Built Environments
15. Built Wetlands

DEFINITION

Built wetlands, also known as *constructed*, *artificial*, or *treatment* wetlands, are water treatment systems built with wetland soils and vegetation to mimic the ecological and biophysical processes that improve water quality in natural wetlands (EPA 2023). They are generally shallow channels or ponds with wetland plants into which wastewater or stormwater is directed for treatment (EPA 2000). Built wetlands can be used to treat urban stormwater runoff as well as wastewater (Scholz 2015). They can remove a variety of pollutants including suspended solids, nitrogen, phosphorus, hydrocarbons, and metals (Gelt 1997).

TECHNICAL APPROACH

There are multiple ways to categorize built wetlands. One primary way is by the direction of flow: horizontal or vertical (UN-HABITAT 2008). Both use similar design and construction approaches, with differences in how water moves through the wetland. General steps for creation of a built wetland are outlined as follows.

1. **Excavation:** The project site is excavated and leveled to create a wetland basin that is level or slightly sloped (0.5% to 1%) toward the outflow in horizontal flow wetlands, with berms sufficient to contain rainfall during storms. Horizontal flow wetlands are generally 30–45 cm deep, and vertical wetlands 50–100 cm deep. If soils are highly permeable or if the wetland will be used for wastewater treatment, a liner should be used to prevent infiltration and protect groundwater quality (UN-HABITAT 2008).
2. **Substrate addition:** The basin is filled with a substrate that distributes flow, traps particles, allows vegetation rooting, and supports the microbial community (UN-HABITAT 2008). A variety of substrates can be used, including natural materials (gravel, sand) or artificial and industrial products. Some artificial and industrial products are designed for high hydraulic conductivity and phosphorus sorption capacity and may be useful when nutrient removal is required (Wu et al. 2015).
3. **Inlet and outlet construction:** Inlet and outlet structures are placed to allow effluent to flow into the built wetland and treated water to flow out of the wetland. There are a variety of inlet structures, including perforated pipes, channels, and gabions (cages filled with rocks). These structures should be placed so that water flows evenly throughout the entire wetland, rather than creating “dead zones” that are not in the flow path; vertical flow wetlands often require a network of pipes or channels to distribute the water over the wetland surface. Outlet structures are usually drainpipes or weirs that can be adjusted to set the water level in the wetland (UN-HABITAT 2008).

4. **Vegetation:** Vegetation is established by transplanting seedlings or plants or by broadcasting seeds (UN-HABITAT 2008). Emergent wetland plants are primarily used in constructed wetlands; in North America, the most used species are *Typha latifolia* and other *Typha* species (Figure 1). Because built wetlands are designed to remove pollutants, it is important to consider the plants' tolerance of the toxins and nutrients in wastewater, as well as their ability to remove pollutants (Wu et al. 2015).
5. **Water:** At first, clean water is introduced into the system to support plant growth. Once plants are established, increasing amounts of wastewater or stormwater effluent can be introduced. Wastewater needs to undergo primary treatment (separating suspended matter through settling) before the effluent is introduced into a built wetland (UN-HABITAT 2008).

OPERATIONS AND MAINTENANCE

Once established, built wetlands are relatively low-maintenance (UN-HABITAT 2008). Regularly required maintenance includes checking inlets and outlets, clearing debris and accu-

Figure 15.1 A stormwater treatment wetland in Apex, NC

Photo courtesy NC Wetlands

mulated sediment (especially if it blocks flows), and removing nuisance and invasive species (EPA 2000). Adjusting water levels and maintaining berms may be needed periodically. Because built wetlands are water treatment systems, water should be sampled and tested regularly to assess treatment efficacy (UN-HABITAT 2008).

FACTORS INFLUENCING SITE SUITABILITY

- ✓ **Historic, degraded wetlands without a water source:** Built wetlands can be used as a restoration approach for historic wetlands that no longer have a reliable water source (EPA 2000).
- ✓ **Medium- to fine-textured soils:** These types of soils are highly suitable for vegetation establishment, water retention, and pollutant trapping (MassDEP Wetlands Program 2008).
- ✗ **In a floodplain, floodway, or existing wetland complex:** Built wetlands should generally be sited outside of floodplain, floodway, or existing wetland areas to avoid degrading natural aquatic resources (EPA 2000).
- ✗ **Highly permeable soils:** Soils that allow rapid infiltration can cause groundwater contamination and make it difficult to create a hydrologic regime suitable for wetland vegetation (EPA 2000). Impermeable liners can be used to prevent infiltration if needed.
- ✗ **Shallow bedrock:** Basin excavation may be cost-prohibitive if bedrock is near the surface (MassDEP Wetlands Program 2008).
- ✗ **Discharge to cold-water fishery area:** Treated effluent may still have higher nutrient levels or temperatures that can disrupt cold-water fish habitat (MassDEP Wetlands Program 2008).

TOOLS, TRAINING, AND RESOURCES FOR PLANNING AND IMPLEMENTATION

Name and Link	Resource Type	Year	Authors/ Authoring Organization	Geography	Description	Resource Includes: Design/Construction Guidance?	Site Selection?	Monitoring Guidance?	Example Projects?
Constructed Wetlands Manual	Guidebook	2008	United Nations Human Settlements Programme	Global	Overview of built wetlands design and construction process	✓	✓	✓	✓
Manual: Constructed Wetlands Treatment of Municipal Wastewaters	Guidebook	2000	US Environmental Protection Agency	National	Explains how built wetlands function, project design, construction, operations, and monitoring	✓	✓	✓	✓
Wetland Construction: Principles, Planning, and Design	Course	N/A	Rutgers University	National	Four-day online course on planning, designing, and constructing a functional wetland	✓	✓	—	—

GRAY INFRASTRUCTURE ALTERNATIVES

Built wetlands can be an alternative to gray stormwater treatment and sewage treatment facilities. The ability of a built wetland to replace or supplement one of these gray infrastructure types depends strongly on the project's location and whether it is designed to create the necessary outcomes. Certain environmental conditions may require gray infrastructure rather than built wetlands. See the gray infrastructure alternative tables in Section 1 for a comparison of built wetlands to these alternatives.

LIKELY BENEFITS AND OUTCOMES

Primary objectives for each strategy are highlighted.

Climate Threat Reduction

- **Reduced flooding:** Built wetlands temporarily store water and can help to attenuate peak flows during storms (MassDEP Wetlands Program 2008).

- **Drought mitigation:** Built wetlands can provide effluent that meets water quality standards for reclaimed water, increasing water supplies during drought (Rousseau et al. 2008).

Social and Economic

- **Aesthetics:** Built wetlands have more aesthetic value than gray infrastructure alternatives (e.g., wastewater treatment plants) (Minnesota Pollution Control Agency 2023).
- **Recreational opportunities:** Built wetlands can provide opportunities for birdwatching, hiking, and other outdoor recreation (Minnesota Pollution Control Agency 2023). However, not all built wetlands are open to the public.

Ecological

- **Improved water quality:** Built wetlands are highly effective in trapping sediment and pollutants associated with sediment and can remove some nitrogen and phosphorus (Minnesota Pollution Control Agency 2023).
- **Supports wildlife:** Built wetlands are valuable for wildlife that use wetland habitats, including birds, reptiles, and amphibians (Minnesota Pollution Control Agency 2023).

BARRIERS AND SOLUTIONS FOR PRACTITIONERS

Common Barriers

Several barriers are common across many of the nature-based solutions strategies; these are described in more detail in Section 1 of the Roadmap. Additional notes about the barriers specific to built wetlands are included here.

- **Expense**
- **Capacity**
- **Public opinion:** In particular, communities are often concerned about the potential for built wetlands to create breeding habitat for mosquitoes (MassDEP Wetlands Program 2008).
- **Conflict with other land uses:** Built wetlands require more land than gray infrastructure alternatives, so they have greater potential for conflict with other land uses.
- **Regulation:** Built wetlands are not functionally equivalent to natural or restored wetlands, so they generally cannot be used for wetland mitigation.
- **Lack of effectiveness data**

Ecological

- **Adverse wildlife effects:** Built wetlands may intercept breeding amphibians trying to reach vernal pools (MassDEP Wetlands Program 2008).

EXAMPLE PROJECTS

Name and Link	Location	Leading Organizations	Techniques Used	Size, acres	Cost, $	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Huie Constructed Wetlands	Clayton County, GA	Clayton County Water Authority	Horizontal flow wetlands	532	30 million (Wysocky 2021)	Constructed in four phases between 2004 and 2010 (Hall 2010)	263 wetland cells treat up to 17.4 million gallons of water per day from the water treatment facility and discharge the filtered water into two reservoirs (Wysocky 2021).	Drought (almost 100% of daily water use is returned to waterways via the treatment wetlands) (Hall 2010).	Built wetlands are more cost-efficient and use less land than the previous system, which used pipes and sprinklers to distribute treated water over timberland (Wysocky 2021).
Demonstration Urban Storm Water Treatment Marsh	San Francisco, CA	Association of Bay Area Governments	Built wetland consisting of multiple ponds, shallow basins, and marshes.	~30	Not available	Constructed in early 1980s; specific duration not available	Constructed wetland built in degraded wetland that had been diked and filled. Water was diverted from an urban creek channel into the built wetland for treatment (Wetzig 1995).	No	Dense cattail growth restricted flow, requiring modification of the weir to restore flow (Wetzig 1995).

Name and Link	Location	Leading Organizations	Techniques Used	Size, acres	Cost, $	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Harbor Brook Constructed Wetlands Pilot Treatment System	Syracuse, NY	Onondaga County Department of Water Environment Protection	Horizontal flow wetland, vertical down flow wetland, and "floating wetland island"	34	4.5 million	3 years (from contracting to completion of construction)	Multiple types of built wetlands treat effluent from a combined sewer overflow (14.9 million gallons treated per year) and discharge into Harbor Brook	No	Pilot project was designed to test the effectiveness of different types of built wetlands; knowledge gained will be used to inform larger built wetland projects in the same area.
South Los Angeles Wetland Park	Los Angeles, CA	City of Los Angeles	Stormwater runoff is pretreated to remove debris, gasoline, etc. and circulated through built wetland pools.	4.5 acres of built wetlands and 4.5 acres of upland habitat	12.4 million	Completed in 2011; specific duration not available	Wetland park with riparian and marsh habitat on a former brownfield site treats urban runoff from a 525 acre watershed.	No	Supplemental water is needed to maintain wetland habitats during droughts. Missed opportunities to connect with local community for recreation and education (e.g., lack of signs in Spanish, no restrooms on site).

Bolding indicates DOI affiliates.

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Authors and Affiliations

Katie Warnell, Nicholas Institute for Energy, Environment & Sustainability, Duke University **Sara Mason,** Nicholas Institute for Energy, Environment & Sustainability, Duke University
Aaron Siegle, Duke University
Melissa Merritt, Nicholas School of the Environment, Duke University
Lydia Olander, Nicholas Institute for Energy, Environment & Sustainability, Duke University

Contributors

Tamara Wilson, US Department of the Interior
Whitney Boone, US Department of the Interior

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