

# salad bowls sur Seine



Harvard Summer School

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## Abstract

Salad Bowls sur Seine is a project that aims to tackle Paris' problems of water pollution, lack of green space, and crowding in one integrative, biologically-inspired approach. The implementation of this project will consist of the deployment of hydroponic islands made of recycled plastics along the Seine River, on which will be grown phytoremediative plants that will absorb pollutants from the water in their growth processes. The project draws upon and combines previous successful uses of both hydroponics and phytoremediation in bodies of water around the world, while also using unique plant species that suit our purposes of cleansing and beautification. This system of islands is meant to resemble the systems of tubules and nephrons in the human kidney, which are a great model of a non-disruptive, specialized fluid filtration system. In addition to treating the water, the islands will add a splash of greenery to the environment, and serve as an educational platform to teach Parisians about the importance of sustainability and environmental conservation. In the long term, Salad Bowls sur Seine will make the Seine a brighter, more hospitable environment, and promote green living and green technology in the city of Paris.



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**Biology, Innovation, and the  
21st Century Smart City**

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“A well-made salad must have a certain uniformity; it should make perfect sense for those ingredients to share a bowl.”

—Yotam Ottolenghi



# the issue

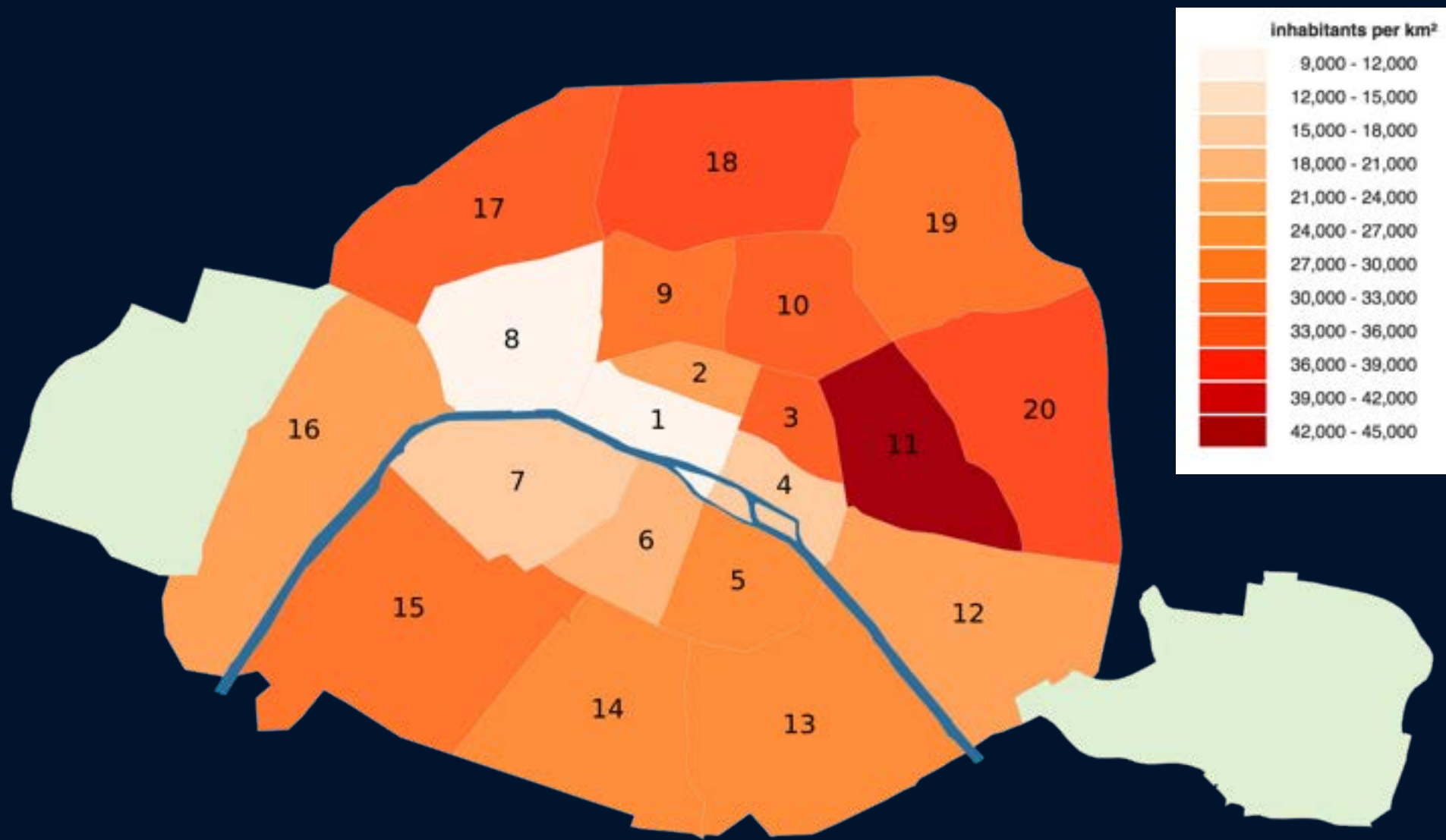


Paris  
is crowded



Paris is one of the most densely populated cities in the developed world, with around 55,000 people per kilometer on average. Much of this space is unmodifiable, due to the strict laws against new development in order to preserve Paris' historic beauty. In a city like this, any area of empty, usable space is a commodity.

Our team's search for open, unoccupied land space to use for a development project led us to look to the Seine—a space that is perhaps too often overlooked as a space with a great deal of development potential.



**Density map of Paris and its surrounding suburbs.** Strict building regulations in historical areas prevent additional housing from being built in certain areas, resulting in dramatic differences in density between the different arrondissements.

**The Seine River is one of the most visited rivers in the world.** As the central river of Paris, the City of Light, the Seine is frequently romanticized and imagined in the hearts and minds of people everywhere to be a beautiful, dreamy body of water. In reality however, this is not the case.

The Seine is a big-city river, and thus, like many big-city rivers, it is heavily polluted. The water pollution was so bad that in the 1970s, it was said that only three species of fish remained in the river.



**the Seine is  
polluted**



Although since then the water quality has drastically improved to the point where salmon are said to have returned to the river, and some scientists claim it is safe for swimmers, the Seine still experiences major water quality problems that are especially worrisome given that the Seine is used as a source of drinking water. There are high levels of heavy metals in the water, as well as significant amounts of medical waste and contaminants from occasional sewer overflows.

Despite all the clean-up efforts, the fact remains that Parisians still do not feel safe swimming in the Seine's waters.







Diverse contaminants pollute the waters of the Seine, including this car, which was removed from the river.



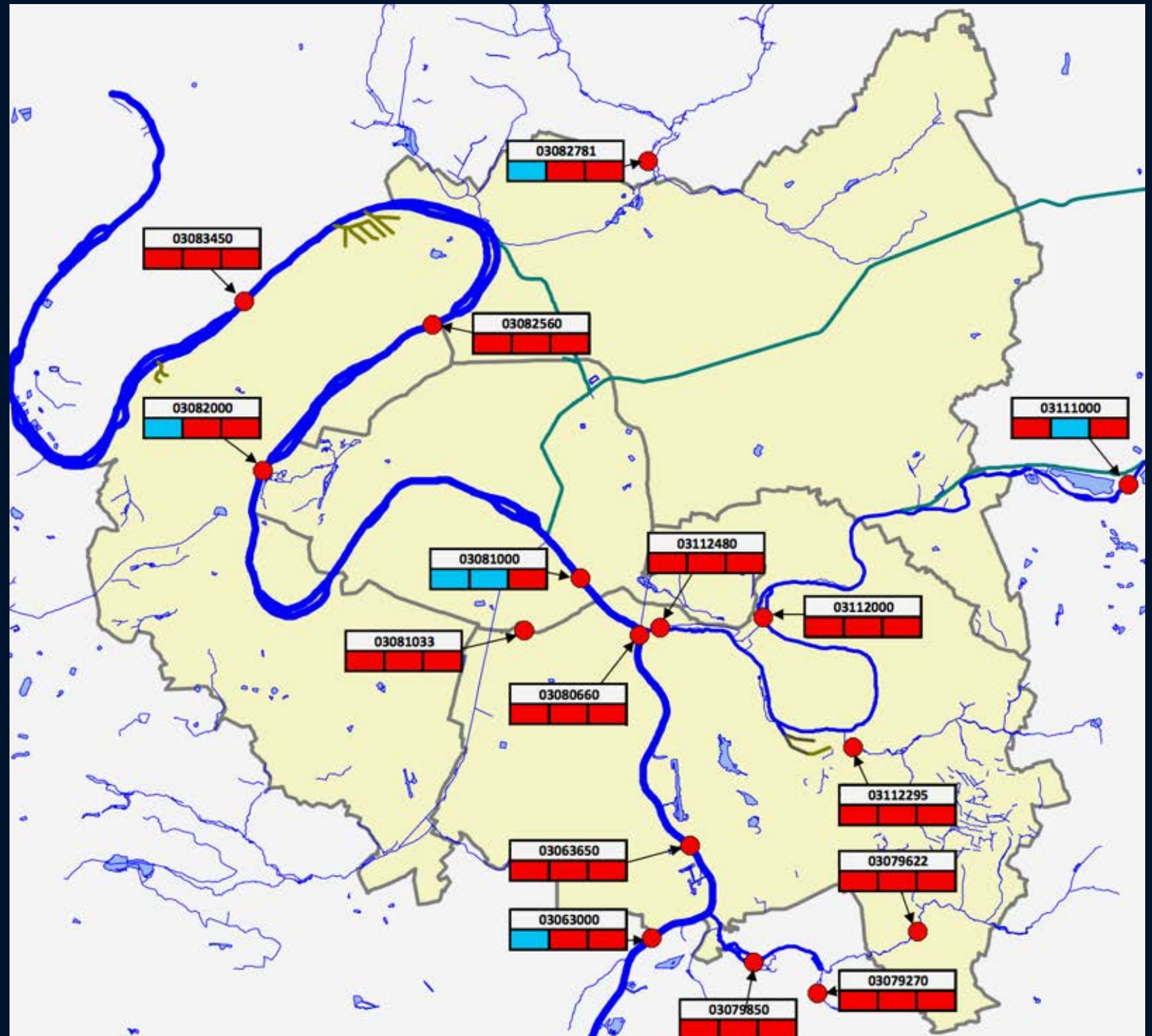
## Légende

| Station |      |      |
|---------|------|------|
| 2008    | 2009 | 2010 |

|              |
|--------------|
| Bon état     |
| Mauvais état |

## Map of the water pollution in the Seine

As the map shows, though poor water quality within the city itself seems to be less severe, water becomes increasingly polluted as it flows through and out of the city of Paris.





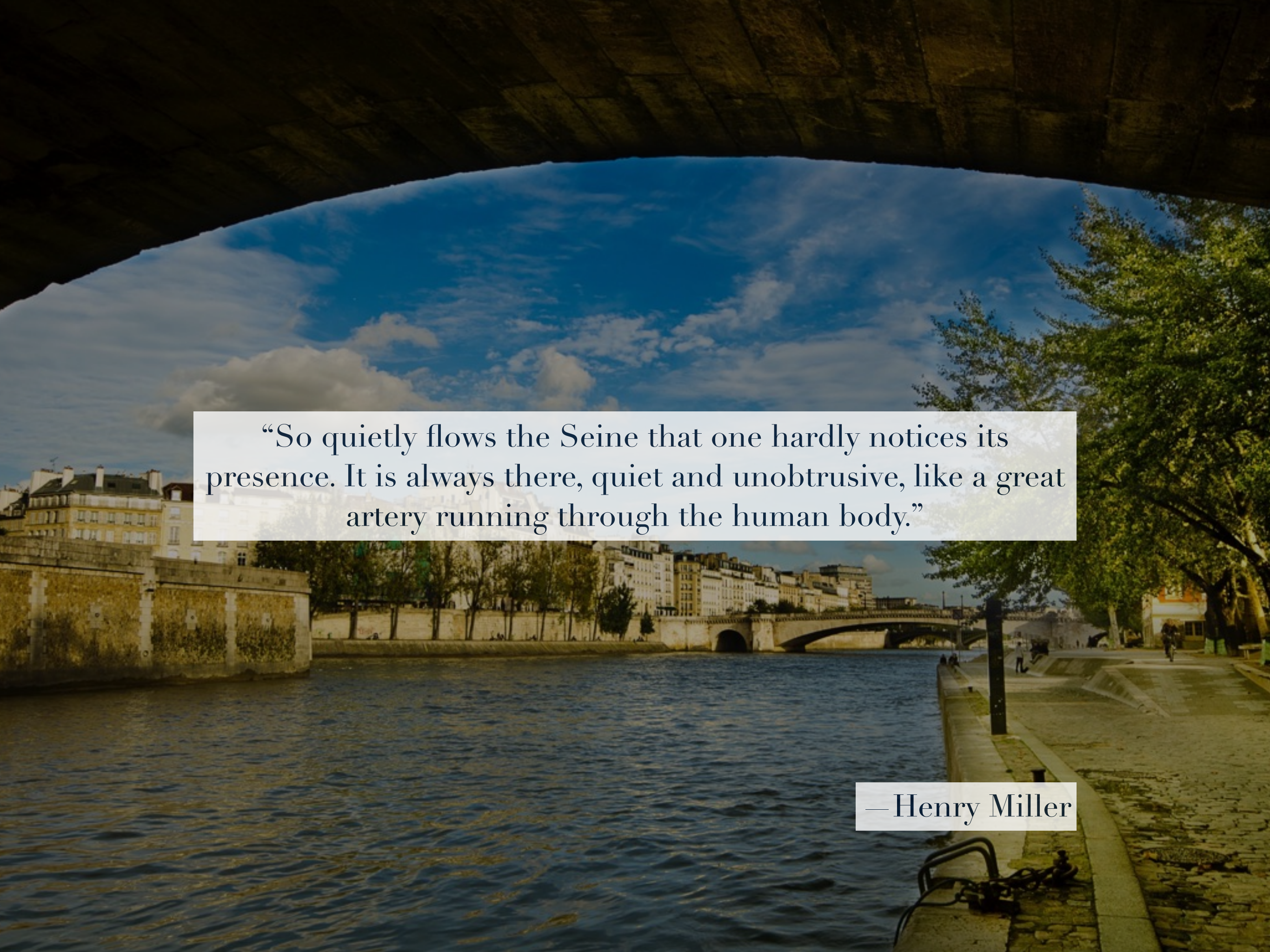
**Paris is a stone city.** The beautiful cream-colored Haussmannian buildings, the quaint, narrow streets, and the wide, sweeping avenues are what give Paris its character and style. Though there are trees lining the broad boulevards and parks scattered throughout the city, most of these green spaces are still very much hard spaces—the trees are carefully manicured, and the ground is made of packed yellow dirt.

Paris is crying out for a splash of green life, but as crowded as the city is, there is a lack of a convenient place to put it.



# Paris is missing greenery





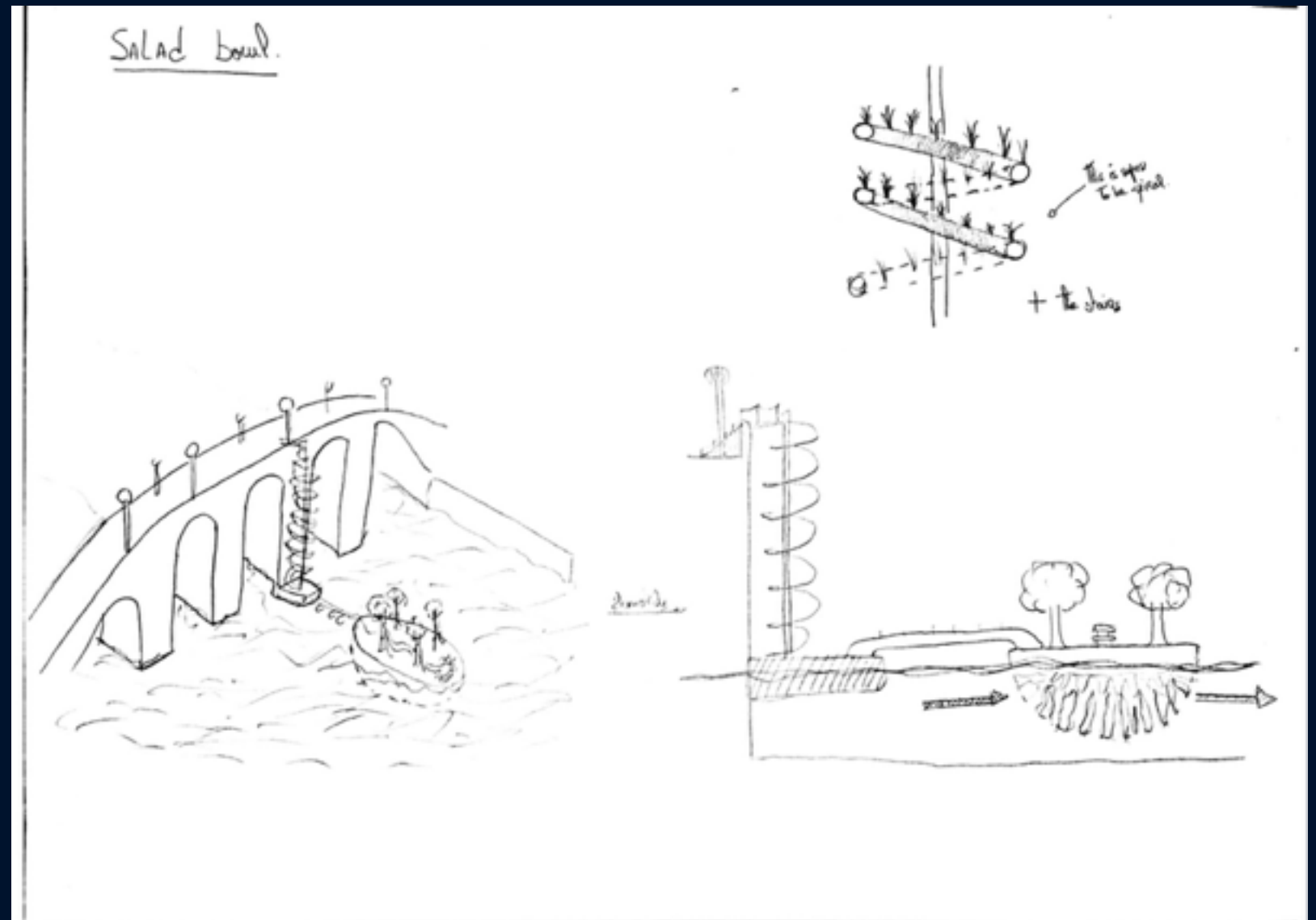
“So quietly flows the Seine that one hardly notices its presence. It is always there, quiet and unobtrusive, like a great artery running through the human body.”

—Henry Miller



# our concept

Our goal is to explore the use of hydroponic islands for the purpose of phytoremediation in the Seine River. That is, we want to create a system of floating islands in the Seine, on which certain species of plants that absorb pollutants like nitrates and heavy metals from the water will be grown. These plants will purify the Seine's waters, and make it more inhabitable for fish and also for swimmers, while simultaneously growing plants that beautify the environment, and that can be sold or donated to city organizations or local small businesses. The islands will also be made out of recycled plastic materials, in order to minimize waste, cost, and negative impacts on the environment.



**Early design sketches for our “salad bowl” islands** Illustrated by Franck Porteous.

# the biology



**The flow of a river's waters is similar to the flow of blood through our bodies.** The way that the bloodstream carries nutrients and waste to different organs and tissues is analogous to the Seine's role as a method of transportation and a supply of water to the city of Paris. Thus, in our efforts to find an organic, non-disruptive way to cleanse the Seine's waters, we looked at the way that the blood is filtered and cleaned as a source of inspiration.

In the human body, blood is filtered by the excretory system—a complex system of organs and blood vessels that remove toxic metabolic waste products from the bloodstream and excrete them from the body in the comparatively harmless form of urine, all while not disrupting the transport of necessary nutrients.

In the excretory system, the kidneys are the primary place of blood filtration.



Each kidney contains around one million nephrons, which are tiny structures that consist of different clusters of tubes that filter and reabsorb water and minerals from the blood.

Our objective to clean the Seine operates on much the same principles as the kidney—**we'd like to clean the Seine's waters of pollutants in a way that does not interrupt the flow of water or traffic.**

**Each individual island would act like a single nephron**, doing its small part in purifying the Seine in a way that would not disrupt the flow of water or traffic, like a large dam would. The roots exposed to the water have high surface area, so a large amount of water would be exposed to the purifier, much like system of blood vessels in nephrons. After the pollutants are absorbed by the plants, those pollutants would be able to be removed from the water in a less harmful form—beautiful plants.

the kidneys are the primary  
place of blood filtration



**Glomerulus and Bowman's Capsule** Filtrate, the precursor to urine, is squeezed out of the blood and into the Bowman's capsule. Red blood cells and large proteins do not get filtered out.

**Proximal convoluted tubule** Beneficial nutrients, water and ions are reabsorbed into the blood.

**Distal convoluted tubule** Potassium, sodium, and calcium are reabsorbed.

**Loop of Henle** More water is absorbed, and sodium and chloride ions are pumped out.

**Collecting ducts** Urine is collected here and taken back down to the center of the kidney.



# the background

Our idea originated from the integration of various concepts that have been previously utilized with different objectives, ranging from water purification to providing a public space. In this section, we will address the existing and already implemented projects that brought the largest pieces of inspiration to our project, discussing their strengths and weaknesses with regards to our own goals, how we plan to adapt their principles to our concept, and how we will manage the combination of all of these different schemes as a response to the problems we intend to expatiate on.



**Hydroponic islands in Amsterdam** Photo by Bruno Moguel Gallegos

## integration of diverse ideas

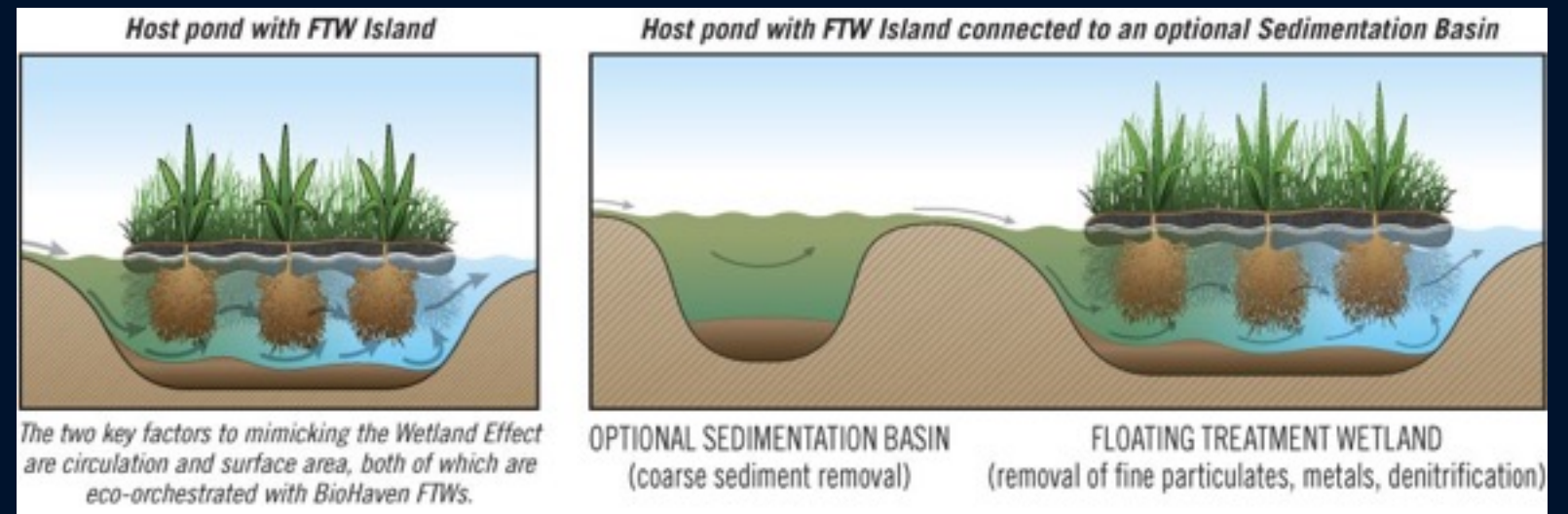


# floating island international

Hydroponic, phytoremediation technology is not new. It has been used in various areas around the world, including in France. In fact, a company by the name of Floating Island International® is already marketing what they call BioHaven Technology®, in which they create floating islands of wetland plants and use them to clean polluted bodies of water like ponds and lakes.

This technology has been used to clean numerous bodies of water, including in Montana, where the company is based. The islands deployed on the polluted Fish Fry lake over four years were able to reduce nitrate levels in the water by 95%, and they only covered about 2% of the surface area of the lake.

This sets the precedent for the use of islands that cover a small surface area of a body of water being used to filter large volumes with great effectiveness.



**Above** An abbreviated explanation of the BioHaven treatment system.

**Right** Image of BioHaven's wetland plant-based floating islands.

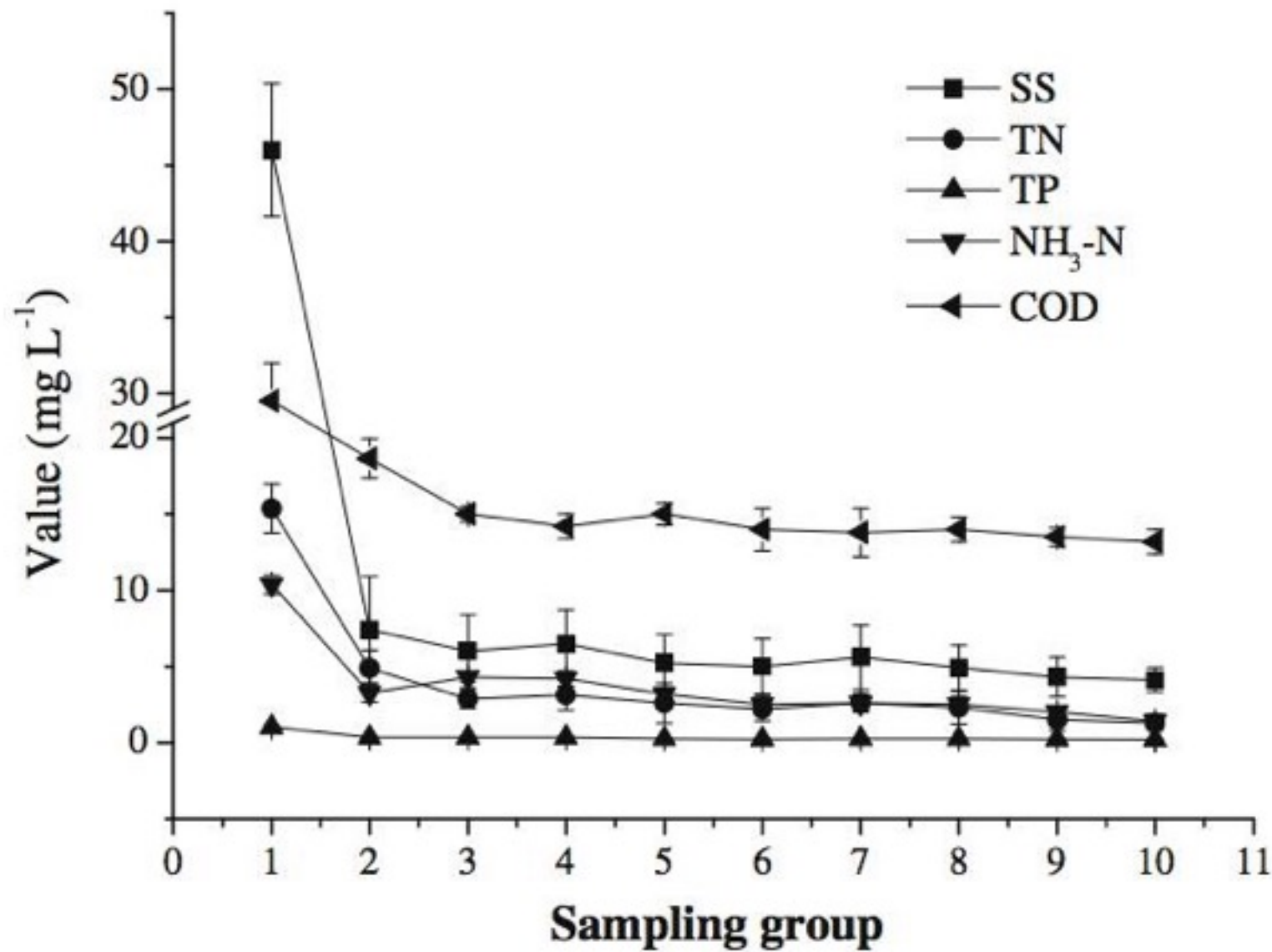
# the . waigangriver

The next logical question is whether or not this type of technology, which has been used on lakes and ponds—relatively slow moving or even stagnant bodies of water—can also be used in river waters, which are constantly in motion. Floating Island International® says yes, but perhaps a more compelling assurance would be the already successful use of phytoremediation technology to clean the Waigang River in China.

Through the use of floating rafts of water hyacinth and ryegrass over a three year period, the levels of harmful toxins in the river water were greatly reduced, and the water transparency also increased dramatically. The study also suggests that this process can be equally as successful in other rivers.







#### KEY:

**SS** suspended solids  
**TN** total nitrogen  
**TP** total phosphorus  
**NH<sub>3</sub>-N** ammonia-nitrogen content  
**COD** chemical oxygen demand

**Results from the Waigang river study**  
 These data points were taken over the course of 36 months.

# recycled park

At the University of Rotterdam in the Netherlands, there is an initiative called Recycled Park to create floating parks out of recycled plastics that have been collected from rivers in the surrounding area. The floating parks are made of subunits that can be fitted together in various shapes and sizes. There are also specialized subunits that are used depending on what type of activity or plant growth will be taking place on top of it.

This initiative is particularly of interest to us because it relates to our goals of recycling and up-cycling waste to create our products, and it also sets an example of man-made river islands made from recycled materials that can act as recreational areas for the public.



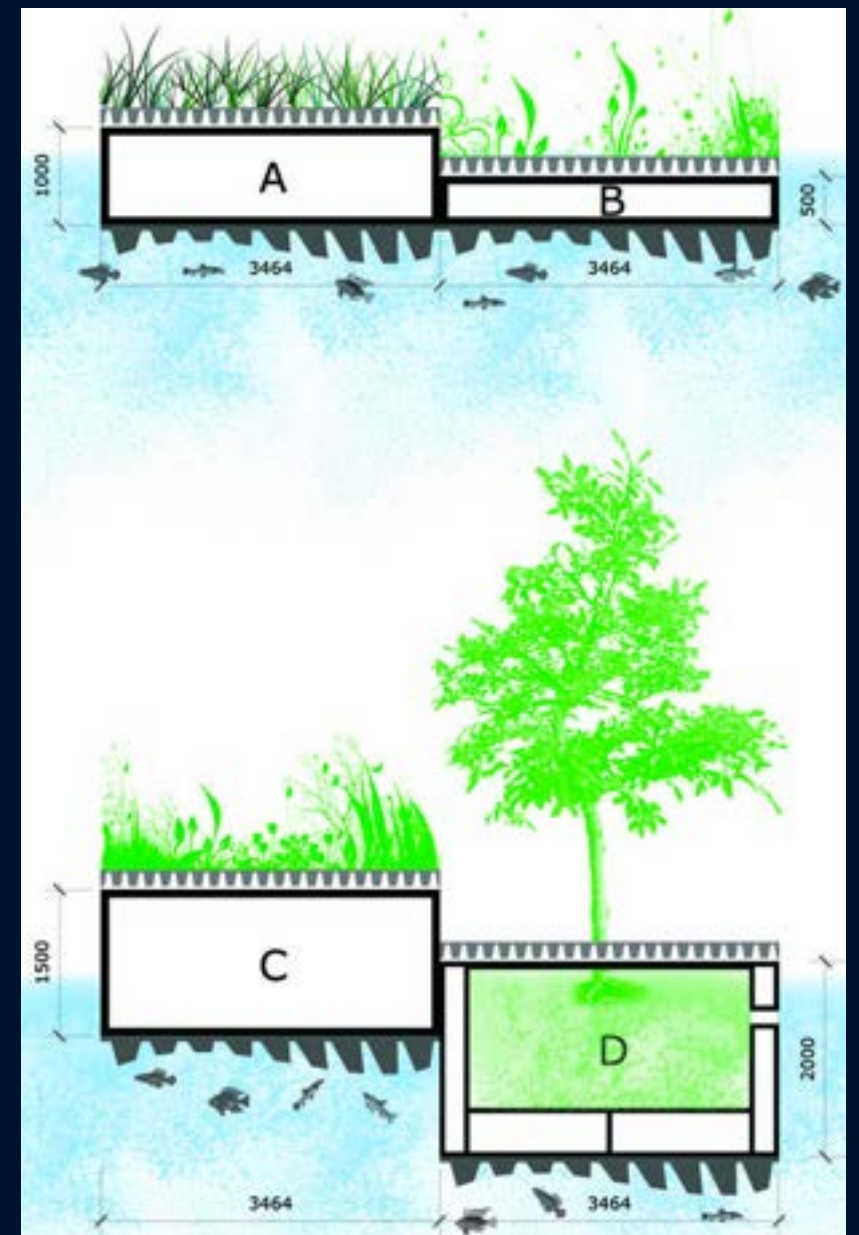
**Above** Cross section of subunit

**Top** Textured surface prevents erosion.

**Middle** Hard, impact resistant shell surrounding lightweight, floating center.

**Bottom** Rough surface provides a medium for aquatic organisms to attach and grow.

**Right** Depictions of the different types of subunits that support different types of plant life. The height of the subunit in water and the thickness of the units are customized according to plant type.







**Above** 3D rendering of Recycled Park's full floating park, which would be open and accessible to the public.



# les berges

In 2013, the city of Paris announced the opening of Les Berges—a project that aimed to revitalize the banks of the Seine and turn them into a public recreational space like they used to be.

The stretch of riverbank from the Musée d'Orsay to Pont de l'Alma has been closed to car traffic and converted into a pedestrian walkway that contains everything from old industrial shipping containers converted into rooms that can be reserved for naps, to play structures and organized arts and crafts workshops for children, to a public fitness trail.

This effort on the part of the city of Paris fits with our own project's goals of revitalizing the area of the Seine by getting Parisians more involved with the Seine and its surroundings.

Additionally, Les Berges is host to floating gardens of their own which are open to the public. This provides us with proof that it is possible to build floating islands that are safe for people to go on.



**Above** Parisian families relaxing by the banks of the Seine.



**Right** Parisians sunbathing on the floating islands.



# Positively Impacting Paris



**Utilizes recycled materials** to eliminate waste and minimize negative impacts on the environment.



**Adds greenery** to the Parisian environment, which will provide a refreshing sight as well as cleaner river waters and fresh air.



**Educates the public** about hydroponic technology, sustainability efforts, and environmental conservation.

our  
design...



Our **Salad Bowl** islands, similar to those of Recycled Park, will be made out of **individual, customizable subunits** that can be attached to each other to form various shapes of islands, depending on the area available on the Seine and the space needed for the plants.

Each subunit will be made of a **flexible and lightweight plastic mesh**, like those of BioHaven, that will float on the surface of the water and will provide a medium for plant growth.

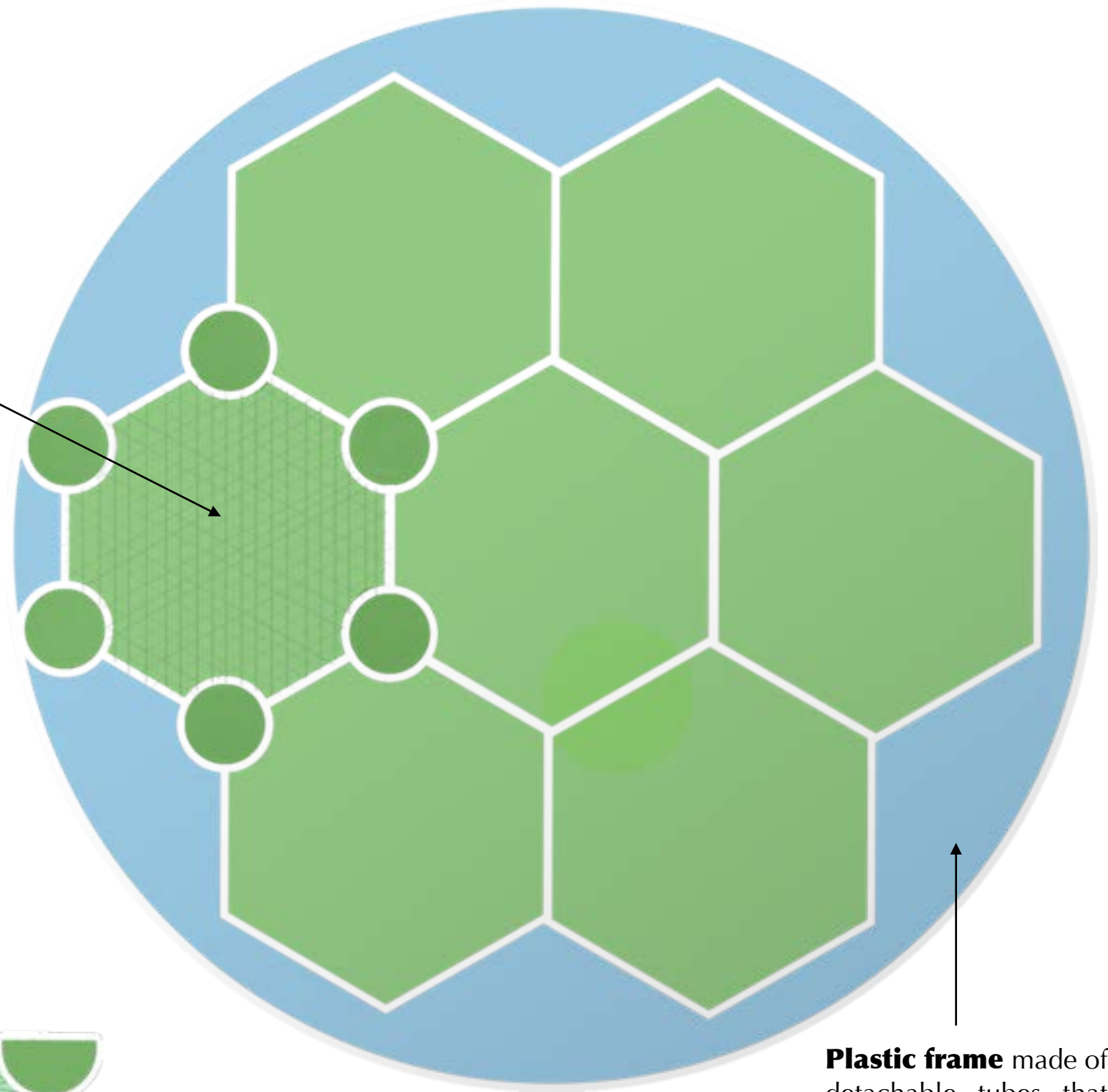
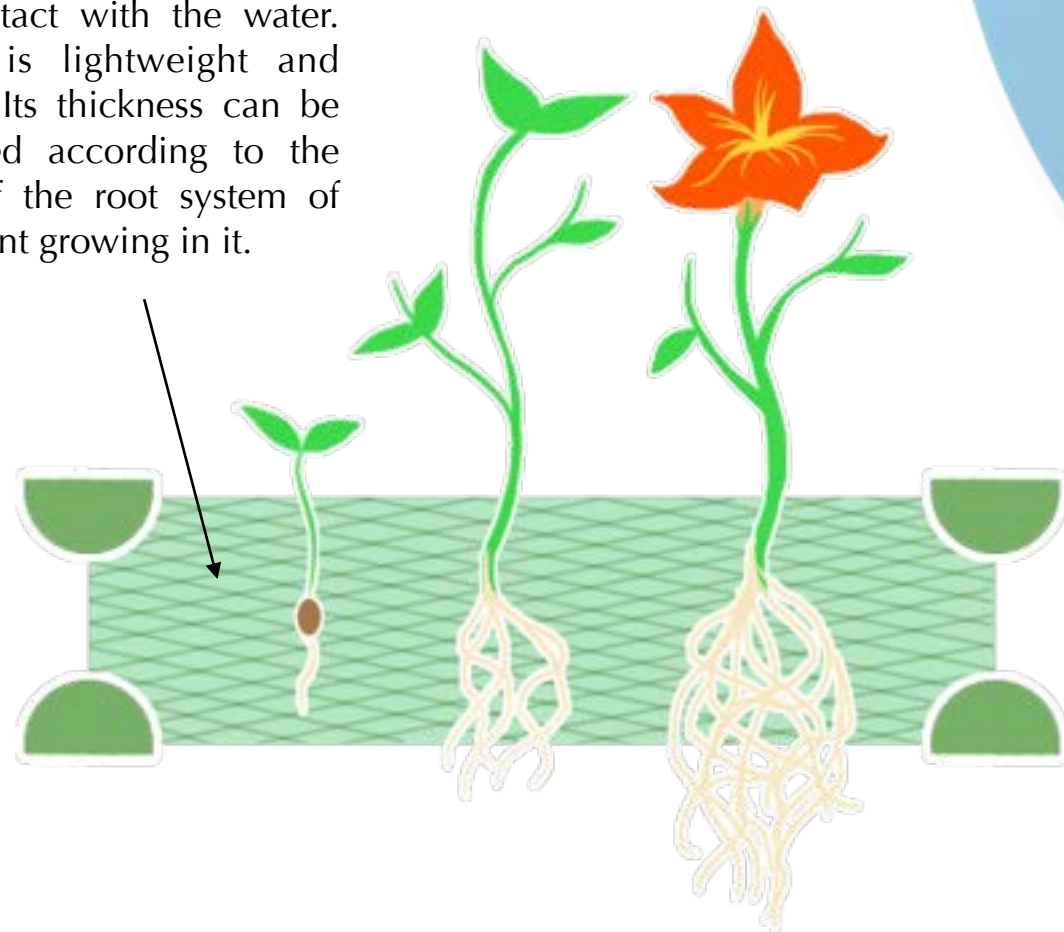
Surrounding the network of mesh will be a **hollow plastic frame** giving additional structural and floatation support to the mesh structures as well as shielding the mesh from impact damage.

The plants that we plan to use have been carefully chosen to filter specific pollutants that cause the greatest problems in the Seine. These plants are also visually beautiful and can be easily sold to florists and shops as any normally grown plants would be able to.

# the bowl

**Subunits** can be attached and arranged in virtually any formation, according to whatever is most convenient for the plants that are grown on them or the area of the river that they occupy. Each subunit will be about one meter long on each of its sides.

**Mesh layer** provides a structural network that provides support to the plant's root system, while also leaving the roots open to contact with the water. Mesh is lightweight and floats. Its thickness can be adjusted according to the size of the root system of the plant growing in it.



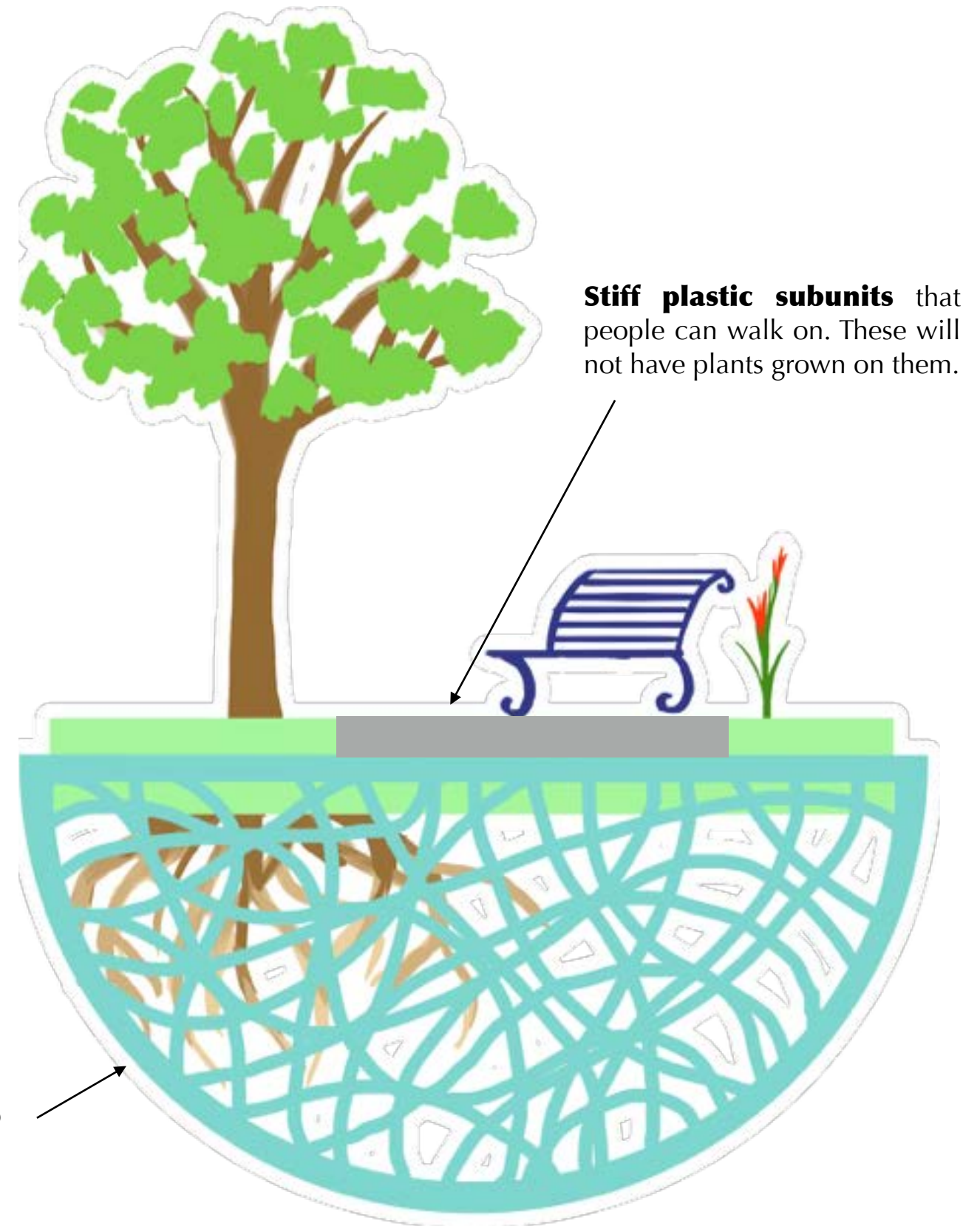
Images produced by  
Harvard Summer School

**Plastic frame** made of detachable tubes that can be arranged in formations to fit the subunits. They are hollow and impact resistant, and provide additional floatation.



**Larger model islands** will be constructed with sturdier frames and subunits that can support trees and the weight of people. These islands will be open to the public to use as recreational space. An **island supervisor** will be employed to maintain the condition of each of the islands and also to teach Parisians about the purpose and function the islands serve. Also included on these large islands will be informational diagrams.

These islands will be located near bridges and islands in the Seine, connected to land by ladders or ramps so that pedestrians can have an easy route of access. They will also be more firmly tethered to the river bed, to minimize the islands' movements as they are hit by waves caused by passing boat traffic. The result will be a structure similar to a floating dock.



**Stiff plastic subunits** that people can walk on. These will not have plants grown on them.

**Stiff plastic frame** to protect and give structural support to tree roots.

# the candidates



**Sunflowers** have been grown hydroponically with great success. They are also a great hyperaccumulator, which means they naturally absorb high levels of heavy metals from their growth medium. The metals that sunflowers absorb include chromium, copper, nickel, manganese, lead, and zinc. Lead and nickel are two of the major pollutants in the Seine.



**Canna lilies** have been grown in European gardens for centuries, but these beautiful flowers are not simply eye candy for European aristocrats. They also have the remarkable ability to remove certain types of industrial and medical waste from waters and render them nontoxic through their metabolic processes, and have been used in wastewater treatment plants as a natural water treatment method. Industrial and medicinal waste in the Seine are a serious concern for many Parisians.



**Spider plants** are a common household plant that are commonly used to filter formaldehyde out of the air, but they also have the ability to absorb trichloroethylene from their growth mediums. Chloroethylenes are one of the major pollutants in the Seine. After they are used in the phytoremediation process, they can then be sold easily in local flower shops as household plants.



Each plant that we plan to use was carefully chosen for their specific cleansing abilities. Although all the plants will be a part of the larger network of the islands treating the river water, each individual plant will have a specific role in the treatment process, much like the different sections of the nephron tubules.

The differentiation and specialization of the sections of the nephron tubules is what allows the nephron to work as efficiently and effectively as it does. Operating alone, each plant and each island will not be able to have a significant effect on pollutant levels in the Seine.



by connecting all the plants and islands in a larger concerted system will we be able to filter out pollutants more efficiently and effectively

# preliminary cost projections

The cost of traditional hydroponic greenhouses can range from \$100 to \$200 per square meter of growing space, and Floating Island International's smaller 2.5 ft x 2 ft islands retail for around \$160 per island. This is not at all a negligible cost, but we expect that our islands will cost significantly less for several reasons.

Our islands will be made out of recycled plastics that can be collected by the city of Paris. This will greatly reduce energy use and costs, as well as material costs. Additionally, traditional hydroponic farms invest large amounts of energy and capital to bring water into the greenhouses and keep it flowing past the plants. Our project has the advantage of already having the Seine—a flowing source of water—for use for watering the plants.

The plants themselves are also a source of offsetting the cost of the islands. Because the plants that we are using are either flowering plants or common household plants, they can easily be sold to florists to help fund our project.

We expect that our project will be a fraction of the cost of other

hydroponic and phytoremediative projects, with each of our 2.6 square meter subunits costing no more than 50 euros to produce. This is achievable because of the simplicity of the structures, and the fact that our only major cost will be for material costs.



**A traditional hydroponic greenhouse** requires large startup costs to build the structures necessary to hold and transport water to the plants. Salad Bowls sur Seine avoids those costs.



# the execution



**Map detailing the position of the islands.** Green circles indicate specific locations, blue circles show possible sites for larger islands.

Our priority for placement of the islands was making sure that they do not disrupt boat traffic on the river. Thus, we decided to place the islands in areas of the river that are not common boat paths. Our plans for placement are mainly near bridges with multiple arches, in wide areas of the Seine, and at the ends of islands in the river that already obstruct traffic.



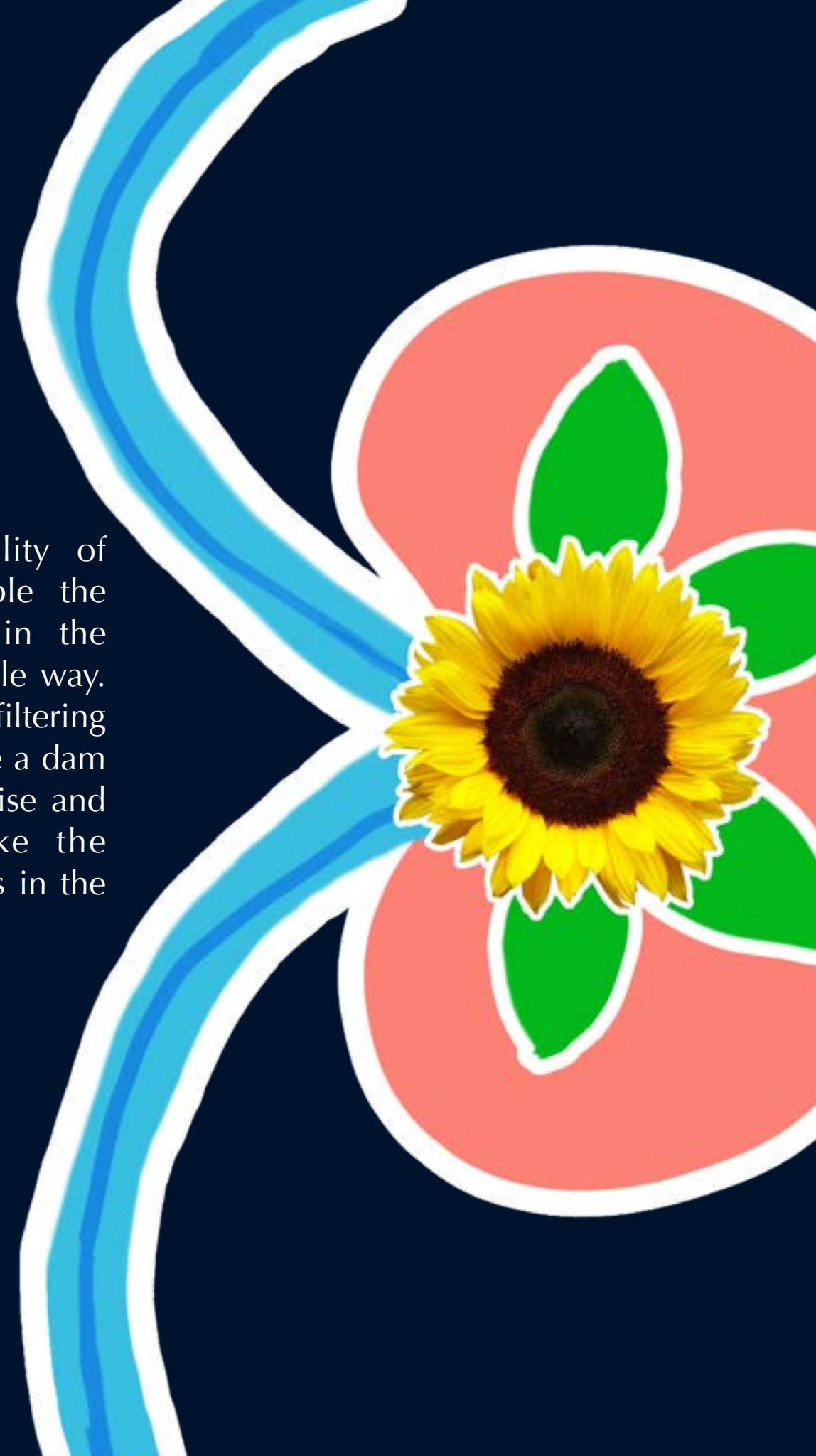
Near the bridges, the islands can be placed near and tethered to the unused or underused arches of the bridges, leaving the main arches still free and open for passing traffic. In wide areas of the river, the islands can be placed in the middle of the river as a lane-marker of sorts that will help to divide the two directions of travel, and thus will not block oncoming boats. Near islands like the Île-de-Cité and Île-Saint-Louis, the pointed shapes of the islands already prevent boats from passing too close to the pointed ends, so that space is free for the installation of islands.





From previous experiments, we have seen that very little surface area coverage is needed to make a significant impact, so our starting projection of using these 11 island placements should be sufficient. However, the flexible, modifiable nature of our islands will allow easy addition and enlargement of islands in the case that these 11 are not cleaning the Seine at a fast enough rate. We can also easily add and expand islands as our project grows in size and scope over time.

Overall, the functionality of these islands will resemble the functionality of kidneys in the human body in a remarkable way. The islands are not simply filtering the Seine by brute force like a dam might, but rather with precise and efficient action, just like the complex network of tubules in the kidney's nephrons.



In addition, once we filter out those pollutants, the pollutants won't simply become toxic waste to be dumped elsewhere to cause further environmental harm. Like the kidneys, our system will convert what was previously a toxic substance—in the kidney's case ammonia and in our case heavy metals and industrial wastes—into a nontoxic, non-harmful substance—urine for the kidneys and flowers for the salad bowls. The pollutants, once incorporated into the plant systems, will either be converted into nontoxic forms, like in the canna lily, or they can be 'mined.' Heavy metals in particular can be extracted from plants like the sunflower in a process known as phytomining and reused and repurposed.





# education

Another important goal of our project is to **educate Parisians about sustainability, green technology, and hydroponics**. Paris is a booming city with a significant pollution problem, and so spreading information about how to be environmentally friendly is a valuable course of action.

Our large-model islands will have educational signage installed on them and near their access points (i.e. on the bridge or island they are connected to), and there will also be signs in areas where the small islands are clustered, explaining to visitors and passersby what the islands are, why they are there, and why they are important.

## Paris as a living, breathing organism



These signs will contain information about the construction of the islands, how they function, and will relate their function and structure to the function and structure of the kidneys. They will also encourage readers to view the city of Paris as a living, breathing organism that must be cared for and protected.

The large model islands will also have attendants working on them who will serve both to maintain the condition and cleanliness of the islands by preventing people from damaging the islands as they step on them, and also to answer any questions visitors may have about the more specific or complex functioning of different aspects of the islands. These attendants will be the human touch on the islands that will better connect the public with what is happening on the islands.

# testing

In order to measure our success at cleaning the river water, we will conduct tests of pollutant levels, including levels of lead, nickel, chloroethylene, and nitrates along key points on the Seine over time. If the levels of these chemicals in the water drop at rates similar to the rates achieved in other efforts, like in the Waigang River, then we can conclude that the islands are working successfully.

Tests will be conducted in areas near where each island is placed, and where islands are clustered. Comparisons will be made between current levels of pollutants, past levels of pollutants, and projected levels of pollutants modeled after the previous experiments.

We will also look at the difference in pollutant levels at certain points of the Seine—upstream, downstream, and within Paris. If, as the islands operate, the water coming out of Paris becomes cleaner than the water within the city of Paris, and comparable to or cleaner than the water entering the city surroundings, then it can be inferred that the islands are successfully cleaning the water.

In addition, we will also conduct small-scale testing of several smaller islands in a Seine canal. Since the canals carry much less water volume, it will be easier to obtain definitive results showing whether or not pollutant concentrations are changing over a short period of time. The results from these small-scale canal tests will be used to test the early efficacy of the islands, and let us know whether and how we can and should expand our project.





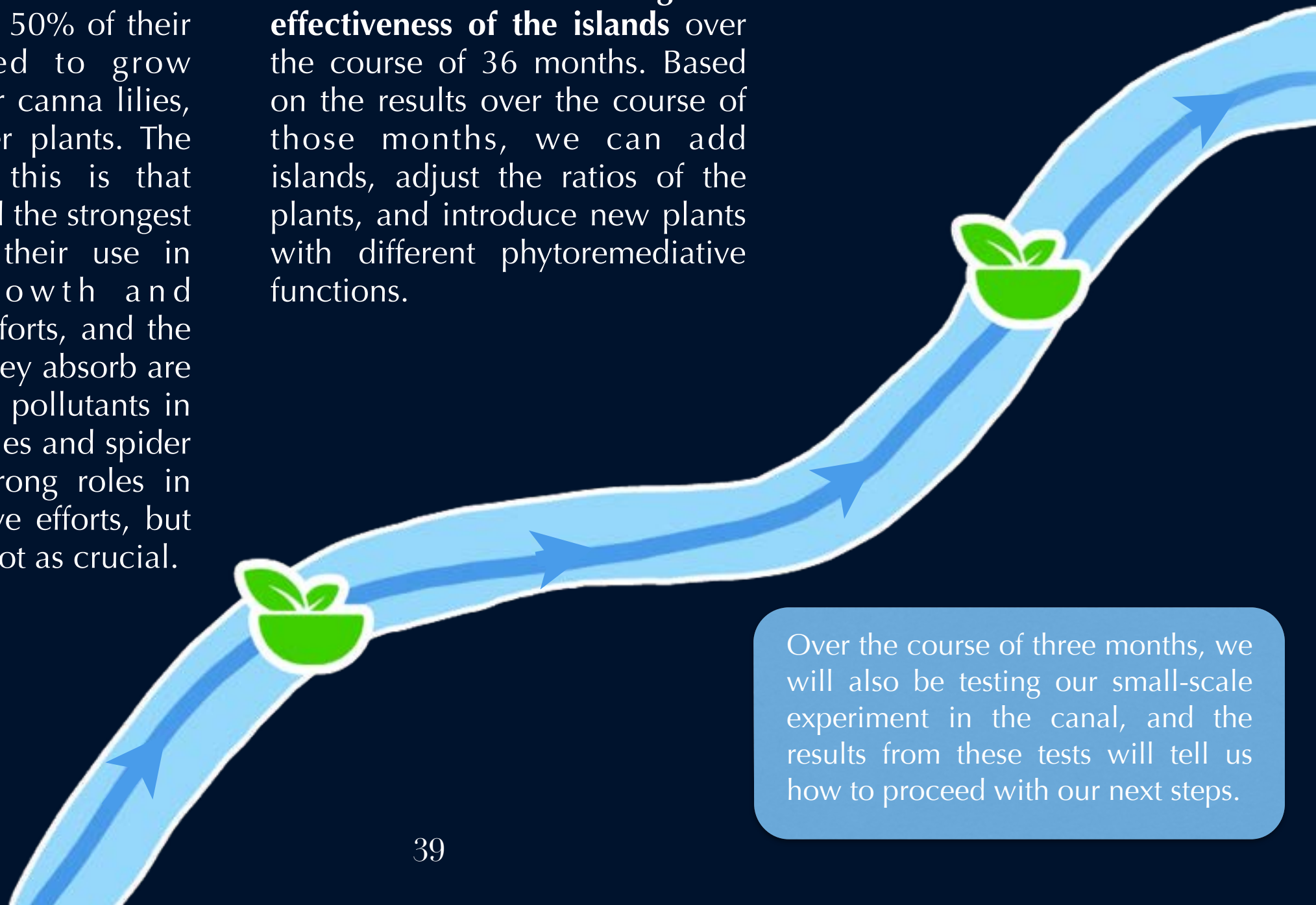
# the plan

## Part 1

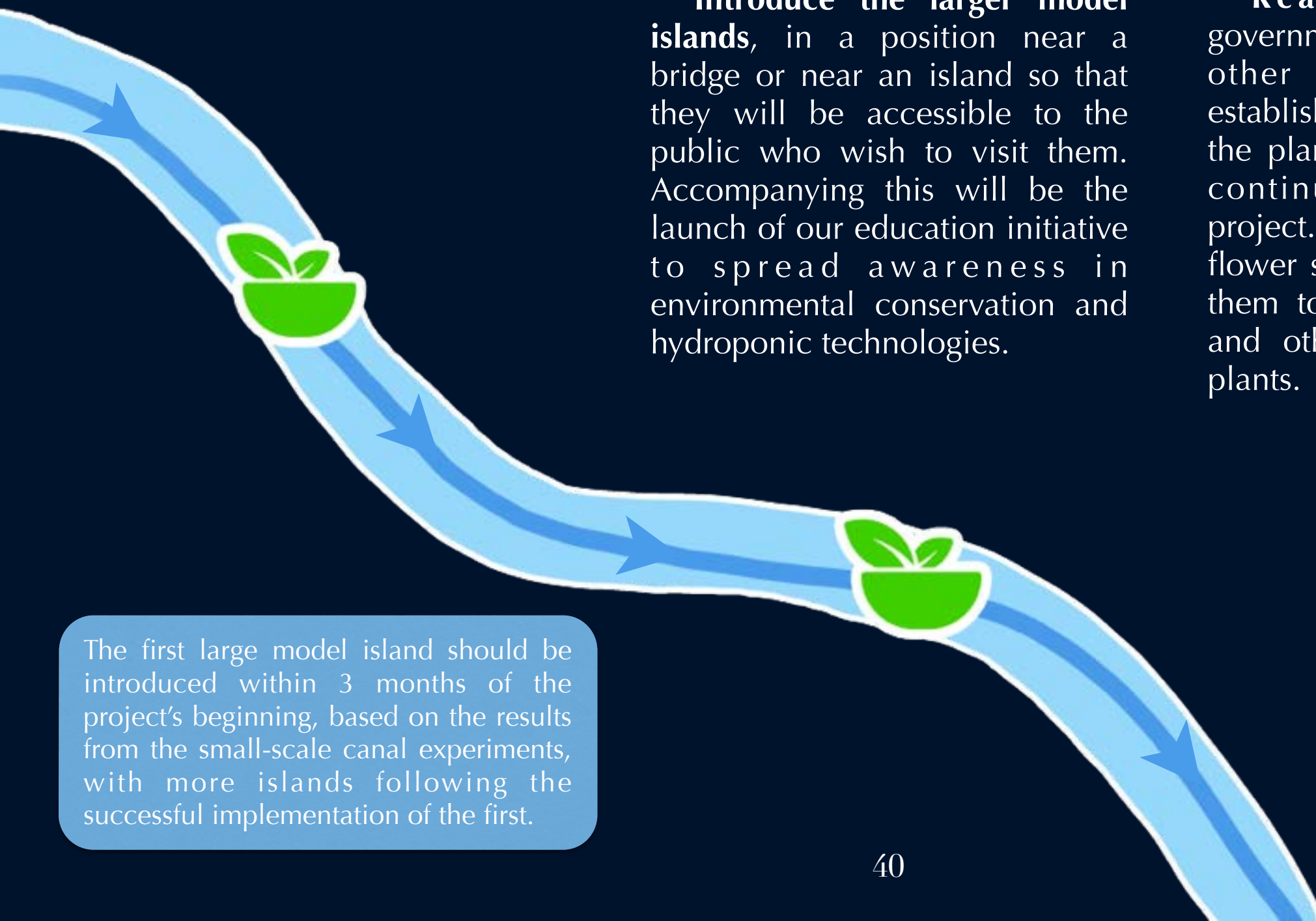
**Deploy our first 11 smaller model islands**, with 50% of their surface area used to grow sunflowers, 25% for canna lilies, and 25% for spider plants. The reasoning behind this is that sunflowers have had the strongest precedent set for their use in hydroponic growth and phytoremediative efforts, and the heavy metals that they absorb are the most prominent pollutants in the Seine. Canna lilies and spider plants also play strong roles in our phytoremediative efforts, but their functions are not as crucial.

## Part 2

**Run tests determining the effectiveness of the islands** over the course of 36 months. Based on the results over the course of those months, we can add islands, adjust the ratios of the plants, and introduce new plants with different phytoremediative functions.



Over the course of three months, we will also be testing our small-scale experiment in the canal, and the results from these tests will tell us how to proceed with our next steps.



### **Part 3**

**Introduce the larger model islands**, in a position near a bridge or near an island so that they will be accessible to the public who wish to visit them. Accompanying this will be the launch of our education initiative to spread awareness in environmental conservation and hydroponic technologies.

### **Part 4**

**Reach out** to the city government, local florists, and other private companies to establish deals to donate or sell the plants to raise funds for the continued operation of the project. The plants can be sold in flower shops or given to labs for them to extract valuable metals and other substances from the plants.

The first large model island should be introduced within 3 months of the project's beginning, based on the results from the small-scale canal experiments, with more islands following the successful implementation of the first.





## **Part 5**

As the Seine is further cleaned and purified, islands will remain in the river to continue to operate, although the number of them can be reduced as pollution in the Seine becomes a less pressing issue. The larger islands can remain and act as parks and relaxation areas on the Seine for the public, as well as continue to educate Parisians about the technologies and principles involved in the project.

# summary of goals

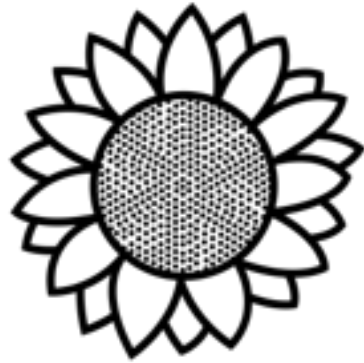


**Cleaning** Our main objective is to clean the Seine. The river is polluted with heavy metals, and we expect to reduce the concentrations of nickel, lead, chloroethylene, and nitrates that are currently present in the Parisian waters.



**Education** We hope to, in the long run, educate Parisians about the green technologies and green living by having qualified personnel on the large islands who will assist citizens and answer their questions.





**Green space** The addition of plants into the city of Paris will help address the issue of the lack of greenery in the metropolis. By using plant species that are native to Europe and keeping the space we occupy to a minimum, we ensure that there will be no further damages to the ecosystem of the Seine as it recovers from the damages that pollution has caused it. The use of flowering plants would create beautiful aesthetics while also being functional.

**Reduce waste** We intend for the flotation devices to be made from upcycled materials like plastic bottles, which would otherwise go to waste. The educational part of the project would be tied to interesting and unconventional facets of recycling and how it can positively impact a community and the natural environment.

# the impact

The dual environmental and social nature of the islands will result in both physical and social impacts. Our goal is to minimize the negative physical impacts that will result from the occupation of space on the Seine, while also providing maximum positive social and environmental impacts.



**A swimming race in the Seine.** These will hopefully become more common after the implementation of our project.



# physical impacts



In addition to purifying the Seine, our islands will add much needed green space and natural beauty to the stony appearance of Paris and the Seine. The city will look gentler and brighter as a result, and pedestrians along the river and boat travelers will have a refreshing sight in their daily commutes.

The city will look gentler and  
brighter

Because our islands will be located on the river's surface, they will inevitably pose as possible obstructions to boat traffic. To avoid this, we tried to strategically place the islands in areas that are not frequently used by boats, although the existence of the islands will still affect the daily habits of those who work or travel on the river. However, we predict that the refreshing greenery and beauty that the islands will add to the Seine and the flexible, modifiable nature of the islands will allow us to offset whatever minimal negative space impacts the islands will cause.

# social impacts

Decades in the past, the Seine was a place of waterside frolicking and swimming races. However, in the 1960s and 70s, the river became so polluted that swimming in the river was banned, and swimming events that were traditionally held were cancelled. Both Anne Hidalgo and a previous mayor of Paris, Jaques Chirac, stated that they had goals to open up the Seine for swimming during their terms. Although Chirac failed to reach this goal, Anne Hidalgo's deadline of 2024 is very possible with the use of our islands, given that this type of technology has been employed to cause significant improvements in water quality in as little as three years. Perhaps Paris will even win the 2024 Olympic bid and be able to host swimming events in the Seine, as Mayor Hidalgo has expressed desire to do.

As the Seine becomes more hospitable, and if it becomes open to the public, the river will also be able to be more fully integrated into the everyday life and experiences of Parisians. The river itself will be able to become a place of recreation, relaxation and connection for the citizens of Paris instead of a dead space or a dividing line, making the entire city more connected and vibrant.



As the Seine becomes cleaner, the way that Parisians interact with the Seine will shift and change.



# the assessment

Given the nature of our project, assessment of its success will be an ongoing process that will take place as the project is going through its stages of implementation. The effects of the islands will be constantly tested in lab, to see if they are effectively lowering pollution levels.

Our preliminary tests in the Seine's canal will be considered to indicate success if the plants are able to grow successfully on the islands, travel in the canals is not significantly disrupted by the presence of the islands, and pollutant levels drop by at least 25% within three months of use.

The islands in the Seine proper will be considered successful if they manage to reduce the levels of the major pollutants of the Seine by at least 70% over the course of three years of use.

The educational component of our project will also undergo rigorous testing.

In order to ensure that we are achieving our goals of making sure that Parisians are more in touch with the Seine and more concerned about sustainability, environmental conservation, and green technologies, we will survey citizens that have not yet interacted with our islands about their attitudes toward and prior knowledge of these issues. We will also have an "exit survey" of sorts on our educationally-oriented islands that can be given by the island supervisor to those that have been on the islands to see if there is a difference in responses between the two groups, and to take suggestions on how their experiences could have been improved.



As our results from both of these assessments come in, we can shift and change our implementation of the program to optimize its functioning. Like how the kidneys can adjust the amounts of nutrients, ions, and water are absorbed by nephrons through hormonal signaling, we can adjust the rate of pollutant absorption by adding or removing plants of certain types, and we can also add to our educational component or shift its focused based on the feedback that we receive.







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