REUSING ON-SITE WATER AT EMORY UNIVERSITY

SOLUTION OVERVIEW

Emory University, located on approximately 700 acres in DeKalb County, Georgia, is a top-tier institution recognized for its medical school and various professional programs, as well as its commitment to environmental sustainability. Over the last decade, sustainable water management has become a critical issue for the metro-Atlanta region, which has struggled with drought, legal disputes over water supply and EPA consent decrees on water quality issues. As a pioneer, community leader and home of the world renowned Center for Global Safe Water, Emory is seeking to comprehensively address local and global water challenges. The WaterHub project is an innovative, on-site solution designed to treat and reuse up to 400,000 gallons of water per day, and decrease potable water demand by over 1/3.

In 2011, Emory used an estimated 390 million gallons of water per year, equating to approximately 1.1 million gallons per day (GPD). Nearly 40% of this use (over 400,000 GPD) is considered non-potable water demand, and can thus be replaced with alternative water supplies. WaterHub reduces Emory's dependence on potable water by reclaiming campus wastewater for non-potable reuse applications. The facility extracts wastewater from the municipal sewer system and treats it through adaptive, ecological technology. Once treated, reclaimed water is reused primarily as process make-up at three central chiller plants and the campus steam plant. Additional uses for reclaimed water include toilet flushing at select residence halls, all compliant with stringent Georgia plant regulations.

ORGANIZATION TYPE

Private University

GOAL

To reduce Emory's potable water demand in the fast-growing Atlanta region

BARRIER

Atlanta has the smallest watershed in the nation for a metropolitan area of its size, with numerous water-related stresses including severe drought potential, critical infrastructure failures and an extended political dispute over water rights

SOLUTION

Emory University's Water Hub uses on-site, adaptive ecological technology to reclaim up to 400,000 gallons of campus wastewater daily

OUTCOME

Potable water consumption has been cut as much as 35 percent, saving millions of dollars over a 20-year period while improving campus operations and opening new opportunities for education and research

POLICIES

- Georgia Comprehensive State-wide Water Management Plan
- Emory's 2025 goals – *currently being finalized*

PROCESS

Emory was first approached by the vendor of the technology, Sustainable Water, at a national sustainability conference. Subsequent discussions led to approval to conduct a feasibility study to understand the potential for, and implications of, the proposed technology. After engineering and economic evaluations showed promise, Sustainable Water facilitated an arrangement where a third party initially owns and operates the facility while Emory purchases as much of the reclaimed water as the system is able to produce. The proposal was brought before and approved by the Emory Board of Trustees. At this point, the project officially went into design phase.

Permitting and Working with Local Authorities

Most states regulate minimum design and construction standards, along with operational requirements, for water reclamation plants to ensure public health and safety. Additionally, local municipal agencies may require permits for construction, wastewater pretreatment, or discharge. The WaterHub is designed in compliance with all state and local permitting requirements. Sustainable Water, the provider of the technology, in conjunction with commercial contractor Reeves Young, provides turn-key project support, supporting all engineering, permitting, construction, commissioning (start-up services), and operational services. It is important as the site owner, however, to leverage existing relationships with the local jurisdictions which will help build trust in the project and possibly streamline any legal requirements that may be necessary (i.e., review times, permits, etc.). An additional benefit would be the recognition of a sewer credit since much of its water is diverted from the municipal sewer system

System Siting

The WaterHub is integrated into the current campus fabric – utilizing underdeveloped parcels and existing open space. The site is co-located between a large sewer collector and multiple central utility plants. The hydroponic greenhouse facility, comprising only 2,100 sq. ft., is located in a small facilities parking lot. In addition to reclaiming wastewater, the facility displaces existing impervious surface and harvest rainwater on-site for reuse. Across the street, additional hydroponic cells and a reciprocating wetland were sited on a small vacant parcel behind the left field fence at Chappell Park.

System Design

As the largest point-source users of non-potable water on campus, central utility plants presented the most impactful opportunity to displace potable water. Emory has six major utility plants and five satellite plants that provide heating and cooling services to campus. Together, these extremely efficient utility plants comprised nearly 34% of total campus water use in 2011– averaging 370,000 GPD. The Michael Street Chiller Plant is the single largest consumer of water at Emory – having used an average 73,000 GPD or nearly 27 million gallons annually in 2011.

The reclamation system has the capability to recycle an estimated 146 million gallons annually, or approximately 40% of total current campus water demand. It will displace 100% of the utility water demand at the campus steam plant, Michael Street Chiller Plant, Woodruff Memorial Building Chiller Plant and Quad Energy Plant. Designed with expandable capacity, the facility is capable of replacing subsequent demand at the Hospital Chiller Plant and Woodruff Library Chiller Plant at a later date. Operating at 100% capacity will allow Emory to displace 90% of all utility water use on campus, while reducing wastewater discharge to the County’s already stressed system.

Wastewater cleaned by the WaterHub is used as process make-up water in Emory's steam and chiller plants and for future toilet flushing in select residence halls. The system will reduce Emory's draw of water from Atlanta's municipal water supply by up to 146 million gallons of water annually.

The WaterHub includes a 50,000 gallon emergency water reserve which will allow Emory's heating and cooling systems to function for an average of seven hours, depending on seasonal operating demands, in the event of any disruption in water availability.

Treatment System Process

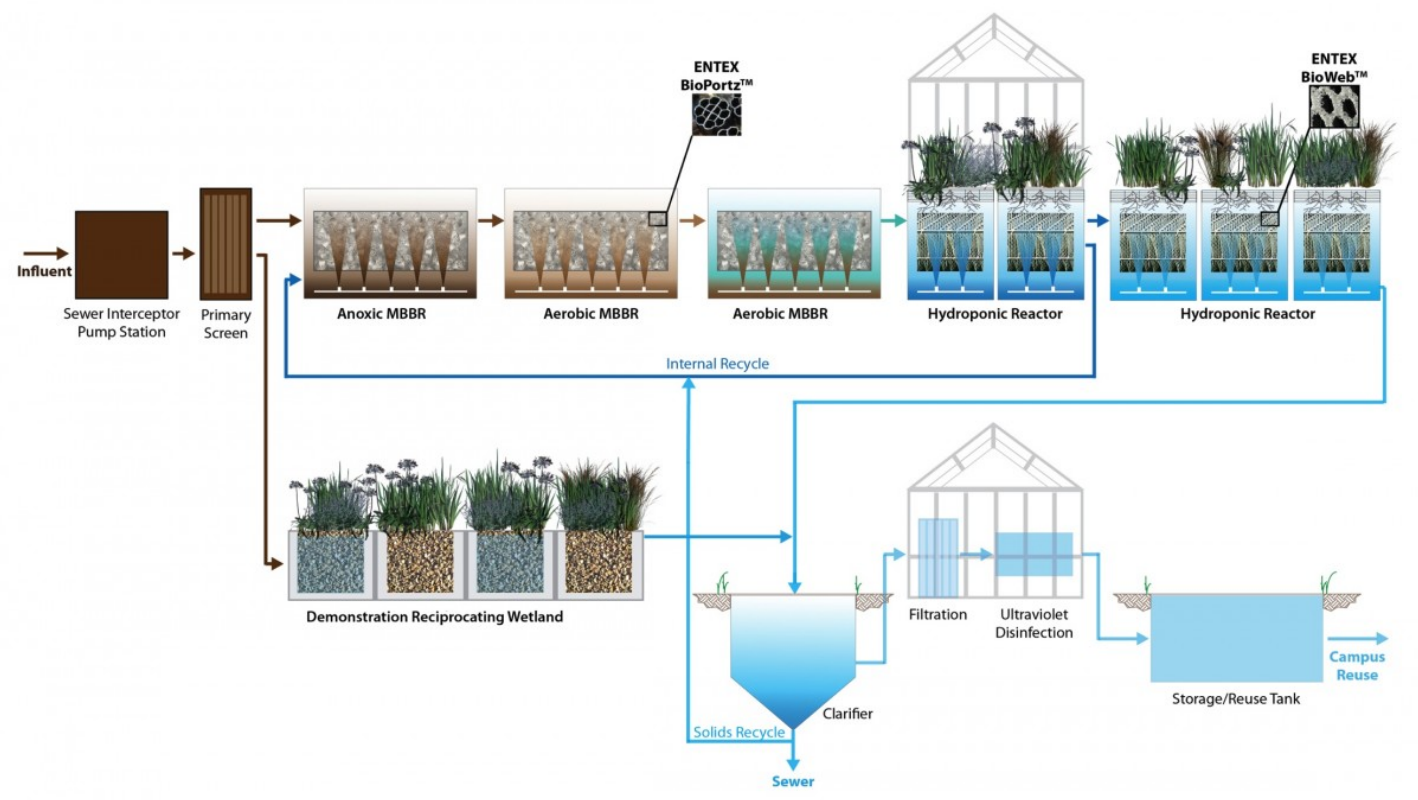
The WaterHub at Emory University is comprised of a number of innovative and proven processes that collect, treat, and distribute water to reuse locations across the campus. See the Treatment Process Diagram for a full illustration of the treatment process.

1) **Sewer Mining -** A below grade duplex pump station pumps influent through a six mm primary screen to remove any trash entrained in the wastewater. Influent flows from the screen into the primary treatment reactors.

2) **Primary Treatment Reactors -** Primary treatment settles and digests biological solids. Three moving bed bioreactors – aerated primary treatment tanks with attached growth media – are located behind a hydroponic greenhouse on the upper site. The attached growth media in these reactors, a floating plastic substrate, is colonized by a community of bacteria called a biofilm that begins the biological treatment process.

The first reactor is an anoxic reactor. Its purpose is to “select” for the growth of floc-forming microorganisms, convert nitrate to nitrogen gas (denitrification) and remove Biological Oxygen Demand (BOD).

The next two moving bed reactors are aerated with coarse bubble diffusers and are the first fully aerobic portion of the treatment process. The purpose of these reactors is to remove a large fraction of the carbonaceous material, measured as BOD, in the influent and to strip odorous gasses from the wastewater. The first three reactors are enclosed, with access through air-tight hatches. All gasses are vented through activated carbon air filters to prevent any odors from escaping by applying proven solutions to ensure odor-free operation.

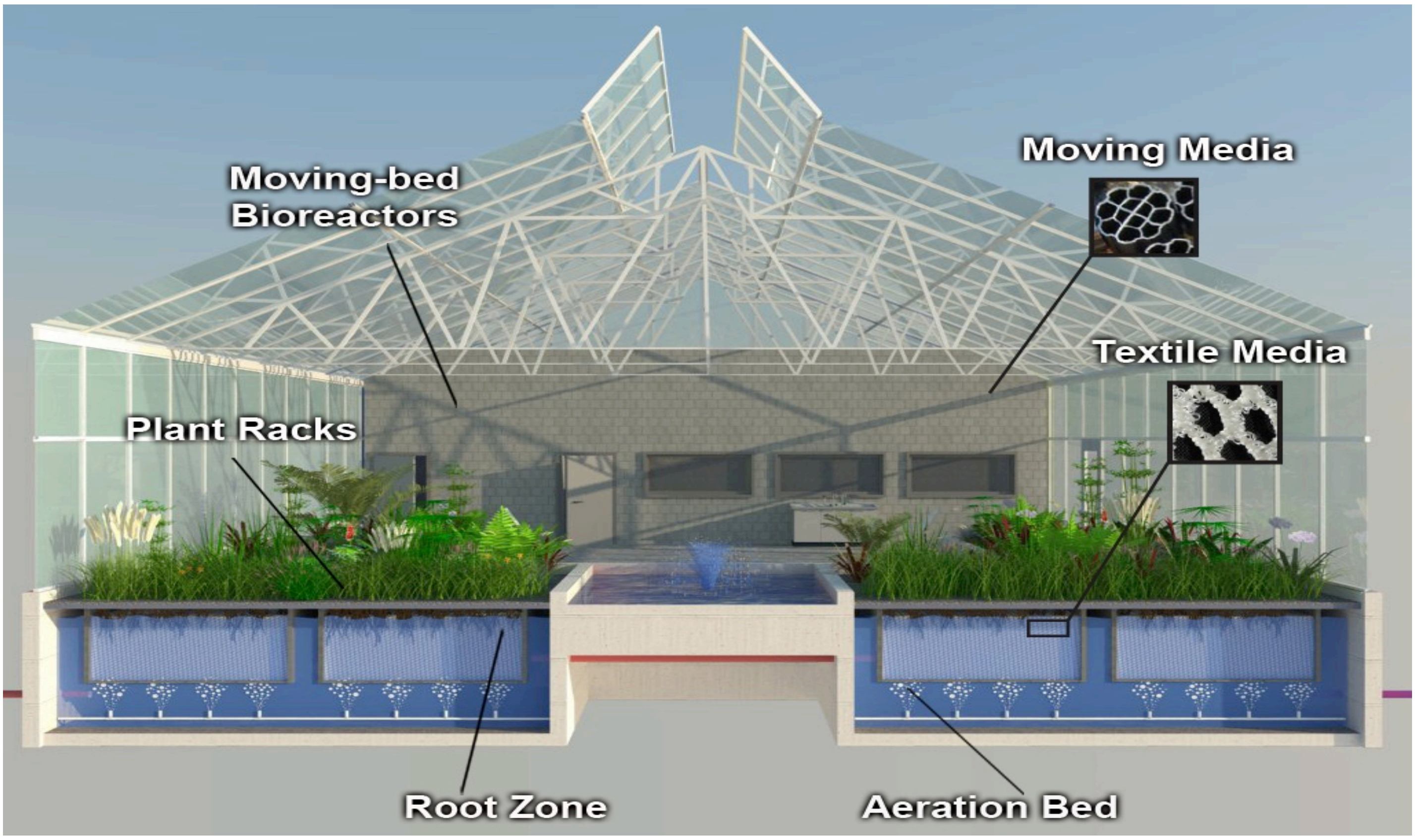


3) **Hydroponic Reactors -** The hydroponic reactors follow the primary moving bed reactors and are located within the greenhouse and on the lower portion of the site. These reactors reduce remaining BOD to secondary levels and complete the nitrification process.

The surface of the hydroponic reactors is covered with vegetation supported on racks. Plants have evolved over millions of years to maximize root surface area for increased nutrient and water uptake. The roots of the vegetation provide ideal surfaces for the growth of attached microbial populations. Similar to the moving bed reactors, greater surface area provides greater habitat for biofilm formation, resulting in more efficient and stable treatment.

The vegetation serves as habitat for beneficial insects and organisms that graze on microbial biomass, as well. This grazing reduces the sludge volume and maintains the microbes at optimal growth rates, resulting in less solids discharge to the municipal sewer. Also, the vegetation and racks decrease the surface turbulence in the reactor, which reduces the formation of aerosols and volatilization of odor compounds. A layer of light-weight expanded shale aggregate is placed on top of the racks, creating a natural biofilter colonized with bacteria that remove any residual odor compounds. A ventilation system with activated carbon scrubbers provides a secondary layer of protection within the indoor Hydroponic Reactors. Direct access to the wastewater is only through secure hatches.

The design of the hydroponic reactor is detailed below:



4) **Polishing and Disinfection -** Following the hydroponic reactors, BOD and ammonium concentrations have been reduced to meet or exceed standards. While a significant portion of the suspended solids have been consumed by protozoa and microcrustaceans in the hydroponic reactors, there is a need to remove the remaining solids and remaining dissolved phosphorus. The first step in this process is to passively settle these solids in the quiescent clarifier tank. The addition of naturally occurring iron or aluminum and the inclusion of vertical plates in the clarifier increase the removal of phosphorus and passive settling of suspended solids. During this process solids are removed to less than 10 mg/l. A portion of these solids are pumped back to the beginning of the treatment process to provide ample bacterial communities to begin the treatment process. A small amount is discharged back to municipal sewer.

After the clarifier, a disc filter located between the greenhouse and MBBR tanks removes any remaining suspended solids through a felt filter membrane. At this point effluent is very clear with no remaining nutrients but small amounts of microorganisms may remain. An Ultraviolet Disinfection (UV) process is utilized to remove any remaining microorganisms. UV at high intensities is able to disrupt the DNA of a variety of microorganisms allowing for energy efficient and chemical free disinfection. To maintain a disinfection residual in the water reuse piping back to the cooling towers and reuse applications, a small amount of chlorine is added. Online instrumentation verifies turbidity and UV transmissivity assuring that reuse criteria are being continuously met. Periodic microorganism and nutrient testing also is performed to verify performance.

5) **Reuse -** Finally, the fully treated, reclaimed water is stored in an underground storage tank at the lower site, providing reliability and redundancy that allows the campus heating and cooling to safely

operate in the event of a major utility disruption for 3-6 hours. Reclaimed distribution pumps send the reclaimed water through the northern part of Emory's campus to the various reclaimed water users, including the steam plant, various chiller plants and planned future use in residence halls for toilet flushing. By reclaiming and extending the life cycle of water, this project helps Emory meet its sustainability vision to help conserve Georgia's precious water resources and reduce the University's impact on the local environment.

System Performance Design	Units (mg/l)	Design Influent	Design Effluent
	Biological Oxygen Demand (BOD)	266	<5
	Total Suspended Solids (TSS)	350	<5
	Total Kjeldahl Nitrogen as Nitrogen (TKN as N)	65	<5
	Turbidity (NTU)	N/A	<3

Living Laboratory

In addition to its functional use as a water reclamation facility, WaterHub can be used as an immersion learning tool to enhance curriculum and advance research in a number of fields. The University believes this facility can help advance disciplines directly related to botany, microbiology, engineering, public policy and urban planning among others. Emory's faculty believe this facility will also bring in additional research funds and enable the University to qualify for new grants in the future.

The innovative treatment design combining moving bed bioreactors, textile modules, and hydroponics provides exciting opportunities for microbiological and botanical research. The various reuse applications provide public health research opportunities, as well. While science and engineering research is generally very narrowly focused and often performed at the benchtop scale, this system provides opportunities for synthetic research projects that study the interaction between different microbiological and ecological systems. Sampling locations are located throughout the system and integrated control systems compile online instrumentation and flow data.

While there are many research studies that can be accomplished using the treatment system, there are studies that are not possible at these large flow rates or without manipulating the treatment process. As a result, a small-scale demonstration system is also included on the lower portion of the site that can be manipulated in a variety of ways to answer research questions not addressed with the larger system.

Student Learning Opportunities	Specific Curricular Tasks can Include

• Core coursework • Student labs • Internships • Immersive learning • Comparative studies	• Performance landscaping • Urban planning • Water quality • Health implications • Sanitary standards • Environmental justice • Social equity • Environmental sciences • Biology • Health sciences • Containment removal • Microbial ecology

OUTREACH

Emory has shared the WaterHub internally through class tours and graduate research, as well with external audiences. Gina McCarthy, Administrator of the Environmental Protection Agency, has toured the site, and presentations and articles have been produced and delivered for the following organizations:

- Association for the Advancement of Sustainability in Higher Education (AASHE) presentation
- Smart & Sustainable Campuses presentation
- Construction Owners Association of America (COAA) presentation
- International District Energy Association (IDEA) presentation
- Treatment Plant Operator article
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) article

TOOLS AND RESOURCES

- Project Overview
- Hub Progress Report
- FAQ
- 'How It Works' Flow Diagram

MEASURING SUCCESS

Emory University employs several water quantity and quality metrics for tracking the success of the WaterHub.

Water Savings – Emory tracks gallons treated per day and gallons treated per year data for WaterHub. Based on this data, they are able to calculate potable water savings for the campus.

Water Quality – Emory carefully measures the water treated by WaterHub using milligrams per liter (mg/l) of four main indicators:

- Biological Oxygen Demand (BOD) is the quantity of oxygen consumed in the course of aerobic processes of decomposition of organic materials, caused by microorganisms.

- Total Suspended Solids (TSS) is the amount of solids in water that can be trapped by a filter.
- Total Kjeldahl Nitrogen as Nitrogen (TKN as N) is the sum of the organic nitrogen and ammonium-nitrogen, nutrients that are primarily contributed by human excretions and the wastewater treatment process.
- Turbidity (NTU) is the cloudiness of water, caused by suspended matter such as clay, silt, and organic matter, as well as by plankton and other microscopic organisms.

Cost Savings – While it is too early to calculate savings, Emory is tracking annual costs associated with maintenance and reduced potable water demand.

Increased Revenue – Moving forward, Emory plans to track revenue gained from the WaterHub, namely grants awarded based on WaterHub research capabilities.

OUTCOMES

Emory University has saved 40 million gallons of potable water since opening the WaterHub. In addition to these savings, the University has realized many tangential benefits, including:

- Redundant water supply (in case of drought or municipal infrastructure failures)
- Additional on-site storage
- Reduced environmental impact
- Flexibility, independence and resilience
- Reduced community resilience
- Minimum recovery time
- Insulation from rising water costs


EXTRACTION
POINT
WATERHUB