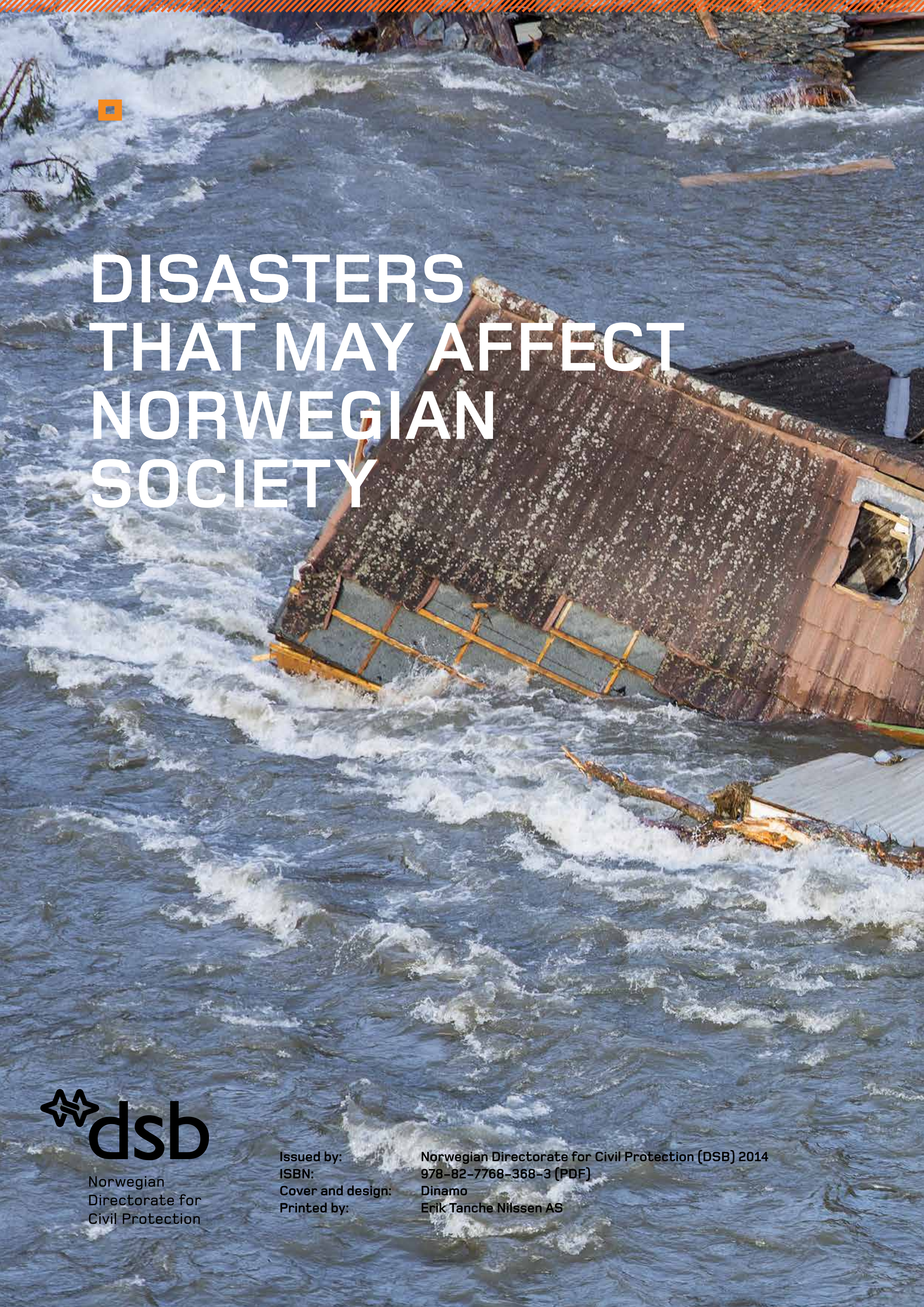
Norwegian Directorate for Civil Protection

National Risk Analysis 2014



DISASTERS THAT MAY AFFECT NORWEGIAN SOCIETY

Norwegian
Directorate for
Civil Protection

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FLOODING IN WESTERN NORWAY
The Flåm River spilled over its banks due to large amounts of precipitation at the end of October 2014, causing a great deal of damage to buildings and properties. Around 200 persons were evacuated from their homes. Photo: NTB/Scanpix

PHOTO: NTB/SCANPIX

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IN WHAT MANNER IS ONE'S OWN SECTOR AFFECTED BY THE EVENTS, AND WHAT RESPONSIBILITY DOES THE INDIVIDUAL SECTOR HAVE FOR PREVENTING AND HANDLING THE EVENTS?

JANUARY FIRE: The major heath fire in Flatanger in Nord-Trøndelag that broke out on 28 January 2014 spread quickly and uncontrollably in strong wind after a long period of drought. Approximately a hundred buildings in Hasvåg and Småværet were lost in the fire.

PHOTO: NTB/SCANPIX

FOREWORD

The Norwegian Directorate for Civil Protection must have a general overview of risk and vulnerability within society. Work on the National Risk Analysis, NRA, is an important part of this. We know that the capacity to acknowledge risk and learn from experience are essential in order to be well-equipped to tackle new crises and disasters. And we do not know for sure what the next disaster will be.

I would like to quote the 22nd of July Commission in this regard: "Professional prevention and handling of serious events requires that those who are responsible develop knowledge of the risks they are facing, and actively adjust their conduct accordingly [...] Good risk comprehension is developed over time, by developing knowledge of the likelihood of various situations occurring, and of the consequences of various outcomes. It is challenging to fathom and implement initiatives concerning the prevention of worst-case scenarios, and to plan a constructive response to not very probable events."

We expect that the National Risk Analysis will be actively used and contribute to improving national risk awareness, which is necessary in order to be well-prepared for possible disasters. The NRA 2014 describes 15 different risk areas and contains 20 analyses of specific disaster scenarios that we believe can affect Norwegian society. These are serious events with low likelihood, but if they should actually occur, they will entail major challenges for society.

In such situations, we must utilise the resources we have available, improvise, and possibly request outside assistance. Even if we cannot be prepared to handle every event, we must have a certain overview of the challenges facing us and plan how we will meet them. Three of the analyses are new, while the others have been presented in earlier editions of the National Risk Analysis.

Assessments of the likelihood of future intentional adverse events such as terrorist attacks, cyber attacks or armed assaults by a foreign power are uncertain, among other things, because the threat level may vary with the prevailing security policy situation. In this edition of the National Risk Analysis, DSB's likelihood assessments in these areas are presented on the basis of threat assessments made at the time the analysis in question was conducted.

The National Risk Analysis is not a complete overview of risk and vulnerability in Norway. The most serious events are often completely unexpected. We also see that there is a need to analyse future social development that can affect work on civil protection and emergency planning. We will comment on the start of this work in the final chapter.

Finally, I would like to thank everyone who has contributed in various ways to the preparation of this year's risk analysis. In this year's edition, more than 50 external authorities and specialist groups have contributed their knowledge in order to make the analyses as good and as up to date as possible. Work on the National Risk Analysis is a dynamic process, and the risk analysis will be expanded to include additional risk areas and scenarios in the years to come. Even though DSB is ultimately responsible for the analysis results and conclusions, we are entirely dependent on specialist input and assessments from sectoral authorities and specialist groups. This helps raise the quality of the analyses, and thus also raises their utility and beneficial value. ◎

Jon A. Lea
Director

SUMMARY

STORM:
The coastal ship the MS Lofoten in a powerful storm in Vest Fjord during its 50th anniversary voyage in the spring of 2014.
Photo: NTB/Scanpix

PHOTO: NTB/SCANPIX

New in the 2014 edition of the NRA

In this year's report, a new scenario has been analysed in each of the three event categories: natural events, major accidents and malicious acts. The specific scenarios are:

- "Earthquake in a City", which has been set in Bergen.
- "Cyber Attack on Electronic Communications Infrastructure", which affects the entire country.
- "Tunnel Fire", in which three tunnels are analysed and a fire in the Oslo Fjord Tunnel is presented in particular.

The earthquake and cyber attack scenarios are considered to have low likelihood and entail relatively large consequences. The analyses of "Tunnel Fire" show relatively small consequences and a high likelihood.

In all three of the scenario analyses, vulnerability in the systems in which the events occur has been surveyed whenever possible. Vulnerability affects both the likelihood of the events, and not least their consequences. In the analysis of a cyber attack on electronic communications infrastructure, five critical societal functions were identified that were affected to a great extent. This results in serious consequential events with consequences for the population.

The "Tunnel Fire" scenario results in few consequential events, while the properties of the systems (tunnels) are decisive for both likelihood and consequences. In particular, the length and gradient of the tunnels are significant to the analysis results. The consequences of an earthquake are largely dependent on how much the infrastructure and buildings can tolerate the stresses, not to mention the local ground conditions.

We have included a new follow-up item in the new analyses for 2014. A point by point formulation of certain weaknesses and opportunities for improvement where DSB sees a need for follow-up is presented. The recommendations are based on the analyses and should be followed up by the responsible authorities.

Finally in this year's NRA, we focus on the future and reflect on what might be included in a risk analysis in the year 2040, based on some development trends in today's society.

Method and process

The National Risk Analysis (NRA) analyses a selection of adverse events with disastrous consequences for society. Norwegian society must be prepared for the occurrence of such events. The complexity of the risk factors requires a broad systems-perspective in the risk analyses. The National Risk Analysis describes all types of catastrophic events, both those caused by nature, and those intentionally and unintentionally caused by people. Common to all of them is the fact that:

- The events have consequences affecting several important societal assets.
- They are catastrophic events that require extraordinary input from public authorities and cannot be managed exclusively through established routines and arrangements.
- The consequences and management of the event transcend sectors and areas of responsibility and require cooperation.
- The events that are analysed are catastrophic events that could conceivably occur in Norway.

The NRA is based on qualitative risk analyses of very serious scenarios based on expert assessments. An important part of knowledge acquisition takes place at seminars. The likelihood and consequences will be quantified at intervals, but the overall risk is not compared with predefined acceptance criteria for risk. General acceptance criteria for risk have not been defined across sectors and fields. What is considered acceptable risk is determined in practice through professional and political decision-making processes within the various areas of risk. Instead of concluding what is acceptable and what is unacceptable risk, we would rather suggest certain follow-up points that can reduce risk in any case.

The adverse events in the NRA should be systematically reviewed by the authorities and organisations responsible for civil protection and critical societal functions, with a view to surveying how they affect each individual organisation. In what manner is one's own sector affected by the events, and what responsibility does the individual sector have for preventing and handling the events? Both the scenario descriptions and the risk analyses can provide important input to risk and vulnerability analyses at the county and municipal levels, as well as for other public authorities.

Risk

In its work on the National Risk Analysis, DSB uses a broad societal approach since the events that are analysed are complex and transcend specialist fields and areas of responsibility. Many fields with various types of data and knowledge must be involved in order to achieve the best possible comprehension of the risk associated with an event.

Risk is always about what might happen in the future, thus there is always uncertainty associated with it. The uncertainty is related to whether a specific adverse event will occur and what consequences the event would have. The uncertainty reflects, for example, the knowledge base for the analysis, for example, and this is explicitly addressed in the description of the analysis results. In the risk analyses, likelihood is used as an expression of how likely we think it is that a specific event will occur within a defined period of time, given our knowledge base.

Natural events

Natural events are triggered by forces of nature or natural phenomenon and not by human activity. Nature itself is the cause of the event, and the consequences can affect people and society in general. Plant, animal and human diseases are also categorised as natural events.

The following risk areas and the associated scenarios have been assessed under natural events:

RISK AREA	SCENARIO
Extreme weather	Storm in Inner Oslo Fjord
	Long-Term Power Rationing
Flooding	Flooding in Eastern Norway
Avalanches	Rockslide at Åkneset with Advance Warning
	Quick Clay Landslide in a City
Infectious diseases	Pandemic in Norway
Forest and wilderness fires	Three Simultaneous Forest Fires
Space weather	100-Year Solar Storm
Volcanic activity	Long-Term Volcanic Eruption in Iceland
Earthquake – **New**	Earthquake in a City– **New**

Major accidents

Major accidents is used here as a collective term for events triggered by system failure in technical installations or devices. System failure encompasses human failure, technical failure and organisational failure. This may involve the failure of critical infrastructure, explosion accidents, transport accidents and emissions of toxic gases or other substances.

The following risk areas and the associated scenarios have been assessed under major accidents:

RISK AREA	SCENARIO
Hazardous substances	Gas Emission from an Industrial Plant
	Fire at an Oil Terminal in a City
Nuclear accidents	Nuclear Accident at a Reprocessing Plant
Offshore accidents	Oil and Gas Blowout on a Drilling Rig
Transport accidents – **New**	Collision at Sea Off the Coast of Western Norway
	Tunnel Fire – **New**

Malicious acts

According to Norwegian Standard (NS) 5830:2012, an intentional adverse act is an event that is caused by an actor acting intentionally. The actor's purpose may be malicious or to promote their own interests. The risk assessments associated with intentional adverse acts are based on risk defined as "an expression of the relationship between the threat to a given asset and the vulnerability of this asset to the specified threat". Risk associated with intentional adverse acts may change from year to year, dependent on the threat assessments that are made. In assessing threat, it is the intention and capacity of the actor that is assessed (ref. new NS 5832:2014 Security Risk Analysis). Threat assessments give an indication of the possibility of an event occurring.

The following risk areas and the associated scenarios have been assessed under malicious acts:

RISK AREA	SCENARIO
Terrorism	Terrorist Attack in a City
Security policy crises	Strategic Attack
Cyberspace	Cyber Attack on Financial Infrastructure
	Cyber Attack on Electronic Communications Infrastructure

Overall risk analysis

The ″Pandemic in Norway″ scenario is assessed as having the highest likelihood of the analysed scenarios. All six scenarios that are assessed as having the highest likelihood are natural events. The likelihood is estimated as low for the malicious acts that have been assessed.

″Earthquake in a City″ and ″Strategic Attack″ are assessed as having very large and large consequences, respectively. ″Three Simultaneous Forest Fires″ and ″Tunnel Fire″ are assessed as having small societal consequences. Among the eleven scenarios that are assessed as having the greatest social consequences, five are natural events, four are intentional adverse acts and two fall under the event category major accidents.

The greatest consequences to life and health are found in ″Pandemic in Norway″, ″Nuclear Accident at a Reprocessing Plant″ and ″Earthquake in a City″, all of which entail extreme consequences for life and health. It is the major accidents that cause the greatest damage to natural and cultural assets. The earthquake and quick clay scenarios result in the greatest consequences for the societal asset nature and culture, primarily due to extensive damage to protected cultural artefacts.

All four scenarios for intentional adverse acts are assessed as threatening to societal stability. Malicious acts are carried out to damage and injure people and society and to create fear. Societal stability will, however, also be challenged by several of the natural events. This may be attributed to the fact that the scope of the consequences is so great that this in itself will create social and psychological reactions. This may result in frustration, anger and mistrust of the authorities if warning is not possible (earthquake and quick clay landslide), or if the capacity of emergency preparedness is not adequate (flooding scenario).

Analysed scenarios placed in a risk matrix with an indication of the uncertainty

SCENARIOS PLACED IN A RISK MATRIX	
1	Storm in Inner Oslo Fjord
2	Long-Term Power Rationing
3	Flooding in Eastern Norway
4	Rockslide at Åkneset with Advance Warning
5	Quick Clay Landslide in a City
6	Pandemic in Norway
7	Three Simultaneous Forest Fires
8	100-Year Solar Storm
9	Long-Term Volcanic Eruption in Iceland
10	Earthquake in a City
11	Gas Emission from an Industrial Plant
12	Fire at an Oil Terminal in a City
13	Nuclear Accident at a Reprocessing Plant
14	Oil and Gas Blowout on a Drilling Rig
15	Collision at Sea Off the Coast of Western Norway
16	Tunnel fire
17	Terrorist Attack in a City
18	Strategic Attack
19	Cyber Attack on Financial Infrastructure
20	Cyber attack on electronic communications infrastructure

FIGURE 1. National Risk Analysis – the composite risk matrix shows assessed risk connected to the serious scenarios that have been analysed.

The ″Earthquake in a City″ and ″Cyber Attack on Electronic Communications Infrastructure″ scenarios are assessed as having the greatest costs by far, consisting primarily of production losses and costs for the reconstruction of infrastructure and buildings.

The risk matrix shows an indication of likelihood and consequences for the 20 scenarios analysed. In addition, the three colours indicate varying degrees of uncertainty associated with the analysis results.

The scenarios ″Pandemic in Norway″, ″Earthquake in a City″, ″Nuclear Accident at a Reprocessing Plant″, ″Long-Term Power Rationing″ and ″Rockslide at Åkneset with Advance Warning″ are the five scenarios assessed as having the highest overall risk. Among the scenarios with the lowest risk, we find ″Gas Emission from an Industrial Plant″, ″Fire at an Oil Terminal in a City″, ″Tunnel Fire″, ″Three Simultaneous Forest Fires″ and ″Strategic Attack″.

As part of the risk analyses, an assessment is made of the uncertainty associated with both the likelihood and the consequences. Uncertainty has been presented using three different colours, which indicate the overall uncertainty for both likelihood and consequence assessments. There is reason to emphasise that all the scenarios that have been analysed are very serious and not very probable. If other, less serious scenarios had been analysed, the likelihood would have been higher, and the scenarios could have ranked differently in relation to each other in the risk matrix.

When we categorise the scenarios in *Natural Events, Major Accidents* and *Malicious Acts,* we see that it is to a great extent the natural events that are assessed as having the highest overall risk. The scenarios that fall under the category of Major Accidents and Malicious Acts are assessed as having a lower likelihood than natural events, but the consequences of some of these scenarios are deemed to be greater than some of the natural events.

The matrix shows the picture that arises if we compare the risk associated with the various scenarios analysed without attaching importance to whether it is a natural event, major accident or malicious act. The overview can therefore be used as general input for discussions that transcend the areas of responsibility and sectoral boundaries.

New opportunities and new challenges in the Norway of the future

Reflection on the future is about being aware of long-term changes and thus being open to new opportunities, prerequisites and events. Emergency preparedness work essentially revolves around experiences from previous events. Since it is impossible to prepare for all conceivable and inconceivable disasters, the last event is the most reliable knowledge base we have for emergency planning. However, no two events are identical, and the next event may present new and unexpected challenges. In order to be as well prepared as possible, it is important to think beyond what is known and based on experience.

DSB uses the so-called STEEP framework as its point of departure when we consider civil protection and emergency preparedness in a long-term perspective. The framework consists of five main factors that are often used in trend analyses: societal, technological, economic, environmental and political factors. Relevant problems in such a perspective may be the development of the ICT area related to the ″Internet of Things″, an ever-greater integration of technology in our lives and the development of smarter and more autonomous systems. Some of the future risk may also involve climate change, which may result in heat waves in Norway. In addition, extensive use of antibiotics may result in resistant bacteria and the challenges that this brings about. ◎

HAZARDOUS SUBSTANCES
Grenland is an area with enterprises prone to major accidents. The spread of toxic gases and incendiary fumes represent the greatest hazard to the population. This photo is from the Herøya Industrial Park.

PHOTO: NTB/SCANPIX

EXERCISES
The scenarios in the NRA may be the basis for national and local exercises.

PHOTO ANITA ANDERSEN

01

AIM AND CONTENT

The National Risk Analysis (NRA) describes serious risk factors and presents results from risk analyses conducted on a selection of adverse events with disastrous consequences for society. These are events that Norwegian society should be able to prevent and manage the consequences thereof. This is not because they will necessarily occur just as they are described in the NRA, but because they represent stresses that a robust society must withstand.

One of the major challenges of serious adverse events today is the fact that their consequences and the management of them cut across areas of responsibility and administrative levels in society. The interdependencies among functions in a modern society are so great that if a single important function is put out of action, problems often propagate to completely different areas.

The NRA attempts to illustrate the complexity of the course of events for serious adverse events, with consequential events and many types of consequences. The aim is for the actors who are affected by the consequences, or play a role in preventing and managing crises, to have a better overview and insight through the risk analyses that are presented.

The complex nature of modern risks requires a broad systems perspective in risk analyses. Risk analyses that were previously limited to technical matters have been replaced at the social level by social methods for the identification of a broad range of consequences, which also include social unrest and cultural assets in society. This is reflected in the procedure for risk analyses in the NRA.

Information in the National Risk Analysis should be included in risk and vulnerability analyses, planning processes and exercises at both national and local levels, and it should be translated into preventive and damage reduction measures. Report no. 29 (2011–2012) to the Storting on Civil Protection states that the *"Government has decided that DSB's National Risk Analysis should form the basis for a common planning foundation across the sectors and sectoral authorities in society. [...] The enterprises should base their planning on this, as a supplement to the overview of risk and vulnerabilities that the enterprises have within their own areas of responsibility. All actors must therefore evaluate what the risk analysis may mean to their area of responsibility."*

THE INTERDEPENDENCIES BETWEEN FUNCTIONS IN A MODERN SOCIETY ARE SO GREAT THAT IF a SINGLE FUNCTION IS PUT OUT OF ACTION, PROBLEMS OFTEN PROPAGATE TO COMPLETELY DIFFERENT AREAS.

01.1 Scope

The 20 scenarios that are included in the NRA 2014 do not represent all of the catastrophic events that can occur in Norwegian society. The next event may be one that we have not seen or analysed previously, and therefore it may be completely unexpected when it occurs. Nevertheless, the DSB believes that if Norwegian society is prepared to meet the events that have been analysed in the NRA, it is also prepared to meet many other events.

Catastrophic events

The National Risk Analysis encompasses both natural and malicious or unintentional man-made events. Common to all of them is the fact that:

- The events have consequences affecting several important societal assets.
- They are events that have disastrous consequences and require extraordinary input from the public authorities and cannot be managed exclusively through established routines and schemes.
- The consequences and management of the event transcend sectors and areas of responsibility and require cooperation.
- The events that are analysed are "catastrophic events" that could conceivably occur in Norway.

The term "catastrophic events" is based on the following definition of a disaster: A disaster is a major upheaval, accident or destruction in which many persons are involved simultaneously and which entail extreme consequences for the population and society. Disaster is also used to refer to events that exceed the capacity and resources of the local community and ordinary support systems to manage the event. A disaster can cause rapid changes or slower destruction.[1]

The scenarios that are analysed are in other words extreme, but they are not inconceivable or unrealistic. A storm or forest fire will normally have far fewer consequences than the scenarios described in the NRA. The NRA can thus not be used directly to dimension emergency preparedness, but it can be used as the basis for evaluation of what the current emergency preparedness can manage.

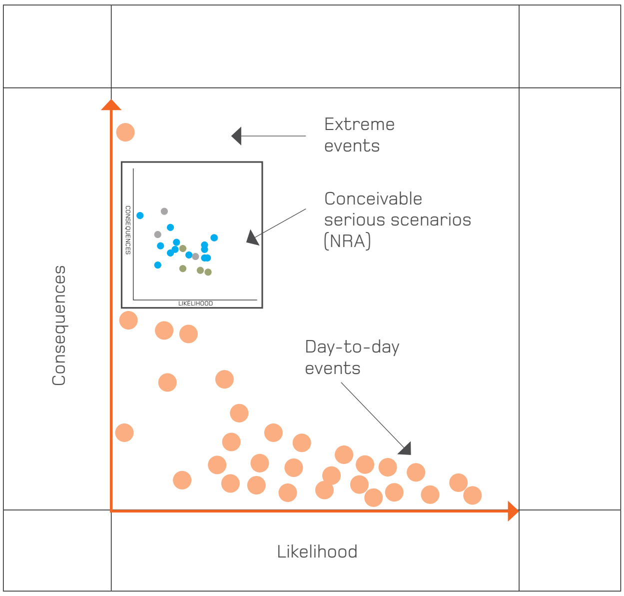


FIGURE 2. The scenarios that are analysed in the NRA are very serious scenarios – not day-to-day accidents, but not the most extreme events imaginable either.

No risk evaluation or measures

The NRA contains qualitative risk analyses of serious scenarios based on expert assessments. Likelihood and consequences will be quantified at intervals, but overall risk is not compared with predefined acceptance criteria for risk (risk evaluation). This is because the acceptance criteria have not been defined for all areas and there are no generally accepted limits for acceptance across sectors and fields. What is considered acceptable risk, is determined in practice through professional and political decision-making processes within the various risk areas.

Risk reduction measures are not proposed in the NRA, since this requires more in-depth knowledge and analyses than are found in the NRA. Risk reduction measures entail economic prioritisation and are a responsibility that lies with the respective authorities for government sectors, counties and municipalities.

DSB will, however, follow up specific weaknesses and challenges that are identified in the risk analyses with the responsible authorities.

[1] www.kriser.no.

01.2 Use of the National Risk Analysis

The NRA urges societal actors at all levels to answer two important questions:

1. How will my sector, county, municipality or organisation be affected by the catastrophic events that have been analysed? All events take place somewhere, and have a "host municipality" and a "host county" that must manage some of the consequences locally. However, all events cannot take place everywhere. Where can a collision at sea or landslide occur? Events also come under the area of responsibility of one or more sectoral public authorities. What events are relevant for separate risk analyses and emergency planning?

2. Which of the major events with national consequences should be scaled down based on local conditions to less serious events that will nevertheless be a disaster for the local community? A weaker storm, a smaller fire or landslide, are possible examples. An assessment should be made as to whether all the national events that are analysed in the NRA should be included in a scaled-down form in local or sectoral risk analyses or emergency preparedness plans.

The basis for risk management across sectors and administrative levels

The consequences of certain adverse events are so extensive that several administrative levels and sectors in society are affected. The adverse events in the NRA must be reviewed systematically to survey how they affect individual enterprises with regard to consequences and responsibility for prevention and emergency preparedness. In what way do the various events affect the power supply, the water supply, and the passability of the road network? Both the scenario descriptions and risk analyses may provide important input to county risk and vulnerability assessments, comprehensive risk and vulnerability assessments in municipalities and risk analyses in government sectors.

The instructions for civil protection work in the ministries (Royal Decree of 15 June 2012) require that the ministries, *"based on an overview of the risk and vulnerabilities in their own sectors and the DSB's National Risk Analysis, (must) assess the risk, vulnerabilities and robustness of critical social functions in their own sectors as a basis for continuity and emergency planning". The Act relating to Municipal Emergency Preparedness, which entered into force on 1 January 2011, states that the "*Municipalities are required to survey the adverse events that may occur in the municipalities, assess the likelihood of these events occurring and how their possible occurrence may affect the municipalities. *The results of this work must be assessed and collated in a comprehensive risk and vulnerability analysis."*

There is a danger of making the risk analyses too narrow within one's own area of responsibility, and not seeing all the dependencies and interfaces with other actors. The risk analyses in the NRA transcend sectors and may include all of the administrative levels to extract knowledge and create awareness of the broad range of consequential events and consequences. Such a broad process is also important in more local and specific sectoral risk analyses. An analysis across sectors and levels can identify the consequences of consequential events in completely different social areas than where the initial event took place.

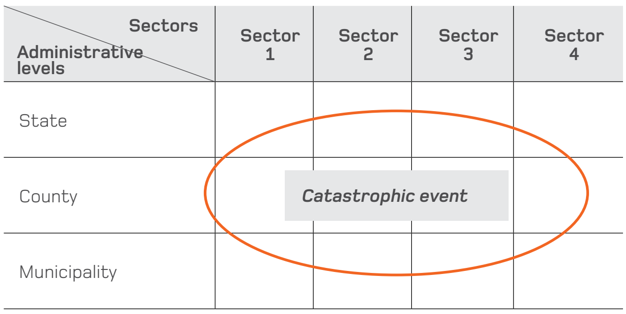


FIGURE 3. Catastrophic events often affect more than one social sector and administrative level.

For example, a powerful storm will result in direct damage that the local authorities must manage. However, a storm may also have consequential events, such as the loss of power, closed roads, railways, ports and airports, loss of telecom and data communications, etc. These are consequential events for which the public authorities are often responsible. Both the direct and indirect consequences of the adverse event should be included in risk analyses to attain a comprehensive view of the risk. There is a need for cooperation across areas of responsibility in prevention, warning, management, rescue and rebuilding.

WHICH OF THE MAJOR EVENTS WITH NATIONAL CONSEQUENCES SHOULD BE SCALED DOWN BASED ON LOCAL CONDITIONS TO LESS SERIOUS EVENTS THAT WILL NEVERTHELESS BE A DISASTER FOR THE LOCAL COMMUNITY?

Target groups

OVERVIEW	Politicians and business leaders need an overall risk analysis across sectors that does not go into detail.
INSIGHT AND RISK MANAGEMENT	Municipalities, counties and sectoral authorities can use the NRA to survey which national events will affect them that they need to be prepared for, and as input for less serious scenarios that they can analyse themselves.
OPERATIVE EMERGENCY PLANNING AND EXERCISES	At the operative level, the scenarios in the NRA can be used as input for exercises and emergency planning. Events with national consequences can be scaled down to local consequences.

FIGURE 4. Figures that illustrate different needs for knowledge of risks in society.

There are different needs for knowledge of risk, depending on the particular role and function. Politicians and the population in general are assumed to have the greatest need for an adequate, but not in-depth, overview of the risk factors in society, both nationally and locally. The managers of private enterprises must also be prepared for crises that can affect them as employers, manufacturers and service providers, and the NRA can be a backdrop for this. Experts in various sectors and at different levels require greater insight, and can obtain a basis for their own risk analyses from the NRA. Rescue agencies (fire, police and ambulance), which have important duties in the acute phase of the events, require specific knowledge of the course of events and can use the scenarios in the NRA for the planning of exercises and preparation of emergency preparedness plans.

Improved risk awareness

A national risk analysis may in itself contribute to greater insight and comprehension of risk in society. The NRA represents such a risk analysis, based on the processes and methods that have been chosen for this work. «Risk comprehension dictates the measures that are to be implemented and is dimensioning for the security and emergency preparedness society chooses to have.»[2]

A specific risk analysis can create both support and opposing views, but in both cases it contributes to greater awareness and discussion of risk in society. Discussing and analysing risk increases the level of knowledge and comprehension of dangers, vulnerabilities and uncertainty. By thinking through what can possibly happen, and understanding the development of catastrophic events and what consequences they may have, we will be better able to meet disasters when they arise.

There will always be a discussion of whether the "right" events are included in a risk analysis, whether the assessments of the likelihood and consequences are precise enough, etc. No one can state with certainty what the risk related to a specific event in the future is. The utility value of the risk analyses that are conducted in the NRA lies just as much in the description of the course of events and consequences as in the "size" of the risk or the placement in the overall risk matrix.

Structure of the report

The report is divided into three sections: an introduction, an analysis section and a summary section. Section 1 in the report discusses the aim of the National Risk Analysis, its content and scope, the target groups and the use of the NRA. Section 2 explains how DSB defines the key terms that are used in the report. Section 3 discusses the methods and procedures used as a basis for the preparation of the NRA.

Sections 4-17 comprise the analysis section, which is divided into subsections based on the type of event: Natural events, major accidents and malicious acts. Within the various types of events, several areas of risk with associated adverse events are described. One or more of the serious scenarios are analysed for each of the risk areas, and the results are presented individually. Any "critical vulnerabilities"

[2] *Official Norwegian Report 2012: 14 Report from the 22nd of July Commission.*

identified are also highlighted. Overall, a total of 15 areas of risk and 20 scenario analyses are presented in the report.

The last section of the report looks at the 20 risk analyses altogether and discusses the similarities, differences and patterns. Analysis results are presented both for each societal asset and for overall consequences and likelihoods. This illustrates the relative risk relationship between the scenarios. The vulnerabilities identified are accentuated through looking at critical factors for the outcomes in the individual analyses.

Certain changes have been made to this year's edition of the National Risk Analysis, based on an evaluation of the former editions. The descriptions of the risk areas have been updated. There are three new scenario analyses included in this year's report: Tunnel Fire, in which three tunnel types are analysed, Earthquake in Western Norway and Cyber Attack on Electronic Communications Infrastructure. Separate reports with far more thorough descriptions than there is space for in the NRA report have also been prepared for the new scenario analyses.

THERE ARE THREE NEW SCENARIO ANALYSES INCLUDED IN THIS YEAR'S REPORT:

- **EARTHQUAKE IN A CITY**
- **TUNNEL FIRE**
- **CYBER ATTACK ON ELECTRONIC COMMUNICATIONS INFRASTRUCTURE**

Future National Risk Analyses

DSB envisions the following development of the National Risk Analysis:

- An online presentation of the National Risk Analysis. That would enable the provision of multiple layers of information adapted to various needs, from a simple, complete overview of the risk analysis to detailed scenario descriptions that can be used in local analyses and exercises.

- Descriptions of new areas of risk and the development of new scenarios. A possible new scenario is an attack on schools or similar institutions by firearms, which are known events from other countries. The expansion of infectious diseases to include food-borne infection and animal disease is planned. CBRN[3] is another area that it is natural to follow up. There is also a need to update some of the oldest scenario analyses, such as the terrorism scenario and the flooding and storm scenario.

- After a few years, there will be a need to revise the scenarios in order to incorporate new knowledge and experience, which may perhaps change the assessments of risk. This is contingent on a process in which the responsible authorities and specialist groups are involved. With an online National Risk Analysis, updates and expansions can be made on an ongoing basis, and not just once a year, as is the case with the annual reports. ◎

[3] *CBRN is an acronym for chemical, biological, radiological and nuclear materials.*

FLOODING
Flooding in May 2013 in the Drammen River near Mjøndalen, Nedre Eiker, Buskerud.

PHOTO: NTB/SCANPIX

02

RISK

Risk analyses are conducted in many fields with different aims and procedures, such as in economics, mathematics, science, medicine and social studies. Therefore there is a need to specify how key terms are defined when a risk analysis is presented. In some fields, the risk analyses are based exclusively on statistics and models, while other fields have a broader and more procedural, knowledge and consensus-based approach. This results in differences in the collection of data (numbers, experience, expert knowledge), analysis process (who and how many are involved), presentation of the results (calculations, verbal descriptions) and evaluations of the uncertainty associated with these (significance, validity, lack of knowledge).

In its work on the National Risk Analysis, DSB uses a broad societal approach because the events that are analysed are complex and transcend specialist fields and areas of responsibility. Many fields with various types of data and knowledge must be involved in order to achieve the best possible comprehension of the risk associated with an event.

An important theoretical difference with respect to risk comprehension is whether risk is perceived as something that exists objectively and independently of who is analysing the risk (objective risk comprehension), or if risk is always an interpretation of reality and thus a construction (subjective risk comprehension). The NRA is based on a subjective approach. We are clear that there is always "someone" who is assessing risk, and the risk is never a true, objective quantity. The premises for the conclusions must be made clear so that the reasoning can be verified by others.

THE PREMISES FOR THE CONCLUSIONS MUST BE MADE CLEAR SO THAT THE REASONING CAN BE VERIFIED BY OTHERS.

02.1 Key terms

Risk is always about what might happen in the future, and therefore there is always a degree of *uncertainty* associated with it. The uncertainty is related to whether a specific adverse event will occur and to the consequences the event will have.

In *risk analyses likelihood* is often used as an expression of how likely we think it is that a specific event will occur, given our knowledge base. *Consequences* are the effects of an adverse event on given societal assets.

The risk analyses in the NRA consist of:

- Selection of adverse events for the development of scenarios.
- Assessment of the likelihood that the scenario will occur.
- Survey of vulnerability in the systems that are affected.
- The consequences the event may have.
- Assessment of uncertainty.

Vulnerability is a way to express the problems a system will have in functioning when it is exposed to an adverse event, as well as the problems the system will experience in resuming operations after the event has occurred (Official Norwegian Report 2000:24). In this connection, a system can be both technical subsystems (for example, infrastructures) and larger organisational systems such as a local community or nation. In other words, vulnerability says something about the capacity the system has to resist the occurrence of adverse events, and the system's capacity to withstand an event without it leading to serious consequences. A robust society has the capacity to both resist and withstand adverse events, and to quickly resume critical societal functions after a failure. The capacity to quickly resume important functions after a disruption is often referred to as organisational or social resilience.

Uncertainty related to the analysis results is expressed through an assessment of the knowledge base they are built upon, and the sensitivity of the results to changes in the prerequisites for the scenario and key assumptions in the analyses.

In addition to the risk results, the *risk analysis*also includes descriptions of the areas of risk and the scenarios analysed (the specific course of events), the assumptions they are based on, and the reasoning behind the assessments of likelihood, consequences and uncertainty.

Risk management *is the entire process of defining in what areas and for what adverse events risk analyses should be conducted, conducting the risk analyses, evaluating the risk results (whether the level of risk is justifiable or not) and implementing any risk-reduction measures.*

The risk analyses in the NRA cover the first three of the five points in the figure below. It is not the responsibility of the DSB to evaluate whether the level of risk is justifiable, or to determine what types of measures must be implemented, if any. ◎

VULNERABILITY SAYS SOMETHING ABOUT WHAT CAPACITY THE SYSTEM HAS TO WITHSTAND THE OCCURRENCE OF ADVERSE EVENTS, AND THE SYSTEM'S CAPACITY TO WITHSTAND AN EVENT WITHOUT IT LEADING TO SERIOUS CONSEQUENCES.

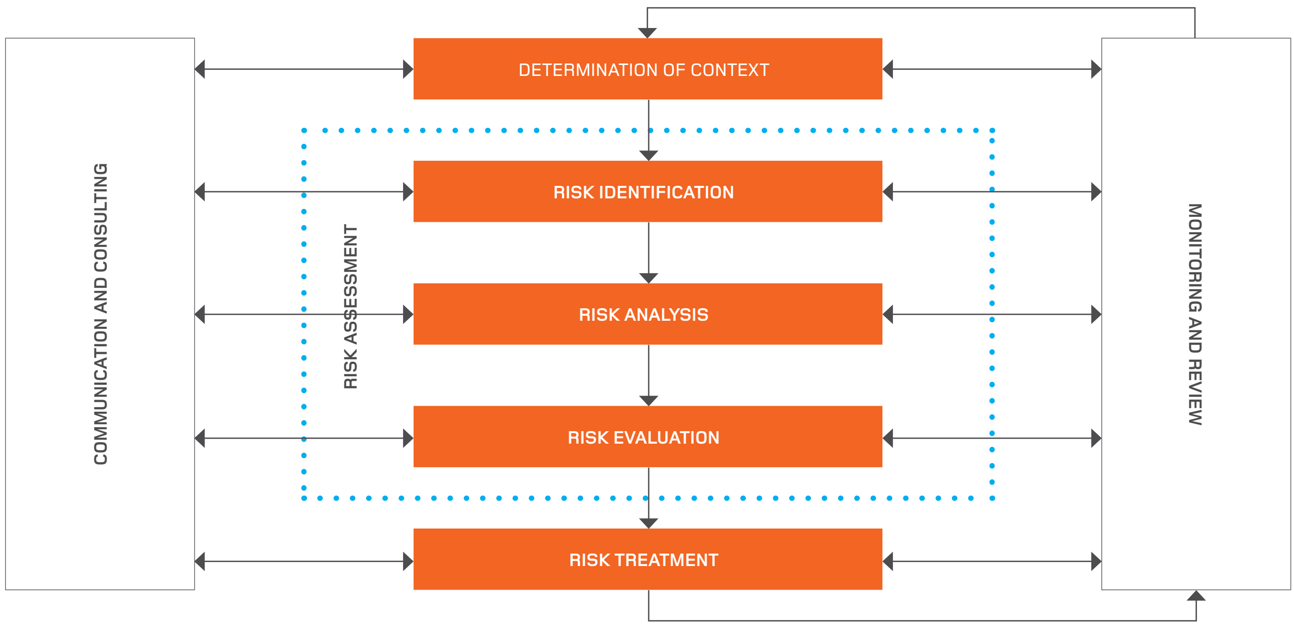


FIGURE 5. Risk analysis is one of the elements of risk management (NS-ISO 31000:2009 Risk Management – Principles and Guidelines).

02.2 Sources of uncertainty

Uncertainty associated with *the knowledge base* for the analysis is often referred to as *epistemic uncertainty*. All risk analyses are based on knowledge, but also on a lack of knowledge. How good is the "explanatory model" or our understanding of the phenomenon that is being analysed, and how good is the data we have? It is important to comment on this uncertainty along with the presentation of the results from the risk analysis.

Method uncertainty is also a dimension of uncertainty. How appropriate is the method chosen for risk analysis in the National Risk Analysis for casting light on the risk associated with catastrophic events in Norwegian society in the future? This is discussed briefly in Chapter 3.

Another type of uncertainty that is often addressed in quantitative risk analyses is *aleatory uncertainty*. This is uncertainty associated with random variations, incidence of events and the representativeness of the selection, and it is often expressed as statistical significance. Since the risk analyses in the NRA are essentially based on qualitative knowledge and not statistics, this source of uncertainty is less relevant.

Elvik (1994) describes four sources of uncertainty in analyses: Statistical uncertainty, theoretical uncertainty, method uncertainty and contextual uncertainty. While statistical uncertainty can be quantified through statistical methods (cf. aleatory uncertainty), the other three sources of uncertainty are difficult to quantify.

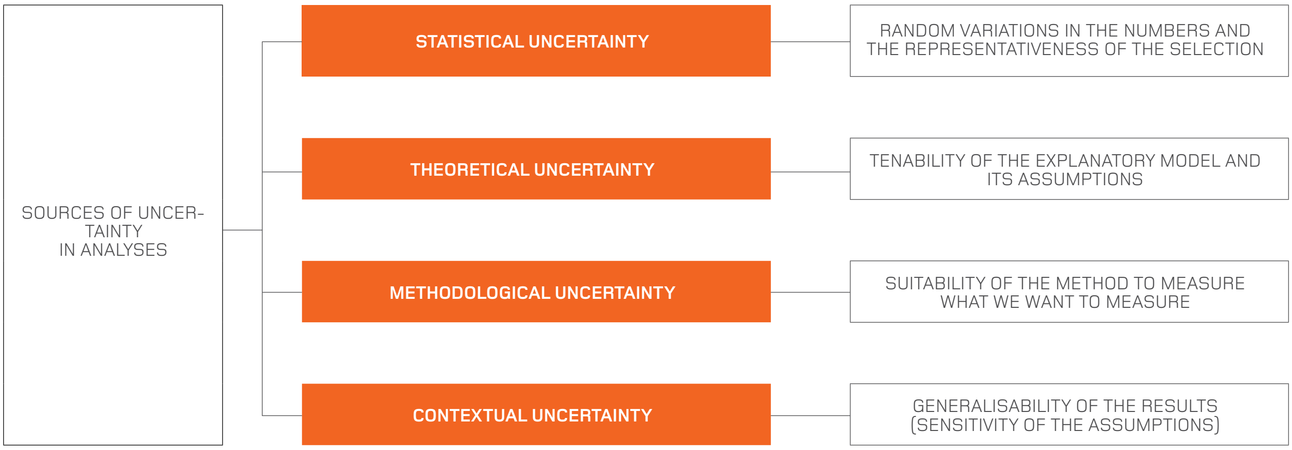


FIGURE 6. Figure illustrating sources of uncertainty related to the theoretical model and method (based on Elvik, 1994).

Treatment of uncertainty in the NRA:

For the very serious scenarios in the NRA, we have by definition little experience from similar events, since they occur so rarely. Statistics are therefore inadequate to give an indication of the likelihood of such an event. Prior events can nevertheless contribute to comprehension of the phenomenon – how it arises and develops.

In order to assess the uncertainty associated with the results from a risk analysis, something must be known about the knowledge and assumptions on which the analysis is based, as well as the method and process for the actual risk analyses. Emphasis has therefore been placed on specifying the assumptions for the scenarios and the analysis results in the National Risk Analysis. An assessment of uncertainty is made related to all the estimates of likelihood and consequences in the analyses, and a summary of these is presented together with the analysis results.

The uncertainty is described through an evaluation of the knowledge base for the analysis and of the sensitivity of the results to changes in the assumptions. Sensitive results are not very generalisable and are sensitive to small changes in the scenarios or assumptions on which the conclusions are based. Three indicators are used to evaluate the strength of the knowledge base, as proposed by Flage & Aven (2009):

1. Access to relevant data and experience.
2. Comprehension of the event/phenomenon that is being analysed (how good is the explanatory model?).
3. Agreement among the experts participating in the risk analysis. ◎

THE UNCERTAINTY IS DESCRIBED THROUGH AN EVALUATION OF THE KNOWLEDGE BASE FOR THE ANALYSIS AND OF THE SENSITIVITY OF THE RESULTS TO CHANGES IN THE ASSUMPTIONS.

02.3 Malicious acts

Risk associated with intentional adverse acts may change to a great extent from year to year, depending on the threat assessments that are made at any given time. In assessing threat, it is the intention and capacity of the actor that is assessed (ref. new NS 5832 Security Risk Analysis). The NRA is based on the annual assessments prepared by the Norwegian Police Security Service (PST), the Norwegian National Security Authority (NSM) and the Norwegian Military Intelligence Agency (Norwegian Intelligence Service).

Threat assessments give an indication of the possibility of an event occurring. Therefore the threat level indicates a form of likelihood. A threat can be classified on the basis of a rising likelihood or threat level.

In the likelihood assessments in the NRA, the prerequisites or possibility of the event occurring as described in the scenario is also assessed. Both the threat assessment and assessment of likelihood say something about how likely it is that the adverse event will occur. The term "likelihood" in the NRA should not be equated with "probability", which is often understood as a mathematical approach to probability. "Likelihood" in this context is a qualitative and knowledge-based assessment of how likely it is that an event will occur. Neither the threat assessments nor the likelihood assessments in the NRA are based on statistics, so they must be based on other complex knowledge and experience.

A five-level scale from very low to very high likelihood is used in the NRA, such that very little threat corresponds to very low likelihood etc.

Both the threat and likelihood assessments will change with new knowledge and new experience. There is a need to point out that someone is making assessments, and that they thus reflect a certain knowledge. There is also a need to address uncertainty associated with the assessments. The likelihood of unintended events depends on the extent to which the prerequisites for the events occurring are present. For malicious acts, these prerequisites will be intention and capacity.

DSB includes malicious acts in the National Risk Analysis, because these events can also have very serious consequences, which we must be prepared to meet. They threaten essentially the same societal assets as other types of catastrophic events, and they require the use of the same emergency preparedness resources. ◎

TERROR ATTACK IN OSLO
22 JULY 2011
The bomb that exploded in the Government Quarter resulted in extensive damage to the building, primarily the high-rise building "høyblokken".

PHOTO: NTB/SCANPIX

03

METHOD AND PROCESS

A common procedure for risk analyses in the NRA is used to ensure consistency in the manner in which the various scenarios are analysed. The method and process are described in a separate pamphlet (DSB 2014: Procedure for Preparation of the National Risk Analysis (NRA) – Pamphlet DSB, May 2014), which is used for conducting the various analyses. The DSB is responsible for the procedure that is used and the conclusions from the analyses, but is dependent on many different sectoral authorities and specialist groups for obtaining background knowledge and the actual risk assessments.

The National Risk Analysis is prepared in four steps.

STEPS FOR PREPARATION OF THE NATIONAL RISK ANALYSIS
1. Definition of the societal assets that are to be protected.
2. Identification of adverse events and development of scenarios.
3. Conducting risk analyses of the scenarios.
4. Presentation of the results from the risk analyses.

FIGURE 7. Procedure for risk analyses in the National Risk Analysis.

Step 1: Definition of societal assets that are to be protected

The starting point for conducting a risk analysis is that there are assets that require protection from the consequences of adverse events. The consequences of the adverse events in the NRA are assessed in relation to how they affect five paramount societal assets. As of 2014, some of the societal assets and types of consequences have been adjusted. The societal asset "Nature and the Environment" has been changed to "Nature and Culture", without any change to the content of the assessments. In addition, the "Capacity to Govern and Territorial Control" has been changed to "Democratic Values and Capacity to Govern". The intention is that the societal asset shall have a broader scope than the consequences resulting from traditional warfare. All the societal assets are concretised through two consequence types each.

As of 2014, the five societal assets with the associated consequence types are:

- Life and health
  - death
  - serious injuries and illness
- Nature and culture
  - long-term damage to the natural environment
  - irreparable damage to the cultural environment
- Economy
  - direct financial losses
  - indirect financial losses
- Societal stability
  - social and psychological reactions
  - impact on daily life

- Democratic values and capacity to govern
  – loss of democratic values and national capacity to govern
  – Loss of territorial control

To assess the scope of various consequences, the types of consequences are divided into intervals ranging from very small to very large. All of the consequences are presented for each scenario in the report. The intervals are also given a numeric value – a score – that makes it possible to present the scenarios in a diagram for each societal asset and in a risk matrix that illustrates the likelihood and overall consequence.

Step 2: Identification of adverse events that threaten societal assets

The adverse events are divided into three event types based on how they arise:

- natural events
- major accidents
- malicious acts

"Natural events" are caused by natural phenomena such as weather, climate, geography, ground conditions, etc. "Major accidents" are caused by human activity. "Malicious acts" are carried out by persons who intend to harm other people or society. Within each type of event, there are several adverse events that are analysed. They belong to different *risk areas*, and they are described in the report before each individual analysis. The adverse events in each area of risk that are assumed to be the most important are described in brief.

Certain adverse events are selected for analysis in the NRA. Since they are essentially general events with a broad range of possible consequences, the event that is to be analysed is developed into a *scenario* – a very specific course of events within the framework of the adverse event. The scenario description includes factors contributing to the event, geographic location, time and duration of the event, strength of the event and consequential events.

The specified scenario is to be a *scenario* that illustrates the most serious consequences the event can have on the entire range of societal assets. The scenario should not, however, be inconceivable or unrealistic; its occurrence should be possible in the course of a year.

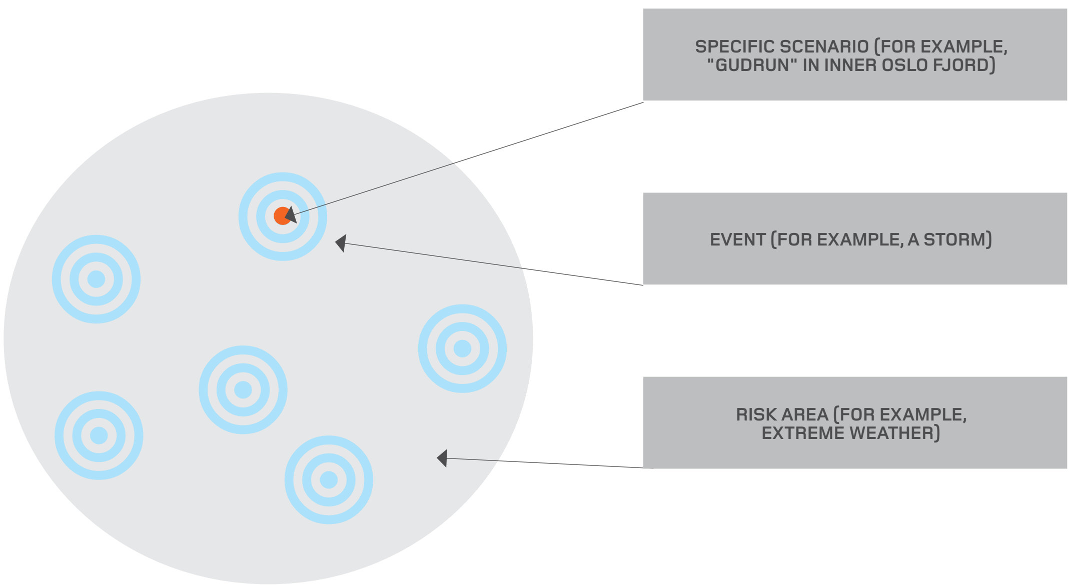


FIGURE 8. The figure illustrates the relationship between risk areas, adverse events and scenarios.

Common to the scenarios is the fact that:

- It must be conceivable that they could occur in the course of a year.
- They must threaten one or more of the societal assets.
- They must have cross-sectoral consequences and require cross-sectoral management.
- They must require extraordinary input from the public authorities.
- They must be based on an event that has actually occurred.

Step 3: Conducting risk analyses of the scenarios

The risk analyses are conducted in a process that consists of:

- Preparatory work: Obtaining relevant knowledge and experience from similar events in Norway and abroad.
- Working seminar: A qualitative expert analysis in which relevant competence is gathered to assess the likelihood of the event and its consequences.
- Follow-up work: Summary of the knowledge obtained and the seminar, which will be sent to the seminar participants and others for quality assurance.

There are two reasons for the selection of an expert analysis as a procedure:

1. The experience or data for the individual scenarios is by definition not adequate to be able to conduct purely quantitative analyses. The scenarios have not previously taken place in this context – they have low likelihood and major serious consequences.
2. The expert seminars produce interdisciplinary knowledge and create a common understanding of a phenomenon that society needs to be prepared for. In addition, the discussions provide the participants with insight into each other's fields and a greater understanding of the breadth of the consequences the scenarios often have.

The figure below is a model of the course of events before and after an adverse event, and functions as a framework for the analyses that are conducted at the expert seminars (bow tie model).

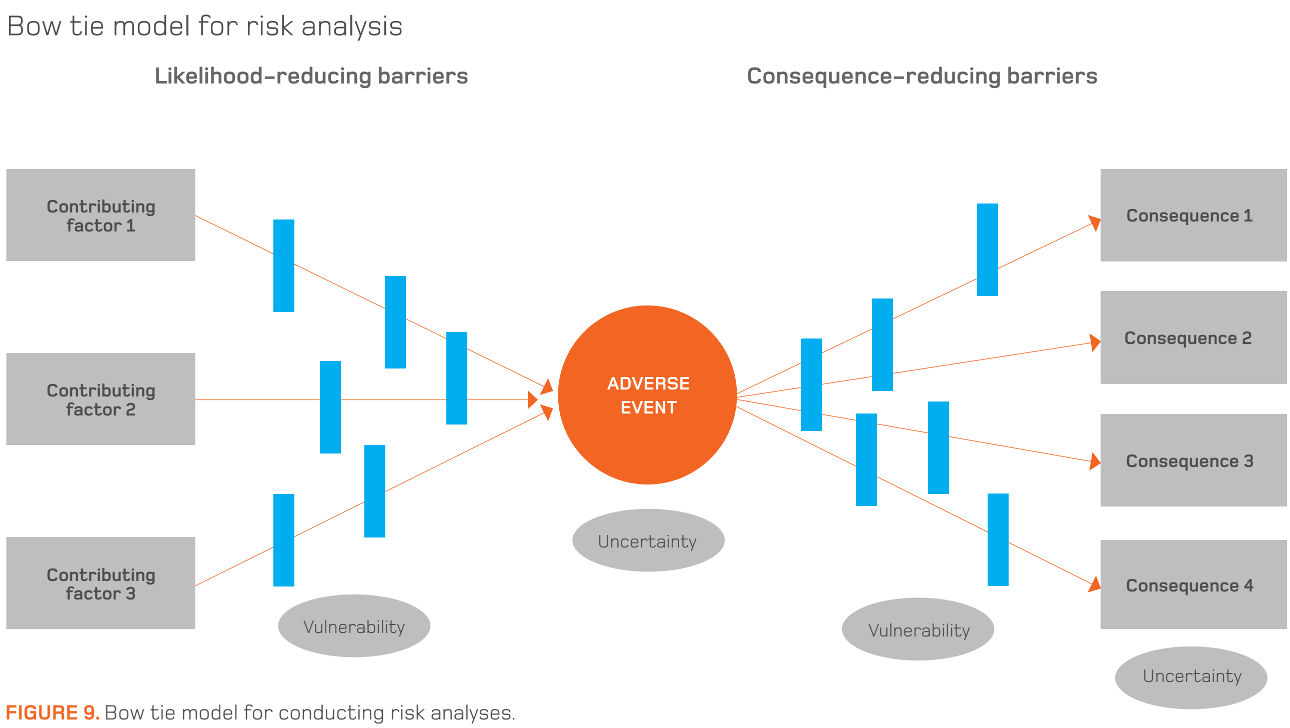


FIGURE 9. Bow tie model for conducting risk analyses.

As a rule there are 20-30 participants at the seminars arranged by DSB. The participants come from those sectors of society and academic communities that are considered to have the best knowledge of the event being studied, including the course of events, established preparedness and possible consequences.

The experts at the seminars shall provide scholarly input to the risk analyses. Even though the analyses are not based on mathematics, both the likelihood and consequences will be quantified to the greatest possible extent.

In order to assess likelihood and consequences, it is necessary to have knowledge of both the event that occurs and the vulnerability of the systems or society that are affected. Sources of vulnerability in a system may be interdependencies between critical functions, complexity and an inadequate overview, inadequate barriers and the lack of redundancy (backup solutions – in analyses conducted as of 2014, the interdependency between critical societal functions is illustrated by assessing to what extent the failure of one function affects other functions.)

Step 4: Presentation of the results from the risk analyses.

The results from the risk analyses of the specific scenarios are presented both verbally with assumptions and explanations, and in matrices with classification in intervals. The intervals reflect that they are events with low likelihood and large consequences that are analysed. The likelihood scale goes down to ″less than once every 10,000 years″ and the consequence type ″death″ goes up to ″more than 300″. Since the intervals are so large, the estimated values are assessed on a three-part scale within each interval to provide a more nuanced assessment.

The scenarios that are analysed often have a complex course of events and may consist of a chain of events. There are *trigger events* that take place before the main *adverse event* that is being analysed, which are prerequisites for the occurrence of the main event. There are *concurrent events* that take place at the same time as the main event and affect the subsequent course of events. *Consequential events* that take place in the wake of the adverse event can also greatly affect the consequences.

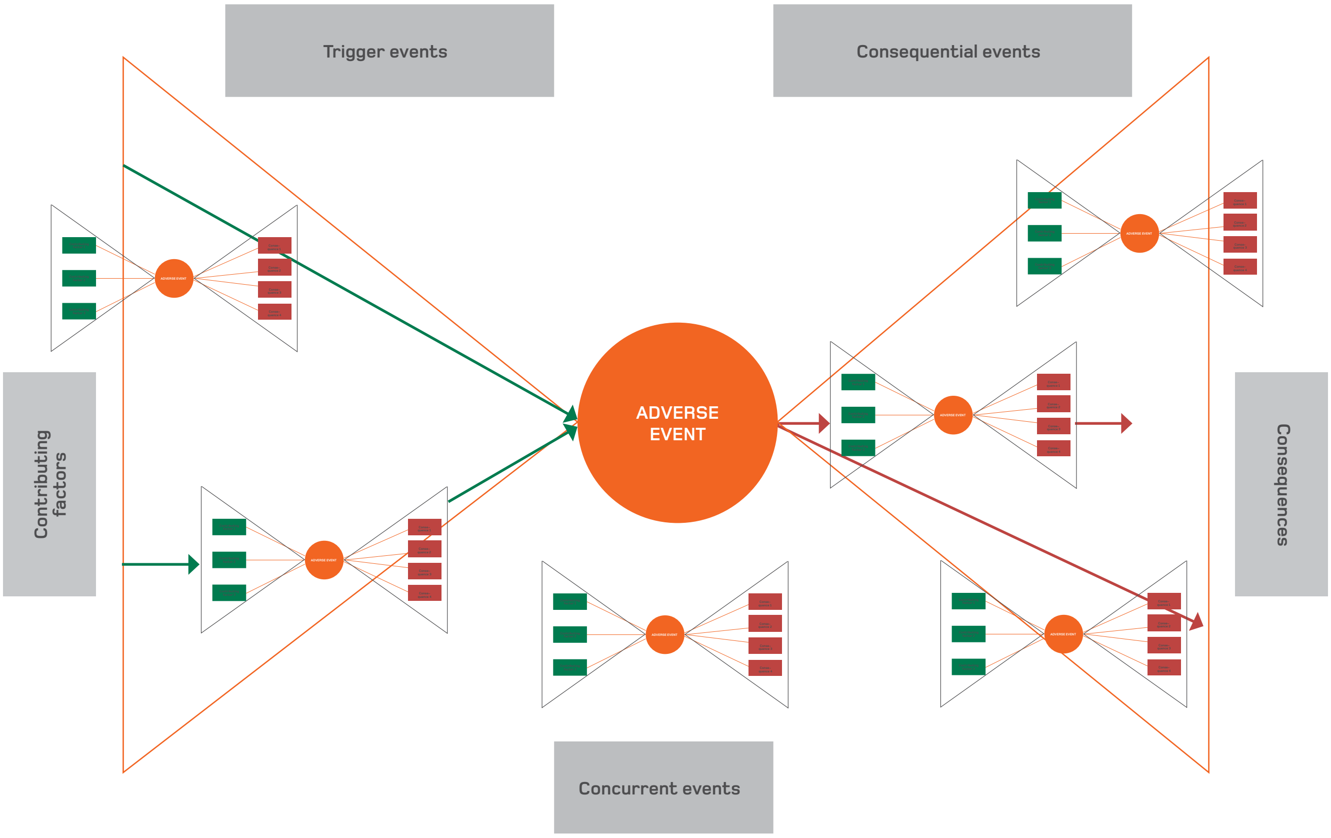


FIGURE 10. The bow tie model illustrating complex sequences of events.

In the flood scenario, for example, a warm front is a contributing factor, a heavy snowmelt is a trigger event and a breached flood defence is a concurrent event. Damaged transmission line masts and roads are consequential events, which contribute to the final consequences of the adverse event of flood. Each of the events can initially be placed in the middle of the bow tie diagram and be analysed as the adverse event, so it is a matter of choice of method as to what is focused on the most.

NATURAL EVENTS

JÆREN, NOVEMBER 2011
The storm Berit had a devastating effect on the coast of Rogaland in the winter of 2011.

PHOTO: NTB/SCANPIX

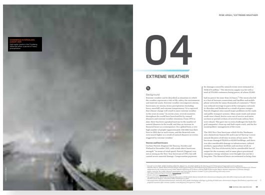
Natural events are triggered by forces of nature or natural phenomena, and not by human activity. Nature itself is the cause of the event, and the consequences can affect both people and society in general. Plant, animal and human diseases are also categorised as natural disasters.

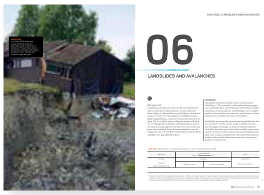
Continuous natural processes, such as weather, wind and geological conditions, help to form and wear away the landscape around us. This erosion has taken place from the beginning of time, and it has resulted in disasters of varying dimensions and scopes. These processes will also result in flooding, landslides, avalanches, storms and hurricanes. Climate change increases the potential for more extreme weather, and it will create new challenges for work in civil protection and preparedness at the local, regional and national levels.

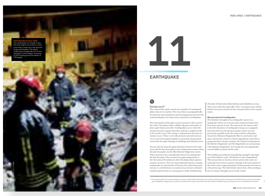
In general, Norway is regarded as being well equipped to meet the challenges posed by nature. Experience shows nevertheless that we will be facing a number of challenges with respect to managing the really big events triggered by natural events in Norway. The greatest challenge to civil protection in the future is perhaps managing the consequences of climate change, which we are starting to see the outline of now.

In order to survey risk and reduce vulnerability to disasters and events triggered by natural events, various forms of risk and vulnerability analyses (RVAs) are used.[4]

RISK AREAS







[4] *Directorate for Civil Protection and Emergency Planning (2007): National Vulnerability and Emergency Preparedness Report (NSBR) 2007.*

KVINNHERAD IN HORDALAND, AUGUST 2005
High water levels in the Fureberg Waterfall after a period of heavy precipitation.

PHOTO: NTB/SCANPIX

04

EXTREME WEATHER

Background

Extreme weather can be described as situations in which the weather represents a risk to life, safety, the environment and material assets. Extreme weather encompasses storms, hurricanes, ice storms, heavy precipitation (including heavy snowfall) and extreme temperatures.[5] It is expected that climate change will result in more extreme weather in the years to come.[6] In recent years, several countries throughout the world have been hard hit by natural disasters and extreme weather situations. From 1970 to date, there has been a gradual increase in the number of natural disasters in the world, and thus an increase in financial losses as a consequence. On a global basis, a very high number of people (approximately 300,000) lost their lives in 2010 due to such events, and the financial costs were much higher as a result of natural disasters or events triggered by extreme weather.[7]

Storms and hurricanes

Cyclone Patrick (Dagmar) hit Norway, Sweden and Finland in December 2011, with winds above hurricane strength.[8] In terms of wind speed, Patrick (Dagmar) was not as strong as the New Year hurricane of 1992, but still caused severe material damage. Compensation payments for damages caused by natural events were estimated at NOK 876 million.[9] The electricity supply was hit with a total of 570,000 customers losing power, of whom 35,000 had no power for more than 24 hours.[10] The storm also led to a loss of Internet connections and landline and mobile phone networks for many thousands of customers.[11] There was reduced coverage in parts of the emergency network in Akershus and Buskerud as a result of power outages. Patrick (Dagmar) also caused major problems on the roads and public transport systems. Many main roads and minor roads were closed, ferries were out of service and entire sections or partial sections of several main railway lines were closed. This gave rise to extra challenges for both the grid companies' clean-up and fault repair work, and for the municipalities' management of the event.

The 1992 New Year hurricane which hit the Nordmøre area claimed one human life and is one of Norway's worst natural disasters of all time in terms of lost assets. The hurricane damaged 50,000 to 60,000 buildings, and there was also considerable damage to infrastructure, cultural artefacts, aquaculture facilities and not least of all, to forestry. The loss of electricity led to considerable loss of output for the economy, and in some places provisional emergency energy solutions were brought into use for a long time. The financial losses are estimated as being close to NOK 2 billion, after subtracting deductibles and losses due to operating problems.[12]

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[5] *St.meld. nr. 22 (2007–2008) Samfunnssikkerhet. [Report no. 22 (2007–2008) to the Storing on Civil Protection.] Cooperation and coordination.*
[6] *Husabø, Idun A. (2010): Ekstremvêrhendingar. Erfaringsgrunnlag for klimatilpassing hos fylkesmannen [Extreme Weather Events. Experiential Basis for Climate Adaptation by the County Governor]; NOU 2010:10 Tilpassing til eit klima i endring [Official Norwegian Report 2010:10 Adaptation to Climate Change].*
[7] *Sigma, Swiss Re. No 1/2011. Natural catastrophes and man-made disasters in 2010: A year of devastating and costly events.*
[8] *Norwegian Meteorological Institute (www.met.no) 26/12/2011.*
[9] *Finance Norway (www.fno.no) 19/01/2012.*
[10] *Norwegian Water Resources and Energy Directorate (NVE) (2012): Første inntrykk etter ekstremværet Dagmar, julen 2011 [First Impressions after Extreme Weather Event Dagmar, Christmas 2011], NVE Report 3/2012.*
[11] *Norwegian Post and Telecommunications Authority (PT) (2012): Foreløpige erfaringer og forslag til tiltak etter ekstremværet Dagmar [Preliminary experience and proposed measures after extreme weather event Dagmar], PT report no. 2 2012.*

In November 2013, the extreme weather event Hilde hit Trøndelag and Helgeland. A large number of subscribers lost power, and there was reduced navigability in the affected areas, due to minor landslides and trees and rocks in the roads.[13] Less than a month later the extreme weather event Ivar hit Central Norway on 12 December. Approximately 111,000 subscribers lost power as a result of the storm, and 29,000 of these subscribers were without power for over 12 hours. The costs of non-supplied energy for the power companies that were affected were close to NOK 50 million, while the costs of compensation to customers who lost power for more than 12 hours were close to NOK 18 million.[14] The majority of the damage caused by the two storms was covered by private insurance, and they did not entail any extraordinary compensation cases for the Norwegian Natural Disaster Fund.[15]

Cyclone Gudrun in January 2005 is considered the most destructive storm that has hit Scandinavia in modern times. In Sweden, which was hardest hit, 18 people were killed. Approximately 730,000 inhabitants lost power, and large areas of forest were destroyed. The costs caused by the storm to economic life and the public sector are estimated at approximately NOK 20.8 billion.[16]

Precipitation
A lack of precipitation can lead to drought and have an impact upon agriculture and food production. In Norway, low levels of precipitation can create challenges due to low inflow into power station reservoirs and therefore low reservoir filling, which can again contribute to a reduced supply of electricity. Transmission of power from abroad will counteract this effect to a certain extent.

In 2010 little precipitation combined with an early winter and low temperatures resulted in record low levels of reservoir filling, and high electricity prices. The situation did not involve any immediate risk of rationing, but was a reminder of the vulnerability to low precipitation.

At the same time, climate forecasts indicate that the weather is going to become wetter, and there are indications that incidences of heavy precipitation have increased over recent years.[17] In 2011, the volume of precipitation was far above normal levels in Norway, and that year was the wettest since 1900. However, there is reason to believe that the climate will vary in the years to come, and that there will also be periods of low precipitation and cold winters.[18]

Risk

Storms and hurricanes
Violent storms and hurricanes are the forms of extreme weather that cause the greatest damage in Norway, particularly in combination with storm surges. The starting point for violent storms and hurricanes is low pressure which releases heat which often leads to high volumes of precipitation. At the same time, storm surges can arise as a consequence of the water levels rising due to strong wind and low air pressure.[19] Storm surges create further consequences and challenges in addition to those caused by high winds.

Based on many years of observations and likelihood calculations, it is possible to estimate return periods for extreme wind conditions. Return period is a term used to indicate how often this type of wind occurs. For the Møre coast, the return period for a hurricane as strong as the hurricane in 1992 is estimated at more than 200 years.[20]

Climate models show little or no change in average wind conditions in Norway up to the year 2100. At the same time, however, in the decades to come the likelihood of powerful storms and hurricanes will tend to increase, even in areas that would previously not have been affected by this type of extreme weather, such as the Oslo Fjord region. There may be occasions when strong winds come from unusual wind directions.[21]

Damage to buildings as a consequence of wind and flying objects are typical consequences of extreme wind conditions. The electricity supply is also vulnerable to storms, and trees falling on power lines is a particular problem. Since a number of infrastructure elements and societal functions are dependent on the continuous supply of electricity, loss of power will, in itself, entail extremely large challenges for the community. In cases in which storms and hurricanes bring with them large volumes of precipitation, this may also involve problems for water and sewerage systems.[22]

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[12] *Finance Norway (www.fno.no) 02/04/2012.*
[13] *DSB. Rapport. Evaluering av myndighetenes forebyggingsarbeid og håndtering av ekstremværet «Hilde» i november 2013. [Report: Evaluation of the Authorities' Preventive Work and Management of the Extreme Weather Event "Hilde" in November 2013.]*
[14] *Norwegian Water Resources and Energy Directorate. Erfaringer fra ekstremværet Ivar, desember 2013. [Experience from Extreme Weather Event Ivar, December 2013.]*
[15] *Directorate of Agriculture (www.slf.no) 03/10/2014.*
[16] *Swedish Civil Contingencies Agency (MSB), Krishantering i stormens spår. Sammanställning av myndigheternas erfarenheter [Crisis Management after the Storm. Compilation of the Authorities' Experience]. KBM Report 2005. (www.msb.se)*
[17] *Norwegian Meteorological Institute (www.met.no) 28/12/2011.*
[18] *NOU 2010:10 Tilpassing til eit klima i endring [Official Norwegian Report 2010:10 Adaptation to Climate Change].*
[19] *Norwegian Meteorological Institute (www.met.no) 27/02/2012.*
[20] *Norwegian Meteorological Institute (www.met.no) 23/09/2008.*
[21] *Haugen and Iversen (2008): Response in extremes of daily precipitation and wind. Norwegian Meteorological Institute.*

Precipitation
A lack of precipitation in Norway may primarily involve challenges for the supply of electricity. In situations where the supply of power is under extreme strain, with ordinary pricing mechanisms being insufficient to achieve a balance between production and consumption (including import and export), other methods must be brought into play. In a worst case, power rationing may be necessary to prevent a serious power situation with greatly reduced supplies of power or complete loss of electricity. Such a situation would involve major challenges. Electricity is an absolute necessity for maintaining a number of critical functions of society such as electronic communications, banking and finance, health and social services, police and emergency services. Loss of these functions will affect households, private enterprises and the public services.[23]

Climate forecasts indicate that Norway will have a warmer and wetter climate.[24] This could be a positive development for generating hydroelectricity and for supply reliability. More precipitation, combined with higher temperatures and shorter winters, could provide a foundation for increased hydroelectricity generation and a reduced energy requirement for heating purposes.[25] At the same time, large volumes of precipitation may represent a hazard. Landslides are often triggered by high levels of precipitation, and the likelihood of rockslides also increases with large volumes of precipitation.[26]

Precipitation can devastate major material and cultural assets, and large parts of society's infrastructure are exposed during this type of extreme weather.[27] Increased volumes of drainage and surface water in built-up and urban areas may also be a challenge.

Prevention and emergency preparedness

The climate is changing, and research scientists point out that we will experience more extreme weather events as a consequence of climate change. How great the consequences will be for different types of climate extremes depends entirely on how we prepare for this. More robust infrastructure and the establishment of early warning systems are important measures for adaptation. The individual sector and the individual level of administration have independent responsibility for reducing the impact of climate change within their specific area of responsibility. The responsibility for climatic adaptation rests with the public sector, business and private individuals. To reduce the impact, it is important both to have preventive measures, via land-use planning, for example, and a contingency system for managing the situation when it arises.

Norway's Planning and Building Act with associated regulations and the Civil Protection Act[28] are crucial to ensuring respect for necessary climate adaptations. For example, the Planning and Building Act specifies requirements for assessing natural damage in all construction activity in Norway.

After the New Year hurricane in the Møre og Romsdal region in 1992, a national plan was established for providing warnings of extreme weather events. The Meteorological Institute is responsible for the contingency plan, which must ensure that different bodies are prepared and able, to the highest possible degree, to maintain society's infrastructure. The warning is given first to the Maritime Rescue Coordination Centres and the NVE's flood warning centre. It is then forwarded to other emergency response bodies both at a national, regional and local level. The contingency plan has proven itself to be a good resource for limiting damage and saving lives.[29]

The regulations on power rationing[30] are intended to ensure that power rationing is carried out in a socially rational manner. The regulations must be activated by the Norwegian Ministry of Petroleum and Energy in each instance. The resources that will be available to the rationing authority, the Norwegian Water Resources and Energy Directorate (NVE), include information and savings campaigns, market-related measures, requisition of energy from generators, disconnection of consumption or enforced supply restrictions. Pursuant to the rationing regulations, resolutions will be passed that order the Norwegian Power Systems Contingency Planning Organisation (KBO) to prepare rationing plans for all supply areas. In practice this means that all grid companies are charged with having a contingency plan for power rationing. ◎

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[22] *St.meld. nr. 22 (2007–2008) Samfunnssikkerhet. Samvirke og samordning [Report no. 22 to the Storting (2007–2008) Civil Protection. Cooperation and Coordination]; NOU 2010:10 Tilpassing til eit klima i endring [Official Norwegian Report 2010:10 Adaptation to Climate Change].*
[23] *National Risk Analysis 2013, In-Depth Section, Kommunenes beredskap mot bortfall av elektrisk kraft [Municipal Emergency Preparedness for Loss of Electricity] and Directorate for Civil Protection and Emergency Planning (2012): Samfunnets sårbarhet overfor bortfall av elektronisk kommunikasjon [Society's Vulnerability to Loss of Electronic Communications].*
[24] *NOU 2010:10 Tilpassing til eit klima i endring [Official Norwegian Report 2010:10 Adaptation to Climate Change].*
[25] *Varmere og våtere klima positivt for kraftbransjen [Warmer and Wetter Climate Good for the Power Industry](www.bjerknes.uib.no) 22/05/2008.*
[26] *Norwegian Geotechnical Institute (www.ngi.no) 03/02/2012.*
[27] *NOU 2010:10 Tilpassing til eit klima i endring [Official Norwegian Report 2010:10 Adaptation to Climate Change].*
[28] *Act of 25 June 2010: Act relating to Municipal Emergency Preparedness, Civil Protection and the Norwegian Civil Defence (the Civil Protection Act).*
[29] *Norwegian Meteorological Institute (www.met.no) 08/03/2012.*
[30] *FOR 2001-12-17 no 1421: Regulations relating to the planning and implementation of the requisition of power and enforced supply restrictions during power rationing.*

SCENARIO

04.1 Storm in Inner Oslo Fjord

An adverse event in the "extreme weather" risk area is a powerful storm in a densely populated area. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific serious scenario.

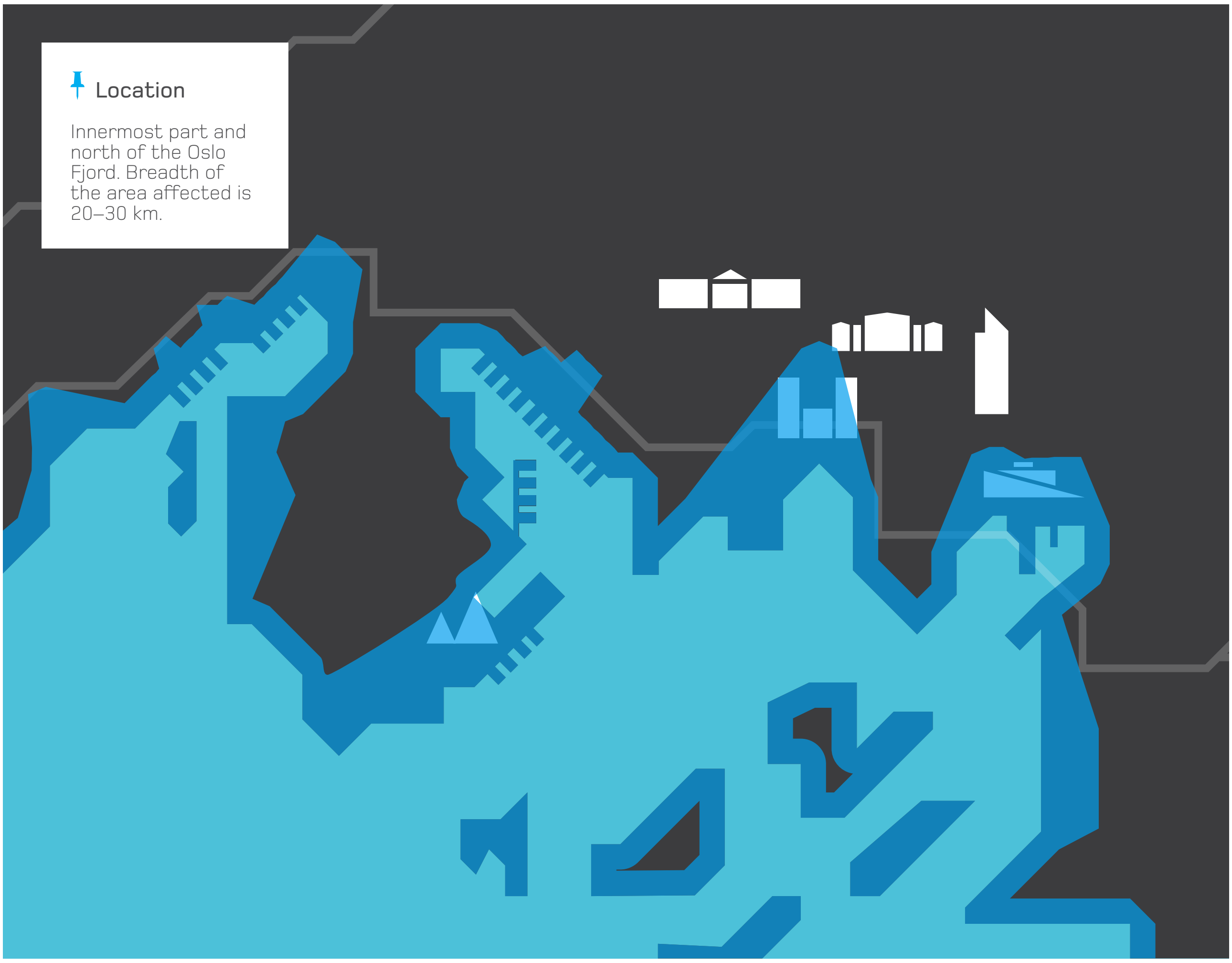
The risk analysis was conducted in the winter of 2010.

Preconditions for the scenario

Time	Duration	Wind speed	Comparable event	Weather conditions	Concurrent event	Consequential events
A night in October at 3 a.m.	16 hours	Average wind speed of 19 m/s with gusts of 34 m/s (hurricane)	Cyclone Gudrun in 2005	30–60 mm rain before the storm, temperature of 5 °C during the storm, period of cold weather afterwards	Storm surge	• Storm surge of 250 cm in inner Oslo Fjord • Loss of power (damage to the distribution grid) • Contamination of drinking water (surface water and inadequate purification)

Location

Innermost part and north of the Oslo Fjord. Breadth of the area affected is 20–30 km.



Assessment of likelihood

A storm in this area and with this wind speed will statistically occur once every 50 years. It will often coincide with heavy precipitation, but rarely with a strong storm surge. The scenario described is expected to occur once every 100 years, i.e. there is a 1% likelihood that it will occur in the course of a year. It is a relatively frequent event among those that are assessed in the National Risk Analysis (NRA) and falls under the category *high likelihood* (once every 10 to 100 years).

Meteorological data over a long period of time provides a good base of knowledge for specifying likelihood. Since this storm coincided with a storm surge and hit an area that was not often exposed to storms, there is, however, little experience of such a powerful storm here. Climate change can increase the likelihood of such events in the future, since more frequent and powerful storms and precipitation are expected in the future, and they are also expected in new locations. The base of knowledge for specifying the likelihood of the specific scenario is assessed as *average* on a three-part scale from small to large. The likelihood estimate is sensitive in relation to the assumption of a storm surge. Based on the knowledge base and the sensitivity, the uncertainty of the estimate is assessed as *moderate*.

TABLE 1. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 1%				◎ (moderate uncertainty)		Once every 100 years based on historical data

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death			◎ (high uncertainty)			Approximately 100 deaths as a direct or indirect consequence
	Injuries and illness				◎ (high uncertainty)		Between 500–1000 injuries or ill people as a direct or indirect consequence
Nature and the environment	Long-term damage			◎ (low uncertainty)			1,000 km² of forest is destroyed 3-10 years of clean-up work
Economy	Financial and material losses				◎ (low uncertainty)		NOK 10-15 billion
Societal stability	Social unrest		◎ (low uncertainty)				Known phenomenon, but difficult to avoid
	Effects on daily life			◎ (moderate uncertainty)			Several hundred thousand are affected by the lack of power and clean water for a few days. Reduced navigability for all means of transport
Capacity to govern and control	Weakened national capacity to govern						Not relevant
	Weakened territorial control						Not relevant
OVERALL ASSESSMENT OF CONSEQUENCES				◎ (moderate uncertainty)			Medium-sized consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

Assessment of consequences

The consequences of the given scenario are assessed overall as *medium-sized*. The scenario will primarily threaten the societal assets life and health and economy. In addition, the scenario will lead to what is defined in the NRA as social unrest, as well as some long-term damage to nature and the environment. The uncertainty related to the various types of consequences varies from *low* to *high*. Overall, the uncertainty associated with the consequence assessment is assessed as *moderate* compared with the other assessments in the NRA.

Life and health

The greatest uncertainty is associated with the number of deaths, injuries and ill people as a direct or indirect consequence of the storm. The number of deaths as a direct consequence of the storm (during the storm or the subsequent clean-up work) is assumed to be at least 20, based on experience from Cyclone Gudrun in Sweden in 2005. When a similar storm hits a far more densely populated area such as the inner Oslo Fjord concurrently with a storm surge, a higher number of deaths and injuries is expected. This is due to the destruction of buildings and structures, being hit by flying objects in the air and chaotic traffic conditions on the roads, railways, sea and in the air – in addition to trees and poles falling over, which is what caused the greatest number of deaths in Sweden in 2005.

There will probably also be deaths, injuries and illnesses as an indirect consequence of the storm due to transport accidents (damaged infrastructure) and the lack of emergency assistance for the sick and elderly due to reduced navigability and the failure of communication systems.

There is a broad range of potential outcomes since there are consequences of several simultaneous events and consequential events. It is assumed that the number of deaths overall – as a direct and indirect consequence of the storm – may be around 100. The number of serious injuries and ill people as a direct or indirect consequence of the storm is assumed to be over 500. The number of injuries and ill people will primarily depend on how long the loss of power lasts and to what extent the storm surge contaminates the drinking water.

Nature and the environment

It is assumed that damage to forests in parts of the storm-ravaged area will be extensive, but not irreparable. An estimated 1,000 km² of forest will be damaged, and the clean-up will take from three to ten years. The base of knowledge for this assumption is assessed as good, and it is based on experience from similar storms.

Economy

Material losses are estimated to be high and range from NOK 10 to 15 billion. This primarily represents repair and rebuilding costs associated with damaged buildings and infrastructure, such as roads, power supply, and water and sewerage systems.

Societal stability

Critical infrastructure such as power lines, road networks and water and sewerage facilities will have extensive local damage with consequences for many people for a short period of time. It is assumed that the least damage will be in Oslo itself, due, for example, to a robust power supply infrastructure (underground cables). Between 1,000 and 10,000 people may have reduced water quality for approximately one week caused by surface water and the lack of purification due to the loss of power.

Due to damages to power lines, it is assumed that approximately 300,000 households may be affected by the loss of power and have no telephone or data communication for 1–7 days. The power supply to Oslo is assessed as robust and dimensioned for a storm of this strength, but the distribution grid outside of the capital is more variable and vulnerable. The loss of power can result in a failure of health and care services, problems heating homes and buildings, as well as in the contamination of drinking water. It is assumed that evacuation will not be necessary.

It is not expected that the storm scenario will cause any significant social unrest. A storm is a familiar event that is generally not particularly frightening. Due to the fact that a storm cannot simply be avoided, it can, however, create a sense of discomfort and feeling of powerlessness.

Capacity to govern and territorial control

It is assumed that the storm scenario will not be of significance to the national capacity to govern or territorial control.

TABLE 2. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
ASSESSMENT OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Experience with a few storms that are similar.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Good meteorological models, but more uncertain simultaneous events and consequential events.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	Both the likelihood and consequences are sensitive to the assumption of a simultaneous storm surge.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is considered to be moderate to low.

TABLE 3. Placement of the scenario in the risk matrix.

"Storm in Inner Oslo Fjord" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE					
MEDIUM				◎	
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The storm scenario is assessed as having a *high* likelihood and *medium* social consequences. The uncertainty surrounding the estimates is assessed overall as *moderate*.

SCENARIO

04.2 Long-Term Power Rationing

An adverse event in the "extreme weather" risk area is a situation with long-term power rationing in an area with a large population. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific serious scenario.

The risk analysis was conducted in the autumn of 2010.

Preconditions for the scenario

Time

From 1 March to 15 May (two and a half months)

Course of events

- From 1 March, all power-consuming industry is ordered to disconnect, while quota rationing is also introduced.
- From 15 March, rotating disconnection is implemented by zone (zones will be disconnected on a rotating time cycle). The rationing will end on 15 May when the spring melt begins.

Concurrent events

The power situation in other parts of the Nordic region and Europe is tight, and opportunities for importing are very limited.

Contributing factors

- Two seasons with little prior precipitation.
- Low water reservoir levels.
- Early, cold winter resulting in a high demand for power.

Assessment of likelihood

An assessment has been made of the likelihood of long-term power rationing in the area in question as a result of a lack of precipitation. This scenario is expected to occur once every 100 to 200 years, i.e. there is a 0.5–1% likelihood that it will occur in the course of a year. In the National Risk Analysis (NRA), this estimate is at the lower end of the category moderate likelihood (once every 100 to 1,000 years). The likelihood of such a rationing situation is assessed therefore as *moderate* to *high*.

Key contributing factors to the event are two seasons with low precipitation, and severely reduced import opportunities from abroad, for example due to to stoppages in Swedish nuclear power generation, cable breakage, etc. A third factor is reduced power generation in Norway, which is described in the scenario as a result of incorrectly estimated reservoir levels.

The uncertainty associated with the assessment of the likelihood of the adverse event is assessed as *moderate* in the NRA. This is due to several circumstances, including the power system's complexity, unforeseen events and the relationship between factors such as generation, importation, consumption and user flexibility.

TABLE 4. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.5-1%			◎			Once every 100 to 200 years based on statistical and sectoral analyses.

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death			◎			Up to 100 deaths as a direct or indirect consequence
	Injuries and illness				◎		300-500 injuries or ill people as a direct or indirect consequence
Nature and the environment	Long-term damage						Not relevant
Economy	Financial and material losses				◎		NOK 10–50 billion
Societal stability	Social unrest				◎		Very large scope and long duration, vulnerable groups are affected, responsibility questioned, reactions such as anger and mistrust
	Effects on daily life					◎	Critical services and deliveries are hit hard; long duration; households, private enterprises and the public sector are affected
Capacity to govern and control	Weakened national capacity to govern						Not relevant
	Weakened territorial control						Not relevant
OVERALL ASSESSMENT OF CONSEQUENCES					◎		Large consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

Assessment of consequences

The social consequences of the given scenario are assessed as *large*. The scenario will primarily threaten the societal assets economy and societal stability. The uncertainty associated with the assessments of the different consequence types varies from *moderate* to *high*. Overall, the uncertainty is assessed as *moderate* compared with the other assessments in the NRA.

Life and health

Long-term rationing will constitute a risk to life and health, and the loss of life is very probable. Inadequate means of maintaining a normal indoor temperature will be very serious in the winter, especially for the elderly or ill people. Furthermore, it is assumed that there will be greater consequences of accidents such as fires and traffic accidents, since the disconnection of power will make it difficult to raise the alarm in connection with accidents and acute illness. The direct and indirect deaths are assumed to reach a total of 100 overall. The number of serious injuries and ill people as a direct or indirect consequence of the rationing is assumed to range from 300 to 500. The uncertainty associated with the estimates is assessed as *moderate*.

Nature and the environment

It is assumed that power rationing will not be of significance to nature and the environment.

Economy

The costs resulting from the scenario are assumed to be high, especially for trade and industry. Financial losses in particular would be large, in the form of lost income due to production stoppages, loss of contracts, etc. Material losses linked to water and frost damage, for example, must also be included in the calculations. Total financial losses are estimated at being between NOK 10 and 50 billion. The uncertainty associated with the estimates is assessed as *moderate*.

Societal stability

Power rationing and rotating power disconnection by zones is a relatively known type of event, and the consequences they entail are known. The disconnected zones have no supply of power. Hospitals and certain other crucial societal functions are given priority, while other customers are given access to electricity for a very limited period of the day (2 x 4 hours). It is assumed that the scope and duration of the rationing that will affect trade and industry and a large number of homes will lead to social unrest and reactions such as anger and aggression.

Those who are affected do not have any opportunity to change the situation, and they are at the mercy of the authorities' management, weather conditions, and opportunities for the import of power. Rationing will affect vulnerable groups in particular, and be perceived as socially unfair. Both trade and industry and the general population are assumed to have the expectation that it should be possible to avoid power rationing, and the event can result in a reduction of trust in the authorities.

Disconnecting the power will have large consequences for a number infrastructures and social functions, and it will result in substantial effects on daily life. In particular, ICT systems will be hard hit. All networks that transmit electronic information require a supply of power, such as landline and mobile telephony. Other systems and functions, such as payment terminals, cooling systems, ATMs, pumps for fuel, transport centres, signalling systems for trains and road traffic, will also have major problems. It is estimated that several hundred thousand people will experience problems in one or more of these areas while rationing takes place.

Power rationing is assumed to threaten societal stability to a significant extent. The assessments are based on analyses and studies in the power and telecommunications sector, among others, but since we do not have experience with such long-term power rationing, the uncertainty associated with the assessments is considered to be *high*.

Capacity to govern and territorial control

It is assumed that the power rationing scenario will not be of significance to the national capacity to govern or for territorial control. ◎

TABLE 5. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Extensive access to historical data for precipitation, temperatures and inflow, sectoral analyses, experience from prior events – but not from events with such a scope and duration.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Power disconnection and rationing is considered to be a known and researched phenomenon, compared with other types of events that have been analysed in the NRA.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The likelihood that the event will occur is sensitive to changes in the assumptions regarding the water reservoir levels and import opportunities from abroad. The consequences are sensitive to changing seasons, average temperature during the period of the event and the duration of rationing. The sensitivity of the results is assessed therefore as moderate.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is considered to be moderate.

TABLE 6. Placement of the scenario in the risk matrix.

"Long-Term Power Rationing" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE			◎		
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The scenario is assessed as having a *medium-high* likelihood and *large* social consequences. The uncertainty associated with the results is assessed as *moderate*.

PHOTO: NTB/SCANPIX

LOT OF WATER IN THE FLÅM RIVER
Flood in Western Norway in 2014
The Flåm River in Aurland spilled well over its banks during the flood at the end of October.

05

FLOODING

Background

At the end of October 2014, large amounts of precipitation in the form of rain even at high elevations in the mountains resulted in major flooding at several locations in Western Norway. Hardest hit were the inland areas of Hordaland and Sogn og Fjordane, where the Flåm River (Flåm, Municipality of Aurdal), Vosso (Voss) and Opa (Odda) had water levels ranging from a 200 to 500 year flood, The E16 highway and the railway between Oslo and Bergen were closed for several days, the Flåm Railway was closed, several bridges were washed out by the flood and many sections of road and several tunnels were closed due to flooding, landslides and the risk of landslides. Many houses were destroyed by the water, and approximately 500 persons were evacuated. In addition, the record flood resulted in major material damage to buildings and infrastructure. The scope of the economic damage is great, but has not yet been calculated.

In May 2013, the Gudbrandsdalen valley was hit by major flooding caused by snowmelt and the subsequent intense period of precipitation over a three-day period. The E6 highway and railway were closed, and flooding, water gone astray, landslides and erosion in caused particularly many events in the sides of the valleys. In some areas, almost all of the roads were destroyed, and one village and several farms were isolated. A total of 220 persons were evacuated. The Oppland County Administration estimated the overall scope of the damage to be close to NOK 1 billion.[31]
Only two years earlier, in June 2011, Southern Norway was hit by a storm surge as a consequence of large volumes of precipitation and snowmelt. Areas particularly hard hit were Gudbrandsdalen in Oppland, Driva in Møre og Romsdal and inland areas of Western Norway, although Østerdalen was also affected. In several places the water flow rate/levels culminated at around the 100-year flood level.[32] Flooding and many landslides led to major destruction. More than 270 people were evacuated from their homes, mainly in Oppland. Helicopters were used in the evacuation due to access problems. In addition, an unknown number of people took care of their own evacuation. For a period, all main transport arteries between Eastern Norway and Trøndelag were closed. In addition, the flooding created problems for the railway, and the Dovrebanen line was closed. Compensation payments for damage caused by natural events were estimated at approximately NOK 800 million.[33] Compensation paid by the Norwegian Natural Disaster Fund comes in addition to this. Compensation of up to NOK 90 million was awarded in August 2014 for the flooding in 2011, but

[31] *Oppland County Administration: "Plan programme: Regional plan for the Gudbrandsdalslågen River and tributaries – including measures against flooding and landslides".*
[32] *Norwegian Water Resources and Energy Directorate, Report 11/2011.*
[33] *Finance Norway (www.fno.no), 29/06/2011.*

this amount may increase even further. At the same time, but independent of the flooding, the Telenor mobile phone network suffered major problems. These problems affected voice traffic and SMS text messages throughout the country, and it took more than 24 hours to correct the fault. This created major difficulties in managing the event.

The flood in Western Norway and the two floods in the Gudbrandsdalen valley are, along with Cyclone Patrick (Dagmar), the most extensive and most costly natural events since the major flooding in Eastern Norway in 1995.
In 1789, the greatest ever known flooding in Norwegian history occurred, subsequently referred to as "Storofsen". Public statistics show that the flooding cost the lives of 72 people, and that more than 1,500 farms were damaged. In 1995, parts of the interior of Eastern Norway were affected by flooding on virtually the same scale, "Vesleofsen". 7,000 people were evacuated and one person was killed. There were reports of approximately 6,900 injuries. It is estimated that the flooding caused damage valued at around NOK 1.8 billion.[34]

History has shown that there are different types of weather that cause the most severe flooding in the various regions of Norway. In Western and Northern Norway, flooding is usually caused either by the remnants of tropical cyclones, or by a high pressure area over Great Britain or the Continent with a strong westerly wind north of the high pressure area. In Southern Norway and near the coast of the Oslo Fjord, severe rain flooding coincides with low pressure close to Great Britain. In Eastern Norway, low pressure tracking from the south or south-east gives rise to the most hazardous flooding.[35]

Risk

Compared to countries located at more southerly latitudes, Norway is spared from the most violent flooding disasters. This is primarily due to Norway's topography.

Nevertheless, from time to time, major flooding with serious consequences does occur in this country too. A review of events over the past two hundred years shows that there have been ten or twelve major floods in Norway during that period. This means that, on average, less than 20 years passes between each incidence of such flooding. A flood's potential for damage in Norway is dependent, however, on the part of the country that is affected. There is flooding in the major watercourses of Eastern Norway and Trøndelag that are assumed to be capable of causing greatest damage, both because of being densely populated and because the watercourses here are less able to channel away extreme volumes of water.[36]

There is reason to believe that, in the years ahead, climate change, in the form of more precipitation and higher temperatures, will mean more frequent and more severe flooding in Norway. Forecasts indicate larger flash floods and earlier spring floods, among other things.[37] The likelihood of meltwater flooding is reduced, while more floods late in the autumn and in the winter are anticipated. It is also expected that more intense local precipitation will create flooding problems in places that were not exposed to flooding previously, particularly in small, steep rivers and streams, and in densely populated regions. In addition, a higher frequency of periods of high-intensity precipitation will increase the likelihood of earth and mud slides – this too in areas that would not previously have been subject to this type of event.

Major flooding can have serious consequences. The historical record contains a series of reports on the loss of human lives in flooding and other watercourse accidents. In more recent times, however, there have been few deaths in Norway as a consequence of flooding. Improved warning and communication systems are important reasons for this. 7,000 people were evacuated ahead of the major flooding in 1995.

However, there can be an immense amount of material damage. Volumes of water which rush in and swamp buildings, bridges, roads and agricultural land can involve huge financial losses. Infrastructure elements such as water and sewerage are also vulnerable to flooding. In addition, flooding may also entail the need for evacuation and reduced navigability for the transport of freight and passengers as a consequence of destroyed infrastructure and reduced service provision. There may also be mental stress in the form of anxiety, unrest and worry.

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[34] *Norwegian Agricultural Authority (www.slf.dep.no), 02/04/2012.*
[35] *Roald, Lars Andreas (2007) Innsamling av data om historiske og framtidige flomhendelser i NVE [Acquisition of Data on Historical and Future Flooding Events in the NVE]. Inception seminar at Gardermoen, 29 March 2007.*
[36] *Roald, Lars Andreas (2012) Hva slags flom er det verst tenkelige som kan ramme Norge? [What is the Worst Conceivable Type of Flooding that Could Affect Norway?] Norwegian Water Resources and Energy Directorate (unpublished).*
[37] *NOU 2010:10 Tilpassing til eit klima i endring [Official Norwegian Report 2010:10 Adaptation to Climate Change].*

Prevention and emergency preparedness

The Norwegian Ministry of Petroleum and Energy has the overall responsibility for preventing flooding and landslides while the operational responsibility has been delegated to the Norwegian Water Resources and Energy Directorate (NVE).[38] This responsibility involves providing assistance in the form of know-how and resources for mapping, land-use planning, protection, monitoring, warning and emergency preparedness in general, etc. The NVE is to hold monitoring and inspections of dams and other watercourse facilities.[39] The general municipal emergency preparedness obligation means that municipal authorities are to identify the adverse events that might occur within their municipality.[40] According to the Planning and Building Act and the Natural Disasters Act, municipal authorities have the responsibility to prevent flooding and landslides, and to protect the inhabitants from these.[41] The municipal authorities' land-use planning is an important instrument in this work.[42] The NVE has drawn up guidelines[43] that describe the way in which municipal authorities ought to identify and take into consideration the danger of flooding and landslides in their land-use plans. The municipal authorities' analyses of risk and vulnerability are crucial in identifying areas at risk of flooding and landslide. The NVE provides assistance and guidance to the municipalities in this work, and is able to provide professional and financial assistance in the planning and implementation of protective measures.[44]

Identification, land-use planning, and protective measures reduce the risk of damages that are the consequence of flooding and landslides. Nevertheless, it is not possible to remove all risk, and the public authorities must therefore make preparations for such events occurring. The NVE is responsible for the national flood warning service and has a continuous 24-hour emergency telephone line.[45] In emergency situations linked to flooding, several emergency response authorities will be involved and will take on responsibility, including municipal authorities, the police, the Maritime Rescue Coordination Centre, the Civil Defence, the Norwegian Public Roads Administration, the Norwegian National Rail Administration and the County Governor. The NVE has had professional responsibility for reducing damage from flooding for almost 200 years and therefore has solid competence in this field. The Directorate provides professional help to municipal authorities, the police and other emergency response authorities in the event of contingencies and emergency situations.[46] ◎

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[38] *Proposition no. 1 S (2011-2012) to the Storting, Norwegian Ministry of Petroleum and Energy.*
[39] *Cf. Norway's Water Resources Act and the Dam Safety Regulations.*
[40] *Act of 25 June 2010: Act relating to Municipal Emergency Preparedness, Civil Protection and the Norwegian Civil Defence (the Civil Protection Act).*
[41] *Cf., for example, Section 20 of the Natural Disasters Act and Sections 11-8 and 28-1 of the Planning and Building Act.*
[42] *NOU 2010:10 Tilpassing til eit klima i endring [Official Norwegian Report 2010:10 Adaptation to Climate Change]; Document 3:4 (2009–2010) Riksrevisjonens undersøking av arbeidet til styresmaktene med å førebygje flaum- og skredfare [Office of the Auditor General of Norway's investigation into the work of the public authorities for preventing the danger of flooding and landslides]; St.meld. nr. 22 (2007–2008) Samfunnssikkerhet [Report no. 22 (2007–2008) to the Storting on Civil Protection] and St.meld. nr. 42 (1996–1997) Tiltak mot flom [Report no. 42 (1996–1997 to the Storting on Measures against Flooding].*
[43] *Norwegian Water Resources and Energy Directorate, Flaum- og skredfare i arealplanar [Risk of Flooding and Landslides in Land-Use Plans], Guidelines 2/2011.*
[44] *Proposition no. 1 S (2011-2012) to the Storting, Norwegian Ministry of Petroleum and Energy.*
[45] *Norwegian Water Resources and Energy Directorate (www.nve.no) 14/02/2012.*
[46] *Proposition no. 1 S (2011-2012) to the Storting, Norwegian Ministry of Petroleum and Energy.*

SCENARIO

05.1 Flooding in Eastern Norway

Major flooding in densely populated areas is an adverse natural event. The specific scenario that has been analysed is extensive flooding due to a very high rate of water flow in the largest rivers in Eastern Norway.

The risk analysis was conducted in the winter of 2011/2012.

Preconditions for the scenario

Weather conditions

Large quantities of snow in the mountains and a cold spring. Warm air front from the south-east results in a rapid temperature rise and snowmelt and brings large amounts of precipitation with it.

Duration

Three days in May with an extreme amount of precipitation and an abnormally high rate of water flow for four weeks

Rate of water flow

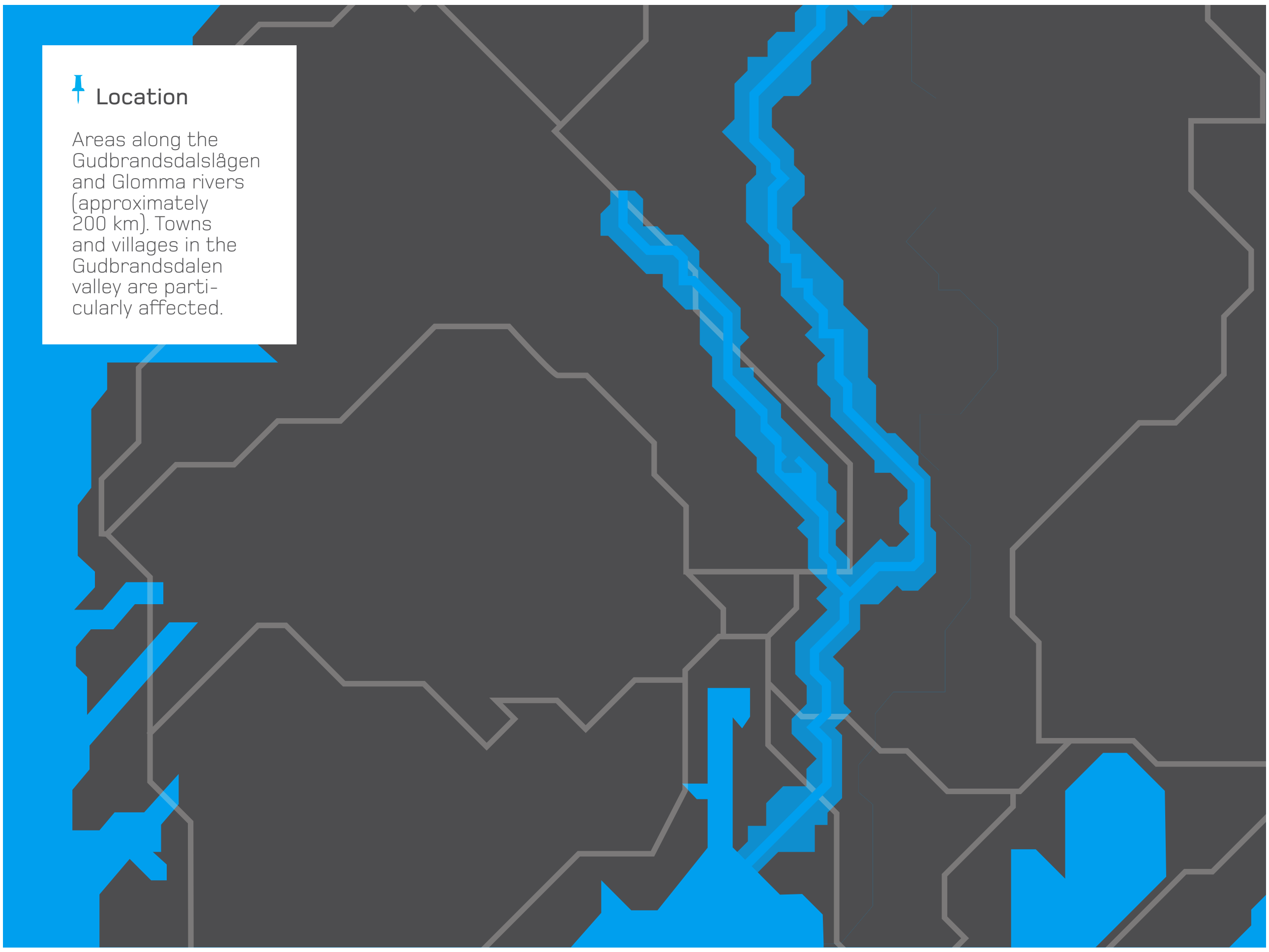
- 3,500–5,000 m³ per second
- Water level in Mjøsa: Eight metres on the local height scale, (2.75 metres above the highest regulated water level (HRWL)

Consequential events

- Several hundred minor landslides
- Flood defences breached

Comparable events

"500-year floods" like Storofsen in 1789 and Vesleofsen in 1995.



Assessment of likelihood

Flooding on such a scale is due to concurrent events that are expected to occur every 500–1,000 years, i.e. there is a 0.1–0.2% likelihood that the event will occur in the course of a year. In the National Risk Analysis (NRA), such major flooding falls under the likelihood category *moderate*. More moderate major flooding occurs far more often in Norway, once every 20 years on average.

The likelihood estimate is based on prior flooding in Norway and Northern Europe from historic times. Such extensive flooding in Norway requires a rare coincidence of several meteorological conditions, such as a strong and relatively stationary warm front moving along an unusual path from the south-east, as well as a lot of snow and cold that results in a late and rapid snowmelt. Climate change is expected to result in more precipitation and higher temperatures in the future, and this will mean more frequent and extensive flooding, especially in the autumn and winter. The uncertainty associated with the likelihood estimate is assessed as *moderate*.

TABLE 7. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.1-0.2%			◎ (moderate uncertainty)			Once every 500 to 1000 years based on statistical and sectoral analyses

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death				◎ (moderate uncertainty)		More than 100 deaths as a consequence of flooding or landslides
	Injuries and illness				◎ (moderate uncertainty)		500-2,500 injuries or ill people as a direct or indirect consequence
Nature and the environment	Long-term damage	◎ (low uncertainty)					Little permanent damage
Economy	Financial and material losses				◎ (low uncertainty)		NOK 5-10 billion
Societal stability	Social unrest			◎ (moderate uncertainty)			Inadequate preparedness (underdimensioned flood protection) and difficult rescue work
	Effects on daily life			◎ (moderate uncertainty)			Approximately 10,000 persons must be evacuated, roads and railways damaged, loss of power
Capacity to govern and control	Weakened national capacity to govern						Not relevant
	Weakened territorial control						Not relevant
OVERALL ASSESSMENT OF CONSEQUENCES				◎ (moderate uncertainty)			Large consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

Assessment of consequences
There are approximately 10,000 people living in the areas that will be affected by the flooding in the scenario. Overall the social consequences are assessed as *medium-sized*. The scenario will primarily threaten the societal assets life and health and economy. In addition, the scenario will entail major damage to critical infrastructure and result in some social unrest. Overall, the uncertainty associated with the assessments is considered to be *moderate* compared with the other assessments in the National Risk Analysis.

Life and health
At least 100 human lives are assumed to perish because the flood defences designed to control the flooding are not dimensioned for such large amounts of water. Thus there is less control over the rate of water flow than there is with lesser flooding. At least 10 human lives are assumed to perish due to the many avalanches that will occur, especially in the Gudbrandsdalen valley. It is assumed that between 500 and 2,500 people will be injured or become ill as a direct or indirect consequence of the major flood. The uncertainty associated with the consequence estimates for life and health is assessed as *moderate* to small, since we know what areas will be flooded, how many people live there, etc.

Nature and the environment
The water will carry away the soil and cultivated land will be eroded and remain under water for a period of time. Both nature reserves and cultural artefacts will be affected, but it has been assessed that the flooding will not entail long-term serious damage to the natural or cultural environment. Even if large areas are flooded, this will not have lasting negative consequences for the environment. The uncertainty in this assessment is assumed to be *low*, because there is a great deal of experience of how flooding affects the natural environment, and there is local knowledge of what natural and cultural assets are affected.

Economy
Financial losses are estimated to range from NOK 5 to 10 billion. This is attributed primarily to damage to infrastructure and buildings, which will be costly to repair and rebuild, as well as to temporary production losses in the affected areas. The uncertainty associated with the financial losses on which the scenario is based is assumed to be *low*.

Societal stability
Flooding is essentially a known event that does not create fear or uncertainty with regard to the course of events and consequences. Flooding of the dimensions that are assumed in the scenario will nevertheless create some social unrest.
People who live in the flood-threatened areas will be warned and have an opportunity to escape. Housing and real estate, however, are very vulnerable to damage. Flooding will affect schools, day care centres and institutions in the area, either directly or indirectly, when the transport system collapses.

People will expect that the authorities manage the event well, since flooding is a known phenomenon and a warning can be given. Underdimensioned flood defences in relation to an extremely high rate of water flow will nevertheless result in a high risk of loss of life and frustration over an inadequate level of preparedness. There may also be a lack of emergency response personnel to secure buildings, rescue animals from farms, etc., during the days and hours before the flooding. Rescue work will be difficult because of inadequate navigability (large amounts of water and damaged roads).

Almost all of the 10,000 people who live in the area subject to flooding will have to be evacuated from a few days up to a month. Almost all of the households will experience problems with the supply of water from the waterworks and electronic communications. There will be a great deal of damage to the roads and railways in the area, and this will affect both local and through-going traffic. It is also assumed that most of the households in the area will lose power for a short period of time (3 to 7 days).

The effects on daily life for those affected by the flooding are assessed as medium-sized overall. The uncertainty associated with the consequence assessments is considered to be *moderate* to low. The outcome of the flooding is dependent on rapid snowmelt coinciding with precipitation, but lesser flooding can also result in extensive damage.

Capacity to govern and territorial control
It is assumed that flooding will not weaken the national capacity to govern or to have territorial control.

TABLE 8. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
ASSESSMENT OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Experience from many floods, but just two of a similar magnitude in Norway.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Good comprehension of causality, the course of events and consequence types.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The key assumption for the likelihood assessment is that weather conditions create coincidence between rapid snowmelt and heavy precipitation. The consequences, especially for life and health, are very dependent on how great the rate of water flow is and whether the flood defences are breached. The sensitivity of the results is assessed as moderate overall.
Overall assessment of uncertainty	The uncertainty associated with the estimates of likelihood and consequences is assessed as moderate to low.

TABLE 9. Placement of the scenario in the risk matrix.

"Flooding in Eastern Norway" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE					
MODERATE			◎		
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The flooding scenario is assessed as having a *moderate* likelihood and *medium* social consequences. The uncertainty associated with the results is assessed as *moderate*.

MUDSLIDES
On 20 May 2012, there was a large landslide along the Gjerivegen road in Gjerdrum in Akershus. Private homes were a total loss and industrial buildings sustained major damage and could no longer be used.

PHOTO: NTB/SCANPIX

PHOTO: NTB/SCANPIX

06

LANDSLIDES AND AVALANCHES

Background

Landslides and avalanches are terms for natural events in which material in the form of snow, rock or soil moves down a slope. As illustrated in the table below, a distinction is made between the various types of landslides and avalanches, depending on what type of material moves down a slope. The term *slip* is often used synonymously with *slide* in everyday speech. Landslides and avalanches are part of the natural geological processes that occur when rocks and loose materials break down. Two scenarios have been developed for two types of slides in the National Risk Analysis: rockslides and quick clay landslides.

Rockslides

Rockslides are defined as slides with a volume of over 100,000 m^3.[47] The reason for a rock avalanche being triggered can be difficult to identify because deformations, finally resulting in a rock avalanche, usually happen over a lengthy period. An increase in water pressure, earth tremors or frost action can be contributory causes of rockslides.

Rockslides are among the most serious natural disasters that can occur here in this country. Large rockslides are rare, but the degree of damage can be great. History indicates that there have been two to four fatal rockslide events every century in Norway. When a large rock massif collapses and slides out, it gains colossal power and range. If the material reaches a fjord or lake, flood waves may arise that can propagate over large areas.

TABLE 10: Classification of landslide and avalanche types in Norway (Source: NVE).

Hard rock	Loose material Coarse ◄——► Fine		Snow
Rockfall	Landslide		Avalanche
Rockslide Deep-seated landslide	Debris flow slide	Quick clay landslide	Wet snow avalanche

[47] Autumn, Jan (2006): Store fjellskred i Norge [Major rockslides in Norway], report for the Norwegian Ministry of Agriculture and Food on behalf of six government ministries. Drawn up by the NGU in collaboration with the Directorate for Civil Protection and Emergency Planning, the Norwegian Public Roads Administration, Norwegian National Rail Administration, Norwegian Agricultural Authority and the Norwegian Mapping Authority.

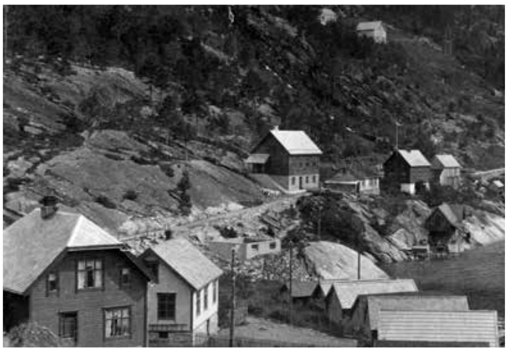
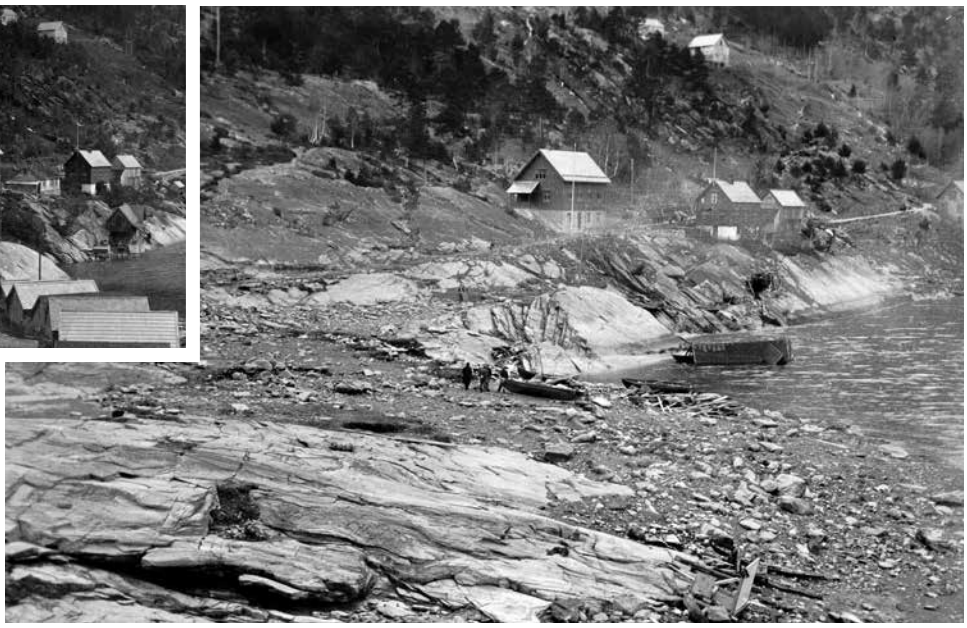



FIGURE 11. The buildings in Fjøra in Tafjord were obliterated by a flood wave from Langhammaren in 1934. Photo: Astor Furseth's photo archive

The last major rock landslide disasters in Norway occurred in the 1930s in Tafjord and Loen. During the landslide in Loen in 1905, 61 people were killed, while the 1936 slide in the same place led to the death of 73 people. For the landslide in *Tafjord*, two years prior, the death toll was 40. The common factor for these landslides was that large rock massifs collapsed and slid down into water and fjord, giving rise to enormous flood waves that had a huge range and a disastrous impact on people, buildings, animals and cultivated land. Figure 11 illustrates how the flood wave from the landslide in Tafjord obliterated the buildings in Fjøra.

Quick clay landslides

The phenomenon of quick clay is linked to the ice age and the subsequent emergence of land in which salt water clay (marine clay) has risen above sea level. Here the interstitial saltwater has been replaced in part by freshwater. The marine clay develops over a long period of time into quick clay in some zones. In Norway, marine clay is most often found in Trøndelag and Eastern Norway, but it is also common many places in Northern Norway and a few places in Western Norway and Southern Norway.

The most characteristic aspect of a quick clay landslide is the fact that the material becomes completely fluid during the actual slide and can cover large areas. No warning signs are given, such as slow crack formation. The largest accident in recent times was the quick clay landslide in *Verdalen* in 1893, when 116 people perished. Figure 12 shows what a quick clay landslide is like.

FIGURE 12. Quick clay landslide in Lyngen, September 2010 Photo: Marius Fiskum

Quick clay landslides can be triggered by natural causes as a result of erosion in a waterway, but in our time it will often be human beings who disturb the natural equilibrium and create the prerequisites for a landslide. Even relatively modest load changes (fill) at the top of a slope can trigger a quick clay landslide, if the conditions are unfavourable. Excavation at the foot of a slope can weaken the counterbalance.

Risk

Landslides and avalanches are among the natural hazards that cause the greatest number of deaths in Norway. Since 1900, over 500 landslides and avalanches have been recorded, and 1,100 lives have been lost. Figure 13 shows an overview of the number of deaths from landslides and avalanches in Norway per decade since 1900 by the type of slide.

Landslides and avalanches are essentially natural processes that will occur at irregular intervals. Human activity and encroachments on the terrain may, however, also affect the risk of slides, and trigger slides. Examples of this include avalanches triggered by skiers, and quick clay landslides triggered by excavation or filling work. Even if we try to avoid settlement and development in areas where there is a high likelihood of events, and to secure areas in which infrastructure and settlement was established before the risk was known, there will always be a residual risk of adverse events. This can result in the loss of life, damage to buildings, damage to nature and the environment, and the failure of critical infrastructure related to transport, power and electronic communication, which can in turn result in financial losses for trade and industry and society in general. The uncertainty associated with the risk of a landslide or avalanche may also entail a negative health impact as a result of anxiety and insecurity. Depopulation may be a real consequence.

Rockslides

In cooperation with the Geological Survey of Norway (NGU), the NVE is surveying rock massifs with a high risk of rockslide. A total of 300 potentially unstable rock massifs have been identified so far. According to the NGU, 400–700 objects of varying sizes that should be subject to inspection and closer assessment could be identified nationally. It is assumed, however, that 70–90 per cent of these objects could

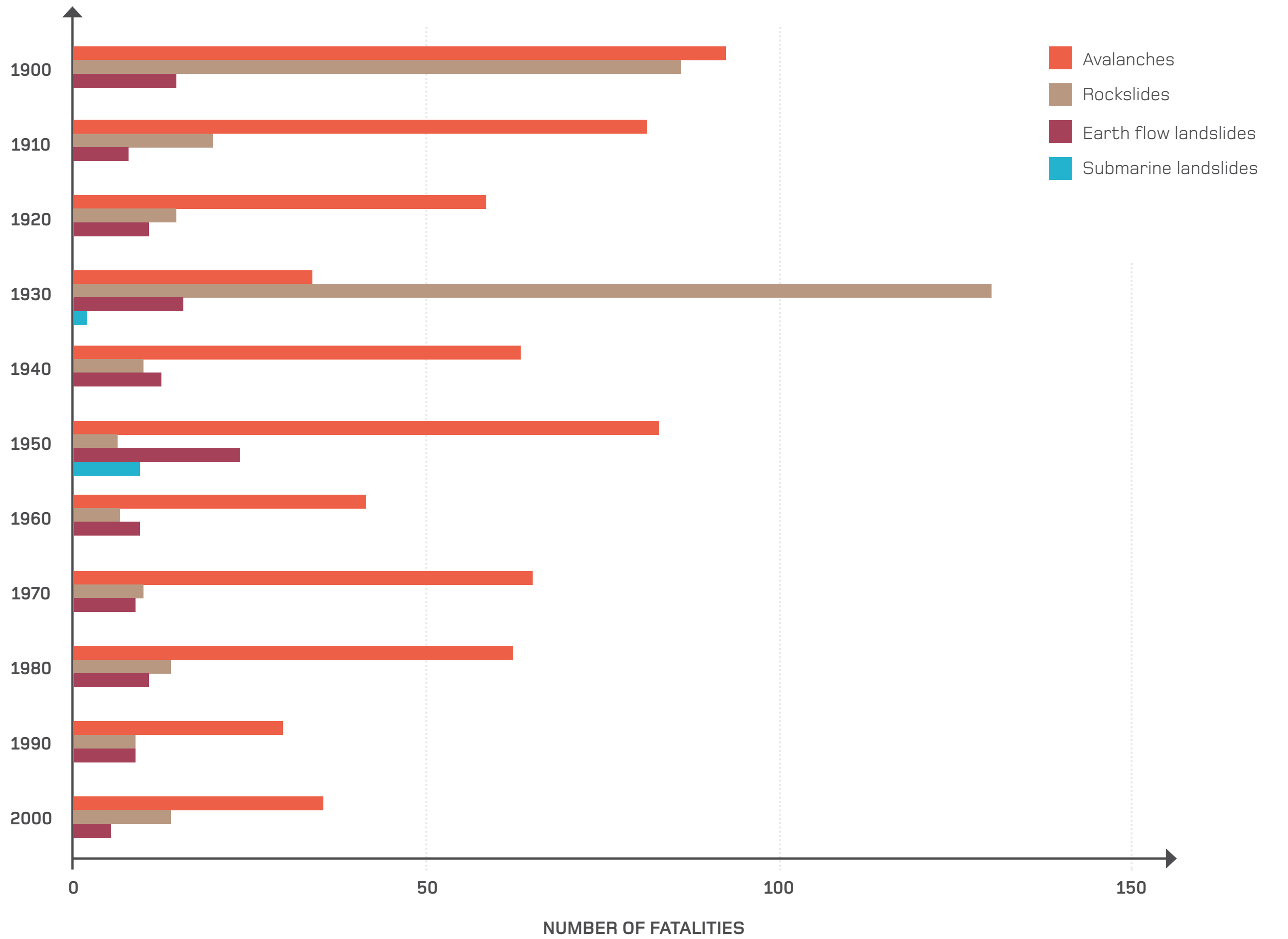


FIGURE 13. Number of recorded fatalities due to landslides and avalanches in Norway per decade since 1900, by type of landslide or avalanche. Source: Skrednett.no.

TABLE 11. Distribution of surveyed zones (quick clay) with regard to the degree of risk and risk classes (risk class 5 has the highest risk).

RISK CLASS / DEGREE OF RISK	1	2	3	4	5
High degree of risk	10	34	114	47	19
Average degree of risk	108	280	451	89	4
Low degree of risk	106	245	237	21	0

be written off as risk objects after preliminary field inspections. Periodic measurements should be taken of the remaining objects. These measurements will form the basis for either writing off the objects, continuing the measurements, or, if they prove to be high-risk objects, implementing risk reduction measures. According to a rough estimate, 10–15 objects nationally could be so-called high-risk objects.

A preliminary risk classification of identified objects (unstable rock massifs) has been completed in Møre og Romsdal, and similar work is being carried out in Sogn og Fjordane and Troms under the direction of the NGU. A method of hazard and risk classification has been developed that is used for the prioritisation of more detailed surveys and the assessment of risk reduction measures, such as periodic or continuous monitoring. The classification is based on data from periodic measurements of movement, structural geological conditions, volume, historical occurrence of land and rockslides, possible run-out distance and potential flood waves in fjords or waterways. In addition, a rough analysis of the consequences in the form of loss of human life in exposed areas is performed.

Quick clay landslides

The survey of quick clay areas with a potentially high landslide risk started after the *Rissa landslide* in 1978. Such survey work has a twofold purpose, in which the boundaries of the zone are surveyed first based on quaternary geology, topography and drilling. Then an assessment is made of the risk based on an assessment of the landslide risk and exposed objects (people/infrastructure) within the zone. Up to now around 1,750 quick clay zones have been surveyed, primarily in Eastern Norway and Trøndelag. Degree of hazard and risk maps have been prepared for these zones. Approximately 64,000 people live in zones where there is a risk of a major quick clay landslide. In addition, there are other buildings, such as schools, day care centres, industry, stores and other central business district buildings within these zones. There are still areas potentially subject to a major quick clay landslide that have not been surveyed. In the NVEs survey plan, a number of areas have been identified that are being assessed for quick clay surveying[48].

Prevention and emergency preparedness

Individual inhabitants, landowners and owners of buildings and infrastructure have a responsibility for safeguarding themselves and their property. The municipalities have a general responsibility for safeguarding their inhabitants and local emergency preparedness, which also includes conducting risk and vulnerability analyses. The municipalities also have responsibility for land-use planning and are required to make sure that any new buildings are located in accordance with the safety requirements for flooding, landslides and avalanches stipulated in Acts and Regulations. Developers are responsible on their side for studying the hazards, including hazards directly related to the construction project, before any new development.[49]

The Norwegian Ministry of Petroleum and Energy has the public administrative responsibility for floods, landslides and avalanches, with the Norwegian Water Resources and Energy Directorate (NVE) as the operative authority. The NVE assists municipalities and society in general with managing the challenges related to floods, landslides and avalanches through hazard surveys, follow-up of land-use plans, implementation of protective measures, monitoring and warning, as well as assistance during events. All sectoral

[48] *Norwegian Water Resources and Energy Directorate (NVE) (2011): Plan for skredfarekartlegging – Status og prioriteringer innen oversiktskartlegging og detaljert skredfarekartlegging [Landslide and Avalanche Risk Mapping Plan – Status and Priorities for General Mapping and Detailed Landslide and Avalanche Risk Mapping] under the direction of the NVE, NVE rapport 14/2011.*

[49] *Meld. St. 15 (2011-2012) Hvordan leve med farene – om flom og skred [Report no. 15 (2011–2012) to the Storting], How to Live with the Risks of Flooding, Landslides and Avalanches.*

authorities have an independent responsibility for the prevention and management of flooding, landslide and avalanche risk within their sectors.

Surveys, land-use planning and protective measures reduce the risk of damages as a consequence of flooding, landslides and avalanches. Nevertheless, it is not possible to eliminate all risk, and society must therefore make preparations for the occurrence of such events. The NVE is responsible for the national flood, landslide and avalanche warning service, which issues warnings at the regional level, while it is up to local actors to monitor the relevant valley sides and avalanche channels. In emergency situations linked to flooding, landslides and avalanches, several emergency response authorities will be involved and responsible, including municipal authorities, the police, the Maritime Rescue Coordination Centre, the Civil Defence, the Norwegian Public Roads Administration, the Norwegian National Rail Administration and the County Governor. The NVE provides professional help to municipal authorities, the police and other emergency response authorities in the event of contingencies and emergency situations.

Large rockslides

Today four known high-risk objects are being monitored continuously along with the associated warning and preparedness measures with a view to evacuation prior to a slide occurring. The intermunicipal company Åknes Tafjord Beredskap (IKS) monitors Åkneset, Hegguraksla, and Mannen in Møre og Romsdal, while Nordnorsk Fjellovervåking IKS monitors Nordnesfjellet in Troms. These systems are built up based on local initiatives, but are funded primarily by public subsidies. Several thousand persons may be directly affected if a rockslide occurs in these locations.

Quick clay landslide

Erosion in waterways is an important natural factor for triggering quick clay landslides. The risk of quick clay landslides can be reduced through protective measures in the form of erosion protection or stability-improving measures. The NVE has implemented such preventive measures in cooperation with the municipalities and other public agencies, including the Norwegian Public Roads Administration, for a number of years. Norwegian Public Roads Administration In addition, the NVE works actively with guidance and follow-up of land-use planning in the municipalities, with the intent of avoiding development in hazardous areas, or of implementing the necessary protective measures prior to development.

A detailed study must be completed to determine the need for protection prior to the implementation of protective measures. At the end of 2011, NVE had closely studied a total of 135 quick clay zones, and completed full or partial protection of 72 zones. Around 40 zones were regarded as fully protected at the end of 2011. ◎

SCENARIO

06.1 Rockslide at Åkneset with Advance Warning

An adverse event in the landslide and avalanche risk area is a large rockslide into a fjord, and subsequent flood waves. To illustrate how extensive the consequences of such an event can be, a risk analysis has been conducted on a specific serious scenario.

The risk analysis was conducted in the autumn of 2010.

Operational preparedness[50] has been established for the object Åkneset, such as monitoring and warning of any rockslides and subsequent flood wave. The side of the mountain over Åkneset is monitored continuously, and movements in the rock massif have been measured since 1986. Fissures in the rock expand from a few centimetres to more than 10 cm per year. From the start of measurements until the start of the scenario, movement has been constant, although with seasonal variations.

Preconditions for the scenario

Course of events

- April: Movement in the rock increases from 0.1 to 1 mm per day
- September: Daily movement of several cm
- Transition from yellow to red preparedness state entails the evacuation of all the areas that may be affected by flood waves
- On 11 September a large rockslide into the fjord occurs
- On 13 October a rockslide twice as large occurs

Volume of slide material

- 18 million m³ in the first landslide
- 36 million m³ in the second landslide

Weather conditions

Large snowmelt that increases the movements in May

Consequential events

- Both of the landslides create flood waves
- Surge height of the flood waves from the last landslide ranges from 7 to 80 meters

Comparable events

- Loen 1905 (approximately 50,000 m³ of crag + 300 000 m³ of scree and moraine)
- Loen 1936 (over 1 million m³)

Assessment of likelihood

A rockslide on this scale in Åkneset is estimated to occur once every 100 to 200 years, i.e. there is a 0.5–1% likelihood that it will occur in the course of a year. In the National Risk Analysis (NRA) this estimate is at the lower end of the category moderate likelihood (once every 100 to 1,000 years). The likelihood that a rockslide on this scale will occur in Åkneset is assessed therefore as *moderate* to *high*.

Åkneset is one of several risk areas that are monitored. Several measurement methods are used here to ensure high reliability. Åkneset is a very well-studied object, but each object is individual and represents a complex system, in which many fissures can not be inserted into a model, for example, and there is a large margin of uncertainty. When we study unstable areas, we will only be able to find some of the reasons why the slides occur. The likelihood for the specific scenario is assessed based on historical data and historical frequencies. The uncertainty associated with the assessment of the likelihood of the adverse event is assessed as *moderate* in the NRA.

TABLE 12. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.5-1%			◎ (moderate uncertainty)			Once every 100–200 years based on landslide and avalanche research, and on risk analyses of monitored rock sections

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death		◎ (moderate uncertainty)				Up to 10 deaths as a direct or indirect consequence
	Injuries and illness		◎ (high uncertainty)				Up to 100 injuries or ill people as a direct or indirect consequence
Nature and the environment	Long-term damage			◎ (moderate uncertainty)			In a 200-300 km long coastal area, cultural artefacts and coastal environment will be lost
Economy	Financial and material losses				◎ (low uncertainty)		Up to NOK 50 billion
Societal stability	Social unrest				◎ (moderate uncertainty)		Difficult to avoid, great deal of damage and a large number of persons affected. Expectations for crisis management Long duration. Reactions such as fear, a great deal of uncertainty and feeling of powerlessness
	Effects on daily life					◎ (moderate uncertainty)	Evacuation of a large number of inhabitants for a long period of time, critical services and deliveries will be disrupted for a long period of time for many people
Capacity to govern and control	Weakened national capacity to govern						Not relevant.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎ (moderate uncertainty)		Large consequences overall

Low uncertainty   Moderate uncertainty   High uncertainty

[50] *Emergency preparedness is organised in five stages: Green: low risk and defines the normal situation. Blue: increased movement observed. Yellow: movement that gives reason to maintain a 24-hour watch at the emergency preparedness centre. Orange: serious danger. Red: critical situation. (Åknes/Tafjord Beredskapssenter IKS – National Centre for Rockslide Monitoring).*

Assessment of consequences

The social consequences of the given scenario are assessed as *large*. The scenario will primarily threaten the societal assets economy and societal stability. The uncertainty associated with the assessments of the different consequence types varies from *low* to *high*. Overall, the uncertainty is assessed as *moderate* compared with the other assessments in the NRA.

Life and health

Because advance warning of a rock avalanche makes it possible to evacuate the population, the estimated number of deaths is assessed as up to ten, while the number of injuries and ill people, including long-term consequential injuries, traumas and post-traumatic stress disorders may reach 100. The outcome depends on a correct estimate of the surge height of the flood waves, and on the evacuation being carried out in accordance with emergency preparedness plans, and that the evacuation order is observed over time, i.e. that the inhabitants do not return at the time of the landslides. The uncertainty associated with the estimates is assessed as *moderate*.

Nature and the environment

It is estimated that the flood waves will inflict damage on or destroy 200–300 km of coastal area. The greatest damage will be inflicted on coastal nature and the environment within the surge height. For nature, it is assumed that a nearly normal state will be restored in three to ten years. Cultural artefacts of national importance are also in the category of the *environment*, such as buildings, burial mounds, objects, coastal environments and features of the landscape. The flood wave will lead to such cultural artefacts being lost or having their preservation value substantially impaired. The uncertainty associated with this assumption is assessed as *moderate* and is based on historical data, local knowledge and experience from prior adverse events in Norway and abroad.

Economy

Even at an early phase of the scenario, the increased risk of a landslide will give rise to a great deal of media coverage and fewer tourists, which is assumed to result in major financial losses, particularly for the travel industry. The direct costs are linked to evacuation, major material damage and damage to private homes, public buildings, tunnels and other infrastructure, as well as loss of income, among other things. The clean-up costs will be high. Destroyed or damaged premises, problems with communication and transport, and the long-term effects on tourism will also entail large financial losses. The total financial losses in a scenario like this are estimated at a maximum of NOK 50 billion. The uncertainty associated with the estimates is assessed as *low*.

Societal stability

It is expected that the rockslide will entail a great deal of social unrest. Even if the landslide risk is known, it is assumed that it will nevertheless create fear and uncertainty with regard to what consequences it will have. Warnings and evacuation contribute to protecting life and health, but at the same time reinforce the experience of fear, uncertainty and feelings of powerlessness. The duration of the development of the landslide and the gradual increase in the preparedness level will in themselves contribute to social unrest. The population may lose confidence that the people who should be handling the situation are making the right assessments, which might lead to people acting against the advice being given. It is assumed that there will be a great need for information, which will be challenging for the authorities to meet.

All areas that may be affected by the subsequent flood waves will be evacuated, an action that will affect up to 100,000 people, of whom around 2,000 are assumed to have no housing. Some people will move or avoid the areas during the warning period. Vulnerable services such as health institutions and schools will be moved in accordance with the escalation of the preparedness level. After the landslide has occurred, it is assumed that between 1,000 and 10,000 people will experience disruption in their everyday lives, such as problems getting to work and problems with communications via ordinary ICT systems. This also encompasses a large number of commuters to the area, who will be affected by disruptions in the power supply, telecommunications and transport (closed ferry docks and most of the important stretches of road destroyed). The uncertainty associated with the estimates is assessed as *moderate* based on the fact that specialist groups have until now focused a great deal on geology, and that there is less data on the consequences relating to societal stability.

Capacity to govern and territorial control

It is assumed that the scenario will not be of significance to the national capacity to govern or to territorial control. ◎

TABLE 13. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Access to historical and geological documentation from a few similar rockslides, local knowledge and experience with flood waves in other countries. Less data for the consequences.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Based on research, analyses and modelling, and historical data, rockslides are considered to be relatively well-known phenomena. The focus has been on geology, and to a lesser extent on the consequences.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The change in the supply of water or temperature cycles beyond normal seasonal variations will be of significance to the likelihood assessments. The course of events related to warnings and evacuation are to a great degree decisive for the outcomes for life and health. The volume of the rock mass is decisive for the surge height. The sensitivity of the results is assessed therefore as moderate.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is considered to be moderate.

TABLE 14. Placement of the scenario in the risk matrix.

"Rockslide at Åkneset with Advance Warning" – overall risk

CONSEQUENCES	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
VERY LARGE					
LARGE			◎		
MODERATE					
SMALL					
VERY SMALL					

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The rockslide scenario is assessed as having a *moderate to high* likelihood and *large* social consequences. The uncertainty associated with the results is assessed as *moderate*.

SCENARIO

06.2 Quick Clay Landslide in a City

A serious scenario for the adverse event "quick clay landslide" is a large landslide in a densely populated urban area. The worst-case scenario takes place in a known quick clay zone in the highest risk class[51], where many people live. Øvre Bakklandet in Trondheim with close to two thousand inhabitants is an example of such an area.

The risk analysis was conducted in the winter of 2013.

Preconditions for the scenario

Course of events

- Initial landslide one night in October, a 10 x 100 meter slice slides out into the river Nidelva
- An evacuation is implemented on the following day
- The main landslide (remainder of the zone) occurs on the following night. The clay runs all the way across the river Nidelva, which is completely dammed up

Volume of the slide

- Approximately 3 million m^3 of clay
- Area of approximately 0.5 km^2

Contributing factors

Construction work or erosion

Consequential events:

- The landslide immediately causes a flood wave upstream and downstream in the river Nidelva, which affects the buildings along the river
- The clay dams up the river Nidelva, and the water level upstream rises quickly to approximately 12 meters above sea level. An area of 1.5 km^2 with around 1,100 inhabitants is flooded, which includes the central business district buildings and Øya.

Concurrent event:

High rate of water flow in the river Nidelva after heavy precipitation (100-200 m^3/s)

Comparable events:

- Rissa landslide in 1978 (5–6 million m^3)
- Kattmarka in 2009 (5–600 000 m^3)

Assessment of likelihood

It has been assessed that a landslide in the zone in question could occur every 2,000-3,000 years, i.e. a likelihood of 0.04% per year. The scenario thus falls under the category of *low likelihood*. This estimate is based on the following assumptions:

- That one "major" quick clay landslide occurs in Norway every year.

- That 80% of these landslides take place in one of 1,765 surveyed quick clay zones.

- The likelihood of a landslide is assessed as somewhat lower than for an average zone due to the erosion protection measures implemented in the river Nidelva, and good control of construction projects.

Øvre Bakklandet is one of the surveyed quick clay zones, with the greatest number of inhabitants and the potentially greatest consequences. If we assume that there are 10 areas in the country with a similar risk assessment as Øvre Bakklandet, the likelihood of a more general landslide scenario of this magnitude will be 10 times as high. This means that a similar landslide could occur every 200 to 300 years, or that there is a 0.4% likelihood that it will occur in the course of a year. The likelihood of a more general landslide event falls then under the category *moderate* in the National Risk Analysis (NRA). The uncertainty associated with the rough estimate of the likelihood is assessed as *moderate*. The survey of the quick clay and risk assessment that has been made provides a relatively good base of knowledge. However, the likelihood of landslides will be highly dependent on the defined frequency of "major landslides", the degree of risk in this zone relative to the average, and on what control exists over construction work in the area.

TABLE 15. Schematic presentation of the results from the risk analysis.

Likelihood assessment							
		VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.04%			◎ (moderate uncertainty)				It is assumed that it could occur precisely in this area every 2,000-3,000 years
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Death				◎ (low uncertainty)		200 fatalities as a direct or indirect consequence of the landslide
	Injuries and illness				◎ (low uncertainty)		2,500 injuries or ill people
Nature and the environment	Long-term damage				◎ (low uncertainty)		Area with little vulnerability. Restoration of the nature within 10 years Habitats for fish and birds impaired. Cultural artefacts of great national importance will be lost. Long-term clean-up work.
Economy	Financial and material losses				◎ (low uncertainty)		More than NOK 30 billion
Societal stability	Social unrest				◎ (moderate uncertainty)		Severe damage and many persons affected. Demanding crisis management and rescue work. The landslide is experienced as shocking and frightening.
	Effects on daily life				◎ (moderate uncertainty)		Evacuation of a large number of people, local loss of power and water, damaged roads and railways.
Capacity to govern and control	Weakened national capacity to govern						Not relevant
	Weakened territorial control						Not relevant
OVERALL ASSESSMENT OF CONSEQUENCES					◎ (low uncertainty)		Large consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[51] *NVE's landslide database.*

Assessment of consequences

The consequences of the given scenario are assessed as *large*. The scenario will primarily threaten the societal assets life and health, nature and the environment, the economy and societal stability. The uncertainty associated with the assessments of the different consequence types varies from *low* to *high*.

Life and health

Over 2,000 people live in the surveyed quick clay zone at Øvre Bakklandet. In addition, there are around 300 people at schools, institutions, etc., who are there daily. The number of deaths as a result of the landslide is estimated to be approximately 200. A decisive assumption for this estimate is the fact that there is an initial landslide many hours before the main landslide, so that there is time to evacuate the entire area.

It is assumed that some people will perish in the initial landslide before the area is evacuated. It is assumed that most people will be killed in the main landslide one day later, and in the consequential events associated with this. For example, there will be people who have not complied with the evacuation order, or who have returned to collect their belongings. It is assumed that some people will perish due to the flood wave that will wash over the buildings along the river, and due to the rise in the water level that will flood the buildings at Øya.

It is assumed that the landslide will cause 500 injuries and make 2,000 people ill as a result of the event. Injuries will occur when people in the area are swept away by the landslide, buildings that collapse, etc. Illness after the event will primarily mean a reduced work capacity and quality of life for those who are affected.

The uncertainty associated with the estimates for fatalities and injuries is assessed overall as *moderate* to *low*, since the area, population and evacuation are given assumptions.

The consequences for life and health are very sensitive to the assumption that there is time for evacuation before the main landslide, i.e. that 24 hours pass between the initial landslide and the main landslide. If, for example, only three hours pass between the landslides, the police will not have time to start an evacuation or to perform rescue work after the first landslide. Geological assessments as grounds for evacuation will not be available either in such a short period of time at night. A main landslide occurring without any warning has been the case in several major quick clay landslides. The number of deaths in a scenario without evacuation will be much higher. It is assumed that at least 1,200 people would perish then (around half of those located in the area).

Nature and the environment

Damage to nature will be limited to the actual quick clay zone and the adjacent areas that are affected by the clay masses. Landslides and the formation of sludge in the river and fjord are natural processes, and it is assumed that the types of nature that are affected will be restored in the course of ten years. This is fairly invulnerable brackish water zone, characterized by prior encroachments. The river will be polluted by construction materials and waste, but only from private homes and not from companies. The habitats for red-listed plant and insect species and vulnerable mammals (such as otters) and birds species may be destroyed. Nidelva has been designated as a National Salmon River System with distinctive salmon stock, and large clay masses will destroy spawning and nursery grounds.

Several cultural artefacts of great national importance such as the Nidaros Cathedral, the Archbishop's Manor, and the royal residence Stiftsgården will be lost or significantly impaired. There will also be major damage to other protected buildings in central Trondheim, and valuable recreation areas such as the Pilgrims' Route.

The uncertainty associated with the estimates is assessed as *low*, and it is based on experience from other quick clay landslides, flood waves and floods.

Economy

The material losses are estimated to be high and in the magnitude of NOK 30 billion. The landslide, flood wave and flood will destroy bridges, roads, railways, private homes and businesses. The rebuilding costs are based on NOK 25–30,000 per m². An estimated 1,000 households must find a new place to live for a long period of time. There will also be significant financial and commercial losses as a result of the destruction of the premises for an estimated 100 stores and restaurants. The estimates are based on experience from prior quick clay landslides and floods, and the uncertainty is assessed as *low*.

Societal stability

The landslide will entail quite a large degree of social unrest. The quick clay zone has been surveyed, but people expect the authorities not to permit anyone to live in a location that is very vulnerable to landslides. Therefore no one will be prepared for a landslide in a densely populated area. People will expect to be warned of a landslide in advance, and this is something that is rarely possible with a quick clay landslide.

A landslide in which the ground suddenly gives way will create fear and a feeling of powerlessness for those who find themselves there. Those who live in other known quick clay zones will also worry and be anxious. A landslide will affect vulnerable groups with mobility problems (the sick and elderly) in particular. Very many people will be indirectly affected as the friends and family of fatalities and injured persons. Rescue work will be very difficult, because it will depend on helicopter support, and many people will want to come to the landslide area to look for missing persons and belongings.

The local and national authorities' management of the situation will be very demanding with regard to obtaining an overview of the situation, and warning, evacuating and informing the inhabitants. An evacuation is time-consuming, and it must take place by going from house to house. Inadequate information before, during and after the landslide may result in weakened trust in the authorities and people acting individually and in panic. The daily life of very many people will be affected. A large area will be evacuated and critical infrastructure such as power, telecommunications, water, roads and railways will be completely destroyed in the release area. It is assumed that many people in Trondheim will be indirectly affected, and that it will take from a week to a month to restore the most important functions. In the release area, it will be several years before the area can be used normally again, while the clean-up and rebuilding work in the run-out area for the clay will go faster. The power grid in the area is finely meshed and robust, so the loss of power of power will not affect a large area.

The assessments are based on long experience with quick clay landslides, but not with consequences of such a magnitude. The uncertainty is assessed as *moderate*.

Capacity to govern and territorial control

It is assumed that the quick clay scenario will not be of significance to the national capacity to govern or territorial control.

TABLE 16. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	There are historic landslide data, landslide databases, quick clay zone surveys and risk assessments, but there is no experience from landslides in urban areas with such large consequences.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Known phenomenon in Norway and other countries. Geology and geo-technics are special fields in which research is conducted on quick clay landslides.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The estimate of likelihood is dependent on the assumed average landslide frequency, the zone's degree of risk relative to the average, and the degree of control over destabilising excavation work. The number of fatalities and injuries is very dependent on whether it is possible to evacuate all the inhabitants or not, which is dependent in turn on the amount of time that passes between an initial landslide, if any, and the main landslide. Without the assumption of evacuation, there may be five to six times as many fatalities. The other consequence types are less sensitive than the number of fatalities. The sensitivity of the results is assessed therefore as high.
Overall assessment of uncertainty	The uncertainty associated with the assessments of the likelihood and consequences is assessed as moderate overall.

TABLE 17. Placement of the scenario in the risk matrix.

"Quick Clay Landslide in a City" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE		◎			
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The quick clay scenario is assessed as having a *low* likelihood and *large* social consequences. The uncertainty associated with the results is assessed as *moderate*.

EBOLA OUTBREAK IN WEST AFRICA
Health workers from the Red Cross prepare to remove a dead body from a house in Freetown, the capital of Sierra Leone. The Red Cross has helped provide safe and dignified funerals by informing the population of how they can protect themselves from the Ebola virus, and at the same time ensuring that relatives were given access to the funeral so that they could pay their respects to the deceased.

PHOTO: NTB/SCANPIX

07

INFECTIOUS DISEASES

Background

An infectious disease is defined as a disease or carrier state which is caused by a microorganism (infectious agent) or part of such microorganism or by a parasite which can be transmitted between people. Diseases caused by toxins from microorganisms shall also be regarded as communicable diseases. The Communicable Disease Control Act[52] defines the term communicable disease that is hazardous to public health as a disease that is particularly infectious, or which may occur frequently, or have high mortality, or may result in serious or permanent injuries and which, a) usually leads to long-term treatment, possibly hospitalisation, long-term sick leave or convalescence, b) may become so widespread that the disease becomes a significant hazard to public health, or c) constitutes a particular hazard because there are no effective preventive measures or curative treatment for the disease.

Large outbreaks are normally referred to as epidemics. A pandemic is an epidemic that occurs in a large geographic area and affects a large portion of the population. The term is not only used for very infectious diseases, such as influenza, but also less infectious diseases (such as the AIDS pandemic). In an emergency preparedness context, the most relevant diseases are those that are infectious and spread rapidly. All societies are very vulnerable to diseases that are readily transmitted by aerosol droplets or airborne transmission, which few people, if any, are naturally immune to, and for which there is no (adequate) vaccine or treatment. No society can effectively shut out such diseases.[53]

Diseases that are transmitted from animals to humans, either directly or via food or water, are called zoonoses. Zoonoses can also be the cause of epidemics or pandemics. Every year a report is prepared that describes the finding of infectious agents that cause zoonoses in feed, animals and food, in addition to cases of zoonotic disease in humans. The Zoonoses Report 2013 shows that there is little transmission between animals and humans in Norway, but that the percentage of food-borne infection is increasing.[54] Monitoring shows that the most common zoonosis found in humans in Norway is the norovirus, followed by campylobacteriosis, salmonellosis and E. coli enteritis. These are gastrointestinal infections that are often transmitted via contaminated foodstuffs or directly from infectious animals.

In 2013, a total of 198 outbreaks of communicable diseases that are hazardous to public health were reported in Norway.[55] The number has increased in relation to the two previous years. The most commonly reported agents were norovirus (72 outbreaks) followed by MRSA (methicillin-re-

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[52] *Act relating to control of communicable diseases (ACT-1994-08-05-44, most recently amended ACT-2012-06-22-46. Lovdata.no.*
[53] *NOU 2000:24 Et sårbart samfunn [Official Norwegian Report 2000:24 A Vulnerable Society].*
[54] *Heier BT, Lange H, Hauge K, Hofshagen M: Zoonoses Report 2013. Norwegian Veterinary Institute, 2014. ISSN 1502-5713.*
[55] *Utbrudd av smittsomme sykdommer i Norge [Outbreak of Infectious Diseases in Norway]. Annual Report 2013. Published by the Norwegian Institute of Public Health, Disease Control Division. July 2014 www.fhi.no.*

sistant Staphylococcus aureus – 8 outbreaks) and influenza virus (7 outbreaks). Over half of the outbreaks were reported by health institutions – and 40% of those who were ill or carriers of infectious agents were health personnel.
A third of the outbreaks were food-borne outbreaks. The percentage of food-borne outbreaks has been increasing over the last five years. In 2014, there was an increase in the number of reported cases of hepatitis A infections. The outbreak in Norway is probably related to an outbreak that has been taking place in several European countries since January 2013. The suspected source of contagion was frozen imported berries.

Since 1510, there have been 18 known pandemics. The time between them has varied, but normal intervals have been 10 to 40 years. In the 20th century there were four influenza pandemics, *Spanish flu* (1918), Asian flu (1957), *Hong Kong flu* (1968) and Russian flu (1977). Of these, the Spanish flu was the most serious with between 14,000 and 15,000 deaths in Norway.[56]

In April 2009, the World Health Organisation (WHO) issued a warning about an outbreak of influenza based on a new virus in Mexico and the USA. The new virus became the starting point for a new epidemic which, during the course of the year, spread throughout the world and involved a large proportion of the population in many countries falling ill with influenza. In June of that same year, the WHO declared a pandemic, i.e. persistent infection in at least two continents.

In Norway, the first cases of the disease were reported as early as the beginning of May, whereas the main wave spread over the country in October/November 2009. Estimates indicate that approx. 900,000 people may have fallen ill with *influenza A (H1N1)* in Norway. For most people, the influenza manifested as a mild illness, but some people were affected severely. 32 deaths linked to the new influenza were recorded in Norway. The management of the influenza pandemic involved the entire health system in Norway and large parts of the community at large.

In February 2014, an outbreak of the Ebola virus started in the West African countries of Guinea, Liberia and Sierra Leone. The outbreak is serious due to the scope and mortality of the disease. It is the largest Ebola outbreak that has ever been reported. In early November 2014, numbers from the World Health Organisation (WHO) showed that approximately 13,300 people have been infected and 4,960 died. Ebola is a fatal haemorrhagic fever that is transmitted by direct contact. Infection was registered in a total of eight countries. In the West African countries that are affected, it is too late to prevent the crisis. The outbreak affects the entire society, children do not go to school, the health systems are collapsing, and it is assumed that the outbreak will cost over NOK 3 billion over the next months.

Several aid workers from Europe, USA and Australia who worked in West Africa were infected and transported to their home countries. A Norwegian health worker who worked for Doctors Without Borders in West Africa was infected by the Ebola virus in October 2014. The health worker was transported to Norway for treatment.

Norway has a well-established disease control regime and according to the Norwegian health authorities, the risk of further transmission is low. The health authorities monitor the situation carefully and follow up the World Health Organisation's assessments and advice. In the autumn of 2014, the Directorate of Health requested the municipalities to review their disease control plans with a view to a possible Ebola outbreak here in Norway.

Risk

The Norwegian Surveillance System for Communicable Diseases (MSIS) has contributed to the monitoring of infectious diseases in Norway for almost 40 years. Annually there are around 16,000 individual reports of infectious diseases in groups A and B, which are regarded as the two most infectious categories.[57] Influenza-like diseases belong to group C.

The number of reports submitted to the surveillance system has increased significantly in recent years. This is attributed to changed reporting requirements and an increased number of analyses, among other things. This increase is, however, also attributed to a real increase in the occurrence of certain diseases, including food and water-borne diseases and infections caused by resistant bacteria. Accordingly, the likelihood that Norway will be hit by a pandemic is assessed as being high.

Influenza pandemics of various degrees of severity are registered globally at intervals of 10-30 years. This means that it is assumed that the future frequency of influenza pande-

[56] *Store norske leksikon [Big Norwegian Encyclopaedia] (www.sln.no).*
[57] *T. Bruun, T. Arnesen, P. Elstrøm, K. Konsmo, Ø. Nilsen og H. Blystad: MSIS og tuberkuloseregisteret [Norwegian Surveillance System for Communicable Diseases and the Tuberculosis Register]. Annual Statistics for 2012 and a description and evaluation of the registers. Norwegian Institute of Public Health, www.fhi.no 2013.*

mics will be higher than one every 100 years, but lower than one every 10 years. The likelihood that Norway will be hit by a serious influenza pandemic like the Spanish flu, however, is lower than for influenza pandemics in general. The three other influenza pandemics in the 20th century and the influenza pandemic in 2009 were considerably less serious than the Spanish flu. Due to better health among the general population and a better healthcare system, the consequences of diseases are less severe.

With regard to likelihood of a large outbreak of other infectious diseases on a global basis, this is difficult to assess. Ever-increasing travel activity between countries and continents entails an increased occurrence of infectious diseases in Norway. A well-functioning disease control regime has prevented a major outbreak so far.

A pandemic involving many people becoming seriously ill and dying, would be a huge burden on the national health service. The demand for health services will increase, including diagnosis, ordinary treatment and intensive treatment. At the same time, healthcare personnel will also become ill, and capacity will therefore be reduced. Extra personnel will have to be called in. Treatment of other diseases will have to be postponed to a large degree, with all the burden that this will entail for the people affected. The review of experience from the 2009 influenza pandemic indicated some vulnerability linked to small units of the health services in the districts and the limited intensive care capacity at the hospitals. Mass vaccination will also involve a huge workload, mainly for the primary care service.

A pandemic may lead to a large proportion of the population becoming ill at the same time, and to an even larger proportion staying away from their workplace. Their absence could be due to people becoming ill themselves, having care responsibilities, or a fear of infection, and might lead to major problems in a number of sectors. A high level of absence from work could lead, for example, to important societal functions, on which the healthcare system is also dependent, being weakened or, in the worst case, breaking down.

In summary, a pandemic could have a serious impact, bearing in mind primarily societal assets, such as life, health, finance and the stability of society. The seriousness of the consequences will depend on the characteristics of the virus and on society's ability to handle the pandemic, with regard to reducing the spread of infection, treating the sick and other aspects of management.

Prevention and emergency preparedness

Norway has a well-established disease control regime, which includes the associated regulatory framework, plans, reporting requirements and routines. This provides a framework and conditions for handling the outbreak of an infectious disease. Norway also has its own national contingency plan for pandemic influenza (the pandemic plan) describing assumptions, responsibilities, roles and actions in conjunction with management.[58] The pandemic plan states that the vaccination of the population is the principal strategy for managing the situation. Until a vaccine is available, emergency stocks of antiviral[59] drugs will be used to treat people who come down with the illness. In addition, general hygiene measures will be used[60].

Experience from handling the influenza pandemic in the autumn of 2009 led to a revision of the pandemic plan.

The Government submitted a report to the Storting in 2013 on the future preparedness for pandemic influenza.[61] In the report, the Government accounts for what general principles, organisation and levels of preparedness should apply.

To achieve robust emergency preparedness for any future influenza pandemic, it is important to plan for a scenario with a potentially serious impact, even if the likelihood of this type of influenza pandemic is lower than the likelihood of a less severe influenza pandemic. ◎

[58] *Helse- og omsorgsdepartementet, Nasjonal beredskapsplan for pandemisk influensa [National Contingency Plan for Pandemic Influenza]. Version 3.0, 2006.*
[59] *Medications that counteract viruses, cf. Store norske leksikon [Big Norwegian Encyclopaedia] (www.sln.no) 13/03/2021.*
[60] *Hygiene measures such as frequent hand-washing, not coughing over other people and staying at home in the event of illness.*
[61] *Meld. St. 16 (2012-2013) Beredskap mot pandemisk influensa [Report no. 16 (2012-2013) to the Storting, Preparedness for Pandemic Influenza].*

SCENARIO

07.1 Pandemic in Norway

An adverse event in the infectious disease risk area is a pandemic in Norway. To illustrate how serious the consequences of such a pandemic can be, a risk analysis has been conducted on a specific scenario. The scenario that is analysed is a somewhat downscaled worst-case scenario from the national pandemic plan from 2006, with Thailand as the country of origin.

The risk analysis was conducted in the autumn of 2010.

Preconditions for the scenario

Time

Initial outbreak in Norway in December.

Duration

The pandemic reaches its peak after six weeks and lasts for four months.

Scope

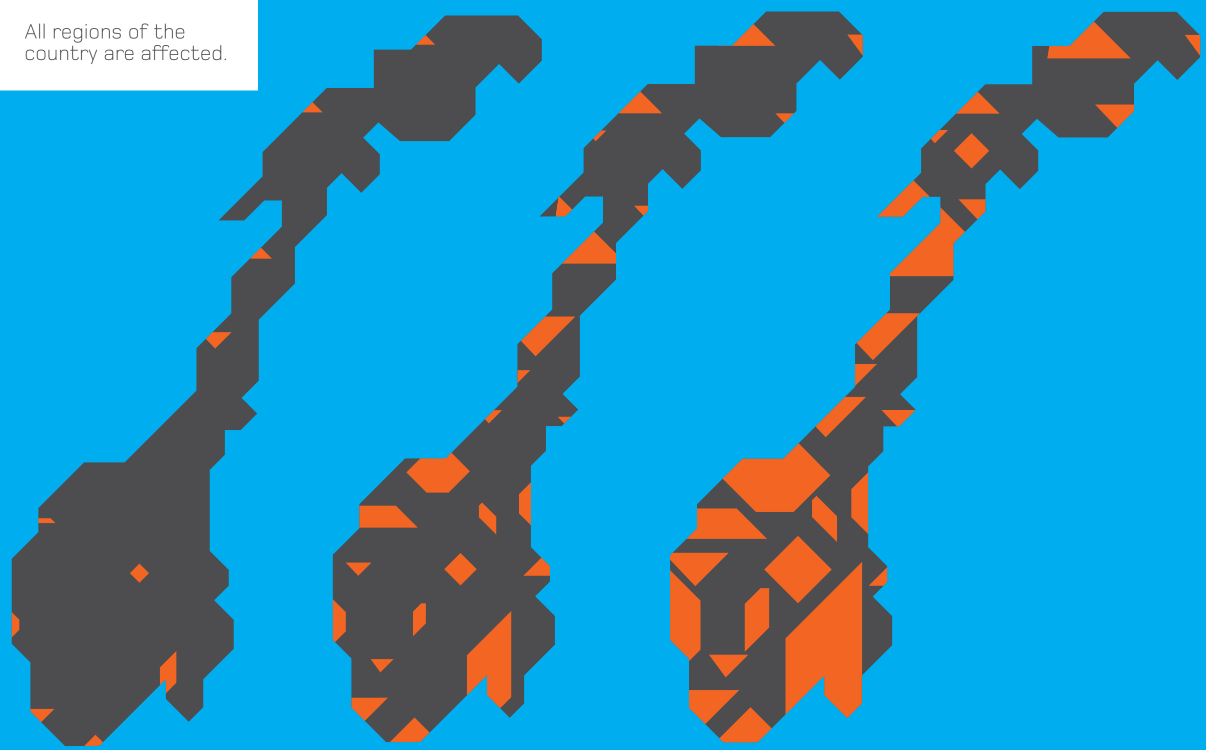
- 25 per cent of the population is infected and the disease lasts for approximately 10 days.
- Aerosol transmission and an incubation period of 1 to 2 days. A vaccine is not available.

Comparable events

- Spanish flu in 1918
- Asian flu in 1957
- Hong Kong flu in 1968
- Swine flu in 2009

Location

All regions of the country are affected.



Assessment of likelihood

On the basis of the historical frequency of influenza pandemics, the likelihood that Norway will again be hit by an influenza pandemic is assessed as being high.

Pandemics of various degrees of severity are registered globally at intervals of 10-30 years. In the 20th century there were three outbreaks in Norway. Increasing travel between countries and continents makes it difficult to limit the spread of disease. Due to better health among the general population and a better healthcare system, the consequences of diseases are less severe. It is assumed that a pandemic as described in the scenario may break out every 50 to 100 years in Norway. A likelihood of 1–2% per year is high, compared with other events in the National Risk Analysis (NRA).

The uncertainty associated with the estimate of the likelihood is attributed primarily to what type of virus in animals is transmitted to humans. The virus types have different properties with regard to the transmission of the disease and its degree of severity. It is assumed that the virus in this scenario is readily transmitted between humans, and this is not the case with all viruses that are transmitted from animals to humans. The uncertainty is assessed as *moderate*.

TABLE 18. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 1-2%				◎		Once every 50 to 100 years based on the historical frequency.

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death					◎	Around 6,000 deaths as a direct consequence of the pandemic and 2,000 due to inadequate treatment for other illnesses.
	Injuries and illness					◎	A total of 35,000–40,000 must be admitted to hospital, and approximately 10,000 will require intensive care.
Nature and the environment	Long-term damage						Not relevant.
Economy	Financial and material losses				◎		NOK 5-50 billion.
Societal stability	Social unrest				◎		Uncertain and frightening consequences, lack of a vaccine, very many are affected.
	Effects on daily life			◎			Reduced public service and transport offerings.
Capacity to govern and control	Weakened national capacity to govern		◉				High absence due to illness, and many are affected by the high number of fatalities.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎		Large consequences overall.

Low uncertainty ○ Moderate uncertainty ◎ High uncertainty ◉

Assessment of consequences

The consequences of the given scenario are assessed as *large* overall. The most serious direct consequences of the pandemic are a large number of fatalities and illness in the population. The scope of health-related consequences will be significant for the impact on society otherwise. This will result in turn in indirect consequences such as a high rate of absence due to illness in all sectors, inadequate public transport, damage to the power supply grid that will not be repaired, and poorer treatment offerings for other illnesses. Altogether this will create unrest and fear in society. The financial losses will also be high because of loss of production and high treatment expenses for hospitals. The consequences of the scenario will be very large for most of the societal assets included in the NRA. There are small consequences for nature and the environment, as well as the national capacity to govern and have territorial control. The uncertainty related to the various consequence types varies from *moderate* to *high*. Overall, the uncertainty associated with the consequence assessment is assessed as *moderate* compared with the other assessments in the NRA.

Life and health

An influenza pandemic has a serious impact, because the people infected can become seriously ill, and many of these could die. The number of people who will fall seriously ill and the numbers who will die are very uncertain and could vary greatly from one influenza pandemic to another. The consequences of an aggressive virus would probably be less serious in our day than the consequences of an equivalent virus at the beginning of the previous century, for reasons such as a better healthcare system, better hygiene conditions and generally better health in the population.

The Norwegian Institute of Public Health has developed a "pandemic calculator" based on data the WHO has collected from pandemics throughout the world in recent decades. This calculator shows that a given virus like the one in the scenario will infect 25% of the population and make approximately 1.2 million people sick. The severity of the illness will vary:

- 20% will visit a doctor, i.e. 245,000 persons.
- 3% will have to be admitted to the hospital, i.e. 36,500 persons.
- 25% of those who are admitted will require intensive care (stay of around 12 days), i.e. 9,188 persons.
- 0.5% of the 1.2 million who become sick will die, i.e. 6,125 deaths.

An assumption that is made in this calculation is that everyone who requires intensive care receives it. This is not the case in a normal situation today, in which there will be a lack of both equipment and healthcare personnel. Those who are sick and require intensive care for other reasons will also suffer from the same insufficient capacity during the four months the pandemic lasts. On this basis, the number of deaths is adjusted from around 6,000 to around 8,000 persons.

The estimates of 8,000 deaths and more than 35,000 seriously ill means that the pandemic outbreak will have the most serious consequences for life and health of all the scenarios that have been analysed in the NRA.

Nature and the environment

Avian flue can annihilate bird populations completely, but it is assumed that this will not occur due to the emergency slaughter of suspected animal populations. It has therefore been assessed that the pandemic outbreak will not result in any permanent damage to nature and the environment.

Economy

A large number of deaths and extensive absence due to illness will result in high production losses. More than 35,000 hospital admissions in the course of four months will also entail a high level of extraordinary expenses. The socio-economic losses are assessed as high.

Societal stability

A pandemic is a rare, but known event in many countries, including Norway. All pandemics, however, are different, so the course of events and consequences will be uncertain and frightening. It is assumed that the scope of the deaths and illness will result in major psychological effects and the feeling of sorrow, fear and powerlessness. There is little opportunity to avoid a pandemic that affects the entire country and neighbouring countries. In certain cases, pandemics can affect certain age groups in the population (such as young people), depending upon previously acquired immunity. The lack of a vaccine can create a feeling of powerlessness and mistrust of the authorities. This will create social unrest.

During a pandemic many people will avoid places where there are large crowds and a high risk of infection, such as public means of transport. Public service offerings will be reduced due, for example, to the high rate of absence due to illness.

Capacity to govern and territorial control

It is assumed that a high rate of absence due to illness will also affect the central public administration and national politicians.

Social and financial consequences will also depend on how robust important societal functions are and whether they are prepared to manage an emergency of this type. The public authorities' crisis management skills and ability to communicate well during the emergency are very important. ◎

TABLE 19. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
ASSESSMENT OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Experience from several similar pandemics in Norway.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	A known and researched phenomenon, however, the mechanisms that result in transmission from animals to humans is not known.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The estimate of the likelihood is dependent on what type of virus in animals is transmitted to humans. The health-related consequences will depend to a great extent on the properties of the virus with regard to illness and infection, as well as on scope and effect of infectious disease control measures. The sensitivity of the results is assessed as high.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is assessed as moderate to low.

TABLE 20. Placement of the scenario in the risk matrix.

"Pandemic in Norway" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE				◎	
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The pandemic scenario is assessed as having a *high* likelihood and *large* social consequences. The uncertainty surrounding the estimates is assessed overall as *moderate*.

JANUARY FIRE:
On 29 January an intense forest and heath fire broke out at Frøya in Sør-Trøndelag. Around 200 persons were evacuated from their homes.

PHOTO: NTB/SCANPIX

08

FOREST AND WILDERNESS FIRES

Background

Significant environmental, financial and quality-of-life assets are linked to forests and wilderness. Forest areas in particular are of great importance to climate and biological diversity. Forests provide a basis for commercial activities and value creation in the production and processing of timber and wilderness products, and they constitute areas for outdoor experiences and recreational activities Fires put many of these assets at risk. Most fires in the wilderness in Norway are relatively small, but under specific conditions, minor fires can rapidly develop into conflagrations in which thousands of acres of forest burn down, or large areas of wilderness are affected by fire. When forest and other wilderness fires arise, it is no longer just the loss of forest areas and the assets linked to them that are at risk, but also buildings, infrastructure and, in the worst cases, human life.

In 2008, a situation of this type arose in the municipality of Froland in the county of Aust-Agder. After a very dry early summer, the risk of a forest fire was extreme, and on 9 June the largest fire of recent times started. Strong winds made the fire spread extremely quickly, even to areas in which forest fires do not normally occur. The fire service, the Armed Forces, Civil Defence and volunteers all came out in force to extinguish the fires. At its peak, a total of 790 men and 15 forest fire helicopters were involved. The village of Mykle was in danger for a period of time, and 77 people were evacuated. It took 13 days for the fire to be completely extinguished. During the course of this period, 19 sq km of productive forest had burnt down. No human lives were lost during the blaze, but around 20 cabins, several high tension masts and hundreds of metres of high and low tension lines were destroyed. The total cost of the forest fire is estimated to be around NOK 100 million.

Three of the largest fires in Norway in recent times occurred during 11 days in January 2014. In the evening of 18 January, a fire started in a private home in Lærdal. The fire spread quickly in the strong wind. 40 buildings, 17 of which were private homes were lost. On 27 January sparks fell from a power line onto the dry grass on the Sørnesset peninsula in the municipality of Flatanger in Nord-Trøndelag. Strong wind caused the fire to spread over large parts of the peninsula, and it ignited buildings in the hamlets. 64 buildings, 23 of which were private/holiday homes were lost. On 29 January, a fire in the heath and scrub at Frøya in Sør-Trøndelag was reported. Only one building was lost, and an area of approximately 10 km^2 with heath and grass burned. All three fires entailed extensive evacuation. Common to all the fires is that they were large on a Norwegian scale in the form of their complexity and scope. The total cost of these three fires is estimated at several hundred million Norwegian kroner.

Risk

Up until now, the most hazardous time of year for fires is spring and early summer, when the forest floor is still covered by tinder-dry, highly flammable dead plant matter from the previous growing season. Most of the forest fires and other wilderness fires, and the largest, therefore usually take place from the end of April to mid-June. After that, grass and green forest-floor vegetation emerges and the risk of forest fires diminishes. In general, the forest fire risk increases in dry, warm weather. In Norway, specific areas with a typical inland climate – hot, dry summers – are those at most risk.[62] The winter of 2013/2014 was unusually dry from Southwestern Norway to Nordland. January was marked by a strong off-shore wind over the same areas. The combination of little precipitation, a lot of wind and cold resulted in dry and highly flammable vegetation. We therefore experienced many wilderness fires throughout the winter and spring of 2014.

Almost all fires in nature are caused by human activity in one form or another.[63] In particular, burning brushwood, grass, straw and bonfires, and children playing with fire, are all causes of many fires.[64] The only natural cause of a forest fire is a lightning strike, but only a small proportion of the forest fires in Norway are caused by this.[65]

The really large forest fires that we hear of from Southern Europe, North America, Russia, Asia and Australia, do not occur in Norway for climatic reasons.[66] Most of the forest fires in Norway are small. Approximately 80 per cent of the fires have affected less than 0.5 hectares of forest, while only 2 per cent have affected more than 10 hectares. Looking at major forest fires in which more than 100 hectares of productive forest have been lost, statistics show that there have been nine fires of that type since 1945.[67] Roughly speaking, this means that, on average, Norway experiences one forest fire of this order of magnitude every ten years. The fires we experienced in January 2014 were in heath, scrub and grass, not in productive forest.

Of the major forest fires since 1945 that have already been mentioned, Froland stands out as having been clearly the biggest. With its 19 sq km of destroyed productive forest, this is the largest forest fire in Norway for more than 100 years.[68] However, this does not mean that it will be that long again until we next experience a similar forest fire. Neither does it mean that it is possible to rule out even larger forest fires. Experience shows that small margins and coincidences are often all that separate minor fire outbreaks from major blazes. For example, we have largely been spared two or more major forest fires ever having raged at the same time. If such situations were to occur, important response factors such as forest fire helicopters, would have to be dispersed during the extinguishing work. Thus the opportunities for preventing the fires from developing are weakened.

There can be several consequences of forest and wilderness fires. As regards nature and the environment, these fires can mean anything from a slight impact to drastic changes in ecosystems. For some animals and plants that are directly affected, a fire can be a disaster, whereas for other species, a fire is a necessity for the continued existence of those species. Forest fires release carbon from the forest's carbon store and thus affect both the concentration of climate gases in the atmosphere and the reflection of solar energy from the burned areas. The scope of forest fires in individual countries is therefore included in the climate gas accounts, which are reported to the Climate Convention.

Large, out-of-control fires can also imply a danger to human life and health. Fire and smoke damage can produce acute and chronic injuries, and, in the worst cases, claim lives. Rescue and fire crews, in particular, are exposed to great risk, while the possibility of evacuation means that the risk to the life and health of the rest of the population can be limited. In Norway, lives are seldom lost as a consequence of forest and wilderness fires, but forest fires have been experienced abroad in which dozens of people have been killed. In July 2014, Sweden experienced one if its largest forest fires ever, several buildings were lost and a human life was lost in the fire in Västmanland.

Buildings and infrastructure can also be lost in forest and

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[62] *Norway's Forestry Extension Institute (2009): It won't happen to us... – about forest fires and forest fire prevention.*
[63] *Ibid.*
[64] *Bleken et al. (1997): Skogbrann og miljøforvaltning. En utredning om skogbrann som økologisk faktor. [Forest Fires and Environmental Management. An Investigation into Forest Fires as an Ecological Factor.]*
[65] *Ibid.*
[66] *Skogbrand insurance: Skogbrann – vern og slokking [Forest Fires – Protection and Extinguishing], pamphlet.*
[67] *Directorate for Civil Protection and Emergency Planning (2008): Rapport fra arbeidsgruppe - Skogbrannberedskap og håndtering av den senere tids skogbranner i Norge. [Report from Working Party – Forest Fire Preparedness and Management of Forest Fires in Recent Times in Norway.]*
[68] *Norway's Forestry Extension Institute (2009): Det skjer ikke oss... – om skogbrann og skogbrannvern [It Won't Happen to Us... – about Forest Fires and Forest Fire Prevention].*

wilderness fires. Apart from the financial losses linked to this, the failure of infrastructure can imply challenges for public service provision, trade and industry, and households. In the event of such fires, fire-fighting is made a priority and is concentrated on built-up areas or where there are particularly important buildings. Setting up fire-breaks and spraying foam on buildings make it possible to limit the damage.

The financial losses from forest and wilderness fires can be significant, depending on scope and duration. In Norway, it is estimated – as a rule of thumb – that a hundred hectares of burnt productive forest is equivalent to approximately NOK 1 million in timber. Added to that is the reduced potential for the wilderness industry, and costs from the loss of buildings and infrastructure. Significant costs are also linked to managing and fighting the fire, characterised by being both of long duration and resource-intensive. In Froland, for example, the costs of fighting the fire constituted around one third of the total costs.

The frequency and scope of forest fires varies depending on the type of forest, topography, and climatic conditions, such as drought and wind, as well as our ability to limit and extinguish the fires. Changes in these conditions therefore affect the risk linked to forest fires. From the 1970s up to the 2000s, the number of forest fires per year and the area of forest acreage burnt annually have shown a downward trend.[69] Restrictions regarding the use of open flames in forests and open country, changes in economic activities, and a wetter climate have probably contributed to fewer fires breaking out.

Better surveillance through the use of aircraft and satellites has at the same time resulted in earlier detection of fires. In addition, people often report fires from mobile phones. A better developed road network and better equipment and methods for fighting fires have contributed to fires not developing as freely as they did previously. The use of fire-service helicopters for support during major, fairly inaccessible forest fires since the mid-1980s has also been significant to the management of forest fires. After the fire in Froland, emergency preparedness and the use of forest fire helicopters changed. Extra preparedness resources and more helicopters are often deployed now for shorter or longer periods of time if the situation indicates a need for increased preparedness. In addition, Norway can request assistance from EU through the European Response Coordination Centre (ERCC). In the winter of 2014, DSB sent a so-called pre-alert to ERCC on the potential need for assistance from aircraft for extinguishing forest and other wilderness fires. It is uncertain how climate change is going to impact the risk assessment. If the development goes in the direction of less snow in lowland areas in the winter, more wind, higher temperatures and periods with drought, this will yield an increased risk with regard to both frequency and scope.70 The fires in the winter of 2014 may be an indication of what we can expect in the future.

Prevention and emergency preparedness

Emergency preparedness encompasses the ability to detect, give warning and fight forest and wilderness fires. Detection and warning can take place both via the general public and through the use of aircraft and satellite surveillance. In Norway, the local fire services are responsible for fighting forest fires within their own areas. Various methods are used to limit fires, but most often natural boundary lines in the terrain are used, such as rivers, roads, power lines and similar in the fire-fighting work.

Small fires should be extinguished before they become major uncontrollable events. It is in the early phases that a forest fire can most readily be extinguished, and the spread of the fire prevented. This is especially important during conditions with a heightened forest fire risk. It is therefore important to respond quickly and with greater use of resources in an early phase than is normally indicated by the severity of the fire. When required, the state can assist the fire service with resources. This may be both in the form of know-how and physical resources, principally through helicopters and support from the Norwegian Civil Defence. The public authorities have their own forest fire helicopter as a contingency measure, and there are agreements in place for requisitioning aircraft and helicopters from other nations. ◎

[69] *Bleken et al. (1997): Skogbrann og miljøforvaltning. En utredning om skogbrann som økologisk faktor. [Forest Fires and Environmental Management. An Investigation into Forest Fires as an Ecological Factor.]*

[70] *Directorate for Civil Protection and Emergency Planning (2008): Rapport fra arbeidsgruppe - Skogbrannberedskap og håndtering av den senere tids skogbranner i Norge. [Report from Working Party – Forest Fire Preparedness and Management of Forest Fires in Recent Times in Norway.]*

SCENARIO

08.1 Three Simultaneous Forest Fires

An adverse event in the forest fire risk area is several simultaneous major fires that get out of control under conditions marked by strong winds and in areas where there has been a long period of drought. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific serious *scenario*.

The risk analysis was conducted in the autumn of 2011.

Preconditions for the scenario

Time

May/June. During the course of two days, three fires break out and get out of control

Duration

A total of four to six days pass before all of the fires are under control, and a further week passes before the fires are extinguished

Weather conditions

A long-term drought in the spring has entailed an extreme risk of fire in the affected areas

Wind speed

South-westerly moderate gale (15 m/s) in the eastern part of southern Norway that lasts for two days before it subsides

Concurrent events

A number of small forest fires arise during the drought period. Fire outbreaks are stopped daily

Comparable events

After six days the forest fire in Froland in 2008 had burned approximately 30 km² (3,000 hectares) of forest before it was under control. This is the largest forest fire in Norway since the Second World War.

Assessment of likelihood

An assessment has been made of the likelihood of three simultaneous major forest fires that get out of control. This is expected to occur once every 100 years, i.e. there is a 1 per cent likelihood that it will occur in the course of a year. In the National Risk Analysis (NRA), this likelihood estimate falls under the category of *high likelihood* (once every 100 years).

The assessment of likelihood is based on historical data and frequencies, as well as factors of significance to simultaneous occurrence of forest fires, including meteorological data on the frequency of particularly dry years, so-called fire years. This provides a good knowledge base, and the uncertainty associated with the assessment of the likelihood of the adverse event is assessed as *low*.

TABLE 21. Schematic presentation of the results from the risk analysis.

Likelihood assessment							
		VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 1%					◎		Once every 100 years based on historical data and experiential data, as well as meteorological data.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Death	◎					Less than 5 deaths as a direct or indirect consequence.
	Injuries and illness		◎				20-100 injuries or ill people as a direct or indirect consequence.
Nature and the environment	Long-term damage			◎			100 km² in total, significant environmental changes, several decades before restoration of the normal state.
Economy	Financial and material losses		◎				Approximately NOK 500 million.
Societal stability	Social unrest		◎				A large number of people in the urban area may be directly affected, and expectations of management may create anger and aggression.
	Effects on daily life		◎				The evacuation of 10,000 inhabitants for 1–2 days may be necessary, reduced navigability, disconnection of power supply.
Capacity to govern and control	Weakened national capacity to govern						Not relevant.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES			◎				Small consequences overall.

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

Assessment of consequences

The social consequences of the given scenario are assessed as *small*. The scenario will primarily threaten the societal asset nature and the environment. The uncertainty associated with the assessments of the different consequence types varies from *low* to *moderate*. Overall the uncertainty is assessed as *low* compared with the other assessments in the NRA.

Life and health

It is assumed that forest fires on this scale will have an impact on life and health. In particular, strong variable winds constitute a major risk factor because fire crews and other intervention personnel operating close to the forest fires could be surrounded. Deaths can therefore not be excluded, but experience indicates that the number could be expected to be low, and probably fewer than five people. The possibility of evacuation makes it fairly improbable that lives will be lost among the general population. Helicopters and other resources for fighting fires are given priority to go to areas where the risk to life and health and material loss is considered greatest.

Fire and smoke injuries can also be expected. Smoke inhalation can produce both acute and chronic injuries. In particular, intervention personnel, but also especially vulnerable groups in the areas concerned (for example, people with respiratory disorders) will be subject to this. Early evacuation can limit the scale of injuries in this latter group, however. The total number of injured people is estimated at between 20 and 100. The assessments are based on experience from earlier forest fires, for example, Froland. The uncertainty associated with the estimates is assessed as *low*.

Nature and the environment

It is expected that the total area of forest destroyed by fire will be approximately 10,000 hectares (100 km²). For those areas concerned, this will mean significant changes to the environment, and several decades will pass before the normal state is restored. The long-term effects are primarily linked to a change in the ecological succession and economic circumstances. Fires can entail fundamental effects on the faunal community, including birds, fish and mammals, but the effects will essentially be dependent on the intensity and severity of the fires, and there are great variations from fire to fire. The scenario will also significantly affect Norway's greenhouse gas accounts for the forestry and land-use sector. The uncertainty for assuming this is assessed as *low*, and it is based on historical and experiential data.

Economy

The financial losses from such an event are linked primarily to the loss of large areas of forest and timber, and buildings and infrastructure. Lengthy fire-fighting with both helicopter and manpower resources will also be costly. In addition, there will be reduced potential for the wilderness industry. The overall financial losses in such a scenario are assumed to be in the range of NOK 500 million, based on experience from earlier forest fires. The uncertainty associated with the estimates is assessed as *moderate*.

Societal stability

It is not expected that the forest fire scenario will cause any significant social unrest. Forest fires are a known event with known consequences. However, the scope of forest fires that threaten urban and cabin areas can lead to reactions such as anger and aggression in a relatively large number of persons with a direct involvement. The scope of the fires can also create unrest and fear in the population in other areas where there is an extreme risk of forest fire. This can also be linked to the fact that those who have a direct involvement are at the mercy of the efforts of the fire-fighters. Any perception of inadequate resources to fight the forest fires may result in weakened trust in the authorities and contribute to anger in the population, and it is assumed that questions concerning the authorities' responsibility will come to the surface.

This forest fire scenario will mean disruption in various ways for the inhabitants of the areas in question. People living in areas that are directly threatened by the fires will have to be evacuated. It may also be necessary to evacuate inhabitants in areas in which smoke and soot constitute a problem. It is assumed that up to 10,000 people will have to be evacuated from their homes for one to two days. However, closed roads or short-term disconnection of the power supply may also mean some disruptions. Challenges related to the roads and railways being unavailable may also arise.

The assessments are based on sectoral analyses and experience from earlier forest fires, and the uncertainty is assumed to be *moderate*.

Capacity to govern and territorial control

It is assumed that the forest fire scenario will not be of significance to the national capacity to govern or to territorial control. ◎

TABLE 22. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Relatively extensive access to historical data, experiential database dating back to 1900, as well as meteorological data.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Relatively extensive access to data, a great deal of knowledge on forest fires and broad experiential data.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The estimate of the likelihood that the event will occur is sensitive to changes in the assumptions regarding the extreme risk of forest fire in three geographically unrelated counties at the same time. The consequences of the events are sensitive to changes in the wind and weather conditions, the type of forest in the affected areas, resources for fire-fighting and the degree of coincidence of the fires. The sensitivity of the results is assessed therefore as moderate.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is assessed as *low.*

TABLE 23. Placement of the scenario in the risk matrix.

"Three Simultaneous Forest Fires" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE					
MODERATE					
SMALL				◎	
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	LIKELIHOOD				

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The forest fire scenario is assessed as having a *high* likelihood and *small* social consequences. The uncertainty associated with the results is assessed as *low*.

NORTHERN LIGHTS OVER KATTFJORDEID, OCTOBER 2012
Particles from the sun hit the earth's atmosphere and create the Northern Lights, which can be seen in many different shapes and colours.

PHOTO: NTB/SCANPIX

09

SPACE WEATHER

Background

The surface of the sun consists of plasma that can be regarded as a very hot electrically conducting gas. The gas flows continuously out from the sun, and together with electromagnetic radiation, this has an effect on the Earth and the area of outer space close to us in a series of processes with a joint designation called "space weather". At times violent explosions occur in the sun's atmosphere, known as "solar storms", in which large amounts of particles, radiation and gas with a magnetic field are ejected into space. The earth's magnetic field provides protection against solar storms, but this protection is weaker at the poles.[71] Space weather and solar storms are therefore a particularly topical factor for Norway since we are located in the far north.

The so-called *Carrington Flare* of 1859 is often referred to as the most powerful solar storm that has ever been experienced. The telegraph system was seriously affected – the operators received electric shocks – and fires arose in telegraph buildings as a consequence of the solar storm. A major solar storm was experienced in 1921 as well. This solar storm was not as powerful as the one in 1859, but involved the same type of consequences and challenges for the society of that time.

Several powerful solar storms over the past 20 to 50 years have meant disruption and cuts in the provision of telecommunications and power at irregular intervals and of varying duration. In 2003, there were many violent electromagnetic storms on the sun. In conjunction with the *Halloween storms*, technical problems with satellites and satellite telephones were reported from several parts of the world. Because of problems with radio communications, international aviation on transatlantic and polar routes was reduced temporarily and traffic redirected, and notice was issued concerning increased radiation risks for aircraft passengers. In the USA, certain major power transformers were also damaged or destroyed, and large areas were left in the dark for some hours. Costs resulting from the solar storm were estimated as being at least NOK 4 billion.

In Sweden, too, several thousand people lost power for a short period of time as a consequence of this storm.[72]

On 23 July 2012, there was a powerful plasma eruption on the sun, and the solar storm that followed is assumed to have been more powerful than the Carrington storm in 1859. If the outbreak had occurred one week earlier, the solar storm would have hit Earth's atmosphere according to estimates.[73]

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[71] *NATO/EAPC, working paper 30 August 2011; Norwegian Space Centre (NRS); www.kriseinfo.no (14/12/2011).*
[72] *National Research Council of the National Academies (2008): Severe Space Weather Events – Understanding Societal and Economic Impacts, Workshop Report; Department of Homeland Security, Federal Emergency Management Agency (FEMA), National Oceanic and Atmospheric Administration (NOAA), US Department of Commerce, Swedish Civil Contingencies Agency (MSB) (2010): Managing Critical Disasters in the Transatlantic Domain – The Case of a Geomagnetic Storm. Workshop Summary, February 23–24 February 2010.*
[73] *Baker, D. N. et al (2013): "A major solar eruptive event in July 2012: Defining extreme space weather scenarios"; Space Weather 11: 585-591*

Risk

The designation "super storms" is used for 100- to 500-year storms. It is assumed that seriously powerful super storms like the one experienced in 1859 will occur, in statistical terms, every 500 years. Major solar storms of a size equivalent to the one of 1921 are assumed to occur once every 100 years.[74] The sun's activity is cyclical, reaching its maximum activity approximately every 11 years. It is assumed that large solar storms, such as the *Halloween storms* of 2003 may occur once during the course of every or every other 11-year cycle. Statistically, most geomagnetically active days occur in the waning part of the solar cycle. The sun is still in an active phase, even if the solar maximum in the current solar cycle was recently passed.[75]

Solar storms are categorised within three different types depending on the type of eruption on the sun: 1) As a rule eruptions send large volumes of *electromagnetic radiation* in the direction of the Earth. The radiation moves at the speed of light and reaches earth within 8 minutes. The duration varies from a few minutes up to an hour. 2) During *proton showers* particles are ejected into space at very high speed and can reach the Earth in 15-60 minutes. The duration varies from a few hours to several days.[76] 3) In addition, large clouds of plasma, known as CME[77], can be ejected into space. If this happens, *geomagnetic storms* are created, which release huge amounts of energy. Particles penetrate the earth's magnetic field and are conducted down over the polar areas. When the plasma clouds move towards earth and interact with the magnetic field, normally after one to three days, it will usually be possible to see the Northern Lights. The more powerful the eruption on the sun, the further south the Northern Lights can be observed.

Neither electromagnetic radiation nor proton showers can injure people, since we are protected by the earth's atmosphere, but the radiation can be very dangerous to people who spend any time in space.[78] Proton showers can also be a potential health problem for aircraft crews who frequently fly over polar areas. The potential impact of a solar storm, for people or society, will essentially involve consequential effects; for example, via the solar storm's effects on the power system, satellite communications and satellite navigation.

If these systems are disrupted or fail altogether, solar storms could have a major impact on society. If a geomagnetic storm is powerful enough, it can lead to drops in voltage over the power network. Experts in the USA have indicated that the impact could be enormous if a high number of large power transformers break down in many countries at the same time, principally because it can take up to a year to replace a transformer.[79] The vulnerability of the power systems varies from one country to another, however, depending on a number of factors such as soil conditions (conductivity), the grid and generation structure, technical solutions, use of earthing, etc. Compared to the systems of other countries, the Norwegian system is considered to be relatively robust with regard to solar storms; due to technical solutions, decentralised production systems and fewer extremely long transmission lines, among other things. As opposed to the USA and Canada, for example, where large amounts of power are generated by a few large units that have to send the energy over long distances, power is generated in Norway from a larger number of smaller power stations with shorter distances to the consumers. The Norwegian power system has also been designed with some redundancy and to provide reconnection options at different voltage levels, to ensure that a power cut in one transformer does not necessarily lead to long-term cuts for end-users. Nevertheless, in the case of major solar storms, it is not possible to rule out that there will be short-term local or regional disruptions (a few hours) in the supply of power to end-users. Certain areas in Norway are more vulnerable than others since they have fewer local generation sources and lower network capacity in and out of the area.

Solar storms can also affect the reception of satellite navigation signals used for positioning, navigation and time information. GNSS (Global Navigation Satellite Systems)[80] offer positioning, speed and time signals. It is not unusual for the signals from systems of this type to be disrupted by solar storms for fairly short periods. The scale of signal disruptions is dependent on the intensity and composition of the solar storm. Lengthy loss of satellite signals is fairly

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[74] *U.S. Department of Homeland Security; Federal Emergency Management Agency (FEMA); NATO/EAPC, working paper, 30 August 2011.*
[75] *Norwegian Space Centre (NRS).*
[76] *NATO/EAPC, working paper, 30 August 2011.*
[77] *Coronal Mass Ejection.*
[78] *NATO/EAPC, working paper, 30 August 2011.*
[79] *National Research Council of the National Academies (2008): Severe Space Weather Events – Understanding Societal and Economic Impacts, Workshop Report.*
[80] *Joint designation for global satellite navigation systems. Today, there are two GNSS operational: the American GPS system and the Russian GLONASS system. A European satellite navigation system, Galileo, is planned to be operational from 2015. China is planning to complete the construction of the global BeiDou/COMPASS system in about 2020.*

improbable.[81] For users, the effect of disruptions will depend on the availability of alternative systems. For most private users, solar storms will be non-problematic, but in crucial operations with strict requirements for performance, standby solutions will have to take over if GNSS cannot be used. Accurate positioning and navigation are used in the maritime sector, for example, including the oil and gas industry. Among other things, accurate time information is used in communications networks, in financial transactions and in the supply of power. The societal effect of critical operations using GNNS having to move over to standby solutions with potentially reduced efficiency, will be assessed specifically for the sector and operation.

Prevention and emergency preparedness

Solar storms cannot be prevented, but daily satellite observations of the sun provide us an 18 to 72 hour prior warning of when an eruption occurs on the sun until a geomagnetic storm hits the earth.[82] This provides public authorities, and other bodies with responsibility for important societal functions, with opportunities to implement previously prepared damage-reduction measures, if a powerful geomagnetic storm were to occur. However, it will not be possible to know how powerful the solar storm is going to be until one or two hours before it hits the earth.

As of today, there is no national arrangement for providing solar storm warnings. However, Norway is a participant in the ESA's[83] new monitoring programme of which a joint European space weather warning is an important element. Today, the Tromsø Geophysical Observatory carries out real-time services, and monitors the geomagnetism and disturbances in Earth's magnetic field. The Norwegian Mapping Authority entered into a collaborative agreement in 2011 with the German Aerospace Centre[84] to monitor the weather in the upper part of the atmosphere.[85]

There are several possibilities for preventing damage to the power system. The Norwegian power supply system is constantly monitored against all forms of operational disruption and to ensure balance within the power system. Immediate action at an operations centre might include controlled disconnection of parts of a facility or parts of the grid, in order to be able to connect it again undamaged, for example.[86] The consequences of these measures for end-users will be anything from no noticeable changes to power outages of a certain duration. Disruptions to or loss of precise time for synchronisation and time stamping in the monitoring of the power grid could mean that fault location and fault correction will take a longer time.

For satellite navigation the access to several independent systems will contribute to reducing vulnerability in the future. Anything solely dependent on GNSS for positioning or time signals will be extremely vulnerable in the event of any failure of the satellite systems. Good awareness concerning operating requirements, vulnerability and emergency preparedness solution are extremely important.

Knowledge of the possible impact of solar storms can contribute to reducing societal vulnerability. Among other things, the effect of providing a warning will depend on whether the authorities responsible for the sector and the users have the necessary knowledge of how the solar storm might affect their own systems, and therefore what measures ought to be implemented. With improved knowledge of solar storms and greater insight into our own systems, there will also be a greater possibility of avoiding having to make use of new technological systems, and to guarantee redundant solutions and increased robustness in the systems, as well as to guarantee competent and efficient management during and after a major solar storm.

[81] *Norwegian Space Centre (NRS).*
[82] *Ibid.*
[83] *Norway's membership in the European Space Agency (ESA) is administered by the Norwegian Space Centre.*
[84] *Deutsches Sentrum für Luft- und Raumfahrt.*
[85] *Norwegian Mapping Authority (www.statkart.no).*
[86] *In addition, reconfiguration, use of power line protection, counter purchases, export minimisation, disconnections, etc., are a few possible measures.*

SCENARIO

09.1 100-Year Solar Storm

An adverse event in the "space weather" risk area is a very powerful solar storm. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific scenario.

The risk analysis was conducted in the autumn of 2011.

Preconditions for the scenario

Time frame for proton shower

15 minutes after the eruption on the sun

Coincidence of three types of solar storm

- UV and X-ray radiation
- proton shower
- geomagnetic storm

UV and X-ray radiation strength

Highest level (level 5) on the NOAA (National Oceanic and Atmospheric Administration, United States Department of Commerce) – powerful increase in radiation

Proton shower strength

Highest level (level 5) on the NOAA space weather scale – powerful magnetic field with unusually high speed towards earth

Geomagnetic storm strength

Highest level (level 5) on the NOAA space weather scale – very intense geomagnetic storm

Consequential events of proton shower

- Breakdown in radio communication
- Problems and deviations in satellite-based services for 24 hours

Time/duration of geomagnetic storm

- The day after the eruption on the sun
- Lasts for 24 hours

Weather conditions

Abnormally cold period (-15 °C).

Comparable event

100-year storm in 1921

Consequential events from geomagnetic storm

- Operational disruptions and loss of power within an hour
- Regional loss of power in vulnerable areas

Location

Entire country.

Assessment of likelihood

It is assumed that a large solar storm may occur[87] during the course of the sun's 11-year cycle of activity. It is anticipated that electromagnetic radiation, [88], a proton shower and a geomagnetic storm of the strength indicated will occur simultaneously once every 100 years, i.e. there is a likelihood of 1 per cent that it will occur in the course of a year. This likelihood estimate falls under the category *moderate likelihood* (once every 100 to 1,000 years). The supposition that the solar storm coincides with an abnormally cold period, and the disturbances implied by the storm within the power supply and satellite systems, is not covered by the likelihood assessment. The uncertainty associated with the assessment of the likelihood of the adverse event, as well as the consequential events, are assessed as *moderate* compared with other likelihood assessments in the National Risk Analysis (NRA).

TABLE 24. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 1%.			◎ (moderate uncertainty)			Once every 100 years based on statistical data

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death	◎ (moderate uncertainty)					Less than 5 deaths as an indirect consequence
	Injuries and illness	◎ (moderate uncertainty)					Less than 20 injuries as an indirect consequence
Nature and the environment	Long-term damage						Not relevant
Economy	Financial and material losses			◎ (high uncertainty)			NOK 0.5 to 5 billion
Societal stability	Social unrest				◎ (high uncertainty)		Unknown and not very recognisable event
	Effects on daily life					◎ (moderate uncertainty)	Several hundred thousand people will be affected by the power outage
Capacity to govern and control	Weakened national capacity to govern						Not relevant
	Weakened territorial control						Not relevant
OVERALL ASSESSMENT OF CONSEQUENCES				◎ (moderate uncertainty)			Medium-sized consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[87] *Violent explosions in the sun's atmosphere that generate a magnetic field consisting of large amounts of particles, radiation and gas, which is ejected into space.*
[88] *Electromagnetic radiation is energy in the form of photons (light particles) that flow with the speed of light from a source of radiation. Electromagnetic radiation can be perceived as waves, and therefore it is also called electromagnetic waves.*

Assessment of consequences

The consequences of the given scenario are assessed as *medium-sized* compared with other scenarios in the NRA. The impact of the scenario primarily involves consequential effects in the form of disruptions to satellite signals and power outages. The uncertainty associated with the assessments of the different consequence types varies from *moderate* to *high*. Overall, the uncertainty is assessed as *moderate* compared with the other assessments in the NRA.

Life and health

The scenario's impact on life and health is assessed as very low. Injuries and accidents as a result of disruptions in critical services, such as power and electronic communications[89] cannot, however, be excluded as a consequence of the solar storm. Disturbances in the satellite signals may, for example, entail an increased risk of accidents in sectors that are dependent on precise signals, such as civil aviation and maritime sectors. The uncertainty associated with the estimates is assessed as *moderate*.

Nature and the environment

It is assumed that solar storm scenario will not be of significance to nature and the environment.

Economy

It is assumed that the financial losses as a consequence of the scenario will range from NOK 0.5 to 5 billion. The loss is linked principally to losses in production and services in the regions affected by power cuts and costs linked to possible damage to the power system. There will also be financial costs through lost working time and production losses within the affected sectors, such as the petroleum industry. Norwegian organisations also operate their own satellites. Satellites can be knocked out completely or partially by high energy radiation[90], which is something that could represent billions of Norwegian kroner in losses. The uncertainty associated with the estimate for the financial costs is assessed as *high*.

Societal stability

Solar storms are a type of event that are assumed to be unknown and not very recognisable for the population, compared with other types of events in the NRA, and we lack experience with a similar solar storm and any consequences it will have for our modern society. A powerful solar storm can thus create fear and uncertainty based on what consequences it will have. As a result of this, the scenario can create social unrest in society.

It is assumed that several hundred thousand inhabitants will be affected by a loss of power for up to ten hours, and subsequently an unstable power supply for the entire day that the storm lasts. Loss of power will primarily affect social functions without sufficient emergency power, vulnerable groups, such as the elderly and sick, and people who only have electric heating systems. However, the limited duration of the power cut in the scenario means that the situation does not become critical, and evacuation will probably not become necessary.

The scenario is assumed to result in various effects on daily life for those who are directly affected by power outages and disturbances in other critical services and deliveries. Even though the power grid in Norway is relatively robust, certain areas in Norway will be more vulnerable than others, since they have fewer local generation sources and lower grid capacity in and out of the area. The strength of this solar storm is regarded as being within the scope that the Norwegian power system could largely withstand, without extensive system damage, but disturbances of various types cannot be excluded.

Disturbances in high-frequency (HF) communications bands[91] as a consequence of the solar storm will affect both air traffic and military users of such communications bands. Communications via low frequency signals will also be affected. It is assumed that more than 100,000 people will be unable to use ordinary electronic communications or public Internet-based services. If other adverse events occur during the period in which the power supply and satellite signals are unstable, this could have a serious impact on life and health because of the reduced ability to contact emergency numbers, central emergency preparedness and emergency response services, and the reduced ability of the emergency services to communicate with one another.

The disruptions to satellite signals can lead to imprecise time

[89] *Electronic communications services.*

[90] *Gamma radiation (electromagnetic radiation from radioactive atomic nuclei) is often divided into two categories «soft» (low energy) and "hard" (high energy) radiation. University of Oslo, Faculty of Mathematics and Natural Sciences (www.mn.uio.no), 01/05/2013.*

[91] *A distinction is made between low frequency, which covers the audible frequency range, and high frequency, which covers frequencies above the audible range. High frequency will be largely the same as radio frequency. For example, the Norwegian Armed Forces makes use of the HF band.*

[92] *Norwegian Space Centre (NRS).*

signals which again can be of significance for the implementation of items such as financial transactions, control systems, telecommunications and operation of critical IT systems.[92] It is uncertain how long-term the effects of the disruptions may be. Re-establishing the normal state can be a lengthy process, which will tie up personnel and could challenge logistics for spare parts and other equipment.

Disruptions in satellite signals entail an increased risk of accidents in sectors in which the control systems depend on precise signals, such as civil aviation, industrial operations, and the maritime and power sectors. As regards navigation, civil aviation will be affected to a small extent, linked to the fact that navigation systems within aviation will be based, until further notice, on conventional (ground-based) systems that will not be affected by disruptions to satellite signals. The uncertainty associated with the assessments is considered to be *moderate* to *high* compared with other consequence assessments in the NRA.

Capacity to govern and territorial control

It is assumed that the solar storm scenario will not be of significance to the national capacity to govern or for territorial control. ◎

TABLE 25. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Some information from earlier major solar storms (100-year storms) and so-called super storms (100 to 500 year storms), but no experience with such powerful solar storms in our modern society.
Comprehension of the event that is being analysed (how known and researched is the phenomenon?)	Solar storms are considered to be a little known and researched phenomenon, compared with other types of events that have been analysed in the NRA. It is uncertain how a major solar storm will affect today's technology and infrastructure.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The key assumption for the assessment of likelihood is the coincidence of electromagnetic radiation, a proton shower and a geomagnetic storm. The duration of consequential power outages and satellite disruptions are critical assumptions for consequence assessments. The sensitivity of the results is assessed as moderate.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is assessed as moderate.

TABLE 26. Placement of the scenario in the risk matrix.

"100-year solar storm" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE					
MODERATE			◎		
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The solar storm scenario is assessed as having a *medium-high* likelihood and *medium-large* social consequences. The uncertainty associated with the results is assessed as *moderate*.

EYJAFJALLAJÖKULL ERUPTION
MAY 2010
The volcanic eruption generated ash clouds and caused major air traffic problems in Europe.

PHOTO: NTB/SCANPIX

10

VOLCANIC ACTIVITY

Background

The explosive *Eyjafjallajökull eruption* in Iceland started on 14 April 2010. The tremendous clouds of volcanic ash and smoke climbed several kilometres into the sky, and unusually stable northerly and north-westerly winds carried the ash clouds to Norway and Europe. The eruption created ash cloud problems over most of Northern Europe. A total of 110,000 flight departures were cancelled in Europe.

There are numerous different types of volcanic eruption. *The Eyjafjallajökull eruption* of 2010 is an example of a *phreatomagmatic eruption,* which is often linked to eruptions in central Icelandic volcanoes that are completely or partially covered by ice. The combination of meltwater in the crater area and magma can lead to violent explosions and very high levels of ash production. A new eruption of the Katla volcano is often highlighted as a feared scenario with potentially enormous consequences as a result of very high levels of ash production.

The eruption in the *Laki* volcano system (Iceland) in 1783-84 is an example of a very large *fissure eruption*. The eruption continued for eight months and sent fountains of lava up to a height of at least 1,000 metres. The total volume of tephra[93] and lava was estimated at 0.4 km³ and 15 km³, respectively, and fountains of tephra and vapour reached heights of seven to thirteen kilometres. The eruption released 122 megatonnes of sulphur dioxide (SO_2). SO_2 is dissolved in small water droplets and forms microscopic airborne sulphate particles (aerosols[94]) that reflect the sun's radiation back into space, allowing less heat radiation to earth. After the Laki eruption a haze of sulphate aerosols hung over Europe and North America for five months, and the harvests failed in many places. Air pollution led to the death of domesticated animals, poor crops and famine on Iceland. 21 per cent of Iceland's population died. The eruption also led to the cooling of the northern hemisphere and crop failures in Europe.

In the middle of August 2014, the strongest earthquake since 1996 was registered in Iceland's largest volcano system, *Bárðarbunga*. The volcano lies under the ice of Europe's largest glacier (in volume) *Vatnajökull*. During the autumn, there have been major lava eruptions in fracture zones on the north side of the volcano, and the air above this area has periodically been closed to air traffic. One of the scenarios that the Icelandic authorities consider possible is a full eruption underneath *Vatnajökull* that reaches the surface. This will result in major flooding and the production of a great deal of ash, which could result in a repeat of the*Eyjafjallajökull eruption* in 2010.

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93 Volcanic materials.

94 When there is high pressure in the earth's crust, gas is dissolved in melted stone (magma). When the magma rises to the surface, the pressure diminishes and the gas is released. Sulphur dioxide and potentially other hazardous gases are released and become oxidised in water droplets, creating sulphuric acid among other things. They are transported in the air as microscopic sulphate particles (aerosols), which reflect solar radiation back into space, so that less heat radiation reaches the earth.

Risk

Norway can be affected by eruptions from several different volcanic systems. It is primarily an eruption from one of Iceland's approximately 30 different volcanic systems that could have an impact on Norway.

Volcanic eruptions are common on Iceland, with small eruptions every four or five years, while eruptions on the same scale as Eyjafjallajökull, for example, have a repetition interval of 10 to 20 years. The largest explosive eruptions, such as the major eruptions in Katla and Laki occur, on average, only at intervals of 500-1,000 years. Global warming could mean a rapid melting of glaciers. Where these cover volcanoes, the melting could mean increased volcanic activity due to the relief of pressure on the earth's crust.[95]

The scope of the ash distribution from an eruption on Iceland is dependent on meteorological conditions such as wind strength, wind direction and precipitation pattern. It is therefore difficult to predict the impact that an eruption on Iceland might have for Norway. The likelihood of aviation being affected to a greater or lesser degree as a consequence of a volcanic eruption is assessed as being very high (more than once in ten years).[96]

Ash from volcanic eruptions can have health consequences for the Norwegian population, because the finest particles of the ash may be breathed in, thereby causing potential harm to health. In addition hazardous gases may be released depending on the materials contained in the magma. Sulphur dioxide, carbon dioxide and fluorine can occur in considerable volumes. The health effects can be irritation of the membranes in the eyes and nose and airways. The most exposed groups are people with pulmonary or cardiovascular diseases and children. The increase in carbon dioxide is only local and will not have any impact in Norway.

The impact of restricting air traffic will include immediate consequences that occur when the airspace is closed and also indirect consequences of importance to the economy and business. The most serious consequences of closed airspace are potential harm to patients as a result of air ambulances being non-functional.

In addition, the financial consequences of an eruption may be great. This is largely due to the dependency of our era on air transport. Aviation operators and the travel industry, as well as subcontractors to these industries, could suffer considerable losses during a long-term closure of the airspace. A modern society is dependent on air traffic for a wide range of services, from the transport of people, goods and medicines to mail. It can take a long time to reorganise transport procedures. Indirect consequences escalate over time, and will become worse the longer the situation involving the disruption of air traffic lasts.

Volcanic eruptions involving ash and air pollution may mean increased vulnerability for various societal functions if other adverse events occur at the same time. For example disruptions in the transportation of important equipment, spare parts etc. will increase the vulnerability of functions and infrastructure that are dependent on the rapid supply of spare parts. The likelihood of this vulnerability being of significance increases with the length and scope of the halting of air traffic.

Volcanic eruption may lead to global cooling. This is linked to the spread of aerosols that reflect the sun's radiation back into space. This may contribute to cooling the earth by several degrees, and this effect may last from two to ten years.[97]

Prevention and emergency preparedness

As with other naturally triggered events, no volcanic eruption can be prevented. The next volcanic eruption that indirectly or directly affects us may be of a different nature and duration than the most recent ones we have experienced. Public authorities should be prepared for new eruptions that may challenge society in various ways.

After the *Eyjafjallajökull eruption* in 2010, the regulations for Norwegian civil aviation have been changed, and future eruptions involving ash clouds will probably have less of an impact on aviation than that experienced in 2010.[98] The new regulations mean that airspace will not be closed, but that risk zones and NOTAMs[99] will be established in which operators will be able to operate in at their own discretion and

95 Directorate for Civil Protection and Emergency Planning (2010): Vulkanutbrudd – når og hvor kommer det neste? En naturvitenskapelig analyse i et norsk perspektiv. [Volcanic Eruptions – When and Where Will the Next One Come? A Scientific Analysis in a Norwegian Perspective.]
96 The Geological Survey of Norway (NGU) and the Norwegian University of Science and Technology (NTNU).
97 Directorate for Civil Protection and Emergency Planning (2010): Vulkanutbrudd – når og hvor kommer det neste? En naturvitenskapelig analyse i et norsk perspektiv. [Volcanic Eruptions – When and Where Will the Next One Come? A Scientific Analysis in a Norwegian Perspective.]
98 Civil Aviation Authority – Norway.
99 Notice to airmen. Information for flight crews concerning important circumstances.

in compliance with their own procedures. The procedures must be approved by the aviation authorities in the country concerned. The scope of the impact depends, however, on the size of the volcanic eruption in terms of production of ash and hazardous gases.

Since the major crisis in 2010, many more airlines are now flying with aircraft that are approved for flights in areas with medium concentrations of ash. Thus situations in which certain countries close their entire airspace can be avoided, even though the airlines have aircraft that are able to fly in the area.

Whether, and possibly how far in advance, warning can be given of an eruption, depends on the type of volcano, recording of data and monitoring of seismic activity. Most volcanoes produce signs of an approaching eruption through small earth tremors and seismic activity. Warnings have been issued for all confirmed volcanic eruptions in Iceland since 1996 on the basis of seismic activity and some also by observing that the volcano is rising. One precondition to enable the planning of action to mitigate the consequences, is sufficient knowledge of volcanoes, ash column collapse and hazardous volcanic gases. The importance of the warning possibilities depends therefore on whether the public authorities and relevant players have sufficient perspective and knowledge.

The Norwegian authorities are responsible for monitoring and providing reports concerning the Beerenberg volcano on Jan Mayen Island. A large eruption here may lead to huge volumes of ash, and, with strong westerly winds, the eruption may affect parts of Northern Norway. Responsible authorities must be prepared to be able to provide reports and meet the need for information in the event of large eruptions from this volcano. The authority and notification procedures linked to monitoring appear to be rather unclear.[100] Administrative responsibility for the island of Jan Mayen lies with the Chief Administrator for the county of Nordland. ◎

[100] *Directorate for Civil Protection and Emergency Planning (2010): Vulkanutbrudd – når og hvor kommer det neste? En naturvitenskapelig analyse i et norsk perspektiv. [Volcanic Eruptions – When and Where Will the Next One Come? A Scientific Analysis in a Norwegian Perspective.]*

SCENARIO

10.1 Long-Term Volcanic Eruption in Iceland

An adverse event in the "volcanic activity" risk area is a major, long-term eruption in Iceland. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific serious scenario.

The risk analysis was conducted in the autumn of 2011.

Preconditions for the scenario

Time

April – September

Eruption height

- 14 km high eruption column with ash and gases
- 1,500 meter high fountains of lava

Emission volumes

- 15 km^3 tephra (volcanic materials)
- 125 megatonnes of sulphur dioxide

Consequential events

- Spreading of ash in airspace (ash clouds)
- Air pollution (ash and SO_2-dominated gases) in Europe

Comparable event

Laki eruption in 1783

Assessment of likelihood

During the course of the past 1,000 years, there have been four eruptions of the same type as Laki. Two of the eruptions have been on an equivalent scale to the scenario defined. The spread of ash and hazardous gases depends on dominant wind directions, wind speed and precipitation patterns. Because of the size of the eruption, it is assumed that Norway will be affected by the scenario regardless of the wind conditions. Based on the eruption history, it is assumed that the scenario will occur approximately once every 500 years,[101] i.e. there is a 0.2 per cent likelihood that it will occur in the course of a year. In the National Risk Analysis (NRA), this likelihood estimate falls under the category of *moderate likelihood* (once every 100 to 1,000 years). The uncertainty associated with the assessment of the likelihood of the adverse event and the consequential events is assessed as *moderate.*

TABLE 27. Schematic presentation of the results from the risk analysis.

Likelihood assessment							
		VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.2%				◎ (moderate uncertainty)			Once every 500 years based on scientific analyses
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Death			◎ (high uncertainty)			Total of 20 to 100 direct fatalities as a result of exposure to fine fraction particles
	Injuries and illness		◎ (high uncertainty)				Total of 20 to 100 persons requiring hospital treatment and/or with long-term consequential symptoms or impaired general health
Nature and the environment	Long-term damage	◎ (moderate uncertainty)					Possible earlier frost and or cold growing season, as well as reduced yields from crops.
Economy	Financial and material losses				◎ (moderate uncertainty)		NOK 5-50 billion
Societal stability	Social unrest				◎ (high uncertainty)		Because of the long duration, the population may react with uncertainty and anger
	Effects on daily life				◎ (high uncertainty)		Large consequences for the transport of people and cargo, increased vulnerability in critical social functions
Capacity to govern and control	Weakened national capacity to govern						Not relevant.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎ (high uncertainty)			Medium-sized consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[101] *Thordarson, T. and Larsen, G. (2007): "Volcanism in Iceland in historical time: Volcano types, eruption styles and eruptive history", Journal of Geodynamics 43:118–152.*

Assessment of consequences

The consequences of the given scenario are assessed as *medium-sized*. The scenario will primarily threaten life and health, the economy and societal stability. The uncertainty associated with the assessments of the different consequence types varies from *moderate* to *high*. Overall the uncertainty is assessed as *high* compared with the other assessments in the NRA.

Life and health

The greatest direct health hazard in Norway is associated with air pollution and the SO_2 concentration. As a consequence of the eruption, the concentration in Norway will reach a level corresponding to the concentration in Southern Europe today. There is great uncertainty linked to studies of the health effects of SO_2, and this has consequently not been included in the assessment of the volcanic eruption's impact on life and health. However, it is assumed that the concentration of SO_2 will not have a dramatic impact on the health of the Norwegian population, but deaths resulting from this cannot be ruled out. Based on the modelled calculations, it is assumed that the concentration of fine fraction particles[102] reaching Norway will correspond to the current level of floating dust in Norwegian towns. Assessments of the scenario's health-related consequences have been made on this basis.[103] Current public health and health services are quite different from the situation when the Laki eruption took place in 1783, and the consequences cannot thus be compared directly.

It is assumed that exposure to fine fraction particles from the eruption might lead directly to the death of 20 to 100 people, but there is a high level of uncertainty here. Exposure to ash particles will also mean additional illnesses and complications for particularly vulnerable groups, such as children and people suffering from pulmonary or cardiovascular diseases. Among these, there will probably be an increased frequency of hospital admissions, involving respiratory problems, respiratory illnesses and/or cardiovascular complaints. It is assumed that between 20 and 100 people will require treatment in a hospital and/or will have long-term consequential symptoms or impaired general health over a prolonged period. These assessments are based on sectoral analyses, calculation models and analyses of air pollution in towns and villages. However, due to a lack of experience with such a large and long-lasting volcanic eruption, the uncertainty associated with the assessments is assessed as *high*.

The indirect impact on health depends on the extent to which the air ambulance service is affected, and whether this will imply serious harm to patients. The duration of the eruption is expected to affect the transport of pharmaceuticals via transatlantic routes. Both Scandinavia and northern Europe will probably also be affected by the eruption, and there may therefore be demand shocks[104] for heart and lung medicines and face masks.

Nature and the environment

One consequence of the volcanic eruption will be a reduction in sunlight getting through the ash/gas clouds. Since sunlight is just one of several critical factors for growth, the scenario is assumed nevertheless to lead to long-term damage to nature and the environment. With regard to crops, the climate in general and the water supply are probably just as crucial as sunlight. Because of large temperature variations in Norway from one day to another, there is no unambiguous connection between global cooling and the temperature in Norway in the short-term. However, the eruption will mean an increased likelihood of earlier frosts and a cold growing season. Together with the drop in sunlight, therefore, there will be a significant likelihood of reduced yields from crops. The assessments are based on sectoral analyses, and the uncertainty associated with the analyses is assessed as *moderate*.

Economy

Economic losses are associated essentially with economic life and financial costs. Because of loss of income, the eruption is assumed primarily to affect actors within Norwe-

[102] *All particles with an aerodynamic diameter ranging from 2.5 to 0.1 micrometer (um). The aerodynamic diameter characterises aerosols and aerosol particles (airborne sulphate particles) and is used, for example, to indicate where in the airways the particles will stop when they are inhaled.*
[103] *Norwegian Public Health Institute, Norway's Institute of Transport Economics and Norway's Climate and Pollution Agency (2007): Helseeffekter av luftforurensning i byer og tettsteder i Norge. [Health Effects of Air Pollution in Towns and Villages in Norway.]*
[104] *Demand shocks are situations in which an unexpected change in the demand for certain goods arises that lies far beyond the variations that the market normally handles, cf. Prop. 111 L (2010–2011). Lov om næringsberedskap (næringsberedskapsloven) [Proposition 111 L (2010-2011). Act on Trade and Industry Preparedness (Trade and Industry Preparedness Act)].*

gian aviation and the travel industry. The scenario will also involve financial costs for both the health service and the shipping industry. The impact on the petroleum industry must be viewed in conjunction with it not being possible to carry out sufficient staff changeovers. Just over 6,000 people[105] are employed in oil and gas extraction at sea. At times these will be affected as a consequence of disruption in air traffic. Due to the reduction in sunlight, it is assumed that agriculture will incur losses as a result of reduced yields from crops. A reduction in crop yields globally will also have financial consequences through increased prices for food.

Based on relevant data and experience, it is assumed that the adverse event will entail overall significant socio-economic costs, and the estimate ranges between NOK 5 and 50 billion. Beyond this, it is difficult to specify a more precise estimate. Studies and calculations after prior events have different numbers in their conclusions, and the uncertainty associated with the cost assessments are assessed as *moderate*, compared with the basis for assessing the other scenarios in the NRA.

Societal stability

Air pollution resulting from the eruption will affect vulnerable groups, such as children and people suffering from pulmonary or cardiovascular diseases. Based on relatively recent experience with ash clouds, it is assumed that the population has expectations that the authorities and aviation actors are essentially prepared to manage the consequences well. The longer the ash clouds create problems for aviation, the greater the reason to assume that the eruption and its consequences will entail reactions such as anger and aggression in the population. The scenario may lead to social unrest as a result of uncertainty and anger in the population. The five-month-long volcanic eruption is assumed to be of significance to critical services and deliveries in large parts of Norwegian society. Closed airspace and disruptions in air traffic will mean increased vulnerability in crucial societal functions if other adverse events occur. For example, disruptions in the transportation of important equipment, spare parts and manpower will increase the vulnerability of functions and infrastructure that are dependent on the rapid supply of spare parts and specialist skills. In addition, it is assumed that many people will experience problems in connection with business and holiday travel.

The assessments have been made based on experience from earlier volcanic eruptions with propagation of ash in the airspace. The uncertainty is assessed, however, as *high*, since today's society has not experienced such a large and long-lasting eruption as assumed in this scenario.

Capacity to govern and territorial control

It is assumed that the volcanic activity scenario will not be of significance to the national capacity to govern or have territorial control.

[105] *Latest available figures from 2009 acquired from Statistics Norway.*

TABLE 28. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Information and data from earlier eruptions are available, but there is no experience with such a large and long-lasting eruption in Iceland in today's society.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Information and data from earlier eruptions are available, but there is no experience with such a large and long-lasting eruption in Iceland in today's society.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts, but somewhat different assessments of the long-term damage to nature and the environment.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	Key assumptions for the likelihood assessment are the height of the eruption column, the volume of ash and SO_2 emissions and the duration of the eruption. In addition to these assumptions, the wind and precipitation conditions are critical assumptions for the consequence assessments. The sensitivity of the results is assessed as moderate.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is assessed as high.

TABLE 29. Placement of the scenario in the risk matrix.

"Long-Term Volcanic Eruption in Iceland" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE					
MODERATE			◎		
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The volcanic activity scenario is assessed as having a *moderate* likelihood and *medium-large* social consequences. The uncertainty associated with the results is assessed as *high*.

VOLCANIC ERUPTION OF BÁRÐAR-BUNGA:
In the autumn of 2014, there were major lava eruptions in the fracture zones of Iceland's largest volcano system Bárðarbunga, and airspace over the area was closed to traffic during certain periods.

PHOTO: NTB/SCANPIX

EARTHQUAKE IN ITALY 2009:
The earthquake at L'Aquila in the Abruzzo region occurred in a fault zone that is seen as a risk area for large earthquakes. The earthquake had a magnitude of 6.3 and resulted in the collapse of around 15,000 buildings and the death of 279 people.

PHOTO: NTB/SCANPIX

11

EARTHQUAKE

Background[106]

The crust of the earth consists of a number of continental plates that are in motion. The areas that are geographically located near the boundaries and meeting points between the continental plates are those most exposed to earthquakes.

The movements of the plates create stresses in the crust of the earth. The plates either collide, slip past each other, or draw apart from each other. Earthquakes occur when the stresses become so great that they unleash a sudden break in the earth's crust. The energy is unleashed in the form of seismic waves. These waves disseminate outward and can vary in size from imperceptible to extremely strong shock waves that do major damage to buildings and infrastructure.

Norway lies far from the plate boundary between the American and the Eurasian plates, but compression stresses from the plate boundary in the Mid-Atlantic Ridge have nonetheless proved to be a considerable factor for earthquakes far into the plate. The second stress generating factor is the elevation of Scandinavia after the deglaciation (glacio-isostatic stresses). The two most important factors causing earthquakes in and outside of Norway have thus been pointed out. As a third factor, in coastal areas stresses will particularly be generated as a consequence of the simultaneous elevation of land and sedimentation and subsidence at sea. The crust is thereby especially "bent" in coastal areas, which further increases stresses in the crust precisely in the coastal zones.

Measurement of earthquakes

The absolute strength of an earthquake is given as a magnitude. There are several scales of measurement that have been and are in use. The reason for the many scales is that the dynamics of earthquake energy are so gigantic from the tiniest to the greatest quakes, and it was not previously possible to use the same scale for all quakes. At present, Moment Magnitude (Mw) is used more and more exclusively, which is a linear logarithmic scale that is proportional to seismic moment. For all practical purposes, the Richter Magnitude and Ms Magnitude are synonymous with Moment Magnitude. Previously, the two magnitudes covered different parts of the scale.

The traditional method of quantifying strength is through use of the Richter scale. The Richter scale is logarithmic. This means that an increase of one unit on the scale corresponds to ten times as great a change in the movement of the earth, and an approximately 32 times greater increase in released energy. The table below shows how often earthquakes of various strengths occur in the world:

[106] Presentation of the risk area Earthquake is based on collated information from the websites of and input from the Department of Earth Science (University of Bergen), NORSAR, Geological Survey of Norway (NGU), Norwegian Geotechnical Institute (NGI), Standards Norway, County Governor in Hordaland and others.

Description	Magnitude	Average number per year
Disastrous	8 or higher	1
Very Strong	7-7.9	18
Strong	6-6.9	120
Moderate	5-5.9	800
Weak	4-4.9	6,200
Small	3-3.9	49,000
Very Small	Less than 3	Magnitude 2-3: approx. 365,000 Magnitude 1-2: approx. 3,000,000

Gutenberg-Richter Law describes the quantitative distribution among large and small earthquakes, and is often used to estimate the frequency or return period for large earthquakes. It has been and is still used in risk calculations, also in Norway.

Events
Norway has the highest amount of earthquake activity in Europe north of the Alps. The majority are weak, but some of these quakes are so strong that they are felt by people. A few larger quakes have been documented, some have even caused damage to buildings and infrastructure, and it can happen again.

- 1819 in Mo i Rana: This earthquake was later calculated to have a strength of M 5.8. A number of landslides were observed, and the shock waves were described as so strong that people and animals could not remain standing upright, but fell over. The damage to buildings from that quake are not known.

- 1904 at Hvaler, Oslo Fjord: This earthquake (M 5.4) caused damage in several places northward along the Oslo Fjord all the way up to Oslo (Christiania), and far from the centre of the quake. Many buildings were damaged, but did not collapse, and there was near panic among the population in several places.

- 2008, M 6.1/6.2 earthquake in Stor Fjord west of Longyearbyen, Svalbard: This quake is the strongest in recent times. It was in the sea far from people and thus did not cause any damage. What is interesting in this context is that the type of tectonics in this area are not significantly different from Western Norway, and thus show to be probable the possibility of a corresponding quake for example on the Øygard fault.

There are also examples of medium strength earthquakes that have had disastrous consequences, for example the quake in L'Aguila in Italy in 2009 (M 6.4) in which 309 people lost their lives.

Risk
We do not know of an earthquake in Norway that had fatalities. Even though the likelihood is low, serious quakes can occur nonetheless, primarily in densely populated areas with building constructions that are not sufficiently robust. The size of the earthquake is often less relevant than where it is located in relation to centres of population. The time of day also affects the consequences.

It is not the earthquake in itself that causes loss of life, but rather the secondary effects of the quake. Powerful shock waves can cause houses, roads and bridges to collapse, and the occurrence of landslides, dam bursts and fires. Several factors lead to earthquakes of a strength less than M 7.0 having large consequences, primarily the distance from the earthquake to population centres, structural design of buildings and local ground conditions.

While wooden structures generally have a high tolerance for shock waves, older brick buildings, particularly apartment houses from the end of the 1800s, are vulnerable due to weaknesses in the structural design. Apartment building developments from the 1960-70s were constructed with prefabricated concrete elements as floor slabs. These are vulnerable to sideways movements. Newer buildings can also be exposed to damage from an earthquake if their design did not take earthquake loads into account.

If buildings are located on clay deposits that amplify the vibrations in an earthquake, there may also be major destruction. Uncompacted materials (sand etc.) that have been saturated by groundwater may be exposed to so-called liquefaction, which entails that the ground becomes very soft, almost liquid, and gives way. Liquefaction will also lead to buried tanks, pipelines and the like floating up to the surface, since they are lighter than the liquid ground.

The statistical material we possess is not comprehensive enough to be able to carry out a detailed calculation of the likelihood of a major earthquake in Norway. Estimates for the return period for an earthquake with a strength of M 6.5 or greater are therefore encumbered with very high uncertainty.

The areas with the most earthquake activity on mainland Norway are:

- Southern Hordaland, in the vicinity of Sunnhordaland and Hardanger.
- Northern Rogaland, in the vicinity of Ryfylke and Haugalandet.
- The coast along Møre og Romsdal.
- Around the Oslo Fjord.
- Major portions of Nordland.

Prevention and emergency preparedness

Monitoring of earthquake activity in Norway is undertaken by the Norwegian National Seismic Network (NNSN) which is operated by the Institute for Geological Science at the University of Bergen along with NORSAR (Norwegian Seismic Array), which contributes data from its measurement stations. NNSN consists of 33 seismic stations on the Norwegian mainland, as well as Svalbard and Jan Mayen.

Earthquakes can essentially not be predicted. No one has unambiguous documented predictions of a larger earthquake before it occurred. Damage-limiting measures are based on statistical calculations of shock waves over time, and the use of these calculations to devise regulations for how much buildings should tolerate.

Preventive measures for adverse consequences of earthquakes are primarily connected to the use of the standards for the design of structures – the so-called *Eurocodes*. *Eurocode 8: Design of structures for earthquake resistance* has been implemented in Norway as of March 2010. The authorities are obligated to adapt regulations so that the Eurocodes can be put to use.

The technical foundation for adaptation of the regulations in Norway is based on earthquake zoning completed in 1998. An important measure in further preventive work is to make use of newer data since 1998, as well as new methods for preparing updated seismic maps of Norway as a basis for the national Eurocode 8 Annex. A closer analysis can then be carried out of how various loose materials are affected by earthquake waves, and possibly include a mapping of the vulnerability of buildings and infrastructure, especially for older buildings in the larger cities.

For the Norwegian continental shelf there are special regulations, and since the mid-1980s offshore structures should be designed to tolerate earthquake stresses. ◎

SCENARIO

11.1 Earthquake in a city

An undesirable event in the risk area "Earthquake" can be a major earthquake that strikes a larger city area on the coast of Western Norway. The scenario analysed was prepared by the Department of Earth Science, University of Bergen, in cooperation with NORSAR.

The serious scenario that has been analysed is set in the municipality of Bergen, which has a population of approximately 270,000. In the city, there are various building structures, both historic and modern, which are exposed to strong shock waves. There are also other densely settled municipalities in the same vicinity, including Øygarden, Sund, Fjell, Askøy, Radøy and Lindås.

Preconditions for the scenario

Point in time / duration

- Earthquake strikes in the middle of the day on a weekday in January.
- Earthquake lasts for 45 seconds. The strongest shock waves last for 25 seconds.
- Danger of after-shocks for several months, and in the worst case several years.

Strength of the earthquake

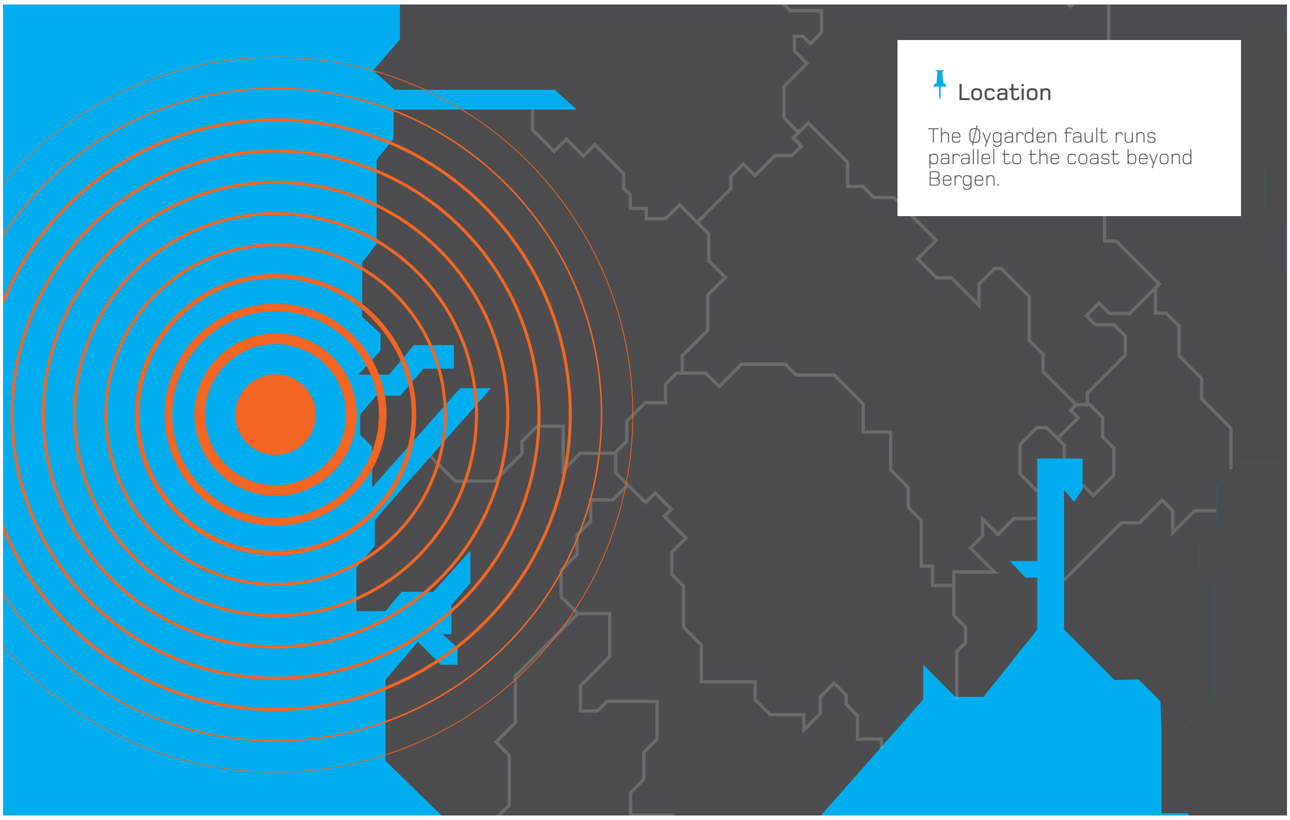
- An earthquake with a magnitude of 6.5 creates strong shock waves in the Bergen area.

Consequential events

- Landslides and falling rocks.
- Partial failure of the power supply.
- Partial disruption of the supply of drinking water.

Comparable events

- 1904 at Hvaler, Oslo Fjord, with a strength of M 5.4. The earthquake occurred during church hours and caused damage to several sites north along the Oslo Fjord, all the way to Oslo. Many buildings were damaged, but did not collapse.
- 2008 in the Stor Fjord west of Longyearbyen, Svalbard, with a strength of M 6.1 / 6.2. It was at sea, far from people, and thus did not cause any damage.
- 2011 in Christchurch, New Zealand, with a strength of M 6.3. The costs after the earthquake were approximately NOK 130 billion.



Assessment of likelihood

The Øygarden fault has been well surveyed due to oil exploration in the area. It runs along the coast from Møre to south of the Hardanger Fjord. Clear signs of micro-seismic activity have been observed along this structure. Such small earthquakes show that the structure is moving and alive. As of today there is no good method for predicting large earthquakes. The Gutenberg-Richter Law describes

TABLE 30. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.01-0.02%		◎				Once every 5-10,000 years based on empirical knowledge and the existing data basis for estimating the return periods for major earthquakes.

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MODERATE	LARGE	VERY LARGE	
Life and health	Death					◎	More than 300 dead as a direct result of the earthquake and collapsed buildings, and as a result of landslides / falling rocks or accidents.
	Serious injuries and illness				◎		Approximately 500 seriously injured as a direct result of the earthquake (and as a consequence of delayed medical treatment).
Nature and culture	Long-term damage to the natural environment	◎					Damage from landslides, but restoration of the nature within 10 years
	Irreparable damage to the cultural environment					◎	Many protected cultural artefacts will be lost.
Economy	Direct financial losses					◎	Reconstruction, repair and compensation costs of at least NOK 35 billion.
	Indirect financial losses			◎			Loss of income, costs of delays, decline in production, reduced trade, costs of evacuation and new housing amount to a combined loss of NOK 1-2 billion.
Societal stability	Social and psycho-logical reactions					◎	Unexpected, shocking event that is experienced by everyone. Major destruction and many deaths and injuries create a sense of helplessness and fear. Extremely demanding crisis management and great need for information.
	Stresses on daily life				◎		Delays on the road network, large portions of the city without power for a period of time and rationing measures, local loss of water, evacuation of a large number of people.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES						◎	Very high (to high) consequences overall.

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

the quantitative distribution between large and small earthquakes, and is often used to estimate the frequency or return period for large earthquakes. The return period for a large earthquake in the Øygard fault can be very roughly estimated from a Gutenberg-Richter distribution of observed earthquakes. For all of Norway south of Trondheim, a study in 1998[107] calculated a return period of 1,110 years for a quake of a magnitude greater than or equal to 6.5. This also included the Oslo Fjord area. It is possible to make a special calculation for the Øygarden/Bergen area, but the numerical data is so weak that all the numbers will be encumbered with high uncertainty.

Earthquakes with a magnitude greater than or equal to 4.5 are not unusual in Hordaland. The occurrence of larger earthquakes in the coastal waters beyond Western Norway has been known for the past 50 years, but most larger quakes (M 5.0 +) have been far from the coast. Estimates for the return period for an earthquake of M 6.5 or greater are therefore encumbered with very high uncertainty. For this specific scenario, the estimated return period is between 5,000 and 10,000 years. In the National Risk Analysis, this corresponds to "low likelihood". *Uncertainty* related to the likelihood estimate is assessed as high.

Assessment of consequences

As a whole, the consequences of the earthquake scenario are assessed to be very large on the scale used in the National Risk Analysis. The scenario entails *very large* consequences for the societal assets life and health, the economy and societal stability. The consequences for the cultural environment are also assessed to be very high, while the consequences for the natural environment are assessed as being very low. The uncertainty related to the consequence assessments varies from *moderate* to *high*.

Only the consequences of the main earthquake have been assessed. Any consequences in the after-shock period have not been included in the assessment. The Bergen area is affected to varying degrees. Collapsed buildings and a large number of damage sites will be spread across the entire area. The greatest number of collapsed buildings will be in the centre of the city.

Life and health

Just over 270,000 people live in the municipality of Bergen. The number of fatalities as a result of the earthquake is estimated at over 300. The majority of the fatalities will be the result of building collapse.

In the centre of Bergen there are approximately 880 brick apartment houses built at the end of the 1800s, in which all the internal structures are of wood. These buildings have from three to five floors. It is estimated that 1 of every 30 of these buildings will collapse, in other words around 30 buildings of this type. It is assumed that on average 16 people live in each building. It is further assumed that half (240) of the residents will be at home when the earthquake occurs, and that half of them (120) perish. Outside of the city centre there are approximately 40 high-rise apartment buildings from the 1960-70s, of ten to twelve stories. It is estimated that 10 per cent of these will collapse, that would be four apartment buildings with a total of 640 residents. It is further assumed that half (320) of the residents will be at home when the earthquake occurs, and that half of them (160) will perish.

Some people will perish in other buildings that collapse, and in accidents that arise when the earthquake occurs. This last group will include pedestrians, cyclists, motorists in the vicinity of buildings that collapse, people who are hit by landslides or falling rocks, or are involved in other accidents.

It is assumed that the earthquake will lead to approximately 500 seriously injured persons. The majority of those who survive in collapsed buildings will have serious injuries. Very many will need emergency medical treatment, and it is assumed that the capacity at Haukeland Hospital, which was not designed to treat so many injured, will be greatly challenged. Damaged/destroyed medical equipment, reduced accessibility for ambulances and time-consuming searches for survivors in collapsed buildings will result in delayed medical treatment, which for many of the patients will mean a worsened health condition.

It is assumed that many survivors in collapsed buildings will experience psychological disorders such as anxiety and post-traumatic stress, but that only a few will have long-term reactions. Many people who witnessed buildings collapse, and who live in similar buildings, are assumed to also be affected by psychological disorders.

[107] *NORSAR and NGI (1998): Seismic zonation for Norway. Report prepared for the Norwegian Council of Building Standardization (Standard Norge).*

Uncertainty related to the estimates is assessed overall as *high* since it is difficult to predict how many buildings will collapse. Experience from larger earthquakes in Norway is extremely limited. An insufficient survey of the ground conditions/loose material zones contributes to high uncertainty. How older brick buildings generally tolerate a medium strength earthquake is also encumbered with high uncertainty; thus all old brick buildings - which for example contain shopping centres, galleries, restaurants/cafes and other activities - are to be considered vulnerable to begin with.

The consequences for life and health are *highly sensitive* to the number of buildings that collapse and to the time of day when the earthquake occurs. The function of collapsed buildings will also have a major impact. If an office building or a school building collapses, the number of fatalities and injured persons may be higher. In the winter, hypothermia will quickly become a life-threatening risk to survivors in collapsed buildings. If technical medical equipment is damaged, the emergency treatment capacity may be sharply reduced with life-threatening consequences.

Nature and culture

The scenario analysed is assumed to entail very little long-term damage to the natural environment. The earthquake may cause landslides, but landslides are natural processes and it is assumed that the types of nature that are affected will be restored in the course of 10 years. It is assumed that there will be some minor events of acute pollution. Acute pollution as a result of a rupture of undersea pipeline systems connected to the major oil and gas installations at Ågotnes, Sture, Kollsnes and Mongstad is not very likely. Today's pipeline systems are designed to be able to tolerate movements/shocks and have several valve systems for shut off at both ends and along the pipelines.

It is assumed that several protected cultural artefacts will collapse or suffer irreparable damage. This primarily applies to the brick buildings in and around the city hall area, such as the Old City Hall, Hagerupsgården/Stiftsgården, Gamle Bergen main fire station, the Old Courthouse and the Magistrate Building.

In general, it is expected that wooden buildings will tolerate the shock waves, but may incur minor damages. This also applies to the unique cultural environment that the old Hanseatic wooden buildings of Bryggen represent.

Uncertainty related to the estimates is altogether assessed as *moderate*, based on experiences and data from abroad. It is uncertain how older brick buildings in general will tolerate a medium strength earthquake. An insufficient overview of loose material zones also represents an uncertainty.

Economy

The direct financial loss is assumed to be very great due to a large number of collapsed buildings and extensive destruction to other buildings, infrastructure and inventory, machines, equipment, etc. This loss is estimated to be at least NOK 35 billion.

To rebuild the 30 buildings that are assumed to collapse will cost around NOK 7.5 billion. The reconstruction costs related to the 4 high-rise buildings are assumed to be around NOK 10 billion. In addition, there will be major repair and replacement and compensation costs associated with material damages. This will include all types of construction such as private homes, apartment buildings, office buildings, industrial buildings, etc. It is estimated that costs related to buildings alone will be at least NOK 25 billion.

Damage to infrastructure will be a major cost driver, particularly damage to the road system caused by any landslides. Tunnels will not be damaged in themselves, but the quake can cause damage to electrical installations. Bridge structures are assumed to be capable of resisting the shocks of an earthquake, but the bridge foundations may slip and be damaged. Regarding the power supply, the economic consequences are primarily assumed to be comprised of repair costs related to damage to transformer stations. Costs related to damaged infrastructure are estimated to amount to NOK 5 billion. Damage to furnishings and fittings, equipment (including technical medical equipment), machinery etc. are assumed to be very extensive. Most buildings are assumed to incur some form of internal damage. It is assumed that 10 per cent of all furnishings and fittings will be damaged. The costs for this area are estimated at NOK 5 billion.

The indirect financial loss will in the first instance be connected to loss of income, decline in production and disruptions of business operations as a consequence of material damages to commercial buildings, reduced accessibility, no more ships calling, costs of delays and decline in consumption. Expenses associated with the evacuation of a large number of buildings and the acquisition of new housing for

[108] *Sample cost estimates: Roermond quake (5.8) in 1992 and the earthquake (6.3) in Christchurch, New Zealand, in 2011.*

a large number of households for a longer period of time will also comprise a portion of the indirect loss. The indirect financial loss is estimated to be NOK 1-2 billion.

The uncertainty related to financial loss is assessed as moderate. There are cost estimates from previous earthquakes abroad[108].

Societal stability

As a whole, the characteristics of the event are assumed to lead to very strong social and psychological reactions among the population.

Earthquakes are a known event, but earthquakes in Norway with fatalities are not known and to a great degree must be assumed to be experienced as an *unknown and highly unexpected event*. The consequences of earthquakes are known, but the total picture of collapsed buildings and a large number of deaths and serious injuries, possible landslides, destruction of infrastructure, extensive damage to furnishings and fittings and the fact that one literally loses his footing, have not been experienced by today's population in Bergen, or in Norway for that matter. The event will be experienced as shocking and there will be alarm and fear of after-shocks.

An earthquake occurs without warning, lasts for a short period, and the consequences will appear after a very short period of time. *There is a lack of possibility to escape* the event, and everyone will have a strong physical experience of the shocks there and then, regardless of where people are. The earthquake will, however, have disparate effects. People who are outdoors will initially be safe or have a greater opportunity to escape the dangers, while people who are in high-rise or apartment buildings will have great difficulty getting to safety, compared to people in detached houses. *Vulnerable groups* such as children, the sick or the elderly are especially exposed, since they do not have the same reactivity as others when it comes to escaping dangers, and therefore have a greater need for assistance in the acute phase.

It is assumed that the residents of brick apartment buildings from the end of the 1800s in the centre of Bergen and in high-rise buildings from the 1960-70s have expectations that the buildings have a greater tolerance capacity for earthquakes than they actually have. There will be high expectations that the authorities manage the events well, both with regard to the rescue response, emergency assistance, and in crisis communication with the population. It is assumed that *breaching these expectations* will create mistrust of the authorities and anger in an early phase.

Crisis management will be very complex: It will take time to establish a comprehensive picture of the situation and many, simultaneous, and widely-spread damage sites will create major challenges. The emergency services will be confronted with chaos, reduced accessibility and major technical challenges associated with search and rescue in collapsed buildings. The situation will be extremely demanding in regard to gaining an overview, implementing rescue operations, evacuation and informing the population. This will affect *the possibility of managing the event* at an early stage, when many people are assumed to experience a high sense of helplessness and a lack of information.
The scenario will also as a whole entail major *stresses on daily life.* In the first instance this is due to delays in transport of people and goods, failures in the power supply, and a great need for evacuation. It is assumed that the high-voltage transmission towers will tolerate the quake. An unstable *power supply* to Bergen city will nonetheless occur since old transformer buildings and transformer stations with gas-insulated switchgear, which are not designed to withstand strong earthquakes, can collapse. The scenario occurs in the winter, and if the quake affects around half of the transformer stations involved in supplying the city, it will to begin with result in a power deficit that will lead to rationing. The situation will be worst during the initial hours after the quake. Then large portions of the city may be without power. However, in the course of 24 hours, the restructuring of operations will be carried out, and a considerable portion of the power supply will be re-established. In the course of the next few weeks, the situation will be further improved. As a consequence of power outages, it is assumed that in some locations there will be a loss of access to *means of payment*. The extent and consequences of this will depend on the duration of the power outage and/or possible electronic communication.

It is assumed that approximately 500 persons will need *evacuation* for more than one month since their home/apartment has been destroyed. In addition,it will be necessary to evacuate residents from the buildings that incurred major damage until the extent of the damage and safety can be assessed. This is assumed to include up to 20,000 persons for two to three days. Those who can remain in their homes may experience an insufficient *supply of drinking water*, but this will be limited and is assumed to affect a few thousand people for up to one week. If there is a breach in the supply of water to Haukeland Hospital, this will become critical after only a few hours. The earthquake may lead to the loss of *electronic communication services*. The cables should however tolerate tension and shock waves, and it is assumed that cable ruptures will not occur. Unstable electronic communications services will therefore primarily be due to network overload. Prioritised subscribers will have access.

TABLE 31. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience	Seismology and applied geophysics are well-established sciences with strong research communities, both globally and nationally, which are continually collecting and analysing data from seismic stations that measure earthquake activity. There is a lot of earthquake activity in Norway, sometimes noticed by people, but seldom causing any material damage. There is empirical knowledge about some large quakes in Norway, but no experience of how such a large quake would affect an urban community in Norway. Broad global experience of large earthquakes.
Comprehension of the event that is being analysed (how well-known and researched the phenomenon is).	An earthquake is a well-known phenomenon, and there is a widespread international geoscience research community. Even though research and assessments have been made of large earthquakes that have struck cities in other countries, it is uncertain how a large earthquake will affect buildings and infrastructure in Norwegian society today.
Agreement among the experts (who participated in the risk analysis)	There are no major disagreements among the experts who contributed to the analysis.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The numerical figures/statistical data base for estimating the return period of large earthquakes in Norway (M 6.5) are insufficient, and estimates of likelihood are encumbered with high uncertainty. Small changes with regard to the distance to the epicentre of the earthquake, the capacity of existing buildings to tolerate shock waves, local ground conditions, consequential events, such as landslides, time of day (daytime versus night-time) or time of year will all have major effects on the consequences. Any concurrent events, such as storms, floods, power outages or major accidents will make crisis management considerably more complicated due to limited emergency preparedness resources and the element of surprise that an earthquake represents.
Overall assessment of uncertainty	The uncertainty associated with the estimates for likelihood and consequences is assessed overall as *high*.

EARTHQUAKE IN A CITY
The scenario analysed is set in Bergen.

PHOTO: NTB/SCANPIX

TABLE 32. Placement of the scenario in the risk matrix.

"Earthquake in a City" – overall risk

CONSEQUENCES					
VERY LARGE		◎			
LARGE					
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The scenario is assessed as having a *low* likelihood and *very* high societal consequences. The uncertainty associated with the results is assessed as *high*.

The transport of people and goods will be affected, and substantial delays are assumed for the road system for up to one week. It is assumed that many people will not come to work in the central areas of the city.

Uncertainty related to societal stability as a whole is assessed as *high*. The uncertainty related to "stresses in daily life" is assessed to be greater than the uncertainty concerning "social and psychological reactions". Uncertainty is related to the scope of the destruction of critical infrastructure, such as the road network, power and drinking water supplies, and electronic communications services. An insufficient survey of the ground conditions and the possibility of landslides contribute to the uncertainty.

Follow-up

The likelihood of a 6.5 magnitude earthquake striking the mainland of Norway is low. The work on this risk assessment has revealed that there is little awareness of the potential consequences of an earthquake in densely settled areas in Norway. Although previous earthquakes in Norway have not caused fatalities, the possibility can not be excluded that a large earthquake with serious consequences may occur.

The results of the analysis indicate that it is first and foremost the capacity of buildings and infrastructure to withstand shock waves that will affect the scope of the consequences. Preventive measures must necessarily be based on closer analysis, including:

- Relevant specialist groups acquiring new knowledge of the consequences of larger earthquakes in Norway for buildings and critical infrastructure, for example by
  - using an earthquake scenario to evaluate the consequences for critical infrastructure and buildings
  - calculating and analysing earth movements in an earthquake scenario with a strength of 6.5, which also takes into account how loose materials such as sand, gravel, and moraine materials will affect earthquake shock waves
  - making use of the newer data from the time since the earthquake zoning of 1998 and new methods for preparing load charts[109] for all of Norway as a basis for the national annex to Eurocode 8[110].

- Having operations that are responsible for critical societal functions evaluating the possible consequences of a major earthquake for their own activities

The analysis results further indicate that the municipalities:

- Should continue work to acquire a comprehensive overview of the ground conditions in densely settled areas, and perhaps carry out mapping of clay deposits and loose materials such as sand, gravel and moraine material.

- Should consider mapping buildings, including older brick apartment buildings and high-rise apartment buildings, which can be especially vulnerable in an earthquake.

[109] *A load chart indicates the seismic stress that various structures must be able to withstand.*
[110] *Eurocode 8 is a Norwegian and European construction standard that sets requirements for the design of structures to withstand seismic stress.*

TSUNAMI AFTER UNDERSEA EARTHQUAKE
The town of Yuriage in Japan with a population of 5,000 was demolished as a result of the tsunami that occurred after a powerful undersea earthquake on 11 March 2011. The tsunami caused more than 15,000 fatalities.

PHOTO: NTB/SCANPIX

MAJOR ACCIDENTS

GULF OF MEXICO, JUNE 2010
The Deepwater Horizon blow-out is considered one of the world's largest oil spills.

PHOTO: NTB/SCANPIX

Major accidents is used here as a collective term for events triggered by system failure in technical installations or devices. System failure encompasses human failure, technical failure and organisational failure. This may involve the failure of critical infrastructure, explosion accidents, transport accidents and emissions of toxic gases or other substances.

Human failure is defined as non-deliberate human errors that lead or contribute to adverse events. Technical failure encompasses errors or faults in technical systems, machines, constructions, etc. Examples of organisational failure or errors include unclear responsibilities, inadequate management, inadequate training or inadequate security routines. Adverse events can arise as a result of one of these types of failures, or multiple types of failures occurring simultaneously. System failure may also occur as consequential events from events triggered by natural events or malicious human actions, which can contribute to social consequences that are larger and more serious than necessary.

Various forms of risk and vulnerability analyses are used by the system owners in their efforts to survey risk and reduce vulnerability to major accidents. Compared with natural events and malicious acts in particular, there is a far greater range of statistics and experiential data that can be used for both the likelihood and consequence assessments.

RISK AREAS

PORSGRUNN
The fog lies low over the river Skienselva in Telemark. The Yara compound fertilizer plant rises above the sea of fog.

PHOTO: NTB/SCANPIX

12

HAZARDOUS SUBSTANCES

Background

On 24 May 2007, a tank at the tank facility belonging to the company *Vest Tank* in Sløvåg in the municipality of Gulen exploded. The explosion was violent and led to one of the facility's tanks being lifted off its foundation and thrown into a rock wall. The explosion also led to a nearby tank containing oil products catching fire. No one was seriously injured in the explosion or in the subsequent fire. After the event, many people who spent time on a daily basis close to the facility experienced discomfort, nausea, vomiting, sore throat and great uncertainty. The health authorities launched a survey of the population that was concluded in December 2013.[111] The main conclusion was that the accident had not resulted in long-term health damage beyond the more short-term health problems reported.

Other serious accidents in Norway include the explosion in the NI ammonia factory at *Herøya* in 1985, in which two people died and one person was seriously injured; the fire in the VCM factory at *Rafnes* in 1998; and the explosion at *Dyno Gullaug* in 2000, which resulted in the entire factory being closed down. The train collision at *Lillestrøm* station in 2000, when a freight train with two cars of propane crashed into a stationary train, could in the worst case scenario have led to a very powerful gas explosion and to a significant number of deaths and the destruction of parts of Lillestrøm. The accident involved the evacuation of over 2,000 inhabitants.

The biggest ever accident involving flammable gas took place in Mexico City in 1984, in which several LPG (Liquefied Petroleum Gas) tanks exploded, resulting in the deaths of almost 600 people and around 7,000 injuries. The biggest ever accident involving toxic gas took place in *Bhopal* in India that same year. An uncontrolled reaction at a chemicals factory led to emissions of methyl isocyanate and the formation of a large cloud of toxic gas, which contained many toxic gases in addition to methyl isocyanate, such as hydrogen cyanide and phosphine. The emission led to more than 3,500 deaths and more than 200,000 injuries.

In 1976, an industrial accident occurred with a major leak and spread of dioxin, among other chemicals, at the town of *Seveso* north of Milan. The event involved evacuation of the population around the site of the accident. The contamination by dioxin and the subsequent clean-up work was very extensive. This event brought industrial safety into focus in the EU, and gave rise to the *Seveso Directive*[112].

The toxic gases of chlorine and ammonia are used widely in industry and business. International surveys show that major accidents involving these gases have resulted in numbers of deaths between 8 and 60, whereas the number of injured have been between 20 and 600.

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[111] *Gro Tjalvin et al. HEALTH SURVEY 3 FROM THE SLØVÅG ACCIDENT, Presentation of the results from the health survey in 2012-13 (final report after the three health surveys (in 2008-09, 2010 and 2012-13). University of Bergen, Occupational and Environmental Medicine, 2013.*

[112] *Directive 2003/105/EC*

According to estimates and reports to DSB, hazardous substances (flammable, reactive and pressurised substances) and explosive substances (blasting agents and pyrotechnical goods) in volumes that might constitute a hazard to life and health for their surroundings are handled in more than 11,000 enterprises in Norway. Geographically, these enterprises are spread across the entire country with the majority in Eastern Norway (especially in the counties of Akershus, Østfold and Buskerud) and Western Norway (especially in the counties of Rogaland and Hordaland), approximately 80 per cent are located in these two regions.

Approximately 320 of these businesses handle such large volumes of hazardous substances that they are covered by the *Major Accident Regulations*[113], which is the Norwegian implementation of the EU's Seveso Directive. The majority of these facilities are also located geographically in Western and Eastern Norway. Tank facilities and explosive stores account for the majority of these facilities. The explosive stores are often connected to building and construction activities, while the tank facilities are connected to the distribution of petroleum products.

Based on the survey in the report "Survey of the Transport of Dangerous Goods in Norway"[114], an average of approximately 25,000 tonnes of dangerous goods are transported daily in Norway by road and rail. There is reason to assume that the real number is somewhat higher. Dangerous goods is a collective term for chemicals, substances, mixtures, products, articles and objects that, due to their properties, represent a risk to humans, material assets and the environment in the event of an acute accident. The majority of the transport of dangerous goods takes place by road. The transport of dangerous goods by road and rail are internationally regulated through a UN-based regulatory framework. The majority of the transport of dangerous goods on Norwegian roads consists of the three substance categories: flammable liquids (approx. 80 per cent), gasses (compressed, liquid or dissolved under pressure (approx. 8 per cent) and corrosive substances (approx. 6 per cent).

Risk

A review of identified hazardous and accident events shows that a number of accidents could affect Norway, linked to the transport of dangerous goods and stationary businesses that handle dangerous goods. Dangerous goods are extensively transported, so the geographical area of impact is large. To varying degrees, stationary facilities are located near built-up areas, but for many of the facilities an accident with hazardous substances could have a serious impact on life and health. DSB's work on areas with elevated risk has put a focus on these problematic issues. The report from the project "Sydhavna (Sjursøya) – an area with elevated risk"[115] pointed out various areas with risk of both a general nature and areas that are particular to Sydhavna in Oslo.

Accidents with hazardous substances cover a large number of different types of events. Through the national platform for disaster risk reduction in the field of hazardous substances, DSB has identified 12 accident scenarios in connection with the transport and handling of hazardous substances, each of which could involve a very serious impact on life, health and the economy.[116]

In addition to accidents, terrorist actions against the transport of dangerous goods and against stationary facilities involving hazardous substances could produce serious consequences for life and health. Great uncertainty surrounds the likelihood of such terrorist actions. The likelihood will depend on the intention of the actors in question (willingness and motivation to carry out an act) and their capacity (ability to carry out a terrorist attack). The extent to which actors with such an intention and capacity exist is assessed by the national security authorities.

Events involving flammable or toxic materials could have a serious impact. Accidents with toxic gases close to or within densely populated areas may have a major impact on life and health for the population around the accident site.

Ammonia and chlorine are the gases that are most relevant in such a context in Norway. Looking at events with low likelihood and large consequences, events involving the detonation of explosives in transport or in stores with contaminated ammonium nitrate cannot be excluded either.

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113 *Regulations of 17 June 2005 on measures to prevent and limit the consequences of major accidents in enterprises in which hazardous chemicals are present (Major Accident Regulations).*
114 *Institute of Transport Economics (2013), Survey of the Transport of Dangerous Goods in Norway.*
115 *Norwegian Directorate for Civil Protection (2014) Sydhavna (Sjursøya) – an area with elevated risk.*
116 *DSB: Annual Report 2012, National Platform for Disaster Risk Reduction in the field of hazardous substances, 6 May 2013.*

The consequences of an accident involving hazardous substances are affected by a number of factors – for example, the type of hazardous substances, temperature, wind direction, location and date and time of accident. In addition, emergency preparedness expertise and capacity, effective warning of the population, and passing on information both before and during an event will affect the scale of the consequences.

Accidents with gases that are both toxic and flammable can have a significant impact on life, health and the economy. Individual toxic materials could also have a major impact on nature and the environment, but in general the long-term effects are more limited. The scope of the impact on societal stability is difficult to assess on a general basis. This applies in particular to the criterion of "social unrest". This is due to the impact of an accident largely being affected by both the advance information possessed by the population, and by the actual handling of an accident.

Challenges in the field of hazardous substances are linked to changes in land use, the ageing of certain types of facilities, and the fact that more flammable gas is being brought into use as an energy source. There is a tendency for built-up areas to come closer to existing buildings with hazardous substances. This will lead to the possibility of the population being affected if an accident were to occur involving hazardous substances. Some cooling facilities with toxic ammonia gas are located in densely built-up areas. At the same time, some of these facilities will be relatively old and therefore not equally safe. The supervisory authority has shown that this particularly applies to refrigeration facilities connected to the fishing industry in the northernmost counties.[117]

Large fuel depots with flammable gas consisting of LNG (liquefied natural gas) associated with commercial activities are often located near built-up areas. In some cases, distribution to consumers will also be established. Geographically this type of facility is most common in the western counties of Møre og Romsdal, Hordaland and Rogaland, but the prevalence is increasing in the other regions of Norway. The gas facilities and transports to and from such facilities imply a risk to the surrounding areas.

Prevention and emergency preparedness

Enterprises that handle or transport hazardous substances are subject to strict safety requirements through regulations, and they are subject to inspection from the HSE authorities. The DSB manages the central regulations for hazardous substances that constitute a risk to life, health and material assets. In Norway, a coordination group has been established led by the DSB to monitor enterprises that store hazardous substances in quantities that makes them subject to the Major Accident Regulations.

DSB is also responsible for *the Contact Committee for the Transport of Dangerous Goods* and for t*he National Platform for Disaster Risk Reduction* in the field of hazardous substances (Samvirkeområdet farlige stoffer), which are collaboration groups for authorities in the hazardous substance field in Norway. These collaborative groups work on the identification of weaknesses and propose actions to increase the level of safety in the this field. Although very good work is done to reduce risk to an acceptable level in industry and public authorities, experience shows that major accidents can still occur. ◎

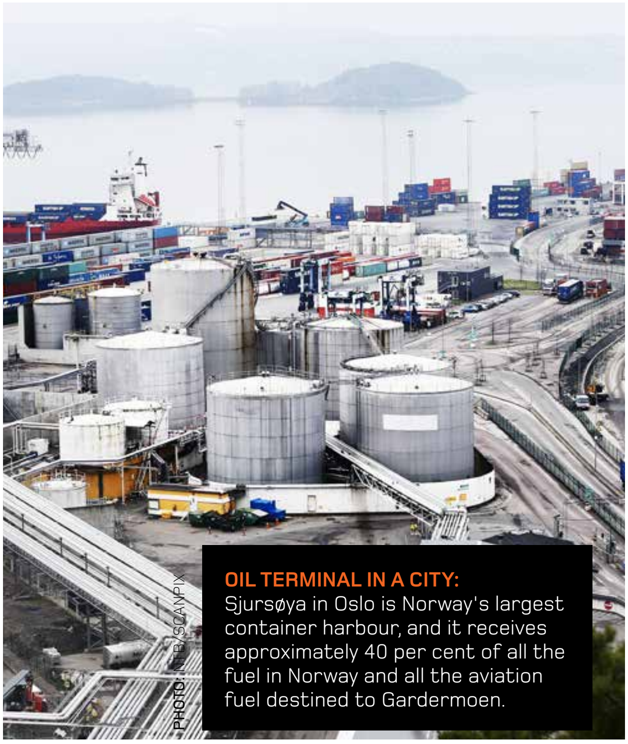


PHOTO: NTB/SCANPIX

OIL TERMINAL IN A CITY: Sjursøya in Oslo is Norway's largest container harbour, and it receives approximately 40 per cent of all the fuel in Norway and all the aviation fuel destined to Gardermoen.

[117] *Norwegian Directorate for Civil Protection (2012) Tilsyn med ammoniakk kuldeanlegg i perioden 2006–2010 [Inspection of Ammonia-based Refrigeration Facilities during the period from 2006-2010].*

SCENARIO

12.1 Gas Emission from an Industrial Plant

An adverse event in the "hazardous substances" risk area is an accident at a large industrial plant in Norway and a subsequent large chemical discharge and dispersal through the air to the surrounding areas. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific scenario.

The risk analysis was conducted in the winter of 2010.

Preconditions for the scenario

Course of events

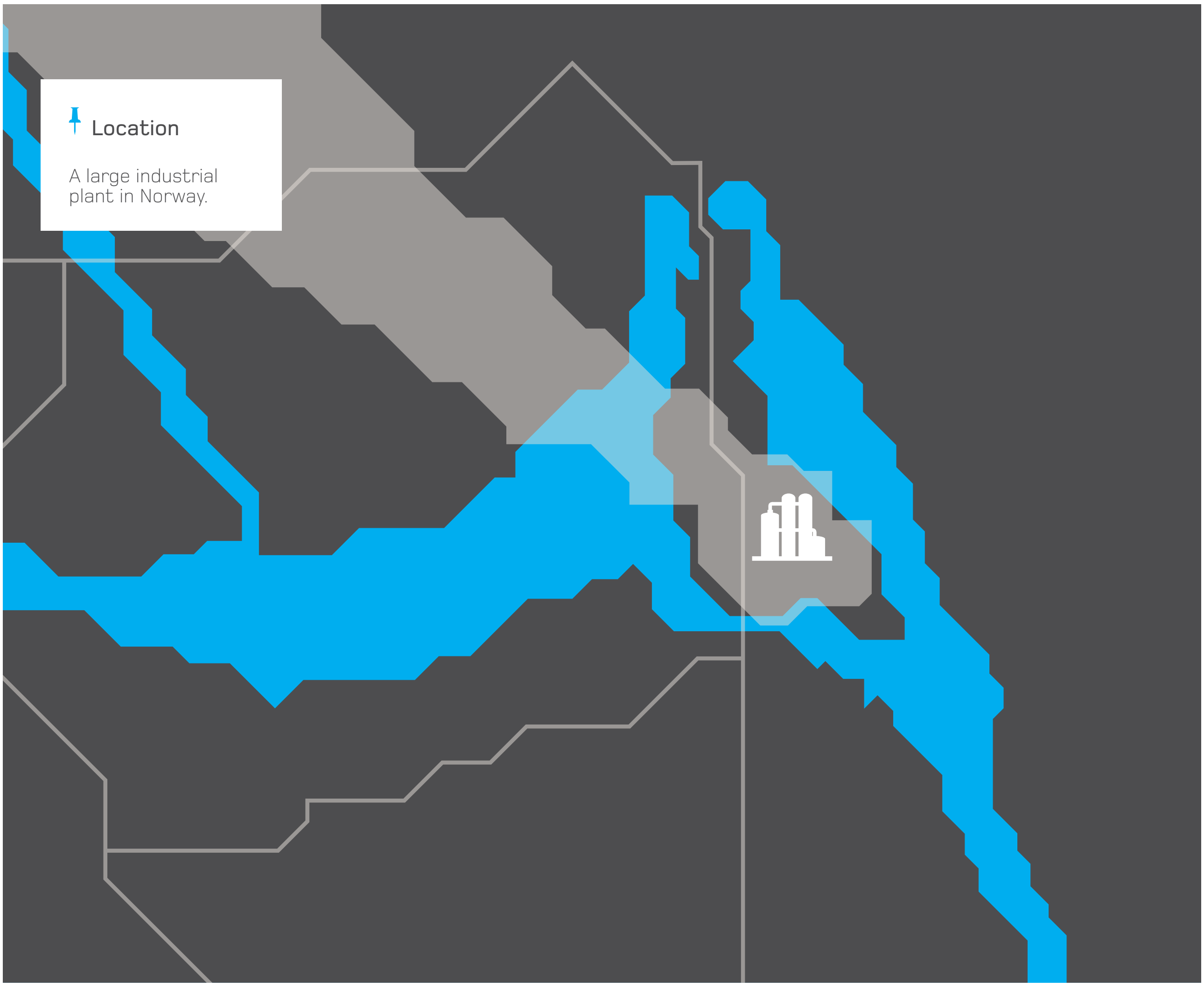
Fractures in the storage tanks at the plant entail a large emission of toxic gas with dispersal through the air to surrounding areas.

Duration

Large volumes of gas were dispersed during the first one or two hours before the emissions and dispersal diminishes.

Wind direction

Dominant wind direction in the area.



Assessment of likelihood

The likelihood that a major emission, as outlined in the scenario, can be caused by system failure at the plant is assessed as very low. This is expected to occur once every 10,000 years, which gives a likelihood of 0.01 per cent that it will occur in the course of a year. In the National Risk Analysis (NRA), this likelihood estimate falls under the category of *very low likelihood* (less than once every 10,000 years).

The likelihood estimate is based on an assessment of the expected accident frequency at the plant as a consequence of system failure, and it is based primarily on the existing risk analyses for this type of industrial plant. The data basis includes statistics from hazardous and accident events and data from the inspection of enterprises that are subject to the Major Accident Regulations[118].

Comprehensive preventive work in the form of barriers, procedures and inspections contributes to a high level of safety at the plant. Malicious acts, extreme natural events or external effects from accidents near plants are also conceivable causes of such a scenario. The likelihood is, however, assessed as being very low. The uncertainty associated with the assessment of the likelihood of the adverse event is assessed as *low*.

TABLE 33. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.01%	◎ (low uncertainty)					Once every 10,000 years based on the existing risk analyses

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death			◎ (moderate uncertainty)			Just under 100 deaths as a direct or indirect consequence
	Injuries and illness			◎ (moderate uncertainty)			Close to 500 injuries or ill people as a direct or indirect consequence
Nature and the environment	Long-term damage						Not relevant.
Economy	Financial and material losses				◎ (high uncertainty)		NOK 10-50 billion
Societal stability	Social unrest			◎ (moderate uncertainty)			Relatively large consequences for life and health, question of responsibility, reactions such as fear, anger and mistrust
	Effects on daily life	◎ (low uncertainty)					Evacuation of a few people may be necessary
Capacity to govern and control	Weakened national capacity to govern						Not relevant.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎ (moderate uncertainty)			Medium-sized consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[118] *Regulations of 17 June 2005 on measures to prevent and limit the consequences of major accidents in enterprises in which hazardous chemicals are present (Major Accident Regulations). The Directorate for Civil Protection and Emergency Planning, Directorate of Labour Inspection, Norway's Climate and Pollution Agency, Petroleum Safety Authority Norway and the Norwegian Industrial Safety and Security Organisation supervise compliance with these regulations, and they can make the necessary decisions and stipulate conditions to implement the regulations within the respective supervisory areas. The Directorate for Civil Protection and Emergency Planning is responsible for the practical coordination of the supervision of the regulations.*

Assessment of consequences

The social consequences of the given scenario are assessed as *medium-sized*. One general feature of a major emission of toxic gas as described in the scenario is that the immediate consequences are relatively large, but the long-term consequences are limited. The scenario will primarily threaten the societal assets economy and life and health. The uncertainty associated with the assessments of the different consequence types varies from *low* to *high*. Overall, the uncertainty is assessed as moderate compared with the other assessments in the NRA.

Life and health

The number of fatalities as a direct or indirect consequence of the emission is estimated to be just under 100. The number of serious injuries and ill people as a direct or indirect consequence of the emission is assumed to be over 500. The weather model that is used to measure the gas dispersal is based on actual weather observations in the area in question. The fact that the uncertainty associated with the consequence estimates for life and health is assessed nevertheless as *moderate* is due to the sensitivity of the results, and that changes in the assumptions, such as the wind direction, temperature and wind speed at the time of the accident will affect the consequence estimates to a great extent.

Nature and the environment

The toxic gas in the scenario will have some immediate environmental effects, but it is assumed that it will not entail long-term or permanent damage to nature and the environment. The uncertainty for assuming this is assessed as *low*, and it is based on experience from prior adverse events.

Economy

The scenario is assessed as having the greatest consequences with regard to financial and material losses, particularly in connection with a change in the framework conditions for trade and industry as a consequence of such an event. A possible long-term loss of reputation with respect to both tourism and people moving to the area will also be of significance to the financial losses. The costs of an such an emission are assessed overall as amounting to many tens of billions of Norwegian kroner, but there is a *high* uncertainty linked to these estimates.

Societal stability

The risk of an emission will not be completely unknown to the inhabitants in the area due to the warning exercises carried out in the affected area. It is assumed that the situation will be unclear, but that it will probably be stabilised when the accident site is under control and an overview of the scope has been established. The relatively high number of fatalities and injuries may, however, create fear and unrest. Crisis communication and distribution of information will be decisive to limit potential social unrest due to the event. It is assumed that the emission in itself, and the consequences for life and health in particular, will be the subject of major discussions among experts and politicians and a hunt for scapegoats. This can result in reactions such as anger and mistrust of the authorities and any private actors that are involved.

The transport of people and cargo by road, rail and sea will stop or be regulated during the accident. This situation will last until the accident is under control and an overview of the consequences for life and health in the affected area has been established.

All and all it is assumed nevertheless that the scenario will not threaten societal stability to any significant extent. The uncertainty associated with the consequence assessments is assumed to be *moderate* to *low*. The social and psychological reactions depend on effective warning, management, and distribution of information. It is assumed that a greater number of fatalities and serious injuries than estimated will also increase the social unrest. How the matter is handled by the media may also be decisive.

Capacity to govern and territorial control

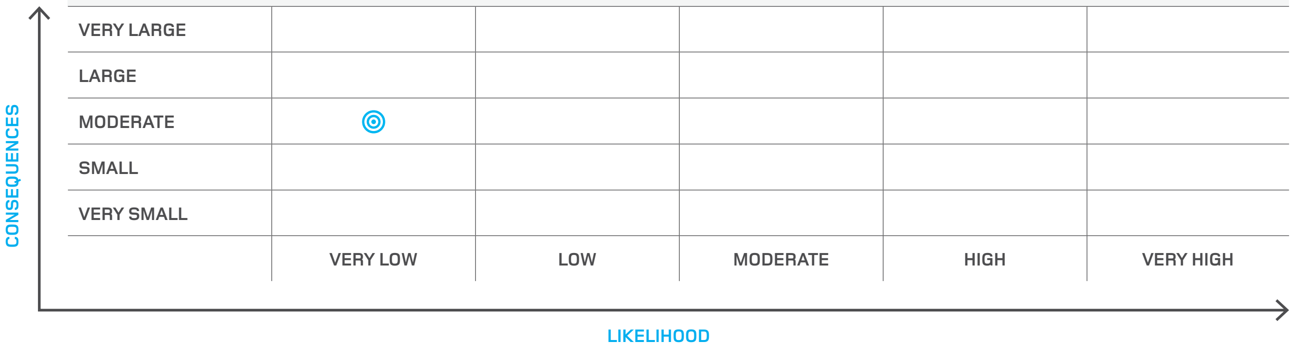
It is assumed that the gas emission scenario will not be of significance to the national capacity to govern or for territorial control. ◎

TABLE 34. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Experiential data from national and international accidents. Extensive data from inspections and the follow-up of industrial plants (Major Accident Regulations).
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Gas emissions are considered a relatively known and researched phenomenon, compared with other types of events that have been analysed in the NRA. Modelling based on actual weather observations in the area.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The key assumption for assessment of the likelihood is the fact that the gas emission was caused by a system failure at the plant. The consequences, for life and health in particular, are dependent on the emission volume, duration, time of day, weather and wind conditions and warnings. The sensitivity of the results is assessed as moderate.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is considered to be moderate.

TABLE 35. Placement of the scenario in the risk matrix.

"Gas Emission from an Industrial Plant" – overall risk



Low uncertainty · Moderate uncertainty · High uncertainty

The gas emission scenario is assessed as having a *very low* likelihood and *medium* social consequences. The uncertainty associated with the results is assessed as *moderate*.

SCENARIO

18.2 Fire at an Oil Terminal in a City

An adverse event in the "hazardous substances" risk area is a fierce fire in connection with an oil terminal located in a major city. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific scenario.

The risk analysis was conducted in the winter of 2011.

Preconditions for the scenario

Time

December during the afternoon rush

Weather conditions

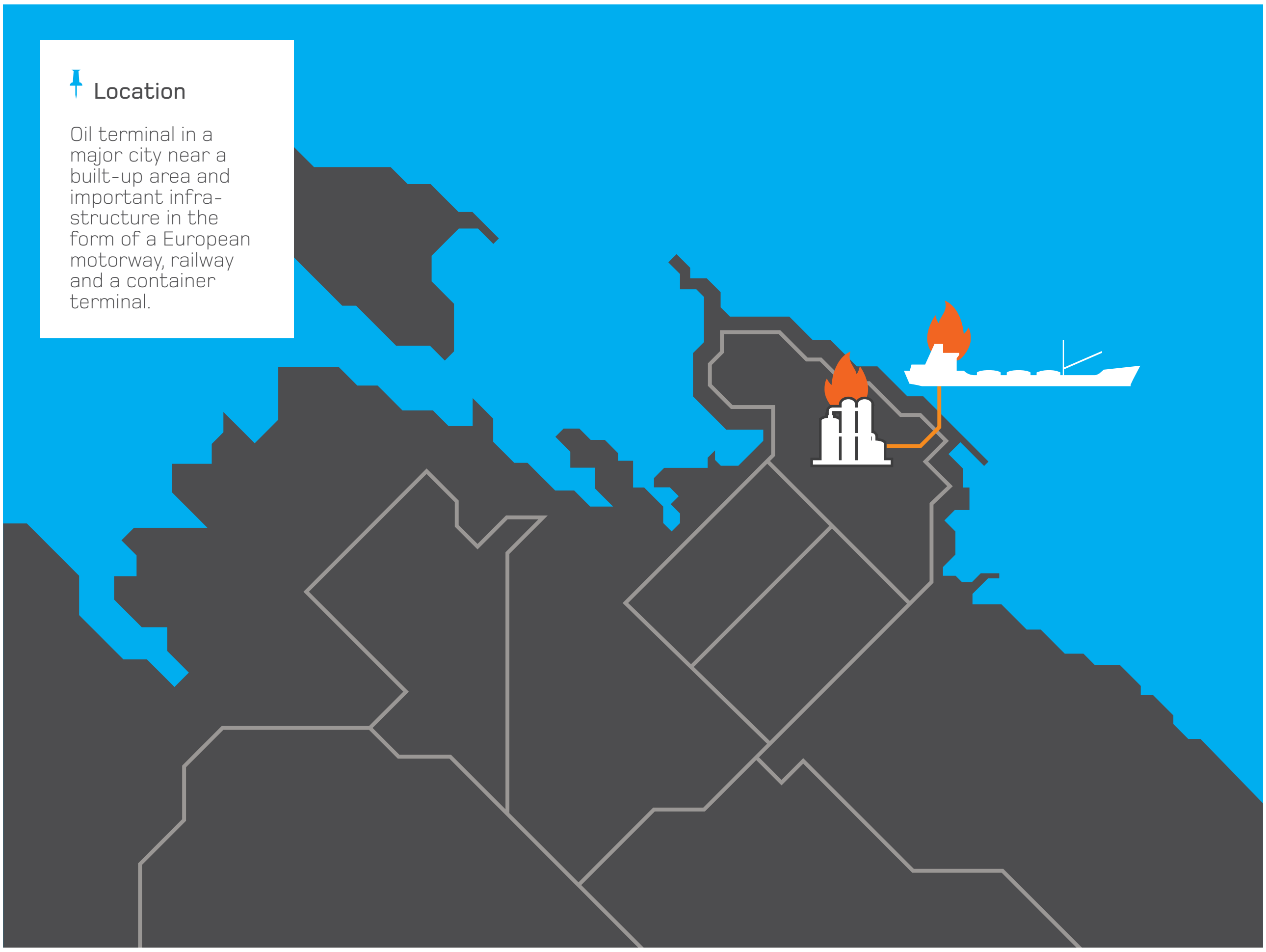
Clear weather and a few degrees above freezing

Wind speed

Calm

Course of events

- Explosive fire in connection with unloading petrol from a tank ship to a land tanker
- Rapidly developing fire in both the onshore tanks and the pier where the tanker is moored
- The tanker, with a total of 7,000 m³ of diesel and 11,000 m³ of petrol, catches fire rapidly
- After quarter of an hour, two onshore tanks each containing 20,000 tonnes of petrol catch fire, and this develops into an explosive fire
- Uncontrolled fire, full alarm and evacuation of the oil terminal



Location

Oil terminal in a major city near a built-up area and important infrastructure in the form of a European motorway, railway and a container terminal.

Assessment of likelihood

An assessment has been made of the likelihood of a disastrous fire in connection with the unloading of petrol from a tank ship to a land tanker at an oil terminal. This is expected to occur once every 1,000 years, which gives a likelihood of 0.1% that it will occur in the course of a year. In the National Risk Analysis (NRA), this likelihood estimate falls under the category of moderate likelihood (once every 100 to 1,000 years).

The estimate is based on existing information and knowledge obtained from the inspection of enterprises prone to major accidents[119], reports from the enterprises, accident statistics, etc. There are also examples of similar events from abroad. The uncertainty associated with the assessment of the likelihood of the adverse event is assessed as low in the NRA.

TABLE 36. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.1%			◎ (low uncertainty)			Once every 1,000 years based on existing information and analyses of industrial fires

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death		◎ (low uncertainty)				From 5 to 20 deaths as a direct or indirect consequence
	Injuries and illness		◎ (low uncertainty)				20-100 injuries or ill people as a direct or indirect consequence
Nature and the environment	Long-term damage						Not relevant.
Economy	Financial and material losses				◎ (low uncertainty)		NOK 10-50 billion
Societal stability	Social unrest		◎ (moderate uncertainty)				Disastrous fire, question of responsibility, reactions of anger and mistrust
	Effects on daily life		◎ (moderate uncertainty)				The evacuation of a few people may be necessary, major disturbances with respect to navigability and transport
Capacity to govern and control	Weakened national capacity to govern						Not relevant.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES			◎ (low uncertainty)				Large consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[119] *Enterprises that handle hazardous chemicals and are encompassed by the Major Accident Regulations.*

Assessment of consequences
The social consequences of the given scenario are assessed as *small*. The scenario will primarily threaten the societal asset economy. The uncertainty associated with the assessments of the different consequence types varies from *low* to *moderate*. Overall the uncertainty is assessed as *low* compared with the other assessments in the NRA.

Life and health
The direct fatalities will generally be caused by fire and smoke inhalation injuries, and it is assumed that the scenario will result in 5 to 20 fatalities. The number of serious injuries and ill people as a direct or indirect consequence of the fire is assumed to be in the category of 20 to 100. Of these a significant number of people with chronic respiratory illnesses, such as COPD and asthma, in large parts of the city could become ill, and in some cases die, because of smoke inhalation. Smoke inhalation injuries will be the most dominant cause of injuries and illness. Road traffic injuries as a consequence of the chaos on the roads in the most badly affected areas cannot be ruled out either. The assessments are based on experience from earlier adverse events with major explosive fires. The uncertainty associated with the estimates is assessed as *low*.

Nature and the environment
The emission of oil into the sea will leave its mark on nature, but it is assumed that the scope of the damage will be limited both with respect to the area affected and to long-term damage. Air pollution as a consequence of smoke and soot could be significant to the local environment, but the effect will be short-term. The uncertainty for assuming this is assessed as *low*, and it is based on experience from prior adverse events of acute emissions.

Economy
The overall financial losses are assumed to be substantial. The direct costs are linked, for example, to the loss of a large volume of petrol and diesel, destruction of the tanker, tank facility and dock facility, and losses as a result of a reduced workforce and damaged premises at the facility. The clean-up, repairs and reinforcement will also entail substantial costs. The indirect commercial costs are linked to lost sales, for example. Based on figures from prior disastrous fires, the overall financial losses, including rebuilding, in such a scenario are estimated to range from NOK 5 to 50 billion. The uncertainty associated with the estimates is assessed as *low*.

Societal stability
The scenario is not assumed to create significant social unrest. Unrest and occasionally chaotic conditions are to be expected due to smoke, closed roads, etc., and this will be very challenging, since it will affect a large number of people (more than 100,000). It is assumed that the question of responsibility and possible scapegoats will surface, and this may entail reactions such as anger and mistrust of the authorities and business owners.

The scenario will entail major disruptions in the daily life of a large number of people during the acute phase. Some days will pass before the fire is under control. Large volumes of smoke may also lead to the closure of schools and daycare centres for shorter periods, and to people being encouraged to stay indoors. Evacuation may be necessary for a small number of persons in the area adjacent to the oil terminal. This will also be of importance to a large number of people who will have to stay home from work. Because the plant that is on fire covers a large portion of Norway's fuel supply needs, it would be conceivable that people will worry about not being able to get hold of fuel and therefore try to build up private stores. The roads and railways will not be navigable for people and cargo during the acute phase, and they will be regulated for the duration of the fire. This will be a major challenge, since it affects the inhabitants in this part of the city (over 100,000), a large number of commuters, as well as travellers and other traffic to and from the country. It is assumed that boat and ferry traffic in the harbour area will also be affected.

The assessments are based on sectoral analyses and experience from major/disastrous fires, and the uncertainty is assessed as *moderate*.

Capacity to govern and territorial control
It is assumed that the scenario will not be of significance to the national capacity to govern or to territorial control.

TABLE 37. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Accident statistics, data from the inspection of enterprises prone to major accidents, experience from explosive industrial fires and events abroad.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Industrial fires are considered a relatively known and researched phenomenon, compared with other types of events that have been analysed in the NRA.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The likelihood of the event occurring is not very sensitive to changes in the assumptions. The consequences of the event are somewhat sensitive to changes in the wind speed and direction. The sensitivity of the results is assessed therefore as low.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is assessed as low.

TABLE 38. Placement of the scenario in the risk matrix.

"Fire at an Oil Terminal in a City" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE					
MODERATE					
SMALL			◎		
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The scenario is assessed as having a *medium-high* likelihood and *small* social consequences. The uncertainty associated with the results is assessed as *low*.

FUKUSHIMA NUCLEAR POWER STATION IN JAPAN:
A tsunami washed over the east coast of Japan on 11 March 2011 as the result of a powerful underwater earthquake. The tsunami caused tremendous damage and also destroyed parts of Fukushima Daiichi. The destruction resulted in a partial meltdown of three of the reactors and the spread of radioactive material. The event was the most serious nuclear accident since the Chernobyl accident in 1986.

PHOTO: NTB/SCANPIX

13

NUCLEAR ACCIDENTS

Background

Some crucial events influence our perception and understanding of risk linked to nuclear accidents. The *Three Mile Island accident* in the USA in 1979 showed that fairly improbable nuclear accidents can occur. The *Chernobyl accident* in the former Soviet Union in 1986 showed that the consequences can become very extensive, and that significantly larger areas than previously assumed can be affected.

Although serious accidents occur far away and have no direct impact on Norwegian territory, they create uncertainty and a need for information and management from the Norwegian public authorities. Like the Chernobyl accident the nuclear power accident at *Fukushima* was classified at the highest degree of severity by the*International Atomic Energy Agency's* (IAEA's) *International Nuclear Event Scale* (INES-7). However, the consequences of Fukushima were less serious for Norway than from Chernobyl, and the accident required a totally different type of handling by the Norwegian authorities.[120]

Nuclear accidents can occur in most types of nuclear plants; nuclear power plants, facilities for the production and processing of reactor fuel (reprocessing plants) or other fissionable material, and plants for storing used fuel and other radioactive waste. In addition, serious accidents can occur during the transport of reactor fuel.

Events involving nuclear weapons also constitute a potential hazard for Norway and Norwegian interests.

Norway is, to a large extent, surrounded by countries in which various forms of nuclear activity take place. Nuclear power stations can be found in Sweden, Finland, Ukraine, UK, Belgium, Germany, France and Russia, among other places. There are reprocessing plants for used reactor fuel in the UK, France and Russia. Facilities for storing used fuel that could constitute a risk to Norway are primarily located on the Kola peninsula in Russia.

Risk

The likelihood of a serious nuclear event occurring and affecting Norway is assessed as low. However, if a nuclear accident does occur the impact could be extremely serious. Radioactive contamination causes exposure to ionising radiation, either directly or through ingesting contaminated foods or breathing in contaminated air. This may have an impact on the health of the population in the form of acute radiation injuries, late radiation tissue injuries (principally an increased risk of cancer) and/or psychological effects.

[120] *StrålevernInfo 8-12 [Radiation Protection Info 8-12]. The Fukushima Accident. www.stralevernet.no ISSN 1891-51-91 (online), 9 March 2012.*

Emissions and the spread of radioactive matter can also have a negative impact on the environment. In addition, radioactive contamination may have consequences such as the contamination of foodstuffs, economic losses as a consequence of reduced market reputation, contamination of property and areas of land, loss of infrastructure, a requirement for the local community to evacuate immediately or move permanently and social unrest and uncertainty.[121]

Risk varies, however, among different potential sources. The likelihood of a nuclear accident is influenced by technical standards, organisation, government control and culture of safety. The impact of a nuclear accident will depend on a number of factors, such as where the accident occurs, the type and quantity of radioactive materials involved, how the emissions are transported and the capacity of the organisations and authorities to manage and implement action.

Western European nuclear power plants generally have good, redundant safety systems, and both measures to reduce the likelihood and impact are emphasised. Nuclear power plants in the former Eastern Bloc countries, on the other hand, are not regarded as being equally safe, and weaknesses in these nuclear power stations were thoroughly documented by the IAEA in the 1990s.[122] It has been estimated that the likelihood of serious accidents at nuclear power plants in this region is 10 to 100 times greater than would be the case for western nuclear power plants, with the exceptions of certain older British nuclear power plants.

On the Kola peninsula, there are numerous plants in which used reactor fuel is being stored under conditions that are fairly unsatisfactory. Some of these plants are located close to Norway, and an accident at one of these could have a significant impact on the environment of the Barents Sea and on Norwegian economic interests.

Investigations into safety at reprocessing plants in the UK and France show that the greatest risk is linked to events at storage tanks for liquid waste that contains large amounts of radioactivity. Any loss of cooling at these plants could lead to emissions that would be far greater than those during the *Chernobyl accident*. Such emissions could affect Norway, depending on the wind and weather conditions.
The *Fukushima accident* occurred as a result of a powerful earthquake followed by a deadly tsunami[123], and it demonstrated the way in which natural events can cause nuclear accidents. The emissions from the nuclear power plant of *Fukushima Dai-ichi* could be measured in Norway, but the values were so low that it did not imply any consequences for health or the environment. At the same time, the event meant that a number of players became involved in extensive work to inform the inhabitants of the event and the relevant consequences for Norway.[124]

Nuclear activity in Norway is limited to two research reactors, one at *Kjeller* and one in *Halden*. Investigations into serious accident scenarios for these plants, in the form of a partial meltdown of the reactor core, have demonstrated that the consequences would be relatively modest.[125] In addition to the rectors named, there are two depots for radioactive waste, one in *Himdalen* and one in *Gulen*. Emissions from these would not be expected to have any serious consequences either.

Norway borders onto shipping channels with relatively high volumes of traffic of reactor-powered vessels, and Norway regularly receives visits from such vessels. An accident involving these vessels in or just outside Norwegian ports, would have a serious impact on people and the environment in the close vicinity, under certain given conditions.[126] Transport of radioactive waste along the Norwegian coast also constitutes a potential threat.

In addition to accidents at nuclear power plants or other plants that handle radioactive materials, the threat linked to terrorist action against such plants must also be taken into consideration. It is also conceivable that terrorist groups themselves could come into possession of nuclear weapons. Any assessment of the likelihood of such terrorist attacks against Norway must be based on national threat assessments. In general, the threat of terrorism against Norway is regarded as heightened in 2014. Internationally, there is concern that non-governmental actors may attempt to acquire the capacity to use chemical, biological and

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[121] Norwegian Radiation Protection Authority (2008): Atomtrusler [Nuclear Threats], Radiation Protection Authority Report 2008:11.
[122] Ibid.
[123] Vindsand (2011): Befolkningsundersøkelse om informasjon etter kjernekraftulykken i Fukushima [Population study of information after the nuclear power plant accident in Fukushima]. Drawn up on behalf of the Norwegian Radiation Protection Authority, NIVI Report 2011:5.
[124] Ibid.
[125] Norwegian Radiation Protection Authority (2008): Atomtrusler [Nuclear Threats], Radiation Protection Authority Report 2008:11.
[126] NOU 1992:5 NB Tiltak mot atomulykker [Official Norwegian Report 1992:5 NB Measures against Nuclear Accidents]. Recommendations for further reinforcement of Norwegian emergency preparedness for nuclear accidents.
[127] CBRN is used here as an abbreviation for chemical, biological, radiological or nuclear substances.

radiological substances, as well as nuclear material in terrorist actions, but there is still no special assessment related to the possible use of CBRN[127] agents in Norway.[128]

The relevance of nuclear power plants has increased in recent years, and many people view the construction of nuclear power plants as an opportunity to generate energy with low CO_2 emissions and thus meet the challenges of climate change. In Finland, a new reactor is under construction, and in both the UK and Russia there are plans to build new nuclear power plants in the years to come. However there are also countries that are considering discontinuation of their generation of nuclear power, such as Germany and Japan.

Prevention and emergency preparedness

The Norwegian Radiation Protection Authority is conducting inspections into safety and emergency preparedness at Norwegian nuclear facilities, including stores/depots for radioactive waste. In addition, there is extensive international cooperation through the IAEA, for example, on improving the level of safety at all types of nuclear facilities regarding accidents and deliberate, adverse actions.

Since 1992, a significant portion of the effort has focused on Northwest Russia. Among other things, Norway has financed measures to strengthen the safety of Russian nuclear power stations, the removal of radioactive strontium batteries from lighthouse beacons, and the scrapping of decommissioned nuclear submarines, as well as protection of the infrastructure in the Andrejev Bay – where used reactor fuel from the Northern Fleet is stored. From the establishment of the nuclear action plan in 1995 until 2014, a total of approximately NOK 1.9 billion kroner has been appropriated through the national budget for nuclear safety cooperation in Northwest Russia.[129] Future priorities for cooperation will be in facilitating the removal of used reactor fuel from the Andrejev Bay, as well as environmental monitoring and measures related to security and emergency preparedness at the nuclear power stations on the Kola peninsula and in St. Petersburg.[130]

Today, Norway has permanent emergency preparedness against nuclear events. The objective of the national nuclear emergency preparedness is that it should be possible to manage all potential events, regardless of likelihood. As part of this work, the Government adopted a set of different scenarios in the spring of 2010 on which the dimensioning of the Norwegian nuclear preparedness is to be based.[131] The six dimensioning scenarios have been categorised based on the challenges they entail with respect to management:[132]

1. Large airborne emissions from plants abroad that can reach Norway.
2. Large airborne emissions from plants or other activities in Norway.
3. Local events in Norway, or in the vicinity of Norway without any local connection.
4. Local events that develop over time.
5. Large emissions to a marine environment in Norway or in the vicinity of Norway, or rumours to this effect.
6. Serious events abroad without any direct impact on Norwegian territory.

The scenarios form an important basis for future emergency preparedness work. On 23 August 2013, a new Royal Decree was issued that establishes a mandate and authority for the nuclear preparedness organisation, effective 1 September 2013.

[128] *Norwegian Police Security Service (PST): Åpen trusselvurdering 2014 [Open Threat Assessment 2014], www.pst.no.*
[129] *Meld. St. 11 (2009–2010) Samarbeidet med Russland om atomvirksomhet og miljø i nordområdene [Report no. 11 (2009–2010) to the Storting, Collaboration with Russia on Nuclear Activity and the Environment in the Northern Areas].*
[130] *Meld. St. 7 (2011–2012) Nordområdene [Report no. 7 to the Storting (2011–2012), The Northern Areas].*
[131] *Norwegian Radiation Protection Authority (2012): Roller, ansvar, krisehåndtering og utfordringer i norsk atomberedskap [Roles, Responsibility, Crisis Management and Challenges in Norwegian Nuclear Preparedness], Radiation Protection Authority Report 2012:5.*
[132] *Norwegian Radiation Protection Authority, www.stralevernet.no, ISSN 1891-5191 (online), 4 March 2014.*

SCENARIO

13.1 Nuclear Accident at a Reprocessing Plant

An adverse event in the "nuclear accidents" risk area is an accident at a nuclear plant that results in radioactive emissions that are carried by air currents to Norway. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific serious scenario, in which the failure of the reprocessing plant Sellafield in the UK results in the emission of radioactive substances[133].

The risk analysis was conducted in the autumn of 2010.

Preconditions for the scenario

Time

- After 9 hours, the emissions reach Norwegian territory
- After 48 hours, the emissions can be recorded throughout the country

Weather conditions

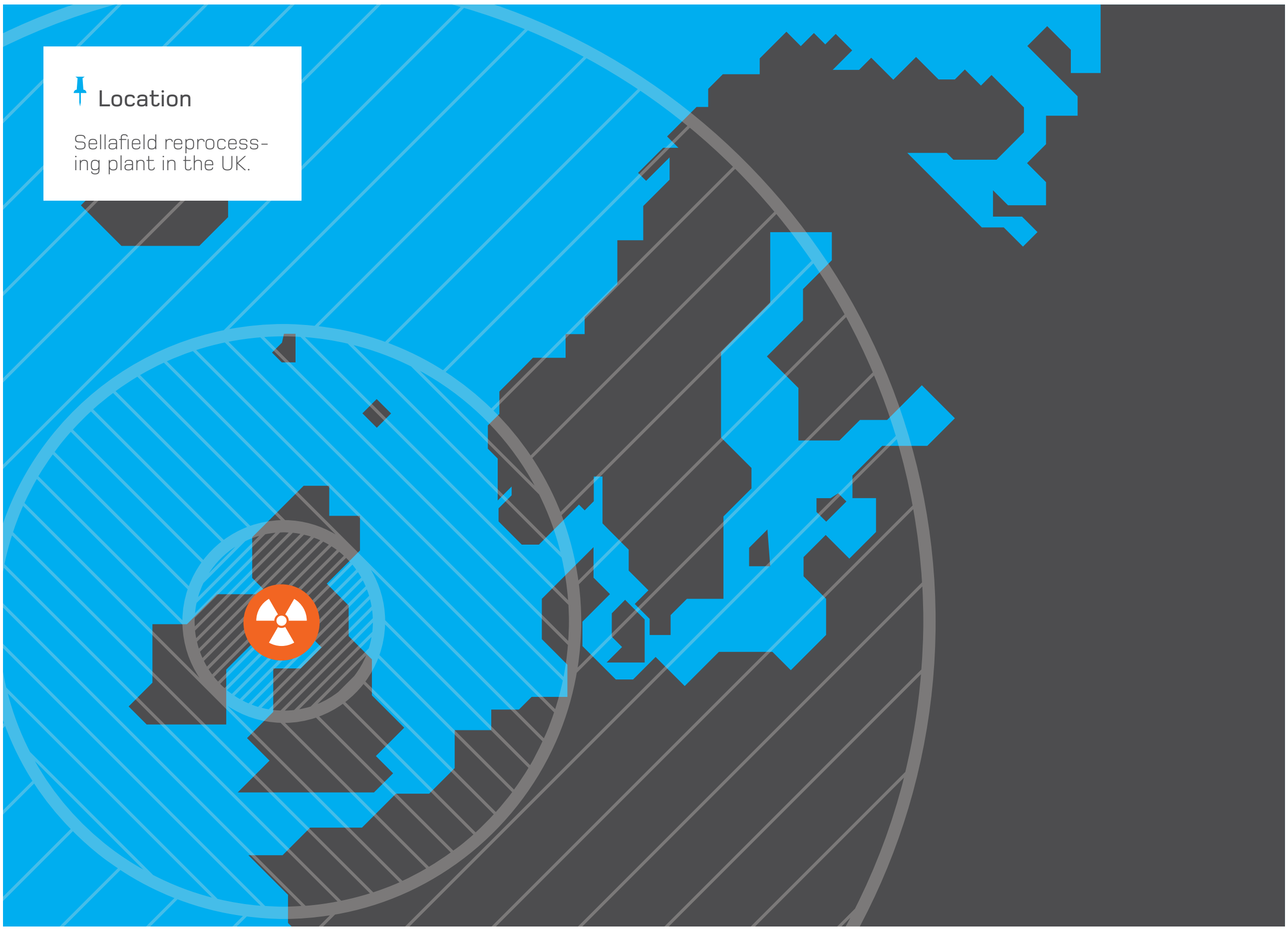
The emission is transported on air currents towards Norway.

Course of events

Explosion in one of the waste tanks at the plant due to a cooling failure – approximately 1% of the waste will be released into the atmosphere

Comparable events

- Three Mile Island accident in the USA in 1979
- The Chernobyl accident in the former Soviet Union in 1986
- Fukushima Dai-ichi in Japan in 2011



Assessment of likelihood

An assessment has been made of the likelihood of an accident at a similar plant, with large emissions that affect Norway. This is expected to occur once every 5,000 years, which gives a likelihood of 0.02% that it will occur in the course of a year. In the National Risk Analysis (NRA), this likelihood estimate falls under the category of *low likelihood* (once every 1,000 to 10,000 years).

The estimate is based on an assessment of the expected accident frequency at similar facilities, adjusted for characteristics and special conditions at the specific facility. Weather observations are also used as grounds for indicating the frequency and occurrence of air currents that could carry the emissions towards Norway. Historical data for such events at this particular plant is limited, and the uncertainty associated with the assessment of the likelihood of the adverse event is assessed in the NRA as *moderate*.

TABLE 39. Schematic presentation of the results from the risk analysis.

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.02%		◎ (moderate uncertainty)				Once every 5,000 years based on the expected accident frequency at similar plants

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death					◎ (high uncertainty)	Several hundred fatalities as a result of a premature death
	Injuries and illness					◎ (high uncertainty)	Several thousand injuries or ill people as an indirect consequence
Nature and the environment	Long-term damage					◎ (low uncertainty)	Area of over 3 000 km², waste problems in products and the animals themselves, duration of several decades
Economy	Financial and material losses				◎ (low uncertainty)		NOK 5-50 billion
Societal stability	Social unrest				◎ (moderate uncertainty)		"Invisible" threat, life-threatening consequences, unclear long-term consequences affecting very many people, question of responsibility, reactions such as fear, anger and a feeling of powerlessness
	Effects on daily life		◎ (moderate uncertainty)				The mobile phone network collapses, people stay at home and important social functions are put of action
Capacity to govern and control	Weakened national capacity to govern						Not relevant.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎ (moderate uncertainty)		High (to very high) consequences overall.

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[133] *Norwegian Radiation Protection Authority 2009:6. Konsekvenser for Norge ved en tenkt ulykke ved Sellafield-anlegget [Consequences for Norway of a Potential Accident at the Sellafield Plant].*

Assessment of consequences

The social consequences of the given scenario are assessed as *large* to *very large*. The scenario will primarily threaten the societal assets life and health and nature and the environment. The uncertainty associated with the assessments of the different consequence types varies from *low* to *high*. Overall the uncertainty is assessed as *moderate* compared with the other assessments in the NRA.

Life and health

No direct deaths are expected, but several hundred people could die in the decades after the event, primarily as a result of an increase in the number of cancer cases. It is estimated that several thousand people will develop non-fatal cancer, cardiovascular disease and psychological problems. Pregnant women who are exposed to radioactive substances may experience birth defects. The estimates of the consequences for life and health in the risk analysis are based on international guidelines. The fallout concentrations over Norway are based on existing propagation models. The consequences are assessed primarily based on the spread of radioactive caesium. Because the emissions will also contain several types of radioactive substances other than what has been used as a basis for this risk analysis, the uncertainty associated with the estimates is nevertheless assessed as *high*.

Nature and the environment

Nature, the environment and food production will be hit hard, and the slaughter of animals, destruction of milk, etc., could become necessary. Action will be required for several decades. The uncertainty of the assumptions is assessed as *low* and is based on experience from earlier events and emission in other countries. Cultural artefacts and cultural environments will also be affected.

Economy

The economic losses will be particularly large for agriculture and agriculture-based food industries. Costs are associated with both direct costs such as slaughter and clean-up, and indirect costs as a result of lost sales and the loss of reputation. It is assumed in such a scenario that 25% of the meat production and 20% of the milk production are affected. A temporary complete stoppage of exports from the fish farming industry can also be expected. The total financial costs in a scenario of this kind are estimated at between NOK 5 and 50 billion. The uncertainty associated with the estimates is assessed as *low*, based, for example, on experience with handling the Chernobyl accident in 1986.

Societal stability

Although the type of event in itself is recognisable, a nuclear accident is a scenario that will create a great deal of social unrest in the population. The consequences will be experienced as life-threatening and as a threat to future generations. Even if the accident takes place beyond Norway's borders, the population knows that the affected areas will be exposed to radioactive contamination that can cause premature death for a large number of people and serious illnesses for thousands of people. Pregnant women are a particularly vulnerable group due to possible birth defects as a result of radioactive contamination. It is assumed that the scenario will create reactions such as fear, anger and a feeling of powerlessness. The question of responsibility and mistrust, and whether the authorities could have done anything to avoid the accident will be relevant. Based on earlier surveys[134] in Norway after the Chernobyl accident, the uncertainty associated with the assessments is assessed as *moderate*.

Such an event will also have effects on daily life. It is assumed that the scenario entails potentially lower water quality for cistern water, but drinking water from other sources will be available. It is assumed that a large number of people will stay at home/indoors instead of going to work, and important social functions, such as public transport and day care centres, will be put out of action as a result of this and thousands of people will be affected. It is expected that 10,000 to 100,000 people will be affected for days.

Capacity to govern and territorial control

It is assumed that the scenario will not be of significance to democratic values and capacity to govern. ◎

[134] *Weiseth L., Tønnessen A. Public reactions in Norway to radioactive fallout. Radiat Prot Dosimetry 1995:62:101-6.*

TABLE 40. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Actual weather observations, the Chernobyl accident in 1986, limited historical data for events like this, uncertainty associated with the effects of substances other than radioactive caesium at low doses of radiation.
Comprehension of the event that is being analysed (how known and researched is the phenomenon?)	Based on recognised international models and standards, nuclear accidents are considered a relatively known and researched phenomenon, compared with other types of events that have been analysed in the NRA.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The likelihood of the emissions affecting Norway is relatively sensitive to changes in the direction of the air currents. The consequences are also sensitive to changes in the wind conditions, in addition to the volume of emissions. The sensitivity of the results is assessed as moderate to high.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is considered to be moderate.

TABLE 41. Placement of the scenario in the risk matrix.

"Nuclear Accident at a Reprocessing Plant" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE					
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty   Moderate uncertainty   High uncertainty

The scenario is assessed as having a *low* likelihood and *large* to *very large* social consequences. The uncertainty associated with the results is assessed as *moderate*.

GULF OF MEXICO, JUNE 2010
The Deepwater Horizon blow-out after an explosion on the drilling rig on 20 April 2010.

PHOTO: NTB/SCANPIX

14

OFFSHORE ACCIDENTS

Background

Society's dependence on fossil energy makes the petroleum industry important; and for Norway production of oil and gas constitutes our largest source of revenue. At the same time, there are risks linked to the petroleum industry. Major adverse events can have serious consequences for people and the environment. Several national and international events illustrate this.

In 2010, a fault occurred when the *Deepwater Horizon* drilling facility drilled a well in the Gulf of Mexico. Gas and oil flowed up through the bore hole. Within a short space of time, the gas ignited and an explosive fire claimed the lives of 11 people.[135] The accident also resulted in large quantities of oil flowing up into the marine environment. During the 87 days it took before the well was sealed, almost 655,000 tonnes of oil had flowed out.[136] It is historically the largest oil spill at sea caused by an accident.

This type of event has also been experienced on the Norwegian continental shelf. The most serious uncontrolled blow-out to date occurred in 1977 on the *Ekofisk B* oil platform in the North Sea. The blow-out, better known as the *Bravo blow-out*, lasted for seven days before it was halted. During the course of this period, between 13,000 and 20,000 tonnes of oil leaked out.[137] This is the biggest oil spill in Norway's history.

Norway has also experienced one of the petroleum industry's most catastrophic events in terms of the loss of human life. In 1980, the semi-submersible rig *Alexander Kielland* capsized while working on the Ekofisk field in the North Sea. In this accident, 123 of the 212 people on board the rig died. Only the 1986 *Piper Alpha accident* in the British sector has been greater in terms of the loss of human life. In that event, 167 people died when the platform exploded.

Risk

While minor accidents occur at regular intervals in the petroleum industry, major accidents are rare. The term "major accidents" is here used to mean acute events, such as major spills, fires or explosions - involving a number of serious injuries or loss of human life, serious damage to the environment or loss of major financial assets.

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[135] *Petroleum Safety Authority Norway (2011): Deepwater Horizon-ulykken — vurderinger og anbefalinger for norsk petroleumsvirksomhet. [The Deepwater Horizon accident – assessments and recommendations for the Norwegian petroleum industry]*

[136] *Petroleum Safety Authority Norway (2011): Forslag til scenarioer relatert til akutt utslipp til sjø fra petroleumsvirksomhet i Nordsjøen og Skagerrak i perioden 2010 til 2030 [Proposals for Scenarios related to Acute Spills into the Sea from the Petroleum Industry in the North Sea and Skagerrak during the Period from 2010 to 2030].*

[137] *Ibid.*

The last time there was a death in a major accident on an offshore facility on the Norwegian Continental Shelf was in 1985, when an uncontrolled gas blow-out with subsequent explosion and fire occurred on the *West* Vanguard drilling platform at Haltenbanken.[138] One person died in the event, while the rest of the crew were evacuated within a short time via lifeboats.

Occasionally, accidents also occur which involve large acute spills. Apart from the *Bravo blow-out* in 1977, there has been one spill of more than 1000 tonnes of oil on the Norwegian Continental Shelf. This occurred in 2007 at *Statfjord A* in the North Sea, when 3,700 tonnes of oil leaked out in conjunction with loading. In 1992 and 2003, spills of 900 and 750 tonnes of oil, respectively, occurred. Most of the spills on the Norwegian continental shelf are, however, small. During the period 2001-2009, a full 97 per cent of the spills were less than 10 tonnes. Developments during the period have also shown a positive trend in that the number of acute spills per year has been reduced by half, from around 90 to 40 per year.[139]

In addition to actual events, trends for *near-miss* events with the potential for the loss of life or acute pollution provide an indication of the development of the risk level in the Norwegian petroleum industry. Of particular interest in this context are development features linked to types of events with a particular potential for major accidents.

Well-control events are one such event type. These are events in which formation fluid flows into the well, resulting – if all the technical barriers fail – in a blow-out of oil and gas. This type of event primarily constitutes a risk of acute pollution. In 2010, a serious situation arose on the Norwegian continental shelf involving a loss of control over the well being drilled from the *Gullfaks C facility* in the North Sea. The event resulted in the long-term loss of a barrier, and it is only by chance that the event did not develop into a major accident.[140] Well-control events can also develop into accidents in which life and health are put at risk. The *Deepwater Horizon accident* referred to above illustrates this.

A summary of well-control events on the Norwegian continental shelf shows that while there was a generally positive development during the period 2001–2008, during the period 2008–2010 there was a marked increase in the number of events, from 11 to 28, respectively.[141] This is a clear increase, even when corrected for the activity level (number of drilled wells). If the potential for loss of life is taken into account during such events, and the potential for acute oil spills at sea, this trend indicates an increased likelihood for loss of life and acute oil spill as a consequence of well control events.

Another relevant type of event is *hydrocarbon leaks*. These are gas leaks that can cause fires and explosions, therefore constituting a direct hazard to personnel. If several barriers fail, this type of event can also result in acute pollution, with the possibility of the total loss of the facilities. A summary of the number of hydrocarbon leaks on the Norwegian Continental Shelf from the mid-1990s shows a generally downward trend during that period, but that there was an increase in the period 2008-2010.[142] The significance of this trend is that the number of potential near-miss fires and explosions increases, and therefore also the likelihood of loss of life and acute oil spills.[143]

A third type with the potential to cause a major accident are *construction events*, including ships and drifting objects on a collision course, as well as collisions with field-related traffic. Reports from the last ten years show that the number of ships recorded as having been on a collision course has dropped considerably.[144] The maritime traffic control centre's control of sea areas surrounding the facilities appears to be an important contribution to this trend, together with the availability of qualified emergency tugboats. At the same time, it is worth noting that the average size of vessels has become significantly larger over the years. This means that the average vessel can do more damage today than it could 20 years ago.

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[138] *Petroleum Safety Authority Norway (2011): Risikonivå i petroleumsvirksomheten. Sammendragsrapport. [Risk Level in the Petroleum Industry. Summary Report.]*
[139] *Petroleum Safety Authority Norway (2010): Risikonivå i petroleumsvirksomheten. Prosjektrapport – akutte utslipp. [Risk Level in the Petroleum Industry. Project Report – Acute Spills.]*
[140] *Petroleum Safety Authority Norway (2011): Risikonivå i petroleumsvirksomheten. Sammendragsrapport. [Risk Level in the Petroleum Industry. Summary Report.]*
[141] *Ibid.*
[142] *Ibid.*
[143] *Petroleum Safety Authority Norway (2010): Risikonivå i petroleumsvirksomheten. Prosjektrapport – akutte utslipp. [Risk Level in the Petroleum Industry. Project Report – Acute Spills.]*
[144] *Petroleum Safety Authority Norway (2011): Risikonivå i petroleumsvirksomheten. Sammendragsrapport. [Risk Level in the Petroleum Industry. Summary Report.]*
[145] *Petroleum Safety Authority Norway (2010): Risikonivå i petroleumsvirksomheten. Prosjektrapport – akutte utslipp. [Risk Level in the Petroleum Industry. Project Report – Acute Spills.]*
[146] *Petroleum Safety Authority Norway (2010): Risikonivå i petroleumsvirksomheten. [Risk Level in the Petroleum Industry.] Project Report – Acute Spills], Petroleum Safety Authority Norway (2011), Risikonivå i petroleumsvirksomheten. Sammendragsrapport. [Risk Level in the Petroleum Industry. Summary Report.]*

All in all, the indicators related to major accidents displayed positive development during the period 2001-2009.[145] During the period 2008-2010, however, there was an increase in the frequency of specific types of events, in particular well control events and hydrocarbon leaks.[146] Bearing in mind the potential for loss of life and acute spills, this type of event is clearly a negative development feature in the offshore petroleum industry.

Prevention and emergency preparedness

The Norwegian Ministry of Petroleum and Energy has overall responsibility for the petroleum industry on the Norwegian Continental Shelf. The Ministry of Labour and Social Affairs is responsible for safety and the working environment, while the Ministry of Climate and Environment is responsible for the emergency preparedness requirements for private enterprises and municipalities. The Ministry of Transport and Communications is responsible for the state emergency preparedness measures to combat acute pollution, including acute oil pollution that is not covered by municipal and private emergency preparedness.

There are strict HES[147] requirements for businesses in the Norwegian petroleum industry. The Petroleum Safety Authority Norway is responsible for work environment and safety in the petroleum business. The Norwegian Environment Agency has corresponding responsibility for the external environment, and stipulates emergency preparedness requirements and performs inspections in the petroleum industry. The operator companies are responsible themselves for taking action to deal with acute spills from petroleum facilities. The operating companies on the Norwegian continental shelf have their own emergency preparedness resources, and they have entered into collaborative agreements through NOFO[148] regarding the establishment, care and further development of emergency preparedness for combating acute pollution. When required, the state can assist with agreed emergency preparedness resources, and the Norwegian Coastal Administration fulfils the duty of the state to carry out inspections to ensure that the responsible polluter implements the measures necessary to prevent and limit acute pollution.

[147] *Health, safety and the environment.*
[148] *Norwegian Clean Seas Association for Operating Companies.*

SCENARIO

14.1 Oil and Gas Blowout on a Drilling Rig

An adverse event in the "offshore accidents" risk area is an oil and gas blow-out on the Norwegian continental shelf. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific scenario.

The risk analysis was conducted in the winter of 2011.

Preconditions for the scenario

Course of events
Well event results in an oil and gas blow-out on the drilling rig

Duration
43 days

Comparable events
Deepwater Horizon accident in 2010

Discharge rate
7,000 tonnes/day

Total discharge volume, approximately 300,000 tonnes of oil

Oil type Oseberg Øst with a density of 842 kg/m³

Consequential events

- Gas on deck ignites after five minutes
- Explosion/fire on the rig with approximately 100 persons are on board
- Long-term discharge of oil

Assessment of likelihood

The scenario encompasses several relatively rare events: That a blow-out occurs, that it results in a leak with ignition, and finally that the event entails a very long-term spill. The likelihood estimate therefore takes into account the likelihood of each of the individual events, and the likelihood of this specific scenario is significantly lower than the likelihood that only one of these individual events will occur. Based on this type of approach, and based on the data available on each of the individual items[149, 150], as well as on today's level of activity on the Norwegian continental shelf,[151], an event of this type is estimated to occur approximately once every 5,000 years. In other words, the likelihood of such an event occurring during the course of a year is estimated at around 0.02%. It is a relatively rare event among those that are assessed in the National Risk Analysis (NRA), and it falls under the category of *low likelihood*.

The uncertainty associated with the assessment of the likelihood of the adverse event, as well as the consequential events, is assessed as *moderate*compared with other likelihood assessments in the NRA.

TABLE 42. Schematic presentation of the results from the risk analysis

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.02%		◎ (moderate uncertainty)				Once every 5,000 years, based on the existing data on the various events and level of activity on the Norwegian continental shelf.

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death		◎ (low uncertainty)				5–20 fatalities as a result of an explosive fire
	Injuries and illness		◎ (low uncertainty)				20-100 injuries or ill people as a direct or indirect consequence
Nature and the environment	Long-term damage					◎ (low uncertainty)	Oil slicks affecting up to 3,000 km of coastline
Economy	Financial and material losses				◎ (low uncertainty)		Up to NOK 10 billion
Societal stability	Social unrest				◎ (moderate uncertainty)		Very extensive spill and large number of people involved, difficult to avoid, expectations of crisis management, reactions such as anger, mistrust and feeling of powerlessness
	Effects on daily life						Not relevant.
Capacity to govern and control	Weakened national capacity to govern						Not relevant.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎ (low uncertainty)			Medium (to large) consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[149] *SINTEF (2010) Blowout and Well Release Characteristics and Frequencies.*

[150] *Petroleum Safety Authority Norway (2011): Forslag til scenarioer relatert til akutt utslipp til sjø fra petroleumsvirksomhet i Nordsjøen og Skagerrak i perioden 2010 til 2030. [Proposals for scenarios related to acute spills into the sea from the petroleum industry in the North Sea and Skagerrak during the period from 2010 to 2030.]*

[151] *Petroleum Safety Authority Norway (2010) Risikonivå på norsk sokkel [Level of Risk on the Norwegian Continental Shelf].*

Assessment of consequences

The consequences of the given scenario are assessed as being at the upper end of the category *medium-sized* consequences. The scenario will primarily threaten the societal assets nature and the environment, and economy. In addition, the scenario will entail what is defined in the NRA as social unrest. The uncertainty associated with the different consequence types varies from *low* to *moderate*. Overall the uncertainty is assessed as *low* compared with the other assessments in the NRA.

Life and health

An event like this will result in the loss of human life. The scenario is based on five minutes passing from when the gas is detected on the deck until the explosion and fire occur. There is therefore a limited possibility of carrying out an evacuation before this, and the subsequent fire makes evacuation more difficult while it is burning. Everyone on board the facility is exposed, but people working on the drill floor will be particularly hard hit. Compression injuries and burns as a consequence of the explosion and fire will be virtually unavoidable. It is estimated that between 5 and 20 people will be killed as a consequence of the explosive fire.

In addition, it is assumed that a large proportion of the remaining people on board the rig will incur serious injuries, either directly from the explosion/fire or during evacuation. In addition, it is assumed that many of the survivors of the event will experience post-traumatic stress. It is estimated that the total number of injuries will range from 20 to 100 persons. The assessments are based on sectoral analyses and experience from similar events in Norway and abroad. The uncertainty associated with the estimates is assessed as *low*.

Nature and the environment

It is assumed that the large volumes of crude oil discharged could have a significant impact on nature and the environment. Initially, oil on the sea may affect a large number of sea birds along the coast. Simulations of similar oil spills also indicate that significant volumes of oil will reach the coast.[152] Even if the fact that the weather conditions , natural and chemical dispersal (dissolution), and mechanical collection are important to the volume of oil that reaches the shore zone is taken into account, oil slicks can be expected to affect up to 3,000 km of coastline. With such widespread slicks, it will be unavoidable for environmentally vulnerable areas not to be affected. However, there is some uncertainty about how, and to what extent, fish and spawn will be affected by such a spill. The assumptions related to the acute oil spill are based on worst-case spills, as these are defined in baseline reports for management plans in Norwegian sea areas.[153, 154] The assessments are based on experience from earlier adverse events, and the uncertainty is assessed as *low*.

Economy

The financial costs of an event like this will be high. The loss of a rig, materials and equipment alone will amount to several billion Norwegian kroner, and the lost oil itself has a value of more than NOK 1 billion. Added to that, major costs will be linked to long-term management and clean-up work. Based on the numbers from earlier events, it is assumed that the losses will be up to a maximum of NOK 10 billion. In addition, oil slicks along the coast may also affect the aquaculture industry, in the form of the soiling of equipment and installations. This could potentially cause uncertainty in the market with regard to quality and food safety. A potential loss of public opinion could mean disappointing sales and reduced exports for the fishing industry. The assessments are based on experience from earlier adverse events, and the uncertainty is assessed as *low*.

Societal stability

The loss of human life and extensive damage to nature and the environment will entail strong reactions such as anger and aggression in the population. The population and the persons who are directly and indirectly affected will have expectations that this is a type of event that the authorities should be prepared to handle. Initially this may imply questions concerning responsibility and blame, in which questions related to safety, preparedness and management will be the most important. The employees on the drilling rig do not have any opportunity to escape the event, and they are at the mercy of rescue efforts by the authorities. In the long term, there may be increased scepticism towards the petroleum industry and the authorities' policies related to oil extraction. The uncertainty associated with this is assessed as *moderate*.

Capacity to govern and territorial control

It is assumed that the oil and gas blow-out scenario will not be of significance to the national capacity to govern or to territorial control. ◎

TABLE 43. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Extensive access to data and experience from similar events on the Norwegian continental shelf and abroad, risk analyses, statistics and sectoral analyses.
Comprehension of the event that is being analysed (how known and researched is the phenomenon?)	An oil and gas blow-out is considered to be a known and well researched phenomenon, compared with other types of events that have been analysed in the NRA.
Agreement among the experts (who participated in the risk analysis)	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The likelihood estimate is dependent on the concurrence of several rare events (blow-out, gas leak with ignition and long-term discharge). The consequence assessments are dependent on the volume discharged, the properties of the oil, and the wind and weather conditions. The sensitivity of the results is assessed therefore as moderate.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is assessed as moderate.

TABLE 44. Placement of the scenario in the risk matrix.

"Oil and Gas Blowout on a Drilling Rig" – overall risk

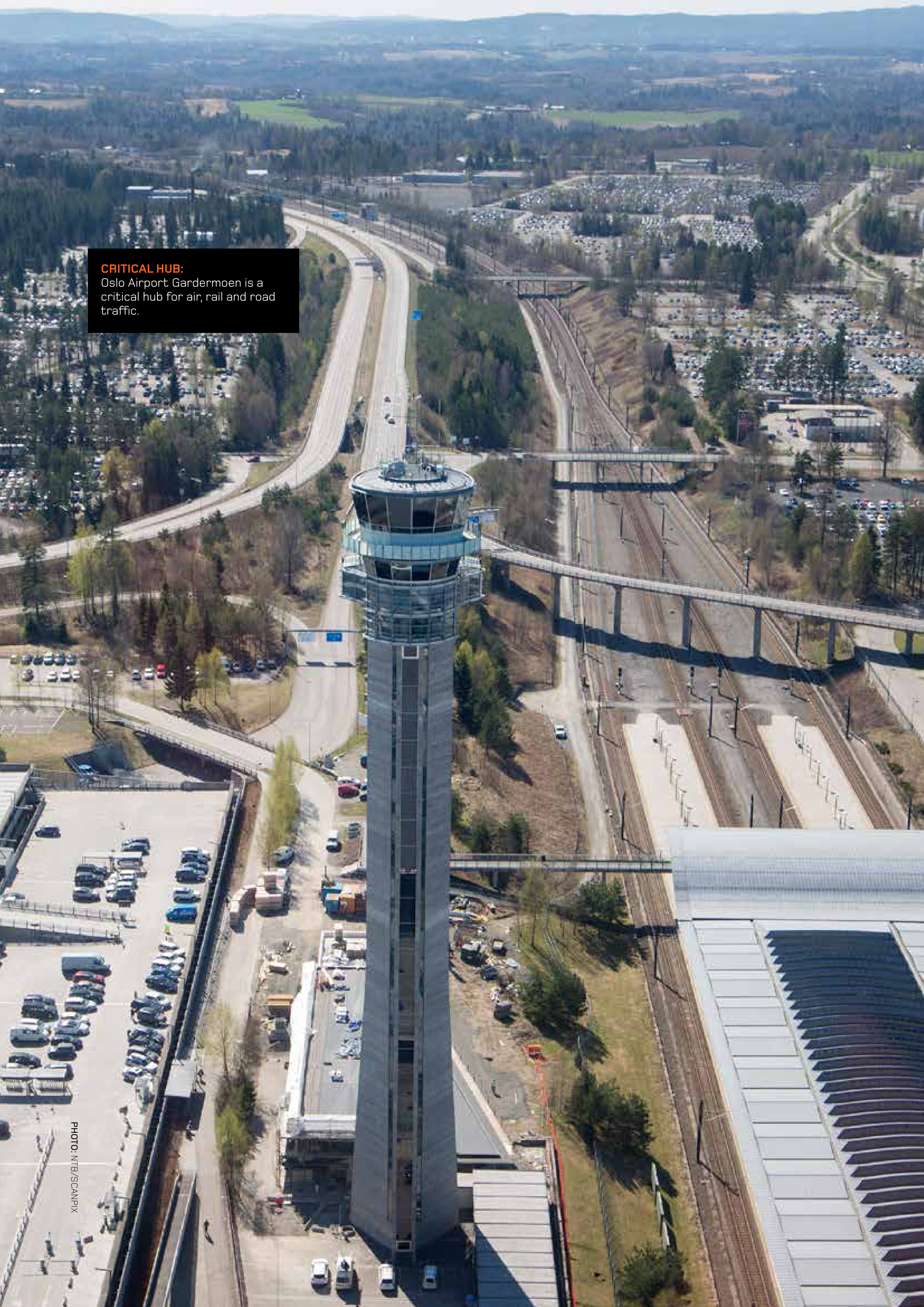
CONSEQUENCES					
VERY LARGE					
LARGE					
MODERATE		◎			
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎   Moderate uncertainty ◎   High uncertainty ◎

The oil and gas blow-out scenario is assessed as having a *low* likelihood and *medium-sized* to *large* social consequences. The uncertainty associated with the results is assessed as *moderate*.

[152] *Norwegian Petroleum Directorate (2011) Helhetlig forvaltningsplan for Nordsjøen og Skagerrak – Oljedrift. [Comprehensive Management Plan for the North Sea and Skagerrak – Oil Operations.]*
[153] *Petroleum Safety Authority Norway (2011): Forslag til scenarioer relatert til akutt utslipp til sjø fra petroleumsvirksomhet i Nordsjøen og Skagerrak i perioden 2010 til 2030. [Proposals for scenarios related to acute spills into the sea from the petroleum industry in the North Sea and Skagerrak during the period from 2010 to 2030.]*
[154] *Norwegian Petroleum Directorate (2011) Helhetlig forvaltningsplan for Nordsjøen og Skagerrak – Oljedrift. [Comprehensive Management Plan for the North Sea and Skagerrak – Oil Operations.]*



CRITICAL HUB:
Oslo Airport Gardermoen is a critical hub for air, rail and road traffic.

PHOTO: NTB/SCANPIX

15

TRANSPORT ACCIDENTS

Background

The Ministry of Transport and Communications has the ultimate responsibility for air, sea, road and rail transport. The National Transport Plan (NTP) presents the Government's overall transport policy. The plan encompasses the following transport agencies: Public Roads Administration, National Rail Administration, Coastal Administration and the state-owned limited company Avinor. The National Transport Plan 2014–2023 states that the Government *has a vision of zero accidents with fatalities or serious injuries in the transport sector* Meld. St. 26 (2012–2013) Nasjonal transportplan 2014–2023 [Report no. 26 (2012–2013) to the Storting on the National Transport Plan 2006–2015]. The state budget framework for implementation of the measures in the NTP is just over NOK 600 billion for the ten-year period.

One of the transport sector's main challenges is that the expected growth in population, especially in urban areas, will increase the demand for transport. This will entail considerable challenges for the navigability of the transport system, and the increasing freight flows will increase pressure on the transport capacity in the same areas.

Risk

Annually, there are more than 200 traffic accident fatalities in Norway, but the number of fatalities in both major and individual accidents is decreasing. The various transport areas have different risk profiles. Of those who die in transport accidents, 90 per cent die in road traffic accidents, In 92 per cent of the fatal road traffic accidents, there is only one person killed. This is in strong contrast to the other forms of transport, where there are significantly fewer accidents, but far more fatalities per accident.

Major accidents

Major accidents in the transport sector are defined as events with at least five fatalities. During the 30-year period from 1985 to 2014, there were 37 major transport accidents in Norway with a total of 659 fatalities. This entails an average of 1.2 major accidents a year with 18 fatalities in each accident. Major transport accidents account for 90 per cent of all the major accidents during the period.

In comparison, there were 63 major transport accidents and 922 fatalities during the 30-year period from 1970 to 2001[155]. During that period there was an average of two major accidents per year with 15 fatalities per accident. The number of major transport accidents has also declined from around

[155] *Research Council of Norway: Risk and Safety in the Transport Sector – RISIT / Final Report 2010.*

TABLE 45. Summary of major accidents in the transport sector during the 30-year period from 1998 to 2014.[156]

Year	Type of accident	Place	No. of accidents	No. of deaths
	AVIATION ACCIDENTS		**11**	**293**
1986	Plane crash	Svalbard		6
1986	Helicopter crash (military)	Bodø		8
1987	Plane crash (charter plane)	Skien		10
1988	Plane crash (Widerøe)	Torghatten, Brønnøysund		36
1989	Plane crash – Partnair	Skagerrak		55
1990	Plane crash (scheduled)	Værøy		5
1990	Plane crash (air taxi)	Haukeliseter		5
1993	Plane crash (Widerøe)	Namsos		6
1996	Plane crash (Russian charter)	Svalbard		141
1997	Helicopter crash – Norne accident	Norwegian Sea		12
1998	Plane crash (Danish business plane)	Stord		9
	MARITIME ACCIDENTS		**10**	**258**
1985	Shipwreck – Concem	Gands Fjord		10
1990	Ship fire Scandinavian Star	Skagerrak		158
1995	Shipwreck – Njord	Arctic Ocean		5
1995	Shipwreck – Novogorodets	Vanna		10
1995	Shipwreck – Maria	Kristiansand		8
1995	Bus overboard from ferry	Os		6
1997	Shipwreck – Leros Strength	Sola		20
1998	Shipwreck – Ulsund	Lista		7
1999	Shipwreck – Sleipner	Sletta		16
2004	Shipwreck – Rocknes	Vatlestraumen		18
	ROAD TRAFFIC ACCIDENTS		**13**	**79**
1985	Traffic accident	Karmøy		5
1988	Traffic accident (bus)	Måbødal Tunnel		16
1989	Traffic accident	Bergen		5
1989	Traffic accident	Råde		5
1991	Traffic accident	Akershus		6
1992	Traffic accident	Gjøvik		5
1995	Traffic accident	Vestby		7
1997	Traffic accident (minibus)	Kragerø		5
1998	Traffic accident (collision between a train and car)	Gol		5
2000	Traffic accident (avalanche)	Lyngen		5
2002	Traffic accident (student party vehicle)	Våler		5
2009	Traffic accident (with fire)	Eiksund Tunnel, Ørsta		5
2011	Traffic accident (minibus)	Balsfjord		5
	RAILWAY ACCIDENTS		**3**	**29**
1990	Train accident	Lysaker		5
1993	Train accident	Nordstrand		5
2000	Train collision (with fire)	Åsta		19
1985–2014	**All major transport accidents**		**37**	**659**

The transport accidents up until 2004 have been obtained from Sklet 2004[157] and supplemented with subsequent accidents.[158]

[156] *What accidents are classified as transport accidents (and not a fire, for example) may vary.*
[157] *Sklet Snorre (2004). Storulykker i Norge de siste 20 årene [Major Accidents in Norway over the Last 20 Years]. Fra flis i fingeren til ragnarokk [From a Sliver in Your Finger to Armageddon]. (pp. 131-159). Trondheim: Tapir Ak. forlag.*
[158] *Public Roads Administration's UAG database.*

two to one a year during the last 40 years, After 2000, there have only been four major transport accidents in 14 years: The Rocknes shipwreck and three road traffic accidents, which further reinforces the trend towards fewer major accidents. The average number of fatalities per accident has, however, increased from 15 to 18 persons from the beginning to the end of the period.

The two most serious transport accidents are the fire on board the Scandinavian Star in 1990, in which 158 human lives were lost, and the aviation accident involving a Russian passenger aircraft on Svalbard, in which 141 human lives were lost.

Road traffic accidents

During the period from 1970 to 2013, the traffic volume has more than tripled, while the number of fatalities in 2013 (187 persons) was only 30 per cent of the number in 1970. The likelihood of a fatal accident per kilometre driven has been reduced by 90 per cent during the period from 1970 to 2013.

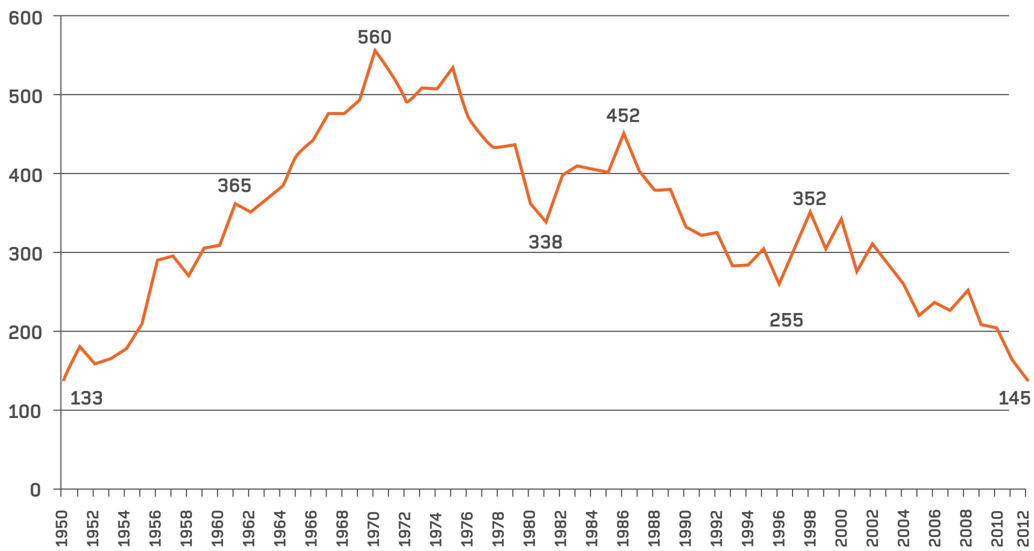


FIGURE 14. Development in the number of fatalities in road traffic from 1950 to 2012[159].

The decline in the number of traffic fatalities can be explained by better roads, better cars and better road users. In addition, improvements in medical treatment have allowed doctors to save many more lives, and more efficient alarm centres and ambulance services have allowed the injured to receive treatment faster[160].

One road traffic accident scenario with a great disaster potential is fire in a tunnel. Norway has approximately 1,100 road tunnels with a total length of approximately 1,000 km. From 2008 to 2011, there was an average of 21 tunnel fires annually in Norway. A total of 44 per cent of the tunnel fires took place in the 4% steepest tunnels, most of which were under water. A common cause was technical problems in heavy vehicles[161]. Road tunnels are normally just as safe as open road, but they have a disaster potential in the event of fire due to the strong concentration of hazardous smoke gases and the lack of escape opportunities for the road users. "Tunnel Fires" is therefore a new scenario analysis in NRA 2014.

[159] *Null drepte og hardt skadde – Fra visjon mot virkelighet [Zero Fatalities and Serious Injuries – From Vision to Reality]. Grounds for discussion of traffic safety in the transport agencies' proposal for the NTP 2014-1023, Public Roads Administration's report no. 119, 2012.*

[160] *Research Council of Norway: Risiko og sikkerhet i transportsektoren – RISIT/sluttrapport 2010 [Risk and Safety in the Transport Sector – RISIT / Final Report 2010].*

[161] *Institute of Transport Economics (TØI) report no. 1205/2012, Kartlegging av kjøretøybranner i norske vegtunneler 2008–2011 [Survey of Vehicle Fires in Norwegian Road Tunnels 2008-2011].*

Aviation accidents
In 2013, there were no accidents with scheduled Norwegian aircraft involving personal injury or material damage. This means that the last fatal accident involving a scheduled Norwegian aircraft took place 20 years ago. The year 2013 was also another year without any accidents and serious events for helicopter transport to and from the Norwegian continental shelf. Domestic helicopter flights have long been the most accident-prone type of commercial flights in Norway, but only one accident without serious personal injury in 2013 confirms a positive trend for the last 10 years. For other commercial aviation, such as charter flights, taxi flights, ambulance flights and school flights, 2013 was yet another year without accidents.[162]

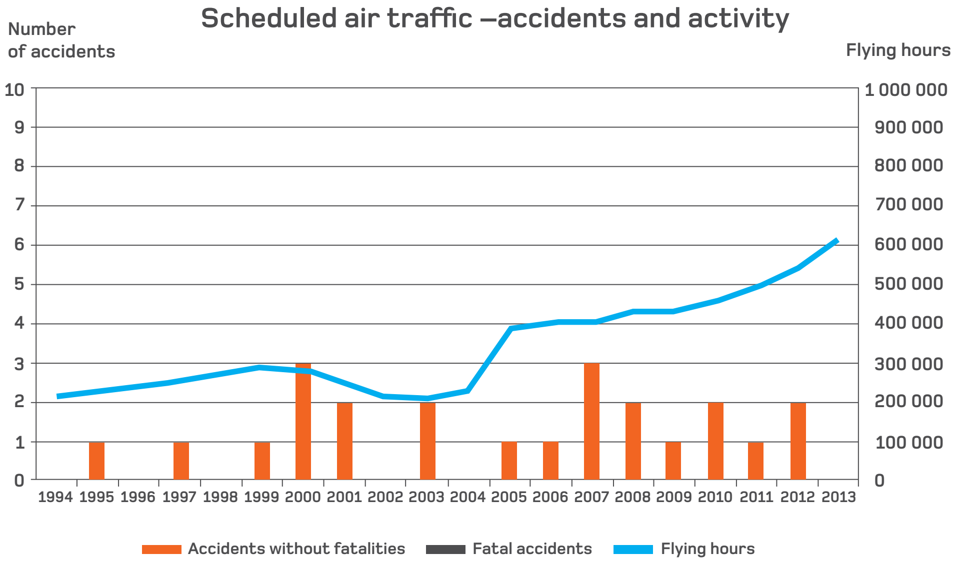


FIGURE 15. During the period from 1994 to 2013 there have not been any fatal accidents with scheduled Norwegian aircraft, even through air traffic has tripled. In 2013, there were no accidents with injuries at all.

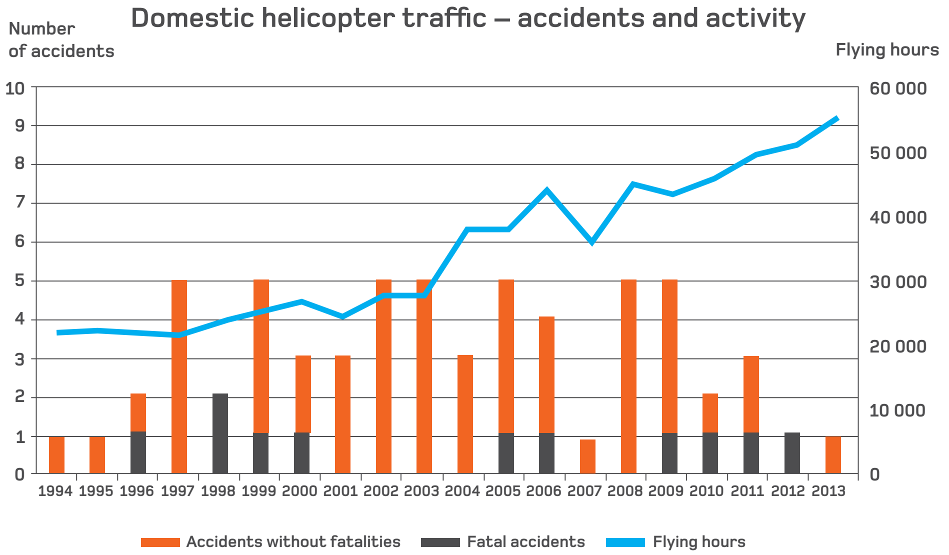


FIGURE 16. There have been more helicopter accidents than aircraft accidents in Norway, but the trend during the last four years has been positive. Helicopter traffic has more than doubled during the last 20 years. In 2013, there were no fatalities involving helicopters.

[162] *Luftfartstilsynet.no.*

There have, however, been fatal accidents in Norwegian aviation in recent times, but with fewer than five fatalities and not involving scheduled aircraft. A medical helicopter from Norsk Luftambulanse with three persons on board crashed during a rescue mission at Sollihøgda in Buskerud on 14 January 2014. The helicopter collided with a high-voltage transmission line 20-30 metres above the ground and crashed. Two people perished in the accident.

A helicopter crashed into the sea near Horten on 27 January 2010. When the helicopter encountered a fog belt above the sea, it stopped in the air, then it lost control and crashed into the sea. All four on board perished.

An aircraft from Atlantic Airways with 16 passengers on board did not manage to brake when landing, ended up outside the runway and caught fire at Stord Airport in October 2006. Four people perished, while twelve people escaped from the aircraft and survived. There was another fatal accident in 1998 involving a Cessna aircraft at Stord that claimed nine lives.

Railway accidents
On 4 January 2000, two trains collided at Åsta station on the Rørøs Railway. A fire broke out on the trains immediately after the collision. A total of 19 people lost their lives in the accident. The dispatcher centre was not aware that the trains were on a collision course until approximately one minute before the accident, and they did not have the means to prevent the accident. The previous major train accident took place on the Dovre Railway in 1975. A total of 27 people perished in a collision north of Tretten Station.

Prevention and emergency preparedness

The Government's primary objective is that there shall be no accidents with fatalities or serious injuries in the transport sector. This vision zero philosophy entails that the transport system, means of transport and regulations shall be designed so that they promote safe traffic behaviour among road users and contribute to human error not resulting in serious injuries. The vision zero philosophy forms the basis for safety work for all forms of transport, but the challenges and the need for measures differ. The forecasts for transport growth indicate that a further reduction in the number of fatalities and serious injuries will be challenging.[163]

Road traffic safety
The subgoal in NTP 2014-2023 is to reduce the number of road traffic fatalities and serious injuries by half. This means that the number of fatalities and serious injuries shall be reduced from an average during the period from 2008 to 2011 of approximately 1,000 per year to 500 or fewer by 2024.

Accidents due to collisions, driving off the road and running into pedestrians and cyclists account for approximately 86 per cent of the fatal accidents, and measures to counteract accidents of this type will be given priority. Special measures will be implemented to ensure that growth in passenger traffic in major urban areas will take place in the form of cycling, walking and public transport without resulting in additional fatalities or seriously injured

ÅSTA ACCIDENT:
The last serious train accident in Norway was the Åsta accident, which claimed 19 lives in 2000.

PHOTO: NTB/SCANPIX

[163] *Meld. St. 26 2012-2013 Nasjonal transport plan 2014-2023 [Report no. 26 (2012–2013) to the Storting on the National Transport Plan 2014–2023].*

pedestrians or cyclists. Tunnels with high traffic volumes will be upgraded so that they satisfy the requirements in the Tunnel Safety Regulations.

Transport safety for rail, air and sea transport
Subgoal: Maintain and strengthen the high level of safety for rail transport, aviation and sea transport. Indicators for whether the goal is achieved are the number of fatalities and injuries, and the number of serious events.

The level of safety for rail transport is basically high. In the future, the focus will be on preventive measures against less serious accidents of high likelihood and serious accidents with a low likelihood. Based on an overall risk assessment, measures to prevent accidents at level crossings and collisions between trains, and measures to protect against landslides, avalanches and floods will be given priority. The goal is an annual reduction in the number of fatalities and serious injuries of 4.5 per cent during the period from 2014 to 2023.

The level of safety in Norwegian waters is high, and the goal is to maintain and strengthen this level. Overall, there is a declining tendency in the number of personal injuries and fatalities resulting from ship accidents in Norwegian waters. The level of safety for sea transport shall be increased through further development of maritime infrastructure and services, development of fairways and navigation devices, and modernisation of the vessel traffic service centres.[164]

The level of aviation safety in Norway is among the best in the world, and the number of serious events is low today. Safety work in the aviation sector encompasses measures to reduce accidents and events in aviation itself (safety) and measures against terror and sabotage (security).

Civil protection
The Government's principal objective for work with civil protection and emergency planning in the transport sector is to prevent adverse events and reduce the consequences of these if they arise. Measures that contribute to ensuring a high degree of navigability and reliability in the transport system, whether by road, rail, air or sea, will be given priority.

The transport sector faces a broad and complex picture of risk, threat and vulnerability. Today's safety and security challenges are primarily related to climate change, major accidents and threats of terrorism. In addition, energy security and ICT security are becoming increasingly important for the reliability of the transport system.
The Government will promote emergency preparedness that ensures the sector will have the shortest possible loss of important transport functions, including traffic management and control systems, freight and passenger transport terminals, harbours and sections of road and rail in the event of a crisis.[165]

Critical infrastructure
The road system is a critical part of the transport system and important so that the rest of society can function. The road network is generally robust with several alternative routes. However, it can not be assumed that the road network is open when societal crises occur. It is vulnerable to traffic accidents and natural events (storms, floods, landslides and avalanches), that can close the roads for a shorter or longer period of time. There will also be roads closed in the winter, slides in tunnels, and bridges that are not passable. Alternate routes often result in long detours and areas can be closed off. Several long road tunnels and more traffic in urban areas will increase the potential for accidents involving dangerous goods. Other sectors of society must therefore take the vulnerability of the road network into account when they are preparing their crisis scenarios and emergency preparedness plans.[166]

Serious events
The transport sector has suffered a number of serious events in recent years. Flooding at the same time as failure of the telecommunications network, extreme weather and the spread of volcanic ash from Iceland are some of the challenges that the sector has faced. The next serious event is at the same time unknown.
The eruption of the Eyjafjällajökull volcano on Iceland caused extensive air traffic disruption in Norway and the rest of Europe. This had large consequences for important societal functions in Norway, such as the ambulance service, search and rescue and military flights.

In the report "Crisis Scenarios in the Transport Sector – KRISIS" (2010), the Ministry of Transport and Communications has assessed a number of events and scenarios that may be challenging for the transport sector. These scenarios challenge the ability to protect life and health, navigability and transport capacity, as well as the maintenance of important societal functions and the security of the realm.

[164] *Meld. St. 26 2012–2013 Nasjonal transportplan 2014–2023 [Report no. 26 (2012–2013) to the Storting on the National Transport Plan 2014-2023].*
[165] *Meld. St. 26 2012–2013 Nasjonal transportplan 2014–2023. [Report no. 26 (2012–2013) to the Storting on the National Transport Plan 2014–2023]*
[166] *Input from the Directorate of Public Roads (5 April 2013).*

- *Terror or threat of a terrorist action* is a scenario that requires extensive coordination among the authorities. The transport sector is vulnerable because much of the infrastructure and services are open and accessible. A terrorist action would at worst result in many fatalities and serious injuries, as well as the loss of critical transport infrastructure.
- *Loss of electronic communications network and services* will put important transport functions out of action. The transport sector is dependent on electronic communications networks and services in order to maintain normal operations for passenger and freight transport. The authorities' ability to coordinate will be put to the test due to the loss of the normal communications channels.
- *Climate change and extreme weather* have a significant impact on infrastructure and traffic management. What we do today in the way of development, management and maintenance will determine how vulnerable our society will be in 20-30 years. Today's transport network is vulnerable to external stresses and the need for maintenance and renovation is increasing. For new installations, it is important to prevent landslides, slips and erosion damage, and to take climate change into account.

Main goals and priority areas

The transport agencies have good knowledge of events in their own sector that can immobilise the transport capacity and impact life, health and the environment. There is, however, a need to continue the cross-sectoral work on risk and vulnerability analyses, together with other authorities and the county administrations as regional actors in the areas of transport safety and public transport. The Ministry of Transport and Communications will reinforce the efforts to maintain a safe transport system with a high degree of reliability and navigability by:[167]

- Reinforcing work on risk and vulnerability analyses and emergency plans.
- Conducting and learning from crisis management exercises.
- Ensuring collaboration with other actors for the management of major events in the area of transport.
- Reinforcing management, maintenance and modernisation of the transport infrastructure to make it more robust against extreme weather and climatic influences.
- Prioritising protection measures against landslides, avalanches, storm surges and flooding.
- Improving the security of important control and traffic management systems and freight and passenger terminals.
- Ensuring that Norway has a high level of preparedness for acute pollution adapted to the risk of discharges, which contributes to the goal of a clean, rich and productive sea.

PHOTO: NTB/SCANPIX

EIDFJORD, AUGUST 1988
The largest road traffic accident up until now took place on 15 August 1988 when a Swedish bus with 34 school children and parents drove into a tunnel wall at the exit from the Måbø Tunnel on State Road 7 in the Municipality of Eidfjord. The accident was caused by worn brakes that failed on the long decline. The driver decided to crash the bus into the tunnel wall to stop the acceleration. A total of 16 people perished, including twelve children ranging from 11 to 12 years of age and four adults (parents and the bus driver). A total of 18 people were injured.

[167] *Meld. St. 26 2012–2013 Nasjonal transportplan 2014–2023 [Report no. 26 (2012–2013) to the Storting on the National Transport Plan 2014-2023].*

SCENARIO

15.1 Collision at Sea Off the Coast of Western Norway

An adverse event in the "maritime accidents" risk area is a collision between two vessels. To illustrate how serious the consequences of such an event can be, a risk analysis has been conducted on a specific serious scenario.

The risk analysis was conducted in the autumn of 2010.

Preconditions for the scenario

Time

Middle of May, at 4:00 a.m.

Weather conditions

Limited visibility due to sea fog (fog that arises when warm, moist air passes over a cold surface)

Wind speed

Moderate north-westerly breeze, 5 m/s

Ocean current

Northerly current of 1 knot (complex current situation due to the tide)

Water temperature

10°C

Air temperature

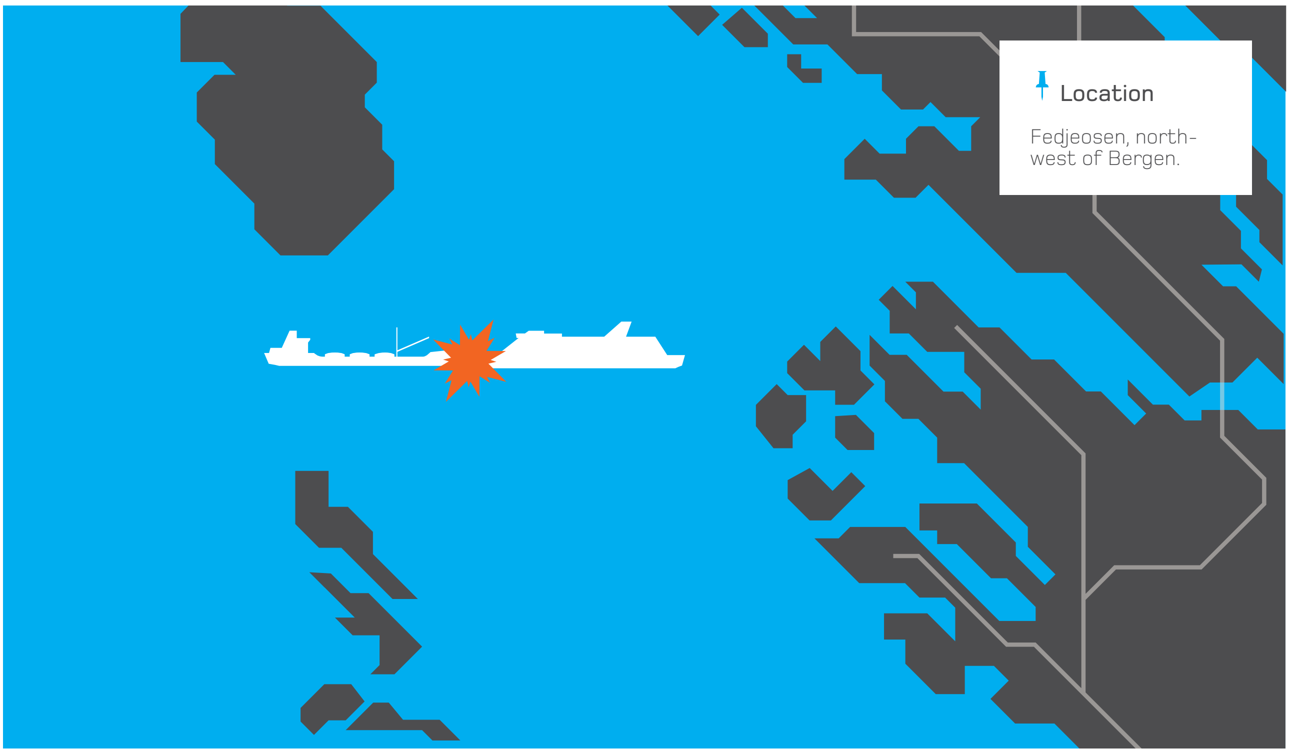
6-8 °C.

Consequential events

- Total discharge of 100,000 tonnes of crude oil on the following day
- Surface fire around the tanker and cruise ship
- Fire on board the cruise ship

Course of events

A cruise ship with 2,350 persons on board experiences a failure of its electrical system and a full motor stop. The ship collides at a speed of 10-12 knots with a fully loaded oil tanker that has a crew of 22.



Assessment of likelihood

The likelihood of a collision between an oil tanker and a fairly large passenger ship has been assessed, with the discharge of approximately 100,000 tonnes of crude oil in the area in question. This is expected to occur once every 1,000 years, i.e. there is a 0.1% likelihood that it will occur in the course of a year. In the National Risk Analysis (NRA) this likelihood estimate falls under the category of *moderate likelihood* (once every 100 to 1,000 years).

The estimate is essentially based on the assessment of existing risk analyses of maritime accidents along the coast of Norway.[168]

The data basis for these analyses are the international accident statistics, adjusted for the conditions in Norway with a view to accident frequencies, accident types, traffic, sailing routes, etc. By itself, the likelihood of a collision at sea is higher than the likelihood of a collision between an oil tanker and a cruise ship. Based on the analysis of various types of collisions at sea, the likelihood of accidents at various locations along the coast, and an increase in cruise traffic, the likelihood of the combination of a cruise ship and an oil tanker has been assessed. The uncertainty associated with the assessment of the likelihood of the adverse event is assessed as *moderate* in the NRA.

TABLE 46. Schematic presentation of the results from the risk analysis

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.1%			◎			Once every 1,000 years, based on existing information and risk analyses of maritime accidents along the Norwegian coast

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death			◎			From 20 to 100 deaths as a direct or indirect consequence
	Injuries and illness			◎			100-500 injuries or ill people as a direct or indirect consequence
Nature and the environment	Long-term damage					◎	1,000 km of polluted coastline, in areas worthy of preservation
Economy	Financial and material losses				◎		NOK 10-50 billion
Societal stability	Social unrest				◎		Difficult to avoid, very extensive spill and large number of people involved, expectations of crisis management, reactions such as anger, aggression and feeling of powerlessness
	Effects on daily life	◎					The evacuation of a few people may be necessary, the sailing route may be closed
Capacity to govern and control	Weakened national capacity to govern						Not relevant.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎		Large consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[168] *Det Norske Veritas (2010): Analyse av sannsynlighet for akutt oljeutslipp fra skipstrafikk lang kysten av Fastlands-Norge [Analysis of the Likelihood of Acute Oil Spills from Maritime Traffic along the Coast of Mainland Norway], Report for the Norwegian Coastal Administration, Emergency Preparedness Department, DNV Report 2010-0085.*

Assessment of consequences

The social consequences of the given scenario are assessed as *large*. The scenario will primarily threaten the societal assets nature and the environment, and economy. The uncertainty associated with the assessments of the different consequence types varies from *low* to *moderate*. Overall the uncertainty is assessed as *low* compared with the other assessments in the NRA.

Life and health

That lives will be lost as a result of the given scenario is very probable. The number of fatalities will depend on whether there is fire around just parts of or around the entire cruise ship, how long it takes before the fire breaks through, and on how the fire on board develops. In the worst case scenario, everyone on board the tanker will die, this under the assumption that the fire will be completely out of control. The direct fatalities will generally be caused by fire and smoke inhalation injuries, and it is assumed that the collision scenario will result in 20 to 100 fatalities. The number of serious injuries and ill people as a direct or indirect consequence of the collision is assumed to be in the category of 100 to 500. Smoke inhalation injuries will be the most dominant cause of injuries and illness. The assessments are based on experience from the Scandinavian Star accident and prior adverse events, for example, in which there have been large oil spills and people have ended up in the water but nevertheless been rescued. The uncertainty associated with the estimates is assessed as *low*.

Nature and the environment

The coast of Western Norway is an intricate coastal area, and the greatest consequences of such a scenario will primarily involve long-term damage to nature and the environment. The scope of this type of oil spill scenario will depend on the type of oil that is spilled, its properties, the weather conditions in the days immediately following the accident, and the amount of oil that can be collected during the days immediately following. With an estimate of approximately 1,000 km of polluted coastal area, the scenario will have environmental effects lasting for several years. Sea birds, coastal fish, cultural artefacts worthy of preservation and environmentally vulnerable areas are affected in particular. The uncertainty for assuming this is assessed as *low*, and it is based on experience from prior adverse events.

Economy

The overall economic losses are assumed to be substantial. Direct costs are connected to the loss of cargo and ships, for example, and material damage to ships and shore facilities. Disruption and stoppage of fishing and aquaculture will involve large financial losses. It is difficult to precisely estimate the costs of the clean-up, since they essentially depend on how long the clean-up takes, how quickly the area can be restored, and on whether sailing routes must be closed. A possible long-term loss of reputation with respect to both tourism and the fishing industry will also be of significance to the financial losses. Based on figures from prior adverse events, the overall economic losses in such a scenario are estimated to range from NOK 10 to 50 billion. The uncertainty associated with the estimates is assessed as *low*.

Societal stability

The scope of the spill and the number of persons directly involved may contribute to reactions such as anger, aggression and a feeling of powerlessness. This can also be linked to the fact that those who are directly affected do not have any opportunity to avoid the event, and they are at the mercy of the rescue efforts of the authorities. The collision will not affect particularly vulnerable groups, but very many families will be affected. The population and the persons who are directly and indirectly affected are assumed to have expectations that this is a type of event that the authorities should be prepared to handle. Reactions such as fear and anger and the question of responsibility are expected.

The evacuation of inhabitants along the coast may be necessary, but, if necessary, it will affect a small number of people who will have to evacuate for a short period of time. The spill will also have an impact on the maritime traffic in the affected area. The uncertainty is assessed as *low* to *moderate*.

Capacity to govern and territorial control

It is assumed that the collision at sea scenario will not be of significance to the national capacity to govern or for territorial control. ◎

TABLE 47. Assessment of the uncertainty associated with the estimates for likelihood and consequences.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	Extensive access to data and experience from similar events, statistics and sectoral analyses.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Collisions at sea are considered a relatively known and researched phenomenon, compared with other types of events that have been analysed in the NRA.
Agreement among the experts (who participated in the risk analysis)	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	The key assumption for assessment of the likelihood is the fact that it involves a collision between two specific types of vessels, a cruise ship and a tanker. The volume of the spill, properties of the oil, wind and weather conditions and the development of the fire are critical assumptions for the assessments of consequences. The sensitivity of the results is assessed as moderate.
Overall assessment of uncertainty	The uncertainty associated with the assessments of likelihood and consequences is assessed as low.

TABLE 48. Placement of the scenario in the risk matrix.

"Collision at Sea Off the Coast of Western Norway" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE			◎		
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The collision at sea scenario is assessed as having a *medium-high* likelihood and *large* social consequences. The uncertainty associated with the results is assessed as *low*.

SCENARIO

15.2 Tunnel fire

A tunnel fire is a transport accident that can have large consequences.

The risk analysis was conducted in the spring of 2014.

Preconditions for the scenario

Time

A Thursday afternoon in August

Duration

More than an hour.

Fire heat output

170 megawatts (MW).

Adverse event

- Collision between a heavy goods vehicle and a passenger car.
- A heavy goods vehicle loaded with wood starts to burn.
- Fully developed fire after 15 minutes.
- Heat from the fire reaches 1 000 degrees Celsius and the tunnel is filled with toxic fumes..

Consequential events

- Structure and technical installations suffer considerable damage, and the tunnel must be closed for a month for repair.
- Detours on roads with a travel time that is much longer.

Comparable events

- Fire in *Gudvanga Tunnel* in Sogn og Fjordane 2013 had a heat output of 30-40 MW. 88 persons were evacuated out of the tunnel in the course of two hours and 66 persons were treated for smoke inhalation injuries.
- Fire in the *Oslo Fjord Tunnel* between Hurum in Buskerud and Frogn in Akershus in 2011 had a heat output of 70-90 MW. 25 road users escaped by themselves and 9 were evacuated by a rescue crew after two hours.
- Fire in the *Mont Blanc Tunnel* on the border between France and Italy in 1999 had an estimated heat output of over 200 MW. A total of 39 human lives were lost. A heavy vehicle loaded with flour and margarine caught fire. It took two days to extinguish the fire.
- The fire in the *St. Gotthard Tunnel* in Switzerland after two heavy goods vehicles collided had an estimated heat output of over 200 MW. The maximum temperature was 1,200 degrees Celsius. The fire took 11 human lives.

The scenario that is analysed is a major fire in a heavy goods vehicle. Since Norwegian tunnels vary greatly with regard to their length, traffic volume, incline, number of bores, etc., the same event has been analysed in three different tunnel systems. The numbers in parentheses indicate the number of tunnels of the relevant type that exist in Norway.[169]

1. A long single-bore rock tunnel (19).
2. A steep single-bore underwater tunnel (30).
3. A heavily-trafficked two-bore tunnel in a city (18).

A total of 67 tunnels fall under one of these three categories.

The tunnel systems chosen are the most exposed to fire. Even if they only represent seven per cent of all tunnels, they represent more than half of all the tunnel fires in Norway in recent years. The specific objects of analysis are the Gudvanga Tunnel (Sogn og Fjordane), a rock tunnel, the Oslo Fjord Tunnel (Buskerud/Akershus), an underwater tunnel, and the Opera Tunnel (Oslo), a heavily-trafficked two-bore tunnel. The results of the analysis of underwater tunnels will be presented in full, while the differences in risk between the three tunnels will be summarised. The results from all three analyses have been described in greater detail in a separate partial report.[170]

TABLE 49. Safety parameters that affect the likelihood and consequences of tunnel fires.

	SAFETY PARAMETERS	LONG SINGLE-BORE ROCK TUNNEL (GUDVANGA TUNNEL)	STEEP SINGLE-BORE UNDERWATER TUNNEL (OSLO FJORD TUNNEL).	A HEAVILY-TRAFFICKED TWO-BORE TUNNEL IN A CITY (OPERA TUNNEL).
1.	Length	11.5 km	7 km	6.6 km
2.	Number of tunnel bores and width	One bore with two traffic lanes (8 m)	One bore with three traffic lanes (11 m)	Two bores with three traffic lanes in each direction (12 m)
3.	Gradient	3.5%	7% in both directions	5% in both directions
4.	Traffic volume	2,000 vehicles/day	7,400 vehicles/day	100,000 vehicles/day
5.	Percentage of heavy vehicles	25%	15%	8%
6.	Breakdown niches and emergency stations	Yes, every 500 m	Yes, every 500 m	Yes, every 250 m
7.	Video surveillance	No	Yes, with event detection	Yes, with event detection
8.	Emergency exits	No	One	Yes, every 250 metres
9.	Dimensioning of ventilation	20 MW fire	50 MW fire	100 MW fire
10.	Direction of ventilation in the event of fire	Towards the west	Towards the west	In the direction of traffic
11.	Response time for the fire service	20 minutes from the east	15 minutes from the east, 20 minutes from the west	4 minutes
12.	Number of road users in the tunnel	60 persons	60 persons	150 persons
13.	Emergency lighting along the tunnel wall	No	Yes, various points	Yes, various points
14.	Lighting	Relatively dark	Normal	Relatively light
15.	Opportunities to close off	Only a red light	Red light and road barrier	Red light and road barrier

System description

The same event may have a different risk depending on what type of system the event occurs in. The table below shows the parameters (geometry and technical equipment) that affect both the likelihood and consequences of tunnel fires.

The first six parameters primarily affect the likelihood of a tunnel fire, and the last eight affect the consequences. Video surveillance affects both the likelihood (early detection of events before a possible fire arises) and the consequences (information on the type of fire and location to the fire service).

The principle used for evacuation from road tunnels is the *self-rescue principle*[171]. This means that the road users should exit on foot or by means of their own vehicles, regardless of the response by the fire service. The direction of the fire

[169] *Directorate of Public Roads' tunnel database as at 1 January 2014.*
[170] *DSB (2014). Risk analysis of tunnel fires – partial report to the National Risk Analysis.*
[171] *Public Roads Administration "Handbook 021 Road Tunnels", 2010.*

ventilation is determined based on the fact that the fire crew is to have "fresh air" at their back in order to enter a smoke-filled tunnel. This is the general rule for fire ventilation stipulated in the emergency preparedness plans for tunnels. In the Oslo Fjord Tunnel, this means that the smoke should be ventilated towards the west, since the fire service will be coming from the east.

Assessment of likelihood

The likelihood assessment is based on statistics and the special characteristics of the tunnel. The likelihood of a 170 MW fire in the Oslo Fjord Tunnel is considered "moderate" on the five-level scale that is used in the NRA.

During the period from 2006 to 2013, there was an average of 21 fires per year in Norwegian tunnels, and 12 of these took place in the 67 most fire-prone tunnels (long rock tunnels, heavily-trafficked urban tunnels and underwater tunnels). Of all the fires, 55 per cent were in heavy vehicles, i.e. 7 out of 12 fires. A fire as large as that in the scenario presupposes that there is a fire in a heavy vehicle. It is assumed that fires in the magnitude of 170 MW represent three per cent of all the tunnel fires.[172] This means that one such large fire can be expected in the course of five years in the 67 tunnels altogether.

Underwater tunnels have a high gradient (more than five

TABLE 50. Schematic presentation of the results from the risk analysis

Likelihood assessment

	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXPLANATION
Likelihood that the event will occur in the course of a year: 0.5%			◎			Once in the course of 200 years – specification based on statistics and special characteristics of the tunnel.

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MODERATE	LARGE	VERY LARGE	
Life and health	Death		◎				10 deaths (5 directly and 5 prematurely).
	Serious injuries and illness	◎					10 smoke inhalation injuries and 5 who develop psychological disorders.
Nature and the environment	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct financial losses	◎					Repair and renovation of road surface and equipment (cables, fans, etc.), as well as rock protection measures of NOK 70-80 million
	Indirect financial losses	◎					Higher transport costs due to detours for businesses and private individuals of approximately NOK 80 million
Societal stability	Social and psychological reactions				◎		It is assumed that a major fire in the Oslo Fjord Tunnel will create fear and anxiety among many road users due to the lack of rescue opportunities.
	Effects on daily life		◎				Closure of the tunnel for a month will result in delays of ½-1 hour for approximately 5,000 road users daily (long-haul transport).
Capacity to govern and control	Loss of democratic values and national capacity to govern						Not relevant.
	Weakened territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES			◎				Small consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[172] *PIARC c3.3 wg 2.*
[173] *Institute of Transport Economics (TØI), 2013: "Brannutsatte undersjøiske tunneler [Underwater Tunnels Vulnerable to Fire]".*

per cent), and they have a higher percentage of fires due to the overheating of the engines and brakes in heavy vehicles. A total of 44 per cent of all the tunnel fires take place in the four per cent steepest tunnels (the 30 underwater + 10 other tunnels)[173]. It is therefore assumed that four of the seven annual fires will occur in the 30 underwater tunnels. If three per cent of these fires are 170 MW fires, it indicates the occurrence of one such major fire in the course of 8 years in one of the 30 underwater tunnels. If the fire likelihood is the same, it indicates one 170 MW fire in the course of 250 years in one of the underwater tunnels.

The special characteristics of the Oslo Fjord Tunnel (long and steep) indicate that the fire risk is somewhat higher in this tunnel than in an average underwater tunnel. Adjusted accordingly, the likelihood is stated as *one expected 170 MW fire in the Oslo Fjord Tunnel in the course of 200 years.*

The uncertainty associated with this statement of likelihood is assessed as moderate. The statistics on small tunnel fires are relatively good and provide a basis for assuming a certain frequency. The percentage of fires that are as powerful as 170 MW is, however, low, and many preconditions must be present in order for this to occur.

Assessment of consequences

"Tunnel Fires" will affect three out of five societal assets defined in the NRA: Life and Health, Economy and Societal Stability. It is particularly the "Social and Psychological Reactions" component under the "Societal Stability" asset that contributes to the consequences. Overall, the consequences are considered "low" on the five-level scale that is uses in the NRA. The uncertainty associated with the various consequence assessments is deemed overall to be relatively low. Major changes would have to occur before the estimates end up in another category. Tunnel fires have natural limitations with regard to how many people can be affected and how great the consequences can be.

Consequences for life and health

The fire breaks out one kilometre from the east entrance of the seven kilometre long tunnel. An estimated 50 out of the total of 60 road users inside the tunnel will be on the west side of the fire and have six kilometres to go to escape out of the tunnel.

The fire ventilation will be turned on and blow towards the west in order to give the fire crews from the east access to the tunnel. With the fire ventilation, the smoke will move westwards at a rate of approximately 10 km/h (3 m/sec) and thus overtake those who are evacuating.

Some cars on the west side of the fire manage to turn around in the relatively wide three-lane tunnel and pick up others who are evacuating on foot. It is assumed that half of the road users on the west side of the fire will manage to get out of the tunnel before it becomes completely smoke-filled. The remaining 25 people will escape on foot on a steep incline in a tunnel that gradually fills completely with smoke. They will take approximately 1.5 hours to traverse the six kilometres to the exit.

It is assumed that 5 out of the total of 25 persons that evacuate on foot towards the west will perish from smoke poisoning, and that an additional 5 will die prematurely due to chronic respiratory problems. Many of the 50 who escape out of the tunnel towards the west in a car or on foot will suffer to varying degrees from smoke inhalation injuries and 10 are assumed to have serious injuries. It is assumed that an additional 5 persons will have subsequent psychological disorders because they have been in mortal danger, such as post-traumatic stress.[174]

Natural and cultural environments

Heavy smoke may blacken the buildings and nature outside the tunnel, but it will not yield lasting damage. It is therefore assumed that tunnel fires will not affect natural assets or the cultural environment (cultural artefacts).

Consequences for the economy

The tunnel and technical equipment suffer severe damage, and the tunnel must be kept closed for a month for the repair work. The direct costs of the fire include the cleaning of soot, repair and renovation of the road surface and equipment (cables, fans, etc.), as well as rock protection measures and new shotcreting after the rock has been exposed to extreme heat. Since it is an underwater tunnel, there will also be the repair of pumps and pump sumps, as well as possible cracks in concrete structures. *Direct financial losses are estimated at NOK 70–80 million.*

The indirect losses will consist of higher transport expenses for businesses and socio-economic costs connected to the longer travel distance and time for the detour. If the Oslo Fjord connection is closed, the detour routes will be the E18/E6 via Oslo or the Horten-Moss ferry.

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[174] *Cf. the fact that 25% of the road users who escaped on foot experienced two dramatic hours in the tunnel before they were rescued during the fire in the Oslo Fjord Tunnel in 2011.*
[175] *Based on EFFEKT.*
[176] *Based on EFFEKT.*

Of all the vehicles in the tunnel, 15 per cent will be heavy (more than 3.5 tonnes) i.e. approximately 1,000 heavy vehicles per day. An average delay of one hour per trip is assumed for both detour routes and an hourly rate of NOK 450 for freight transport.[175] The increased transport expenses for businesses will amount to NOK 15 million in the course of a month.

The socio-economic costs related to the detours for passenger cars are based on the following assumptions: Of the detours, 75 per cent will be via Oslo and have a travel time of ½-1 hour longer, depending on the rush traffic. The remaining 25 per cent will use the Horten-Moss ferry and have a travel time that is at least one hour longer. There are 7,400 vehicles per day in the Oslo Fjord Tunnel and the average time cost per hour is NOK 200.[176] Socio-economic costs related to delays for passenger cars will be approximately NOK 45 million. In addition, there will be additional vehicle and fuel costs of approximately NOK 18 million due to the detour. *The indirect financial losses will total approximately NOK 80 million.*

Total financial losses after the fire in the underwater tunnel will be approximately NOK 150 million.

Societal stability

A major tunnel fire may result in social and psychological reactions such as fear, stress and anxiety in portions of the population. Norwegian and Swedish surveys show that 30 per cent of the road users are anxious about driving in tunnels.[177] People who find themselves in such a dramatic situation will react with shock and act based on survival instincts. They will follow simple instructions, do as others do and be unable to analyse the situation. Afterwards there may be reactions such as despair, anxiety and anger.[178]

Characteristics of the tunnel fire event that cause emotional reactions, even in those who are not directly involved:

1. It affects vulnerable groups in particular, because the sick (especially those with breathing difficulties), elderly, children and physically disabled have the greatest problems evacuating.
2. There is no means of avoiding the event. It is difficult to turn around and drive out; it is a long way to the exit (1.5 hours), many become trapped by the smoke and have trouble breathing.

Comparison of risk among the three tunnel systems.

TABLE 51. Comparison of the results from the risk analyses of the various tunnel systems.

Topic for consideration	Oslo Fjord Tunnel	Gudvanga Tunnel	Opera Tunnel
LIKELIHOOD	In the course of 200 years.	In the course of 350 years.	In the course of 450 years.
LIFE AND HEALTH	25 fatalities and injuries	40 fatalities and injuries	12 fatalities and injuries
FINANCIAL LOSSES	NOK 150 million	NOK 100 million	NOK 350 million
SOCIETAL STABILITY	Strong reactions, delays for 5,000 road users	Strong reactions, delays for 2,000 road users	Mild reactions, delays for 200,000 road users

[177] *Lauvland 1990 and SVEBEFO 1997.*
[178] *Input from Psychologist Dagfinn Winje,UiB, at the seminar on 15 January 14.*

3. The fire service has no means of rescuing the road users on the other side of the fire, where most of the people are located. This part of the tunnel is filled with smoke due to the direction of the ventilation and the opportunities for saving themselves are poor. This leads to a breakdown of the road users' expectations of being rescued.

A major fire in the Oslo Fjord Tunnel is expected to create fear and anxiety associated with driving in this tunnel or other underwater tunnels by a large portion of the road users.

Closure of the Oslo Fjord Tunnel will result in a detour for east-west traffic between the E6 and E18 and delays for the high percentage of freight transport, for example. The possible detour routes are via Oslo, which adds 30 minutes to the travel time outside of rush hour and quite a lot more in rush traffic. The alternate detour route is the Moss-Horten ferry, which results in a travel time that is at least one hour longer. It is assumed that three-fourths of the traffic will go via Oslo. It is assumed that half of the road users will use the tunnel daily or often and will be significantly inconvenienced by closure of the tunnel. The same applies to 1,000 heavy vehicles daily.

Closure of the Oslo Fjord Tunnel for a month will result in delays of ½-1 hour for approximately 5,000 road users daily (long-haul transport). The level of the effects on daily life for the population as a result of the tunnel fire is considered low.

Tunnel fires have different outcomes in the three tunnels. A fire in the Opera Tunnel results in the greatest economic costs and delays if the tunnel is closed, but entails relatively few fatalities and injuries and small psychological reactions. A fire in the Gudvanga Tunnel results in the highest number of fatalities and injuries and strong psychological reactions, but the costs and delays are moderate. The Oslo Fjord Tunnel lies between the other two for all types of consequences (closest to the Gudvanga Tunnel). The Oslo Fjord Tunnel, however, has a significantly higher likelihood for fire than the other two and therefore higher risk overall, as it is assessed in the NRA.

Vulnerability

The number of emergency exits (and hence the number of tunnel bores), length, gradient and lighting conditions are of great importance to the opportunities for saving oneself in the event of a tunnel fire. In addition to the fact that two-bore tunnels in cities have emergency exits, a broader profile, etc., the fire service often has a shorter response time and can make a greater rescue and fire fighting effort. The location thus makes the robust two-bore tunnel even more robust.

The long single-bore rock tunnels and underwater tunnels are more vulnerable in the event of a fire due to the lack of escape opportunities, steep incline in some cases and often poor lighting. In addition, the fire service often has a long response time and the road users are essentially left to rescue themselves. The location makes the vulnerable tunnels even more vulnerable.

The fire ventilation also contributes to reinforcing the difference in vulnerability. In two-bore tunnels, the smoke is ventilated out in the direction of travel and no one is trapped in the smoke behind the fire. In the long single-bore tunnels, the general rule is that the direction of the ventilation shall be the same direction as the fire service enters the tunnel. If the fire is close to the fire service's area of operation, then there is a risk that the smoke will be sent to the largest section of the tunnel where most of the road users are located.

Follow-up

- *Underwater tunnels*
  Statistics show that underwater tunnels are far more prone to fires than other tunnels. It is the length and especially a gradient greater than five per cent that is problematic, since heavy braking for a long period of time may result in engine and brake overheating in heavy vehicles. It is difficult to do anything about the gradient in existing tunnels, and the underwater tunnels therefore have an inherent risk. The Public Roads Administration should consider compensating for this risk with measures that contribute to rapid detection of fire and better escape opportunities for the road users, such as camera surveillance, adequate lighting in the event of fire, good emergency preparedness plans and the construction of two tunnel bores if possible.

- *Direction of fire ventilation*
  Through camera surveillance or the use of a fire extinguisher or emergency phone in the tunnel, the traffic management centre will know exactly where in the tunnel the fire is and can control the smoke to the advantage of the road users instead of the fire service – in accordance with the self-rescue principle. When drawing up emergency preparedness and operative plans for the individual tunnel, the emergency services and the Public Roads Administration should consider the principle that the direction of the ventilation should be determined in each individual tunnel fire based on knowledge of the fire's location and traffic. The emergency preparedness should compensate for the risk associated with the tunnel geometry and not reinforce it.

TABLE 52. Assessment of the uncertainty associated with the likelihood and consequence assessments.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	There is data and experience from several minor tunnel fires every year, including the tunnel analysed. Fires with an heat output of 170 MW are, however, rare. The likelihood is therefore uncertain, while the consequences are relatively known and certain.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Tunnel fires are a known and researched phenomenon both in Norway and abroad.
Agreement among the experts (who have participated in the risk analysis).	Some disagreement on the likelihood assessment, but not the consequence assessments.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and consequences?	Changes to the safety parameters in Table 49 will change the assessments of both the likelihood and consequences. The likelihood estimate is very sensitive to the assumption of the percentage of such powerful fires.
Overall assessment of uncertainty	The uncertainty associated with the estimates of likelihood and consequences is assessed as low to moderate.

TABLE 53. Placement of the scenario in the risk matrix.

"Tunnel Fire" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE					
MODERATE					
SMALL			◎		
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

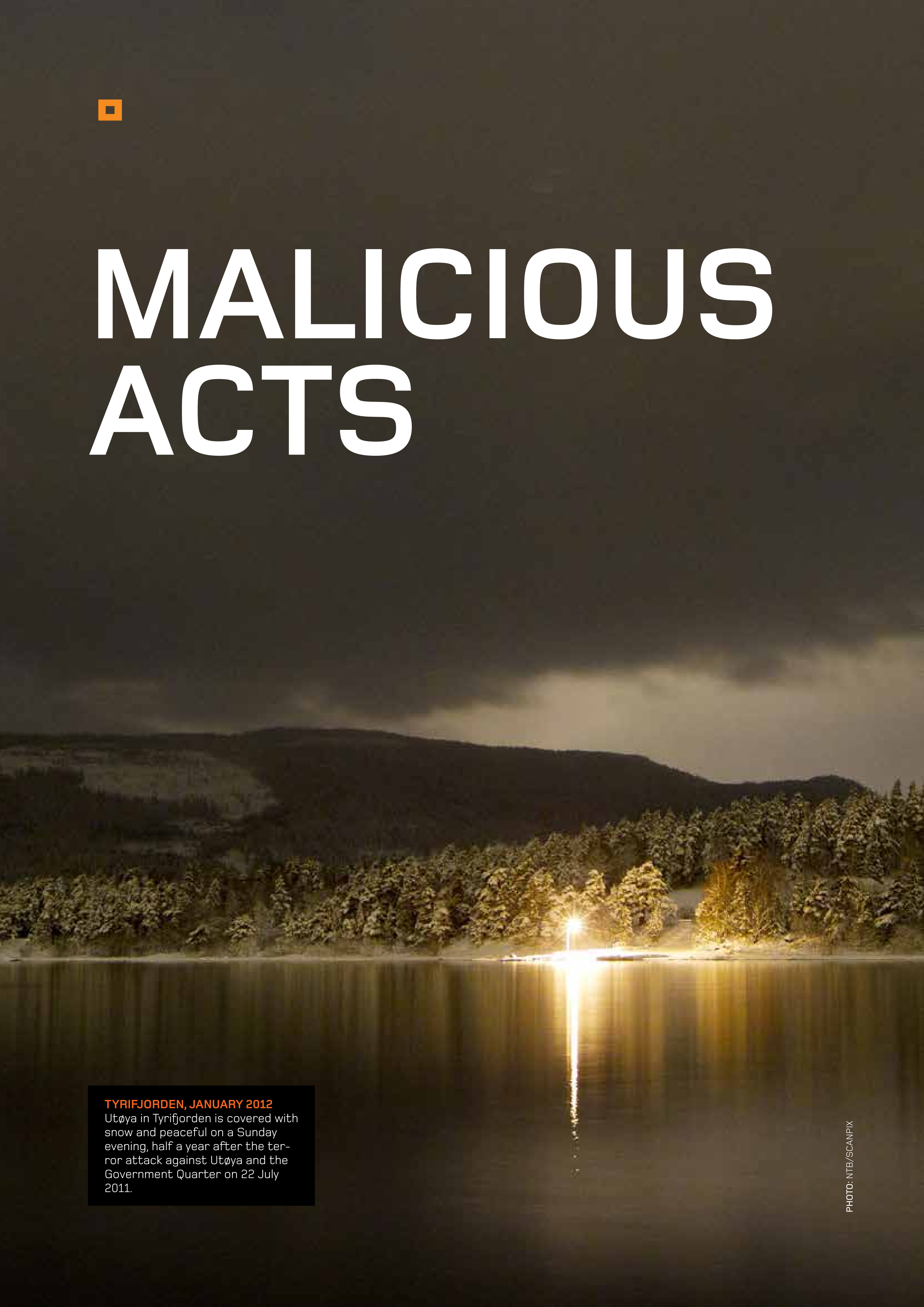
Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The scenario is assessed as having *medium-high* likelihood and *small* social consequences. The uncertainty associated with the results is assessed as *moderate*.

FIRE IN THE OSLO FJORD TUNNEL: On 23 June 2011, the engine of a heavy vehicle loaded with paper caught on fire and 34 road users were forced to evacuate in dense smoke.

PHOTO: NTB/SCANPIX

MALICIOUS ACTS



TYRIFJORDEN, JANUARY 2012
Utøya in Tyrifjorden is covered with snow and peaceful on a Sunday evening, half a year after the terror attack against Utøya and the Government Quarter on 22 July 2011.

PHOTO: NTB/SCANPIX

In accordance with NS 5830:2012 *Samfunnssikkerhet – Beskyttelse mot tilsiktede uønskede handlinger – Terminologi* [Civil Protection – Protection against Intentional Adverse Acts – Terminology] an *intentional adverse act* is an event that is caused by an actor acting on purpose. The actor's purpose may be malicious or to promote their own interests.

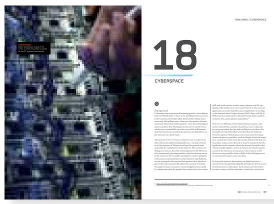
In the NRA, consequence analyses have been conducted on four specific serious scenarios of intentional adverse acts: *Terror Attack in Oslo, Strategic Attack, Cyber Attack on Financial Infrastructure and Cyber Attack on Electronic Communications Infrastructure.*

Risk associated with intentional adverse acts may change to a great extent from year to year, depending on the threat assessments that are made at any given time. In assessing threat, it is the intention and capacity of the actor that is assessed (ref. new NS 5832 Security Risk Analysis). The NRA is based on the annual *threat assessment* prepared by the Norwegian Police Security Service (PST), the Norwegian National Security Authority (NSM) and the Norwegian Military Intelligence Agency (Norwegian Intelligence Service). The point in time for the scenario analyses is specified for each individual scenario. No new analysis of likelihood has been conducted after this.

Threat assessments give an indication of the possibility of an event occurring. The scenarios that are analysed in the NRA are serious and very rare events for which there are no statistics. The specification of "likelihood" will therefore be a qualitative and knowledge-based assessment and reflect the background knowledge of whoever specifies the likelihood. It will not be an estimate based on statistics or the past repeating itself.

The description of the risk areas*Terrorism, Security Policy Crisis* and *Cyberspace* are based on open, unclassified information from the security authorities.

RISK AREAS



TERROR ATTACK
OSLO, 22 JULY 2011
The high-rise building *Høyblokka* was a total loss. The photo of the broken glass from the windows has become a symbol of the terror attack.

PHOTO: NTB/SCANPIX

16

TERRORISM

Background

Terrorist activities represent serious crime that often has cross-border branches, and impacts civil society to a great extent. The effect of terrorist actions is greater than just the loss of human life and material damage, due to the fear and insecurity that they create.

Even though there is no generally accepted definition of terrorism in the world today, it is nevertheless necessary to define some limits for what types of activities are to be regarded as terrorism. In the Security Act terrorist actions are defined as: *"illegal use of, or the threat of use of, force or violence against persons and property, in an attempt to exert pressure on the authorities of a country or the population or society in general in order to achieve political, religious or ideological aims."*[179]

In recent years there has been increasing concern about and increased attention given to terrorism in Scandinavian countries. The terror threat against Norway in July 2014 was an example of instability in certain regions of the world may be of important to the threat level in Norway. Dysfunctional states with weak or absent government control and internal conflicts, such as in Syria or Libya, create opportunities for terror groups to establish "free ports" that they can use as a point of departure for planning attacks against Europe or European interests abroad. In recent years an increasing number of persons linked to Norway have travelled to conflict areas and joined militant Islamists.[180]

Since the end of the 1990s and the terrorist attacks of 11 September 2001 in the USA, the al-Qaida network has dominated international terrorism. Extreme Islamist networks loyal to al-Qaida have comprised an ever greater threat in Europe. The terrorist attacks in Madrid in 2004 and in London in 2005 are examples of attacks in which many people lost their lives. Militant Islamist groups that defend a global Jihad ideology still represent the greatest threat of terrorism against western interests. However, the current threat of terrorism no longer originates only from al-Qaida's core organisation, even if this organisation still represents a significant threat. The threat emerges as fragmented and complex, because it originates from a number og groups and networks with a loose connection both to each other and to al-Qaida's significantly weakened core organisation. Al-Qaida's ideology is in many cases adapted to local agendas, and the organisation's authority is simply set aside in some cases. As result of this, terror planning against the West is no longer carried out primarily by al-Qaida's core organisation, but to a greater extent by other strong groups with an increasing capacity to carry out attacks.[181]

On 18 September 2014, the Australian police carried out an anti-terror operation, and they arrested 15 persons who they suspected of being accomplices of the group the Islamic State of Iraq and the Levant (ISIL). The police fear that the group would perform an execution on the open street.[182]

On 15 April 2013, two bombs were detonated during the Boston Marathon in the USA. Three people were killed and over 200 were injured, many of them very seriously.[183] In 2010

[179] *Act relating to Protective Security Services (Security Act), Section 3 Definitions.*
[180] *Norwegian Intelligence Service. "Fokus 2014 [Focus 2014]".*
[181] *Norwegian Intelligence Service. "Fokus 2014 [Focus 2014]".*

attacks were carried out in Sweden and Denmark. These were also carried out by individuals who were acting on the background of inspiration from other people, but who were responsible on their own for carrying out the attack.

In recent years, there has also been a tendency for attempts to perpetrate higher numbers of smaller, more wide-spread actions, carried out by autonomous groups or individuals. The events on the island of Utøya and in the Government Quarter in 2011 are one of the most serious terrorist attacks in European history. A perpetrator detonated a bomb in Oslo's Government Quarter and eight people lost their lives, many people were wounded and the explosion involved substantial material damage. Immediately following this, the same perpetrator shot and killed 69 people on the island of Utøya, where around 600 young people had gathered for the annual summer camp held by the youth section of the Norwegian Labour Party (Arbeiderpartiet). Many of the young people were injured both mentally and physically. The perpetrator was an ethnic Norwegian with an extreme ideology, and he carried out the attacks alone.

Threat

At the beginning of 2014, the Norwegian Police Security Service (PST) and the Norwegian Intelligence Service (NIS) found that threats of terrorism against Norway and Norwegian interests abroad would increase during the year. The greatest threat against Norway comes from a multi-ethnic extreme Islamic community in Eastern Norway. The community consists primarily of young men who have grown up in Norway. Important activities in the community include radicalisation, recruitment and travel to war and disaster areas.[184]

The Norwegian Police Security Service (PST) collaborates with the Norwegian Intelligence Service (NIS) in the field of terrorism. As Norway's civil domestic intelligence and security service, the PST is responsible for the nation's internal security. The Norwegian Intelligence Service (NIS) does not assess the threat of terrorism in Norway, but it does collect, process and analyse information on foreign states, organisations or individuals that may represent a real or potential threat to our national interests. In the opinion of the NIS, militant Islam still represents the most serious threat to Norwegian interests abroad. The current threat situation against Europe is assessed as more fragmented and unclear than previously, characterised by a number of different organisations and networks, which are not dependent on central management in order to carry out a terrorist attack. A weakened core organisation for al-Qaida has entailed increased importance and influence for the regional branches.[185] The most important threat today is from the Islamic groups in Syria.

"The situation in Syria has significantly increased the threat of terrorism against Europe. The development in which foreign fighters with links to Norway travel to participate in fighting has emerged as a particularly serious element in the threat of terrorism against Norway and western interests."[186]

The threat of terrorism against Norwegian interests abroad is primarily a consequence of militant Islamists' enemy image of the West in general and not Norway in particular. The increasing number of Norwegian Islamists with fighting experience from Syria will, however, increase the direct threat of terrorism against Norway and Norwegian interests in 2014.[187]

The services[188] have expressed concern for the consequences of persons with links to Norway travelling to conflict areas in which Islamists are operating. *"Travel activities may increase the threat level. This is because those who travel may obtain an increased will and capacity to carry out terrorist actions on Norwegian soil, or against Norwegian interests abroad. During such periods abroad, they receive ideological training, battle experience and expand their network of contacts with extreme Islamists. Most importantly, by participating in hostilities, their capacity and will to participate in violence and killing may increase. It is expected therefore that the potential for violence in parts of the community will increase.*

[...] Norwegian citizens who stay with militant Islamist groups abroad are regarded as contributing to a stronger international focus on Norwegian interests. In general, the threat of terrorism abroad is regarded as a consequence of militant Islamists' image of the West as an enemy in general, and not as against Norwegian interests abroad in particular."[189]

While the threat from militant Islamists is increasing, today the right-wing or left-wing extremists emerge primarily as a public nuisance problem. However, extreme communities often attract unstable individuals, and these individuals may represent a significant portion of the threat level in Norway.[190] The Norwegian Police Security Service (PST), Norwegian National Security Authority (NSM) and Norwegian Intelligence Service (NIS) point out in their

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182 www.nrk.no.
183 www.aftenposten.no.
184 Norwegian Police Security Service. "Åpen trusselvurdering 2014 [Open Threat Assessment 2014]".
185 Fokus 2013 [Focus 2013]. Assessment of the intelligence service. Norwegian Intelligence Service (NIS).
186 Norwegian Intelligence Service. "Fokus 2014 [Focus 2014]".
187 Ibid.
188 Norwegian Intelligence Service (NIS), the Norwegian National Security Authority and the Norwegian Police Security Service.
189 Trusler og sårbarheter 2013 [Threats and Vulnerabilities 2013]. Coordinated assessment from the Norwegian Intelligence Service (NIS), the Norwegian National Security Authority (NSM) and the Norwegian Police Security Service (PST). The NIS, NSM and PST.

coordinated assessment from 2013 that the main challenge is the potential extremists who do not belong to organised communities.

"Such persons may have an extremist conviction, without necessarily communicating this. Hatred of the authorities, often combined with conspiracy theories, is also a common denominator here. Such individuals and environments are difficult to identify.

Anders Behring Breivik will continue to inspire certain individuals in Norway and abroad. There are several examples of foreign sympathisers who have planned terrorist actions inspired by Breivik's actions, such as in Poland and the Czech Republic. It is also possible that Norwegian sympathisers may attempt to carry out violent actions. These may be inspired by both Breivik as a person, his ideological message, and his actions. Even though most of the sympathisers in Norway appear to oppose the terrorist actions on the island of Utøya, there are several who support the attack against the Government Quarter and the Government.

It has been assessed as most probable that any threats of terrorism from right-wing extremists or Islam-hostile actors aimed at Norway or Norwegian interests abroad will come from individuals or small groups."[191]

At the start of 2014, the Norwegian Police Security Service (PST) found that it is probable that the new Government parties will experience an increase in threatening or troublesome overtures in the future. The scope will depend on whether some of the persons of authority are linked to individual issues or themes that rouse strong feelings. In general, there is little correspondence between the threats that are made and the actual will and capacity to carry out the action that is threatened. The Norwegian Police Security Service (PST) is, however, handling an increasing number of statements with threatening elements, and there is a risk that some of these may affect the freedom of speech of persons of authority.[192]

Prevention and emergency preparedness

In order to attain a conscious and acceptable degree of risk, decision-makers must prepare a strategy for how risk is to be managed, based on risk assessments.

"Risk can be managed in different ways. It can be accepted as it is. In addition, risk can be affected by reducing or eliminating the threat. Risk can also be reduced through vulnerability-reducing measures, so that national assets and interests are safeguarded in a satisfactory manner."[193]

Rapid technological development and ongoing globalisation have made the challenges linked to politically motivated violence complex. The Internet has made terrorist propaganda more accessible. Digital networks have made it possible for those who support extreme Islam to organise their activities in new ways. In addition, the globalisation of communications networks have made Norway visible internationally in a completely new way. Political debates, standpoints and initiatives which are promoted in a national context can gain a global audience today. Work on preventing and combating violence of this kind must therefore be done on the terms of a state governed by the rule of law and through broad-based coalition of police, public authorities and other civilian players.

In the autumn of 2010, the Norwegian National Security Authority (NSM), the National Police Directorate and the Norwegian Police Security Service (PST) published guidance on security and emergency preparedness measures against terrorist actions.[194] The guidance is intended to act as a resource for public and private operations to adapt baseline security and emergency preparedness measures to their own operation. The guidelines describe responsibilities and roles of the relevant authorities, the process on which the implementation of security measures against terrorist actions, emergency preparedness systems, and emergency preparedness levels should be based, and examples of tangible security measures.

To strengthen and formalise cooperation between the Norwegian Intelligence Service (NIS) and the Norwegian Police Security Service (PST), the joint counter-terrorism centre was established in 2014. The purpose of the joint counter-terrorism centre is to ensure a timely and relevant exchange of information between the services, coordinate and facilitate efficient operative cooperation and prepare analyses of the threats of terrorism aimed against Norway and Norwegian interests. [195]

[190] *Norwegian Police Security Service. "Åpen trusselvurdering 2014 [Open Threat Assessment 2014]".*
[191] *Trusler og sårbarheter 2013 [Threats and Vulnerabilities 2013]. Coordinated assessment from the Norwegian Intelligence Service (NIS), the Norwegian National Security Authority (NSM) and the Norwegian Police Security Service (PST). The NIS, NSM and PST.*
[192] *Norwegian Police Security Service. "Åpen trusselvurdering 2014 [Open Threat Assessment 2014]".*
[193] *Trusler og sårbarheter 2013 [Threats and Vulnerabilities 2013]. Coordinated assessment from the Norwegian Intelligence Service (NIS), the Norwegian National Security Authority (NSM) and the Norwegian Police Security Service (PST). The NIS, NSM and PST.*
[194] *Norwegian National Security Authority, National Police Directorate and the Norwegian Police Security Service (2010): En veiledning – Sikkerhets- og beredskapstiltak mot terrorhandlinger [A Guide – Security and Emergency Preparedness Measures against Terrorist Actions].*
[195] *Meld. St. 21 (2012–2013) Terrorberedskap [Report no. 21 to the Storting (2012–2013, Preparedness for Terrorism]. Ministry of Justice and Public Security.*

SCENARIO

16.1 Terrorist Attack in a City

A large terrorist attack in Oslo is an example of a malicious adverse act in the "terrorist attack" risk area. To illustrate how serious the consequences of such an event can be, a consequence analysis has been conducted on a very serious scenario in which groups of terrorists carry out simultaneous attacks against several targets.

The analysis was conducted in the autumn of 2010.

Preconditions for the scenario

Time

A weekday at the end of September, at the end of working hours

Duration

Less than 24 hours

Capacity

Several extremist/militant organisations/groups have access to military resources and equipment.

Intention

- In recent years, the police in several European countries have uncovered plans for terrorist attacks that encompass several mobile attack teams with a high degree of brutality.
- An increasing number of attacks are being carried out by militant Islamists that have a standing intention to harm the West.

Comparable events

- Attack in Mumbai in 2008, in which more than 170 people lost their lives, and 370 were injured. The attack lasted for three days and was directed at ten different locations.
- Attack on the gas plant in In Amenas, Algeria in 2013, in which 38 employees from a number of countries were killed, including five Norwegians.

Assessment of likelihood

The threat was assessed based on the "Open Threat Assessment 2010" published by the Norwegian Police Security Service (PST) and the assessments made in connection with the risk analysis work. That a large terrorist attack of this type could occur in Norway was assessed as a possible, but not very probable threat.

Threat assessments give an indication of the possibility of an event occurring. Therefore the threat level indicates a form of likelihood. A threat can be classified on the basis of a rising likelihood or threat level. The fact that the scenario was assessed as a possible, but not very probable threat, indicates a low likelihood in the context of the NRA.

TABLE 54. Schematic presentation of the results from the risk analysis.

Likelihood assessment						Explanation
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	
There is a known and possible, but not very probable, threat.		◎ (High uncertainty)				A number of actors have access to military equipment. An increasing number of attacks are being carried out by militant Islamists that have a standing intention to harm the West.

Consequence assessment							
SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death				◎ (Moderate uncertainty)		From 100 to 300 deaths as a direct or indirect consequence
	Injuries and illness				◎ (Moderate uncertainty)		300-1,200 injuries or ill people as a direct or indirect consequence
Nature and the environment	Long-term damage						Not relevant.
Economy	Financial and material losses			◎ (Moderate uncertainty)			NOK 0.5 to 5 billion.
Societal stability	Social unrest					◎ (Moderate uncertainty)	Difficult to avoid, a large number of fatalities and injuries, group with"evil intentions", question of responsibility – will result in reactions such as fear, anger and a feeling of powerlessness
	Effects on daily life		◎ (Low uncertainty)				Navigability and transport affected somewhat
Capacity to govern and control	Weakened national capacity to govern		◎ (Moderate uncertainty)				The Norwegian central authorities and the associated institutions will be affected
	Weakened territorial control						Not relevant
OVERALL ASSESSMENT OF CONSEQUENCES					◎ (Moderate uncertainty)		Large consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

Assessment of consequences

The social consequences of the given scenario are assessed as large compared with other consequence assessments in the National Risk Analysis (NRA). The scenario will primarily threaten the societal assets life and health, and societal stability through the consequence type social unrest. The uncertainty associated with the assessment of the various consequence types varies from low to moderate and is assessed as moderate compared with other assessments in the NRA.

Life and health

This specific terrorism scenario will have serious consequences for life and health. It might be anticipated that up to a few hundred people would be killed and a corresponding number injured as a result of the attacks. Direct fatalities will be attributed to the shooting and bomb explosions. It is assumed that at least one of ten injured persons will have serious injuries. The estimate will depend, for example, on the types of weapons and bombs used, and to what extent bombs will result in structural damage and cause buildings to collapse. In the aftermath, it might be expected that those directly affected or victims, intervention personnel, friends and relatives and other or random witnesses will have delayed psychological injuries and traumas, but it is assumed that this will be on a limited scale.

Nature and the environment

It is assumed that the scenario that has been analysed will not be of significance to nature and the environment.

Economy

The financial consequences that the terrorism scenario is expected to entail are linked to extensive destruction of buildings, among other things. The scope of the structural damage depends on whether buildings collapse, or if an extensive fire arises as a result of the bomb explosions. The clean-up, repair and rebuilding costs will be substantial, and it is assumed that individual buildings and/or commercial premises will have to close for several months. This will also entail a reduction in the workforce and a substantial loss of sales. There will be extraordinary measures linked to management and restoration, and it is assumed that there will be costs linked to the consequences of new requirements, regulations and rules that will have a long-term effect or last for some time. Overall, economic losses are estimated to total NOK 500 million to NOK 5 billion, based on experience with corresponding events abroad, including the terrorist attacks in Mumbai in 2008.

Societal stability

It is assumed that the terrorist attack scenario will entail significant social unrest. The scope of three simultaneous attacks and the large number of fatalities and injuries will create reactions such as fear, anger and a feeling of powerlessness. This can also be linked to the fact that those who are directly affected do not have any opportunity to avoid the event, and that they are at the mercy of the terrorists' actions. It is the fact that it is an intentional action, planned and carried out by a group/organisation with "evil intentions" that will reinforce these reactions, and lead to a high degree of social unrest. There will be expectations that this is a type of event that the authorities should have been prepared for, and which should have been avoided. It is assumed that there will be aggressive criticism in the initial period after the event, and the media will play an important role. The question of responsibility will arise and may entail anger in the population. Crisis information will be very important, also in the period after the event with regard to the follow-up of survivors, dependants and relatives. If the social unrest and insecurity become very prominent, societal stability may become so threatened that the actual system of government become unbalanced.

The event is expected to entail significant effects on daily life. It is assumed that the scenario will not entail any significant lack of local access to critical services and deliveries, except for the fact that it is assumed that the use of public transport/underground will be regulated/closed for a few days in the city centre.

Capacity to govern and territorial control

It is also assumed that the scenario will result in a weakened national capacity to govern, but only for a short period of time. ◎

TABLE 55. Assessment of the uncertainty associated with the analysis results.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	A threat assessment is based on knowledge of the actors' intention and capacity to carry out the threat. New information can quickly change the threat level and represent grounds for new assessments. There is therefore a great deal of uncertainty associated with the likelihood that malicious acts can occur. Consequence assessments are based on research and access to some data and experience from similar events, for example, in the Middle East and Afghanistan, and earlier hotel events.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Terror attacks are considered a known and researched phenomenon, compared with other events that have been analysed in the NRA.
Agreement among the experts (who contributed to the risk analysis)	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions for the scenario affect the estimates for likelihood and consequences?	The type of hand weapons, explosives and targets, whether the explosions cause buildings to collapse, time of day, and crisis information provided are critical assumptions for the consequence assessments. The sensitivity of the results is assessed therefore as *moderate*.
Overall assessment of uncertainty	The uncertainty is assessed as *moderate*.

TABLE 56. Placement of the scenario in the risk matrix.

"Terrorist Attack in a City" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE		◎			
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The scenario is assessed as having a *low* likelihood and *large* social consequences. The uncertainty associated with the results is assessed as *moderate*.

UNREST IN THE UKRAINE IN 2014: A volunteer standing guard in the village of Peski near Donetsk, in the eastern Ukraine. During the last year there has been unrest and demonstrations throughout the entire country. The unrest started as a reaction to corruption and poor government in the country. Russian interference has, however, contributed to an escalation of the conflict.

PHOTO: NTB/SCANPIX

17

SECURITY POLICY CRISES

Background

The events in the Ukraine in 2014 have changed the European security landscape and revitalised the need for traditional state security in a Europe that has been marked by disarmament for several decades. The events have shown that the defence alliance NATO still has a role to play in its territory as a guarantor of a collective defence, after several years of "out of the area" operations. The debate on division of the burden among the member states of the alliance is of current interest, and this includes a discussion concerning a tightening of the member countries' defence budgets. Defence cooperation in NATO remains the anchor for Norway's security policy. At the same time, the events in the Ukraine have shown that the EU has grown to become a significant security policy actor in Europe, with both the capacity and willingness to use diplomatic and economic power.

Up until 1990, state security in our part of the world was primarily linked to the threat of invasion. Since 1990, the situation has been characterised primarily by the danger of different forms of political and military pressure, limited episodes, crises and evaluations. Today Norway is facing a complex security policy scenario with several worrying features. Overall the challenges encompass new geopolitical development trends, persistent globalisation challenges linked to terrorism and the spread of weapons of mass destruction, and increasing global environmental challenges. In different ways, all of the challenges could affect Norway and Norwegian interests, while the opportunities, alone, of influencing some of the challenges would be very limited.[196]

In just over 20 years, the security policy situation has gone from superpower rivalry between the USA and the former Soviet Union, via a unipolar order dominated by the USA, to an increasingly more multipolar order in which old and new superpowers compete for economic and political power and influence.[197] As a consequence of the growing multipolarisation, the impression today is that there is an increasing trend towards superpower rivalry in which the territorial state and state security again appear to gain increased importance.[198]

The emergence of new superpowers such as China and India, with regional and, in part, global ambitions, and the revitalisation of a former superpower such as Russia, collectively give rise to increasing unpredictability and a more complex threat assessment.[199] Russia's self-image as an international actor has grown stronger. This is attributed to the agreement on Syria's chemical weapons, among other things. Regional integration in the post-Soviet era remains the country's highest foreign policy priority. The Russian reactions to the Ukraine's approach to the EU in December

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[196] *St.prp. nr. 48 (2007–2008) Et forsvar til vern om Norges sikkerhet, interesser og verdier. [Proposition no. 48 (2007–2008) to the Storting, A Defence Force to Protect Norway's Security, Interests and Assets.]*

[197] *St.meld. nr. 15 (2008–2009) Interesser, ansvar og muligheter – Hovedlinjer i norsk utenrikspolitikk [Report no. 15 (2008–2009) to the Storting: Interests, Responsibilities and Opportunities – Main Features of Norwegian Foreign Policy].*

[198] *St.prp. nr. 48 (2007–2008) Et forsvar til vern om Norges sikkerhet, interesser og verdier [Proposition no. 48 (2007–2008) to the Storting, A Defence Force to Protect Norway's Security, Interests and Assets].*

[199] *St.meld. nr. 15 (2008–2009) Interesser, ansvar og muligheter – Hovedlinjer i norsk utenrikspolitikk [Report no. 15 (2008–2009) to the Storting: Interests, Responsibilities and Opportunities – Main Features of Norwegian Foreign Policy].*

2013, and the subsequent events in the Ukraine in 2014 demonstrated this in its entirety. At the same time, Russia desires to be a "balancing factor" in international politics, and increasingly cooperates with China. China's tremendous economic growth has made the country more self-assertive, but it has also entailed internal challenges and a new and potentially more dangerous conflict dynamic in Asia.[200]

Norway's position in this picture is primarily associated with two dimensions, both of great international, regional and national importance:

- Globalisation challenges and new geopolitical development trends, which emphasise Norway's central position in the strategically important northern regions and which in recent years has attracted increased international attention – politically, financially and environmentally.

- Regional resource management, in which Norway holds a central position regarding both energy and fisheries resources, which means that the country has a much greater strategic weight in the area of resources than its size and population would otherwise indicate.[201]

Risk

A threat consists of the capacity and the intentions possessed by an actor. All of Norway's neighbouring states have military capacities that could inflict extensive damage on Norway. However, there is no concrete or impending threat against Norway today. However, in the worst case, the spread of weapons of mass destruction and long-range weapons can, in the long term, represent extremely serious threats towards Norwegian territory.[202]

Norway's security policy situation is, however, characterised by the country being located in a strategically sensitive area, with NATO, the EU and Russia as central players. The annexation of Crimea and the fighting in the eastern Ukraine have created a great deal of tension in Europe that is of importance to Norway's security. Developments within these actors, and within the UN and the Nordic region, constitute important premises for Norwegian security policy.[203]The possibilities of limited military pressure against Norway in order to change Norwegian policy can never be ruled out. Possible desires from other countries to achieve advantages in the north at Norway's expense cannot be ruled out. Norway could be faced with new episodes and possibly also situations involving a danger of security policy crises being ramped up.[204]

Situations that will also entail challenges for state security cannot be excluded.[205] International interest in the Arctic is increasing in parallel with the ice melting and new sea routes opening. An increasing number of actors are active in the area. There most important individual actor in the area is Russia, which has significant interests of both a financial and strategic nature. The conflict potential in the area is nevertheless considered to be low.[206]

Future challenges to Norwegian security will essentially be different forms of political pressure, or violations and episodes that challenge Norwegian sovereignty. These would most probably be of a limited military scope, but could arise quickly, demanding rapid handling.[207]

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[200] *Norwegian Intelligence Service. "Fokus 2014 [Focus 2014]".*
[201] *St.prp. nr. 48 (2007–2008) Et forsvar til vern om Norges sikkerhet, interesser og verdier. [Proposition no. 48 (2007–2008) to the Storting, A Defence Force to Protect Norway's Security, Interests and Assets.]*
[202] *St.meld. nr. 15 (2008–2009) Interesser, ansvar og muligheter – Hovedlinjer i norsk utenrikspolitikk [Report no. 15 (2008–2009) to the Storting: Interests, Responsibilities and Opportunities – Main Features of Norwegian Foreign Policy].*
[203] *St.prp. nr. 48 (2007–2008) Et forsvar til vern om Norges sikkerhet, interesser og verdier [Proposition no. 48 (2007–2008) to the Storting, A Defence Force to Protect Norway's Security, Interests and Assets].*
[204] *St.meld. nr. 15 (2008–2009) Interesser, ansvar og muligheter – Hovedlinjer i norsk utenrikspolitikk [Report no. 15 (2008–2009) to the Storting: Interests, Responsibilities and Opportunities – Main Features of Norwegian Foreign Policy].*
[205] *St.prp. nr. 48 (2007–2008) Et forsvar til vern om Norges sikkerhet, interesser og verdier [Proposition no. 48 (2007–2008) to the Storting, A Defence Force to Protect Norway's Security, Interests and Assets].*
[206] *Norwegian Intelligence Service. "Fokus 2014 [Focus 2014]".*
[207] *St.prp. nr. 48 (2007–2008) Et forsvar til vern om Norges sikkerhet, interesser og verdier [Proposition no. 48 (2007–2008) to the Storting, A Defence Force to Protect Norway's Security, Interests and Assets].*

Prevention and emergency preparedness

In the security policy field, change can happen rapidly, and all countries must have emergency preparedness for territorial threats, which cannot be excluded although they have low likelihood. The main objective of the security policy is to take care of Norway's fundamental security interests and objectives. Maintaining sovereignty, territorial integrity and political freedom of action are some of those fundamental security interests.[208]

As mentioned, there are no obvious scenarios that emerge as direct threats to basic Norwegian state security.[209] The potential security challenges against Norway, however, will far exceed the country's own defence capability, so Norway for this reason has actively participated in and sought support from the transatlantic security alliance NATO.[210] The cooperation does not only entail a guaranteed response in the event of an attack on one of the member countries, but is also a means of deterrence to prevent an attack taking place.[211] In addition, active investment in the north continues, and in the future great emphasis will be placed on having a military presence in the northern sea areas in order to be able to assert sovereignty and exercise authority.[212] The most important duty of the Norwegian Armed Forces will always be to defend Norway, and the northern areas are still the Government's primary strategic area of focus.[213]

FOTO NTB/SCANPIX

BODØ, JANUARY 2010
In Bodø, two F-16 aircraft are ready 24 hours a day, year round, to perform missions for NATO.

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[208] *Norwegian Ministry of Defence (2009): Evne til innsats — Strategisk konsept for Forsvaret [Capacity for action – Strategic concept for the Norwegian Armed Forces].*
[209] *St.meld. nr. 15 (2008–2009) Interesser, ansvar og muligheter – Hovedlinjer i norsk utenrikspolitikk [Report no. 15 (2008–2009) to the Storting: Interests, Responsibilities and Opportunities – Main Features of Norwegian Foreign Policy].*
[210] *Ministry of Defence: Evne til innsats — Strategisk konsept for Forsvaret [Capacity for action – Strategic concept for the Norwegian Armed Forces] (2009)*
[211] *Norwegian Intelligence Service. "Fokus 2014 [Focus 2014]".*
[212] *Prop. 1 S (2011–2012), Forsvarsdepartementet [Proposition no.1 S (2011-2012) to the Storting, Ministry of Defence].*
[213] *Prop. 1 S (203-2014), Forsvarsdepartementet [Proposition no.1 S (2011-2012) to the Storting, Ministry of Defence].*

SCENARIO

17.1 Strategic Attack

An intentional adverse act in the “security policy crises” risk area may be an attack against a limited number of geographic hubs in Norway.214 A strategic attack is when a state attacks limited geographic areas of a country’[214] A strategic attack is when a state attacks limited geographic areas of a country's territory with the aim of forcing a political change in the country they are attacking.[215] Often the term "warlike actions" is used for a strategic attack. To illustrate how serious the consequences of such an event can be, a consequence analysis has been conducted on a specific scenario in which a foreign state occupies strategic locations in Norway.

The analysis was conducted in the winter of 2010.

Preconditions for the scenario

Capacity

State X has the capacity to maintain the operation for a long period of time.

Intention

- In the opinion of state X, Norway is not managing the fisheries resources in the Norwegian economic zone in a responsible and fair manner, and it finds that Norway is discriminating in favour of itself and certain other European nations.
- The authorities from state X aim to exploit this occupation by forcing the Norwegian authorities to make concessions.

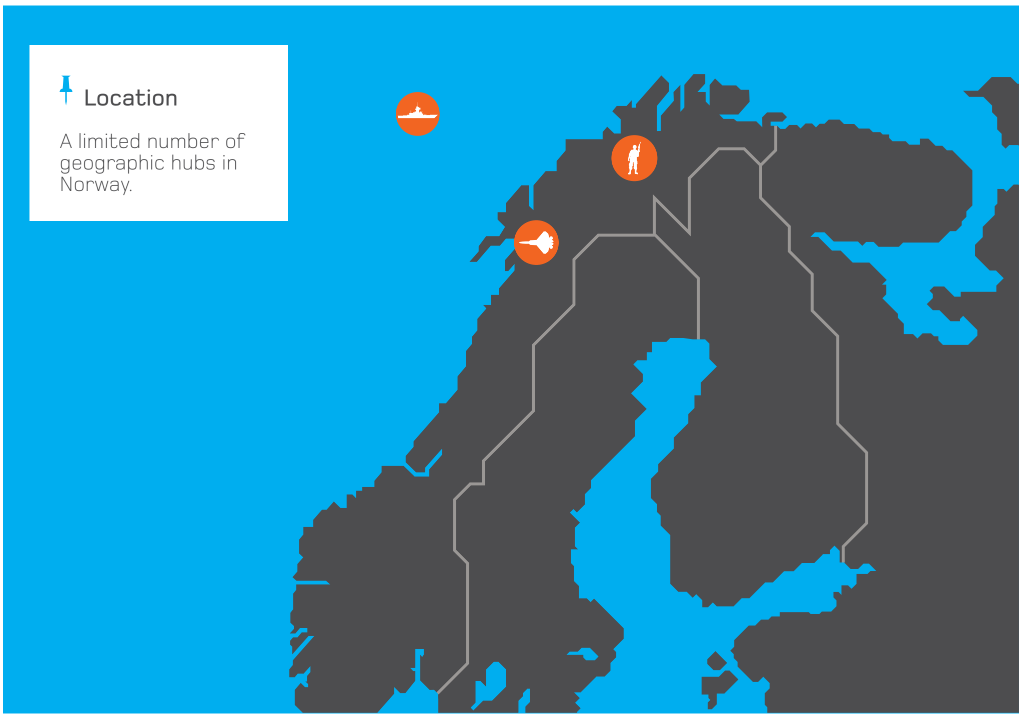
Background

The assumption made for this scenario description is the fact that certain changes have taken place internationally, for example:

- A displacement in the balance of financial power.
- Increasing uncertainty with respect to the security policy guarantees on which Norwegian security police is based.
- Increasing conflict in our vicinity, for example related to climate change and fisheries and petroleum resources.

Course of events

- A crisis is about to escalate between Norway and state X.
- This state X initiates an extensive information campaign during its annual military exercise. It cannot be ruled out that forces participating in the exercise will be used in a ploy to place the Norwegian authorities under pressure by threatening to use military force and to violate the frontier, if it is regarded as appropriate.
- To strengthen the defence of its own military bases and other important infrastructure, state X establishes time-limited control over strategic locations in Norway. An attack on Norway starts when a bomber aircraft violates Norwegian airspace. Then foreign land forces arrive and are distributed among several towns in a geographically limited area of Norway.
- Warships from state X patrol along the coast of the occupied area, and strike aircraft control the airspace in the same area.



Assessment of likelihood

The threat was assessed based on the the work of the Norwegian Defence Research Establishment and assessments made in connection with the risk analysis work. The threat level was assessed as very low, given the threat situation in the autumn of 2010.

Threat assessments give an indication of the possibility of an event occurring. Therefore the threat level indicates a form of likelihood. A threat can be classified on the basis of a rising likelihood or threat level. A very low threat level indicates very low likelihood in the context of the NRA.

TABLE 57. Schematic presentation of the results from the risk analysis

Likelihood assessment						Explanation
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	
There is no known or identifiable threat.	◎					The very low threat level indicates a very low likelihood. The scenario is based on a number of assumptions on international changes.

Consequence assessment							
SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	1.1 Deaths			◎			From 20-100 deaths as a direct or indirect consequence
	1.2 Injuries and illness			◎			100-500 injuries or ill people as a direct or indirect consequence
Nature and the environment	2.1 Long-term damage						Not relevant
Economy	3.1 Financial and material losses					◎	Several hundred billion Norwegian kroner
Societal stability	4.1 Social unrest					◎	Warlike actions on Norwegian soil that will affect the entire population and create reactions such as fear, anger and a feeling of powerlessness
	4.2 Effects on every-day life					◎	Evacuation of a few people may be necessary, critical services and deliveries and the supply of power will not be affected
Capacity to govern and control	5.1 Impaired national capacity to govern				◎		Authorities will have a reduced functional capacity and capacity to govern
	5.2 Impaired control over territory					◎	Authorities lose control both geographically and functionally
OVERALL ASSESSMENT OF CONSEQUENCES						◎	Very large consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

[214] *Point of departure from the reports Hagen, J.M., Fridheim, H. and Grunnan, T. 2010: (U) Sikkerhetspolitisk krise, nasjonal kriseleiing og sivilmilitært samarbeid [Security Policy Crisis, National Crisis Management and Civilian-Military Collaboration.] FFI Report 2010/01009. Kjeller: Norwegian Defence Research Establishment. LIMITED, and Johansen, I. (2006): Scenarioklasser Forsvarsstudie 2007 – en morfologisk analyse av sikkerhetspolitiske utfordringer mot Norge [Scenario Classes in Defence Study 2007 – A Morphological Analysis of Security Policy Challenges to Norway. FFI Report 2006/02664. Kjeller: Norwegian Defence Research Establishment.*

[215] *Ibid, Johansen, I. (2006).*

Assessment of consequences

The social consequences of the given scenario are assessed as very *large* overall. The scenario will primarily threaten the societal assets economy, societal stability and democratic values and capacity to govern. The uncertainty associated with the assessment of the various consequence types varies from *low* to *high* and is altogether assessed as *moderate* compared with other assessments in the National Risk Analysis (NRA).

Life and health

It is assumed that around 25,000 people live in the area that is directly affected. The emergency response capacity with respect to the number of hospital beds will be low, and the hospitals will run out of medicines in the course of a few days. This will increase the number of fatalities. Overall it is assumed that the event will result in 20 to 100 deaths. The number of serious injuries and ill people as a direct or indirect consequence of the event is assumed to be in the category of 100 to 500. Over time those directly involved, such as injured persons, witnesses and relatives, may develop mental disorders. In addition, it is assumed that many people, not just those who are directly affected, will experience post-traumatic stress (strong reactions following traumatic experiences). The longer the event lasts, the greater the possibility of developing disorders such as post-traumatic stress.

Nature and the environment

It is assumed that the security policy crisis scenario will not be of significance to the societal asset nature and culture.

Economy

The total economic losses are assumed to be very large and in the magnitude of several hundred billion Norwegian kroner. Material losses and damages are expected in the occupied areas, and for critical infrastructure in a larger area. There will be large indirect commercial losses as a result of a lack of supply and demand, a reduced workforce, and problems with communication and transport. It is assumed that restoration will take more than one year. A long delivery time for parts and equipment will, for example, contribute to a long restoration period for electronic communications. How long will depend, for example, on international politics.

Societal stability

Not much else will entail greater fear than warlike actions on Norwegian soil. Even though the type of event is recognisable, it is assumed that a strategic attack will create a great deal of fear and anxiety, and also panic reactions, both among the inhabitants in the areas directly affected and in the rest of the population in Norway. This will apply in particular to the portion of the population that has previously experienced war or warlike situations. It is assumed that the situation will be experienced as unclear and threatening, with potential consequences that can threaten the living conditions for future generations in Norway. Even though many people will leave the areas that are directly affected if they have an opportunity to do so, it is assumed that the population will regardless have a perception of being left at the mercy of a course of events that they cannot influence. This will create fear, uncertainty and a feeling of powerlessness. The event also has a potential to affect vulnerable groups, such as children, the elderly and sick, and disabled persons, in particular. The fact that it is an intentional action carried out by a state with "evil intentions" will bring about a great deal of fear and disbelief. Overall the event will create extreme social unrest.

It is expected that a large number of people in the affected areas will move away, if they have the opportunity to do so. It is also assumed that around 10,000 inhabitants will be greatly affected by a potential lack of food. Villages are more vulnerable with regard to the supply of food, partly because there are no emergency stores, and partly because private households do not have food for a longer period of time. Services and deliveries that are dependent on electronic communications, including means of payment, will be not be functional. The supply of fuel will be affected, and navigability and transport will either stop completely or be severely regulated, which will in turn prevent people from coming to work, which will in turn affect the service offerings. Transport by sea or air will also stop completely or be severely regulated. It is assumed that the supply of power will be disconnected in the areas that are directly affected. Overall the event will have very great effects on daily life, and as a whole, it is assumed that the scenario will threaten societal stability to a very high degree.

Capacity to govern and territorial control

Even if the attack is limited geographically, it will have serious national consequences. A strategic attack will lead to the central authorities losing control over parts of the country, geographically and functionally. This will entail a weakened national capacity to govern and weakened territorial control. Since the focus will be completely different from what the central public administration, including the Government, does on a daily basis, it is assumed that the event will affect the exercise of authority to a great extent. There will be a great deal of uncertainty as to how extensive the event is or will become, and thus the capacity to govern will not function normally as long as the event has not been clarified. Depending on the type of sector, it is assumed that the sectors will perform their own tasks. Political freedom of action will be reduced. ◎

TABLE 58. Assessment of the uncertainty associated with the analysis results.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	A threat assessment is based on knowledge of the actors' intention and capacity to carry out the threat. New information can quickly change the threat level and represent grounds for new assessments. There is therefore a great deal of uncertainty associated with the likelihood that intentional events can occur. Consequence assessments are based on extensive research and analysis communities, and access to a great deal of data based on previous security policy crises.
Comprehension of the event that is being analysed (how known and researched is the phenomenon?)	Security policy crises are considered to be a known and researched phenomenon, compared with other events that have been analysed in the NRA.
Agreement among the experts (who contributed to the risk analysis)	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions for the scenario affect the estimates for likelihood and consequences?	The scope of the attack, whether the occupation entails battles/skirmishes on land, at sea or in the airspace are critical assumptions for the consequence assessments. The sensitivity of the results is assessed therefore as high.
Overall assessment of uncertainty	The uncertainty is assessed as *moderate*.

TABLE 59. Placement of the scenario in the risk matrix.

"Strategic Attack" – overall risk

CONSEQUENCES					
VERY LARGE	◎				
LARGE					
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The scenario is assessed as having a *very low* likelihood and *very large* social consequences. The uncertainty associated with the results is assessed as *moderate*.

SERVER ROOM
Cyber attacks are a type of ICT crime, in which the attack is aimed at the ICT systems themselves.

PHOTO: NTB/SCANPIX

18

CYBERSPACE

Background

Cyberspace has experienced booming growth. According to Internet World Stats[216], there were 2.8 billion Internet users in the world in December 2013. In December 2000, there were only 360 million users. However, the number of users is just one dimension of this growth – how the technology is used is another. The development of services on the Internet has been formidable since the turn of the millennium, and most businesses and private persons are dependent on the Internet on a daily basis.

The growth of new services is about to turn in a direction that will create additional dependencies. A trend referred to as the Internet of Things is perhaps the greatest area of growth for exploitation of the Internet. The Internet of Things is a term to describe a development in the direction of a continuously growing number of devices having access to the Internet. For example, pacemakers can be equipped with sensors and monitored via the Internet, and diabetics can be equipped with sensors that monitor their blood sugar levels and automatically adjust the amount of insulin. Examples of more consumer-oriented applications would be refrigerators that let people know when there is no more milk and send a notice to their smart phones, and the updating of the software in cars via the Internet. The areas of application are only limited by our imagination. According to the research firm Gartner Group (2013), there will be 30 billion devices connected to the Internet by 2020, and this excludes PCs, smart phones and tablets.[217]

The service offerings in the cloud continue to grow, and in the wake of this a number of problems arise related to privacy protection, the law and intelligence activities. For example, the Snowden affair revealed that the National Security Agency (NSA) had access to data stored at major American service providers, such as Google. Users no longer have control over their own data in the cloud. If the data are located in a data centre abroad, it must be assumed that the legislation in the country where the data are located is that which actually applies. Access to data in the cloud requires access to the Internet. In situations where access to the Internet is not possible, there will be a risk of losing access to your greatest assets, your own data.

In step with society's dependency on digital services, a network has emerged that illegally attempts to obtain access to information in cyberspace. Such crimes are referred to as cyber crimes, and the methods of attack are varied and

[216] *http://www.internetworldstats.com/stats.htm.*
[217] *Gartner Group (2013). Forecast: The Internet of Things. Worldwide: Gartner Group.*

increasingly more sophisticated and well-organised The attacks use a combination of methods in targeted attacks. The National Security Authority (NSM) points out that economic gain, espionage and patriotism are the most important motives for this type of crime. Those who are behind this range from so-called hacktivists to organised crime and nation states.

One of the NSM's duties is to identify and handle network operations against Norwegian ICT networks. They report that advanced espionage operations against specific targets of high financial or social value are on the rise. The scope of financial crime by non-governmental actors remains at a high level. New and more advanced forms of ICT crime are observed. Online activism and digital vandalism are phenomena that are often seen and which will continue.[218]

Proposition no. 48 (2007-2008) to the Storting states that *"modern society has proven itself to be very vulnerable in relation to attacks in cyberspace which, in the worst case, may cause a total breakdown in vital societal functions such as energy supply, transport, payment services and food supply"*. A relatively new type of cyber attack is aimed at Supervisory Control and Data Acquisition (SCADA) systems, which are process and control systems. It is also an expression of the fact that the competence of the attackers has become very high. Such attacks can affect critical societal functions in that others acquire control over the systems.

Risk

In the annual publication, Global Risks, by the World Economic Forum, cyber attacks were included in the list of the most probable event types for the first time in 2012. In its annual publication, Global Risks, the World Economic Forum has identified cyber attacks as one of the risks with the highest likelihood and highest consequences for the first time in 2013. They do the same in the 2014 edition.

The NSM has noted a great increase in the number of online security events, from around 1,500 in 2011 to 3,900 in 2013. NSM also notes an increasing number of data espionage cases. NorCERT handled 50 serious cases in 2013, compared with 62 cases at the end of the 3rd quarter of 2014.[219] *Et forsvar for vår tid [A Defence for Our Time]*, Proposition 73 (2011-2012) to the Storting points out that cyber attacks are one of the fastest growing threats to private individuals, businesses and public institutions. The attacks are rapid, the methods and tools change quickly, and it is difficult to identify the threat perpetrators. Control and management systems are often developed to function in closed data environments, which means that they are very vulnerable to digital attacks when they are connected to the Internet. In 2013, the newspaper Dagbladet revealed through the Zero CTRL project several vulnerabilities linked to such systems. The owners were often not aware that the system was also available to others.

In today's society, organisations are highly dependent on computer networks and Internet infrastructure. An attack aimed at critical points in the Norwegian Internet structure could therefore cut across multiple sectors and have large consequences for enterprises that are dependent on communications systems that function over the Internet. The loss of critical societal functions will be especially serious.

Successful attacks against SCADA systems, for example, may paralyse or otherwise affect power production, power transmission, refineries, water supply, treatment plants, transport and oil platforms. When unauthorised parties take control of such systems, they are given access to a lot of sensitive and classified information. In the worse case scenario, the systems can be destroyed. Previously, such systems had been isolated computer systems with no connection to any external networks. There appears to be a tendency for systems to be increasingly linked to the companies' other computer networks and in some cases linked directly to the Internet. This makes the systems considerably more vulnerable to intruders taking control of them. Cyber attacks of this nature are rare, but very serious, and extraordinary efforts are required to handle and combat them. In 2010, the NSM discovered for the first time that Norwegian companies had been subjected to so-called "Trojans", which had been specially designed to take control of SCADA systems in Norway.[220]

"In 2014 the NSM assessed that national assets were still exposed to a significant risk of espionage, sabotage and terror". Some of the NSM's observations are:

- Enterprises do not value their information highly enough, and information worthy of protection is stored and processed in unclassified networks.
- Enterprises purchase commercial security products

[218] *Sikkerhetstilstanden 2014 [Security Status 2014]. Norwegian National Security Authority.*
[219] *Norwegian National Security Authority. 2nd/3rd Quarter Report 2014.*
[220] *Aftenposten 29 august 2010, "Norge utsatt for nytt datavåpen" – "Målrettet angrep mot vann, olje og gass [Norway subject to new cyber weapon – Targeted attack on water, oil and gas]".*

that are not suitable for stopping anything but known malware.
- Some enterprises do not install the necessary security upgrades.
- It is too easy to obtain access to critical computer systems, either physically or through the Internet.
- Many enterprises do not have dedicated security groups.
- Already established groups do not have the necessary emergency planning and crisis management competence.
- As many as a third of the supervisory objects could not provide documentation of the necessary security approval for classified information systems.[221]

According to the Norwegian Intelligence Service (NIS)[222], several states have developed advanced malware for the purpose of destroying infrastructure, interfering with important societal activities or affecting decision-making and information processes. Several states use cyberspace primarily for the collection of information.

The lack of security awareness among computer users is a challenge. Many enterprises and individuals underestimate this risk. The NSM concludes that enterprises are more willing to accept risk beyond what the NSM considers justifiable for society. The high risk acceptance is often due to the management's inadequate risk comprehension. The management has to acknowledge that their own enterprise may be exposed. Only then can they introduce risk-reducing measures.

Prevention and emergency preparedness

Thorough risk analyses are necessary in order to improve the level of security. Awareness of what represents an acceptable degree of risk is the basis for determining an adequate and acceptable level of baseline security, and a good risk assessment provides a basis for implementing necessary and sufficient security measures. Risk analyses must also form the basis for compensatory measures beyond baseline security for heightened preparedness.[223]

In order to implement relevant risk-reducing measures, you must perform a valuation first. How much is the information worth to the enterprise? How bad would it be if an unauthorised party got hold of it? System separation is an important risk-reducing measure, i.e. to have sealed bulkheads between computer networks that are used for controlling the computers and computer systems that are used for communication with the outside world. The NSM has capacities to assist with prevention and the handling of network operations in both the public and private sectors. In addition, a national information security strategy that public agencies are required to observe has been prepared.[224] The individual system owner or user is, however, responsible for taking care of his own security.

The Norwegian Cyber Force ensures that military systems are secure and assists with their unique expertise if civil authorities request assistance. The responsibility of the intelligence service is to prevent and maintain an overview of threats from abroad, while the police – the Norwegian Police Security Service (PST) and National Criminal Investigation Service (Kripos) in particular – are responsible for domestic threats and investigating cyber crime[225].

The public electronic communications infrastructure is managed by the Norwegian Post and Telecommunications Authority (PT), but it is owned by private actors with Telenor as clearly the largest actor. Telenor's infrastructure is nationwide, and Broadnet is the only other actor that has its own national transport network. This means that all other providers are dependent on Telenor and Broadnet for the provision of their services. Pursuant to Section 2-10 of the Electronic Communications Act, the providers are required to ensure a proper level of security for their electronic communications networks and services. ◎

[221] *Sikkerhetstilstanden 2014 [Security Status 2014]. Norwegian National Security Authority.*
[222] *Fokus 2014 [Focus 2014], Norwegian Armed Forces Intelligence Service.*
[223] *Sikkerhetstilstanden 2014 [Security Status 2014]. Norwegian National Security Authority.*
[224] *Nasjonal strategi for informasjonssikkerhet [National Strategy for Information Security] (2013), Government.*
[225] *www.forsvaret.no.*

SCENARIO

18.1 Cyber Attack on Financial Infrastructure

An intentional adverse act in the "cyberspace" risk area could be an extensive attack that affects all the payment terminals in Norway, at the same time as a coordinated and massive network attack is launched against online Norwegian banks. To illustrate how serious the consequences of such an event can be, a consequence analysis has been conducted on a serious scenario.

The analysis was conducted in the autumn of 2010.

Preconditions for the scenario

Intention

It is not clear if profit is the motive for the attack.

Capacity

- The complexity and scale of the attack means that only organisations or actors with substantial resources can implement such attacks.
- Card services do not operate over open networks, which means that the attack on payment terminals probably requires assistance from actors on the inside.

Time

Occurs on a Friday evening and lasts for a week.

Course of events

- An extensive cyber attack that affects all the payment terminals in Norway.
- At the same time there is a coordinated, massive network attack on online Norwegian banks.
- It is a DDoS (distributed denial of service) attack that is carried out by means of poorly secured computers that have been infected by malware and used in a botnet.[212]

Assessment of likelihood

The Cyber Attack on Financial Infrastructure was assessed as a possible, but not very probable threat. An attack has never been carried out on the scale described here, and there is some uncertainty as to who has the capacity and intention to commit an act of this sort. The complexity indicates that only organisations or players with significant resources can implement such attacks. The limited number of relevant players and the need for "inside help" to carry out the attack indicate that the likelihood of the threat is low.

Threat assessments give an indication of the possibility of an event occurring. Therefore the threat level indicates a form of likelihood. A threat can be classified on the basis of a rising likelihood or threat level. The fact that the scenario was assessed as possible, but not very probable threat, indicates a low likelihood in the context of the NRA.

TABLE 60. Schematic presentation of the results from the risk analysis

Likelihood assessment						Explanation
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	
There is a known and possible, but not very probable, threat.		◎				The limited number of relevant players and the need for "inside help" to carry out the attack indicate that the likelihood of the threat is low

Consequence assessment							
SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Death						Not relevant
	Injuries and illness						Not relevant
Nature and the environment	Long-term damage						Not relevant
Economy	Financial and material losses				◎		NOK 5-50 billion
Societal stability	Social unrest					◎	High degree of predictability, very large scope, difficult to avoid, reactions such as fear, aggression and mistrust
	Effects on daily life					◎	A means of payment will be disabled, disruptions/failure of critical services and deliveries, reduced navigability
Capacity to govern and control	Weakened national capacity to govern			◎			Payment systems disabled, weakened financial institutions
	Weakened territorial control						Not relevant
OVERALL ASSESSMENT OF CONSEQUENCES					◎		Large consequences overall

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

Assessment of consequences

The social consequences of the given scenario are assessed as *large*. The scenario will primarily threaten the societal assets economy, societal stability and national capacity to govern. The uncertainty associated with the assessment of the various consequence types varies from *moderate* to *large* and is assessed as *moderate* compared with other assessments in the National Risk Analysis (NRA).

Life and health

No direct consequences are anticipated for life and health from this scenario. Necessary emergency medical treatment will be given in compliance with the public authorities' guidelines, and it is assumed that people who are dependent on medicines to survive are assumed to receive these despite not having the capacity to pay.

Nature and the environment

It is assumed that the cyber attack scenario will not be of significance to nature and culture.

Economy

Like the systems in the other Nordic countries, the Norwegian system is characterised by the links between the banks being based on electronics in a completely different manner than in the USA, for example. The Norwegian bank system is therefore particularly exposed if anyone were to succeed in taking control of or destroying this system. If the financial " blood circulation" is affected, it is assumed that it will result in financial losses of NOK 5–50 billion. It is primarily the financial losses that are expected to be large, and the scenario will, for example, entail a week of of greatly reduced national sales, reduced foreign trade and indirect commercial losses.

Societal stability

It is expected that the scenario will cause significant social unrest. There is reason to believe that the scale of the attack will create fear that bank deposits may disappear. The duration and the situation being unclear for a week will contribute to insecurity and anger. It is assumed that "irrational" financial transactions and hoarding/raiding will occur. Individuals will feel that they are "caught in a trap" without being able to influence the situation, and this will contribute to a feeling of powerlessness. Due to the fact that it was an intentional event by someone with "evil intentions", it is assumed that it will bring about reactions such as fear, disbelief and anger. At the same time, there will be great expectations for the authorities' ability to handle the situation, and the question of responsibility and "scapegoats" will arise. This can result in reactions such as anger and mistrust.

The population will experience substantial strains on their daily life. Several hundred thousand people will experience that their daily life must be organised differently than normal. A means of payment will be crippled, and it will not be possible, for example, to use payment cards in shops or other establishments. The ATMs will run out of money and all that will be left are any cash holdings. Normal sales of household articles and fuel will stop, and the situation could become relatively chaotic. Important systems, such as the NAV system, will be challenged. Transport problems as a result of the inability to pay for transport and fuel will increase while the event is taking place. The scenario will threaten societal stability to a great extent. The authorities' handling of the situation and their ability to communicate and organise extraordinary measures will influence the consequences.

Capacity to govern and territorial control

Cyber attacks on financial institutions and payment systems could also mean a reduced capacity to function and govern for the central Norwegian authorities and associated institutions. It is assumed that the scenario will not *be* of significance to territorial control. ◎

TABLE 61. Assessment of the uncertainty associated with the analysis results.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience.	A threat assessment is based on knowledge of the actors' intention and capacity to carry out the threat. New information can quickly change the threat level and represent grounds for new assessments. There is therefore a great deal of uncertainty associated with the likelihood that malicious acts can occur. In the consequence assessments, information is used from research and analysis communities and security authorities with access to data, experience from events – but an action has never been carried out on this scale.
Comprehension of the event that is being analysed (how known and researched is the phenomenon?)	Cyber attacks are well-known among the experts, but little known among the population, a lot of research – but rapid development of technology and no experience with an attack on this scale.
Agreement among the experts (who have participated in the risk analysis).	No major disagreements among the experts.
Sensitivity of the results	
To what extent do changes in the assumptions for the scenario affect the estimates for likelihood and consequences?	The duration and the authorities' ability to provide information and manage the situation are critical assumptions for the consequence assessments. The sensitivity of the results is assessed therefore as high.
Overall assessment of uncertainty	The uncertainty is assessed as *moderate.*

TABLE 62. Placement of the scenario in the risk matrix.

"Cyber Attack on Financial Infrastructure" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE		◎			
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The scenario is assessed as having a *low* likelihood and *large* social consequences. The uncertainty associated with the results is assessed as *moderate*.

SCENARIO

18.2 Cyber attack on electronic communications infrastructure

The scenario encompasses an attack on Telenor's transport network, which goes down for five days. Since Broadnet and Telenor share some infrastructure in their transport networks, Broadnet will also drop out for five days. A transport network is the portion of the infrastructure that links connections over long distances. In Norway, only Telenor and Broadnet own national transport networks.

The scenario was prepared by the Norwegian Post and Telecommunications Authority (PT) and the Norwegian Defence Research Establishment (FFI) based on an outline from the National Security Authority (NSM). The risk analysis was conducted in the summer/autumn of 2014.

Preconditions for the scenario

Intention

No known motivation for any actors at present.

Capacity

- A successful attack as outlined in the scenario is very challenging and requires a very high level of competence and capacity.
- Such competence and technical capacity is only found among a limited number of actors at present.

Specific event

- A logical attack on central nodes in Telenor's transport network.
- The cyber attack is an attack on Norway, in which it is expected that other measures will be implemented.
- The attack destroys both physical components and important software, which results in the loss of the nationwide transport network.

Comparable events

- Loss of Telenor's mobile network, June 2011, concurrent with a major flood in Eastern Norway. The entire country was affected for 18 hours.
- Landlines and Netcom's and Telenor's mobile network went down in Northwestern Norway during the storm Dagmar in December 2011 due to a power failure, loss of base stations and cable breakage due to a landslide.

Time

A Monday in September

Duration

- All electronic communications services are lost for five days.
- Subsequent period of instability with gradual normalisation in the course of a month.

Consequential events

- Telephone and data services, such as telephony and the Internet, drop out throughout the entire country, including international connections.
- Failure of critical societal functions. See Figure 17 and a more detailed discussion on page 191.

Due to the complexity of the scenario, the analysis was divided into two parts. The first part consisted of a vulnerability analysis, in which it was surveyed how the loss of electronic communications affects other critical societal functions (consequential events). In the second part, an assessment was made of the overall consequences for the population of both the loss of electronic communications and the consequential events.

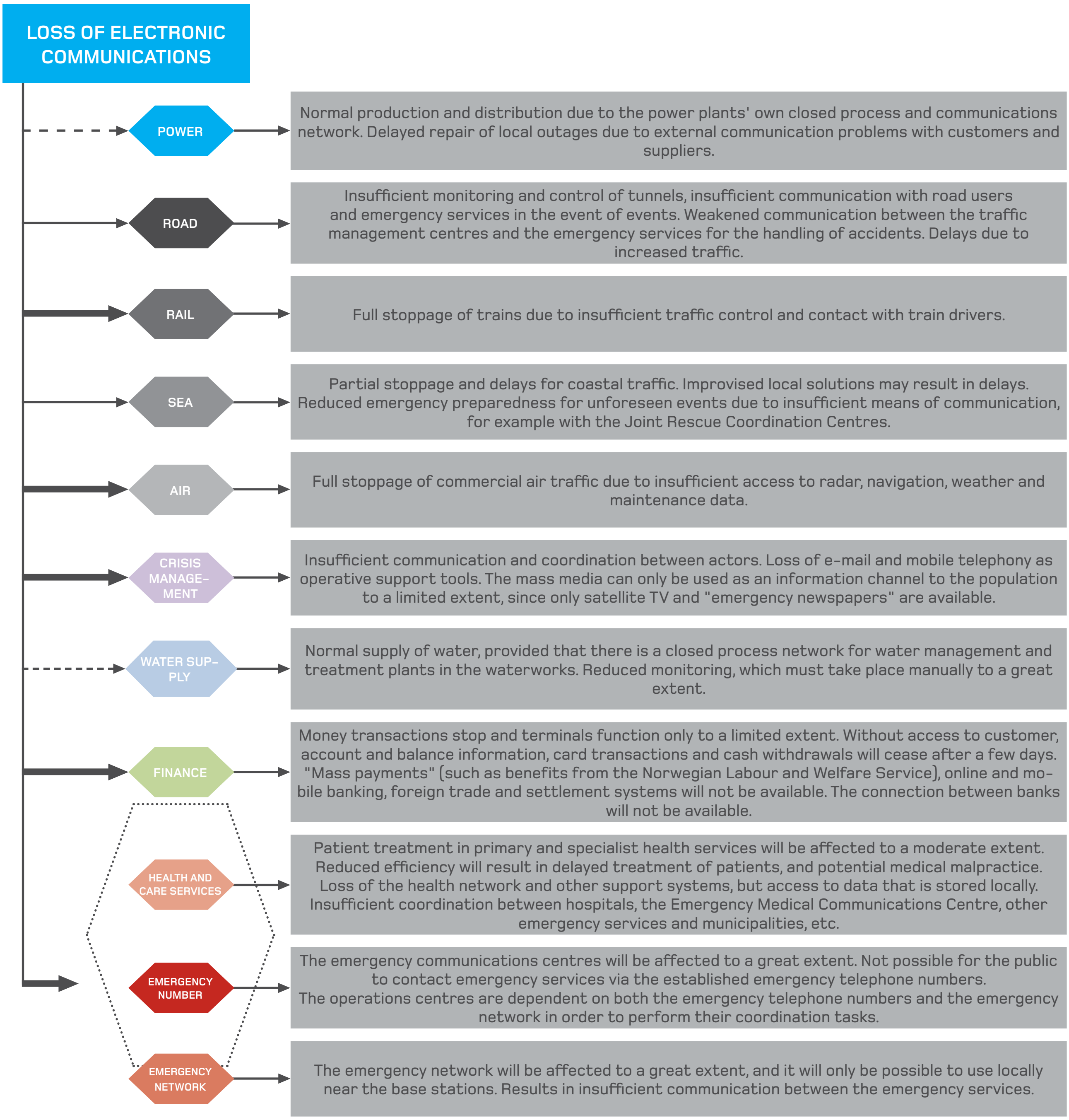


FIGURE 17. The figure shows how the loss of electronic communications affects other critical societal functions and results in serious consequential events. A thick line indicates a large effect, a thin line indicates a moderate effect and a dotted line indicates a small effect.

The critical societal functions that have been assessed have been selected based on the KIKS model, which describes critical infrastructure and critical societal functions (DSB 2012). Only the societal functions (and the input factors) that are assumed to be most affected by the scenario and can have consequences for the defined societal assets in the NRA have been assessed. The functions have been assessed sector by sector, as reflected in Figure 17.

Conclusions of the vulnerability analysis

Of the nine societal functions examined, two are affected to a limited extent, two are affected to a moderate extent and five are affected to a great extent. The consequential events are described in greater detail in a separate report, in which the mutual influence of the consequential events is assessed.[226] A point-by-point summary of the main conclusions from the vulnerability analysis follows below.

1. A failure of the nationwide transport network for electronic communications results in a number of consequential events that may have serious consequences for the population.
2. The transport sector, health sector and finance sector are those most affected by the loss of electronic communications.
3. Handling the crisis at the political and administrative levels is less affected, due to lack of opportunities for communication and coordination.
4. Important information channels to the public are lost. NRK radio and TV will not be able to broadcast, but satellite transmissions from abroad can be received and some emergency newspapers can be published.
5. The rescue efforts by the emergency services, Joint Rescue Coordination Centres and others will be significantly reduced because telephone communications are down and the emergency numbers and Emergency Network do not function. Society will be very vulnerable to other simultaneous events during the loss of electronic communications.
6. The infrastructure for electronic communications is complex, and it is difficult for actors responsible for critical societal functions to keep track of all the dependencies. The nationwide transport network is essentially very stable, but it represents a possible common source of error for many electronic communications services.
7. There are no reliable backup solutions with adequate capacity to fulfil the need for communication in the event of the loss of the nationwide transport network. The capacity and range of satellite and radio communications is limited.
8. Dependence on electronic communications is increasing rapidly. The propagation of IP telephony, smart phones, cloud services and the "Internet of Things" is taking place at a rate controlled by the market.
9. Only a few enterprises that have their own dark fibre will be able to continue to function when the transport network is down, such as the Norwegian Armed Forces, power plants, the Metro in Oslo and the health trusts under the South-Eastern Norway Regional Health Authority.

Assessment of likelihood

Both the Norwegian Police Security Service (PST) and the Norwegian Intelligence Service (NIS) write in their open assessments about government actors who develop advanced digital intelligence capacities and malware that can be used in cyberspace. Government actors have the capacity to cause substantial damage through sabotage, and digital operations can be aimed at infrastructure or control systems and cause disruption, physical damage or destruction. In general, it is the infrastructure for power production and distribution and communications that represent the most vulnerable targets. Several countries have established a significant capacity to conduct operations in the domain of cyberspace.[227]

Conducting a successful cyber attack as outlined in this scenario is very challenging and requires a very high level of competence and capacity. It is assumed that such capacity is found among a few actors. It is, however, difficult to find any reasonable motivation for such an attack against Norway. It can therefore be maintained that there is *a possible, but not very probable threat* of this specific cyber attack against the transport network for electronic communications in Norway.

Threat assessments give an indication of the possibility of an event occurring. Therefore the threat level indicates a form of likelihood. A threat can be classified on the basis of a rising likelihood or threat level. In the NRA the category, *very low likelihood* corresponds to there not being any known threat. In this scenario, there is a possible and known threat, and the assessment is therefore that the likelihood for this scenario is low in an NRA context.

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226 *DSB (2014). National Risk Analysis: Scenario "Cyber Attack on Electronic Communications Infrastructure" – Critical consequential events and consequences in the population.*

227 *Norwegian Police Security Service (2014). Open threat assessment 2014 and the Norwegian Intelligence Service (2014). The Norwegian Intelligence Service's assessment FOKUS 2014 [FOCUS 2014].*

If the scenario had been more complex, for example, a simpler cyber attack in combination with a physical attack aimed at special points in the electronic communications infrastructure, the likelihood would have been higher, without the consequences necessarily being less serious. Other variants of a cyber attack scenario with less physical destruction of nodes and components could also be more probable. In this analysis, however, we wanted to look at the consequences of a very comprehensive and serious loss of electronic communications.

The level of uncertainty associated with the assessment of likelihood is considered to be high. Less serious cyber attacks take place daily in Norway and comprehension of the phenomenon is good. However, we have no experience with such an extensive cyber attack as in this scenario. Even if the threat from other states or terrorist organisations seems to be low today, both the security policy situation and threat of terrorism are something that may change.

TABLE 63. Schematic presentation of the results from the risk analysis

Likelihood assessment	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	Explanation
There is a known and possible, but not very probable, threat that the event can occur.		◎ (high uncertainty)				Only a limited number of actors have the capacity, but there is no known intention.

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MODERATE	LARGE	VERY LARGE	
Life and health	Death			◎ (high uncertainty)			50 additional deaths as a result of an the lack of means to call for an ambulance and notify the emergency services in the event of acute events.
	Serious injuries and illness			◎ (high uncertainty)			200-300 serious injuries and illness as a result of delayed treatment or malpractice.
Nature and the environment	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct financial losses				◎ (moderate uncertainty)		Repair and replacement costs associated with destroyed system components of NOK 2-10 billion.
	Indirect financial losses					◎ (moderate uncertainty)	Loss of income, delay costs, production losses and reduced trade result in an overall loss of approximately NOK 10 billion.
Societal stability	Social and psychological reactions					◎ (high uncertainty)	Insufficient information from the authorities, weakened crisis management and an unknown and malicious act create unrest and anxiety.
	Effects on daily life				◎ (high uncertainty)		Insufficient access to telephone and data services and means of payment. Freight and passenger transport delays.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern				◎ (moderate uncertainty)		Attack on very important infrastructure, which carries society's capacity to govern. Ability of central institutions to function is threatened. Violation of democratic values and individual rights.
	Loss of control over territory						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎ (high uncertainty)		High (to very high) consequences overall.

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

Assessment of consequences

Only the consequences of the loss of electronic communications have been assessed, and not any acts of war that the cyber attack is a part of. Overall, the consequences of the loss of electronic communications and the consequential events are assessed as high to very high on a scale that is used in the National Risk Analysis. The scenario entails significant consequences for all five societal assets with the exception of nature and culture. The consequences have been described in greater detail in a separate partial report.[228]

Only the consequences during the five-day period when the transport network is completely down have been assessed. During the restoration period (from a few days to a month), however, there will be limitations in the network. The uncertainty associated with the various consequence assessments varies from moderate to high, and the overall uncertainty is assessed as high.

Life and health

Several consequential events may have consequences for life and health: Lack of opportunity to notify the emergency services on the emergency telephone numbers in the event of acute events, no possibility to call an ambulance in the normal manner, inadequate communication and coordination between the emergency services because the Emergency Network only functions locally, as well as reduced efficiency and delayed treatment of patients in the health and care sector.

The assessment of the number of deaths is based on the fact that there are 240 emergency ambulance calls nationwide in a normal situation, which is assumed to reflect the number of persons who are seriously ill or injured and require immediate medical treatment. An assumption is made in the analysis that around five per cent of those who are acutely ill or injured will die due to delayed treatment.

When the emergency numbers cannot be used, an ambulance must be called by other means or replaced by transport in a passenger car. This is assumed to take one half to one hour longer than normal transport by ambulance. Delayed medical treatment will be critical in some cases. *This means that the scenario will result overall in approximately 10 more deaths per day or approximately 50 deaths during a five-day period.* This represents an increase of approximately 10 per cent in relation to the normal daily death rate. It is assumed that any deaths or injuries due to delayed rescue efforts by the fire service or police will be included in the number of ambulance calls, since ambulances are called for any events where life or health are at risk.

The loss of electronic communications can result in the delay of scheduled treatment due to the reduced efficiency and possible medical malpractice as a result of the unavailability of patient information (core records, case summaries and laboratory results) that are available on a public network. In order to assess the number of persons who will become significantly sicker, it is assumed that the hospitals receive 1,450 patients daily for scheduled treatments. Between 40 and 70 of these patients are cancer patients. We assume that half of all the scheduled treatments will be postponed until the situation has normalised. We also assume that one to two weeks' delay will in most cases have little effect, but that it may worsen the outcome for cancer patients. *During a five-day period, we assume that 200-300 persons will become significantly sicker as a result of the reduced level of treatment*.

Uncertainty associated with the estimates for the number of additional deaths and illnesses is considered high, since it is difficult to predict exactly how the hospitals, Emergency Medical Communications Centre and the rest of the national health service will handle such a situation in practice. The health sector does not have any experience with long-term and extensive loss of communications as in this scenario. Experience shows that unexpected problems are solved in new ways, but it is difficult to estimate the effect of these solutions in advance.

Nature and the environment

It is assumed that the scenario that is analysed will not entail any long-term damage to the natural environment or irreparable damage to the cultural environment unless there are concurrent events, such as fire or accidents with acute pollution.

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[228] *DSB (2014). National Risk Analysis: Scenario "Cyber Attack on Electronic Communications Infrastructure" – Critical consequential events and consequences in the population.*

Economy

It is assumed that the direct financial losses will be NOK 2 to 10 billion and that they will be associated with the necessary repair and replacement of physical components and infrastructure, as well as with returning the electronic communications networks to working order.

The indirect financial losses will be associated with loss of income, production losses and a decline in consumption, orders and deliveries. Production in the country will decline as a result of inadequate logistics, workforce, orders, deliveries and raw materials. All trade and industry will be operating "at slow speed". A functioning payment system is a prerequisite for being able to pay for the delivery of goods and services, as well as the trading of financial instruments. Without working logistics and payment systems, grocery trade revenue will decline, especially in the larger cities. Fresh produce and online trading will be especially affected.

The finance sector's emergency solutions may reduce the amount of damage if the network functions intermittently, but if the communication fails completely, all financial transactions will stop. If the circulation of money stops, it will affect the finance sector, trade and industry, the public and public enterprises. It is assumed that the fact that financial registers and common national components such as the Central Coordinating Register for Legal Entities[229], land register[230] and Altinn[231] will not be functioning will result in delay costs.

Based on the gross national product (GNP) for 2013, which was approximately NOK 3,000 billion, overall production in Norway during a period of five days will be approximately NOK 40 billion. It is assumed that around a third of the normal production (approximately NOK 13 billion) will be lost as a result of the loss of electronic communications. *Even if some of the lost revenue can be recouped, it is assumed that the net loss will exceed NOK 10 billion.* Of this loss, the loss of income by the electronic communications providers will be NOK 3 to 5 billion, based on the normal level of revenue for a five-day period.

Uncertainty associated with the assessment of financial losses is assessed as moderate. In some sectors there is data that can be used to estimate the delay costs, etc.

Societal stability

It is assumed that the scenario will result in major social and psychological reactions, such as unrest, uncertainty, fear, feelings of powerlessness and mistrust of the authorities.

Suspicion that this is an intentional cyber attack against Norway will mean that the event will be experienced as *strange and frightening*. Neither the causes, duration or extensive consequential events are known, and the attack occurs without warning. *The sick and elderly* are affected to a greater extent than others due to their dependency on phones for contact with the outside world and health and care services. People in acute emergency situations will not be able to contact the police, ambulance service, causality clinic or fire services at the emergency telephone numbers. This is assumed to result in a feeling of a lack of control over one's own situation and weakened trust in the authorities.

Crisis management will be very complicated due to the lack of information channels to the population. Communication among the emergency preparedness actors must take place by means of backup systems that have a very limited capacity. This applies both to VHF radio and handheld satellite phones. The Norwegian Armed Forces Communications Infrastructure (FKI) is dependent on the national transport network to a significant degree. The connection to FKI for other emergency preparedness actors is often dependent on public infrastructure, which will not work. NRK radio and TV will drop out, and only satellite broadcasts from abroad[232] and emergency editions of certain newspapers can be used as information channels to the population. *The lack of information* from the authorities and normal contact with others will contribute to social unrest. In addition, it is assumed that people will have high expectations for the ability of the authorities to prevent and handle such an event. These *expectations will not be met*.

People will react differently to the crisis. After a few days, it is assumed that the concern and uncertainty will result in the hoarding of food, which will further reinforce the unrest. Norway is a country in which the population has a high level of trust in the authorities and in each other, which dampens the level of fear,[233] but it is assumed at the same time that solidarity and unity requires that their own basic needs are met.

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[229] *The principal task of the main Central Coordinating Register for Legal Entities (ER) is to coordinate information on business and industry and government agencies that exists in the various public registers.*
[230] *The Land Register contains master data on real property, and it is an amalgamation of the Property, Address and Building Register and the Digital Property Map.*
[231] *Online solution for public reporting.*
[232] *Approximately 30% of the population had a satellite dish in 2012.*
[233] *Cf. Skirbekk and Grimen "Tillit i Norge [Confidence in Norway]", Res Publica (2012).*

The entire *freight transport chain* is dependent on online systems and large delays in the delivery of goods will arise. Most stores have access to two to four weeks of stock at a normal trading level. Fresh produce will, however, be depleted during the five-day period and people will start to hoard food. The stocks of groceries kept by most households together with the food available in stores will hardly result in any extensive lack of food. Payment terminals are dependent on electronic communications in order to function normally, but they can store over 1,000 transactions locally, which means they can be used to some extent. It is assumed that approximately one-fourth of the population in the major cities (an estimated 250,000 persons), will experience problems and significant inconvenience because they *do not have any means of payment* during the period.

Passenger transport will be impacted by the stoppage of air traffic affecting approximately 700,000 passengers, and the stoppage of train traffic affecting approximately 100,000 passengers during the five-day period. If 100,000 air passengers and almost all the train passengers travel by car instead, we will have an increase in road traffic of 40,000 daily trips. We assume that 30,000 of the new daily trips will take place in major cities that already have capacity problems during rush hour. If 20,000 of the new trips take place in the Oslo region, there will be delays, but no traffic chaos. Normally, there are 180,000 trips per day in Oslo, and an additional 20,000 trips will represent an increase of approximately 10 per cent. We assume that other major urban areas will experience the same percentage increase.

The increase in the number of short car trips to compensate for the lack of electronic communications is difficult to estimate. They are estimated, however, to be in the same magnitude, i.e. approximately 10 per cent and increasing as the five-day period progresses. It is assumed that the greatest increase in road traffic will be in Oslo and other major urban areas. An estimated 1 million people will experience road traffic delays of up to 30 minutes per trip.

Access to *drinking water from waterworks* will only be affected to a limited extent by the loss of electronic communications. It will result in insufficient notification and delayed repair of local faults in the waterworks or distribution grid. It is assumed that up to 5,000 persons will not have clean drinking water in their taps during the five-day period. It is assumed that overall the scenario will result in *major effects on daily life*.

The uncertainty associated with the assessment of both social and psychological reactions in the population and to effects on daily life is assessed as being *high*.

Democratic values and capacity to govern

The scenario is a targeted attack on one of the country's most important infrastructures, which is a carrier for society's capacity to govern. Based on an assessment of the above characteristics, it is assumed that the *scenario will to a great extent entail the loss of democratic values and the national capacity to govern for a limited period of time*.

In addition to a weakening of the capacity of central institutions and national institutions elected by the people to perform their intended duties, the Storting [Parliament] and Government must handle being under attack by a foreign power. It will be possible to make decisions, but the information basis will be insufficient, and the implementation of decisions will be difficult. The loss of electronic communications will make crisis management difficult. The Norwegian Armed Forces will have an important role in handling the attack against Norway, and they will receive assistance from NATO for this. The central administration, finance sector and the press will not be able to perform their ordinary tasks and intended functions either. This particularly applies to specific emergency preparedness actors with defined crisis management duties.

If people know that the cause is an intentional attack on Norwegian society, the event could be perceived as a *violation of shared cultural and democratic values*. The event may also be perceived as a violation of fundamental individual rights and personal security. Individual citizens will be deprived of the opportunity to have normal contact with social institutions that are essentially supposed to take care of them and contribute to their safety, whether it be the health and care sector, emergency services, Norwegian Labour and Welfare Service or their closest social and family network. People will to a great extent be directly affected by the loss of electronic communications and its consequential events, and the consequences are experienced as being very close-range. The feeling of safety among the population is weakened.

The scenario does not entail any direct loss of geographic territory, but it results in weakened control over their own services in cyberspace. The stoppage of air and train traffic may result in smaller geographic areas becoming isolated from the rest of the world.

The uncertainty associated with democratic values and capacity to govern is assessed as moderate. For assessment of whether the event entails a violation of democratic values and the national capacity to govern, the most critical factor is whether the cause of the loss of electronic communications is an intentional event (attack on Norway) or is an unintentional failure.

Follow-up

The loss of electronic communications services can be caused by both intentional and unintentional events. Regardless of the likelihood, society must be prepared to face the consequences of an extensive loss of electronic communications.
The vulnerability analysis shows that five of the nine critical services and functions will be affected to a great extent. This says something about:

- Society's dependency on electronic communications services.
- The dependency of the electronic communications services on the nationwide transport network.
- The need for an overview of the dependence of one's own services on electronic communications.
- The need for well though-out preparedness in the event of a long-term loss of electronic communications.
- The central role of the municipalities to provide for the security and safety of the population in the event of a long-term loss of electronic communications.

The analysis results point out a need that enterprises responsible for critical societal functions at the various administrative levels:

- Must include the loss of electronic communications in their risk and vulnerability analyses in order to establish an overview of the likelihood that it can occur, vulnerabilities, dependencies and consequences for their own production of services.
- Must assess whether the actual capacity of the backup solutions for communication will meet the need (for example, the capacity and range of satellite and radio communications).
- Must ensure having necessary insight into the dependence of their own electronic communications services on the nationwide transport network.
- Must ask whether their emergency preparedness is good enough for the services they are responsible for performing.
- Must assess the need for the establishment of new barriers and measures.
- Must conduct exercises for the scenario of a total loss of all electronic communications services.

In addition, the analysis results point out that the municipalities:

- Must consider establishing routines for communication within their own municipality when the telephone and data network is down for several days. Especially important is a system for the population to contact the police, Emergency Medical Communications Centre and fire service in emergency situations. ◎

TABLE 64. Assessment of the uncertainty associated with the analysis results.

Uncertainty assessment	
INDICATORS OF THE KNOWLEDGE BASE	**EXPLANATION**
Access to relevant data and experience	A threat assessment is based on knowledge of the actors' intention and capacity to carry out the threat. New information can quickly change the threat level and represent grounds for new assessments. There is therefore a great deal of uncertainty associated with the likelihood that malicious acts can occur. Several prerequisites, such as the intention and capacity of the attacker, must be present in order for the cyber attack to succeed. The level of threat from other states or terrorist organisations appears to be low today. However, both the security policy situation and the threat of terrorism are situations that can change. There are therefore many factors that can contribute to uncertainty about how likely it is that the scenario will occur. The assessment of consequences is based on experience from smaller cyber attacks and less extensive losses of electronic communications. We have no experience, however, with the loss of the entire national transport network and the extensive consequential events and consequences that this entails.
Comprehension of the event that is being analysed (how well known and researched is the phenomenon?).	Smaller cyber attacks are a well-known phenomenon, but we do not have any experience with such an extensive loss of the national transport network. The scenario entails extensive consequential events for a number of critical societal functions, and the overall consequences are very complex and intricate. We do not have any previous knowledge of such a situation.
Agreement among the experts (who participated in the risk analysis)	No major disagreement among the experts who have contributed to the analysis.
Sensitivity of the results	
To what extent do changes in the assumptions affect the estimates for likelihood and conse-quences?	The duration of the loss of the nationwide transport network and the duration of the restoration period are decisive for how serious the consequences will be. Any concurrent events, such as a storm, power outage or major accident, will have far greater consequences than normal due to the lack of communication opportunities and reduced emergency preparedness.
Overall assessment of uncertainty	The uncertainty associated with the threat and consequence assessments is assessed overall as*high.*

TABLE 65. Placement of the scenario in the risk matrix.

"Cyber Attack on Electronic Communications Infrastructure" – overall risk

CONSEQUENCES					
VERY LARGE					
LARGE		◎			
MODERATE					
SMALL					
VERY SMALL					
	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH

LIKELIHOOD

Low uncertainty ◎ Moderate uncertainty ◎ High uncertainty ◎

The scenario is assessed as having a *low* likelihood and *high (to very high)* social consequences. The uncertainty associated with the results is assessed as *high*.

OVERALL RISK ASSESSMENT

KVAM, MAY 2013
The river Storåa at flood level passes under the railway in the centre of Kvam in Gudbrandsdalen.

PHOTO: NTB/SCANPIX


PHOTO: NTB

PHOTO: NTB/SCANPIX

19

OVERALL RISK ASSESSMENT AND VULNERABILITIES IN SOCIETY

The overall results from 20 risk analyses are presented and discussed in this section. First the consequences from the 20 analyses are presented, then the likelihood, and then the consequences are illustrated broken down into the various consequence types. The analysis results are also presented in a common risk matrix. The risk matrix is presented in two ways. The first presentation shows the assessments of likelihood, consequences and uncertainty for all of the scenarios. The second presentation illustrates the distribution by event category (natural events, major accidents or malicious acts).

Three of the scenarios are new since the last edition of the National Risk Analysis. These are "Earthquake in a City", "Cyber Attack on Electronic Communications Infrastructure" and "Tunnel Fire". In 2013, the method for the specification of social consequences was adjusted, and consequences are now divided into ten different consequence types. For the scenarios that were analysed prior to 2014 (the remaining 17 scenarios), the consequences are divided into eight consequence types. The will be discussed in greater detail under the section on the distribution of consequence types.

Vulnerability is linked to the properties of the system in which the event occurs and says something about the system's ability to withstand and tolerate events without entailing any serious consequences. The vulnerability of the system is of importance to both likelihood and consequence assessments. The vulnerability of the system is therefore assessed as part of the risk analysis. Vulnerability that is identified often indicates weaknesses and the need for measures. Finally in this chapter, we take a closer look at the vulnerability of the systems that have been analysed in the three new scenarios.

19.1 OVERALL PRESENTATION OF ANALYSIS RESULTS

Common to the scenarios that are analysed in the National Risk Analysis is the fact that the likelihood that they will occur is very low and the consequences are very large (see Figure 18), without the scenarios thus be inconceivable or unrealistic. In other words, when the likelihood in the NRA is assessed as relatively high, it means nevertheless that it is low, and when the consequences are assessed as relatively small, it means that they are nevertheless large compared with everyday accidents.

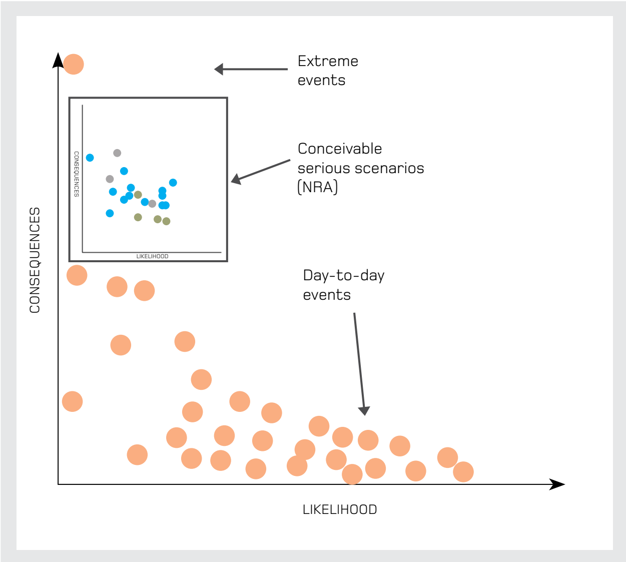


FIGURE 18. The scenarios that are analysed in the NRA are very serious scenarios – not day-to-day accidents, but not the most extreme events imaginable either.

Consequence assessment by scenario

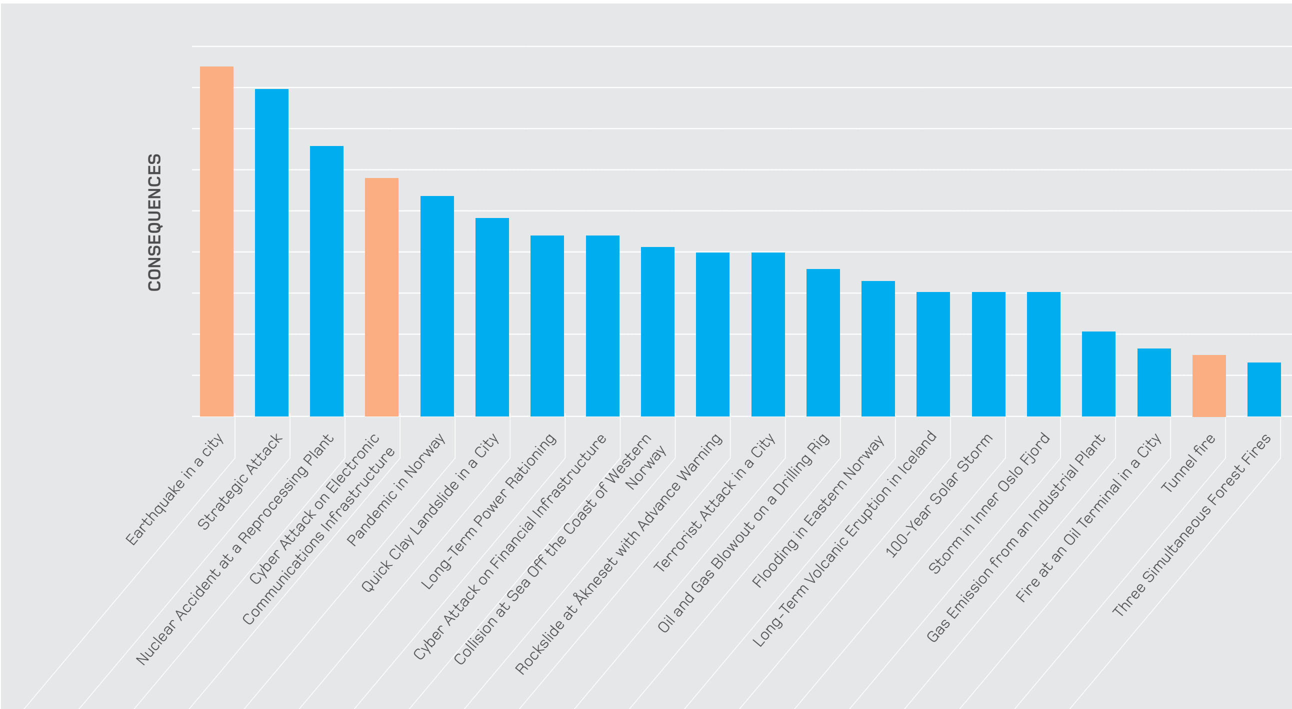


FIGURE 19. The bars show the overall score for all of the consequence types for each scenario. The three new scenarios are marked in orange.

There is a wide gap between the scenarios that are assessed as having the largest and the smallest social consequences, even if all of the scenarios entail large consequences for society. "Earthquake in a City" and "Three Simultaneous Forest Fires" have been assessed as having very large and small social consequences, respectively. Eight of the scenarios analysed fall under the NRA category *large social consequences.*

Among the eleven scenarios that are assessed as having the greatest social consequences, five are natural events, four are intentional adverse acts and two fall under the event category major accidents.

Likelihood assessment by scenario

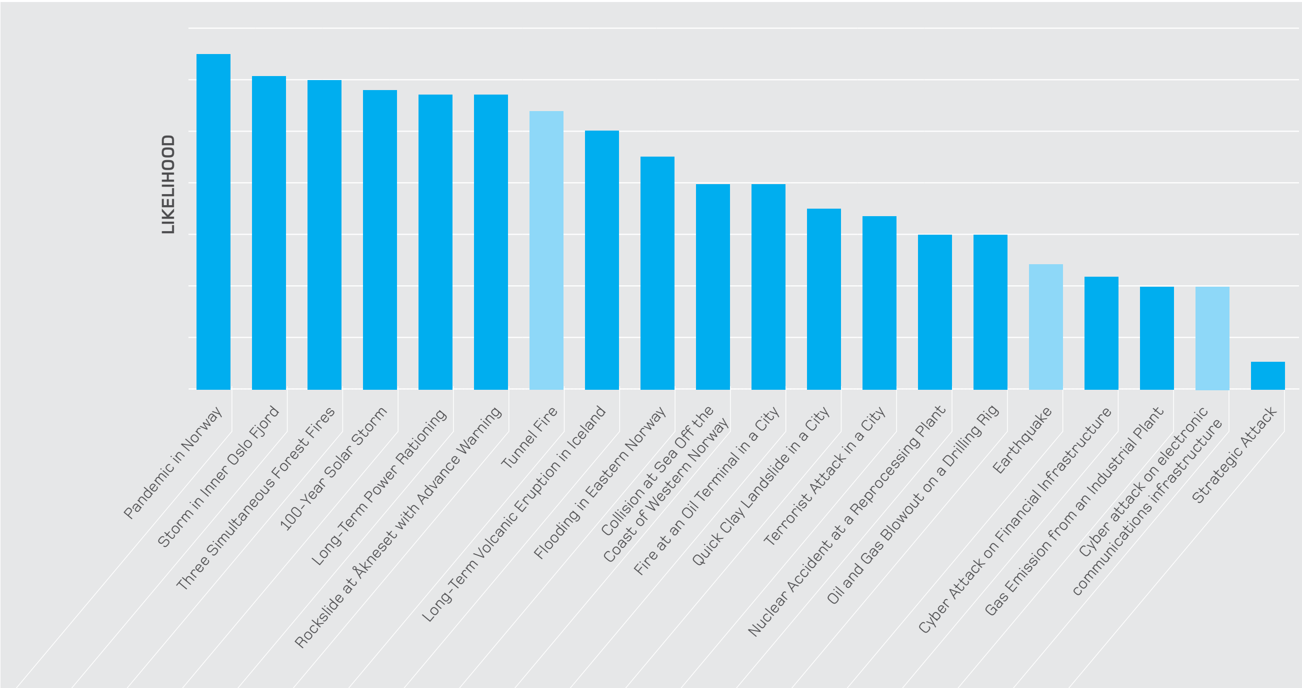


FIGURE 20. The bars illustrate the likelihood score for the scenarios analysed. The specification of likelihood is based on an assessment of how likely it is that they will occur. The three new scenarios are marked in light blue.

The likelihood that the scenarios will occur is assessed on a scale from *very low* to *very high* likelihood, where *very low* likelihood is less than once every 10,000 years and *very high* likelihood is once or more every 10 years.

Of the 20 scenarios analysed, three of the scenarios are assessed as having very low likelihood. They are "Gas Emission from an Industrial Plant", "Cyber Attack on Electronic Communications Infrastructure" and "Strategic Attack". At the other end of the scale, the "Pandemic in Norway" scenario is assessed as having the highest likelihood of the analysed scenarios. The likelihood for a pandemic in Norway is assessed as *high* (once every 50-100 years). None of the analysed scenarios are assessed to have a *very high* likelihood.

Distribution of consequence types – all scenarios

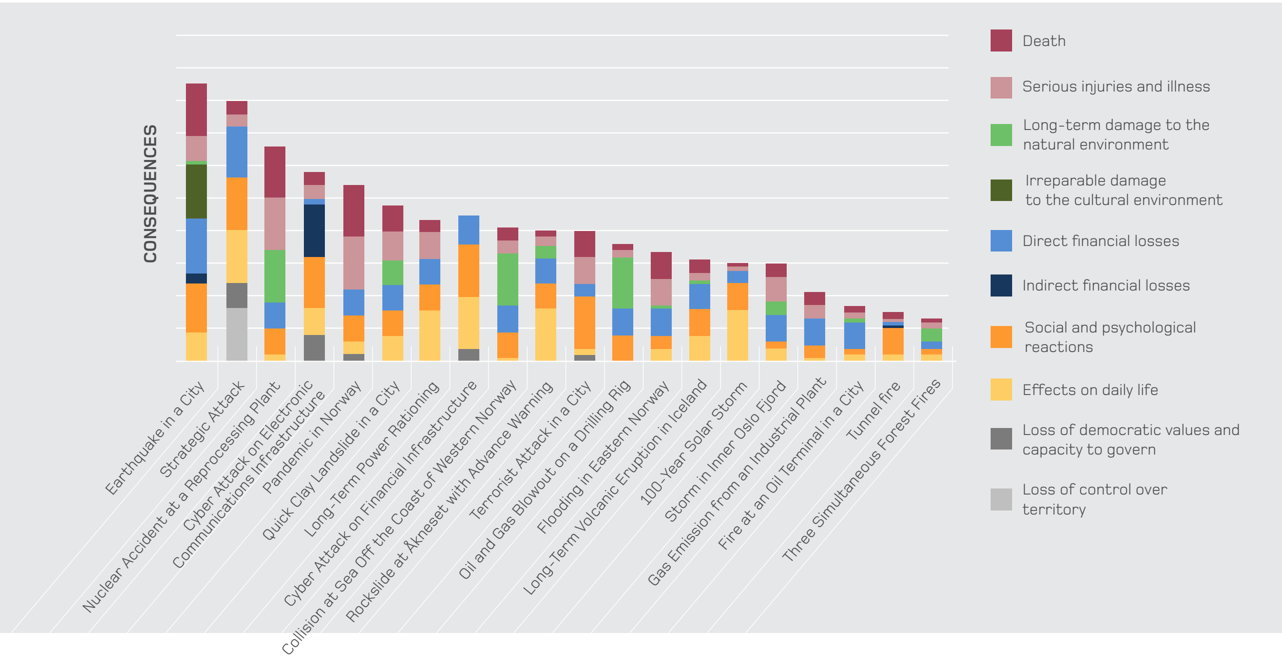


FIGURE 21. The bars illustrate the overall consequences for each scenario, broken down by ten consequence types.

In 2013, two new consequences were introduced, “irreparable damage to the cultural environment” and “indirect financial losses”. Therefore only the analyses of the three new scenarios have specified consequences in these consequence types. For the scenarios that were analysed prior to 2014 (the remaining 17 scenarios), the consequences are divided into the former eight consequence types. This may entail that the new scenarios score somewhat higher on overall consequences, since damage to the cultural environment and indirect financial losses were previously part of the basis for assessment of the consequence type “nature and environment” and “economic losses”

The different types of consequences contribute in very different degrees to the overall consequences. The greatest consequences to life and health are found in ″Pandemic in Norway″, ″Nuclear Accident at a Reprocessing Plant″ and ″Earthquake in a City″, all of which entail extreme consequences for life and health. ″Cyber Attack on Financial Infrastructure″ is the only scenario that is not assessed as causing fatalities, or serious injuries or illness.

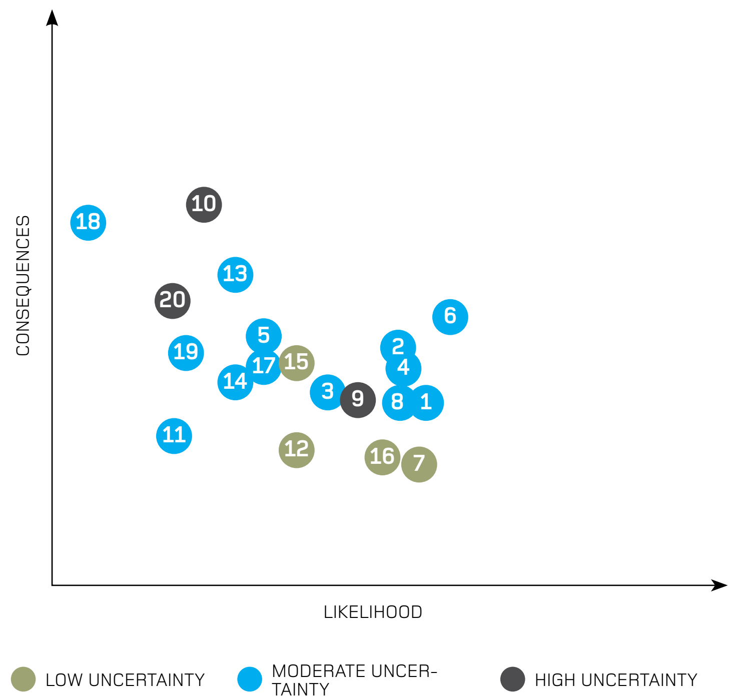
Of the 20 scenarios analysed, it is assumed that 11 will result in long-term damage to nature and the cultural environment. The consequences for nature and culture range from vary small to very large damage It is the major accidents that cause the greatest damage to natural and cultural assets. In three of the seven major accidents that have been analysed, there is talk of substantial long-term contamination. Natural events are assumed to lead to minimal damage to nature and culture. Nature has the ability to restore itself within a relatively short period of time after natural events. Of the natural events, only in the ″Quick Clay Landslide in a City″ scenario is there a high score for the consequences for nature and culture, because of the permanent damage to valuable cultural environments, including national cultural artefacts.

″Social and psychological reactions″ and ″Effects on daily life″ (indicators for the societal asset societal stability) contribute significantly to the overall consequences of malicious acts and natural events, but only to a limited extent to the consequences of major accidents. An explanation for this may be the fact that the major accidents that were analysed are known risks that do not arouse fear and unrest in the population. In addition, they do not destroy infrastructure in a larger area and create problems for daily tasks. Natural events also entail the loss of critical infrastructure that impacts in turn critical societal functions that affect a large geographic area and many people. In addition, evacuation is necessary in many of these scenarios in the natural event category.

All the four scenarios for intentional adverse acts are assessed as threatening societal stability to a great extent due to the social and psychological reactions they arouse. Actions that are carried out with "evil intentions" to cause damage or injuries and to create fear and fright. Societal stability is also challenged by a number of natural events. The explanation for this may be that the consequences are unexpectedly large and bring about shock and fear in the population. People expect to be warned about serious natural events and that the authorities are prepared to handle them. If this is not the case (as in the quick clay landslide, flooding and earthquake scenarios), this can result in frustration and mistrust of the authorities.

It is assumed that all of the scenarios will result in economics losses. It has been assessed that the "Earthquake in a City" and "Cyber Attack on Electronic Communications Infrastructure" scenarios will entail the greatest costs. It is assumed that the scenarios "Three Simultaneous Forest Fires" and "Tunnel Fire" will have the lowest costs. The economic losses consist primarily of production losses and costs for rebuilding infrastructure and buildings. For the "Cyber Attack on Electronic Communications Infrastructure" the loss of revenue and thus the loss of income will also be very great.

Analysed scenarios placed in a risk matrix with an indication of the uncertainty



SCENARIOS PLACED IN A RISK MATRIX	
1	Storm in Inner Oslo Fjord
2	Long-Term Power Rationing
3	Flooding in Eastern Norway
4	Rockslide at Åkneset with Advance Warning
5	Quick Clay Landslide in a City
6	Pandemic in Norway
7	Three Simultaneous Forest Fires
8	100-Year Solar Storm
9	Long-Term Volcanic Eruption in Iceland
10	Earthquake in a City
11	Gas Emission from an Industrial Plant
12	Fire at an Oil Terminal in a City
13	Nuclear Accident at a Reprocessing Plant
14	Oil and Gas Blowout on a Drilling Rig
15	Collision at Sea Off the Coast of Western Norway
16	Tunnel fire
17	Terrorist Attack in a City
18	Strategic Attack
19	Cyber Attack on Financial Infrastructure
20	Cyber attack on electronic communications infrastructure

FIGURE 22. National Risk Analysis – the composite risk matrix shows assessed risk (likelihood, consequences and uncertainty) connected to the specific serious scenarios that have been analysed.

The four malicious act scenarios are the only scenarios that will threaten democratic values and capacity to govern. The pandemic scenario will result to a certain extent in a weakened national capacity to govern, because very high absence due to illness will affect both political control and public services. Only the scenario "Strategic Attack" is expected to result in the loss of territorial control.

The risk matrix illustrates the indication of the likelihood and consequences for the 20 scenarios analysed without attaching importance to whether it is a natural event, major accident or malicious act. The overview can therefore be used as general input for discussions that transcend the areas of responsibility and sectoral boundaries. The three colours indicate varying degrees of uncertainty associated with the analysis results.

The scenarios "Pandemic in Norway", "Earthquake in a City", "Nuclear Accident at a Reprocessing Plant", "Long-Term Power Rationing" and "Rockslide at Åkneset with Advance Warning" are the five scenarios assessed as having the highest overall risk. "Earthquake in a City" distinguishes itself somewhat, as this is the scenario that is assessed as causing the most extensive social consequences of all the scenarios assessed. However, the likelihood for this scenario is low, and the uncertainty associated with the analysis results is high. The uncertainty associated with the other four is assessed as *moderate*.

Among the scenarios with the lowest risk, we find "Gas Emission from an Industrial Plant", "Fire at an Oil Terminal in a City", "Tunnel Fire", "Three Simultaneous Forest Fires" and "Strategic Attack". This is attributed either to the overall consequences being relatively small compared with the other scenarios, or that it is regarded as not very likely that the scenario will occur, as is the case with "Strategic Attack".

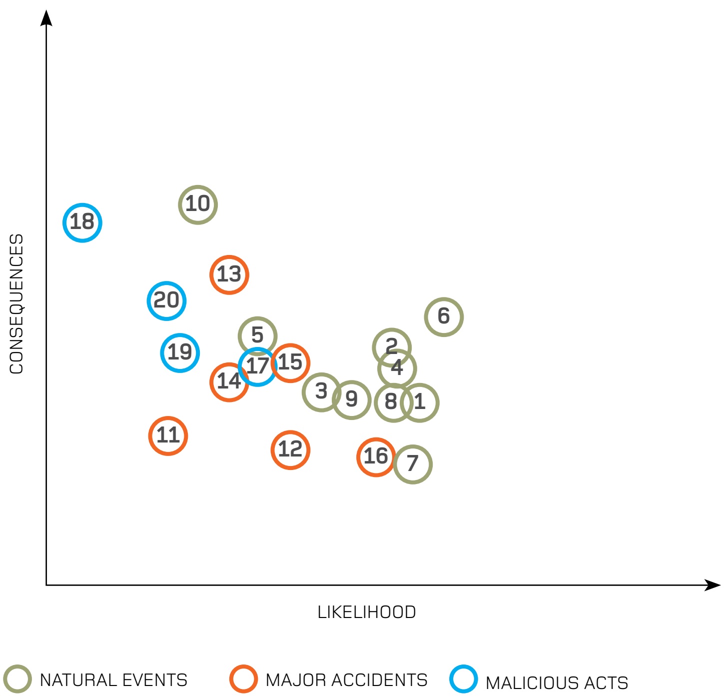
As part of the risk analyses, an assessment is made of the uncertainty associated with both the likelihood and the consequences. Uncertainty has been presented using three different colours, which indicate the overall uncertainty for both likelihood and consequence assessments. In cases where the uncertainty has been assessed differently in the likelihood and consequence assessments, the greatest importance has been attached to the consequences.
The uncertainty assessments in the matrix illustrate the relative uncertainty between the 20 scenarios that have been analysed. As mentioned earlier, risk associated with malicious acts will be particularly challenging to assess. How likely it is that such scenarios will arise will change over time.

In 4 of the 20 scenarios analysed, the uncertainty associated with the analysis results is assessed as low. This applies to "Three Simultaneous Forest Fires", "Fire at an Oil Terminal", "Collision at Sea Off the Coast of Western Norway" and "Tunnel Fire". There is a relatively good knowledge base for assessing both the adverse event and any subsequent consequential events, and there has been a great deal of agreement among the experts.

The uncertainty is assessed as high in the three scenarios: "Long-Term Volcanic Eruption in Iceland", "Earthquake in a City" and "Cyber Attack on Electronic Communications Infrastructure". This is attributed, for example, to the fact that the scenarios contain certain special prerequisites. In the case of the Long-Term Volcanic Eruption in Iceland, a long-term discharge of sulphuric gases is assumed, which is something that we have little experience with in today's society. Correspondingly, a major earthquake in densely populated areas is something that we do not have experience with in Norway, and the assessment of how likely it is that the scenario will occur is subject to a great deal of uncertainty.

The uncertainty associated with the analysis results for the remaining 13 scenarios has been assessed as *moderate*.

Analysed scenarios placed in a risk matrix – event categories.



SCENARIOS PLACED IN A RISK MATRIX	
1	Storm in Inner Oslo Fjord
2	Long-Term Power Rationing
3	Flooding in Eastern Norway
4	Rockslide at Åkneset with Advance Warning
5	Quick Clay Landslide in a City
6	Pandemic in Norway
7	Three Simultaneous Forest Fires
8	100-Year Solar Storm
9	Long-Term Volcanic Eruption in Iceland
10	Earthquake in a City
11	Gas Emission from an Industrial Plant
12	Fire at an Oil Terminal in a City
13	Nuclear Accident at a Reprocessing Plant
14	Oil and Gas Blowout on a Drilling Rig
15	Collision at Sea Off the Coast of Western Norway
16	Tunnel fire
17	Terrorist Attack in a City
18	Strategic Attack
19	Cyber Attack on Financial Infrastructure
20	Cyber Attack on Electronic Communications Infrastructure

FIGURE 23. National Risk Analysis – the composite risk matrix shows assessed risk connected to the specific serious scenarios that have been analysed. The colour coding indicates which event category the scenario belongs to.

When we categorise the scenarios into *Natural Events*, *Major Accidents* and *Malicious Acts*, respectively, we see that it is to a great extent the natural events that are assessed as having the highest overall risk. The exception here is "Nuclear Accident at a Reprocessing Plant", which belongs to the category *Major Accidents*, but which is also classified as one of the events with a relatively *high risk*.

The scenarios that fall under the category of Major Accidents and Malicious Acts are assessed as having a lower likelihood than natural events, but the consequences of some of these scenarios are deemed to be greater than some of the natural events.

There is reason to emphasise that all the scenarios that have been analysed are very serious and not very probable. If other, less serious scenarios had been analysed, the likelihood would have been higher, and the scenarios could have ranked differently in relation to each other in the risk matrix.

The risk matrix provides a general view across the individual risk analyses, but it does not go in-depth for the individual risk analyses. The matrix contributes limited information on the specific efforts to strengthen civil protection in the various areas. To provide relevant information on the risk factors in society, and more specific input for work both within and across sectors and administrative levels, it is necessary to take a closer look at what vulnerabilities and critical factors are pointed out by the risk analyses in the NRA.

19.2 ASSESSMENT OF VULNERABILITIES IN SYSTEMS AFFECTED BY THE EVENTS

The same event may entail different levels of risk in different systems, because the system's vulnerability affects both the likelihood for the event and its consequences. "A system" can be defined at many levels, from a limited physical or technical system to more complex societal functions and infrastructures. Systems at the social level are

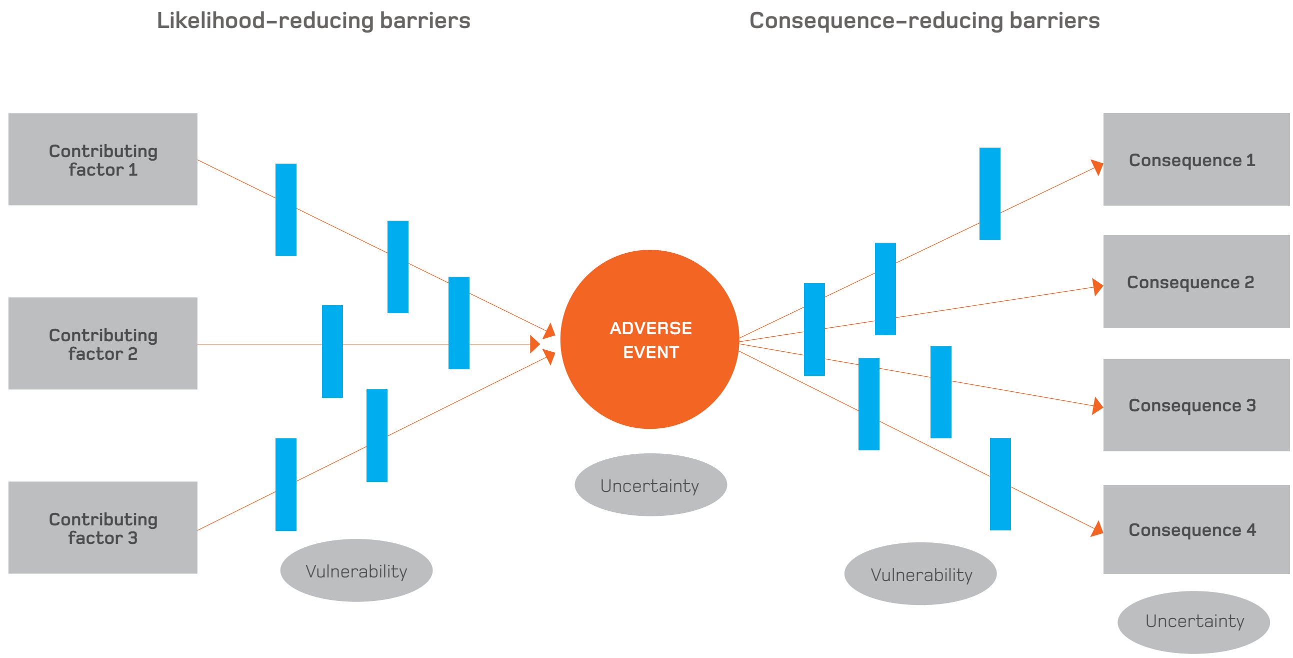


FIGURE 24. Risk analysis should identify vulnerabilities in the system being analysed, so that potential likelihood and consequence-reducing barriers can be established or reinforced.

often "socio-technical", which means that they consist of both an infrastructure and an organisation that manages the system. Society can also be described as an "organisational system", but it is often too large and complex to be the subject of a comprehensive vulnerability analysis. A picture of society's vulnerability must therefore be created through the analysis of subsystems.

The vulnerability of a system is the capacity the system has to withstand adverse events, and the system's capacity to withstand an event without it leading to serious consequences. The vulnerability is affected greatly by what barriers exist to interrupt the adverse course of events. The bow tie figure (also mentioned in Chapter 1) illustrates that the system's vulnerability is included as an element in the analysis, both before the adverse event occurs and with regard to assessing the consequences as a result of the adverse event.

Society's vulnerability in the three new scenarios that have been analysed in the NRA in 2014 have been mapped out more explicitly than earlier. A more detailed course of events and greater insight into what will happen and why it will happen emerges from this mapping. This can provide new knowledge of how adverse chains of events can be interrupted. The prerequisites and assumptions regarding the analysis results become more visible at the same time.
In the new scenario analyses, vulnerability has been studied through:

1. Surveying how the properties of the systems in which the event occurs affect the likelihood of the adverse event (as described in the scenario) occurring.
2. Surveying how the adverse event affects the various subsystems (including critical societal functions).

The "Cyber Attack on Electronic Communications Infrastructure" results in a failure of key components of the nationwide transport network for electronic communications. Important electronic communication services, such as telephony and the Internet, are thus lost. This has consequences for critical societal functions, which cannot deliver services to the population due to their dependency on electronic communications. Five of the nine societal functions analysed are assessed as being affected to a high degree by the loss of electronic communications. The original event in the scenario has a number of consequential events that contribute to the overall consequences for the population.

The analysis shows two levels of electronic communication dependence: Firstly, there is the fact that critical societal functions are dependent (to a higher degree than previously) on electronic communications services to deliver their services. Secondly, electronic communication services are dependent on the central transport network to work. Thus the security and safety of the population are also dependent on the central transport network for electronic communications. It is important to identify this entire course of events through vulnerability assessments in order to establish effective barriers at several points in the course of events.

A barrier for the consequences of the loss of electronic communications is to lay separate optical fibre cables for electronic communications, independent of other networks, as certain sectors and enterprises have already done (such as the power sector, Norwegian Armed Forces and South-Eastern Norway Regional Health Authority). A nationwide second network could also reduce the vulnerability to losing one of the networks. Ordinary emergency preparedness measures in the event of a loss of electronic communications are backup solutions, such as radio and satellite links. If there is a great need for communication, these solutions will hardly have adequate capacity and do therefore not represent a reliable barrier.

In the "Tunnel Fire" scenario only one consequential event with consequences for society has been identified, namely closure of the tunnel due to repair work after the fire. This results in local delays for the transport of passengers and cargo and reduced navigability for emergency vehicles.

In this specific, limited system, it is the properties of the tunnel that are decisive for both the likelihood of the fire and its consequences. The same fire in heavy vehicles was analysed in three different tunnel systems and there were three different outcomes. In the risk analysis, the vulnerability was surveyed in the form of the tunnel's physical properties, such as the length and gradient, and organisational circumstances such as preparedness for a fire. Underwater tunnel systems were assessed as being the most vulnerable in the event of fire, and thus they have the highest level of risk out of the three tunnel systems analysed.

The vulnerability of a tunnel system is primarily associated with the escape opportunities for the road users. If there is a long distance to fresh air (lack of emergency exits) and difficult conditions for escaping (smoke, darkness and an incline), then this will contribute in a high degree to the consequences for life and health. Effective barriers in the form of rapid fire detection, short response time for the fire service and fire ventilation that moves the smoke away from the road users are particularly important in underwater and long tunnels.

In the "Earthquake in a City" scenario, consequences such as the collapse of buildings, destruction of infrastructure and local power outages were identified. The consequences of an earthquake in a city are large, but the chains of events are relatively short and clear compared with the consequential events associated with the loss of electronic communications. In a large urban area, there will be many different types of buildings and ground conditions. A city will have infrastructures with varying properties, some of which will withstand the stresses from an earthquake and others not. The vulnerability analysis shows in this case that there is a need for better local knowledge on the various building types and ground conditions, before particularly exposed or vulnerable areas can be assessed.

The vulnerabilities in Norwegian society will still be the subject of new analyses. For many of the scenarios, this will require a more detailed analysis of the various chains of events and more detailed knowledge of the various subsystems, such as how the failure of one system propagates to a failure of other systems. The CICS (Critical Infrastructure and Critical Societal Functions) Report and the National Vulnerability Report are of key importance to this work. The method and system for how these analyses are compared is under preparation.

19.3 NEW OPPORTUNITIES AND NEW CHALLENGES IN THE NORWAY OF THE FUTURE

Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world
– Albert Einstein

Imagine the following: The year is 1855. This is the year when Norway's first telegraph line is opened and four years before Richard C. Carrington first observed a solar particle eruption, an eruption that affects the telegraph system in Europe and North America (see p. 85). You have just completed a risk analysis of the new telegraph line on behalf of the Royal Commission that is to report

[234] *NOU 1986:12 Datateknikk og samfunnets sårbarhet [Official Norwegian Report 1986:12 Computer Science and the Vulnerability of Society].*

on the development of the telegraph system in Norway. With regard to the fact that solar storms are still not a phenomenon that has been discovered, do you foresee that the particles that are slung out from the sun and into the Earth's atmosphere may have an impact on the telegraph network in Norway?

Also imagine: The year is 1980, a decade before the Internet is opened up to commercial use. You have seen how communication technologies have developed in the course of a long life, and you have been appointed to sit on the Seip Commission, which is to report on vulnerability in a society dependent on computer science.[234] The Commission is future-oriented, and you recognise the potential of the new telecommunication systems based on computer science, which "enables the transmission of all types of data, i.e. text, sound (telephony), traditional data, still images and in time living images (video)".[235] The Committee identifies certain circumstances and events that can result in a failure of important data services, such as "international crises, disasters, internal unrest and other adverse situations in peacetime, as in war or warlike conditions".[236] Based on the fact that the Commission has a limited picture of computer science and telecommunication systems in the future,[237] do you foresee cyber attacks in a future, global and open Internet, as it has been described in one of the scenarios in this year's NRA?

Imagine then that: The year is 2014, two decades before Norwegian society can seriously be called an Internet of Things society, in which daily life is marked by IoTs, that is hardware and sensors that communicate between themselves in self-governing systems.[238] You are well past retirement age, but still extremely interested in the development of technology. You have been asked to sit on the Lysne Commission, which is to study "digital vulnerabilities that Norway faces today and in the close future".[239] Do you foresee a data virus outbreak that affects people with transplanted *IoT*-based organs in 2040?[240]

New prerequisites, new events

This exercise in imagining the future has of course a purpose: if you were in doubt earlier, you should now be convinced that it is difficult to foresee the future. An underlying premise when we talk about analysing the future therefore is that we are not predicting what will happen in the future. Reflection on the future is about being aware of long-term changes and thus being open to new opportunities, new prerequisites and new events. Borrowing the words of the Futurist Erik F. Øverland: "What is important is not to be right for posterity, but to make mistakes in interesting ways".[241] An open exploration of the future is in other words not based on likelihood assessments, but on describing possible futures.[242]

Why should we spend time looking to the future, if it is nevertheless impossible to predict what will happen? Emergency preparedness work is essentially based on experiences from previous crises. Since it is impossible to prepare for all conceivable and inconceivable crises, the last crisis is the most reliable knowledge base we have for emergency planning. However, no two crises are identical, and the next crisis may present new and unexpected challenges. In order for us to prepare ourselves for the next crisis, and not just the previous crisis, it is important to think further than what is known and based on experience. In addition, the future scenarios force us to look at the consequences to a greater degree and less at the likelihood.

New events and crises	A	A + B
Today's events and crises	Today	B
	Today's prerequisites	Future prerequisites

Figure 25. Today's National Risk Analysis analyses disasters that can arise in today's society with the prerequisites that exist today (A). Risk 2040 assesses new events and crises that can occur in tomorrow's society, in which the prerequisites have changed (A+B).[243]

[235] *Ibid., p 20.*
[236] *Ibid. p 9.*
[237] *See also the description of the intelligent network in Official Norwegian Report 1983:32 Telematics, p 37.*
[238] *http://www.aftenposten.no/digital/Tingenes-internett--7539010.html.*
[239] *http://www.regjeringen.no/nb/dep/jd/pressesenter/pressemeldinger/2014/Regjeringen-nedsetter-digitalt-sarbarhetsutvalg.html?id=764159.*
[240] *See Eirik Newth's lecture at DSB's conference on civil protection in Norway of the future: https://www.youtube.com/watch?v=DsjTZGd9pY4.*
[241] *See Erik F. Øverland's lecture at DSB's conference: https://www.youtube.com/watch?v=6pWGocvPI6s.*
[242] *MSB (2013): Strategic challenges for societal security. Analysis of five future scenarios.*
[243] *The model has been taken from MSB (2012): Framtida utveckling som kan påverka arbetet med samhällsskydd och beredskap [Future Developments that Can Affect Work with Civil Protection and Emergency Preparedness].*

In 1855, a solar storm with consequences for the telegraph network would be a new event under the prerequisites of the time (A), since a solar storm was still an unknown phenomenon and telegraph lines already existed. A future prerequisite (B) in 2014 would, for example, be development of the Internet of Things and *IoT*-based human organs, which will have completely new and more extensive consequences than already known events that render all or parts of the information and communications systems inoperable (for example, a cyber attack or solar storm). In 1980, a cyber attack would be a new event under future prerequisites (A + B), since there was no experience of an open, global and vulnerable Internet at the time, and thus no experience of a cyber attack either.

National Risk Analysis 2040

DSB is in the start-up phase with regard to looking at civil protection and emergency planning in a long-term perspective within the NRA framework, and we would like to work systematically with analysing the future in the time to come. We will use the so-called STEEP framework, which is an acronym for the five main factors that are often used in trend analyses:[244]

- Societal: demographics, population increase, ageing, migration, urbanisation.
- Technological: information and communication technology, nanotechnology, biotechnology.
- Economic: economic globalisation, economic trends.
- Environmental: climate change, balance in ecosystems.
- Political: national and international politics, EU/Schengen, terrorism.

ILLUSTRATION OF THE FUTURE:
The illustration from the DSB seminar on civil protection in Norway in the future that was held from 27 to 28 January 2014. The purpose was to discuss methodology problems and relevant driving social forces that may create new prerequisites for civil protection. The illustration was designed by the graphic facilitators Annette Haugen and Zenia Strunck Mikkelsen.

[244] *See the Police analysis of the world around us 2012.*

As a preview of this work, we will take a closer look here at three relevant areas that may have consequences for civil protection in Norway of the future.

Cyber attack in Norway of the future
The scenario analysis of a cyber attack on electronic communications infrastructure in the NRA describes various serious consequences of an attack on the electronic communications networks. What will the consequences for a corresponding attack in 2040 be like? What possible futures can we imagine for the Norwegian electronic communications infrastructure, and what new vulnerabilities will the various development scenarios result in?

The Futurist Eirik Newth points out that information technology has not finished transforming the world.[245] He points out three ICT trends that may result in changed prerequisites in the future. Cloud computing will probably be expanded to also include hardware, and we will continue to move towards a society in which the things around us are linked together in virtual clouds. In addition, we are developing an ever-tighter relationship with technology, and hardware will become increasingly integrated into our lives. The third tendency is a development towards ever-smarter and more autonomous systems, which are capable of learning. Systems that can draw conclusions based on enormous amounts of data, or so-called "Big Data", and self-driving cars are examples of smart technology that is already under development. Newth points out that the development of technology results in increased vulnerability at the same time, and we are in the process of creating very complex systems that we do not have a full overview of or control over.

A possible future is a continued development towards a market-controlled, undefinable and complex virtual world, in which the very complexity of the systems represents the greatest vulnerability. Another possible future is a more fragmented and controlled Internet. The Swedish Civil Contingencies Agency (MSB) assesses the risk and consequences for cyber attacks in Sweden of the future based on different future scenarios.[246] In one of the scenarios, there is a far greater degree of government control than today, and this includes control over the Internet. In such a future scenario, a fragmentation of the Internet is conceivable, with separate national or regional network systems that are subject to government control. Such a fragmentation can protect against cyber attacks from other states, but limit the flow of information at the same time.

These two possible scenarios for what ICT-based Norway will look like in 2040 are just as interesting points of departure for thinking about risk and vulnerability in Norway of the future. Since reflection on the future is the most productive when one does not limit oneself by what the most probable future is and focuses instead on possible futures, freeing ourselves to explore and perhaps discover unexpected consequences for civil protection based on several different scenarios. What consequences will a cyber attack have in a society where hardware functions, information storage and sensor-based objects are linked together in complex and autonomous virtual system in a global Internet? What limitations will a fragmented Internet entail, and what new vulnerabilities will be created in a government controlled and limited net system?

From a normative future perspective, that is an approach in which one defines what a desirable future development would be, one can ask what an acceptable level of risk and the necessary robustness would be in various possible ICT futures. What should one do today to prepare society in the best possible manner for future prerequisites and events in the ICT area?

Heatwaves in Norway of the future
In a report from 2012, the British Government Office for Science points out two factors in an expanded STEEP framework, which they believe will give a heightened risk of future disasters: global climate change and demographic changes.[247] For Norway a possible future scenario as a result of climate change may, for example, be extreme temperatures in the form of heatwaves.[248] If we use a scenario for climate change that results in more extreme weather as our point of departure, we can envision more frequent and more extreme events in Norway corresponding to the heatwave in Europe in 2003. It is estimated that 52,000 people died in Europe as a result of this heatwave.[249]

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245 https://www.youtube.com/watch?v=DsjTZGd9pY4.
246 *MSB (2013): Strategic challenges for societal security. Analysis of five future scenarios.*
247 *The Government Office for Science (2012): Foresight Reducing Risks of Future Disasters: Priorities for Decision Makers. Final Project Report.*
248 *World Meteorological Organisation defines a heat wave as five or more consecutive days with temperatures that exceed the average maximum temperature by 5 degrees C.*
249 http://www.earth-policy.org/plan_b_updates/2006/update56. *A report commissioned by the EU estimates 80,000 more deaths than usual in 12 European countries in 2003.*

In its national risk analysis, MSN has a scenario that involves a long-term heatwave in the Örebro region. The consequences they outline include lower water quality in the area, accidents and traffic delays, due, for example, to the buckling of railway tracks as a result of the sun, heath and forest fires, power outages and an increase in deaths among the elderly, particularly in vulnerable groups.[250] More frequent heatwaves combined with the elderly representing a greater portion of the population in the future may create new challenges in Norwegian society. What consequences will a heatwave scenario have for parts of the current infrastructure, such as the supply of water or power, as well as the transport of passengers and cargo? Is society prepared to take care of persons in vulnerable groups in such an event?

Antibiotic resistant bacteria in Norway of the future
A possible future scenario that may have serious consequences for civil protection in Norway is the increasing number of antibiotic resistant bacteria as a result of excessive and incorrect use of antibiotics.

MSB has developed a future scenario in which only a limited number of effective antibiotics can be used for the treatment of infections, since a large percentage of the bacteria have become multi-resistant, which means that the bacteria have developed resistance to three or more antibiotics.[251] The scenario is a point of departure for studying what consequences more extensive resistance to antibiotics would have for civil protection in Sweden. In this scenario, it is primarily life and health that is affected by the development of resistance to antibiotics, and it is assumed that many people will die from infections that can currently be treated relatively quickly with antibiotics. To prevent the spread of antibiotic-resistant bacteria, the scenario will also result in consequences for the healthcare system and possible restrictions with respect to food production, supply of drinking water and sewerage management.

What can we do today to avoid such a scenario becoming a real situation in the future?

The future is not what is once was

How can we prepare for a future that we still do not know what it looks like? Albert Einstein gives us an answer; imagine the future. By using our unique human ability to imagine possible futures, we can prepare ourselves for new prerequisites and new events that will mark our society in the future. We can also be more active by imagining what sort of future we actually want, and thus have an opportunity to create the future, or at least correct an unfavourable development. Or as Abraham Lincoln said: "The best way to predict your future is to create it". Spend therefore a few minutes looking through the scenarios in the NRA one more time, and imagine what the same events would be like in 2040. How can you prepare, for example, for a cyber attack under new future prerequisites? How should we adapt society in the future so that it is capable of handling new, possible scenarios, such as heatwaves and antibiotic-resistant bacteria?

REFLECTION ON THE FUTURE IS ABOUT BEING AWARE OF LONG-TERM CHANGES AND THUS BEING OPEN TO NEW OPPORTUNITIES, PREREQUISITES AND EVENTS.

[250] *MSB (2013): Risker och förmågor 2013 [Risks and Capabilities]. See also MSB (2013): Strategic challenges for societal security. Analysis of five future scenarios.*
[251] *MSB (2013): Antibiotikaresistens ur ett säkerhetsperspektiv [Antibiotic Resistance from a Security Perspective].*

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