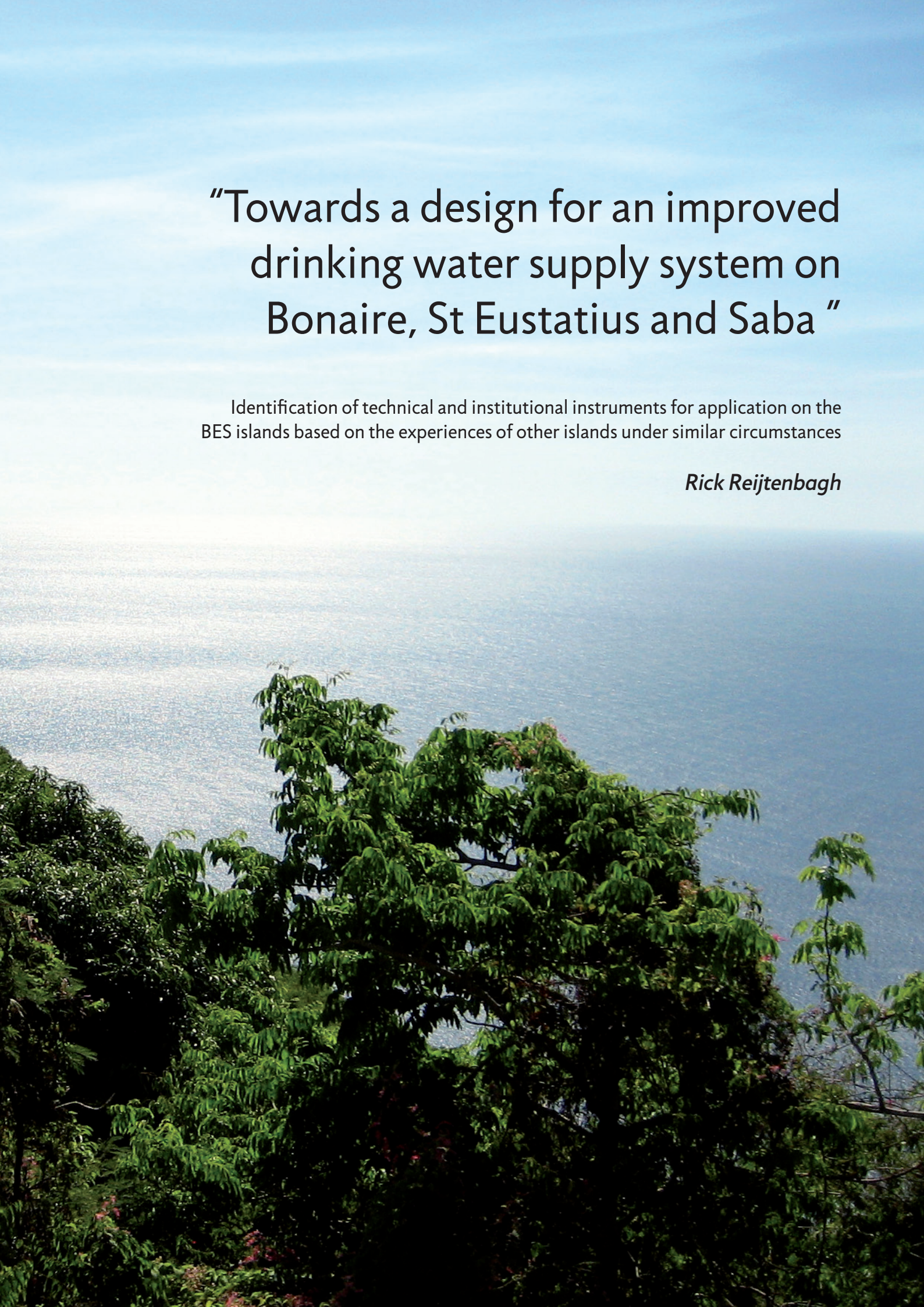


# “Towards a design for an improved drinking water supply system on Bonaire, St Eustatius and Saba ”

Identification of technical and institutional instruments for application on the BES islands based on the experiences of other islands under similar circumstances

*Rick Reijtenbagh*





## “Towards a design for an improved drinking water supply system on Bonaire, St Eustatius and Saba ”

*Identification of technical and institutional instruments for application on the BES islands based  
on the experiences of other islands under similar circumstances*

Delft University of Technology, Faculty of Technology, Policy and Management  
Ministry of Housing Spatial Planning and the Environment (VROM)

Author: Rick Reijtenbagh

### Thesis committee

Professor:	Dr. ir. W.A.H. Thissen	Faculty of TPM, Policy Analysis
1st Supervisor:	Dr. ir. L.M. Hermans	Faculty of TPM, Policy Analysis
External supervisor:	ir. F.A.M. Swinkels	Ministry of VROM, VROM Inspectie
2nd Supervisor:	Dr. ir. B. Broekhans	Faculty of TPM, POLG
External supervisor:	Dr. ir. J.Q.J.C Verberk	Faculty of CitG, Sanitary Engineering



## Preface

In 2008, the author has conducted a research study on behalf of the Caribbean Water Association on the consequences of the constitutional change of the Netherlands Antilles for the drinking water supply on Bonaire, St Eustatius and Saba (BES). This research study formed the basis for further research in the form of this MSc. thesis. Being the responsible Ministry for the supply of drinking water on the future BES islands, VROM positively embraced the idea to study solution alternatives to improve the current situation on the BES islands. The Ministry of VROM granted the author with the financial means and support to conduct this thesis research study. In chapter 7 of this report a set of guidelines and instruments is presented that can support the Ministry of VROM in defining and preparing an improved drinking water supply on the BES islands.



## Table of Contents

Preface .....	2
Summary .....	5
1 Introduction .....	9
2 Research methodology .....	11
3 Problem analysis .....	26
4 Basis of design .....	40
5 Source site identification .....	56
6 Lessons from source sites .....	64
7 Conceptual design .....	78
8 Reflection .....	86
Acknowledgements .....	90
References .....	91
Appendix A .....	95
Appendix B Interview summary .....	96
Appendix C Field visit BES islands .....	98
Appendix D Stakeholder analysis .....	106
Appendix E Goals and objectives .....	116
Appendix F Means-ends diagram .....	122
Appendix G Causal diagrams .....	127
Appendix H System diagrams .....	132
Appendix I Sub-system diagrams Bonaire .....	134
Drinking water quality .....	135
Continuity of drinking water supply .....	137
Protection of water resources .....	139
Energy-efficiency of drinking water supply .....	139
Drinking water monitoring .....	139
Accessibility of drinking water .....	139
Drinking water costs .....	139
Appendix J Sub-system diagrams Saba/Statia .....	142
Rainwater harvesting .....	143
Drinking water monitoring and inspection .....	143
Drinking water quality .....	143
Drinking water continuity .....	147
Drinking water costs .....	149
Energy efficiency .....	149
Appendix L Interview questions field visit US Virgin Islands .....	150
Appendix M Source site lesson drawing .....	152

Appendix N	Integration of lessons with conceptual instruments.....	179
------------	---	-----

## Summary

On October 10 2010, the Country the Netherlands Antilles is going to be dismantled; the individual Antillean islands will get a different status within the Kingdom. Curacao and St Maarten will become autonomous countries within the Kingdom; Bonaire, St Eustatius and Saba (BES) will become Dutch public entities. From the transition date onwards, the responsibility for the supply of drinking water on the BES islands is transferred to the Dutch Ministry of Housing Spatial Planning and the Environment (VROM). In order to be prepared for the status change of the BES islands, the Ministry of VROM has to formulate drinking water policy and inspection programs that will ensure a safe and reliable drinking water supply on the BES islands.

The existing drinking water supply system on the BES islands suffers from a variety of technical, and institutional problems. The Antillean drinking water regulations are currently not fully implemented on the BES islands: drinking water suppliers often lack valid concessions for producing and distributing drinking water. There is no effective drinking water regulatory authority appointed on the individual islands. Drinking water quality inspections are not conducted appropriately on Bonaire, on Saba and St Eustatius drinking water supply systems are not subjected to any form of regulation and inspection.

On Saba and St Eustatius, rainwater is the main source of potable water. The consumption of rainwater can be dangerous since the bacterial composition of rainwater is generally unstable; this can lead to serious health implications.

The BES islands have no proper waste and wastewater treatment systems; this leads to serious quality risks for the surrounding water resources and indirectly for intake water of desalination plants.

The insular conditions and drinking water supply methods on the BES islands deviate strongly from the situation in the Netherlands. There is no specific expertise within the Ministry of VROM on the local drinking water systems on the BES islands. Square-and-ready solution alternatives are therefore not available. Research is necessary to define the necessary technical and institutional instruments that the Ministry can apply to improve the drinking water supply system and prepare the BES islands for the constitutional change. The main research goal and research question for this research study are:

### Research goal

*"Providing the Ministry of VROM with a design for an improved drinking water supply system on the BES islands, consisting of technical and institutional instruments"*

### Main research question

*"What are suitable technical and institutional instruments that can help to improve the drinking water supply system on the BES islands and how do these instruments need to be applied?"*

The methodology that is used for this thesis research project is 'lesson drawing'. This concept is concerned with the process of examining best-practices on one location (source site) with the intention to adapt them in another location (target site). The object of looking at other locations is to learn under what circumstances and to what extend *lessons* from these locations may be effective in your own situation. The starting point for this research project is to define locations that have implemented successful drinking water supply systems under comparable circumstances as on the BES islands. By learning *from* and adaption *of* their experiences, potential instruments are gathered to develop a design for an improved drinking water supply system on the BES islands.



In order to define lessons at other locations, first the problem situation at the BES islands is analyzed using different policy analysis techniques (objectives trees, means-ends analyses, causal relation diagrams) and a stakeholder analysis. The main problem mechanisms, critical stakeholders and the objectives for a new drinking water supply have been integrated in the Basis of Design (BoD); this BoD forms the basis for further lesson drawing processes. The following conclusions are drawn from the system analyses on the BES islands:

Main problem areas regarding the supply of drinking water on the BES islands:

- Organization of an overseas drinking water regulation and inspection authority
- Quality of drinking water on the BES islands
- Continuity of the supply of drinking water on Saba and Statia
- Protection of available water resources on the BES islands
- Accessibility and introduction of public drinking water on Saba and Statia

The following stakeholders are critical for the design process:

*Ministry of Housing Spatial Planning and the Environment (VROM)*

The Ministry of VROM is responsible for the supply of drinking water on the BES islands after the transition date of 10-10-10.

*Inspection authority of the Ministry of VROM (VI)*

The VI is the responsible regulatory and inspection authority for drinking water on the BES islands as delegated by the Ministry of VROM.

*Island governments of the individual BES islands*

The island governments are individually responsible for the realization of drinking water supply facilities on the BES islands. They can appoint local drinking water suppliers and provide them with the necessary concessions.

*Local Health Authorities on the individual BES islands*

The local health authorities on Bonaire will be partly responsible for local drinking water regulation and inspection duties, supervised by the VROM Inspection authority.

In order to define locations for the lesson-drawing research study, a set of selection criteria has been determined based on the local conditions and drinking water supply systems that are available on the BES islands. Since the local conditions and problem areas on the individual BES islands vary, a distinction has been made between Bonaire on the one hand and Saba/Statia on the other hand. Therefore, two sets of selection criteria have been defined, leading to two different sources sites. These are:

- Saint Barth and Saint Martin

The French Caribbean Islands are selected since they have similar conditions and drinking water supply systems as Bonaire. The islands are subjected to the general French drinking water law, including the European directives on drinking water, since the islands are officially part of the European Union (UPG status). The islands used to depend on rainwater and gradually switched to public drinking water.

- US Virgin Islands (USVI)

The US Virgin Islands have similar drinking water supply systems and conditions as Saba and Statia. The USVI are selected as a source site because the drinking water norm levels are high, based on the US Safe Drinking Water Act. Also, specific regulations are implemented

regarding the use and construction of rainwater systems. Rainwater harvesting is a major source of fresh water on the USVI, similar to Saba and Statia.

Lessons have been drawn on the French and US Islands based on structured and exploratory interviews with various stakeholders in the drinking water sector. Interviews have been held with drinking water suppliers, regulatory authorities and local drinking water consumers. The main problem areas on the BES islands formed the starting point for the identification process of potential solution alternatives in the form of technical and institutional lessons. Lessons have been drawn on the following topics:

Saint Barth and Saint Martin:

- Organization of a central overseas drinking water quality inspection system
- Waste management systems that can be used for cooperation with Saba and Statia
- Instruments to prevent cross contamination between rainwater and public water systems

US Virgin Islands:

- Organization of a decentralized overseas regulatory and inspection system
- Regulations and guidelines on the construction and management of rainwater systems
- Negative experiences regarding the introduction of public drinking water
- Instruments to stimulate the consumption of public drinking water above rainwater
- Emergency drinking water strategies

The lessons that have been drawn at the source sites have been adapted for application on the BES islands. Together with the initial instruments from the basis of design, these lessons have been integrated into a set of technical and institutional instruments that can serve as guidelines to improve the existing drinking water supply system on the BES islands. The instruments are gathered in a design, this design provides more information on the instruments themselves and the way these instruments can be applied on the BES islands. The design consists of the following guidelines:

- Modify BES drinking water law

It is recommended to do adjust the new BES drinking water law; it is advised to modify the existing drinking water quality parameters in order to meet the local conditions at the BES islands. Furthermore, specific regulations can be included regarding the distribution of drinking water with trucks. Also, regulations can be included that aim at preventing cross-contamination between rainwater and public drinking water systems.

- Design drinking water regulatory organization for the BES islands

An overseas drinking water regulatory and inspection organization needs to be defined on the BES islands. In order to maintain only a small (permanent) VROM Inspection representation on the BES islands, it is advised to delegate some regulatory and inspection duties to the local health authorities on the BES islands. These duties can be delegated after a fixed training and certification period. The local regulatory authorities can be made locally responsible for the implementation, inspection and enforcement of the new BES drinking water law. Examples of similar decentralized programs have been gathered at the US Virgin Islands.

Drinking water laboratories need to be appointed and accredited for the analysis of drinking water samples. Bonaire is advised to expand its existing laboratory or cooperate with nearby islands (e.g. Curacao, Aruba) to perform drinking water inspection duties. Saba and Statia can establish arrangements with existing laboratories on nearby islands (e.g. St. Maarten).

- Develop solid and liquid waste management systems on the BES islands

Waste and wastewater management plans need to be developed for the three BES islands to reduce the pollution of local water resources (used as input for drinking water plants) and to prevent capacity problems (and therefore unsanitary circumstances) when wastewater loads increase due to the gradual introduction of public drinking water.

It is recommended to define construction guidelines for new domestic wastewater systems on the three BES islands, including design requirements on the capacity and location of these systems. It is advised to collect and treat domestic wastewater from septic tanks and cesspits. For that, wastewater treatment plants are required on all islands; the effluent coming from these plants can be used for agricultural purposes.

- Support correct use and construction of rainwater systems on Saba and Statia

Rainwater is still the main source of drinking water on Saba and Statia, mismanagement and lack of maintenance of rainwater systems can lead to unsanitary situations and water shortages. One solution to prevent these issues is to apply specific construction regulations and management guidelines on rainwater systems. These regulations can include design requirements on the capacity, location and materials of rainwater systems.

- Prepare Saba and Statia for the introduction of public drinking water

Once Saba and Statia have proper wastewater collection and treatment systems, the islands can prepare the introduction of public drinking water as their main source of drinking water (instead of rainwater). In order to support this transition, three elements are necessary: public support from the future consumers, reliable public drinking water supply systems, and enough economic incentives to make drinking water an affordable alternative for unstable rainwater and bottled water. The development and expansion of future drinking water production and distribution systems need to occur gradually, depending on the actual drinking water demand on the islands.

- Sustainable drinking water production

The final (long-term) step is to close the fresh water cycle on the BES islands by generating drinking water from wastewater effluent. In this way, limited amounts of seawater need to be desalinated to maintain a fresh water cycle on the BES islands. This can result in a more sustainable and economic drinking water supply system.



# 1 Introduction

On October 10 2010, the Country the Netherlands Antilles will be dismantled. Curacao and Sint Maarten will proceed as autonomous countries within the Kingdom. The islands of Bonaire, Saint Eustatius and Saba (BES) will become 'public entities' within the Kingdom of the Netherlands<sup>1</sup>. From October 10, the Dutch government instead of the Antillean government is directly responsible for the three BES islands. The existing roles and responsibilities of the former Antillean government will then be transferred to the relevant Dutch ministries.

The main starting point for the transition is that the Antillean legislation will be maintained on the BES islands<sup>2</sup>. Special 'transfer and installation laws' have been developed that are used as frameworks to integrate the former Antillean legislation into the Dutch legislation<sup>3</sup>. The ministry of Housing, Spatial Planning and the Environment (VROM) will be the responsible legislative authority for the supply of drinking water on the BES islands. The legal basis for the production, distribution and supervision of drinking water on Bonaire, St Eustatius and Saba will be the 'BES drinking water law'<sup>4</sup>. This new drinking water law is based on the former Antillean drinking water law<sup>5</sup> and will be adjusted in the coming two years to fit the new constitutional situation<sup>6</sup>. The Island Governments themselves will be responsible for the realization of reliable drinking water infrastructures and systems, assisted by the Ministry of VROM. The VROM Inspection Authority will be responsible for the overall supervision of both the supply and quality of drinking water on the BES islands.

In order to be prepared for the status change of the BES islands, the Ministry of VROM has to formulate drinking water policy and inspection programs that can ensure a safe and reliable drinking water supply on the BES islands.

In 2008, the author conducted a research study on behalf of the Caribbean Water Association into the consequences of the status change for the drinking water sector on the BES islands. This research showed that there are several issues relating the existing drinking water systems on the BES islands that could pose significant risks for the continuity of the water supply and potentially for public health<sup>7</sup>.

The climate and conditions on the BES islands are optimal for *Legionella* bacteria growth; there are however no adequate regulations available on this issue. Another important issue is that the local authorities and the drinking water suppliers both do not comply with the existing Antillean drinking water legislation. As a result of this, the majority of the drinking water companies on the BES islands do not have the necessary concessions for their operations. Next to that, there are no public regulatory authorities that monitor the technical and economic activities of the drinking water suppliers and distributors. Drinking water quality inspection programs are either not executed (Saba and St Eustatius) or they are not sufficient (Bonaire).

The BES islands have no waste management systems or central wastewater treatment systems; massive landfills and private cesspits pose a serious threat to the quality of the surrounding coastal zone waters. These waters are used as input for water desalination plants on the islands. The BES islands each have different drinking water supply systems; Bonaire desalinates seawater and distributes this water via a piped network. The distribution network covers 95% of the island, the houses that are not connected get a weekly supply of drinking water via water trucks. On Saba and Statia the inhabitants collect rainwater from their roofs and store it in underground tanks (cisterns). Since the price-rates of desalinated water are high (5 Euros per cubic meter on Saba and 9 Euros on Statia) and the quality is not consistent<sup>8</sup>, rainwater is the

---

<sup>1</sup> Pechtold, et al., 2005

<sup>2</sup> Nicolai, 2007

<sup>3</sup> MinBZK, 2008

<sup>4</sup> MinVROM, 2009

<sup>5</sup> P.B. No. 72, 2006

<sup>6</sup> MinVROM, 2009

<sup>7</sup> Reijtenbagh, 2008

<sup>8</sup> Reijtenbagh, 2008

main source of potable water for the majority of the population. The microbiological quality of rainwater is however very unstable; when consumed without additional treatment it can lead to serious health implications. The last three years, precipitation rates on the islands have decreased and the inhabitants are frequently forced to buy desalinated or bottled water. The capacity of the local drinking water plants is very limited; inhabitants sometimes have to wait for one week before their water is delivered. The main problem areas focus on the regulation, quality and quantity of drinking water on the BES islands, the specific issues relate to mainly technical, organizational and policy aspects of the existing drinking water supply.

From October 10 2010, the Ministry of VROM is not only responsible for the supply of drinking water in the Netherlands but also in the three Dutch public entities overseas. By adopting the Antillean drinking water regulations into the Dutch legislation, the existing problems on the BES islands will not disappear. On the other hand, the Ministry of VROM cannot simply replicate the Dutch drinking water law on the BES islands; these regulations are not suitable given the local conditions of the BES islands. Therefore, customized and unique instruments need to be defined to tackle the pending issues; existing Antillean regulations need to be adjusted or extended, technical solution alternatives need to be defined and an overseas inspection program needs to be developed. The climate, geography, culture and drinking water supply methods deviate strongly from the situation in the Netherlands. Together with the large distance from the mainland, these are important reasons that there is no specific expertise on these systems with the Ministry of VROM. Square-and-ready solution alternatives are therefore not available. Research is necessary to define the necessary policy, legislation and technical instruments that the Ministry of VROM can apply to improve the drinking water supply system and prepare the BES islands for the constitutional change.

Main research goal

*“Providing the Ministry of VROM with a design for an improved drinking water supply system on the BES islands, consisting of technical and institutional instruments”*

Since there is not enough information on and experience with the specific problem context on the BES islands, the main research challenge of this project is to gather suitable instruments that lead to a new design for an improved drinking water supply system on the BES islands.

The next chapter describes the research methodology that is used for this research project. The main research question is answered by defining 6 sub-questions. The methodology chapter describes these research sub-questions together with the steps that are necessary to answer these questions. Chapter 3 determines the main problem areas, the objectives of the design and the critical actors that are needed to realize this design. Preliminary instruments are determined that can serve as starting point for the final design alternative. Chapter 5 determines locations from where useful instruments can be gathered. Based on a set of selection criteria, two potential locations are selected and a methodology is presented to find the necessary instruments. Chapter 6 provides an overview of the potential lessons that have been gathered on the selected locations from chapter 5. The lessons have been adapted and combined with the preliminary instruments from chapter 4 into an overall design alternative presented in chapter 7.

## 2 Research methodology

### 2.1 Introduction

The previous chapter describes the main goal of this research project. This chapter defines the research methodology that is used for this project to meet this goal.

The Ministry of VROM has been passed on with the legal responsibility for the supply of drinking water on the BES islands. The existing drinking water supply system on the BES islands suffers from technical and institutional problems that need to be resolved once the Dutch Ministry of VROM is formally responsible. This is a specific problem situation for which no technical instruments or policy are readily available. The drinking water systems and problem context on the BES islands differ from the situation in the Netherlands, specific knowledge on these systems are therefore not available within the Ministry of VROM. Solution alternatives need to be defined based on other information sources. One way to define alternative solutions to the existing problem situation on the BES islands is to apply best practices from locations with similar drinking water systems. These best practices need to be adapted for application on the BES islands.

The chapter starts with the definition of the main research goal and research question. In section 2.3, the choice *for* and application *of* the research theories, 'Lesson Drawing' and 'Policy Transfer' will be motivated. Based on the methodology framework presented in section 2.3, sub-research questions have been formulated in section 2.4. The last section describes the step-by-step plan that is applied to answer these sub-questions. The research project is divided into 5 research phases; in each phase one or more research sub questions are taken into consideration.

### 2.2 Main research goal and research question

#### Research goal

*"Providing the Ministry of VROM with a design for an improved drinking water supply system on the BES islands, consisting of technical and institutional instruments"*

#### Main research question

*"What are suitable technical and institutional instruments that can help to improve the drinking water supply system on the BES islands and how do these instruments need to be applied?"*

### 2.3 Learning from the experience of others

Since conventional design alternatives to improve the drinking water supply system on the BES islands are not applicable, other alternatives need to be determined. The situation on the BES islands differs from the situation in the Netherlands and the Ministry of VROM has no particular expertise on these systems. Therefore, alternative locations need to be defined from where information on solution alternatives can be gathered. A reasonable starting point is to define locations that have implemented successful drinking water supply systems under comparable conditions as on the BES islands. By learning *from* and adaption *of* best practices used at other locations with similar circumstances, the right instruments might be gathered to develop a design for an improved drinking water supply system on the BES islands. These instruments can consist of certain policy, technical applications, regulations or institutional settings. In this research project, an instrument can refer to certain legislation, organizational set-up, drinking water distribution technique or any other element that potentially can improve the existing drinking water supply system on the BES islands. The overall design describes how these instruments can be combined and applied to get to a desired situation.



During the last decennium there has been a growing body of literature within political science and international studies that analyzes *policy change* or the processes of examining best practices in one location with the intention to adapt them in another location. The object of looking at these locations is to learn under what circumstances and to what extent these lessons that are effective elsewhere may also work in your own situation<sup>9</sup>. There are mainly 4 classifications of policy change; *policy diffusion*, *policy learning* and *policy transfer*. Policy transfer is often used as an umbrella term for both policy learning and policy transfer.

Policy diffusion is referred to as a form of internal policy transfer; the gradual process of policy convergence between states, regions or provinces<sup>10</sup>. Policy transfer is focused on policy transfer between different political systems<sup>14</sup>. Policy learning describes the process of lesson drawing as a source of policy change; policy learning can take place both across time (past and present) and space (regions, countries)<sup>11</sup>.

Important authors in the field of policy learning and policy transfer are Richard Rose<sup>9</sup> and Dolowitz and Marsh<sup>12</sup>. The latter two are related to the concept of *policy transfer*; Rose coined the concept of *lesson drawing*.

De Jong, Mamadouh and Lalenis<sup>13</sup> describe the concept of borrowing institutional best practices in one country and adapting them in another as '*institutional transplantation*'. They use this term to underline the danger of policy transfer: badly adapted transplantations often fail because the 'host body' rejects the 'new organ' or 'new blood'. "This points out the need to care for the compatibility of the transplant within the new host"<sup>13</sup>. Policy transfer therefore strongly depends on a careful analysis of the relation between the goals of the transfer and the local conditions at the host country.

Both the 'policy transfer' and 'lesson drawing' concepts are applied for this research study, the next sections describe the basic principles of the *lesson drawing* and *policy transfer* theories. Elements of these two theories that are important for this research project are elaborated in more detail.

### 2.3.1 Policy transfer

Dolowitz and Marsh<sup>14</sup> state that 'policy transfer' refers to a process in which knowledge about policies, administrative arrangements and institutions in one time or place is used in the development of policies, administrative arrangements and institutions in another time political system. Dolowitz and Marsh explore the explanations of transfer, the actors involved and the 'artifact' that is transferred. In order to analyze and explain the transfer of ideas or policies between countries, Dolowitz and Marsh formulated a conceptual policy transfer framework. This framework advances the general understanding of the policy transfer process. Dolowitz and Marsh<sup>15</sup> define three types of explanation for policy transfer; they can be seen as points on a continuum instead of discrete categories. These are:

- Voluntary transfer

Policy and decision-makers voluntarily engage in transfer following some level of dissatisfaction with existing domestic policy.

- Direct coercive transfer

---

<sup>9</sup> Rose, 2005

<sup>10</sup> Bennett, 1991

<sup>11</sup> Rose, 1993

<sup>12</sup> Dolowitz and Marsh, 1996

<sup>13</sup> De Jong, et al., 2002

<sup>14</sup> Dolowitz and Marsh, 2000

<sup>15</sup> Dolowitz and Marsh, 1996

This type relates to influence (or force) by an organization, country or supra national body to make another region to adopt a certain policy. An example of this type of 'direct coercive' policy transfer can be the European Union as a *policy pusher* through various directives.

- Indirect coercive transfer

Dolowitz and Marsh suggest that this type of transfer is voluntary but driven by a perceived necessity to change policy. A certain region A might feel obliged to adopt the policy of region B, e.g. because region B is an important market for A's exports

For this research study, the Ministry of VROM is faced with a transition of responsibilities. Due to the constitutional transformation the existing roles and responsibilities concerning the supply of drinking water will change. The reason to apply policy transfer in this particular study is rather voluntary; one could also develop new instruments internally. It is however likely that without the necessary internal expertise this process will be less efficient and potentially less effective than learning from best practices elsewhere.

The definition '*Policy transfer*' suggests that transfer only relates to 'policy'. Dolowitz and Marsh<sup>14</sup> state that in theory anything can be transferred from one political system to another, depending upon the issue or situation involved. Generally the following categories are identified:

- Policy goals/content/instruments
- Institutions
- Ideologies
- Ideas and attitudes
- Negative lessons

### 2.3.2 Lesson drawing

In "*Lesson Drawing in Public Policy*", Rose explores how lessons are drawn through policy-makers' dissatisfaction with the status quo and subsequently decide that a 'programme' elsewhere may be capable of improving the own environment<sup>16</sup>. Rose describes a *programme* as "the set of policy measures that organizes and directs major resources of government (laws, money, personnel, organization) towards identifiable ends". "Programmes combine the 'hardware' and 'software' needed to advance to towards a policy goal<sup>17</sup>. The challenge in lesson drawing is to define the necessary features of a foreign programme in order to create a portable model that transcends it to a national context. A *lesson* is the outcome of learning; it specifies a new programme drawing on knowledge of programmes in other countries dealing with similar types of problems. Lessons have an empirical base, since they are the result of observation and evidence of measures currently in effect elsewhere. The analytic challenge of this methodology is to find out under what circumstances and to what extent a programme that works elsewhere can provide a lesson that works in the own situation. Lessons are therefore not simply replications of existing programmes, they need to be adapted in order to be successful within the national context. A lesson needs to provide a detailed cause and effect description of a set of actions that a government can consider in the light of experience elsewhere, including a prospective evaluation of whether what is done elsewhere could someday become effective in their own situation.

Rose discusses lesson drawing as a source of policy change; he points out that lessons can be drawn across time (i.e. from region A's past experience) and across space (i.e. from other regions)<sup>16</sup>. He suggests that the starting point for policy-lesson drawing is learning from the

---

<sup>16</sup> Rose, 1993

<sup>17</sup> Rogers, 1995

past in one's own region. Then, lessons from other regions are more likely to succeed if the exporting regions:

- Share similar policy conditions (particularly economical conditions)
- Share similar geographical borders
- Share similar ideologies
- Form exemplars with demonstrable expertise

In lesson drawing and policy transfer literature, the concepts of 'source site' and 'target site' are frequently used. Source sites have potentially interesting experiences to offer, and at target sites there is an interest in learning from the experiences elsewhere<sup>18</sup>.

According to Rose<sup>19</sup> the extent of learning from foreign programmes at source sites can vary; the following types of policy learning are distinguished:

- *Complete duplication*: This is mainly possible *within* political systems because of the identity or close similarity of institutions and laws. Copying is more difficult across nations because of differences in culture, language and legislation. The danger for this type of lesson is that if no detailed analysis has been done on the specific lessons and their context at the source site, the risks are high that the lesson might not be correctly implemented at the target site and the transfer will fail<sup>20</sup>.
- *Adaptation*: This is mainly a strategy for nations importing policies from other regions that need to be adapted to the local circumstances.
- Making a *hybrid* from the exporting and importing region; extracting some aspects of an exporting program and applying them internally.
- *Synthesis*, extracting some aspects of one or more exporting programs.
- *Inspiration*; in this case the substance may be less important than the chance it affords for policy makers to see that policies can be successful when they are implemented in the right way. The risk for transfer failure is smaller when lessons are used purely as inspiration; the actual instrument then needs to be defined specifically for application at the target site.

Whereas *policy learning* and *policy transfer* are presented as two different theories, Dolowitz and Marsh state: "We do not think that the difference in nomenclature is overly significant"<sup>21</sup>. The two theories seem to describe the same phenomena, namely the implementation of successful policies and instruments from certain source sites at certain target sites. In this report *policy learning*, *policy transfer* and *lesson learning* are used alternately, the theory intended is however the same. The *policy transfer* theory is used as a practical tool for this research project; elements of this theory are combined with the step-by-step plan of *lesson drawing* defined by Rose (2005). Based on the steps in lesson drawing, research sub-questions have been defined that are derived from the main research question.

## 2.4 Combining policy transfer framework and systems analysis approach

In his book "Learning From Comparative Public Policy. *A practical guide*" Rose describes the steps that need to be taken in order to draw lessons successfully<sup>22</sup>. These steps serve to guide a policymaker from creating awareness for a certain problem at hand into the implementation process of an adapted policy model that is based on foreign programs.

---

<sup>18</sup> Bardach, 2004

<sup>19</sup> Rose, 1993

<sup>20</sup> James and Lodge, 2003

<sup>21</sup> Dolowitz and Marsh, 1996

<sup>22</sup> Rose, 2005

Ten steps in lesson-drawing as formulated by Rose:

- 1 Learn the key concepts of lesson drawing
- 2 Catch the attention of policymakers
- 3 Scan alternatives and decide where to look for lessons
- 4 Learn by going abroad
- 5 Abstract from what you observe a generalized model of how a foreign program works
- 6 Turn the model into a lesson fitting your own national context
- 7 Decide whether the lesson should be adopted
- 8 Decide whether the lesson can be applied
- 9 Simplify the means and ends of a lesson to increase its chances of success
- 10 Evaluate a lesson's outcome prospectively and, if it is adopted, as it evolves over time

The key concepts of the main research methodology, lesson drawing and policy transfer, have been addressed in the previous sections (step 1). The policymaker, in this case the Ministry of VROM, has been made aware of the problem situation by the author (step 2). The sudden jump from step 1 to step 2 seems a little odd. Before addressing a certain problem situation, the problem situation itself also needs to be defined and analyzed. An additional research step seems therefore necessary. The dissatisfaction with the status quo at the target site needs to be determined before steps 2 to 9 can be executed. Although the problem determination procedure is not included in his step-by-step plan, Rose does mention this prerequisite step briefly<sup>23</sup>.

#### 2.4.1 Diagnosis of the problem situation at the target site

Rose states that the first step before initiating the lesson drawing procedure, is to diagnose the cause of the problem at hand. The purpose of this diagnosis is not just to explain the problem but also to prescribe an intervention that will improve conditions<sup>22</sup>. It is however not clear from his literature, how this diagnosis needs to be conducted and what analytical tools need to be used. Some information is provided on how to determine dissatisfaction with the status quo; this procedure is mainly focused on political evaluations of the existing national programmes<sup>24</sup>. Evidence-based evaluations of existing problem situations are determined briefly, this type of problem evaluation compares key indicators from the current situation with previous situations of the same programme. It provides however no analytical procedure on how to perform these evaluations or how to determine key indicators when they are not readily available.

Generally, the first step in the lesson drawing process is not described profoundly. No analytical procedures or tools are provided to determine the cause and context of the dissatisfaction with the existing programme (or problem situation) at the target site. In order to determine the need for lesson drawing, an objective assessment of the problem situation at the target site is crucial. This should help to get a better grip on the context-specific conditions at the target site, which is needed for informed decisions about promising source sites and the lenses through which experiences elsewhere need to be analyzed<sup>25</sup>.

Rose describes clearly how analytic models can be constructed from foreign programmes by tracing the cause-and-effect links between its elements<sup>23</sup>. Similar analytical models can also be constructed from the existing problem situation at the target sites; problem-structuring methods (PSM) can be useful tools to represent the unstructured problem into a simplified model<sup>26</sup>. Converting a complex and unstructured problem into a simplified but accurate model will lead to a better reflection on the problem situation at hand<sup>27</sup>. Next to that, an accurate model of the problem situation at the target site will improve the evaluation process of

---

<sup>23</sup> Rose, 2005

<sup>24</sup> Rose, 1993

<sup>25</sup> Hermans, 2010

<sup>26</sup> Mingers and Rosenhead, 2004

<sup>27</sup> Enserink, Koppenjan, et al., 2003

programmes at other locations. The more accurate the model of the problem situation is, the more fundamental are the solution alternatives<sup>27</sup>. That is, when the content and system boundaries of the problem situation are sharp and the model itself determines both the causes of the existing problem situation and the relevant factors through which these causes can be influenced<sup>28</sup>.

Analytical tools and methods that are helpful to structure problem situations that are generally complex and ill structured are used in the 'systems analysis' approach<sup>29</sup>.

### *Stakeholder analysis*

The 'systems analysis' approach is a useful tool for developing structured models of complex problem situations. The complexity of a given problem situation is not only determined by its internal elements, but is also related to its stakeholder arena. Generally, a given problem situation cannot be considered from the perspective of the problem owner only. The problem owner is frequently dependent of other stakeholders that often have different perspectives, objectives and interests regarding the same problem situation.

The 'systems analysis' approach takes into the cause and effect relations between various factors that together form the *technical* problem description. However, the *institutional* context in which the problem takes place is not fully determined. The systems analysis tool therefore can be complemented with a stakeholder analysis (see section 2.6), taking into account the multi-actor context in which problem situations are embedded. This is particularly useful for situations where no one is wholly in charge, but many are involved, affected or has some partial responsibility to act<sup>30</sup>. In order to identify other important actors that are involved in the problem context, as defined by the problem owner, a systems analysis can be used as a starting point. Stakeholders can be identified by determining these actors who can directly or indirectly influence certain factors within the system. System diagrams, describing the cause and effect relations between the factors within the system boundaries are useful tools for this determination process. Another important method is to define the formal structure of a certain policy field by analyzing relevant legislation and regulations<sup>31</sup>. In this way a first indication of relevant stakeholders is gained. More information on the application of the stakeholder analysis in relation to this research study can be found in section 2.6, phase 2.

#### 2.4.2 Systems analysis approach to determine the problem situation at the target sites

The system analysis approach supports the transformation of ill defined and complex policy fields in a multi-actor environment into a structured model. The structured model can help the analysts to make their own assumptions and expectations explicit. Next to that, the model provides the basis for communication with the client. The systems analysis approach provides several tools that enable the analyst to elaborate quite detailed and comprehensive models of a policy domain<sup>29</sup>. The disadvantage of systems analysis is that it is necessarily incomplete; it cannot take into all considerations that may be relevant<sup>32</sup>. Therefore it is important to carefully determine the system boundaries and scope of the project in order to capture the essential elements of the system at the target site.

The systems analysis approach is based on the analysis of *systems*. A system is described as a part of the reality that is being studied as a result of the existence of a problem or the suspicion thereof<sup>29</sup>. The analyst can clarify this system by translating it into a *system model* that defines its boundaries and structure (main elements and links, flows and relationships among them)<sup>33</sup>.

---

<sup>28</sup> Hoogerwerf, 1987

<sup>29</sup> Enserink, Hermans and Kwakkel, 2009

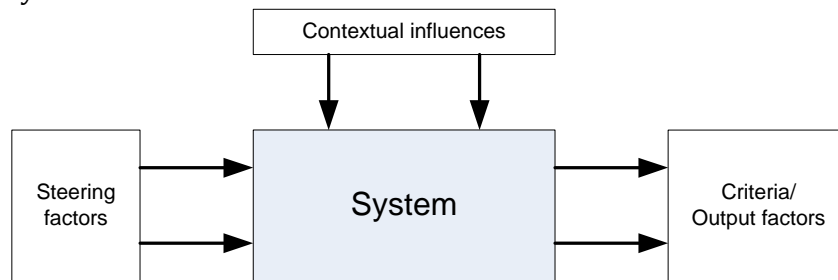
<sup>30</sup> Bryson and Crosby, 1992

<sup>31</sup> Enserink, Koppenjan, et al., 2003

<sup>32</sup> Quade and Miser, 1985

<sup>33</sup> Walker, 2000

The system model consists of three main elements: input, output and contextual influences (see Figure 1). The output of the system diagram is characterized as the *criteria*. In order to overcome the dissatisfaction with the existing problem situation, a desired situation is formulated using objectives. Objectives are measured using criteria, which form the output of the system diagram. The input of the system diagram are steering factors or instruments. These *instruments* are used to influence the system in such a way that the criteria move into the direction of the desired situation. The *contextual influences* or *external factors* are elements from outside the system boundaries, over which the problem owner has no control, that influence the system<sup>29</sup>.





the objectives-tree<sup>34</sup>. In Figure 3 the relationship is shown between the means-ends diagram and the system diagram.

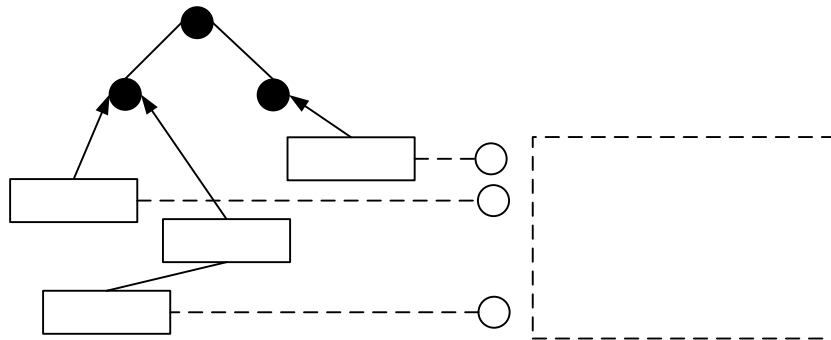


Figure 3 Relation between means-ends and system diagram (Enserink et al., 2009)

### 3. Specify the causal relations between the input, output and external factors in a system diagram

In the previous steps, the input and output of the system model are defined. To clarify the causal relations between the instruments and the objectives and other factors that are relevant to the problem situation, causal relation diagrams are formulated. These causal relation diagrams determine how factors within the system model influence each other. Next to that, the analysis can bring about additional factors over which the problem owner has no control (external factors). Causal relation analyses are usually conducted using the previous system analysis tools complimented with additional literature research or interviews with relevant stakeholders<sup>34</sup>. The causal relations that are mapped in the causal diagram can be structured in a system diagram (see Figure 4). The system diagram provides the analyst with a useful basis for interpretation and/or further analysis, but also with a useful tool to communicate about the essence of his/her findings with the client, fellow analysts, or other actors<sup>35</sup>.

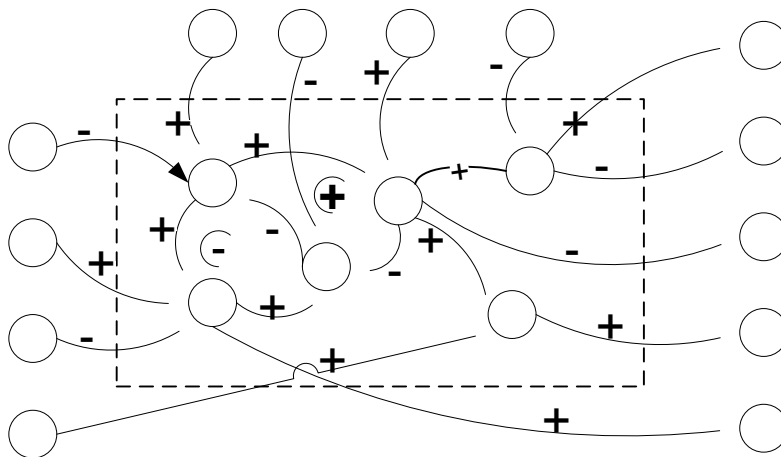


Figure 4 Relation between causal diagram and system diagram (Enserink et al., 2009)

The policy analysis approach that has been described in this section provides enough analytical support to determine the system model of the target site. This model serves as the starting point (or the first step) for the lesson-drawing procedure as described by Rose. The project continues with steps 3 to 9 of the lesson-drawing plan, step 10 is within the scope of this research project. It is however important that the Ministry of VROM reflects on both the process and the

<sup>35</sup> Walker, 2000

effectiveness of the design that eventually is going to be applied. By doing this, other policymakers or successors have the opportunity learn from this particular project and the steps that have been followed. Based on the policy analysis approach and the lesson-drawing methodology, specific research sub-questions have been defined that coincide with the subsequent analyses related to these methodologies.

## 2.5 Research sub-questions

The main research question has been specified into 7 sub-questions. By determining the answer the subsequent set of research sub-questions, the main research questions can be answered. Sub-questions 1 to 3 are necessary to determine the problem situation at the target site. Based on the policy analysis approach, system models are constructed to provide the analyst and problem owner more insight into the boundaries, dynamics and context of the problem situation on the target sites. Questions 1 to 3 guide the analyst in the subsequent policy analyses (objectives analysis, means-ends analysis and causal relations analysis) necessary to define the system diagrams. Question 4 is necessary to determine the stakeholder arena in which the problem situation takes place. An actor analysis is used to identify crucial stakeholders that are relevant for this project. Sub-questions 5 to 7 are inspired on the lesson-drawing framework in section 2.4 and relate to the identification of source sites and the lesson drawing and adaptation methodologies.

The sub-research questions are answered in the relevant research phases; each phase determines the answer to one or more research questions. The research phases are described in the next section.

### Research sub-questions:

- 1 What are the main problems and risks regarding the drinking water supply systems on the BES islands?
- 2 What are the goals and performance criteria for a desired drinking water supply system on the BES islands with respect to the local conditions?
- 3 What are initial instruments that can be applied to meet the formulated performance criteria?
- 4 Who are the stakeholders that are involved in the current and new drinking water supply system?
- 5 What are suitable locations, given the problem areas and the specific insular conditions of the BES islands, from where lessons are likely to be drawn?
- 6 What are potential lessons that can be drawn from these selected locations (source sites)?
- 7 How can the lessons and initial instruments be integrated into an overall design for an improved drinking water supply system?

## 2.6 Research phases

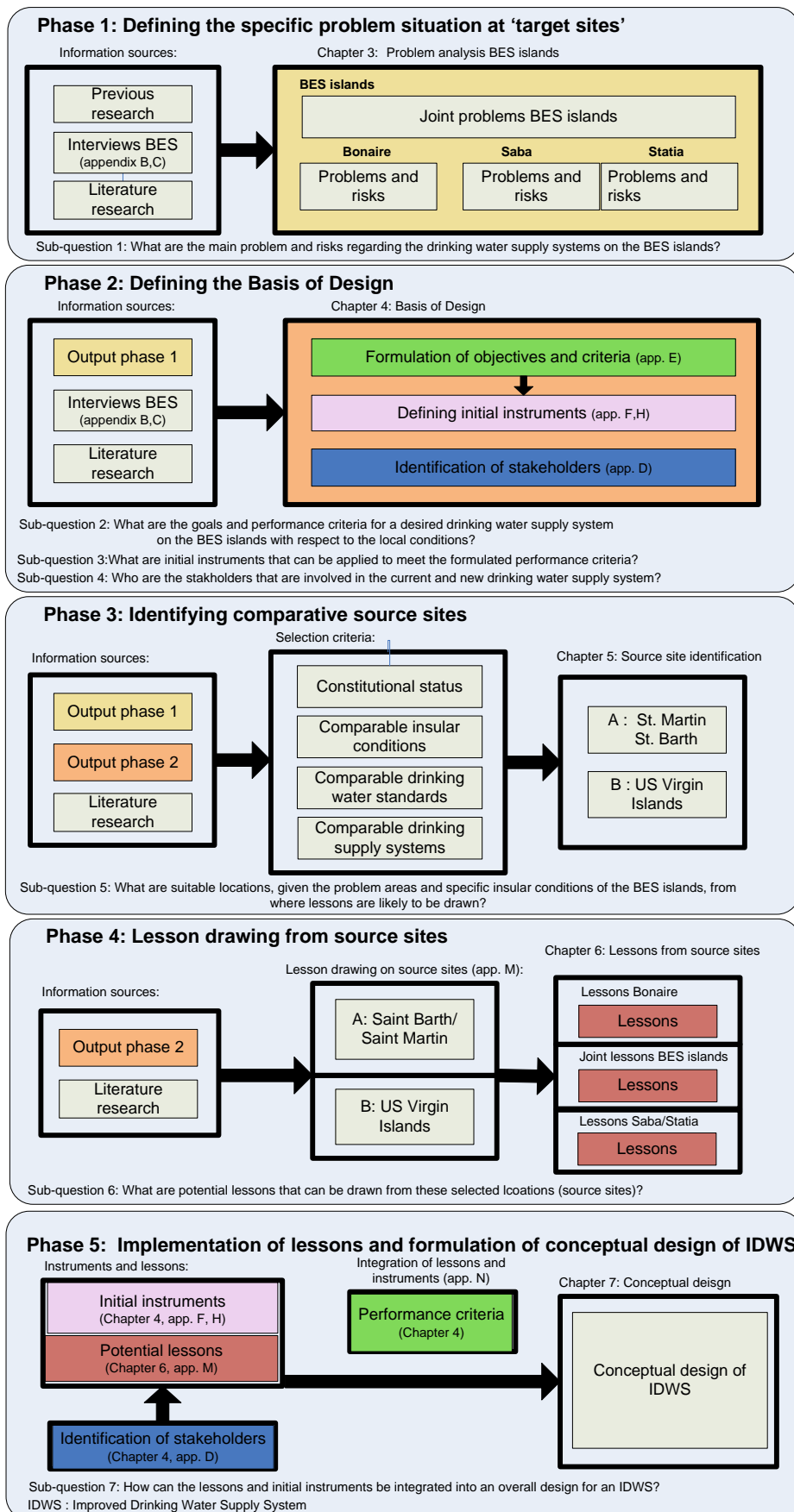


Figure 5 Overview of the subsequent research phases

## Phase 1: Defining the specific problem situation at the target sites

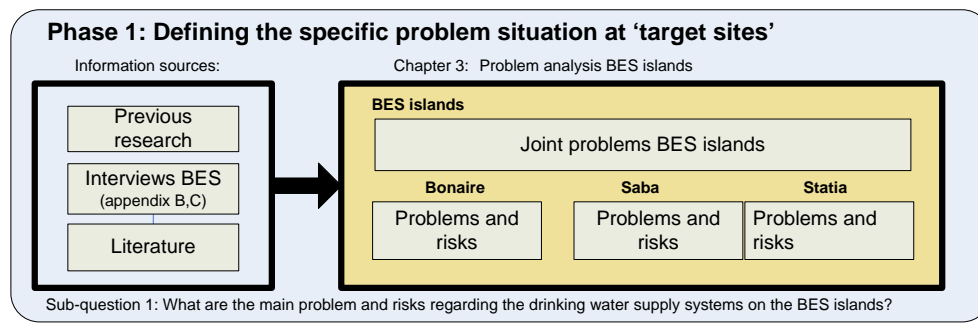


Figure 6 Research phase 1

Research sub-question:

- 1 *What are the main problems and risks regarding the drinking water supply systems on the BES islands?*

The first phase of this study is focused on determining the main problems and risks that can form a potential threat to the drinking water supply systems on the BES islands. A distinction has been made between general issues that apply to the joint BES islands and specific issues that play a role on the individual islands. The information that is necessary to define the problem situation is provided through previous research<sup>36</sup>, interviews with stakeholders on the BES islands and by literature research.

For this research study, two field visits to source sites have been executed (see research phase 3 and 4). The first field visit, to the French Antilles, has been combined with a short visit to the BES islands. During this stopover, a number of exploratory interviews (and unstructured conversations) have been held with stakeholders in the drinking water sector<sup>37</sup>. The goal of these exploratory interviews was to gather more information, from different perspectives, on the problem situation in general. Additional problems and risks have been identified and goals for an improved drinking water system have been determined from the stakeholders' perspective on the BES islands. The outcomes of these interviews have been used to define the problem demarcation in phase 1 and to determine the 'Basis of Design' in phase 2.

## Phase 2: Defining the basis of design

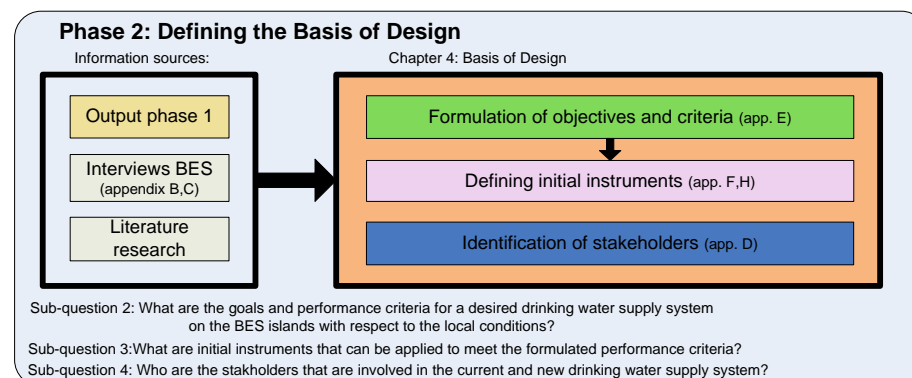


Figure 7 Research phase 2

<sup>36</sup> Reijtenbagh, 2008

<sup>37</sup> in appendix B a table is presented with summaries of these interviews

Research sub-questions:

- 2 What are the goals and performance criteria for a desired drinking water supply system on the BES islands with respect to the local conditions?
- 3 What are initial instruments that can be applied to meet the formulated performance criteria?
- 4 Who are the stakeholders that are involved in the current and new drinking water supply system?

In the previous phase, the main problems and risks concerning the drinking water supply on the BES islands have been determined (sub-question 1). In this phase, the Basis of Design (BoD) is developed for an improved design of the drinking water supply on the BES islands. The basis of design is the starting point for the design process and defines the system boundaries between which design alternatives can be determined<sup>38</sup>. The main element of the BoD is the *system analysis* of the problem situation at the target sites. The system analysis yields the main design criteria, key factors within the system that influence these criteria and initial instruments that can assist in reaching the design criteria.

Besides the system analysis, the BoD also contains a stakeholder analysis. The stakeholder analysis serves as a valuable supplement to system analysis. The system analysis is based on the perspective, interest and instrument of only the problem owner<sup>39</sup>; where the problem situation on the BES islands takes place in a complex multi-actor context. A stakeholder analysis can support the design process by mobilizing knowledge and information from a broad stakeholder base, which is likely to improve the quality of the problem analysis<sup>39</sup>. This is particularly useful for situations where no one is wholly in charge, but many are involved, affected or has some partial responsibility to act<sup>40</sup>. In this research study, the stakeholder analysis is important to define the arena in which potential institutional instruments need to be implemented. A comparison has been made between the stakeholders that are currently involved in the drinking water supply system and the conceptual stakeholders after the constitutional change<sup>41</sup>. The outcome of this analysis are presented using formal charts, these charts describe the formal relations between the involved actors for a particular problem situation. The formal charts are based on the systems analysis and by analyzing the existing and new drinking water law.

The stakeholder analysis focuses on the changing roles and responsibilities within the drinking water sector and how these changes relate to the new institutional organization and the implementation of policy instruments at the target sites.

The Basis of Design (BoD) is determined using several system analysis techniques that have been described in section 2.4.

Through *objectives-trees* (appendix E), the main- and sub-objectives have been defined for the improved drinking water designs on the individual BES islands. These sub-objectives have been translated into quantifiable performance criteria. The necessary data to perform this research step are derived from previous research, literature research and interviews that have been held on the BES islands as part of the field visit to the French Antilles. The next step in this phase is to develop initial instruments that support the objectives of VROM and mitigate the existing problem situation. These instruments are formulated with '*means-ends analyses*' (appendix F) using data from interviews on the BES islands and through previous research. The problem analysis of chapter 3 and the performance criteria and initial instruments from the previous analyses are used to develop '*system diagrams*' (appendix H). These diagrams provide more insight into the system as a whole and determine the effect of the problems and initial

---

<sup>38</sup> Blok-Bockstael, 2005

<sup>39</sup> Enserink, et al., 2009

<sup>40</sup> Bryson and Crosby, 1992

<sup>41</sup> based on the conceptual "BES Drinking Water Law" (MinVROM, 2009)

instruments on the performance criteria. They also provide information on the elements within the system that cannot be influenced: the external factors. The outcomes of the previous analyses are used in chapter 4 to construct the BoD. More information on the methods and contents of the relevant system analyses can be found in appendices E to H.

The system models are used as a starting point for the lesson drawing procedure in chapter 6 (phase 4). Lessons are derived from drinking water supply systems at the source sites in order to serve as instruments for the systems on the target sites. These lessons are derived based on similarities between the system models on the source sites and systems on the target sites. In the next research phase, these source sites are identified based on a predefined selection procedure.

### Phase 3: Identifying comparative sources sites

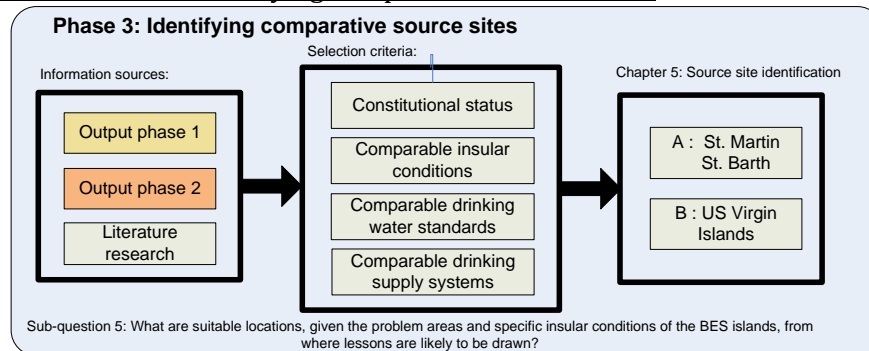


Figure 8 Research phase 3

### Sub-question 5:

- 5 What are suitable locations, given the problem areas and the specific insular conditions of the BES islands, from where lessons are likely to be drawn?

In this research phase, source sites are identified from where lessons will be drawn. This phase is based on step 3 as defined by Rose: "Scan alternatives and decide where to look for lessons"<sup>42</sup>. The problems analysis in chapter 3 shows that the individual supply systems on the BES islands are not similar; the problems and insular conditions vary per island. In order to gather lessons for the islands individually, locations need to be identified that function as source sites for the target sites (BES islands). Source sites need to be identified that have predetermined similarities with the individual BES islands *and* at the same time maintain higher-quality drinking water supply systems. A set of selection criteria has been defined that is used to identify and select potential source sites. In this way, two source sites are identified: the US Virgin Islands and the French islands of St Martin and St Barth. The French islands show mainly similarities with the specific conditions on Bonaire, the US Virgin Islands show similarities with both Bonaire and Saba/Statia.

The next step is to gather lessons at these source sites; the methodology to execute this procedure is described in the next research phase.

<sup>42</sup> Rose, 1993

#### Phase 4: Lesson drawing from source sites

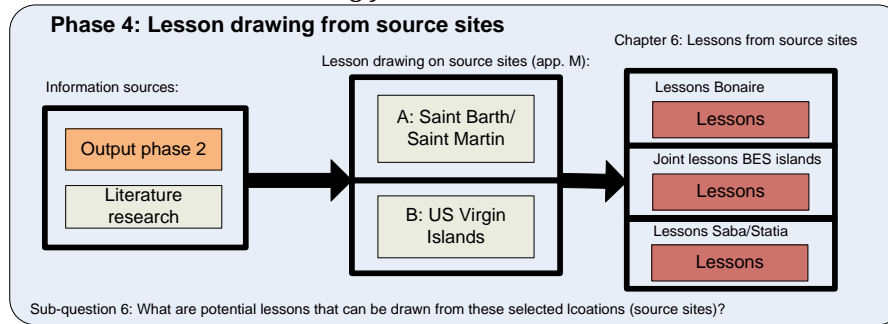


Figure 9 Research phase 4

#### Sub-question 6:

#### 6 What are potential lessons that can be drawn from these selected locations?

In the previous phases the problem situation concerning the water supply system at the target sites has been defined. The next steps are to go abroad and explore the drinking water systems at the source site. These are steps 5 and 6 in the framework of Rose: "Learn by going abroad" and "Abstract from what you observe a generalized model of how a foreign programme works"<sup>43</sup>. The drinking water supply system and its institutional context are analyzed using interviews and literature research. Once the programmes at the source sites have been analyzed, the challenge is to define the necessary features of these foreign programme in order to create a portable model that transcends its national context"<sup>44</sup>. The model forms the precondition for the lesson-drawing procedure and determines the quality of the lessons drawn. The model of a foreign programme (or system) is a generic description of how the programme works. The purpose of making a model is to describe the programme sufficiently in terms of laws and regulations, responsible organizations, inputs and outputs. The model must be comprehensive in order to direct attention towards all the elements that are necessary for a programme to operate and at the same time leave out the non-essential elements<sup>44</sup>.

The next step in this research phase is to extract lessons from the models that have been developed of the foreign programmes. Lessons are practical and descriptive outlines of the means and ends of foreign policies. Lessons identify the regulations, appropriations and organizational requirements that are essential to make a certain programme work<sup>44</sup>. The challenge is to draw a lesson that specific information to develop a programme that can achieve similar effects (or avoid similar disaster) as on the source site. These lessons are ultimately used as instrument in the system model from chapter 4. A distinction has been made between lessons that apply for the BES islands in general and particular lessons that apply for a specific island<sup>45</sup>.

The next research phase combines the lessons drawn at the source sites with the initial instruments (yielded at the target sites) from phase 2 into an overall design for an improved drinking water supply system in chapter 7.

<sup>43</sup> Rose, 1993

<sup>44</sup> Rose, 2005

<sup>45</sup> For this research project, this also means that step 7 of the framework by Rose is taken: lessons have only been drawn at the source site when they seemed to be suitable for application at the target sites.

*Phase 5: Implementation of lessons and formulation of a conceptual design*

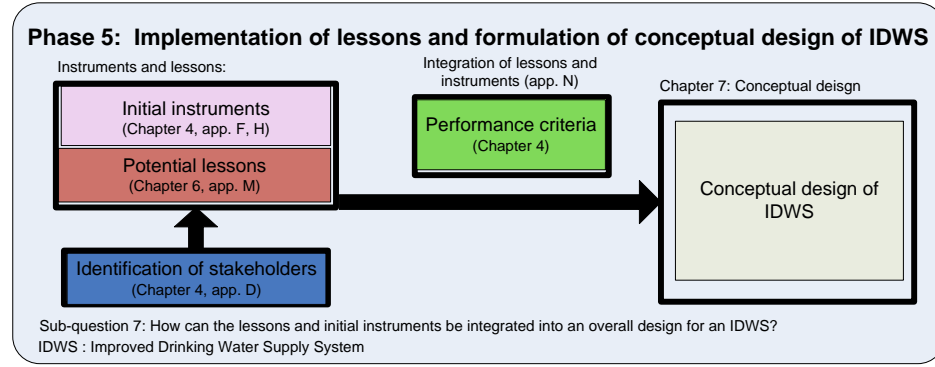


Figure 10 Research phase 5

Sub-question 7:

- 7 How can the lessons and initial instruments be integrated into an overall design for an improved drinking water supply system?

The last phase uses the lessons and initial instruments from the previous research phases to develop a design for an improved drinking water supply system. This corresponds generally to steps 6 to 9 of the framework by Rose. Step 7 (“Decide whether the lesson can be adapted”) is indirectly executed in the previous research phase.

The lessons that are derived from the source sites are tested on the performance criteria in the system models from phase 2. Lessons are only adapted when they support the objectives for an improved drinking water supply system, that is when the lessons have a positive influence on at least one of the performance criteria.

The next step is to adapt the lessons to fit the context of the target sites and to identify the stakeholders who are likely to be involved in the implementation process. The critical stakeholders have been identified in chapter 4. Finally, the lessons (now adapted to instruments) and the initial instruments are integrated into the final design. During the integration procedure lessons and initial instruments are combined or, when this is necessary, replaced by one another. The final design describes the process of how and to what extend these instruments need to be applied in order to improve the existing drinking water supply system on the BES islands.



### 3 Problem analysis

#### 3.1 Introduction

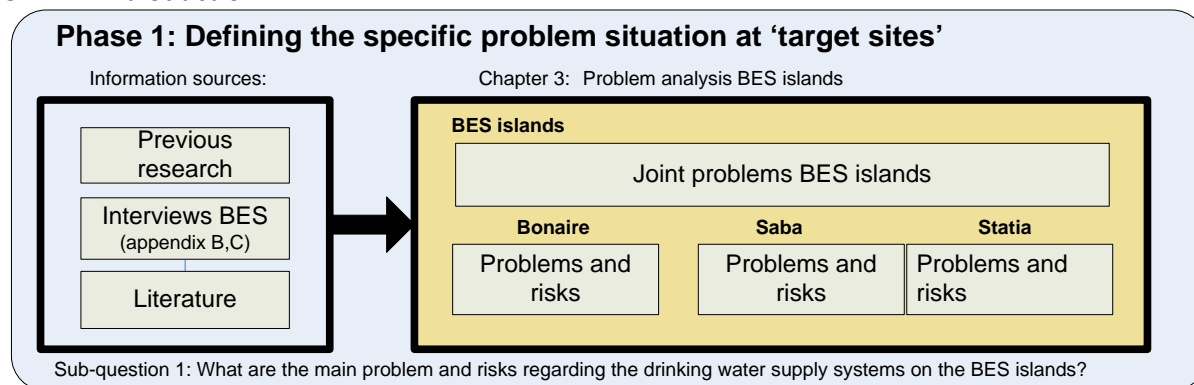


Figure 11 Research phase 1

This chapter defines the problem context of this research project; information is provided on the main problems and risks that are currently forming a threat to the overall drinking water supply system on the BES islands. The problem analysis provides the answer to research sub-question 1 and points out the need to develop a design for an improved drinking water supply system. This design is presented in chapter 7 and contains a set of instruments that are likely to mitigate the problems and risks that are identified in this chapter. The problem analysis is based on previous research<sup>46</sup> and exploratory interviews held on the BES islands<sup>47</sup>. Additional literature research has been conducted on specific problem areas such as 'legionellosis' and the use of rainwater harvesting on Saba and St. Eustatius.

This chapter starts with a short explanation of the constitutional reformation of the BES islands. Next, an overview is provided of the technical and institutional aspects of the existing drinking water supply systems of the individual islands. Section 3.4 describes general problem areas for the joint BES islands. In section 3.5 two summarizing tables are presented, providing an overview of the properties of the individual drinking water systems and the problem analyses in this chapter.

#### 3.2 Constitutional reformation of the Netherlands Antilles

The Kingdom of the Netherlands currently consists of three countries: the Netherlands, the Netherlands Antilles and Aruba (Figure 12). On the Netherlands Antilles, there are two governing layers, the 'Landsregering' (Government of the Antilles) and the five 'Eilandsbesturen' (Island Governing Bodies). The government of the Antilles is established in Willemstad on the island of Curacao<sup>48</sup>.

The inhabitants of the Netherlands Antillean islands have chosen by referenda in 2006 for the islands to remain part of the Kingdom. Curacao and St Maarten both opted for a position as



Figure 12 Netherlands Antilles

<sup>46</sup> Reijtenbagh, 2008

<sup>47</sup> An overview of these interviews is provided in appendix B, the interviews themselves can be found in an external appendix. More detailed information on the specific problem contexts of the BES islands can be found in appendix C.

<sup>48</sup> <http://www.minbzk.nl/onderwerpen/de-nederlandse/algemene-informatie> Visited on June 2009

autonomous countries within the Kingdom. Bonaire, Saba and St Eustatius choose for more intensive ties with the Netherlands<sup>49</sup>. With this outcome, all islands together choose for a general dismantling of the “Country the Netherlands Antilles”.

The islands that have voluntarily chosen for a permanent association with the Netherlands are referred to as the ‘BES islands’ (Bonaire, St Eustatius and Saba). These three islands will get the status of ‘public entities’ within the Netherlands’ constitution<sup>50</sup>.

The Country the Netherlands Antilles currently has the status of ‘LGO’ (Overseas Countries and Territories) within the Kingdom. After the reformation process, the individual BES islands remain the LGO status<sup>51</sup>. With this status, the BES islands do not form part of the European Union and are therefore also not subjected to European guidelines. The European drinking water directives do not have to be implemented within the new legal system.

Once the BES islands have been separated from the Netherlands Antilles, the Antillean legislation is not valid anymore. The BES islands are not part of the Netherlands Antilles are then *public entities* within the Kingdom. The “Slotverklaring” signed by the political leaders of the Netherlands and the Netherlands Antilles on October 11<sup>th</sup> 2006, states that one of the starting points of the constitutional reformation is to maintain the *content* of the existing Antillean legislation. When necessary or desirable, elements of the Antillean law or regulations can be adjusted<sup>52</sup>.

In the new situation as *public entities*, the existing Antillean drinking water legislation is adopted and forms the basis for the new ‘BES drinking water law’ that is embedded in the Dutch legislation. This is the new drinking water law for the BES islands, formulated and enforced by the Ministry of VROM from October 10 2010. In order to safeguard the supply of drinking water on the BES islands, some elements of the original legislation and regulations will be changed. Some elements in the final design of this report describe additional regulations or adjustments of the existing regulations. Due to the legal acceptance and implementation trajectories, any adjustments in the existing law or regulations that will be made in the BES Drinking Water Law are not valid until 2012.

## Drinking water supply system on the BES islands

### 3.3 Bonaire



Figure 13 Seawater desalination plant on Bonaire

Bonaire is one of the 5 islands territories of the Netherlands Antilles. It consists of the main island of Bonaire and the uninhabited islet of Klein Bonaire. Together with Aruba and Curacao it forms a group referred to as the ‘ABC islands’, the southern island chain of the Lesser Antilles<sup>53</sup>. Bonaire has a surface area of approximately 288 km<sup>2</sup> with a population of circa 15.000 inhabitants; the capital of Bonaire is Kralendijk (see Figure 12). The main languages on the islands are Papiamentu and Dutch.

#### 3.3.1 Drinking water supply

The main source of drinking water on Bonaire is desalinated seawater. Drinking water is produced using SWRO (Seawater Reverse

<sup>49</sup> Pechtold, et al. 2005

<sup>50</sup> Nicolai, et al., 2007

<sup>51</sup> MinBZK, 2008

<sup>52</sup> Nicolai, Booij and Hooker, 2006

<sup>53</sup> <http://en.wikipedia.org/wiki/Bonaire>

Osmosis) filtration systems (see Figure 13). WEB NV, the local utilities company on Bonaire, is the main drinking water supplier on the island. The production of drinking water is outsourced by WEB NV to a private party (General Electric). WEB NV remains responsible for the production, post treatment and distribution of drinking water. Next to that, the Antillean drinking water legislation prescribes that WEB NV needs to perform an internal quality inspection program.

The desalinated water that is produced by General Electric is buffered in large storage tanks and subsequently distributed on the island via a piped network. The majority of the households on Bonaire, about 95%, are connected to the communal drinking water distribution system. The other 5% of the households can order drinking water that is delivered by WEB NV with water trucks. The price of drinking water on Bonaire is 2,50 Euros per cubic meter<sup>54</sup>.

The drinking water distribution infrastructure is public property; the SWRO production units are leased by WEB NV from General Electric.



Figure 14 Drinking water bags at Plaza Resort Bonaire

Besides the main public drinking water company, there are several private drinking water producers on the island. There are four tourist accommodations having private drinking water facilities on Bonaire<sup>55</sup>. The production and supply of drinking water is outsourced to two private parties, Veolia and Desalpro. They both serve these four tourist accommodations and provide them with desalinated water using SWRO techniques. The reason for these resorts to supply drinking water internally instead of using the public drinking water supply is usually because of economical considerations<sup>56</sup>; it is

cheaper for resorts to produce their own drinking water. Another reason is that the quality of the public drinking water is sometimes unstable; the distribution pressure varies and the color of the water is sometimes brown.

### 3.3.2 Inspection and regulation of drinking water on Bonaire

The main regulatory authority for drinking water on the BES islands is the Antillean Public Health Inspection Authority. This organization is located in Willemstad (Curacao) and has delegated its regulatory authorities to the Public Health Authority on Bonaire ("Dienst Gezondheid en Hygiene" or DGH). The DGH performs an external drinking water quality program; the inspectors of the DGH take samples from the public drinking water network and all private drinking water companies. These water samples are subsequently distributed to a laboratory in Curacao for analysis. At this laboratory, the samples are subjected to both chemical and bacteriological analyses to determine the overall water quality.

Drinking water producers are legally required to execute internal drinking water quality programs that analyze a limited set of basic quality parameters.

When drinking water samples from either internal or external drinking water quality programs are not compliant with the legal quality requirements, the DGH is informed. The DGH informs the drinking water producers and makes a public announcement on this event.

---

<sup>54</sup> Reijtenbagh, 2008

<sup>55</sup> Domacasse, interview #1

<sup>56</sup> van de Weteringe-Buijs, interview #5

### *Long process times of quality sample analyses*

An important aspect of the current drinking water quality-monitoring program is the external inspection of drinking water samples. The logistic process of shipping water samples to the “General Diagnostic Laboratory” in Curacao is not always efficient. The total process time between sampling and receiving the analysis results varies between 5 and 7 days (see Figure 15). When water samples would be analyzed in a laboratory on Bonaire, the total process time is estimated to be less than 24 hours (the legal requirement)<sup>57</sup>. Drinking water producers and distributors need to be aware of drinking water quality deviations on a timely basis in order to prevent potential public health implications.

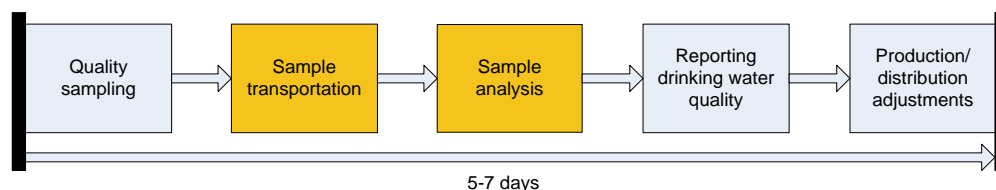


Figure 15 Quality control processes Bonaire

### *Limited quality inspection program*

Drinking water producers conduct limited inspection programs at their production sites, these include a limited set of basic quality parameters (see blue triangles in Figure 16). The drinking water inspection authority conducts external inspection programs at both the production sites and at the distribution networks (see red triangles); water quality samples are conducted twice per week<sup>58</sup>. The scope of the external drinking water quality inspection program is rather limited and needs to be updated to get a more representative overview of the chemical and bacterial composition of drinking water on the island<sup>58</sup>. No external inspection samples are taken from intake water at drinking water plants, while this is legally required<sup>59</sup>. Next to that, the conditions on the BES islands are optimal for harmful bacteria growth within the distribution systems (legionellosis). Risk analyses need to be conducted to determine ‘vulnerable’ locations within the drinking water supply system. These are usually locations within the distribution systems that are exposed to high temperatures and stagnant water volumes. In Figure 16, one crucial location where currently no samples are taken is marked with an exclamation mark.

In general, the existing drinking water quality inspection programs need to be updated; the sampling frequencies and the sampling locations are currently not sufficient or representative and need to be redefined<sup>60</sup>.

The problems related to the quality-sampling process in Figure 15 and the quality inspection programs (Figure 16) result in a decreased awareness of potential water quality problems. When there is no timely awareness of potential water quality deviations, health authorities and drinking water companies risk the chance that potentially unsafe water is considered potable.

### *No external regulation of drinking water suppliers*

The Antillean Ministry of Public Health is the official regulatory authority for supervision of drinking water suppliers on Bonaire. However, the Antillean Ministry has never delegated her regulatory duties to local authorities on Bonaire. Currently, there is no economic regulation or supervision of drinking water production and distribution rates.

<sup>57</sup> Reijtenbagh, 2008

<sup>58</sup> Domacasse, Martina, interviews #1 and #3

<sup>59</sup> P.B. No. 37, *Landsbesluit Kwaliteit Drinkwater*, Willemstad, 2006.

<sup>60</sup> Van de Weteringe-Buijs, interview #5



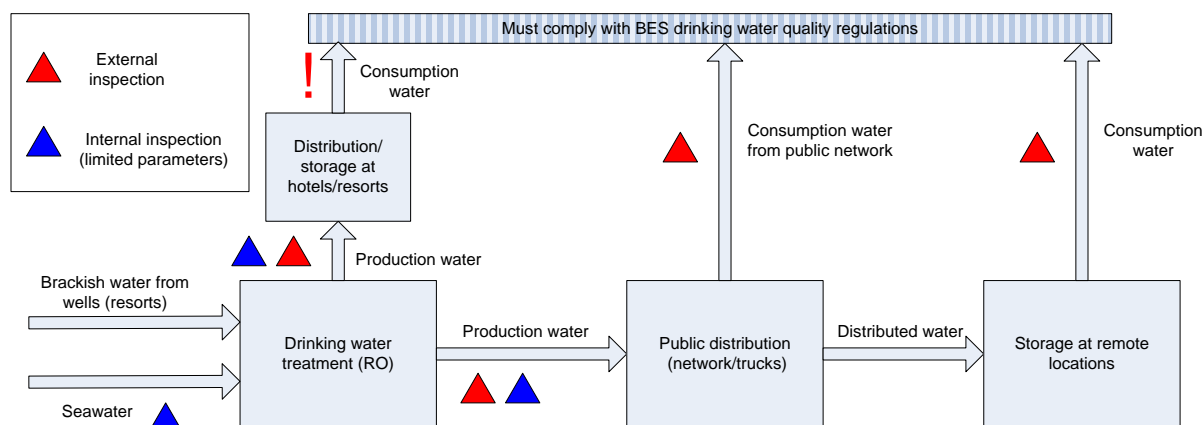


Figure 16 Quality inspection locations on Bonaire

There is no enforcement of the Antillean drinking water legislation. Drinking water suppliers are not regulated; many suppliers maintain their own operating procedures and often have no valid concessions for the production or distribution of drinking water.

### 3.4 Saba and St Eustatius

Saba and St Eustatius have almost identical drinking water supply systems and therefore share many similar problems and risks. This section provides information on the drinking water supply systems on the individual islands and their specific problems. The next sections provide more information on the joint aspects and problems of Saba and Statia.

#### 3.4.1 Saba

Saba is the smallest island of the Netherlands Antilles. It consists largely of the dormant volcano, Mount Scenery (877 m), the highest point of the Kingdom of the Netherlands. Saba has a land area of 13 km<sup>2</sup>. The total population counts approximately 1500 inhabitants. The largest villages on the island are, The Bottom, Windwardside, Hell's Gate and St. Johns. Despite the island's Dutch affiliation, English is the principal language spoken on the island.



Figure 17 Public rainwater catchment on Saba

#### Drinking water supply system

Saba has a very limited drinking water supply system; there is no public drinking water producer and no distribution network. Two private companies produce and distribute drinking water on the island; they both operate their systems with expired (not valid) concessions from the island government<sup>61</sup>. The private drinking water production systems have limited production capacities and mainly provide water to the local hospital, Medical University, the home of the elderly and student dorms<sup>62</sup>. The majority of the population on the islands depends on rainwater as their primary source of fresh water. Only when there is not enough rainwater

<sup>61</sup> Reijtenbagh, 2008

<sup>62</sup> Johnson and Zagers, interview #9

available, desalinated drinking water is ordered from one of the two private drinking water producers. Drinking water is distributed by the same private companies with the use of water trucks. The costs for drinking are approximately 5 Euros per cubic meter, the additional distribution fee varies between 20 to 40 Euros per truckload of water. Since the production capacity of the private production facilities is limited, the waiting time for drinking water can run up to 7 days<sup>63</sup>.

Besides the private rainwater systems, the island government of Saba maintains a large public rainwater cistern and accompanying catchment area (see Figure 17). This public cistern system is used for the island's fire hydrant system and as an emergency drinking water provision for the island's hospital.

### 3.4.2 St Eustatius

Sint Eustatius (Statia) is part of the Leeward Islands, located southeast from Saba. Sint Eustatius has a total land surface of 21 km<sup>2</sup>, and the capital is Oranjestad. In 2001, the population counted 2,292 inhabitants<sup>64</sup>.



Figure 18 Dormant volcano "The Quill" on Statia

### Drinking water supply

Statia has a public drinking water plant with a limited distribution network. The government of Statia granted the local public utilities company (GEBE NV) with a concession to operate the public drinking water plant and distribution system. This concession has been outdated for several years already. Drinking water is distributed via a very small distribution network; the network consists of 6 connections (mainly tourist accommodations) next to the drinking water



Figure 19 Water distribution pipe on Statia

plant. Drinking water is therefore mainly distributed with water trucks (Figure 19); the trucks are property of the island government. The concession to distribute drinking water with these trucks is granted to a private party.

The price for a cubic meter of drinking water (including the distribution fee) is currently 9,15 Euros. Desalinated drinking water is mainly distributed to public facilities and tourist accommodations; the majority of the local population uses rainwater as their primary source of fresh water.

Private homeowners typically only order desalinated drinking water when their main supply of rainwater runs dry. During periods with less rainfall, the capacity of the public drinking water plant is not sufficient to provide the population with enough drinking water. The waiting time for drinking water can sometimes run up to a week. Usually drinking

water is stored in the same tanks in which rainwater is collected. Drinking water that is mixed with

<sup>63</sup> Hassell and Johnson, interview #12

<sup>64</sup> <http://en.wikipedia.org/wiki/Statia>

rainwater does not necessarily meet the legal quality parameters for drinking water anymore. This can be a risk for public health of the consumers<sup>65</sup>.

#### *Extension of the distribution network*

The local government has the intention to extend the existing drinking water distribution network. Through this extension around 70-80% of the houses on the island will be connected to the main drinking water network. This project is still being developed; it is expected to be finished before 2012<sup>66</sup>.

It is unknown if the future users of this new infrastructure will consume enough drinking water to guarantee a continuous flow in the network. It is known that people tend to cling on their existing rainwater systems (as was the case on Bonaire and St Maarten) even when they have a public drinking water connection. When people only consume water when their rainwater tanks are empty the consumption pattern will be low and stagnant volumes of water can appear in the network. The quality of stagnant drinking water can deteriorate easily in relative high-temperature surroundings; this can be a risk for public health<sup>66</sup>.

#### *Integration of rainwater systems with public distribution network*

When households are connected to the new drinking water network, it is crucial that households do not mix clean drinking water from the network with their own cistern water. This can happen when households cross-connect their new water connection with their rainwater reservoir. Physical separation of the distribution network from the private cistern systems or implementation of filtration systems at the water tap is therefore necessary<sup>67</sup>. Guidelines to prevent cross-connection and therefore contamination need to be drafted for the new situation.

### 3.4.3 Inspection and regulation of drinking water on Saba and Statia

There are no regulatory authorities for the supply of drinking water active on Saba and Statia. Although the regulatory duties are officially delegated to the local Public Health Authorities, inspection and supervision duties are not performed. The main reason is that there is no capacity, equipment and knowledge on the islands<sup>68</sup>.

The public drinking water producer on Statia (GEBE NV) conducts a limited drinking water quality program; the frequency of this sampling program is not sufficient to monitor the actual daily drinking water quality (samples are not taken on a daily basis). One of the reasons that quality inspections are not conducted in accordance with the official regulations is that Statia has no drinking water laboratory; the producer therefore needs to transport samples to a laboratory on St Maarten<sup>68</sup>.

An overview of the water quality inspection programs on Statia and Saba is given in Figure 20. Since there are no external inspection programs, only the internal monitoring program is indicated on Statia (with blue triangles).

Locations indicated with red exclamation marks are critical; at these locations the water is considered to be suitable for human consumption. The first two exclamation marks on the left represent locations that officially need to be inspected by the regulatory authorities. This is drinking water coming from the production plant and from the drinking water trucks. Currently, the drinking water trucks are not subjected to any form of inspection. The hygienic circumstances of the water distribution trucks are doubtful; the trucks are also used for other types of water and it is not clear whether the tanks are disinfected<sup>69</sup>.

The third exclamation mark from the right indicates the location where pure drinking water and rainwater are mixed (in cisterns). This water is assumed to be suitable for human consumption,

---

<sup>65</sup> Reijtenbagh, 2008

<sup>66</sup> Dijkshoorn, interview #8

<sup>67</sup> Gittens, interview #7

<sup>68</sup> Reijtenbagh, 2008

<sup>69</sup> Hassell and Johnson, interview #12

but since the drinking water is mixed with unstable rainwater the quality is now unknown. This location is not subjected to external drinking water quality inspections; once drinking water is distributed to the house this is the responsibility of the consumer. The same applies for the first exclamation mark from the right; homeowners that apply disinfection treatments to their rainwater are themselves responsible for drinking water quality inspections.

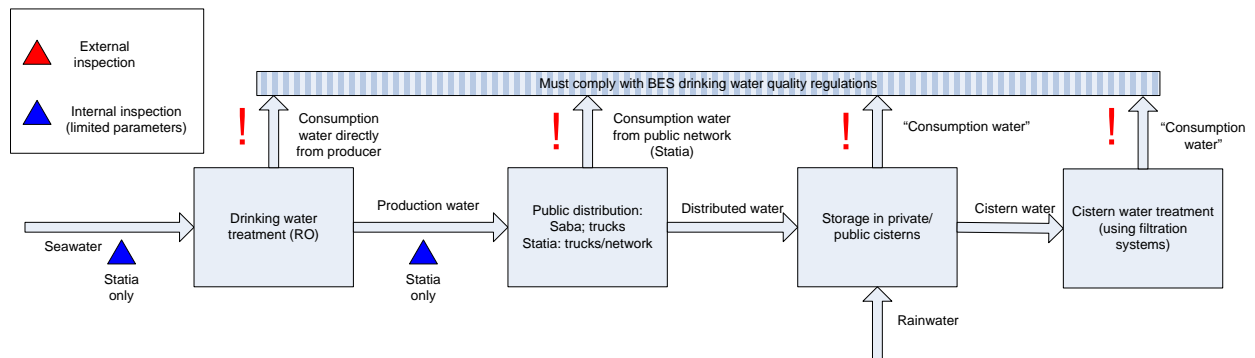


Figure 20 Drinking water quality control Statia and Saba

### 3.4.4 Problems with rainwater harvesting on Saba and Statia

Although there are drinking water plants available on the islands, the majority of the traditional population collects and consumes rainwater. Rainwater harvesting is a principle that has been used on the islands for centuries, it is therefore part of the local culture. The system is simple and does not require expensive components. Rainwater is the main source of fresh water and is used for human consumption, washing and cleaning. Next to that, rainwater systems form the main lifeline for the population during natural disasters (see next section).

Houses on Saba and St Eustatius are constructed to support the collection of rainwater. In the foundation of a typical house there are usually multiple cavities that are used for storing rainwater (Figure 22). The roof functions as a catchment area for the rainwater system; precipitation is transported via gutters and rain pipes into the internal basins (cisterns). Some older houses have external cisterns usually made of brickwork. These structures are placed next to the house in the garden and can be recognized by a large rounded-off concrete slab that functions as the catchment area (see Figure 21). Gutters



Figure 21 Traditional rainwater cistern on Saba

and pipes from other buildings are connected to the external cisterns. A manhole cover is placed on top to inspect and maintain the inside of the cistern. This hatch is also used to disinfect the rainwater. Local users typically use chlorine tablets or guppies to keep the water safe and potable. Chlorine is dosed to extinguish all forms of microbiological activity in the water. The guppies are used to eat mosquito-larvae, one of the sources microbiological contaminations<sup>70</sup>. There are two types of issues regarding rainwater harvesting, water quality and water quantity problems.

<sup>70</sup> Reijtenbagh, 2008



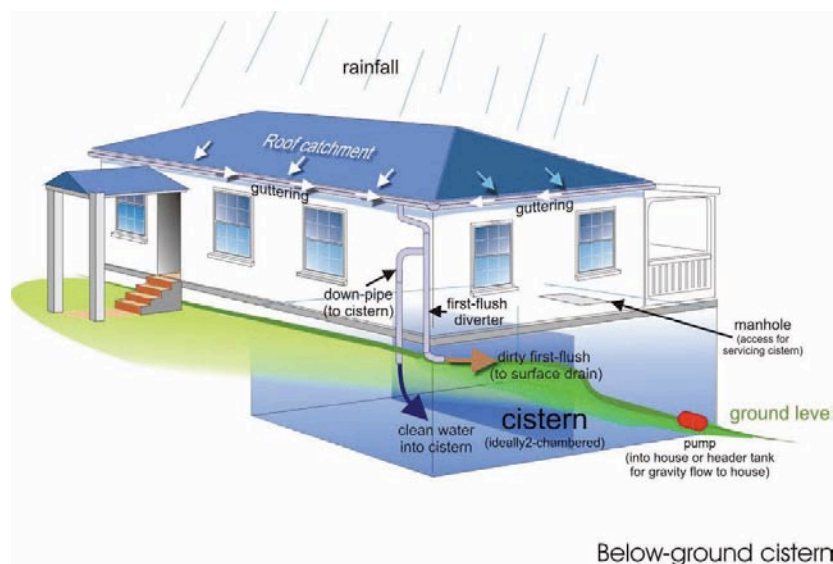


Figure 22 Integrated rainwater system in modern house

### *Water quantity issues*

The average precipitation in the northern Caribbean region is high, on average 1100 millimeters per year. In theory this is sufficient to provide the population of Saba and Statia with enough drinking water. During the last years, there seems to be less rainwater available for potable use. One reason for this might be changing weather patterns. The rainy season is getting shorter and is characterized by more intensive periods of precipitation<sup>71</sup>. Another reason might be that inhabitants of the islands consume more rainwater than before. In the last decade modern household equipment (dishwashers, washing machines, flush-toilets) was introduced on the islands; these are typically large water consumers. The traditional cisterns are not dimensioned to keep up with the increasing consumption patterns<sup>72</sup>.

### *Quality issues*

Rainwater harvesting also suffers from quality problems; recent analyses of rainwater samples from private cisterns show excessive levels of total coliform, e-coli-form, enterococci and total plate count values<sup>73</sup> (see also appendix A). The indicated values exceed minimum WHO quality guidelines for potable water and can therefore lead to serious health problems.

Inhabitants of Saba and Statia who frequently consume untreated rainwater sometimes suffer from gastric disorders<sup>72</sup>, these might be caused by the 'helicobacter pylori' bacterium. This bacterium is mainly responsible for stomach ulcers<sup>74</sup>. The microbiological composition of rainwater is usually very unstable and *can* be harmful for public health<sup>70</sup>. One explanation for this is because rainwater-harvesting systems are typically vulnerable to external sources of pollution. Animal (iguana's, goats, birds) excrements are an important source of rainwater contamination. Particles carrying bacteria and viruses float through the air onto roofing materials via gutters and pipes into the cisterns.

Another important source of pollution is human fecal contamination; sources of fecal bacteria can be found everywhere on the island in the form of open street sewers and wastewater infiltration systems. The main problem is that there are no collective sewer systems on the BES islands; most of the villages have open street sewers, many households have private septic tanks or infiltration tanks<sup>70</sup>. The fecal contamination problem is mainly related to the location of these wastewater systems relative to the rainwater cistern. When wastewater infiltration tanks or open street sewers are located close to cisterns, bacteria and viruses can percolate through

<sup>71</sup> Zagers, interview #10

<sup>72</sup> Hassell and Johnson, interview #12

<sup>73</sup> Reijtenbagh, 2008

<sup>74</sup> Koot, interview #11

the walls and plaster into the cistern. There is no minimal distance defined between wastewater systems and cisterns, also no regulations are available that define the materials that need to be used to seal cisterns.

Both animal and human fecal contaminated water can cause serious health implications<sup>75</sup>. Therefore, treatment of the rainwater is highly recommended before consumption<sup>76</sup>.

### 3.4.5 Lack of emergency drinking water systems on Saba and Statia

Saba and Statia lack proper drinking water supply and distribution systems, the majority of the population on the islands depends on rainfall for their daily water supply. When there is an emergency situation, and there is not enough drinking water available, there need to be back up systems that can safeguard the continuity of the drinking water supply. At this moment, rainwater cisterns are the primary and back-up systems for drinking water. There are no emergency supply and storage systems for drinking water.

In extreme situations, when there is not enough water available, the Dutch Navy can supply drinking water on the islands (see Figure 23). This is a difficult and time-consuming operation since the islands have no equipment to receive and distribute drinking water from boats. This has been concluded in 2008, when the Dutch Navy provided humanitarian assistance to Saba when there was not sufficient water available due to an extreme period of drought<sup>77</sup>.



Figure 23 Dutch Navy providing emergency water supplies on Saba during an extensive period of drought

## 3.5 General problems on the BES islands

The previous sections described specific issues of the individual BES islands; the following issues apply for all BES islands. The joint problems have been divided into three main topics: protection of water resources, 'legionellosis' and natural disasters. A summary of these issues is presented in Table 2.

### 3.5.1 Protection of water resources

#### *Landfills*

The BES islands lack proper waste management systems. Solid waste is collected with trucks and dumped on massive landfills without separation of detrimental substances (see Figure 24). Chemicals, fossil fuels and other pollutants can easily infiltrate the soil and will eventually end up in the ocean. Landfills are often set on fire to reduce its volume. The smoke coming from burning landfills can affect the quality of the collected rainwater. Airborne particles coming from the



Figure 24 Landfill on Statia

<sup>75</sup> Rodrigo, et al, 2007

<sup>76</sup> Gould and Nissen-Petersen, 1999, page 141

<sup>77</sup> Zwier, interview #14

incineration process fall down on roofs, gutters, and catchment areas and finally end-up in the rainwater cisterns (only on Saba and Statia)<sup>78</sup>.

### Wastewater

Another important polluter is wastewater; communal collection and treatment systems are not available on the islands. Wastewater is normally dumped directly in the ocean or biologically degraded with infiltration pits (cesspits, Figure 25) or septic tanks (Figure 26). The majority of the houses on Bonaire have cesspits or septic tanks; they are used for controlled infiltration of

household wastewater. However, most of these private wastewater systems do not function properly; the biological treatment process that should take place in these systems is often very limited. Wastewater from septic tanks and cesspits flows unprocessed into the subsoil and will

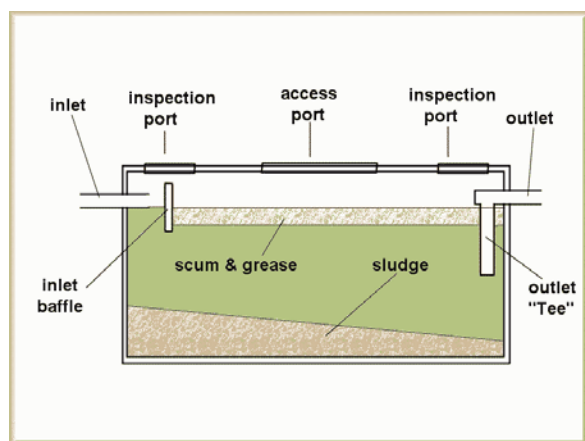


Figure 26 Septic tank

eventually end up in the ocean. Most of the houses and resorts located at the coast dump their wastewater directly into the ocean<sup>79</sup>.

Wastewater and contaminants from landfills are major threats for the water quality of the coastal waters. The surrounding ocean serves as intake-water for drinking water plants; a steady seawater quality is crucial for the seawater desalination process. Heavy contamination of intake water will eventually lead to more purification efforts and can lead to quality deviations of the produced drinking water<sup>79</sup>. Another consequence of dumping waste (-water) is the negative effect it has on coral reefs. Due to nitrification of the ocean with waste and wastewater, algae growth is stimulated. The algae cover the reefs, "suffocating" and eventually killing coral reefs<sup>80</sup>.

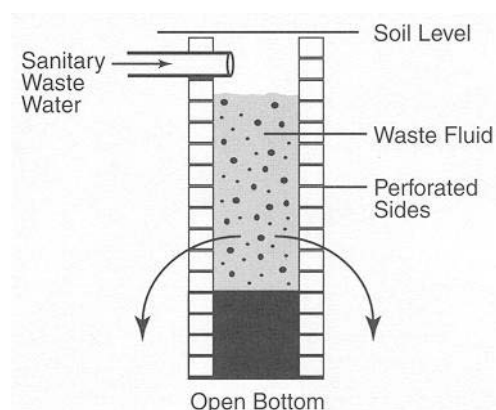


Figure 25 Cesspit

### 3.5.2 Legionellosis

An important risk for the overall safety of the drinking water supply on the BES islands is *legionellosis*<sup>81</sup>. The climate on the BES islands is, in the right situation, perfect for the growth of legionella bacteria. When there are stagnant volumes of drinking water in the distribution systems, the chances are high that legionella bacteria might form.

Perfect conditions for the reproduction of legionella bacteria can be found in quantities of stagnant water within the temperature range between 25 and 50 degrees Celsius, especially when there is a biofilm available in the piping of the construction<sup>82</sup>. The bacterial quality problem is especially dangerous for vulnerable people amongst the local population or tourists, especially the elderly, children and the diseased<sup>81</sup>.

<sup>78</sup> Johnson and Zagers, interview #9

<sup>79</sup> Reijtenbagh, 2008

<sup>80</sup> <http://www.nacri.org/nutmon.html>

<sup>81</sup> CWA, 2006

<sup>82</sup> de Moel, et al., 2006

The Antillean drinking water law states that precautionary measurements should be taken at locations where there is an increased risk to suffer from 'legionella pneumonia' or legionellosis<sup>83</sup>. There are no normative guidelines on legionella in the Antillean drinking water legislation. Also, no precautionary inspection measures have been implemented to indicate or mitigate the presence of legionella bacteria<sup>84</sup>.

### 3.5.3 Natural disasters

#### *Hurricanes*

An important aspect of the Leeward Islands is the hurricane threat that is imminent in the period from June till November (hurricane season). The chance that a hurricane hits Saba and Statia is high, the islands are directly located in the hurricane belt. Bonaire is located at the edge of the hurricane belt; the risks are therefore lower. Hurricanes can be extremely powerful and therefore cause a lot of damage and disruption on the islands. During and even after a hurricane event, the islands are completely isolated from the outside world. Airports are closed and boats are unable to navigate due to the extreme weather conditions. Power plants are frequently shut down deliberately to prevent damage. Without the supply of power, the production of drinking water stagnates. Another reason for the drinking water production process to stop is when the turbidity of the seawater is too high. Filtration systems can get clogged and the system will eventually fail. To prevent this drinking water producers usually shut down the system beforehand.

The distribution of drinking water can usually continue under free gravitational flow; storage tanks are strategically located at high locations. When these storage tanks are empty, water is rationed and people can fill empty containers at the drinking water plant. This scenario only applies for Bonaire; on Saba and Statia are no extensive drinking water distribution networks available.

The majority of the inhabitants on Saba and Statia remain dependent on their rainwater cisterns during hurricanes. Rainwater harvesting during and after a hurricane is not possible because the collection systems are often clogged or broken because of debris. During a hurricane the atmosphere is sprayed with seawater and cisterns therefore need to be covered. The rainwater system first needs to be cleaned and disinfected after a hurricane before it can be used again. The capacities of typical rainwater cisterns are large enough to provide homeowners with sufficient drinking water during these kinds of natural disasters<sup>84</sup>.

#### *Seismic activity*

The BES islands are located in the Greater Antillean seismic belt; there are frequently reports of seismic activity on the islands<sup>85</sup>. Seismic waves, when severe, can disrupt electricity or drinking water production. Concrete and brickwork cistern systems are vulnerable to heavy shocks; cracks can make leaks in the cisterns and therefore support external bacterial contamination.

### 3.6 Conclusion

In this chapter an overview is provided of the existing drinking water supply systems on the individual BES islands and the problems that are related to these systems. The problem context that is defined in this chapter provides an answer to research sub-question 1 (see Figure 11):

*"What are the main problems and risks regarding the drinking water supply systems on the BES islands"*

---

<sup>83</sup> Landsbesluit Kwaliteit Drinkwater, Bijlage A, voetnoot 14

<sup>84</sup> Reijtenbagh, 2008

<sup>85</sup> KNMI, 2009

The problem analysis in this chapter forms the basis for the system analysis conducted in chapter 4. One of the conclusions of this problem analysis is that the properties (see Table 1) and problem context (see Table 2) regarding the supply of drinking water on the BES islands varies significantly per island. The majority of the issues on the BES islands relate to technical and institutional elements within the drinking water supply systems. In this chapter a distinction has been made between issues that relate to the individual islands and issues that relate to the joint BES islands.

In general, the existing (Antillean) drinking water regulations are neither fully implemented nor enforced on the three BES islands. Drinking water suppliers produce and distribute drinking water without the necessary concessions from the local island government. Next to that, official drinking water regulatory authorities have either not been erected or perform only a limited set of inspection duties.

Legionellosis is an important risk for public health on the BES islands; the technical drinking water distribution system and local climate conditions can, under the right circumstances, create optimal breeding conditions for various types of legionella bacteria.

Another important problem area that applies for the joint BES islands is the protecting of the available water resources; water bodies that are used for drinking water production are continuously polluted by infiltration of solid and liquid waste. Collective sewerage systems are not available and solid waste is dumped on massive landfills.

The BES islands are faced with two types of natural disasters: seismic activity and hurricanes. Especially Saba and Statia are vulnerable since they are centrally located in the Caribbean hurricane belt.

Bonaire has a drinking water distribution network that covers almost the entire island, providing 95% of the population with desalinated seawater. The main problems on Bonaire are related to the regulation and inspection of drinking water.

Saba and Statia mainly depend on the use of private rainwater harvesting systems since desalinated drinking water is either expensive or not available. Important issues relate to the quality of rainwater for human consumption and the availability of both desalinated and rainwater. The microbiological instability of domestically collected rainwater can endanger public health on the islands. Longer periods of drought and rather short and intense periods of precipitation cause that rainwater collection is not sufficient to provide a normal dwelling with enough water throughout the year.

Furthermore, Saba and Statia both lack official regulatory authorities and laboratory facilities for the inspection of drinking water.

Technical and institutional instruments need to be defined by which the preceding problems can be remedied efficiently. New policy and technical systems can only be implemented effectively when they are embedded in an improved institutional design that can regulate and inspect the supply of drinking water on the BES islands. An important aspect is the erection of an overseas drinking water regulatory system for the BES islands that is supervised by the Dutch Ministry of VROM.

The insular characteristics of the BES islands are varied (see Table 1 and Table 2); it is therefore not possible to define only instruments that apply for the joint BES islands. To improve the individual drinking water supply systems on the BES islands, island-specific technical and institutional instruments are necessary. Considering the many similarities that Saba and Statia share, it is decided to classify both islands as one group. The final design for an improved drinking water supply system will therefore consist of technical and institutional instruments for the joint BES islands, for Bonaire and for Saba/Statia.

Table 1 Drinking water supply BES islands

Drinking water supply:	Bonaire	St. Eustatius	Saba
Drinking water producer:	Public utilities company WEB NV	Public utilities company GEBE NV (concessions)	2 Private drinking water producers (no

	(concessions expired)	expired)/ Homeowners (rainwater)	concessions)/ Homeowners (rainwater)
Water source and production method:	Seawater, Reverse Osmosis technique (SWRO)	Seawater, Reverse Osmosis technique (SWRO)/ Rainwater harvesting	Seawater, Reverse Osmosis technique (SWRO)/ Rainwater harvesting
Drinking water distributor:	Public utilities company WEB NV (concessions expired)	Public utilities company GEBE NV, private distributors (concessions expired)	Private distribution company (no concessions)
Distribution methods:	Distribution network/Water trucks	Limited distribution network/ Water trucks	Water trucks
Price per cubic meter of drinking water:	2,50 Euro	9,15 Euro	5 Euro
Distribution rate (for water trucks):	-	-	20-40 Euro

Table 2 Main problems and additional risks

Table 2 Main problems and additional risks			
Main problem areas:	Bonaire	St Eustatius	Saba
Inspection and regulation	-Limited water quality inspection program -Long process time of external drinking water sample analyses	- No drinking water quality inspection programs	
	- Drinking water suppliers have no valid concessions for their operations		
	- No external supervision/regulation of drinking water suppliers		
	- No drinking water laboratories available for sample analyses		
Drinking water continuity:		-Rainwater shortages due to periods of drought and large water consuming household equipment -No emergency drinking water systems available	
Drinking water quality:		- Risk of animal and human fecal contamination of rainwater - Disinfection of drinking water trucks	
	<u>Protection of water resources:</u> -No solid waste management systems -No wastewater management systems		
Accessibility of drinking water:		Extension of drinking water distribution network Statia (and potentially Saba): -Uncertainty about future consumption patterns (standing water) -Potential cross-contamination due to integration with existing rainwater systems	
Additional risks:	-Optimal breeding conditions for various types of legionella bacteria		
		-Yearly hurricane threat	
	-Risk of seismic activity		



## 4 Basis of design

### 4.1 Introduction

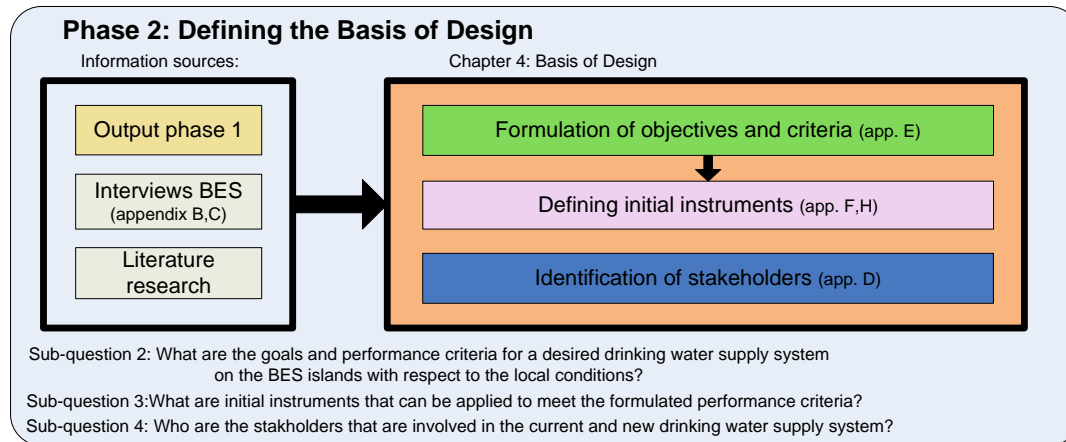


Figure 27 Research phase 2

In the previous chapter the problem context has been determined; the main problems and risks regarding drinking water on the BES islands have been identified. The specific problem context is used in this chapter to conduct a system analysis of the drinking water supply on the BES islands. The system analysis will generate the general objectives and performance criteria for the improved drinking water supply design. These objectives are based on the goals of the Ministry of VROM and of the individual BES islands as formulated by local stakeholders. Next to that, initial instruments are put forward that can support the achievement of these objectives. The cause and effect relations between instruments and objectives are put forward into system models. These system models provide more insight into the individual problem contexts regarding the supply of drinking water on the BES islands and therefore support the selection of appropriate solution alternatives to mitigate the existing problems and risks. A stakeholder analysis has been conducted in order to identify the changing roles and responsibilities in the drinking water organization due to the constitutional transition. Based on this analysis, key stakeholders can be appointed for the implementation of the design in chapter 7. Also, the stakeholder analysis serves as the context based on which institutional instruments need to be defined.

The system analysis and stakeholder analysis are combined in to the Basis of Design (BoD)<sup>86</sup>. The basis of design is the starting point for the lesson-drawing process and defines the system boundaries between which design-alternatives are determined. The BoD provides answers to research questions 2, 3 and 4, see Figure 27.

Section 4.2 provides an overview of the objectives and related performance criteria for the desired drinking water supply system on the BES islands. These objectives and criteria are derived from 'objectives tree' analyses, more information on the method and the outcomes of these analyses can be found in appendix E. Section 4.3 provides an overview of the initial means that can be applied to achieve the objectives from the previous section. These means are derived from 'means-ends' analyses that can be found in appendix F. The next section provides a summary of critical mechanisms within the overall drinking water supply on the BES islands. These mechanisms (or sub-systems) provide an overview of the relations between important problem areas, relating performance criteria and initial means that can mitigate the existing problems. The outcomes of the stakeholder analysis can be found in section 2.5, the conclusions are presented in section 2.6.

<sup>86</sup> Blok-Bokstael, 2005

## 4.2 Research objectives and performance criteria

The main research objectives for an improved drinking water supply system are based on both the goals of the Ministry of VROM and the goals formulated by the relevant stakeholders on the BES islands. The inhabitants of the BES islands are the actual users of the drinking water supply systems; it is therefore important to also take into account their opinions, tips and objectives. The island governments and inhabitants have more insight in the local problem situation *and* potential opportunities for improvement. Therefore the objectives of the islands are combined with the objectives of the formal problem owner, the Ministry of VROM. The objectives of the BES islands and the Ministry are graphically represented in *objectives trees*. Objectives trees are an analysis technique in which a main objective is split into a number of sub-objectives; sub-objectives are translated into quantifiable performance criteria<sup>87</sup>. The performance criteria serve to measure the degree in which the objectives are being met. In appendix E more information on the function of the objectives trees are presented together with additional information on the individual objectives and performance criteria.

### 4.2.1 Objectives tree Ministry of VROM

The objectives (Figure 28) for the design of an improved drinking water supply system are directly related to the formal mission of the Ministry of VROM, that is creating a *safe living environment and a sustainable future for the next generations*<sup>88</sup>.

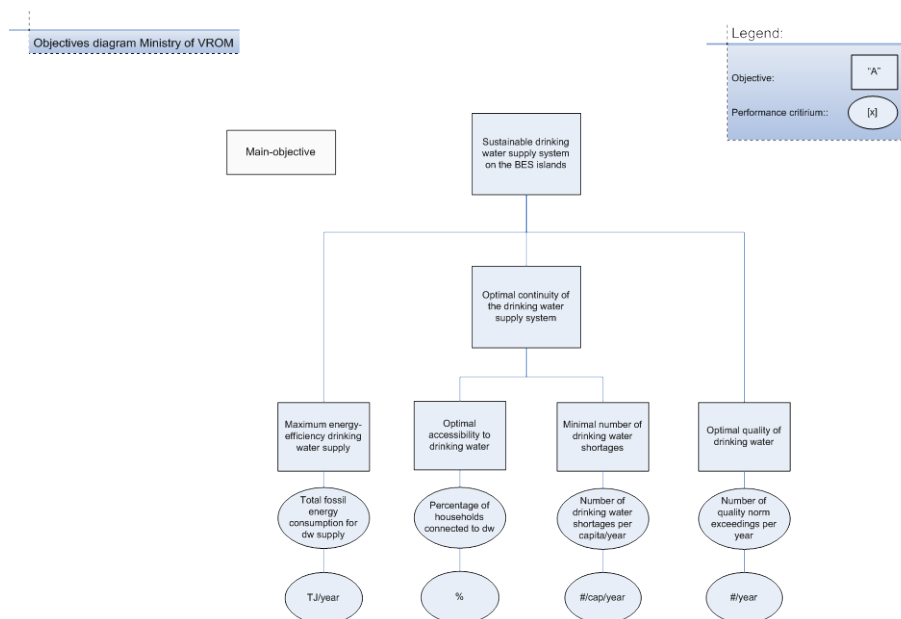


Figure 28 Objectives tree Ministry of VROM

### 4.2.2 Objectives tree Bonaire

The objectives of in Figure 29 are based on the ideas and goals of the local drinking water suppliers and the inhabitants of Bonaire (see appendix A and B). An important difference with the objectives of VROM is that the objectives tree for Bonaire includes a new sub-objective: “Minimal costs for drinking water”. Next to that, the main objective is not so much focused on the sustainability but rather on reliability of the drinking water supply system.

<sup>87</sup> Bots, 2002

<sup>88</sup> <http://www.vrom.nl/organisatie>, visited December 2009



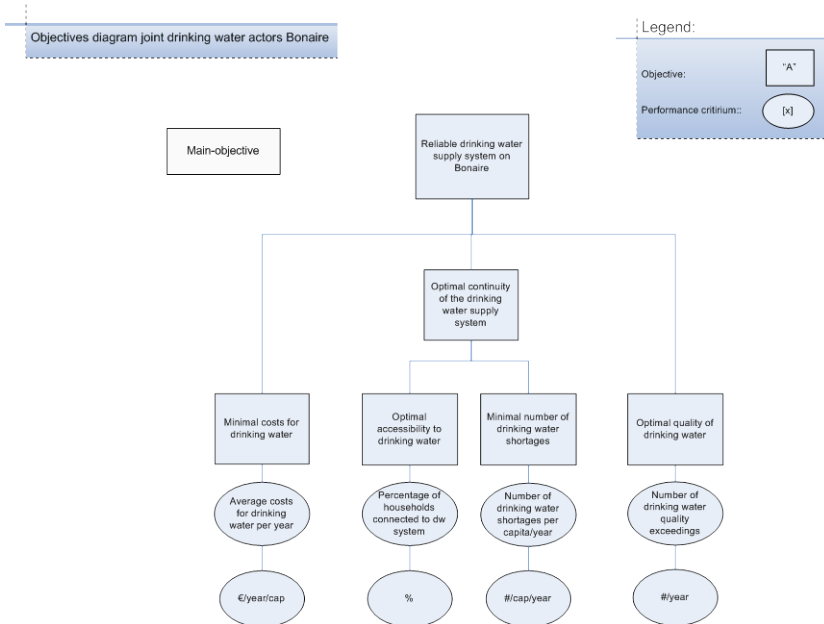


Figure 29 Objectives tree Bonaire

#### 4.2.3 Objectives Saba and Statia

The objectives of Saba and Statia are almost identical and are therefore merged into one objectives tree for both islands (Figure 30). The objectives for Saba and Statia are identical to the objectives of Bonaire except for one additional sub-objective: “Maximum capacity of emergency drinking water”. This sub-objective is particularly important for the islands considering the yearly hurricane threat.

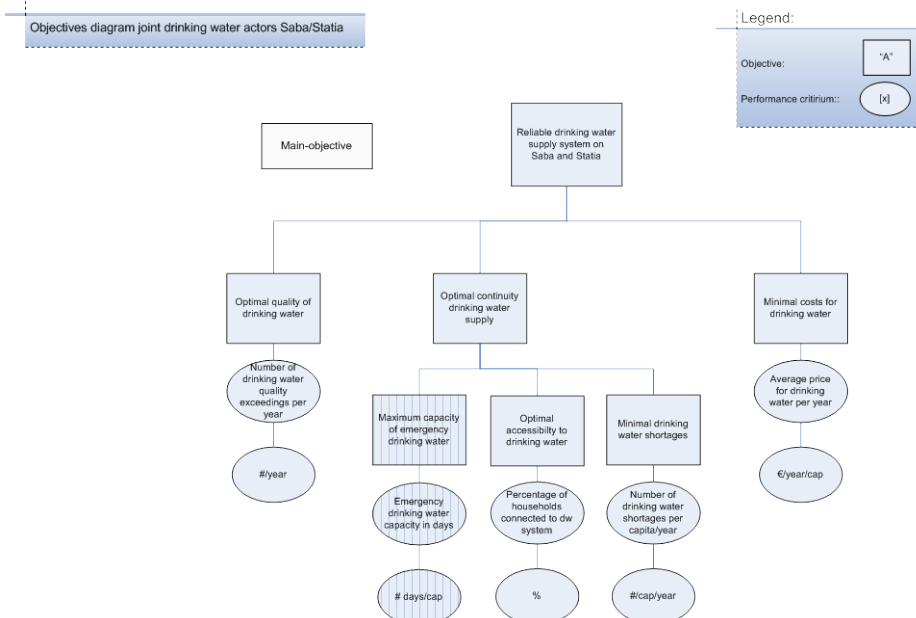


Figure 30 Objectives tree Saba/Statia

#### 4.2.4 General objectives and performance criteria

Considering the different problem contexts and objectives of the three individual BES islands, objectives have been defined for both for Bonaire and Saba/Statia. These objectives and performance criteria are summarized in Figure 31.

Objectives and performance criteria:		
Objectives:	Criteria:	Unit:
Optimal quality of drinking water	Number of quality norm exceedings per year	#/year
Minimal drinking water shortages	Number of drinking water shortages per capita/year	#/cap/year
Optimal accessibility to drinking water	Percentage of households connected to drinking water network	%
Maximum energy-efficiency within drinking water supply system	Total fossil energy consumption for drinking water supply	TJ/year
Minimal costs for drinking water	Average total costs for drinking water per year	E/cap/year
Additional objective for Saba/Statia only:		
Maximum capacity of emergency drinking water supply	Emergency drinking water capacity estimated in days	# days/cap

Figure 31 Summary of objectives and performance criteria

#### *Critical objectives:*

'Optimal quality of drinking water' and 'Minimal drinking water shortages' are considered essential objectives for the desired situation. These objectives relate to the basic sanitary conditions of the drinking water consumers. The related critical performance criteria are:

- 'Number of quality norm exceedings per year'

The quality of drinking water is determined using microbiological, chemical, organoleptic and esthetical indicator parameters. Incidents that caused exceedings of these indicator parameters are determined by quality inspections and by filed complaints of consumers.

- 'Number of drinking water shortages per capita per year'

The number of drinking water shortages is determined by counting the number of incidents during which drinking water production and distribution facilities (including drinking water trucks) are unable to supply drinking water.

In the Netherlands, the main quality indicator to measure the performance level for the supply of drinking water is defined in "substandard supply minutes" (SSM). This indicator quantifies the number of minutes of insufficient delivery of water per customer per year by a water company<sup>89</sup>. SSM is normally used as the base for a uniform method of incident registration for drinking water companies. The incidents that lead to substandard supply minutes can be distinguished into:

- Delivery disruption in main distribution pipes
- Pressure decrease below legal norm
- Qualitative incidents

The reason why the SSM quality indicator is not selected as the main performance criterion for the BES islands is that the indicator is not fully applicable to the BES islands. There are no large drinking water distribution networks (except for Bonaire) and the majority of the households on Saba and Statia depend on private rainwater harvesting. The average household on the BES islands has therefore no direct access to public drinking water. It is not possible to measure pressure decrease incidents, since drinking water is often supplied via water trucks. In general it is not possible to apply the substandard supply minutes approach as a performance indicator, since the type supply is not continuous. It is however possible to measure incidents individually, such as the number of times that drinking water is not available or the number of times that the water quality is below the legal norm. For the supply of public drinking water, disruptions and qualitative incidents can be inspected externally and counted using consumers complaints. For the supply of private drinking water, which is the case for domestic rainwater harvesting, these incidents can only be measures using questionnaires or interviews.

<sup>89</sup> Alberga, 2005

### 4.3 Problem overview

The objectives for a desired drinking water supply system have been determined in section 4.2. Based on these objectives a means-ends analysis has been conducted<sup>90</sup> to define initial instruments (means) to achieve the objectives from the previous section See Figure 32).

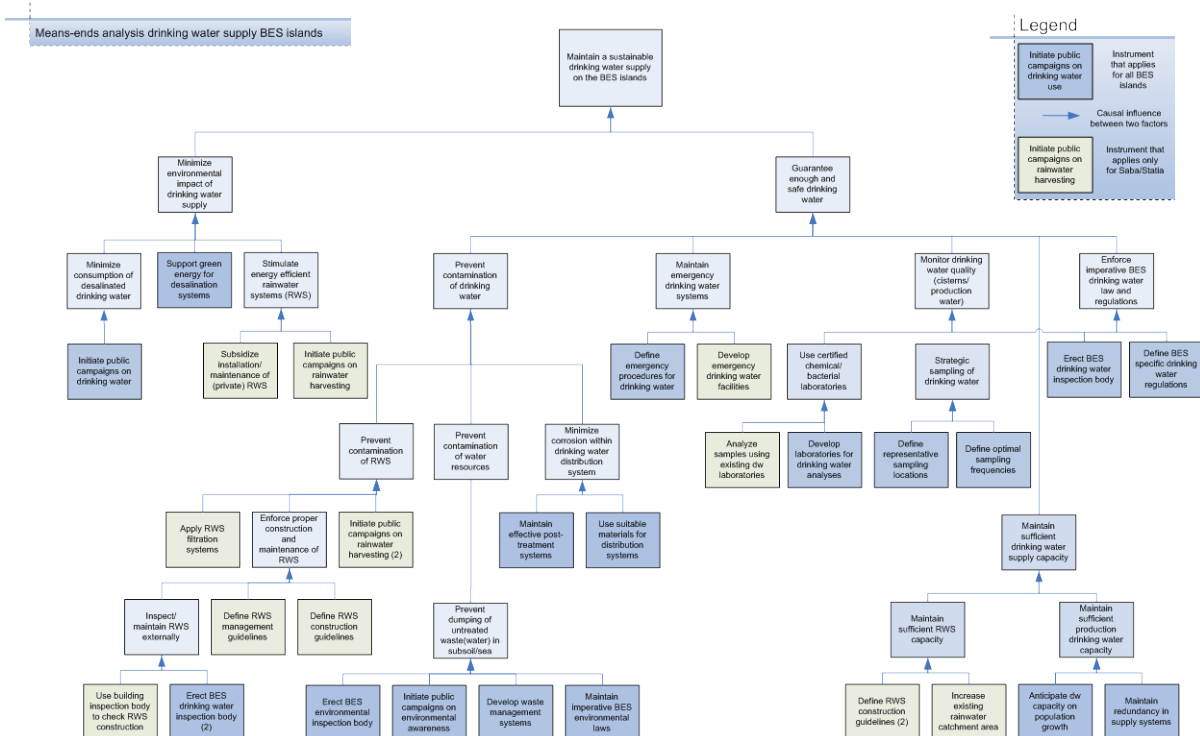


Figure 32 Means-ends diagram

The means-ends diagram presented above describes the relations between the main objective of the research project, “Maintaining a sustainable drinking water supply system on the BES islands” and sub-objectives placed in lower levels of the branches (such as “Minimizing environmental impact of drinking water supply”). The last elements of each branch represent the means to achieve these sub-objectives, due to the bottom-up approach of this analysis, these means also contribute to the main objective of this project. A distinction has been made between means that apply for Saba and Statia only and those that apply for all islands. The main systems that are described later on in this section can be traced back into the different branches of this means-ends diagram.

Using the objectives from section 4.2, the means (instruments) from Figure 32 and the problem context described in chapter 3, causal relation diagrams have been formulated of Bonaire and Saba/Statia (see appendix G). These causal relation diagrams provide more insight into the interactions between problem factors, performance criteria and instruments. The outcomes of these analyses are quite unstructured and not easy to interpret. Organized summaries of these causal relations diagrams are developed using system diagrams (see appendix H and I). Complex cause and effect relations are hidden and replaced by sub-systems, summarizing and simplifying important problem mechanisms. The following system diagrams have been developed for Bonaire (Figure 33) and Saba/Statia (Figure 34).

<sup>90</sup> Appendix F contains the full analysis and provides more information on the methodology

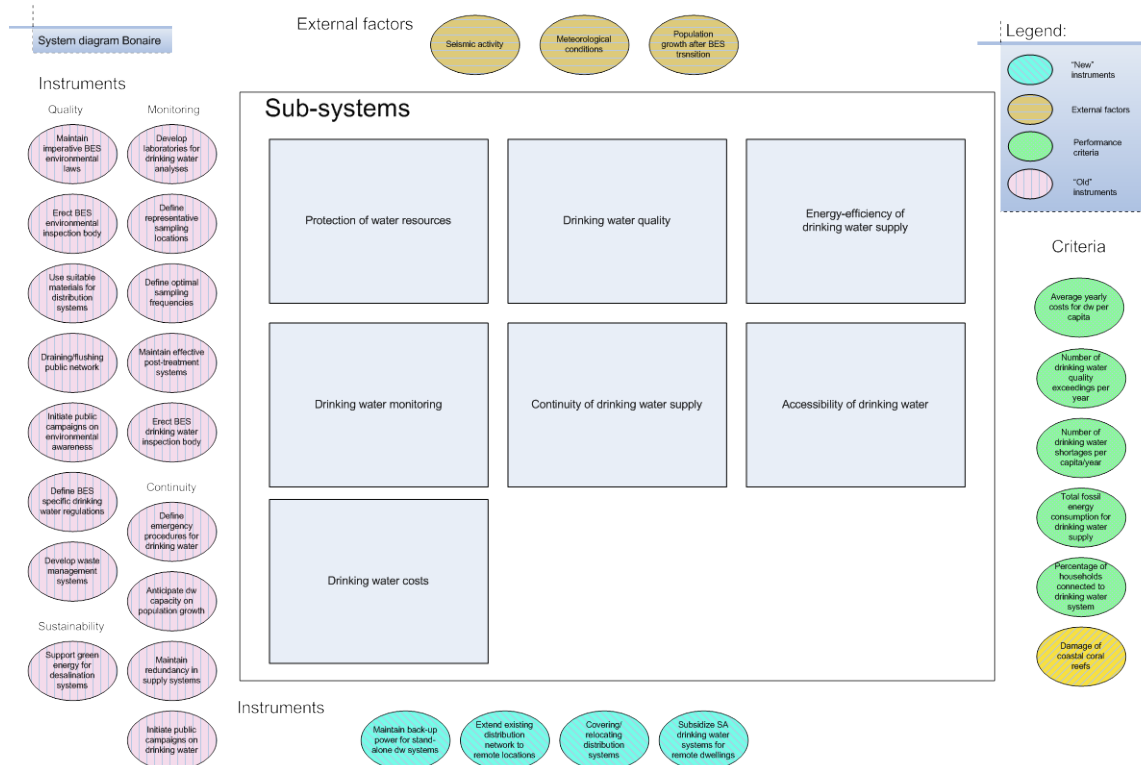


Figure 33 System diagram Bonaire

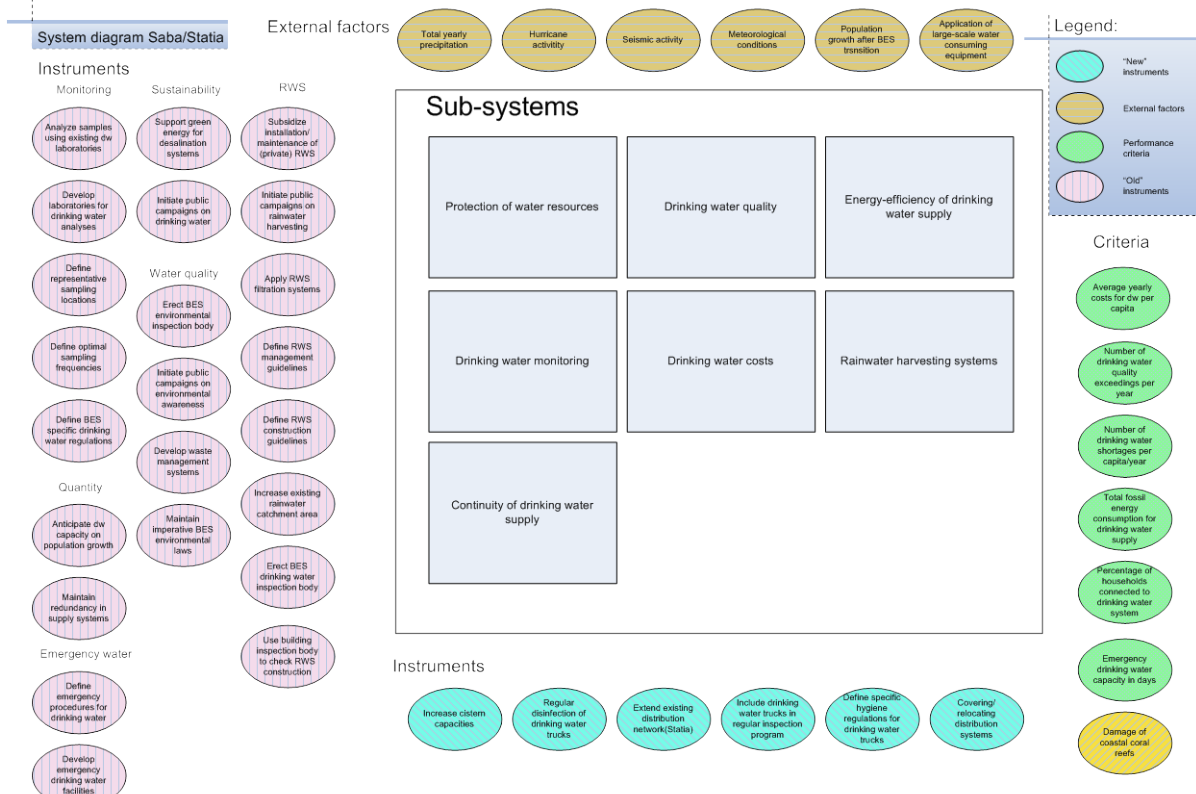


Figure 34 System diagram Saba and Statia

In this section, essential problem areas within the drinking water system on the BES islands are identified, based on the sub-systems from within the system diagrams in Figure 33 and Figure 34. These problem areas are considered essential since they directly influence the two critical performance criteria described in the previous section.

Within the system description of these essential problem areas, the interactions between instruments, performance criteria and external factors are highlighted. The systems themselves are aggregated; some factors of the original sub-systems are not included to simplify the diagram and increase the readability. A distinction is made between sub-systems that apply for the BES islands and for Saba/Statia only.

#### 4.3.1 Main problem systems on the BES islands

For the joint BES islands, the following problem areas have been highlighted:

- Inspection and regulation ('drinking water monitoring' in the original sub-systems of Figure 33 and Figure 34)
- Protection of water resources

For Saba and Statia:

- Drinking water quality
- Drinking water continuity

#### *Inspection and regulation of drinking water*

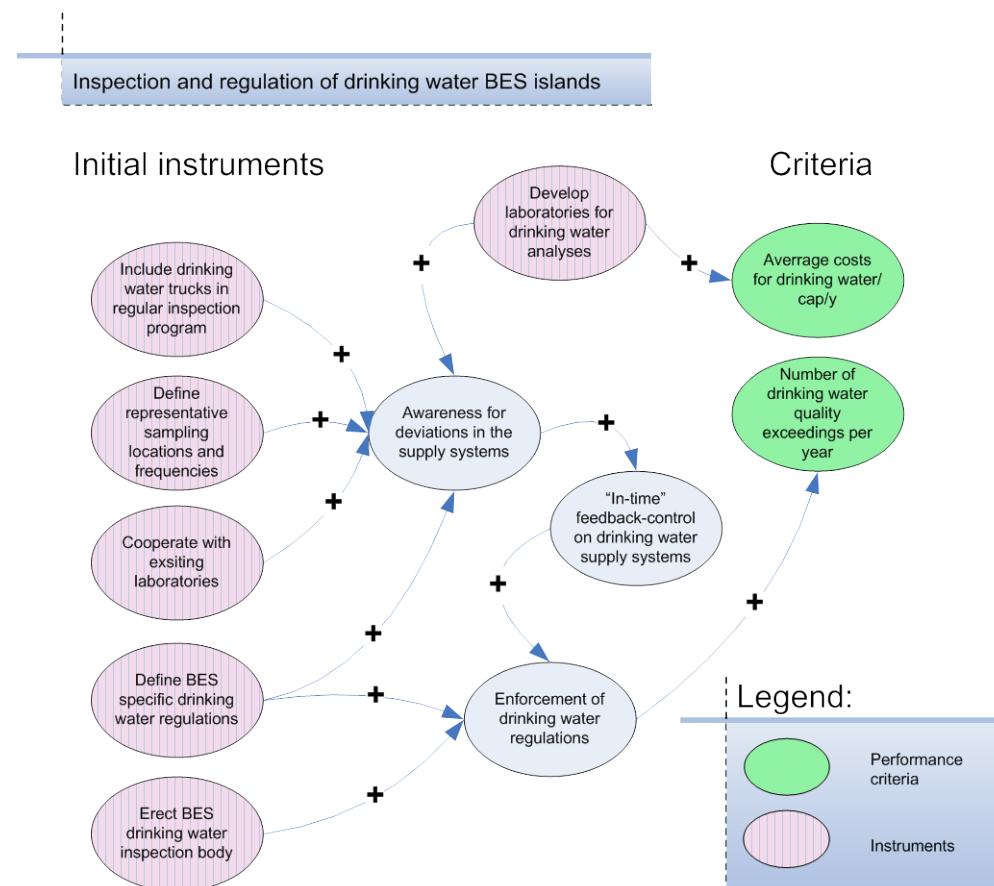


Figure 35 Inspection and regulation problem mechanism

Regulatory authorities for drinking water are either not erected or they perform only a limited inspection program. Lacking a proper drinking water inspection system results in a decreased awareness of potential drinking water quality deviations. By *erecting a BES drinking water inspection authority*, the drinking water regulations can be enforced leading to more effective (and safe) supply systems. The existing drinking water legislation needs to be adjusted; proper regulations on drinking water quality parameters and specific regulations on drinking water

trucks and ‘legionellosis’ need to be included. When the drinking water regulations suit the conditions on the BES islands, it is easier for the regulatory authority to enforce these regulations.

*Defining optimal sampling locations and frequencies* will increase the quality of drinking water sampling programs. Furthermore, *drinking water laboratories need to be developed (this will increase the total drinking water costs) or arrangements with existing laboratories on other islands need to be defined* in order to analyze these drinking water samples. Drinking water trucks need to be included in the inspection program, together with the previous instruments this will increase the overall awareness of quality deviations. By providing timely feedback (on quality deviations) to the drinking water suppliers, they are (more) aware of quality deviations. Then, drinking water suppliers can adjust their systems to mitigate the existing quality deviations. This will reduce the risk of drinking water quality exceedings.

System:	Related performance criterion:	Initial instruments:
Inspection and regulation	<ul style="list-style-type: none"> <li>Number of drinking water quality exceedings</li> <li>Average costs for drinking water per capita per year</li> </ul>	<ul style="list-style-type: none"> <li>Define optimal sampling frequencies and locations</li> <li>Erect BES drinking water inspection authority</li> <li>Develop laboratories for drinking water analyses/ cooperate with existing laboratories</li> <li>Include drinking water trucks in the inspection program</li> <li>Define BES specific drinking water regulations</li> </ul>

### Protection of water resources

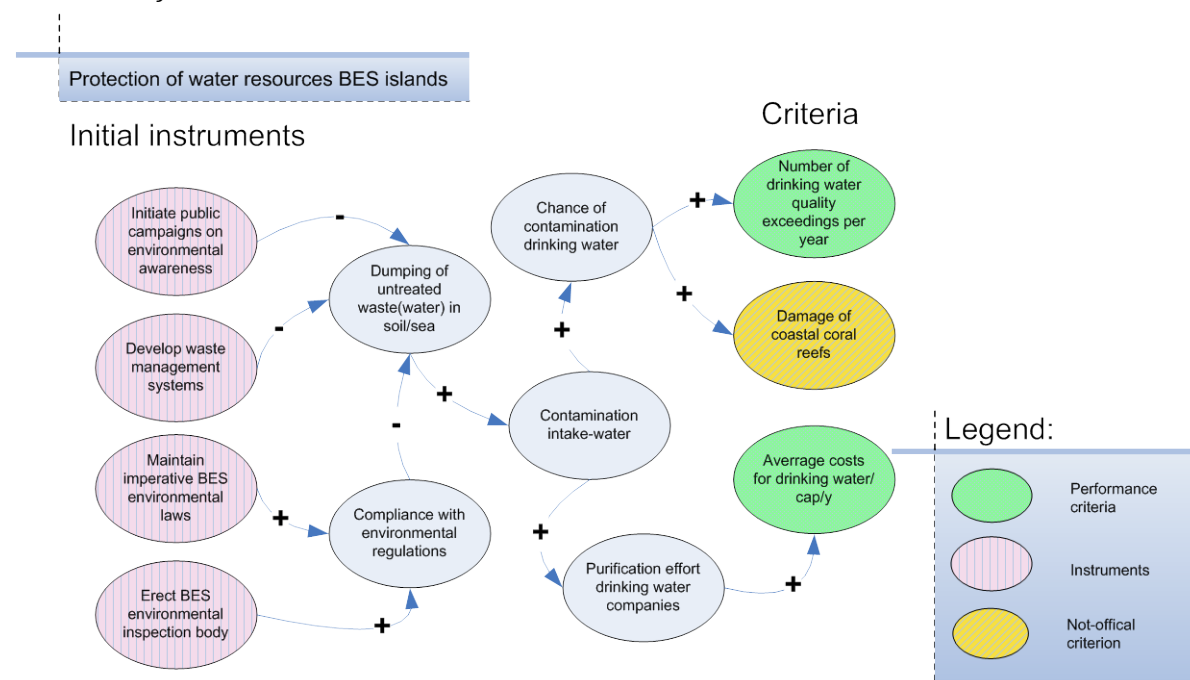


Figure 36 Protection of water resources problem mechanism

An important problem is the permanent pollution of the available water resources on the BES islands due to the lack of proper waste and wastewater systems. When seawater gets polluted, the chance increases that intake water for desalination plants also gets contaminated. When contaminated intake water is used for drinking water production, drinking water quality deviations can occur. The previous risk can be reduced by *maintaining imperative environmental regulations* and by using *environmental inspection authorities*. These imperative environmental regulation need to provide regulations on waste management and pollution, the authorities need to enforce these regulations.



Another way is to reduce the pollution of water resources by *developing waste management systems* that can safely process solid and liquid waste. A fourth option is to initiate *environmental awareness campaigns*, to make the population aware of the consequences of dumping waste and wastewater. By applying the previous instruments, the water resources can remain unharmed and the quality of drinking water can be safeguarded.

Another positive side effect is that the purification efforts of not-contaminated intake water will be lower and this will reduce the overall drinking water costs.

System:	Related performance criterion:	Initial instruments:
Protection of water resources	<ul style="list-style-type: none"> <li>Number of drinking water quality exceedings</li> <li>Average costs of drinking water per capita per year</li> </ul>	<ul style="list-style-type: none"> <li>Maintain imperative environmental regulations on the BES islands</li> <li>Erect environmental inspection authority on the BES islands</li> <li>Initiate public campaigns on environmental awareness</li> <li>Develop waste management systems on the BES islands</li> </ul>

#### 4.3.2 Main systems of Saba and Statia

##### Drinking water quality

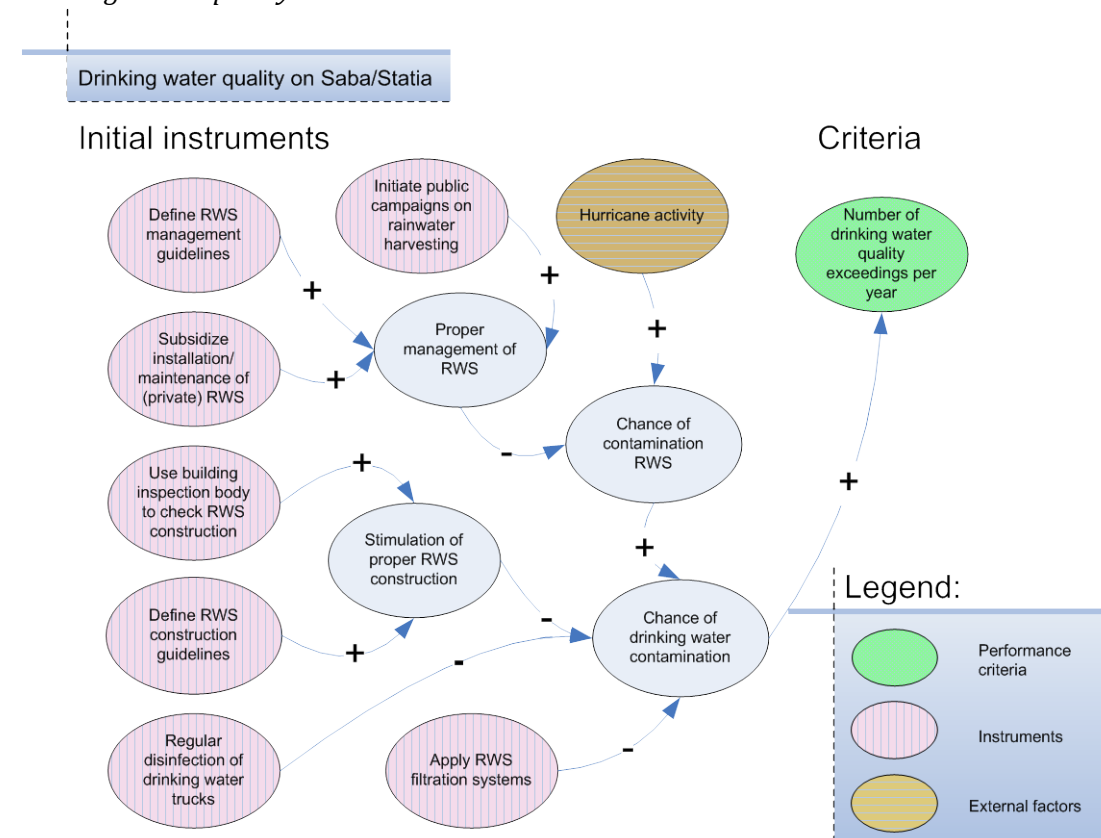


Figure 37 Drinking water quality problem mechanism

The main factor in this system is the risk of drinking water contaminations. Drinking water on Saba and Statia consists of potable rainwater and desalinated water from local drinking water suppliers. The quality of cistern water mainly depends on two factors; *proper management of rainwater systems* (cleaning, maintaining, disinfection) and *proper construction of rainwater systems* (preventing leaks, cross-contamination). Proper management of rainwater systems can be stimulated by providing rainwater management guidelines (available via for example

websites/leaflets), this can be done by public authorities. Another instrument is to create awareness on cleaning, maintaining and disinfecting rainwater systems with public campaigns. Maintaining rainwater cistern is a very labor-intensive activity. Many homeowners have contractors clean and maintain their rainwater cisterns. This is very expensive and can be an economic burden for many people on the islands. When cisterns are not well maintained and cleaned, the quality of cistern water will deteriorate. An option to stimulate proper management of rainwater cisterns is to subsidize a part of the maintenance costs. Another instrument to safeguard to quality of cistern water is to use personal filtration systems.

Desalinated drinking water is distributed in drinking water trucks; these trucks are not only used for transporting drinking water. By disinfecting these trucks according to specific hygienic regulations, the risk of drinking water contamination can be reduced.

Proper construction of rainwater systems can be enforced by having the local building inspection authority check building plans of *new* rainwater systems. This is only possible when specific regulations on the construction of rainwater systems are defined and implemented. These regulations need to include requirements on the location of cisterns relative to the wastewater systems and the construction materials that need to be used. By enforcing these regulations the chance on cross contamination via external bacterial sources will reduce.

System:	Related performance criterion:	Initial instruments:
Quality of drinking water	<ul style="list-style-type: none"> <li>Number of water quality norm exceedings</li> </ul>	<ul style="list-style-type: none"> <li>Initiate public campaigns on rainwater harvesting</li> <li>Subsidize maintenance of rainwater systems</li> <li>Apply rainwater filtration systems</li> <li>Use building inspection body to inspect cistern construction</li> <li>Regular disinfection of drinking water trucks</li> <li>Define rainwater system construction guidelines</li> <li>Define rainwater harvesting management guidelines</li> </ul>

### Drinking water continuity

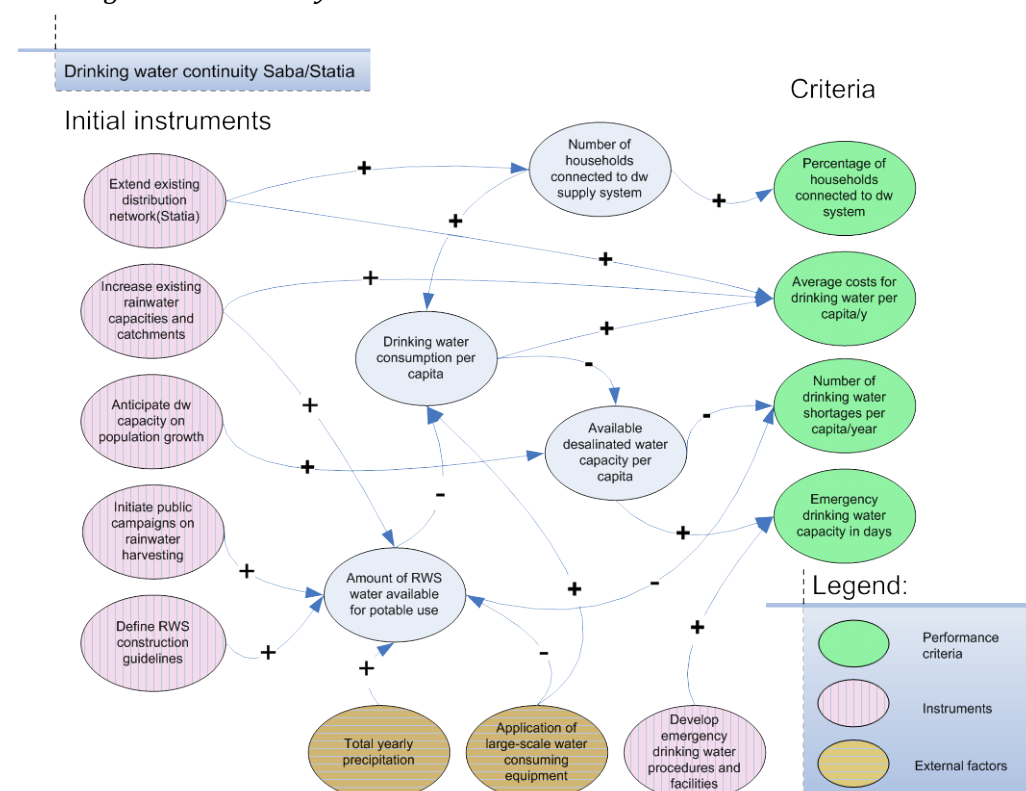


Figure 38 Drinking water continuity problem mechanism



On Saba and Statia, rainwater is the primary source of drinking water. Due to more and longer periods of drought and the introduction of large water consuming appliances, rainwater cisterns run dry more frequently. By *expanding the existing catchment areas and increasing the internal capacity of the rainwater storage tanks*, more water can be retained for during periods of precipitation. This will result in an increased amount of rainwater that is suitable for private consumption. Next to that, *campaigns on rainwater harvesting* can be held to inform the population how you can manage your rainwater system in an efficient way. This will make the people more conscious of their rainwater use, leading to reduced consumption patterns. In this way households can remain dependent on rainwater for a longer time, having the same cistern capacity.

Specific building regulations for the construction of new rainwater cisterns can be implemented. These regulations need to include minimum storage capacities for rainwater. By preparing modern houses on higher consumption rates and longer periods of drought, the number of rainwater shortages (thus drinking water shortages) can be reduced.

Another side effect of increasing the available amount of rainwater for consumption is that less desalinated water is consumed. This is important since the capacity of the existing drinking water production plants is limited, an increasing number drinking water shortages can be avoided.

To guarantee the continuity of the drinking water supply, emergency drinking water systems and procedures need to be available during natural disasters. This will increase the emergency drinking water supply and decrease the risk on drinking water shortages.

Another sub-aspect of this system is the accessibility of drinking water. On Saba and Statia, there is no direct access to safe public drinking water. To increase the percentage of houses that have access to drinking water, the *existing drinking water distribution network needs to be extended* (this only applies for Statia, Saba has no distribution network). A negative consequence of increasing the accessibility is that the consumption patterns of drinking water will increase. Drinking water suppliers need to anticipate on this increased consumption rate otherwise shortages can occur. More information is needed how a new distribution network can be integrated with mainly private rainwater systems; what instruments are necessary to safeguard to quality of drinking water that is consumed. It is also unknown whether the people that now use rainwater will consume enough desalinated water to keep the system safe (no stagnant water volumes) and profitable (sufficiently high consumption patterns to compensate for the investment costs).

Important factors that influence the average yearly drinking water costs for the consumer are the investment costs of *expanding the distribution system* and *the amount of drinking water that is consumed per capita*. The investment costs for distribution systems are likely to be discounted for in the average drinking water rates, these rates are already considerably high.

System:	Related performance criteria:	Initial instruments:
Continuity of drinking water supply	<ul style="list-style-type: none"> <li>Number of drinking water shortages per capita per year</li> <li>Emergency drinking water capacity in days</li> <li>Average drinking water costs per capita per year</li> </ul>	<ul style="list-style-type: none"> <li>Initiate public campaigns on rainwater harvesting</li> <li>Increase existing cistern capacities and catchments</li> <li>Define rainwater system construction guidelines</li> <li>Define emergency procedures and facilities for drinking water</li> <li>Anticipate drinking water production capacity on population growth</li> </ul>
Accessibility of drinking water	<ul style="list-style-type: none"> <li>Percentage of households connected to drinking water supply systems</li> </ul>	<ul style="list-style-type: none"> <li>Extend existing distribution networks</li> </ul>

## 4.4 Stakeholder analysis

The stakeholder analysis compares the existing drinking water organization with the formal stakeholder network that is defined in the Antillean drinking water legislation. The next step is to compare the existing situation with the future stakeholder network. The Antillean legislation is the main starting point for the new BES drinking water law; changing roles and responsibilities are defined. The extended stakeholder analysis can be found in appendix D.

### 4.4.1 Antillean drinking water stakeholder network

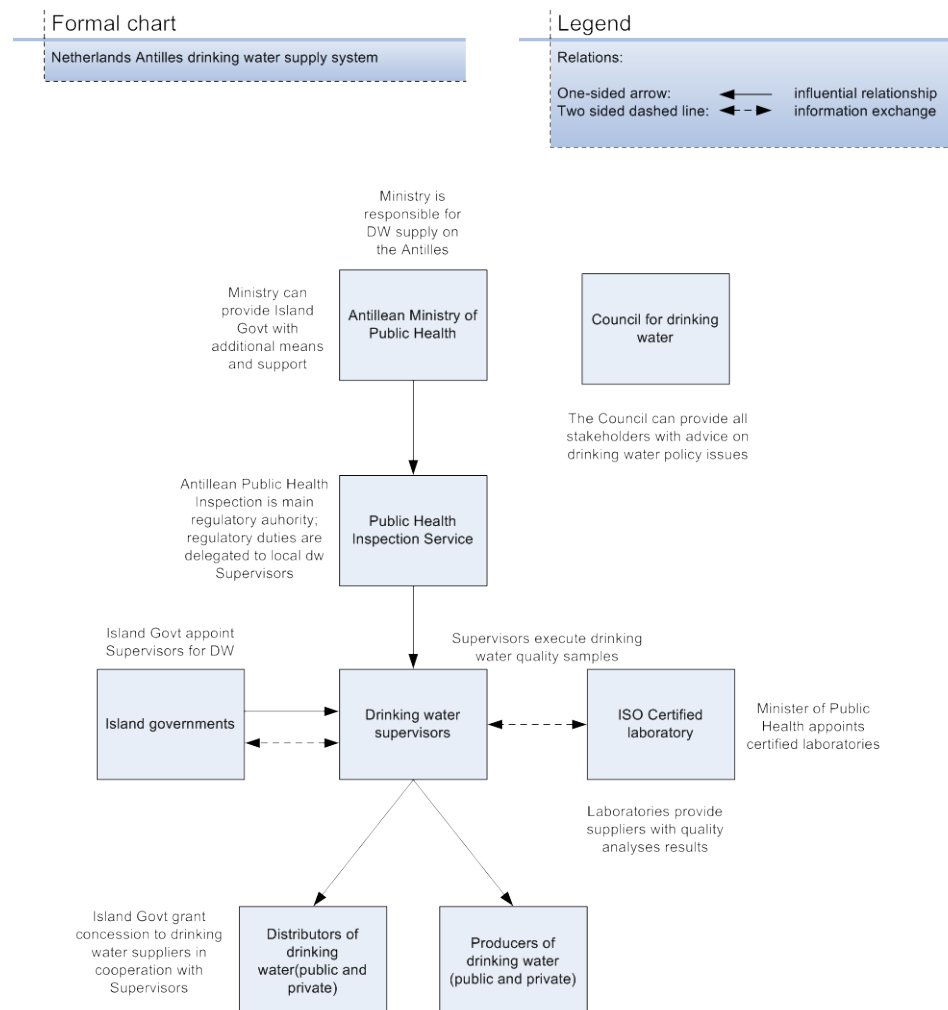


Figure 39 Current Antillean drinking water stakeholder network

#### *Regulatory authorities*

The formal organization of the drinking water stakeholder network is described in the Antillean drinking water law (see appendix D and Figure 39). In the current situation, the Ministry of Public Health on Curacao is responsible for the supply of drinking water within the Country the Netherlands Antilles. The Public Health Inspection of the Ministry is the main regulatory authority for drinking water. The individual island governments need to appoint 'Supervisors for Drinking water' that will execute local regulatory duties on behalf of the Public Health Inspection.

At this moment, only Bonaire has appointed an official Supervisor for Drinking water (Public Health Authority), on Saba and Statia no supervisors have been appointed. The communities on Saba and Statia don't have enough human resources or knowledge to erect such authorities.

Supervisors for Drinking water are not only important to conduct regulatory and inspection duties; they also assist the island governments at the decision procedures for granting concessions to drinking water producers and distributors.

Since there have been no Supervisors on Saba and Statia from the implementation of the new Antillean drinking water law in 2006, there has been no external inspection or regulation of drinking water suppliers and previous concessions have been granted without consulting the Supervisors.

#### *Laboratories for drinking water*

Drinking water laboratories analyze drinking water samples that are collected by the Supervisors at the drinking water suppliers. Laboratories need to be accredited by the Minister of Public Health in Curacao. The BES islands do not have the necessary laboratories to perform drinking water analyses. Therefore, Bonaire needs to ship drinking water samples to the accredited laboratory of Curacao. For the analysis of drinking water samples, Saba and Statia are forced to cooperate with existing drinking water laboratories (that are accredited) on nearby islands. Analytic drinking water laboratories are available on St Maarten and Anguilla.

#### *Council for Drinking Water*

The Antillean islands are required to erect Councils for Drinking Water. These Councils consist of 5 drinking water experts that can provide the Minister, the Island Government and the suppliers with recommendations on various drinking water topics. Currently, the BES islands do not have these Councils.

### 4.4.2 Future drinking water stakeholder network

The new conceptual drinking water organization for the BES islands is presented in Figure 40

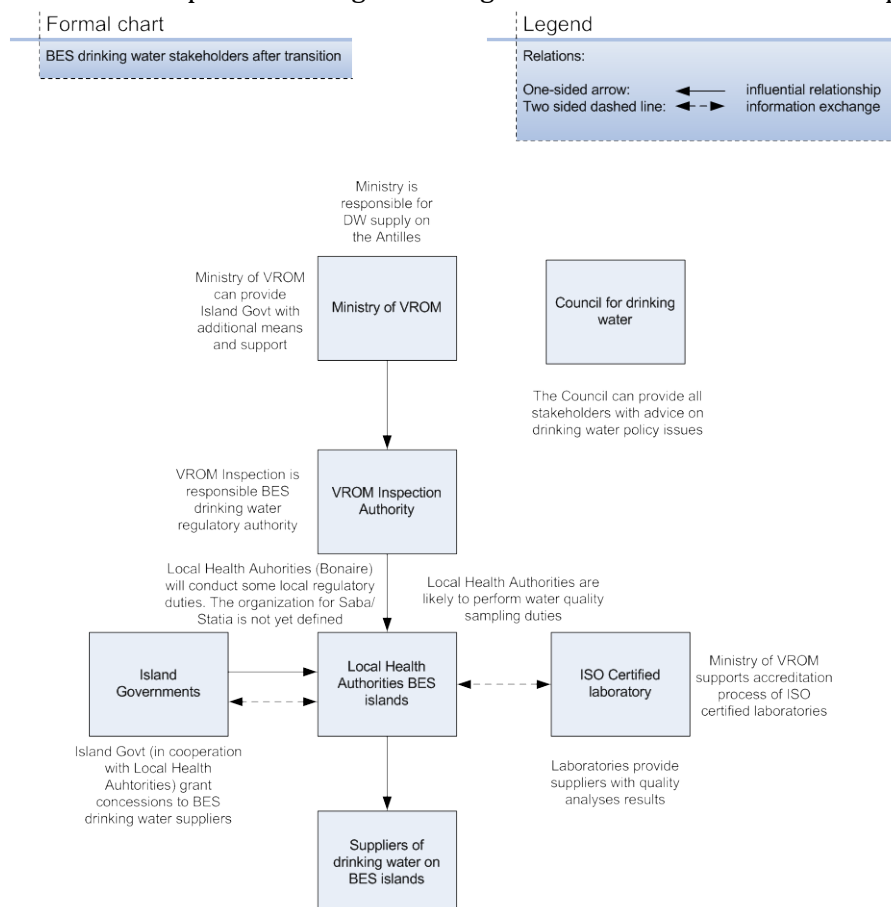


Figure 40 Conceptual drinking water stakeholder network BES islands

### *Responsible authorities*

The starting point for the new drinking water organization is based on the Antillean drinking water law. The public authority that will be responsible for the supply of drinking water on the BES islands is the Dutch Ministry of VROM. This is currently the Antillean Ministry of Public Health. The Ministry of VROM appoints the new regulatory authority for drinking water; this is the Inspection authority of VROM (VI).

Additional agreements have been made with the individual BES islands; Bonaire will execute most of the regulatory duties themselves through the Local Health Authority. Saba and Statia do not have enough human resources and knowledge to perform regulatory duties. Therefore Saba and Statia needs additional help and support to perform their regulatory duties<sup>91</sup>. Although certain regulatory duties are performed by the Local Health Authorities on the BES islands, the VROM Inspection authority remains the ultimate responsible regulatory authority.

Although the Ministry of VROM is responsible for the supply of drinking water, the decision to develop drinking water production and distribution systems lies with the individual island governments<sup>92</sup>. The investment costs for drinking water supply systems are therefore initially financed by the islands themselves. The islands can appeal to certain funds such as the Social Economic Initiatives Projects (SEI) for the development of large sanitary projects. The Ministry of VROM can support with additional means when this is necessary<sup>93</sup>.

The costs that are related to the regulatory responsibilities of the VROM Inspection authority for drinking water on the BES islands are not defined yet. It is not known how potential costs in the future are divided between the BES islands and the Ministry.

The Ministry of VROM has a fixed annual fund available for environmental issues on the BES islands from the transition date onwards. The fraction of this structural fund that is available for the supply and regulation of drinking water is not determined yet.

### *Quality inspection of drinking water*

In the Netherlands, drinking water suppliers are responsible for drinking water quality inspections. Drinking water samples are taken by the drinking water suppliers according to the quality inspection program as defined in the Dutch drinking water law.

On the BES islands, the local regulatory authorities are responsible for the inspection of the drinking water quality. The Antillean Public Health Inspection has delegated its inspection duties to the Local Health Inspection on Bonaire. The Local Health Inspection takes drinking water samples from all drinking water suppliers according to the quality inspection program as defined in the Antillean drinking water law.

In the new situation, inspection authorities need to be developed on all BES islands to perform quality inspection programs. The VROM Inspection authority will assist and supervise the inspection duties. The VROM Inspection Authority has no experience with delegating regulatory duties and/or supervising overseas distribution areas. The organizational design for the new overseas regulation and inspection system has not been designed yet.

### *Appointing drinking water suppliers and laboratories on the BES islands*

In the Netherlands, the VROM Inspection Authority is authorized to appoint drinking water suppliers. After the transition on the BES islands, Island Governments remain the competent authorities to appoint drinking water suppliers and grant them the necessary concessions. The Island Governments remain supported in their decisions by the Supervisors for Drinking water (the Local Health Authorities).

---

<sup>91</sup> Beckman Lapre, 2010

<sup>92</sup> MinVROM, 2009

<sup>93</sup> Beckman-Lapre, 2010

At this moment the Antillean Ministry of Public Health is responsible for the accreditation process of drinking water laboratories, in the new situation the Ministry of VROM will take over this responsibility.

#### *Council for Drinking Water*

The concept of the Drinking Water Council is maintained in the new organizational setup. The Dutch Minister of VROM has to appoint 5 independent drinking water experts who need to provide recommendations to particular stakeholders in the arena when this necessary.

#### 4.4.3 Important changes after the transition

After the transition of the BES islands into public entities, the Ministry of VROM is responsible for the supply of drinking water on the BES islands. The Inspection Authority of VROM will be the responsible regulatory authority. Although some inspection duties are delegated to the local Health Authorities on Bonaire, the VROM Inspection Authority remains responsible. Saba and Statia do not have the means, capacity and knowledge to perform delegated inspection duties themselves. Therefore the Ministry of VROM needs to provide the necessary support to erect a new quality inspection organization on these islands.

In contrary to the Dutch system, the Local Health Authorities (on Bonaire) will be responsible for the execution of drinking water quality inspections instead of the drinking water suppliers. Local quality inspection authorities for Saba and Statia have not been defined yet.

The VROM Inspection authority will supervise and assist any overseas inspection processes. The VROM Inspection authority has however no experience with delegating regulatory duties and/or supervising overseas distribution areas. The organizational design for the new overseas regulation and inspection system has not been designed yet.

Although the Ministry of VROM is responsible for the supply of drinking water on the BES islands, the Island Governments appoint drinking water suppliers and grant concessions. This needs to be done in cooperation with the Supervisors for Drinking water on the individual islands. The Minister of VROM is responsible for appointing drinking water laboratories for the BES islands; this remains unchanged in the new situation. The Island Governments are also responsible for the development and financing of new drinking water facilities on the BES islands. Potential projects can be supported with EU funds or additional means of the Ministry of VROM.

The Ministry of VROM is required to erect a Council for Drinking water on the BES islands, that function as an independent advisory authority for the drinking water stakeholders.

#### 4.5 Conclusions

In this chapter, both system analyses and stakeholder analyses have been conducted of the different drinking water supply systems on the BES islands. The results of these analyses have been gathered to form the Basis of Design (BoD) for this research study. The system analyses provide answers to sub-research question 2 *“What are the goals and performance criteria for a desired drinking water supply system on the BES islands with respect to the local conditions?”* and question 3 *“What are initial instruments that can be applied to meet the formulated performance criteria?”*

The stakeholder analyses provide an answer to sub-question 4 (see Figure 27): *“Who are the stakeholders that are involved in the current and new drinking water supply system?”*

The main objective of the Ministry of VROM is: *“To maintain a sustainable drinking water supply on the BES islands”*

Two essential performance criteria for the overall drinking water supply system on the BES islands are that serve to measure the degree in which technical and institutional instruments meet the related objectives are:

- 'Number of quality norm exceedings per year'
- 'Number of drinking water shortages per capita per year'

The results of the system analyses have been used to develop system diagrams. These system diagrams provide more insight into the interactions between the objectives, instruments and problem mechanisms of the drinking water supply systems of Bonaire and Saba/Statia. Essential sub-systems derived from these system diagrams have been elaborated in more detail. These sub-systems describe the main problem mechanisms for the joint BES islands and the islands of Saba and Statia.

The BES islands generally suffer from two main problem areas; the inspection and regulation of drinking water and the protection of water resources on the BES islands. The latter issue is directly and indirectly affecting the overall quality of drinking water on the islands.

The islands of Saba and Statia have problem areas regarding the quality and quantity of drinking water. These issues are mainly related to the management and construction of rainwater harvesting systems that are currently the primary sources of drinking water on the islands.

The problem areas that have been defined in this chapter serve as the starting point for the lesson drawing procedure in the following chapters of this research study. Lessons are drawn from other locations that show (or showed) similar problem conditions as the drinking water systems on the BES islands. The detailed analysis of the underlying cause and effect relations of the specific problem areas will increase the quality of the lesson-drawing procedure in the following chapters.

The other element of the Basis of Design is the stakeholder analysis; this analysis determines the formal stakeholder network in the current situation and compares it with the stakeholder network after the constitutional transition. One of the consequences of the changing roles and responsibilities is that a new overseas drinking water regulatory and inspection organization needs to be formulated. This regulatory and inspection organization is supervised by the Inspection authority of the Ministry of VROM and executed both by the national and local inspection authorities. On Bonaire, regulatory and inspection duties will be conducted by the local health inspection authorities. On Saba and Statia new inspection authorities need to be defined. The Ministry of VROM and the VROM Inspection authority will play an important role in the training and certification processes of these local authorities. Examples of other foreign overseas inspection and regulation systems will be investigated during the lesson drawing procedure in chapter 6. The key stakeholders that have been identified in this chapter will be used during the formulation and integration of lessons in chapters 6 and 7.

## 5 Source site identification

### 5.1 Introduction

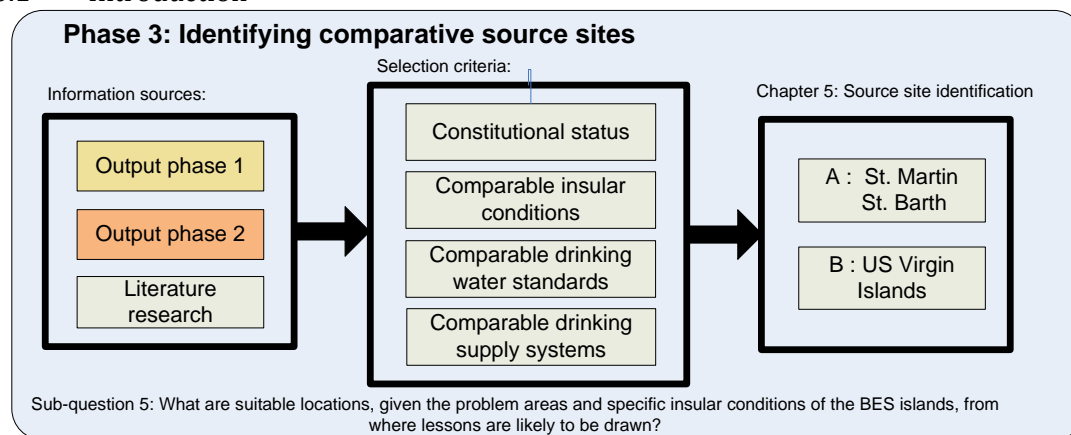


Figure 41 Research phase 3

In the previous chapters the problem context has been demarcated and the basis of design has been developed for an improved drinking water supply on the BES islands. The next step is to gather lessons in order to define useful instruments that support the objectives from the BoD and mitigate the existing problem situation on the BES islands.

This chapter provides an answer to research sub-question 5 (see Figure 41) by defining the source sites on which the lesson drawing procedure is conducted. These sources sites are identified using a predefined set of selection criteria. Based on a pre-selection criterion, a list of potential sites has been defined and these sites are scored on the main selection criteria. Two locations have been selected; one that matches the specific conditions on Bonaire, the other one matches the conditions on Saba and Statia.

Section 5.2 defines the selection criteria, section 5.3 presents a set of potential source sites. The selection procedure is conducted in section 5.4. The last section presents descriptions of the two source sites and the lesson drawing methodologies that are applied.

### 5.2 Selection criteria

Table 1 Selection criteria for source sites

Table 1 Selection criteria for source sites		
Criteria:	Source site A	Source site B
Constitutional status:	Overseas territories of Western oriented (preferably European) territorial countries. Source sites maintain national legislation of the mainland.	
Specific insular conditions:		
Climate:	<ul style="list-style-type: none"><li>Sub-tropical, rainfall rates &lt; 400mm/year</li></ul>	<ul style="list-style-type: none"><li>Sub-tropical, rainfall rates &gt; 400mm per year</li></ul>
Geography:	<ul style="list-style-type: none"><li>Oceanic Caribbean islands</li><li>Hilly conditions, subsoil consisting of impenetrable rock</li></ul>	<ul style="list-style-type: none"><li>Oceanic islands located in the Caribbean hurricane belt</li><li>Hilly/mountainous conditions, subsurface consisting of impenetrable rock</li></ul>
Demography:	Population size: 5000-50.000	Population size: 1000-10.000
Drinking water quality standards:		
	<ul style="list-style-type: none"><li>Internationally recognized drinking water standards.</li></ul>	<ul style="list-style-type: none"><li>Internationally recognized drinking water standard</li><li>Specific policy instruments regarding rainwater harvesting</li></ul>
Drinking water supply systems:		
	<ul style="list-style-type: none"><li>Seawater desalination</li><li>Distribution with public networks</li></ul>	<ul style="list-style-type: none"><li>Rainwater harvesting</li><li>Additional desalination production</li><li>Minimal public distribution networks</li></ul>

The BES islands can be divided into Bonaire on the one hand and Saba and Statia on the other hand. Saba and Statia have almost identical geographical conditions, similar sources of drinking water, insular context and demography. Bonaire is geographically different, has a larger population size and is faced with other types of issues regarding the supply of drinking water.

#### 5.2.1 Constitutional status

The BES islands are Caribbean overseas territories of a European country. Once the BES islands are public entities of the Netherlands, the Dutch government takes the responsibility for the supply and regulation of drinking water on the BES islands. The main legislator and regulatory authority is located in the Netherlands and not on the BES islands. Local drinking water suppliers and supply systems need to be regulated, monitored and inspected on overseas territories, supervised from the mainland.

When identifying source sites for lesson learning, it is interesting to analyze locations for which other Western countries have chosen to maintain their national drinking water legislation and regulate overseas drinking water supply systems from the mainland. Useful information can be drawn from these locations on how to implement and adapt the national drinking water legislation and how to organize regulatory authorities for overseas drinking water supply systems. It is decided, for practical reasons, to select locations from within the Caribbean region; not only does this narrow down the wide range of small islands that potentially qualify but it is also a guarantee for some important conditions that need to be met. The Caribbean region is located in the hurricane belt, ranging from coast of West Africa to the southern states of the US. Next to that, the Caribbean region consists of many islands that are generally comparable in formation and geography. The fact that locations within the Caribbean region have some similar conditions may simplify the selection process.

#### 5.2.2 Specific insular conditions

The BES islands are all located in the Caribbean. However, the geographical and climatological conditions of the individual BES islands differ significantly. Also the size of the island, total yearly precipitation and methods of drinking water provision vary per island. Bonaire has different conditions than Saba and Statia, this needs to be taken into account with the following selection criteria.

##### *Geography, climate and demography*

##### Source site A:

Potential source sites need to be located in the Caribbean, having a sub-tropic climate; rainfall rates need to be less than 400mm/year. This makes rainwater not the primate source of drinking water. The location needs to have a relatively hilly character, consisting of impenetrable rock. There is minimal infiltration into the subsurface layers; all run-off flows are directly diverted to the ocean. Therefore the source site has no major fresh groundwater resources or aquifers (wells, springs, etc) that can serve as alternative water source. The previous criteria are necessary to guarantee that this island is fully dependent on seawater desalination.

The number of inhabitants should be comparable to Bonaire, preferably between 5000 and 50.000 inhabitants.



#### Source site B:

Source sites need to be situated in a tropical humid climate, preferably within the Caribbean hurricane belt. Yearly precipitation rates should be high, more than 400mm/year, allowing the use of rainwater harvesting as a primary source of drinking water<sup>94</sup>.

The geological structure of the island needs to consist of impenetrable rock, under hilly/mountainous conditions. The specific soil conditions prevent the source site from having enough fresh groundwater resources.

The population size for potential source site should be comparable with Saba/Statia, around 1.000-10.000 inhabitants.

#### 5.2.3 Drinking water quality standards

For all potential source sites it is important to maintain either internationally recognized drinking water standards, examples are WHO guidelines<sup>95</sup>, European guidelines for drinking water<sup>96</sup> or US EPA guidelines as put forward in the Safe Drinking Water Act<sup>97</sup>. Other drinking water standards or regulations are possible, as long as they provide the same level of public health protection as the Dutch or the aforementioned standards.

The Dutch drinking water sector has no experience regarding rainwater harvesting as a means of potable drinking water provision. Therefore it is desirable to identify source sites that do have policy measures, legislation or guidelines concerning the collection, storage and consumption of rainwater (as a primary source of drinking water). This only applies for source site B.

#### 5.2.4 Type of drinking water supply systems

##### Source site A:

Potential source sites should use, seawater desalination techniques. Drinking water needs to be supplied via communal distribution networks or using water trucks.

##### Source site B:

Rainwater harvesting should be the main source of drinking water for the majority of the inhabitants. Rainwater needs to be harvested from rooftop catchments and stored in cisterns.

#### 5.3 Source site selection

This section defines a set of potential source sites; these locations will be rated on the selection criteria in a scorecard. The location with the highest score will be selected as source site.

Overseas territories from other various countries are mainly ex-colonial and can be found all over the world. Countries that govern overseas territories are Spain, Portugal, the United Kingdom, France and the United States.

##### 5.3.1 Pre-selection on constitutional status

Using the first criterion: “constitutional status” as a starting point, the range of potential sources sites can be narrowed down significantly. From the previous countries, the British Overseas Territories do not meet the first criterion. The UK has 14 Overseas Territories; they are however not part of the United Kingdom itself. The Territories are the remnants of the British

---

<sup>94</sup> Department of Sustainable Development, 2008

<sup>95</sup> Guidelines for Drinking-water quality, 2008

<sup>96</sup> Council Directive 98/83/EC, 1998

<sup>97</sup> US Safe Drinking Water Act, 1974

Empire that have not acquired independence or have voted to remain British territories. All overseas territories have their own system of government, and maintain localized laws and regulations not being international standards<sup>98</sup>.

The potential sites that remain are overseas territories of Spain, Portugal, France and the USA. From these countries, only the USA and France have islands that are qualified since Spain and Portugal do not have overseas territories in the Caribbean region.

### 5.3.2 Potential source sites

#### *United States*

The US have many insular areas (or insular possessions), these areas are divided into *incorporated areas*, *unincorporated areas* and *freely associated states*. The freely associated states are sovereign territories that are not within US jurisdiction<sup>99</sup>. The only incorporated area is an uninhabited atoll and does therefore not qualify. The unincorporated areas maintain the US EPA drinking water regulations. Within the unincorporated areas there are two areas that qualify the pre-selection criterion, these are:

- Puerto Rico
- US Virgin Islands (consisting of 4 different islands)

#### *France*

The Republic of France has several overseas territories, separated into overseas *Departments*, *Regions* and *Collectivities*. Overseas departments (Départements d'Outremer) usually maintain the same constitution and laws as on the French mainland. For French overseas collectivities (Collectivités d'Outremer) the situation varies; some collectivities maintain high degrees of autonomy others are governed like the French overseas departments<sup>100</sup>. The following French overseas locations meet the remaining selection criteria:

- Guadeloupe
- Martinique
- Saint Martin
- Saint Barthelemy

### 5.3.3 Selection process for source site A:

<b><u>Selection criteria:</u></b>	<b>Puerto Rico</b>	<b>USVI</b>	<b>Guadeloupe</b>	<b>Martinique</b>	<b>Saint Barth</b>	<b>Saint Martin</b>
Climate:	+/-	+/-	+/-	+/-	+/-	+/-
Geography:	X	+	X	X	+	+
Demography:	X	+	X	X	++	++
Drinking water standard:	++	++	++	++	++	++
Drinking water supply systems:	X	+	X	X	+	++
<b>Total score:</b>	<b>X</b>	<b>+</b>	<b>X</b>	<b>X</b>	<b>+</b>	<b>++</b>

<b>Legend:</b>	
+/-	Potentially qualified
+	Qualified
++	Highly qualified
X	Not qualified

<sup>98</sup> <http://www.fco.gov.uk>, visited on April 19, 2010

<sup>99</sup> United States Office of Insular Affairs, visited April 20 2010

<sup>100</sup> Ambassade de France, Frankrijk Overzee, visited on July 15 2009

Puerto Rico, Guadeloupe and Martinique failed for the criteria 'Demography' and 'Drinking water supply system' and are therefore not qualified. The three islands are much larger than Bonaire; Guadeloupe has the smallest population size with 400.000 inhabitants. Puerto Rico has more than 4 million inhabitants. The scale of these islands cannot be compared with a small island like Bonaire. Next to that, the geography of the islands allows the presence of large fresh water resources that serve as the primary source of drinking water<sup>101,102</sup>. The drinking water supply systems are therefore different to systems on Bonaire.

The US Virgin Islands, Saint Barth and Saint Martin have high average scores for all selection criteria. The climate of the three islands is somewhat different than on Bonaire, since the islands suffer from longer rain seasons.

The US Virgin Islands consist of 4 islands; some of the islands meet the criteria for Bonaire, this has mainly to do with the specific demography of the individual islands. In general there are two major sources of drinking water on the islands: rainwater and desalinated seawater<sup>106</sup>.

On Saint Barth communal drinking water networks are combined with public standpipes and private rainwater collection, Saint Martin is mainly using communal drinking water networks and additional rainwater harvesting<sup>103</sup>.

Saint Martin has the highest score; the USVI and Saint Barth have equal scores for this selection procedure.

Since Saint Martin and Saint Barth are only a few miles separated from each other, it is decided to jointly select them for source site A. In this way an extra source site can be included to increase the possibility to draw lessons.

#### Source site A: Saint Martin/Saint Barth

#### 5.3.4 Selection process for source site B:

<b><u>Selection criteria:</u></b>	<b>Puerto Rico</b>	<b>USVI</b>	<b>Guadeloupe</b>	<b>Martinique</b>	<b>Saint Barth</b>	<b>Saint Martin</b>
Climate:	++	++	++	++	++	++
Geography:	+	++	++	++	+	++
Demography:	X	+	X	X	++	+/-
Drinking water standard:	+	++	++	++	++	++
Drinking water supply systems:	X	++	X	X	X <sup>104</sup>	X <sup>104</sup>
<b>Total score:</b>	<b>X</b>	<b>++</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>

The selection criteria for source site B are based on the conditions on Saba and Statia; small volcanic islands that mainly depend on rainwater harvesting. Next to that, the source site must also have drinking water regulations regarding the use of rainwater for human consumption.

The only islands that actively use rainwater harvesting as a source of drinking water are Saint Barth, Saint Martin and the USVI. The US Virgin Islands are one of the few areas<sup>105</sup> in the world where harvesting of rainfall contacting roof surfaces and subsequent storage of this water is required by law<sup>106</sup>. Next to that, the USVI maintain specific legislation for the construction of public and private rainwater harvesting systems<sup>107</sup>. Rainwater, next to seawater, is an important

<sup>101</sup> Environmental Protection Agency (EPA), visited on July 2009

<sup>102</sup> Institut National de la Statistique et des Etudes Economiques, visited on July 2009

<sup>103</sup> Saal, 2002

<sup>104</sup> Rainwater harvesting is a major source of fresh water on these islands, but there are no specific regulations implemented regarding the use or construction of rainwater systems itself

<sup>105</sup> Other locations that maintain specific legislation regarding the construction of cistern systems are Barbados, the Turk and Caicos Islands and Bermuda<sup>105</sup>. The latter locations do not meet internationally recognized drinking water standards and are not considered as good examples for source sites.

<sup>106</sup> Smith, et al., 1999

<sup>107</sup> Gould, J., Nissen-Petersen, E., 1999

source for communal drinking water supply. Therefore both Saint Barth and Saint Martin do not qualify.

#### Source site B: US Virgin Islands

### 5.4 Source sites and methodology

#### 5.4.1 Source site A: Saint Martin and Saint Barth

Since 2004, St Martin and St Barth are 'Collectivités' of the French Republic. This status is comparable the future relation between the BES islands and the Netherlands (Public Entities). Before 2004, St Martin and St Barth were grouped within the 'Territoire d'Outremer' of Guadeloupe. Being Collectivités of the French Republic, the islands have the status of ultra peripheral region (UPG) which makes them part of the European Union<sup>108</sup>.

##### *Saint Barth*

La Collectivité de Saint Barthelemy is located a 10 miles southeast from Saint Martin, the country has a total surface of 21km<sup>2</sup> and counts approximately 9000 inhabitants (see Figure 42). The island is mainly hilly, consisting of volcanic rock. The population counts 12.000 inhabitants during the high season and about 6.000 during low season. The island depends heavily on the influx of tourists. Saint Barth is very popular among sailors and facilitates luxury yachts with high profile tourist services<sup>109</sup>.



Figure 42 Saint Martin and Saint Barths

##### *Saint Martin*

La Collectivité de Saint Martin is the southern half of the island St Maarten. St Maarten has a total land surface of approximately 87 km<sup>2</sup> that is divided between France (53 km<sup>2</sup>) and the Netherlands Antilles (34 km<sup>2</sup>). St Maarten is the smallest inhabited sea island divided by two nations. The total population on the French Side counts around 40.000 inhabitants. The economy is mainly tourism based<sup>109</sup>.

#### Lesson drawing methodology

The French islands of Saint Martin and Saint Barth have been visited for 7 days, from the 19<sup>th</sup> to the 26<sup>th</sup> of September in 2009. Lessons have been drawn mainly based on exploratory interviews with drinking water stakeholders<sup>110</sup>. In total two interviews have been held, 1 on Saint Barth and 1 on Saint Martin. Interviews have been held with the managers of the public drinking water suppliers of Saint Martin and Saint Barth (Union Caraïbe de Desallement d'Eau de Mer). Transcripts of these interviews can be found in the external interview appendix. Based on the interviews, an overview of the drinking water supply systems has been developed. Useful elements of the drinking water supply system have been described as potential lessons in the next chapter.

<sup>108</sup> Ambassade de France, 2009

<sup>109</sup> Wikipedia, visited on May 2nd 2010

<sup>110</sup> It turned out to be quite hard to find and contact potential respondents on the French Antilles. The interviews or discussions were unstructured and exploratory.

## 5.4.2 Source site B: US Virgin Islands

### Introduction

The US Virgin islands (USVI) are a group of islands in the Caribbean, 140 km east of Puerto Rico (see Figure 43). The USVI are surrounded by the British Virgin islands on the northeast side and the Spanish Virgin Islands on the west side and consist of 4 main islands: St Thomas, St Croix, St John and Water Island. The total surface area of the combined islands is approximately 346 km<sup>2</sup>; the total population counts 108.000 inhabitants. The islands are relatively small (none having an area exceeding 90 square miles) and are for the most part of volcanic origin. The economy is principally supported by tourism; therefore the population numbers vary significantly throughout the year<sup>111</sup>.



Figure 43 US Virgin Islands

### Lesson drawing methodology

The US Virgin Islands have been visited for 9 days, from the 22<sup>nd</sup> to the 30<sup>th</sup> of March in 2010.

The lessons that have been drawn on the US Virgin Islands are based on 3 interviews with local drinking water stakeholders. These stakeholders were the public drinking water supplier (VI Water and Power Authority) and the regulatory authority for drinking water (VI Department of Planning And Natural Resources).

Interview questions have been defined beforehand. The interview questions can be found in appendix L. With the interview questions, the drinking water supply system on the Virgin Islands has been analyzed as a whole. The main technical, institutional and regulatory systems have to be determined in order to define potential lessons. Other

interview questions focus on the problems or risks that are currently experienced by the respondents. These problems can be potential negative lessons, and should be avoided on the BES islands.

During the field trip an additional interview has been held with Professor Smith, head of the Water Resources department of the University of the Virgin Islands. This exploratory interview led to more information on the introduction of the drinking water distribution network, wastewater problems and on rainwater harvesting on the Virgin Islands (see chapter 6 and appendix M).

## 5.5 Conclusions

In this chapter research sub-question 5 has been answered: “What are suitable locations, given the problem areas and the specific insular conditions of the BES islands, from where lessons are likely to be drawn?” Two source sites have been identified that are used for the lesson-drawing procedure. Based on the specific conditions of the target sites (Bonaire and Saba/Statia), selection criteria have been defined. These selection criteria are classified into the following categories:

<sup>111</sup> Smith, et al., 1999

- Constitutional status:

This criterion identifies locations in the Caribbean region that are governed by Western (oriented) countries and have implemented drinking water legislation from the mainland

- Specific insular conditions

The source sites need to meet specific properties that relate to Bonaire and Saba/Statia. The insular conditions are categorized into geographical, climate and demographical properties.

- Drinking water quality standards

Potential source sites need to have implemented internationally recognized drinking water quality standards in order to serve as an example for the BES islands.

- Type of drinking water supply system

In order to draw lessons from the source sites, the type of drinking water supply system needs to match the systems available on the BES islands. In this case, source site A needs to have a drinking water supply system based on desalination of seawater. Source site B needs to have both desalination and rainwater systems in order to match the situation on Saba and Statia.

Based on the selection process two source sites have been selected. Source site A meets the selection requirements for Bonaire. Source site B meets the requirements for Saba and Statia. The following locations have been identified:

Source site A: Saint Martin and Saint Barth

Source site B: US Virgin Islands

In the next chapter these source sites are used to perform the lesson drawing procedures. Field visits have been conducted to both islands and interviews have been held with critical stakeholders within the local drinking water sector.

## 6 Lessons from source sites

### 6.1 Introduction

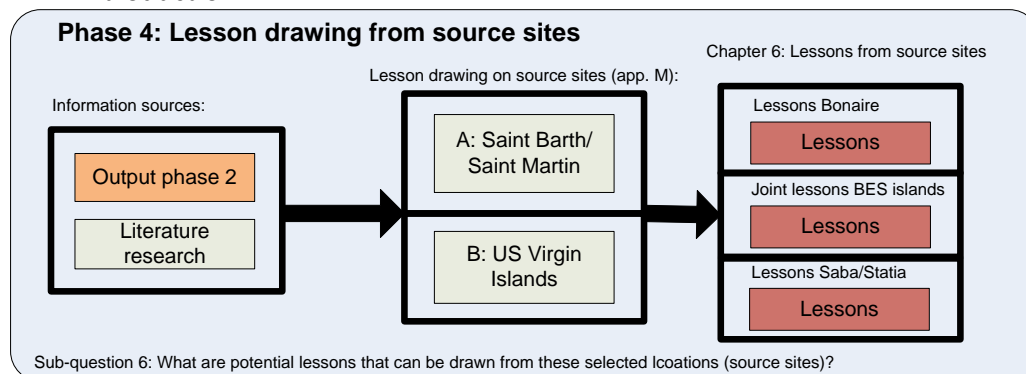


Figure 44 Research phase 4

The previous chapter has defined the source sites for lesson drawing; these are the French Antillean islands of Saint Martin and Saint Barth and the US Virgin Islands. Two field trips have been conducted to these source sites to explore the drinking water supply systems and their context. The data that is gathered during these field trips is used to develop models from the drinking water supply systems that serve as the basis for the lesson-drawing procedure. The lessons that are derived from this procedure provide the answer to sub-question 6 (see Figure 44). A large number of lessons have been drawn on the individual source sites; only a critical selection has been presented in this chapter. Descriptions and a summary of the full selection of lessons can be found in appendix M.

Section 6.2 elaborates the lesson-drawing procedure. The lessons from the French islands are presented in section 6.3 and the lessons from the US Virgin Islands in section 6.4. The chapter finishes with the conclusions in section 6.5

In the next chapter, the lessons that are gathered at the source sites are combined and integrated with the initial instruments from chapter 4 to develop the overall design for an improved drinking water supply system.

### 6.2 Lesson drawing procedure

The objective of the two field trips is to understand how a foreign drinking water supply *programme* works there in order to draw lessons that can serve as a means to improve the drinking water supply on the BES islands.

The drinking water supply system and its institutional context at the two source sites are analyzed using interviews and literature research as the main data sources<sup>112</sup>. Important elements and characteristic features of the foreign drinking water supply systems are defined in order to create models from the drinking water supply systems at the source sites. The purpose of these models is to provide a generic description of how the supply systems at the source site function by showing the relations between its elements. The models form the precondition for the lesson-drawing procedure.

In appendix M, models are presented of the drinking water supply systems of Saint Barth/Saint Martin and the US Virgin Islands (this appendix also includes all references to interviews). These models contain a technical overview of the foreign supply methods and technology. Furthermore, the models describe the relevant institutional aspects of the foreign drinking water supply systems. Information is provided on the drinking water legislation, specific regulations and the stakeholder network that is involved in the supply and regulation of

<sup>112</sup> The relevant interview questions and interview transcripts can be found in appendix L and in the additional interview appendix



drinking water. The last element of the models is the description of specific sub-systems within the foreign programmes. Based on the sub-systems described in section 4.3 similar sub-systems on the source sites have been identified. Important technical and institutional elements within these foreign sub-systems that can potentially improve specific sub-systems on the target sites are elaborated in more detail. The best practices identified within each sub-system form the basis for potential lessons.

The next step is to extract lessons from the models that have been developed of the foreign drinking water supply systems. These lessons are formulated as practical and descriptive outlines of the means and ends of foreign policies. These lessons can ultimately be integrated with the existing instruments in the system models from section 4.3 to support the system criteria. In this chapter a distinction has been made between general lessons that apply for the BES islands and lessons that apply for a specific island<sup>113</sup>.

## 6.3 Lessons from source site A: French St Martin and St Barth

### 6.3.1 BES islands

- *Central water quality inspection program*

Problem area:	<ul style="list-style-type: none"> <li>• Drinking water regulation and inspection</li> </ul>
Performance criterion:	"Number of quality norm exceedings per year"
Stakeholders involved for implementation:	<ul style="list-style-type: none"> <li>• Ministry of VROM</li> <li>• VROM Inspection</li> <li>• Local Health Authorities</li> <li>• Drinking water laboratories</li> </ul>

An important difference between the drinking water organizations on the French Antilles and the BES islands is that on the French islands the individual island governments are responsible for both drinking water supply and regulation (see Figure 45). After the constitutional reformation of the BES islands, the Dutch ministry of VROM will be responsible for drinking water supply and regulation.

The local drinking water regulatory authority on the French Antilles, the "Direction de La Sante et Développement Social" (DSDS), is the main regulatory authority for health related topics (including drinking water). The DSDS is therefore responsible for the quality inspection of drinking water on the French Collectivitees. The DSDS is the only authority that is allowed to collect drinking water samples from public water systems for external quality analysis. Drinking water samples from Saint Barth, Saint Martin and Guadeloupe are all centrally analyzed in a public laboratory on the largest French island Guadeloupe. Water samples are packed and shipped by plane to "L'Institute Pasteur", located approximately 200 kilometers from the Collectivités. The results of drinking water analyses are sent by fax to the individual water suppliers on Saint Martin and Saint Barth. The quality of drinking water samples deteriorates over time; the DSDS have made arrangements with local airline companies that drinking water samples have priority on fixed connections to Guadeloupe. The DSDS authority of Guadeloupe receives the samples at the airport directly on arrival and transports them to the laboratory. The laboratory sends the quality analysis results by fax to the relevant water suppliers and to the regulatory authority on Saint Martin and Saint Barth.

<sup>113</sup> For this research project, this also means that step 7 of the framework by Rose is taken: lessons have only been drawn at the source site when they seemed to be suitable for application at the target sites.

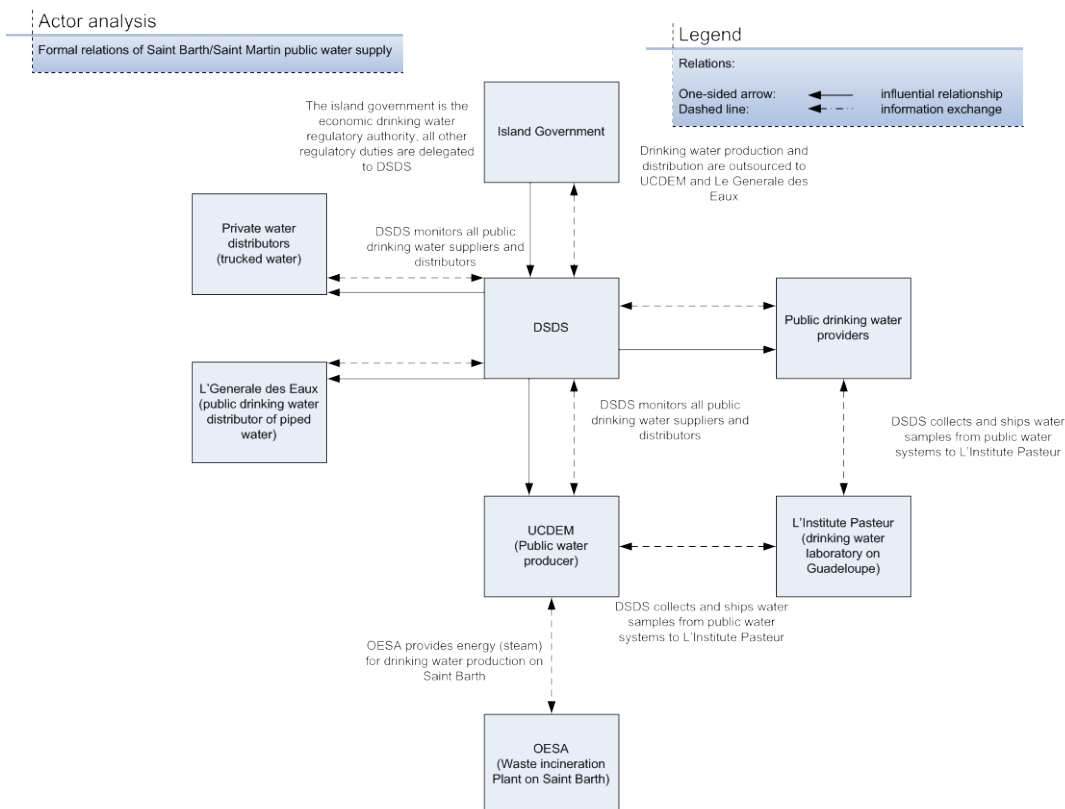


Figure 45 Drinking water organization Saint Barth/Saint Martin

The regulatory authority on the French Antilles serves as a good example of a central water quality inspection and regulation system. A similar system can also be an option for the BES islands. From an economic point of view it is infeasible for the individual BES islands to develop their own drinking water laboratories; the number of water quality samples is not sufficient. Central water quality inspection programs using only one central analysis laboratory turned out to be a feasible and efficient alternative for the French Antilles. The costs related to the process of drinking water quality sampling are rather expensive due to the logistics<sup>114</sup>.

The process time of water quality sampling, from taking the samples to sending back the analysis results takes about 12 hours on Saint Martin and Saint Barth, on Bonaire this takes currently 5-7 days. This is an important lesson for the BES islands; central water quality inspections in cooperation with other islands *can* be an economical and efficient option. However, solid arrangements and contracts with the involved stakeholders are crucial. E.g. instead of relying on only one airline company, arrangements can be made with multiple companies to make sure that water quality samples arrive at the right location within the restricted timeframe.

- *Sustainable waste-management system on Saint Barth*

Problem area:	<ul style="list-style-type: none"> <li>• Protection of water resources</li> </ul>
Performance criterion:	"Number of quality norm exceedings per year"
Stakeholders involved for implementation:	<ul style="list-style-type: none"> <li>• Ministry of VROM</li> <li>• VROM Inspection</li> <li>• National French Government</li> </ul>

Saint Barth has a sustainable solid waste recycling and incineration program; solid waste is separated into different waste flows. Waste that can be recycled is sent to France or Guadeloupe for further processing, all other types of waste are processed in a local incineration system. The

<sup>114</sup> Frank Greaux, interview #15

heat that is produced in the incineration process is used to produce drinking water. The local public works department operates the waste collection and incineration system. The drinking water production system is operated by the public drinking water supplier: the “Union Caraïbe de Dessalement d’Eau de Mer” (UCDEM)<sup>115</sup>. The system is built in 2001 and is financed by federal French grants (see Figure 46). Since Saint Barth has the UPG status and is therefore part

of the European Union, the waste management system has to comply with the European waste regulations.



Figure 46 Waste incinerator on Saint Barth

Solid waste forms a major environmental issue on all BES islands, often causing pollution of the subsurface soil, groundwater resources and the coral reefs (see chapter 3). Saint Barth provides an good example of how solid waste can be collected and processed on small Caribbean islands. Cooperation with larger islands is crucial for a small island as Saint Barth to benefit from additional recycling processes that would be infeasible on small island communities. Saint Barth has the facilities,

contracts and infrastructure to collect, sort, distribute and incinerate solid waste on the island itself. Saba and Statia can try to benefit from this existing waste management system by establishing an cooperation arrangement with Saint Barth. Solid waste can be transported from Statia and Saba to Saint Barth for further treatment within hours, since the islands are located less than 40 kilometer from each other. In this way, many environmental problems on Saba and Statia can be avoided. It will also decrease the risk that either rainwater or intake water for desalination plants gets contaminated. Developing a waste-management site on either Saba or Statia would probably be infeasible considering the scale and the economies on the islands. Bonaire has a larger population size, comparable to Saint Barth. Research is needed to determine if a similar system could also be feasible for Bonaire.

### 6.3.2 Saba and Statia

- *Specific regulatory duties regarding sanitary status of households*

Problem area:	<ul style="list-style-type: none"> <li>• Drinking water regulation and inspection</li> <li>• Drinking water quality</li> </ul>
Performance criterion:	“Number of quality norm exceedings per year”
Stakeholders involved for implementation:	<ul style="list-style-type: none"> <li>• Ministry of VROM</li> <li>• VROM Inspection</li> <li>• Local Health Authorities</li> </ul>

Management of private wastewater and rainwater systems are a major issue on the BES islands, currently there are no inspection bodies that monitor the sanitary status of these systems. Next to that, there is hardly public information or guidelines available on the use of private wastewater or rainwater systems.

Private wastewater tanks that do not function properly or that are located in the close proximity of rainwater cisterns can cause dangerous unsanitary situations. Fecal bacteria coming from these wastewater systems can contaminate rainwater in the cisterns. Also, if homeowners do not properly maintain rainwater systems, they can become a breeding place for

<sup>115</sup> Frank Greaux, interview #15

mosquitoes (for more information see appendix C). This can also lead to unhygienic circumstances regarding the quality of the rainwater<sup>116</sup>.

On the French Antilles, the regulatory authority, the DSDS, is allowed to enter properties and conduct random inspections (only outside private properties) of both cisterns and wastewater systems. When these systems are considered unsanitary, potentially harming third parties, the DSDS provides instructions to the particular users on how to avoid these unhygienic situations. The DSDS also publishes guidelines (via their website and local media) for proper management of both cistern and septic tanks. The DSDS is authorized to give fines to homeowners that refuse or neglect the instructions of regulatory authority.

On the BES islands, a new local drinking water regulatory organization needs to be erected supervised by the VROM Inspection authority. To prevent contamination of rainwater (used for human consumption) due to the unhygienic situations related to private waste and rainwater systems, this new drinking water regulatory authority can include sanitary inspections of private water systems within their regulatory duties. These activities need to be legally defined by the Ministry of VROM within the 'activity program' of the VROM Inspection and in the related regulations.

- *Specific regulations on private rainwater cisterns*

Problem area:	<ul style="list-style-type: none"> <li>• Drinking water regulation and inspection</li> <li>• Drinking water quality</li> </ul>
Performance criterion:	"Number of quality norm exceedings per year"
Stakeholders involved for implementation:	<ul style="list-style-type: none"> <li>• Ministry of VROM</li> <li>• RIVM</li> <li>• VROM Inspection</li> <li>• Local Health Authorities</li> <li>• Drinking water distributors</li> </ul>

The French Antilles, like the BES islands, experienced negative sanitation issues regarding the use of private rainwater cistern systems. Homeowners with a public drinking water connection frequently integrated internal drinking water plumbing systems with their rainwater systems. When this integrated plumbing system is not engineered in the right way, low-quality rainwater can flow back into the public distribution system leading to potential contaminations.

The island governments initially decided to prohibit rainwater cistern systems in 2001. In practice this did not succeed; all households maintained their rainwater cisterns as their primary source of fresh water. The government therefore changed its strategy from prohibition to education. The island governments provided information on management guidelines of rainwater cisterns to the general public. Specific guidelines are provided on the design, maintenance and disinfection of rainwater systems. This turned out to be more effective than prohibition of rainwater systems; people got more aware of the risks of rainwater harvesting and afterwards public drinking water consumption patterns increased<sup>117</sup>.

Furthermore, specific regulatory and technical measures have been introduced to prevent cross-contamination regarding cistern systems. An additional regulation has been added to the French drinking water law; it is required to physically separate rainwater cisterns from the public drinking water network. Drinking water suppliers are required to install double 'anti return' valves to prevent rainwater from flowing into the public network.

For the BES islands, faced with similar issues, the previous lessons is quite important. When new public drinking water networks are developed on Saba and Statia, one should take into account that the local population is not likely to cease the use rainwater cistern systems. Taking into account the experiences on the French Antilles, the local Health Authorities and VROM Inspection authority can implement similar instructions and regulations on rainwater

<sup>116</sup> Kolsky, 1997

<sup>117</sup> Richardson, interview #14

harvesting systems. The VROM Inspection authority, in cooperation with (for example) the RIVM can initiate similar awareness projects as on the French Antilles. The additional regulations on 'no-return valves' and construction guidelines for rainwater cisterns are also recommended; these can be integrated into the BES building codes and the BES drinking water law.

## 6.4 Lessons from source site B: US Virgin Islands

### 6.4.1 BES islands

- *Organization of an overseas regulatory authority*

Problem area:	<ul style="list-style-type: none"><li>• Drinking water regulation and inspection</li></ul>
Performance criterion:	"Number of quality norm exceedings per year"
Stakeholders involved for implementation:	<ul style="list-style-type: none"><li>• Ministry of VROM</li><li>• RIVM</li><li>• VROM Inspection</li><li>• Local Health Authorities</li></ul>

On the BES islands, a new drinking water regulatory authority needs to be defined, based on the conceptual drinking water organization as presented in chapter 4. The starting point of this new regulatory system is that the local health authorities will be delegated some regulatory duties on behalf of the VROM Inspection Authority. The VROM Inspection authority will remain the ultimate responsible authority that supervises and assists local health authorities on the BES islands.

#### *Set-up of regulatory authorities*

The drinking water regulatory system on the USVI can serve as an example of how a decentralized overseas regulatory system is developed over time (Figure 47). The local drinking water regulator on the USVI is a separate branch of the Department of Natural Resources (DPNR). This regulator: the Public Water Supply Supervision authority (PWSS) has been delegated regulatory duties by the federal environmental regulatory authority, the EPA. The PWSS has been trained and certified by the federal EPA to gain the so called 'primacy status'. The EPA grants the primacy status to when they consider an authority (in this case the PWSS) qualified to execute certain regulatory duties. Once the primacy status has been gained, the EPA and the PWSS still cooperate closely using an online drinking water supply monitoring system, the Safe Drinking Water Information System (SDWIS)<sup>118</sup>. This publically available system contains all reports, notifications and violations from local drinking water regulatory authorities in all US states. The EPA monitors the drinking water supply system on the USVI via this database. This system is also used to request additional information or assistance from the federal EPA. Through this SDWIS system, there is no need for a large permanent representation of the EPA on the individual Virgin Islands. The EPA still has an office on the USVI, but it houses only a small number of all-round EPA officials experienced in various environmental areas<sup>119</sup>. When the database system does not provide the necessary information or support, the local EPA office can be consulted for specific assistance.

A similar training and cooperation system as on the USVI can be used for the new regulatory organization on the BES islands. The VROM Inspection Authority can develop training and certification programs for the local regulatory authorities; when this training period has finished a defined set of regulatory and inspection duties can be delegated to the local regulators. The VROM Inspection Authority can erect a small back-office on the BES islands for various environmental topics (waste, spatial planning, etc). When necessary, this back-office can be consulted for assistance or specific knowledge. The VROM drinking water inspection authority in the Netherlands can monitor the status and reports of the BES islands via a similar database system as on the Virgin Islands.

In order to implement and establish similar organizational structure, more research on this particular institutional system is necessary.

<sup>118</sup> Website US Environmental Protection Agency, Water Resource SDWIS

<sup>119</sup> Harold Mark, interview #17

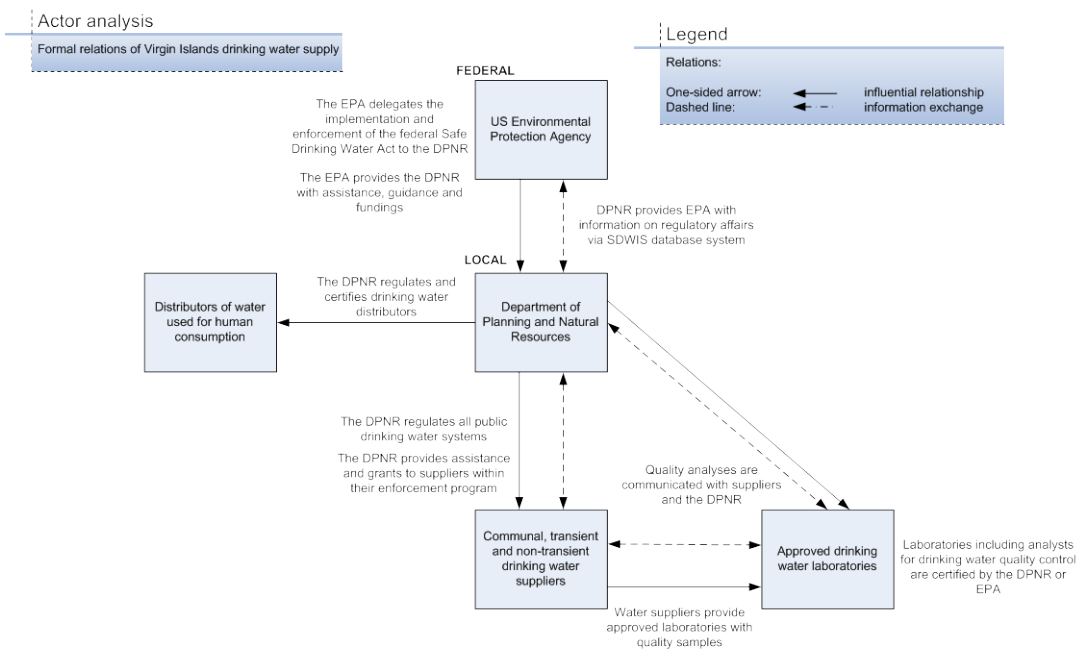


Figure 47 Drinking water organization US Virgin Islands

### *Training and certification duties*

The PWSS not only performs supervision and regulatory duties, the authority is also involved in training and certification programs. The EPA authorized the local PWSS to train and certificate drinking water suppliers and distributors. The EPA sometimes assists in these activities, especially for the certification of laboratories since this procedure requires both specific knowledge and personnel capacity. By delegating certification and training duties to the local drinking water regulator, EPA representative do not have to be flown in from Puerto Rico where the Caribbean headquarters are located. This makes the certification programs more economical and efficient<sup>120</sup>.

The local drinking water inspection authorities on the BES islands can be delegated with similar training and certification duties. They can train drinking water suppliers on, for example, performing internal drinking water quality analyses. Also, the local inspection authorities (in cooperation with the VROM Inspection authority) can get involved in the certification process of drinking water truck distributors. To avoid costly professionals to be flown in every so often to perform relatively simple training and inspection sessions, the local BES drinking water regulators can be authorized to perform these duties themselves. For specific assignments, the VROM Inspection authority or drinking water research institutes such as KIWA and the RIVM can be consulted.

### *Drinking water trucks*

Specific regulatory duties regarding the inspection and certification of drinking water distribution trucks (and their operators) are currently not included in the new BES drinking water law. On all



Figure 48 Drinking water truck on St Thomas

<sup>120</sup> Harold Mark, interview #17



three BES islands, drinking water is distributed using water trucks. Regulatory, inspection and certification duties regarding the distribution of drinking water via trucks are therefore recommended. The VI regulations<sup>121</sup> on drinking water trucks can serve as a suitable example for implementation in the BES drinking water law. These regulations prescribe that all drinking water trucks that are engaged in the transportation of water for human consumption shall be inspected and registered annually by the DPNR. Next to that, operators of drinking water trucks need to maintain records that indicate that water loads are coming from sources that are in compliance with Virgin Islands Safe Drinking Water Act.

#### 6.4.2 Saba and Statia

- *Measures to support the introduction of public drinking water*

Problem area:	<ul style="list-style-type: none"> <li>• Accessibility of drinking water</li> </ul>
Performance criterion:	Percentage of household connected to drinking water network
Stakeholders involved for implementation:	<ul style="list-style-type: none"> <li>• Ministry of VROM</li> <li>• Island Governments</li> <li>• Local Health Authorities</li> </ul>

Desalinated water was produced and distributed by the US Navy in the 1940's using a military water infrastructure on the US Virgin Islands. The development of the first drinking water supply system was purely a military operation that didn't need public acceptance or local support. Later on, this military supply system was expanded to provide the commercial and residential buildings on the islands with safe drinking water. The public distribution network has been constructed in the 1960's and was financed with US federal grants<sup>122</sup>.

The main goal of the local USVI government was to stimulate the to consume desalinated water instead of low-quality rainwater. In order to get the population connected to the new public network, both the drinking water rates and the connection fees are heavily subsidized (50%) using local USVI taxes. The rate for a cubic meter of desalinated drinking water is approximately 2,80 Euro. Desalinated drinking water that is distributed with water trucks is expensive: approximately 12 Euros per cubic meter.

Although the VI population was already acquainted with desalinated water and the rates are heavily subsidized, residents have been rather reluctant to connect themselves to the new public network. Approximately 50% of the households are currently connected to the public drinking water network since the introduction. There are many branches within the distribution network that are not used until today<sup>123</sup>. Although houses are connected to the public drinking water network, rainwater cisterns are still the main source of drinking water; public water is incidentally used to replenish empty rainwater cisterns. The residential distribution network is currently economically infeasible<sup>123</sup>. Dead ends within the distribution network are generally dangerous; standing water can (under the right conditions) be a breeding place for bacteria.

What can be learned from this negative lesson on the USVI is that for the introduction of a public drinking water network, *public acceptance* is critical. You can't assume that when a public drinking water network is developed, homeowners will automatically get connected and consume desalinated water. Every house has its own source of drinking water; there is really no necessity (from the perspective of the inhabitants) to switch to expensive and chlorinated public drinking water. Even after the application of economical incentives, the objective to connect the majority of the households to the public network has not been reached yet.

<sup>121</sup> *US Safe Drinking Water Act*, Title XIV of the Public Health Service Act (42 U.S.C. 300f-300j-9), Public Law 93-523. Dec 16, 1974

<sup>122</sup> Henry Smith interview #18

<sup>123</sup> Michael Quetel interview #15

When introducing or expanding drinking water networks on Saba and Statia, the following measures can be implemented in order to stimulate the consumption of desalinated drinking water and to reduce the risk of low consumption patterns.

*Provide information/initiate campaigns on the introduction of public drinking water*

People do not have a positive association with the desalinated water that is currently produced: the quality is unstable, the prices are relatively high, and there is a limited production capacity and no external quality inspection (see chapter 3). In order to get the population to switch from unstable rainwater to desalinated drinking water, support from the future consumers is crucial. Information needs to be provided on the *motivation* to change from rainwater to public drinking water. It is important to provide information on the risks of drinking rainwater and the benefits of consuming safe public drinking water. Next to that, it is important to *involve* the population when developing plans to introduce public drinking water networks. These initiatives need to be taken by the Ministry of VROM and the Island Governments (in cooperation with the local health authorities).

*Develop drinking water networks incrementally, depending on demand*

Based on the experience on the US Virgin Islands, it is important to develop and construct drinking water distribution networks in phases. When it is proven that there is public acceptance for the introduction of a distribution network and there is sufficient demand for desalinated water, an initial distribution network can be constructed. When this system is feasible and the demand for public water increases, additional networks can be connected. In the meantime, not connected homeowners can be supplied with drinking water trucks. In this way, infeasible networks and dead-ends can be avoided. The initiative to develop drinking water networks lies with the local island governments. Potential initiatives can be developed in cooperation with the Dutch Ministry of VROM. Additional financial means from European funds or the Social Economic Initiatives (SEI) might be necessary to construct communal distribution systems.

*Implement economic incentives to stimulate consumption rates*

Drinking water rates of desalinated drinking water are generally high on small islands. One way to stimulate the consumption of public drinking water might be to reduce the water rates artificially. In this way public drinking water can economically compete with rainwater or even bottled water. When public drinking water is affordable and available, it might be more interesting than to consume unstable rainwater. On the USVI, drinking water is subsidized using local taxes. Since the economic scale of the Virgin Islands is larger than the BES islands, national grants might be necessary to subsidize drinking water rates. More research into economic incentives in the form of subsidies is necessary.



Figure 49 Construction of rainwater cistern

- *Regulations and guidelines on rainwater cistern constructions*

Problem area:	<ul style="list-style-type: none"> <li>• Drinking water regulation and inspection</li> <li>• Drinking water quality</li> </ul>
Performance criterion:	"Number of quality norm exceedings per year"

Stakeholders involved for implementation:	<ul style="list-style-type: none"> <li>• Ministry of VROM</li> <li>• VROM Inspection</li> <li>• Local Health Authorities</li> <li>• Local Building Inspection Authority</li> </ul>
---	--

On the US Virgin Islands, rainwater harvesting is an important source of fresh water next to desalinated water. Rainwater harvesting is practiced for centuries and is therefore part of the culture and everyday life. The local USVI government would like the population to switch to safe public drinking water but is aware that this is not likely to happen soon, considering the cultural and economical aspects. Therefore, in order to safeguard public health, the USVI government decided to apply economic incentives to support the use public drinking water and at the same time to maintain specific regulations and guidelines regarding the use and construction of rainwater systems<sup>124</sup>.

### *Implement regulations and guidelines*

The USVI are the only country in the world that legally *requires* rainwater cisterns when houses are not located within the vicinity of public drinking water networks. Next to that, specific building regulations define both dimensions and construction methods of new rainwater systems (see Figure 49). The local building regulations on the BES islands do not include regulations on the construction of rainwater systems. On the BES islands, catchment areas and/or cistern capacities are generally too limited and do not compensate for modern water consumption patterns. Next to that, many sanitary problems are related to the construction, location and materials of rainwater cisterns. Based on the positive experience with cistern construction regulations on the USVI, similar building regulations legislation can be introduced and implemented on the BES islands.

Next to building regulations for new rainwater systems, additional *guidelines* can be introduced that prescribe how rainwater cisterns can be maintained and disinfected (Figure 50). Specific information on the disinfection methods and their positive and negative aspects need to be included. From past experiences on the USVI, it is known that providing information or guidelines on rainwater harvesting alone is not enough. People need to be informed on the reasons why regulations and guidelines are necessary. People also need to be *aware* of the dangers of drinking potentially contaminated rainwater. Pro-active campaigning and informing the local population is crucial to bring about knowledge and awareness<sup>124</sup>.



It is important to remark that from a legal perspective, the people themselves are responsible for managing their own private rainwater systems on the BES islands. The Ministry of VROM can only implement requirements on the construction of cisterns and provide enough information with the intention to promote proper rainwater management.

- *Emergency drinking water facilities on the USVI*

Problem area:	<ul style="list-style-type: none"> <li>• Continuity of drinking water supply</li> </ul>
Performance criterion:	"Number of drinking water shortages per capita per year"
Stakeholders involved for implementation:	<ul style="list-style-type: none"> <li>• Ministry of VROM</li> </ul>

<sup>124</sup> Henry Smith, interview #18

	<ul style="list-style-type: none"> <li>• Local Public Works department</li> <li>• Local Health Authorities</li> <li>• Public water supplier</li> </ul>
--	--

The USVI have specific emergency drinking water supply systems. Next to fixed emergency storage capacity at the public drinking water production plants, there are also emergency drinking water production units that can be placed at strategic locations on the islands. Several mobile Reverse Osmosis desalination units and small water storage containers are located on the islands. When necessary, the National Guard in cooperation with the public drinking water supplier (WAPA) distributes and installs these emergency drinking water systems. The production units and storage tanks provide safe drinking water for a small number of people for several days<sup>125</sup>.

On the field of emergency drinking water provision, lessons are drawn that might be applicable for the BES islands. Two of the BES islands are directly located in the Caribbean hurricane belt and need to be prepared for drinking water supply disruptions. Mobile emergency drinking water production units that are applied on the Virgin Islands can be a reliable back-up system when desalination facilities are not operational and rainwater cisterns cannot be used. These mobile desalination units can be operated, maintained and placed by the Local Health Authority, Public Works department or by the public water supplier (Statia). Another important lesson that can be drawn is that having enough redundancy within your drinking water supply system is crucial. It is important not to depend on one drinking water production plant (or unit) only; the same goes for main water storage tanks. Multiple production units and storage tanks in combination with back-up pumps and other accessories can reduce the risk of water supply disruptions significantly<sup>125</sup>. These measures can be included in the BES drinking water law by the Ministry of VROM.

- *Improve wastewater systems before introducing public drinking water*

Problem area:	<ul style="list-style-type: none"> <li>• Protection of water resources</li> </ul>
Performance criterion:	"Number of quality norm exceedings per year"
Stakeholders involved for implementation:	<ul style="list-style-type: none"> <li>• Ministry of VROM</li> <li>• Ministry of Transportation and Water management</li> </ul>

There is no central public sewer system on the US Virgin Islands; inhabitants use private septic tanks or cesspits. An estimated 50% of these private wastewater systems does not function properly or is inoperable<sup>127</sup>; this is mainly due to the geological circumstances and due to lack of maintenance (similar to the situation on the BES islands).

The introduction of the public drinking water network on the US Virgin Islands in the 1950's initially led to many wastewater problems. Once the drinking water distribution network had been introduced, the consumption patterns of the inhabitants increased. Traditional rainwater cistern users are very water efficient and consume 38-76 liters of rainwater per capita per day<sup>127</sup>. With the introduction of public drinking water on the USVI, people got less efficient and consumed around 70 liters per capita per day<sup>126</sup>. The increased drinking water consumption rates resulted in an increased wastewater flow. The balance of the water cycle was not stable anymore; wastewater systems were initially dimensioned for rainwater consumption patterns. The existing wastewater systems could not handle the increased load of wastewater; this resulted in more untreated wastewater flowing directly out of the wastewater systems. "Extra wastewater can lead to outbreaks of diseases, pollution of the environment and overall unsanitary situations"<sup>127</sup>. Introducing public drinking water supply systems on small islands, especially with these specific geological conditions in which 'leeching' is not optimally possible, can be very dangerous<sup>127</sup>. Considering the existing issues regarding erosion and contamination

<sup>125</sup> Michael Quetel, interview #16

<sup>126</sup> Koot, interview #11

<sup>127</sup> Henry Smith, interview #18

of water resources by untreated wastewater *and* the expected problems regarding the introduction of public drinking water, effective measures need to be taken to avoid more damage to the local ecosystems.

It is therefore very important to take into account the full water cycle when introducing public drinking water systems on Saba and Statia. Before designing a new drinking water supply system, there needs to be an operational wastewater system that can process the existing and future wastewater loads.

To avoid capacity problems due to the introduction of public drinking water on Saba and Statia, a wastewater management plan needs to be developed by the Ministry of VROM in cooperation with the Ministry of Transport and Water Management. The existing septic tanks on the islands need to be expanded, increasing the processing capacity. Over time, leeching cesspits and cesspools need to be replaced by more effective and less polluting septic tanks. To enforce the previous measures, specific building regulations on private wastewater systems need to be implemented, defining requirements on type, capacity, materials and location of new private wastewater systems. Public campaigns and guidelines need to inform the general public on the importance of maintaining and managing wastewater systems.

## 6.5 Conclusion

In this chapter lessons have been drawn from the source sites that were identified in the previous chapter. Two source sites have been identified; the French Islands of Saint Barth and Saint Martin and the US Virgin Islands. The lessons that have been drawn on these islands serve as potential instruments to achieve the objectives for an improved drinking water supply on the BES islands and provided the answer to research sub-question 6: *“What are potential lessons that can be drawn from the selected locations (source sites)?”*

In order to conduct the lesson drawing procedure, models have been constructed of the foreign drinking water supply systems. These models provide a general overview of the foreign systems and describe the essential technical and institutional elements of the individual systems. Furthermore, the models identify and elaborate these elements (sub-systems) of the drinking water supply systems on the source sites that show similarities with known problem areas on the target sites.

The formulation of the system-models formed the precondition for the lesson drawing procedure. Based on the models of the drinking water supply systems on the French Antillean islands and the US Virgin Islands, technical and institutional lessons have distilled for application on the BES islands. Furthermore, specific lessons have been drawn that describe the process based on which some instruments can be applied. What are the preconditions before certain policies or technical solutions can be used and what is the preferred sequence of events? These lessons are mainly based on negative experiences of the source sites.

The French islands of Saint Barth and Saint Martin provided a useful example of a centralized overseas drinking water quality inspection organization that can serve as inspiration for the new overseas regulatory organization on the BES islands. Next to that, the French islands presented a sustainable waste management system that can help to improve the protection of water resources on the BES islands. Specific policy lessons have been drawn with regard to inspection of private household in relation to the use and construction of rainwater cisterns.

The US Virgin Islands provided important information on their federal overseas drinking water inspection and regulation program. This program provided specific lessons on the delegation of federal regulatory duties to local inspection authorities. Furthermore, lessons were drawn on the general interaction between federal and local inspection authorities. The US Virgin islands provided specific policy lessons on the use, management and construction of rainwater harvesting systems. Next to that, valuable information has been retrieved on the introduction of public drinking water on the USVI. These lessons can be used to prevent certain negative experiences on the US Virgin Islands.

The next chapter takes into account the initial instruments that have been gathered in chapter 4 and integrates (or replaces) these instruments with the lessons that are drawn at the source

sites. This results in a set of technical and institutional instruments that can be used as guidelines to improve the existing drinking water supply at the BES islands.

## 7 Conceptual design

### 7.1 Introduction

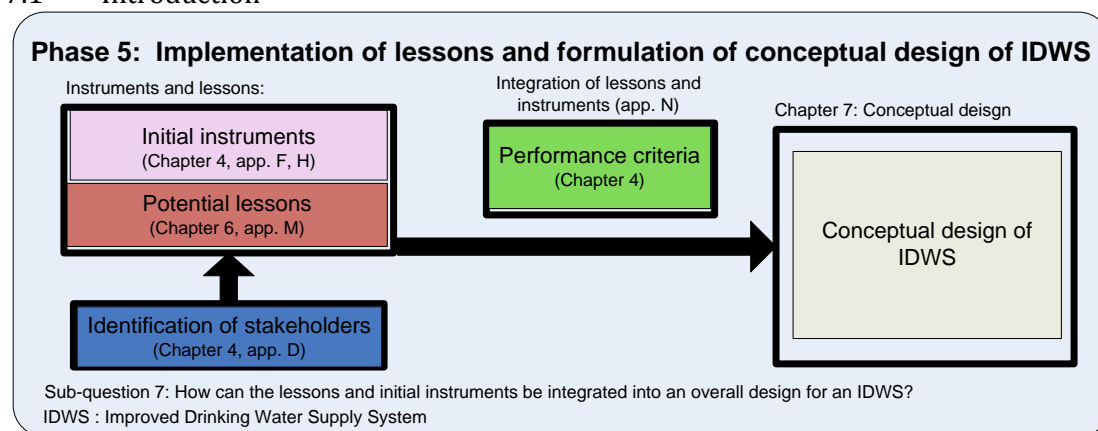


Figure 51 Research phase 5

In the previous chapter lessons have been drawn at source sites with specific properties that resemble the problem context of Bonaire, Saba and Statia. These lessons are based on models that have been made of the drinking water supply systems on the two French Antillean islands and the US Virgin Islands. The lessons that have been drawn consist of technical and institutional instruments in the form of best practices, organizational structures, policy, legislation and technical applications. This research study is based on the experiences of two source sites only, so the validity of the lessons is not fully tested. Therefore, the design that is presented in this chapter provides *guidance* on how to improve the existing drinking water supply systems on the BES islands. The technical and institutional instruments within this design do not describe the final solution to the existing problems; they serve as inspiration and guidelines for further research and policy-making.

The design provides an answer to research sub-question 7 (Figure 51) and also the main research question:

*“What are suitable technical and institutional instruments that can help to improve the drinking water supply system on the BES islands and how do these instruments need to be applied?”*

The design in this chapter is formulated by integrating and combining the lessons from the source sites with the initial instruments that are derived from the system analyses of the target sites. In appendix N, the integrating procedure is visually represented using diagrams, in which the difference between lessons and the existing instruments are shown. The lessons complement, specify or replace the initial instruments. Both the lessons and the instruments are tested on the performance criteria specified in chapter 4 and combined in a final set of technical and institutional instruments. More information on the methodology that is used to integrate the lessons and the initial instruments can be found in appendix N. This chapter describes the way in which the technical and institutional instruments can be applied as a sequence of steps. These steps intend to support the achievement of the objectives for an improved drinking water supply system on the BES islands.

### 7.2 Design steps

#### 7.2.1 Modify BES drinking water law



The Antillean drinking water legislation has been the legal starting point for the new BES drinking water law. The former Antillean law has been adjusted for application in the new constitutional situation. References within the regulations referring to former Antillean authorities have been replaced with the appropriate Dutch and local authorities on the BES islands. Besides these technical corrections, the BES drinking water law needs additional adjustments on the following topics:

- Drinking water quality indicators<sup>128</sup>

It is recommended to determine proper drinking water quality indicators for the BES islands; it is not likely that the current quality indicators within the new BES drinking water law are all relevant for the BES islands. Next to that, specific regulations need to be implemented concerning the presence of legionella bacteria. Research needs to be conducted into the specific indicators and threshold values that need to be adjusted or implemented by specialized organizations (for example the RIVM research institute).

- Regulations on drinking water trucks

The distribution of drinking water by truck is currently not subjected to specific regulations within the new BES drinking water law. Drinking water distributors are currently not required to perform specified procedures regarding management and disinfection of water trucks. The US Virgin Islands have implemented specific regulations on the distribution of drinking water with trucks within the Virgin Islands' Safe Drinking Water Act. These regulations can be used as reference material for application on the BES islands. The regulations include management and hygiene procedures and certification procedures for distributors and equipment.

- Regulations to prevent cross contamination with rainwater systems<sup>129</sup>

In 2010/2011, a drinking water distribution network is developed on Statia; houses that are currently equipped with rainwater cisterns can be connected to this network. When the internal rainwater system of a house is connected to the public distribution system, there is a risk of cross-contamination. Rainwater with an unstable quality can infiltrate into the public drinking water network. The French islands of Saint Martin and Saint Barth have introduced a specific regulation within their drinking water legislation that prescribe drinking water distributors to install a set of 'no-return valves' at each connected house. This system

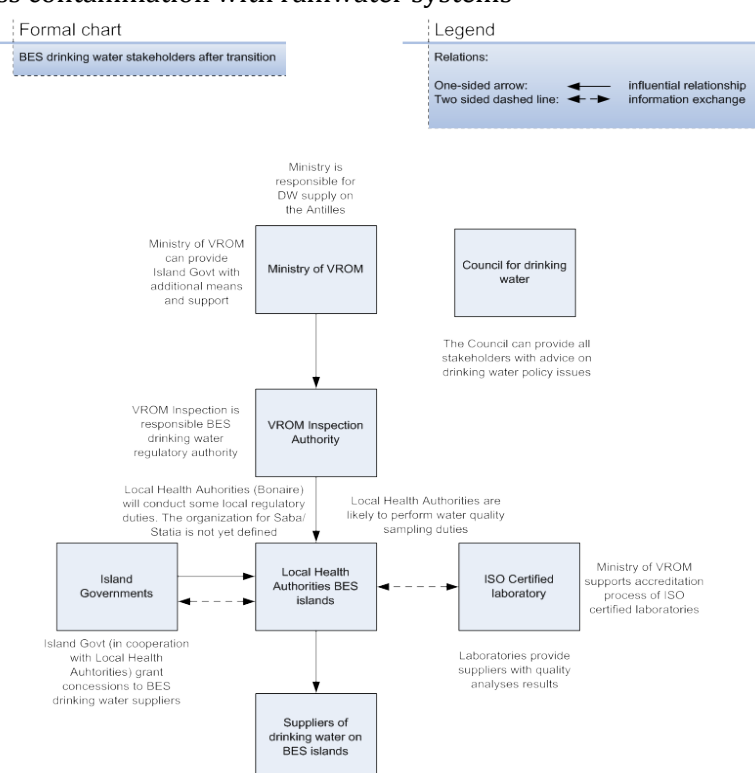


Figure 52 BES drinking water organization

<sup>128</sup> Initial instrument as proposed from within the VROM inspection authority

<sup>129</sup> Based on lessons from Saint Martin and Saint Barth

prevents unstable rainwater from flowing into the public network. Similar regulations can be integrated within the BES drinking water law.

## 7.2.2 Organize overseas drinking water regulatory authority for the BES islands

After the constitutional reformation, the Ministry of Housing Spatial Planning and the Environment is responsible for the supply of drinking water on the BES islands. The VROM Inspection authority is the main regulatory authority for drinking water on the BES islands. The conceptual organization of the drinking water stakeholders for the BES islands is represented in Figure 52<sup>130</sup>.

- Design BES islands drinking water inspection organization

The Inspection Authority of VROM is formally responsible for the regulation and inspection of drinking water on the BES islands. The Local Health Authorities on the BES islands are likely to perform the actual drinking water inspection duties under the supervision of the VROM Inspection authority. The organizational structure that is used on the US Virgin Islands can serve as an example for the development for an overseas inspection organization.

The VROM Inspection Authority (VI) trains and certifies the Local Health Authorities to perform a delegated set of inspection duties. The supervision of these inspection duties can be supervised using a small VI representation on one of the BES islands in the form of a field-office. The VI representatives in this field office can support the local authorities on multiple VROM related issues. When necessary experts from the VI or other authorities within the Netherlands can be flown in to the BES islands.

- Define quality inspection programs<sup>131</sup>

In order to maintain an effective drinking water quality inspection system on the BES islands, the existing Antillean quality inspection programs need to be redefined. New quality programs need to be based on risk analyses developed by the BES drinking water suppliers and approved by the VROM Inspection Authority. Quality inspection programs include guidelines on water quality sampling (sampling locations, frequencies and the range of quality indicators that need to be analyzed). Additionally, the new water quality inspection programs need to be adjusted for the inspection of water trucks and sanitary inspections of yards (rainwater and wastewater systems).

- Appoint drinking water laboratories<sup>132</sup>

Drinking water quality samples need to be analyzed at drinking water laboratories; these are currently not available on the BES islands. Considering the vulnerability of drinking water samples, it is critical that drinking water samples are shipped and processed properly. The Minister of VROM is responsible for the accreditation of these drinking water laboratories. Bonaire can either develop its own drinking water laboratory or the island can cooperate with existing laboratories on nearby islands (e.g. Curacao, Aruba). For Saba and Statia, considering the limited number of drinking water samples, it is economically not feasible to develop a drinking water laboratory. It is expected to be more efficient and feasible to cooperate with an existing drinking water laboratory on one of the nearby islands (e.g. St Maarten). Examples on the French West Indies have shown that centralized forms of drinking water inspection systems can work properly. However, due to more complex logistical processes, the system is more expensive than decentralized inspection systems.

- Erect Council for Drinking Water<sup>130</sup>

A Council for Drinking water needs to be erected, consisting of 5 drinking water experts. These experts provide recommendations and feedback on various drinking water issues to the relevant stakeholders.

---

<sup>130</sup> Based on the conceptual BES drinking water law (MinVrom, 2009)

<sup>131</sup> Based on internal recommendation within VROM and lessons from the USVI

<sup>132</sup> Based on lessons drawn on the US Virgin Islands, Saint Barth and St Martin

### 7.2.3 Develop solid and liquid waste management systems on the BES islands

Waste management systems need to be developed on the BES islands; waste and wastewater form an immediate risk for the quality of the available water resources and the contamination of rainwater systems.

- Develop solid waste management systems<sup>133</sup>

Bonaire can either develop its own solid waste management system or can cooperate with existing waste management systems on nearby islands. St Barth has a solid waste management system that can serve as a sustainable example for Bonaire; a similar system can potentially be developed on Bonaire to process, recycle and incinerate solid waste.

Saba and Statia do not produce enough solid waste to develop their own waste management system; they can potentially cooperate with the existing solid waste management system on St Barth.

- Develop wastewater collection and treatment systems on the BES islands<sup>134</sup>

Wastewater management systems can be developed on the three BES islands. Wastewater from private wastewater systems can be collected and centrally processed. The treated wastewater can be used for either recharging fresh water resources or for agricultural purposes. In the future, effluent can be used for drinking water production, see section 7.3.7.

- Develop construction regulations for wastewater systems<sup>135</sup>

Construction regulations can be developed for wastewater systems (septic tanks) on the BES islands, prescribing required capacities, materials and the location of wastewater systems. The existing cesspits and septic tanks do not function properly or do not have enough capacity to process increasing wastewater loads. To avoid capacity problems due to the introduction of public drinking water on Saba and Statia, wastewater management plan can be developed by the Ministry of VROM in cooperation with the Ministry of Transport and Water Management.

The existing septic tanks on the islands can be expanded, increasing the processing capacity. Over time, leeching cesspits and cesspools can be replaced by more effective and less polluting septic tanks. To enforce the previous measures, specific building regulations on private wastewater systems need to be implemented, defining requirements on type, capacity, materials and location of new private wastewater systems. Public campaigns and guidelines need to inform the general public on the importance of maintaining and managing wastewater systems.

- Enforcement of BES waste regulations using environmental inspection authority<sup>136</sup>

Environmental regulations on waste management are either not implemented or enforced. In order to prevent people from disposing their waste and wastewater in an irresponsible way, it is highly recommended to implement and regulate the BES environmental laws using the local environmental inspection authority. The authorities can enforce the waste management regulations by introducing negative economic incentives. Campaigns and workshops can be initiated in which the consequences of irresponsible waste management can be discussed. These campaigns can positively influence the general perception on waste management and help enforce the BES environmental regulations.

### 7.2.4 Support correct use and construction of rainwater systems on Saba and Statia<sup>137</sup>

Private rainwater harvesting serves as an important source of drinking water on both Saba and Statia. Rainwater harvesting is used for over 5 centuries and is part of the local culture. Private rainwater supply systems are the only lifelines during and after major natural disasters.

---

<sup>133</sup> Based on lessons from Saint Barth

<sup>134</sup> Based on lessons from the USVI

<sup>135</sup> Based on negative experiences on the USVI

<sup>136</sup> Based on initial instruments from the system analyses

<sup>137</sup> Based on lessons drawn at the US Virgin Islands, St Martin and St Barth

Rainwater is likely to remain an important source of drinking water for the coming years. A potential transition from rainwater to public drinking water is expected to evolve slowly (see 7.2.5).

At this moment, the use of rainwater for human consumption is related to both water quality and quantity issues. These issues are for the large part directly related to management and construction of rainwater system. Management and construction of rainwater harvesting systems are the responsibility of the system users. Although the Ministry of VROM is *not* legally responsible for the supply of rainwater within private households, it is highly recommended to provide a minimal set of instructions and regulations to prevent water shortages and unsanitary conditions that can lead to personal health implications (in the absence of proper drinking water infrastructures). The following instruments are meant as short-term instruments to safeguard public health on Saba and Statia while rainwater is still the main source of drinking water. It is therefore advised to apply these instruments to prevent unsanitary situations before and during the transition period towards a proper public drinking water supply.

- Define building regulations on rainwater systems

It is highly recommended to implement specific construction regulations for rainwater cistern systems within the BES building codes. These regulations serve to prevent rainwater shortages, pollution by toxic construction materials and the risk of infiltrating wastewater. Another important goal is to safeguard the structural integrity of houses; rainwater cisterns often serve as the foundation of the structure.

The building regulations need to include requirements on the location, capacity and the construction type of rainwater systems. Also a specific requirement needs to be added that prohibits a physical connection of private water systems (using rainwater) with public drinking water networks. Since compliance with this regulation cannot be guaranteed, drinking water distributors should be required to apply 'double anti-return valves' to prevent rainwater from infiltrating the public water system. This technical instrument can help to reduce the risks of cross-contamination with unstable rainwater (7.2.1).

For the implementation and enforcement of these building regulations, cooperation with the local building inspection authorities is required.

- Provide rainwater management guidelines

It is recommended to provide the users of rainwater systems with proper management instructions to prevent quality and quantity issues. The Local Health Authorities and the Ministry of VROM can organize rainwater campaigns in which the local population of Saba and Statia can be actively involved. Management instructions can be distributed via various media. These management instructions can include information on maintaining, cleaning and disinfecting rainwater systems.

- Apply economic incentives for cistern maintenance

Cleaning and maintaining rainwater systems are expensive procedures that are often executed by local contractors on Saba and Statia. Rainwater systems are frequently not well maintained due to lack of time or financial means. Poorly maintained rainwater systems can seriously affect the quality of cistern water. Economic incentives in the form of subsidies can potentially stimulate rainwater users to maintain and repair their systems when necessary.

## 7.2.5 Prepare Saba and Statia for the introduction of public drinking water<sup>138</sup>

From the perspective of public health, it is recommended to make public drinking water (instead of rainwater) the *primary source* of potable water on Saba and Statia. This transition implies that people need to change from using free natural rainwater to expensive and chlorinated desalinated drinking water. This transition process will face many cultural, psychological and economical barriers and is therefore expected to develop slowly (5-10 years). By simply constructing public drinking water plants and connecting houses to a distribution

---

<sup>138</sup> Based on lessons drawn on the US Virgin Islands

network, inhabitants will not automatically start to consume public water. From earlier experiences on the US Virgin Islands, it is known that public acceptance of public drinking water is *leading* for its success.

In order to stimulate a potential shift from consuming rainwater to safe public drinking water, the following steps can be useful:

- Provide information on transition project

The first step is to inform the public on the initiative to introduce public drinking water as the main water supply for human consumption. The Local Health Authorities and the Ministry of VROM can provide specific information on the risks and problems that are related to rainwater and emphasize the benefits of safe and reliable public water in order to increase the support from the local population. The population needs to be actively involved during the implementation processes on Saba and Statia, taking into account their opinions and ideas.

- Apply economic incentives

In order to stimulate the consumption of desalinated water, economic incentives are recommended to artificially reduce the rates for public drinking water. A certain percentage of the drinking water rate can be subsidized in order to make public water an economically feasible alternative for rainwater or bottled water. On the US Virgin Islands, the rates for drinking water are subsidized for 50% using local USVI income taxes. More research is needed on the feasibility of subsidizing and the potential economical structures to implement these subsidies.

- Develop drinking water infrastructures based on expected demand

When the decision is made to provide inhabitants with *direct access* to public drinking water, it is crucial to define the type of infrastructure for the local situation. When public drinking water is just introduced on the island (Saba), it is recommended to expand drinking water networks gradually and in phases. When consumption patterns increase, the drinking water distribution network can be safely extended knowing that the network is going to be used, preventing volumes of standing water. By implementing a full distribution network when consumption patterns are (still) limited, the system will become economically infeasible and standing water within the system result in quality risks. A simple infrastructure in which drinking water is distributed with water trucks might then be a more suitable and feasible solution<sup>139</sup>.

The previous instruments apply to both Saba and Statia, Statia is already equipped with a public drinking water plant and has the intention to extend the existing distribution network to cover the majority of the houses on the island (before 2012). Saba has no public drinking water supply system; the initiative to develop drinking water production and distribution facilities is taken by the island government and can potentially be supported by the Ministry of VROM. The local island governments are also responsible for appointing drinking water producers and distributors to operate the public drinking water facilities. Although the islands governments have to take the initiative to develop drinking water infrastructures, the Ministry of VROM can already make the necessary preparations to support a smooth and gradual transition to safe and sufficient drinking water.

### 7.3.6 Implement emergency drinking water procedures for the BES islands

The BES islands are generally vulnerable to natural disasters mainly in the form of hurricanes and seismic waves. Therefore it is important to maintain sufficient emergency drinking water procedures and facilities when drinking water supply systems are temporarily disrupted. The following measures are recommended:

---

<sup>139</sup> Based on actual experiences on the USVI in the 1960's, when communal drinking water networks were introduced on St Thomas and St Croix

- Install emergency drinking water facilities and procedures on Saba and Statia<sup>140</sup>

Emergency drinking water facilities and procedures need to be developed for Saba and Statia; such systems are necessary to distribute drinking water during emergencies. Former emergency procedures were delegated via the central Antillean government, an alternative organization and accompanying procedure is required. It is also recommended for the BES islands to have mobile emergency desalination and storage systems available. These systems can be located at strategic locations to provide temporary emergency drinking water supply during crises (e.g. hurricanes).

### 7.3.7 Sustainable drinking water production

Drinking water desalination is a very energy intensive process; the price of desalinated drinking water is directly related to the price of fossil fuels. In order to reduce the consumption of fossil fuels and thus the drinking water rates, a number of short and long-term strategies can be applied.

- Initiate drinking water campaigns (short-term)<sup>141</sup>

The island authorities and the Ministry of VROM can initiate drinking water campaigns in order to provide the population on the BES islands with information to reduce their public water consumption. Similar campaigns have been successfully executed on the US Virgin Islands.

- Develop a sustainable water cycle on the BES islands (long-term)<sup>141</sup>

Fresh water is scarce and thus expensive on the BES islands, it is therefore important to use and recycle fresh water resources whenever possible. When the BES islands do have the necessary wastewater collection and treatment systems, it is only a small step to transform treated wastewater into drinking water. However, strong psychological burdens from the perspective of the future consumers can be expected; therefore long-term preparation and marketing activities are required for before implementation.

When treated effluent is mixed with seawater, the purification effort that is needed to produce drinking water reduces. Generating drinking water from treated wastewater is generally 4-5 times less expensive than the regular seawater desalination process. In this way a sustainable and economic fresh water cycle can be maintained on the BES islands.

## 7.4 Conclusion

This chapter defines technical and institutional instruments that serve as rough guidelines to improve the existing drinking water supply systems on the BES islands. The design that is presented in this chapter is not so much a technical design that includes the exact specifications of an improved drinking water supply; it provides an overview of a process that can be applied to mitigate some of the critical problems that are currently experienced.

The design that is presented in this chapter is developed by integrating the initial technical and institutional instruments derived from the system analyses of the supply systems at the BES islands together with the lessons that have been drawn at the two source sites. Both the lessons and the instruments have been combined into one approach for an improved drinking water supply system; that describe the various instruments and the process that can be applied achieve the objectives for the desired situation on the BES islands. With the formulation of this design both research sub-question 7 and therefore also the main research question have been answered:

*“What are suitable technical and institutional instruments that can help to improve the drinking water supply system on the BES islands and how do these instruments need to be applied?”*

<sup>140</sup> Based on an interview with Commander Henk Zwier of the Royal Dutch Navy and lessons drawn at the US Virgin Islands

<sup>141</sup> Based on lessons drawn at the US Virgin Islands

The design presented in this chapter describes a process based on which the technical and institutional instruments can be applied or executed. The timeframe in which these steps need to be executed varies; some instruments can be implemented directly, whereas others require multiple years before they can be implemented or executed. The instruments and lessons that are included in the design are not leading; they can provide some guidance in the process of improving the existing drinking water supply systems on the BES islands. The lessons are based on the experiences of only two source sites; they therefore serve as useful examples and not as leading principles. More specific research is needed to define the operational design of the desired drinking water supply system.

The first design step in this chapter describes how the BES drinking water law can be adjusted; some drinking water quality parameters can be modified and specific regulations can be added regarding the distribution of drinking water with trucks.

The organization of an overseas drinking water regulatory and inspection authority needs to be defined to cover the new distribution areas on the BES islands. The responsible drinking water regulatory authority needs to implement and enforce the new BES drinking water law within the new distribution areas. Local inspection authorities on the BES islands can be made responsible for the collection and transportation of drinking water samples to accredited drinking water laboratories; these laboratories need to be appointed by the Ministry of VROM.

At the same time, the island governments of Saba and Statia can appoint official drinking water suppliers and grant them with the necessary concessions to produce and distribute drinking water. Before Saba can appoint any drinking water supplier, a public drinking water production plant needs to be developed. The initiative to develop this drinking water plant lies with the local island government.

The next step is to develop waste and wastewater management plans for the three BES islands; these systems are necessary to reduce the contamination of the available water resources and to prevent unsanitary circumstances when future wastewater loads increase (introduction of public drinking water, increasing population).

Rainwater is still (and is likely to be) the main source of drinking water on Saba and Statia, the Ministry of VROM and the BES islands themselves actively need to prevent unsanitary situations and water shortages related to the use of rainwater for human consumption. This can be done by implementing specific regulations and providing public information on rainwater harvesting. One option is to let newly constructed rainwater cisterns comply with specific building regulations that are enforced by the local BES building inspection authorities. These regulations can for example include requirements on the capacity, location and materials of rainwater systems. Rainwater users can be informed about proper management of their systems; the Local Health Authorities and the Ministry of VROM can provide public guidelines on these matters. These guidelines can include information on how to maintain, use and disinfect rainwater systems.

When Saba and Statia have proper wastewater collection and treatment systems, the islands can be prepared for the introduction of public drinking water as their main source of drinking water. In order to support this transition, three elements are necessary: public acceptance, reliable public drinking water supply systems, and enough economic incentives to make drinking water an affordable alternative for unstable rainwater.

The final (long-term) step is to close the fresh water cycle on the BES islands by generating drinking water from wastewater effluent. In this way limited amounts of seawater need to be desalinated to maintain a fresh water cycle on the BES islands. This results in a more sustainable and economic drinking water supply system.



## 8 Reflection

### *Scope*

When developing the problem demarcation of this research study, the main challenge was to determine the proper scope of the project. The variety and levels of the issues on the BES islands is quite extensive. Next to that, the issues themselves are defined from different perspectives and angles: from the point of view of the BES islands and from the perspective of the Ministry of VROM. It is quite a challenge to translate (or distill) this rather extensive problem description into a univocal problem demarcation that covers all major complexities of the drinking water supply on the BES islands without losing essential information.

When determining the system boundaries of the problem context, it is not known on what kind of problem areas lessons will be drawn. By defining the scope of the research study too narrow, important lessons for specific problem areas might be overlooked because these areas are not located within the system boundaries. By defining the scope of the system too wide, it is difficult to determine the main problem mechanisms; there are too many problems for which lessons can be gathered. The scope of this research study is taken quite wide; defining the different problem mechanisms and the interactions between these systems has been a complex and time-consuming activity. On the other hand, by studying the interactions between these various problem factors, more insight is gained into the system and into potential solution alternatives. Since the internal dynamics of the system have been determined quite intensively, the impact of solution alternatives on the system can be predicted more precisely. The scope of this research study could have been significantly reduced when only a limited set of critical objectives would have been defined.

### *Research methodology*

The research methodology that is used for this research study is based on the framework presented in the book of Richard Rose: "Learning From Comparative Public Policy. *A practical guide*". Although the book provides a lot of information on the methodology, the lesson drawing framework did not always provide enough support to construct your own 'lesson drawing' case study. When explaining the various steps within this framework, theoretical details are sometimes lacking. The research phases that are executed for this research study have not always been consistent with the original framework by Rose; improvisation and some pioneering were often required.

This research study not only depends on the theoretical framework described by Rose, additional systems analysis techniques were essential. Rose described clearly how to draw lessons embedded in foreign systems, a similar description to define models from the target systems has not been made explicitly. Before one is able to draw lessons that are potentially suitable for application at a target site, both the source system and target system need to be analyzed. Only then, more insight is gained into the context in which lessons are (going to be) integrated. The process of determining the target system provides more detailed information on the factors that influence the existing problem situation. These factors need to be used when identifying and selecting potential lessons at a given source site. Foreign lessons can seem to be positive or successful, but if the underlying mechanism is not 'compatible' with the mechanism at the target site, adaptation of this lesson might not lead to the expected result.

In order to analyze the problem context on the BES islands (actually two systems were used for one target site), policy analysis techniques have been applied. The same techniques can also be used to define a system at the source site. The process of determining and comparing problem contexts of source and target sites might be a helpful addition to the methodology described by Rose and an elaborated specification of what Rose describes as a *lesson drawing model*.

A difficulty that arises when determining models (systems) at a source site is that you are restricted to a limited set of information sources. It turned out to be particularly difficult to find out why or how models have developed in certain ways over time; this requires specific

(historical) information that is not always known to the present stakeholders. When defining lessons, you are usually confronted with bounded rationality problems.

#### *Added value of the lesson drawing theory for this research study*

The application of lesson drawing as a methodology to use experiences of others as a source of information to improve a problem situation in another location turned out to be quite interesting and also successful. Potentially useful lessons have been drawn at a limited set of source sites with a limited amount of preparation time. Although a number of lessons provided a confirmation of solution alternatives that have already been brought up at the BES islands or by the Ministry of VROM, the lessons from the source sites frequently serve as a *detailed specification* of some of the original solution alternatives. Because more information has been gained on the motivation, context and implementation process of certain instruments, one is better prepared to adapt and implement these lessons at the target sites. This decreases the risk of policy transfer failure.

Another group of lessons that provided crucial information were *historical lessons* from the source sites. The source sites that have been selected were ahead of the BES islands regarding certain environmental issues (including drinking water). Only because the source sites experienced certain processes (e.g. introduction of public drinking water, collective wastewater systems) earlier than the BES islands, both positive and negative experiences could have been drawn regarding these processes. These lessons are valuable for the BES islands because the historical context of these processes provided specific success and failure factors for the implementation. Next to that, many lessons have been gathered based on the perspectives of multiple respondents; leading to more objective and detailed information.

Negative lessons that have been gathered from the source sites are often not documented (since they were failures); these lessons would not have been gathered using alternative research methodologies.

It is important to remark that for this particular research study, only two case studies have been conducted. It is therefore difficult to determine the exact value of each lesson. The validity of the lessons can only be determined more precisely when a large number of case studies would be conducted and all lessons would be compared. It is therefore important to interpret the results of this study with a certain form of reservation. Profound research into the overall effect and extrapolation of lessons is highly recommended. It is important to avoid tunnel vision by looking at a limited set of locations as a source of lessons. Instead, "policymakers can learn from the poly-diffusion of ideas through the multiple networks in which they are embedded"<sup>142</sup>

#### *Lessons and economic incentives*

There are several lessons drawn at the source sites that are based on economic incentives in the form of subsidies. Also, some instruments at the source sites have been made possible through large structural investments by national governments. It is unclear whether all lessons that have been gathered at the source sites are economically feasible for adaptation and implementation on the BES islands. For example, the French and US budgets for structural social development of their overseas territories are much larger than the Dutch budgets. The economical scale of some of the source sites is larger than the BES islands; therefore some lessons from the source sites might not be applicable to the BES islands (e.g. subsidizing public drinking water rates using local USVI income taxes). More research into the feasibility of certain lessons is required.

Generally, in order to support certain transitions, whether supporting the consumption of public drinking water instead of rainwater or subsidizing private wastewater systems, more instruments need to be applied besides economic incentives. The instrumental effect of incentives frequently depends on various other factors, it is therefore important to identify

---

<sup>142</sup> Mossberger and Hale, 2002

these other factors. Changing these factors with additional instruments can increase the effect of the original economic incentives<sup>143</sup>. On the US Virgin islands, regarding the stimulation of public drinking water, one of these depending factors was public acceptance.

### *Factors supporting the design in the research study*

Two key factors that can influence the process towards a new drinking water supply on the BES islands are public acceptance and political support. Without one of these two factors, the project is likely to fail.

The inhabitants are critical actors in the transition process to safe public drinking water on Saba and Statia. The common interests of the Ministry of VROM and the population are rather the same; everybody wants to have access to safe and reliable drinking water. However, their might not be consensus on how to realize this safe and reliable drinking water supply; whereas the Ministry of VROM might be in favor of public distribution networks on Saba and Statia, the local inhabitants do not want to pay high drinking water rates for chlorinated drinking water when they have access to free rainwater. Instead, they might expect practical interventions to improve their existing rainwater systems, not affecting their insular lifestyle and traditions. The problem perceptions of authorities and inhabitants might be different. Since the future consumers are critical for the success or failure of a new drinking water supply system<sup>144</sup>, it is important to reach for consensus among all stakeholders before decisions are made. The inhabitants are highly dedicated actors that do not necessary have the same problem perspective and can therefore block certain interventions from public authorities to change the status quo. To describe them in stakeholder analysis terms, they are not 'barking dogs' but 'biting dogs'<sup>145</sup>. The complexity of this problem situation does not allow for imperative steering from the side of the government; cooperation with the local inhabitants is highly required. In a steering process that is characterized by such interdependency and pluriformity, voluntariness is one of the central properties of potential instruments<sup>143</sup>. It is therefore important that all parties will come to a certain degree of consensus about the nature of the problem situation, the objectives and instruments that might be used. Consensus is the result of prior discussions and negotiations. For these discussions to be fruitful, a common frame of reference is essential<sup>146</sup>. Therefore, it is important to inform and include all relevant stakeholders for any transition process from the very beginning. This is necessary to create a common goal, and to be able to apply instruments that are both accepted and supported by all stakeholders. In the end, the inhabitants of the BES islands are the users of a new drinking water supply system and they will also be involved in the execution of many related regulatory duties.

The problems regarding the drinking water supply on the BES islands are relatively stable; the political context within the Netherlands is not. The time horizons of politicians differ, and therefore also their willingness to think about introducing changes in public policy. According to Rose "drawing lessons is about getting to grips with technicalities of programmes in different countries, the adoption of a lesson is an exercise in political judgment"<sup>147</sup>.

The problem solving techniques that have been applied in this research study provided a clear problem situation, objectives and potential instruments to solve the dissatisfaction with the status quo. These analyses are based on a rational model that assumes that a problem can be tackled using distinct phases in which the agenda is set, the problem analyzed and solutions are selected. Real-world problem solving processes are less structured than is assumed by the rational model<sup>148</sup>. The problem solving techniques in this research study do not take into

---

<sup>143</sup> De Bruijn and Ten Heuvelhof, 1997

<sup>144</sup> as seen on St Thomas and St Croix

<sup>145</sup> Enserink, Koppenjan, et al., 2003

<sup>146</sup> De Bruijn and Ten Heuvelhof, 1997

<sup>147</sup> Rose, 2005

<sup>148</sup> Cohen, March and Olsen, 1972

account the dynamic political context in which the problem takes place, but that eventually will determine if policy changes will occur.

Policy innovations often occur in two contrasting time-scales. Some changes are the outcome of lengthy processes of deliberation in which policymakers puzzle over the dissatisfaction with the status quo, after which finally improvements are introduced<sup>149</sup>. These situations lack immediate pressure to respond by either external factors or stakeholders. Other changes occur, seemingly, abrupt when certain events create so much dissatisfaction that the demand for new policy forces policymakers to take immediate action<sup>150</sup>.

Timing seems to be critical for policy changes, advocates of new policy must wait for a concurrence of events to make changes possible: the window of opportunity<sup>151</sup>. The status quo on the BES islands will not change when the policymakers and the political agendas are not aligned.

The streams model as defined by Kingdon<sup>151</sup> takes into account the previously mentioned political complexities within decision-making processes. He describes three important streams in public decision-making processes: problems, solutions and political events. With changing political coalitions and social climate within the Netherlands, problems and solutions for the drinking water supply on the BES islands will either gain or lose political favor. Without the coupling of the three streams, the window of opportunity, the decision makers can and will not take action no matter how urgent the situation or how promising the design might be.

It is therefore essential to bring the problem situation on the BES islands to attention so it stays on the political agenda; the BES islands and the Ministry of VROM also need to articulate actively the solutions in order to get them accepted and implemented when the window of opportunity arises. Another, tragic, window of opportunity may arise when the existing problem situation on the BES islands will lead to a serious incident, and immediate action is required.

The future composition of the Dutch cabinet will determine to a great extent the political and financial support for important environmental and sanitary projects on the BES islands. This will affect the range of solution alternatives and the time-scale in which these alternatives can be applied. More importantly, the type of support will determine if our overseas neighbors will have access to safe drinking water and basic sanitation (Millennium Development Goal 7c).

---

<sup>149</sup> Hecllo, 1974

<sup>150</sup> Polsby, 1984

<sup>151</sup> Kingdon, 1984

## Acknowledgements

I would like to thank my thesis committee, especially my supervisor Leon Hermans for his support, constructive feedback and positive approach throughout the project. Also, I would like to thank Frans Swinkels for his assistance and valuable input on behalf of the VROM Inspectie.

I am very grateful that the Ministry of VROM provided me with the opportunity, means and assistance to conduct this research study and allowed me to explore other islands to learn from their experiences. It has been a one-of-a-kind experience.

Special thanks are due to Stef Strik who accepted my research proposal in the early days of this project; it is through his efforts that I was able to conduct this research study at the Ministry of VROM. I highly appreciate his continuous enthusiasm, support and assistance throughout the project.

This thesis research is the result of many discussions and interviews with various people in the drinking water sector, both in the Netherlands and on the islands of Bonaire, Saba and St. Eustatius, Saint Martin, Saint Barthelemy and the US Virgin Islands. I am extremely thankful to all the persons who were willing to share their knowledge and experience with me; without the valuable input of these people this research project could not have been realized.

Thank you, Alexander Vos de Wael, for the discussions we had throughout the project. They were indispensable for testing and validating my findings.

## References

### Books/papers:

- Alberga, S. (2005) *Substandard supply minutes in relation to risk management for water supply*, thesis research study, Faculty of Civil Engineering and Geosciences, section Water management, Delft
- Bardach, E. (2004) *Presidential address. The extrapolation problem: How can we learn from the experience of others?* Journal of Policy Analysis and Management, Vol. 23, No. 2, pp 205-220
- Barzelay, M. (2007) *Learning from second-hand experience: Methodology for extrapolation-oriented case research*. Governance: An international journal of policy, administration and institutions, Vol. 20, No. 3, pp 521-543
- Beckman Lapre, M.C. (2009) *'Drinkwater In Een Notendop'*, Ministerie van VROM, Den Haag
- Beckman Lapre, M.C. (2010) *Toezichts- en handhavingsplan VROM Inspectie, onderdeel Drinkwater*, Notitie, Ministerie van VROM, 2010
- Bennett, C.J. (1991) *What is policy convergence and what causes it?* British Journal of Political Science, 21, 2, 215-33
- Beuge, Carolus, et al. (2004) *Banden met Brussel: De betrekkingen van de Nederlandse Antillen en Aruba met de Europese Unie*, Willemstad, Curaçao.  
Available online at: <http://www.minbzk.nl/contents/pages/9267/bandenmetbrussel.pdf>
- Blok-Bokstael, W., Herder, P. (2005) *Reader Engineering design SPM4110*. Faculty of Technology Policy and Management, Delft
- Bots, P.W.G. (2002) *Inleiding Technische Bestuurskunde*, Faculty of Technology Policy and Management, Delft.
- Bryson, J. and Crosby, B. (1992) *Leadership for the common good: Tackling public problems in a shared power world*. San Francisco, CA: Jossey-Bass.
- Cohen, M.D., J.G. March and J.P. Olsen (1972) *A Garbage Can Model of Organizational Choice*. Administrative Science Quarterly, 17, No. 1, pp. 1-25
- Crabtree, K.D., Ruskin, R.H., Shaw, S.B., Rose, J.B. (1996) *The detection of cryptosporidium oocysts and giardia cysts in cistern water in the US Virgin Islands*. Wat. Res., Vol. 30, No. 1, pp. 208-216.
- De Bruijn, J.A., Ten Heuvelhof, E.F. (1997) *Sturinginstrumenten voor de overheid: over complexe netwerken en een tweede generatie sturinginstrumenten*. Stenfert Kroese, Houten
- Department of Sustainable Development (2008) *Rainwater harvesting from rooftop catchments*. Organization of American States, Washington.
- Caribbean Water Association and KWR (2006) *Onderzoek naar betekenis en bestrijding van Legionella bacteriën in het leidingwater bij transport en distributie*, Curacao
- Dolowitz, D.P., Marsh, D. (1996) *Who learns what from whom: A review on the policy transfer literature*, Political studies, vol. XLIV, pp. 343-357
- Dolowitz, D.P., Marsh, D. (2000) *Learning from abroad: The role of policy transfer in contemporary policy-making*. Governance: An international Journal of Policy and Administration, Vol. 13, No. 1, pp. 5-24
- Enserink, B., Koppenjan, J.F.M., Thissen, W.A.H., Kamps, D.P., Bekebrede, G. (2003) *Analyse van Complexe Omgevingen*, Faculty of Technology Policy and Management, Delft.

- Enserink, B., Hermans, L., Kwakkel, J. (2009) *Policy Analysis of Multi-Actor Systems (reader EPA1121)*. Faculty of Technology Policy and Management, Delft.
- Gould, J., Nissen-Petersen, E. (1999) *Rainwater catchment systems for domestic supply. Design, construction and implementation*. Intermediate Technology Publications, London.
- Heclo, H. (1974) *Modern Social Politics in Britain and Sweden*. New Haven: Yale University Press.
- Hermans, M. (2009) *An approach to support learning from international experience with water policy*. Water Resources Management (forthcoming)
- Hoogerwerf, A. (1987) *De levensloop van problemen: definiering, precisering en oplossing*. Beleidswetenschap, 1, pp. 159-181
- James, O., Lodge, M. (2003) *The limitations of 'policy transfer' and 'lesson drawing' for public policy research*. Political studies review, Vol. 1, pp 179-193
- De Jong, Lalenis, K., Mamadouh, V. (2002) *Institutional transplantation*. Kluwer Academic publishers, the Netherlands, pp 1-16
- Kingdon, J.W. (1984) *Agendas, Alternatives and Public Policies*. Boston: Little, Brown
- Kolsky, P. (1997) *Engineers and Urban Malaria: Part of the Solution or Part of the Problem?* Waterlies, Vol. 16, No. 2, pp 10-12
- Lye, D. (1992) *Legionella and amoeba found in cistern systems*, Proceedings of the Regional Conference of the International Rainwater Catchment Systems Association, Kyoto, Japan, pp. 534-537
- De Moel, Verberk, Van Dijk (2006) *Drinking Water, Principles and Practices*; Delft, pp 267
- Mingers, J. and Rosenhead J. (2004) *Problem structuring methods in action*. European Journal Operation Research, Vol. 152, pp. 530-554
- Ministerie van BZK (2008), *Uitgangspunten Wet Openbare Lichamen Bonaire, St Eustatius en Saba*, Den Haag.
- Moseberger, K.A., Hale, K. (2002) *Polydiffusion in Intergovernmental Programs*, American Review of Public Administration, 32, 4, 398-422
- Nicolai, et al. (2007) *Overgangsakkoord nieuwe staatkundige verhoudingen*, Philipsburg, Sint Maarten.
- Pechtold, et al. (2005) *Hoofdlijnenakkoord tussen de Nederlandse Antillen, Nederland, Curaçao, Sint Maarten, Bonaire, Sint Eustatius en Saba*, Curaçao.
- Polsby, N. (1984) *Policy Innovation in America*. New Haven: Yale University Press.
- Reijtenbagh, R. (2008) *Consequences of the constitutional reformation for BES islands' drinking water companies*, Caribbean Water Association/TU Delft, Sint Maarten.
- Riddle J. and Speedy R. (1984) *Rainwater cistern systems: The Park Experience*, Proceedings of the 7<sup>th</sup> International Conference on Rain Water Cistern Systems, US Virgin Islands, E4, pp1-7
- Rodrigo, S., Sinclair, M., Cunliffe, D., Leder, K. (2007) A critical assessment of epidemiological studies for the investigation of the health risk of drinking untreated rainwater. Conference paper for Int. Rainwater Catchment Systems Conference, Sydney.
- Rogers, E.M. (1995) *Diffusion of Innovations*. New York: Free Press, 4<sup>th</sup> edition



Rose, R. (1993) *Lesson-drawing in public policy*. Chatham House, New Jersey.

Rose, R. (2005) *Learning from comparative public policy. A practical guide*. Routledge, London.

Saal, K. (2002) *On the Waterfront*. Evolution, Business and Technology Magazine, No.2.

Smith, H.H., Fok, Y.S., Heitz, L.F. (1999) *Considerations for developing guidelines for rainwater catchment systems in the U.S. Virgin Islands*, Conference paper for 9<sup>th</sup> International Rainwater Catchment Systems Conference. Petrolina, Brazil

United Nations Environmental Program (2009) *Rainwater, Catch it while you can. Handbook for rainwater harvesting for the Caribbean*. UNEP Publication, 2009

Walker, W.E. (2000) *Policy Analysis: A Systematic Approach to Supporting Policymaking in the Public Sector*. J. Multi-Crit. Decis. Anal. 9: 11–27

World Health Organization (2008) *Guidelines for Drinking-water quality. Third edition incorporating the first and second addenda*. Geneva.

#### Legislation:

Ministerie van VROM (2009), *Concept BES drinkwaterwet*, TK,2008-2009:31959-14.1, Den Haag

P.B. No. 37, *Landsbesluit Kwaliteit Drinkwater*, Willemstad, 2006.

P.B. No. 72, *Landsverordening Drinkwater*, Willemstad, 2006.

*US Safe Drinking Water Act*, Title XIV of the Public Health Service Act (42 U.S.C. 300f-300j-9), Public Law 93-523. Dec 16, 1974

*US Virgin Islands Building Code*, Title 29, Chapter 5, Section 308

*US Virgin Islands Drinking Water Standards*. Title 19 Public Health Act, Part VI Regulatory Provisions Concerning Public Health, Chapter 51. October 13, 1994

#### Websites:

Ambassade de France, Frankrijk Overzee

<http://www.ambafrance-nl.org/frnace-paysbas/spip.php?article693>

Visited on July 2009

British Foreign and Commonwealth Office

<http://www.fco.gov.uk>

Collectivité de Saint-Barthelemy

<http://www.comstbarth.fr> Visited on April 15, 2010

Department of Planning and Natural Resources US Virgin Islands

<http://www.dpnr.gov.vi/PublicWaterSup.htm>

US Environmental Protection Agency, Water Resource SDWIS

<http://oaspub.epa.gov/enviro/> Visited on July 2009

US Environmental Protection Agency, Organization

<http://www.epa.gov/epahome/whatwedo.htm> Visited on April 20 2010

Institute National d'Environnement Industriel et des Risques

<http://www.ineris.fr/> Visited on July 2009

Institut National de la Statistique et des Etudes Economiques

[http://www.insee.fr/fr/insee\\_regions/guyane/themes/antiane/AE63/AE63\\_art01.pdf](http://www.insee.fr/fr/insee_regions/guyane/themes/antiane/AE63/AE63_art01.pdf) Visited on July 2009

KNMI, Press release of November 15<sup>th</sup> 2006 on Seismic activities on the Lesser Antilles  
[http://www.knmi.nl/cms/content/5224/knmi\\_volgt\\_vulkanen\\_en\\_bevingen](http://www.knmi.nl/cms/content/5224/knmi_volgt_vulkanen_en_bevingen) bovenwindse\_eilanden

Ministere de la Sante, et des Sports  
<http://www.sante-sports.gouv.fr> Visited on March 4<sup>th</sup> 2010

Ministry of Housing, Spatial Planning and the Environment  
<http://www.vrom.nl/organisatie> Visited on December 9 2009

Government of the Netherlands Antilles  
<http://www.gov.an> Visited on February 12<sup>th</sup> 2010

National Safety Foundation  
<http://www.nsf.org> Visited on May 10<sup>th</sup> 2010

Netherlands Antilles Coral Reef Initiative  
<http://www.nacri.org/nutmon.html> Visited on July 2010

Organization of American States, Department of Sustainable Development  
<http://www.oas.org/usde/publications/Unit/oea59e/ch10.htm> Visited on March 10<sup>th</sup> 2010

United States Office of Insular Affairs  
<http://www.doi.gov/oia/Firstpginfo/Islandfactsheet.htm> Visited on April 20 2010

United Nations Environment Program, Examples of rainwater harvesting and utilization around the world  
<http://www.unep.or.jp/letc/Publications/Urban/UrbanEnv-2/9.asp> Visited on July 18<sup>th</sup> 2009

Virgin Islands Division of Wastewater  
<http://www.viwwa.org/wastewater.aspx> Visited on May 8<sup>th</sup> 2010

Parameter	Unit	WHO Volume 1&2	NA Water Law	Statia Water Company	Hoyed Hook	Wim de Jong	Linney Water Plant	Corvel Johnson	Tropics Resort Orchard	Method
Island District				Statia Lodi	Statia Concoridia	Statia Cherry Tree	Saba Fort Bay	Saba Bottom	Saba Windwardside	
Sample type				Storage Tank	Cistern	Cistern	Storage Tank	Cistern	Cistern	
Sample date				18-Jul-08	18-Jul-08	18-Jul-08	30-Jul-08	30-Jul-08	30-Jul-08	
Sample time				4:35:00 PM	5:40:00 PM	4:05:00 PM	1:25:00 PM	1:40:00 PM	12:20:00 PM	
<b>Chemical Analysis</b>										
pH		6.5-8.5	7.8-8.5	7.98	9.14	9.08	8.21	8.05	9.25	sm 4500 B
Specific Conductivity, 25 °C	µS/cm	-	1000	344	200	134	1007	78	101	sm 2510 B
Total dissolved solids(cal.c.)	mg/l	1000	-	172	100	67	504	39	51	sm 2540 B
Chloride	mg/l	250	150	94	24	13	<b>327</b>	9	11	sm 4500 C
Total alkalinity	mg/l CaCO <sub>3</sub>	-	-	8	51	43	5.2	21	2.4	sm 2320 B
Total hardness	mg/l CaCO <sub>3</sub>	-	100-250	7	45	42	15	26	29	hach 8226
Calcium hardness	mg/l CaCO <sub>3</sub>	-	-	5	38	34	3.8	24	28	hach 8222
Orthophosphate	mg/l	-	-	0.38	0.28	0.19	0.00	-	-	hach 10055
Zinc	mg/l	3	3	0.15	0.01	0.04	0.02	0.02	0.01	hach 8009
Iron	mg/l	0.3	0.20	0.01	0.11	0.02	0.01	0.01	0.02	hach 8008
Aluminum	mg/l	0.2	0.200	0.006	0.084	0.141	0.000	0.180	0.144	hach 8326
Silicate	mg/l SiO <sub>2</sub>	-	-	0.017	5.52	4.35	0.068	9.00	5.77	hach 8282
Turbidity	NTU	5	1-4	0.08	0.61	0.66	0.11	0.41	0.46	hach 8195
Free chlorine	mg/l	0.6-1.0	0.3-2.0	0.50	<b>0.00</b>	<b>0.00</b>	0.27	<b>0.00</b>	<b>0.00</b>	hach 8021
<b>Bacteriological Analysis</b>										
Total Coliform	cfu/100 ml	0	0	0	<b>250</b>	<b>81</b>	0	<b>190</b>	<b>810</b>	hach 10029
E.Coli form	cfu/100 ml	0	0	0	<b>2</b>	<b>57</b>	0	<b>7</b>	<b>410</b>	hach 10029
Enterococci	cfu/100 ml	-	0	-	<b>14</b>	<b>39</b>	0	<b>7</b>	<b>31</b>	hach 1600
Total Plate Count, 48hr	cfu/ ml	500	-	0	<b>1500</b>	<b>5300</b>	19	<b>3400</b>	<b>43000</b>	sm 9215 B

sm:Standard Methods

hach: Hach Company, Colorado USA

**Comments:**

The cistern waters do not meet **sanitary** requirements for drinking water and require immediate intervention (disinfection), especially in the case of Tropics Resort Orchard on Saba where there appears to be an active source of faecal contamination.

A.F. Gumbs

Head Water Quality Control

NV GEBE

## Appendix B Interview summary

Target site interviews						
Location:	Nr :	Respondent:	Function:	Topics discussed:	Issues mentioned:	Instruments mentioned:
Bonaire	1	Mr Domacasse	Local Manager DESALPRO	-Quality monitoring drinking water	-Delays in monitoring process -Insufficient monitoring process	-Execute all drinking water analyses on Bonaire
Bonaire	2	Mrs van Luling Mr Emers	Medical laboratory analysts	-Microbiological laboratory on Bonaire -Experience with public drinking water -Use of personal filtration systems -Drinking water provision in remote areas	-Microbiological analyses have long processing times -Quality problems regarding public water	-Installing filtration systems to prevent brown (public) water -Employ a certified microbiologist to execute all analyses on-island
Bonaire	3	Mr Martina	Inhabitant of Bonaire	-Remote dwellings and their drinking water provision by public drinking water company	-Energy supply of systems -Temperature of the supplied water	-Change energy supply system -Put drinking water facilities underground
Bonaire	5	Mr vd Weteringe Buijs	Facility Manager Plaza Resort Bonaire	-Private drinking water production at hotels/resorts -Problems with public water system -Goals for an improved design	-Ineffective external quality monitoring systems -Frequency of brown water events	-Use laboratory on Bonaire to increase efficiency of quality monitoring -Increase the frequency and # of sampling locations
Statia	6	Terry Keogh	General Manager NUSar Oil Terminals	-Drinking water plant at NUSar -Possibility to use NUSar drinking water plant for emergency operations	-No concession granted to supply drinking water -No back-up systems for drinking water on Statia	-Enforcement of current legislation
Statia	7	Mr. Hyden Gittens	Lt. Governor	-Drinking water goals -Current problems	-Integration of new system with existing RWS -Inspection of drinking water -Roles and responsibilities Statia after transition	-Effective drinking water monitoring system based on Dutch principles -Regulations for integrations of RWS and distribution network
Statia	8	Mr. Dijkshoorn	Head Planning bureau (similar to public works)	-New drinking water distribution network Statia -NUSar oil terminal	-Integration new distribution network with existing RWS -Potentially long residence times within network -No concession granted to NUSar	-Stimulate consumption of distributed water economically -Public campaigns to stimulate distributed water
Saba	9	Chris Johnson Bruce Zagers	Governing body of Saba	-Goals for drinking water supply Saba -Current situation	-Inspection - Quality/quantity	-Construction of public water plant -Erection of local

				regarding drinking water	-Contamination of water resources	inspection -Waste-management systems
Saba	10	Robert Zagers	Head planning bureau Saba	Public rainwater harvesting systems	-Quantity problems of rainwater system	-Expanding rainwater catchment area -Connecting system to existing water plants
Saba	11	Gijs Koot	Island GP	-Health implications of rainwater consumption	-Frequently reported stomach problems	-Filtration systems for rainwater harvesting systems
Saba	12	Mrs. Hassell, Mrs Johnson	Local inhabitants	-Rainwater collection on Saba -Drinking water consumption on Saba	-Health implications of rainwater -Hygiene of drinking water	-Proper legislation for rainwater collection -Regulations for drinking water supply
Curacao	13	Henk Zwier	Commander Royal Dutch Navy	Emergency drinking water procedures on Saba and Statia	-No storage and distribution capacity on Saba -New emergency protocol needed after constitutional reformation	-Construction of drinking water reservoir and connection point -Locate multiple large distribution trucks on Saba and Statia

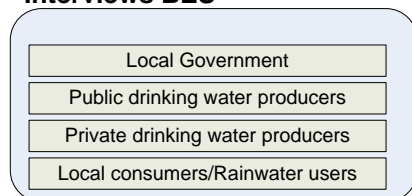
#### Source site interviews

Location:	Nr :	Respondent:	Function:	Topics discussed:	Issues mentioned:	Instruments mentioned:
St Martin, FWI	14	Glenn Richardson	Manager Drinking Water Plant St Martin	-Drinking water supply on St Martin -Regulation and inspection of drinking water on Saint Martin/Saint Barth	-Rainwater cisterns, cross contamination	-Physical separation of rainwater and public water systems -Apply no-return valves
St Barth, FWI	15	Frank Greaux	Manager Drinking Water Plant St Barth	-Drinking water supply on St Barth - Solid waste management St Barth	-	-Waste to drinking water system
St Thomas, USVI	16	Michael Quetel	Line Loss Manager VIWAPA	Drinking water supply on the US Virgin Islands	-Rainwater cisterns -Extension of public network	-Apply regulation on rainwater cisterns - Recommendations to extend existing drinking water network
St Croix, USVI	17	Harold Mark	Supervisor Public Water System	Inspection/Regulation on drinking water supply USVI	Private rainwater systems	-Example of USVI drinking water regulatory system
St Thomas, USVI	18	Henry Smith	Professor Water Resources Department UVI	Drinking water supply on small Caribbean Islands	-Wastewater management -Introduction of public drinking water -Rainwater cisterns	-Apply regulation on private wastewater systems -Essential steps to introduce drinking water on the BES islands

## Appendix C      Field visit BES islands

When planning the field trip to source site A, the author got the opportunity to gather more information at the target sites by integrating them within the original field trip to the French Antilles. Apart from Bonaire, all other islands (including the French Antilles) are within a 15-mile radius. It was decided to first visit the BES islands and then proceed to St Maarten to conduct research at the French part of the island *and* at the adjacent island of Saint Barthelemy. During the short preparation period for the BES field trip, the author decided to focus the research on gathering of missing information. There were still unknown factors regarding the drinking water supply that might influence the description of the supply systems as a whole. By using contact persons from the Caribbean Water Association and the Ministry of VROM, appointments were made with the local government, drinking water consumers and other stakeholders. Most of these interviews were unstructured and exploratory.

### Interviews BES



The next section contains descriptions of the individual field trips. A summarizing table can be found in appendix B, providing an overview of the conducted interviews on all islands.

### Bonaire

#### Introduction

Since there has been no information available on other sources of drinking water production than the *public* distribution system, the main focus on Bonaire was to define how private drinking water supply systems are managed and inspected. During this investigation, several problems regarding the inspection of drinking water samples emerged.

Additional research has been conducted on remote households and the means by which they are provided with drinking water.

#### Private drinking water production

All private drinking water producers on the island have been mapped using local information sources. Two of the private production plants have been visited and interviews have been held with the managers of the drinking water plants. The interviews were focused on the production processes, management and inspection of the produced water. During the interviews, the interviewees could freely describe problems and risks that were associated with the production and inspection of drinking water. They also mentioned objectives for an improved supply system in the future.

There are four tourist accommodations having private drinking water facilities on Bonaire, these are the “Plaza Resort”, “Captain Don’s Habitat”, “Buddy Dive Resort” and the “Divi Flamingo Resort”<sup>152</sup>. The production and supply of drinking water is outsourced to two private parties, Veolia and Desalpro. They both serve the four tourist accommodations and provide them with desalinated water using ‘reverse osmosis’ techniques. The reason for these resorts to

---

<sup>152</sup> Domacasse, interview #1

supply drinking water internally instead of using the public drinking water supply is usually because of economical considerations<sup>153</sup>; it is cheaper for resorts to produce their own drinking water. Furthermore, the public network sometimes faces distribution problems, disrupting the supply of drinking water. Drinking water consumers also frequently experience “brown” water; this is not favorable for hotels or resorts<sup>154</sup>. In order to safeguard the continuity and quality of drinking water, these resorts have outsourced the production of drinking water.

The four resorts at Bonaire share the same issues regarding the internal production and supply of drinking water. The main problems are related to the monitoring of drinking water; the time it takes to return analysis results, the locations from where samples are taken and the high costs related to the analysis procedure.

#### *Time-delay in sampling procedure*

Drinking water samples are taken twice per week both at the drinking water production and distribution facilities. These samples are taken by the “Dienst Gezondheid en Hygiene”, as delegated by the Antillean Ministry of Health. The samples taken by the DGH are then transported to a specialized drinking water laboratory in Willemstad, Curacao. The time it takes to ship, analyze and return the results to the drinking water producers can take up to 7 days<sup>152</sup>. According to both the drinking water producers and the resorts, this is too long. In case a water quality issue is observed, the resorts need to turn off their drinking water plants and notify their guests as soon as possible<sup>155</sup>. The analysis procedure should not take longer than 24 hours; in this way the risk of guests drinking potentially contaminated water can be mitigated. The reason for the delay in the sampling procedure is probably due to the fact that the drinking water samples have to be shipped by airplane, this takes a considerable amount of time during which the quality of the samples deteriorates. Once the samples arrive in Curacao, they are set apart until all local samples have been analyzed. Then all other samples from outside of Curacao are analyzed<sup>156</sup>. One way to avoid these time-delays is to upgrade the local laboratory on Bonaire to be suitable for drinking water analyses. The laboratory is currently capable of executing various medical analyses, in order to process drinking water samples an accredited microbiology section has to be added<sup>157</sup>.

It turns out that not only the drinking water sector is affected by the lack of a microbiological laboratory on Bonaire. The analysts at the medical laboratory at the “Fundashon Mariadal” hospital explained that their department is forced to send certain medical samples for microbiological analysis to Curacao. The hospital is usually faced with significant delays; from the moment of sending the samples to the ADC laboratory until the analysis results are available takes approximately 7 days. If the hospital could send the same samples to a laboratory on Bonaire, they could reduce the delay from 7 days to approximately 3 days and this would result in a more effective treatment for their patients<sup>156</sup>.

#### *Sampling locations*

Another issue related to the monitoring of drinking water concerns the location from where samples are taken. According to the private drinking water producers and the *not-connected* households, the specimens taken from their systems are not always representative for the overall quality of the consumed drinking water<sup>158</sup>. The reason for this is because the samples are usually taken directly from the distribution system, just after the production unit (or direct from the reservoir, in case of a stand-alone system). When the sample is taken directly after the reverse-osmosis and post-treatment steps, the water quality is expected to be different from the water at the tap. Most distribution systems at resorts -but certainly the stand-alone systems- are located above ground and are therefore directly exposed to sunlight. When the water

---

<sup>153</sup> Van de Weteringe Buijs, interview #5

<sup>154</sup> Van de Weteringe Buijs, Van Luling and Emers, interview #5, #1, #2

<sup>155</sup> Domacasse, Van de Weteringe Buijs, interview #1, #5

<sup>156</sup> Van Luling and Emers, interview #2

<sup>157</sup> Reijtenbagh, 2008; interview #2

<sup>158</sup> Domacasse and Martina, interview #1, #3



remains static in the pipes too long (low-season at resorts) with high surrounding temperatures, the quality of the water deteriorates significantly. At this moment, these effects are not taken into account with the current monitoring procedure. By taking samples extra samples; just after production, from strategic places within the network *and* from the tap, a better overall picture of the water quality can be presented.

Another aspect of private drinking water production that is not taken into consideration is the analysis of intake-water. Usually intake water for desalination plants is extracted directly from sea, there are however some plants that use intake-water from dug wells. Since these wells (and the resorts) are usually located in more densely populated areas, there is a risk of groundwater-contamination. Periodic analyses of intake water need to be included in the regular monitoring program to indicate potential contamination of the water resources.

#### *Objectives a new drinking water supply system*

The main objective is to maintain: “A reliable drinking water supply system”. Currently, there are no adequate quality inspection programs conducted, that can decrease the awareness of potential quality deviations. Next to that, the overall quality of the public drinking water system is often instable and needs to be improved.

#### Water supply for remote households

The current coverage of the public drinking water distribution network is approximately 95%, 5% of the households have no drinking water connection in their house. In order to investigate how these households provide themselves with drinking water, a family has been visited that lives in a remote part of Bonaire. The family explained the methods by which they are provided with drinking water and the current issues that are related to this process. Houses and traditional *kunuku*'s (little and remote farms) outside the drinking water distribution area can order drinking water tanks at the public drinking water company. The water company places these stand-alone systems; the users pay a monthly fee (6 Euro) for renting the system. The system typically consists of a plastic water container with a pump, a water meter with an inspection-tap and a solar-power unit. The drinking water company refills the tanks and takes an inspection sample of the water every week<sup>159</sup>.

According to the users, there are a number of problems related to these systems. The system only has enough power to distribute water when the solar panels receive enough sunlight. This is not always the case during the rainy season (July until November), therefore the user had to connect the system to the normal power grid to provide it with enough energy. Another issue is related to the temperature, since the water tank and pipes are directly exposed to sunlight, the water coming from the system is extremely hot. Apart from being very uncomfortable, this *can* also seriously hamper the water quality in the system. The users would like the distribution system to be located underground to avoid any heat-related problems.

The costs for this type of water supply system are, according to the user, rather high. Apart from the monthly fee, that includes 5 free cubic meters of water, the average (2 person) family needs to pay an additional amount of 24 ANG (9,70 Euro) for consuming 4 extra cubic meters over the included 5 meters.

#### Drinking water quality

All interviewees refer to the presence of “brown water” on Bonaire. In multiple areas of the island, within certain fixed periods during the day, drinking water consumers frequently receive water that has a light brownish color. According to the users, this color is due to corrosion within the distribution network. The pipes of the distribution system are made of cast-iron and seem to corrode, leaving behind traces of oxidized metal particles in the network. These

---

<sup>159</sup> Van de Weteringe Buijs, interview #5

particles mainly seem to appear during the morning (high consumption rates). People also refer to the many ongoing building projects on the island as another potential cause for the brown water. Because of these projects, the distribution system will frequently be adjusted or extended. These activities cause sudden flow changes in the grid, probably moving heaps of oxidized particles through the network.

In order to prevent further deterioration of the distribution network, broken parts of the system are now gradually replaced with plastic pipes and connections. In the Netherlands, corrosion in the distribution network is normally prevented by producing water within a fixed pH range to make sure the water is not 'aggressive'. Drinking water also must contain minimum amounts of calcium and magnesium, leaving a small layer on the inside of the distribution pipes. This layer acts a sort of protective coating and prevents the water from oxidizing the metal.

In order to remove large amounts of oxidized particles in the pipes, distribution systems are sometimes strategically flushed, pushing the drinking water (with the unwanted particles) into one direction and finally out of the system<sup>160</sup>.

## **Saba**

### **Introduction**

The field trip to Saba has been used to gather more information on the water supply of private households. Information on the use, management and construction of rainwater systems has been gathered; problems *and* potential solutions were mentioned during interviews with local inhabitants. Next to that, the objectives of the island, regarding an improved drinking water supply system, have been discussed with the Governing Body of Saba, Lt. Governor Johnson and Commissioner Zagers (see section 4.4). Furthermore, the potential medical implications of drinking (untreated) rainwater have been discussed with local island doctor Mr. Koot.

### **Private drinking water supply on Saba**

Local inhabitants have been approached to get more insight in the supply and use of drinking water on the island. The inhabitants shared their experiences on harvesting rainwater and the issues related to this process. They also explained alternative methods of providing themselves with drinking water. The interviewees could designate clearly the problems at hand and gave useful advice how to improve the current system. The following items were discussed:

#### *Water quantity issues*

During the last 5 years there have been several cistern water shortages on both Saba and Statia<sup>161</sup>. There are said to be two causes for the increased number of water shortages during the last years; more extensive periods of drought during the dry period (December to May) and an increased consumption pattern of rainwater due to modern household equipment<sup>162</sup>. The latter is mainly due to introduction of large water consumers such as washing machines, flush-toilets and dishwashers. The original cisterns are not calculated on the current water consumption patterns.

When inhabitants want to order drinking water from one of the private producers, they usually have to wait several days (up to 7 days) before their water is delivered. It is said that this is due to the limited production capacity of the drinking water plant. The hygienic circumstances of the water distribution are doubtful; the trucks are also used for other types of water and it is not clear whether the tanks are disinfected<sup>162</sup>.

#### *Cistern construction and maintenance*

---

<sup>160</sup> de Moel, et al., 2006

<sup>161</sup> Johnson, Zagers, Koot, Hassell, Johnson, interview #9, #10, #11, #12

<sup>162</sup> Hassell and Johnson, interview #12

Traditional houses on Saba and Statia have a cistern located in the garden, “modern houses” have their cisterns integrated in the foundation of the house. Cesspits are also located in the foundation, usually at the outer corners of the house near the kitchen or bathroom. Sometimes cesspits and cisterns are located next to each other, separated by one concrete wall. Due to the proximity of the cesspits to the cisterns, the risk of contamination is expected to be high: there can be permeation of liquids through walls or cracks (seismic activity). In general, there are no guidelines for the construction of cisterns. There is no minimal distance defined between cesspits and cisterns, also no regulations are available for the materials that need to be used. According to local users, public information campaigns on the management of rainwater systems could solve some of the current problems.

Another aspect of cistern constructions is the total water capacity of the system. Two elements of the rainwater system are crucial for the total collected water volume: the size of the rainwater catchment surface and the capacity of the cistern. In order to meet the modern water consumption patterns, guidelines on capacities and dimensions should be defined<sup>163</sup>.

The quality of cistern water is directly related to the structural state and hygienic circumstances of the overall system. According to local users, the extent to which people clean and maintain their system varies significantly. Typically, the roofs, gutters and pipes are cleaned every two months, and the cistern itself is cleaned every two years. People use chlorine to disinfect the system and the water, dosed in unknown quantities. There are no regulations or guidelines for the management or maintenance of these systems. For older people cleaning their cisterns can be very difficult, having it cleaned by a third party costs around 900 USD<sup>163</sup>.

## Objectives of the island

In order to define the objectives and goals regarding an improved drinking water supply system, the responsible members of the island government have been interviewed (see interview #9). The main problems on Saba are related to drinking water *quality* and water *quantity*. In order to provide the inhabitants of Saba with enough and safe drinking water, the following main targets need to be achieved:

- Installation of a public drinking water company, replacing the illegal producers
- Erection of a public drinking water inspection body
- Use of filtration systems at private rainwater systems

The main objective is: “A reliable drinking water supply system on Saba”

## Waste disposal and drinking water

Another important problem on Saba is the disposal of waste and wastewater<sup>164</sup>. Both Saba and Statia have no waste disposal and treatment systems, there are also no communal sewerage systems on the islands. Households have cesspits or septic tanks through which wastewater infiltrates directly in the soil. Solid waste is collected and dumped into designated landfill sites; there the garbage is incinerated in open air. The solid and liquid contaminants entering the soil and seawater affect the water quality in cistern systems through permeation. Contaminants entering the sea can affect the quality of intake seawater for the used for the desalination plant. No research on the previous risks has been conducted yet.

Next to that, the smoke coming from burning landfills can affect the quality of the collected rainwater. Airborne particles coming from the incineration process fall down on roofs, gutters, and catchment areas and finally end-up in the cistern.

---

<sup>163</sup> Hassell and Johnson, interview #12

<sup>164</sup> Johnson and Zagers, interview #9

## Sanitary issues regarding rainwater harvesting

Inhabitants of Saba and Statia who frequently consume untreated rainwater sometimes suffer from diarrhea<sup>166</sup>. In order to verify this phenomenon, the island doctor of Saba, Mr Koot, has been interviewed. Potential medical risks related to the use of rainwater have been discussed in detail; useful strategies have been put forward by Mr Koot to mitigate the health risks.

### *Quality of cistern water*

From previous research study, it became clear that the microbiological status of tested cistern water *can* be very unstable. Mr Koot confirmed these findings and explained that due to the consumption of (untreated) rainwater from cisterns the chance of gastric disorders *can* increase. The reason for these gastric disorders might be the 'helicobacter pylori' bacterium; this bacterium is mainly responsible for stomach ulcers<sup>165</sup>. From interviews with inhabitants<sup>166</sup> it became clear that even long-time local users sometimes experience stomach pains, intestinal problems or diarrhea.

Sometimes cisterns show traces of fecal contamination<sup>167</sup>; sources of fecal bacteria can be found everywhere on the island: in the form of open street sewers, leaking cesspits, or animal activity around the cistern systems. Because of these contamination risks, untreated rainwater from cistern systems is dangerous for *immuno-compromised people*, such as the very young, the very old, cancer patients, diabetics, organ transplanted or HIV-positive individuals. For this risk-group, treatment of the rainwater is highly recommended before consumption<sup>168</sup>. The local home for the elderly is provided with untreated rainwater from the public cistern in the Bottom, also the Government House and the hospital are provided with this water<sup>169</sup>. The hospital uses the water only for emergencies; it is unknown whether this water is treated. To safeguard the risk-groups, filtration units for rainwater systems are highly recommended<sup>165</sup>.

From literature it is known that people who are used to drink rainwater with small amounts of bacteriological contamination tend to build up a resistance to these bacteria and generally suffer no ill effects<sup>170</sup>. A visitor, however, who is used to drink only pure or treated water, may suffer directly from diarrhea (gastroenteritis) or even dysentery when drinking the same water. For healthy adults diarrhea is normally not a serious condition. For small children, severe diarrhea (if untreated) can be life threatening. More generally, proving direct causal links between water quality and health effects is difficult, especially when the contamination levels are low. There are, however, many references to pathogens including Salmonella, Clostridium, Cryptosporidium, Giardia, and Campylobacter having been isolated from rainwater samples<sup>171</sup>. Quality considerations with regard to drinking rainwater therefore have to be taken very seriously. Therefore, the recommendation of Dr Koot to introduce filtration units for rainwater systems can significantly reduce the risk of health problems among the inhabitants.

### *Mosquito breeding in cistern systems*

One of the problems related to storing large quantities of fresh water is the risk for mosquito breeding inside the storage tanks. Currently, inhabitants of Saba and Statia insert either chlorine or guppies in their cisterns to prevent mosquito breeding and disinfect the water<sup>166</sup>. The link between rainwater storage and mosquito breeding has been extensively researched; a clear causal relation exists between the presence of mosquito larvae and rainwater storage containers. When storage tanks are open or lack secure covers or screens, they are far more vulnerable to infestation. There is a particular concern with mosquitoes in tropical areas where

---

<sup>165</sup> Koot, interview #11

<sup>166</sup> Hassell and Johnson, interview #12

<sup>167</sup> Reijtenbagh, 2008

<sup>168</sup> Gould and Nissen-Petersen, 1999, page 141

<sup>169</sup> Zagers, interview #10

<sup>170</sup> Riddle and Speedy, 1984

<sup>171</sup> Lye, D. 1992

they are vectors of serious diseases as malaria, yellow fever, dengue fever and filariasis<sup>172</sup>. Based on these findings, guidelines for cistern constructions need to be implemented. Clear instructions on how to build and manage a cistern system can prevent mosquito breeding *and* therefore also the use of chemicals to disinfect rainwater.

## **Statia**

### **Introduction**

Statia is in many ways similar to Saba; all issues of rainwater harvesting present at Saba do also apply for Statia. The main difference between the two islands is that Statia has an official public drinking water company with a small distribution network. This network is going to be extended throughout the island in the coming year (2010). The challenges related to the new distribution network have been discussed with Mr. Dijkshoorn, head of the Public Works department at Statia. The goals for an improved drinking water system have been discussed with the Lt. Governor of Statia, Mr. Gittens. An additional interview has been held with Terry Keogh, manager of NUSar Oil Terminals. NUSar has its own drinking water plant and used to provide drinking water during emergency situations.

### **Introduction of an extended public water supply network**

#### *Continuity of water distribution*

The new distribution network for Statia is providing 80% of the island with drinking water. It is yet unknown if the users of this new infrastructure will consume enough drinking water to guarantee a continuous flow in the network. It is known that people tend to cling on their existing rainwater systems (as was the case on Bonaire and St Maarten) and will only buy drinking water when their rainwater cistern is empty. When there is not enough circulation in the network, stagnant volumes of water can appear. The quality of stagnant water can deteriorate rapidly in relative high-temperature surroundings; this can cause serious health implications to the consumer<sup>173</sup>.

#### *Integration of rainwater and public distribution systems*

When households are connected to the new drinking water network, it is crucial that households do not mix clean drinking water from the network with their own cistern water. This can happen when households cross-connect their new water connection with their rainwater reservoir. Physical separation of the distribution network from the private cistern systems or implementation of filtration systems at the water tap is therefore necessary<sup>174</sup>. Guidelines to prevent cross-connection and therefore contamination need to be drafted for the new situation.

### **Objectives for drinking water**

The issues related to drinking water described by the Governing Body of Statia are identical to the situation on Saba: quantity and quality problems related to the use of rainwater systems. Waste-management is also a severe problem on Statia, potentially threatening the quality of desalinated and cistern water.

The main objective of the Governing Body is “A reliable drinking water supply on Statia”. Safeguarding the continuity and quality of drinking water on the island. It is important to erect an independent drinking water inspection body, monitoring desalinated and cistern water

---

<sup>172</sup> Kolsky, 1997

<sup>173</sup> Dijkshoorn, interview #8

<sup>174</sup> Gittens, interview #7

quality. The methods and procedures should be identical to the Dutch monitoring system<sup>174</sup>. Next to that, special attention needs to be paid to the new distribution network and the integration with the existing rainwater systems. Cisterns are still considered to main lifeline for drinking water supply during natural disasters and need to be maintained.

#### Emergency drinking water

##### *NUStar drinking water production*

NUStar Oil Terminals has its own drinking water production facility that produces drinking water for internal industrial processes. In the past, this system was used to provide drinking water for its own compound. Since there is a public drinking water company active, NUStar is not allowed to provide drinking water to its employees and to the public anymore by local government. Even during emergencies NUStar is not allowed to provide emergency drinking water to the island<sup>175</sup>. According to Antillean drinking water legislation, private drinking water producers are, theoretically allowed to provide third parties with drinking water.

##### *Dutch Navy and emergency water supply*

Last year, the Dutch Navy had to assist Saba during an extreme period of drought by providing the island with large quantities of desalinated drinking water. An interview has been held with the responsible Navy Commander, Mr Zwier, to get more insight in this operation.

The Dutch Navy provides drinking water to the BES islands when necessary. There are procedures for the provision of material aid to the Dutch Antilles. These procedures need to be adjusted to fit the new constitutional situation.

Another issue concerns the storage and distribution capacity of Saba and Statia. During the last emergency procedure it turned out that Saba (and Statia) are not capable of receiving and distributing large quantities of drinking water. There are no storage and pumping facilities available at the main harbors, this makes the delivery of drinking water by boat a time-intensive procedure. Next to that, there are not enough distribution trucks to distribute drinking water throughout the islands. In order to make emergency drinking water provision more effective and less time-consuming new procedures and facilities need to be arranged<sup>176</sup>.

---

<sup>175</sup> Gittens, interview #7

<sup>176</sup> Zwier, interview #13

## Appendix D Stakeholder analysis

### Introduction

This section describes the roles and responsibilities of the actors within the BES drinking water sector. A distinction is made between the situation *before* and *after* the constitutional transition. The complications of the current actor arena have been identified in more detail. Based on this analysis and taking into account the institutional shift of responsibilities, a reorganization of responsibilities has been proposed.

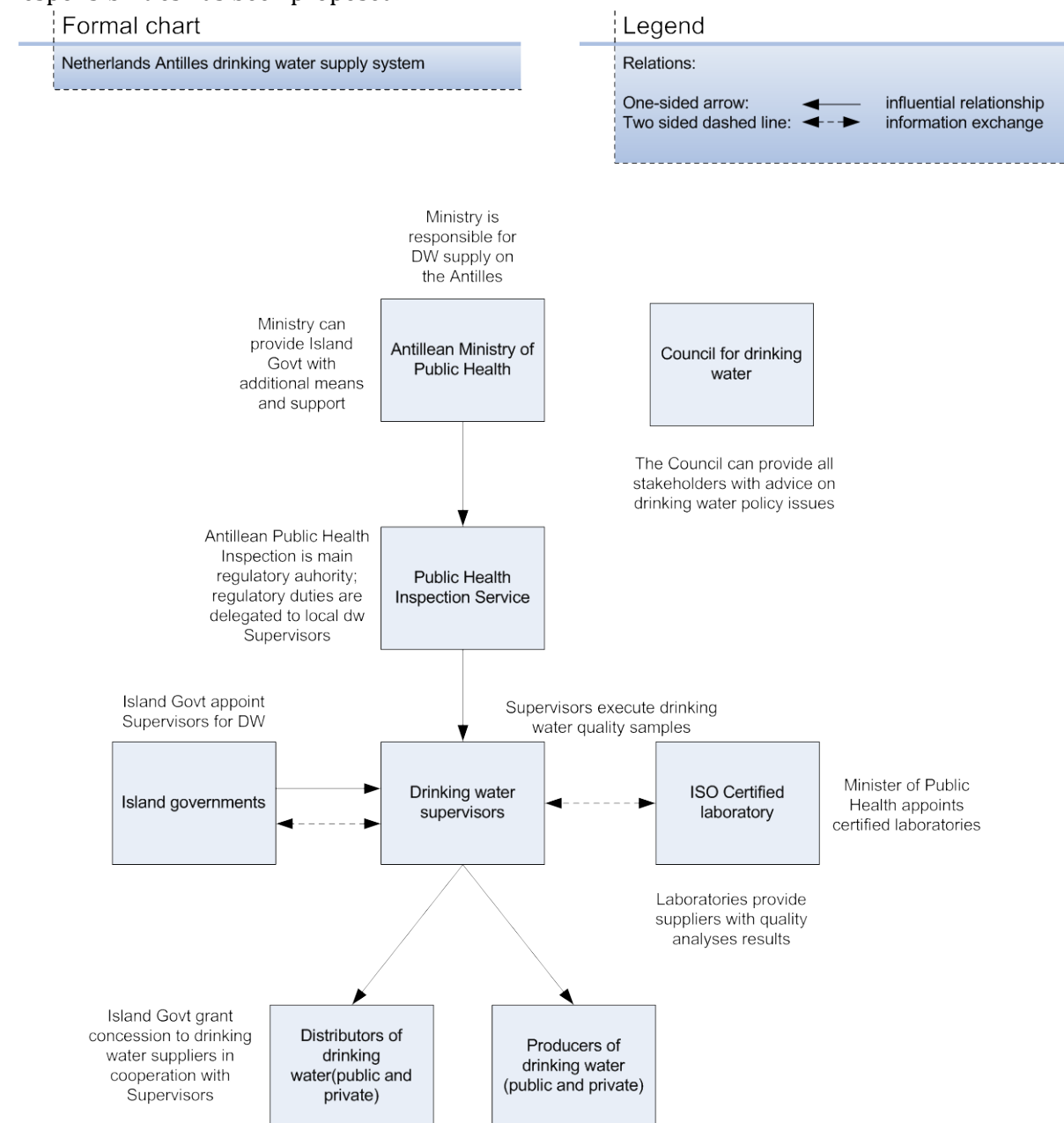


Figure 53 Antillean drinking water organization  
Current roles and responsibilities for the Netherlands Antilles

In the current constitutional setting, all responsibilities regarding drinking water supply are put down in Antillean legislation. The legislature for drinking water rests with the ministry of Public



Health in Curacao. The Public Health Inspection is entrusted with law-enforcing authorities<sup>177</sup>. The Inspection for drinking water has delegated many of its responsibilities to the BES Island Governing bodies. The formal chart of the Antillean drinking water sector can be found in Figure 48. The following stakeholders are of importance:

#### *Antillean Minister of Public Health*

The Minister of Public Health is responsible for maintaining drinking water laws and regulations on behalf of the Country the Netherlands Antilles. The Minister can provide the Island Governing Bodies (GB) with additional (financial) means and support for their drinking water supply. Finally, the Minister is responsible for the appointment of laboratories for drinking water analyses.

#### *Antillean Public Health Inspection*

The islands GB needs to inform the Inspection when drinking water does not meet Antillean quality regulations *and* during calamities. The Inspection can provide the GB with advice and additional means when necessary. Within the scope of law-enforcing authority, the inspection body can issue penalties, administrative coercion or legal investigations. These duties are usually delegated to the Island Governing Bodies.

#### *Council for Drinking Water*

Consists of independent experts in the field of drinking water. The Council provides (un-) solicited advice to related actors on drinking water laws, regulation and ongoing issues.

#### *Island Governing Body*

The Island Governing Body bears the responsibility for good drinking water and the approval of the drinking water distribution system. For that matter the GB grants concessions and permits for the production and distribution of drinking water. In order to be eligible for concessions, production and distribution processes need to meet quality and efficiency regulations. The Island GB is also responsible for the supervision and support during calamities and the provision of information to the population.

#### *Drinking Water Supervisors*

Drinking Water Supervisors are entrusted with delegated responsibilities of the Public Health Inspection (advisory role towards GB concerning concessions and calamities) and are appointed by the island governments. Furthermore, the supervisors are responsible for the inspection of drinking water producers and distributors. The supervisors assess the drinking water monitoring programs that are defined by the drinking water companies *and* take the necessary water samples themselves<sup>178</sup>.

#### *Laboratories*

Laboratories for drinking water analysis are appointed by the Minister of Public Health and need to be certified (ISO 17025). Drinking water laboratories analyze drinking water samples provided and report back the results to the supervisors and the drinking water companies.

#### *Producers/Distributors*

The producers and distributors bear the responsibility of providing enough and good (quality) drinking water, they are obliged to define monitoring programs, management and research plans, and risk analyses. They are also obliged to notify the drinking water supervisors when there are calamities.

---

<sup>177</sup> <http://www.gov.an>, visited February 2010

<sup>178</sup> P.B. No. 37, *Landsbesluit Kwaliteit Drinkwater*, Willemstad, 2006

Drinking water producers bear the costs related to the monitoring programs (taking and analyzing samples)<sup>179</sup>.

## Stakeholder analysis BES islands

The previous section defined the roles and responsibilities as defined in the Antillean drinking water law. The actual situation on the BES islands is however different than the official division of roles and responsibilities. This section describes the deviating actor networks of Bonaire, Saba and Statia.

### Bonaire

The actor network on Bonaire is presented in Figure 49. The following issues are related to the structure of the existing network:

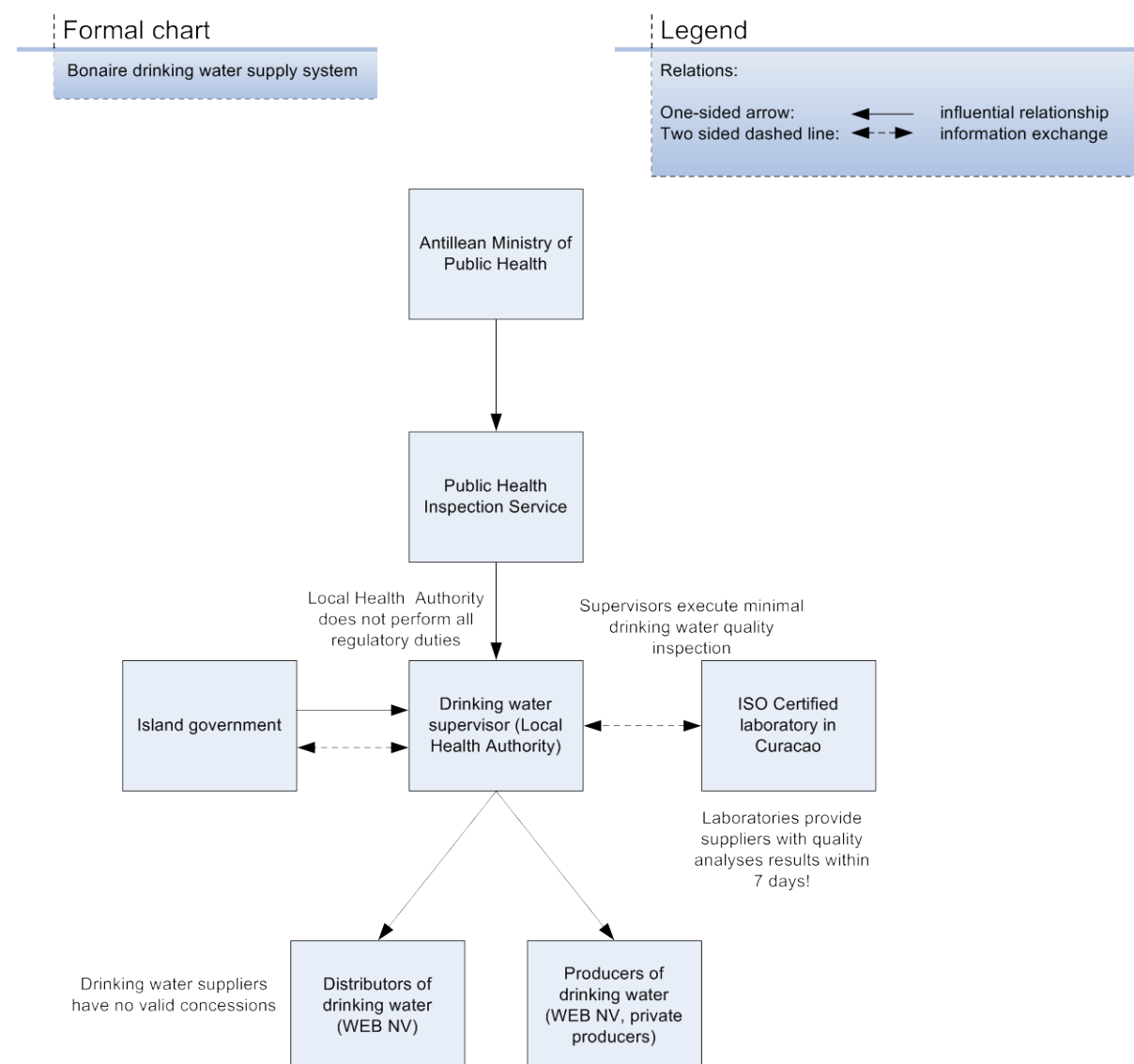


Figure 54 Drinking water organization on Bonaire

<sup>179</sup> Beckman Lapre, M.C., 2009

#### *Regulation of drinking water supply*

There are currently no drinking water council and supervisor appointed; this has a result that there is no external supervision of the drinking water supply system.

The drinking water council has never been installed, nor are its duties delegated to other authorities. One of the duties of the supervisor, drinking water sampling, has been delegated to the DGH (see next paragraph). The other responsibilities of the drinking water supervisor are currently not performed. This has as a consequence that there is no information available on performance and status of drinking water producers and distributors. The island GB and the Public Health Inspection therefore lack crucial information on the quality of the drinking water supply system.

#### *Drinking water quality monitoring*

The drinking water supervisor is officially responsible for quality control of drinking water; regulatory authority assesses monitoring programs and executes drinking water sampling. The sampling procedure has been delegated to the DGH, this does not apply for the assessment of monitoring and audit programs.

#### *Drinking water laboratory*

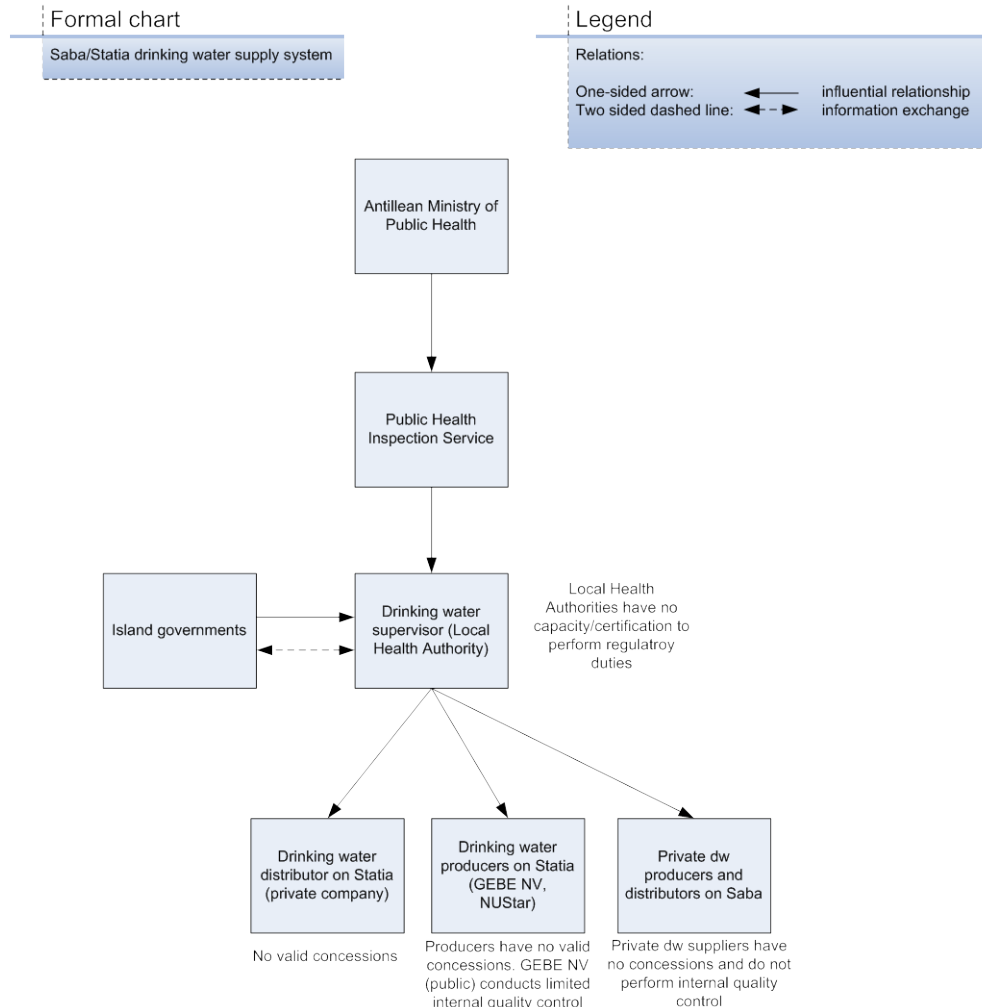
The existing laboratory on Bonaire, BONLAB, is not certified to conduct drinking water analyses; therefore the DGH sends samples to the ADC laboratory in Curacao. The lack of a drinking water laboratory on Bonaire has particular consequences for the monitoring system (see section 4.3.2)

#### *Conclusion*

Bonaire does not comply with the Antillean drinking water legislation; several actors that should be involved in drinking water regulation and inspection system have never been installed. Currently, the only authorities performing limited supervision duties are the Governing Body and the 'Dienst Gezondheid en Hygiene'. Some regulatory duties that should be performed by the Drinking water Supervisors and the Council for Drinking water are currently not executed. In this way, the drinking water monitoring program is not fully functional and there is no external regulatory authority to change this situation. Without a functional drinking water regulation and monitoring program, the drinking water supply system can be considered a black box. Drinking water companies themselves can now set the standard for quality and operations.

## Saba and Statia

The drinking water organization on Saba and Statia (see Figure 50) is deviating from the official Antillean actor network. The main reason for this deviating actor network is that the Antillean drinking water legislation has never officially been implemented and enforced. Saba and Statia have always been dependent on rainwater and there has never been a public drinking distribution network. Statia has a public drinking water plant, Saba has two private drinking water plants. Both islands lack a drinking water regulatory authorities, therefore none of the existing drinking water suppliers are regulated or inspected.



### *Private drinking water plants on Saba*

There are two drinking water plants that produce and distribute desalinated RO drinking water on Saba. Both producers do not have governmental concessions for their operations and are therefore illegal. Next to that, their production facilities and procedures do not meet the official drinking water standards.

### *Public drinking water plant on Statia*

The public drinking water company on Statia is operated by GEBE NV, the utilities company from St Maarten. The company was granted the official concessions for drinking water production and distribution by the Governing Body of Statia.

### *Private drinking water plant on Statia*

The NUStar oil terminal has its own drinking water plant, this plant used to provide drinking water to the population before Statia had a public drinking water plant. This private production plant has no concession to produce or distribute public drinking water. During emergencies, this plant is used for additional drinking water supply capacity. There are however no official arrangements for this procedure.

#### *Regulation and inspection of drinking water*

There is no external supervision of drinking water producers or distributors on Saba and Statia. The islands lack drinking water councils, supervisors and laboratories. The island GB are responsible for granting and extending concessions to their drinking water companies, they are not supported by external advisors in their decisions.

There are no actors on Saba and Statia that perform drinking water inspection duties. Most importantly, the islands lack certified human resources and facilities to perform monitoring processes. Local health authorities can only provide feedback to drinking water producers and the population when there seem to be drinking water related health issues.

#### Conclusions:

Both Statia and Saba have not implemented the official Antillean drinking water legislation. There are currently no regulatory authorities responsible for the supervision and inspection of drinking water producers and distributors.

On Statia, the Island Governing body provided the concessions for the production and distribution of drinking water to GEBE NV. On Saba, no official concessions have been provided. On both Saba and Statia there are illegal drinking water suppliers that produce and distribute drinking water via trucks. There are also hotels and resorts that collect and distribute rainwater to their guests. Since the operations of illegal drinking water suppliers are not subjected to regulations or inspection, significant health risks are created. The only authority than can provide feedback to drinking water suppliers are the Health Authorities. This is usually done when local drinking water consumers complain about the water quality.

#### Post-transition

After the constitutional transition, the Dutch government takes over the role and responsibilities of the Antillean government for the BES islands. The Antillean drinking regulations have been legally adapted for implementation in Dutch legislation. The original Antillean legislation has been modified to form the conceptual “BES drinking water law”. This specific drinking water law describes the provisional roles and responsibilities of the new drinking water actor network<sup>180</sup> on the BES islands. The new conceptual actor network is presented in Figure 51. This roles and responsibilities that are presented in the new BES drinking water law are conceptual and subjected to change. Therefore, the descriptions given in this section need to be considered as a starting point and do not necessarily represent the formal actor network in the post-transition situation.

#### New roles and responsibilities

##### *Ministry of VROM*

The Ministry of VROM takes over the legal responsibility for drinking water from the Antillean Ministry of Public Health. After the constitutional transition, the Dutch Ministry will be the official legislator for drinking water. The Minister of VROM is also responsible for the accreditation of drinking water laboratories. Next to that, the Ministry provides the Governing Bodies of the BES islands with the necessary financial means to improve the current drinking

---

<sup>180</sup> Ministry of VROM, Conceptual BES drinking water law, 2009

water supply system to comply with the BES drinking water law. The BES islands will receive a yearly structural funding for drinking water supply and inspection activities.

#### *VROM Inspection (VI)*

The Inspection service of VROM is responsible regulatory authority for drinking water on the BES islands from within the Netherlands. The inspection of public drinking water and other regulatory duties will partially be delegated to the local health authorities on the BES islands (Bonaire only)<sup>181</sup>.

#### *Drinking water suppliers*

The drinking water suppliers are responsible for the execution of internal quality control of drinking water. According to the new BES drinking water law, they will conduct quality sampling and execute analysis procedures, reports of these analyses will be send to the regulatory authorities.

#### *Supervisors for drinking water*

The role "Supervisor for drinking water" is also maintained in the new situation. Most of the responsibilities will be taken over by the Local Health Authorities (this was already the case on Bonaire). The capacity of the local health authorities on Saba and Statia is rather limited, in order to perform regulatory and inspection duties; both physical facilities and certified human resources need to be arranged. Therefore assistance and capacity is needed from the Ministry of VROM. It is unknown how the inspection organization is going to be realized for Saba and Statia.

#### *Drinking water laboratories*

Bonaire has no certified laboratory for drinking water analyses, it can either decide to remain the cooperation with the laboratory in Curacao or they can develop their own laboratory.

There are currently no drinking water laboratories on Saba and Statia. It is economically not feasible to build new individual laboratories on Saba and Statia, the number of samples that will be taken is too limited. Therefore, it is more likely that the islands will need to cooperate with existing laboratories on other islands.

#### *Council for Drinking Water*

Consists of independent experts in the field of drinking water. The Council provides (un-) solicited advice to related actors on drinking water laws, regulation and ongoing issues. The composition of this new actor is not yet defined. It is clear that a mixture of both local and Dutch experts will take place in this advisory council.

---

<sup>181</sup> Beckman Lapre, 2010

## Formal chart

### BES drinking water stakeholders after transition

## Legend

### Relations:

One-sided arrow:  influential relationship  
Two sided dashed line:  information exchange

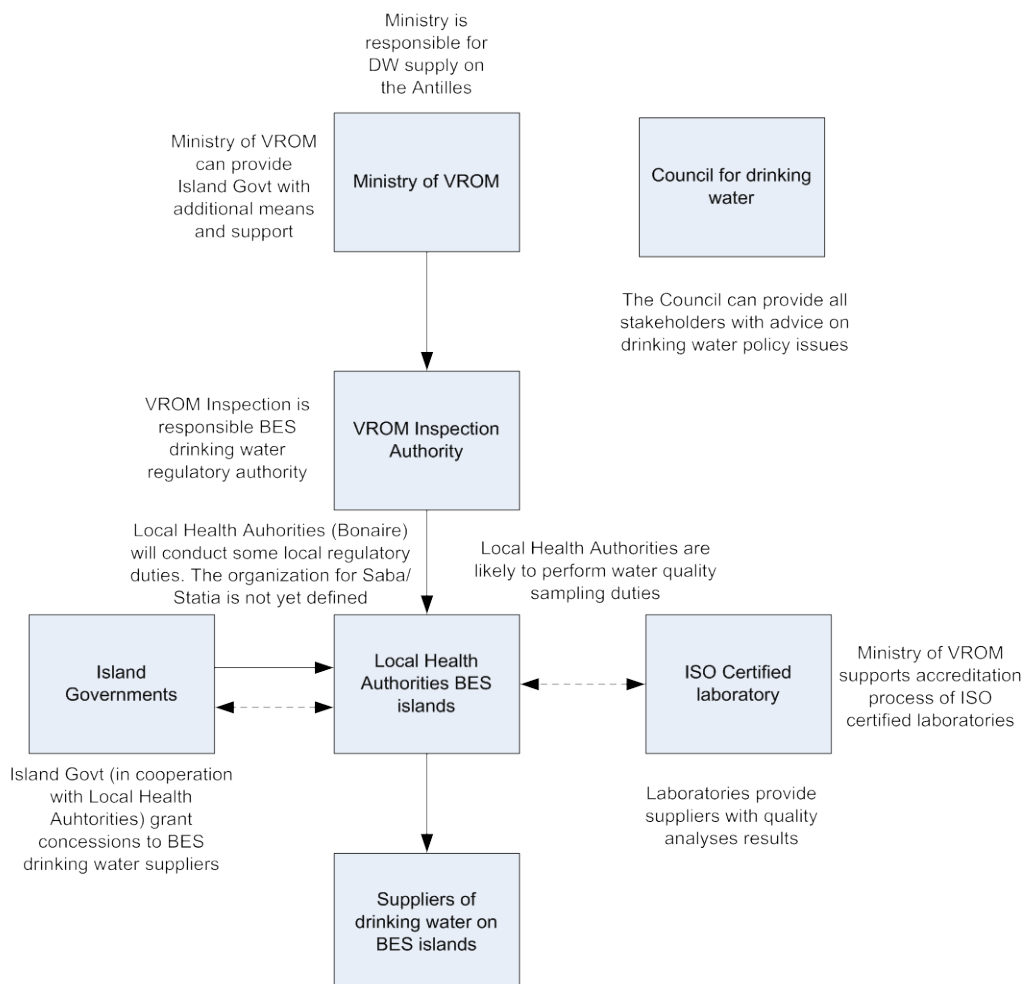


Figure 56 Conceptual drinking water stakeholder network BES islands





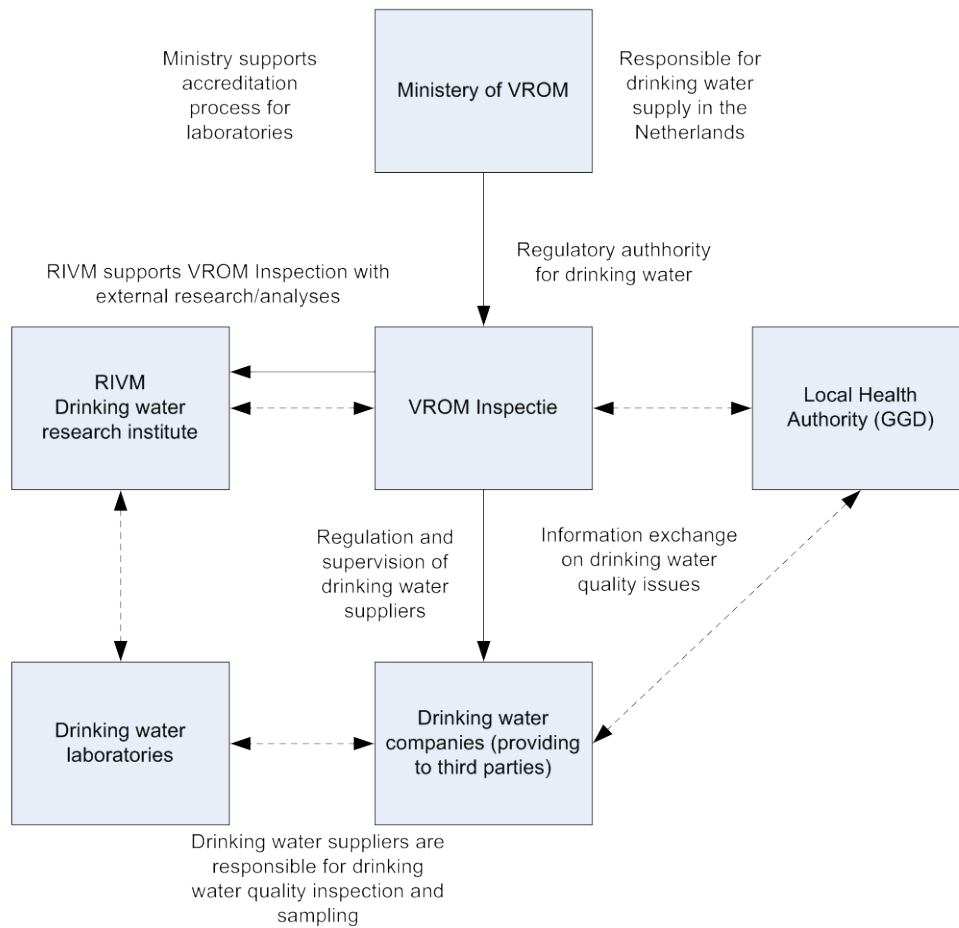
## Formal chart

### Drinking water stakeholders in the Netherlands

## Legend

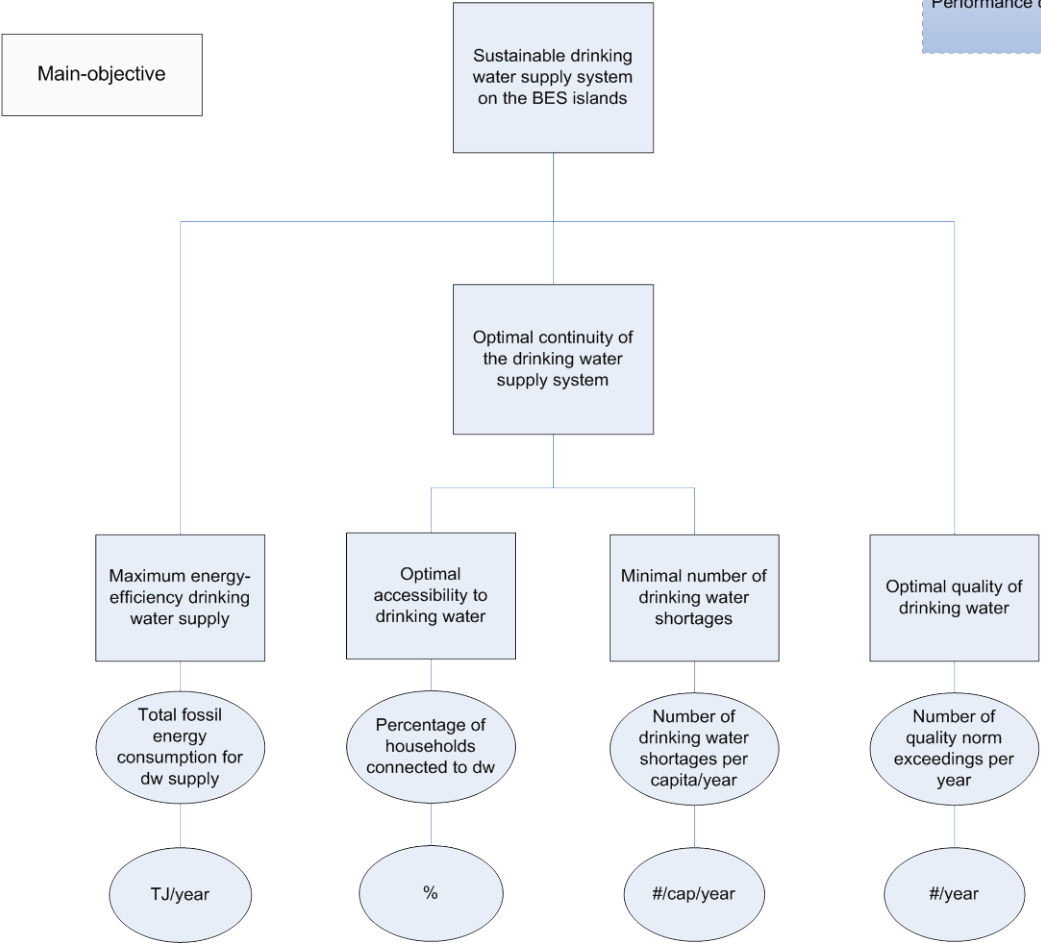
### Relations:

One-sided arrow:  influential relationship  
Dashed line:  information exchange



Appendix E      Goals and objectives

Objectives diagram Ministry of VROM



Legend:

Objective: "A"

Performance critirium:: [x]

Main objective:

*“A sustainable drinking water supply system on the BES islands”*

The following sub-objectives are derived from the main objective:

Sub-objectives:

- Optimal quality of drinking water

The quality of drinking water (whether it be rainwater, groundwater or desalinated water) must comply with the chemical and bacterial parameters formulated in the applying drinking water regulations. The criterion, relating to this goal, is defined as the total number of occasions per year in which the drinking water quality does not meet the legal quality regulations.

- Minimal drinking water shortages

The number of events during which a person is not able to have access to enough drinking water needs to be minimized. The criterion is defined as the total number of drinking water shortages per capita during a year.

- Optimal accessibility to drinking water

This sub-objective refers to accessibility of drinking water; generally drinking water is distributed via drinking water trucks or via a direct connection via a piped distribution network. The more people are directly connected to a distribution network, the better the access to safe drinking water. This objective is measured as the percentage of the households that is connected to a drinking water distribution point.

- Maximal energy-efficiency for drinking water supply

The production and distribution of drinking water need to take place in the most energy-efficient way. This can be quantified as the total number of TJ (Joules) consumed in a year for the supply of drinking water.

## Objectives diagram joint drinking water actors Bonaire

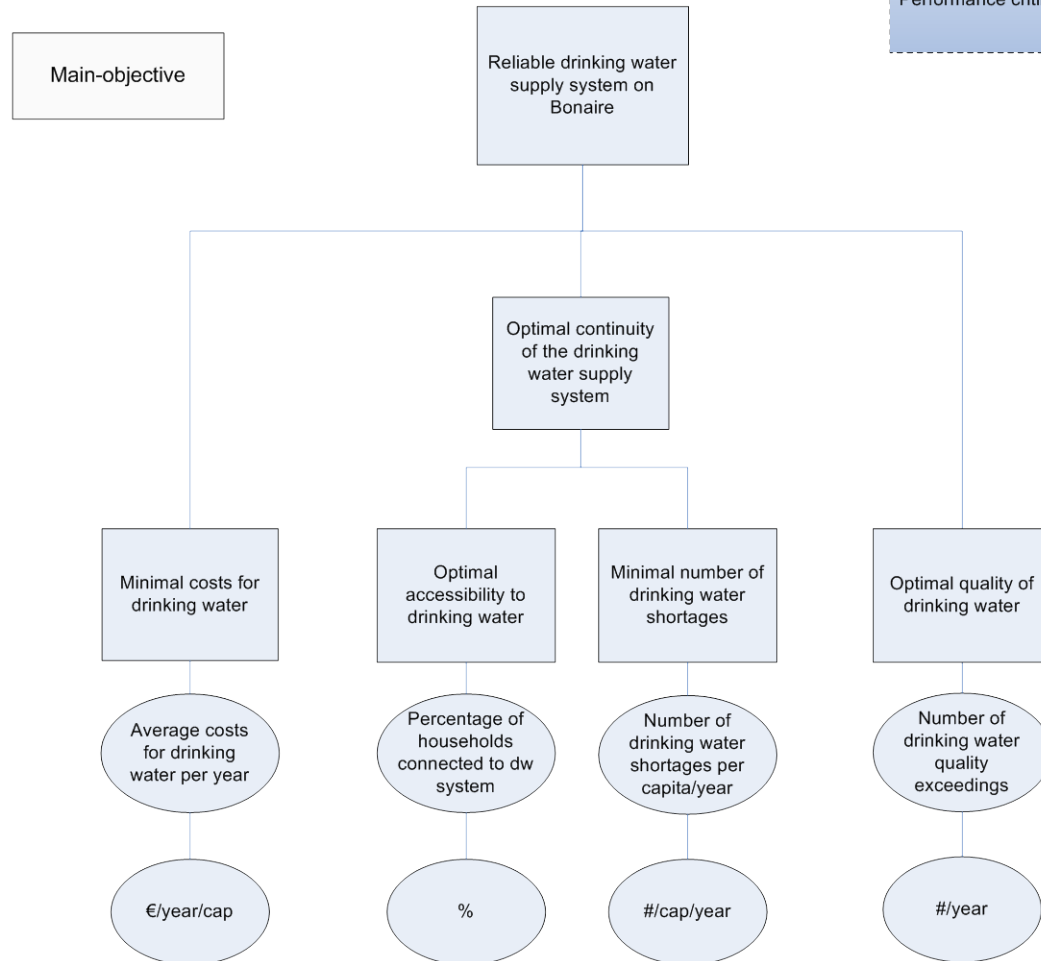
## Legend:

Objective:

"A"

Performance critirium::

[x]



Main objective:

*“A reliable drinking water supply system on Bonaire”*

The main objective of Bonaire is to provide a steady and economic efficient supply of drinking water to its inhabitants. Next to that, the drinking water quality should meet all necessary regulations. Therefore, monitoring of drinking water takes an important position within the drinking water supply system.

The following sub-objectives are derived from the main objective:

Sub-objectives:

- Optimal quality of drinking water

The quality of drinking water (whether it be rainwater, groundwater or desalinated water) must comply with the chemical and bacterial parameters formulated in the applying drinking water regulations. The criterion, relating to this goal, is defined as the total number of occasions per year in which the drinking water quality does not meet the legal quality regulations.

- Minimal drinking water shortages

The number of events during which a person is not able to have access to enough drinking water needs to be minimized. The criterion is defined as the total number of drinking water shortages per capita during a year.

- Optimal accessibility to drinking water

This sub-objective refers to accessibility of drinking water; generally drinking water is distributed via drinking water trucks or via a direct connection via a piped distribution network. The more people are directly connected to a distribution network, the better the access to safe drinking water. This objective is measured as the percentage of the households that is connected to a drinking water distribution point.

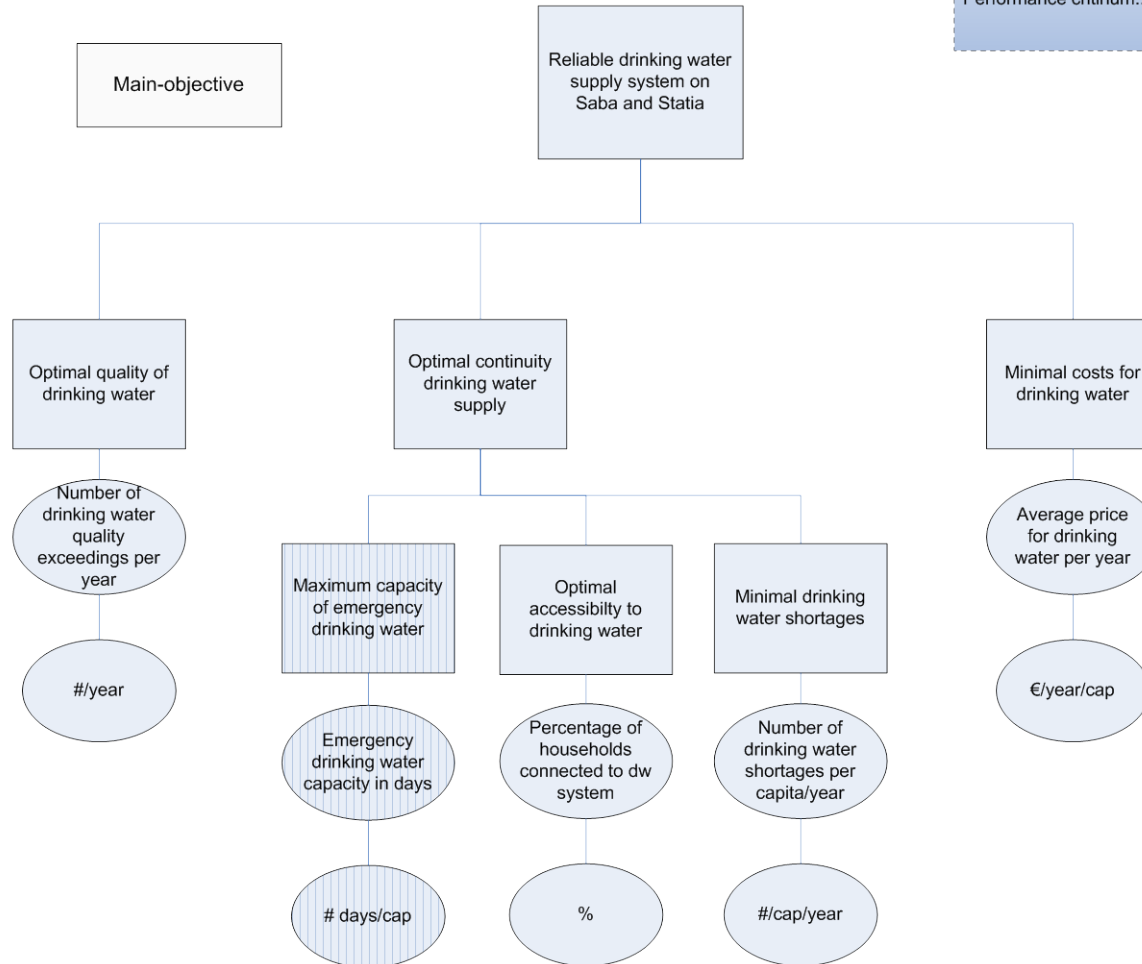
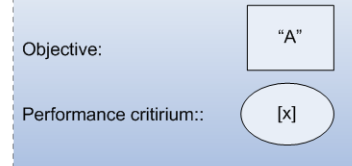
Specific sub-objective Bonaire:

- Minimal costs for drinking water

The costs for drinking water should be reasonable and meet the economic regulations in the new BES drinking water law. The costs for drinking water are calculated per capita per year. The average costs include connection-fees, fixed monthly costs, and variable costs.

# Objectives diagram joint drinking water actors Saba/Statia

## Legend:



Main objective:

*"A reliable drinking water supply system on Saba and Statia".*

This objective is identical to the main objective of Bonaire. Since the circumstances on Saba and Statia are quite different compared to Bonaire, the sub-objectives are not the same as on Bonaire.

Sub-objectives:

- Optimal quality of drinking water

The quality of drinking water (whether it be rainwater or desalinated water) must comply with the chemical and bacterial parameters formulated in the applying drinking water regulations. The criterion, relating to this goal, is defined as the total number of occasions per year in which the drinking water quality does not meet the legal quality norms.

- Minimal drinking water shortages

The number of events during which a person is not able to have access to enough drinking water needs to be minimized. The criterion is defined as the total number of drinking water shortages per capita during a year.

- Optimal accessibility to drinking water

This sub-objective refers to accessibility of drinking water; generally drinking water is distributed via drinking water trucks or via a direct connection via a piped distribution network. The more people are directly connected to a distribution network, the better the access to safe drinking water. This objective is measured as the percentage of the households that is connected to a drinking water distribution point.

- Minimal costs for drinking water

The costs for drinking water should be reasonable and meet the economic regulations in the new BES drinking water law. The costs for drinking water are calculated per capita per year. The average costs include connection-fees, fixed monthly costs, and variable costs.

Specific sub-objective Saba/Statia:

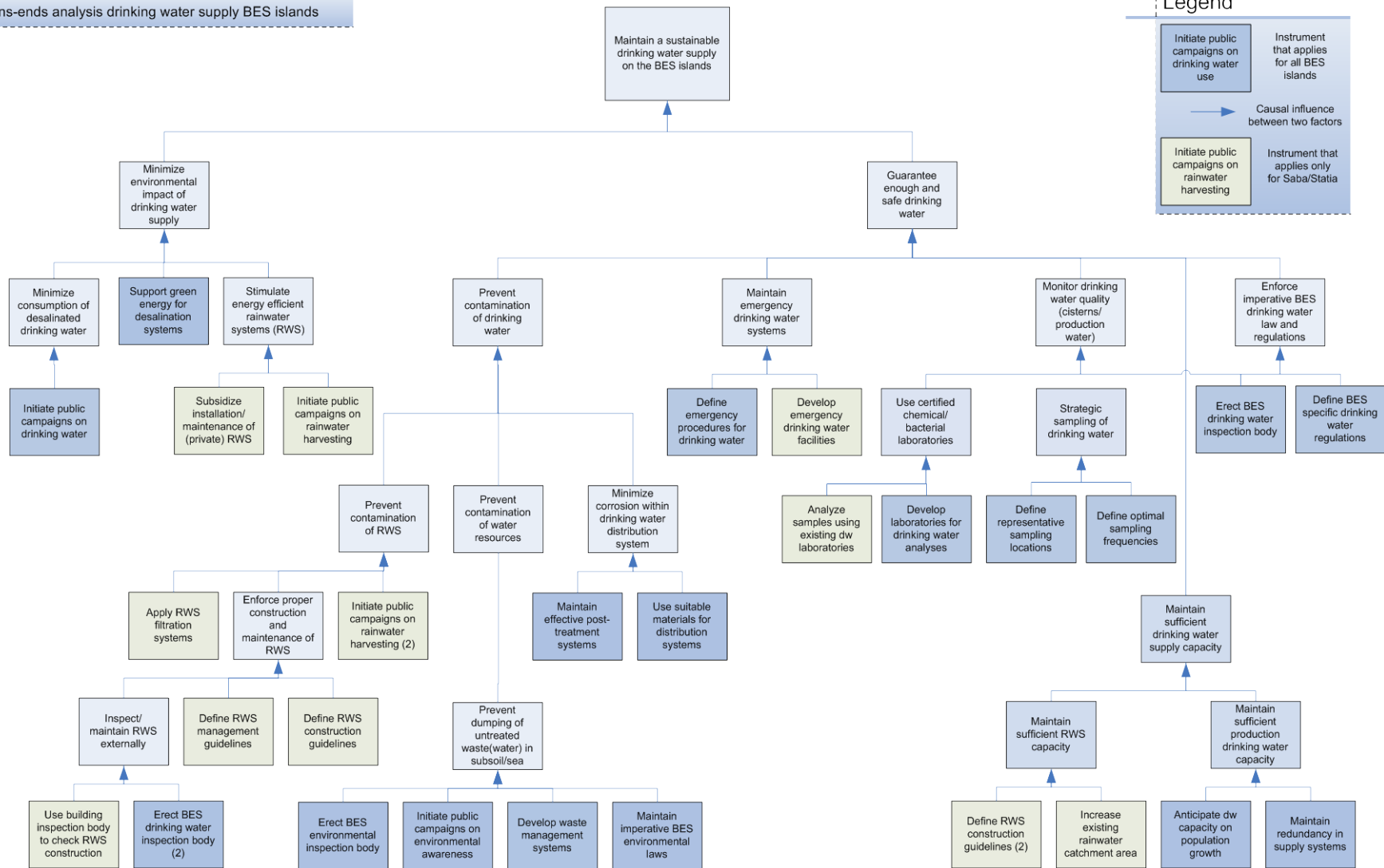
- Maximum capacity of emergency drinking water

This sub-objective is particularly important for Saba and Statia since the islands are located in the hurricane belt. When natural disasters take place, the islands are completely isolated and are therefore entirely depending on their own resources. The emergency capacity for drinking water is quantified in the number of days during which there is enough drinking water available for every inhabitant.



## Appendix F Means-ends diagram

### Means-ends analysis drinking water supply BES islands



## Explanation means-ends diagram:

A means-ends-diagram serves as a tool to systematically map a wide range of potential strategies and instruments that might support the realization of a certain goal<sup>182</sup>. In a means-ends diagram, the elements are formulated as activities, arrows are used to indicate how activity A can contribute to activity B. It is possible that one means or measure can support multiple goals<sup>183</sup>. The measures or instruments that are generated by this diagram can be retrieved in the causal diagrams and system diagrams (appendices G, H and I).

There are two types of instruments that can be found in the diagram: one group of instruments that applies for Statia and Saba (pink) only and the other group that applies for all BES islands (blue). For the explanation of the individual instruments they will be divided into groups, relating to their main objectives.

### **1 Minimize environmental impact of the drinking water supply system**

#### *1.1 Initiate public campaigns on drinking water*

By providing detailed information on the *value* of drinking water to the public (in the form of public presentations, distribution of leaflets or television commercials) people might use water more consciously. Examples can be given on how people can reduce their personal water consumption and how this affects their own expenses as well. These campaigns can help reduce the total consumption of fossil fuels for the drinking water supply system.

#### *1.2 Support green energy for desalination systems*

The local or national government can invest in green energy sources for the production and distribution of drinking water. This can be done in the form of subsidizing solar panels, wind-turbines or biodiesel installations that can provide green energy.

#### *1.3 Subsidize maintenance of RWS (Saba/Statia)*

The other way to save fossil fuels is to stimulate the use of rainwater harvesting systems (RWS). Rainwater systems are sustainable, using hardly any energy (compared with seawater desalination) for the supply of drinking water. Households can be stimulated to use RWS using positive economic incentives (subsidization). Rainwater systems need to be maintained periodically to guarantee a stable water quality. Maintenance consists of cleaning the system and replacing broken parts, this is a time-consuming and mostly expensive activity.

People are reluctant to use RWS because they high investment and maintenance costs that are related to the systems. When the government can assist in subsidizing these activities, more people might want to use RWS.

#### *1.4 Initiate public campaigns on rainwater harvesting (Saba/Statia)*

By initiating information campaigns on rainwater harvesting, people get stimulated to use rainwater systems and manage these systems properly.

### **2 Prevent contamination of RWS**

#### *2.1 Apply RWS filtration systems (Saba/Statia)*

Rainwater can cause serious health effects when it is consumed without further treatment. In order to safeguard a constant quality and eliminate any contaminations in cistern water, special filtration units can be installed. Generally these systems consist of multiple filters, active carbon and UV treatment steps.

#### *2.2 Use building inspection body to check RWS construction (Saba/Statia)*

Rainwater harvesting systems are constructed in various ways since there are currently no general guidelines available. Dimensions, set-up and materials may vary; usually general rules

---

<sup>182</sup> Enserink, et al., 2003

<sup>183</sup> Enserink, et al., 2009

of thumb are used when constructing rainwater cistern systems. The lack of proper building regulations can have a negative effect on the continuity and quality of rainwater systems. In order to check and inspect RWS constructions, building plans can be checked for compliance by the local building inspection authorities. When RWS are being constructed, the local building inspection authorities can check if the RWS constructions actually comply with the building plans.

### *2.3 Erect BES drinking water inspection body*

At this moment, the Inspection authority of the Antillean Ministry of Public Health is responsible for the regulation and inspection of drinking water on the BES islands. The authority delegates various health inspection duties to local authorities on the BES islands. For drinking water, this applies for Bonaire only; on Saba and Statia there are no drinking water inspection activities. In order to inspect if public and private water producers comply with drinking water regulations *and* to monitor the drinking water quality, a local BES drinking water inspection authority needs to be erected.

### *2.4 Define RWS management guidelines (Saba/Statia)*

There are no instructions available on how to manage a rainwater harvesting system. Maintaining and repairing RWS requires specific knowledge and clear instruction guidelines. Practical guidelines should be made available to the public to help households manage RWS correctly and to prevent contamination of cistern water. Some of the guidelines that are crucial can be integrated as regulations in the BES drinking water law.

Cleaning RWS might seem unnecessary since people also can add filtration units that eliminate impurities in cistern water. In order to minimize the costs of replacing internal filters, and to guarantee a constant efficiency of the filtration unit, it is better to clean the RWS regularly.

### *2.5 Define RWS construction guidelines (Saba/Statia)*

Regulations and guidelines need to be developed in order to safeguard proper rainwater constructions. Dimensions of cisterns need to match modern water consumption patterns, non-toxic and impermeable materials need to be used for the inside of the tank and the location of cisterns should not be too close to bacterial sources. These are just a few examples that might be included within these guidelines. As for the management guidelines, the can also be included as regulation within the BES drinking water law or within the BES building codes.

## **3 Prevent contamination of water resources**

### *3.1 Erect BES environmental inspection body*

The presence of an active environmental inspection body might encourage inhabitants of the BES islands to manage their waste-(water) more carefully and comply with BES environmental laws and regulations. The inspection body has the authority to give instructions or impose financial sanctions to those who deviate from the law.

### *3.2 Initiate public campaigns on environmental awareness*

Campaigns on environmental awareness can address the problems related to waste and wastewater. The public should be informed about the consequences of unprocessed waste for their living environment, personal health and tourism. During campaigns can be explained what the people can do themselves in order to improve the environmental system.

### *3.3 Develop waste-management systems*

One important instrument to avoid pollution of the water resources is to develop sound waste-management systems. Wastewater can be collected and treated to safe effluent that can serve agricultural purposes. Recycling systems can be introduced, reducing the total solid waste-volume. Waste incineration plants can be used to safely process all other materials.

### *3.4 Maintain imperative BES environmental laws*

In order to contribute to a safe and clean environment, suitable and feasible environmental regulations need to be formulated. Current environmental laws need to be adjusted fitting local BES conditions. By maintaining regulations that match local circumstances, it is easier to comply with and enforce these regulations.

## **4 Minimize corrosion in distribution systems**

### **4.1** *Maintain effective post-treatment systems*

Desalinated drinking is post-treated directly after the reverse-osmosis process; chemicals are added to improve the taste and quality of drinking water. Next to that, the hardness of the water is managed by adding calcium products. The latter process is important to prevent corrosion in the distribution network; the calcium creates a thin layer protecting the inside of the water pipes. When post-treatment steps are executed appropriately, the chance of corrosion can be minimized (reducing the presence of brown water).

### **4.2** *Using suitable materials for distribution systems*

Anti-corrosion post-treatment steps are necessary when the distribution network consists of corrosive materials (for example: cast-iron). To prevent corrosion in the systems, non-corrosive materials such as plastics can be used. Replacing the full distribution network is economically not feasible; old (or broken) parts can gradually be replaced with non-corrosive sections.

## **5 Maintain emergency drinking water systems**

### **5.1** *Define emergency procedures for drinking water*

For remotely located islands such as the BES islands, emergency procedures for drinking water are very important. When drinking water supply systems fail (natural disasters, power-disruption, etc) there need to be back-up drinking water systems available. The procedures describe how and when these systems are used and who is responsible for the organization of the emergency drinking water provision.

### **5.2** *Define emergency drinking water facilities (Saba/Statia)*

For Saba and Statia it is important to develop emergency drinking water facilities since the islands lack normal drinking water supply networks. During calamities, special facilities need to be available that can produce, store and distribute emergency drinking water.

## **6 Use certified chemical/bacterial laboratories**

### **6.1** *Analyze samples using existing drinking water laboratories (Saba/Statia)*

On Saba and on Statia there are currently no drinking water laboratories available for the analysis of drinking water quality samples. Since the number of samples that need to be taken on both islands is small, it is likely to be more feasible to send these samples to laboratories on other islands for analysis. In the case of Saba and Statia, one could think of cooperation projects with St Maarten or St Kitts. These islands have certified laboratories and are closely located.

### **6.2** *Develop laboratories for drinking water analyses*

The drinking water monitoring process on Bonaire can be made more efficient when water samples were to be analyzed at the existing laboratory in Kralendijk. In order to realize this, the laboratory needs to be equipped with additional facilities for microbiological analyses.

## **7 Strategic sampling of drinking water**

### **7.1** *Define representative sampling locations*

In order to get a realistic picture of the overall drinking water quality, samples need to be taken at strategic and representative locations. Risks analyses need to be conducted to define the appropriate locations.

## 7.2 *Define optimal sampling frequencies*

The Antillean drinking water regulations prescribe audit-frequencies for drinking water monitoring. These audit-frequencies need to be updated fitting the local water systems at the BES islands.

# 8 **Enforce imperative BES drinking water law and regulations**

## 8.1 *Erect BES drinking water inspection body*

See 2.3

## 8.2 *Define BES specific drinking water regulations*

The Antillean drinking water regulations form the basis for the new BES drinking water law. The Antillean regulations need to be revised and expanded where necessary; regulations on legionellosis are not sufficient and quality indicator parameters for drinking water are not representative or suitable for the BES islands.

# 9 **Maintain sufficient drinking water supply capacity**

## 9.1 *Develop RWS construction guidelines*

See 2.5

## 9.2 *Increase existing rainwater catchment areas (Saba/Statia)*

An important measure to collect more rainwater, and thus prevent cistern water shortages, is to increase the catchment surface located at each house. Additional catchment areas can be constructed or additional roofs can be connected to the RWS.

## 9.3 *Anticipate drinking water capacity on population growth*

The BES islands, and Bonaire in particular, are expected to receive relatively more immigrants from Holland after the constitutional reformation. Conditions for Dutch retirees to immigrate to the BES islands are expected to be more attractive than in the current situation<sup>184</sup>. Next to the natural growth rates of the population, growing tourist numbers, also the new group of retirees should be taking into account when defining drinking water capacity rates.

## 9.4 *Maintain redundancy in supply systems*

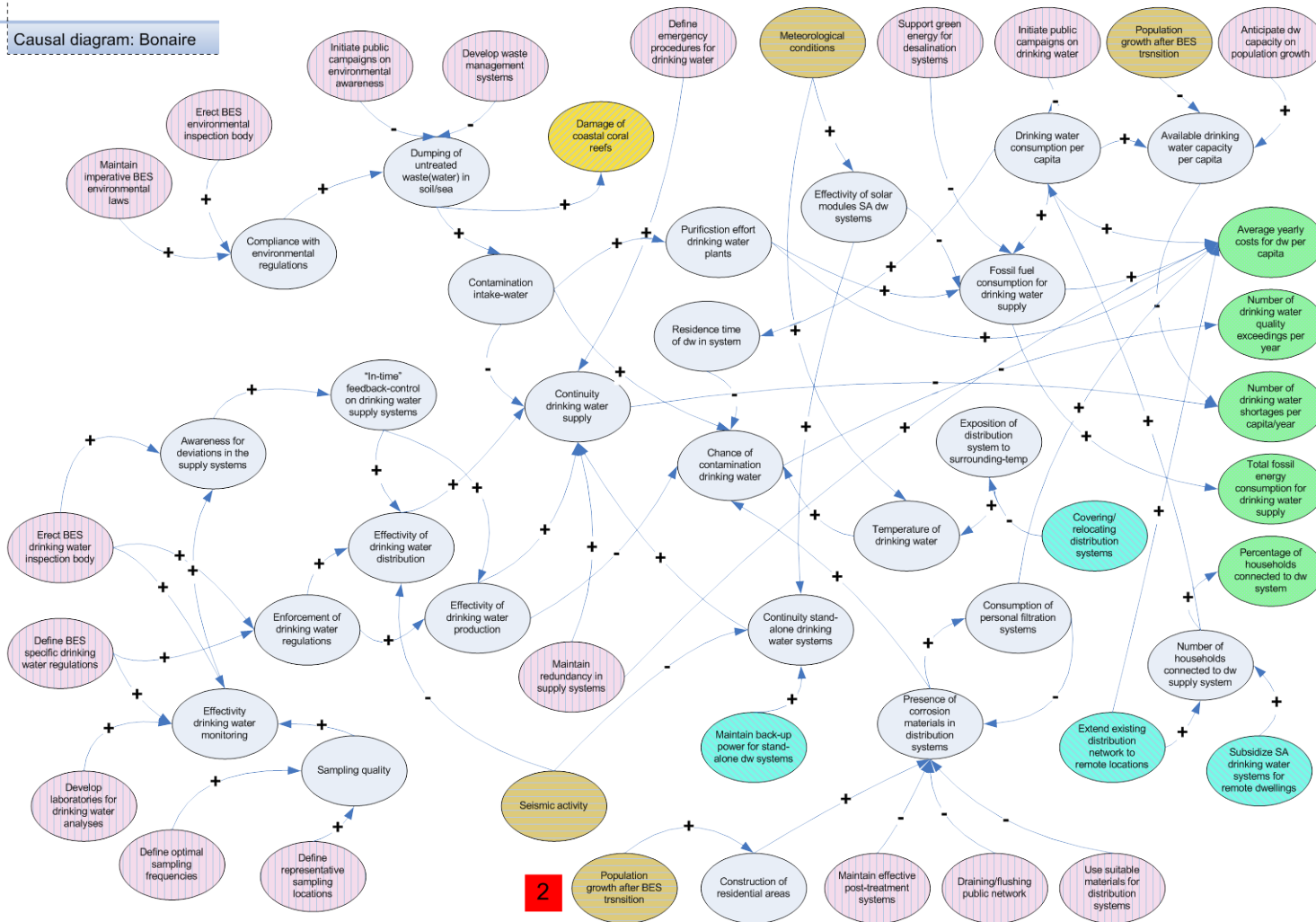
In order to safeguard the continuity of drinking water supply on the BES islands, the production and distribution systems need to be equipped with enough redundant parts/systems.

---

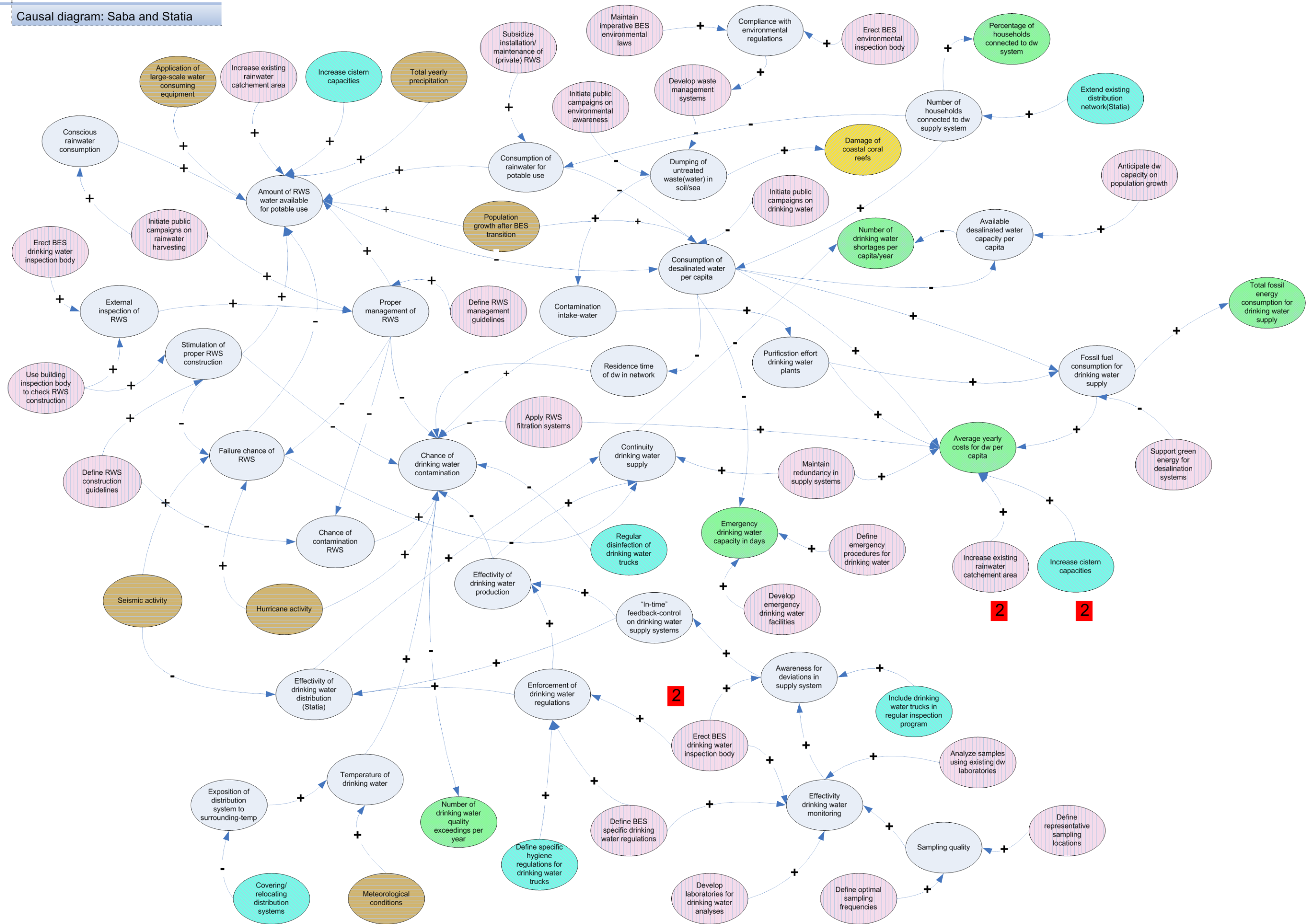
<sup>184</sup> Reijtenbagh, 2008

## Appendix G Causal diagrams

Causal diagram: Bonaire



Causal diagram: Saba and Statia



## Explanation of causal relation diagrams

The causal relation diagrams in this section clarify the causal relations between factors that are relevant to the problem. The theories for these diagrams are based on previous research by the author, interviews and literature research. The diagrams are formulated using the performance criteria from the objectives-trees and the instruments (means) from the means-ends analysis as starting points<sup>185</sup>. The relations between instruments, criteria and other factors are represented by arrows. An arrow from A to B means that factor A influences factor B in a certain way. These relationships are causal; when factor A changes, than factor B changes accordingly. The nature of the relations between arrows are shown by adding “+” or “-” symbols to the arrows. A “+” next to an arrow between A and B means that if A increases B must increase as well, for a “-” symbol goes the opposite<sup>186</sup>.

By developing causal relation diagrams more insight is provided about the problem situation. New insight into certain elements of the system can sometimes lead to additional instruments that can contribute to the performance criteria. These ‘new’ instruments are explained in the next sections:

### Additional instruments:

#### **Bonaire**

##### *Maintain back-up power for stand-alone drinking water systems*

Solar energy as the main power source for stand-alone water systems on Bonaire is not always sufficient, therefore the water systems should have a power back up. One solution alternative is to connect. This can be done by connecting the stand-alone water systems to the main power-grid.

##### *Extend existing distribution network to remote locations*

To increase the number of households with a direct connection to the main distribution network, the existing network can be extended to remote locations. Since these extensions are not feasible, the local or Dutch government could invest in these extensions.

##### *Covering/relocating distribution systems*

Currently, many distribution pipes and storages are located above ground, directly exposed to sunlight. Temperatures in the distribution system are very high and can, under the right circumstances, lead to quality deterioration. These problems can be resolved by covering or relocating parts of the existing distribution systems; they can be placed underground or equipped with isolation materials.

##### *Subsidize stand-alone drinking water systems for remote dwellings*

Remote dwellings can ‘rent’ individual drinking water tanks. For that, homeowners have to pay connection and user fees. Not all households can afford this and are therefore not connected to a public drinking water source. The government introduce economic incentives to support these households be introducing subsidy schemes for these drinking water installations.

#### **Saba/Statia**

##### *Increase cistern capacities*

By increasing the capacities of cistern systems, more water can be collected for personal use. Since the average yearly amount of rainfall is enough to provide everybody on the islands of Saba and Statia with enough drinking water. The problem with rainwater shortages is related to

---

<sup>185</sup> Enserink, et al., 2009

<sup>186</sup> Bots, P.W.G., 2002



the average cistern capacity and the surfaces of catchment areas. When both factors are increased, there should be enough rainwater available per household through the year. The physical execution of these tasks needs to be supported by legal regulations/guidelines concerning new standards for catchment areas and cistern capacities.

#### *Regular disinfection of drinking water trucks*

Drinking water trucks are used on the BES islands to distribute drinking water to (remote) customers. Currently there are no hygienic regulations for the distribution of drinking water with trucks on Saba and Statia. Drinking water trucks are not disinfected on a regular basis (or not at all), this might lead to quality problems of the transported drinking water (temperature, bacteria, etc.). To prevent this, the trucks, hoses, and other equipment need to comply with new hygienic regulations that can be included in the BES drinking water law.

#### *Define specific hygienic regulation for drinking water trucks*

See previous instrument.

#### *Include drinking water trucks into regular inspection program*

The trucks and related equipment also need to be included in the drinking water inspection program that will be developed for the BES islands. In this way hygienic circumstances (and compliance with regulations) can be checked.

#### *Covering/relocating distribution systems*

See same instrument at Bonaire section.

#### *Extend existing distribution network (Statia)*

Extending the new distribution network on Statia can significantly increase the number of households with a fixed drinking water connection. With the new distribution network, the number of drinking water connections will be increased to 70%. This distribution network is fully financed by the EU via SEI funds, the total budget is however limited and certain areas still remain unconnected. Extension of the distribution network to these unconnected areas could be financed by local/Dutch government to increase the connection rate to approximately 90%.

### External factors

Bonaire:

#### *Seismic activity*

The Leeward Islands (including Saba and Statia) are located in the Greater Antillean seismic belt; there are frequently reports of seismic activity on the islands<sup>187</sup>. Seismic waves, when severe, can disrupt electricity or drinking water production. Concrete and brickwork cistern systems are vulnerable to heavy shocks; in the worst-case scenario, cracks can arise in the walls that can puncture the reservoir and make the cisterns vulnerable to bacterial contamination.

#### *Population growth after BES transition*

An expansion of the current populations is expected after the transition to the status of public entity. Producers and distributors of drinking water need to anticipate on an increased consumption pattern.

#### *Meteorological conditions*

The most important aspect of this factor is the amount of sun-hours that is available for the use of solar panels. The problems arise during the hurricane season, since the skies are then

---

<sup>187</sup> KNMI, 2009

cloudier and solar panels do not function effectively. The amount of sun-hours also affects the temperature of drinking water in the distribution system.

Saba/Statia:

*Total yearly precipitation*

The yearly amount of rainfall has been quite steady on Saba and Statia and is averagely 1100 mm. Since the last three years there seem to be more and longer periods of drought, decreasing the total yearly precipitation.

*Hurricane activity*

From July till October the hurricane season is present at Saba and Statia, characterizing for this period are the torrential rain showers and thunder storms. Usually meteorological depressions pass by the islands in the form of tropical storms and typhoons.

*Seismic activity*

See Bonaire

*Meteorological conditions*

See Bonaire. For Saba and Statia only the temperature is relevant for the system.

*Population growth after BES transition*

See Bonaire.

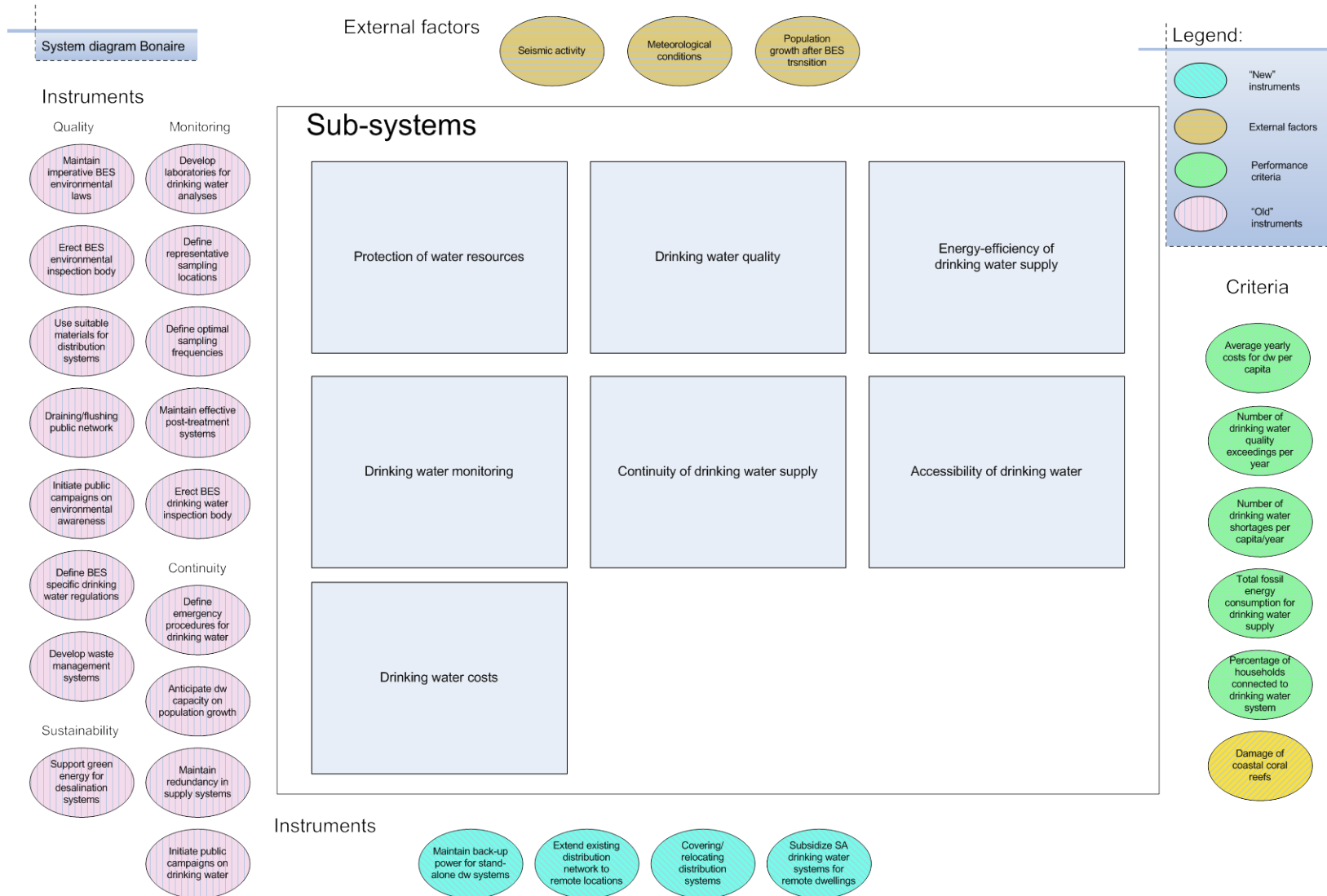
*Application of large-scale water consuming equipment*

During the last decades, also on Saba and Statia modern household equipment was introduced. Due to that, the average water consumption patterns increased, exhausting the cisterns. The existing cisterns on Saba and Statia were not designed to account for these major water consumers.

## Explanation of the System Diagrams

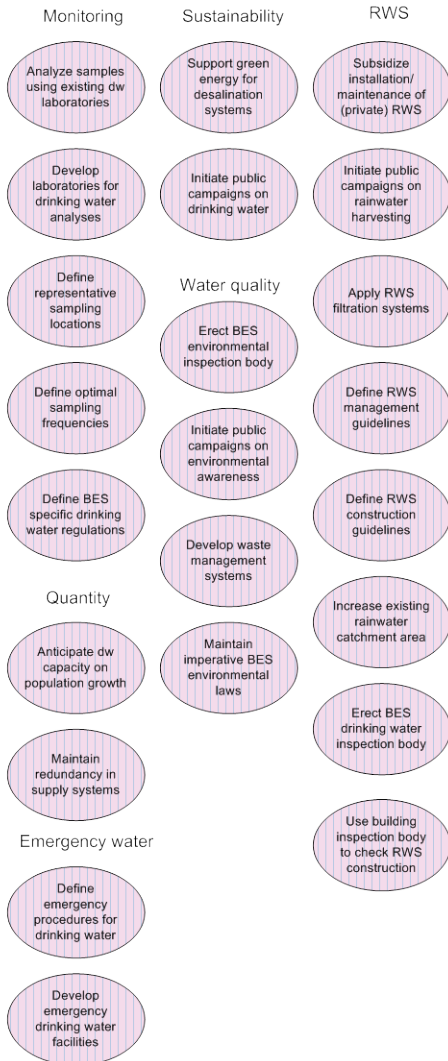
The system diagram gives an overview of the problem situation, showing the factors that are included within system boundaries of the research project. The causal relation diagram has been simplified, representing the sub-systems as black boxes. The sub-system are elaborated in more detail in appendix I. Instruments are placed on the left side of the system, the external factors are located on top and the performance criteria on the right. Additional instruments, not derived from the means-ends diagram, are placed at the bottom of the diagram.

## Appendix H System diagrams



## System diagram Saba/Statia

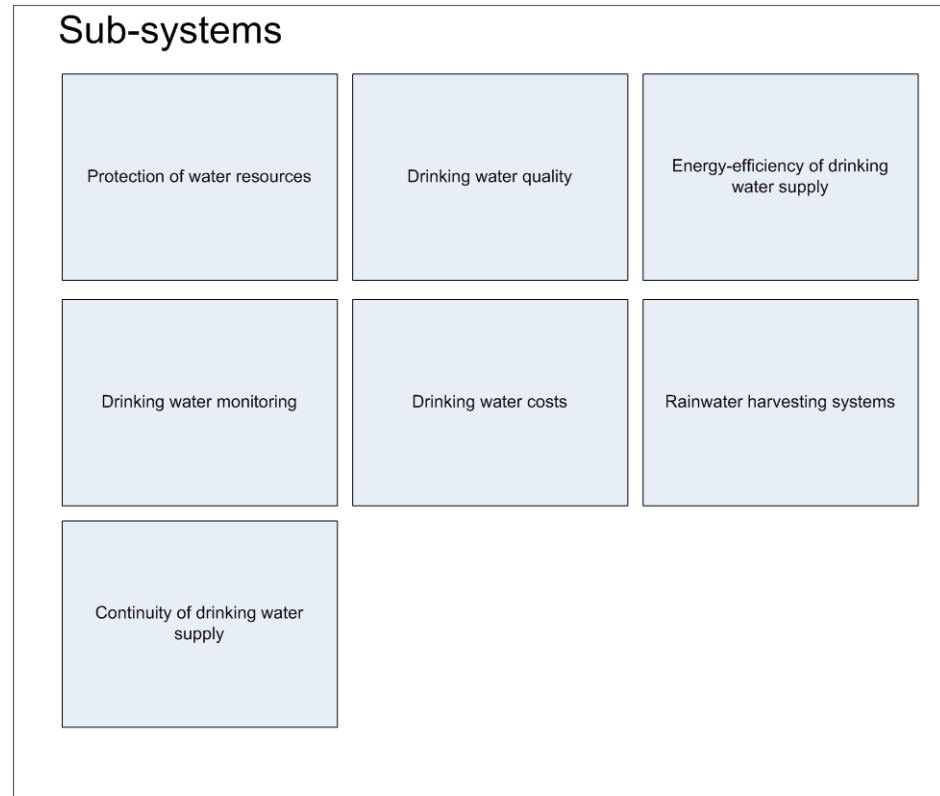
### Instruments



### External factors



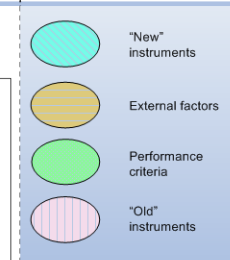
### Sub-systems



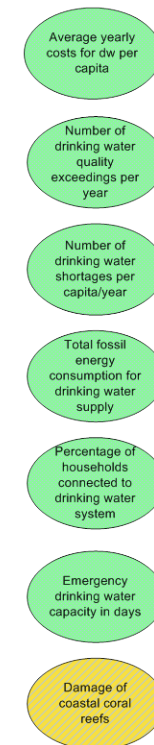
### Instruments



### Legend:

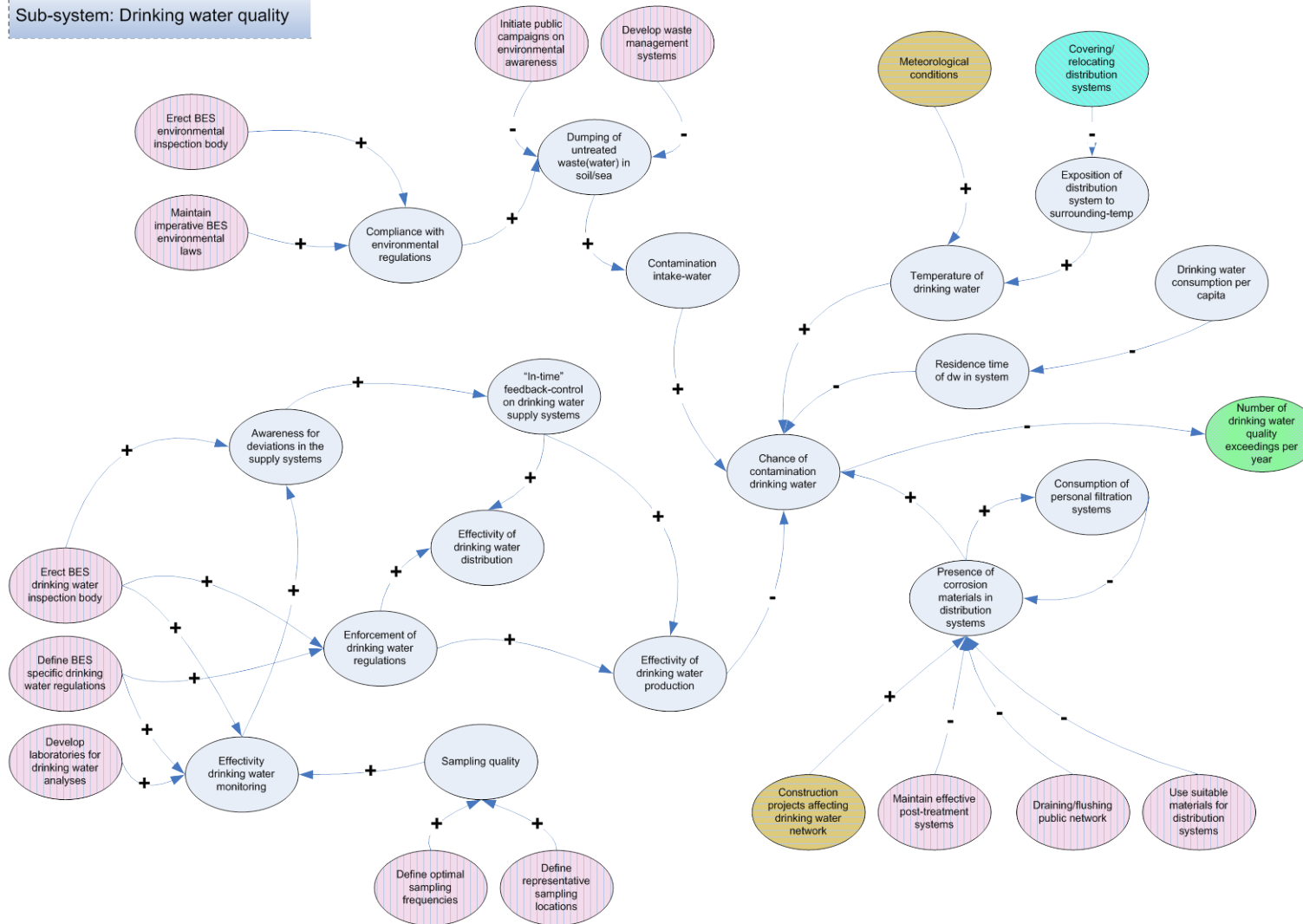


### Criteria



## Appendix I Sub-system diagrams Bonaire

Sub-system: Drinking water quality

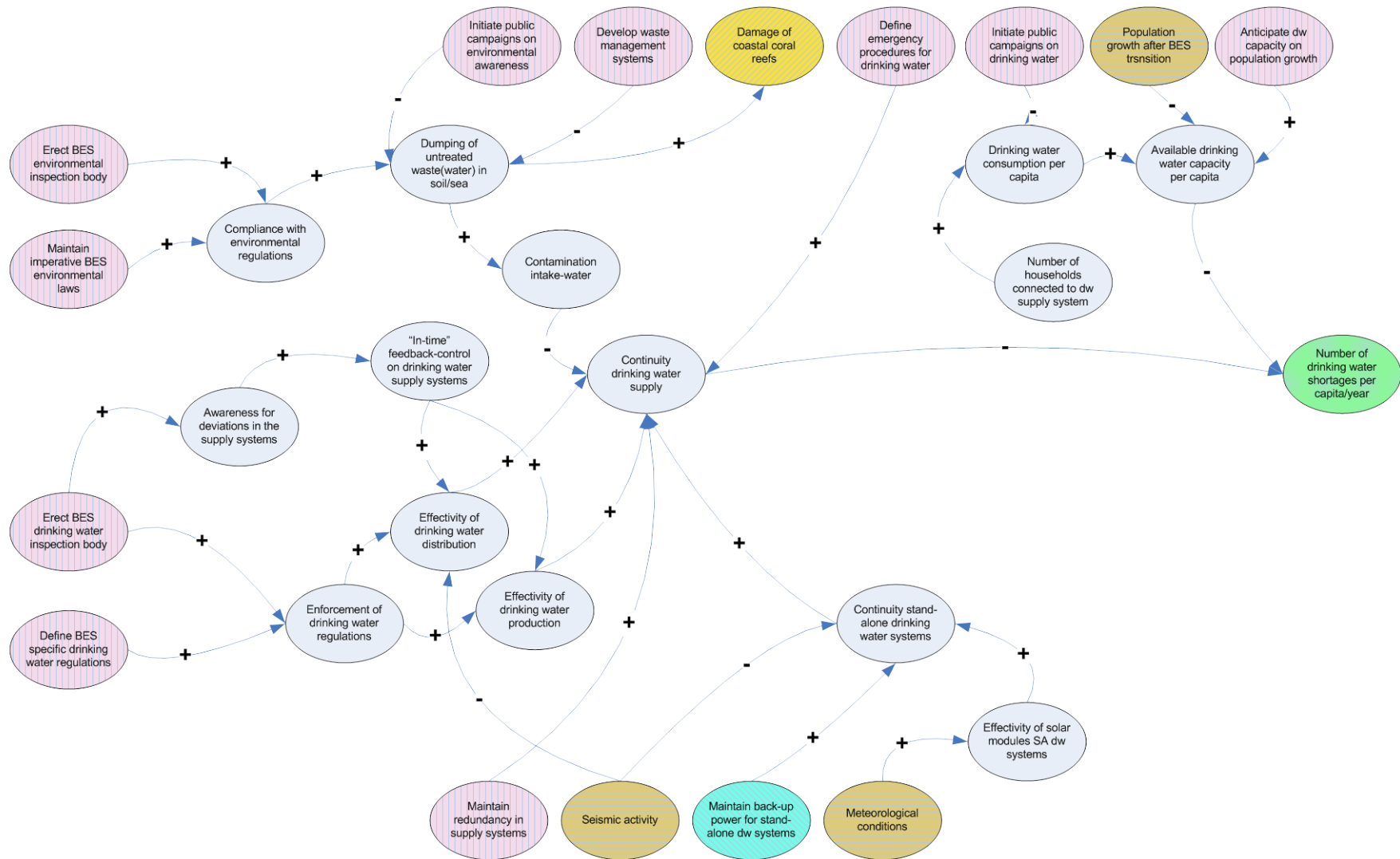


## Drinking water quality

The main factor in this sub-system is “chance of contamination drinking water” having a direct causal relation with the performance criterion “Number of drinking water quality exceedings per year”. The main factor is surrounded with sub-systems that affect the quality of drinking water, increasing or decreasing the contamination risk. The following factors affect the chance of drinking water contamination:

- *Presence of corrosion materials in distribution systems*  
If corrosion in the distribution system is not prevented, oxidized metal particles appear in the distribution system. These particles contaminate the water and give the water a brownish color. Inhabitants of Bonaire have bought filtration systems to prevent these particles from flowing out of the tap. These systems are quite expensive and have to be maintained on a regular basis, this increases the average yearly drinking water price.
- *Residence time of drinking water in system*  
The quality of stagnant water in distribution systems in a high-temperature environment will deteriorate significantly. This can be prevented by continuous consumption patterns. When people have a cistern *and* a public drinking water connection, there is a risk that people will only use free cistern water until the tank runs dry. The result is twofold, the public drinking water connection will not be feasible for the provider and there will be stagnant water segments in the system. Connection and minimum consumption quantities should prevent this from happening.
- *Temperature drinking water*  
Temperature is a determinant factor for the quality of drinking water. High temperatures can stimulate the growth of unwanted bacteria leading to contamination of drinking water.
- *Contamination-intake water*  
Intake water (from the ocean) is used as input for the desalination process of drinking water, contamination of intake water can have effects on the quality of drinking water. Depending on how severe the intake water is polluted, the desalinated water needs to undergo a second or third RO process to filter out all contaminants. More information on this factor can be found at sub-system “Protection of water resources”.
- *Effectivity of drinking water production*  
This factor is related to the production process of drinking water. Drinking water production processes and procedures need to comply with the prevailing drinking water regulations. Equipment needs to be maintained properly by certified mechanics, filters need to be changed in time, etc. etc. The drinking water regulation and inspection system is very much related to this factor. The presence of a drinking water inspection authority can stimulate the enforcement of drinking water laws and regulations. Next to that, the inspection body can give feedback to drinking water producers, increasing the effectivity of the overall process. More information on drinking water monitoring can be found in the sub-system “Drinking water monitoring”.

## Sub-system: Continuity of drinking water supply



## Continuity of drinking water supply

The main factor in this sub-system is “continuity of drinking water supply”, directly related to the performance criterion “number of drinking water shortages per capita per year”.

- *Contamination of intake-water*

When intake-water is too polluted, the continuity of the drinking water production process can be jeopardized. Filters can get clogged more frequently, the existing desalination process cannot meet the required performance criteria, etc.

- *Define emergency procedures for drinking water*

When proper procedures are in place, the provision of emergency drinking water can prevent disruption in the supply system.

- *Available drinking water capacity per capita*

The available drinking water capacity per capita is directly related to the main performance criterion; water shortages can arise either due to continuity problems or capacity problems. The capacity of desalinated drinking water per capita depends on the total capacity of the water plant, population growth and the consumption pattern of the population.

- *Continuity stand-alone drinking water systems*

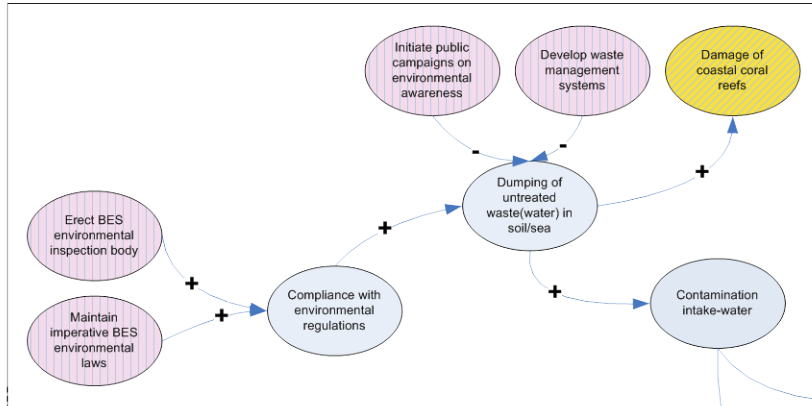
Remote locations often have personal water supply systems, these systems are part of the overall drinking water system on the island. The continuity of these systems depends on the meteorological conditions; they are all equipped with solar power units.

- *Effectivity of drinking water production/distribution*

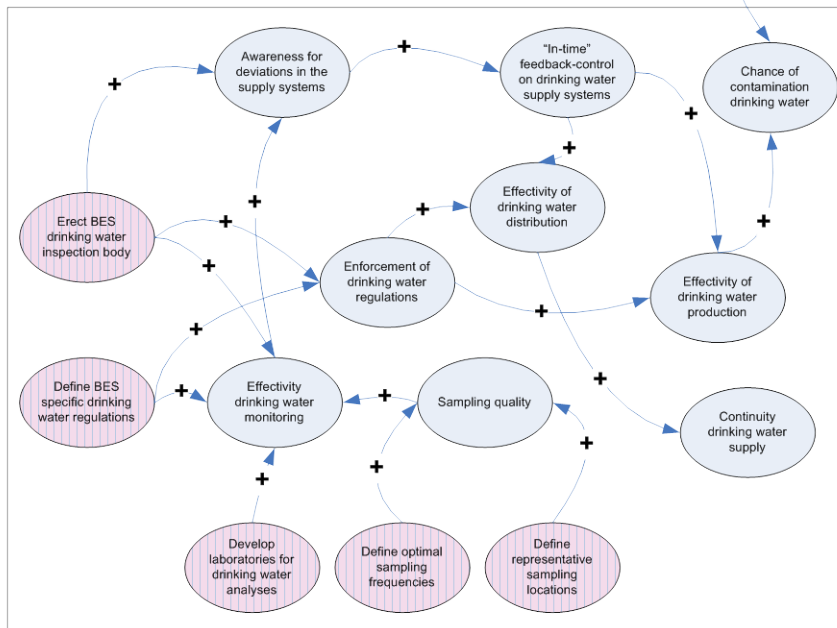
This factor is related to the drinking water monitoring sub-system. When the drinking water regulations are properly enforced, the effectiveness of both the drinking water production and distribution are safeguarded.



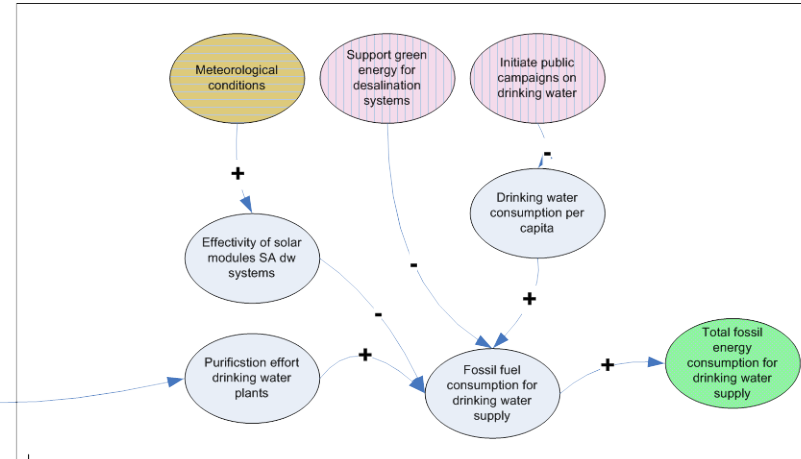
### Sub-system: Protection of water resources



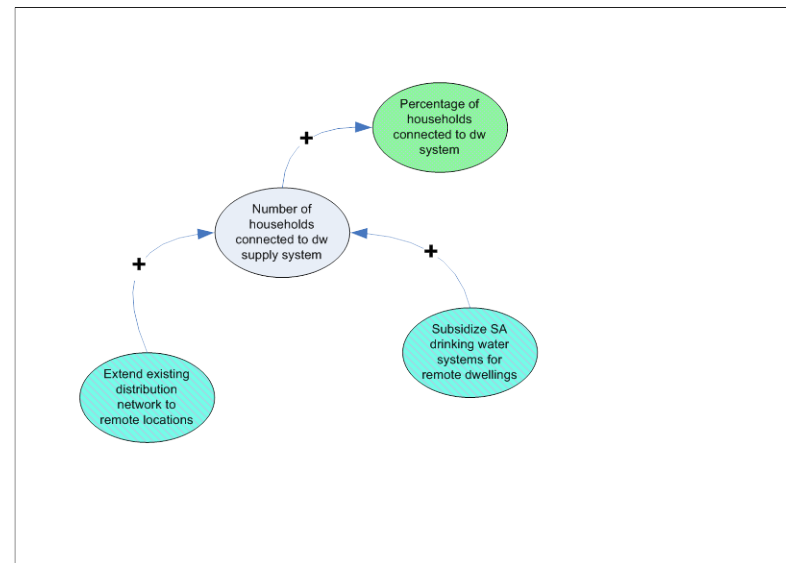
### Sub-system: Drinking water monitoring



### Sub-system: Energy efficiency of drinking water supply



### Sub-system: Accessibility of drinking water



## Protection of water resources

Water resources on the BES islands are mainly polluted by solid and liquid waste. Since there are no waste management systems available on the islands, all types of waste are dumped or burned in open air. Chemicals, bacteria and other unwanted substances can freely enter the subsoil and ocean contaminating the waters. Dust particles from waste incineration scatter around on the island and are eventually ending up in rainwater cisterns.

To prevent dumping of waste(-water), environmental measures must be taken in the form of waste-regulations, waste management systems and creation environmental awareness among the public. In order to stimulate and enforce a correct disposal of waste, an environmental inspection body should supervise the activities.

## Energy-efficiency of drinking water supply

The total fossil energy consumption is very much related to the production of desalinated drinking water. Stimulation of alternative energy sources (solar power for stand-alone systems, biodiesel energy plants, wind power) will diminish fossil energy use.

## Drinking water monitoring

### *Enforcement of drinking water regulations*

Part of the drinking water inspection and regulation system is to check drinking water suppliers on compliance with the prevailing regulations. The factor refers to 'stimulating' enforcement of drinking water regulations by creating laws that fit local BES circumstance (and makes them more manageable) and by introducing an inspection body for drinking water.

### *Effectivity drinking water monitoring*

Monitoring of drinking water is crucial to safeguard public health, the effectivity of the monitoring system depends, among others, on the quality of taking drinking water samples and the presence of a drinking water inspection body.

### *In-time feedback control on drinking water supply systems*

The presence of a drinking water inspection body and by monitoring the quality of drinking water, raises the awareness on deviations in the supply chain. By being aware of complications in the system, feedback can be given to the responsible actors to adjust, repair or shutdown their systems. This results in more dynamic feedback, improving the effectivity of both the drinking water production and distribution systems.

## Accessibility of drinking water

The number of households that is directly connected to a drinking water distribution system increases by either extending the existing distribution network to remote locations or by installing stand-alone water units.

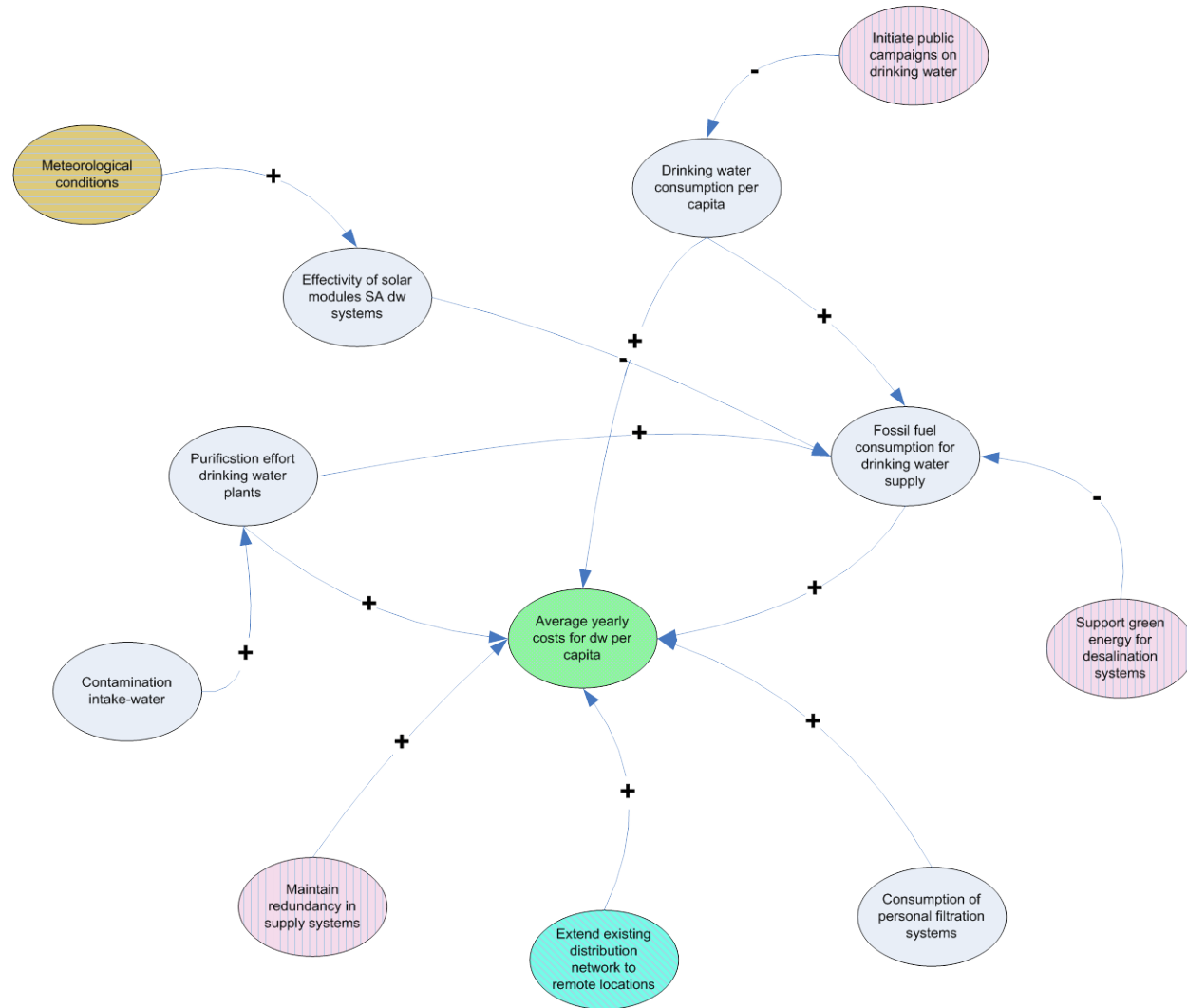
## Drinking water costs

The average yearly costs for drinking water are influenced by several factors, the most important being the "total consumption of desalinated water per capita". Desalinated water per cubic meter is relatively expensive, because the purification processes are energy-intensive using high-tech equipment. Applying redundant systems within the supply system, safeguarding continuity, will increase the price per cubic meter of drinking water even more.

For the production of desalinated water fossil fuels are consumed. Prices for crude oil are still unstable and tend to increase gradually over time; the price for one cubic meter of water is expected to rise as well.

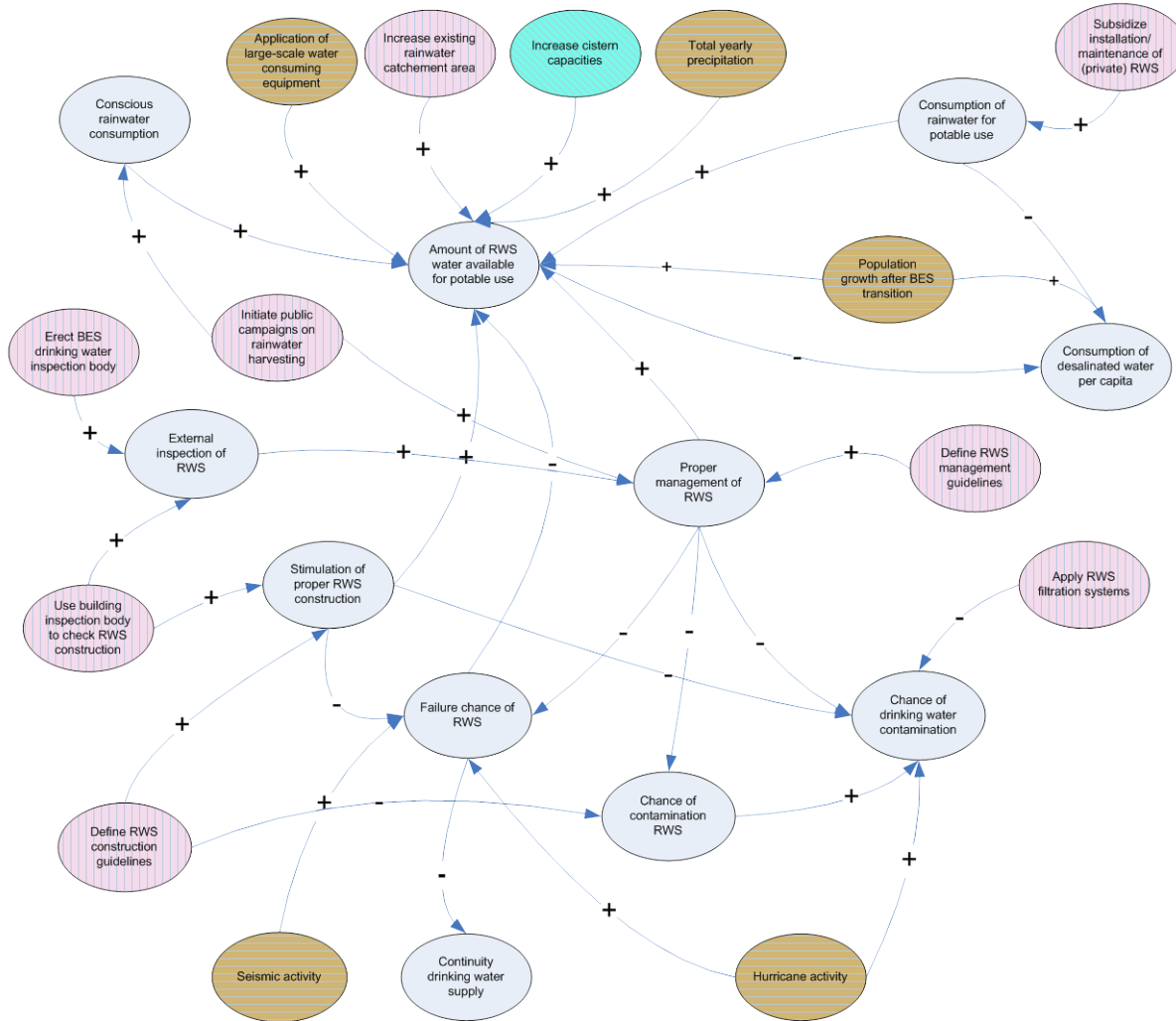
The quality of intake water is important for the intensity with which seawater has to be purified. The more polluted the intake water is, the more treatment steps it takes to produce drinking water meeting all quality requirements. This will lead to more expensive treatment steps and more energy consumption, leading to a higher average price per cubic meter.

Sub-system: Drinking water costs



## Appendix J Sub-system diagrams Saba/Statia

### Sub-system: Rainwater harvesting



## Rainwater harvesting

This sub-system is specific for Saba and Statia; since the majority of the inhabitants use rainwater system, the total consumption of desalinated and bottled water is significantly less than on Bonaire. By *stimulating the use of RWS* (providing grants, loans or subsidies) the *consumption of desalinated* water and fossil fuels can be reduced. The *potential population growth* on the BES after the transition can result in the construction of more rainwater systems or an increased consumption of desalinated water.

Rainwater harvesting is a personal issue, currently there are no laws regulating the use of these systems. The result is that everybody builds, maintains and uses rainwater systems in their own way. Proper management of RWS prevents contamination of rainwater and safeguards the failure chance of the system as a whole. Inhabitants tend to clean their gutters and pipes using chlorinated water, other people have cisterns built next to cesspits; these are examples of dangerous situations that might affect the overall quality of rainwater. By *initiating public campaigns on rainwater harvesting*, proper maintenance and management of RWS can be stimulated. This might eventually result in more conscious rainwater use, decreasing failure rates and smaller chance of rainwater contamination.

Other ways to enforce and stimulate proper management and construction of RWS is to develop specific regulations and building codes for the use of RWS. By erecting a drinking water inspection body, rainwater-harvesting systems, including the water itself, can be inspected for compliance with local regulations.

## Drinking water monitoring and inspection

See identical sub-system for Bonaire.

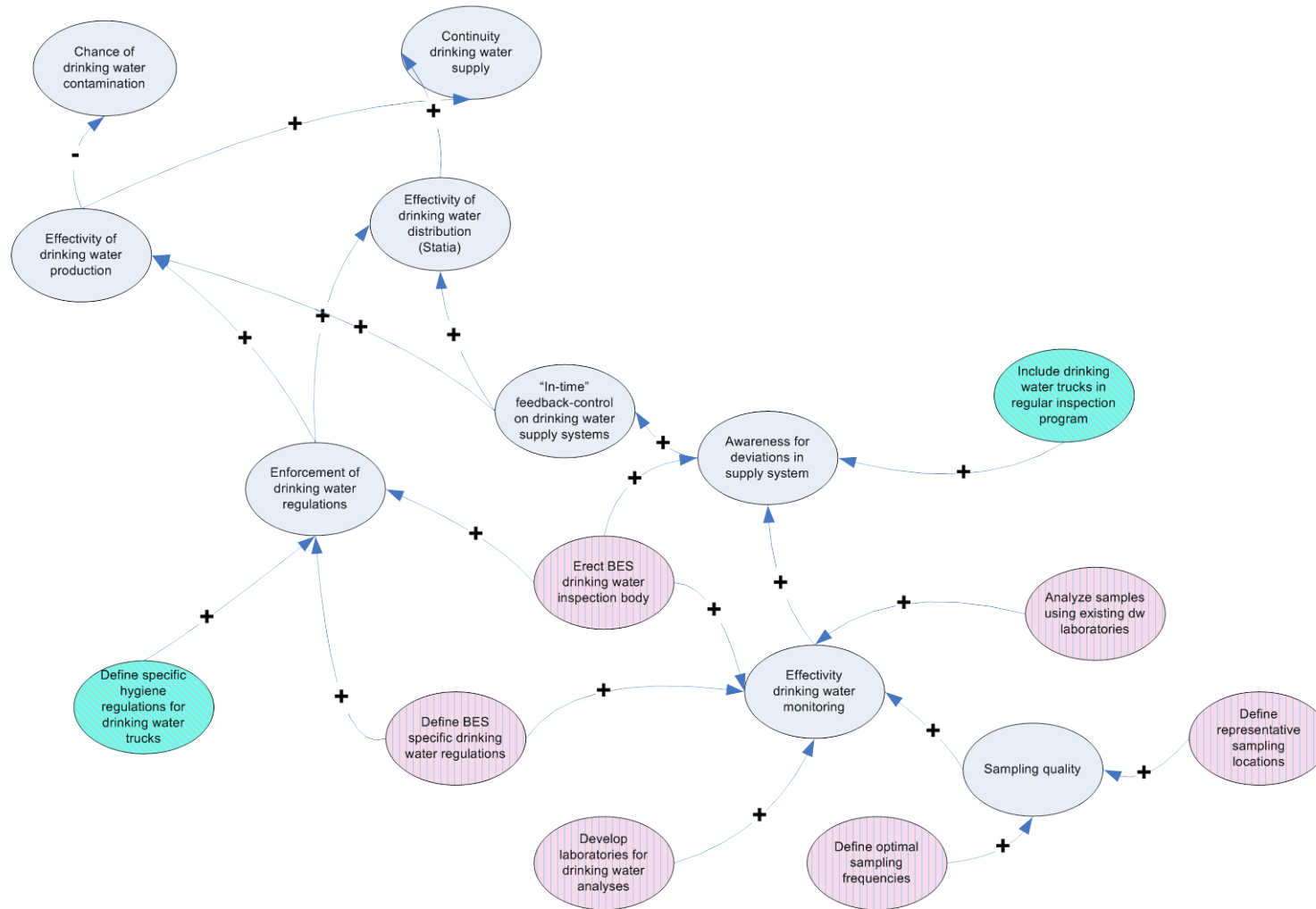
Some minor differences between Saba and Statia relate to the inspection and regulation regarding drinking water trucks.

## Drinking water quality

This sub-system is a combination of two other subsystems: "Drinking water monitoring and inspection" and "Rainwater harvesting". The main factor in this sub-system "Contamination of drinking water" describes the chance that drinking water can be polluted by other factors. An effective drinking water monitoring system can decrease the chance on contaminated drinking water. The other sub-system "Rainwater harvesting" also affects the overall quality of drinking water; potable rainwater is also considered to be drinking water. When RWS are managed, constructed and inspected properly, the chance that cistern-water is contaminated remains small.

Temperature is another factor that can affect the quality of drinking water, see Bonaire: "Drinking water quality".

## Sub-system: Drinking water monitoring/inspection

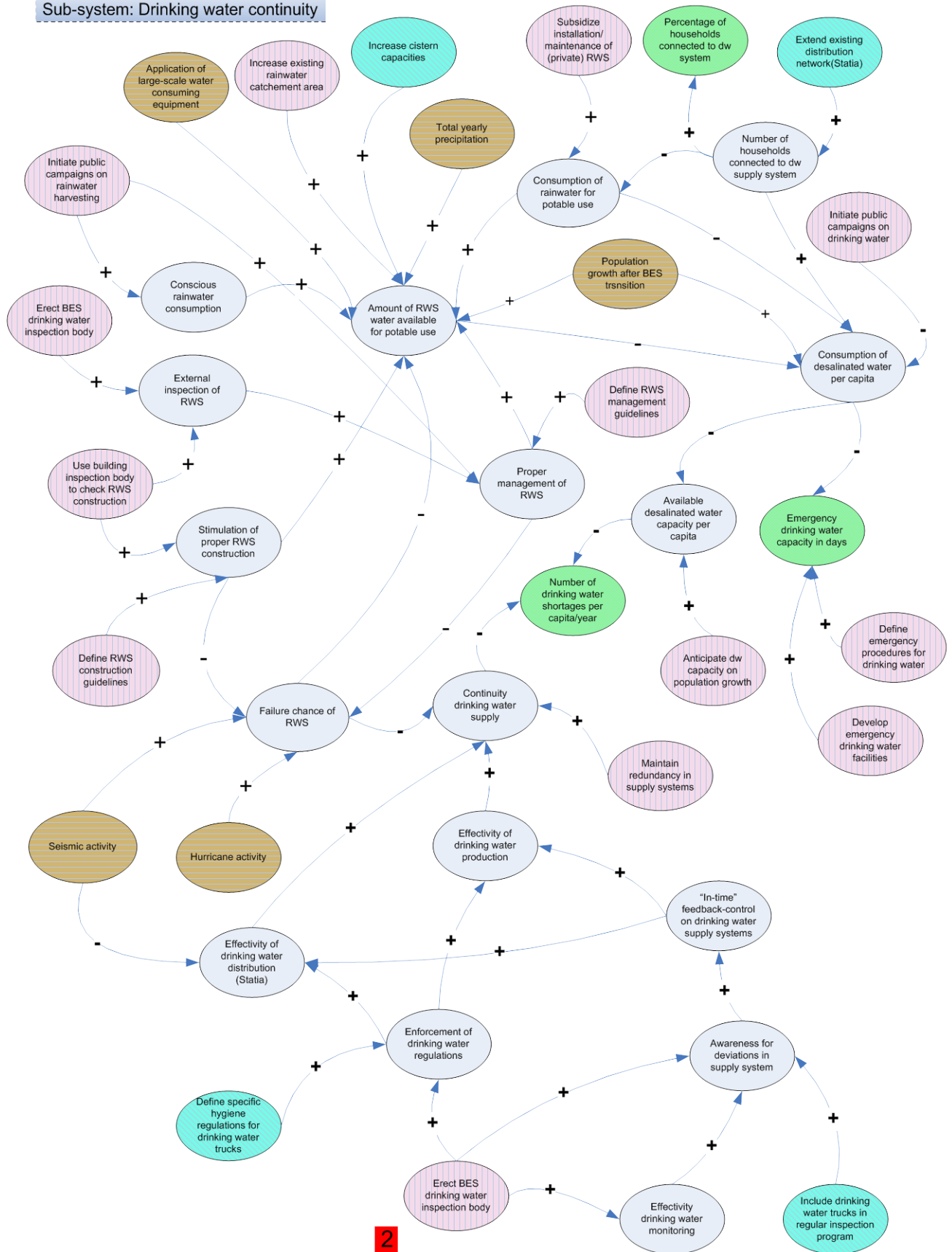


Sub-system: Drinking water quality





## Sub-system: Drinking water continuity



## Drinking water continuity

The main factor in this sub-system is “continuity of drinking water supply”, directly related to the performance criterion “number of drinking water shortages per capita per year”. Another performance criterion in this system is “Emergency drinking water capacity”, regarding the amount of drinking water that is available for consumption during natural disasters.

The system itself is almost similar to the sub-system “Continuity of drinking water” at Bonaire. The main difference between the two systems is related to the use of rainwater. When more rainwater is available for potable use, less desalinated drinking will be consumed, leading to more sustainable systems and lower yearly costs for drinking water. The failure chance of rainwater systems is related to the continuity of the supply system. Every rainwater system is part of the total supply system; a disruption of the individual system can lead to water shortages.

- *Available amount of rainwater for potable use*

The amount of rainwater that is netto available for potable use depends on the dimensions of the RWS itself, the average yearly rainfall on the island, and the failure chance of the system, consumption patterns and the overall management of the system.

- *Contamination of intake-water*

When intake-water is too polluted, the continuity of the drinking water production process can be jeopardized. Filters can get clogged more frequently, the existing desalination process cannot meet the required performance criteria, etc.

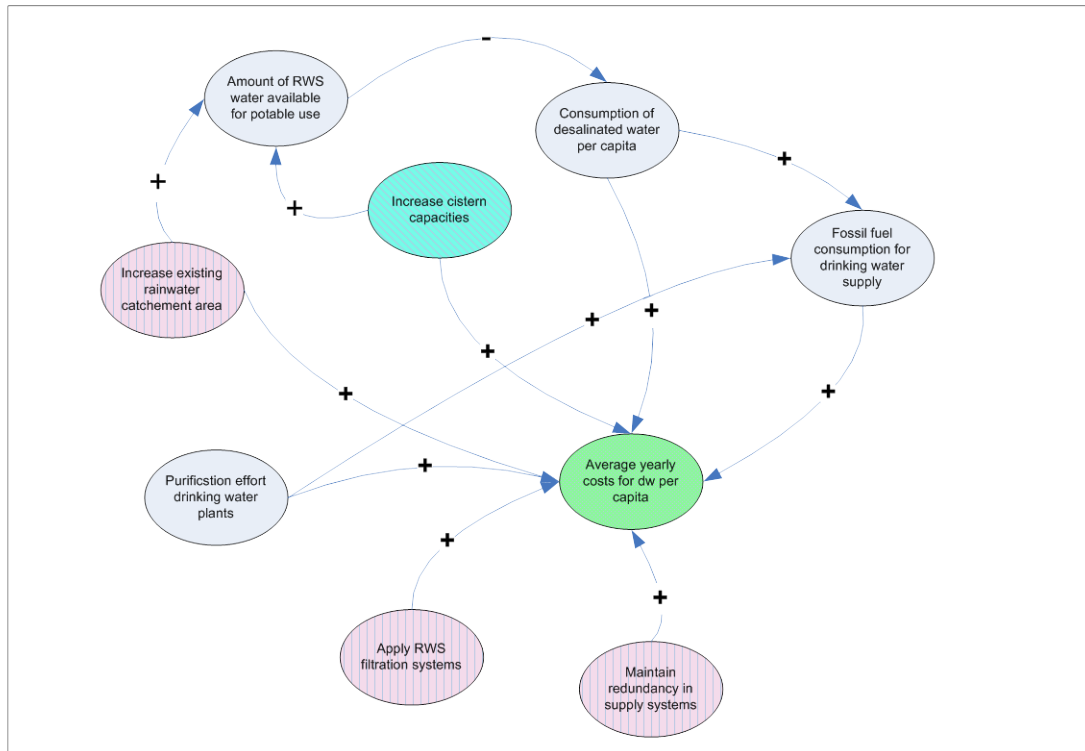
- *Available desalinated water capacity per capita*

The available drinking water capacity per capita is directly related to the main performance criterion; water shortages can arise either due to continuity problems or capacity problems. The capacity of desalinated drinking water per capita depends on the total capacity of the water plant, population growth and the consumption pattern of the population.

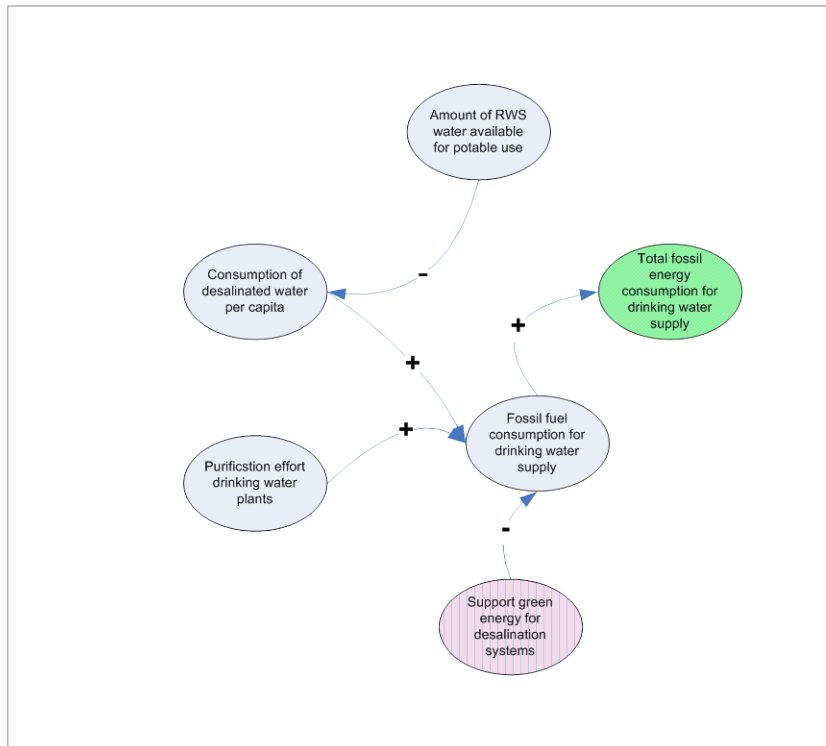
- *Effectivity of drinking water production/distribution*

This factor is related to the drinking water monitoring sub-system. When the drinking water regulations are properly enforced, the effectiveness of both the drinking water production and distribution are safeguarded.

### Sub-system: Drinking water costs



### Sub-system: Energy-efficiency



## Drinking water costs

The average yearly costs for drinking water are influenced by several factors, the most important being the “total consumption of desalinated water per capita”. Desalinated water per cubic meter is relatively expensive, because the purification processes are energy-intensive using expensive high-tech equipment. Applying redundant systems within the supply system, safeguarding continuity, will increase the price per cubic meter of drinking water even more.

The amount of consumed desalinated water depends on whether inhabitants have other sources of drinking water available. When inhabitants can use rainwater for potable purposes, the total consumption of desalinated (and bottled) water will decrease.

The amount of available rainwater per capita depends on the capacity of both cisterns and catchment surfaces. Expansion of these systems will lead to high investments per capita, increasing the personal yearly costs for drinking water. The same goes for the application of rainwater filtration systems to purify the harvested water.

For the production of desalinated water fossil fuels are consumed. Prices for crude oil are still unstable and tend to increase gradually over time; the price for one cubic meter of water is expected to rise as well.

The quality of intake water is important for the intensity with which seawater has to be purified. The more polluted the intake water is, the more treatment steps it takes to produce drinking water meeting all quality requirements. This will lead to more expensive treatment steps and more energy consumption, leading to a higher average price per cubic meter.

## Energy efficiency

The total fossil energy consumption is very much related to the production of desalinated drinking water. Stimulation of alternative energy sources (solar power for stand-alone systems, biodiesel energy plants, wind power) will diminish fossil energy use.

## Appendix L      Interview questions field visit US Virgin Islands

Field visit US Virgin Islands      March 22<sup>nd</sup> – 29<sup>th</sup> 2010

### **System analysis of Saint Thomas/Saint Croix drinking water supply system**

Interview questions:

**Actor: Virgin Islands Water and Power Authority**

Topic: Drinking water supply, introduction public network, not-connected areas, emergency water provision

Current situation:

- 1      Name, function of respondent
- 2      Who are the main actors in the drinking water supply system of the USVI?
- 3      In what ways is VIWAPA involved in the drinking water supply system of the USVI?
- 4      What are the goals/performance indicators that VIWAPA maintain with regard to the production and distribution of drinking water?
- 5      What are the activities that VIWAPA undertake to meet these goals/criteria?
- 6      What are the main methods of drinking water production/distribution on the USVI?
- 7      Does VIWAPA currently experience difficulties/problems related to the current drinking water supply system?
- 8      Are there any suggestions to mitigate/solve these problems; are other actors involved in these solutions?
- 9      What are the different laws/acts or regulations for drinking water that VIWAPA has to comply with?
- 10     Any other remarks on the previous questions/topics?

Introduction public distribution:

- 1      When were the existing public drinking water networks installed on the USVI?
- 2      How were the inhabitants of the USVI by that time involved in the connection process?
- 3      What kind of arrangements/regulations were maintained with regard to the implementation of a public distribution system; What is the role of the rainwater system in this transition?
- 4      Did VIWAPA experience complications during the implementation of the public drinking water network?
- 5      What could VIWAPA or other actors have done to avoid or mitigate these complications?
- 6      Are rainwater systems used by VIWAPA customers that are now connected to the public drinking water distribution system?
- 7      How are public drinking water systems and private rainwater systems combined in 'normal' households?
- 8      Does the combination of two separate systems in one household lead to difficulties?
- 9      Any other remarks on the previous questions/topics?

Remote areas (non-connected households):

- 1      What is the current percentage of households that is connected to the public drinking water distribution system?
- 2      What is the reason that not all households are connected to the main distribution network?

- 3 How are these households that are not connected to the main distribution network provided with drinking water?
- 4 What kind of arrangements/regulations applies for these households with regard to the consumption and supply of drinking water?
- 5 Do these households depend more on rainwater or on desalinated water?
- 6 Are there any problems/complications with regard to these remote households?
- 7 Any remarks/comments on the previous questions?

#### Internal drinking water monitoring:

- 1 How is the quality of drinking water inspected on the USVI? What actors are involved in the related processes?
- 2 What regulations/procedures are followed for these processes?
- 3 Does VIWAPA maintain quality control systems?
- 4 If so, what are the procedures involved?
- 5 Are there any suggestions to improve these processes?

#### Emergency procedures:

- 1 What kinds of emergency procedures exist for the supply of drinking water during natural disasters; What other actors are involved with these procedures?
- 2 Do you have suggestions to improve these emergency procedures?

#### **Actor: DPNR (Department of Planning and Natural Resources)**

Topics: Legislation, enforcement, inspection

#### Current activities:

- 1 Name, function of respondent
- 2 In what ways is the DPNR involved in the supply of drinking water on the USVI?
- 3 What are the goals/objectives of the DPNR with regard to drinking water supply on the USVI?
- 4 What kind of activities does the DPNR undertake to meet these objectives/goals?
- 5 What kind of legal framework is used for the execution of the DPNR duties?
- 6 Are there any other stakeholders involved in the duties/operations of the DPNR?
- 7 Did the DPNR experience any complications in meeting their objectives/goals?
- 8 Do you have any suggestions to solve these complications; Are other actors involved with these solutions?
- 9 Any other comments on the previous questions?

#### Use of rainwater harvesting

- 1 Are public or private rainwater harvesting systems subjected to any kind of monitoring or inspection program of the DPNR?; What other actors are involved in these programs?
- 2 Are rainwater systems subjected to any kind of law/regulation; Are these regulations enforced by the DPNR; What other actors are involved in the enforcement processes?
- 3 Does the DPNR currently experience any problems/complications with regard to the use of public/private rainwater systems?
- 4 How can these problems be mitigated? Are other actors involved with these solutions?

## Appendix M Source site lesson drawing

### Source site A: Saint Barthelemy/Saint Martin

#### Drinking water supply

The people on Saint Barth and St Martin mainly depend on rainwater collection. More than 70% of the households have integrated rainwater cisterns. Some of the households treat rainwater before consumption; this is usually done by filtrating or boiling the water. The majority of the population drinks water straight from the cistern.

Saint Martin and Saint Barthelemy have public water distribution networks that cover approximately 70% of the households on both islands. Drinking water is produced using reverse osmosis and seawater distillation techniques. The households that are not connected to the public water network can order 'truck' water from private distributors.

Households that are within the vicinity of the public drinking water network can voluntarily connect themselves for a fixed rate per month. To ensure a certain water consumption pattern, the public distribution company includes 10 free cubic meters of drinking water within the fixed monthly fee of 30 Euros, every extra cubic meter costs 5,5 Euro<sup>188</sup>.

#### Drinking water legislation

The legal framework for water supply and sanitation consists mainly of two main laws: The Loi sur l'Eau (Water law) of January 3, 1992 and the Loi sur l'eau et les milieux aquatiques (Water and Aquatic Environment Law) of December 30, 2006. The latter transposes the EU Water Framework Directive into French law. Drinking water quality standards are defined by the European Union through the Drinking Water Directive<sup>189</sup>. The French drinking water legislation applies for the Republic, the Départements d'Outremer, Territoires d'Outremer and the Collectivités. Because of deviating circumstances on the overseas territories, specific exceptions or additions might be added.

#### Actor network

Water supply, sewerage and wastewater treatment is a municipal responsibility in France. In the case of Saint Martin and Saint Barths, the island governments are responsible for drinking water supply. The local governments have contracted out the water supply to the private sector through long-term contracts (affermages). The following actors are involved in the drinking water supply system (see Figure 52):

##### *UCDEM*

The 'Union Caraïbe de Desallement d'Eau de Mer' (UCDEM) is a private party that produces drinking water on both Saint Barths and Saint Martin on behalf of the Collectivités. The production plants that are operated by UCDEM are property of the island territories<sup>190</sup>. The total production capacity on Saint Barths varies between 2000-3000m<sup>3</sup>/day, on Saint Martin the total production rate is 9000m<sup>3</sup>/day.

##### *Le Generale des Eaux*

The 'Generale des Eaux' is the public authority responsible for the distribution of drinking water on both Saint Martin and Saint Barthelemy. The distribution networks are property of the island territories.

---

<sup>188</sup> Frank Greaux, interview #15

<sup>189</sup> EU Drinking Water Directive, Council Directive 98/83/EC

<sup>190</sup> Glenn Richardson, interview #14

#### *Private water distributors*

There are a few private distribution companies on both islands that deliver drinking water using water trucks. These distributors perform their duties on behalf of the island territories and are inspected by the DSDS.

#### *Direction de la Sante en du Développement Social de la Guadeloupe (DSDS)*

There is no national regulatory authority regarding the production and distribution of drinking water in France. There are also no regulatory agencies at the level of Regions and Departments. Municipalities themselves are responsible for regulatory duties regarding drinking water. For overseas territories, the Collectivitees have the same obligations as municipalities and are jointly responsible for the erection of a regulatory agency<sup>191</sup>. For Guadeloupe, Saint Martin and Saint Barth the DSDS is responsible for specific sanitary inspections. The DSDS is part of the French “Ministere de la Sante et Sports”.

#### *L’Institute Pasteur*

The Pasteur institute is a governmental inspection laboratory in Guadeloupe. Drinking water samples from all French Collectivitees in the Eastern Caribbean are sent to this laboratory for inspection. The water samples are checked for conformity with French drinking water quality regulations as stated in article D1321-104 du Code de la Sante Publique<sup>192</sup>.

#### *Ouanalao Environnement SA (OESA)*

‘OESA’ is a private company that operates a solid waste incinerator plant on Saint Barths on behalf of the island government. This waste incinerator plant commercially provides steam to the seawater desalination plant of UCDEM. This is an advanced form of cogeneration that can serve as a good example of sustainable drinking water production.

#### *Island Governments*

The island governments are responsible for the drinking water supply system and drinking water regulation on their islands. The drinking water production has been outsourced to private companies, the distribution of drinking water is in public hands. Drinking water quality regulation is outsourced to the DSDS, a public entity. The island government itself is responsible for the economic regulation of private service provision. The Collectivitees themselves approve tariffs and control service standards for both drinking water and wastewater services.

### **Drinking water regulation and inspection**

The French drinking water regulations are incorporated in the French Water Law, this law applies to the Republic and all DOM/TOM and Collectivités. All water systems that provide water to third parties, not being the producer, are considered public and are therefore subjected to the French drinking water regulations. All materials that are used for the production and distribution of drinking water in public water systems have to comply with “Le Decret no 89-3” of the French Health Law<sup>193</sup>.

Since the French Republic doesn’t have a national drinking water regulatory authority, inspection duties are arranged on a municipal level. Smaller municipalities frequently cooperate to organize a joint drinking water inspection service. On the French Collectivités of Saint Martin and Saint Barths, the DSDS is the drinking water regulator. Besides this regulatory function, the DSDS also performs other environmental inspection duties:

- Sewer systems/private septic tank inspection

---

<sup>191</sup> Website Ministere de la Sante, et des Sports, visited March 4th 2010

<sup>192</sup> Glenn Richardson, interview #14

<sup>193</sup> Code de la Sante Publique, 1989



- Environmental inspections
- Mosquito inspections
- Cistern inspections

The DSDS is authorized to give instructions to inhabitants of the Collectivités regarding the management of private sanitation equipment (cesspits, septic tanks, cisterns, overall environmental status of yards). When necessary, the DSDS is authorized to disinfect elements of sanitary systems with chemicals. The costs of these particular disinfection treatments are charged to the polluters.

All public water systems on Saint Barth and Saint Martin are listed by the DSDS. Every new public system has to be enrolled within the drinking water inspection program of the DSDS. Once a public water system has been introduced, water samples are taken by the DSDS to test on a variety of chemical and bacterial indicators. When analyses show that none of the samples contain harmful elements, the frequency of sampling for specific indicators will decrease.

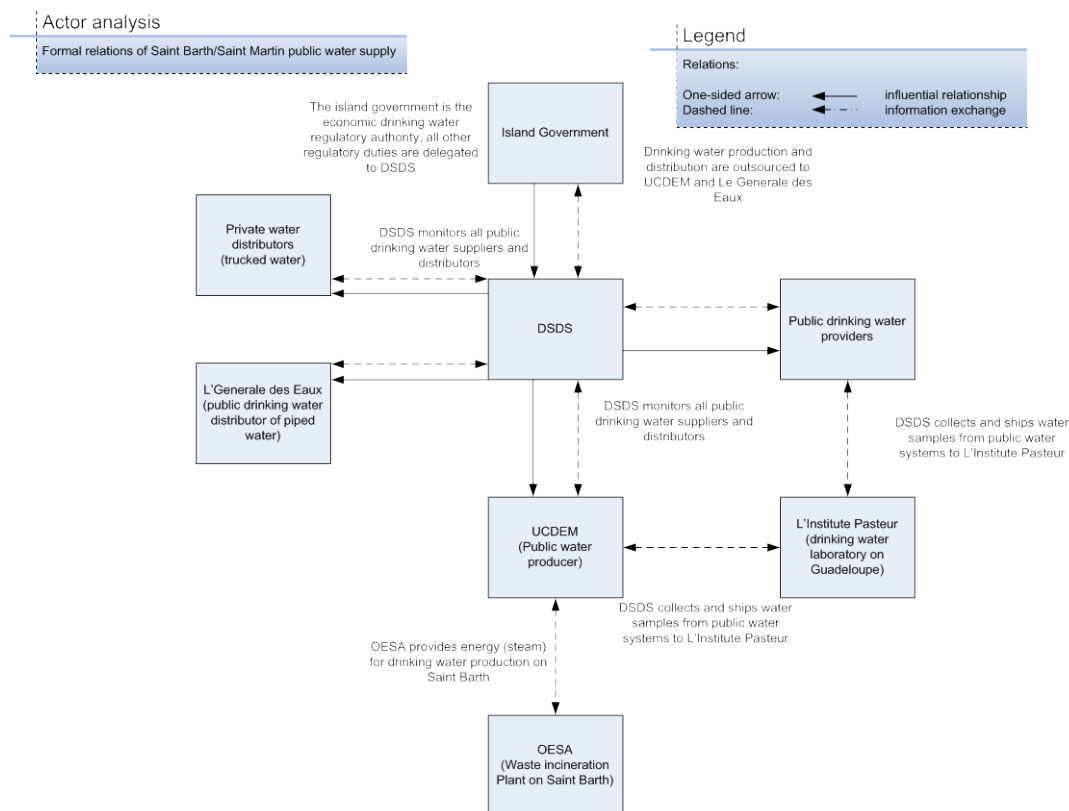


Figure 57 Drinking water organization Saint Martin/Saint Barth

The DSDS takes water samples from:

- Seawater intake points of desalination plants (1/2 times per month)
- Produced drinking water at the plants (1/2 times per month)
- Random locations within distribution networks (1/2 times per month)

Water samples that are gathered by the DSDS are shipped to Guadeloupe where they are analyzed by a governmental inspection laboratory (L'Institute Pasteur). The reason for sending these samples to Guadeloupe is that the Pasteur institute is the main laboratory specialized in water analyses for the overseas Collectivitees. Developing similar laboratories on Saint Martin or Saint Barth would be infeasible considering the scale of the islands and number of water samples.

The sampling frequency changes dynamically over time, based on the presence of unwanted substances in the water. When certain systems show traces of unwanted substances, the frequency of water sampling will be increased. This frequency reduces when the specific quality threat is not indicated anymore. The DSDS charges the costs of taking and shipping drinking water samples directly to the public water producers.

Drinking water samples are taken, packed and shipped in compliance with article D1321-104 du Code de la Sante Publique. In case of negative results, L'Institut Pasteur is able to respond within 12 hours after taking water samples<sup>194</sup>. The Institute charges the costs of analyzing water samples directly to the public water producers.

## Lessons

### *Water quality inspection*

The local drinking water regulatory authority on the French Antilles, the DSDS, is the only authority that is allowed to collect water samples from public water systems for external quality control. On the BES islands, it is highly likely that public drinking suppliers themselves will be responsible for water quality sampling.

In terms of drinking water quality analysis, the French Antilles maintain an interesting system that is based on cooperation with a general French water laboratory on the larger island of Guadeloupe. Water samples are sent to L'Institut Pasteur, located 200 kilometers from the Collectivités. The results of drinking water analyses are sent by fax to the individual water suppliers on Saint Martin and Saint Barth.

Compared to the situation on Bonaire, the French Antilles provide a good example that cooperation with water laboratories on other islands can be both feasible and efficient. Whereas on Bonaire, the average analysis time is 5-7 days, on The French Antilles this is 12 hours.

This is an important lesson for the BES islands; cooperation with other islands regarding drinking water quality analyses can be an economical and efficient option, solid arrangements and contracts with these islands are however crucial.

Another important lesson that can be drawn from the French Antilles concerns the locations from where samples are taken. On Bonaire, water samples are only taken at the production and at some locations within the distribution network. On the French Antilles, samples are not only taken at the public supply systems but also at the seawater intake locations. Apart from some internal water quality inspections by the public water suppliers, these locations are not included within the external water quality inspection program. By checking the water quality at the source, an accurate early warning indication is provided whether these water sources are polluted. The existing water-sampling program for the BES islands can be adjusted to include water samples from surrounding water resources.

### *Inspection duties*

Management of private wastewater and cistern systems are a major issue on the BES islands, currently there are no inspection bodies that monitor the sanitary status or hygienic conditions of these systems. Next to that, there is also hardly public information or guidelines available on the use of private wastewater or cistern management. On the French Antilles however, the DSDS is allowed to enter properties and do random inspections of both cisterns and septic tanks (or cesspits). When these systems are considered unsanitary, the DSDS is authorized to provide instructions and advice to the particular users. The DSDS also publishes guidelines (via their website and local media) for proper management of both cistern and septic tanks.

On the BES islands, a new drinking water regulatory inspection authority needs to be erected. To prevent issues with private waste and rainwater systems, the new drinking water regulatory authority can extend their duties with similar sanitary inspections of private water systems.

---

<sup>194</sup> Frank Greaux, interview #15

Cooperation with the local BES building inspection body can be necessary for the execution of these tasks.

## **Rainwater harvesting**

Problem areas:

- Regulation and inspection of drinking water
- Drinking water quality

The majority of the houses on Saint Martin and Saint Barths depend on rainwater. All traditional houses have integrated cisterns. When necessary, these cisterns are replenished with desalinated water from the public water suppliers. In the past, several sanitary problems occurred that were related to the use of private rainwater cisterns. These problems were almost identical to the issues that are currently present on the BES islands.

- Cistern water contamination; cisterns were not maintained, repaired or disinfected properly. This affected the overall water quality in the cistern.
- Groundwater pollution; due to increased human activity on the island, subsoil groundwater has been polluted by chemicals, batteries and different kinds of fossil fuels. Groundwater can permeate in cisterns through cracks and not plastered brickwork, affecting the overall cistern water quality
- Mosquito breeding; closed cistern systems with standing water provide optimal conditions for mosquito breeding. Without proper disinfection of cisterns with either chlorine or guppies, mosquitoes multiply rapidly. Mosquito plagues can spread diseases over the island.
- Cross contamination of cistern water with public drinking water; both systems are frequently integrated into one household system. Contaminated cistern water (see previous bullets) can potentially penetrate the public system.

In 2000, the French Government decided that it was not allowed anymore to build cisterns into new residential buildings; an additional article that prohibits cistern constructions had been added to the National French Building Code.

In 2001, the local government on St Martin decided to discard the formal prohibition of cistern systems. It turned out that the new legislation could not prevent the existing users of cistern systems from using them for potable water purposes. Instead, the island government introduced policy interventions to mitigate the existing issues.

To ensure a safe use of cistern systems, the island government now provides education (via the DSDS) on the use, maintenance and disinfection of cistern systems. Information leaflets have been made, containing information on water filtration systems and other disinfection procedures (type and quantity of chlorine). These flyers are distributed via mail during sanitation campaigns, several times per year. The same information is also available via the website of the island government.

Another policy intervention that has been introduced is a specific regulation on the construction of household water systems. A new article in the French Public Health Law now prescribes that private cistern systems and public water systems should be physically separated to prevent cross-contamination of different water types. This measure has been explicitly mentioned during all sanitation campaigns. There is however no guarantee that people will comply with this new regulation, therefore all individual public connections are gradually equipped (by UCDEM) with 'no-return valves' to prevent low quality water to enter the public system<sup>195</sup>.

## **Lessons**

---

<sup>195</sup> Glenn Richardson, interview #14

The French Antilles, like the BES islands, experience sanitation issues regarding the use of private cistern systems. The island governments initially decided to legally prohibit cistern systems. In practice, all households maintained their cisterns as their primary source of potable water. Therefore the government changed its strategy from prohibition to education and providing information to the public. Furthermore, specific regulatory and technical measures have been introduced to prevent cross-contamination regarding cistern systems. The newly introduced information campaigns and policy interventions seem to be more effective than the previous prohibition of cisterns.

For the BES islands, faced with similar issues, the previous information is quite important. When planning new public drinking water networks on the BES islands, one should take into account that the local population will not cease to use cistern systems. Since there are many sanitary and health issues involved regarding the construction and use of cisterns, it would be better from a medical perspective that (in the future) everybody switched from rainwater to safe public drinking water. This will not happen within short time, it is better to invest in proper education at schools, information campaigns and implementation of guidelines to create sanitary awareness with the population and hopefully improve the use and quality of cistern systems.

VROM Inspection in combination with the RIVM can initiate similar awareness projects as on the French Antilles. These projects can be initiated and hosted in combination with the local drinking water regulatory authorities. It is crucial to keep continuing these activities to increase the overall effect. Additional technical measures in the form of 'no-return valves' are recommended for new public networks on both Saba and Statia.

## **Sustainable drinking water production**

Problem area:

- Protection of water resources
- Energy efficiency

Drinking water is produced by UCDEM on behalf of the islands government of Saint Barths. The production plant consists of three separate production units, two seawater reverse osmosis modules (3000 m<sup>3</sup>/day) and one seawater distillation unit (1200 m<sup>3</sup>/day). The seawater distillation unit is mainly used for additional capacity during the high season. Normally the water consumption rate is approximately 2000 m<sup>3</sup>/day, this number can increase up to 3500 m<sup>3</sup> during high season<sup>196</sup>.

### *Waste to drinking water*

Saint Barth has one of the most sophisticated solid waste recycle programs in the Eastern Caribbean. Solid waste is collected and transported by the local public works department to a central distribution site. At the central collection site all solid waste is sorted out into different waste flows; metal, plastics, chemicals and car wrecks are all compressed and sent to Guadeloupe for recycling. Glass and more specific waste are sent to France for further treatment. All other types of waste that is not suitable for recycling is incinerated on-site.

The waste incinerator is operated by Ovanalao Environnement SE and is capable of processing 1500 kilogram of solid waste per hour. The energy recovery rate of the system is 80%, generating 4500 kilograms of steam per hour. The steam produced by the incinerator is transported via pipeline to a seawater distillation unit operated by UCDEM. The maximum drinking water production rate of the distillation unit is 1350 m<sup>3</sup>/day. The waste-to-drinking water system has been introduced in 2001 and has been completely financed using federal grants. The total investment costs for this system are 8 million Euros; the annual expenses for the system are 900.000 Euros<sup>197</sup>.

---

<sup>196</sup> Frank Greaux, interview #15

<sup>197</sup> Greaux, interview #15

## Lessons

In contrary to the BES islands, Saint Barth has a sophisticated solid waste collection and recycling program. Waste that can be recycled is sent to Guadeloupe or France; all other forms of waste are incinerated using a modern facility with a high-energy recovery rate. The waste incinerator produces steam that is used for additional drinking water production capacity during the high season. The waste-to-drinking water system proved to be an energy efficient and sustainable system. Solid waste is processed safely, meeting all EU regulations, and relatively cheap drinking water is produced in a sustainable way. The water that is distilled can either serve as additional drinking water capacity during the high season or it can replace expensive RO water during the low season.

Solid waste forms a major environmental issue on all BES islands, eventually leading to pollution of the subsurface soil, groundwater resources and the coral reefs (see chapter 4). Saint Barth provides an excellent example on how solid waste can be collected and processed on small Caribbean islands. Cooperation with larger islands is crucial for a small island as Saint Barth to benefit from additional recycling and waste treatment facilities at larger island economies. Saint Barth has the facilities, contracts and infrastructure to collect, sort, distribute and incinerate solid waste on the island itself. Saba and Statia can try to establish an arrangement with Saint Barth to join their waste management system. Solid waste can be transported from Statia and Saba to Saint Barth for further treatment. In this way, many environmental problems on Saba and Statia can be mitigated whereas the additional waste flow can create more jobs and a more feasible waste incineration system on Saint Barth. The extra waste flow can provide a more steady energy source (steam) for drinking water distillation, replacing the expensive RO water.

Developing a waste-processing site on either Saba or Statia would be infeasible considering the scale and the economies on the islands.

Bonaire can either decide to develop a similar waste management system on Saint Barth; the scale and the economy of the islands are comparable. Another option is to cooperate with other surrounding islands that already have waste management systems, in a similar way as Saba and Statia.

## Source site B: US Virgin Islands (USVI)

### Drinking water supply system

Rainfall in the USVI averages about 44 inch (1,12 m) annually. High transpiration rates have been estimated to return 96% of the rainfall to the atmosphere, therefore surface water is scarce on the islands. The little groundwater resources, due to thin soil layers, that exist on the island are increasingly threatened because of bacterial contamination of septic tanks and chemical pollution from commercial and industrial sources<sup>198</sup>.

Desalination is the principle source of drinking water on the island for commercial demands. This is a costly principle since the technology is fully dependent on fossil fuels. Next to that, economies of scale are not possible since a large-scale distribution network cannot be realized. The different Virgin Islands are separated from each other, unable to be connected with distribution pipes. The local mountainous conditions do not allow the main islands to be covered with a distribution network. Multiple desalination plants are sized and built to meet water demands in proximate service areas based on engineering, demographic and geographic conditions<sup>199</sup>. The consequence is that residents and facilities located outside of the drinking water service areas must use alternative ways of obtaining drinking water. Hotels and resorts usually install small desalination systems, or like some residents order drinking water using a water truck.

Since desalination plants and trucked water are usually expensive for the local USVI resident, an alternative source of drinking water is often used: rooftop harvesting. The local Virgin Island Building Code requires that houses, not within the vicinity of drinking water service areas, must be equipped with a rooftop harvesting system and store the collected water in a cistern<sup>200</sup>. The building code prescribes a certain storage capacity based on the number of stories and the total roof surface of the house. An average house has a rooftop *footprint* of approximately 1.600 square feet, this necessitates that a cistern with a capacity of approximately 16.000 gallons (60 m<sup>3</sup>) need to be constructed. Considering the investment costs of these storage facilities, cisterns are a contributing factor for the high cost of home construction in the Virgin Islands<sup>198</sup>. Recently, the provisions have been made to relax the required storage capacity for houses in the proximity of a drinking water service area<sup>201</sup>. Apart from rainwater and desalinated water, more of the younger Virgin Islanders consume bottled water. However, an estimated 50% of the population drinking their rainwater straight from the cistern<sup>198</sup>.

#### *Water Island and St John*

The two smaller islands of the US Virgin Islands, Water Island and St John do not have public networks; water is supplied using standpipes. The system consists of a small reverse-osmosis water plant, one storage tank and a connected standpipe. Water is distributed using water trucks. Like St Thomas and St Croix, all households have cistern systems and use them as their primary source of drinking water. Public water is a supplementary source of drinking water.

### Drinking water legislation

The US Virgin Islands are officially an unincorporated, organized territory of the United States. The islands are part of the United Nations non-self-governing territories. The US considers the Virgin Island as a US governed, unincorporated territory without the ability to vote in presidential elections. All US federal laws apply for the USVI, the same goes for the US Safe Drinking Water Act (SDWA)<sup>202</sup>. The SDWA provides a federal framework based on which the

---

<sup>198</sup> Henry Smith interview #18

<sup>199</sup> Michael Quetel, interview #16

<sup>200</sup> US Virgin Islands Building Code, Title 29, Chapter 5, Section 308

<sup>201</sup> US Virgin Islands Building Code, Title 29, Chapter 5, Section 308, Subsection (b)(1)

<sup>202</sup> Safe Drinking Water Act, 1974

USVI can define, regarding local insular conditions, drinking water regulations. The USVI Drinking Water Standards are included in the Public Health Service Act<sup>203</sup>.

## **Actor network**

The following actors are involved in the drinking water supply system on the USVI:

### *Virgin Islands Water and Power Authority (VIWAPA)*

VIWAPA is the main drinking water and electricity provider on the 4 islands of the Virgin Islands. VIWAPA produces and distributes water through service connections and a truck bulk loading facility (standpipe). VIWAPA must meet the requirements of the Safe Drinking Water Act and other regulatory requirements. VIWAPA strives to abide by all American Water Works Association Standards and to provide 24 hours service to all customers<sup>204</sup>.

### *Department of Planning and Natural Resources (DPNR)*

The environmental protection division is responsible for the implementation and enforcement of the US EPA regulations. In particular, the division is responsible for implementing the Safe Drinking Water Act. The DPNR has to demonstrate the EPA that they have the ability to enforce all federal EPA regulations. Once the DPNR has proven to be capable of enforcing the EPA regulations, they get the so-called primacy status. Once provided with this status, the DPNR is allowed, independently, to implement and enforce the Safe Drinking Water Act. Based on the primacy requirements, the DPNR has to report to the EPA on a quarterly basis<sup>205</sup>.

### *Environmental Protection Agency (EPA)*

The Environmental Protection Agency has the mission to protect human health and to safeguard the natural environment. The EPA implements Congressional laws by defining new national standards or regulations. States and territories enforce these standards through their own regulations. On the USVI, the EPA has delegated all environmental regulatory duties to the DPNR. The DPNR is responsible for enforcement and implementation of environmental regulations; the EPA provides assistance, guidance and funding to execute these tasks<sup>206</sup>.

The DPNR has to report to the EPA on a frequent basis, this is done using a special database system. The EPA provides all US states and territories subjected to the federal Safe Drinking Water Act with a system called SDWIS (Safe Drinking Water Information System). The regulatory authorities use SDWIS to report violations, enforcement actions and inventory data of regulated water systems.

### *“Community”, “transient” and “non-transient” drinking water suppliers*

The Safe Drinking Water Act makes a distinction in public water systems; there are community water systems, transient and non-transient water systems. Only these types of drinking water systems are subjected to the regulatory authority of the DPNR. See section 7.3.4 for more information.

### *Drinking water distributors*

Since the majority of the houses on the USVI do not have public drinking water connections, people order drinking water from water delivery companies. These companies use trucks to load water from public standpipes and usually deliver the water directly into the cisterns of the consumers. Distributors are subjected to specific regulations in the Safe Drinking Water Act regarding the transportation of water used for human consumption<sup>207</sup>. The Act requires for example that all trucks and tankers that are engaged in the transportation of water for human consumption are inspected and registered annually by the DPNR.

---

<sup>203</sup> USVI Drinking Water Standards, 1994

<sup>204</sup> Interview Michael Quetel, #16

<sup>205</sup> Interview Herald Mark, #17

<sup>206</sup> Website Environmental Protection Agency, visited April 20 2010

<sup>207</sup> Safe Drinking Water Act, section 1303-17

### Independent laboratories for water sampling

As part of the regulations in the Safe Drinking Water Act, all community, transient and non-transient water providers need to take drinking water quality samples. Quality analyses of the samples are executed in approved laboratories. Laboratories are either approved by the DPNR or certified by the EPA<sup>208</sup>.

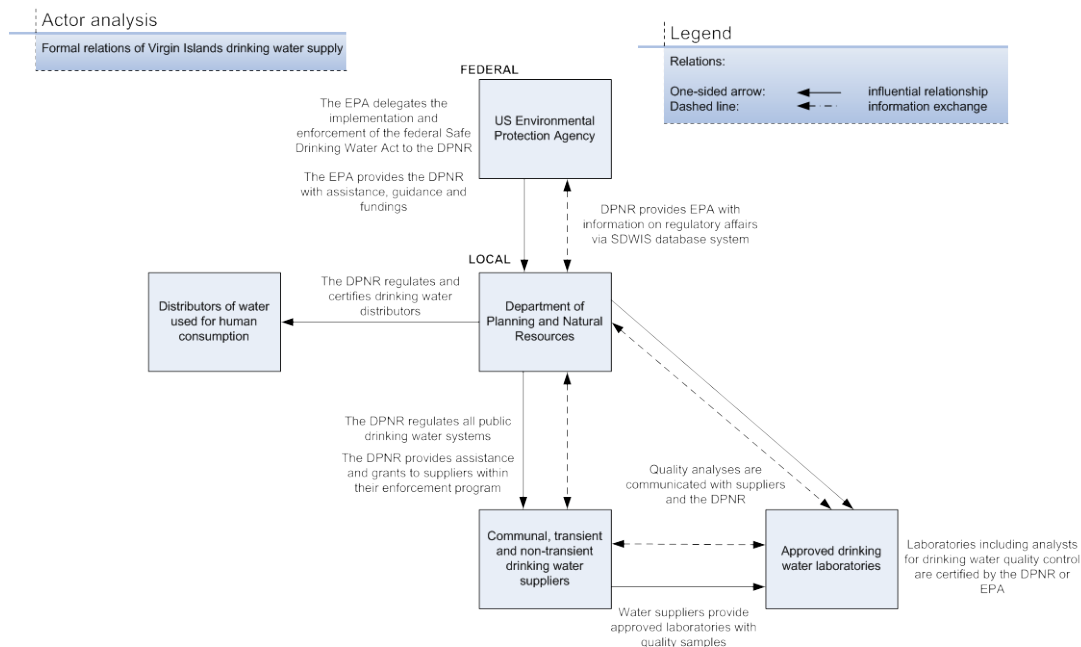


Figure 58 Actor analysis drinking water supply USVI

### Drinking water regulation and inspection

On the US Virgin Islands, the Department of Planning and Natural Resource is the delegated regulatory entity for all provisions of the Virgin Island Safe Drinking Water Act. The ultimate enforcement responsibility lies with the Regional Administrator of the US Environmental Protection Agency. The EPA has a small regional field office on the USVI for additional assistance and guidance of all environmental programs within the DPNR<sup>209</sup>.

#### Public Water Supply Supervision

Within the DPNR, the Public Water Supply Supervision (PWSS) program is responsible for the inspection and regulation of public water systems. The PWSS maintains an advanced database system called SDWIS in which an inventory of public water systems of the territory is stored and directly shared with the EPA regional field office. The inventory contains administrative and technical information for each public water system, including water quality monitoring data<sup>210</sup>.

The PWSS program is involved in the following duties:

- Conducting sanitary surveys of public water systems

A sanitary survey consists of an onsite review of the water source, equipment, operation and maintenance procedures. These aspects are considered for an evaluation of the adequacy for producing and distributing safe drinking water.

<sup>208</sup> Safe Drinking Water Act, section 1303-12

<sup>209</sup> Herald Mark interview #17

<sup>210</sup> Website Department of Planning and Natural Resources, visited April 20 2010



Within the sanitary surveys, also the annual registration and inspection of tankers that haul water for human consumption is included.

- Collection of surveillance samples

Drinking water quality samples are collected during every sanitary survey and water hauler inspection. These samples are analyzed by a DPNR/EPA certified laboratory for microbiological contamination.

- Providing technical assistance

The PWSS provides technical assistance to water purveyors and investigate quality complaints by the public.

### *Public drinking water systems*

There are different public water systems on the USVI, community and non-community water systems. The following systems are defined:

- Community water systems serve at least 15 service connections used by year-round residents or regularly serves at least 20 year-round residents. Examples of these systems are the Water and Power Authority (WAPA) and apartment complexes with private water systems.
- Transient (non-community) systems provide drinking water to more than 20 persons that reside for a short period (hotels, resorts).
- Non-transient (non-community) systems provide drinking water to more than 20 non-residing persons (public facilities, offices)<sup>211</sup>.

On the USVI there are approximately 80 public water systems that are regulated by the DPNR. The largest community water systems consist of the two WAPA (Water And Power Authority) networks, condominiums and apartment buildings. The DPNR also regulates non-transient water systems, consisting of schools, offices, daycare centers and other public buildings.

Public water systems are not necessarily connected to the public drinking water network. On St Thomas there are approximately 5300 service connections, on St Croix there are 6900 connections<sup>212</sup>. Roughly can be stated that 50% of the households on the USVI have a public service connection<sup>213</sup>.

All other structures, not within the vicinity of the public network are legally required to have a cistern. This is cistern is used to store water from different sources; rainwater, well water or desalinated water distributed by truck. For the Virgin Island Drinking Water Standards the source of drinking water at public water systems is irrelevant. Any type of water that is distributed to more than 20 people, being a community, transient or non-transient system need to meet all quality requirements as put forward in the Safe Drinking Water Act.

Example of a transient system using multiple water sources:

There are commercially exploited apartment buildings and resorts on St Croix, not located within the vicinity of the public drinking water network, that use wells and rainwater as their main source of drinking water stored in huge underground cisterns. Only when necessary, these cisterns will be replenished with desalinated water from the public water company. A drinking water treatment unit purifies the water from the cistern before it is distributed through the complex. These buildings are an example of a transient system since people usually do not reside year-round. Most transient systems have their own water operators that are responsible for external water quality sampling, checking of chlorine and turbidity levels and maintenance of filtration systems.

---

<sup>211</sup> Safe Drinking Water Act, section 1303-11

<sup>212</sup> Michael Quetel, interview #16

<sup>213</sup> Henry Smith, interview #18

### *Self-monitoring policy*

Public water systems are required to self-monitor the quality of water distributed by having samples collected and analyzed by a DPNR or EPA certified and approved laboratory. The analytical results must be submitted to the DPNR. An exception is made for the measurement of turbidity and free chlorine residual; any person acceptable to DPNR may perform these measurements<sup>214</sup>.

### *Enforcement instruments*

The Department of the Environmental Protection and the Public Water Supply Supervision issues Notices of Violation and Assessment (NOVA), administrative orders and civil penalties.

The NOVA is a written notice issued by the Commissioner of the DPNR or his designee, which accuses a respondent of violating the Drinking Water Act and assesses a civil penalty for the violation<sup>215</sup>.

A major part of the compliance management efforts involve facility and site inspections, permitting, compliance reporting and other environmental monitoring processes. The PWWS learned over time that in many cases the quickest means to ensuring compliance with environmental laws and regulations is through the provision of information, coordination and collaboration with the involved actors<sup>216</sup>.

### *Drinking water laboratories*

All US Virgin Islands, except St John and Water Island have their own independent drinking water laboratory. These laboratories are usually private and combine both drinking water and wastewater analyses. The laboratories are small and are only equipped with the necessary certified equipment and laboratory personnel to execute the most common analyses. These are mainly micro bacterial and chemical analyses of various water types. The laboratories receive samples from public drinking water suppliers and wastewater purification plants. Laboratories are annually checked and certified by the DPNR and EPA.

## **Lessons**

On the BES islands, a new drinking water regulatory authority needs to be defined. The starting point of this new regulatory system is that the local health authorities will be delegated the role and duties of the VROM Inspection body on the BES islands. VROM Inspection will remain the ultimate responsible authority that supervises and assists the local health authorities.

### *Set-up of regulatory authorities*

The drinking water regulation system on the USVI forms an excellent example of how such a regulatory system can work and develop over time on the BES islands. The DPNR, and more specifically the PWSS uses the “primacy status” principle. The primacy status can be gained by the DPNR when the EPA considers the local regulatory authorities qualified to execute their duties. An intensive training period during which officials of the EPA assist and educate the PWSS officials precedes the eventual qualification procedure. Once the primacy status has been gained, the EPA and the PWSS cooperate closely using a special database system. A similar training period and cooperation method could be used for the new regulatory authority on the BES islands.

The EPA has a permanent representational office on the USVI, the office houses a small number of EPA officials experienced in various environmental areas. When the database system does not provide the necessary information or support, the local EPA office can be consulted for specific assistance.

---

<sup>214</sup> Safe Drinking Water Act, section 1303, article 48

<sup>215</sup> Safe Drinking Water Act, section 1309, article 1

<sup>216</sup> Harold Mark, interview #17

The VROM Inspection Authority can construct a similar system for the BES islands, considering the scale and number of drinking water supply systems; support offices are not necessary for all three islands. One support office of the VROM Inspection Authorities (for example) on Bonaire can assist the three public health authorities on the BES islands when this is necessary.

The new drinking water regulatory system on the BES islands is supposed to follow the same regulatory principles as in the Netherlands. This means that the drinking water suppliers are responsible for a guaranteed drinking water quality. The suppliers have their water sampled and tested by independent and approved laboratories. This principle is also maintained by the USVI, however public drinking water systems are only regulated when the system supplies to more than 20 consumers. In the Netherlands, and also on the BES islands, all drinking water systems that commercially distribute to third parties are regulated.

#### *Actor network*

The drinking water actor network that is presented in the new BES drinking water (see chapter 4) involves the local Governing Bodies, the Minister of VROM and a Drinking water Council. On the USVI, the actor network for drinking water is rather limited. Drinking water suppliers only communicate with one authority, the DPNR. The EPA is only involved when necessary: for assistance, training or licensing duties. The benefit of keeping the network small is that the delegation of duties and powers is more transparent for the actual stakeholders. Next to that, communication between actors is faster and more effective because decisions can be taken by the responsible actors themselves and are not delayed by authorization of higher authorities.

#### *Regulatory duties*

The DPNR not only perform supervision and regulatory duties, the authority is also involved in training and certification. The EPA authorized the DPNR to train and certificate drinking water samplers and to approve laboratories for both drinking water and wastewater analysis. The EPA does sometimes assist in these activities, especially for the certification of laboratories since this requires both specific knowledge and personnel capacity.

By being authorized to perform the latter activities, all training and certification sessions can be executed on the Virgin Islands, instead of in Puerto Rico where the Caribbean headquarter of the EPA is located. This makes the certification programs easier, more economical and faster.

Whereas in the Netherlands, multiple research institutes can assist in training and certification on the BES islands no specific professional organizations are available. To avoid costly professionals to be flown in every so often to perform relatively simple training and inspection sessions, the BES drinking water regulatory authorities should be authorized to do as many duties on a local level without being directly dependent on the mainland. For specific assignments, the VROM Inspection authority, KIWA or the RIVM can be consulted.

#### *Water haulers*

Specific regulatory duties that are currently not included in the BES drinking water law, but that do occur on the USVI are the inspection and certification of drinking water distribution trucks (regulations on 'water haulers'). On all three BES islands water is distributed using trucks, regulatory and certification duties regarding the distribution of drinking water via trucks is therefore recommended. The concerning VI legislation is perfectly suitable for implementation in the BES drinking water law.

### *Construction of cisterns*

Another specific regulatory aspect of the DPNR is the supervision duties regarding the construction of rainwater cisterns for public water systems. This has as a goal to safeguard both quality and quantity aspects of rainwater system. Cistern construction regulations are not included in the drinking water legislation but in the local VI building codes. Enforcement of cistern construction regulations is performed by both the VI Building Inspection and the PWSS. On the BES islands, several public water systems on Statia and Saba use cistern systems. For future building projects it is important to include some type of regulation on the construction of cisterns in the BES drinking water law. This is to prevent water quantity issues or structural design flaws.

### *Laboratories*

On the BES islands, the scale of the public drinking water systems and the total number of analyses that need to be executed do not necessarily require a water laboratory on all BES islands. It seems economically more feasible to make sound arrangements with internationally certified existing laboratories on nearby islands.

## **Introduction of public drinking water network**

Problem areas:

- Accessibility of drinking water

### *Introduction of the public network*

The Virgin Islands were bought from the Danish in 1917 then being the “Virgin Islands of America”. From 1917 until 1931, the Virgin Islands were under US Navy Rule and several major public works and social reform projects were undertaken<sup>217</sup>.

The initial decision to install a public network took place in the early thirties, around 1926 by the US Navy. The Navy built their own drinking water distribution network providing desalinated water. First, all military structures, barracks and facilities were connected to the distribution network. The next step is that all commercial businesses were connected to the desalinated water network. The current drinking water network that connects the remaining areas with the traditional network has been built during the 1950's when the Islands experienced a major economic boom. The introduction of desalinated public water evolved gradually over a longer period of time. Many people on the islands worked as military personnel on the Navy Bases and slowly got used to the benefits of clean desalinated water as an alternative to rainwater<sup>218</sup>.

When the USVI were not any longer under US Navy Rule, the distribution of drinking water was handed over to the department of public works; the production was delegated to the VI Power Authority. Through new legislation in 1988, the distribution of drinking water was transferred to VIWAPA as well<sup>219</sup>.

### *Drinking water legislation*

With the introduction of the now *public* drinking water network, specific legislation was installed that had to stimulate the consumption of desalinated water to make the system feasible. New regulations in the VI building codes prescribed that when you want to build a house in an area with a public distribution network close by, a cistern is not required. When you live quite remote, in an area without a distribution network, you are legally *required* to build a cistern. In practice, new houses are always built with a cistern since Virgin Islanders are too accustomed to the use of rainwater, and they know the value of these systems during natural disasters. There is no legal requirement to connect to the public distribution network, nor is

---

<sup>217</sup> Michael Quetel, interview #16

<sup>218</sup> Henry Smith, interview #18

<sup>219</sup> US Virgin Islands Drinking Water Standard, 1994

there a fixed periodic fee for the use of the public water system. Everybody that lives within the vicinity of a public network can be connected to the water system through VIWAPA. The homeowner pays a subsidized price for the connection that is depending on the distance from the network.

#### *Public network coverage*

The drinking water network is covering 30-40% of St. Thomas (5300 service connections) and 60-70% of St Croix (6900 service connections). On Water Island and St John there are no public networks available, only stand pipes. Approximately, 50% of the houses are connected to the public drinking water networks. The reason that not all households are connected is twofold, either the homeowner doesn't want to connect or there is no public network available. There is no full coverage on the islands; expanding the distribution system on the islands is expensive since the geographical conditions are very unfavorable. Expanding the existing distribution network is not feasible; WAPA already has a negative turnover for residential customers. The break-even point for the existing system is reached within 11-12 years. To reach the break-even point, assuming a full distribution network on the islands, will take up to 30 years. The public network is only expanded for politically driven projects, using either federal or local Virgin Island grants<sup>220</sup>.

#### *Stimulation of public drinking water consumption rates*

In order to stimulate the consumption of desalinated water (and the number of connections), drinking water is subsidized for about 50%. The production and distribution price of drinking water is artificially reduced using local Virgin Island taxes; through this economical construction no federal reimbursement is necessary<sup>221</sup>.

There are currently two rates for drinking water, a commercial rate and a residential rate. The residential rate is currently \$0,014 per gallon (2,81 Euro per m<sup>3</sup>). The rate for a truckload of drinking water is quite expensive, nearly 133 Euros for 11 cubic meters (12 Euro per cubic meter).

Although public drinking water is heavily subsidized, public water is still used as a supplementary source of drinking water for the majority of the population. All people that had a cistern kept using it as their primary source of drinking water. However, during the introduction of the new network, the subsidization of the drinking water rates lowered the burden to connect to the public network significantly, about 50% of the homeowners are connected<sup>221</sup>.

The consumption patterns of public water are generally low; the general rule is that that rainwater is used first; when necessary cisterns are replenished with public drinking water.

Typically, the local population uses rainwater for human consumption; public water is used for all other purposes. Local people associate rainwater with something pure, whereas public water is artificial and has a different taste (mainly because of the chlorine). The local government had the intention (from a public health perspective) to stimulate to use of desalinated water; this project did not succeed well.

During the introduction of the network, more attention should have been paid to public information provision, the population should have been provided with more information on the benefits of clean public water versus the disadvantages of rainwater.

### **Lessons**

The introduction of a public drinking water distribution network on St Thomas and St Croix occurred in a different way than on the BES islands. Desalinated water was produced and distributed by the Navy in the 1940's using their military infrastructure at the USVI. The development of the first drinking water supply system was a military operation that didn't need public acceptance for it to continue. Drinking water was necessary for the military bases and

---

<sup>220</sup> Herald Mark, interview #17

<sup>221</sup> Michael Quetel, interview #16

fuelling of naval submarines on St Thomas. Later on, this military supply system was expanded for civilian purposes. Although the VI population was already acquainted with desalinated water, residents were very reluctant to get connected to the public system. Until today, rainwater is still an important source of drinking whereas public water is mainly used as a supplementary source to replenish empty cisterns. Because of this, the public distribution networks remain economically infeasible to operate and rainwater of unstable quality is the main source of drinking water.

What can be learned from this particular example on the USVI is that for the introduction of a public drinking water network, involving the local population in the project is crucial. You can't assume that when a public network is available, the population will automatically want to be connected to this network. The initial goal of the VI local government was to make desalinated water the primary source of potable water and to maximize the number of public service connections. These goals were however not reached; although 50% of the population has access to the public water network, rainwater is still the main source of drinking water. Information campaigns, public involvement and eventually economical incentives are crucial to create a public support and acceptance of desalinated water.

When developing new drinking water supply systems for Saba and Statia, the previous information is very important. People do not have a positive association with the desalinated water that is currently produced: the quality is unstable, the prices are high, and there is a limited production capacity and no external quality inspection. In order to get the population to switch from rainwater to desalinated drinking water a psychological and cultural revolution are necessary. These things will not occur as soon as there is a public network available. Therefore, before any project can be planned, the local population needs to be informed and consulted thoroughly.

Another important lesson is that the construction of an expensive distribution networks is not without economical risks. The Virgin Islands did construct many distribution grids that are not used until today<sup>222</sup>. Since people are reluctant to connect to the public water system and consumer consumption rates are limited, the system itself becomes economically infeasible. Next to that, dead ends within the distribution network are dangerous; standing water in dead ends can be a breeding place for bacteria.

Although 50% of the homeowners do have public water connections; people consume just enough water to replenish their cistern systems. For that purpose, the islands can also be equipped with enough drinking water truck and a single standpipe. In this way an infeasible and potentially dangerous distribution network can be avoided (St. John, Water Island). Unless you know that the population will use desalinated water as their primary source of drinking water, a limited supply system using only stand pipes and water distribution trucks, might be sufficient. Good examples of these situations are St John and Water Island.

## **Rainwater harvesting**

Problem areas:

- Regulation and inspection
- Continuity of drinking water supply
- Quality of drinking water supply

### *Introduction*

The Virgin Islands like all other volcanic islands do not have many natural fresh water resources; rainwater harvesting has always been the primary source of fresh water. Until today, rainwater is still a major source of fresh water for the majority of the VI population. An

---

<sup>222</sup> Michael Quetel, interview #16

estimated 50% of the Virgin Islanders drink water directly from their cisterns without any form of treatment. The other 50% of the population drink treated (boiled, chlorinated or filtered) rainwater, bottled water or public drinking water. The Virgin Islands are the only country that maintains specific legislation on the construction of cistern systems<sup>223</sup>. This section describes the way rainwater harvesting is integrated in the drinking water supply system on the Virgin Islands.

#### *Cistern legislation*

In the early 40's of the previous century, when the VI were not under the Navy Rule anymore, specific legislation was introduced regarding the construction of cisterns. This law required that *all* buildings had to be designed and built with cisterns in the foundation. From then on, new constructions were equipped with integrated cisterns. Their capacity was directly related to the roof surface and the number of floors. The volume of a cistern is calculated by multiplying the total roof surface (in square foot) by 10 gallons. For multiple floor buildings, the multiplying factor is 50 gallons. Over time, regulations have been added defining the materials that are required for the construction of cisterns, gutters, paint and roofing materials. All components that are used for rainwater harvesting systems need to comply with the National Safety Foundation P151 protocol. This protocol is required for all materials that are used for the distribution and treatment of potable water for human consumption<sup>224</sup>.

Public water has been introduced on the islands during the 50-60's, from that moment the legislation regarding the construction of cisterns has been changed. You are only required to build a cistern when there is no access to the public distribution network. The reason to maintain this law is based on the idea that everybody house needs to have his own water supply during natural disasters. People connected to the public distribution network rely on public emergency drinking water supplies; people with a cistern rely on their own rainwater supply.

Building plans for cisterns are inspected by the DPNR, when the plans meet all requirements, building permits are granted. During the construction of cisterns, on-site inspections are conducted by the PWSS to make sure that the building plans are followed.

Even when it is legally not required, still the majority of the newly constructed houses are equipped with cisterns. This is quite remarkable, since the construction costs of a cistern are typically 25% of the total housing price. The reason that the majority of these houses do have cisterns is that the owners value the importance of such systems, they function as a water insurance during natural disasters. Although connected to the public distribution network, people know, this is not a guarantee for drinking water during a major hurricane.

#### *Public rainwater harvesting*

By the initial cistern legislation in the early 1940's, all public facilities on the USVI required cisterns, rainwater was used for public distribution and for fire-fighting purposes. In the same period the government constructed large catchment areas on the hillsides for the retention of rainwater (see Figure 59). A positive by-effect of these catchments areas is that they prevented erosion during heavy rainfall. During the 1960's the US government decided that it was too dangerous to provide untreated rainwater freely to the local population. Untreated public rainwater could not be provided anymore. This decision was mainly based on rainwater quality considerations. Next to that, many of the public catchments were constructed using large asbestos sheets. Many of the traditional rainwater catchments have been removed.

---

<sup>223</sup> Henry Smith, interview #18

<sup>224</sup> Website National Safety Foundation, visited May 9th 2010

Treated rainwater is still used as a source for many public water systems on the USVI. Many resorts, condominiums and hotels are located in areas with no drinking water service connections. These buildings are therefore legally required to have very large cistern systems; rainwater from these cisterns is often used as the primary source of drinking water. If these systems provide water to more than 20 residents/guests, they have to meet all EPA water requirements. Rainwater is therefore subjected to additional treatment steps before distribution.

#### *Private rainwater harvesting*

The majority of the houses on the USVI are equipped with cisterns. The oldest types of cisterns are made of brickwork and are usually located next to the house. These cisterns are very similar to ones found on Saba and Statia. From the 1940's, cisterns are located in the foundation of the house (see Figure 60). By law, cisterns require certain minimal storage capacities, depending on the roof surface and the number of floors. In practice, these minimum capacities are generously exceeded. The reason to maximize the total cistern volume is mainly to remain independent for your personal water supply system.



Figure 59 Public rainwater catchment on St Thomas

Once the cisterns are constructed and time passes by, users should maintain their cisterns in a careful way to safeguard the quality of cistern water. To stimulate good housekeeping, the DPNR recommends cistern users to clean, plaster and disinfect cisterns regularly. Leaflets are available at the DPNR office, and the same information can be found on their website. In the past, the department of Health and the Water Resources Department of the University of the Virgin Islands was more actively involved in providing information on proper cistern use. Since more people are nowadays connected to piped public drinking water, the authorities do not provide enough information as in the past. "More information need to be shared on the use of rainwater systems, awareness need to be created at the side of the users"<sup>226</sup>.

In practice, cistern users are not too concerned about managing their cisterns. "People do apply some of the guidelines provided by the DPNR, but not as frequently as should be the case"<sup>225</sup>. People do add chlorine to their cisterns, but usually not with the right dose or the right frequency as is recommended by the DPNR. Since many people do not have the means to check the chlorine level in their cistern, they have no idea whether they add enough. People can be convinced that they are drinking disinfected water, whereas it might be contaminated<sup>226</sup>. Next to that, the majority of the people are not that concerned about the quality of their cistern water. Some people won't even add chlorine or use other treatment steps. The majority of the people hardly clean their gutters or other parts of the rainwater system.

---

<sup>225</sup> Henry Smith, interview #18

<sup>226</sup> Harold Mark, interview #17



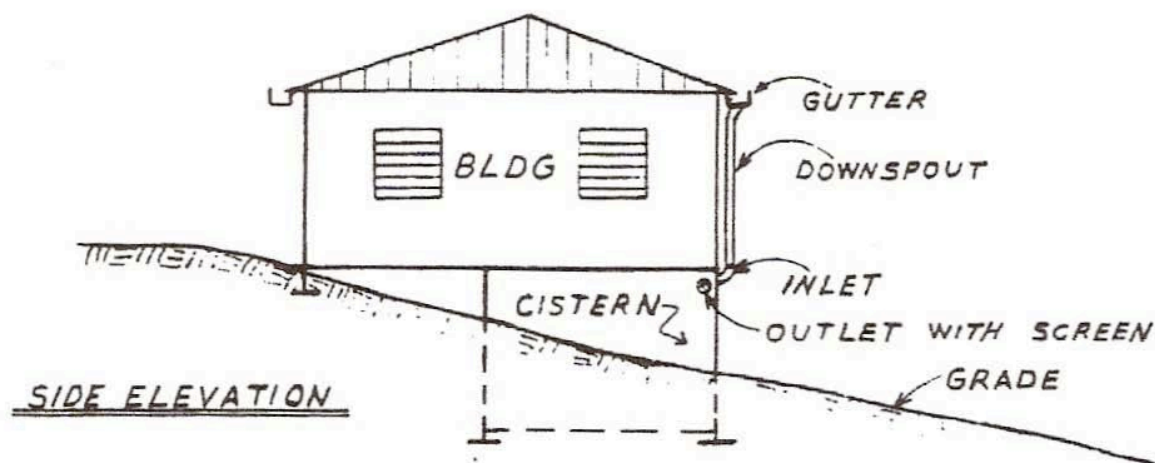


Figure 60 Construction drawing of typical VI house

Only a very small selection of the population uses filtration systems. “The use of filtration systems can be dangerous in the sense that, if you don’t have the economical means to maintain them, they can be a breeding place for bacteria”. Filtration systems are costly for multiple reasons; the initial costs, power use and maintenance costs. “When the owners do not have the means to change the filters in time, the quality of the water can be worse than when you would drink it straight from the cistern”. Introducing water filters rather create more potential quality problems than they solve<sup>227</sup>.

Another problem with cisterns is related to the Building Code and Inspection. When people build a new house, there are specific design requirements for the cistern that is integrated. There is however no control when people expand their house with additional (commercial) apartments. Typically, since they are located in the foundation, the dimensions of cisterns are not compensated to the new capacity of the residence. For septic tanks, the same principle applies. The lack of rainwater can be compensated by buying desalinated water, the lack of the septic tank capacity cannot be compensated. That is where the problems will arise (see section 7.4)<sup>228</sup>.

### Lessons

On the US Virgin Islands, rainwater harvesting is part of the culture and everyday life. Rainwater is the primary source of drinking water for the majority of the inhabitants. The government would like the population to switch to safe public drinking water but is aware that this is not likely to happen soon. Therefore, the government decided to use both economical incentives to keep supporting the use public drinking water and to simultaneously maintain specific regulation and guidelines on the use of rainwater systems. A positive side effect of rainwater harvesting is that the risk of erosion during heavy rainfall is significantly reduced. Next to that, it is a very sustainable and reliable method. It is even proven that rainwater harvesters are more aware of the value of fresh water and are therefore very conscious consumers.

### *Regulations and guidelines*

The USVI are the only country that legally requires cisterns when houses are not able to connect to the public drinking water network. Besides the requirement to build a cistern, specific regulations define both dimensions and construction methods. The BES islands do have local

<sup>227</sup> Herald Mark, interview #17

<sup>228</sup> Henry Smith, interview #18

building codes but they do not include regulations on the construction of rainwater systems. On the BES islands, cisterns are generally too small and do not compensate for modern water consumption patterns. Next to that, many sanitary problems are related to the construction, location and materials of cisterns. Based on the positive experience with cistern construction regulations on the USVI, similar legislation should be introduced on the BES islands.

One should recognize that rainwater harvesting is something cultural that will not stop to exist once the BES islands are public entities of the Netherlands. Besides that, natural disasters force the population to be water-independent and rely on their own water insurance (in the form of cisterns). The Dutch government should never try to prohibit private rainwater harvesting because of the water quality risks that are associated with the consumption of rainwater. Instead, the conditions under which rainwater is harvested can be improved by defining proper regulations and guidelines. Since you can't avoid rainwater harvesting, it is more strategic to safeguard the quality of rainwater by some simple building rules and by providing enough information on how to use the system properly. The following regulations and guidelines can support the quantity and quality of rainwater harvesting on the BES islands.

Cistern construction regulations need to include requirements on:

- Capacity of the cistern
- Building materials
- Location of the cistern relative to wastewater systems
- Structural integrity
- Connection with public networks

Guidelines on rainwater use should include information on:

- Rainwater harvesting systems (pros/cons)
- How to construct rainwater systems
- How to maintain/repair systems
- How to disinfect rainwater systems

From experience on the USVI, it is known that providing information or guidelines on rainwater harvesting is not enough. People need to be informed why regulations and guidelines are necessary. People also need to be *aware* of the dangers of drinking contaminated water. Pro-active campaigning and involving local people during information evenings is crucial to bring about knowledge and awareness.

It is important to remark that people themselves are responsible for managing their rainwater system. The government can only implement requirements on the construction of cisterns and provide enough information hoping that it will lead to proper rainwater management.

#### *Rainwater filtration*

It is not recommended to equip households with rainwater filtration systems since the involved sanitary risks *can* be more dangerous than not using the filters at all. If rainwater filters are not maintained, used or installed properly by either the owner or any other public authority, the quality of the filtered water can come in danger. The initial starting point of the Ministry of VROM was to install every household on the BES islands with personal filtration systems. These systems could either be maintained privately or publically. However, due to the potential risks is recommended that the government does not support the use of such filtration systems.

It seems to be more safe and effective to provide proper guidelines and instructions on how to disinfect rainwater systems using chlorine. This can be done by initiating public campaigns and by providing information via the local media.

## Emergency drinking water supply

Problem area:

- Continuity of drinking water supply

The USVI are located in the Caribbean hurricane belt, therefore there is an annual risk of being hit by a hurricane or major tropical storm. There is also the

significant risk of seismic activity on the islands. In order to safeguard the supply of drinking water on the islands during natural disasters, there are several measures in place.



Figure 61 Drinking water storage tanks on St Thomas

- Emergency storage of drinking water

The public water company maintains large storage capacities for drinking water (see Figure 61). During power failures or other disruptions of the main production processes, drinking water can still be distributed under free gravitation using large water buffer tanks. When the public distribution system is not operational, the population can get free jerry cans filled with water at the public water company. The federal government covers the costs of free drinking water supply during emergency situations. The total emergency capacity of the public water company is approximately 10-12 days under normal distribution conditions<sup>229</sup>.

Storing large amounts of drinking water is not without complications; quality deterioration (water aging), stratification and oxidation within the tanks are some of the problems that are faced by WAPA. It is therefore recommended to spread the total water storage capacity over several water tanks.

- Cistern water storage

Cistern systems serve as the main source of drinking water for the Caribbean. When there is a natural disaster, both communal and private cistern systems form the main lifeline for individual homeowners to provide themselves with water. Based on the average capacity of cisterns, average households can typically remain self-supporting for approximately 1 month<sup>230</sup>. It is important to remark that rainwater harvesting during and after a major hurricane is not recommended since the rainwater collection system tend to be contaminated with salt, debris and other pollutants<sup>231</sup>.

- Emergency RO systems

When no other means of drinking water supply are possible on the USVI, the US National Guard can install and operate mobile drinking water desalination units. The National Guard has

<sup>229</sup> Michael Quetel, interview #16

<sup>230</sup> UNEP, 2009

<sup>231</sup> Henry Smith, interview #18

several reverse osmosis units readily available on the Virgin Islands that can be used under emergency circumstances<sup>232</sup>.

## **Lessons**

The USVI has specific emergency drinking water supply systems. Next to emergency storage capacity at the public drinking water company, there are also emergency drinking water units that can be placed at strategic locations on the islands.

On the field of emergency drinking water provision, lessons can be drawn for the BES islands. Two of the BES islands are located in the hurricane belt and need to be prepared for drinking water supply disruptions. Mobile emergency drinking water production units can be a sound back-up system when the main water production facility is not operational. These units can be operated, maintained and placed by employees of the public water company in cooperation with other public authorities (public works). Another important lesson that can be drawn is that having enough redundancy within your drinking water supply system is crucial. It is important not to depend on only one production plant (or unit) for your whole island, the same goes for your main storage tank<sup>232</sup>. Multiple production units and storage tanks in combination with back-up pumps and other accessories can reduce the risk on water supply disruptions significantly.

## **Protection of water resources**

### *Introduction*

The USVI has different wastewater systems; the majority of the houses on the islands have septic tanks or cesspits. In the more populated areas of the islands, mainly around the major cities, public sewer systems are available. On all other parts of the islands, people rely on their private wastewater systems.

### *Central sewage systems*

By local VI regulations, once you are located within 60 feet of the system, you are required by law to connect to the public sewer system. The sewerage user fee is incorporated into the property tax bill. The Division of Wastewater outsources the sewerage treatment process to private companies.

The Virgin Islands have 8 sewerage systems, mainly in the more densely populated areas of St Thomas, St Croix and St John. With these systems, approximately 60% of the total raw sewerage production on the USVI is collected, pumped, treated and disposed using 8 wastewater treatment plants. The total daily load of the combined treatment plants is 17.000 m<sup>3</sup>. The treatment plants are 'Sequencing Batch Reactors' (SBR), using an activated sludge process with aeration and sludge settlement in the same tank. The treated wastewater is disinfected using UV systems. The treatment process is subjected to EPA and local VI regulations; the quality of the residual meet NSF protocol P151 standards. The treated wastewater is currently disposed into the ocean<sup>233</sup>.

The Division of Wastewater that is responsible for the collection and disposal of wastewater is planning secondary treatment plants next to the existing plants. The secondary treatment step makes it possible to reclaim the treated wastewater for agricultural purposes or groundwater recharging. This so-called 'water reclamation project' makes it possible to provide a year-round water source for local farmers<sup>234</sup>.

According to Dr. Smith, Professor at the Water Resources Department of the University of the Virgin Islands, it is not efficient to dispose the treated wastewater into the ocean. "The quality of the treated wastewater is high and with quite simple and relatively cheap methods this water

---

<sup>232</sup> Michael Quetel, interview #16

<sup>233</sup> Henry Smith interview, interview #17

<sup>234</sup> Website VI Division of Wastewater, visited on May 8th 2010

could be turned into drinking water". With a secondary treatment step, treated wastewater can be used for potable purposes. A suitable secondary treatment option would be reverse osmosis, using the treated wastewater as input. This is an easier and therefore cheaper process than processing seawater, since the treated water is not salty and contains less organic materials. Since this process is 5 times cheaper than desalinating seawater, it can be an additional source of drinking water<sup>235</sup>. "If not used for drinking water, it can serve many other valued purposes such as groundwater recharging or irrigation".

#### *Private wastewater systems*

In 2000, less than 52% of housing units had public sewer connections, while 45% were on septic tank or cesspool systems. Less than 4% of units were reported as using other means of sewage disposal<sup>236</sup>.

- *Cesspits or cesspool systems*

The majority of the housing units on the USVI and the BES islands use cesspits or leeching cesspool systems. In its most basic form a cesspit is a hole in the ground that receives sewage, the walls of this hole are usually lined with stone or concrete blocks. Solids in the sewerage remain in the pit; effluent is absorbed into the soil below and at the sides of the cesspool. Floating grease and scum collects at the top, liquid seeps into the ground via the sides and bottom of the cesspool<sup>237</sup>. Most of the cesspits and cesspools in the Caribbean are of the leeching type, this means that solids can infiltrate through the bottom of the pit. Non-leeching cesspits detain solids and need to be emptied on a regular basis.

- *Septic tanks*

Septic tanks are quite similar to the cesspits described previously; the natural biological treatment in the system is however more effective. A septic tank is a solid concrete box with one outlet through which the biologically degraded sewerage can flow out. The quality of this water is theoretically higher than the water seeping out of the cesspits. Water is detained within the system for a longer period; the aerobic treatment process can therefore remove more organic materials before disposal<sup>235</sup>.

#### *Problems with septic tanks*

Septic tank and cesspit wastewater systems are a major problem on the USVI. People have cesspits or septic tanks in their house but they seldom function properly or effectively. This is mainly because the systems are poorly designed, constructed or maintained. People generally tend to put more effort and money in designing and constructing a rainwater cistern system than in a wastewater treatment system. An estimated 50% of the private wastewater treatment system does not function properly and form an immediate threat to the environment and public health<sup>242</sup>.

Septic tanks and leeching cesspools depend on the geographical conditions in which the systems are located. The biological degrading process that is necessary for the effluent usually takes place in the soil surrounding the system. The specific geography of volcanic islands plays an important role in the overall effectiveness of the private wastewater systems. "On the USVI, but also on the BES islands (except for Bonaire) the wastewater treatment process basically depends on the cracks in the bedrock and flows directly to the ocean, rather than on any biological processes"<sup>238</sup>. Wastewater is usually flowing out from the wastewater systems through cracks in the volcanic rocks directly to the ocean, rather than being biologically treated. This is mainly due to the fact that wastewater is not really detained and processed in the soil. The soil layer on the islands is very shallow; it is a very thin layer on top of the volcanic bedrock.

---

<sup>235</sup> Michael Quetel, interview #16

<sup>236</sup> Website US Department of Commerce, National Oceanic and Atmospheric Organization, Visited on May 8th 2010

<sup>237</sup> Henry Smith, interview #18

<sup>238</sup> Henry Smith, interview #18

Septic tanks have therefore limited processing capacities on the Caribbean islands<sup>242</sup>. Next to that, private wastewater systems lack proper maintenance; apart from the geological conditions this is the second reason why half of the systems are currently inefficient.

The geographical structure of the islands forces wastewater to flow almost directly to the ocean without further treatment, therefore the water still contains a lot of nutrients. This has a result that algae grow is stimulated and nearby coral reefs will suffocate because they get covered with these algae. Next to that, the quality of ocean intake water for desalination processes can be affected, since wastewater is seeping in at the coastline.

Soil-infiltrated wastewater can permeate through cistern walls and deteriorate the quality of rainwater. These are the same problems as on the BES islands: contamination of rainwater through permeation of wastewater from cesspits<sup>239</sup> and pollution of the ocean leading to suffocation of coral reefs and deterioration of intake water<sup>240</sup>. As a result of these malfunctioning private wastewater systems, all public water systems need to be checked yearly on nitrate levels by VI drinking water regulations<sup>241</sup>.

### *Introduction of public drinking water*

The introduction of the public drinking water network on the USVI in the 1950's initially led to many wastewater problems. Once the drinking water distribution network had been introduced, the consumption pattern of the inhabitants increased. Drinking water is readily available from the tap, without needing further treatment (cistern water). The easiness and freedom that the public network provided to a small number of people already resulted in an increased consumption of drinking water per capita. Traditional cistern water users are very water efficient and consume 10-20 gallons (38-76 liters) per capita per day. With the introduction of public water, people got less efficient and consume around 50 gallons per capita per day (190 liters)<sup>242</sup>. The increase in drinking water patterns automatically resulted in an increased wastewater flow. The water cycle is not a closed system anymore; wastewater systems were initially dimensioned for rainwater consumption patterns. With public water readily available, an additional water flow is now introduced. The existing wastewater systems cannot handle the increased load of wastewater and become less effective or even inoperable. This resulted in more untreated wastewater flowing directly out of the wastewater systems.

"The reason to install a public drinking water network is usually based on a political decision with the intention to raise the living standards of the population"<sup>242</sup>. The opposite effect is often created since the full water cycle is not taken into account; the increased water consumption leads to an increased wastewater flow that can be very dangerous for the overall sanitary circumstances on the island. "Extra wastewater can lead to outbreaks of diseases, pollution of the environment and overall unsanitary situations"<sup>238</sup>.

Introducing public drinking water supply systems on small islands, especially with these specific geological conditions in which leeching is not optimally possible, can be very dangerous. There are several islands in the Caribbean region that were provided with piped water during the last decades, according to Dr Smith "you can see the sewage running down the streets". Therefore, it is very important to take into account a full water cycle when introducing public drinking water systems on small Caribbean islands. Before you can even think of designing a new drinking water supply system, you need to have an operational wastewater plan.

## **Lessons**

### *Consider the hydrological cycle*

---

<sup>239</sup> see appendix J, sub-system "Drinking water quality"

<sup>240</sup> see appendix I, sub-system "Protection of water resources"

<sup>241</sup> Harold Mark, interview #17

<sup>242</sup> Michael Quetel, interview #16

Based on the previous sections on wastewater issues, it is now obvious that the introduction of public drinking water networks on both Saba and Statia need to be matched with appropriate wastewater plans. Considering the examples on both the USVI and other Caribbean islands, the introduction of affordable and high-quality drinking water results in both higher consumption and wastewater patterns. Current private wastewater systems on the BES islands are basically not effective given geological circumstances and are not designed for increased wastewater loads. When the wastewater systems are overloaded, untreated wastewater will spill out causing highly unsanitary circumstances and major pollutions. Considering the existing issues regarding erosion and contamination of water resources by untreated wastewater *and* the expected problems by the introduction of public drinking water, effective measures need to be taken to avoid more damage to the ecosystems.

#### *Adjust construction and management of private wastewater systems*

To avoid capacity problems due to the introduction of public drinking water on Saba and Statia, the existing septic tanks on the islands might need to be expanded, increasing the processing capacity. Over time, leeching cesspits and cesspools might need to be replaced by more effective and less polluting septic tanks.

To stimulate the previous measures, specific building regulations need to be in place, defining requirements on type, capacity, materials and location of new private wastewater systems. Public campaigns need to inform the general public on the importance of maintaining wastewater systems.

To encourage the population to manage their wastewater systems properly, information and guidelines need to be provided by the relevant public authorities.

#### *Collection and treatment of wastewater*

Considering that private wastewater systems do not function properly on Saba and Statia, it is crucial, besides adjusting the design, to also collect wastewater from private systems. This measure is necessary to prevent further nitrification of the coastal zones and contamination of water resources. An additional step is to centrally process the collected wastewater with small treatment plants. The treated water can be used for a variety of agricultural purposes or can be used as a supplementary source of drinking water using a secondary treatment step.

Collecting raw sewerage can either be done using central sewer systems or by using special vacuum trucks. On Saba and Statia mainly vacuum trucks are necessary since the geological circumstances are not favorable for construction full-scale sewer networks. On Bonaire, a central sewer and treatment plant is being developed for the western coastal zone. Vacuum trucks can be used for the remaining wastewater load on the island.

## Lessons for the joint BES islands:

Problem area: Drinking water regulation and inspection	Related criteria
<b>Lessons:</b> Drinking water regulatory authority	
Extend regulatory duties BES drinking water inspection body with private sanitary surveys/inspections	Number of drinking water quality norm exceedings per year
Maintain a limited drinking water actor network for transparency and to prevent complex decision making	
Apply USVI model for cooperation/training national and local regulatory authorities	Number of drinking water shortages per capita per year
Extend regulatory duties BES drinking water inspection body with education/certification activities	
Cooperate with the local building inspection body for the inspection of rainwater cisterns (as on the USVI)	Average yearly costs for drinking water per capita
Drinking water legislation	
Apply specific hygienic and certification regulations for drinking water distribution trucks as on USVI	
Drinking water quality inspection	
Cooperate with other islands for the analysis of drinking water samples (as on the FA)	

## Lessons for Bonaire:

Problem area: Continuity of drinking water supply	Related criteria
<b>Lessons:</b> Emergency drinking water supply	
Maintain sufficient storage capacity at public drinking water plants	Number of drinking water shortages per capita per year
Apply portable RO units for emergency situations	
Public drinking water network	
Apply enough redundancy at public water supply systems	
Problem area: Drinking water quality	Related criteria
<b>Lessons:</b> Solid waste Protection of water resources	
Existing waste management systems on St Barth can serve as an example for Bonaire	Number of drinking water quality norm exceedings per year
Wastewater	
Centrally collect and treat wastewater from the new sewer system, cesspits and septic tanks	Number of drinking water shortages per capita per year
Develop wastewater treatment plants with secondary treatment step for reuse of effluent	
Initiate public information campaigns on private wastewater management	Average costs for drinking water per capita
Define new (building) regulations for the construction of private septic tanks prohibiting cesspits	
	<b>Unofficial criterion:</b>
	Damage of coastal coral reefs
Problem area: Energy efficiency of drinking water production	Related criteria
<b>Lessons:</b> Public drinking water network	
Apply cogeneration for desalination processes (waste to drinking water/power to drinking water)	Total fossil energy consumption for drinking water supply system
	Average costs for drinking water per capita

## Lessons for Saba and Statia:

Problem area: Continuity of drinking water supply	Related criteria
<b>Lessons:</b> Rainwater harvesting systems	
Apply specific building regulations for the construction of rainwater cisterns	Number of drinking water shortages per capita per year
Emergency drinking water supply	
Maintain sufficient storage capacity at public drinking water plants	Emergency drinking water capacity in days
Apply enough redundancy at public water supply systems	
Apply portable RO units for emergency situations	Average yearly costs for drinking water per capita



**Problem area: Accessibility of public drinking water**
**Related criteria**

Introduction/ extension public drinking water network	Percentage of households connected to drinking water supply system
Provide public information/initiate campaigns/involve inhabitants when introducing public water network	
Initiate economic incentives to stimulate the use and consumption rates of public water	
Develop initially limited distribution systems, expand systems over time	

**Problem area: Quality of drinking water**
**Related criteria**

<b>Lessons:</b>	Protection of water resources	Number of drinking water quality norm exceedings per year
Solid waste	Cooperate with existing waste management systems on St Barth	
Wastewater	Develop wastewater management plans for Saba and Statia before extending drinking water supply	Number of drinking water shortages per capita per year
	Centrally collect and treat wastewater from cesspits and septic tanks	
	Develop wastewater treatment plants with secondary treatment step for reuse of effluent	<b>Unofficial criterion:</b>  Damage of coastal coral reefs
	Initiate public information campaigns on private wastewater management	
	Define new (building) regulations for the construction of private septic tanks prohibiting cesspits	
	Rainwater harvesting systems	
	Apply regulation that prohibits physical integration of rainwater and public water systems	
	Apply double anti-return valves for public water network to prevent cross-contamination	
	Apply information campaigns on proper use and disinfection of rainwater systems	
	Disapprove public distribution and installation of private rainwater filtration systems	

**Problem area: Energy efficiency of drinking water production**
**Related criteria**

<b>Lessons:</b>	Public drinking water network	Total fossil energy consumption for drinking water supply system
	Apply cogeneration for desalination processes (power to drinking water)	
		Average costs for drinking water per capita

## Appendix N Integration of lessons with conceptual instruments

### Implementation of lessons

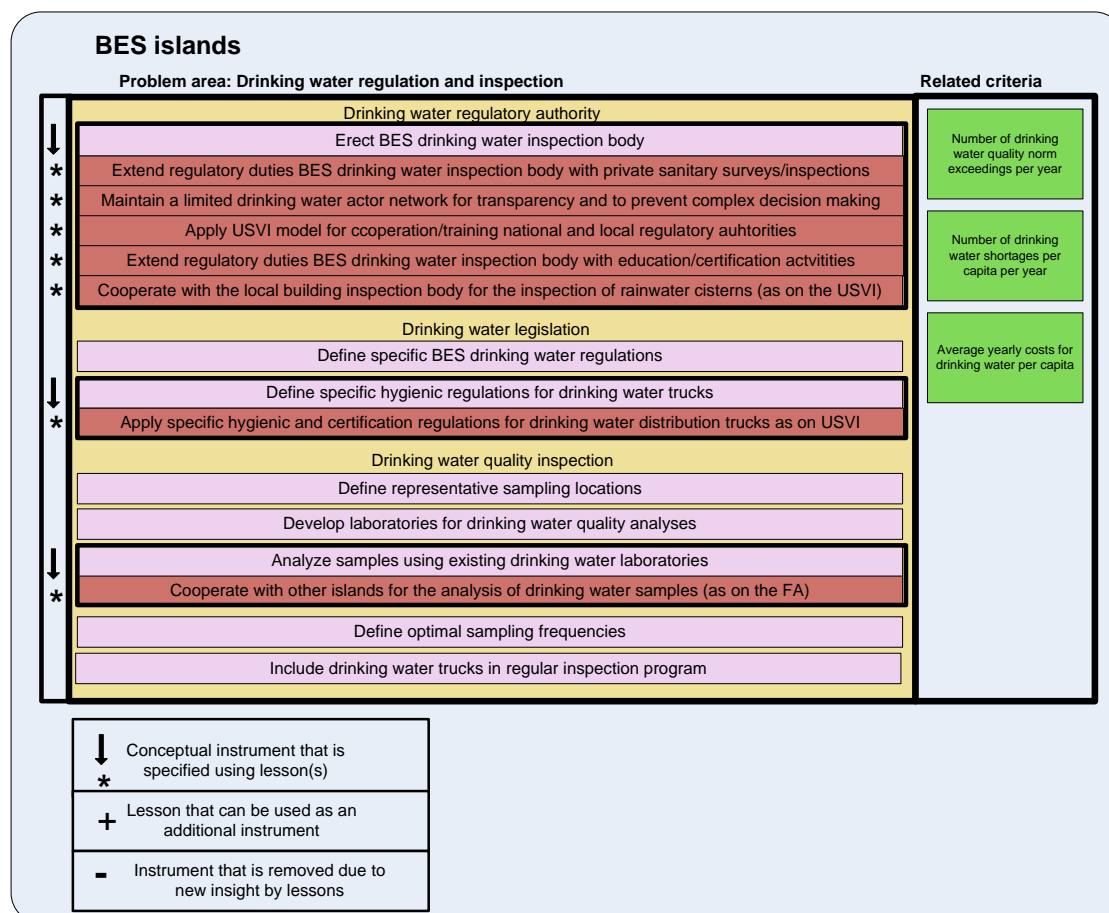
Chapter 4 provides the basis of design for the drinking water supply system on the BES islands. Based on interviews with drinking water stakeholders, conceptual instruments (policy, organizational and technical) have been gathered that are likely to mitigate some of the existing problems. These lessons are now combined, integrated or removed by the newly adopted lessons from the appointed source sites.

The *instruments* from chapter 4 are categorized into specific problem areas, some of the instruments are related to multiple problem areas (see appendix I,J). The *lessons* that have been gathered in chapter 6 are also categorized into the same problem areas (see appendix M). In this section, the instruments and lessons have been combined, leading to a new arrangement and specification of instruments.

Per problem area will be determined what aspects of the lessons will be transferred and how this can be done taking into account the existing initial instruments. Next to that, the actors will be determined that necessary for this transplantation process.

### BES islands

By defining fitting BES drinking water regulations and maintaining a well-organized regulatory authority, the chance that drinking water quality exceedings occur will decrease (see appendix I and J). Next to that, positive influences are expected for the total number of water shortages and the overall drinking water price.



### *Drinking water regulatory authority*

The instrument '*Erect a BES drinking water inspection body*' provides a very general solution to the existing regulatory problem. Since there is no effective drinking water regulatory authority functional on the islands, a new local authority needs to be defined supervised by the VROM Inspection authority. According to the actor analysis in chapter 5, the VROM Inspection authority is likely to become responsible for the overall regulation and inspection of drinking water. The local health authorities are likely to be delegated some of the responsibilities and tasks of the National Inspection authority. An interesting framework for defining a regulatory system in which a national and local regulatory authority are involved is provided by the US Virgin Islands' Department of Planning and Natural resources. An additional lesson is drawn on the French Antilles on the range of duties that such a regulatory authority can execute. The following instruments provide guidelines and inspiration to define the organizational structure of these future authorities:

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Extend regulatory duties BES drinking water inspection body with private sanitary surveys/inspections	Policy instrument	Inspiration	-Ministry of VROM -VROM Inspection -Local health authorities
Maintain a limited and transparent drinking water regulatory actor network to prevent complex decision making	Institution	Inspiration	-Ministry of VROM -VROM Inspection -Local health authorities
Apply USVI model for cooperation/training national and local regulatory authorities	Institution	Synthesis	-Ministry of VROM -VROM Inspection -Local health authorities
Extend regulatory duties BES drinking water inspection body with education/certification activities	Idea	Inspiration	-Ministry of VROM -VROM Inspection -Local health authorities
Cooperate with the local building inspection body for the inspection of rainwater cisterns (as on the USVI)	Policy instrument	Inspiration	-VROM Inspection -Local health authorities -BES building inspection

### *Drinking water legislation*

Currently there are no specific regulations on the distribution of drinking water using water trucks. The USVI provided an important lesson on what kind of legislation is used to regulate, inspect and certify drinking water trucks. This lesson can be used as a specification of the conceptual instrument '*Define specific hygienic regulations for drinking water trucks*'.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Apply specific hygienic and certification regulations for drinking water distribution trucks	Policy instrument	Adaptation	-Ministry of VROM -Vrom Inspection Authority -Local Health Authorities

### *Drinking water quality inspection*

The French Antilles provided a successful example on how the small French Collectivitees cooperate with a drinking water laboratory on the larger island of Guadeloupe for the inspection of drinking water quality samples. This lesson can serve as a specification of the existing instrument '*Analyze samples using existing drinking water laboratories*'. The French Antilles prove that it is logistically and technically possible to distribute drinking water samples to existing drinking water laboratories on nearby islands.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Cooperate with other islands for the analysis of drinking water samples (as on the French Antilles)	Policy instrument	Inspiration	-VROM Inspection Authority -Local Health Authorities

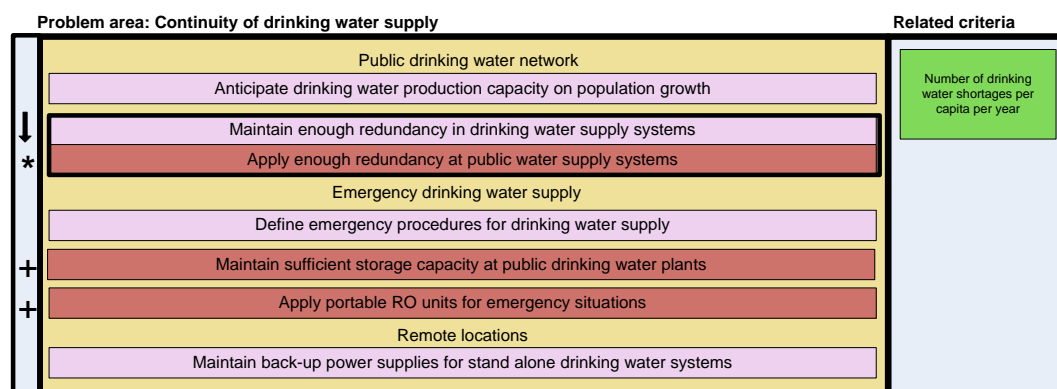
			-Drinking water laboratories
--	--	--	------------------------------

## Bonaire

The lessons that are drawn for application on Bonaire relate to three different problem areas:

- Continuity of drinking water supply
- Energy efficiency of drinking water production
- Drinking water quality

### Continuity of the drinking water supply system



By improving the continuity of the drinking water supply system on Bonaire, the chance on drinking water shortages is likely to decrease. Most of the lessons focus on the reliability of the public distribution network and the application of emergency measures during calamities.

### Public drinking water supply

The US Virgin islands provided a lesson that confirmed the importance of the proposed instrument 'Maintain enough redundancy at drinking water supply systems'.

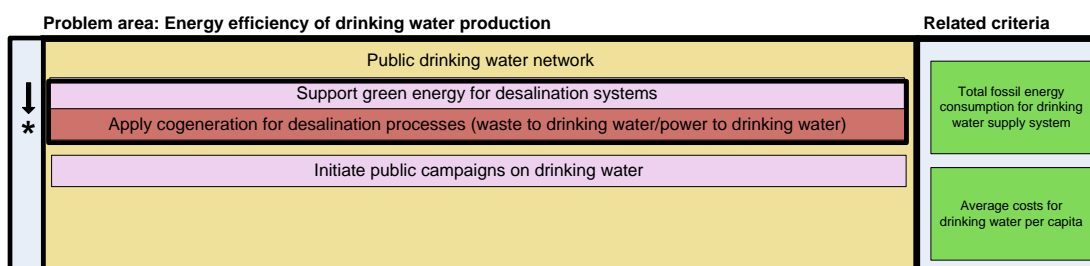
Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Apply enough redundancy at public water supply systems	Policy instrument	Adaptation	- Public drinking water producers -Public drinking water distributors

### Emergency drinking water supply

Lessons that were drawn on the US Virgin Islands on the supply of emergency drinking water serve as additional instruments for Bonaire.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Maintain sufficient storage capacity at public drinking water plants	Policy instrument	Adaptation	-Public drinking water producers
Apply portable RO units for emergency procedures	Technical instrument	Adaptation	-Public drinking water producers -Local Health Authorities -Public works dept.

### Energy efficiency of drinking water production

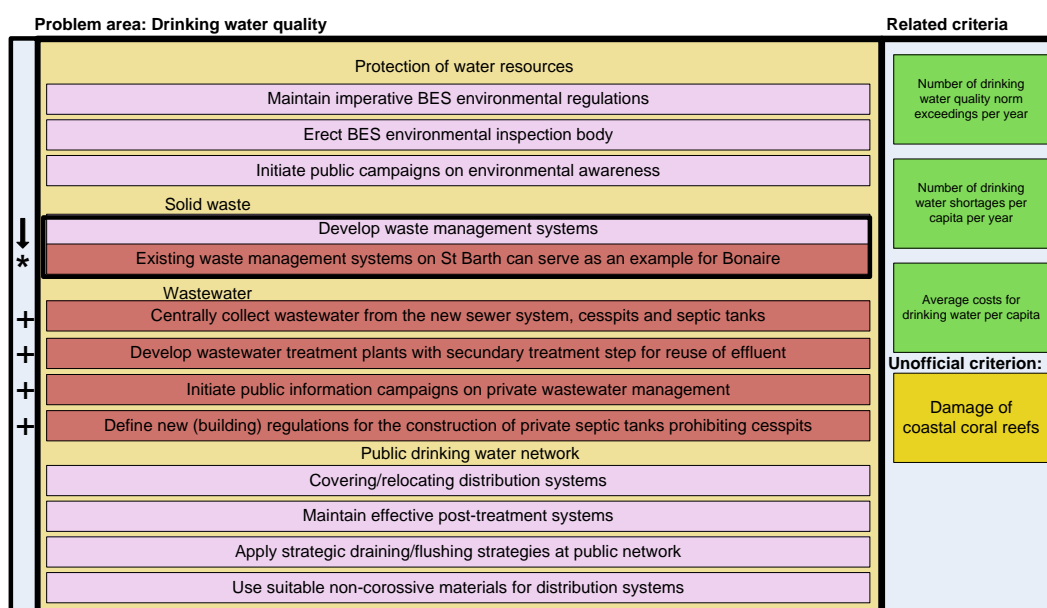


The desalination process of drinking water is highly energy intensive; the price of drinking water is therefore related to the price of fossil fuels. By using other sustainable energy sources, both the price of drinking water and the consumption of fossil fuels can be reduced.

Both the French Antilles and the US Virgin Islands provided interesting lessons on how energy can be saved by applying cogeneration.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Apply cogeneration for desalination processes (waste to drinking water/power to drinking water)	Technical instrument	Inspiration	-Public drinking water producers -Utilities companies -Island Governments

## Drinking water quality



Lessons are drawn on the US Virgin Islands that concern the protection of water resources. By developing waste management programs and facilities on Bonaire, pollution of the soil, ocean (and therefore production intake-water) and the suffocation of coral reefs can be prevented. The chance that quality norm exceedings will occur on the island should therefore decrease. Additional advantages are that the chance on drinking water shortages and the average drinking water price are likely to decrease (see appendix I and J).

### *Protection of water resources: Solid waste*

The French island of St Barth has its own solid waste collection and treatment system. This system serves as a good example and specification of the existing instrument to 'Develop waste management systems' on Bonaire.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Existing waste management systems on St Barth can serve as an example for Bonaire	Technical instrument	Inspiration	-Ministry of VROM -Island Govt. Bonaire -Selibon (Dept. of waste)

### *Protection of water resources: Wastewater*

Lessons on private wastewater systems are mainly derived as negative experiences on the US Virgin Islands. The problems that they faced with private wastewater systems need to serve as useful information for Bonaire and the BES islands in general. The negative experiences on the USVI can now be used as additional instruments on the BES islands.

Other lessons concern the collection and treatment of wastewater; these lessons can be used as valued additional instruments to increase the protection of water resources.

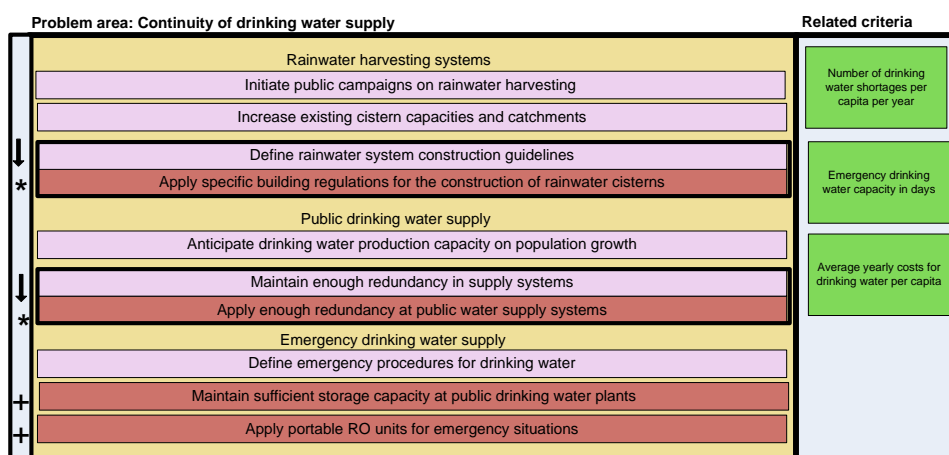
Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Centrally collect wastewater from new sewer system, cesspits and septic tanks	Technical instrument	Inspiration	-Island Government -Ministry of VROM -Ministry of V&W -Selibon
Develop wastewater treatment plants with secondary treatment step for reuse of effluent	Technical instrument	Inspiration	-Island Government -Ministry of VROM -Ministry of V&W -Selibon
Initiate public campaign on private wastewater management	Policy instrument	Synthesis	-Ministry of VROM -Local Health Authorities
Define new building regulations on the construction of private septic tanks	Policy instruments	Synthesis	-Ministry of VROM -Local Building Dept.

## Saba and Statia

The lessons that are drawn for application on Saba and Statia relate to the following problem areas:

- Continuity of the drinking water supply system
- Energy efficiency of the drinking water production
- Quality of drinking water
- Accessibility of public drinking water

### Continuity of the drinking water supply system



This problem area focuses on the integration of rainwater cistern systems and the development and expansion of public drinking water supply systems. Another important aspect is the development of both emergency drinking water procedures and facilities since the islands very vulnerable for natural disasters (hurricanes, seismic activity). These topics directly relate to the chance that drinking water shortages occur, the availability of emergency drinking water supplies and the also the total costs for drinking water.

#### *Rainwater harvesting systems*

Most lessons concerning rainwater harvesting have been drawn on the US Virgin Islands. From literature it was known that the USVI have implemented specific regulations that prescribe capacity, materials, construction method and the location of rainwater cisterns. These regulations give interpretation to the existing instrument 'define rainwater system construction guidelines'.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Apply specific building regulations for the construction of rainwater cisterns	Policy instrument	Adaptation/Synthesis	-Ministry of VROM -Local Health Authorities -Local Building Dept.

#### *Public drinking water supply*

The lesson 'apply enough redundancy at the public water supply systems' serves the same function as on Bonaire and specifies the existing instrument 'maintain enough redundancy at supply systems'.

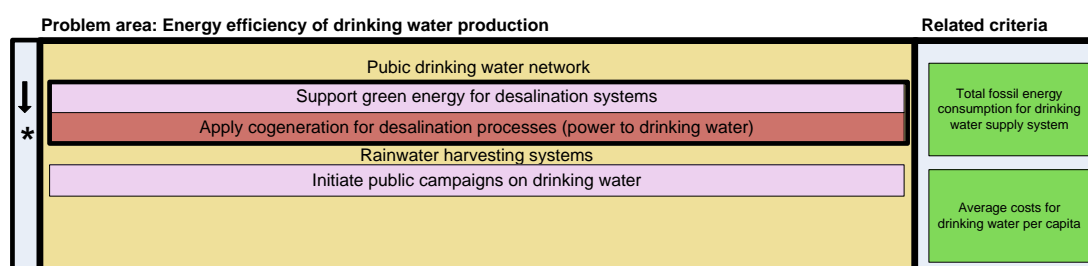
Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Apply enough redundancy at public water supply systems	Technical instrument	Inspiration	- Public drinking water producers -Public drinking water distributors

#### *Emergency drinking water supply*

Two additional instruments are included following from lessons on the US Virgin Islands. These are the same instruments as used for Bonaire in section 8.4.1.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Maintain sufficient storage capacity at public drinking water plants	Policy instrument	Adaptation	-Public drinking water producers
Apply portable RO units for emergency procedures	Technical instrument	Adaptation	-Public drinking water producers -Local Health Authorities -Public works dept.

### Energy-efficiency of drinking water production

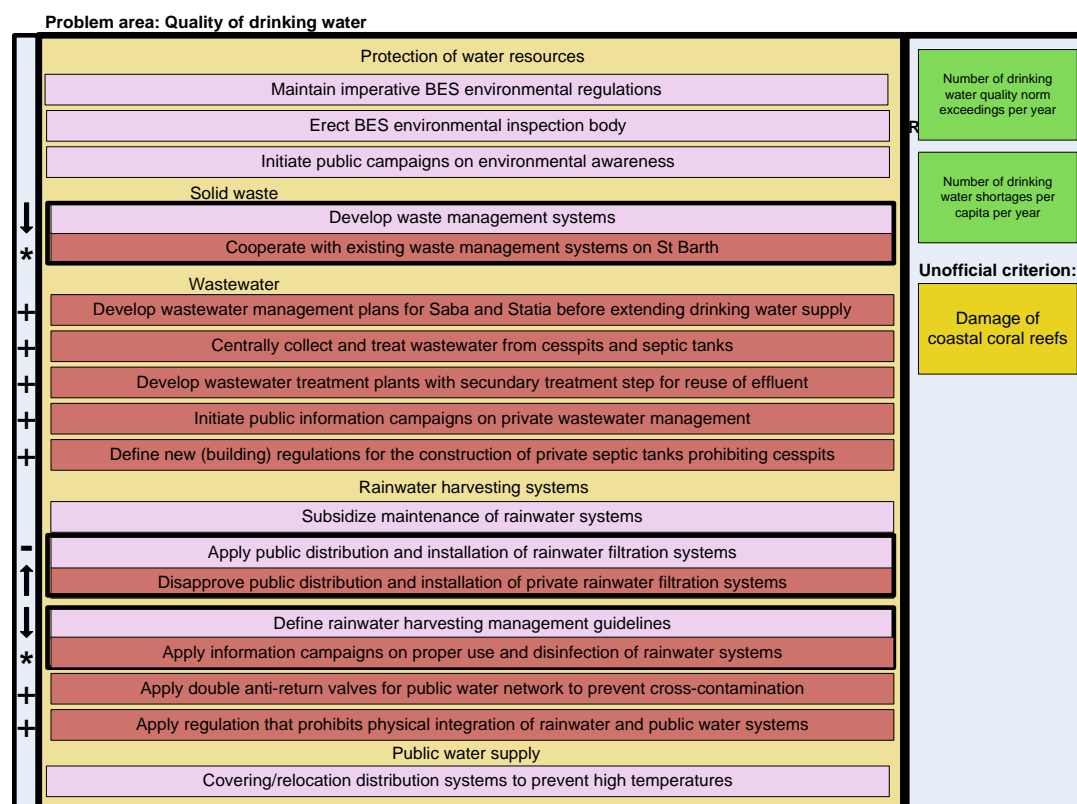


### Public drinking water network

One additional instrument has been added, see section Bonaire 8.4.2.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Apply cogeneration for desalination processes (waste to drinking water/power to drinking water)	Technical instrument	Inspiration	-Public drinking water producers -Utilities companies -Island Governments

### Quality of drinking water



This problem area is almost similar to Bonaire, the main difference is that it includes an additional section about the use of rainwater harvesting.

### Protection of water resources: Solid Waste

The French island of Saint Barth provided a good example of how solid waste can be collected and treated. Unlike Bonaire, Saba and Statia are too small to implement a similar waste processing system. They can however try to cooperate with St Barth's system in order to solve their solid waste issues in an efficient and sustainable way. This lesson serves as a specification of the original instrument: *'Develop waste management systems'*.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Cooperate with existing waste management systems on St Barth	Policy instrument	Inspiration	-Ministry of VROM -Island Govt. of Saba/Statia -Island Govt. of St Barth -Dept. of Public Works



### *Protection of water resources: Wastewater*

The lessons that have been drawn on the US Virgin Islands regarding wastewater apply to both Bonaire and Saba/Statia. One additional lesson is specific for Saba/Statia: *'Develop wastewater management plans for Saba and Statia before extending drinking water supply systems'*. Since both Saba and Statia have plans to provide the inhabitants with public drinking water, future wastewater plans are essential.

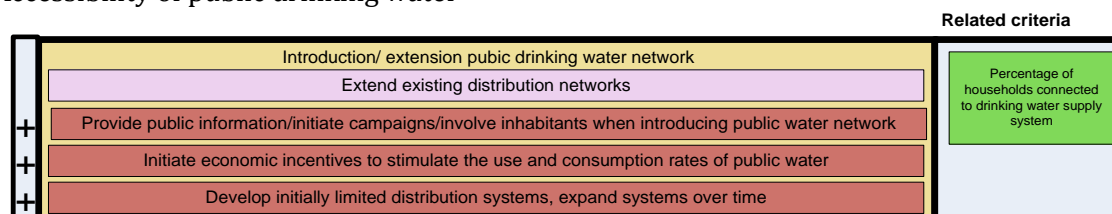
Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Develop wastewater management plans for Saba and Statia before extending drinking water supply systems	Negative lesson	Inspiration	-Island Governments -Ministry of VROM -Ministry of V&W
Centrally collect wastewater from new sewer system, cesspits and septic tanks	Negative lesson	Inspiration	-Island Governments -Ministry of VROM -Ministry of V&W
Develop wastewater treatment plants with secondary treatment step for reuse of effluent	Technical instrument	Inspiration	-Island Governments -Ministry of VROM -Ministry of V&W
Initiate public campaign on private wastewater management	Policy instrument	Adaptation	-Ministry of VROM -Local Health Authorities
Define new building regulations on the construction of private septic tanks	Policy instrument	Adaptation	-Ministry of VROM -Local Building Dept.

### *Rainwater harvesting systems*

Specific lessons on the integration of rainwater harvesting systems within the drinking water supply system are drawn on the US Virgin Islands. These lessons provided material for new instruments but they also led to adjustment of one existing instrument *'Apply public distribution and installation of private rainwater filtration systems'*.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Disapprove public distribution and installation of private rainwater filtration systems	Negative lesson	Inspiration	-Island Governments -Ministry of VROM -Ministry of V&W
Apply information campaigns on proper use and disinfection of rainwater systems	Policy instrument	Adaptation	-Island Governments -Ministry of VROM -Local Health Authorities
Apply double anti-return valves to prevent cross-contamination	Technical instrument	Adaptation	-Ministry of VROM -Public drinking water distributors
Apply regulation that prohibits physical integration of rainwater and public water systems.	Policy instrument	Adaptation	-Ministry of VROM -Local Building Dept.

### Accessibility of public drinking water



Extensive drinking water supply networks are currently not available on Statia and Saba. The US Virgin Islands showed that the transition from rainwater to public drinking water can be quite slow and not without further issues. Based on these lessons, additional instruments can be formulated for the BES islands.

### *Introduction/extension public drinking water network*

The following lessons are added to the existing instruments.

Lesson:	What is transferred:	Degree of transfer:	Actors involved:
Provide public information/initiate campaigns/involve inhabitants when introducing public water network	Negative lesson	Inspiration	-Island Governments -Ministry of VROM -Local Health Authorities
Initiate economic incentives to stimulate the use and consumption rates of public drinking water	Policy instrument	Inspiration	-Island Governments -Ministry of VROM -Public drinking water producers/distributors
Develop initially limited distribution systems, expand over time	Negative lesson		-Ministry of VROM -Public drinking water distributors

## Conclusion

The majority of the lessons that were drawn in the previous chapter are institutional and technical instruments that need to be adjusted for implementation on the BES islands. The degrees of transfer vary from *adaptation*, *synthesis* to *inspiration*. In that latter case, customized instruments need to be defined to fit the conditions at the BES islands. Another important group form the ‘negative lessons’, these are useful in the sense that they can avoid or mitigate problems that were previously experienced at the source sites. These negative lessons also need to be transferred into policy and technical instruments.

The lessons are not always new; similar conceptual instruments have already been defined with the same goal/tactic. In that case the lesson can serve as a confirmation of the usability of the existing instruments, or they can specify the instrument in more detail.

For transplantation and implementation of the previous lessons, the Ministry of VROM needs to cooperate closely with local public authorities and drinking water companies.

The lessons generally focused on the following issues:

- BES drinking water regulatory authority
- Integration of rainwater systems
- Programs for waste and wastewater
- Emergency supply of drinking water
- Extension/introduction of public drinking water supply systems





Delft University of Technology, Faculty of Technology,  
Policy and Management

Ministry of Housing Spatial Planning and the  
Environment (VROM)

**Author: Rick Reijtenbagh**

**Thesis committee**

Professor: Dr. ir. W.A.H. Thissen Faculty of TPM,  
Policy Analysis

1st Supervisor: Dr. ir. L.M. Hermans Faculty of TPM,  
Policy Analysis

External supervisor: ir. F.A.M. Swinkels Ministry of  
VROM, VROM Inspectie

2nd Supervisor: Dr. ir. B. Broekmans Faculty of TPM,  
POLG

External supervisor: Dr. ir. J.Q.J.C Verberk Faculty of  
CitG, Sanitary Engineering

