is based on the number of travellers travelling on the link the costs previous to and post to a network assignment may not be equal. Hence an iterative process between the demand model and the network assignment model results in a solution were there is consistency between choices in all dimensions and the level of congestion, reflected in travel times on the network. These iterations are often very time-consuming and therefore generally only a few iterations are made.

2.1.2.1 Features in Sampers used in QCity

Samper contains submodels for all trips in Sweden, international, long distance, regional and local trips. As local traffic control policies applied in the study areas may affect a whole region, we model regional and local trips of an area including all of Stockholm County (illustrated in Figure 2 on page 8), using the submodel for regional and local trips. Long distance trips and heavy traffic are also included, but are fixed in terms of Origin and Destination (but can change routes).

The model parameters are estimated on the National Swedish Travel Survey 1994-2000, and calibrated for the year 2001. In this application, the road and public transport network for year 2005 is used. The complete network consists of approximately 6 000 regular nodes and 1 500 centroids. A centroid is a node symbolising a zone generating or attracting trips. Each centroid has related fictive links called connectors on which traffic demand is distributed to the network. Figure 5 shows the study area Södermalm encircled in red where centroids and connectors are illustrated in green and regular nodes and links in black. Each link has a direction defined by a start-node and an end-node. Accordingly a two-way street is represented by two links with reversed directions. (Note that a link and its reversed link are given equal geographical representation.)

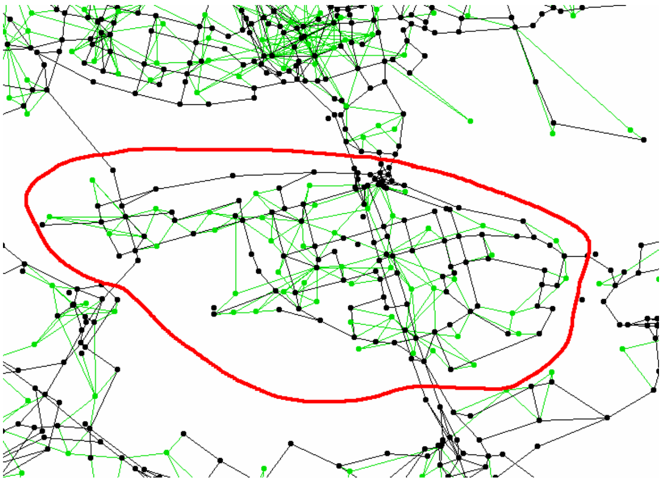

Figure 5: Study area Södermalm modelled in Emme/2.

Attributes describing links and connectors are mode, length, number of lanes and volume delay function. Numerous functions are defined to model different kinds of roads such as free ways and local streets. The mode attribute describes which modes are allowed on a link, e.g. train to model a railroad or bus and car to model roads. Transit lines are defined by the link attributes name, transit mode, vehicle type, headway and speed. Transit mode illustrates if it is e.g. a bus or a train line whereas vehicle type describes if it is e.g. a commuter train or a high-speed train. Headway is the frequency of the transit line, i.e. the average time interval between two departures.

The road network and public transit lines are modelled in the integrated analysis package Emme/2. When evaluating different traffic control policies as restricting car traffic to specific links and restricting speed, the package is used to introduce these changes in the original model network. For example it is possible to restrict car traffic in an area by not allowing cars on the specific links, or reduce speed limits by changing volume delay functions. Note that all changes affect the whole travel pattern. If a strategy is to forbid car traffic on a link, this will force people who used to travel on the link to choose another route. However they may also change destination, mode or even cancel the trip, all depending on the change in accessibility due to the policy.

If a traffic forecast is made for future conditions, it is possible to set parameters in Sampers related to national factors such as economic development and changes in petrol taxes. However this feature will not be used in this task, as all changes are assumed to take place “today”. We only make modifications related to the network and keep all other variables and parameters fixed. Hence we can study effects of a traffic policy by comparing its results with the traffic pattern of a base scenario represented by the original network.

Sampers models six different trip purposes: work, business, school, social activities, recreation and other. In the network assignment procedure, the resulting demand is divided into several user classes with different values of time. This is necessary to reflect different route choice behaviour for different user classes when economic restrictions are imposed. The value of time parameter reflects the amount of money a traveller is willing to pay to decrease his or her travel time by one time unit. As an example the transport industry such as logistics firms belong to the group with highest value of time. To a large extent, results pertaining to different categories can be displayed. This option is used when input data to the noise map software is calculated, for details see section 2.3.2.

What is not modelled in most traffic simulation models including the Sampers model used is departure time choice; i.e. at what time travellers decide to actually make their trip. This dynamic feature is important since the travel times depend of the number of vehicles travelling in the network. However in Sampers it is handled on a highly aggregate level. A day is divided in three time periods, 7-9 a.m., 9 a.m.-16 p.m. and 16-18 p.m., reflecting the peak and off peak conditions. Traffic demand for each trip purpose and user group is distributed to these time periods in different shares. For example all work and school trips are set to take place in the peak hours (the first and the last period). The periods and distributions have been set to capture the dynamics of traffic during the day. An illustrative example is Figure 6 showing the traffic distribution on a European highway south of Stockholm City, with model periods marked in green.

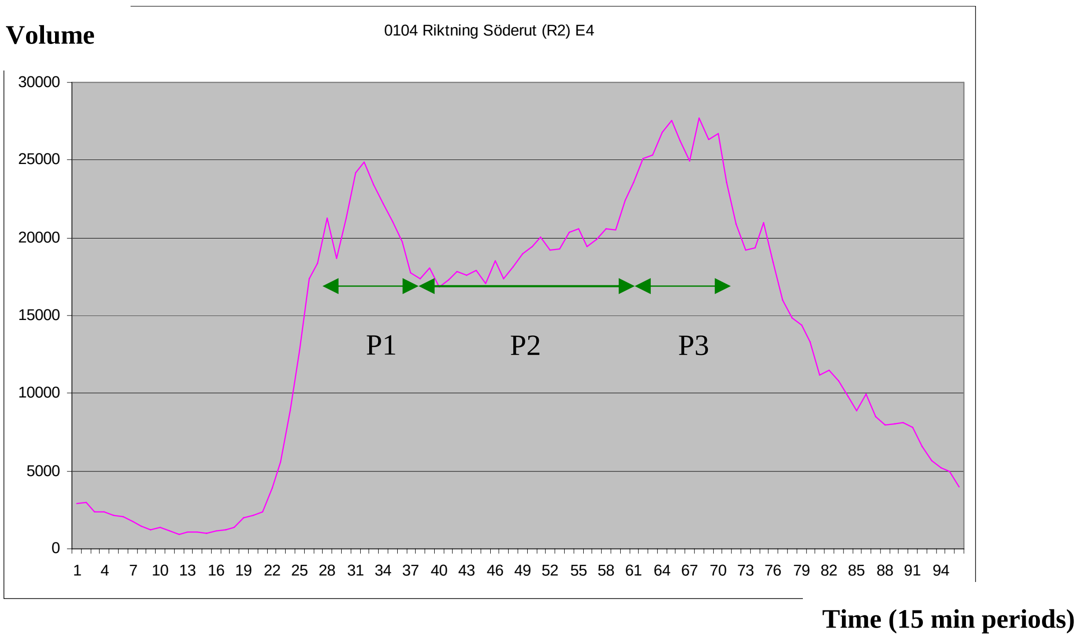

Figure 6: Traffic distribution during a day

Simulation of travel demand for the first and the last period are assumed to give similar results (however with reversed direction). Thus by only simulating the first and second time period, representing peak and off-peak hour traffic, calculation time is saved. Nevertheless the simulation time for our base scenario used in QCity is approximately 30 hours.

The outputs of a simulation represent traffic conditions of an average hour of each time period. Figure 7 illustrates a part of Stockholm County and the auto volumes for a morning peak hour in our base scenario, study areas encircled in blue. Figure 8 illustrates an off-peak hour volume.

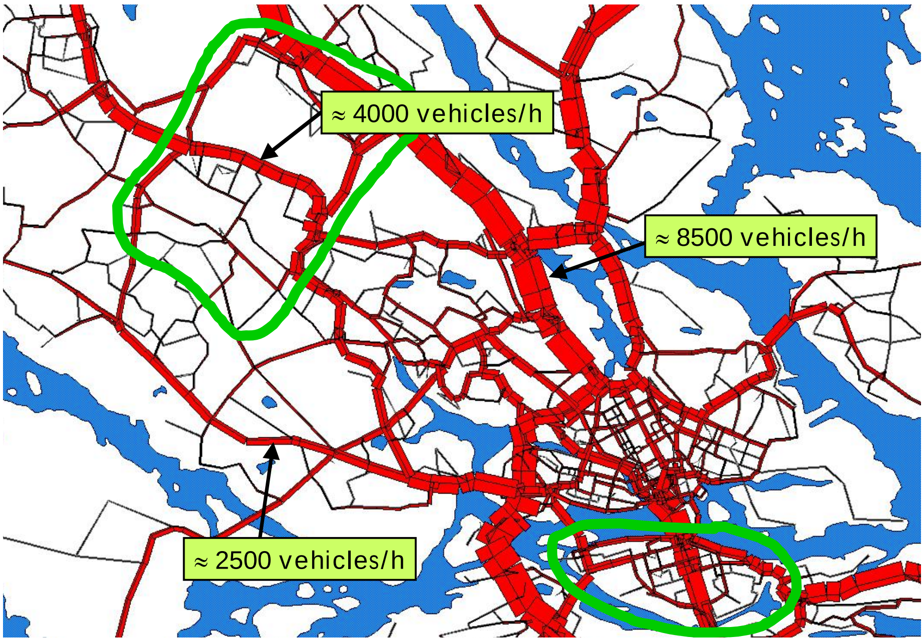

Figure 7: Automobile traffic volumes of morning peak hour (base scenario)

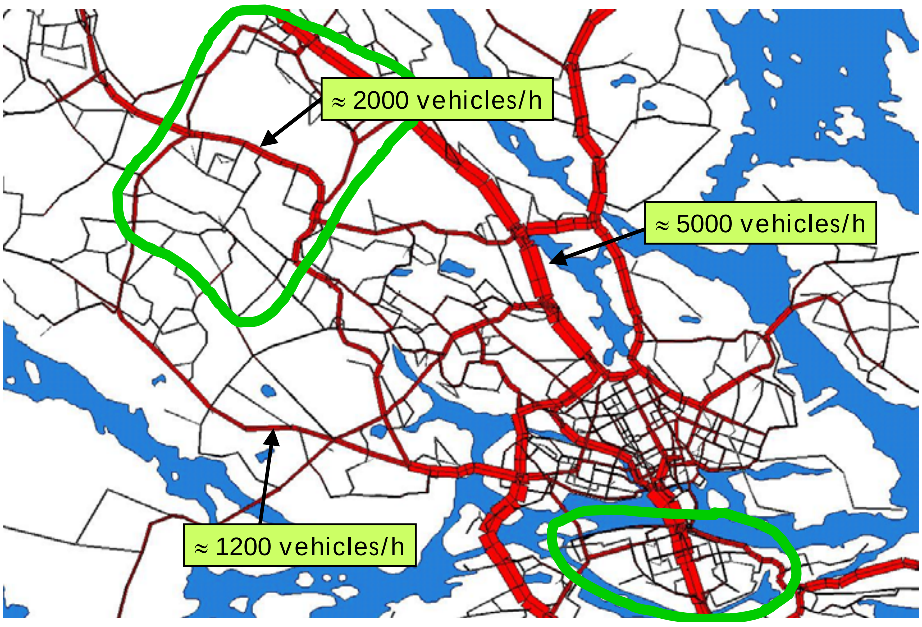

Figure 8: Automobile traffic volumes of off-peak hour (base scenario).

In a congested traffic condition like the morning peak hour in Stockholm, the model captures the reduction in speed due to capacity constrains. This is exemplified in Figure 9 showing the link speeds of the base scenario in the study area Järva. The formally allowed speed limit of the road “Hjulstavägen” marked in green is 70 km/h. As illustrated, simulation results in lower values particularly on the links with direction towards the city centre where the speed is approximately 40 km/h. However for off-peak hours the speed is approximately 60 km/h on the same stretch of road, illustrated in Figure 10. This feature is important when creating noise maps, as speed is an important noise factor. Another issue is the fact that the official speed limits are generally used as input when calculating traffic noise levels. To analyse the sensitivity of speed data we created one noise map using speed limits and one with modelled speed. (How we create noise maps is described in the forthcoming chapter). Figure 11 shows the difference plot between these two maps (speed limit – modelled speed). It illustrates that use of speed limit give higher noise levels than use of modelled speed. As expected main distinctions appear close to congested roads with approximately 3dB(A) difference. This analysis indicates the magnitude of dB levels that are missed out in studies of traffic control measures if fixed speed is used. Ability to forecast speed is therefore essential.

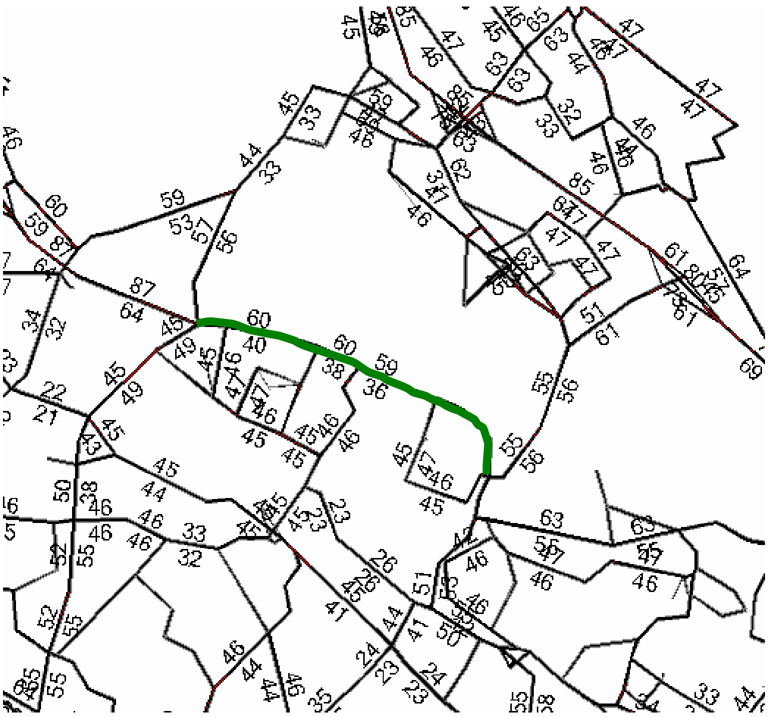

Figure 9: Link speeds in Järva morning peak hour (base scenario).

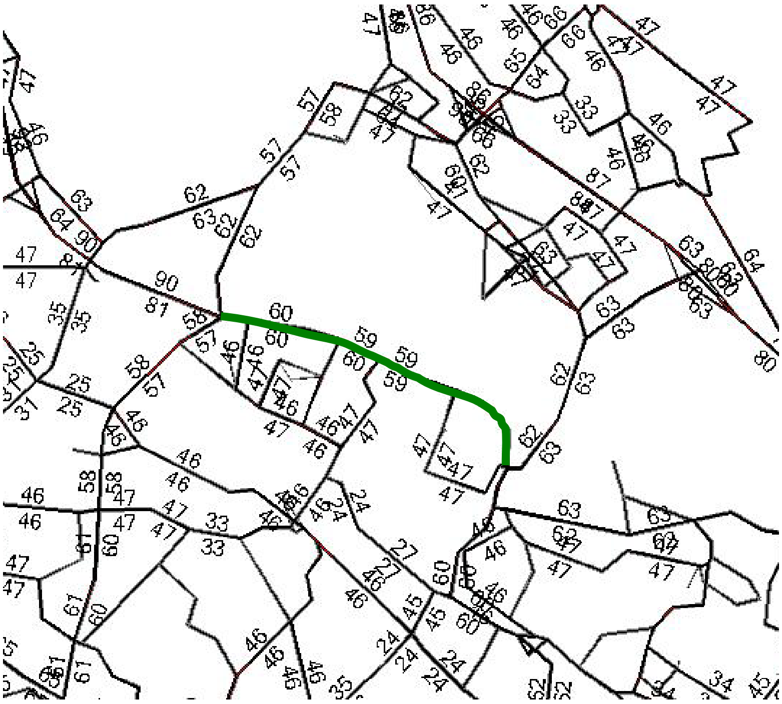

Figure 10: Link speeds in Järva off-peak hour (base scenario).

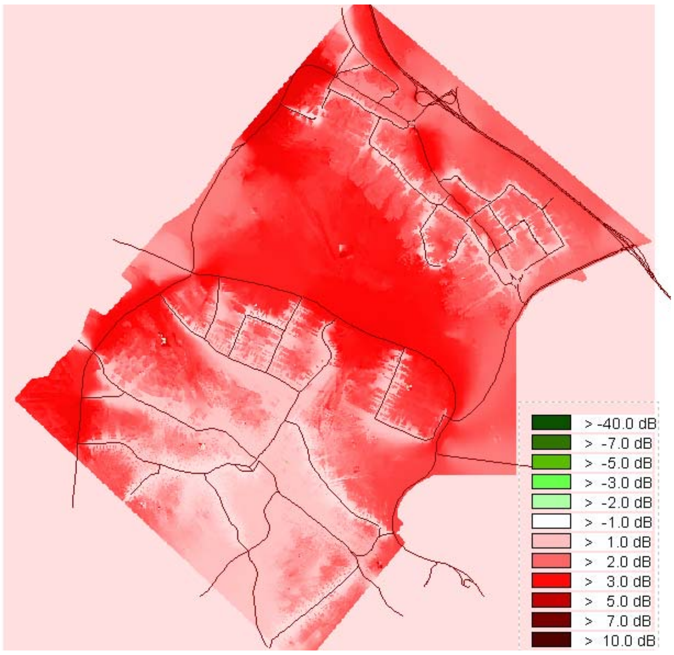

Figure 11: Difference in using speed limit instead of modelled speed.

The uncertainty of speeds (and flows) modelled by the assignment model may also be an issue when using the model to provide input to noise calculations. For this task, we aim at describing effects of different policies rather than the actual current situation, and therefore the precision of describing the current situation is somewhat less important here.

Finally Figure 12 gives an overall picture of the structure of Sampers and its integration with Emme/2. Note that a traffic control policy applied on the network is input to Emme/2.

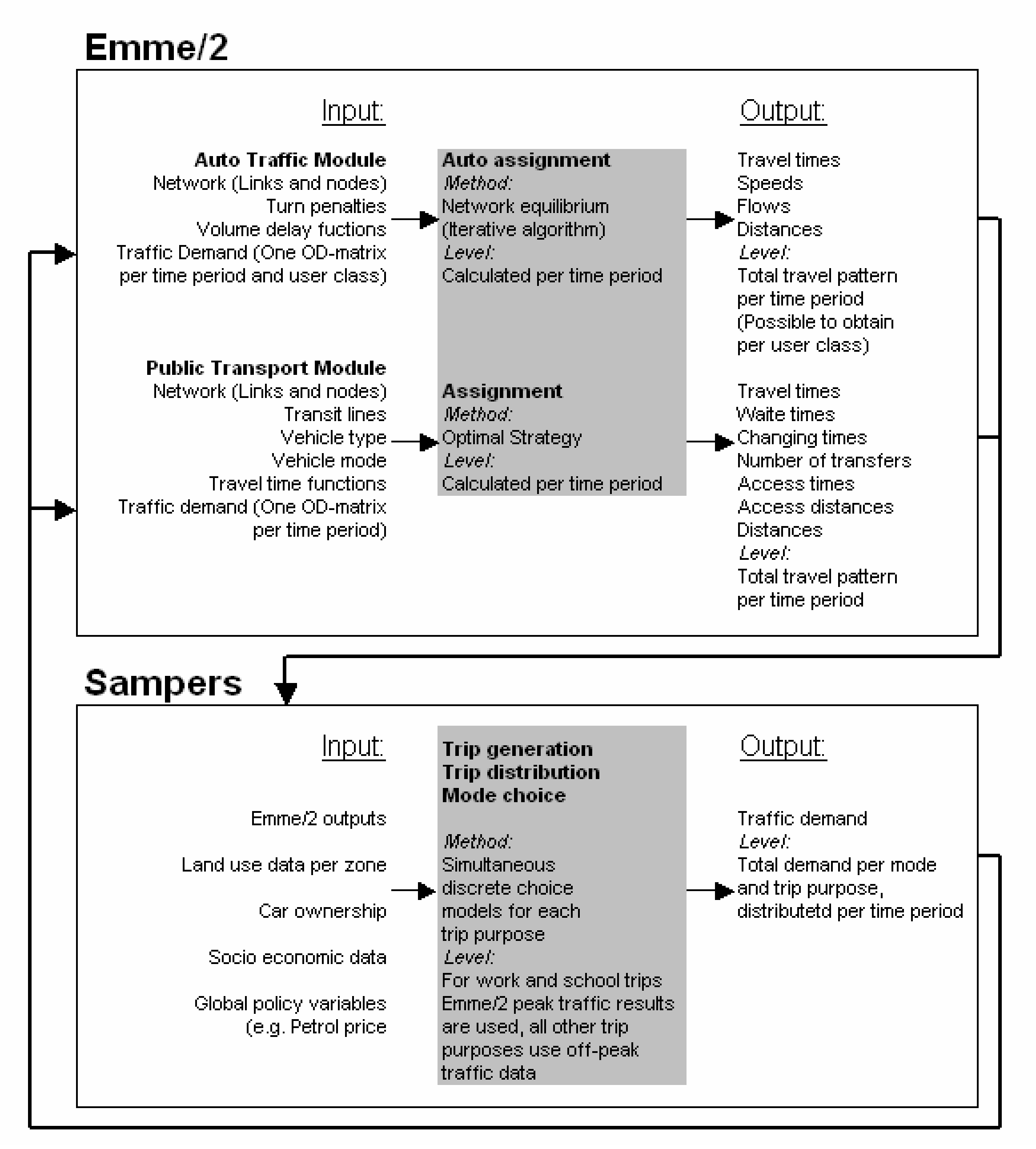

Figure 12: Structure of the transportation modelling system Sampers and its integration with Emme/2.

2.2 THE NOISE MAPPING SOFTWARE CADNAA

When creating noise maps CadnaA (developed by Datakustik GmbH, Munich) is used. Calculations are performed according to official Nordic prediction methods for respective source. For road traffic noise the Nordic prediction method for road traffic noise, rev. 1996, is used.

The CadnaA software automatically manages the effects of ground absorption, screening, reflections etc. according to the official prediction method.

Calculations demand a 3 dimensional map (Data Terrain Model, DTM) as well as data for the different kinds of sources, e.g. the amount of traffic on a specific road or the sound spectrum for a specific source.

The terrain model is built with contour lines defining the height along the line. Locations of larger wooded areas, lakes shore lines, locations of buildings and screens as well as their height are then implemented to complete the digital terrain model (DTM). The DTM used in these studies have been developed in SP1 and more information is found in deliverable D1.1.

The 24 hours representing the day is divided according to the EU directive 2002/49/EC;

- Day 06 - 18
- Evening 18 - 22
- Night 22 – 06

Traffic data needed to calculate noise levels is speed, flow and share of heavy vehicles of a road represented per time period. In addition it is possible to calculate noise levels of each period separately.

The roads as well as the railways are fitted to the DTM. The bridges and overpasses are taken into account by letting the road “float” at the defined height. No source are placed when roads or railway are in a tunnel.

When the sources are in place the calculations result in a grid showing the calculated sound pressure level. For the study areas in Stockholm the grid will have a receiver spacing of 10 by 10 meter and a receiver height of 4 meter.

More information about CadnaA can be found on the webpage www.cadna.de.

2.3 ADAPTING TRAFFIC FORECASTS TO NOISE MAPPING SOFTWARE

In order to use the outputs of Sampers as input to the noise mapping software CadnaA we have created an interface. As the two models work with different graphical representation in different geographical reference systems, the first step was to create a key between the networks; this was made using SweTrans (SWEGIS, Sweden) a software to transform GIS shape files to different graphical reference systems and the GIS software ArcView GIS (ESRI, USA). Secondly the traffic data outputs of a macro simulation are modified to match the inputs needed to create noise maps.

2.3.1 Geographical correspondence

A basic input is shape files describing roads of the study areas. The files are represented in the Stockholm local reference system ST74 and are used as input to CadnaA when noise maps are created. Roads are divided into two segments, main roads and local streets, and are represented by polylines in two different shape files (shown in Figure 13, main roads in black, local streets in blue). A European highway is running traverse the study area farthest north (in Figure 13 coloured in green).

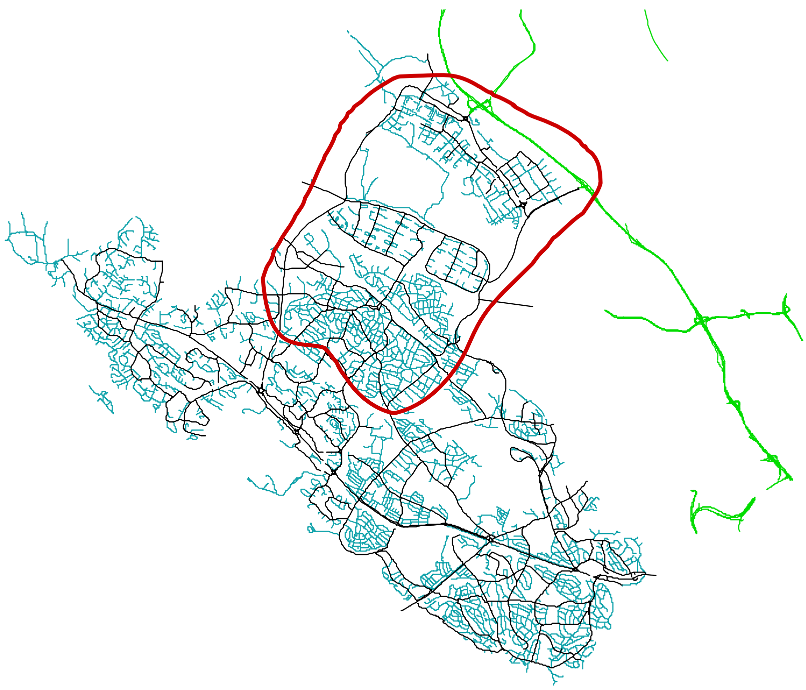

Figure 13: Main roads, local streets and European highway E4. Järva study area encircled.

Via a short script in ArcView we could create shape files of links and nodes of the model network defined in Emme/2. By using SweTrans the files were transformed from the reference system used in Emme/2 (RT90 2,5 gon V 0: -65) to ST74. Figure 14 shows the model road network of Järva and Figure 15 main roads and the model network represented in ST74.

Figure 14: Road network of Järva in Emme/2 (reference system ST74).

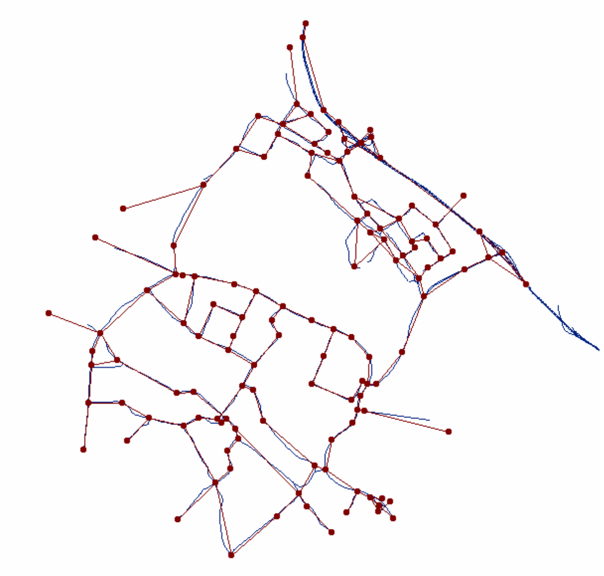

Figure 15: Emme/2 network and main roads (reference system ST74).

Once the two networks were represented in equal format, in equal reference system using ArcView we could manually create a key between the roads in the shape file used in CadnaA and the links in Emme/2. (From now on we will use roads as a reference to the network used in CadnaA and links as a reference to the Emme/2 network). Four different relations were treated: 1:1, 1:n, n:1, and no straightforward match.

In the case of a one to one relation the nodes representing the associated link were added to the attribute data base file of the corresponding road. If a road represented a two-way street the reversed node combination was also added. An example is illustrated in Figure 16 and the corresponding node connection is shown in Table 1.

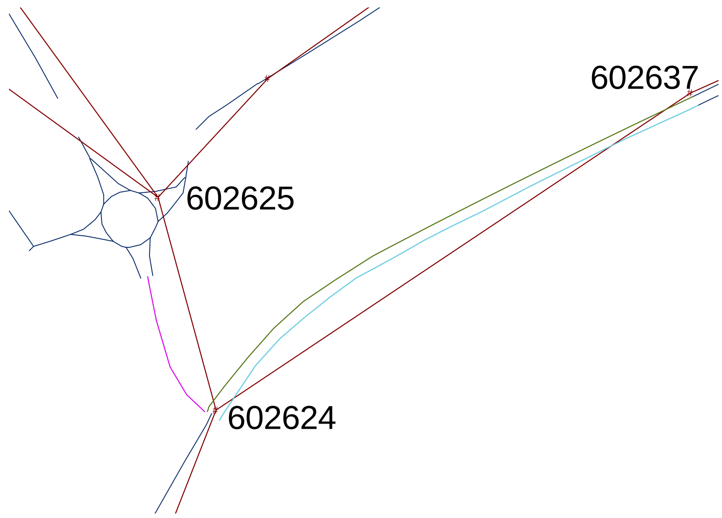

Figure 16: Network example.

Table 1: Example of link/node connection

	Fnode1	Tnode1	Fnode2	Tnode2
Green road	*602637*	*602624*	*0*	*0*
Turquoise road	*602624*	*602637*	*0*	*0*
Cerise road	*602624*	*602625*	*602625*	*602624*

If one road corresponded to several links the road polyline was split into the same number of polylines as there were related links and like the one to one case the link/node relation was added to the dbf-file. (The cuts were made at positions on the road polyline that corresponded to the positions of the nodes in the Emme/2 network.) In some situations more than one road polyline corresponded to one link. Here the identical node relation was added to each road.

Since the CadnaA network is more detailed than the Emme/2 network a few junctions emerged where there were no straightforward relation between the networks. In these cases characteristics such as speed limit of roads and links in the entire intersection were adopted. Road lines describing mid circles in roundabouts, seen for example in Figure 16, cannot be related to any link and they are therefore excluded when noise maps are created. In conclusion we want to emphasize those local areas containing roads with no straightforward match should be treated with extra care when noise maps are analysed.

When creating the key we started working with the shape file describing main roads. Roads that could not be related to the Emme/2 network were consequently moved to the local street shape file. In addition some of the local streets were represented in the Emme/2 network and were therefore moved to the main roads shape file. As a result the main roads shape file only contains roads with link connections whereas the local streets shape file has no direct link match. (Note that this is the main road shape file illustrated in Figure 15.) Finally for both shape files each road was given a unique identification number.

2.3.2 Traffic data interface

The key between main roads and Emme/2 links makes it possible to transfer traffic data results from Sampers to the road network used in CadnaA. However the inputs needed in CadnaA are not at the same aggregation level as the outputs of Sampers. We therefore use a program written in Matlab (MathWorks, USA) to recalculate selected simulation data.

2.3.1.2 Main roads

As described in paragraph 2.1.1 outputs of Sampers are average values per hour of each time period simulated. Using an Emme/2 macro we create ASCII files with outputs represented per link for every time period simulated, one for automobile results and one for public transport results. The outputs saved are described in Table 2 below. A specific user class contains truck transports and the value is used when calculating the share of heavy vehicles on a road.

Table 2 Outputs stored

Automobile traffic	Public Transport
Car volume [Vehicles per hour]	Volume [Vehicles per hour]
Speed [Kilometres per hour]	Speed [Kilometres per hour]
Volume of heavy vehicles [Vehicles per hour]	

The interface program created reads and stores the simulation outputs files as well as a text file describing the key between main roads and links. The text file is a selection of the database file associated to the main roads shape file and contains the road id-numbers plus the link or the link and return link related to each road.

Using the road/link relation and the definitions below we compute traffic volume, speed and share of heavy vehicles of a road per time period using the formulas 1, 2 and 3. Note that the average speed of a road is calculated by weighting the link and return link speed by their traffic volumes. This is due to the fact that for e.g. morning peak hours traffic volumes are high on links with direction towards the centre of Stockholm and low on links going out of Stockholm. Thus equal weights would not give results reflecting this dynamics. Here we only consider road traffic, which means that for public transport only buses are considered.

V_i - Average traffic volume on road *i* [vehicles per hour]

S_i - Average speed on road *i* [kilometres per hour]

SHW_i - Share of heavy vehicles on road *i* [percent]

$$V_i = V_{c,i} + V_{cr,i} + V_{t,i} + V_{tr,i} + V_{pt,i} + V_{ptr,i} \quad (1)$$

$$S_i = \frac{(V_{c,i} + V_{t,i}) \cdot S_{ct,i} + (V_{cr,i} + V_{tr,i}) \cdot S_{ctr,i} + V_{pt,i} \cdot S_{pt,i} + V_{ptr,i} \cdot S_{ptr,i}}{V_i} \quad (2)$$

$$SHW_i = \frac{V_{t,i} + V_{tr,i} + V_{pt,i} + V_{ptr,i}}{V_i} \cdot 100 \quad (3)$$

where,

$V_{c,i}$ - Car volume of the link related to road *i* [vehicles per hour]

$V_{cr,i}$ - Car volume of the return link related to road *i* [vehicles per hour]

$V_{t,i}$ - Truck volume of the link related to road *i* [vehicles per hour]

$V_{tr,i}$ - Truck volume of the return link related to road *i* [vehicles per hour]

$V_{pt,i}$ - Public Transport volume of the link related to road *i* [vehicles per hour]

$V_{ptr,i}$ - Public Transport volume of the return link related to road *i* [vehicles per hour]

$S_{ct,j}$ - Car and truck speed of the link related to road *i* [kilometres per hour]

$S_{ctr,j}$ - Car and truck speed of the return link related to road *i* [kilometres per hour]

$S_{pt,i}$ - Public transport speed of the link related to road *i* [kilometres per hour]

$S_{ptr,i}$ - Public transport speed of the return link related to road *i* [kilometres per hour]

In a first step we calculate traffic data for peak traffic and off-peak traffic respectively, moreover we weigh together the results to obtain values representing an average daytime hour to use as input to CadnaA. As the time periods simulated represents traffic conditions between 07-09 a.m. and 9 a.m.-16 p.m. and in CadnaA a day is defined between 06 a.m. – 18 p.m., we use the weights 4 hour peak traffic and 8 hour off-peak traffic respectively. Using this relation and indexes *p*, *op and D* representing peak hour, off-peak hour and day results, we calculate day traffic data using the formulas 5, 6, and 7.

$$V_{DAY,i} = \frac{4V_{P,i} + 8V_{OP,i}}{12} \quad (4)$$

$$S_{DAY,i} = \frac{4S_{P,i} + 8S_{OP,i}}{12} \quad (5)$$

$$SHW_{DAY,i} = \frac{4(V_{Pt,i} + V_{Ptr,i} + V_{Ppt,i} + V_{Pptr,i}) + 8(V_{OPt,i} + V_{OPtr,i} + V_{OPptr,i} + V_{OPptr,i})}{4V_{P,i} + 8V_{OP,i}} \cdot 100 \quad (6)$$

The results as well as the road id-number are stored in a text file where the same attribute names used in CadnaA are applied. Using the id-number as key we are able to connect the traffic results to the database associated with the main roads shape file and thus obtain a geographic file with input data ready to use in CadnaA.

In CadnaA it is possible to calculate noise levels also based on evening and night-time traffic conditions. The general use of traffic simulation models is to model traffic during daytime as this is the period of time when traffic systems are most loaded and vulnerable. However, it is doable to model evening and night conditions by using shares of the travel demand related to the off-peak hour period with distribution in accordance with the dynamics illustrated in Figure 6 on page 13. Though in these studies we only consider daytime traffic, as we believe this is sufficient to be able to evaluate the measures studied.

2.3.2.2 Local streets

In deliverable D2.4 we present a method how to consider noise level impacts on streets that are not represented in the Emme/2 network i.e. local streets. The method is based on template values and changes in demand per centroid due to a studied measure. However analysed scenarios did not give large effects on local demands and would consequently not give any significant noise impact. For that reason the method has not been used; we only study traffic on main roads.

3 SCENARIOS STUDIED

This subchapter describes the scenarios and measures studied and how they were implemented. Results are presented in chapter 4.

3.1 CLOSING OFF THROUGH TRAFFIC

A link specific measure to reduce noise levels is to close a road for through traffic. This action will reduce noise levels near the closed road but may cause increases on other links due to rerouting. To show examples of this we created two scenarios, one in each study area. In Järva, car traffic was prohibited on a regionally important and therefore heavy loaded link, marked by an arrow in Figure 17. In Södermalm the city link marked in Figure 18 was closed. This street has been discussed for years by the City of Stockholm, as there is a problem with high noise levels and emissions from car traffic. In both scenarios buses were still allowed to use the specific links.

Figure 17: Closed road in Järva (Hjulstavägen).

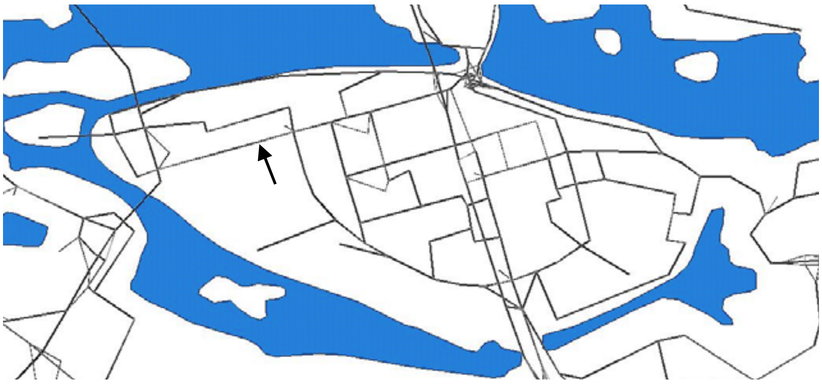

Figure 18: Closed road on Södermalm (Hornsgatan).

3.2 DECREASED SPEED

If the average speed on a road is reduced, noise levels will decrease in its nearest surrounding. In the base scenario the main road marked by a red line in Figure 19 is modelled as a 70 km/h road, which is the present situation. To study a measure related to reduced speed limit a scenario was created where the links were modified to model a 50 km/h road. Note that since the model captures speed reductions due to congestion this does not mean that we study noise effects when speed is reduced from 70 km/h to 50 km/h. The selected road is heavy loaded and as shown in Figure 9 and Figure 10 the road speed is approximately 60 km/h in the base scenario. In peak hour traffic though, the speed is approximately 40 km/h (inbound direction, i.e. towards the city centre).

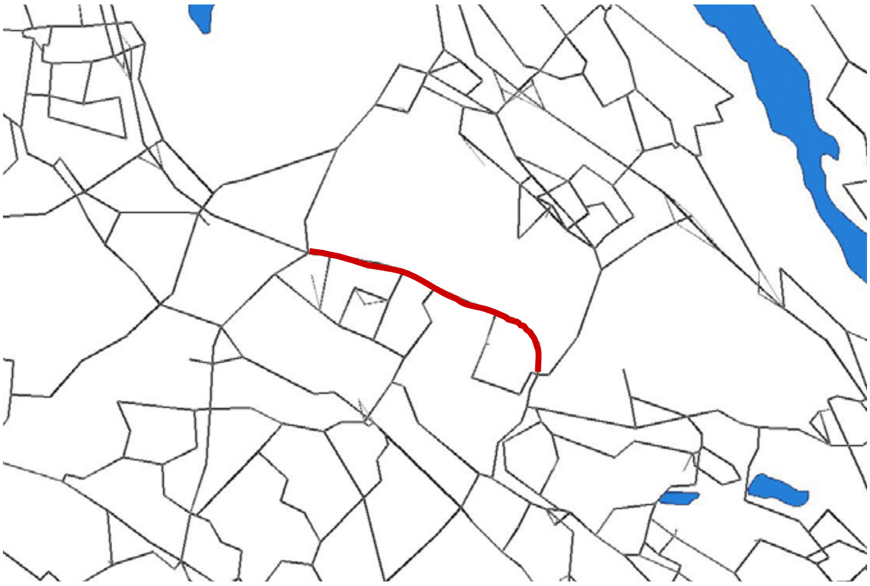

Figure 19: Road with reduced speed limit (Hjulstavägen).

3.3 Restrictions on Noisy Vehicles

A possible way to create quiet areas is to apply restrictions on noisy vehicles to enter a zone. The feasibility of such a measure depends however on the provision of adjacent parking space and quiet vehicles. Here we modelled future scenarios where non-quiet vehicles were restricted by road barriers or had to pay a charge to enter or leave the area. In order to make the results more general, we decided to use a generalised network. We also decided to place the generalised network in a realistic context to enable capturing redistribution effects. The restricted area, illustrated in Figure 20, was therefore a generalised street network placed in Södermalm. The size of the zone is approximately 2 km^2. We also removed all connections to the tunnel passing under the area to make it more general. The existing population and activities of Södermalm were used. Further, to analyse the impact of the zone size, scenarios were modelled where the restricted area was reduced (see Figure 21).

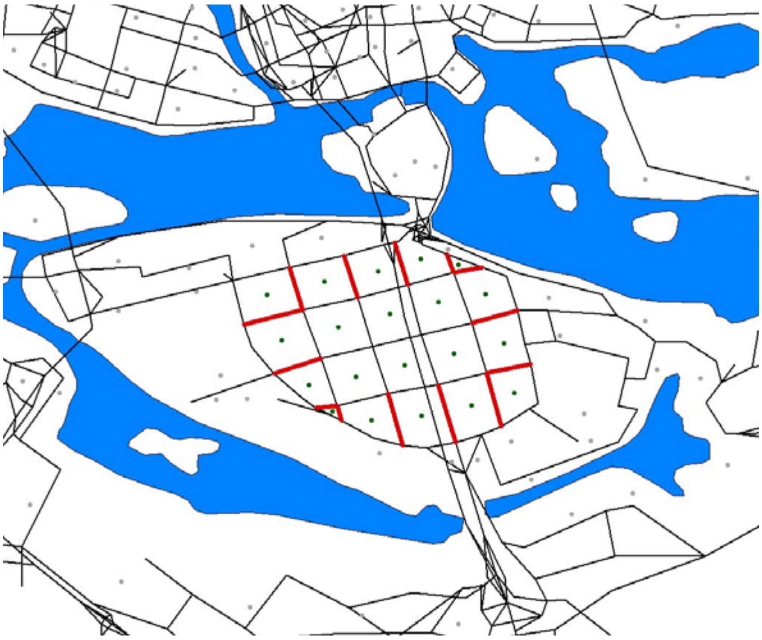

Figure 20: Large zone area, restricted links marked in red.

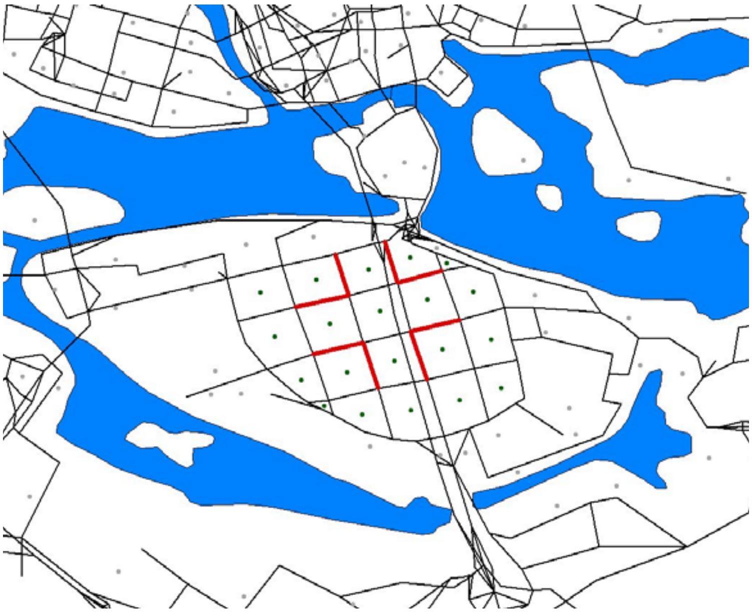

Figure 21: Small zone area, restricted links marked in red.

To model quiet and non-quiet vehicles we extended the number of user classes defined in the Sampers system. (5 user classes of non-quiet vehicle owners with different value of time and 5 user classes of quiet vehicle owners with the same distribution of value of time as for non-quiet vehicle owners.) Moreover for each scenario modelled we set the share of car ownership of quiet vehicles of each centroid inside the area and each centroid outside the area respectively. Below is a table of the scenarios modelled where the first represents a base scenario. How to reach these future levels of quiet vehicles is discussed in deliverable D2.12 where a car type model is applied (D2.12 'Small prototypes for Car ownership measures for vehicles'). Charging levels were set in accordance with the highest and lowest fare used during the Stockholm trial, a full-scale trail of congestion charges in Stockholm City (for more information see www.stockholmsforsoket.se).

Table 3: Modelled scenarios to create quiet areas.

Restricted Zone size	Share of quiet vehicle owners **inside** zone	Share of quiet vehicle owners **outside** zone	Restriction for non-quiet vehicle owners
-	5%	5%	None
Large	100%	5%	Road barrier
Large	20%	5%	2 euro charge
Large	20%	5%	1 euro charge
Small	100%	5%	Road barrier
Small	20%	5%	2 euro charge

In the model owners of noisy vehicles (including heavy vehicles) now will face a barrier or a fee to enter or exit the restricted area. If they do not want to pay (in the fee case), they can choose other options, like parking outside and walk in to the area, change route, change travel mode to e.g. public transport or change destination. In the model there was no limitation of parking space.

When creating noise maps forecasted traffic data was used. In CadnaA we worked with two shape files, one with data of non-quiet vehicles and heavy vehicles and one with quiet vehicles. In calculations quiet vehicles where modelled to have a tyre/road noise 5 dB(A) lower and an engine noise 10 dB(A) lower than non-quiet vehicles. In consolidation with acousticians at Acoustic Control we believe the values are trustworthy to use for these future scenarios. E.g. in QCity Subproject 3 tyres to reduce tyre/road noise are developed and it is reasonable to believe that in a couple of years they will give reductions in the magnitude of 5 dB(A). Additionally, pass-by measurements made by Head Acoustics in Subproject 2 (Deliverable D2.10), show that L_{max} in dB(A) for the hybrid car Toyota Prius is lower than average for all passenger cars and driving situations studied. E.g. at a constant pass-by with 30 km/h the L_{max} level is approximately 3 dB(A) lower and approximately 6 dB(A) lower at a constant pass-by with 50 km/h. Moreover the hybrid car has no idle sound as the engine is shut off at a stand still. The average idle sound for the other passenger cars measured is approximately 50 dB(A). To refine our noise calculations one could consider adjusting the noise reductions relatively to speed.

In the network model we only changed the car traffic street network whilst the public transport network (mainly underground) was kept the same in all scenarios. To simplify data handling, buses were excluded in the noise calculations.

Fictive building blocks were created that matched the generalised street network and are illustrated in Figure 22. Between each road junction there are approximately 8 building blocks with sizes related to present blocks. Distances between buildings within a street block constitute pedestrian streets. (It is not possible to simulate a finer road traffic network due to the aggregation level of the model). In the noise calculations buildings were modelled with reflecting façade material. Moreover to make the scenario as generalised as possible the whole area was defined to be zero meters above sea level.

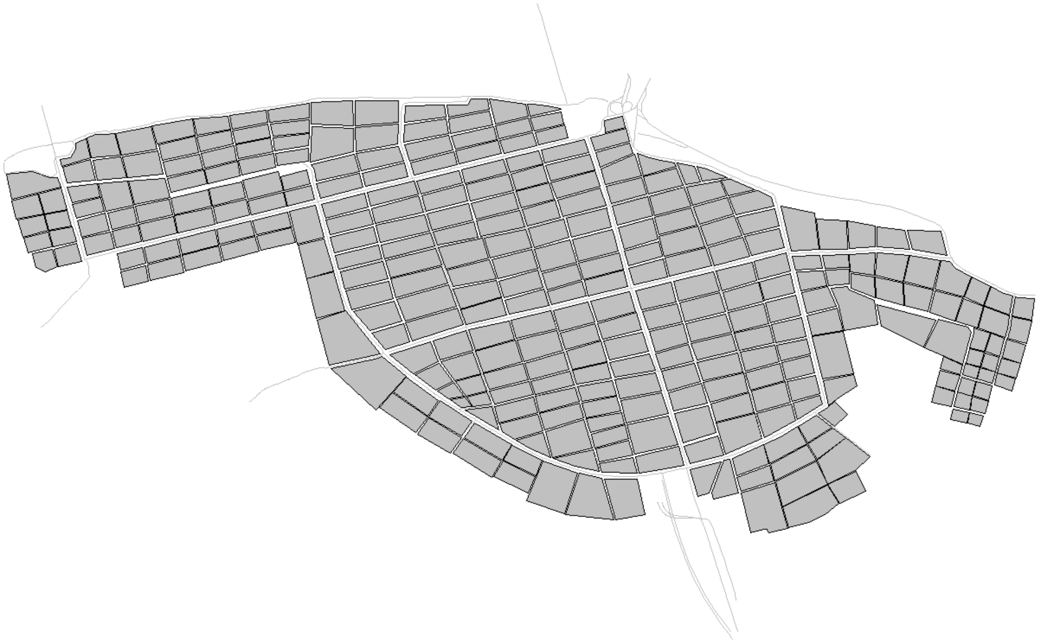

Figure 22: Fictive building blocks on Södermalm.

4 RESULTS

In this chapter we present results of the scenarios described above. Both their impacts on noise levels and total network effects such as change in travelled kilometres and mode shift pattern are reported. However effects of a noise mitigation measure related to traffic management will always be network dependent and site specific. Here, we therefore present effects less precise than for physical noise mitigation devices. It is important to understand that the relative changes presented are depending on the size of the modelled network, and serve here more as a reminder of the presence of such effects.

4.1 BASE SCENARIO NOISE MAPS

Using the methods described we have created a noise map of the base scenario in Järva (no measure applied), shown in Figure 23. The map illustrates sound pressure levels calculated for daytime traffic on main roads (L_{Day}) where the grid has a receiver spacing of 10 by 10 meter and a receiver height of 4 meter. All roads are set to the ground level except for a bridge in the centre of Järva. Note that neither railroad traffic nor local streets are included. Figure 24 and Figure 25 illustrates the base noise map of Södermalm and of the fictive Södermalm respectively. Note that in the fictive scenario all streets lay zero metres above sea level. (On page 15 and 16 in Figure 9 and Figure 10 speed data of the base scenario in Järva is shown. Auto volume data is found in Appendix A together with base scenario data of Södermalm. Volumes per vehicle type of the fictive base scenario in Södermalm are found in Appendix B.)

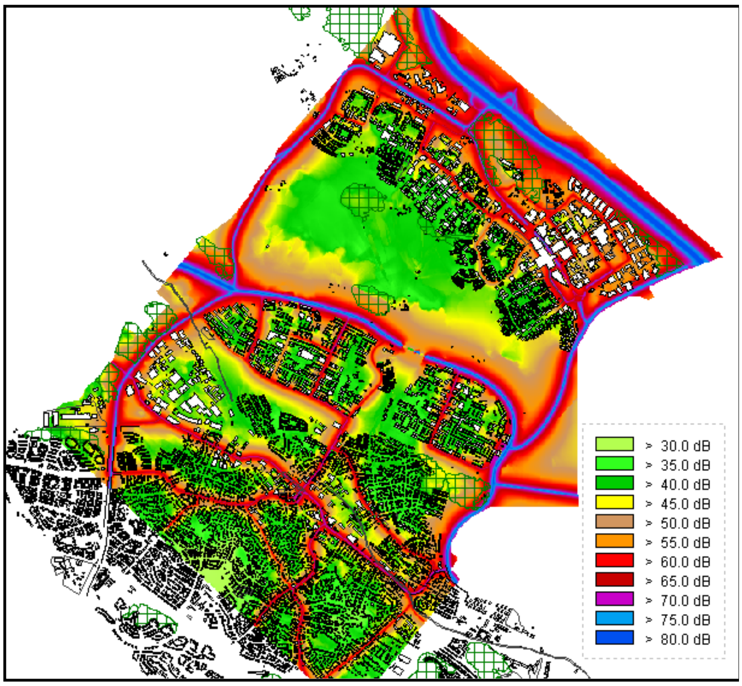

Figure 23: Noise map of base scenario Järva, L_{DAY}.

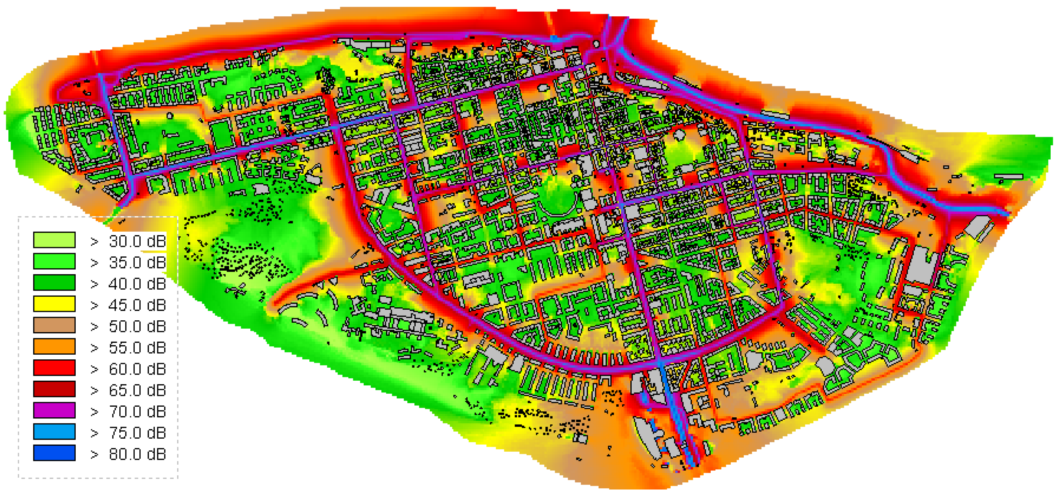

Figure 24: Noise map of base scenario Södermalm, L_{DAY}

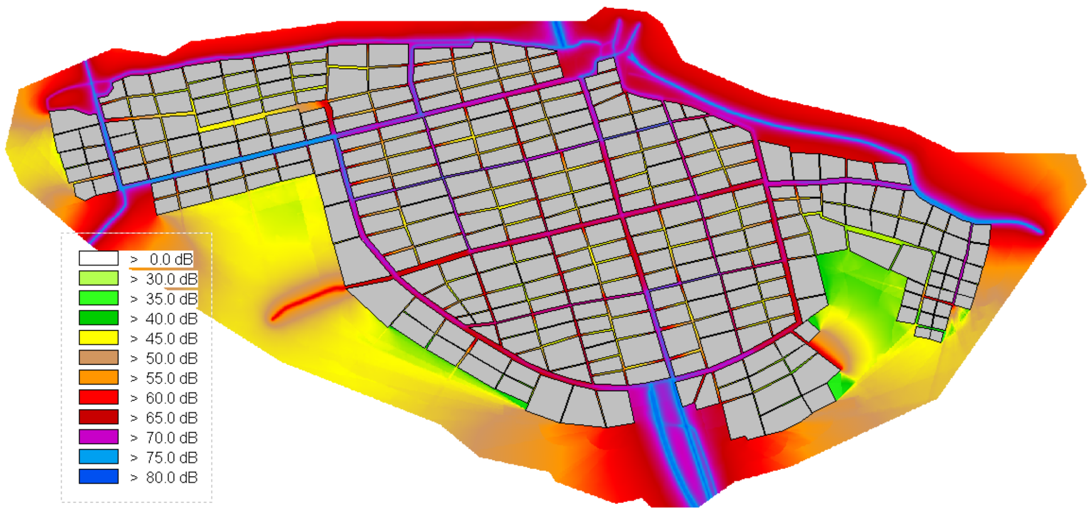

Figure 25: Noise map of base scenario fictive Södermalm, L_{DAY}

4.2 CLOSING OFF TROUGH TRAFFIC

Figure 26 illustrates the difference in peak hour auto volume when the link in the Järva area is closed for through traffic. It illustrates the change in absolute numbers relative to the base scenario; green indicates a decrease and red an increase. The measure gives as expected large volume reductions on the closed road and we get increased volumes on alterative routes. Roads with increased volumes get decreased speed and vice versa. Off-peak hour results show the same pattern. Speed changes and off peak hour results are found in Appendix A.

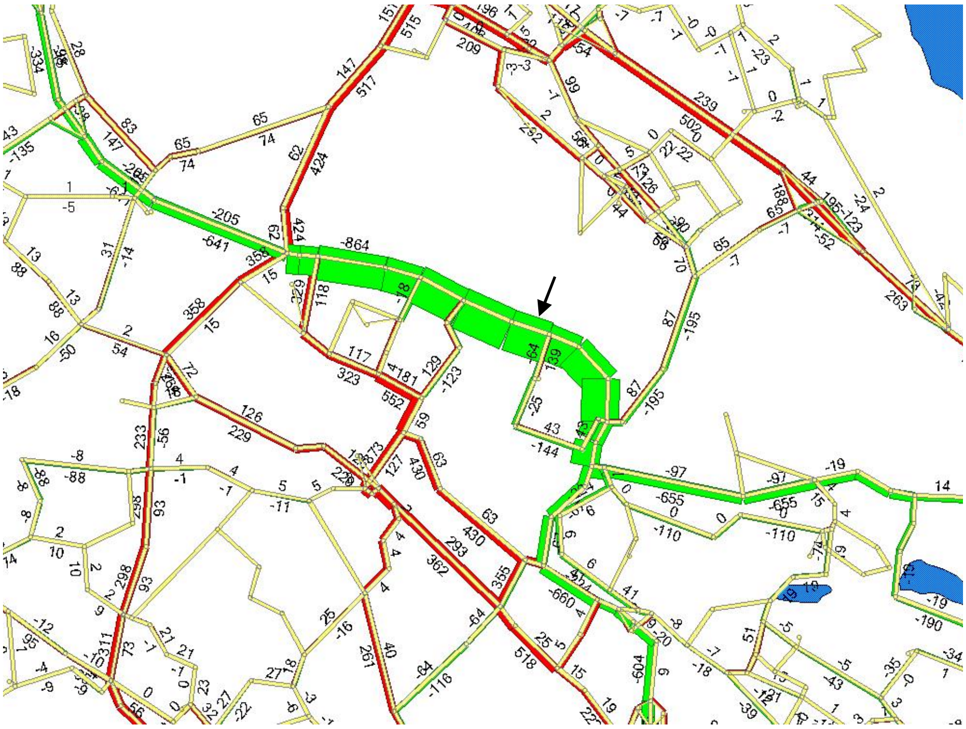

Figure 26: Auto volume change due to closed road (Peak hour).

The difference in noise levels compared to the base scenario is illustrated in Figure 27. The plot shows as expected large noise reductions near the closed connection, in some areas up till –14 dB(A). Due to rerouting, increased levels are obtained on alternative roads. The highest increase, approximately 4 dB(A) is found on roads southwest of the closed road since these roads have the largest relative change in traffic volume. As for all policies related to traffic management, such effects need to be considered when a measure is applied.

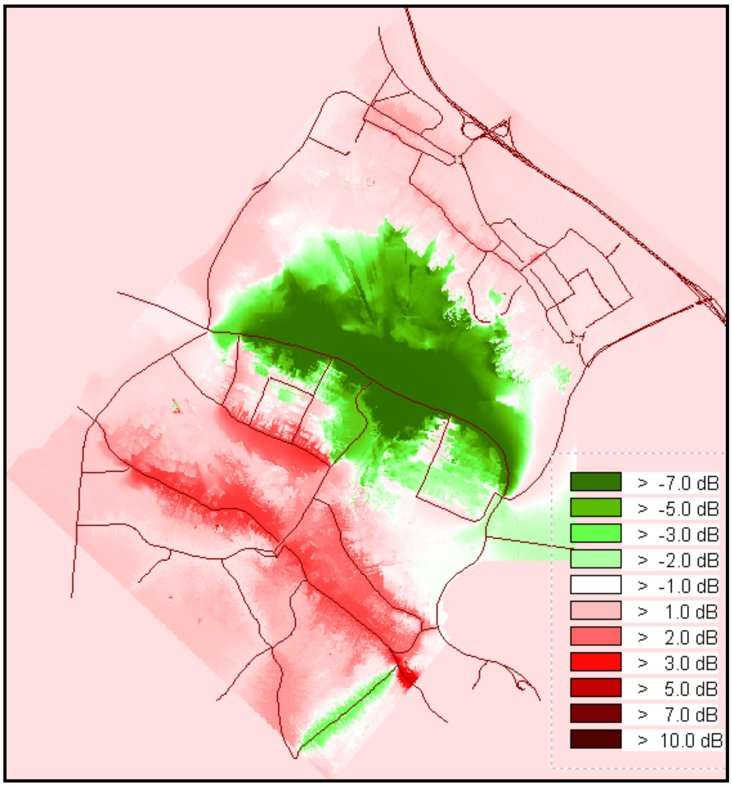

Figure 27: Difference in noise level when closing road for through traffic.

Below is a diagram illustrating the share of exposed inhabitants in 5 dB intervals. As shown, the curve moves to the left, a positive direction. There is a clear reduction of exposure in levels around 55 dB(A).

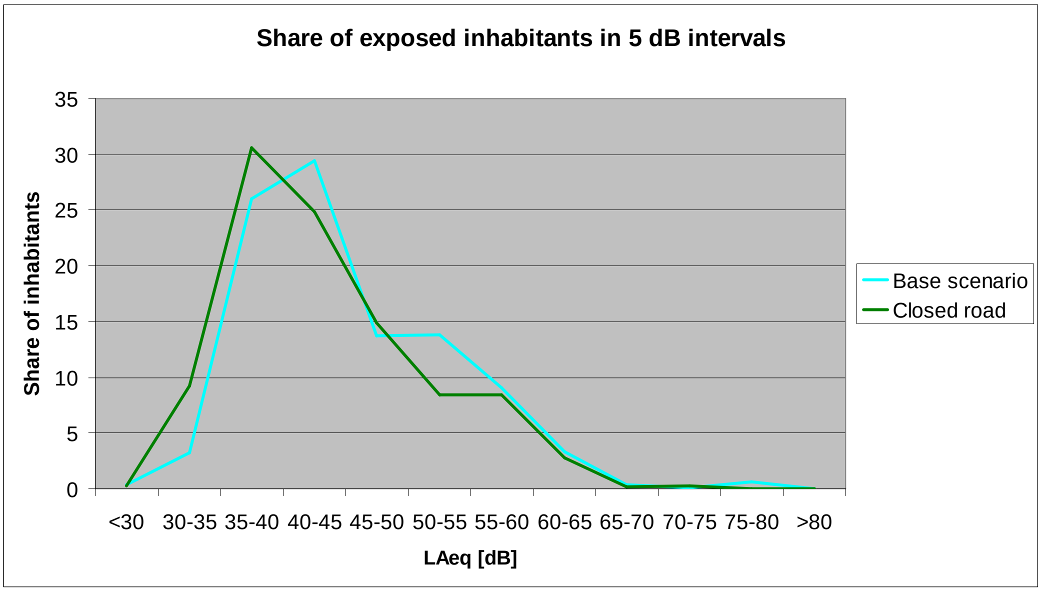

Figure 28: Share of exposed inhabitants in Järva for different scenarios.

The used forecasting system models a network much larger than the study area and includes the whole Stockholm County. Below is a diagram and table showing total effects on travel pattern, vehicle kilometres and total travel time due to the applied measure. Though the closed road is an important link with high traffic volumes, the effects are not large at a total network level. However it may have large local effects that need to be investigated further if this type of measure is applied. Notable is that person hours in car is increased but the total car kilometres travelled is decreased. This is because new routes are shorter but have higher travel times than routes including the closed link.

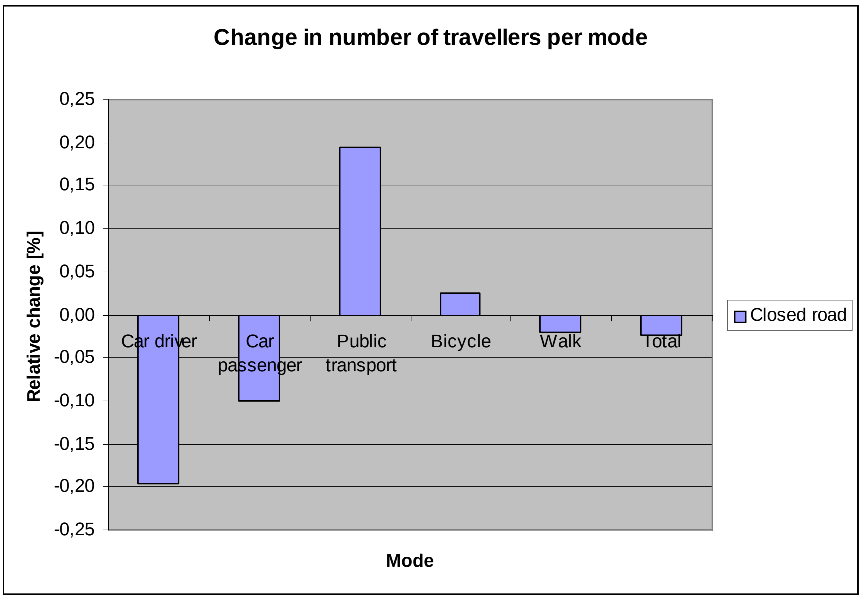

Figure 29: Change in number of travellers per mode due to closed road, relative to base scenario (total network level).

Table 4: Effects at total network level relative to base scenario due to closed road in Järva.

Total car kilometres per day	- 40 000 km
Person hours in car per day	+ 1 500 h

Effects on peak traffic volumes when the city street on Södermalm is closed are shown in Figure 30. Again we get rerouting effects but here the effects are more concentrated than in the previous example. Off peak hour shows the same pattern and is found in appendix A. Speeds are as expected increased with decreased volumes and decreased with higher volumes; these results are also found in appendix A.

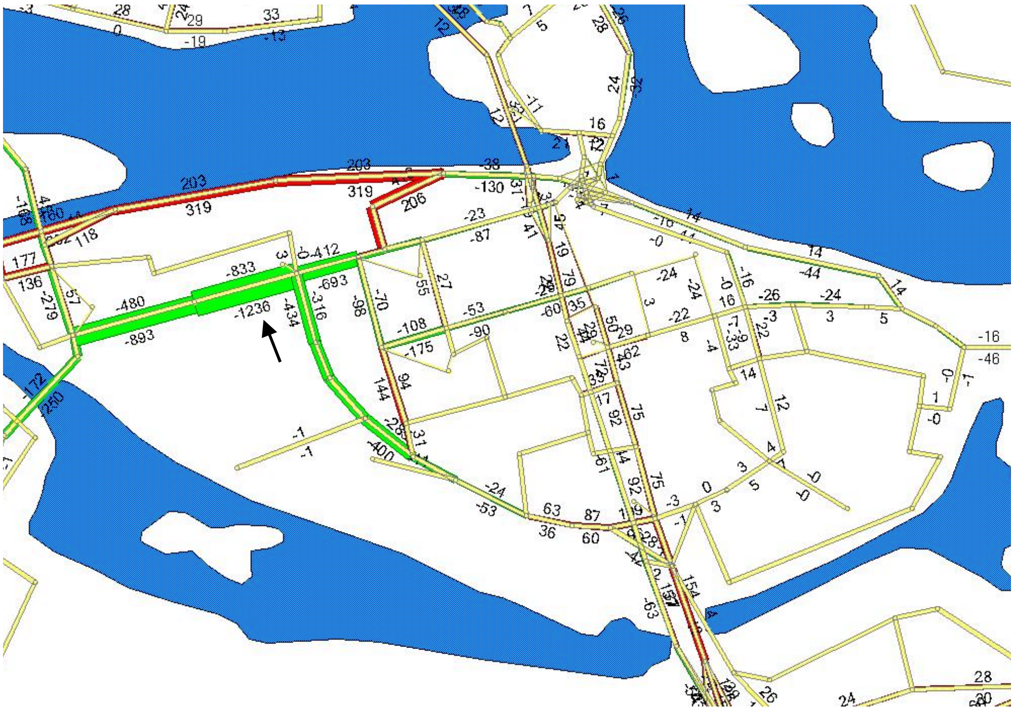

Figure 30: Difference in auto volumes relative to base scenario, (Peak hour).

The effect on noise levels is shown in Figure 31. There is a maximum reduction of approximately –12 dB(A) and in average – 4 to –5 dB(A). The increase on streets with increased traffic is around 3 dB(A). If we study the redistribution of exposed inhabitants in different noise levels we notice in Figure 32 that the share of exposed inhabitants within the interval 60 to 75 dB(A) is decreased. Thus this may be an effective method to handle the noise problems in the area. Emissions on the specific street are also likely to be reduced since traffic is diverted.

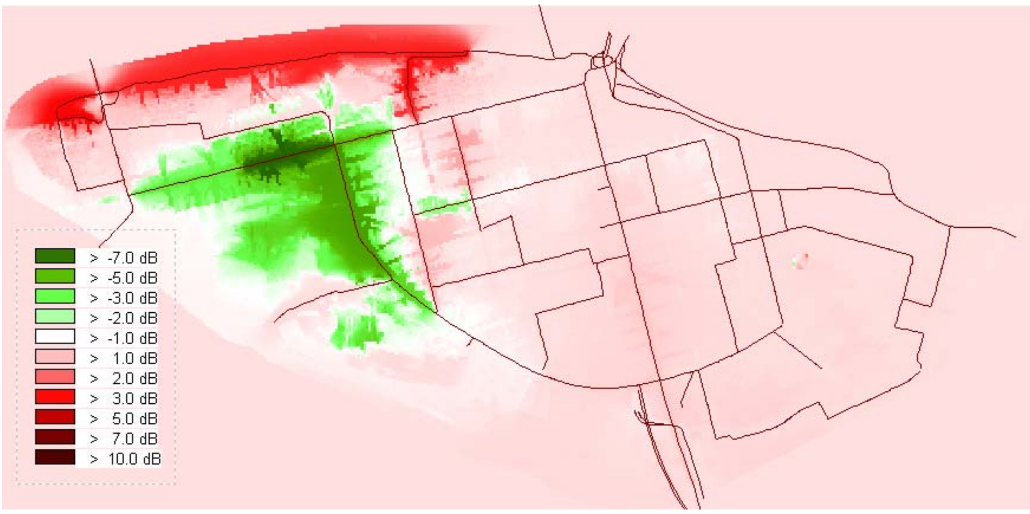

Figure 31: Difference in noise levels due to closed road on Södermalm.

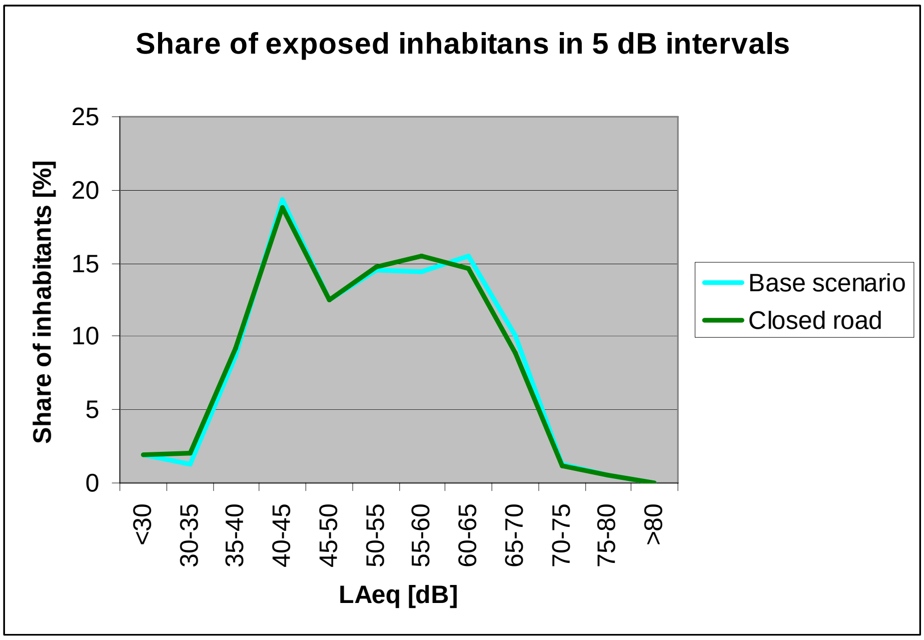

Figure 32: Share of exposed inhabitants in 5 dB intervals in Södermalm.

As this is a local action applied on one specific city link, overall effects on travel patterns are minute. Our studies show that the effects on e.g. travelled kilometres and person hours are negligible and lay in the precision level of the model. These figures are therefore not relevant to show.

To close a road for through traffic is not an expensive measure to implement and our studies show that it can reduce noise levels significantly. However the studies are site specific and network size dependent. If this type of measure is to be implemented, further investigations must be carried out possibly at both local and regional level depending on the situation and expected levels of impact. As mentioned redistribution effects must be considered. A good solution would be to divert traffic to roads with no close by dwellings though this is probably in many cases difficult to do.

4.3 DECREASE SPEED

The change in traffic volumes due to reduced speed limit on a main road in the Järva study area is shown in Figure 33. Traffic volumes are reduced on the specific road but as expected not to the same extent as when the road is closed for through traffic. The speed is reduced from approximately 60 km/h to approximately 45 km/h. Though in the inbound direction in the morning peak hour the speed is decreased from around 40 km/h to approximately 30 km/h. Off peak hour results are found together with speed changes in appendix A.

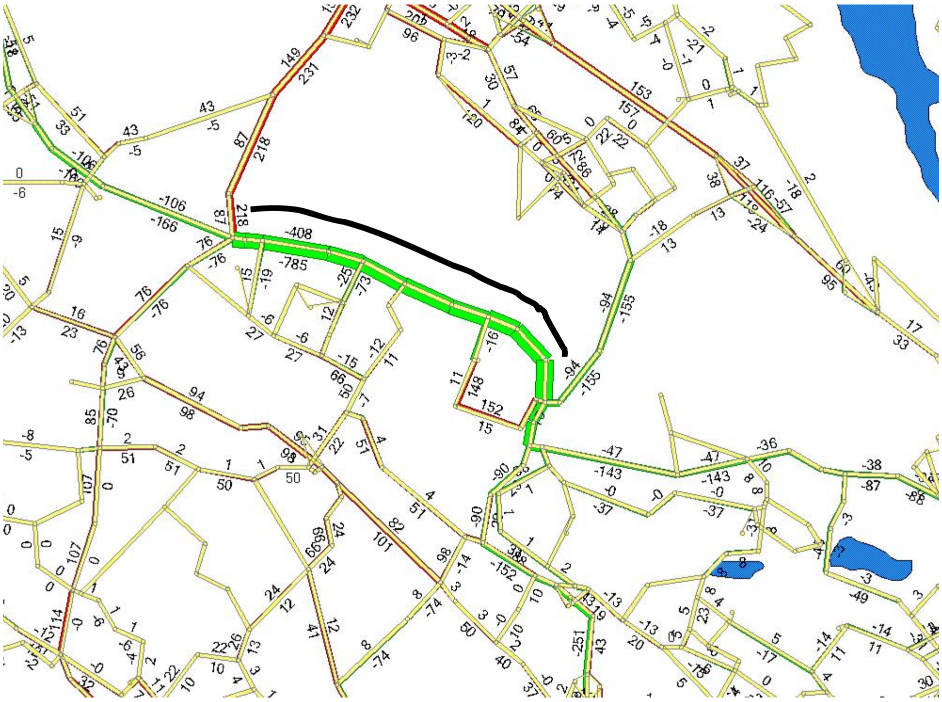

Figure 33: Difference in auto volume due to reduced speed.

The difference in noise levels caused by this measure is also shown in Figure 34. The plot shows a noise reduction of approximately 4 dB(A) near the road with reduced speed. Due to rerouting there is an average increase of 2 dB(A) on alternative routes. Below is a diagram illustrating the share of exposed inhabitants in 5 dB intervals. There is a reduction of exposure in levels around 55 dB(A), as expected not as large as when the road was closed for through traffic. But the reduction is still significant.

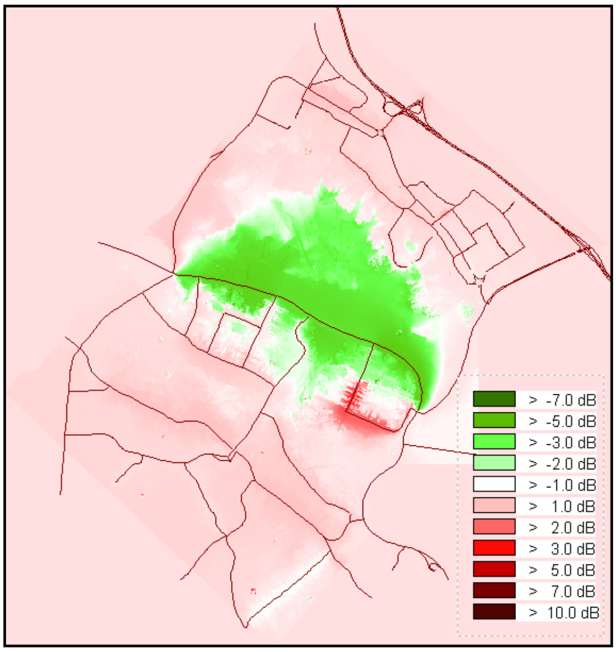

Figure 34: Difference in noise levels due to reduced speed.

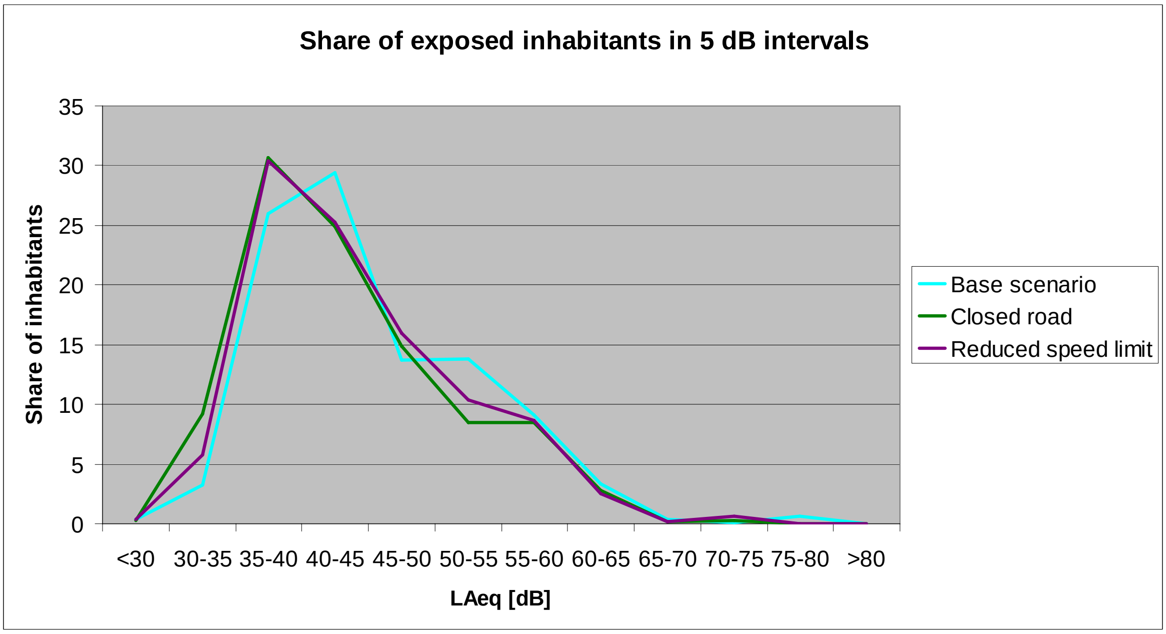

Figure 35: Share of exposed inhabitants.

Below is a table showing overall effects on travel pattern, vehicle kilometres and total travel time due to the reduced speed limit. Again, though the modified road is an important link with high traffic volumes, the effects are not large at a total network level. All changes are less than 1 % and lie close to the precision level of the forecasting model. Again person hours in car are increased whilst the total car kilometres travelled is decreased. This is due to new routes are shorter but have higher travel times than routes including the road with reduced speed.

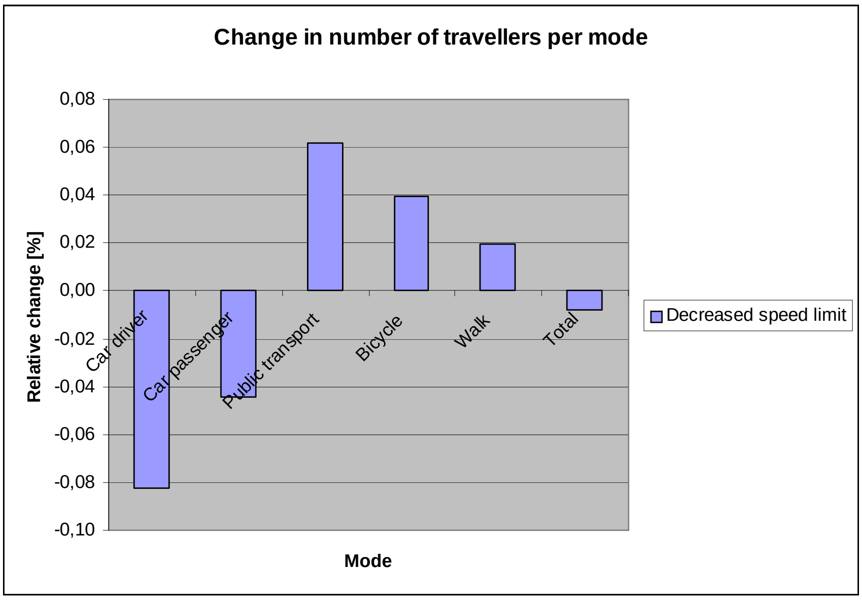

Figure 36: Change in number of travellers per mode relative to base scenario (total network level).

Table 5: Effects at total network level relative to base scenario.

Total car kilometres per day	- 25 000 km
Person hours in car per day	+ 500 h

Other research and studies show that reducing speed limits have positive effect on noise levels and our results are in line with these results (e.g. a few studies are summed up in the SILVIA related report “Traffic management and noise reducing pavements-Recommendations on additional noise reducing measures”). However studies show that many people drive faster than the new speed limits. In average the speed is reduced but not as much as the traffic signs show. If supervision is increased or if a “noise reducing” sign supplements the speed limit sign a larger speed reduction is likely to be achieved, as these actions would increase people’s motivation to slow down. Thus, when studying noise level impacts due to speed limit reductions it is important to consider peoples behaviour with regard to speed limits.

Reducing speed limits is an easy and quick measure to implement and has a relatively low implementation cost. Redistribution effects must be considered also in this case, but they are much smaller than if a road is closed. If several roads in an area get reduced speed limits, redistribution effects may be even smaller, though noise reductions due to decreased volumes will be less. Additionally, reduced speed also goes hand in hand with traffic safety. It is known that low speed causes less severe accidents than high speed. In the report “A Nordic perspective on noise reduction at the source” it is stated that “In addition to noise reduction, traffic safety benefits are often substantial and air quality in the area is somewhat improved”.

4.4 RESTRICTIONS ON NOISY VEHICLES

As presented in 3.3, a base scenario was modelled assuming a 5 % share of quiet vehicles for all car owners in the Stockholm County. When road barriers were applied the quiet vehicle share was assumed to be 5% outside the restricted zone and 100% for people living inside the restricted zone. Figure 37 illustrates the difference in noise levels for the barrier scenario with the large zone area applied relative to the base scenario. Inside the area the noise reduction on car roads is large, in average 10 dB(A) and at maximum around 14 dB(A). On pedestrian streets the reduction is approximately 3-4 dB(A). Boundary roads get higher noise levels due to rerouting, in average 2-3 dB(A) and approximately 6 dB(A) at maximum. There are small leakage effects near the boundary on pedestrian streets but no leakage close to the barriers, because it is offset by the reduced traffic on these streets. (For this example we show traffic volume results in Appendix B).

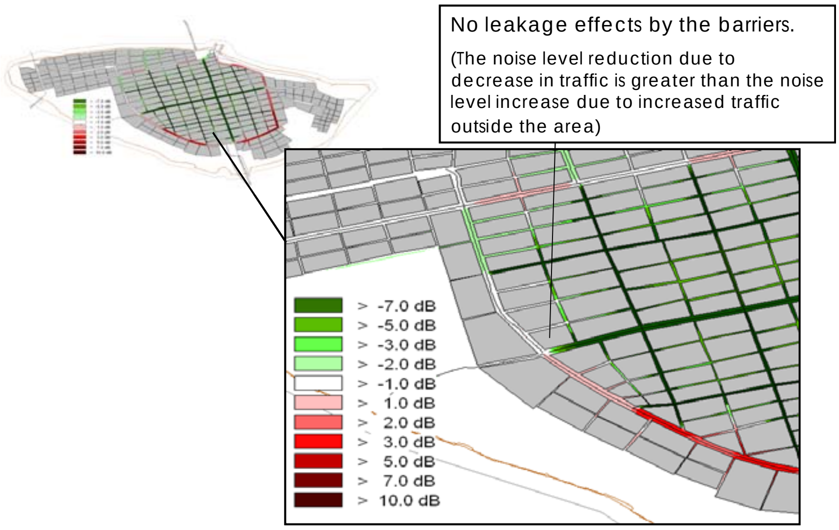

Figure 37: Difference in noise levels due to road barriers for noisy vehicles, building blocks in grey.

Figure 38 illustrates a difference plot where owners of noisy vehicles need to pay a charge of 2 euro to enter or leave the large restricted area. In this scenario the car ownership of quiet vehicles is assumed to be 20% inside the area and 5% outside. Again there are large noise reductions inside the area in average 7 dB(A) and at maximum 11dB(A). Pedestrian streets get a reduction of approximately 2 dB(A) and we get small leakage effects by the boundary. The increase in noise levels on the ring road is approximately 2-3 dB(A) and at maximum around 6 dB(A).

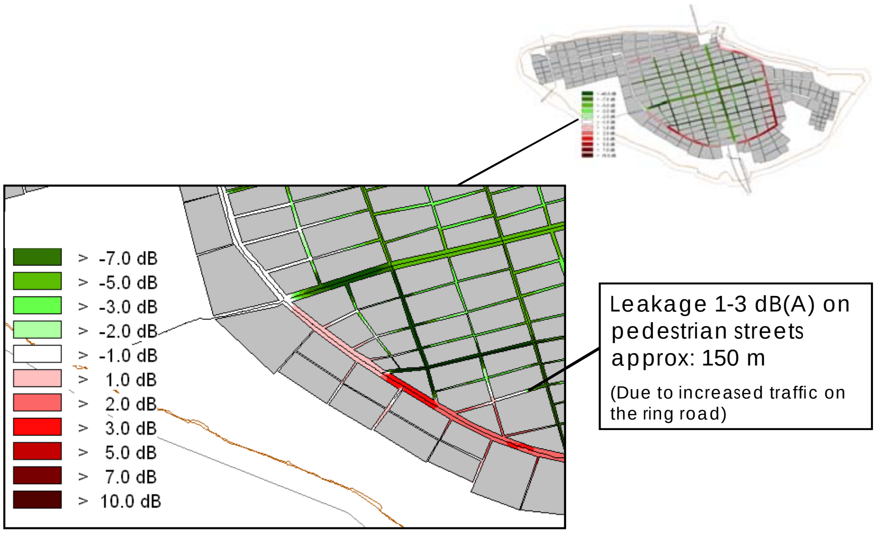

Figure 38: Difference in noise levels due to charging of noisy vehicles.

Large difference plots for all scenarios modelled are found in appendix B. The noise effects are similar if a small area is applied. Though with the smaller area there are more alternative routes and the noise is therefore more spread out. The 1-euro charge shows the same noise pattern as with the 2-euro charge, but as expected with somewhat lower effects.

Effects related to vehicle kilometres and total travel time for the complete network for the two scenarios presented previously are not large and lay in range of the model precision. In the tables below, effects on car trip destinations are reported. It should be borne in mind that even if the destination is within the restricted area, it is still possible to park the car outside the area and walk to the final destination. Therefore the reduction of car traffic entering the area is larger than the reduction of car trips with destination in the area.

Table 6: Destination changes due to road barriers, large zone.

From \ To	*Outside*	*Inside*
Outside	< 1 %	-11 %
Inside	< 1 %	+ 2 %

In the next table, effects of the 2-euro fee are compared to the base scenario.

Table 7: Destination changes due to 2 euro charge, large zone.

*From \ To**	*Outside*	*Inside*
Outside	< 1%	-11%
Inside	- 7%	+11%

*Note that the share of quiet vehicle owners is lower compared to the previous scenario.

For the 2-euro scenario, the effect on car traffic with final destination in the restricted area is about the same. The reason is that the fee is large enough to make it worthwhile to park the car and walk to the final destination. Effects are different with respect to traffic originating inside the area, because the assumption on the share of quiet vehicles owned is 20 percent instead of 100 percent. The revenue for the 2-Euro case is estimated to about 4.5 million euros.

The 1-euro scenario gives a somewhat lower, but still substantial, effect. We have not tried to optimise the fee, but it seems as if it would be possible to obtain noticeable effects with lower fees.

To analyse each scenarios' impact on noise exposure we made a generalized calculation. We assumed a population density of 1 person per 40 square meters in the building blocks within the restricted area and calculated the share of exposure of equivalent levels. Results are shown in Figure 39. The method applies the highest equivalent levels at façade for each building. This give high noise levels, as the buildings are large blocks and not representative for real dwellings. Thus, it is important is to analyse the relative change and not look at the absolute noise levels. We see that when applying the large area and road barriers the exposure is decreased significantly. With charges the reduction is also considerably large. When studying the smaller area we get reductions but also increase of exposure. This is because the calculation still refers to the larger area, and therefore some additional streets will suffer from redistribution effects when the small area is applied. (See the noise maps of the scenarios with a small area in Appendix B.)

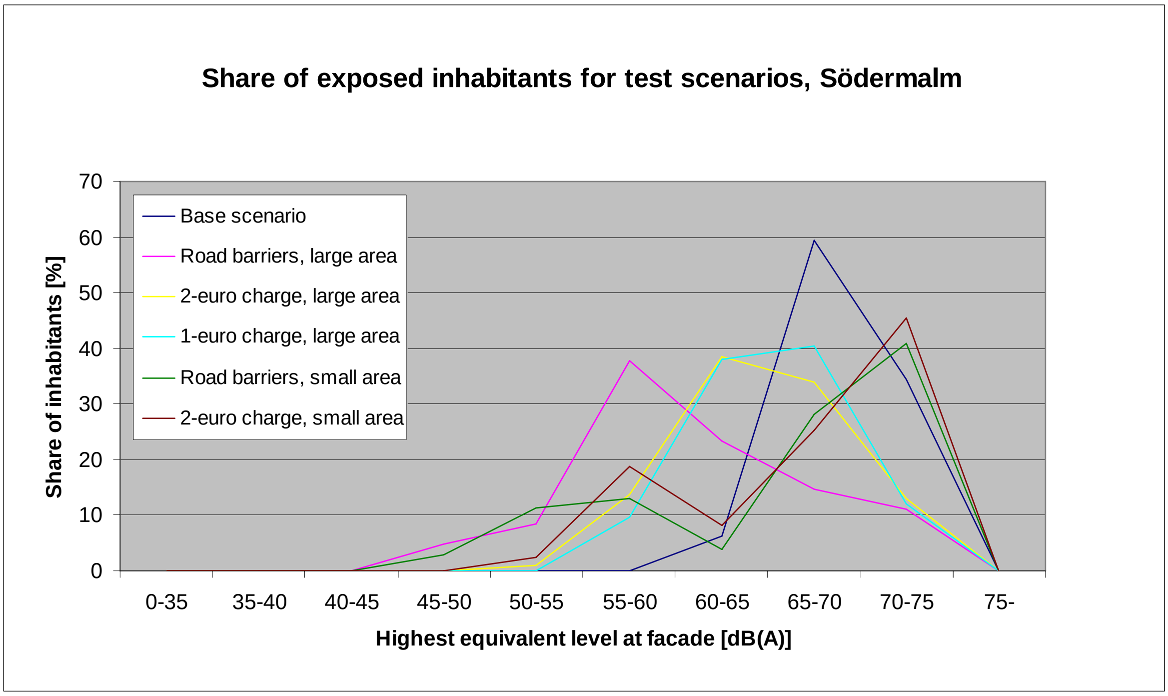

Figure 39: Share of exposed inhabitants of highest equivalent levels at facade [dB(A)], within the restricted area.

Our noise calculations are generalized and we are modelling ideal conditions (e.g. high share of quiet vehicles, no limitation of parking space and heavy vehicles need to follow the restrictions). Nonetheless our analyses show that this concept has a large noise reduction potential. However an implementation would be expensive. Additional parking space outside the area must probably be supplied and a system to register passing vehicles must be developed and applied. On the other hand a well-designed charging system will in the long run give revenues.

The large zone area with a 2-Euro charge is estimated to give yearly revenue of approximately 4.5 million euro. This money should be used to finance the system but possibly also to pay for measures to reduce negative noise boundary effects. An idea is to apply sound absorbing façade material on exposed buildings. Note that 2-euro and 1-euro charge are only examples, the level of the charge have to be optimized to accomplish stated goals.

Further investigation is needed and before a measure of this type could be applied a thorough cost-benefit analysis must be undertaken. One ought to consider both environmental effects and effects on commerce and accessibility. We may also face a new traffic safety issue, accidents caused by people not noticing the quiet vehicles.

5 DISCUSSION AND CONCLUSIONS

The QCity project is mainly related to noise mitigation measures on vehicles or along the road, reducing noise but not affecting traffic itself. In this work package we in addition study measures affecting the noise source directly, i.e. traffic. The nature of such measures is different in two important ways. The first is that they impact not only noise, but also accessibility, other emissions and accidents etc. The second is that traffic management measures, undertaken to obtain an effect at some desired site, also will have redistribution effects, i.e. diverted traffic will cause noise (and other) effects elsewhere. These effects need to be considered to avoid sub optimization. Here we studied examples of measures related to **traffic control** using a traffic forecasting system and a noise mapping software. **Noise reduction** and **noise redistribution** is considered as well as impacts on accessibility.

Differences in speed due to traffic management measures are important, as it affects noise levels as well as travel times. Ability to forecast speed changes is therefore essential and should be considered if any measure related to traffic management measure is to be applied. A sensitivity analysis made on speed data in the study area Järva shows that using speed limits instead of modelled flow dependent speed gives up to 3 dB higher noise levels. This is because high traffic volumes give lower speed due to congestion.

Our study examples and calculations of daytime noise levels show that closing off through traffic can give a large noise reduction, up to – 14 dB(A). This causes less people being exposed to high noise levels in the range 55 to 75 dB(A). In our cases diverted traffic gives noise increases around up to 4 dB(A). But if traffic can be diverted to roads with no close by dwellings the negative effects would be reduced. The implementation cost of this measure is relatively low but one should consider overall effects in a cost-benefit analysis.

Reduced speed gives a noise reduction of approximately –4 dB(A). Redistribution effects are much smaller than in the case of closing a road and noise increases are also less, approximately 2 dB(A). Additionally our study with reduced speed on a road in the study area Järva show that the share of inhabitants exposed to levels around 55 dB(A) are decreased almost to the same extent as for closing the same stretch of road for through traffic. Moreover reduced speed also generally has a positive impact on traffic safety aspects and air quality. Implementation costs are relatively low and it is an easy measure to implement. We consider it being a very efficient measure to reduce noise.

Further, a first study shows that a potential way to create quiet areas is to apply restrictions on noisy vehicles entering or leaving an area. With road barriers the noise reduction within a generalized study area averages 10 dB(A). With a 2-euro charge the reduction is approximately 7 dB(A). On boundary roads the noise increase is around 2 to 3 dB(A) but noise leakage into the restricted area is small. Revenues should be used to finance the system but possibly also to pay for measures to reduce negative noise boundary effects. The feasibility of this measure depends however also on the provision of adjacent parking space and quiet vehicles. The concept shows a great potential and further research is needed.

All modelled policies show low impacts on accessibility in terms of travel time and person hours travelled. These results are however relative to the total network; locally the effects can be much larger.

Acceptance of applying any of the measures studied is related to the number of people affected. We believe that reduced speed has higher acceptance than closing off trough traffic as it generally impacts the driver less and is also related to positive traffic safety effects. Creation of quiet areas using restrictions on noisy vehicles will most likely have a low level of acceptance. But for people living inside the area and for owners of quiet vehicles the level of acceptance would possibly be much higher.

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Web pages

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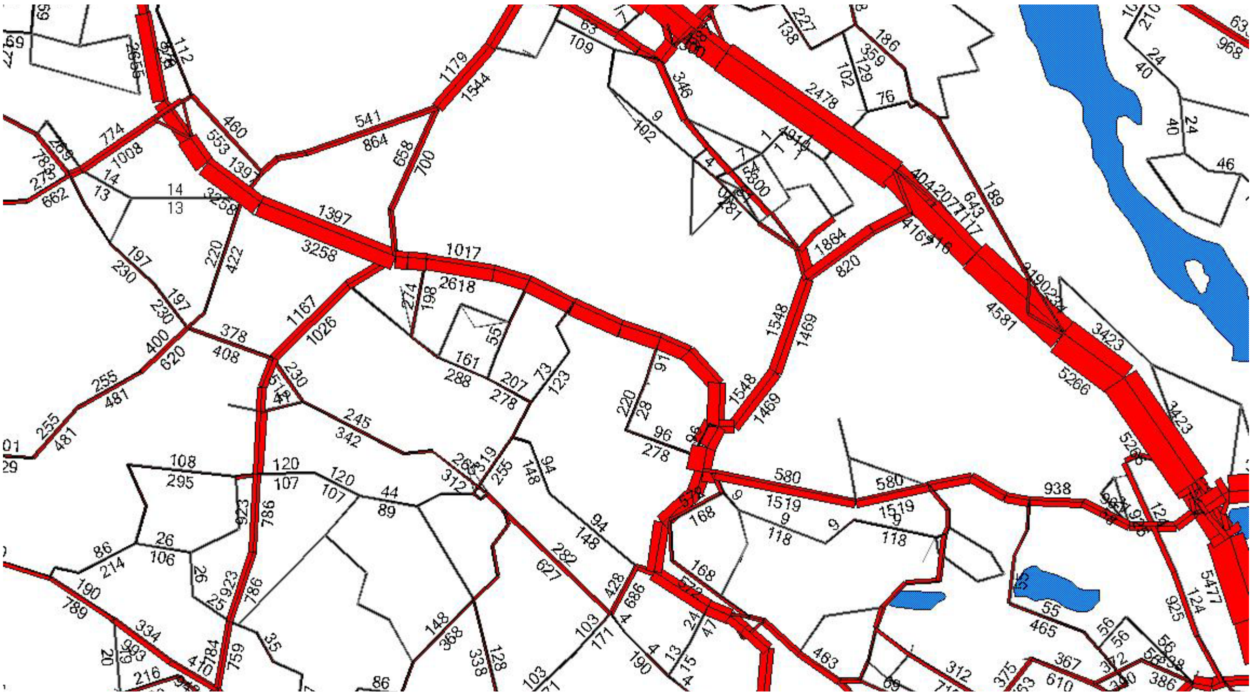
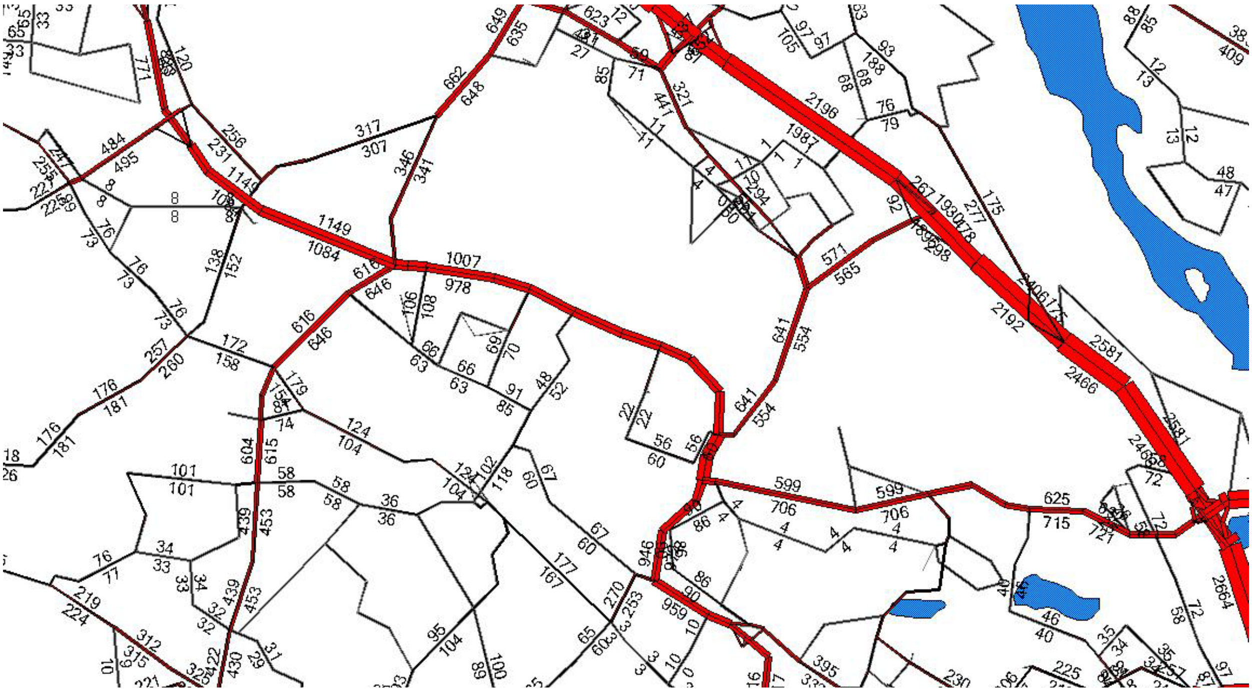
APPENDIX A – SPEED AND AUTO VOLUME IMPACTS

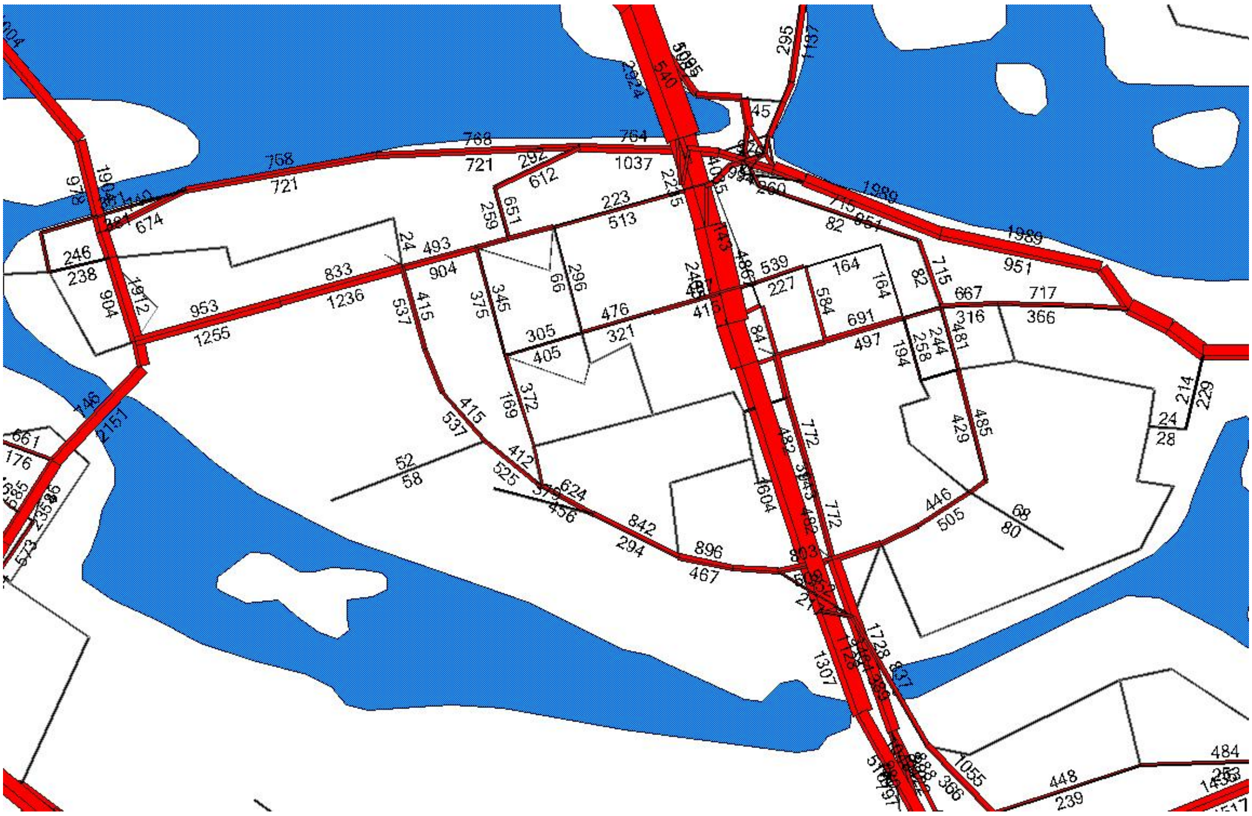
Pictures below illustrate volume changes in off peak hour traffic and speed impacts in peak and off peak hour traffic for the scenarios related to closed streets and speed limit change. Though the six first present base scenario data in Järva and Södermalm.



Appendix A Figure 1: Auto volume in Järva, base scenario peak hour.

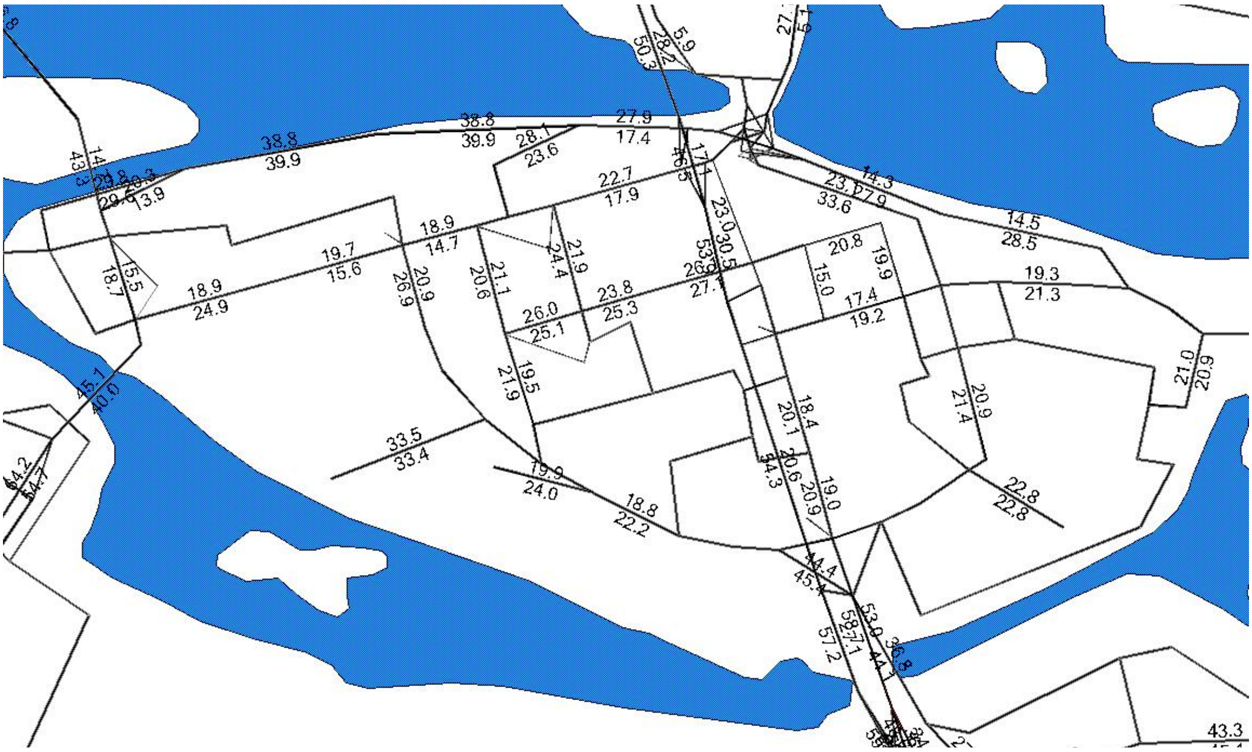


Appendix A Figure 2: Auto volume in Järva, base scenario off-peak hour.

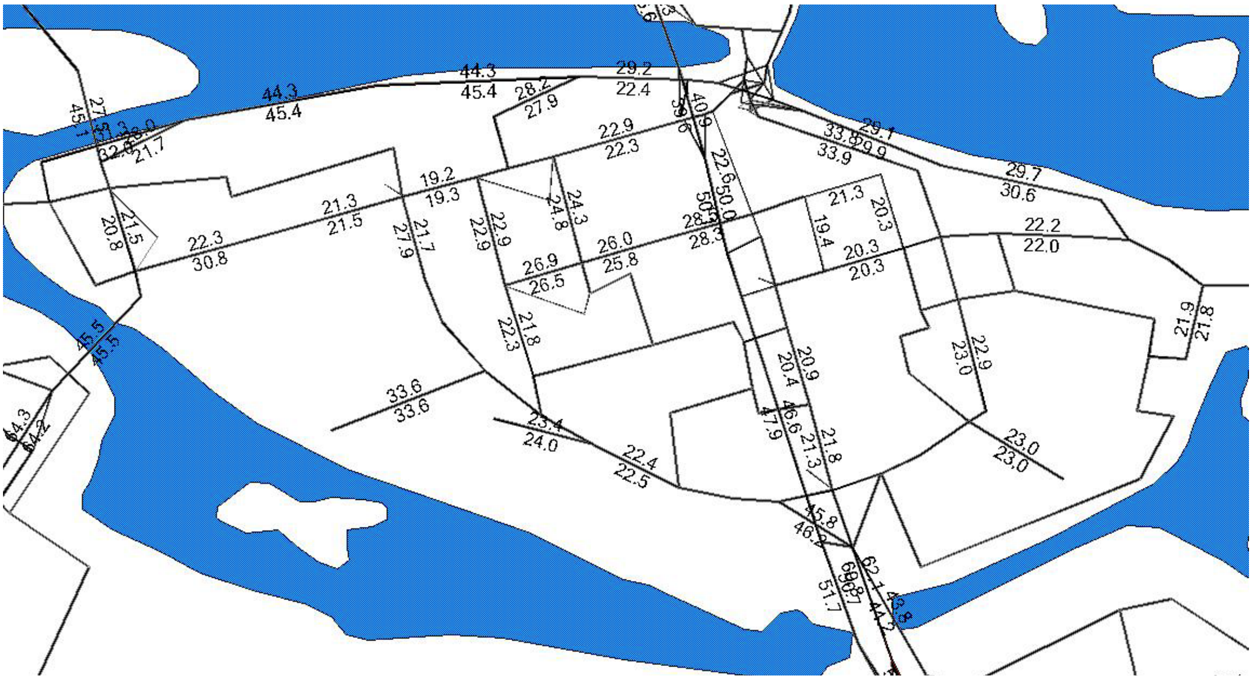


Appendix A Figure 3: Auto volume in Södermalm, base scenario peak hour.

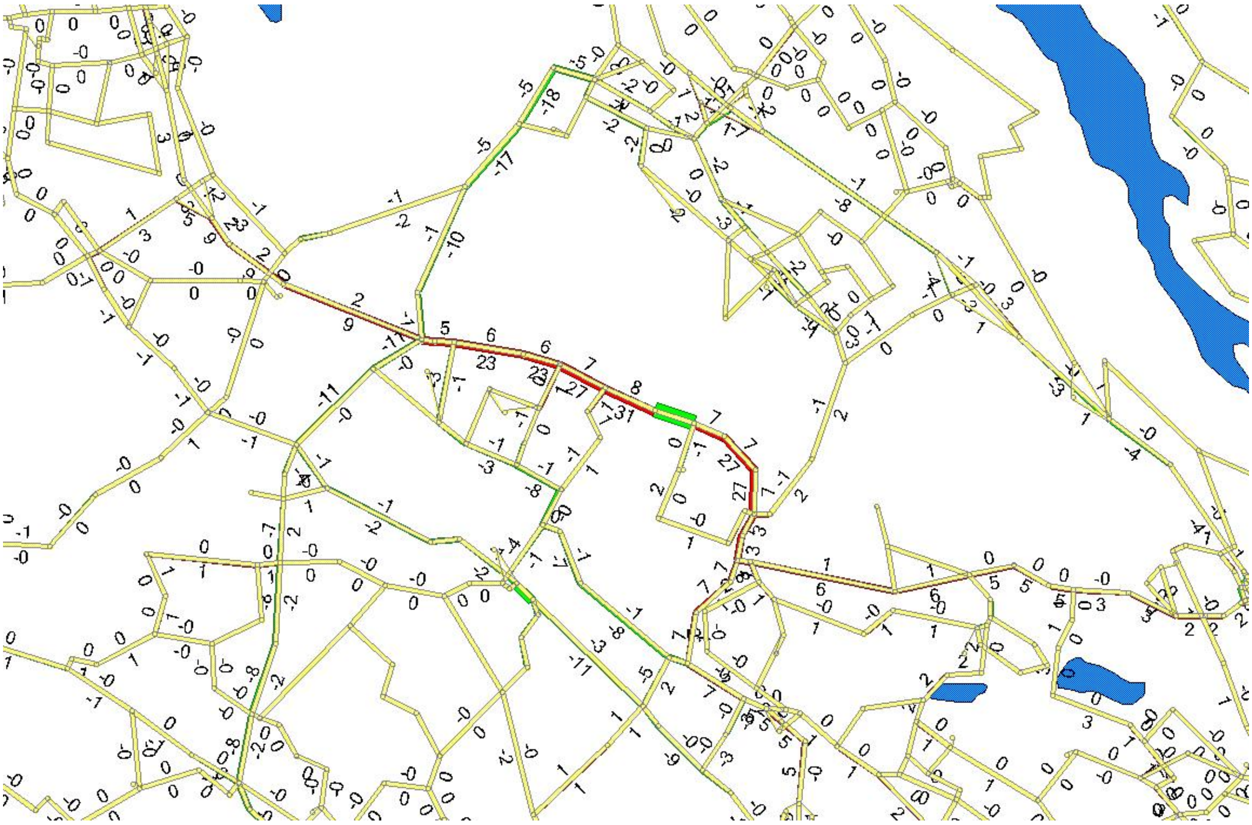
Appendix A Figure 4: Auto volume in Södermalm, base scenario off-peak hour.



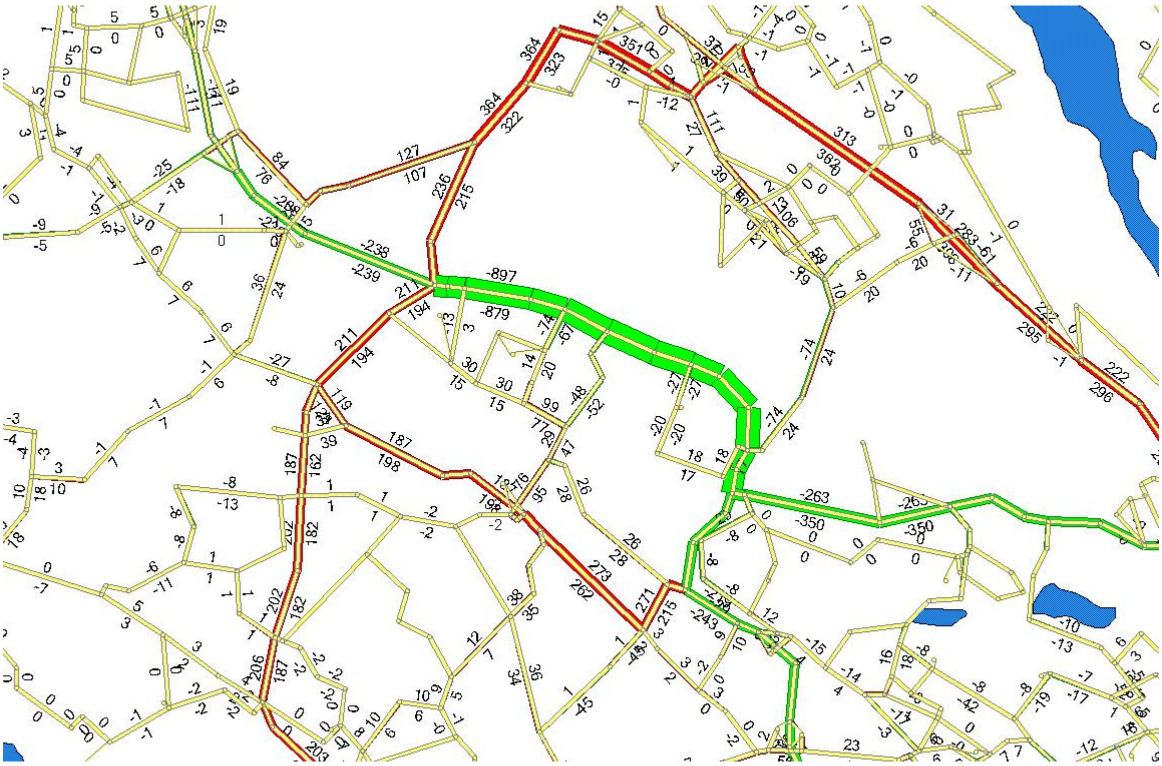
Appendix A Figure 5: Auto speed in Södermalm, base scenario peak hour.



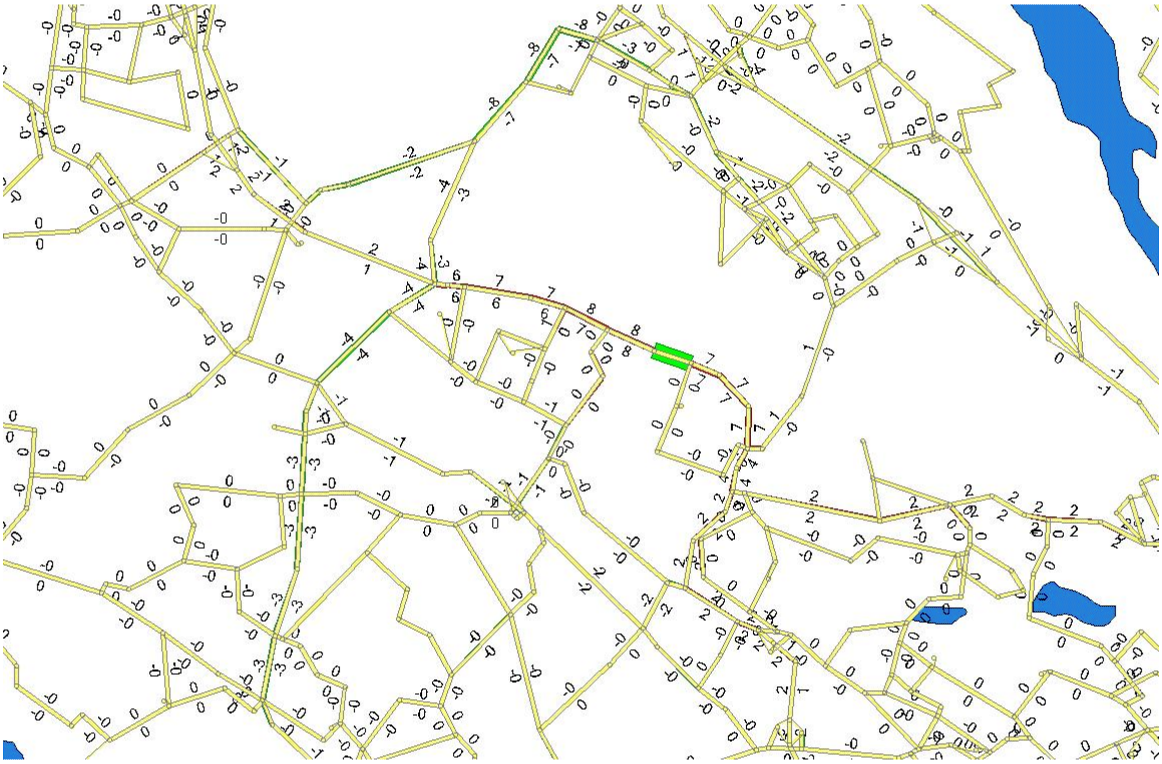
Appendix A Figure 6: Auto speed in Södermalm, base scenario off-peak hour.



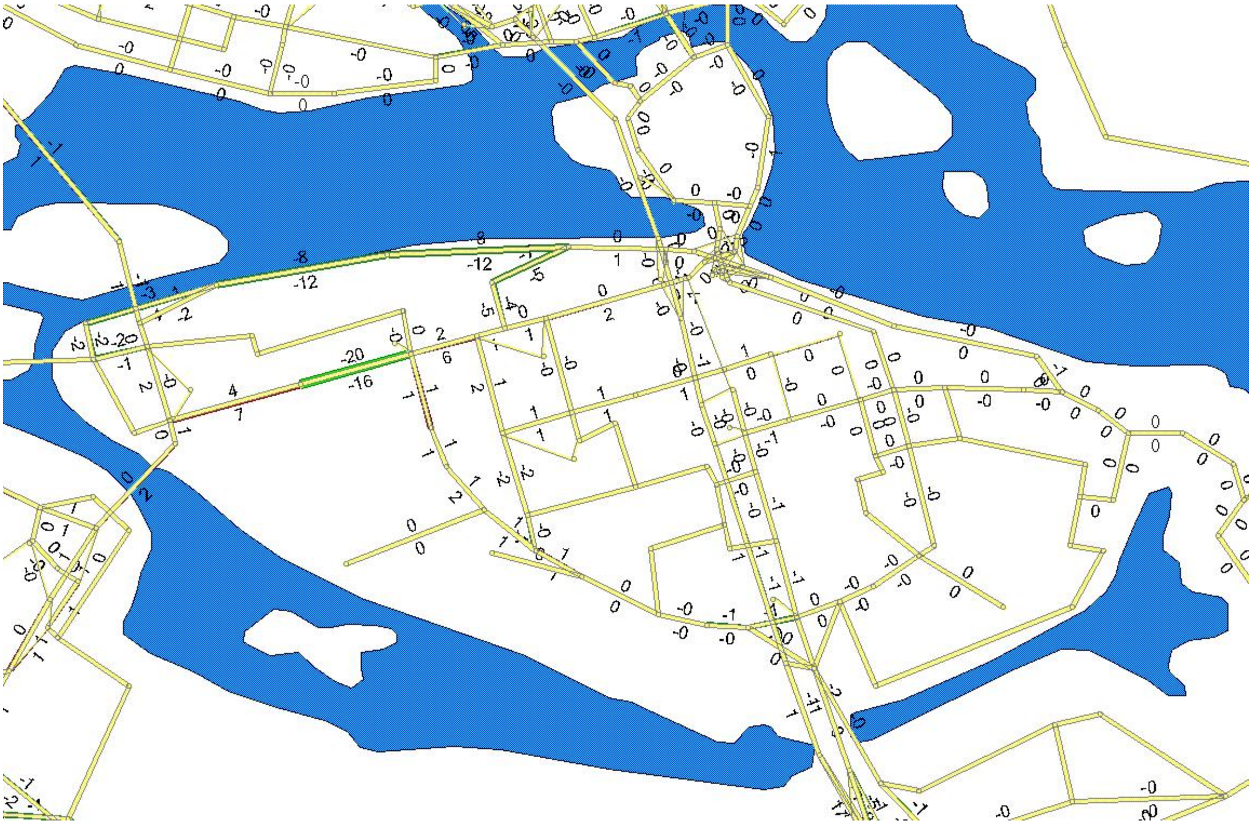
Appendix A Figure 7: Absolute difference in speed due to closed road in the Järva area, peak hour traffic.



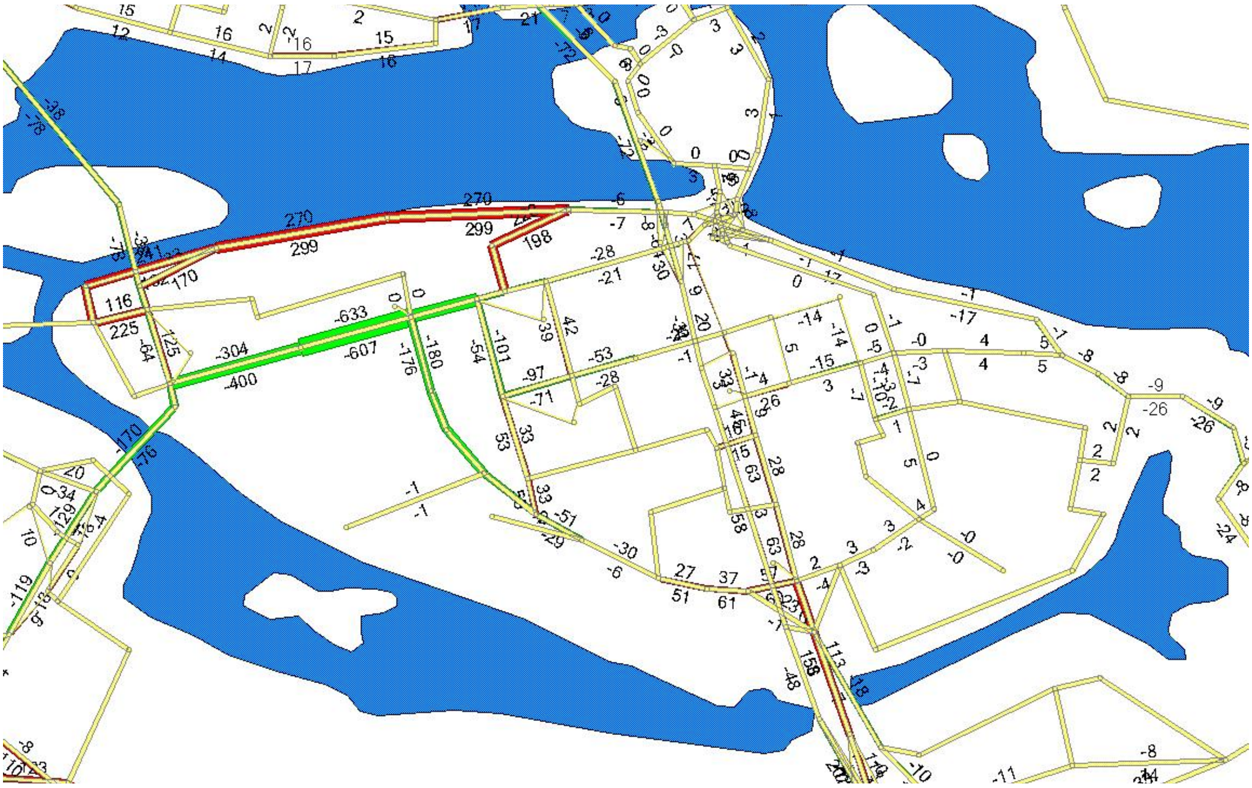
Appendix A Figure 8: Absolute difference in auto volume due to closed road in the Järva area, off peak hour.



Appendix A Figure 9: Absolute difference in speed due to closed road in the Järva area, off peak hour traffic.

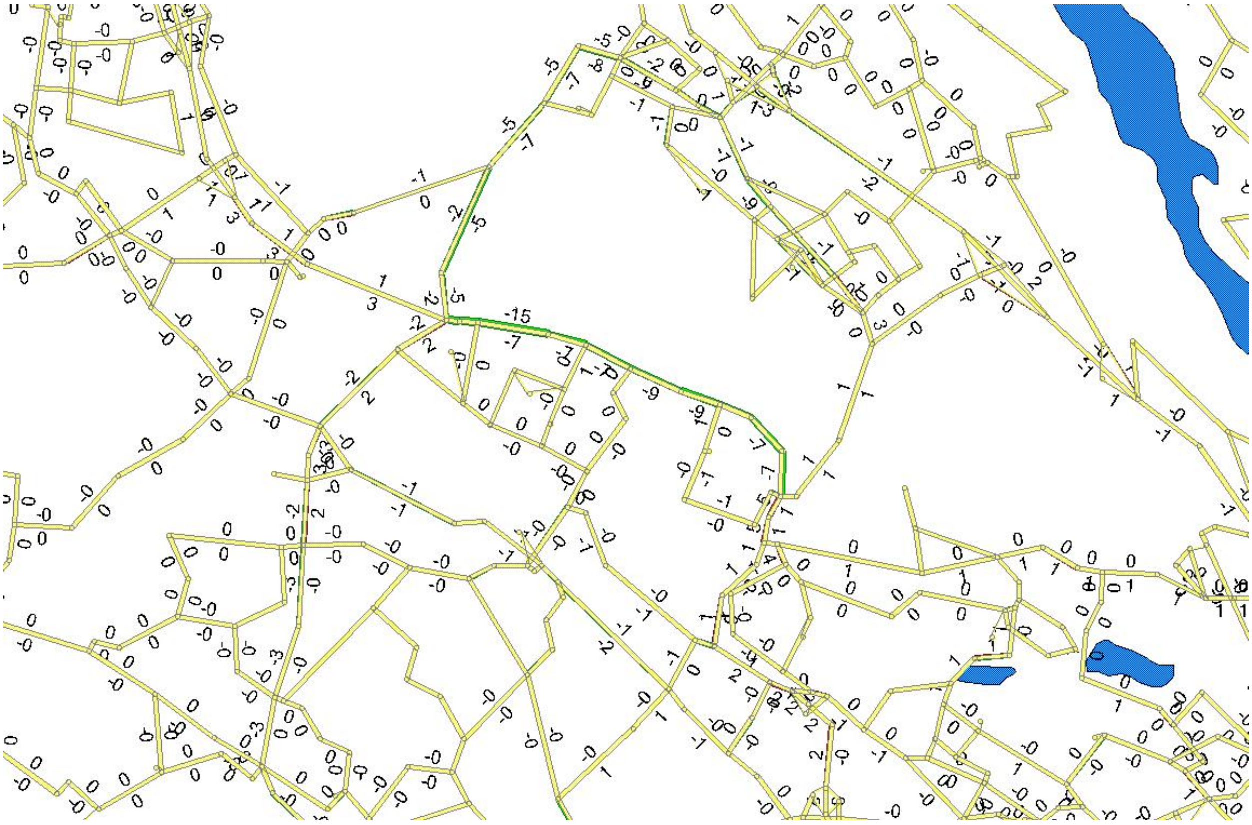


Appendix A Figure 10: Absolute difference in speed due to closed street on Södermalm, peak hour traffic.

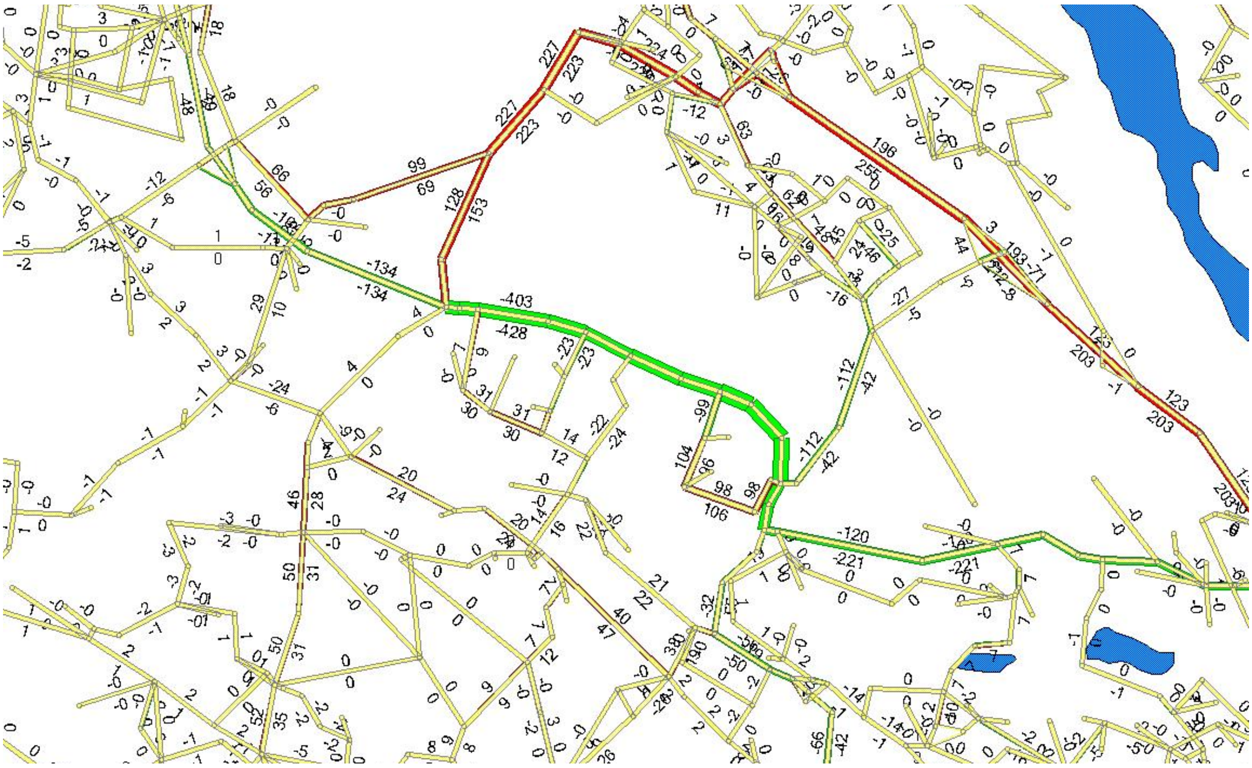


Appendix A Figure 11: Absolute difference in auto volumes due to closed street on Södermalm, off peak hour.

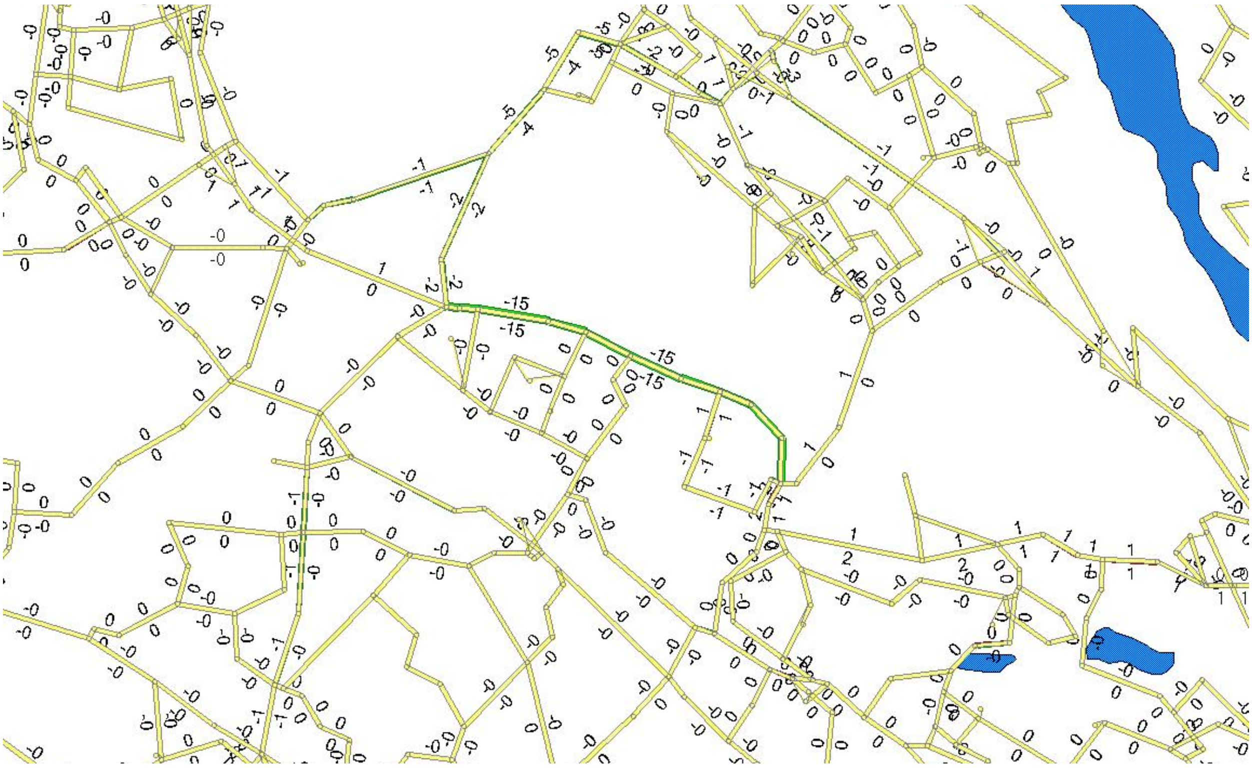
Appendix A Figure 12: Absolute difference in speed due to closed street on Södermalm, off peak hour traffic.



Appendix A Figure 13: Absolute difference in speed due to reduced speed limit on a road in the Järva area, peak hour traffic.

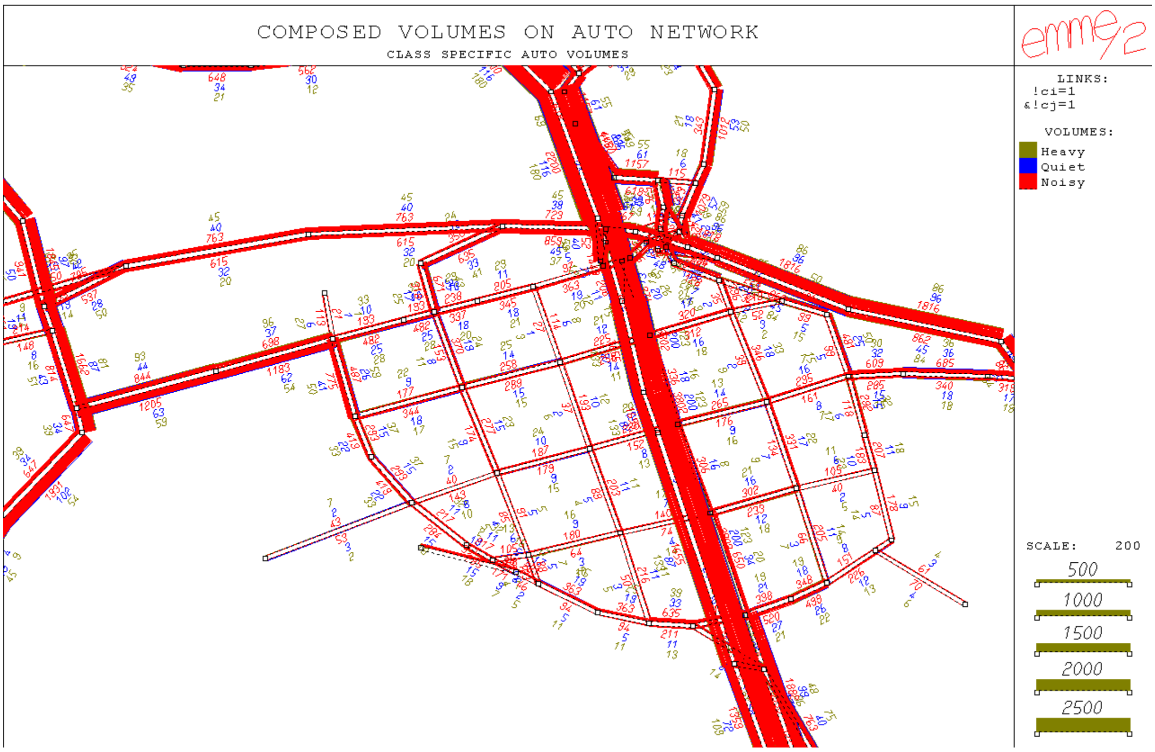


Appendix A Figure 14: Absolute difference in auto volumes due to reduced speed limit on a road in the Järva area, off peak hour.

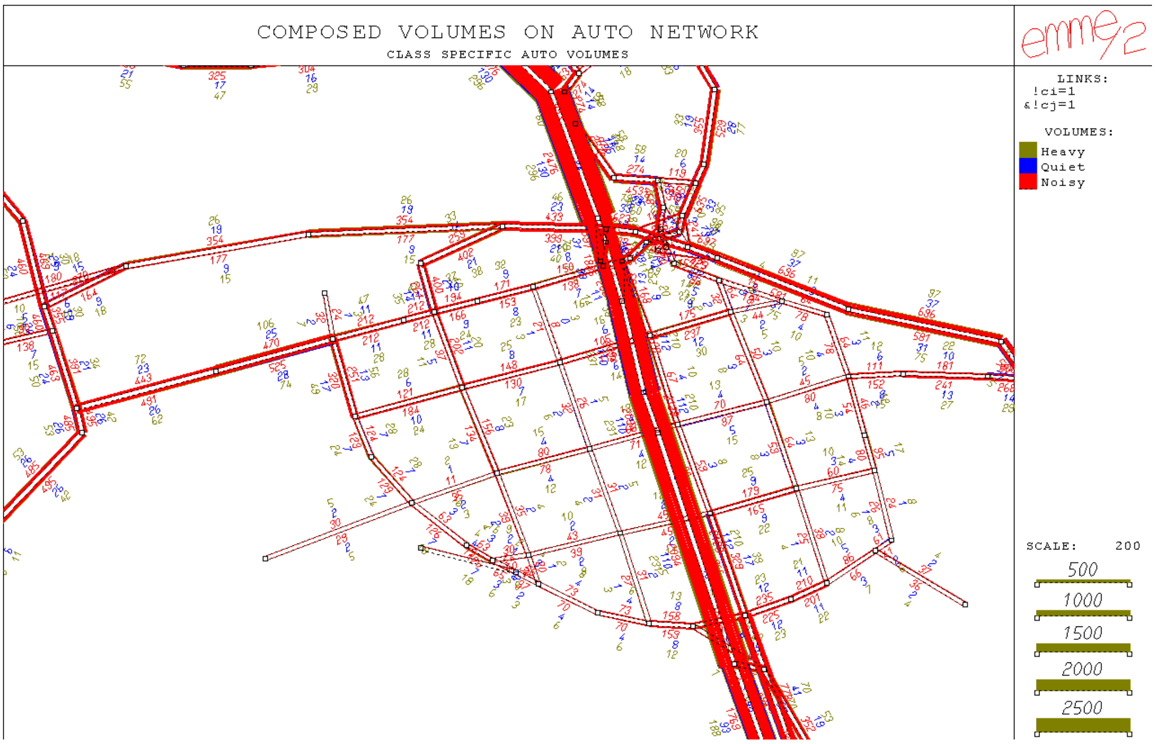


Appendix A Figure 15: Absolute difference in speed due to reduced speed limit on a road in the Järva area, off peak hour traffic.

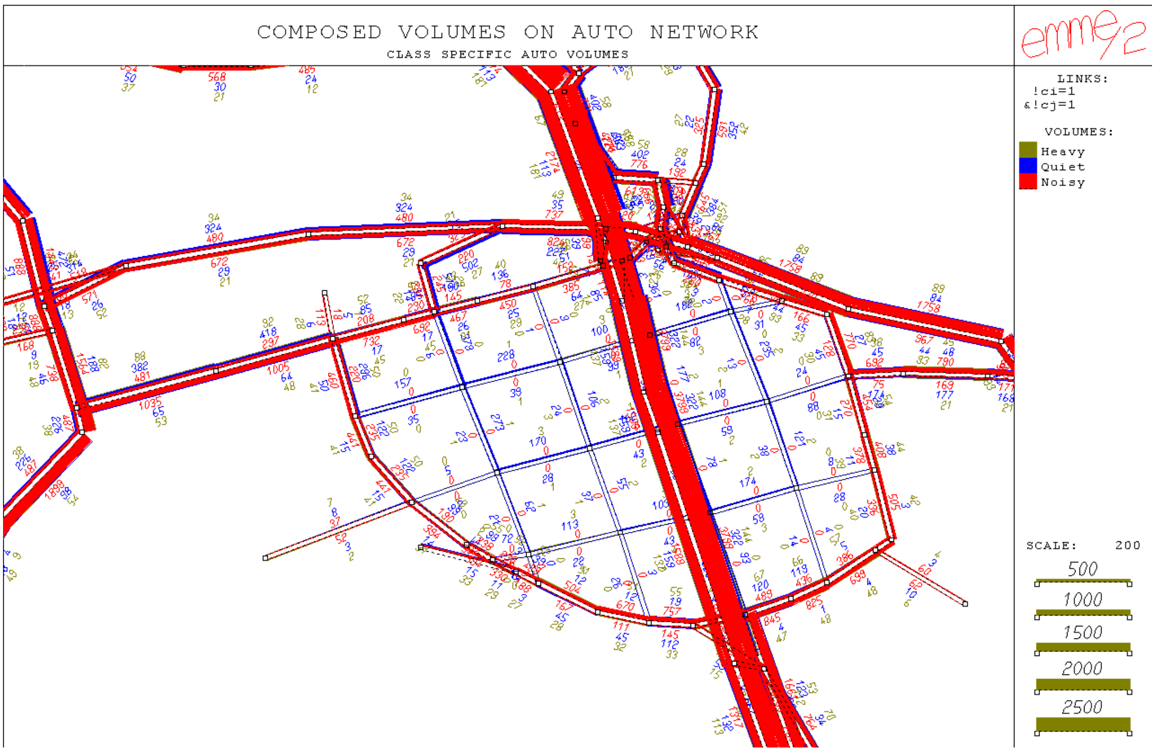
APPENDIX B – TRAFFIC VOLUMES AND NOISE MAPS OF SCENARIOS RELATED TO QUIET AREAS



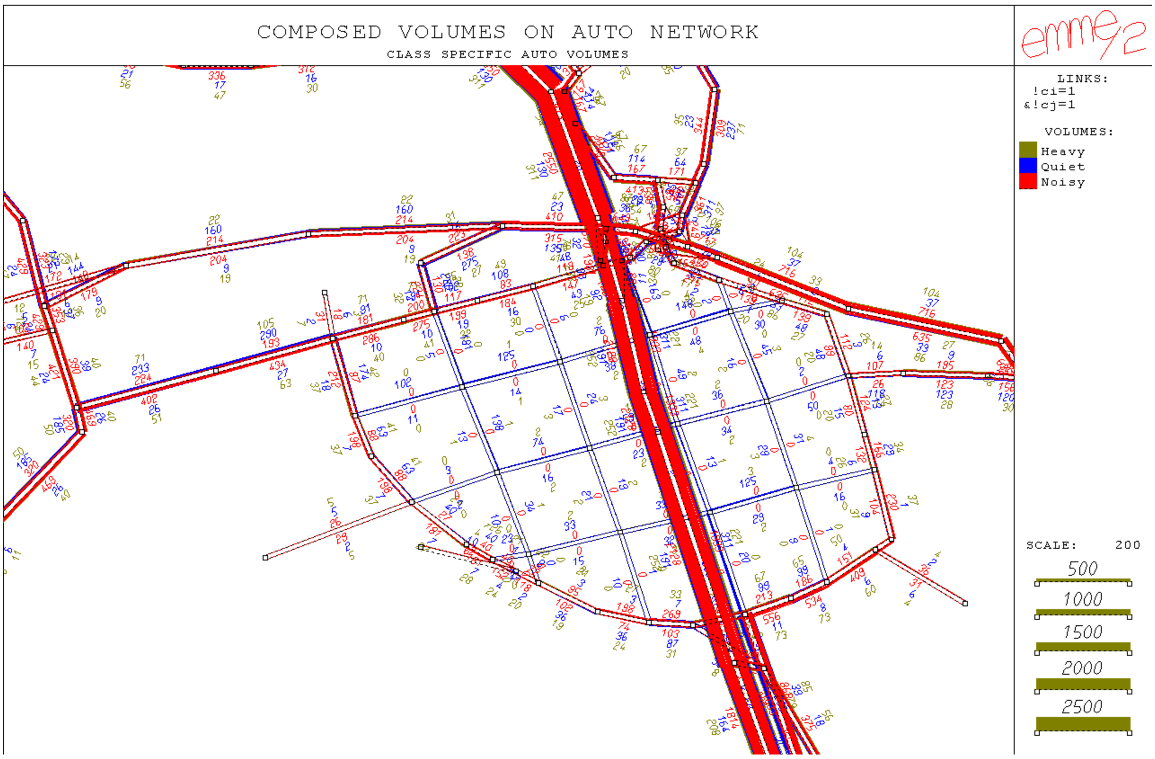
Appendix B Figure 1: Volumes per vehicle type of the fictive base scenario in Södermalm, peak hour.



Appendix B Figure 2: Volumes per vehicle type of the fictive base scenario in Södermalm, off peak hour.



Appendix B Figure 3: Volumes per vehicle type of scenario 1 (road barriers 5% quiet vehicles outside zone, 100% inside zone), peak hour.



Appendix B Figure 4: Volumes per vehicle type of scenario 1 (road barriers , 5% quiet vehicles outside zone, 100% inside zone), off peak hour.

Scenario 1 – Large area, road barriers, car ownership of quiet vehicles: 5% outside and 100% inside the area.

Appendix B Figure 5: Noise level impact of scenario 1.

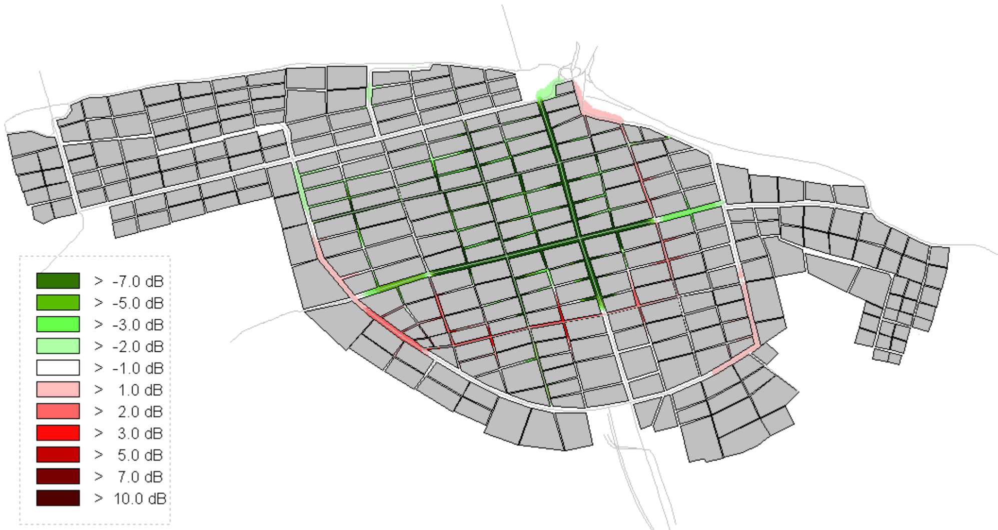
Scenario 2 – Large area, 2 euro charge, car ownership of quiet vehicles: 5% outside and 20% inside the area.

Appendix B Figure 6: Noise level impact of scenario 2.

Scenario 3 – Large area, 1 euro charge, car ownership of quiet vehicles: 5% outside and 20% inside the area.

Appendix B Figure 7: Noise level impact of scenario 3.

Scenario 4 – Small area, road barriers, car ownership of quiet vehicles: 5% outside and 100% inside the area.



Appendix B Figure 8: Noise level impact of scenario 4.

Scenario 5 – Small area, 2 euro charge, car ownership of quiet vehicles: 5% outside and 100% inside the area.

Appendix B Figure 9: Noise level impact of scenario 5.