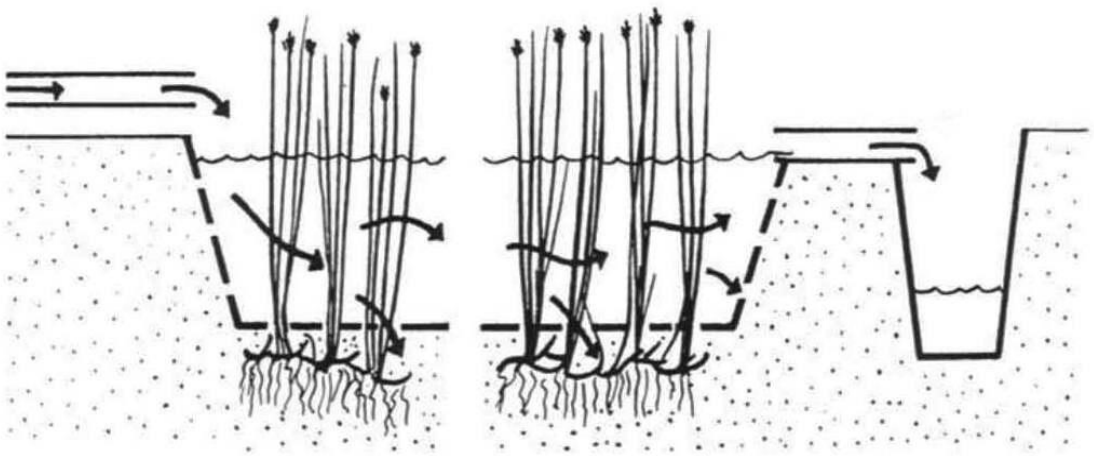
Constructed Wetlands

Constructed wetlands (CWs) are planned systems designed and constructed to employ wetland vegetation to assist in treating wastewater in a more controlled environment than occurs in natural wetlands. Hammer (1990) defines constructed wetlands as a designed, manmade complex of saturated substrate, emergent and submerged vegetation, animal life, and water that simulate wetlands for human uses and benefits. Constructed wetlands are an "eco-friendly" alternative for secondary and tertiary municipal and industrial wastewater treatment. The pollutants removed by CW's include organic materials, suspended solids, nutrients, pathogens, heavy metals and other toxic or hazardous pollutants. In municipal applications, they can follow traditional sewage treatment processes. Different types of constructed wetlands can effectively treat primary, secondary or tertiary treated sewage.

- **Types of Constructed Wetlands**

  Constructed wetlands for wastewater treatment can be categorized as either Free Water Surface (FWS) or Subsurface Flow (SSF) systems. In FWS systems, the flow of water is above the ground, and plants are rooted in the sediment layer at the base of water column. In SSF systems, water flows through a porous media such as gravels or aggregates, in which the plants are rooted. Table 1 illustrates the type of wetlands, vegetation types and water column contacts in constructed wetlands.



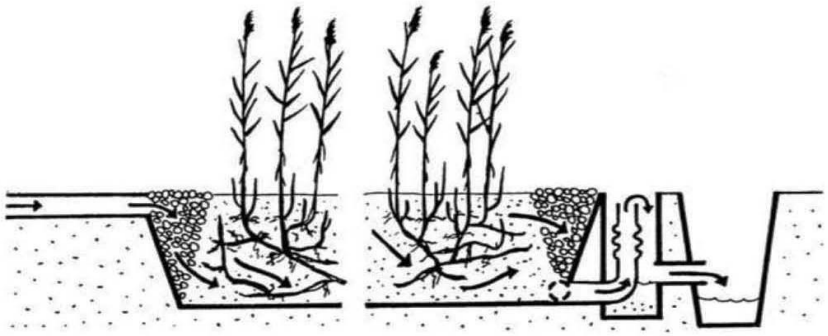


Table 1. Vegetation type and water column contact in constructed wetlands

Constructed wetland type	Type of vegetation	Section in contact with water column
Free water surface (FWS)	Emergent	Stem, limited leaf contact
	Floating	Root zone, some stem / tubers
	Submerged	Photosynthetic part, possibly root zone
Sub-surface flow (SSF)	Emergent	Rhizome and root zone

SSF systems are most appropriate for treating primary wastewater, because there is no direct contact between the water column and the atmosphere. There is no opportunity for vermin to breed, and the system is safer from a public health perspective. The system is particularly useful for treating septic tank effluent or grey water, landfill leachate and other wastes that require removal of high concentrations organic materials, suspended solids, nitrate, pathogens and other pollutants. The environment within the SSF bed is mostly either anoxic or anaerobic. Oxygen is supplied by the roots of the emergent plants and is used up in the Biofilm growing directly on the roots and rhizomes, being unlikely to penetrate very far into the water column itself. SSF systems are good for nitrate removal (denitrification), but not for ammonia oxidation (nitrification), since oxygen availability is the limiting step in nitrification.

There are two types of SSF systems: horizontal flow SSF (hSSF) and vertical flow SSF (vSSF). The most common problem with hSSF is blockage, particularly around the inlet zone, leading either to short circuiting, surface flow or both. This occurs because of poor hydraulic design, insufficient flow distribution at the inlet, and inappropriate choice of porous media for the inlet zone. Properly-designed SSF systems are very reliable.
FWS systems are very appropriate for polishing secondary and tertiary effluents, and for providing habitat. The environment in the FWS systems is generally aerobic at, and near, the surface, tending toward anoxic conditions near the bottom sediment. The microbial film grows on all available plant surfaces, and is the main mechanism of pollutant removal. FWS usually exhibits more biodiversity than does SSF systems.

The objective of using CWs is to remove organic matter, suspended solids, pathogenic organisms, and nutrients such as ammonia and other forms of nitrogen and phosphorus. The growing interest in wetland system is due in part to recognition that natural systems offer advantages over conventional activated sludge and trickling filter systems. When the same biochemical and physical processes occur in a more natural environment, instead of reactor tanks and basins, the resulting system often consumes less energy, is more reliable, requires less operation and maintenance and, as a result costs less. They also are used for removing heavy metals and toxic compounds. This manual is concerned with the design, operation and maintenance of sub-surface flow constructed wetlands.