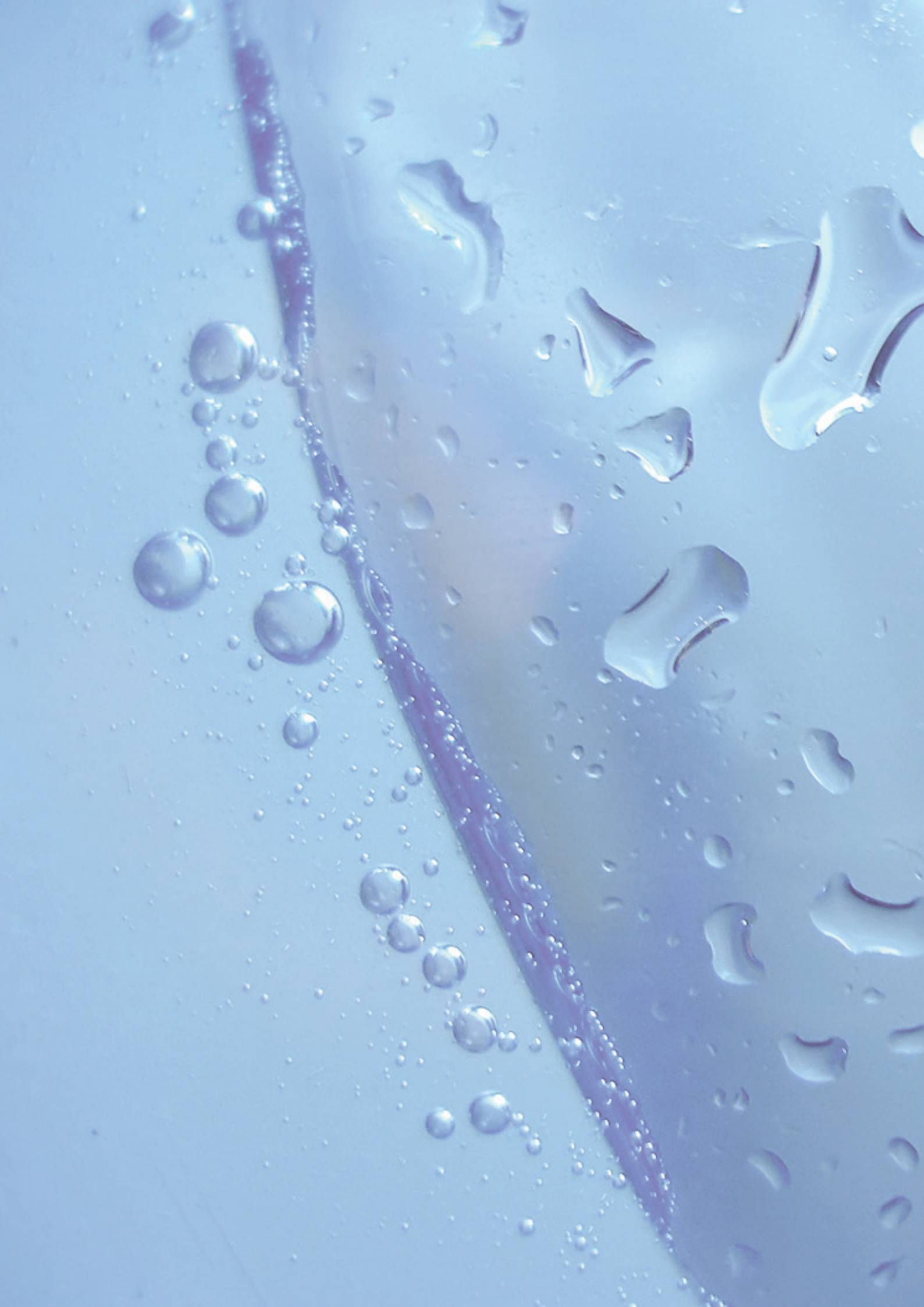
Norwegian Water

Selected SUMMARIES of water reports 2015 – 2018

Norwegian Water



About Norwegian Water

Norwegian Water (in Norwegian: Norsk Vann) is a national association representing Norway`s water industry. It acts on behalf of the members, which are mainly municipalities and companies owned by the municipalities. Norwegian Water in total represents 370 municipalities, with 95 % of the population.

Norwegian Water also has affiliated members like consultants, producers, suppliers and educational and research institutions.

Norwegian Water serves both as a special interest organisation and a competence building organisation for the members.

The organisation works within the vision of «clean water – our future» with emphasis on:

- Strengthening the reputation and customer relation for the water sector
- Lobbying for better framework conditions, by representing the water sector in contact with politicians and authorities on regulations etc.
- Strengthening the education system and the recruitment to the water sector
- Development and transfer of competence, through:
  - the Norwegian Water project system
  - courses and training
  - meetings and conferences
  - information systems, such as webpages, a magazine, newsletters etc.

The Norwegian Water project system

Projects at a value of 10 million NOK (1 million EUR) are performed each year through the project system in Norwegian Water. The project system is financed by the members as a voluntary additional fee.

The projects are proposed, approved and partly governed by the members, while specialists in the secretariat have the role as project managers. The best consultants in the marked are hired to perform the projects and write the reports and guidelines from the project system.

Most of the projects are presented as a Norwegian Water report. The reports can be purchased from www.norskvann.no, and may be downloaded for free for the members taking part in the project system. The project system has so far produced 240 reports and guidelines for the members.

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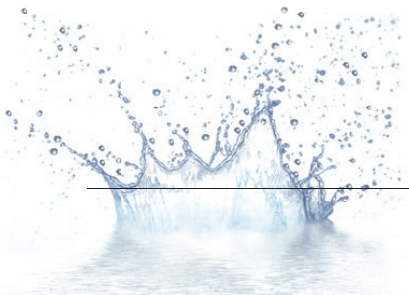


Experiences with ozon-biofiltration for drinking water treatment

Report 211 – 2015

Authors: Bjørnar Eikebrokk
Karl Olav Gjerstad

Keywords: Water, ozonation, biofiltration, NOM, biostability, experiences

Number of pages: 56

Today, more than 30 utilities are applying ozonation and biofiltration (OBF) as a single-stage drinking water treatment process in Norway, along with corrosion control (increase in pH, Ca and alkalinity) and disinfection. Most plants are now using UV for disinfection (> 40 mJ/cm²), with chlorine-free distribution systems.

The number of OBF-plants is increasing, mainly because of the fact that this kind of water treatment is attractive due to some major characteristics: relatively simple design and operation, no coagulation chemicals, minor amounts of sludge, as well as good taste and odour in treated (ozonated) water.

Until now, steinsvika WTP in skien is the largest OBF-plant in Norway (50 000 pe). However, IVAR in stavanger are designing an OBF-plant with close to 10 times higher capacity.
This report describes operational experiences from 12 OBF-treatment facilities in Norway, including raw and treated water characteristics. In addition to site visits, surveillance of available operation data and water quality data from routine sampling, more advanced water quality analyses was performed, including rapid NOM-fractionation, BDOC and ATP analyses as tools for improved NOM characterization and treatment performance diagnostics.

The results show that most utility owners are happy with their OBF-plants. The applied ozone doses range from 1.5 to 9 mg/l, with TOC-specific doses in the range of 0.5 – 2.0 mg O_3/mg TOC. The applied ozone doses and ozone contact times yields Ct-values and log-reductions that indicate that the OBF process can be defined as a hygienic barrier against bacteria, viruses and most parasites (except Cryptosporidium), according to the Norwegian Drinking Water Regulations. Furthermore, the ozonation process will remove taste and odour-causing substances, break metal-NOM complexes, oxidize and precipitate metals (e.g. Fe).

The results also show that ozonation transferred biologically stable, hydrophobic NOM fractions in the raw water into more biodegradable, hydrophilic NOM-fractions in ozonated and treated waters. Accordingly, the BDOC levels were higher in treated water than in raw water at all of the OBF-utilities investigated.

Results from routine sampling revealed that the hetero-trophic plate counts (HPC, 3 days, 22 °C) in water samples from the distribution network did exceed the recommended maximum level of 100 per mL at 9 out of the total 12 OBF utilities (75 %). Thus, providing biologically stable water is considered a major challenge for this kind of water treatment utilities in order to avoid regrowth and/or formation of sludge/deposits in the distribution system. In order to control the HPCs, small amounts of chlorine were used at 8 utilities.

The results indicate that application of OBF as the only treatment step should be restricted to raw waters with low to moderate NOM-content (e.g. colour < 25 – 30 mg Pt/L). This is mainly due to the fact that raw waters with a high NOM content require a high ozone dose, thus generating significant amounts of biodegradable organic matter (BDOC) through the ozone-induced transforma-tion of hydrophobic NOM-fractions (VHA) to hydrophilic and more biodegradable fractions (CHA). Today, biofilters are being designed with EBCTs of 20 – 30 minutes regardless of raw water quality, applied ozone dose, actual BDOC-load and acceptable BDOC levels in treated water. As a result of this, most of the biofilters investigated were overloaded and not capable of removing BDOC to levels considered acceptable in order to control regrowth (0.15 – 0.25 mg BDOC/L). Thus treated water with excess BDOC is distributed, resulting in regrowth and high HPC levels.

In order to safeguard a successful application of OBF as a treatment technology, there is a need for a revision of the biofilter design criteria. The revised design criteria should bebased on the actual BDOC-load and an acceptable BDOC level for chlorine-free distribution. In addition, a strict control of the ozone dose and adaptation of this to the prevailing raw water quality is required in order to minimize excess formation of biodegradable NOM fractions.

Guideline for design and dimensioning of water treatment plants
Report 212 – 2015

Authors: Hallvard Ødegaard, NTNU/SET
Jon Brandt, Asplan Viak
Svein Forberg Liane, Sweco
Stein Østerhus, NTNU

Keywords: Drinking water, water treatment plants, design and dimensioning
Number of pages: 128

This report gives guidelines for the design and dimensioning of unit processes for the treatment of drinking water as well as recommendations on how to put unit processes together to become a full drinking water treatment plant for raw waters from typical Norwegian drinking water sources.

The guideline report includes recommendations for those who plan and project drinking water treatment plants. These recommendations should not be viewed as rules for approval. There might be reasons for choosing other criteria than those recommended here. However, by following these recommendations, one can assure that the plant will not be under-dimensioned.

Even though the guideline report puts an emphasis on unit processes that are most commonly used in Norway, other unit processes that can be expected to be used in the future, are also included. The reference to the unit processes is organized according to what the purpose of the treatment is. In addition to introductory chapters on design basis and pre-treatment, the guideline report includes chapters on method for the treatment of:

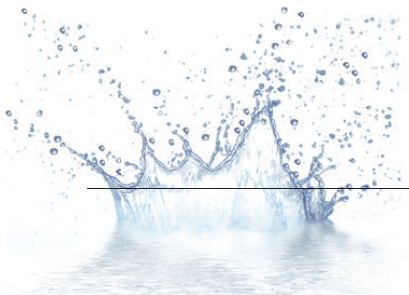
- **particles** - including coagulation, flocculation and floc separation (sedimentation, flotation, sand- and membrane filtration)
- **humic substances (natural organic matter - NOM)**
- - including coagulation/floc separation, membra-ne(nano) filtration, ozonation/biofiltration and ion exchange
- **easily biodegradable organic substances** – including biofiltration and slow sand filtration
- **organic micro-pollutants** – including activated carbon adsorption, chemical oxidation, biofiltration and membrane filtration
- **gases (gas transfer)** – including aeration and stripping of gases
- **inorganic substances** – including methods for removal of iron and manganese, calcium and magnesium, nitrogen compounds, fluoride and arsenic, radionuclides and heavy metals
- **taste and odor** – including activated carbon adsorption, chemical oxidation and biofiltration
- **infectious microorganisms** – including removal as well as inactivation (disinfection by chlorine, ozone and UV-irradiation)

The guideline report also includes chapters on corrosion control as well as on **selection of unit processes for various raw water sources.**

In each chapter (that is organized according to the purpose of the treatment) dimensioning criteria are given for unit processes that may be used for the treatment purpose in question. Under each unit process, the process as such, as well as its area of application and its constructive design is described and dimensioning criteria for the unit process used for the treatment purpose in question.

There is an emphasis on sizing of the treatment reactors that are to be used. Dimensioning of equipment such as pumps, chemical dosing containers, machine- and electro-technical equipment including process control equipment etc. is not dealt with.

As in all guidelines of this sort, a certain safety factor is included in order to prevent under-dimensioning. Where the dimensioning criteria are not obvious, it is recommended that lab- and pilot-experiments are used to establish sound dimensioning criteria.



Examples of sustainable projects in the water industry – a guidance

Report 219 – 2016

Authors: Lars Enander, Sweco
Vegard Busk, Sweco

Keywords: Sustainability, water and wastewater services, best practice, projects, strategies, examples

Number of pages: 48

The purpose of this guide is to increase the level of knowledge on sustainability in the water industry, and to provide motivation and inspiration for the individual water business to start the implementation of sustainability in their entity.

Despite the fact that the term sustainability is widely used, the content of the sustainability concept is often perceived as unclear. A sustainability guide providing practical, tangible best practice-projects can demonstrate how to implement sustainability in practice.

A guide containing examples of sustainable projects can inspire and motivate a greater focus on sustainability in the planning and execution of new projects and in the management of water and wastewater systems. Individual projects will still not be sufficient to reach comprehensive sustainable management of the water systems. The projects have to fit a larger context. Sustainable management of water and wastewater services has to be given a central place in the overall strategic performance management based on objectives and strategies, in the implementation of measures and in the subsequent monitoring of goal achievement.

Implementation of a sustainable perspective requires that businesses map their situation with regard to the use of resources, working methods and tools for planning. The agency has to define the objectives behind its sustainability initiative. It is important to clarify the level of ambition and to set a general direction for the sustainability focus. This helps ensure individual measures fit a larger context, and supply motivation for the members of the organization to make efforts in implementing sustainability. Sustainability should be an integral part of corporate governance and must therefore be included in the strategic policy.

The guide contains examples of best practice-projects from the water industry. The examples range from being simple and familiar to complex and innovative. The guide aims to inspire both participants who are on the threshold of committing to a larger degree of sustainability and those who already have awareness of the concept.

The examples in the guide cover all the phases known from projects in the water sector, from planning and design to construction, operation and maintenance of water and wastewater systems. Some of the examples belong to more than one phase.

Projects and strategies shown in the guide are presented thematically. The first examples cover an overarching approach to sustainability, and show how an organization can have a sustainable approach to business management and maintenance. The other examples are tangible strategies and projects related to:

- Measures on the water and wastewater pipe systems
- Energy production in the water supply system
- Measures at wastewater treatment plants
- Use of sewage sludge as a resource
- Stormwater management and site planning

The examples are designed in the same way. First, the background for the example and the initial challenges faced are presented. A sustainable solution to the challenges is then presented in more detail. An assessment of the sustainability in the current project and transfer value to other parties are other central elements in the presentations of the individual projects. For all examples, contact information to a resource with knowledge of the project is given.

It is proposed that the guide is published electronically to give opportunity for continuous updates. This way, the guide can maintain and develop its relevance.

Critical pipelines in the water sector – Classification and planning of activities

Report 220 – 2016

Authors: Jørn Harald S. Andersen, Norconsult
Kevin H. Medby, Norconsult

Keywords: Risk, critical pipelines, RAV, classification
Number of pages: 24

Norwegian Water initiated, during spring 2015, the project "Risk pipelines in the water sector". Risk pipelines is a term some actors have used for the water and wastewater pipes, manholes, culverts or tunnels which emerges as critical if they become non-functional as a result of incidents.

Since the focus is consequences, such water objects are referred to as critical pipelines* and have received the following definition:

- A water and wastewater pipeline with accompanying manholes, culverts or tunnels, that because of its function or surroundings can cause considerable damage or inconvenience for people, environment, reputation, material assets or infrastructure.

By critical we mean the pipeline's impact to the system it is part of, and how serious the consequences are if it is affected by an undesirable event. A pipeline may be critical with respect to nearby objects or infrastructure, when either pipelines damages the surroundings or events in the surroundings damages the pipelines.

In this project, it has been developed a methodology to identify, classify and evaluate measures for critical pipelines. Norconsult has undertaken the project, in cooperation with the steering group and the reference group, and through interviews of selected water companies in Norway.

The method

The proposed method for classification of critical pipelines is linked to current RAV methodology (Risk and Vulnerability analysis), as it is described in The Norwegian Food Safety Authority's guide "Increased safety and emergency in water supply". The connection between the proposed method and RAV takes place in two different steps:

1) Risk identification: The method presented in this project's chapter 2 and 3 may be used to identify and classify critical pipelines. By associating undesirable incidents to the critical pipelines, the risk of these may be considered in the RAV analysis.

2) The RAV analysis' last step: The measures analysis – the proposed assessment method takes into account both function, environment and technical condition of critical pipelines.

The method that identifies and classifies critical pipelines consists of a number of yes/no-questions. These questions are grouped in relation to the pipeline's functions and surroundings. The questions ensures that most conditions relating to criticality are discussed – but it is let to the water professional´s judgement to decide whether the relationship is strong enough to justify the pipelines being classified as a critical pipeline. It has been important for the working group to ensure that water professional´s judgement is not replaced by a rigid system. The proposed method should be perceived as a guide in the implementation of RAV analyses.

The aim of identifying critical pipelines is to ensure that these are receiving an active risk management in daily operations. Examples of active risk management is: Increased inspection activity, regular maintenance, cleaning/preparation ahead of extreme weather, information to those who may be affected, stricter requirements for those working with or near critical pipelines, technical improvements or strengthening preparedness.

It is important that critical pipelines constitute a manageable number of objects in the water system, so that available resources to engage active risk management are implemented where they have the greatest impact. Critical pipelines normally constitutes a small part of the total number of objects in the water and wastewater systems.

* Any use of the term "pipelines" in this report means "water and wastewater transport systems with accompanying manholes, culverts or tunnels".

NoDig technology
Report 221 – 2016

Authors: Hilde Nystog Aas, SWECO
Espen Killingmo, SWECO
Vegard Busk, SWECO

Keywords: NoDig, trenchless
Number of pages: 80

This report provides a general description of the various methods of NoDig renewal of water and sewer systems. In addition to overall knowledge of the NoDig methods, also known as trenchless methods, the report offers an overview of the opportunities and constraints associated with each method, presented through project examples, design guidelines and guidance on contract forms.

The report is especially targeting municipalities that do not use or rarely use NoDig methods. The goal is to create interest and motivation for the use of NoDig.

This report is not a textbook. Municipalities involved in NoDig projects are advised to engage a competent consultant, not only for the sake of planning and designing, but also to aid in negotiations with and employing of contractors.

Trenchless methods are based either on the use of existing pipelines as formwork for the new pipe, or the establishment of new pipes in virgin terrain. A fundamental philosophy is that the existing pipelines – whatever condition – are considered a resource, e.g. as conduits for new pipes.

The different trenchless methods are suitable to different degrees, depending on the condition of the existing pipe. A structural method implies that the new pipe by itself can resist forces acting on it throughout its life span. When using semi-structural methods, the renovation product is partly dependent of support from the existing pipe. If a non-structural method is used, the renovation product relies entirely on support from the existing pipe.

The Norwegian water and wastewater infrastructure is in considerable need of renewal. Utilization of NoDig technology is a smart and efficient way of renovating pipelines. By using the different NoDig methods, pipe owners will find their renewal rates increasing.

After more than 50 years of NoDig activity in Norway, the methods are now well-developed for most purposes. Norwegian NoDig contractors and suppliers have worked systematically to adapt the trenchless techniques to Norwegian conditions.

NoDig renewal of pipelines is sustainable. Trenchless methods mean lower emissions from construction equipment, in the form of reduced mass transportation and less problems related to dust and noise, compared to conventional trench based projects. In addition, the construction phase is on many occasions much shorter for trenchless projects. The disadvantages for a third party (e.g. stores, industry) during the construction period are in many cases substantially reduced.

The Norwegian Public Procurement Act (lov om offentlige anskaffelser) states that the government, municipal and county authorities and statutory bodies shall, when planning each procurement, have regard to life-cycle costs, universal design and environmental consequences of the procurement.

Consequently, taking the environmental consequences of the procurement into account is mandatory.

NoDig methods should always be considered as an option when initiating a new project. However, it is important to emphasize that trenching may be the right method, often in combination with NoDig solutions.

Financing needs in the water sector 2016-2040

Report 223 – 2017

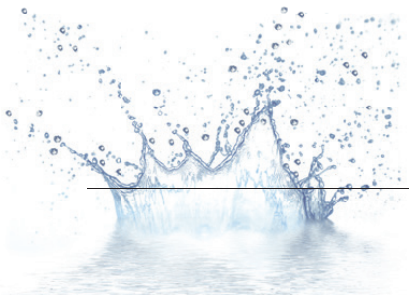
Authors: May Rostad, Kinei AS
Keywords: Investment needs, water and wastewater fees, replacement cost, increased engineering needs
Number of pages: 76

Municipal investment needs in water and wastewater infrastructure till 2040 are estimated to approx. NOK 280 billion based on today's cost level, of which 56 % in municipal water supply and 44 % in municipal wastewater service. More than 64 % of the investment needs are linked to renewal of the water and sewage networks, where the current investment level has to be increased by approx. 50 % due to maintenance needs as well as sustainable infrastructure management until 2040. Another important reason for investment needs is an estimated population growth of 1.1 million up to 2040, which requires increased capacity in the infrastructure. Other important reasons are measures that must be implemented to comply with laws and regulations such as treatment requirements, increased focus on safety and preparedness and various types of climate adaptation measures.

The municipal water and wastewater services are financed with fees from the customers. Based on estimated investment needs and assumed population growth, the average growth in annual fees for water and wastewater for household customers is estimated to 4 % per year in addition to price growth. However, the population growth will vary widely from municipality to municipality. In order to prevent such an increase in fees, the water sector in Norway must cooperate to develop new technologies and more efficient services in order to reduce the cost for the customers.

The most critical factor for implementing the required investment needs, will be access to competent engineers. Education of more engineers, recruitment from other industries and reduced engineering needs by innovation in planning, construction and operation will be important measures.

The replacement cost of the public water and waste- water facilities is estimated to 800 billion NOK. The replacement costs for private water and wastewater facilities, like the houseowners connections, wells and treatment plants, is estimated to 500 billion NOK.



Pressure sewer system in rural and urban areas
Report 225 – 2017

Authors: Kjersti Tau Strand, Asplan Viak
Geir Henning Hansen, Asplan Viak
Keywords: Pressure sewer system, conventional sewer system, rural areas, urban areas
Number of pages: 56

A pressure sewer system consists of small pumping units connected to a network of pipes from other pumping units in the same area. Pressure sewer systems are used in certain areas because of the technical unsuitability or high cost of a conventional sewer system.

Pressure sewer systems have been built in the Nordic countries since mid 1970'ies. Most of these pressure sewer systems are still in function. Pressure sewer systems in Norway and the Nordic countries have since the beginning used both multivane open impeller pumps with grinder device and semi-positive displacement pumps with grinder device. There is no complete overview over the number of pressure sewer systems that are installed in Norway. Pressure sewer systems have until now mostly been used in rural areas with low population density or seasonal occupancy, but can also be an alternative in urban areas.

The pressure sewer system is described in the European Standard EN 1671:1997, which has been adopted as Norwegian Standard NS-EN 1671:1997. In addition there are two «best practice» guidelines (VA/Miljø-blad), nr. 66 «Pressure sewer systems. Calculation and design» and nr. 67 «Pressure sewer systems. Operation and maintenance».

When designing pressure sewer systems it is important to choose the right dimensions for the pipes depending on the type and size of the pumps. The design requirements give smaller pipe-dimensions when using semi-positive displacement pumps, compared to multivane open impeller pumps. It is essential to optimize the pressure sewer system and choose pumps that secure safe operation and reduce maintenance costs. The pipe system must be designed in accordance with design requirements for minimum velocity and maximum retention time, so as to avoid problems with clogging and gas formation.

The report is a combination of a guideline for pressure sewer systems in general, and a study of how to use pressure sewer systems in urban areas. The guideline describes the main elements of a pressure sewer system, environmental aspects and benefits when using pressure sewer systems compared to conventional sewer systems, and summarize best practice for planning, design, commissioning, operation and maintenance of pressure sewer systems.

Pressure sewer systems can give environmental benefits compared to conventional sewer systems with less negative effects on natural habitats, climate and air pollution. The flexibility of pressure sewer systems makes it easier to avoid or reduce construction work in vulnerable natural- or historic sites and areas. It is also easier compared to a conventional sewer system, to combine pressure sewer systems with other types of infrastructure as water and el-distribution and road construction.

Compared to a conventional sewer system there are some challenges that the municipality needs to address when planning a pressure sewer system, especially concerning municipal ownership and financing. The report lines out three different models:

- Model nr. 1 – the municipality is responsible only for the main pipeline in the pressure sewer system
- Model nr. 2 – the municipality is responsible for planning and construction of the whole pressure sewer system including the pumps, but the responsibility for operation and maintenance of the system from the main pipeline to each household is transferred to the private owners
- Model nr. 3 – the municipality is responsible both for planning, construction, operation and maintenance of the pressure sewer system including the pumps

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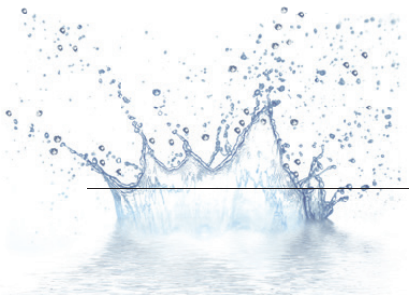
The report gives an overview of advantages and disadvantages of the three models concerning ownership, financing, operation and maintenance.

The study on use of the pressure sewer system in urban areas focuses on how this can contribute to more effective methods for rehabilitation of existing sewer systems. Pressure sewer systems in urban areas can give environmental benefits in combination with trenchless (NoDig) technology and alternative solutions for stormwater management. Pipes for pressure sewer systems can be inserted in existing sewer mains instead of digging a trench in a busy street in the city. New pipelines for pressure sewer systems can be constructed under buildings and roads by drilling boreholes. An existing combined sewer and stormwater main can be reused as a stormwater main by constructing a pressure sewer system for the buildings connected.

Still there are issues that need to be solved and which suggest that the principles of pressure sewer systems in rural areas must be adjusted in an urban setting. First of all the number of pumps in a pressure sewer system must be reduced in order to be economically sustainable in an urban area, compared to a conventional sewer system. It is also essential to develop technical solutions for pumps and pump units that serve for example a block of buildings in a city. The study shows that pressure sewer systems can be a good and innovative solution in an urban setting provided that these issues are solved.



Safeguarding and securing water supply facilities against premeditated and malicious acts

Report 229 – 2017

Authors: Leif Riis, Forsvarsbygg
Anniken Hareide, Forsvarsbygg

Keywords: Water supply, safeguarding, securing, premeditated and malicious acts
Number of pages: 52

A new regulations regarding drinking water (Drikkevannsforskriften) came into effect January 1st 2017; this pose stricter requirements to water authorities regarding securing water supply facilities. Taking into account todays security threat assessment against Norway, this means the ability to safeguard and secure against premeditated and unwanted attacks, such as acts of terror, espionage, sabotage, vandalism and other criminal acts.

Many of today's water treatment facilities and distribution systems were built decades ago, at a time when the security threat and guidelines for securing and maintaining water supplies was quite different. In many situations therefore, both the water treatment facilities and the distribution systems do not meet the demands of current regulations, nor have the ability to handle potential threats against them.

The purpose of this guide is to provide more information to owner and operators regarding effectively safeguarding and securing water supply facilities against premeditated and malicious acts of terror. These security countermeasures will have the potential to prevent, stop and reduce the consequences of acts of terror. The guide is divided into three main sections; chapter titles are posed as questions that will give the reader an understanding of what subject the chapter intends to focus on. The following is a short summary of the three main sections.

Why do water supplies need securing?
The supply of Norway's drinking water is categorised as critical national infrastructure by The Norwegian Directorate for Civil Protection (Direktoratet for samfunnssikkerhet og beredskap/DSB). Access to fresh water is a fundamental prerequisite for maintaining life and is important with regard to hygiene and sanitation. Failure in the supply of fresh drinking water could also have the potential to disrupt other critical functions such as food production, health care and industry.

The new regulation sets minimum requirements with regard to the quality, quantity and supply of water. Paragraph 10 requires that water treatment plants and distribution system to have sufficient physical security measures. The term sufficient is quite vague, but can be interpreted as a series of security measures that include physical, electronic, administrative and organizational security.

What needs to be secured, and against whom do we secure?
The most fundamental question that needs addressing before planning any security measures is determining what assets you possess, and which assets need to be secured. Water authorities must therefore identify and rank all assets belonging to the water supply system according to the negative consequence to the water system should that asset be removed or destroyed. The ranking of assets is the starting point for determining what assets should be secured and how well they should be secured.

A number of acts relating to terror, espionage, sabotage, vandalism and other criminality could affect Norwegian water fresh water supplies. These acts could range from telephone call bomb threats, vandalism and burglary; they could involve explosives and other forms of physical sabotage, they could also rely on a computer virus that could deactivate security systems or even poison the water using forms of chemical, biological, or radiological substances. It is possible to imagine attacks against pumping stations, water treatment facilities, water pipelines and direct supply to specific buildings. Attacks on water facilities could be perpetrated as acts of vandalism, acts by mentally unstable people, disgruntled employees or in crises situation sabotage from foreign military powers.

It is important to note that this chapter is not designed to be an official threat assessment of Norwegian water supplies but more of a guide that owner of water treatment plants can use while developing their own threat assessments. The reason for this is that all water supply systems are exposed to different

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kinds of threats that are dependant on factors such as size and location, as well as who and or what the water is supplying. It is crucial therefore that every water authority make their own threat assessment to determine which threats are relevant to them.

How to secure water supply systems? Principles and best practice

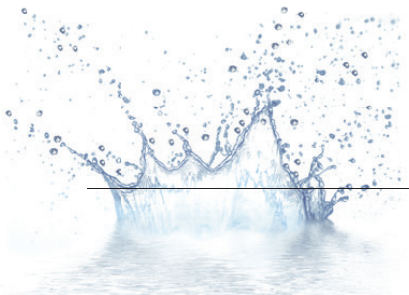
Security countermeasures should be good enough to cause a potential attacker to consider the likelihood of a successful attack as being low. Security countermeasures would therefore act as an effective deterrent. If an attacker nevertheless decides to go through with an attack, measures must be in force to be able to detect the attack as quickly as possible, delay an attacker and to deploy counter measures to reduce potential damage. To achieve this level of security a comprehensive security system should be established that would consist of physical barriers, detection, verification, reaction and recovery. For security measures to have the desired effect it is important that a healthy security culture is established within the organisation. It is people that ultimately implement the organisations technical and organisational security measures. Employees that either do not understand or do not agree with an organisations security culture could quickly reduce the effect of expensive physical and electronic security measures.

In Norway there are several thousand waterworks. These range from small private waterworks that supply small villages, to large public waterworks that supply water to over a hundred thousands households. It is not possible to describe security countermeasures that could be implemented for all of these waterworks. This is due to the enormous variation in design and construction as well as the different water supply systems that can be exposed to different types of threat according to vulnerability, size, location and who the end consumer of water is.

A risk-and vulnerability analysis would help determine what level of basic security and additional security would be appropriate. An analysis would assess an organisations assets, the vulnerability of these assets with regard to a selection of different threat scenarios, assess risk and propose how to manage the risk. This type of analysis would give the water authorities a guide to the risk they face and would be a valuable tool to assess what should be secured, how individual waterworks should be secured and what would be considered an appropriate level of security with regard to a potential threat defined in the analysis. This guide attempts to provide an overall description of good basic security countermeasures for the different parts of a water supply system and to give water authorities a better understanding of what can be considered good basic security countermeasures. This is not a complete list and should not be use as a replacement for a risk- and vulnerability analysis.

The guide is summarised with a checklist for how the owner of waterworks can achieve the appropriate securitylevel for their water treatment plants and distribution system. The checklist contains administrative, organizational, physical and electronical security countermeasures.

- All waterworks should have risk and vulnerability analysis for their system
- All waterworks should establish routines for background check and system for security follow-up with the employees
- All waterworks should establish a good security-culture and routines for security-trading
- All waterworks should have routines for information-security
- All waterworks should have physical and other countermeasures to delay an offender
- All waterworks should secure the most important parts of the supply system in own sections
- All waterworks must have a system for detection of attacks, and the verification of such events
- All waterworks must have a plan to alert employees, local authorities, police and suppliers
- All waterworks must have a plan and routines for recovery and damage decreasing measures
- All waterworks must have a contingency plan and perform contingency exercises
- All waterworks must have a reporting-system in relevance to security
- All waterworks must secure their data and operations (described in other reports)



Plastic pipes for water and wastewater – how to achieve a lifespan of minimum 100 years

Report 232 – 2018

Authors: Gunnar Mosevoll
Co-author: Odd Lieng, Norsk Rørsenter

Keywords: Plastic pipes, material properties plastic pipes, pressure pipes, pressureless pipes, history plastic pipes, polyvinylchloride, polythylene, polypropylene, fiberglass reinforced pipes
Number of pages: 228

Plastic pipes is a common term for several plastic materials, and the report deals with both thermoplastics and thermoset plastics, although the main emphasis is on thermoplastics. There has been rapid development since plastic pipes became available in the market, and the quality of the pipes produced today cannot be compared to those produced in the 1960s and 1970s.

An important premise for this report is that we have assumed a minimum lifespan of 100 years! This makes sense from both an economic and operational point of view, as the pipe costs represent a relatively small share of the total construction costs. The costs and disadvantages when replacing pipes with «short life span» are large, especially in urban areas.

Proof of adequate life span will probably always be associated with some uncertainty. It is important to perform the relevant or recommended tests. The preparation of «Curves for stress – time to failure» also called «Creep curves» (relationship between material tension and time to break) is important and useful, but such attempts do not necessarily tell the whole story, and some degree of professional judgment may also be necessary.

For non-pressure multilayer pipes «Creep curves» are not available.

As this report is extensive, it is not intended to be read page by page, but should be considered as a reference work, where the individual chapters can be read separately.

First chapter accounts for almost half the report by number of pages, giving a general introduction with examples of usage, history, lifetime considerations, dimensioning rules, standardization / certification, and a thorough review of the structure and properties of the various plastic pipe types.

Sewer pipes with constructed pipe walls (multilayer) are discussed, and it is a section with the classification of plastic pipes where one deals with safety factors, dimensioning conditions and more.

The remaining chapters deal with:

2. Material properties for plastics
Deals with deformation properties and different fracture types for thermoplastics, elasticity, length extension due to temperature, material properties at high and low temperatures, and leakage of substances from plastic water pipelines.

3. Dimensioning of plastic pipes with internal water pressure and external soil and water pressure
For internal water pressure, tensile stress is described in longitudinal and transverse directions, and cross contraction. Otherwise, external loads such as external water pressure, earth loads and traffic loads are discussed, and relationship between the pipeline and external loads (especially for non-pressure pipes). The effect of scratches in the pipe wall, high pressure flushing, pressure shock, damage by digging near pipes etc. are also matters that need to be taken into account.

4. Lifespan of at least 100 years for thermoplastic tubes: How to achieve it?
The requirement of at least 100 years' lifespan is supported, and reference is made to surveys and lifespan reports before assessing different pipe types. Furthermore, a conclusion or recommendation of the various types of pipe is given (tabulated).
The recommendations are supported by the workgroup for the report.

5. Current types of thermoplastic - Documentation of lifespan
This chapter contains a documentation of the recommendations in Chapter 4, and may be viewed as an attachment.
The above should be looked upon as a brief summary of the content of the report. Professional conclusions are difficult to provide on such a large subject with few words, but recommendations are included in Chapter 4.

Guidelines for use of concrete pipes
Report 233 – 2018

Authors:	Petter Hauge, Ivar Johan Urke and Kjell Lauritz Keseler, Norconsult

Keywords:	Concrete pipes, concrete manholes, reinforced and unarmed concrete pipes, quality, durability, internal roughness, quality requirements, seal rings
Number of pages:	64

The main goal for this guideline is to increase the knowledge of concrete as material, the properties of concrete pipes and proper use of, and construction of, concrete pipes. HSE is also included, based on the products of concrete pipes and manholes on the market today. By using the proper products and do the construction well, the best result may be achieved.

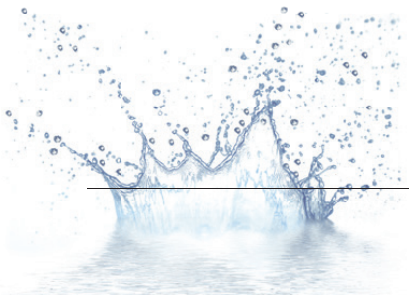
The guideline may be of interest for several:

- Representatives from the builder organization (often technical staff from the municipalities)
- Consultants/ planners
- Contractors/ entrepreneurs

The building of sewer and storm water pipes increased in the period from 1950 to 1970, and at the end of this period concrete pipes had a market share of 90%. After that the use of other pipe material increased, but concrete pipes are still used, especially at large diameters.

In 1968 «Kontrollrådet for betongprodukter» was established (now «Kontrollrådet»), to control the quality of concrete products (independent, 3rd part control). The stricter quality requirements led to fewer producers, and to the creation of producer organizations. Today there are two producer organizations; Basal and Østraadt Rør Gruppen.

The quality has increased during the years, and you seldom find damages or failures on concrete pipes produced after 1970.



Pipe Inspection Manual
Report 234 – 2018

Authors: Hans Jørgen Haugen, Asplan Viak AS
Keywords: CCTV inspection, sewer system, water supply system, sewer pipelines, water pipelines
Number of pages: 131

The report describes requirements for conducting and reporting CCTV-inspection for water mains, drains and sewers, and is a revision of the previously published Norsk Vann reports on the subject. One goal has been to gather all content in one report. It has also been important to make the CCTV-report for drains and sewers more suited for preliminary sorting of pipelines needing renovation, to be monitored, or no further action needed.

Major changes made in this report:

- Drop measurement are now described with two levels of accuracy. Precise measurement for new constructed pipelines, and indication of drop for rapid control or other purposes.
- Characterization of observations are more detailed described, and they are given abbreviations for easier use.
- The circumferential location of connections on the main pipeline are reported with more details and given more value when evaluated.
- Deformation on rigid pipes can now be reported as fissure / break, grading 3 and 4. This will make it easier to evaluate suitability for renovating the pipeline with a liner.
- Maximum acceptable sizes for drilled holes in rigid pipelines have been introduced.
- Displaced joint distinguish between rigid and flexible pipes. Rigid pipes are graded by the measured internal gap in the joint.
- Exfiltration of wastewater can be reported.
- Some errors and ambiguities have been removed.

The report will hopefully contribute to more accurate reporting from CCTV-inspection, and make it easier to report and assess damage and operating problems.

Methodology for calculating Sustainable Economic Level of Leakages (SELL)

Report 239 – 2018

Authors: Annika Malm, RISE Research Institutes of Sweden,
Gilbert Svensson, RISE Research Institutes of Sweden
og Vattenforum
Jon Røstum, Powel

Keywords: Water losses, leakages, tool, benchmarking, Sustainable Economical Level of Leakage

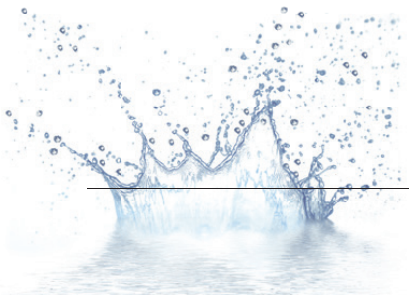
Number of pages: 51

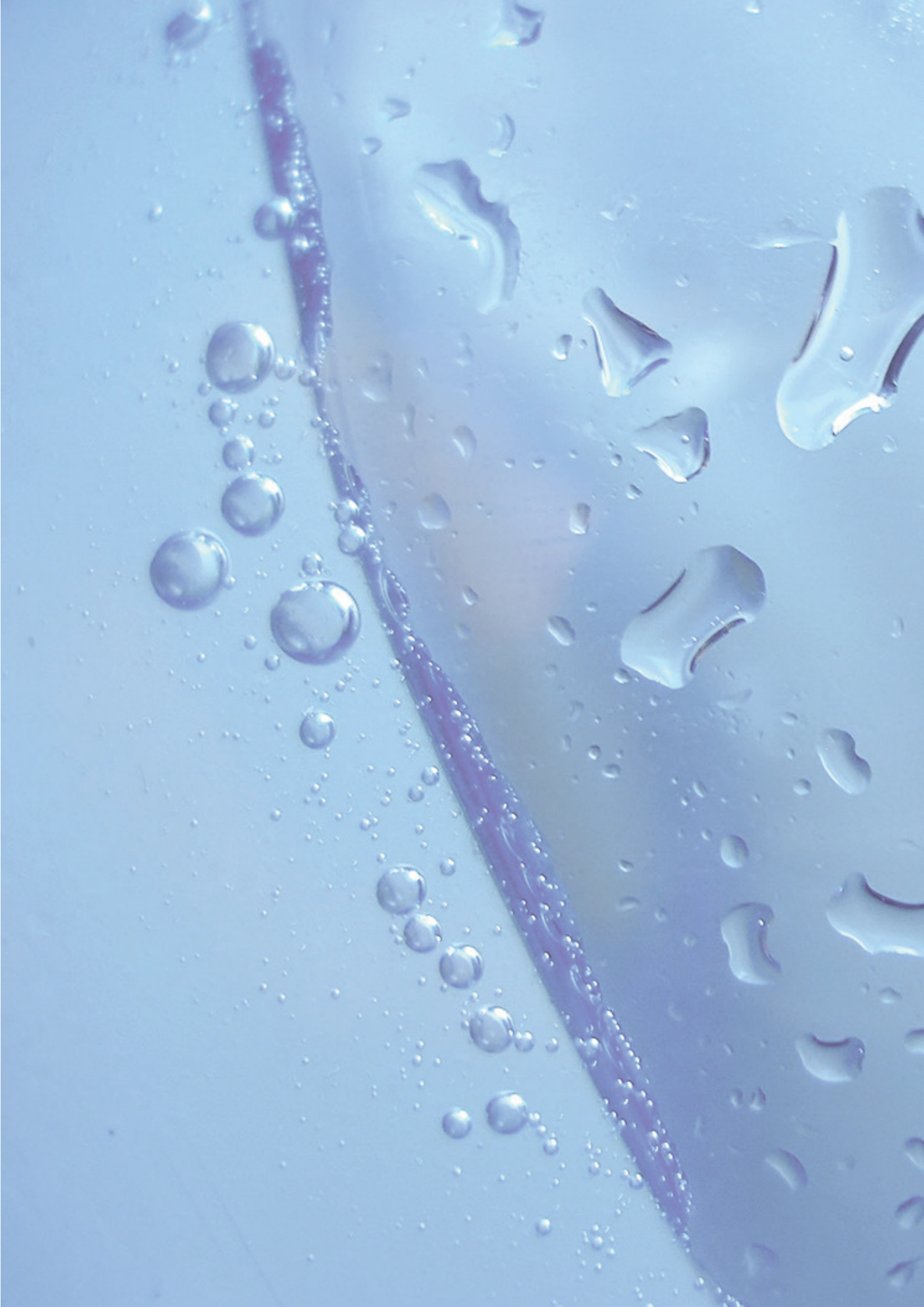
According to the sustainability strategy for Norwegian Water from 2017 water utilities in Norway should within 2020 develop individual plans for how to reach a sustainable economic level of leakage in the water supply system. As a part of the project different tools for assessing the sustainable leakage level for each water company has been developed.

SELL stands for Sustainable Economic Level of Leakage. SELL includes not only the long-term costs and benefits which are internal to the utility, but also external social and environmental costs of leakage. Social costs are e.g. traffic disruption etc. from pipe repair and replacement work, but also health risk effects from unpressured leaking pipes. Environmental benefits are e.g. carbon reduction.

The manual includes a water balance, including default value for e.g. unbilled legal water consumptions if no local data is available. The manual will also include a spreadsheet tool for calculation of SELL for different conditions. Default values for leak reduction management, installing of new technology will be included and the results can be valued for different conditions. Also values of health risk will be included. Moreover, an uncertainty analysis will be included so results can be seen as a span.

When all externalities are included, and when new leak reduction techniques are developed, the value of SELL is lower than expected a priori. We believe that the manual will be a great tool to fight water losses, especially for small and medium water utilities.





Norwegian Water

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