



# CONSTRUCTED WETLANDS

RW10

ADDRESSED  
HAZARDSPROTECTED CRITICAL  
INFRASTRUCTURE

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Constructed wetland for stormwater runoff in Woodcroft Estate, Australia.  
Image Credit: Jan Vymazal, 2010. Open access Creative Common CC BY license;

## Primary functions and key services

- **Flood Risk Reduction:** absorbs and retains excess stormwater, helping to reduce peak flows and mitigate flood risks to nearby infrastructure, such as **housing, local roads and conventional drainage systems**. (Kumar et al., 2021; Justino et al., 2023)
- **Erosion Control:** supports sediment collection and contributes to reduce sediment transport near **housing and roads** infrastructure.
- **Water Quality Improvement:** filters pollutants and sediments from runoff, supporting wastewater management and enhancing water quality before it reaches **drainage systems** (Rigotti et al., 2020; Justino et al., 2023).
- **Stormwater Management:** reduces pressure on urban **drainage systems**, lowering the risk of system overload (Malaviya & Singh, 2012).
- **Sediment Trapping:** helps prevent sedimentation in downstream infrastructure like **dams, reservoirs, and water treatment plants** (Braskerud, 2001).

## Environmental impacts (EU taxonomy)

- Climate change mitigation
- Climate change adaptation
- Sustainable use and protection of water and marine resources
- Transition to a circular economy
- Pollution prevention and control
- Protection and restoration of biodiversity and ecosystems.

## ▶▶ What is it?

**Constructed wetlands** are engineered systems designed to mimic the natural processes of wetland ecosystems. They use vegetation, soil, and microbial activity to treat water, improve water quality, and manage stormwater. Constructed wetlands are effective in removing pollutants like nutrients, heavy metals, and sediments. They also enhance biodiversity, reduce flood risks, and provide recreational spaces, making them valuable nature-based solutions for water management. (Vymazal, 2010).

## Challenges this NbS addresses

Constructed Wetlands deliver main services to support mitigation of hydrological hazards such as:

- **Pluvial flood caused by heavy rainfall** - mitigation
- **Fluvial flood** - mitigation
- **Coastal flood**, like the ones originated by storm surges - mitigation
- **Surface runoff** reduction, by providing retention functions
- **Fluvial sediment transport** reduction
- **Sheet erosion and rill erosion** - control and/or mitigation
- **Gully erosion** - mitigation
- **Coastal and shoreline erosion** - mitigation

This NbS typology can also partially contribute with a more limited capacity to debris flood control, and to reduce heat and drought stress.

## Ecosystem services

- ▶ **Water Quality Improvement:** filters pollutants (e.g. nutrients, heavy metals, and sediments).
- ▶ **Carbon Sequestration:** CO<sub>2</sub> capture and storage in biomass depends on vegetation, highest with trees, shrubs, and reeds. Re-wetting soil enhances CO<sub>2</sub> capture to higher, sustained levels, creating valuable carbon sinks.
- ▶ **Biodiversity support:** supports biodiversity by providing habitats for various species.
- ▶ **Nutrient Cycling:** effluent can be used as fertigation water, applying plant-available nitrogen and phosphorus to enhance soil fertility.
- ▶ **Recreation and Aesthetic Value:** offers spaces for leisure, education, and community engagement.
- ▶ **Microclimate Regulation:** plants and water in constructed wetlands help cool the surrounding air through evaporation and transpiration.



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## Site suitability, scale and coverage

The scale of application can vary widely between small- to large-scale systems, depending on the target function and performance.

Constructed wetlands, or treatment wetlands, are generally divided into four main types (Dotro et al., 2021): Horizontal Flow, Vertical Flow, French Vertical Flow and Free Water Surface. The site conditions, contaminant removal targets and inlet flow characteristics determine the most suitable system or combination of systems:

- **Horizontal Flow Wetland:** normally applied for secondary and tertiary treatment, to be effective as primary treatment when there is need to remove particulate matter to prevent clogging of the filter. Advisable for sites with a large surface available and no diseases related to prolonged water-saturated conditions (Castaner et al., 2020, Dotro et al., 2021., Kadlec & Wallace, 2008, Sezerino et al., 2015).
- **Vertical Flow Wetland:** recommended for sites that allow the water to percolate vertically through the filter (Dotro et al., 2021). It is suitable for enhancing coupled contaminant removal processes: aerobic and anaerobic, which helps with nitrification and denitrification (Castaner et al., 2020).
- **French Vertical Flow Wetland:** advisable for screened wastewater and in sites that allow for having a slope gradient in order to facilitate the two stages series operating and in parallel, suitable for raw wastewater without primary treatment (Dotro et al., 2021).
- **Free Water Surface Wetland:** requires sites with large available areas and pre-treated wastewater (i.e. suitable for tertiary treatment). It is important to avoid using invasive species, which can have severe impacts to the local flora and ecosystem. (Dotro et al., 2021)

## Main components

- **In- and Outlet Structures:** control water flow into and out of the wetland.
- **Planting Beds:** vegetation is planted, often with specific design for roots to interact with water, enhancing filtration and pollutant removal.
- **Substrate Layer:** a layer of soil, gravel, or sand that provides support for plant roots and acts as a filtration medium.
- **Water Flow Channels:** engineered pathways that guide the water through the constructed wetland.
- **Reservoirs:** depressions where water can be temporarily stored, allowing for sedimentation.
- **Buffer Zones:** areas surrounding the wetland that help prevent contamination from external sources.

Implementation should include more nature-based solutions with groundwater connection and e.g. based on soil and water bioengineering techniques for bank, inlet and outlet designs or plant establishment. On the other hand, designs including more technical or grey structures or geocells might also be offered. However, constructed wetlands need thorough planning and the involvement of experts with the required know-how.

## Cost-benefit profile

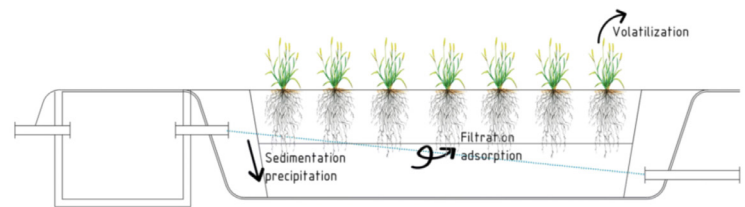
Similarly to other NbS, standard construction and O&M costs for Constructed Wetlands are difficult to determine as they are highly site-dependent and thus vary even within the same geographical context, depending on land-use zoning and local site-specific market conditions (Dotro et al., 2021).

In general, the capital costs for the construction of a constructed wetland range within the same order of magnitude as conventional wastewater treatment technologies. However, the O&M costs of constructed wetlands are much lower, due to their mechanical simplicity and much lower electricity consumption (Castañer et al., 2020; Dotro et al., 2021).

The capital costs consist of land acquisition, materials (pumps and pipes, substrates, plants, etc.), and site construction (Dotro et al., 2021), as well as indirect costs (technical site assessment, permit processes, other services of start-up activity) (Kadlec & Wallace, 2008). Land acquisition tends to be the highest incurred cost as Constructed Wetlands require relatively large surfaces (Dotro et al., 2021).

The annual O&M costs for a single-stage Vertical Flow wetland with design size of eight Population Equivalent (PE) for a farmhouse in Austria (as of 2015) amount to (Dotro et al., 2021):

- 180 EUR per year for external sampling and analysis (authorities requests).
- 120 EUR per year for primary sludge removal from the septic tank.
- One hour per month for additional sampling and analysis (pH and ammonia nitrogen effluent concentration), as well as visual checking, including cleaning when required.
- Five hours per year for vegetation maintenance.



**Schematic of Constructed Wetland, NbS family River, Floodplain and Wetland Management**

Image Cite: [Castañer, C.M, et al.], [2020], Used with permission.



## Examples of installation

### ▶ 1. Two Horizontal Constructed Wetland systems

- ▶ **Location:** Brazil
- ▶ **Implemented by:** Local entities guided by the research department from Florianopolis
- ▶ **Description and results:** both are systems projected as horizontal constructed wetlands. The one installed in Florianopolis (south of Brasil) has a total surface of 10 square meters and uses gravel and gross sand as the drainage substrate. The vegetation utilised are *Cyperus papyrus*. The second system has a 50 square meters total surface, its substrate is made of a combination of gross sand with rice hulls, and the plants used are *Zinopsis bonariensis*. Their removal efficiency for the Chemical Oxygen Demand was of around 80 to 90 % for both of them, and nutrients decreased in between 50 to 55 % (Sezerino et al., 2015).



**Constructed wetland for wastewater treatment of the City of Dicomano (FI)**  
Image Credit: [IRIDRA], [2003], Used with permission.

### ▶ 2. Constructed wetland for wastewater treatment of the city of Dicomano (FI)

- ▶ **Location:** Municipality of Dicomano (FI), Region Tuscany, Italy
- ▶ **Implemented by:** client was Municipality of Dicomano (FI)
- ▶ **Description and results:** among the largest secondary constructed wetlands in Europe. Covers an area of 6080 square meters and the project was completed in 2003. (IRIDRA, 2024)



**Constructed wetland for wastewater treatment of the City of Orheit (Moldova)**  
Image Credit: [IRIDRA], [2012], Used with permission.

### ▶ 3. Constructed wetland for wastewater treatment of the city of

- ▶ **Orheit Location:** City of Orheit (Moldova)
- ▶ **Implemented by:** Client was the World Bank, Global Environmental Facility Project - P.I.U. Moldova Gov.
- ▶ **Description and results:** largest constructed wetland system in Europe and among the largest in the world. Covers an area of 50,000 square meters and was completed in 2012-2013. (IRIDRA, 2024)

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