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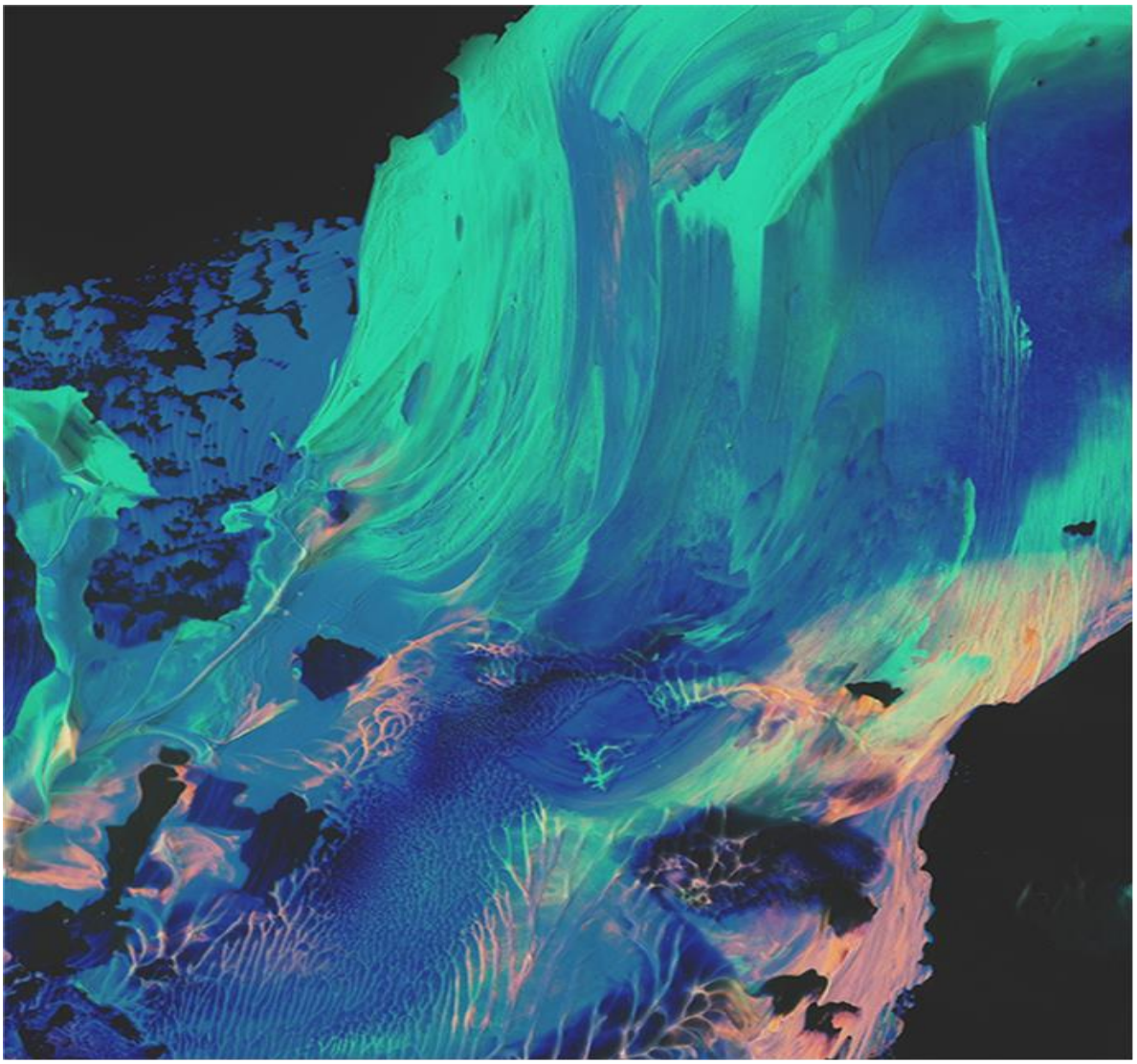

Emergency Water Planning and the Issues with making Drinking Water Accessible for Everyone

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Abstract

In Sweden, the access to drinking water is something that often is taken for granted. But several incidents where regions have found themselves without drinking water shows that we should be more concerned about crisis management concerning drinking water. Regulations state that even in a situation with drinking water disturbance the municipality is responsible for providing all citizens with drinking water of acceptable quality. When drinking water is not delivered in regular pipelines it is called *emergency water*, which is an alternative way to distribute drinking water within the region. During a crisis it is important that the authorities can act quickly in order to minimize the consequences that will occur if a region is without drinking water. *The National Food Agency* (Livsmedelsverket) have therefore developed a guide for municipalities how to make an *emergency water plan*. It contains information of how to map and prioritize water users. This is a case study of Nordmaling Municipality that investigates how and why water users should be prioritized during a disturbance in drinking water. The aim has also been to locate emergency water containers for citizens and study the accessibility of these locations and the level of justice within the society connected to citizens (in)accessibility. In order to do this study, the guide from the National Food Agency have been studied along with consultation with the municipal administration. Then a quantitative *Multi Criteria Analysis* (MCA) in GIS has been performed in order to find "optimal" locations for emergency water resources. Recommendations from the National Food Agency have been followed within the frame, ability and visions of Nordmaling Municipality. The study displays the functions that will obtain emergency water, and recommendations and regulations behind the decisions. Along with 12 different locations which have been decided based on results from the MCA. Water users (with extra consideration to vulnerable water users) living outside of the geographical "catchment-area" of a location with emergency water have been studied. This has shown that the locations are not accessible for everyone within the municipality. Constrained accessibility can be seen especially for elderly and those living in the sparsely parts of Nordmaling, which displays an unjust society.

Keywords: emergency water plan, drinking water shortage, Livsmedelsverket, accessibility, justice

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1. Introduction

1.1 Background

In Sweden, the access to drinking water is often taken for granted but experiences from the reality have shown several situations where regions have found themselves without drinking water. Östersund Municipality experienced an eruption of a parasite in the drinking water source in 2010, which made the water undrinkable for a long time (Livsmedelsverket, 2017a). Another example is from Öland where there was an absolute lack of drinking water in 2015-2016 due to low precipitation (Borgholm Energi, n.d.). During situations like these it is crucial that authorities know what to do. Experiences have shown the complexity of quickly providing regions with drinking water during a disturbance, which points to the critical need of planning and preparedness for a potential crisis in order to handle the immediate situation and minimizing the consequences (Livsmedelsverket, 2017a). A disturbance or lack of quality in drinking water can create large problems for inhabitants, businesses and institutions, and a potential worst-case scenario could put people's health at risk and most often result in extensive financial damages. Calculations from the National Food Agency (2017a) state that a total shut-down of drinking water during 48 hours in a municipality with 60 000 inhabitants would cost the society around 100-150 million SEK. It is important to understand that a disturbance in drinking water affects the whole society, and the list with possible chain reactions can be made long. For example, if pre-schools and schools do not get access to drinking water they will have to close temporarily. In turn this force parents to stay at home from their workplaces, which during a crisis situation are in need of their regular staff. Another example could be central kitchens that deliver meals to nursing homes, which will not be able to cook and distribute food without drinking water (Livsmedelsverket, 2017a).

During a situation where the regular supply system for drinking water is out of service, water needs to be distributed in an alternative way. Drinking water that is distributed in another way than pipelines is called *emergency water*, which only is meant to cover the most basic needs, such as drinking, cooking and hygiene (Barup & Samuelsson, 2010). As a way to help municipalities prepare for a potential crisis in drinking water the National Food Agency have developed a guide from 2017, called *Guide for planning emergency water supply* (Guide för planering av nödvattenförsörjning). It is meant to work as a tool for municipalities in Sweden to create an *emergency water plan*. The guide consists of several steps where people and functions are mapped and a preliminary assessment of consequences are made. By creating a dialogue with affected water users the municipality will be able to calculate their need, and then estimate their ability to deliver emergency water. This will help the municipality to act correctly and quickly when a crisis occurs (Livsmedelsverket, 2017a). The National Food Agency (2017a) states that it is most often not possible to provide everyone with emergency water, which makes it necessary to prioritize water users. When it comes to inhabitants the National Food Agency (2017a) argues for the importance of considering specific vulnerable water users within the society, such as children, elderly and people with home care. Furthermore, it is important to focus not only on the registered people within the municipality, but also commuters, asylum-seekers and potential tourists. Functions that should be prioritized in an

emergency water plan are mainly those that are of importance for people's life and health and for the society to function. But the National Food Agency (2017a) also brings up functions that have a large importance for the environment and those that represent large financial interests. Here it is valuable that the municipality have an understanding of the vulnerability of the function and what consequences that would occur if they were without drinking water (Livsmedelsverket, 2017a).

1.2 Problem statement

The National Food Agency (2017a) state that many municipalities today are missing an emergency water plan or have plans that are not viable. This is problematic since the consequences could be severe if people and functions do not get access to drinking water. The emergency water is delivered in some sort of container, most often by a truck or tank. It means that it will be delivered to a selection of functions and placed in some predetermined locations for citizens (Barup & Samuelsson, 2010). The importance of acting quickly will limit the number of different locations (Livsmedelsverket, 2017a). It is important that the municipality have a plan that follows the recommendations from the National Food Agency of how to prioritize inhabitants and functions, since it will not be possible to provide all water users with emergency water. As a result, some inhabitants may find themselves outside the geographical "catchment-area". Therefore, critically reflecting upon the accessibility of emergency water resources and for what groups it will or will not be accessible for is necessary. For inhabitants not to have access to emergency water is problematic since the Swedish society qualifies as a welfare state. It means that the state and municipalities have a large responsibility in providing people with, for example, healthcare, education, sewage and in this case drinking water (Nationalencyklopedin, n.d.). It is therefore possible to question the justice within the society if inhabitants do not have access to emergency water.

1.3 Aim and research questions

The aim of the thesis is to study how to prioritize and localize emergency water resources during a drinking water disturbance by doing a case study of Nordmaling Municipality. This by using recommendations from the National Food Agency of how to prioritize inhabitants, institutions and businesses within the frames of the municipality and to study the accessibility of the emergency water and the level of justice connected to accessibility.

- Which inhabitants, institutions and businesses in Nordmaling Municipality should be prioritized during a potential disturbance in drinking water, and why?

- How accessible is the emergency water for different social groups in Nordmaling Municipality, and are there groups that will experience constrained accessibility?

1.4 Delimitations

Drinking water shortage is most often connected to drought in countries in the global south. However this study focus on a global north, and more specifically Swedish perspective. The study is based on an assessment of Nordmaling Municipality from the time period 2018-01 to 2018-06. Disturbance in drinking water can be connected to several scenarios, but this study focused on a total stop in drinking water. The focus has also been to cover all of Nordmaling, but in reality it is more likely that a drinking water shortage would occur in a limited area. This means that the ability to provide the entire municipality at the same time will probably not be needed, and the results therefore provide an absolute worst-case scenario.

2. Literature review

2.1 Regulations regarding drinking water

2.1.1 Drinking water

Regulations concerning the public drinking water (surface- and groundwater) state that water sources should be protected from pollutions and other influences (SOU 2016:32b). The protection of these is a central part of providing the water producers with crude water. The most common way to protect water bodies is by establishing *Water Protection Areas* (vattenskyddsområden) (SOU 2016:32a). Water protection areas are covered by the *European Water Framework Directive* (Europeiska Unionens vattenramdirektiv) (Länsstyrelsen Västerbotten, n.d.). The European Water Framework Directive, implemented in the *Environmental Code* (miljöbalken), is a collective regulation of water issues within the European Union (EU). This directive includes *the Drinking Water Directive* (dricksvattendirektivet) (SOU 2016:32a), which contains regulations that needs to be followed by drinking water producers (Livsmedelsverket, 2017b).

2.1.2 Distribution of drinking water

The responsibilities concerning drinking water and its distribution is spread over several central, regional and local levels of government. Actors in the central governmental level are *the National Board of Housing, Building and Planning* (Boverket), *the National Food Agency* (Livsmedelsverket), *the Marine and Water Agencies* (Havs- och Vattenmyndigheten), *Sweden's Geological Survey* (Sveriges geologiska undersökning) and *the Civil Protection and Preparedness Authority* (Myndigheten för Samhällsskydd och Beredskap), just to name the most important actors (SOU 2016:32a). On a regional level the *County Administrative Board* (Länsstyrelsen) has many responsibilities concerning drinking water, and work holistically over several sectors in order to coordinate different society interests. The role of the County Administrative Board is also to be a support for municipalities and monitor their work with water services (SOU 2016:32a). The ultimate responsibility for drinking water is on the local level, in the country's municipalities. They have the responsibility to provide drinking water according to The *Water Service Act* (vattentjänstlagen) and have a public control of drinking water facilities according to the *food legislation* (livsmedelslagstiftningen). The public drinking water distribution consists of the municipality, the responsible person for the Water and Sewer (WS) plant, the distributor and the producer. Privatization within the WS systems are limited to plant operations and reconstruction, and the responsible authorities of the municipality have retained the core service (SOU 2016:32a).

2.1.3 Drinking water shortage

A drinking water shortage is incorporated in a crisis event and threatens basic needs and functions of the society (SOU 2016:32a). The *Act of Extraordinary Events* (Lagen om extraordinära händelser) state that the municipality need to have an increased preparedness in order to handle a crisis during a variety of events (Livsmedelsverket, 2017a). The *Responsibility*

Principle (ansvarsprincipen) state that the municipality have the ultimate responsibility to provide those within the municipality with drinking water. Producers and distributors of drinking water have no designated responsibility concerning drinking water during crisis. However, it is stated that they, according to the Drinking Water Regulations, should act as soon as possible if the drinking water does not fulfil the quantity or quality. The person responsible for the WS plant is to maintain a reasonable level of security in order to prevent damages (SOU 2016:32a). The Water Service Act states that the municipality are responsible for providing the drinking water with consideration to people's health and protection of the environment. Regulations state that it is household uses (drinking, cooking and hygiene) that should be prioritized. Isgård and Olsson (2003) state that some water users are extra vulnerable against drinking water shortage and are therefore prioritized according to the *Drinking Water Regulations* (dricksvattenföreskrifterna), these are hospitals, call services and emergency rooms, health clinics, nursing homes, schools and food producers. As long as regulations are fulfilled the municipality are free to prioritize water users (Livsmedelsverket, 2017a). Regulations concerning emergency water are that containers and tanks should be clean and that there are staff available to deliver it. A recommendation from the National Food Agency is that a reasonable distance to an emergency water resource is 500 meters (Livsmedelsverket, 2012). For municipalities without emergency water resources, VAKA (the national disaster group established by the National Food Agency) has containers and other equipment for emergency water available at six different locations (Borås, Stockholm, Eslöv, Sundsvall, Luleå and Visby), with the capacity to provide 350 000 people with three litres per person per day (PPPD) (SOU 2016:32a).

2.2 Emergency water in other regions

2.2.1 Past incidents

As mentioned, there have been several incidents where drinking water shortages have occurred. This chapter will bring up situations where the authorities have had to solve the problem with an alternative drinking water supply, such as emergency water. The examples are from both Sweden and other parts of Europe and variations of how authorities choose to act can be seen. All incidents points to the importance of being prepared and to evaluate what consequences a drinking water shortage would have on all different society functions (Barup & Samuelsson, 2010).

2.2.2 Nokia, Finland

In 2007 Nokia, Finland, with its 31 000 inhabitants had problems with lacking quality of the drinking water due to contamination from purified sewage water. The day after the discovery inhabitants got restrictions to boil the drinking water and emergency water containers were placed in different locations in the city. Police were called to the different locations of the emergency water resources in order to protect it from sabotage or hoarding, and the military was called in to distribute bottled water. The next day the municipality started to deliver emergency water to inhabitants who did not have the ability to get to the locations of the emergency water resources. The restrictions to boil water lasted for two months, during that

time emergency water was distributed in bottles and containers to 10 000 - 15 000 water users. Some society functions had to alter their way of working, such as central kitchens which had to use disposable plates and change their orders towards more processed foods (Barup & Samuelsson, 2010). Within the health care sector problems arise over time due to the increasing demand for washing clothes and bed sheets. Barup and Samuelsson (2010) argue that this could be a lesson from the incident, since the analysing of consequences for actors within the entire society had not been fully made.

2.2.3 Gloucestershire, England

In 2007, the water work in Gloucestershire had to shut down due to high flows in the river nearby, which resulted in 160 000 households without a functioning drinking water supply. The authorities had to provide 350 000 inhabitants with emergency water. Due to the severity of the situation the WS actors could not handle the situation by themselves and help to distribute emergency water came from both local construction companies, military, police and volunteers (Barup & Samuelsson, 2010). Furthermore, equipment such as tanks and containers were borrowed from other regions. Some issues were that the inhabitants used more emergency water than the calculated 10 litres per person per day (PPPD), and some hoarding occurred. This resulted in that the military and police had to be present at the locations of the emergency water resources to stop people from sabotaging and stealing (Barup & Samuelsson, 2010).

2.2.4 Helsingborg, Sweden

Helsingborg in an example from Sweden, where a large water leak occurred in 2009. This resulted in a risk of drinking water shortage. However the problem was solved quickly and the city could use water as normal 24 hours after the leak was discovered, the incident is a good example of the authorities' preparedness. In order to handle the situation, the biggest water consumers were told to be careful with water usage, and shortly after that the general public were informed. Containers and transportation for emergency water distribution were prepared a few hours after the incident, and these were then placed in different locations of the city. However, the emergency water resources never needed to be used. Barup and Samuelsson (2010) argue that the call to be careful with water usage had a very positive response, and water usage went down drastically. Larger companies such as training facilities and indoor swimming pools closed for the day, and the hospital produced water from their own reserve water work instead of using the communal drinking water (Barup & Samuelsson, 2010).

2.2.5 Östersund, Sweden

Another Swedish example is Östersund, which suffered from an eruption of the waterborne parasite *Cryptosporidium* in the drinking water in 2010. As a response to the eruption the authorities instructed inhabitants to boil the water before use, however 27 000 cases of illness were reported (Ramböll, 2014). The authorities decided to not deliver emergency water to inhabitants and normal food operations due to that the water could be used after boiling, and it was stated to be too demanding to provide the entire society with emergency water (Johansson et al, 2012). Important society functions such as the hospital were provided with drinking water by the County Council (Landstinget). The emergency services and police used their own reserve

drinking water source and the municipality provided other important society functions with water from another drinking water source (Johansson et al, 2012). Several society functions had to rearrange parts of the activities. For example, some meal services had to receive food instead of cooking it, and kitchens that prepared food got emergency water delivered. Within the health and social care, a lot of resources were spent on boiling, cooling and distributing drinking water (Ramböll, 2014). The total cost for the society was calculated to be between 141-221 million SEK and includes everything from short-term costs such as overtime, to long-term costs such as loss in tourism (Ramböll, 2014).

2.2.6 Öland, Sweden

In 2015-2016 an acute shortage of drinking water occurred on Öland due to low precipitation (Länsstyrelsen Kalmar län, 2018). According to T. Färm (WS manager) (personal communication, 8th of February 2018) the inhabitants and functions were prioritized according to prevailing regulations. In order to tackle the drinking water shortage a water pipeline was built between Kalmar and Öland. Reconstructions of water establishments were also made in order to increase the production, distribution and infiltration. T. Färm (personal communication, 8th of February 2018) states that transportation of drinking water between water facilities was very helpful and resulted in that emergency water was not needed. However, the municipality have a plan for the locations of emergency water resources based on population density. There are also agreements with larger transport companies for the distribution of emergency water outside of their own resources, and for larger incidents VAKA is called in. T. Färm (personal communication, 8th of February 2018) states that one lesson from the incident was to in the future have safer parking and ramps for water tanks. To stop a similar situation from occurring again a new water work that uses desalination from Östersjön has been built.

3. Theoretical framework

3.1 Accessibility

The accessibility to drinking water, or more specifically emergency water resources are important in order to have a socially sustainable society where people have access to basic needs. The concept can in short be explained as the number of opportunities or activity sites available within a certain distance or travel time (Pacione, 2009). Accessibility is used in many different scientific fields, such as; transport, planning, urban planning and geography, and it has an important role when it comes to policy-making (Geurs & van Wee, 2004). When studying the concept further it becomes more complex, and accessibility is often misunderstood or poorly defined, which has resulted in many different perspectives. Geurs and van Wee (2004) have presented four types of components within the concept, (1) land-use, (2) transportation, (3) temporal and (4) individual components. Land-use components reflect the land-use system and consists of the amount, quality and spatial distribution of activities, as well as the demand for them. Transportation components describe the transportation system, expressed as the difficulty of an individual to travel between two places using a specific mode for transportation, in this case time, cost and effort are included. Temporal components reflect the availability of opportunities at different times of the day, as well as the time available for individuals to participate in certain activities. Individual components reflect the needs, abilities and opportunities of individuals. There is also complexity with measuring accessibility and Geurs (2006) have defined different measures, which focus on perspectives from infrastructure to individual ability.

Much of the complexity within the concept is related to the non-spatial factors, such as individual resources and space-time as well as social restrictions. Furthermore, there's no absolute boundaries that determine what is "near" or "far", and different individuals may have different perception of what is near or far, and what constitutes as an acceptable distance will most likely vary depending on the type of amenity. There is no consensus in the literature of the precise definition of what is accessible, and also no optimal best approach to measure the concept since it is highly dependent on the specific purpose and individual. Access is by no means only a matter of spatial relations, but also a matter of age, education, household characteristics and health issues, and includes socioeconomic factors, such as gender, age, income, ethnicity and other characteristics (Haugen, 2012). Farrington (2007) uses the term constrained access for describing groups with lower levels of accessibility, which is needed to be considered in policy-making in order for them to be socially and economically included. Furthermore, Farrington (2007) argues for strong accessibility, which is the condition where accessibility levels are high for all groups and individuals wherever they are located. The issues with defining what is accessible have introduced a relativistic basis within policy-making, and decision-makers may apply accessibility-related policies derived from their own relativist concept of what is acceptable for citizens. Even though the complexity of the concept it is still a very useful when creating a sustainable society, since greater accessibility among a society can be seen as a means of achieving greater social inclusion, hence social sustainability.

3.2 Justice

Accessibility can be included in the pre-conditions for social justice since the access to important functions, such as drinking water should include everyone in the society. Constrained accessibility in the context that inhabitants is not granted opportunities of participation in the society is not a 'just' society (Farrington & Farrington, 2005). The concept of 'justice' takes on different meaning, and it's important to understand that the definition is relativistic, since what it means to participate in a society differs from space, time and individual (Farrington & Farrington, 2005). Furthermore, the focus within the scholarly has shifted from finding a common definition of justice in order to measure it, towards an understanding of the idea of justice that is relative and contextualized, and more focused on understanding and addressing the problem than on constructing an ideal (Liljenfeldt, 2017). Liljenfeldt (2017) presents the view that from a spatial perspective the perfectly even development, socio-spatial equality, distributional justice, as well as universal human rights can never be achieved. Furthermore, stating that something is equal or unequal is a descriptive term that describes a condition of difference of something between different groups of people. It can also be stated that without difference there is no geography. In order for an inequality to become an injustice there must be some form of claim of unfair treatment or argument asserting the severity of an unequal situation. Liljenfeldt (2017) mentions many different frames of justice, and in a practical perspective, the frames show a concern for (in)equality and (in)justice in relation to the distribution of 'benefits or burdens'. However, an uneven distribution to some extent is avoidable since most activities needs some predetermined requirements. But when benefits or burdens from a distribution of a certain activity falls unevenly on different social groups, defined by for example income, gender or age, there is a reason to be concerned about the social implications of the accessibility to the activity (Liljenfeldt, 2017).

4. Study area

4.1 Nordmaling Municipality

Nordmaling Municipality (see figure 1) is located in Västerbotten County and lies by the coast between Örnsköldsvik and Umeå (Nordmalings kommun, 2016b). The municipality is sparsely populated with 5,8 inhabitants/km^2, compared to the overall population density in Sweden which is 24,8 inhabitants/km^2 (Sweden Statistics, n.d.) and consists of many nature reserves and water bodies (see figure 2) (Nordmaling, 2017d). The municipality inhabits 7060 people (Nordmalings kommun, 2016a) and central Nordmaling is the administrative centre. Central Nordmaling is also the most densely populated part and inhabits 2600 people. The population in smaller villages within the municipality varies from a few to 800 inhabitants (Nordmalings kommun, 2016b). The water source is one groundwater basin and provides five water works with drinking water (Nordmalings kommun, 2017a). The municipality have no reserve water source, which makes the drinking water sensitive along with that the largest water work, Floxen, is outdated (P. Alfheim, personal communication, 21st of February 2018). This points to the critical need of crisis management concerning drinking water.

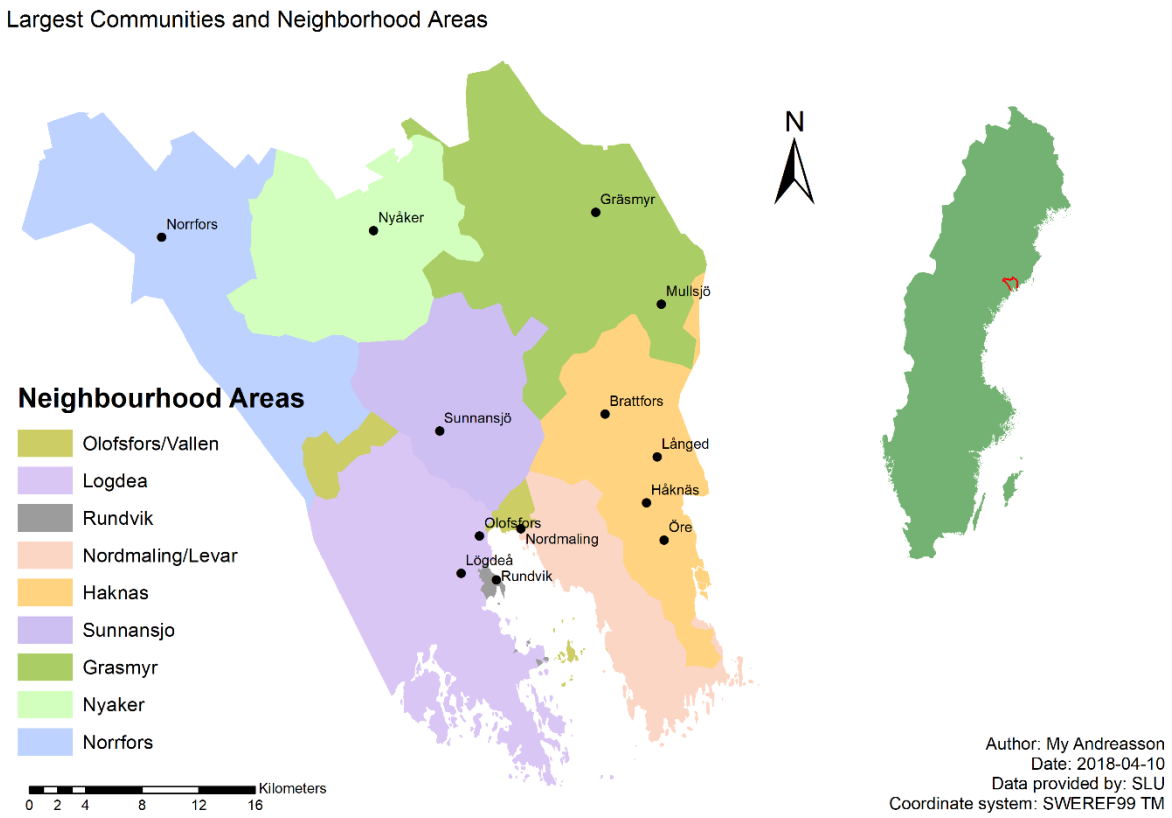

Figure 1. Reference map of Nordmaling Municipality.

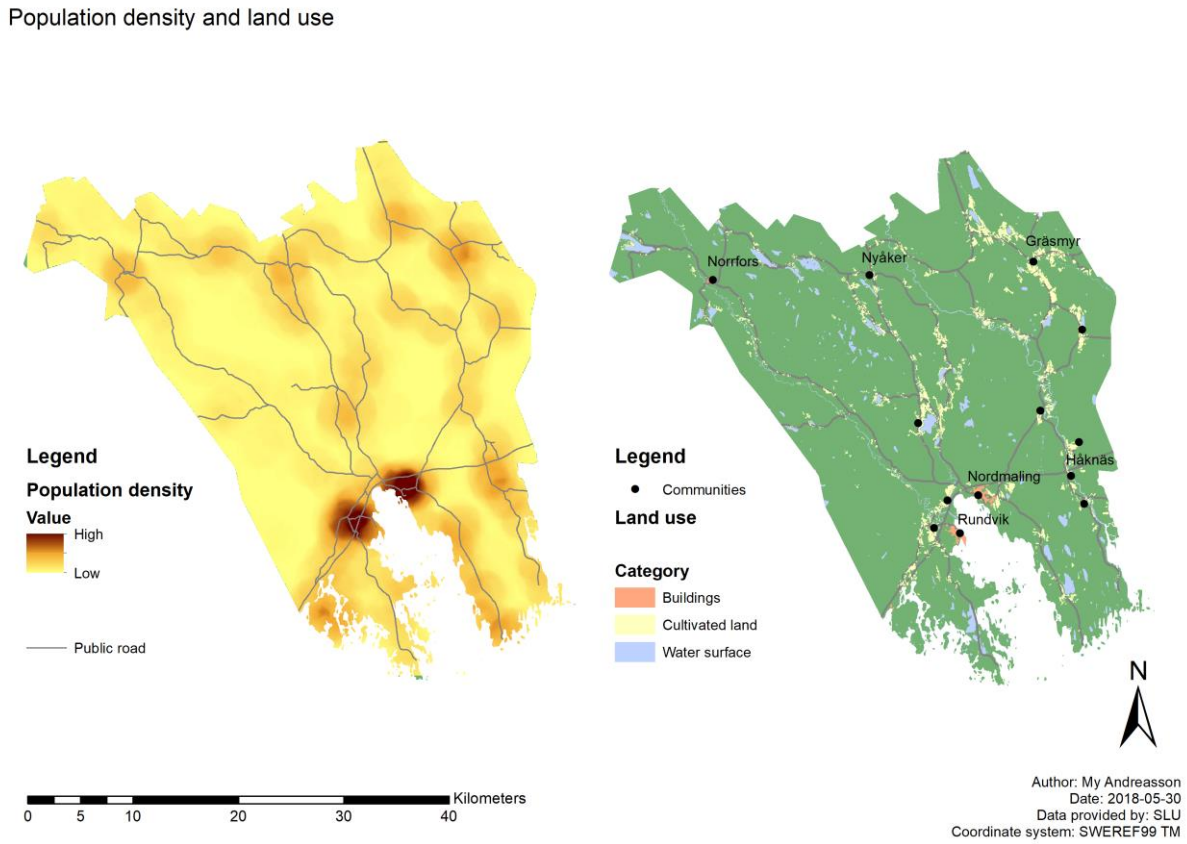

Figure 2. Population density and land use.

4.2 Crisis management for drinking water disturbance

In the latest Risk and Vulnerability Analysis, covering the years 2016-2019, the municipality have identified several important society functions. These are energy supply, financial services, supermarkets, health care and childcare, information and communication, infrastructure, municipal supply, public administration and protection and security (Nordmaling Municipality, 2016b). However, a deeper analysis of critical dependencies within the geographical area has not been made. Nordmaling Municipality (2016b) states that they are lacking in crisis management and argue that a deeper analysis of crisis should be done for important society functions in the next Risk and Vulnerability Analysis in order to improve the crisis management, primarily within the drinking water distribution.

5. Methodology

5.1 Choice of method

In order gain an understanding of how functions and inhabitants should be prioritized in an emergency water plan the methodological choice was of quantitative nature. This methodology was considered the most useful since it was important to get an overview of water users and land use in order to find the optimal locations for emergency water resources. Since the study comprises a large amount of both inhabitants and different functions a contrasting qualitative approach would have made the study too extensive. Access to drinking water, is a very sensitive subject and one can assume that people would not be satisfied with a longer distance to drinking water if they were to be asked. It is in broad terms described as the collection and measuring of numerical data, which is argued to have a more objective conception of the reality, compared to qualitative methods (Bryman, 2012). To have a more neutral view was important and is better achieved with a quantitative approach were the results were based on unbiased recommendations from a state-owned institution (the National Food Agency). Measurements were used in the study and can according to Bryman (2012) provide the research with a consistent device for making distinctions and to see differences. Official statistics have been used as indicators that stand for the concept accessibility and justice.

5.2 Quantitative method

This thesis made use of a *Multi Criteria Analysis* (MCA) in ArcMap, GIS, with the aim to study how water users should be prioritized during a drinking water shortage and to find optimal locations for emergency water resources. Functions were handled differently from inhabitants, because many functions such as hospitals and nursing homes need to run without any disturbances and therefore need emergency water directly (Nordmalings kommun, 2016b). For inhabitants, emergency water resources will be placed in different locations since it is too costly and time consuming for the municipality to deliver emergency water to each citizen. In order to do this, inhabitants and functions were identified and prioritized by following the recommendations from the National Food Agency within the frame of Nordmaling Municipality in consultation with P. Alfheim (manager within the WS sector at the municipal administration in Nordmaling). As a first step, functions that are of importance for the society were identified and information was then coded in order for the results to be quantified. Coding and quantifying information is frequently used in quantitative methods (Bryman, 2012). Regarding the inhabitants their different characteristics were identified through data provided by the *Swedish University of Agriculture Science* (SLU) in order to decide where emergency water resources should be located in order to be accessible. The locations for emergency water resources were identified in ArcMap with a MCA following criteria and constraints based on administrative, political and social structures. The next section will further explain the method divided between functions followed by the inhabitants of Nordmaling Municipality.

5.3 Emergency water to functions

5.3.1 Selection of functions

The first selection of institution and businesses included everything from very critical functions, such as the health care centre, nursing homes and schools to less critical functions, such as the library, training facilities and industries. They were identified in the Risk and Vulnerability Analysis (Nordmalings kommun, 2016b) and the official webpage of the municipality. The functions were then sorted into different categories (ranging from one to six) based upon goals from the government of how to prioritize functions. These categories were: (1) functions that are of importance for life and health, (2) functions that are of importance for the society to function, (3) functions that have a large importance for the environment, (4) functions that have large financial values, (5) functions that have a large importance for social and cultural values and (6) other functions (Livsmedelsverket, 2017a).

5.3.2 Data analysis of institutions and businesses

A list of the different functions was presented to P. Alfheim, since it is the responsibility of the municipal administration to prioritize water users (Livsmedelsverket, 2017a). It was also important to get a view from the municipal administration because they may have an understanding of the importance of certain functions that are not included in the recommendations from the National Food Agency. Results from talking to the municipal administration were used to make the final decisions of which functions that should be prioritized. This resulted in that several functions were omitted from the emergency water plan. Both because the municipal administration knew that they had their own solutions to obtain water or due to that the municipal administration did not feel that the function was important enough to prioritize in the emergency water plan (P. Alfheim, personal communication, 20th of March, 2018). The information that was collected was transferred into data, which means that information was coded into numbers or categories before it was quantified (Bryman, 2012). The data was coded into these categories: type of function, priority class (1-6), address, coordinates. Information that was not possible to code was written in comments.

5.4 Emergency water to inhabitants

5.4.1 GIS and Multi Criteria Analysis

In order to find optimal locations for emergency water resources for inhabitants in Nordmaling Municipality a MCA was performed in ArcMap. It is used for identifying either the most preferred option or to rank options. MCA is a way of looking at complex problems by breaking the problem into more manageable pieces. The re-assembling of the pieces to present an overall picture to decision-makers serves as an aid to thinking and decision making. MCA has advantages over informal judgements due to that it is open and explicit. The choice of objectives (criteria and constraints) are open for analysis and change if they are felt to be inappropriate (Communities and Local Government, 2009). When working with MCA the first step was to state the problem and the goals with it, which in this research was to find optimal locations for emergency water resources. The goal was a map showing potential sites, which is called a

Ranked Suitability Map (ESRI, 2016). Some constraints and criteria were defined, based on administrative, political and social structures from the National Food Agency and Nordmaling Municipality (Communities and Local Government, 2009). Each class was then assigned a value from one to six (ESRI, 2016), which will be explained in section 5.4.4.

5.4.2 Data selection

Locations for emergency water resources were identified with geodata from SLU with information covering administrative, political and aggregated information of social characteristics. The information was considered representative since it covered the entire population. In the MCA data of population density, consisting of aggregate information in 100x100 meter squares, was used with the aim to cover as many inhabitants as possible. Data covering the demography of the inhabitants, consisting of aggregate information in 250x250 and 1000x1000 meter squares, was important to consider when establishing locations for emergency water since age can affect the level of accessibility. Two different age groups considered as vulnerable water users (Livsmedelsverket, 2017a) were focused on. These were inhabitants in the ages 65+, which should be given extra consideration because elderly more often require extra support. The other groups was inhabitants in the ages 0-6 because they should be prioritized according to *the Convention on the Rights of the Child* (Barnkonventionen) (Livsmedelsverket, 2017a). Data of administrative features was important because tanks and containers that transport and contains emergency water require infrastructure. Here data of different types of land use and closeness to roads was used. After performing the MCA and creating a Ranked Suitability Map additional data was used in order to find potential locations for emergency water tanks. Closeness to bus stops and other facilities was valued as important, as well as the physical space of the locations. All constraints and criteria are described more in detail in the next section.

5.4.3 Constraints and criteria

In the MCA geographic measures to define and implement criteria and constraints were required. However, defining constraints and criteria has no universal technique, which makes it a flexible step (Marcianó, 2017). Thus, in order to do this the guide *Guide for planning emergency water supply* from the National Food Agency (2017a) was studied, and the final list of criteria and constraints used was:

- **Population density.** The emergency water resources should be located in areas where people live, the locations will therefore to a large extent be based on population density, which consist of 100x100 meter squares with aggregate information from 2015.

- **Demography.** Inhabitants aged 65+ and children in the ages 0-6 was focused on in the MCA. This because retired inhabitants will need extra support, therefore the distance to emergency water resources should be shorter in areas with many inhabitants in ages 65+. Contrary to areas with many healthy adults, which can have a longer distances to emergency water resources. Another vulnerable group is children in the ages 0-6, due to the Convention on the Rights of the Child (Livsmedelsverket, 2017a). The data that

was used was from 2015 and had a resolution of 1000x1000 and 250x250 meters in densely built-up areas.

- **Closeness to roads.** In order for tanks or other vehicles to deliver emergency water resources to different locations the areas have to be connected to roads, a maximum distance of 250 meters was chosen for the MCA.

- **Land-use.** Certain types of land use such as farmland, water bodies and nature reserves are not suitable for emergency water resources. Furthermore, land use that consists of industrial areas and recreational areas is not an optimal location for emergency water resources. It is also important that the location has enough space for a truck and/or tank to unload/fill emergency water (Livsmedelsverket, 2017a).

- **Closeness to public transportation.** Locations close to bus stops have been chosen not because people are expected to take the bus to these locations but rather because the location of the bus stop most likely have been chosen in order to be accessible for those living in that area. It therefore works as an indicator for accessibility. Bus stops have been identified through Google Maps and has been valued high when finding locations for emergency water resources after doing the MCA.

- **Closeness to other facilities.** Locations close to other facilities that have monitoring and people in movement decrease the risk of sabotage (Livsmedelsverket, 2017a), and has therefore been favoured. Functions have been identified through Google Maps after the MCA and locations close to them have been favoured when possible.

- **Distance from other emergency water locations.** When finding locations for emergency water the different locations has to be at a certain distance from each other, therefore emergency water locations was spread over the municipality and preferably a minimum distance of one kilometres from each other.

5.4.4 Data analysis of inhabitants

A *Weighted Overlay* was performed of population density, percentage of citizens in ages 65+ and 0-6, land use and buffer zones around roads. Population density and the share of elderly and children was divided into six different classes. The highest population density and highest share of elderly and children was given the highest class (6). Regarding land use, built areas along with unspecified areas was given the highest class (6). Industrial and recreational areas were assigned a low class (3) and water bodies and cultivated land were restricted (0). The road buffer zones were assigned the highest class (6) and everything outside was restricted (0). This provided a Ranked Suitability Map with six different classes, were the value of six was the most preferable locations for emergency water resources. However, the Ranked Suitability Map presented large areas suitable for locating emergency water resources. Therefore, other information was used to make decisions after the MCA. The Ranked Suitability Map was used together with the population density layer in order to see the areas with most inhabitants, as well as the areas with high shares of elderly and children. This was also combined with the

satellite base map in ArcMap, Eniro and Google Maps in order to find locations with the physical space required, close to bus stops and facilities.

A first selection of different locations was chosen and visualized in ArcMap and presented to the municipal administration in order for them to comment on the results. A fixed number of locations was then decided in accordance to what was considered doable (Livsmedelsverket, 2017a), which has affected the final judgement of locations. The alterations were performed and updated to fit the visions and ability of the municipal administration. In order to decide the amount of emergency water needed for each location the inhabitants within the neighbourhood area of the closest location was calculated in ArcMap. Information of the amount of emergency water, which was found in *Support materials & Examples* (Livsmedelsverket, 2017c) was presented in both tables and maps for the municipal administration. In this step, five litres PPPD was used as a standard measure for the first day and 10-15 litres PPPD for days two and three. In order to study the accessibility to locations with emergency water resources, buffer zones of two kilometres were created around the chosen locations and all inhabitants within the buffer zones was calculated. The aggregated information of elderly and children was used to further estimate the number of sensitive water users living more than two kilometres from a location. The distance of two kilometres was chosen instead of 500 meters since the 500 meters only is a recommendation and two kilometres would better reflect the long distances to the locations and the low population density of Nordmaling.

5.5 Reliability and validity

In this thesis the data that was used was measures from official statistics, and not people's subjective views, and therefore provides a good definition validity. Esaiasson et al (2012) argue that definition validity is defined as the conformity between theoretical definition and operational indicator and the absence of systematic errors. One could argue that the theory of accessibility is complex since there is no defined measure of what is accessible or not, however it was easy to study and with a good discussion it was possible to reflect on what really was accessible. Justice could also be considered as complex since it depends on whose perspective, but also here a discussion will help with giving a reflection of the level of justice. Furthermore, definition validity is easier to obtain when the theoretical definition that is being measured are closely connected to the operational level (Esaiasson et al, 2012). As mentioned, the data came from official statistics, which served as an indicator that systematic and random errors that can arise when data is collected due to careless mistakes was decreased (Esaiasson et al, 2012; Bryman, 2012). Reliability can be achieved when the researcher avoids random errors in the study (Esaiasson et al, 2012). Due to that the researcher did not collect the data there is a lack of control in the data collection, which has affected the reliability. However the data is not primary data, it originates from Sweden Statistics which would point to the fact that the data is of high quality. For the steps where control was possible, the researcher was aware of the possibilities of random errors and necessary steps was taken, such as using member checking to make sure that nothing has been misunderstood and that the data felt relevant to others, as well as comparing the results with information from different sources. Finally, Esaiasson et al

(2012) argue that a good definition validity together with a good reliability provides a good result validity, which in broad terms is that we measure what we say we measure.

5.6 Method discussion

Quantitative research has been the focus of a great deal of criticism, which makes reflections highly relevant. The largest critique is that it fails to distinguish people and their individuality (Bryman, 2012). This could be argued for as true in some sense since inhabitants were studied through data and numbers and not by interviews, and therefore will not give a perfect reflection of the reality. For example, the accessibility of two people in the age of 75 could be very different. This was not possible to include in the research, but perhaps would have been possible with more in-depth studies of inhabitants. Furthermore, the only data that examines the characteristics of inhabitants are demography, which provides a very simplistic view of the reality. The data covering population consist of aggregated data, which also affects the level of detail in the study. Other flaws in the representativeness of the population data is that it was from 2015, which is important to include in the results since the population have increased with 200 people between 2015 and 2017. It is also important to include commuters, asylum-seekers and potential tourists. But due to lack of information this has not been done.

Data that would have created more representative results where accessibility had been easier to measure are data of citizens with home care, more detailed information of demography, data of car ownership and data of private wells. However it would, if used, be considered as very sensitive data. Critique can also be directed towards that the limited number of locations has resulted in that the final locations are in areas with the highest population density, which also was areas with many vulnerable water users. Therefore, elderly and children are not visible in the results. Closeness to other functions was also valued high, which may have taken away focus from locating emergency water resources close to vulnerable water users. Another critique is that due characteristics such as a low population density, country roads and scattered farms have affected the final results, and since the guide from the National Food Agency is made to fit all municipalities in Sweden some recommendations have not been followed exactly. Some adjustments was made to fit the characteristics of the municipality and visions from the municipal administration. It is also possible to question if a "neutral overview" of water users have been possible, since final decisions mainly is built on the knowledge and visions of the municipal administration. Buffer zones which measure Euclidian distance was chosen as a method to measure accessibility to the location with emergency water. Another possibility to measure accessibility would have been to perform a network analysis, which uses roads and walkways to calculate the time it would take to reach the destination (ESRI, n.d.). A network analysis would have been preferred since it focuses more on accessibility and the time it takes to travel. However, the number of citizens with longer distances would not have changed remarkably, which is why buffer zones were chosen as a method of measuring the accessibility. Ethical reflections are that emergency water plans are connected to a great deal of vulnerability in a society. However, this research only provides the basis for developing an emergency water plan and not a finished plan that is ready to be used.

6. Results

6.1 Prioritization of functions

The final list of functions that are prioritized in the emergency water plan can be seen in the appendix (table 1-6). They are prioritized according to the recommendations from the National Food Agency (2017a) along with consultation with P. Alfheim, at the municipal administration. Most functions belong to priority class one and two (see figure 3) and are mainly clustered in central Nordmaling.

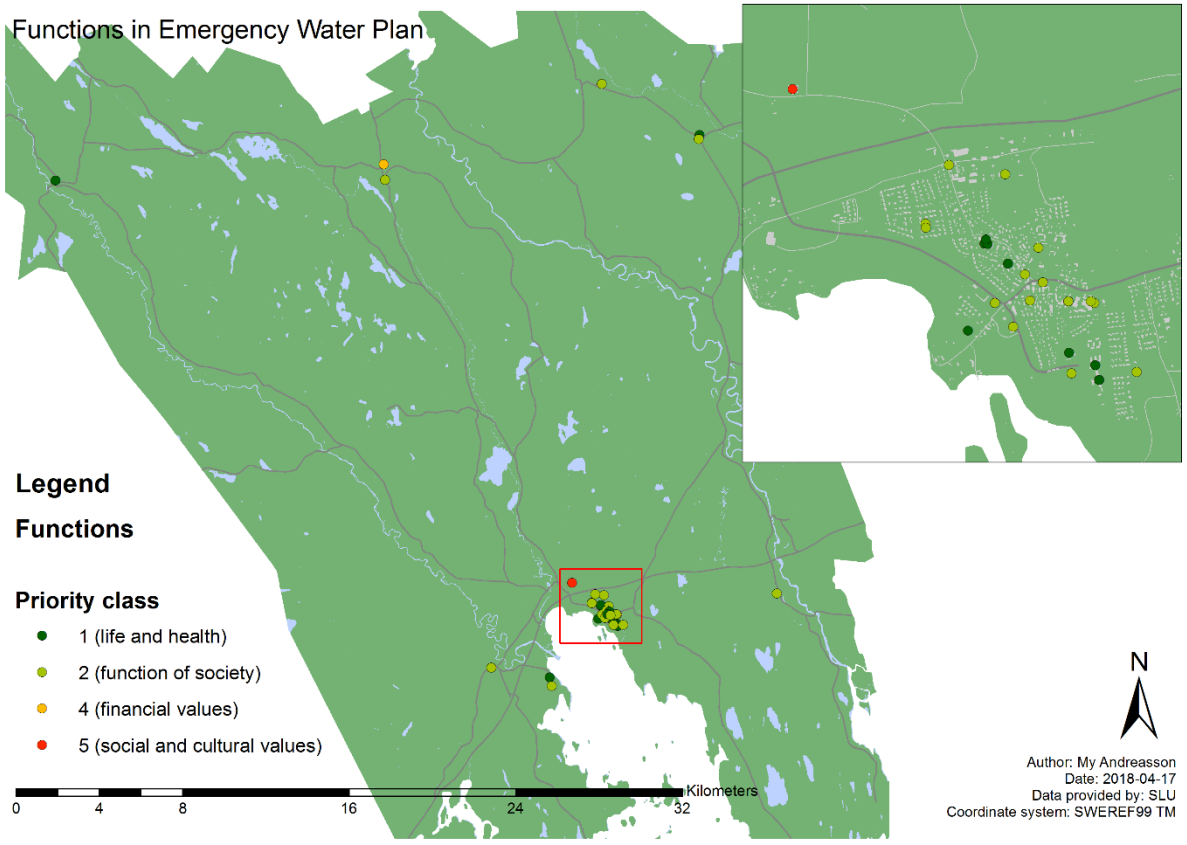

Figure 3. Map of functions in emergency water plan.

The functions of the highest importance are those connected to life and health (priority class 1). Incorporated here are Nordmaling health centre (see table 1), which receives around 200 patients/day and requires drinking water for patients and staff that have strict requirements of hygiene (G. Mikaelsson, director of department, personal communication, 18th of April 2018). Nursing homes for elderly and people with disabilities are sensitive water users and a disturbances would cause immediate problems with drinking and hygiene (Livsmedelsverket, 2017a). There are five nursing homes for elderly, six nursing homes and short-term accommodations for people with disabilities, as well as two home care services within the municipality (see table 2). The nursing home Tallbacken prepares meals for several nursing homes and the home care services and the National Food Agency (2017a) states that central kitchens need to be prioritized since drinking water is needed in order to cook food.

Functions that are of importance for the society to function (priority class 2) comprise many different functions. The fire station and police station (see table 1) are functions that are important during crisis management (Nordmalings kommun, 2016b). The municipal administration office also belongs to priority class two since it is important that the affected sectors can work with solving the drinking water shortage. Pre- and elementary schools (grades F-6) are prioritized since these cannot function without drinking water, and a domino effect is likely to occur in a situation where different functions are in need of their regular staff in a crisis situation. This means that pre- and elementary schools need to function from a crisis management perspective (Livsmedelsverket, 2017a). Within the municipality there are nine pre-schools and five elementary schools (see table 3) (Nordmalings kommun, 2017b). District heating, which Solör Bioenergy (see table 4) produces in Nordmaling (T. Sundqvist, personal communication, 23rd of Mars 2018) is sensitive to a water shortage because they use communal water and can therefore lose capacity or shut down during a longer disturbance in drinking water (Livsmedelsverket, 2017a). This is especially important during cold temperatures. Other important energy supplies are Vattenfall AB and the gas station Circle K (P. Alfheim, personal communication, 20th of Mars 2018). Grocery stores are important to incorporate in an emergency water plan since the staff needs water for drinking and adequate hygiene (Livsmedelsverket, 2017a). Within the municipality, Coop Konsum and ICA Supermarket will be prioritized (see table 5).

There are no functions included in the emergency water plan in priority class 3 (functions that have a large importance for the environment). The recycling centre could be important for the environment in a long-term perspective, but was not critical enough to include in the emergency water plan according to the municipal administration (P. Alfheim, personal communication, 20th of March 2018). Functions that have large financial values (priority class 4) are Nyåkers Pepparkakor (UC AB, 2012) (see table 6), which depend on drinking water for their production. This is the only function in category four that are prioritized, since other large companies such as Olofsfors AB and SCA do not use communal water for their industry (P. Alfheim, personal communication, 20th of Mars 2018). Functions that have a large importance for social and cultural values (priority class 5) are Nordmaling riding club (see table 6), since the horses are sensitive to a drinking water shortage (P. Alfheim, personal communication, 20th of Mars 2018). However, drinking water for animals are according to the Animal Welfare Act the responsibility of the owner and not the municipality (Livsmedelsverket, 2017a).

6.2 Location of emergency water resources for inhabitants

The Ranked Suitability Map (see figure 4) was used as a basis and shows the most suitable areas for emergency water resources to inhabitants. There are large areas in Nordmaling Municipality that have a ranking value of six, indicating that these areas are the most preferable for locating emergency water resources based on the criteria and constraints of land use, roads, population density and share of vulnerable water users (ages 65+ and 0-6). The areas ranked zero are restricted in the MCA, and therefore areas where emergency water resources should not be located.

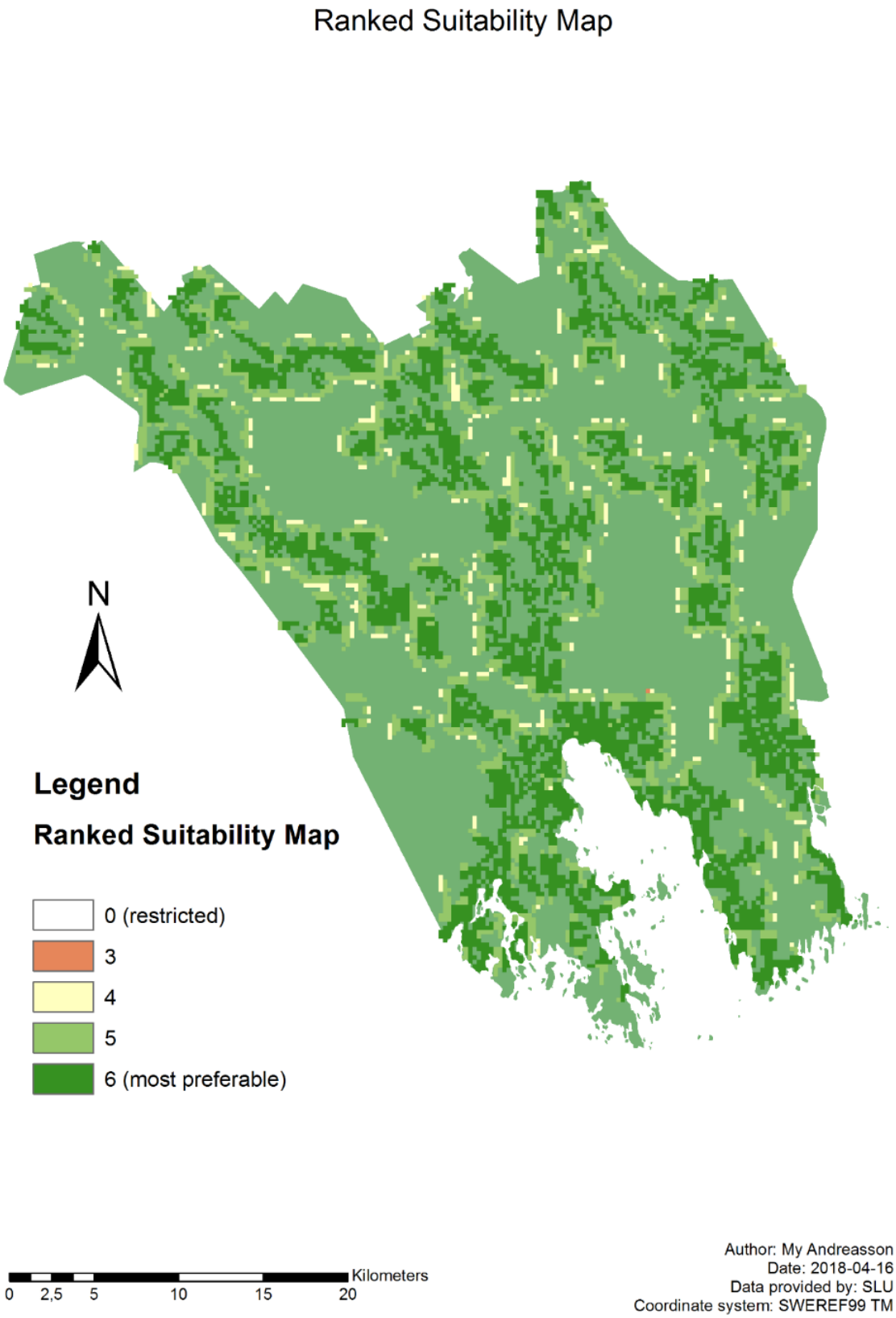

Figure 4. Ranked suitability map.

Figure 5 shows the roads in the municipality that are required for transportation of emergency water resources. Bus stops is an indicator that the location is accessible for inhabitants, which was used when locating emergency water resources.

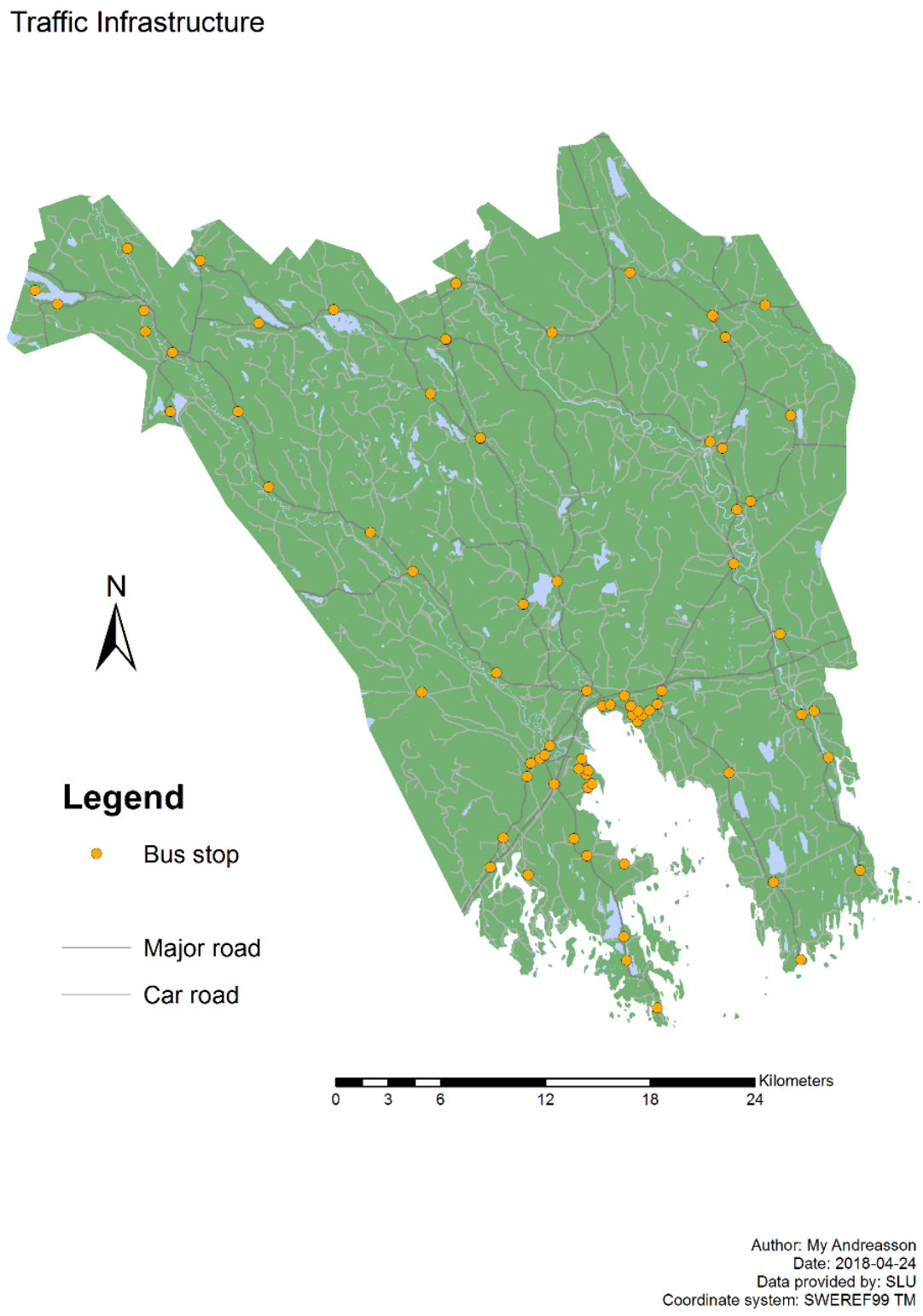

Figure 5. Traffic infrastructure and bus stops.

The citizens in ages 0-6 (left) and 65+ (right), valued as vulnerable water users (see figure 6), are found in many areas of the municipality. When focusing on the areas in Nordmaling Municipality with the highest share of citizens aged 65+ and 0-6 (see figure 7) results show that the highest share (25-50 percent) of citizens aged 0-6 are concentrated to a few areas. Areas with the highest share (72-100 percent) of citizens aged 65+ are found in larger parts of the municipality. Here the distance up to two kilometres from the residence of the different age groups is visualized.

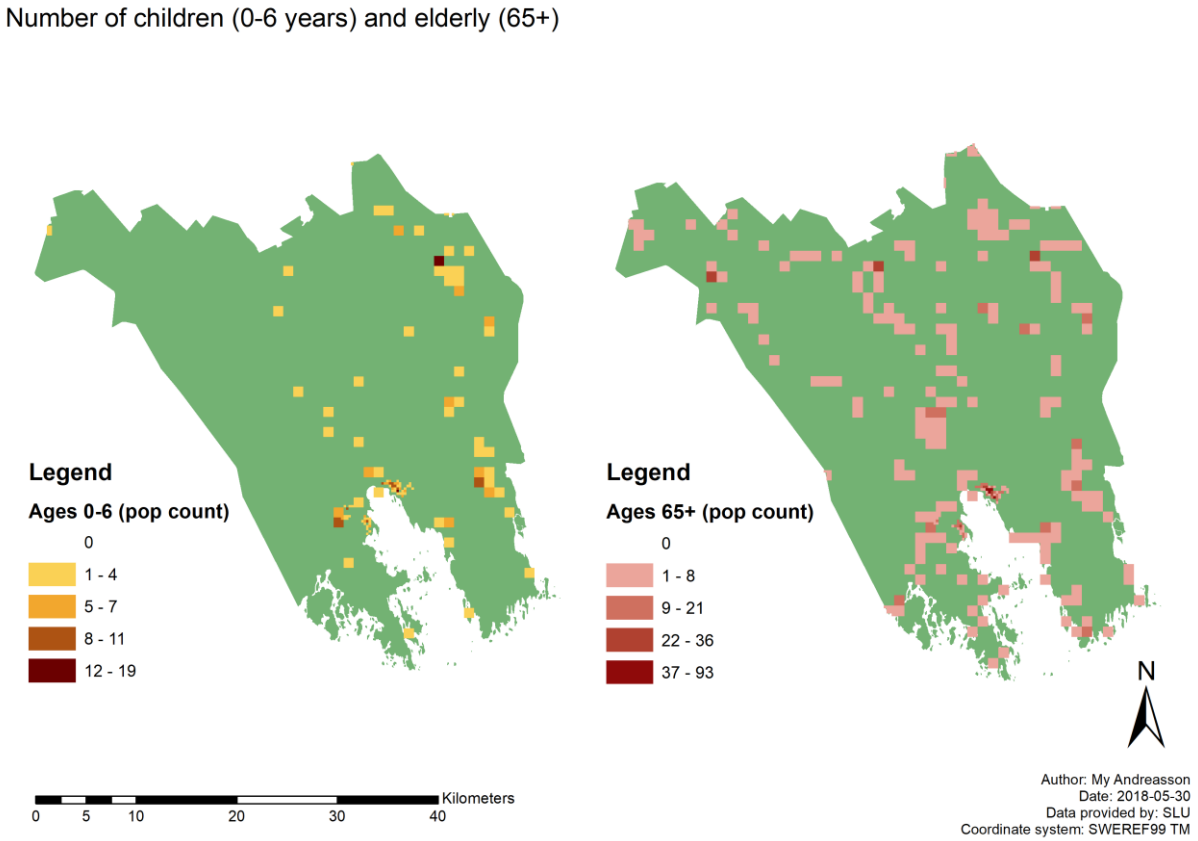

Figure 6. Number of children (0-6) and elderly (65+).

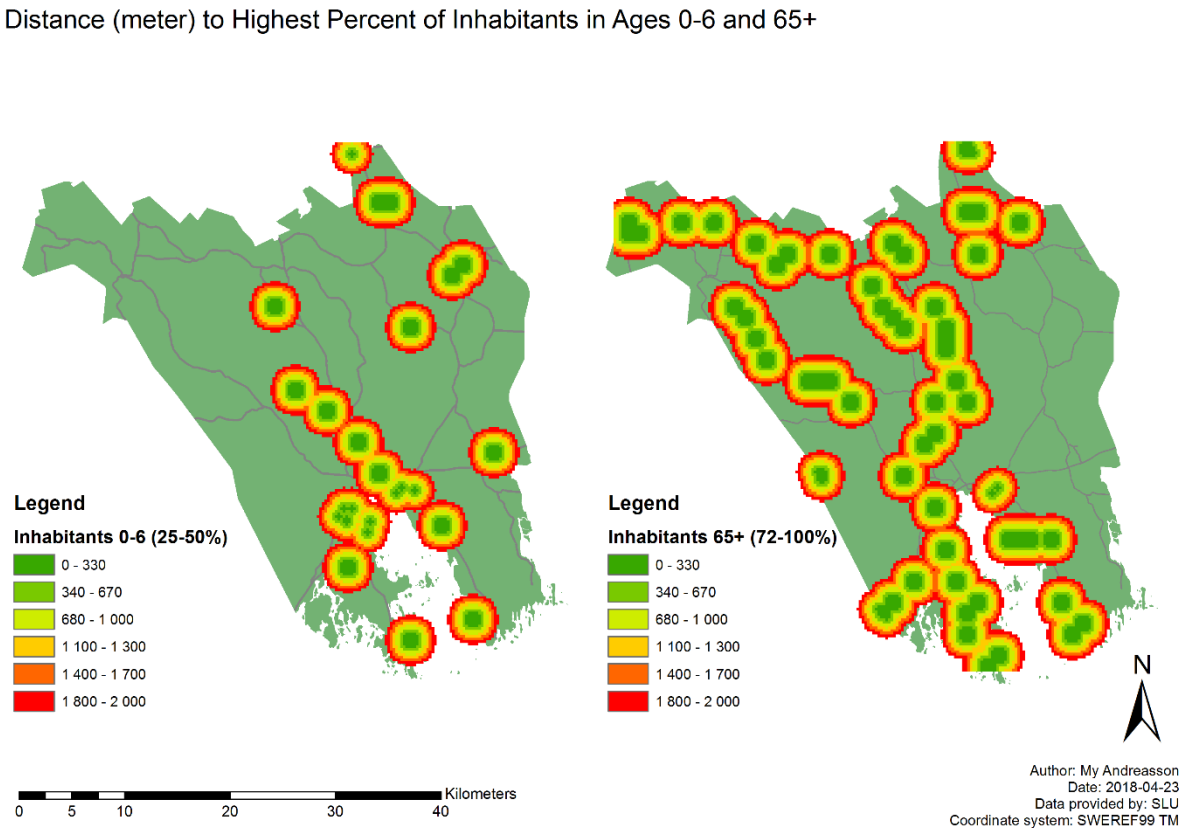

Figure 7. Distance (meter) to areas with highest percentage of inhabitants in ages 0-6 and 65+

As stated, Nordmaling Municipality is sparsely populated and most inhabitants live in central Nordmaling, Olofsfors, Rundvik and Lögdeå (see figure 2, left). In central Nordmaling and Rundvik (see figure 2, right), high settlements and industrial buildings are found, and many areas outside of the densely built-up areas consist of cultivated land. The first selection of locations for emergency water resources shows 72 different locations (see figure 8, left). When looking at inhabitants living in a radius of one kilometre from a location with emergency water resources in the first selection (see figure 9) many locations only have around five inhabitants within a radius of one kilometre and there are still some inhabitants living almost five kilometres from a location with emergency water resources.

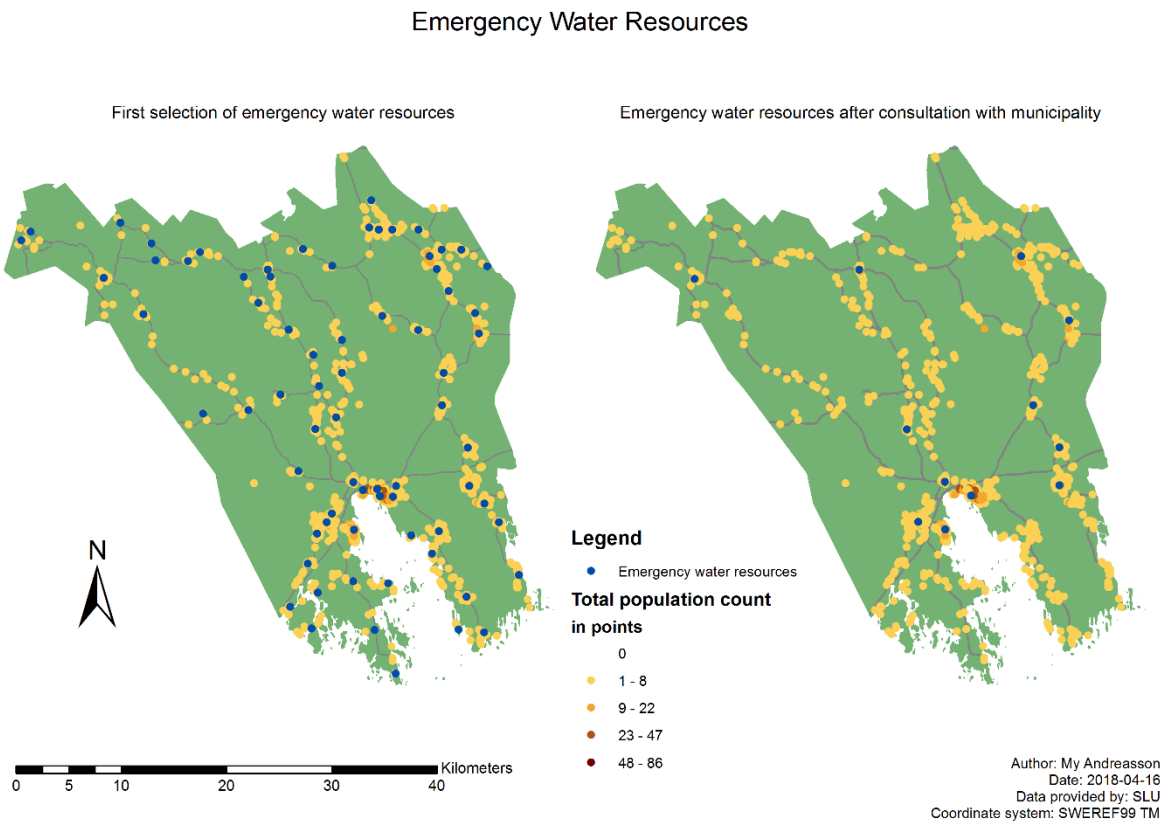

Figure 8. Emergency water resources selection 1 and 2.

When consulting with P. Alfheim (personal communication, 11th of April 2018) the capacity of the municipal administration could not sustain 72 different locations with emergency water resources. Which would require a large amount of material and drivers to sustain all the locations with emergency water. Another concern was that it was important that the locations with emergency water resources was not placed by a roadside, due to the risk of sabotage or stealing. The National Food Agency (2017a) states that locations close to functions or companies create security. Since Nordmaling Municipality is sparsely populated and has large areas of cultivated land many of the locations in figure 8 (left) are by a roadside and therefore also exposed to sabotage or stealing. P. Alfheim (personal communication, 11th of April 2018) also expressed that an emergency water resource could not be placed on someone else's property. This narrowed down the options of different locations in the more sparsely parts in the municipality. A vision from P. Alfheim (personal communication, 11th of April 2018) was therefore to only focus on the largest communities (see figure 1). A selection of fewer emergency water resources was made, which resulted in 12 different locations (see figure 8, right). Here all locations are found in the most densely populated parts of the municipality with the aim to have at least one location in every neighbourhood area. All locations are located at a large parking space, either by a function or company or by a residential area (see table 7 in appendix for a more detailed description of the locations).

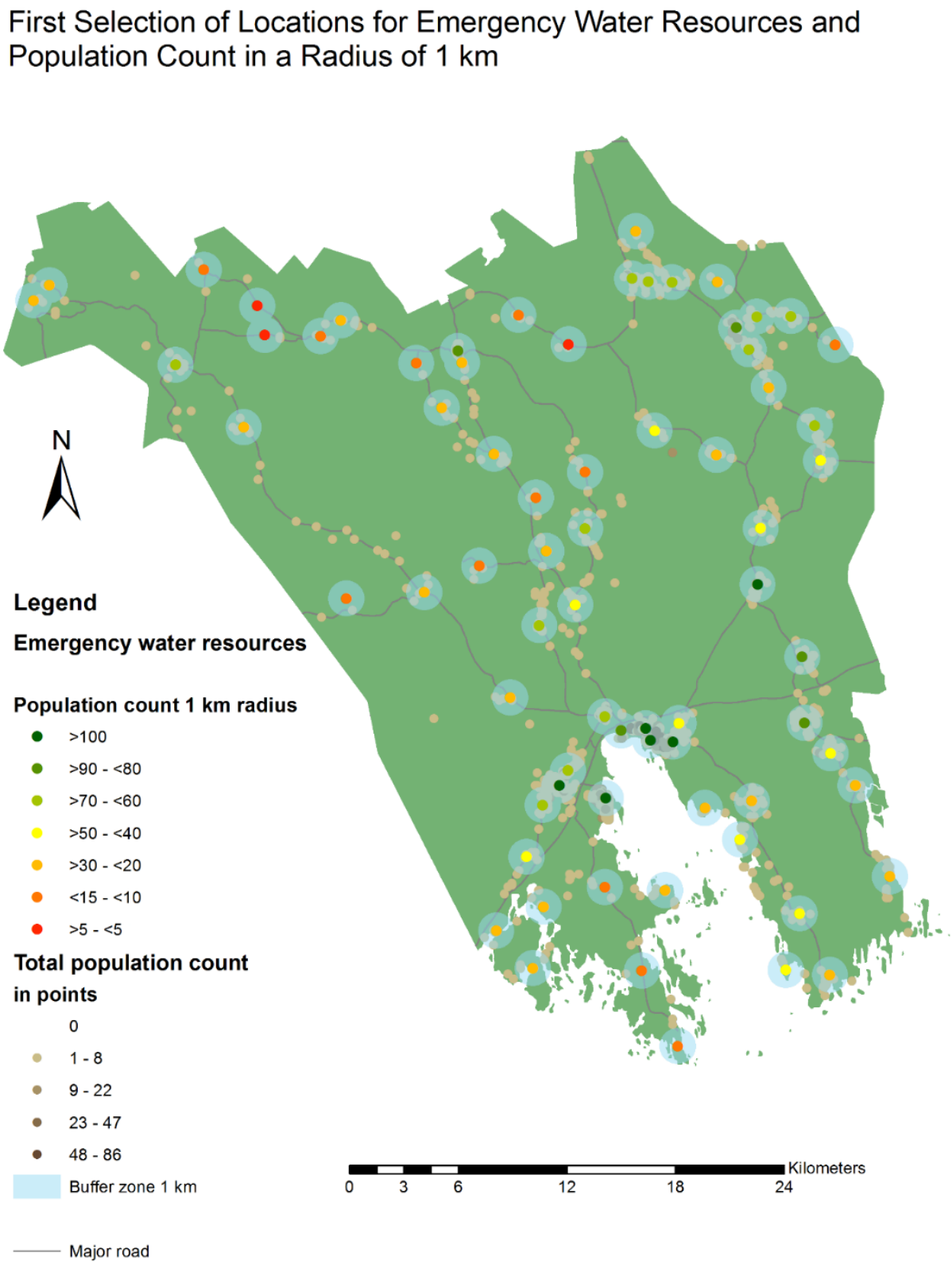

Figure 9. First selection of locations for emergency water resources and population count in a radius of 1 km.

In figure 10 the green bars represent the total population in Nordmaling Municipality distributed to which emergency water location they live closest to in that neighbourhood area. When looking at the inhabitants accessibility to emergency water resources the blue bars in figure 10 shows the number of inhabitants that live in a radius of two kilometres from a location with emergency water resources. This means that there are a total of 1359 inhabitants that live more than two kilometres from a location with emergency water resources in the final selection. If the distance would be decreased to the recommended 500 meters the amount of inhabitants outside of the "catchment-area" would increase even more. However, Hamngatan 8 in central Nordmaling is an exception due to the fact that central Nordmaling is divided between the neighbourhood areas Nordmaling/Levar and Olofsfors, which means that there are more people living two kilometres from Hamngatan 8 even if they live in the neighbourhood area Olofsfors.

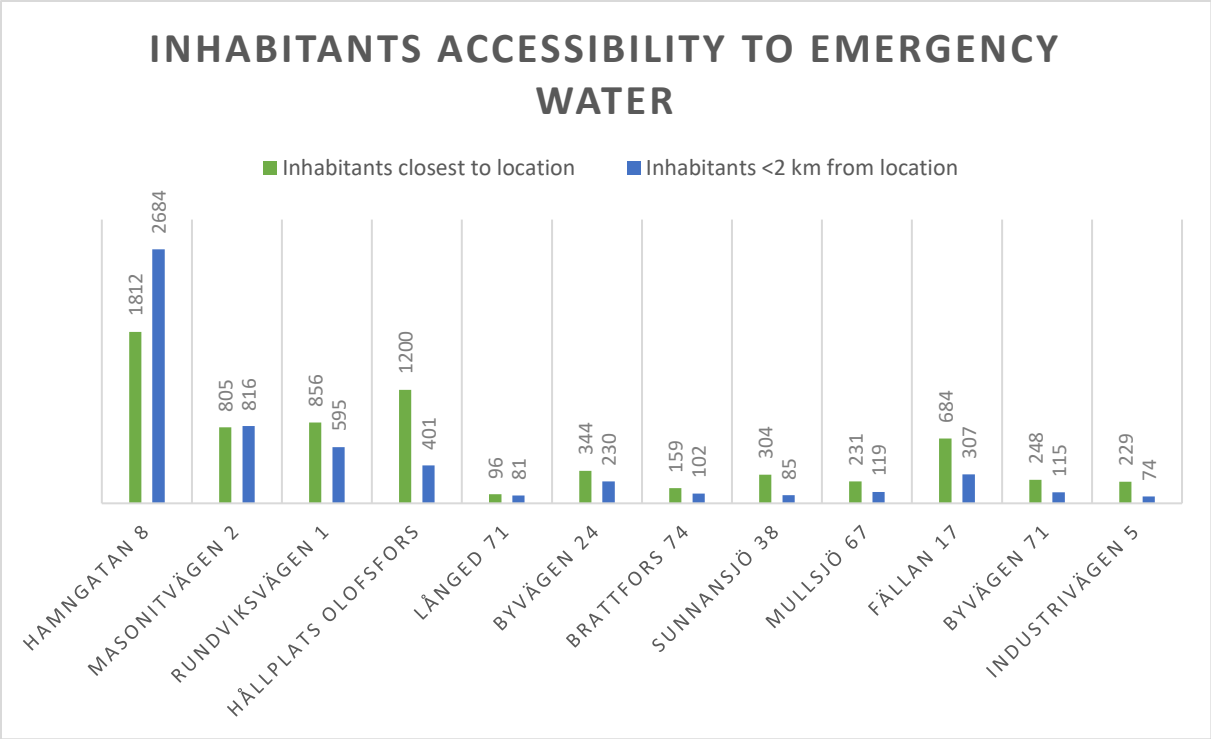

Figure 10. Inhabitant's accessibility to locations with emergency water resources.

When studying the final locations for emergency water resources and the number of citizens in the ages 65+ and 0-6 living more than two kilometres from a location the results show that a large number of elderly (see figure 11) live outside of the "catchment-area". The number of children living outside of the "catchment-area" however is much lower (see figure 12).

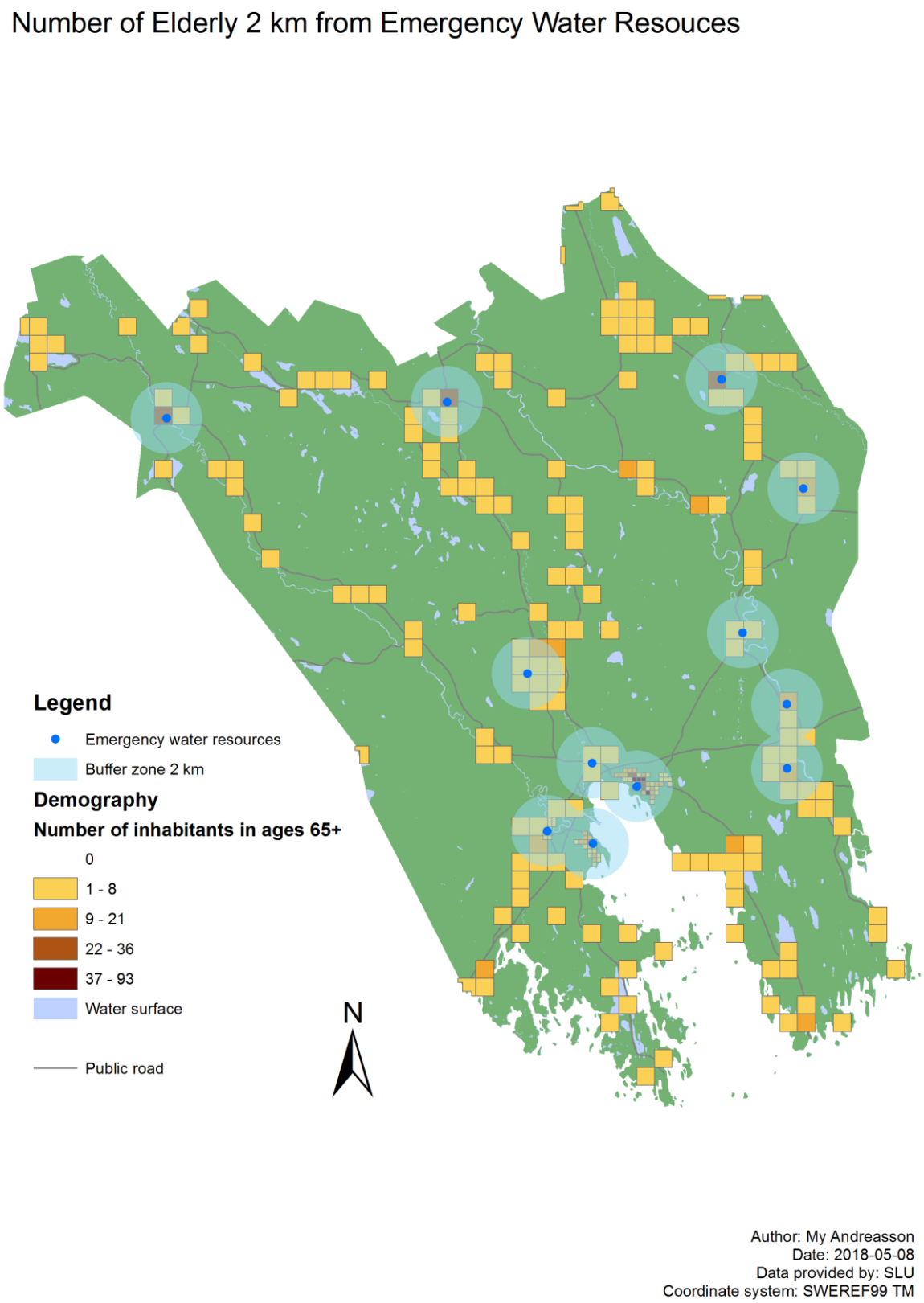

Figure 11. Number of inhabitants in ages 65+ and emergency water resources with 2 km buffer zones.

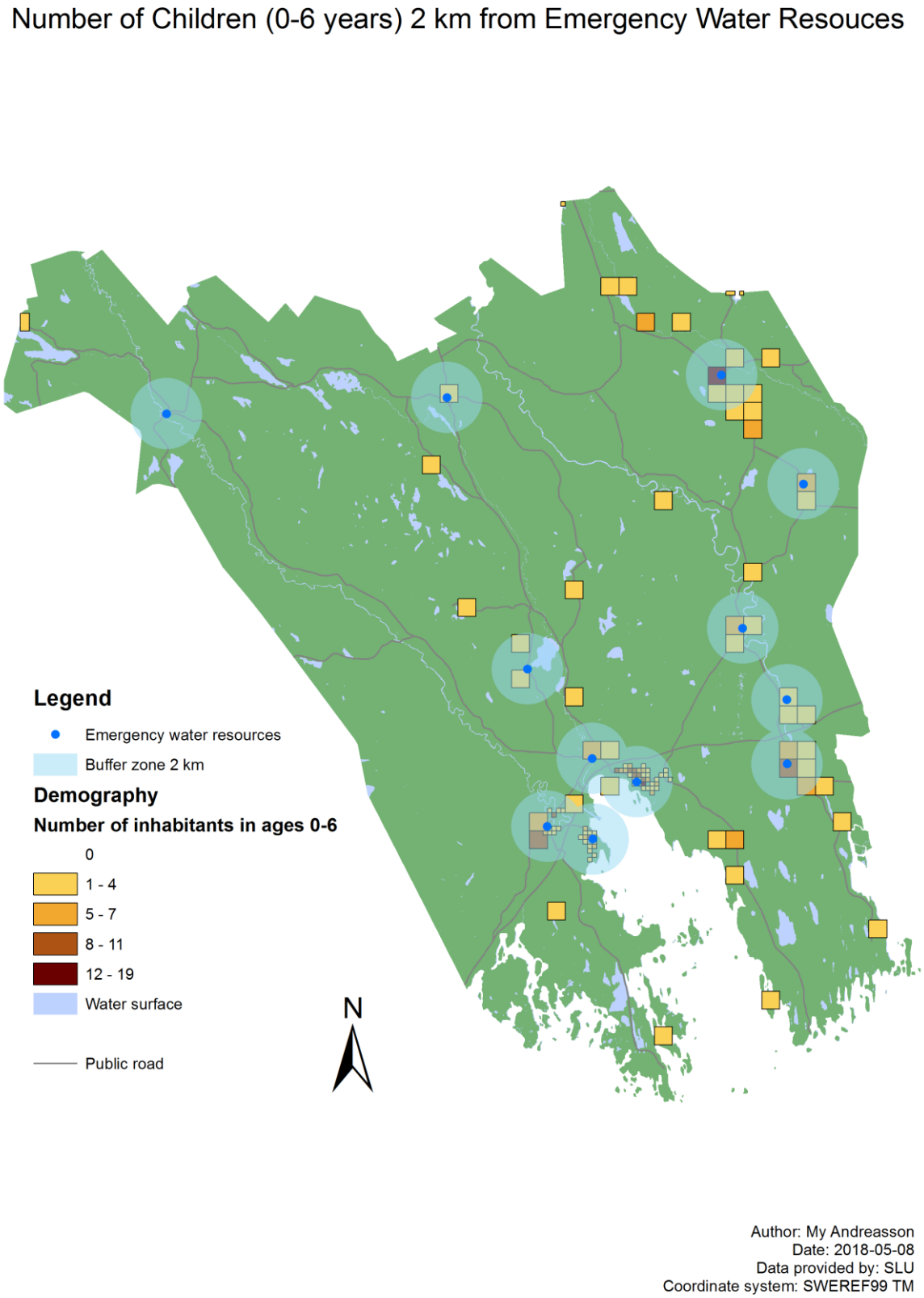

Figure 12. Number of inhabitants in ages 0-6 and emergency water resources with 2 km buffer zones.

The final locations of emergency water resources (see figure 13) shows that in the more densely populated areas the amount of emergency water would have to be 4000-9000 litres/day in order to sustain the inhabitants.

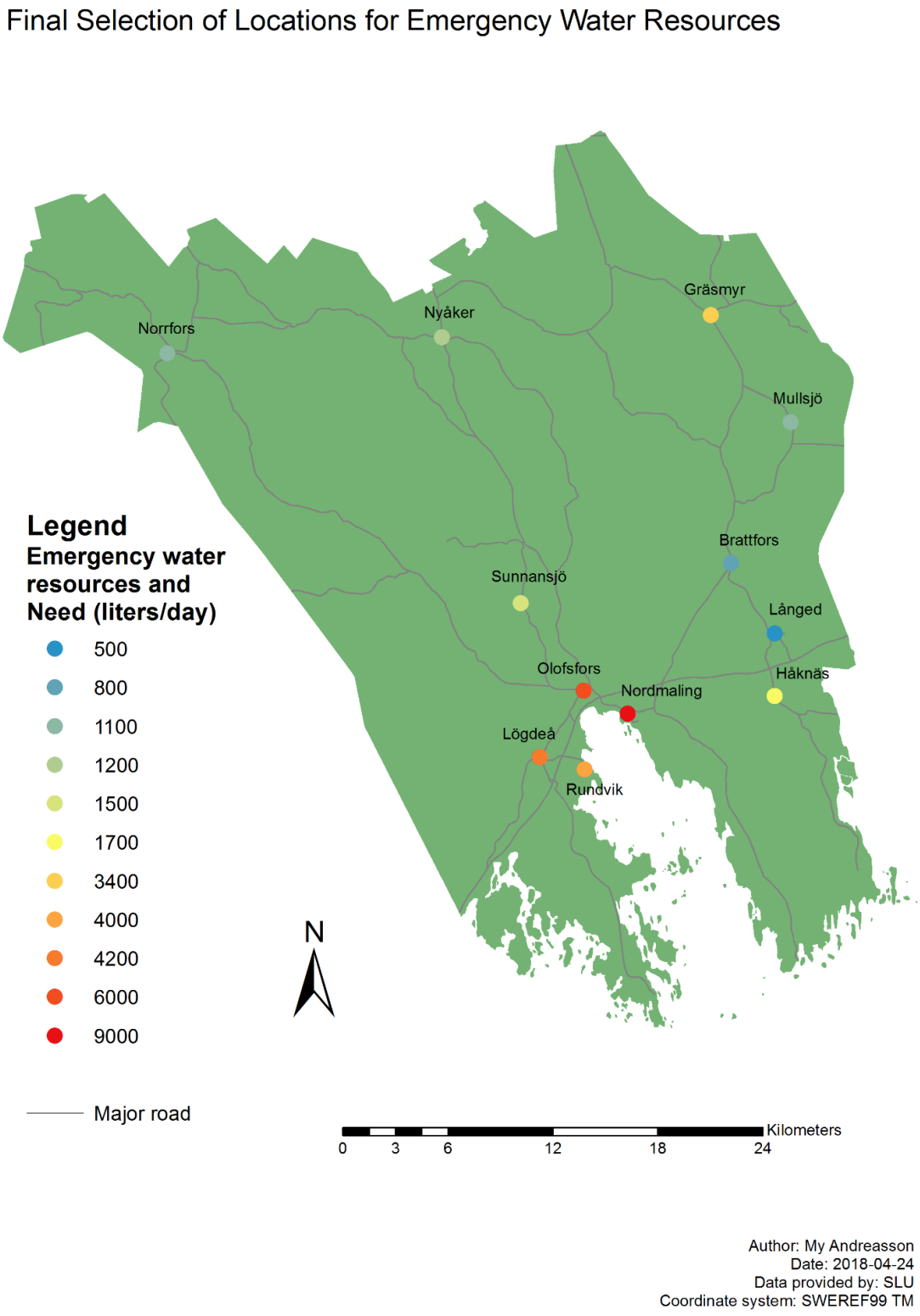

Figure 13. Final selection of locations with emergency water resources and the estimated need (litres/day)

7. Concluding discussion

7.1 Prioritizing of functions and inhabitants

Regulations state that the municipality, according to the Water Service Act and the Responsibility Principle, is responsible for providing drinking water with consideration to people's health and protection of the environment (SOU 2016:32). This concerns both functions and citizens within the municipality. Citizens will obtain emergency water from tanks in different predetermined locations and all inhabitants should be prioritized during a disturbance in drinking water and have access to household uses. But inhabitants that are assessed as vulnerable water users and therefore should be given extra consideration are elderly and children, because of the extra support that elderly need and due to the Convention on the Rights of the Child (Livsmedelsverket, 2017a). But due to other factors that affect the number of different locations, as well as the location itself it is important to reflect upon inhabitant's accessibility to these emergency water resources. This is complex and will therefore be discussed further in section 7.2.

Functions that are prioritized in a situation with emergency water are first and foremost **functions that are of importance for life and health**. These are: Nordmaling health centre, all the nursing homes for elderly and people with disabilities, all short-term and group accommodations as well as the home services. The reason is that care recipients get immediate problems with drinking and hygiene if the function is without drinking water. As long as the requirements from the Water Service Act and Responsibility Principle are fulfilled, decisions of how to prioritize water users are built on the municipalities own decisions (Livsmedelsverket, 2017a). **Functions that are of importance for the society to function** are the fire station, the police station, the municipal administration, as well as all pre- and elementary schools (in the grades F-6). This because the fire station, police station and municipal administration are important from a crisis management perspective. This is also the case for pre- and elementary schools, which need to be open in order for staff within other functions to be able to work. Vattenfall (electricity), Circle K (fuel), Solör Bioenergi (district heating) and two grocery stores are prioritized due to that the society might experience severe consequences if they cannot operate. **Functions that have large financial values** are Nyåkers pepparkakor, which is a food producer and therefore completely dependent on drinking water for the production. However, the consequences are only connected to financial losses. What can be seen as problematic is that this is the only large industry that is included in the emergency water plan. The difference is that the other industries are not in need of communal drinking water in their production, but in order to operate the staff need water for drinking and hygiene, which means that they will have to find their own solutions for providing drinking water to the staff. **Functions that have a large importance for social and cultural values** are Nordmalings riding club, which is dependent on drinking water for the horses. But regulations state that drinking water to animals is the responsibility of the owner and not the municipality (Livsmedelsverket, 2017a). What makes it interesting is that this is the only function with retention that is prioritized. Perhaps it could be seen as unfair against other inhabitants with retention, which will have to find their

own solution to obtain drinking water for their animals during a drinking water disturbance if they today rely on communal drinking water.

Furthermore, there are many functions within the municipality that will not obtain emergency water. But none of them are connected to people's health and protection of the environment and therefore do not violate any regulations. Long-term consequences during a drinking water shortage could include financial losses if large industries cannot operate. Or a negative impact on the local environment if for instance the recycling centre is out of service for a longer period. There are also potential consequences from a crisis management perspective for some individuals if newspapers cannot be delivered with information about the crisis. This could be seen as a weakness with that municipalities are free to prioritize water users as long as regulations are followed, and consequences for the society could occur if the municipal administration lacks knowledge of possible dependencies between functions and why it is important to prioritize them.

7.2 Accessibility to locations with emergency water resources

There are no regulations (only recommendations) defining what is an accessible distance, therefore much seems to be built upon the municipalities own decisions. This has resulted in that decision-makers apply policies based on their own relativist concepts of what is accessible for citizens (Farrington, 2007). The recommended distance of <500 meters (Livsmedelsverket, 2012) has not been followed in Nordmaling Municipality, based on factors such as the capability of the municipality and the needed level of security for the locations, which will be discussed further in this section. The results show that almost 1400 inhabitants live more than two kilometres from a location with emergency water resources (see figure 10), and the citizens that live <500 meters from a location with emergency water resources are those living in the densely built-up areas in 12 of the largest communities. When discussing accessibility, Geurs and van Wee (2004) bring up different components within the concept, such as land use, transportation, temporal and individual components, which reflects the land-use system, the transportation system and the availability of opportunities at different times of the day. But the individual components are especially interesting since this means that accessibility differs based on an individual's needs, abilities and opportunities. These could be age, household characteristics and health issues and there is no absolute distance that is "near" or "far" since this may vary between different individuals (Haugen, 2012).

This makes it interesting to discuss the characteristics of inhabitants within Nordmaling Municipality further. Individual components within the concept accessibility mean that a location for emergency water resources could be inaccessible even with a shorter distance for an individual who may have less mobility because of old age. A location could at the same time be accessible for a person even though it is more than two kilometres away depending on that person's ability, which for example could be the access to a car. Some inhabitants in the sparsely populated parts of the municipality between the communities live around five kilometres from a location, which is a long way to travel with water filled containers. Furthermore, for an elderly

person with reduced mobility traveling with emergency water can be difficult, or even impossible.

It is plausible that a large amount of the 1400 citizens, mainly elderly will have constrained accessibility and might need to be considered in policy-making processes in order to be socially and economically included (Farrington, 2007). Results show that citizens in ages 65+ are found all over the municipality, and an estimated absolute minimum is 150 citizens that live outside of the "catchment-area" of two kilometres (see figure 11). The citizens in ages 0-6 outside of the "catchment-area" is significantly lower. Children are also not as vulnerable to constrained accessibility as elderly due to that they do not live on their own. Furthermore, since such a large number of inhabitants live outside of the catchment-area it is possible to also draw the conclusion that there are individuals that will experience constrained accessibility due to other non-spatial factors. This can be connected to different aspects within the individual component of accessibility, such as individual resources, space-time and social restrictions (Haugen, 2012).

If a maximum distance of one kilometre should be fulfilled and used as a measure for what is accessible the municipality would have to deliver emergency water to at least 72 different locations. But that is not possible due to lack of resources, as well as the needed security and physical space required. For almost all chosen locations emergency water resources were placed next to a facility or business in order to increase the level of security (Livsmedelsverket, 2017a). To place emergency water resources on a roadside was avoided since this would expose it to stealing or sabotage, which has occurred in other incidents where police and military had to be present at the locations of emergency water resources (Barup & Samuelsson, 2010). To sustain 72 different locations with emergency water as well as keeping these locations safe with human resources would therefore be very costly. One can discuss the possibilities of establishing locations for emergency water that are accessible for everyone in the municipality, due to all the different factors that have to be taken in consideration. Furthermore, is it relevant to place emergency water resources in an area with only five inhabitants? However, when looking at examples from other incidents emergency water was delivered to inhabitants who could not get to the location themselves (Barup & Samuelsson, 2010). Perhaps this is one way to bridge the constrained accessibility that some groups and individuals will experience. Even with the complexity of the concept accessibility, it is useful for creating a sustainable society, since greater accessibility within a society leads to greater social inclusion (Farrington, 2007).

7.3. Justice connected to accessibility

The goal for a society should be a condition where accessibility levels are high and equal for all groups and individuals regardless of where they are located (Farrington, 2007). Accessibility is included in the pre-conditions for social justice since the access to important functions, such as drinking water, should include everyone in the society (Farrington & Farrington, 2005). However, a perfectly even development with distributional justice is hard to achieve, and Liljenfeldt (2017) presents the view that without difference there is no geography. Due to the predetermined requirements an even distribution of locations with emergency water resources has not been possible, which Liljenfeldt (2017) states is common for most activities. Perhaps citizens that have chosen to live further away from the more densely built-up areas cannot have

the same justice connected to accessibility? The inhabitants that live further away from the largest communities also have longer distances to other important activities that is located in more densely built-up areas, such as grocery stores, and therefore may have the ability to travel further to importance activities. However one could argue for that a long distance to a grocery store is easier to plan around, compared to long distances to drinking water. Also one cannot assume that the choice to live far from centres and most activities are by choice. The reason could also be due to household characteristics (such as the household's economy), which makes the constrained accessibility for the citizens in more sparsely populated areas problematic. Furthermore, regulations state that all citizens living within a municipality should have access to drinking water for household use, and the society is not just if not all inhabitants have access to it. The access to emergency water falls unevenly on elderly and citizens living in the sparsely populated areas, which therefore are not granted the opportunities of participation in the society due to constrained access. This is a reason to be concerned about the justice within the society (Liljenfeldt, 2017).

7.4 Deficiencies in the method

A large shortcoming of developing an emergency water plan that would be accessible and just for everyone is the issues with not being able to provide a perfect reflection of reality. Relevant information, such as car ownership, state of health, more detailed information of demography, commuters, tourists, asylum-seekers and private wells have resulted in that much of the citizens needs and resources have not been possible to take into account. With more detailed information of inhabitants and non-registered people it would have been possible to see what people within the municipality that require extra help and then make sure that these will have access to emergency water. It could also result in that the capacity is increased during certain times of the year because of tourism. Another positive aspect with more information of citizen's resources would also create an emergency water plan that is more efficient, since it might show which citizens that have the possibility to travel further distances to locations with emergency water resources.

7.5 Future studies

The shortcomings in the emergency water plan shifts focus to how the plan could be further improved and deepened. More time invested in studying the dependencies and consequences for the society would make the plan more viable, especially in a situation of a longer drinking water shortage, which would require that more functions need to be prioritized. A dialogue with those in charge within different functions could also result in better collaboration between them, examples of this can be seen in Östersund where there was a rearrangement within some central kitchens (Ramböll, 2014), which could be done in Nordmaling. Other positive benefits from dialogues could be that a function might not need emergency water delivered but instead could find their own solutions in a crisis situation. In both Helsingborg and Östersund important functions, such as the hospital and police station had their own reserve drinking water source (Johansson et al, 2012; Barup & Samuelsson, 2010). This could be positive for both the municipality that can spend less time delivering emergency water and for the function that does not have to rely completely on the delivery of emergency water. To create a dialogue with other

regions in Västerbotten County could open up for collaboration between municipalities, which have been seen in other incidents (Barup & Samuelsson, 2010). Perhaps Västerbotten could share resources in order to increase the capacity for smaller municipalities like Nordmaling. Furthermore, to actively work with collaboration concerning emergency water planning the viability of the plan could be increased as well. In short, the emergency water plan could be much more viable and reflect the reality better with more in depth studies about functions and possible collaborations, as well as more detailed information of the inhabitant's characteristics in order to make emergency water accessible for everyone.

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9. Appendix

Table 1. Security, protection and municipal administration.

Function	Priority class	Address	Postal code	Location	Coordinates N	Coordinates E
Nordmalings health center	1	Hemvägen 12	91431	Nordmaling	7056213	723751
Fire station	2	Hamngatan 8	91431	Nordmaling	7056762	723009
Police station	2	Storgatan 11	91433	Nordmaling	7056720	723407
Municipal administration	2	Kungsvägen 41	91432	Nordmaling	7056909	723351

Table 2. Nursing homes and home care.

Function	Priority class	Address	Postal code	Location	Coordinates N	Coordinates E
Nursing home Ankaret	1	Genvägen 1	91441	Rundvik	7053738	720483
Nursing home Juliagården	1	Parkvägen 5	91493	Norrfors	7077611	696759
Nursing home Strandholmen	1	Hemvägen 10	91431	Nordmaling	7056319	723724
Nursing home Tallbacken	1	Hemvägen 12	91431	Nordmaling	7056213	723751
Nursing home Tobiasgården	1	Tobiasvägen 10	91495	Gräsmyr	7079801	727677
Group home disability Kungsvägen	1	Kungsgatan 63 D	91432	Nordmaling	7057186	722933
Group home disability Hantverksgatan	1	Hantverksgatan 3	91431	Nordmaling	7057042	723102
Group home disability Hemvägen	1	Hemvägen 5 N	91431	Nordmaling	7056409	723537
Group home disability Envägen	1	Envägen 1	91431	Nordmaling	7056566	722816
Short term accommodation disability Liljan	1	Kungsvägen 63 C	91432	Nordmaling	7057182	722957
Short term accommodation disability Draken	1	Kungsgatan 63 B	91432	Nordmaling	7057214	722945
Home care Nordmalings kommun	1	Kungsvägen 41	91432	Nordmaling	7056913	723357
Home care Aleva Omsorg AB	1	Kyrkogatan 8	91433	Nordmaling	7056780	723260

Table 3. Pre- and elementary schools.

Function	Priority class	Address	Postal code	Location	Coordinates N	Coordinates E
Pre-school Holken	2	Korpvägen 19	91431	Nordmaling	7057327	722514
Pre-school Bergslyan	2	Bergsvägen 36 B	91441	Rundvik	7053327	720592
Pre-school Rödhaken	2	Korpvägen 21	91431	Nordmaling	7057298	722515
Pre-school Skogsdungen	2	Bryggaregatan 5	91432	Nordmaling	7057155	723318
Pre-school Tulpanen	2	Violvägen 12	91433	Nordmaling	7056270	724018
Pre-school Bullen	2	Aspeåvägen 7	91492	Lögdeå	7054200	717683
Pre-school Speldosan	2	Stallgatan 16	91433	Nordmaling	7056762	723717
Pre-school Pepparkakan	2	Byvägen 37	91494	Nyåker	7077634	712583
Pre-school Kullerbyttan	2	Åsvägen 67	91496	Håknäs	7057763	731393
School (2-5) Kyrkovallens skola and school for learing disabilities	2	Skolgatan 1	91433	Nordmaling	7056773	723532
School (F-1) Levarskolan	2	Stallgatan 16	91433	Nordmaling	7056774	723691
School (F-3) Lögdeå skola	2	Aspeåvägen 7	91492	Lögdeå	7054200	717683
School (F-6) Hörnsjö friskola	2	Skolvägen 412	91490	Hörnsjö	7082247	722989
School (F-6) Gräsmyrs skola	2	Fällan 39	91495	Gräsmyr	7079600	727646

Table 4. Energy and fuel.

Function	Priority class	Address	Postal code	Location	Coordinates N	Coordinates E
Solör bioenergi (district heating)	2	Hemvägen 8	91431	Nordmaling	7056260	723553
Vattenfall AB	2	Viltvägen 8	91432	Nordmaling	7057679	723082
Circle K	2	Kungsvägen 94	91432	Nordmaling	7057745	722681

Table 5. Grocery stores.

Function	Priority class	Address	Postal code	Location	Coordinates N	Coordinates E
Coop konsum	2	Kungsvägen 47	91432	Nordmaling	7056965	723221
ICA supermarket	2	Butiksgatan 2	91432	Nordmaling	7056591	723138

Table 6. Food industry and retention.

Function	Priority class	Address	Postal code	Location	Coordinates N	Coordinates E
Nyåkers pepparkakor	4	Stationsvägen 11	91494	Nyåker	7078394	712517
Nordmalings ridklubb	5	Torsbäcken 14	91491	Nordmaling	7058287	721568

Table 7. Information of emergency water locations.

Neighborhood Area	Address	Postcode	Location	Coordinates N	Coordinates E	Emergency water need first day (2,5-5 liters/p/day)	Emergency water need day 2 and 3 (10-15 liters/p/day)	Comments
Nordmaling/Levar	Hamngatan 8	91431	Nordmaling	7056743	723009	9000	18000	The fire station. Access to reserve power.
Rundvik	Masonitvagen 2	91441	Rundvik	7053543	720550	4000	8000	Next to NLS, Handlar'n and Resturang & Pizzeria Picaroon.
Logdea	Rundviksvagen 1	91492	Logdea	7054250	717988	4200	8400	Next to Little Bobbys I Logdea AB and Norr.
Olofsfors	Hallplats Olofsfors	91491	Nordmaling	7058061	720509	6000	12000	Next to bus stop close to Olofsfors AB. Large parking space without possibility to keep emergency water resource inside.
Haknas	Langed 71	91490	Nordmaling	7061343	731405	500	1000	Large parking space next to Anders & Nils Oscarssons Skor.
Haknas	Byvagen 24	91496	Haknas	7057754	731412	1700	3400	Next to Kullerbyttans pre-school och Haknas elementary school.
Haknas	Brattfors 74	91490	Nordmaling	7065353	728927	800	1400	Next to bus stop. Large parking space but close to private homes without possibilities to keep emergency water resource inside.
Sunnansjo	Sunnansjo 38	91491	Nordmaling	7063072	716885	1500	3000	Large parking space next to the company Ylva Hagglund.
Grasmyr	Mullsjo 67	91480	Nordmaling	7073439	732329	1100	2200	Large parking space close to private homes, without possibilities to keep emergency water resource inside.
Grasmyr	Fallan 17	91495	Grasmyr	7079551	727751	3400	6800	Large parking space next to Bilisten Grasmyr and ICA Nara Grasmyr Bensin & Livs.
Nyaker	Byvagen 71	91494	Nyaker	7078282	712377	1200	2400	Large parking space, ca 100 m from Nyakers pepparkakor, without possibilities to keep emergency water inside.
Norrfors	Industrivagen 5	91493	Norrfors	7077375	696683	1100	2200	Large parkingspace next to Nya Norrfors Mekaniska AB.