Waterdrive case area in the catchment area of Odense Fjord

Introduction to the case area

In the Waterdrive project the catchment area of Odense Fjord has been selected as a case area. The catchment area of Odense Fjord is a part of the main water catchment area of Odense Fjord and constitutes an area of 105.600 ha, of which the agricultural area constitutes approximately 63.960 ha.

”According to the River Basin Management Plan, nitrogen emissions to Odense Fjord must be reduced by a total of 549,3 tonnes N. Of this, a reduction of 345,8 tonnes N has to be reached by 2021. The remaining reduction requirement has been postponed to the third Water Plan period. The reduction requirements correspond a reduction of agricultural nitrogen emission by 38 % before 2021 and by a full 64 % in total. It is a very extensive reduction requirement with major consequences for agricultural production, if most of the effort is to take place on cultivated land. For this reason, it is relevant to examine the options of either completely or partially replacing restrictions on cultivated land with nitrogen measures on the edge of or outside of cultivated land.”

The Waterdrive project collaborates with landowners in two selected sub-catchments to Odense Fjord, as it is impossible to work with all landowners in this very large catchment area. Instead we have decided to focus on a smaller area, which according to the program SCALGO should be potentially well suited for the establishment of drainage measures and wetlands. In Denmark, we have approximately 3000 sub-catchments called ID 15 each of them with an individual number. The areas are called ID 15 because they each represent approximately 1500 hectares and the main purpose is to use the retention in the specific area in the action plan.

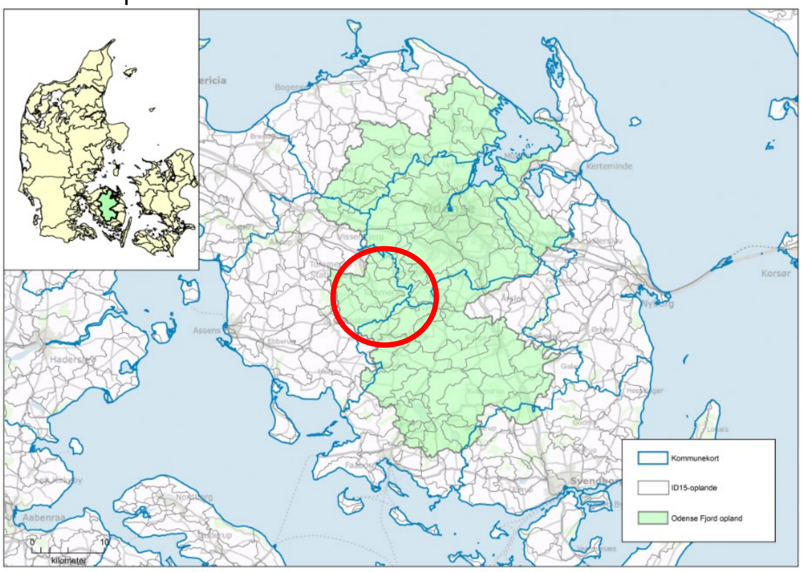


Figure 1. Odense Fjord catchment area.

Most of the Odense Fjord catchment area lies within the municipalities of Odense, North Funen, Assens, Faaborg-Mid Funen and Kerteminde and a smaller area within the municipalities of Nyborg and Svendborg. In Figure 1. ID15 catchments are marked. Odense Fjord Catchment (light green) and 2 ID15 sub-catchments (red circle).

The Waterdrive case area was selected on the basis of SCALGO analyses (green dots) and an indicative national map of potential drainage catchment areas for constructed wetlands. Known digitized drains (red markings) supplied by the municipalities of Odense and Assens.

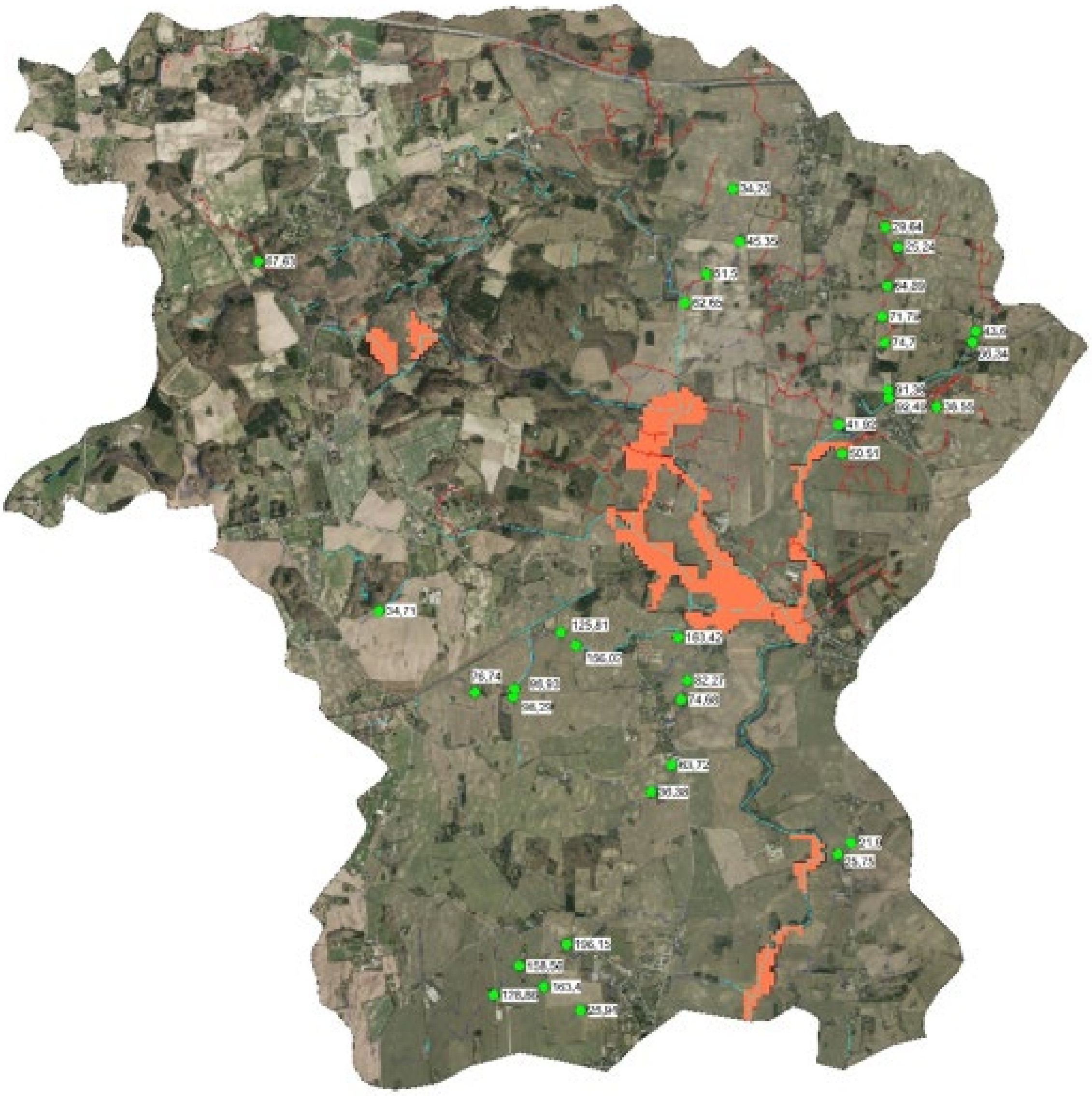


Figure 2. Waterdrive case area ID 15 42.320.719 Holmstrup/Brylle and ID15 42.320.119 situated east of Tommerup St. on Funen. Green spots are potential areas for drainage measures and red are potential areas for wetlands.

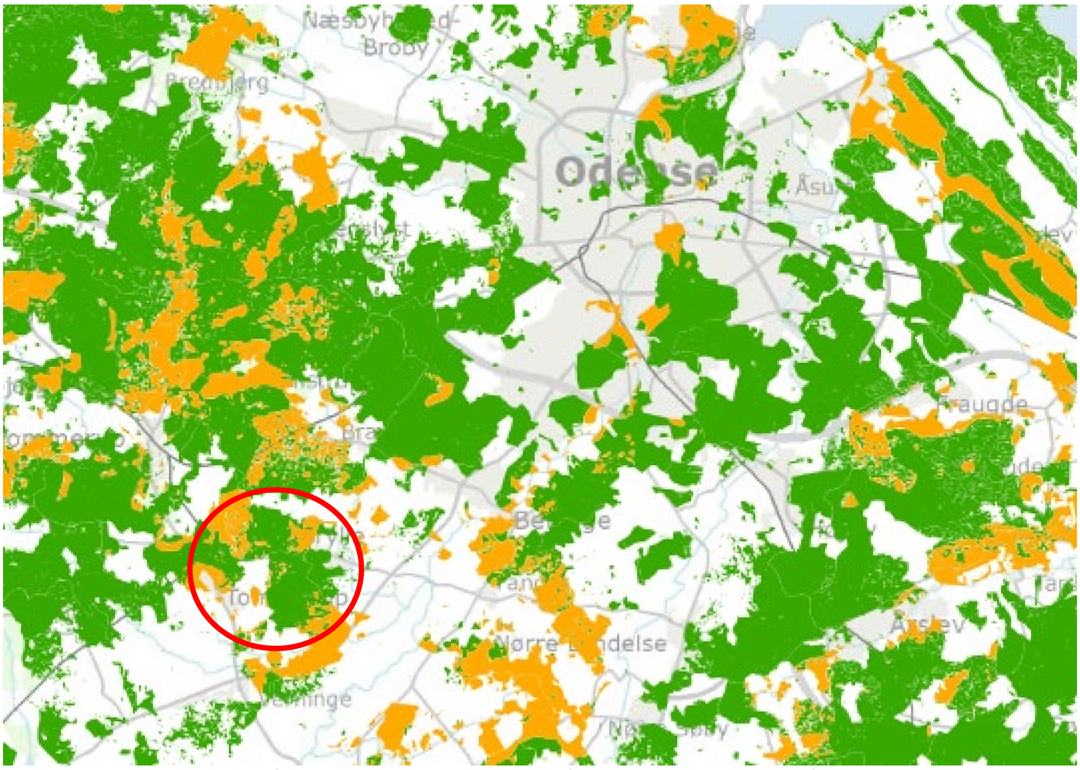
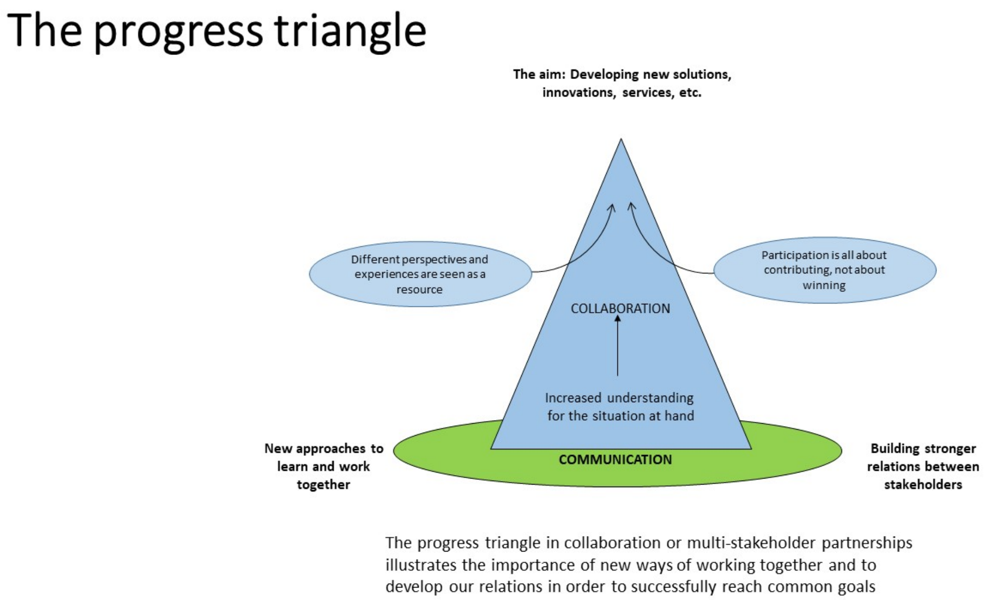


Figure 3. National map of potential well suited spots for the establishment of constructed wetlands. Case area in the red circle. Green indicates clay soils.

Strategic tasks & goals in the catchment

The strategy is to involve landowners nearby the watercourses in the two areas. This is done by a current variation of focus group meetings, individual farm visits and by involving municipalities and experts to make everyone understand the potentials and limitations of the landscape as well as landowners' approach to various environmental measures in the area. The starting point is that landowners are best at relating to the local area as they often know the area very well.

The work in Waterdrive, Denmark is based upon *the progress triangle* made by Magnus Ljung Swedish University of Agricultural Sciences.



Focus Groups - local actions and implementation

The main focus will be implementation of new drainage measures and establishment of wetlands. Waterdrive will examine cross-sector cooperation through involved parties in one or more focus groups. The cooperation is described under Focus group meetings Denmark. Involved parties:

- Landowners
- Local farmers union
- Local advisory service
- Local catchment officers
- Municipalities of Odense and Assens
- SEGES, the national advisory service

Report about the case area

The following description of the Waterdrive case study areas in the catchment area of Odense Fjord is based on selected parts of the report ”Kvælstofindsatsen i oplandet til Odense Fjord” (Nitrogen reduction measures in the catchment area of Odense Fjord) prepared by SEGES in 2014. The report examines whether it is possible to replace the planned targeted nitrogen regulation, which will lead to restrictions on cultivated land, by increased collective efforts with voluntary measures such as wetlands, constructed wetlands, forest or new drainage measures like constructed wetlands with woodchips, intelligent buffer zones, saturated buffer zones with woodchips etc.

The report laid the grounds for choosing the catchment area of Odense in the Waterdrive project, as described in the report the demands for this catchment area are very high, which is why SEGES chose the area.

Read more about drainage measures on www.waterdrive.dk under measures. Also see the catalogue from SEGES ”Targeted environmental measures” (The catalogue is the last picture on the page).

Short extracts from the report with main focus on the text about drainage measures

The potential for constructed wetlands depends particularly on the size of the drained area in the catchment area. SEGES has estimated that 34,200 ha of cultivated land has been drained – which is 61 % of the area. SEGES has also conducted a GIS-analysis, which identifies areas potentially suitable for constructed wetlands (or other drainage measures). 23.000 ha were estimated to be suitable for this.

On the basis of an estimated nitrogen loss of 30 kg N per ha from drainage to the point where the water runs into the watercourse SEGES estimates that 1 ha constructed wetland can reduce emission to the fjord by 615 kg N. This estimation is based on the assumption that the constructed wetland removes 25 % of the supplied nitrogen.

SEGES estimates that it is possible to establish constructed wetlands with open basins on a maximum of 50% of the area potentially suitable for constructed wetlands. (23.000 ha). According to the regulation this would require constructed wetlands with a total water surface of 115 ha to reduce nitrogen emission to the fjord with approximately 71 tonnes N per year. The potential for nitrogen removal in constructed wetlands with open basins is thus approximately 10 tonnes N larger than the planed collective effort with constructed wetlands. If the aim is to avoid targeted regulation altogether a nitrogen removal of at least 208,2 tonnes must be obtained with drainage measures.

SEGES considers establishment of constructed wetlands to the extent planned under the collective effort to be a major challenge, and in our opinion constructed wetlands with open basins can only to a limited extent replace targeted regulation on cultivated land. However, this could change if reduction demands were changed to include phosphorus and the time-related distribution of the measures effect on emission to the fjord. Constructed wetlands effectively reduce phosphorus emission.

It is obvious that the potential of constructed wetlands with open basins (25 % nitrogen removal) is insufficient. If drainage measures are to lift the larger part of the nitrogen efforts then a higher nitrogen removal is needed, and there is a need for a wider range of drainage measures, so that drainage measures can be established on a larger part of the drained area than it is possible to do with only constructed wetlands. It is important that the authorities act quick in approving other drainage measures than constructed wetlands with open basins amongst others constructed wetlands with woodchips – they take up less space and remove more nitrogen. It should be possible to choose the most suitable drainage measure for each individual area.

Potential for nitrogen removal with constructed wetlands

The average nitrogen emission through drainage to the point where the water runs in to the watercourse is estimated to approximately 30 kg N per ha.

According to the Danish National Catalogue of Environmental Drainage Measures (Eriksen et al, 2014), there is an expected effect of constructed wetlands with open basins (surface water) of 25-30 %, when nitrogen supply is in the order of 30 kg N per ha. This means that constructed wetlands can reduce nitrogen emission through drainage to the point where the water runs into the watercourse by 7,5 kg N per ha of the catchment area, which corresponds to 750 kg N per ha constructed wetland. This implies that the constructed wetland constitutes 1 % of the drainage catchment area. At an average nitrogen retention of 17 % in surface water for the potential drainage catchment areas to constructed wetlands, constructed wetlands will in average have an effect on the marine discharge of 615 kg N per ha constructed wetland. This corresponds to 6,15 kg N per ha drainage catchment area.

Clearly, it is far from possible to purify all drainage water with constructed wetlands. Many drainage catchment areas are too small. Other areas are so flat that too much soil needs to be removed to establish a basin with a depth of 1-1,5 metres. In other areas the slope is too steep.

Table 10-1 shows how much nitrogen can be removed with constructed wetlands with open basins, if they receive drainage water from 20, 30, 40, 50 og 60 % of the potential drainage catchment area for constructed wetlands of 23,000 ha.

Table 10-1. Scenarios for nitrogen removal with constructed wetlands with open basins by treatment of the drainage water from 20-60 % of the potential drainage catchment area for constructed wetlands in Odense Fjord. Calculated at a nitrogen supply of 30 kg N/ha drainage catchment area.

	Scenarios for constructed wetlands with open basins				
Percentage of potential drainage catchment area for constructed wetlands	20 %	30 %	40 %	50 %	60 %
Drainage catchment area for constructed wetlands in total, ha	4,600	6,900	9,200	11,500	13,800
Constructed wetland area, ha	46	69	92	115	138
Reduction of nitrogen discharge to the fjord, tonnes N	28	42	57	71	85

SEGES estimates that the maximum realistic goal is to establish constructed wetlands with open basins for approximately 50% of the drainage water from the potential drainage catchment area for constructed wetlands (23,000 ha), if the water is actually to be led to a constructed wetland. This would require establishing constructed wetlands with a total water surface of 115 ha (table 10-1). The expected reduction in nitrogen discharge to the fjord is approximately 71 tonnes N per year. However, in the River Basin Management Plan it is implied that constructed wetlands – as part of the collective efforts – should reduce emissions by 60.4 tonnes N. This would require constructed wetlands with a total water surface of 98 ha and a drainage catchment area of 9,800 ha corresponding to 43 % of the potential drainage catchment area for constructed wetlands.

Achieving the expected impact with constructed wetlands with the planned collective efforts will be a major challenge. And if we should succeed in covering 50 % of the potential drainage catchment area with constructed wetlands, this will only provide a further reduction in the emission to the fjord of approximately 10 tonnes N. Further to consider is that according to the River Basin Management Plan, the targeted regulation is expected to reduce nitrogen emissions to the fjord by 147,8 tonnes N.

SEGES considers just the establishment of constructed wetlands to the extent planned under the collective effort to be a major challenge, it is very unlikely that we can establish constructed wetlands with open basins to such an extent that they can replace the need of targeted regulation on cultivated land. and in our opinion constructed wetlands with open basins can, only to a limited extent, replace targeted regulation on cultivated land. However, this could change if reduction demands to the fjord are changed to include phosphorus and the time-related distribution of various measures' effect.

Drainage measures

It is possible to reduce the nitrogen content in drainage water in a variety of ways. Please find below an overview of the effect of different drainage measures according to Erichsen et al., 2014. Constructed wetlands with open basins are included as a measure in the River Basin Management Plans 2015-21. The other measures have not yet been approved by authorities.

In addition to nitrogen removal, most drainage measures are also very effective in phosphorus reduction. This aspect should be included in the River Basin Management Plans. Phosphorus is a relevant nutrient for both lakes and fjords and should thus be ranked alongside nitrogen in the River Basin Management Plans.

Table 11-2 overview of the effect of different drainage measures, percentage removal of added nitrogen. * Danish National Catalogue of Environmental Measures, AU 2014. ** American studies. *** Preliminary results from BufferTech and estimates.

Constructed wetland with open basin	Constructed wetland with woodchips	Bioreactor	Interruption of drainage before discharge to streams	Intelligent bufferzone	Saturated buffer-zone
20-30 % *	35-50 % *	43 % **	50 % *	25-50 % ***	50 % **

Constructed wetland

A constructed wetland with open basins has become a well-proven measure in Denmark. It is in the process of being approved and put into use in the nitrogen regulation until 2021. A constructed wetland with open basins normally consists of a sedimentation basin somewhat smaller than the other basins followed by a larger basin divided into sections of alternately deep (approximately 120 cm) and shallow water (approximately 20 cm). The nitrogen reduction primarily happens by denitrification in the sediment of the constructed wetland where anaerobic conditions occur. For one thing, the effect depends on the residence time for the water in the basin. In order to achieve a good effect, it is recommended that the constructed wetland constitutes at least 1 % of the drainage catchment area that drains into the constructed wetland.

Based on the previous tests, nitrogen removal is estimated to 20-25 % at a supply of less than 20 kg N per ha per year. It is possible that the effect increases as the constructed wetlands mature (build-up of carbon-rich sediment layer at the bottom of the basins).

Constructed wetland. Drone photo: SEGES.

Constructed wetland with woodchips

A constructed wetland with woodchips consists of several excavated basins, of which one or more basins are filled with woodchips or other carbon sources. The nitrogen reduction occurs by denitrification in the matrix with the carbon source. It is important that the plant is designed so that the drainage water runs through the entire matrix and that the water has a suitable residence time in the matrix basin. A constructed wetland with woodchips requires a smaller area than a constructed wetland with open basin. To have a high effect in the matrix plant, it can be beneficial to have an impounding basin to even out the flow of the drainage water. A constructed wetland with woodchips will typically take up 0,3 - 0,6 % of the drainage catchment area draining to the area of the constructed wetland.

Previous American studies suggest that a 50 % (35 %-75 %) nitrogen removal can be achieved.

Bioreactor

A bioreactor with woodchips or other carbon source is very similar to a constructed wetland with woodchips. A bioreactor consists of an oblong excavation filled with willow chips or another carbon source. The drainage water should run through the bioreactor. The nitrogen removal occurs by denitrification. The bioreactor may be covered with soil to allow for the area to be cultivated.

Constructed wetland with woodchips / Wood chip bioreactor / Bioreactor. Drone photo: SEGES.

Among other things, the effect depends on the reactor size compared to the amount of drainage water. At the right dimensions you can probably achieve a nitrogen removal of 43 % or more (35-75 %).

Interruption of drainage before discharge to watercourses

The measure is simple – you simply interrupt the drainage pipes from cultivated land and lead the drainage pipes to the soil surface eg at the slope of the transition between highland and river valley. The drainage water will either irrigate the lowland or infiltrate into the soil. It should be avoided for the drainage water to form a stream channel to the watercourse, so it might be necessary to establish a distribution ditch or a distribution channel.

The effect depends on whether the drainage water irrigates the lowland or infiltrates into the soil. The effect also depends on whether the land between the drainage outlet and the watercourse is humus soil or mineral soil and of the size of the lowland compared to the drainage catchment area. If the scale is 1:10 you can probably achieve a nitrogen removal of 50 % by irrigation of 50-75 %, when the drainage water infiltrates into the meadow soil. The effect may vary considerably (20- 75 %). Normally, it is assumed that a high effect of 50-75 % requires that the irrigated meadowland or wetland must constitute at least 10 % of the catchment area drained by the drainage system.


Interruption of drainage. Drone photo: SEGES.

Intelligent bufferzone (IBZ)

An intelligent bufferzone can be established along a watercourse in drained fields. There must be some slope from the field towards the watercourse. The width of the bufferzone could eg be 10 m. The drainage is interrupted at the transition from field to bufferzone and a distribution ditch is established along the bufferzone. Trees or bushes of permanent character are planted in a strip along the watercourse. Between the distribution ditch and the strip with bushes and trees there may be a grass strip.

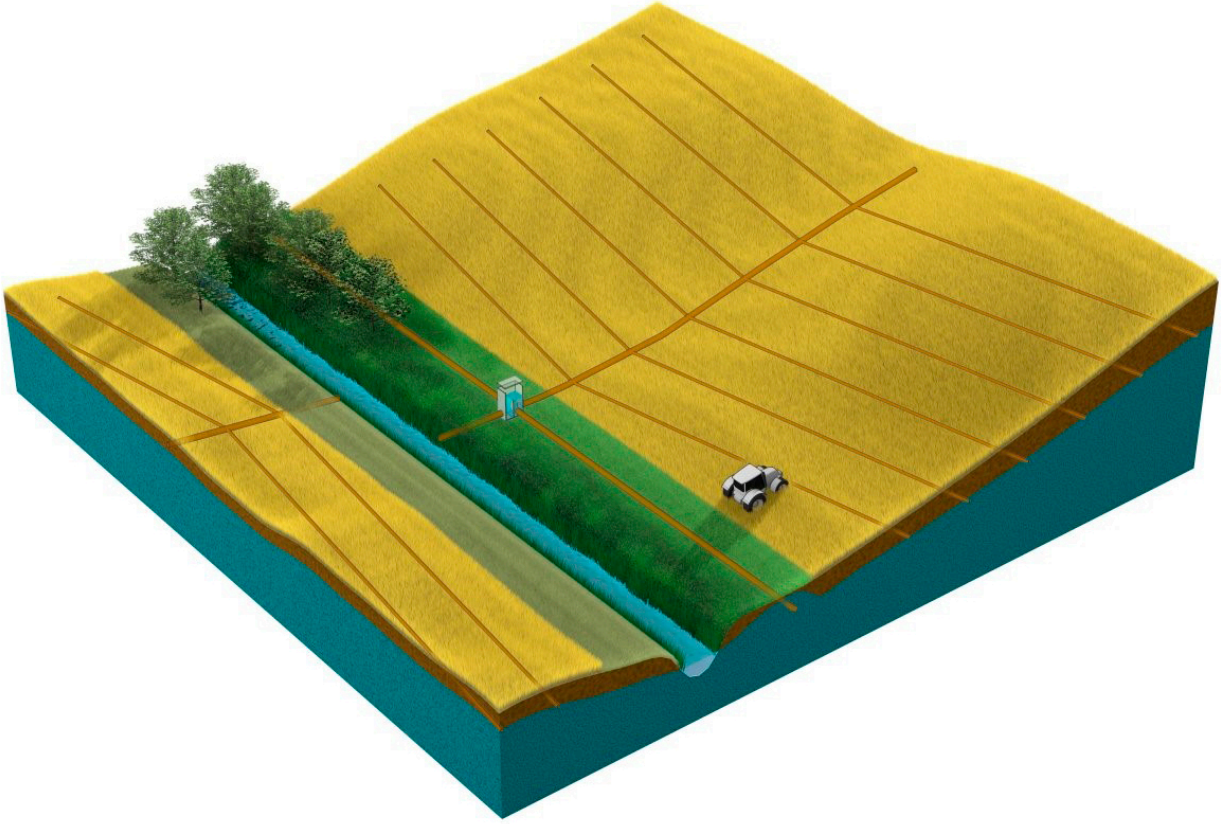
Intelligent bufferzones are being tested in Denmark and preliminary studies show good effect. Foreign studies have shown nitrogen removal between 30 and 99 %. The effect is likely to be in the range of 25-50 % depending on infiltration and size compared to run-off.

Intelligent bufferzone Sillerup in Denmark. Drone photo: SEGES.

Saturated bufferzone

A saturated bufferzone is very similar to an intelligent bufferzone. You establish a drainage ditch along the watercourse at the edge between the drained field and the bufferzone. It has to be possible to block the direct outlet to the watercourse in the drainage ditch, so that instead the drainage water is discharged into a distribution drain along the bufferzone. The nitrogen removal occurs by denitrification, when the drainage water seeps through the bufferzone into the watercourse. The effect depends on the carbon content of the soil. On top of the bufferzone there may be grass or the bufferzone may be cultivated with other crops. The effect depends on the width of the bufferzone. The width should not be more than 8-10 m.

Preliminary American studies indicate that the effect will be approximately 50 % but that it will vary a lot depending on soil conditions etc. (35-75 %) (Jaynes and Isenhart, 2014).



Saturated bufferzone. Illustration by SEGES.

STØTTET AF

Promilleafgiftsfonden for landbrug