



Columbia University GSAPP 2022-2023 Portfolio  
MSAAD-  
Zijian Hao [zh2535]

Summer 2022

- ARCH 4402 A sec 001-TRANSSCALARITIES
- ARCH 4488 A sec 001-ARGUMENTS
- ARCH 6853 A sec 001-ADVANCED ARCH DESIGN STUDIO

Fall 2022

- ARCH 4005 A sec 001-ADVANCED STUDIO V
- ARCH 4469 A sec 001-THE HISTORY OF ARCH THEOR
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- AARCH 6894 A sec 001-NET ZERO HOUSING

Spring 2023

- ARCH 4006 A sec 001-ADVANCED STUDIO SEMESTER
- ARCH 4845 A sec 001-GENERATIVE DESIGN
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## 01 Beyond farming-A Vertical Farm and Pasture for future

[Location] Hokkaido, Japan  
[Instructor] David Benjamin  
[Academic] 2023 MS AAD Spring Studio  
[Group/Individual] Individual Work  
[Date] 01/16/2023-04/27/2023  
[Duration] 14 Weeks

### Why?

As global warming intensifies, we must keep global temperature rise to 1.5 degrees celsius. To do so, carbon emissions must be cut in half by 2030 and entirely eliminated by 2050. It is worth noting that buildings, which contribute 40% of global emissions, are expected to double in the next 30 years. Therefore, it is essential to find ways to significantly reduce the total amount of carbon in all buildings, while also dramatically increasing the number of buildings, to avoid irreversible catastrophe.

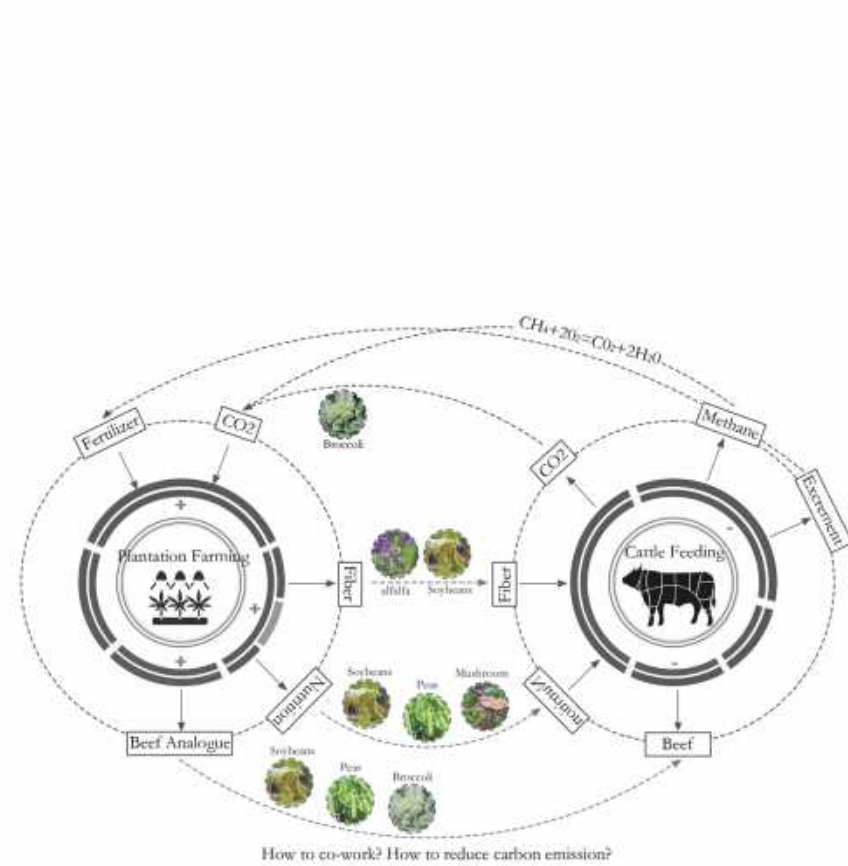
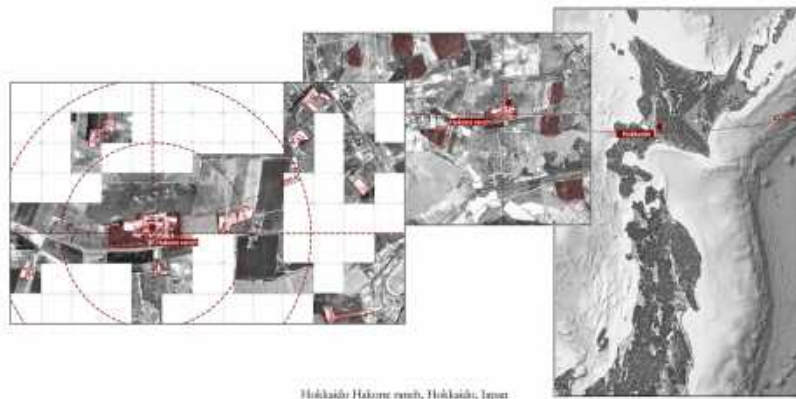
### What?

Hokkaido is an important base for agriculture and animal husbandry in Japan. The vertical farm and pasture will serve as a new mixed farming prototype, gradually replace part of the former horizontal farming system over the next few decades.

### How?

The design focuses on the food production industry and aims to address carbon emissions problem in two directions: one is to address inefficient land use problem through vertical growth structures, and the other is to address carbon emissions problem from cattle through plant capture and photosynthesis.

Looking at the bigger picture, this design is poised to serve as a "bridge" project that will span several decades, bringing together cutting-edge technology, sustainable farming practices, and a forward-thinking approach. As our dietary preferences continue to evolve, and we make adjustments in our consumption patterns, the demand for beef is expected to decrease significantly. This, in turn, will lessen the impact of cattle farming on global temperature change. As we move towards this new reality, the innovative combination of vertical farm and pasture that this design incorporates will be transformed into a state-of-the-art vertical farm.





feed need - 6h(12 times)/day



chew the cud - 7h(10 times)/day

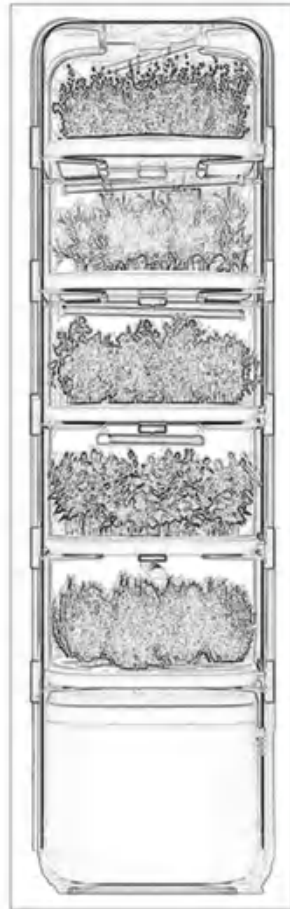


social need- 2h/dy



rest need - 14h/day





Soybeans



Lentils



Broccoli



Mushroom



Peas



alfalfa

Efficient absorption of CO<sub>2</sub>  
 Suitable for forage crops  
 Rich in protein  
 Climate can be adapted



Sowing seeds (machine auto)



Growing (artificial lighting)

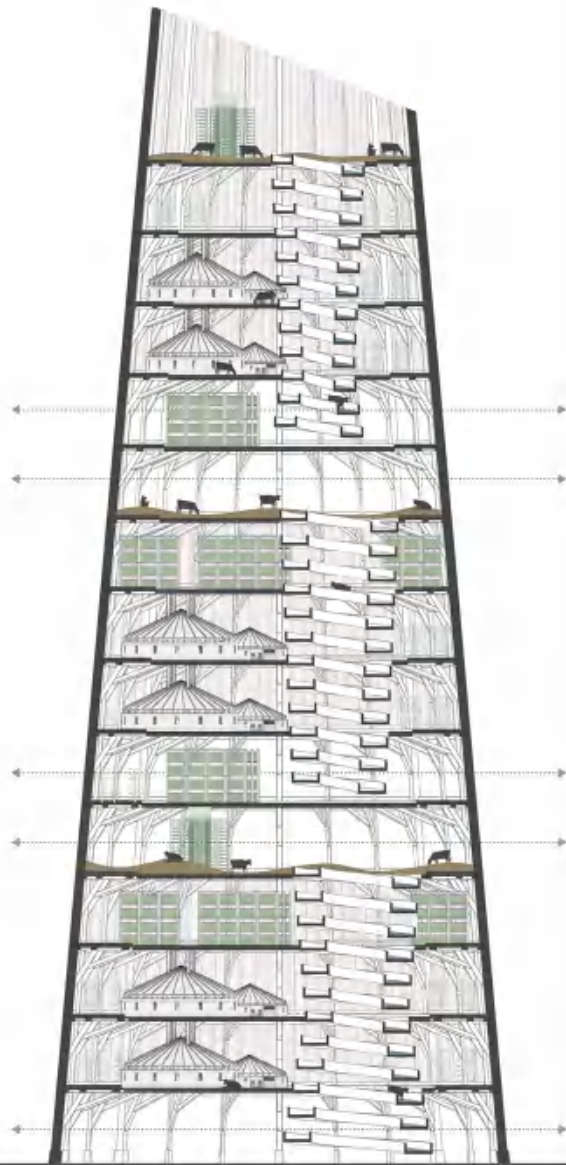


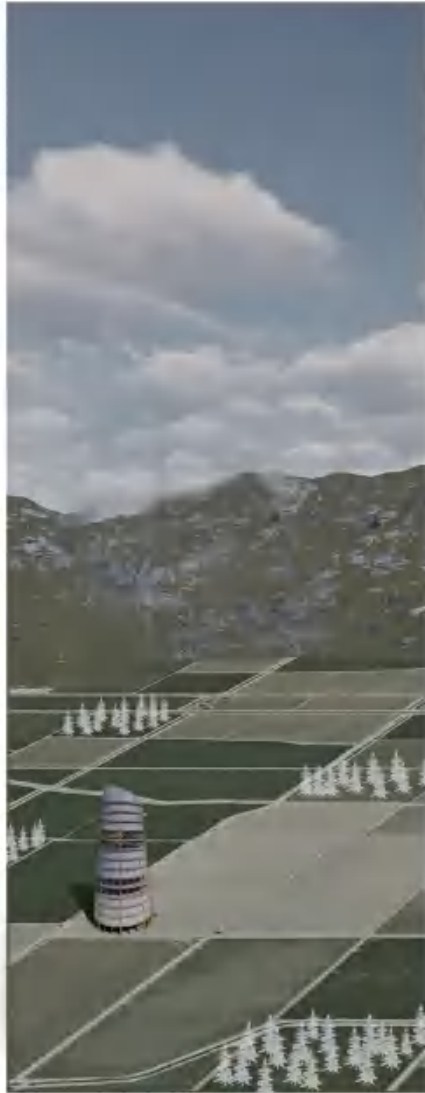
Cultivate (multi-layer dish)



Marketing/ forage crops







#### Scenario-2025

The first vertical farm and pasture will be built in Hokkaido, Japan. Serving as an experimental new prototype, the building brings together sustainable farming practices and a forward-thinking approach. So far, due to the technical limitations, the vertical farm and pasture hasn't been able to reach net zero.



#### Scenario-2040

By establishing more vertical farms, farmers attempt to cultivate most of the plants suitable for vertical growth in the buildings. This, in turn improves the land use efficiency and relieves the pressure on traditional land cultivation practices, returning more land to nature. The increase in the proportion of vertical farms also gives birth to a new farming model—horizontal and vertical mixed pattern.



#### Scenario-2060

With the development of cutting-edge technology, vertical farms have reached net zero. This breakthrough has broadened the market for vertical farms, bringing the proportion of them to over 50% in food production industry. The number of vertical farms increases, leading to the transformation of the interior space of the buildings—part of the pasture will be demolished and rebuilt as plants cultivation area.



#### Scenario-2080

As human's dietary preferences continue to evolve, the demand for beef is expected to decrease significantly. This, in turn, will lessen the impact of cattle farming on global temperature change, pave the way for cattle to return to their natural free-grazing patterns. By far, the buildings have completed their duty as a "bridge" and will transition from their current use to become fully functioning vertical plants farms.





## 02 A museum with nothing inside for Tomkins Cove Quarry

[Location] Tomkins Cove Quarry, NY  
 [Instructor] Lindy Roy  
 [Academic] 2022 MS AAD Fall Studio  
 [Group/Individual] Individual Work  
 [Date] 09/01/2022-12/10/2022  
 [Duration] 14 Weeks

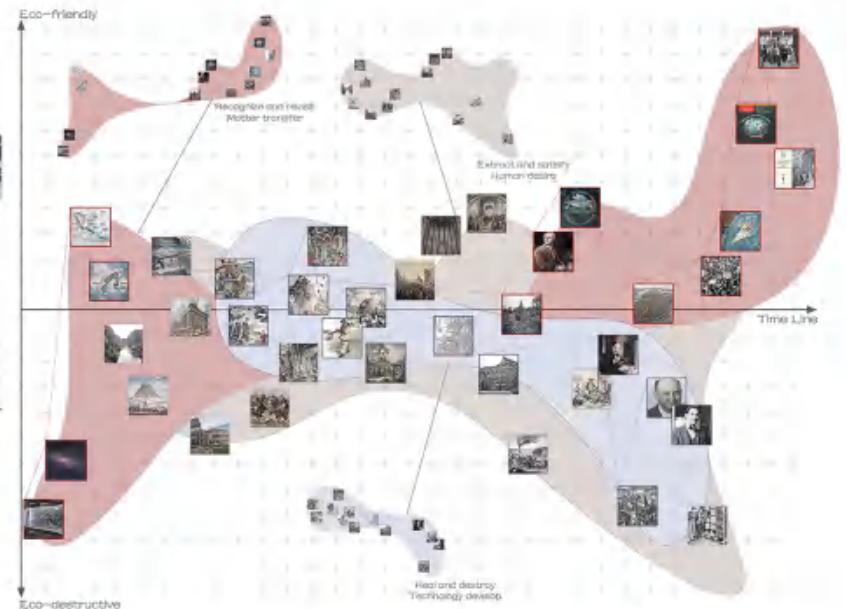
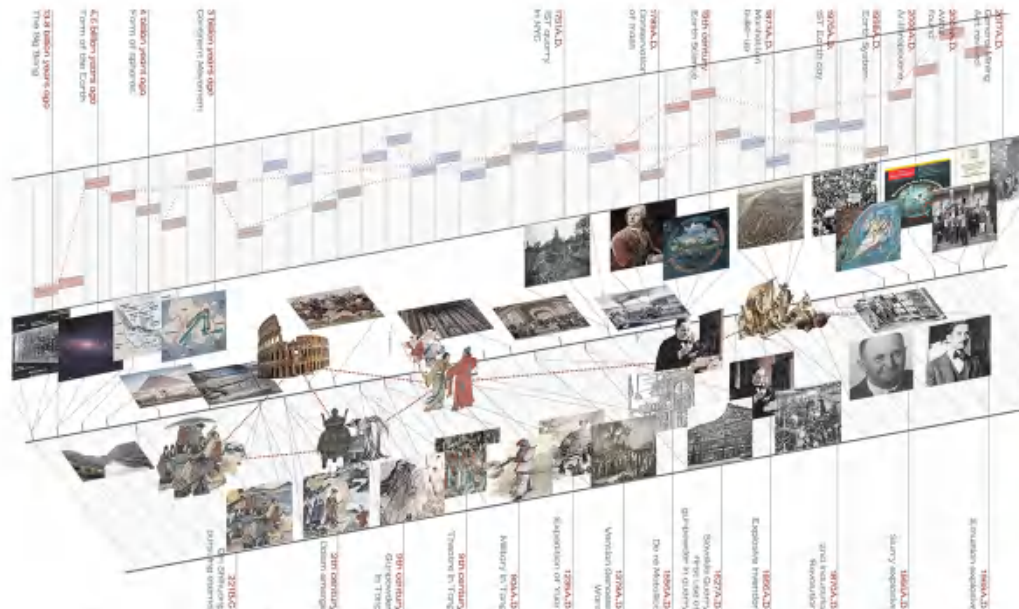
Tomkins Cove Quarry is the straight consequence of 200 years of non-stop quarrying. After three-week-long research, I figure out that what I wanna do is an educational project, like take the whole quarry as a museum—a museum with nothing inside and everything outside. So, first off, I chose five parts on the edge of the quarry that I thought could provide visitors with different sceneries, and then made five huge stairs cutting inside the quarry, from top to the bottom. At several special levels, an inward-facing space was excavated to allow access to the interior of the quarry. Then, I use several trail to draw connection among the five stairs. The trail allow people to observe the quarry from different points with AR glasses to enhance their experiences. At the end of each trail, visitors get to the benches on different levels. Go back to the idea of taking the whole quarry as a museum, you can consider these area as outdoor exhibition halls majority linked to the trail, which have special traces after extraction. So keep moving on the trail and encounter these unique area, visitors are like going from one exhibition area to another.

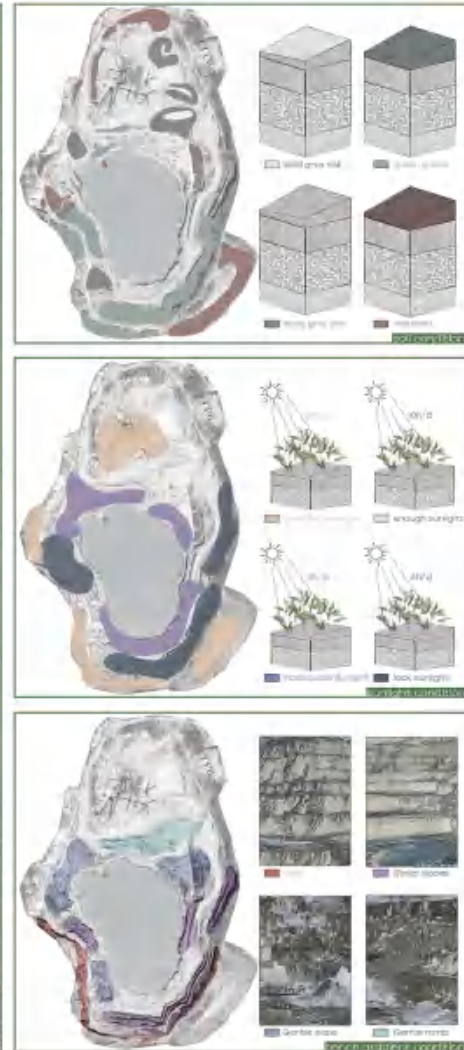
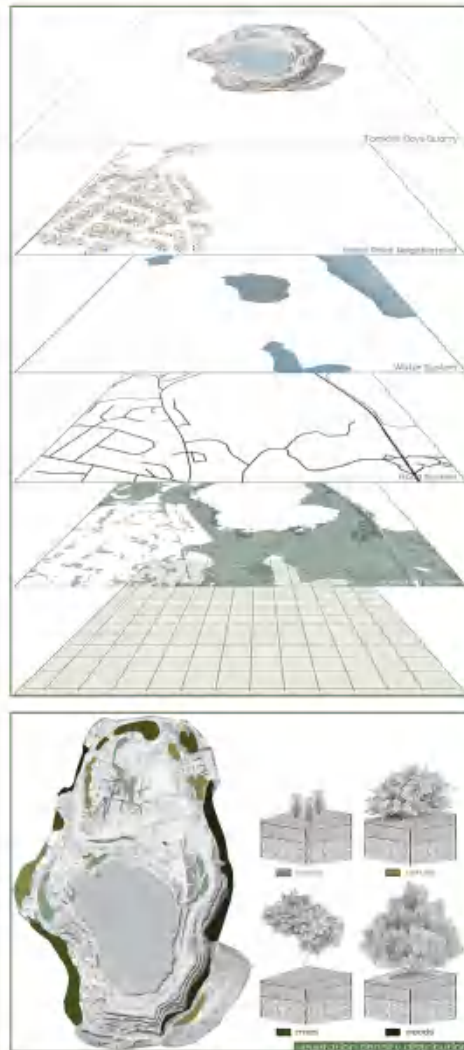
The interesting thing here is that when I merged the three-story lines, like what I did in this chart, the red part represents the anthropocene story. It appears too late, compared with the other two stories (gunpowder story and extraction story). And I think there is a specific pattern to the exploitation of resources. First, the government in some kind of need extract the resources. Despite a few objections, the progress of extraction will not slow down until the resources are exhausted. I call this model the old pattern. Obviously this model is incorrect because by the time the government realizes the severity of the problem and seeks conservation strategies from experts, the problem is irreversible. So I'm thinking about a new pattern where extraction, revisit, and protection simultaneously happen. In order to make people aware of the importance of the shift from old pattern to the new one, Tomkins Cove Quarry has a special significance because the quarry itself is the straight consequence of 200 years of non-stop quarrying. So I figure out that what I wanna do is an educational project, like take the whole quarry as a museum. And if we think about 200-year-long extraction, it's a museum with nothing inside and everything outside (because all the limestones were shipped to culture park or other part of Manhattan). Then I'm thinking that a simple museum may not be educational enough, so I decide to add some interactive element through the design. In a nutshell, I'm taking the whole quarry as a museum, and the two keywords are educational and interactive.

The first problem I had in the design part was that what should I show the visitors, since my concept was a museum with nothing inside. In this chart, after observing the different sections of the site from a human perspective, I chose five parts that I thought could provide visitors with different sceneries, and then I made five huge stairs cutting inside the quarry, from top to the bottom, not only to provide several entrances and exits for visitors, but also to connect the benches at different levels. Because of the scale of the site, these huge open-air stairs can be used for temporary rest or exhibition. And at several special levels, an inward-facing space was excavated to allow access to the interior of the quarry and to see the limestone stratification created by years of quarrying. (this is the first part I wanna show to the visitors.)

Then, I use several trail to draw connection among the five stairs. The trail allow people to observe the quarry from different points. Goes back to the keywords—interactive and educational. I'm assuming that every visitor could get a pair of AR glasses to enhance their experiences. Inspired by a tiny contraption on little island, children stepping on different metal floors will make different sounds, and continuous jumping will produce songs, I decide to add Gravity sensing device to activate AR system at specific locations on the trail. Once visitors step on the device, their AR glasses will work, allowing them not only see invisible objects, but also add or delete virtual objects to the quarry from their point of view (like flora or fauna) and upload their ideas to the database. It's kind of like a collective thought about the future of the quarry.

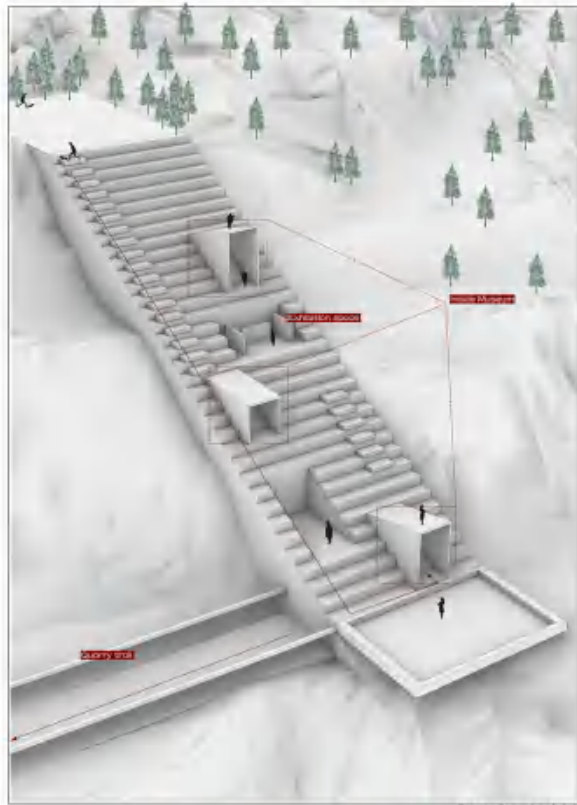
At the end of each trail, visitors get to the benches on different levels. This got me thinking about the many possibilities for the quarry surface. I did a research on it, analysis the characteristic of different part of the surface. Here, I draw a series of drawing about plantation distribution, sunlight condition, soil condition, gradient of the bench, then overlapping them to look for interesting points in the quarry. Go back to the idea of taking the whole quarry as a museum, you can consider these area as outdoor exhibition halls majority linked to the trail, which have special traces after extraction. So keep moving on the trail and encounter these unique area, visitors are like going from one exhibition area to another. Like, from the red gravel area here with shrubs growing on it, and has a gentle slope to a looser area with nothing growing on it but has enough sunlight to a cliff area with Exposed limestone and barely get sunlight. These different areas are appealing to me, and also interactively, I'm thinking about Organizing different events on these different part. And also very importantly, the trail allow people transfer matter from one area to another.



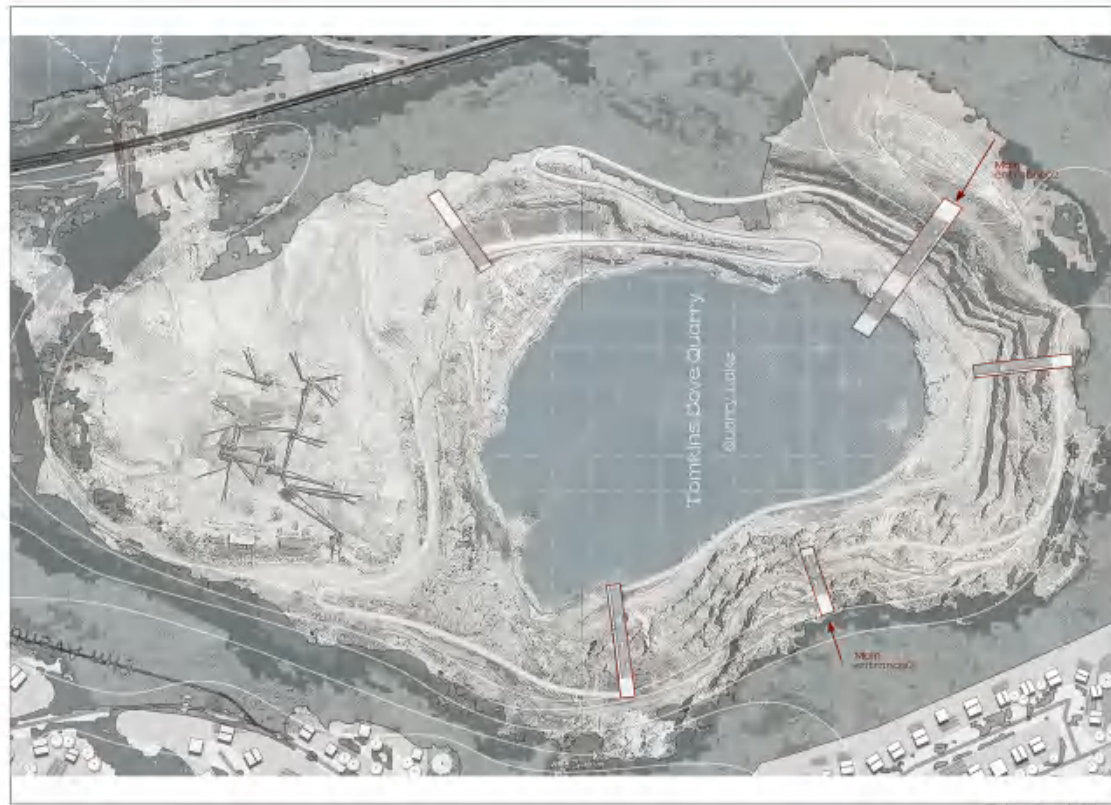


### Site Analysis

After making the decision to build an interactive museum, I return to the site to analyze the basic site conditions. From there, this series of analysis above maps the site characteristics from four perspectives: soil conditions, sunlight conditions, vegetation density distribution, and bench gradient conditions. By overlaying these four analysis diagrams, I obtain a special chart that shows the richness of the surface condition of the seemingly empty and homogeneous site after 200 years of limestone quarrying, from which the design will begin.



Open-air stairs detail

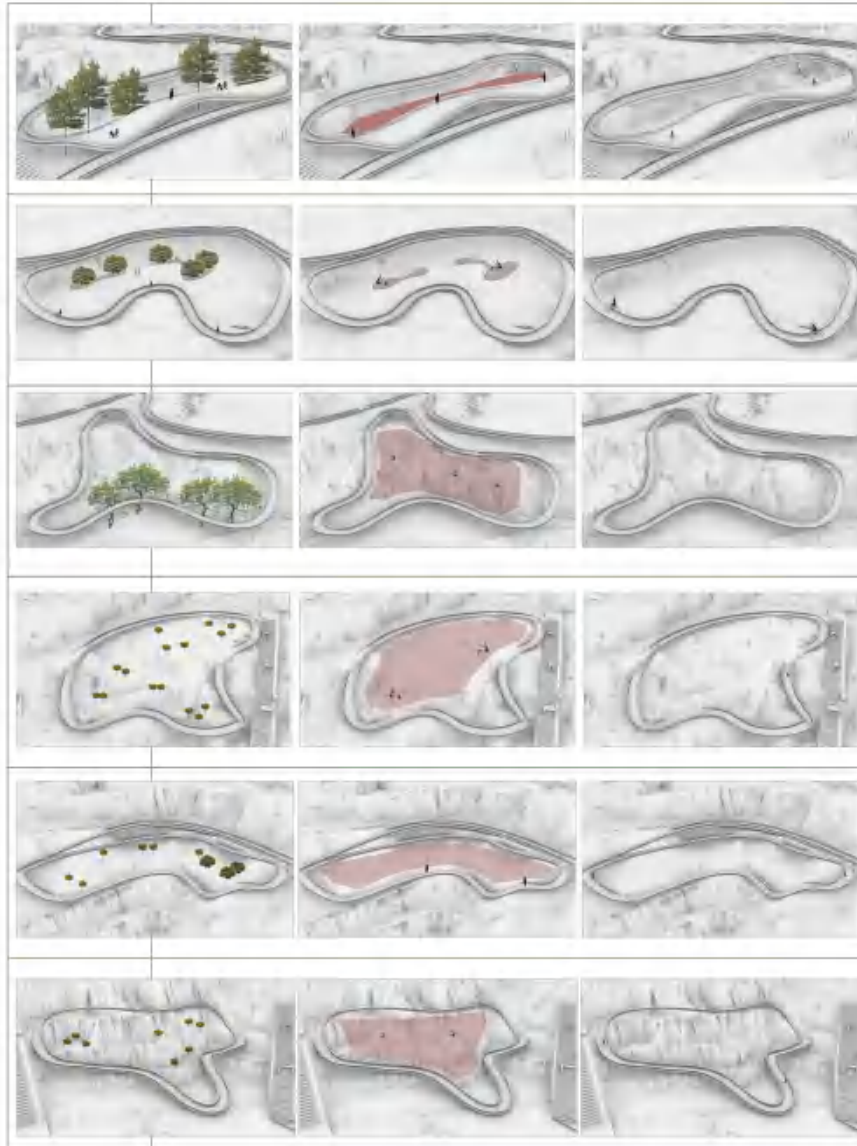


Stair system plan view



A-A Section







### 03 A wastewater treatment and detection center for NY

[Location] Pier 14, NY  
 [Instructor] Dan Wood  
 [Academic] 2022 MS.AAD Summer Studio  
 [Group/Individual] Individual Work  
 [Date] 06/01/2022-08/06/2022  
 [Duration] 11 Weeks

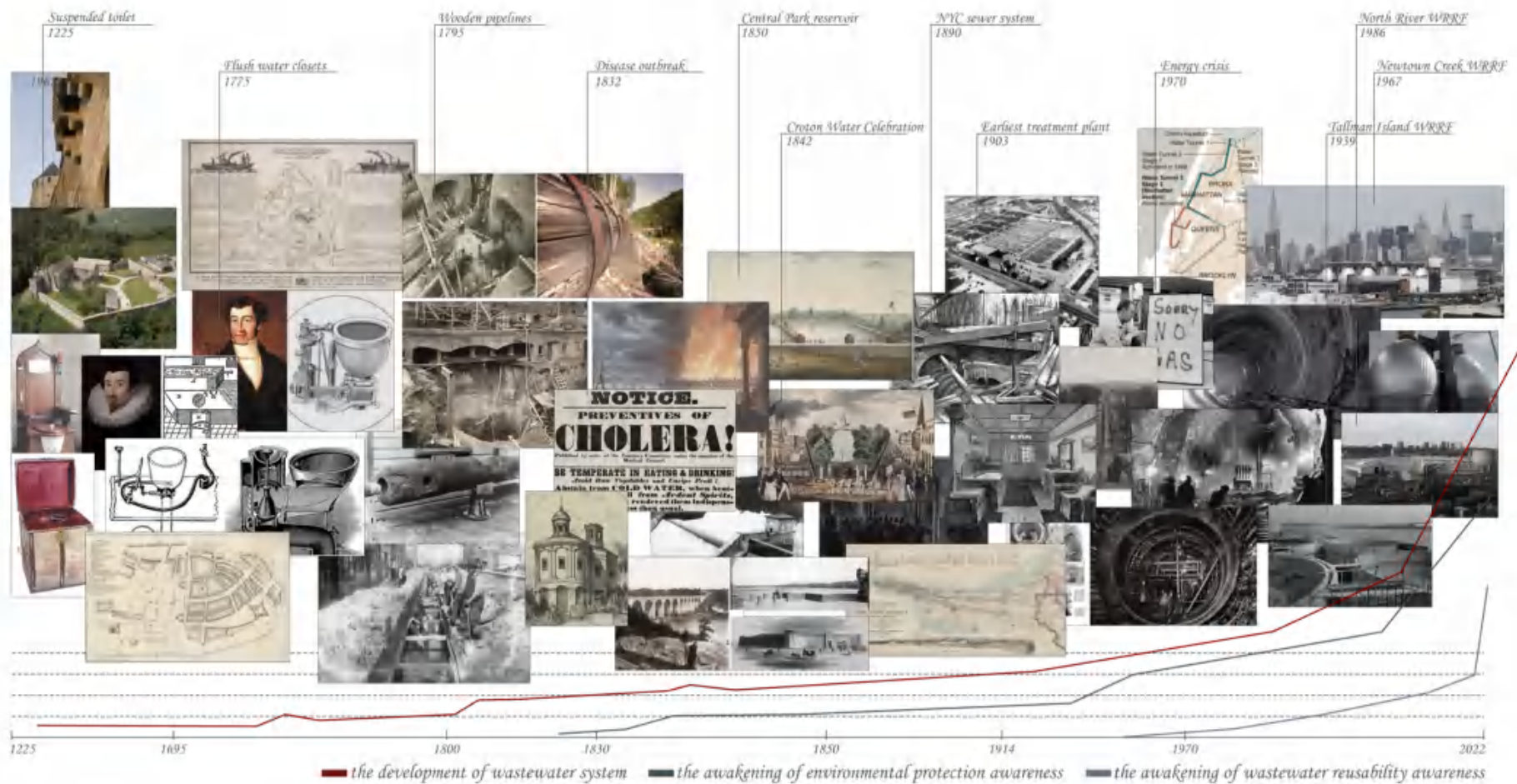
Hello everyone, my design is an wastewater treatment and detection institution, focusing on the invisible information hidden in wastewater. New York has a long history of wastewater treatment. Nowadays, there are 14 wastewater treatment facilities and combined together, 1.3 billion gallons of wastewater will be treated. Undergoing 5 main processes, water treated goes back to rivers and at the same time, the system produces useful bio-solid and biogas.

With the outbreak of covid-19 in 2020, the sewage detection system was brought into public view. So far, NYC has two types of wastewater detection systems, one for covid-19 and the other for illicit drugs. I feel it's really interesting that besides the reusing of wastewater, public sanitation authorities begins to pay attention to the invisible part of wastewater.

Actually, since the history of wastewater detection is short, I believe that the system has the potential to undertake more responsibilities in the future. What if we can tell one's health condition through the detection of their excretion. Or what if we can predict and prevent upcoming virus outbreak? Or what if the information collected through waste-detection help us to distribute resources when confronted extreme catastrophes?

So, I'm thing about a rosy illusion that in the near future in 2050, a series of wastewater treatment and detection institutions will be established near by Hudson River, cooperating the former 14 factories and focusing on neighborhood scale. As one of these institutions, my design will renovate the old pier 32 and serve for 60,000 people in the nearby neighborhoods of Tribeca, Soho and Hudson Square.

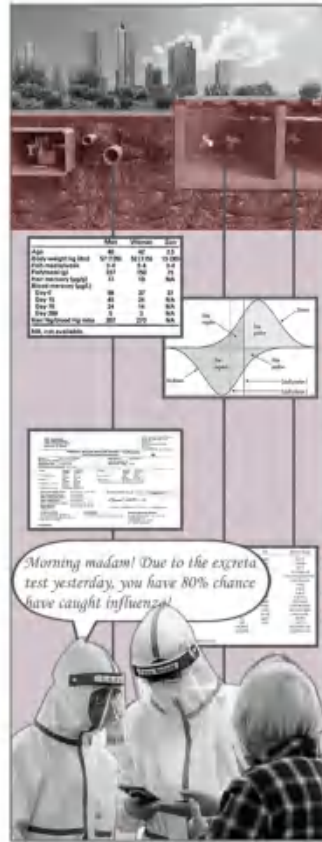
To be more specific, besides testing covid-19, common virus and illicit drugs, the institution will also undertake the responsibilities of neighborhood health condition surveillance, bio-solid research, biogas research and public education.



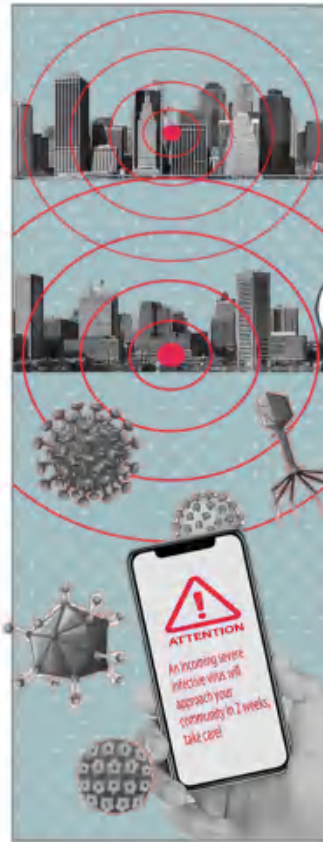




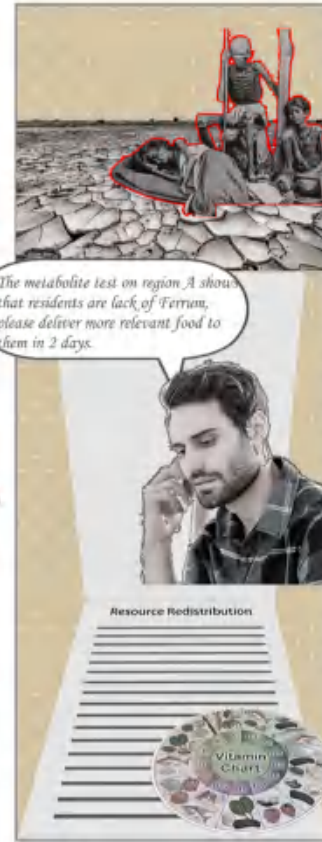
*Drug testing (illicit drugs)*



*Community healthy surveillance*



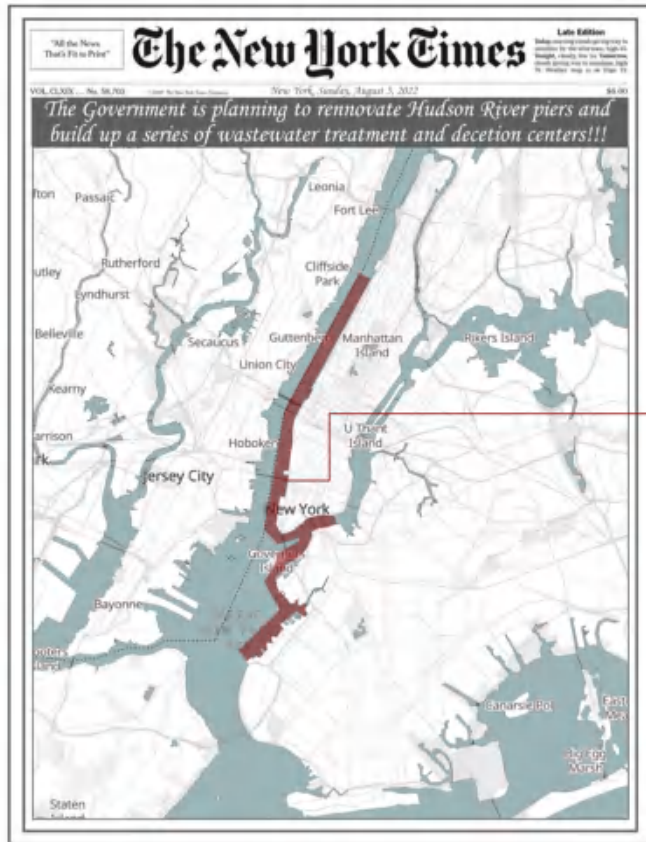
*Emergency disease warning*



*Distribution of supplies*



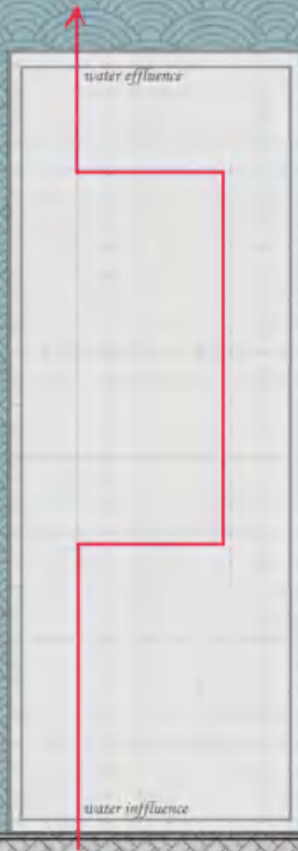
*COVID-19 & Virus testing*



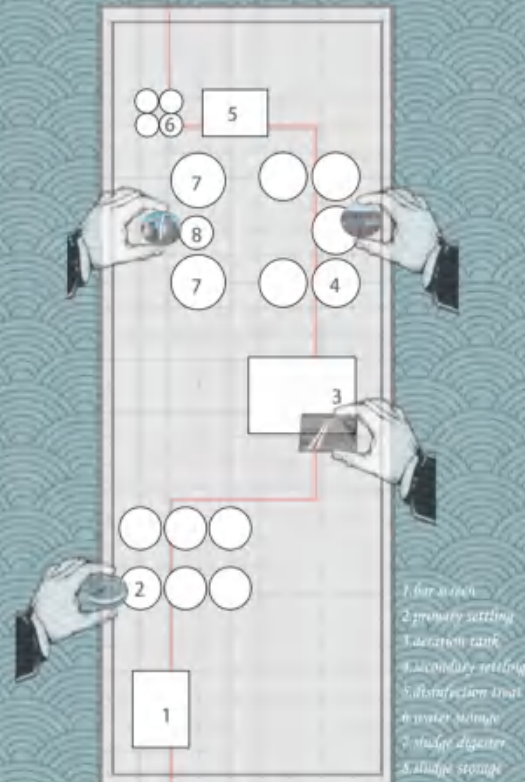
Finally, they are going to renovate these abandoned piers



step1: confirm water flow direction

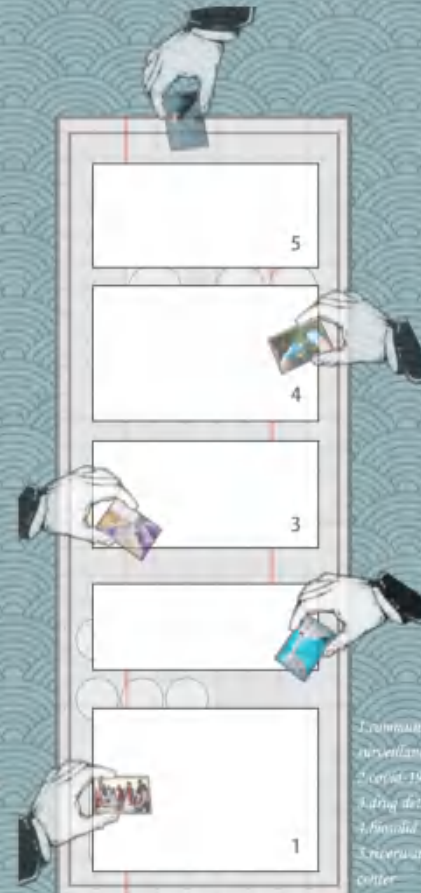


step2: add treatment system



- 1 bar screen
- 2 primary settling
- 3 aeration tank
- 4 secondary settling
- 5 sludge clarifier
- 6 water storage
- 7 sludge digester
- 8 sludge storage

step3: overlap detection system



- 1 community health surveillance center
- 2 covid-19 detection center
- 3 kiosk detection center
- 4 biosolid test center
- 5 recirculation detection center

step4: entangle the box



