SOILS2SEA DELIVERABLE NO. 1.2

BONUS

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

Requirements Report

SOILS2SEA

Reducing nutrient loadings from agricultural soils to the Baltic Sea via groundwater and streams

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SOILS2SEA

Reducing nutrient loadings from agricultural soils to the Baltic Sea via groundwater and streams

This report is a publicly accessible deliverable of the Soils2Sea project. The present work has been carried out within the project ‘Reducing nutrient loadings from agricultural soils to the Baltic Sea via groundwater and streams (Soils2Sea)’, which has received funding from BONUS, the joint Baltic Sea research and development programme (Art 185), funded jointly from the European Union’s Seventh Programme for research, technological development and demonstration and from The Danish Council for Strategic Research, The Swedish Environmental Protection Agency (Naturvådsverket), The Polish National Centre for Research and Development, The German Ministry for Education and Research (Bundesministerium für Bildung und Forschung), and The Russian Foundation for Basic Researches (RFBR).

Refsgaard JC (Editor) Requirements Report, Soils2Sea Deliverable 1.2. Geological Survey of Denmark and Greenland, Copenhagen, June 2014, www.Soils2Sea.eu

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1. Executive Summary

1.1 Objectives of the project and of the present report

1.1.1 Soils2Sea project idea and outcomes

Both the Baltic Sea Action Plan and the EU Water Framework Directive requires substantial further reductions of nutrient loads (N and P) to the Baltic Sea during the coming years. Achievements of these goals will only be possible by the implementation of fundamental changes in agricultural practices and land use. This will require the introduction of additional new and innovative measures, because the easiest applicable measures have, in most cases, already been utilised. Soils2Sea proposes to exploit the fact that the retention (removal by biogeochemical processes or sedimentation) of nutrients in groundwater and surface water systems shows a significant spatial variation, depending on the local hydrogeological and riverine regime to achieve the goals for nutrient load reduction set out in the Baltic Sea Action Plan. The traditional uniform regulations do not account for local data and knowledge and are much less cost-effective than spatially differentiated regulations with measures targeted towards areas where the natural retention is low. In order to fully exploit the potential of differentiated regulations it is required to utilise all local information and find locally designed and optimised solutions. Besides the need for improved knowledge on the subsurface and nutrient transport and retention processes on a local scale, this calls for new innovative governance regimes with active involvement of key stakeholders. Not the least as the new measures most probably will differentially affect stakeholder groups with conflicting interests.

If we more accurately can predict where in a catchment N and P are retained by estimating the retention in the different compartments along the flow path, and also include the delayed effects of mitigation measures due to long solute travel times in groundwater, then we can more cost-effectively design measures to reduce the nutrient loads to the Baltic Sea. Soils2Sea will therefore study the retention of N and P between the soils/sewage outlets and the coast, including transport pathways such as overland flow and flows in macropores, subsurface tile drains, shallow and deep groundwater, rivers, wetlands and lakes.

The key outcomes of Soils2Sea will be:

- New methodologies for the planning of differentiated regulations based on new knowledge of nutrient transport and retention processes between soils/sewage outlets and the coast.
- Evaluation of how differentiated regulation can offer more cost efficient solutions towards reducing the nutrient loads to the Baltic Sea.
- Analysis of how changes in land use and climate may affect the nutrient load to the Baltic Sea as well as the optimal location of measures aiming at reducing the load.
- A high-resolution model for the entire Baltic Sea Basin with improved process descriptions of nutrient retention in groundwater and surface water tailored to make detailed simulations of management regulations differentiated in space.

- New knowledge based governance and monitoring concepts that acknowledge the relevant aspects of EU directives and at the same time are tailored towards decentralised decision making. The proposed spatially differentiated regulations will aim for incorporation of local scale knowledge to optimally design solutions.

1.1.2 The Requirements Report

This report is the first publication from Soils2Sea. Its aims are i) to map the interdependencies between work packages and partners; ii) to briefly describe the methodologies to be used; and iii) to prepare a detailed coherent project work plan. The primary target group for the present report is the Soils2Sea project group. The secondary target group comprises persons with particular interest in Soils2Sea such as external collaborative partners and other scientists working on the same topics and/or same study sites. The report is not aimed at stakeholders and policy makers.

1.2 Methodologies

1.2.1 Changes in climate, land use and nutrient loads

Joint scenarios for plausible developments of climate change and land use will be established and their impacts on leaching of N and P from agricultural areas will be assessed. A range of scenarios will be designed including combinations of: i) Climate change projections for the period 2025 – 2055 using RCP 8.5 from the regionally downscaled CMIP5; ii) Land cover and land use change considering proportion of agriculture, type of agriculture (annual and perennial crops), nutrient input intensity in accordance with CMIP5 storylines; iii) Measures to reduce nutrient losses and enhance retention in the landscape; and iv) Spatially differentiated application of all measures considered.

Nutrient loads will be assessed at different spatial scales ranging from small case study catchments in Denmark, Sweden and Poland, to the Baltic Sea Basin scale. For the small scale studies detailed spatial data at farm scale or less will be utilised, while available national, regional or European databases will be utilised at the Baltic Sea Basin scale.

1.2.2 Nutrient reductions in groundwater

At the Norsminde case site in Denmark, where about 50% of the nitrate leaching from the root zone is reduced in the groundwater system before reaching the river system, a detailed field study (hill slope scale) will be carried out to obtain improved understanding on flow paths, travel times and nutrient retention immobilization enabling a more accurate modelling of these phenomena at small spatial scales and an upscaling of the process descriptions to larger scales for use at the Baltic Sea Basin scale. At the Kocinka case site in Poland analyses will be performed to identify the relationship between agricultural practice, nitrate pollution of the underlying important aquifer and export of nitrate towards the Baltic Sea. State-of-the-art modelling tools like MODFLOW, Mike SHE and HydroGeoSphere will be used in the analyses.

Furthermore, detailed model analyses will support the evaluation of new concepts for spatially differentiated regulation and associated monitoring. The results will be compared to HYPE simulations for the same catchment and procedures to improve the HYPE simulations (upscaling) will be developed. Finally, the constructed model will be used to project future changes in runoff and nutrient loads with changing climate and land cover.

1.2.3 Nutrient transport and retention in surface water

New methodologies will be developed for assessing the variation in retention of P and decay of P and N among different surface water systems. This will include tracer tests and interpretation of available monitoring data using time series analyses. An extensive field campaign including tracer tests will be performed along a stretch of the Tullstorp Brook in Sweden and the Kocinka river in Poland to improve the understanding of nutrient retention in surface waters. The aim is to link stream reach characterization with solute transport behavior on the reach scale as well as generalizing this understanding on the catchment scale for planning of remediation actions.

To assess the potential for reducing nutrient loads to the Baltic Sea through changed reservoir operation, the impacts of hydropower regulation on the retention of nutrients in a river will be analysed using data from the heavily regulated Dalälven in Sweden. Furthermore, assessments will be made of the impacts of potential measures such as restoration/alternation of the stream morphology (wetlands, flooding zones, sediment traps, increased meandering).

1.2.4 Baltic Sea Basin scale

The results from the focus areas with respect to improved process descriptions of nutrient reductions in groundwater and surface water systems will be incorporated into the HYPE model applied for the entire Baltic Sea Basin area. The results from using these upscaled process descriptions will be tested against the existing process conceptualisation for nutrient reduction/retention/release in HYPE under present and historical conditions. To assess the capability of HYPE to predict changes in nutrient loads to the Baltic Sea specific tests will be performed against historical data for areas and periods, where significant trends have been observed.

Finally, HYPE will be used to assess nutrient loads to the Baltic Sea for the various scenarios of land use and climate change. In this respect the robustness of spatially differentiated regulation measures towards climate and land use change will be assessed. The results of the scenario analyses will be made publicly available via a web platform.

1.2.5 Governance, monitoring and stakeholder processes

A range of policy instruments for a new governance regime targeted at spatially differentiated output based regulations will be analysed with a focus on how to regulate agriculture and monitor nutrient loads. The instruments that will be evaluated through active involvement of local stakeholders via a series of workshops in case areas in Denmark, Sweden and Poland, include change of current land use and intensity, payment for ecosystem services, tradable permits, stricter input based regulation, voluntary exchange of land, and output based regulation and monitoring.

The case areas are characterised with different histories and degrees of agricultural regulation as well as very large differences in the stakeholder awareness of the nutrient problem. The resulting concepts will subsequently be tested at stakeholder meetings at other locations, including Russia and Germany. In parallel to the workshops and the work on the policy options, ethnographic studies will be undertaken to ensure the inclusion of cultural perspectives into the formulation of policy options. The aim is to understand the culture-induced knowledge and perceptions of the different stakeholder groups.

Groundwater threshold values for nitrogen has been identified as a policy instrument in the Groundwater Directive. Soils2Sea will further develop this concept for operational use in connection with spatially differentiated regulation.

1.2.6 Dissemination strategy

Soils2Sea results will be disseminated to the scientific community, practitioners and policy makers using different instruments. The project homepage www.Soils2Sea.eu will serve as a regularly updated site, from where all publicly available project outputs can be downloaded.

Soils2Sea will publish its results in internationally peer reviewed scientific journals and present the results at international conferences, including taking an active role in convening sessions at conferences, seminars and workshops.

The dissemination material for practitioners and policy makers will be gradually targeted towards the specific needs and interests of various stakeholder groups. The following material is envisaged: i) Project flyer; ii) Electronic newsletters; iii) Fact sheets; and iv) Policy Brief. Towards the end of the project the final results will be presented to key stakeholders such as policy makers and farmer associations as well as to the scientific community at a final Baltic Sea Conference.

1.3 Case areas

The studies will be carried out in seven study areas covering spatial scales from a few km^2 to 10^6 km^2. The three smaller sites (Norsminde in Denmark, Tullstorp in Sweden and Kocinka in Poland) will be used for combined field and modelling studies to gain insight in transport and retention processes in groundwater and river systems aiming at improved model descriptions both at local and at the Baltic Sea Basin scales. Furthermore, a range of policy instruments regarding governance and monitoring will be analysed in these areas through active involvement of local stakeholders. In two larger areas (Pregolya in Russia/Poland and the entire Baltic Sea Basin) modelling exercises will be complemented by one stakeholder workshop to test the new governance concepts. The last two areas (Horsens Fjord catchment in Denmark and Dalälven in Sweden) will be used for a few specialised analyses.

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2. Introduction

2.1 Soils2Sea concept, objectives and key outputs

Both the Baltic Sea Action Plan and the EU Water Framework Directive requires substantial further reductions of nutrient loads (N and P) to the Baltic Sea during the coming years. Achievements of these goals will only be possible by the implementation of fundamental changes in agricultural practices and land use. This will require the introduction of a combination of new and innovative measures acting in series on land prior to recipient water, because the easiest applicable measures have, in most cases, already been utilised. Not all the nutrients that are leached from the root zone reaches the coast of the Baltic Sea. Some can be removed by biogeochemical processes such as nitrate transformation (reduction) to nitrogen in the soils where reduced geochemical conditions exist. Others may be retained such as phosphorous absorption to the soil sediments in the groundwater zone or sedimentation of particulate phosphorous to the bottom of lakes or wetlands, from where it may later be released if the biogeochemical conditions change. For ease of referencing we denote all these *removal/absorption/sedimentation* processes as *retention*. Soils2Sea proposes to exploit the fact that the retention (removal by biogeochemical processes or sedimentation) of nutrients in groundwater and surface water systems shows a significant spatial variation, depending on the local hydrogeological and riverine regime to achieve the goals for nutrient load reduction set out in the Baltic Sea Action Plan. The traditional uniform regulations do not account for local data and knowledge and are much less cost-effective than spatially differentiated regulations with measures targeted towards areas where the natural retention is low. In order to fully exploit the potential of differentiated regulations it is required to utilise all local information and find locally designed and optimised solutions. Besides the need for improved knowledge on the subsurface and nutrient transport and retention processes on a local scale, this calls for new innovative governance regimes with active involvement of key stakeholders. Not the least as the new measures most probably will differentially affect stakeholder groups with conflicting interests.

If we more accurately can predict where in a catchment N and P are retained by estimating the retention in the different compartments along the flow path, and also include the delayed effects of mitigation measures due to long solute travel times in groundwater, then we can more cost-effectively design measures to reduce the nutrient loads to the Baltic Sea. Soils2Sea will therefore study the retention of N and P between the soils/sewage outlets and the coast, including transport pathways such as overland flow and flows in macropores, subsurface tile drains, shallow and deep groundwater, rivers, wetlands and lakes. The concept and the Soils2Sea work packages are illustrated in Figure 2-1.

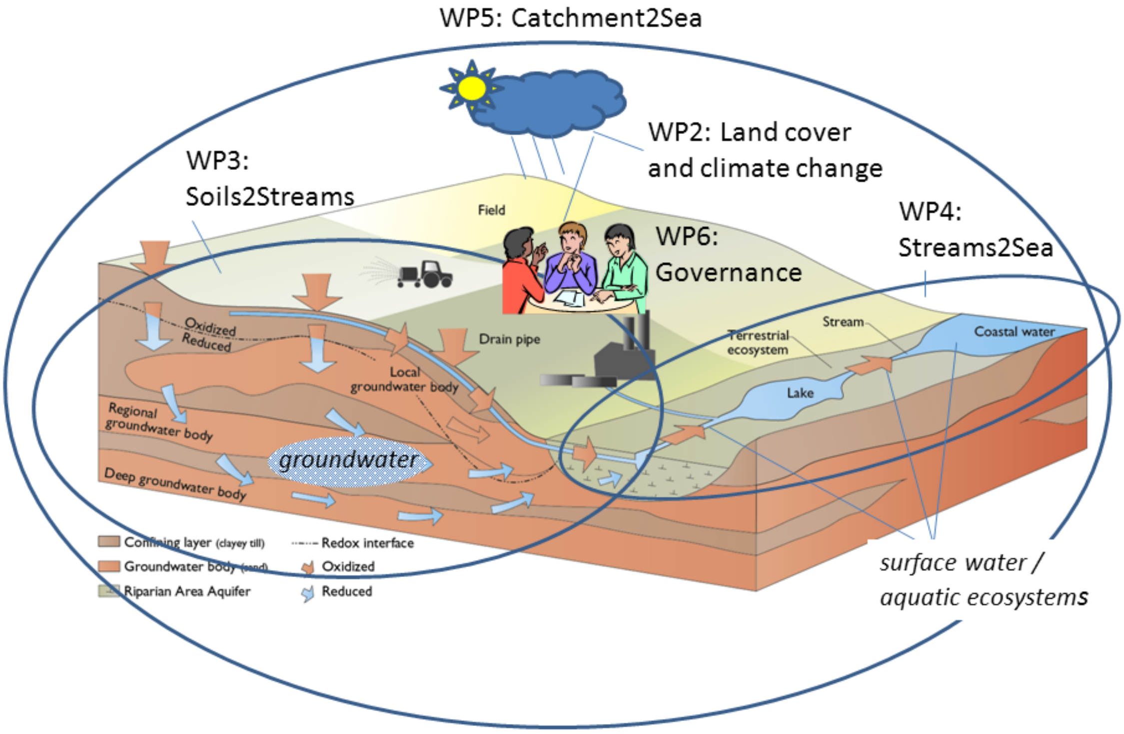

Figure 2-1 The project concept and work package structure of Soils2Sea.

The scientific objectives of Soils2Sea are:

- To analyse how changes in land cover, agricultural practices and climate may affect the nutrient load to the Baltic Sea and to test how robust nutrient load reduction measures are towards plausible climate change and land use scenarios (WP2).
- To develop and test new methodologies for identifying areas with small, respectively large, retention in the subsurface of nutrients leaving the soil surface or the root zone by improving process understanding of flow paths, travel times and nutrient retention immobilization (WP3).
- To develop and test new methodologies for assessing the variation in retention among different surface water systems by improving the understanding of nutrient retention in surface waters (surface runoff, drain runoff, rivers, wetlands, lakes) (WP4).
- To evaluate the reliability of high-resolution multi-basin scale models for assessing the impacts of land cover and climate changes including the effects of possible nutrient reduction measures and to assess the possible overall impacts of new spatially differentiated regulation strategies on the total riverine nutrient loading to the Baltic Sea (WP5).
- To develop new governance concepts targeted at differentiated output based regulations including threshold values for N in groundwater through active involvement of stakeholders in implementation and monitoring (WP6).

Soils2Sea will carry out a joint research effort at a macroregional level with the following key outcomes:

- New methodologies for the planning of differentiated regulations based on new knowledge of nutrient transport and retention processes between soils/sewage outlets and the coast.
- Evaluation of how differentiated regulation can offer more cost efficient solutions towards reducing the nutrient loads to the Baltic Sea.
- Analysis of how changes in land use and climate may affect the nutrient load to the Baltic Sea as well as the optimal location of measures aiming at reducing the load.
- A high-resolution model for the entire Baltic Sea Basin with improved process descriptions of nutrient retention in groundwater and surface water tailored to make detailed simulations of management regulations differentiated in space.
- New knowledge based governance and monitoring concepts that acknowledge the relevant aspects of EU directives and at the same time are tailored towards decentralised decision making. The proposed spatially differentiated regulations will aim for incorporation of local scale knowledge to optimally design solutions.

The concept and tools will be tested at a hierarchy of scales ranging from small scale (km^2) through medium scale catchments (10^3 km^2) to the Baltic Sea catchment scale (10^6 km^2).

The results will be disseminated to policy makers (involvement in development of new governance concepts, seminars, policy briefs, website) and stakeholders (newsletters, test of concept against local stakeholders, regional stakeholder forum, website) as well as through the traditional scientific channels (scientific conferences, journal papers, website).

2.2 Purpose and content of report

2.2.1 Objective, target group and limitations

Soils2Sea is a multidisciplinary project using a variety of methodologies and comprising a lot of interdependencies. The overall aims of the present report (Deliverable 1.2) are i) to map the interdependencies between work packages and partners; ii) to briefly describe the methodologies to be used; and iii) to prepare a detailed coherent project work plan. The report includes descriptions on:

- Case study areas
- Scenario developments for land use and climate
- Field studies and experiments
- Modelling tools and studies
- Plans for stakeholder involvement
- Initial ideas for governance and monitoring concepts to be tested and further developed throughout the project
- Project dissemination strategies

The primary target group for the present report is the Soils2Sea project group. The secondary target group comprises persons with particular interest in Soils2Sea such as external collaborative partners and other scientists working on the same topics and/or same study sites. The report is not aimed at stakeholders and policy makers.

As the present report is an introductory report to the Soils2Sea project focussing on requirements to various aspects of the future project work in order to achieve the ultimate project objectives, the report may in some aspects appear somewhat inwards looking. Similarly, it is only possible to present ideas and plans at this very initial stage of the project. The real project results will follow in subsequent publications during the coming 3½ years.

2.2.2 Reader's guide

In addition to the Executive Summary and the present Introduction the report consists of seven chapters. Each chapter is written, so that it should be possible to read them separately without necessarily having to read all the other chapters also.

The content of the seven chapters are:

- Chapter 3 describes the five main case study areas and how they are used throughout the project for field studies and modelling as well as for stakeholder processes.
- Chapter 4 addresses development of scenarios for changes in land cover, agricultural practices and climate and their impacts on loadings of N and P at different spatial scales.
- Chapters 5 and 6 describe the studies related to nutrient retention in groundwater and surface water systems, respectively. An important aspect here is how the local data and process knowledge can be upscaled and utilised for modelling at the Baltic Sea scale.
- Chapter 7 focuses on modelling studies for the entire Baltic Sea basin.
- Chapter 8 describes the initial ideas on new governance and monitoring concepts and the plans for developing and testing these through stakeholder processes.
- Chapter 9 describes Soils2Sea's strategy for dissemination to the scientific community as well as to stakeholders and policy makers.

2.3 Acknowledgement

The present work has been carried out within the project 'Reducing nutrient loadings from agricultural soils to the Baltic Sea via groundwater and streams (Soils2Sea)', which has received funding from BONUS, the joint Baltic Sea research and development programme (Art 185), funded jointly from the European Union's Seventh Programme for research, technological development and demonstration and from The Danish Council for Strategic Research, The Swedish Environmental Protection Agency (Naturvårdsverket), The Polish National Centre for Research and Development, The German Ministry for Education and Research (Bundesministerium für Bildung und Forschung), and The Russian Foundation for Basic Researches (RFBR).

2.4 References

More information can be found on www.Soils2Sea.eu

3. Case studies

3.1 Motivation and role of case studies

Full studies, including modelling and stakeholder processes will be performed in three case study areas. In an additional two cases, modelling exercises will be complemented by one stakeholder workshop. An overview of the case studies is provided in Sections 3.2-3.7 below.

Further, modelling studies will be carried out for two additional areas:

- Horsens Fjord catchment, a 800 km^2 catchment located just south of the Norsminde catchment. This area will be used to test the groundwater retention methodologies developed for Norsminde for a larger area with modelling experiments at different spatial resolution, including E-HYPE, enabling better linkages between the local scale and the full Baltic Sea scale.
- Dalälven, a 29,000 km^2 catchment located in mid-Sweden. This will be used to study the impacts of hydropower regulations on nutrient transport in rivers.

The location of all the study sites is shown in Figure 3-1, and summary characteristics of the five full case studies are listed in Table 3-1.

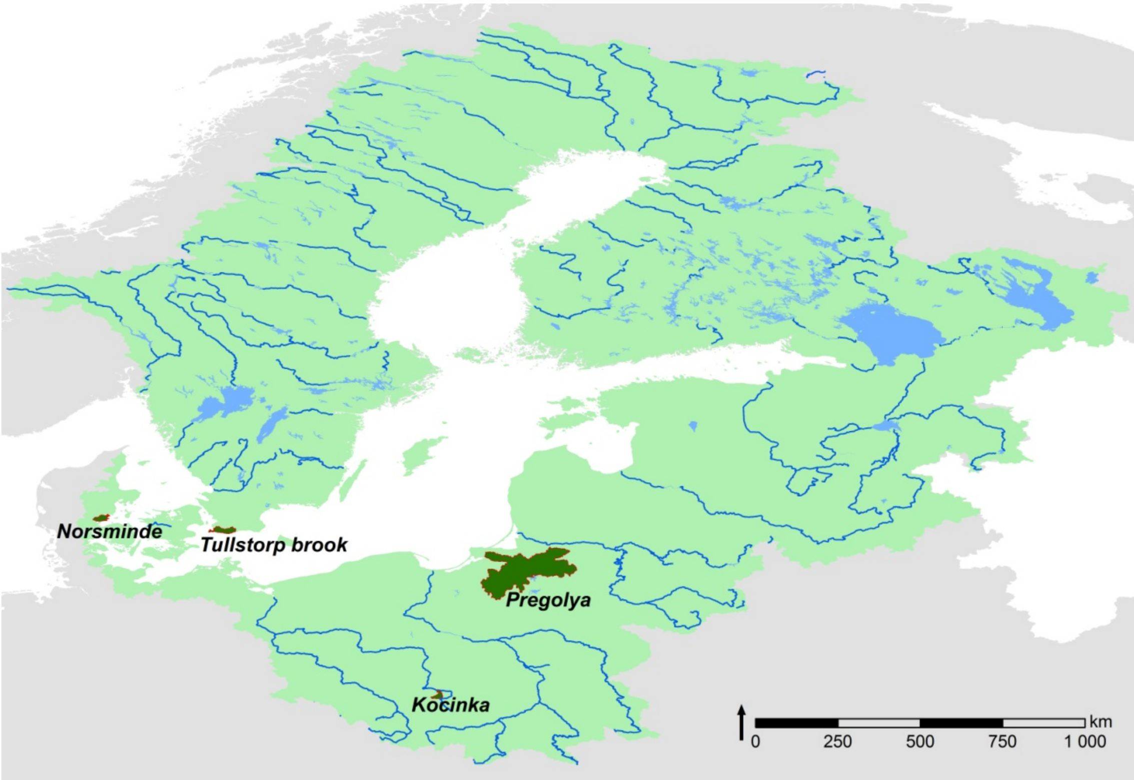

Figure 3-1 Location of case study areas

Table 3-1 Characteristics of the five full case studies

Catchment	**Norsminde**	**Tullstorp Brook**	**Kocinka**	**Pregolya**	**Baltic Sea basin**
Area (scale)	101 km^2 (hillslope+catchment scale)	63 km^2 (reach + catchment scale)	258 km^2 (catchment scale)	13,700 km^2 (catchment scale)	1.8 million km^2 (basin scale)
Hydrology	Glacial till, groundwater dominated	Glacial clays and till, dominated by groundwater tile drainage	Glacial till and glacio-fluvial sands and gravels underlain by karstic-fractured Jurassic limestones	60% of Pregolya runoff goes into the Vistula Lagoon, and 40% into the Curonian Lagoon. The river plain is flat, saltwedge intrusions.	Varied. Boreal forests in North, agriculture in south, 8 % wetland, lake dominance in large regions
Agricultural land	100%	85%	66%	56%	
Nutrient problem statement	N and P loads from catchment should be reduced by 25-50 % in order to a comply with the WFD and GWD	N and P load from the catchment should be reduced by 30 and 52% in order to obtain good ecological status according to WFD	Increasing use of fertilizers and local point sources. Nutrient inputs from Czestochowa city to the lower, karstic aquifer	Diffusion sources dominate. Transboundary basin between Poland and Russia.	N and P load for each country around the Baltic Sea should be reduced by amount stipulated in Baltic Sea Action Plan
Focus of study in case area	Flow paths and retention in groundwater, differentiated regulation, land use and climate scenarios, governance and monitoring concepts	Surface water retention, interactions with shallow groundwater, scenario analyses of local measures	Retention in the local and regional groundwater flow systems, interaction with surface water	Water discharge redistribution between the arms which goes to Curonian and Vistula Lagoon. Estimate of nutrient load from the Russian and Polish territories.	Upscaling of improved retention knowledge. Scenarios for changes in climate, anthropogenic impacts and management/governance
Model types used	HyroGeoSphere, MIKE SHE, E-HYPE	COMSOL, MIKE, HydroGeoSphere, S-HYPE	MODFLOW, SWAT, Balt-HYPE	HYPE, MIKE 11, FyrisNP	Balt-HYPE
Stakeholder processes	Develop new governance and monitoring concepts	Develop new governance and monitoring concepts	Develop new governance and monitoring concepts	Transboundary governance and monitoring concepts	Test acceptance of new governance and monitoring concepts
Recent previous study in area	NiCA (http://www.nitrat.dk/)	Project Tullstorpsån (http://www.tullstorpsan.se)	GENESIS http://www.thegenesisproject.eu/	ECOSUPPORT http://www.baltex-research.eu/ecosupport/	ECOSUPPORT http://www.baltex-research.eu/ecosupport/

Table 3-2 Agricultural information on the case studies in Norsminde, Kocinka, Tullstorp and Pregolya

Norsminde	
Does the case study lie within a Nitrate Vulnerable Zone (fully / partially / not at all)? If partially, to what extent?	Some of the area is located within areas with special drinking water interest (OSD). Within these areas some areas has on the basis of geological assessments been appointed groundwater vulnerable zones where the municipality has possibilities to impose special, additional restriction on agricultural practice in order to protect the groundwater resources from nitrate pollution. The groundwater vulnerable zones are relatively small areas around some of the local well fields.
What are the compulsory requirements that farmers must follow (e.g. application, timing of inputs)?	There is a comprehensive set of very detailed regulations that farmers must follow. This for instance sets an upper limit for how much fertiliser can be used; puts restriction on when organic manure or slurry may be applied on the fields, how much winter cereal or catch crops must be used, etc. Each farmer must report a fertiliser plan to the General Farming Register (GLR) in the Ministry of Food, Agriculture and Fishery. Non-complience to these regulations implies that the support from EU will be lost.
Are voluntary measures available that farmers can apply for (for example, agri-environment measures, or payments for ecosystem services from water companies? What are these measures? What is the uptake (percent of farmers in the case study area; high/low) and reasons behind the level of uptake?	The water companies have the possibility to make voluntary measures paying farmers for providing ecosystem services. One example of such measure is agreements on restrictions to fertiliser and pesticide applications for the coming up to 20 years. This is applicable only in areas where groundwater supply is at risk. This is not the main risk in the Norsminde catchment, where nitrate load to surface water constitutes a larger area, and water companies have no motivation, nor legal instruments to mitigate that.
What is the level of awareness about N / P issues?	Large
What is the farming structure in the case study area? • arable, livestock, mixed • Number of farms • Median farm size • degree of professionalism (full-time, part-time, supplementary)	Data from 2010 (http://nitrat.dk/xpdf/technicalnote---nitrate-leaching_chrthirup.pdf) • 75% of the catchment is arable. According to the General Farming Register (GLR) there are 7389 ha with intensive agriculture and fertiliser application up to the allowed norms. In addition, there are 739 ha of agricultural land not appearing in the GLR and without fertilizer account. The 7389 ha can be considered run by professional, typically full-time, farmers, while the 739 ha typically is small farms with extensive farmed areas operated by part time farmers. • The average density of livestock corresponds to 0.85 animal units per ha. • Number of farms: 186 farms growing 7389 ha distributed among 1586 fields • Average farm size: 62 ha.

Kocinka	
Does the case study lie within a Nitrate Vulnerable Zone (fully / partially / not at all)? If partially, to what extent?	Kocinka catchment does not lie within a Nitrate Vulnerable Zone.
What are the compulsory requirements that farmers must follow (e.g. application, timing of inputs)?	Farmers must follow rules of Good Agricultural Practice designated by Ministry of Agriculture and Rural Development. Non-compliance to these regulations implies that the support from EU will be lost. The Agency of Restructuring and Modernisation of Agriculture (ARMA) are obligated to control these regulations.
Are voluntary measures available that farmers can apply for (for example, agri-environment measures, or payments for ecosystem services from water companies? What are these measures? What is the uptake (percent of farmers in the case study area; high/low) and reasons behind the level of uptake?	The water companies don't arrange any measures available for farmers. They have own monitoring system measures water quality in few deeper wells owned by local people, but they not inform about the result.
What is the level of awareness about N / P issues?	Large
What is the farming structure in the case study area? • arable, livestock, mixed • Number of farms • Median farm size • degree of professionalism (full-time, part-time, supplementary)	• 54% of the catchment is arable. Typically full-time farmers is about 3255 , while part time farmers is about 2000 in the vast majority very small, mixed farms. • The average density of livestock corresponds to 0.091 livestock units per ha. • Number of farms: 4656 farms growing 13 780.645 ha. • Average farm size: 2.96 ha.

Tullstorp	
Does the case study lie within a Nitrate Vulnerable Zone (fully / partially / not at all)? If partially, to what extent?	The catchment of the Tullstorps Brook lies fully within a Nitrate Vulnerable Zone (NVZ) according to the Swedish Board of Agriculture (Johansson and Bång, 2014), based on modelled nitrate concentrations in soil water leakage from the root zone to groundwater bodies, which exceeded pollution class 5 (> 10 mg/L nitrate-N). Stream water concentrations of nitrate and nitrite, however, were measured at the catchment outlet (years 2009-2012) but did not exceed surface water criteria for NVZ designation (50 mg/L). The concentrations at the outlet varied between close to zero and 10 mg/L. Johansson and Bång (2014), *Översyn av känsliga områden 2014*, Swedish Board of Agriculture Rapport 2014:11, http://www2.jordbruksverket.se/download/18.37e9ac46144f41921cd14ea2/1401279595790/ra14_11.pdf
What are the compulsory requirements that farmers must follow (e.g. application, timing of inputs)?	All farmers in Sweden are affected by the Swedish Board of Agriculture (2013) injunction regarding environmental concerns in agriculture. It is summarized below. In general farmers should avoid applying more nutrients than the crops can use and the spreading of manure should be adapted for local environment and economic conditions. There are also several compulsory requirements that farmers working on sensitive land must follow when applying manure. - If fertilisers are spread on bare soil the soil should be tilled or covered within 4 hours after application. - Fertilisers should not be spread on saturated or flooded land, neither on snow covered or frozen land. - Fertilisers should not be spread within a distance of two meters from a stream or lake or if the slope towards a stream or a lake is greater than 10 %. - As a general rule, not more than 22 kg phosphorous may be spread per year and hectare. The maximum level varies depending on amounts of animals. In sensitive areas not more than 170 kg nitrogen may be spread per year and hectare. At autumn the maximum levels are even lower depending on type of crop. - The fertilizers must be evenly spread out over the permitted cropping area. - Certain technics must be used when spreading liquid manure. - In the region of Skåne, where Tullstorps Brook is located there are specific restrictions during certain periods of the year. Between the 1st of August and the 31st of October it is only allowed to apply manure on areas with growing crops, if the soil clay content is less than 15 %. If the clay content exceeds 15 % manure could be spread on bare soils before seeding of certain crops. However certain kinds of solid manure can be spread during the last part of the period, 1st October – 31st October. Between 1st November and 28th February there is forbidden to apply any kinds of manure. Furthermore, the injunction concerns storage of manure. There are both restrictions on how much manure a farm is allowed to store, depending on location and type and size of husbandry, and requirements on how manure should be stored to prevent leakage.

	There are also requirements on when crops should be seeded and harvested to maximize the time of year that fields are vegetated. No kinds of crops may be harvested before the 20th of October except for winter surviving crops that is harvested in the spring. The latest date for seeding is dependent on type of crops and varies between the 31st of July and the 15th of October. Swedish Board of Agriculture (2013), *Actions against Plant Nutrient Losses from Agriculture*, OVR125GB, Oct 2013, http://webbutiken.jordbruksverket.se/sv/artiklar/ovr125gb.html
Are voluntary measures available that farmers can apply for (for example, agri-environment measures, or payments for ecosystem services from water companies? What are these measures? What is the uptake (percent of farmers in the case study area; high/low) and reasons behind the level of uptake?	There are several voluntary measurements which farmers in Sweden can involve in to improve environmental conditions and water quality within the Rural Development Programme (Swedish Board of Agriculture, 2013). Economic support can for example be received from the government for undertaking environmental protection actions and actions aimed to decreased nitrate losses. Agri-Environmental payments to reduce plant nutrient losses apply to: - Environment protection measures (crop production plan, nutrient balance, soil mapping, determination of nitrogen content in liquid manure) - Reduced nitrogen leaching (catch crops, spring tillage), - Riparian strips - Wetlands - Cultivated grasslands. The Swedish Board of Agriculture, The Federation of Swedish Farmers and The County Administration Boards collaborates in the organisation Focus on Nutrients (Greppa näringen) and offers free advises to farmers on how to improve profitability on the farm, and at the same time reduce its negative impact on the environment. In the catchment area of the Tullstorps Brook, most farmers keep a six meter wide protection zone along the brook which is not farmed and for which they receive compensation. Many farmers have also received compensation for constructed wetlands. However, the landowners around Tullstorps Brook have gone further than that. With the aim to keep nutrients at the fields, prevent eutrophication of the recipient (The Baltic Sea) and to manage problems with flooding, an economical association was started by the Environmental Department and regional county 2008. The association welcomes all farmers in the catchment area and has realised several different measurements in the catchment area and along the Tullstorps Brook. The project started with a few wetlands but has now grown to include a complete restoration of the brook, biogas production and eco-tourism. Undertaken restoration actions included establishing the measurements listed below. - Wetlands - Stony bottom substrate - Meandering - Increase of vegetation along the brook - Improvement of riparian zones (slope, vegetation)

	- Sediment traps More can be read about the project at their webpage; http://www.tullstorpsan.se/index.php. Swedish Board of Agriculture (2013), *Actions against Plant Nutrient Losses from Agriculture*, OVR125GB, Oct 2013, http://webbutiken.jordbruksverket.se/sv/artiklar/ovr125gb.html
What is the level of awareness about N / P issues?	The awareness is relatively high compared to other areas thanks to the economic association and the Tullstorps Brook Project. The board of the economic association consists predominantly of landowners in the area and the discussion with and involvement of other farmers and landowners is a central part of the association. Most landowners (more than 100) are members in the association. The farming in this region of Skåne is generally well organised and environmental questions is discussed widely. The aim is always to act in favour for the environment without damage the farming. According to one of the farmers active in the economic association the compensation for the protection zones is too small to be the only motivation and that environmental engagement is essential. However for wetlands, the compensation is considered good enough. The mentioned farmer constructed a wetland on 7 ha of his land with the motivation that he rather have 14 ha productive land and a beautiful wetland than 21 ha unproductive arable land.
What is the farming structure in the case study area? • arable, livestock, mixed • Number of farms • Median farm size • degree of professionalism (full-time, part-time, supplementary)	85 % of the catchment area contains of agricultural land with mostly arable farming. The soil in this region is one of the most productive in Sweden and it has led to maximum usage of the land. Because it is profitable, many old, smaller farms (around 30 ha and less) are retained and the owners either lease out the land or do farming aside from another occupation. However also bigger farms occur, from 100 ha up to 1000 ha and all land is farmed fulltime. According to Eurostat (2010), the average farm size is around 50 ha in the region (= 0.5 km2). The catchment of the Tullstorps Brook has an area of 63 km^2. Dividing the arable area by the average farm size results in around 100 farms in this area. 63 km2 * 0.85 / 0.5 km2/farm = 107 farms Eurostat, European Commission, Online data, *Average size of farms, by NUTS 2 regions, 2010 (1)*. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php?title=File:Average_size_of_farms,_by_NUTS_2_regions,_2010_%281%29_%28hectares_of_utilised_agricultural_area_per_agricultural_holding%29.png&filetimestamp=20130528071541

Pregolya	
Does the case study lie within a Nitrate Vulnerable Zone (fully / partially / not at all)? If partially, to what extent?	The notion of "Nitrate Vulnerable Zone" is not used for the territory of Russia. Russian Water Code defines buffer protection zones for all water bodies. They have a size of 30-50 m (for rivers with a length less than 10 km), 100 m (for rivers with a length of 10-50 km), 200 m (for rivers longer than 50 km). The following is prohibited within the water protection zones: 1) use of wastewater for fertilization; 2) placement of cemeteries, burial grounds, burial sites of production and consumption waste, radioactive, chemical, explosive, toxic, poisonous and toxic substances; 3) implementation of aviation measures to combat pests and plant diseases; 4) movement and parking of vehicles; 5) ploughing; 6) placing piles of eroded soils; and 7) grazing of farm animals and the organization for their summer camps baths.
What are the compulsory requirements that farmers must follow (e.g. application, timing of inputs)?	Farmers must comply with the law and local statutory acts
Are voluntary measures available that farmers can apply for (for example, agri-environment measures, or payments for ecosystem services from water companies? What are these measures? What is the uptake (percent of farmers in the case study area; high/low) and reasons behind the level of uptake?	Farmers as citizens of Kaliningrad Oblast can submit applications for holding agro-environmental activities in local and regional governments. Their request will be considered. In special cases, the event will be included in the work plan.
What is the level of awareness about N / P issues?	Kaliningrad Oblast Government publishes an annual report about the environmental situation in the region. It includes questions about the status of water bodies, the activities carried out, the costs. Information about pollution in the atmosphere, water bodies, soil from fertilizer application, wastewater is available in the State statistics Committee of Oblast.
What is the farming structure in the case study area? • arable, livestock, mixed • Number of farms • Median farm size • degree of professionalism (full-time, part-time, supplementary)	90 agriculture enterprises and farms are located within Russian part of Pregolya River All agriculture enterprises and farms of Russian part of Pregolya River have 50 ths. of cattle, 29 ths. of pigs and 1.5 ths. of sheep and goats 4% of the economically active population of Kaliningrad Oblast employed in agriculture

3.2 Norsminde

3.2.1 Description

The Norsminde Fjord catchment is located on the east coast of Jutland in Denmark (Figure 3-2). The catchment is intensively farmed with more than 70% of the catchment area being agricultural land.

The catchment is dominated by a moraine landscape from Weichsel with mainly clayey soils and some sandy soils in the southern part of the catchment. The topography varies from around 100 m to sea level. An extramarginal stream valley from Weichsel, running from Southwest to Northeast, divides the catchment into a western more elevated and rather hilly part and an eastern part consisting of a flat low lying plain. The climate is temperate with an average precipitation for the period 1995-2003 of 773 mm/yr and an average evapotranspiration estimated to 555 mm/yr. Rævs stream and its tributaries contribute to the main part of the discharge from the catchment to the fjord. The average discharge at the most downstream gauging station (area 86 km^2) was 232 mm/yr for the period 1995-2003.

The stratigraphy in the Norsminde area consists of Paleogene and Neogene sediments covered by a sequence of Pleistocene glacial deposits. The Paleogene layers consist of fine-grained marl and clay, which has low permeability. The Neogene layers above comprise a Miocene sequence of marine origin, typically up to 40 m thick. The formation is clay-dominated but with interbedded sand units, which can be more than 10m thick. The Miocene is only found in the western part of the catchment and the glacial deposits are therefore found directly above the Paleogene clay in the eastern part. In some parts of the area, the Paleogene and Miocene deposits are cut by buried valleys, in particular in the southern part of the catchment where the Boulstrup tunnel valley is found. The glacial sequence consists of both sandy and clayey sediments. The clay deposits include a variety of lithologies from glaciolacustrine clay to clay till, whereas the sandy deposits mainly are of glaciofluvial origin. The clayey sediments dominate the sequence with the sandy sediments occurring as small and distributed units within the clay. The glacial sequence is in some areas heavily tectonically deformed with occurrences of rafts of Paleogene clay (He et al., Submitted).

The clayey soils in most of the area are typically drained using tile pipe drains. This is believed to highly influence the subsurface flow paths in the catchment.

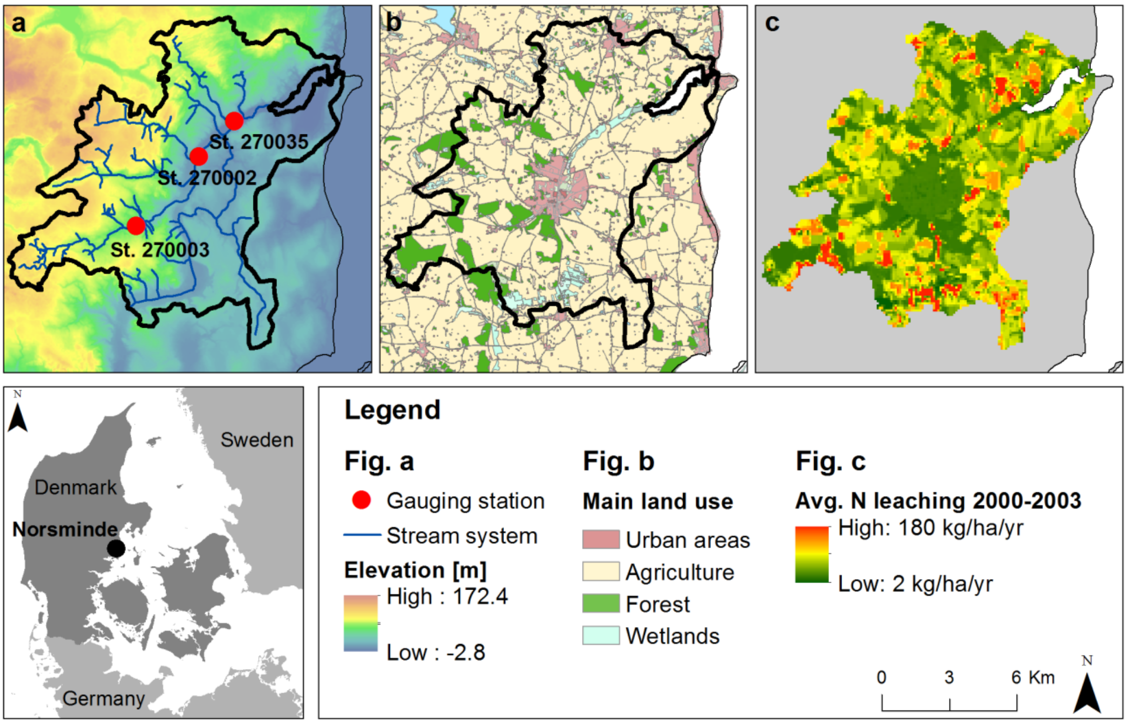

Figure 3-2 The Norsminde catchment area with A) topography, river network and gauging stations; and B) land use; and C) N leaching. Figure adapted from Hansen et al., 2014).

Figure 3-3 Typical landscape in the Norsminde catchment (Photo: Vibeke Ernstsen)

3.2.2 Data availability and previous studies

The data availability in the area is generally very good. Similar to the data for the rest of Denmark the following types of data are available:

- *Climate data*. Danish Meteorological Institute has established easily accessible datasets with gridded data (10 km for precipitation and 20 km for other climate variables) with daily values since 1990. In addition, some station data exist further back in time.
- *Discharge data*. Daily values exist for the three stations shown in Figure 3-2 for most of the period between 1990 and 2007. The downstream station reopened in 2012. The Nature Agency is responsible for the current monitoring and the national database is hosted by Aarhus University.
- *Geological data* is easily accessible from the national database JUPITER hosted by GEUS. The area has geological information from more than 100 well logs, as well as some time series of groundwater heads, groundwater abstraction and groundwater quality.
- *Soil data* and data on soil hydraulic properties exist with a 500 m resolution (Greve et al., 2007) from Aarhus University.
- *Land use and agricultural practice.* Information on crops and fertilizer application at field scale is available in the General Farming Register (GLR). Land use in areas not contained in GLR is available in the Area Information System AIS).
- *Topography.* High resolution digital terrain data are available.
- *River network geometry.* The river network geometry and available river cross-sections are built into the Danish National Water Resources Model (DK-model) (Stisen et al., 2012, Højberg et al., 2013).

In addition, comprehensive and relevant data have been collected in a number of research projects,of which the most relevant for Soils2Sea are:

- The EU-LIFE project *AGWAPLAN* (http://www.agwaplan.dk/agwaplan.htm)) from 2005 to 2009 was the first research/demonstration project in the catchment dealing with WFD issues.
- The *NiCA* project funded by the Danish Strategic Research Council (www.nitrat.dk; Refsgaard et al., 2014) collected high-resolution airborne geophysical data from the SkyTEM system based on transient electromagnetic measurements from a helicopter (Figure 3-4). The data covers the entire Norsminde Fjord catchment area and is available as a dataset with spatial resolutions of 20 x 20 x 2 m^3 extending from the surface down to approximately 100 m. The real footprint (spatial support scale) is 30-50 m in top layers and increasing with depth. The geophysical dataset has been combined with borehole data to generate a number of equally plausible geological models for the area using the stochastic geological modelling software TPROGS (He et al., 2014).
- The *IDRÆN* project and other demonstration projects funded by the Ministry of Food, Agriculture and Fisheries in Denmark have established a number of gauging stations for measuring discharge, N and P in drainage pipes and small streams. These stations are operated by Aarhus University and the Knowledge Center for Agriculture.

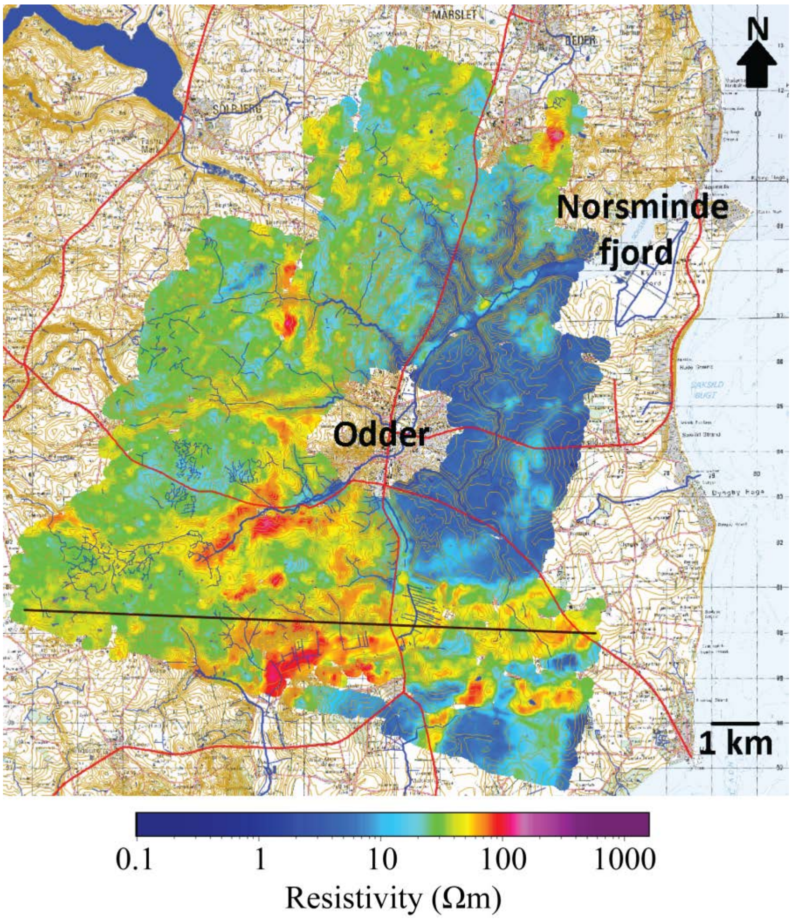

Figure 3-4 SkyTEM results from the Norsminde catchment: Mean resistivity map of the depth interval 15-20 m. Results are obtained after a spatially constrained inversion with 29 layers from 1.5 m to 150 m depth. Light brown lines correspond to topographical isolines, blue ones to streams, and red ones to main roads (Figure from Refsgaard et al., 2014).

3.2.3 Water management issues

The Norsminde Fjord catchment faces two major, somewhat interrelated, water management problems. One issue is related to possible contamination of deep groundwater by nitrate and pesticides potentially threatening drinking water supply in the area. The other issue is related to the ecological status of the coastal water in Norsminde Fjord. Soils2Sea will only address the latter issue.

Norsminde Fjord is an important resting and breeding area for birds and is designated as an EU-bird protection area. The ecological status in Norsminde Fjord and stream system has been monitored since 1989. The nutrient load to the fjord has been reduced during the monitoring period; however, the nutrient load is still too high and Norsminde fjord is classified as having a poor ecological status. Sewage treatment plants in urban areas have been extended to include effective nutrient removals, so today the nutrient load to the fjord mainly consists of nitrogen from agriculture. The load was on average 134 ton N/year during the period 2000-2003. According to the newly adopted Water Management Plan for the area the N load to the fjord must be reduced with 30 ton N/year for the coming period and most likely even more in the next Water Management Plan period (Danish Nature Agency, 2013).

This situation reflects one of the key problems Denmark is facing with respect to WFD implementation. Although Denmark has reduced nitrate leaching from the root zone by 50% since 1987, additional reductions of 30-50% will be required to meet the WFD objectives, even when climate change impacts are not considered. Under the current regulation regime, reductions in nutrient inputs of this magnitude would have such serious impacts that agricultural operations in many regions effectively would need to shut down.

The key stakeholders in the area with respect to the nutrient load from agricultural areas to the fjord are:

- *Farmers*. Agriculture is heavily regulated today. Farmers see the new N reduction targets as potentially economically devastating for individual farmers as well as for the agricultural sector as such. Danish farmers have a 150 year long tradition for being very well organised and using a well developed and scientifically based agricultural advisory service. The farmers in the Norsminde area are organised in the local farmers union "Landboforeningen Odder-Skanderborg" (DLØ; http://www.lbfos.dk/) that send a letter of support to Soils2Sea's proposal. The agricultural advisory system is owned by the farmers union and scientifically supported by the Knowledge Centre for Agriculture, VFL (http://www.vfl.dk/English/NyEnglishsite.htm) that is the professional arm of the national farmers union Danish Agriculture and Food Council (http://www.agricultureandfood.dk/). VFL, which is located in Skejby in the Aarhus area about 30 km north of the Norsminde area, is professionally very resourceful. Both the local union (DLØ) and the national knowledge centre (VFL) follow and participate actively in the many research and demonstration projects in the area.
- The organisation "Østjydsk Familielandbrug" is a national farmer's organisation. It represents political and economic interests of farmers and provides advisory services (http://www.lro.dk/default.asp?i=218). Its local branch in Odder is called "Odderegnens Familielandbrug".
- *Green organisations*. The Danish Society for Nature Conservation (http://www.dn.dk/Default.aspx?ID=4592) has local branches in the area and resourceful competent local persons as active members (http://www.dn.dk/Default.aspx?ID=267).
- The "Dansk Ornitologisk Forening, Lokalafdeling for Østjylland" promotes the protection of birds and their habitat in the region (http://dofoj.dk/om/).
- As part of an EU project, the "FLAG Odder" was established, a partnership between fisheries actors and other local private and public stakeholders. The FLAG Odder focuses on fisheries and coastal area development, as well as rural development (https://webgate.ec.europa.eu/fpfis/cms/farnet/flagsheet/flag-factsheet-denmark-odder)
- *Authorities*.
    - *The Danish Nature Agency, Ministry of Environment* (http://www.naturstyrelsen.dk/) has the responsibility for preparing River Basin Management plans for the WFD. *The "*Naturstyrelsen – Aarhus" is one of the 21 local branches.

- *The Danish AgriFish Agency, Ministry of Food, Agriculture and Fishery* (http://naturerhverv.dk/) has the responsibility for implementing the EU common agricultural policy and for the agricultural regulation decided by the Danish Government.
- *Municipalities* have the responsibility for implementing the WFD measures. There are two municipalities in the catchment, Aarhus Kommune (www.aarhus.dk) and Odder Kommune (http://www.odder.dk).The Odder Kommune decided to become a “Klimakommune” signing a declaration with the Danish Society for Nature Conservation to reduce CO_2 emissions by 2% each year (http://www.dn.dk/Default.aspx?ID=29799).
- Odder Spildevand A/S is a municipally owned enterprise that is responsible for waste water treatment (http://www.odderspildevand.dk/). In the Aarhus Kommune, Aarhus Vand A/S is responsible for the water supply and waste water treatment (http://www.aarhusvand.dk/Om-Arhus-Vand/).

The stakeholders have on their own initiative established Oplandsrådet for Norsminde Fjord (the Catchment Council for Norsminde Fjord - http://oplandsråd-norsminde-fjord.dk/) with 20 members and a board comprising two farmers, one person from a green organisation and one person form a municipality. The council has three aims: i) to work for identifying smart and innovative measures and solutions that can contribute to a good ecological status in Norsminde Fjord and at the same time enable a continuous development of the agriculture in the catchment; ii) to work to commit government authorities to include all knowledge and recommendations from the council in the governmental water planning; and iii) to contribute to and work with sharing of knowledge among all actors and stakeholders.

3.2.4 Case study focus

Soils2Sea will address the water management issue in the Norsminde catchment dealing with nutrient loads to Norsminde Fjord. The Danish Commission on Nature and Agriculture pointed to the need for a more spatially differentiated regulation of nutrient leakages from agriculture that targets outputs rather than inputs (Natur- og Landbrugskommissionen, 2013). Soils2Sea will contribute by developing and bringing forward methodologies and tools to support spatially differentiated regulations and by identifying the potentials, possibilities and constraints for such a fundamentally new management paradigm. The Norsminde case study will contribute to key Soils2Sea outputs by serving as test bed for:

- developing new methodologies for the planning of differentiated regulations based on new knowledge of nutrient transport and retention processes in the groundwater system;
- evaluating how differentiated regulation can offer more cost efficient solutions towards reducing the nutrient loads to the Baltic Sea;
- analysing how changes in land use and climate may affect the nutrient load to the Baltic Sea as well as the optimal location of measures aiming at reducing the load; and
- developing and testing stakeholder acceptance for new knowledge based governance and monitoring concepts tailored towards decentralised decision making.

3.2.5 Planned field and modelling studies

The Norsminde case will be studied in connection with the following Soils2Sea tasks:

- Tasks 2.2 and 2.3: The scenario analysis for future land use and climates will be used on Norsminde.
- Tasks 3.1, 3.2 and 3.3: Detailed field investigations (hillslope scale) will be conducted in the Norsminde area to study flow paths and nutrient transport processes in the saturated zone.
- Task 3.4: The findings from the hillslope field site will be upscaled by modelling and used to the full Norsminde catchment as well as to the larger neighbouring Horsens Fjord catchment.

Details on these studies are provided in chapters 4 and 5 of the present report.

3.2.6 Stakeholder’s role in Soils2Sea

In Norsminde, stakeholders are already engaged in different participation processes. Furthermore, they are aware of problems and challenges, both, from an agricultural as well as from a political point of view. Consequently, the stakeholder process in Norsminde can already build on a certain level of knowledge and needs to be closely linked to existing stakeholder exercises. Furthermore, a certain extent of social capital is already available. Soils2Sea will assess the stakeholder attitudes to several governance concepts in relation to spatially differentiated regulations, where all farmers are not treated equally. Furthermore, Soils2Sea will assess the stakeholder attitudes to several monitoring concepts based on control of outputs instead of inputs, implying that farmers may need to make collective commitments, because it is not always clear from which farm an output, e.g. measured in a drain, originates.

Two workshops are foreseen in Norsminde, in order to facilitate discussions with stakeholders. The first workshop is envisaged for October 2014:

Workshop in late 2014 on differentiated regulation and monitoring concepts

- Participants: 8-10 stakeholders organised through the local catchment council. Maybe 50% farmers + representatives of green organisations and authorities/municipalities. In addition, experts and facilitators. The Knowledge Centre for Agriculture should also be invited.
- Input: The following material must be available in writing and presented at the workshop:
    - Existing modelling results from NiCA, i.e. the maps that Anne presented at the kick-off meeting. Some of the stakeholders will have seen those maps in connection with NiCA’s final public meeting to be held later this year (maybe early autumn 2014). This information is factual but has large uncertainties and must be presented including the uncertainties
    - Economy in alternative regulation practices (uniform versus spatially differentiated). This information will be available from NiCA – calculations are being made during the summer of 2014 for a couple of farmers.
    - Outlines of possible monitoring concepts highlighting key advantages and limitations. This needs to be presented open minded, so that possible ideas

from participants are not blocked. We need to elaborate a couple of alternative concepts beforehand.

- Output:
    - o Stakeholders' perception of the large uncertainties in model results – will that close some regulation options and open others? – will we get court cases? – Who should carry the risks of making imperfect decisions?
    - o Stakeholders' views on monitoring concepts
    - o Views on further process within Soils2Sea, including wishes for modelling analyses in Task 3.4

The aim of the first workshop is to take aboard the stakeholders, to get them involved into the project, to pick them up and to take them along. To this end, the first series of workshops will use the Disney Method, a workshop method

- to depart from the usual way of thinking,
- to start group discussions, and
- to agree on action.

We propose to use this method combined with mind mapping (see chapter 8.2.2 for a detailed description of the workshop format).

A second workshop is planned for spring 2016. The aim of the second workshop is to present the policy options and to discuss them in depth. The World Café Method is very well suited to serve this end (see chapter 8.2.2 for a detailed description of the workshop format). Participants will be the same stakeholders that attended the first workshop so that the information circle is closed.

3.2.7 References

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3.3 Kocinka

3.3.1 Description

The Kocinka catchment (surface area of 257.8 km^2) is located in the south of Poland (Figures 3-5 and 3-6) in the Oder river catchment. The 40.2 km long Kocinka river discharges to the Liswarta river. The catchment is covered by 1 - 33 m thick Quaternary deposits (Paczyński, Sadurski, 2007) of fluvio-glacial and aeolian origin underlain by the Upper Jurasic limestones (Fig. 3-7). The Jurassic strata contain one of the largest groundwater bodies in Poland – the Major Groundwater Basin 326 (MGWB-326). Dominant soils are mainly sandy and clay soils (Figure 3-9). The topography is slightly undulating with elevations varying between 185 to 317 m a.s.l (Figure 3-10). The climate is temperate with an average annual precipitation of 600-700 mm/yr and average air temperatures between 7.5 to 8°C. The average discharge and the baseflow discharge at the gauging station (Figure 3-6) were 218 mm/yr and 158 mm/yr, respectively for the period 1974 - 1983. The catchment is mostly agricultural with pine forests dominating in the lower reach (Figures 3-9 and 3-11).

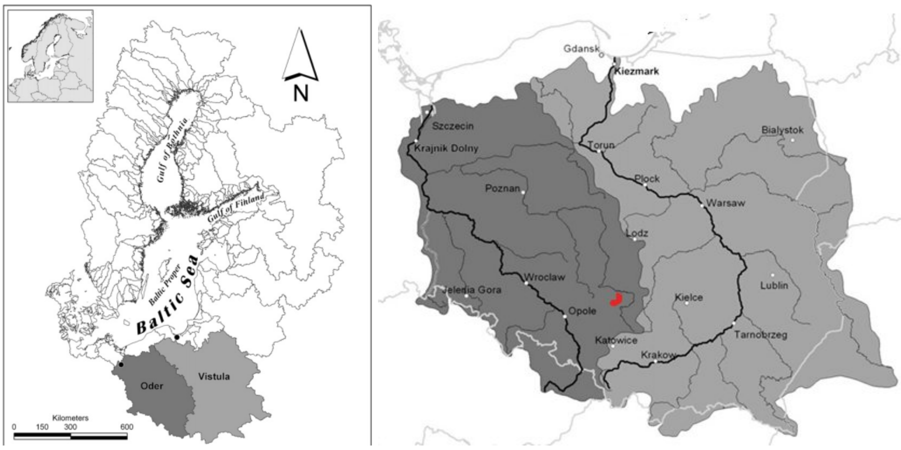

Figure 3-5 The Kocinka catchment (in red) in Poland and in the Oder river catchment.

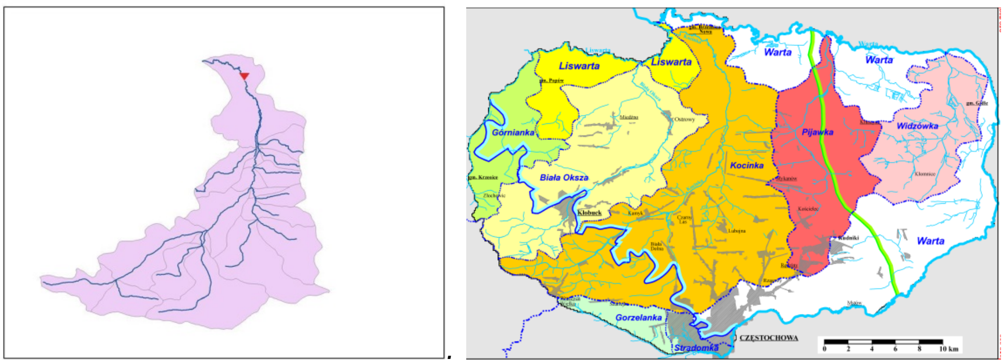

Figure 3-6 River network of the Kocinka and the neighbouring catchments. Location of the gauging station marked by the red triangle.

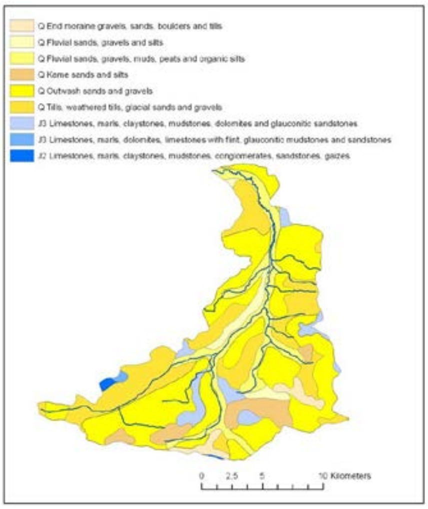

Figure 3-7 Geological map

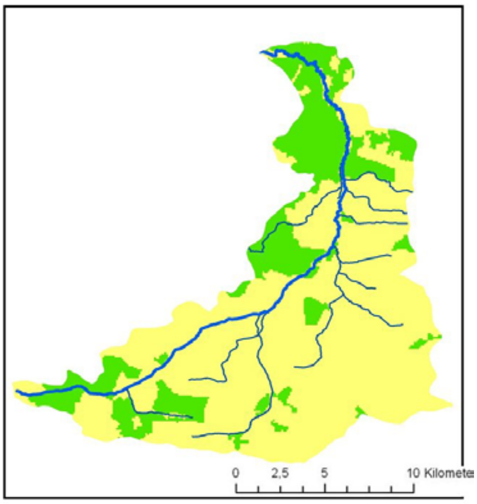

Figure 3-8 Simplified land-use map. Green colour denotes forests, yellow colour – other land-uses

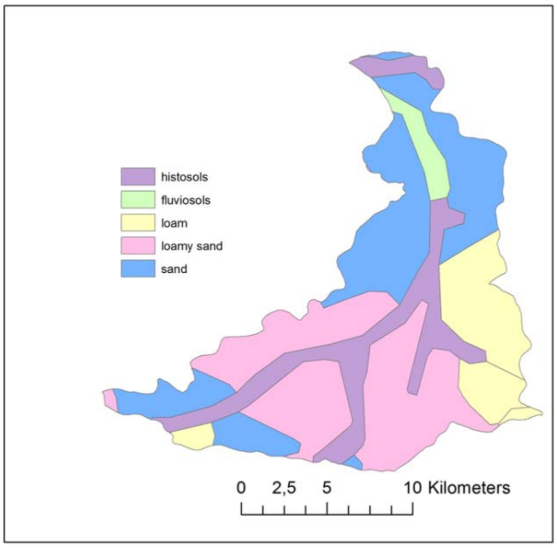

Figure 3-9 Soils of the Kocinka catchment.

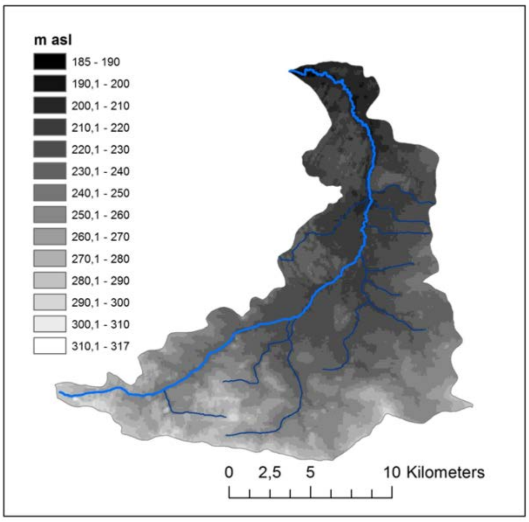

Figure 3-10 Relief of the Kocinka catchment.

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Figure 3-11. Regulated stretch of the Kocinka and the riparian forest in the lower part of the river.

3.3.2 Data availability and previous studies

Data availability for the area is generally poor, except for the data available at the regional and national levels.

- *Climate data*. Institute of Meteorology and Water Management - National Research Institute (*Instytut Meteorologii i Gospodarki Wodnej - Państwowy Instytut Badawczy,* IMGW-PIB), Kraków Branch is responsible for monitoring at the Hydro-Meteorological Station in Częstochowa at the southern border of the catchment.
- *Discharge data*. Daily values exist for the only gauging station shown in Figure 3-5 for the period between 1974 and 1991. Monitoring was performed by the IMGW-PIB.
- *Geological data*. Polish Geological Institute - National Research Institute (*Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy*, PIG-PIB) manages basic multisheet serial maps covering the whole country in the scale of 1: 50 000:

Detailed Geological Map of Poland, Hydrogeological Map of Poland and Geological Economical Map of Poland compiled with the use of the digital GIS technology.

- *Soil data.* Maps of land cover - Corine Land Cover (CLC) are available from the Chief Inspectorate of Environmental Protection (*Główny Inspektorat Ochrony Środowiska,* GIOŚ), soil maps are available from the Institute of Soil Science and Plant Cultivation in Puławy (IUNG-PIB). Analyses of soil parameters are performed by the Regional Chemical-Agricultural Station in Gliwice (*Okręgowa Stacja Chemiczno-Rolnicza* ,OSChR).
- *Land use and agricultural practice.* Information on crops and fertilizer application at field scale is prepared by Agricultural Advisory Boards in Częstochowa, Kłobuck and Pajęczno (*Powiatowy Zespół Doradztwa Rolniczego* - PZDR) and Central Statistical Office (*Główny Urząd Statystyczny* - GUS). Land use information available from CORINE will be refined by field observations.
- *Topography*. Digital Terrain Model – DTM from the IMGW-PIB.
- *River network geometry.* The river network geometry is built into the Digital Terrain Model – DTM and a map of the river network is prepared by IMGW-PIB.

In addition, many data were collected in research and monitoring projects on the MGWB-326. The most relevant for Soils2Sea are:

- Groundwater numerical model of groundwater flow and contaminant transport in VISUAL MODFLOW and data from 30 years of environmental tracer observations (Zuber et al., 2011).
- Groundwater quality and quantity monitoring is performed by Polish Geological Institute and by the Chief Inspectorate of Environmental Protection. Three hydrogeological stations belonging to this network (Kazimierski, 2012) are located in the case study area: spring in Wierzchowisko and two water supply wells (station number II/1346/1 in Częstochowa and station number II/951/1 in Cykarzewo).
- A detailed study on the Quaternary aquifer in the upper Liswarta river catchment adjacent to the Kocinka was performed between 2001 to 2003 (Guzik, 2009).

3.3.3 Water management issues

The main water management issue is in this case reduction of nutrient loads associated with agricultural and wastewater effluents that threaten water quality in:

- the Kocinka river and its tributaries,
- the MGWB-326 aquifer underlying the Kocinka catchment.

Interaction between the groundwater and surface waters is probably bidirectional as the upwelling groundwater may discharge into the river. The aquifer contains one of the largest groundwater bodies in Poland which supplies good quality drinking water to the inhabitants of the area. The unconfined, karstic fissured aquifer is vulnerable to pollution. Nitrate levels exceeding 50 mg/l have already been detected in the southern part of the groundwater body and water extracted from the polluted wells is subjected to denitrifying treatment. Two plausible sources of this pollution are: (i) inadequate sewage management in the town of Częstochowa and in the municipalities of the catchment and/or (ii) agricultural activities. In addition, the Kocinka river is popular for trout fishery.

The key stakeholders in the area interested in the reduction of nutrient loads to the aquifer, to the Kocinka river and to the Baltic Sea are:

- *Częstochowa Regional Association of Municipalities for Water and Sewage System (Związek Komunalny Gmin d/s Wodociągów i Kanalizacji w Częstochowie).* Ten municipalities forming this association have a common network of drinking water supply, sewage disposal and wastewater treatment. The association creates a strategy for the development of this network and supervises the integrated system of management and protection of the groundwater resources in the area (Malina et al., 2007).
- *Water and Sewage System Company of the Częstochowa District - Joint Stock Company (Przedsiębiorstwo Wodociągów i Kanalizacji Okręgu Częstochowskiego Spółka Akcyjna w Częstochowie -* http://www.pwik.czest.pl/en*)*. This enterprise provides drinking water and is responsible for the management of wastewater on the area of the ten municipalities forming the Association.
- *„WARTA" S.A. w Częstochowie* is the sewage plant of Częstochowa for the Warta river (http://www.wartasa.eu/news).*Authorities*.
    - *Municipality of Mykanów (Gmina Mykanów – www.mykanow.pl) and three other municipalities of the catchment.* The municipalities are responsible for preparation of the development plans that regulate activities affecting the environment, in particular the quality of surface water and groundwater. For instance, the municipality of *Kłobuck* installed a wastewater system in 2013 that directly affects the water quality in the Kocinka river (http://www.gminaklobuck.pl/samorzad/Opis_projektu.html).
    - *National Water Management Authority – KZGW (Krajowy Zarząd Gospodarki Wodnej – www.kzgw.gov.pl)* and *Regional Water Management Board (RZGW) in Poznań* are responsible for implementation of the WFD in Poland and in the Warta river catchment, respectively.
    - *Institute of Meteorology and Water Resources Management – IMGW (Instytut Meteorologii i Gospodarki Wodnej – www.imgw.pl)* is responsible for carrying out hydrological and meteorological measurements and observations, their collection, analysis, processing and dissemination, as well as assessing the water resources quality. The IMGW cooperates with and supports the public sector and offers various services and expertises in the field of meteorology and hydrology.
    - *Chief Inspectorate of Environmental Protection – GIOS (Główny Inspektor Ochrony Środowiska - www.gios.gov.pl)* and its regional branch *WIOS* are responsible for monitoring of the surface water and groundwater quality and for inventorying of point sources of pollution.
- *Industries*.
    - *SD Huta Czestochowa Sp. z o.o*. is one of the largest steel producing companies in Poland (http://huta.isd-poland.com/in-english).
    - The *Koksownia Częstochowa Nowa* is a leading manufacturer of coke in Poland (http://www.koksownianowa.pl/).
    - *Guardian Częstochowa* is a glass plant that belongs to an American company (http://guardian-czestochowa.com/index.php?Lang=en).

  - There are also several automotive components suppliers, e. g. *TRW Automotive* (security systems), *CSF Poland* (cables, anti-vibration systems and seals), *Brembo* (brake system components) *or CGR Polska.*
- *Mykanów Circle of the Polish Angling Association – PZW (Polski Związek Wędkarski - http://www.pzwmykanow.zafriko.pl)* supervises the Kocinka fishery.
- *Razem na wyżyny* is a local action group (LAG) of the European Union LEADER project. A regional development strategy is developed to enhance the quality of life in the region. The LAG already held an environmental workshop, however environment in general is not a main focus of their work http://www.razemnawyzyny.pl/index.php?option=com_content&view=article&id=90&Itemid=100.
- Green organizations. There is a regional branch of the Polski Klub Ekologiczny (Friends of the Earth Poland) in Gliwice (http://www.pkegliwice.pl/kontakt/onas.html).
- Farmers. The Polish Union of Farmers and Farmers Associations (KZRKIOR) has a regional branch in Czestochowa (http://kolkarolnicze.eu/O-nas/Struktura-KZRKiOR/Regionalny-ZRKiOR-Czestochowa).

3.3.4 Case study focus

Work performed in this case site will address the following issues:

- identification of nutrient pollution sources,
- characterization of spatial and temporal variations of nutrient levels and fluxes in the Kocinka,
- retention of nutrients in the river.
- interactions between groundwater and surface water in the catchment with respect to the fluxes of nutrients exchanged between these two compartments and exported from the catchment,
- time lags in responses of river water quality to the measures undertaken with respect to agricultural activities and land-use (Kania and Witczak, 2009; Witczak, 2011).

The Kocinka catchment is fairly representative for Poland with respect to soil types, land-use and agricultural practices. Results of work performed in this case study will therefore be important for the development and testing of the differentiated regulations concept in Poland. The Kocinka case study will contribute to the fulfilment of Soils2Sea objectives related to WPs 2-4 and 6 particularly to:

- analysis of effects of current and future land-use and agricultural practices on nutrient loadings to groundwater and surface water,
- characterization on nutrient retention processes in the subsurface,
- characterization of groundwater – surface water interactions and of their role in nutrient retention,
- formulation of the new governance concepts relevant to Polish conditions.

3.3.5 Planned field and modelling studies

The Kocinka case will be studied in connection with the following Soils2Sea tasks:

- Tasks 2.2 and 2.3: data on nutrient losses will be collected for the Kocinka, modelling of nutrient losses under different scenarios will be performed.
- Task 3.5: observations and modelling of nutrient levels in groundwater in order to assess groundwater retention will be performed.
- Tasks 4.1 and 4.4: tracer experiments and observations of nutrient levels in the Kocinka in order to assess surface water retention will be performed.

3.3.6 Stakeholder's role in Soils2Sea

Unlike the Norsminde case study, stakeholders in Kocinka are not yet aware of problems related to N and P loadings – or are aware only to a certain extent. Furthermore, stakeholders are not yet engaged in preceding projects and therefore need to be approached from a different angle: 1) We need to build up a working relationship with stakeholders in the region in order to build social capital. 2) Stakeholders need to get to know the problems and challenges related to N and P loadings, where they come from and to what consequences this leads. 3) Stakeholders need to understand the facts related to 2) and then, 4) need to agree to it before they can become active and supportive stakeholders in the process. This process of "recruiting" stakeholders so that they become stakeholders in practice, i.e. interested and engaged, is not manageable within one workshop but needs a bit more time and communication. However, this process can start in parallel to the first workshop.

Like in Norsminde, two workshops are foreseen in Kocinka, in order to facilitate discussions with stakeholders. The first workshop is envisaged for November 2014:[1]

Workshop in late 2014 on awareness raising and regulation

- Participants: 8-10 stakeholders, maybe 50% farmers + representatives of green organisations and authorities/municipalities. In addition, experts and facilitators:
    - A key stakeholder seems to be the Water and Sewage System Company as they are directly interested in maintaining good water quality in the area and have means for that and the Municipality of Mykanów that is interested in maintaining agricultural development (fertilisation) on one hand and the quality of surface water and groundwater on the other. http://www.pwik.czest.pl/en
    - Częstochowa Regional Association of Municipalities for Water and Sewage System (Związek Komunalny Gmin d/s Wodociągów i Kanalizacji w Częstochowie)
    - Municipality of Mykanów (Gmina Mykanów – www.mykanow.pl) and three other municipalities of the catchment.
    - National Water Management Authority – KZGW (Krajowy Zarząd Gospodarki Wodnej – www.kzgw.gov.pl) and Regional Water Management Board (RZGW) in Poznań.

[1] In Poland, municipal elections are being held on 16 November 2014. The first workshop should preferably take place after that.

    - Institute of Meteorology and Water Resources Management – IMGW (Instytut Meteorologii i Gospodarki Wodnej – www.imgw.pl)
    - Chief Inspectorate *of Environmental Protection – GIOS (Główny Inspektor Ochrony Środowiska - www.gios.gov.pl)*
    - *Mykanów Circle of the Polish Angling Association – PZW (Polski Związek Wędkarski - http://www.pzwmykanow.zafriko.pl)*
- Output:
    - Raising stakeholders' awareness about the consequences of nutrient pollution for the surface water ecosystems and the Baltic Sea.
    - Stakeholders' views on monitoring concepts
    - Views on further process within Soils2Sea

The aim of the first workshop is to take aboard the stakeholders, to get them involved into the project, to pick them up and to take them along. To this end, the first series of workshops will use the Disney Method, a workshop method

- to depart from the usual way of thinking,
- to start group discussions, and
- to agree on action.

We propose to use this method combined with mind mapping (see chapter 8.2.2 for a detailed description of the workshop format).

A second workshop is planned for spring 2016. The aim of the second workshop is to present the policy options and to discuss them in depth. The World Café Method is very well suited to serve this end (see chapter 8.2.2 for a detailed description of the workshop format). Participants will be the same stakeholders that attended the first workshop so that the information circle is closed.

3.3.7 References

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3.4 Tullstorp Brook

3.4.1 Description

Tullstorp brook is a 30 km long stream located in the south of Sweden. The stream drains a 63 km^2 large area and discharges into the Baltic Sea close to the small town Skateholm. The watershed consists predominantly of glacial clays and till, and is intensively farmed with around 85% of the catchment area being agricultural land. Due to the climatic and geological conditions a majority of the agricultural land is tile drained to increase the runoff from the soil and provide optimal conditions for agriculture.

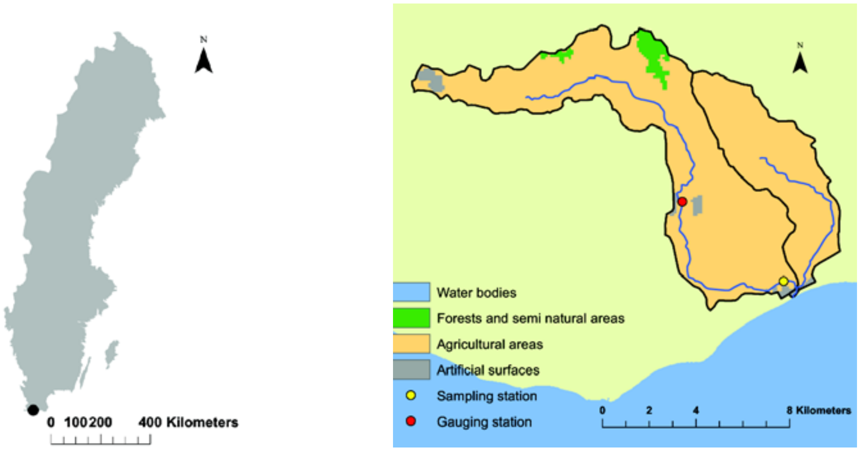

Figure 3-12 The Tullstorps Brook catchment with, on the left, location within Sweden, and, on the right, river network, gauging station (red point), sampling station for nutrients (yellow point) and land use.

3.4.2 Data availability and previous studies

The data availability for the Tullstorp Brook catchment is generally very good, based on national databases and site specific knowledge though previous research/agricultural projects carried out in the catchment. The following types of data are available:

- *Climate data*: Gridded precipitation and air temperature time series at 4 km resolution available through a database hosted by the Swedish Meteorological and Hydrological Institute (SMHI).
- *Discharge data*: SMHI has equipped the stream with a pressure gauge for measuring the stream level at 15 minute time resolution since 2012, rating curves are being measured and discharge time series will become available during 2014 for the observation point indicated in Figure 3-12.
- *Nutrient concentrations:* Bi-monthly total nitrogen and total phosphorus measurements at the catchment outlet are available through a database hosted by the Swedish Agricultural University (SLU) from 1996 to 2009, with more recent measurements possibly available on request.
- *Geological data and soil data:* is accessible through a database hosted by the Swedish Geological Survey (SGU).

- *Land use and agricultural practice:* is accessible through the database CORINE hosted by the European Environment Agency (EEA).
- *Topography:* High resolution digital terrain data are available from Lantmäteriet.
- *River network geometry.* The river network geometry for entire Sweden have been vectorized in a database hosted by SMHI. Additional information about river cross-section at a high temporal resolution can be found from previous projects in the area.

An important rationale for choosing the Tullstorps Brook as field study is the catchment's historical development of agricultural practises. The catchment has been highly managed during the last century which has led to high nutrient loads to the Baltic Sea. As a direct consequence, a large project to restore the stream channel and to reduce the nutrient loading was started in 2008 and is still running. The project is conducted by Tulllstorpsån Ekonomiska Förening (http://www.tullstorpsan.se) with the key partners Swedish Environmental Research Institute (IVL), SMHI, and Ekologgruppen. The aim is to reduce the nutrient transport to the Baltic Sea through constructional remediation actions in the stream channel, including increased meandering, streambed restoration, and construction of wetlands, riparian zones, stream-banks that allows for inundation of the flood plains. Hence, detailed knowledge of topology, river network geometry and stream hypsography, together with bi-weekly time series of N and P from 2009-present is readily available (sampling point indicated in Fig 3-12). To perform additional investigations on a site already used for research provides a unique opportunity to build on the already existing knowledge and to evaluate the processes governing the nutrient retention in the already existing remediation measures highlights their role from a more scientific standpoint.

3.4.3 Water management issues

The construction of extensive tile drainage systems, dredging, excavation and straightening of the stream channel and removal of in-stream vegetation and riparian zones have altered the local hydrological cycle of the Tullstorp Brook catchment. Due to the management of the catchment, the residence times of both water and nutrients have decreased significantly during the last century, which together with intensified agricultural activities have led to a high load of nutrients to the Baltic Sea. The loads of nitrogen and phosphorous are 250 ton/year and 4 ton/year, and hence exceeds the thresholds to obtain good ecological status. According to the Water Framework Directive, nitrogen and phosphorous load from the catchment should be reduced by 30 and 52% in order to obtain good ecological status.

The key stakeholders in the area with respect to the nutrient loading from agricultural areas to the Baltic Sea are:

- *Farmers*. Around 90 property owners in the Tullstorps Brook catchment have organized themselves in an economic association (http://www.tullstorpsan.se) in order to coordinate the measures to improve the ecological status of the area. Karl-Otto Alwén is one of the farmers especially engaged in the project (http://www.fishsec.org/2013/06/09/race-for-the-baltic-team-visits-tullstorp-stream-pilot-project-2/).

- The Federation of Swedish Farmers (*Lantbrukarnas Riksförbund*, LRF) has a regional branch for the region and several local groups (http://www.lrf.se/Skane).
- *Green organizations*. Swedish Society for Nature Conservation has a local branch in the area (http://nftrelleborg.se) and has an interest in the activities occurring in the catchment.
- The Fisheries Secretariat (FISH) is a small non-profit organisation working towards sustainable fisheries in Europe with a strong focus on the Baltic Sea. They were founded by the Swedish Society for Nature Conservation, the WWF Sweden, and the Swedish Anglers' Association. The NGO has an office in Stockholm (http://www.fishsec.org/about-us/).
- Fisheries. The Swedish Anglers' Association has a regional office in Malmö (http://www.sportfiskarna.se/Omsportfiskarna/RegionSydMalm%C3%B6/tabid/131/Default.aspx).
- *Authorities*
    - Swedish government, Ministry of the Environment, (http://www.regeringen.se/sb/d/1471) bears overall responsibility for the environmental quality objectives and for WFD implementation in Sweden.
    - The Swedish Environmental Protection Agency (http://www.swedishepa.se) is responsible for national environmental protection and provides the government with expert advice on current status on environmental issues and how to achieve environmental objectives.
    - Swedish Agency for Marine and Water Management (https://www.havochvatten.se)
    - The South Baltic Water District Authority (www.vattenmyndigheterna.se/Sv/sodra-ostersjon) coordinates the work on preserving and improving the quality of water in accordance with the WFD.
    - County administrative board of Skåne (http://www.lansstyrelsen.se/skane) has a coordinating part in work to achieve the Swedish environmental objectives.
    - Trelleborg Municipality (http://www.trelleborg.se) translating national and regional objectives into local aims and actions. The department called "Vatten och avlopp VA-avdelningen" is in charge of water supply and waste water treatment.

3.4.4 Case study focus

An extensive field campaign will be performed along a stretch of the Tullstorp Brook including investigations of geophysical, topographical and hydraulic properties. Key features in the campaign include tracer tests where ^{15}N enriched nitrogen, ^{32}P labeled phosphate, and tritiated water will be injected into the stream during different stream flow conditions. Each experiment is designed to span over several stream reaches with different geomorphologic conditions and, hence, different prerequisites for nutrient retention and attenuation. This unique field campaign will therefore focus on:

- Phenomenological studies to increase knowledge of different in-stream remediation actions.

- Derive exchange relationships based on physical measures on a form that can be incorporated in solute transport models on the catchment scale.

3.4.5 Planned field and modelling studies

Field and modelling work in the Tullstorp Brook will be used in the Soils2Sea project in the following tasks:

- Task 4.1: Performing field experiments along a stretch of the Tullstorp Brook including investigations of geophysical, topographical and hydraulic properties. The tracer test will subsequently be evaluated with a transport model with focus on the retention and attenuation of the solutes and its connection to specific remediation actions.
- Task 4.2: The findings from the monitoring and tracer experiment data will be utilized to develop a catchment scale model representing nutrient transport in a stream network.
- Task 4.3: Scenario analysis using the network model developed in Task 4.2. The key objective is to represent the transport of nutrients affected by different anthropogenic manipulations and investigate how different remediation actions are affecting nutrient transport and retention.
- Task 5.3: The Tullstorp Brook catchment will be used as testbed catchment for upscaling procedures of nutrient reduction measures to the subbasin resolution of the Balt-HYPE model.

3.4.6 Stakeholder's role in Soils2Sea

A third case study setting is the one for Tullstorp Brook. Similar to the case in Kocinka, stakeholders are not yet involved in any consultation or participation processes. However, it can nevertheless be assumed that they are already aware of the problems and challenges related to N and P loadings (similar to the case in Norsminde).

Since the focus of Soils2Sea lies on assessing stakeholders' attitudes to several governance concepts in relation to spatially differentiated regulations, where all farmers are not treated equally, this is what will be explored in the first workshop. These ideas and concepts will be new to these stakeholders, which is why the issue has to be carefully explained.

Two workshops are foreseen in Tullstorp Brook, in order to facilitate discussions with stakeholders. The first workshop is envisaged for November 2014:

Workshop in late 2014 on differentiated regulation and monitoring concepts

- Participants: 8-10 stakeholders, maybe 50% farmers + representatives of green organisations and authorities/municipalities. In addition, experts and facilitators:
    - Swedish government, Ministry of the Environment (http://www.regeringen.se/sb/d/1471)
    - The Swedish Environmental Protection Agency (http://www.swedishepa.se)

    - Swedish agency for marine and water management (https://www.havochvatten.se)
    - The South Baltic Water District Authority (www.vattenmyndigheterna.se/Sv/sodra-ostersjon)
    - County administrative board of Skåne (http://www.lansstyrelsen.se/skane)
    - Trelleborg Municipality (http://www.trelleborg.se)
- Output:
    - Stakeholders' views on monitoring concepts
    - Views on further process within Soils2Sea

The aim of the first workshop is to take aboard the stakeholders, to get them involved into the project, to pick them up and to take them along. To this end, the first series of workshops will use the Disney Method, a workshop method

- to depart from the usual way of thinking,
- to start group discussions, and
- to agree on action.

We propose to use this method combined with mind mapping (see chapter 8.2.2 for a detailed description of the workshop format).

A second workshop is planned for spring 2016. The aim of the second workshop is to present the policy options and to discuss them in depth. The World Café Method is very well suited to serve this end (see chapter 8.2.2 for a detailed description of the workshop format). Participants will be the same stakeholders that attended the first workshop so that the information circle is closed.

3.5 Baltic Sea Basin

3.5.1 Description

The Baltic Sea basin covers a land area of around 1.8 Mio. km^2 in Finland, Russia, Estonia, Latvia, Lithuania, Belarus, Poland, Germany, Denmark, Norway, and Sweden, as well as small land-surface fractions from Ukraine, Slovakia, and the Czech Republic (Figure 3-13). The climate in the basin ranges from temperate in the south to arctic in the far north. The highest mountain ranges are located in Scandinavia along the north-western basin boundary. The Karkonosze Mountains extend along the southern boundary. The landscape forms in the whole basin are heavily influenced by their glacial or periglacial history. Geologically, the northern parts of the basin belong to the Fennoscandian shield, consisting of silicate bedrock with low permeability and thin soils. Lakes cover large fractions of the land surface here. The southern parts are geologically more diverse and non-consolidated quaternary sediments occur extensively, providing for larger sub-surface water volumes.

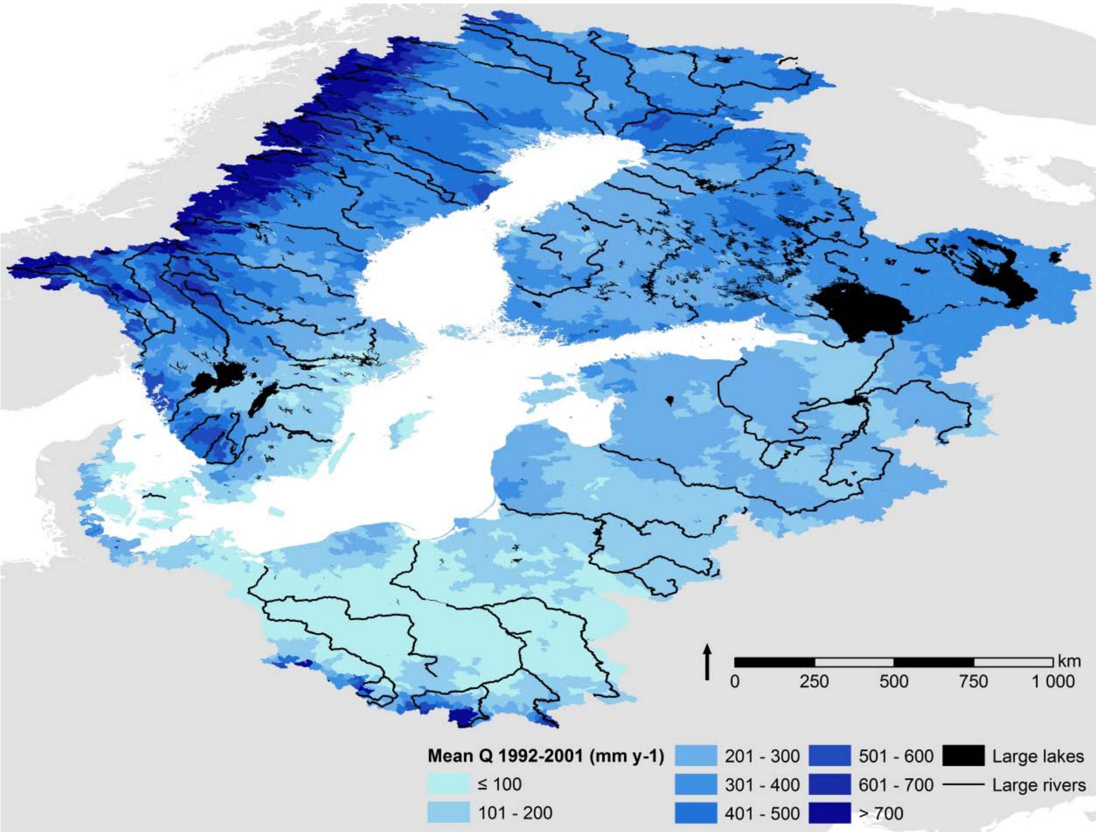

Figure 3-13: Spatial extent of the Baltic Sea basin with E-HYPE-modelled long-term average runoff from model sub-basins.

Owing to the cold climate and less-developed soils, land cover in the northern parts is dominated by forests, while agriculture is prevalent on suitable soils in the southern parts of the basin (Figure 3-14).

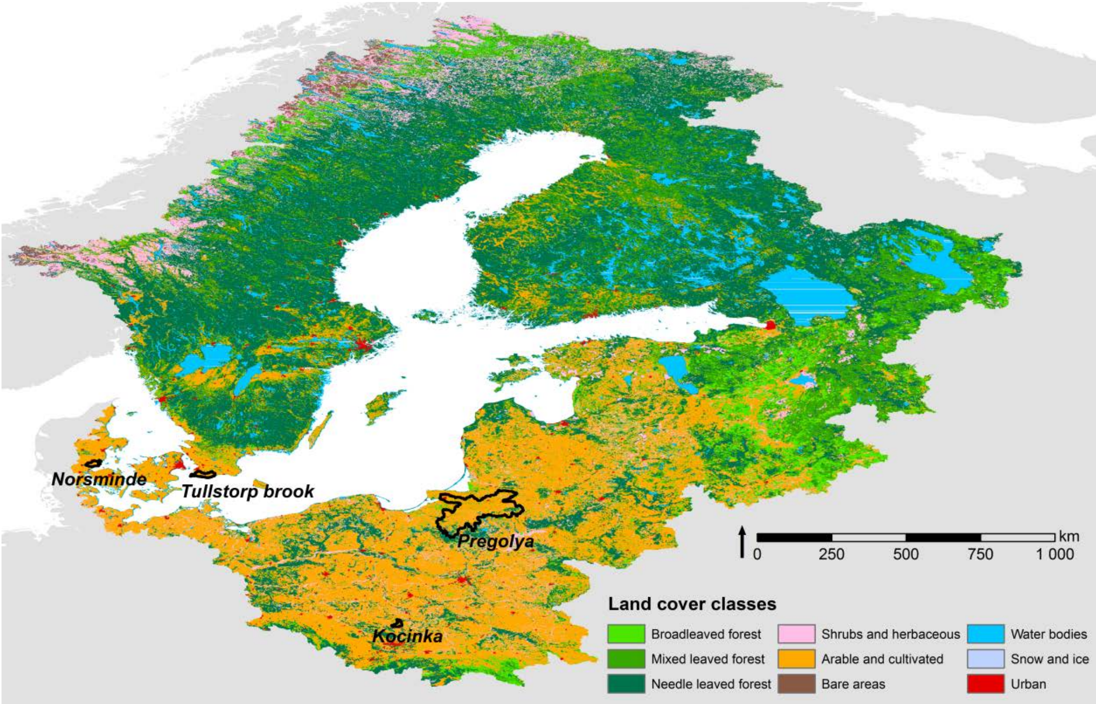

Figure 3-14: Land cover classes in the Baltic Sea basin, with case study catchment locations outlined. Simplified classification based on Global Land Cover 2000 data (Bartholomé and Belward, 2005).

3.5.2 Data availability and previous studies

The Balt-HYPE model set-up will be based on the existing E-HYPE model, which covers the whole of Europe. Data available for the region include:

- Hydrosheds and Hydro1K for topography
- CORINE and Global Land Cover 2000 land use data
- Lake data from the Global Lake and Wetland Database (GLWD)
- European Soils Database and Digital Soil Map of the World (DSMW) for soil types
- HYDE population database, EEA treatment level database, and European Pollutant Release and Transfer Regulation (EPRTR) database for point sources
- MATCH model results for atmospheric nitrogen deposition
- Climate forcing data: ERA-INTERIM and WATCH re-analysis data sets
- Evaluation data:
    - Discharge measurements from GRDC, EWA, and BHDC data bases
    - Nutrient concentrations from GEMS and EEA WISE data bases and national archives

Completed research projects in the region with relevance to Soils2Sea:

- The GEOLAND2 project, funded by the EU's FP7 framework, where runoff and net loads of nutrients to sea basins and source apportionments were evaluated (Arheimer et al., 2012a).

- Within the BONUS funded project ECOSUPPORT, nutrient reduction targets for the Baltic Sea according to the Baltic Sea Action Plan (BSAP) were evaluated using an earlier version of the Balt-HYPE model (Arheimer et al., 2012b).
- The E-HYPE model has been previously used to simulate dynamic riverine nutrient loads to pan-European sea basins in the EU FP7 funded JERICO project (Donelly et al., 2013).

3.5.3 Case study focus

Soils2Sea aims at providing differentiated regulation measures for the Baltic Sea region using the above-mentioned focus study areas. On the level of the entire Baltic Sea basin, the overall effect of the implementation of such measures will be evaluated. The Baltic Sea basin study is therefore not another case study within the scope of Soils2Sea, but will utilize and integrate the detailed findings from the previous studies to provide stakeholders with scenario impact projections for the entire region. A large-scale catchment model, Balt-HYPE, will be used for this purpose. The added value of this project part is a compilation of large scale impacts on nutrient cycling of differentiated measures under different scenarios. The main steps performed to reach these goals for the Baltic Sea basin within Soils2Sea are:

- To develop an up-scaling methodology for differentiated regulation measures identified at the local scale.
- To regionalise local findings from study catchments to areas throughout the Baltic Sea basin.
- To evaluate the capability of the Balt-HYPE model to capture relevant process dynamics responsible for nutrient release, retention, and removal.
- To apply scenarios developed in WP2 using the Balt-HYPE model and compile projected impacts for the Baltic Sea as a water body.

3.5.4 Stakeholder’s role in Soils2Sea

Stakeholders on the Baltic Sea Basin level include only those on the supra-national level, in this case, HELCOM (Baltic Marine Environment Protection Commission - Helsinki Commission) and other relevant bodies on the international level such as the International Council for the Exploration of the Sea (ICES), Council of the Baltic Sea States (CBSS) and finally the BONUS Secretariat (although they will always be presented with the findings produced in Soils2Sea).

Since these stakeholders act on the supranational level and in the political arena, not in the agricultural sector itself, they are not part of a “complete” stakeholder involvement circle. However, these stakeholders can – and perhaps also should – still include project findings into their policies and therefore will be addressed with a workshop particularly tailored to their information needs. This means that policy recommendations will be formulated which aim particularly at the transnational level and the room for manoeuvre that these authorities have. This workshop is planned for autumn 2016 and aims at presenting the policy options for the national level and how the inter- or supra-national level can support these efforts.

The World Café Method is very well suited to serve this end (see chapter 8.2.2 for a detailed description of the workshop format).

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3.6 Pregolya

This will not be a full case study, but can be understood as part of WP 6.4.

3.6.1 Description

All the main water systems of the Kaliningrad Oblast are transboundary. These are the coastal waters of the Baltic Sea, the Vistula Lagoon catchment and the Curonian Lagoon catchment.

The Vistula Lagoon is classified as a low salinity non-tidal estuarine lagoon (Chubarenko, Margonski, 2008) and is a transboundary (Andrulewicz et. al., 1994) water body itself (Figure 3-15). Its volume and area equal 2.3 km^3 and 838 km^2 respectively, 64% of the lagoon volume (1.47 km^3) and 56% (472.5 km^2) of the lagoon water area belong to Kaliningrad Oblast (the Russian Federation), and the rest belongs to Poland (Solovjev, 1971). Since the Baltiysk Strait, as a single inlet connecting the lagoon with the Baltic Sea, is situated on the Russian territory, the Kaliningrad Oblast is formally responsible for the quality of waters coming into the Baltic Sea from the lagoon (Chubarenko, 2008).

The biggest part (64% of the lagoon catchment) is formed by the transboundary basins of Lyna-Lava and Angrapa-Wangorapa rivers (both are 56% of the lagoon catchment) and a catchment of the main stream of Pregolya passing across the Kaliningrad Oblast (Figure 3-17). A small part of the lagoon basin (90 km^2 or 0.4%) belongs to the catchment of Vishtynets Lake in Lithuania.

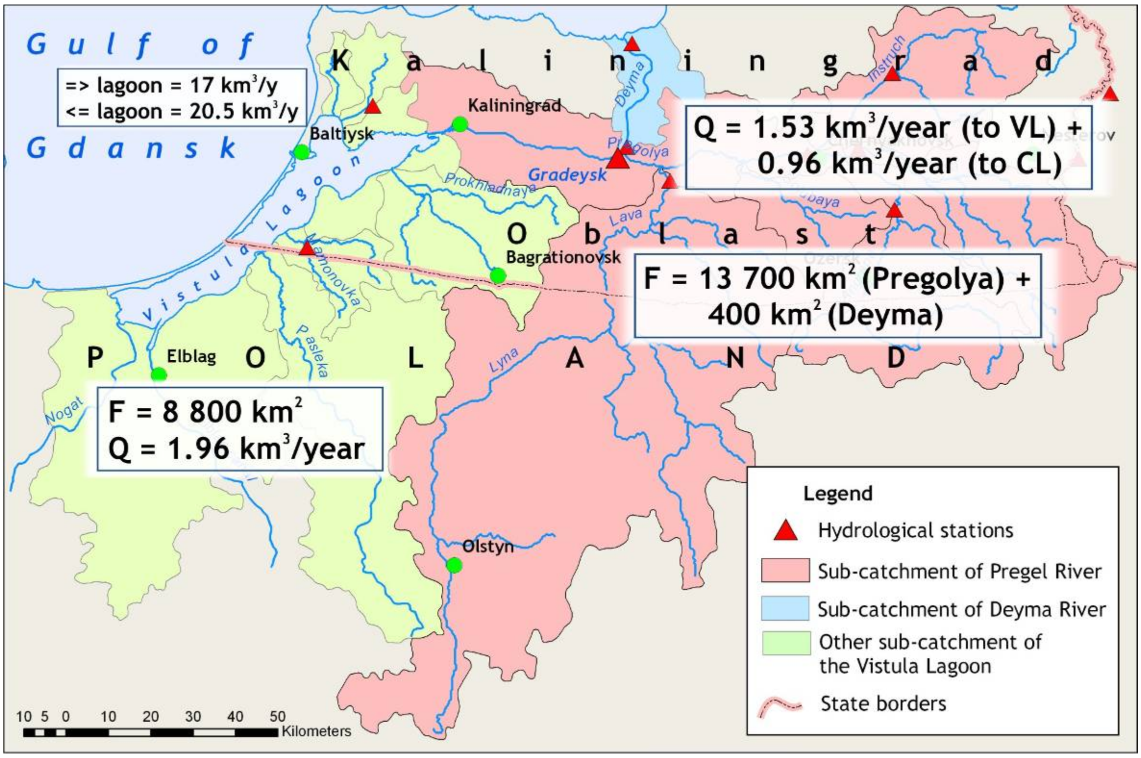

Figure 3-15 Catchment area of the Vistula Lagoon (Domnin, Chubarenko, 2011)

The catchments of Vistula and Curonian Lagoons are connected by the Deyma arm, which is often called as Deyma Branch (Chubarenko, 2008). Deyma (Figure 3-16), being an arm of the Pregolya River, outflows from main Pregolya stream at the City of Gvardeysk and connects Pregolya with the Curonian Lagoon. This means an overlapping of the catchments of the Vistula and Curonian lagoons. Approximately 34% of the Pregolya River runoff is turning towards the Curonian Lagoon through Deyma Branch (Silich, 1971). Thus, the catchment of the Pregolya River, that is above the City of Gvardeysk, including transboundary catchments of the rivers Lyna-Lava, Angrapa-Wangorapa and Pissa (13,700 km^2 in total), belongs to both the Vistula and Curonian lagoons' catchments. This overlapping of the catchments of the two Baltic lagoons isn`t usually taken into account (Markova&Nechai, 1960). The total Pregolya River catchment is usually attributed to the Vistula Lagoon catchment (Silich, 1971), and the only catchment of the Deyma Branch itself, and the total runoff from Deyma are referred to the Curonian Lagoon (Kucheriaviy, 2002). A little part of the river basin (about 60 km^2) is located in Lithuania (close to Vishtynets Lake).

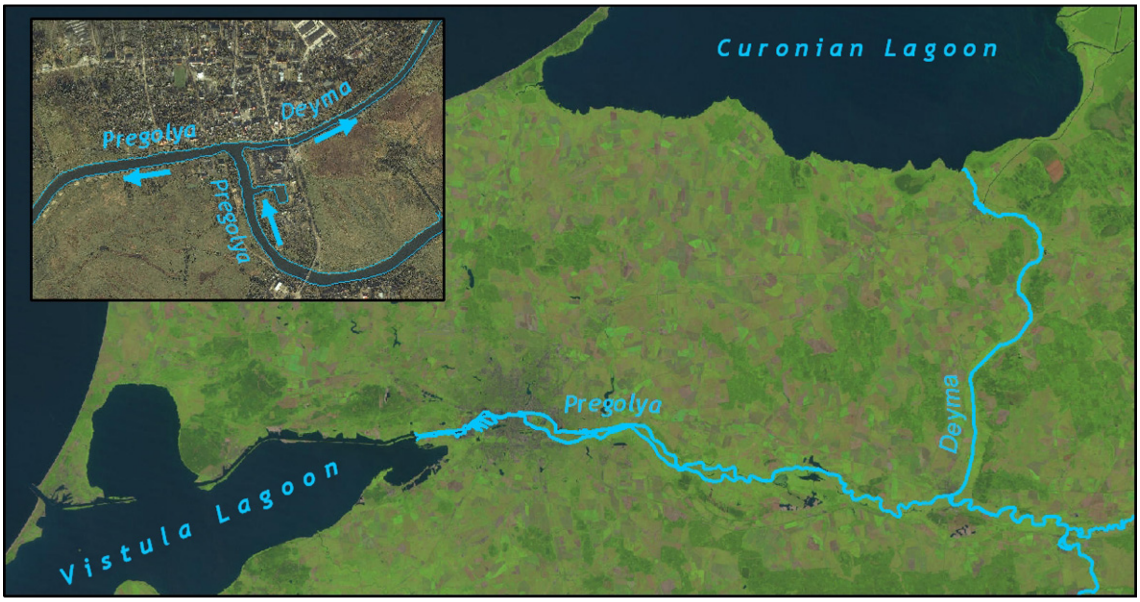

Figure 3-16 The lagoon-estuarine system of Vistula Lagoon - Pregolya River - Deyma Branch - Curonian Lagoon (Domnin et al., 2013)

Pregolya River is the main river that feeds the Vistula Lagoon. It is formed by the confluence of the Instruch and Angrapa rivers and runs on the territory of the Kaliningrad oblast. Pregolya River is a peneplain river. Its bed began to form after deglaciation of the Baltic, about 15,000 years ago (Geography of the Amber region of Russia, 2004).

According to estimations via GIS tool (Domnin, Chubarenko, 2008), the basin of Pregolya River itself amounts to 1,700 km^{2,} the Instruch River catchment is 1,350 km^2, the Angrapa River catchment is 2,200 km^2, the catchment of Pissa (with the basin of Vishtynets Lake) totals 1,500 km^2, the Golubaya River catchment amounts to 540 km^2, and the Lava River catchment is 7,200 km^2. The mean difference between the magnitudes of the differ catchment areas amounts to about 3% depending on literature source.

The length of the Pregolya River is 123 kilometers, and its length with Angrapa is 292 kilometers. The width of the riverbed is 40-80 m in the middle reachesand 200-300 m at the mouth (meteo39.ru).

The Pregolya River is located in transitional climate zone from moderate-continental to marine area. This region is characterized by a very mild winter, often without the formation of stable snow cover, warm and rainy autumn, moderately warm summer and high humidity throughout the year. The region is under the influence of cyclonic circulation six months of the year. About 175 fronts pass through the region annually causing overcast sky conditions, moderate and strong winds. The average annual temperature is around 8°C with 17°C in July and -3°C i January. The average number of rainy and snowy days is 185 and 55 snow, respectively. The prevailing wind direction is western with an average speed of 4 m/s (vsereki.ru). The annual average water discharge of the Pregolya river is 90 m^3/s, generally formed by rainy waters (40%), groundwater discharge (25%), and snow melt (35%). Floods on the Pregolya River occur in March and April, while low flows are observed in summer and autumn. Strong western winds can cause surges, leading to coastal flooding (Markova, 1999).

Marshes and lakes form parts of the Pregolya River floodplain (bogginess - 3%, lake's area - 1%). There are several former river-beds, the largest of them are Voronie and Pustoe (Silich, 1971).

The average slope of the downstream part of Pregolya River is 0.009 m/km causing this part of the river system to be an estuarine system. Water masses penetrate from the Vistula Lagoon upstream to riverbed of the Pregolya River and from the Curonian Lagoon upstream to Deima river almost unimpeded during wind surges. So all river flow near Gvardeysk is dumped into the Curonian Lagoon during western winds and into the Vistula Lagoon during northern winds.

The Pregolya catchment lies in landscapes formed byglaciers with the following dominating landscape areas (Geography of the Amber region of Russia, 2004):

- *Pregolya plain.* This area is located at the southern part of the Pregolya River valley. The landscape was formed by glacial waters. Moraine sediments cover flat monotonous surfaces, composed of clays. The soils of this area are waterlogged due to the flat relief and poor drainage conditions of the clay soils. The area is therefore covered by a network of drainage canals and subsurface drainage. A large part of the land use is forest, while agriculture as well as upland and lowland bogs cover considerable areas.
- *Valley of Pregolya River.* It is formed by the confluence of Angrapa and Instruch and crosses the central part of the Kaliningrad Oblast in the latitudinal direction from east to west. The natural shape of the river has been changed significantly by human activities. Shifting riverbeds have created a well-developed floodplain with alluvial sediments. A significant part of it is swampy and drained using polders. Woody vegetation is almost absent due to long-standing land development. Willow thickets and small islands of pine-bilberry are located on ancient alluvial sediments along the riverbed (Figure 3-18). The dominating soils are alluvial sod soils, occu-

pied by grass-forb meadows with an admixture of sedge marsh. Floodplain lands are used for hay, pasture, and partly arable.

Figure 3-17 The Pregolya River Valley.

- *Instruch hill.* This area occupies the right bank of the Instruch River and part of the Pregolya River with a ridge composed of moraine loams extending up to 40-70 m. There are small tracts of coniferous and deciduous forests in the southern part of the area with oak, spruce and birch as the main species. Ravines and gullies dissect the eastern slope of the moraine ridge. They are fixed by broad-leaved trees (linden, oak, hornbeam). The area is mainly used as farmland.
- *Angrapa-Sheshupe plain.* It is located in the eastern part of the Kaliningrad Oblast and occupies the territory between the Instruch and Sheshupe rivers. The average elevations are 20-25 m. The area is characterized by increasingly continental cli-

mate. Agricultural lands cover territory of spruce-broadleaf forests. The soil consist of well-cultivated soddy weakly podzolic and cryptopodzolic soils.

- *Vishtynets hill.* It is located to south-east of the Kaliningrad Oblast within the sediments of the South-Lithuanian stage and is a spur of the Baltic Ridge. This area is characterised by a hilly moraine hill with a distinct ridge-hilly relief. The height decreases from south-west to north-east from 200 to 50 meters. The largest absolute mark in the Kaliningrad Oblast is Mount Bezymyannaya - 230 m. The Vyshtynets Lake, the largest lake in the Kaliningrad Oblast, is located here.

More than half of the catchment area (54%) is occupied by agricultural areas, while both deciduous and mixed forests occupy 16% each, and coniferous forest 9%. 3% of the land is occupied by cities and 2%by open water bodies (Figure 3-18).

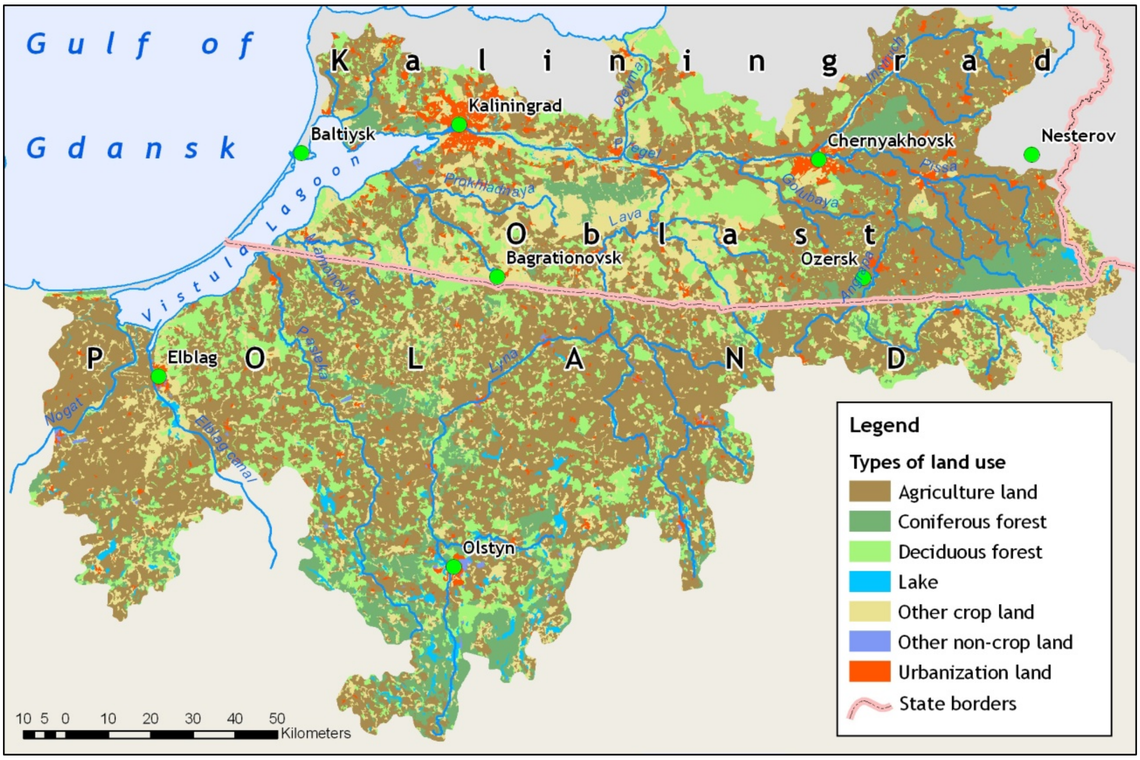

Figure 3-18. Scheme of land use of the catchment basin of the Vistula lagoon (Domnin, 2013)

3.6.2 Data availability and previous studies

The availability of data for the study area is good enough. However, there are problems with data comparability for different territories due to transboundary and different measurement techniques and data sources.

The following data types are available to use for research in basin of the Pregolya River:

- *Climate data*. The measured data of temperature and precipitation, required for modelling, cover the periods: 1989, 1992-1996, 1998-2013 for meteorological stations located inside of the catchment area (Kaliningrad, Baltiysk, Chernyahovsk, Olsztyn, Elbląg). In addition, there are data from climate model projections (1981-2098 years).

- *Hydrological information (water level and discharge)*. The main hydrological measuring point for the Pregolya River is located near the City of Gvardeysk. It is located 56 km upstream from the mouth of the Pregolya River just upstream the divergence point Pregolya-Deyme (Figure 3-15). There are data covering the period 1981-1996, 2001-2013.
- *Hydrological information (salinity and temperature)*. ABIORAS has monitored the Russian part of the Vistula Lagoon, Kaliningrad Marine Canal and the mouth of the Pregolya River since 1994. There are 12 monitoring stations at the mouth of the Pregolya River (nn 24-30), covering only the lowest part of the estuary within the Kaliningrad city. At 2012 the network of stations has been extended upstream covering both the lower branches: New Pregolya (northern branch) and Old Pregolya (southern branch) (Figure 3-19).

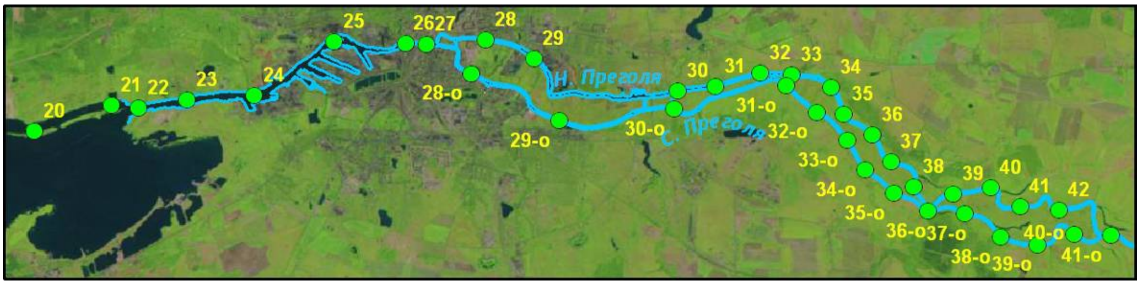

Figure 3-19 Location of monitoring points to determine salinity of water at the Pregolya River. The stations located in the Old Pregolya are marked by "o".

- *Soil texture*. Soil maps for the Kaliningrad Oblast of Russia (Lazareva, 2002) and Poland (Dobrzanski, 1974), calculation by GIS.
- *Land use*. Map of land use of the Kaliningrad Oblast (Scheme..., 2008), data of Corine Land Cover for Poland (Corine Land Cover), calculation by GIS.
- *Topography*. Data of Satellite Radar Topographical Monitoring SRTM (SRTM: CGIAR-CSI SRTM 90m DEM Digital Elevation Database, http://srtm.csi.cgiar.org/), including values of relief heights gridded with a spacing of 90 meters and a height resolution of 1 meter, calculation by GIS.
- *River network geometry*. Data of geographical maps (Dobrzanski et.al., 1974, E-HYPE) and satellite photos *LandSAT 7 ETM*, calculation by GIS (TauDEM, ArcHydro).

Data collected in previous studies can also be used:

- Specialized geographic information system for the analysis of river catchment basins and conduction on its basis of modeling of hydrological processes (grant of RFBR 10-05-90713-mob_st: Domnin, Chumachenko, 2010) was formed. It combined spatial information for river network, DEM, administrative and catchment borders, and time series for water discharge, precipitation, temperature. Also the mathematical modelling of the response of freshwater component of the water balance of the Vistula Lagoon were studied during grants RFBR 08-05-92421-BONUS_a (Chubarenko, Domnin, 2008-2011) and grant RFBR11-05-90727-mob_st (Domnin, Kondratyev, 2011,). Issues of inflow from the Vistula lagoon to estuarine part of the Pregolya River were studied during grant RFBR 12-05-31248_mol a (Domnin, 2012-2013).

- Nutrient loads were estimated by monitoring and modelling for the Instruch River (Project HarmoBalt, 2009, lead. Chubarenko B.V., responsible executor: Gorbunova Yu.A.), for the Primorskaya River (Project Moment-Pri, 2012, lead. Chubarenko B.V., executors: Gorbunova Yu.A., Domnin D.A.), for the Mamonovka River (Project BaltHazar, 2012, lead. Chubarenko B.V., responsible executor: Domnin D.A.).

3.6.3 Water management issues

Most river basins in the South-Eastern Baltic are transboundary (Chubarenko, 2008). The non-coincidence of natural and administrative boundaries makes water management in the region rather complicated. Furthermore, the transboundary catchments have different management experience and legal basis in the respective countries. Lithuania and Poland as members of European Union are obliged to follow the EU Water Framework Directive, while Kaliningrad Oblast as a part of the Russian Federation uses Russian Water Code as a principal law of water usage and protection. To achieve a sustainable management of water resources joint goals needs to be established and the same standards and procedures in water usage, water quality control, water monitoring and management should preferably be implemented within all shared catchments.

The territory of the Kaliningrad Oblast belongs to the Baltic Basin District, which covers part of the Russian part of the Neman river basin and other river basins of the Baltic Sea in the Kaliningrad Oblast (Baltic Basin District, 2008). This water management area borders with Lithuania to the north and east, with Poland to the south, and borders the Baltic Sea to the west. The Baltic Basin District is divided in three sub-districts (for the Neman River, Pregolya River and other rivers). The Pregolya River sub-district (7100 km^2) covers the Pregolya River catchment and of small rivers flowing into the Vistula Lagoon. Deyma Branch officially belongs to the third sub-district “Rivers of the Baltic Sea basin within the Kaliningrad Oblast without the Pregolya and the Neman rivers” (4300 km^2). Russian Water Code is the main legislation to regulate water use issues in the Russian Federation (Water Code, 2005).

The Agreement signed on 07.17.1964 (Warsaw, Poland) between the governments of the Union of Soviet Socialistic Republic and the Government of the Polish People's Republic on the water sector in boundary waters is a bilateral agreement for protection of water resources, regulating the activity of hydro-constructions, water supply, flood control and erosion of river basins of Neman, Pregolya and Vistula. This Agreement is still the single document which regulate bi-lateral relations between Russia and Poland, as non- and EU counties, as Water Framework Directive (WFD) is not applied to non-EU countries.

The main authorities that regulate water use in the Kaliningrad Oblast are:

- Government of Kaliningrad Oblast
- Neva-Ladoga Water Basin Administration Department (Kaliningrad office)
- Kaliningrad Center for Hydrometeorology and Monitoring of Environment

3.6.4 Case study focus

The objectives of the Soils2Sea project for the Pregolya River study are:

- To analyse impacts of changes in climate and land use on nutrient loads from the Pregolya River catchment.
- To assess the possibility for retention of nutrients by surface water in the Pregolya River catchment.

3.6.5 Planned field and modelling studies

- Tasks 2.1&2.4: Develop joint land use and climate change scenarios and scenarios for the Baltic Sea basin
    - Review of scenarios of land use for transboundary areas of the Pregolya river catchment and probable climate changes (2014-2015);
    - Analyses of retention scenarios of nitrogen and phosphorus from territory of Pregolya River catchment (2014-2015);
    - Analyses of scenarios of South-East Baltic region development (2014-2015).
- Tasks 6.3&6.4: Test of policy instruments and monitoring concepts for differentiated regulations
    - Screening-monitoring of nutrients concentration for the Pregolya River catchment (2014-2016).
- Task 5.2: Testing basin scale model setup for simulations in Pregolya catchment
    - Testing of a numerical model to nutrients retention in the Pregolya river catchment (2014-2016);
    - Testing of modelling results for nutrient load on historical data for a long time period (2016);
    - Analyses of results of nutrients retention by different mid-catchment areas of the Pregolya River catchment (2016)
    - Zoning area of Pregolya River Catchment by retention capacity of nutrients in the basin scale (2016).
- Task 6.5 Policy Brief
    - To recommend measures to reduce loads from the catchment basin (2016).

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4. Changes in land cover, agricultural practices and climate and their effects on nutrients loads to the Baltic Sea

4.1 Objectives

The aim is to analyse how combinations of changes in land cover, land management and climate may affect the source loading of nitrogen and phosphorus from the land to the groundwater, drains and surface waters for catchments around the Baltic Sea. The following specific objectives are pursued:

- To analyse how changes in land cover, agricultural practices and climate may affect the nutrient (nitrogen and phosphorus) losses from land areas
- To test how robust nutrient load reduction measures are towards plausible climate change and land use scenarios
- To develop coherent climate and land use/management scenarios for individual catchments and the entire Baltic basin
- To estimate field scale N flows and N leaching losses under baseline and scenario conditions for individual catchments and the entire Baltic basin
- To estimate risk of P losses under baseline and scenario conditions individual catchments and the entire Baltic basin

4.2 Methodology

4.2.1 Land use and climate change scenarios

Initially, a review of published scenario studies of nutrient load and leakage studies will be conducted. This review provides the basis and benchmark for designing scenarios in Soils2Sea. The review will provide an overview of

- Current methods for scenario design
- Measures (policy and specific measures) considered for nutrient load and leakage reduction
- Efficiency and cost-effectiveness of measures according to catchment type and study methodology
- The spatial allocation of measures
- Methodology for and effect of including climate change

An initial range of scenarios will be designed to include combinations of the following factors:

- Climate change (current, low/high for 2050 using regionally downscaled CMIP5 (Taylor et al., 2012) projections from a coupled ocean atmosphere model shown to give more realistic conditions for the Baltic Sea region (Meier et al., 2012)

- Land cover and land use change considering proportion of agriculture, type of agriculture (annual and perennial crops), nutrient input intensity in accordance with CMIP5 storylines, including changes in N deposition (Dalgaard et al., 2012).
- Measures to reduce nutrient losses and enhance retention in the landscape (Dalgaard et al., 2011).
- Spatially differentiated application of all measures considered. All scenarios will be compared to a reference that represents the current situation.

Climate change scenarios for the Baltic Sea Basin will be prepared as gridded daily data sets at 25 km spatial resolution for the 2040s period (30 year transient from 2025 to 2055). For the preparation of climate change forcing data at this scale, a downscaling chain will be employed: GCM projections will be dynamically downscaled using an RCM model over the Baltic Sea Basin domain, and further bias-corrected using meteorological re-analysis data, which is used as forcing data for calibration of the pan-Baltic hydrological model under current climate conditions. Representative Concentration Pathway RCP 8.5 (Vuuren et al., 2011) was chosen as greenhouse gas concentration scenario for the evaluation of future climate conditions. Given the relatively short-term future time slice which is going to be included in the project, uncertainty is mainly related to GCM model uncertainty, and the choice of RPC scenario plays only a secondary role in the overall projection uncertainty (Hawkins and Sutton, 2009). Projection uncertainty will be evaluated by incorporating two GCM model results, from the Hadley Centre HadCM3 and the Max-Planck-Institute ECHAM6 models; both dynamically downscaled using the Rossby Centre RCA3 regional model. The regional model time series will then be bias-corrected using the DBS (Distribution Based Scaling) method (Wei et al., 2010) or a similar suitable bias correction method. Daily precipitation, daily mean air temperatures, global radiation and reference evapotranspriation will be delivered as forcing data for hydrological impact analyses on a 50km grid scale.

All land use scenarios will be designed to comply with objectives of the EU Water Framework Directive. As a basis for this the targets for N loads will be defined for the different time slices based on assumptions on critical load depending on future climate conditions, which will be defined based on literature search and discussions with aquatic and marine ecologists. The basic scenario farming condition will thus define critical loads for each catchment and the entire Baltic Basin and time slice in the climate change projection.

The scenarios will further consider the global drivers for enhanced food and biomass production as well as the visions by EU and the Nordic Council of Ministers for a bio-based economy. A first outline of the scenarios will be presented to the project group to ensure that they comply with modelling methodologies and approaches, i.e. that they can be implemented in the model complex applied in Soils2Sea. Since the biophysical and socioeconomic characteristics differ considerably between the different case study areas (catchments), land use scenarios will likely differ considerably in between catchments. However, they will be designed to follow the storylines and environmental objectives relevant for both the entire Baltic basin and the respective catchments. The resulting scenarios will thus be expectations on major land use categories (e.g. agriculture, grasslands, forestry, nature, urban etc.) and the intensity of the management of the agricultural land (i.e. yield levels) for the different catchments as well as the entire Baltic Basin and for time slices related to the climate change scenarios.

The scenarios will be further detailed during year two of the project through stakeholder interaction, both in the selected catchments and across the Baltic area (in collaboration with WP6). The outcome will be detailed scenario storylines for the entire Baltic Sea area, as well as detailed and spatially explicit scenarios for the study catchments in Soils2Sea.

4.2.2 Spatially differentiated N measures in catchments

The current land cover, land use and management of the selected catchments will be collected at as fine spatial scale as possible and stored in a database. This data collection will be based on local georeferenced data on land use (agriculture, forestry, nature etc.), soil types (texture and soil organic matter), farm types (arable, pig, dairy, cattle, sheep etc.) with additional information on farming intensity (livestock numbers, fertilisation) and on farm management (manure management, fertilisation strategies, tillage etc.). These data will be obtained through cooperation with case study managers, and where data are not sufficiently available they will be supplemented with data from available databases, often at larger scales (Wulff et al., 2014). The land use will be obtained from the CORINE dataset, where newer and more detailed data is not available.

The spatial distribution of N surplus will be estimated under the reference and future scenarios using a combination of methodologies, including a farm scale model (FarmAC, that estimates farm N flows and losses) to derive fertiliser and manure amounts for field application. The dynamic Daisy model will be used to estimate typical seasonal cycles in N leaching (Abrahamsen and Hansen, 2000). The estimates of N leaching will be based on the empirical N-LES model developed in Denmark (Kristensen et al., 2008). However, this model will be evaluated for the other regions involved in Soils2Sea and modified to include effects of variation in climate thus accounting for estimated effects of climate change (Doltra et al., 2014). These models will simulate N leaching losses under different scenarios. These results will be fed into HydroGeoSphere, MIKE SHE as well as HYPE to estimate nutrient loading to groundwater and streams. The Daisy model will also be used in combination with considerations of farm type to estimate effects on agricultural production of the different scenarios, thus quantifying the eco-efficiency of different measures. Focus in the scenario studies will be on spatial location of nitrate reduction measures.

Focus in the scenario studies will be on spatial location of N leaching reduction measures. These measures will include measures related to land use (agriculture, forestry, nature, urban), N inputs (manure and fertiliser amount, manure types, spatial differentiation in N fertilisations), crop types (arable crops versus permanent crops, including spatial location), crop rotations (crop sequence, cover crops), crop management (timing of sowing, fertilisation etc.), and drainage management (filter technologies, re-established wetlands). The scenarios will be defined to correspond to different governance schemes as defined in WP6. This may thus include different emphasis on land use and management as well as drainage management, including relocation of activities within the landscape.

4.2.3 Spatially differentiated P loss measures in catchments

A P loss index for surface and subsurface transport processes will be established for the Norsminde catchment by adapting and updating the current DK P Index (Heckrath et al., 2008). It ranks fields according to the risk of P loss. The necessary data on soil P status and land management will be collected in cooperation with the farmers' association or are obtained from public farm industry and geo-databases. Data from an existing network of drainage and stream monitoring stations, the P monitoring of Task 3.1 and new erosion and surface runoff surveys will be used to systematically evaluate the P index. Both the P index input and the evaluation data will be gathered in a database that is shared for regional-scale modelling.

The following data will be collated and integrated in the existing P index database for Denmark. Specific farm data are obtained in collaboration with the local farm advisors group.
- Field map
- Actual drainage map
- Updated erosion risk map with new parameter settings compared to original P index
- Actual soil P status (Olsen P) at the field scale based on farmers information
- Phosphorus input based on general administrative records

The higher degree of spatial resolution in the input data and the accommodation of land use and climate scenarios require some modifications to the P index model. For different scenarios updated P indices for Norsminde will therefore be produced and critical source areas for P mapped. This information is made available to other workpackages (e.g. WP5) and P index scenarios will be updated as new data become available.

To evaluate the new P index for Norsminde, high resolution images of fields vulnerable to erosion will obtained with the help of UAVs during several surveys in the Norsminde catchment during runoff seasons 2014-2017. Additionally, manual GPS surveys are conducted on the same occasions. Erosion and deposition patterns will be mapped based on the imagery and compared with the erosion model output. This will serve as qualitative evaluation of the P index for erosion. Detailed data on P in drainage waters are collected from 7 strategically placed automated drainage stations in WP3.1 during 2014-2017. Monitoring data will be compared with the rankings of the P index for subsurface transport to drains. The findings from monitoring of erosion patterns and P loss in drainage waters will be evaluated regarding the usefulness of P indexing.

For the assessment of P loss risk in the other catchments, data on land cover, land use and management will be taken from task 2.2.2. This will be combined with information on soil P status in the different catchments from existing local or regional sources. The spatial distribution of P sources will be estimated under the reference and future scenarios using a risk index of P losses. The results will be fed into the surface water models used for Dalälven and Kocinka, including the S-HYPE and the Balt-HYPE for catchment scale scenario analyses.

Focus in the scenario studies will be on spatial location of P reduction measures. These P reduction measures may include targeted fertiliser and manure application, restriction on tillage, buffer zones along streams and lakes and conversion from arable land to permanent crops. Further filter technologies for reducing P outputs through drainpipes may be considered.

4.2.4 Baltic Sea Basin

The impact of combined climate and land use change, and differentiated nutrient regulation scenarios in the Baltic Sea Basin will be modelled using a HYPE model set-up, Balt-HYPE. HYPE is a process-oriented conceptual rainfall-runoff and nutrient transfer model that spatially discretises the model domain into sub-basins with varying size. Balt-HYPE will have a median sub-basin size of around 200 km^2. The sub-basin discretisation requires a translation of grid-based climate data to evaluate climate change impacts on the hydrological cycle and nutrient loads.

Each sub-basin in Balt-HYPE consists of one or several, non-discretised soil-and-land use classes, representing a fraction of the total sub-basin surface. Land-use scenarios will be used to adapt the model configuration accordingly for each scenario.

4.3 Outputs

WORKPACKAGE 2.1

Output expected for other tasks: Overview of existing scenario studies of relevance to spatially explicit management of nutrients to reduce loadings of N and P to the Baltic Sea Basin. Description of elements in the scenarios to be applied in Soils2Sea with specific reference to climate change and to land use and management and how this links to projected needs for the goods and services provided by the land use for current and future conditions. This will feed into tasks 2.2 and 2.3 and to the stakeholder interactions in WP6.

Deliverables and milestones: D2.1 Review report on existing scenario studies of nutrient reductions (M6). D2.2 Report on Soils2Sea scenarios for nutrient reductions (M18).

M2.1 Methodology for scenario work designed and documented (M9).

Journal articles/dissemination: Journal paper on review of scenario analyses, and a possible journal paper on spatial explicit scenarios under different management schemes.

WORKPACKAGE 2.2

Output expected for other tasks: Modelling of N flows and losses (in particular N leaching) at fine spatial scale for the different catchments for baseline and scenario conditions (current and future climate) will feed into the analyses in task 3.3, 3.4 and 5.1. Scenarios will be defined for different governance regimes in collaboration with WP6 and thus also be used in WP6.

Deliverables and milestones: D2.3 Report on scenario analyses spatially differentiated N measures in catchments (M42).

M2.2 Data on current land use in selected catchments and BSR ready for use (M12).

M2.3 Scenario workshops with stakeholders completed (M16).

M2.4 Preliminary scenario results for stakeholder feedback (M30).

In addition the N balance and leaching models will be tested for the different catchments (M24).
Dissemination: Journal papers on N-balances and N leaching under current and future land use and management scenarios for the different catchments.

WORKPACKAGE 2.3
Output expected for other tasks: A P risk index that can use used to evaluate effects on P losses and which will be tested against P losses measured in Norsminde. This will be tested against the BaltHype model in WP5 along with relevant data on land use and management and soil P status.
Deliverables and milestones: D2.4. Report on scenario analyses for spatially differentiated P measures in catchments (M42).
The following plan will be adopted: 1) Data for P index collected (M12), 2) P index model updated (M14), 3) Data for P loss through erosion and drainage collected (M38)
Dissemination: Journal article

WORKPACKAGE 2.4
Output expected for other tasks: Simulated results at Baltic Sea Basin scale on loadings of N and P to the aquatic ecosystems using the Balt-HYPE model.
Deliverables and milestones: Contributions to deliverable reports D2.3 and D2.4.
Dissemination: Contributions to journal article on scenarios for the Baltic Basin in collaboration with WP5.

4.4 Timing and dependencies with other project activities

The activities in WP2 form the basis for work in WP3, WP5 and WP6. The design of the scenarios will be aligned with the stakeholder interactions in WP6.
The collection of basic information on land use and management will be aligned with activities at catchment scale in WP3 and basin scale in WP5.
The collection of data on P flows will be aligned with the data collection in task 3.1.

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5. Nutrient transport and retention in groundwater

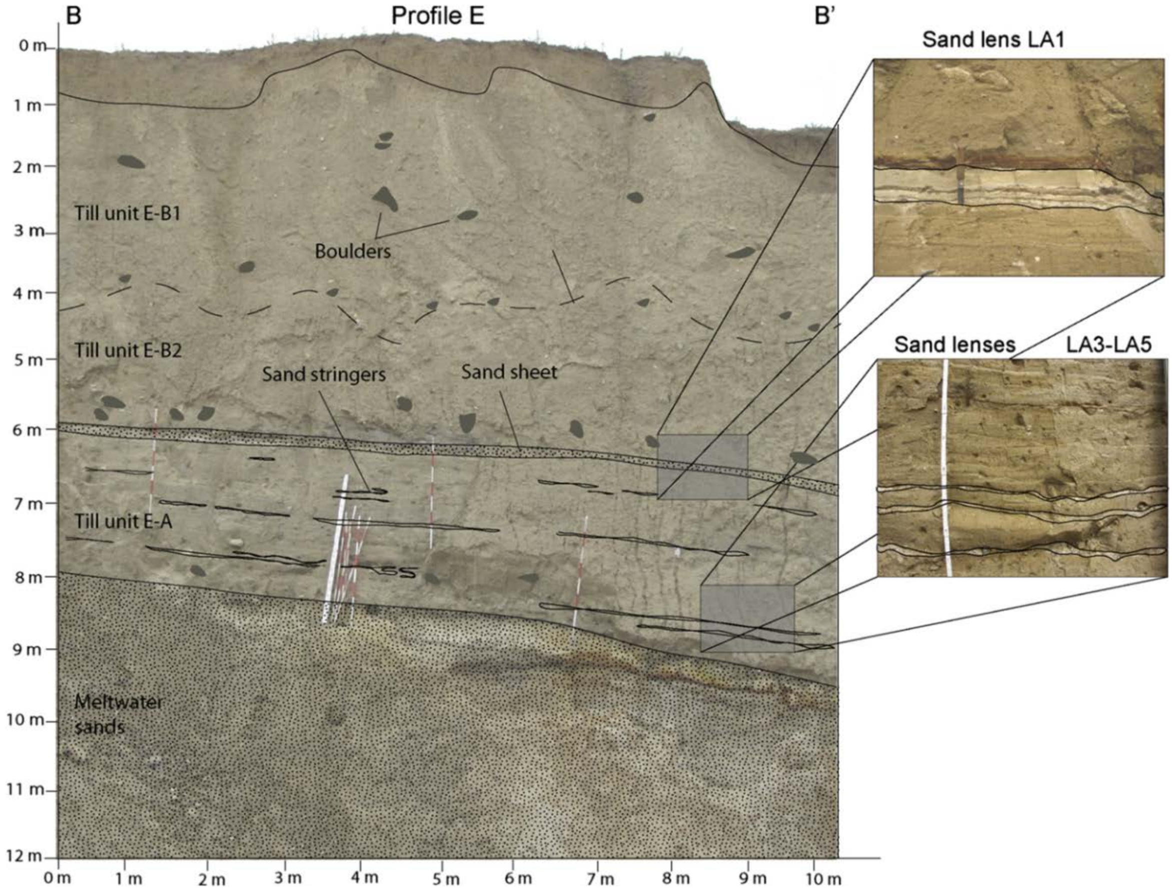
5.1 Objectives

In the context of devising approaches to spatially differentiated regulations of nutrient application in agriculture, WP 3 focuses on 1) quantification of the amount of nutrients leaching from soils, reaching streams and rivers, which ultimately discharge to the sea, 2) description of the pathways and time lags for the transport of nutrients from the soil to the stream, 3) description and quantification of the effect of transport and attenuation processes (sorption, biotic and abiotic degradation, jointly termed removal) in the groundwater zone, and 4) upscaling of detailed results and understanding for improved modelling of regional catchments and ultimately the complete Baltic Sea basin.

In this context the groundwater zone includes the unsaturated zone below the root zone and includes drain pipes typically found in fine grained agricultural soils. The objective is to obtain a detailed understanding of the hydraulic and biogeochemical processes in the groundwater zone, controlling nutrient transport, and attenuation (European Commission, 2009, Hinsby et al., 2008, 2012, Dahl and Hinsby, 2013), from soils to streams, and hence the fluxes of nutrients to streams and rivers. This knowledge is then utilized together with knowledge about transport and retention in streams and lakes obtained in WP4 and 5 to estimate the total nutrient loadings to transitional and coastal waters (Hinsby et al., 2012), and ultimately for the development of cost-efficient monitoring and governance tools in WP6 based on measurements of nutrient outputs, the concept of groundwater threshold values (Dahl et al., 2010, Hinsby and Dahl, 2010) and spatially differentiated regulation. The obtained insight will have a form so that it can be used to find improved ways of identifying fields and sub-catchments associated with low, respectively high, removal in the subsurface of nutrients leaving the root zone. The ultimate aim is the protection of coastal aquatic ecosystems of the Baltic Sea.

5.2 Methodology

The types of systems we are inclined to study are intrinsically complex. Two case study sites have been selected and are described in more detail in Chapter 3. One site, the Kocinka site, is in Poland and is a catchment of 258 km^2 characterized by a top cover dominated by glacial till and glacio-fluvial sands and gravels underlain by karstic-fractured Jurassic limestones. The Danish site comprises the Horsens Fjord Catchment and the Norsminde catchment that will be used for modelling and within the Norsminde catchment the sub-catchment of the Fensholt Stream that will be the focus of the detailed studies on transport pathways and biogeochemical processes. The Danish site is situated in an area characterized by a glacial till cover. The till consists of a clayey matrix with a low hydraulic conductivity hosting fractures and embedded sand bodies. Due to the difference in geology and scale of these two sites the methods to be used will differ, but there are also similarities in terms of a complex Quaternary sediment cover that should allow some transfer of insights during the project. The sediments of the Danish site are characterized by a rather shallow anoxic zone with a high denitrification potential, while this is not the case for the Polish site.



Figur 5-1 Till sediment with fractures and embedded sand lenses (Kessler et al., 2012)

5.2.1 Small scale field site Fensholt, Norsminde

The Norsminde site studies will be focused on the catchment to Fensholt stream in the upper part of the catchment to Norsminde fjord (Figure 3-2). In the till deposits characterizing the Norsminde site, the water transport is primarily through vertical and horizontal fractures as well as embedded sand bodies of different sizes and geometries because the hydraulic conductivity of these features are 4-6 orders of magnitude higher than found in the clay matrix. The precise geometry and connectivity of these sand bodies for the Fensholt area is not known, though we have very detailed airborne geophysical data indicating the relative sand content on a 25 meter scale. An impression of what the geometry could be like is shown in Figure 5-1 from a study by Kessler et al. (2012) in a similar Danish till. As Fig. 5.1 shows most of the features are small lenses and stringers, but there are also larger features, so called 5-30 cm thick sand sheets which may extend up to 15 m and 1-5 m thick sand layers (not included in Figure 5-1) which may reach lengths of 50 m. Though small scale features may affect results from individual observation points, especially with regards to biogeochemical effects, then as the scale is increased, to the 200-1000 m characteristic of a drainage catchment, the importance of the individual heterogeneities for the overall processes in the system is diminished.

Many of the fields at the site have been fitted with drain pipes (see sect. 5.2.2.1) to facilitate agriculture. This shows that the interconnectivity of the higher conductivity sand features, is not adequate for providing sufficient natural drainage, which is also seen in a generally low bulk hydraulic conductivity derived from modelling. The hydraulic characteristics and the presence of the drain pipes, result in that the majority of the water and nutrients infiltrating below the root zone end up in drain pipes before reaching the Fensholt Stream. Some water will enter the drains immediately after leaving the root zone while some water travels down through the groundwater zone before being caught by drains closer to the streams. Observations at the field site indicate that many drains lead to the meadows surrounding the stream, but drains leading directly into the stream have also been observed in the iDRAIN project (see section 5.2.2.1).

5.2.2 Measurements and analysis at Norsminde field site

To reach the objectives it will be necessary to address the close coupling of the biogeochemical processes that affect the reactive N and the P in the system, and the flow system that controls pathways and residence times, which again affect especially the extent of N transformations but also the P retention as this is related to the geochemical conditions encountered along the flowpaths. In addition to this level of complexity, the flow paths in the unsaturated zone are not constant but depend on the interacting effects of soil matrix potential, the soil pore-size distribution and infiltration rate (Kjaergaard et al., 2004; Glæsner et al., 2011). The planned measurement and monitoring strategies described in the following aim at addressing the process couplings as well as the complexity in flow i.e. to quantify the importance of both biogeochemical and physical processes.

5.2.2.1 Drainage catchment monitoring

The Fensholt sub-catchment comprises 612 ha of which 460 ha is used for agriculture (Figure 5-2). The soil type is mainly low permeability clay equipped with a dense and cross-linked drainage network. Eight well defined drainage catchment areas ranging from 4 to 34 ha have been mapped based on topography and the extent of the drainage networks obtained from maps or landowner interviews. A monitoring infrastructure measuring drainage discharge from each of the eight drainage catchments is already established from the iDRAIN project (Kjaergaard and Iversen, unpublished results).

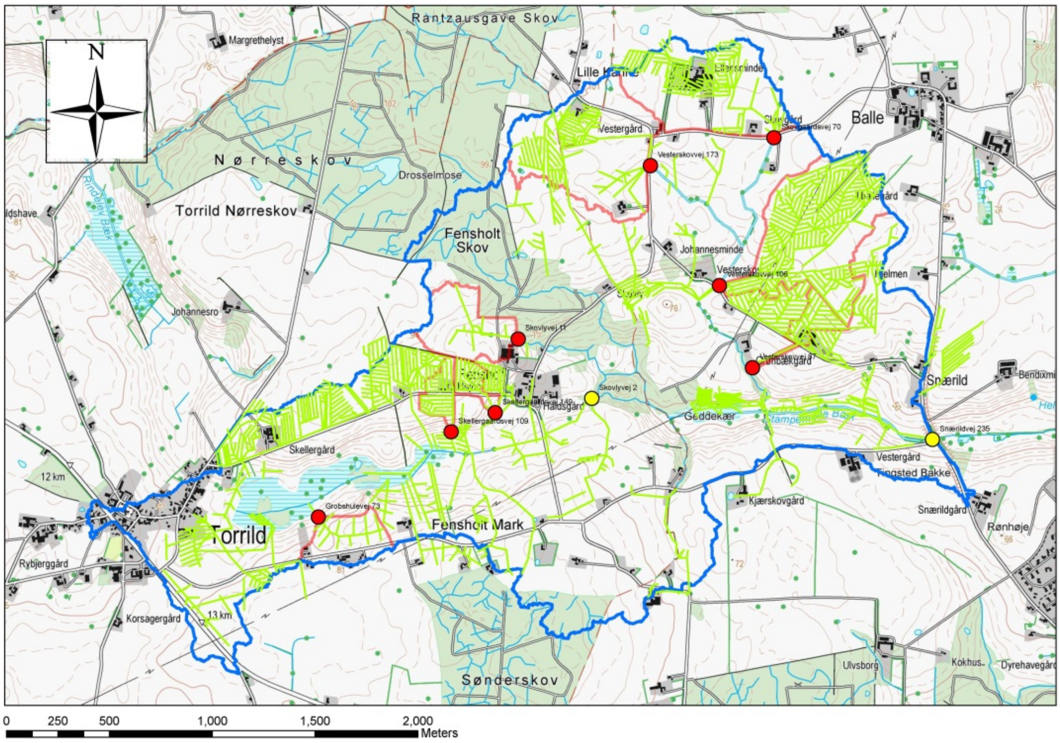


Figure 5-2 Fensholt sub-catchment within the Norsminde catchment with the iDRAIN monitoring infrastructure. Figure shows drainage network (green), drainage catchment areas (red perimeters), drainage water stations (red dots) and stream stations (discharge and chemistry) (yellow dots) (Kjaergaard and Iversen, unpublished, 2012).

At the outlet of each drainage catchment a drainage discharge station equipped with an electromagnetic flow meter is measuring the discharge from the drain pipe network. Discharge has been measured on an hourly basis since 2012. In addition hourly precipitation has been recorded from two climate stations installed within the catchment. The drainage discharge to precipitation ratio (Q/P) during winter runoff (October to March) from the eight drainage catchments ranges from 43 to ~100%. In addition, the iDRAIN monitoring infrastructure also includes two stream gauging stations equipped with ISCO3700 automated water samplers. One located at the catchment outlet and another one further upstream (Figure 5-2). Stream discharge and daily nutrient transport (total nitrogen (TN) and total P (TP), turbidity, pH, EC) have been recorded since autumn 2012.

To investigate fluxes of N and P in pipe drains from the drainage catchment, a number of drainage discharge stations will be equipped with automatic water samplers (ISCO3700). Nutrients in the drainage water may include both soluble and colloidal components (Schelde et al, 2006). The reactive N leaving agricultural fields through drains is mainly nitrate-N with minor amounts of organic-N. The major P forms (dissolved reactive P and particulate P forms) may be closely coupled to precipitation events, with colloidal bound P often dominating during peak flow events. Water subsamples will be taken with hourly resolution and pooled to daily samples. Sample analysis will be conducted based on the hydrograph, separating base flow samples from peak flow samples at daily resolution. Basic sample analysis includes total N (TN), total P (TP), turbidity, pH, temperature, and electric conductivity.

More detailed sample analysis additionally include NO_3^-, NH_4^+, total dissolved P (TDP), dissolved reactive P (DRP), total Fe, sulphate and tracers (e.g. for estimation of residence times). Results from the drainage catchment monitoring will be included in the hill slope investigation to support interpretation of nutrient transport, dilution and attenuation along the drainage catchment hill slope (WP3, task 3.2), the hill slope modelling (WP3, task 3.3), scenario analysis for P losses in the Fensholt sub-catchment (WP2, task 2.3) as well as the development of improved governance and monitoring tools in WP6.

New innovative passive sampling methods for monthly / seasonal monitoring of nutrient fluxes and flow weighted nutrient concentrations will be tested in selected drain pipes and possibly in streams in the Norsminde catchment focusing on drains located in the sub-catchments to the Fensholt stream. Such data are envisaged to be a management and governance tool (Chapter 8).

5.2.2.2 Unsaturated and saturated zone hill-slope monitoring

The intention is to carry out the detailed process studies of the unsaturated and saturated zone on a hill slope scale. The actual hill slope, or in this case more precisely the drainage sub-catchment, needs to be selected. As described above there are a number of drainage sub-catchments that are mapped out and preferable we should select the one that has the higher probability of enabling the collection of a representative set of data. This implies that the drainage catchment should have a typical size and geology, and a considerable part of the infiltrating water should go past the drains in to the underlying groundwater in order to enable the inclusion of the transport and nutrient removal processes occurring there in both observations and modelling. The final choice of monitoring methods will depend on the drainage catchment chosen, in terms of the type of drainage system, the scale and the detailed geology of this. This implies that once the drainage catchment is chosen an assessment of the geology, especially with regards to embedded sand bodies needs to be made. Depending on the number and the extent of larger features such as sand sheets and especially sand layers, the sand bodies may have a major control on the flow in the system. In addition, the larger sand features may potentially be exploited as natural integrators of processes taking place in the sediments above the sand body. The mapping will be a combination of ground based geophysical measurements combined with drilling, well logging and coring.

The aim of the monitoring is to lead to insights in how the combination of the biogeochemical processes and physical processes controlling the flow paths determine the time resolved flux of nutrients to the stream. The nutrients are primarily transported in a dissolved state to the stream; however, in particular for P there may be a flux associated with waterborne colloids especially at extreme events. In any case, the nutrient flux is associated with the flowing water. This could indicate that only the flowing water needed to be monitored. Though tempting, the flowing water is only part of the picture because only a small part of the processes affecting the nutrient content of the water actually take place in the flowing water *per se*. The processes that affect the nutrients to a large extent take place in the clayey matrix, where the major part of the reduction capacity towards NO_3^--N and the adsorption capacity for P and NH_4-N is located. These capacities are embedded in the sediment in the form of electron donors such as organic matter and pyrite and adsorbing surfaces of such as Fe-oxides, Al-hydroxides and clay minerals. In addition, a more dynamic pool of reduction and adsorption capacity may be present in the fractures and sand bodies where it may be deposited or removed by the flowing water depending on season and wet/dry periods. In summary, this implies that both water samples and sediment samples need to be taken and the just mentioned sediment parameters important for the biogeochemical processes and the dissolved components discussed below need to be determined.

The transport of nutrients into the clayey matrix will, due to the low hydraulic conductivity, primarily take place by diffusion, which is a slow process beyond distances of cm scale. This implies that the extent of reaction with the intrinsic reduction and adsorption capacity of the sediment residing inside the clay matrix will be determined by the time available for the nutrient to interact with the clayey matrix, which again will depend on the water flow velocity. Over time the reduction capacity near the fractures will decrease as a function of the amount of reaction accumulated over time, which again will depend on the distribution of the water flux between the fractures in the system.

Reactive N in the form of nitrate can be transformed to N_2 through the reduction of nitrate by either organic matter or pyrite, leading to the additional reaction products inorganic C or dissolved sulphate, enabling the tracing of the nitrate reduction by monitoring these (Postma et al., 1991). Compared to the Postma et al. (1991) study the situation is complicated by the presence of calcite in the sediment in the Fensholt till sediment, which implies that the inorganic C can be affected by dissolution or precipitation of calcite. Ways of circumventing this through observation of additional parameters, other ions or possibly isotopes, need to be found. Reactive N in the form of ammonium (NH_4^+) can be transformed by oxidation by oxygen to nitrate or in the absence of oxygen to N_2 by reaction with nitrite. Due to the atmospheric N_2, it is not possible to trace the transformation of reactive N to N_2 in the unsaturated zone in contact with the atmosphere, but this can be done in the saturated zone by measuring the dissolved N_2/Ar ratio (Andersen et al., 2007). Though precise quantification of the amount of nitrate reduced is difficult, the N_2/Ar can clearly indicated water affected by nitrate reduction.

Due to the above described complexity, plus the likely spatially and temporally variable input from the root zone, the flux of reactive N out of the root zone towards the stream through the drainage system and by groundwater flow in the saturated zone is assumed to have a very large variability on a small scale. Describing this variability in great detail will probably not lead to insights on how e.g. general soil moisture status and time resolved infiltration rates and the derived flow paths, affect the flux of nutrients to the stream. Therefore the sampling strategy must aim at obtaining results that represent larger volumes, but still are detailed enough to show what processes are occurring and hopefully also the dynamics of these if there are any.

Given that the heterogeneity with the combination of sand lenses and fractures is 3D in nature, this needs to be addressed by the sampling scheme. Samples could be taken in a 3D grid, but it would imply a very large number of installed samplers and samples, this makes it more realistic to assume that the effect of the heterogeneities can be averaged based on observations in a 2D sampling system. In any case the approach implies placing of a large number of sampling screens in the saturated zone at several depths above and below what appears to be the transition from the oxic to the anoxic zone of the groundwater. This will enable us to monitor the effects of the physical and biogeochemical processes as the water moves downward through the system. The area or length covered by this installation should be large enough to even out effects of small heterogeneities and the density of the samplers should be high enough for deriving meaningful averages. Exactly what enough samplers implies is very difficult to know beforehand. A first estimate must be based on the observations from the investigations of the geology. If the first measurements indicate a need for supplementing with further observation points the applied installation scheme should allow for this. By combining the chemical observations with modelled water fluxes the nutrient fluxes can be estimated.

Through near-surface geophysical measurements, combined with data obtained during the installation of samplers it may be possible to identify a sand sheet or layer naturally embedded in the till within a couple of meters below the water table. Given the large contrast in hydraulic conductivity between the clayey matrix and such a sand body, this sand body would collect the nutrient flux of an, ideally, representative area and associated volume of the system, thereby integrating the effects of the overlying heterogeneities. Given this is possible, it would then make sense to also have a few local measurements within this representative area and volume in the unsaturated and saturated zone above the sand body, to address the variability at least in a qualitative way. To assess the flux and its variation from the representative area and volume, the related embedded sand body should be sampled by a cross section of samplers, and the flux distribution of water represented by each sampler should be known. Obtaining the precise flux distribution is probably not feasible, and it may be necessary to assume that given enough samplers a representative flux is obtained. If a good sand layer could be located, it would also be a possibility to install time integrating Sorbisense samplers in small diameter wells in the sand layer.

In any case groundwater samplers could be installed using horizontal wells. This would limit the interference with the agricultural activities on the surface.

An alternative to naturally embedded sand lenses could be the construction of, a funnel and gate system made by sheet piling with a connected water flux measurement and sample collection system. A funnel and gate system would in itself collect water from a given volume and not require the presence of a “correctly placed” embedded sand body or averaging of point observations. It could be established as a collection system around an upstream section of a drainage pipe to a depth deep enough to intersect the groundwater flow from the catchment corresponding to the chosen subsection of the drainage pipe, collecting the water from an area half way out to the adjacent drainage pipes. The drainage pipe should preferably be oriented in the direction of the groundwater flow. This system would presumably make it possible to establish precise fluxes out of the system and relate these to infiltration rates, fertilization patterns etc. There are however a number of foreseeable problems; it would be difficult to establish the system without disturbing normal farming practice, and it would be a challenge to devise the system so that the natural flow of the system was maintained and - the vertical depth of the sheet piling needed to ensure capturing all of the upstream groundwater flow could be quite deep. In addition, the costs would be high, so currently this is not considered a viable option.

Another technique that could be applied both in a natural or a constructed setting is tracer tests addressing transport times, pathways, retention, attenuation (depending on the chosen tracers) as well as the water balance in the system. Coupled with the flux sampling of the nutrients at the drainage station it might be possible to derive time resolved relative fluxes of nutrients between the groundwater and drainage water. Tracer test could be done on a local or even field scale, but the potential for obtaining useful results should be evaluated by modelling beforehand. If modelling indications are positive the tracer tests are one option of getting more information on the flow and processes in the system and an option for a calibration on the transport model.

While speculating further on the various options, the first step will be to establish a detailed piezometric surface based on shallow piezometers. Based on this we will establish a 2D cross section of small screens (Figure 5-3) along an apparent flow line for monitoring chemical parameters as well as piezometric head. If possible these piezometers will be logged with a small diameter gamma probe in order to obtain knowledge on the presence of embedded sand bodies down to 5-10 cm in thickness. If these can be found they can be used in the monitoring of the nutrient fluxes as described above.

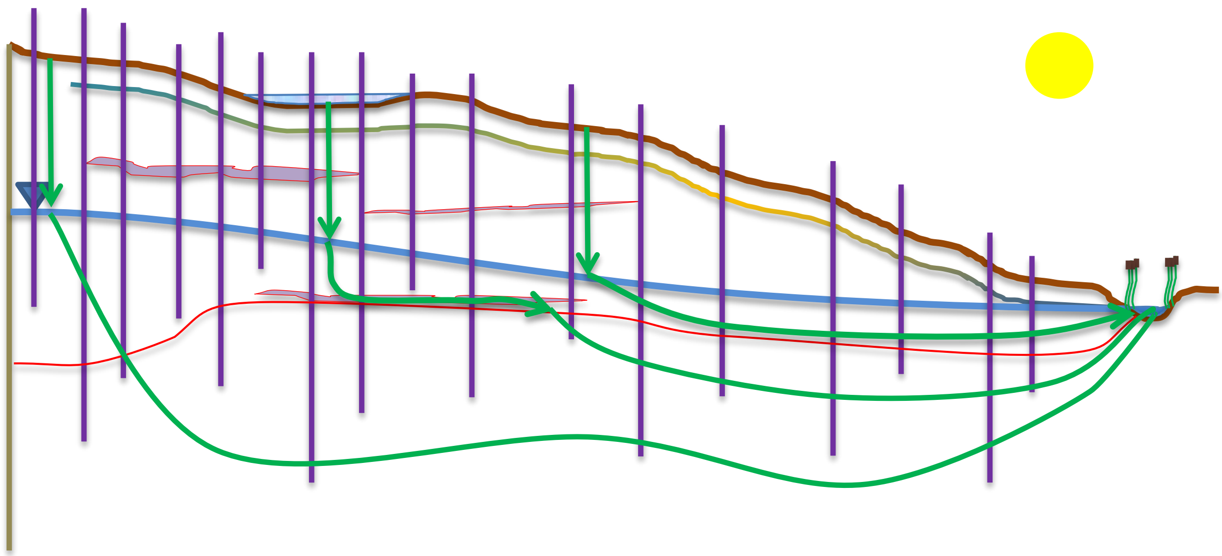


Figure 5-3 Cross-section showing piezometers installed along a flow line from the top of the drainage subcatchment to the stream (indicated by bulrush) established from a detailed piezometric surface. Thick blue line is the water table, thin red line the redox interface and the green lines show flow paths to the streams that may or may not encounter sand lenses (red contours with bluish fill) and may or may not pass below the redox interface.

It is the hope that the installation of piezometers and the 2D cross section can be done using hand operated equipment, but it will depend on the lithology, especially the size and frequency of rocks in the till. The current target drainage catchment is the area just southeast of the village Balle (Figure 5-2). The fields here are systematically drained and the position of the drains is well known. From the iDRAIN project we also know that a considerable part of the infiltration on the catchment goes into the groundwater.

5.2.3. Modelling of hill slope for Norsminde

5.2.3.1 Background and objective

Nitrate reduction in the saturated zone occurs when the water has been depleted of oxygen. This can often be seen as a redox interface, often marked by a color change from brownish to grayish, defining the transition from oxic to reduced conditions (Ernstsen 1996, 1998; Fujikawa and Hendry 1991; Hansen et al. 2008; Hendry et al. 1984; Pedersen et al. 1991; Postma et al. 1991; Rodvang and Simpkins 2001). A large part of Denmark is covered by young glacial sediments (Weichselian age) and because the young sediment still contains reactive reductants, the redox interface is normally found close to the surface. The near surface redox interface together with a groundwater dominated hydrology results in a high extent of nitrate reduction in the saturated zone in Denmark. The amount of nitrate reduction in an area depends on the depth of the redox interface, but also on the groundwater flow patterns as the nitrate needs to be transported below the redox interface with the flowing groundwater. The major challenges regarding estimating the amount and the spatial distribution of nitrate reduction using hydrological models is therefore to estimate the location of the redox interface and to accurately simulate the shallow groundwater flow above and around the redox interface. The focus of this modelling study is on the latter of these issues.

In order to correctly simulate the groundwater flow two issues are important. Firstly, the model must be able to simulate a correct distribution of water flow routes, especially the distribution between water going into tile drains and water going to the groundwater. In Denmark close to 50% of the agricultural land is tile drained, especially the clayey till soils dominating the eastern part of the country (Olesen 2009). Tile drainage has been shown to significantly impact the hydrology and flow patterns in a catchment (Carluer and de Marsily 2004; Dayyani et al. 2010; Rozemeijer et al. 2010b; Singh et al. 2006; Stamm et al. 2002; van den Eertwegh et al. 2006). In order to simulate groundwater flow patterns in a tile drained catchment accurately, it is thus very important to include tile drains in the hydrological model (Kiesel et al. 2010). Secondly, the model must have a correct representation of the water flow lines in the shallow part of the groundwater zone, as this will affect the amount of nitrate reduction in the model. Model simulation of water flow route distribution can be improved by including tile drain discharge observations in the calibration of the model (Rozemeijer et al. 2010a). A tracer test using a conservative tracer can also be used to improve the simulation of tile drainage. The simulation of shallow groundwater flow lines can be evaluated by using environmental tracers such as tritium (^{3}H), CFCs, SF_6 and ^{85}Kr (Bohlke et al. 2002; Troldborg et al. 2008) to give water ages that can be compared with simulated water ages.

The objective of this task is to set up a 3D field scale model that can simulate the distribution of water between tile drainage and groundwater, the tile drainage dynamics over the year and the groundwater flow lines in the shallow groundwater. Multiple types of field observations will be used to constrain the model: hydraulic head measurements, tile drain discharge, nitrate concentration in groundwater and tile drains, environmental tracers and a conservative tracer test. To use these types of field observations in hydrological modelling is not new, but to our knowledge no studies have used them in combination, as the focus in previous studies have been either on simulating the distribution between tile drain and groundwater flow (Rozemeijer et al. 2010a) or on groundwater flow lines (Bohlke et al. 2002; Troldborg et al. 2008).

5.2.3.2 Model code options

The numerical model to be used in this study must be capable of simulating fully integrated 3D unsaturated and saturated flow as well as tile drain dynamics together with evapotranspiration. It should furthermore be able to simulate the transport of a conservative tracer as well as transport and reduction of nitrate using a 1.order reaction. Two models that meet these requirements are HydroGeoSphere (Therrien et al. 2010) and FEFLOW (DHI-WASY 2013). Both models are finite element models with a fully integrated description of surface, subsurface and tile drain flow and transport.

5.2.3.3 Considerations on model setup

- **Study Area:** The model will be set up for one of the tile drain catchments in the Fensholt subcatchment (Figure 5-4).
- **Spatial extent:** The model will be set up in 3D and will have a horizontal extent of somewhere between 500 – 1000 m. In the vertical extent the model should cover the upper Weichselian till unit where the redox interface is found. Based on existence data (99 borehole observations from Norsminde Catchment: mean depth: 5.4 m, min depth: 1.2 m, max depth: 16 m), the redox interface is expected to be found somewhere within the upper 10 meters. The upper till unit is around 20-30 meters thick in the Fensholt area.
- **Spatial discretization:** The model should have a spatial discretization of the model grid of around 2 m in horizontal direction and from 10 cm increasing downwards to 50 cm in the saturated zone in the vertical direction.
- **Boundary conditions:**
    - **Upper boundary:** Time-varying precipitation and potential evapotranspiration flux boundaries
    - **Vertical boundaries:** No-flow boundaries along model domain, if it is possible to delineate the model domain so this makes sense. If this is not possible and horizontal flux is going in or out of the model domain, we will assign a time-varying constant head or flux boundary based on simulation results from an already existing MIKE SHE model for the whole of Norsminde catchment
    - **Lower boundary:** the bottom of the model will be somewhere in the upper clay till sequence and no natural no-flow boundary can be defined. The lower boundary will therefore be defined as a time-varying constant head from the existing MIKE SHE model.
    - **Drain outlet:** Critical depth boundary

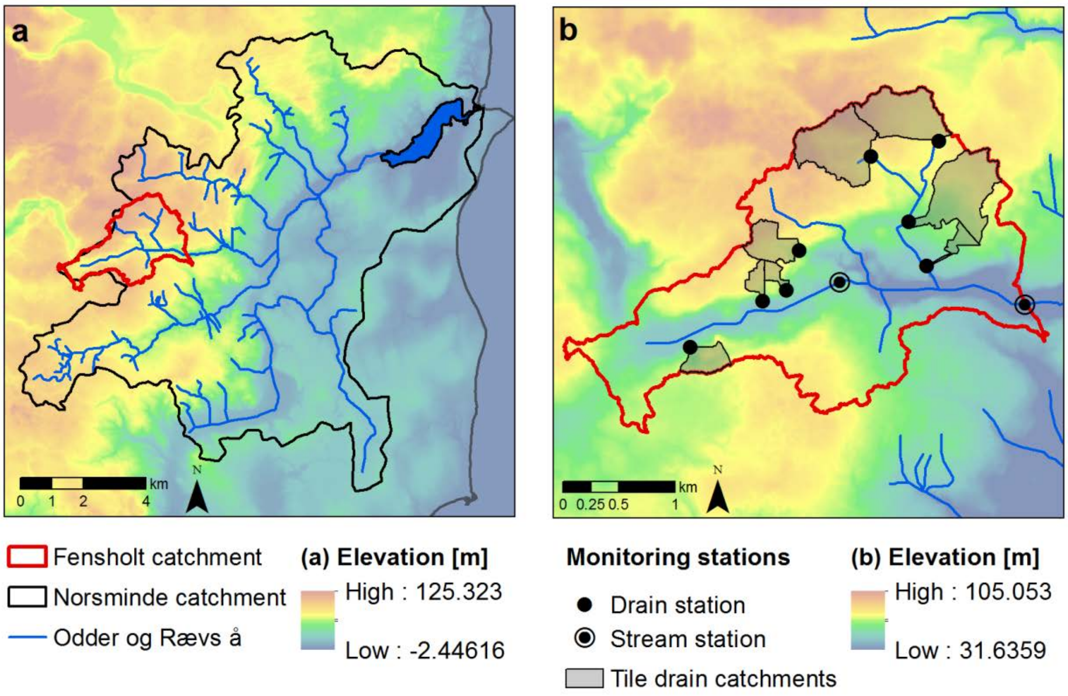


Figure 5-4 a) Location of the Fensholt subcatchment within the Norsminde catchment. b) Fensholt catchment and location of tile drain catchments and monitoring stations

5.2.3.4 Model data

- **Climate data:** Available from nearby climate station or from the gridded climate data (10 km grid for precipitation and 20 km for reference evapotranspiration) from the Danish Metrological Institute (DMI)
- **Geological data:** An already existing geological model can be obtained from the Ni-CA project. This model is based on borehole data and geophysical data measured with the transient AEM system SkyTEM. We can maybe obtain additional geophysical measurement over the near-surface geology using the Dual EM method from the iDræn project, however these measurement have not been made yet.
- **Observation data:**
  - ➢ **Hydraulic heads:** One or two shallow wells (2 m) already exist in each tile drain catchment with manual measurements over a period of 2 years from the iDræn project. We will make additional wells in the drain catchment we choose.
  - ➢ **Nitrate concentrations in groundwater:** Will be measured in this project
  - ➢ **Environmental tracer concentrations in groundwater:** Will be measured in this project
  - ➢ **Tile drain discharge:** Tile drain discharge at the outlet from the drain catchments have been measured during 2 years by the iDræn project. We will continue the tile drain discharge measurements at the drain catchment we choose.
  - ➢ **Tile drain nitrate load:** Has not been measured yet, will be measured at the outlet from the drain catchment we choose.
  - ➢ **Tracer test:** Will maybe be conducted in this project, if the first model results indicate that useful results can be obtained within the given time frame.

5.2.3.5 Considerations on model calibration

The model will be calibrated using a combination of the observation data mentioned above. The model will be calibrated using an automated calibration method such as the nonlinear parameter estimator code PEST (Doherty 2005). The calibration will be set up as a multi-objective calibration based on an optimization of performance criteria comparing measured values with simulated values as done in the studies by e.g. Stisen et al. (2011) and Hansen et al. (2013).

5.2.4 Differentiated regulations for Horsens Fjord catchment

5.2.4.1 Background and objectives

A prerequisite to differentiated regulation is the possibility to discriminate between areas where the reduction of nitrate leaving the root zone is large (robust areas) and small (sensitive areas), respectively. To accomplish this, the groundwater flow paths and the location of the redox interface must be known and combined. In this study, robust and sensitive areas will be delineated by use of hydrological modelling. Critical to the delineation of robust and sensitive areas are knowledge of the physical system (hydrogeology and geochemistry).

Heterogeneity in hydrogeology, controlling the local groundwater flow paths, and the location of the redox interface, separating the upper oxic (no nitrate reduction) and the lower reduced (nitrate reduction) part of the groundwater zone, is the focus in the research project NiCA (Refsgaard et al., 2014; www.nitrat.dk). These factors will thus not be in focus in the present study, but knowledge from the NiCA project will be utilised. In the present study focus will be on improved process understanding, their relative importance, and how this can be integrated in catchments scale modelling, to improve the reliability by which robust and vulnerable areas can be identified. The hypotheses are 1) the present representation of the shallow groundwater flow and transport in catchment scale models are not adequate to correctly describe the dynamics of the upper (oxic) groundwater system and the fractioning between groundwater producing drain flow vs. groundwater infiltrating to the deeper aquifer systems, and 2) the simplistic representation of the redox conditions in the groundwater as a redox interface separating oxic and reduced conditions do not represent the actual complex situation below the root zone especially in fractured dual porosity settings with reduction in microenvironments, but is an adequate representation in catchment scale models.

5.2.4.2 Modelling approach

A catchment scale model will be developed for the entire Norsminde catchment (101 km^2) and the neighbouring larger catchment for Horsens Fjord (~520 km^2), Figure 5-5. The Norsminde catchment is described in details in chapter 3. Horsens Fjord catchment is comparable to the Norsminde catchment with respect to land use and hydrological as well as hydrogeological conditions (Hinsby et al., 2012). Data availability is also similar for the two catchments. Horsens Fjord has previously been studied in details for assessing groundwater and stream threshold values (Hinsby et al., 2012) and climate change impacts (Henriksen et al., 2013; Højberg and Olsen, 2012; Sonnenborg and Henriksen, unpublished).

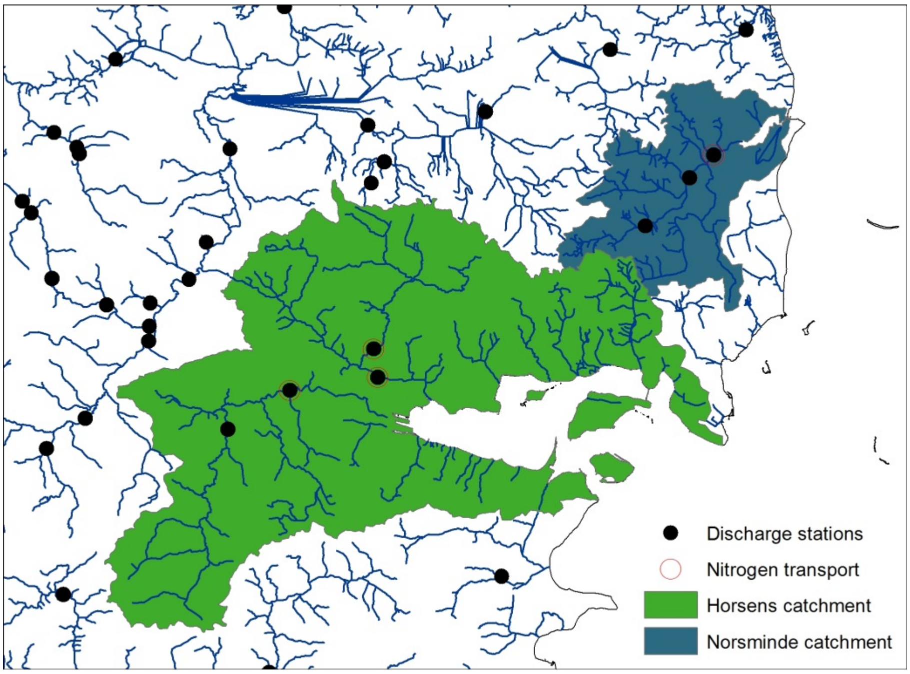


Figure 5-5 Norsminde and Horsens catchments and locations of monitoring stations from the Danish national monitoring programme

The models will be developed in MIKE SHE / MIKE11, which is a deterministic integrated surface- groundwater model code and provides a 1 D representation of the unsaturated zone and a fully 3 D description of the saturated groundwater flow including interaction with drainage systems and surface waters. A horizontal discretisation of 100 m will be used for both models. In the vertical direction the discretisation will vary with a fine resolution in the upper part enabling a detailed description of the shallow groundwater flow paths and an adequate representation of the redox interface.

The model developments will build on the existing models from NiCA (Norsminde) and Sonnenborg and Henriksen (unpublished) for Horsens Fjord. Both models are developed in the MIKE SHE / MIKE11 system and have been calibrated and validated to hydrological data (groundwater heads and stream discharges) for present conditions, following the Danish national guideline for hydrological modelling (Sonnenborg and Henriksen, eds., 2005; Refsgaard et al., 2011). In the Norsminde catchment model the redox interface has furthermore been calibrated based on estimated nitrogen leaching from the root zone and observations of total nitrogen load to Norsminde fjord. The calibration was based on a particle tracking approach to describe nitrate transport in the groundwater zone (Hansen et al., accepted). In the present study transport will be solved by the solute transport approach (advection-dispersion), which may require a redefinition of the model layers and possibly a recalibration of the redox interface. For the Horsens catchment nitrogen leaching from the root zone will be adopted from an ongoing national project on nitrate transport at the national scale (Højberg et al., 2013). Location of the redox interface will similarly be adopted from the national project, but a re-calibration will be required to reflect the local variations. Calibration of the redox interface will follow a two-step approach:

1. An initial calibration will be based on the approach currently used to represent the drainage system and redox conditions (a redox interface) in catchment scale mod-

els, which will be used as a reference setup for comparison of alternative formulations.

2. When improved process representations have been included in the models, it will be evaluated if a second calibration is required prior to the utilisation of the models as input for the other project tasks.

The calibration will be supplemented by model validation, by which the model results are compared to observation data not included in the calibration.

5.2.4.3 Up-scaling

Soils2Sea addresses nutrient transport and reaction at various scales ranging from the detailed hillslope field investigations and modelling to catchment and basin scale modelling. The detailed hillslope studies will improve the process understanding, which needs to be up-scaled for modelling at larger scales. From the catchment scale models, describing the entire catchment transport from soils to streams, knowledge of the effectiveness of spatially differentiated regulations are obtained, which must be up-scaled to the basin scale model for modelling of scenarios for the entire Baltic Sea basin. Two types of up-scaling is thus required; 1) up-scaling of process understanding from the detailed hill slope study to the catchment and basin scale models; and 2) up-scaling of the effect of spatially differentiated measures.

Process up-scaling will include a two-step approach:

1. From Hillslope to Catchment. This up-scaling approach will be based on the hillslope studies located within the Norsminde catchment and the catchment scale modelling in Norsminde/Horsens. Based on the improved process understanding obtained from the field studies (section 5.2.1-2) and the detailed hill slope modelling (section 5.2.3) in Norsminde, different up-scaling approaches will be tested to explore how the small scale dynamics can be represented in the catchment scale models. This will include, but not be limited to, a test of different spatial parameterisations of the physical properties and development of effective parameter values that can be derived from the heterogeneity in the physical properties. Specific focus will be given to the representation of drain flow with respect to quantity, dynamics and nitrate concentration. Furthermore, the validity of representing the redox conditions by a redox interface will be tested. The basis for evaluating the different approaches will primarily be based on comparison to the detailed hill slope model results. Additionally, the model results will be analysed for varying aggregation levels to evaluate how the importance of correct representation of the small scale processes may vary for increasing scale. The model code applied in the catchment scale modelling is the commercial MIKE SHE/ MIKE 11 modelling system, where it is not possible to alter the process descriptions included in the code. The up-scaling approach will thus explore different approaches to represent the physical system but may identify needs for further code development.
2. From catchment to Basin. Modelling at the entire Baltic Sea basin scale is carried out by the HYPE model, which is improved within the Soils2Sea project, based on the results and experiences from catchment scale modelling in the study sites: Pregolya, Norsminde/Horsens, Kocinka and Tullstorp Brook. The HYPE model is

constructed with a spatial discretisation identical to the Horsens catchment allowing a direct comparison of the model results obtained from the catchment scale models and HYPE. For Tullstorp Brook and Pregolya a HYPE model with a finer spatial resolution is constructed. Up-scaling from catchment scale to basin scale modelling includes the development of methods to map small scale processes into the larger scale models, which may result in the development of effective parameters. HYPE is developed by the project partner SMHI and improvement to the model code is thus possible. The up-scaling will be developed in close collaboration with activities described in chapter 7.

Effectiveness of spatially differentiated measures is largely dependent on the heterogeneity in the natural denitrification processes, where a high degree of heterogeneity makes it possible to target the measures to locations where natural reduction are lowest. Up-scaling of effectiveness of measures will thus be focused on identifying spatial heterogeneity with respect to nitrate leaching and natural denitrification processes. Where information on spatial heterogeneity in groundwater reduction potential do not exists, it will be tested if readily available data, such as soil types, can be used as a proxy. Based on the heterogeneity descriptions, effectiveness of spatial differentiated measures vs. uniform regulations will be assessed. This will be an extrapolation of the results obtained from catchment scale modelling.

5.2.4.4 Model applications

While solute transport simulations can provide an estimate of the total nitrogen loads to the surface water system, it cannot be used to delineate robust and sensitive areas. This will instead be accomplished by particle tracking in which a uniform distribution of particles is released initially in each model grid. Keeping track of the fraction of particles entering the anoxic zone, where nitrate is assumed to be reduced, the potential reduction capacity for each model grid can be computed.

The motivation to obtain an improved process understanding and description hereof in the catchment model is to improve the model results with respect to the estimated loads to the surface water system, the delineation of robust and sensitive areas, and the derivation of groundwater and stream threshold values for the protection of Norsminde Fjord. The model's ability to estimate loadings will be assessed by the model validation. Areas that are robust or sensitive cannot in practice be identified from field studies except at a few intensively studied sites, and the reliability of the delineation based on the model results can thus not be addressed directly. In the NiCA project, alternative maps of the depth to the redox interface was constructed by employing different assumptions with respect to the factors controlling the spatial pattern. Utilising these maps it was found that the total loading to the Fjord could be simulated for very different spatial representations of the redox interface (Hansen et al, accepted). An absolute measure of the reliability of the estimated spatial pattern of robust and sensitive areas is therefore not possible. Instead, it will be analysed how the new up-scaled process representation will affect the distribution of robust and sensitive areas. Supplementing these results with those found in NiCA on possible variations in the redox interface and the effect of geological heterogeneity, and the different monitoring data obtained in Soils2Sea the reliability of the identified robust and sensitive areas will be assessed quantitatively.

Applying the joint climate and land use scenarios for 2050 (chapter 3) the optimised models for the two catchments will be utilised to estimate possible changes in total runoff and nitrate loadings from the catchments to transitional and coastal waters of the Baltic Sea.

Groundwater and stream threshold values for N and P (P only for streams) were recently established for the catchment of the Horsens Fjord (estuary) under present and simple future land use scenarios using an ensemble of linked models (Hinsby et al. 2012) including the Danish National Water Resources Model (Højberg et al., 2013; Stisen et al., 2012). However, threshold values were only derived for the actual climate conditions, and the projected climate change will most probably affect groundwater threshold values (Hinsby et al., 2012; Sonnenborg et al., 2012). To improve the assessment of thresholds taking future land use and climate into account, model results based on the land use and climate scenarios will be utilised further in the threshold derivation in order to assess possible effects of climate change on future groundwater threshold values (chapter 8).

5.2.5. Groundwater retention at the Kocinka catchment

The Kocinka catchment is underlain by an important aquifer (MGWB-326) which contains one of the largest groundwater bodies in Poland (see Figure 3-7). The aquifer is hydraulically connected with the streams of the catchment. The unconfined karstic-fissured aquifers are vulnerable to pollution because of the presence of the fast flow components related to fissures and karstic conduits where denitrification is inhibited by the aerobic conditions.

Nitrate levels exceeding 50 mg/l have already been detected in the southern part of the groundwater body and water extracted from the polluted wells is subjected to denitrifying treatment (Malina et al., 2007). Two plausible sources of this pollution are: (i) inadequate sewage management in the city of Częstochowa and in the municipalities of the catchment and/or (ii) agricultural activities. The main research questions in this regard are:

- mapping of nutrient levels in groundwater
- identification and quantification of nutrient sources,
- identification of pathways and transformations of nutrients from the sources through the shallow Quarternary aquifers and the deeper Jurassic aquifer to the Kocinka,
- influences of land-use, agricultural activities and water resources management on retention of nutrients,
- estimation of nutrient leaching from agriculturally used soils,
- incorporation of nutrient retention processes into the refined 3D numerical model of groundwater flow and contaminant transport.

5.2.5.1 Drainage system, mapping and monitoring

Tile drainage system will be identified on the basis of the archived maps and field surveys. Active outlets of the system representative for different land use will be selected as monitoring sites. The monitoring will include flow measurements, grab sampling for nutrient concentrations and nutrient load estimation by use of SorbiCells. Seasonal variations in loads will be addressed. The dual EM method for identification of drainage network may be used in cooperation with University of Aarhus and GEUS.

5.2.5.2 Land use, fertilization

Roughly two-thirds of the catchment is used agriculturally. The CORINE land-use map will be updated and refined by field observations. A specific feature of land-use in this part of Poland is a large amount of fallows (abandoned farmland) subjected to spontaneous reforestation. Information on crops and fertilization rates will be collected from the municipalities of the catchment, from the Agricultural Advisory Boards and by interviews with the farmers.

5.2.5.3 Monitoring targets and scale

Groundwater quality and quantity monitoring is performed by the Polish Geological Institute and by the Chief Inspectorate of Environmental Protection. Three hydrogeological stations belonging to this network are located in the case study area: a spring in Wierzchowisko and two water supply wells (station number II/1346/1 in Częstochowa and station number II/951/1 in Cykarzewo). Four points of the regional hydrogeological monitoring are located in the catchment. Additionally the dug wells can be used to monitor shallow groundwater. A piezometer transect will be established from a hill top to the river. Monitoring of drains is described in 5.2.5.1. Stable isotopes ($\delta^{15}N$, $\delta^{18}O$) in nitrates will be used for identification of nitrate sources (fertilizers vs municipal wastewater) and to find evidence for denitrification in the unsaturated and saturated zones. GEOPROBE profiling will provide information on vertical variations of soil, bed rock and hydrochemical properties. Based on the results obtained from the first sampling campaigns, further geological and geophysical investigation may be decided.

5.2.5.4 Modelling

A numerical model of groundwater flow and nutrient transport at the catchment scale in VISUAL MODFLOW v. 4.6 will be developed to address the following issues:

- Coupling with the model of nutrient leaching from soils (SWAT or the model provided by the Aarhus University),
- Identification of source areas of groundwater discharging into the stream network,
- Time lags in the responses of groundwater (and the related surface water) to changes in land-use patterns and fertilization rates (nutrient leaching) and to remediation measures. Time lags have to be estimated separately for the unsaturated (assumed to be equal 10 years in average – from the vulnerability map of Poland (Witczak ed., 2011) for this area) and saturated zones.

The current numerical flow and transport model covers an area of 951,5 km^2 (significantly exceeding the 258 km^2 within the Kocinka catchment with a 100 x 100 m grid. It consists of 12 layers delineated mainly to assess the vertical flow in the Jurassic aquifer which should be considered in assessing the transport of contaminants in the fissured-karstic system. At this stage the fissured-karstic aquifer has been treated as an equivalent porous media in the groundwater flow modeling using the MODFLOW code incorporated in the VISUAL MODFLOW package. The groundwater flow model for steady-state conditions was firstly calibrated on measured hydraulic heads (from 145 points: drilled or dug wells as well as piezometers) and water fluxes using trial and errors method. A model properly calibrated hydrodynamically is not necessarily sufficient for transport modelling, and, if not recalibrated, may yield wrong predictions of pollutant migration (Zuber et al., 2005; Zuber et al., 2011). Environmental tracer data (tritium data available for 21 wells and springs in the modeled area, some of them from the long period 1991-2013) was used to calibrate the transport model in the first stage. Results of the transport model calibration, point out the need for recalibration of the flow model and, if necessary, adjustments of the conceptual model.

5.2.5.5 Denitrification in the groundwater system

Up to now there is no evidence for a distinct transition from oxidizing to reducing conditions nor for denitrification in the aquifer. On the other hand, the majority of water in karstic-fissured systems can be contained in matrix pores where denitrification may occur (Einsiedl and Mayer, 2006). Hydrochemical and stable isotope observations will be used to identify potential denitrification zones. There are also no observations on phosphorus behaviour in the aquifer. Denitrification and phosphorus removal may occur in the river valleys where the upwelling groundwater comes in contact with the water-saturated alluvium. Observations in the piezometer transect(s) from hillslope to the river will be designed to address this question.

5.2.6 Risks and risk management

The level of ambition in terms of the level of detail in the insights that we aim at is high. It needs to be understood that given the complexity of both the hydrogeology of these heterogeneous geologies combined with the potentially complex couplings between nutrient removal and flow paths as well as regimes, a complete description of the system cannot be obtained. Still we need to reach a level of understanding that makes it feasible to upscale the processes based on our understanding of the most important factors controlling the nutrient fluxes – in order to reach the overall objectives of the project. In this the upscaling is central. The quality of the upscaling, will be determined by how well we understand the processes and to what extent we can generalize these on a basin scale, An upscaling can be made, the risk is that the uncertainty is too high for making meaningful decisions. By choosing a sequential approach, allowing us to modify our field methods as results are obtained we will enable an optimization of the results within the constraints of the given resources. This approach should limit the risk of not reaching the needed level of understanding.

5.3 Outputs

The output will be a description of the two field sites the instrumentation and a description of processes and dependencies controlling the flux of nutrients from the bottom of the soil zone through the drain and groundwater system to the stream, based on the results obtained. The description should facility a parameterization that can be implemented in the detailed hill-slope scale model and also transferred to the larger catchment and basin scale models and should include parameters that will be affected by climate change. Some of the anticipated parameters controlling the flux could be precipitation and infiltration patterns, the redox boundary position, organic matter in the fracture system, distance to stream and water divide related to infiltration area size and depth of the flow system, system anisotropy and other factors that can be included in the hill-slope scale.

From this scale a scheme for upscaling the processes to catchment and further up to basin scale, based on the most important as well as the most available parameters will be devised. Many of the mentioned anticipated parameters are related to geological, geometrical and climatic conditions, which are generally available, implying that in catchments were data on more specific data such as e.g. redox boundary position are not present, methods for using the generally available data need to be devised, tested and applied. The devised upscaling schemes will be used as input to catchment scale models for the Horsens Fjord and Kocinka catchments and be used in proposing effective differentiated regulations on nutrient applications and for deriving the probable impact on nutrient fluxes and the uncertainty related to this.

The work on the drainage part of the nutrient fluxes will result in the development of a prototype of a device capable of measuring drainage derived nutrient fluxes based on the Sorbisense passive sampling technology.

5.4 Timing and dependencies with other project activities

The timing of WP3 is illustrated in Appendix A which also shows deliverable and milestones. There will be some level of parallel development of the different scale of models. Still, for the catchment scale study of Horsens Fjord, the hill slope scale will need to be finished before the MIKE SHE basin scale model can be completed and both models depend on obtaining data from the field sites. As the project develops it will hopefully be possible to obtain a closer coupling and integration of the activities and results obtained in the Fensholt sub-catchment and the Kocinka catchment study.

The interdependencies and general relation to other WP's is illustrated in Figure 5-6. The diagram shows how the results from WP 2.3+4 based on possible regulation schemes as well as probable climate scenarios will feed into the the subactivities in WP3 and cascade through to the basin scale model established in WP5.

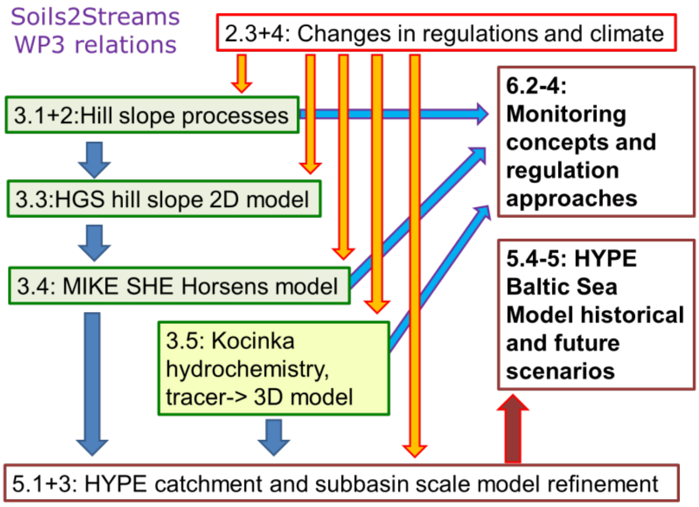


Figure 5-6 WP3 interdependencies with other WorkPackages.

5.4 References

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6. Nutrient transport and retention in surface water

6.1 Objectives

- To develop and test new methodologies for assessing the variation in retention of P and decay of P and N among different surface water systems. These objectives include the performance of simultaneous tracer tests and interpretation of available monitoring data using time series analyses.
- To improve the understanding of nutrient retention in surface waters (surface runoff, drain runoff, rivers, wetlands, lakes). This will include attempts to link stream reach characterization with solute transport behavior on the reach scale and generalizing this understanding on the watershed scale for planning of remediation actions.

6.2 Methodology

6.2.1 Field experiment and formulation of exchange relationships

An extensive field campaign will be performed along a stretch of the Tullstorp Brook including investigations of geophysical, topographical and hydraulic properties. Key features in the campaign include tracer tests where ^{15}N enriched nitrogen, ^{32}P labeled phosphate, and tritiated water will be injected into the stream during different stream flow conditions (Figure 6-1). A main objective of these tests is to investigate several stream reaches with different geomorphologic conditions and, hence, different prerequisites for nutrient retention and attenuation. In order to cover a sufficient number of different stream reach characteristics, the final selection of injection sites will be decided later on with account take to

- Agreements with land owners and the permission from the Swedish Radiation Safety Authority
- Stream reach characterisation
- Available monitoring data
- Installed remediation features, such as reintroduced wetlands or restored stream shape
- Performance feasibility

The final design of the experiment in terms of exact location and number of sampling stations will depend on prevailing hydrological conditions, but the initial set-up is to have 5-8 stations along a 20-30 km stretch of Tulltorps Brook. Tulltorps Brook has been subjected to several remediation actions and there is a general interest to evaluate the effectiveness of these using the proposed tracer test technique. However, similar information can be obtained also in other stream systems, such as e.g. in the Kocinka watershed. We will also measure the spatial vertical distribution of ^{32}P and ^{15}N in combination with a number of governing environmental variables in the stream-bed sediment (hydraulic conductivity, organic content and grain size distribution) at a number of places along the river. In addition, novel methodologies using electric resistivity imaging (Ward et al., 2010) of an electrically conductive tracer (dissolved NaCl) will be used to quantify subsurface retention zones arising from the exchange between the surface water and shallow groundwater.

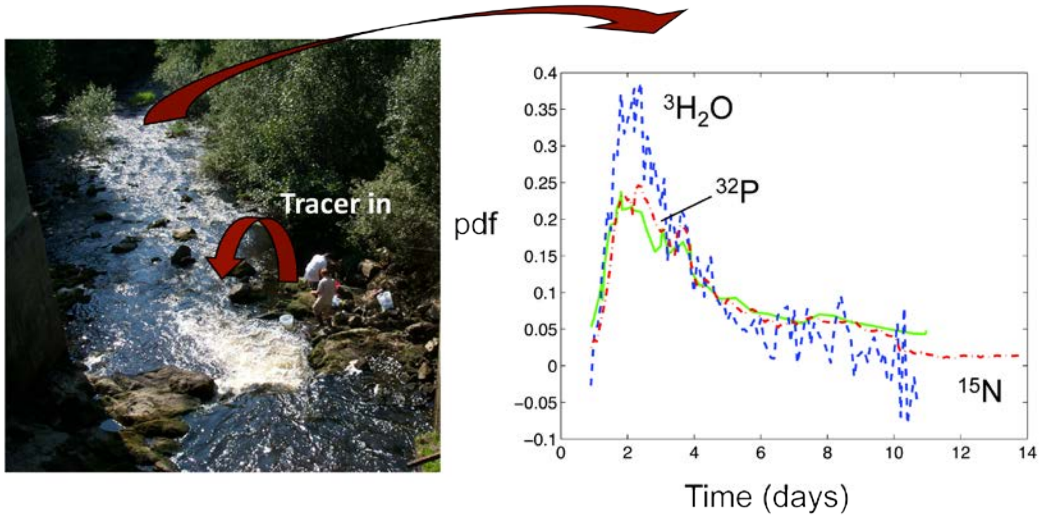

Figure 6-1 Schematic of tracer test performance (left-hand side) and normalised break-through curves for tritium, P-32 and N-15 as determined in a previous test in a treatment wetland.

A model framework will be developed for coupling the in-stream transport processes with temporal trapping due to advective or diffuse exchange with adjacent transient storage zones of reactive solutes applying existing transport models (e.g. COMSOL (COMSOL, 2008)-, Advective Storage Path model (Wörman et al., 2002). The purpose of these reach-wise (geometrically delimited) studies is to derive a mechanistic understanding of the importance of stream hydraulics and morphology on the different exchange mechanisms responsible for nutrient removal. The results from the tracer test will be interpreted in order to evaluate residence time distributions, reactions rates, and nutrient fluxes in individual stream environments/key retention zones as function of stream discharge. Model interpretations of the hydraulic and biogeochemical processes are to be used to prepare for up-scale results from the reach scale to stream networks on the watershed scale and to derive exchange relationships to be utilized in the HYPE model that is applied on the watershed scale (WP5).

6.2.2 Nutrient reduction at watershed scale

Spectral analysis will be used to investigate scale relationships of the observed data on a number of selected watersheds (Tulltorps Brook, Rönne River, Norsminde watershed, Dalälven River Basin, Kocinka Watershed and more) and connect the outcome to the dominant retention mechanism. The analysis will also evaluate suitable frequency for future monitoring programs associated to spatial scales, and assess what information can be derived using existing monitoring time series. The power spectral density of a time ries describing the stream flow at the effluent of a river basin, P_Q, is a product of the power spectrum of the source of the water (precipitation, snow melt, evapotranspiration), P_{Prec} - P_{ET}, and a spectral function, P_{IUH}, describing the watershed filtering mechanisms (i.e. the watershed travel times) according to (Wörman, et al., 2010):

$$P_Q = (P_{Prec} - P_{ET})P_{IUH} \tag{6.1}$$

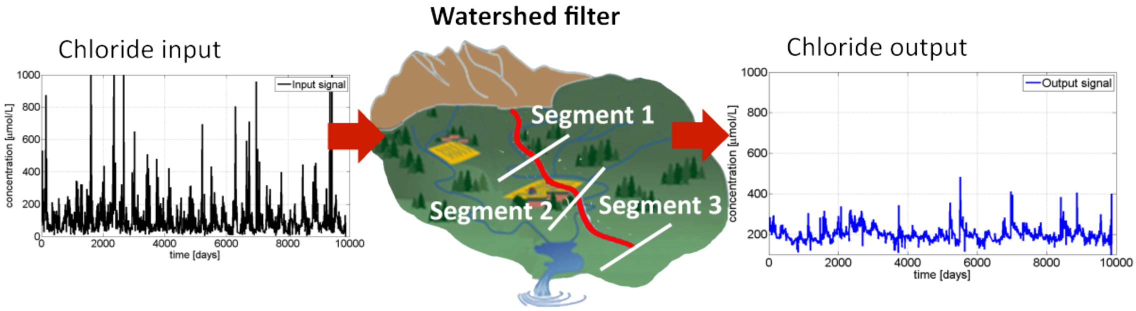

Figure 6-2 Schematic showing natural solute tracer input to a watershed and the damped output signal that reflects the filtering mechanisms on the watershed scale.

where P_{Prec} is the power spectrum of precipitation and P_{ET} is the power spectrum of evapotranspiration. The filtering spectral function, P_{IUH}, can be derived as a function of geomorphologic and hydraulic dispersion within the watershed. If there are distinctive changes in the network gy (geomorphological dispersion) or hydrodynamic dispersion, one can note a change in the ratio at each frequency range of P_Q and (P_{Prec}-P_{ET}). In a similar fashion, the power spectrum of solute concentrations can be related to an additional filtering caused by physicochemical processes providing scaling regimes that controls the nutrient export on the watershed scale (Guan et al., 2011; Riml et al., 2014). For general water quality parameters of rivers, assuming that the solute load function can be linked in some form to either precipitation or river discharge (i.e. the load of solutes is proportional to river discharge generation) we can use a proportionality similar to:

$$P_{Lw} = (P_{Prec} - P_{ET}\ )\ P_{IUH}\ P_{\Psi w} \tag{6.2}$$

where P_{Lw} is the power spectrum of solute concentration at the watershed effluent and $P_{\psi w}$ is the corresponding filtering of the solute signal, i.e. the solute travel time probability density function. An aim is that the exact form of Eqn. (6.2) will have to be thoroughly evaluated in the project. By deriving a closed form solution of the solute transport the power spectra of the load function and the solute concentration at the watershed effluent can be related at different frequencies that represent different pathway segments of the watershed as indicated in Figurer 6-2 (Riml et al., 2014). This relation provides physiochemical scaling factors that may infer information about the processes governing solute transport. The model framework used to represent the transport of nutrients in a river network will be developed based on the relevant morphological, hydraulic and geochemical nature of the selected watersheds. The outcome of these studies on the watershed scale and the tracer tests will be used to parameterise watershed models and perform principal feasibility studies of technological measures to reduce nutrient export (section 6.2.3) and WP5.

Remediation actions will account for typical measures for agricultural land, such as installation of dams with connected wetlands, morphological modification of the stream course and vegetation pattern, but also a tentative study on the connection between regulation practice and nutrient export. Because many rivers are regulated for various reasons, e.g. due to hydropower, and the WFD requires integrated river basin management plans, it has a general interest to explore how environmental constraints can be linked to regular management models used to optimize hydropower production. While transport in rivers can be represented by combining a one-dimensional hydrodynamic model with a one-dimensional transport model, the dynamics of nutrients in regulated rivers with reservoirs can be particularly complex due to the characteristic presence of a vertical stratification that depends on temperature. The aim of the tentative analysis is to define the general optimization principle in a modelling framework (mathematical model) and explore the implication of different nutrient export (solute transport) constraints on the optimization of the objective to produce hydropower. In other words, a main question is what is the change of energy production for imposing constraints related to a change in management. An important aspect to consider will be the modelling of nutrient sedimentation and resuspension dynamics in reservoirs, which plays a major role on the fate of these contaminants. The river Dalälven, located in Southern Sweden and discharging into the Baltic Sea, will be taken as a case study. Discharge data for Dalälven are made available by SMHI through VattenWebb, which also provides time series of Nitrogen and Phosphorus loads estimated with the HYPE model. Useful data may also be provided by other companies involved in the daily operation of the river, in particular Vattenregleringsföretagen and Fortum AB, with which collaborations are already active. The estimated nutrient loads will be used for comparison with stream quality standards / thresholds (assessment of chemical status) required for achieving good chemical and ecological status of associated coastal waters to be used as a policy instrument in WP6.

6.2.3 Technological measures to reduce nutrient export in streams

Scenario analyses will be performed based on existing and generically simulated measures of restoration/alternation of the stream morphology, including measures like dams, wetlands, flooding zones, sediment traps, increased meandering and vegetation pattern. Further, we will evaluate the subsequent effects of individual measures and stream reach characterisation both in terms of the solute residence time distributions and on the nutrient fluxes. A main objective of the scenario analysis is to provide tentative understanding for the necessary amount of remediation measures on the overall nutrient reduction in terms of e.g. number of remediation sites as well as optimal distribution of sites in the stream network with account taken to the source distribution as well as the role of individual measures for the network behaviour. In a subsequent phase, a multiobjective optimization model for multi-reservoir operation will be developed. The aim is to design optimal operating policies that can be used in combination with other remediation measures to reduce nutrient loading into the sea. The model will integrate hydropower production and flood control objectives with water quality objectives. The river Dalälven will be analysed as a case study, and the implications and effectiveness of different operating strategies will be assessed.

6.2.4 Surface water retention in the Kocinka watershed

The following activities will be carried with respect to the environmental hydraulics of the Kocinka:

- Survey of the morphodynamic (valley bottom and channel morphology, channel pattern, gradient, grain size, in-stream features, stream power) properties of the Kocinka and of the main tributaries (mostly the Sekawica which receives effluents from the wastewater treatment plant).
- Morphodynamic classification of river reaches.
- Selection of reachesd representative for main morphodynamic classes (logistics).
- Characterization of bottom sediment properties (hydraulic conductivity, grain size distribution, chemical composition) in the selected reaches.
- Preliminary tracer tests with KBr in the selected reaches to: (i) identify and compare types of responses to the conservative tracer injections, (ii) to evaluate effective time scales of solute transport, (iii) to estimate dicharges.
- Tracer tests with tritium along a longer river stretch with multiple sampling points in order to address larger scale hydrodynamic response of the river.
- Identification (and quantification) of exchange between groundwater (hyporheic zone) and surface water by measurements of temperature and radon.

The following activities will be made to assess nutrient retention in the Kocinka

- Observations of N and P contents in water (seasonal changes, trends along the selected reaches). Stable isotope analyses of nitrates for identification of nitrate sources. Supplemented with data on discharge and other water quality parameters.
- Observations of N2O emissions from the stream, identification of “hot spots” of denitrification.
- Tracer tests with 15N and/or 32P labelled nitrates in the reaches characterized by methods described above.

6.2.5 Upscaling from the reach scale to the watershed scale

To efficiently design remediation actions and to make reliable predictions about the effect of these measures, evaluations of the key mechanisms that are governing their retention and attenuation processes are needed. In addition, investigations of the combined effect of spatially differentiated remediation actions demand model analyses of the hydraulic and biogeochemical processes that can be up-scaled from the reach scale to entire stream networks on the watershed scale. To do so, exchange relationships on a form that can be utilized in the HYPE model (WP5) will be derived on the reach-scale and generalised for the network of streams based on stream characteristics. The tentative approach to obtain these relationships is to use key retention and attenuation properties, induced by the respective restoration/remediation object based on measurable properties of geomorphology, hydrology, and biogeochemistry, to transfer the results between scales and generalize the findings. Previos studies (Wörman et al., 2002) demonstrate the methodology by using the ASP model, but the exact form of the exchange relationships must be decided in line with the work of WP5.

6.3 Outputs

- D4.1 Report on impacts of river damming on nutrient export and optimized reservoir operation with multi-objectives (M24)

- D4.2 Report on tracer tests and the effect of solute retention and attenuation on the stream reach scale (M33)
- D4.3 Report on impact assessment of water course remediation measures to increase self-purification using different in-stream model concepts (M40)
- D4.4 Report on efficiency of alternative water management strategies for reducing nutrient loads to the Baltic Sea (M44)

6.4 Timing and dependence with other project activities

6.4.1 General dependencies

The application of multiple theoretical approaches is likely to enhance model performance for predictive purposes and therefore strengthen the assessment of different remediation measures used in scenario analyses. Scenario analyses will be developed for already performed and potentially new remedial measures including distributions of wetlands, riparian buffer zones, stream-channel modification, and regulation strategies (for regulated rivers). This will include validation of a model to simulate the changes resulting from remedial measures. A few key field experiments, using N and P tracers, will provide specific information on retention and reduction processes that have not previously been available. The combination of such specific data will be combined with much longer time-series of monitoring data using spectral analysis and process-based models on the stream-reach scale as well as the watershed scale. The field studies will primarily focus on the Tulltorps Brook, Sweden, and the Kocinka watershed, Poland - two watersheds dominated by agricultural activities. The results from reach and watershed scales will be utilized to improve process descriptions in HYPE (see section 6.2.5).

6.4.2 Input (to WP4) dependencies

WP2 Land2Soils / WP3 Soils2Streams. For the watershed scale analysis in WP4 (6.2.2) data on nutrient load and export from Norsminde watershed is needed. This work is partially performed within task 2.3 “Scenario analyses for spatially differentiated P loss measures in watersheds” and task 2.4 “Scenarios for the Baltic Sea basin”.

6.4.3 Output (from WP4) dependencies

There are several outputs from WP4 (D4.1 – D4.4) with implications for WP5. Results on nutrient retention on the stream network scale and effects on remediation actions on the network scale can be utilized in

- Task 5.1 “Regionalisation of subsurface and in-stream retention systems at basin scales”
- Task 5.3 Representation of measures at Baltic Sea subbasin scales

The time-series analysis method developed particularly to detect nutrient retention (section 6.2.3) can be of importance for assisting in

- Task 5.4 Model tests against historical data for cases with changes in nutrient loads over time

The overall analysis of the implication of remediation actions in stream networks will be of importance for

- Task 5.5 Scenario analyses for a changed Baltic Sea using differentiated regulations

Furthermore, the results obtained in WP4 and WP5 will be of general importance for development of governmental concepts and policy in WP6, such as in

- Task 6.2 Policy instruments for differentiated regulations
- Task 6.3 Monitoring concepts for differentiated regulations
- Task 6.4 Test of policy instruments and monitoring concepts
- Task 6.5 Policy Brief

6.5 Literature references

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7. Baltic Sea basin scale

7.1 Objectives

This part of the project aims at the integration of local to regional results, established in the focus areas, into the modelling of the entire Baltic Sea basin. We will use a conceptual hydrological multi-catchment model with integrated nutrient retention/release/removal processes for the Baltic Sea basin to project regulation scenario impacts to the entire basin. To achieve this overall goal, the work package tasks formulate a number of objectives, which will be addressed during the project.

The transfer of focus catchment findings to the basin scale requires up-scaling and regionalisation routines. In work packages 3 and 4, different approaches are used in each focus catchment to investigate the locally and/or regionally dominant nutrient sources and transfer processes. The insights of the various experiments and model exercises will be used to provide information on effective nutrient reduction measures and regulation strategies in the focus areas. In order to up-scale these findings to the sub-basin scale at which the Baltic Sea basin model operates, the results must be generalised to match the process representation in the model as well as the available data for the whole region. This is referred to as up-scaling. The focus area results will also be evaluated for how representative they are for larger regions around the Baltic Sea, in order to facilitate a regionalisation procedure on where the regulation strategies should be applied in scenarios. The regional basin model itself will be evaluated in terms of its capability in representing the process dynamics involved in the regulation strategies. Lastly, combined scenarios including regulation strategies and climate change forcing data will be used to assess basin scale impacts on riverine nutrient loads to the Baltic Sea under the scenario assumptions and get comparable views on the overall impact of locally targeted programs of measures.

7.2 Methodology

The objectives in the project activities of work package 5 will be achieved using a range of methods connected to the individual tasks. Central to this work package is the semi-distributed rainfall-runoff and nutrient transport model HYPE, which will be used for modelling the pan-Baltic Sea basin within Soils2Sea.

7.2.1 Short HYPE model description

The methodology to enable modelling of riverine nutrient load reduction measures encompasses the above-mentioned regionalisation and up-scaling of focus area project results. The modelling will be done using an implementation of the HYPE model (Hydrological Predictions for the Environment) in the Baltic Sea basin, BaltHYPE. The model set up will be based on a pan-European HYPE implementation, E-HYPE, and encompasses a total of 7000 sub-catchments. The model is set-up using available continental-scale open data, climate forcing data from ERA-INTERIM or WATCH re-analysis products as well as physical catchment properties from e.g. CORINE and Globcover 2000 land use data bases, GLWD (Global Lake and Wetland Database) Lake and reservoir data, Hydrosheds and Hydro 1K topography and routing, among others (Donnelly et al., 2013). HYPE runs at daily time steps and incorporates up to three soil storage boxes each in a number of SLC (combined soil and land use) classes. HYPE also contains dedicated lake and reservoir classes with separate model routines. The model domain is divided into sub-basins, each of which is composed of one or several SLC classes, which account for the total sub-basin area. Thus, the model is semi-distributed, and uses sub-basin boundaries to discretise the model domain, unlike most large scale hydrological models which are grid-based. HYPE sub-basins are connected through a routing network (Figure 7-1).

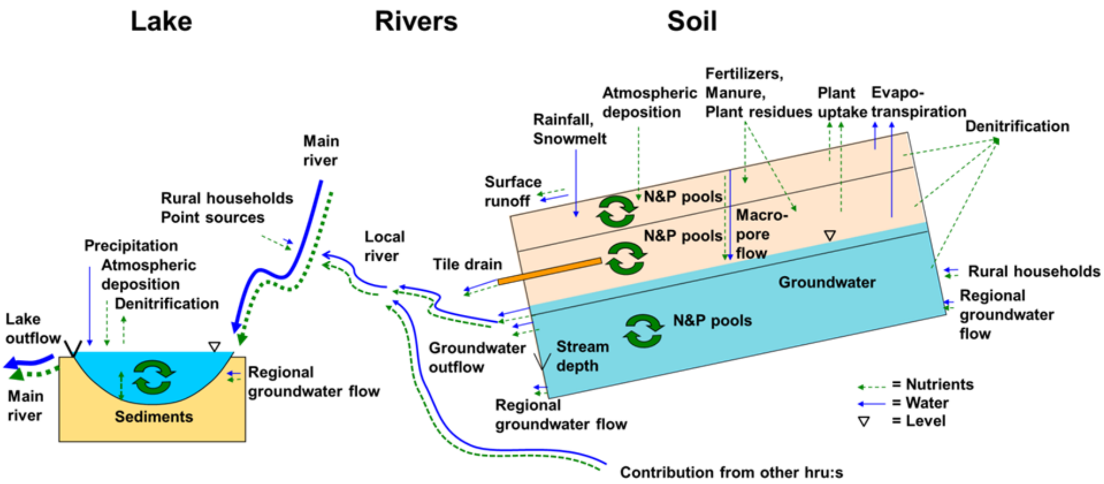

Figure 7-1 Conceptual model structure of the HYPE model.

7.2.2 HYPE modelling in the Pregolya catchment

The Pregolya River is the main river discharging into the Vistula Lagoon in the South-Eastern Baltic with an average annual discharge of 1.53 km^3, which equates 44% of the total freshwater discharge to the lagoon. The Pregolya River catchment has an area 13,700 km^2 (Figure 7-2).

The main contribution to Soils2Sea is a comparison between HYPE model set-ups of the Pregolya basin using different data sources in order to evaluate the value of local data with higher resolution and more detail compared to large-scale databases within the HYPE model framework. The model set-ups will build on:

1. Data available at the EU scale (already included in E-HYPE) and local and more de-tailed data from the study area
2. Existing process descriptions in HYPE and the updated process descriptions de-veloped in Soils2Sea

Detailed information for land use structure, which is based on the existing present land use structure for the Kaliningrad Oblast (according to the Territorial Planning Agency of the Kaliningrad Oblast) and CORINE Land Cover data for the Polish parts of the Pregolya catchment will be used during the project. The results of land use patterns change assessment that have been developed in the FP7 LAGOONS project can be used for scenarios of possible changes in the land use structure for the Pregolya River catchment (Russian and Polish parts).

A detailed assessment of the external boundaries and internal sub-catchment delineation of the Pregolya River catchment will be conducted. This includes the bifurcation into Pregolya main stem and Deyma branch in the lower reaches of the Pregolya river, which results in a division of discharge from the Pregolya River watershed into two receiving Lagoons (Vistula and Curonian Lagoon).

Large-scale climate forcing data will be compared to data of current weather stations in and near the catchment (sparse network in Figure 7-2) to describe the boundary meteorological conditions for each sub-catchment of the Pregolya River.

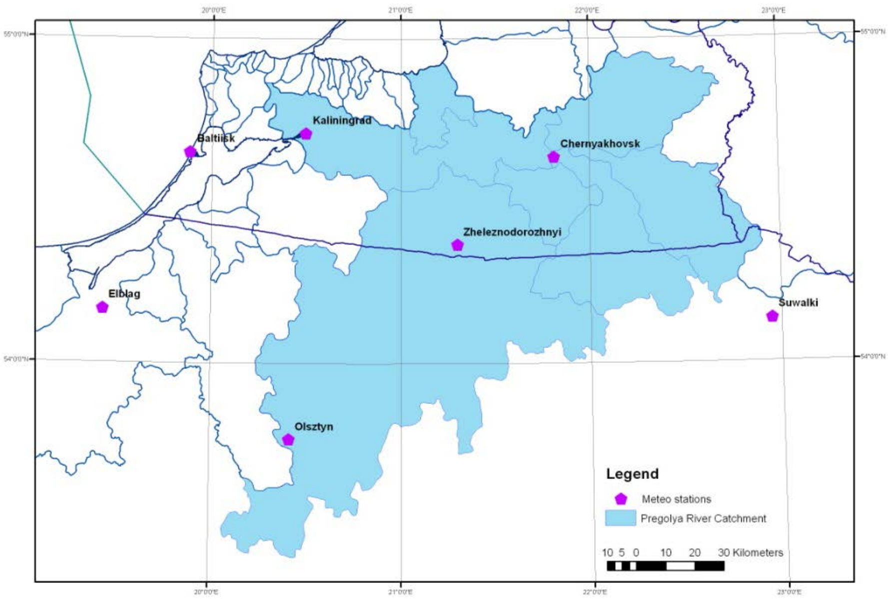

Figure 7-2 Pregolya River Catchment with sub-basin delineation and location of meteorological stations. Baltic Sea with Vistula Lagoon in the north-western corner of the map.

Transport and removal of nutrients from within the Pregolya River and its tributaries under current conditions will be modelled using available information on land use and point sources, and the total loads into the Vistula Lagoon will be estimated. Impacts of model set-up and scenario assumptions (climate land use change) will be assessed.

Data for the implementation of the tasks:

- Data from official statistics of the nutrient load from the settlements and farms (2006-2013)
- Diffuse load will be assessed according to official statistics for administrative units and taking into account land use structure (2006-2013)
- Meteorological parameters will be used from data of state monitoring system and open sources (1980-2013)
- Data for hydrological and hydrochemical parameters will be drawn from the state monitoring and additional monitoring, which is conducted in the Soils2Sea project.

Model calculations for verification of specified process descriptions (developed in the Soil2Sea Project) will be conducted based on monitoring data for 2014-2015.

7.2.3 Measures at sub-basin scale

The median sub-basin resolution of the E-HYPE set-up is 214 km^2, which is larger than most of Soils2Sea's focus areas. The available process conceptualisations for nutrient retention/release/removal will be tested for present and historical conditions and improved on the basis of results from work packages 3 and 4. To this end, model sub-basins which cover the focus areas can be extracted from the overall model set-up and changes in parameterisation, flow path conceptualisation, and SLC class composition can be evaluated. This includes a validation of the continental data bases on which the initial model set-up is built, using the local to regional information available from work packages 3 and 4. Model sensitivity analyses will be performed to assess the influence of (a) model parameterisation, (b) modelled process conceptualisations, and (c) SLC class composition of the BaltHYPE model set-up on the overall representation of nutrient process dynamics relevant to programs of measures for riverine load reductions. The extracted sub-models can include downstream catchment areas down to the eventual outlet into the Baltic Sea to evaluate impacts of on net nutrient loads into the sea.

Up-scaling options in BaltHYPE will strongly depend on the nutrient transport/retention processes identified as important for targeted remedial measures in WP3 and WP4. HYPE is structured around soil/groundwater and lake volumes which act as discrete storages and reactors for nutrient processes (these are lumped conceptual model structures). Furthermore, there are nutrient processes in the stream network. The model domain is discretised in sub-catchments, which consist of one or several of the above-mentioned model structures, each parameterised to represent a certain generic soil-land use combination (SLC). Parameterisation in this context includes both physical properties, e.g. runoff coefficients and field capacities, and nutrient process related properties, e.g. fertilisation amounts crop nutrient uptake, or denitrification rates. HYPE's SLC classes represent hydrotopes which react uniformly over the whole model domain, even though some regional correction to SLC properties can be applied. This means that a certain SLC class will react uniformly over the whole model domain, whereas the modelled state of an SLC class within specific sub-catchment can vary greatly during runtime due to different forcing conditions. Currently, we envisage the following general types of process up-scaling challenges to be solved in Soils2Sea:

- Processes which can be coupled to existing or implementable spatial units of HYPE. An example for such a process could be a refined SLC classification with varying denitrification rates based on computed travel times to the groundwater surface which would allow testing the impact of dedicated changes in fertilisation regimes in high risk areas.
- Processes where no direct coupling to spatial units is possible and which require changes in the process conceptualisation, e.g. buffer strips along stream, which currently are implemented as simple percentage of the total stream length within a sub-catchment with fixed retention efficiency. For testing of differentiated measures,

it might be needed to refine the concept to allow for non-linear filter efficiencies and/or coupling to certain SLC classes.

For the Tullstorps Brook focus area, a HYPE model with higher sub-basin resolution will be compared with the generic BaltHYPE set-up in order to elucidate scale resolution dependencies within the HYPE model concept. In the Tullstorps Brook catchment, a number of remedial measures have been implemented in recent years to decrease nutrient loads in the river system. These include re-establishment of wetlands, stream bed remodelling, and buffer zones. These locally targeted measures in combination with nutrient monitoring provide an opportunity to test the BALT-Hype model's capability to represent these measures within the model concept.

7.2.4 Tests against historical data

Concurrently to the Baltic Sea Basin model implementation and evaluation work, the model will be tested against historical data series of nutrient concentrations and/or loads in river systems where such data are available (publicly or within the partner network), e.g. from national monitoring data bases or the European Environmental Agency's WISE database, at measurement sites where historical trends are detectable.

This requires the acquisition and preparation of suitable measurement series, and data-based analysis, i.e. trend detection, on selected data sets. A priority will be given to series, where riverine nutrient load trends correspond to legislative initiatives and programs of measures as e.g. the EU Nitrates Directive.

In a second step, the time series will be compared to corresponding BaltHYPE model results, and the model's capability to reconstruct the observed trends will be evaluated. The results from this exercise will provide important information for the interpretation of scenario impacts, as they shed light on the dynamic (or non-dynamic) behaviour of the model structure and can thus serve to qualify scenario results. Similarly, the insights gained here will also aid in setting up the scenario run procedure to be used in task 5.5, e.g. how initial conditions for scenario runs are to be attained or how static model constructs must be altered in order to be able to include dynamic scenario assumptions.

7.2.5 Scenario analyses at Baltic Sea scale

Scenario analyses require a robust BaltHYPE model set-up (as a result from tasks 5.1 and 5.3) as well as climate change and nutrient reduction measure scenarios (from task 2.4). The scenarios or combinations thereof will be used to assess impacts of climate change and projected anthropogenic changes on the Baltic Sea Basin scale. A focus will be the evaluation of net reductions of nutrient loads to the Baltic Sea. The results will be compared to nutrient load reduction targets, and non-uniform regulation strategies (programmes of measures) will be tested to assess the cross-regional impact. The results will be visualised in interactive maps to illustrate the impact of targeted regulation measures. The results will be made available to stakeholders and the public via an interactive web platform.

Climate change impacts on stream flow thresholds, established to ensure good ecological status of Baltic Sea coastal waters, will be assessed (in collaboration especially with tasks 2.4 and 6.3). Multiple climate change forcing data sets will be used in order to gauge climate projection uncertainty and its influence on overall reductions. The interaction of differentiated P and N measures will also be assessed in order to determine optimisation of a combined approach to reduce P and N.

7.3 Outputs

There are five deliverables connected to this work package. Four deliverables are reports on results of one or more individual work package tasks, which will be either submitted in form of a project report or a scientific article:

- Report detailing model application results for the pan-Baltic Sea model. Here, results from task 5.1 and 5.3 will be presented and discussed.
- Report detailing BaltHYPE model performance for the Pregolya River basin and discussion of model reliability at various scales. Connected to results from task 5.2.
- Report detailing reliability of the BaltHYPE model to simulate change in nutrient load. Here, results from task 5.4 and 5.3 will be presented and discussed.
- Report detailing projected impacts of climate, anthropogenic change and remedial measures for nutrient loads to the Baltic Sea. This deliverable is connected to task 5.5 and will present an integrated overview of the Baltic Sea modelling effort taken on in this project.

In addition to the document outputs, the list of deliverables from this work package also include a web platform, on which model results are made available to end-users at the end of the project. The platform will build on existing similar platforms hosted by the Swedish Meteorological and Hydrological Institute (SMHI), e.g. http://e-hypeweb.smhi.se.

7.4 Timing and dependencies with other project activities

The timing of the five tasks is shown in the Gantt diagram in Appendix A together with the timing of the deliverables and milestones.

Most tasks in this work package commence only towards the second half of the project, owing to the integrative character of the project activities here (Appendix A). The one exception is the HYPE model exercise in the Pregolya river catchment, which starts at project month three, early on in the project. The Pregolya study is one of the focus areas in the project, but, given that it is by far the largest area, it holds a somewhat special position and will be modelled with HYPE as well, but with different sub-basin scales and more localised input data and thus serve also as test-bed for the impact modelling capabilities of the Baltic Sea basin model.

Again owing to the integrative character, many tasks in this work package rely heavily on prior results from work packages 2, 3, and 4. This becomes important where the “donor” tasks in those work packages do not finish before late in the overall project time. Here, knowledge transfer has to be organized between the respective tasks. This is the case for task 2.1 and 2.4, Scenarios for the Baltic Sea Basin, which cover information on land use cover as well as scenarios of programs of measures. Even though the relevant task in this work package, 5.5, also runs only in the last year of the project, there is still an overlap in task run times. Results from work packages 3 and 4 on relevant nutrient retention/release/removal processes will feed into tasks 5.1 and 5.3, where they are used to improve the Baltic Sea sub-basin scale process representation.

The results of model and experimental work in the focus catchments, in work packages 3 and 4, will inform scenario construction in work package 2, and thus also have indirect connections to activities in this work package. The relevant tasks, however, overlap with the tasks in this work package, and knowledge transfer deadlines need to be established in order for scenarios to be readied timely for final analysis in task 5.5.

On the downstream side of information flow within the project, work package 5 results will feed into work package 6, as scientific basis for discussions with stakeholders at work shops in task 6.4 and publication to stakeholders and the wider public in policy briefs.

7.5 References

Donnelly C, Arheimer B, Capell R, Dahné J, Strömqvist J (2013) Regional overview of nutrient load in Europe – challenges when using a large-scale model approach, E-HYPE. IAHS Publ. 361, 49-58.

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8. Governance, monitoring and stakeholder process

8.1 Objectives

The aim of WP6 is threefold:

- First, new governance concepts will be developed and tested. These will be targeted at differentiated output-based regulations and include the concept of thresholds for nitrogen in groundwater.
- Second, monitoring concepts for differentiated regulations will be presented and discussed.
- Lastly, stakeholders will be involved in the project, particularly in the development of new governance concepts.

This WP will eventually lead to a Policy Brief in which the project outcomes are summarised and translated into policy recommendations targeted at different policy levels (i.e. local, regional, national and supra-national level). Figure 8-1 illustrates how the different parts of the WP are connected to each other.

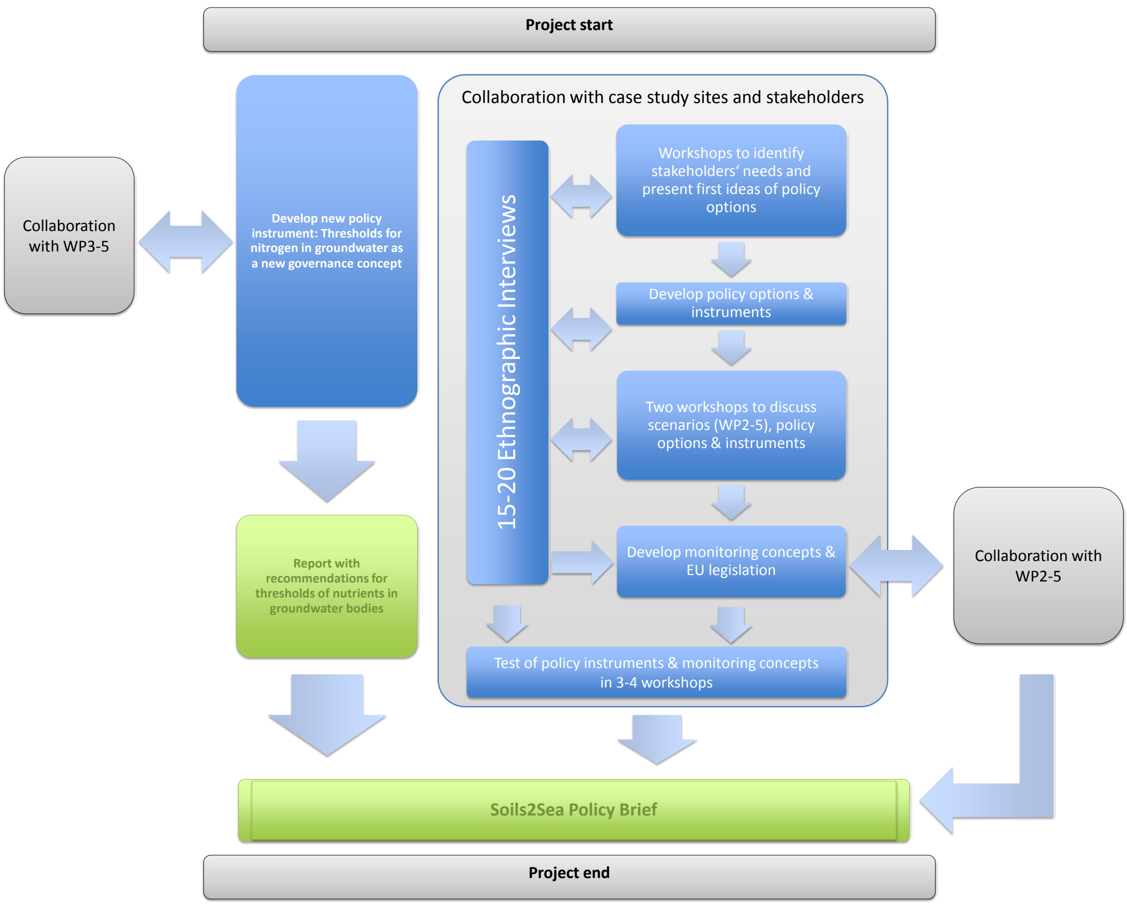

Figure 8-1 Different elements of the WP and their interconnectness

8.2 Methodology

8.2.1 Thresholds for nitrogen in groundwater

According to the Water Framework Directive ("WFD", Directive 2000/60/EC)) the EU member states should ensure good status of all surface water and groundwater bodies in 2015. The Groundwater Directive ("GWD", Directive 2006/118/EC), adopted in 2006 as a daughter directive of the WFD, stipulates that groundwater threshold values have to be established for groundwater bodies where existing quality standards do not ensure good status of groundwater dependent terrestrial and associated aquatic ecosystems. A methodology for derivation of groundwater threshold values was proposed by the EU FP6 project "BRIDGE" (Müller et al., 2006, www.wfd-bridge.net)), demonstrated in a number of European case studies (Hinsby et al., 2008) and finally developed into a guidance on groundwater status and trend assessment (European Commission, 2009).

Box 8-1 Groundwater chemical status and threshold values

NOTE! Groundwater has poor chemical status and does not comply with the good status objectives of the Water Framework Directive if the average of concentrations in shallow oxic groundwater exceeds the average groundwater threshold value of a catchment established to ensure good ecological status in an associated or dependent aquatic or terrestrial ecosystem. However, some parts of the catchment (fields or sub-catchments) may not exceed the threshold value. Hence, these comply with the Water Framework Directive and are not obliged to introduce new measures to reduce nutrient loadings. It is therefore of importance to identify fields or sub-catchment which comply or do not comply with the WFD in order to be able to differentiate and optimize required regulations between different parts of the sub-catchments. Passive sampling of oxic groundwater and drainage water for estimation of time and flow-weighted average TN concentrations is probably the most cost-efficient way to monitor the output from specific fields to document that the leakage of nutrients does not breach the established threshold values and hence comply with the good status objectives of the Water Framework Directive.

Currently most EU member states report and use the general quality standard for nitrate listed in Annex I of the GWD (50 mg/l) as the threshold value in River Basin Management Plans, as they argue that data and general system understanding to derive groundwater threshold values based on the environmental objectives of dependent terrestrial and associated aquatic ecosystems are generally not available (Scheidleder, 2014). While this is often the case Hinsby et al. (2008, 2012) suggest an approach to derive groundwater threshold values based on monitoring data and good status objectives of transitional and coastal waters and demonstrate by examples in the catchments to Odense estuary (Odense Pilot River Basin) and Horsens estuary, respectively, how threshold values may be calculated provided that sufficient monitoring data in both the estuaries and the river basins are available. The calculation requires that a sound understanding of the ecosystem status and functioning is available for the investigated aquatic ecosystem at risk so that nutrient target values (maximum acceptable nutrient loadings) can be established. The examples of threshold value derivation in the catchments of the Odense and Horsens estuaries demonstrate that the general quality standard is often not sufficient to ensure good ecological status of associated aquatic ecosystems, and that the threshold value for nitrate in many cases need to be significantly lower than the general quality standard of 50 mg/l nitrate to protect these ecosystems.

Maximum acceptable nutrient inputs are typically established as target values (= total acceptable annual loadings of e.g. total nitrogen = TN or total phosphorus = TP) to ensure good ecological and environmental status of aquatic ecosystems such as e.g. the Baltic Sea (HELCOM, 2007) or transitional and coastal waters (e.g. Odense and Horsens Fjord, Hinsby et al., 2008, 2012), and these target values should be used as the point of departure for derivation of corresponding groundwater and stream threshold values protecting these ecosystems.

Box 8-2 Ecosystem target nutrient loads and groundwater threshold values

Generally, groundwater threshold values for protection of groundwater dependent or associated aquatic ecosystems need to be derived based on target values (maximum acceptable loads) for the relevant aquatic ecosystem. This requires extensive monitoring and modelling data that allows for a reliable quantification of the different sources of the nutrient inputs to the aquatic ecosystem in question. However, when target values and the sources are identified and quantified e.g. by the use of dynamic and physically distributed integrated groundwater-surface water models (Hansen et al., 2009; Hinsby et al., 2012; Højberg et al., 2014), it is possible to estimate nutrient loadings and threshold values for the main nutrient source, which is typically large rivers or streams discharging to transitional and coastal waters. That is if the target nutrient load to an estuary (or alternatively a lake etc.) is estimated to be 75 % of the actual load then the total nutrient flux from streams and groundwater to the estuary typically need to be reduced to 75 % of the actual loading (Figure 1 – Hinsby et al., 2008, 2012, Dahl and Hinsby, 2013). Note though that required reduction in nutrient loads in some cases may be obtained more efficiently by reduction in atmospheric sources (Schernewski, 2014).

8.2.1.1 Using innovative monitoring concepts and threshold values for groundwater, drains and streams for WFD compliance tests and differentiated regulation

Threshold values can be established at different levels (whole catchment, sub-catchment or plot scale) as a governance and management tool in e.g. coastal catchments depending on the available data and the need for differentiated regulation based on measurements of actual output of nutrients. The required reduction in total loadings could for instance be reflected in a similar required reduction for the most important direct input to the receptor such as a river (Box 8-1, Figure 8-2). In this case, it is generally relatively easy to derive a river/stream threshold value if sufficient monitoring data (nutrients concentrations and runoff / flow-weighted nutrient concentrations) at the discharge point are available. It is more difficult to estimate the corresponding threshold value for groundwater or streams in the upper part of the catchment as this requires estimation of the Dilution Attenuation Factor (retention factor) of the nutrients in groundwater (Müller et al., 2006; Hinsby et al., 2008; European Commission 2009) and the nutrient retention in streams and lakes (Hinsby et al., 2012). However, threshold values for upstream reaches and groundwater corresponding to the threshold value for the stream at the discharge point to the estuary in the catchment may be established based on knowledge of dilution and attenuation (the Dilution Attenuation Factor, DAF) of the nutrients flowing through groundwater and the nutrient retention in streams and lakes if sufficient monitoring data are available (Hinsby et al. 2008, 2012). The DAF for TN may be estimated as the ratio between the average concentration of TN (alternatively nitrate) in streams (C_{obs}) and the average TN concentration in oxic groundwater (C_{ae}) in relevant catchments or sub-catchments assuming the TN concentration in anoxic groundwater is insignificant, see note below. The nutrient retention vary between different types of streams and lakes, but is generally considered to be percentual low, but relatively high in absolute retention in streams, rivers and lakes in the Baltic Sea basin in the winter time, where the highest nutrient loadings occur (Windolf et al., 1996),. Hence, stream threshold values in the upper part of the catchment generally need to consider the estimated nutrient retention in streams and lakes between the investigated location in the upper part of the catchment and the discharge point to the estuary in the lower part of the catchment (Figure 8.2).

Box 8-3 Nitrate and TN in oxic and anoxic groundwater

Note! There is no nitrate / NO_3-N in anoxic groundwater and TN (total organic nitrogen + total inorganic nitrogen = NO_3-N + NO_2-N + NH_4-N) concentrations are generally insignificant in anoxic Danish aquifers compared to oxic aquifers (1-2 orders of magnitude lower). The DAF has been estimated for the catchment of the Odense estuary in Denmark to be between 0.4 and 0.6 values (Hinsby et al., 2008), which are typically values for Danish catchments. If we assume an average of the DAF of 0.5 in Danish catchments the threshold value for TN in oxic groundwater (TV_{OG}) will generally be: $TV_{OG}= TV_{US}/0.5$ or twice the threshold value estimated for streams. TN concentrations in oxic and anoxic aquifers, however, depend on the local geological setting, and they should be monitored in both oxic and anoxic parts of the relevant aquifers in specific catchments in order to be able to estimate the Dilution Attenuation Factor properly for the investigated catchment or sub-catchment.

Threshold values for drainage waters, which typically are composed of oxic or dominated by oxic groundwater, and shallow oxic groundwater depend on the nutrient dilution and attenuation between the discharge points of the drains, or between the recharge areas of the shallow groundwater and the stream. Let’s consider six possible examples:

1) The drain discharges directly to the stream and no significant instream retention occur between the discharge point and the associated ecosystem at risk (drain 1, Figure 1).
2) The drain discharges to a wetland (contructed or natural), which are not protected nature, and which has been documented to remove all nutrients before it ultimately discharge to the stream (drain 2, Figure 1)

3) The drain discharges to a wetland, which removes only 50% of the incoming nutrients before discharge to the stream
4) The drain discharges to a protected wetland with protected flora and fauna
5) The field is not drained and is has been shown that all recharged groundwater below this field has a relatively high residence time in the anoxic groundwater zone before discharge to associated ecosystems at risk
6) The field is not drained but it is shown that only 25% of the recharged groundwater flows through the anoxic groundwater zone and the DAF is estimated to be 0.75.

Re 1) In this case the threshold value for TN the drain equal the threshold value for the stream at the discharge point divided by the dilution attenuation factor in groundwater ($TV_{D1,TN} = TV_{US}$ / DAF). If significant nutrient retention occur in streams and lakes between the discharge point of the drain and the discharge point to the protected ecosystem, then this should be taken into account in the calculation of the upstream threshold value and hence the drain threshold value i.e. $TV_{US} = TV_{DS}$ / RF and $TV_{D1,TN} = TV_{DS}$/DAF x RF , where DAF is the Dilution Attenuation Factor in groundwater and RF is the retention factor in streams and lakes, see box 8-4).

Re 2) This drain need no specific threshold value as the nutrients are removed before discharge to associated aquatic ecosystems

Re 3) The threshold value for TN for this drain ($TV_{D2,TN}$) is twice the threshold value for the stream ($TV_{D2,TN} = TV_{US}$ / DAF = TV_{US}/0.5 = 2xTV_{US}). Note this is only the case where the removal of nutrients in the wetland has already been taken into account in the calcution of the general dilution attenuation factor in the subcatchment i.e. when the drain discharge was located at the bottom of the hillslope (at the edge of the wetland) at the calculation of the DAF. If the discharge point of the drain is moved from the stream to the edge of the wetland after calculation of the dilution attenuation factor then the increased attenuation in the wetland may be included accordingly in the calculation of the drain threshold value.

Re 4) The protected terrestrial ecosystem most probably have stricter thresholds than then associated aquatic ecosystem and the drain need to be redirected to unprotected or constructed wetlands

Re 5) All nutrients are removed before discharge to the ecosystem at risk and no specific thresholds are required (i.e. the general quality standard for e.g. nitrate defined in the Drinking Water, Nitrate and Groundwater directives apply if drinking water resources are at risk)

Re 6) The threshold value for oxic groundwater ($TV_{OG,TN}$) below this field is: $TV_{OG,TN}$ = TV_{US}/DAF = TV_{US}/0.75 = 1.3 x TV_{US})

Box 8-4 Abbreviations

DAF = dilution attenuation factor in groundwater
RF = retention factor for nutrients in streams and lakes
TV = threshold value
TGV = target value
TV_{DS} = threshold value downstream just before discharge to associated aquatic eco-system
TV_{US} = threshold value upstream in upper part of catchment
$TV_{D1,TN}$ = threshold value for total nitrogen in drain 1
$TV_{D2,TN}$ = threshold value for total nitrogen in drain 2
$TV_{OG,TN}$ = threshold value for total nitrogen in oxic groundwater
$TV_{AG,TN}$ = threshold value for total nitrogen for anoxic groundwater

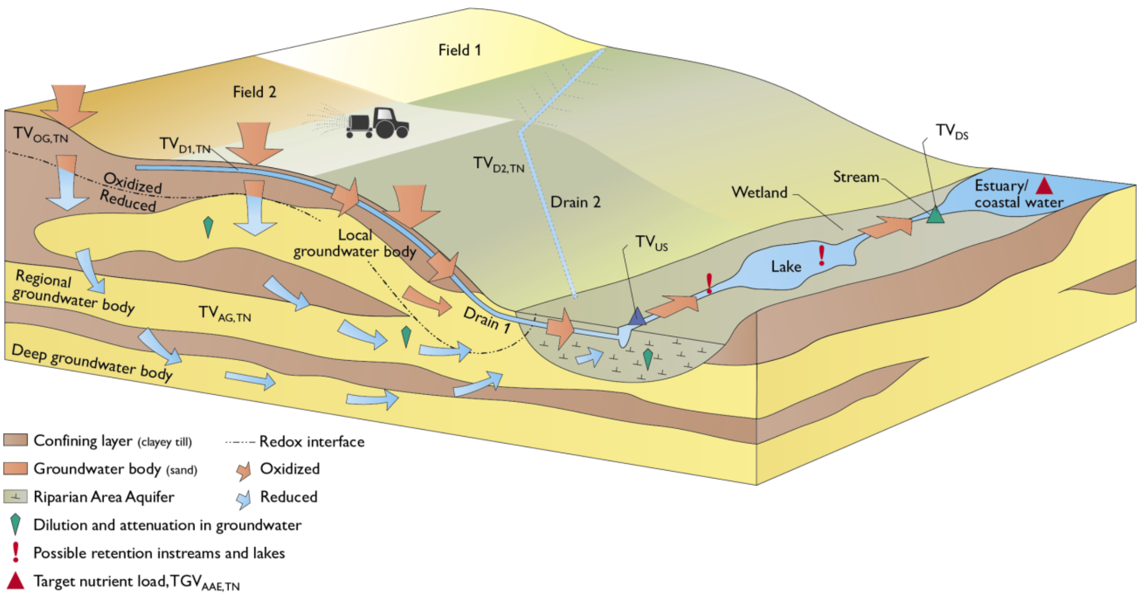

Figure 8-2. Conceptual model of coastal catchment with indication of total nitrogen (TN) fluxes / flow paths. The use of target nitrogen loads (target values) for the estuary (groundwater associated aquatic ecosystem) and threshold values for different sources for compliance testing are also indicated. Drain 1 discharges directly to the stream, drain 2 discharges to wetland, which remove all or part of the dissolved nitrogen. See box 8-2 for explanation of abbreviations.

On farm lands where it can be shown that the major part of the infiltrating water passes through anoxic groundwater zones at shallow depths the threshold value may even be higher than the general quality standard of 50 mg/l of nitrate if this water does not put any ecosystem or water supply well fields at risk. In contrast thresholds for drainage waters from sub-catchments or fields which are practically completely drained (~ 100 % of net precipitation) directly to streams should have the same threshold as derived for the stream discharging to the protected aquatic ecosystem provided that insignificant retention occurs in the stream (Figure 8-2). For the catchment to the Horsens Fjord estuary the estimated flow-weighted threshold for the streams discharging to the estuary is 3 mg/l of total nitrogen

(TN) (Hinsby et al. 2012). Hence with an estimated average attenuation and dilution factor of about 0.5 in groundwater between soils and streams the average groundwater threshold value for total nitrogen in shallow oxic groundwater in the whole catchment have been estimated to be approximately 6 mg/l (3/0.5) under current conditions (Hinsby et al., 2012). Due to different conditions such as varying degrees of drainage and the relative importance of flow paths through the anoxic groundwater zone i.e. varying attenuation and dilution factors between soils and streams in different parts of the catchment; the threshold value may in reality vary between the threshold value for streams (3 mg/l TN), where drainage waters are discharged directly into the stream, and the general quality standard for nitrate in the GWD of 50 mg/l (~ 11 mg/l NO_3-N). The latter may be even higher if it can be documented that the infiltrating waters are reduced before they reach water abstraction wells or vulnerable ecosystems (Hinsby et al., 2012). Where the drainwater is discharged into wetlands (natural or constructed) the attenuation in the wetland can be taken into account and hence allow for higher threshold values for TN. Note, however, that if the wetland and its vegetation are protected as e.g. a Natura 2000 site, the threshold value may be even stricter than for aquatic ecosystems i.e. most probably considerably less than 3 mg/l of TN.

We suggest using the application of groundwater, drain and stream threshold values as basis for a new governance concept for developing differentiated regulation based on monitoring total nitrogen load or flow-weighted concentrations in drains (outputs from farms) and streams and compare these to the derived threshold values for groundwater and streams i.e. to define the groundwater and stream chemical status according to the European Water Framework and Groundwater directives and guidelines (Directive 2000/60/EC, Directive 2006/118/EC, European Commission 2009, Hinsby et al., 2008, 2012, Dahl and Hinsby, 2013) also at local scale. New monitoring device developments e.g. by Sorbisense (to be tested in WP3) for the passive sampling and monitoring of average flow-weighted drain and stream nitrogen concentrations (fluxes) appear to be a promising and cost-efficient tool for this purpose with a large potential for future water monitoring, management and governance in line with requirements of EU directives and the “Blueprint to safeguard Europe’s water Resources” of the European Commission (European Commission, 2012). The system is relatively easy to apply for both farmers and authorities.

The monitoring and governance tools will be developed and tested in the case study sites: the Norsminde Fjord/estuary, Horsens Fjord/estuary the Warta river with its wetlands and the Jeziorsko reservoir. The tool will be used to demonstrate which part of the groundwater bodies in a catchment that breaches the derived threshold value, and hence do not comply with the environmental objectives of the Water Framework Directive. The tool needs to take into account variable dilution and attenuation of the nutrients between soils and streams in the catchment primarily occurring in groundwater as described above.

8.2.2 Developing policy options for differentiated regulations in cooperation with stakeholders

Several alternative policy options will be proposed, including ones that empower local stakeholders collectively to commit to targets and decide on technical measures to implement. The new policy options will be evaluated in close interaction with local stakeholders (i.e. farmers, land owners, land managers and their organisations, NGOs, community members and local political decision makers) in the case study areas, namely Norsminde (DK), Tullstorp (S) and Kocinka (PL).

In order to ensure a smooth cooperation with stakeholders, the process of developing the policy options is divided into five interrelated steps (Figure 8-1). The stakeholder interaction will include two formal consultation rounds. One session will be held in the beginning of the project with an emphasis on identification of stakeholders' needs to maximise impacts of project deliverables (step 1). The input gathered from this series of workshops will be used to formulate policy options (step 2). In parallel to the first workshop series and work on the policy options, ethnographic interviews will be conducted (step 3). Their results will also feed into the ultimate formulation of policy options. Once these have been formulated, they will be presented and discussed at the second series of workshops (step 4). In parallel to these steps, legal analysis (step 5) will ensure that the policy options formulated fit within the existing legal framework and are feasible from a legal point of view (see 8.2.3). The following sections will present each individual step in depth.

8.2.2.1 First round of workshops: setting the scene together with the stakeholders (step 1)

Soils2Sea will assess stakeholder attitudes to several policy options for spatially differentiated monitoring and regulation of nitrogen loadings, where the focus is on control of outputs instead of inputs. Drain pipe measurements do not indicate the source point of Nitrogen input over a large farming area. This implies that farmers may need to make collective commitments in order to achieve a reduction of outputs.

The aim of the first workshop is to introduce the project to stakeholders and to engage them in actively contributing to the assessment of policy options. To this end, the first series of workshops will use mind mapping combined with the Disney Method, a workshop method used:

- to depart from the usual way of thinking,
- to start group discussions, and
- to agree on action.

Disney Method, combined with mind mapping

Initially the group thinks as **"outsiders"** and review the facts, data and external viewpoints regarding the issue at hand (in our case: reducing N and P loadings from agricultural land running into the Baltic Sea). Group participants may take on the roles of consultants, customers, suppliers or competitors in order to get a more rounded view of the issue. Findings are noted down on wallpaper so as to remain visible during the duration of the workshop.

The group then leaves the room and re-enters as **"dreamers"**. Participants strive to imagine an ideal solution without any constraints. They brainstorm ideas to resolve the problem using divergent and creative thinking. No criticism or judgment is allowed. Many ideas are generated and written down in a mind map.

The group leaves the room and then returns as **"realisers"** – realists with a practical, constructive mindset. They review the ideas that the dreamers generated and apply criteria to converge on the best ideas. Once they have selected the best idea, they work on a project plan with costs, timescales, risks and benefits. These thoughts are added to the mind map using a different colour.

Lastly, the group assumes the role of a **"critic"** who reviews the plan in order to identify problems, obstacles and risks. Participant's comments are not negative or cynical but critical and constructive. Their objective is to spot the issues within and improve upon the plan. Notes will again be made in an additional colour to the mind map. At this stage, the process might be complete or you might want to go back to one of the other styles in order to get an outsider's view of the plan, to dream of new or enhanced plans or to work as realisers on the details of the plan. This method generally delivers good ideas and well-considered "project plans". Source: Adapted from http://www.destination-innovation.com/articles/?p=238, 24 March 2014.

The Disney Method combined with mind mapping is well suited for the first round of workshops in which we would like to develop – together with the stakeholders – basic ideas and central elements of potential policy instruments. The workshop can be opened with a presentation about the (preliminary or planned) findings from WPs 2-5. We will then apply the Disney Method to develop ideas of possible policy instruments together with the stakeholders.

8.2.2.2 Formulating policy options (step 2)

The next step is the formulation of policy options and corresponding policy instruments – based on the results of the first stakeholder workshop – in detail, to be presented halfway through the project. In this sense, a policy option is a certain measure that can be implemented through different types of policy instruments. For an overview of different types of policy instruments, see Table 8-1 below.

Table 8-1: Types of Policy instruments

Regulatory instruments	Compulsory regulation, bans, standards, limits
Planning instruments	Regional planning, land-use, urban planning
Market-based instruments or economic instruments	Revenue-generating instruments (taxes, charges) Subsidies (direct payments, tax allowances) Property rights (licenses, tradable permits) Others (user benefits, environmental liability, payments for ecosystem services)
Public investments	Infrastructure investments, procurement, R&D spending
Cooperation-based instruments	Voluntary commitments, negotiations, networks
Information-based instruments	Information campaigns, education, advisory services and capacity building, labelling, environmental reporting, environmental monitoring, access to information and justice rights

The ideas outlined here are first attempts towards the formulation of policy options.

<u>Option 1: Change of current land use and land management</u>

Short description
The degree of nutrient loss depends on different factors, such as agricultural practices, crop type grown, and use of fertilisers and manure in relation to climatic and geographical conditions. These factors can be taken into consideration for reducing nutrient loss – and as a con-

sequence for reducing the need for fertilisers. For example, appropriate crop management and good fertiliser management could be options to enhance use efficiencies of fertilisers and thus reduce losses. Measures like grassland upheaval should be restricted depending on the soils with the aim to reduce the nutrient leaching in general. In order to ensure that the best practices are used, campaigning or training material on land use management as well as land use change could be produced, accompanied by an advisory service that could be provided by a (local) authority.
Type of policy instrument
Information-based instrument
Actor (authority) responsible for defining the policy instrument
Authority responsible for implementing WFD. Sweden: The Water Authority (Vattenmyndigheterna) is responsible for the development of RBMPs, including the PoM. It could, therefore, together with the national authority for marine and inland waters (Havs och Vattenmyndigheten), be responsible for defining the policy instrument. Denmark: The Danish Nature Agency under the Ministry of Environment is in charge of developing RBMPs. It could, therefore, be the relevant authority. Poland: Responsibility of formulation and implementation of RBMPs is split over various actors at different levels in Poland. A relevant authority for this policy options would need to be identified in cooperation with stakeholders.
Actor (authority) responsible for implementing the policy instrument
Authority responsible for implementing WFD would need to decide which land management practices should be promoted in what way and by whom. Farmers are addressed as the target group and should eventually improve their techniques.
Target group
Farmers, extension and advisory services
Legal aspects
If the competent authorities engage informally in training measures, information dissemination etc., no specific legal rules would normally be required. However, the legal[1] framing of this option depends on whether the uptake of any new or changed agricultural methods is compulsory for the farmers or would entitle them to any benefits, notably receiving subsidies. In the event that these methods are to be prescribed in as compulsory, they would be contained in administrative law or in an EU directive or regulation. For example, the German "Düngeverordnung"[2] (Regulation on fertilizing) sets forth in detail the application of fertilisers. A need for monitoring would arise if there were such binding rules on the uptake of such measures or any financial incentives linked to it.

Option 2: Payment for Ecosystem Services (PES)

Short description
When taking other ecosystem services than crop-yield into consideration, for example clean water and high biodiversity, the payment for habitat management and other practises could be considered. Measures like re-establishing wetlands; establishing pesticide-free margins or uncultivated buffer zones along watercourses and lakes could deliver ecosystem services like reduced pollution, provision of clean water, and increased biodiversity, and therefore could be

[1] The following comments on legal issues are made against the background of German and/or EU legislation. It is likely that many of them would also apply in other legal orders, but this has not been double-checked.
[2] German text available online at http://www.gesetze-im-internet.de/d_v/.

a reason for the remuneration of farmers. Since many of these services are used by humans, animals and the like, the payment of the ecosystem services is a critical aspect. Good examples of this approach can be found in Munich, where the Munich public utility company ('Stadtwerke Muenchen' – SWM) supports organic farming practices to protect groundwater. Another example can be found in France, where the company Vittel pays for best practices in dairy farming in order to improve the water quality. If farmers reduce N and P loadings and thus contribute to ecosystem services, PES would provide incentives for actually doing so. Payments can be calculated based on the monetary value of ecosystem services provided by the land users or according to the income foregone due to extensification of land use.
Type of policy instrument
Market-based instrument/Economic instrument
Actor (authority) responsible for defining the policy instrument
The instrument is either defined by the Managing Authorities of Rural Development Programmes or private actors (e.g. Water companies) depending on type of payment (public or private).
Actor (authority) responsible for implementing the policy instrument
The instrument is either implemented by the Managing Authorities of Rural Development Programmes or private actors (e.g. Water companies) depending on type of payment (public or private).
Target group
Farmers, RDP managing authorities, public and private water companies, industry
Legal aspects
The legal rules necessary for implementing this option depend on the character of the PES scheme. For the three types of PES schemes (Greiber 2009:11ff)--purely private PES schemes, PES trading schemes[3] and public schemes-- a functioning overall legal system, including clear allocation of property rights over territory and/or natural resources as well a court-system where contracts can be enforced are necessary. Beyond that, however, the different types vary concerning the legal structure behind them: - Purely private PES schemes, such as the Munich and Vittel examples, would be dealt with through private contracts. For this purpose, no changes in the law will be required. The relevant actors would negotiate a private law contract that they could enforce, if needed, in civil law courts. - Public PES schemes, where a public body acts as the only or primary purchaser or provider of a specified ecosystem service, require a specific legal framework defining the rights and obligations of the public entity in particular. PES could be part of a grant/subsidies scheme, the details of which would normally be subject to either a public or private contract, depending on the national legal order. However, there would have to be an underlying legal act enabling the public authorities to spend money for PES purposes; this could be either a law/regulation (as is the case for grant schemes of the EU, e.g. the agri-environment-climate measures under the RDP) or incorporation of a budget line for this purpose in the overall public budget for a given year (which is the legal technique in Germany). The underlying legal act, if any, would regulate the basics of what kinds of payments are made to whom and under which conditions. Details of monitoring/verification could be either regulated and dealt with in the implementing contract – and enforced by contractual means – or in the underlying regulation.

[3] For PES trading schemes see policy option 3.

Option 3: Tradable permits

Short description
When taking other ecosystem services than crop-yield into consideration, for example clean water and high biodiversity, the payment for habitat management and other practises could be considered. Measures like re-establishing wetlands; establishing pesticide-free margins or uncultivated buffer zones along watercourses and lakes could deliver ecosystem services like reduced pollution, provision of clean water, and increased biodiversity, and therefore could be a reason for the remuneration of farmers. Since a lot of these services are used by humans, animals and the like, the payment of the ecosystem services is a critical aspect.
Type of policy instrument
Market-based instrument/Economic instrument
Actor (authority) responsible for defining the policy instrument
The instrument is either defined by the Managing Authorities of Rural Development Programmes, or private actors (e.g. Water companies) depending on what type of payment it is (public or private).
Actor (authority) responsible for implementing the policy instrument
The instrument is either implemented by the Managing Authorities of Rural Development Programmes, or private actors (e.g. Water companies) depending on what type of payment it is (public or private).
Target group
Farmers, RDP managing authorities, public and private water companies, industry
Legal aspects
With trading schemes, where different participants can trade pollution permits or credits for reducing environmental harm (e.g. emissions trading) a specific legal framework is required; this is true in particular as these schemes are normally established at the regional or national level to allow for a meaningful number of participants (Greiber 2009: 13). The relevant legal framework would have to define, among other, the allocation of credits and set up a mechanism for trading them. Monitoring and verification on whether activities leading to the generation of credits have actually been carried out will need to take place.

Option 4: Stricter input-based regulation

Short description
Targets for reducing N and P have to be met. However, current efforts are not sufficient in order to meet these targets. One option to further reduce N and P loadings would be to impose stricter top-down regulation. In order to ensure the implementation of a stricter regulation, fines could be imposed on those who do not comply with it. The problem with this measure may be that N and P loadings often have poor correlations with N and P inputs in particular field and farms, unless also agricultural land use and management of other forms are taken into account.
Type of policy
Regulatory instrument
Actor (authority) responsible for defining the policy instrument
Authority responsible for implementing the WFD. Sweden: The Water Authority (Vattenmyndigheterna) is responsible for the development of RBMPs, including the PoM. It could, therefore, together with the national authority for marine and inland waters (Havs och Vattenmyndigheten), be responsible for defining the policy instrument. Denmark: The Danish Nature Agency under the Ministry of Environment is in charge of devel-

oping RBMPs. It could, therefore, be the relevant authority. Poland: Responsibility of formulation and implementation of RBMPs is split over various actors at different levels in Poland. A relevant authority for this policy options would need to be identified in cooperation with stakeholders.
Actor (authority) responsible for implementing the policy instrument
Authority responsible for implementing WFD would need to decide on stricter regulatory instruments and on potential fines for non-complying farmers.
Target group
Farmers
Legal aspects
From a legal point of view, strengthening regulations and setting stricter target values at the EU level or at the national level would require monitoring and sanctioning.

<u>Option 5: Voluntary exchange of land</u>

Short description
Usually, a voluntary exchange of agricultural land[4] between landowners is undertaken to reduce operating costs and to improve the competitiveness of agricultural enterprises. With spatially differentiated knowledge on the danger of N and P leaching, exchanging land can be one option to increase yield while decreasing the needed amount of fertilizers. In addition to the spatially differentiated knowledge, this approach would presumably also require a solid basis of trust between all involved parties as well as a financial backup for the administrative costs. For example, within the rural development program (RDP) of Lower Saxony (Germany) a voluntary exchange is financially supported under the programme ZILE, *Zuwendungen zur integrierten ländlichen Entwicklung* (grants for integrated rural development) particularly for land consolidations. Alternatively, a different option could be working together with foundations or NGOs that could support land exchange programmes (e.g. through buying up fields that are in danger of leaching N and loosing P).
Type of policy
Cooperation-based instrument
Actor (authority) responsible for defining the policy instrument
Farmers themselves would jointly agree on how to (better) meet the existing targets for reducing N and P loadings.
Actor (authority) responsible for implementing the policy instrument
Farmers would need to create an authority and would need to agree on certain rules for making decisions, implementing agreements, etc.
Target group
Farmers and other landowners (incl. foundations, communities, churches, NGOs)
Legal aspects
A voluntary exchange of land is unlikely to need new or additional legislation. It would be done on the basis of existing property laws, through a civil law contract between the landowners. Only if financial support is provided from public budgets, would there need to be a specific legal basis allowing this financial provision.

<u>Option 6: Output-based regulation and monitoring</u>

[4] Soils2Sea will generate knowledge about how vulnerable certain areas are towards N and P leaching. This knowledge can be used for a spatially differentiated approach upon which a classification of vulnerability types can be built.

Short description
Formal regulations with clear reduction targets for nutrient losses together with constant monitoring, enforcement and follow up is identified as a good approach for reducing use of fertilizers. For Denmark, however, there is a need to improve fertiliser use and reduce leaching even further (Tan & Mudgal 2013). One approach could be the focus on output based regulations. Geographical, geological, water, stream and soil conditions are taken into consideration for defining levels and thresholds of output-based regulation. This relatively new approach requires answers to questions like: What geographical level describes the output (catchment, sub-catchment or even farm-level)? When different farmers share 'one' output, how can this be differentiated and how can individual responsibilities be assigned? How to assure farmers' acceptance of differentiated allowances according to certain soil typologies (e.g. through paying compensations)? And how could such a collective responsibility be enforced?
Type of policy
Cooperation-based instrument, Regulatory instrument and/or Information-based instrument
Actor (authority) responsible for defining the policy instrument
Farmers themselves would jointly agree on how to (better) meet the existing targets for reducing N and P loadings.
Actor (authority) responsible for implementing the policy instrument
Farmers would need to create an authority and would need to agree on certain rules for making decisions, implementing agreements, etc.
Target group
Farmer groups
Legal aspects
An output–based approach would have to be put in formal legislation. Some of the legal difficulties that would have to be addressed are the following: - Would such an approach be taken at the EU level or the national level? If the latter, does current EU legislation allow for its adoption? - How can the requirements of legal certainty and predictability, requiring that the addresses of legal rules know in advance what they need to do be reconciled with targets for individual farmers? Would local authorities be authorised to set differentiated targets? - Is it possible to impose a collective obligation to reach a certain target on a group of several farmers? How could such obligations be enforced and against whom? Would the farmers have to agree on a legal arrangement between them as a precondition?

8.2.2.3 Ethnographic interviews (step 3)

In parallel to the workshops and the work on the policy options, ethnographic studies will be undertaken to ensure the inclusion of cultural perspectives into the formulation of policy options. The aim is to understand the culture-induced knowledge and perceptions of the different stakeholder groups in the case study regions, especially towards risks stemming from groundwater and river pollution and prerequisites for possible acceptance of policy options.

In this case, "culture" refers to a group of individuals who know and share beliefs and values, but also behaviours, materials, social organisation and rituals. Specific characteristics of the local environment influence the character of a culture and, in turn, that culture's capacity to adapt to changes. For example, since the late 19th century, anthropologists and geographers have documented the close dependence of culture on the local environment, including how cultures develop knowledge and practices to exploit natural resources and manage, with varying degrees of sustainability, the environment (Dove et al., 2008).

For a number of reasons, it is rational to include a place-based focus in our cultural research. First, many of the impacts of nutrients loads are experienced at the local level, which is also the site for policy and programme intervention. Thus, it is important to understand the cultural dimensions that affect remedial action. Second, a focus on specific places and regions can lead to an increase specificity in what we mean by “culture” and what aspects of culture in particular affect possible uptakes of policy recommendations. Third, a research and policy focus on culture and river and ground water pollution would benefit from the comparison of case studies that are explicit in their theoretical and methodological approach to culture and capable of producing detailed and finely grained qualitative and quantitative findings and recommendations (Martinez et al., 2014). Finally, the way people think about environmental pollution is closely tied to how they think about a place as individuals within society. Perceptions are therefore not universal but rather located in a societal culture (e.g. of a nation/region) and embedded in institutions (e.g. environmental organizations or government agencies) and competing priorities in management of the environment. (Douglas et al., 1983) In this way, perceptions are profoundly political and need to be taken into consideration within the policies which Soils2Sea aims to develop and examine.

The Soils2Sea case study regions in Poland, Denmark and Sweden will provide those place-based research backgrounds. Information will mainly be collected through desk-research and narrative qualitative interviews:

- *Desk-research*: Researchers will screen available data to assess what information is readily available, and what gaps need to be filled from interaction with stakeholders. Sources will include archival material (e.g. photographs, images, maps, newspapers or public documentations of hearings) and policy documents, academic and grey literature, raw data and surveys.
- *Qualitative interviews*: Researchers will carry out interviews with selected stakeholders in the case study sites and at the broader regional/national level. Interviews will be conducted with local end-users (e.g. farmers and local authorities) and local residents. In addition, scientists from the disciplines of the humanities and social sciences, other cultural knowledgeable people as well as stakeholders from the ministries of environment and agriculture and/or agricultural networks will be interviewed. Identification and approach of stakeholders will take place in close collaboration with case study partners (CSP) and other contacts in the region. For example, Polish interviews will kick-off in October 2014 by attending the International Trade Fair for Environmental Protection (POLEKO). In cooperation with the International Office of the German Ministry of Education and Research (BMBF), a first set of invited stakeholder interviews will be carried out at the booth of the BMBF. The interview process will be timed to occur after the first Soils2Sea workshop in Kocinka in fall 2014.

In total, it is estimated that approximately 15-20 interviews, evenly distributed between stakeholders groups, will be conducted in the three case study sites/countries. Socio-cultural-ecological data is usually qualitative and will be presented in narrative text format. Interviews will be carried out face-to-face as well as by telephone. Interviews will be recorded by a digital voice recorder and transcribed into a document. As the information collected in the interviews will be used as part of our research, interviewees will be informed beforehand and will be able to request parts of the interview to remain confidential. Transcriptions of the interviews will not be made publically available and will be handled with confidentiality within the project for their relevant purposes. Consultation sessions may be included back to back with the workshops mentioned earlier. These sessions can take a range of formats and can vary in size according to the purpose of the consultation, constraints and the type and willingness of the stakeholders to be consulted. They can focus on a specific stakeholder group or can involve a mixed group of actors who may or may not be in conflict with one another. These sessions can engage 5 – 20 people, but the total can be larger if stakeholders are then divided into smaller sub-groups so that they again do not exceed a maximum of 20 people.

The socio-cultural-ecological data to be collected will include:

- Understanding/ explanation of the respective culture in general and the connection to nature/ the environment in particular, and the role of farmers in management of the land, nature and environment;
- The local/regional culture for dealing with agricultural pollution (beliefs, values, habits, political and economic context);
- Perceptions of output and input-based regulation;
- Perceptions and experiences of collective action among farmers;
- Information on individual and community perceptions of nutrient loadings;
- Information on the acceptance and uptake of reduction measures and plans;

It is expected that these socio-cultural-ecological data will deepen the understanding of the situation in the case study sites and will inform the development of locally appropriate measures, plans and policies.

For conducting the interviews at the local level it is expected that local language skills are required and hence sub-contractors may be needed (e.g. as interviewer or moderator/ facilitator and translator of the interviews into English). For the envisaged interviews at regional and national level, English might be sufficient as a research language.

8.2.2.4 Second round of workshops: from ideas to action (step 4)

Once the basic ideas stemming from the first round of workshops have been developed into fully-fledged policy options, stakeholders will be presented the results within a second series of workshops where they will discuss these options in depth. The World Café Method is very well suited to serve this end.

World Café Method

Drawing on seven integrated design principles, the World Café methodology is a simple, effective and flexible format for hosting a large group dialogue.

1) Setting: create a **"special" environment**, most often modelled after a café (i.e. small round tables covered with a chequered tablecloth, butcher block paper, coloured pens, a vase of flowers and an optional "talking stick" item). There should be four chairs at each table.

2) Welcome and Introduction: the host begins with a warm welcome and an introduction to the World Café process, setting the **context**, sharing the Café Etiquette and putting participants at ease.
3) Small Group Rounds: the process begins with the first of three or more twenty minute rounds of **conversation** for the small group seated around a table. At the end of the twenty minutes, each member of the group moves to a different new table. They may or may not choose to leave one person as the "table host" for the next round, who welcomes the next group and briefly fills them in on what happened in the previous round.
4) *Questions*: each round is prefaced with a **question** designed for the specific context and desired purpose of the session. The same questions can be used for more than one round, or they can be built upon each other to focus the conversation or guide its direction.
5) Harvest: after the small groups (and/or in between rounds, as desired) individuals are invited to share insights or other results from their conversations with the rest of the large group. These **results** are reflected visually in a variety of ways, most often using graphic recorders in the front of the room.
Adapted from http://www.theworldcafe.com/method.html, 24 March 2014.

As a result of the second workshop series, we will be able to prioritise the different policy options according to questions like:

- What is effective?
- What is acceptable?
- What is efficient?
- What is (too) expensive?
- What is technically feasible? etc.

These results will then be fed into the Policy Brief.

8.2.2.5 Output-focused monitoring and regulation approach (EI) (step 5)

Thus far, regulation of agricultural production has typically been based on monitoring and control of inputs (e.g. crop types and amounts of fertilisers). For example, in Germany the Düngeverordnung (“Regulation on Fertilisers”) defines what fertilisers farmers can apply, in which quantity, when and where; it serves as the implementation of the Nitrates Directive. Certain breaches of this regulation are considered misdemeanours and can lead to the imposition of a fine. In addition to compulsory regulation such as the Nitrates Directive, input-focused voluntary measures are also available to farmers through Rural Development Programmes, in particular through the agri-environment measure (future agri-environment-climate measure). The input-focused regulation and voluntary measures put a significant administrative burden on farmers without allowing them the flexibility to find solutions based on the specific biophysical conditions of their farms, local knowledge and economic constraints. The monitoring of water pollution and the impact of regulation/voluntary measures on pollution levels is carried out by competent authorities of the Member States, and farmers/landowners themselves are removed from this process.

In the area of biodiversity-protection, several EU Member States have begun testing so-called “results-based” or “indicator-based” agri-environment measures, where the payment to farmers is based on providing a certain result or outcome, rather than on prescribing management actions or control of inputs (Hasund 2013; Burton and Schwarz, 2013).

In this project, an alternative monitoring and regulation approach will be proposed which focuses on the control of outputs, in particular by controlling measurements of pollutants present in groundwater, tile drains and ditches. The new monitoring and regulation approach will be evaluated with respect to technical feasibility and social acceptance in the second round of consultations (step 4). Here, focus will be on identifying possible barriers (e.g. acceptance of collective responsibility in contrast to individual responsibility and on aspects of legality) due to uncertainty regarding where the nutrient from one farmer's field flows and in which drain and ditch it will be measured (the technical aspect of this is studied in WP3).

A monitoring and regulation approach focused on outputs may require the acceptance of collective responsibility and the application of a collective approach by farmers. Currently, collective approaches are not integrated in the Nitrates Directive or the Environmental Quality Standards (Directive 2008/105/EC).

Collective targets/pollutants monitored by the polluters themselves are not covered in the current relevant EU instruments, notably the Nitrates Directive, and the Environmental Quality Standards (Directive 2008/105/EC). All of these directives follow a classical top-down regulatory approach with the legislator/regulators adopting measures (including setting maximum levels) and being responsible for monitoring and enforcement.

However, in other areas of EU (and consequently) Member States' environmental law, approaches based on the self-monitoring of companies exist. Examples of this approach include the Kimberley Regulation, the Timber Regulation as well as the draft Regulation for implementation of the Nagoya Protocol. In these schemes, operators are required to pass on certain information to each other and provide re-assurance to each other that the respective commodity complies with the applicable legal requirement, i.e. they have a due diligence duty. Independent third-party bodies are tasked with verifying compliance; authorities have a limited role in admitting-the third-party verifiers and controlling them. However, these approached all relate to the management of supply chains for certain commodities and do not include any binding limits to pollution or other quantitative targets. Therefore, they do not provide guidance on the important questions of whether it is legally feasible to entrust polluters with monitoring their own pollution targets, who can be held liable by which standards when collective targets (should they exist) are not met, and how sanctioning/enforcement could work, taking into account rule-of-law principles. While some lessons may be drawn from the mentioned legal instruments building on self-regulation, it is necessary to go beyond these instruments.

For this purpose, a brief literature review will be conducted to assess if there are any indications of legal structures for self-regulation within common-based natural resource management (within the EU). This type of natural resource management is done in a setting where users (or polluters) of a certain natural resource use that resource by agreed upon rules and take collective responsibility for monitoring and enforcing these rules with a view towards sustainability as a "commons". Elinor Ostrom and others have investigated commons or common-pool resources, and have identified certain design principles that make the use of commons sustainable over long periods of time (Ostrom 1991: 90). These principles include: the use of the resource is monitored by monitors who verify the conditions of the common-pool resource and are credible to the ones using the resources; a system of graduated sanctions is applied; there are low-cost, quick conflict-resolution mechanisms; and there is a minimal recognition of the right to organise (i.e. the users of a resource can the devise their own institutions without government interfering with this right). It is thus expected that that body of literature on commons-based natural resource management could inform the development of appropriate legal tools, despite the majority of the existing literature on commons focusing less on the actual legal arrangements than the practical results achieved.

The ultimate aim of this step is to provide some guidance on if and how collective, stakeholder-based approaches towards setting self-monitoring and enforcing pollution limits, which are potentially developed with involvement of polluters themselves, could be built into the existing legal system of EU and German environmental law.

8.2.3 Test of the output-focused monitoring and regulation approach outside of case study areas

Preliminary versions of the new policy instruments and monitoring concepts developed through interactions with stakeholders in the three case areas will be tested in three national/regional workshops, where 15-20 stakeholders will be invited to comment. In these workshops, the new concepts will be discussed and verified with different stakeholders at different levels (e.g. farmers, farmers associations, or state agencies). In addition to the project partners, who will present their scientific findings, subcontractors for administrative tasks of the workshops (e.g. involving possible workshop participants, moderation or translation) are required.

Ideally, there will be three workshops at different levels to test new policy instruments and monitoring concepts. They will span from a regional to national level, concerning aspects of transferability and up-scaling of project results.

- The first workshop can be held adjunct to the work carried out in the case study site of Pregolya. This is the only case study site in the project, where transboundary problems are acknowledged. This case can be supported by interviews. One main task of this workshop will be raising awareness for the topic of eutrophication. Further information about the case study and the stakeholder involvement can be found in Chapter 3.
- For a workshop in Germany, we could focus on the regional level. We will test the responses to the different policy options that were discussed in Detail in WP6.2. The Landwirtschaftskammer, Agricultural Commissioner for Schleswig-Holstein, has stated his support in the proposal. Other stakeholders could stem from the Ministry of Environment in Schleswig-Holstein or the State Agency for Agriculture, Environment and Rural Areas.
- The workshop with the widest focus could be held in Denmark. Experts from a national level can be invited to discuss an up-scaling of the project results. Stakeholders could come from the Danish Ministry of Environment or the Knowledge Centre for Agriculture, Denmark, which have already confirmed their support in the proposal.

The format of the three workshops should be based on methods used in previous WPs. First, the results of the project will be presented by project-partners. The language of the workshops should generally be in the language of the respective country, exceptions can be made when the list of participants are conducted. Secondly, an interactive format, like the World-Café Method, will elaborate on the issues of transferability, up-scaling and acceptance of the project results.

8.2.4 Policy Brief

The key findings and messages identified in WP2, WP3, WP4 and WP5 as well as in Tasks 6.1 to 6.4 will be synthesised into one policy brief (10 to 15 pages). The policy brief will aim to foster involvement of political decision makers at local and regional level by illustrating opportunities and scope for reductions of nutrient loads as well as choices of measures for sub-catchments. Therefore, recommendations will be made to policy-makers to provide them with a better understanding of different governance approaches and policy instruments for the main retention areas.

The brief will be tailored to audiences in the Baltic Sea region at local and regional levels and will be used in dissemination activities in WP1. Hence, the project findings will be translated into accessible languages and easily understood concepts, making them valuable for a wider audience of local and regional policy makers.

8.3 Outputs

WORKPACKAGE 6.1
Output expected for other tasks: Concept for TV-derivation and groundwater chemical status assessment as a governance and policy instrument for presentation and evaluation in WP 6.2-6.5
Deliverables and milestones: D6.1 Report with recommendations for approach to groundwater threshold derivation for nutrients (M36)
Journal articles/dissemination: Paper (e.g. for Env. Science and Policy)

WORKPACKAGE 6.2
Output expected for other tasks: Discussions about the different policy options will be the basis for WP 6.4. and will feed into the policy brief (WP6.5).
Deliverables and milestones: D6.2 Report on new governance concepts including results of stakeholder consultations and ethnographic studies (media analysis/interviews) (M36)
M6.1. Workshops on new policy instruments (M10). The outcome of these Workshops will feed into a short report of the achieved results for each Workshop.
M6.2. Ethnographic study (M36). Interviews will be held at all case study sites. The results will be documented and published in one report in English.
Dissemination: The results of each workshops will be concluded in a short report made available at the Soils2Sea Webpage.

WORKPACKAGE 6.3

Output expected for other tasks: Feasibility of monitoring concepts (pros and cons; barriers) will be important element of the workshops.
Deliverables and milestones: D6.3 Report on new monitoring concepts including results of stakeholder consultations (M36) from a legal perspective. The report will be available on the Soils2Sea Webpage.
Dissemination: Journal article

WORKPACKAGE 6.4
Output expected for other tasks: Results of the Workshops will feed into the policy brief.
Deliverables and milestones: D6.4 Report with results from national stakeholder workshops on transfer of new concepts (M44). The report will be available on the Soils2Sea Webpage.
Dissemination: Journal article

WORKPACKAGE 6.5
Dissemination: Policy Brief (ca. 10-15 pages) will be translated in four languages (e.g. Swedish, English, Danish, and Polish) (M45). It will include the results of the different WPs and aimed at policymakers at local and regional levels.

8.4 Timing and dependencies with other project activities

The scenarios that will be developed within WP2 (see chapter 4) are highly relevant for presenting them at the stakeholders workshops in the different case study areas. However, until autumn 2014, when the first series of workshops will take place, only the scenarios for Norsminde will be ready. These would then also serve as visual aids for Tullstorp and Kocinka.

Concerning the first series of workshops, one will be held in October, two will be held in November.

The workshops to test the output-focused monitoring and regulation approach outside of case study areas are scheduled for summer 2017.

Further details can be found in the gannt chart in Appendix A showing the time schedule for activities and the key dependencies in terms of milestones.

8.5 References

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9. Dissemination strategy

9.1 Objectives

In accordance with its Description of Work Soils2Sea aims at disseminating its results externally to a broad range of persons, institutions and organisations for whom Soils2Sea results are perceived to be of interest from academic and implementation points of view. The key target groups are the scientific community, water resources professionals as well as local, national and European stakeholders and policy makers.

The objectives of the present chapter are to describe the dissemination strategy and the stakeholder dissemination plan to be used to achieve the Soils2Sea dissemination goals.

9.2 Dissemination to the scientific community

Soils2Sea will disseminate its results to the scientific community via the following channels:

- *Publication in internationally peer reviewed scientific journals*. This classic scientific dissemination ensures the most widespread, the longest lasting and the highest impact with respect to dissemination of scientific results and at the same time provides peer review and hence an international quality recognition of Soils2Sea results. Soils2Sea aims at converting most of its reporting of deliverables into scientific journal papers. In order to enable presentation of more holistic results than is often possible in single journal papers, Soils2Sea will aim at contributing to establishing and publishing in Journal Special Issues targeting topics of particular relevance for Soils2Sea research. Soils2Sea researchers will, where possible, aim at publishing results as Open Access papers.
- *Presentation of results at international conferences*. This will include the regular high profile, huge conferences like EGU and AGU as well as more targeted conferences, seminars and workshops. Soils2Sea will take an active role in contributing to organising sessions at conferences, seminars and workshops.
- *Project website (www.Soils2Sea.eu)*. All public project deliverables will be available for download at the project website together with information on project publications and contributions to conferences and workshops.

9.3 Stakeholder dissemination plan

The Soils2Sea description of work identifies the project's key outputs and groups that should be involved and informed of our research. However, connecting people with research results in a manner that is relevant for them requires thought and planning. This section presents the initial structure of the stakeholder dissemination plan that will guide all dissemination activities with stakeholders undertaken throughout the Soils2Sea project. This dissemination plan will establish a communication vision for the project and will be a living document, subject to review and revision throughout the project.

9.3.1 General approach amongst partners

When: The agreed upon contact person for each project partner (usually the partners Steering Committee member) will be approached at the beginning of the project for an overview of stakeholders, events and project activities relevant to Soils2Sea. Previous research (eg. Reports, articles, fact sheets) relevant to Soils2Sea will also be collected. After this first update, partners will be contacted every 4 months afterwards for an activity update.

How: This update will be carried out via skype/phone call, following which each partner will be asked to fill out a template (provided by Ecologic).

What: The template should be completed with information on recently held and forthcoming events, announcements relevant to Soils2Sea, and any new research insights relevant to stakeholders. Based on the feedback received from these updates, content for dissemination materials, including website updates, newsletters, fact sheets and policy briefs.

9.3.2 Stakeholder identification and mapping

To increase the uptake and use of research generated by Soils2Sea, it is imperative to identify relevant stakeholders to develop an understanding of their interests and to align dissemination activities with their needs and priorities. The key target groups include water resource professionals, as well as local, national and European stakeholders and policy makers.

Stakeholder Identification: As an initial step, we will map the contacts of Soils2Sea partners to identify the target group for all dissemination activities. This will be initially conducted via a brief skype/phone call between Ecologic and a contact person from each partner. Partners will then be asked to fill in a template of their relevant contacts, including those most relevant to the case studies. Partners will also be asked to identify any relevant stakeholders outside of their own networks of contacts, for whom the results of Soils2Seas may be of interest. Ecologic will attempt to gather contact information for these groups to the extent possible

Once this initial group of contacts has been collected, it will be analyzed to identify if there are any notable gaps in terms of type of stakeholder and geographic area. In cases where notable gaps are identified, Ecologic (with support from partners) will attempt to find additional contacts through desk research.

Stakeholder Mapping: Stakeholders participating in the initial advisory panel meetings and the scenario workshops will be briefly surveyed on their habits and needs regarding dissemination (either via short written survey or informal group consultation). Questions will focus on levels of awareness, information needs, and preferred dissemination tools and channels (eg: are they more likely to read information at workshops or online). The results of this information gathering will shape the type, form and content of Soils2Sea dissemination activities, including fact sheets, newsletters and the policy brief agreed upon in the dissemination strategy.

9.3.3 Event mapping

At the beginning of the project, an index of events (including academic conferences, stakeholder workshops, etc) will be produced by Ecologic. Project partners will be asked to fill in a template identifying such relevant events. This map of relevant events will be used to help coordinate dissemination activities, and maximize opportunities for dissemination of project materials. Referring to this map of events will help make sure that important opportunities are not missed for awareness raising and disseminating project results.

This map of events will be updated periodically, as part of the reoccurring consultations with partners outlined in the general approach.

9.3.4 Dissemination material

As discussed, the types of dissemination material produced in Soils2Sea will depend upon the results of the stakeholder mapping in section 9.3.2. Generally speaking, however the following dissemination materials are envisioned:

1. *Project flyer*: A 3-sided flyer providing a brief overview of Soils2Sea will be produced, including an overview of the Soils2Sea context, objectives, activities and projected results.
2. *Newsletter*: An annual newsletter will be produced, overviewing key Soils2Seas events, insights, outputs and other information relevant to stakeholders. The ultimate form of this newsletter will be decided based on input on stakeholder needs and preferences identified in the mapping activities (eg: a traditional physical newsletter vs an e-mail based newsletter).
3. *Fact Sheets*: Two sets of fact sheets will be produced in advance of the stakeholder workshops. These will be designed according to the needs identified in the mapping of stakeholders, and will be designed to support the activities of these workshops.
4. *Policy Brief*: This policy brief (delivered in Month 45) will synthesise key findings and messages identified in WP2, WP3, WP4 and WP5 as well as in Tasks 6.1 to 6.4. The policy brief will be aimed at all target groups, providing context to the main problems that Soils2Sea seeks to address, as well as overview of the key project findings. It will be finalized in advance of the Baltic Sea Conference discussed in Section 9.5

9.3.5 Monitoring and evaluation

Monitoring and evaluation of the activities of dissemination strategy will be undertaken in line with the periodic reporting. Some tools, such as online tools like the website will be continuously monitored, through statistics. An overall internal evaluation will focus on the performance of the plan, and the project team. Key questions to be considered include:

- Has the plan been followed?
- What remains to be done?
- Who has responsibility for the remaining elements?
- Have past deadlines been met? Are activities on track to meet upcoming deadlines?

- Have dissemination activities been appropriately budgeted for? Which measures were most cost effective?
- Have the activities worked towards the vision of Soils2Sea outlined in the plan?

Based on the results of these questions, the plan will be updated, and project partners will be notified of any key changes.

9.4 Project website

The project website www.Soils2Sea.eu includes both a public and an internal site. Both sites will be regularly updated. The website will remain active at least three years after the end of the project.

The internal site is password protected and used for internal project coordination. It includes the following material:

- Project documents such as Grant Agreement and Consortium Agreement.
- Steering Committee material such as agenda and minutes and other relevant documents from meetings.
- Material from project meetings such as copies of presentations and material produced during the meetings.
- Relevant literature.
- Draft versions and working documents for Deliverables (work in progress).
- Powerpoints and other presentation material for common use by project partners.
- Site for exchange of data between partners.

The external site will contain the following information:

- Project description such as Description of Work and simpler versions.
- All public deliverables as soon as they are submitted to the BONUS Secretariat.
- Project dissemination material such as newsletters, flyers, fact sheets, policy material and notes.
- Information on project events.
- Publication list.
- Description of project partners including links to partner websites.
- Links to funding agencies, relevant projects and organisations.

9.5 Baltic Sea Conference

Towards the end of the project the final results will be presented to key stakeholders such as policy makers and farmer associations as well as to the scientific community at a final Baltic Sea Conference. Such conference will either be organised as a separate Soils2Sea event or Soils2Sea will co-organise a major conference with other organisations depending on which format can provide the greatest dissemination impact for Soilss2Sea results.

Appendix A – Time Schedule

The Time Schedule on the next two pages is a further elaboration of the Gannt chart in the Description of Works (DoW), which following the analyses made in connection the preparation of the Requirements Report has been updated as follows:

- The activities are the same as in the DoW, but the timing has been adjusted slightly for a few of the activities.
- The Deliverables are the same as in the DoW and with the same timing. They have been inserted into the Gannt chart to provide a better overview.
- All the Milestones in the DoW have been preserved, but the timing has been slightly adjusted for a few of them. In addition a few extra milestones have been added to enable easy checks of critical dependencies between work packages.
- The partner responsibilities in relation to the various tasks have been included to the right in the Gannt chart.

WP, Tasks, Deliverables and Milestones	2014–2018	Partners (Lead partner in **bold**)
WP1 Coordination and dissemination		
1.1 Project meetings		**GEUS**, AU, AGH, KTH, SMHI, EI, SOR, ABIORAS
1.2 Project website		**GEUS**, EI
1.3 Detailed project description		**GEUS**, AU, AGH, KTH, SMHI, EI, SOR, ABIORAS
1.4 Dissemination to stakeholders and users		**EI**, GEUS, AU, AGH, KTH, SMHI, SOR, ABIORAS
1.5 Advisory Panel		**GEUS**
1.6 Baltic Sea Conference		**GEUS**, EI
1.7 Periodical financial and progress reporting		**GEUS**, AU, AGH, KTH, SMHI, EI, SOR, ABIORAS
D1.1 Web site		**GEUS**
D1.2 Requirements Report		**GEUS**, AU, AGH, KTH, SMHI, EI, SOR, ABIORAS
D1.3+1.6 Dissemination Plan + Dissemination Material		**EI**, GEUS
D1.4+1.5+1.7+1.9 Periodic Reports		**GEUS**, AU, AGH, KTH, SMHI, EI, SOR, ABIORAS
D1.9 Baltic Sea Conference Proceedings		**GEUS**, EI
D1.10 Final Report		**GEUS**, AU, AGH, KTH, SMHI, EI, SOR, ABIORAS
M1.1 Project operational		**GEUS**
M1.2 Advisory Panel functional		**GEUS**
M1.3 Baltic Sea Soils2Sea Final Conference		**GEUS**, EI
WP2 Land2Soils: Climate change, land use and nutrient load		
2.1 Land use and climate change scenarios		**AU**, SMHI, ABIORAS
2.2 Scenario analyses for nitrate at catchment scale		**GEUS**, AU, AGH
2.3 Scenario analyses for phosphorus at catchment scale		**AU**, AGH, KTH
2.4 Scenarios for the Baltic Sea Basin		**SMHI**, AU, GEUS, KTH, ABIORAS
D2.1 Review of existing scenarios		**AU**
D2.2 Soils2Sea scenarios		**AU**
D2.3 Scenario analyses N		**GEUS**, AU, AGH
D2.4 Scenario analyses P		**AU**, AGH, KTH
M2.1 Methodology for scenario work designed and documented		**AU**
M2.2 Data on current land use in selected catchments and BSR ready for use		**AU**
M2.3 Scenario workshops with stakeholders completed		**EI**, AU
M2.4 Preliminary scenario results for stakeholder feedback		**EI**, AU
WP3 Soils2Streams: Transport and retention in subsurface waters		
3.1 Hill slope field experiment, Norsminde	Monitoring period	**GEUS**, AU, AGH, SOR
3.2 Nutrient retention processes and travel times at hill slope scale		**GEUS**, AU, AGH, SOR
3.3 Physically based distributed hill slope model		**GEUS**, AGH
3.4 Differentiated regulations, Horsens Fjord catchment		**GEUS**, AU, SMHI
3.5 Groundwater retention, Kocinka catchment		**AGH**, GEUS, SMHI
D3.1 Field siste		**GEUS**, AU, AGH, SOR
D3.2 Upscaling		**GEUS**, AGH
D3.3 Prototype sensors		**SOR**
D3.4 Biogeochemical processes and flow paths		**GEUS**, AGH
D3.5 Differentiated regulation Horsens		**GEUS**, AU
D3.6 Differentiated regulations Kocinka		**AGH**, AU
M3.1 Norsminde test site operational		**GEUS**, AU, SOR
M3.2 Kocinka test site operational		**AGH**
M3.3 Hills slope model constructed and calibrated		**GEUS**
M3.4 Horsens Fjord model constructed and calibrated (input to tasks 2.2+2.3)		**GEUS**
M3.5 Kocinka model constructed and calibrated (input to tasks 2.2+2.3)		**AGH**
M3.6 Upscale concepts for groundwater retention ready for use in WP5		**GEUS**, AGH

WP4	**Streams2Sea: Transport and retention in surface waters**	
4.1	Reach scale, Tullstorp Brook	**KTH**, AGH, SMHI
4.2	Catchment scale, Dalälven	**KTH**, AU, SMHI
4.3	Technological measures, surface water retention, Dalälven	**KTH**
4.4	Surface retention, Kocinka catchment	**AGH**, KTH, SMHI
D4.1	River damming and reservori operation	**KTH**
D4.2	Tracer tests	**KTH**, AGH
D4.3	Water course remediation	**KTH**
D4.4	Alternative water management strategies	**KTH**
M4.1	River reach tracer experiment performed	**KTH**
M4.2	Measures for studies of increased self-purification selected	**KTH**
M4.3	Methodology for reservoir optimization study ready	**KTH**
M4.4	Tulstorp catchment model ready (input to tasks 2.2+2.3)	**KTH**
M4.5	Upscale concepts for surface water retention ready for use in WP5	**KTH**
WP5	**Catchment2Sea: Transport and retention at Baltic Sea basin scale**	
5.1	Regionalisation of retention to basin scale	**SMHI**, GEUS, AGH, KTH
5.2	Testing basin scale model in Pregolya catchment	**ABIORAS**, SMHI
5.3	Measures at Baltic Sea subbasin scales	**SMHI**, GEUS, AGH, KTH
5.4	Tests against historical data for changes in nutrient loads over time	**SMHI**, KTH
5.5	Scenario analyses, differentiated regulations for Baltic Sea Basin	**SMHI**, AU, AGH, KTH
D5.1	Baltic Sea model	**SMHI**, AGH, KTH, GEUS
D5.2	HYPE Pregolya river basin	**ABIORAS**, SMHI
D5.3	HYPE reliability	**SMHI**, AGH, KTH, GEUS
D5.4	Impact assessments Baltic Sea basin	**SMHI**, AU, AGH, KTH
D5.5	HYPE web	**SMHI**
M5.1	Workshop for transfer of knowledge from field up to basin scale	**SMHI**, GEUS, AGH, KTH
M5.2	Release of updated/validated Balt-HYPE version for use in scenario runs	**SMHI**
M5.3	Input files for scenarios of land use change and measures produced	**SMHI**
WP6	**Governance, monitoring and stakeholder processes**	
6.1	Threshold values for N in groundwater	**GEUS**, AGH, SMHI, EI, ABIORAS
6.2	Governance concepts for differentiated regulation	**EI**, GEUS, AU, AGH, KTH, ABIORAS
6.3	Monitoring concepts for differentiated regulation	**EI**, GEUS, AU, AGH, KTH, SOR, ABIORAS
6.4	National stakeholder workshops	**EI**, GEUS, AU, AGH, KTH, SMHI, ABIORAS
6.5	Policy Brief	**EI**, GEUS, AU, AGH, KTH, SMHI, ABIORAS
D6.1	Thresholds guidelines	**GEUS**, AGH, SMHI, EI, ABIORAS
D6.2	Governance concepts	**EI**, GEUS, AU, AGH, KTH, ABIORAS
D6.3	Monitoring concepts	**EI**, GEUS, AU, AGH, KTH, SOR, ABIORAS
D6.4	National stakeholder workshops	**EI**, GEUS, AU, AGH, KTH, SMHI, ABIORAS
D6.5	Policy Brief	**EI**, GEUS, AU, AGH, KTH, SMHI, ABIORAS
M6.1	Workshops on new policy instruments	**EI**, GEUS, AU, AGH, KTH, SMHI, SOR, ABIORAS
M6.2	Ethnographic study	**EI**

↑ Start — Activity — High-intensity activity — ☺ Deliverable — Milestone — ⌘ Conference — ◆ Meeting — * Stakeholder workshop — ↑ End

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Appendix B - Deliverables

Purpose and Content of this Appendix

The content of the Soils2Sea deliverables is only given by a short title in the Description of Work. The purposes of this appendix are i) to provide more information, albeit still a short description, about the content of each of the Soils2Sea deliverables; and ii) to outline the quality assurance process that is intended to be adopted for each of the deliverables.

The Soils2Sea Steering Committee is responsible for ensuring good scientific quality of the deliverables from the project. In this respect the Steering Committee has decided at its first meeting on 27th February 2014 that all deliverables shall undergo internal review before submission to the BONUS Secretariat. In addition to the responsible WP leader at least one other Soils2Sea scientist shall perform a review of the draft version of deliverable. The Steering Committee will currently decide how this principle will be implemented in practice with due consideration to the considerable differences in nature and production processes between the different deliverables.

The appendix includes one table for each of the deliverables with information on the content and on the planned quality assurance procedure. The aim is that the appendix becomes a living document that will currently be updated during the remaining part of the project period and ultimately become an appendix to the Soils2Sea Final Report.

List of Soils2Sea deliverables

Del. no.	Deliverable name	WP no.	Nature	Dissemi-nation level	Deliv-ery date
1.1	Website with description of project and its results as well as work space for project partners	1	OT	PU/CO	3
1.2	Requirement Report with detailed description of research studies	1	RE	PU	6
1.3	Dissemination plan + flyer + standard presentation material	1	RE+OT	PU	6
1.4	Periodic progress report – first year	1	RE	CO	14
1.5	Periodic progress report – second year	1	RE	CO	26
1.6	Dissemination material - project concepts and preliminary results suitable for dialogues with stakeholders and policy makers	1	OT	PU	30
1.7	Periodic progress report – third year	1	RE	CO	38
1.8	Proceedings from final Baltic Sea Conference	1	ER	PU	45
1.9	Periodic progress report – fourth year	1	RE	CO	50
1.10	Final Report	1	RE	CO	50
2.1	Review on existing scenario studies of nutrient reductions	2	RE/SP	PU	6
2.2	Soils2Sea scenarios for nutrient reductions	2	RE/SP	PU	18
2.3	Scenario analyses for spatially differentiated N measures in catchments	2	RE/SP	PU	42
2.4	Scenario analyses for spatially differentiated P measures in catchments	2	RE/SP	PU	42
3.1	Description of established experimental field site	3	RE/SP	PU	12
3.2	Upscaling of knowledge and data from hillslope scale to catchment scale and to Baltic Sea basin scale	3+4	RE/SP	PU	30
3.3	Prototype of new sensors for flux measurements of N and P	3	RE+PT	PU	36
3.4	Biogeochemical processes and flow paths from hillslope site	3	RE/SP	PU	36
3.5	Proposal for differentiated regulations for Horsens Fjord catchment	4	RE/SP	PU	44
3.6	Proposal for differentiated regulations for Kocinka catchment	3+4	RE/SP	PU	44
4.1	Report on impacts of river damming on nutrient export and optimized reservoir operation with multi-objectives	4	RE/SP	PU	24
4.2	Report on tracer tests and the effect of solute retention and attenuation on the stream reach scale	4	RE/SP	PU	33
4.3	Report on impact assessment of water course remediation measures to increase self-purification using different in-stream model concepts	4	RE/SP	PU	40
4.4	Report on efficacy of alternative water management strategies for reducing nutrient loads to the Baltic Sea	4	RE/SP	PU	44
5.1	Model application results for pan Baltic Sea model	5	RE/SP	PU	34
5.2	Balt-HYPE model performance for the Pregolya River basin and discussion of model reliability at various scales	5	RE/SP	PU	34
5.3	Reliability of Balt-HYPE model to simulate change in nutrient load	5	RE/SP	PU	40
5.4	Projected impacts of climate, anthropogenic change and remedial measures for nutrient loads to the Baltic Sea	5	RE/SP	PU	46
5.5	HYPE web platform showing results of scenarios published	5	OT	PU	46
6.1	Guidelines for thresholds of nutrients in groundwater bodies	6	RE/SP	PU	36
6.2	Proposal for new governance concepts including results of stakeholder consultations and ethnographic studies	6	RE/SP	PU	36
6.3	Proposal for new monitoring concepts including results of stakeholder consultations	6	RE/SP	PU	36
6.4	Results from national stakeholder workshops on transfer of new concepts	6	RE/SP	PU	44
6.5	Policy Brief	6	RE/PP	PU	45

1.1 Website

<table>
<tr><td>Deliverable number</td><td colspan="2">1.1</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Website with description of project and its results as well as work space for project partners</td></tr>
<tr><td>Author(s)</td><td colspan="2">GEUS</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">The website www.soils2sea.eu has a public and an internal part.

The public part includes information on
• Project content, including the DoW
• Partners
• Project publications
• Case study areas
• Project deliverables
• Dissemination material
• Project events

The internal part includes information on
• Grant Agreement, Consortium Agreements
• Steering Committee decisions
• Material from project meetings
• Deliverables – work in progress
• Relevant literature
• BONUS material
• Space for exchange of data
• Mailing lists</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Website</td></tr>
<tr><td>Status</td><td colspan="2">Established in February 2014. First consolidated version ready by August 2014</td></tr>
<tr><td>Review / QA process</td><td colspan="2">Format and layout approved at Steering Committee Meeting on 27th February 2014. Content to be reviewed by Steering Committee and approved at meeting on 8-9th September 2014.</td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:
June 2014
Jens Christian Refsgaard</td><td>QA reviewer:
N/A</td></tr>
<tr><td colspan="2">Steering Committee: To be approved September 2014</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">The website will be currently updated throughout the project and maintained for several years after project completion.</td></tr>
</table>

1.2 Requirements Report

<table>
<tr><td>Deliverable number</td><td colspan="2">1.2</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Requirement Report with detailed description of research studies</td></tr>
<tr><td>Author(s)</td><td colspan="2">GEUS (Editor) + all partners</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">The overall aims of the deliverable are i) to map the interdependencies between work packages and partners; ii) to briefly describe the methodologies to be used; and iii) to prepare a detailed coherent project work plan. The table of contents is
1. Executive Summary
2. Introduction
3. Case studies
4. Changes in land cover, agricultural practices and climate and their effects on nutrients loads to the Baltic Sea
5. Nutrient transport and retention in groundwater
6. Nutrient transport and retention in surface water
7. Baltic Sea basin scale
8. Governance, monitoring and stakeholder process
9. Dissemination strategy
App A. Project time schedule
App B. Deliverables</td></tr>
<tr><td>Format</td><td colspan="2">Report</td></tr>
<tr><td>Status</td><td colspan="2">The report is complete</td></tr>
<tr><td>Review / QA process</td><td colspan="2">Each chapter was quality assured by the WP leader responsible for the particular subject and reviewed by one other scientist plus the coordinator</td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:
June 2014
Jens Christian Refsgaard</td><td>QA reviewers:
May 2014
Jørgen E Olesen, Anders Wörman, Przemyslaw Wachniew, Anker L Højberg, Doris Knoblauch, Rene Capell, Jens Christian Refsgaard</td></tr>
<tr><td colspan="2">Steering Committee: June 2014</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">This report will form the foundation for the remaining project implementation.</td></tr>
</table>

1.3 Dissemination Plan

<table>
<tr><td>Deliverable number</td><td colspan="2">1.3</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Dissemination plan + flyer + standard presentation material</td></tr>
<tr><td>Author(s)</td><td colspan="2">EI (Editor) + GEUS</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">Dissemination Plan describing how Soils2Sea will disseminate its results to the scientific community, how relevant stakeholders are identified and mapped, how dissemination networks will be established, and what kind of dissemination material will be produced and when. The Dissemination Plan also establishes a process for reviewing the effectiveness of dissemination activities, and revising accordingly. The Dissemination Plan is a Report that has been prepared as an integrated part of the Requirements Report (Chapter 9 in Deliverable 1.2).
Project flyer: A 3-sided flyer providing a brief overview of Soils2Sea
Soils2Sea standard powerpoint presentation</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report + flyer + powerpoint</td></tr>
<tr><td>Status</td><td colspan="2"></td></tr>
<tr><td>Review / QA process</td><td colspan="2">The Dissemination Plan was reviewed as part of the Requirements Report. The flyer and other presentation material has been reviewed by the Steering Committee.</td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:</td><td>QA reviewer:
Steering Committee</td></tr>
<tr><td colspan="2">Steering Committee: June 2014</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2"></td></tr>
</table>

1.4 Periodic Progress Report 1

<table>
<tr><td>Deliverable number</td><td colspan="2">1.4</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Periodic progress report – first year</td></tr>
<tr><td>Author(s)</td><td colspan="2">GEUS (Editor) with input from all partners</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">According to requirements of BONUS</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report</td></tr>
<tr><td>Status</td><td colspan="2">Not yet initiated</td></tr>
<tr><td>Review / QA process</td><td colspan="2">To be decided by Steering Committee</td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:</td><td>QA reviewer:</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2"></td></tr>
</table>

1.5 Periodic Progress Report 2

Deliverable number	**1.5**	
Deliverable title	**Periodic progress report – first year**	
Author(s)	GEUS (Editor) with input from all partners	
Expected or final Content	According to requirements of BONUS	
Expected or final Format	Report	
Status	Not yet initiated	
Review / QA process	To be decided by Steering Committee	
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

1.6 Dissemination Material

<table>
<tr><td>Deliverable number</td><td colspan="2">1.6</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Dissemination material – project concepts and preliminary results suitable for dialogues with stakeholders and policy makers</td></tr>
<tr><td>Author(s)</td><td colspan="2">EI and project team</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">As Dissemination material we identified:
• Project flyer: revision or reprint of the flyer prepared under deliverable 1.3 as required
• Newsletter: An annual newsletter will be produced. The form (eg: print vs electronic) will be determined by stakeholder needs.
• Fact Sheets: Two sets of fact sheets will be produced in advance of the stakeholder workshops. They will be designed according to needs of stakeholders.</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Printed material (Flyer, Newsletter, etc), scientific articles, presentations, and material for the website (including electronic versions of printed material).</td></tr>
<tr><td>Status</td><td colspan="2">Started with the Dissemination Plan</td></tr>
<tr><td>Review / QA process</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:</td><td>QA reviewer:</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2"></td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">All materials in this deliverable are intended for dissemination to multiple target groups, including scientific community and stakeholders.</td></tr>
</table>

1.7 Periodic Progress Report 3

Deliverable number	**1.7**	
Deliverable title	**Periodic progress report – third year**	
Author(s)	GEUS (Editor) with input from all partners	
Expected or final Content	According to requirements of BONUS	
Expected or final Format	Report	
Status	Not yet initiated	
Review / QA process	To be decided by Steering Committee	
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

1.8 Final Baltic Sea Conference

Deliverable number	**1.8**	
Deliverable title	**Proceedings from final Baltic Sea Conference**	
Author(s)	GEUS (Editor) probably with input from all partners	
Expected or final Content	To be decided when the event is planned. It could be conference proceedings, or plans for a Special Issue followed by a brief summary and evaluation of the event.	
Expected or final Format	Report	
Status	Not yet initiated	
Review / QA process	To be decided	
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

1.9 Periodic Progress Report 4

<table>
<tr><td>Deliverable number</td><td colspan="2">1.9</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Periodic progress report – fourth year</td></tr>
<tr><td>Author(s)</td><td colspan="2">GEUS (Editor) with input from all partners</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">According to requirements of BONUS</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report</td></tr>
<tr><td>Status</td><td colspan="2">Not yet initiated</td></tr>
<tr><td>Review / QA process</td><td colspan="2">To be decided by Steering Committee</td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:</td><td>QA reviewer:</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2"></td></tr>
</table>

1.10 Final Report

<table>
<tr><td>Deliverable number</td><td colspan="2">1.10</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Final Report</td></tr>
<tr><td>Author(s)</td><td colspan="2">GEUS (Editor) with input from all partners</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">According to requirements of BONUS</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report</td></tr>
<tr><td>Status</td><td colspan="2">Not yet initiated</td></tr>
<tr><td>Review / QA process</td><td colspan="2">To be decided by Steering Committee</td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:</td><td>QA reviewer:</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2"></td></tr>
</table>

2.1 Review of Existing Scenarios

<table>
<tr><td>Deliverable number</td><td colspan="2">2.1</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Review of existing scenario studies of nutrient reductions</td></tr>
<tr><td>Author(s)</td><td colspan="2">AU with Fatemeh Hashemi as lead author</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">Overview of existing published scenario studies with particular emphasis to the following issues:
• Current methods for scenario design
• Measures (policy and specific measures) considered for nutrient load and leakage reduction
• Efficiency and cost-effectiveness of measures according to catchment type and study methodology
• The spatial allocation of measures
• Methodology for and effect of including climate change</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Article to peer reviewed journal</td></tr>
<tr><td>Status</td><td colspan="2">The review is in progress. References have been collected and an overview of studies have been established. A manuscript is currently being drafted.</td></tr>
<tr><td>Review / QA process</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:
Jørgen E. Olesen</td><td>QA reviewer:
To be determined</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">This work will form the basis for developing the initial land use and management scenarios in WP2.</td></tr>
</table>

2.2 Soils2Sea Scenarios

<table>
<tr><td>Deliverable number</td><td colspan="2">2.2</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Soils2Sea scenarios for nutrient reductions</td></tr>
<tr><td>Author(s)</td><td colspan="2">AU (lead Fatemeh Hashemi) with assistance of GEUS, SMHI and Ecologic</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">The report will cover the following issues:
- Assessment of measures to reduce N loadings from agricultural systems
- Description of different systems (comprising different scenarios) that will allow measures to be applied in a spatially varying way, but using different governance systems.
- Climate change scenarios to be applied</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report, and if possible with additional data om effects on scenarios as a manuscript(s) for peer reviewed publication</td></tr>
<tr><td>Status</td><td colspan="2"></td></tr>
<tr><td>Review / QA process</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:
Jørgen E. Olesen</td><td>QA reviewer:
To be determined</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">This will form the basis for estimating spatial differences in N loadings from agricultural fields in task 4.2.2.</td></tr>
</table>

2.3 Scenario Analyses N

<table>
<tr><td>Deliverable number</td><td colspan="2">2.3</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Scenario analyses for spatially differentiated N measures in catchments</td></tr>
<tr><td>Author(s)</td><td colspan="2">Jørgen E. Olesen, Christen Børgesen and Fatemeh Hashemi (AU)</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">Data on nitrate leaching for current and future scenarios are provided for the catchment study sites (Norsminde, Horsens, Kocinka, and Tullstorp) where modelling is employed and at the Baltic sea scale.

Yearly nitrate leaching is estimated using the statistical model NLES, which are modified to include effects of changing climate conditions and evaluated for regions included in Soils2Sea. Seasonal variations are estimated by the Daisy model.</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report, if possible in manuscript form for journal publication.</td></tr>
<tr><td>Status</td><td colspan="2"></td></tr>
<tr><td>Review / QA process</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:
Jørgen E. Olesen</td><td>QA reviewer:
To be determined</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">N-leaching data for current and future scenarios are applied in the model simulations at both catchment and basin scale</td></tr>
</table>

2.4 Scenario Analyses P

Deliverable number	**2.4**	
Deliverable title	**Scenario analyses for spatially differentiated P measures in catchments**	
Author(s)	Goswin Heckrath (AU) with assistance of SMHI	
Expected or final Content	A P loss index will be established for the Norsminde catchment. The extent to which this P loss index can be applied for the other catchments will be explored by evaluating effects on variation in terrain, soils, land use and management. This will form the basis for estimating sources of P under both current and future land use and climatic conditions.	
Expected or final Format	Report, if possible as manuscript for peer reviewed journal	
Status		
Review / QA process		
Approved	WP leader: *Jørgen E. Olesen*	QA reviewer: To be determined
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable	These results will be applied in the modelling at the Baltic basin scale and for stakeholder discussions	

3.1 Field Site

<table>
<tr><td>Deliverable number</td><td colspan="2">3.1</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Description of established experimental field site</td></tr>
<tr><td>Author(s)</td><td colspan="2">GEUS + AGH (Editors Rasmus Jakobsen and Przemyslaw Wachniew) with contributions from the WP3 participants involved in the field site work and planning.</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">The report will describe the Norsminde and the Kocinka field site installations, the background for the chosen approach and the type of results that are expected based on the approach. The description will be based on graphical representations of the installations.¨The description will contain tables of installed devices, their designated numbers and coordinates. Any geological, geophysical or similar data acquired during the planning and installation will be included in the report graphically or in tables depending on the material. As far as possible, and if relevant, the graphics and tables should be made in a form that can easily be transformed into figures in publications.</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report</td></tr>
<tr><td>Status</td><td colspan="2">Not initiated</td></tr>
<tr><td>Review / QA process</td><td colspan="2">WP3 people at AGH (headed by ?) reviews the Norsminde part and WP3 people at GEUS (headed by ?) reviews the Kocinka part of the report,</td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:
Rasmus Jakobsen
December 2014</td><td>QA reviewer:
To be determined
December 2014</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">The deliverable will serve as a reference for further work in the field during data collection and for setting up and calibrating the hillslope model.</td></tr>
</table>

3.2 Upscaling

<table>
<tr><td>Deliverable number</td><td colspan="2">3.2</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Upscaling of knowledge and data from hillslope scale to catchment scale and to Baltic Sea basin scale</td></tr>
<tr><td>Author(s)</td><td colspan="2">GEUS (Editor) + AGH + possibly others</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">Two types of up-scaling is required
1. up-scaling of process understanding from the detailed hill slope study to the catchment and basin scale models
2. up-scaling of the effect of spatially differentiated measures.

Process up-scaling will include the development of methods to map small scale processes into the larger scale models. It is anticipated that this will results in defining effective parameters. No model code development is included.

Effectiveness of spatially differentiated measures is largely dependent on the heterogeneity in the natural denitrification processes, where a high degree of heterogeneity makes it possible to target the measures to locations where natural reduction are lowest. Up-scaling of effectiveness of measures will thus be focused on identifying spatial heterogeneity with respect to nitrate leaching and natural denitrification processes. Where information on spatial heterogeneity in groundwater reduction potential do not exists, it will be tested if readily available data, such as soil types, can be used as a proxy.

Based on the heterogeneity descriptions, effectiveness of spatial differentiated measures vs. uniform regulations will be assessed. This will be an extrapolation of the results obtained from catchment scale modelling.</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report, if possible in manuscript form for journal publication.</td></tr>
<tr><td>Status</td><td colspan="2"></td></tr>
<tr><td>Review / QA process</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:
Rasmus Jakobsen</td><td>QA reviewer:
To be determined</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">The up-scaling approach will be utilised in
1. Catchment scale modelling
2. HYPE

Development of up-scaling approach for spatially differentiated measures will be developed in close collaboration with the development on N-scenarios (D2.3)</td></tr>
</table>

3.3 Prototype Sensors

Deliverable number	**3.3**	
Deliverable title	**Prototype of new sensors for flux measurements of N and P**	
Author(s)	SOR (editor; Hubert de Jonge)	
Expected or final Content	Mounting flow-weir units are constructed for flow-proportional sampling from tile drains at the end of Ø50, Ø110, or Ø160 mm drainage pipes. The units are equipped with 2 SorbiCells passive samplers and are dimensioned for sampling periods of 1-3 months. The units are tested and demonstrated at the Norsminde site in Denmark for the monitoring of nutrients.	
Expected or final Format	Commercial available product, including product sheet, User manuals and technical compendium.	
Status	Not initiated	
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable	The new sampling approach and product features are presented at relevant national and international seminars and conferences and will be marketed world-wide to end-customers hereunder farmer organisations, environmental authorities and consultants.	

3.4 Biogeochemical Processes and Flow Paths

<table>
<tr><td>Deliverable number</td><td colspan="2">3.4</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Biogeochemical processes and flow paths from hillslope site</td></tr>
<tr><td>Author(s)</td><td colspan="2">GEUS (Editors: Rasmus Jakobsen, Anker L Højberg)</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">Based on the results from the field and model simulations the report will describe the flow dynamics and biogeochemical processes occurring in the groundwater zone, including the unsaturated zone and drainage system. Possible relations between the types of biogeochemical processes, their spatially distributed rates and dependencies on environmental parameters such as lithology, precipitation amounts/intensities and temperature will be analysed. The description should include ways of transforming the obtained results into relations that can be used in the up-scaling to catchment and basin scale.</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report, if possible in manuscript form for journal publication.</td></tr>
<tr><td>Status</td><td colspan="2">Not initiated</td></tr>
<tr><td>Review / QA process</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:
Rasmus Jakobsen
December 2016</td><td>QA reviewer:
To be dermined
December 2016</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">The results in the deliverable will form the background for the up-scaling of processes and flow paths to catchment scale.</td></tr>
</table>

3.5 Differentiated Regulation Horsens

Deliverable number	**3.5**	
Deliverable title	**Proposal for differentiated regulations for Horsens Fjord catchment**	
Author(s)	GEUS	
Expected or final Content	Through model calibration to observed nitrogen transport in stream gauging stations in the Horsens Fjord catchment a best estimate of the depth to the redox interface is determined. Two alternative maps are produced in which the drainage system is represented by 1) the approach presently used in catchment scale models and 2) the presentation based on the up-scaling approach developed in Soils2Sea. Based on the alternative maps of the redox interface, the natural nitrate reduction in the groundwater and its spatial variability is computed and provided as maps. An analysis is carried out on how the different representations of the drainage system alters the delineation of areas with high and low nitrate reduction, respectively, and which implications this will have on the differentiated regulation	
Expected or final Format	Report, if possible in manuscript form for journal publication.	
Status		
Review / QA process		
Approved	WP leader: *Rasmus Jakobsen*	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable	A map of the nitrate reduction potential is provided as input for WP2 to develop scenarios analysis for N. Results are presented at relevant national and international seminars and conferences.	

3.6 Differentiated Regulation Kocinka

Deliverable number	**3.6**	
Deliverable title	**Proposal for differentiated regulations for Kocinka catchment**	
Author(s)	AGH (Editors: S. Witczak, J. Kania)	
Expected or final Content	Identification of the sources and mapping of nutrient levels in the coupled groundwater – surface water system is a prerequisite for modelling of nutrient retention. The 3-D numerical model of groundwater flow and nutrient transport coupled with the model of nutrient leaching from soils provides information on the pathways, timescales of groundwater flow and retention of nutrients in the system. Differentiated regulations for the Kocinka catchment are based on the understanding of nutrient retention in this specific geological setting characterized by permeable soils underlain by the karstic-fissured aquifer where retention capabilities might be limited. A supplementary GIS-based approach provides vulnerability maps indicating time lags associated with the transport of nutrients between the source areas and the Kocinka and its tributaries.	
Expected or final Format	Report, if possible in manuscript form for journal publication.	
Status		
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level		
Plans regarding further collaboration, dissemination and/or use of this deliverable	Knowledge of the sources and levels of nutrients provides input for WP2 to develop scenario analysis for N. The vulnerability maps are an important output to stakeholders.	

4.1 River Damming and Reservoir Operation

Deliverable number	**4.1**
Deliverable title	**Report on impacts of river damming on nutrient export and optimized reservoir operation with multi-objectives**
Author(s)	Nicholas Zmijewski, Anders Wörman
Expected or final Content	The use of alternative watershed regulation objectives for reducing nutrient load to the Baltic sea is investigated, first as a (generic) model study and then case specific applied to river Dalälven. The study comprises the impact of imposing an additional constraint, such as nutrient transport, on power production of a controlled watershed. A multi-objective optimization model is developed including nutrient flow dynamics. The general form of the model dynamics enables a clear assessment of regulation strategies on production as well as environmental benefit. A simplified description of reservoir dynamics is used in a large-scale watershed optimization model including one-dimensional hydrodynamic flow description. Management strategies are evaluated and for nutrient control crucial regulation impact parameters determined.
Expected or final Format	A report, preferably in terms of a scientific paper
Status	
Review / QA process	
Approved	WP leader: / QA reviewer: Steering Committee:
Dissemination level	Public
Plans regarding further collaboration, dissemination and/or use of this deliverable	

4.2 Tracer Tests

Deliverable number	**4.2**	
Deliverable title	**Report on tracer tests and the effect of solute retention and attenuation on the stream reach scale**	
Author(s)	The report will include descriptions and analyses of a series of tracer experiments with solute injections in streams using inert solutes, such as Rhodamine WT, as well as P^{32}, N^{15} and tritiated water. Experiments will be performed in the Tulltorps Brook and possibly other streams. The aim of the study is to quantify nutrient retention and attenuation processes and to connect these processes to hydrological conditions and geomorphological characteristics. Additional investigations such as measurements of electric resistivity and hydraulic conductivity may further be used to aid the characterisation of the different reaches and provide additional information to the tracer evaluation. Comparison between reaches with different geomorphic and hydraulic characteristics will be made in order to different between processes/measures important for reducing the nutrient export on reach-scale.	
Expected or final Content	A report, preferably in terms of a scientific paper	
Expected or final Format		
Status		
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

4.3 Water Course Remediation

Deliverable number	**4.3**	
Deliverable title	**Report on impact assessment of water course remediation measures to increase self-purification using different in-stream model concepts**	
Author(s)	Joakim Riml, Anders Wörman	
Expected or final Content	The report aims at making a comparative analysis of different measures to reduce nutrient export on the watershed scale. Key parts are: 1. A distributed stream network model that includes a representation of the retention/attenuation processes important for reducing the nutrient export 2. Specific knowledge on how different measures affect hydrological and biogeochemical retention/attenuation processes The latter will include specific findings mainly from D4.2, but does also include novel methodologies for evaluating processes on the watershed scale using spectral analysis. These analyses are based on time series of nutrient loads to the stream (modelled) and in the stream water (observed), which mainly comes from Norsminde, Denmark (in connection with WP2 and WP3).	
Expected or final Format	A report, preferably in terms of a scientific paper	
Status		
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

4.4 Alternative Water Management Strategies

<table>
<tr><td>Deliverable number</td><td colspan="2">4.4</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Report on efficacy of alternative water management strategies for reducing nutrient loads to the Baltic Sea</td></tr>
<tr><td>Author(s)</td><td colspan="2"></td></tr>
<tr><td>Expected or final Content</td><td colspan="2">Based on the results of reach characteristics and nutrient reduction, scenario analyses will be performed for optimal set of remediation plans for river reaches and networks of rivers. The remediation actions include restoration of the stream morphology, including measures like dams, wetlands, flooding zones, sediment traps, increased meandering and vegetation pattern. A study will also be made on the possibility to account for environmental constraints as part of multiobjective optimization model for hydropower production. A main objective of the scenario analysis is to provide tentative understanding for the necessary amount of remediation measures on the overall nutrient reduction in terms of e.g. number of remediation sites as well as optimal distribution of sites in the stream network with account taken to the source distribution as well as the role of individual measures for the network behaviour.</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">A report, preferably in terms of a scientific paper</td></tr>
<tr><td>Status</td><td colspan="2"></td></tr>
<tr><td>Review / QA process</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:</td><td>QA reviewer:</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2"></td></tr>
</table>

5.1 Baltic Sea Model

Deliverable number	**5.1**	
Deliverable title	**Model application result for pan Baltic Sea model**	
Author(s)	**SMHI**, AGH, KTH, GEUS	
Expected or final Content	BaltHYPE model evaluation, both in terms of model performance and robustness of the process representation. The BaltHYPE model will be applied to the entire Baltic Sea basin, which implies a scale jump compared to the detailed model applications in Soils2Sea's focus areas. Coupled hydrological and hydrochemical model applications at the basin scale are constrained by trans-regional data availability, e.g. distribution of crop types or point source pollution, but also by rainfall-runoff and nutrient transfer process conceptualisations. The deliverable will summarise BaltHYPE's capability to model water and nutrient dynamics and details improvements in process conceptualizations made on the basis of findings in WP3 and WP4.	
Expected or final Format	Report	
Status		
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

5.2 HYPE Pregolya River Basin

Deliverable number	**5.2**	
Deliverable title	**Balt-HYPE model performance for the Pregolya River basin and discussion of model reliability at various scales**	
Author(s)	ABIORAS + SMHI	
Expected or final Content	0. Introduction 1. Description of the Pregolya River basin 2. Balt-HYPE model setup for the Pregolya River basin 3. Temporal and spatial data collection for model calibration 4. Climate & land use scenarios 5. Scenarios modelling 6. Discussion of modelling results 7. Discussion of model reliability 8. Conclusions 9. References App A - … (if needed)	
Expected or final Format	Report	
Status	Plan	
Review / QA process	*???*	
Approved	WP leader: *SMHI*	QA reviewer: ???
	Steering Committee: *October 2016*	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable	This report will form the foundation for the remaining project implementation. Basis for scientific publications & recommendations	

5.3 HYPE Reliability

Deliverable number	**5.3**	
Deliverable title	**Reliability of Balt-HYPE model to simulate change in nutrient load**	
Author(s)	**SMHI**, AGH, KTH, GEUS	
Expected or final Content	The HYPE model, i.e. the conceptual model at the heart of the BaltHYPE model application, will be examined for constraints in process conceptualisations regarding nutrient modelling and scenario impact assessment relevant for programs of measures developed in Soils2Seas. This includes examination of model results in Soils2Sea focus areas as well as evaluation of other available nutrient measurements within the BaltHYPE model domain. The results presented in this report will provide a guideline of expectable model reliability for scenario elevation and provide an evaluation of BaltHYPE's capability and limitations in up-scaling of Soils2Sea management scenario assumptions.	
Expected or final Format	Report	
Status		
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

5.4 Impact Assessments Baltic Sea Basin

Deliverable number	**5.4**	
Deliverable title	**Projected impacts of climate, anthropogenic change and remedial measures for nutrient loads to the Baltic Sea**	
Author(s)	**SMHI**, AU, AGH, KTH	
Expected or final Content	Results from a BaltHYPE based model testing framework to assess basin-wide impacts of combined climate and programme-of-measures scenarios developed within Soils2Sea. Different scenario combinations will be presented and assessed for their effectiveness as mitigation strategy for achieving nutrient load reduction targets into coastal waters. Scenario impact evaluation will be framed by a discussion of combined uncertainties along the impact model chain: climate scenarios, scenarios of measures, model structural uncertainties, and model calibration uncertainties.	
Expected or final Format	Report	
Status		
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

5.5 HYPE web

Deliverable number	**5.5**	
Deliverable title	**HYPE web platform showing results of scenarios published**	
Author(s)	SMHI	
Expected or final Content	Interactive web interface to visualise basin-scale model results, spatial pattern of water and nutrient fluxes, and modelled scenario impact results. The platform is supposed to serve as an information tool for stakeholders and provide a holistic view of modelled impacts of scenario measures and differences as a result of proposed management strategies.	
Expected or final Format	Web platform, a renewed version of the currently out-dated Balt-Hype web platform http://balt-hypeweb.smhi.se/, possibly as a special section of the EHYPE web platform at http://e-hypeweb.smhi.se/	
Status		
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

6.1 Thresholds Guidelines

Deliverable number	**6.1**	
Deliverable title	**Guidelines for thresholds of nutrients in groundwater bodies**	
Author(s)	GEUS (Klaus Hinsby, JC Refsgaard), Ecologic (Doris Knoblauch, +?), AU (Jørgen E. Olesen)	
Expected or final Content	Methodology for application of threshold values and monitoring concepts for spatially differentiated regulation and assessment of groundwater chemical status at local (plot to subcatchment) scale	
Expected or final Format	Report if possible as paper for e.g. Environmental Science and Policy	
Status	To be initiated fall 2014	
Review / QA process		
Approved	WP leader: *Ecologic*	QA reviewer: ?? but should preferably include Rüdiger Wolter
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable	The work will be coordinated with a report for the European Commission on groundwater and aquatic ecosystems planned to be published in 2015	

6.2 Governance Concepts

<table>
<tr><td>Deliverable number</td><td colspan="2">6.2</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Propoposal for new governance concepts including results of stakeholder consultations and ethnographic studies</td></tr>
<tr><td>Author(s)</td><td colspan="2">Doris Knoblauch, Grit Martinez, Nico Stelljes</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">Report on new governance concepts including results of stakeholder consultations and ethnographic studies (media analysis/interviews).
Synthesis of the different reports for each workshop.</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report, available at the Soils2Sea Webpage</td></tr>
<tr><td>Status</td><td colspan="2">Due M36</td></tr>
<tr><td>Review / QA process</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:</td><td>QA reviewer:</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2">Discussions about the different policy options will be the basis for WP 6.4. and will feed into the policy brief (WP6.5).</td></tr>
</table>

6.3 Monitoring Concepts

Deliverable number	**6.3**	
Deliverable title	**Proposal for new monitoring concepts including results of stake-holder consultations**	
Author(s)	Christiane Gerstetter, Doris Knoblauch, Nico Stelljes	
Expected or final Content	Report on new monitoring concepts, including results of stakeholder consultations, from a legal perspective.	
Expected or final Format	Report, available at the Soils2Sea Webpage. Journal Artical, if applicable.	
Status	Due M36	
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

6.4 National Stakeholder Workshops

<table>
<tr><td>Deliverable number</td><td colspan="2">6.4</td></tr>
<tr><td>Deliverable title</td><td colspan="2">Results from national stakeholder workshops on transfer of new concepts</td></tr>
<tr><td>Author(s)</td><td colspan="2">Nico Stelljes, Doris Knoblauch, Grit Martinez</td></tr>
<tr><td>Expected or final Content</td><td colspan="2">Report with results from national stakeholder workshops on transfer of new concepts. Main aspects will be transferability and up-scaling of project results</td></tr>
<tr><td>Expected or final Format</td><td colspan="2">Report, available at the Soils2Sea Webpage.
Journal Article, if applicable.</td></tr>
<tr><td>Status</td><td colspan="2">Due M44</td></tr>
<tr><td>Review / QA process</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Approved</td><td>WP leader:</td><td>QA reviewer:</td></tr>
<tr><td colspan="2">Steering Committee:</td></tr>
<tr><td>Dissemination level</td><td colspan="2">Public</td></tr>
<tr><td>Plans regarding further collaboration, dissemination and/or use of this deliverable</td><td colspan="2"></td></tr>
</table>

6.5 Policy Brief

Deliverable number	**6.5**	
Deliverable title	**Policy Brief**	
Author(s)	Andrew Reid, Doris Knoblauch, Christiane Gerstetter, Grit Martinez, Nico Stelljes	
Expected or final Content	Policy Brief will include the results of the different Work packages and aims at policymakers at local and regional level.	
Expected or final Format	Short (ca. 10-15 pages) report, translated in four languages (e.g. Swedish, English, Danish, and Polish).	
Status	Due M45	
Review / QA process		
Approved	WP leader:	QA reviewer:
	Steering Committee:	
Dissemination level	Public	
Plans regarding further collaboration, dissemination and/or use of this deliverable		

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The present work has been carried out within the project 'Reducing nutrient loadings from agricultural soils to the Baltic Sea via groundwater and streams (Soils2Sea)', which has received funding from BONUS, the joint Baltic Sea research and development programme (Art 185), funded jointly from the European Union's Seventh Programme for research, technological development and demonstration and from The Danish Council for Strategic Research, The Swedish Environmental Protection Agency (Naturvårdsverket), The Polish National Centre for Research and Development, The German Ministry for Education and Research (Bundesministerium für Bildung und Forschung), and The Russian Foundation for Basic Researches (RFBR).