MAY 2019

Using Constructed Wetlands to Mitigate the Impacts of Combined Sewage Overflows

Stacker: A Conceptual Solution for 2030

PREPARED BY: OCEANS5

THE TEAM

William Bender
Computer Science '19

Will is a senior Computer Science student at Pace University. He enjoys exploring all aspects of technology and aims to apply technology to solve problems. His interest in SDG's goal 6 and 14 is simple: despite being an incredibly important resource, water quality is widely neglected.

Mackenzie Dolishny
Computer Science '20

Mackenzie is a junior Honors computer science major at Pace University. She will be focusing on developing and creating technologies throughout the project which aligns with her passion. Mackenzie's goal for CBI is for clean water to be recognized as a global standard for humanity.

Kyle Hanson
Information Science '21

Kyle Hanson is a student at Pace University and is majoring in Information Systems with a minor in Computer Science. He aims to bring his skills from working in IT and environmental systems to the team setting, helping to create innovative ideas.

Sven Lativonic
Film Studies '19

Sven Latinovic is a senior at Pace University studying Applied Psychology and Film Studies. During the CBI project he will be focusing on the artistic and creative aspects of OCEANS5's vision. He wants to track and present the team's endeavors in a way that would bring the whole experience closer to all.

Nathanael Linton
History '19

Nathanael Linton is a senior History major at Pace University. As part of his major course of study, Nathanael did research in a few areas including the historiography of African-American subculture and subjective/objective practice in historical thought. He will focus on the research aspects related to the problem, as well as the implementation of the proposed solution

Executive Summary

According to the United Nations Millennium Development Goals Report, 783 million people worldwide do not have access to clean and safe drinking water. Pace University's Design Factory Team, Oceans5, analyzed water related issues in the United States, specifically in the State of New York. Among the water related issues, Combined Sewage Overflow (CSO) poses a significant threat to the health of aquatic, environmental, and human life in the Hudson River region.

CSO events are discharges of untreated or partially treated human waste, industrial waste, and debris that enter bodies of water, such as the Hudson River. These events typically occur in wet weather. On average, 20 billion gallons of raw sewage are discharged in New York every year, and during the Super Storm Sandy 10 billion gallons were released in 3 days. A precipitation or wet weather event occurs in New York once every 3 days. CSOs are not just a problem that pertains to New York, and have had horrible health consequences throughout the United States. Due to contaminated water, approximately 90 million waterborne illnesses are estimated each year in the United States, and 19.5 million of those illnesses came from drinking water.

This project aims to create a conceptual solution for 2020– 2030 for CSO events. We propose a design that can improve the processing of harmful discharges using artificially constructed wetlands that integrate fiber optic technologies developed at CERN. In addition to mitigating the impacts of CSO, our solution aims to contribute to restoring the biological estuary in the lower Hudson River region. We apply forecasting techniques to inform the feasibility of our design. Overall, our solution aims to inspire others to ensure clean water for a sustainable future.

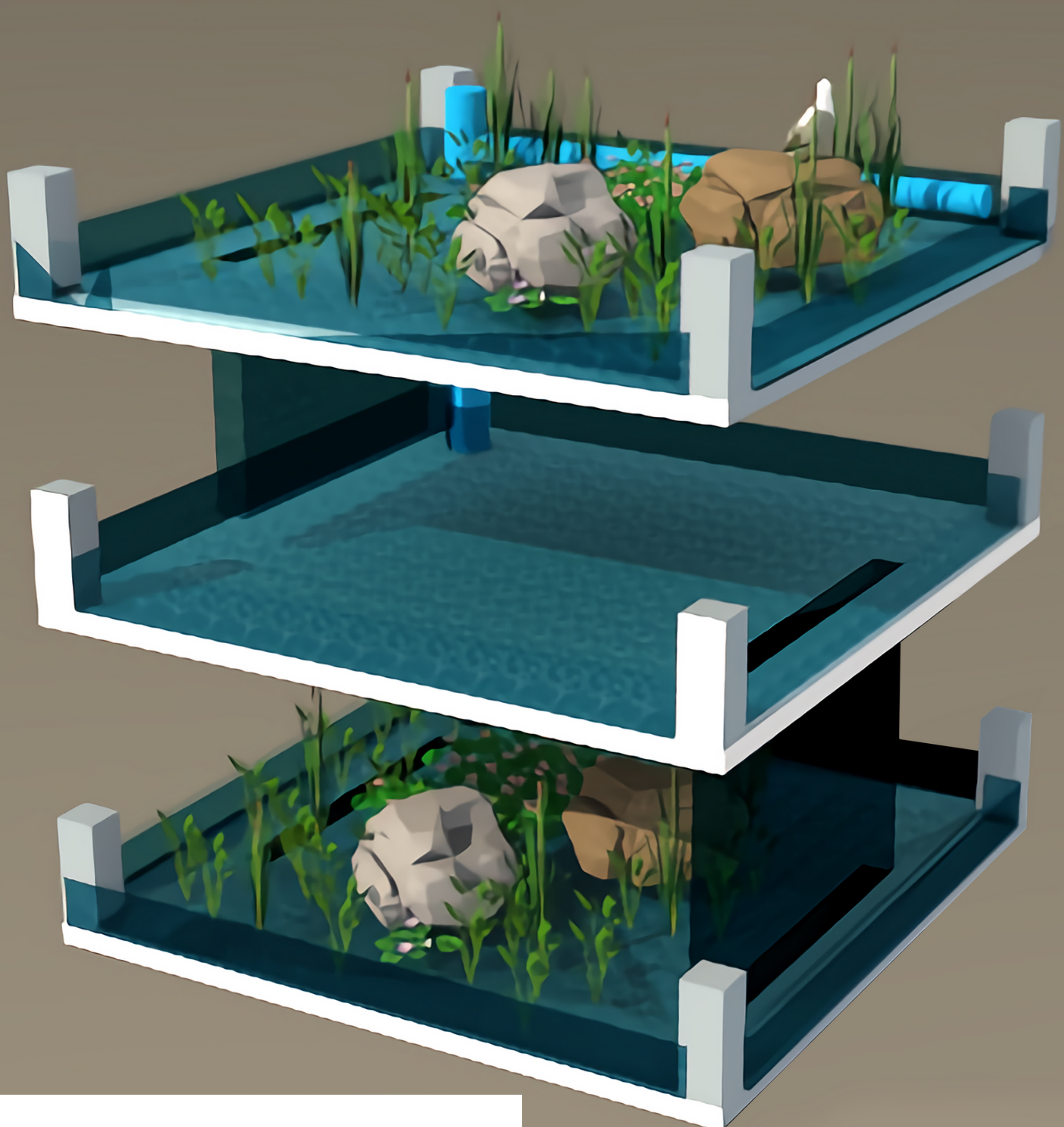
Problem Statement

Precipitation events can overburden sewage treatment plants causing a release of untreated sewage into the Hudson River. Such discharges are also the cause of future problems including emerging pollutants, and the increase of waterborne illnesses

Solution:

We propose a vertically constructed wetland, called Stacker, that embeds sensor technologies to enhance the water flow in sewage treatment facilities by processing higher volumes of water. Stacker is a modular system. Our New York City system has three specific layers. The first and third layer are constructed wetlands. The second layer is a deep-water nutrient re-mixing pool. The top layer forms the first filtration layer for incoming combined sewage. Water moves slowly through the subsurface of the wetland where vegetation, algae, and bacteria form micro-environments, trapping nutrients and pollutants in the passing sewage.

Various species of vegetation such as the cattail, water grass, spike rush, sedges, and bulrushes collect nutrients for the bacterial and algae colonies. The second layer consists of a 3-5 feet deep pool of water where nutrients are redissolved and monitored by embedded CERN fiber optic technology. If the water is of sufficient quality, it will be discharged into the environment. If not, it is discharged and evenly distributed into the third constructed wetland where higher concentrations of aerobic and anaerobic bacteria further treat the water before re-entering the Hudson River.



Stacker: A Conceptual Solution

User Interface

Stacker will require regular maintenance and monitoring. Therefore, its users will be a combined workforce of technical and maintenance workers.

Their duties will include:

Technical:

- Data analysis and insight derivation
- Ecological monitoring of constructed wetlands
- Environmental impact monitoring
- Sewage treatment system impact

Maintenance:

- Vegetation pruning and care
- Fiber optic sensor calibrations and modifications
- Monitoring sewage input and output

Form, Scale, and Aesthetic

Stacker is a modular unit designed to meet the requirements of its urban location and sewage handling capacity. In general, a Stacker layer is about the size of a small city block and about eight to ten feet tall. A three-layer Stacker structure is 30 to 40 feet tall and floats in the Hudson River. The modular layers are uniform and can be built using one production process which lowers both time and cost. Also, it mirrors the style of New York City structures resulting in seamless visual integration. The plant life built into Stacker improves the aesthetic appeal.

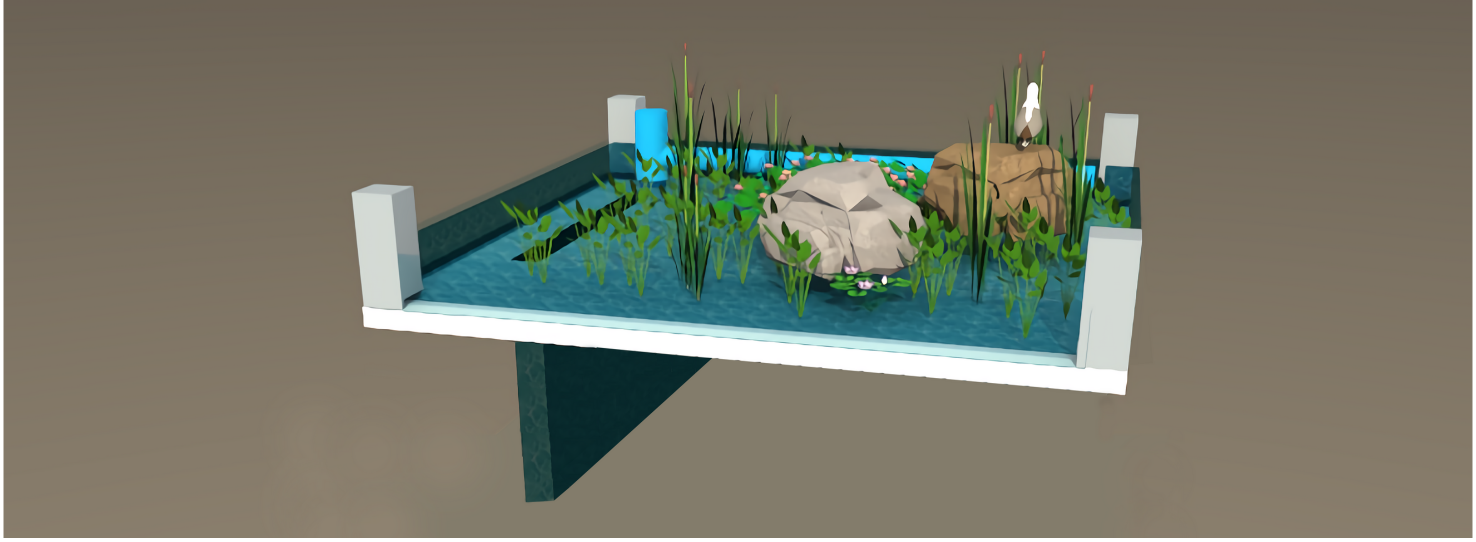
Functionality

Stacker serves multiple functions. First, Stacker intakes large volumes of waste water from sewage discharge points throughout NYC and outputs clean water. Second, Stacker provides habitats for local wildlife, and a new environment for the re-introduction of native species to the Hudson River estuary. The top layers are open platforms that provide landing and nesting grounds for waterfowl and native avian species. These layers are seeded with native marsh plants to improve air quality and add aesthetic appeal. The bottom layer is submerged in the river and provides a nutrient-rich habitat for kelp and other seaweed. Finally, Stacker floats which allows it to operate during extraordinary precipitation events when conventional waste water treatment plants are overwhelmed.

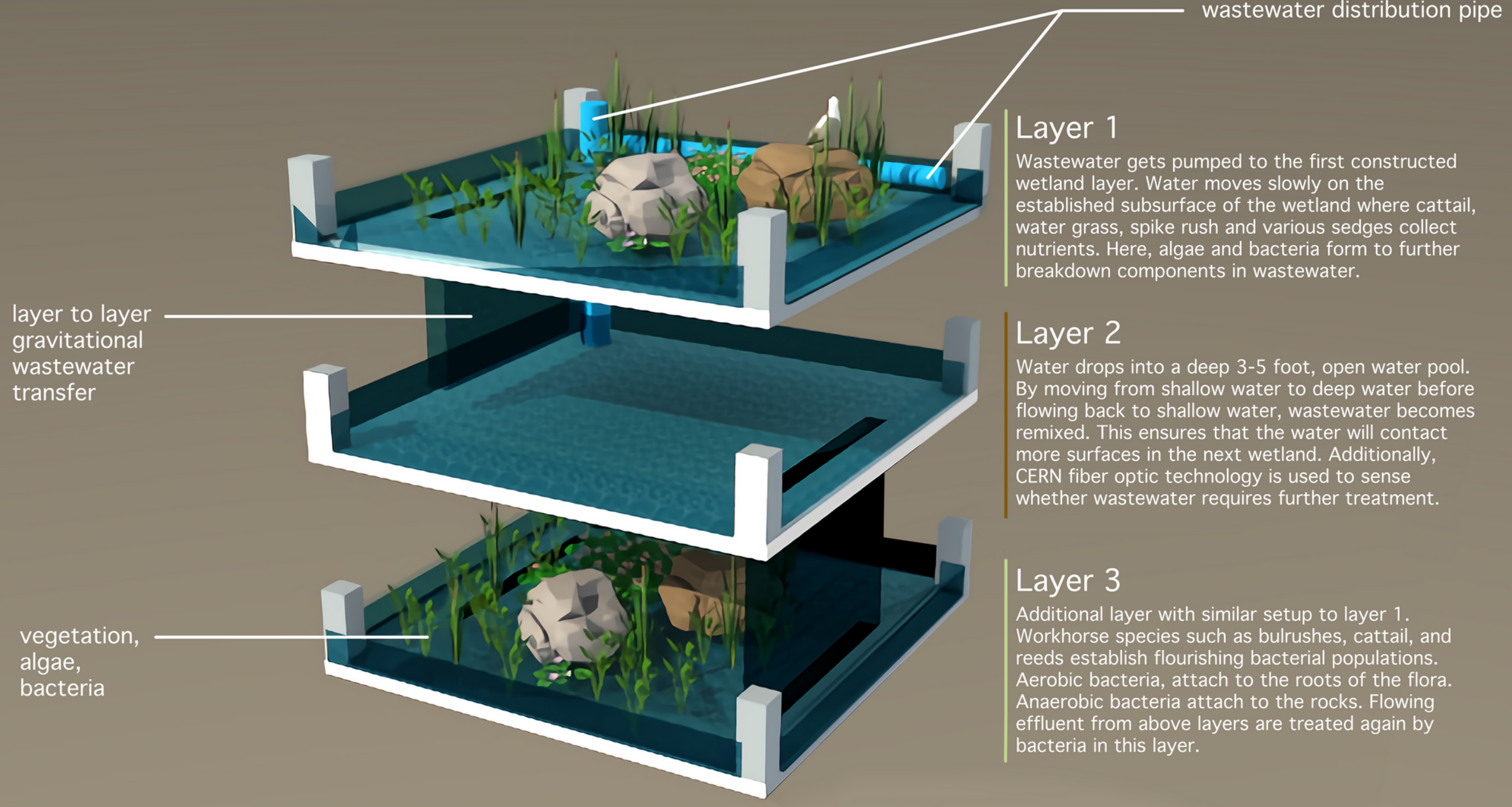
Materials

- Steel
- HDPE Skeleton (durable plastic)
- PET + Marine Foam

The modular unit would be made from a high-density polyethylene (HDPE), a durable form of plastic. In addition, Polyethylene terephthalate (PET) will also be used; this is what most disposable bottles are made from. The choice to use these materials was made in the interest in using light but strong objects that would be resistant to corrosion. In the Stacker system configured for New York City we also configured it with a steel floating hull because while heavy, steel has certain properties like its malleability and strength which are important to keep the structure afloat in the Hudson. The other main part of Stacker besides the structural elements are the pumps used to move waste water around. Stacker implements large high volume pumps similar to those used in waste treatment plants. The materials used in the constructed wetland consist of marsh plants such as: Cattail, water grass, spike rush and various sedges, bulrushes, pondweed. The reason for this would be for the sewage to be properly treated by the action of the specific bacteria attached to the plant roots and rocks.



Operations



Layer 1

Wastewater gets pumped to the first constructed wetland layer. Water moves slowly on the established subsurface of the wetland where cattail, water grass, spike rush and various sedges collect nutrients. Here, algae and bacteria form to further breakdown components in wastewater.

Layer 2

Water drops into a deep 3-5 foot, open water pool. By moving from shallow water to deep water before flowing back to shallow water, wastewater becomes remixed. This ensures that the water will contact more surfaces in the next wetland. Additionally, CERN fiber optic technology is used to sense whether wastewater requires further treatment.

Layer 3

Additional layer with similar setup to layer 1. Workhorse species such as bulrushes, cattail, and reeds establish flourishing bacterial populations. Aerobic bacteria, attach to the roots of the flora. Anaerobic bacteria attach to the rocks. Flowing effluent from above layers are treated again by bacteria in this layer.

System Design Considerations

Stacker complements the existing sewage treatment infrastructure. Stacker is minimally invasive and accepts input from multiple CSO discharge points in the sewage treatment system. The electrical power to run Stacker comes from the New York City power grid. The floating component of Stacker takes the surrounding environment into design consideration. In this case, real-estate is at a premium, thus, occupying unused space is a productive decision.

Value Proposition

i. Gains/Pros
   - Clean Water
   - Clean Hudson and increase recreational activities
   - Reduced smell after rain
   - Support water fowl
   - Add jobs

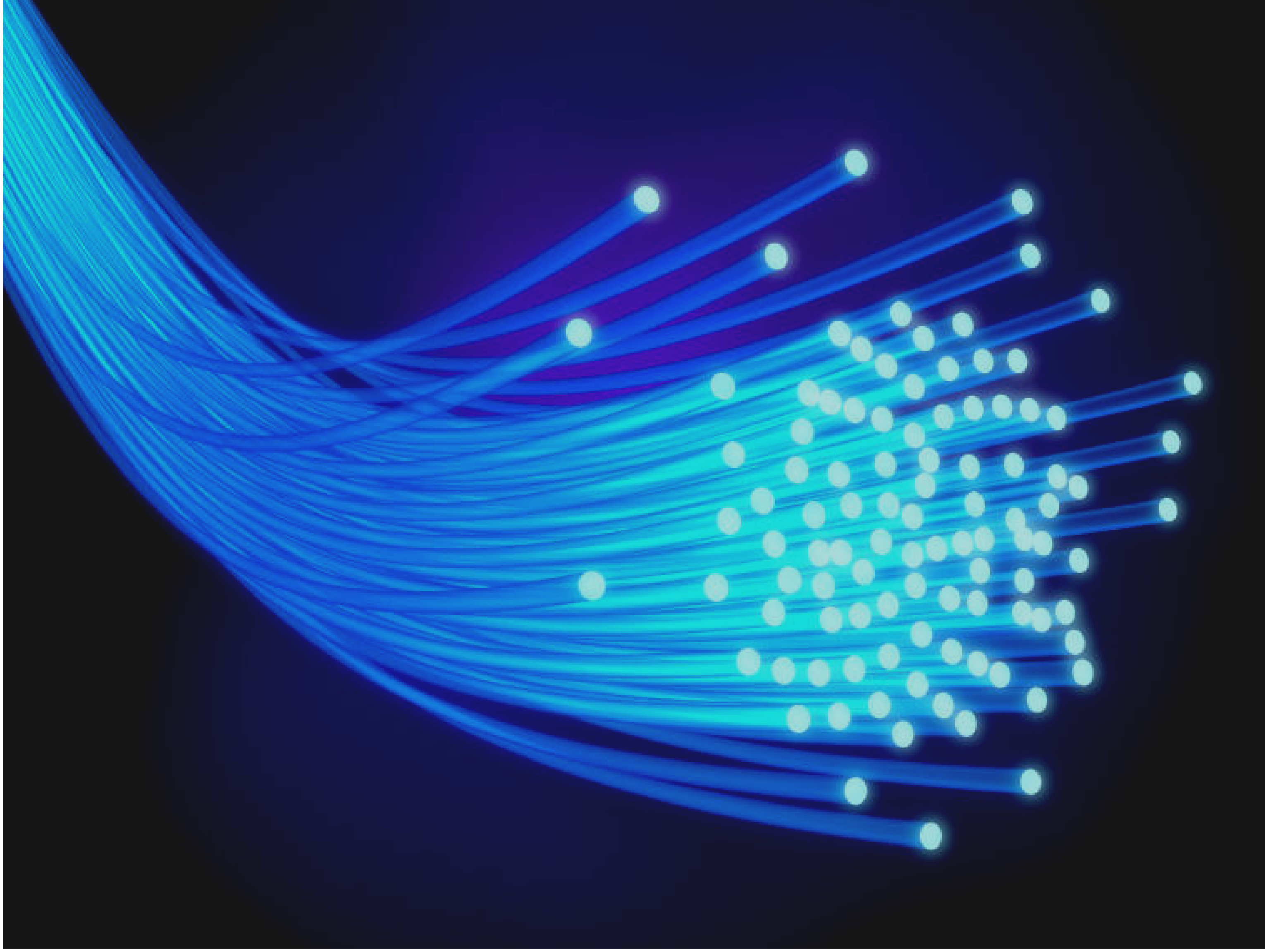
ii. Cons/Losses
   - Consumes a lot of space
   - Expensive
   - Reduce space for marine traffic
   - Might disrupt certain near shore marine life

Funding

The funding needed for our constructed wetland is coming from governmental sources: city, state, and federal levels. Examples of such funding would come from the EPA Clean Water State Revolving Fund, Department of Environmental Conservation Hudson River Estuary Grants Program, and the New York City Department of Environmental Protection Gowanus and Flushing Watershed Initiative (GFWI). We would use this funding to get the capital needed to support our research and development of our research model and the continued funding to maintain the platform during the production phase.

Physical Aspects

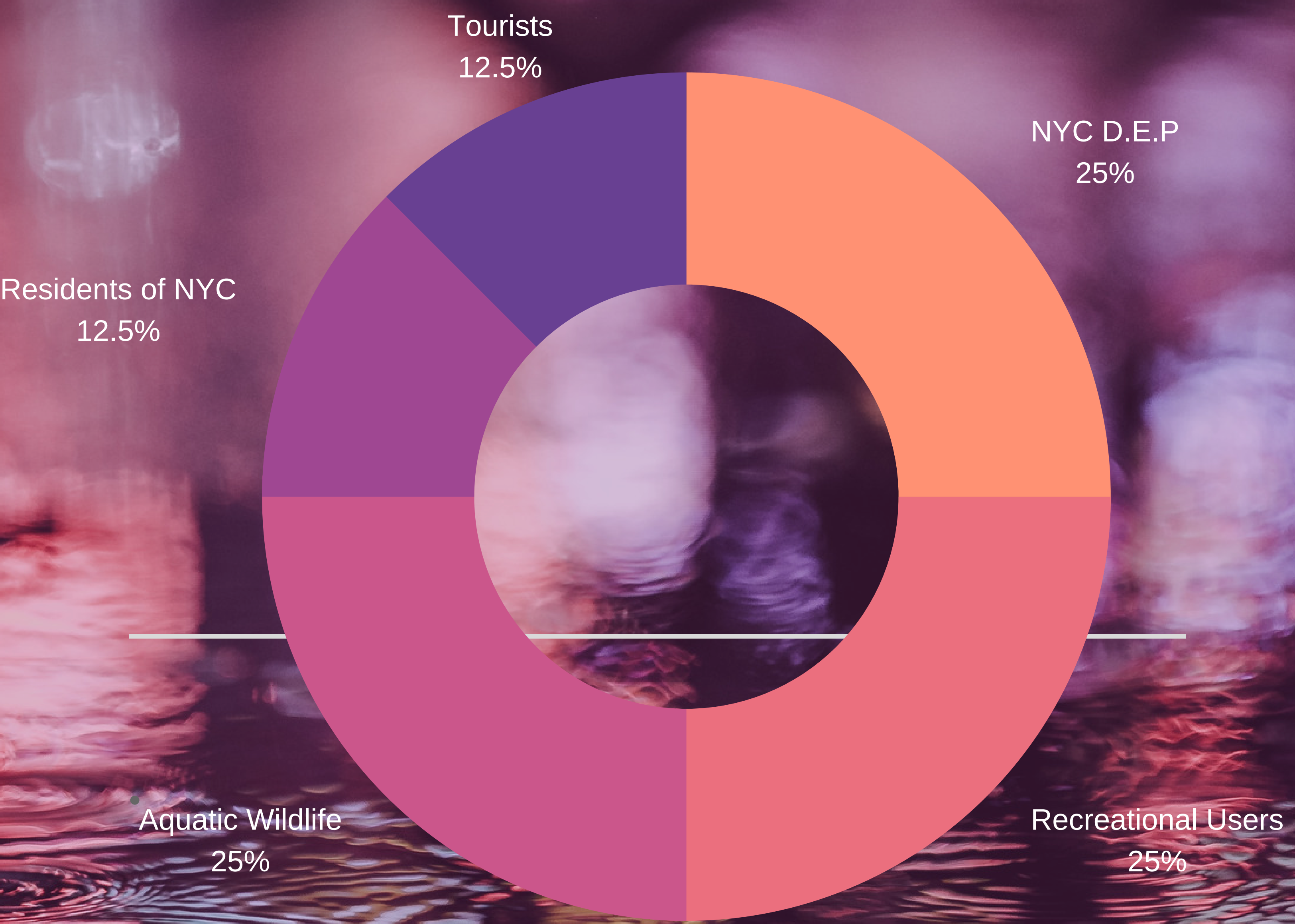
The land/footprint for this project would be at a CSO point. The reason for the floating aspect of the project is because there is limited space for construction within the city. However, Stacker can also be placed on land due to its modular ability. Stacker can be layered as much or as little as needed. Specific locations would be along the Hudson River at preexisting CSO points. Due to being located at CSO points, we would use the output of the CSO as the input to the Stacker. Also, we would have a powerline from the shoreline connecting to our structure to provide our constructed wetland with power.



CERN Technology

The fiber optics sensors developed at CERN monitor our wetland treatment system's performance and nutrient loading. There will be a mixture of point and disturbed sensors throughout various levels of Stacker to ensure maximum efficiency. The applications of the wetland that our sensors would cover are industrial, civil and chemical. The sensors first process the flow rate, which is part of the industrial complex. The civil application relates to the temperature of the wetland and the structural monitoring. Finally, they cover chemical aspects by handling certain gases present within the wetland, such as oxygen, carbon dioxide, hydrogen, etc.

STAKEHOLDER MAP



Stakeholder Engagement

Low Priority:

Tourists: The tourists would see a cleaner Hudson River. Local advertisements would promote the continued cleanness of the Hudson River.

Keep Informed:

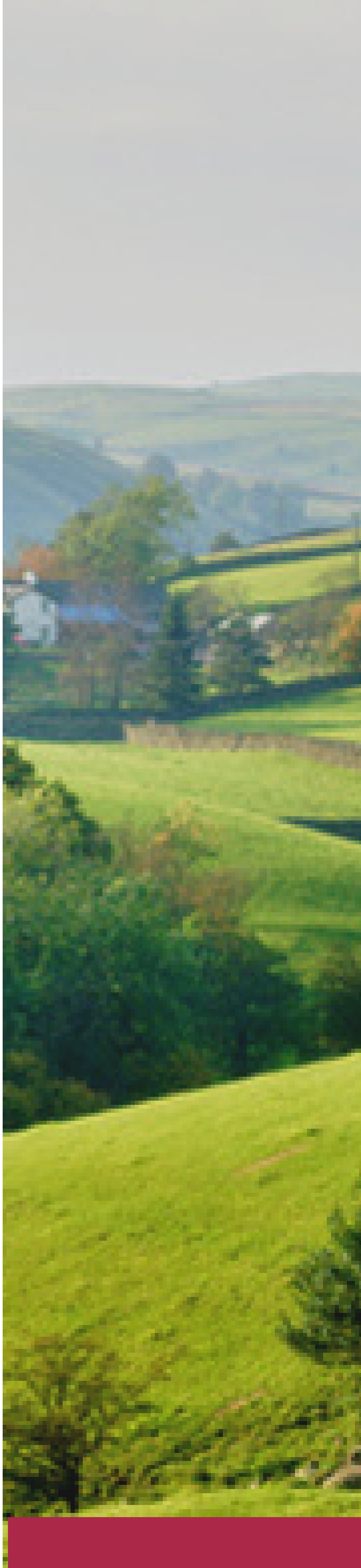
Residents of NYC: Local residents would be engaged by audio/ visual informational messages. The message to this stakeholder group would be bringing back their pristine environment and glory of the Hudson River.

Meet their needs and key player:

DEP NYC: Formal channel of communication; two way conversation about cleaning the river together.

Recreational users of Hudson: Resident engagements include boat launches and beaches, as well as informational signs near bodies of water.

Aquatic Advocates: All scientific information and the intents of Stacker's governing body are relayed to advocates interested in the aquatic impacts of the project.



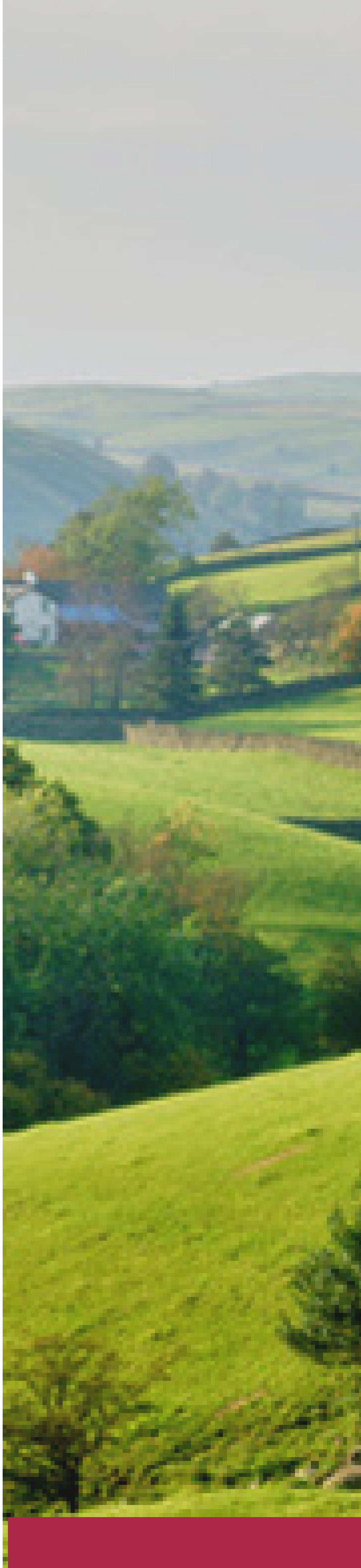
Future Scenario: 2020

Utopia

Government and Corporations recognize that development in environmental sectors is necessary and hope to achieve this in the near future. They have a goal in cleaning up local bodies of water and improving the lower Hudson estuary. The application of real-time monitoring on water issues becomes an important aspect of understanding the environment. The post recession era is now changing and the economy is beginning to stabilize.

Dystopia

The current government has started moving away from protecting the environment. The economic crash that has been predicted in the stock market occurs. People's main goal is worrying about their well-being instead of the the environment. People are slowly consuming more information on their smartphones, yielding less face-to-face interactions and spending less time in the outside world.



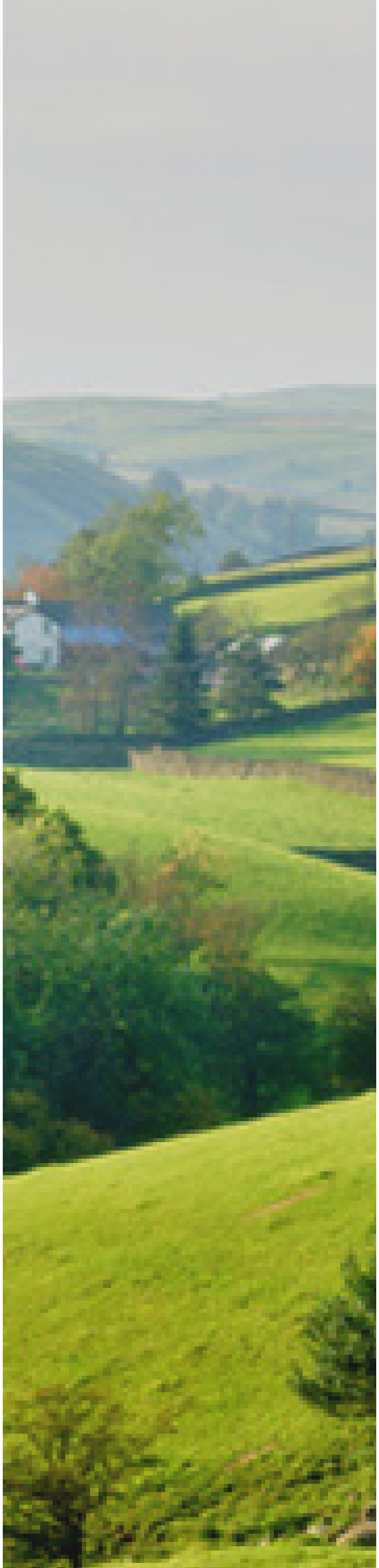
Future Scenario: 2025

Utopia

The individual efforts of governments and corporations to tackle environmental issues have begun. Real-time monitoring has now expanded in its applications and uses beyond its original scope. The economy is now stabilized and is now reaching higher heights.

Dystopia

All legislation initially protecting the environment has now been abolished. The economy crash has now happened plunging many individuals into debt, and concerns about the environment are refocused on one's personal survival. Advancements in virtual reality have become popular with early adopters, leading to further isolation from social life.



Future Scenario: 2030

Utopia

With the threat of climate change, governments and corporations have come together to better regulate their impact on the environment. The Hudson River is cleaner and the expansion of biodiversity in our local water bodies has begun.

Technology has grown exponentially resulting in a never-before-seen era of data collection, optimizing our current technological struggles.

Due to the positive change in the environment and technology, the economy in the Hudson River Valley region became a leader in worldwide environmental technology and industry, bringing in billions of dollars, and most importantly, being a beacon for the world to follow.

Dystopia

Climate change has spiraled out of control. With global warming reaching unprecedented levels, sea levels have risen, flooding low-level areas in the Hudson River Valley and flooding certain parts of New York City, including those of the waste-water sanitation facilities leading to further contamination of the environment. Technology has consumed the lives of the people so much that they do not care about the physical world anymore. This has lead to a lack of care and degradation of the environment, as people do not care whether it is clean or dirty. The economy has dropped, leading individuals to retreat to the virtual world

Future Scenario: 2030

ILLUSTRATION BY OCEANIX/BIG-BJARKE INGELS GROUP

Conclusion

Stacker is a vertical wetland structure that can process higher volumes of water than existing sewage treatment facilities. Stacker's purpose is simple: to use nature's natural treatment system. The impact of this solution is multi-faceted. First, it helps alleviate the problem of combined sewage overflows in waterways that surround cities. Second, it improves the quality of life for marine animals in the Hudson River Estuary. Third, it reduces the number of water-bourne illnesses by ameliorating the effects of pathogens caused by combined sewage overflow events. Imagine a world where nature picks up where man left off; the beginning of it starts with Stacker.

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