Analysis of the drivers and barriers for implementation of non-conventional sanitation systems in the projects Drielanden and the Waterspin and a performance assessment of these systems

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Preface

This research is performed in the framework of my study Environmental Science at Wageningen University and is part of the completion of my Masters study. This research is done for the Urban Environment Group of the Wageningen University.

For this report the projects Drielanden and the Waterspin were investigated. Part of the research is based on data from literature, however also interviews among actors in the projects were held in order to gain insight in the user perspective about the systems and in order to gain insight in the drivers and barriers for the actors to participate in the projects. I would like to thank Erwin Koetse and Paul Telkamp for making these interviews and for providing me the data from the interviews that was necessary to write this report.

I would also like to thank Adriaan Mels, who gave me the opportunity to carry out this research and who supervised me during the research process. I performed the research with much interest and I think my knowledge about unconventional wastewater treatment systems is increased significantly during this research.

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Table of Contents:

1 Introduction and background

1.1 Background of the research

The Netherlands is known all over the world as a country of which one third lies below sea level. Therefore in the Netherlands there has always been a struggle against flooding, and on this field the Dutch have become real specialists. (WATERLAND, 2006)
However, flooding is not the only water related problem with which the Dutch have to deal. Another problem is a more global problem: the wastewater problem.

Already since 1920 wastewater treatment plants are being build in the Netherlands to protect the surface water. In 1958 the wastewater of about 2 million people was being treated before it was discharged into the surface water. (STOWA, 2005)
Since 1970 there is a law which is called “Wet Verontreiniging Oppervlaktewateren (WVO)”, which translates as “Surface Water Pollution Act”. The aim of this policy is to reduce the pollution of surface water as much as possible. (Universiteit Leiden, 2003)
The WVO takes as its starting point the prohibition of the discharge of wastes into the surface water without a permit. (Hallo, R., 1998)

Since the introduction of the WVO, the pollution of the surface water was approached on a large scale. This resulted in more and more wastewater to be treated in plants, and in the year 2004 about 98% of the polluted water is being treated before it is discharged into the surface water. (STOWA, 2005)

Especially in urban areas in the Netherlands the wastewater is being transported to the wastewater treatment plants through a large-scale sewage system. This system is functioning quite well, especially when looking at some major functions of the system: The protection of the surface water and the environment against pollution and the protection of human health. However with an increasing amount of rain and an increasing population density (particularly in urban areas) the present sewage system is up for improvements. The reduction of the amount of rainwater exposed to the sewage system and the (further) lowering of the concentration of pollutants from the wastewater treatment plants to the surface water are two important improvements which have to take place. Besides these improvements, the European “Kaderrichtlijn Water” subscribes the use of tertiary purification techniques. (STOWA, 2005)

Alternative purification techniques, such as a bio-rotor or a reed bed filter, are available for the treatment of wastewater, however these alternatives have not been thoroughly investigated because of a reluctance to experiment with any system, which could cause a risk to human health. (Eiswirth, Hötzl, Burn, 2000)

Nevertheless, during the last decennia a lot of information is gathered about the different projects which explore the possibilities of improving the wastewater treatment under several different conditions. This gives insight in the opportunities for different ways of wastewater treatment. This information is however scattered over many different reports, and one clear overview of all this information is lacking. Also a large scale comparison between the different projects is missing, which makes it hard to point out the positive and negative aspects of the different projects. To get an insight in the possibilities of alternative purification techniques, it is important to organize this information as much as possible.

In this report two projects will be discussed: “Drielanden” and “The Waterspin”. At the time of conducting this research, a lot of information about these projects is gathered. This research aims at making this information surveyable so that a good comparison between both sites and the present conventional sewer system in the Netherlands can be made.

1.2 Central research question

The aim of this research is to give an answer to the following central research question(s):

> What are drivers and barriers for the involved parties to develop a project like Drielanden and the Waterspin?
> Are projects like Drielanden and the Waterspin a possible alternative for the current conventional domestic wastewater treatment system in the Netherlands, when looking at the performance assessment protocol?

1.3 Sub research questions

In order to find an answer to the central research question, an answer to the following sub-research questions has to be found:

1. What are the drivers and barriers for the implementation of a non-conventional wastewater treatment system (like in Drielanden and in the Waterspin) according to the stakeholders that were involved during the phase of technology selection?

2. What is the background of the projects Drielanden and the Waterspin (i.e. where are the sites located, what is the size of the area, who were involved in the realization of the projects, etc.) and which water-related technologies are used in these areas?

3. What is the performance of the wastewater treatment system in Drielanden and in the Waterspin when looking at the performance assessment protocol (see chapter 2, table 2.3)?

4. What is the performance of the current conventional domestic wastewater treatment system in the Netherlands when looking at the performance assessment protocol?

5. What is the performance of Drielanden and the Waterspin compared to the performance of the conventional domestic wastewater treatment system in the Netherlands when looking at the different aspects of the performance assessment protocol?

1.4 Outline of the report

This research mainly concentrates at Drielanden and the Waterspin. Each site is described in a different chapter: chapter 3 gives a description of Drielanden, chapter 4 about the Waterspin. After a short introduction to the sites is given, the technology selection will be discussed. In this section, the drivers and barriers for the choice for a non-conventional wastewater treatment system are given. After the technology selection, there will be a paragraph in which the performance of the sites is described. This includes the users opinion about the sites, based on interviews among inhabitants of the areas.
In chapter five the current wastewater treatment in the Netherlands will be described. This information is being compared with the information about Drielanden and the Waterspin in chapter 6. Chapter 6 is followed up by a discussion. After this, in chapter 8 there are drawn conclusions from the comparison between the (non-conventional) sites Drielanden and the Waterspin with the current (conventional) wastewater treatment system in the Netherlands.

1.5 Terminology

In this research the terms “Constructed wetland” and “Reed bed system” are both being used. Although there is no international agreement about which of the terms should be used, there is a difference in the situation when the terms are being used. Constructed wetland is usually being used to describe a soil based marsh system in which the water flows over the soil substrate. The term Reed bed system is mostly being used to describe a gravel based system in which the wastewater flows vertically or horizontally through the substrate. (FH Wetland Systems Ltd., 2006)
Therefore, in the case of Drielanden the term “Constructed wetland” will be used, and in the case of the Waterspin there will be spoken of a “Reed bed system”.

2 Research methods

This research is based on a review of literature and internet sources and an empirical part in which on-site data was collected.

The reviewed data about the Waterspin and Drielanden mainly come from information brochures and the internet.

For the empirical part of the research interviews were made with participants that were involved with initiating the projects Drielanden and the Waterspin and with the technology selection. Also interviews were made among inhabitants of Drielanden and the Waterspin who now use the system. Actors who were involved in making the technology choice are interviewed about the drivers and barriers, which can be found in this chapter and also in the appendix.
Inhabitants of Drielanden and the Waterspin are interviewed about their perception of the system. The questions asked can be found in the appendix.

An overview of the investigated drivers can be found in the table below:

Drivers:	Unimportant				Very important
	0	1	2	3	4
Environmental aspect					
Positive feeling about environmental behaviour					
Water saving					
Prevention of drought in the soil					
Reduction of water emissions					
Recycling of water					
Protection of the surface water					
Protection of the ground water					
Recycling of nutrients					
Reduction of energy use					
Quality of the landscape in the area					
Financial aspect					
Lower designing costs (compared to conventional system)					
Lower operational costs (compared to a conventional system)					
Lower consumption of drinking water (lower bill)					
Lower energy costs (than with a conventional system)					
Lower sewerage taxes (than a conventional system)					
Lower costs for levy on water-board district (compared to a conventional system)					
Social and administrative aspect					
Intensified contact with the neighbours / partnership with the neighbours					
Involvement with the purification process / taking responsibility for the system (e.g. reduction of emissions)					
Higher quality of life					

Table 2.1: Investigated drivers for the implementation of an unconventional wastewater treatment system

Besides the drivers for the implementation of an unconventional wastewater treatment system there is also a list of possible barriers. An overview of the investigated barriers can be found in the table below:

Barriers:	Unimportant				Very important
	0	1	2	3	4
Environmental aspect					
Health risks					
Risk of flooding					
Chemical risks					
Injuries because of contact with the system					
Financial aspect					
Higher design costs (compared to conventional system)					
Higher operational costs (compared to a conventional system)					
Higher energy costs (compared to a conventional system)					
No reduction of the sewerage taxes					
No reduction of the levy on water-board district costs					
Social and administrative aspect					
Difficult technology					
Unclear who is the system owner					
Unclear who is responsible for the maintenance					
Maintenance has to be done by the households					

Table 2.2: Investigated barriers for the implementation of an unconventional wastewater treatment system

Besides the barriers mentioned above, also a question about laws and regulations which possibly hindered the implementation of non-conventional elements in the design was asked. This question is formulated as followed:

“Which laws and regulations hindered implementation of which non-conventional elements in the original design? (Specify)”

	Law or regulation	Influence on non-conventional design elements
1		
2		

To gain insight in the drivers and barriers, the following parties are interviewed:

<u>Drielanden:</u>

- Vereniging Ecologisch Wonen Groningen (EWG)
- The municipality of Groningen (system owner)
- The housing corporation Nijestee

<u>The Waterspin:</u>

- The wastewater expert (Ecofyt)
- The society for the management of the Waterspin
- The housing corporation Vestia

To gain insight in the user perception, the habitants (tenants and house owners) of the different sites were interviewed.

The information about the current conventional domestic wastewater treatment system in the Netherlands is mostly found in literature and on the internet.

To compare the information from the different projects, a performance assessment of the involved projects is done. This makes it possible to make a comparison between the different projects and to compare the different projects with the conventional wastewater treatment methods in the Netherlands.

The following indicators were used to evaluate the performance of the systems: (Betuw et al, 2007)

Performance indicator	Means of verification
1. Public health protection	Is there a chance for the house owners / tenants to get in contact with excreta or untreated wastewater? Is the effluent quality of wastewater flows that are treated in the neighbourhood monitored? If so, does the effluent quality comply with local standards?
2. Sub functions	Is there a system for rainwater/stormwater management? Does the system contribute to the ecosystem in the area?
3. User perspective	Are the yearly costs for house owners/tenants equal/higher/lower compared to the conventional system? Does the system cause nuisance (vermin, noise, odours)? What are the operation & maintenance inputs of house owners/tenants? How is the presence of the system in the area experienced?
4. Robustness	What is the nature and frequence of system failure? What is the average downtime per failure? Who operates the system and what are the operational requirements? What is the time input for the operation and what are the costs? What are the maintenance costs and how much time does this take? How frequent does the process exceed the effluent standards?
5. Environmental aspects	Are the emissions to surface water of nutrients and BOD equal/higher/lower compared to the conventional system? Does the system save or recover resources (water, nutrients, energy, etc.) compared to the conventional system?

Table 2.3: Indicators to evaluate the performance of Drielanden and the Waterspin

3 Description of Drielanden: background, drivers & barriers and technology description

3.1 Background description of Drielanden

In 1989 a group of people in Groningen (a city in the north of the Netherlands) started the Association of Ecological Residing Groningen (in Dutch: Vereniging Ecologisch Wonen Groningen, or in short EWG).
After consulting the housing corporation Groningen, the municipality of Groningen and the architect, Jan Giezen, the EWG decided to aspire the building of an ecological housing project in Groningen. The goal of the EWG was that during the building of the project environmental aspects were considered as much as possible. In practice they considered saving energy, saving raw materials and saving water as very important aspects. They also wanted to use as much sustainable construction materials as possible and also wanted to realize a lot of green in the area.

After finding a location for the project with confirmation of the municipality of Groningen, (quite ambitious) programs with the demands for the spatial planning of the area and for the architecture of the houses were started.

When the contractors started to make calculations, it got clear that not all the ambitious plans could be realized. This resulted in canceling the plans for heating water with solar collectors and also the canceling of the installation of compost toilets, because this was too expensive. Also a pipeline for the transportation of rainwater was not constructed and the area became not entirely free of cars. (Drielanden, 2006)

In spite of these setbacks, in 1995 the first houses were built. This resulted in 166 houses, of which 26 rental houses in the social sector, and 140 owner occupied houses. (Omslag, 2005)
Drielanden is located between the neighbourhoods “Lewenborg” and “Beijum” in the North East of Groningen, in the middle of the conurbation park “Noorddijk”. The neighbourhood consists of three areas: “Waterland”, “Zonland” and “Mooiland”.
(Drielanden, 2006)

In Drielanden there are private-owned houses and rental houses. Because the broker did not have interest in making potential buyers aware of the ecological aspects of Drielanden, some of the house owners are hardly aware of the ecological aspects of the district. Therefore a group of tenants started an association for keeping the awareness of the ecological aspects, such as the constructed wetlands, and in that way to make sure these ecological aspects are maintained. (Drielanden, 2006)

The water management in Drielanden is a unique project in the Netherlands. During the stage of development of the project there were pleas for measures in the field of an environmental friendly water economy and sustainable municipal water management. These measures contain the following elements: (Dijk, 2000)

- Saving drinking water
- Separated drainage of rainwater and storage in ponds and in the soil
- Environmental friendly water- and shore management
- Revaluate water systems within the aerial planning of new (living) areas
- The use of reed bed systems for grey wastewater treatment

The next paragraph gives a more detailed description of these elements, with the use of reed bed systems for grey wastewater treatment in special, because this is part of the main subject of this research.

3.2 Description of the used technology in Drielanden:

In Drielanden the following elements are important for reaching an environmental friendly water economy and sustainable municipal water management: (Dijk, 2000)

3.2.1 Saving drinking water with water saving sanitation

To save water, water-saving showerheads and water-saving (mixture) taps were installed. In Waterland Gustavberg-toilets were installed (Dijk, 2000)

The Gustavberg-toilets have a four litres water reservoir. To prevent clogging as a result of too less flush-water, a so-called flow-increaser is installed. The water from toilets flows into a pipeline which lays 2,10 m from the outside of the house. After every 15 houses this pipe ends into a flow-increaser, which exists of a container of 18 litres. When this container is full, the water is flushed further into the sewerage system. (Drielanden, 2006)

3.2.2 Separated drainage of rainwater and storage in ponds and in the soil

The drainage of rainwater in the districts Zonland and Mooiland takes place by an improved separated sewage system and in Waterland rainwater is removed through a rainwater sewer or by free drainage to the surface water of the district. (Dijk, 2000)

3.2.3 Environmental friendly water- and shore management

To store as much rainwater as possible the total water surface of the area consists of 10% of the total surface of the living area. The surface water system of Drielanden is a closed system. The inflow of water from outside the district in this system is prevented as much as possible. These measures have led to a very high quality of the surface water in Drielanden, with a very high ecological quality. (Dijk, 2000)

3.2.4 Revaluate water systems within the aerial planning of new (living) areas

During the development of the project the existing surface water in the area has been assigned new functions as mentioned above. Also there were build new ecological water systems in the area, such as reed bed systems. (Dijk, 2000)

3.2.5 The use of a reed bed system for grey wastewater treatment

In the district Waterland a reed bed system is used for the treatment of grey water. (Grey water is water that comes from kitchen, shower, dishwasher or washing machine.)

This reed bed system falls under the ownership of the municipality of Groningen, who is also responsible for the proper operation of the system. The system is being monitored in the framework of research, but does not take place on a regular base. The table below illustrates the parties involved with the reed bed system in Drielanden:

The reed bed system in Drielanden		
Owned by:	Operated by:	Monitoring:
The municipality of Groningen	The municipality of Groningen – "public works"	Yes; in the framework of research, however no regular monitoring.

Table 3.2.1. Overview of involved parties reed bed system Drielanden (source: Mels, Betuw, Baten, 2006)

In total 110 households are connected to a separated sewage system which takes of the grey water to free surface, horizontal flow reed bed system. The surface of this grey wastewater filter is 0,3 ha and it has a depth of 30 cm. The amount of grey wastewater that is treated is around 25 m^3/day and the retention time in the filter is 18 days. (Dijk, 2000)

After mixture of the effluent of the reed bed system with the surface water of the district, in a ratio of 1:7, the water is pumped into a second filter of the same size; the district water filter. The retention time in this second filter is about two days. Because the level of the district water filter is about 30 cm higher than the surface water system in the district, the effluent can flood freely into the surface water. This flooding results in a light flow in the total surface water system of the area.

In a surface flow constructed wetland the bacterial activity is strongly reduced in temperatures below 10°C. Therefore the system is not being used during the winter months. During this period the grey wastewater flows into the sewerage system.
(Dijk, 2000)

The filters are 3000m^2 each, and in every district there are 2 filters. This makes the total surface of the filter 6000m^2 per district. (interview tenants (Dijk, J. van), 2005)

3.3 Drivers and barriers for the technology choice in Drielanden:

The choice for the technology was made by several parties, namely the EWG, the municipality of Groningen and the housing corporation Nijestee. They all had their own drivers and barriers for choosing the reed bed filter to be used in Drielanden.

3.3.1 Drivers for the EWG

The EWG was started because a group of people wanted to develop an ecological living area. The ecological aspects of the whole project are therefore one of the most important drivers for the EWG to participate (or initiate) the project in Drielanden. This is also shown in the table below:

	Unimportant				Very important
	0	1	2	3	4
Environmental aspect					
Positive feeling about environmental behaviour					X
Water saving					X
Prevention of drought in the soil		X			
Reduction of water emissions					X
Recycling of water					X
Protection of the surface water					X
Protection of the ground water					X
Recycling of nutrients					X
Reduction of energy use					X
Quality of the landscape in the area				X	
Financial aspect					
Lower consumption of drinking water				X	
Lower energy costs (than conventional systems)				X	
Social aspect					
Intensive contact and cooperation with the neighbours			X		
Involvement with the system and the responsibilities for the purification process				X	

Table 3.3.1.1 Overview of the drivers for the EWG for implementation of the system (Interview EWG, 2005)

The table above shows that prevention of drought in the soil was an unimportant aspect for the EWG to participate in the project. The location of Drielanden has a high level of the groundwater, so drought was not one of the first environmental problems the EWG thought about. The quality of the landscape in the area was of some importance; however this was more a positive side effect of the whole project than a driver to start the project.

For the EWG, there were no real financial drivers. They were driven by the thought that they would save drinking water and that their energy costs would be lower than in conventional houses, however this was more a driver from an ecological point of view than from an economical perspective.

The original ecological drivers were very ambitious, but the EWG did not feel that they were impossible. However, after the whole project was finished, this opinion changed. There where several setbacks which resulted in cancelling of several of the original plans. The EWG did not expect all the barriers in advance, and when they would have had the same knowledge before the start of the project as they have now, they would think twice before starting the same project all over again. (Interview EWG, 2005) It took much more time than they expected and the progress of the project was less successful than they had hoped.

Besides ecological and financial drivers, there were also some social drivers for the EWG to start the project.
The contact with the neighbours intensified during the project and the inhabitants got involved in the whole purification process. This increased the environmental awareness of the inhabitants and their knowledge about water use and saving water. According to the EWG the presence of the system in the area increased their quality of life.

3.3.2 Barriers for the EWG

One of the first persons who took part in the EWG and the whole project reflected in an interview that the process was very difficult and tiresome. The reasons behind this remark are mainly that the EWG stood against a lot of pressure from the local authorities and the housing market. The local authorities did not really cooperate because they did not want to be involved too much with the project. Because the whole development stage took about ten years, a lot of the initial buyers of the houses dropped out. This caused extra pressure, because new buyers had to be found, and this went at the cost of the attention to the ecological aspects in the area. Also a lot of house owners sold their house after 4 years, because they could get a good price for it. However this also resulted in less attention to the ecological aspects, because a lot of new house owners did not know anything about the ecological aspects of the area. (Interview EWG, 2005)

Besides these organizational problems there were some other barriers (important considerations) for the EWG to implement the system, which can be found in the table below:

	Unimportant				Very important
Environmental aspect	0	1	2	3	4
Health risks			X		
Risk of flooding	X				
Chemical risks					X
Injuries because of contact with the system	X				
Financial aspect					
Higher costs for designing the project (compared to a conventional alternative)			X		
Higher operational costs (compared to a conventional alternative)			X		

Higher energy costs (compared to a conventional alternative)			X		
No reduction of the sewerage taxes	X				
No reduction of the levy on water-board district costs	X				
Social and administrative aspects					
Difficult technology				X	
Owner unclear			X		
Maintenance responsibilities unclear			X		
High maintenance costs for households				X	

Table 3.3.2.1 Barriers for the EWG to implement the system (Interview EWG, 2005)

This table shows that possible health risks were taken into consideration before implementing the system. The EWG wanted to be sure that no health risks would occur, however they were convinced that the possibility of the occurrence of health risk caused by the system was very low.

They were however concerned about chemical risks. This does not mean they thought that the system would form a chemical risk to humans, but more the other way round. They were concerned about the use of detergents and other cleaning products (like chloride or turpentine) by the inhabitants of Drielanden, which would affect the system negatively. This awareness should live among all inhabitants of Drielanden, also the house owners, and this could be a problem in the future.

The table above also shows that the financial barriers were of some importance, however they were not seen as very important. The ecological aspects of the project were of more importance than the costs, which does not take away that there had to be enough funds to finance the project.

Finally there were also some social and administrative barriers. First of all the technology choice was difficult, because the EWG did not have much knowledge about the different unconventional systems in advance. Furthermore, it was unclear who would be the system owner and who would have the responsibility to maintain the system. The fear was that the households would have much more maintenance than which would be the case when a conventional system was being used. (Interview EWG, 2005)

3.3.3 Drivers for the system owner (the municipality of Groningen)

The reed bed system is owned by the municipality of Groningen. They participated in choosing the technology for Drielanden. For the municipality the following aspects functioned as a driver to participate in the project and choose for the reed bed filter:

	Unimportant				Very important
Environmental aspect	0	1	2	3	4
Positive feeling about environmental behaviour					X
Water saving					X
Prevention of drought in the soil	X				
Reduction of water emissions					X
Recycling of water					X
Protection of the surface water					X
Protection of the ground water	X				
Recycling of nutrients					X
Reduction of energy use			X		
Quality of the landscape in the area				X	

Financial aspect					
Lower consumption of drinking water				X	
Lower energy costs (than conventional systems)		X			
Social aspect					
Intensive contact and cooperation with the neighbours					X
Involvement with the system and the responsibilities for the purification process				X	

Table 3.3.3.1 Overview of the drivers for the municipality of Groningen for implementation of the system (Interview Municipality of Groningen, 2005)

According to the municipality most of the above drivers were met when the project was finished. Only the reduction of water emissions and the recycling of water were not as efficient as they hoped for during the development stage of the project.

3.3.4 Barriers for the municipality of Groningen

There were several important aspects which influenced the decision of the municipality to participate in the project and to choose for an unconventional system or not. The biggest barriers are shown in the table below.

	Unimportant				Very important
Environmental aspect	0	1	2	3	4
Health risks					X
Risk of flooding		X			
Chemical risks				X	
Injuries because of contact with the system				X	
Creating awareness and education					X
Example position			X		
Financial aspect					
Higher costs for designing the project (compared to a conventional alternative)			X		
Higher operational costs (compared to a conventional alternative)			X		
No reduction of the levy on water-board district costs					X

Table 3.3.4.1 Overview of the barriers for the municipality of Groningen (Interview municipality of Groningen, 2005)

For the municipality of Groningen the most important aspect of the system was to prevent human health from possible diseases. The unconventional system should not have more health risks than the risks with a conventional sewer system.
The same thing counts for chemical risks and possible injuries: the use of an unconventional sewer system should not increase the possibility of risks.
For the municipality another important aspect of the project was to create environmental awareness among inhabitants (and to carry out the environmental awareness of the municipality itself). This can be seen as a driver if the goal is reached, however it needs an investment of time first, and therefore it is mentioned as a barrier. Furthermore, there was a lack of knowledge about non-conventional technologies among the participants in the beginning.

Another barrier was that still the full costs for the treatment of sewage water had to be paid. There is no reduction possible for unconventional wastewater treatment installations. This makes the whole project less cost-effective. (Interview municipality, 2005)

Besides the barriers mentioned in the table above, there were also some setbacks on the policy-field. The province of Groningen was very strict in following the Dutch law for the pollution of surface water (Wvo). The financing of the project therefore did not go as planned, because the municipality had to convince the province that the system would be reliable.

Furthermore, the municipal water company did not want to build a second water pipeline for rainwater. This made the re-use of rainwater in households impossible.
(Drielanden, 2006)

3.3.5 Drivers for the housing corporation Nijestee
Housing corporation Nijestee did not participate in the choosing the technology for Drielanden. Their participation started when the project was already further in its development stage. Therefore Nijestee did not have the same drivers and barriers as the other participants, however they were satisfied with the involvement of the inhabitants with the project, which causes a better contact between neighbours. Another important driver for Nijestee is the improved life quality in the district.
In the future it will not be a good idea to give the responsibility over the ecological aspects of the system to the housing corporation, because they have a lack of knowledge in this field. Sustainable building is something that appeals to Nijestee, but the ecological details are not within their knowledge. The building of compost toilets and flow greenhouses (for the treatment of grey water) in Drielanden was in their opinion to risky (there was not enough knowledge about these technologies at the time) and too expensive.

3.3.6 Barriers for the housing corporation Nijestee
The housing corporation Nijestee was not involved in the technology selection (see paragraph 3.3.5).

3.4 Performance assessment:

3.4.1 Public health protection

One of the main goals of a sewerage system is to protect the public health. To prevent the public from getting diseases from the wastewater, it is important that there is no contact between the wastewater and the inhabitants who use the system.

When using a reed bed filter like in Drielanden, it is unlikely that a person comes into contact with wastewater, because there is a fence around the reed bed filter. People in the area are aware that the water in the reed bed filter contains a fraction of wastewater. Also children are made aware that it is not allowed to enter the reed bed filter.

In the case of Drielanden, the effluent of the reed bed filter is monitored during the seasons of 1996 until 1999. The monitoring showed that the performance of the filter for cleaning the wastewater is good. The quality of the effluent from the grey wastewater filter, from the district water filter and the surface water in the area all comply with the strict demands. (Dijk, 2000)

3.4.2 Sub functions of the system
In Drielanden drinking water is saved by the use of water saving showerheads and water saving (mixture) taps. In Waterland Gustavberg-toilets are installed.

The drainage of rainwater in the districts Zonland and Mooiland takes place by an improved separated sewage system and in Waterland through a rainwater sewer or by a free drainage to the surface water of the district. (Dijk, 2000)

To store as much rainwater as possible the total water surface of the area is increased to 10% of the total surface of the living area. The surface water system of Drielanden is a closed system. In this system the influent of water from outside the district is prevented as much as possible. These measures have led to a very high quality of the surface water in Drielanden, in which the ecology develops very well. (Dijk, 2000)

3.4.3 User perspective: The tenants about the system and the district

To get an insight in the perspective of the tenants, in total 10 tenants of the total of 26 rental houses were interviewed (which is a response of 38%).

For the tenants the ecological aspects of the area were a major driver to rent a house in Drielanden. They like the presence of a lot of (surface) water in the area and the fact that rainwater is drained of into the soil and into the surface water of the district.

The total environmental awareness of some tenants is increased because of the system. They have to think about which cleansing agents they use (which will not harm the reed bed system) and get more aware about the amount of water they use. This environmental awareness is seen as a positive thing: people do not feel that they cannot do certain things because they live in an ecological area.

The use of this system in similar areas can be recommended, however not without the adaptations which are already done, like the return-flow of some of the effluent into the reed bed system. There also should be taken measures against the problems with bad odours from the reed bed system. Placing the filter at some more distance from the houses than which is the case in Drielanden will reduce the problems caused by the bad odour and will create some more space around the houses which lay directly next to the system.
Also some tenants recommend other water-saving systems, like the use of grey water for the washing machine (something which was not realised during the development of the project: see paragraph 3.2)

The costs for maintenance of the system are included in the rent. Therefore not all tenants are aware of the costs for operating the system.

The tenants did not get any subsidy for the use or realisation of the system.

The tenants still have to pay the total sewage treatment costs (the same price as people have to pay who are not connected to an ecological system). Also the cost for renting a house in Drielanden is somewhat higher than the costs for a similar house in a non-ecological area.

3.4.4 User perspective: The house owners about the system and the district

To get insight in the perspective of the house owners about the district, in total 8 house owners were interviewed (which is 6% of the total amount of 140 owner occupied houses).

For some of the house owners the ecological aspect of Drielanden was not a driver to buy a house. Most of them were not aware of the ecological aspects before they came to live in Drielanden, because after the first phase of selling houses in Drielanden, the ecological aspects were no longer pointed out to potential buyers.
House owners who did know about the ecological aspects in the area where attracted to the area by this fact, and they are also mostly positive about the system. These house owners are most of the time a member of the EWG.

For the environmental awareness of the house owners the same things are important as for the tenants. They also get more environmental aware because they cannot use all products anymore.

House owners also recommend the system to likewise areas, however they do not say anything about adaptations to the system.

The presence of (clean) surface water and the presence of much green in the area did have a positive influence on their opinion about the area. In that way they are positive about the system.

Also the house owners have to deal with bad odours around June, July and August, but they are not convinced that this is caused by the reed bed system. It could also be a natural cause, like a to low level of the surface water.

The sewerage taxes for house owners are not lower than in areas which are connected to conventional sewerage systems.

House owners sometimes have problems with the Gustavberg-toilets, because they tend to clog. A cause of this clogging can be the diameter of the sewage-pipe: this is 7 cm, which is much too small according to some. Also there is only one water-stream-expander for every 15 houses, which is also to less (the water-stream-expander causes the water to flow harder through the pipelines which should prevent clogging).

There are house owners who think that because the municipality shows not much involvement in the project, some of the inhabitants of the area also get less involved/less aware.

Under the interviewees was also one house owner who adapted his house so that he can use rainwater for the toilet, the shower and for the washing machine.

To summarize, house owners are on the overall less aware of the ecological aspects. The house owners who are aware, think it is important to inform new house owners about the ecological aspects, else in the future things can go wrong (the system could get dysfunctional).

3.4.5 Total costs

The maintenance costs are especially the costs for mowing and dredging. Mowing costs about € 2,- per m^2 per year. Dredging is necessary once in the twenty years, and costs about € 2,- per m^2 per year extra. These are the same costs as the maintenance costs for normal watercourses.
This means that the (standard) maintenance costs are € 4,- per m^2 per year, which brings the total costs at € 4,- * 3000 m^2 = €12.000,- per year. This means that the costs per household per year are € 12.000,- / 166 households = € 72,30 per household per year.

Some additional yearly costs of about € 1200,- to € 1500,- are made for cleaning the cascade. Each year the lava stones have to be taken out and rinsed clean. This is a step which should not be necessary, and there must be found another solution for this. (Interview municipality, 2005)

After the contractors made calculations, it appeared that not al the ambitious plans could be realized. Because the EWG wanted to sell the houses themselves, this would save 10% on the housing costs. Although already 60% of the houses were put on option for sale, the municipality decided to board out the sale of the houses to a broker's business. This caused an increase of costs of 10%. This increase of costs made some of the plans to expensive.

Therefore plans for heating water with solar collectors and also the building of compost toilets were cancelled. (Drielanden, 2006)

3.4.6 Robustness

In Drielanden there have been some problems with long periods of oxygen deficiency in the grey wastewater filter and the tremendous emission of bad odours. To reduce these problems there were taken some measures: (Dijk, 2000)

- The influent is diluted with surface water from the district in a 1:1 composition.
- A cascade is built to increase the input of oxygen and at the same time it functions as a settler tank.
- A part of the effluent is led back into the grey wastewater filter to reduce the loss of active bacteria.

These measures functioned well to settle the oxygen levels in the grey wastewater filter back to normal conditions. The whole season the oxygen level remained at the appropriate level for the filter to function well.
The reduction of the bad odour however was less successful. The emission of bad odour was reduced, but under specific weather conditions the emission of odour is so strong that this affects the living conditions negatively. (Dijk, 2000)

According to the municipality the reed bed system in Drielanden is build too close to the houses. People complain about too much reed next to their houses and the problems with bad odour can also result in complaints (however until the conduction of this interview, there were no complaints). (Interview system owner, 2005)

Until now there where no system failures. However there was a year in which there was forgotten to turn on the system again after the winter period (in which the system is not being used because of the low bacterial activity under low temperatures). (Interview system owner, 2005)

The reed bed system is expected to function well over a period of about 25 years. Then the soil is expected to be saturated with phosphate. (Kilian Water, 2007)

3.4.7 Environmental aspects

The results of the monitoring of the system in 1999 can be found in the table below:

Drielanden – Groningen (Horizontally flooded reed bed system)		
	Influent	Effluent 1999
COD (mg O_2/l)	550	45
BOD_5 (mg O_2/l)	298	2
N-total (mg N/l)	12,6	1,6
NH_4-N (mg N/l)	3,8	0,22
NO_3-N (mg N/l)	<0,03	0,11
P-total (mg P/l)	1,8	0,31
PO_4-P (mg P/l)	0,94	0,23

Table 3.2. Details of the reed bed system in Waterland (source: Mels, Betuw, Baten)

This table shows that the performance of the filter for cleaning the wastewater is good. The BOD_5 of the influent has a value of 298. The BOD_5 of the effluent has a value of 2. This shows that the reed bed filter significantly lowers the BOD of the wastewater.

The quality of the effluent from the grey wastewater filter, from the district water filter and the surface water in the area all comply with the strict demands.

Furthermore the systems saves (drinking) water, because part of the treated water can be used again.

4 Description of the "Waterspin": background, drivers & barriers and technology description

4.1 Background description of the Waterspin

In 1992 the association "De Waterspin" (translates as "The Water spider") submitted plans to the municipality of The Hague for the use of the (empty) buildings of the waterworks-company "Zuid-Holland". These buildings are located in the "Spijkermakerskwartier", between "Buitenom" and the "Prinsegracht" (both well-known streets in The Hague). They wanted to start a new project which concentrated at sustainability, ecology, affordability, self-control and preservation of valuable elements. The municipality had ears to this project and also the housing corporation Vestia (owner of the buildings) was enthusiastic. (Dool, 1998)

In spite of this enthusiasm there were several setbacks for the project. The waterworks-company Zuid-Holland left the buildings in 1996, which was much later then expected. Also the finances gave problems, because the location of the Waterspin made the construction quite difficult. The costs for the more difficult construction were not calculated in advance. (Dool, 1998)

In the beginning of 1995 the municipality decided that the squatters from "De Blauwe Aanslag" (a building located close to the Waterspin), could have a new accommodation in the Waterspin. This was not very supporting for the association The Waterspin, but also the squatters themselves did not want to move to the Waterspin. Later on it appeared that these plans resulted from the misunderstanding that "De Blauwe Aanslag" and the Waterspin were both the same group of buildings, and the plans were cancelled. However, this resulted in a delay of six months. (Dool, 1998)

Fortunately the original (ecological) goals of the project were not affected by these setbacks. There are used sustainable materials for the construction, water saving measures are taken and the Waterspin is the first project in the region in which a heat pump is being used. The Waterspin also uses a reed bed system for the treatment of (grey) wastewater, which was designed in corporation with the sanitation expert Ecofyt.
Only the plans for wall heating and compost-toilets had to be cancelled, due to financial problems. (Dool, 1998)

In 1997 the first housing started, and a good year later the first houses could be delivered. (Dool, 1998)

Figure 1.1. Waterspin (source: EGBF, 2001)

After the housing was finished, the ecological aspects of the Waterspin attracted national and international attention. (Dool, 1998)

The ecological aspects had the result that the Waterspin has been assigned the role of pilot project for the Sustainable and Energy Efficient Construction programme by the Dutch Ministry of Housing, Planning and the Environment and the Ministry of Economic Affairs. One of the major objectives of the project was to preserve the valuable characteristics of the site. Two existing buildings have been retained by renovation and two new buildings (I and II) have been built. In one of the old buildings (Alcatraz building, 1908), nine rental homes, five offices and four workshops have been constructed. The new Building I consists of eight social rental houses and Building II consists of eighteen owner-occupied houses in various price categories. (EGBF, 2001)

In total 21 rental houses, 18 owner-occupied houses and 9 business accommodations were realised in the Waterspin. (SenterNovem, 2001)

Finally the members of the association The Waterspin became inhabitants of the Waterspin themselves, and they drew up a contract with the housing corporation Vestia about self-management over the project. This means that the association became responsible for arranging new tenants, the inning of rent and the arranging of rental subsidy. (Omslag, 2005) From now on the association The Waterspin became the association for the management of the Waterspin.

The project has several ecological aspects. The next paragraph describes the aspects which are all more or less related to the water use in the Waterspin in more detail.

4.2 Description of the used technology in the Waterspin:

4.2.1 Heat pumps for space heating and domestic hot water

Three energy-efficient heat pumps were installed by energy distribution company ENECO. The heat pumps make use of ground water from a depth of 50m. This ground water has a constant temperature of 13 ^{o}C.
During the winter the heat pumps can distract energy from the ground water; by means of a heat exchanger the ground water gets a temperature of 60^{o}C, which is used for low temperature space heating (55^{o}/40^{o}) and a separate domestic hot water system.
During the summer the heat pumps can be used to cool down the houses by pumping around the relatively cool ground water through the system.

4.2.2 "Geostones" for the reduction of water in the sewer

Special paving-stones (the so-called geostones) have a much lower runoff-coefficient. This causes the rainwater to flow into the soil instead of into the sewer.

4.2.3 Rainwater for toilets, washing machines and garden sprinklers

Rainwater is collected on the roofs of all buildings and used for flushing the toilets. A pumping system brings the water to the toilets. Rainwater for flushing the toilets saves annually 750 m^3 on tap water. Furthermore, water preservation is achieved by methods such as circulation limiters and special water-saving showerheads. (EGBF, 2001)

4.2.4 Waste water treatment with a reed bed system

The water that comes from the washing machines in the central washing rooms is being purified in a reed bed system. The water is being pre-treated in a septic tank with a volume of 800 litres, before it is being pumped into a vertically flowed reed bed system. (Dool, 1998)

After the water is being treated in the reed bed system, the clean water is being stored in a reservoir of 3000 litres to maintain a constant pressure (Interviews, 2005), before it is re-used for the common washing machines, for cleaning and for the garden sprinklers. (EGBF, 2001)

The following table shows the parties involved with the reed bed system:

The reed bed system in the Waterspin		
Owned by:	Operated by:	Monitoring:
Housing cooperation The Hague (Vestia)	Habitants of the Waterspin/ association Waterspin	Habitants of the Waterspin/ association Waterspin

Table 2.2. Overview involved parties reed bed system Waterspin (source: Interviews, 2005)

4.3 Drivers and barriers for the technology choice in the Waterspin:

There were several parties involved in the choice of which technology should be used in the Waterspin. These are the following parties: the association for the management of the Waterspin, the housing corporation Vestia and the wastewater expert Ecofyt.

4.3.1 Drivers for the society for the management of the Waterspin

The society (for the management of) the Waterspin owns the grey water system (including the reed bed system) and the three washing machines which run on grey water. The management of this system also lies in the hands of the society for the management of the Waterspin. They made the technology choice, together with Ecofyt (the wastewater expert). The final decision about the plans lay by the housing corporation (Vestia) and by the main contractor (Kanters).

The drivers for choosing the technology can be found in the table below:

	Unimportant				Very important
Environmental aspect	0	1	2	3	4
Positive feeling about environmental behaviour				X	
Water saving					X
Prevention of drought in the soil			X		
Reduction of water emissions	X				
Recycling of water					X
Protection of the surface water				X	
Protection of the ground water	X				
Recycling of nutrients	X				
Reduction of energy use	X				
Quality of the landscape in the area				X	
Financial aspect					
Lower consumption of drinking water	X				
Lower energy costs (than conventional systems)	X				
Social aspect					
Intensive contact and cooperation with the neighbours	X				
Involvement with the system and the responsibilities for the purification process				X	
Influence of inhabitants in the design of the system					X

Table 4.3.3.1: Overview of the drivers for the society for the management of the Waterspin for the technology choice (Interview society for the management of the Waterspin, 2005)

For the society for the management of the Waterspin water saving and recycling of water were the most important drivers to choose for the system. The positive feeling about environmental behaviour was not a very important driver, because this feeling was not increased by the choice for this system; the people of the society already were environmental aware.
The reduction of water emissions was not seen as an important driver for the society, because when there is used less drinking water and water is recycled, this automatically means a reduction of water emissions.
The protection of ground water, the recycling of nutrients and a reduction of energy are all not part of the system and therefore were not seen as a driver to implement the system.
The system was seen as an improvement of the quality of the landscape in the area, and therefore this also stimulated the choice for the unconventional system.

The idea that the project could create more insight in similar projects stimulated the society to choose for the unconventional system. They liked the idea that the Waterspin could function as an example for other projects in the future. According to the society for the management of the Waterspin there is a good future for similar projects, but only after adaptations are made which prevent the same problems as occurred in the Waterspin. It is also important that the government keeps subsidising this kind of projects, so they can be further developed and improved. (Interview with the society for the management of the Waterspin, 2005)

The society was satisfied about the way decisions during the project were made, however there was a problem with the finances. The next paragraph describes this problem.

4.3.2 Barriers for the society for the management of the Waterspin

The costs for the system were the most important barrier. The municipality subsidised the whole, however there was only looked at the investment costs for the technologies and not to the total lifetime and liability of different technologies. Several different parts of the system had to be realised by different executors, which caused the course of the total project not to go very smoothly.

4.3.3 Drivers for the housing corporation Vestia

The housing corporation is, together with W-E-consultancy, the owner of the rainwater system for the toilets. (Interview society for the management of the Waterspin, 2005)
The drivers for the implementation of the system for housing corporation Vestia are shown in the table below:

	Unimportant				Very important
	0	1	2	3	4
Environmental aspect					
Positive feeling about environmental behaviour					X
Water saving			X		
Prevention of drought in the soil	X				
Reduction of water emissions				X	
Recycling of water				X	
Protection of the surface water	X				
Protection of the ground water	X				
Recycling of nutrients	X				
Reduction of energy use					X
Quality of the landscape in the area				X	
Social aspect					
Intensive contact and cooperation with the neighbours					X
Involvement with the system and the responsibilities			X		

for the purification process					
Higher quality of life				X	

Table 4.3.5.1: Drivers for the housing corporation Vestia in making the technology choice (Interview housing corporation Vestia, 2005)

Housing corporation Vestia wants to have a sustainable character. Therefore the positive feeling about the environmental behaviour was an important driver for Vestia to participate in project the Waterspin.
Saving water was not seen as a very important driver, because it was unsure how much water could be saved by the system. More important was the reduction of water emissions, the recycling of water and the quality of the landscape in the area.
The reason that Vestia calls the reduction of energy use a very important aspect is most of all because the system can make people aware of the total energy use. After all the system does not lower the use of energy significantly, but it can increase the awareness of the amount of energy used.
The protection of surface water and ground water, and the recycling of nutrients, are not part of the function of the system and were therefore not seen as an important driver.

Vestia feels that all environmental goals were met by the implementation of the system. The aspect of water saving even exceeded their expectations, probably due to the rainwater system.
The social aspects of the project also were of importance for Vestia. The involvement of the inhabitants in the project, and the existence of the society for the management of the Waterspin were good developments according to Vestia, because this made clear what inhabitants wanted or not in their living area. Also the environmental awareness of the inhabitants and the creation of nice looking houses were seen as important drivers for Vestia.

Besides the environmental aspects and the social aspects which functioned as a driver for Vestia, there were also several financial drivers, which can be found in the table below:

	Unimportant				Very important
	0	1	2	3	4
Financial aspect					
Lower design costs than a conventional system					X
Lower operational costs than a conventional system	X				
Lower consumption of drinking water				X	
Lower energy costs than conventional system			X		
Lower sewerage taxes that a conventional system			X		
Lower taxes for the treatment of wastewater than conventional system			X		

Table 4.3.5.2: Financial drivers for the housing corporation Vestia in making the technology choice (Interview housing corporation Vestia, 2005)

The table with financial drivers shows that Vestia did not have insight in the realistic costs for the system. They expected that there could be more economical benefit by the use of the system in advance.
They did not have to pay much money for the system because most investments were made by other actors, however they thought the total costs would be lower than they finally were. According to the housing corporation the reed bed system will only have a future in other projects if there is more economical benefit in the future, like lower costs for emitting less wastewater into the sewer. (Interview housing corporation Vestia, 2005)

4.3.4 Barriers for the housing corporation Vestia

The only environmental aspect which formed a barrier for Vestia to choose for an unconventional system like in the Waterspin were the risk of Legionella bacteria and the amount of noise produced by the system.

4.3.5 Drivers for the wastewater expert (Ecofyt)

Ecofyt is the company which investigated the technical details of the reed bed system during the development stage. They advised about which technology should be used in the situation of the Waterspin. They did not choose the technology all alone. Also persons of the society for the management of the Waterspin were involved in the technology choice (this society is also the initiator for the whole project). About some parts of the system there was no discussion possible, because these parts are necessary parts for the proper functioning of the system. This means that Ecofyt was responsible for the final choice for technology, which covers the choice for the reed bed system, the grease-trap, the pump-pits (reservoirs) and the delivered pumps.

The following table shows the different aspects which more or less form the drivers for Ecofyt in making the technology choice. Aspects which were not taken into consideration were left out of this table.

	Unimportant				Very important
	0	1	2	3	4
Environmental aspect					
Positive feeling about environmental behaviour					X
Water saving					X
Prevention of drought in the soil	X				
Reduction of water emissions				X	
Recycling of water					X
Protection of the surface water	X				
Protection of the ground water	X				
Recycling of nutrients	X				
Reduction of energy use				X	
Quality of the landscape in the area		X			
Financial aspect					
Lower consumption of drinking water					X
Lower energy costs (than conventional systems)	X				
Social aspect					
Intensive contact and cooperation with the neighbours					X
Involvement with the system and the responsibilities for the purification process					X

Table 4.3.1.1: Overview of the drivers for Ecofyt for the implementation of the system (Interview Ecofyt, 2005)

The table shows that the recycling of water and saving of drinking water were important aspects for making the technology choice. The prevention of drought in the soil was no function of the system which Ecofyt had to choose the technology for (the reed bed system, the grease-trap, the pump-pits (reservoirs) and the delivered pumps) and therefore this aspect is marked as unimportant in the table with drivers.

Because under normal conditions the water from the system does not get into contact with surface water or with ground water, the protection of surface water and ground water is marked as not important. The only importance is that the contact between water from the system and surface or ground water is prevented.

In the system, recycling of nutrients does not take place, only the recycling of water is an important aspect in the Waterspin.
When choosing the technology for the system the energy costs were not part of the decision making because the amount of energy used by the system is very low.
(Interview Ecofyt, 2005)

Financially the system is not profitable. The annual purification costs are €52,- for a household with one person and €156,- for a household with more than one person. In the Netherlands a reduction of the annual purification costs for households is only possible if a household which pays €156,- reduces its emission of wastewater drastically. For example, the disconnection of rainwater drainage from the main sewerage system will result in 30% less emission of wastewater into the sewerage and this is too low to get a reduction.
The only financial profit there is coming from a lower consumption of drinking water.

According to Ecofyt, the aspects which functioned as a driver for the projects are met after completion of the system. However, if the project should be repeated in the future, some technical adjustments should be made. One important adjustment would be to create more streams (instead of one) on the reed bed system to prevent clogging. (Interview Ecofyt, 2005)

4.3.6 Barriers for the wastewater expert (Ecofyt)
Because Ecofyt is used to work with unconventional systems like in the Waterspin, there were no barriers for Ecofyt to choose for the non-conventional elements. Also the costs for the system were no barrier for Ecofyt, because they got paid by installing the system.

4.4 Performance assessment:

4.4.1 Public health protection
In 1999 Ecofyt analysed the system. At that time the system functioned well. The effluent of the system has an average BOD of 95mg O_2/l.
The monitoring of the system still is in hands of Ecofyt. (Interview Ecofyt, 2005)

Ecofyt thinks that the washing of diapers in the washing machines could result in the occurrence of the E. coli bacteria in the system. (Interview Ecofyt, 2005)

For the prevention of the drinking water system there had to be installed an atmospheric interruption (this is part of the Dutch drinking water law). This system had to be applied to the whole drinking water system, which costs very much energy. (Interview Society for the management of the Waterspin, 2005)

In the first years after completing the construction of the system there was no maintenance contract and also there were no finances for monitoring the system. (Interview Society for the management of the Waterspin, 2005)

4.4.2 Sub functions of the system
Special paving-stones (geostones) cause rainwater from the pavement to flow into the soil instead of the sewer. Furthermore rainwater is collected on the roofs of the buildings and used for flushing the toilets. This saves annually about 750 m^3 of drinking water.
The amount of rainwater which flows into the sewer is therefore strongly reduced. The only rainwater which flows into the sewer falls directly on the reed bed filter or flows into the reed bed filter from the edge of the filter.

4.4.3 User perspective: The tenants about the system and the district
In total 8 tenants (38% of the total of 21 rental houses) were prepared to give an interview.

When deciding to rent a house in the Waterspin, the tenants were attracted to the ecological aspects of the area. The tenants like the idea that the system is good for the environment, and that rainwater is being used efficiently.

Tenants with children teach their children not to play nearby or in the reed bed system. Therefore there is no direct health-risk because of the system. (Another reason that the children are not allowed to play in the reed bed system is that the young reed in the system is vulnerable in a young stage of growth.)

Unfortunately the tenants have to pay the full costs for water purification taxes and the costs for being connected to the main sewer system.
Also the tenants themselves did not receive subsidy from the government for using the system. This money went to society the Waterspin for the realisation of the project.
Therefore it can be said that the total economical benefits of the system are not very high. (The only economical benefit comes from the saving of drinking water)

There are also some problems with the system. Sometimes there can be smelled a bad odour, however this does not occur often. Also the hot water pump makes noise whenever being used.
The cistern of the toilets (which flush with rainwater) sometimes keep running after using the toilet, which costs much water. The cisterns were replaced already a couple of times, however the problem remains. Some tenants think this is caused by the use of rainwater instead of drinking water. When such a problem does occur, this is being fixed within 24 hours.
The laundry is not always very clean, in which case tenants use normal drinking water.
During maintenance of the system the grey water circuit is disconnected, which is uncomfortable.

Although these problems do occur, the tenants are satisfied about the system, and according to them the system as a whole can be recommended to similar living areas elsewhere.
Especially the grey water system has a good future perspective, because this saves water, which delivers an economical advantage.
(Interviews tenants, 2005)

4.4.4 User perspective: The house owners about the system and the district
There was one house owner who gave a positive response about giving off an interview in order to get insight in the perspective of house owners on the system. This is 6% of the 18 owner occupied houses.

The interviewee is positive about the ecological aspects of the area and is satisfied about the way the system functions, and about the fact that the system helps to save the environment.
The house owner does experience some bad odours from the reed bed system, especially during the summer.
It is not really clear who is monitoring the system: Ecofyt or Kilian Water (a company which delivers rainwater systems).

A good idea would be to place a rain barrel, so also rainwater can be used to water the plants.
For the rest the system functions well, and it can be recommended to households in other living areas.

4.4.5 Total Costs:
The building costs of the total system were about €82.000,- per rental house. (Mels, A., Zeeman, G., Bisschops, I., 2005)
The costs for the reed bed system (about €50.000) were financed by the municipality under the framework of sustainable building. (Senden, 2003)

4.4.6 Robustness

The maximum amount of rainwater the system can handle is 100mm rainfall/m^2, because with more rainfall the sewer gets overloaded, so the system cannot get rid of the effluent anymore. (Interview Ecofyt, 2005)

During the construction of the system there were some financial problems. Due to these problems, the rainwater system had to be simplified to lower the costs. Consequently a safety-system which prevents flooding of the system was not installed. In addition, the system was installed by the contractor, instead of by the supplier (so with less experience).
After completing the system, more funds became available and the system to prevent flooding by rainwater was installed after all. (Interview Society for the management of the Waterspin, 2005)

There was a filter on the pump which pumps up the water to the washing machines, which broke down because of solid particles in the water. The inhabitants of the Waterspin exchanged this filter themselves, in consultation with Ecofyt (the wastewater expert). The biggest diameter of a particle can be 5,5 mm before problems with the system occur. (Interview wastewater expert, 2005)
In seven years time there were reported two more incidents of the filter getting clogged. These problems could be solved in about 15 minutes (after being noticed). According to Ecofyt (the wastewater expert), these are the only problems reported in seven years. (Interview Ecofyt, 2005)

Furthermore an extra meter to monitor the efficiency is installed on the rainwater system.
In the grey water system an electronic control system was replaced by a more simple float system.
In the future this project should have more reliable pumps and a more energy efficient security system for the drinking water system (instead of the atmospheric interruption). (Interview Society for the management of the Waterspin, 2005)

According to Ecofyt, most inhabitants of the Waterspin are content with the system. There are about 3 to 4 persons who are not happy with the washing machines which work with the recycled water from the reed bed system, but those are the only complaints. (Interview Ecofyt, 2005)

The time needed for maintenance of the system is about 2-8 hours per household per year. (Interview Ecofyt, 2005)

4.4.7 Environmental aspects

Because the wastewater contains grease, the design of the system was altered with a grease-trap. Also there is a law in the Netherlands which says that all houses have to be connected to the conventional sewer. This meant that there still had to be installed long pipelines to the main sewer system. (Interview Ecofyt, 2005)

Heavy metals and pathogens have no influence in the influent on the purification process. Phosphate, nitrogen and organic matter in the influent could affect the purification process, because the system is small scaled and therefore more sensible for changes in the concentrations. (Interview Ecofyt, 2005)

5 Description of the current wastewater treatment in the Netherlands

To protect human health and to protect the environment, wastewater from urban areas in the Netherlands is being collected in large-scale sewerage systems through which it is being transported to wastewater treatment plants. After the wastewater is being purified, it is drained off into the surface water. (Mels, A., et al., 2005-12)
The wastewater treatment plants are efficient enough to purify the wastewater to such conditions that it can be drained of to the surface water and comply with the discharge standards of the Water Pollution Act. The biggest problems of the wastewater system do not lay with the wastewater treatment plants, but are related to the sewerage system which transports the water to these plants. These are problems like clogging or collapsing of the sewerage system, however also problems like the overflow of untreated water into the surface water during heavy rainfall do occur.
For comparing the unconventional wastewater treatment systems to the current situation in the Netherlands, the strength and weaknesses of the current sewerage system is of crucial importance.

5.1 Public health protection

The sewerage system prevents wastewater to drain of into the surface water or into the soil untreated (however leakage does occur). People are not getting into contact with the wastewater, which prevents them from diseases. (Mels, A., et al., 2005-12)

Effluent of the system is continuously monitored before it is being drained off to the surface water. The performance of the purification system are good under normal conditions.

However during heavy rainfall the sewerage system can be overloaded, which causes an overflow of untreated water into the surface water. This causes pollution of the surface water with pollutants from the sewer. If this surface water is located near a living area this can cause a health risk because the chance of people getting into contact with the polluted surface water becomes much higher. (Mels, A., et al., 2005-12)

5.2 Sub functions of the system

The sub functions of the conventional sewerage system in the Netherlands remains limited to drain off rainwater and storm water (besides the normal wastewater from households and industries). There are parts in the Netherlands were the drainage of rainwater is disconnected from the main sewer system, so that the rainwater can infiltrate into the ground. This prevents the groundwater levels to drop to low.
The ambition in 2006 was to disconnect 60% of the rainwater drainage in new housing locations and to disconnect 20% of the rainwater drainage from the main sewer system in existing living areas. Especially in the existing living areas it will be hard to reach this goal. (Geel, 2007)

5.3 User perspective

In the framework of this research no interviews were taken off among users of the conventional sewerage system in the Netherlands. Therefore there is no specific information about the user perspective. Still some things can be said about the system:

Households do not have to maintain the system except for the cleaning and maintenance of toilets and maintenance of the pipe systems inside the houses and the connection to the sewer in the streets. The operation and maintenance of the main sewer system is done by the municipality.

The area above ground usually remains limited to the toilets in the houses, and rainwater inlets on the streets.

The system produces sound during the flushing of the toilet and during the refilling of the cistern. Although this sound is not produced constantly, it does make quite much noise.

Because the wastewater flows directly from the houses into the sewer, negative effects of bad odours are taken away. Only when the system gets clogged problems could occur with bad odours, however under normal conditions this happens rarely.

5.4 Total costs

The costs for the current wastewater treatment system in the Netherlands start with the investment costs for building the sewerage system. The costs for the building the sewerage system per household are between €3500 and the €7800 in 2002. (Mels, A., et al., 2005)

In 2005 the average annual costs of the sewerage taxes were €116,- for a household with one person and €125,- for a household with more than one person. Furthermore the annual purification costs in 2005 were €52,- for a household with one person, and €156,- with a household with more than one person. (Rioned, 2005)

The costs for the sewerage taxes are currently only 85% of the total costs for the maintenance of the sewer. Also the investment costs for connection tot the sewerage system are excluded, because these costs are being calculated in the price for new houses. (Mels, A., et al., 2005)

5.5 Robustness

The Dutch sewerage system can be called robust. There are sometimes failures with clogging or with collapsing of the system but the amount of times these problems occur remains within the acceptable standards. Because the Dutch sewerage system is an old system (more than 100 years old) there is much known about these problems and how to prevent them.
However, the fact that the Dutch sewerage system is old also makes the maintenance costs higher every year. In the next couple of years an important part of the sewerage system must be replaced or renovated.
Furthermore, many sewers have not enough capacity to drain of water, which leads to very frequent discharge of polluted water into the surface water. (Mels, A., et al., 2005-12)

Also on several locations in the Netherlands, the sewerage system lays below the groundwater level. This causes groundwater to leak into the sewerage system, which causes an extra amount of water up to about 100% above the normal amount of wastewater (in dry weather conditions). (Mels, A., et al., 2005-12)

5.6 Environmental aspects

When the sewerage system functions 100% like it should, the impact on the environment would be very low. However, the current sewerage system in the Netherlands does not function a 100%, mainly because of several disadvantages as mentioned in the paragraph above. This results in the discharge of polluted water into the environment.

Another important issue is that the rainwater is now in most cases drained off instead of letting it flow into the soil. This causes the groundwater level to drop and the soil to dry up. Furthermore grey water is not being reused, so there is no reduction of drinking water either. Also there is (almost) no re-use of nutrients from the wastewater, however there are now two wastewater treatment plants in the Netherlands which do re-use nutrients from the wastewater.

The construction of a sewerage system costs much raw materials (for the concrete), which are not necessary in such high amounts the case of for example a septic tank.

6 Comparison between “Drielanden”, “Waterspin” and the current wastewater treatment in the Netherlands

Within the framework of this thesis project the performance assessment as shown in Table 2.3 is used to compare different wastewater treatment systems. This chapter will make the comparison between “Drielanden”, the “Waterspin” and the current wastewater treatment in the Netherlands by showing remarkable differences and/or similarities.
To make this comparison, the different performance indicators will be used. Furthermore the most important drivers and barriers in the choice for non-conventional systems will be compared. The comparison between drivers and barriers of the systems will be made in paragraph 6.1.
For each performance indicator the most remarkable aspects will be discussed in this chapter under paragraph 6.2.

6.1 Comparison between drivers and barriers in the choice for unconventional systems

Both projects were initiated by future inhabitants that were interested in sustainable building and environmental-friendly living. In both case the municipality became involved and supported these initiatives.

The main drivers for the future inhabitants and the municipality with respect to water were:
- Positive feeling about environmental behaviour;
- water saving / water recycling;
- reduction of water emissions;
- protection of the surface water;
- protection of the ground water;
- a positive financial stimulant because of a lower bill for drinking water;
- intensive contact and cooperation with the neighbours;
- involvement with the system and the responsibilities for the purification process.

The main barriers for future inhabitants and the municipality with respect to water were:
- Possible health risks;
- not all cleansing and washing products can be used because they could harm the system;
- not enough knowledge about unconventional systems.

All participating parties agree that when similar projects should be repeated in the future some changes should be made to the total execution. Several aspects in the whole process could be done more efficient, and also the choice for technology could in some cases be made more efficiently. At the beginning of the projects Drielanden and the Waterspin there was not much knowledge among participants, and there was a total lack of experience in constructing such projects among several participating parties. However, there are several different drivers which make the participants to have a positive feeling about the projects, and which could also be a driver in the future to perform similar projects:

- By using a reed bed filter, an attractive living area is created. There is more green in the area and the whole sight of the area is more attractive than in normal living areas. Also the area has more open water, which is also considered to be attractive.

- There is less emission of harmful components into the environment because by using unconventional systems the amount of overflows of untreated wastewater into the surface water are reduced.

- The amount of wastewater going into the sewer is reduced because the grey water is not disposed into the sewer.

- The use of an ecological system gives a positive feeling about the environmental behaviour among the participants.

Besides the drivers mentioned above there are also some barriers which can be found in every project with a non-conventional sewage system. These barriers should be avoided in the future as much as possible, which for a big part is the responsibility of the government.

- The treatment of wastewater is to prevent health, but it could also bring health-risks if the effluent of the wastewater treatment system is of bad quality. Therefore, in the conventional wastewater treatment system the effluent is monitored continuously. It is also important that monitoring of the effluent of the unconventional systems becomes a standard procedure.

- The costs of investment for a separated system (grey water and drinking water) are higher than the costs for a conventional system, because more pipelines are needed.

- Some actors involved did not have much knowledge about unconventional systems. The government should have a role in providing such information. (Interview Vestia, 2005)

6.2 Comparison between the performance indicators of Drielanden and the Waterspin and the current wastewater treatment in the Netherlands

1: Public Health: Drielanden and the Waterspin are both being monitored, however not on a regular basis. It is unclear if the monitoring will continue in the future. In order to have absolute control over possible health problems, monitoring of the system is a must. If monitoring of both systems in the future will continue, the score will be positive. If monitoring will not be maintained, the score will be negative.

2: Sub functions: In Drielanden and the Waterspin there are several systems to save drinking water and to reduce the amount of water drained of into the sewerage.
In Drielanden they make use of Gustavsberg-toilets to save drinking water. Also the drainage of rainwater in the districts Zonland and Mooiland takes place by an improved separated sewage system and in Waterland rainwater is removed through a rainwater sewer or by free drainage to the surface water of the district.
In the Waterspin there is installed a rainwater system which makes it possible to use the rainwater from the roofs of the buildings to for example flush toilets, which saves annually about 750 m^3 on tap water. Besides, in the Waterspin they use treated water from the reed bed system for the common washing machines, cleaning purposes and for garden sprinklers. Also they use special paving stones in the Waterspin which have a much lower runoff-coefficient.

3: User perspective: The costs for both systems are higher than the savings. Compared to the use of the conventional sewage system, the inhabitants of Drielanden and the Waterspin pay more. They save some costs on the drinking water bill due to the efficient use of rainwater for several purposes and by the use of low-flush Gustavsberg-toilets.
The users of the system do not have to maintain the system. This is done by a third party.

In both cases there are problems with bad odour, arising from the treatment system (constructed wetland and reed bed) especially during warm months. In Drielanden there was a problem with long periods of oxygen deficiency, however this problem have been solved.

4: Robustness: In the Waterspin, a filter on the pump which pumps up the water to the washing machines once broke down because of solid particles in the water.
Because these are about the only problems and most of these problems (except the problems with bad odour) are solved, both systems do not score positive or negative in comparison with the conventional sewage system in the Netherlands.

5: Environmental aspects: In both the Drielanden and the Waterspin on yearly basis a lot of drinking water is saved. In Drielanden this happens by using the so-called Gustavberg-toilets and in the Waterspin they use treated grey water system to flush the toilets and fill the washing machines. Therefore the score for both projects is positive on this point. In addition, both projects have reduced emissions of pollutants to surface water because rainwater is not led to the sewer system and, as a consequence, storm water overflows are absent.

The results of the points can be found in the table below:

Performance indicator		Drielanden	Waterspin
1. Public health protection		0/-	0/-
2. Sub functions		+	+
3. User perspective	Costs	-	-
	Nuisances	0	0
	O&M	0	0
4. Robustness		0	0
5. Environmental aspects	Resource use / recovery	+	+

Table 6.1: Performance evaluation of Drielanden and the Waterspin (in comparison with the conventional sanitation system) based on the pre-defined performance indicators. (Betuw, van, et al 2007)

7 Discussion

The non-conventional systems that were studied within the framework of this thesis do meet the objectives of the conventional wastewater system: they protect human health in an efficient way and they protect the environment. Both systems also have a rainwater management system in place.
There are also several advantages compared to the conventional system. For example, the ecological aspects of the system are attractive. Systems like a reed bed filter create more green zones in an area, which according to most people improves the quality of the living area.
Also most of the times the treated water which comes back from the system can be used another time. In the Waterspin for example they use the treated water from the system for the common washing machines or for garden sprinklers. This is also the case in other projects, like in “Polderdrift” in Arnhem where they use the treated water from the system for the washing machines and for the garden sprinklers, but also for flushing the toilets. (Mels et al., 2005)

This means a reduction of the use of drinking water, which is an (small) economical advantage.

There are also some disadvantages (barriers) for the unconventional wastewater treatment systems as applied in the Drielanden and Waterspin. One of the main disadvantages is that according to the Dutch law each household that lies within 40 m of a general sewer pipeline must still be connected to the main sewerage system. This means that, independently of how efficient an unconventional wastewater treatment system may be, the costs for being connected to the main sewerage system will still have to be made.

Another major disadvantage (in the Netherlands) is that the fact that, although a non-conventional system may reduce the pollutant load of a household into the sewer, it does not automatically mean a reduction in the annual purification costs that a household pays to the water board. The annual purification costs are approximately €52,- for a household with one person (i.e. one population equivalent) and €156,- for a household with more than one person. A reduction is only possible if a household which pays €156,- reduces its emission of wastewater with more thane one population equivalent. The disconnection of grey water from the main sewerage system will result in 30% less emission of wastewater into the sewerage and this is too low to get a reduction.

The costs for installing and maintaining a wastewater treatment system like a reed bed system will not lead to cost saving in the way things are currently arranged in the Netherlands, unless the saving of costs for drinking water are higher than the investment costs and the costs for operating and maintaining the system. However with the current prizes of drinking water and with the amount of drinking water used in a normal household this will not be the case.

When the Dutch law would recognise unconventional wastewater treatment systems for the good performance they have, and if there would be an economical compensation for the use of these systems, then it would become more attractive to use these systems.

Nowadays the Dutch government already invests a lot of money to separately collect rainwater from domestic wastewater. For this purpose infiltration systems are being installed, so that the rainwater is not collected in the sewer anymore, but infiltrates into the soil. This lowers the amount of water entering wastewater treatment plants, so they can work more efficiently. It is also beneficial to the groundwater levels and to the quality of surface water. This shows that the government is interested in the use of non-conventional systems.

However, most of the projects with a reed bed system in the Netherlands are an initiative of the inhabitants. Not only in Drielanden and the Waterspin this was the case, but for example also in “Het Groene Dak” in Utrecht the inhabitants gave the initiative.
This is a good thing, because this shows the involvement of the inhabitants with the environment. However in the future the government must also show initiative in starting likewise projects, because not all inhabitants of the Netherlands will be motivated to use non-conventional systems. To convince the government that non-conventional sewage systems are a good alternative to the conventional sewage system, more projects should be performed to show the (possible) success of these systems.
When the government wants to reduce the amount of wastewater which comes out into the sewer, and when the government wants to protect the environment and wants to keep the groundwater at level, an unconventional wastewater treatment system can help in meeting these goals.

8 Conclusions

Drivers and barriers
The participating parties in the projects Drielanden and the Waterspin agree that the main drivers which stimulated them to participate in the projects were met after the projects were finished. These drivers were:

- Positive feeling about environmental behaviour;
- water saving / water recycling;
- reduction of water emissions;
- protection of the surface water;
- protection of the ground water;
- a positive financial stimulant because of a lower bill for drinking water;
- intensive contact and cooperation with the neighbours;
- involvement with the system and the responsibilities for the purification process.

Some participating parties had some drivers in advance which afterwards appeared to be unrealistic, like the lowering in costs due to emitting less water into the sewer. However, also not all barriers appeared not to be a problem after the projects were finished. The possible health risks appeared to be overstated because the systems function well.

Performance assessment:

- The non-conventional sanitation systems that were studied within this project meet the goal of protecting human health, provided that a protocol for regular monitoring of the effluent of the unconventional systems is in place.

- These systems help saving drinking water and can improve the ecology in living areas. Furthermore there is less emission of harmful components to the environment than with the use of the conventional sewerage system.

- The costs for a non-conventional system are higher compared to a conventional sewerage system. There is a small economical benefit as a result of the saving of drinking water but this does not earn back the investment costs. A non-conventional system does result in emitting a lower pollutant load into the sewer; however this does not result in a reduction of the annual purification costs for households.

- The conventional sewerage system, on the average, is more robust than non-conventional systems. This is also a result of the lack of knowledge about non-conventional systems.

- Projects with non-conventional wastewater treatment techniques create more knowledge about the use of these systems and can help improve other systems in the future. This results in a positive development of non-conventional systems.

Final conclusion:

There can be concluded that when only looking at the performance of the systems and when looking at the positive sub functions of the systems non-conventional systems can have a future. However the systems are not cost-efficiently and this is a very important factor in the succeeding of these systems in the future. To assure a future for projects with unconventional systems, the government must make investments in such projects by providing subsidies, by gathering more knowledge around the systems and by reducing the costs for households which are connected to unconventional systems. Non-conventional systems will probably never be cheaper than the conventional sewerage system. But when the investment costs become lower than they are now, due to the positive side effects the non-conventional systems will become more and more attractive for the government and for people who make use of the system.

Recommendations:
During the projects Drielanden and the Waterspin there was lack of knowledge among participants, which made it more difficult to make choices between different available techniques. This made the whole process to go not as smoothly as it should have gone. More information about non-conventional systems should be more at hand, especially information about the advantages and disadvantages of the several available systems. This includes the (average) costs for the building and maintenance of the systems.

In the conventional wastewater treatment plants monitoring of the effluent is a standard procedure. In non-conventional wastewater treatment plants however, this is not the case. To protect human health, the monitoring of the effluent of the unconventional systems should take place on a regular base.

The costs for a non-conventional system are nowadays still too high. The government should compensate households who make use of the non-conventional systems in some way, so more people get interested in using non-conventional systems.

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Interviewees:

Drielanden:
- Vereniging Ecologisch Wonen Groningen (EWG): Karsch, T. (2005)
- The municipality of Groningen (system owner): Bruggers, E., Niezen, J. (2005)
- The housing corporation Nijestee: Bouma, R. (2005)

The waterspin:
- The wastewater expert (Ecofyt): Dien, F. van (2005)
- The society for the management of the Waterspin: Pauw, T. de, Hofman, J. (2005)
- The housing corporation Vestia: Eijheren, R. van (2005)

Appendix: Interview questions

Two different lists of interview questions are used for this research. The first list of questions is about the drivers and barriers for the technology choice. These questions are asked to the actors involved in choosing the technology for the sites. The second list of questions is about the user perspective on the whole project. These questions are asked to the inhabitants of the sites. Both lists of questions can be found in this appendix.

<u>Question list 1: Questions about drivers and barriers</u>

Questions about the design

1. Can you give a description of the technical and organizational aspects of the purification system?
2. Did you participate in the technology choice for the purification system in the area? (Yes/No)
3. When was the system build and how long did it take to build the system?
4. Which actors were involved in the technology choice? What was their role?
5. How were decisions made? (consensus/authority)
6. Did you agree with this way of making decisions? (Yes/No, because…)
7. Who was responsible for the final decision of the technology choice? (Which parts?)
8. How often did you have an appointment with other people involved in choosing the technology? (how many times per month)

Environmental "Drivers"

9. Which environmental aspects for the purification system were of importance for you and other actors when you were making the technology selection for the system?

	Unimportant				Very important
	0	1	2	3	4
Environmental aspect					
Positive feeling about environmental behaviour					
Water saving					
Prevention of drought in the soil					
Reduction of water emissions					
Recycling of water					
Protection of the surface water					
Protection of the ground water					
Recycling of nutrients					
Reduction of energy use					
Quality of the landscape in the area					
Other…					
Other…					

10. Which environmental aspects where **realised** after the system was build?

	Unimportant				Very important
	0	1	2	3	4
Environmental aspect					
Positive feeling about environmental behaviour					
Water saving					
Prevention of drought in the soil					

Reduction of water emissions					
Recycling of water					
Protection of the surface water					
Protection of the ground water					
Recycling of nutrients					
Reduction of energy use					
Quality of the landscape in the area					
Other…					
Other…					

Environmental- and human health "barriers"

11. Which "barriers" were in the way in making the choice for unconventional parts in the design?

Environmental aspect	Unimportant				Very important
	0	1	2	3	4
Health risks					
Risk of flooding					
Chemical risks					
Injuries because of contact with the system					
Other…					
Other…					
Other…					

Legal and policy "barriers"

12. Which laws and regulations hindered implementation of which non-conventional elements in the original design? (Specify)

	Law or regulation	Influence on non-conventional design elements
1		
2		
3		
4		
5		

Financial "drivers"

13. Which financial considerations were "drivers" in making the decision to implement non-conventional elements in the design?

	Unimportant				Very important
	0	1	2	3	4
Lower designing costs (compared to conventional system)					
Lower operational costs (compared to a conventional system)					

Lower consumption of drinking water (lower bill)					
Lower energy costs (than with a conventional system)					
Lower sewerage taxes (than a conventional system)					
Lower costs for levy on water-board district (compared to a conventional system)					
Other…					
Other…					

Financial "barriers"

14. Which financial considerations were "barriers" in making the decision to implement non-conventional elements in the design?

	Unimportant				Very important
	0	1	2	3	4
Higher design costs (compared to conventional system)					
Higher operational costs (compared to a conventional system)					
Higher energy costs (compared to a conventional system)					
No reduction of the sewerage taxes					
No reduction of the levy on water-board district costs					
Other…					
Other…					
Other…					

Social and administrative "drivers and barriers"

15. Which social aspects of the purification system were of importance for you and other actors during the designing of the system?

Aspects	Unimportant				Very important
	0	1	2	3	4
Intensified contact with the neighbours / partnership with the neighbours					
Involvement with the purification process / taking responsibility for the system (e.g. reduction of emissions)					
Higher quality of life					
Other…					
Other…					
Other…					

16. Which social end administrative decisions were hindering the implementation of non-conventional elements in the design?

Aspects	Unimportant				Very important
	0	1	2	3	4
Difficult technology					
Unclear who is the system owner					
Unclear who is responsible for the maintenance					
Maintenance has to be done by the households					

Other…					
Other…					
Other…					

Present and future position of the purification system

17. Were you actively involved during the period of building the area until now? (Yes/No, if no, skip the next two questions)

18. Are there made any changes/modifications to the purification system in the period from the start until now? (No/Yes, which and why?)

19. Are there any changes to the purification system which you think will be performed in the future?

Common part

20. Which aspect(s) of the purification system has, according to your opinion, a good future?

21. Who is, according to your opinion, the most important actor in the development/start-up of the use of a non-conventional system? Why?

22. If you could do the project all over again, would you do it in the same way or would you handle things differently?

<u>Question list 2: Questions about the user perspective</u>

Information about the household:

1. Of how many persons does your household exist?

2. What is the composition of the household? (single/one parent family/two parents family/married, no children/cohabitation)

3. How many members of the household spend the day out of house (school, work, etc.)?

4. How many persons sleep at home for a minimum of 5 nights a week?

5. For how long do you live in the area?

6. Are you the owner of the house? (owner/tenant)

7. Did you came to live here because of the ecological aspects in the house or were you not aware of this? (Ecological aspects / not aware)

Description of the wastewater system:

8. Which elements are part of the sewerage system?

<u>Elements:</u>		<u>Kind of system (parts):</u>
Rainwater system	yes/no	………………………
Grey water system	yes/no	………………………

Black water system	yes/no	………………………
Urinal reservoir	yes/no	………………………

9. Who is the owner of the system?

10. Who is responsible for the system?

11. Did you bring in money to support the project (or the start of the project)?
(…Euro/household)

12. How much money did you pay for the realisation and the building of the wastewater treatment system and what was included in this all?
Total: …. Euros

<u>Parts:</u>	<u>Costs: (if known)</u>
………………..	………………..Euros
………………..	………………..Euros
………………..	………………..Euros

13. What are the (estimated) operational costs of the purification system per household?
…. Euro/household

14. Did you receive subsidy for the use of the purification system? (yes, how much… / no)

Dimension: performance of "invisibility" and "user friendliness":

15. On what extend are you satisfied with the system?
I find the system …. (explenation)
-really terrible
-terrible
-neutral
-nice
-terrific
Because …………

16. Did you make any alterations to the system (in its primary form) yourself? If so, what and why? (No / Yes, namely:…. Because…..)

17. Are you involved with any of the monitoring activities of the system? (No, skip the next question/yes)

18. What monitoring activities do you perform and how much hours per month does this take you?
Activity:………………… Time: …………… hour/month
Activity:………………… Time: …………… hour/month
Activity:………………… Time: …………… hour/month

19. How many hours per household per year does the common maintenance of the system take? Who performs the maintenance?
Total system:…….. hours/household/year. Performed by:…………………..

<u>Maintenance to:</u>	<u>Time:</u>
Rainwater	…….hours/year
Grey water	…….hours/year
Black water	…….hours/year

Urinal reservoir	…….hours/year
System inspections	…….hours/year
Different	…….hours/year

20. What is the volume of the surface part of the purification system present in the house?
…m^3/household

21. How many square meters per household is taken by the surface parts of the purification system in the house?
…m^2/household

22. How much space does the surface part of the purification system take outdoors but on your property? (expressed in m^3 per household)
…m^3/household

23. How much space does the surface part of the purification system take outdoors but not on your property? (expressed in m^3 per neighbourhood)
(What is the depth? ….. m)
…….m^2/neighbourhood

24. How much space does the purification system take below the surface in the neighbourhood, expressed in m^3/neighbourhood?
…m^3/neighbourhood

25. Does the process produce bad odours in your opinion?
-always
-very often
-sometimes
-almost never
-never

26. In which months doe you experience the most problems with bad odour?
Jan. – Feb. – March – April – May – June – July – Aug. – Sept. – Oct. – Nov. – Dec.

27. Is there a visible part of the purification system present in or nearby your house? (yes/no, skip the next two questions)

28. What do you think of the visible part of the purification system in or near your house?
-really terrible
-not nice
-no problem
-nice
-fantastic
Because………….

29. Is the visible part of the purification system vulnerable for damage or failure?
-always
-often
-sometimes
-a little bit
-never
Which part is vulnerable? ………………………

Dimension: system and robustness:

30. Is the purification system being analysed/monitored? How?

31. How many times a year does a failure occur?
……. Failures/year (if the answer is 0, skip the next two questions)

32. Which parts of the purification system did not function well or was defect? What was the problem? When and how often did the problem occur? How and by whom was the problem solved?

Part of the system	Problem	When (date)	How often? (t/m/y)	Solution	By whom?

33. When the system has a failure, how long does it take before it functions well again?
…… hours/failure

Dimension: public health:

34. Did you/do you have any health problems which could be related to the purification system? (No/yes, explenation….)

35. Is there anyone within your household who has gotten injured during the use of the system or during maintenance of the system? (if yes, how often, what was the injury and how was it caused?)

Dimension: Impact on the ecosystem:

36. How much is the drinking water usage in m^3 per household per year?
….. m^3/household/year

Questions about user perception:

Background questions:

37. Which form of education did you follow?
-VMBO (formally MAVO)
-HAVO
-VWO
-different: …….

38. Did you also follow higher education?
-no
-yes, LBO
-yes, MBO
-yes, HBO
-yes, University
-yes, different, namely:………

Questions about involvement:

39. Do you feel that you are environmental aware?
    -always
    -very often
    -sometimes
    -a little bit
    -never

40. Did the purification system make you more environmental aware? (yes/no)

41. Could you recommend the system to other households in other neighbourhoods?
    -no
    -not without adjustments
    -no opinion
    -yes, that is an option
    -yes, I can really recommend the system
    Comments: ……………

42. Which aspects of the system do you think have a good future?

43. What is your opinion about the visible parts if the purification system inside or outside your house?
    -really terrible
    -irritating
    -not irritating
    -nice
    -beautiful

44. Does the system produce an annoying sound?
    -always
    -very often
    -sometimes
    -almost never
    -never

45. Doest the system attract vermin?
    -always
    -very often
    -sometimes
    -almost never
    -never

46. Which advantages does the system bring you?

47. Which disadvantages does the system bring you?