

Number of the programme	P12-27																		
Title of the programme and acronym	WATER NEXUS – salt-containing water as a new driver for economy in delta areas																		
Programme leader	Prof. dr. Ir. H.H.M. Rijnaarts, Wageningen University, Environmental Technology																		
Participating organisations	<p>Applying research institutes: Utrecht University - Physical Geography; Delft University of Technology - Water Resources Management, Environmental Biotechnology; Wageningen University – Soil Physics and Land Management, Environmental Technology; Leiden University – Catalysis and Surface Science; University of Twente – Membrane Science and Technology; VU University of Amsterdam – Systems Ecology; University of Amsterdam – Institute for Biodiversity and Ecosystems Dynamics.</p> <p>Potential users: - Knowledge institutes: Alterra, Deltares, TNO, KWR Water Cycle Research Institute (note these institutes also have commercial consulting activities) - Companies: Eijkelkamp, Pentair, Priva, Nijhuis, Magneto, Paques, RoyalHaskoningDHV, Grontmij, Fugro Geoservices, Shell, Dow Benelux, Oasen - Other organisations: STOWA. Hoogheemraadschap van Rijnland, WLN</p>																		
Duration of the programme	<i>(Maximaal 6 jaar)</i>																		
Budget <u>Personnel positions:</u> X PhD students X Postdocs X Other temporary scientific personnel, including additional researcher, holders of a masters degree, medical graduates X Non-scientific personnel, including technical assistant X Casimir candidates X PDEng trainees	<p>Programme budget (€)</p> <table> <tr><td>- programmatic activities:</td><td>0</td></tr> <tr><td>- personnel costs:</td><td>3.196.296</td></tr> <tr><td>- consumables:</td><td>1.024.853</td></tr> <tr><td>- travel abroad:</td><td>183.000</td></tr> <tr><td>- equipment:</td><td>566.368</td></tr> <tr><td>- Total:</td><td>€ 4.970.510</td></tr> </table> <p>Contribution by users / other parties</p> <table> <tr><td>- <i>in cash:</i></td><td>1.420.000</td></tr> <tr><td>- <i>in kind:</i></td><td>1.389.991</td></tr> <tr><td>- Total:</td><td>€ 2.809.991</td></tr> </table> <p>Requested budget from STW (€) €3.550.510</p>	- programmatic activities:	0	- personnel costs:	3.196.296	- consumables:	1.024.853	- travel abroad:	183.000	- equipment:	566.368	- Total:	€ 4.970.510	- <i>in cash:</i>	1.420.000	- <i>in kind:</i>	1.389.991	- Total:	€ 2.809.991
- programmatic activities:	0																		
- personnel costs:	3.196.296																		
- consumables:	1.024.853																		
- travel abroad:	183.000																		
- equipment:	566.368																		
- Total:	€ 4.970.510																		
- <i>in cash:</i>	1.420.000																		
- <i>in kind:</i>	1.389.991																		
- Total:	€ 2.809.991																		

Keywords:

Saline water, water treatment, water harvesting, cascading, wetlands, membranes, electrochemical removal, microbiology, water management, resource mapping

A. Description of the programme

1. Summaries

1.1 Summary of the programme objectives, focus and ambitions

The ambition of the program WATER NEXUS is to develop integral solutions for problems with water scarcity in delta areas worldwide. The central paradigm shift is to consider saline (salt containing) water as a resource, and not as a threat: saline water where possible, freshwater where essential.

Worldwide, delta areas are of immense economic importance: dense concentration of population, industry and agriculture. Half the world's population will live in delta areas this century. The economy of delta areas relies on freshwater. Severe scarcity is imminent due to growing demand and saltwater intrusion. Present attempts to find solutions are fragmented (focusing on partial solutions) and are often connected with high costs and poor sustainability. Furthermore, it is clear that these solutions cannot create sufficient water quantities to really solve the scarcity. For a genuine breakthrough, a radically different approach is needed: integral water quantity and quality management. WATER NEXUS will develop a coherent set of technologies that will enable such a breakthrough. It focuses on large volume sectors (agri/horticulture and industry) with a high impact in solving scarcity.

WATER NEXUS is a paradigm shift in water sourcing and use. Saline water is not treated as a threat but as an opportunity: creating alternative water sources for economic use - saline water as a new economic driver – and protecting essential freshwater resources:

- *Water distribution control:* control models are developed to create an optimal spatial distribution of saline and freshwater (saline water where possible, freshwater where essential).
- *Alternative sources:* treatment technologies are developed to make saline water suitable for large, specific applications (such as cooling and agriculture), with minimal costs, i.e. only removing those substances that hinder use (e.g. monovalent salts), and maintaining substances beneficial to use (e.g. nutrients).

Key to WATER NEXUS is that it covers the entire innovation chain: partners involved are universities, institutes for applied research, technology providers, consultants and end users (including Dutch water managers). WATER NEXUS combines excellence in fundamental and applied sciences with application knowledge from private companies.

1.2 Summary of the applications and industrial and/or societal relevance

Good quality freshwater is essential for public health, food production and certain types of industry. Worldwide, freshwater scarcity is an immense problem, and rapidly increasing:

- For agriculture the shortage already is more than 100 billion m³/yr.
- For domestic use, a shortage of 50% is forecasted for 2020.
- For industry demand in 2025 is predicted to be at twice the level of the year 2000.

The pressure on resources from growing demand (and increasing pollution) is enhanced by predicted changes in climate (extremes in drought and precipitation and rising sea levels) and soil subsidence (saltwater intrusion)¹.

WATER NEXUS is unique in its integral approach of water scarcity. It creates practical, high impact, solutions that can be implemented by authorities and large industries to safeguard and control water availability on both the short and the long term. Other programs like the MIT Global Change Program are limited to a description of developments in demand, and do not identify intervention options.

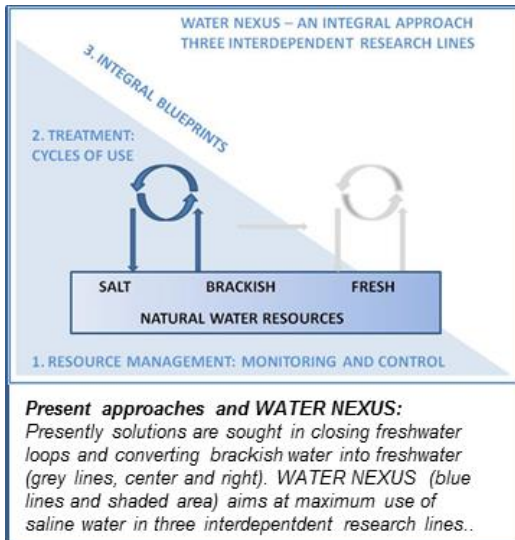
WATER NEXUS solutions offer excellent export opportunities, strengthening the leading position of Dutch institutes and private companies. Worldwide, Dutch knowledge institutes and private companies are recognized as leading in developing integral solutions for water management: treating quantity and quality aspects as inseparable parts of water supply and demand. The Netherlands has a unique research infrastructure including test sites where solutions can be tested in field trials. WATER NEXUS combines validation of models and technologies in a national (using the facilities available) with validation and testing in representative cases abroad. These practical demonstrations of WATER NEXUS solutions can serve as reference projects for future marketing. Users participating in WATER NEXUS are committed to taking the necessary steps for full market implementation after completion of the program.

¹ Soil subsidence is not only caused by natural settling of the sediments in delta areas, but also by over extraction of ground water. An extreme example is the Jakarta area in Indonesia, with a soil subsidence rate of 1 cm/yr (see for instance www.sciencepalooza.nl).

2. Main scientific challenges and research lines

State of the art

Historically, delta areas solely rely on freshwater cycles-of-use, i.e. intake – treatment – use – treatment – discharge. Saltwater intrusion is countered by flushing freshwater through canals and rivers, a well-known practice in the Netherlands. But this approach is no longer sufficient to secure water supply essential for domestic, industrial and agricultural use.



WATER NEXUS innovation

WATER NEXUS is a high impact paradigm shift in water supply: saline water is not treated as a threat but as an opportunity.

The figure to the left compares WATER NEXUS to present developments. Solutions are now sought through saving water by closing loops and by converting brackish water into freshwater (e.g. PURO project in the Netherlands).

In WATER NEXUS saline water is used to protect essential freshwater resources, and to create saline water alternatives for freshwater use.

The program consists of three interdependent research lines: *Resource management*: the focus of this research line is to obtain (and maintain) an optimal spatial distribution of saline and freshwater (saline water where possible, freshwater where

essential) by developing models and control tools for strategic and operational water management. Instead of using scarce freshwater to reach such a distribution – e.g. flushing as described above – saline water is used to push freshwater to critical areas. Special attention will be given to salt concentrations at root zone levels, essential for food production and nature development. Here especially monovalent salts can be detrimental.

- *Treatment cycles of use*: the focus of this research line is to develop treatment technologies enabling the use of saline water as an alternative to freshwater use. Sources can be either natural saline water, or water from industrial production such as from oil and gas production. Technologies are sustainable and cost efficient, removing only those substances that hinder use of saline water (e.g. monovalent salts and pesticides) and maintaining those that are beneficial to the end use (e.g. nutrients).
- *Integral blueprints*: this research line focuses on developing integral solutions, combining the new technologies from WATER NEXUS, for optimal use of freshwater and saline water quantities and qualities. Integral solutions and underlying models will be validated and tested in simulated and practical cases.

Research lines and scientific challenges

WATER NEXUS consists of three research lines, with a total of 5 projects.

Research line 1. Resource management: monitoring and control

The first research line – resource management – develops mapping and control models that enable authorities and large industries to assess vulnerabilities in the water system, and reach an optimal spatial distribution of saline and freshwater. Models developed remove the barrier of lack of data in mapping and include forecasts (climate change and weather variations) that make control more effective.

Project 1.1 Resource analysis and regional water management (project leader: M. Bierkens – UU, participating research groups: Physical Geography – UU, Water Resources Management – DUT)

The focus of the project is to develop models and techniques that enable strategic and operational water management, resulting in an optimal spatial distribution of saline and freshwater, on a regional scale. The project consists of the following parts:

- *Rapid mapping*: combining readily available global data and (a minimum of) earthbound data into models for accurate monitoring and prediction of spatial distribution
- *Rapid modelling*: developing a toolbox for quick and comprehensive model construction and scenario development, enabling identification of vulnerabilities and opportunities for water distribution control, and the robustness of the water system against autonomous and anthropogenic changes.
- *Operational management*: integrating forecasts on weather and water transport into models for prediction-based control of regional water distribution. The models are scalable to enable the assessment of the effects of interventions on both a regional and local scale.

Project 1.2 Local operational water management and control (project leader S. van der Zee – WU, participating research groups Soil Physics and Land Management – WU, Systems Ecology – FU)

This project focuses on operational management and control of water availability on a local (farm or plant) scale. The project consists of the following parts:

- *Anticipatory drainage*: development of a dynamical model coupling the vadose (or unsaturated) zone with ground and surface water enabling prediction based active drainage for water level control.
- *iNurture*: development of a model for water quantity and quality at the root zone, incorporating transpiration and (stochastic) meteorological forcing.
- *iRe-use*: development of a integral model for chemical balance in case of reuse of wastewater.

Scientific challenges research line. The major scientific challenges are:

- *Monitoring*: The main challenge is to develop models that accurately describe spatial distribution by with a minimum of earth bound data. Thorough understanding of the hydrological characteristics of the subsoil and transport flows of water and pollutants is needed to enable accurate modelling based on airborne data. The new models not only reduce monitoring costs significantly, but also enable fast and reliable monitoring in data poor regions.
- *Scalability*: The challenge is to develop models that can 'zoom' between local and regional scale, incorporating both autonomous and anthropogenic changes (e.g. population growth, climate change and water extraction). Authorities responsible for water quantity and quality focus on a regional or delta level. For (large) industries and agriculture, the main focus is local availability (plant or farm scale). However, the impact of industry and agriculture on the water availability on a regional scale is becoming more and more important, and vice versa measures on a regional scale may affect local availability.
- *Quality distributions*: The challenge is to develop models that accurately predict salt levels at the root zone the crucial factor for plant growth. Salt, in particular monovalent salts, have a direct negative effect on plant growth and can induce irreversible deterioration of soil quality. Existing models can predict the presence of water quantities to some extent, but perform poorly on quality distribution. Transport of salts (and other relevant pollutants) through the soil and reliable predictions of saline-freshwater boundaries must be included in the new models.
- *Anticipatory drainage*: The challenge is to combine weather forecasts, smart telemetric measurements of soil humidity and salinity into models that can control drainage systems in such a way that maximum buffering of water can be achieved (levelling out peaks in precipitation) with good control of salinity at root levels. Allowable bandwidth of control is determined by researching plant resistance to salt shock loads.
- *Replenishment of resources*: The challenge here is to fill the knowledge gap on the of pollutants on soil quality. Saline water (including wastewater) can be used to supplement available water quantities, but long term effects of such replenishment are unknown. Pollutant transport and accumulation will be investigated.

Research line 2. Treatment cycles of use²

Research line 2 – treatment cycles of use - develops sustainable, cost efficient treatment technologies that enables the use of saline water in specific, large volume end uses. Targeted technologies remove only those pollutants that prohibit the use of saline water, and maintain substances beneficial to the end use.

Project 2.1 biological nutrient removal (project leader H. Temmink – WU, participating research groups Environmental Technology, Laboratory of Microbiology – WU, Environmental Biotechnology - DUT)

This project focuses on enhancing salt tolerance of anaerobic and aerobic granular sludge processes for nutrient removal. Nutrient removal is important for industrial applications of salt water (preventing growth of micro-organisms). The project consists of the following parts:

- *granule stability*: research on the mechanisms underlying the effect of salts on mechanical granule stability
- *microbial activity*: research on the mechanisms underlying the effect of salts on the microbial composition and activity of granules
- *process development*: developing and testing on pilot scale of processes with improved salt tolerance.

2.3 Electrochemical removal (project leader K. Nijmeijer – UT, participating research groups Membrane Science and Technology – UT, Catalysis and Surface Science – UL, Environmental Technology - WU)

This project focuses on removal of organic pollutants, pathogens and monovalent salts. The technologies developed enable use of industrial (produced) water in agri/horticulture and closing loops in agri/horticulture. Saline water has a high conductivity, which offers excellent opportunities for electrochemical removal. Flexible systems are developed that can treat a wide range of water qualities, combining electrochemical removal with membranes for specific removal. The project consists of the following parts:

² Note, the initial program proposal contained a project 2.2 devoted to eutectic freezing to remove salts. After questions by the evaluation commission, and discussions with a number of parties involved, the conclusion was that the overlap with existing initiatives was large, and WATER NEXUS could not create sufficient added value to justify an additional effort.

- **Electrodes:** development of modified electrode surface (e.g. boron doping or lead oxide anodes) for effective degradation of recalcitrant organic pollutants and attacking cell wall/membranes of pathogens.
- **Membranes:** development of membranes for specific removal of monovalent salts and organic pollutants that cannot be removed with electrochemical treatment.
- **Plant-microbial desalinization cells (PMDC):** development of cells that combine low pressure membrane desalinization with in situ electricity generation.

Scientific challenges research line 2. The major challenges are:

- **Microbiology:** The challenge is to 'push the envelope', i.e. develop processes with higher salt tolerance. Microbiological removal of pollutants has many advantages. Generally speaking, energy use is low and with anaerobic processes biogas can be produced; a green energy carrier. The use of granular sludge, an area where Dutch industry is strong, has additional advantages, as it allows compact (low investment cost) construction. But salt can prohibit granule formation and stability, especially monovalent salts. Developing stable and effective processes requires thorough understanding of the mechanisms underlying granule formation, stability and microbial activity.
- **Electrochemical removal:** The challenge is to develop electrodes that effectively degrade organics (e.g. pesticides that are detrimental for use in agriculture) and recalcitrant fractions of TOCs (especially humics), and neutralize pathogens. Saline water has high conductivity compared to freshwater. Where typically the presence of salts is considered a problem, in fact it is an opportunity for effective removal of pollutants with electrochemical technologies
- **Membranes:** The challenge here is to develop new membrane materials and chemistry that effectively and specifically remove monovalent salts and organic micro-pollutants that cannot be removed electrochemically. Achieving specificity of salt removal takes away the barrier of osmotic pressure limitation of desalination membranes.
- **PMDC:** The challenge is to develop effective, tubular shaped, electrode assemblies combined with specific ion removal membranes and to stimulate the development of electrochemically active micro-organisms.
- **System development:** The challenge is to develop flexible systems that can treat a large variety of water qualities. The components developed in the other work packages are combined and integrated to reach optimal removal efficiency, i.e. coupling pollutant characteristics with properties of electrodes (including electrical loading patterns), membrane chemistry and PMDC-microbial activity.

3. Integral blueprints (project leader (and program leader) H. Rijnaarts – WU, participating research groups Environmental Technology – WU, Institute for Biodiversity and Ecosystem Dynamics – UoA)

Research line 3 – integral blueprints - focuses on the development of integral solutions on system level for practical, high impact, cases. Maximising the use of alternatives for freshwater is supported by developing (real time) models connecting the availability of fluctuating quantities of water of different qualities and a variety of end uses. The project consists of the following parts:

- **Dynamical modelling:** developing modelling techniques for optimal, real time matching of supply and demand.
- **Natural systems:** developing wetland type systems for water purification, storage and biomass production. Model systems will be developed and tested for different climate zones.
- **Integral solutions:** developing integral strategies that combine treatment technologies, boundary conditions for use and dynamical modelling. The strategies will be tested and validated in practical cases.

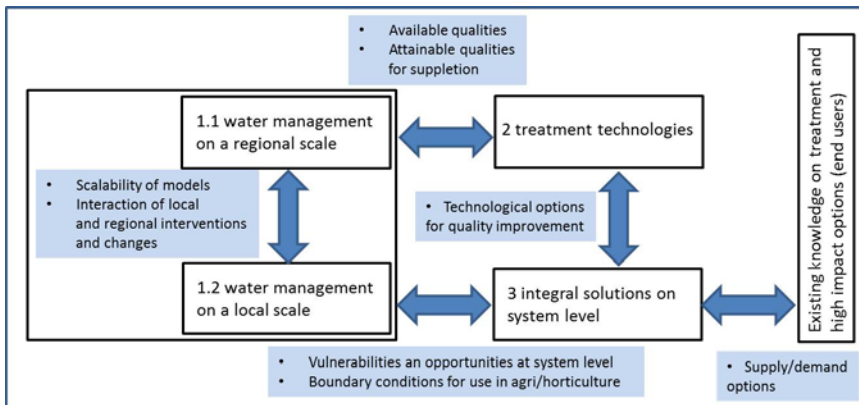
Scientific challenges research line 3. The major challenges are:

- **Dynamical modelling:** The challenge is to develop effective modelling techniques that enable real time matching of supply and demand. Existing models either focus on single pollutants (e.g. pinch analysis) or only produce a static overview of supply and use pathways. The reality is that water supply comes with a mix of pollutants and varies over time.
- **Natural systems:** The challenge here is to remove those substances that limit use and to maintain those substances that promote biomass growth. Wetland type systems offer opportunities for both water purification and large volume storage. The latter can be used to level out temporal fluctuations in supply and demand, safeguarding availability for critical applications. Wetlands can also be used to produce biomass that can serve as feedstock for the biobased economy. Developing wetland systems as a component of supply-demand schemes is particularly interesting for areas where large volumes of water are produced such as in the gas and oil industry, and coal gasification in Northern China. Water typically not only contains salts but also a variety of aromatics.
- **Enabling technologies:** the challenge here is to identify those technological options that open up high impact pathways for use of saline water, as an alternative to freshwater use. New (research line 2) and existing treatment technologies, new knowledge on natural systems (research line 3) and dynamic modelling of supply and demand (research line 3) will be combined with boundary conditions for

applications and reuse (research line 1 and discussions with end users). Integral strategies developed are tested and validated in practical, high impact cases.

Coherence, multidisciplinary, and programmatic value

WATER NEXUS is a multidisciplinary program. Its execution requires a combination of scientific disciplines, such as geohydrology, soil physics, microbiology, membrane technology, electrochemistry, catalysis and surface science, and systems ecology. Scientific disciplines are combined at project level, but also at program level: research line 3 integrates the results of the other projects.



The figure left describes the interactions between the different projects in the WATER NEXUS program. The value of executing WATER NEXUS as a coherent program is self-evident, results are exchanged between project and integrated in research line 3 on a system level. This could never been achieved as effectively with separate projects. The interchange and integration of results is supported by the project organisation (see § 5).

3. Application perspective at the programme level

Societal and economic relevance and impact

Present attempts at finding solutions (e.g. reuse of freshwater) are fragmented and can alone not create sufficient quantities to secure future supply. WATER NEXUS introduces a paradigm shift in water supply and use: treating saline water as an opportunity – saline water where it can, freshwater where it must. By developing integral solutions for water management and enabling the use of saline water as an alternative to freshwater use, WATER NEXUS creates high impact options to meet the future challenges. Agri/horticulture and industry – both users of large quantities of water – are important focal points.

The availability of good quality freshwater is crucial to public health, food production and certain types of industry. Its societal and economic relevance is enormous. Scarcity of freshwater is a large, and rapidly increasing, problem worldwide. The figure below shows some aspects of the problem: existing and forecasted shortages and the location of areas which are most threatened. The map shows that scarcity is by no means limited to developing countries. The largest problems are found in highly developed, and fast growing economies.

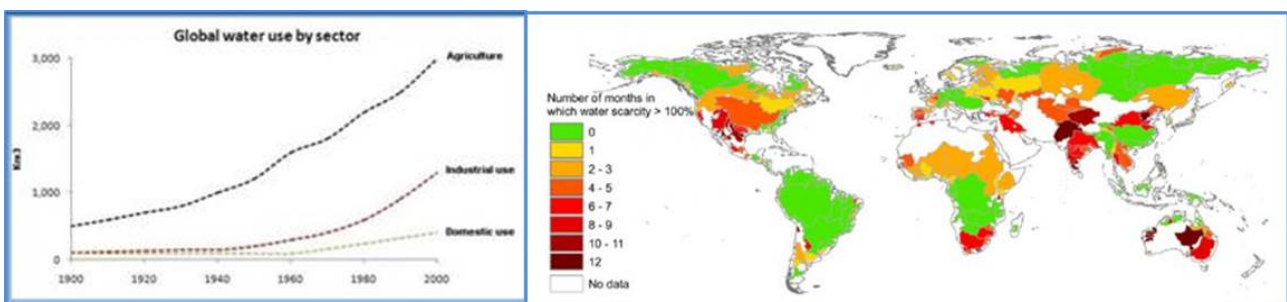


Figure 1: global water use (left), and areas with existing freshwater shortages (right).

Scarcity of freshwater is an immense problem in highly developed areas, and developing economies. Already shortages exist, and shortages are predicted to grow rapidly. For agriculture, worldwide shortage already is more than 100 billion m³/year, for domestic use a shortage of 50% is forecasted for 2020, industrial use is expected to double in 2025, compared to 2000 levels.

Delta areas (and coastal zones) are of special importance to economic activity and development. Two thirds of the world's largest cities are in deltas and coastal zones, and half the world's population will live in delta areas in this century. Availability of freshwater is threatened by growing demand and pollution, aggravated by predicted climate change (rising sea levels and prolonged periods of drought). Solutions must be found to secure good quality freshwater for critical applications, and to improve robustness of water supply to autonomous and anthropogenic changes and interventions.

WATER NEXUS has an international orientation: it aims at solutions for areas worldwide. For the Netherlands, the effects are twofold:

- *Water shortage*: the national water plan predicts freshwater shortages from 2015 onward. Solutions developed in WATER NEXUS can be implemented in the Netherlands. In fact, the Netherlands are an excellent test environment for those solutions as knowledge levels on an integral approach of water quantity and quality issues are high. The Netherlands also has a unique research infrastructure and facilities for field trials.
- *Export opportunities*: the solutions developed in WATER NEXUS provide excellent export opportunities for Dutch private companies and knowledge institutes. Potential end users are both governments and (large) industries. Common practice is that private companies can directly work with industries, whereas governments are best approached by combined groups of applied knowledge institutes (e.g. Deltares, TNO, Alterra and KWR) and private companies. As such knowledge institutes play a pivotal (and business) role in government markets.

The new technologies and models developed in research lines 1 and 3 can be implemented on the short term. In fact, the Netherlands already has a strong position in developing and offering integral solutions for water management. Technologies developed in research line 2 will have a longer time-to-market (in the order of 3-5 years) but implementation profits from the already strong position of Dutch companies, and international presence, in key areas involved.

Demand steering and commitment of users

partner	Description relevant to role in WATER NEXUS	participates in
Technology suppliers		
Eijkelkamp	Supplier of smart, telemetric equipment for moisture measurements, consultant on irrigation planning	1.1, 1.2, 3
Pentair	Supplier of advanced membranes and green membrane systems	2.3
Priva	Supplier of total systems for internal climate control in housing and horticulture, including water treatment	2.3
Nijhuis		2.1
Magneto	Supplier of electrodes and equipment for electrochemical water treatment	2.3
Paques	Supplier of anaerobic water treatment equipment	2.1
RoyalHaskoningDHV	Supplier of aerobic water treatment equipment	2.1, 3
Voltea	Supplier of capacitive deionization equipment for desalinization	2.3
Plant-e	Supplier of PMDC systems	2.3
Consultants (including knowledge institutes with commercial consultancy practice)		
RoyalHaskoningDHV	Consultancy on spatial planning including water systems and water treatment	3
Witteveen+Bos	Consultancy on spatial planning including water systems and water treatment	2.1
Fugro Geoservices	Mapping of (hydro-)geological features and water systems	1.1
Alterra		1.2
Deltares	Consultancy on spatial planning including water systems, and water system infrastructure	1.1, 3
TNO	Consultancy on spatial planning including water systems and water treatment	1.1
KWR	Consultancy on integral planning of water cycles	1.2, 3
End users		
Shell	Producer of oil and gas	1.1, 1.2, 2.1, 2.3, 3
Dow Benelux	Producer of bulk and fine chemicals	2.3, 3
Hollandsce Greenkeeping Mij.	Owner of golf courses and sports fields	1.2
Oasen	Drinking water producer and supplier	2.3
STOWA	Joint research organisation and platform for knowledge dissemination of the Dutch water managers	1.1, 1.2, 3
Hoogheemraadschap Rijnland	Water board, responsible for water quantity and quality control	1.1
WLN	Technology centre of Waterbedrijf Groningen Waterleidingmaatschappij (drinking water producers and suppliers)	2.1, 3

Throughout the definition of the WATER NEXUS program, and detailing of the projects, the involvement of end users has been intensive. Project meetings have been used to define key research questions, concrete market opportunities and project results that can be marketed on the short to midterm. The information of the end users on high impact cases has been crucial in selecting practical cases that can be used for testing of the results, but that also will serve as reference cases in marketing. The WATER NEXUS consortium covers the entire innovation chain, knowledge institutions, technology suppliers, system developers (both private

consultants and applied knowledge institutes), and end users (see table above). The consortium members contribute in cash and in kind (joint research), to a total of more than 35% of the total program budget.

Utilisation

The users are committed to taking the necessary steps for full market implementation after completion of the program. For all research lines, technologies and models developed will be tested in practical circumstances. The involvement of the users is crucial here, as they supply data for practical cases, and facilities for testing. Project deliverables have been defined in such a way that users can readily implement results, i.e. pilot scale tested treatment technologies, and models that can be rapidly converted to software for consultancy practice.

4. Strategic relevance of the programme

Positioning in international research

The integral approach of WATER NEXUS is worldwide unique, and connects to the specific strength of the Dutch industrial and knowledge infrastructure of 'delta technology'. It combines excellence in water management and water treatment technology. Water scarcity in delta areas – areas where half of the world's population will reside in this century – is imminent and rapidly increasing.

Present research programs are fragmented, i.e. focus on partial solutions. Making more efficient use of freshwater resources (closing loops and use of waste water), and converting brackish and saltwater into freshwater are insufficient to resolve the problem of water scarcity, and in many cases are connected with high costs and poor sustainability. Only an integral approach of resource management and water use can provide a real solution. The projects of WATER NEXUS provide the building blocks for this integral approach, enabling control of the distribution of fresh and saltwater, and enabling cost-efficient and sustainable cycles-of –use of saline water.

WATER NEXUS can create a breakthrough in water supply and use, and will strengthen the leading position of the Netherlands in an integral delta approach.

Other initiatives

WATER NEXUS contributes to strategic goals of the Dutch government, and builds on the strengths of the Dutch Delta Approach:

- The Dutch ministry of Economy, Agriculture and Innovation signed the innovation contract 'Delta Technology, bring in the Dutch' of the top sector water. This contract contains the business case 'Living with salt'. This business case will benefit from tools and models developed in WATER NEXUS. WATER NEXUS also contributes to the general export ambitions of the top sector water.
- The NWO³ program 'urbanizing cities of the world', is directed at sustainable economic development in river deltas, with water and food security as primary issues. It can profit from the high impact solutions developed in WATER NEXUS.
- In the prior project 'Knowledge for Climate', an analysis was made of salinity issues in the west of the Netherlands. The knowledge developed, provides a good starting point for WATER NEXUS. Available data can be used to test models and tools developed in research line 1.
- In Wetsus a variety of treatment technologies is developed, including some treatments of saltwater. WATER NEXUS will use the knowledge developed in Wetsus, and will concentrate on complimentary technology to avoid overlap.
- The Center of Expertise Delta Technology (an initiative of the Universities for Applied Sciences of Zeeland, Rotterdam and Larenstein), aims to improve educational programs for delta technology and perform applied research. Students from the universities will be involved in research line 3, in field trials, as part of their training. They will be embedded in the scientific and business oriented environment of WATER NEXUS; a unique and excellent learning experience.
- E4water, an FP7 EU project on reducing water footprint of chemical industry by closing process loops and improving efficiency. It does not provide the integral solutions as WATER NEXUS does.
- MIT Global Change Program, this program and similar initiatives focus on a description of future trends. WATER NEXUS is unique in the sense that trend analysis is combined with developing models, tools and treatment technologies that enable interventions in the water system, to solve scarcity problems.
- As part of the NWO national program for investment in large research facilities, the so-called MODUTECH facility (Modular Biobased and Environmental Sciences and Technology Facility) was created at Wageningen University. This facility offers the opportunity to create simulated ecosystems and will play a central role in research line 3.

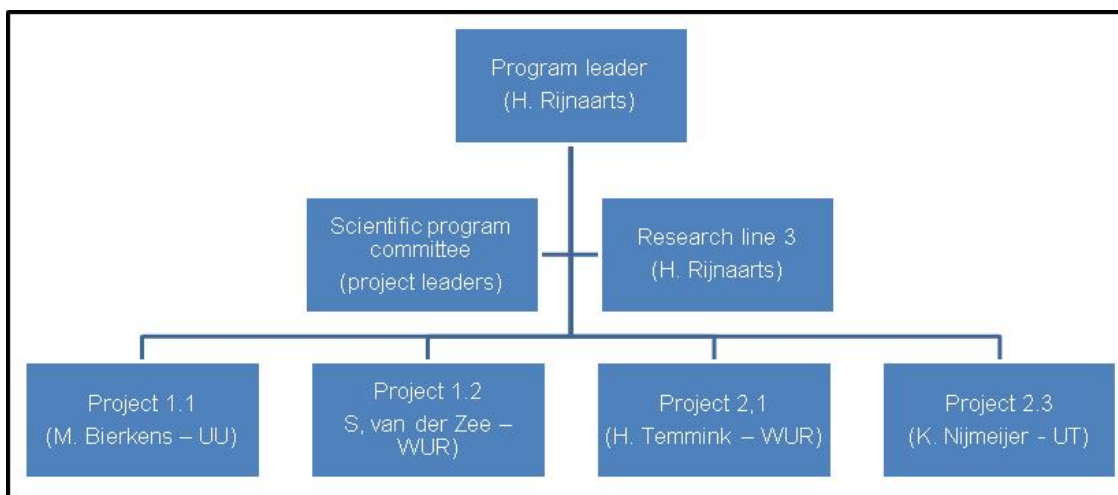
³ The Netherlands Organisation for Scientific Research

Innovation in knowledge networks

WATER NEXUS broadens the scope of solutions offered, and can create real breakthrough solutions. WATER NEXUS combines excellence in fundamental and applied science with excellence in market and application knowledge of private companies, and practical knowledge of key end users. Several of the partners have worked together in smaller groups, but never in consortia on the scale of a program like WATER NEXUS.

5. Structure and organisation of the programme

The organisational structure of WATER NEXUS supports and strengthens the interaction between the research lines and projects described above.



The program leader is directly responsible for exchange and integration of the results:

- He is project leader of research line 3, the research line where all results are combined in integral solutions on system level. He is supported by 3 PhD students and a postdoc, working in research line 3.
- Co-workers of the program leader are active in a several of the projects, part of their role is integration of results at project level. The research group of the program leader, thus, creates a 'natural backbone' for fast exchange of results and synergy options between projects.
- The senior researchers, that act as project leaders, form the scientific committee. The committee, chaired by the program leader, is responsible for scientific progress and forward planning, and exchange of results.
- As is the custom in STW programs, for each project a user committee is formed, consisting of potential users of the results directly connected to the projects. In these users committees, results are discussed from a perspective of utilisation. The user committee of research line 3 serves as an integration platform for the entire program. Focus here is on maximising utilisation options by combining results of all projects.

The exchange of results will further be supported by PhD seminars, organised by the program leader.

Research lines	Projects	Applying research groups ⁴	Potential users
1.	1.1	<ul style="list-style-type: none"> Utrecht University Physical Geography (QANU 4,4,4,5), prof. dr. Ir. M.F.P. Bierkens Delft University of Technology, Water Resources Management (QANU 3,3,4,3), prof. dr. Ir. N.C. van de Giesen 	Eijkelpark, Fugro Geoservices, Shell, Deltares, TNO, Hoogheemraadschap Rijnland, STOWA
	1.2	<ul style="list-style-type: none"> Wageningen University, Soil Physics and Land Management (QANU 4,4,4,4), prof. dr. S.E.A.T.M. van der Zee, prof. dr. C. Ritsema VU University of Amsterdam, Systems Ecology (QANU 4,4,4,5), dr.ir. P.M. van Bodegom 	Eijkelpark, Shell, KWR, HGM, STOWA, Alterra
2.	2.1	<ul style="list-style-type: none"> Wageningen University, Environmental Technology (QANU 4,5,5,4), dr. Ir. B.G. Temmink, Microbiology lab, dr. C.M. Plugge Delft University of Technology, Environmental Biotechnology (QANU 5,4,5,4), prof. dr. Ir. M.C.M. van Loosdrecht 	Paques, RoyalHaskoningDHV, Shell, WLN, Nijhuis, Witteveen+Bos
	2.3	<ul style="list-style-type: none"> University of Twente, Membrane Science and Technology (QANU 4,5,4,5), prof. dr. Ir. K. Nijmeijer Leiden University, Catalysis and Surface Science (QANU 4,3,4,4), prof. dr. M.T.M. Koper Wageningen University, Environmental Technology (QANU 4,5,5,4), prof. dr. Ir. C.J.N. Buisman 	Pentair, Magneto, Shell, Priva, Oasen, Voltea, Dow Benelux, Plant-e
3	3	<ul style="list-style-type: none"> Wageningen University, Environmental Technology (QANU 4,5,5,4), prof. dr. Ir. H.H.M. Rijnaarts University of Amsterdam, Institute for Biodiversity and Ecosystem Dynamics, (QANU 4,4,4/5,3/4), prof. dr. W.P. de Voogt, dr. J.R. Parsons 	Dow Benelux, Shell, Eijkelpark, RoyalHaskoningDHV, Deltares, KWR, STOWA, WLN

Table 1 Schematic overview of the programme

⁴ With the research groups the most recent QANU score is given. QANU is the Dutch rating system for research audits (peer review). 5 (maximum score) = internationally leading, 4 = nationally leading, international player, 3 nationally competitive, internationally visible. Marks are given for scientific quality, productivity, relevance, and viability, respectively.

The research lines have been described in § 2, detailed descriptions of the projects are added as separate files. The table below shows the overall planning of the projects, detailed planning of activities in projects are part of the project descriptions in the separate files.

Table 2. schematic representation of the research planning

Research line	Project	0-6 month	6-12	12-18	18-24	24-30	30-36	36-42	42-48	48-54	54-60	60-66	66-72
1	1.1												
	1.2												
2	2.1												
	2.3												
3	3												

6. Financial planning

Budget	Requested from STW	Co-funding (cash)	Co-funding (in kind)
Programme activities	€ 0	3 PhD seminars, budget neutral	
Project 1.1	Personnel positions: - 3 PhD: € 543.669 - 1 Postdoc: € 119.714 Consumables: € 248.000 Travel abroad: € 79.000 Investment: € 99.618	- TNO € 100.000 - Deltares: € 70.000 - Rijnland: € 60.000 - Shell: € 50.000 - Eijkelpark: € 25.000 - STOWA: € 20.000 - Fugro: € 15.000	- TNO € 100.079 - Deltares: € 123.760 - Eijkelpark: € 11.600 - STOWA: € 12.450 - Fugro: € 100.000
Project 1.2	Personnel positions: - 3 PhD: € 543.669 Consumables: € 347.000 Travel abroad: € 29.000 Investment: € 114.250	- Shell: € 25.000 - Alterra: € 100.000 - KWR: € 70.000 - HGM: € 60.000 - STOWA: € 25.000 - Eijkelpark: € 5.000	- Alterra € 71.400 - KWR € 76.160 - HGM € 17.600 - STOWA € 11.600 - Eijkelpark 12.450
Project 2.1	Personnel positions: - 2 PhD: € 362.446 - 1 Postdoc: € 119.714 Consumables: € 140.000 Travel abroad: € 15.000 Investment: € 135.000	- Shell: € 40.000 - Paques: € 40.000 - RHDHV: € 40.000 - Nijhuis € 40.000 - W+B: € 40.000 - WLN: € 15.000	- Paques: € 10.000 - RHDHV: € 19.040 - Nijhuis € 50.005 - W+B: € 39.400 - WLN: € 5.000
Project 2.3	Personnel positions: - 4 PhD: € 724.892 - 1 NWP: € 44.257 Consumables: € 155.353 Travel abroad: € 28.000 Investment: € 87.500	- Shell: € 50.000 - Dow: € 50.000 - Priva: € 50.000 - Pentair: € 40.000 - Oasen: € 40.000 - Magneto: € 30.000 - Voltea: € 20.000	- Dow: € 48.150 - Priva: € 29.988 - Pentair: € 141.000 - Oasen: € 36.850 - Magneto: € 101.150 - Voltea: € 56.700 - Plant-e: € 101.000
Project 3	Personnel positions: - 3 PhD: € 543.669 - 1 Postdoc: € 194.266 Consumables: € 134.500 Travel abroad: € 32.000 Investment: € 130.000	- Shell: € 100.000 - DOW: € 100.000 - RHDHV: € 20.000 - KWR: € 30.000 - Deltares: € 30.000 - Eijkelpark: € 5.000 - STOWA: € 10.000 - WLN: € 10.000	- DOW: € 96.300 - RHDHV: € 29.988 - KWR: € 29.988 - Deltares: € 54.978 - Eijkelpark: € 2.490 - STOWA: € 10.115 - WLN: € 5.000
Total	€ 3.500.000	In cash: € 1.420.000.	In kind: € 1.389.991.

B. Description of the projects in the programme

Project number: 1.1

Project title: Resource analysis and regional water management

Project leader: Prof. dr. ir. Marc F.P. Bierkens (Utrecht University).

Requested research positions: 3 PhDs, 1 Postdoc

Budget: Requested from STW: k€ 750
Contribution by users: k€ 340 (*in cash*) & k€ 348 (*in kind*)

I. Scientific description of the project

I.1 Background

Project 1.1 focusses on enabling maximum use of saline water by controlling the subsurface fresh-saline water distribution on a regional level. Key elements are:

- Developing advanced, integral models for long term, strategic water management.
- Developing prediction-based models for operational water management.

The project considers a regional/delta scale approach and is closely related to local- and field scale water management solutions from project 1.2.

I.2 Scientific challenges

- **Rapid and accurate mapping using airborne geophysics.** The challenge is to accurately map regional water quantity and quality distributions, making maximum use of airborne data. Conventional measurements (e.g. observational wells) are expensive and the necessary infrastructure is often not available (data poor regions). There are abundant global data (e.g. satellite data) on land use and geological properties but geophysical models based on these data are insufficiently accurate. Thorough understanding of the hydrological subsoil characteristics and transport flows of water and pollutants (in particular salts) is needed to achieve a breakthrough in the use of airborne data. This knowledge enables combining hydrological modelling of the subsoil with airborne geophysics to obtain reliable models of water quantity and quality. In situ (earthbound) measurement can be kept to a minimum, only used for validation of data and models. The breakthrough achieved means that water quantity/quality distributions can be mapped rapidly, even for data poor regions.
- **Reliable forecasting of salt-fresh water distribution development.** The challenge is to reliably predict changes in regional saline freshwater distributions caused by macro trends (e.g. climate change, socio-economic developments and weather variability). Present scenarios for macro trends many describe effects on a global scale, e.g. sea level rises. For regional water management global changes must be translated to regional effects. This requires thorough understanding of the hydrogeological processes in a region. In this project, this type of knowledge is developed and used for scenario predictions on a regional scale. The results can be used for risk assessment (revealing vulnerabilities of the water system), and strategic policy development.
- **Assessment of the sustainability of local interventions on the region.** The challenge is to translate the impact of local (individual catchment, farm or production plant) interventions to the regional scale (and vice versa). Local interventions (e.g. prediction based drainage of project 1.2) affect the water availability on a regional scale; regional water distribution determines local intervention options. 'Zooming in and out' (scalability) between regional and local scale is crucial for integral management for balanced operational water management. Scalability has been achieved for meteorological and hydrodynamic models, but not for groundwater hydrology. In this project in-depth knowledge of regional hydrology will be developed, enabling integral and scalable modelling suited for operational control.

I.3 Workplan

WP1: Rapid regional mapping of salt-fresh water distributions

- To assess and monitor locations and volumes of fresh and brackish water in deltas.

Research steps:

- Research on water and pollutant transport flows in relation to hydrological characteristics of the subsoil. 3D Mapping of groundwater salinity distributions and hydraulic subsoil properties using an airborne geophysical mapping. Initial mapping capabilities will be improved by an estimation of uncertainty and using joint-inversion with hydrogeological model results.
- Cross-validation to investigate the relation between mapping accuracy and available (in situ) data.

WP2: Rapid modelling and scenarios for strategic policy development

- To predict changes in the regional saline-freshwater distributions based on macro trends

Research steps:

- Developing knowledge to connect macro trends to regional scale (hydrology and transport flows). Development of ensembles of scenarios for autonomous changes (climate, sea level and socio-economic) for integration in WP2. These scenarios can be used to test the vulnerability and robustness of water systems.
- Development of regional-scale models fit for integration with global scenarios of socio-economic development and climate change to predict current and future groundwater and surface water availability (fresh/salt).

WP3: Operational management of regional salt-fresh water resources

- To enable day-to-day saline-freshwater control for both water managers and water users.

Research steps:

- Forecasting*: development of a near real-time forecasting model of fresh water flow and groundwater resources by integrating:
 - meteorological, hydrological and agricultural data with the model from WP1;
 - models for salt transport (from project 1.2).
- Prediction-based control*: Development of models for the prediction of the effect on regional scale of local interventions (e.g. inlet of freshwater from buffers) and vice versa. This allows closing the loop of water control and intervention assessments.

To ensure optimal exchange of research results, PhD students working in the project will spend part of their time at the facilities of the project partners (e.g. at TNO and Deltares).

Results will be validated in two representative case studies, one in the Netherlands (with abundant data) and one abroad (data-poor region). These case studies have been selected together with the project partners, to maximize their validity and their value for future marketing.

	Year 1	Year 2	Year 3	Year 4	Year 5
WP1					
1					
2					
WP2					
1					
2					
3					
WP3					
1					
2					

I.4 Deliverables

- Rapid modelling and scenarios for: the strategic policy development of fresh/salt water systems.
- Software for operational water management based on near real-time forecasting and prediction-based control of fresh-salt water resources.

The project delivers models and software tools that can be integrated in existing software packages from the consultancy partners (see utilisation plan). This allows rapid utilization of the results in day-to-day consultancy activities. Intermediate results can be used for rapid assessment and accurate mapping of the 3D salinity distribution.

II. Utilisation plan

II.1 Economic and societal benefits

The international challenges on sustainable water management offer excellent export opportunities for Dutch private companies and knowledge institutions. The results of the project will strengthen their already leading position in developing integrated solutions.

Delta areas, areas of high economic value worldwide, are often threatened by scarcity of freshwater. Freshwater availability is crucial to public health and economic development. There is an urgent need for models and control tools that enable an integral approach of water management, both on a regional and local scale, to safeguard freshwater for critical applications, and enable alternative (saline) sourcing. The end users of these models and tools are:

- **Authorities.** This project provides authorities responsible for water availability and ecological quality with scenario tools to visualize the combined effects of interventions in different areas of responsibility. The experience so far is that the best marketing approach is teaming up of knowledge institutions and private companies in the development of delta-wide or regional strategic planning and operational control.
- **Industry:** Industry faces two challenges:
 - availability of freshwater is essential for the continuity of production;
 - minimizing impact of production on local water resources becomes a 'license to produce'.
 Industrial customers work directly with private consultants. So far, effect analyses focus on a local scale (production plant and direct vicinity), though there is a trend towards effect analyses on larger scales. For these customers, scalability is of prime importance. This project provides models and tools for the assessment of freshwater availability and the impact of their operations.

II.2 Utilisation plan

The project partners cover the entire innovation chain for the development of integral and sustainable solutions for delta areas. Partners include consultancy firms, knowledge institutes, technology suppliers and end users. Case studies are key in model development and validation, but also provide reference projects for future marketing. In the project, the following partners are involved:

- **UU and DUT.** Scientific partners.
- **Deltares and TNO.** Scientific partners and commercial consultants. In the latter role, they will incorporate the results in their model suites and consultancy practice. They will supply the project with existing data and models and will cooperate in the case studies.
- **Eijkelkamp.** This private company supplies intelligent measuring equipment and analysis software, mainly for water quantity, on a local scale. For the company both project 1.1 and 1.2 offer an unique opportunity to expand the product range to water quality in an international context. The company has a special interest in simplified versions of the models. Within the project, they will participate in the case studies, especially in providing and analysing earthbound data. Eijkelkamp will use the results for international marketing of new equipment and software.
- **Fugro.** This private company is worldwide involved in mapping of water resources. They are particularly interested in the development of models and new mapping capabilities, in particular for data-scarce regions. These models open up new market opportunities in areas so far not covered. In the project Fugro will bring in new (sounding) technology in the case studies.
- **STOWA and Hoogheemraadschap Rijnland:** STOWA is the organisation for joint knowledge development and dissemination of the Dutch water managers. The water managers are particularly interested in the development of measures to counter effects of salt water intrusion in ground- and surface water. Direct participation of the Hoogheemraadschap Rijnland (water board) not only ties in practical knowledge on water management options, but also provides a test ground for control interventions. Rijnland was previously involved in vulnerability analyses for the western part of the Netherlands.

All partners provide both in-kind and cash contributions to the project and contribute to the research program. In addition, the partners offer pilot locations and participate in pilot research. The following table summarizes the individual partner contributions.

Partner	TNO	Deltares	Rijnland	Shell	Eijkelkamp	Fugro	STOWA	Total
Cash	100.000	70.000	60.000	50.000	20.000	15.000	25.000	340.000
In-kind	100.079	123.760			12.450	100.000	11.600	347.889
Total	200.079	193.760	60.000	50.000	32.450	115.000	36.600	687.889

Project number: 1.2

Project title: Local Operational Water Management and Control

Project leader: Prof. Dr. Sjoerd E.A.T.M. van der Zee – Wageningen University

Requested research positions: 3 PhD

Budget: **Requested from STW:** k€ 749
Contribution by users: k€ 285 (*in cash*) & k€ 189 (*in kind*)

I. Scientific description of the project

I.1 Background

Project 1.2 focusses on operational management and control on a local (farm) scale to safeguard water availability. For plant growth a special point of attention is humidity and salinity at the root zone level (needed for food production and nature development). Salinity, in particular monovalent salts, can on the short term adversely affect plant growth and on the long term lead to irreversible soil degradation. Solutions include:

- Management of underground fresh water quantities: integrate modelling, monitoring and remote control management of drainage to optimize water use and storage, depending on (seasonal) weather patterns.
- Salinity control of the root zone: develop operational tools in drainage/irrigation management to limit upward seepage of salt groundwater and stabilize salt-freshwater gradients. Model adjustment and determination of plant and crop tolerance to short term variations in soil salinity.
- Cross sectorial use: determine the effects of groundwater replenishment with industrial (produced/waste) water on soil, agricultural crops and groundwater quality.

This project interacts with project 1.1 on scalable models for regional to local scale and vice versa, and with research line 2 on options to use industrial (produced) water sources.

I.2 Scientific Challenges

- **Prediction of salinity at root level.** The main challenge is to develop models that accurately describe water quantity and quality at root zone level. This will enable effective control of water quantity (humidity) and quality (in particular salinity) through drainage and irrigation systems. Present models are limited to the prediction of water quantity. In this project, salt transport models will be developed and combined with models for drainage and irrigation. Research will also be performed on the resistance of crops, natural vegetation and soil to salt shock loads to determine the allowable bandwidth of control measures.
- **Day-to-day management: pro-active drainage systems.** The main challenge in the development of prediction-based control models for pro-active drainage systems. Present adaptive drainage systems use humidity data to initiate control measures. More recent developments strive at including weather predictions. This allows water level buffering to even out temporal differences in precipitation (weather). The drainage systems have relatively long reaction times, though weather changes are abrupt. To make maximum use of buffering capability, present weather forecast models based on meteorological data must therefore be included. Meteorological data will be combined with smart telemetry of humidity and salt levels. The latter requires the development of new sensors.
- **Regional management of drainage strategies.** The challenge is to develop models that enable regional, rather than farm level drainage control. This is necessary as the requirements for water availability and quality differ from site to site (e.g., farm versus nature) and interventions at one site can affect other sites. Presently the effects of local interventions on a regional scale cannot be predicted. In collaboration with project 1.1 scalable models are developed that connect local interventions with regional impacts. Salt and water transport mechanisms on a regional scale will be researched to enable model development.
- **Assessment of long-term effects of waste water use.** The challenge is to predict the long term effects of replenishment of groundwater with industrial (produced/waste) water. Industrial water is rich in salts and a variety of other pollutants. Knowledge on the combined, long term effect of

salts and other pollutants on plant growth, soil- and groundwater quality is lacking. In this project, research will be performed and models developed, on transport and accumulation of pollutants and their effects on agricultural crops and wild plant species growth/quality and soil characteristics.

I.3 Work plan

WP1: iDrain – Anticipating drainage systems in salt affected lowlands

- Develop validated models for optimal water storage by intelligent drainage management.

Research steps:

1. Develop remote field drainage management systems using advanced instrumentation and remote monitoring techniques.
2. Coupled modelling of salt and water transport and crop growth as affected by drainage management, based on a newly developed module platform for ensemble forecasting under erratic rainfall for irrigated and drained salt affected regions. Contaminant and sodicity functionalities of WP3 will be incorporated.
3. Optimization of local and regional drainage management to achieve optimal water storage for dry periods (cooperation with project 1.1) using soil-water-plant models that are improved in WP2.

WP2: iNurture – Stabilise existing salt-freshwater distributions and limit temporal variations

- Improve a Soil-Water-Plant model platform for weather and salinity proof drainage.
- Develop models for stable salt-fresh gradients in nature (development) sites.

Research steps:

1. Monitoring and modelling of various nature (development) sites to support water level management that allow stable salinity gradients under erratic weather conditions.
2. Experimental salt tolerance assessment and the eco-physiological mechanisms thereof for wild plant and agricultural crop species with temporary salt stress.
3. Adjust soil-water-plant model platform with improved plant salt tolerance functions (WP1).

WP3: iRe-use – Economizing marginal (waste) water

- To develop a Decision Support Module for integrated risk analysis of waste water re-use

Research steps:

1. Inventory of integrated quality constraints of soil-groundwater-crop. The project will incorporate advanced biogeochemical frameworks to assess sustainability of re-use of contaminated wastewater in irrigated agriculture, city greens and sports fields.
2. Development of integrative models that predict the transport and accumulation of emerging contaminants (such as pharmaceuticals, pathogens and oil and gas production chemicals).
3. Incorporation of sodicity driven soil structure degradation (WP1).

	Year 1	Year 2	Year 3	Year 4	Year 5
WP1					
1					
2					
3					
WP2					
1					
2					
3					
WP3					
1					
2					
3					

I.4 Deliverables

1. Tools, models, and methodology guidelines for integrated drainage water management.
2. Improved soil-water-plant models, with validated plant tolerance.
3. Integrated and validated sustainability assessment tool for use of marginal (waste) water in irrigated and drained horti- and agriculture and city greens.

The tools and models will be directly applicable in the consultancy activities of the project partners and at current site of end-users, such as HGM. In addition, the water management solutions can be directly applied to existing and future ADS systems, both for local and regional water management.

II. Utilisation plan

II.1 Economic and societal benefits:

Saline groundwater affects delta areas, coastal plains and major lakes worldwide. For sustainable agriculture, appropriate water management must ensure regular washing of salts out of soil, whereas for nature it is necessary to stabilise existing salt-freshwater distributions and limit temporal variations. The new models and tools for management and control of salt-freshwater distribution, developed in this project, offer great potential to control salinity in such a way that crop production and nature development are less dependent on changes in freshwater supply (e.g., precipitation, surface water levels). The (re-)use of waste water generates additional control options. End users include:

- **Authorities.** The project will enable authorities to control salt-freshwater distributions on a day-to-day basis. This increases the robustness of food production and nature development both on a local and regional scale (connection with project 1.1). In this market segment teaming up of knowledge institutions and private consultants is the best approach.
- **Agriculture.** A secure and safe water supply is vital for agribusiness. Both the availability of water and salinity at root level are important factors. Integrated water management options for drought and salinity control, in particular in areas where fresh water lenses are vulnerable, are therefore of major importance. Project 1.2 will enable farmers to effectively control the water supply to their fields. Private consultants can work directly with farmers, often part of cooperatives or wholesalers supply chains.
- **Managers of Sports fields and city greens.** (Re-)use of waste water may be a sensitive subject in agriculture, but is certainly interesting for the maintenance of sports fields and city greens. It is important to know the short- and long-term effects of using waste or saline water. Project 1.2 provides this knowledge. Private consultants can work directly with customers in this segment.
- **Industries.** An important aspect in industries is the need to minimize the impact of their operations on local water quantity and quality. Project 1.2 generates tools for reliable prediction of the effects of local extraction and creates options for cross-sectorial use of water (re-use of waste water) and the mitigation of the effect of the release of waste water. Private consultants can work directly with industry.

The case studies in project 1.2 can serve as reference projects for future marketing.

II.2 Utilization.

Project 1.2 includes universities, knowledge institutes, technology providers and consultancy firms:

- **WU and VU.** Are the scientific partners.
- **Alterra.** Is a scientific partner and consultant. Alterra will include the knowledge delivered and the tools that will be developed in project 1.2 in their consultancy activities, providing added value.
- **KWR Watercycle Research Institute.** This research institute aims to provide tailored knowledge to optimally organize and manage the water cycle. In particular the results in the area of nature conservation and management and the protection of groundwater reserves for drinking water are interesting for future consultancy opportunities.
- **HGM.** This private golf course and sports field owner intends to directly use results for day-to-day management of its own grounds, and to use the the acquired expertise for consultancy of similar companies abroad.
- **Eijkelpark.** This private company supplies intelligent measuring equipment and analysis software, mainly for water quantity, on a local scale. For the company both project 1.1 and 1.2 offer an unique opportunity to expand the product range to water quality in an international context. The company has a special interest in simplified versions of the models. Within the project, they will participate in the case studies, especially in providing and analysing earthbound data. Eijkelpark will use the results for international marketing of new equipment and software.
- **Shell** is as an industrial partner particularly interested in creating options for cross-sectorial use of water.
- **STOWA** is the organisation for joint knowledge development and dissemination of the Dutch water managers and aims to apply the results in their activities.

Partner	Alterra	KWR	Shell	HGM	STOWA	Eijkelpark	Totaal
Cash	100.000	70.000	25.000	60.000	25.000	5.000	285.000
In kind	71.400	76.160		17.600	11.600	12.450	189.210
Total	171.400	146.160	25.000	77.600	36.600	17.450	474.210

Project number: 2.1 Project title: Biological nutrient removal

Project leader: Dr.ir. Hardy Temmink (Wageningen University)

Requested research positions: 2 PhDs, 1 Postdoc.

Budget: **Requested from STW:** k€ 557
 Contribution by users: k€ 215 (*in cash*) & k€ 123 (*in kind*)

I. Scientific description of the project

I.1 Background

In industrial processes water of lower than drinking water quality can be used in many different applications. Prerequisite is that certain pollutants, in particular biological nutrients, are removed. This, to prevent unwanted growth of bacteria and pathogens, leading to biofouling and health and safety risks.

Project 2.1 develops compact anaerobic and aerobic granular biomass technology for biological treatment of saline wastewater, thus removing these organic pollutants. In combination with post-treatment in wetlands (project 3) or membrane and electro-cracking (project 2.3) this will provide for a water source fit for use in industrial processes. From a sustainability point of view, biological removal has large advantages compared to treatment technologies, such as filtration.

I.2 Scientific challenges

The scientific challenges are:

- To 'push the envelope' of granular biomass technologies by developing robust and active anaerobic and aerobic granules with improved salt tolerance. Although the underlying mechanisms are largely unknown, high concentrations of NaCl have a negative impact on treatment performance of granular technology. This is mainly attributed to:
 - gradual wash-out of viable biomass;
 - osmolytic inhibition of the microbial activity.

Although never tested before on granular biomass, indications are that this can be counteracted by several measures including:

- application of salt-tolerant microbial inocula;
- addition of multivalent cations to counteract the negative impact of monovalent cations;
- addition of compatible osmolytes to protect the microbes from the increased salinity;
- adjusting the organic composition of the wastewater to optimize the microbial population.
- To understand the unknown relationship between specific wastewater characteristics and the applicability and characteristics of the granular sludge technology. Once unravelled, expensive and laborious long-term pilot-scale testing becomes obsolete. This knowledge also supports the selection between anaerobic and aerobic granular technologies.
- To determine the operational strategy and design rules for full scale treatment of complex saline wastewaters. Typically, industrial waste water suffer from time variations in salinity and shock loads of (organic) compounds. This can significantly inhibit conversion. Indications are that granular sludge processes are more robust to such variations, but the conditions for this robustness must still be determined.

I.3 Work plan

WP1: Formation of robust granules under saline conditions

- Research into the mechanism of granule formation and granule activity at different salinity levels and stimulation of granulation at high salinity.

Research steps

1. In laboratory scale reactors fed with synthetic wastewater, the two dominant processes contributing to granulation will be studied at different salinity levels:
 - a. precipitation of salts which can act as granule nuclei;

- b. microbial production of extracellular polymeric substances (EPS) which form the backbone of microbial aggregates.

This involves granule and EPS characteristics and composition as well as microbial population dynamics, EPS producing capacity of the microbial population and the sensitivity of these to osmotic toxicity.

2. For higher salinity levels, where granulation proves to be difficult, stability and activity in response to several countermeasures will be studied, including application of salt tolerant inocula, addition of EPS bridging multivalent cations and compatible osmolites. To challenge granule formation, organic pollutants will be used that give a low EPS yield.

WP2: Feasibility of granule reactor technology for specific saline wastewaters

- To predict the potential of saline granular technology in relation to wastewater characteristics.

Research steps

1. Review of saline wastewater characteristics, including volume, temperature, organic pollutant and ion composition and strength and the presence of potential toxic organic compounds (also see WP3).
2. For a representative set of wastewater characteristics granule reactors will be assessed for treatment performance, granular stability and microbial activity. If necessary, the appropriate countermeasures (see above) will be included.
3. The results will be tested in pilot-scale reactors operated by project partners.

WP3: Operational strategy and design for time varying salinity

- Response of granular technology to fluctuating salt concentrations and shock loads of toxic compounds.

Research steps

1. The granular sludge reactors from WP1 will be exposed to defined, but fluctuating salinity levels and to concentrations of selected potential toxic compounds (step 1 in WP2).
2. A similar exercise will be performed under more realistic conditions with pilot-scale reactors operated by the industrial partners. The effect on process stability will largely determine the necessity to buffer and pre-treat wastewaters.

	Year 1	Year 2	Year 3	Year 4	Year 5
WP1					
1					
2					
WP2					
1					
2					
3					
WP3					
1					
2					

I.4 Deliverables

1. Validated proof-of-principle of anaerobic and aerobic granular sludge technology for the removal of (bulk) organic pollutants from saline wastewaters.
2. Overview of those saline wastewaters which can be treated with granular technology, those wastewaters requiring specific countermeasures and selection criteria between anaerobic and anaerobic granular sludge technology.
3. Operational strategies to cope with varying salinity levels and the presence of toxic compounds.
4. Design rules for granular sludge reactors under saline conditions;

II. Utilisation plan

II.1 Economic and societal benefits

The importance and share of saline wastewater streams containing organic pollutants is increasing rapidly e.g., as a result of the upcoming biodiesel and bioethanol industries and an increase of food production in saline environments. Currently, these water streams are mainly discharged after energy and chemicals consuming (expensive) treatment processes. The development of solutions for cascading offer great economic perspective and societal benefits, as it reduces fresh water demand and prevents disposal. This can be accomplished by direct biological treatment technologies.

Anaerobic and aerobic granular treatment technologies offer a sustainable and low-cost solution. This technology was developed for fresh water by Dutch companies and knowledge institutes. In view of the already large and expected increase in saline wastewater volume, the market potential expected for saline adapted granular sludge technology is large. At the same time, end-users (water treatment companies and industries) will be provided with new opportunities:

- **Waste water treatment companies:** Robust, competitive and compact granular sludge technology as the key process for reuse of saline wastewaters will expand the market potential for technology suppliers from fresh water wastewaters to saline wastewaters, and from water discharge technology to water re-use technology.
- **Industries:** Saline water adapted granular sludge technology offers industries with saline wastewaters the opportunity to reduce their dependency on fresh water resources and at the same time to generate energy from their pollutants in the form of biogas. In addition, the technology allows industries to reduce costs, energy and chemicals associated with the upgrading of their effluent to process water.

II.2 Utilisation plan

Project 2.1 brings together end-users, technology suppliers, consultants and knowledge institutes. All of them have a broad experience in the field of wastewater treatment and the problems and challenges associated with saline wastewaters and reuse of wastewater. Results of laboratory research will be implemented to operation of pilot-scale reactors operated by partners. This supports rapid market implementation after conclusion of the project.

- **WU and DTU** are the scientific partners.
- **Paques** is world leader in the field of anaerobic treatment technology with 30 years of experience. The proposed technology would further increase their international market for this technology.
- **RoyalHaskoningDHV** is a consultancy company and supplier of Nereda technology, i.e. aerobic granular sludge technology, which was recently successfully put in the market. Nereda technology for saline wastewater would enlarge their market position.
- **Shell** is an industry partner that generates large volumes of industrial saline wastewaters. Both anaerobic and aerobic granular technology would allow them to implement a higher level of water re-use, which is required not only in The Netherlands but also abroad.
- **WLN** is the water quality and water technology centre for the Dutch drinking water companies WMD and WBG and also for their industrial water companies NorthWater and NieuWater. Also water boards, industries and organizations where water quality plays an important role are supported by WLN's facilities and expertise. The results of this project will support WLN's activities and consulting power on the biological treatment of saline (waste)water streams.
- **Nijhuis** specializes in the design and manufacture of industrial wastewater treatment, recycling and waste-to-value projects. The project provides them new solutions to treat and re-use brackish and salt water from these industries.
- **Witteveen+Bos** is a consulting companies with a wide experience in the field of wastewater treatment. The project will give them new solutions in projects for more use of brackish and/or salt water in agro-food, industry and domestic sectors.

Partner	Paques	Shell	Witteveen+Bos	RHDHV	WLN	Nijhuis	Total
Cash	40.000	40.000	40.000	40.000	15.000	40.000	215.000
In kind	10.000		39.400	19.040	5.000	50.005	123.445
Total contribution	50.000	40.000	79.400	59.040	20.000	90.005	338.445

Project number: 2.3
Project title: Removal of sodium and micro-pollutants
Project leader: Prof. dr. ir. K. Nijmeijer

Requested research positions: 4 PhDs, 1 NWP

Budget: Requested from STW: k€ 750
 Contribution by users: k€ 290 (*in cash*) & k€ 501 (*in kind*)

I. Scientific description of the project

I.1 Background

This project focuses on developing treatment technologies that enables the connection between two sectors with high impact opportunities to reduce freshwater scarcity: industry and agri/horticulture.

About 70% of the global water demand stems from agri/horticulture. The potential for using saline water is large. Chemical industries produce large quantities of water that could be used in agri/horticulture (cross-sectorial reuse). This water is rich in salts and hydrocarbons. As an example, enhanced-oil-recovery technologies generate produced water containing high concentrations of polymers and surfactants, anti-scaling chemicals and oil residues. These need to be removed prior to cross-sectorial reuse e.g. for irrigation purposes. A further issue to address is the removal of monovalent salts, in particular sodium, that have a direct negative effect on plant growth, and can induce irreversible deterioration of soil quality (other salts do not have similar effects, and can even act as fertilizers). The technologies developed can also be used for closing loops in agri/horticulture.

This project develops new, breakthrough technologies for the removal of sodium, hydrocarbons, micro-pollutants and pathogens from saline water. This enables cross-sectorial use of industrial water in agri/horticulture. And saline water cycles-of-use (closing loops) in agri/horticulture.

Salts often present problems in water treatment processes, e.g. limiting the use of microbiological treatment or causing severe scaling in membrane processes. But salts also present unique opportunities: the higher conductivity of saline water makes electrochemical processes an exciting option, with in some cases the extra benefit of electricity generation. Project 2.3 develops flexible technologies that combine electrochemical treatment (electro-cracking and PMDC) with selective membrane removal that can cover a wide range of saline water streams. These technologies can act as stand-alone treatment or as pre-treatment in for example biological treatment (project 2.1) and wetland systems (project 3).

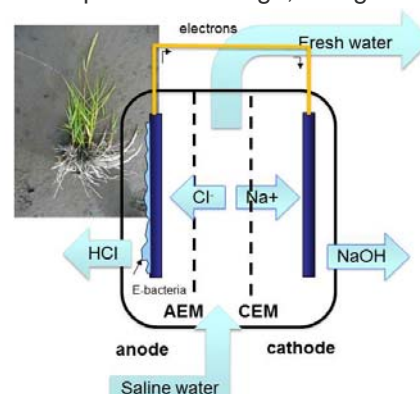
I.2 Scientific challenges

The major scientific challenges are:

- Current technologies, such as wetland treatment, do not remove recalcitrant organic residues. These include humic-acid complexes, polycyclic aromatic hydrocarbons, poly-acryl-amides and agro-industrial pesticides. Project 2.3 develops stable electrodes for generation of acid hydroxyl radicals for degradation of recalcitrant organic residues, and disinfection. Currently, acid generation lacks activity, whereas radical generation lacks selectivity. Development of disinfection requires detailed microbiological research into disinfection attack mechanisms, and efficacy.
- Currently, there are no efficient removal processes for certain types of micro-pollutants, e.g. poly acrylamides and oil residues. They cannot completely be removed with electro-cracking and require additional treatment. In project 2.3 selective membranes are developed for this treatment. The challenge is to tailor the chemistry of the membranes (molecular chemistry, charge, hydrophility/phobicity, etc.) for the removal of this specific group of pollutants.
- The challenge is to remove Na-salts from saline water, without affecting other salts. Desalination membranes lack in specificity, and are not suited for highly concentrated solutions (limited by high osmotic pressure). Project 2.3 will develop membranes for controlled transport of specific ions, without osmotic pressure limitation (removal of other pollutants such as plant nutrients is

prevented). Membrane chemistry will be tailored to the goal, with emphasis on charge, charge density and covalent binding of selective groups that capture specific target ions.

- Plant-microbial desalination cells (PMDC) is an emerging technology that combines low pressure, membrane, desalination with electricity generation. This technology has great potential for salt removal through direct use of power generated (see figure). Although in its early stages of development, it fits nicely with the developments in project 2.3 and 3. The challenges are to develop effective tubular shaped electrode assemblies combined with specific ion removal membranes and to stimulate the development of electrochemically active micro-organisms.



I.3 Workplan

WP1: Electrodes

- Deliverable: for electro-cracking and disinfection

Research steps:

- Develop anode surfaces (e.g. boron-doped or lead oxide) for generation of acids and radicals
- Determine the mechanisms underlying electro-cracking and the predominant factors (e.g. temperature, salt concentrations, applied potential program (dc, ac, block) and electrode material).

WP2: membranes

- Deliverable: membranes and membrane modules for removal of micro-pollutants and specific salts

Research steps:

- Determining ion and micro-pollutant characteristics relevant to targeted membrane removal
- Development of new membranes materials (charged polymer, layer-by-layer or Zwitter ionic, specific interaction)), characterisation of flux and specificity of retention, and development of membrane units.

WP3: PMDC

- Deliverable: tubular membrane-electrode assemblies, active populations of micro-organisms

Research steps:

- Development of tubular membrane-electrode assemblies, integrating membranes for specific removal (from WP2)
- Investigate electrochemical activity (end electricity generation) of micro-organisms and options for stimulation

WP4: system integration

- Deliverable: flexible systems combining electrochemical and membrane removal tested

Research steps:

- Integrate electro-cracking and membranes for specific removal of ions and micro-pollutants into system for treatment of a wide range of saline waters
- Development of full tubular PMDC systems
- Pilot testing of systems, coupling system design to water type

	Year 1	Year 2	Year 3	Year 4	Year 5
WP1					
1					
2					
WP2					
1					
2					
WP3					
1					
2					
WP4					
1					
2					
3					

II. Utilisation plan

II.1 Economic and societal benefits

Water scarcity is a large and imminent problem in delta areas worldwide, threatening public health and economic development. There is an urgent need for high impact solutions that really make a difference in solving scarcity, as opposed to present developments of partial solutions with limited yield.

In this project treatment technologies are developed that enable high impact solutions to water scarcity. The project results are flexible systems, combining electro-cracking and specific membrane removal that can treat a wide variety of saline waters. Knowledge generated in the project is directly used in PMDC development for breakthroughs in electrode and membrane assemblies. PMDC is an emerging technology with great potential for integration in wetland systems, and the added benefit of electricity generation.

Two main market segments can be distinguished:

- **Industry:** (petro-)chemical industry produces large volumes of saline water polluted with a varying range of organics. The option of cross-sectorial use (industrial water in agri/horticulture) reduces the negative impact of produced (waste) water on the environment, and helps alleviate scarcity. For industries, solving these issues more and more becomes a 'license to produce'.
- **Agri/horticulture:** the technologies developed enable setting up safe cycles-of-use (closing loops in production)

The technologies developed create excellent export opportunities for Dutch technology suppliers, and consultancies.

II.2 Utilisation plan

The project 2.3 team covers the entire innovation chain. The partners are:

- **UT, UL, WUR** : universities, scientific partners
- **Magneto, Pentair**: producers and suppliers of electrodes and membranes, respectively. For them the electro-cracking/specific membrane systems offer an opportunity of expansion of their product range and export volume, whereas the PMDC development offers them an opportunity to gain a foothold in an interesting emerging technology.
- **Voltea**: producer of capacitive deionisation technology (CDI) for desalinisation. Membrane materials developed can be used as electrode coating to enhance selectivity of CDI.
- **Plant-e**: small, start-up technology supplier, develops and commercialises PMDC. Initially technology development targeted electricity generation only. For them the PMDC development offers the opportunity to expand their knowledge base, create opportunities in new markets (water treatment, salt recovery) and make the step to commercialisation of complete PMDC systems.
- **Priva**: supplier of complete systems for horticulture, including water treatment. For them the project creates new market opportunities – saline water cycles of use – solving the problem most urgent from their perspective: Na-salt removal.
- **Shell, Dow Benelux**: end users with a particular interest in the development of options for cross-sectorial use of produced water. Another point of interest is possible use of saline water for cooling. The membrane technology developed, produces two different water streams, one containing multivalent salts but no Na (fit for agri/horticulture), and another containing Na but not multivalent salts. The latter can be useful as cooling water, where multivalent salts cause problems with scaling and corrosion. Shell and Dow want to investigate this option.
- **Oasen**: end user, water supplier in the Netherlands, the possibility to treat saline water offers new sources for water production.

Contribution:

All partners provide both cash and in-kind contributions to the project (see table below in euro).

Partner	Magneto	Pentair	Voltea	Plant-e	Priva	Shell	Dow	Oasen	Total
cash	30.000	40.000	20.000		50.000	50.000	50.000	50.000	290.000
In kind	101.150	141.000	42.450	101.000	29.988		48.150	36.850	500.588
Total	131.150	181.000	62.450	101.000	79.988	50.000	98.150	86.850	790.588

The private partners and universities will jointly perform pilot research with the technologies developed, which supports rapid market implementation after completion of the project.

Project number: 3
Project title:

Integral Blue Prints

Technology and natural system integration enabling multi-sourcing and fresh water footprint reduction

Project leader: Prof. dr. ir. H.H.M. Rijnaarts

Requested research positions: 3 PhDs, 1 Postdoc

Budget: Requested from STW: k€ 744

Contribution by users: k€ 290 (*in cash*) & k€ 229 (*in kind*)

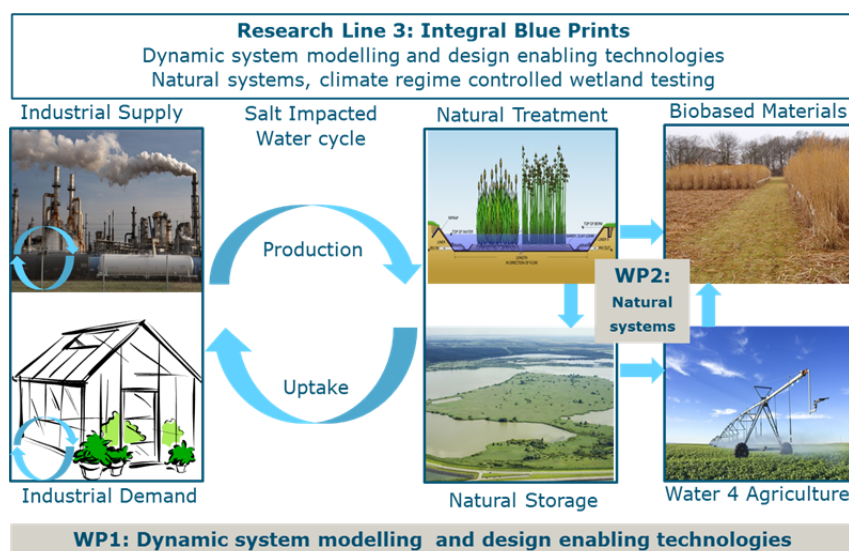
I. Scientific description of the project

I.1 Background

Delta regions face major challenges in fresh water supply; seasonally and/or regionally fresh water scarce situations occur, and industry, agriculture, households and ecological sectors compete for the same scarce resources. The challenges are aggravated by changes in climate conditions and socio-economic dynamics. Integral solutions are required to balance supply and demand, and secure freshwater availability for critical applications.

This project focuses on developing high impact strategies for balancing supply and demand and making maximum use of alternative (saline) sources: saline where possible, freshwater where essential. Special attention is given to industry and agri/horticulture where large volumes of water are produced and demand is high.

I.2 Focus and scheme of the project



In WATER NEXUS, saline water is considered as a useful resource, alleviating pressure on freshwater resources. This project aims at developing integral solutions at system level:

- WP1: Dynamical models are developed connecting sources of different qualities with applications with different requirements. In urban settings, the Resource Harvest Approach proved able to reduce water use with 40-60%.^{5,6} This approach will now be developed for delta systems with

⁵ Agudelo - Vera CM, A Mels, K Keesman, H. Rijnaarts, 2012. The urban harvest approach as an aid for sustainable urban resource planning, Journal of Industrial Ecology 16 (6), 839-850

large volumes of industrial water use. Solutions found in research lines 1 (quality distribution of water resources and requirements for use/supplementation in agriculture) and 2 (treatment options opening new pathways for connections between supply and demand) are combined with existing knowledge on water treatment in the overall modelling on system level.

- WP2: End users from large industry have a keen interest in wetland type systems. These systems not only can be used for water purification, but also as large volume buffers (option to solve problems with temporal variation in supply and demand) and for production of biomass. Water from wetland systems can either be used in industry again, or can be made suitable for agricultural use. Here, results from research line 1 (requirements) and 2 (treatment options) are used to develop cross sectorial strategies. The presence/removal of monovalent salts and natural and industrial organic compounds has been identified as critical factors.

To maximise application (utilisation) potential, the models and system strategies developed will be tested in three different climate regimes and industrial settings, in close connection with large industry.

I.2 Scientific challenges

The major scientific challenges are:

- The interplay between different quality supply, use options with different requirements and storage capabilities is highly dynamic. Existing models either focus on single pollutants (e.g. pinch analysis) or only produce a static overview of supply and use pathways. The reality is that water supply comes with a mix of pollutants and varies over time. New modelling techniques must be developed to handle complex pollutant mixes and time variations.
- Wetland systems are already used worldwide, but there are large knowledge gaps where pollutant fate, uptake in plants, and degree of biomass production are involved in relation to the chemical composition of the influent, water throughput and climate conditions. The MODUTECH facility at WU will be used by researchers of UvA and WU to build model systems³ for different climatic regimes, and to develop monitoring tools for fate of pollutants⁴ and effects on biomass⁵.

I.3 Workplan

	Year 1	Year 2	Year 3	Year 4	Year 5
WP1					
1		Develop modelling techniques			
2		Identification of demand types			
3		Identification of sources			
4				Demand/supply integration	
5					Case testing
WP2					
1		Identification of relevant parameters (composition, climate)			
2		MODUTECH simulations and design			
3		Development of analytical instrumentation (monitoring)			
4				Toxicity and removal testing	
5				Plant selection/salt removal test	
6	Research on effects salt concentration				
7	& pollutant conversion/biomass prod.				
8		Design strategies for wetland systems			

I.4 Deliverables

1. Dynamic Model and Extended Resource Harvest Approach
2. Analytical and monitoring protocol to assess treatment performance of wetland systems
3. Three optimal and representative designs of natural (wetland) treatment and storage systems (Integral Blue Prints) and their performance on removal of organic compounds and monovalent ions (including sodium), and biomass production for the biobased economy⁵
4. Integral Technology Trains of enabling technologies (of 2.1 and 2.3, and existing technologies) in multi-sourcing approach, using saline waters and reducing freshwater use.

⁶ Agudelo-Vera CM, WRWA Leduc, AR Mels, HHM Rijnaarts, 2012 [Harvesting urban resources towards more resilient cities](#), Resources, Conservation and Recycling, 64, 3–12.

³ Electricity generation by a novel design tubular plant microbial fuel cell Timmers, R.A., Strik, D.P.B.T.B., et al. 2013 Biomass and Bioenergy 51, pp. 60-67.

⁴ Haftka JJH, Govers HAJ, Parsons, JR, 2010, Influence of temperature and origin of dissolved organic matter on the partitioning behaviour of polycyclic aromatic hydrocarbons. Environ. Sci. Pollut. Res. 17-5, 1070-1079;

⁵ Bos, HL, Meesters, KP et al.; 2012. Accounting for the constrained availability of land: a comparison of bio-based ethanol, polyethylene, and PLA with regard to non-renewable energy use and land use. BIOFUELS BIOPRODUCTS & BIOREFINING-BIOFPR: 6-2, 146-158

II. Utilisation plan

II.1 Economic and societal benefits

Scarcity of freshwater is a large problem in delta areas worldwide. It is by no means restricted to poor, developing countries; pressure on water resources is high in developed and fast growing economies. The availability of sufficient water is crucial for food production, ecological functions, public health and economic development. In this project, models and system solutions are developed with high impact capabilities for solution of the problems. Societal importance is high, and the models and tools offer good potential for Dutch private enterprises and knowledge institutions.

II.2 Utilisation plan

For solutions at system level, two market segments must be distinguished:

- **Authorities:** the experience (and existing practice) is that authorities responsible for water quantity and quality are best approached by combinations of knowledge institutions and private companies. Deltares, KWR, RoyalHaskoningDHV, and WLN/NewWater, will use the results of the project to expand their consultancy business. The focus of the knowledge institutes is more on the research of water systems and initial consulting (identifying global options). They want flexible research type models. The private consultants most heavily are involved with designing practical solutions to be implemented on the short to midterm. They prefer faster, more standardised models. Such models will be developed as spin offs of the research type models, to enable fast implementation in private consultancy practice.
- **Industry:** private consultancy firms and technology suppliers can work directly with (large) industrial clients. Eijkelkamp will use the results of the project to expand their export business in telemetric monitoring and treatment systems for agri/horticulture. Dutch private companies (and knowledge institutions) already are leading in developing integral solutions for water management. An important trend in connection with industrial production is the shift in environmental impact assessments from the industrial plant level to a regional level. Environmental effects must be identified and remediated on a larger scale than before. The system approach, and the testing in different climate conditions enables the private consultancies to expand their international business with increased knowledge and new tools for regional approaches.

The group of project partners covers the whole innovation chain from knowledge developers to end users. The project is supported by two large industrial companies (Shell and Dow Benelux). They have a clear interest in both securing water supply, minimising environmental impact (license to produce) and contribute to cross-sectorial water use sustaining green infrastructure, agriculture and new bio-based economy approaches from wetland produced biomass. These companies have supplied (and will supply) important information on the national and international business environment. This is of major importance for the selection of practical cases where the new models and tools will be tested. These cases can serve as reference projects for the other partners.

For Dow Terneuzen, a strategic goal is to produce independently from drinking water sources (water is now transported from the Biesbosch – a national freshwater buffer – to Terneuzen to supplement local water quantities). For the area surrounding the Terneuzen site, an integral approach is developed, together with the water supplier Evides and local industry and authorities. Dow and Evides have a testing facility that can be used for field trials of WATER NEXUS. The Terneuzen site serves as a reference for Dow production facilities worldwide. Dow and Shell work internationally together on an evaluation of wetland sites presently in use, with one of the focal points how combinations of wetlands and other treatment technologies can maximise the use of saline water.

Contribution:

All partners provide both in-kind and cash contributions to the project see table below). In-kind, cash and total contribution of the industrial partners to the project (in €).

Partner	Shell	DOW	RHDHV	KWR	Deltares	Eijkelkamp	STOWA	WLN	Total
Cash	85.000	100.000	20.000	30.000	30.000	5.000	10.000	10.000	290.000
In kind		96.300	29.988	29.988	54.978	2.490	10.115	5.000	228.859
Total	85.000	196.300	49.988	59.988	84.978	7.490	20.115	15.000	518.589

The partners of the universities will contribute to the case studies by jointly analysing data from practical situations in different areas of the world, setting boundary conditions for water use, and identifying relevant characteristics of water sources. Further details are given in the support letters.

C. Letters of support

Letters of support project 1.1

TNO
Deltares
Hoogheemraadschap van Rijnland
Shell
Eijkelpark
Fugro
STOWA

Letters of support 1.2

Alterra
KWR Watercycle Research Institute
Shell
Hollandsche Greenkeeping Maatschappij (HGM)
STOWA
Eijkelpark

Letters of support 2.1

Paques
Shell
Witteveen + Bos
RoyalHaskoningDHV
WLN
Nijhuis

Letters of support 2.3

Magneto
Pentair
Voltea
Plant-e
Priva
Shell
DOW Benelux
Oasen

Letters of support 3

Shell
DOW Benelux
RoyalHaskoningDHV
KWR Watercycle Research Institute
Deltares
Eijkelpark
STOWA
WLN

Return address: P.O. Box 80015, 3508 TA Utrecht, The Netherlands

Utrecht University
Department of Physical Geography
prof. dr. Ir M. F. P. Bierkens
P.O. Box 80.115
3508 TC UTRECHT
The Netherlands

Princetonlaan 6
3584 CB Utrecht
P.O. Box 80015
3508 TA Utrecht
The Netherlands

www.tno.nl

T +31 88 866 42 56
F +31 88 866 44 75
infodesk@tno.nl

Subject

Support letter project Resource analysis and regional water management

Date

13 May 2013

Our reference

TNO-060-UT-2013-00366

E-mail

frans.vangeer@tno.nl

Direct dialling

+31 88 866 47 57

Direct fax

+31 30 256 47 55

Dear Prof. Bierkens,

The Geological Survey of the Netherlands/TNO has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of Resource analysis and regional water management, in which we will participate.

The Geological Survey of the Netherlands/TNO is the Netherlands' central geoscientific information and research centre for the sustainable management and usage of the subsurface and the natural resources found there. The main task is to provide information on the structure and properties of soil and groundwater. Therefore, we have expertise in monitoring, characterisation and interpretation of subsurface processes, amongst which processes related to chloride concentration in de subsurface.

We are interested in participation in the project because it aims at improving methods to characterize subsurface structures as well as the dynamic behaviour of saline groundwater in deltaic areas. With these methods we expect to improve our 3D and 4D subsoil modelling products which will be made available for our stakeholders.

Cofinancing

In this project we will perform the following actions:

- Providing data and expert knowledge concerning the occurrence of geological structures and saline groundwater.
- Joint research in the PhD projects, in particular WP 1.
- Hosting of PhD students during periods to ensure fruitful cooperation.

The General Terms and Conditions for commissions to TNO, as filed with the Registry of the District Court in the Hague and with the Chamber of Commerce and Industry in The Hague, shall apply to all commissions to TNO. Our General Terms and Conditions are also available on our website www.tno.nl. A copy will be sent upon request.

Trade register number 27376655.

Date
13 May 2013

Our reference
TNO-060-UT-2013-00366

Page
2/2

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	841	119	100.079
Equipment (depreciation)			PM
Materials (cost price)			PM
Cash			100.000
Total contribution			200.079

Utilisation

The Geological Survey of The Netherlands provides sub soil information through web service (DINO-loket) to all parties that need that information. We expect to develop new subsoil information products on fresh and saline groundwater and make it available via web service.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,

Name: Drs. T. M. van Daalen

Function: Deputy Director Geological Survey of the Netherlands

Signature:



Universiteit Utrecht Faculteit Geowetenschappen
Faculteit Geowetenschappen
Attn. Prof. dr. ir. M.F.P. Bierkens
P.O. Box 80115
3508 TC UTRECHT

Date	Our reference	Number of pages
3 June 2013	1206377-000-BGS-0003-cl	3
From	Direct line	E-mail
Remco van Ek	+31 (0)88 33 57 765	remco.vanek@deltares.nl

Subject
STW Perspectief, WATER NEXUS

Dear Mr Bierkens,

Deltares has been involved in the definition of the STW Perspectief program WATER NEXUS and detailed planning of the Water NEXUS project, in which we will participate.

Deltares is a leading independent institute for applied research, operating worldwide in the field of water, subsurface and infrastructure. Since it was established in 2008, more than 800 Deltares specialists have developed innovative insights to make living in deltas safe, economically and socially achievable and environmentally sustainable.

Our main focus is on deltas, coastal regions and river basins. Managing these densely populated and vulnerable areas is complex, which is why we work closely with governments, businesses, other research institutes and universities at home and abroad. Our motto is *Enabling Delta Life*. As an applied research institute, the success of Deltares can be measured in the extent to which our expert knowledge can be used in and for society. For Deltares the quality of our expertise and advice is foremost. Knowledge is our core business. Our research is organized into five themes:

- Flood risks
- Ecosystems and environmental quality
- Water and subsoil resources
- Delta infrastructure
- Sustainable delta planning

Within these themes knowledge programs are executed. The theme Water and subsoil resources includes the following knowledge programs:

- River basin management
- Fresh water supply in urbanizing deltas
- Sustainable energy from water and subsoil
- Characterisation and visualization of the subsurface

The programs develop applicable knowledge and tools that facilitate the management of water and subsoil with regard to fresh water supply and proper management of saline water resources. This is done in close cooperation with all relevant stakeholders to assure a good linkage between the development and usage of knowledge.

Date
3 June 2013

Our reference
1206377-000-BGS-0003-cl

Page
2/3

We are interested in participation in the project because it matches closely with the mission of Deltares and the scope of our research knowledge programs mentioned above, in particular the program Fresh water supply in urbanizing deltas.

We herewith explicitly express our interest in project 1.1: *Resource analysis and regional water management*. The main objective of this project 1.1 is to develop monitoring, modelling and water management tools in order to achieve an optimal distribution and use of salt and fresh water in delta's. These tools are useful in our present and future international projects in delta's throughout the world, focusing on increasing (fresh) water availability and on developing water management strategies, such as the Mississippi delta, Singapore, Bengal Delta Bangladesh, Mekong Delta Vietnam. The three PhD research topics of this project are:

- WP 1: Rapid large-scale mapping of salt-fresh water distributions in delta's;
- WP 2: Rapid modelling and scenario toolbox for fresh-salt water use and control;
- WP 3: Cockpit day-to-day control of regional salt-fresh water resources.

Cofinancing

In this project we will perform the following actions: 1. Cash contributions and 2. In-kind contribution in joined research. All three PhD's will be positioned part-time at Deltares. Deltares is well equipped to model and monitor salinization in (ground)water systems and can provide field pilots for the WATER NEXUS project. Deltares will actively contribute to project 1.1 through in kind contributions and supply data, model instruments and field expertise where needed.

We commit the following contribution to the project:

Project 1.1 (*Resource analysis and regional water management*):

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	1040	119	123.760,-
Cash			70.000,-
Total contribution			193.760,-

This letter and this commitment replaces our letter dated 23 May 2013 with reference 1208100-000-BGS-0001-cl.

The following Deltares personnel will be actively involved in the project:

- Dr. ir. Gualbert Oude Essink is geohydrologist/groundwater modelling expert at Deltares. Gualbert Oude Essink has high level expertise on quantifying salinization in groundwater systems and makes use of "state of the art" monitoring and modelling techniques. For example, Gualbert contributed to the Interreg IV CLIWAT project in which the results of airborne electromagnetic (SkyTEM or HEM) and reflection seismic surveys were validated against ground truth using monitoring and modelling results from Deltares. In addition, Gualbert is also at the fore-front of developing promising measures for local and regional water supply (e.g. Knowledge for Climate programme).

Date
3 June 2013

Our reference
1206377-000-BGS-0003-cl

Page
3/3

- Drs. P.G.B. (Perry) de Louw is PhD student at Deltares on the subject "Dynamics of shallow brakish-salt groundwater systems". Perry has previously demonstrated his research skills in numerous projects on regional (ground)water systems. Finalisation of his PhD thesis is planned at the beginning of 2013. His research focusses in the quantification and manipulation of shallow fresh water lenses in a surrounding of brackish groundwater, and on the salinization of deep polder areas through so-called boils.

Utilisation

Deltares seeks to develop modelling and analysis tools for water-related research. One of the focus areas is water scarcity and drought in deltaic areas. The outcomes of all three PhDs will be added to our monitoring, modelling and software toolboxes for (rapid) characterizing delta's under the pressure of climate and global change worldwide. Our customers are the Dutch government and water boards, as well as foreign water management bodies and local and regional government. In addition, we will use the deliverables in larger projects in tandem with Dutch and foreign consultants. This is done in two ways: 1) by developing methods and tools to identify the best locations to apply technologies that increase fresh water availability, create fresh water or use brackish and salt water as a resource; 2) by developing innovative water management strategies and tools to optimize the distribution of fresh, salt and brackish water in space and time in support of their consumption and use.

We already expect to implement spin-off (prototypes and products) of the executed research by the PhD's in our daily international projects during the course of this WATER NEXUS program (period 2015-2018).

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support this STW Topsector Water program WATER NEXUS.

Yours sincerely,


dr. ir. A.G. Segeren
Director Subsurface and Groundwater Systems



13.34780

Hoogheemraadschap van
Rijnland

your reference:

our reference:

13.34780

attachments:

from:

M. Kramer

direct line:

(071) 306 33 62

subject:

STW Perspectief, WATER NEXUS

Utrecht University

Attn. Mister prof. dr. Marc F.P. Bierkens

P.O.Box 80115

3508 TC UTRECHT

Leiden, 5 juni 2013

Dear Mr Bierkens,

The Rijnland District Water Control Board has been involved in the definition of the STW Perspectief program WATER NEXUS and detailed planning of project 1.1, in which we will participate.

The Rijnland District Water Control Board ensures clean water and dry feet. Rijnland, as a local governmental organization, has as key-tasks:

- ensuring that dunes, dikes and embankments are in good condition and fit to provide adequate flood-protection (flood defenses);
- ensuring a good quality of open water so that it can be used for recreation, watering cattle and as a habitat for a large variety of plants and animals (water quality);
- ensuring that the water levels are adequate throughout the area; there must be sufficient (fresh) water, not too much and not too little (water management);
- ensuring that polluted river, canal- and lakebeds are cleaned in order to balance the water-ecosystem so that the water provides opportunities for natural development in the countryside as well as in towns and cities (water management plus).

One of the goals of the *Delta Program* is the long term availability of fresh water. We are interested in participation in the project because it closely fits within the *Delta Program* and our water management mission to ensure clean and enough water at the right time and the right place.

We herewith explicitly express our interest in project 1.1: *Resource analysis and regional water management*. The main objective of this project 1.1 is to develop monitoring, modelling and water management tools in order to achieve an optimal distribution and use of fresh water in lowland catchments. These tools are useful for better understanding our water management system, and can help us in improve our water management system for now and in the future. We are in particular interested in the operational management of regional salt-fresh water resources especially in brackish polder systems like the *Haarlemmermeer*.

Archimedesweg 1

postadres:

postbus 156

2300 AD Leiden

telefoon (071) 3 063 063

telefax (071) 5 123 916

internet: www.rijnland.nete-mail: post@rijnland.net



Hoogheemraadschap van Rijnland

Cofinancing

We will perform a cash contribution to the project. The Rijnland District Water Control Board is well equipped to provide interesting pilot areas. We can also supply data on water and salt fluxes in (ground)water systems for the WATER NEXUS project. The Rijnland District Water Control Board can actively contribute to project 1.1 through model instruments, monitoring data and field expertise where needed.

We commit the following contribution to the project:

Project 1.1 (*Resource analysis and regional water management*):

Cash			€ 60.000,-
Total contribution			€ 60.000,-

Utilisation

The Rijnland District Water Control Board seeks to use up-to-date water management tools to ensure clean water at the right time and the right place. The outcomes of the research of project 1.1 will be added to our software toolboxes for management of water and salt fluxes in our polder areas, to develop innovative water management strategies (e.g. with the Delta Programme Fresh Water).

We already expect to implement spin-off of the executed research during the course of this WATER NEXUS program (period 2015-2018).

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support this STW Topsector Water program WATER NEXUS.

Yours sincerely,

Timo van Tilburg
Department of Policy



Shell India Markets Private Limited
Shell Projects & Technology
RMZ Centennial Campus B
No. 8B, Kudalahalli Main Road
Bengaluru 560 048, India
Phone: +91 80 4021 7137
Fax: +91 80 4021 7160

University of Utrecht
Faculty of Geosciences
Prof.dr.ir. M. Bierkens
Heidelberglaan 2
Willem C. van Unnikgebouw - Zonneveld vleugel
Room Zon 128
3584CS Utrecht
The Netherlands

Bangalore, June 3rd 2013

Subject: Support letter project 1.1

Dear Prof. Bierkens,

Shell has been involved in the definition of the STW Perspectief program WATER NEXUS and the detailed planning of the project Strategic Resource Management and Control. Hence, we are pleased to inform you that we have decided to participate in this project.

We are a global group of energy and petrochemicals companies with around 87,000 employees in more than 70 countries and territories. Advanced technologies, new ways of operating and partnerships are helping to manage our environmental impact as we contribute to meeting the world's growing energy needs. We are interested in participation in this project because Shell is becoming increasingly concerned about its water use as water becomes scarcer at a global level. New approaches and advanced technologies are helping us to reduce the amount of water we need for our operations.

We commit to a financial contribution of 50 K€ to the project for a 5-years period, i.e. 10 K€ per annum.

Our interest in project 1.1 particularly lies in the development of tools for mapping and prediction of water distribution on a regional level. We will work together with you on data analysis of model results.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We look forward to a successful cooperation.

With kind regards,

A handwritten signature in blue ink, consisting of a stylized 'A' followed by a horizontal line that curves upwards and to the right.

Prof.dr.ir. A.J.H. Janssen
Manager Water R&D

Prof. dr. Marc F.P. Bierkens
Van Unnik Building - Zonneveldvleugel, room 128
P.O. Box 80115 Utrecht
3508 TC Netherlands

Date: May, 24 2013

Re: Support letter project 1.1: Resource analysis and regional water management

Dear Prof. dr. Marc F.P. Bierkens,

Eijkelkamp Agrisearch Equipment has been involved in the definition of the STW Perspective program WATER NEXUS, and detailed planning of 1.1: Resource analysis and regional water management, in which we will participate.

Eijkelkamp Agrisearch Equipment BV (in the remainder of this document referred to as EAE) is very interested in this program, and is willing to take part in users committees and contribute directly to the experimental work in the projects.

EAE is an international organization offering solutions geared to customer needs in soil and water research. Through its innovative and sustainable services and products, and based on its expertise gained in a century of serving its markets, EAE is confident it can significantly contribute to the WATER NEXUS program.

The current product range of Eijkelkamp Agrisearch Equipment can best be described as equipment for soil, water, plant, climate and residual substances research and is intended primarily for agricultural, hydrological and environmental studies. Our wide Product range from the worldwide known soil augers upto the latest environmental water and soil sensors connected trough the cloud to the customer named carefree solutions.

Our most important customers are active in soil, water and environmental research and related fieldwork. More than 60 distributors represent Eijkelkamp all over the world. Our dedicated and well-trained partners are our eyes and ears in the local market. At our premises in Giesbeek about 85 employees are working. Company training and consultancy expertise in relation to the NEXUS project is added for planning, installing and operating of our products within the project. Personal competences are the development of various environmental sensors and telemetric data communication, as well as worldwide commercialisation of products and services.

We are interested in participation in the project because we are active in marketing solutions using our products and development of new products and services built on our telemetric sensor platform. Already there are sensors available measuring the surface and ground water table including conductivity as measure of the amount of soluted salts.

These measurements can be of strategic importance for ground proofing remote sensing technologies. We plan to complete our portfolio in the salt intrusion using the Water Nexus project results. The use of sensor information combined with prediction models can lead to an information and control system with great importance to the optimisation of threatening situations. Furthermore the project will give us the opportunity to get introduced in the specific projects around salt and delta problematic that are relevant for business development.

Last but not least we have also the SonicSampDrill technology and services that enables to drill groundwater monitoring wells most effective. There is an international fieldwork experience placing high quality monitoring wells using this technology.

For 1.1 We plan to contribute in fieldwork using the sensor technology of salt concentration monitoring in surface- and groundwater, soil profiling for moisture, conductivity and temperature. Also we want to integrate the prediction models along with data presentation and graphical visualisation into the sensor telemetric network.

Cofinancing

In this project we will perform the following actions:

We will support by means of senior technician and consultants in planning, advise and installation assistance of fieldworks.

We commit the following contribution to the project:1.1

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• technician	50	€83	€4150
• consultancy	100	€83	€8300
Cash			€20000
Total contribution			€32450

Utilisation

We will actively integrate and promote the project results for monitoring of salt intrusion by training our partners and clients, providing documentation, product presentations. Also international sales missions and exhibitions will be attended. Also the combination with commercial project partners will enhance our mutual activities.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,



Fons Eijkelkamp,
Eijkelkamp Agrisearch Equipment



Veurse Achterweg 10
Postbus 63
2260 AB Leidschendam
tel.: 070-3111223

Wageningen University
Department of Environment and Water
Technology
Attn. prof. dr. H.H.M. Rijnaarts
P.O. Box 17
6700 AA WAGENINGEN

13031/MP/snh

Leidschendam, 3 June 2013

Subject : Support letter project "Resource analysis and regional water management"

Dear professor Rijnaarts,

Fugro GeoServices B.V. has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of project 'Resource analysis and regional water management', in which we will participate.

Fugro is one of the leading global engineering companies on data acquisition of the earth's surface and subsurface. With 12.000 employees, revenue EUR 2,9 billion (2012) and presence in more than 60 countries we are ranked in the top ten of global engineering companies.

The investigation of the world's resources such as oil, gas, minerals and water is the core business of our company. In the last 30 years we build up a groundwater consultancy group specialized in using the latest data collection and modeling techniques to identify and assess water resources. Fugro develops and uses a wide range of geophysical and invasive data acquisition and monitoring techniques to map geology and identify groundwater resources.

The coming decades many countries, even the Netherlands, will suffer major freshwater deficits. This trend is certainly not only an issue for governments but also has serious impacts on businesses in many sectors. Sustainable groundwater management is becoming more important to secure water resources.

We are interested in participation in the project because it can provide us a leading position in the development and use of new technologies to detect and monitor groundwater resources. One of these new technologies is the Multi-Parameter Detection Probe which allows us real-time collection of several subsurface parameters. The data that we collect provides us a basis for modeling and thus understanding of the geohydrological system and possibilities of groundwater abstraction and injection in saline groundwater environments.

Due to this combination of field surveying and hydrological expertise we are able to advise our clients on sustainable groundwater solutions for groundwater exploration and well development for oil & gas, mining and food & beverage industries.

Cofinancing

In this project we will perform the following actions:

The In kind contribution for the period 2014 - 2018 contains the participation of senior (MSc) geohydrologists and geophysicists in joined research activities with UU, Deltares and TNO to develop and test new Detection Probes and data integration techniques to combine different data sources for groundwater modeling. The models will be used to calculate climate scenario's and optimize salt-fresh water resources management measures with the goal to provide sustainable water resources solutions at regional and local scale.

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	600	125	75.000
Equipment (depreciation)			
Development and testing of Multi Parameter Detection Probe (CPT, MIP, HPT)	80	312	25.000
• CPT – Cone Penetration Test			
• MIP - Membrane Interface Probe			
• HPT - Hydraulic Profiling Tool			
Materials (cost price)			
Cash			15.000
Total contribution			115.000

Utilisation

Fugro serves many industrial clients of various sectors which are increasingly asking for expertise on groundwater resources management and sustainable water well development. For most of the water resources issues our clients are dealing with, a thorough understanding of the regional and local geohydrological situation is essential to provide sustainable solutions. The new technologies and methodologies for the collection, integration and modeling of subsurface and groundwater data at different scales, can directly be used for solving complex groundwater resources issue for clients. Since water shortage is increasingly affecting many of the primary processes of most industries, these will put priority on new and efficient methods to secure their resources. We expect a Return on Investment in 2 - 3 years.



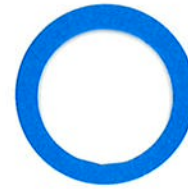
We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program

Yours sincerely,
Fugro GeoServices B.V.

Ing. M. Pehlig
Director

A handwritten signature in blue ink, appearing to read "M. Pehlig", is written over the typed name and title. The signature is enclosed within a large, loopy oval shape.



Utrecht University
Attn. Mister prof. dr. Marc F.P. Bierkens
Van Unnik Building – Zonneveldvleugel, room
128
P.O.Box 80115 Utrecht
3508 TC Utrecht
The Netherlands

ONDERWERP	Support letter STW-perspectief Water Nexus 1.1
DATUM	Amersfoort, 3 juni 2013
ONS KENMERK	2013-0243-RR/MT-446.723
UW KENMERK	

Dear Mr. Bierkens,

STOWA (Dutch acronym for the Foundation for Applied Water Research) has been involved in the definition of the STW Perspectief program WATER NEXUS and detailed planning of the Water NEXUS project, in which we will participate.

STOWA is the knowledge centre of the regional water managers, especially the water boards in the Netherlands. STOWA develops, collects and disseminates knowledge needed for the tasks of the waterboards. The STOWA projects cover the following fields: collection, transport and treatment of waste water; management of the quality and quantity of surface and ground water; urban water management; climate adaptation, freshwater and safe regional water defenses, prevention against flooding and maintenance of water barriers.

The research goals of the projects are directly relevant to the STOWA program 'Deltaproof' and 'Watermozaiek', focussing on challenges with regards to self supporting regional watersystems in facts of water quantity, and challenges with regard to ecosystem functioning.

We are interested in participation in the project because it closely fits within our mission, coordinating and commissioning research on a large scale of water management issues.

We herewith explicitly express our interest in project 1.1: Resource analysis and regional water management. The main objective of this project 1.1 is to develop monitoring, modeling and water management tools in order to achieve an optimal distribution and use of fresh water in lowland catchments. These tools are useful for better understanding our water management system, and can help us in improve the water management systems of water Boards in the coastal zone.

Co financing

The STOWA will support the project with a contribution amounting to 25.000 € in cash by transferring five tranches of 5.000 € equally distributed over the 5-year duration of the project. STOWA can actively contribute to project 1.1 through communication and knowledge sharing of the results to the water boards, NL wide, e.g. via reporting and co-organizing symposia. Therefore in addition, STOWA and participating waterboards will support the project in kind with efforts adding up to 11.600 €.

Project 1.1 (*Resource analysis and regional water management*):

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
Senior reasercher	100	116	11.600,-
Cash			25.000,-
Total contribution			36.600,-

The capitalization, against standard STW tariffs, of hours only represents a nominal value of hours STOWA will spend on the project. The resulting amount is not claimable as a cash contribution.

STOWA seeks to provide water managers with scientific knowledge and practical instruments they require for carrying out their jobs sufficiently, e.g. via our so-called Deltafacts. The outcomes of the research of project 1.1 can be added to the existing tools such as the National Hydrological Instrumentarium to model the interaction of subsurface, unsaturated zone and surface water system from a salt component point of view. In addition, we think that the outcomes of this project will contribute to indicate the potential and consequences of up scaling capabilities of the Water Nexus technologies to the whole coastal zone of Netherlands, and beyond.

We already expect to implement spin-off of the executed research during the course of this WATER NEXUS program (period 2015-2018).

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support this STW Topsector Water program WATER NEXUS.

Yours sincerely,



Drs. B. van der Wal

Director STOWA



Postbus 47 | 6700 AA Wageningen

Prof. Dr. Sjoerd van der Zee
Chair group Soil Physics and Land Management
Wageningen University
P.O. Box 47
6700 AA Wageningen
Netherlands

Dear Prof van der Zee,

Alterra, Wageningen UR, is very interested in the concept of the WATER NEXUS program and is willing to support and participate in project 1.2.

The mission of Alterra is to contribute to the realisation of a high quality and sustainable green living environment in all parts of the world by qualified an independent research. Aspects of our green environment that Alterra focuses on include flora and fauna, soil, water, climate, vegetation, land cover and land use, the use of geo-information and remote sensing.

Alterra has a special interest in Water Nexus as many research activities of the program with respect to Resource Analysis correspond with our priorities for a) soil, water & food security and b) water resources & climate change adaptation and mitigation. Besides this, the activities also fit well in our program for the Dutch "Topsector Water, living with salt". The results of the program can be used in particular to develop our knowledge and modelling tools on processes in the upper soil-plant-atmosphere system in Delta's with shallow, salt and brackish groundwater. Hereby, Alterra commits itself to support project number 1.2; Local Operational Water Management and Control. The objective of project 1.2 is to explore solutions to safeguard water availability and prevent both drought and salinity at the root zone level at field level of farmers. This will be achieved in 3 research topics:

- Anticipating drainage systems in salt affected lowlands; development a validated tool for optimal water storage by intelligent drainage management
- Stabilise existing salt-freshwater distributions and limit temporal variations: improvement of Soil-Water-Plant model platform to be weather and salinity proof and investigate conditions needed to accomplish stable salt-fresh gradients in nature (development) sites
- Economizing marginal (waste) water; to develop a Decision Support Module for integrated risk analysis of waste water re-use

This project interacts with project 1.1 to scale models from regional to local scale and vice versa

Co-financing

We will support project 1.2 by cash contribution and in-kind contribution in joined research. Our support is summarized in table 1.

Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	600	119	71.400,-
Cash			100 000
Total contribution			171.400,-

Our in-kind contribution will include

- Supply of data
- Bring in our key-expertise on design, construction, inspection and monitoring of control drainage systems

Board of Directors
Environmental
Sciences Group

DATUM
June 4, 2013

ONDERWERP
Support letter STW Water
Nexus project for project 1.2

ONS KENMERK
20130212

POSTADRES
Postbus 47
6700 AA Wageningen

BEZOEKADRES
Wageningen Campus
Gebouw 101
Droevendaalsesteeg 3A
6708 PB Wageningen

INTERNET
www.wur.nl

CONTACTPERSOON
ir. A.H. de Bruin

Wageningen UR (Wageningen University, Van Hall Larenstein University of Applied Sciences and various research institutes) is specialised in the domain of healthy food and living environment.

DATUM
13 juli 2011

ONS KENMERK
2012-11-05

PAGINA
2 van 2

- Support in the design of ADS, choice of field sites and set-up of field experiments
- Support in application en development of modelling (SWAP and 2D modelling)

Alterra researchers that will be involved are Lodewijk Stuyt, Peter Schipper, Joop Kroes and Piet Groenendijk.

Utilization

Alterra develops modelling tools and decision support systems to optimize integrated water and river basins management and to adapt to climate change and future developments like urbanization, green economy and increasing food demand. One of our focus areas is to develop solutions for water scarcity and drought and how to develop solutions to improve the efficiency of water, nutrients, waste water and energy in agriculture irrigation and drainage systems.

The outcomes of project 1.2 will be used to further development of our modelling tools that we supply in the Netherlands (for instance to support decision making on fresh water supply for the delta program) and worldwide. Especially with respect to our state-of-the art modelling chain of water and salt transport in the soil (saturated and vadose zone), crop growth including feedbacks with climate. The outcomes of project 1.2 will also be used to improve existing functions of salt stress of agriculture crops and natural vegetation and to incorporate validated salt stress in our modelling tools.

The conceptual innovations that are developed in project 1.2 are packed into a generic set of decision support rules which are integrated in a tailor-made (i.e. region specific), automated and anticipating water management protocol. This innovation will be available for (i) innovative companies that supply devices for adaptive monitoring and management of fresh-saline water management at field scale, and (ii) regional water resources authorities that have the ambition to optimize water management at regional scale, e.g. Deltaic areas. The abovementioned clients will have to incorporate the set of decision support rules in their own software platforms and applications.

We have taken notice of the STW guidelines for intellectual property and will participate in the user committee.

Yours sincerely,



Ir. Auke de Bruin,
Director Operations Alterra



Soil Physics and Land Management
Attn. Prof. Dr. Sjoerd E.A.T.M. van der Zee
Wageningen University
Postbus 47
6700AA WAGENINGEN

Groningenhaven 7
Postbus 1072
3430 BB Nieuwegein
The Netherlands

P +31 30 606 95 11
F +31 30 606 11 65
I www.kwrwater.eu

Subject Support letter project 1.2 Operational Water Management
and Control
Information Jan Vreeburg, +31(0)30 6069576
E-mail jan.vreeburg@kwrwater.nl
Date 3 June 2013
Our reference 13060008/JVR/CK

Dear prof. dr. van der Zee,

KWR Watercycle Research Institute has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of 1.2 Operational Water Management and Control in which we will participate.

KWR Watercycle Research Institute creates knowledge that is vital to providing two of life's basic needs:

- healthy and safe drinking water;
- a pollution free environment.

Our researchers combine new knowledge and the knowledge and experience already at their disposal through their own expertise and KWR's extensive network. KWR's research focuses on four important themes: Healthy, Sustainable, Advanced and Efficient water.

Ecology and geohydrology are important knowledge fields in which KWR bridges between science, business and society. Part of this knowledge is condensed in our Waterware tools (<http://www.waterware.nl>) and in subsurface water technologies such as the Fresh Keeper and Fresh Maker.

We are interested in participation in the project for the following reasons:

- Project 1.2 of WATER NEXUS studies the effects of salt on natural vegetation. These effects are important for our principle clients: Dutch water supply companies.
- Project 1.2 of WATER NEXUS complements our activities regarding fresh water availability for water supply companies and the agricultural sector (Knowledge for Climate ASR-pilots and techniques such as Fresh Maker and Fresh Keeper).

Cofinancing

In this project we will perform the following actions:

- We will participate in the research on the effects of salt on natural vegetation.
- We will cooperate in the pilot with Adaptive Drainage in agricultural plots.

We commit the following contribution to the project:

	hours	rate (euro/hr.)	amount (euro)
Senior researcher (in kind)	640	119	76 160
Cash			70 000
Total contribution			144 160

Utilization

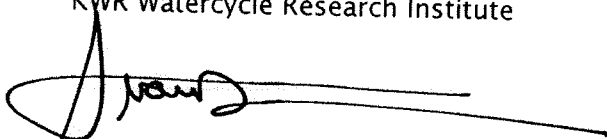
We will include salt effects on natural vegetation in KWR's methodology for prediction of Natural Vegetation. The water management tools for agricultural practices will allow us to extend our services with respect to fresh water availability, such as ASR, Fresh Maker and Fresh Keeper.

This allows us to contribute to an increase in efficiency of Dutch water supply companies with respect to water resources management. Moreover we will export these tools and expertise via the WaterShare programme of KWR (<http://www.watershare.nl>).

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Kind Regards,
KWR Watercycle Research Institute



Prof. Dr. W. van Vierssen
Chief Executive Officer



Shell India Markets Private Limited
Shell Projects & Technology
RMZ Centennial Campus B
No. 8B, Kudalahalli Main Road
Bengaluru 560 048, India
Phone: +91 80 4021 7137
Fax: +91 80 4021 7160

Wageningen University
Soil Physics and Land Management
Prof.dr.ir. S. van der Zee
PO box 47
6700AA WAGENINGEN

Bangalore, June 3rd 2013

Subject: Support letter project 1.2

Dear Prof. Van der Zee,

Shell has been involved in the definition of the STW Perspectief program WATER NEXUS and the detailed planning of the project Operational Management and Monitoring. Hence, we are pleased to inform you that we have decided to participate in this project.

We are a global group of energy and petrochemicals companies with around 87,000 employees in more than 70 countries and territories. Advanced technologies, new ways of operating and partnerships are helping to manage our environmental impact as we contribute to meeting the world's growing energy needs. We are interested in participation in this project because Shell is becoming increasingly concerned about its water use as water becomes scarcer at a global level. New approaches and advanced technologies are helping us to reduce the amount of water we need for our operations.

We commit to a financial contribution of 25 K€ to the project for a 5-years period, i.e. 5 K€ per annum.

Our interest in project 1.2 particularly lies in the development of tools prediction of local water availability and options for use of industrial water in agri/horticulture. We will work together with you on data gathering and analysis of model results.

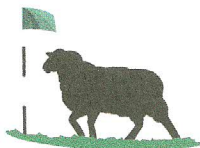
We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We look forward to a successful cooperation.

With kind regards,

A handwritten signature in blue ink, appearing to be 'A.J.H. Janssen', written over the printed name.

Prof.dr.ir. A.J.H. Janssen
Manager Water R&D



HOLLANDSCHE
GREENKEEPING
MAATSCHAPPIJ

To: Prof. Dr. Coen J. Ritsema and Prof. Dr. Sjoerd van der Zee
Chair group Soil Physics and Land Management
Wageningen University
P.O. Box 47
6700 AA Wageningen
Netherlands

Date: 17 May 2013

Re: Support letter STW Water Nexus project for project 1.2

Dear Prof Ritsema and Prof van der Zee,

The Hollandsche Greenkeeping Maatschappij (HGM) has been involved in the definition of the STW Perspectief program Water Nexus, and detailed planning of one of the anticipated PhD projects within project 1.2, in which it will participate.

The Hollandsche Greenkeeping Maatschappij (HGM) is a company that maintains golfcourses. HGM maintains 15 golfcourses with a turnover of 5 mln euro per year.

We are specifically interested in participation in the STW Water Nexus project because we feel that through our collaboration and financial contribution to one particular PhD project within project 1.2 more knowledge will be gained regarding operational water management and control issues on turfgrass sport fields. This is of essential importance for HGM regarding its company goal to design and implement sustainable water management systems on sport field locations. The design, testing and evaluation of sustainable water management and control systems for sport field locations will provide HGM with relevant scientific knowledge and a potentially marketable product for further commercial use and distribution within the Netherlands and abroad.

Aannemersbedrijf met als specialisme Onderhoud, Renovatie en Aanleg van golfbanen en groenprojecten

Hollandse Greenkeeping Maatschappij B.V.
Oudendijk 94
4285 WL Woudrichem
www.hmggolf.nl

hans@hmggolf.nl
BTW (NL) 8502.9087.9.B.01
KvK 52078027
Rabobank 15.82.83.686



HOLLANDSCHE
GREENKEEPING
MAATSCHAPPIJ

Hereby, HGM commits itself to co-finance this particular PhD project within sub-project 1.2 of the STW Water Nexus program with a total amount of 60,000 €. Within this framework, HGM expects a close collaboration with the SLM chair group of Wageningen University regarding the selection of the PhD candidate, further outlining and detailing the specific PhD work programme, as well as executing the field trials and monitoring programmes. In this respect, HGM will be able to provide suitable golf course locations for this purpose, and HGM staff to jointly participate in this project.

In summary, we commit the following in-kind and cash contribution to the project:

	hours	rate (euro/hr.)	amount (euro)
HGM staff (in-kind)	200	83	16 600
Measuring equipment (in-kind)			1 000
Materials (in-kind)			
Cash			60 000
Total contribution			77 600

HGM has taken notice of the STW guidelines for intellectual property, and will participate in the user committee, if required.

To conclude, HGM enthusiastically supports the WATER NEXUS program, and looks forward to start this exciting initiative in close collaboration with Prof Ritsema and Prof van der Zee.

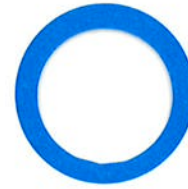
Yours sincerely,
HGM

Ir. Ian Ouwerkerk
Technical Director

Aannemersbedrijf met als specialisme Onderhoud, Renovatie en Aanleg van golfbanen en groenprojecten

Hollandse Greenkeeping Maatschappij B.V.
Oudendijk 94
4286 WL Woudrichem
www.hgm-golf.nl

hans@hgm-golf.nl
BTW (NL) 8502.9087.9.B.01
KvK 52078027
Rabobank 15.82.83.686



Wageningen University
Attn. Mister prof. dr. ir. S.E.A.T.M. van der
Zee
Soil Physics and Land Management
Wageningen University
Postbus 47
6700AA Wageningen
The Netherlands

ONDERWERP Support letter STW-perspectief Water Nexus 1.2
DATUM Amersfoort, 3 juni 2013
ONS KENMERK 2013-0242-MT/RR-446.723
UW KENMERK

Dear mr. Van der Zee,

STOWA (Dutch acronym for the Foundation for Applied Water Research) has been involved in the definition of the STW Perspectief program WATER NEXUS and detailed planning of the Water NEXUS project, in which we will participate.

STOWA is the knowledge centre of the regional water managers, especially the water boards in the Netherlands. STOWA develops, collects and disseminates knowledge needed for the tasks of the waterboards. The STOWA projects cover the following fields: collection, transport and treatment of waste water; management of the quality and quantity of surface and ground water; urban water management; climate adaptation, freshwater and safe regional water defenses, prevention against flooding and maintenance of water barriers.

The research goals of the projects are directly relevant to the STOWA program 'Deltaproof' and 'Watermozaiek', focussing on challenges with regards to self supporting regional watersystems in facts of water quantity, and challenges with regard to ecosystem functioning.

We are interested in participation in the project because it closely fits within our mission, coordinating and commissioning research on a large scale of water management issues.

We herewith explicitly express our interest in project 1.2: Operational Water Management and Control. The main objective of this project is to develop monitoring, modeling and water management tools in order to achieve optimal conditions for crop production and/or nature by managing the spatial distributions of fresh groundwater water at the field scale. Moreover, this project aims at assessing the impact of salt on both crop production and natural vegetation. This knowledge and tools help us to improve the water management systems of water Boards in the coastal zone.

Co financing

The STOWA will support the project with a contribution amounting to 25.000 € in cash by transferring five tranches of 5.000 € equally distributed over the 5-year duration of the project. STOWA can actively contribute to project 1.1 through communication and knowledge sharing of the results to the water boards, NL wide, e.g. via reporting and co-organizing symposia. Therefore in addition, STOWA and participating waterboards will support the project in kind with efforts adding up to 11.600 €.

Project 1.1 (*Resource analysis and regional water management*):

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
Senior reasercher	100	116	11.600,-
Cash			25.000,-
Total contribution			36.600,-

The capitalization, against standard STW tariffs, of hours only represents a nominal value of hours STOWA will spend on the project. The resulting amount is not claimable as a cash contribution.

STOWA seeks to provide water managers with scientific knowledge and practical instruments they require for carrying out their jobs sufficiently, e.g. via our so-called Deltafacts. The outcomes of the research of project 1.2 can be used to improve tools such as WATERNOOD, HELP and 'Effect module Natuur' to model the effect of (adaptive) water management on agriculture and nature. In addition, we think that the outcomes of this project will contribute to indicate the potential and consequences of upscaling capabilities of the Water Nexus technologies to the whole coastal zone of Netherlands, and beyond.

We already expect to implement spin-off of the executed research during the course of this WATER NEXUS program (period 2015-2018).

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support this STW Topsector Water program WATER NEXUS.

Yours sincerely,



Drs. B. van der Wal

Director STOWA

Prof.Dr. Sjoerd E.A.T.M. van der Zee
Wageningen University
Soil Physics and Land Management, Environmental Sciences Group
P.O.Box 47
6700 AA Wageningen

Date: May, 24 2013

Re: Support letter project 1.2: Operational Water Management and Control

Dear Prof.Dr. Sjoerd E.A.T.M. van der Zee,

Eijkelkamp Agrisearch Equipment has been involved in the definition of the STW Perspective program WATER NEXUS, and detailed planning of 1.2: Operational Water Management and Control , in which we will participate.

Eijkelkamp Agrisearch Equipment BV (in the remainder of this document referred to as EAE) is very interested in this program, and is willing to take part in users committees and contribute directly to the experimental work in the projects.

EAE is an international organization offering solutions geared to customer needs in soil and water research. Through its innovative and sustainable services and products, and based on its expertise gained in a century of serving its markets, EAE is confident it can significantly contribute to the WATER NEXUS program.

The current product range of Eijkelkamp Agrisearch Equipment can best be described as equipment for soil, water, plant, climate and residual substances research and is intended primarily for agricultural, hydrological and environmental studies. Our wide Product range from the worldwide known soil augers upto the latest environmental water and soil sensors connected trough the cloud to the customer named carefree solutions.

Our most important customers are active in soil, water and environmental research and related fieldwork. More than 60 distributors represent Eijkelkamp all over the world. Our dedicated and well-trained partners are our eyes and ears in the local market. At our premises in Giesbeek about 85 employees are working. Company training and consultancy expertise in relation to the NEXUS project is added for planning, installing and operating of our products within the project. Personal competences are the development of various environmental sensors and telemetric data communication, as well as worldwide commercialisation of products and services.

We are interested in participation in the project because we are active in marketing solutions using our products and development of new products and services built on our telemetric sensor platform. Already there are sensors available measuring the surface and ground water table including conductivity as measure of the amount of soluted salts.

These measurements can be of strategic importance for ground proofing remote sensing technologies. We plan to complete our portfolio in the salt intrusion using the Water Nexus project results. The use of sensor information combined with prediction models can lead to an information and control system with great importance to the optimisation of threatening situations. Furthermore the project will give us the opportunity to get introduced in the specific projects around salt and delta problematic that are relevant for business development.

Last but not least we have also the SonicSampDrill technology and services that enables to drill groundwater monitoring wells most effective. There is an international fieldwork experience placing high quality monitoring wells using this technology.

For 1.2 we plan to contribute in fieldwork using the sensor technology of salt concentration monitoring in surface- and groundwater. Also the integration of meteorological parameters including i.e. precipitation, evaporation, soil profiling for moisture, conductivity and temperature. Furthermore we see chances in integration and commercialisation of the osmotic tensiometer developed in an earlier STW program. Next to monitoring we plan to incorporate the control of the drainage system (ADS).

Cofinancing

In this project we will perform the following actions:

We will support by means of senior technician and consultants in planning, advise and installation assistance of fieldworks.

We commit the following contribution to the project:1.2

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• technician	50	€83	€4150
• consultancy	100	€83	€8300
Cash			€5000
Total contribution			€17450

Utilisation

We will actively integrate and promote the project results for monitoring of salt intrusion by training our partners and clients, providing documentation, product presentations. Also international sales missions and exhibitions will be attended. Also the combination with commercial project partners will enhance our mutual activities.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,



Fons Eijkelkamp,
Eijkelkamp Agrisearch Equipment



Paques bv
T. de Boerstraat 24
8561 EL BALK
P.O. Box 52
8560 AB BALK
The Netherlands

t +31 (0)514 60 85 00
f +31 (0)514 60 33 42
e info@paques.nl
i www.paques.nl

Dr.ir. H. Temmink
Sectie Milieutechniek
Wageningen Universiteit
PO Box 17
6700 AA WAGENINGEN

Our ref. : RJH/CKA/2013/WUR 001B
Subject : Support letter project 2.1

Balk, 5 June 2013

Dear Mr Temmink,

Paques B.V. has been involved in the definition of the STW Perspectief program WATER NEXUS and detailed planning of project 2.1 in which we will participate.

Paques helps companies and municipalities contribute to the major challenges of today: to reduce their water and carbon footprints and reclaim valuable resources. Paques does this by developing ingenious anaerobic water purification systems that produce energy from wastewater, whilst purifying the water and facilitating water reuse. The biogas produced in the purifying process is a source of green energy, a field of emerging interest worldwide.

Paques has its own research and testing facilities, performs research on anaerobic treatment in cooperation with universities, and regularly performs pilot scale tests at customers' locations.

We are interested in participation in the project because granular sludge technologies for saline water streams open up new markets (in particular in chemical industry) and enlarge our existing market position. The technology fits Paques' core strategy to develop sustainable solutions.

Co-financing

In this project we foresee to perform the following actions:

- Joint research and development activities;
- Building of the pilot reactors;
- Participation in pilot scale testing of the developed technologies.

We anticipate a commitment of the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	84	119	€ 10.000
Cash			€ 40.000
Total maximum contribution			€ 50.000

**Utilisation**

Paques will integrate the results of the project in their international marketing and product portfolio.

Paques has taken notice of the STW guidelines for intellectual property and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

With kind regards,

A handwritten signature in blue ink, appearing to read "Rob J.J. Heim". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

Rob J.J. Heim
CEO



Shell India Markets Private Limited
Shell Projects & Technology
RMZ Centennial Campus B
No. 8B, Kudalahalli Main Road
Bengaluru 560 048, India
Phone: +91 80 4021 7137
Fax: +91 80 4021 7160

Wageningen University
Sub-department of Environmental Technology
Dr.Ir. H. Temmink
P.O.Box 17
6700AA, Wageningen
The Netherlands

Bangalore, June 3rd 2013

Subject: Support letter project 2.1

Dear Dr. Temmink, dear Hardy

Shell has been involved in the definition of the STW Perspectief program WATER NEXUS and the detailed planning of the project 'Biological treatment technologies salt impacted waters'. Hence, we are pleased to inform you that we have decided to participate in this project.

We are a global group of energy and petrochemicals companies with around 87,000 employees in more than 70 countries and territories. Advanced technologies, new ways of operating and partnerships are helping to manage our environmental impact as we contribute to meeting the world's growing energy needs. We are interested in participation in this project because Shell is becoming increasingly concerned about its water use as water becomes scarcer at a global level. New approaches and advanced technologies are helping us to reduce the amount of water we need for our operations.

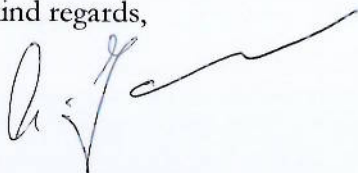
We commit to a financial contribution of 40 K€ to the project for a 5-years period, i.e. 8 K€ per annum.

Project 2.1 develops microbiological technologies that can help us in solving issues with treatment of saline water. We work together with you on data gathering and analysis of pilot trial results.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We look forward to a successful cooperation.

With kind regards,

A handwritten signature in black ink, appearing to be 'A.J.H. Janssen', written in a cursive style.

Prof.dr.ir. A.J.H. Janssen
Manager Water R&D

Wageningen University
Department of Environment and Water Technology
Attn. dr.ir. Hardy Temmink
P.O. Box 17

6700 AA WAGENINGEN

date
3 June 2013

your reference
-

reference
ZZAW5000-12/row/004

handled by
ir. J.F. Kramer

telephone
+31 (0)570 69 74 82

subject
support letter project:
biological nutrient removal
project number 2.1.

Dear Mr Temmink,

Witteveen+Bos has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of 'Biological nutrient removal 2.1', in wich we will participate.

Almere
Amsterdam
Breda
Deventer
Den Haag
Heerenveen
Maastricht
Rotterdam

Belgium
Indonesia
Kazakhstan
Latvia
Russia

member of



International
directory
number 134011

Witteveen+Bos is an employee owned, fully independent Dutch firm of engineering consultants. Established in 1946, the firm expanded to a professional staff of over 850. The many successfully completed projects over the years show that we are able to keep abreast with changes in society and thus with the wishes of clients by our continuing to be creative and innovative in combination with cost-effective solutions. Our expertise is not confined to engineering and technological issues only, but also extends to economic, social and organisational aspects, which, in our view, is essential for undertaking complex technical and engineering projects. The Witteveen+Bos organization is made up of 26 product-market combinations (PMCs), clustered into seven sectors. Besides our head office in Deventer, we have offices in Almere, Amsterdam, Breda, The Hague, Heerenveen, Maastricht and Rotterdam. Outside the Netherlands we maintain international offices in Belgium, Indonesia, Kazakhstan, Latvia, Russia and Vietnam.

We offer our clients top-class consultancy and designs for water, infrastructure, environment and construction projects. In the water domain, our specialists provide advice and engineering services on water collection, preparation of drinking and technical water, sewer systems, treatment and re-use of waste water (industrial and municipal), integrated water management and process automation.

Water Nexus Programme, project 2.1.

We are interested in participation in the STW Perspectief program WATER NEXUS, project 'Biological nutrient removal 2.1', because the potential outcome of this research will enhance the cost-effective (granular) waste water treatment technology at high salinity and will open



reference
ZZAW5000-12/row/004

date
3 June 2013

opportunities for additional reuse/recycling of water in broad range of industrial and domestic applications. It will give us new knowledge to design more cost effective treatment steps for the production of drinking, process and boiler feed water including ZLD plants.

Cofinancing

In this project we will perform the following actions:

- Validation and interpretation of research results for operational purposes.
- Translating research results into existing and/or new concepts for water, waste water treatment and process solutions including Zero liquid discharge plants.
- Interim evaluation of research results to technical and economic application in practice.
- Contribute directly to the experimental work in the projects.

We commit the following contribution to the project:

Table 1. Witteveen+Bos contribution, project 'Biological nutrient removal 2.1'.

	hours	rate (euro/hr.)	amount
staff			
senior / academic level	200	116,--	23.200,--
junior / HBO level	200	81,--	16.200,--
total in kind contribution for 5 years			39.400,--
cash (5 years, EUR 8.000/year)			40.000,--
total contribution			79.400,--

Utilisation

We expect that WATER NEXUS results will provide us the following commercial perspectives:

- Research and development of new cost effective (waste) water technology.
- Strengthening of our national and international position in consultancy, design and engineering of waste water and process water treatment systems, (industrial) reuse/recycle applications and ZLD water units.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours faithfully,

ir. Peter de Jong
Director Sector Water

Cc prof. dr. ir. H.H.M. Rijnaarts - Wageningen University

Wageningen Universiteit,
Sectie Milieutechnologie
Attn. Dr. ir. Hardy Temmink (projectleider 2.1)
P.O. Box 17
6700 AA WAGENINGEN

HaskoningDHV Nederland B.V.
Water Technology
Laan 1914 no. 35
3818 EX Amersfoort
P.O. Box 1132
3800 BC Amersfoort
The Netherlands
T +31 88 348 2000
F +31 88 348 2801
E info@rhdhv.com
W www.royalhaskoningdhv.com

Amersfoort, 22 May 2013

your ref : STW Perspectief, Water Nexus
our ref : WT-PI20130006
subject : Support letter
dealt with by : Andreas Giesen
tel, e-mail : +31 88 3482497, andreas.giesen@rhdhv.com
classification : Client confidential

Dear Mr Temmink, dear Hardy,

Royal HaskoningDHV has been involved in the definition of the STW Perspectief program WATER NEXUS and the detailed planning of subtask 2.1, in which we will participate.

Royal HaskoningDHV is an international consultancy and engineering firm with expertise and leadership in innovation and sustainability. We have an integrated approach to complex problems, particularly in the areas of infrastructure and mobility, water and environment, land and real estate and industry. Our services cover the entire project cycle, including management consultancy, advice, design and engineering, project management, contract and asset management.

Royal HaskoningDHV is strongly involved in municipal and industrial wastewater treatment using aerobic granular biomass with our so-called Nereda® technology: a technology developed by TUD/STW. We expect that the project outcomes will support us in widening up application fields for granular biomass and would potentially enable us to maintain the Dutch advanced position in this field. If STW decides to fund this program our total contribution over a 4 year period will be as follows:

In kind	Hours	Rate (€/h.)	Amount €
Staff			
Senior / Academic level	160	119	€ 19.040
Junior / HBO level			
Equipment (e.g. pilot installation)			
Measurements / analyses			
Materials			
Total in kind contribution			
Cash			€ 40.000
Total contribution			€ 59.040


Royal HaskoningDHV has a long history of collaboration with universities and experience with the marketing of research results.

As part of the project we will perform the following activities:

- Deliver input for setting of research boundaries with sufficient focus on practical applications in water industry;
- Deliver input for several case studies or actual practical projects to develop and/or verify the developed models;
- Collect and provide data inputs from Nereda aerobic granular biomass plants;
- Assist in data processing and evaluation;
- Assist your research team where possible with executing dedicated measurements or monitoring at actual plants.

We are looking forward to participating in the Water Nexus program.

Yours sincerely,

 HaskoningDHV Nederland B.V.

René Noppeney MSc MBA
Global Director Water Products and Innovation

Wageningen University
Department of Environment and Water Technology
dr. Ir. Temmink
P.O. Box 17
6700 AA Wageningen

ref.: s.13.u0066

Date: June 03rd, 2013

RE: Letter of Support - Water Nexus STW perspectief programma, project 2.1 Biological Nutrient Removal

Dear Dr. Temmink,

WLN has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of project 2.1 Biological Nutrient Removal, in which we will participate.

WLN BV (approx. 65 employees, turnover 6.5 M€) is the water quality and water technology centre for the Dutch drinking water companies WMD and WBG and also for their industrial water companies NorthWater and NieuWater. Also water boards, industries and organizations where water quality plays an important role are supported by WLN's facilities and expertise.

We are interested in participation in the project because the results will support our activities and consulting power on the biological treatment of saline (waste)water streams.

Cofinancing

Except cash payment, WLN will contribute in kind by the co-execution and support of pilot research by our staff (junior and senior level), as well as the performance of water quality measurements (laboratory analysis and online sensing).

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	12.5	116	1.450
• Junior researcher	12.5	81	1.012
Equipment (depreciation)			
• Measurements/ Analysis			2.538
Materials (cost price)			
Cash			15.000
Total contribution			20.000

Our support will be equally spread over five years, i.e. € 4.000,- per year (€ 3.000,- cash + € 1.000,- in kind).

Utilisation

The gained knowledge will be used to support our consultancy, amongst others for the salt wastewater treatment plant of Northwater in Farmsum, NL, potentially leading to adjustment of the current system or design of a new system within five to ten years.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

Yours sincerely,



Ir. H.D.M. Prummel
Director WLN

Wageningen University
Department of Environment and Water Technology
dr. ir. H. Temmink
Postbus 17
6700 AA WAGENINGEN

Re.: STW Perspectief, WATER NEXUS project 2.1

Dinxperlo, 30 May 2013

Dear Mr. Temmink, dear Hardy,

Nijhuis Water Technology BV has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of project 2.1 Biological nutrient removal, in which we will participate.

Nijhuis Water Technology specializes in the design, manufacture and complete delivery of "ready for use" industrial wastewater treatment, recycling and waste-to-value projects. Nijhuis is active worldwide and has 2400 references in more than 50 countries with focus on the Food, Beverage, Dairy, Textile, Pharma, Oil, Gas and Agricultural industries.

Nijhuis has 130 employees and is an innovative knowledge-based company with technologies, processes and products which are mostly developed in-house and are integrated into turn-key solutions. Nijhuis' vision and company mission "Realizing the value of (waste) water" underlines Nijhuis' determination to fulfil the market needs for innovative, sustainable solutions at the lowest possible operational cost. With offices in the Netherlands, Poland, Russia, Indonesia, U.S. and Colombia and a global network of over 40 certified partners, customers are guided to meet environmental standards to create value from (waste) water.

Co-financing:

In project 2.1 we will perform the following actions:

- contribute to make an overview of saline wastewaters with their characteristics, which can be treated with granule technology;
- validation and interpretation of research results in design parameters for granular sludge reactors for saline conditions;
- translating research results into existing and/or new concepts for biological nutrient removal;
- interim evaluation of research results in technical and economic application in practice;
- contribute directly to the experimental work in project 2.1.



We commit to the following contribution to the project:

	hours	Rate (euro/hr.)	Amount
Staff			
Senior / Academic level	340	119,-	40.460,-
Junior / HBO level	115	83,-	9.545,-
Total in-kind contribution for 5 years			50.005,-
Cash (EUR 8.000,- per year)			40.000,-
Total contribution for 5 years			90.005,-

Utilisation:

Nijhuis Water Technology has a special interest in the outcome of the program because:

- It will give us new solutions to treat and re-use brackish and/or salt water in the Food, Beverage, Dairy, Textile, Pharma and Oil and Gas industry;
- It will give us new knowledge about anaerobic and aerobic granule formation under (varying) levels of salinity. This knowledge will be used to design more cost effective treatment steps for the treatment of waste water and the production of process and boiler feed water.

Furthermore, we expect that the results of project 2.1 will provide us the following commercial perspectives:

- Research and development of new cost effective (waste) water technology;
- Strengthening of our national and international position as total solution provider in design and engineering of waste water and process water treatment systems.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,

Ir. Wilbert Menkveld
Manager R&D

Prof.dr.ir. Kitty Nijmeijer
University of Twente
Membrane Science and Technology
PO Box 217
7500 AE Enschede

Schiedam, 30 May 2013
Our ref. PHA/ahve/130056

Re: Removal of sodium and micro-pollutants from saline water enabling re-use (project 2.3)

Dear Mrs. Nijmeijer,

MAGNETO special anodes B.V. has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of Removal of sodium and micro-pollutants from saline water enabling re-use (project 2.3) in which we will participate.

MAGNETO special anodes B.V. is an independent Dutch SME specialized in the development, design and manufacturing of electrodes with proprietary electrocatalytic coatings as well as complete electrochemical cells incorporating such electrodes. These products are supplied to the international electrochemical industry, like Metal Plating, Impressed Current Cathodic Protection and Water Treatment.; Magneto has office and manufacturing facilities in Schiedam NL (65 people; turnover of 10 million euro, serving the western industrialized world) and Suzhou CN (45 people; turnover of 7 million euro, serving the South East Asian market)

We are interested in participation in the project because the development, design and manufacturing of electrochemical cells for water treatment applications is part of the core-strategy of MAGNETO. At the moment, MAGNETO already does supply amongst others cells for seawater-chlorination (electrolysers) for anti-fouling in cooling water systems and cells for treatment of swimming pool-water and wastewater.

The development of cells and electrocatalytic electrode-coatings for treatment of tap water, groundwater and industrial process water is ongoing at the moment at a small scale. Especially the development of electrode-coating that have a higher Over-Potential (a higher capacity to degrade pollutants in the water) is ongoing and we want to give this an extra boost. These electrocatalytic coatings can be based on Boron Doped Diamond or PbOx or SnOx/SbOx etcetera. Developing these catalysts and testing them in designed cells on the various types of water is the main drive for MAGNETO to participate in this project.

In the future such cells can be supplied to, and applied in applications like horticulture, industrial process water systems and polishing of pretreated water discharges.

Cofinancing

In this project we will perform the following actions:

- Co-develop the new electrode-coatings with higher Over Potentials in our own laboratory
- Design, manufacturing and supply of lab-samples of the new developed electrode-coatings to our research partners.
- Design, manufacturing and supply of prototype electrochemical cells for lab or pilot testing.
- Run accelerated lifetime test on the developed electrode coatings in the specific test equipment in our own laboratory.

- Evaluating and commenting on the supplied and tested cells after some period of use; supply of further developed cells and/or electrodes for continued development and testing.

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	250	119	29.750
• Junior researcher	300	83	24.900
Equipment (depreciation)			
• Anode life-time testing equipment			17.500
Materials (cost price)			
• Electrodes for lab-testing			4.000
• Electrochemical cells for testing			20.000
• Lab chemicals consumed in tests			5.000
Cash			30.000
Total contribution			131.150

Utilisation

The results from project 2.3 will allow MAGNETO to advance their electrodes and electrochemical cells. In this respect, MAGNETO will not be a supplier of turn-key water treatment systems (thus not an OEMer). For the sales and marketing, MAGNETO will be cooperating with qualified OEMers in the water treatment areas.

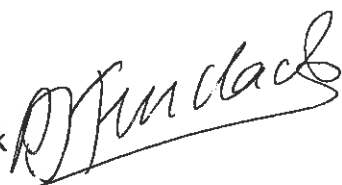
Refurbishment of supplied cells (supply of replacement sets for worn-out electrodes after 3 or 5 years of operation) will be a significant business volume as well, and can be through the OEMer or directly to the End-User.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,

Ir. P.J.F.M. Hack
 Director
 MAGNETO special anodes B.V.



University of Twente
Membrane Science & Technology
Attn. Prof. Dr. Ir. Kitty Nijmeijer
PO Box 217
7500 AE Enschede

Enschede, 22-5-2013

Subject: Support letter STW Perspectief program WATER NEXUS

Dear Prof. Nijmeijer,

Pentair X-Flow has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of the project "salt containing water as a new driver for economy in delta areas", in which we will participate.

Pentair X-Flow is a leading membrane technology supplier for the global water, wastewater and industrial market. In the past 15-20 years the company has matured from a regional player into a market leader in many of its target markets. Pentair X-Flow membranes are used in the field of microfiltration and ultrafiltration in both capillary and in tubular shape, allowing a vast range of applications. Pentair X-Flow has expertise and experience in all water areas, from potable water production to the treatment of process and wastewater and the pre-treatment of seawater, but also in the food, beverage and pharmaceutical industries. Our extensive portfolio of membrane products guarantees the right specifications for each application.

Having developed and marketed many products employing micro- and ultrafiltration technology, we are currently developing a capillary nanofiltration platform of products. This particular platform is aimed at removing dissolved materials from water, e.g. natural organic matter (NOM), micro-pollutants such as pesticides, herbicides and endocrine disrupting compounds (EDC) and ions such as Calcium, magnesium, sulphates etc. We aim at the development of new products that have the potential to be launched in 12-36 months. Since an important part of our market is related to applications in saline water, the topic of WATER NEXUS has a lot of relevance for our current strategy as it coincides with developments .

Cofinancing

For this project our actions will consist of:

- the development and manufacturing of test membranes
- the development and manufacturing of modules and pilot equipment
- execution of pilot tests for establishing membrane properties and performance

We commit the following contribution to the project:

In kind contribution over a 5 year period			
Staff	hours	rate (euro/hr.)	amount (euro)
Senior researcher	500	119	59.500
Junior researcher	500	83	41.500
Equipment (depreciation)			20.000
Materials (cost price)			20.000
In cash over a 5 year period	8.000	per year	40.000
Total contribution			181.000

Utilisation

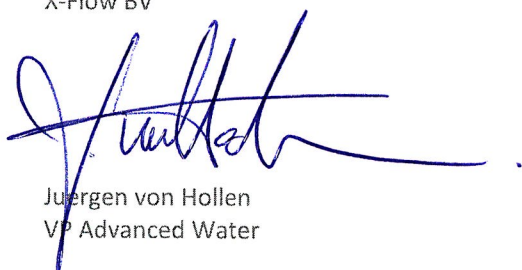
The results of this project will be utilized immediately in new product launches for both municipal as well as industrial applications.

We have taken notice of the STW guidelines for intellectual property and we will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,

X-Flow BV



Juergen von Hollen
VP Advanced Water

Prof. dr. ir. Kitty Nijmeijer
Membrane and Science Technology
University of Twente
PO Box 217
7500AE Enschede

Sassenheim, 2 juni 2013

Onderwerp: Support letter project Water Nexus

Dear Kitty

Voltea b.v. has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of project 2.3 in which we will participate.

Voltea b.v. was founded early 2006 as a spin-off company from Unilever R&D and has as a key objective to develop and commercialize a proprietary new desalination technology called capacitive deionization (CDI). The approach of setting up a new company around a proprietary technology was chosen to combine the management structure and facilities of Unilever with the entrepreneurial spirit and flexibility of a small company. Voltea sells CapDI systems for both residential applications such as water softeners as well as for industrial applications such as cooling towers, waste water treatment etc. In August 2009 Voltea closed an investment deal with Pentair Waters, which is one of the launching partners for residential water systems and in 2010 a further investment was obtained from Rabobank Ventures. Voltea currently employs 35 full time employees and is internationally seen as a leading player in the field of electrochemical water desalination.

Voltea has set-up joint development agreements and collaborations with key players in the field of waste water treatment, point of entry whole-house water suppliers, commercial dish wash manufacturer, food services and cooling towers.

Voltea is interested in participating in the project because we believe that ion selective membranes are an ideal fit with Voltea's capacitive deionization technology. We are very keen to be involved in the supervision of the ion selective membrane development and in the testing of the membrane prototypes, which will be developed by the project. Voltea will do the testing at its location in Sassenheim in its CapDI systems. Over the years Voltea has had many requests from markets in Europe and the US, as well as developing markets for the selective removal of ions, such as sodium, arsenic, selenium and nitrate. There is therefore a clear market need for such ion selective membranes.

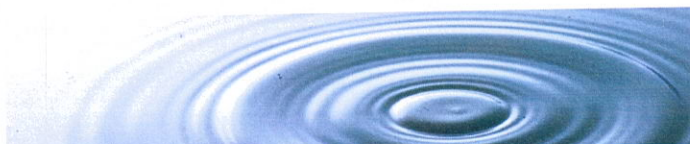
Cofinancing

In this project we will perform the following actions:

- Define the specifications of ion selective removal membranes for use in CapDI
- Test prototype ion selective membranes in CapDI stacks (produced by Voltea) in the lab with waters of different composition
- Select ion selective membranes and test locations for field trials in CapDI

Wasbeekerlaan 24
2171 AE Sassenheim
The Netherlands

Phone +31 (0)252 200 100
E-mail info@voltea.com
Rabobank 144.30.354
KvK 243.33.338



- Conduct and monitor field trials with the ion selective membranes in CapDI

We will also offer our R&D facilities to conduct part of the PhD work where needed.

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	150	119	17850
• Junior researcher	200	83	16600
Equipment (depreciation) Test system			6000
Materials (cost price)			2000
Cash			20000
Total contribution			62450

Utilisation

We will evaluate which applications for selective ion removal are commercially the most promising. It is Voltea's intention to implement ion selective membranes in CapDI systems as soon as successful field trials have been completed.

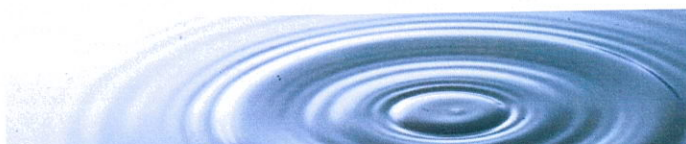
We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,



Prof. Dr. Ir. Bert van der Wal



University of Twente
Membrane Science & Technology
Attn. Prof. Dr. Ir. Kitty Nijmeijer
PO Box 217
7500 AE Enschede
Datum: June 03, 2013

Re: Support letter project 2.3: Removal of sodium and micro-pollutants from saline water enabling re-use

Dear prof. Nijmeijer,

Plant-e has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of project 2.3: Removal of sodium and micro-pollutants from saline water enabling re-use, in which we will participate.

Plant-e is a technology development company that develops products that produce electricity with living plants via Plant-Microbial Fuel Cell technology. First product, a consumer-gadget, is under crowdfund at the moment. Larger products, like the green electricity roof and large-scale electricity productions in wetlands are under development.

We are interested in participation in the project because a Plant-Microbial Desalination Cell strongly related is to the Plant-Microbial Fuel Cell technology. It adds desalination to our existing technology and could easily be combined and integrated in our current development.

Cofinancing

In this project we will perform the following actions:

We will actively participate in knowledge exchange between the project and our company. In this way the project can fully use the knowledge and experience of Plant-e in developing the large-scale desalination systems.

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	500	119	59.500
• Junior researcher	500	83	41.500
Equipment (depreciation)			
•			
•			
Materials (cost price)			
•			
•			
Cash			
Total contribution			101.000

Utilisation

We will as soon as possible integrate the new insights for desalination in our products for large-scale electricity production in wetlands. The large-scale Plant-Microbial Fuel Cell is expected to be launched in the market in 2017. As soon as new knowledge comes out of this project, this will directly be implemented in the products.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,



Marjolein Helder, CEO
Plant-e



Priva
Zijlweg 3
2678 LC De Lier
P.O. Box 18
2678 ZG De Lier
The Netherlands
T +31 (0)174 522 600
F +31 (0)174 522 700
www.priva.nl

Prof. Dr.Ir. D.C. Nijmeijer
University of Twente
Science and Technology
Meander, ME 325
7500 AE Enschede
The Netherlands

E-mail
Reinder.prins@priva.nl

Subject
Support letter project 2.3 of Water Nexus

Date
May 28, 2013

Dear professor Nijmeijer,

Priva B.V. has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of Water Nexus, in which we will participate.

Priva provides sustainable solutions for the more efficient control of energy and water within indoor environments, as a means to conserve scarce resources and reduce our impact on the planet. Priva is a world leader in developing and supplying sustainable technologies for the control of indoor environments within horticulture and the built environment. Together with local partner organisations, we offer our customers across the world access to high-quality hardware, software and services.

The decisive reason for Priva to participate in the Nexus project is the part sodium removal from water. As discussed with you, selective sodium removal will be dealt with in part 2.3 of the project. Sodium in irrigation water is a very important limiting factor for closed water cycles. As most plants do not use significant amounts of sodium, the level of sodium is increasing strongly in recirculating systems. Current emissions of fertilized irrigation water with high sodium levels and also brine injections in ground water have to be minimised.

Cofinancing

Besides the cash payment and active participation in the relevant committees, the in kind contribution from Priva is to jointly operationalize the developed solutions in the project.

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	252	119	€ 29.988
Cash			€ 50.000
Total contribution			€ 79.988



Subject

Date

May 28, 2013

Utilisation

Effective selective removal of sodium from irrigation water is a must for closed irrigation systems in the Netherlands. It will contribute also to availability of scarce suitable irrigation water worldwide. The solutions developed in this project offer new opportunities for Priva.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours faithfully,

Reinder Prins
CEO



Shell India Markets Private Limited
Shell Projects & Technology

RMZ Centennial Campus B
No. 8B, Kudalahalli Main Road
Bengaluru 560 048, India

Phone: +91 80 4021 7137

Fax: +91 80 4021 7160

Twente University
Science and Technology
Prof. Dr.Ir. K. Nijmeijer
Meander, ME 325
P.O. Box 217
7500 AE Enschede
The Netherlands

Bangalore, June 3rd 2013

Subject: Support letter project project 2.3

Dear Prof. Nijmeijer,

Shell has been involved in the definition of the STW Perspectief program WATER NEXUS and the detailed planning of the project 'Electro and membrane pre and post treatment technologies. Hence, we are pleased to inform you that we have decided to participate in this project.

We are a global group of energy and petrochemicals companies with around 87,000 employees in more than 70 countries and territories. Advanced technologies, new ways of operating and partnerships are helping to manage our environmental impact as we contribute to meeting the world's growing energy needs. We are interested in participation in this project because Shell is becoming increasingly concerned about its water use as water becomes scarcer at a global level. New approaches and advanced technologies are helping us to reduce the amount of water we need for our operations.

We commit to a financial contribution of 50 K€ to the project for a 5-years period, i.e. 10 K€ per annum.

Project 2.3 develops technologies for the specific removal of salts and organics, enabling the use of produced water in agri/horticulture, and possibly as cooling water. We will work together with you on identification/characterization of pollutants in produced water and analysis of pilot trial results.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We look forward to a successful cooperation.

With kind regards,

A handwritten signature in black ink, appearing to be 'A.J.H. Janssen', written over a light blue horizontal line.

Prof.dr.ir. A.J.H. Janssen
Manager Water R&D



Dow Benelux B.V.
Herbert H. Dowweg 5
NL-4542 NM HOEK
The Netherlands

Terneuzen, June 4, 2013

Prof. Dr. Ir. D.C. Nijmeijer
University of Twente
Membrane Science and Technology
P.O. Box 217
7500 AE Enschede

Subject: Support letter STW Perspectief program WATER NEXUS

Dear Prof. Nijmeijer,

Dow Benelux BV has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of project 2.3, in which we will participate.

Dow Benelux is a subsidiary of The Dow Chemical Company. Dow was founded 113 years ago in Midland, Michigan US and employs about 54,000 people globally today. Dow combines the power of science and technology to passionately innovate what is essential to human progress. The Company connects chemistry and innovation with the principles of sustainability to help address many of the world's most challenging problems such as the need for clean water, renewable energy generation and conservation, and increasing agricultural productivity.

Dow's history in the Benelux started in 1955, in Rotterdam, with the opening of a business office. Now, more than half a century later, Dow Benelux has grown to be a key player within the industry. Approximately 1,850 employees in 7 locations and 23 plants in the Netherlands and Belgium are working on technology driven chemistry on a world wide scale. The plastics and chemicals that are produced in the Benelux find their way to clients and markets all over the world.

The heart of Dow in the Benelux is in Terneuzen, Zeeuws Vlaanderen. With its 18 plants and approximately 1,700 employees Dow Terneuzen is the second largest production location of the Dow Chemical Company. As the largest employer of Zeeuws Vlaanderen, Dow has contributed to the economic and social success of the region for almost 50 years.

Dow operates world scale chemical facilities around the globe and is increasingly facing fresh water availability issues. In these areas, where urban, industry and rural areas 'compete' for fresh water, cascading water applications based on a fit-for-use purification enable multiple cross-sectional reuse.

Dow has, in its location in Terneuzen, developed expertise in the reuse of treated wastewater from both municipal and industrial sources. Together with private and public project partners a high level of process integration has been achieved for Dow's facilities in Terneuzen.

We committed to this project because Dow Benelux, as a major water consumer, strives to reduce its dependency on remote fresh water sources, i.e. Biesbosch water, which also is a major source for potable water in the western part of the Netherlands. Within the region of Zeeuws-Vlaanderen Dow with its local partners is exploring the possibility to utilize various process and surface water streams in industrial processes and agriculture. Dow is interested in the use of wetlands for buffering and purification of these streams as they represent a potential low cost treatment with a spin-off to produce raw materials for biobased product developments.

Hence, Dow highly values to support the water NEXUS project as whole, which aims to achieve new concepts in water utilization and integrates the different sub-projects to an overarching vision.

The water NEXUS project 2.3 is of special interest because technology questions with respect to brackish water application (like BW cooling tower operation), the abatement of micro-pollutants and the integrated desalination function by exploring the PMDC (Plant-Microbial Desalination Cell) - concept, will be answered.

Cofinancing

In this project Dow will perform the following actions:

- Dow will provide expertise in water reuse from multiple sources in various industrial applications, including the definition of process critical parameters for certain applications. Both personnel from Dow Benelux and those from the Dow Chemical corporate sustainability group will be participating in this project.
- Dow will facilitate demonstration trials on site in cooperation with water NEXUS project partners, which can comprise the treatment of different raw water sources, like treated municipal and industrial wastewater, storm and rainwater, various industrial recycle streams like cooling tower blow down and slightly contaminated condensate streams, and surface water. The demo-facility infrastructure, installed in the EU FP7 "E4Water" project (www.e4water.eu), where so called mild desalination technologies are investigated, can be utilized for water NEXUS trial in the latter stage of the project.
- The HZ University of Applied Sciences (Vlissingen), with the Dow project lead Niels Groot as acting lector of the research group on Water Technology, carries the Center of Expertise (CoE) on Delta Technology – this CoE is actively involved in related projects in the region and the Dow location, and in this ability will provide in-kind expertise and facilitate internships for BSc students in the Water NEXUS project.

We commit the following contribution to the projects:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	300	119	35,700
• Junior researcher	150	83	12,450
Cash			50,000
Total contribution			98,150

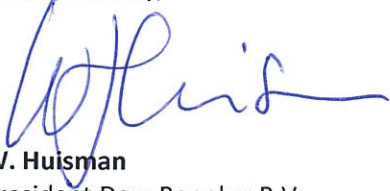
Utilisation

Dow Benelux anticipates the application of the Water NEXUS technology development in regional wetlands for buffering and reuse of brackish water streams from various origin. Moreover the knowledge gained will be leveraged within Dow's corporate sustainability group and to other production locations within The Dow Chemical Company.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,

A handwritten signature in blue ink, appearing to read 'W. Huisman', is written over the typed name.

W. Huisman

President Dow Benelux B.V.

University of Twente
Membrane Science & Technology
Prof. dr. ir. D.C. Nijmeijer
PO Box 217
7500 AE ENSCHEDE

Re: Support letter project: Removal of sodium and micro-pollutants from saline water enabling reuse

Dear prof.dr.ir. Nijmeijer

Oasen NV has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of **Removal of sodium and micro-pollutants from saline water enabling reuse**, in which we will participate.

Oasen NV is one out of 10 drinking water utilities in the Netherlands. Oasen NV produces and supplies yearly 45 Mm3 tapwater to 0.8 million people (345.000 connections) in the Province of South-Holland. The core business is the production and distribution of drinking water in the province of South-Holland, the Netherlands. Oasen NV produces drinking water for 750,000 people and 7,200 organisations. Water quality is the main priority, therefore Oasen NV invests continuously in the treatment plants, based on membrane filtration, the distribution network and its knowledge. The main drinking water source is river Lek water (80%). Oasen NV is a public owned privatised company. The company employs 260 staff and has a yearly turnover of €78 million.

We are interested in participation in the project because as Water Supply Company we have to cope with the pressure on resources from growing demand (and increasing pollution) is enhanced by predicted changes in climate (extremes in drought and precipitation), and rising sea levels and soil subsidence (saltwater intrusion). Therefore we are interested in new membrane technologies that enable both strategic and operational management of water resources; treating saline water as an asset and not only as a threat. Solutions provided will enable Oasen NV, responsible for drinking water quantity and quality in our region, to safeguard and control drinking water availability both on the long and short term.

Cofinancing

In this project we will perform the following actions:

- We will be involved as a launching customer and will collaborate from the perspective of applying the new technology.
- run the pilot plant experiments at Kamerik (The Netherlands)
- carrying out water quality analysis.

Oasen N.V.

Nieuwe Gouwe O.Z. 3
Postbus 122
2800 AC Gouda

T 0182 59 33 11
www.oasen.nl

KvK 290.10639
BTW 001998079 B01



31 mei 2013

Bijlagen
geen

Voor informatie:
T 0182 59 34 02
walter.van.der.meer
@oasen.nl

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	50	119	5950
• Junior researcher	300	83	24900
Equipment (depreciation)			
• Pilot Plant			5000
Materials (cost price)			
• Chemicals			1000
Cash			50000
Total contribution			86850

Utilisation

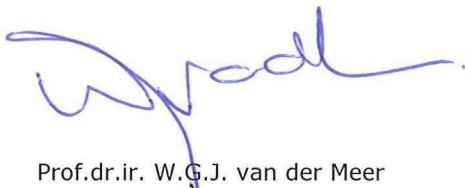
Oasen NV will use the developed polymeric membranes for the controlled, selective removal of ions, especially sodium, chlorid and ammonium, and organic micro pollutants from our saline or brackish river bank water. The developed polymeric membranes have the potential, to become the heart of our membrane filtration treatment plants with a potential market, only for Oasen locations, of approximately 100.000 m2 of membrane surface.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

31 mei 2013

Yours sincerely,



Prof.dr.ir. W.G.J. van der Meer
Director Oasen NV



Shell India Markets Private Limited
Shell Projects & Technology
RMZ Centennial Campus B
No. 8B, Kudalahalli Main Road
Bengaluru 560 048, India
Phone: +91 80 4021 7137
Fax: +91 80 4021 7160

Wageningen University
Sub-department of Environmental Technology
Prof.Dr.Ir. H. Rijnaarts
P.O. Box 17
6700 AA Wageningen
The Netherlands

Bangalore, June 3rd 2013

Subject: Support letter project 3

Dear prof Rijnaarts / dear Huub,

Shell has been involved in the definition of the STW Perspectief program WATER NEXUS and the detailed planning of the project 'Reality blueprints: wetlands and technology trains enabling multi-sourcing'.

Hence, we are pleased to inform you that we have decided to participate in this project.

We are a global group of energy and petrochemicals companies with around 87,000 employees in more than 70 countries and territories. Advanced technologies, new ways of operating and partnerships are helping to manage our environmental impact as we contribute to meeting the world's growing energy needs. We are interested in participation in this project because Shell is becoming increasingly concerned about its water use as water becomes scarcer at a global level. New approaches and advanced technologies are helping us to reduce the amount of water we need for our operations.

We commit to a financial contribution of 85 K€ to the project for a 5-years period, i.e. 17 K€ per annum.

Shell is very interested in the central approach of WATER NEXUS, i.e. focusing on saline water combining a delta approach (resource management) with different water treatment options. In project 3, these elements come together in solutions that can help us predict and solve issues in the vicinity of our production plants. WATER NEXUS is unique in developing practical solutions on regional and local scale. Other programs are restricted to descriptions of possible future scenarios and do not include the effects of interventions in water management. We will work together with you on selecting and analysing practical, high impact cases.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We look forward to a successful cooperation.

With kind regards,

A handwritten signature in blue ink, appearing to be 'A.J.H. Janssen', with a long, sweeping horizontal line extending to the right.

Prof.dr.ir. A.J.H. Janssen
Manager Water R&D



Dow Benelux B.V.
Herbert H. Dowweg 5
NL-4542 NM HOEK
The Netherlands

Terneuzen, June 4, 2013

Prof. Dr. Ir. H.M Rijnaarts
Professor in Environmental and Water Technology
Subdepartment of Environmental Technology
Dep. of Agrotechnology & Food Sciences
Wageningen University Research Centre
P.O. Box 17
6700 AA Wageningen

Subject: *Support letter STW Perspectief program WATER NEXUS*

Dear Prof. Rijnaarts,

Dow Benelux BV has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of project 3, in which we will participate.

Dow Benelux is a subsidiary of The Dow Chemical Company. Dow was founded 113 years ago in Midland, Michigan US and employs about 54,000 people globally today. Dow combines the power of science and technology to passionately innovate what is essential to human progress. The Company connects chemistry and innovation with the principles of sustainability to help address many of the world's most challenging problems such as the need for clean water, renewable energy generation and conservation, and increasing agricultural productivity.

Dow's history in the Benelux started in 1955, in Rotterdam, with the opening of a business office. Now, more than half a century later, Dow Benelux has grown to be a key player within the industry. Approximately 1,850 employees in 7 locations and 23 plants in the Netherlands and Belgium are working on technology driven chemistry on a world wide scale. The plastics and chemicals that are produced in the Benelux find their way to clients and markets all over the world.

The heart of Dow in the Benelux is in Terneuzen, Zeeuws Vlaanderen. With its 18 plants and approximately 1,700 employees Dow Terneuzen is the second largest production location of the Dow Chemical Company. As the largest employer of Zeeuws Vlaanderen, Dow has contributed to the economic and social success of the region for almost 50 years.

Dow has, in its location in Terneuzen, developed expertise in the reuse of treated wastewater from both municipal and industrial sources. Together with private and public project partners a high level of process integration has been achieved for Dow's facilities in Terneuzen.

Dow operates world scale chemical facilities around the globe and is increasingly facing fresh water availability issues. In these areas, where urban, industry and rural areas 'compete' for fresh water, cascading water applications based on a fit-for-use purification enable multiple cross-sectional reuse.

We are committed to this project because Dow Benelux, as a major water consumer, strives to reduce its dependency on remote fresh water sources, i.e. Biesbosch water, which also is a major source for potable water in the western part of the Netherlands. Within the region of Zeeuws-Vlaanderen Dow with its local partners is exploring the possibility to utilize various process and surface water streams in industrial processes and agriculture. Dow is interested in the use of wetlands for buffering and purification of these streams as they represent a potential low cost treatment with a spin-off to produce raw materials for biobased product developments.

Hence, Dow highly values to support the water NEXUS project as whole, which aims to achieve new concepts in water utilization and integrates the different sub-projects to an overarching vision.

The water NEXUS project 3 is of special interest as this project addresses the desire to connect water streams and unit operations on a regional scale, thereby optimizing the entire water chain. The technologies developed in the related projects will be integrated and allow an optimum water distribution based on both availability, quality and demand.

Cofinancing

In this project Dow will perform the following actions:

- Dow will provide expertise in water reuse from multiple sources in various industrial applications, including the definition of process critical parameters for certain applications. Both personnel from Dow Benelux and those from the Dow Chemical corporate sustainability group will be participating in this project.
- Dow will facilitate the modelling of a regional implementation of the water NEXUS technologies associated with the local infrastructure including brackish wetlands and regional water streams. These activities will occur in close cooperation with water NEXUS project partners.
- The HZ University of Applied Sciences (Vlissingen), with the Dow project lead Niels Groot as acting lector of the research group on Water Technology, carries the Center of Expertise (CoE) on Delta Technology – this CoE is actively involved in related projects in the region and the Dow location, and in this ability will provide in-kind expertise and facilitate internships for BSc students in the Water NEXUS project.

We commit the following contribution to projects 3:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	600	119	71,400
• Junior researcher	300	83	24,900
Cash			100,000
Total contribution			196,300

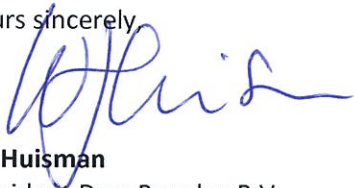
Utilisation

Dow anticipates application of the developed tool and models at our premises in the Middle East, Far East but also in countries like the USA, Argentina, Germany, Spain and The Netherlands.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely



W. Huisman

President Dow Benelux B.V.

Wageningen University
Department of Environment and Water Technology
Attn. prof. dr. ir. H.H.M. Rijnaarts
P.O. Box 17
6700AA WAGENINGEN

HaskoningDHV Nederland B.V.
Water Technology
Laan 1914 no. 35
3818 EX Amersfoort
P.O. Box 1132
3800 BC Amersfoort
The Netherlands
T +31 88 348 2000
F +31 88 348 2801
E info@rhdhv.com
W www.royalhaskoningdhv.com

Amersfoort, 30 May 2013

your ref	: STW Perspective, WATERNEXUS – project 3: Integral Blue Prints
our ref	: WT-WWW20130100
file	: BC1120-100-102
project	: Water nexus
dealt with by	: Robbert van der Kuij
tel, e-mail	: +31 88 3482277, robbert.van.der.kuij@rhdhv.com
classification	: Client confidential

Dear professor Rijnaarts, dear Huub,

Royal HaskoningDHV has been involved in the definition of the STW Perspectief program WATER NEXUS and the detailed planning of project 3, in which we will participate.

Royal HaskoningDHV is an international consultancy and engineering firm with expertise and leadership in innovation and sustainability. We have an integrated approach to complex problems, particularly in the areas of infrastructure and mobility, water and environment, land and real estate and industry. Our services cover the entire project cycle, including management consultancy, advice, design and engineering, project management, contract and asset management.

Royal HaskoningDHV provides consultancy and technology packages in projects worldwide for Dutch or European financiers, International Development Bancs (e.g. ADB), large international operating companies and local clients. One of our products fitting in the NEXUS program is the Crystallactor® for cleaning the salty brine, coming from membrane reactors.

Because Royal HaskoningDHV wants to be a global player within the field of water production, treatment and transport, as a consultant as well as a technology provider, she has a special interest in the outcomes of the program and in particular of project 3.

If STW decides to fund this program, besides participation in de user committee, our total contribution over a 5 year period will be as follows:

In kind	Hours	Rate (€/h.)	Amount €
Staff			
Senior / Academic level	252	119	€ 29.988
Junior / HBO level			
Equipment (e.g. pilot installation)			
Measurements / analyses			
Materials			
Total in kind contribution			
Cash:			
- 2015			€ 2.000
- 2016			€ 6.000
- 2017			€ 6.000
- 2018			€ 6.000
Total contribution			€ 49.988

Royal HaskoningDHV has a long history of collaboration with universities and experience with the marketing of research results.

As part of the project we will perform the following activities:

- Deliver input for setting of research boundaries with sufficient focus on practical applications;
- Deliver input for several case studies or actual practical projects to develop and/or verify the developed models;
- Assist in data processing and evaluation;
- Assist your research team where possible with executing dedicated measurements or monitoring at actual plants.

We are looking forwards participating in the Water Nexus program.

Yours sincerely,
HaskoningDHV Nederland B.V.



ir. E. Bosman,
Director Business Unit Water Technology NL



Wageningen University
Sub department Environmental Technology
Attn. prof. dr. ir. H.H.M. Rijnaarts
P.O. Box 17
6700 AA WAGENINGEN

Groningenhaven 7
Postbus 1072
3430 BB Nieuwegein
The Netherlands

P +31 30 606 95 11
F +31 30 606 11 65
I www.kwrwater.eu

Subject Support letter project Integral Blue Prints
Enclosure(s) -
Information Jan Vreeburg, +31(0)30 6069576
E-mail jan.vreeburg@kwrwater.nl
Date 3 June 2013
Our reference 13050059/JVR/CK

Dear Prof. Rijnaarts,

KWR Watercycle Research Institute has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of the project Integral Blue Prints, in which we will participate.

KWR Watercycle Research Institute assists society in optimally organising and using the water cycle by creating knowledge through top-quality research, building bridges between science, business and society and promoting societal innovation by applying the best knowledge available. KWR Watercycle Research Institute provides its services for the attainment of a well-functioning water cycle through optimal water management; or, expressed in terms of our research themes: healthy, sustainable, advanced and efficient Water. These themes are echoed in many of the institute's activities.

We are interested in participation in the project because it fits within the goals of the organisation in optimising the watercycle through sound research in combination with well positioned applications, truly committed to our motto "Bridging science to practice". With the results of the project we will be able to explore the possibilities of saving and re-allocating fresh water sources and tailor the wishes of industrial water users into the needs of our main shareholders, the water companies.

Cofinancing

In this project we will perform the following actions:
Our contribution to the project is a combination of cash funding and in kind funding. The latter will be done through close cooperation in research of the PhD students and post doc committed to WP1 with our senior researcher, to develop the modelling and application of the Extended Resource Harvest Approach. The cash contribution is used to facilitate and finance partly the PhD student.

We commit the following contribution to the project:

	hours	rate (euro/hr.)	amount (euro)
Senior researcher (in kind)	252	119	29.988
Cash			30.000
Total contribution			59.988

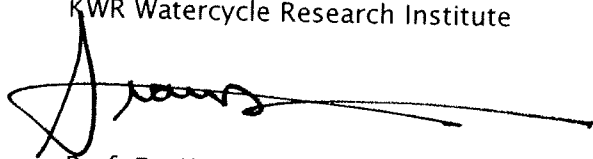
Utilisation

The tools and models as described earlier will enable us to work closely together with industrial water users, water companies and other large water users. The developed knowledge, integrally applied, will make clear where the optimal balance can be found in the application of resources; how various water flows within the water cycles in a densely populated delta area may be utilised beyond the borders of the individual stakeholders.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Kind Regards,
KWR Watercycle Research Institute



Prof. Dr. W. van Vierssen
Chief Executive Officer

Wageningen Universiteit
Attn. prof. dr. ir. H.H.M. Rijnaarts
P.O. Box 17
6700 AA WAGENINGEN

Date	Our reference	Number of pages
28 May 2013	1206377-000-BGS-0001-cl	3
From	Direct line	E-mail
Remco van Ek	+31 (0)88 33 57 765	remco.vanek@deltares.nl

Subject
STW Perspectief, WATER NEXUS

Dear Mr Rijnaarts,

Deltares has been involved in the definition of the STW Perspectief program WATER NEXUS and detailed planning of the Water NEXUS project, in which we will participate.

Deltares is a leading independent institute for applied research, operating worldwide in the field of water, subsurface and infrastructure. Since it was established in 2008, more than 800 Deltares specialists have developed innovative insights to make living in deltas safe, economically and socially achievable and environmentally sustainable.

Our main focus is on deltas, coastal regions and river basins. Managing these densely populated and vulnerable areas is complex, which is why we work closely with governments, businesses, other research institutes and universities at home and abroad. Our motto is *Enabling Delta Life*. As an applied research institute, the success of Deltares can be measured in the extent to which our expert knowledge can be used in and for society. For Deltares the quality of our expertise and advice is foremost. Knowledge is our core business. Our research is organized into five themes:

- Flood risks
- Ecosystems and environmental quality
- Water and subsoil resources
- Delta infrastructure
- Sustainable delta planning

Within these themes knowledge programs are executed. The theme Water and subsoil resources includes the following knowledge programs:

- River basin management
- Fresh water supply in urbanizing deltas
- Sustainable energy from water and subsoil
- Characterisation and visualization of the subsurface

The programs develop applicable knowledge and tools that facilitate the management of water and subsoil with regard to fresh water supply and proper management of saline water resources. This is done in close cooperation with all relevant stakeholders to assure a good linkage between the development and usage of knowledge.

Date
28 May 2013

Our reference
1206377-000-BGS-0001-cl

Page
2/3

We are interested in participation in the project because it matches closely with the mission of Deltares and the scope of our research knowledge programs mentioned above, in particular the program Fresh water supply in urbanizing deltas.

We herewith explicitly express our interest in project 3. Deltares is interested in maptable technology-based adaptation evaluation tool to shape regional fresh and saline water adaptation strategies, incorporating field-scale showcase research results. Nowadays, different field-to-regional scale adaptation measures have been tested to maximize fresh water efficiency. Results are, however, location-specific and will not be universally applicable. Upscaling of showcase results to the regional and even national scale is paramount for successful incorporation in adaptation strategies. Furthermore, decision makers lack an instrument to shape adaptation strategies together with all relevant stakeholders. Deltares is interested in applying the research line 1.1 development in the research line 3.

Cofinancing

In this project we will perform the following actions: 1. Cash contributions and 2. In-kind contribution in joined research that is strongly related to research line 1. Deltares is well equipped to model and monitor salinization in (ground)water systems and can provide field pilots for the WATER NEXUS project. Deltares will actively contribute to project 3 through in kind contributions and supply data, model instruments and field expertise where needed.

We commit the following contribution to the project:

Project 3 (*Reality blueprints*):

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	462	119	54.978
Cash			30.000
•			
Total contribution			84.978,-

This letter and this commitment replaces our letter dated 23 May 2013 with reference 1208100-000-BGS-0001-cl.

The following Deltares personnel will be actively involved in the project:

- Ing. J. (Hans) D.G. van Duijne is project manager with Deltares and with the Wageningen University in the field of soil and groundwater quality projects and participates and leads international projects in the EU Framework programmes since 1998. Also responsible for the application of research in the international setting with North and South America. The input of his expertise and experience will be used to give the results an international connection and application.
- Dr. ir. Gualbert Oude Essink is geohydrologist/groundwater modelling expert at Deltares. Gualbert Oude Essink has high level expertise on quantifying salinization in groundwater systems and makes use of "state of the art" monitoring and modelling techniques. For example, Gualbert contributed to the Interreg IV CLIWAT project in which the results of

Date
28 May 2013

Our reference
1206377-000-BGS-0001-cl

Page
3/3

airborne electromagnetic (SkyTEM or HEM) and reflection seismic surveys were validated against ground truth using monitoring and modelling results from Deltares. In addition, Gualbert is also at the fore-front of developing promising measures for local and regional water supply (e.g. Knowledge for Climate programme).

- Drs. P.G.B. (Perry) de Louw is PhD student at Deltares on the subject "Dynamics of shallow brackish-salt groundwater systems". Perry has previously demonstrated his research skills in numerous projects on regional (ground)water systems. Finalisation of his PhD thesis is planned at the beginning of 2013. His research focusses in the quantification and manipulation of shallow fresh water lenses in a surrounding of brackish groundwater, and on the salinization of deep polder areas through so-called boils.

Utilisation

Deltares seeks to develop modelling and analysis tools for water-related research. One of the focus areas is water scarcity and drought in deltaic areas. The outcomes of the PhDs and postdoc will be involved in the first research line to form the bridge with research line 1 and 3 where the monitoring, modelling and software toolboxes for (rapid) characterizing delta's under the pressure of climate and global change worldwide is developed and connected to the reality blue prints. Our customers are the Dutch government and water boards, as well as foreign water management bodies and local and regional government. In addition, we will use the deliverables in larger projects in tandem with Dutch and foreign consultants. We already expect to implement spin-off (prototypes and products) of the executed research by the PhD's in our daily international projects during the course of this WATER NEXUS program (period 2015-2018).

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support this STW Topsector Water program WATER NEXUS.

Yours sincerely,


Dr. ir. A.G. Segeren
Director
Subsurface and Groundwater Systems

Prof. dr. ir. H.H.M. Rijnaarts
Wageningen University
Department of Environment and Water Technology
P.O. Box 17
6700AA Wageningen

Date: May, 24 2013

Re: Support letter project 3: Reality blueprint,

Dear Prof. dr. ir. H.H.M. Rijnaarts,

Eijkelkamp Agrisearch Equipment has been involved in the definition of the STW Perspective program WATER NEXUS, and detailed planning of 3: Reality blueprint, in which we will participate.

Eijkelkamp Agrisearch Equipment BV (in the remainder of this document referred to as EAE) is very interested in this program, and is willing to take part in users committees and contribute directly to the experimental work in the projects.

EAE is an international organization offering solutions geared to customer needs in soil and water research. Through its innovative and sustainable services and products, and based on its expertise gained in a century of serving its markets, EAE is confident it can significantly contribute to the WATER NEXUS program.

The current product range of Eijkelkamp Agrisearch Equipment can best be described as equipment for soil, water, plant, climate and residual substances research and is intended primarily for agricultural, hydrological and environmental studies. Our wide Product range from the worldwide known soil augers upto the latest environmental water and soil sensors connected trough the cloud to the customer named carefree solutions.

Our most important customers are active in soil, water and environmental research and related fieldwork. More than 60 distributors represent Eijkelkamp all over the world. Our dedicated and well-trained partners are our eyes and ears in the local market. At our premises in Giesbeek about 85 employees are working. Company training and consultancy expertise in relation to the NEXUS project is added for planning, installing and operating of our products within the project. Personal competences are the development of various environmental sensors and telemetric data communication, as well as worldwide commercialisation of products and services.

We are interested in participation in the project because we are active in marketing solutions using our products and development of new products and services built on our telemetric sensor platform. Already there are sensors available measuring the surface and ground water table including conductivity as measure of the amount of soluted salts.

These measurements can be of strategic importance for ground proofing remote sensing technologies. We plan to complete our portfolio in the salt intrusion using the Water Nexus project results. The use of sensor information combined with prediction models can lead to an information and control system with great importance to the optimisation of threatening situations. Furthermore the project will give us the opportunity to get introduced in the specific projects around salt and delta problematic that are relevant for business development.

Last but not least we have also the SonicSampDrill technology and services that enables to drill groundwater monitoring wells most effective. There is an international fieldwork experience placing high quality monitoring wells using this technology.

For 3

The reality blueprint we hope to be introduced in projects proofing the project concept. This means actively involvement in projects with i.e. industrial and agriculture applications.

Cofinancing

In this project we will perform the following actions:

We will support by means of senior technician and consultants in planning, advise and installation assistance of fieldworks.

We commit the following contribution to the project:3

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• technician	10	€83	€830
• consultancy	20	€83	€1660
Cash			€5000
Total contribution			€7490

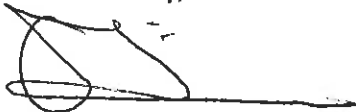
Utilisation

We will actively integrate and promote the project results for monitoring of salt intrusion by training our partners and clients, providing documentation, product presentations. Also international sales missions and exhibitions will be attended. Also the combination with commercial project partners will enhance our mutual activities.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

We enthusiastically support the WATER NEXUS program.

Yours sincerely,



Fons Eijkkelkamp,
Eijkkelkamp Agrisearch Equipment



Wageningen University Research Centre
Subdepartment of Environmental Technology
Dep. of Agrotechnology & Food Sciences
Professor in Environmental and Water
Technology
t.a.v. Prof. Rijnaards
P.O. Box 17
6700 AA Wageningen

ONDERWERP	Letter of commitment Waternexuss project 3
DATUM	Amersfoort, 03 juni 2013
ONS KENMERK	2013-0244-RR/MT-446723
UW KENMERK	

Dear Prof. Rijnaards,

STOWA (Dutch acronym for the Foundation for Applied Water Research) has been involved in the definition of the STW Perspectief program WATER NEXUS and detailed planning of the Water NEXUS project, in which we will participate.

STOWA is the knowledge centre of the regional water managers, especially the water boards in the Netherlands. STOWA develops, collects and disseminates knowledge needed for the tasks of the waterboards. The STOWA projects cover the following fields: collection, transport and treatment of waste water; management of the quality and quantity of surface and ground water; urban water management; climate adaptation, freshwater and safe regional water defenses, prevention against flooding and maintenance of water barriers.

The research goals of the projects are directly relevant to the STOWA program 'Deltaproof' and 'Watermozaiek', focussing on challenges with regards to self supporting regional watersystems in facts of water quantity, and challenges with regard to ecosystem functioning.

We are interested in participation in the project because it closely fits within our mission, coordinating and commissioning research on a large scale of water management issues.

The STOWA will support Project 3 Reality Blueprints with a contribution amounting to 10.000 € in cash, distributed over the 5-year duration of the project. In addition, STOWA and participating water boards will support the project in kind.

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	85	119	10.115
Cash			10.000
Total contribution			20.115

The capitalization, against standard STW tariffs, of hours only represents a nominal value of hours STOWA will spend on the project. The resulting amount is not claimable as a cash contribution.

Research questions that are addressed in the project, and that are of specific interest to STOWA and participating water boards are: How can the self-sufficiency of regional systems be enhanced by 'refreshing' saline water. The questionnaires in more detail:

- Can slightly salted water be stored and protected?
- How can the local water cycle be closed by the re-use of waterstreams, including slightly salted water?
- Can wetland water storage be combined with eco- and biobased targets?
- Can we arrange wetlands in such a way that they are salt resisting?

STOWA is keen to enhance integration of the project with other planned and on-going research and will encourage and coordinate collaboration of the participating research teams. The in-kind contribution of the STOWA and waterboards is made available through involvement of STOWA and waterboard employees, who will spend hours to support the project by:

- Coordinating contributions of the water boards, regarding selected case studies and relevant data
- Coordination of the collaboration between the Water Nexus program and other planned and ongoing research projects on regio
- Communication the project and its results to water boards

The STOWA is looking forward to collaborating with the research team to pursue the goals of the project.

The STOWA has taken notice of STW's IE policy, and will unconditionally follow this policy.

Sincerely yours,



Drs. B. van der Wal
Director STOWA

Wageningen University
Department of Environment and Water Technology
Prof. dr. ir. H. Rijnaarts
P.O. Box 17
6700 AA Wageningen

Ref.: s.13.u0067

Date: June 03rd, 2013

RE: Letter of Support - Water Nexus STW perspectief programma, project 3 Integral Blue Prints

Dear Prof. Rijnaarts,

WLN has been involved in the definition of the STW Perspectief program WATER NEXUS, and detailed planning of project 3, Integral Blue Prints, in which we will participate.

WLN BV (approx. 65 employees, turnover 6.5 M€) is the water quality and water technology centre for the Dutch drinking water companies WMD and WBG and also for their industrial water companies NorthWater and NieuWater. Also water boards, industries and organizations where water quality plays an important role are supported by WLN's facilities and expertise.

We are interested in participation in the project because the results will support our activities and consulting power on water quality management.

Cofinancing

Except cash payment, WLN will contribute in kind by the co-execution and support of pilot research by our staff (junior and senior level), as well as the performance of water quality measurements (laboratory analysis and online sensing).

We commit the following contribution to the project:

In kind			
Staff	hours	rate (euro/hr.)	amount (euro)
• Senior researcher	12.5	116	1.450
• Junior researcher	12.5	81	1.012
Equipment (depreciation)			
• Measurements/ Analysis			2.538
Materials (cost price)			
Cash			10.000
Total contribution			15.000

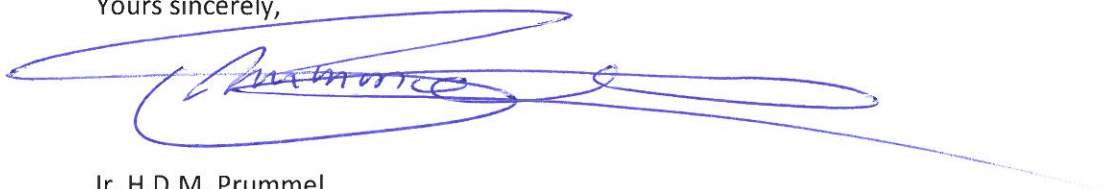
Our support will be equally spread over five years, i.e. € 3.000,- per year (€ 2.000,- cash + € 1.000,- in kind).

Utilisation

The gained knowledge will be used to support our knowledge and consultancy power related to (industrial) water quality management.

We have taken notice of the STW guidelines for intellectual property, and will participate in the user committee.

Yours sincerely,



Ir. H.D.M. Prummel
Director WLN