OPERATIONAL IN 2008, COSTS WILL BE 35,500,000 EURO

Wastewater treatment plant Hilversum: ambition and challenge

Infiltration of effluent of the wastewater treatment plant Hilversum requires almost total removal of nutrients. The level of ambition is high: the wastewater treatment plant must produce effluent of superior quality with MBR technology on a limited area and will have a beautiful architectonic design that fits well in the landscape. The biological treatment is a system of 18 tanks in series; anaerobic, anoxic, aerobic and anoxic respectively. The pilotplant results demonstrated the need to use chemicals to produce low phosphorus and nitrogen concentrations. The design of the membrane tanks is based on the principle of the 'universal' membrane tank.

The existing wastewater treatment plant Hilversum is located in the eastern part of the municipality of Hilversum in an area known as Anna's Hoeve. This area lies about 4 - 5 meters above sea level at the foot of the eastern slopes of the Gooise Heuvelrug. Just across the municipal border in the municipality of Laren a nature reserve is situated. In this nature reserve a number of lakes (Laarder Wasmeren) is present. Originally the area was composed of sandy deposits formed some 300,000 years ago by glaciers.

Nowadays the whole area is strongly influenced by human activities. Being the lowest area and outside the city limits, this area has been used to dump solid waste as well as for discharging wastewater.

The dumping of solid waste started before 1885. Since 1920 - 1930 the solid waste was distributed from a transfer station by a narrow-gauge railway. Nearby an incinerator was in operation for dead animal bodies. Combustible industrial waste and waste from public gardens was incinerated in the open air to reduce the amount of waste to be dumped. Ash has been used for filling up low lying recreational areas nearby. The landfill was closed in 1959 but illegal incineration of industrial waste has been practised longer.

Consequently the soil in Anna's Hoeve is heavily contaminated with heavy metals, PAH etc. The discharge of wastewater started as early as 1875, when an open storage area was constructed. From the storage the wastewater was distributed in the surrounding heath land and infiltrated in the soil. In 1940 the discharge of raw sewage was upgraded by the introduction of trickling filters. As a consequence the Laarder Wasmeren and the subsoil in these areas are heavily polluted with e.g. heavy metals.

The present wastewater treatment plant Hilversum was constructed in 1975 and the effluent is discharged in the Gooyergracht, some 5 km to the North. From there the effluent flows into the Eemmeer and finally into the North Sea. (The photo shows the area in its present state).

For Anna's Hoeve and Laarder Wasmeren a masterplan was developed. This plan includes as main items:

- Removing of the deposits in the Laarder Wasmeren
- Soil sanitation of large areas of Anna's Hoeve
- Storage of contaminated soils in a new 24 m high hill in Anna's Hoeve
- Realisation of new ponds and ditches
- Building of some 700 houses
- Construction of a new wastewater treatment plant Hilversum.

These different projects are realised by the municipality of Hilversum or the water board Amstel Gooi and Vecht (AGV). Other important stakeholders are the province of Noord-Holland and the owner of the nature reserve Goois Natuur Reservaat. As a result of the limited areas available, the different interests and the strong interactions it took many years to co-operate, but with an integrated design master plan as a result to be proud of.

Anna's Hoeve, view to the north; the new wastewater treatment plant Hilversum will be located exactly in the centre of the photo, just east of the present plant.

Wastewater and surface water systems

The present situation is indicated in the upper part of figure 1. About 50% of the sewersystem is combined. Because no surface water is available, all stormwater is stored and discharged after treatment in the wastewater treatment plant. The stormwater from the separated sewersystem is discharged in the local ponds and the Laarder Wasmeren. The effluent of the wastewater treatment plant is discharged with a pipe in the Gooyergracht.

One of the important changes in the future situation is that 2/3 of the effluent of the wastewater treatment plant will be infiltrated in the soil in order to reinforce the natural groundwater flows from the

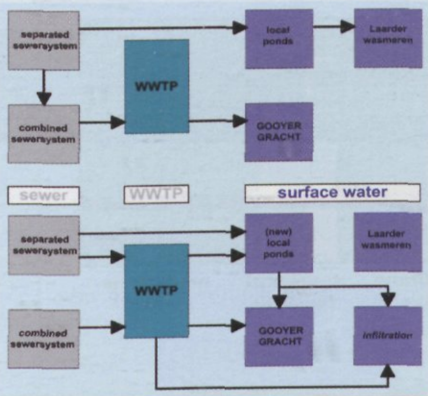


Figure 1: *Sewer system, wastewater treatment plant and surface water at present and in future.*

Gooise Heuvelrug to the west, where some natural lakes suffer from a lack of water. In order to facilitate this reinforcement, the choice was made to apply the best technical means for the wastewater treatment; the effluent standards for nutrients will be as low as 0.15 mg/l total-P and 2.2 mg/l total-N. The wastewater treatment plant is designed as Membrane Bio Reactor (MBR).

In the future situation the system will change as indicated in the lower part of figure 1.

After the cleaning of the Laarder Wasmeren it is no longer allowed to discharge any water in these lakes. New local ponds will be made to replace the storage capacity of the Laarder Wasmeren. Most effluent (2/3) will be discharged to the infiltration area directly by pipe or indirectly via the local pond system. The remaining effluent will be discharged to the Gooyergracht like nowadays. The effluent pipe may be used for discharging the excess stormwater from the local ponds as well. The concentrated wastewater from the separated system will be introduced as a separate flow in the wastewater treatment plant at all times. The other inflow is from the combined sewer and/or the stormwater storage (not indicated in figure 1).

All opportunities to cooperate and to design sewerage, wastewater treatment and the surface water as an integrated system were fully utilized.

Design

The level of ambition is high: the wastewater treatment plant must produce effluent of superior quality with MBR technology on a limited area and have a beautiful architectonic design that fits well in the landscape.

Many aspects of the design result from the knowledge and experience of the pilotplant, in operation since November 2001 and still an indispensable source of knowledge and experience.

Design characteristics MBR Hilversum.

capacity	91,000 p.e.
hydraulic capacity	1,500 m^3/h
DWF (dry weather flow)	450 m^3/h average, 618 m^3/h max
SWF (storm weather flow)	882 m^3/h
effluent quality	P = 0.15 mg/l N = 2.2 mg/l
phosphate removal	biological
F/M ratio	0.044 g BOD/(kg MLSS.day)
MLSS	7.8 g/l
design temperature	10°C
biological treatment	1 lane concept
biological sludge production	3,000 kg/d solids
sludge treatment	mech. thickening and transport to central facility
redundancy of equipment	based on risk analysis
odour and noise	zero nuisance

The plant will be operational in 2008 and the costs will be 35,500,000 euro.

The separation in the sewer system between the separated and combined system is continued as much as possible in the wastewater treatment plant (Figure 2).

Except for the influentbuffer in the DWF-line both the DWF and SWF lines have the same scheme for pre-treatment: screening (3-4 mm), sand removal and sieving (0.50 - 0.75 mm). The influent buffer in the DWF line has multiple functions: equalize flow and concentration of DWF, reduce flow through aeration tanks and membranes with 11%, removal of floating material and extra anaerobic retention time (assisted by adding some activated sludge).

The DWF line is connected to the anaerobic tank whereas the SWF line bypasses the anaerobic tank and is connected to the predenitrification (Figure 4). This prevents a reduced retention time in the anaerobic tank by the (more diluted) SWF. Moreover the possible introduction of oxygen with stormwater in the anaerobic tank is eliminated.

The biological treatment is a cascade/plugflow system of 18 tanks of about equal size and dimensions in series. The oxygen conditions are anaerobic, anoxic, aerobic and anoxic respectively. The flexibility in the design is demonstrated by the possibility to recycle a low nitrate flow from tank 6 to tank 1 as well as from tank 18 to the anaerobic tank 1. Optional recirculation from tank 18 to 7 results in changing the cascade/plugflow into a recirculation character. Additional flexibility is introduced by the possibility to convert the tanks 5, 6, 13, 14 and 18 into aerated tanks. The pilotplant results showed that it was not possible to produce low P and N concentrations without the use of chemicals. In Figure 3 the use of acetic acid and methanol is indicated, but it is also possible to use ferric chloride and another carbon source e.g. a waste product.

Tank 19 is the last tank ahead of the separate membrane tank. The tank is aerated to prevent EPS to enter the

Figure 2: *Sewersystem and pre-treatment.*

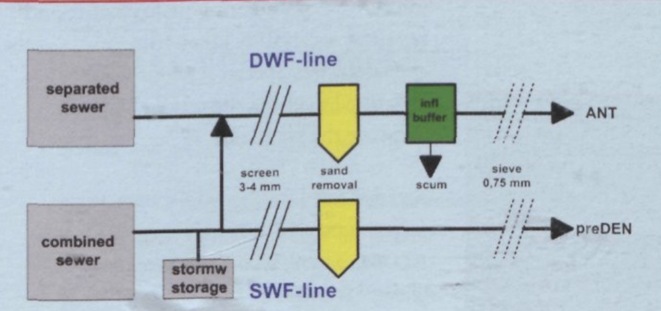
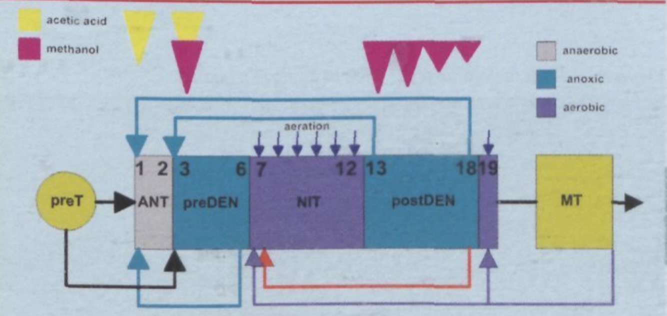


Figure 3: *Biological treatment and membranes. preT = pre-treatment, ANT = anaerobic tank, preDEN = predenitrification, NIT = nitrification, postDEN = postdenitrification, MT = membrane tank.*



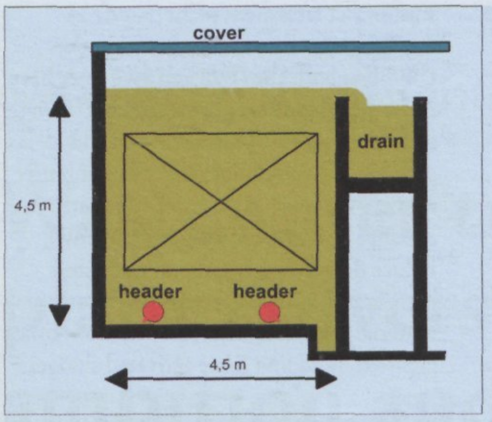


Figure 4: *Cross section of the 'universal' membrane tank.*

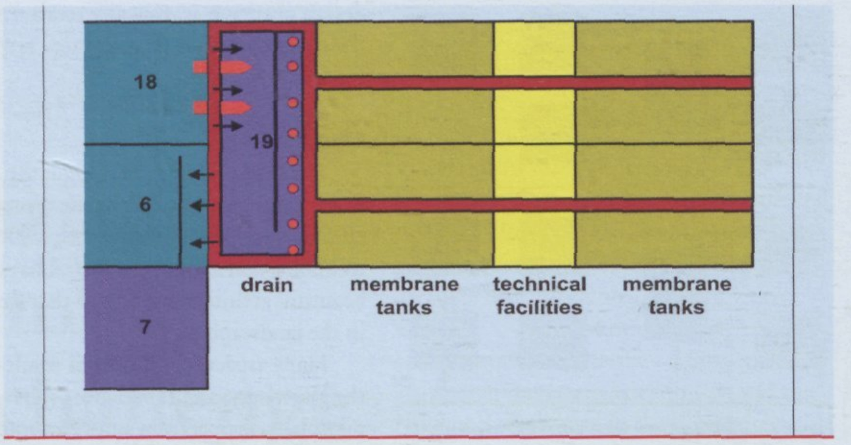


Figure 5: *Layout of membrane tanks.*

membrane tank and also contains the submersible pumps for feeding the membrane tanks. The recycling from the membrane tanks can be divided in any proportion between tank 7 (effect: introducing the oxygen in the nitrification but decreasing the retention time in the tanks 7 - 18) and tank 19 (no effect).

The design of the membrane tanks is based on the principle of the 'universal' membrane tank. This tank can accommodate membrane systems of all major suppliers, submersed and dry systems, eventually with small adjustments ('one size, fits all'). This prevents that dependence on one specific supplier arises during commissioning or in the future, when the membranes have to be replaced. The cross section of the membrane tank is presented in Figure 4. The sludge is distributed in the membrane tank by two headers with a number of restricted openings pointing 45° down.

Figure 5 presents the lay-out of the 8 membrane tanks, the centrally located technical facilities and the drain system for the recycle of activated sludge with the overflow to the tanks 7 and/or 19.

The process control of the wastewater treatment plant Hilversum will reflect the flexibility of the design. This control system will be designed based on a model of the processes of the wastewater treatment plant. The results of the pilot plant will be used for calibration and validation of the process parameters. This enables to design the control system on a trial and error basis while testing the control system for response to different dynamic loading conditions. Once the control system of the model meets the objectives it will be used for source code generation of the plants SCADA system. The method for 'model based design' has been chosen because:

- the design of a good control system without 'seeing what it does' is not considered possible for complicated systems like this wastewater treatment plant with its stringent effluent standards;
- reprogramming the control system of the model for SCADA application is not only expensive, but also a source of errors;
- testing and adjusting under operational conditions is not possible because of the high effluent quality required.

The control system will optimize both effluent quality and costs for energy and chemicals during DWF (89% of the time) and mainly effluent quality during SWF (11% of the time).

Landscape and architecture

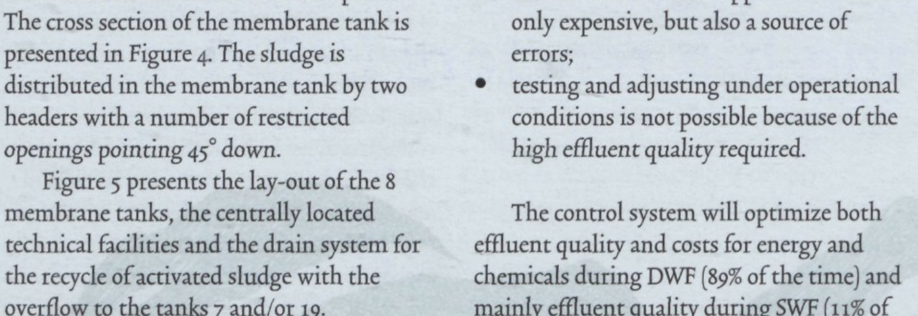
An important aspect of the ambition level is a beautiful architectonic design of the wastewater treatment plant that fits well in the landscape. Initially the plant was designed as a compact but more or less traditional wastewater treatment plant. The large buildings with a typical height of eight meter would have been clearly visible from the adjacent nature reserve. The required area was about two ha.

In February 2004 a landscape study was commissioned by the municipality of Hilversum or the water board AGV. The result of this study by Grontmij was that the main part of the wastewater treatment plant should be situated under the hill of polluted soil (double land utilization). Based on this idea the final architectural design was made by Snelder Compagnons. The result is that all buildings will be 'hidden' under the hill, except the office building. This part is designed as a beautiful 30 m high landmark. The excellent opportunity to discharge the treated process and vent air at this altitude with an invisible stack inside the landmark was immediately recognized and will be a major advantage to fulfil the zero nuisance objective. The required footprint was reduced to about one ha.

All logistics (trucking of solid waste, sludge and chemicals) will take place from an incision in the hill, accessible from two sides. Figure 6 shows the outlines of the hill and the situation of the wastewater treatment plant and Figure 7 an artist impression of the office building.

In such a wastewater treatment plant health and safety are extremely important. From the start of the design, health and safety, especially during maintenance and repair, was carefully taken into consideration. Special sessions were organised to check the results and/or improve the standards.

Figure 6: *Artist impression of the office building as a landmark.*



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