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Sky-field: a Vertical Farming Solution for Urban New York

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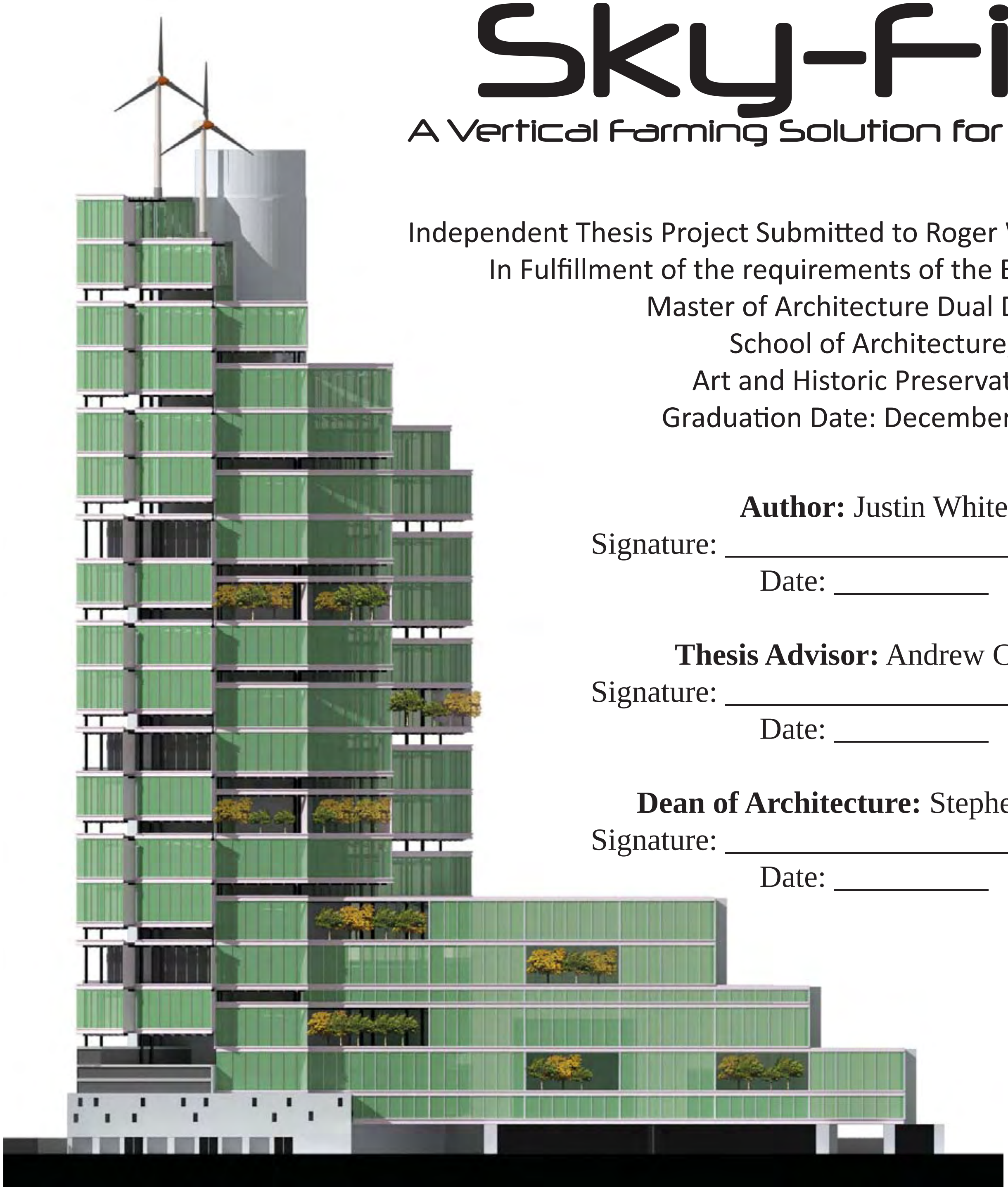

Sky-Field

A Vertical Farming Solution for Urban New York.

Independent Thesis Project Submitted to Roger Williams University SAAHP
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Abstract

Farming has not changed significantly in thousands of years. We still go about blanketing the ground with acres and acres of crops far away from the people who eat it.

"We now have to talk and bring the green movement into our food supply. We will find a place in NY to do this," states Scott Stringer, Manhattan Borough President.[1]

The concept is to design a vertical farm tower which will feed thousands of local residents, allowing them cheaper, organic, disease-free crops. The supply structure of the agricultural industry needs a big change. It is no longer becoming economical due to population increases, crop failures, fuel prices, and dealing with the changing outer environment. Erecting a farm that is close in proximity to the people which it serves is the way to bring a quick and lasting transformation to the industry of food production.

Introduction

Whenever I turn on the television, the first station to check is the rather new channel, Planet Green. If the show "Renovation Nation" is on, I am immediately entranced not moving until the episode is over. I find it exciting to watch as the host travels from house to house to either explore or teach all new green construction practices and technologies. It is amazing to reveal the many inventive techniques and products that are available on the market that people simply just don't know about. These sometimes quick fixes can show the homeowner dramatic savings whether it be through energy consumption or water conservation. Advances in technology are allowing us to make a large stride towards off-the-grid sustainable living, it is just a commitment in educating the public that these practices exist and are proven successful.

My fascination with the environment and how we as humans are having such an impact on earth has led me to this project. People can turn around and stop their negative effects on the planet; it is a matter of changing peoples' habits and usual lifestyles. The only way to do this is to design and build something that accomplishes this goal. A constructed alternative which effectively operates within a different value system can become a true catalyst for change.

Problem Statement

The year is 2050. 80% of the population, which has grown from 6.8 billion to 9 billion, is living in urban centers like New York. Food is not scarce yet certainly not cheap.[2] Gasoline prices have tripled since the year 2000 and have affected every market due to transportation costs. The population increase has sprawled out west over a great amount of what was previously farmland.

Because of this, total cost of food importation from neighboring countries has gone from 40 billion back in 2002 to over 80 billion in 2007, increasing prices in the local grocery store even more.[3] The middle class is struggling to purchase the basic necessities of life.

Certainly this has not yet happened, but it is becoming a possibility if standard practices are resistant to change. By the year 2050 an estimated 2.5 trillion acres of new land, which is roughly 20% more land than the area of Brazil, will be needed to grow enough food to feed the increase in population. As of today, 80% of the land suitable for raising crops is currently in use.[4] 15% of that land is wasted because of poor management of the crops.

It is not just the increase in population and transportation costs that are having an effect on our food. Deforestation keeps on; clearing more land for more farms. Because of this clearing, global warming has increased, giving rise to higher temperatures in certain climate zones. These areas now experience more droughts or in some cases more flooding than usual. Pesticides that are being used are continuously getting stronger because insects develop better resistance. Also, it is estimated that only 5% of all pesticide sprayed actually hits its intended weed and pest targets.[5] The rest is either absorbed into the ground, into the water supply, or into the food which we eat.

Civilization has gone on for thousands of years with all sorts of ideologies from different cultures and societies. These ideas are then changed or evolved through research and through the advancement in technology. With all these discoveries every profession has achieved incredible breakthroughs in every possible way. Farming, on the other hand, hasn't really changed in the overall spectrum. Of course farming has gained better efficiency and mass production but has the ideology of the occupation altered in any manner? Not really. The farm is still planted in a horizontal fashion blanketing the landscape. That is not efficient.

Technology allows us to build higher and higher into the sky. Why has farming not even touched the 3rd dimension?

Outline

Project statement – Tells the design proposal and what it includes.

Understanding Hydroponics – Talks about the fundamentals of hydroponics.

Advantages of Hydroponics – Gives the benefits of using hydroponic technology.

Advantages of Vertical Farming – Tells specifically the pros of farming in a tower structure.

Related Articles – Articles reinforcing this proposal.

Program – Delegates the users as well as programmatic areas and square footages. Gives detail to which species of crops are to be considered for growing in the building.

Problem Themes/Architectural Intentions – Shows the main themes and architectural ideas.

Site Identification – Explains the identified site and rationale.

Environmental Summary Report – Deals with site conditions relative to zoning and code requirements.

Precedent Analysis – Features several similar projects of which are particular interest.

Process Conceptual Design – First phase of development to the project.

Process Schematic Design – Second phase of development to the project.

Process Design Development – Third phase of development to the project.

Final Presentation – Final presentation drawings.

Conclusion – Explains final thoughts.

Bibliography – Shows all sited information.

Project Statement

The idea is to create a tower of farming which will support the needs of thousands of local residents. Instead of using large expanses of horizontal space, that same area can be stacked on top of each other into a sustainable and practical way in any urban environment, resulting in the same farming over a much smaller footprint. The incorporation of the most state of the art technologies as well as new sustainable practices will need to be researched and utilized. Part of the proposal will include the use of hydroponics, which is the growing of plants in nutrient mineral water rather than soil. First, there are an extraordinary number of benefits for using technologies such as hydroponics. Secondly, combining this technology with the notion of a vertical farming structure brings to light even more benefits.

Farming will not be the only aspect of the project. A large marketplace will be incorporated so that the building can sell its products to its intended buyers, the neighboring 20,000 residents of Stuyvesant Town. To reinforce the marketplace with additional attraction, rentable vendor spaces will accompany the market area. Also, public ammenities will be added such as restaurants and retail areas. Lastly, an agricultural school will be included so that students of the future will become more aware of the environmental challenges the human species has placed on the planet.

The building will have an impact on the people near its surroundings. It is a challenge to change peoples' habits of shopping at the grocery store, and instead shopping at a farmer's market to purchase fresh and organic produce, but by supporting local production, it will help to change the current food supply structure.

In total, the vertical farm will respond to the site context as most beneficial as possible to change the lifestyle of people and the industry of agriculture.

Understanding Hydroponics

Hydroponics originating from the Greek words hydro - water and ponos – labor, is a way of growing plants utilizing nutrient solutions rather than soil. Plants can be grown with their roots in either a mineral nutrient solution only or have an additional component such as gravel or mineral wool. In the late 19th century, plant physiology researchers discovered that plants absorb their essential mineral nutrients as inorganic ions in water. Naturally, soil acts as a nutrient reservoir and is not itself in any way essential to plant growth. When these nutrients absorb into the soil, plants are able to extract them. When nutrients are artificially introduced into the plant's water supply, soil is no longer needed for the plant to develop.[6]

Today, hydroponics is an established branch of science. There has been rapid progress and results from many countries proving it very practical over traditional methods of horticulture. These particular examples come from the Emirates Hydroponic Farms in Abu Dhabi.[7]

Advantages of Hydroponics

Possibly the greatest advantage to hydroponics is the increased yield of crops. These large increases due to hydroponics versus that of soil are because of a combination of several factors outlined in the following pages. Shown in the table below are the vast differences in yielding per acre of many different vegetables. Tomatoes benefit the most with a whopping 30 times more production occurring.

Table: Comparative Yields Per Acre in Soil and Soilless Culture[8]

Crop	Soil	Soilless
Soya	600 lb	1,550 lb
Beans	5 tons	21 tons
Peas	1 ton	9 tons
Wheat	600 lb	4,100 lb
Rice	1,000 lb	5,000 lb
Oats	1,000 lb	2,500 lb
Beets	4 tons	12 tons
Potatoes	8 tons	70 tons
Cabbage	13,000 lb	18,000 lb
Lettuce	9,000 lb	21,000 lb
Tomatoes	5-10 tons	60-300 tons
Cucumbers	7,000 lb	28,000 lb

Table: Advantages of Soilless Culture versus Soil Culture[9]

	Cultural Practice	Soil	Soilless
1	Sterilization of growing medium	Steam, chemical fumigants; labor-intensive; time required is lengthy, minimum of 2-3 weeks	Steam, chemical fumigants with some systems; others can use simply bleach or HCl; short time needed to sterilize.
2	Plant nutrition	Highly variable, localized deficiencies, often unavailable to plants due to poor soil structure of pH, unstable conditions, difficult to sample, test and adjust.	Completely controlled, relatively stable, homogeneous to all plants, readily available in sufficient quantities, good control of pH, easily tested, sampled and adjusted.
3	Plant spacing	Limited by soil nutrition and available light.	Limited only by available light; therefore closer spacing is possible; increased number of plants per unit area, therefore more efficient use of space which results in greater yields per unit area.
4	Weed control, cultivation	Weeds present, cultivate regularly.	No weeds, no cultivation.

5	diseases and soil inhabitants	Many soil-borne diseases, nematodes, insects and animals which can attack crop, often use crop rotation to overcome buildup of infestation.	No diseases, insects, animals in medium; no need for crop rotation.
6	Water	Plants often subjected to water stress due to poor soil-water relations, soil structure and low water-holding capacity. Saline waters cannot be used. Inefficient use of water; much is lost as deep percolation past the plant root zone and also by evaporation from the soil surface.	No water stress. Complete automation by use of moisture-sensing devices and a feed-back control mechanism; reduces labor costs, can use relatively high saline waters, efficient water use, no loss of water to percolation beyond root zone or surface evaporation; if managed properly, water loss should equal transpirational loss.
7	Fruit quality	Often fruit is soft or puffy due to potassium and calcium deficiencies. This results in poor shelf life.	Fruit is firm with long shelf life. This enables growers to pick vine-ripened fruit and still be able to ship it relatively long distances. Also little, if any, spillage occurs at the supermarket. Some tests have shown higher Vitamin A content in hydroponically grown tomatoes than those grown in soil.

8	Fertilizers	Broadcast large quantities over the soil, non-uniform distribution to plants, large amount leached past plant root zone (50-80%), inefficient use.	Use small quantities, uniformly distributed to all plants, no leaching beyond root zone, efficient use.
9	Sanitation	Organic wastes used as fertilizers on to edible portions of plants cause many human diseases.	No biological agents added to nutrients; no human disease organisms present on plants.
10	Transplanting	Need to prepare soil, uproot plants which leads to transplanting shock. Difficult to control soil temperatures, disease organisms which may retard or kill transplants.	No preparation of medium required prior to transplanting; transplanting shock minimized, faster "take" and subsequent growth. Medium temperature can be maintained optimum by flooding with the nutrient solution. No diseases present.
11	Plant maturity		With adequate light condition, plant can mature faster under a soilless system than under soil.

12	Permanence of medium	Soil in a greenhouse must be changed regularly every several years since fertility and structure break down. Under field conditions, must fallow.	No need to change medium in gravel, sand or water cultures; no need to fallow. Sawdust, peat, vermiculite may last for several years between changes.
13	Yields	Greenhouse tomatoes 15-20 lb/year/plant.	25-35 lb/year/plant.

Overall, the main advantages of hydroponics over soil culture are more efficient nutrition regulation, availability of crops in regions of the world having non-arable land, more efficient use of water and fertilizers (if preferred), no weed control or cultivation, no diseases or insects from the use of a soil medium, and higher-density planting, leading to increased yields per acre.[10]

Advantages of Vertical Farming

It should be understood that hydroponics is the wave of the future with all of the overwhelming positive advantages. Now it is time to look at specifically the pros of taking that hydroponic technology and putting it into a vertical tower structure.

1. In an enclosed building, optimum temperatures can be controlled and maintained allowing for healthier, faster growing plants and additionally, a year round production schedule.
2. Every 1 acre indoors is equal to an average 4-6 outdoor acres depending upon the species. This is due to the fact that many layers of plants can be stacked on top of each other as well as other considerations of crop failures caused by the outside environment.
3. There are no crop failures due to the environment whether it be droughts, floods, pests, etc.
4. Every crop grown is able to receive its special defined diet concerning nutrient balance. No fertilizers, pesticides, or herbicides would be needed. All crops would be healthy and organic.

5. Vertical farming eliminates runoff of these chemicals into the environment and water supplies.
6. Massive amounts of forests needing to be cleared for farmland would no longer be necessary. The landscape can finally be returned back to nature and ecosystems restored.
7. There would be an elimination of infectious diseases that are started at the agricultural level due

to the usage of feces as fertilizer.[11]

8. The usage of fossil fuels would be greatly reduced, therefore global warming. Currently, 1/5th of all fossil fuel is used for agriculture. This fuel is used for plowing fields, harvesting, storing and refrigerating the goods, shipping either by boat or by tractor trailer, or in some cases shipping to other processing plants. An unbelievable 1500 miles is the average distance that any given piece of produce travels until it finally reaches the grocery store.[12]

9. The importation of foods to the United States would be lessened. Every year U.S. imports of food increases, shelling out money outside of our country.

10. Urban centers can now be considered sustainable environments.

11. Without first testing an indoor farm on earth, we will not be able to live on the moon, Mars, or beyond. "At present a lot of research is being carried out to develop hydroponic systems for the growing of vegetables on the space station to be constructed in the future. Closed-loop re-circulating systems are being designed and tested to operate under micro-gravity environments. Hydroponic systems will grow food to nourish astronauts on long space missions."[13] The best way to test these systems would be to have them realized in industry use.

Related Articles

Food Travel

How Far Does Your Food Travel to get to Your Plate?

On the Hawaiian island of Maui sits a sugar museum. In this museum tells the history of sugar production. Right next door is a large processing plant surrounded by many acres of sugar growing. Once the sugar is grown, the plant next door processes the sugar, but only to the "raw sugar" stage. It is then shipped to California where it is refined into white sugar. This isn't the end of the journey. Next, the sugar is shipped across country to New York where it is then packaged into individual paper packages to go onto tabletops. From there it is redistributed all over the country, even back to Hawaii.

If one is to drive from the sugarcane field the café, the sugar packet on the table has traveled 10,000 miles. This is not the only product that does this. It's not out of the ordinary by any means. In fact, this is the standard for our current food system. Shipping food long distances for processing and packaging, or importing and exporting foods that don't need to be are standard practices nowadays. "It is not only tropical foodstuffs such as sugar, coffee, chocolate, tea, and bananas that are shipped long distances to come to our tables, but also fruits and vegetables that once grew locally, in household gardens and on small farms."[14]

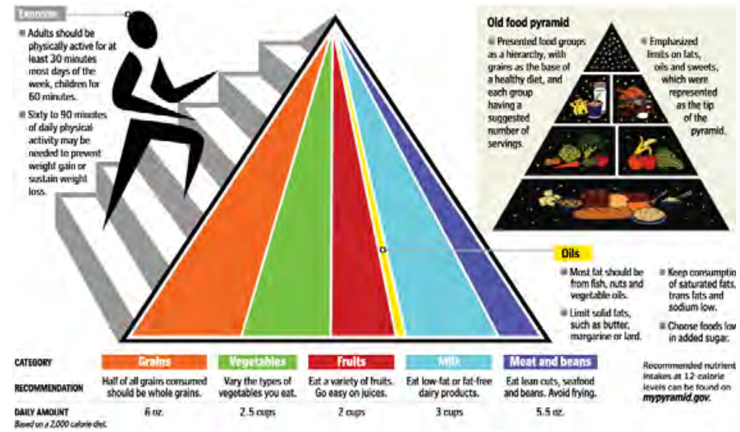
It is estimated that the average meal travels 1500 miles to get from a farm to your plate. Why is this a big deal? Again, large-scale transportation is consuming huge portions of fossil fuels. " We put about 10 kcal of fossil fuel energy into our food system for every 1kcal of energy we get as food."[14] This transportation exerts huge amounts of CO2 pollution into the air. Also, in order to transport food such long distances, much of the food is picked unripe and then gassed to a ripened stage afterwards, or highly processed in factories using preservatives, irradiation, or other means. Scientists are even experimenting with genetic alteration to produce longer-lasting produce.

A major study put out by the Leopold Center for Sustainable Agriculture in Iowa compiled data for the U.S. Department of Agriculture to find out how far crops traveled to a Chicago "terminal market." This is where wholesalers purchase these goods to sell to grocery stores. These statistics were then compared to figures of Ferry Plaza Farmers Market in California. Here are the results showing the average distance each type of produce travels to arrive at the market:[14]

- average distances from farm to market -

	Terminal Market	Ferry Plaza Farmers Market
Apples	1,555 miles	105 miles
Tomatoes	1,369 miles	117 miles
Grapes	2,143 miles	151 miles
Beans	766 miles	101 miles
Peaches	1,674 miles	184 miles
Winter Squash	781 miles	98 miles
Greens	889 miles	99 miles

Program



The tower will include a variety of different users:

1. Farmers will be present to harvest, maintain, and process the crops. They will also be present on the first floor marketplace selling produce.
2. Researchers will have dedicated lab space to study better ways of growing and make sure that operations are running smoothly.
3. Students will be in the building attending the agricultural school program. Education of the younger crowd will ensure that vertical farming becomes a long and lasting trend in the future.
4. The general public will be in part of the building to purchase food and to go to the restaurants.

Due to the many users, specific zones will need to be established and programmatically designed correctly to keep the building efficient and effective.

The largest part of the program will include the main farming area providing enough food for 20,000 people, or all of Stuyvesant Town. Based on a 2,000 calorie diet, the 20,000 people will need approximately 2,250,000 sq feet of growing area.[15] The crops being grown to allow for a healthy diet will be lettuce, strawberries, cucumbers, peppers, carrots, tomatoes, and soybeans. Processing will take place in each section to either prepare the goods for sale or shipment.

VEGETABLES & FRUIT	2,250,000 sf.
PROCESSING	12,000 sf.

Protein is an essential part of the diet as well. To satisfy this need, chickens will be raised for not only themselves but for their eggs. Also, Tilapia will be grown as they are the favored fish to harvest because of their rapid growth and ease of maintenance.

CHICKENS SLAUGHTER	97,000 sf.
PROCESSING	7,000 sf.
CHICKEN LAYERS	45,000 sf.
PROCESSING	6,000 sf.
TILAPIA	24,000 sf.
PROCESSING	4,000 sf.

The marketplace will sell all of the goods which the farm produces. It will be an alternative to using a grocery store.

MARKETPLACE	14,000 sf.
LOBBY	120 sf.

Accompanying the marketplace will be rentable vendor stations. These will add attraction to coming to the market. Vendors from the traveling Greenmarket could rent these out several days during the week to sell their goods.

VENDOR SPACES	4,000 sf.

A couple restaurants will be included in the building so that the food being farmed can be enjoyed right on site. The delicious grown food will persuade the public to purchase goods down in the marketplace.

RESTAURANTS	8,000 sf.

A school will be part of the program so that children can learn of the future farming techniques. They can learn in the classroom, take tours of the building, and carry out lap operations.

SCHOOL	24,000 sf.

Offices will be used by the people who are keeping the building running smoothly. They may be either researchers, teachers, or business administration dealing with the marketplace. A meeting room will help as additional support for when collaboration is needed.

OFFICES	800 sf.
MEETING	100 sf.

The control room will be placed on every floor to make sure that operations are running correctly. A large amount of mechanical space will be needed for all hydroponic and grey water systems, as well as normal building mechanics. Storage space will be required to store food which has either not been brought out into the marketplace yet, or is being held for upcoming shipment.

CONTROL	3,000 sf.
MECHANICAL (HYDRO, GREY WATER, ETC.)	20,000 sf.
STORAGE	6,000 sf.

NET:	2,525,020 sf.

Program Summary

Farming:	
Vegetables & Fruit	2,250,000
Processing	12,000
Chickens Slaughter	97,000
Processing	7,000
Chicken Layers	45,000
Processing	6,000
Tilapia	24,000
Processing	4,000
Public:	
Lobby	120
Marketplace	14,000
Vendor Spaces	4,000
Restaurants	8,000
School	24,000

Administration:	
Offices	800
Meeting	100
Services:	
Control	3,000
Mechanical	20,000
(Hydro, Grey Water, etc.)	
Storage	6,000

NET: 2,525,020 sf.

Problem Themes / Architectural Intentions

Creating an efficient space is certainly one of my top desires. In any type of industry, business plays a key role. It is all about cutting internal costs and increasing price to return the highest possible revenue. In agriculture this is certainly the case. A cash crop is one that is able to give an abundance of product with a high yield. My job is to take an existing technology and incorporate it into an efficient and architecturally desirable building. It must be aesthetically pleasing, as well as functionally sound.

The building will incorporate a modern and sustainable vision, one that surpasses all that has been built before it. Pulling energy from the wind and from the sun, it will transform those elements into energy for the processes of the building. It must find those green practices that are true and successful and add to them.

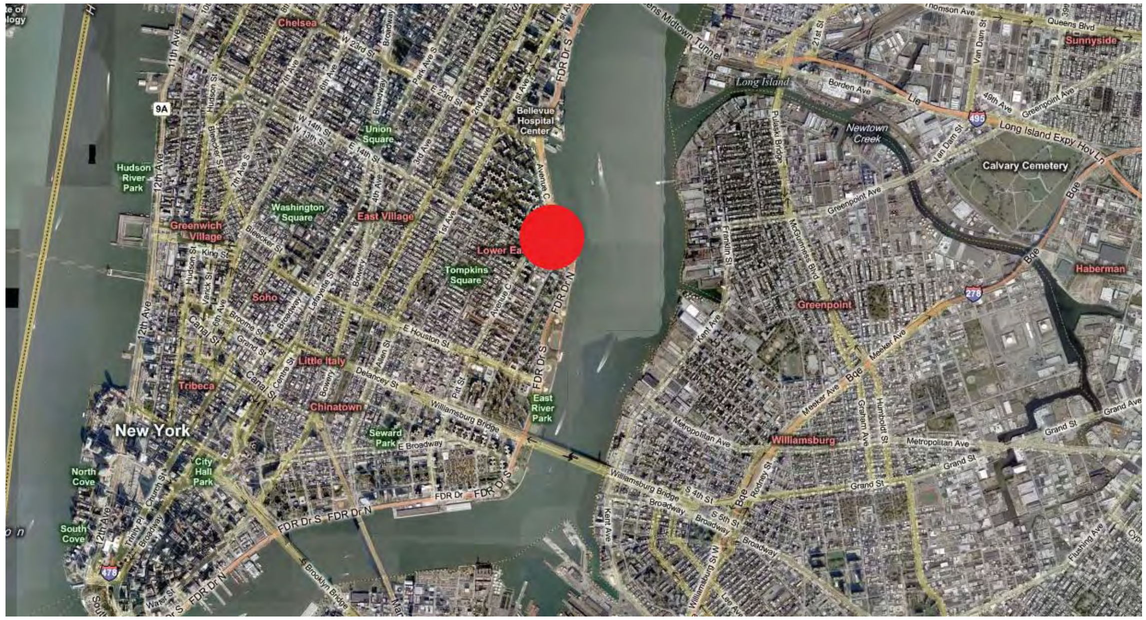
The tower will convey to the public that a change in lifestyle is warranted. It will show that the benefits of this vertical farm far outweigh the conventional grocery store in every aspect.

Site Identification

The site chosen for this project is on the island of Manhattan, New York. New York City is hailed by many as the best place in the United States, is the financial capital of the world, and is a symbol of America in numerous ways. It is the most dense and populated city in the country as well. If the idea of vertical farming can be done in New York, it can and will be constructed in other cities around the country. It would be a new icon which would be marveled over and bring more fame to the city. Scott Stringer, Manhattan Borough President states, "We now have to talk and bring the green movement into our food supply. We will find a place in NY to do this."[16]

The site should be in an urban center so that the marketplace could function as an effective and close alternative to the grocery store. Also, the farm should be situated next to a large housing community that would take advantage of all the building has to offer. Lastly, the location required easy access to a highway system in case produce needed to be shipped throughout the area.

The chosen site is in the Lower East Side at the corner of Avenue C and East 15th Street. The



other half of the site borders the FDR Highway right next to the East River.

The site is occupied by a sea of parking, a small park space, and a commercial building. To the south is a large power plant which is perfect for water and energy conservation. "More hydroponic greenhouse operations will be linked with industries having waste heat. Such cogeneration projects already exist in California, Colorado, Nevada and Pennsylvania. Electrical power generating stations use water in their cooling towers. This heated water can be used both for heating the greenhouse and providing distilled water free of minerals for the growing of plants in re-circulating systems. This clean water is of particular advantage to growers in areas having normally hard raw water."[17]

Aerial view of entire site.

Site situated next to the Stuyvesant Town housing project.

Dimensions of the site.

Blue - Housing, Pink - Mixed use between housing and commercial, Yellow - Industrial, and Orange is a highway.

Aerial looking south. Notice the large power plant adjacent to the site.

Aerial looking west.

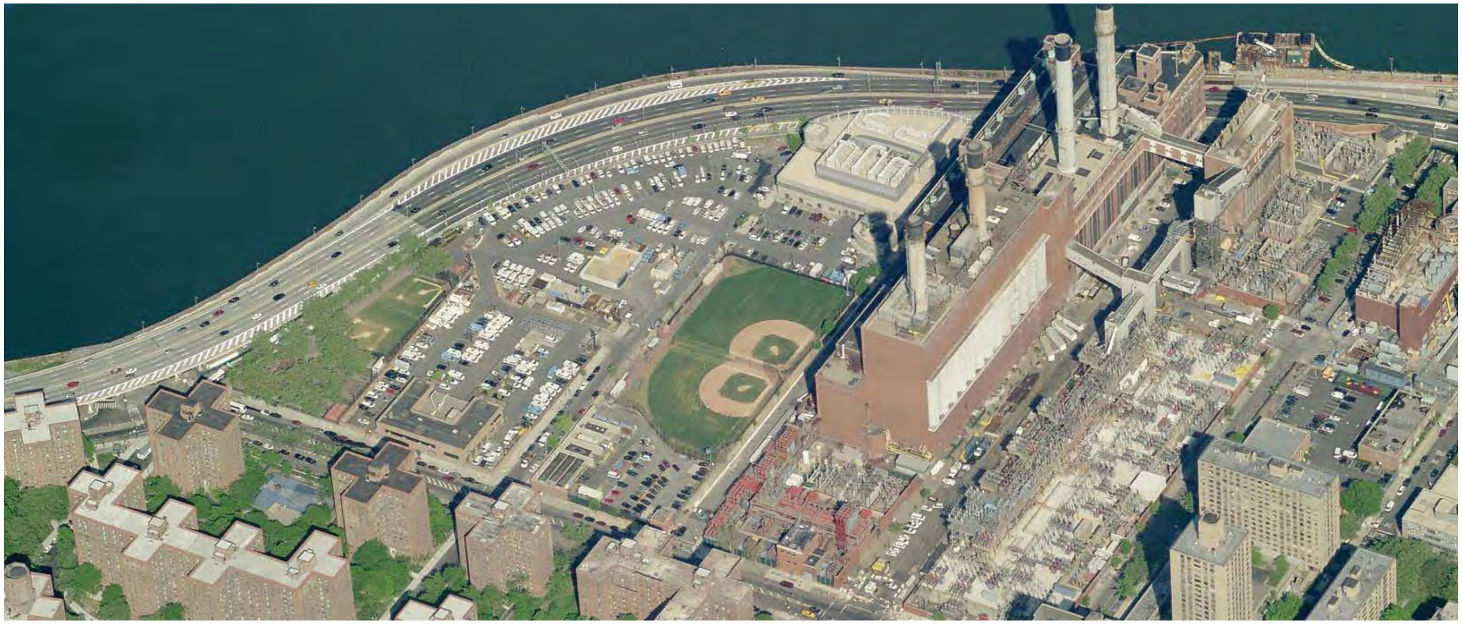


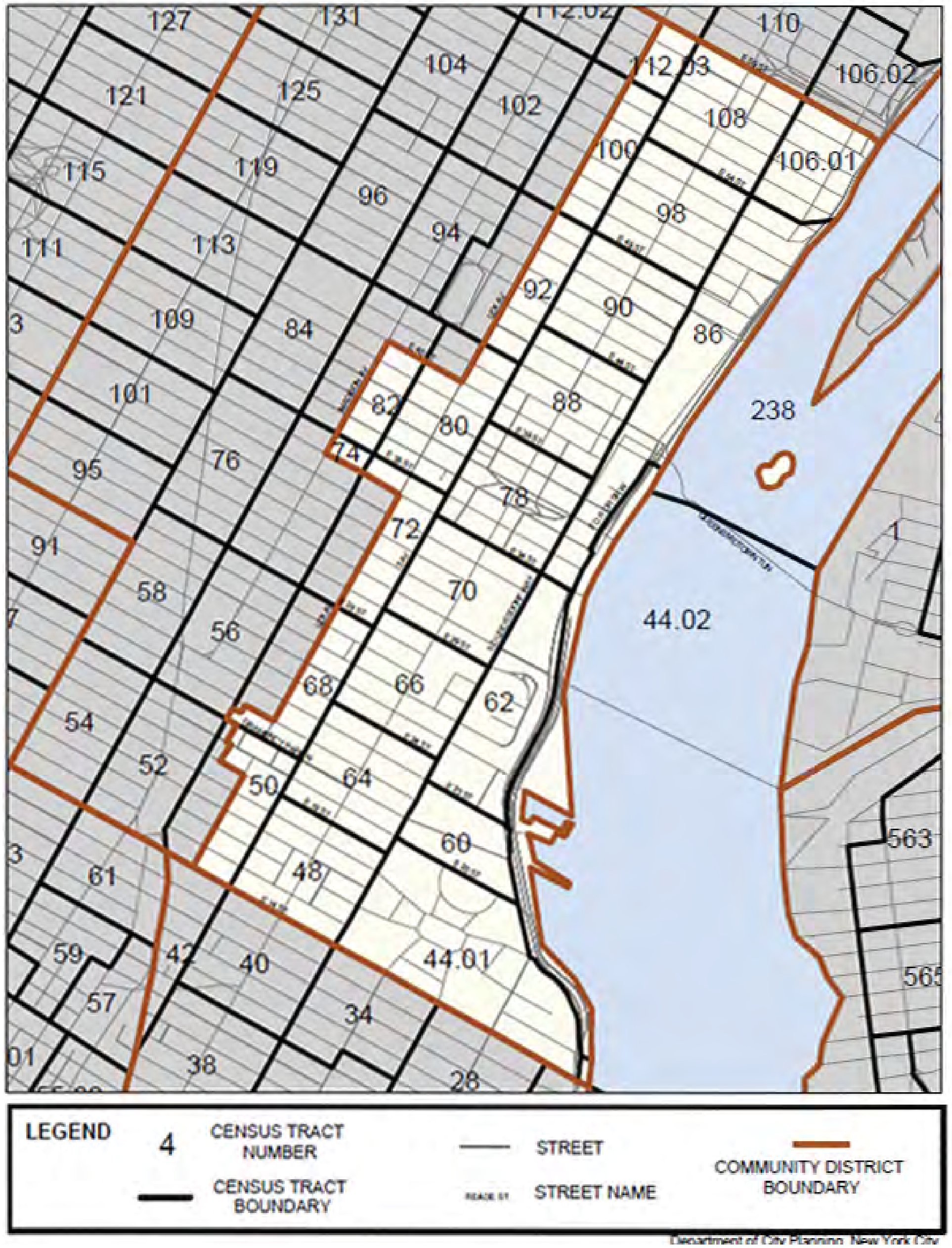
Table: Suitable Site Characteristics[18]

When considering a site location, a grower should try to meet as many of the following requirements as possible to reduce any risks of failure:

1	Full east, south and west exposure to sunlight with windbreak on north.
2	Level area or one that can be easily leveled.
3	Good internal drainage with minimum percolation rate of 1 inch/hour.
4	Have natural gas, three-phase electricity, telephone and good quality water capable of supplying at least one-half gallon of water per plant per day.
5	On a good road close to a population center for wholesale market and retail market at greenhouses if you choose to sell retail.
6	Close to residence for ease of checking the greenhouse during extremes of weather.
7	North-south oriented greenhouses with rows also north-south.
8	A region which has a maximum amount of sunlight.
9	Avoid areas having excessively strong winds.

Here is an excerpt taken out of a hydroponic book stating the ideal characteristics of the site for growing. All these conditions are met 100%. The building has open space, enough to be situated in any direction to maximize sun orientation. Wind will be used to ventilate the building. Sustainable technologies will be incorporated into this building including wind power. Other technologies can include water exchange from the power plant and solar collection.

CENSUS 2000: MANHATTAN COMMUNITY DISTRICT 6 [19]



This census report shows the following population demographic around the area. The red highlighted areas add up to a total of around 20,000 people. This is the population that the building is proposed to support concerning food needs for the entire year. It doesn't look like a great deal, but this is a high density area primarily comprised of high-rise housing.

Change in Total Population, 1990 to 2000
Manhattan Community District 6[19]

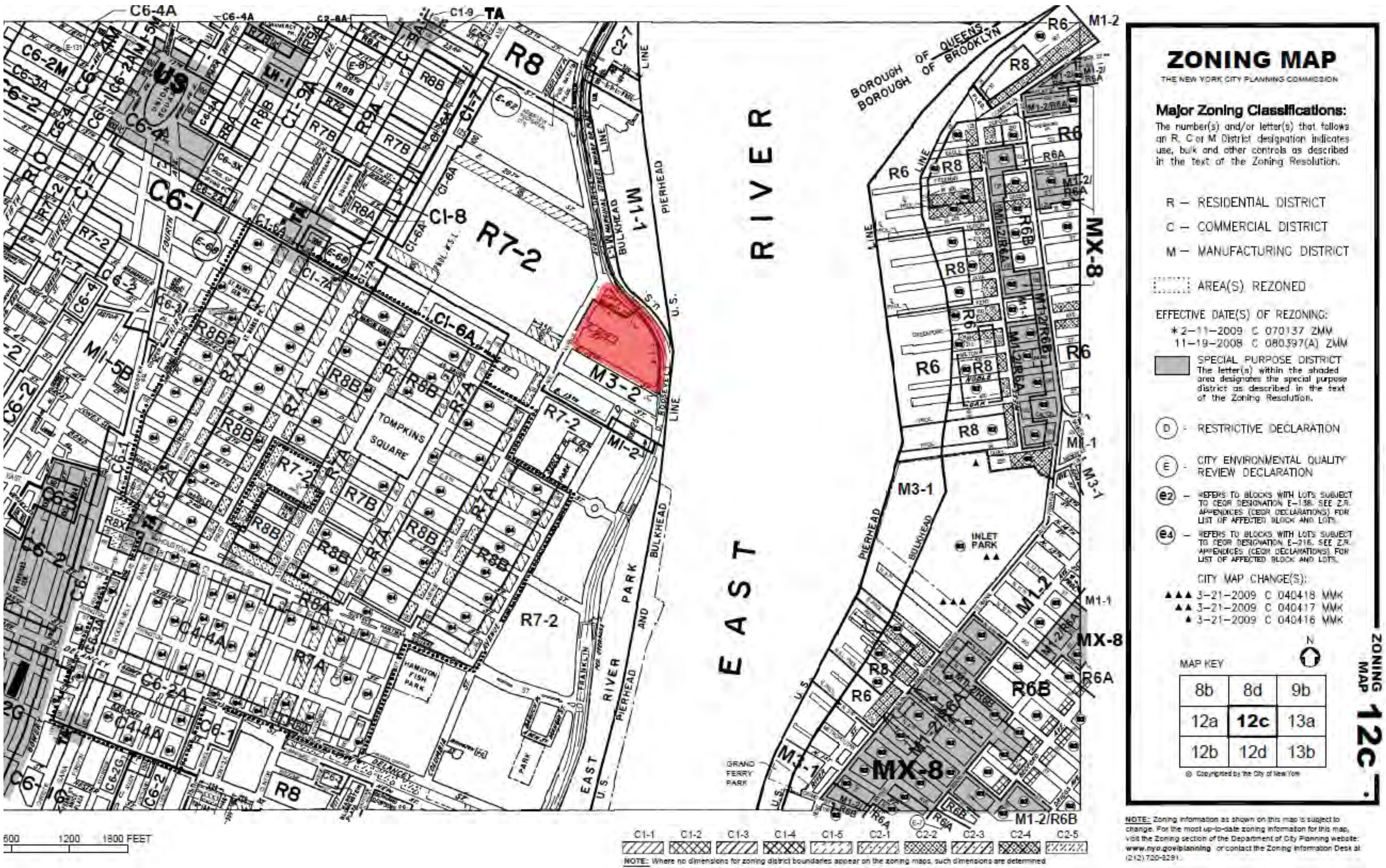
Census Tract	Total Population		Population Change, 1990-2000	
	1990	2000	Number	Percent
0024 *	5,596	5,080	(516)	(9.2)
004401	15,233	15,112	(121)	(0.8)
004402	2,902	2,976	74	2.5
0048	6,934	6,402	(532)	(7.7)
0050 *	5,455	5,695	240	4.4
0060	4,195	3,989	(206)	(4.9)
0062	2,874	2,103	(771)	(26.8)
0064	7,743	7,334	(409)	(5.3)
0066	11,838	11,841	3	0.0
0068 *	6,203	6,753	550	8.9
0070	7,195	7,763	568	7.9
0072 *	7,435	8,111	676	9.1
0074 *	3,367	3,712	345	10.2
0078	5,991	7,471	1,480	24.7
0080 *	5,289	5,392	103	1.9
0082 *	2,565	2,764	199	7.8
0086	7,521	7,267	(254)	(3.4)
0088	6,929	7,345	416	6.0
0090	7,428	7,599	171	2.3
0092 *	1,463	1,334	(129)	(8.8)
0098	6,979	7,066	87	1.2
0100 *	1,663	1,822	159	9.6
010601	7,869	7,968	99	1.3
0108	7,686	8,079	393	5.1
011203 *	1,186	1,255	69	5.8
0238 *	8,190	9,520	1,330	16.2

Table & Map: Greenmarket 2009[20]

Shown here is the farmer's market locations and schedule for every day of the week. Not too far in proximity from the proposed site is Union Square which is the largest market of all of Manhattan. Also, Stuyvesant Town and Tompkins Square are even closer which feature the market on a couple of days. Stuyvesant is actually the farthest east market available. After the farming tower is complete, residents on the eastern coast will now have a much closer market to go to.

MANHATTAN				S	M	T	W	T	F	S
1. Staten Island Ferry / Whitehall	Inside Terminal Building	Year Round	8 - 7			T			F	
2. Bowling Green	Broadway & Battery Place	Year Round	8 - 5			T		T		
3. Zuccotti Park	Cedar St - Broadway & Church	April - Dec	8 - 6			T		T		
4. City Hall Park	Broadway & Chambers	Jun - Dec	8 - 5			T			F	
5. Tribeca	Greenwich St & Chambers	Apr - Dec Year Round	8 - 3 8 - 3				W			 S
6. EBT LES/Grand Street	Norfolk & Grand Sts	July - Nov	8 - 4	S						
7. Tompkins Square	E 7 St & Ave A	Year Round	8 - 6	S						
8. St. Mark's Church	E 10 St & 2 Ave	May 26 - Dec	8 - 7			T				
9. Stuyvesant Town	Stuyvesant Town Oval 14th St loop & Ave A	Jun - Nov	9:30 - 4	S						
10. Abingdon Square	W 12 St & 8th Ave	Year Round	8 - 2							S
11. Union Square	E 17 St & Broadway	Year Round	8 - 6		M		W		F	S
12. Murray Hill	2 Ave & E 33 St	June 27 - Nov	8 - 3							S
13. Dag Hammarskjold Plaza	E 47 St & 2 Ave	Year Round	8 - 4				W			

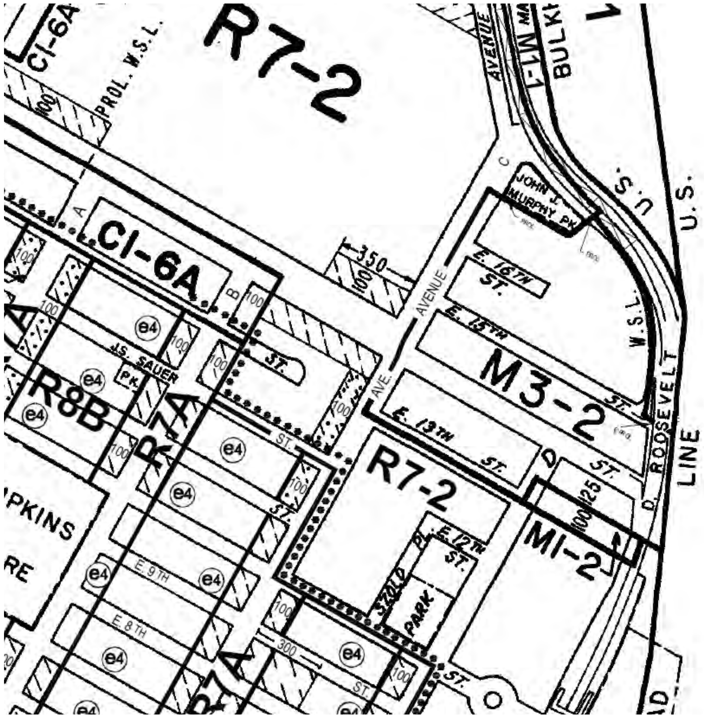
Environmental Summary Report



Looking in the New York Zoning Resolution, the proposed site is listed as:

M3-2 Heavy Manufacturing District (Low Performance)

Images[21]



ZONING RESOLUTION Web Version

THE CITY OF NEW YORK

THE CITY OF NEW YORK
Michael R. Bloomberg, Mayor

CITY PLANNING COMMISSION
Amanda M. Burden, Director

Articles I - XII

School District Boundary & Number	■ Elementary Schools	● Middle Schools	◆ High Schools
1 School Key	▲ K-12 Schools & JHS/HS	★ Colleges/Universities	▼ Other Schools

Data Source: NYS Education Department, October 2006

Fall '09 Thesis

Env. Summary Report

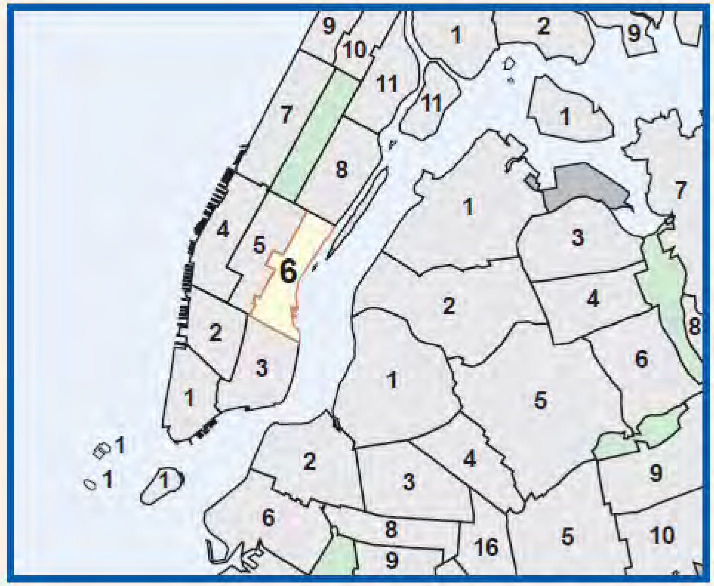
SKY-FIELD

Justin White

MANHATTAN COMMUNITY DISTRICT 6

TOTAL POPULATION	1980	1990	2000
Number	127,556	133,748	136,152
% Change	—	4.9	1.8

VITAL STATISTICS	2000	2005
Births: Number	1,259	1,220
Rate per 1000	9.2	9.0
Deaths: Number	929	834
Rate per 1000	6.8	6.1
Infant Mortality: Number	2	5
Rate per 1000	1.6	4.1



INCOME SUPPORT	2000	2007
Public Assistance (AFDC, Home Relief)	1,058	911
Supplemental Security Income	1,777	1,605
Medicaid Only	1,559	4,574
Total Persons Assisted	**4,394**	**7,090**
Percent of Population	**3.2**	**5.2**

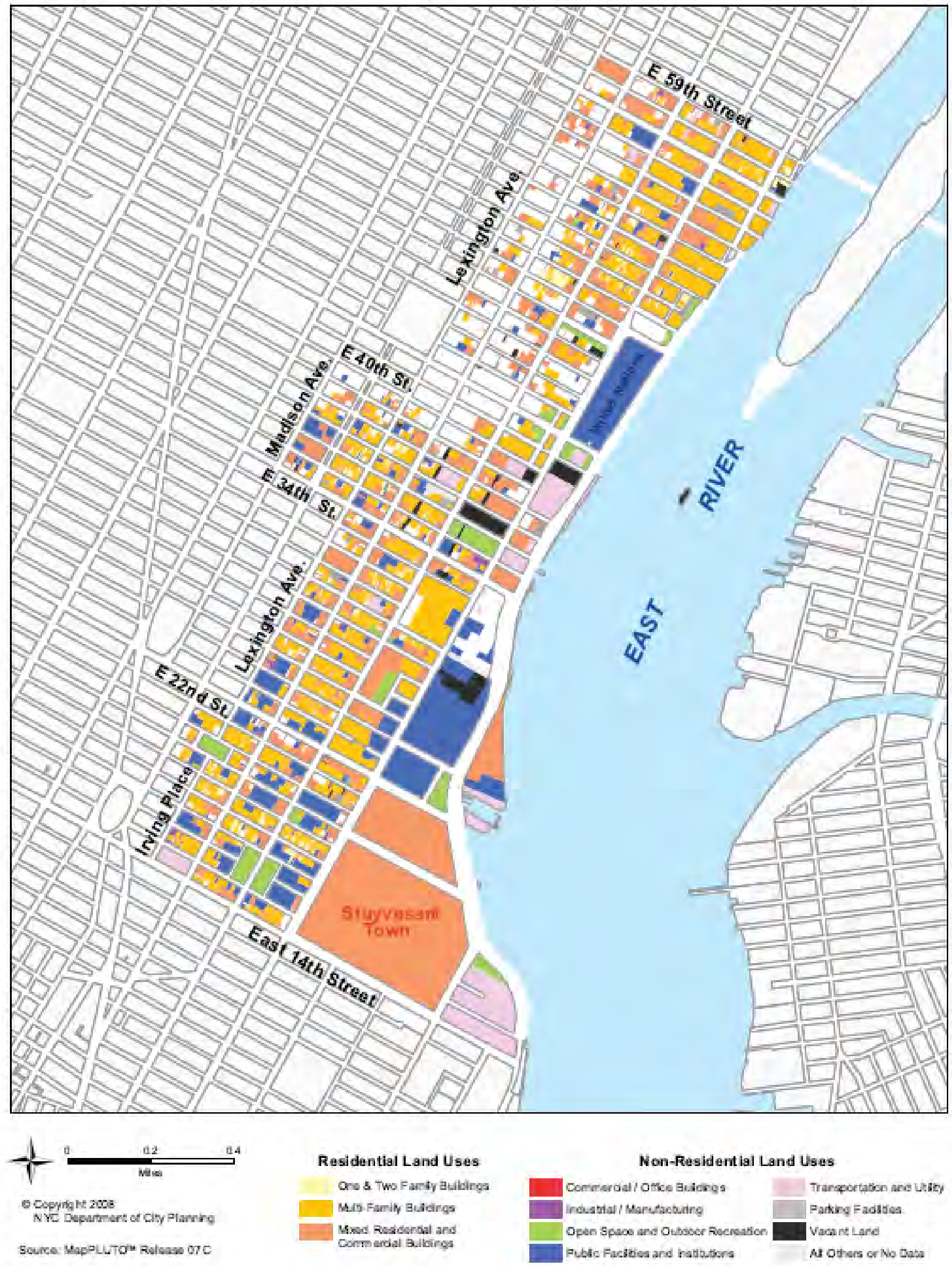
TOTAL LAND AREA	
Acres:	**888.4**
Square Miles:	**1.4**

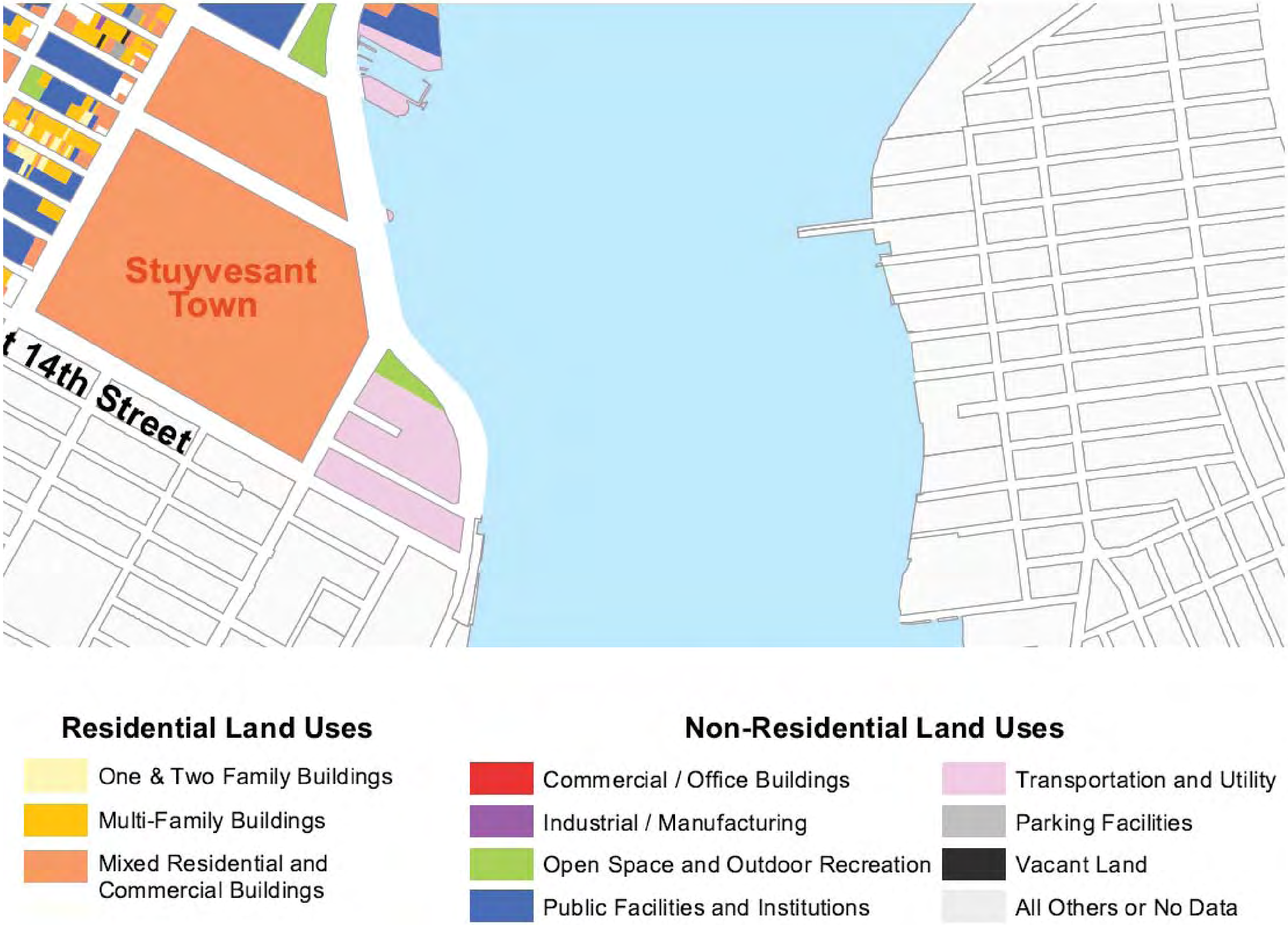
LAND USE, 2006

		Lot Area	
	Lots	**Sq. Ft.(000)**	**%**
1- 2 Family Residential	234	392.0	1.5
Multi-Family Residential	1,060	6,257.9	24.5
Mixed Resid. / Commercial	778	7,640.4	29.9
Commercial / Office	429	3,747.8	14.7
Industrial	31	118.7	0.5
Transportation / Utility	43	1,710.1	6.7
Institutions	211	4,078.5	16.0
Open Space / Recreation	29	872.6	3.4
Parking Facilities	32	226.9	0.9
Vacant Land	62	437.9	1.7
Miscellaneous	18	61.5	0.2
Total	**2,927**	**25,544.1**	**100.0**

Images[21]

Manhattan Community District 6




Stuyvesant Town
14th Street
Residential Land Uses
One & Two Family Buildings
Multi-Family Buildings
Mixed Residential and Commercial Buildings
Non-Residential Land Uses
Commercial / Office Buildings
Industrial / Manufacturing
Open Space and Outdoor Recreation
Public Facilities and Institutions
Transportation and Utility
Parking Facilities
Vacant Land
All Others or No Data

Images[21]

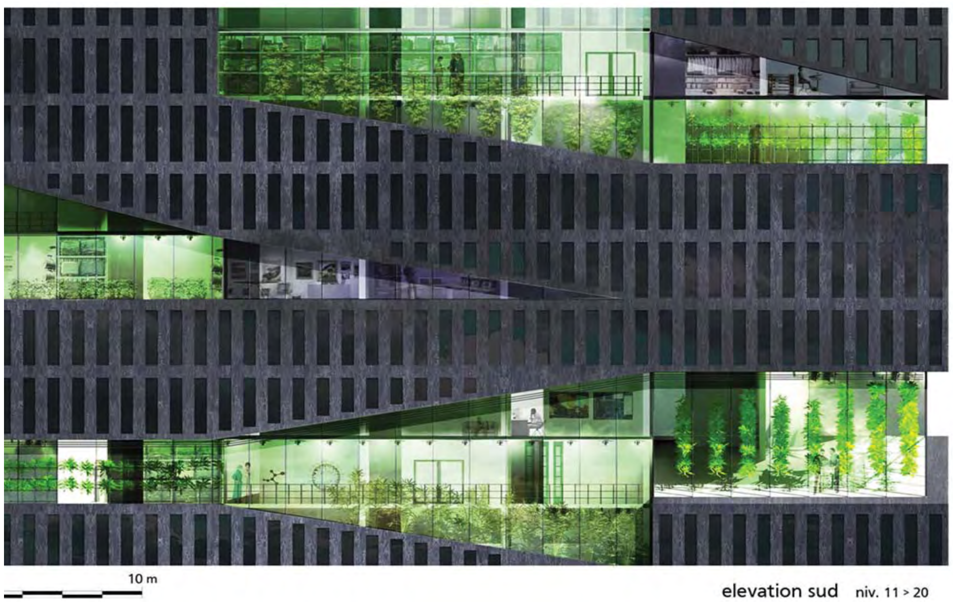
Precedents

General Note: This section is composed of precedents which are all considered concepts. Since the idea of vertical farming is still in the development and research stage, nothing has yet to be physically constructed. Many architects have brought to light their thoughts on the matter and come up with some type of model, which will be portrayed here.

"The Living Tower"
By: SOA Architects

Images[22]

Site Plan



South Elevation

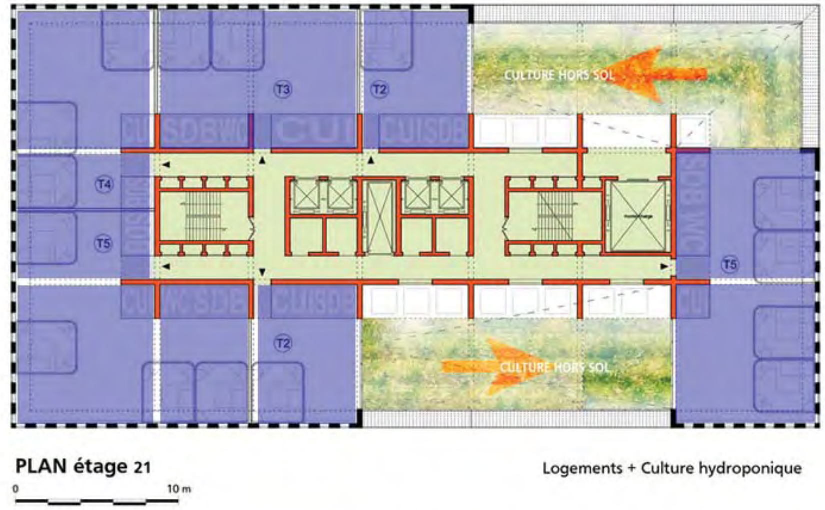
Called the "Living Tower" by SOA Architects, the vertical farm is located in Rennes, France. This tower is very modern in style and portrays a wrapping of sorts around the exterior façade. This artistic wrap is very functional as well due to the combination of program consisting of not only farming but housing and business. The idea from the start was to see if it would be possible to integrate the key farming aspect into a mixed

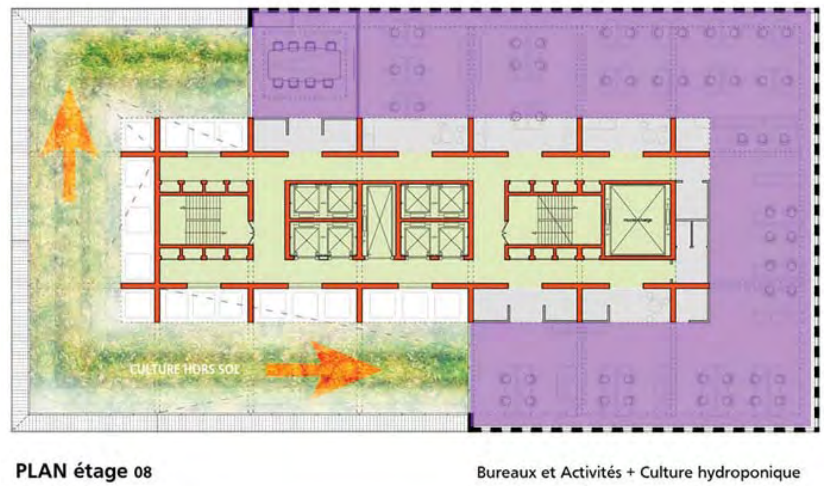
program.

From the outside the clear glass accommodates the farming aspect, while the darker band consists of small windows for the apartments and meeting rooms. In this fashion, each floor plate is a mix of two types of programs with one always being the farming.

Ground Plans - Market areas

Upper Plan - Showing apartments with integrated farming.

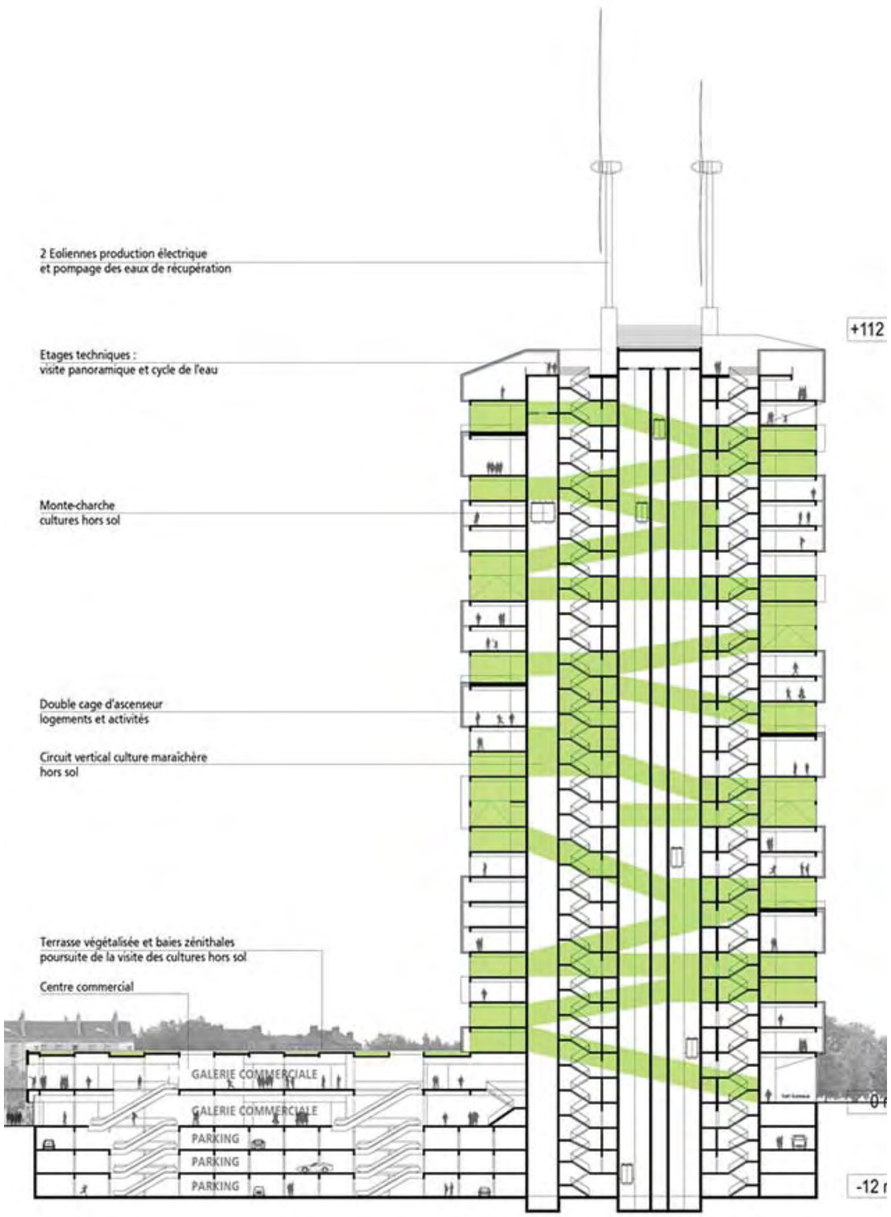




Upper Plan - Showing business offices and meeting rooms with integrated farming.

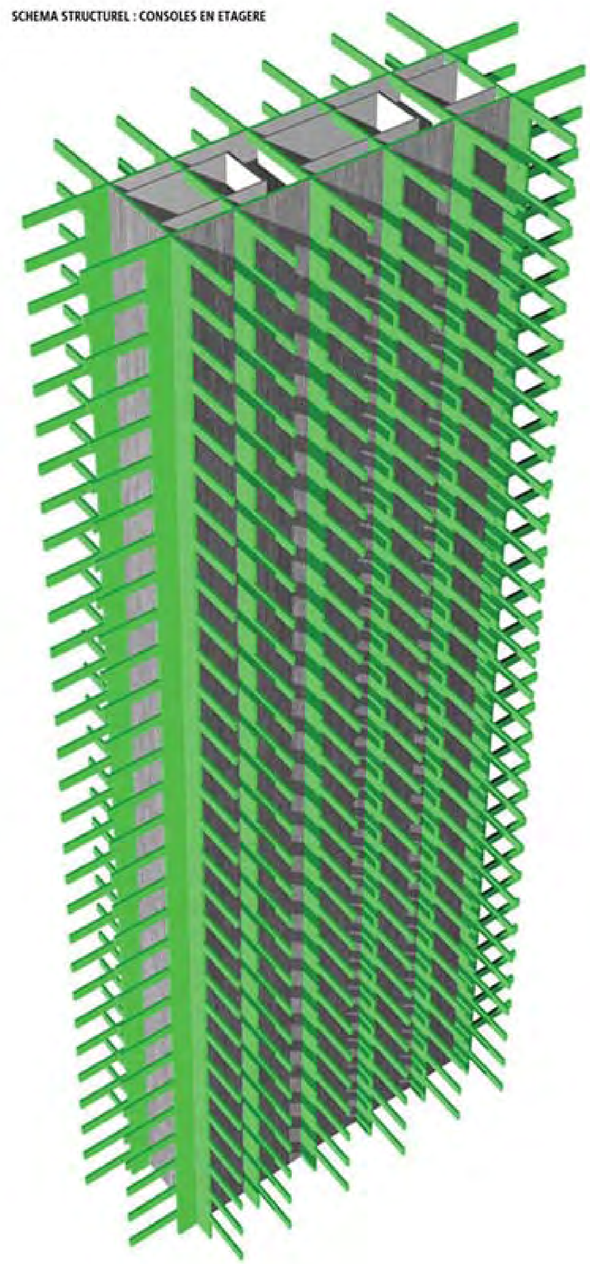
In section it can be seen that the farming is actually sloped just as it is perceived from the façade. This is most likely for purposes of sun orientation so that the crops can receive the most light.

Also, the center contains the core of the building with all circulation as well as harvesting and containment of the crops.

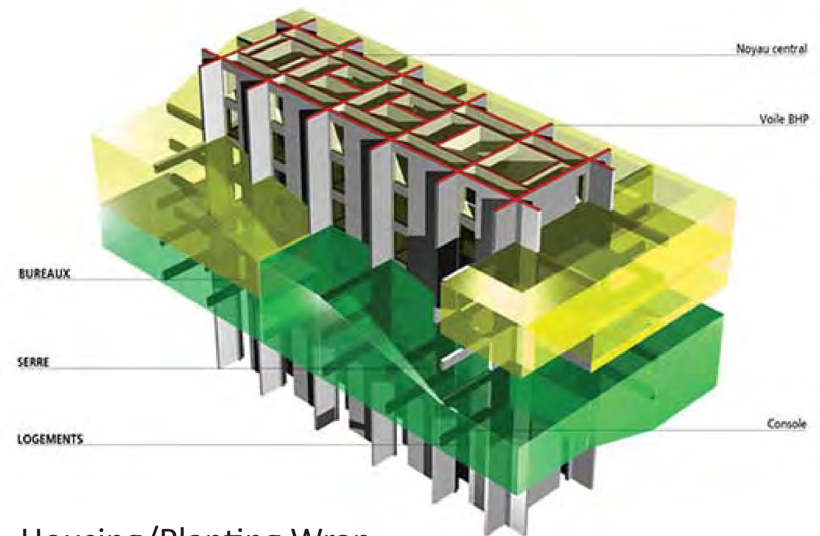


Section - Showing vertical circulation core and plant locations sloping throughout.

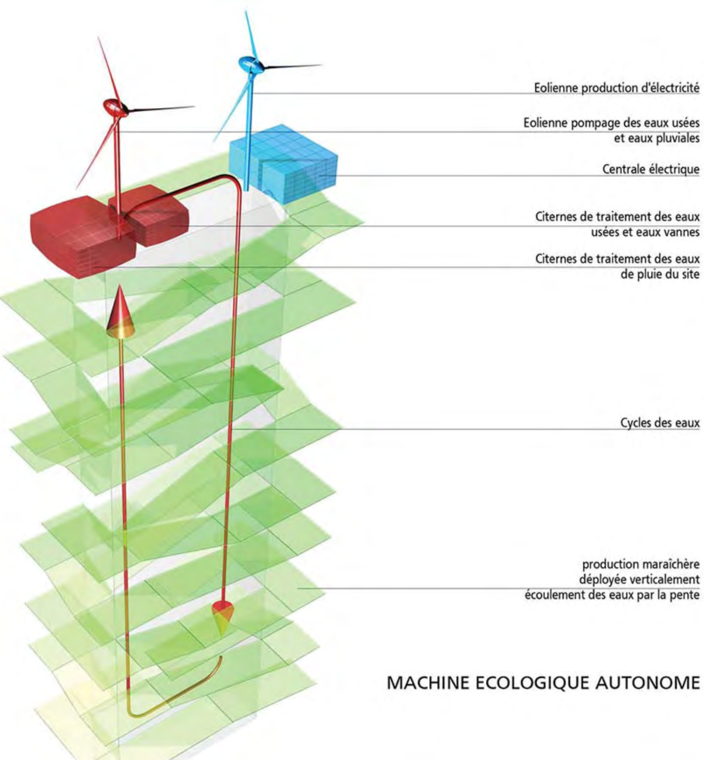
Construction Detail and Facade



Structure



Housing/Planting Wrap



Energy Production

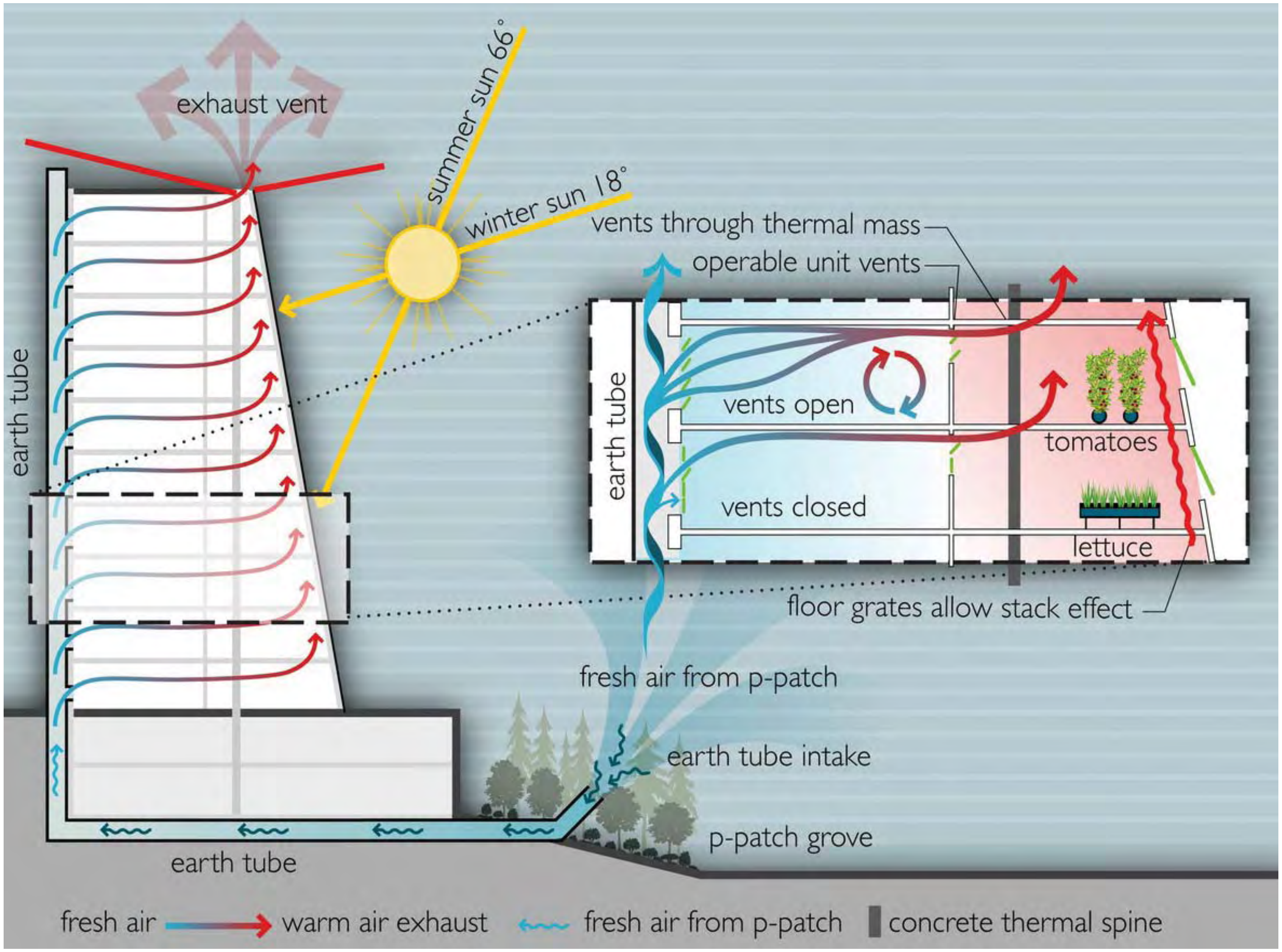
Interior - Showing crops.

Interior - Business Meeting Rooms

"The Eco-Laboratory"
By: Weber Thompson

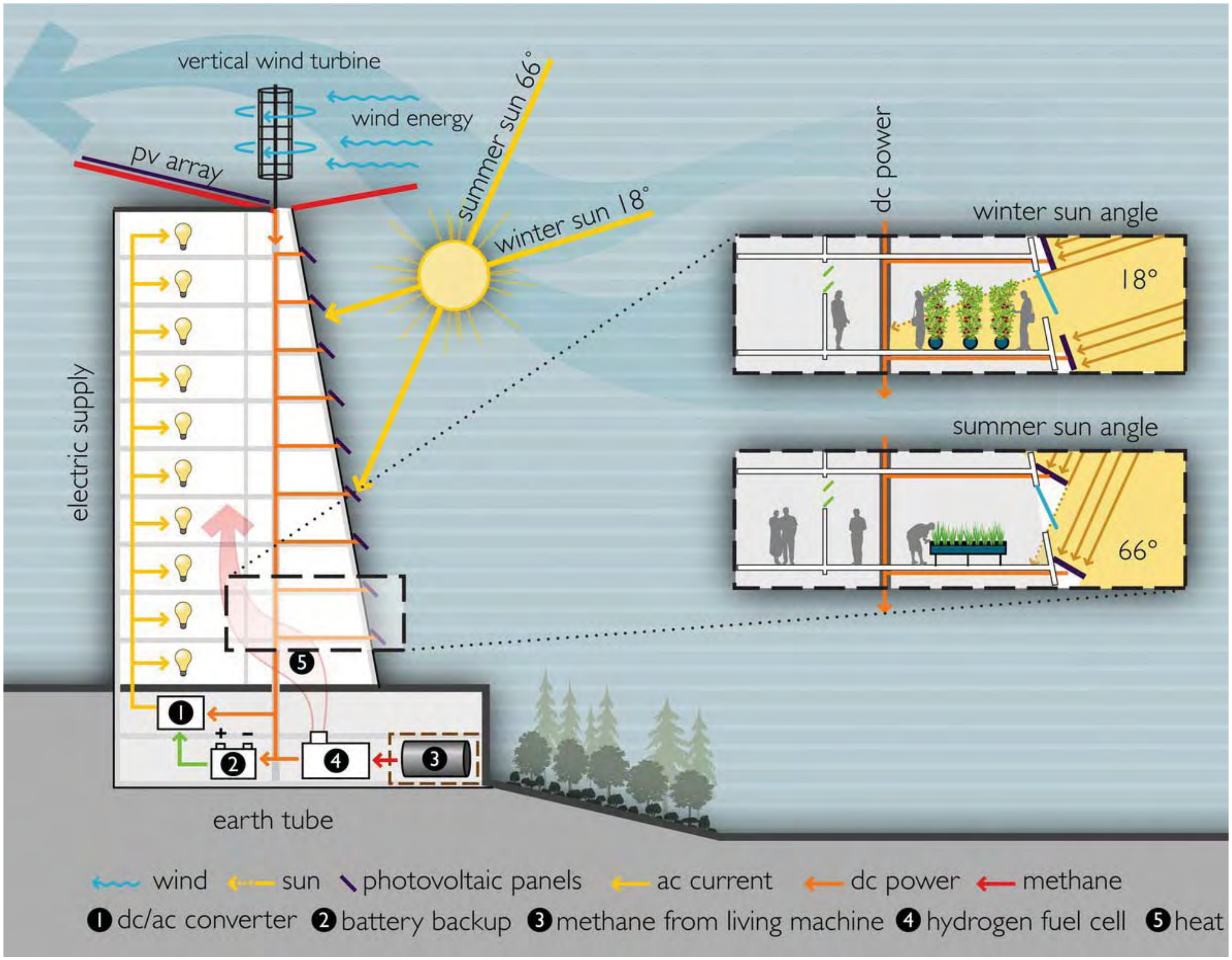
Images[22]

The Eco-laboratory by Weber Thompson is a combination of a laboratory, housing, and of course, farming. A strong emphasis is put into making the building sustainable. First through building ventilation a variation of temperatures can be customized for different crop species through mechanical louvers. The system starts outside capturing fresh air from a p-patch, another name for a garden, and forces that air into the building. The cool air is pumped up from the bottom exhausting the hot hair out of the top. Vents can be closed to keep the temperature warm for tomatoes for instance that prefer the hotter climates.



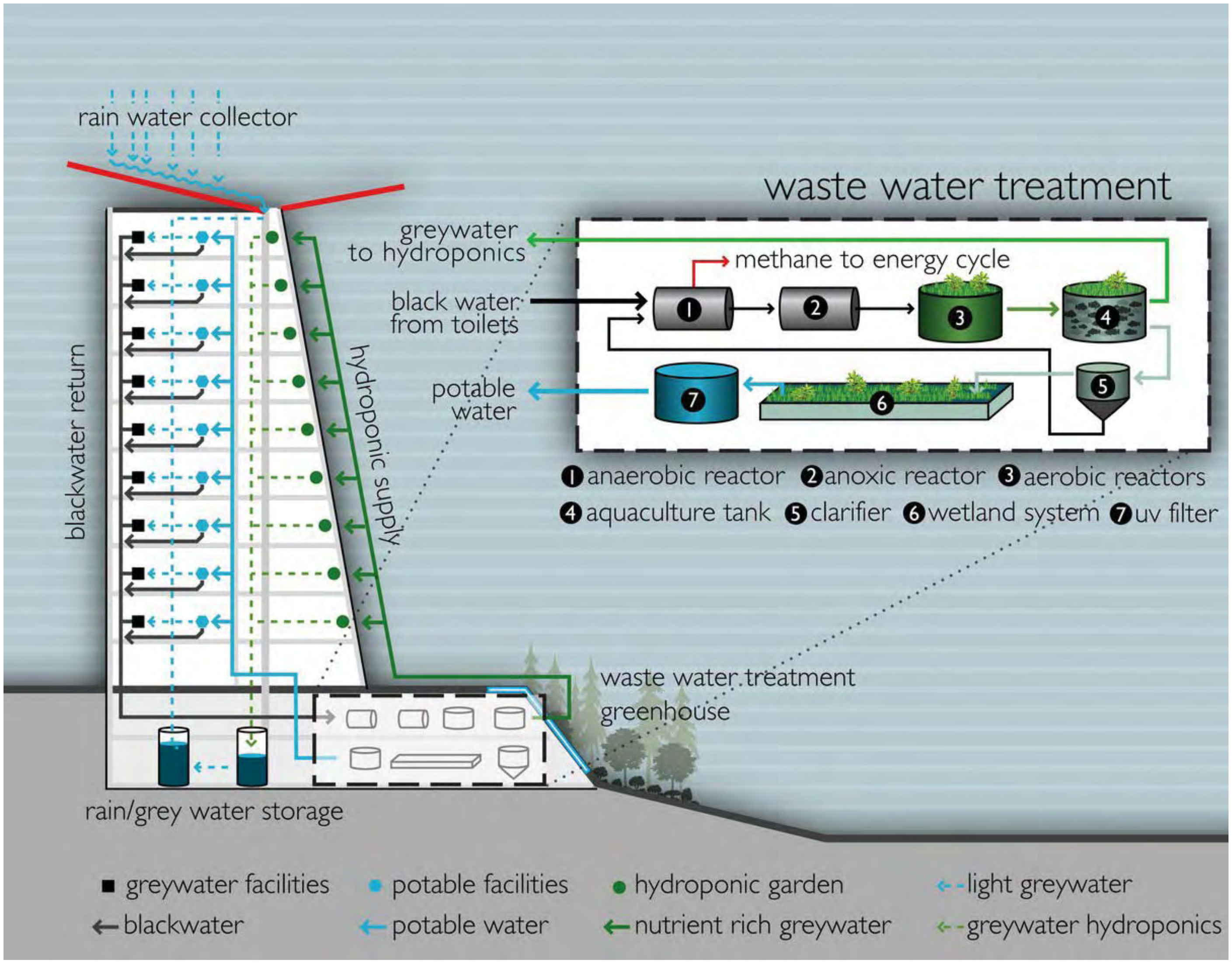
Building Ventilation

In terms of energy, the laboratory tries to capture as much energy as possible from all elements. Wind turbines are located on the rooftop. Solar panels to capture the sun's rays are not only located on the roof but on the southern façade too. This building also takes methane from the plants waste.



Energy Cycle

The water cycle is another interesting aspect. The shape of the roof was designed in a shape to best capture rainwater. The rainwater is then used for all of the housing throughout the building. Once used both grey water and black water are recycled through a waste water treatment greenhouse. After treatment all of the water is considered grey water and now continues onto the hydroponic systems for the plants.



Water Cycle

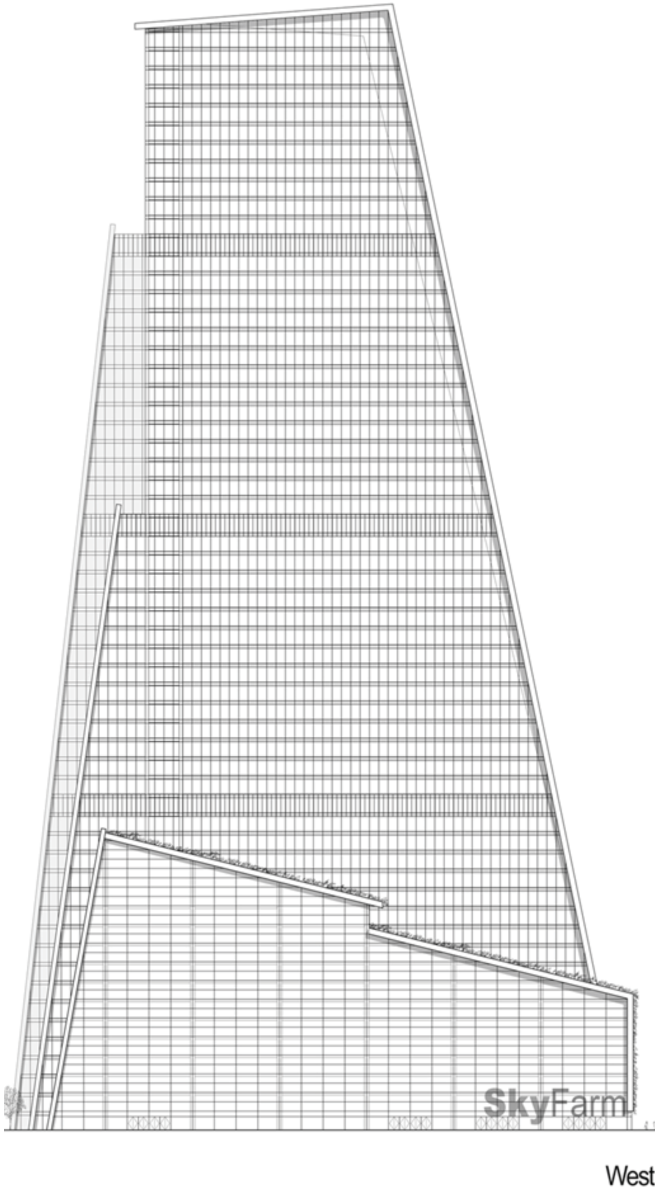
NE View

Section

"The Vertical Farm"
By: Chris Jacobs


Images[22]

“The Vertical Farm”
By: Gordon Graff



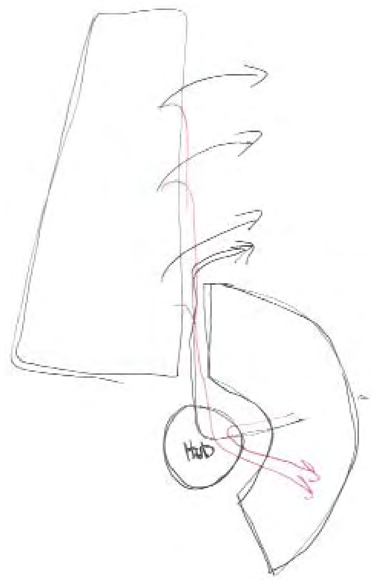
Images[22]

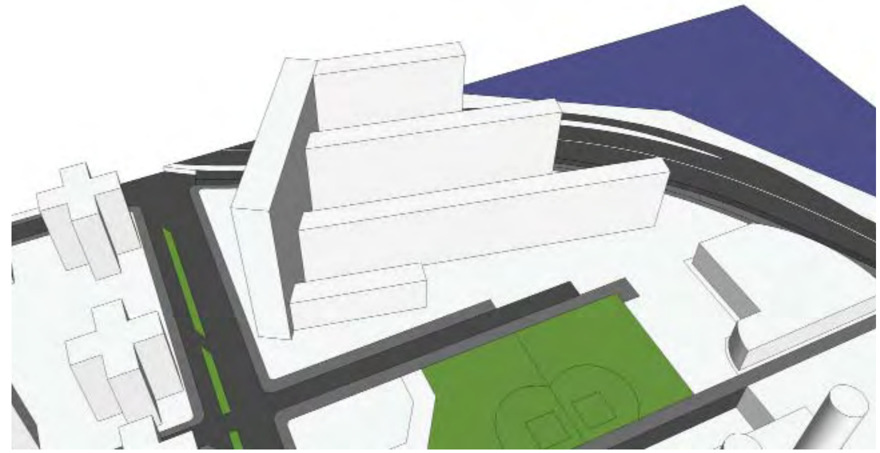
Process - Conceptual Design

In the initial stage of development, many ideas were explored on a range of different levels. First, I knew that feeding all of Stuyvesant Town required a massive amount of crops, thus a large amount of growing area. Keeping in mind that the main goal was to get in as much sunlight as possible, the tower needed to be thin and tall. Knowing that there was also several program requirements, all of the program didn't necessarily need to be in one large building. The chickens and fish didn't need maximum sunlight, nor did the market or service areas. I began exploring different ideas of having multiple buildings and arranging them on the site, all of which organized around a main central core. At certain levels around the vertical shafts, specialized program could be located: labs, meeting rooms, or public functions such as restaurants. The lower levels could be the marketplace and retail area.

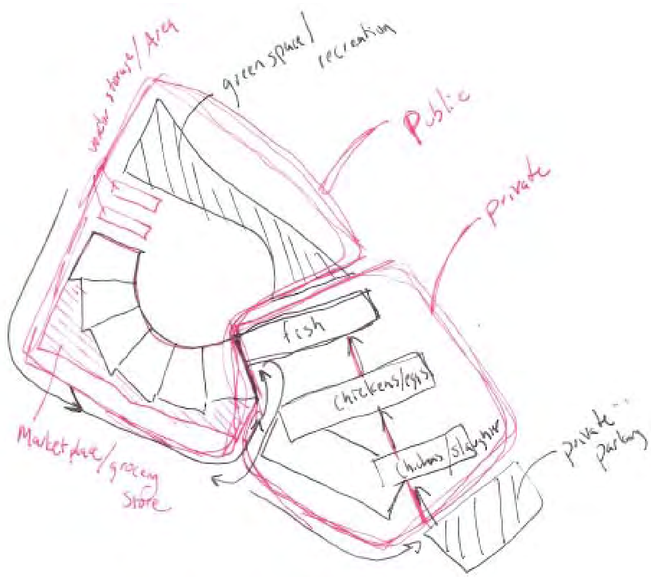
The following pages contain some initial sketches of ideas and the Schematic Design presentation.

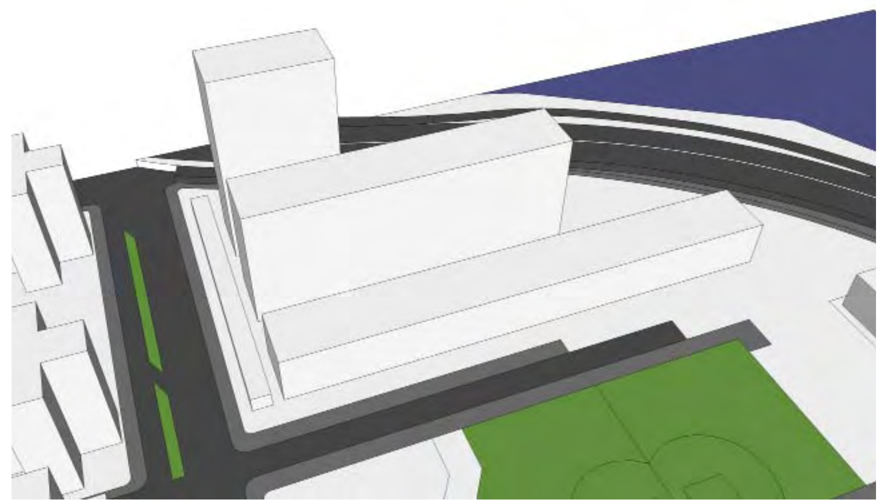
Process and Sketches





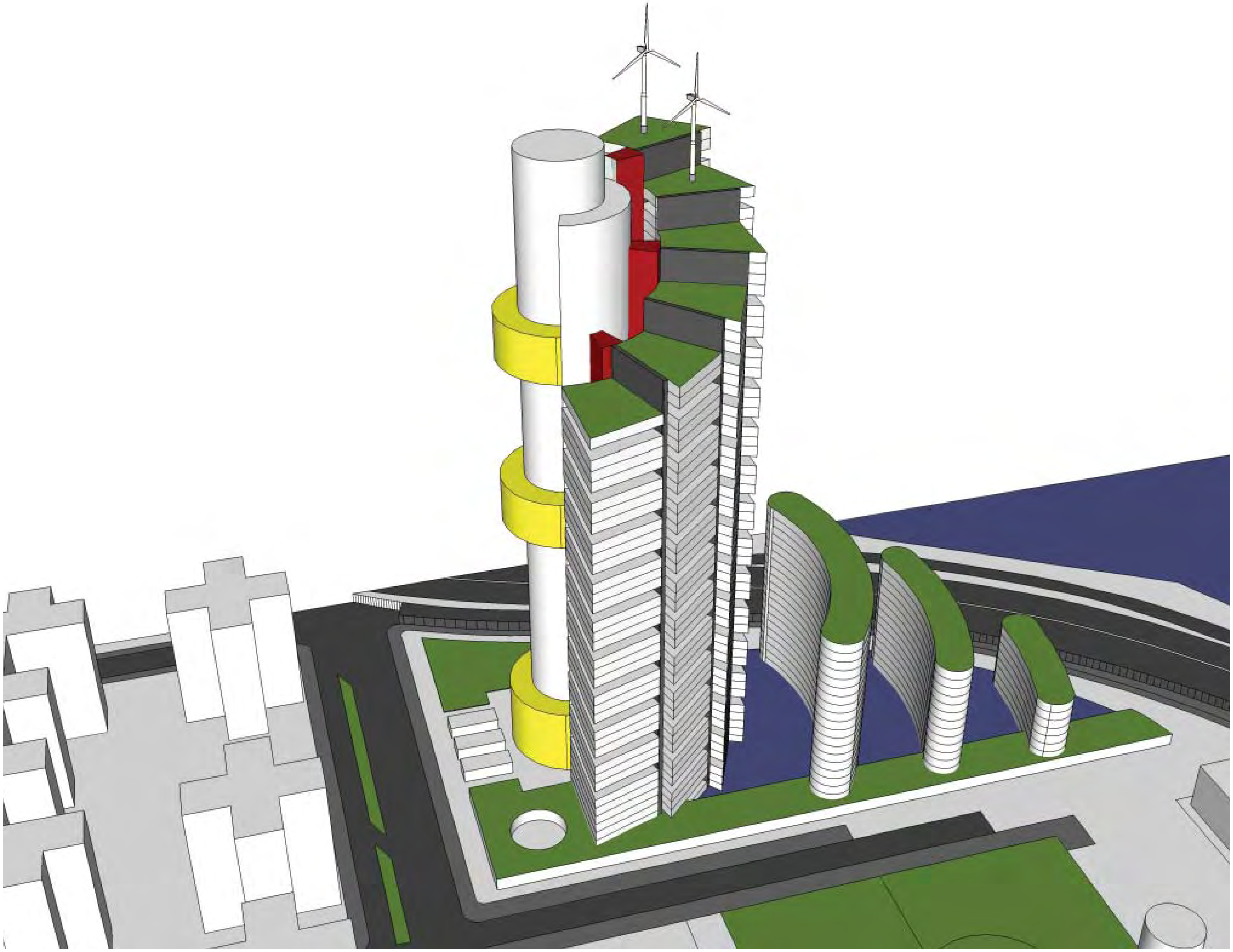
Alternative 1 - Multiple structures rising from West to East.

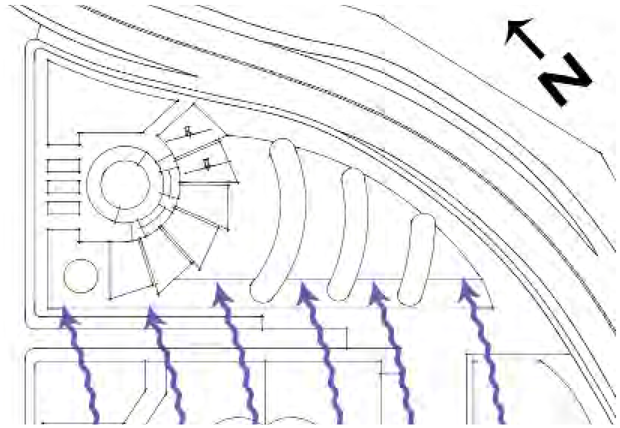




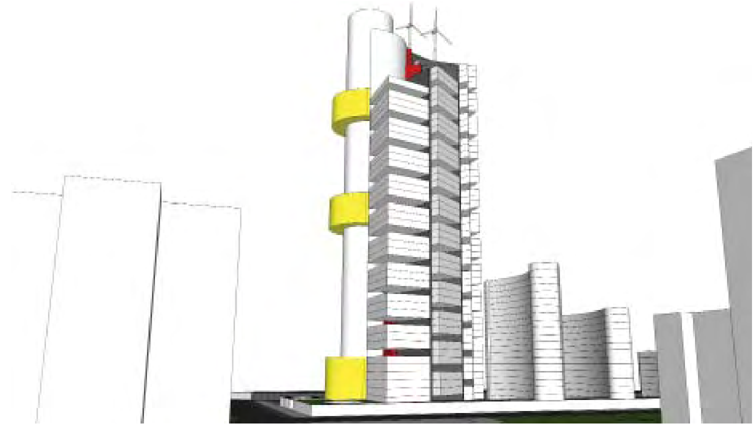
Alternative 2 - Multiple structures rising from South to North.

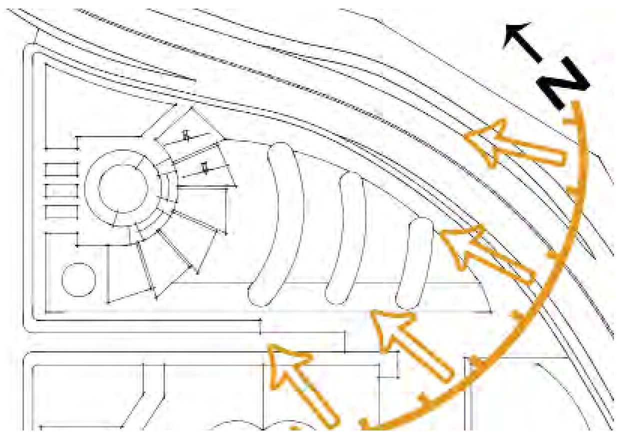
Conceptual Design Presentation



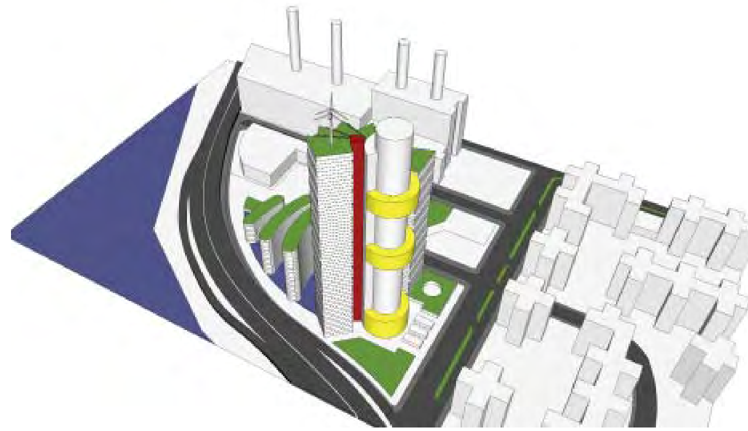


Oriented for wind ventilation.

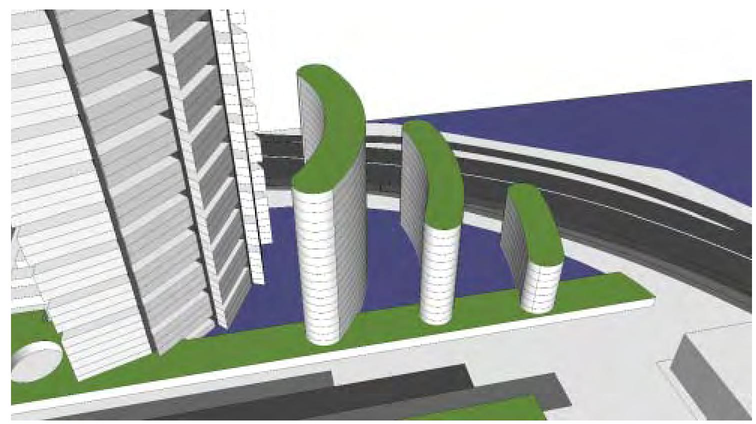

Open spaces to let light in and ventilate.

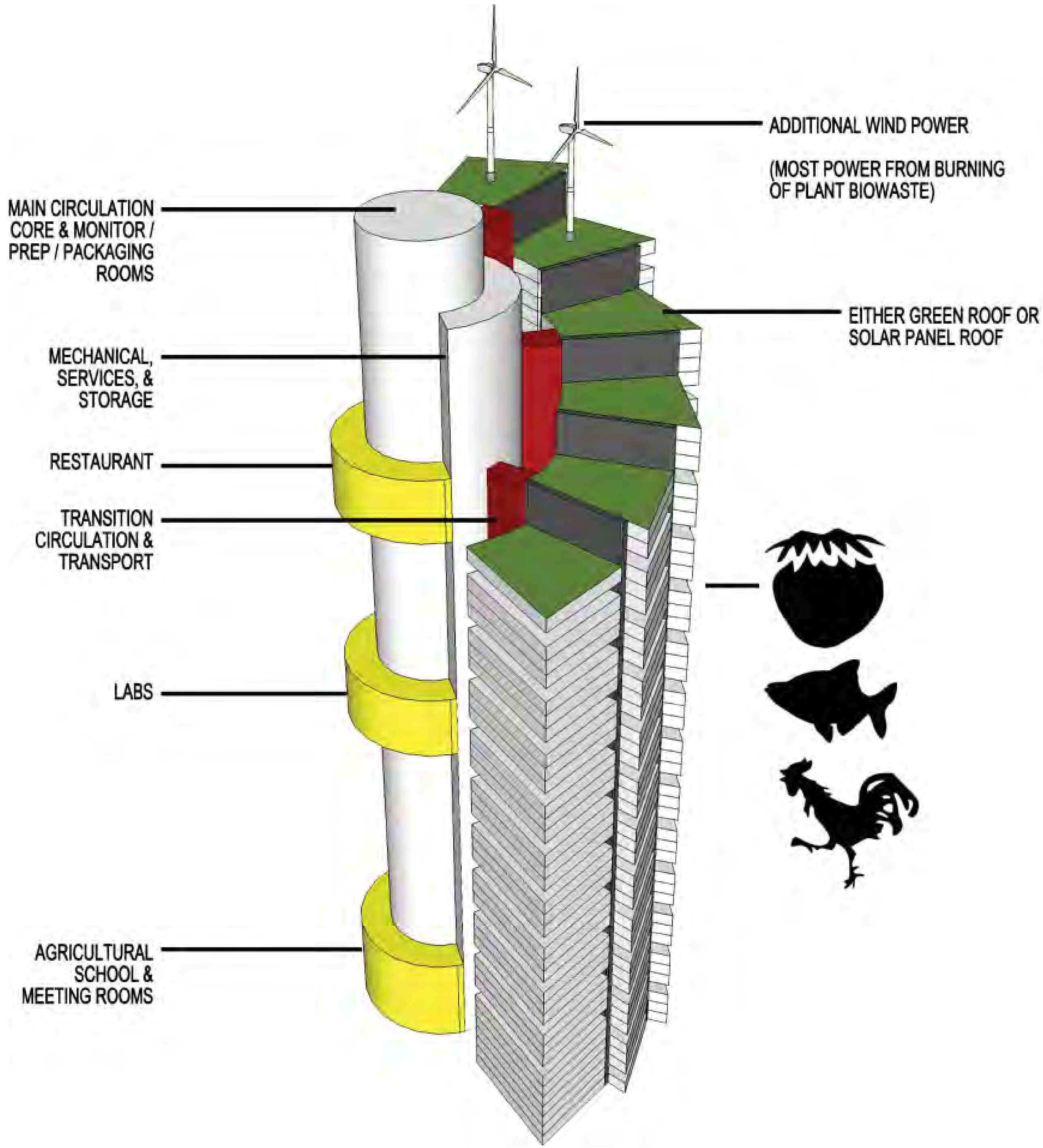


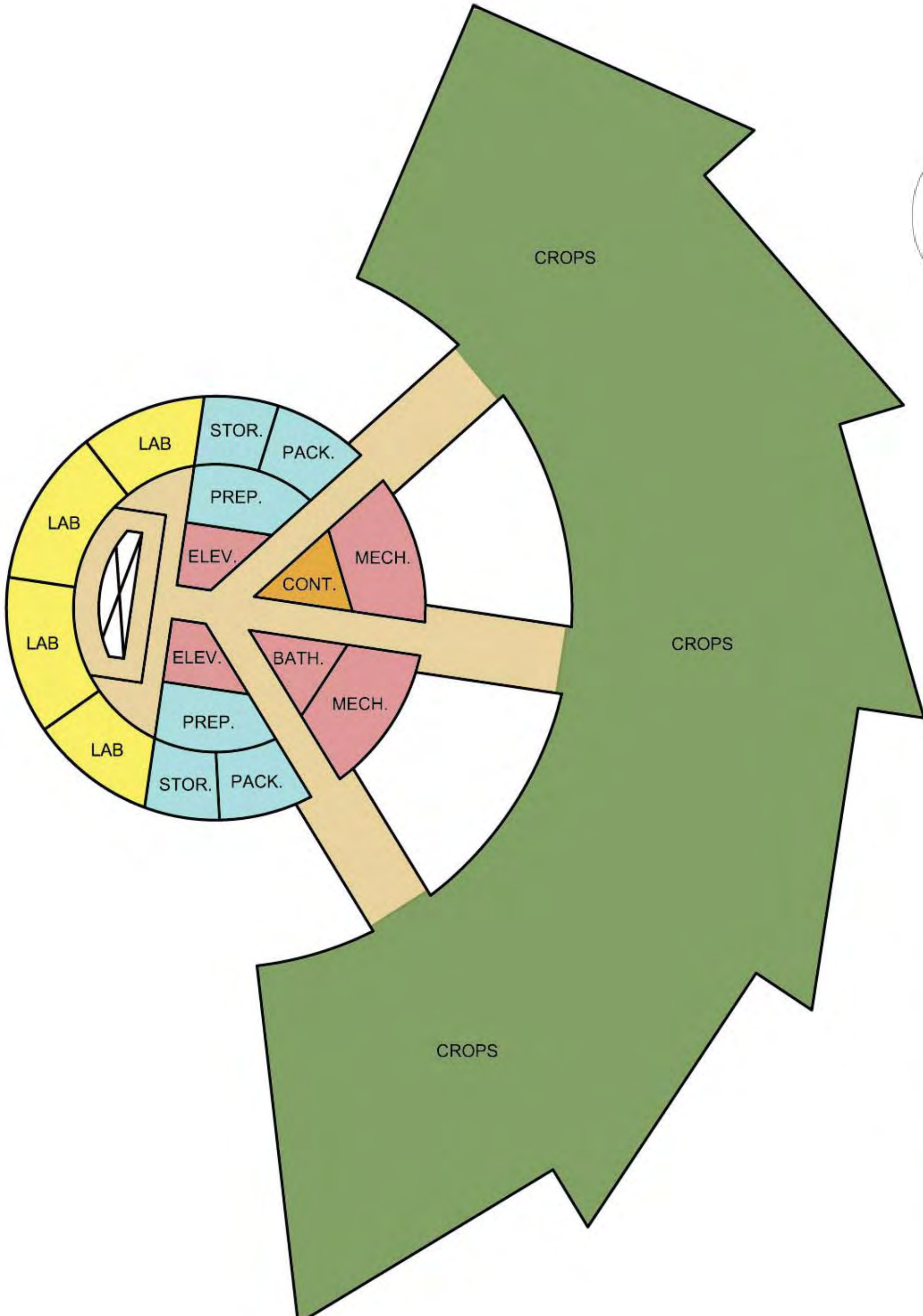
Positioned for maximum sunlight.


Specialty floors around core when needed.

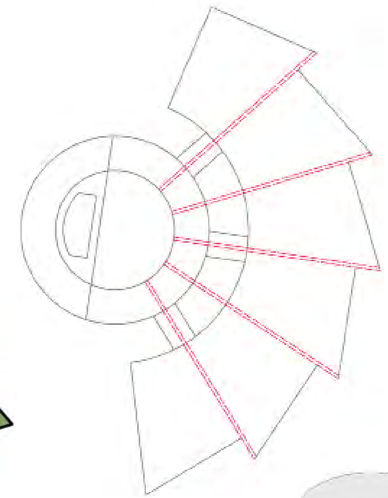

Additional towers for fish and chickens.


Water retention for hydroponics.


ADDITIONAL WIND POWER
(MOST POWER FROM BURNING OF PLANT BIOWASTE)
MAIN CIRCULATION CORE & MONITOR / PREP / PACKAGING ROOMS
EITHER GREEN ROOF OR SOLAR PANEL ROOF
MECHANICAL, SERVICES, & STORAGE
RESTAURANT
TRANSITION CIRCULATION & TRANSPORT
LABS
AGRICULTURAL SCHOOL & MEETING ROOMS

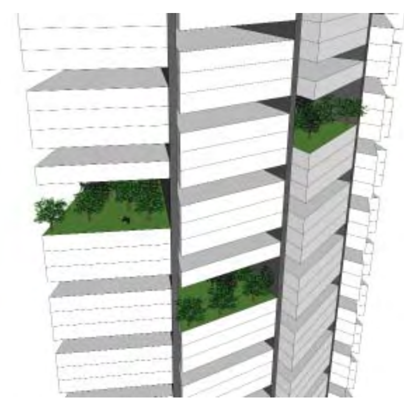


Typical floor plan with core.

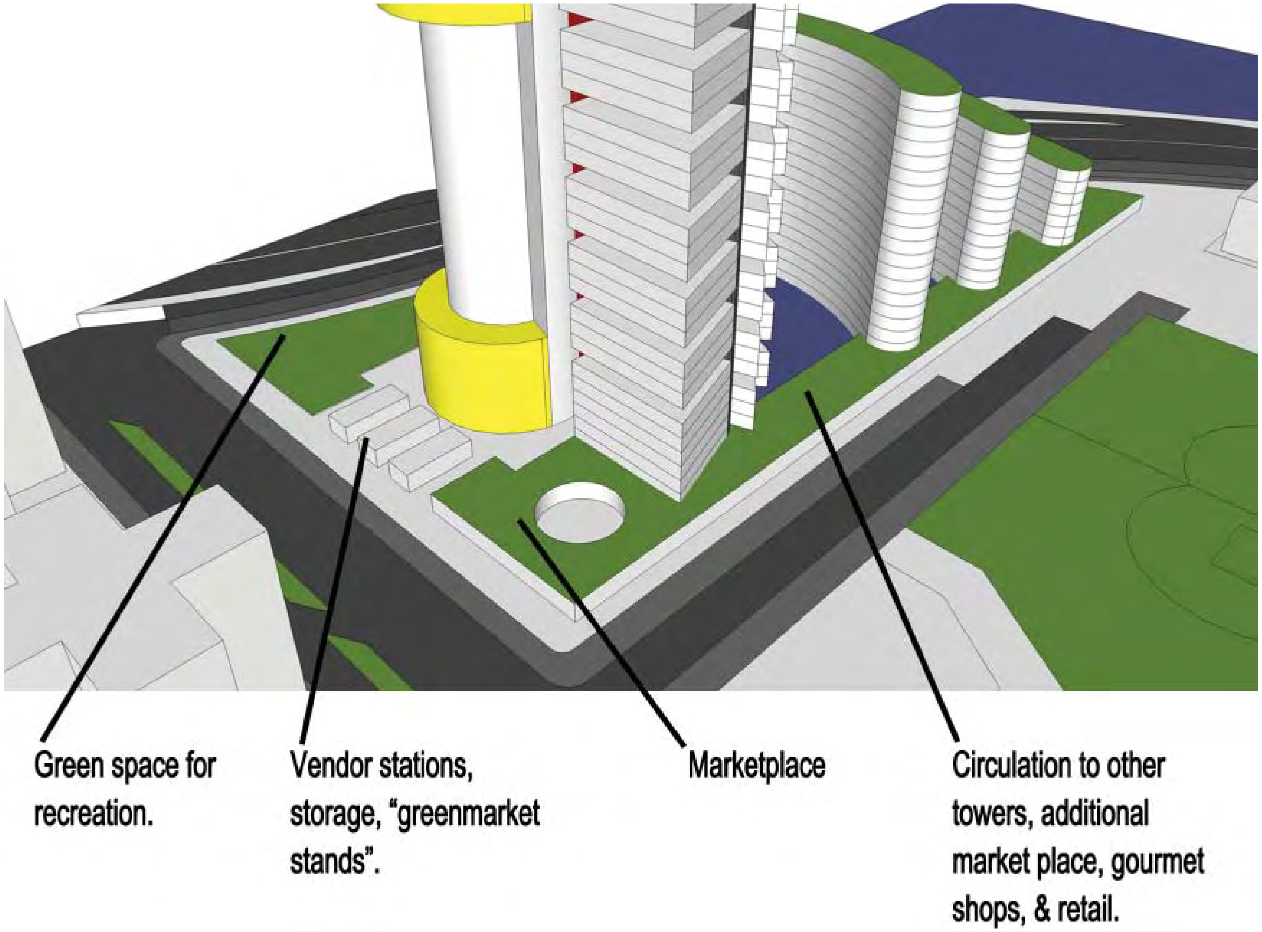


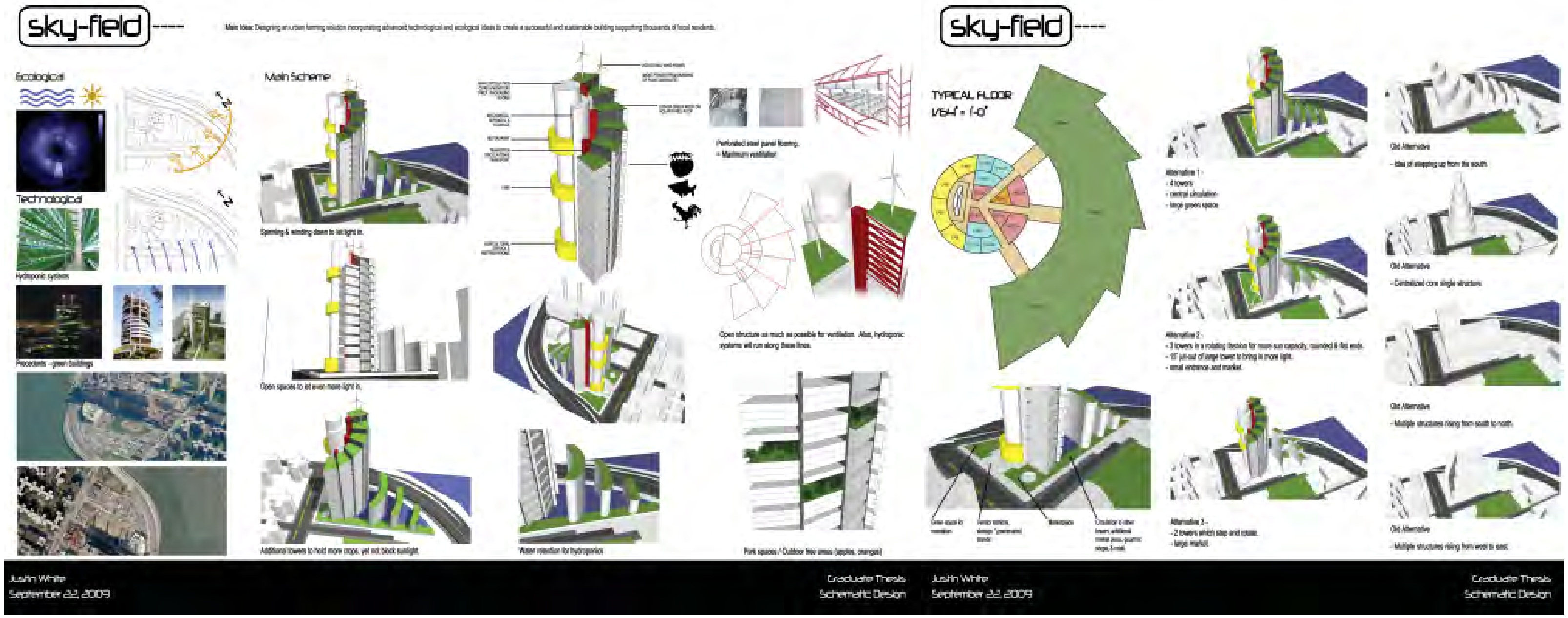
Structure

Structure attached to core.



Park spaces / outdoor growing areas (apples, oranges).


Green space for recreation.
Vendor stations, storage, "greenmarket stands".
Marketplace
Circulation to other towers, additional market place, gourmet shops, & retail.



Presentation Boards

Study Model

Conceptual Design Conclusion

There were several important points of criticism after this stage. First, the tower seemed to be spiraling down in a somewhat inefficient direction. In fact, the opposite direction would have actually been more successful in terms of light penetration. Another factor of the tower was that the core seemed to be too large. It wasn't necessary to have preparing, packaging, and storing rooms on every floor. This program needed to be taken out of the center of the core and perhaps attached to the side of the core only when needed, similar to the labs. Another factor was that the other three descending structures were blocking the light from each other. The circulation to them was not fully understood either.

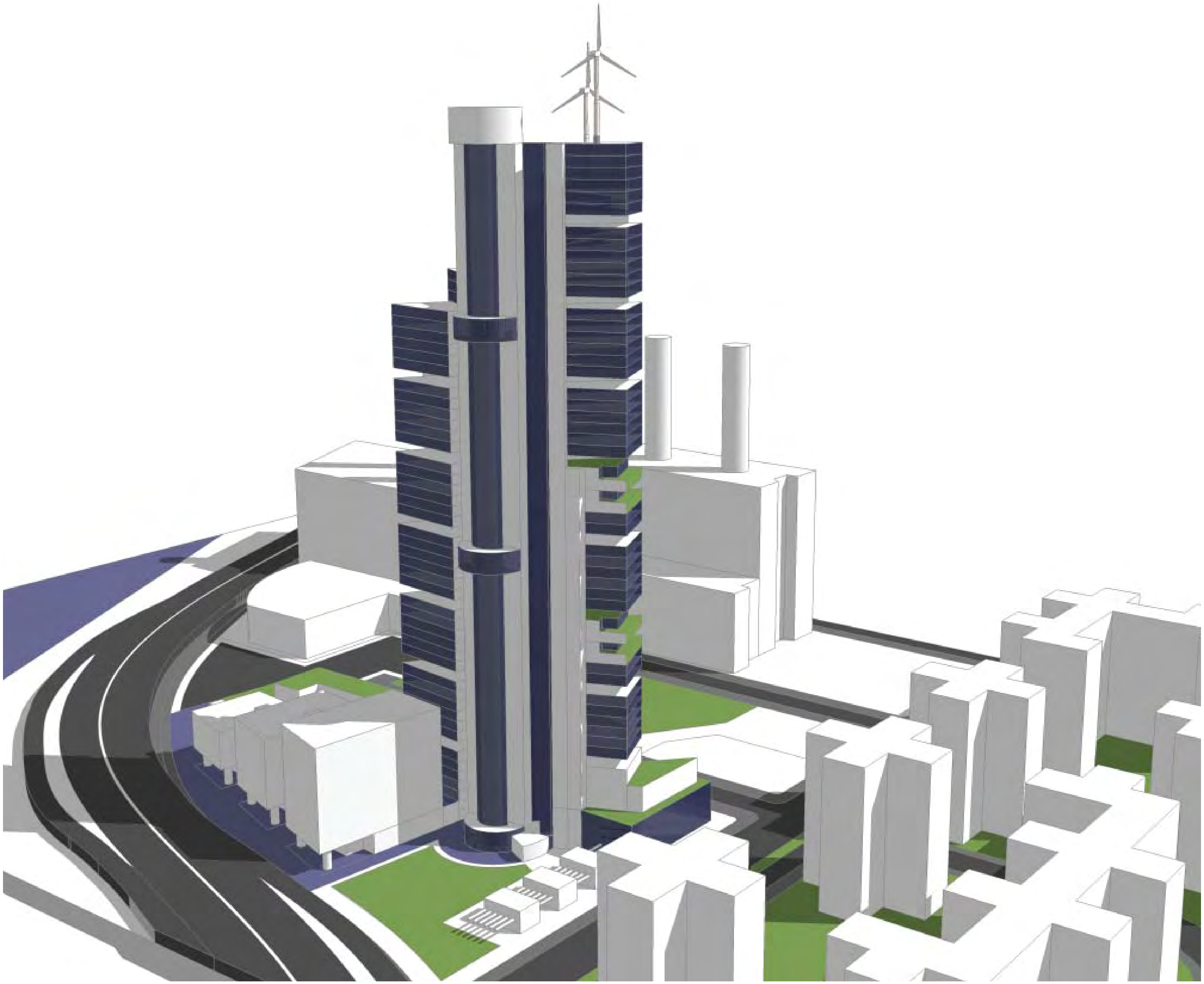
Of course, there were a number of factors that needed to be thought out more in depth but the tower structure and spiraling form were admired.

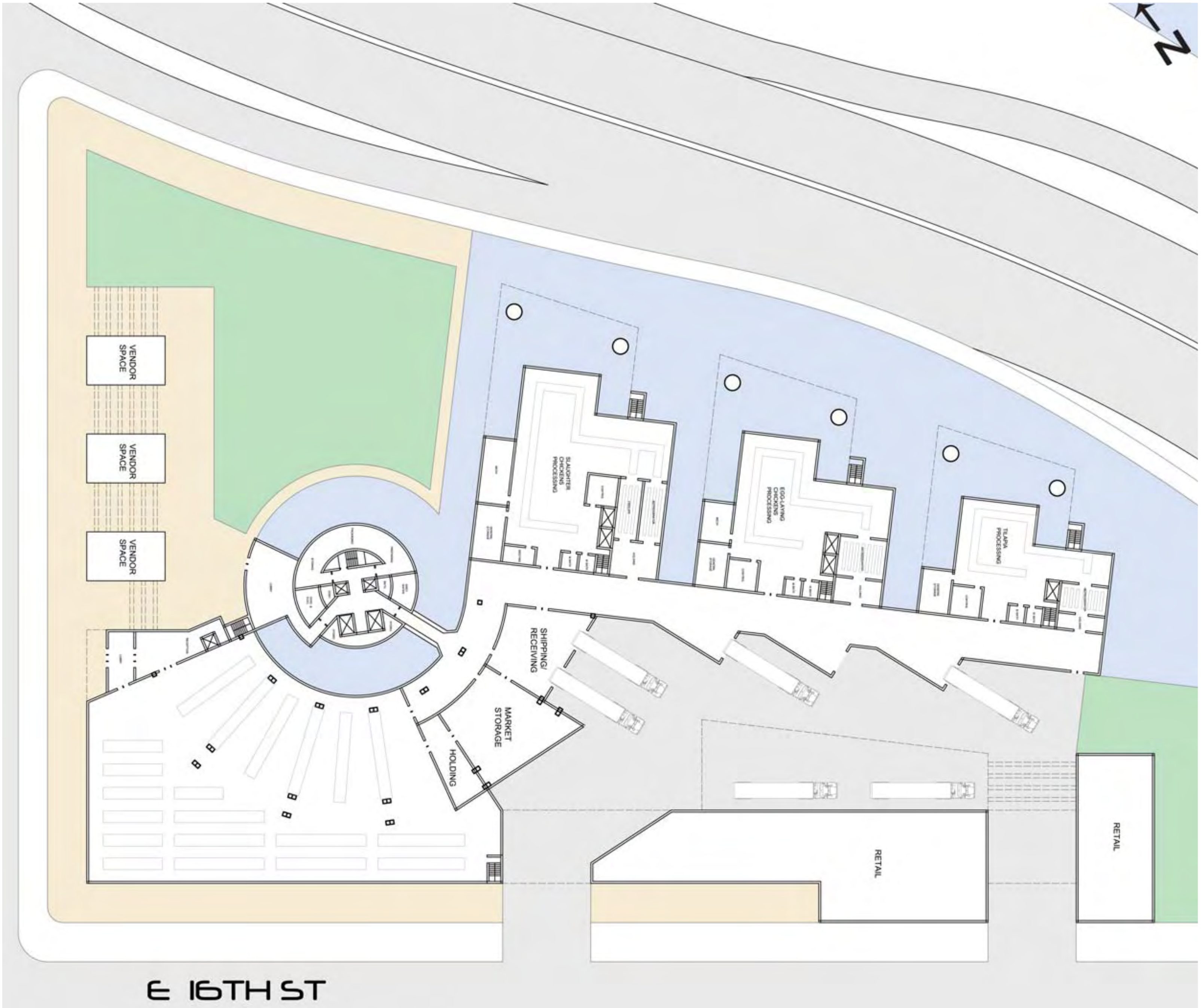
Process - Schematic Design

In this second stage of process, the intent was to take one design concept and coordinate its ideas and strategies into a single coherent design scheme. At this point, I already had a very good idea of my concept; I just needed to push it further. I worked on establishing basic programmatic relationships as well as location proximities relevant to each other and the site. I started to map out all of the plans focusing on one key aspect, fastest circulation times from the upper level crop floors, to the preparing and packing rooms, and then to either the market to sell or the service corridor to ship. Planning for the best possible efficiency in that premise first, would ensure that my building works before molding it to my liking afterwards.

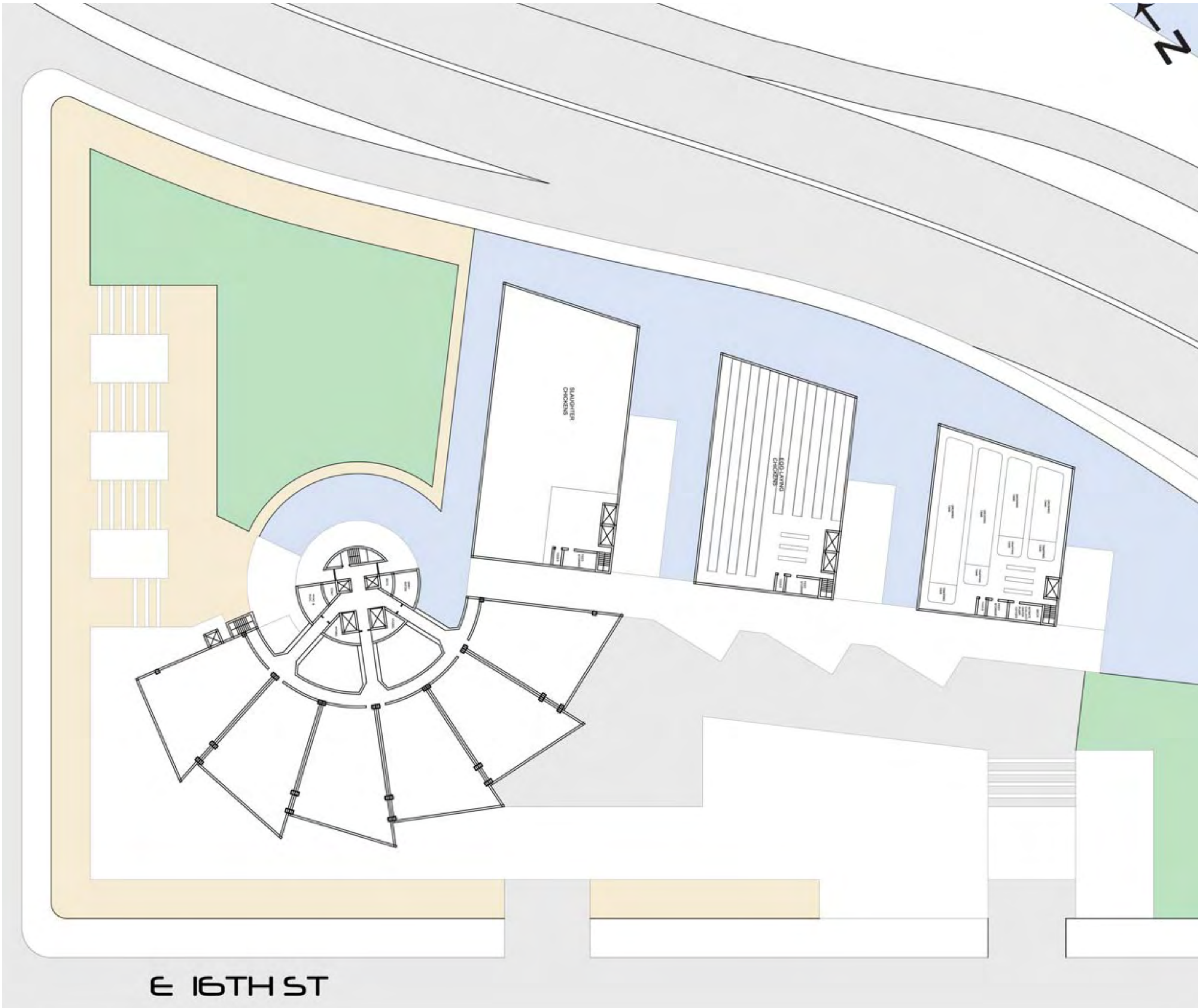
The following contains the schematic design presentation drawings.

Schematic Design Presentation

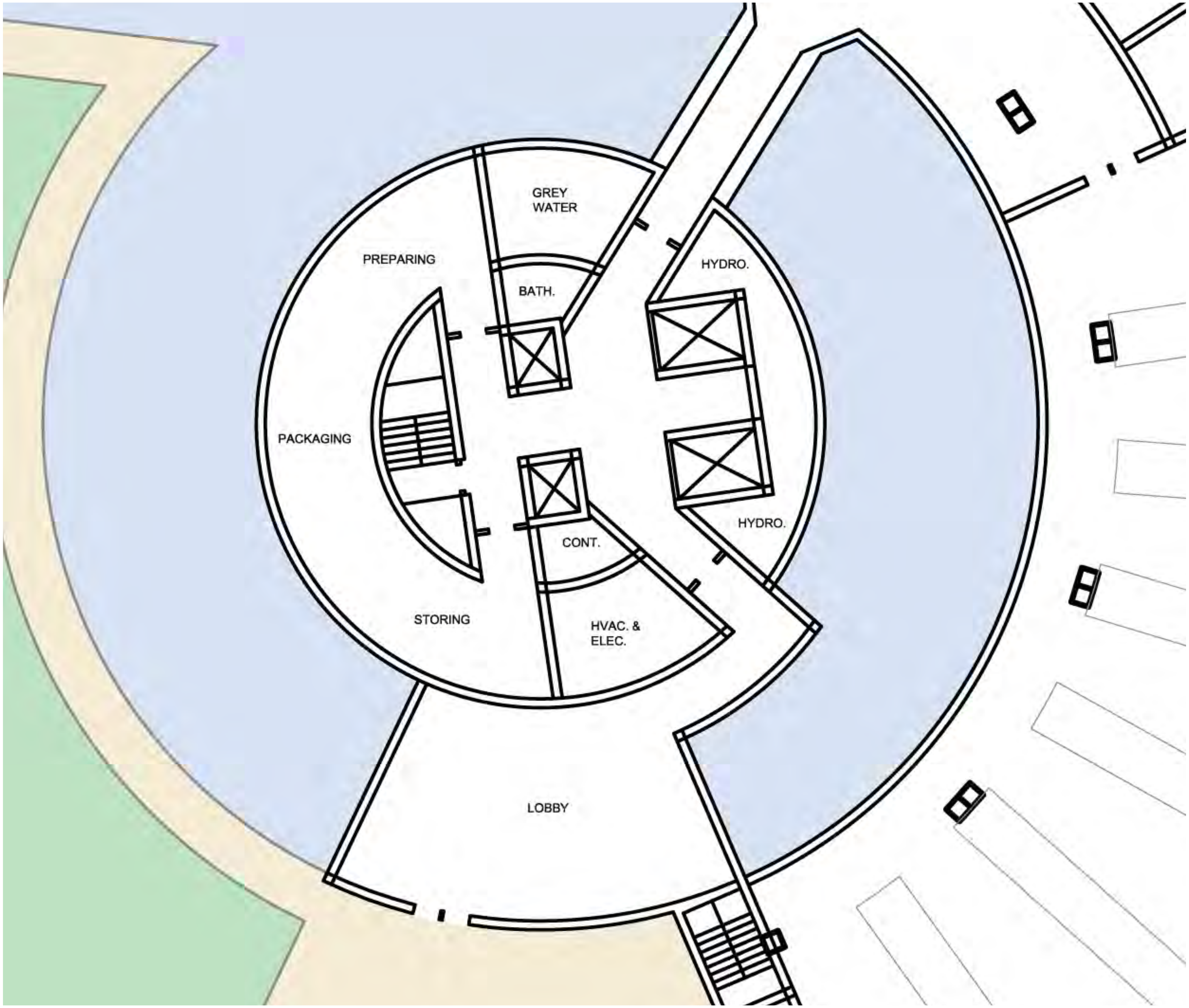



N
VENDOR SPACE
VENDOR SPACE
VENDOR SPACE
SHIPPING/ RECEIVING
MARKET STORAGE
HOLDING
RETAIL
RETAIL
E 16TH ST

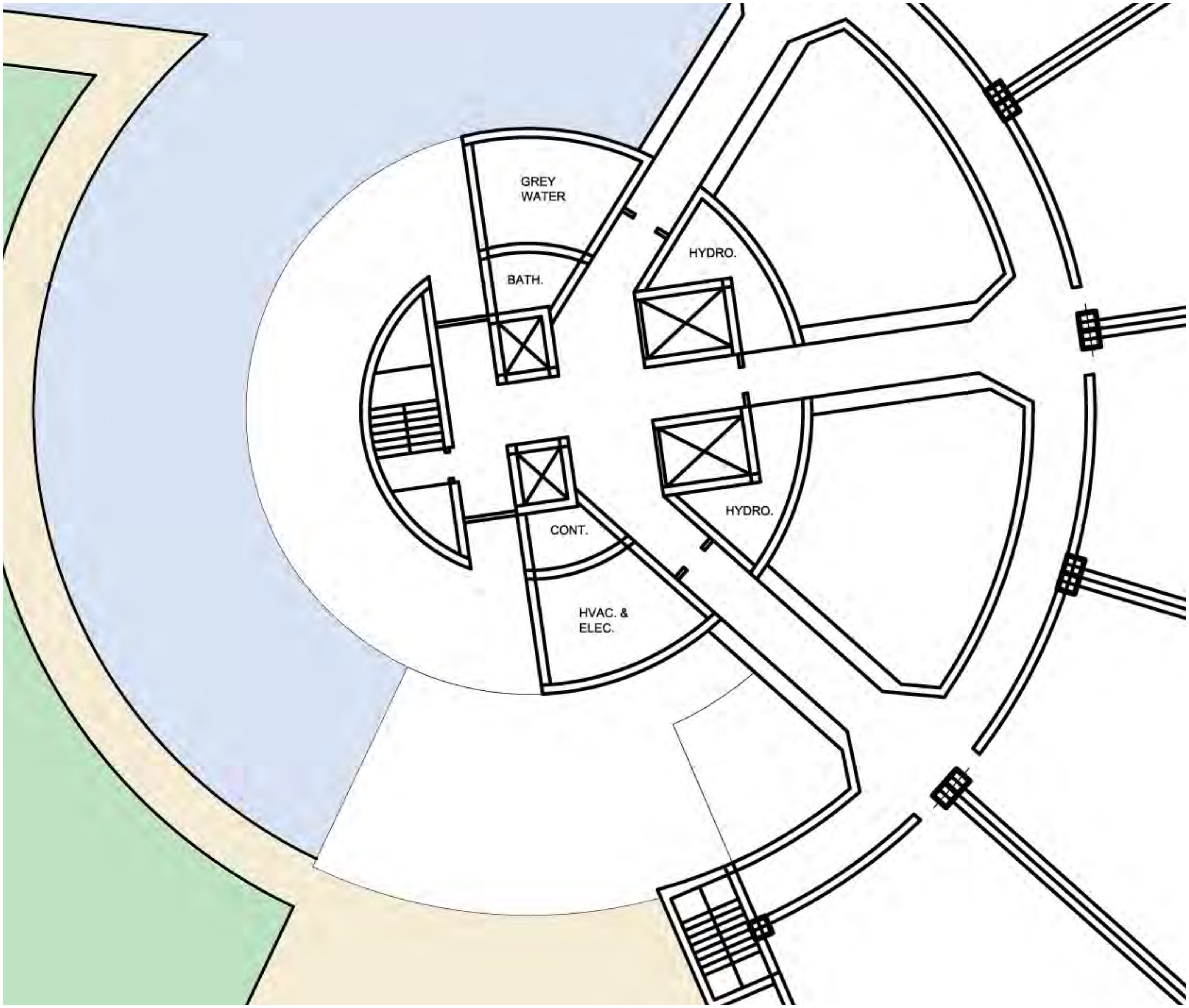
1st Floor



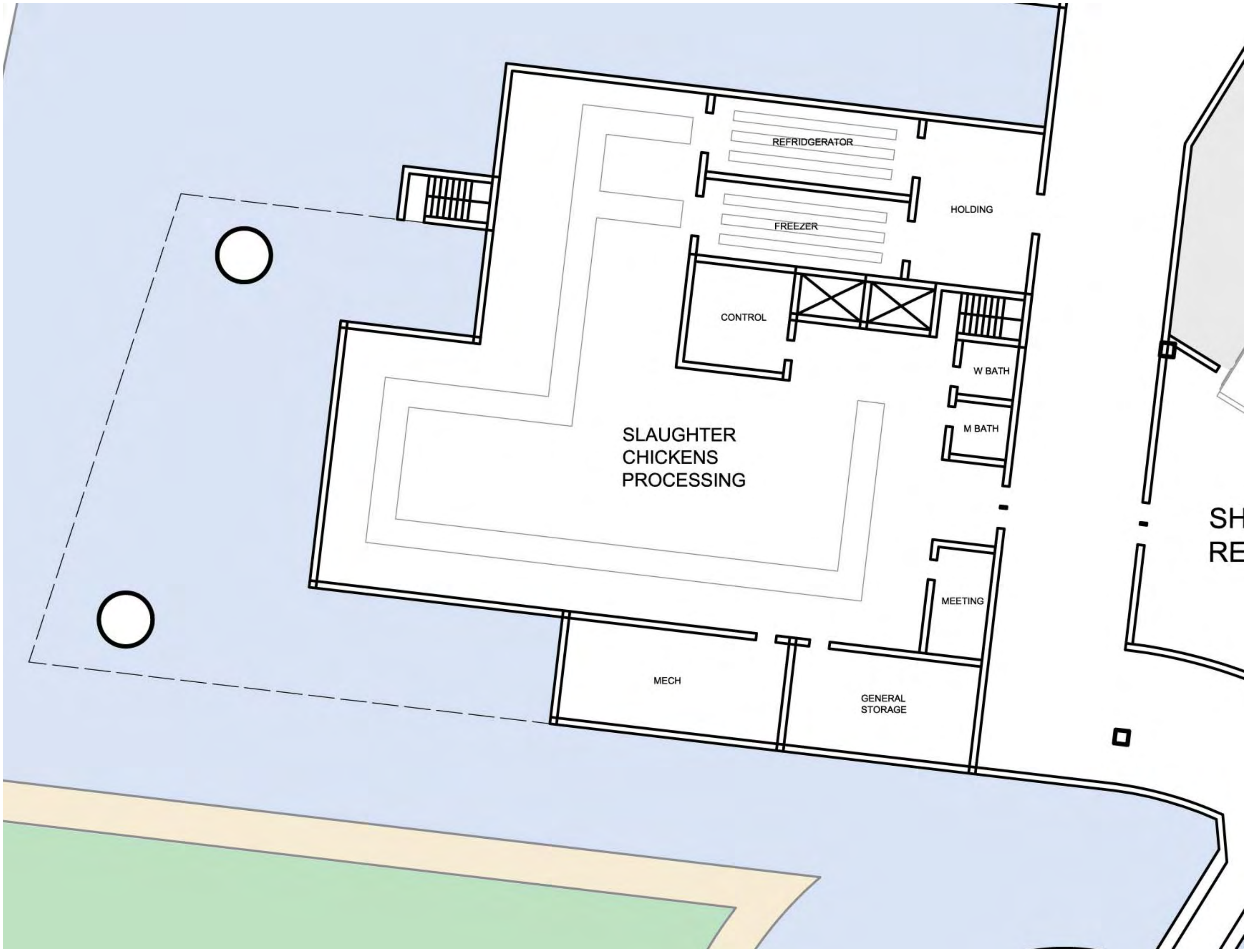
2nd Floor



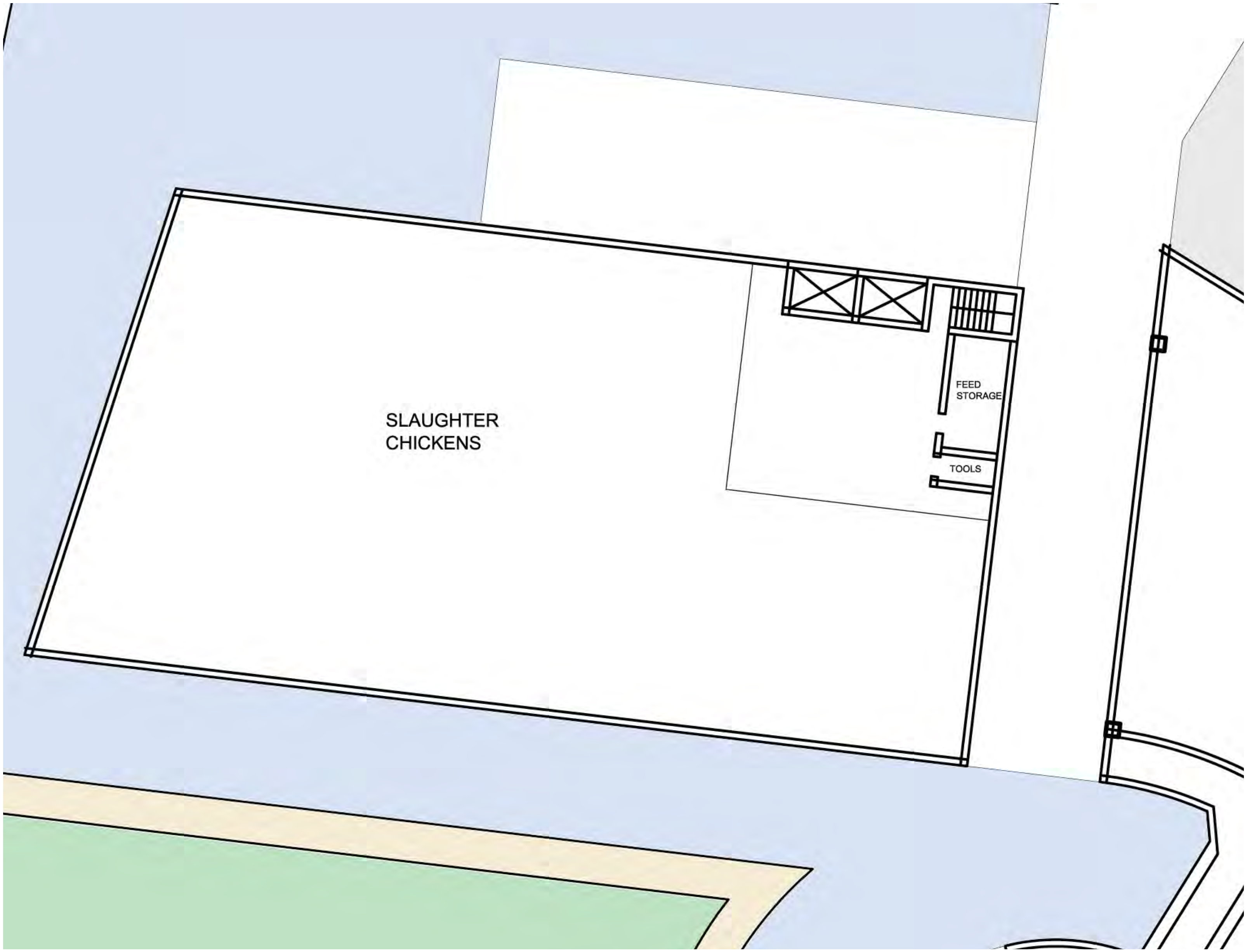
1st Floor Core Area



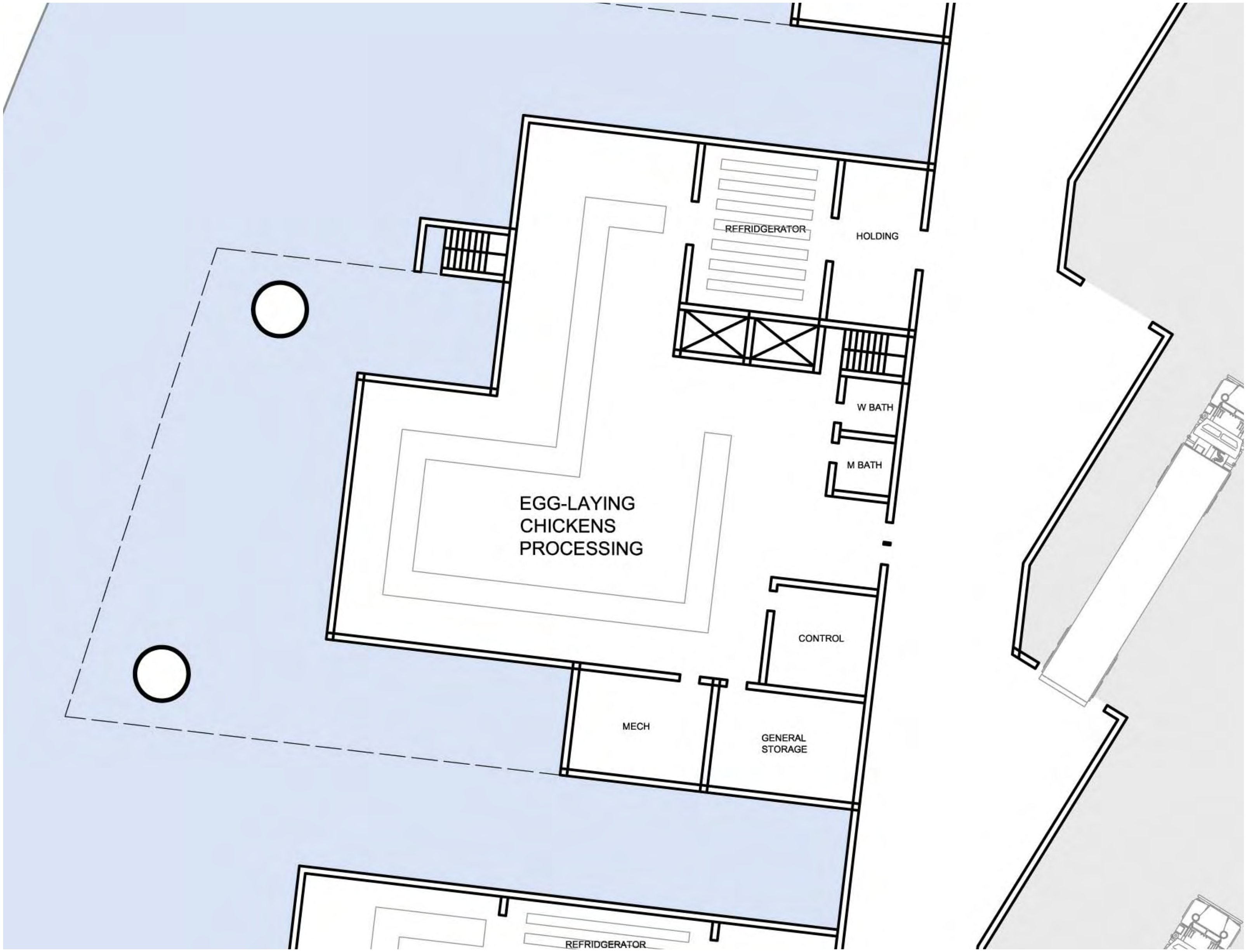
2nd Floor Core Area



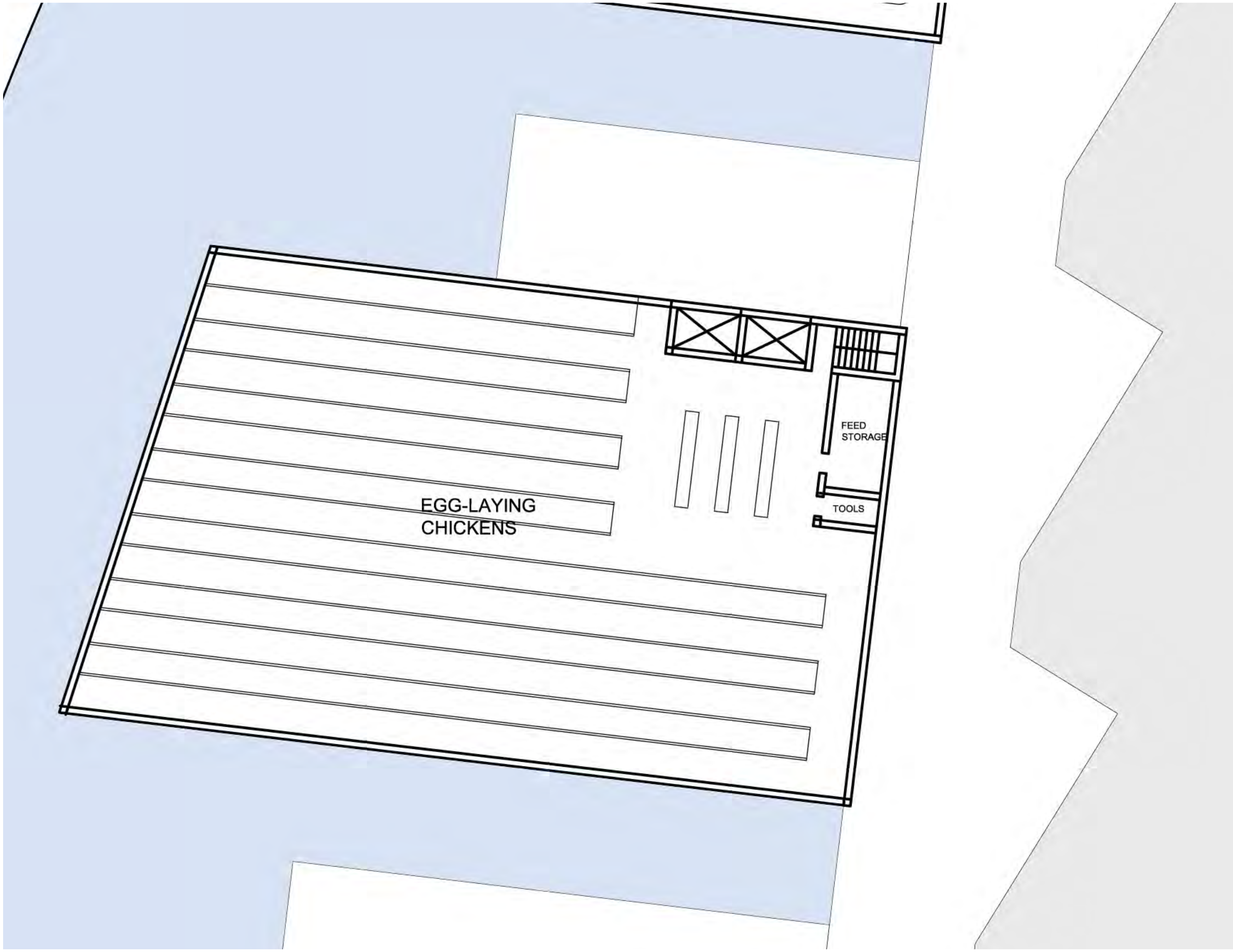
1st Floor Slaughter-Chickens Processing



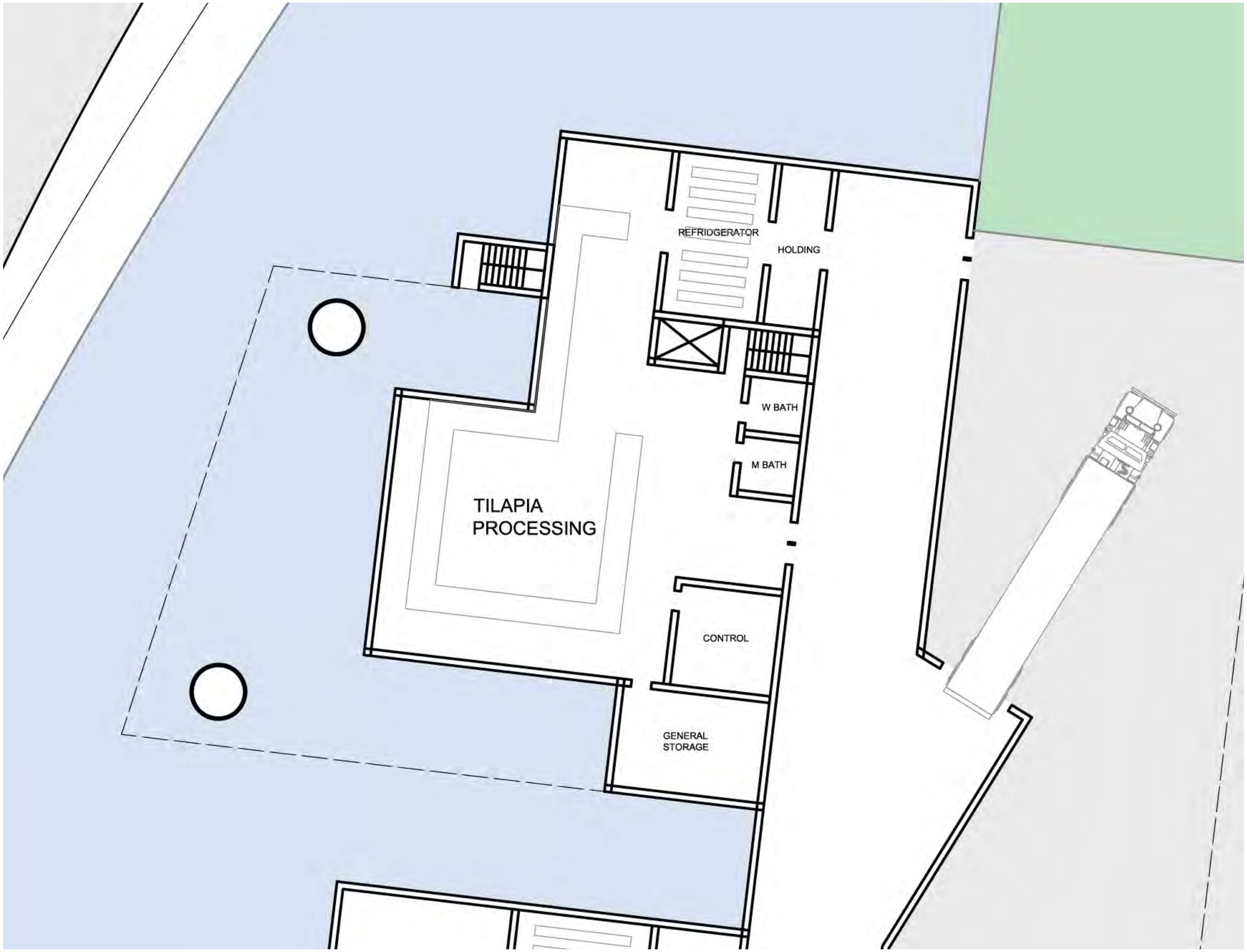
2nd Floor Slaughter-Chickens



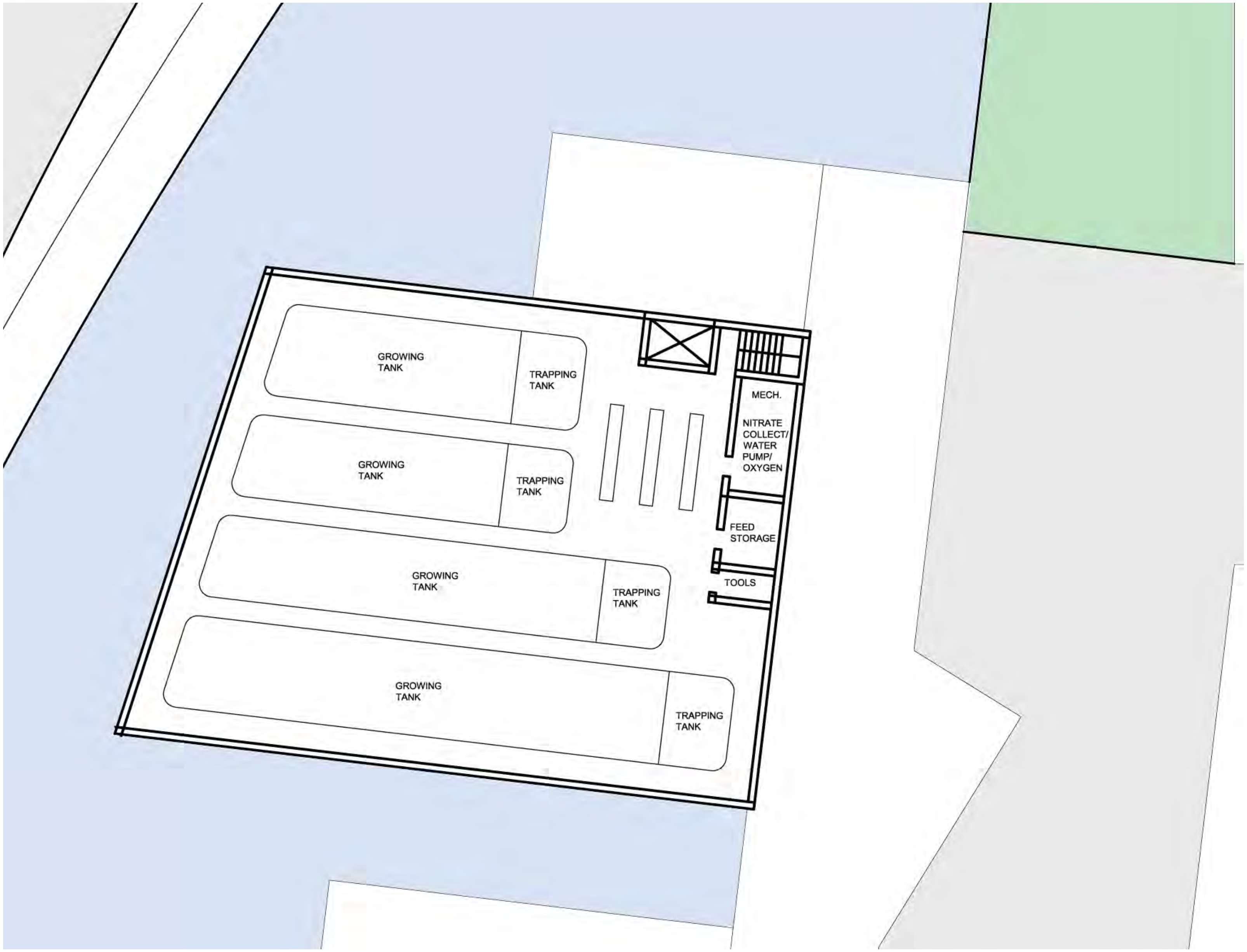
1st Floor Egg-Laying Chickens Processing



2nd Floor Egg-Laying Chickens

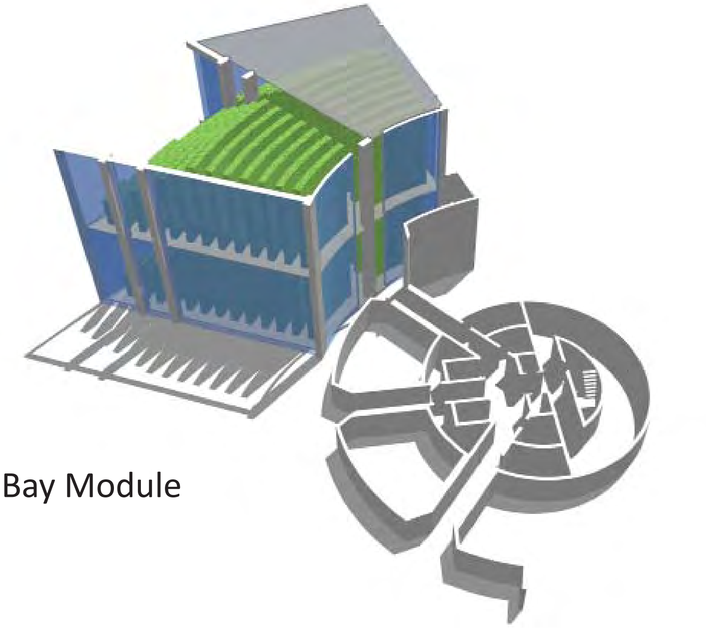


1st Floor Tilapia Processing

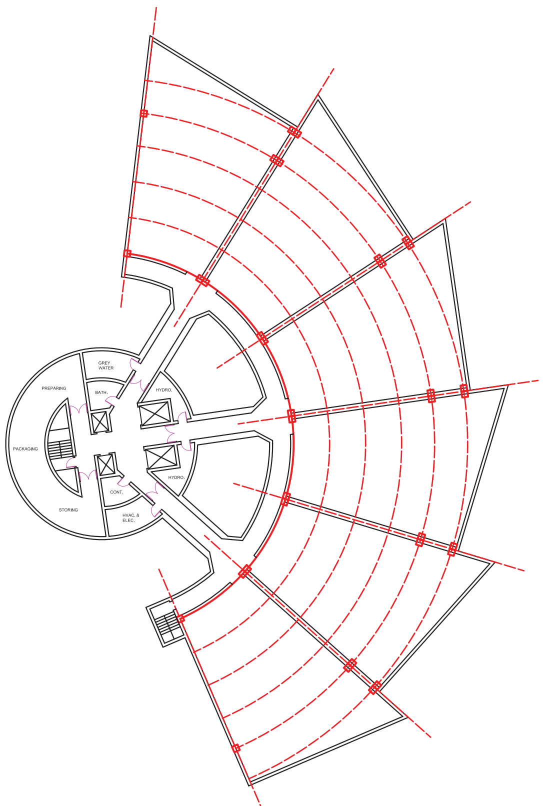


2nd Floor Tilapia

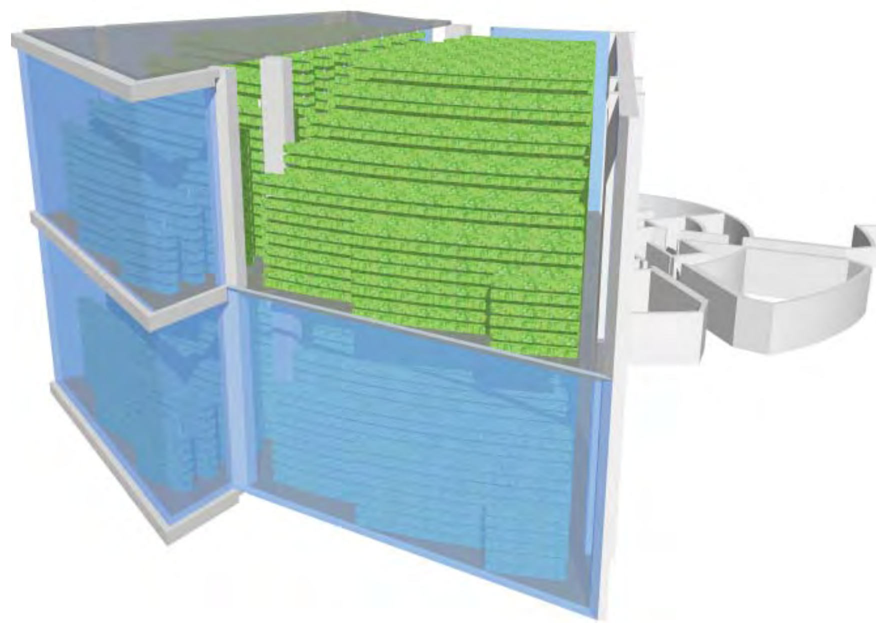
Site Plan



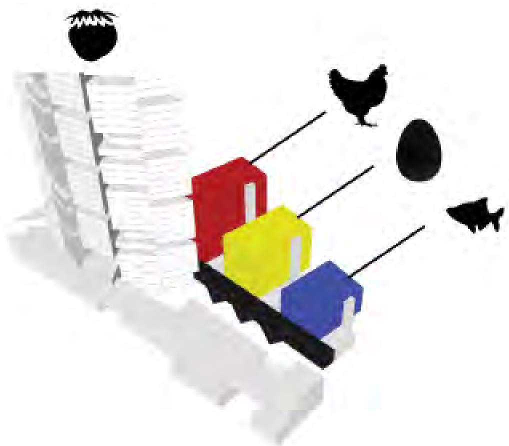
60' Bay Module



Structure

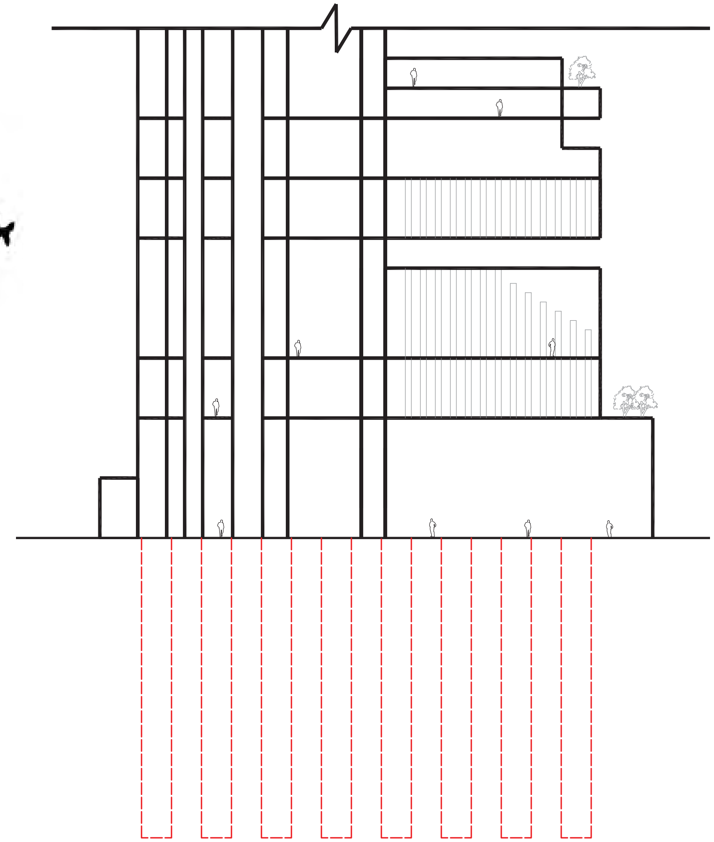


Zone Control of Crops

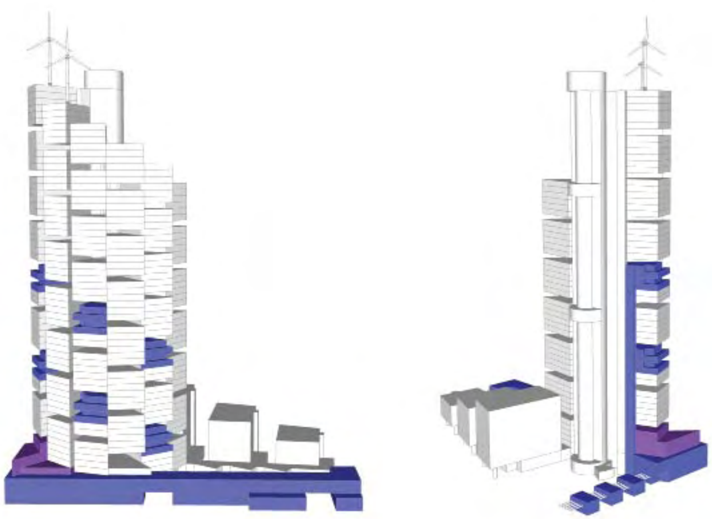


Program

Green Spaces / Offices

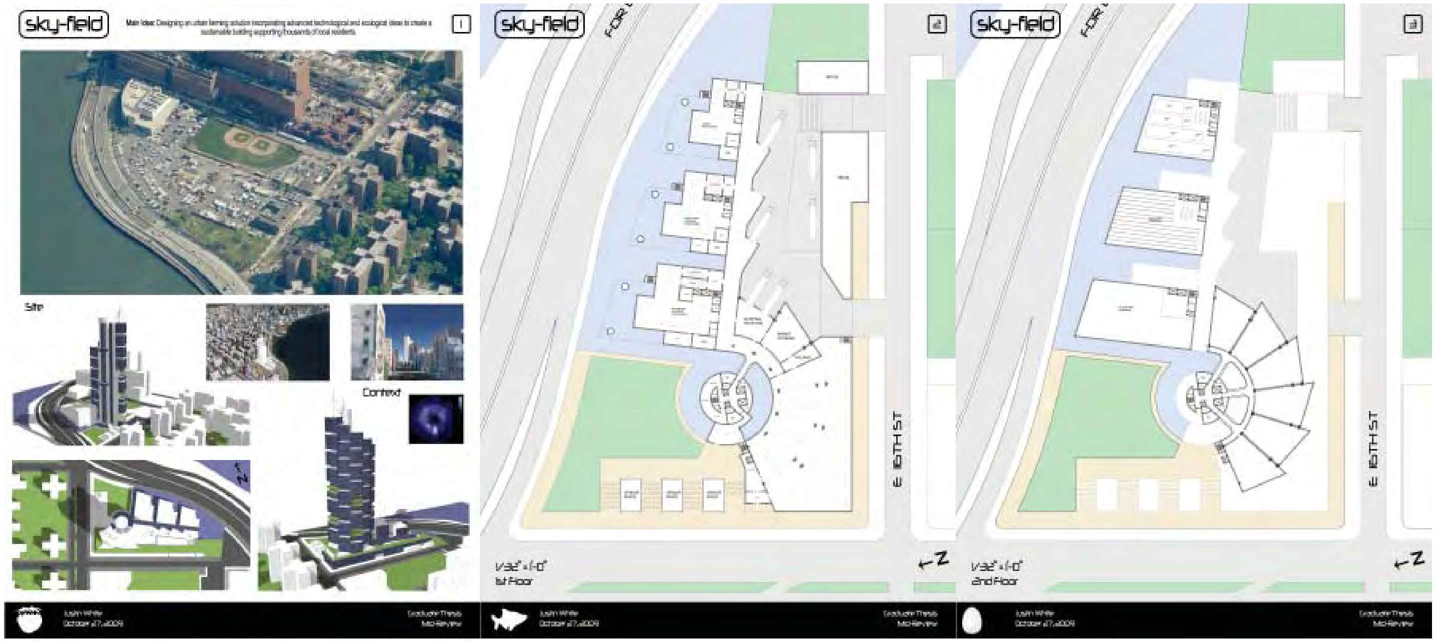


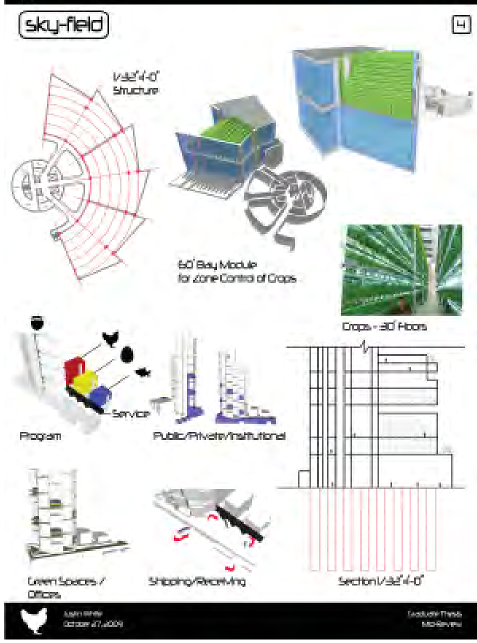
Section



Public / Private / Institutional

Shipping / Receiving





Presentation Boards

Study Model

Schematic Design Conclusion

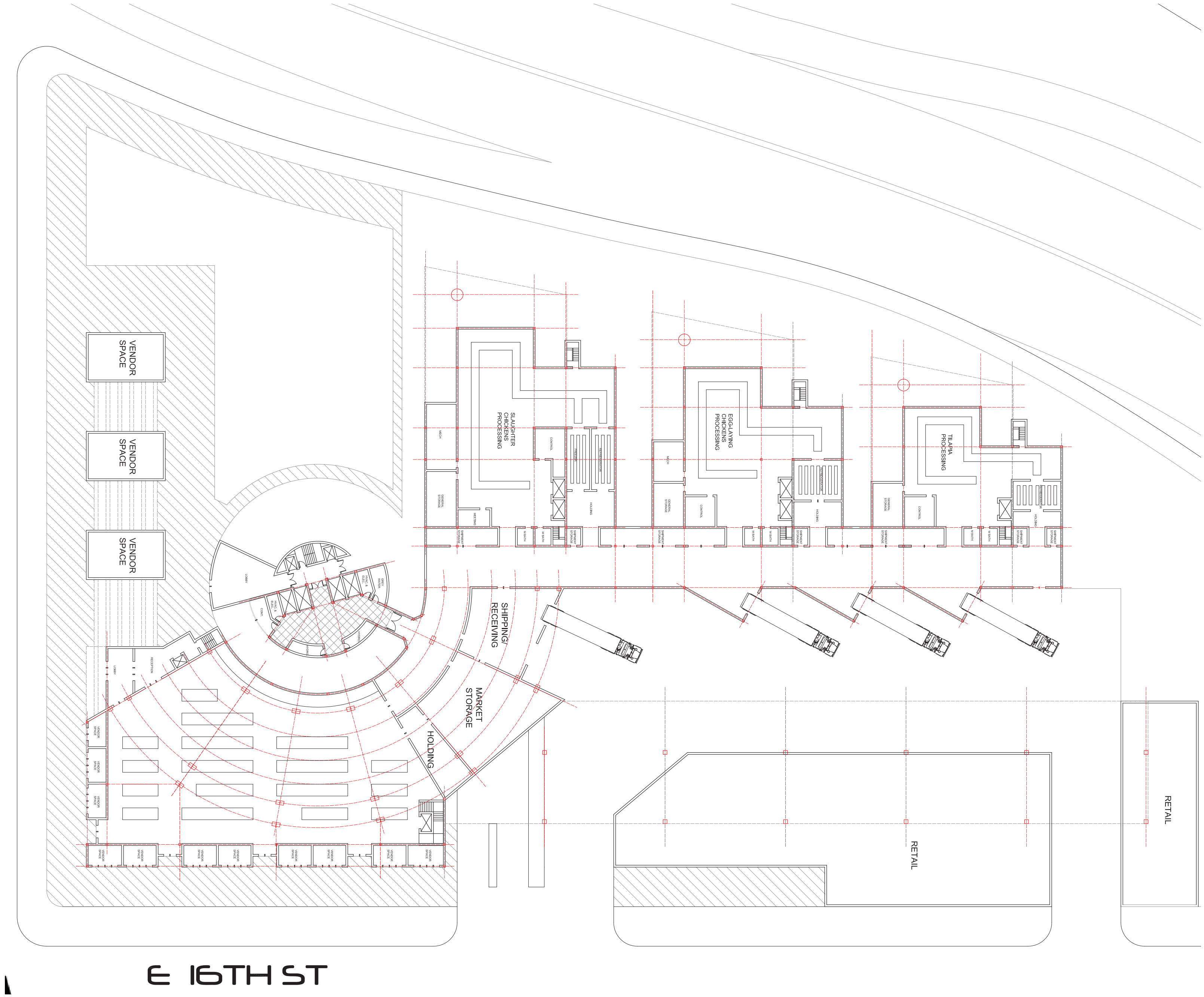
There were a couple of comments which followed this review. First, the core still needed some work because it didn't seem to relate to the activities that it served. The corridors impeded the flow of goods rather than encouraging it. To solve this some functions within the core needed to be moved around and enlarged, especially major circulation paths. Also, the ventilation space between floors seemed to be too large and unpractical. The slab conditions needed to be investigated in order to lower this dimension.

The second comment was a rather large suggestion. The idea of maxing out the site with crops came into question. An addition of a horizontal element was strongly advised. This would give more crop production and use the full amount of sunlight that is brought upon the site.

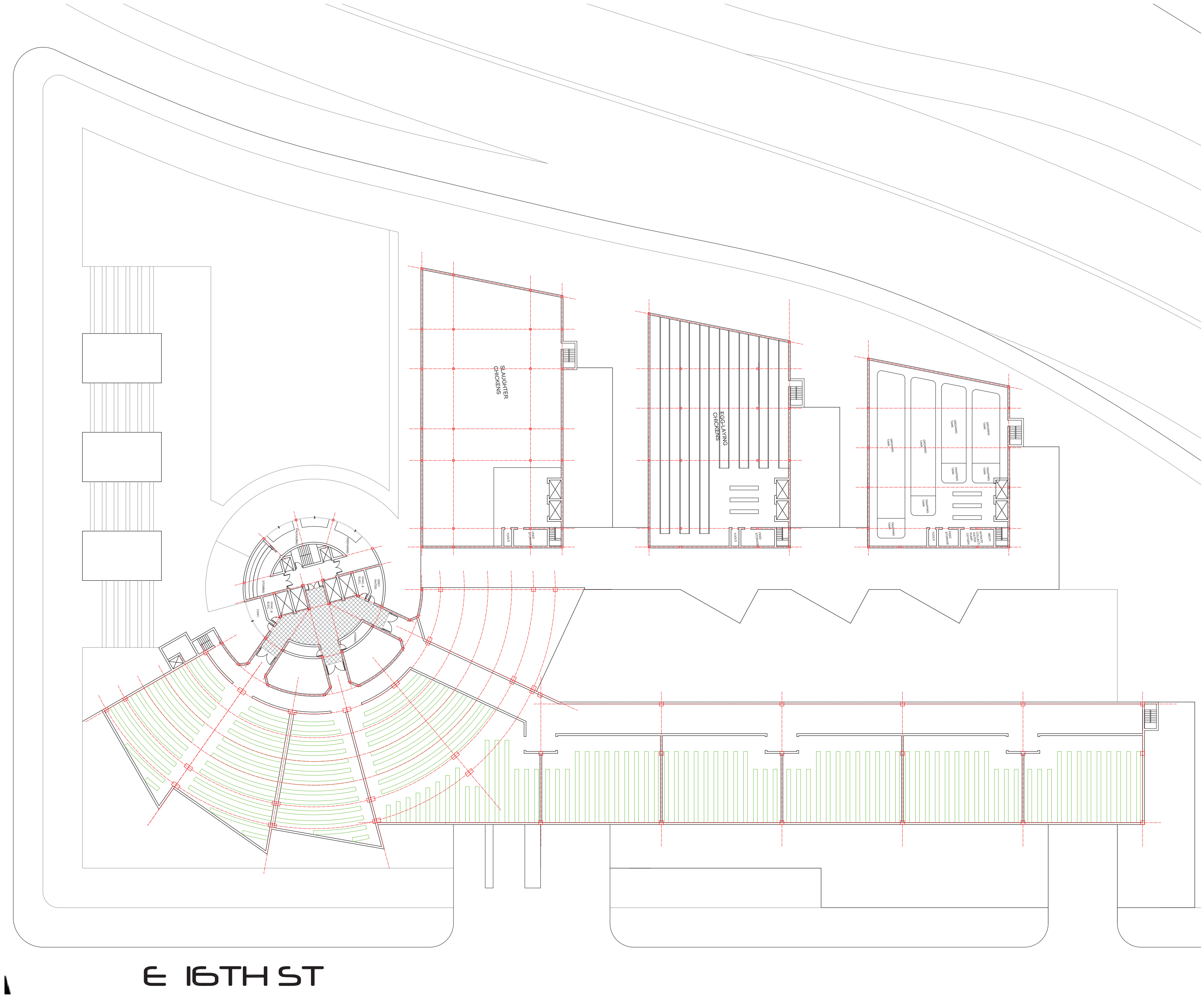
Process - Design Development

In the third stage of process, the building needed to gain more rigidity in its structure, construction, services, and presence. Once being satisfied with the form and presentation of the building from previous assignment, it was now time to nail down some dimensions and detail. During this time I focused on coming up with a gridded structural system which would support the building. I developed the idea of specialty plans and worked in detail on how the crop bays would work. I went further into detail drawing the facade and even how the light would bounce into the distant crop areas. Last, I worked on hydroponic details and what they might look like.

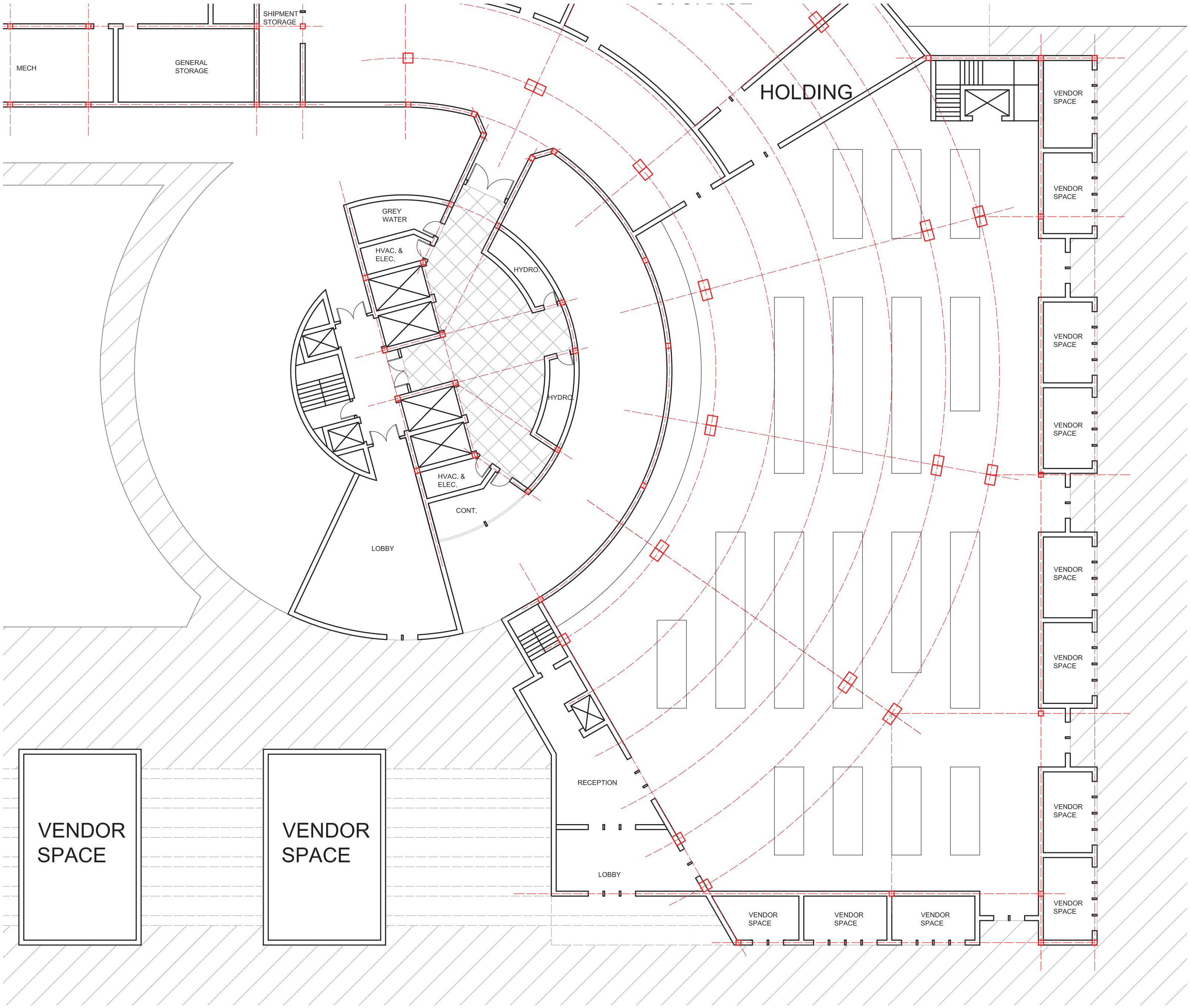
The following contains the design development presentation drawings.


VENDOR SPACE
VENDOR SPACE
VENDOR SPACE
SLAUGHTER CHICKENS PROCESSING
EGG-LAYING CHICKENS PROCESSING
TILAPIA PROCESSING
SHIPPING/ RECEIVING
MARKET STORAGE
HOLDING
RETAIL
RETAIL
E 16TH ST

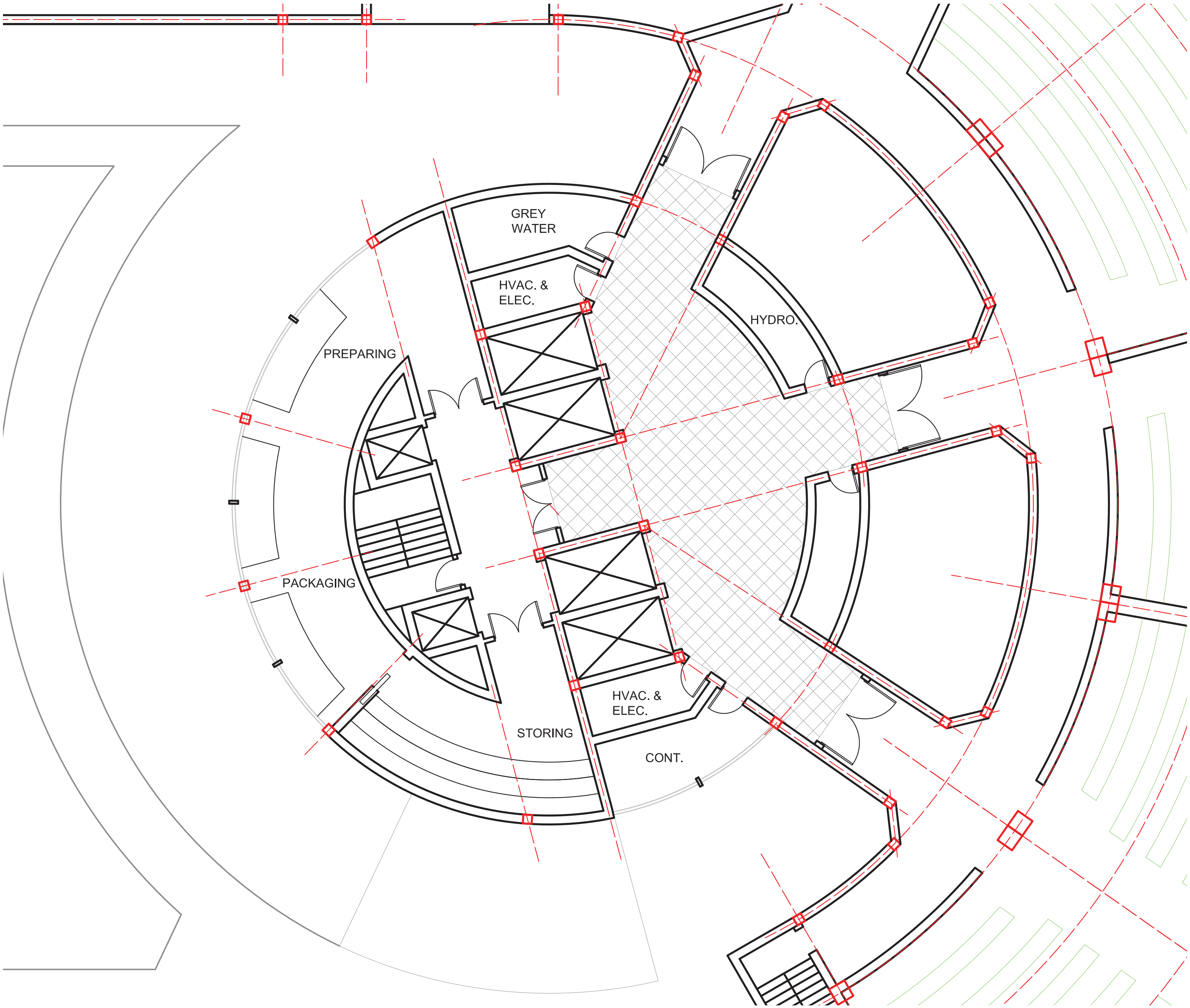
1st Floor



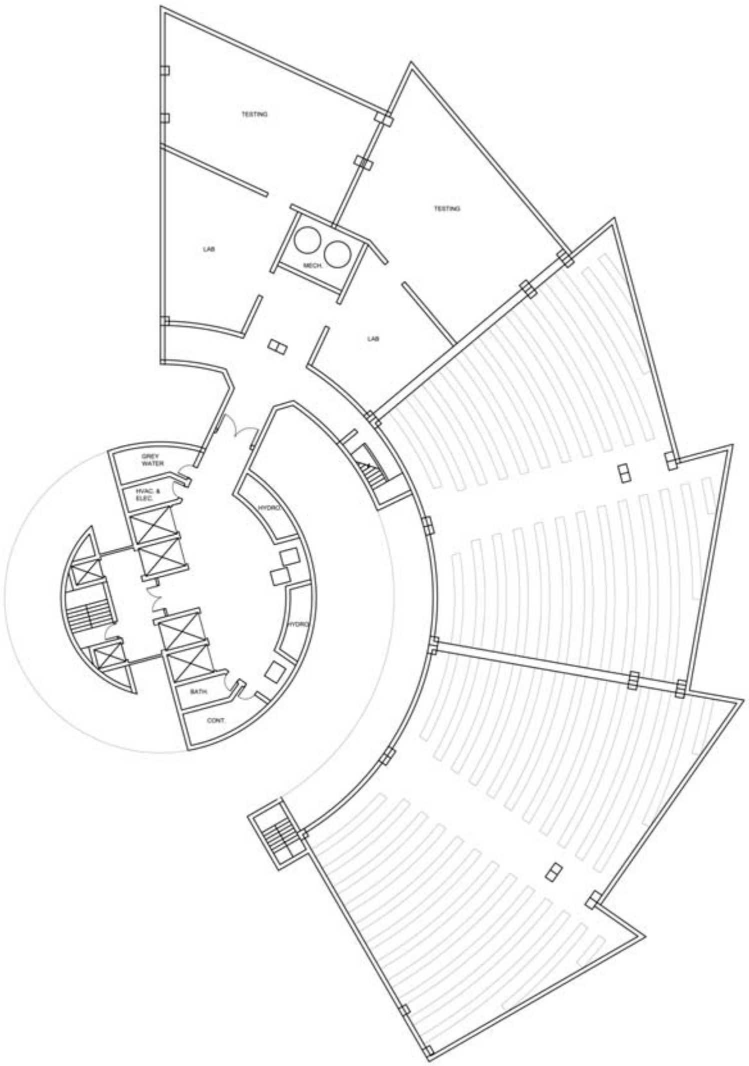
2nd Floor



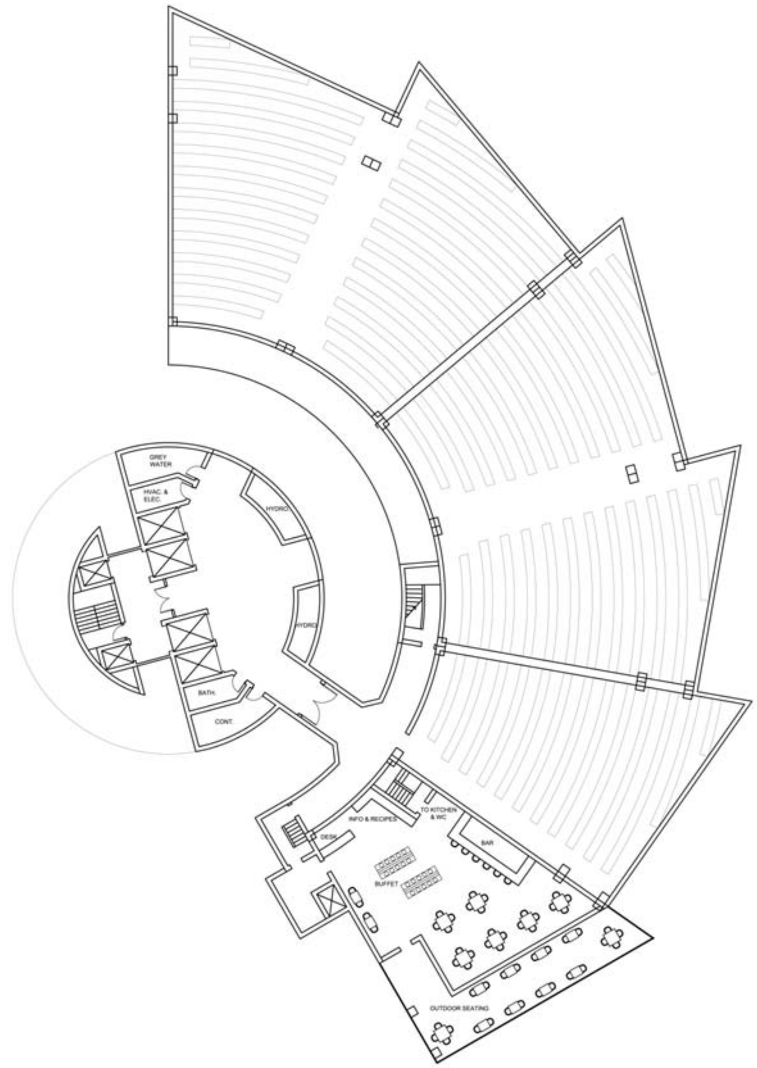
Marketplace



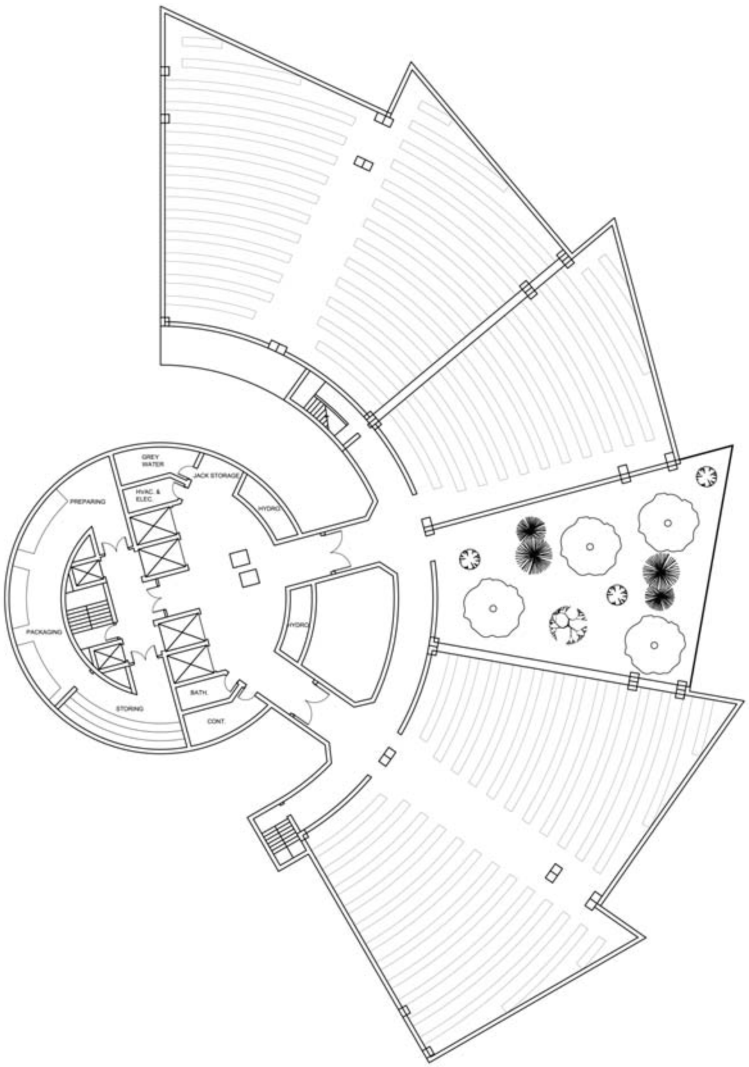
Typical Preparing Floor



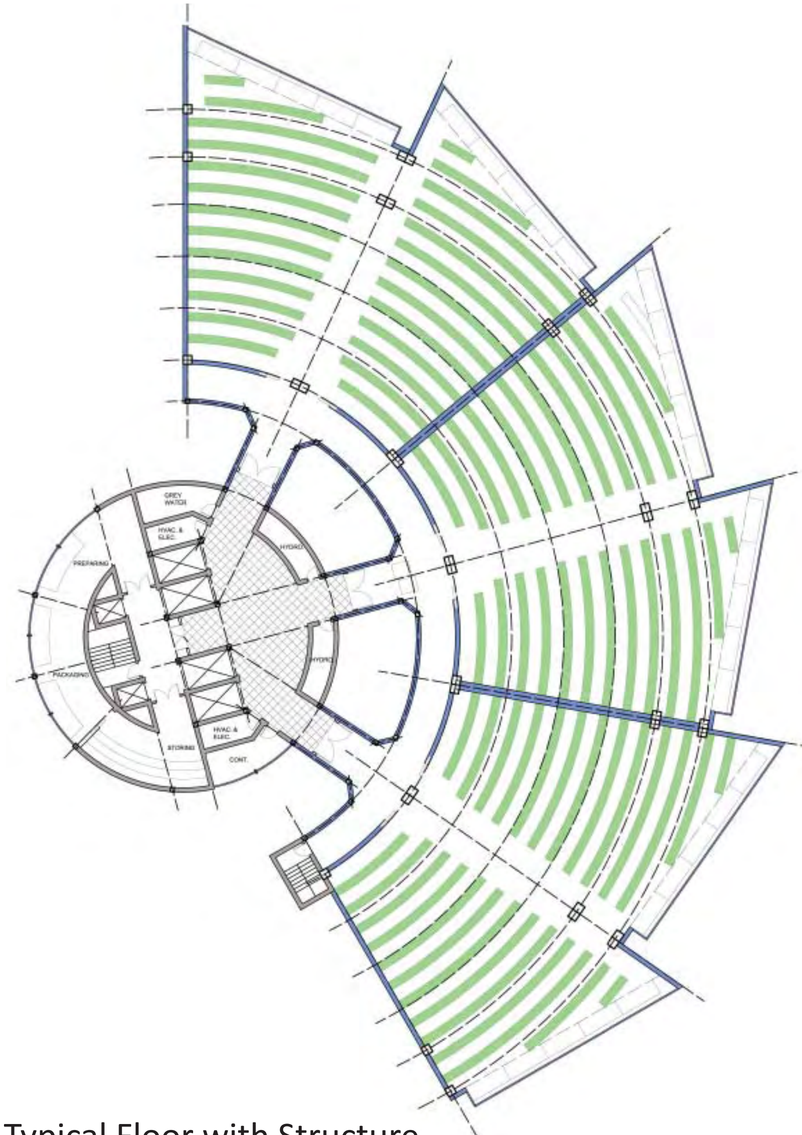
Labs



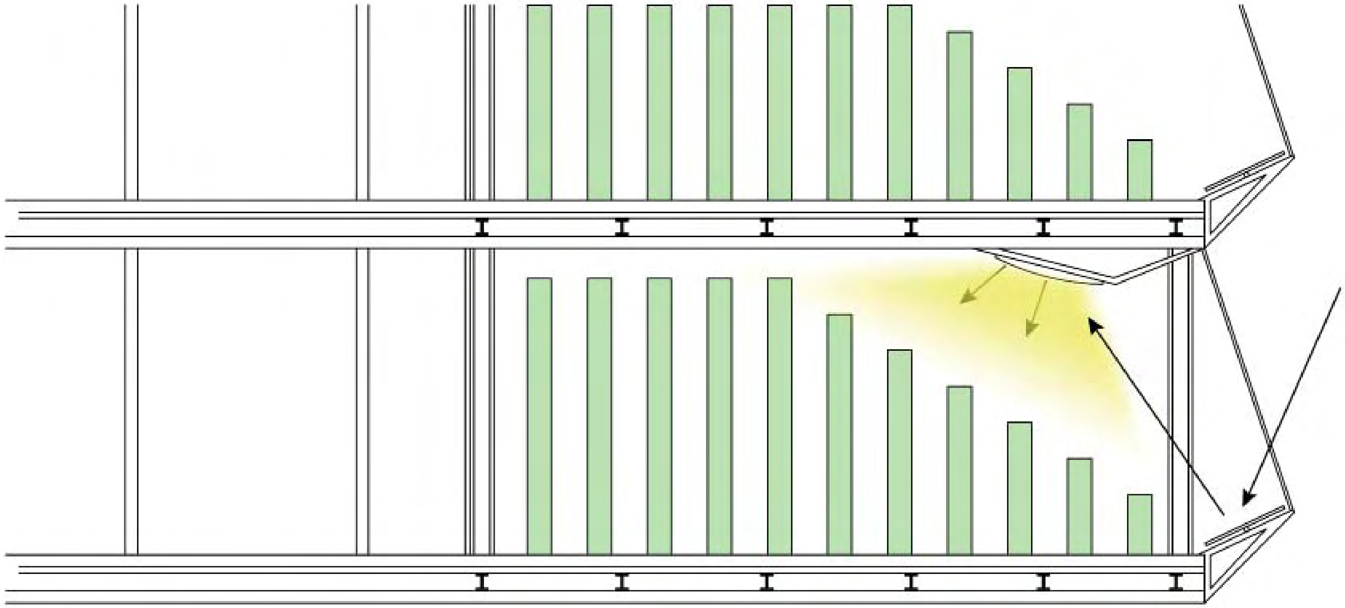
Restaurant



Park Space / Fruit Growing



Typical Floor with Structure

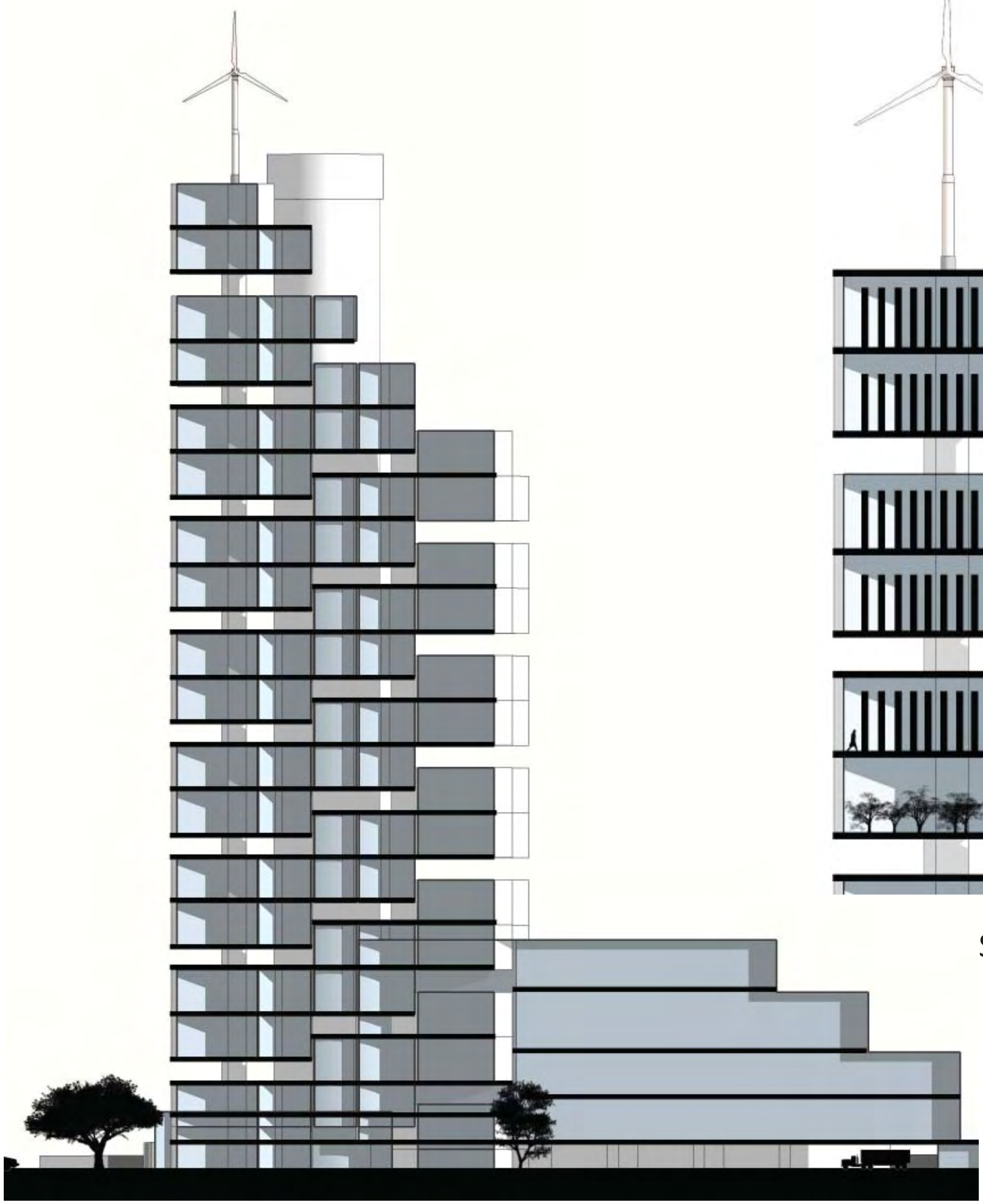


Computer-controlled mirrors track the sun.

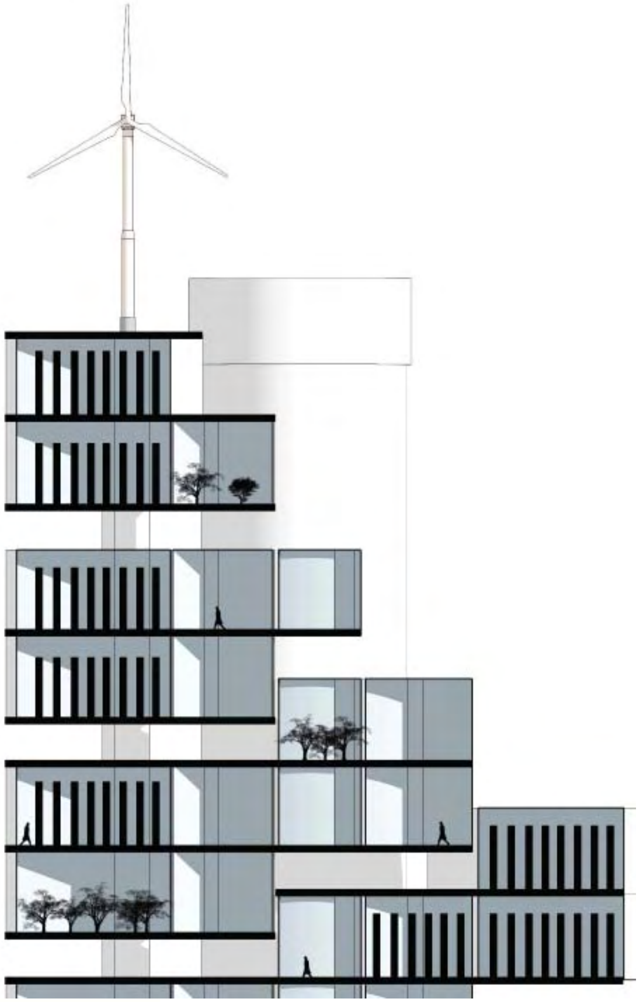
Illustrated in Black Available Colour is Grey	SmartCrate Part Number	Dimensions L x W x H (mm)	Collapsed Height (mm)	Return Ratio	Capacity (Litre)	Weight (Kg)	Quantity Per Pallet Full *	Quantity Per Pallet Collapsed **
	# AP6411	Ext: 600 x 400 x 127 Int: 575 x 375 x 110	35.6	3.6 to 1	24.04	1.47	85	160

Transportation of crops with crates.

Electric pallet jack used for transport.



Longitudinal Section



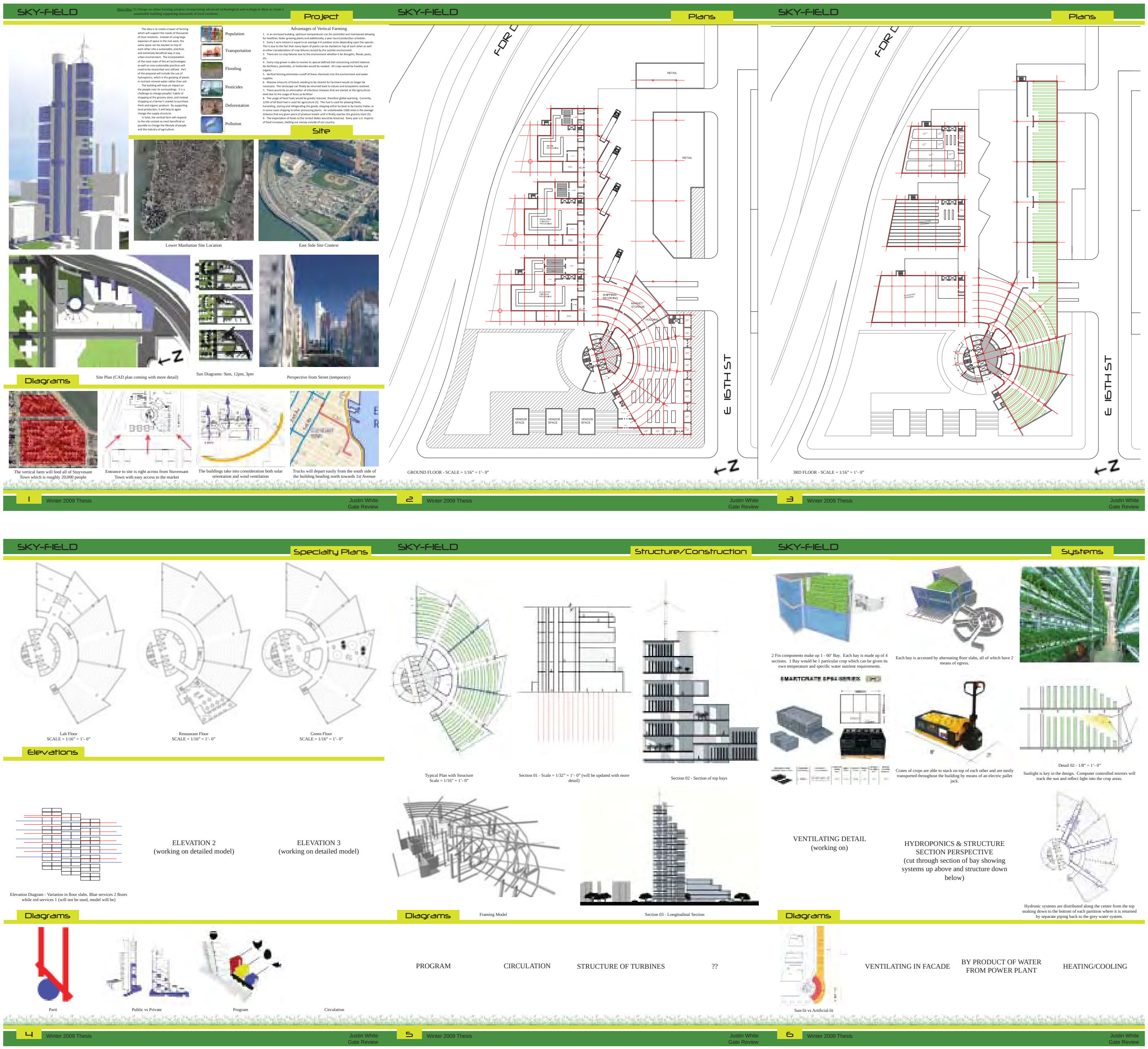
Section of top bays.

Fall '09 Thesis

Design Development

SKY-FIELD

Justin White



Presentation Boards

Design Development Conclusion

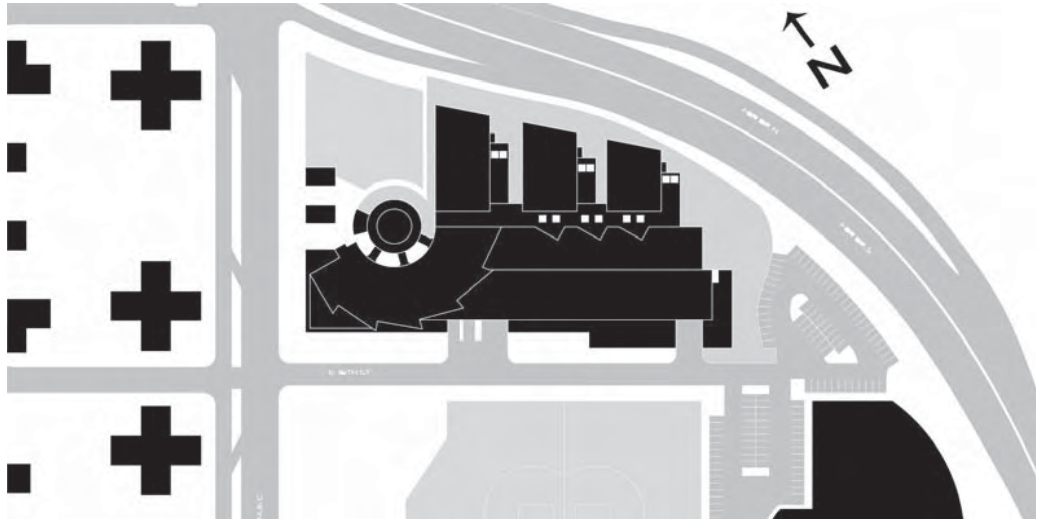
This presentation was a pin-up only to make sure the project was on track. Therefore, no feedback was given.

Final Presentation

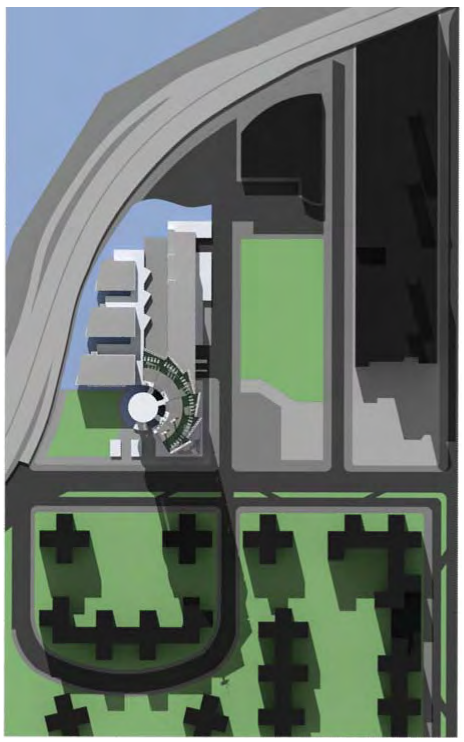
The final stage consisted of ironing out all the wrinkles in the design. Fairly early in this process I had finalized the floor plans. I had also managed to create some very interesting sections with varying floor slabs. Now it was a matter of looking at the elevations of not only the crop areas but also what the marketplace and other public areas were going to look like. Presentation was the primary focus towards the end, in other words making everything look good. More perspectives were started in this process, and really trying to get a feel for what it would be like to be in this building.


SKY-FIELD

Feeding Stuyvesant Town

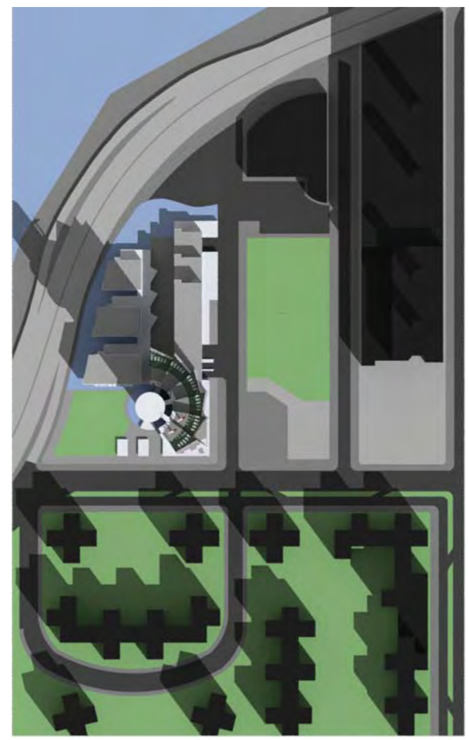


Site Plan
Scale = 1/256”

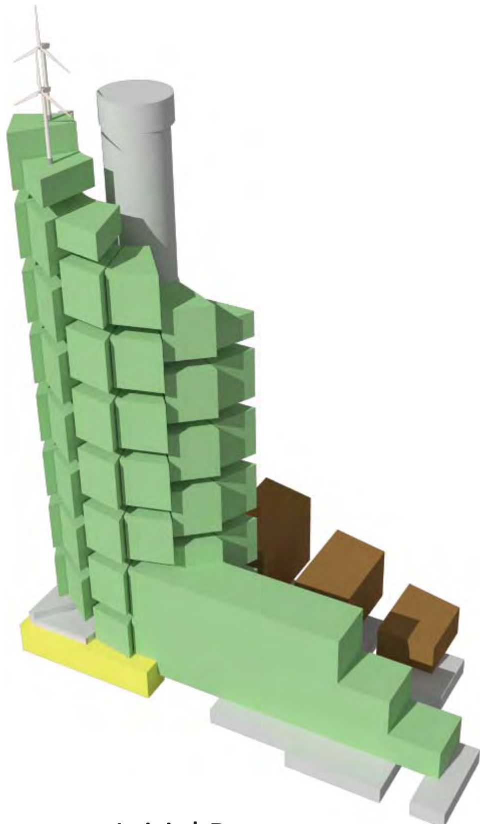


9 AM

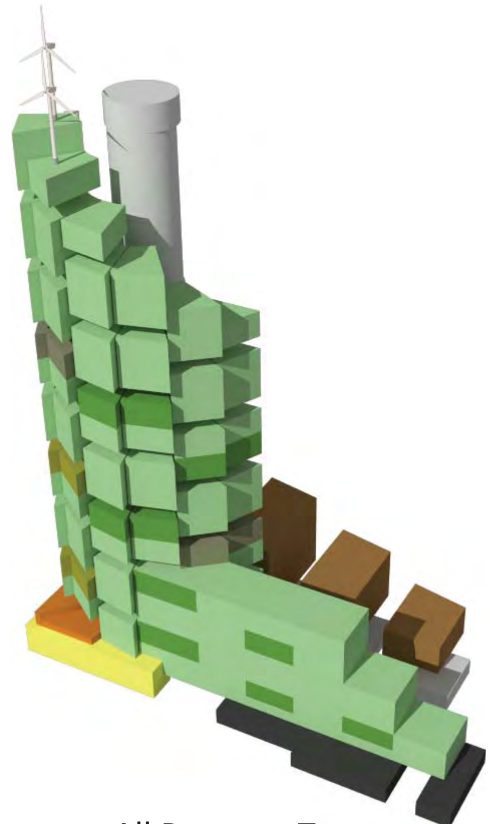
12 PM



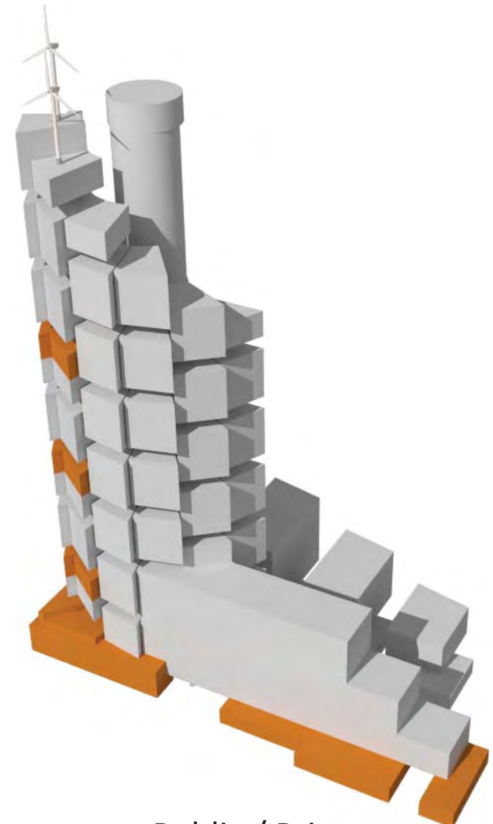
3 PM



Initial Program



All Program Types

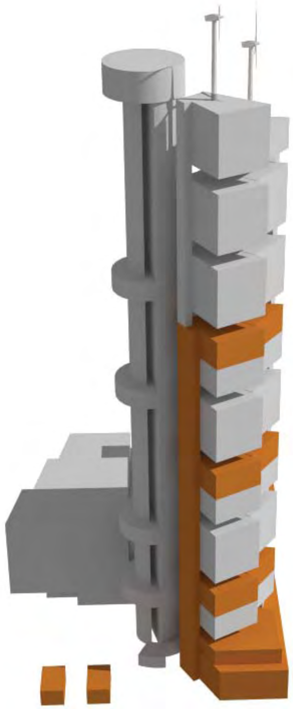


Public / Private

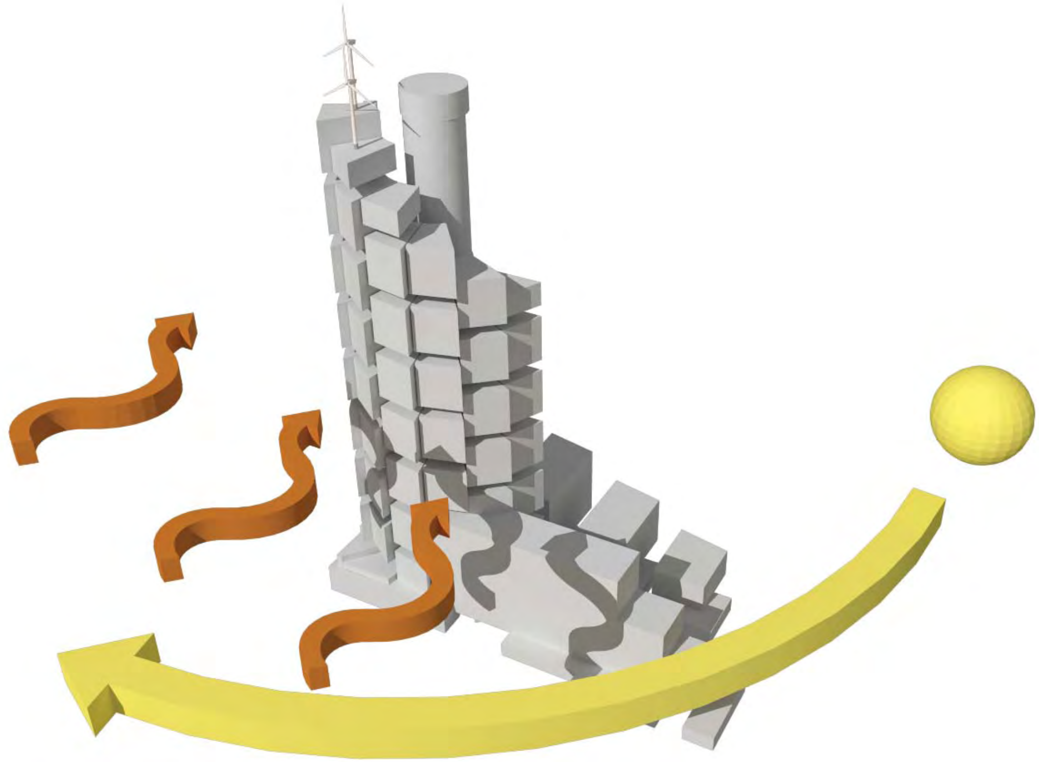
Entrance to Site

Trucking

Conserved Park

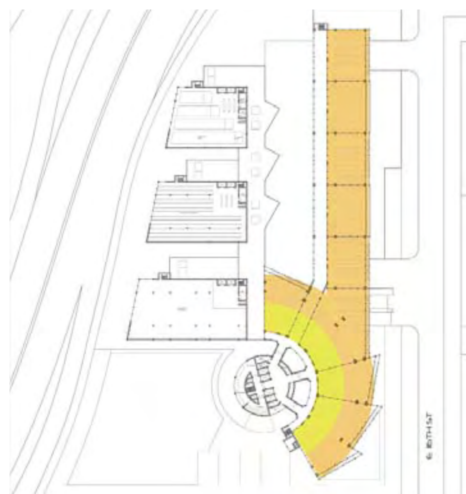


Public / Private 2

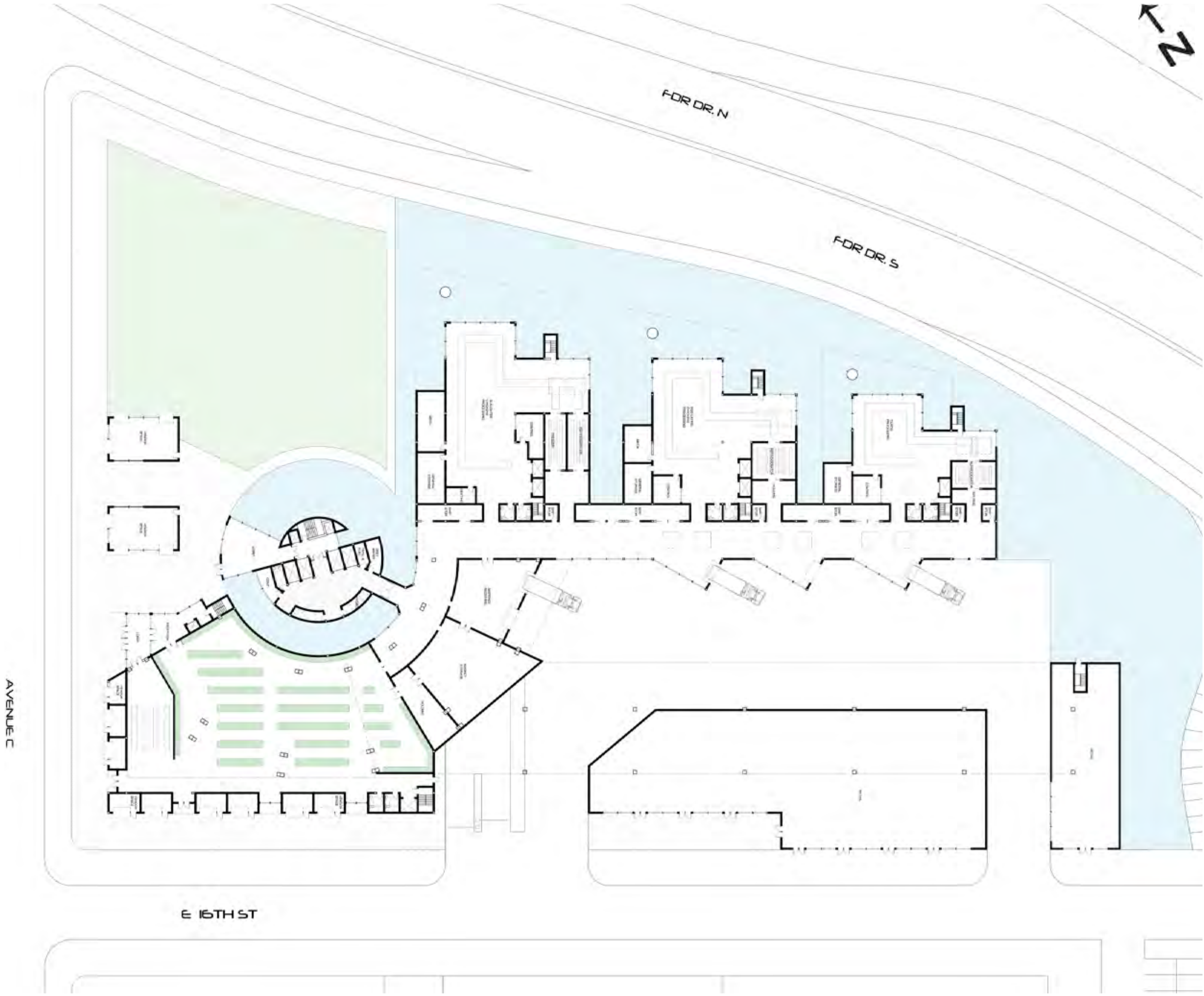


Sun & Wind

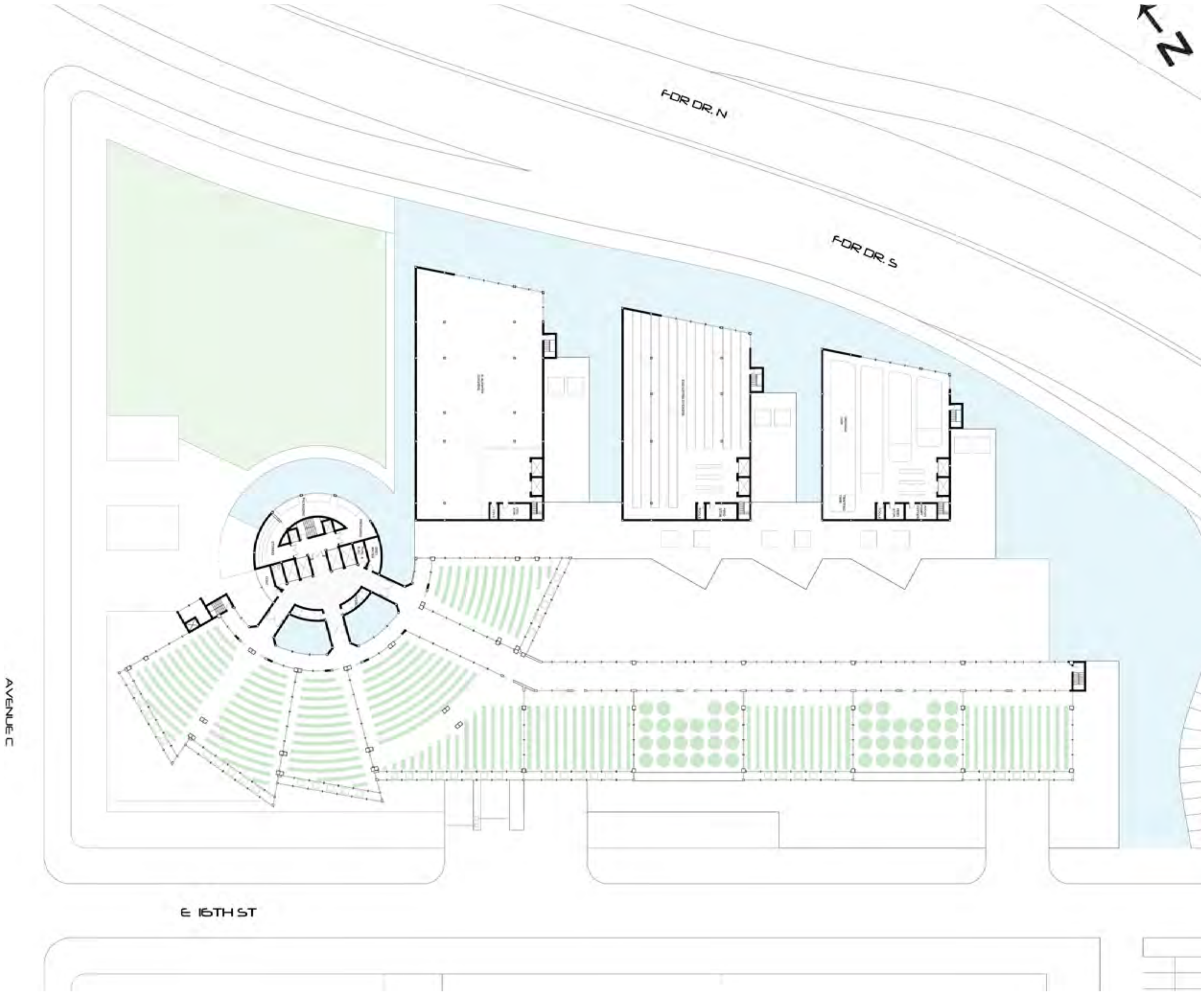
Demineralized By-product



Sunlit Vs. Artificial Lit

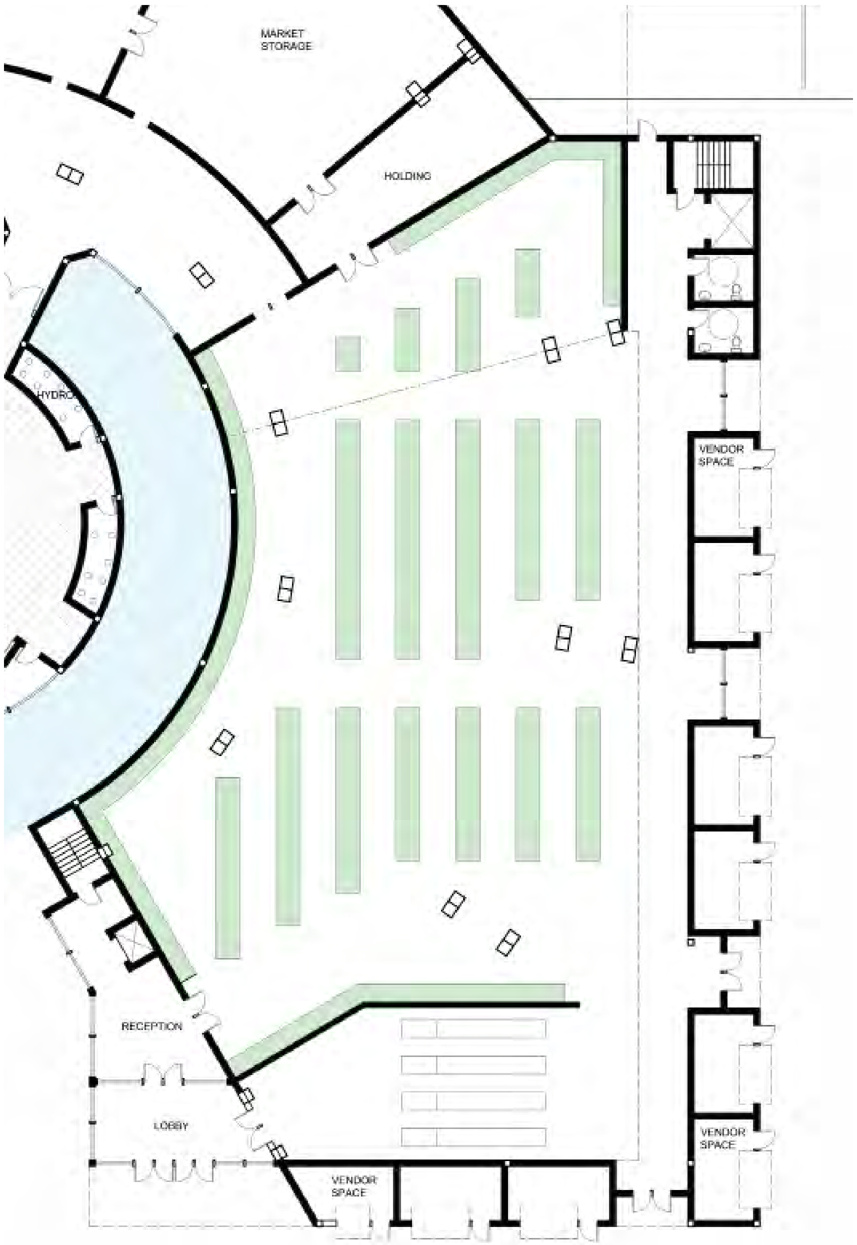


1st Floor
Scale = 1/80"

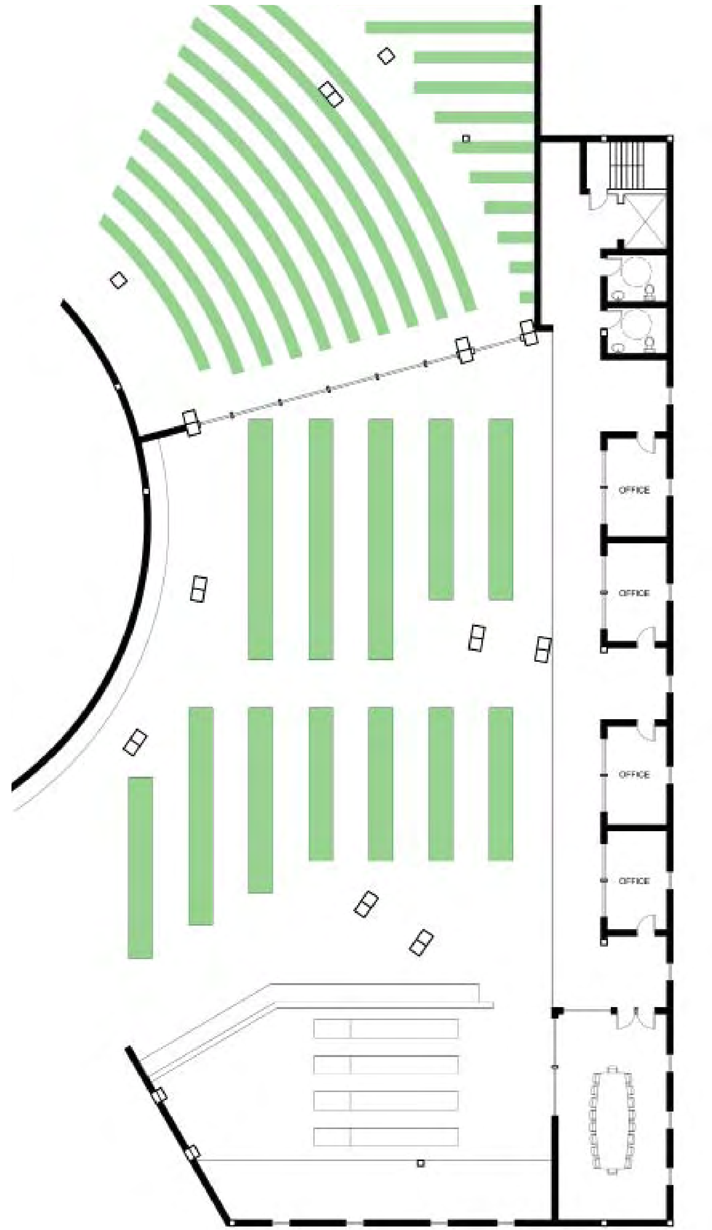


2nd Floor
Scale = 1/80”

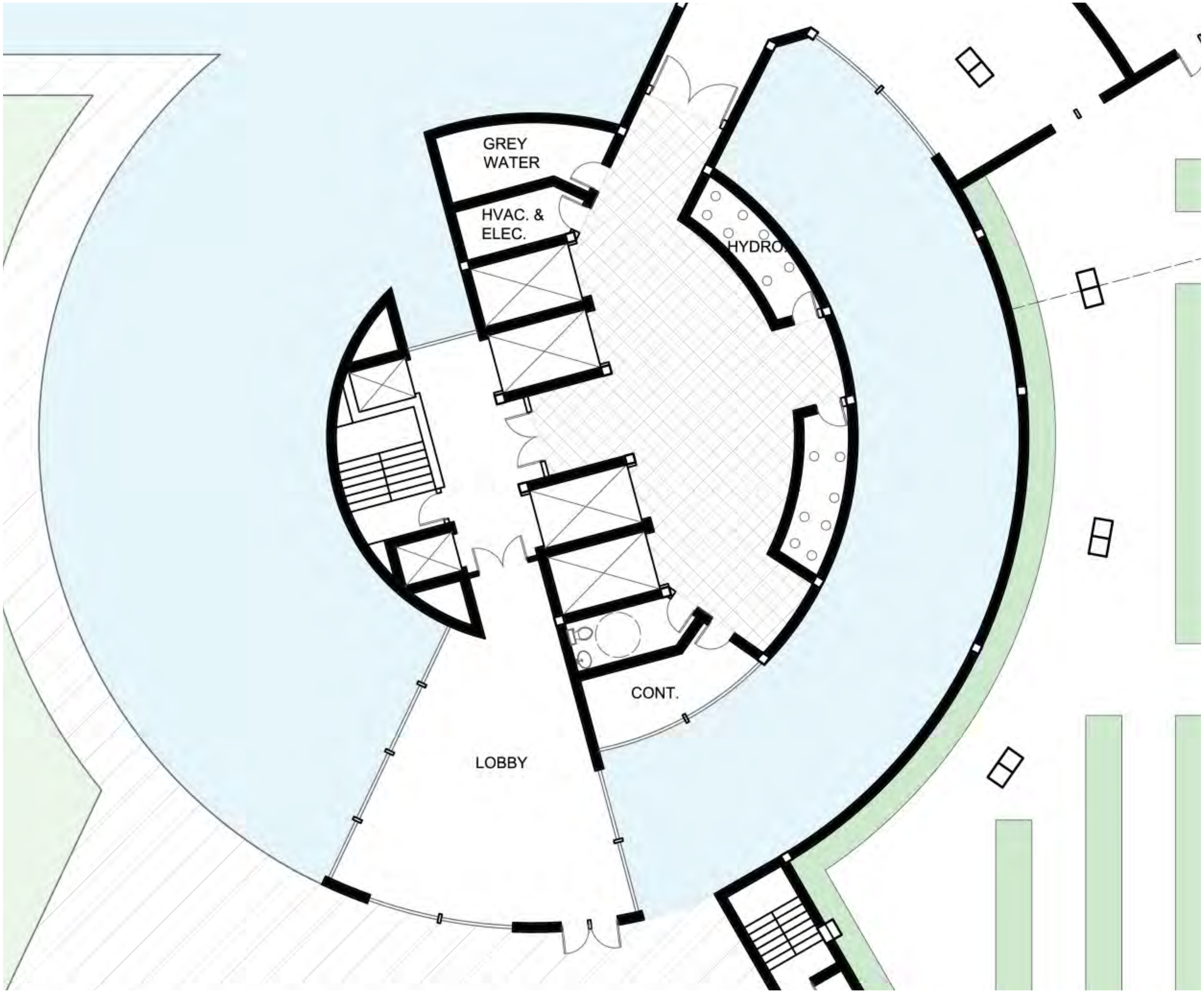
Conserving Murphy Park



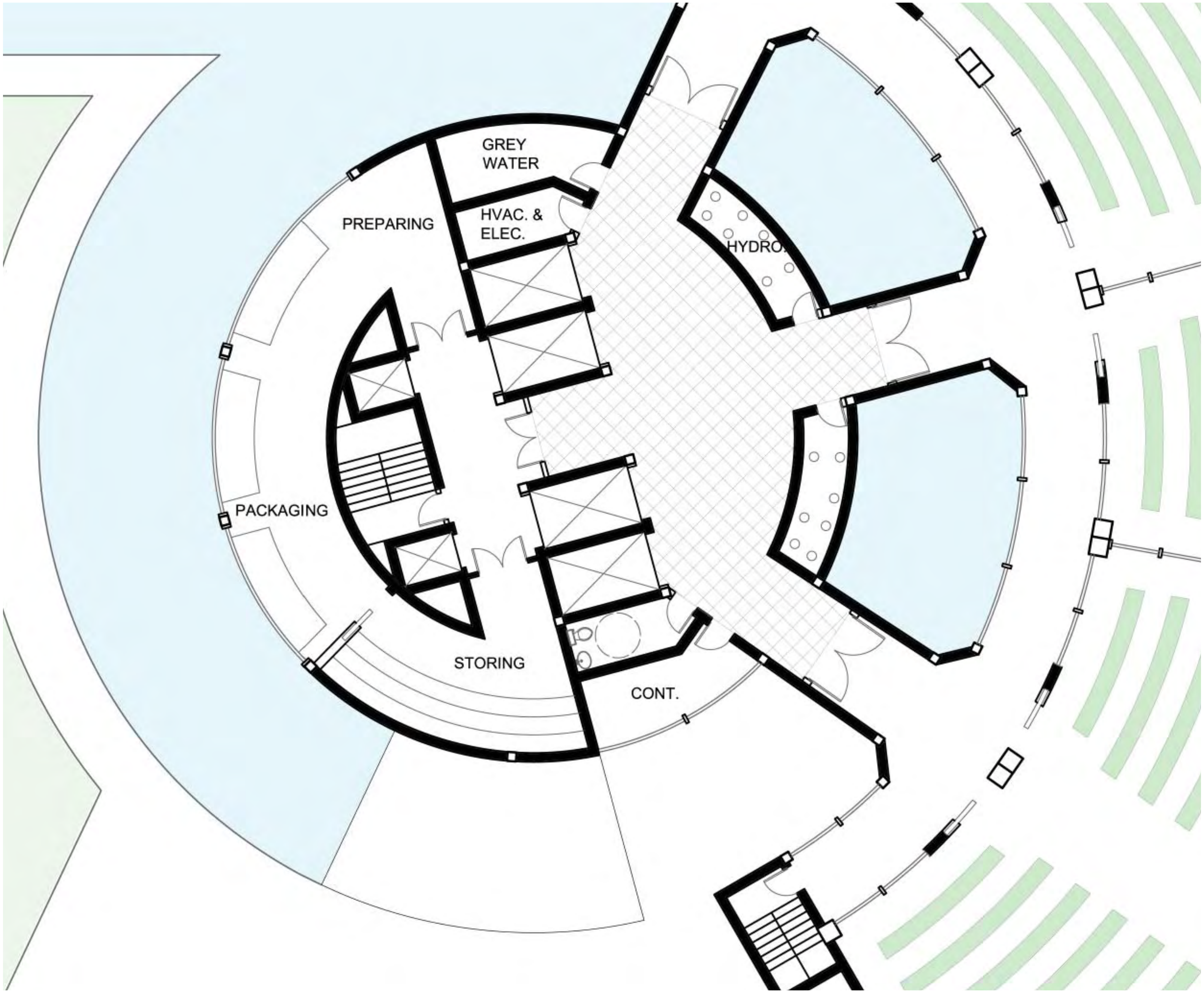
Marketplace
Scale = 1/32”



Mezzanine Floor
Scale = 1/32”

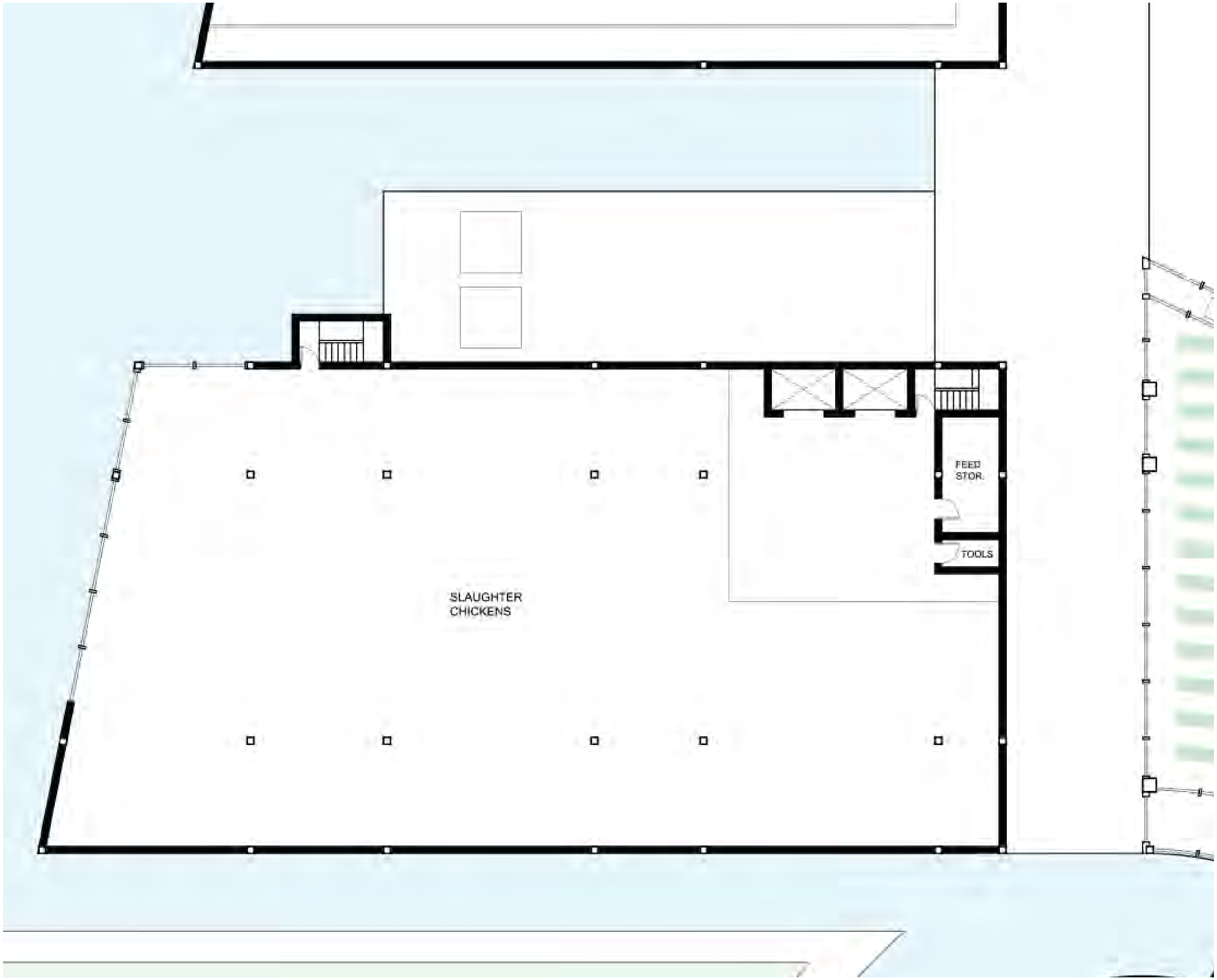


1st Floor Core
Scale = 1/16"



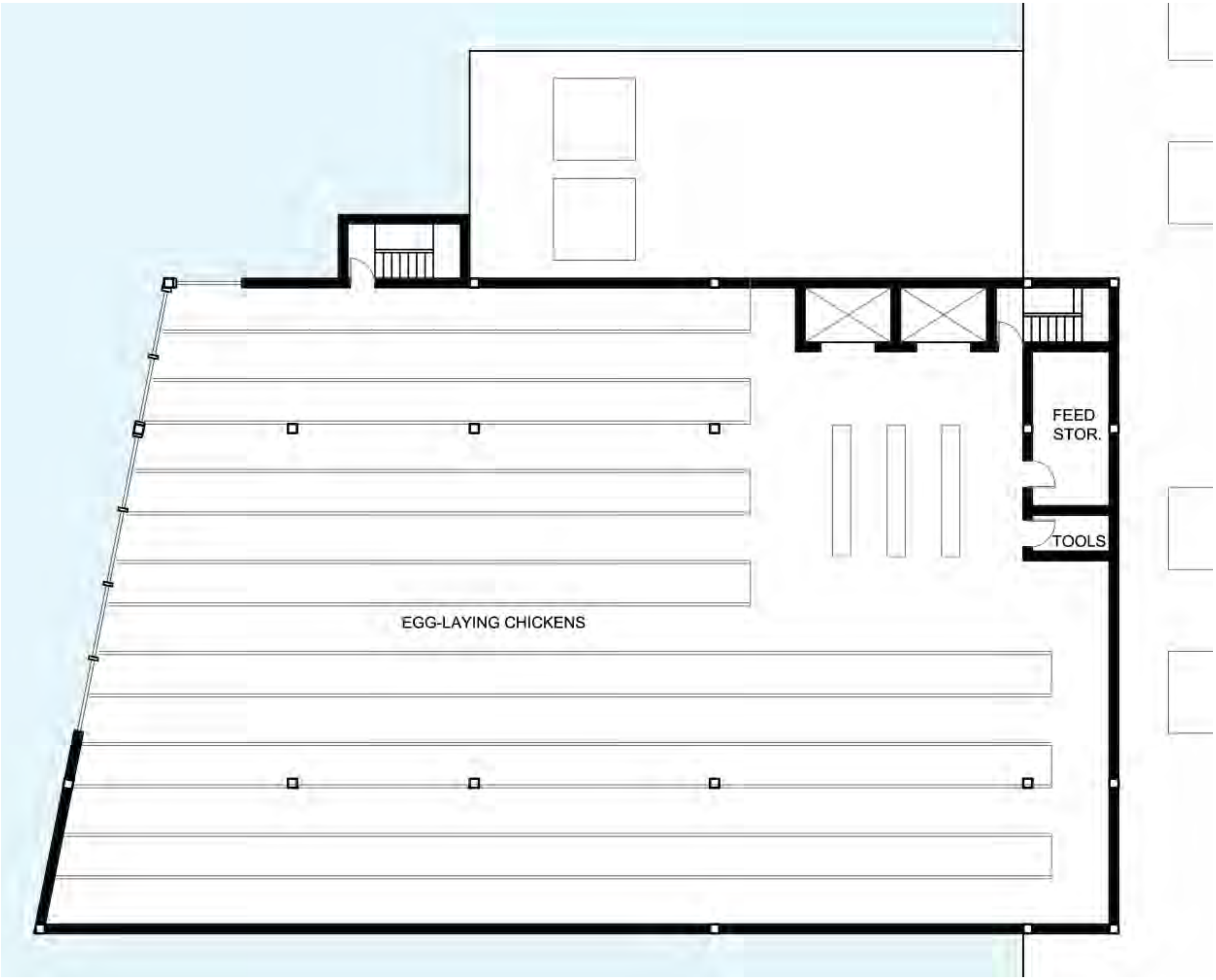
2nd Floor Core
Scale = 1/16"

1st Floor Slaughter-Chickens Processing
Scale = 3/64"

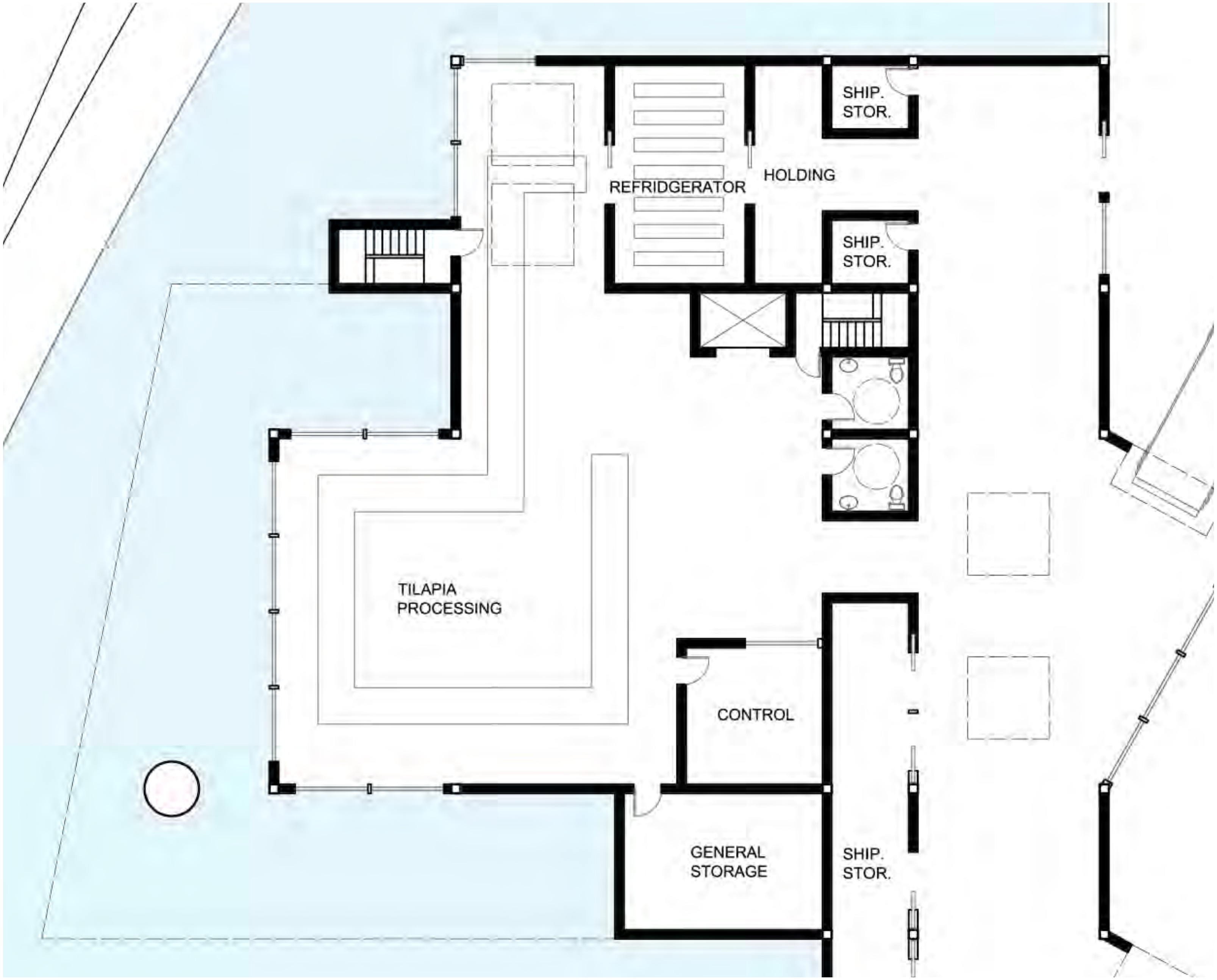


2nd Floor Slaughter-Chickens
Scale = 3/64”

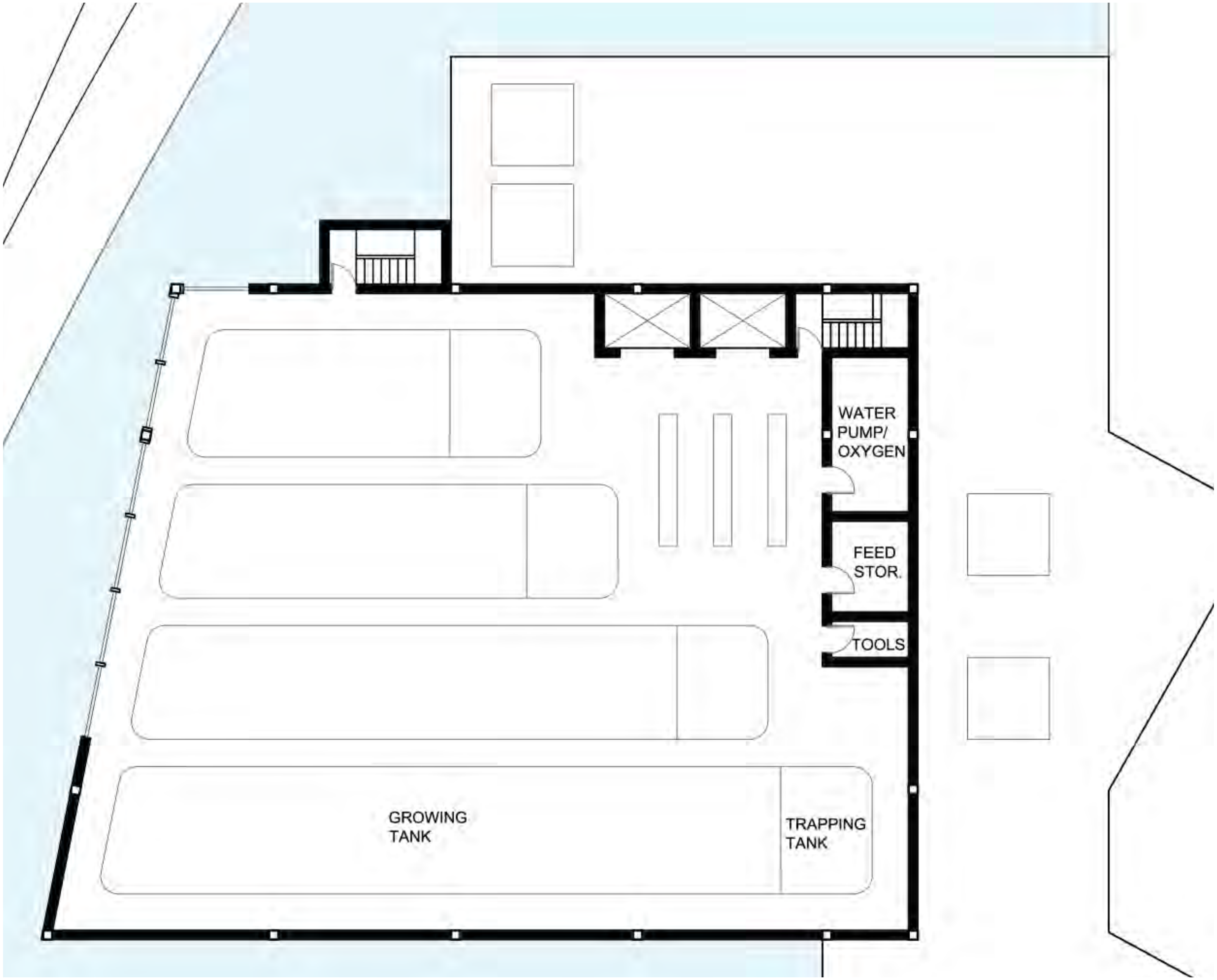
1st Floor Egg-Laying Chickens Processing
Scale = 3/64"



2nd Floor Egg-Laying Chickens
Scale = 3/64”



1st Floor Tilapia Processing
Scale = 3/64"



2nd Floor Tilapia
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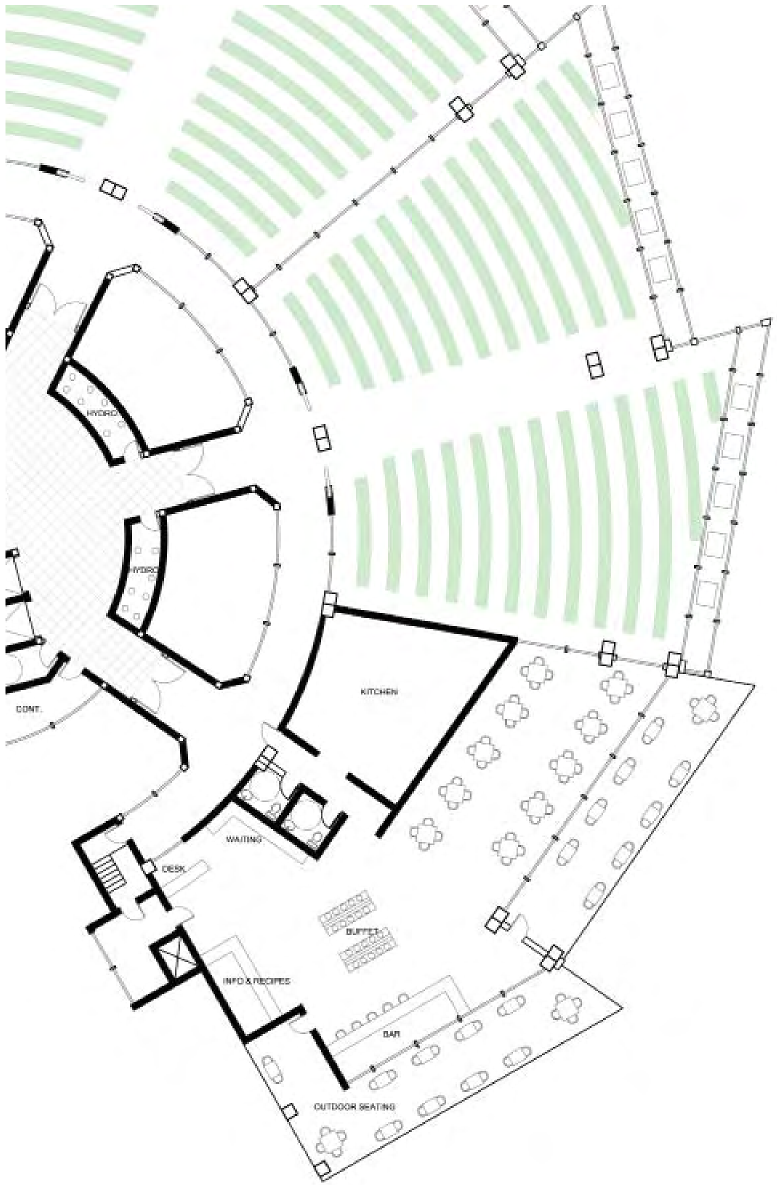
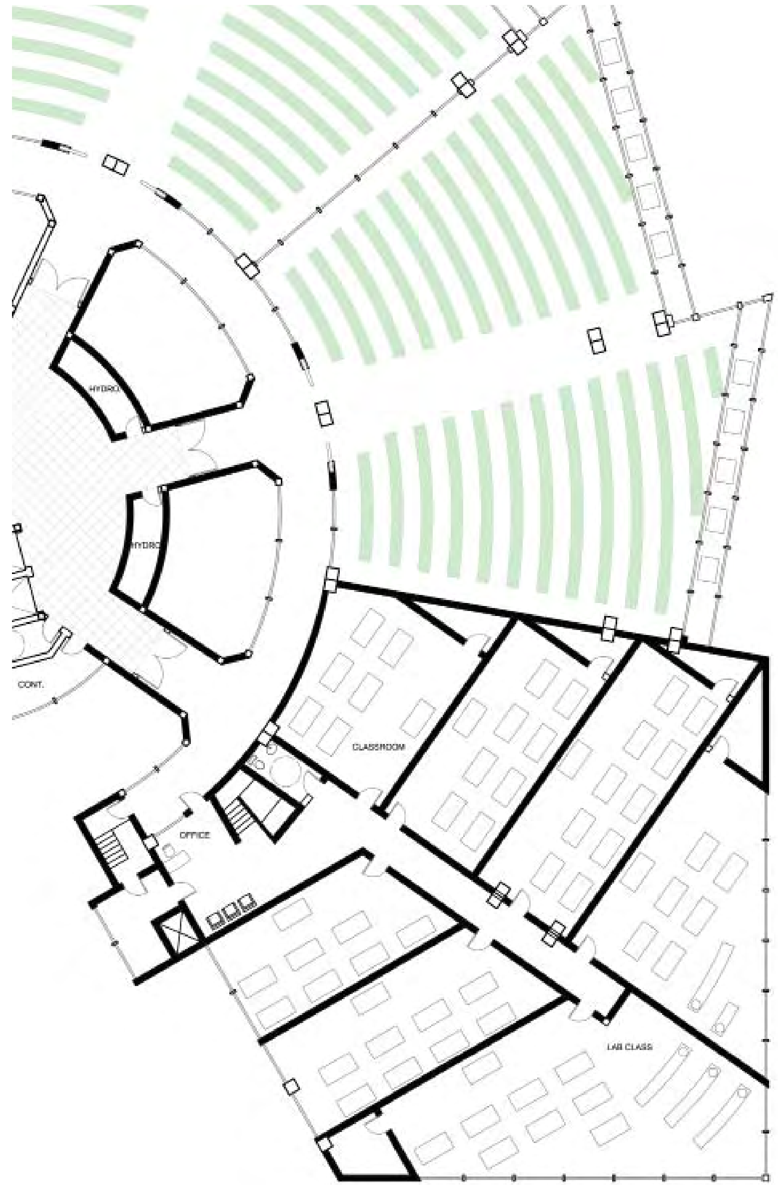
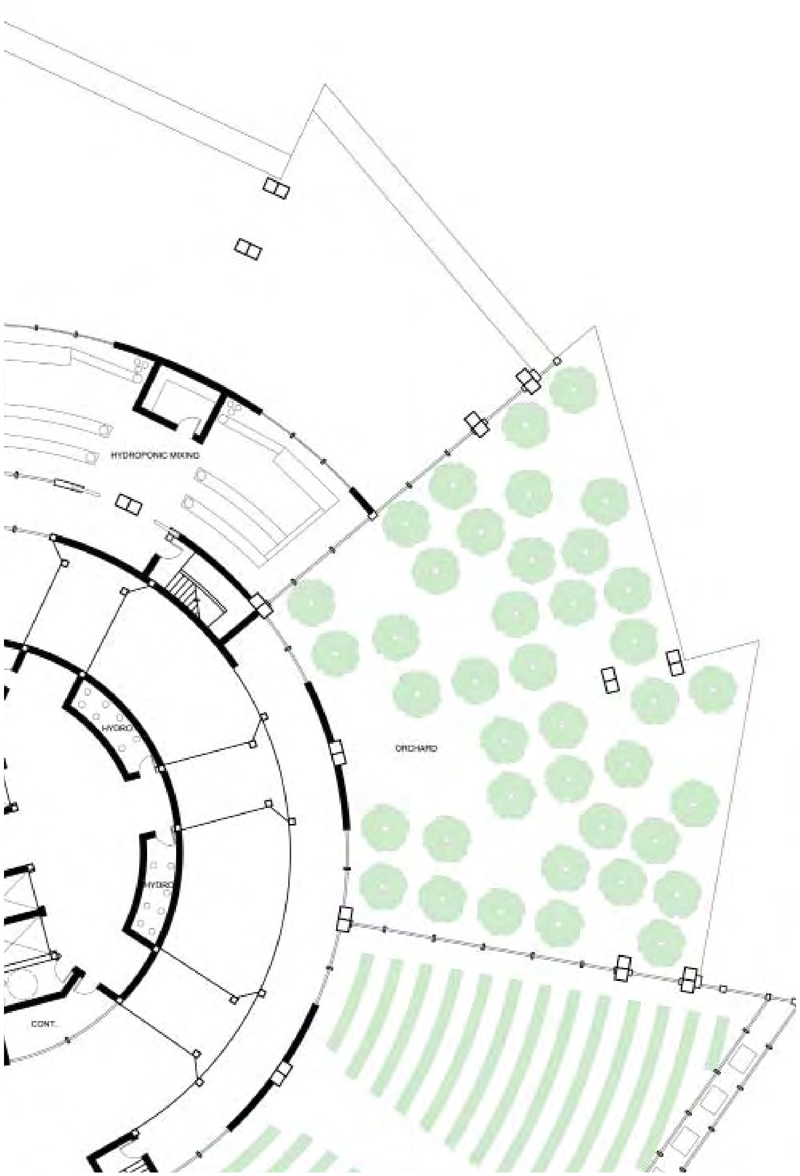


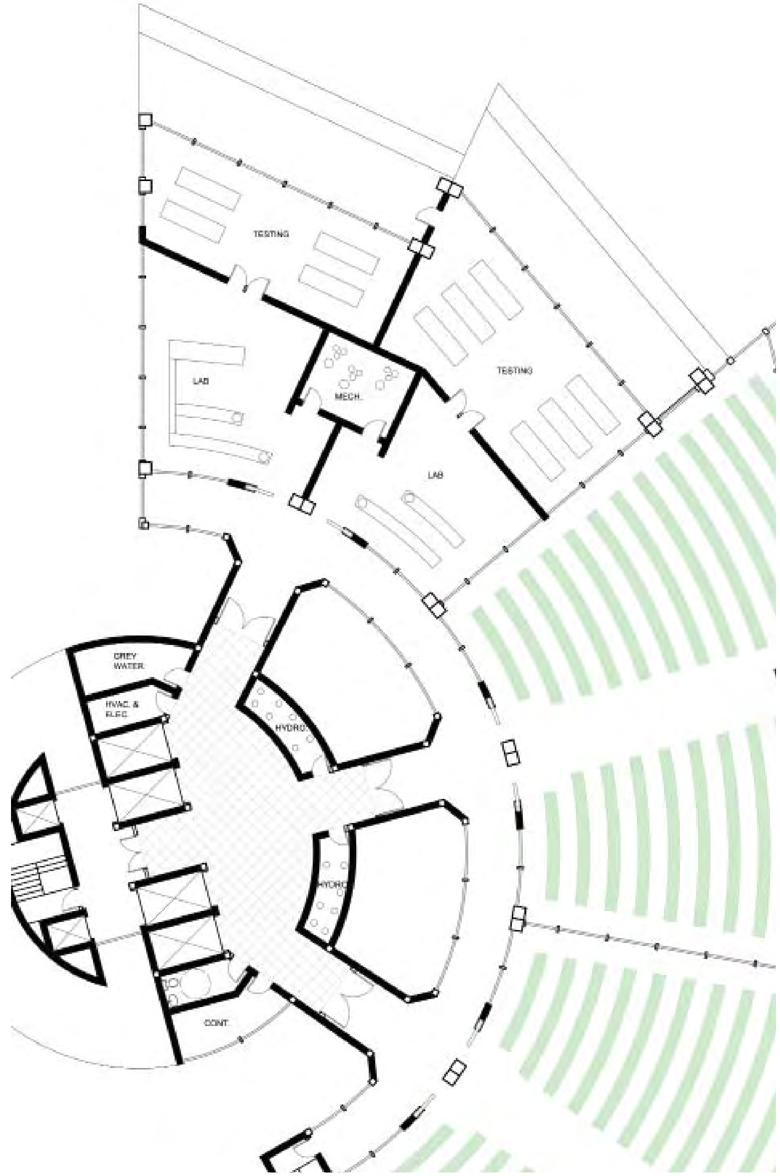
Restaurant Floor
Scale = 1/32"



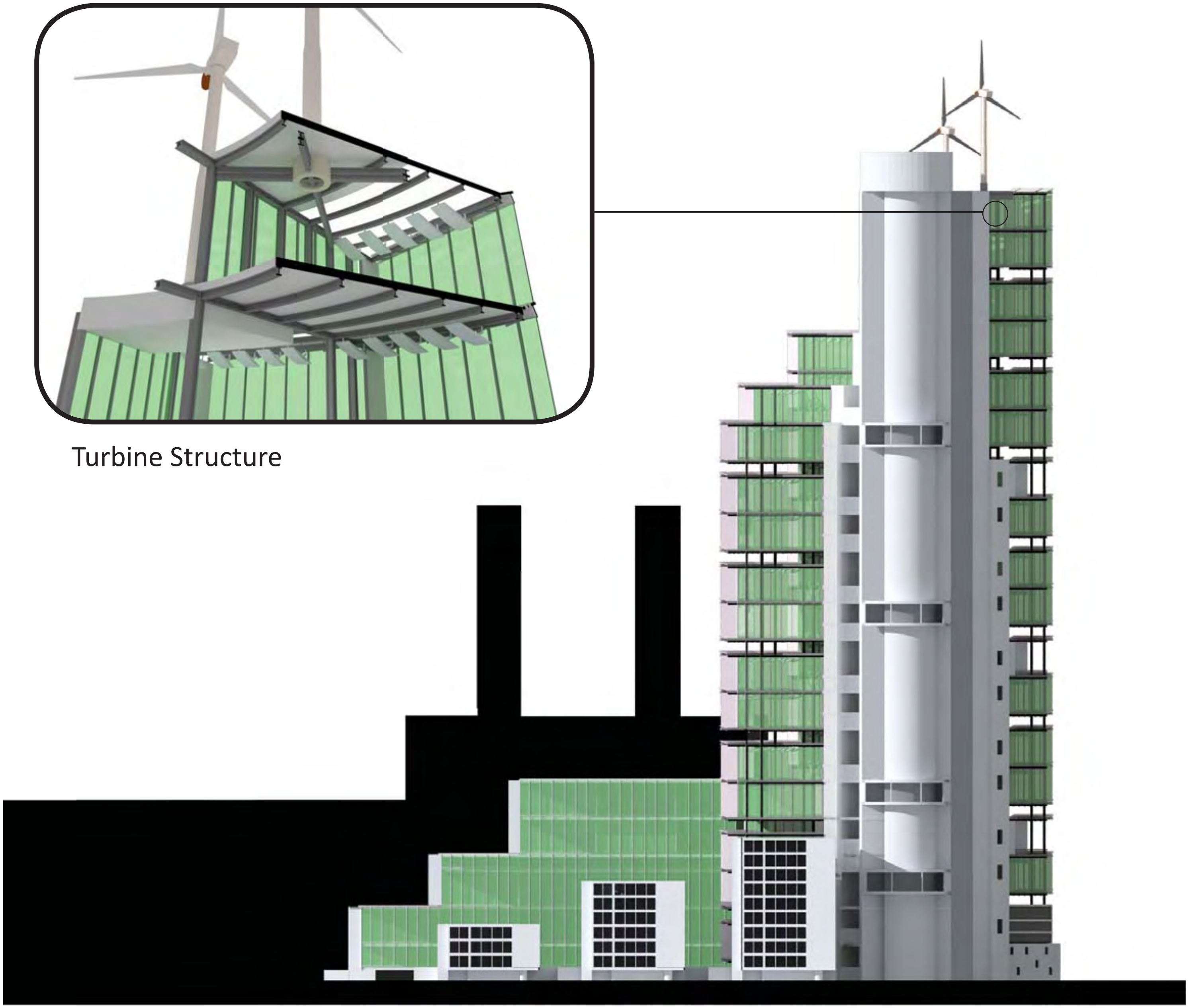
School Floor
Scale = 1/32"



Orchard Floor
Scale = 1/32"

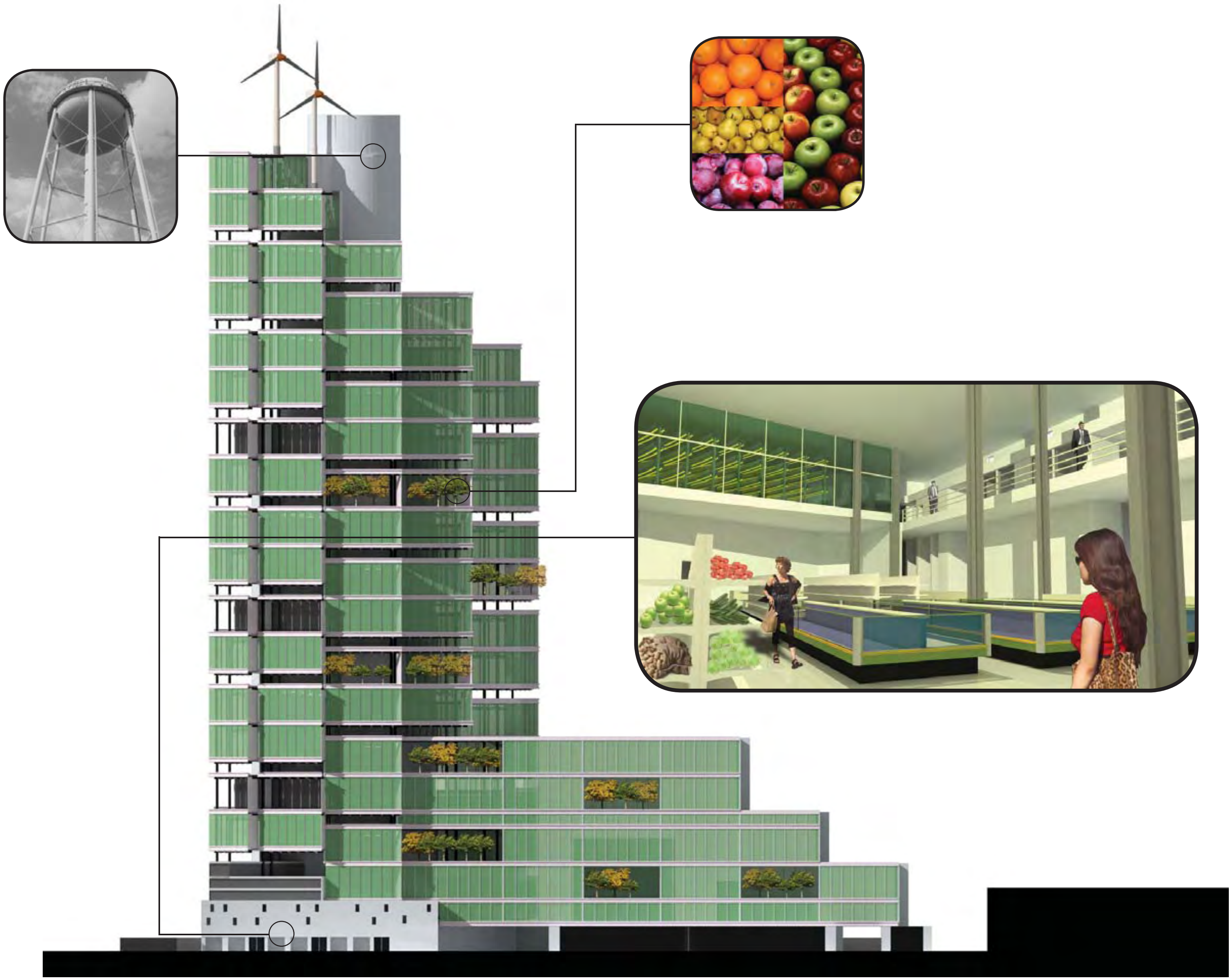


Lab Floor
Scale = 1/32"

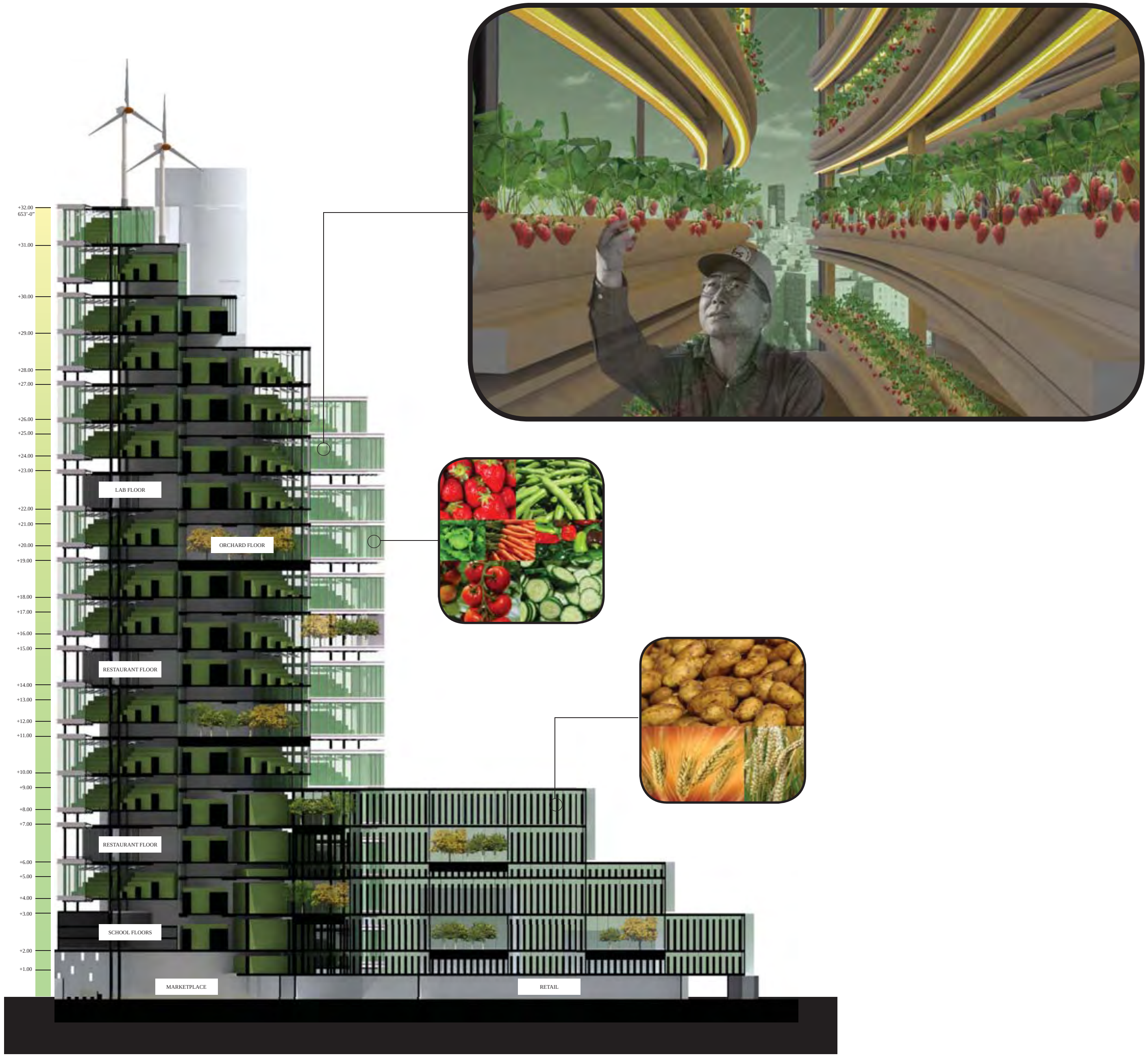


Turbine Structure

North Elevation
Scale = 1/128"



South Elevation
Scale = 1/128"



Section
Scale = 1/128"

Section

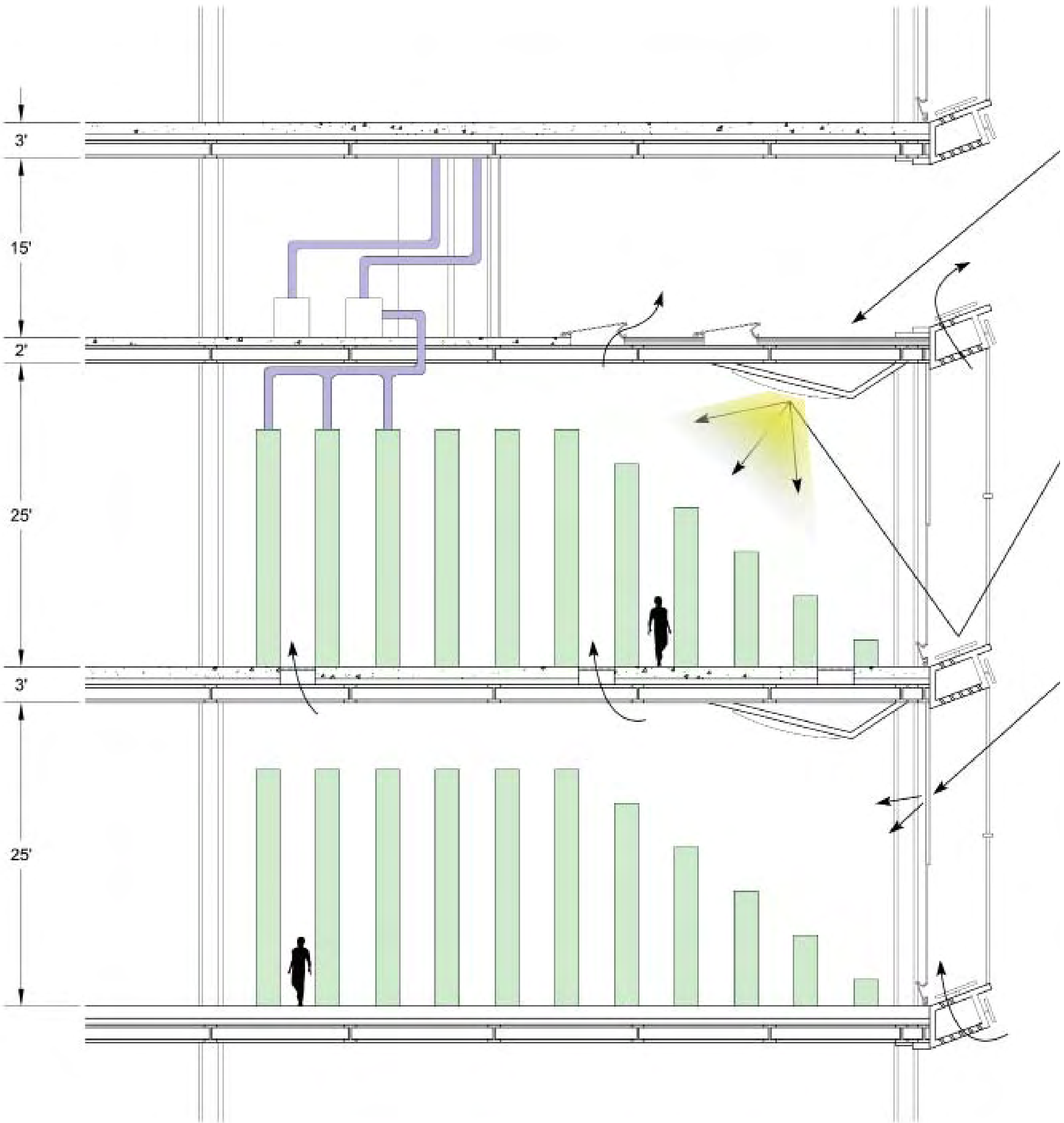
SKY-FIELD

Justin White

Final Presentation

Fall '09 Thesis

Crop Bay



Crop Bay
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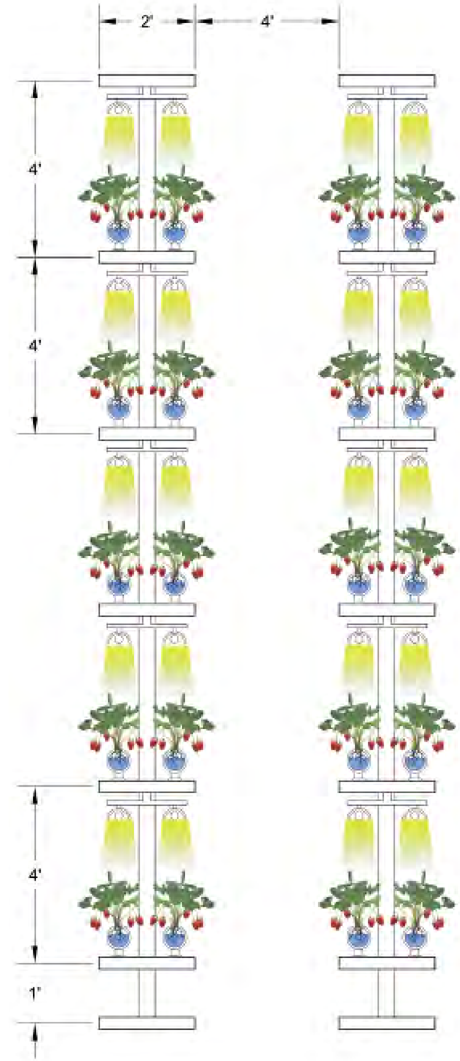
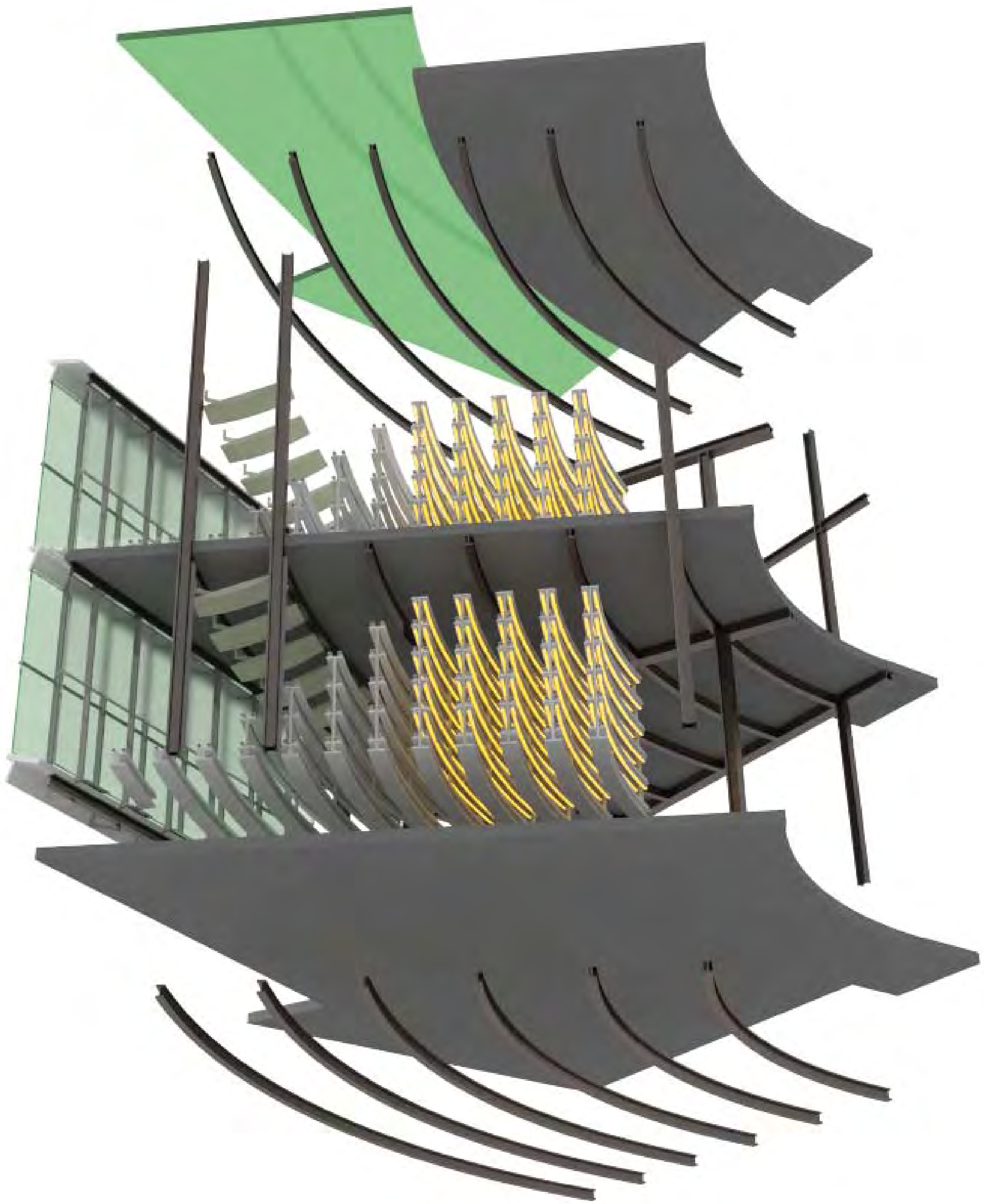
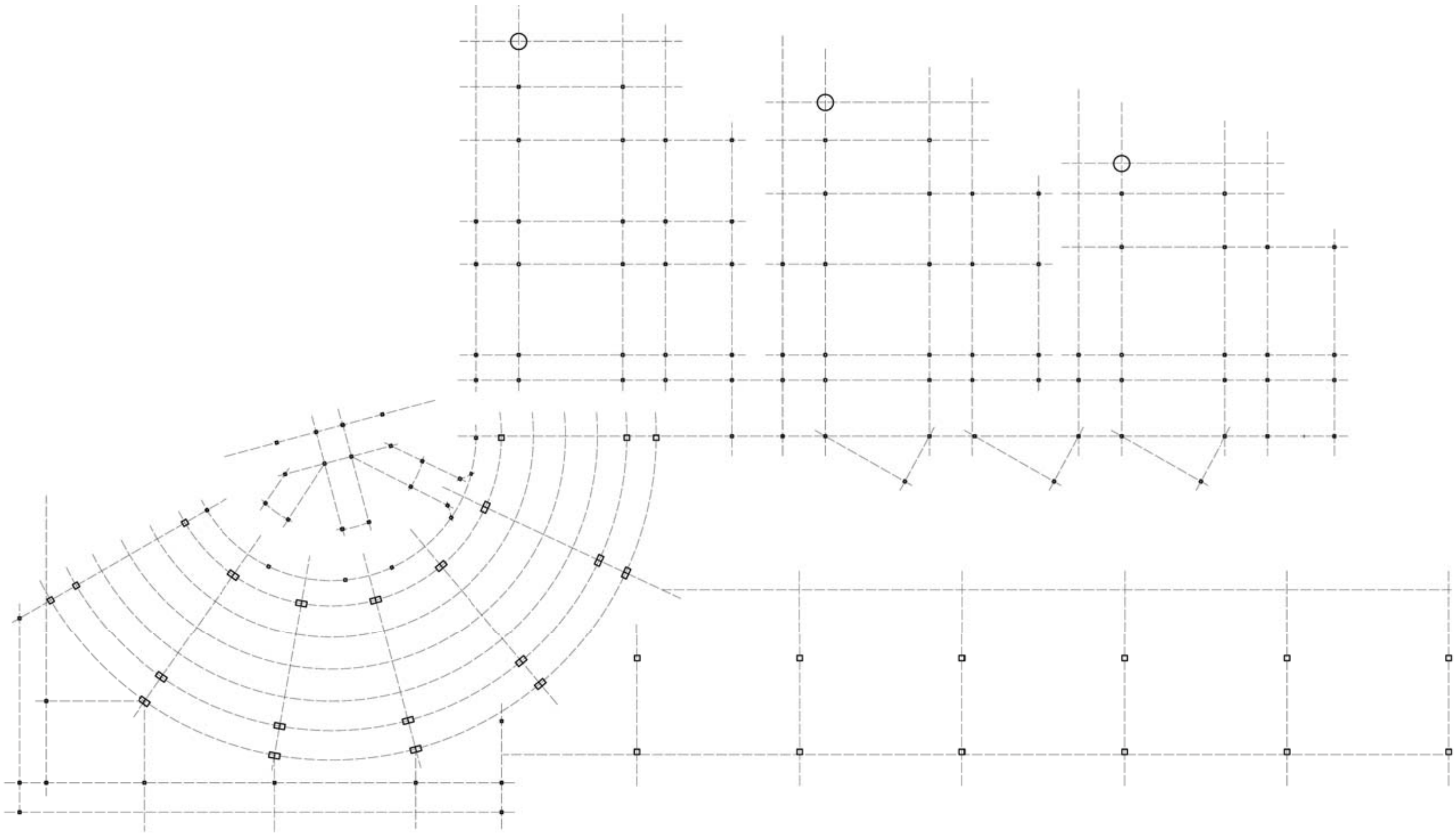


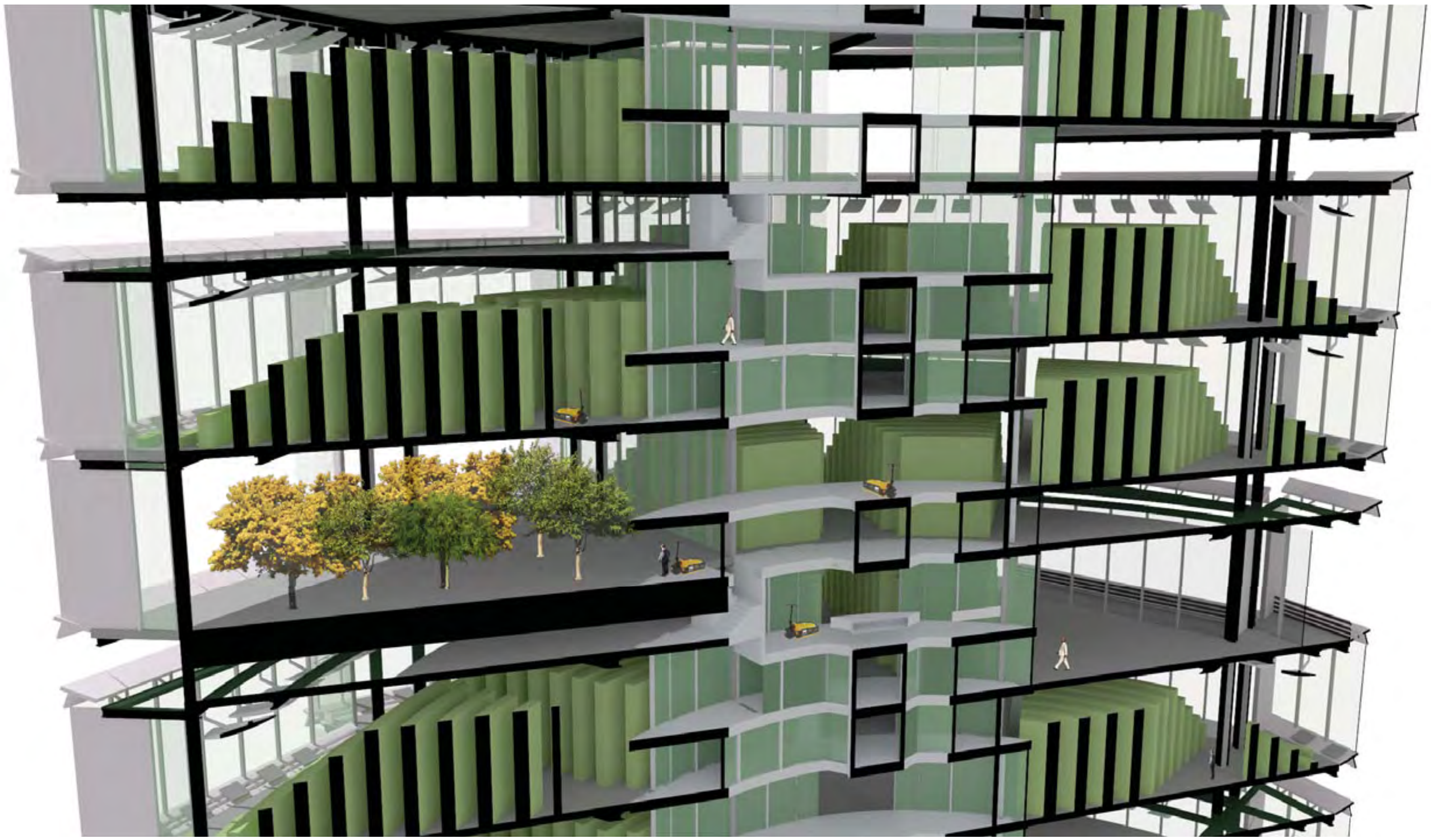
Hydroponics
Scale = 1/8”



Bay Structure



Structure Plan
Scale = 1/100”



Sectional Perspective

View from FDR

View from Stuyvesant Town

Presentation Boards

Conclusion

In total, the design is quite a success. Aesthetically I find it pleasing and eye-catching while at the same time I find it efficient and beneficial to the community. With all of the advantages of having a vertical farming tower, to me it just doesn't make sense that a structure like this has not yet been constructed. With all of the money and fuel we spend transporting goods to and from halfway across the country, we could be investing that money into the future of farming. Past agricultural practices are not going to be able to withstand the population increases. Pesticides just keep becoming stronger to deal with the conditions outside. Our crops are constantly being wiped out by floods and fires caused by climate change. The cost of food is consistently increasing due to the beginning lack of fossil fuels. All of these problems can be solved with a solution such as what has been presented in this document. It's time for a change to be built.

Notes

[1] Danzico, Matt. Discovery Channel. 20 August 2008. 21 May 2009 <http://dsc.discovery.com/videos/earth-urban-farms-grow-up.html>.

[2] Walsh, Bryan. TIME. 11 December 2008. 21 May 2009 <http://www.time.com/time/magazine/article/0,9171,1865974,00.html>.

[3] Brooks, Nora, Anita Regmi and Alberto Jerardo. "U.S. Food Import Patterns." August 2009. United States Department of Agriculture. 14 January 2010 <http://www.ers.usda.gov/Publications/FAU/2009/08Aug/FAU125/FAU125.pdf>.

[4] Despommier, Dickson. Vertical Farm. 2009. 7 January 2010 <http://www.verticalfarm.com/>.

[5] Pesticide Facts. 21 May 2009 <http://www.chebucto.ns.ca/environment/RATE/pestfact.html>.

[6] Resh, Howard. Hydroponic Food Production: A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower. Lawrence Erlbaum Associates, 2002: 30.

[7] Emirates Hydroponics Farms. 14 January 2010 <http://emiratesfarms.com/index.html>.

[8] Resh, 33.

[9] Resh, 31.

[10] Resh, 34.

[11] Despommier.

[12] Food Travel. 21 May 2009 <http://www.cuesa.org/sustainable_ag/issues/foodtravel.php>.

[13] Resh, 30.

[14] Food Travel.

[15] United States Department of Agriculture. MyPyramid. 14 January 2010 <http://www.mypyramid.gov/>.

[16] Danzico.

[17] Resh, 29.

[18] Resh, 30.

[19] New York City Department of City Planning. 21 May 2009 <http://www.nyc.gov/html/dcp/home.html>.

[20] Council on the Environment of New York City. 14 January 2010 <http://www.cenyc.org/files/gmkt/map.pdf>.

[21] New York City Department of City Planning.

[22] Despommier.

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Brooks, Nora, Anita Regmi and Alberto Jerardo. "U.S. Food Import Patterns." August 2009. United States Department of Agriculture. 14 January 2010 <http://www.ers.usda.gov/Publications/FAU/2009/08Aug/FAU125/FAU125.pdf>.

Council on the Environment of New York City. 14 January 2010 <http://www.cenyc.org/files/gmkt/map.pdf>.

Danzico, Matt. Discovery Channel. 20 August 2008. 21 May 2009 <http://dsc.discovery.com/videos/earth-urban-farms-grow-up.html>.

Despommier, Dickson. Vertical Farm. 2009. 7 January 2010 <http://www.verticalfarm.com/>.

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Food Travel. 21 May 2009 <http://www.cuesa.org/sustainable_ag/issues/foodtravel.php>.

Jerado, Andy. US Food Importation. February 2008. 21 May 2009 <http://www.ers.usda.gov/AmberWaves/February08/DataFeature/>.

New York City Department of City Planning. 21 May 2009 <http://www.nyc.gov/html/dcp/home.html>.

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Resh, Howard. Hydroponic Food Production: A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower. Lawrence Erlbaum Associates, 2002.

United States Department of Agriculture. MyPyramid. 14 January 2010 <http://www.mypyramid.gov/>.

Walsh, Bryan. TIME. 11 December 2008. 21 May 2009 <http://www.time.com/time/magazine/article/0,9171,1865974,00.html>.