THE MAGLE WETLAND
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This paper has been written to answer some of the many questions we have been asked about the wetland during the first year of operation. It contains a short background for the project and also some reduction results from 1995.

BACKGROUND

The restoration of Lake Finjasjön

In Hässleholm the concept of “environmental debt” has had very profound consequences.

L. Finjasjön was in the early 1900’s much used for swimming, fishing and recreation. It was also the main source for drinking-water in the city of Hässleholm.

From 1900 to 1960 the population of the town increased from 2000 to 20000 people due to its situation as railroad cross-point, its military regiments and schools. In the 50’s the lake showed its first signs of eutrophication as a consequence of the load of nutrients to the lake from sewage, run-off water and farming. The sewage treatment was improved step by step, but by the time highly efficient phosphorus reduction was introduced in 1977 the damage was already done. Blooms from the toxic blue-green algae Microcystis Wesenbergi arose each summer so intense that in spite of re-infiltration of the water we didn’t dare to use it for drinking water in the summer. Since the algal blooms started no swimming was aloud in the lake.

In the early 80’s a political decision was made that the lake should be restored saying that “in our time our children should be able to swim in the lake again”.

The early investigation pointed out that the reason for the eutrophication was the large amount of nutrient rich sediment in the lake. Through dredging the top sediment layer should be taken away. By doing this the leakage of nutrients from the sediments should decrease and the algal blooms stop. After some tests the dredging started in full scale 1989 and continued to spring 1991. By that time about 20% of the planned dredging had been done.

At that time the dredging was stopped, as it for most people involved was clear that by this method there would never be more than a marginal decrease of the amount of algae in the lake. (The sediment layer revealed was also rather rich of nutrients and to take all the sediment away was not possible).

From 1992 the restoration strategy was based on

- continued reduction of the phosphorus load. Magle wetland for further reduction in the treated sewage water, Sjörröds storm-water wetland, sewage piping refining och protection zones by the streams to the lake are examples of such measures taken.

- bio-manipulation in the lake.
The bio-manipulation was based on the simplified conceptual model below. It indicates that removal of cyprinides in an eutrophic lake results in increasing amounts of zoo-plankton and thereby increased grazing on the algae. The decreased amount of algae results in better transparency and better possibilities for the pescivores to control the cyprinides. According to this model the decreased amount of algae also affects the bottomleakage of phosphorus. With decrease in bottomleakage the growth of algae also will be limited by the access of phosphorus.

**EKZOLOGICAL MODEL FOR A EUTROPHIC LAKE**

The bio-manipulation was done during October 1992 to June 1994 with until now very fine results. Since then there has been no blue-green blooms and the water is again suitable for swimming. The bottomleakage decreased in 1994 and disappeared almost completely in -95. The transparency as well as all other parameters indicating the status of the lake showed that the lake was restored.

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**Secchi disk transparency**  
*in L. Finjasjön 1990-95*
Nitrogen reduction demand

Today all coastal-near sewage treatment plants must have nitrogen reduction as a part of the national decision to reduce nitrogen to the Baltic sea with 50%. Hässleholm was also regarded as coastal-near depending on the size meaning that nitrogen removal had to be built.

Nitrogen removal in the sewage plant?

An investigation of traditional nitrogen removal at the sewage treatment plant was made in 1989. The results showed very high costs depending on the need for supplying an external carbon source. In other plants problems with keeping low phosphorus concentrations and a more demanding maintianance was reported. Our interest in such an extension was therefore rather low, and we began to look for alternative solutions that could combine phosphorus and nitrogen reduction.

Landscape architecture

In many places in Sweden (among others Halmstad) reported good results in storm-water treatment in ponds. A central thought here was that sewage treatment could be built in such a way that it enriches the landscape instead of making damage to it. This thought became important for us while constructing the wetland. The higher costs such a way to build creates are well motivated as the area because of this also has become an attractive spot for recreation. Through making the treated sewage water visible we also believe that the working staff as well as people in general feels a greater responsibility for what goes into the sewage.

Combination effects

We found that a combination of measures at the existing sewage plant and a wetland should be able to give both phosphorus- and nitrogen removal. In this way it should be possible to solve the partly opposite goals to reduce phosphorus load to the lake, to reduce nitrogen to the Baltic Sea and at the same time create a for the area new and interesting biotope.

Pilot wetland

To get some knowledge of how such a wetland would function a one year test with a small 3000 m² wetland was carried out.

The result was that results from other studies seemed to work well. The question if macrophytes would grow in treated sewage water also got a clear answer. After one year we had a well established vegetation with mainly *Typha*, *Polygonum* and *Phragmites*.

Reactions on the proposal

Within the community there was great enthusiasm for the proposal from all instances. The county administrative board who were to give the allowance were more conservative and the swedish environmental protection board giving its considerations to the county board said no to the proposal. After a more detailed information on our plans and some minor changes the proposal was accepted.
WHAT HAPPENS IN A WETLAND?

Phosphorus reduction

We expect that about 50% of all supplied phosphorus will be “trapped” in the wetland. That the phosphorus concentrations in the water leaving the wetland are lower mainly depends on two different processes:

Assimilation

Dissolved phosphorus can be used by plants and algae as nutriment. This uptake is higher the faster the growth is meaning that the process is important during spring and summer but almost zero in winter. The phosphorus stays in the plants until these are degraded. To prevent degradation the wetland will be harvested each second year. Estimations from similar plants shows a possible result of about 40 kg phosphorus/ha (or 800 kg for the whole wetland). This means that it should be possible to take out about 400 kg phosphorus/year compared to the calculated 350 kg/year trapped phosphorus. In theory more phosphorus should be taken away from the system than trapped in it.

Sedimentation och mineralization

Parts of the phosphorus are bound to small particles. At low flow rates these will sedimentate. The same will happen to dead plants. At the slow degradation that follows, parts of the phosphorus will be resolved to the water, but other parts will be bound harder to minerals. At high oxygen levels this mineralization will work rather efficiently but at low levels more phosphorus will be resolved. To ensure good oxygen conditions the system is constructed with very shallow ponds in the later part of the wetland. The process is almost independent of time of the year.

Nitrogen reduction

We expect about 30% of the nitrogen reaching the wetland to “disappear”.

The picture for nitrogen is somewhat more complex than for phosphorus. It comes in two dissolved forms - nitrate and ammonium nitrogen and in the natural revolution nitrogen gas (79% of the air) is another form. Processes of importance in a wetland are:

Assimilation

Plant uptake in much the same way as for phosphorus. A yearly uptake of about 10 000 kg is estimated. Just as for phosphorus this process is greatly dependent of the time of the year. Ammonium is the form that is most easily assimilated, but also nitrate could be used.

Sedimentation

As for phosphorus nitrogen sedimentates and can be trapped in the sediment. Nitrogen compounds are generally rather soluble, so we don’t expect this process to be of any greater importance. It should however be independent of the season.
Denitrification

In a wetland with plants there is an ongoing microbiological degradation of organic matter. Here organic bound carbon is converted to carbon dioxide by use of oxygen dissolved in the water. If the oxygen concentration in the water is low other oxygen sources for the degradation are used. One group of bacteria uses the oxygen in the nitrate molecule for this degradation. At this process the nitrogen atom will be the rest product and released as nitrogen gas to the surrounding air.

This process is called denitrification and requires organic carbon, low oxygen levels and nitrogen in the form of nitrate.

If the conditions are right this process can be very efficient. (every year 250 000 kg nitrogen is removed by this process)

To optimize the system for denitrification

• the sewage treatment is carried out in such a way that most of the nitrogen is in the form of nitrate when it reaches the wetland.

• the ponds especially at the beginning of the wetland are rather deep resulting in low oxygen levels.

• plant establishment is favoured by shape and introduction of macrophytes giving access to easy degradable organic carbon.

• the size of the wetland is large enough to give acceptable retention time. The area is 30 ha, by which 20 are water covered and the medium depth is 0.45 m. This gives a volume of 90 000 m$^3$ meaning a 5-6 days retention time at normal flow (16 000 m$^3$/day).

Denitrification increases with temperature but does not stop completely during winter.

If both oxygen and nitrate should be used up sulphate ions would be used as oxygen source. This would give hydrogen sulphide as rest product that is a toxic and bad smelling gas. To avoid this we do not want completely anaerobic conditions and neither want we to reduce all nitrate. With the high nitrate concentrations we are working with here this risk however seems to be negligible.
FUNCTION

The wetland in figures

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<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Area:</strong></td>
<td>30 ha with 20 ha water covered.</td>
</tr>
<tr>
<td><strong>Volyme:</strong></td>
<td>90,000 m³</td>
</tr>
<tr>
<td><strong>Water depth:</strong></td>
<td>45 cm (maximum ca 2 m)</td>
</tr>
<tr>
<td><strong>Retension time:</strong></td>
<td>6 days</td>
</tr>
<tr>
<td><strong>Estim. nitrogen reduction:</strong></td>
<td>30% (35 tons/år)</td>
</tr>
<tr>
<td><strong>Estim. phosphorus reduction:</strong></td>
<td>50% (350 kg/år)</td>
</tr>
<tr>
<td><strong>Water flow:</strong></td>
<td>185 l/s (=16000 m³/day)</td>
</tr>
<tr>
<td><strong>Harvest:</strong></td>
<td>10 ha/year</td>
</tr>
</tbody>
</table>

Water flow in the wetland

The Magle wetland is besides the sewage plant the most important part for treating water from Hässleholm to L. Finjasjön, but other changes have also been made. In Sjörröd sited north of the sewage plant a 10 ha pond system for treating stormwater from the west part of Hässleholm has been built. Earlier this water ran directly to the lake in a small stream called Sjörrödsbäcken. Today all storm-water passes the pond system before it reaches the lake. These pond also takes up treated sewage water above the flow limit and also works as a recipient for brim water at high flow rates from the sewage plant.

To ensure long enough retension time in the Magle wetland the inflow rate is limited to 300 l/s (ab. 95% of the yearly flow from the sewage plant). If the flow is higher, the exceeding water will be pumped to the Sjörröd ponds.

One of the ponds here are separated from the rest and used as a brim magazine. The water from this is taken back to the sewage plant at times with lower flow, but if the capacity of this magazine is execeeded water from this will also reach the Sjörröd ponds.

**PRINCIPLES FOR POND SYSTEM AT THE HäSSLEHOLM SEWAGE TREATMENT PLANT**

- Storm-water from Hässleholm W, Hässleholm E
- Incoming sewage water
- Brim-magazine
- Storm-water ponds in Sjörröd
- Treated water exceeding 300 l/s
- To L. Finjasjön
- To L. Finjasjön
- Treated water up to 300 l/s
- Magle wetland for treated sewage water
In the wetland more water flow sources has to be considered. To be able to evaluate outlet concentrations some information about "irrelevant water" to the wetland and outflow besides the outlet channel has to be known. The scheme below shows the most important flows to and from the wetland and a rough estimation on their size.

**Groundwater**

The wetland is seated at the base of a small ridge and has its outflow in Maglekärrsbäcken. The groundwater has its lowest point in the area under this stream. North of the stream the groundwater level rises slowly. The flow direction for the groundwater is under the wetland and towards the stream with a slight bend towards L. Finjasjön. We therefore expect that changes in ground water concentrations will be limited to area nearby the wetland.
ENVIRONMENT

Surroundings

Before lowering of the lake the place was march with good connections to the lake. It’s southern part lies by a small ridge - Göingeåsen and was before the wetland pete march with low trees. The rest of the area was sandy meadows.

Trough the wetland a wandering path, Skåneleden, passes. Smaller roads around some of the ponds makes the main parts of the wetland suitable for walking and easy maintanance.

Just north of the wetland runs a new road, S. Kringelvägen. The building of this road has been co-ordinated with the construction of the wetland to minimize the need for masses and transportation.

In the east part of the wetland a small barn - Torkels lada is seated. It is planned to work as an exhibition and meeting place for visitors and bird-watchers. A bird tower and benches have also been placed in the area. The whole wetland is closed for cars with gates, but bicycles are allowed.

Biology

We know from the pilot plant that macrophytes will establish very rapidly, but to increase the variation of species some planting was done during summer 1995. *Phragmites, Phalaris, Elodea and Typha* were established.

The big areas with shallow overgrown water in combination with minor areas of firm land and left piles of twigs makes excellent spots for varoius seabirds. During the first year large numbers and many species of birds stayed at the wetland.

During the first year the biomass in spring was dominated by *Cladofora*. During june they were replaced in most ponds by *Lemma*. In autumn *Typha* and *Elodea* dominated in growth.
REDUCTION RESULTS

The results for reduction of nitrogen and phosphorus after almost one year's function (the wetland was taken in use in Feb. 1995) looks as a whole as we expected.

Monthly average 1995 for Magle wetland

<table>
<thead>
<tr>
<th>Month</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To wetland</td>
<td>From wetland</td>
</tr>
<tr>
<td>1995</td>
<td>mg P/l</td>
<td>mg P/l</td>
</tr>
<tr>
<td>Feb</td>
<td>0.27</td>
<td>0.22</td>
</tr>
<tr>
<td>Mar</td>
<td>0.21</td>
<td>0.17</td>
</tr>
<tr>
<td>Apr</td>
<td>0.18</td>
<td>0.11</td>
</tr>
<tr>
<td>May</td>
<td>0.18</td>
<td>0.10</td>
</tr>
<tr>
<td>Jun</td>
<td>0.12</td>
<td>0.13</td>
</tr>
<tr>
<td>Jul</td>
<td>0.14</td>
<td>0.17</td>
</tr>
<tr>
<td>Aug</td>
<td>0.14</td>
<td>0.11</td>
</tr>
<tr>
<td>Sep</td>
<td>0.16</td>
<td>0.08</td>
</tr>
<tr>
<td>Oct</td>
<td>0.16</td>
<td>0.10</td>
</tr>
<tr>
<td>Nov</td>
<td>0.16</td>
<td>0.11</td>
</tr>
<tr>
<td>Dec</td>
<td>0.16</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>0.17</td>
<td>0.13</td>
</tr>
</tbody>
</table>

When the wetland was taken into operation it took about one month before anything happened, but in April the wetland started reducing nutrients.

Nitrogen reduction was as expected most intense during summer almost 60% reduction during July-August. After this period the reduction decreased due to lower temperature.

We had expected some leakage of phosphorus mainly from the turf layers this first year and this happened also in the period June-August. At the same time the outlet water also contained humic acids resulting in more brown colored water and higher concentrations of organic matter (measured as both COD and BOD). The probable cause for this is that great areas of turf have been exposed to drastic changes (pH changes from about 5 to 7 and changes in bacterial exposure). We expect these effects to be reduced as the water and plants create a sediment layer in balance with the new situation in the wetland. As a result of the leakage the phosphorus reduction this year was only 25% compared to the 50% expected when the wetland is in balance and with well-established plants.
MORE INFORMATION...

... on the wetland construction and results can be achieved at the municipal office laboratory, tel +46-451-682 93

... on plants and harvesting at the municipal office gardening dep. tel. +46-451-682 57

... on birds and animals in the wetland by Göingebygdens biological organization (chm. Arne Gustavsson) tel. +46-451-155 51