# Extreme Rainfall Plan for Sundsvall Municipality

Action plan for priority sites of community importance

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# 1. Introduction

Sundsvall Municipality's Extreme Rainfall Plan was developed in the Collaborative Learning Initiative Managing and Adapting to The Environment (CLIMATE) project. This project has been funded with support from the EU — the Interreg Programme for the Northern Periphery and Arctic (NPA) — as well as Region Västernorrland and Sundsvall Municipality.

# 2. Summary

As the climate changes, the community increasingly needs to adapt. Stormwater management has been identified as one of Sundsvall's key adaptation requirements for our expected future climate. This action plan aims to reduce the risk of adverse impacts of extreme rainfall events, which are expected to become both more intense and more frequent in the years ahead.

The action plan identifies several priority sites in central Sundsvall. All the sites selected have key community functions and are subject to the risk of dangerously high water levels after heavy downpours. The risk assessment was based on a model that simulates extreme rainfall events over Sundsvall. Mapping of extreme rainfall can continue to serve as a knowledge basis for ongoing community planning and an information service to external parties.

As the lowest adaptation level for the sites of community importance in this action plan, the baseline chosen was a 100-year rainfall event* to which a 'climate change factor' (multiplier) was applied. For sites that are especially vital to the community, like the Hospital, a higher level of adaptation (500-year rainfall event) was found necessary. Adaptation levels were chosen based on national recommendations and other cities' cost-benefit analyses.

The sites under municipal management identified were placed in an internal order of priority and split into three categories, according to the years by which the sites must be investigated in detail. Investigation of each site must include an impact assessment for an extreme rainfall event on the defined scale. Where measures are clearly needed, action proposals and cost-benefit analyses of introducing the recommended measures must also be developed.

# 3. Background

Excessive rainfall and flooding have occurred throughout history, and happen every year in several locations in Sweden, often at great cost to the community. Heavy downpours can also potentially lead to life-threatening situations due to landslides or extreme flood water depths.

An 'extreme rainfall event' (*skyfall*) is defined by the Swedish Meteorological and Hydrological Institute (SMHI) as 50 mm or more of rain falling in one hour, or at least 1 mm in one minute. An extreme rainfall event may also be seen as consisting in rain too heavy for the designed capacity of the public stormwater mains.

* A '100-year rainfall event' is one with rainfall levels reached or exceeded once every 100 years on average.

In the acute phase of an extreme rainfall event, many municipalities have experience of working through the Emergency and Rescue Services, which can put temporary flood banks and pumps in place. Many, however, lack an integrated long-term plan for all the municipal administration for reducing damage from heavy downpours. A probable factor contributing strongly to this state of affairs is that responsibility for dealing with water volumes exceeding the dimensioned capacity of the water and sewerage (WS) systems has not been assigned.

Precipitation management in Sweden has long focused on capacity in stormwater mains pipes, but dimensioning these pipes to suffice for all expected extreme rainfall events is not economically defensible or always practically feasible. Minimising costs that result from intense rainfall requires not only action plans for the acute phase, but also long-term spatial planning of above-ground stormwater management.

## 3.1 Extreme rainfall in Sundsvall

Sundsvall was hit by several major floods in the early 2000s because of extreme rainfall. The costs of damage to the Municipality's various services from just one of the extreme rainfall events in the early 2000s amounted to approximately SEK 65 million. In 2011, once again, there was extensive flooding when it rained 77 mm in 2 hours; this caused, for example, 80 basement floods due to hydraulic overload in the mains pipes.

With a warmer climate, heavy bursts of intense rainfall are expected to become considerably more common in the Sundsvall of the future. SMHI's climate simulations show that successive rises in autumn and winter precipitation volumes are likely. Between now and 2070, extreme rainfall events with an average return period (recurrence interval) of 10 years are expected to be roughly 25 per cent more intense.

Several preventive measures to enhance resistance to extreme rainfall events have been implemented in Sundsvall since the heavy downpours of the early 2000s. Action has included implementation of the Sundsvall CLIMATE project, which was intended to boost knowledge of potential implications of climate change for the Municipality and its activities. In this project, stormwater management was found to be one of the Municipality's greatest and most crucial needs for adaptation to an expected future climate.

# 4. Objective

The objective of this action plan is to help reduce the impacts and restoration costs of future extreme rainfall events in Sundsvall.

Known and particularly vulnerable locations and sites must, in the long term, be adapted to enable risks of future damage and disruptions to be minimised. One important part of this work is to spread knowledge of the risks associated with extreme rainfall events in Sundsvall, both internally within the municipal organisation and externally to other stakeholders.

Municipal employees involved in planning, permit management, supervision, procurement, project planning and construction must be well aware of the problems of intense rainfall, and must use the mapping of extreme rainfall that has been developed.

When Sundsvall Municipality invests in new buildings and infrastructure or converts existing structures, these must be adapted to withstand heavy future downpours in a changed climate.

# 5. Scope and limitations

The action plan for extreme rainfall covers the central parts of Sundsvall. The high-density urban development and the city's geographical location make the risk of flooding due to excessive rainfall considerably higher in the centre of the Municipality than elsewhere. In the long term, action plans should also be developed for the Municipality's local service hubs.

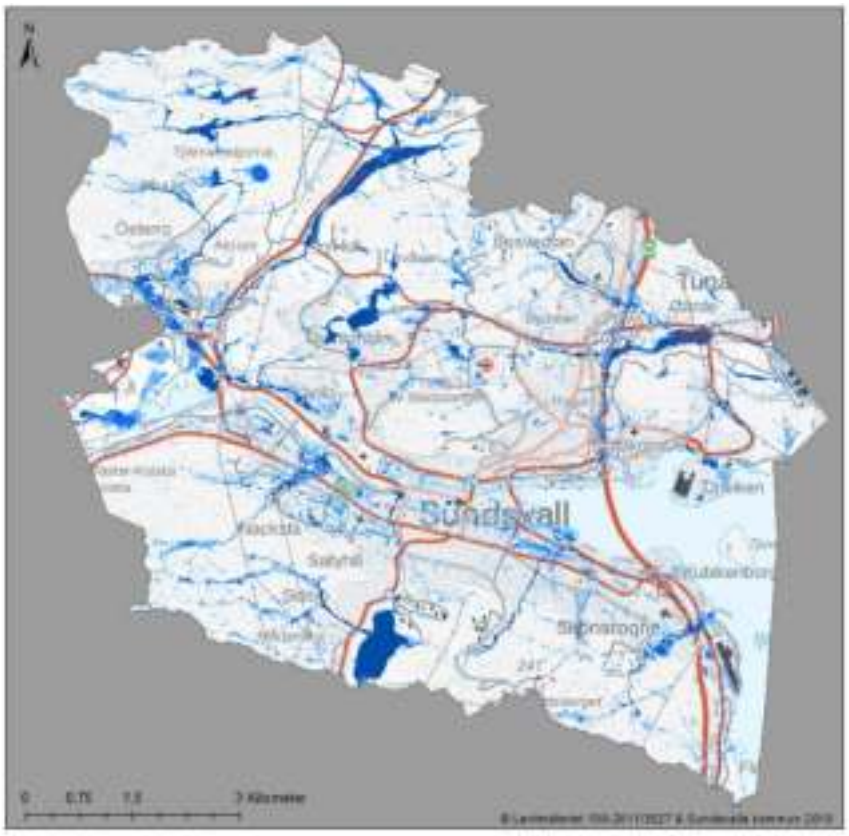


**Image 1. Geographical demarcation of the municipal extreme-rainfall map.**

The action plan does not cover flood risk from high water levels in the sea or watercourses, such as the Selångersån river. In the longer term, extreme-rainfall mapping should be supplemented with flow calculations in watercourses to give a more accurate picture of flood risks in areas close to the watercourses.

The plan contains no action proposals. For suitable measures to be devised, in-depth studies and cost-benefit calculations are required for each individual site. Instead, the plan provides an overview of the sites seen as most in need of adaptation in community terms, and lists priority the Municipality should adopt for investigating the sites within its area of authority.

# 6. Mapping extreme rainfall

The mapping of extreme-rainfall mapping developed to date is intended to serve as a knowledge basis for the Municipality's ongoing spatial planning, and as information for external parties facing the risk of flooding during intense rainfall events.

The model shows probable ranges for surface runoff during extreme rainfall events, and the water depths that may be expected. Designated risk areas need to be investigated in more detail for identification of appropriate measures that can reduce the risk of adverse effects.

Various scenarios can be simulated in the dynamic extreme-rainfall model that has been developed. Initially, three categories of rainfall event, with estimated statistical return periods of 30, 100 and 500 years, have been selected. To adjust historically measured volumes of rain to the expected future increases in rain intensity, the rainfall has been multiplied by a climate change factor of 1.25.

When precipitation comes in from the east and/or southeast, rain volumes may rise by 20–40% in central Sundsvall. This phenomenon is caused by the precipitation-boosting effect above the mountains around the city. Since this local increase is not discernible in the historical statistics, past figures have been multiplied by 1.3 over and above the climate change factor to compensate for the local boost to precipitation. This multiplier is applied throughout the model area.

The duration of the rainfall simulated in the model has been six hours, with varying intensity during these hours to resemble a typical extreme rainfall event. Below, the simulated volumes of rain are shown. The total rain volume is based on local historical measurements with an added climate change factor and local boosting effect.

| | **30-year rainfall event** | **100-year rainfall event** | **500-year rainfall event** |
|---|---|---|---|
| Total volume (mm) | 94.3 | 137.4 | 229.9 |
| Intensity, max (mm/h) | 191.8 | 286.0 | 488.1 |
| Intensity, min (mm/h) | 3.4 | 4.5 | 6.8 |
| Intensity, average (mm/h) | 15.7 | 22.9 | 38.3 |
| Intensity, median (mm/h) | 6.6 | 9.2 | 14.9 |

During extreme rainfall, the capacity of the water mains network is of limited importance in relation to the large water volumes that arise. In the development of the runoff model, much time and resources have therefore been saved by excluding precise modelling of the mains network's capacity. Instead, to avoid overestimating distribution areas and water depths during extreme rainfall, standard deductions from mains capacity corresponding to a five-year rainfall event have been made for all paved surfaces.

## 6.1 Limitations of extreme-rainfall model

The model of extreme rainfall that has been developed gives a simplified picture of reality, and the outcome involves uncertainties that those who interpret the results should bear in

mind. The model is suitable as a basis for identifying areas that are particularly vulnerable to such rainfall. In these areas, new, more high-resolution models, which are also combined with field measurements and inventories, are needed for suitable action proposals to be devised.

The calculations in the extreme-rainfall model have been made with a spatial resolution of 4 metres square. In some cases, this can lead to misleading results. Problems can arise, for example, when two buildings are less than four metres apart. The model does not then take note of the passage between them; instead, it treats the two buildings as a single, connected structure that blocks the water from flowing. In the results, because of this, there is a risk that bodies of water may, misleadingly, appear more extensive than they are.

The fact that a general estimate of the mains network's capacity has been used instead of its actual capacity entails a further source of uncertainty. In cases where the actual capacity is greater than what is simulated there is, again, a risk of the flooding shown in the model being more widespread than in reality and vice versa. However, in simulations of extreme rainfall, any such difference is relatively insignificant.

Watercourses are not correctly described in the model. How far culverts and mains inlets stem the flow is exaggerated in this model, compared with a hydrologically correct description of the watercourses. This makes the results associated with watercourses uncertain as well, even if a hydrologically correct account is, broadly, deemed to show the same problem areas.

Peak water levels in Sundsvall occur almost exclusively within six hours. However, in the model there are natural land areas where runoff times are longer than this. Accordingly, full runoff from these areas does not take place within the time used in the calculation. The runoff from these areas nevertheless collects in streams, which are not described in this model.

# 7. Adaptation level

There is no law in Sweden that regulates the minimum permitted performance of a WS system. Instead, this level is governed by a national industry standard (known as '*P110*'), which is set by the Swedish Water & Wastewater Association (SWWA). Pipe requirements vary, depending on the type of building development in the area. The most stringent requirement is for new systems in central developments: these must handle flows corresponding to rainfall events with a return period of 30 years. WS facility owners are not responsible for water volumes exceeding this level.

There is a lack both of legislation and of a general industry standard on the severity of extreme rainfall events a town or city should be capable of managing when rain volumes exceed the WS network's capacity. The Swedish Civil Contingencies Agency (Myndigheten för samhällsskydd och beredskap, MSB) and SWWA recommend adopting, as the minimum safety level in terms of damage to buildings in new developments, a return period of at least 100 years, multiplied by a climate change factor. However, it is up to each municipality to decide which level will apply.

In planning their adaptation to climate change, several urban areas in Sweden and other countries have already chosen a 100-year rainfall event as their baseline. Economic benefits

have been assured through cost-benefit analyses of climate change adaptation in, for example, Copenhagen. This analysis shows that a level of adaptation to extreme rainfall statistically likely to recur once in 100 years is clearly economically viable for the community.

WS facility owners' planning responsibility for stormwater extends only up to 30-year rainfall events, in accordance with the industry guidelines in *P110*. According to MittSverige Vatten & Avfall's (MSVA) stormwater guidelines, new projects are intended to investigate what flows can be expected in at such a low frequency as a 100-year rainfall event. However, the Municipality's responsibility for adaptation, planning and measures to manage rainfall events is greater than that of WS facility owners —that is, up to a 30-year rainfall event.

The level of 100-year rainfall events has been chosen as the lowest in terms of adaptation for the priority sites in this action plan. Sites considered particularly vital have been made subject t, an adaptation level for 500-year rainfall events. The specific water depths that are acceptable for these rainfall events have not been stated, since they can vary greatly based on the sites' divergent conditions. However, the requirement is that it must be feasible to maintain the activities without major disruptions at the respective adaptation level assigned.

# 8. Site prioritisation

For the community's continued functioning despite flooding caused by intense rainfall, it is vital to identify activities and sites for primary protection, to avoid human injuries and major disruptions to the area. In this action plan, site selection is based on the following criteria.

**Vital community infrastructure**
This category comprises physical infrastructure that helps to preserve vital community functions, such as electrical substations, transformers, WS and communication facilities, and critical roads and railway lines.

**Vital community services**
These are services that need to function to prevent crises arising or to manage them once they have arisen. They are activities of such importance that a loss of, or serious disruption in, their functioning would entail great risk or danger to residents' lives and health. They may, for example, include hospitals, emergency and rescue services or health and social care.

**Other priority sites**
These are areas or sites that, in the event of flooding, may have major negative impacts on society. Examples are environmentally hazardous activities, polluted land and facilities whose activities are unique or otherwise risk affecting a high proportion of the population.

A number of sites that are, according to the extreme-rainfall maps, at risk of being flooded in a 100-year rainfall event, and also meet one or more of the criteria, have been identified. However, it is not practical or financially feasible to simultaneously investigate and rectify all the areas identified. Priority ranking of the sites under municipal management has therefore been carried out, with specific years by which, at the latest, they must have been surveyed.

Each individual investigation must answer the questions of whether, when and how suitable adaptation measures should be implemented. For the sites under municipal management, the costs of more detailed investigation of the risk situation and any appropriate measures have been estimated. Note that the costs of implementing measures are not included in the estimated cost of investigation. The true cost of the investigation may, moreover, prove to be higher or lower than the estimate.

The priority scheme for further investigation of sites under municipal management has been determined on the basis of points scored in the following four assessment areas:

**Impact**
A relatively high impact in the form of, for example, risk to life and health, major environmental impact or far-reaching economic consequences gives a higher score. Since this category is considered to be the most important, points scored in this category have been multiplied by 3.

**Complexity**
Sites considered to require measures that are relatively complex and/or costly have been given a lower score than those judged to be less complex to remedy.

**Modification**
Sites that may be come to be affected by ongoing or planned modification (and thus have potentially lower adaptation costs) get higher scores. Since this category is judged to be of greater importance in the ranking than Complexity and Synergies, points have been multiplied by 2.

**Synergies**
The sites judged remediable by means of multifunctional surfaces or measures that could otherwise yield positive side effects, over and above mere reductions in negative effects, during intense rainfall have been given a higher score.

To rank the sites internally, all the sites in each area have been assigned 1–5 points, where a higher score gives a higher priority than a lower one. Based on the total aggregate points from all the areas, the sites identified have then been divided into three according to target year. By the end of these years, the sites concerned must have been investigated in detail.

Investigation of each site must include a detailed impact statement for a 100-year or, alternatively, 500-year rainfall event, depending on site type. If the need for measures is ascertained, concrete proposals for measures must be developed. A cost-benefit analysis must also be carried out for implementation of the proposed measures. The years by when the sites must be investigated are 2020, 2022 and 2024 (see Appendix 1).

# 9. Municipally run sites identified

### Sundsvall Central Station
Priority: 2020

**Responsible**: Swedish Transport Administration/Sundsvall Municipality — Urban Planning Department

**Adaptation level**: 100-year rainfall event

**Impact**: 4

**Complexity**: 3

**Modification**: 5

**Synergies**: 2

**Estimated investigation cost**:

SEK 50–100 thousand

**Image 2. Sundsvall Central Station in a simulated 100-year rainfall event.**

#### Description

The Central Station, one of Sundsvall's two train stations, is of designated national interest and great importance for anyone travelling by train. The Station, with its associated rail yard, is also vital for the large volumes of goods that pass through Sundsvall daily. In the rail yard, which includes a goods area, various petroleum products and chemicals that can be harmful to the environment are also stored. The Central Station will be converted into a new travel hub, with the addition of a coach terminal by 2020.

#### Risk

The extreme-rainfall mapping shows the risk of water depth levels of 20–70 cm throughout the track area in a future 100-year rainfall event. The volumes of floodwater pose not only a risk of all train traffic being disrupted, but also a significant environmental risk, since the water can affect and disperse substances, including oil pollutants deposited in the soil.

#### Requirements

A detailed investigation, culminating in recommendations to enable the Central Station to withstand a 100-year rainfall event with no major disruptions or negative environmental impacts, should be implemented before or during the conversion of the station area into a new travel centre. The investigation should be carried out by the Swedish Transport Administration, which is responsible for the rail yard, in collaboration with the Municipality, which is in charge of the waiting room and the planned bus and coach terminal. The Urban Planning Department is responsible for liaising with the Transport Administration.

## **Sidsjö Dam**. Priority: 2022

**Responsible**: Sundsvall Municipality — Urban Planning Department

**Adaptation level**: 500-year rainfall event

**Impact**: 5

**Complexity**: 3

**Modification**: 1

**Synergies**: 2

**Estimated investigation cost**: SEK 100–150 thousand

**Image 3. Sidsjö Dam after extreme rain in August 2001.**

### Description

Sidsjön is a lake area just south of central Sundsvall, popular for recreation and rambling. Without Sidsjö Dam, the expanse of the reflecting Sidsjö water would be considerably smaller than it is today.

### Risk

A dam breach at Sidsjön could have catastrophic consequences for downstream settlements and endanger people's lives and health. In the event of damage to the Dam, the operation of the Sidsjöverket power station is also at risk. The latter lies immediately downstream of the Dam and has several important functions for Sundsvall's drinking water supply, including emergency water supplies.

### Requirements

An investigation of the Dam's status should be made to ensure that it can withstand a 500-year rainfall event with no risk of a dam breach.

## Parkgatan: main road

Priority: 2020

**Responsible**: Sundsvall Municipality — Urban Planning Department

**Adaptation level**: to be investigated

**Impact**: 4

**Complexity**: 3

**Modification**: 5

**Synergies**: 1

**Estimated investigation cost**: SEK 300–400 thousand


**Image 4. Parkgatan in a simulated 100-year rainfall event.**

### Description

The thoroughfare of Parkgatan, with its viaduct under the railway, is strategically important, not least for the Emergency and Rescue Services, which use it as an emergency route. Historically, this is a place that has been hit by severe floods on numerous occasions.

### Risk

Extreme-rainfall mapping indicates major problems with a risk of water over 3 metres deep in the viaduct during a future 100-year rainfall event. A closed viaduct leads to considerably longer response times for the Emergency and Rescue Services, which are then forced to take detours. There is also a marked risk of inattentive drivers driving down and getting stuck in the water. In the worst-case scenario, if the water level rises rapidly, this could endanger life and health.

### Requirements

The Municipality is responsible for Parkgatan, and therefore also in charge of investigating suitable measures concerning the viaduct.

## SOS Alarm/Emergency and Rescue Services

Priority: 2022

**Responsible**: Sundsvall Municipality — Emergency and Rescue Services/Drakfastigheter

**Adaptation level**: 500-year rainfall event.

**Impact**: 5

**Complexity**: 3

**Modification**: 3

**Synergies**: 1

**Estimated investigation cost**: SEK 25–75 thousand

**Image 5. SOS/Emergency and Rescue Services in a simulated 100-year rainfall event.**

### Description

During historical extreme rainfall events, the building that houses SOS Alarm and the Fire Station has been badly affected by flooding. The functioning of these services can be directly crucial for life and health, and it must therefore be able to withstand a 500-year rainfall event without major disruptions.

### Risk

Extreme-rainfall mapping indicates that a 100-year rainfall event already poses a risk of high water levels in the area.

### Requirements

Planning is under way to relocate the Emergency and Rescue Services, so it is important to ensure that the new location is suitable in terms of flood risk. To save resources, it should be investigated whether any feasible temporary contingency measures can safeguard the functioning of the Services, until their relocation, during a 500-year rainfall event. Sundsvall Municipality owns the building and is responsible for investigating which measures are required.

**Oil Harbour**. Priority: 2024

**Responsible**: Sundsvalls Hamn AB/Private — Svenska Cellulosa Aktiebolaget (SCA)

**Adaptation level**: 100-year rainfall event

**Impact**: 3

**Complexity**: 3

**Modification**: 1

**Synergies**: 2

**Estimated investigation cost**: SEK 50–100 thousand


**Image 6. The Oil Harbour in a simulated 100-year rainfall event.**

## Description

The Oil Harbour (Oljehamnen), located on Vindskärsudde on the south side of the Firth of Sundsvall (Sundsvallsfjärden), is run by Sundsvalls Hamn AB. Sundsvall Municipality owns 85% of the company and SCA owns 15%. The Harbour is of great importance for the handling of petroleum products for the Middle Norrland region. Petroleum products are stored both in rock shelters and in above-ground cisterns.

## Risk

There are environmentally hazardous activities with soil pollution, and cisterns and rock shelters with large quantities of environmentally hazardous substances, posing a risk of dispersion during floods.

## Requirements

Sundsvalls Hamn AB needs to investigate possible measures so that the Harbour can withstand a 100-year rainfall event without the risk of major disruptions or spread of hazardous substances.

**Korstaverket power station**.
Priority: 2024

**Responsible**: Sundsvall Energi
**Adaptation level**: 500-year rainfall event
**Impact**: 4
**Complexity**: 3
**Modification**: 1
**Synergies**: 1
**Estimated investigation cost**: SEK 25–75 thousand

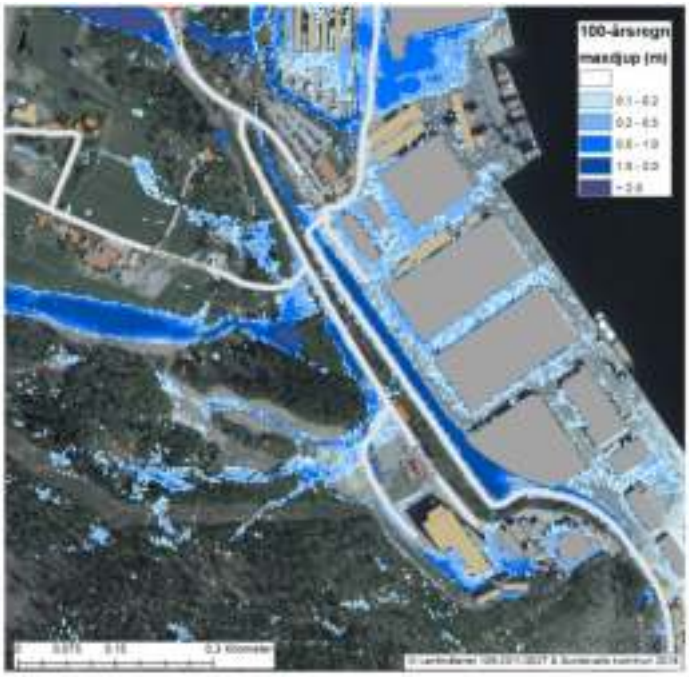

**Image 7. Korstaverket in a simulated 100-year rainfall event.**

### Description

Korstaverket power station at Tunadal Harbour is a key facility for Sundsvall Energi AB, which is a wholly owned subsidiary of Sundsvall Municipality through the Municipality's parent company Stadsbacken AB. The station produces heat for the district heating network and energy for the electricity grid through waste incineration. This facility is considered especially important to the community since disruptions have repercussions on energy and heat supply to large parts of Sundsvall. Owing to the risk of major negative impacts in the event of a disruption, an adaptation level for a 500-year rainfall event is recommended for the facility.

### Risk

Extreme-rainfall mapping shows a risk of water levels exceeding 50 cm around the buildings during a 100-year rainfall event, and a few more decimetres in a 500-year rainfall event.

### Requirements

Sundsvall Energi needs to investigate what measures are required for the facility to withstand a 500-year rainfall event without major disruptions.

## 9.1 Other priority sites

### **Water supply**. Priority: Continuous work

**Responsible**: MittSverige Vatten & Avfall (MSVA)

**Adaptation level**: 100-year rainfall event

#### Description

Within the investigation area, there are several critical facility elements for the water supply: mains pipe networks, reservoirs, aerators, booster stations and valve chambers.

#### Risk

A heavy downpour corresponding to a 100-year rainfall event means a risk of the Obs — Bydalen booster station being flooded. A general risk of pipe breakage exists in vulnerable locations as a result of mudslides and landslides.

#### Requirements

Today, MittSverige Vatten & Avfall is already prepared to manage risks linked to extreme weather conditions. The company works continuously to improve safety at the facility within the framework of regular maintenance operations. The risks to existing installations should be taken into account in spatial planning, building conversion and new construction.

### **Wastewater treatment works**. Priority: Continuous work

**Responsible**: MittSverige Vatten & Avfall

**Adaptation level**: 100-year rainfall event

#### Description

Within the investigation area, there are several installation elements for wastewater disposal: water mains networks, wastewater treatment plants and pumping stations.

#### Risk

The existing tunnel entrance to the Tivoli facility is in the risk zone at high water levels. Several pumping stations may be affected if water levels are high. The consequences could be flooding of wastewater into the recipient (Selångersån out to Sundsvall Bay).

#### Requirements

Today, MittSverige Vatten & Avfall is already prepared to manage risks linked to extreme weather conditions. The company works continuously to improve safety at the facility within the framework of regular maintenance operations. The risks to existing installations should be taken into account in spatial planning, building conversion and new construction.

**Electricity grid**. Priority: Continuous work

**Responsible**: Sundsvall Elnät

**Adaptation level**: 100-year rainfall event

### Description

Within the investigation area, there are numerous power distribution boxes, cable terminal cabinets and transformer stations, all of which are highly vulnerable to flooding. At a water depth of 0.2 m, their operation is already liable to be knocked out.

### Risk

Widespread flooding is likely to affect a large number of electrical facilities that could take a long time to restore to working order, resulting in major disruptions to the community.

### Requirements

Investigating which facilities are at risk of being affected by extreme rainfall is essential. The locations of the grid and transformer stations should be included in the comprehensive and/or detailed development plan. For existing plants that may be located in areas with flood risk, Sundsvall Elnät should investigate whether it is economically viable to relocate these to a safe level for floods.

# 10. Non-municipally run sites identified

## County Hospital

**Responsible**: Region Västernorrland

**Adaptation level**: 500-year rainfall event

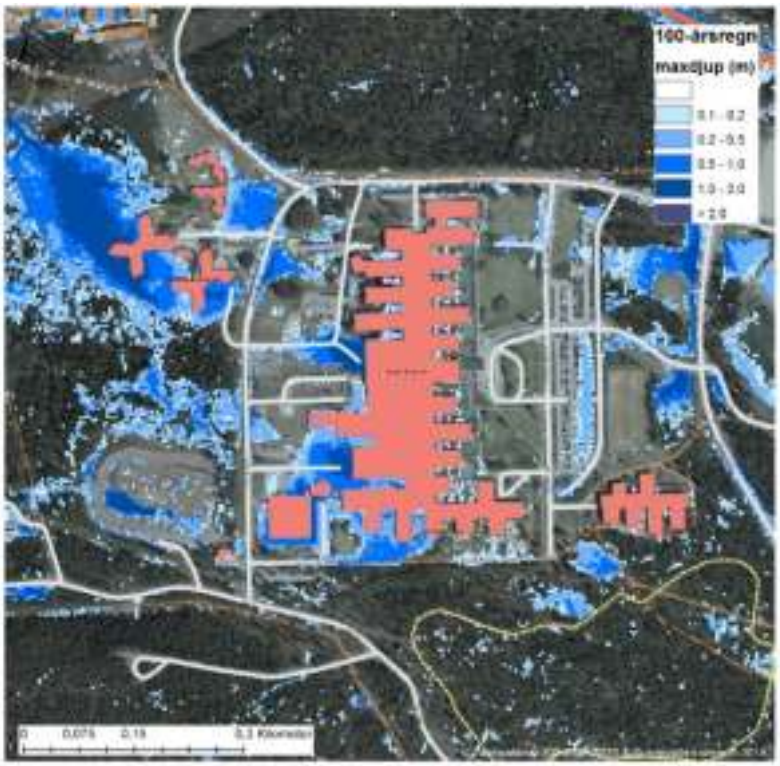


**Image 8. The County Hospital in a simulated 100-year rainfall event**

### Description

The County Hospital in Sundsvall has such a vitally important function in the community that it should have an adaptation level to withstand a 500-year rainfall event without major operational disruptions.

### Risk

Extreme-rainfall mapping indicates the risk of significant disruptions during a 100-year rainfall event. Along the building's west and south sides, the water levels could be 50 cm or more. There is a risk not only of the water entering the building, but also of it affecting accessibility for ambulances and other traffic to and from the Hospital.

### Requirements

The Hospital is owned by Region Västernorrland, which is thus responsible for investigating which climate-change adaptation measures are suitable for the building and surrounding land. Until a long-term solution has been adopted for the area, the Emergency and Rescue Services should prepare an action plan to deal with the situation in an acute phase.

## Sundsvall Forensic Psychiatric Hospital

**Responsible**: Region Västernorrland

**Adaptation level**: 100-year rainfall event

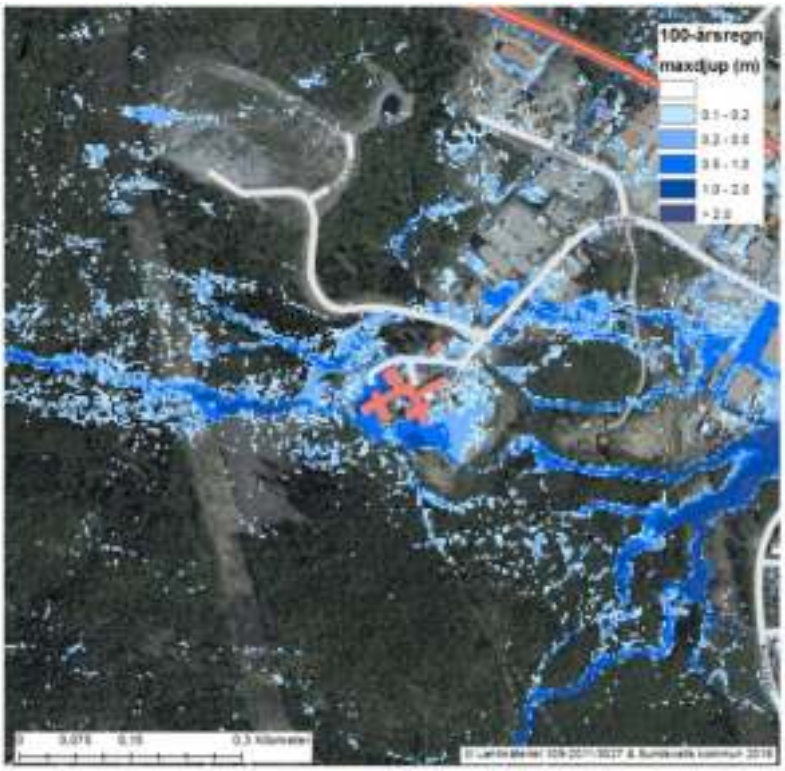


**Image 9. Sundsvall Forensic Psychiatric Hospital in a simulated 100-year rainfall event.**

### Description

The regional Forensic Psychiatric Hospital in Sundsvall is one of Sweden's largest inpatient units for the care and treatment of mentally ill offenders. The Hospital's ambition is to always be able to accommodate and receive patients 24 hours a day.

### Risk

Extreme-rainfall mapping shows a risk of water levels exceeding 1 metre adjacent to the building in a 100-year rainfall event.

### Requirements

Region Västernorrland owns the building and is responsible for investigating measures. Measures should be taken to ensure that buildings do not need to be evacuated during future extreme rainfall events.

## Granlo Electrical Substation

**Responsible**: Eon

**Adaptation level**: 500-year rainfall event


**Image 10. Granlo Electrical Substation in a simulated 100-year rainfall event.**

### Description

The Electrical Substation in Granlo supplies large parts of Sundsvall with electricity. It is therefore considered to be of particular importance to the community, and should have an adaptation level for a 500-year rainfall event.

### Risk

During historical extreme rainfall events, the area has proved to be subject to major floods. Extreme-rainfall mapping indicates a risk of extreme flooding around the electrical substation, with water depths of up to several metres. In addition to major operational disruptions, there is also a risk of environmentally hazardous substances spreading during a flood.

### Requirements

The substation is owned by Eon, which is thus responsible for investigating which measures to counteract flooding are appropriate. Measures may be necessary on surrounding land, and this may necessitate cooperation with the Municipality.

## The railway line

**Responsible**: Swedish Transport Administration

**Adaptation level**: 100-year rainfall event

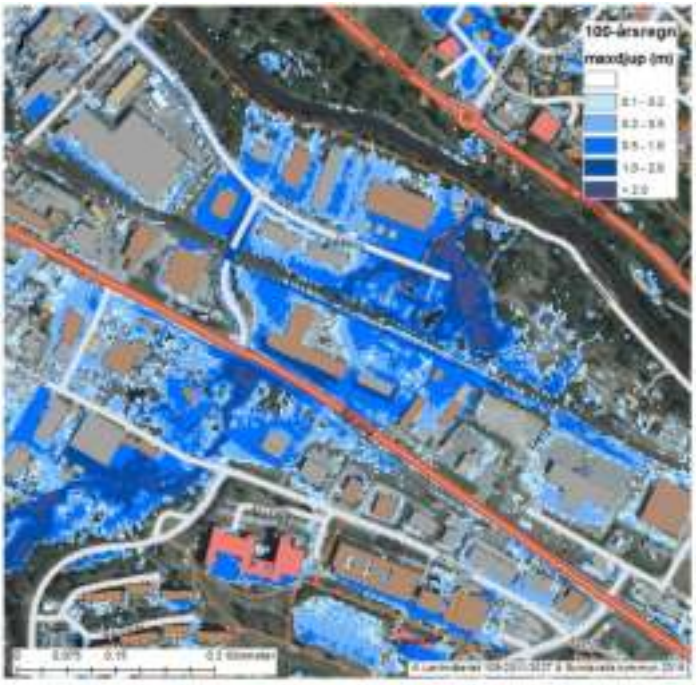


**Image 11. The railway line across Sandbergsbäcken in a simulated 100-year rainfall event.**

### Description

The railway line is defined as being of national interest and has a vital function in the community, affecting transport options both for Sundsvall and the rest of Sweden.

### Risk

With flooding on and around the railway line, electricity and signal technology functions are at risk. High flows and water levels could also create landslides and undermine the tracks. In a 100-year rainfall event the railway line, which runs through central Sundsvall, is at risk of flooding in several places or being undermined by water. Extreme-rainfall mapping indicates a particularly high flood risk at the Central Station and where the railway line crosses the two streams (Sandbergsbäcken and Sidsjöbäcken).

### Requirements

A more detailed map of the railway route through Sundsvall is necessary, to allow clearer identification of where the flood and erosion risks are greatest. In the two streams, Sidsjöbäcken and Sandbergsbäcken, flow calculations should be carried out to ensure that the culverts diverting water under the railway are dimensioned to handle expected flows during at least a 100-year rainfall event. Regular inspections of drains and culverts should be carried out to prevent clogging. The Swedish Transport Administration is responsible for investigation.

## European Highway E4

**Responsible**: Swedish Transport Administration

**Adaptation level**: 100-year rainfall event

**Image 12. The E4 at the northern abutment in a simulated 100-year rainfall event.**

### Description

European Highway E4, which extends through Sundsvall, is of national interest. The road is not only an important route for local and regional traffic, but also vital for the Emergency and Rescue Services, which have considerably further to travel during an emergency response if they cannot use the E4.

### Risk

Extreme-rainfall mapping indicates that the greatest risk of problems is at Kubikenborg Aluminium AB (Kubal) and the roundabouts at the southern and northern abutment, and in Skönsberg and Gärde. At all these sites, there is a risk of 50 cm of water or more in a 100-year rainfall event. A water depth of 50 cm will also make access difficult for the Emergency and Rescue Services' vehicles, with their relatively high ground clearance. Flooding of the areas around Kubal and the Oil Harbour entails risks of cisterns being undermined and pollutants deposited in soil and sediment dispersed.

### Requirements

The Swedish Transport Administration is responsible for the maintenance of the E4 and needs to investigate what measures are required for the road to manage a 100-year rainfall event. Measures taken should ensure not only that the E4 can withstand a 100-year rainfall event, but that polluted land adjacent to the road is not flooded. Measures may therefore need to be implemented jointly with the Municipality and private stakeholders.

## European Highway E14/Bergsgatan

**Responsible**: Swedish Transport Administration

**Adaptation level**: 100-year rainfall event

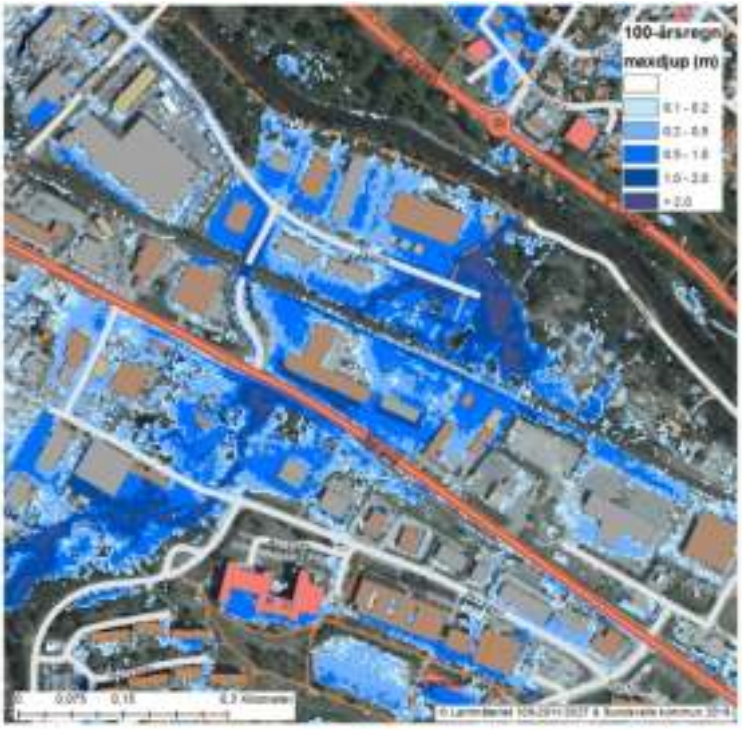


**Image 13. Bergsgatan (E14) at Sandbergsbäcken in a simulated 100-year rainfall event.**

### Description

European Highway E14 connects Sweden's east coast at Sundsvall with the Norwegian coast at Stjørdal and is therefore an important transport route for people and goods alike. The road, like the E4, is an important part of the national road network and is of national interest. The E14 through Sundsvall is also an important emergency route for the Emergency and Rescue Services.

### Risk

Extreme-rainfall mapping indicates that the E14 is at risk of flooding in Nacksta, with water depths of up to 1 metre in a 100-year rainfall event. There is a risk of problems arising, especially where Sandbergsbäcken is culverted under the road. The stormwater is eventually discharged into the Selångersån river.

### Requirements

The Swedish Transport Administration is responsible for the E14 and should calculate the expected flows in Sandbergsbäcken during a 100-year rainfall event and investigate whether culvert capacity is sufficient. Given the high flood risk for the railway line in the same area, investigations and recommendations should be coordinated.

## Social Insurance Agency and Government Employee Pensions Board

**Responsible**: Fastighets AB Örebacka (property company)

**Adaptation level**: 100-year rainfall event


**Image 14. FK and SPV in a simulated 100-year rainfall event.**

### Description

The Swedish Social Insurance Agency (Försäkringskassan, FK) and the Swedish National Government Employee Pensions Board (Statens tjänstepensionsverk, SPV) are two central government institutions that are considered to be of particular importance to Swedish society. Operational disruptions exert effects not only locally in Sundsvall, but also nationally.

### Risk

Extreme-rainfall mapping shows the risk of water depths of up to 1 metre adjacent to the buildings during a 100-year rainfall event.

### Requirements

The properties are privately owned, and the Municipality therefore lacks a management role. Instead, responsibility for measures lies with the owner or the operator. Actions taken by the Municipality will inform the persons responsible about flood risk.

## 10.1 Other priority sites

**Industrial areas and environmentally hazardous activities**

Supervisory authorities can act on the basis of the Swedish Environmental Code's general rules on due care and consideration, and of the Ordinance on Operator Self-inspections regarding risks associated with extreme rainfall. At the beginning of 2018, a new chapter in the Environmental Code entered into force whereby operators must also identify risks and describe the consequences of climate change in their environmental impact assessments and strategic environmental assessments.

A list of existing environmentally hazardous activities at risk of being affected by flooding from future extreme rainfall events must be compiled, to enable information on the risk situation at each site to be communicated. The CEO's Staff are responsible for issuing this information and, assisted by the Environmental Office, they also investigate which activities to contact. The work of contacting current activities must be completed in 2019.

**Residential areas**

Many individual buildings in various residential areas are subject to flood risk in future extreme rainfall events. According to the law, the Municipality may not favour individual private property. In these cases, the Municipality's task will therefore be to inform the property owners of the flood risk so that the owners themselves can decide which preventive measures, if any, to take.

### SCA Ortviken paper mill

At this site, there are environmentally hazardous activities with soil pollution. The operator must be informed of the flood risks in the event of extreme rainfall and requested to take appropriate adaptation measures.


**Image 15. SCA Ortviken paper mill in a simulated 100-year rainfall event.**

## Kubikenborg Aluminium AB (Kubal)

There are environmentally hazardous activities with soil pollution. The operator must be informed of the risks of flooding in the event of extreme rainfall and requested to take appropriate adaptation measures.


**Image 16. Kubal in a simulated 100-year rainfall event.**

# 11. Recommendations for further work

The action plan for priority sites of community importance should be seen as the beginning of more extensive adaptation to extreme rainfall in Sundsvall Municipality. While the priority sites in the action plan were being developed, several additional measures outside the scope of this action plan were identified. Needs are listed below to serve as a basis for continued work on reducing the risk of damage due to excessive rainfall in Sundsvall Municipality.

- The current action plan covers the central parts of Sundsvall only. In the long term, corresponding action plans should also be developed for the service hubs in the Municipality and the area north of the centre, including such areas as Birsta.

- The mapping of extreme rainfall that was developed as a basis for the action plan should, to reduce cartographic uncertainties, be supplemented with models of watercourses and hydraulic calculations relating to the mains network.

- Besides action plans for priority sites of community importance, comprehensive structural plans for stormwater management should be drawn up on the basis of watersheds. Clear structural plans can serve as a long-term planning basis with scope for enhancing resilience, during extreme precipitation, of large parts of built-up districts in vulnerable areas. A long-term structural plan also enables measures in connection with other ongoing modifications. If it is feasible to coordinate extreme-rainfall measures with other modifications, this can yield major cost savings.

- Decisions should be made about a general level of planning for new construction and a long-term level of ambition for existing buildings regarding the volumes of rain that should be manageable without causing significant negative impacts. Simultaneously, it is necessary to determine acceptable water levels for a defined rainfall category. We suggest following the recommendations in the Swedish Water & Wastewater Association's (SWWA) Publication *P110*, which proposes a 100-year rainfall event as a minimal level in planning of new construction. A 100-year rainfall event may also be a suitable level for what should be manageable for existing buildings in the long term.

- A model that takes into account surface drainage, watercourses and mains networks affords major advantages in planning work for both MittSverige Vatten & Avfall (MSVA) and Sundsvall Municipality's Urban Planning Department. However, the questions of who is to be responsible for administering shared models and how personnel resources and funding of updates etc. should be apportioned need to be clarified.

# Appendix 1. Weighting of priority sites

| Site | Impact | Complexity | Modification | Synergies | Total |
|---|---|---|---|---|---|
| Sundsvall Central Station | 12 (4x3) | 3 | 10 (5x2) | 2 | 27 |
| Parkgatan: main road | 12 (4x3) | 3 | 10 (5x2) | 1 | 26 |
| SOS Alarm/Emergency & Rescue Services | 15 (5x3) | 3 | 6 (3x2) | 1 | 25 |
| Korstaverket power station | 12 (4x3) | 3 | 2 (1x2) | 1 | 18 |
| Sidsjö Dam | 15 (5x3) | 3 | 2 (1x2) | 2 | 22 |
| Oil Harbour | 9 (3x3) | 3 | 2 (1x2) | 2 | 16 |

| Year | 2020 | 2022 | 2024 |
|---|---|---|---|
| Score | 26–45 | 19–25 | 7–18 |
| Number | 2 | 2 | 2 |

| Sites not under municipal management |
|---|
| Granlo Electrical Substation |
| FK & SPV |
| Railway |
| European Highway E4 |
| European Highway E14 |
| Hospital |
| Forensic Psychiatric Hospital |
| SCA Ortviken paper mill |
| Kubal |