water for now and in the future

Long-Term Vision on the Vitens 2020-2050 Infrastructure

Vitens

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Appendix

‘The development of future-proof abstractions, water savings and making the drinking water infrastructure more flexible and intelligent are our top priorities.’

Main office Zwollee

1 management summary

Reliable drinking water is one of life's basic necessities and the organisation and implementation of a sustainable and efficient drinking water supply is the responsibility of drinking water companies. Vitens wants to use this Long-Term Vision on the Vitens Infrastructure (LTV) to internally and externally show how the drinking water company perceives the drinking water supply, the developments which are important within that context and how Vitens wants to guarantee the reliability of the drinking water supply both now and in the future. Vitens expects this description of the drinking water interests will form an excellent basis for a constructive dialogue with all stakeholders, focussed on finding sustainable solutions for the drinking water supply. This LTV is primarily about the long-term perspective and not about bottlenecks which can be resolved within a relatively short period of time.

This LTV has been further tightened in a number of areas compared to the previous LTV (2016). One clear difference is that the 2020 LTV identifies the underlying principles and preconditions wherever possible, instead of merely describing Vitens' position. For example, the 2016 LTV expresses a preference for groundwater, whilst no preference is stated in the 2020 LTV and Vitens is open to all possible options, such as surface water, providing it can satisfy a number of preconditions to guarantee the reliability and sustainability of the drinking water supply. The options will also need to fit in with Vitens' objectives where sustainability, costs and safety are concerned. It is expected that, by indicating the principles, preconditions and goals, the dialogue with society can be conducted in a more constructive manner, ultimately resulting in the realisation of better solutions at system level.
Additionally, the water system is even more central compared to the 2016 LTV, where, in addition to a sustainable water system design, water savings and a sustainable water abstraction design are also specific spearheads.

The 2020 LTV consists of: descriptions of the developments, trends and challenges, four scenarios, the desired situation, the strategy for realising the desired situation, options to realise the strategy and, finally, the activities to be continued, accelerated or developed (see figure A). These subjects also serve as the guideline for the management summary.
Many things are (apparently) presented without any kind of substantiation at the heart of the LTV. It's therefore been decided to keep the LTV clear and not too long. More detailed information can be found in the appendices.

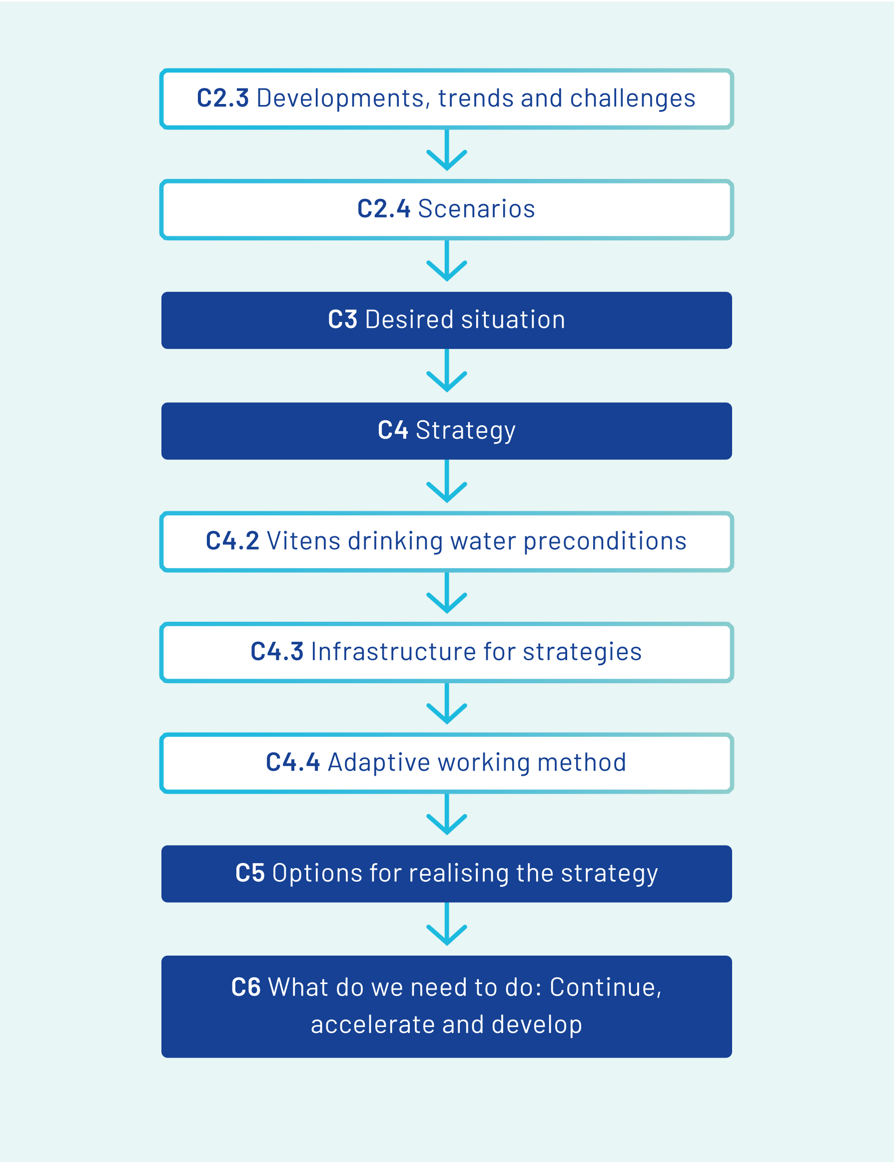


Figure A - Outline of design

Developments, trends and challenges

The demand for drinking water is increasing, which means more capacity is required in the form of abstraction permits. This while Vitens is already dealing with a shortage of permit reserves and the provinces are looking for additional strategic stocks for possibly even stronger growth in the (very) long-term. Climate change has resulted in abstractions now being less desirable in certain locations and these must therefore be moved to more climate-resistant locations. This puts pressure on the available space and abstraction possibilities. On the other hand, shrinkage may also occur due to demographic changes and disappointing economic developments (in parts of the Vitens area).
The quality of the abstractions continues to be a concern, as one third of the abstractions doesn't meet the targets set by the European Water Framework Directive and this is not expected to improve in the future.
Technological developments are also following each other in rapid succession, plus society wants more transparency and sets higher demands which the service needs to satisfy. All of this has resulted in Vitens now needing to investigate whether the current sources and drinking water infrastructure are sufficiently future-proof to ultimately guarantee the drinking water supply in this increasing uncertainty.

Scenarios

The environmental scenarios in this LTV are aimed at 2050. This emphatically concerns extreme scenarios (not business as usual or desirable scenarios), where radical developments put pressure on the current method of supplying reliable and affordable drinking water. The scenarios are therefore more of a 'stress test' than a prediction. The scenarios have been developed based on two main axes (see figure B):

- More demand than supply, or more supply than demand;
- Centralisation or decentralisation.

The four scenarios are:

- Drinking Water Delta Works
- Wild Water West
- Drinking Water Bubble
- Dilution

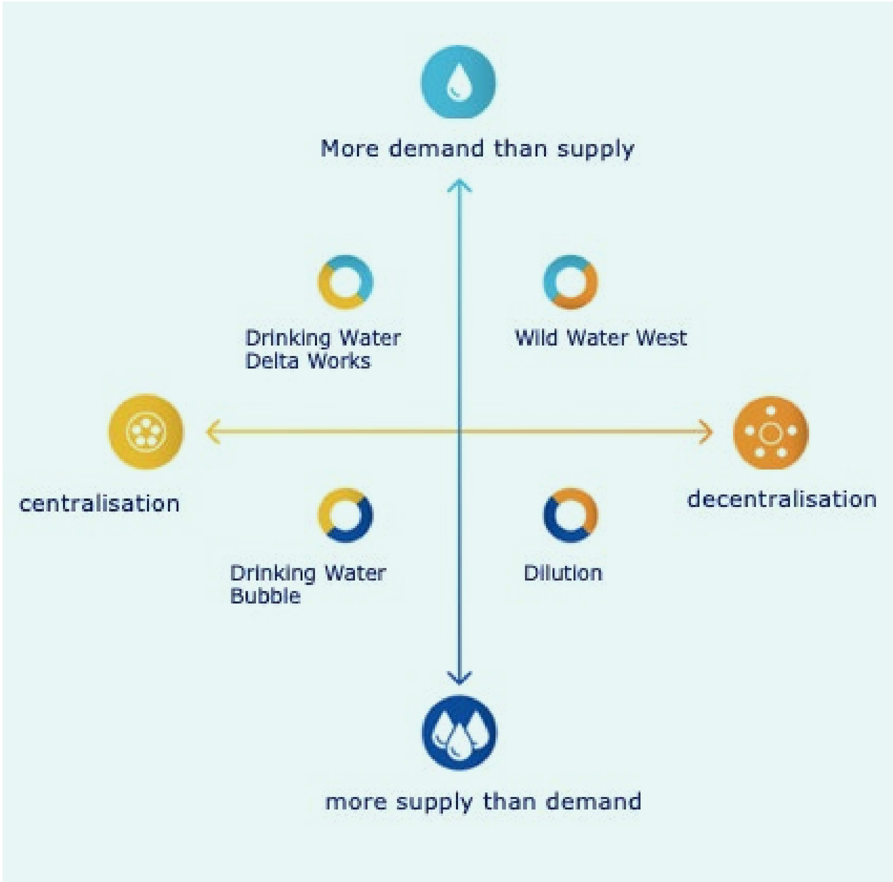


Figure B - Four scenarios

Drinking Water Delta Works: There is a major shortage of drinking water. The drinking water company has insufficient production capacity and can't cope with the ever-increasing demand. Climate change has resulted in existing sources now having an insufficient amount of water, or these have been seriously contaminated and the redistribution of sources is required at national level. The government has taking over control of the drinking water company and is building large-scale infrastructure.

Wild Water West: There is a major shortage of drinking water, partly as a result of customers placing increasing demands on the quality of the water, demands which the drinking water company can't meet. The market is responding to this and is coming up with tailor-made solutions on a small, but also larger scale, to customers with the same requirements.

Drinking Water Bubble: There is a great deal of unused infrastructure, as demand has fallen sharply. This is the direct result of some very substantial water savings by individuals and strict regulations set by the government.

Dilution: The full focus is now on local and circular solutions. The hydrogen economy is booming. Integral area work is in place, aimed at spatial quality, within which the water supply is regulated by collectives and companies. The drinking water company sometimes still takes on the role of quality assurance and the boundaries between surface, drinking and waste water have become blurred.

Desired situation

The scenarios have been used to describe the desired situation from extremes. The desired situation is described using the primary organisational goals which Vitens uses to describe its core task. This means that whatever strategic or operational choices are made, they will always have to contribute to realising the desired performance for each of these goals.

The goals are:
A. Provide sufficient and reliable drinking water, both now and in the future;
B. Make sure the drinking water is affordable;
C. Ensure safe and healthy working conditions are in place;
D. All tasks are executed in a sustainable manner with care for nature and the environment;
E. Safeguard drinking water's impeccable reputation in a good relationship with stakeholders (customers, government authorities and interest groups).

The five primary organisational goals link into the Sustainable Development Goals (SDG's).

The goals will be briefly explained, whereby goal C (ensuring safe and healthy working conditions are in place) will not be described, as this goal always applies and is not distinctive where the long-term choices are concerned.

A. Provide sufficient and reliable drinking water, both now and in the future
Vitens sees it as its duty to provide both sufficient and reliable drinking water. Activities or changes in the drinking water system which pose a risk to the safety of the drinking water must be prevented at all times. A sustainable integration and efficient protection of the sources and underground pipeline infrastructure are therefore important.

The drinking water supply system must be able to respond to changes in supply (availability) and demand. The availability of sources can change as a result of climate change, which has an impact on both availability and quality. Demand development is uncertain too, for example as a result of water savings, innovations, population growth, economic growth and decentralised (circular) solutions.

Vitens strives for a future-proof abstraction infrastructure, where the water abstracted in the abstractions is available in all possible climate scenarios, has the best possible quality and the absolute minimum acceptable environmental damage.

An efficient and intelligent drinking water system, using reliable data, is an important condition for increasing reliability. In addition, this also enables Vitens to transparently provide both society and customers with good information.

B. Make sure the drinking water is affordable
Drinking water has to be accessible to everyone, which is why its affordability is essential. An important starting point is that we don't pass any costs onto future generations.
A good condition of the drinking water infrastructure is important in addition to a healthy financial position, in order to keep the drinking water supply affordable and guaranteed in the long-term too. Vitens will therefore ensure sufficient investments are made in new infrastructure and that any aging infrastructure will be replaced in time.

D. All tasks are executed in a sustainable manner with care for nature and the environment
This means Vitens will affect the natural environment as little as possible and will, where possible, have a positive impact.

Using sustainable and future-proof abstractions and stimulating the quality of the living environment are important objectives here. Vitens wants to reduce any harmful abstractions wherever possible and move these to areas where they will have a less harmful impact, in order to prevent the desiccation of vulnerable nature areas.
Water losses during production and the transport of water will be limited. Water wastage and unnecessary use of drinking water are counteracted.

Vitens also wants to become climate-neutral. Energy consumption will be limited as much as possible, energy will be generated wherever possible and the remaining energy needs are purchased sustainably. All residues will be recycled to a high standard. The use and purchase of materials and consumables is organised as sustainably as possible.

Vitens strives to increase and strengthen biodiversity when designing water abstraction areas and other sites.

E. Safeguard drinking water's impeccable reputation in a good relationship with stakeholders (customers, government authorities and interest groups)
Realising the above goals and ensuring healthy working conditions are in place are important conditions for a good reputation. Good relationships can also be realised by creating the highest social value wherever possible. Vitens wants to find the best solutions for the drinking water infrastructure in a co-creation process with relevant stakeholders.

Strategy: Resilience

There are many uncertainties which must be taken into account in order to realise the goals described in the desired situation. Vitens' drinking water infrastructure boasts an extensive network, within which abstractions and users are linked together in a complex manner. This network's assets usually have a long lifespan, are capital intensive and have a long development period. The development of demand is uncertain and social and technological changes are happening in rapid succession. Vitens has opted for developing resilience in the drinking water infrastructure as its strategy, in order to achieve results in this complex situation, with many mutual interdependencies. Vitens' approach is to do this along three lines (see figure C):

1. What are we going to do? Vitens has opted to create resilience in the infrastructure on the basis of the infrastructure strategies: robust, tolerant, flexible, sustainable and intelligent.
2. How are we going to work? Vitens has opted for an adaptive working method, or working with 'options' (possible solutions in the drinking water infrastructure to get to the desired situation) which minimally meet the Vitens Drinking Water Preconditions (VDP's). Depending on developments, such as the demand for drinking water, the decision will be made as to which options are going to be used. The scenarios described will provide us with tools for monitoring the developments and to assess which options should or shouldn't be used.
3. Who are our partners? Vitens has opted to develop and implement the options together with stakeholders in a co-creation process, taking the interests of all parties involved into account.

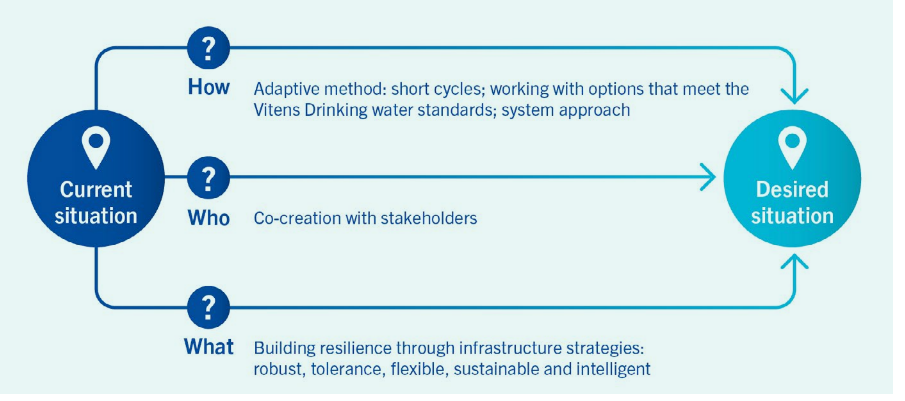


Figure C - Approach for developing resilience

It's important for all stakeholders to state their interests before the start of the process when working on a co-creation process. Vitens has established the drinking water interests in VDP's. These guarantee the safety and reliability of the drinking water supply and are often derived from legal requirements.

Vitens Drinking Water Preconditions:

VDP 1: Each source has sufficient water in all climate scenarios.

VDP 2: There is sufficient diversification in the sources.

VDP 3: Reserves in the capacity to be extracted must be available for a very long time (minimum LTV planning period) and without limitations.

VDP 4: Each source is tolerant: the drinking water supply can continue to run for a while in the event of a serious disruption (in quality and/or quantity), allowing for measures to be taken to guarantee continuity.

VDP 5: The quality of the drinking water is guaranteed by several barriers:
- The cleanest possible source with a constant quality;
- Reliable purification;
- Safe transport and distribution system.

VDP 6: Risks in relation to the microbiological quality are as small as possible.

VDP 7: There is sufficient flexibility in the drinking water system to accommodate changes.

VDP 8: The security of supply is guaranteed.

VDP 9: The drinking water system has been structured in a logical, as simple as possible, coherent manner, offering the possibility of intelligently controlling the different parts.

Infrastructure strategies

Infrastructure strategies are ways to introduce resilience in the infrastructure.

1) Robust: the drinking water system has been designed in such a way that the drinking water supply will remain intact despite any external disruptions.
2) Tolerant: the drinking water system can tolerate (temporary) disruptions. The system will continue to reliably function for some time despite a disruption, providing sufficient time for taking the appropriate measures to guarantee continuity.
3) Flexible and adaptive: the drinking water system can adapt in line with changing circumstances.
4) Sustainable and circular: the drinking water system has been sustainably designed. Vitens thereby uses the following approach:
   - Preventing any impact on the natural environment;
   - Minimising any negative impact on the natural environment;
   - Maximising the positive impact on the natural environment;
   - The starting point for sustainability is that measures, as would be the case with other asset management decisions, look at the entire system and the entire life cycle.
5) Intelligent, coherent and timely: the drinking water infrastructure has been structured in a logical and coherent manner and can be intelligently monitored and controlled. This increases the reliability of the supply, ensures better asset management decisions can be made and allows for proactively informing customers and society.

Adaptive working method

The adaptive working method is a working method which uses options which can be developed internally or externally (and therefore not with a blueprint of the desired future situation). The options must match Vitens' goals and strategy and must comply with the VDP's to guarantee the reliability and safety of the options.
You have to work in a short cyclical manner when working with options, preparing several options which will probably not all be realised. The decision as to whether or not to use an option will depend on indicators such as demand development, source

availability and social and customer developments (as described in the scenarios). It's important for the options to be developed in external dialogues and coordinated with the relevant stakeholders, in order to obtain good social solutions. A system approach is essential here. The adaptive working method is, both internally and externally, a significant change compared to the current way of working.

Options; abstract and realistic options

A distinction is made between abstract options, which describe the possibilities for an option at conceptual level, and realistic options, which can be clearly identified and realised. An abstract option in a certain area can be used to develop a realistic option. The LTV is not intended to deal with realistic options, but provides direction towards abstract options, which are then further elaborated on in other plans. Within this context, Vitens has elaborated on an abstract option, which is referred to by the term 'water mains engineering perspective', as it's based on water mains engineering interests.

Vitens has mainly spread groundwater abstractions across the area. One specific focus point is the groundwater abstractions on the dry sandy soil in the east of the supply area, which extract water from small-scale vulnerable water systems and which cause significant drought damage, which is reinforced by climate change. These abstractions are therefore only future-proof to a limited extent. There are better opportunities for abstracting water in the Vitens area, allowing for these abstractions to be more effectively relieved or, if necessary, closed. The most suitable Vitens areas for abstracting water are areas where ample surface water and/or groundwater is available in all climate scenarios and where the effects on the environment are expected to be the smallest. These areas are referred to as strategic cores: south Friesland, the IJssel Valley, the strategic Central Netherlands core and the River Area.
In times of growth, the major demand centres are to be connected with eachother, and connected to the strategic cores as much as possible, in order to guarantee a future-proof infrastructure. Depending on the growth, more areas will be connected to each other, whilst in times of contraction pipelines can be cancelled. Figure D shows this first water mains engineering perspective for future-proof infrastructure. This doesn't yet take administrative preferences, stakeholder interests, costs and technical feasibility into account. That would be a next step in the process.

What do we need to do: continue, accelerate and develop

Vitens will be working with adaptation paths, in order to keep an overview between the various possible options and to know when certain options are required. An adaptation path describes which option will be chosen if something changes and when that needs to take place.

Continue
Many activities which are already taking place will be continued. This will primarily involve a drinking water company's core tasks, such as the production and distribution of good and reliable drinking water, the guaranteeing of the drinking water quality and the construction, replacement and maintenance of the drinking water infrastructure.
The sustainable use of materials, sustainable energy use and maximising the reuse of residual materials is also an ongoing important focus point, as is ensuring good availability and protection of the source. In addition, making sure there are sufficient abstraction permits and enough operational production capacity are also important focus points. Vitens currently has a shortage of permit reserves. It's essential to obtain the necessary permits as soon as possible, in order to guarantee the continuity of the drinking water supply. Any possibilities which can be realised quickly will be used whenever possible, in view of the long lead time where obtaining these new permits is concerned.

Accelerate
There are three activities which need to be accelerated in order to realise the strategy:
- Developing future-proof abstractions;
- Managing the water consumption (water savings);
- Making the drinking water infrastructure more flexible and intelligent.

Develop
Knowledge is currently lacking for the implementation of the strategy. We are focussed on knowledge development using the following four themes:
- Increasing flexibility in the drinking water system;
- Reducing the impact on the environment and surroundings;
- Increasing the intelligence in the drinking water system;
- Increasing our insight into new developments.

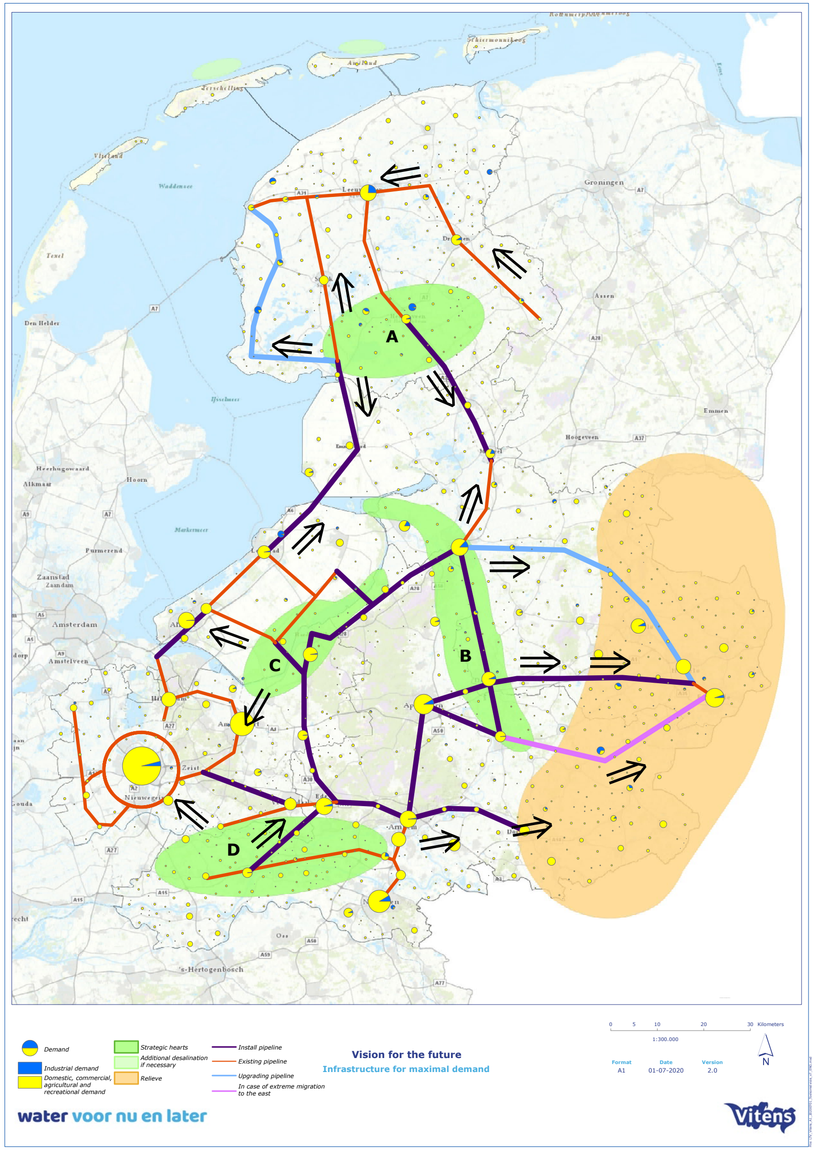
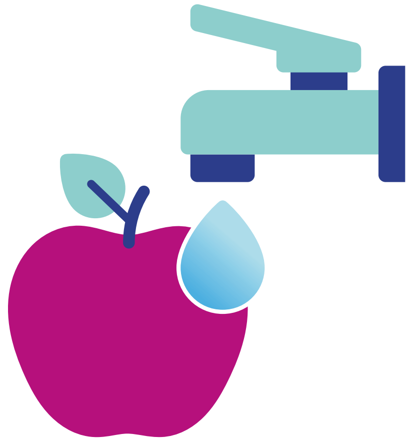


Figure D - Option on system: a water mains engineering perspective

Vitens is of the opinion that collaborations and co-creation are essential both internally and externally, particularly in relation to the necessary acceleration and knowledge development. Various different stakeholders play a role in this process and we need to check how this can be most efficiently organised and which knowledge and competences are needed for this.

The Government, the provinces, the municipalities and water boards are all important where the creation of good conditions is concerned. Fellow drinking water companies and other infrastructure managers are dealing with comparable tasks and knowledge institutes and universities play an important role in knowledge development.



2

introduction

Vitens wants to use this long-term vision (LTV) on the drinking water infrastructure to internally and externally show how it perceives the drinking water supply, the developments which are important within that context and how Vitens wants to guarantee the reliability of the drinking water supply both now and in the future. Vitens expects this description of the drinking water interests will form an excellent basis for a constructive dialogue with all stakeholders, focussed on finding sustainable solutions for the drinking water supply. This LTV is primarily about the long-term perspective and not about bottlenecks which can be resolved within a relatively short period of time.

For this purpose, this introductory chapter provides an overview of the importance of drinking water (drinking water as one of life's basic necessities, paragraph 2.1), the tasks and legal framework for the drinking water supply (paragraph 2.2), the most important long-term developments, trends and challenges (paragraph 2.3) and the scenarios used (paragraph 2.4) And finally, paragraph 2.5 explains the further structure of the LTV.
Many matters are presented without substantiation in chapter 2. We have opted for this to ensure the chapter is both clear and easy to read. More detailed information about most of the subjects can be found in the appendices.

2.1 Drinking water as one of life's basic necessities

Reliable drinking water is one of life's basic necessities and has an incredibly long history. The ancient Greeks and Romans attached a great deal of value to their personal hygiene. The Romans therefore built bathhouses, public toilets with a sewage system and impressive water mains systems. These were no longer maintained after the collapse of the Roman Empire and they therefore fell into disrepair. The population once again had to rely on rainwater, local wells and local surface water. Faeces and waste were simply dumped into the streets and in the water and there was a distinct lack of personal hygiene. Unsurprisingly the direct result of this was infectious diarrhoea and illnesses like the plague and smallpox, causing a sharp decline in the population.

The industrial revolution (from approximately 1760) attracted many people into the cities, which quickly resulted in major hygiene problems in these areas. Contaminated drinking water and poor hygiene conditions led to a major cholera epidemic around 1820. The cholera bacteria was the result of intensified trading from India to Europe. Water companies were founded to improve the quality of the drinking water supply. Amsterdam was the first city in the Netherlands to have a drinking water company in 1853. Water companies were being founded in the Vitens area until 1890 in Nijmegen (1879), Utrecht, de Bilt (1883), Arnhem, Baarn, Soest (1885), Gorinchem, Hilversum (1886), Leeuwarden, Kampen (1888), Zutphen (1889), Tiel and Amersfoort (1890).

Most of the municipal companies merged to a provincial scale after the Second World War, in order to organise the drinking water supply more effectively and efficiently. Supra-provincial mergers also took place around the turn of the century, from which Vitens originated.

2.2. Characteristics, tasks and legal framework of the drinking water supply

The drinking water supply is a public task. The duty of care for securing the drinking water supply rests with the government. The organisation and implementation of a sustainable and efficient drinking water supply is the drinking water companies' responsibility, the mandate of which has been laid down in laws. The drinking water infrastructure uses two systems: the 'drinking water supply and the technical network' and the 'space and water system' from which the water is extracted. This has turned the drinking water infrastructure into a complex system and one in which several different parties play a role.

A balance must be struck between the two systems between purifying and distributing the required amount of water and the acceptable damage to the space and water system (see figure 1). This differs from many other social infrastructures, such as gas and electricity, where the abstraction and distribution are separated from each other and a split has been made between public and private management. This while the total drinking water infrastructure is managed by the government or by drinking water companies with public shareholders.

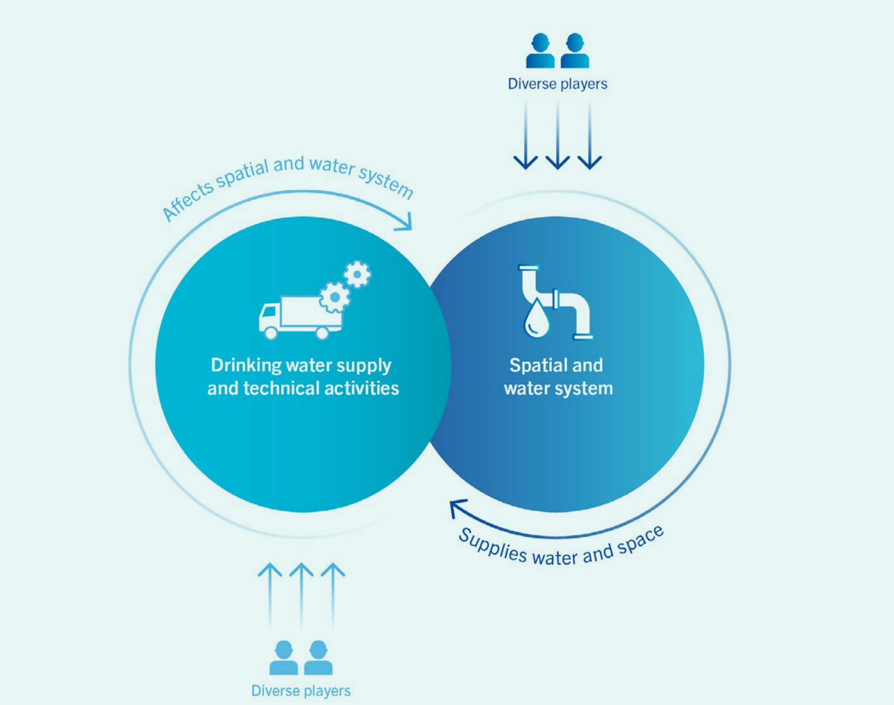


Figure 1 - Drinking water infrastructure: complex interplay between the technical network and the space and water system

Both systems have their own characteristics and have different laws and regulations.

Drinking water supply and technical network
The European Drinking Water Directive has been implemented in the Drinking Water Act. This law states that drinking water companies must establish and maintain a sustainable and efficient drinking water supply, whereby they must make a reasonable, transparent and non-discriminatory offer to everyone who wants a drinking water connection. Drinking water companies have a great responsibility where the quality of the drinking water is concerned and will protect the drinking water sources together with the government. The quality standards are further elaborated on in separate guidelines. The Drinking Water Act also requires the drinking water company to take all appropriate measures to meet the future needs for drinking water. In addition, the drinking water company must prepare an analysis of any possible disruption risks and introduce measures to prevent disruptions as much as possible. And finally, the Drinking Water Act dictates that a Drinking Water Policy Document is drawn up every six years. The first Drinking Water Policy Document (2014) stated that drinking water is a vital function and one of major importance.

The Minister of Infrastructure and the Environment established the WACC[1] (Weighted Average Costs of Capital), in order to financially direct the drinking water companies. For drinking water companies, this means consistent long-term financial planning, making sure the rates are sufficient to cover the necessary investments and operating costs with a maximised WACC, while ensuring any costs resulting from insufficient investments or maintenance are not passed onto future generations.

One unique aspect for the drinking water supply in the Netherlands is that no chlorination takes place. For Vitens this means that the microbiological safety of the drinking water is based on the abstraction of bacteriologically reliable (bank) groundwater, with sufficient underground residence time to kill off any pathogenic bacteria, viruses and parasites. The soil ensures disinfection and there is no additional disinfection at most production locations. This has resulted in most customers not buying bottled water in the supermarket. Plus tap water is a great deal cheaper for the consumer.

Space and water system
The drinking water infrastructure has many interfaces with the environment, the space and water system and affects many stakeholders. This playing field is becoming more and more complicated, because the world is constantly changing and at an increasingly more rapid pace.

The European Water Framework Directive (WFD) is important to maintain the quality of the source. The WFD aims to guarantee the surface water and groundwater quality

1 The WACC is intended to determine the capital costs which the drinking water companies can maximally take into account when determining their rates. The WACC is the weighted average of the cost of capital for equity and borrowed capital. In 2019, it was announced that the WACC would be reduced from 3.4% to 2.75%.

within EU Member States in an identical manner. The WFD works with river basins and protected areas for this purpose. Member States must ensure that any deterioration in river basins is prevented, in order to reduce the level of purification required for drinking water production (article 7 WFD).

Laws and regulations have been put in place to protect the environment and to make good use of it. A multitude of laws about the living environment have been combined in the Environmental Act. The Environmental Act prescribes that environmental visions are drawn up at national, provincial and municipal level and that these visions indicate the relationship between space, water, the environment, nature, landscape, traffic and transport, infrastructure and cultural heritage. These plans indicate the framework within which solutions for the drinking water supply must be found.

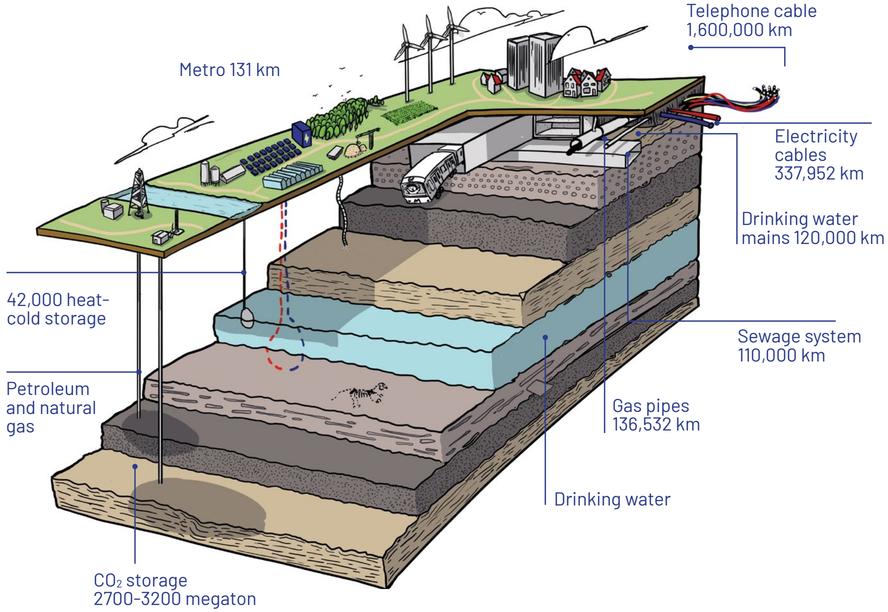


Figure 2 - The pressure for space in the Dutch subsoil (copied from 'Over Morgen' (About Tomorrow) with permission; NGinfraMagazine 2 (pressure for space) (2019))

2.3. Most important long-term developments, trends and challenges

Following is a brief discussion of the main challenges for the physical environment, socio-economic, political-administrative and technical subjects.

2.3.1. Physical environment

Chemical water quality: overall picture of the abstractions remains worrying
The general picture of the abstractions remains worrying, as one third of the abstractions does not meet the WFD raw water targets and is not expected to improve any time soon.

Vitens currently uses the majority of the groundwater. The natural background quality of groundwater differs greatly in the Netherlands. The purification steps required to remove iron, manganese and methane and to decrease the hardness therefore vary widely, depending on the groundwater type. Salinisation by chloride mainly occurs in the abstractions around Deventer and in some Frisian abstractions. Salinisation also takes place in a few abstractions with a shallow fresh-salt interface.

In addition, there is a group of chemical substances which do not naturally occur in groundwater, but that have ended up there through human behaviour: the anthropogenic substances. Approximately 75% of the Vitens abstractions are vulnerable to such anthropogenic pollutants, as pollutants from ground level can easily reach these abstractions. Vulnerable abstractions can mainly be found on the sandy soils in Overijssel and the Achterhoek and the consequences of intensive agriculture are certainly visible here. Deeper abstractions, which have been protected by thick layers of clay, are not deemed to be vulnerable.
Another threat is groundwater infiltration from surface water and leaking sewers. Very low concentrations of drug residues, pesticides and other new (industrial) substances - the properties of which are often unknown - are currently found in the abstracted water. This is expected to increase during the forthcoming years and these substances will also be found at greater depths.
Traces of old pollutants (mainly from factories and launderettes) are also being found in some places.

There is now also increasing concern arising from the energy transition, where use is made of the subsoil (heat-cold storage, geothermal energy) which can cause groundwater to become polluted, but which can also make it easier for ground level contamination to penetrate into the soil and thereby pollute the groundwater.

Microbiological water quality: a continuous focus point
Producing biologically stable water is essential for being able to manage microbiological problems, such as Aeromonas, contamination with coli group bacteria and legionella. This means there should preferably be no nutrients present in the purified drinking water. Another factor which could potentially lead to microbiological problems in both the wells and the pipelines is the temperature. The law includes a standard of a maximum of 25°C for the drinking water in the mains network. This standard was exceeded in the network in 2018 and 2019. It's expected that the 25°C limit in the water mains/tap water temperature will be exceeded more often in the future.

Climate change: can have a major impact
Climate change can also lead to reduced water availability and poorer water quality in the sources used by Vitens. Any negative effects of the abstractions will be more pronounced as a result of the reduced water availability, resulting in less acceptance for the environmental effects. This now mainly applies to dry sandy soil abstractions. The Delta Programme for Fresh Water and Fresh Water Supply in the East of the Netherlands (FEN) is aimed at developing measures which will anticipate climate change.

Climate change can also cause a higher temperature in the mains network.

2.3.2. Socio-economic

Drinking water demand: uncertainty asset
Contrary to previous years, both rising and falling demands for drinking water must now be taken seriously. This depends on changes in demographics, population growth, new companies, economic growth or recession, climate change, technology and innovation, but also, for example, on changes in the use of drinking water (water savings). In addition, demand development differs by area and predictions about future use will occasionally need to be adjusted.

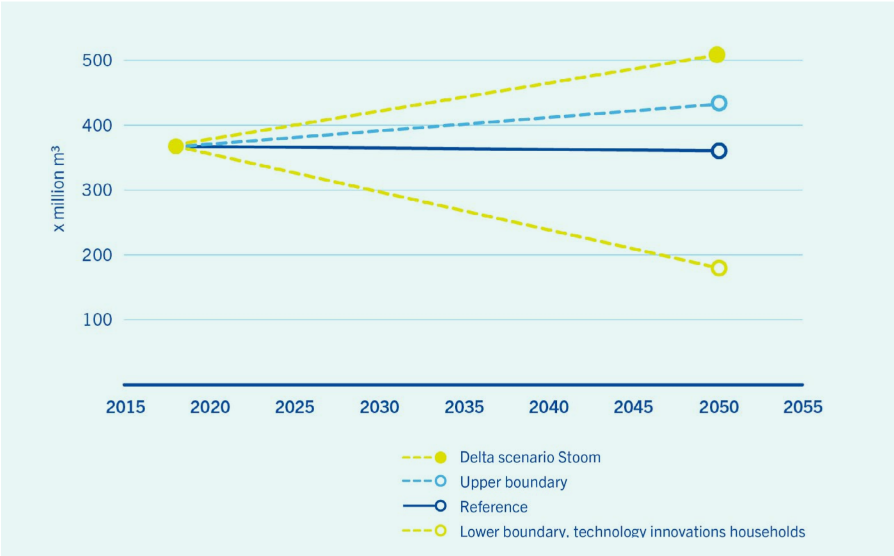


Figure 3 - The four possible drinking water demand developments

The Government has drawn up the so-called Delta Scenarios for Rest, Warm, Pressure and Steam for the forecast of the drinking water demand. The most impactful scenario (Steam) assumed a 38% increase in demand for the next 30 years. At the other end of the spectrum, there is the Rest scenario which accounts for a 20% drop in demand. In addition, there are WLO2015 scenarios [PBL and CPB, 2015] which assume, for example, successful water saving measures (separate systems); in these variants, the scenarios predict an increase of up to 20% in drinking water demand for the next 30 years.

The above scenarios show a wide spread in the expected development of drinking water demand. Vitens uses the national VEWIN forecast model for the drinking water demand forecast, which is based on a reasoned development (see figure 3).

Pressure for space: the pressure is increasing

The pressure both above and below ground is increasing for various different reasons, including the energy transition (gas-free households, construction of hot water pipes, geothermal energy, etc), population growth, economic growth and the construction of new networks, like 5G.

This has consequences for the available space for drinking water installations, protection areas, abstractions and pipelines. The increasing pressure on the space means people are working closer together, which increases the risk of malfunctions.

2.3.3. Political-administrative

Security and safety: the risks are increasing

The risk that third parties will disrupt the drinking water supply has increased in recent years and these risks are expected to continue to increase during the forthcoming years.

Deregulation and decentralisation: puts pressure on working proactively on many fronts

Deregulation and decentralisation has become an important political ambition during the last decade. The Environmental Act will be the most important development for drinking water companies in the foreseeable future, which will come into force in 2021. The Environmental Act is less focussed on protecting partial interests, but invites initiatives and responsibility.

Customer expectations: will change over time

Socio-cultural developments can lead to a specific customer group, and therefore the value system, becoming dominant. Plus if this group becomes less satisfied with the current drinking water supply (for example, due to water scarcity and contamination), this may lead to a different 'social contract' and a different design of the drinking water system. Customers are also expecting Vitens to 'move with the times' from a digital perspective and use, for example, smart meters; after all, other utility companies are doing that too.

The roles in drinking water supply can shift between market companies, citizens, collective or public/government

More space can be created for private entrepreneurship as a result of new technological developments and citizens' needs to be more self-sufficient. It's also difficult to predict the political climate in the longer term and therefore how the relationship between the market, the government and citizens is perceived.

Sustainability and circularity: continuous focus point

Sustainability has traditionally always been a core value of the drinking water supply in the Netherlands. No water is being abstracted which is not replenished too (no mining) and less water is always abstracted than replenished by useful precipitation (circularity). Circular solutions are also used on a smaller scale in other countries with a great scarcity of water, such as the reuse of sewage water into drinking water or reuse in the home (eg hydraloop). Circularity is expected to become of increasing importance. There's currently no certainty as to how much impact this will have on the water flows in the drinking water supply, as it impacts the water system, energy consumption and the use of materials and chemicals and an optimum therefore needs to be sought here. An appropriate division of costs also needs to be taken into account.

The hydrogen economy can significantly increase the demand for water. It's unclear to what extent drinking water is being used for this. There will be a sharp increase in demand if drinking water becomes an important source of the hydrogen economy.

One specific area where circularity will increasingly play a role is the materials for pipelines, materials and ancillary materials in the production companies and for the energy required in the total drinking water supply. The sustainable purchase, use and disposal of materials, taking the total life cycle into account, therefore now requires increasing attention.

Optimal scale: central or decentral?

Technical and social challenges can be tackled at different scale levels. Local authorities are now increasingly being given responsibilities and powers through deregulation and decentralisation. The degree of centralisation and decentralisation is influenced by, for example, technical economies of scale and geographical factors, but also by social preferences. Examples include discussions in energy with proponents of large offshore wind farms and nuclear power plants and proponents of local energy generation at home and at community level.

The Sustainable Development Goals: an enormous challenge

Society faces the challenge of making its supply and use of raw materials sustainable.

In recent years, goals have been developed at global, European and Dutch level (Sustainable Development Goals (SDG's), the Paris Agreement, climate agreement, etc). Supplying reliable drinking water is Vitens' most important contribution to the SDG's. But Vitens also wants to contribute to the SDG's in other areas. This includes a resilient infrastructure and a sustainable production and energy supply, promoting innovation and stimulating full employment.

2.3.4. Techniques

Condition of the drinking water infrastructure: guaranteeing a good condition
The infrastructure's condition is good. There are manageable numbers of pipe failures, relatively low water losses and also the necessary pipe replacement rate is manageable.

Technical possibilities are increasing: so are the expectations
ICT techniques have increased the possibilities for water quality monitoring with sensors in *real time*. This offers opportunities to improve the reliability of the drinking water supply, but it also provides information about the infrastructure's performance, based on which maintenance and investments can be optimised and much better and more transparent decisions can be made. A direct result of this is that more and more substances can now be measured. On the other hand, new purification techniques offer increasing possibilities for purifying the water.
Fast and big data analyses offer opportunities to better understand and predict the drinking water infrastructure's process and condition. The new ICT possibilities have allowed for customers and society to be given much better and more transparent information.
There are many options for reducing the environmental impact of purifications. The purification of the future definitely contributes to sustainability, with high quality residual products, minimal energy consumption and water loss and greatly reduced methane emissions.

2.4 Scenario's

The above developments may give rise to major system changes within which the drinking water supply must operate. We know some of these developments will definitely take place, but not yet to what extent. For example, will climate change stay limited to 1.5 °C, or will this be more? Other developments are much more uncertain and could even go in different directions. Will most of the solutions be at individual community or user levels, or perhaps more at (inter)national level? Is the demand for drinking water going to see a sharp increase or decline? Creating scenarios which can hold up the long-term strategy will help to formulate robust policies.

The environmental scenarios in this LTV are aimed at 2050. This emphatically concerns extreme scenarios (not *business as usual* or desirable scenarios), where radical developments put pressure on the current method of supplying reliable and affordable drinking water. The scenarios are therefore more of a 'stress test' than a prediction. Ultimately, scenarios are a means to be prepared for the future, even if such scenarios rarely, if ever, come to fruition.

The past has taught us that profound, structural changes in infrastructure, such as energy, waste and water management, are the result of a whole chain of interacting trends from the environment and reactions from the system. The developments and their implications have been explored in interviews with Vitens employees and others.

The greatest disruption occurs when trends and unexpected events come together to form a perfect storm and in case of ambiguous developments which can cause major controversy around the drinking water supply. It's actually this ambiguity which can, in turn, lead to innovation, conflict, diversity and critical self-evaluation. Given Vitens' and other stakeholders' major influence on the drinking water system, the scenarios aren't desired images or strategies, but they're not purely 'exogenous' either. The sector, including Vitens and other stakeholders, can actively respond to the scenarios and thereby influence the direction. It's therefore not just about technical and spatial changes, but also about 'governance'.

So it's important to look at the different combinations, but there are literally thousands of imaginable combinations of trends and reactions. In order for us to explore the various possible futures in the best possible way in a few of these scenarios, we have developed four scenarios based on two main axes:

- More demand than supply, or more supply than demand;
- Centralisation or decentralisation.

The four scenarios are:

- Drinking Water Delta Works
- Wild Water West
- Drinking Water Bubble
- Dilution

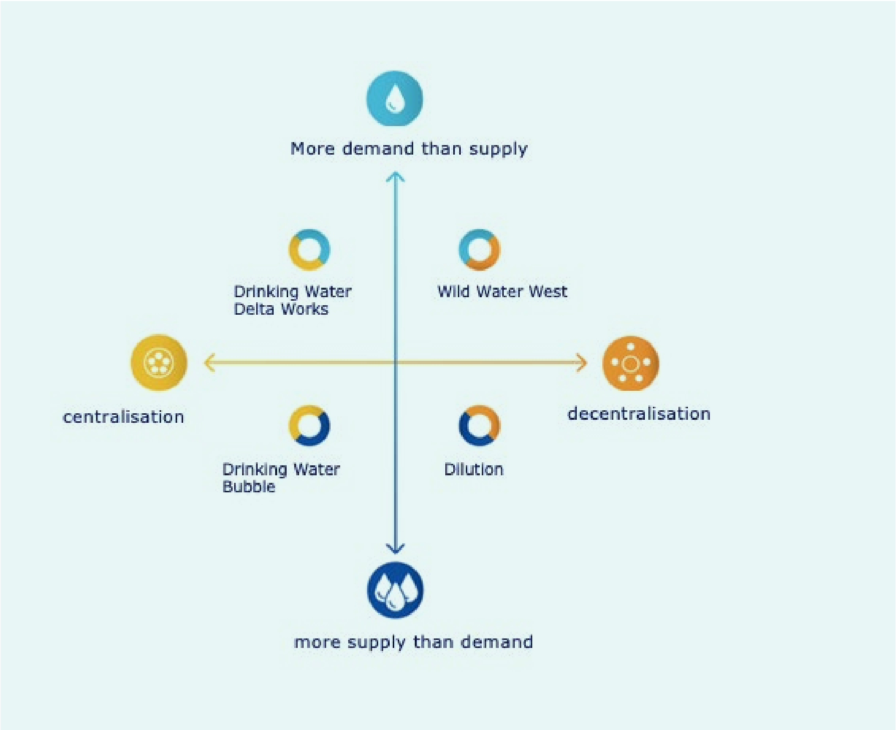


Figure 4 - Four scenarios, based on two main axes

Certain developments (spatial pressure, climate change, technical innovation) take place to an extreme degree for each scenario. The differences between the scenarios are caused by uncertain developments in different directions. An explanation and elaboration of these developments can be found in chapter 7 and appendix XX.

2.4.1. Drinking water delta works

We will have a strong, centrally-controlled drinking water system in the Netherlands in 2050. We are used to having plenty of good quality water and there is a broad awareness that only the government can guarantee this. This became evident after new analysis techniques and large-scale toxicological studies caused major public health concerns, which, in turn, led to an avalanche of new, much stricter standards. The pollution couldn't be tackled at the source of the pollution, as disturbances in the subsoil have already taken place and (the pharmaceutical) industry and agriculture are taking too long to switch to other production methods. Most of the pollution has already occurred and is slowly making its way into the groundwater. This means that multiple sources become unusable and large investments in often central purification are required.

A second problem is the security of supply due to growing (peak) demand and climate changes and the increasing demand for water due to the hydrogen economy. Households are demanding an ever-increasing amount of water due to a growing population and economy and, in practice, they still prefer a green garden and extensive showering over water savings, even during dry periods.
On the supply side, more flexibility is required due to much more severe dry and wet periods. In practice, this means that surface water from rivers and the sea is mainly used during the winter and groundwater, which can potentially cause nuisance, during wet periods. This allows other groundwater sources to recover from periods of drought during the summer months. In addition, large water factories will be set up which can purify sewage water into ultra pure drinking water and underground water supplies under clay layers have been designated as strategic reserves. Together they will lead to a high-tech and resilient drinking water supply.

In addition, the drinking water supply, agriculture and nature management will all be confronted with each other during times of drought. Only a strong government, which widely separates spatial functions, can break the deadlock around these competing interests. This means a reduction in drinking water abstractions in and around nature and agricultural areas and the development of large-scale water abstraction landscapes which cover the entire recharge area. Some regions have water 'left over' in the summer, others during the winter period. The optimal allocation of the scarce water is best organised at a national or even international level. Regional autonomy is declining and the construction of an overground national water transport network has now been started.

2.4.2. Wild Water West

Nothing beats the market when it comes to smart solutions for scarce goods like water. In 2050 we have come to realise that the biggest problem of the old 2020 drinking water supply ultimately wasn't so much climate change and the resulting scarcity, but the whole idea that water is a *commodity* and a public good. But of course that isn't the case. Drinking water, as a healthy drink, is a great deal more valuable than domestic water and 'spray water'. This was once again made clear by the pollution of the groundwater sources and the social controversies this resulted in. Various different parties simply have different requirements where water is concerned and this inevitably also leads to different prices. Water is a differentiated product and a service: drinking water comes from bottles and these bottles vary from private label to *high end*; companies and wealthier communities want control over the quality and quantity through their own stocks, pipelines and purification; and water as a service is worth a great deal more than the couple of tenners a month households used to spend on water in 2020.

These new markets mainly arise where the drinking water system leaves gaps. For example, where the quality must be much higher or lower and around peak periods. However, it was quite a shock to users and governments that there was a decrease in the security of supply and an increase in costs. There were also quite a few scandals surrounding the new cowboys in the water sector, especially to start with. The ever-increasing use of bottled water has resulted in a reduction in the water quality requirements in the pipeline network. A strong lobby will emerge to break through the monopoly of the old drinking water companies, as more parties are becoming commercially successful at abstracting, transporting and supplying water. The infrastructure and supply were split and a smart meter system for billing and quality control allowed for open access to the pipeline network.

2.4.3. Drinking Water Bubble

And yet it still happened unexpectedly: the major investments in new sources, pipelines and such like after the droughts of 2018 and 2021-2024 proved unnecessary. Demand fell sharply because both the water suppliers and their customers became aware of their water consumption behaviour after these droughts. Households and companies are regularly switching to rain barrels for their gardens, circular showers, home purification with a hydroloop, water-free toilets and more efficient production processes where the water is being reused. Even if this ends up costing a little more. And their concerns don't stop at the front door. They are fully aware of the fact that safe water is a basic right for everyone and should be accessible to groups which are unable or unwilling to reduce their water consumption. Especially now more is known about the potentially harmful effects of all kinds of substances in the water.
This can lead to a difficult situation for the drinking water sector. On the one hand, the sector is confronted with large investments in water quality and the depreciation of previous capacity expansions. On the other hand, the volume, and therefore the revenue, is decreasing and low prices, high availability and (increasingly higher) quality are still very much in demand too. After all, politicians and citizens will always continue to demand that the drinking water supply serves as a social (emergency) facility. It therefore can't shrink with demand and, more to the point: even if that was possible, the shareholders still wouldn't be prepared to accept the loss.

2.4.4. Dilution

A large part of the material, energy and water cycles will be organised locally in 2050. It all started during the cluster crisis of the early 2020's (including the corona, PFAS, construction, climate, ecological, political and nitrogen crises). This made it clear, once and for all, that local, circular solutions are the most resilient, effective and therefore ultimately the cheapest. Integral, area-specific customisation is central and the drinking water supply is aimed at improving spatial quality. All this requires local customisation and municipalities are given the tasks and resources to supervise this. The motto is to do things 'together'. As a result, the boundaries between (public) drinking water suppliers

and citizens' collectives are diluting, who aren't just acting as customers, but also as co-decision makers and producers.
The fading boundaries also apply to drinking water companies, water boards, waste water treatment plants, nature managers, etc. The old partitions in the water chain from source to tap, from drain to surface and from surface to source are disappearing. And it's not just the roles which are starting the fade, the landscape literally is too. The 2040 map which shows water consumption looks suspiciously like it did in the seventeenth century in places: with a great deal of water on the surface and in the (swampy) soil. The water is being abstracted like in the olden days, in wells in the district and subsequently purified, abstracted and reused using *high tech* or *nature-based* methods. This has been reinforced by the increasing influence of the hydrogen economy.

The mixing of all kinds of economic functions and chains requires a suitable organisational form. For example, for the integral management of the soil and underground infrastructure. Landscape management focuses on ecology, with clean water being just one of many ecosystem services. The location-specific solutions fragment the supply area and make the techniques and applications used much more diverse. This leads to greater local differences in water quality, availability and prices.

2.5. Structure of the long-term vision and differences compared to the previous one

This chapter describes the developments, trends and challenges, as well as four possible scenarios. The desired situation is described using the extreme scenarios. This is not a blueprint, which defines what the desired infrastructure looks like, but is a description of goals based on the mission and company values. These values are also the basis for the risk matrix (see appendix xx – Company Values/Risk Matrix), which Vitens uses for strategic and asset management decisions. It goes without saying that Vitens focuses on more than purely the company values, but in the long term these company values serve as the yardstick. The legitimacy of any strategy lies in the ultimate contribution to these goals. Vice versa, a strategy is also not an effective strategy if it doesn't provide (direct or indirect) added value to the company values.

Vitens' mission on which the company values are based is:
'We supply drinking water. Reliable and available. For now and in the future.'

The goals based on the company values are:
A. Provide sufficient and reliable drinking water, both now and in the future;
B. Make sure the drinking water is affordable;
C. Ensure safe and healthy working conditions are in place;
D. All tasks are executed in a sustainable manner with care for nature and the environment;
E. Safeguard drinking water's impeccable reputation in a good relationship with stakeholders (customers, government authorities and interest groups).

Many uncertainties have to be taken into account in order to realise the goals. Vitens' drinking water infrastructure boasts an extensive network, within which abstractions and users are linked together in a complex manner. This network's assets usually have a long life, are capital intensive and have a long development period. The development of demand is uncertain and social and technological changes are happening in rapid succession.
Vitens has opted to develop the Resilience as a Strategy concept, in order to achieve results in this complex situation, with many mutual interdependencies. Vitens' approach is to develop resilience along three lines: What, How and Who (see chapter 4). An important part of the strategy is working with options, which is further explained in chapter 5. In order to realise the strategy, many ongoing activities must be continued, such as providing reliable drinking water, but there are also activities which need to be accelerated or developed. This is further elaborated on in chapter 6. This working method and the structure of the long-term vision is schematically shown in figure 5.

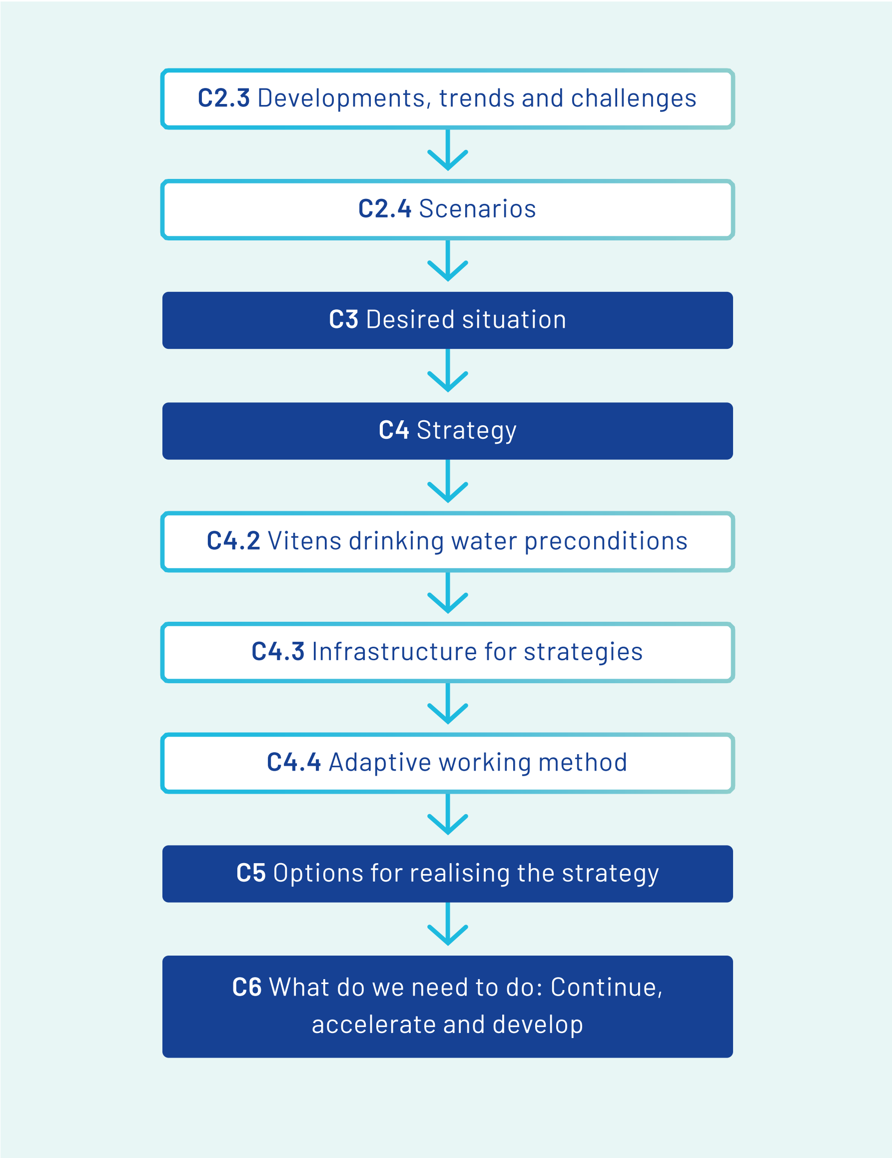


Figure 5 - Outline of design

The differences between the 2020 LTV and the 2016 LTV

The 2020 LTV is an extension of the 2016 LTV, but there are a number of changes. The main differences are briefly explained below.

The time horizon of the 2020 LTV is longer (2020-2050) than of the 2016 LTV (2016-2040), because a longer time horizon is more appropriate for the drinking water infrastructure's low rate of change.

The Resilience as a Strategy concept was first introduced in the 2016 LTV. Resilience was defined as the smart combination of the robust and flexible building blocks in the infrastructure in the 2016 LTV, allowing for the infrastructure to supply reliable drinking water both now and in the future, despite changing circumstances. The 2020 LTV further elaborated on the Resilience concept, the building blocks were referred to as 'infrastructure strategies' and a number of other infrastructure strategies were added too.

One major difference between the 2016 LTV and the 2020 LTV is that the 2020 LTV identifies the underlying principles and preconditions wherever possible, instead of merely describing the position. For example, a preference for groundwater is expressed in the 2016 LTV, whilst no preference is mentioned in the 2020 LTV and Vitens is open to all possible options, including surface water, providing this satisfies a number of preconditions for guaranteeing the reliability of the drinking water supply. It is expected that, by indicating the principles and preconditions, the dialogue with society can be conducted in a more constructive manner, ultimately resulting in the realisation of better solutions. Options have also been identified in line with this. An option is not a blueprint of the future situation, but an option is a possibility which may or may not be realised. This will depend on the circumstances and how they develop.

Finally, we need to mention the fact that the sustainability subject, and water savings in particular, has been further elaborated on in the 2020 LTV.

Opening Hooiberg Vechterweerd

3 desired situation

3.1. Goals based on company values

The 'outside world' (legislator, governments, competent authorities, customers, interest groups, etc) all have numerous requirements and wishes where Vitens' working method and results are concerned. Vitens has translated this into five primary organisational objectives ('company values'):

A. Provide sufficient and reliable drinking water, both now and in the future;
B. Make sure the drinking water is affordable;
C. Ensure safe and healthy working conditions are in place;
D. All tasks are executed in a sustainable manner with care for nature and the environment;
E. Safeguard drinking water's impeccable reputation in a good relationship with stakeholders (customers, government authorities and interest groups).

These primary organisational objectives represent the core of the task Vitens is faced with and all have long-term validity. The ultimate task is to permanently realise these goals. This means that whatever strategic or operational choices are made, they will always have to contribute to realising the desired performance where each of these goals is concerned.

The five primary organisational goals link into the Sustainable Development Goals (SDG's): supplying everyone with reliable drinking water (SDG 6) and Vitens building a resilient infrastructure for this purpose (SDG 9). Vitens will make sure that climate change and the subsequent impact are limited as much as possible (SDG 13) and that the energy supply is sustainable (SDG 7). Vitens also works as sustainably as possible (SDG 12).

The goals are further elaborated on in the next paragraph, whereby the provision of safe and healthy working conditions is not described, as this goal always applies and is not specific to the long-term choices.

3.2. Elaboration of primary organisational goals

The primary organisational goals are further elaborated on in this paragraph, with the exception of goal C (providing safe and healthy working conditions), as this is not specific to the long-term choices.

A. Provide sufficient and reliable drinking water, both now and in the future

Vitens sees it as its duty to provide both sufficient and reliable drinking water. Activities or changes in the drinking water system which pose a risk to the safety of the drinking water must be prevented at all times. A sustainable integration and efficient protection of the sources and underground pipeline infrastructure are therefore important.

The drinking water supply system must be able to respond to changes in supply (availability) and demand. The availability of sources can change as a result of climate change, which has an impact on both availability and quality. Demand development is uncertain too, for example as a result of water savings, innovations, population growth, economic growth and decentralised (circular) solutions.

Vitens strives for a future-proof abstraction infrastructure, where the water abstracted in the abstractions is available in all possible climate scenarios, has the best possible quality and the absolute minimum acceptable environmental damage.

An efficient and intelligent drinking water system, using reliable data, is an important condition for increasing reliability. In addition, this also enables Vitens to transparently provide both society and customers with good information.

B. Make sure the drinking water is affordable

Drinking water has to be accessible to everyone, which is why its affordability is essential. An important starting point is that we don't pass any costs onto future generations. A good condition of the drinking water infrastructure is important in addition to a healthy financial position, in order to keep the drinking water supply affordable and guaranteed in the long-term too. Vitens will therefore ensure sufficient investments are made in new infrastructure and that any aging infrastructure will be replaced in time.

D. All tasks are executed in a sustainable manner with care for nature and the environment

This means Vitens will affect the natural environment as little as possible and will, where possible, have a positive impact.

Using sustainable and future-proof abstractions and stimulating the quality of the living environment are important objectives here. Vitens wants to reduce any harmful abstractions whenever possible and move these to areas where they will have a less harmful impact, in order to prevent the desiccation of vulnerable nature areas. Water losses during production and the transport of water will be limited. Water wastage and unnecessary drinking water use are combated.

Vitens also aims to become climate-neutral. Energy consumption will be limited as much as possible, energy will be generated wherever possible and the remaining energy needs are purchased sustainably. All residues will be recycled to a high standard. The use and purchase of materials and consumables is organised as sustainably as possible.

Vitens strives to increase and strengthen biodiversity when designing water abstraction areas and other sites.

E. Safeguard drinking water's impeccable reputation in a good relationship with stakeholders (customers, government authorities and interest groups)

Realising the above goals and ensuring healthy working conditions are in place are important conditions for a good reputation. Good relationships can also be realised by creating the highest social value wherever possible. Vitens wants to use an adaptive working method to find the best solutions for the drinking water infrastructure in a co-creation process with relevant stakeholders.

4 strategy

Softening system Manucaturing company Tull en 't Waal

4.1. Introduction

Many uncertainties have to be taken into account in order to realise the goals. Vitens' drinking water infrastructure boasts an extensive network, within which abstractions and users are linked together in a complex manner. This network's assets usually have a long life, are capital intensive and have a long development period. The development of demand is uncertain and social and technological changes are happening in rapid succession.

Vitens has opted to develop the Resilience as a Strategy concept, in order to achieve results in this complex situation, with many mutual interdependencies. Vitens' approach is to develop resilience along three lines: What, How and Who (see figure 6).

1. What are we going to do? Vitens has opted to create resilience in the infrastructure on the basis of the infrastructure strategies: robust, tolerant, flexible, sustainable and intelligent.
2. How are we going to realise this? Vitens has opted for an adaptive working method, or rather working with options which minimally satisfy the Vitens Drinking Water Preconditions (VDP). Depending on developments, such as the demand for drinking water, the decision will be made as to which options are going to be used.
3. Who are our partners? Vitens has opted to develop and implement the options together with stakeholders in a co-creation process, taking the interests of all parties involved into account.

Figure 6 - Approach for developing resilience

Vitens wants to work with stakeholders in a co-creation process. It's important for all stakeholders to declare their interests at the very start of this process. Vitens has laid down the drinking water interests in a number of preconditions, the Vitens Drinking Water Preconditions (VDP's). The VDP's guarantee the safety and reliability of the drinking water supply and are either derived from legal requirements, or follow on from infrastructure strategies. The VDP's are listed in paragraph 4.2.
The infrastructure strategies are intended to bring resilience to the system and are detailed in paragraph 4.3. The adaptive working method is described in paragraph 4.4.

4.2. Vitens Drinking Water Preconditions

The VDP's are a collection of preconditions which any options used for the drinking water infrastructure must minimally meet. These preconditions either arise from legislation and regulations, or are requirements which have arisen from infrastructure strategies (see paragraph 4.3).

VDP 1: Each source has sufficient water in all climate scenarios.
VDP 2: There is sufficient diversification in the sources.

VDP 3: Reserves in the capacity to be extracted must be available for a very long time (minimum LTV planning period) and without limitations.

VDP 4: Each source is tolerant: the drinking water supply can continue to run for a while in the event of a serious disruption (in quality and/or quantity), allowing for measures to be taken to guarantee continuity.

VDP 5: The quality of the drinking water is guaranteed by several barriers:
- The cleanest possible source with a constant quality;
- Reliable purification;
- Safe transport and distribution system.

VDP 6: Risks in relation to the microbiological quality are as small as possible.

VDP 7: There is sufficient flexibility in the drinking water system to accommodate changes.

VDP 8: The security of supply is guaranteed.

VDP 9: The drinking water system has been structured in a logical, as simple as possible, coherent manner, offering the possibility of intelligently controlling the different parts.

The VDP's have been further elaborated on in appendix IV.

4.3 Drinking water infrastructure strategies which contribute to resilience

Resilience means that the drinking water supply continues as efficiently as possible, despite major changes or threats. There are several ways of responding to changes, which is why resilience is a broad and ambiguous concept. These ways are referred to as infrastructure strategies. These infrastructure strategies can reinforce each other, but sometimes it may not be possible for these to be combined. It's important that all infrastructure strategies can be found in the drinking water system, as this will create the greatest resilience.

Five infrastructure strategies are discussed below.

1 Robust

The drinking water system has been designed in such a way that the drinking water supply remains intact despite external disruptions. Disruptions can occur, for example, if sources fail, or if demand drastically changes in a short period of time.

One possibility for making the system robust is to duplicate critical systems (or components) (physical redundancy), or to ensure another system (or component) can take over the function (functional redundancy). As an entire drinking water system is difficult to duplicate, functional redundancy at system level is very important. In practice, this means ensuring sufficient variation. If all abstractions from a drinking water system use water from the same river, there is no functional redundancy to take water in case of serious pollution in the river. It's therefore essential for there to be sufficient independent sources, so the drinking water system won't fail in the event of serious disruptions (pollution or insufficient discharge of a river from which water is being abstracted). It's also important to have reserve capacity in the system and in the abstraction permits. The reserve capacity in permits is intended to be deployed over time and must therefore be available for a long time, preferably unlimited and without restrictions. However, if there are any limitations (for example where the purchase is concerned), then this can only apply to a very small percentage of the reserve.

Climate change can make the availability and quality of a resource critical during extreme periods. The environmental effects of an abstraction are increasing too. A robust source has sufficient water in all (climate) conditions, with admissible quality and acceptable environmental effects. Robustness is further increased when the infrastructure is properly combined with other suitable activities (suitable function combinations). After all, the chance of other activities which can't be combined can decrease if several activities are disrupted as a result. Good maintenance is an important principle to main robustness while using the infrastructure.

2 Tolerant

The infrastructure will remain intact whilst the infrastructure strategy is robust, while the tolerant strategy is all about situations in which the infrastructure can't function in the disrupted situation. Tolerance allows the drinking water supply to continue to function reliably until measures have been taken to continue the drinking water supply; the system tolerates (temporary) disruptions. At the time, having sufficient time to take measures (tolerance) was the underlying idea for the existing 25-year protection zones around groundwater abstractions. Pollutions within the 25-year zones are prohibited and there will be 25 years to take measures if there is a case of serious contamination outside the groundwater protection area. Analytical basins at surface water abstractions also allow time to conduct good water quality analyses and to stop the intake if there are problematic substances in the water to be taken in.

Building in reserves, in permits or in the water distribution, also results in increased tolerance (and flexibility). Incorporating overcapacity at critical points also results in tolerance for accommodating any changes.

3 Flexible
The drinking water system can quickly adapt to the changed situation if a disturbance or change occurs.

Reducing (unnecessary) complexity is an important principle for increasing flexibility. This can be realised by applying standardisation, unification and a modular structure. Unification and standardisation will result in parts and systems which can be used anywhere, including at other locations if necessary. Custom solutions are only applicable to the specific purpose for which they were developed.

Dividing systems into subsystems (cluster) and sub-subsystems (balance areas) with a certain degree of independence is an important principle for reducing complexity, but also to prevent a disruption from spreading throughout the system like an oil slick. This is also important for isolating disruptions and to allow the rest of the drinking water system to continue to function uninterruptedly. Dividing into areas which are too small can be at the expense of flexibility, because there would be too little flexibility to use alternative solutions in a small area. It's all about finding the right scale(s) and method of collaboration both on and between the different scale levels.

4 Sustainable
Sustainability is described as the ability to affect the natural environment as little as possible and, where possible, to have a positive impact.

The starting points associated with this are:

- Preventing any impact on the natural environment (eliminate the cause)
  Activities associated with this are:
  - prevention of drought damage in valuable, sensitive areas;
  - preventing the use of space in sensitive, valuable areas;
  - water savings to avoid unnecessary use;
  - preventing the supply of high quality water, when low quality (with a lower environmental impact) would suffice;
  - using renewable energy;
  - using materials and ancillary materials with the lowest possible environmental impact.

- Minimising any negative impact on the natural environment (compensating for unavoidable damage)
  Activities associated with this are:
  - minimising drought damage through a smart water management system;
  - minimising the use of space (for example, not making an unnecessary spatial claim, but assuming the actual risks in protection areas);
  - not generating waste flows, but arranging material flows in a circular manner;
  - minimising energy consumption;
  - minimising the use of materials and ancillary materials.

- Maximising the positive impact on the natural environment
  Activities associated with this are:
  - strengthening biodiversity in water abstraction areas and other areas which have a relationship with the drinking water supply;
  - smartly combining drinking water areas with social tasks (SDG's) in order to strengthen the natural environment (recreation, landscape, etc).

One essential precondition for all sustainability measures is that a systems approach is crucial for preventing that profit in one area will be at the expense of a much greater loss elsewhere. This is about the total sustainability gain.

For example, a specific measure can provide energy gains, but if this is going to result in extra material costs, or if systems and pipelines need to be removed, this will result in a burden on the environment.

The starting point for sustainability is that measures, as would be the case with other asset management decisions, look at the entire system and the entire life cycle.

5 Intelligent
The drinking water infrastructure is a complex system and in order to be able to guarantee the reliability of the drinking water supply, it's essential for the various different parts to be managed coherently and intelligently. Given the long lifespan and time it takes to build new infrastructure, it's necessary to make timely decisions based on a future vision.

An intelligent drinking water system will allow for:

1. asset management decisions to be factually substantiated.
   Real-time condition measurements make it possible to make better and integral choices in relation to the replacement, management and maintenance of the drinking water infrastructure. An insight into the performance of the infrastructure is also required in order to come up with a long-term vision of the infrastructure and to be able to conduct analyses to test and improve the drinking water infrastructure in the most cost efficient way.

2. manage the primary process more effectively.
   A more consistent and reliable drinking water quality and quantity can be produced and supplied through the use of early *(early warning)* and continuous *(real-time)* measurements and the use of algorithms, model calculations and scenario analyses. It will also allow for faster response times where disruptions and deviations are concerned. The operational management can become more efficient by automating repetitive work and optimising the use of chemicals. Plus it's also desirable to safeguard the drinking water system knowledge in connection with the outflow of personnel *(brain drain)*.

3. provide the customer with a better service.

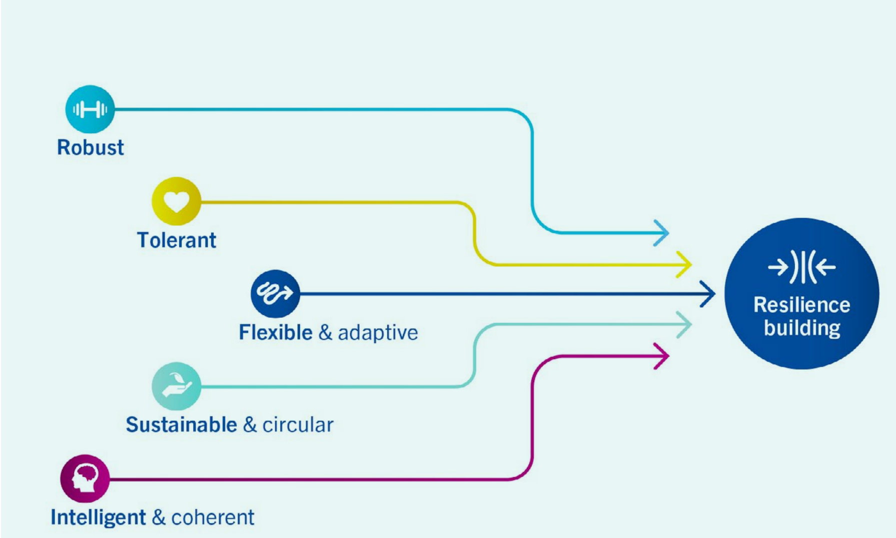


Figure 7 - Infrastructure strategies for increasing resilience

Customers can be proactively informed about disruptions to the water quantity and quality and smart water meters can provide an insight into water consumption and also allow for more effective management of the water consumption and application of different rates. In addition, customers would then be issued with invoices based on actual use instead of estimates and a settlement afterwards. One disadvantage of this is that customers with payment problems may end up in trouble due to the changing accounts.

4.4. Adaptive working method

The adaptive working method is a working method which uses options which can be developed internally or externally and therefore not with a blueprint of the desired future situation. The options must match Vitens' goals and strategy and must comply with the Vitens Drinking Water Preconditions (VDP's) to guarantee the reliability and safety of the options.

You have to work in a short cyclical manner when working with options, preparing several options which will probably not all be realised. The decision as to whether or not to use an option will depend on indicators such as demand development, source availability and social and customer developments.

It's important for the options to be developed in external dialogues and coordinated with the relevant stakeholders, in order to obtain good social solutions. A system approach is essential here. A system approach involves looking at all involved systems and mutual interactions to avoid opting for sub-optimal solutions.

Why a system approach

The existing drinking water system has a history and is based on social and political ideas and technical design principles. We have to expressly take the long lifespan and high costs of parts of the drinking water infrastructure into account. The drinking water system can't just be changed; this is a gradual, complex and adaptive process, whereby we need to carefully consider the mutual interdependencies and interactions with other systems.

Water is abstracted from the water system, drinking water mains are located near cables and pipelines from other infrastructure systems (drinking water, energy, gas, housing, recreation etc) and these systems also place claims on the same space. These interactions can have a reinforcing effect, but they can also make systems weaker. It's essential to properly distinguish between symptoms and the underlying problems when looking at the history, the total lifespan of assets and the interrelationships. Removing a symptom without solving the real problem costs money and energy, but eventually doesn't actually solve the problem.

Including the overall system and its interactions with other systems will allow us to make it more complex, as we'll be working with more interests and stakeholders and introducing more coordination problems, but we are convinced the only way to solve problems sustainably, rather than merely combating symptoms, and to subsequently provide increased social value, is to introduce an integrated systems approach combined with good coordination.

Examples of tackling symptoms rather than a total system

- Combating desiccation was an important political issue in the nineteen nineties. Various different projects were launched in order to resolve this desiccation, for which, in hindsight, we can definitely say we were far too focussed on symptoms (resolving desiccation) and not nearly focussed enough on the total system and the underlying problems.
  Water supply plans were drawn up for abstractions not too far from the IJssel, which were being supplied from the IJssel, resulting in agriculture being given a much better water balance and no drought damage occurring as a result of the drinking water extraction. This also worked well during the dry years of 2018 and 2019. One aspect which was overlooked was that the supplied surface water contained pollutants which were spread across a large area as a result of the water supply plans, resulting in these pollutants ending up in, for example, the drinking water extraction wells.
- The construction of a domestic water system was also seen as an anti-desiccation measure at that time, as water for high quality and low quality use could be abstracted from other places in the water system. In retrospect, it turned out that public health risks were insufficiently taken into account by supplying households with a lower quality of water and that there was also a significant shift to other environmental aspects, as the double system required extra materials and energy.

A number of lessons can be learned about what is needed to realise successful changes in an adaptive working method (see Experiences appendix) from the literature on adaptive working and projects executed in the past. It's also important to learn from projects which went wrong, so the same mistakes won't be repeated again in the future. Successful factors are:

Leadership and entrepreneurship
This means that vision, courage, entrepreneurship and perseverance are all required to bring about real changes in the public environment.

Co-creation and (cross-border) collaborations
It's necessary to work with stakeholders on a joint plan or idea in order to realise changes at the living environment level (systems level). Everyone must be prepared (willing, able and daring) to investigate their own (organisational) boundaries in order to determine the optimal outcome for the system. This also means that the interests and responsibilities of the various organisations are clear to everyone and that the costs and benefits are shared fairly. The joint plan is subsequently the compass for the realisation.

Learning, developing, experimenting and short-cyclical evaluations
It's important to experience and investigate step by step, in order to realise projects in a complex system. The results need to be evaluated, after which the approach can be adjusted. This short-cyclical working method forms an important part of the adaptive working method.

Regularly evaluating the drinking water demand forecast plays a crucial role where the development of the infrastructure is concerned. The developments and possible trends in the max-day factor must also be considered here.

The way in which Vitens translates the strategy into well-considered and transparent choices regarding the assets is at the heart of the asset management process which is carried out in accordance with the standards and requirements set by ISO 55001.

Manufacturing company Leidsche Rijn

5 options

5.1. Introduction

Options are measures for the infrastructure, which can be deployed depending on the circumstances. Requirements which these options need to satisfy are that they comply with the strategy and the Vitens Drinking Water Preconditions (VDP's) and that they contribute to realising the goals. A distinction is made between abstract options, which describe the possibilities for an option at conceptual level, and realistic options, which can be clearly identified and realised. An abstract option in a certain area can be used to develop a realistic option.

A few examples to illustrate working with options:
- A production company can apply various different purification techniques (realistic options) in order to improve the quality, but not all purification options will be realised.
- On a slightly larger scale, there are several realistic options (different transport routes, different material types and different pipeline diameters) for taking water from production companies to consumption centres. Which solution will be opted for will depend on the circumstances, such as costs, the expected drinking water demand development, etc.
- One abstract option is to *combine usage functions*, which can be developed in an area for a location where water abstraction, nature and agriculture have been smartly combined.
- Abstract options, like *combining energy water* or a *self-sufficient island* can be used to challenge those involved to develop new creative solutions which are ultimately captured in realistic options.

Vitens strives to display the realistic options at different scale levels, whereby possible choices are presented on the basis of certain developments in adaptation paths.

This long-term vision (LTV), focussed on Vitens' scale, or rather system level, mainly concerns abstract options. Paragraph 5.2 describes a possible option, the water mains engineering perspective, and paragraph 5.3 lists a number of abstract options for parts of the drinking water process.

5.2 A water mains engineering option at system level

Vitens has mainly spread groundwater abstractions across the Vitens area. This has developed like this historically, as traditionally groundwater could be abstracted as close to the demand centres as possible. The pipeline network is a derivative of this and has grown organically, with the exception of Flevoland, where the entire infrastructure has been built from a design philosophy.

Surface water is also used as bank groundwater abstractions in addition to groundwater. Many water abstractions extract water from well-protected thick aquifers with acceptable environmental effects.

One specific focus point is the abstractions on the dry sandy soil in the east of the supply area, which extract water from small-scale vulnerable water systems and which cause significant drought damage, which is reinforced by climate change. The same abstractions also suffer from pollutants from pesticide metabolites and from eutrophication. These abstractions are therefore only future-proof to a limited extent.

There are hydrologically better opportunities for abstracting water in the west of the Vitens area because there are thick aquifers with fresh or brackish groundwater and there is a great deal of surface water too. Vitens expects sustainable abstractions to be developed here, so that vulnerable abstractions on dry sandy soils can be relieved or, in extreme cases, closed.

The most suitable Vitens areas for abstracting water are areas where ample surface water and/or groundwater is available in all climate scenarios and where the effects on the environment are expected to be the smallest. These areas are indicated with the strategic cores term. These are:
- Thick aquifers in southern Friesland (fresh water) and Northwest Friesland (brackish water);
- IJsselvallei with the IJssel and seepage water from the Veluwe and the Sallandse Heuvelrug;
- The Central Netherlands strategic core with good aquifers with brackish water or

with good nutrition from the Veluwe. If necessary, supplemented with surface water from the Randmeer and IJsselmeer;
- The river area, with seepage water from the Veluwe and surface water.

In addition, the Veluwe, the Utrechtse and Sallandse Heuvelrug also offer opportunities for extra abstraction capacity, possibly supplemented with area-specific water. One specific focus point is the complex Veluwe weir in particular. Mapping this out and predicting the effects of an abstraction are complicated.

The major demand centres must be connected to each other as they grow and must be connected to the strategic cores as much as possible in order to guarantee a future-proof infrastructure. Depending on the growth, more areas will be connected to each other, while pipelines can be reduced *(relining)* in case of shrinkage, or decommissioned in order to avoid quality problems. Figure 8 provides an indication of a future-proof infrastructure, which also indicates the desirable extensions, in addition to the existing main pipelines.
The indicative future-proof infrastructure is built on the basis of the best abstraction opportunities and the expected increase or decrease in demand (see figures 9 and 10). A ring structure is indicated through the large cores around the Veluwe, as the best abstraction opportunities are around the Veluwe. There are limited abstraction opportunities in the east, which is why three types of transport pipelines have been indicated in the direction of Twente, which are shown depending on the degree of growth. As the abstraction opportunities are much better in the west compared to the east, no transport from east to west will preferably take place and, as a consequence, the North East Polder is supplied with water from southern Flevoland or Friesland. The Wadden Islands have become as self-sufficient as possible, in order to avoid vulnerable dependencies on so-called Wadleidingen. The focus here is on sustainable abstraction opportunities, with desalination being a possible option in the event of strong growth.

This figure therefore represents a water mains engineering perspective and is consequently still one-sided. That's because this perspective doesn't just take administrative preferences and stakeholder interests into account. Plus this only provides an initial indication, which will be further elaborated on during the years ahead and coordinated with relevant stakeholders.

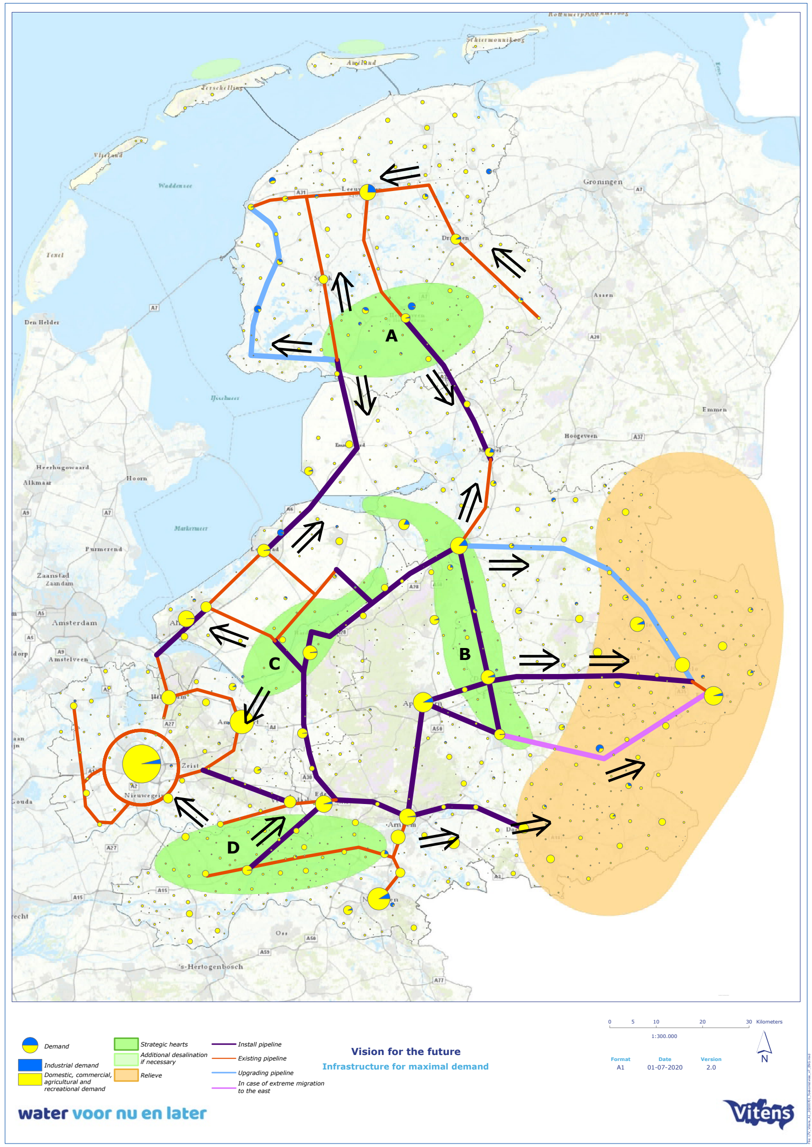


Figure 8 - Water mains engineering perspective on possible future infrastructure

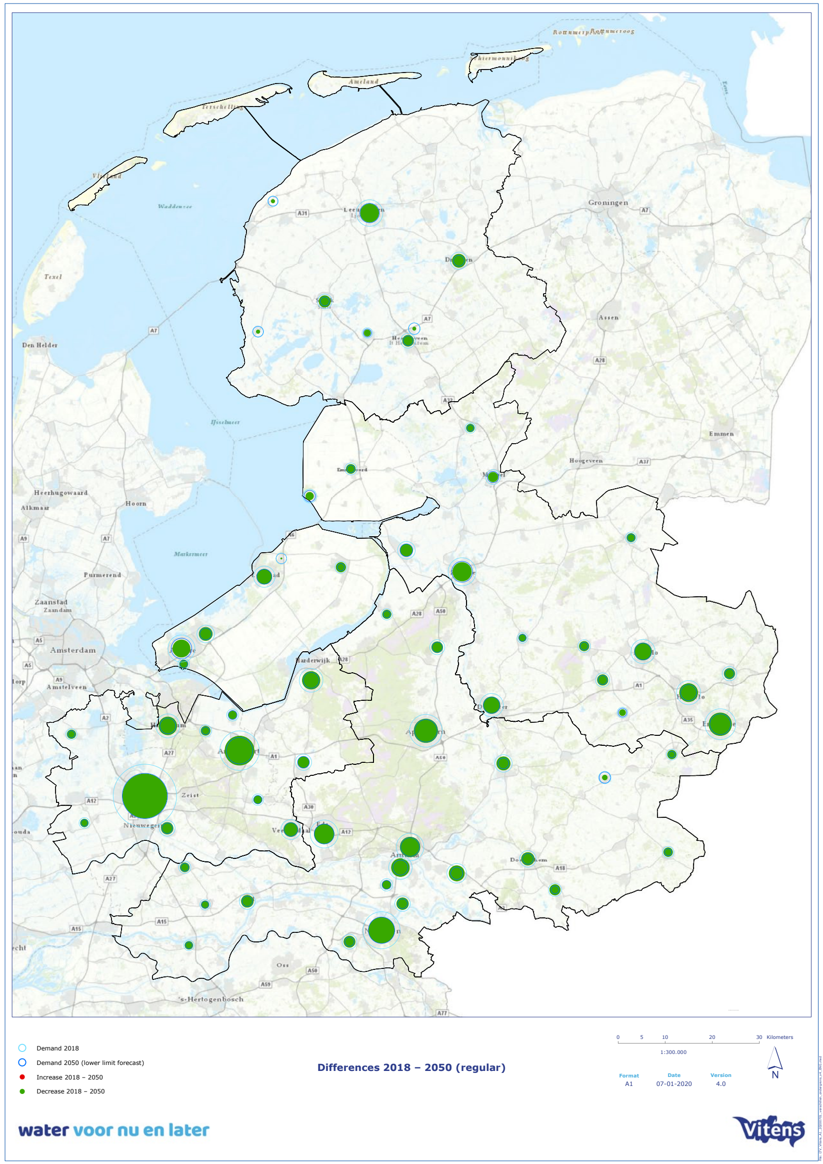


Figure 9 -2018-2050 differences for lower limit forecast

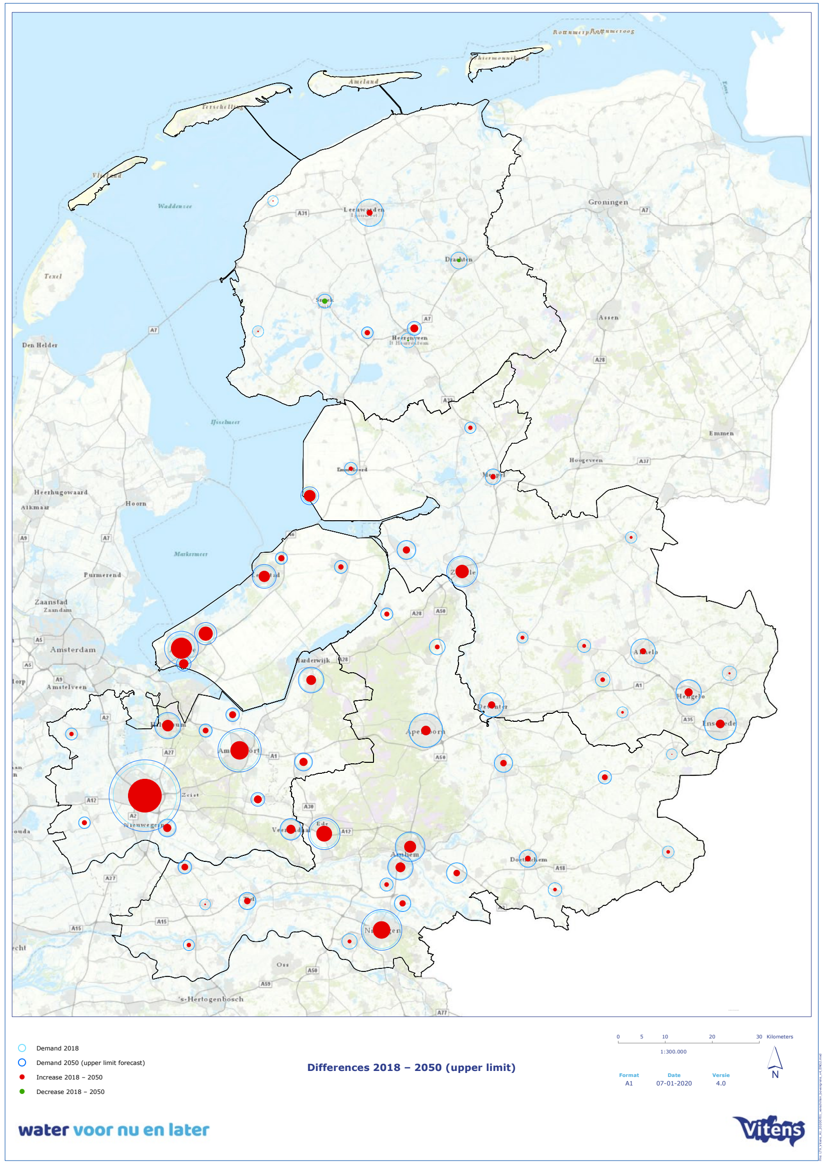


Figure 10 - 2018-2050 differences for upper limit forecast

5.3. Abstract options

We will describe a number of abstract options in this paragraph. It's not intended to be a complete overview, but merely to demonstrate the fact that abstract options are already being applied and that there are a number of abstract options which Vitens would like to develop further.

5.3.1. Abstract options for the source

- Vitens has completed many projects in the past and evaluations (see appendix VI) show that a number of abstract options can be derived from some of these projects.
- Optimising the water system:
  - water supply
  - retain, store and water level management
  - (deep) infiltration for the benefit of storage and/or replenishment of groundwater supplies
- Optimising the spatial design:
  - function follows water
  - combining water abstraction with social tasks
  - stacking functions sustainably
  - climate-robust design

Abstract options which are currently still in development and which have not yet been applied in the Vitens area:

- **Abstraction of (non-anthropogenic polluted) brackish water.** There are thick aquifers with clean brackish water which can very effectively be abstracted in both Friesland and the Flevopolders. One specific focus point is to find a sustainable solution for the brine which will be released during this process.
- **A flexibly deployable abstraction** which can be sustainably used in the environment, with an increase or decrease in the abstraction capacity causing no or minimal additional environmental damage.
- **A sustainable circular water landscape** with closed water and substance flows, the primary function of which is drinking water abstraction. The water landscape encompasses the entire abstraction area. Other function are possible too, providing they work with closed substance flows. This is the starting point in the Panorama Waterland concept, which has been supplemented with an open plan process from the *function follows water* principle.
- One possibility when realising options is to link up with the strategy and measures from the Delta Programme for Freshwater and Freshwater Supply in the Eastern Netherlands (SEN).

5.3.2. Abstract options for purification

Abstract options for purification which are currently still in development and which have not yet been applied in the Vitens area:

- Use of intelligent monitoring and management of the purification processes to make the purification efficient, stable and predictable. Smart purification, together with abstraction and distribution, forms an intelligent chain from source to tap. The purification can subsequently anticipate disruptions in the source at an early stage and disruptions in the purification are translated into consequences for the end user in a timely manner.
- Bank filtrate or any other nearby anthropogenically loaded source can be converted into an ultra-pure semi-finished product with the aid of reverse osmosis. This semi-finished product can be mixed with water from existing purifications, making sure the ultra pure water doesn't need to be cured or conditioned. The reverse osmosis, combined with soil passage, forms a fairly complete barrier against anthropogenic substances and can be quickly switched on or off. The soil passage during bank filtration also provides damping and storage, making sure any impact on purification is limited in case of a disaster upstream.
- This design principle means a more resilient and modular operation will be within easier reach. Existing purifications can largely supply independently in periods of low demand and the capacity can effectively be doubled by mixing during periods of high demand. Softening on existing purifications can also be switched off and abstractions can be reduced.

5.3.3. Abstract options for the transport and distribution system

The transport and distribution system connect supply and demand and possible options are therefore related to this.
Abstract options for the pipeline network system are:

- The source, demand or a combination of the two are leading in the water distribution system design.
- Apply the triangle principle for the interconnection of demand centres, i.e. all (larger) demand centres are supplied with water from two sides, which creates an intensive connection between all demand centres. The production companies are connected to this too. Research conducted by Vitens and Deltares shows it's not necessary to connect all production companies and demand centres. The performance gains increase rapidly when a few demand centres and manufacturing companies are connected, but when a certain degree of connectedness is achieved, the costs increase sharply, while the extra performance gains are only small (decreasing returns).
- Separating (low pressure) transport and (high pressure) distribution systems in order to limit quality risks and reduce energy consumption.
- Increasing flexibility in water distribution by making additional storage available in reservoirs, i.e. storage above the iron stock (the amount needed for day flattening).
- Do not reject pipelines in case of shrinkage, in order to be prepared for changes in demand.
- Preserve production overcapacity in such a way that it can be used in case of extremely high water demand.
- Permits and locations for abstracting water are valuable assets and must be protected as much as possible and only be submitted after careful consideration.
- Routes for desired ring structures or transport pipelines must be spatially reserved. Construction can then take place as soon as this is desirable from the water distribution's perspective.

5.3.4. Abstract options for demand development (water savings)

Influencing demand development is about influencing the quantity of the (drinking) water supplied.

Willingness to take action and experiences with water conservation
Research has shown there are roughly four groups of Dutch people who are or aren't willing to save water.

- Idealists (17%) want to live as sustainably as possible and, if necessary, are happy to make sacrifices or pay for it.
- Savers (9%) do their best to use as little water as possible, but are sceptical about the effects.
- Pragmatists (48%) don't mind doing their bit to save water, but they are not willing to make any sacrifices where comfort or extra costs are concerned.
- Comfort-oriented (25%) are sceptical about the usefulness, do not want to sacrifice comfort or pay extra.

The question was also asked as to who is primarily responsible for water savings. Most respondents stated the Central Government (35%), local government authorities (11%) or the business community (23%). Only 15% see themselves as being primarily responsible for this (source: Water Governance 02/2019).

The RIVM conducted a study about scenarios in drinking water demand for the 2015-2040 period, as well as the availability of sources (RIVM report 2015-0068). The RIVM indicated that intensive water saving efforts have been made over the past decades. Per capita consumption has decreased from 137 litres per person per day in 1995 to 119 litres per person per day in 2013 (TNS-NIPO 2014). This was mainly due to the use of economic washing machines/ dishwashers and water-saving toilets and shower heads. The industrial consumption decreased from 454 million m^3/year in 1990 to 356 million m^3/ year in 2010. Savings in drinking water consumption have mainly been realised through water reuse, substitution of drinking water by other water and own abstractions (Geudens 2012). The savings opportunities in the business market are difficult to estimate, as they depend on economic development and whether or not more far-reaching regulations in the field of waste water discharge are implemented. The drinking water demand in the agricultural sector is strongly influenced by political and economic developments, such as infectious diseases or the release of the milk quota.

There are various different possible goals where saving water is concerned. The abstract options can be derived from these goals. The possible goals are:

1. Reducing dessication and spatial claim of abstractions. The spatial claim is mainly due to restrictions on other activities in groundwater protection areas and other areas for the drinking water supply.
2. Water savings in order to increase overall sustainability.
3. Preventing operational supply problems, preventing permits from being exceeded and investing more than necessary.

There are various different abstract or more realistic options which can be used to realise the goals:

Short-term options:
- Public campaigns aimed at changing people's behaviour;
- Limit water losses during abstraction and distribution.

Medium-term options:
- Rate differentiation;
- Use alternatives for low value use for business customers;
- New technical installations for saving water;
- Regulations for limiting water consumption.

Long-term options:
- Moving abstractions to locations which put a smaller claim on space and water.

Focus points are:
- Water saving measures should not lead to a shift towards other environmental compartments, resulting in a negative overall sustainability profit.
- Water saving measures should not lead to microbiological risks. In an evaluation (2003) about the pilot project with domestic water in Leidsche Rijn, the Council for Transport Safety indicated that the drinking water company has a great deal of knowledge and experience in this area and is therefore primarily responsible for guaranteeing the reliability of the drinking water.

6

what do we need to do: continue, accelerate and develop

Projection soil protection Dutch national railways (NS) marshalling yard Zwolle

6.1. Introduction

The drinking water infrastructure has the following characteristics: long lifespan, capital intensive and a long development time for new parts. This is difficult to combine with a rapidly changing world. Vitens has opted to develop resilience, in order to guarantee the drinking water supply in this area of tension as effectively as possible, both now and in the future. Resilience is developed along three lines:

1. Develop resilience through infrastructure strategies: robust, tolerant, flexible, sustainable and intelligent.
2. Work in line with an adaptive working method.
3. Work together with stakeholders in a co-creation process.

In order to implement these three strategy lines, the first important thing is to identify the current (or ongoing) activities, in order to secure the drinking water supply both now and in the future. These can also be referred to as no-regret-activities (paragraph 6.2). There are also activities which need to be accelerated in order to realise the desired situation (paragraph 6.3). Other activities require the development of knowledge before they can be implemented (paragraph 6.4). Many of these activities are often better tackled together with stakeholders, instead of purely working on these within Vitens. This collaboration question is addressed in paragraph 6.5.

Vitens works with a number of plans, within which the activities are recorded. The knowledge questions (paragraph 6.4) are included in the innovation and research agenda. The no-regret-activities (paragraph 6.2), activities which need to be accelerated (paragraph 6.3) and the collaboration possibilities will be recorded in annual plans. It's often desirable to further develop activities at Vitens level, for example where costs and feasibility are concerned. This is done in the long-term options plan. All activities are tested against the Vitens goals and strategy in the infrastructure test before they can be included in the regional infrastructure plans which form the basis for the investment plan.

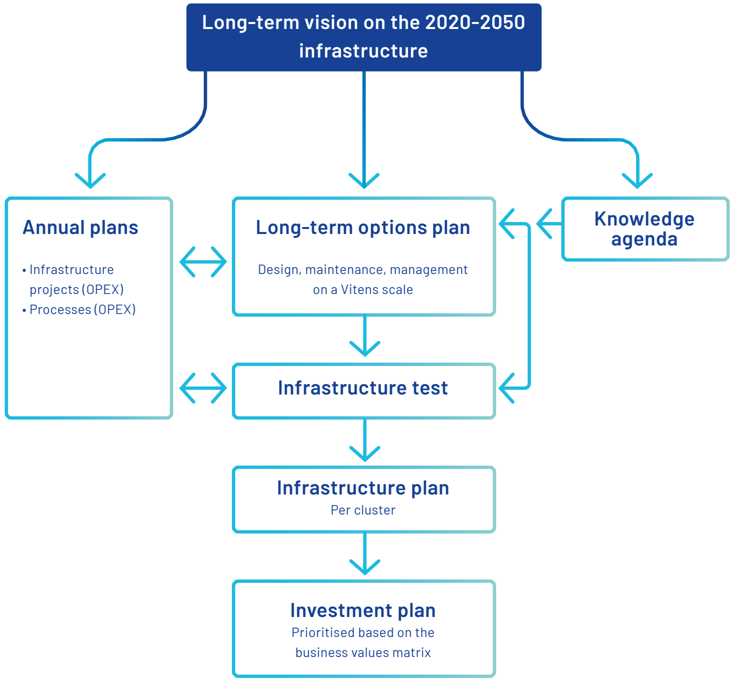


Figure 11 - Overview of plans

Vitens will be working with adaptation paths, in order to keep an overview between the various possible options and to know when certain options are required. An adaptation path describes which option will be chosen if something changes. For example: reducing dessication-sensitive abstractions. If demand decreases, these abstractions can be reduced much sooner than if demand increases. Having an alternative also influences the moment of reduction.

The adaptation paths are not created at system level (LTV level), as this would make them too abstract. Adaptation paths are made on a smaller scale as a follow-up to the LTV, whereby concrete abstractions and activities can be identified. The (underlined) subjects identified in the following paragraphs are a first step towards adaptation paths.

6.2. Current (or ongoing) activities (no regret)

Many activities which are already taking place will be continued. This will primarily involve a drinking water company's core tasks, such as the production and distribution of good and reliable drinking water, the guaranteeing of the drinking water quality and the construction, replacement and maintenance of the drinking water infrastructure.

The sustainable use of materials, sustainable energy consumption and maximising the reuse of residual materials are also continuously important focus points. Sustainability and circularity are points which are given continuous attention and this will continue to be the case throughout the upcoming years. Vitens has devoted a great deal of attention to the reuse of residual materials, the reduction of rinse water losses and sustainable energy generation at its own locations during recent years.

In addition, making sure there are sufficient abstraction permits is also an important focus point. Vitens currently has a shortage of permit reserves. It's essential to obtain the necessary permits as soon as possible, in order to guarantee the continuity of the drinking water supply. Any possibilities which can be realised quickly will be used whenever possible, in view of the long lead time where obtaining these new permits is concerned.

Good availability and protection of the source is also an ongoing focus point.
The quality of the source is important, as this is the input of the drinking water system. Pollutants not in the water naturally don't need to be removed either. This makes good protection of the utmost importance, whereby risk-oriented protection is desirable to prevent unnecessary space claims. This must take the three spatial dimensions and the time it takes for a pollutant to reach the abstraction into account. As the development of new abstractions is a complicated process, the protection is focussed on making an abstraction as permanent as possible.

6.3. Activities which need to be accelerated

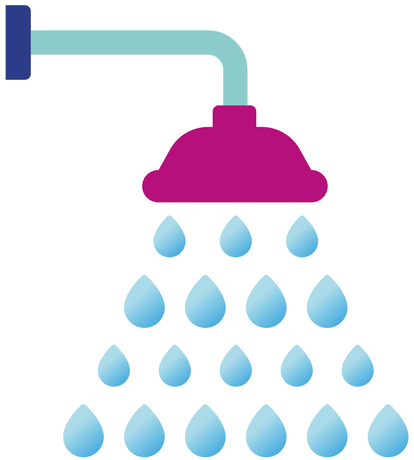
Developing future-proof abstractions
Future-proof abstractions are distinct from others by being in the best places in the water system, with ample water and minimal environmental damage. They also meet the Vitens Drinking Water Preconditions (VDP's).

Climate change, increasing spatial pressure and an increase in demand have made it necessary to develop these abstractions in the short-term. The future-proof abstractions have allowed for the relief of abstractions which are insufficiently future-proof, for example because they cause too much environmental damage.

Managing the water consumption (water savings)
Water savings are important to prevent unnecessary dessication and spatial claims and it helps to prevent operational supply problems and abstraction permits from being exceeded. Water savings can also increase overall sustainability, providing this doesn't increase the burden on other environmental compartments. The building of installations to save water should not pose any microbiological or other quality risks.

It's important to consider the short-term options (consumer savings campaigns, reduction of losses during the drinking water process), medium-term options (regulatory options, use of alternatives for low value business customers and technical solutions) and to scale up or implement long-term options (moving abstractions with high environmental damage) as quickly as possible, given the current permit shortage and expected growth.

Making the drinking water infrastructure more flexible and intelligent
Vitens has a robust infrastructure, where a great deal of attention has been devoted to solid installations which are often tailor-made. Flexibility is limited and it's necessary to introduce more flexibility to the system without losing the necessary robustness, in order to accommodate changes in supply and demand. In addition to robustness, it's also important to ensure there is sufficient intelligence in the drinking water system for the timely monitoring of changes in quantity and quality, making sure there is enough time to introduce measures or inform stakeholders. Intelligence in the system is also important for making good asset management decisions, saving money, increasing the reliability of the drinking water system and informing stakeholders more effectively.



6.4. Required knowledge development

It's essential to continuously develop new knowledge to enable the development of a resilient future infrastructure. The need for knowledge to achieve a resilient infrastructure can be summarised in four themes. The table below shows the research questions related to the themes and their contribution to the infrastructure strategies.

Increasing flexibility in the drinking water system
New abstraction concepts, such as the use of brackish water, represent an important building block for a flexible infrastructure. It's possible to respond to changing water demand more quickly by mixing ultra pure water from a flexible source with existing production companies and by designing production companies and abstractions in a flexible and modular manner.

Reducing the impact on the environment and surroundings
Vitens' impact on the environment and surroundings can be reduced by better integrating abstractions into the environment, minimising the production companies' climate and environmental impact and by making end users increasingly aware of their water consumption levels.

Increasing the intelligence in the drinking water system
Digitising and monitoring and analysing assets more intelligently can lead to increased intelligence in the drinking water system and will enable Vitens to anticipate changes in a timely manner.

Increasing our insight into new developments
New measuring techniques will enable Vitens to signal changes in the quality of the drinking water at an early stage, which will ultimately lead to a more robust and tolerant drinking water system.

	Robust	Tolerant	Flexible and Adaptive	Sustainable and Circular	Intelligent, Coherent and Timely
Increasing flexibility in the drinking water system					
What are the options for preserving (parts of) production companies and how quickly can they be deployed?					
What are the chances and possibilities for using brackish water as a source?					
How can the use of ultra pure water from flexible sources be used for increased flexibility?					
How can the islands become self-sufficient?					
Which new abstraction concepts would fit in with a robust and flexible water system?					
Reducing the impact on the environment and surroundings					
How can the climate and environmental impact caused by the production companies be minimised?					
How can existing abstractions be integrated in the environment more effectively?					
How can the end user become more aware of his water consumption?					
Increasing the intelligence in the drinking water system					
How can Vitens' digitisation lead to a more intelligent, tolerant and robust drinking water process?					
What is the optimal replacement moment for our assets?					
What is the social value of large infrastructures, how do we enter into uniform agreements about the way in which values are reported on?					
Which techniques, methods and data analyses exist to describe, measure and report on the availability and reliability of the infrastructure?					
Increasing our insight into new developments					
What are the most promising techniques for measuring water quality and how do you apply this?					

Table 1 - Research questions relating to the themes and their contribution to the infrastructure strategies

6.5. Collaboration

Working together with stakeholders is essential for realising the best possible social results. What kind of collaboration is desirable has been indicated for a number of stakeholders.

Collaboration with municipalities, water boards and provinces

- Developing initiatives and plans, in which water abstraction is (one of) the function(s) where a high level of spatial quality and good climate-proof water management are realised. The opportunities offered by the Environmental Act are made use of here.
- Making use of the opportunities offered by the Environmental Act in order to realise good projects.
- Focussing on improving the groundwater and surface water quality.
- Developing knowledge about the risks for the drinking water supply and socially desirable activities (for example, the energy transition).
- Collaborating on replacement tasks and establishing the protection of underground infrastructure in spatial plans, as well as the guaranteeing of possibilities for new pipelines.
- Investigating and implementing the possibilities for sustainable demand management (water savings).

Collaboration with water supply companies
Water companies have many different interfaces and good coordination and collaboration where a large number of subjects are concerned is of the utmost importance.

Collaboration with infrastructure managers
Infrastructures are now increasingly more intertwined. Interdependencies need to be well understood in order to be effectively prepared for any possible changes and it's important to develop integrated response strategies. NGinfra, a collaboration between Vitens, RWS, Alliander, the Port of Rotterdam, Schiphol and ProRail, is looking into the interdependencies and the possibilities for working in a more integrated manner.

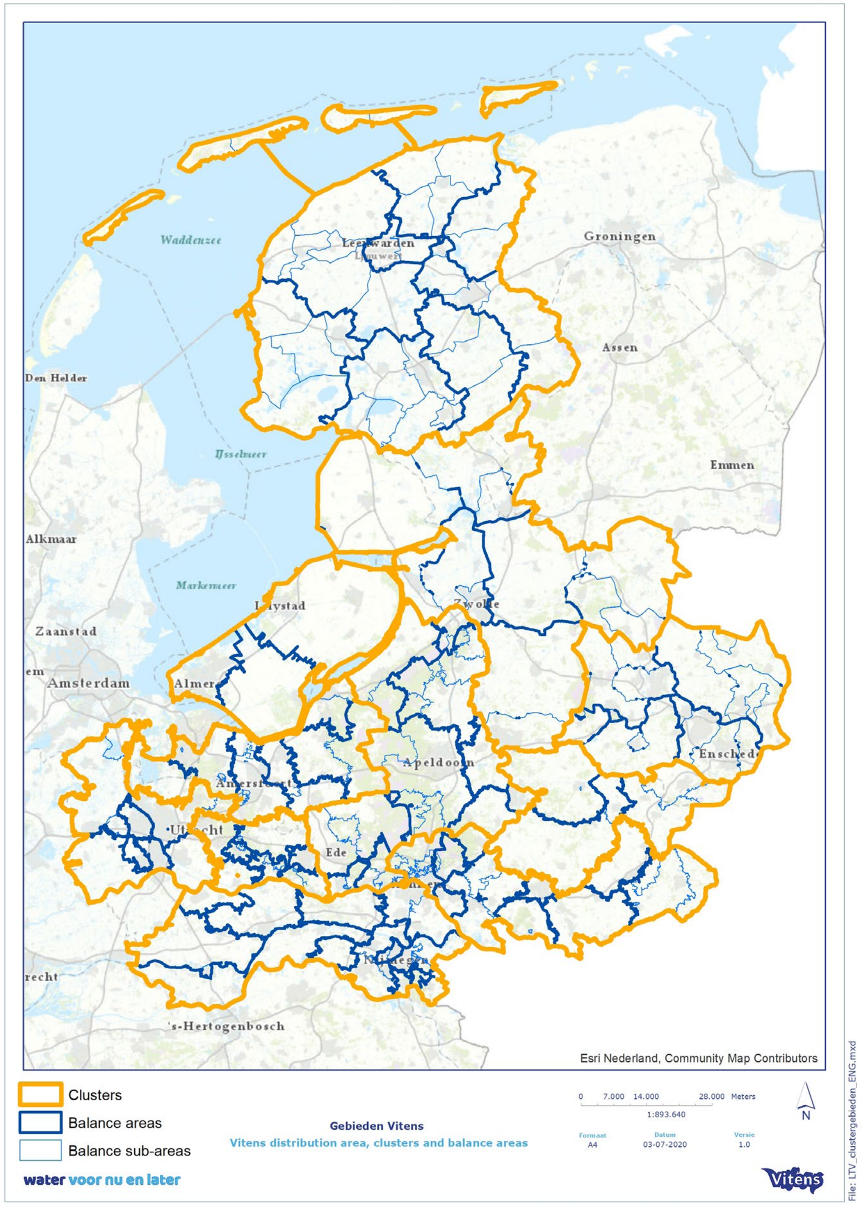
Collaboration with universities and knowledge institutes
Collaborations have been entered into with universities and knowledge institutes for the knowledge development.

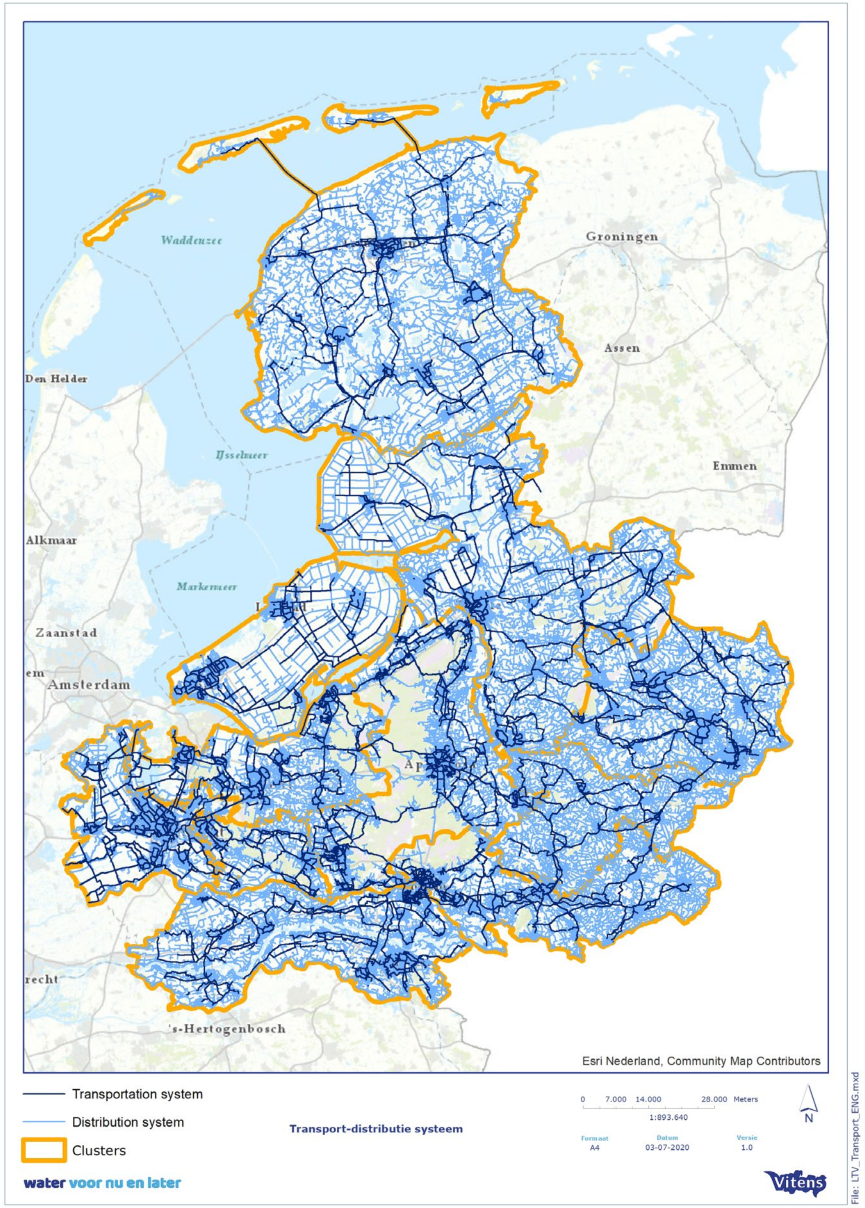
7 appendix I description of the current infrastructure

In order to be able to supply reliable and affordable drinking water 24/7, Vitens has a drinking water infrastructure which includes 117 abstraction fields with 1,250 abstraction wells for groundwater abstraction, 93 production locations for the purification and 49,400 kilometres of pipelines.

3 maps:

1. Map of distribution area, clusters and balance areas
   - 11 clusters
     A cluster is a combination of linked balance areas for a dynamic water supply
   - 80 balance areas
     A balance area is fed directly form at least one production company
   - 189 partial balance areas
     A partial balance area is supplied by one ore more production plants and of which the total inflow can be measured. (Municipality or city level.)
2. Map with transport-distribution system
3. Map with sources

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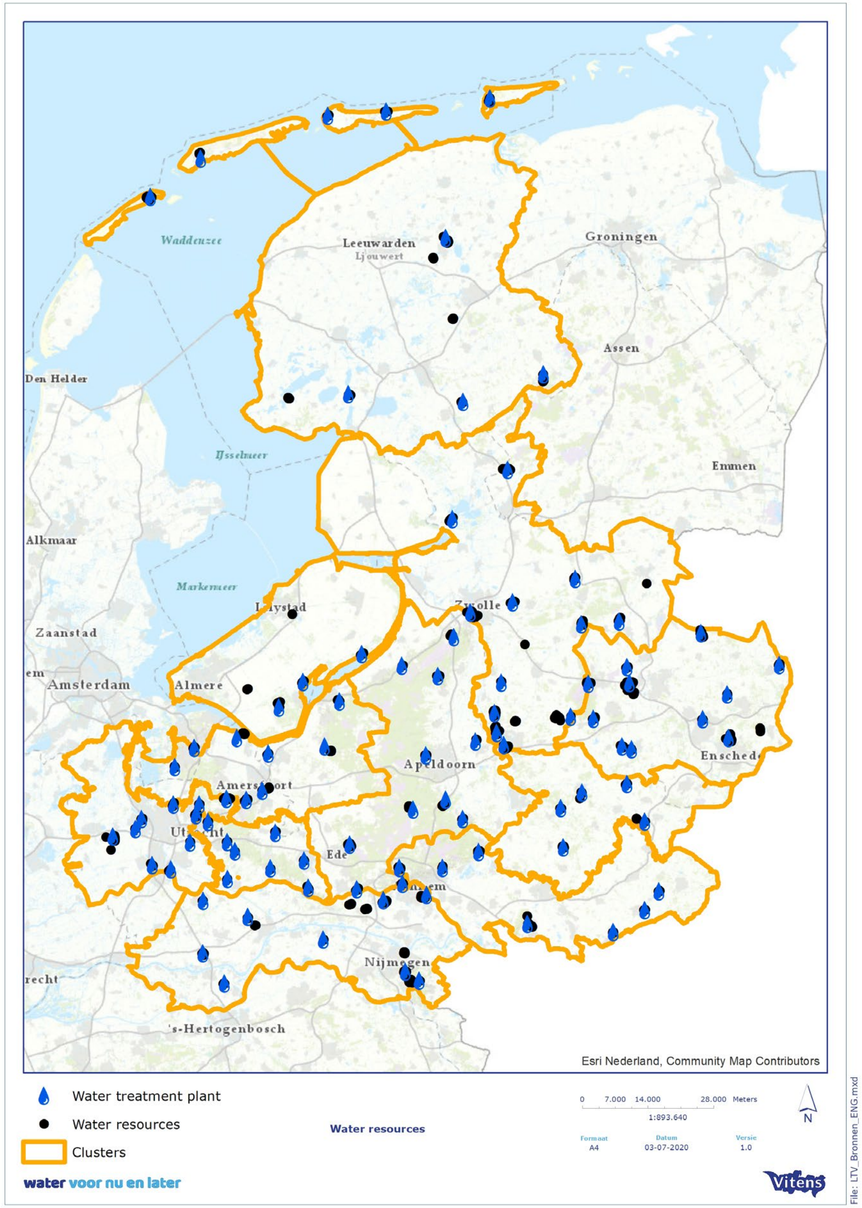
Waddenzee
Leeuwarden
Ljouwert
Groningen
Assen
Den Helder
IJsselmeer
Emmen
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Almere
Apeldoorn
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7.1. Characteristics of the drinking water infrastructure

The drinking water infrastructure is a complex system. This is further explained using figure 1, which shows the drinking water infrastructure system. This system consists of the socio-technical system, with the technical network and all the activities required to produce drinking water. In addition, the drinking water infrastructure system is also linked to the spatial and water system, which includes other users and where the government has a regulating role.

One characteristic of both systems is that they are linked to different time dynamics. The daily operation is linked to infrastructure which was built up to a hundred years ago and which can't just be changed. The following table distinguishes between four different time layers, which are shown as separate layers, but which actually also interact.

A number of striking matters in the drinking water supply in the Netherlands from 1900 are:
- 1947: driest year (30 cm of precipitation)
- 1976: warm and dry year (54 cm of precipitation) (90% dry year)
- 1986: Disaster year; 1) explosion at the Chernobyl nuclear reactor, 2) discharge of many tons of chlorobenzene into the Rhine, and 3) the release of large quantities of pesticides as a result of a fire at Sandoz (Basel)
- 1998: wettest year with 124 cm of precipitation
- 2017: GenX (PFAS) pollution which led to intake stops
- 2018, 2019: consecutive hot, relatively dry summers. Precipitation in 2018: 67 cm; 2019: 86 cm. Long-term annual average precipitation is 85 cm.

Time scale		Drinking water supply and technical network	Spatial and water system
Layer 1	**Embedding** Usually impossible to calculate (slow changes)	Informal design ideas which define the current infrastructure	Informal ideas about the possibilities to use and design the earth, which are visible in the current consumption levels
Layer 2	**Institutional environment** (Changes every 10-100 years)	Technical standards, design agreements and models	Rules and permits for using the spatial and water system
Layer 3	**Management and control** (Changes every 1-10 years)	Protocols, routines, operational decisions and the best techniques available	Administrative agreements
Layer 4	**Daily operation, maintenance and consumption** (continuous adjustments)	Daily decisions in relation to the operation and consumption of drinking water	Daily decisions and consumption of the spatial and water system

Table 2 - Four time layers

8 appendix II in-depth look into: developments, trends and challenges

8.1. Increasing spatial pressure

The pressure on the top and subsoil is increasing, which has consequences for the available space for drinking water installations, protection areas, abstractions and pipelines. This problem is further exacerbated by the fact that demand for drinking water is increasing in the forecasts and drinking water companies need additional permit capacity and the provinces must designate areas with additional strategic reserve stocks (ASS areas).

The extraction of fresh groundwater for drinking water and industrial water has been the most important activity in the shallow subsoil for decades. The energy transition has changed this and the shallow subsoil is now increasingly being used for cold heat storage and geothermal energy and this is expected to continue to see significant increases.

Climate change places a greater burden on the water system's bearing capacity and causes critical drought and wet situations. This also influences the effects of abstraction, which is expected to lead to discussions about the acceptance of this damage, especially in the dry sandy soils. The abstractions from dry sandy soils are under discussion.

Another aspect is that the use of space in groundwater protection areas limits other spatial developments both above and below ground. Here it's important that only the actual risks are prevented or limited and that areas which do not pose a risk to the drinking water supply are not limited. Risk-oriented protection is important in order to realise this, whereby, in addition to the ground level (2D protection), the subsoil is also included (3D protection). A 4D approach is used if the time it takes for pollutants to be extracted is also taken into account, which is best suited to a risk-oriented approach.

Underground pipeline infrastructure
There are several major challenges in the cable and pipeline sector. The current pipeline infrastructure must be replaced or renovated in a busy overground and underground environment. Several social trends and transitions require an extension of, or addition to, underground networks. This can result in an already busy subsoil becoming even busier. The most important trends with a spatial impact in the shallow subsoil are the energy transition, climate adaptation (in particular water storage and the construction of green areas), the introduction of the 5G network, urbanisation and changing government policy (in particular compensation schemes).

- The energy transition mainly concerns the sustainability of the urban area and specifically the housing sector. This includes, among other things, heat networks and the increase in power consumption (for example, with electric cars or electric heating systems). The increase in power consumption will have an impact due to the large investments which will have to be made in the electricity network. In addition, larger or multiple cables will be required to meet the energy demand. There is currently still a great deal of uncertainty about the spatial impact of heat networks. It's not yet known how this will equate to an extension of the routes. There is also still some uncertainty about the potential impact of heat networks on the drinking water infrastructure where temperature increases are concerned.
  In addition to the relationship between the infrastructure in the subsoil and the energy transition, the extraction of heat (heat sources) will also put demands on the subsoil (for example, wells for HCS systems or geothermal energy). What the spatial impact of these sources will be is not yet clear.
- Climate change will result in changes in peaks and troughs in the supply and discharge of rainwater and surface water in rivers. In addition, urban areas can also suffer from heat stress. Climate adaptation is an attempt to counteract these developments, for example by constructing water storage facilities, expanding sewers and by planting greenery in cities. These climate adaptation measures will impact the spatial planning of the subsoil, particularly in urban areas.
- The roll-out of the 5G network is planned for 2020. This roll-out requires an expansion of, and investment in, the underlying fixed networks and ensures a (spatial) doubling the fibre optic network.
- Urbanisation is increasing, partly due to the growth of cities within existing city limits. This creates densification: more homes, people and facilities per hectare. The amount of cables and pipelines is increasing and will compete with other claims (mainly mobility, waste collection, water storage and the quality of life). In addition, construction will be faster, which will increase the pressure for faster adaptation of underground infrastructure.
- Municipalities will integrate existing regulations (for example, with regard to digging) into environment plans with the introduction of the Environmental

Act. This could potentially provide a different basis for compensation for loss and diversion schemes (this development is already noticeable). However, the Environmental Act will promote coordination and information sharing and can thereby provide an incentive for direction (and therefore has the potential to act as a catalyst).

The challenges which these trends will result in can lead to significant integration problems and can have major financial consequences. This is expected to further increase in the future. We need to implement smarter distribution of the very limited space in the subsoil in order to realise all the desired developments. The pressure in the subsoil is now increasingly becoming a bottleneck because the coordination between the various users of that subsoil is inadequate.

There are a number of different causes for the problems and challenges the underground pipeline infrastructure is subjected to. There are often combinations of causes, which are all responsible for the occurrence of problems, only in a few cases can a problem be specifically linked to one cause. Identified causes are:

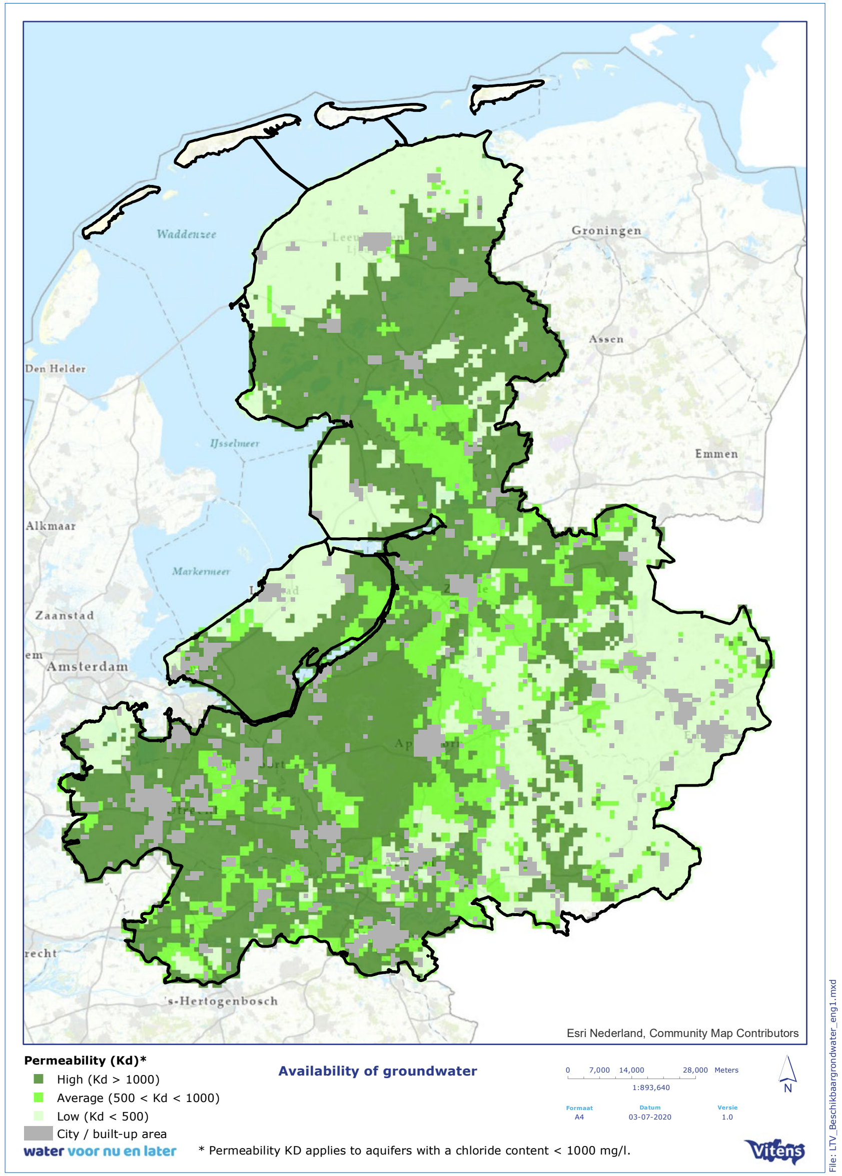
- Pressure on the underground space;
- Inadequate information provision;
- Different interests and inadequate collaborations.

Especially where this last point is concerned, we will need to find a different way of working together in the subsoil. After all, it's important to realise that the entire sector is responsible for this complex challenge; the drinking water companies are not alone. Many problems which are being experienced at operational level are caused by a lack of cooperation and not making choices at tactical and strategic level. In addition, differences in principles among parties can create barriers where collaborations are concerned. This means parties are only focussed on optimising their own processes, without any consideration for the overall impact. Municipalities realise they have to take on this role, but they lack strategic vision, urgency, competencies and/or capacity.

8.2. What are the options for abstracting water in the Vitens area?

Groundwater and surface water are available as a source in the Vitens area. Thick aquifers with fresh and brackish groundwater are available in the west of the area. Abstraction possibilities decrease further to the east, as the aquifers are thinner and the geomorphology is much more erratic, creating a fragile landscape with vulnerable nature reserves. Surface water is also available in much larger quantities in the west (IJssel and IJsselmeer) compared to the east, where there are only relatively small streams. However, there are canals which take the water from the IJssel to the east. Rainwater and waste water treatment plants are also available, where storage or replenishment from other sources must be available to be able to supply during periods of peak consumption.

On average, Vitens uses less than half a percent of the total amount of available water within and along the supply area. This can increase up to approximately 2% (please refer to the Water Balance appendix) during dry periods.



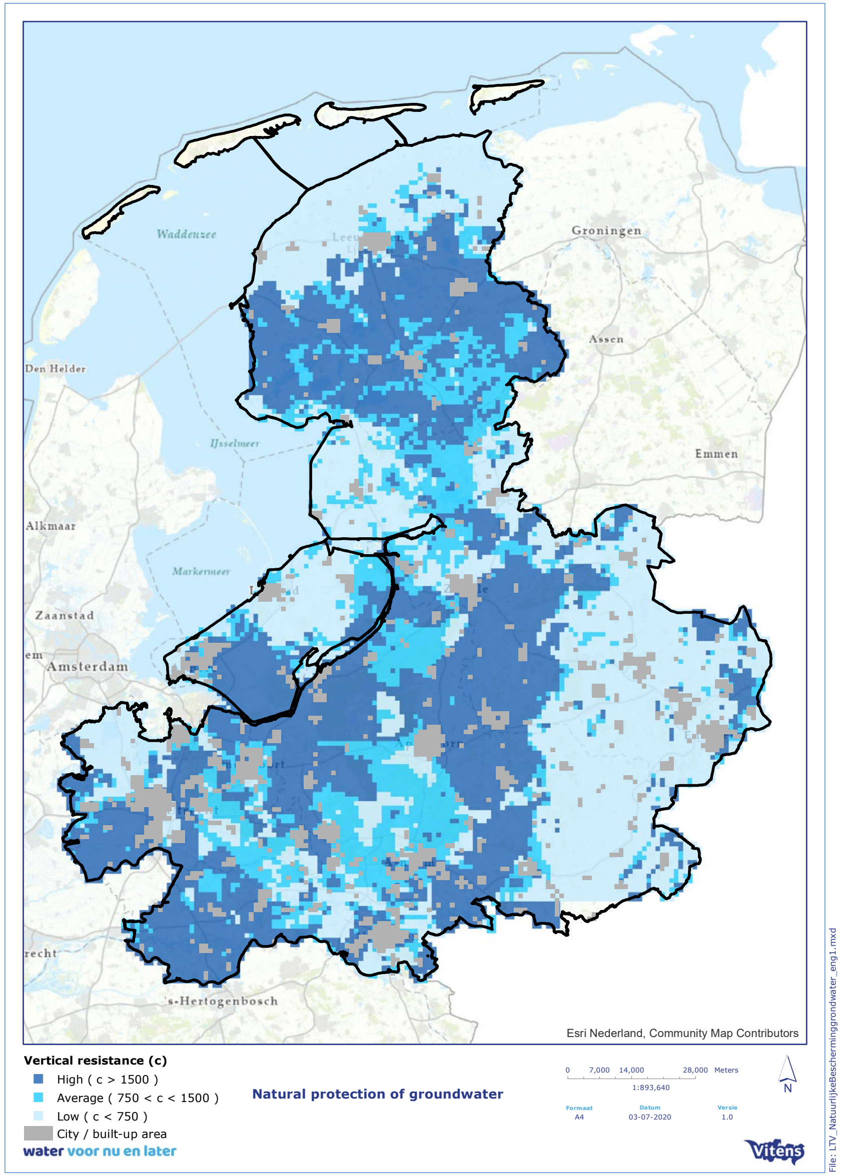


Figure 12 - Availability and natural protection of groundwater

The primary source of groundwater is the precipitation surplus and also infiltration from rivers when the river level is higher than the groundwater in the immediate vicinity. The precipitation surplus in the Netherlands is reasonably uniformly distributed, but how much of it drains fairly quickly into surface water or penetrates deeper into the soil depends on the permeability of the soil.
The permeability of the subsoil is also important at deeper levels. With higher permeability, groundwater can be attracted from larger areas. More and more wells are needed to abstract the same amount of groundwater as the permeability decreases, until a limit is reached below which the number of wells no longer outweighs the yield.

Clay layers protect abstractions against influences from above, at least in the sense that clay layers increase the duration of the groundwater from ground level to the wells and increase the abstraction's extraction area. The protection is therefore not absolute and essentially concerns buying time, although this can run into many hundreds of years. Unfortunately, the pump filters are actually located above rather than below the significant clay layers with many of the abstractions. In part this still has historical origins, from times when ground level emissions were less risky or insufficient resources were available to make deeper pumping stations.

8.3. Water Balance

The table below shows the available volumes for groundwater and surface water within the Vitens area. Vitens' average monthly production[2] amounts to 29 million m^3. At most, just under 1 million m^3 (3%) comes from surface water via bank bed passage. The monthly production can increase up to 46 million m^3 during dry periods with peak consumption levels (peak factor of 1.6).

2 We work with monthly figures in order to also include a dry period in the analysis.

Source[3]	Average monthly volume (million m^3)	Monthly volume in case of extremely low water (million m^3)
Groundwater	375	N/A
Neder-Rijn (Driel Boven)	1,270	20
Waal (Tiel)	3,750	1,540
IJssel (Olst)	950	320
Vecht	100	Half of the drinking water consumption[4]
IJsselmeer[5]	30	Nil
Total	**6.475**	**1,900 + groundwater from storage**

Table 3 - Water availability in the Vitens area

For groundwater: where the groundwater is concerned, the maximum recoverable amount is equal to the precipitation surplus (approximately 300 mm/year). This amounts to approximately 375 million m^3/month for the Vitens area (surface area of more than 15,000 km^2). This does not take the amount of groundwater which infiltrates from the surface water into account. Vitens uses approximately 7% of this. We need to look at a longer-term period (years) where the availability of groundwater is concerned. The summer replenishment deficit is more than offset by the winter replenishment surplus (resulting in the aforementioned 300 mm/year).
The drinking water extractions can continue to function if the groundwater sinks several meters deeper in an extremely dry period. The pumps usually hang more than 10 meters below the groundwater level, so they will remain well under water. However,

3 The numbers for the drains at Driel, Tiel and Olst are based on measurement series which can be consulted and downloaded via https://waterinfo.rws.nl. The measurements for 20th November 2018 have been used for the lowest discharge.
4 The natural drainage from the Vecht is virtually nil during dry periods. The drainage during dry periods mainly consists of effluent. In fact, at that time there would be a temporarily closed water chain if the (bank bed) water were to be used for the preparation of drinking water.
5 The IJsselmeer's average only takes the precipitation surplus into account. For the sake of convenience, we have assumed we do not want to touch the storage during dry periods and the recoverable amount has therefore been set to zero. The amount of water which flows into the IJsselmeer from the IJssel has already been shown as a separate item.

higher production levels during dry times can lead to more damage to agriculture and nature (and possibly buildings due to extra settlement), whilst we must consider how significant that is compared to a dry situation without abstraction.

For surface water: The availability of surface water, either direct or via bank bed water abstraction, is very extensive compared to the drinking water requirement, even during periods with low river discharge. At the lowest drains of the IJssel, Vitens' total water requirement for the entire peak production amounts to approximately 14% of the discharge, for the Waal this is less than 3%.

On average, Vitens uses less than half a percent of the total amount of available water within and along the supply area. This can increase up to approximately 2% during dry periods.

Finally, it should be noted that, although Vitens extracts water from the water system for the drinking water supply, the majority of that water is returned to the water system via sewers and sewage treatment, albeit usually at a location other than where the water was abstracted. The net extraction of water from the water system for the drinking water supply is therefore very low.

8.4. (Geo)chemical water quality

Vitens operating standard for raw water: geogenous ladder and source values
The natural background quality of groundwater differs greatly within Vitens' supply area. The required purification steps therefore vary greatly depending on the type of groundwater. A preferred sequence for groundwater types is therefore used, with a view to minimising the purification effort: the geogenous ladder.

Table 4 shows the typical water systems for the Vitens area with the associated groundwater types, in order of increasing purification effort. The geogenous ladder is used for the selection of new abstraction locations and the displacement or closing of existing abstractions. A source value for macro parameters has been derived for each type of groundwater, in order to test whether the raw water quality still fits in with 'simple purification'.

Geogenous ladder		
Water type	**Water system**	**Type of purification**
(sub)oxic	Lateral moraine	single filtration
anoxic	Beekdal landscape	double filtration
deep anoxic	Peat area	intensive aeration + double filtration + softening
deep anoxic	Peat area	NF/RO
brackish	Near ZZ interface	RO
salt	Below ZZ interface	RO

Table 4 - Geogenous ladder

In addition, there is a large group of chemical substances which do not naturally occur in groundwater, but actually have a human origin (anthropogenic substances). These substances can reach groundwater through infiltration of contaminated surface water, or through local activities in the abstractions' extraction areas.

We distinguish between (a) substances which have been labelled as Substances of Very High Concern by the Central Government (SVHC)[6] (because of their carcinogenic properties), (b) substances which have been standardised by the Drinking Water Decree (DWD) in table II and finally (c) other anthropogenic substances. In the shorter term, the aim is to comply with source values which correspond with the DWD standards, whereby the strictest values based on the precautionary principle apply to the SVHC. For the longer term, the aim is to have the lowest possible values (ALARA principle), in any case less than 0,1 μg/l, 0,01 μg/l for SVHC respectively. This is in line with the signalling values from the WFD Protocol for Monitoring Drinking Water Sources.

6 This is the category of substances which have a major impact on people and the environment and Vitens applies an extra

Anthropogenic substances	Short-term (0-20 y)	Long-term (> 20 y)
Substances of Very High Concern	0.1 μg/l/sum 0.5 μg/l	0.01 μg/l/sum 0.05 μg/l
Standardised substances	standard/guide value	ALARA (<<0.1 μg/l)
Other substances	1 μg/l/sum 5 μg/l	ALARA (<<0.1 μg/l)

Table 5 - Source values for anthropogenic substances

The situation mapped out

The trends in the raw water quality from the abstractions are assessed using four themes: eutrophication, salinisation, background quality and anthropogenic substances. Arsenic is highlighted separately given its health relevance.

The influence of fertilisation has been assessed on the basis of four parameters: nitrate, sulphate, nickel and total hardness . The consequences of intensive agriculture are particularly noticeable in the Achterhoek and Overijssel. Salinisation by chloride mainly occurs in the abstractions around Deventer and in some Frisian abstractions. Salinisation also takes place in a few abstractions with a shallow fresh-salt interface.

Arsenic bottlenecks are spread across the Vitens area, including some newer abstractions, where concentrations have not yet stabilised. Relatively high values are also visible with older abstractions in peat areas - Loosdrecht and Hammerflier for example.

The background quality is assessed based on four parameters: iron, ammonium, methane and total hardness[7]. Increased values or sharply rising trends are visible in about a third of the abstractions. High methane values have been found in Friesland and in a ring south of Utrecht. The groundwater is naturally very soft in the lateral moraines of the Utrechtse Heuvelrug, Veluwe, Sallandse Heuvelrug and East Twente.

7 Hardness can have both a natural as well as an anthropogenic origin. A distinction was made at location level, based on historical trends and land use in the abstraction area, for the purpose of the assessment.

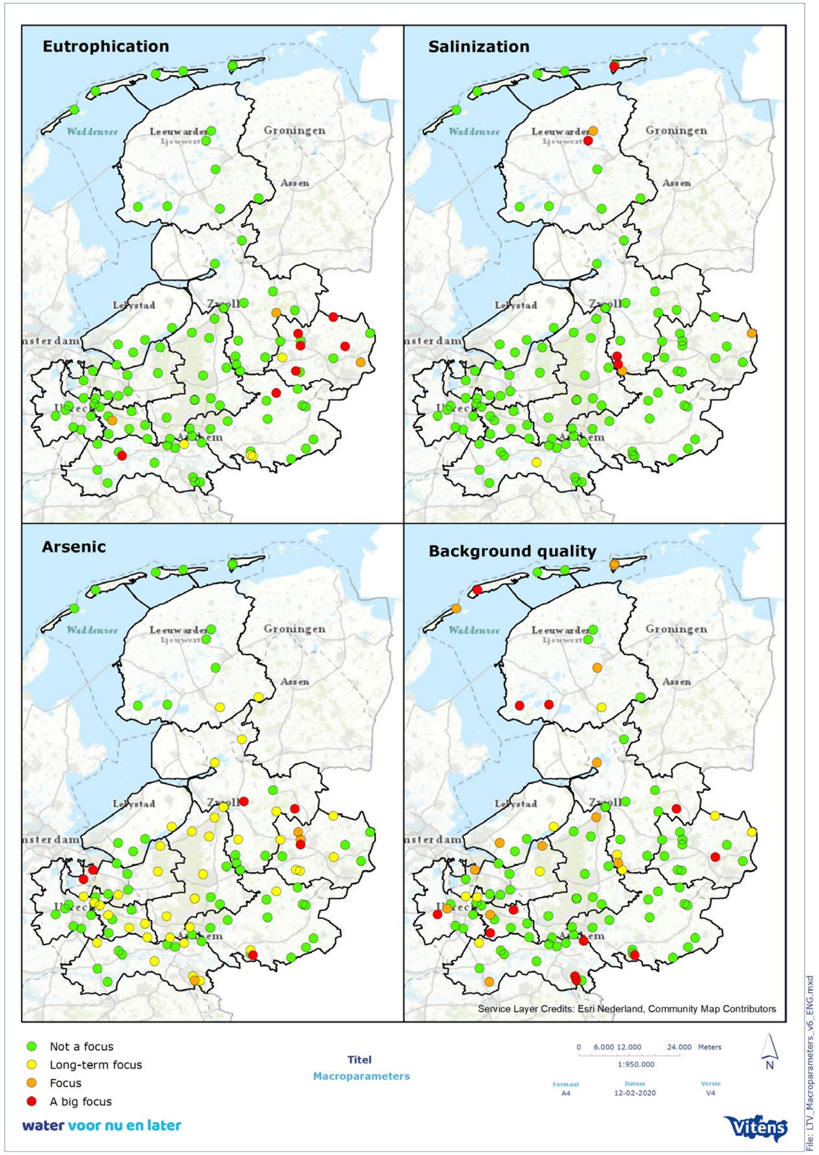


Figure 13 - Forecasts for the raw water quality of all abstractions in Vitens' supply area

The map at the top left of figure 13 shows the influence of agricultural activity on the basis of nitrate, sulphate, nickel and total hardness. The top right shows the trends in chloride and sodium; the bottom left the arsenic trends and the bottom right the most important other background parameters: iron, methane, ammonium and hardness.

- Green: no expected problems during the next 30 years
- Yellow: (one of) the parameter value(s) will exceed 80% of the source value within 10-30 years
- Orange: (one of) the parameter value(s) will exceed the source value within 10-30 years
- Red: (one of) the parameter value(s) will exceed the source value within the next 10 years

Figure 14 shows the presence of anthropogenic substances in the raw water. A distinction has been made between pesticides, medicines, industrial substances and volatile substances (often from historical local pollutants). Pesticides are found in raw water of about half of the abstractions. In addition to bentazone and MCPP, metabolites of the herbicides metolachlor, dimethenamid and chloridazone are mainly found. Medicines - such as gabapentin - reach the groundwater through infiltration of contaminated surface water and leakage from sewers.

Industrial substances can be supplied via surface water (such as dioxane), but landfills or even atmospheric deposition can also play a role here. Most bottlenecks are caused by SVHC. A number of other bottlenecks are caused by substances which are less relevant from a health perspective, but the concentrations of which are steadily increasing (trifluoroacetic acid and sweeteners). Volatile substances (for example trichlorethylene) are present in at least 25 Vitens abstractions from (former) industrial and small business locations. A number of former dump sites also have an impact.

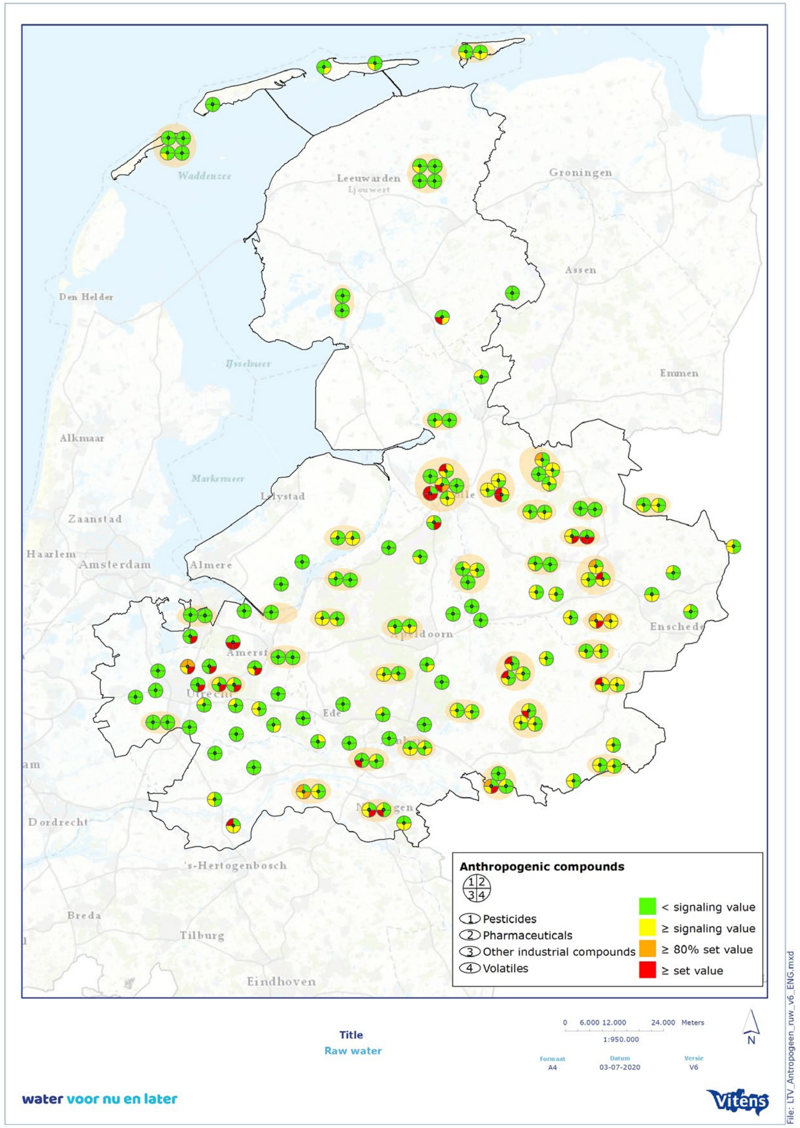


Figure 14 - Retrospective overview (2017-2019) of anthropogenic substances in raw water of all abstractions in Vitens' supply area

- Green: no bottlenecks
- Yellow: (one of) the parameter value(s) will exceed the source value (LT)
- Orange: (one of) the parameter value(s) will exceed 80% of the source value (ST)
- Red: (one of) the parameter value(s) will exceed the source value (ST).

Vitens company standards for the drinking water produced: limit and threshold values

Vitens applies quality requirements for the production of drinking water, which are largely based on the legal standards as included in the Drinking Water Decree. However, Vitens has recently adjusted the quality requirements for the anthropogenic substances. An explicit distinction has been made between chemical substances which present a negligible risk to public health (such as some medicines and sweeteners) at the concentrations found today and those which may pose a definite risk to public health (such as SVHC). The most important thing is that Vitens always supplies drinking water in accordance with the law, but that the strictest quality requirements are set for the latter category of chemical substances (SVHC), which are based on the precautionary principle.

The situation mapped out

Anthropogenic substances are found sporadically and are location-specific in the drinking water produced (see figure 15). The drinking water meets the legal standards in almost all cases, but in some cases bottlenecks have become visible as a result of the application of stricter requirements, as set out in the Vitens limit and threshold values. The sum concentration of pesticide metabolites (metolachlor ESA and OA) is a bottleneck for the production companies Vorden and Dinxperlo. For the latter, this was caused by the purchase of German drinking water, the purchase quantity of which was already reduced in early 2020.

Drugs such as gabapentin and caffeine have been found in drinking water at some locations. These are usually very low concentrations which do not pose a risk to public health. A chain-wide prevention approach for maintaining long-term quality is preferable, as most production locations are insufficiently equipped to purify these drug residues.

Some industrial substances, like sweeteners and trifluoroacetic acid, occur in raw mater in relatively high concentrations. As these substances are not effectively removed during the purification process, traces of these are also found in the

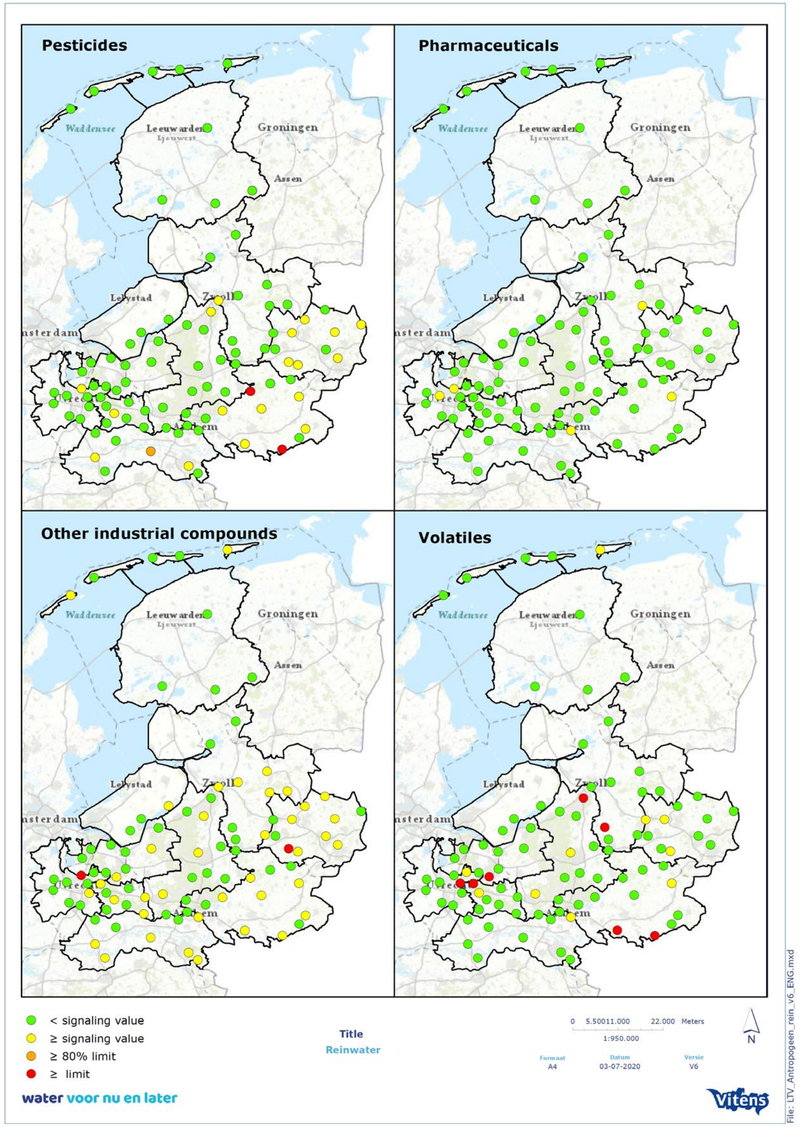


Figure 16 - Retrospective overview (2017-2019) of anthropogenic substances in the drinking water of all production companies in Vitens' supply area

drinking water produced. It's important to continue to effectively monitor this, as the concentrations of these substances in the environment are increasing.
And finally, the volatile substances, mostly from historical local pollutants, form a number of bottlenecks in the produced drinking water. These bottlenecks, including trichlorethylene, which is included on the SVHC list, are monitored and, where necessary, actively controlled with specifically targeted interception measures in the extraction areas.

- Green: no bottlenecks
- Yellow: (one of) the parameter value(s) will exceed the Vitens signalling value
- Orange: (one of) the parameter value(s) will exceed 80% of the Vitens limit value
- Red: (one of) the parameter value(s) will exceed the Vitens limit value

Strategic aspects
The general picture of the abstractions remains worrying as one third of the abstractions does not meet the WFD raw water targets and is not expected to improve any time soon. That's why it will remain of great importance to continue to critically monitor developments and to formulate a strategy and enter into agreements here in consultation with stakeholders (competent authority, business community, knowledge partners, etc). The WFD goals are guiding and the objective towards the last planning period for drinking water production is clear:
'The purification efforts for the preparation of drinking water must be reduced'.

Various different measures are necessary for this, whereby it's ultimately up to the entire chain. A preferred approach at source is to prevent anthropogenic substances from entering the environment during the production and use of materials. But it's also about adequate licensing, sufficient provision and awareness among all stakeholders. *End-of-pipe* solutions as an additional purification step at waste water treatment plants can't be excluded from the chain approach either.

The necessary and possible measures depend on the type of pollution:
- The action perspective is partly limited because it concerns natural substances (such as arsenic or nickel). In some cases, optimisation of the existing purification is sufficient, for example with manganese.
- With salinisation the action perspective is a combination of optimisation of

the abstraction capacity, possibly in combination with advanced purification techniques.

The action perspective for reducing pollution at source is greater where the emissions of anthropogenic substances are concerned, as well as with regard to the burden on manure and lime (hardness) in agriculture.

However, an increasingly complex mixture of impurities is involved with many of the abstractions with focus points. This can be explained by the fact that pollutants can reach deeper groundwater over time and the measuring techniques have been improved too. The latter is good for the transparency and awareness of the quality of the (drinking) water, but also requires attention for formulating policy answers to all these new insights.

Despite several decades of far-reaching efforts to reduce emissions, little improvement has yet been noticed in the pumped up groundwater. On the one hand, this is due to the long travel times in groundwater, for example with the many abstractions in the river area and, on the other, the implemented measures have not yet proved sufficiently effective for the quality of young groundwater. It's important to focus on a joint chain approach for each substance or source.

8.5. Microbiological water quality

8.5.1. Framework and standards for microbiological water quality

Under article 21, paragraph 1 of the Drinking Water Decree, micro-organisms may not occur in drinking water in such a concentration that it can negatively affect public health. In accordance with article 13, first paragraph of the Drinking Water Decree, the owner of a drinking water company must ensure the drinking water meets the quality requirements set in the tables in Appendix A, which forms part of this Decree, at the supply point and at the tap point.

In Appendix A, table I, this is operationally translated into the absence of *E. coli* and enterococci in 100 ml of drinking water. *E. coli* and enterococci are indicators of faecal contamination with pathogenic bacteria and should be analysed using a culture method or analysed with a faster RT-PCR method for *E. coli*. The RT-PCR method for enterococci is currently being validated. Additional microbiological parameters have also been included in table I: *Cryptosporidium*, *Giardia*, (entero)viruses[1], *Campylobacter* and bacteriophages (in any case somatic coliphages and F-specific bacteriophages). These are pathogenic micro-organisms. No maximum value has been included for this, but a risk analysis must be completed, as it's not possible to measure concentrations at the very low level at which exposure is relevant to the user's health. The microbiological safety of the drinking water produced must be demonstrated by data on the quality of the source (groundwater from vulnerable abstractions and surface water) in combination with the effectiveness of the purification. The Drinking Water Decree does not provide a concrete interpretation of the way in which the risk analysis must be completed. The 'Analysis of microbiological safety of drinking water' guideline (AMSD), dated 2019, must be used for this purpose.

The theoretical infection risk calculated using this risk analysis is subject to a limit value of one infection per 10,000 people per year. If the calculated infection risk is greater than the stated limit value, the owner must consult with the Human Environment and Transport Inspectorate (HETI) about the measures to be implemented.

Legionella

In accordance with article 36 of the Drinking Water Decree, the owner of a collective water supply or collective mains network must ensure the drinking water or hot tap water available to third parties at the point of delivery contains less than 100 colony-forming units of legionella bacteria per litre of the types of legionella bacteria to be decided on by the ministerial regulation. This will be elaborated on in more detail in the Legionella Prevention for Drinking Water and Domestic Hot Water regulation, partly as a result of the indication from the care institutions category.

Indicators – Operating parameters

In addition to the microbiological parameters mentioned above, water quality assessments are also carried out on technical microbiological parameters Aeromonas (30°C), bacteria from the coli group, *Clostridium perfringens* (including spores) and colony count at 22°C and microbiological growth-related parameters (DOC/TOC and temperature). DOC/TOC are indicators for imperfections in the production or distribution of drinking water. These parameters don't pose a direct threat to public health. Aeromonas is a bacteria which can multiply in the pipeline network and is an indicator of regrowth. Regrowth of micro-organisms in the distribution systems is undesirable, as this can be a breeding ground for other bacteria and animal organisms. They can also cause odour and taste problems.

8.5.2. Current situation and focus points regarding microbiological water quality

Vitens doesn't use any means of chemical disinfection in its regular business operations. This means the microbiological safety of the drinking water is based on the abstraction of microbiologically reliable groundwater with sufficient underground residence time to kill off any pathogenic bacteria, viruses and protozoa. UV disinfection is sometimes used for abstractions which are strongly influenced by surface water. It's important for the drinking water not to be microbiologically contaminated during the process from abstraction to delivery to the customer. This is one of the reasons why it's necessary to work in accordance with the applicable Drinking Water Hygiene Codes.

A water quality assessment is performed on microbiological parameters in order to check this (in accordance with appendix A of the Drinking Water Decree), within the context of the statutory measurement programme, after activities and in case of complaints.

The following focus points can be defined based on the collected water quality data:

- Exceedances of the drinking water standard occur more often with microbiological than with chemical parameters.
- Exceeding technical Aeromonas parameters in the distribution network. Producing biologically stable drinking water starts with the production company. The most important component for the growth of micro-organisms is their nourishment. Any measures introduced in the distribution network won't make much sense for as long as the supply of food continues (TOC and AOC). Flushing provides temporary improvement of the regrowth, but regrowth of micro-organisms will continue to occur due to the continued supply of food. If regrowth continues to occur in the distribution network, there will also be a greater risk of finding *Legionella* in the distribution network. The growth of animal organisms is common in distribution areas where the drinking water is biologically unstable. The abundance of animal organisms, especially *Asellidae*, can lead to pressure complaints from customers due to water meters getting clogged up by these organisms.
- Exceedance of the technical parameters of bacteria of the coli group in a specific supply area, which can't be related to imperfections in the business operations / purification at the production location or the activities being executed.
- Exceedance of *Legionella* and colony count at 22°C occurs every year.
- The maximum temperature in the pipeline network per year, during the period from 2014 to 2019, is slightly below the limit of 25°C. Exceedance of the drinking water's legal 25°C standard in the pipeline occurred in 2018 and 2019.

8.6 Purification

Water purification is a drinking water company's core activity. Water purification is necessary at virtually all abstraction locations before it can be delivered to the consumer. In virtually all cases, the aim of the purification is to remove geogenous substances such as methane, iron, manganese and ammonium. These substances can be removed with relatively simple natural purification processes. In addition, user comfort is increased at a number of locations by lowering the total hardness and colour of the drinking water.

However, changes in the environment, climate and society put pressure on the traditional abstraction and purification methods. The presence of anthropogenic substances makes more complex purification necessary at some locations. The current state of technology makes it theoretically possible to make good drinking water from almost all water qualities. However, there are a number of substances of concern which are difficult to remove. The consequences of more complex and robust treatment include higher costs, greater space utilisation, greater environmental impact and, with some techniques, a higher degree of water loss. In addition, there will always be a risk of unknown substances which are difficult to remove through purification. Research remains necessary to anticipate new anthropogenic substances.

Climate change and desiccation can force Vitens to use less clean sources. One example of a less clean source is bank groundwater. It's a well-known fact that bank groundwater contains a wide variety of anthropogenic substances. The purification of bank groundwater therefore requires a robust purification barrier against these substances. This also offers opportunities: if bank groundwater is completely treated with reverse osmosis membranes, almost all anthropogenic substances will be removed with a very high level of efficiency. The water is also extensively softened. This very soft and very clean water can be transported to existing production locations and mixed there. The advantage of this concept is that abstractions can be reduced at these existing production locations and any possible softening present can be switched off.

Intelligent monitoring and management of the purification processes ensure the purification can be realised as efficiently, stably and predictably as possible. Smart purification, together with abstraction and distribution, forms an intelligent chain from source to tap. The purification can subsequently anticipate disruptions in the abstraction at an early stage and disruptions in the purification are resolved in a timely manner. The aging population and associated outflow of expert personnel can be more effectively absorbed by recording knowledge in digital systems.

There are many options for reducing the environmental impact of purifications. The purification of the future definitely contributes to Vitens' sustainability goals, with high quality residual products, minimal energy consumption and water loss and greatly reduced methane emissions.

8.7. Developments in drinking water demand: uncertainty asset

Uncertainty about the development of demand for drinking water is not a new phenomenon. Many different factors can influence this: changes in demography, population growth, new companies requiring water, economic growth or recession, climate change, technology and innovation, but also, for example, behaviour (water savings).
The domestic water consumption (approximately three quarters of the total consumption) has been stabilising for some time at around 120 litres per inhabitant per day. Water saving campaigns may change this. On the other hand, the effects of climate change are uncertain. If we can expect more long dry summers, this will certainly have an effect on peak consumption and annual consumption levels.

A great deal of uncertainty concerns the large business and industrial water consumption (approximately 11% of the total supply). Fluctuations in demand depend on economic developments. There appears to be a trend that more large customers are relying on Vitens to supply them with water, partly because they are closing down their own facilities as a result of salinisation or pollution and measures to combat dehydration. However, reliable long-term prospects appear to be lacking.
The agricultural consumption (approximately 5% of the total supply) is stabilising. The question is whether the government measures will result in a structural reduction of livestock, or a switch to circular agriculture in the coming years.

Vitens was able to rely on a stable development of drinking water demand without many problems up to 2015. That relative certainty resulted in the required coverage of 10% reserve in cluster level permits not always being maintained; in some cases it fell below 3%. A break in the trend has been visible since 2015, which, in combination with the two hot summers of 2018 and 2019, meant extra attention needed to be devoted to the reserves per area.

The Government has drawn up the so-called Delta Scenarios for Rest, Warm, Pressure and Steam for the forecast of the drinking water demand. The most impactful scenario (Steam) assumed a 38% increase in demand for the next 30 years. At the other end of the spectrum, there is the Rest scenario which accounts for a 20% drop in demand. In addition, there are WLO2015 scenarios(PBL and CPB, 2015) which assume, for example, successful water saving measures (separate systems); in these variants, the scenarios predict an increase of up to 20% in drinking water demand for the next 30 years.

The above scenarios show a wide spread in the expected development of drinking water demand. Vitens uses the national forecast model for its drinking water demand forecast, which is based on a reasoned development (see figure 2.3. 2). This model takes a maximum increase of 20% in 2050 into account for the development of the drinking water demand. This model also provides for a possible drop in the drinking water demand. Various different scenarios have been prepared for this purpose. Vitens uses the elaboration of technological innovations for households included in the national forecast document.

This is based on three things: ozone washing machines, circulation showers and rainwater for toilets. This scenario predicts a 50% decrease in the drinking water demand in 2050 compared to 2017.

The basis for this national forecast model is the triennial survey of drinking water consumption at home. This research has already shown a downward trend for years. The drinking water sector recently decided to switch to a new research agency to carry out the research with greater reliability and with differentiation within the Vitens area. We are expecting these results to become available during the first quarter of 2021.

8.8. Infrastructure performance

The infrastructure's performance is monitored periodically. At the moment this mainly concerns available or clean sources and reliable and affordable drinking water. A number of performance indicators are discussed:

Customer Minutes Lost (CML)
Customers are without water for approximately 20 minutes per year, due to activities, faults, maintenance, remediation or reconstructions. 25-30% of the CML (and approximately 30% of the investment volume) is caused by reconstructions. Vitens wants to be able to maintain this level in the long-term. That's going to be a challenge, as there are many uncertainties due to increasing failure behaviour due to the aging of the infrastructure. In addition, the risk of excavation damage will increase due to the intensification of the use of the subsoil. In order to prevent this as much as possible, good collaborations will need to be set up with the underground infrastructure partners.

Condition of the infrastructure
Vitens uses a risk model for the strategic replacement of the underground pipelines in which the probability of failure (and its impact on customers) plays an important role. This is determined on the basis of various factors such as pipeline properties and the location conditions. The condition of a pipeline is expressed in an Asset Health Index. Based on this analysis, Vitens expects to be able to replace the aging infrastructure in a (financially) controlled manner.

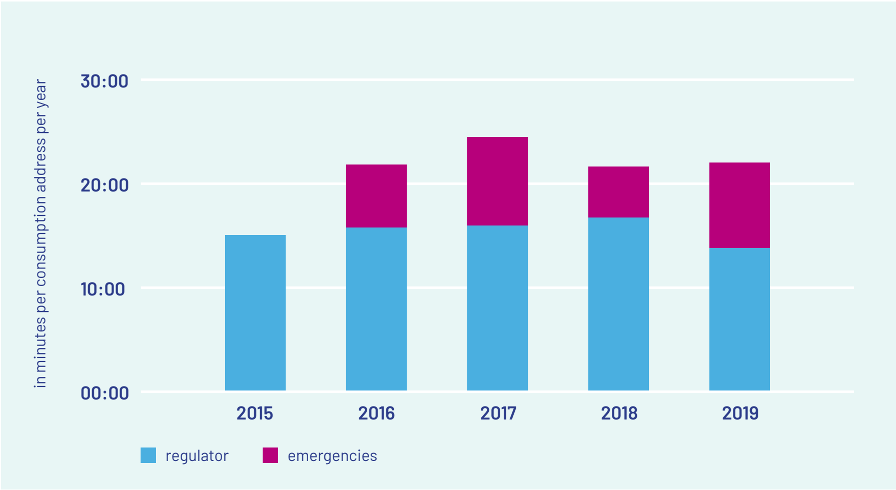


Figure 16 - Number of SSM per household per year

Water losses
A distinction is made between production losses and Non-revenue Water (NRW). Reducing production losses, the difference between the amount of groundwater extracted and the amount of drinking water introduced from the production sites, is a specific focus point for Vitens. Partly due to the application of new technologies, that difference has been reduced, but there is also an increase because purification techniques which require a great deal of rinse water are used more often.

There is also a difference between the amount of water that is brought into the network from the production locations and the water that is charged for (NRW). Causes can be, for example, leakage losses, measurement inaccuracies, illegal consumption and flushing mains after a pipe burst. The NRW has amounted to approximately 6% of the the total water supply. Within the context of water savings, there may be potential gains to be made here.

Exceedances of water quality standards
Vitens monitors the water quality and looks for exceedances of legal standards (which are reported to the ILT) and its own standards.

Permit reserves

Vitens has formulated a reserve policy in order to anticipate unexpected demand trends. On the one hand a standard of 10% applies to non-operational reserves (licensed, but no infrastructure) and 10% extra available infrastructure on current/expected demand. Getting these reserves in order (see also paragraph 6.8) will be an enormous challenge over the forthcoming years.

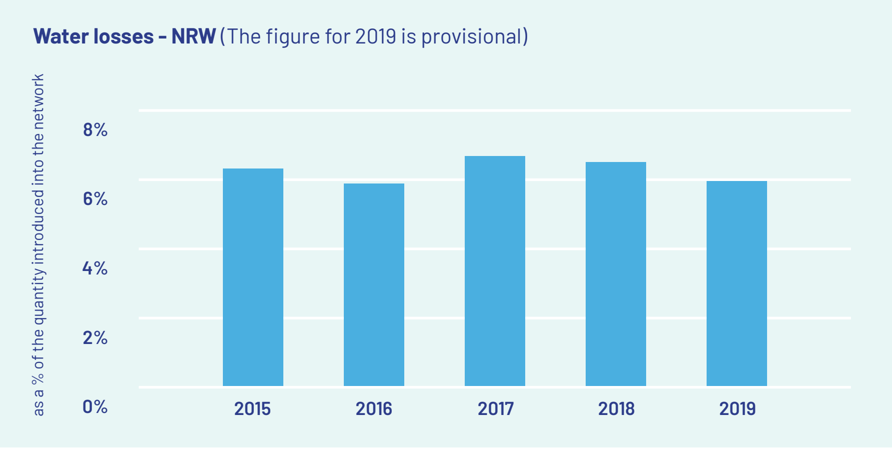


Figure 17 - CNC per year

Figure 18 - ILT measurements per year

8.9. Digitisation; Vitens, a data-driven company

A few years ago, Vitens set itself the goal of developing into a data-driven and people-oriented water company. Digitisation is an opportunity to improve drinking water processes, to actually substantiate decisions and to provide customers with a better service. In addition, new techniques will enable Vitens to:

- respond to changes faster;
- continue to be an attractive employer;
- make decisions based on good and correct data and information;
- proactively inform customers;
- be in a position to provide transparent information about the business operations both internally and externally.

A number of pilot projects have been conducted in recent years during the development into a data-driven and people-oriented company, including the placement of sensors, the installation of smart meters, the implementation of *remote control* tools and we've made control instruments available too. The challenge during the years ahead will be to implement these pilot projects from an integrated vision into a single, integrated and intelligent water supply system.

The digitisation possibilities are enormous and are constantly developing. Other possibilities include:

- *Model based control*: control of the production and purification processes based on algorithms;
- Sensors in the distribution network, allowing for the monitoring of quality and quantity;
- Remotely controllable valves;
- Installation of smart meters with (business) customers (more efficient water consumption and invoicing);
- *Early warning* system (detection of possible source pollution).

8.10. Security and protection

The risk that third parties will disrupt the drinking water supply has increased in recent years and these risks are expected to continue to increase during the forthcoming decades. People who act on behalf of a state, criminals and vandals are a threat from the outside and possibly also from the inside. The cyber threat in particular has increased significantly in recent years, with specific measures having been implemented to protect employees, the integrity of the water supply (disruption and/or deliberate contamination), assets (financial and material), information and management and data systems.

Vitens has implemented organisational, structural, electronic and responsive physical and information security measures in line with the Drinking Water Act and the Network and Information Systems Security Act. Vitens has a security organisation in place with specific tasks, responsibilities and powers, continuously pays attention to its employees' awareness, screens officers for high-risk functions and standardises the physical security of all its production locations. To ensure good security, Vitens works together with the NCTV, AIVD and the NCSC and, more operationally, with two external *security operation centres* (SOC's) for the monitoring and follow-up of (cyber) security threats and incidents. Vitens has a trained and practised 24/7 all hazard approach emergency organisation to manage major security incidents. Vitens continuously follows the threat assessment and makes every effort to continue to resist any such threats.

8.11. Implemented sustainability measures

Vitens has implemented sustainability measures in recent years, which are described in this paragraph. The sustainability strategy for the forthcoming years can be found in chapter 4.

The starting point for the measures implemented is that the drinking water infrastructure and business operations depend on the natural environment. Vitens doesn't want to degrade or be threatened by the natural environment.

Vitens absorbs water as a raw material directly from the natural environment and then purifies it so that it can be safely consumed. The natural environment adds (filter zero) a fundamental value to the drinking water and this alone is a reason for Vitens to design the drinking water infrastructure and operations in such a way that the capacity of the natural environment is protected and strengthened. The starting point is that Vitens aims to realise the smallest possible negative and the greatest possible positive impact. Reducing waste flows can also serve to further reduce the impact. For example, the membrane technology requires a relatively large amount of rinse water, which is partly reused. Residual materials are already reused as much as possible (iron, sludge, lime, humic acids, methane gas).

Vitens reports on the Scope 1, 2 and 3 emissions. The current emissions amount to approximately 150 kilo tons of CO_2. These emissions still have to be (and can be) significantly reduced, although the 'low hanging fruit' has now disappeared. For example, methane gas released during the purification process at the Spannenburg production location is captured and reused as a source of energy. An investigation is currently being conducted into how this can also be done on a smaller scale.

Vitens' energy consumption in 2018 was 167 gigawatt hours, which was purchased sustainably, making sure the CO_2 impact was nil. Much of the energy is consumed in the primary process. Further reductions will be difficult to realise because the benefits of a more efficient and energy-efficient production process are offset by the increasing need for tougher and more energy-intensive purification.

One of the ways in which the positive impact is achieved is by designing the water abstraction areas (which are predominantly owned by Vitens) in a natural way. This means the water abstraction and nature functions in these areas are combined, whereby biodiversity is strengthened and, where possible, increased. Major biodiversity guarantees a resilient, well-functioning ecosystem.

The natural environment is also spared as much as possible during the development of new abstractions and the natural value of the environment is increased where possible.

The water footprint

Professor Arjen Hoekstra (1967-2019) introduced the water footprint in order to introduce the *supply chain* thinking into water management, focussing on the relationship between water management, consumption and trade. He founded the Water Footprint Network in 2008 and was a co-initiator of the Water Footprint Research Alliance (2015).

A few examples:

- The production of a cup of coffee costs 130 litres of water.
- The production of a litre of soft drink costs 1,000 litres of water.
- The production of a pair of jeans costs 10,000 litres of water.

The water footprint in the western world is 4,000 litres per person per day.
CNC and production losses form part of the water footprint.

Back wash water pond

9

appendix III in-depth look into the scenarios

9.1. From trends to scenarios

The background to the scenarios is outlined in this paragraph. As described in paragraph 4.2, the scenarios are not the most probable, but more like stress test scenarios for the resilience of the Vitens infrastructure. To this end, we will start with outlining the biggest uncertainties which form the basis for the scenarios.

We will look at the current situation and developments visible within that in order to identify the driving forces behind the scenarios, but we will also look at a number of possible new developments which could present themselves over the forthcoming decades. These are in line with the developments mentioned in paragraph 2.3. Current developments distinguish between current developments for which there is still some level of uncertainty as to whether or not they will happen (or which direction they will go in) and relatively certain developments for which it may not yet be clear how they will manifest themselves, but that they will happen in almost every conceivable future. There is no certainty that the possible new developments will happen.

9.2. Current developments which are relatively certain

From the current developments described in chapter 3, there are three developments which recur in all scenarios, as these are relatively certain.

- Spatial pressure: spatial pressure will increase as a result of the energy transition (geothermal energy, new cables), socio-economic developments and other competitive claims on space both above and below ground.
- Technological possibilities/digitisation: technology which has already been proven, but which is not yet widely used in (drinking) water infrastructure, offers great potential for innovations. This concerns *real time* sensors which measure the quality and volume of the water, more possibilities for transparency to the customer about water quality and origin, etc. This potential can be increased even further by developments like nanotechnology, bio-engineering, bio-chips, neurotechnology, *augmented reality*, robotisation and artificial intelligence.
- Climate change: this assumes a major effect of climate change on the hydrological cycle. Mainly with more extensive wet and dry periods, with a temperature rise which will be 1.5°C in 2050 and will continue to rise.

9.3. Current developments which are uncertain

It's important to identify the main trends which will have a possible impact on the current and future drinking water supply, as a follow-up to the developments mentioned in the previous paragraph. This doesn't merely look at the technical and physical developments, but also considers social changes. These trends are summarised in the following seven developments, based on a large number of reports and on interviews and workshops at Vitens:

1. Demand for tap water: how much would the drinking water supply need to provide? Underlying trends: economic and demographic developments, water savings and decreasing losses. One major uncertainty is the effect climate change will have on demographics. Are (large groups) of people moving from low-lying land in the west to higher land in the east? The peak in water consumption is very likely to increase during prolonged hot periods. This means the supply during the peak becomes decisive, while the water quality during periods of low consumption must also be guaranteed.

2. Available sources: is the drinking water supply sufficient? Underlying trends: climate change is causing sources to provide too little water during periods of prolonged drought. Climate change causes increasing water scarcity for agriculture, ecology and drinking water supplies and causes changes in the landscape (desiccation or water logging).

3. Dominant control of the drinking water supply: at market companies, the individual, collective or public/government. Deregulation and decentralisation has become an important political ambition during the last decade. The Environmental Act will be the most important development for drinking water companies for the foreseeable

future. Many laws are brought together in this act, with the aim of making procedures simpler, more efficient and more effective. In addition, sustainability and new initiatives are stimulated and municipalities, provinces and water boards are given more room for regional differences. Regional and local customisations are stimulated. The Environmental Act is less focussed on protecting partial interests, but invites initiatives and responsibility.

Two potential and somewhat opposing forces on the drinking water system are becoming visible as a result of social and ecological developments, although more in the long-term. On the one hand, an increasing (attention to) scarcity in space and groundwater, and with it the need to bring different policy areas together, brings out the public character of drinking water systems. On the other hand, although this is still a much weaker trend, the social trends mentioned in the previous chapter could also lead to an administrative-political trend towards more space for private entrepreneurship. It's also difficult to predict the political climate in the longer term and therefore how the relationship between the market, the government and citizens is perceived.

These (medium to) long-term developments have together caused a great deal of uncertainty as to whether the drinking water supply will remain predominantly public, or whether citizens, companies from the market sector, or collectives/ cooperatives will also start playing an important role.

4. Scale: technical and social challenges can be tackled at different scale levels. For example, a greater role for the government can lead to both large-scale interventions at (inter)national level and to decentralised solutions where municipalities are the main ones to take responsibility. The degree of centralisation and decentralisation is influenced by, for example, technical economies of scale and geographical factors, but also by social preferences. Examples include discussions in energy with proponents of large offshore wind farms and nuclear power plants and proponents of local energy generation at home and community level

5. Pollution: is the safety of drinking water in danger? Underlying trends: social acceptance of (new) risks, new analysis techniques and public health studies, sources of pollution (nutrients, industrial substances, metabolites, drug residues).

6. Shifts in the dominant customer group: Vitens has a diversity of customers, who have different views on what the drinking water sector should focus on and how it should be organised, with the current system also being sufficient for many customers. The KWR Watercycle Research Institute has conducted research into customer types in the Vitens area. Four types of customers have been distinguished between *(Brouwer et al., Perspectives beyond the meter: a Q-study for modern segmentation of drinking water customers; Water Policy, 2019)*

- I-customers see their health as being of the utmost importance. The drinking water quality must be as high as possible, because your own health is your top priority. This customer group is concerned about whether that quality can be guaranteed in the future. Additional products and services which do not directly benefit them personally are not necessary. Saving water is secondary in daily practices. Percentage of I-customers in the Vitens area: 10% (national 13%).
- You-customers want to be taken care of, they want easy access to drinking water and they want it to easily drain away. They rely on the drinking water company to have the right knowledge and techniques to always be able to provide them with reliable drinking water. Percentage of you-customers in the Vitens area: 26% (national 27%).
- They-customers see caring for others as very important. Drinking water is one of life's basic necessities and a human right of such importance that it must be equally accessible to everyone. Drinking water must therefore also be as cheap as possible and remain publicly organised, as this is the only way to show solidarity with those who are financially disadvantaged worldwide and with future generations. Percentage of they-customers in the Vitens area: 33% (national 31%).
- We-customers are concerned about the environment and strive for a sustainable world. Vitens must be sustainable in everything it does. They-customers have a great deal of confidence in humanity and in (green) technology, sustainable actions and jointly

working towards a sustainable system, for example by recycling waste water and saving energy. Percentage of we-customers in the Vitens area: 30% (national 29%).

Socio-cultural developments can lead to a specific customer group, and therefore the value system, becoming dominant. Plus if this group becomes less satisfied with the current drinking water supply (for example, due to water scarcity and contamination), this may lead to a different 'social contract' and a different design of the drinking water system.

7. Circularity in the water chain: the way in which circularity is implemented. Circularity whereby there is also sufficient water in the long-term to meet demand has traditionally always been a core value of the drinking water supply. The water abstracted from the water system will ultimately be returned to the water system again (hydrological cycle) and water is not abstracted if it can't be replenished *(mining)*, i.e. less water is always abstracted than replenished.
   Circular solutions have also been developed on a much smaller scale (hydraloop for example), or the reuse of sewage water into drinking water. Circularity will definitely become of increasing importance. However, how much influence this will have on the water flows in the drinking water supply is still uncertain.
   Circularity will therefore play an important role in every scenario. How the concept of circularity is going to be interpreted can differ fundamentally, as various social parties are able to influence this. On the one hand, there are solutions which mainly start from a 'narrow' concept of circularity, which only looks at the water cycle. For example, by using rainwater, the recovery of water from effluent and separation of functions. On the other hand, a broad, integrated perspective on circularity is also visible, which focuses on the relationship between water, energy materials, soil quality, multiple use of space and ecology.

9.4. Translations to scenarios

The above developments form the basis for the four scenarios. The certain developments apply to all scenarios, the seven uncertain developments actually lead to different scenarios. The first two uncertainties (supply and availability of sources) are on the vertical axis: more supply than demand/more demand than supply). The third and fourth uncertainties (scale and dominant direction) are bundled on the horizontal axis: centralisation/decentralisation. Centralisation looks at large-scale solutions under public control at national level. With decentralisation the emphasis is on small-scale solutions, where the business community (Wild Water West scenario) or local collectives (Dilution) are in charge. The following table lists the dominant developments per scenario.

	Development	Drinking Water Delta Works	Wild Water West	Drinking Water Bubble	Dilution
Demand/ supply (y-axis)	Demand for tap water	Strong increase	Strong increase	Strong increase	Strong decline
	Availability of sources	Low	Low	Low	High
(de-) centralisation (x-axis)	Dominant control	Central Government	Central Government	Central Government	Collective
	Scale size	Large scale	Large scale	Large scale	Small scale
	Pollution	High	High	High	Low
	Dominant customer group	'You'	'You'	'You'	'We'
	Circularity	Narrow	Narrow	Narrow	Wide

Table 6 - The four scenarios

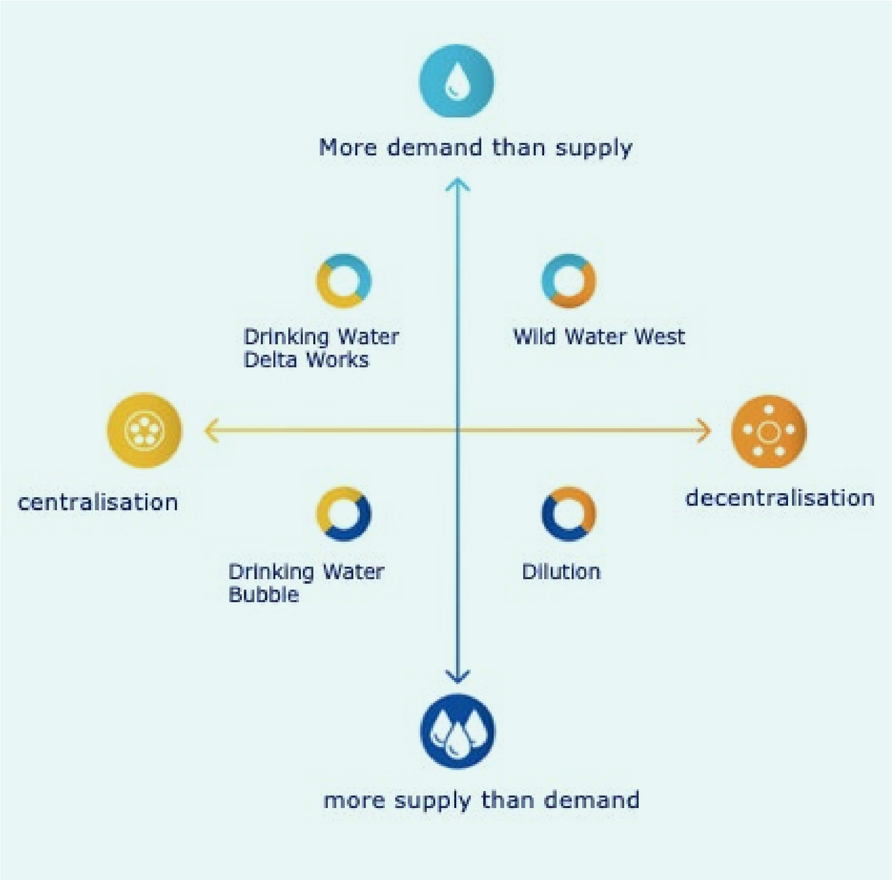


Figure B - Four scenarios

A number of elements still require some explanation. The infeasibility of a highly integrated, local approach is assumed in situations where there may be major (concerns about) pollution. Public health concerns require central management, protection of drinking water and costly technical purification, which are often less possible locally. The starting point is that major pollution is more likely to push developments in the direction of one of the other scenarios. The dominant customer group doesn't just influence the demand of households as consumers, but also the public values on which the drinking water supply is based: the solidarity of the they-perspective, the self-reliance of the we-perspective, etc. A number of elements, such as the applied tariff system, are not included as a development, but any interested readers can interpret these themselves from the scenarios. For example, high fixed costs fit in with the drinking water infrastructure's role as a 'collective backup' to the Drinking Water Bubble scenario, while major tariff differentiation for different types of water is in keeping with the Wild Water West.

And finally, examples from other sectors have directly and indirectly contributed to the interpretation of the scenarios. Transitions in different sectors can never be compared like for like, but there are lessons to be learned from the similarities and differences. That's why inspiration is mainly drawn from transitions in sectors which, like the drinking water supply, have a large, expensive infrastructure. This infrastructure increases relative stability (compared to, for example, retail, consumer electronics or IT), but also limits manoeuvrability when other requirements are placed on a sector faster than expected due to a combination of circumstances. Parallels can therefore be drawn for each of the above scenarios.

- Drinking Water Delta Works: the development of delta works, main ports, railways and highways and the transition from coal to gas in the twentieth century.
- Wild Water West: sectors which have become much more fragmented and market-driven, such as the liberalisation and decentralisation of (sustainable) energy production and the transition from telecom to IT services.
- Drinking Water Bubble: sectors which were confronted with an excess of infrastructure: natural gas infrastructure in the transition to 'natural gas-free communities', overcapacity of waste incineration plants, due to the emergence of the circular economy, postal infrastructure (post offices, postmen and mailboxes) and public libraries which now have competitors, but are still of public interest.
- Dilution: local circular chains, decentralisation of welfare and youth care, participatory society and energy cooperatives.

Appendix IX explains the method and methodology used by DRIFT.

10 appendix IV elaboration of the vitens drinking water preconditions


Cascade manufacturing company Noardburgum

The Vitens Drinking Water Preconditions (VDP's) are further elaborated on and explained in this appendix.

VDP 1: Each source has sufficient water in all climate scenarios.

- The source has sufficient water available in all climate scenarios (sources which dry up during a long drought are therefore not acceptable).
- The source is accepted by stakeholders and is not threatened by other developments.

VDP 2: There is sufficient diversification in the sources.

- There are multiple independent sources which use different independent water systems at system level and subsystem level.
- The sources differ in terms of environment (nature, agriculture, urban area, etc) and the effects caused at system level and subsystem level, which means not all sources are called into question if a certain effect is called into question.

VDP 3: Reserves in the capacity to be withdrawn must be available for a very long time (minimum LTV planning period) and without limitations.

Obtaining a new permit and subsequently developing a production company takes between 10 and 20 years. It's therefore necessary for Vitens to have spare capacity, which can be divided into operational and non-operational where cost savings are concerned. The provinces assign additional strategic stocks (ASS) for possible maximum demand developments in the long-term. As the reserves (Vitens business reserve and ASS) are intended to be used in unforeseen moments in the (very) long-term, it's important for these to be available without specific conditions. After all, they are intended for periods with a special increase in demand and those are the times when competition with other users is also greater. This means minimising the risk of them not being available. The LTV's planning period is 30 years (2020-2050), which is the minimum period for which there must be certainty about the availability of possible reserves. Given the long development period, this period is still on the short side and this minimum period may only apply to a small part of the reserve capacity. This makes purchasing more of a solution for the next ten to twenty years and less suitable as a reserve.

VDP 4: Each source has sufficient tolerance; the drinking water supply can continue to run for a while in the event of a serious disruption in quality and/or quantity, allowing for appropriate measures to be taken.

When a threat (pollution) has been identified, the source can continue to function without the threat entering the source, until measures have been taken to guarantee a safe and reliable drinking water supply. Examples of sources with tolerance: groundwater abstraction, bank groundwater abstraction and surface water abstraction with basins (for example, the Biesbosch). Direct abstraction from surface water has insufficient tolerance without additional facilities.

VDP 5: The quality of the drinking water is guaranteed by several barriers:

A. The cleanest possible source with a constant quality
B. Reliable purification
C. Safe transport and distribution system.

Clean source with a constant quality

- Maximum use of the protective effect of clay layers and geochemistry.
- Use sources which are as high on the geogenous ladder as possible.
- Quality deterioration with risks for the source can be monitored in a timely manner (early warning systems).
- Risk-oriented protection of existing (and planned) groundwater abstractions is necessary to be able to guarantee the continuity and quality of the source.
- Risks of quality deterioration at the source can be prevented or mitigated. Resources for this include:
  - The establishment of collection points and a water abstraction area will prevent or minimise the risks (for example, physically redundant implementation of collection points).
  - Protection zones or basins with spatial and environmental measures to prevent or minimise the risks.
  - Interception of polluted water flows, remediation and discharge.

Reliable purification

- Purification processes to remove anthropogenic substances rather than to convert them are preferred, to prevent conversion resulting in the introduction of new toxic substances into the water.
- High-risk sources require additional purification barriers to quickly anticipate emerging substances (precautionary principle).
- Monitoring system and operating system to detect deviations in a timely manner.

Safe transport and distribution infrastructure

- Pipelines are constructed in such a way that changes in flow produce minimal quality deterioration risks.
- A good monitoring system for the timely detection of quality changes.
- Timely replacement of pipelines which are vulnerable to pollution and pipelines which have reached the end of their service life.

VDP 6: Risks in relation to the microbiological quality are as small as possible.

- If the biological quality is insufficient, many people can become ill and that risk must be as small as possible. This is a crucial precondition for the development of new (water saving) installations or systems.
- Water quality problems must be predicted in a timely manner, using harmless indicators and/or online biological measurements, in order to be able to intervene more quickly with changing water quality and/or emergencies.
- It's essential to prevent leaks and to work hygienically in order to minimise the risk of microbial pollution in the distribution network.
- The temperature in the drinking water mains must be manageable in order to safeguard the microbiological water quality. Measures are related to the design of the public space both above and below ground and require cooperation with, for example, municipalities. Any adjustments will go hand in hand with activities carried out by municipalities and these take time.
- An additional effect of climate change is that the discharge capacity is limited during long dry periods and/or the discharge/cleaning capacity is limited from a water saving point of view. However, a direct consequence of this is that the regrowth potential will increase and the residual pollution (sediment) present in the network poses a risk to the water quality, which is subsequently expected to deteriorate (in the long-term). From this perspective, the distribution network must be designed so that risks of deterioration in quality are minimal. This includes the construction of self-cleaning nets and preventing the mixing of water types and commuting zones and the limitation of nutrients, making sure the biological stability improves, or that the regrowth (potential) decreases. This can be achieved by not using pipeline materials which release a relatively large amount of growth-promoting substances in the distribution system and drinking water installation. In addition, purification can be improved to remove more organic matter (AOC/TOC).
- The energy transition is also a focus point in addition to climate change. The management policy for *Legionella* is based on the fact that hot tap water has a temperature above 60°C and cold water remains below 25°C. There are developments, such as the use of solar water heaters, where this required temperature of 60°C is not achieved without additional heating.
- The energy transition results in the construction of small and large scale heat networks. It's important that the drinking water doesn't heat up as a result of these heat networks. The risk of the heating up of drinking water can take place in the street, but also in the meter cupboard. National agreements are indispensable to safeguard drinking water interests in this energy transition.
- Water quality inspections are essential. The water quality assessment is properly arranged via the Drinking Water Act in case of a central supply of drinking water by drinking water companies. This doesn't particularly apply to decentralised facilities. The quality depends (especially for private individuals) on their own maintenance efforts and this is not monitored, which may result in risks for the drinking water quality. There is (virtually) no control within the current legal frameworks and a great deal of responsibility is placed on private users, who may not always be aware of this.

VDP 7: There is sufficient flexibility in the drinking water system to accommodate changes.
Flexibility can be guaranteed in several different ways, which complement and reinforce each other:

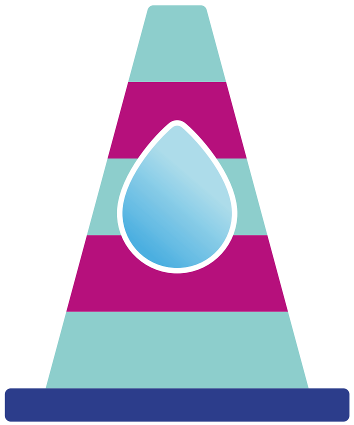
- Sources have sufficient permit reserves to quickly respond to changes.
- Sources are flexible where increasing or decreasing the abstraction capacity over different time periods is concerned, without causing unacceptable damage to the environment. This is preferably laid down in flexible withdrawal permits.
- The transport/distribution infrastructure is capable of absorbing changes in supply and demand (quantity, quality).
- The abstraction infrastructure and purification are flexible where increasing and decreasing the capacity over different time periods is concerned.
- Unification, standardisation and modular construction.
- Providing multiple options for responding to changes.
- The bank filtrate can be converted into an ultra-pure semi-finished product with the aid of reverse osmosis. This semi-finished product can be mixed with water from existing purifications, making sure the ultra pure water doesn't need to be cured or conditioned. The reverse osmosis, combined with soil passage, forms a fairly complete barrier against anthropogenic substances and can be quickly switched on or off. The soil passage during bank filtration also provides damping and storage, making sure any impact on purification is limited in case of a disaster upstream.

This design principle means a more resilient and modular operation will be within easier reach. Existing purifications can largely supply independently in periods of low demand and the capacity can effectively be doubled by mixing during periods of high demand. Softening on existing purifications can also be switched off and abstraction can be reduced.

VDP 8: The security of supply is guaranteed.

- All critical components are known and control measures have been implemented (such as a redundant implementation) to guarantee the reliability of the drinking water supply.
- Monitoring systems have been put in place to monitor quantity and quality *(early warning)*.
- The area is divided into smaller areas, making sure any disruptions can be isolated.
- The pipeline infrastructure is protected in a well-organised, safe underground. The information about the underground infrastructure's location is accurate and shared.

VDP 9: The drinking water system has been structured in a logical, as simple as possible, coherent manner, offering the possibility of intelligently controlling the different parts.



Manufacturing company Vlieland

11 appendix V system descriptions and indications of options per province

11.1. Friesland

- Recent years have shown that the increase in corporate use is one of the greatest risks for demand forecasting. Monitoring the nature of this increase is necessary in order to respond to market demand more effectively. The development of the max day factor must also be considered.
- Demand is expected to increase slightly in the years ahead, but is likely to decline thereafter. Growth is also limited in the most extreme (maximum) scenario.
- In view of the demand development expectations (decline over time), the best existing sources (including Luxwoude) will be used and we will not be working on the assumption of new sources.
- There are large aquifers with very good water abstraction possibilities in the south of Friesland. There are good aquifers in the north and west too, but they have not been put into use because they have become saline. There are a number of abstraction possibilities in the east, but the aquifers are thinner here and the risk of desiccation of vulnerable nature is greater.
- Two or more production companies in the south, possibly with multiple abstraction fields, which have been modularly constructed because of their size, provide a robust water abstraction infrastructure.
- Various scenarios will be taken into account for the design of PB Spannenburg's total renovation (expected around 2035), by making the purification design modular. The number of modules can be adjusted over time (with increasing insights), in line with the latest expectations. In order for the renovation to run smoothly, it's desirable to have additional production capacity at other locations, which can then be used during the renovation works. This means there won't be any need for complex bypass constructions or temporary purifications and such like to be installed at Spannenburg. Work must be started on this soon.
- The transport infrastructure has been set up like 'spokes', which run from south to north, to which spokes can be added when demand increases and one or more spokes can be decommissioned in case of shrinkage.
- The security of supply will primarily be guaranteed by the modular production companies in case of shrinkage.
- In case of growth, the south-north spokes will be strengthened and interconnected in the south-north direction. Security of supply is now guaranteed by the transport infrastructure in addition to the production companies.
- The Wadden Islands have become as self-sufficient as possible, in order to avoid vulnerable dependencies on so-called Wadleidingen. The focus here is on sustainable abstraction opportunities, with desalination being a possible option in the event of strong growth.

11.2 Overijssel

- Recent years have shown that the increase in corporate use is also one of the greatest risks for demand forecasting in Overijssel. This mainly concerns Urk, Zwolle and Enschede. Monitoring the nature of this increase, as well as the companies which currently have their own abstractions, is necessary in order to respond to market demand more effectively.
- Demand is expected to increase slightly in the years ahead, but is likely to (significantly) decline thereafter. Growth is also limited in the most extreme (maximum) scenario. However, there are differences between the rural areas and the cities.
- As the best possibilities for abstracting water are in the west and the possibilities for abstracting water in Twente are limited (due to a vulnerable landscape, thin aquifers and little surface water flowing through), the water distribution takes place from west to east as much as possible. From that perspective, it makes more sense to supply the Noordoostpolder from southern Flevoland, because all the available water in the west of Overijssel is needed to make up for the shortage in the east.
- As there are many vulnerable sources in Twente, it's desirable to either reduce them or close them altogether. From a water distribution point of view, it's desirable to transport water from the Deventer-Zutphen (IJsselvallei) area to Enschede in order to achieve this, which is subsequently distributed across Twente from a large reservoir. If there is sufficient water, this transport axis can also be used to relieve transport from East Gelderland. To avoid the pipeline being too large in case of declining water use and quality problems arise, the pipeline is installed twice, so that one pipeline can be 'relined' to a smaller diameter and, if necessary, be closed in

case of a strong decline in use. It's also desirable for the transport axis to transport a constant quantity and to absorb peak consumption in the region. This also means that not all abstractions can be closed and that sufficient capacity must remain in the region.

- The supply of water from the west is best realised with a constant amount, with the local abstractions absorbing the peaks. The annual extraction volume of vulnerable abstractions in Twente is decreasing, which means the desiccation resulting from these abstractions is decreasing too.
- Water is now also being purchased. However, the quantity of any purchased water must remain limited (no more than the reserve capacity of permits), making sure we don't become vulnerable and in order to keep control of the water distribution.
- The water distribution in Overijssel (from 'tray' to 'tray') is relatively complex. The advantage of working with a tray-tray system is that it offers plenty of flexibility and that it can effectively be optimised through automation and knowledgeable operators. Optimisations may well be possible, but a system change is what's wanted: instantly solving the biggest problem (the supply of water to Enschede) will result in a completely different system and areas will be disconnected.
- In addition to the southern axis, there is already a northern transport axis, the so-called Integral Drinking Water Overijssel (IDO) axis. When the southern axis is commissioned, the northern (IDO) axis will have to transport less water to Enschede and this can subsequently be made more use of locally. The idea behind IDO to realise a new abstraction in the north (between Zwolle and Kampen) remains important because the capacity is limited and to absorb the loss of capacity at Vechterweerd. Vechterweerd appears to be vulnerable and scaling up to the planned 8 million m^3/year during extremely dry periods is risky.

11.3 Gelderland

Gelderland is described using the Achterhoek, Veluwe and River area.

- The Achterhoek has a small-scale landscape with relatively thin aquifers which are sensitive to desiccation and vulnerable to ground level influences.
- A large stock of good quality groundwater is present in a thick aquifer in the Veluwe lateral moraine complex, which is abstracted at various locations along the edges of the Veluwe. New abstraction opportunities are limited on the Veluwe, mainly because the withdrawals from the edges sometimes have a local effect on valuable nature and, in addition, almost the entire Veluwe has been designated as a Natura 2000 area.
- The River area offers good abstraction opportunities, but the risk of settlement damage

General:
Various Gelderland abstraction permits were surrendered between 2008 and 2015 (OSDG). At that time, Vitens had far more permits in Gelderland than was necessary for the production of drinking water which had been forecast. A number of permits were therefore surrendered because of the spatial claims this large number of permits entailed (groundwater protection areas). In total 25 Mm^3/year (from 185 to 160), above that 15 Mm^3 was designated as NOR.

However, the demand for drinking water has started to increase since 2013. The growth is mainly around the large cities and along the Randmeren region. As a result, a shortage of permits has now arisen in Gelderland. Finding new abstraction locations is becoming increasingly complex due to the many spatial interests and the current Nature and Environment Act.

Traditionally there have always been many small and medium-sized abstractions in Gelderland, which mainly sell the drinking water produced locally. Exceptions are the larger abstractions in the large cities. These cities are located near lateral moraines. This is where the great demand and the possibilities for larger abstractions come together. The infrastructure is also characterised by height differences, for which high-altitude reservoirs, which determine the pressure in large parts of the area, have been used since the creation of the drinking water infrastructure. These large abstractions were expanded later and now also cover other areas. For example, part of the water[8] from Arnhem and the surrounding area is sold to De Liemers and the Achterhoek. This usually concerns medium-sized abstractions for the rest of Gelderland, which sell the water locally. The systems are tightly sized in line with current demand. There aren't any larger induction loops and links between cores of consumption and abstractions yet. This

8 From the Sijmons, La Cabine and Ellecom locations and, to a lesser degree, Fikkersdries

means the system is not flexible. Seasonal use and/or the (temporary) absorption of abstractions is not possible. The current system is therefore not resilient.

There is a large-scale, extensive process in Gelderland which all stakeholders are involved with, in order to designate Additional Strategic Stocks (ASS). The province of Gelderland is responsible for this designation. Extensive preliminary investigations were carried out within the context of this ASS process. An EER plan will be drawn up in 2020, containing various future scenarios. The designation of the ASS areas is relevant to where Vitens could possibly expand in the future.

Possible development directions

- The areas around the Veluwe, where run-off Veluwe water arises and where a great deal of surface water can also be found, appear to have good abstraction potential (IJsselvallei, River area, Gelderse Vallei).
- There also appear to be possibilities for extra capacity around Lochem and Montferland. Seasonal abstraction and compensation could supplement this to make the concept more sustainable. For example, using the Lochemse Berg during the wet periods of the year has been suggested, in order to infiltrate non-polluted local surface water and then use it for the drinking water supply during dry periods.
- A ring which connects the consumption centres around the Veluwe would offer many opportunities for flexibly responding to changes in demand, but also to changes in supply. Two smaller rings are being considered for the Achterhoek, as the eastern part is higher and therefore has its own pressure level. The existing ring will have to be further expanded for the River area.
- These rings come together at Arnhem-Nijmegen and part of the Achterhoek is already supplied from here. This link creates support options between the clusters. The connections to Flevoland and Utrecht were made in the ROL projects via Holk. It's therefore highly desirable to retain Holk's permit (10 Mm^3/year) from a water distribution perspective. This is also an opportunity to connect clusters.
- In view of the great spatial pressure, it's important to reserve pipelines for a possible target structure early on during spatial planning, after which that structure can be gradually developed. This is dependent on the development of demand, busyness in the area and other infrastructure.

11.4 Utrecht

- The past design philosophy in the province of Utrecht has always been based on the principle that all overcapacity must be available on 'the Ring Utrecht'.
  In addition to the Ring, the connection between Utrecht, Soestduinen and Hilversum, the so-called Aorta, is central to Utrecht's water distribution. Most large production locations are directly or indirectly connected to this system. This has created an infrastructure which has a high degree of flexibility. The new Benschop abstraction will also be connected to this system via PB Linschoten and Leidsche Rijn.
  The Ring and Aorta, which are quite spaciously dimensioned and often laid with multiple redundant pipelines, offer a great deal of flexibility to connect new cores with a smaller ring, but new abstractions can also be connected.
  One specific focus point is that no right in rem is established in many of the Aorta locations. Spatial reservation of this route (and possible extensions) is recommended and should be further elaborated on in a long-term plan.
- A ring structure around the Veluwe can be connected to this too and a connection can also be established with a possible supply from the strategic heart of the central Netherlands. Amersfoort and the Utrecht South cluster are not yet connected to the Aorta either, which may be desirable. This is further elaborated on in the long-term plan.
- Expansion options are planned in Schalkwijk (7 Mm^3/year) and Eemdijk (3 Mm^3/year) for the anticipated demand development. These locations will have to be locally weighted or expanded if they are going to be connected to the Ring and Aorta.
- It's highly desirable to retain capacity in Holk for water distribution, as the water supply around Amersfoort is vulnerable and there is limited abstraction capacity there.
- ASS areas have been reserved in the south of the province, which can be used if demand increases. If demand increases further, there will be limited abstraction possibilities in Utrecht and water will have to be supplied from outside of the province.
- The water distribution structure will remain intact if demand increases significantly, but it may be desirable to reduce any infrastructure which is too large.

11.5 Flevoland

- The infrastructure in Flevoland has been built in a logical and coherent way, based on the ring structure philosophy. The transport ring structure connects the production sites and reservoirs at the demand cores, transporting the water under low pressure.
- There are high pressure distribution ring structures surrounding the larger demand cores, which are fed from the reservoirs.
- Flevoland therefore has a separate transport (low pressure) system and distribution (high pressure) system.
- Lelystad has a relatively high number of business customers.
- If demand increases, it's desirable to strengthen the southern axis of the transport ring infrastructure.

12 appendix VI lessons learned from realised projects

Wellfield Wierden-Dennekamp

A number of projects were carried out by Vitens' predecessors, but only the Vitens name was used in this overview for the sake of clarity.

12.1. Integrated Water Management at Schiermonnikoog Pilot Project: Wadden and science are joining forces

The Integrated Water Management at Schiermonnikoog Pilot Project has been launched in order to find a solution for desiccation and the increasing demand for drinking water. The parties involved (the province, municipality, Nature Monuments, the Nature, Forest, Landscape and Fauna Consultancy, Rijkswaterstaat and Vitens) have developed and realised a joint plan. Anti-desiccation measures have been implemented, such as converting softwood into hardwood, sod cutting in dune valleys, improving water management and relocating the abstraction of the Hertenbosvallei to the Westerplas area. The new abstraction extracts water at a greater depth from the edge of the island and is integrated into the water system in such a way that the effects on vulnerable nature have become much smaller, which meant the abstraction capacity could be increased. In addition, a number of water saving measures have been implemented at recreation companies and households. The end result is better nature and more drinking water for Schiermonnikoog. Schiermonnikoog's integrated water management concept was later also successfully applied on Vlieland and Terschelling.

12.2. Integrated and joint area vision: Organising the space together

The Engelse Werk park is located between Zwolle's station area and the IJssel. In addition to a recreational and nature function, the Engelse Werk park also has an important function as a water abstraction area, where drinking water is abstracted and produced for the Zwolle region. The abstraction suffered from soil contamination from the station area.

There is also an area of great spatial pressure around the Engelse Werk park due to:
- expansion of the railway lines (Hanzelijn) and new station functions;
- the secondary channel for the Space for the River project;
- the increasing recreational function of the area for Zwolle;
- the area's nature values as part of the IJssel landscape.

The parties involved have drawn up an integral and joint area vision at Vitens' initiative, in order to find a good spatial solution for all interests. These included the IJsselzone hamlet, the municipality of Zwolle, the province of Overijssel, the Drents Overijsselse Delta water board, Staatsbosbeheer and the Schellerberg estate. The landscape character has been strengthened, the desired Hanze railway line has been realised, the plans for Space for the River have been realised and the abstraction has been secured. Part of the abstraction field has been moved and designed in interaction with the design of the secondary channel. The water abstraction area connects to the characteristic floodplain landscape with hawthorn hedges on the other side. By jointly organising the space, the city of Zwolle has an area where the characteristic IJssel landscape has been strengthened, which both recreation and nature can benefit from and in which a large strategic drinking water abstraction has been anchored. The concept of a joint organisation, using integrated and joint policy visions, was later successfully applied at other locations.

12.3. Artificial infiltration projects: Dare to do

The drinking water abstractions in Epe and Schalterberg (near Beekbergen) are located on the eastern flank of the Veluwe. The groundwater level here is a few meters below ground level. Lower areas are nature areas with wet heath and seepage-dependent grasslands, swamp forests and brooks and streams, which form part of Natura 2000 Veluwe, the Gelderland Nature Network (GNN) and/or designated as HEN-/SED streams. These areas are very sensitive to sinking groundwater levels and changes in seepage flux. Thanks to nature restoration measures, peat bogs, swamps and clean, winding streams have once again been created, with plant species such as sundew, marsh club moss, carex panicea and meadow thistle. The drinking water abstractions which extract water here are phreatic abstractions. Both abstractions are sensitive to pollution from ground level due to the lack of a protective layer. The risk of this is small, as the extraction area of the abstractions lies almost entirely within the

Veluwe nature reserve. The groundwater quality is so good, that a simple sand filter purification is sufficient. The abstractions have a lowering effect on the groundwater level and affect the seepage flux towards nature and streams on the eastern flank of the Veluwe. Clean, area-specific water has therefore been infiltrated at Epe since 1998, and at Schalterberg since 2016 too, with the ultimate goal of significantly reducing net groundwater extraction and therefore limiting any effects on nature and/or streams as much as possible.

The drought damage in agricultural areas has also been compensated for with water supply plans from the IJssel. The first water supply plan was realised at Espelo in the Vitens area, after which this concept was also applied to other abstractions. The water supply plans resulted in a good water management situation in the dry summers of 2018 and 2019. One drawback of these water supply plans is that foreign water (IJssel) is supplied, so many substances in the IJssel are now also found in these abstractions.

The artificial infiltration concept offers possibilities to compensate for the adverse effects of water abstraction from phreatic aquifers on nearby high nature values or other values. However, a sufficiently thick unsaturated zone is required if water is buffered and availability of sufficient quality water (native water). Areas which can be considered are other lateral moraines (Veluwe) or the hilly countryside. The geological structure is decisive for the success, as the effects of infiltration are unpredictable in a complex weir such as in the Veluwe. This can lead to watering problems in, for example, urban or agricultural areas.

12.4. Combining functions: Zeist – integrating water abstraction in the city in a sustainable and robust manner

Water abstractions for a city used to be built close to the city. Urban expansions have placed these areas in a number of places in the city. The water abstraction area in Zeist became an area which was mainly used for dog walking. Upgrading the area was necessary to guarantee the reliability of the drinking water, but also to improve the quality of life and the quality of the environment. At Vitens' initiative, the municipality of Zeist and the 'De Kombinatie' housing association, this water abstraction area became a park which could be used by the entire community in 2010. The new water park is a combination of open and closed. The water abstraction area is an open place in the forest. The forest section has been designed for forest games, with a flower meadow and a football field in the open space. A water playground also introduces children to water abstraction, the production company is visibly located in the park and the risks of pollution have subsequently significantly decreased.

12.5 Application of domestic water[9]: Reliable quality is key

The Ministry of Housing, Spatial Planning and the Environment designated a number of pilot projects for the application of domestic water in the late 1990's, including the Leidsche Rijn Vinex location in Utrecht. This location was attractive, as it was a newly built community of approximately 30,000 homes in 2015. In addition, a suitable source was available in the vicinity of the district. The Water Transport Company Rijn-Kennemerland (WRK) extracts surface water from the river Lek and turns it into a semi-finished product for the dune companies in the west of the country, which then use it for the preparation of drinking water. This semi-finished product boasts better quality than surface water, but is not yet suitable for drinking. Vitens conducted a feasibility study in consultation with the municipality, which showed that semi-finished products such as domestic water seem financially feasible and that support is expected for the implementation of this plan. A protocol has been established for quality requirements which domestic water had to meet, in consultation with KWR, the ministry, the inspectorate and Vitens. The domestic water network was subsequently installed in Leidsche Rijn together with a drinking water network. A large amount of pollution was detected at the end of 2001, with residents from approximately 1,000 homes drinking contaminated water for a number of days. It was also found that a number of homes had incorrect connections installed, supplying domestic water instead of drinking water. Evaluations were carried out by Vitens and the inspectorate,

9 Domestic water is defined as tap water which is exclusively intended for flushing the toilet, use in washing machines or watering the garden in the Water Supply Decree.

after which domestic water projects were shut down in connection with:

- extra measures (and therefore higher costs) to prevent contamination such as at Leidsche Rijn;
- the discovery of new viruses which place higher demands on the quality of domestic water;
- the decline in public support due to the contamination at Leidsche Rijn.

The Transport Safety Board issued a report in 2003, although domestic water projects had been halted because the Board felt that the quality awareness of the parties involved was insufficient for innovative projects. The Board stated that the drinking water company is primarily responsible as an expert party and that responsibility can't be assumed by a supervisor, the inspectorate or a contractor.

12.6. Raw Water Old Land (R.O.L.): Cross-border collaborationg

A number of abstractions in Gelderland and Utrecht were under pressure due to desiccation. The most environmentally friendly way of sparing these abstractions in Utrecht and Gelderland was sought. There were opportunities to abstract more in Flevoland for the so-called 'Old Land'. This interprovincial solution was realised in the Raw Water Old Land project, whereby the abstraction of groundwater in vulnerable areas is reduced and this reduction is compensated for with an increase in abstractions in a less vulnerable area. The special thing about this project is that the best solution for the water system was looked at across management boundaries: not administrative boundaries, but the water system was leading at all times.

Manufacturing company Noard Burgem

13

appendix VII legal framework

- A number of European directives are important where the drinking water supply is concerned. The most important ones are:
- Drinking Water Directive; this directive has been implemented in the Drinking Water Act and the Drinking Water Decree;
- Water Framework Directive; this directive has been translated into national policy principles, frameworks and instruments.

Drinking Water Directive (DWD)
The DWD is an important foundation for safe drinking water in the EU. The aim is to protect human health from contaminations via drinking water. Clean drinking water sources are essential for achieving the DWD goals. It's therefore important that the responsibility the Member States have where protecting drinking water sources is concerned is included in both the DWD and the WFD, in order to guarantee a coherent European water policy.

Water Framework Directive (WFD)
The WFD aims to guarantee the surface water and groundwater quality within EU Member States in an identical manner. The WFD works with river basins and protected areas for this purpose. Member States must ensure that any deterioration in river basins is prevented, in order to reduce the level of purification required for drinking water production (article 7 WFD).

The WFD is not optional. Realising the environmental goals is an obligation which economic sanctions are linked to. That's why the WFD requires reports on the status of surface water, groundwater and protected areas. A monitoring programme has been prepared for this purpose. This programme is used to determine which measures must be introduced.

The WFD's goal is that the quality of all waters, both chemical (clean) and ecological (healthy), must be in order throughout Europe by 2027. In order to realise this, the directive provides:
- protection of all water: rivers, lakes, coastal waters and groundwater;
- reduction and limitation of pollution, irrespective of the source (agriculture, industrial activities, urban areas, etc);
- the obligation to draw up a management plan for each river basin;
- active participation in water quality management and cross-border cooperation between countries and between all involved parties and stakeholders, including civil society organisations and local communities;
- the obligation to pursue a water price policy;
- the polluter and the user pay;
- balancing environmental interests and the interests of those who depend on the environment.

Waters in international river basins (water systems) are central to WFD's approach. A catchment includes all the water in a particular region. In addition to rivers, this also includes branches, lakes and groundwater. The Dutch waters form part of the catchment areas of the Ems, Rhine, Meuse and Scheldt.

A river basin management plan (RBMP) is drawn up for each river basin, in which the technical characteristics of the water bodies located within the river basin, the objectives, measures, possible delays and associated ground for exception are substantiated.

Measure programmes have also been drawn up, in addition to the RBMP's. This sets out the measures to achieve these objectives. Examples of measures are the removal of water beds, improving the purification capacity of the waste water treatment plants and reducing the use of pesticides.

The management plans and measure programmes are reviewed every six years. The implementation period of the second generation of RBMP's (2016-2021) is now in force and the water managers are preparing for the drafting of the third generation (2022-2027).

The following are included in the 'Protected Areas Register': Natura 2000 areas, swimming water locations, shellfish waters and bodies of water from which extraction takes place for human consumption.

Groundwater Directive

This is a European directive which is related to the WFD.
The Groundwater Directive requires a good chemical status of the groundwater.
The good chemical status of groundwater is particularly linked to two protective objectives:

1) The WFD recognises the importance of the interactions between groundwater, surface water and terrestrial ecosystems. The WFD indicates that groundwater must not have a negative impact on achieving the goals of the associated surface waters and groundwater-dependent terrestrial ecosystems.
2) The human use of groundwater. The WFD requires a good status of both the surface water and the groundwater. This should facilitate the protection and availability of drinking water sources.

The WFD also stipulates that the groundwater supply must be stable (good quantitative status). For example, nature areas are not permitted to dry out due to a low groundwater level caused by man.

Drinking Water Act

The drinking water supply is a public task. The duty of care for securing it lies with the government (Article 2): Governing bodies ensure the sustainable security of the public drinking water supply. During the exercising of powers and the application of statutory regulations by administrative bodies, the sustainable safeguarding of the public drinking water supply is an important reason of great public interest.
The organisation and implementation of a sustainable and efficient drinking water supply is the responsibility of drinking water companies, the tasks of which are laid down in the Drinking Water Act and are further elaborated on in, for example, the Drinking Water Decree and the Drinking Water Regulations.

Article 5 indicates that the drinking water company has the exclusive power and obligation, in accordance with Article 8, to supply drinking water.

The legal duties of a drinking water company in the distribution area are (Article 7):

- Establishing and maintaining a sustainable and efficient public drinking water supply.
- Establishing and maintaining the infrastructure necessary for the production and distribution of drinking water in that distribution area.
- The supply of drinking water.
- Ensuring the quality and sustainability of the production and distribution process and the supplied drinking water.
- Contributing to the protection of the sources of drinking water supplies in its distribution area against pollution, such as, in any case, conducting research into the quality of these sources and managing areas around these sources, aimed at preventing or limiting pollution of these sources.
- Contributing to the responsible handling of drinking water by owners, consumers and other customers from a public health point of view between the point of supply and the point where the drinking water becomes available for consumption, always including: providing consumers with information and drawing up technical requirements regarding the connection to its distribution network and carrying out inspections.

The drinking water company’s obligations in the distribution area (articles 8 and 11)

- Providing anyone asking for a drinking water connection with a quotation and supplying water to everyone with a drinking water connection.
- Conditions must be used which are reasonable, transparent and non-discriminatory and rates which will cover costs and are transparent and non-discriminatory.

Care for the quality and quantity of the drinking water (articles 21, 32, 33 and 34)

- The drinking water contains no organisms, parasites or substances, in numbers per unit volume or concentrations, which can have adverse consequences for public health.
- The design and condition of the water supply works, appliances and mains networks must not pose any risk of contamination of the connected water supplies.
- Under normal circumstances, the supply of decent drinking water is always guaranteed in such an amount and under such pressure as is required in the interest of public health.
- The drinking water company will take all appropriate measures to meet the future needs of drinking water in the distribution area established for its drinking water company.
- The drinking water company will prepare an analysis of any possible disruption risks and introduce measures to prevent disruptions as much as possible.

Drinking Water Policy Document

The Drinking Water Act, article 6, states that the cabinet must issue a 'policy document regarding the public drinking water supply' every 6 years. The first drinking water policy document was published in 2014. The most important points are:

- Drinking water is a vital function of major social importance.
- The drinking water quality is high, but the sources are under pressure. Drinking water sources must be well protected.

appendix VIII business values matrix

14

Water main construction

Version April 2020	Effect							Opportunity				
	Supply reliability		Finances	Health and safety	Sustainability and environment	Stakeholder interests		**Unlikely** Not heard of in the NL DW sector	**Rare** Occurred within the NL-DW sector	**Possible** Occurred at Vitens	**Likely** Once every couple of years	**Very likely** Several times a year
	Quantity	*Quality*	*Claims* *Fines* *Consequential damage*	*Employees* *Contractors* *Third parties*	*Materials and ancillary materials* *Waste and residues* *Water* *Energy and emissions* *Soil and water system*	*Customers (households, companies)* *Competent authorities* *Environmental partners*		*< 1x / 50 y*	*1x / 15 - 50y*	*1x / 5 - 15 y*	*1 x / 1 - 5 y*	*> 1x / y*
								A	B	C	D	E
Very serious	**Very serious supply effects** > 200 mln OLM (> 76:55 min) ('large transport pipeline/average production location 1 week; large municipality (80,000 households) several days')	**Very serious quality disturbance** Exceedance of Vitens limit values (large-scale (large municipality, 80,000 households) > 1 week; 'many cases of illness, fatal situations vulnerable consumers')	**Very serious financial effects** > € 40 mln	**Very serious H&S effects** Fatal; serious disability ('paraplegia')	**Very serious sustainability/environmental effects** Abstraction function permanently no longer possible ('major soil contamination with irreversible effect on flora and fauna')	**Very serious damage to stakeholder interests/ reputation** Consumption drops significantly Vitens under guardianship, long-lasting afterglow effect ('Many customers ill, fatal situations vulnerable customers') (Stakeholders: 'Vitens is unreliable')	**5**					
Serious	**Serious supply effects** 50 - 200 mln OLM (19:14 - 76:55 min) ('average production location 3 days; large municipality (80,000 households) 1 day')	**Serious quality disturbance** Exceedance of Vitens limit values (medium-sized (average municipality, 20,000 households) > 1 week; 'Many cases of illness, suspected fatal situations vulnerable consumers')	**Serious financial effects** € 10- € 40 mln	**Serious H&S effects** Permanent disability ('damage to hearing')	**Serious sustainability/environmental effects** Abstraction function is significantly reduced ('salinisation part of the abstraction field')	**Serious damage to stakeholder interests/ reputation** With a limited number of key stakeholders, after-glow effect Large-scale negative media attention (> 1mln media words), Supervisory board is held accountable for their supervisory responsibility ('Successful hack with serious impact') (Stakeholders: 'serious damage to trust')	**4**					
Considerable	**Considerable supply effects** 10 - 50 mln OLM (3:50 - 19:14 min) ('average production location (30,000 households) 18 hours; average municipality (20,000 households) 1 day')	**Considerable quality disturbance** Exceedance of Vitens limit values (medium-sized (average municipality, 20,000 households) <1 week; 'various cases of illness')	**Considerable financial effects** €2.5 - € 10 mln	**Considerable H&S effects** Can be serious, but temporary (hospital admission > 24 hours; notification to the Ministry of Social Affairs & Employment inspectorate)	**Considerable sustainability/environmental effects** Abstraction function possibly temporarily limited ('serious environmental pollution near abstraction field, extensive soil remediation')	**Considerable damage to stakeholder interests/ reputation** With a key stakeholder, with a significant group of customers Significant negative media attention (0.05 - 1 mln media words), management is held accountable for their management responsibility ('Fraud cause with an effect on the rate') (Stakeholders: 'Relationship with Vitens is difficult, awkward')	**3**					
Moderate	**Moderate supply effects** 2 - 10 mln OLM (00:46 - 03:50 min) ('average production location (30,000 households) 4 hours; community (pc4; 2,000 households) 1 day; average municipality (20,000 households) 4 hours')	**Moderate quality disturbance** Exceedance of Vitens limit values (medium-sized (average municipality, 20,000 households) <1 week; 'possible cases of illness, bad organoleptic quality')	**Moderate financial effects** € 0.5 - 2.5 € mln	**Moderate H&S effects** Accident resulting in absence ('hospital admission < 24 hours')	**Moderate sustainability/environmental effects** Abstraction function is not disturbed; possibly extra temporary monitoring ('serious environmental pollution near abstraction field, limited soil remediation')	**Moderate damage to stakeholder interests/ reputation** Limited negative media attention (< 50k media words) First line is held accountable for their management responsibility (Major fault not dealt with well') (Stakeholders: 'We are approaching Vitens extra critically')	**2**					
Minimal	**Minimal supply effects** < 2 mln OLM (< 0:46 min) ('average production location (30,000 households) <1 hour; community (pc5, 250 households) 1 day; community (pc4, 2,000 households) 8 hours; average municipality (20,000 households) 1 hour')	**Minimal quality disturbance** Exceedance of Vitens limit values (small-scale (community, 2,000 households) < 1 day; 'preventative cooking advice, noticeably reduced organoleptic quality')	**Minimal financial effects** < € 0,5 mln	**Minimal H&S effects** Accident without absence	**Minimal sustainability/environmental effects** Abstraction function is not disturbed) ('limited diesel leakage in nearby abstraction field, easy to clear')	**Minimal damage to stakeholder interests/ reputation** Minimal impact on stakeholder interests ('Forgotten to inform HETI', 'usual fault') (Stakeholders: 'Vitens sufficiently reacts to non-compliance')	**1**					


Manufacturing company Spannenburg

15 appendix IX methodical accountability scenarios

The scenarios were developed by DRIFT (a research agency set up by Erasmus University), partly based on earlier joint research conducted by DRIFT and Wageningen University. These scenarios are intended as extreme scenarios to test the organisation's resilience, aiming for scenarios which are plausible but not necessarily probable. Scenarios rarely, if ever, come true, certainly not these kinds of scenarios, but the idea is that components of scenarios will reveal themselves in the future and that the scenarios also help to strengthen the overall resilience of an organisation. There are many different types of scenarios. Van Notten's[10] typology classifies scenarios based on their goals, process and content (see the table below). The three-point scale represents the Vitens scenarios' position on nine dimensions. Or rather: the purpose of the Vitens scenarios in terms of function is mainly to stimulate the learning process; focussed on exploration rather than desired images and the scope is Vitens' environment.

The above choices and methodology are briefly explained in this appendix. We will start off with examining what transitions and resilience are, which activities DRIFT and Vitens have undertaken and what this means for the different types of scenarios. We will then look at the underlying dynamics, which activities DRIFT and Vitens have undertaken and the method of drawing up the scenarios themselves.

Transition versus resilience: Goal of the scenarios

Transitions are long-lasting, social changes in which a social function is carried out in a fundamentally different way[11] . For example, take an energy transition, such as from coal to gas, or from fossil to sustainable. There is a functioning energy supply before and after the transition. But one based on other values, parties, rules, techniques, routines etc. The chaos and turbulence during a transition is often not visible in developed countries, or only to a limited extent. But insiders see the chaos suffered by organisations, which often can't cope with the pace of change during a transition.

Goal	Function	learning process	●	●	○	content
	Normative framework	explorative	●	○	○	desirable
	Scope	environment	●	○	○	organisation
Process design	Input	qualitative	●	○	○	quantitative
	Method	participatory	●	○	○	modelling
	Group composition	all stakeholders	○	●	○	experts
Content	Transience	chains and paths	●	○	○	final image
	Factors	diverse	●	○	○	homogeneous
	Interaction	integral	●	○	○	separately

10 According to Van Notten (2005) in Sondeijker et al. (2006), Imagining sustainability: the added value of transition scenarios in transition management, Foresight Vol 8, N05, p 15-30

11 Geels (2002), Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study, Research Policy 31 (8-9), 1257-1274

Resilience, the ability to remain the same under changing circumstances, initially seems to be the opposite of transition. One example: if we start cooling down coal-fired power plants with seawater due to climate change, we improve resilience, but are likely to hinder a sustainability transition. However, there are cases where resilience and sustainable transition are in line with each other and you have to 'change in order to stay the same':

1) When a transition is needed from a little to a more resilient system;
2) When resilience is needed, because a transition can't be ruled out;
3) When resilience is considered to be a function which may require an underlying transition (transformation) of the system.

DRIFT has mapped out this tension field[12] between transition and resilience around the drinking water supply in the Vitens area in a transition analysis and compared it to transition analyses from other fields. This showed that three cases play a role at Vitens:

- Climate change, competition for groundwater and possible pollution issues, among other things, make the existing, fairly robust drinking water system more vulnerable.
- Vitens is dealing with the infrastructure paradox: large investments, a monopoly position and optimisation make drinking water relatively insensitive to disruptive change, but this stability and very limited manoeuvrability also make drinking water vulnerable to a relatively faster-changing environment.
- Vitens considers the drinking water supply to be more important than the organisation's interest to remain the same ad infinitum. In short, this means that it's wise to take a transition within the drinking water supply into account, but that this is not by definition unavoidable, necessary, or even desirable. This is a luxury compared to the energy sector, mobility and agriculture, where the shelf life is much more emphatically under discussion, but it's also no reason to simply sit back and wait.

The goals of the scenarios have therefore been determined in consultation with Vitens. Because it's also not been unequivocally established that a transition is necessary where Vitens' employees and other stakeholders are concerned, as the main goal was to involve them in a learning process around developments and signals that a transition is possible: broadening the mind. This process goal was paramount and was supported by substantive desk research. Instead of transitional scenarios (which describe normative, desirable fundamental changes of a sector), it has been decided to work more exploratively in order to broaden everyone's thinking. Where an exploration of the desirability was part of the study, not its starting point. The implications for the drinking water system's organisation are part of the broader dialogue between stakeholders, which this long-term exploration forms part of. This is exactly why environmental scenarios have been developed. These serve as stress tests for Vitens. These scenarios are intended to help Vitens and other stakeholders to develop a strategy and tactics. These can span the entire spectrum from moving along to counteracting, and from pursuing robustness to profound change.

12 DRIFT (2019), Vitens system analysis, March 2019

The dynamics of transitions and resilience: content, process and lessons

Research into transitions and into (social) ecological systems (where the concept of resilience comes from) has an important similarity: both fields start from a very similar world view (ontology) and management philosophy[13] . Research into transitions and ecosystem changes shows that these rarely have a single cause and that the outcome (the new system state) is determined by a multitude of interacting developments. Positive and negative feedback loops whereby developing, strengthening or weakening each other play an important role. In order to arrive at a good stress test, we must therefore look for developments which reinforce each other and form, as it were, a 'perfect storm' and therefore challenge the existing drinking water supply. In terms of content, the focus is therefore on chains of events and developments, where both social and more technical and spatial aspects play a role and interact.

In order to achieve a maximum learning effect, the scenario development was a participatory process: a co-production between DRIFT, Vitens employees and external stakeholders. A balance was thereby sought between involving as many different stakeholders as possible and the various areas of expertise within and around Vitens. The emphasis on jointly exploring a wide range of possible developments and discussing their significance has resulted in the scenario study being of a high quality.

13 Van der Brugge en Van Raak (2007), Facing the adaptive management challenge: insights from transition management, Ecology and Society 12:33

This makes the employees involved the main source of knowledge. Existing studies and publications have indeed played an important role in this process, but mainly as a result of the expertise of those involved and the underlying system analysis conducted by DRIFT, which can be requested separately.

An important step and an example of the approach described above, was a wild card workshop which was organised with Vitens employees in May 2019[14]. Wild cards are major developments at micro and macro level, with a low probability but a high impact. DRIFT developed eleven wild cards and the risks and vulnerabilities (for Vitens) and implications for resilience and monitoring were mapped out for each of these wild cards. The text box below shows an example of one of these wild cards. The lesson learned during this workshop was that the most disruptive force lies in (1) a combination of wild cards and developments; and (2) situations which are ambiguous: where the drinking water sector acknowledges an element of truth where the social dissatisfaction with the drinking water system is concerned. These lessons and the wild cards were subsequently further explored in a series of interviews.

Based on the wild cards, a smaller number of scenarios (for the overview) was chosen based on a larger number of mutually reinforcing developments. Ultimately a commonly used model was deployed, which distinguishes between four scenarios on the basis of only two developments, which together form a coordinate system. The reactions showed that the scenarios were easier to interpret than scenarios which differ on seven dimensions. The scenarios were subsequently developed on the basis of two fundamental challenges for Vitens' regional role in the drinking water supply:

- An infrastructure which is too small to be able to provide safe, sufficient water versus an infrastructure which is oversized because significant water savings have unexpectedly been realised, or because there is a need for much smaller, circular systems.
- A regional organisation must deal with both local and national interests. This presents a major challenge if, at one extreme, decentralisation takes place and new cooperative or commercial entrants in the drinking water supply play an important local role and the boundaries between drinking water, ecology, other infrastructures and the like may even disappear. And at the other extreme, centralisation can also be leading, whereby the central government will take on a strong guiding role and, as a result, the implementing organisation becomes more separated from the current, broad playing field in which it operates and will become increasingly task and implementation-oriented.

Additional developments were subsequently added to this. To such an extent that they would reinforce these problems and be different from each other. These developments have been tested against the previously developed wild cards, themes and interviews for the sake of completeness. These scenarios were tested and explored with Vitens employees during a workshop on 29th January 2020. This showed that the coordinate system approach does require a clear explanation of the fact that the total complexity and number of possible futures can never be completely captured in a coordinate system.

Two other important lessons from this workshop were (again) that the scenarios are especially valuable as a recurring 'exercise' with stakeholders and that it's quite possible for shifts between scenarios to occur. For example, when a Wild Water West leads to conflicts, after which the government takes back control in response to this (Drinking Water Delta Works), or if a more small-scale cooperative model (Dilution) becomes the norm.

Not only future challenges, but also existing developments will become visible by discussing the scenarios together. The scenarios have been described in such a way that the advantages and disadvantages for the drinking water supply have emerged and that Vitens can take different positions. Interestingly, many participants were of the opinion that the Drinking Water Delta Works is most in line with the current organisation of the drinking water system, a great deal is expected from the Dilution scenario, while the Wild Water West scenario was seen as the most threatening.

14 DRIFT (2019), report following the Vitens wild card meeting

Wild card example: Fluoride debate 2.0

Event

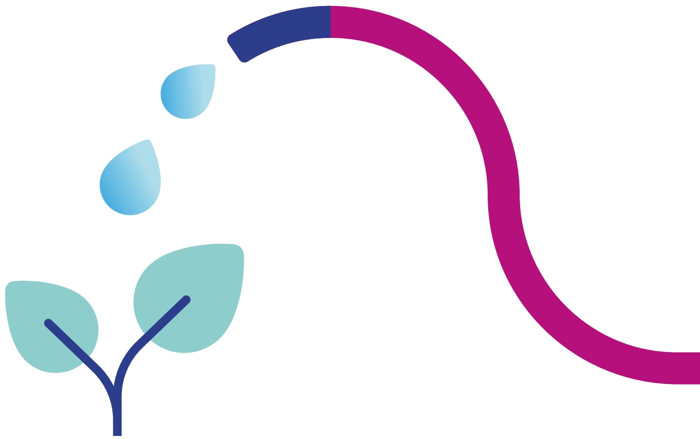
Two decades of economic stagnation in the Netherlands and the rest of Europe have resulted in some major health differences by 2030, inevitably resulting in problems for a constantly growing group.

There is a current in politics which advocates a much more socially active government which, also with the limited means at its disposal, needs to organise major programmes for reducing socio-economic differences.
One of these programmes is all about healthy food. This is more expensive than unhealthy food, but will ultimately lead to lower healthcare costs, as well as a reduced risk of losing a job or ending up in social isolation.

New food supplements (trace elements, supplemented with a mixture of vitamins) are constantly being introduced to the market, which serve to reduce the appetite for fatty foods. Richer people often buy bottled water, which these types of substances have already been added to by the manufacturers. In order to reduce the major health differences, there are now an increasing number of people advocating for these substances to also be made available and accessible to poor people. A legal foundation will be introduced and Vitens will be obliged to add a list of trace elements to its water within a year. However, this clashes with the social movement of people who feel the government has passed them by after decades of economic crisis and who are therefore extremely suspicious of any form of authority. They see this programme as a plot by the government to keep the population docile by adding drugs to the water.

Consequences for Vitens

Social movements start with aggressive protests at Vitens' production companies and the discussions on social media are just as fierce.
An increasing number of towns and villages in the Netherlands have announced their wish to 'disconnect' themselves by way of protest and have already raised money to rent mobile drinking water installations, which are usually deployed during disasters and in developing countries.



Colophon

Produced by Rian Kloosterman in close cooperation with many colleagues from Vitens.
Design and lay-out Kris Kras, context, content and design

water
for now
and in the future

'The drinking water infrastructure is a complex system due to the large amount of assets with long lifespans, high costs and many mutual interdependencies. The system is also intertwined with various different stakeholders. Resilience is the best strategy in this complex environment to allow for the supply of reliable drinking water, both now and in the future.'