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

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.

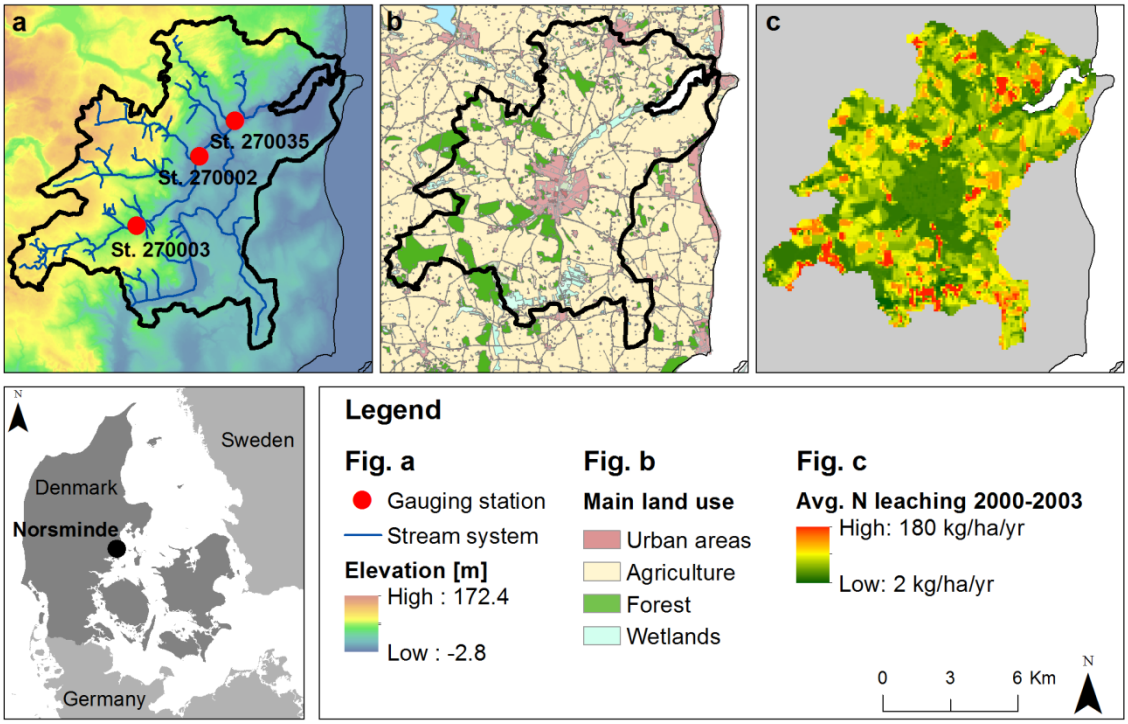

Figure 3-2 The Norsminde catchment area with A) topography, river network and gauging stations; and B) land use; and C) N leaching. Figure adapted from Hansen et al., 2014).

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.

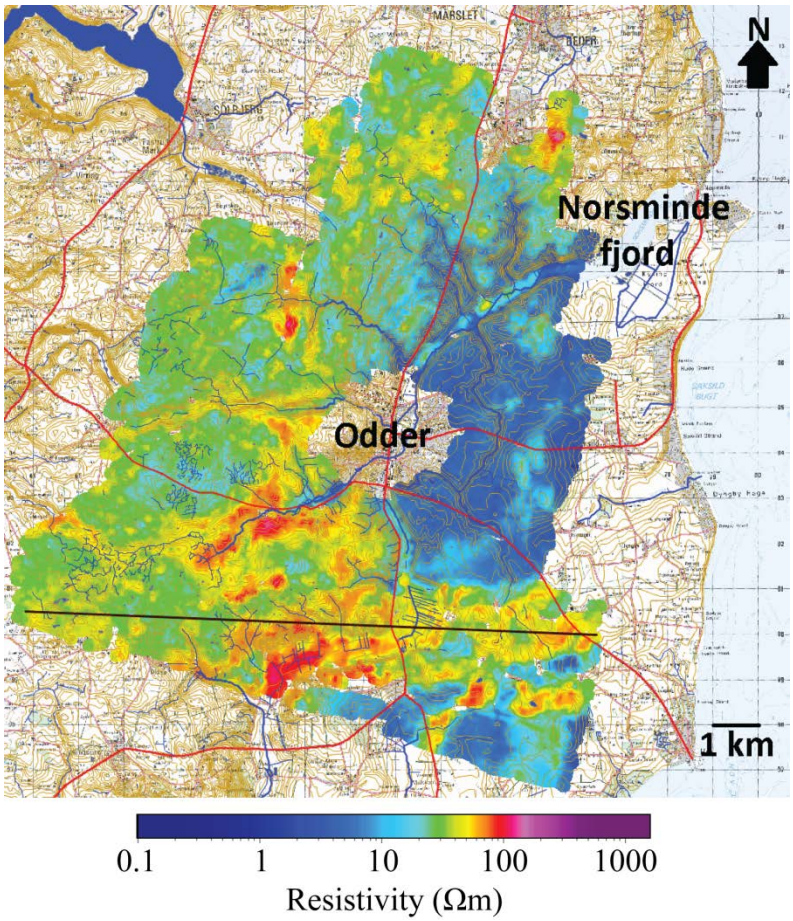

Figure 3-4 SkyTEM results from the Norsminde catchment: Mean resistivity map of the depth interval 15-20 m. Results are obtained after a spatially constrained inversion with 29 layers from 1.5 m to 150 m depth. Light brown lines correspond to topographical isolines, blue ones to streams, and red ones 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:
  - 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?
  - Stakeholders' views on monitoring concepts
  - 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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