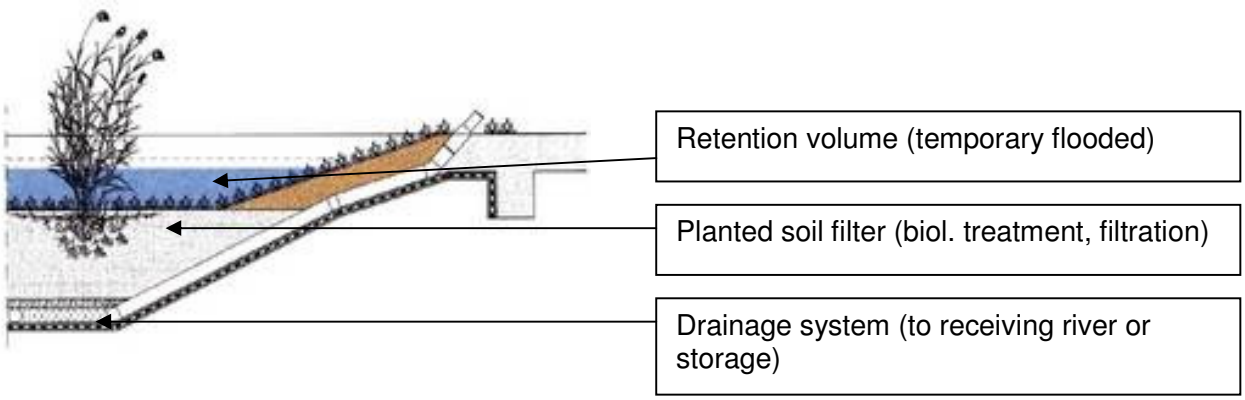
Treatment of storm water and combined sewer overflow with planted retention soil filters

History of treating storm water and combined sewer overflows in Germany

After completing the expansion of the local waste water treatment plants, pollutant freights which are discharged into receiving waters are increasingly reduced.

With regard to the water purification further reduction of the load through combined waste water overflows can be achieved and the discharge of the rain water to the receiving water is under special importance.
Therefore to protect the receiving waters from excessive hydraulic and material load due to combined waste water overflows special measures are taken.
This is done mostly in the form of storm water overflow basins in which the mixed water is cleaned mechanically.
As basis for the dimensioning of these release structures in the combined sewer system the guidelines of the worksheet-A 128 (ATV 1992) are regarded as a technical system of rules.
For this convectional possibility the mixed water treatment had become the compliance of the minimum standards for the past years.

The number of planted retention soil filters increased over the last decade and has been successfully used.
With this innovative procedure it is possible not only to meet minimum demands or ongoing demands on combined water treatment but to achieve a full treatment of combined water.
Comparing mechanical cleaning efficiency of conventional rain overflow basins with a planted retention soil filter – apart from the settling effect – the retention planted soil filter achieves even a high biological cleaning result.



Cross section of a retention planted soil filter

Picture of a retention planted soil filter

Processes in a planted soil filter

The storm water is collected in a gravity storm water network or by surface channels and is discharged on top of the planted soil filter. At combined sewers the combined waste water flows over an overflow structure into the retention soil filter once the combined sewer is filled by the storm water.

In larger systems the storm water can also be stored in a separate lagoon before it enters the planted soil filter.

The separate storage lagoon and/or the retention volume above the planted soil filter (freeboard) allows for the storage of the collected storm water. After the short term filling during the rain and storage the storm water is send slowly over days through the planted soil filter for treatment.

Besides the sedimentation of solids and filtration of floating particles the planted soil filter combines aerobic and anaerobic decomposition processes in a 1.0 m thick soil or substratum layer. The polyethylene lined and refilled basins are planted with helophytes like Phragmites communis, Typha latifolia, Typha angustifolia or other aquatic macrophytes.

The storm water percolates the filter substrate vertically or horizontally to the bottom or side drains.

Besides the microbial and fungal decomposition of organic matter and pollutants in the rooted soil or substrate matrix, chemical and physical precipitation, adsorption and filter processes occur due to soil constituents like clay minerals and humus particles. This is most important for phosphate and ammonia binding. Some of the storm water nitrogen is released out of the artificial ecosystem to the atmosphere as nitrogenous gases (denitrification).

Through intermittent loading of the reed beds a radical change of oxygen regime is achieved. After water saturation by feeding with the distribution system or by flooding the complete planted soil filter a drainage network at the base or sides

collects the purified water. The pore space of the substrate is refilled with air thus enabling aerobic decomposition processes.

Another part of oxygen transfer into the rhizosphere happens through a special helophyte tissue in the plant stems and roots (aerenchym) from the air.

Clogging effects of the filter substrates (soil, sand, gravel) are prevented by the continuous growth and decay of roots and rhizomes of the aquatic macrophytes and the thereby remaining soil macro pores. In this manner, long-term water transport into the soil matrix is guaranteed.

The substrate, which is filled in the sealed earth basins, is a sitespecific mixture of selected components determined by aspects of hydraulic conductivity and physico- chemical properties.

After the storm water passed through the planted soil filter it can be discharged into the next receiving water body or can be stored for a later reuse for irrigation.

Differences between planted retention soil filters for storm water / combined sewer overflows and planted soil filters for waste water:

Planted soil filter	
Stormwater treatment	**Sewage treatment**
Task: • Treatment of stormwater • Treatment of combined sewer overflow • Storage of stormwater/overflow Charakteristika: • Short term high solid load • Short-term flooded • Weather induced without loading Components: • Overflow structure/pump station • Separate settlement and storage pond or retention volume above soil filter • Planted soil filter • Outflow structure to river, sea and groundwater (infiltration area) or storage and pump station to irrigation	Task: • Sewage treatment Charakteristika: • Little solid load • No flooding • Continious intervall operation Components: • Pretreatment (screen, settlement basin) • Pump station • Planted soil filter • Outflow structure to river, sea and groundwater (infiltration area) or pump station to irrigation

Outlook for U.A.E.

Comparing Europe to the U.A.E. rainfall only appears in some days per year. In this case the collected rainwater should not only be treated by a planted retention soil filter and discharged to a receiving water (mostly seawater) or ground but should also be stored and reused for irrigation. The storage can be realized with a pond or storage even below the planted filter. To prevent eutrophication and re-pollution of the stagnant stored water the same retention soil filter which is used for treating the storm water at the time of entering the system can be used for treatment of the stored water by recirculation of the stored water through this filter during non rainy season.

The storage pond and the filter can be combined in one unit (storm water treatment biotope), see projects at the end of the document.

Additional to the storage and treatment of the storm water, these storm water treatment biotopes can also treat and store the temporary emergency outflow of a STP or the sewage or grey water from adjacent developments.

A planted retention soil filter can therefore be used for sewage, grey water and storm water treatment.

The achieved quality of the treated water will be below the irrigation limits.

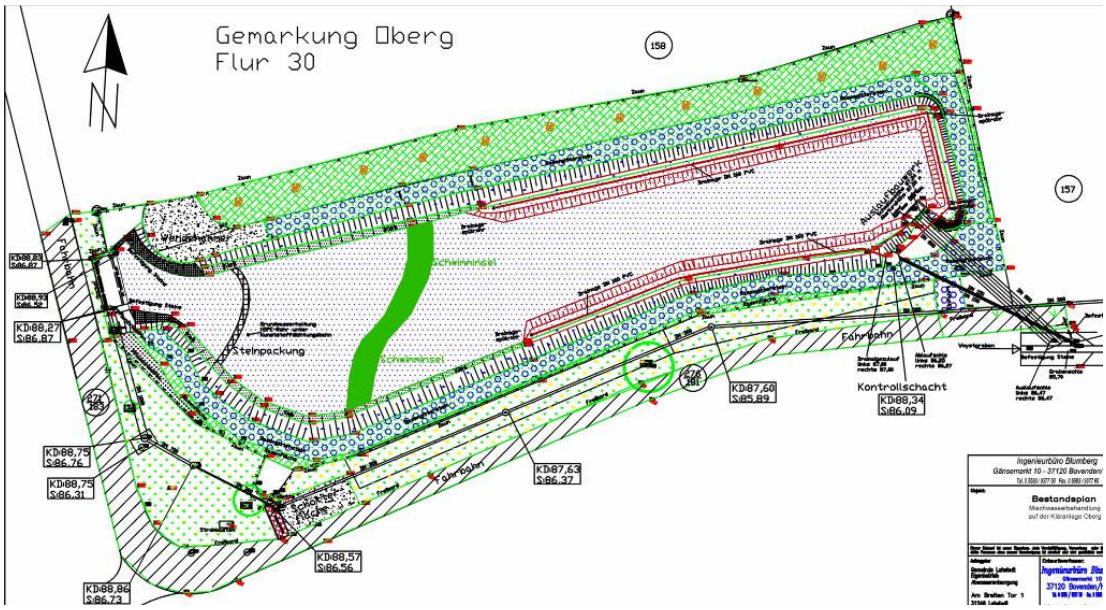
The water for reuse will not be pumped out of the storage pond directly, but out of the planted soil filter which will lead to filtrated water.

Therefore the planted soil filter is used for a treatment of the raw storm water, the permanent treatment of the stored water and a final filtration before reuse for irrigation.

After a longer period without precipitation and when all stored storm water is reused it is maybe necessary to supply the marsh plants on the filter with additional water. The amount per sqm is not higher than for normal turf irrigation and as described before sewage or grey water from adjacent developments can be used to water the marsh plants and get treated at the same time. During rainy season the system will be used for treatment of storm water, grey water and/or sewage and during dry season only grey water and/or sewage will be treated with the system to avoid additional irrigation.

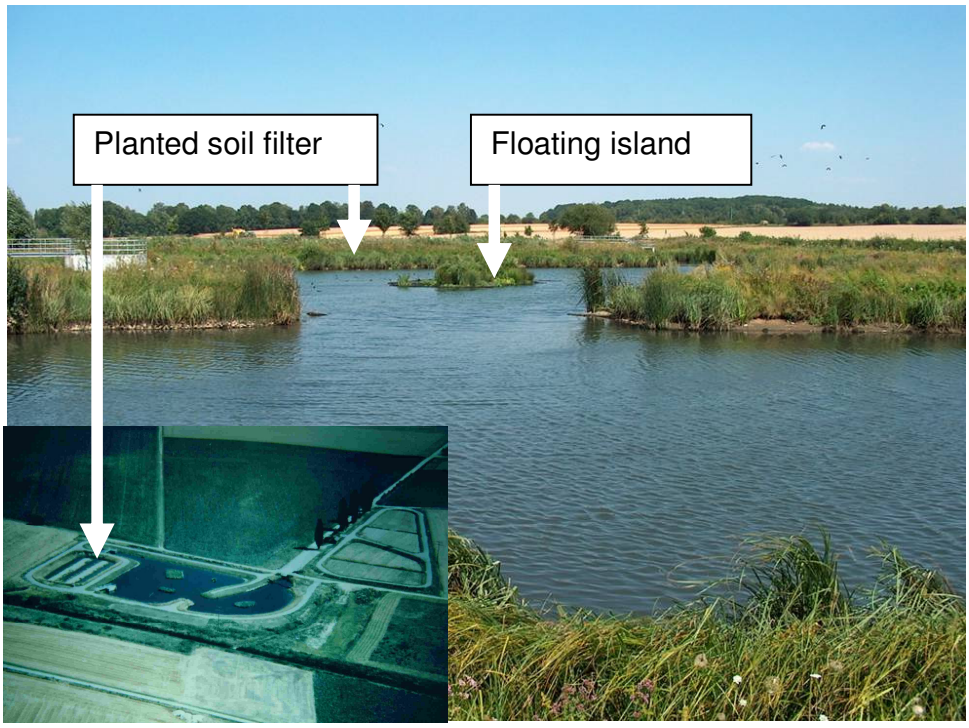
A planted retention soil filter with storage has the following functions:

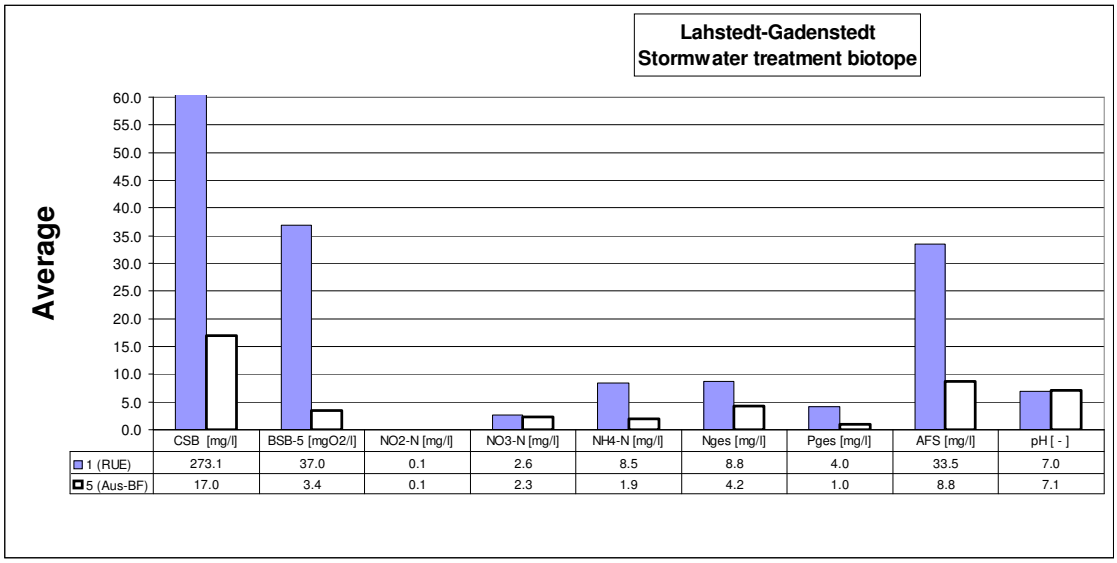
- Collection of the storm water
- Storage of the storm water
- Filtration of the storm water
- Biological treatment of the storm water
- Storage of the treated storm water
- Supply of irrigation water
- Supply of firefighting water
- Supply of process water
- A wetland complex with valuable biotope functions will be created
- Slow infiltration of treated surplus water into the ground if not reused
- Additional treatment of sewage or grey water



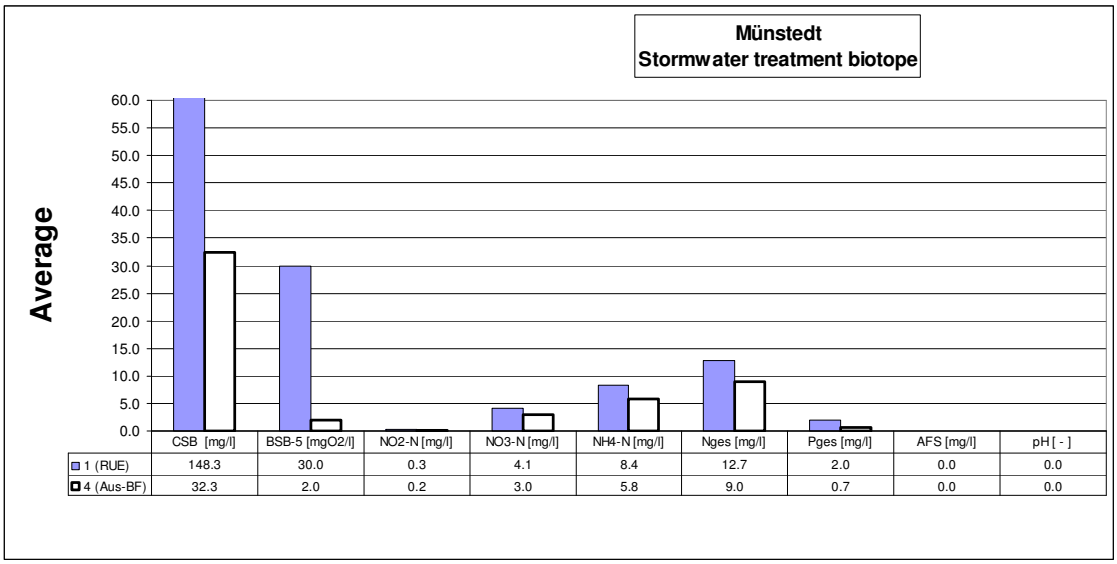
Layout drawing of a planted retention soil filter combined with storage lagoon

Analyses and photos of retention soil filter biotopes for combined sewer overflow:





	CSB [mg/l]	BSB-5 [mgO2/l]	NO2-N [mg/l]	NO3-N [mg/l]	NH4-N [mg/l]	Nges [mg/l]	Pges [mg/l]	AFS [mg/l]	pH [-]
1 (RUE)	273.1	37.0	0.1	2.6	8.5	8.8	4.0	33.5	7.0
5 (Aus-BF)	17.0	3.4	0.1	2.3	1.9	4.2	1.0	8.8	7.1



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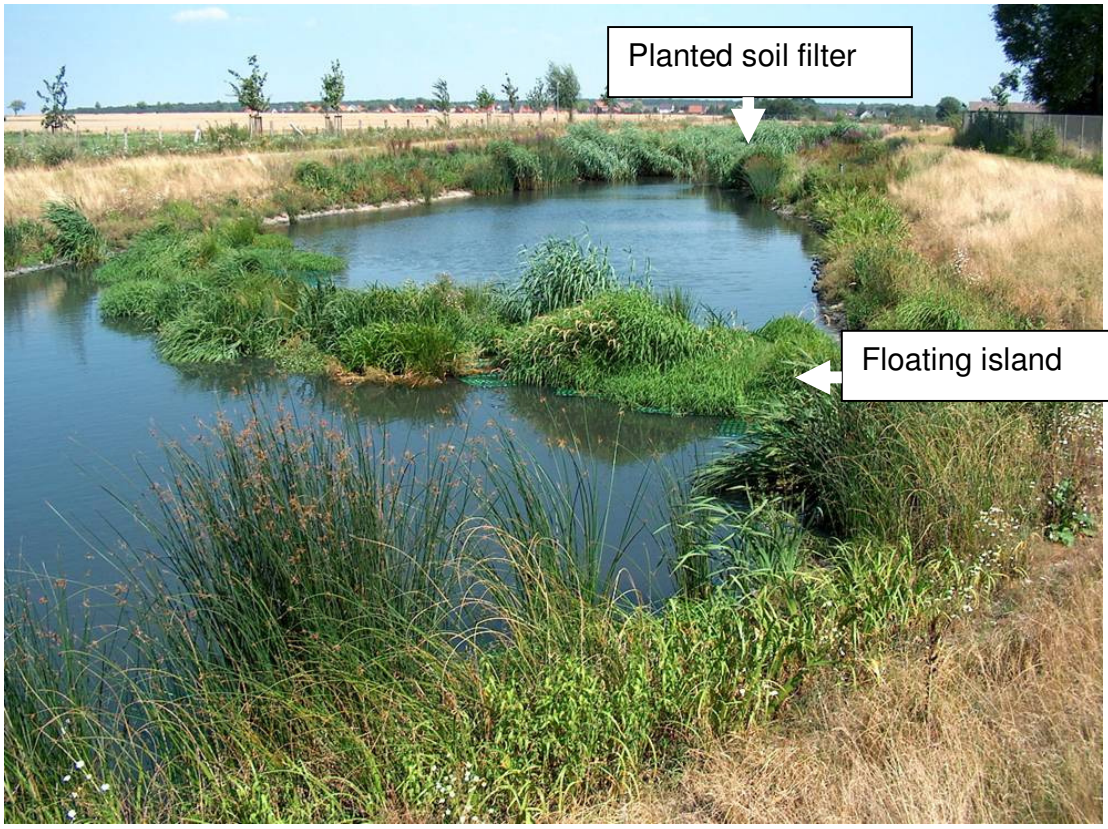
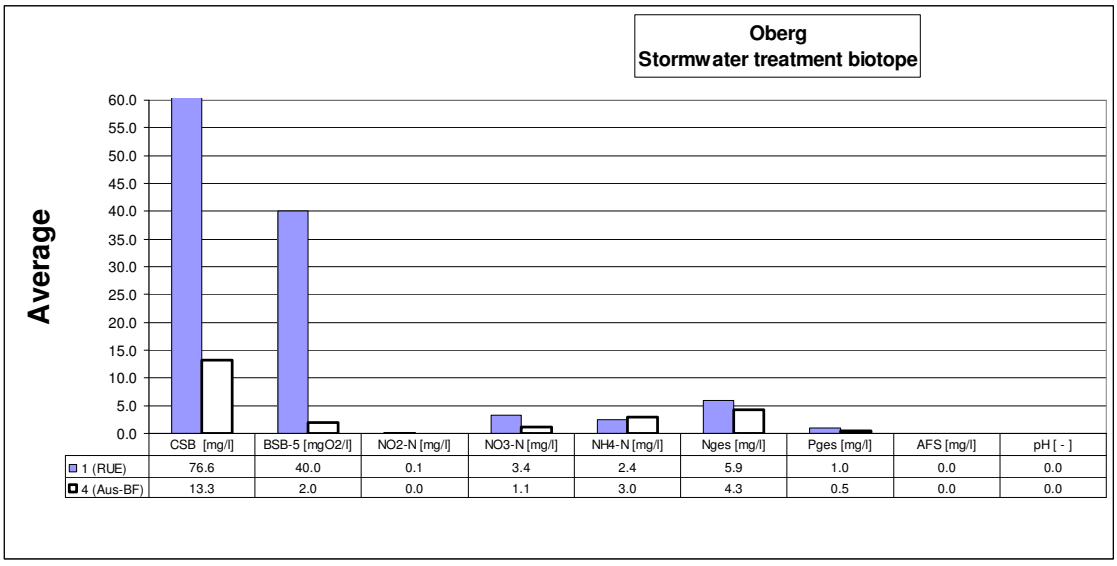
1 (RUE)	148.3	30.0	0.3	4.1	8.4	12.7	2.0	0.0	0.0
4 (Aus-BF)	32.3	2.0	0.2	3.0	5.8	9.0	0.7	0.0	0.0





	CSB [mg/l]	BSB-5 [mgO2/l]	NO2-N [mg/l]	NO3-N [mg/l]	NH4-N [mg/l]	Nges [mg/l]	Pges [mg/l]	AFS [mg/l]	pH [-]
1 (RUE)	76.6	40.0	0.1	3.4	2.4	5.9	1.0	0.0	0.0
4 (Aus-BF)	13.3	2.0	0.0	1.1	3.0	4.3	0.5	0.0	0.0