Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Landscape Architecture, Horticulture and Crop Production Science

Stenungsund hazards: coastal flooding

Amin Behnamfar

Degree Project • 30 hec

Urban Landscape Dynamics

Alnarp 2014

Stenungsund hazards: coastal flooding

Strategier för att hantera stigande havsnivåer I Stenungsund

Amin Behnamfar

Supervisor: Erik Skärbäck, SLU, Department of Department of Landscape Architecture, Planning and Management

Examiner: Tim Delshammar, SLU, Department of Department of Landscape Architecture, Planning and Management

Credits: 30 hec
Project Level: A2E
Course title: Master Project in Landscape Planning
Course code: EX0377
Programme: Urban Landscape Dynamics

Place of publication: Alnarp
Year of publication: 2014
Online publication: http://stud.epsilon.slu.se

Keywords: Coastal flooding, Flood management, Flooding, rational method

SLU, Swedish University of Agricultural Sciences
Faculty of Landscape Architecture, Horticulture and Crop Production Science
Department of Landscape Architecture, Planning and Management

Acknowledgments

First of all, I would like to thank my spouse, Shahrzad Askaripour Jazi for all her love and encouragement and support that I have been gotten from her for proceeding not only this master thesis but also my every goals. She has always been patient and has listened to all my Ideas and arguments and has given me useful advices which help in making it fruitful. I have learned about life, research and how to handle and solve problems from her.

Furthermore, I am very grateful to my supervisor, Professor Erik Skärbäck, for his perceptive comments, consultations and his motivating comments. His technical knowledge and attention to details guide this project to the point.

I also want to thank municipality of Stenungsund, especially to Erik Olmårs how provides me with data I needed which significantly improved my work.

Finally, I would like to thank my mom who devotes all her love for my improvement, dad and my brothers for their infinitive supports.

Table of Contents

Introduction

Nature is a pleasant word for us as humans. But some natural phenomena can put human lives at risks. Therefore, necessity of human awareness of natural hazard should be considered in parallel with taking advantage of nature in order to managing hazards. From happened climate changes over the world, today natural hazard have been being felt greater than before. Physical involvements of humans in nature and natural resources have been perceived as the reason of increasing frequency of natural hazard events (Organization of American States. Dept. of Regional Development and Environment. & United States. Agency for International Development. Office of U.S. Foreign Disaster Assistance., 1991, pp. 3, Ch 01).

From the effects of climate change over northern Europe and coastal zones, temperature rises more than global average is flushing; which would decrease snow and ice coverage and increase river flows, sea level rises and acidity of ocean (E. E. E. Agency, Füssel, & Jol, 2012, p. 27).Flood risk is one of those natural hazards which are getting more and more

noticeable with accusation of climate changes (Warner, 2011, p. 01).

Flooding would occur if precipitations and continuous rainfalls exceed the soil absorptive capacity (Organization of American States. Dept. of Regional Development and Environment. & United States. Agency for International Development. Office of U.S. Foreign Disaster Assistance., 1991, pp. 2, Ch 08). Increased precipitation due to climate changes on one hand and continuously expansions of constructions and cities' developments results in reducing permeability of the soil on the other one, would lead into flooding rise dramatically (Watson & Adams, 2011, p. 49). Therefore most of the heavy rainy days would end in flood stocking daily life stream.

Sea level rises would cause coastal flooding, which would erose the coast or cause flat coastal regions loses (E. E. E. Agency et al., 2012, p. 102). It also can harm fixed structures including highways and railroads (Organization of American States. Dept. of Regional Development and Environment. & United States. Agency for International Development. Office of U.S. Foreign Disaster Assistance., 1991, pp. 7, Ch 01). In general, flooding has social, economic and environmental impacts. Property and infrastructural damages, agricultural lands and production loses are economic impacts of flooding. Possible social influences of flooding, especially flash flooding, can be inhabitant loss of life or their displacement (E. E. E. Agency et al., 2012, p. 118). Flooding can frighten peoples and because they expect governments to provide security, it can effect societal governability (Warner, 2011, p. 5). Untreated inundation can be a major source of pollution by collecting and distributing harmful chemicals and materials from surfaces which contains toxins, bacteria and viruses to the watercourse and treat human health («Urban flooding POSTnote 07/289,» 2007, p. 1).

The known taken approaches for managing flood by planners and engineers has been being such as collecting runoffs from the streets and roof tops and directing them to channels and drainage systems («Urban flooding POSTnote 07/289,» 2007, p. 1). Gilbert F. White was geographer who demonstrated that many engineered solutions are defective against floods and they might increase flooding. He suggested nonstructural solutions as a compatible way of adaptation to flooding, flood proofing, elevation of structures, building restrictions and flood abatement zoning are some example of nonstructural solutions (Sylves, Kershaw, & ebrary Inc., 2004, pp. 1-2). Moreover, protecting, restoring or replicating vegetation and landscape in order to reduce soil erosion and convey water into the soil are the most effective course leading to flood reduction (Watson & Adams, 2011, pp. 78, 81-82).

Theoretical part this thesis report includes studding hydrological cycle and factors which contributing floods and identifying and comparing different flood management methods. Concentrating on coastal flooding and assessing coastal flooding affected areas on the Stenungsund as case study and suggesting some ideas for future developments is the .

In summary, The mentioned flood management methods are: Nonstructural Flood Defense Method, Low Impact Development Method and Best Management Practice Method.

1- Nonstructural Flood Defense Method (NFDM):

This method is about protecting flood prone areas from floods and sea level raises hazards by creating artificial flood defense system and reservoirs. Land use management also has been assessed carefully in this

method in different flood prone zones.(Watson & Adams, 2011)

2- Low Impact Development method (LID):

The hydrological analysis of this method is based on the Soil Conservation service (SCS) and TR-55 hydrologic model(United States Department of Agriculture, 1986).

The approach of this method is to match the development condition of rainfall abstraction to the pre-developed condition as much as possible by making balance through infiltration potential, evapotranspiration and surface storage. In this method increasing excess runoff travel time would lead in pace reduction of runoff concentration («Low Impact Development Hydrologic Analysis,» 1999).

3- Best Management Practice method (BMP):

This method emphasis on promotion of pollution prevention of the sources and the ways of putting this concept in to practice before it cause environmental problems (U. S. E. P. Agency, 1992) for newly developed areas and developed areas.

Erosion prevention, sedimentation and discharge of other pollutants during construction; long term impacts from runoff from the completed development and associated land uses are the goals of this method.(«Stormwater Best Management Practice, New Development and Redevelopment,» 2003)

Within the broad spectrum of possible solutions in flood management I would like to focus on how to manage coastal flooding hazards and overcome threats.

As a second year master student in Urban Landscape Dynamics with constructing road and buildings background in bachelor level, I would take my master thesis as an opportunity to look into flood management solution from a multidisciplinary perspective. Investigating geographical data of flood prone areas would be my area of concern in this project.

Geographic Information System is the methodology, tool and application used in this thesis.

Aim

The aim of this thesis is to:

1- Discuss problems and planning methods related to coastal flooding.

2- Suggest measures to handle coastal flooding in the municipality of Stenungsund Sweden.

Flooding

Water is one of the important elements of this world which mostly means life for habitats. This element also can take the habitats life by its absence or sometimes by its unnatural or sudden presence. Therefore, it is important for us as humans to manage this element not only for our needs but also for other habitats. It is not possible to manage something without knowing that thing; therefore, this part is briefly gives general knowledge about hydrology and water movements on the earth. It is also explain important factors which directly affect this movement on the ground and also under the ground.

Hydrologic Cycle

Hydrology, study of water movement on the earth and in the atmosphere which known as hydrologic cycle and contain three important phases; Evaporation and Evapotranspiration, Precipitation and runoff (Raghunath, 2006, p. 11). Therefore, it is important to understand the system as well as to be aware of its hazard in order to manage part of the system. In the beginning of this chapter basic knowledge of hydrology like precipitation and water movement after it and the hydrological calculation methods will be discus, after that different flood management methods and different storm management devices will be presented.

Any precipitation has independent characteristics of duration, depth, frequency and intensity. Duration is length of time (hours) which precipitation occurs and the amount of it called depth (millimeters). Repetition of the same precipitation is called frequency and amount of precipitation per duration of it called intensity (millimeters per hour) ("Virginia Stormwater Management Handbook VOLUME II," 1999, pp. 2, Ch 04).

As shown in figure 1, in the beginning of precipitation, surface vegetation causes high interception, water loss and it would gradually decreases in duration of precipitation. During precipitation, water evaporation and transpiration from plant leaves occurs. in that case, irrigated or cropped land also can cause evapotranspiration. Parts of water absorbs by the surface of the ground which called infiltration and ground water moves from one basin to another (Raghunath, 2006, p. 60).

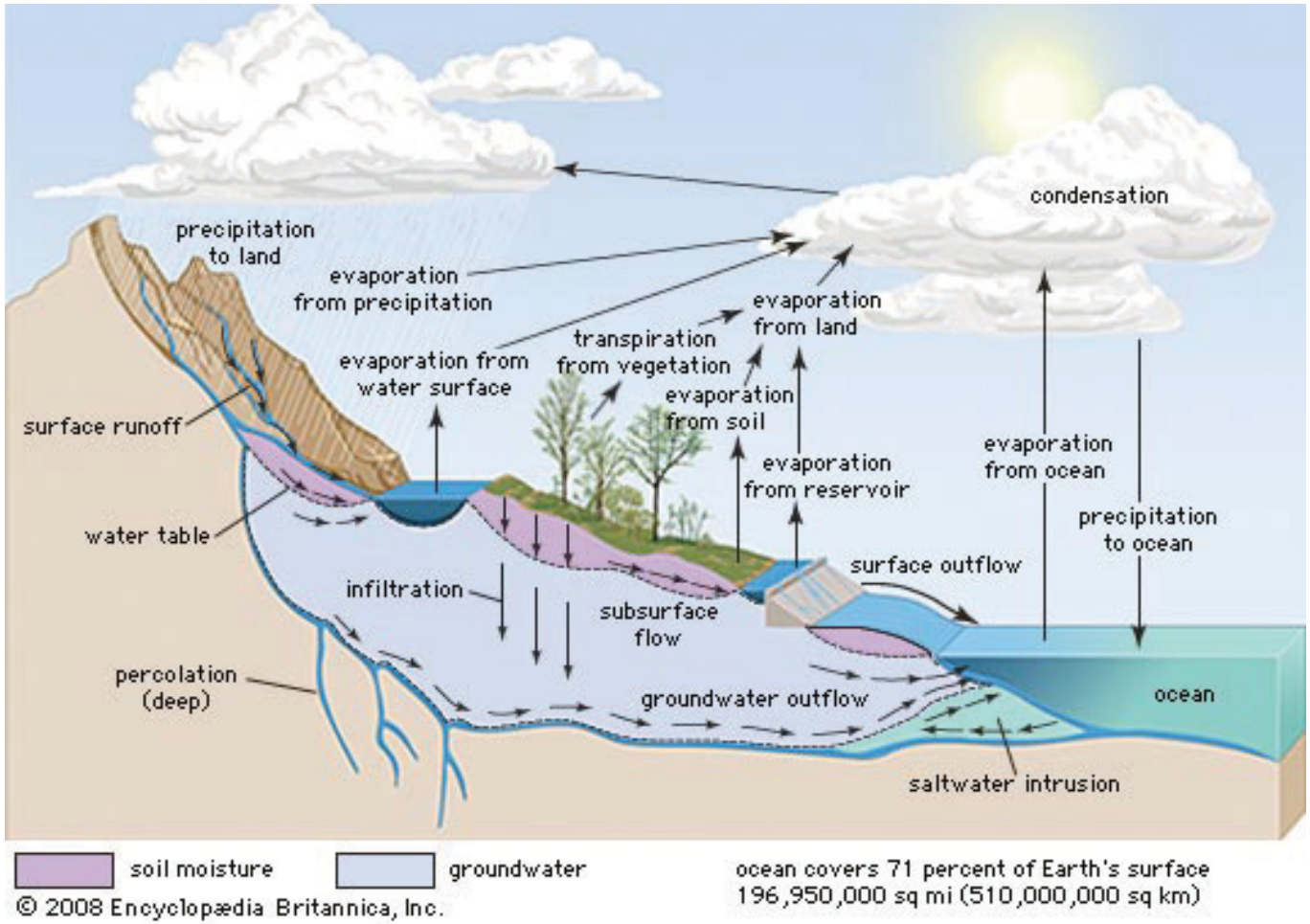


FIgure 1: this diagram illustrate the water cycle http://wwwbritannica.com/EBchecked/topic/278858/hydrologic-cycle 2013-03-17

Runoff factors

Storm characteristics, Meteorological characteristics, Basin characteristics and Storage characteristics are important factors which can affect runoff.

Type or nature of storm and the season when it occurs, intensity, duration and frequency of precipitation, precipitation extent, preceding precipitation and direction of storm movement are the different element which can be categorized as storm characteristic. Temperature, humidity, wind velocity and pressure variation are Meteorological characteristics which can effect evaporation and transpiration. Basin characteristics such as size, shape, slope, altitude (elevation), topography, geology (type of soil), land use / vegetation, orientation and adjacency to ocean and mountain ranges are the factors which effect runoff (Raghunath, 2006, p. 105).

Figure 2: Land cover and runoff (Amin Behnamfar 2012)

Runoff occurs when rainfall rate is greater than infiltration rate or any other occurrences which described above. The stream of runoff on the ground surface follows the topography of the ground («Virginia Stormwater Management Handbook VOLUME II,» 1999, pp. 13, Ch 04). And when precipitation intensity exceeds the catchment capacity of upstream, surface stream level would unusually increase and cause flooding («Designing for Flood Risk,» p. 4).

Soil Groups

There are different methods for calculating hydrological flows and surface runoffs. Rational Method, Modified Rational Method and SCS Method are from those methods which are used most. What are really important in calculating runoffs are infiltration rate and runoff travel time. Depends on different soil infiltration capacity, hydrological soils are phenomena that are categorized here in different groups of A,B,C and D. Group A has high infiltration rate with low runoff potentials; sand, loamy sand or sandy loam are in this category. Group B, silt loam or loam is in this category because of their moderate infiltration rate which causes low runoff. Group C, infiltration possibility is low and therefore the runoff potential is moderately high; sandy clay loam is in this category. Soils which has very low infiltration rate and high runoff potential are in group D such as clay loam, silty clay loam, sandy clay, silty clay or clay («Virginia Stormwater Management Handbook VOLUME II,» 1999, pp. 30-31, Ch 04).

Figure 3: Soil type in the Stenungsund area (Amin Behnamfar 2012)

Runoff Travel Time

Runoff travel time, which is known as the time of concentration is another important factor in runoff calculation. It is the time which takes from runoff to travel from upper hand of the watershed to the outlet («Urban Hydrology for Small Watersheds TR-55,» June 1986, pp. 1, Ch 03). Increasing or changing the travel time can affect the runoff volume. By increasing this time, the possibility of infiltration can increase and therefore the volume of runoff would decrease. The factors which can affect the concentration time are surface roughness, channel shape and flow patterns and the slope of the watershed («Urban Hydrology for Small Watersheds TR-55,» June 1986, pp. 1, Ch 03).

Bellows comes the formulas which use to define the travel time are («Urban Hydrology for Small Watersheds TR-55,» June 1986):

$$T_t = L/(3600\ V)$$

T_t: travel time (hr)
L: flow length (m)
V: average velocity (m/s)

According to this formula, by increasing the flow length or decreasing the velocity of the flow the travel time would increase.

$$T_t = (0{,}007(nL)^{0{,}8})/((P_2)^{0{,}5}\ S^{0{,}4}))$$

Tt: travel time (hr)
n: manning's roughness coefficient
L: flow length
P2: 2-year, 24-year rainfall (cm)
S: slope of hydraulic grade line (land slope, m/m)

Moreover, from this formula we can get into this pint that by increasing the roughness coefficient which can obtain by changing the surface cover type, increasing the flow length and decreasing the slope, the travel time would increase.

Average velocity of runoff flow also obtains from below formula:

$$V = (1{,}49 r^{2/3}\ S^{1/2})/n$$

V: average velocity (m/s)
r: hydroloc radious (a/pw)
a: cross sectional flow area (m2)
pw: wetted perimeter (m)
s: slope of hydraulic grade line (land slope, m/m)
n: manning's roughness coefficient for open channel flow

therefore, it can be resulted that, by decreasing the slope, increasing open channel roughness and increasing wetted perimeter, the average velocity of flow would decrease.

Surface description		n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)		0.011
Fallow (no residue)		0.05
Cultivated soils		
	Residue cover ≤%20	0.06
	Residue cover ≥%20	0.17
Short grass prairie		0.15
Dense grasses[2]		0.24
Bermudagrass		0.41
Range (natural)		0.13
Woods[3]		
	Light underbrush	0.40
	Dense underbrush	0.80

1. The n values are a composite of information compiled by Engman (1986).

2. Dense grasses Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3. When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Table 1: Roughness cofficients (Manning´s n) for sheet flow («Urban Hydrology for Small Watersheds TR-55,»)

Landslide and Debris

Landslides are rapid or slow movement of earth to downhill and can cause gradual damages. Debris flow or mudslide flow are kind of fast moving landslides where consist mud, rock and large items like trees. and heavy rainfall, erosion, poor construction practices, freezing and thawing, earthquake shaking, and volcanic eruptions are the factors which would result in these two mentioned phenomena. Landslides are mostly happens during heavy rain fall or snowmelts which can worsen the effect of flooding. Existing old landslides, bases of steep slopes and drainage channels and developed hillsides with leach field septic system usage are areas which are prone to landslide and debris (Talking About Disaster: Guide for Standard Messages, 2007, pp. 83, 84).

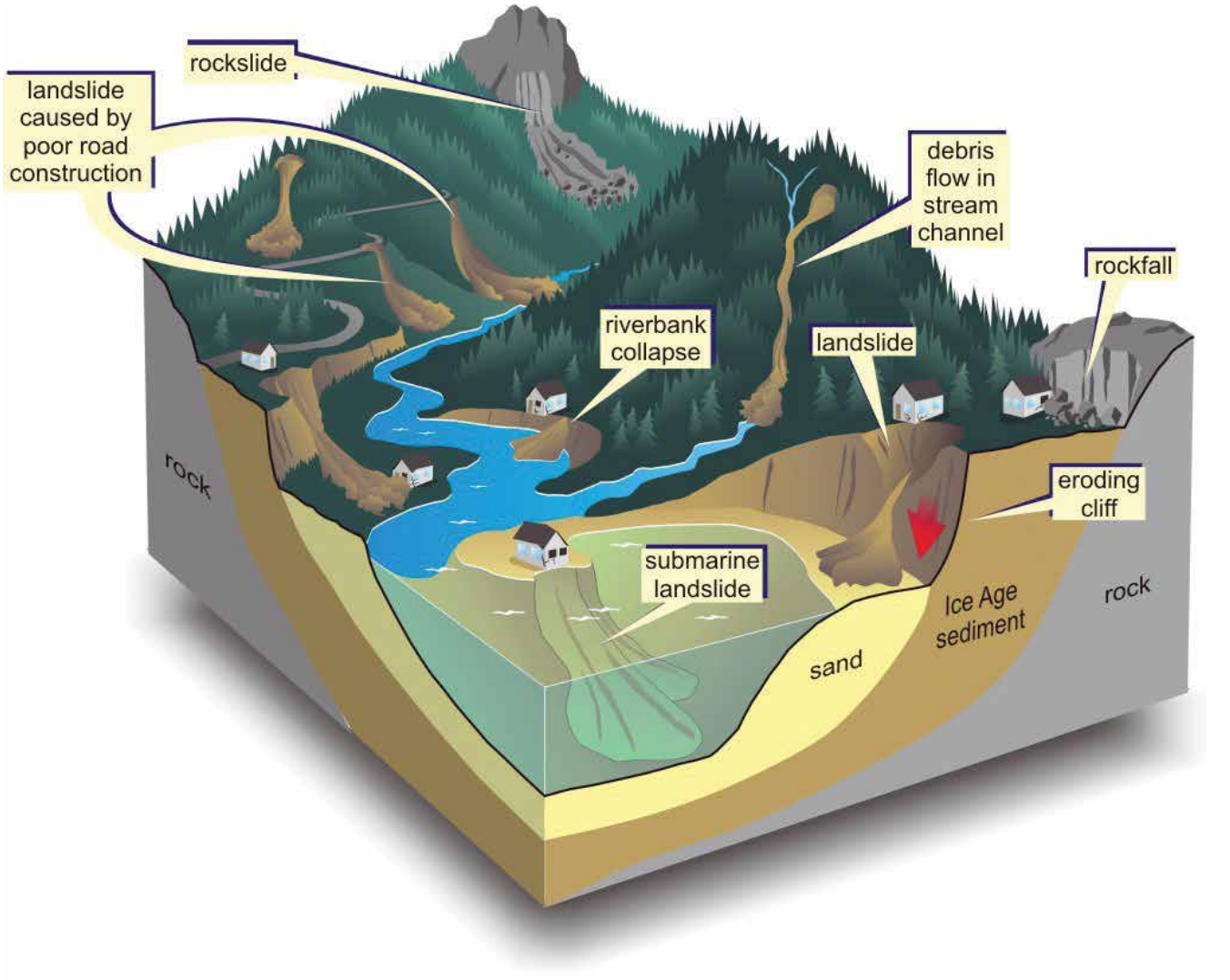


Figure 4: Landslide and Debris flow (http://web.viu.ca/geoscape/landslide!.htm 06-04-2013

Comments

As explained before, water movement on the earth and the factors which can effect this movement needs to be studied. It is important to know that how small changes in different areas can change this movement on the earth or in the atmosphere. Changes like soil roughness or slope of the watershed can dramatically alter the surface runoff and velocity of the flows. The soil coverage or permeability of the soil is another important factor which is known as hydrological soil groups. It shows that, the infiltration rate is depends on the porosity of the soil. Therefore, infiltration rate of non-compacted soils or soils with more porosity is more than compacted soils or soils with less porosity. Moreover, there are other hazards which can worsen the effect of flooding like landslides and debris which happens during heavy rainfalls and snowmelts. Therefore, it is really important to be aware of these kinds of hazards and selecting suitable flood control system in order to not only manage floods, but also manage other hazards which can happen by heavy rainfalls, runoffs and snowmelts.

Application in Systems

Each flood management method is based on different flooding systems, weather structural or nun-structural. Each one has its own advantages and limitations depend where and how it is applied. Zoning and land use system is one method of managing floods which is base system of this thesis.

Zoning and Land Use

Flood barriers are standard responses to the flooding. Lack of coordination between flood barriers and landscape can cause poor neighborhoods linkage which can result in poor public and private space quality and in some cases lack of identity and sense of neighborhood («Designing for Flood Risk,» p. 3).

This system identifies land uses on different flood zones (as shown in figure 5). Flood zones are based on the probability of river or coastal flooding. In this system, land divides to 4 flooding zones; each zone is an interval between two levels depends on topographical level of the land. Zone 4 is between normal water level and 100 year river flooding or 200 year sea flooding which has high vulnerability of flooding. Zone 3 is between 100 year river flooding or 200 year sea flooding and 200 year river flooding or 500 year sea flooding which has moderate high possibility of flooding. Zone 2 is between 200 year river flooding or 500 year sea flooding and safe zone which has moderate low possibility of flooding. Zone 1 which has low flood risk («Designing for Flood Risk,» pp. 11, 12).

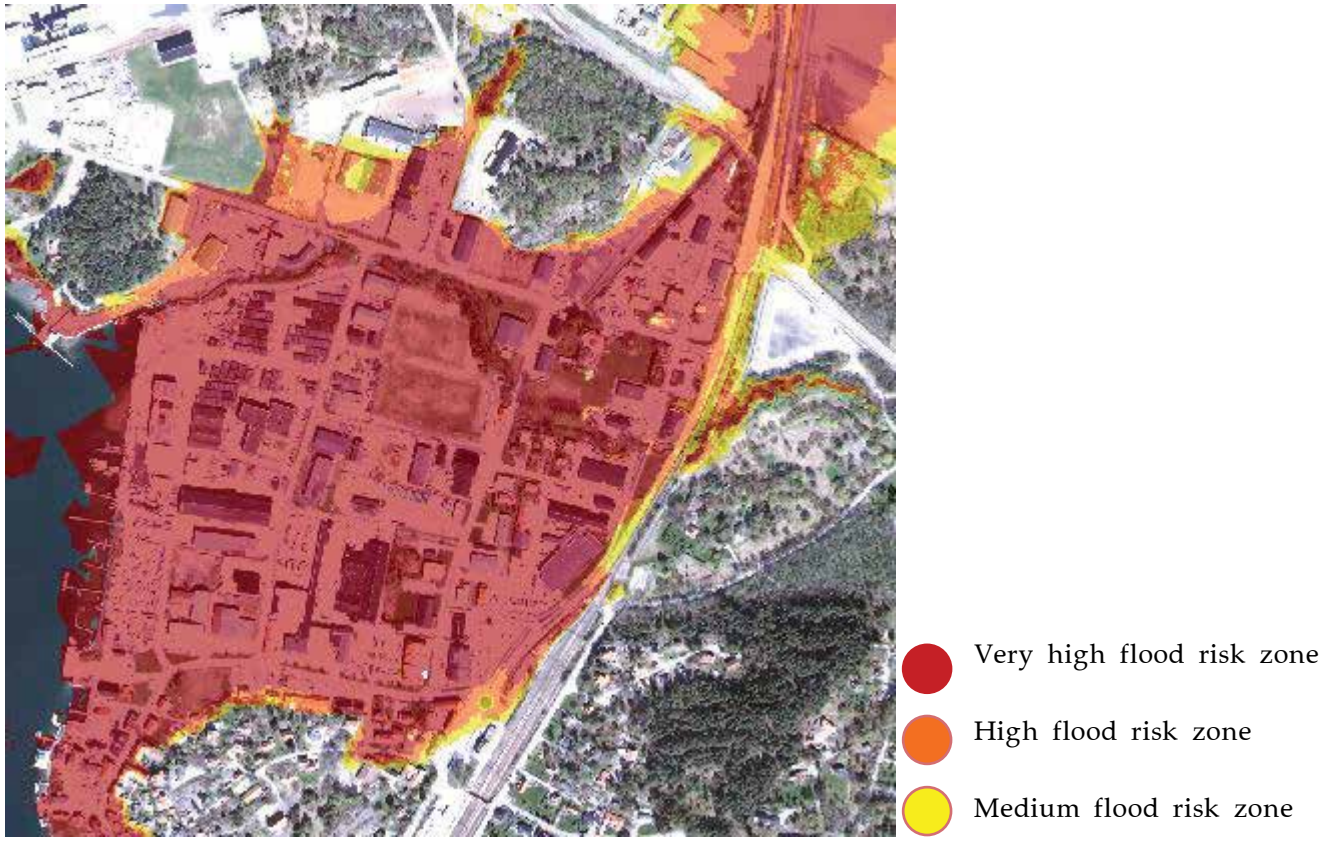


Figure 5: Flood risk zones (Amin Behnamfar 2013)

Designing sequence of this system is first assessing the flood risk by identifying the probability of flooding considering the factors of historical storm events and future climate change, flood heights and flood design height and flood design volume. Secondly, importance of uses and vulnerability of buildings, infrastructures and setting land use strategy for each flooding zone should be identified. Reducing flood risk by using other flood defense systems in order to controlling the flood is the next step of this system that is to be done. Then, minimizing flood consequences by setting safety strategy for inhabitants, structures and infrastructures. And finally, by estimating and re-estimating of flood impacts on inhabitant safety, neighborhoods, environment and climate change

Advantage of this system is land use planning. By mixing different uses, land would use efficiently at places with flooding risk. Land use will be match with natural topography of the site («Designing for Flood Risk,» pp. 12, 17).

Table 2 shows different land uses category and the possibility of implementation of them in different flood zones with or without flood mitigation systems.

Land use category	Low risk	Medium risk	High risk	Very high risk
Agriculture and fisheries	●	●	●	●
Forestry	●	●	●	●
Utilities and infrastructure - renewable energy production and distribution	●	●	●	●
Recreation and leisure - outdoor amenity and open spaces	●	●	●	●
Defence	●	●	●	●
Transport - car parks, vehicle storage, goods and freight handling	●	●	●	●
Minerals (extraction)	●	●	●	●
Utilities and infrastructure - refuse disposal	●	●	●	●
Industry and business - storage and wholesale distribution	●	●	●	●
Industry and business - manufacturing	●	●	●	●
Industry and business - offices	●	●	●	●
Recreation and leisure - indoor	●	●	●	●
Retail	●	●	●	●
Transport - tracks, ways, terminals and interchanges	●	●	●	●
Residential - hotels, boarding and guesthouses	●	●	●	●
Residential - dwellings	●	●	●	●
Utilities and infrastructure - energy production and distribution, water storage and treatment	●	●	●	●
Residential - residential institutions	●	●	●	●
Community services - medical, healthcare, education, and community (emergency) services	●	●	●	●
● Suitable use ● Requires mitigation ● Requires mitigation and defence ● Avoid use				

Table 2: Land use category on different flood zones (Designing for Flood Risk. Retrieved from http://www.architecture.com/FindOutAbout/Sustainabilityandclimatechange/Flooding/DesignGuide.aspx)

Stenungsund; Case Study

Location

Stenungsund is an industrial city of Sweden which locates in western part of the country in Västra Götaland region at latitude of 58°04› N and a longitude of 11° 49›E in north direction of Göteborg along the Bohuslän coast.

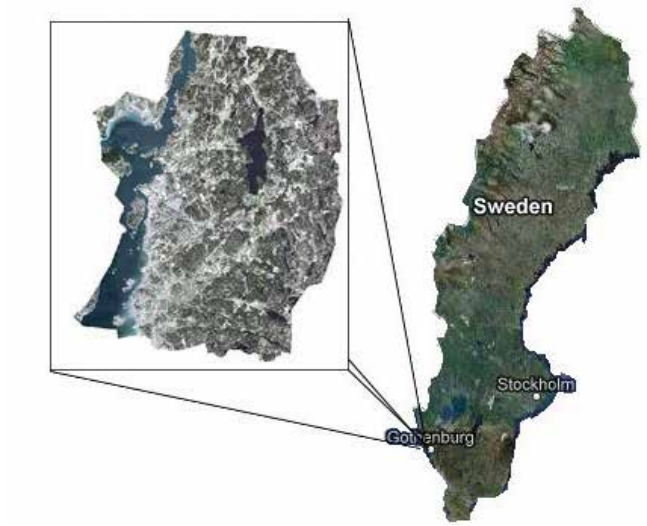


Figure 6: Stenungsund location (Google map 2012)

The municipality of Stenungsund was formed in 1952 by combining the small municipalities of Norum, Spekeröd, Ucklum and Ödsmål with approximate size of 252 km^2 surrounded by sea forest and rocks. In 1971 the Stenungsund had 4700 inhabitants but, today Stenungsund municipality has more than 24000 inhabitants. (Stenungsunds-kommun-2013-04-11)

History

For thousands of years fisherman and hunters was residents of this area. After herring disappearance from the sea, in 18th century agriculture became the main industry. The commerce of the region maintained merely farming, gardening and trading along with small scale industries until 1950's. (Stenungsunds-kommun-2013-04-11)

Because of excellent water, road, rail and aerial connections of the area in the early1960s, Stenungsund has been identified as an ideal location for large industries such as petrochemical production center and many other small and medium sized businesses. (ChlorVinyls)

Figure 7: Historic photo of the Stenungsund
(Stenungsunds-kommun-2013-04-11. (2013-04-11). Facts about Stenungsund 2013-04-11 Retrieved 2013-04-11, from http://stenungsund.se/webbsidor/huvudmeny/kommunpolitik.4.33232ad813188aec56b8000413.html)

Area and population

In 1971 the Stenungsund had 4700 inhabitants but, in 2013 Stenungsund municipality is an expanding costal municipality about 252 Km^2 and has more than 24000 inhabitants. In 2011 adults (age range of 20 to 64) had 55% of the population in the area and from those 83% were employed in the municipal area. Possibility of accommodation by the sea and outdoor recreations and activities are advantages which provide constant growth of the municipality. (Stenungsunds-kommun-2013-04-11)

Figure 8: Stenungsund Center; Community services
(Stenungsunds-kommun-2013-04-11. (2013-04-11))

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Infrastructure and Accessibility

Stenungsund is an industrial city which locates about 45 kilometer in north direction of Göteborg in Västra Götaland province. The city is situated by the sea; it is accessible through road E-6 and railway. Green express busses and Västra Götaland local trains are public transportation systems for commuting between Göteborg, second largest city of Sweden, and Stenungsund.

As discussed above, Stenungsund has area of 252 km^2. About 14 km^2 of the area apportioned to residential areas, 5.5 km^2 to industrial areas, 3 km^2 to road and rail network, 2 km^2 to constructed areas and the rest are green areas, forest, wetlands and water bodies.

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Amin Behnamfar 2013

Figure 9: Existing Land Useage in the Stenungsund (Amin Behnamfar 2013)

Land cover

As discussed in first chapter, land cover is one of the runoff factors. Gathering data about land cover type, their location and extend are important factors which can effect further expansion of the city and its direction.

Stenungsund region has variety of land cover types. Apportion of land cover types in the region are about 9 km^2 Green urban areas, 1 km^2 Sport facilities, 1,5 km^2 Golf courses, 0,5 km^2 Camping fields, 52 km^2 Arable lands, 24 km^2 Pastures, 49 km^2 Broadleaved forest, 154 km^2 Coniferous forest, 34 km^2 mixed forest, 31 km^2 Shrubs, 3,8 km^2 Clear cut areas and 2 km^2 Sparsely vegetated areas.

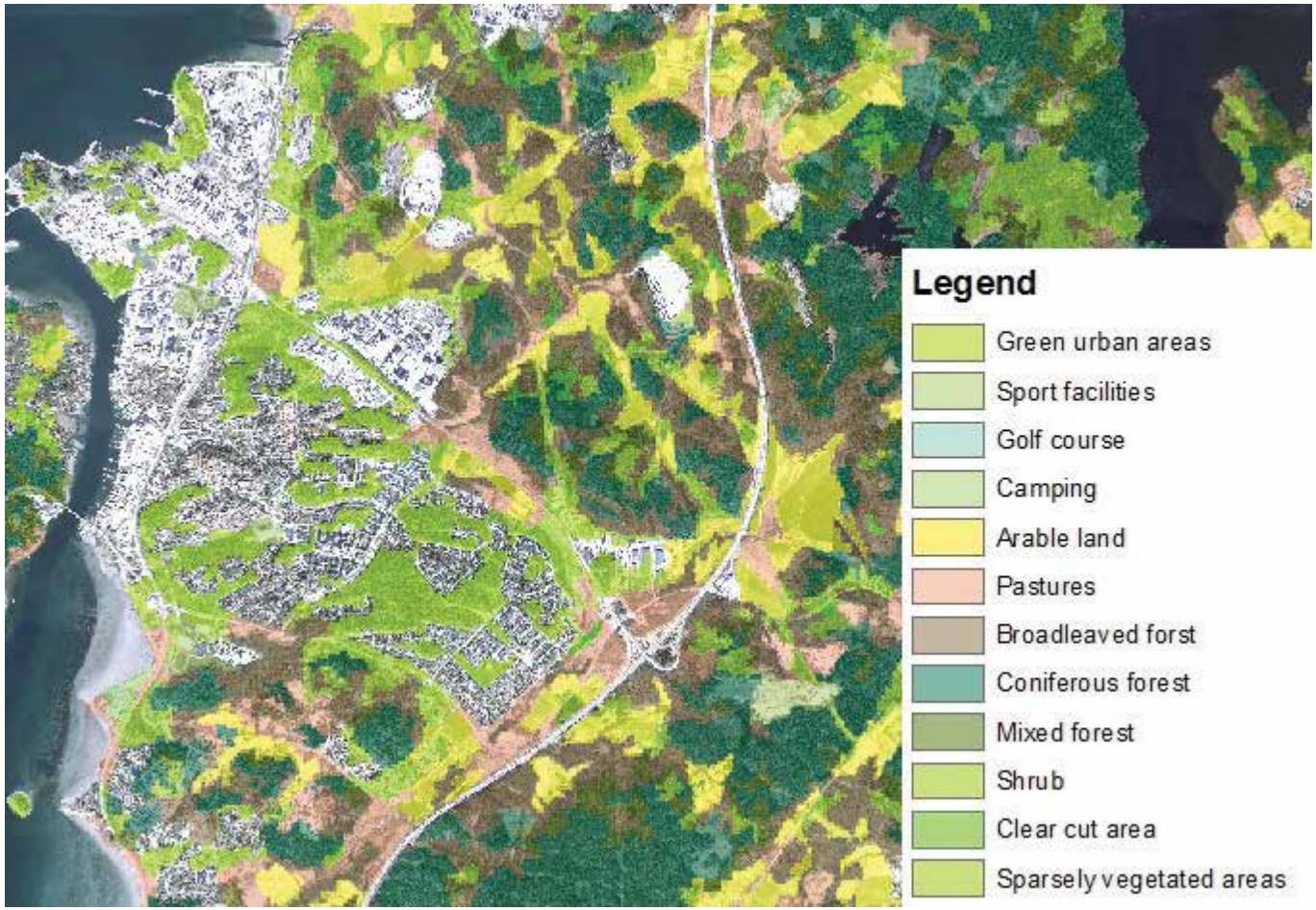


Figure 10: Existing Land Cover in the Stenungsund (Amin Behnamfar 2013)

Pollution sources

Fueling areas, Maintenance Bays and Docks, vehicle washing areas, Outdoor Material Storage areas, Outdoor Work areas and Outdoor Processing areas are the source of pollutions in the area.

Location of all this pollution sources on flood prone zone can pollute water and harm the nature and ecology of the Stenungsund. This kind of pollution might affect aquatic organism lives and also fishing industry.

Figure 11: Existing Pollution sources in the Stenungsund (Amin Behnamfar 2013)

Geology

Presented geological maps of this area shows soil and bedrock texture of the area which is Granit, Granodiorite and monzonite are generally composed the bedrock while topsoil are mostly clay, sand and bedrock (Granit, Granodiorite and monzonite). Texture of the topsoil shows that hydrological soil group of the area are A, C and in some parts D. Because of low infiltration capacity of the topsoil, runoff would take place for short time after precipitation starts.

Slope map of the area, which produced from elevation data with help of Arcmap software, is another basin factors which can affect runoff. It shows spots which have high stream velocity, places which are prone to erosions and locations which can face with landslide and debris.

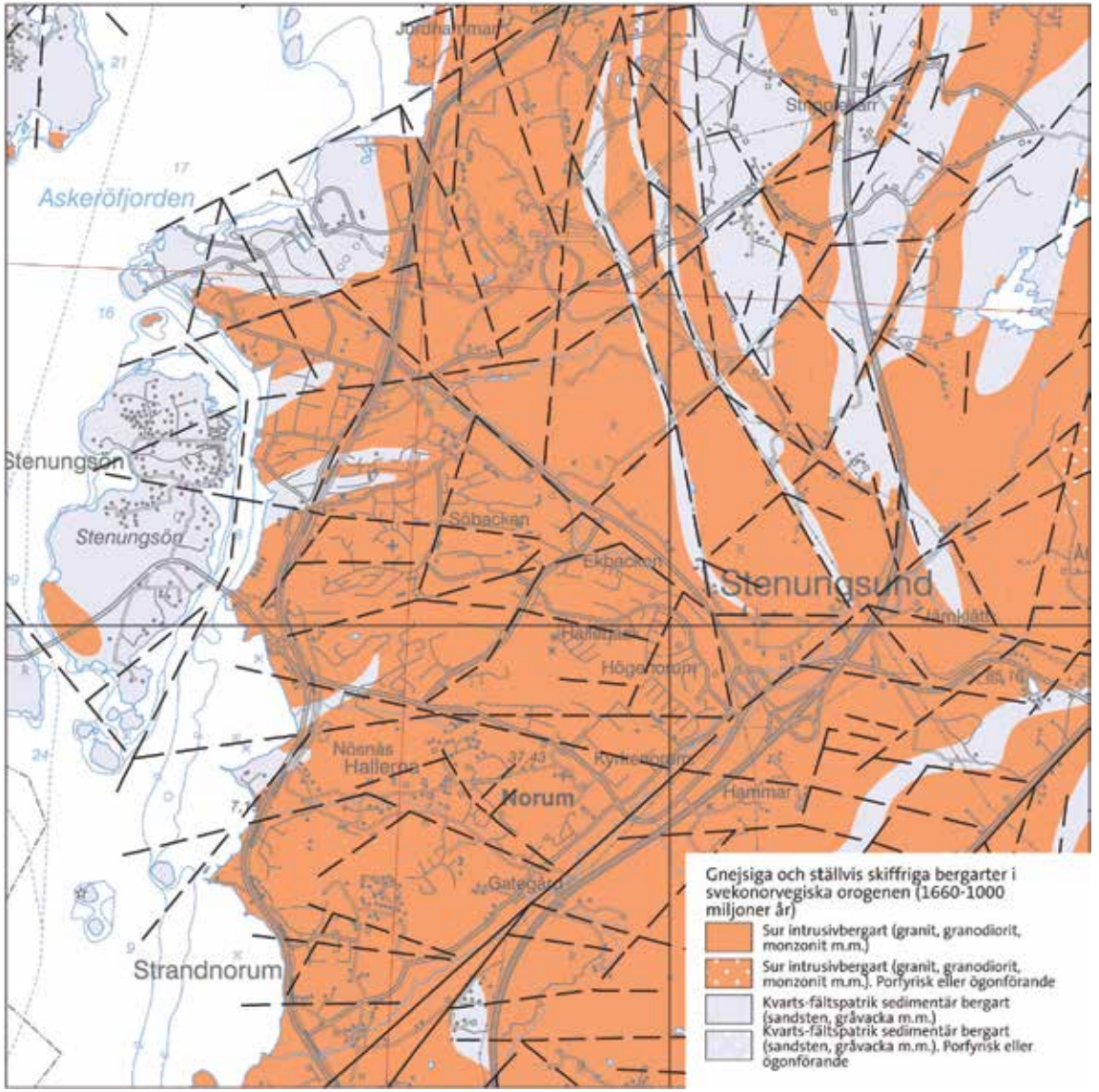


Figure 12: Existing Bedrock in the Stenungsund
(SGU, Sveriges geologiska undersökning, Geological Survey of Sweden 2013-0415 http://www.sgu.se/sgu/sv/produktertjanster/kartvisare/index.html)

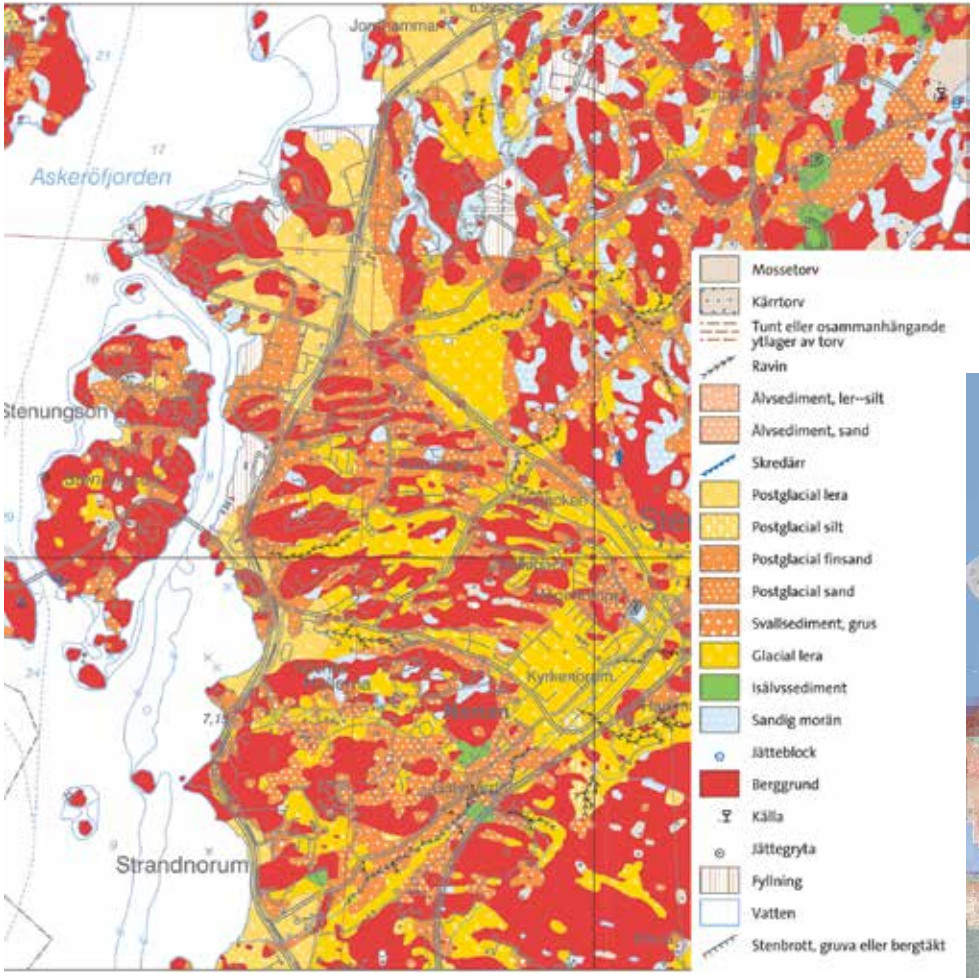


Figure 13: Existing Topsoil in the Stenungsund (SGU, Sveriges geologiska undersökning, Geological Survey of Sweden 2013-0415 http://www.sgu.se/sgu/sv/produktertjanster/kartvisare/index.html)

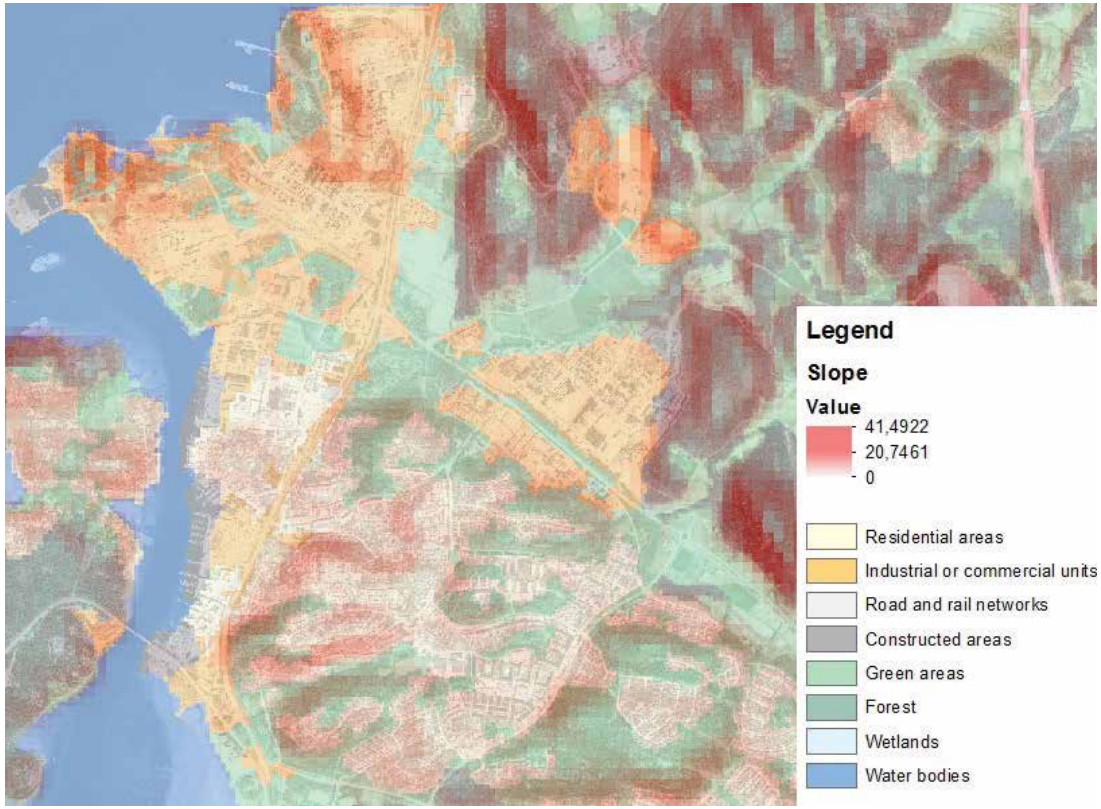


Figure 14: Existing Surface Slope in the Stenungsund (Amin Behnamfar 2013)

Climate

According to the precipitation data, average precipitation of the area was between 50-100 mm in January from 1961-1990. But according to the climate forecasts, precipitation rate would change to 100-150 mm in January from 2011-2100. This means the precipitation would have continues growth of 30-40 mm from 2011-2040 to 40-50 mm from 2040-2100.

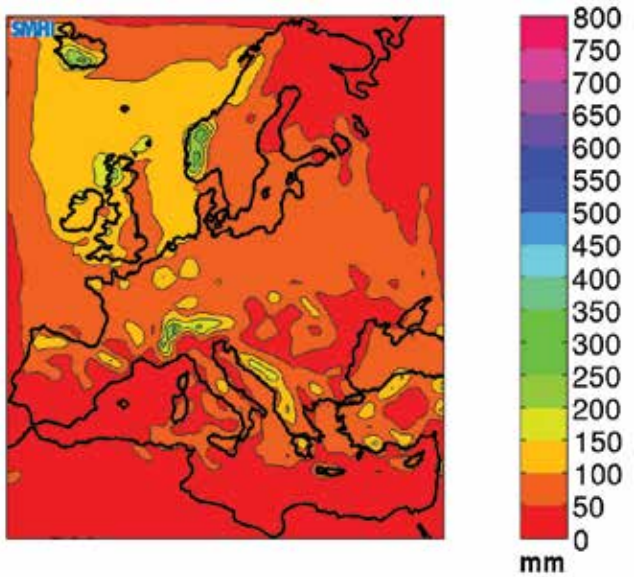


Figure 15: Precipitation summary 1961_1990_jan
(SMHI 2013-04-15 http://www.smhi.se/kli-matdata/klimatscenarier/kli-matanalyser)

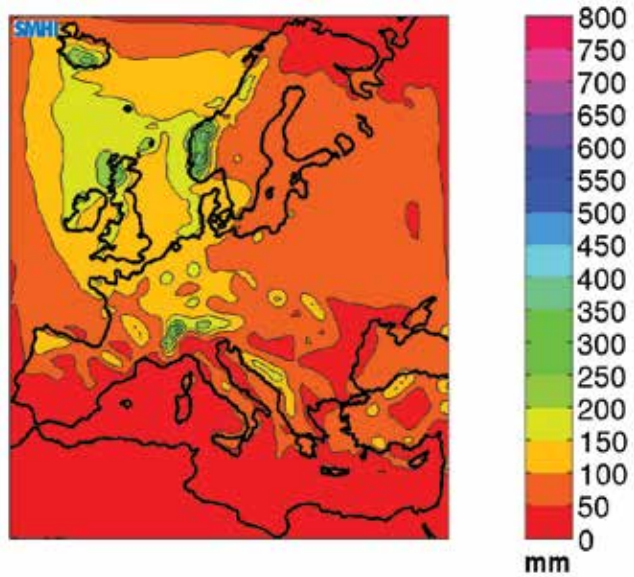


Figure 16: Precipitation summary 2011_2040_jan
(SMHI 2013-04-15 http://www.smhi.se/kli-matdata/klimatscenarier/kli-matanalyser)

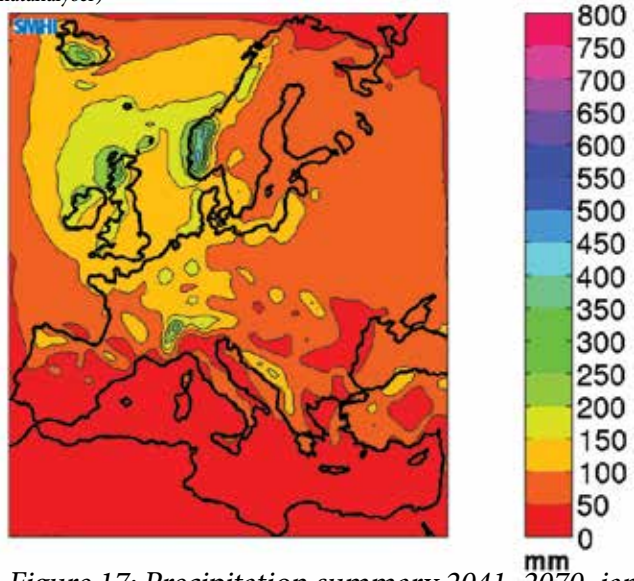


Figure 17: Precipitation summary 2041_2070_jan
(SMHI 2013-04-15 http://www.smhi.se/kli-matdata/klimatscenarier/kli-matanalyser)

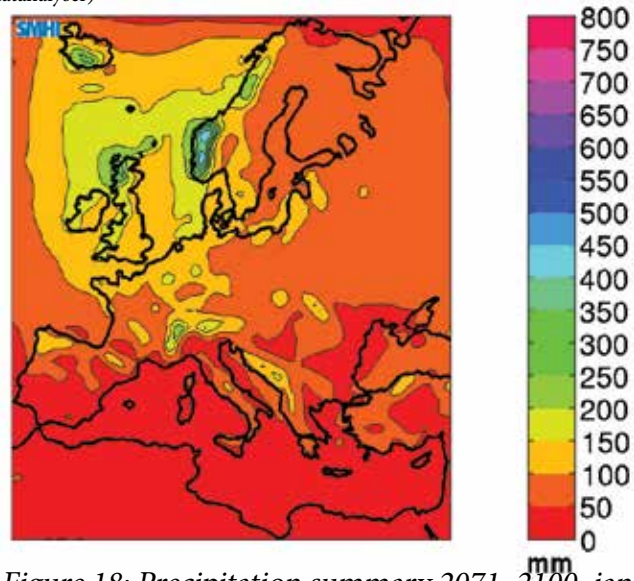


Figure 18: Precipitation summary 2071_2100_jan
(SMHI 2013-04-15 http://www.smhi.se/kli-matdata/klimatscenarier/kli-matanalyser)

Drainage network

Identifying precipitation flow direction, runoff streams and drainage network of the area are important not only for controlling runoff but also for preventing distribution of pollutant by water from the polluted areas to another.

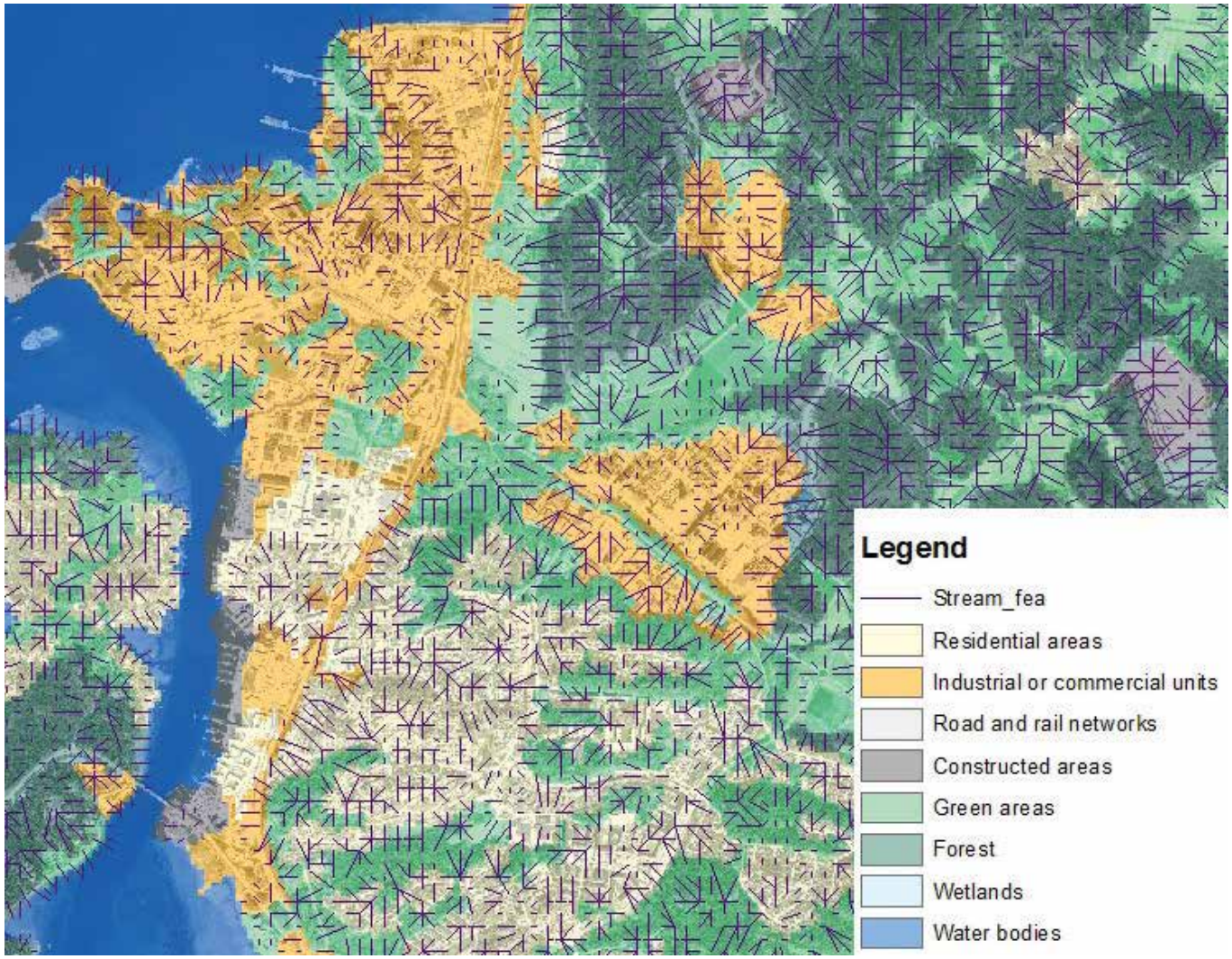


Figure 19: Existing Water Flow Lines in the Stenungsund (Amin Behnamfar 2013)

Stenungsund coastal flood zones

Future water level (m)							RH2000 (masl)
Location	100 year flood	Wave effect	Calculated water level	Mean water level	Sea level rise	Uplift	Future water level
Stenungsund	1,70	0,075	1,875	0,00	1,00	0,31	2,6

Table 3: Hundred Years Sea Level Flooding (Faktablad – planeringsnivåer Version 1.0 - Stigande vatten – en handbok för fysisk planering i översvämningshotande områden Faktablad för kusten, Vänern och vattendrag. (2012)

Table above shows that 100 years sea level flooding would rise to 1.7 meter in the future. Moreover, The rate of sea-level rise has accelerated and it would rise about 0.9 m (3 ft) above modern high tide in a 100 year. («Faktablad – planeringsnivåer Version 1.0 - Stigande vatten – en handbok för fysisk planering i översvämningshotande områden Faktablad för kusten, Vänern och vattendrag,» 2012)

Security Level 1			RH2000 (masl)
Location	Future water level	Extra margin of safety	Security Level 1
Stenungsund	2,6 (m)	0,5 (m)	3,1 (m)

Table 4: Interval Between coastal Flood Zone 4 and Zone 3
(Faktablad – planeringsnivåer Version 1.0 - Stigande vatten – en handbok för fysisk planering i översvämningshotande områden Faktablad för kusten, Vänern och vattendrag. (2012)

Table above shows the interval between zone 4 (moderate high coastal flood zone) and zone 3 (high coastal flood zone). («Faktablad – planeringsnivåer Version 1.0 - Stigande vatten – en handbok för fysisk planering i översvämningshotande områden Faktablad för kusten, Vänern och vattendrag,» 2012)

Security Level 2			RH2000 (masl)
Location	Future water level	Extra margin of safety	Security Level 2
Stenungsund	2,6 (m)	1,0 (m)	3,6 (m)

Table 5: Interval Between coastal Flood Zone 3 and Zone 2

(Faktablad – planeringsnivåer Version 1.0 - Stigande vatten – en handbok för fysisk planering i översvämningshotande områden Faktablad för kusten, Vänern och vattendrag. (2012)

Table above shows the interval between zone 3 (high coastal flood zone) and zone 2 (moderate low coastal flood zone). («Faktablad – planeringsnivåer Version 1.0 - Stigande vatten – en handbok för fysisk planering i översvämningshotande områden Faktablad för kusten, Vänern och vattendrag,» 2012)

As a result of analyzing data above different zoning heights in the area are as below:

Zone (RH2000 masl) Location	Zon 4 = below Future water level	Zon 3 = interval between the Security Level 1	Zon 2 = interval between the Security Level 2	Zon 1 = over the Security Level 2
Stenungsund	2,6 (m)	3,1 (m)	3,6 (m)	3,6 (m)

Table 6: coastal Flood Zones Hights

(Faktablad – planeringsnivåer Version 1.0 - Stigande vatten – en handbok för fysisk planering i översvämningshotande områden Faktablad för kusten, Vänern och vattendrag. (2012)

My proposal

Efforts of this chapter are to achieve criteria of this project. Proposed plan in this chapter is built upon analysis and investigations based on data and information in pervious sections.

More clarification can be attained through the analyzing of presented maps.

Coastal Flooding zones

According to coastal flood zone tables and Stenungsund elevation data, coastal flooding areas and vulnerable land uses in this areas which made by Arcmap software are shown in figure 33.

This figure shows areas which are vulnerable to coastal flooding in 100 year sea level rises. Zone 4 which is marked as read are areas which are in very high risk coastal flooding zone. High coastal flood risk zones are marked as orange and named as coastal flooding zone 3. The medium coastal flood risk zone on the map is zone 2 which has been remarked in yellow. The rest of the zones are the ones which are threatened less by coastal flood risk.

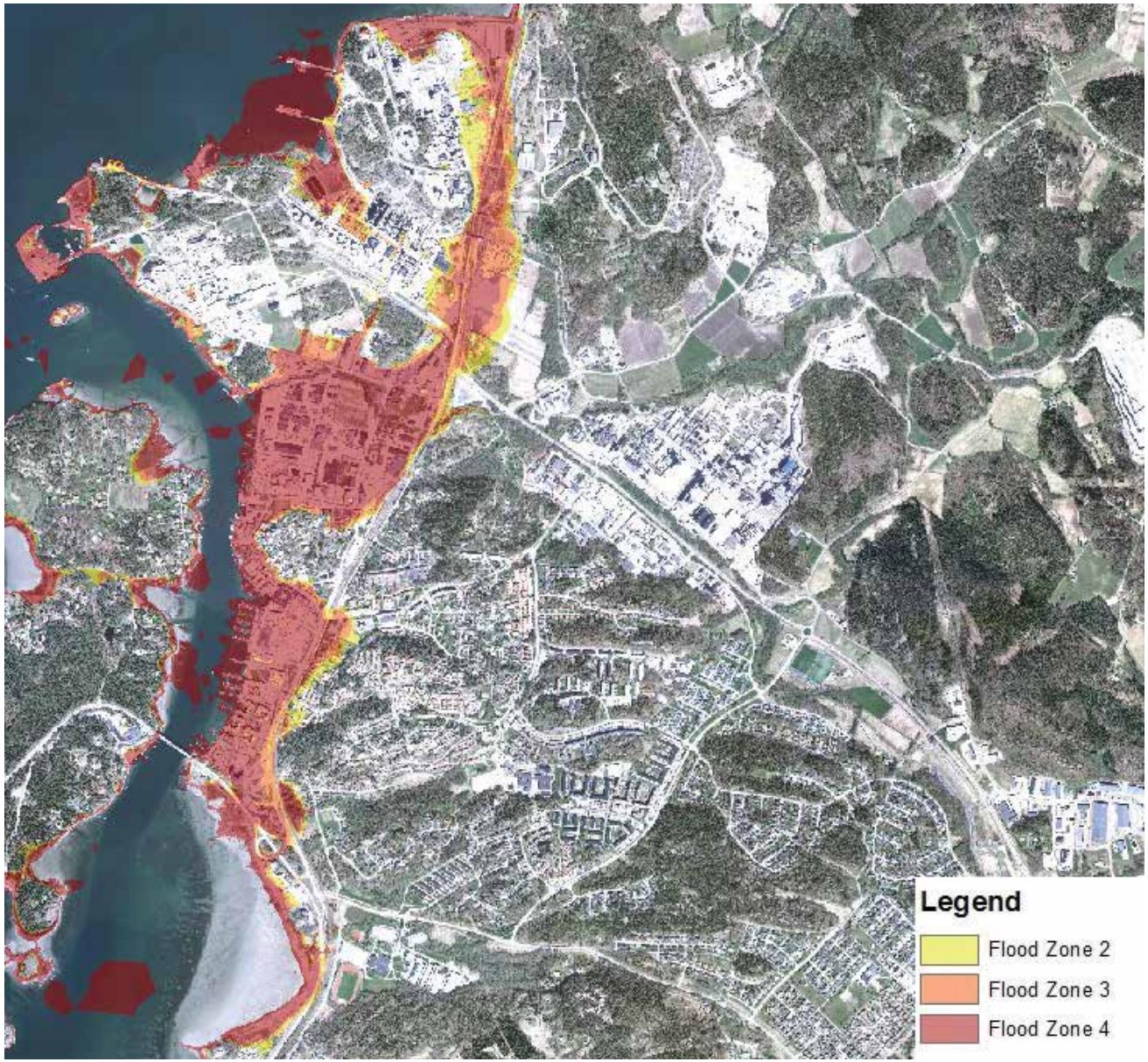


Figure 20: Coastal Flood Zone Map (Amin Behnamfar 2013)

Land uses in different coastal flooding zones

Table 6 in previous chapter presents land use category for each coastal flooding zone. But first it is important to reveal that which land uses are in different floodplain.

Summary of land use distributions in different coastal flooding zones, which are showed in previous figures, are:

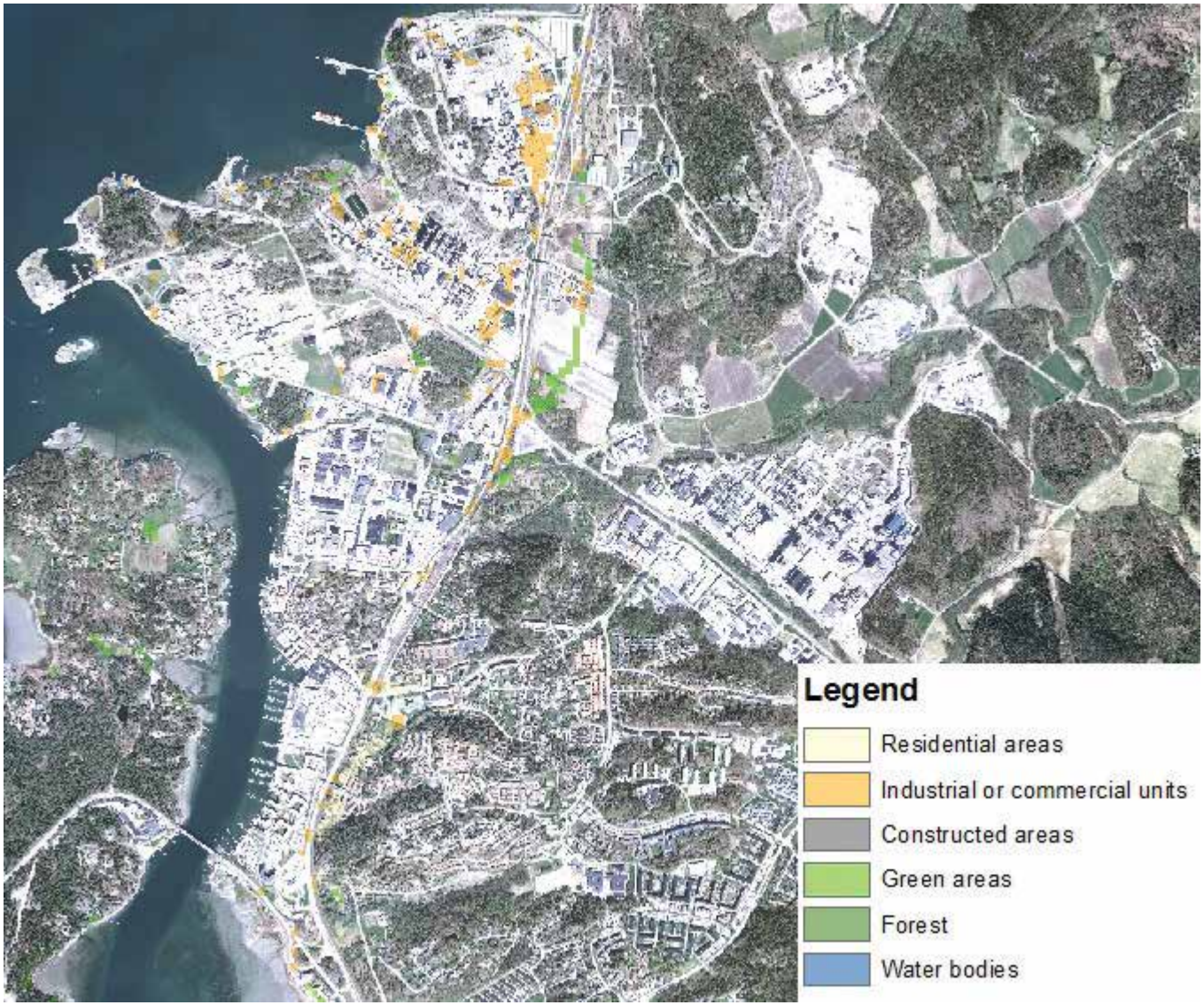


Figure 21: Existing Land Uses in Coastal Flood Zone 2 (Amin Behnamfar 2013)

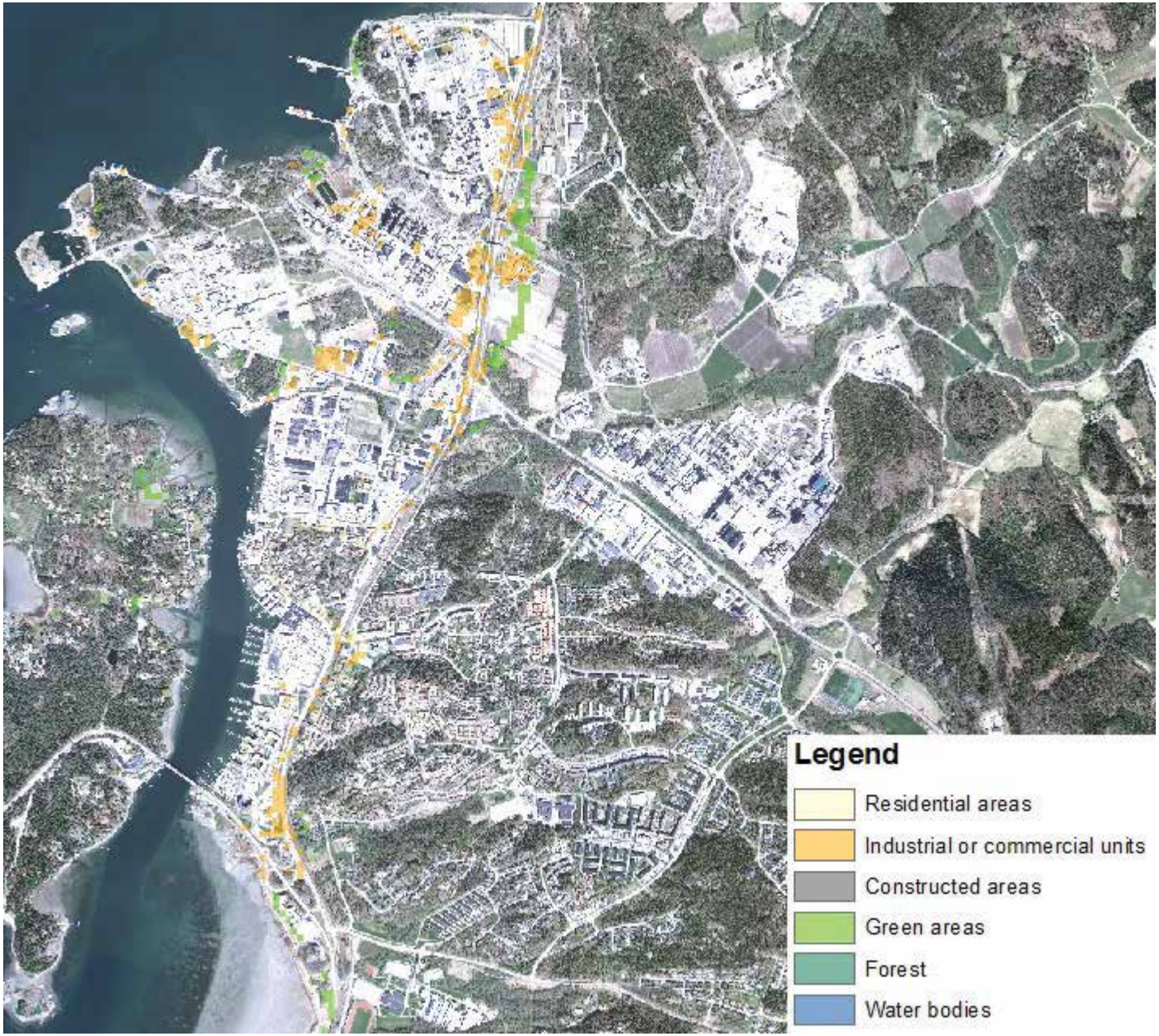


Figure 22: Existing Land Uses in Coastal Flood Zone 3 (Amin Behnamfar 2013)

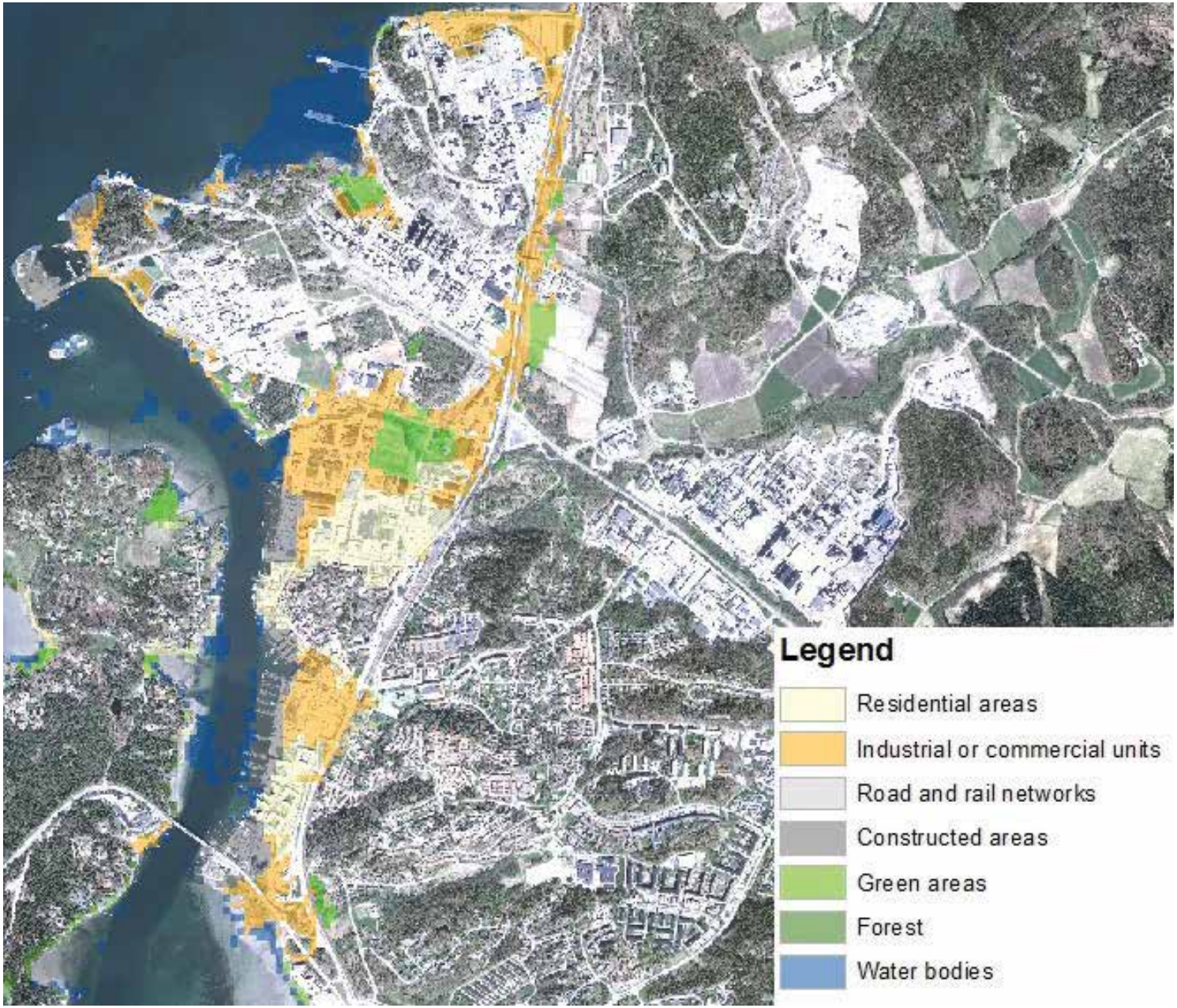


Figure 23: Existing Land Uses in Coastal Flood Zone 4 (Amin Behnamfar 2013)

category	Zone 4 (m^2)	Zone 3 (m^2)	Zone 2 (m^2)	Zone 1 (m^2)
Residential areas	560	91	95	13405
Industrial or commercial units	951	294	208	4011
Road and rail networks and associated land	1	0	0	2916
Constructed areas	270	7	2	1544
Green areas	2267	675	656	84848
Forest	1031	231	248	274739

Table 7: Vulnerable Land Use Areas (Amin Behnamfar 2013)

According to table above 4% of the residential area and 17.4% of the industrial or commercial units are located in zone 4. Buildings located in this zone are mostly in the center of the Stenungsund. Buildings such as Stenungsund health center, Stenungsund center (regional shopping center) with about 80 stores, banks, restaurants and etcetera, and gas stations are prone to flood.

Distribution of land uses in Zone 3, which has high flooding risk, are as table 7. According to mentioned table, about 0,5% of residential units and more than 5% of industrial or commercial units of whole Stenungsund area locates in this zone. And as well, about 0,5% of residential units and 5% of industrial or commercial units are in flooding zone 2. In total, more than 27% of industrial or commercial units and 5% of residential units are prone to flood.

Coastal Flooding Zone 2

This zone has medium coastal flood risk. According to table 2, land uses like parking lots, indoor recreation and leisure, industry and business areas require strategies for mitigating flood affects. Main roads and railways, residential areas infrastructures and community services in this zone not only require mitigation plan but also needs flood defense strategy.

Coastal Flooding Zone 3

Residential institutions and community services like medical, healthcare centers, educational places and emergency services should not be located in this area and if they are some of them already exist in this zone they need to relocate to zone 2 or zone 1 (zone 1 has low flood risk). For other land uses like residential areas, industrial areas and main road and railways ,flood mitigation plans in combine with flood defense methods are proposed to be applied.

Coastal Flooding Zone 4

As previously discussed 4% of residential areas (about 560 square meters) and 17.4% of commercial areas (about 950 square meters) are located in coastal flood zone 4 which needs to relocate. In order to relocating these areas, it is really important to consider developments on flooding and flooding effects on the structures. Moreover, it is important to have land cover data of the area for preserving natural resources and trees. Collecting data and information from coastal flood zone map, pollution distribution maps, slope and stream maps and analysis of all these data are not sufficient; it needs some techniques for minimising flood damage as well.

Final Discussion - Prioritization of Measures In Time

Future coastal flooding might affect inhabitant lives. Because of current location of Stenungsund health center, which is located in very high flood risk zone, if 100 years flooding occurs, this community service might lost its functionality. Therefore, inhabitants might face difficulties of accessing to health center.

Because some parts of railway and main roads, especially road which connect Stenungsön Island to the Stenungsund, are in high coastal flood risk zone, in case of flooding traffic disorders might happens in this area which might brought up inhabitants commuting problems.

Current location of the shopping center in this area is another issue; Stenungsund shopping center is now locates in very high risk coastal flood zone. 100 years sea flooding would surround this area and the parking lot close to it. For this reason, functionality of this place might disturbed therefore people might face with problem of accessing to this area for providing their needs.

Businesses might also get affect by sea flood. More than 27% of industry and commercial areas are in medium, high and very high flood risk zones. If 100 years sea flooding occurs in this area, industrial and commercial productivity might decline and their activities might cease. Therefore, downturn might occur and business owners might facing capital loses.

If industrial and commercial areas got affect by flood, employees of those industrial or commercial units which are locate in medium, high and very high coastal flood zones might also get affect. Declining productivity, cease activities, downturns and capital loses in industrial and commercial units are reason which might raise unemployment rate dramatically.

As discussed before, coastal flooding and surface runoffs can distribute pollution from pollution sources to other areas. Pollutions can harm water, nature and ecology of the Stenungsund. Therefore, aquatic organism life might get affected and because of that fishing industry of the area might get affect.

Last but not least, people might migrate from the city to adjacent urban areas. Therefore taking action for managing flood is necessary.

Based on what have been discussed on previous pages, time management with the purpose of controlling sea flood in this area is so important. Although, coastal flood planning controls in zone 3 and 2 in comparison with zone 4 are less costly, but it doesn't have to forgotten that coastal flood zone 4 covered most part of Stenungsund centrum and its infrastructures. Because calculations sea level rises of this area are for a period of 100 years, one way could be dividing this time to four periods of 25 years. Locating an ideal location for displacing vulnerable areas and infrastructures based on table 2 would have done in first period, as the further constructions and expansions in vulnerable areas would have control. Next period would be constructing infrastructures and expansion of the city toward ideal locations. Third step would be relocating community services, industries and businesses and residential areas from coastal flood zone 4 also mitigating land uses which are allowed in table 2. And last step would be relocating or mitigating vulnerable land uses on coastal flood zone 3 and 2.

References

Agency, E. E. E., Füssel, H.-M., & Jol, A. (2012). Climate change, impacts and vulnerability in Europe 2012. [An indicator-based report]. doi: 10.2800/66071

Agency, U. S. E. P. (1992). NPDES Stormwater Sampling Guidance Document Vol. EPA 833-B-92-001. Retrieved from http://www.epa.gov/npdes/pubs/owm0093.pdf

California Stormwater Quality Association Stormwater Best Management Practice New Development and Redevelopment Hand book. (2003). Retrieved from http://www.cabmphandbooks.com/Development.asp

ChlorVinyls, I. Retrieved Monday 15 April 2013, from http://www.ineoschlor.com/aboutus/stenungsund.shtml

Designing for Flood Risk. Retrieved from http://www.architecture.com/FindOutAbout/Sustainabilityandclimatechange/Flooding/DesignGuide.aspx

. Faktablad – planeringsnivåer Version 1.0 - Stigande vatten – en handbok för fysisk planering i översvämningshotande områden Faktablad för kusten, Vänern och vattendrag. (2012).

Low Impact Development Hydrologic Analysis. (1999). Retrieved from www.epa.gov/owow/NPS/lid_hydr.pdf

Low Impact Development Stormwater Management Planning and Design Guide. (2010). Toronto and Region Conservation Authority & Credit Valley Conservation Authority.

Organization of American States. Dept. of Regional Development and Environment., & United States. Agency for International Development. Office of U.S. Foreign Disaster Assistance. (1991). Primer on natural hazard management in integrated regional development planning. Washington, D.C.: Dept. of Regional Development and Environment, Executive Secretariat for Economic and Social Affairs, Organization of American States.

Raghunath, H. M. (2006). Hydrology principles, analysis and design (pp. xii, 463 p. ill. 424 cm.). Retrieved from http://site.ebrary.com/lib/calbaptist/Doc?id=10323304

Shaun Leinster, E. M., Jim Binney and Duncan Thomson. (2010). A Business Case For Best Practice Urban Stormwater Management. 1,1.

Stenungsunds-kommun-2013-04-11. (2013-04-11). Facts about Stenungsund 2013-04-11 Retrieved 2013-04-11, from http://www.stenungsund.se/webbsidor/topmeny/english/factsaboutstenungsund.4.41f1947e1334a5a707b8000394.html

Stormwater Best Management Practice, New Development and Redevelopment. (2003). Retrieved from http://www.cabmphandbooks.com/documents/Development/DevelopmentHandbook.pdf

Stormwater Best Management Practices Manual. (2007). Retrieved from http://www.ncsu.edu/ehs/environ/DWQ_StormwaterBMPmanual_001[1].pdf

Sylves, R., Kershaw, P. J., & ebrary Inc. (2004). Reducing future flood losses the role of human actions -- summary of a workshop, March 2, 2004, Washington, DC (pp. iv, 17 p.). Retrieved from http://site.ebrary.com/lib/calbaptist/Doc?id=10075681

Talking About Disaster: Guide for Standard Messages. (2007). American Red Cross.

United States Department of Agriculture, N. R. C. S., Conservation Engineering Division. (1986). Urban Hydrology for Small Watersheds, Technical Release 55 Technical Release 55 Retrieved from http://www.cpesc.org/reference/tr55.pdf

Urban flooding POSTnote 07/289. (2007). Retrieved from http://www.parliament.uk/documents/post/postpn289.pdf website:

Urban Hydrology for Small Watersheds TR-55. (June 1986). Retrieved from http://www.cpesc.org/reference/tr55.pdf

Warner, J. (2011). Flood Planning : The Politics of Water Security. London: London : I.B.Tauris & Co. Ltd.

Watson, D., & Adams, M. (2011). Design for flooding : architecture, landscape, and urban design for resilience to flooding and climate change. Hoboken, N.J.: John Wiley & Sons.

Virginia Stormwater Management Handbook VOLUME I. (1999). Retrieved from http://www.dcr.virginia.gov/stormwater_management/stormwat.shtml#vswmhnbk

Virginia Stormwater Management Handbook VOLUME II. (1999). Retrieved from http://www.dcr.virginia.gov/stormwater_management/stormwat.shtml#vswmhnbk

Pictures:

Figure 1

Encyclopædia Britannica, Inc., http://www.britannica.com/EBchecked/topic/278858/hydrologic-cycle 2013-03-17

Figure 4

http://web.viu.ca/geoscape/landslide!.htm 2013-04-06

Figure 7, 8
Stenungsunds-kommun-2013-04-11. (2013-04-11). Facts about Stenungsund 2013-04-11 Retrieved 2013-04-11, from http://stenungsund.se/webbsidor/huvudmeny/kommunpolitik.4.33232ad813188aec56b8000413.html

Figure 12, 13
SGU, Sveriges geologiska undersökning, Geological Survey of Sweden 2013-04-15 http://www.sgu.se/sgu/sv/produkter-tjanster/kartvisare/index.html

Figure 15, 16, 17, 18
SMHI 2013-04-15 http://www.smhi.se/klimatdata/klimatscenarier/klimatanalyser

Table

Table 2
Designing for Flood Risk. Retrieved from http://www.architecture.com/FindOutAbout/Sustainabilityandclimatechange/Flooding/DesignGuide.aspx

Table 3, 4, 5, 6
Faktablad – planeringsnivåer Version 1.0 - Stigande vatten – en handbok för fysisk planering i översvämningshotande områden Faktablad för kusten, Vänern och vattendrag. (2012).

Maps, tables, charts and figures which are not listed above are created and captured by Amin Behnamfar

Appendix A
Stenungsund Facts and Zoning Codes

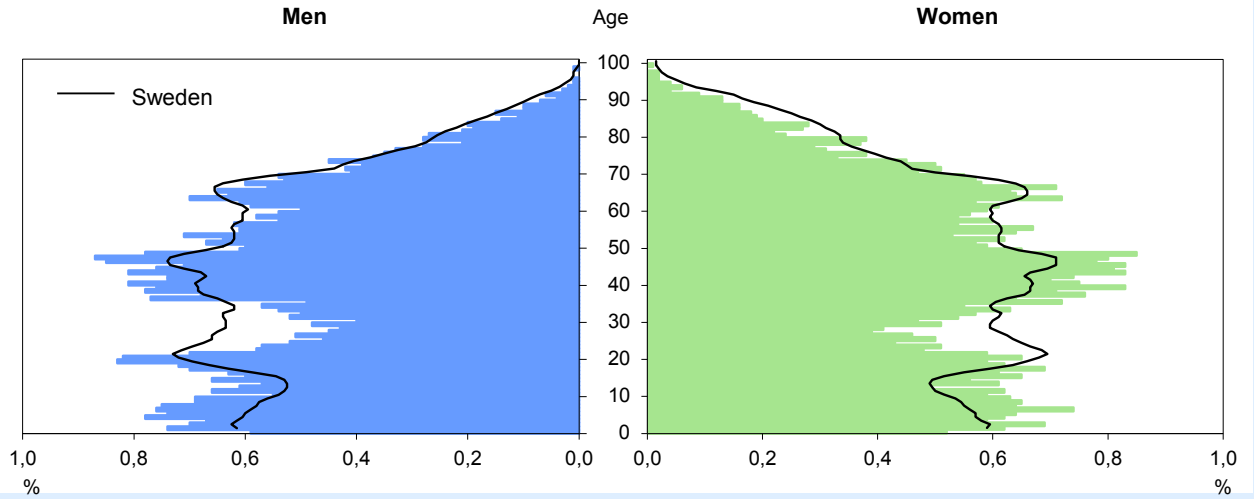
Stenungsund

2012

Municipal facts

Land area: 252 sq km **Inhabitants/sq km: 98**

Population by age, 2011



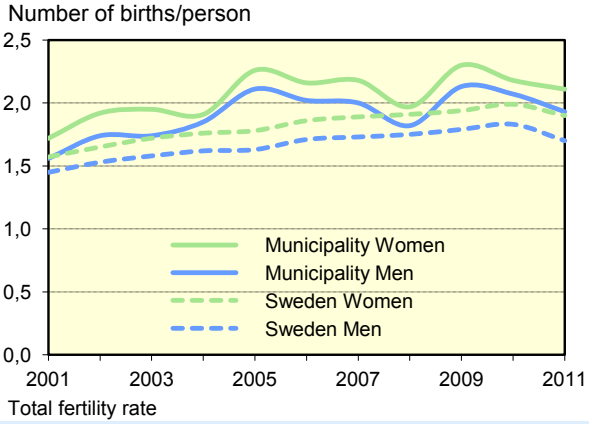
Population by age, 2011

Age	Percentage distribution Municipality			Sweden		
	M	W	Tot	M	W	Tot
0–6	10	9	9	9	8	8
7–15	12	11	11	10	9	10
16–19	6	5	5	5	5	5
20–24	6	5	6	7	7	7
25–44	24	25	25	26	25	26
45–64	26	26	26	26	25	26
65–79	13	14	13	13	14	14
80–	3	5	4	4	7	5
Total, %	100	100	100	100	100	100
Total (thou)	12	12	25	4 727	4 756	9 483

Population trends, 2001–2011

Year (31 Dec.)	Population Number	Excess of births over deaths	Net migration	
			M	W
2001	21 175	66	218	214
2002	21 755	74	219	290
2003	22 291	101	226	207
2004	22 742	125	104	218
2005	22 947	120	63	20
2006	23 190	116	70	52
2007	23 389	148	9	41
2008	23 657	115	64	89
2009	23 983	156	12	158
2010	24 292	108	116	86
2011	24 601	54	168	85

Live births per woman/man



Migrations, 2011

	Men	Women
In-migration	737	739
within the county	545	548
from another county	102	107
from another country	90	84
Of which, ages 18–24	133	158
Out-migration	569	654
within the county	426	491
to another county	98	119
to another country	45	44
Of which, ages 18–24	162	243
Net migration	168	85

Births and deaths, 2011

Number	Men	Women
Births	144	131
Deaths	121	100

Foreign born, 2011

Prop. (%) of all inhabitants	M	W	Tot
Municipality	8	9	9
Sweden	15	15	15

SCB 2012

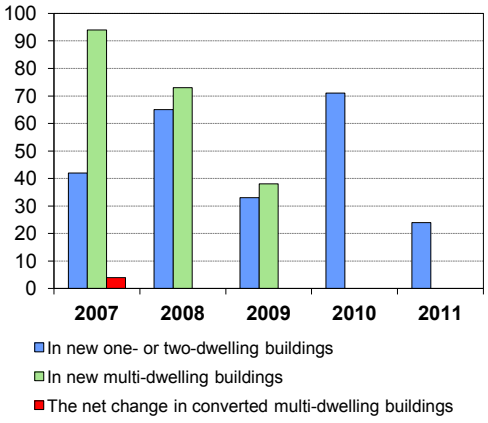
Stenungsund

Seats in the Municipal Council

Political party	Number of seats after the election			
	2006		2010	
	Men	Women	Men	Women
Moderate Party	7	3	6	6
Centre Party	2	2	1	2
Liberal Party	3	2	3	2
Christian Democratic Party	1	2	0	2
Green Party	1	1	2	1
Social Democratic Party	7	7	7	6
Left Party	1	1	1	1
Sweden Democrats	0	0	1	0
Other parties	0	1	0	0
Samtliga partier	22	19	21	20

Completed/converted dwellings

Number of dwellings



Population by level of education, 31 December 2011

Level of education	Percentage distribution								
	Municipality			County			Sweden		
	M	W	Tot	M	W	Tot	M	W	Tot
Compulsory schooling	14	10	12	16	12	14	15	12	14
Upper secondary	55	49	52	49	45	47	49	45	47
Post-secondary education	29	40	35	33	42	37	33	42	37
Unknown	1	1	1	2	1	2	2	2	2
Total, %	100	100	100	100	100	100	100	100	100
Total (1 000)	7	7	14	475	460	935	2 802	2 719	5 522

Refers to age group 20–64

Employed by age group, 2010

	Prop. (%) of all within ages		
	Men	Women	Total
Municipality			
20–24	70	66	68
25–44	89	85	87
45–64	85	79	82
20–64	85	80	83
County			
20–24	58	57	58
25–44	81	78	79
45–64	79	76	77
20–64	77	75	76
Sweden			
20–24	57	56	56
25–44	81	78	79
45–64	79	76	78
20–64	77	75	76

Refers to the night population

Night population:
residing in the municipality, regardless of workplace

Day population (jobs):
working in the municipality, regardless of residence

Employment by sector, 2010

	Night population		Day population	
	Men	Women	Men	Women
Municipality	6 212	5 791	6 776	5 080
Business sector	5 669	3 279	6 342	2 990
Public sector	543	2 512	434	2 090
County (1 000)	387	358	392	362
Business sector	335	192	340	194
Public sector	52	166	52	168
Sweden (1 000)	2 286	2 117	2 279	2 114
Business sector	1 962	1 182	1 956	1 179
Public sector	323	935	322	935

Number of persons ages 16 and over

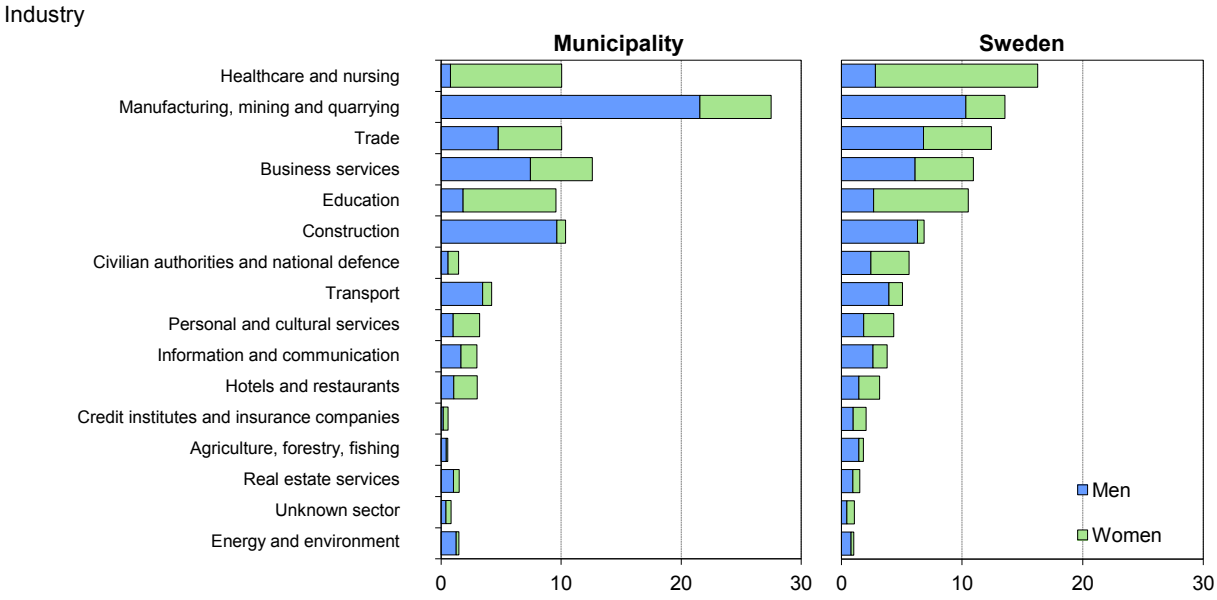
Commuting, 2010

	Men	Women
Commuting in	3 699	2 076
within the county	3 516	2 021
from another county	183	55
Commuting out	3 135	2 787
within the county	2 930	2 680
to another county	205	107
Net commuting	564	-711

Number of persons ages 16 and over

SCB 2012

Employment by industry, 2010



Refers to ages 16 and over

Employed in the municipality, regardless of residence (day population)

Self-employed, 2010

Number of employed	Men		Women	
	Self-empl. in lim.comp.	Self-employed	Self-empl. in lim.comp.	Self-employed
1	106	307	16	203
2–4	121	55	35	25
5–9	68	13	24	3
10–	77	0	14	0
Total	372	375	89	231

Number of persons ages 16 and over Refers to the day population

Sickness/activity compensation, 2011

	Prop. (%) of all within ages		
	Men	Women	Total
Municipality			
55–59	8	13	10
60–64	11	25	18
20–64	4	8	6
Sweden			
55–59	12	18	15
60–64	18	27	22
20–64	6	9	7

Replace benefits for disability pension and sickness

Job seekers

	Proportion (%) of all within age group								
	Municipality			**County**			**Sweden**		
	M	W	Tot	M	W	Tot	M	W	Tot
March, 2011									
Ages 20–64	4	3	4	7	6	6	7	6	7
Unemployed	2	2	2	3	3	3	4	3	4
Labour market progr.	1	1	1	3	3	3	3	3	3
Of which, ages 20–24	7	5	6	11	9	10	12	9	11
Number, ages 20–64	261	226	487	31 481	27 401	58 882	191 868	169 917	361 785
March, 2012									
Ages 20–64	4	3	4	7	6	7	7	6	7
Unemployed	3	2	2	4	3	4	4	3	4
Labour market progr.	1	1	1	3	3	3	3	3	3
Of which, ages 20–24	9	7	8	12	9	10	13	10	11
Number, ages 20–64	275	241	516	33 626	27 489	61 115	197 576	172 173	369 749

SCB 2012

Employment and employed, 2010 – Total

Industry	Day population				Night population			
	Municipality		County	Sweden	Municipality		County	Sweden
	Number	%	%	%	Number	%	%	%
Agriculture, forestry, fishing	66	1	1	2	73	1	1	2
Manufacturing, mining and quarrying	3 259	27	16	14	2 393	20	16	14
Energy and environment	175	1	1	1	165	1	1	1
Construction	1 229	10	7	7	1 109	9	7	7
Trade	1 191	10	13	12	1 543	13	13	12
Transport	500	4	5	5	716	6	6	5
Hotels and restaurants	358	3	3	3	322	3	3	3
Information and communication	355	3	3	4	361	3	3	4
Credit institutes and insurance companies	69	1	1	2	114	1	1	2
Real estate services	179	2	2	2	169	1	2	2
Business services	1 494	13	10	11	1 320	11	10	11
Civilian authorities and national defence	174	1	5	6	465	4	5	6
Education	1 136	10	10	11	1 080	9	10	10
Healthcare and nursing	1 191	10	17	16	1 673	14	16	16
Personal and cultural services	382	3	4	4	396	3	4	4
Unknown sector	98	1	1	1	104	1	1	1
Total	11 856	100	100	100	12 003	100	100	100

Refers to ages 16 and over

Employment and employed, 2010 – Men

Industry	Day population				Night population			
	Municipality		County	Sweden	Municipality		County	Sweden
	Number	%	%	%	Number	%	%	%
Agriculture, forestry, fishing	51	1	2	3	53	1	2	3
Manufacturing, mining and quarrying	2 557	38	24	20	1 764	28	23	20
Energy and environment	149	2	1	2	133	2	1	2
Construction	1 145	17	12	12	1 012	16	12	12
Trade	566	8	14	13	822	13	14	13
Transport	410	6	8	8	485	8	8	8
Hotels and restaurants	127	2	3	3	134	2	3	3
Information and communication	196	3	4	5	225	4	4	5
Credit institutes and insurance companies	21	0	1	2	41	1	1	2
Real estate services	122	2	2	2	98	2	2	2
Business services	884	13	12	12	711	11	12	12
Civilian authorities and national defence	69	1	4	5	177	3	4	5
Education	218	3	5	5	216	3	5	5
Healthcare and nursing	94	1	5	5	151	2	5	5
Personal and cultural services	120	2	3	4	143	2	3	4
Unknown sector	47	1	1	1	47	1	1	1
Total	6 776	100	100	100	6 212	100	100	100

Refers to ages 16 and over

Employment and employed, 2010 – Women

Industry	Day population				Night population			
	Municipality		County	Sweden	Municipality		County	Sweden
	Number	%	%	%	Number	%	%	%
Agriculture, forestry, fishing	15	0	1	1	20	0	1	1
Manufacturing, mining and quarrying	702	14	9	7	629	11	8	7
Energy and environment	26	1	0	0	32	1	0	0
Construction	84	2	1	1	97	2	1	1
Trade	625	12	13	12	721	12	13	12
Transport	90	2	3	2	231	4	3	2
Hotels and restaurants	231	5	4	4	188	3	4	4
Information and communication	159	3	2	2	136	2	2	2
Credit institutes and insurance companies	48	1	2	2	73	1	2	2
Real estate services	57	1	1	1	71	1	1	1
Business services	610	12	9	10	609	11	9	10
Civilian authorities and national defence	105	2	6	7	288	5	6	7
Education	918	18	16	16	864	15	16	16
Healthcare and nursing	1 097	22	29	28	1 522	26	29	28
Personal and cultural services	262	5	5	5	253	4	5	5
Unknown sector	51	1	1	1	57	1	1	1
Total	5 080	100	100	100	5 791	100	100	100

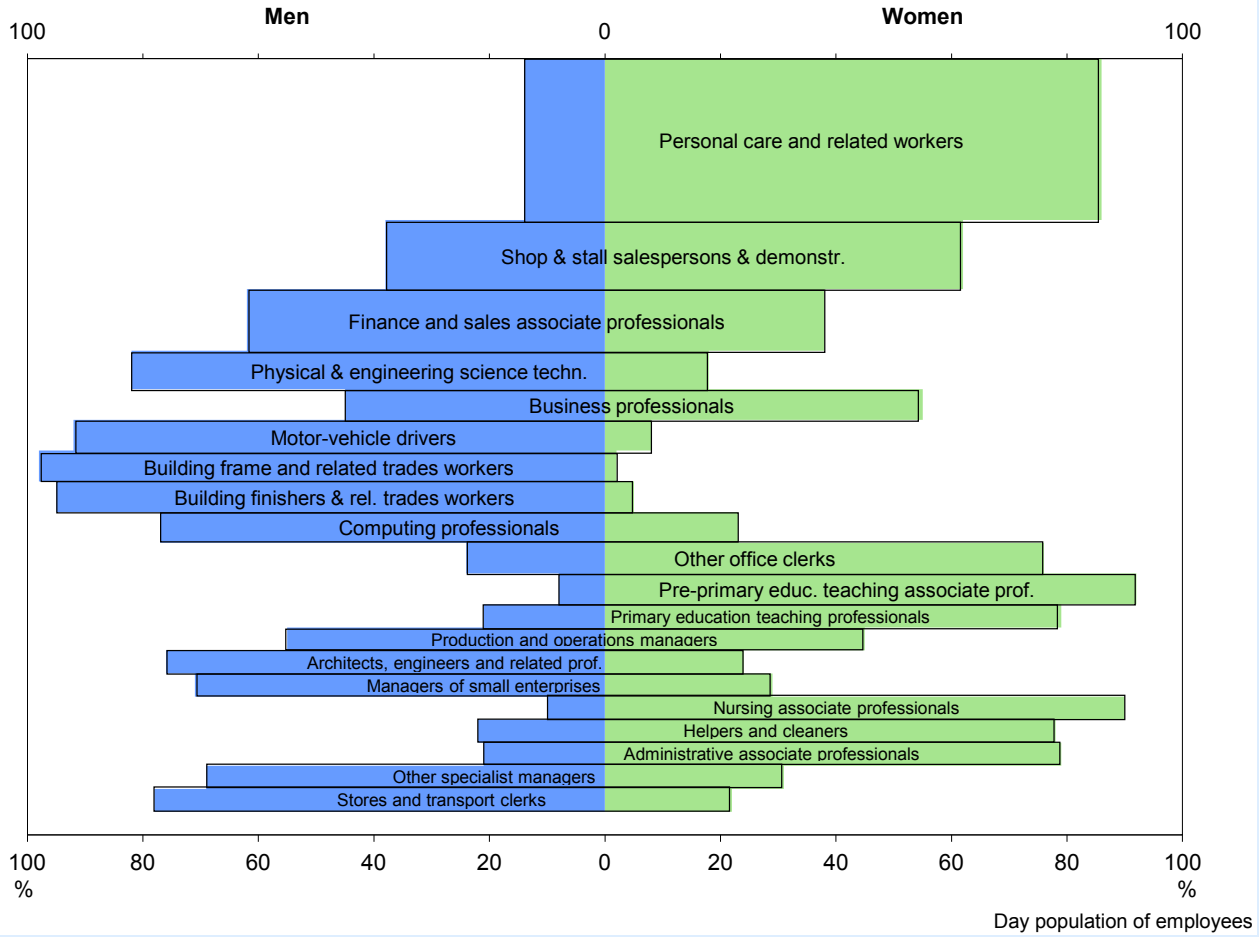
Refers to ages 16 and over

Stenungsund

The 20 most common occupations in the municipality, 2010

Day population of employees	Number		Perc.distr.			Sex distr. (%)	
	Men	Women	M	W	Tot	M	W
Personal care and related workers	61	981	1	21	10	6	94
Chemical-processing-plant operators	694	99	11	2	7	88	12
Physical & engineering science techn.	510	133	8	3	6	79	21
Shop & stall salespersons & demonstr.	168	377	3	8	5	31	69
Building finishers & rel. trades workers	456	31	7	1	4	94	6
Architects, engineers and related prof.	292	121	5	3	4	71	29
Building frame and related trades workers	342	6	6	0	3	98	2
Motor-vehicle drivers	310	24	5	1	3	93	7
Finance and sales associate professionals	178	148	3	3	3	55	45
Primary education teaching professionals	55	216	1	5	2	20	80
Pre-primary educ. teaching associate prof.	15	220	0	5	2	6	94
Production and operations managers	149	80	2	2	2	65	35
Other specialist managers	163	64	3	1	2	72	28
Machinery mechanics and fitters	202	7	3	0	2	97	3
Metal mould., welders, sheet-metal work., & rel. wor	187	2	3	0	2	99	1
Helpers and cleaners	25	162	0	3	2	13	87
Electrical & electron. equipm. mechan. & fitters	178	6	3	0	2	97	3
Managers of small enterprises	127	54	2	1	2	70	30
Other office clerks	42	137	1	3	2	23	77
Agricultural & other mobile-plant operators	166	9	3	0	2	95	5
Total 20 occupations	4 320	2 877	69	61	66	60	40
All occupations	6 217	4 733	100	100	100	57	43

The 20 most common occupations in the country, 2010



SCB 2012

Stenungsund

Preschool activities and care of school-age children 2011

Enrollment	Municipality Number	Municipality %	Sweden %
Pre-school, 1–5	1 348	82	83
Leisure time centre, 6–12	1 376	62	56
Pedagogical child care, 1–5	84	5	3
6–12	6	0	0

Proportion (%) of all within age group

Elder care - Refers to ages 80 and over

	Prop. (%) of all within group Municipality M	Municipality W	Sweden M	Sweden W
Home-help services 1)	12	23	19	26
Special housing 1)	8	14	10	17
Transport service 2010	31	50	26	40

1) 1 October 2011.

Total income, 2010

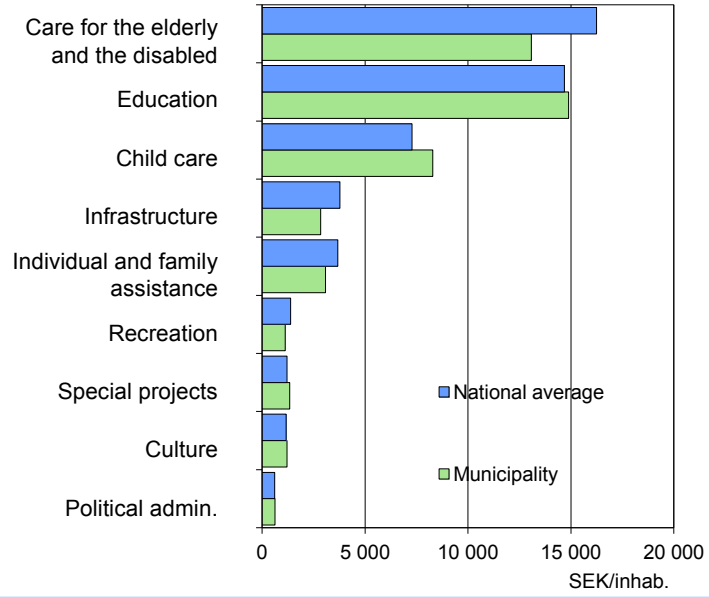
	SEK thousand Men	Women	Total
Average income			
Municipality	344	244	294
County	294	225	260
Sweden	299	229	265
Median income			
Municipality	331	244	281
County	291	230	257
Sweden	290	231	257

Income from employm. and business, age gr. 20–64

Social assistance, 2010

Type of household	Recipient households Municipality Number	Municipality %	Sweden %
Cohabiting			
without children	35	8	5
with children	41	9	12
Single men			
without children	172	38	40
with children	12	3	3
Single women			
without children	125	28	25
with children	69	15	16
Total	454	100	100

Expenditures SEK, per inhabitant, 2010



Local taxes, 2012

Municipality	
Total local tax rate	32,52
of wich to municipality	21,64
Tax base, SEK/inhab.	185 279
Tax base, index	105
County average	
Total local tax rate	32,05
of wich to municipality	21,17
Tax base, SEK/inhab.	172 692
Tax base, index	98
National average	
Total local tax rate	31,60
of wich to municipality	20,59
Tax base, SEK/inhab.	176 054
Tax base, index	100

Index, Sweden = 100

Statistiska centralbyrån
Statistics Sweden

Information and sales:
Elisabeth Blom tfn +46 19-17 63 88, fax +46 19-17 70 88
Harriet Löfqvist tfn +46 19-17 60 48, fax +46 19-17 70 88
E-mail: regionalt@scb.se
Web site: www.scb.se/kommunfakta

Address to the municipality:
Stenungsunds kommun

444 82 STENUNGSUND
0303-730000

Municipal facts 2012

Definitions, Commentary, Sources

DWELLINGS
Source: Housing Construction, Statistics Sweden www.scb.se/BO0101
Reconditioned dwellings are now reported under the heading converted dwellings. Conversion refers to more extensive measures where the disposition of dwellings is changed.

Municipal facts 2009 will only be presenting the net change in the number of dwellings in renovated multi-dwelling buildings, as opposed to previous years when the presentation referred to the total number of dwellings after renovation.

EDUCATION
Source: Education Register, Statistics Sweden www.scb.se/UF0506
The register contains information on completed education in the main educational system. The classification of levels follows the Swedish education nomenclature, SUN.

ELECTION RESULTS, GENERAL ELECTIONS
Source: Citizen influence, Statistics Sweden www.scb.se/ME0104
The table "Seats in the municipal council" presents the parties that are represented in parliament.

INCOME
Source: Total Income Statistics, Statistics Sweden www.scb.se/HE0110
This information is from the taxation records supplied to Statistics Sweden by the Tax Board.

Total earned income consists of income from employment and business activities. The Average income is the sum of incomes for the age group 20–64 years divided by the number of persons in this group at year-end. This includes individuals without income. The Median income is the income representing the middle value after sorting the income of all individuals by size.

JOB SEEKERS
Source: Swedish Public Employment Service. www.arbetsformedlingen.se
The statistics on persons seeking employment are produced from a register maintained by the Swedish Public Employment Service. The information is continuously collected from data storage of the Swedish Public Employment Service.

Programmes with activity support include the following measures: Starting up a business, Work experience, Trial opportunity, Practical competence development, Work guarantee for young people, Work and development guarantee, Occupational rehabilitation, Introduction to working life, Activities within counselling guidance and placement service, Projects with employment policy orientation, In-depth assessment and counselling guidance, Development guarantee phase 3, Labour market training and Preparatory training courses.

Quality and comparability
As of March 2008 unemployment statistics shall be reported as indicated below.
The statistics produced by Statistics Sweden differ from those of the Swedish Public Employment Service regarding regional and age distribution.

Region
The Swedish Public Employment Service uses information from the register of job seekers concerning the home municipality and local employment office at the given time. In contrast Statistics Sweden presents the job seekers in the municipality where they are registered according to the Total Population Register at the turn of the year for the statistics of 31 March, and 30 September for the statistics of 31 October. Persons who moved during January-March and In October are thus presented in the area where they were previously registered. Those who moved to Sweden from abroad during the same period are not included.
The statistics from the Swedish Public Employment Service on job seekers broken down by local employment office or home municipality thus includes persons who can be registered in both the municipality in question and another municipality. In the same way, job seekers in a particular municipality in Statistics Sweden's statistics can be registered at employment offices in other municipalities and have another municipality as their home in the register of the Swedish Public Employment Service.

Age
The Swedish Public Employment Service makes a breakdown of job seekers by their age at the end of the reporting month. In Statistics Sweden's tables, the age of job seekers at the end of the year applies.

Open unemployment refers to those registered in the Swedish Public Employment Service categories 11 Unemployed 96-98 Unemployed, (temporary).

LABOUR MARKET
Source: Register-based labour market statistics, Statistics Swede www.scb.se/AM0207
Employment is determined from the statements of earnings and taxation annually supplied by employers to the tax authorities as well as from information on company income from the taxation register.

Commuting. Commuters are persons who have their place of work in another municipality than where they live. Commuting between municipalities in the same county and commuting to/from another county are reported here.

Employment – day population includes persons working in the municipality and who live in or outside the municipality.

Gainfully employed. A person is classified as gainfully employed if they have received income from work over a period of on average at least one hour per week in the month of November.

Gainfully employed – night population includes all gainfully employed persons who live in the municipality irrespective of which municipality in which they work.

Industry. As of 2008, Labour Market Statistics use the Swedish Standard for Industrial Classification (SIC) 2007, which is coordinated by the EU industrial standard NACE vers. 2. The revision work has meant a number of changes.

Information about SIC 2007 is available on Statistics Sweden's website www.scb.se/sni2007

Sectors. The category Business sector includes Limited/Incorporated companies (not state-owned), Other companies (not state-owned), State-owned companies and organisations, Municipal-owned companies and organisations, Other organisations. The Public sector includes Central government administration, Public service companies, Primary government administrative bodies, County councils, and Other governmental institutions.

The **Self-employed** are reported broken down into those with their own incorporated company and other self-employed. The latter group includes businessmen with sole proprietorships, partnerships, limited partnerships, etc.

Occupation
Source: The Swedish Occupational Register, Statistics Sweden
Classification according to SSYK96.

MUNICIPAL BUDGET
Source: Public sector economy, Statistics Sweden www.scb.se/OE0101

Expenditures in SEK per inhabitant
Information is based on financial statement statistics that Statistics Sweden annually collects from the municipalities.
Administration expenditures for the municipality and related activities and office expenses are allocated to each activity. However, administration expenditures related to political leadership and governance of the municipality are reported under Political activities. Expenditures are calculated as gross expenditures minus internal revenues and sales of activities to other municipalities and county councils. Thus, the expenditure concept corresponds to the municipality's expenses for its own consumption. See also the book "Vad kostar verksamheten i Din kommun?"

Municipal taxes
The tax rate (tax levy) refers to the percentage of earned income subject to taxation that the tax-payer is obligated to pay as municipal income tax. Following the separation of the Swedish church from the Swedish state, the total municipal tax rate currently comprises only the tax rates for the municipality and the county council. The taxation base consists of taxable earned income going to municipal income tax. The tax base is reported in terms of SEK per inhabitant, also called tax-paying capacity, and in terms of the share of the national average.

POPULATION
Source: Population Statistics, Statistics Sweden www.scb.se/BE0101
The Population Register (TPR) is a copy of the tax authorities' register of individuals, which is renewed periodically with reports on changes in births, deaths, migration, marriages, divorces and changes in citizenship.

Foreign born. This includes persons born outside of Sweden regardless of whether the parents were born in Sweden or outside Sweden.

Population density per sq. km and land area. More detailed calculations of area have been carried out from 1 January 2012. For this reason, it is not advisable to compare data from before 2012 with data relating to after 2012. Furthermore, for the years following 2012, data for municipalities will not match the total for counties, because of enclaves, which have not been possible to divide into municipalities. Land area includes watercourses of a width of 6 metres or less, and meres and smaller pools of water up to maximum of several 10km² in size.

Total fertility rate refers to the average number of children per woman and man respectively if the fertility of the specific year for each age category is extrapolated into the future.

REGIONAL DIVISIONS

Heby was transferred to Uppsala county from Västmanland county on 1 January 2007.

SOCIAL WELFARE

Preschool activities and care of school-age children
Source: National Agency for Education www.skolverket.se
Child care is now referred to as preschool activities and care of school-age children and comprises preschool, pedagogical child care and leisure time centres. A preschool class is not a part of the preschool activities and care of school-age children but rather a separate form of schooling and is thus not reported here.

As of July 2009, the concept of a family daycare centre was replaced by pedagogical child care in the Education Act 1985:1100 and related legislation. Statistics about pedagogical child care exists

as of the autumn of 2009, statistics on family day care centres exists for years between 1994 and 2008. There are no comparable statistics for pedagogical child care because those statistics were first collected in October of 2009.

Pedagogical child care is a collective concept where family day care centres form one of many variant activities within pedagogical day care. Other variants can include such things as multiple family solutions.

The number of children in preschool and leisure time centres and the number of children in pedagogical child care is reported by age groups 1–5 years and 6–12 years.

Elder care
Includes persons 80 years of age and older.

Source: National Board of Health and Welfare *www.sos.se*
Home-help services refers to support, service and personal care in the residence. Special housing is the name for service and care which municipalities are required to provide.

Source: Transport analysis www.trafa.se
Transportation service permit refers to a municipal decision to receive transportation from the transportation service (taxi or special vehicle).

Sickness compensation/activity compensation
Source: Swedish Social Insurance Agency www.forsakringskassan.se
A new pension system became effective in 2003, replacing benefits for disability pension and sickness with sickness compensation/activity compensation.

If the ability to work is reduced by at least 25 percent, persons aged 19-29 are allowed activity compensation and persons aged 30-64 are allowed sickness compensation.

Social assistance
Source: National Board of Health and Welfare *www.sos.se*
Social assistance is reported here by type of household.

LÄNSSTYRELSEN
VÄSTRA GÖTALANDS LÄN

Faktablad - VATTENDRAG

Underlag till rapporten *Stigande vatten – en handbok för fysisk planering i översvämningshotade områden*. Gäller för Västra Götalands län.

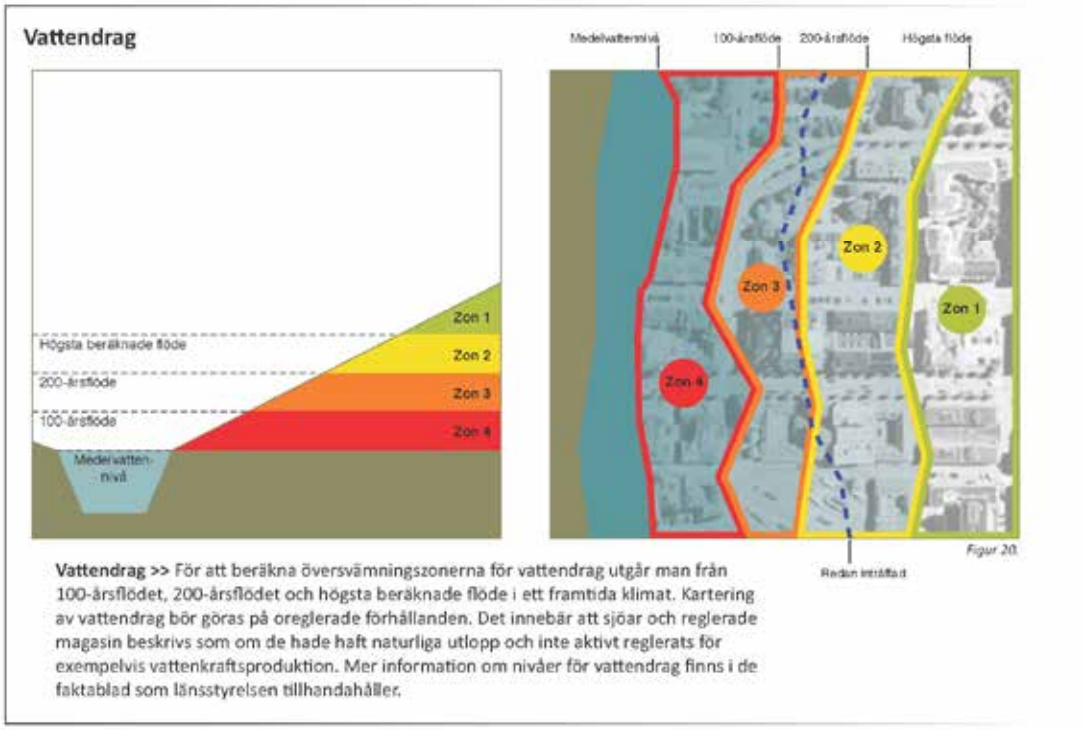
Handboken *Stigande vatten* utgår från en planeringsmodell där översvämningsrisken kartläggs i översvämningszoner. I handboken presenteras inga exakta siffror eller nivåer för zonerna. Kunskap och bedömningar kan komma att ändras i takt med att ny forskning tas fram. I detta faktablad presenteras underlag som är tillgängligt i nuläget för att ta fram planeringsnivåerna.

Översvämningszoner och planeringsnivåer

Översvämningszonerna för ett vattendrag är indelade i fyra zoner, se illustration nedan. Zonindelningen är kopplad till återkomsttider och olika riskgrad. I zon 4 (röd) är sannolikheten för att en översvämning inträffar högst och i zon 1 (grön) är den lägst.

Planeringsnivåerna för ett vattendrag utgår från ett 100-årsflöde, ett 200-årsflöde och ett högsta beräknade flöde i ett framtida klimat. En översvämningszon definieras av ett intervall mellan två nivåer med utgångspunkt i markens nivå. Det innebär att zon 4 (röd) utgörs av intervallet mellan *medelvattennivån* och *100-årsflödet*, zon 3 (orange) av intervallet mellan *100-årsflödet* och *200-årsflödet,* och zon 2 (gul) mellan *200-årsflödet* och ett *högsta beräknade flöde*. Zon 1 (grön) utgörs av all mark över nivån för ett *högsta beräknade flöde*. Dock kan andra typer av översvämningar som till exempel skyfall, inträffa i denna zon.

Vilka funktioner som är lämpliga att placera i de olika zonerna framgår av markanvändnings-diagrammet i handboken. För en funktion som enligt rekommendationerna anses lämplig att placera i zon 2 (gul) betyder det att funktionen (byggnaden) som lägst kan placeras på nivån för *200-årsflödet*. Funktionskrav är alltid kopplade till funktioner som placeras i zon 2 (gul), zon 3 (orange) och zon 4 (röd).



LÄNSSTYRELSEN
VÄSTRA GÖTALANDS LÄN

Information för att beräkna nivåer

Länsstyrelsen tillhandahåller inte de exakta nivåerna för specifika vattendrag. I *Klimatanalysen för Västra Götaland (SMHI Rapport Nr 2011-45)* har dock 10 vattendrag analyserats med avseende på framtida förändringar i 100-årstillrinning. Analysen omfattar vattendragen Ätran, Viskan, Mölndalsån, Säveån, Örekilsälven, Strömsån, Nossan, Upperudsälven, Tidan och Gullspångsälven.

Myndigheten för samhällsskydd och beredskap (MSB) har genomfört översiktlig översvämningskartering för flera vattendrag i Västra Götalands län. Detaljeringsgraden i dessa beräkningar kan ökas genom att resultat och vattennivåer från den hydrauliska modellen kombineras med en detaljerad höjdmodell, till exempel Lantmäteriets nya modell NNH. Det är möjligt att låna de hydrauliska modellerna kostnadsfritt från MSB för att göra egna analyser och scenarier av andra återkomsttider eller för att öka detaljeringsnivån.

Observera att kartering av vattendrag bör göras på oreglerade förhållanden. Det innebär att sjöar och reglerade magasin beskrivs som om de hade haft naturliga utlopp och inte aktivt reglerats för exempelvis vattenkraftproduktion.

LÄNSSTYRELSEN
VÄSTRA GÖTALANDS LÄN

Faktablad - KUSTEN

Underlag till rapporten *Stigande vatten – en handbok för fysisk planering i översvämningshotade områden*. Gäller för Västra Götalands län.

Handboken *Stigande vatten* utgår från en planeringsmodell där översvämningsrisken kartläggs i översvämningszoner. I handboken presenteras inga exakta siffror eller nivåer för zonerna. Kunskap och bedömningar kan komma att ändras i takt med att ny forskning tas fram, därför presenteras de aktuella planeringsnivåerna i detta faktablad och kan komma att uppdateras.

Översvämningszoner och planeringsnivåer

Översvämningszonerna för kusten är indelade i fyra zoner, se illustration på nästa sida. Zonindelningen är kopplad till riskgrad. I zon 4 (röd) är sannolikheten för att en översvämning inträffar högst och i zon 1 (grön) är den lägst.

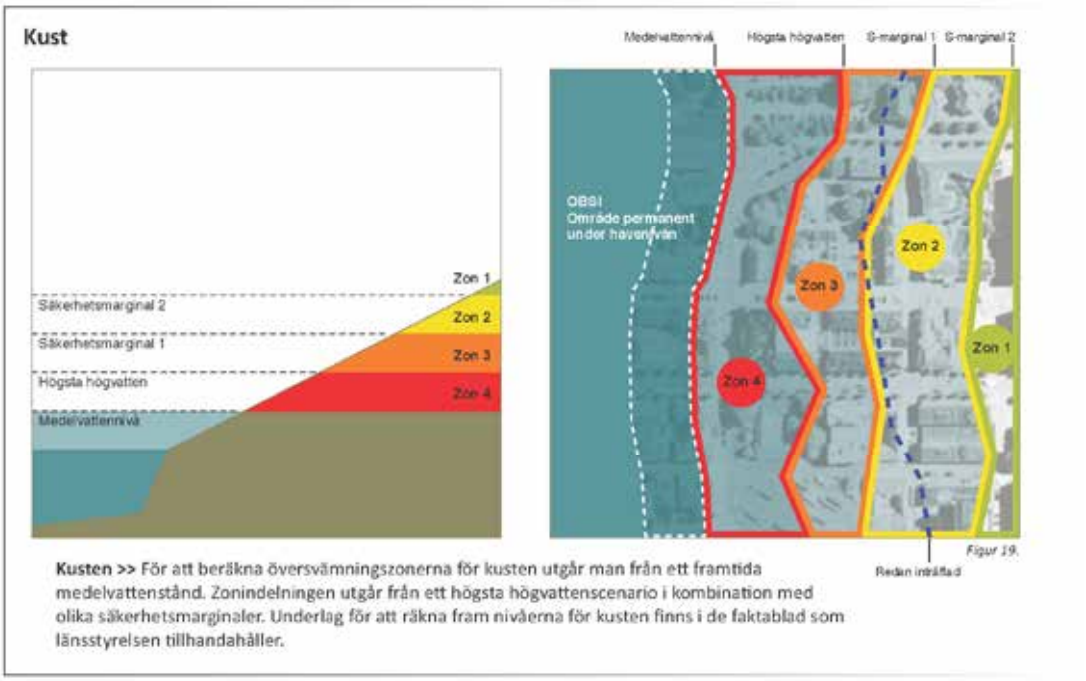
Planeringsnivåerna för kusten utgår från ett framtida högsta högvatten i kombination med säkerhetsmarginaler. Långa tidsserier med observationer från ett antal mätstationer längs kusten utgör underlag för beräkningar av de högsta havsnivåerna som kan uppstå i dagens klimat. Till dessa nivåer läggs den prognostiserade globala havsnivåhöjningen som underlag för beräkning av de framtida högsta högvattennivåerna. För att kunna hantera dels skillnader i markanvändningens och bebyggelsens betydelse och vikt för samhället, dels osäkerheter i klimatprognoserna, har olika säkerhetsmarginaler lagts på för att räkna fram nivåerna.

En översvämningszon definieras av ett intervall mellan två nivåer med utgångspunkt i markens nivå. Det innebär att zon 4 (röd) utgörs av intervallet mellan *medelvattennivån* och nivån för *högsta högvatten*, zon 3 (orange) av intervallet mellan *högsta högvatten* och *säkerhetsnivå 1,* och zon 2 (gul) mellan *säkerhetsnivå 1* och *säkerhetsnivå 2*. Zon 1 (grön) utgörs av all mark över nivån för *säkerhetsnivå 2*. Dock kan andra typer av översvämningar som till exempel skyfall, inträffa i denna zon.

Vilka funktioner som är lämpliga att placera i de olika zonerna framgår av markanvändnings-diagrammet i handboken. För en funktion som enligt rekommendationerna anses lämplig att placera i zon 2 (gul) betyder det att funktionen (byggnaden) som lägst kan placeras på d*säkerhetsnivå 1*. Funktionskrav är alltid kopplade till funktioner som placeras i zon 2 (gul), zon 3 (orange) och zon 4 (röd).

Aktuella planeringsnivåer finns presenterade på nästa sida, samt kompletterande uträkningar. Nivåerna är framräknade med utgångspunkt i följande underlag: *Klimatanalys för Västra Götaland (SMHI, rapport Nr 2011-45).*

KUSTEN - zoner:



Figur 19.

Kusten >> För att beräkna översvämningszonerna för kusten utgår man från ett framtida medelvattenstånd. Zonindelningen utgår från ett högsta högvattenscenario i kombination med olika säkerhetsmarginaler. Underlag för att räkna fram nivåerna för kusten finns i de faktablad som länsstyrelsen tillhandahåller.

KUSTEN - zoner och planeringsnivåer:

Zon 1	***Zon 1 = över:***
(RH2000 möh)	***Säkerhets-***
Ort	***nivå 2***
Kungsvik	**3,3**
Smögen	**3,3**
Stenungsund	**3,6**
Göteborg	**3,9**
Varberg/Ringhals	**3,5**

Zon 2	***Zon 2 = intervallet mellan:***	
(RH2000 möh)	***Säkerhets-***	***Säkerhets-***
Ort	***nivå 1***	***nivå 2***
Kungsvik	**2,8**	**3,3**
Smögen	**2,8**	**3,3**
Stenungsund	**3,1**	**3,6**
Göteborg	**3,4**	**3,9**
Varberg/Ringhals	**3,0**	**3,5**

Zon 3	*Zon 3 = intervallet mellan:*	
(RH2000 möh)	***Framtida beräknade***	***Säkerhets-***
Ort	***högvatten***	***nivå 1***
Kungsvik	**2,3**	**2,8**
Smögen	**2,3**	**2,8**
Stenungsund	**2,6**	**3,1**
Göteborg	**2,9**	**3,4**
Varberg/Ringhals	**2,5**	**3,0**

Zon 4	*Zon 4 = under:*
(RH2000 möh)	***Framtida beräknade***
Ort	***högvatten***
Kungsvik	**2,3**
Smögen	**2,3**
Stenungsund	**2,6**
Göteborg	**2,9**
Varberg/Ringhals	**2,5**

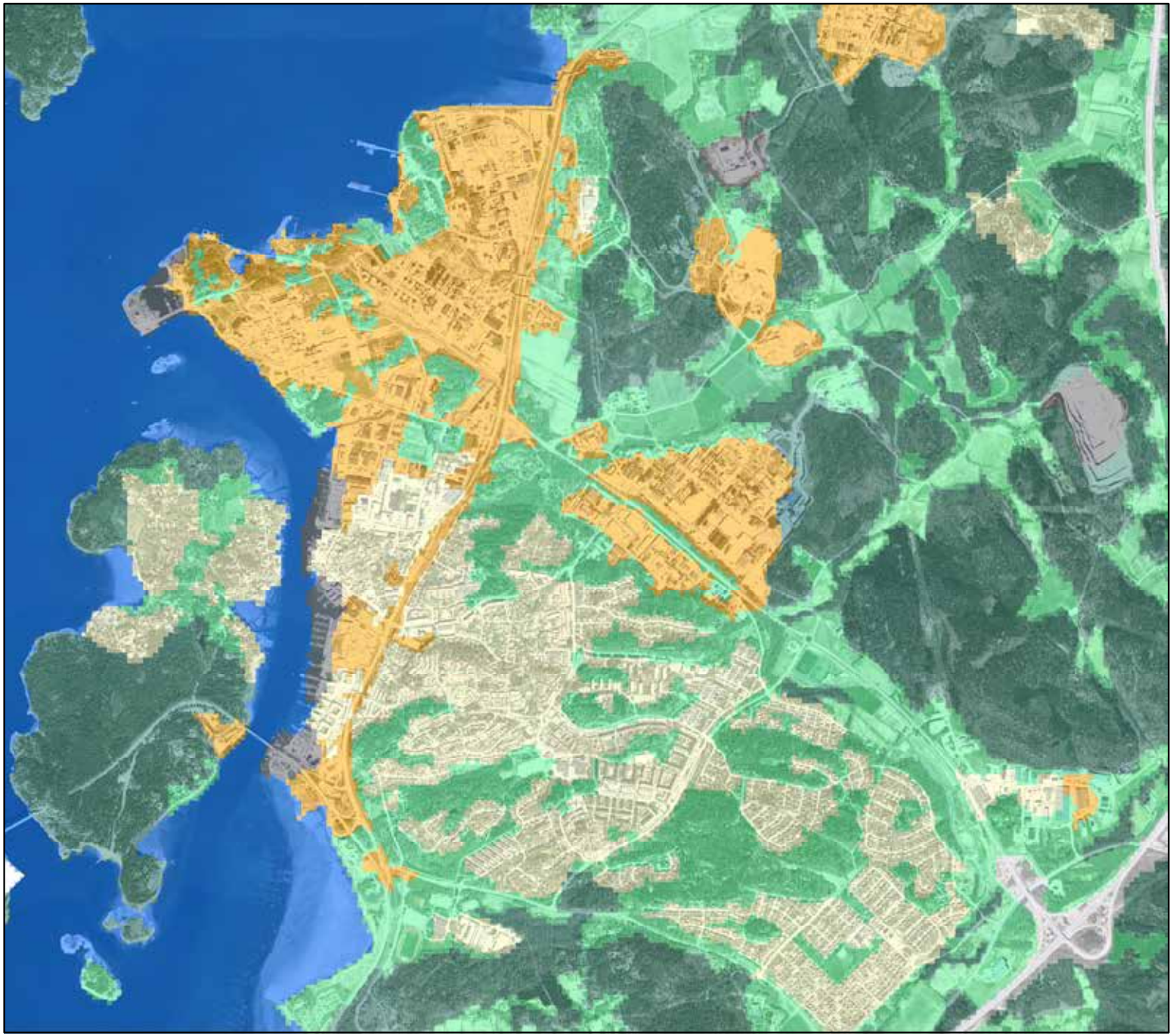
KUSTEN - uträkning nivåer:

Säkerhetsnivå 2			*RH2000 (möh)*
		Extra	
	Framtida	*säkerhets-*	***Säkerhets-***
Ort	*beräknade högvatten*	*marginal*	***nivå 2***
Kungsvik	2,3	1,0	**3,3**
Smögen	2,3	1,0	**3,3**
Stenungsund	2,6	1,0	**3,6**
Göteborg	2,9	1,0	**3,9**
Varberg/Ringhals	2,5	1,0	**3,5**

Säkerhetsnivå 1			*RH2000 (möh)*
		Extra	
	Framtida	*säkerhets-*	***Säkerhets-***
Ort	*beräknade högvatten*	*marginal*	***nivå 1***
Kungsvik	2,3	0,5	**2,8**
Smögen	2,3	0,5	**2,8**
Stenungsund	2,6	0,5	**3,1**
Göteborg	2,9	0,5	**3,4**
Varberg/Ringhals	2,5	0,5	**3,0**

Framtida beräknade högvatten									*RH2000 (möh)*
	100-årsnivå	*Vind-*		***Beräknat högvatten***	*Medel-*	*Havsnivå-*	*Land-*	***Netto-***	***Framtida***
Ort	*i dagens klimat*	*uppstuvning*	*Vågeffekt*	***i dagens klimat***	*vattenstånd*	*höjning*	*höjning*	***havshöjning***	***beräknade högvatten***
Kungsvik	1,47	0,10	0,075	**1,645**	-0,03	1,00	0,33	**0,67**	**2,3**
Smögen	1,45	0,10	0,075	**1,625**	-0,03	1,00	0,31	**0,69**	**2,3**
Stenungsund	1,70	0,10	0,075	**1,875**	0,00	1,00	0,31	**0,69**	**2,6**
Göteborg	1,65	0,30	0,225	**2,175**	0,04	1,00	0,26	**0,70**	**2,9**
Varberg/Ringhals	1,52	0,10	0,075	**1,695**	0,05	1,00	0,15	**0,80**	**2,5**

Appendix B
Stenungsund maps



N
W E
S

Stenungsund
Existing Land Use

Legend

- Residential areas
- Industrial or commercial units
- Road and rail networks
- Constructed areas
- Green areas
- Forest
- Wetlands
- Water bodies

500 250 0 500 Meters

Amin Behnamfar
Spring 2013

N
W E
S

Stenungsund
Existing Land Cover

Legend

- Green urban areas
- Sport facilities
- Golf course
- Camping
- Arable land
- Pastures
- Broadleaved forst
- Coniferous forest
- Mixed forest
- Shrub
- Clear cut area
- Sparsely vegetated areas

0 350 700 1 400 2 100
Meters

Amin Behnamfar
Spring 2013

N

W E

S

Stenungsund Contour Map

Legend

- Contour
- Residential areas
- Industrial or commercial units
- Road and rail networks
- Constructed areas
- Green areas
- Forest
- Wetlands
- Water bodies

500 250 0 500 Meters

Amin Behnamfar
Spring 2013

N
W E
S

Stenungsund
Surface Slope

Legend

Slope

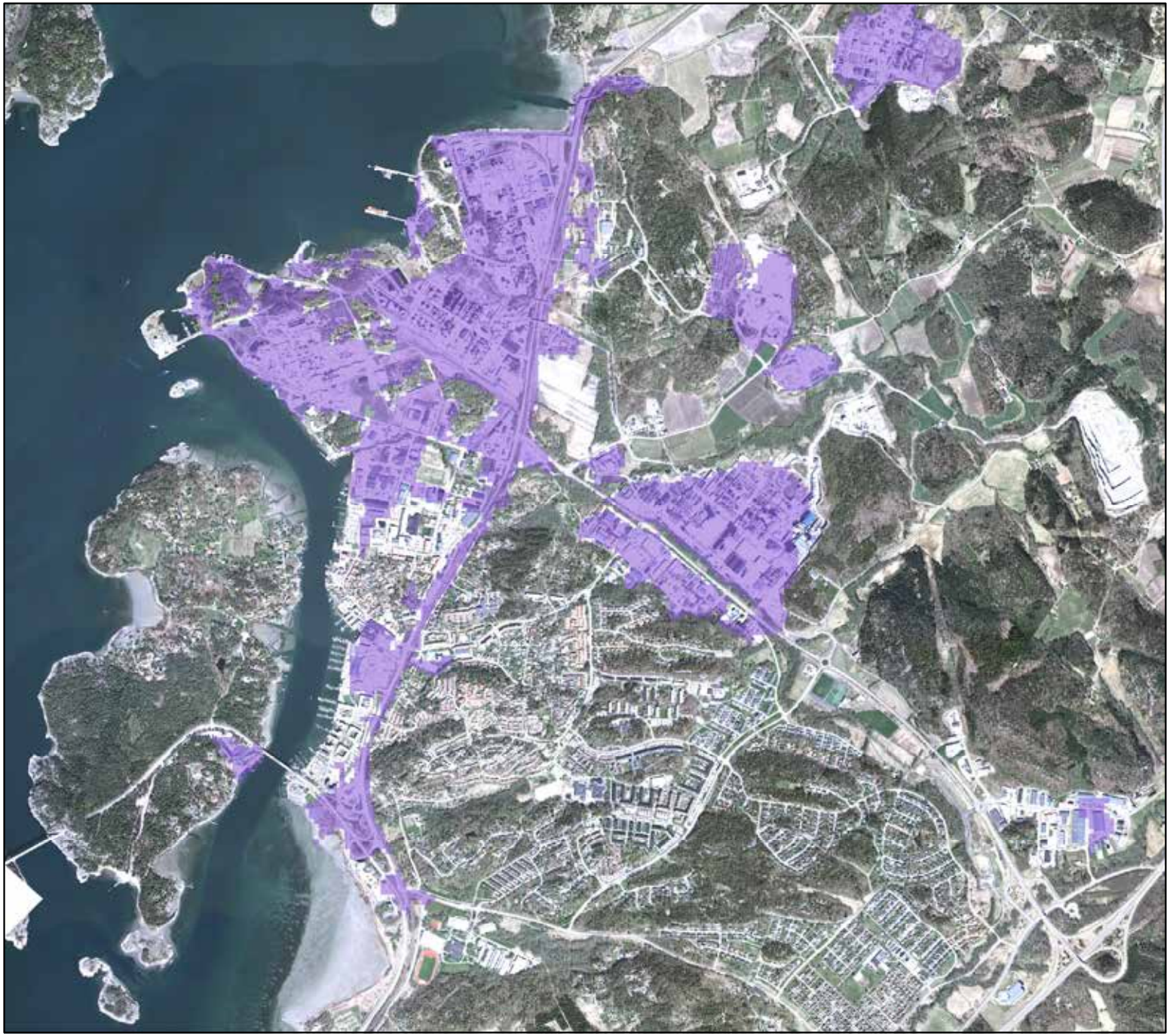
Value

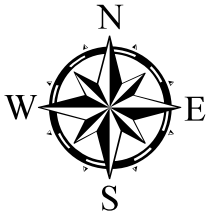
41,4922
20,7461
0

Residential areas
Industrial or commercial units
Road and rail networks
Constructed areas
Green areas
Forest
Wetlands
Water bodies

500 250 0 500 Meters

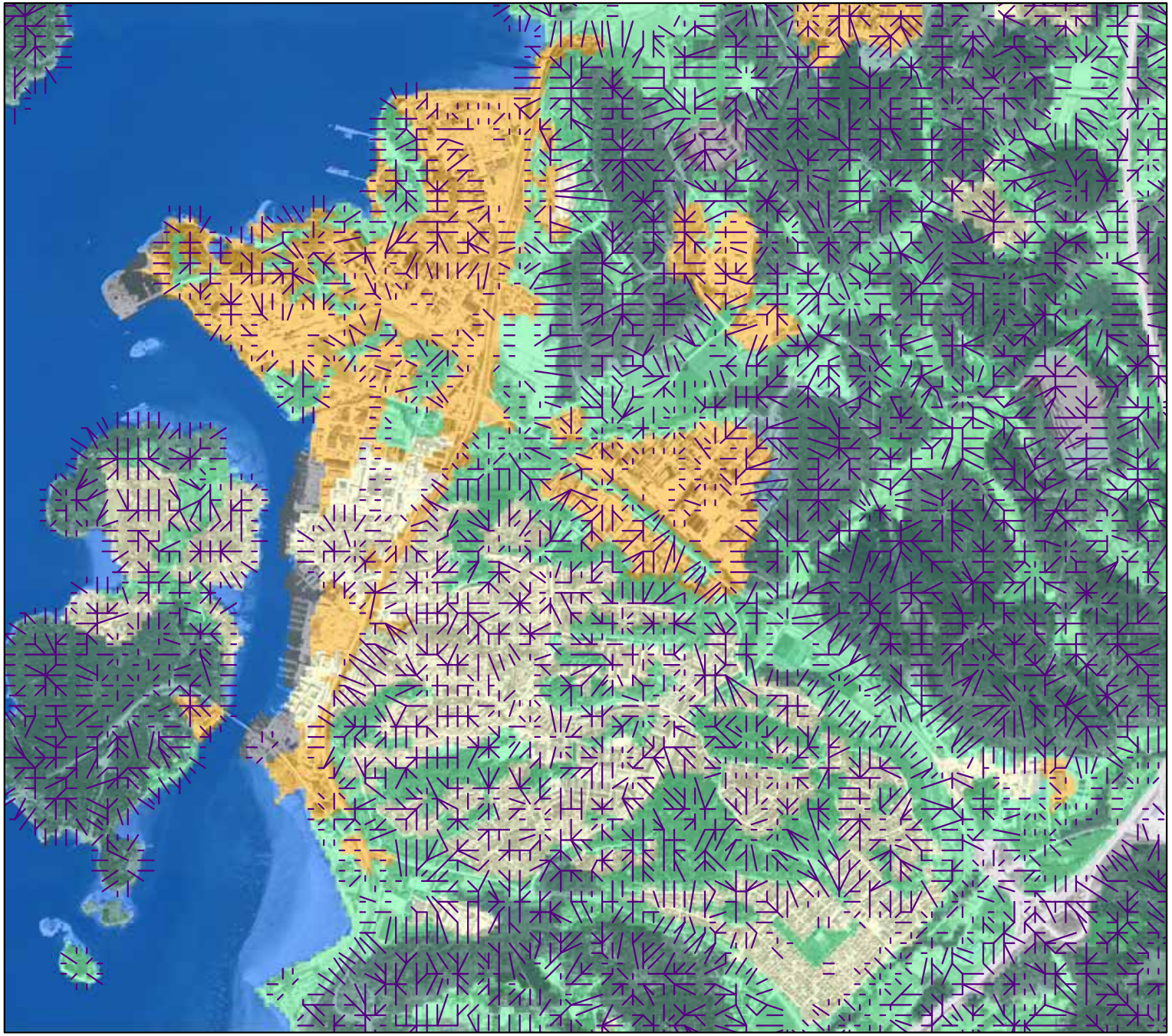
Amin Behnamfar
Spring 2013

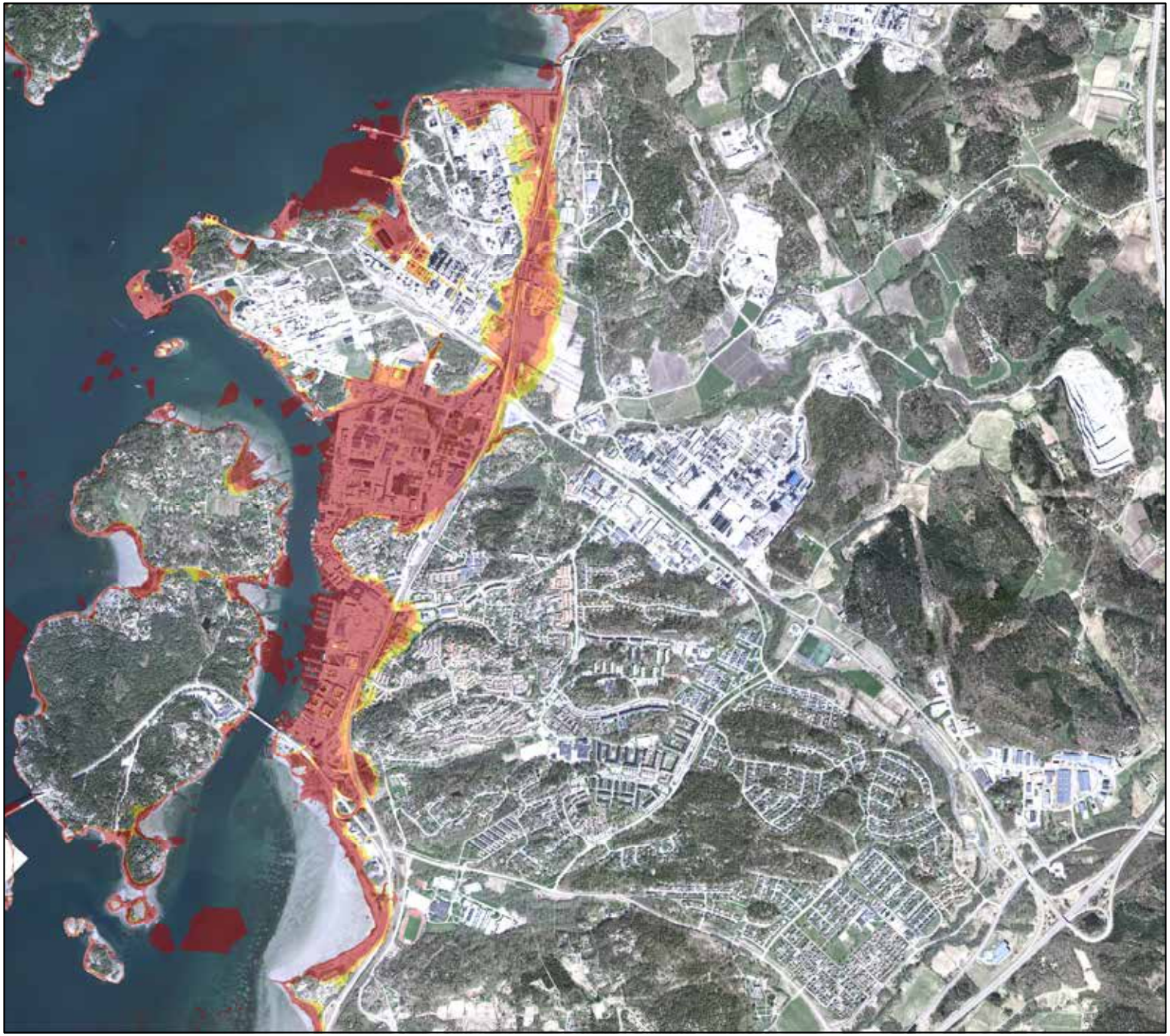




Stenungsund
Pollution Sources

Amin Behnamfar
Spring 2013


N
W
E
S
Stenungsund
Water Flow Lines
Legend
Stream_fea
Residential areas
Industrial or commercial units
Road and rail networks
Constructed areas
Green areas
Forest
Wetlands
Water bodies
500 250 0 500 Meters
Amin Behnamfar
Spring 2013



N
W E
S

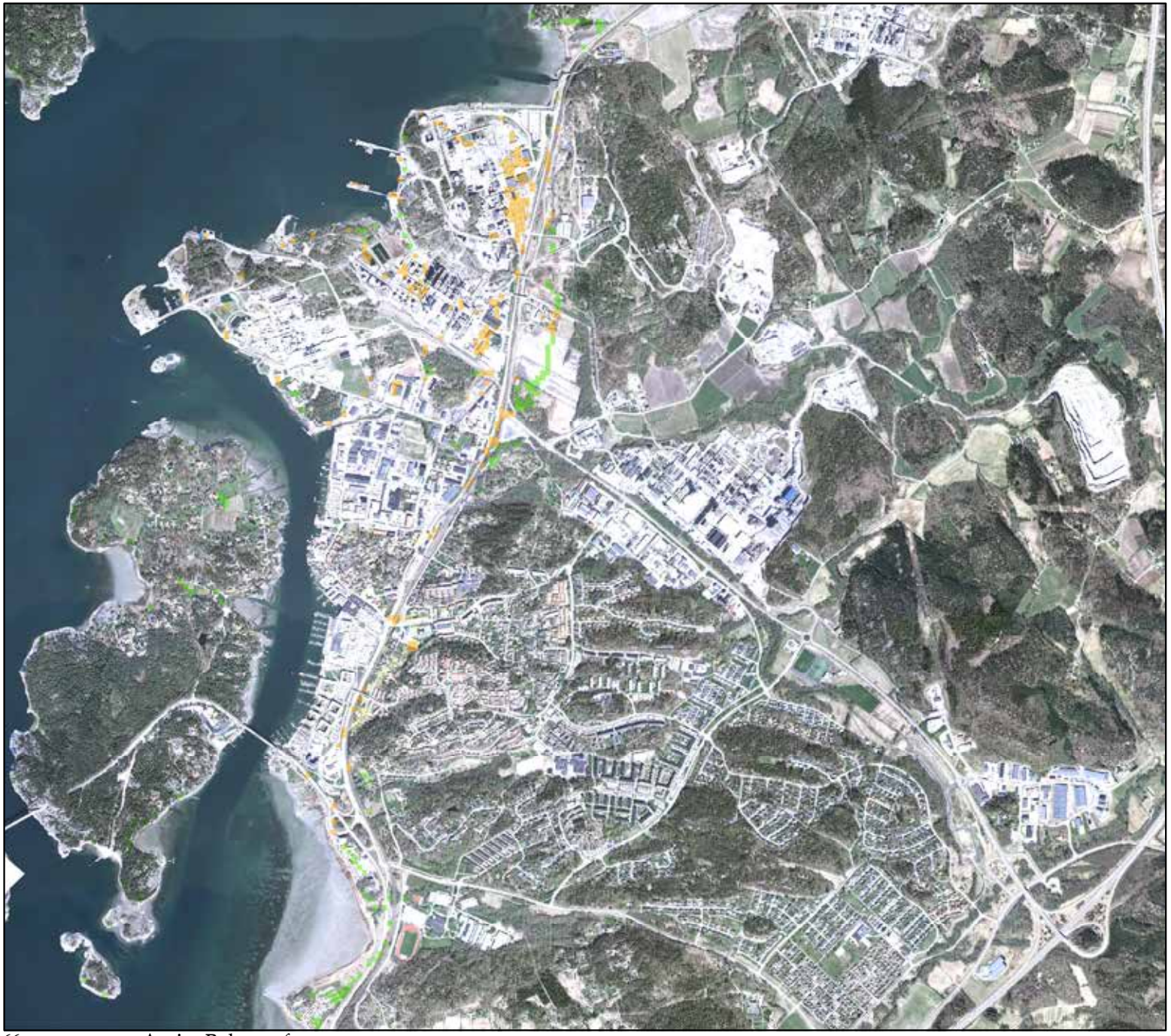
Stenungsund
Flood Zone

Legend

- Flood Zone 2
- Flood Zone 3
- Flood Zone 4

500 250 0 500 Meters

Amin Behnamfar
Spring 2013



N
W E
S

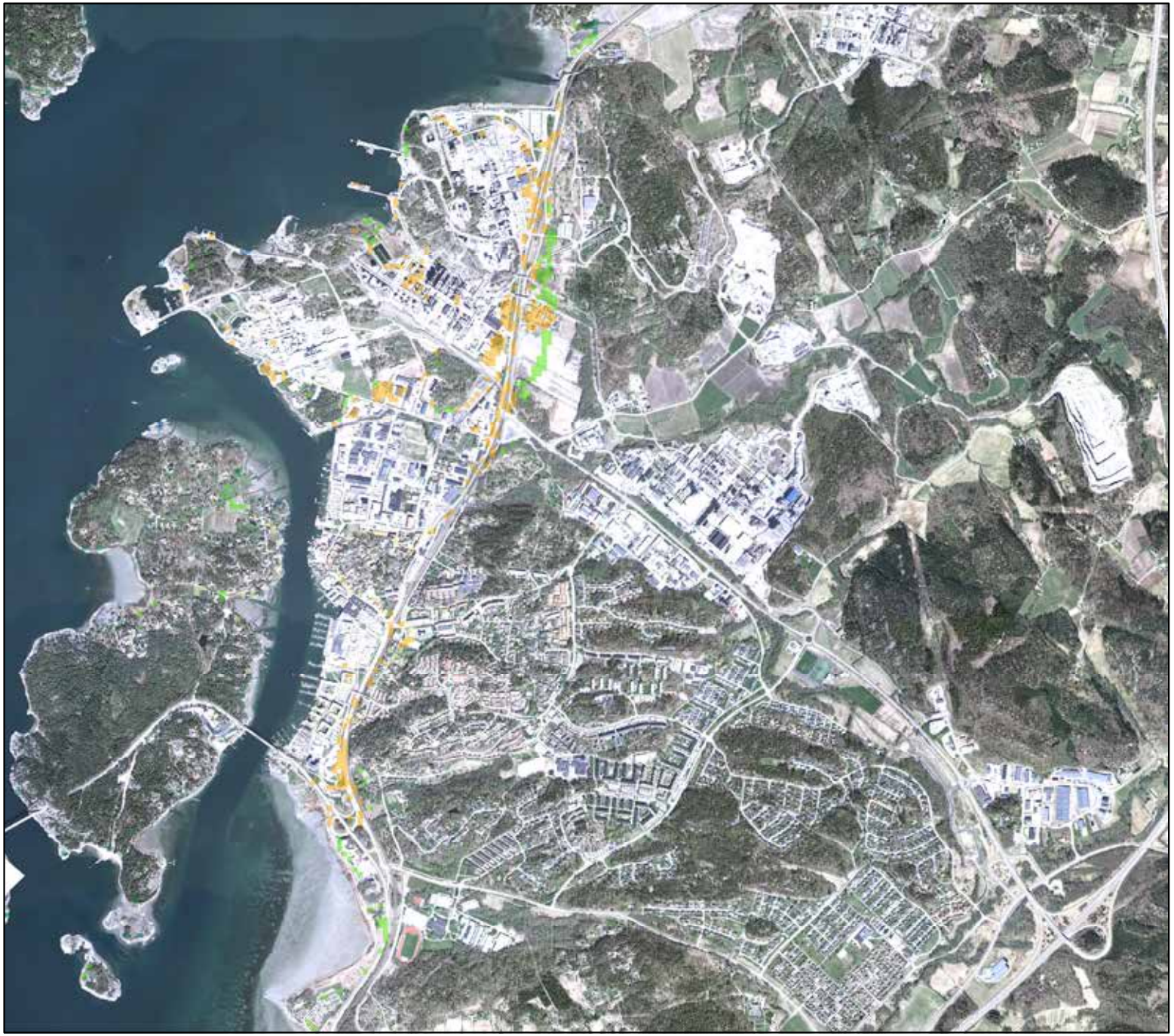
Stenungsund
Existing Land Uses
in Flood Zone 2

Legend

- Residential areas
- Industrial or commercial units
- Constructed areas
- Green areas
- Forest
- Water bodies

500 250 0 500 Meters

Amin Behnamfar
Spring 2013



N
W E
S

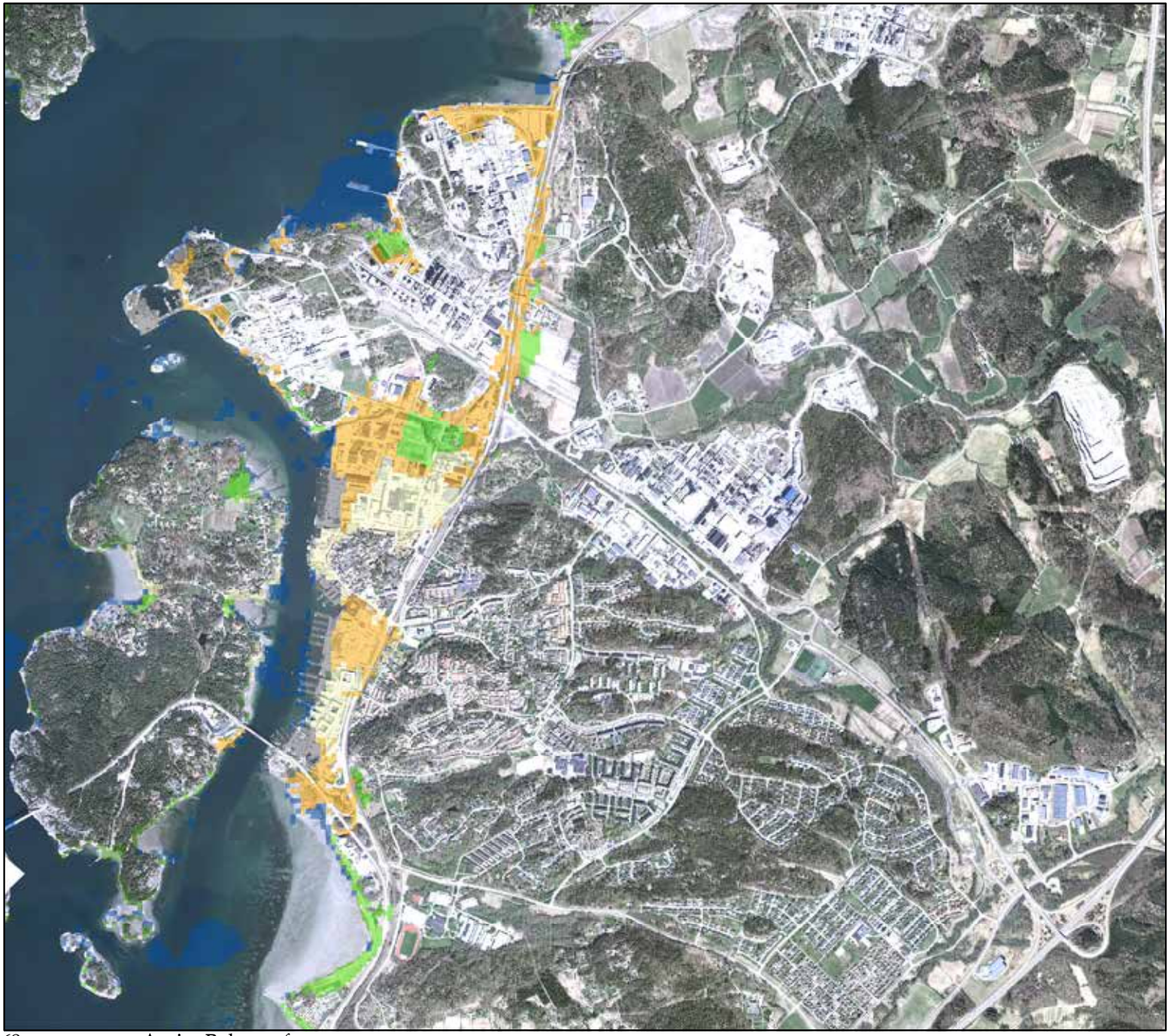
Stenungsund
Existing Land Uses
in Flood Zone 3

Legend

- Residential areas
- Industrial or commercial units
- Constructed areas
- Green areas
- Forest
- Water bodies

500 250 0 500 Meters

Amin Behnamfar
Spring 2013



N
W E
S

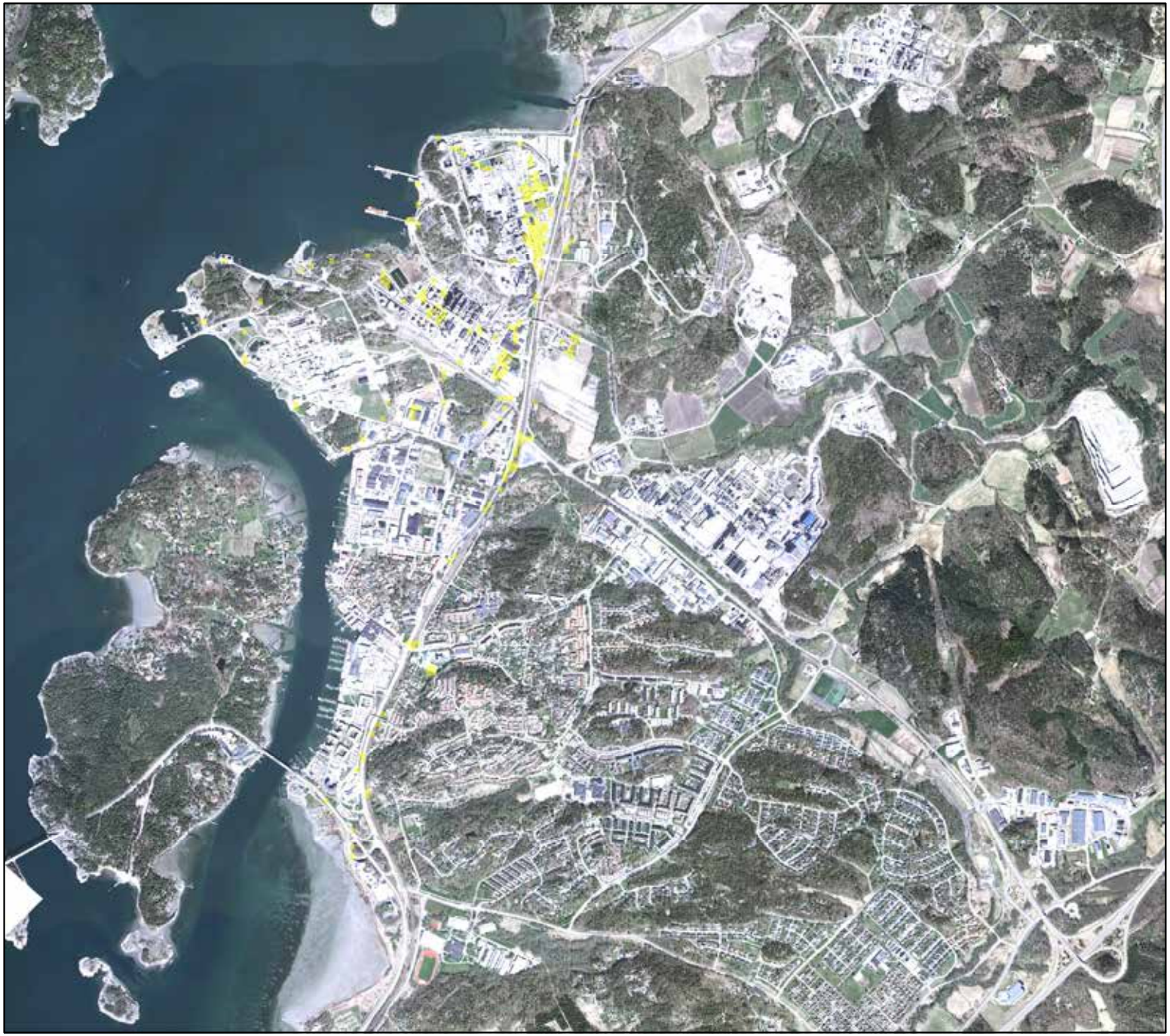
Stenungsund
Existing Land Uses
in Flood Zone 4

Legend

- Residential areas
- Industrial or commercial units
- Road and rail networks
- Constructed areas
- Green areas
- Forest
- Water bodies

500 250 0 500 Meters

Amin Behnamfar
Spring 2013

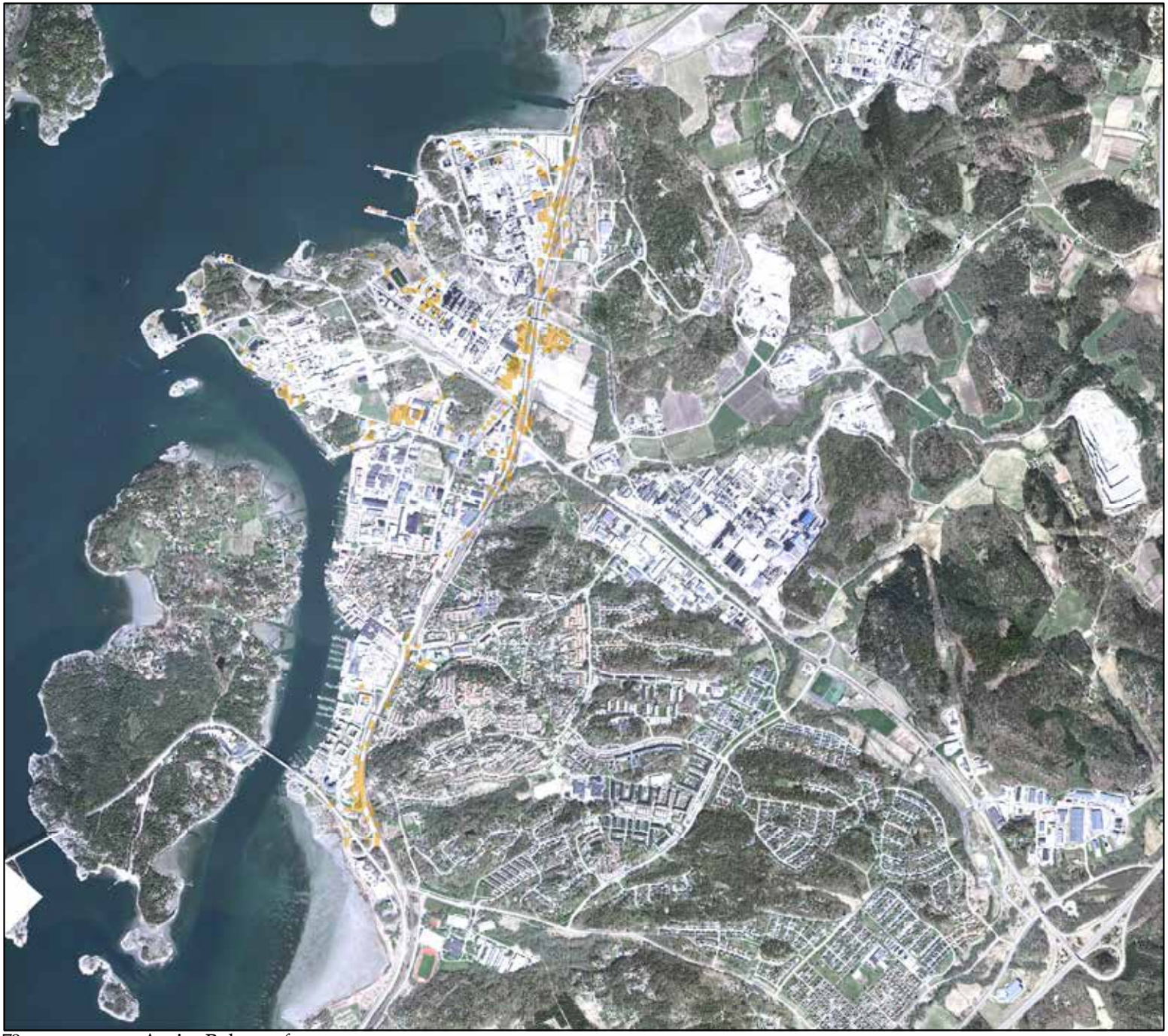


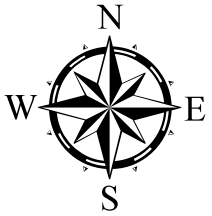
N
W E
S

Stenungsund Pollution Sources in Flood Zone 2

500 250 0 500 Meters

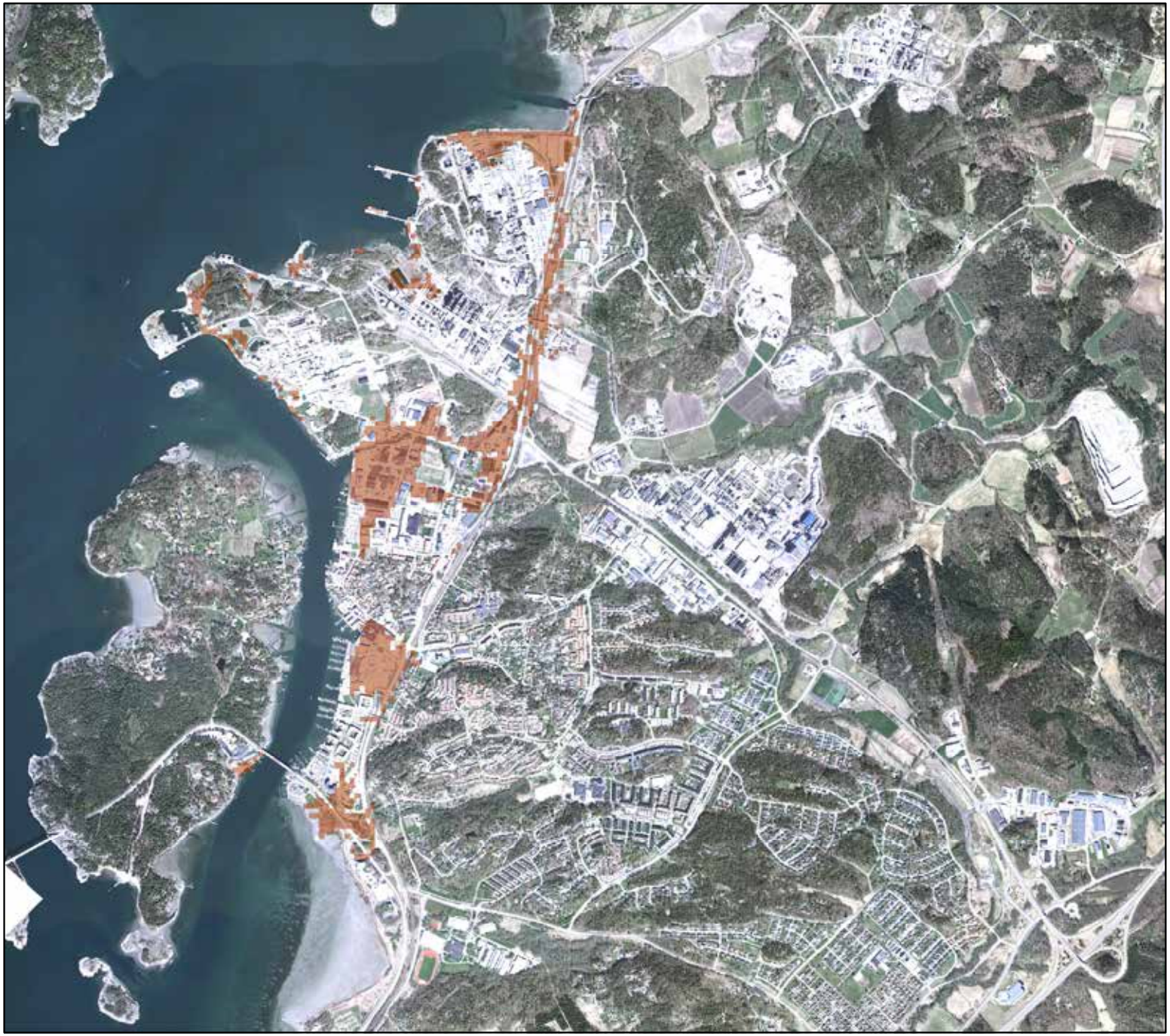
Amin Behnamfar
Spring 2013





Stenungsund
Pollution Sources
in Flood Zone 3

Amin Behnamfar
Spring 2013



N
W E
S

Stenungsund Pollution Sources in Flood Zone 4

500 250 0 500 Meters

Amin Behnamfar
Spring 2013