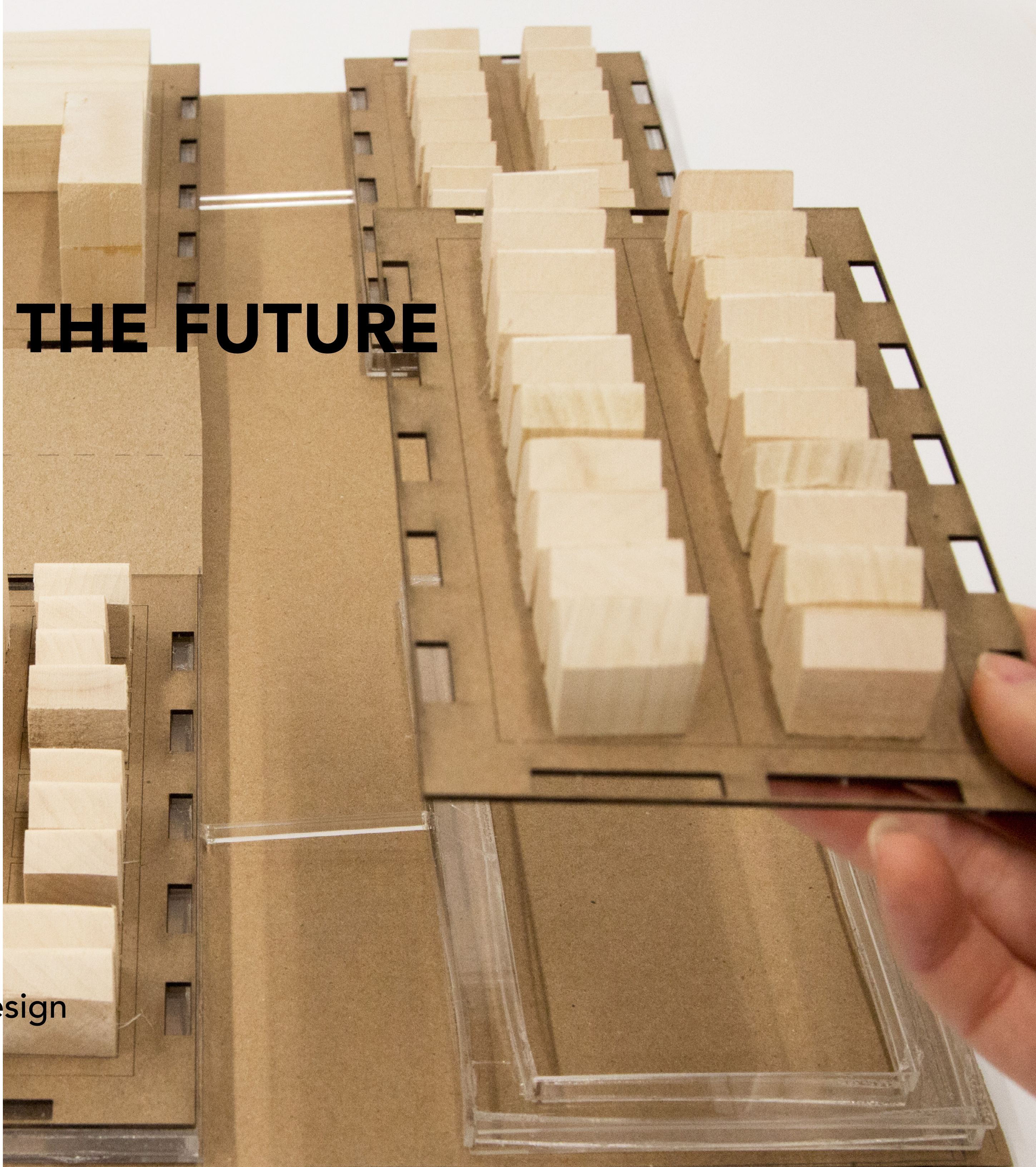

WATER FOR THE FUTURE

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MLA CANDIDATE 2017
Rhode Island School of Design

A thesis submitted in partial fulfillment of the requirements for the Master of Landscape Architecture Degree in the Department of Landscape Architecture of the Rhode Island School of Design, Providence, Rhode Island.

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Date 05/18/2017

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Contents

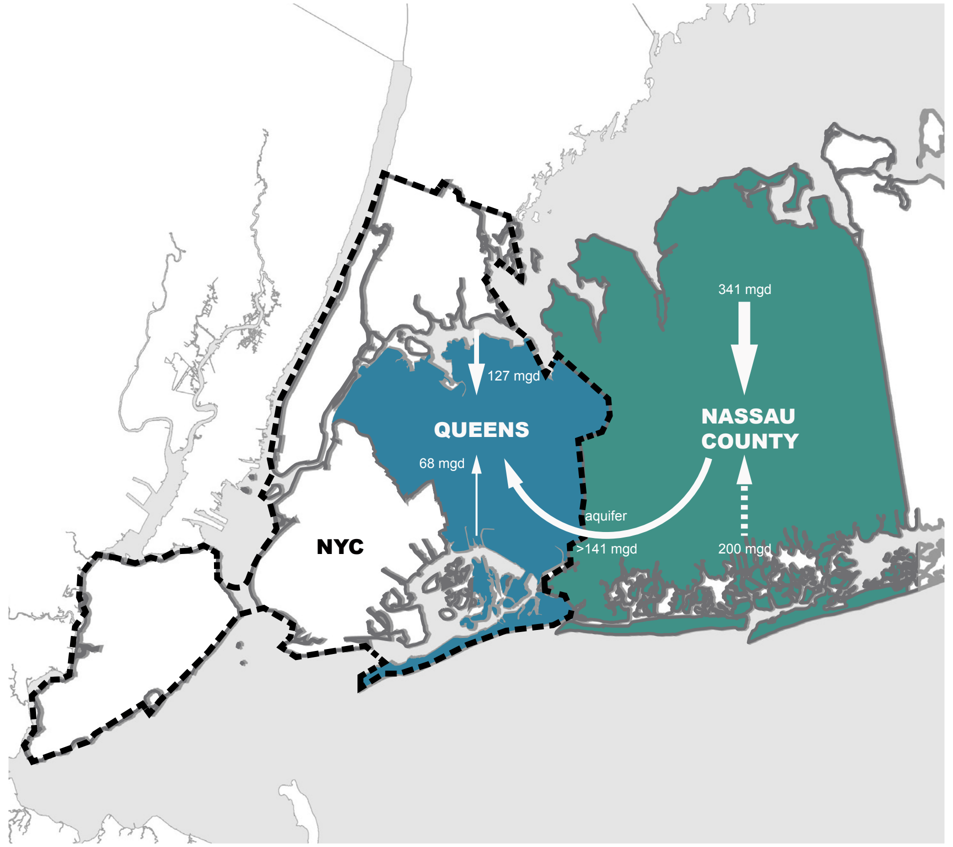
Overview

Water is a fundamental element for lives. Located in Long Island detached from the mainland of New York State, the densely-populated counties - Kings, Queens, Nassau, and Suffolk Counties - rely on groundwater for their sole freshwater source for a long time. The underground geology determines the groundwater movement on western Long Island: from Nassau County to Queens. When overpumping happens in Queens, Nassau County is firstly threatened by lowered water table. The thesis is aiming to propose a local solution to mitigate the problem brought by groundwater movement when overpumping.

In Phase 1, the study focuses on the underground geology of aquifers, and groundwater flow to understand the relationship between aquifers and groundwater system. Phase 2 provides a framework to a potential solution in regional scale based on three criteria. Phase 3 proposes a growing system starting from a granular scale to mitigate the problem.

Site

The site is located in Queens groundwater supply area, where overpumping causes the lower water table in Nassau County adjacent to Queens because of the water movement underground. Queens groundwater supply area is a massive residence district including mainly five residential typologies. Only this portion of Queens relies on groundwater as it sole freshwater source, while the rest of NYC relies on watersheds upstate for its freshwater supply. Historically, groundwater withdrawals from the aquifers underlying Queens varied temporally and spatially during the 20th century and caused extreme changes in water levels not only in Queens, but also in Nassau County.



Phase 1 Investigation
Aquifers and Freshwater Supply System

Abstract

New York City sits on a deep harbor that almost never freezes, making it an ideal port. However, the development of New York City has as much to do with the fresh water beneath it as the seas surrounding its shores. In western Long island (including Queens and Brooklyn), excessive pumping of aquifers in Queens has caused seawater intrusion, resulting in the shortage of freshwater supply in Nassau County during the 20th century.

This phase: (1) provides a brief pumping history of Queens and Brooklyn, (2) summarizes the hydraulic characteristics of aquifers on Long Island, (3) describes the influences of saltwater intrusion regionally on Long Island.

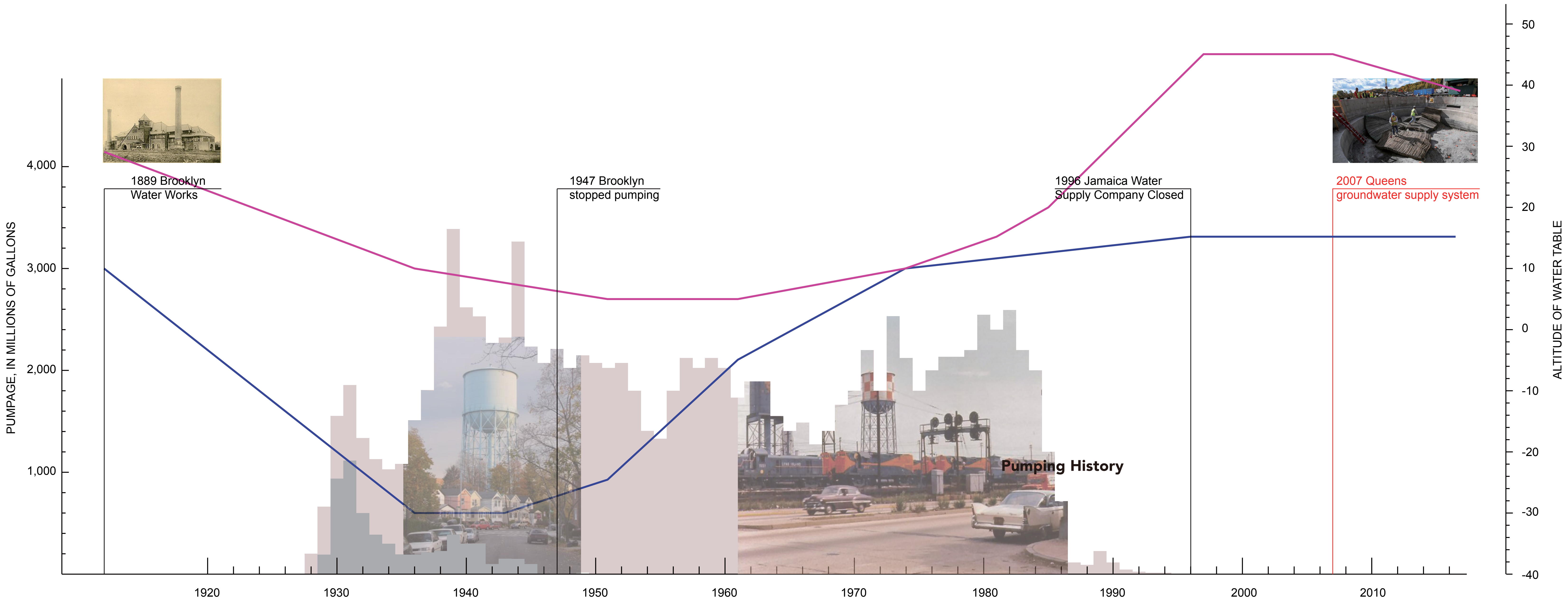
Introduction

This phase focuses on the relationship between aquifers and groundwater system. The four counties of Long Island (Kings, Queens, Nassau, and Suffolk) are underlain by four aquifers. The pumping condition influences the flow direction of groundwater significantly, which caused saltwater intrusion in specific area. Also, because of the rising sea level, this problem is aggravated. Saltwater intrusion then affects the groundwater supply in that area because of increasing salinity and contamination. Because NYC relies on the reservoir for freshwater, saltwater intrusion doesn’t influence its freshwater supply. While according to the potentiometric contour at each aquifer, the lower water table in Queens causes groundwater flowing from Nassau County to Queens, which threaten the sole freshwater resource in Nassau County.

Methods

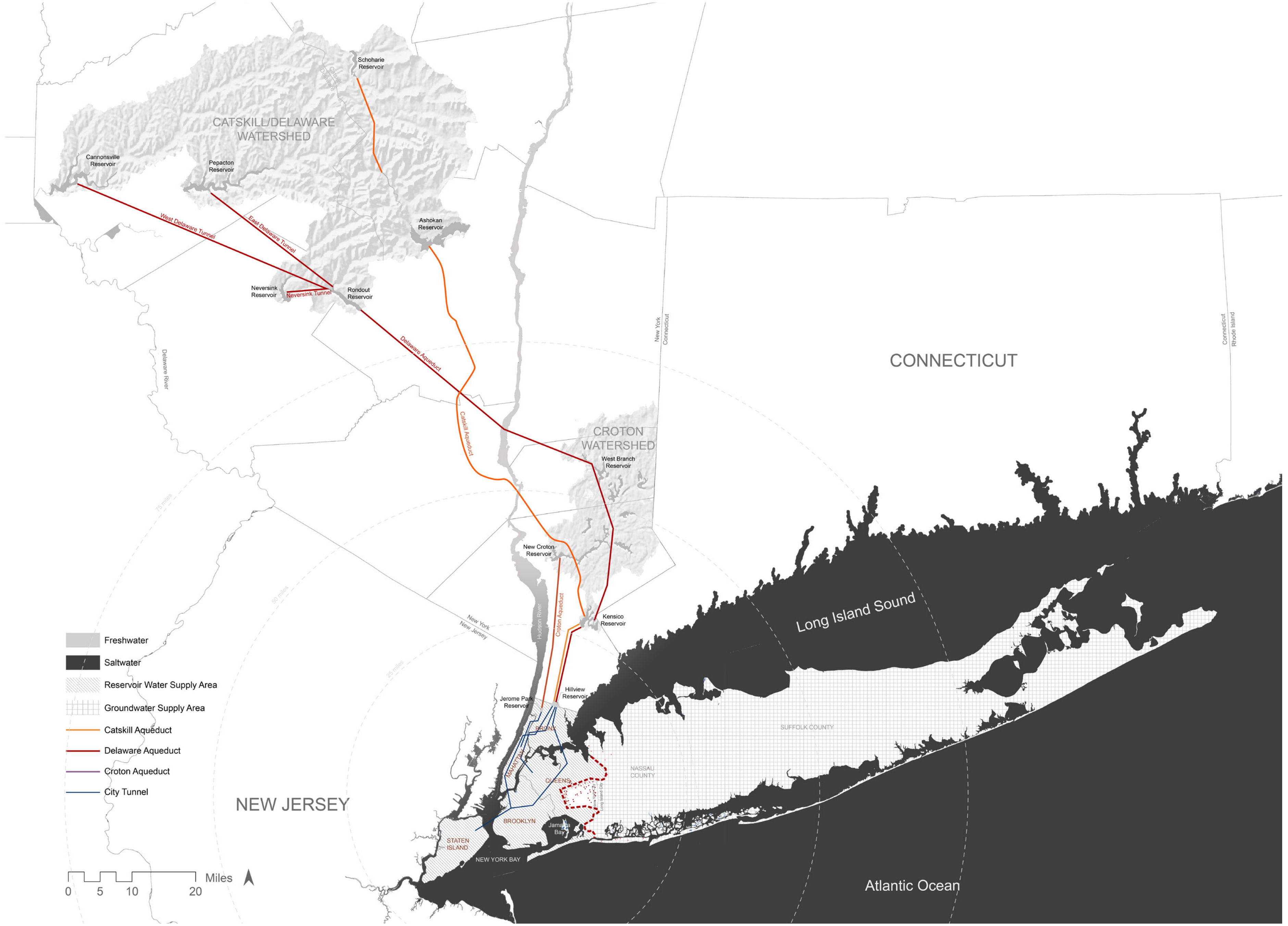
1. Data Collecting: contour map of each aquifer, potentiometric contour, pumpage amount, historical water table
2. Mapping: groundwater supply wells location, saltwater intrusion extent, large water users
3. Physical Modeling: aquifers in sections across Long Island

Phase 1 Pumping History in NYC

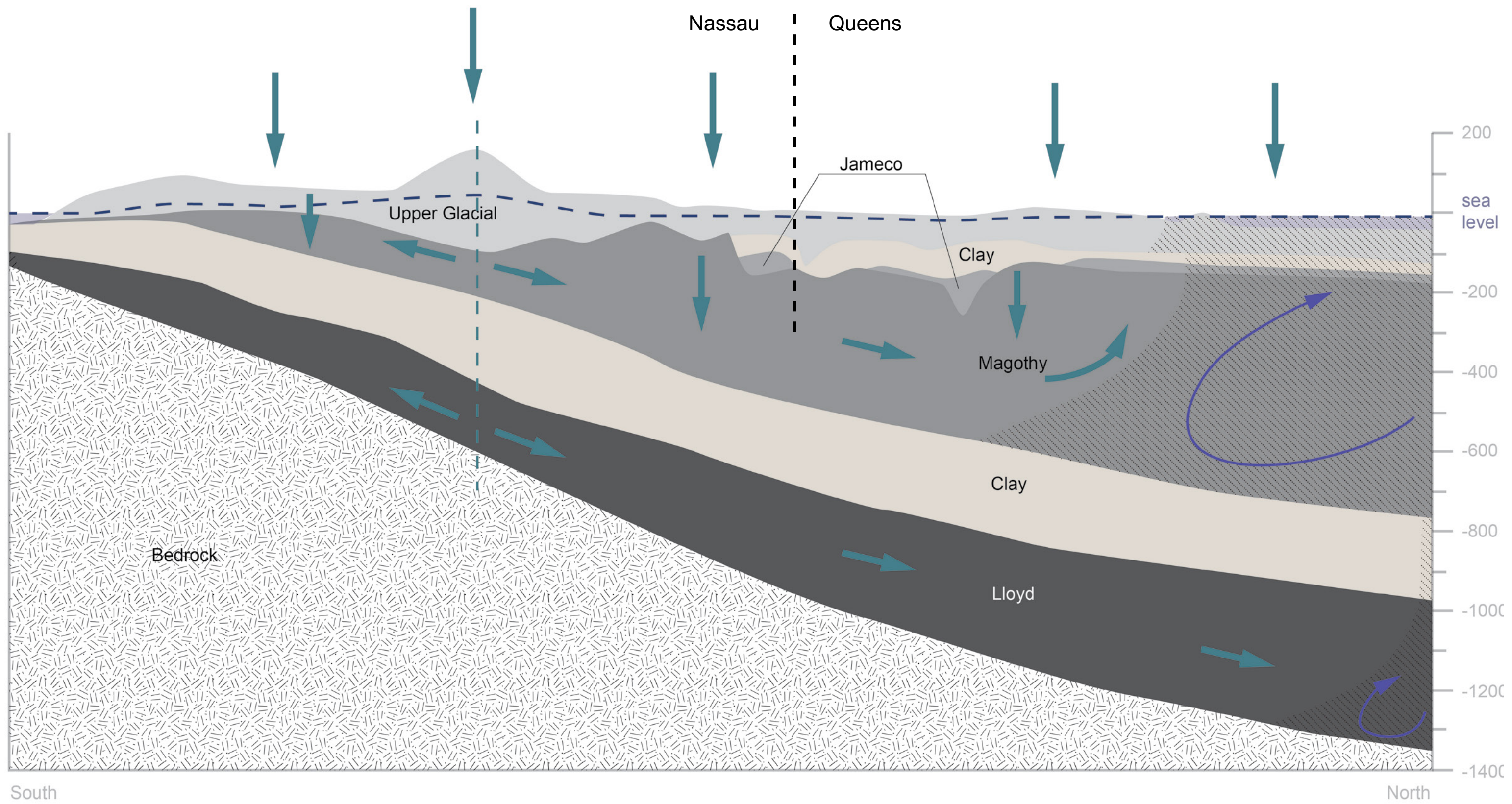


Water table change along with the history of pumping in Queens and Brooklyn

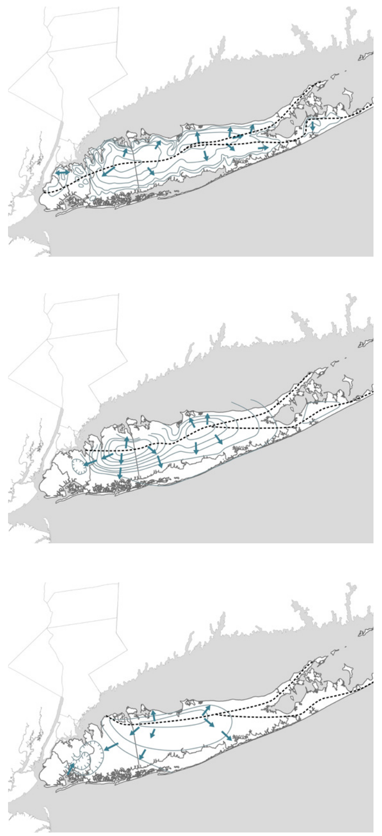
Phase 1 Freshwater Supply System



Phase 1 Groundwater Movement



Potentiometric Contour

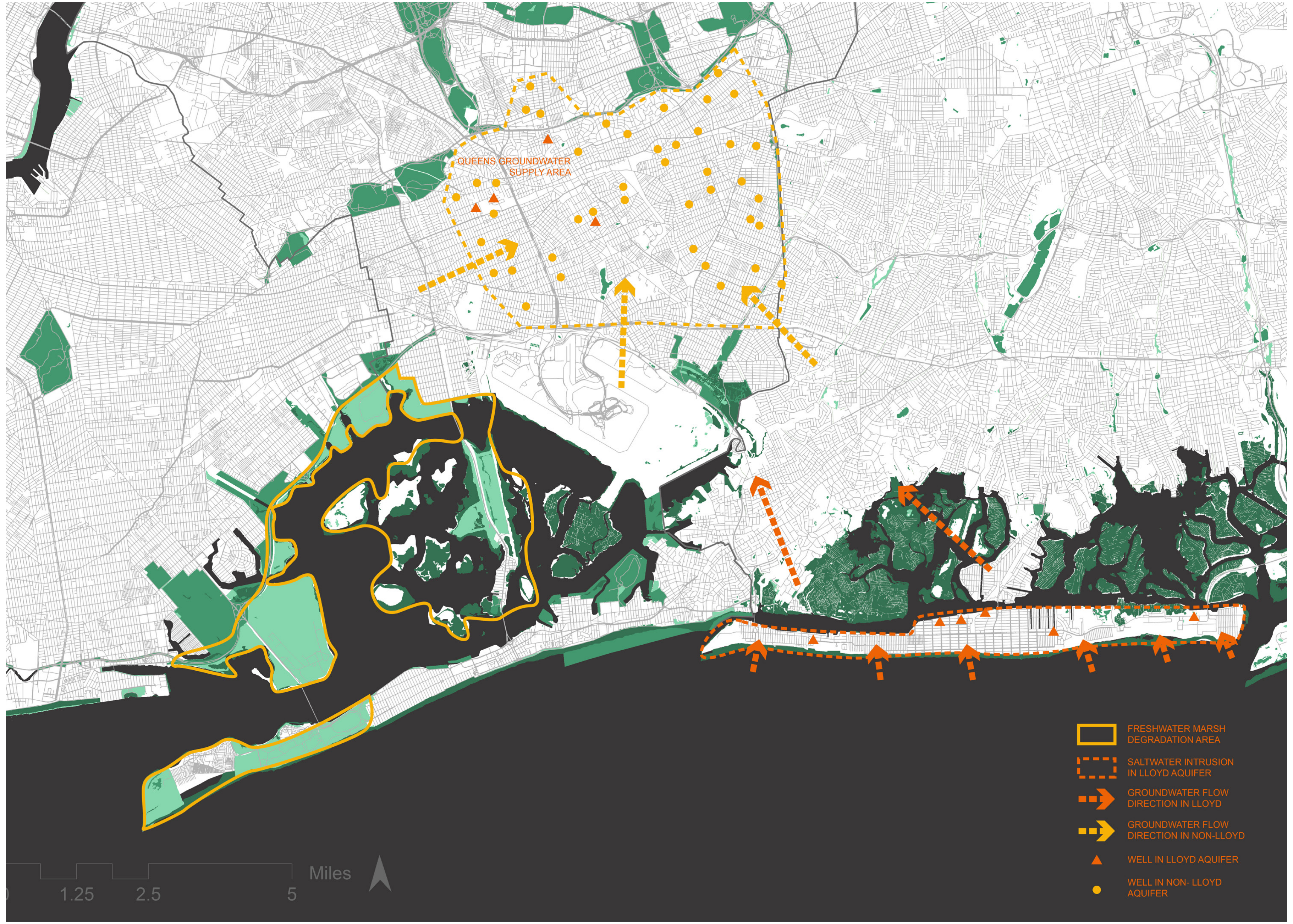


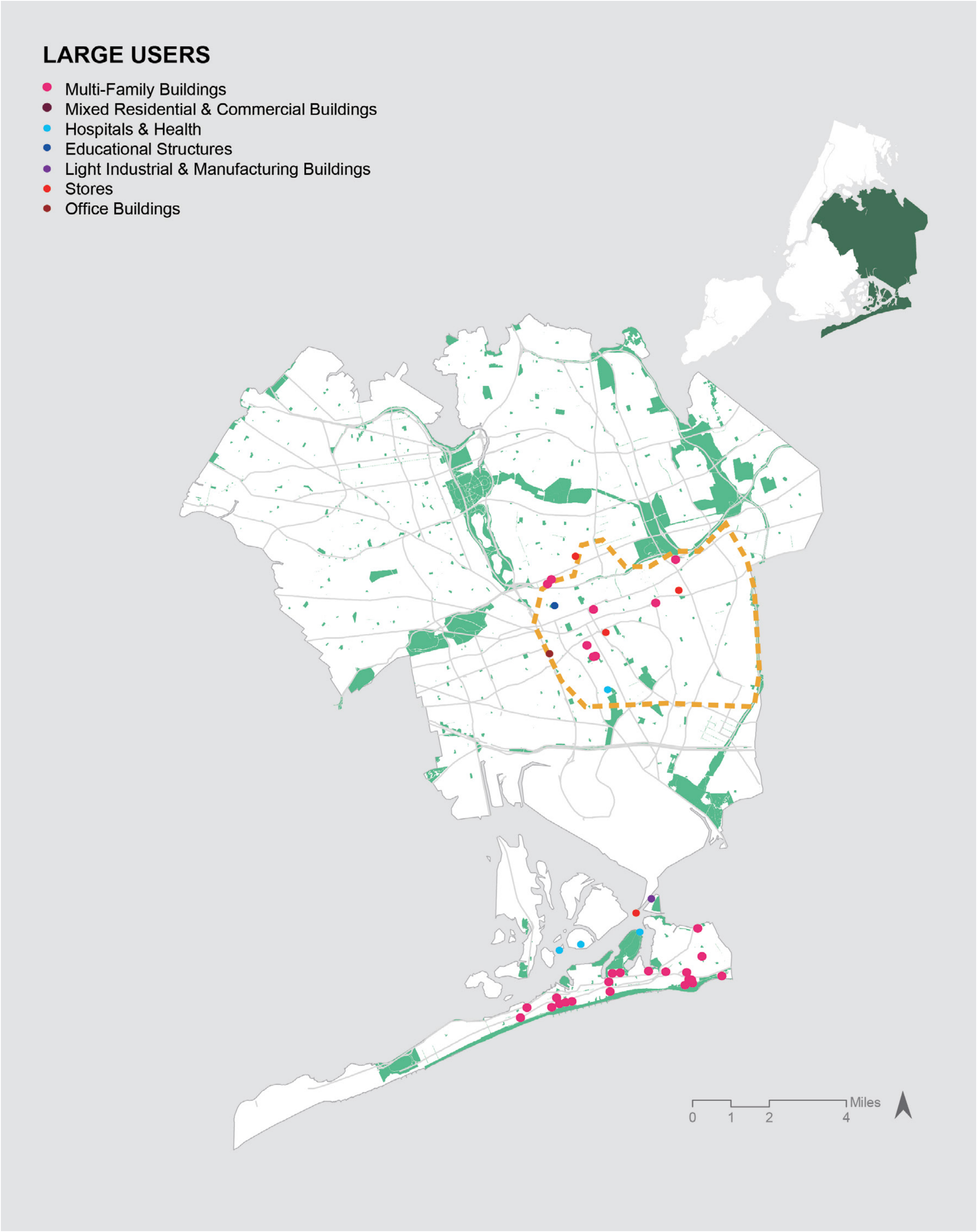
Cross section of Queens and Nassau County: Groundwater movement is from Nassau County to Queens because of the potentiometric contour in each aquifer

Phase 1 Aquifer Models

Cross sections of Queens and Nassau County: Aquifer layers thicken from east to west

Phase 1 Queens Groundwater Supply Area





Overpumping in Queens causes lower water table aggravate saltwater intrusion near shoreline.

Findings + Conclusions

Long Island's aquifer system, including the Lloyd, Magothy, Jameco, and upper glacial aquifers, supplies over 2.8 million people for freshwater resource. As a coastal aquifer system, it is susceptible to saltwater intrusion, which threatens the sole-source for people living in Long Island. Because NYC relies mostly on the reservoir water supply system for its freshwater resource for 20 years, and the only groundwater supply area in Queens is more than 20 miles away to the coastal area, saltwater intrusion does not influence its groundwater supply in Queens. However, because of the lower water table at each aquifer in Queens groundwater supply area, groundwater has a tendency to flow from Nassau County to Queens so that the freshwater supply in Nassau County could run short.

Unconsolidated coastal plain sediments of Cretaceous age and glacial deposits of Pleistocene age compose the principal aquifers that underlie Long Island. Above the bedrock, there are Lloyd aquifer, clay, Magothy aquifer, Jameco aquifer, clay, and Upper Glacial aquifer from bottom to the top. Lloyd aquifer is the only confined one in these four, which means that it is hard for water to infiltrate to this layer because there is a relatively impermeable clay layer on top of it. Therefore, saltwater intrusion is more severe in Lloyd aquifer than other three. In coastal area, especially beach along south Long island, people can not pump water from shallow aquifer where water is already contaminated by saltwater. Instead they use water from Lloyd aquifer. While most groundwater supply wells in Queens are pumping from non-Lloyd aquifer and there are only four Lloyd wells there. According to the different infiltration rate in those aquifers, it is easier to recharge non-Lloyd aquifers, but hard to recharge Lloyd aquifer.

Water from precipitation that is not evapotranspired or that does not run off in storm drains or streams infiltrates the permeable soil and moves both downward and horizontally through the porous rocks in response to gravitational or withdrawal-induced gradients. A map of the potentiometric surface of each of the principal aquifers represents the pressure surface to which water will rise in tightly cased wells open to the aquifer and indicates the general direction of ground-water movement, which is down the hydraulic gradient and generally perpendicular to the potentiometric contours. For Lloyd and Magothy aquifer, which are two thickest aquifers on Long Island, there is a basin at Queens groundwater supply area on the potentiometric map. Groundwater already has a tendency flowing from Nassau County to Queens. The lower water table in Queens would aggravate saltwater intrusion.

Assessment

This phase investigation provides a good deal of data and knowledge, but not conclusion yet. The issue itself seems important for each individual person, but the scale is way to big so that there is a disconnection between the big system and the public. Next step requires to be more synthetic than analytical. Visualizing how causes and effects are related might be able to see where the investigation can fit in and make an impact.

Before having a spatial strategy, a few questions have to be answered:

- How do you know the cause of saltwater intrusion?
- What is the problem with saltwater intrusion?
- How do you mitigate the problem?
- What is the practical time frame for making an impact? How does that impact what you choose to do?
- Is it most effective to act at an infrastructural or granular scale? Is impact achieved at a regional or temporal scale?

Phase 2 Hypothesis
Urban Aqueduct

Abstract

In phase 2, the investigating focuses on how to decrease the impact of pumping in Queens that influences Nassau County's freshwater supply. Locally on Long Island, the water source is not going to run short again after few years because the recharge to the aquifer is more the pumping amount. But there are some imbalances in some localized areas – the most noticeable part is Queens and Nassau County.

This phase: (1) seeks for possibility to mitigate the problem at different scale, (2) sets up three criteria to locate a new water system.

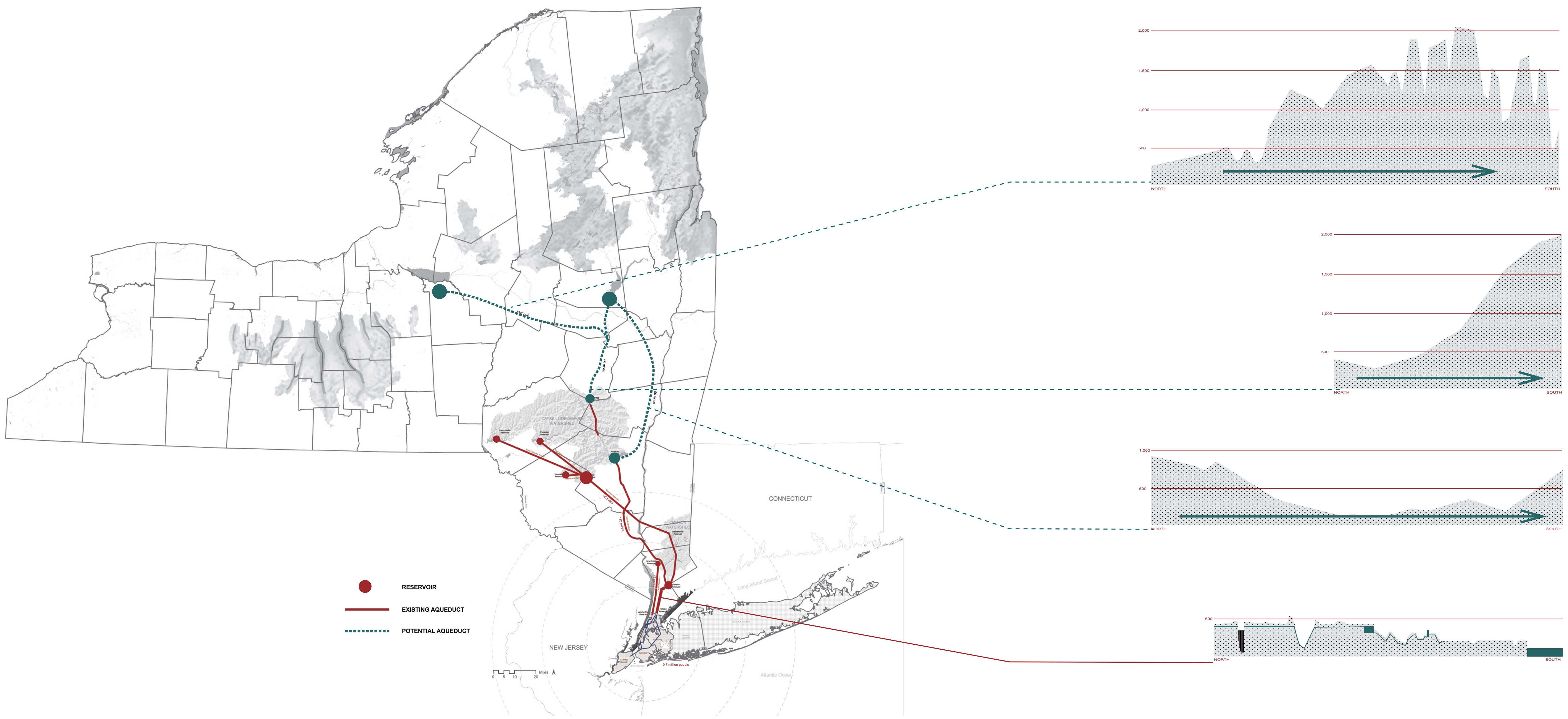
Introduction

This phase seeks for efficient solution to mitigate the pumping problem at Queens at two scales: regional watershed scale and localized county scale. The topography of New York State is an obstacle to convey more water from upstate watershed. Then the investigating focuses back on local solution on Long Island. Capturing the rainfall and reverse the water flow direction on the surface is the main strategy in phase 2. Through the research about aqueduct, this phase aims at creating an urban aqueduct system based on three criteria.

Methods

1. Mapping: Watersheds and aqueducts, topography, road system, open space
2. Hypothesis: A potential way to move water in a large scale
3. Case studies: Different types of aqueduct
4. Typology Analysis: Existing conditions

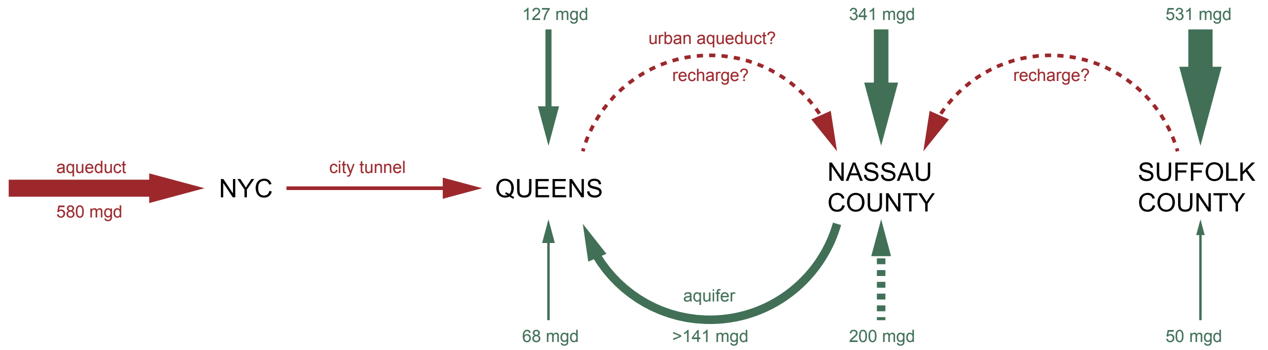
Phase 2 Distance of Shipping Water From Upstate

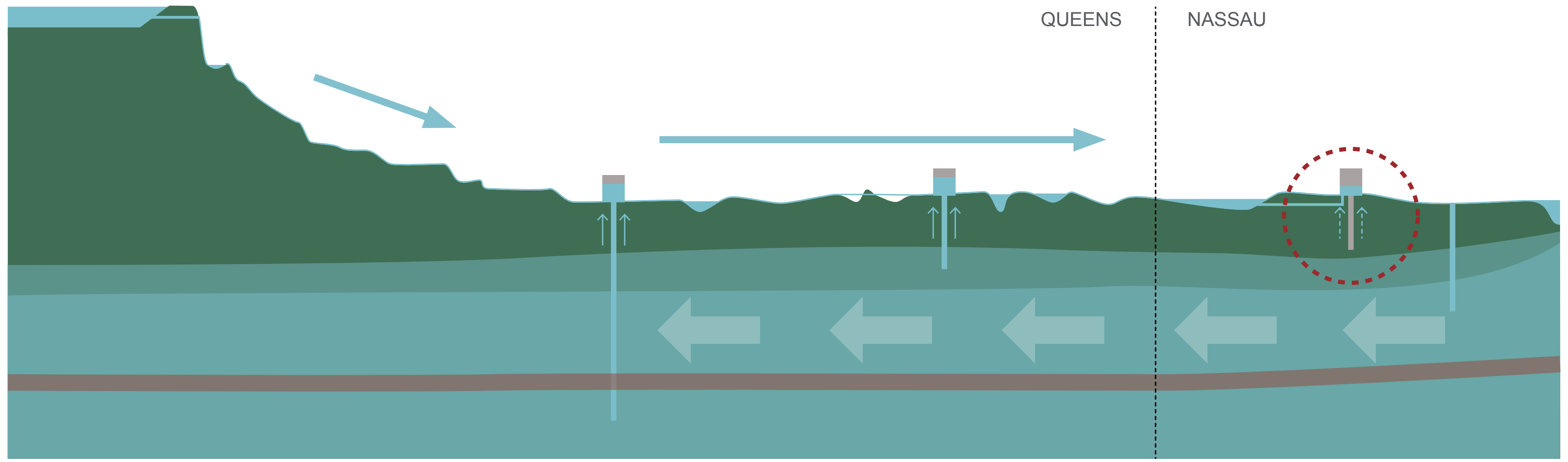


Watersheds at upstate NY is lower those which already used as freshwater source for NYC. The topography increases the difficulty and price to construct new aqueducts for conveying more water.

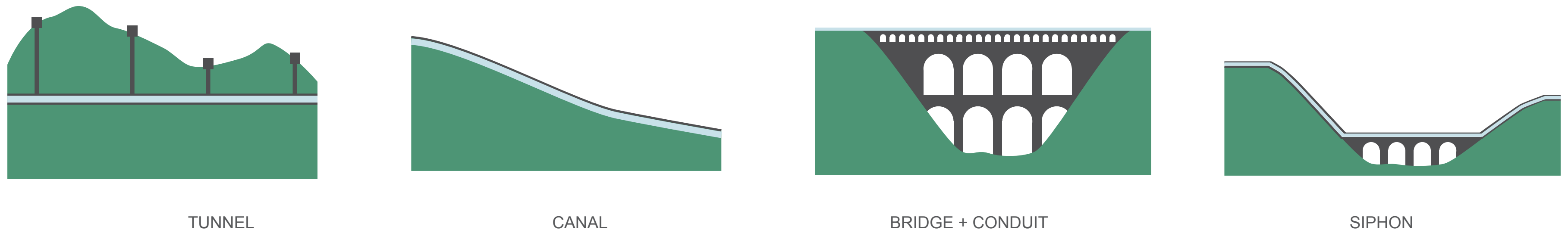
Phase 2 Urban Aqueduct

The proposed urban aqueduct is to reverse the water flow direction, helping to compensate the amount that flows from Nassau County to Queens underground.

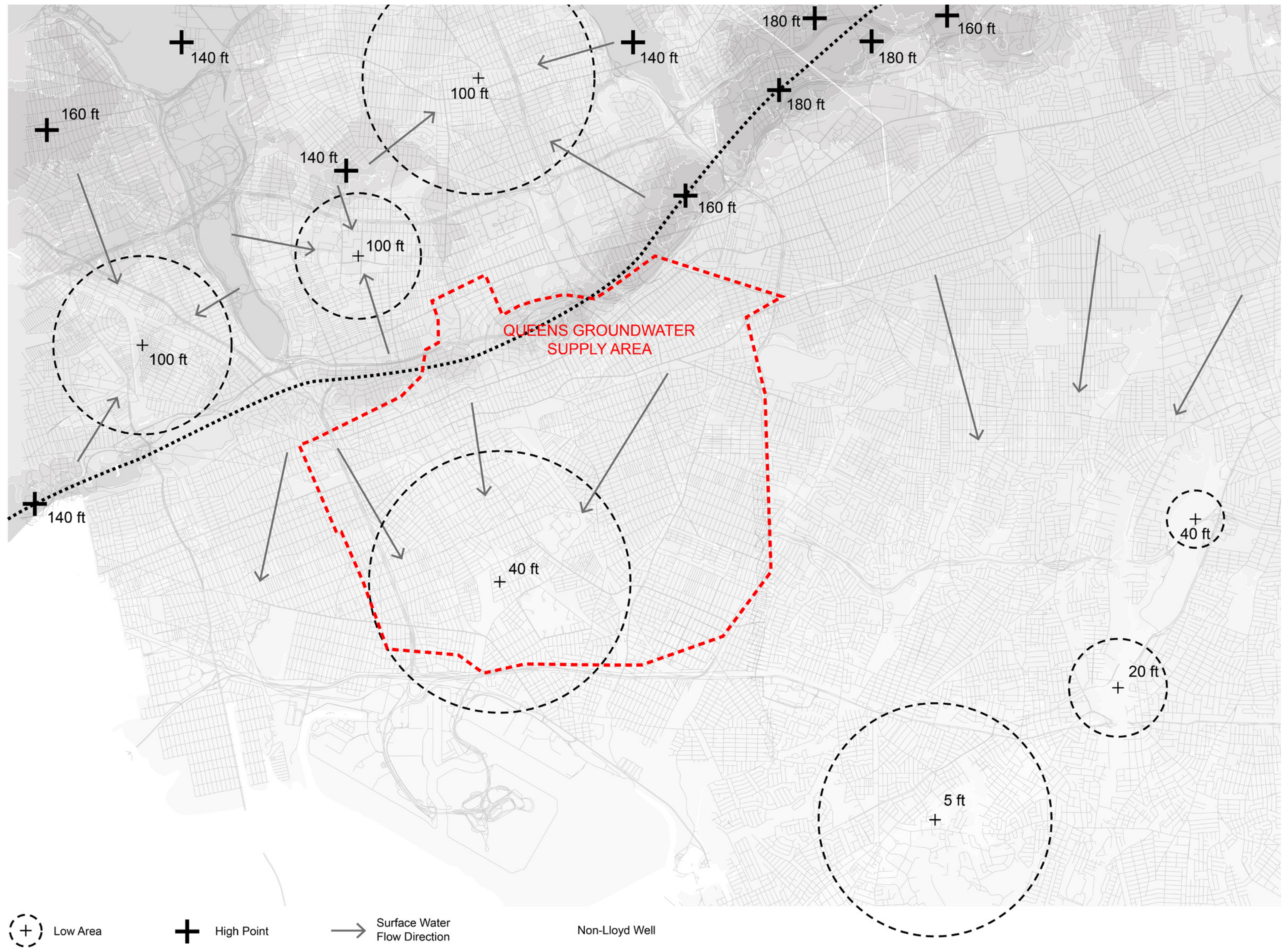




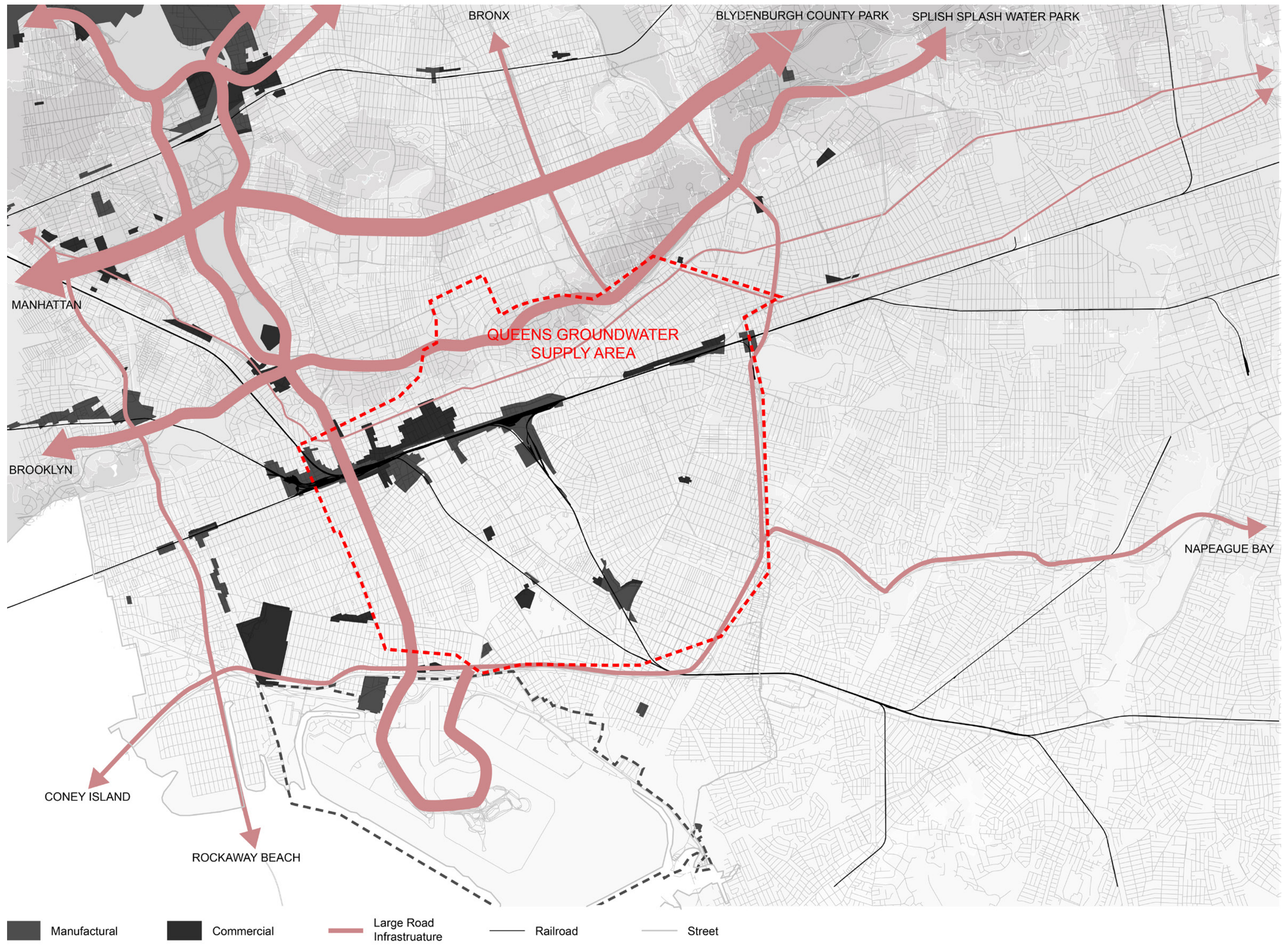
Aqueduct Precedents



Phase 2 Three Criteria

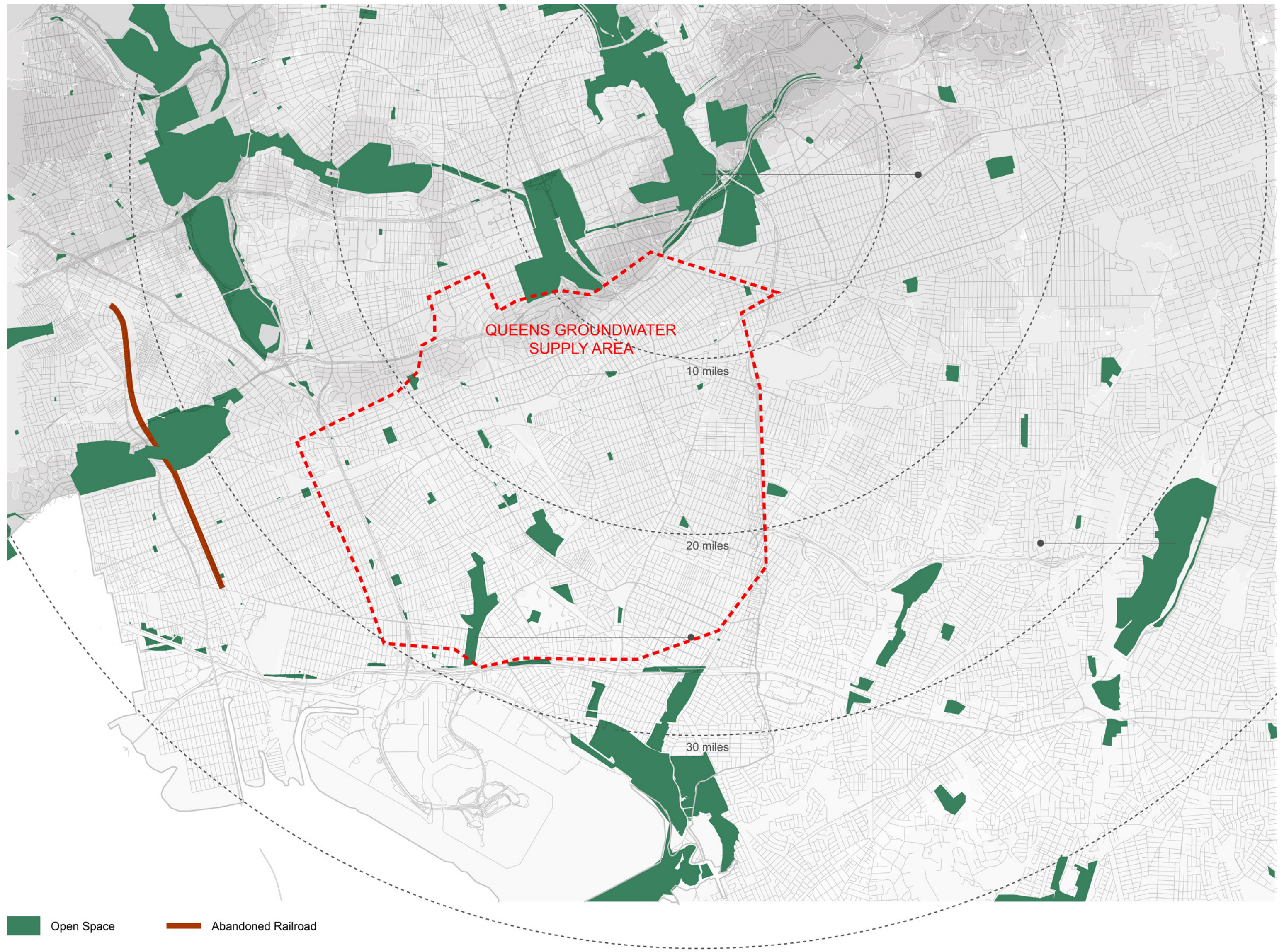


1. From High to Low Point / on the Plain: Take advantages of the gravity by moving water from high to low.



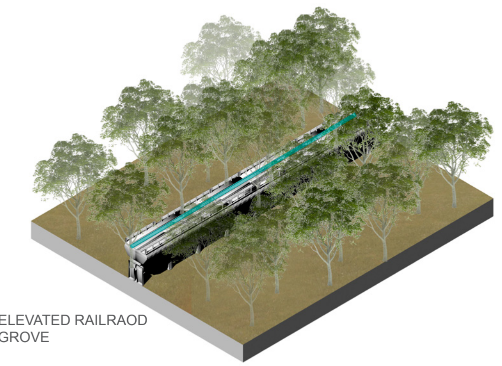
2. Along Large Road / Infrastructure: There is a massive residential area at the south side of Queens and Nassau County. In order to minimizing the disturbance of daily lives in the neighborhood, the aqueduct system should avoid crossing through small streets.

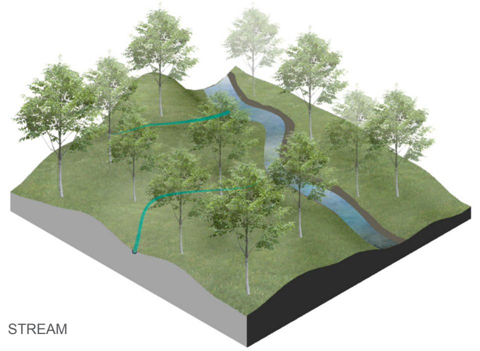
Phase 2 Three Criteria

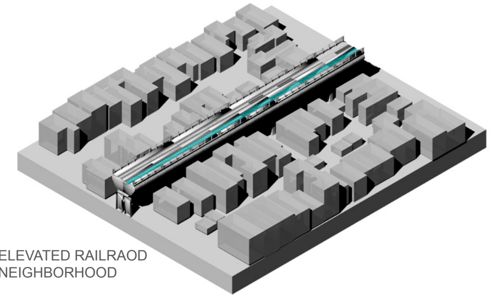


3. Link Open spaces: It is an opportunity to create new open spaces at different scales for the massive residential area.

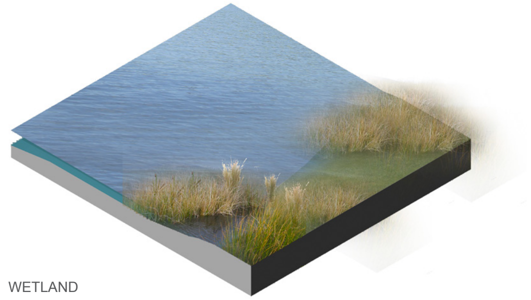
Phase 2 Prototype of Urban Aqueduct

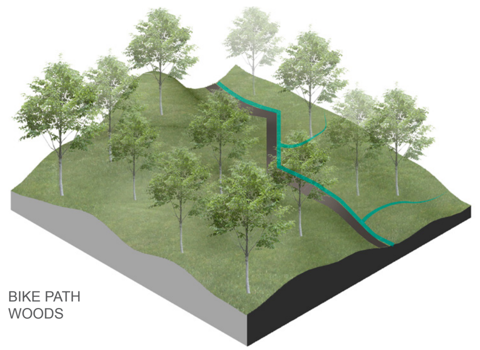

ELEVATED RAILRAOD
GROVE

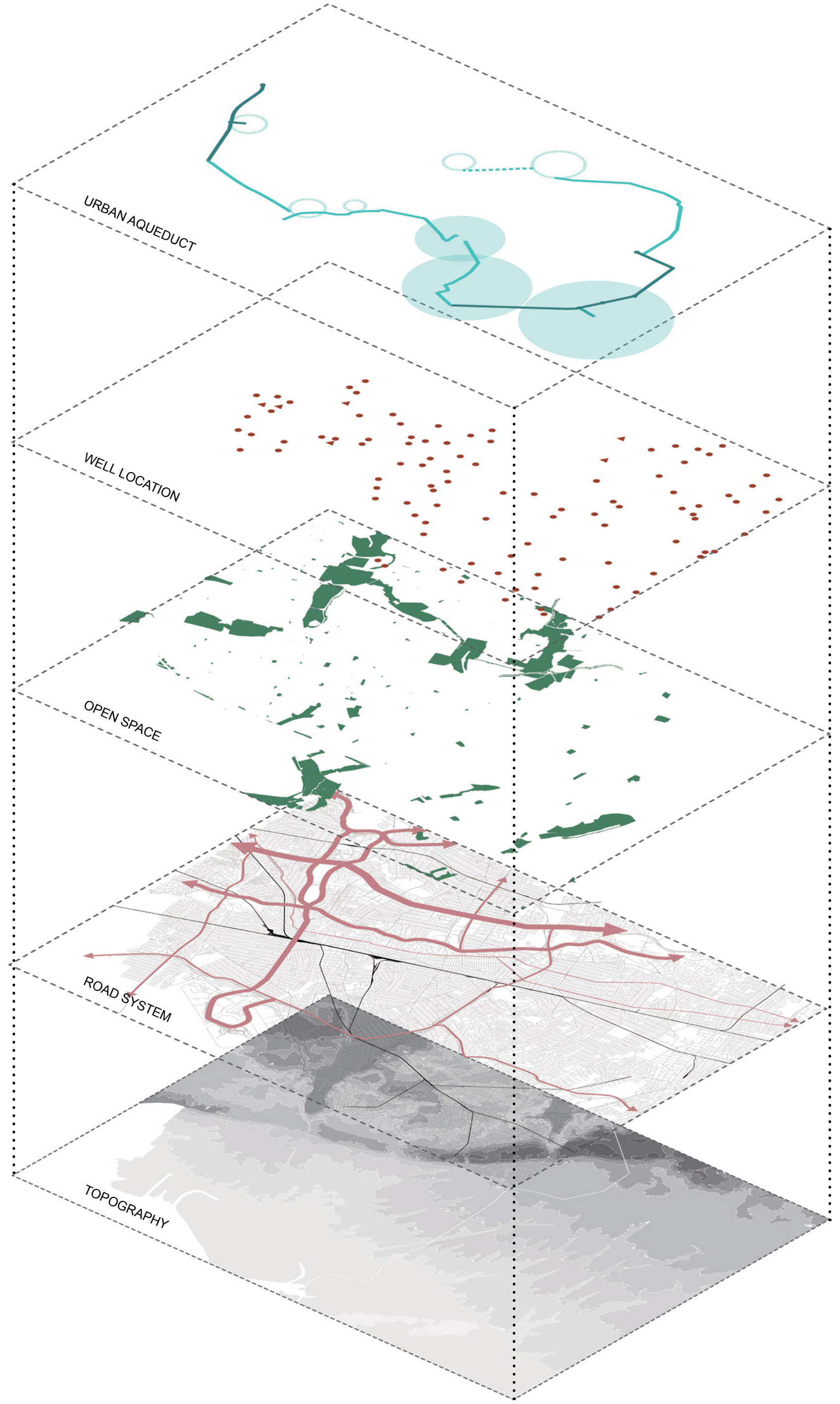

STREAM


ELEVATED RAILRAOD
NEIGHBORHOOD


ELEVATED RAILRAOD
GROVE


WETLAND


BIKE PATH
WOODS



Combined three criteria, the route of urban aqueduct is created.

Findings + Conclusions

Watersheds at upstate NY is lower those that already used as freshwater source for NYC. The topography increases the difficulty and price to construct new aqueducts for conveying more water for 1.352 million of people at Nassau County, which occasionally has drought in wells because of the overpumping at Queens. According to *Water Worries*, a report from Suffolk County, "the choice is ours to either avert a large-scale, costly and almost irreversible problem, or watch it all unfold." Therefore, it is necessary to review the problem and seek for a local solution on Long Island if possible.

From the data of recharge and discharge on Long Island, the recharge for aquifer is enough for discharge as freshwater supply. However, the groundwater moves a great amount from Nassau County to Queens, which lowers the water table in Nassau County and causes droughts in some wells. The proposed surface water system - urban aqueduct - is to reverse the water flow direction, helping to compensate the amount, which flows to Queens underground.

Referring from the aqueduct precedents, three criteria are set up to locate the urban aqueduct: (1) from high point to low point, (2) along large roads or infrastructures, (3) link greens spaces. The watershed across Queens and Nassau County divides the water flow into two directions from the ridge located across Highland park to Cunningham park. The park system provides an opportunity to develop into an "urban reservoir", which collects water from the rainfall. There is a massive residential area at the south side of Queens and Nassau County. In order to minimizing the disturbance of daily lives in the neighborhood, the aqueduct system should avoid crossing through small streets. Also, open spaces at the south provide destinations along the way where urban aqueduct goes.

The urban aqueduct system relies on big infrastructures and goes across different types of land. According to the elevation of different area, the forms can be chosen to develop new open space for people to interact at different scales.

Assessment

The criteria from this phase still have to be under discussion. Long Island is quite a flat coastal plain, which has small area of high spots to collect enough amount of water. Usually in the urban area, water is tended to be collected at the low points directly into the sewage system.

There might be an opposite view to the second criterion. The purpose of the project is to let people interact with the new water system as much as possible in order to have deep understanding. Letting water expose to every street increases the chance that people encounter with.

Before having a spatial strategy, a few questions have to be answered:
• Is the street section ever right?
• Is it most effective to act at an infrastructural or granular scale?
• How much water should the reservoir collect for sufficient water storage?
• How to effectively collect water from the high points in the urban area?
• Should the city propose a certain amount area to contain water?

Phase 3 Proposal
Rainwater Reuse System

Abstract

According to the investigation from Phase 2, Long Island plain has small area of high points for collecting great amount of water to mitigate the problem. Phase 3 proposes a local solution in a small scale that is able to expand over time based on certain circumstances. The new system aims at reuse the under-utilized rainwater for flushing toilets.

This phase: (1) seeks for possibility to mitigate the problem at a granular scale that permeates to every house in Queens, (2) sets up criteria to for different prototypes of residential area.

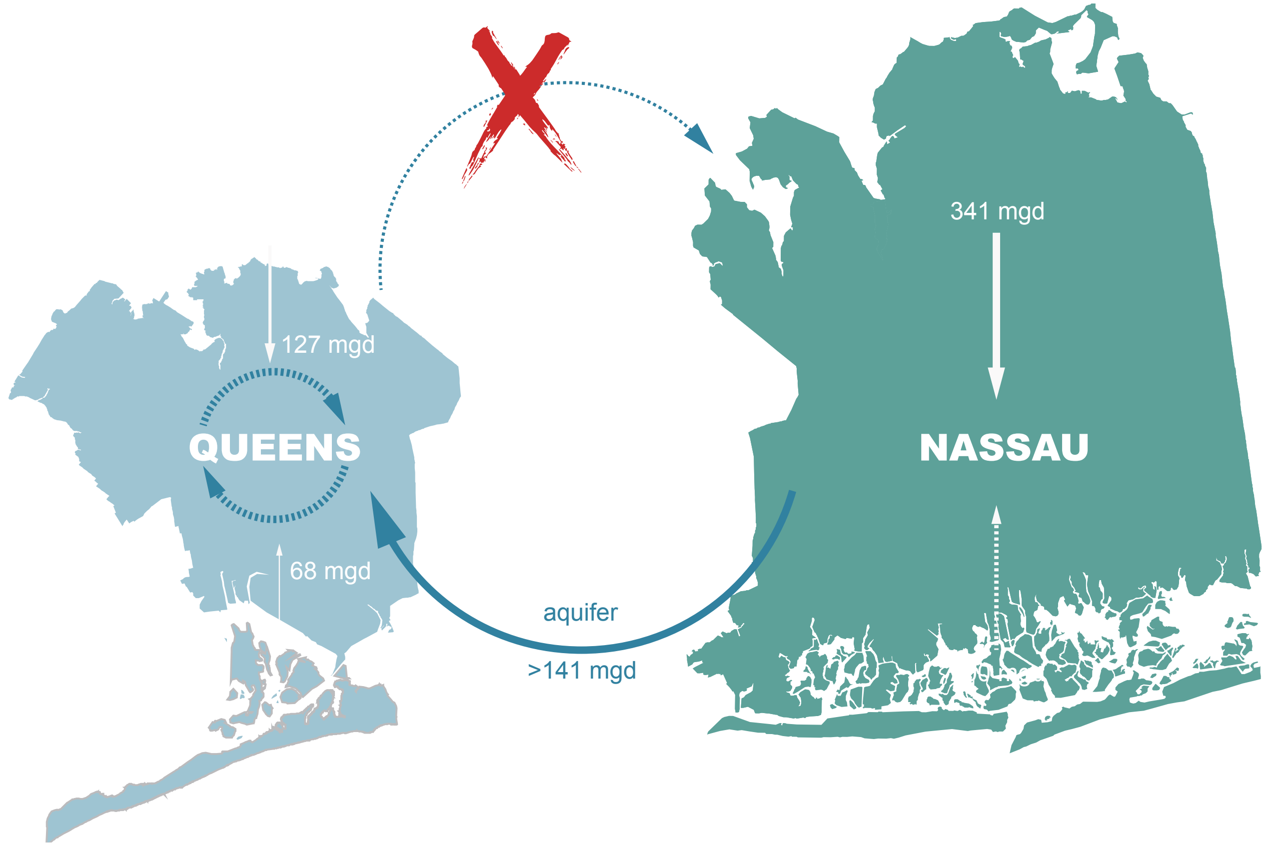
Introduction

In order to minimize the use of freshwater, 141 million gallons of water from another source is required. Through the testing from Phase 2, a large infrastructural scale solution is not efficient nor realistic because it requires a large area for water storage, which doesn't exist in a massive residential area in southeastern Queens. This phase digs into the existing water use conditions of each house and proposes a new system to connect the rainwater, roof collection, and toilet water. Capturing the rainfall and storing it in a water tank under each block, then supplying for toilet water is the main strategy in phase 3.

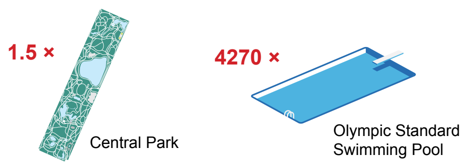
Methods

1. Quantifying: Amount of water in the issue
2. Mapping: Phases for system expansion
3. Diagramming: Mechanism of the proposed system
4. Typology analysis: Solutions for different residential areas
5. Modeling: Proposed system

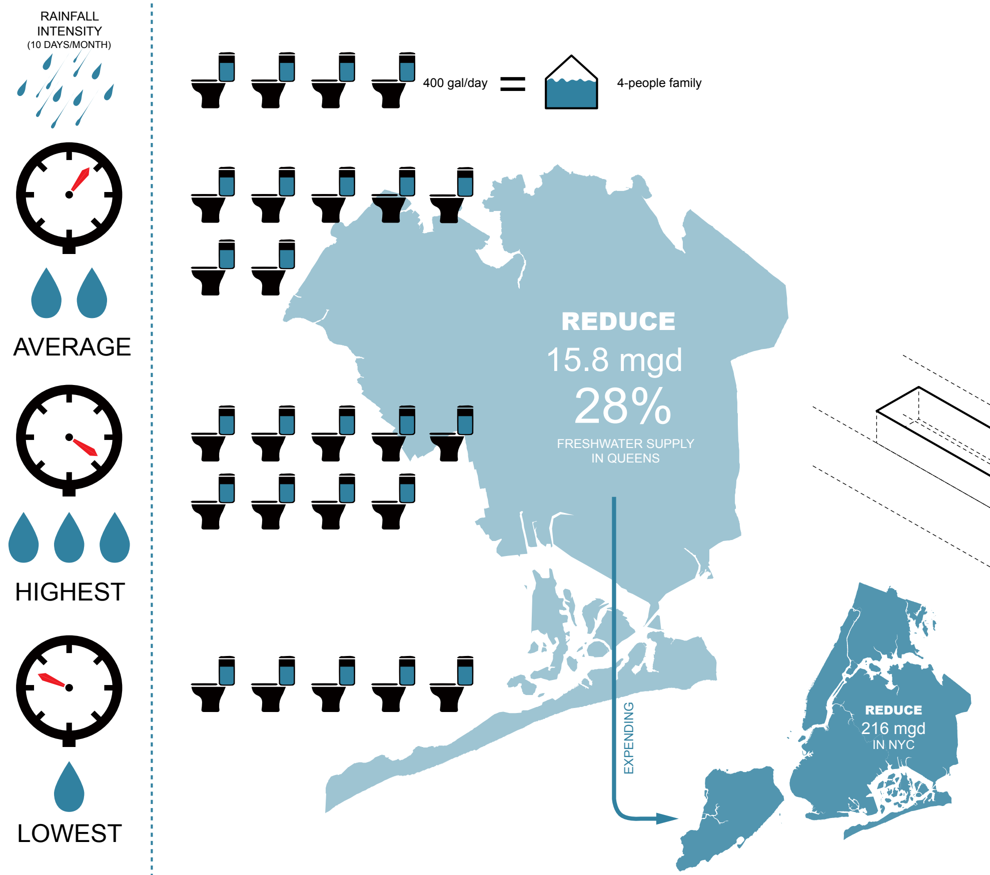
Phase 3 Water We Need

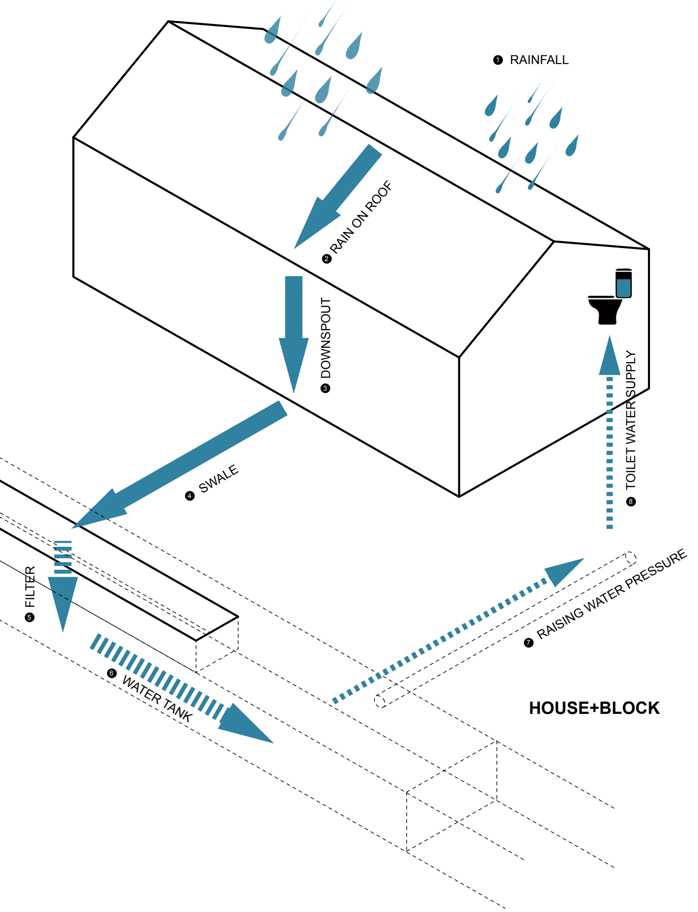


Area 1,319 acres
Volume 141 million gallons

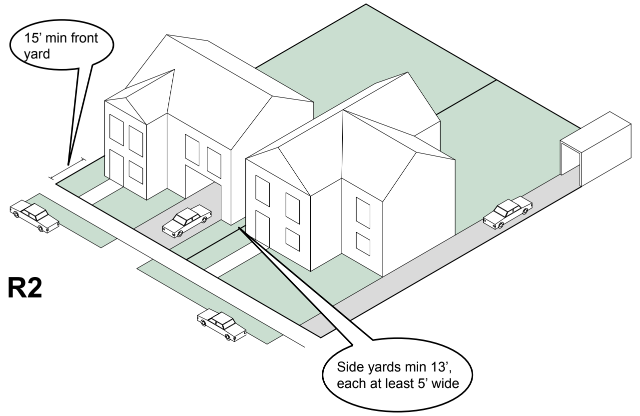


In order to solve the problem of draining 141 million gallons of water per day from Nassau County, 1.5 times of area of central park to store water for one day is needed. The volume of 141 million gallons of water can fill in 4,270 Olympic standard swimming pools.

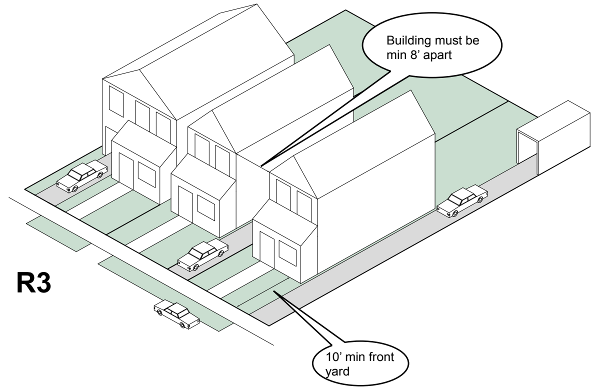




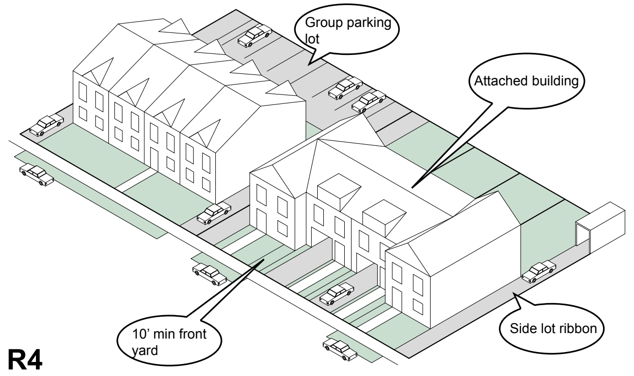
Phase 3 Expanding System Phases



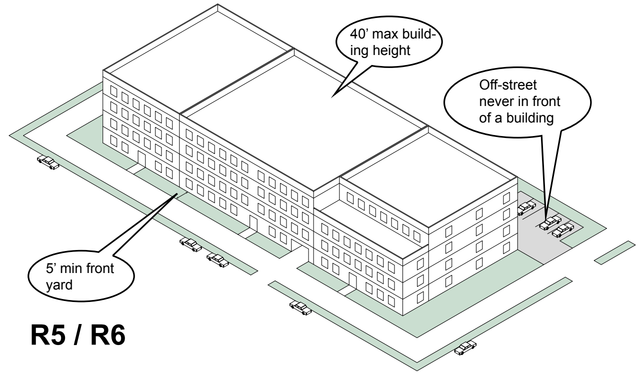
R2



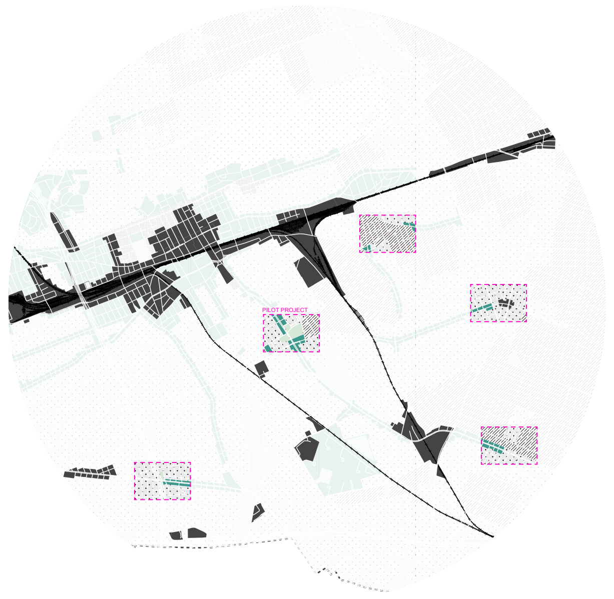
R3



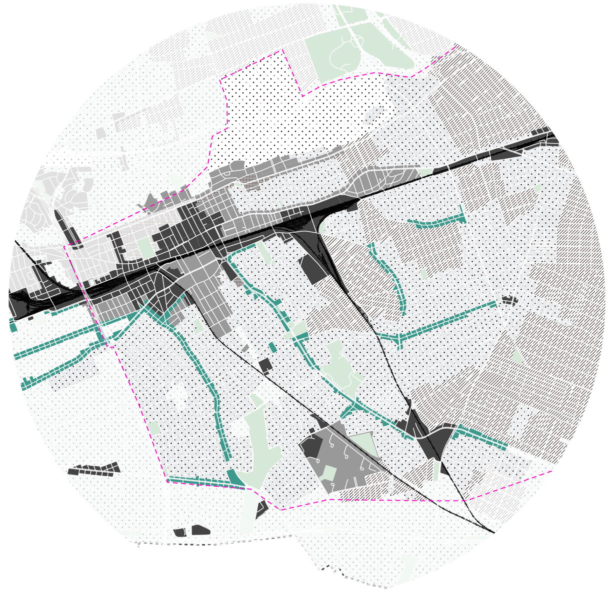
R4



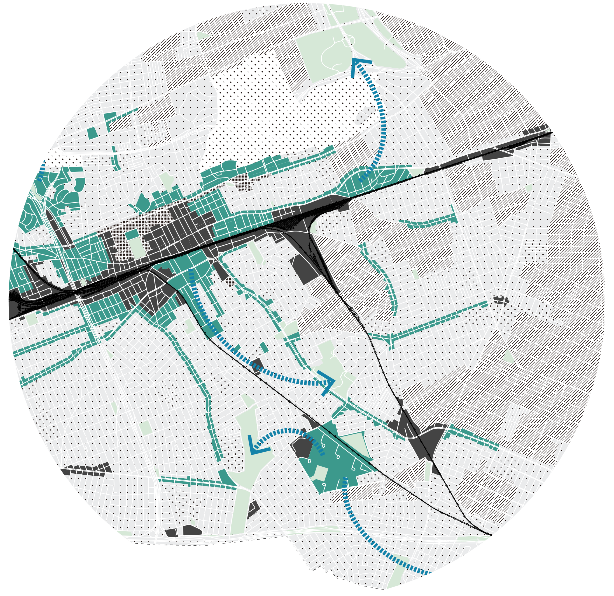
R5 / R6



Pilot Projects within Few Blocks

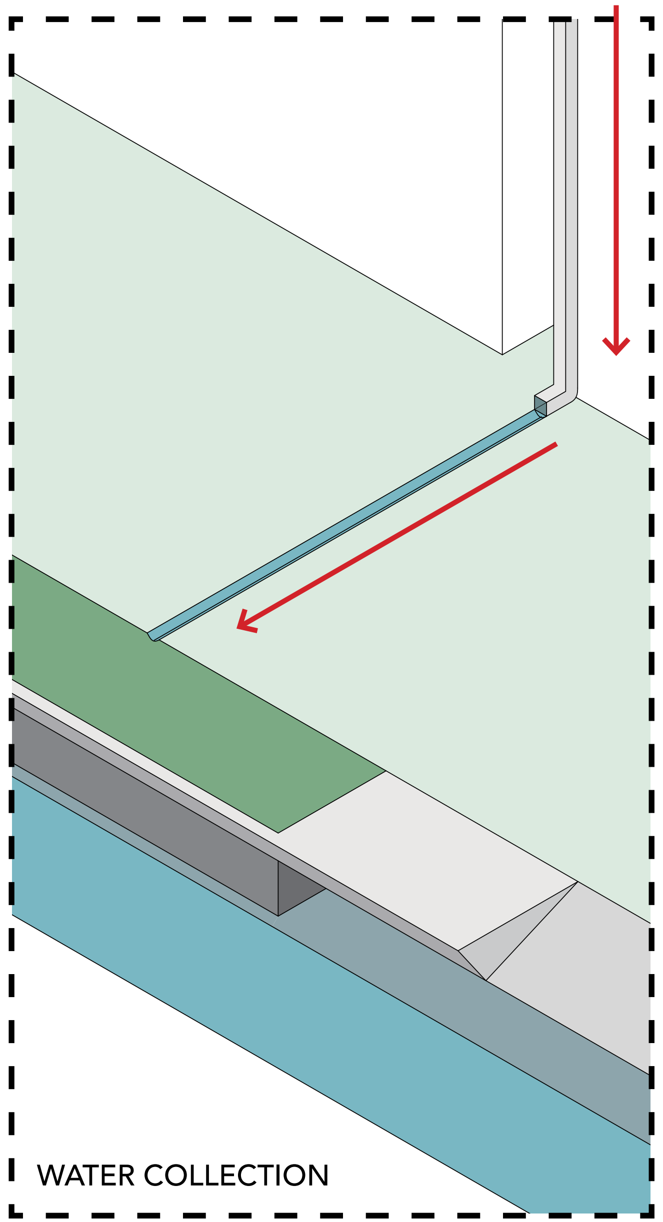


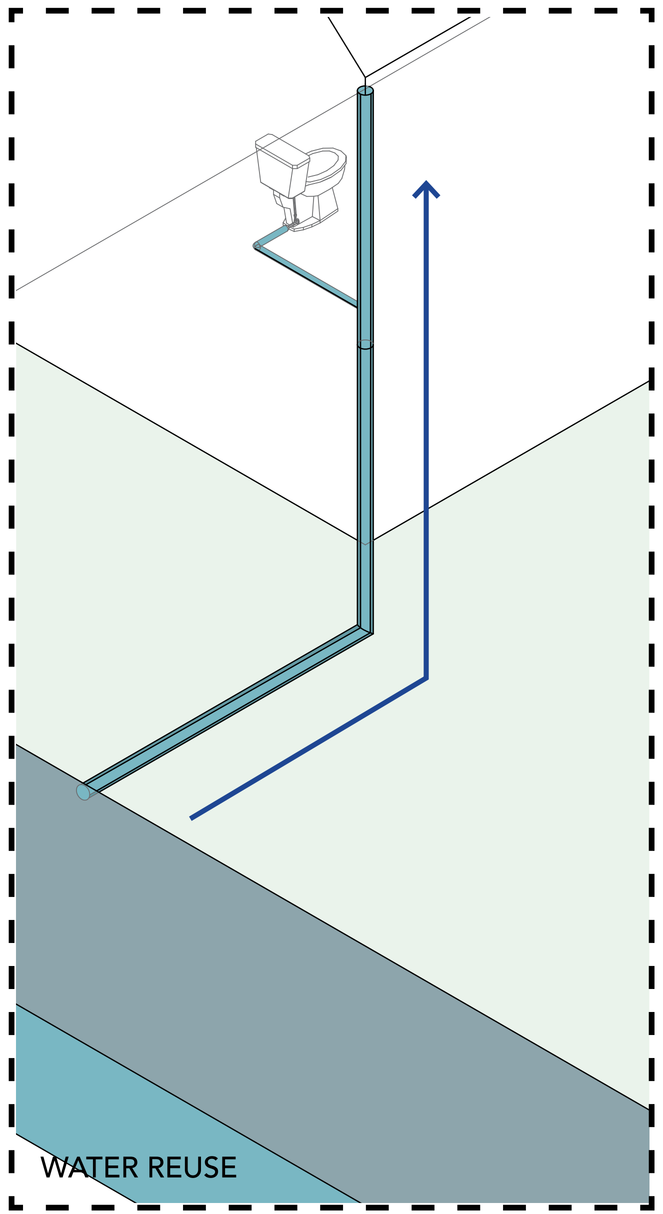
Queens Groundwater Supply Area



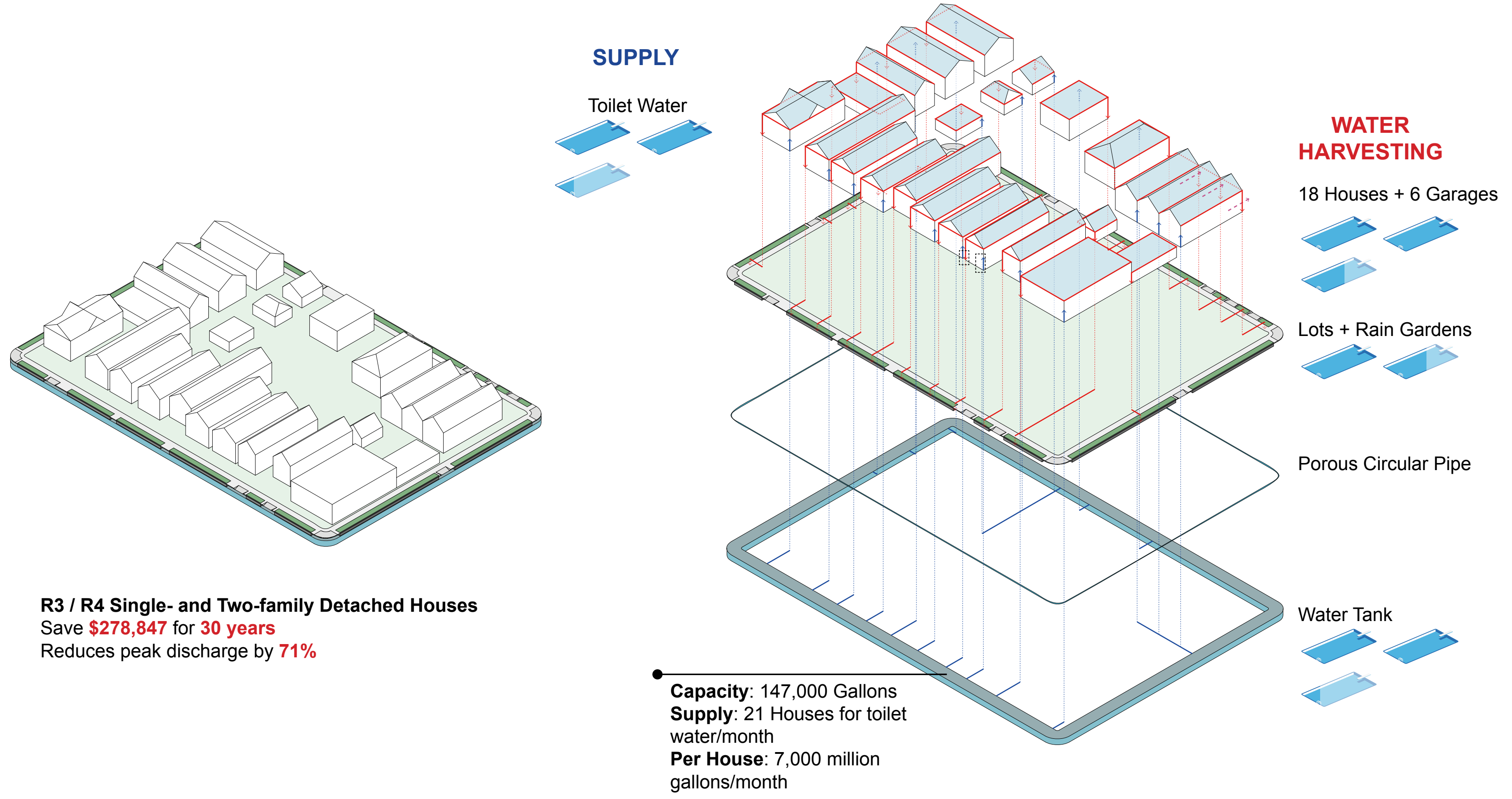
Citywide Collection and Supply

Phase 3 Residence District Prototypes

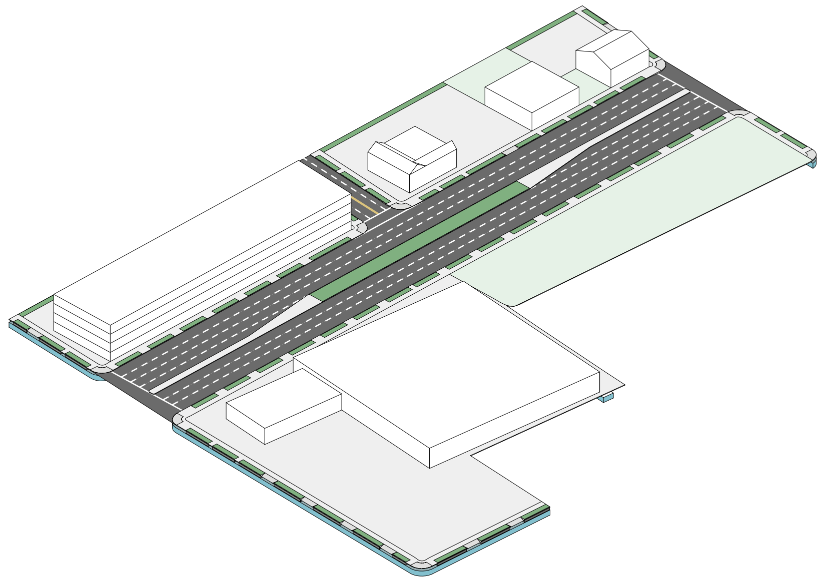


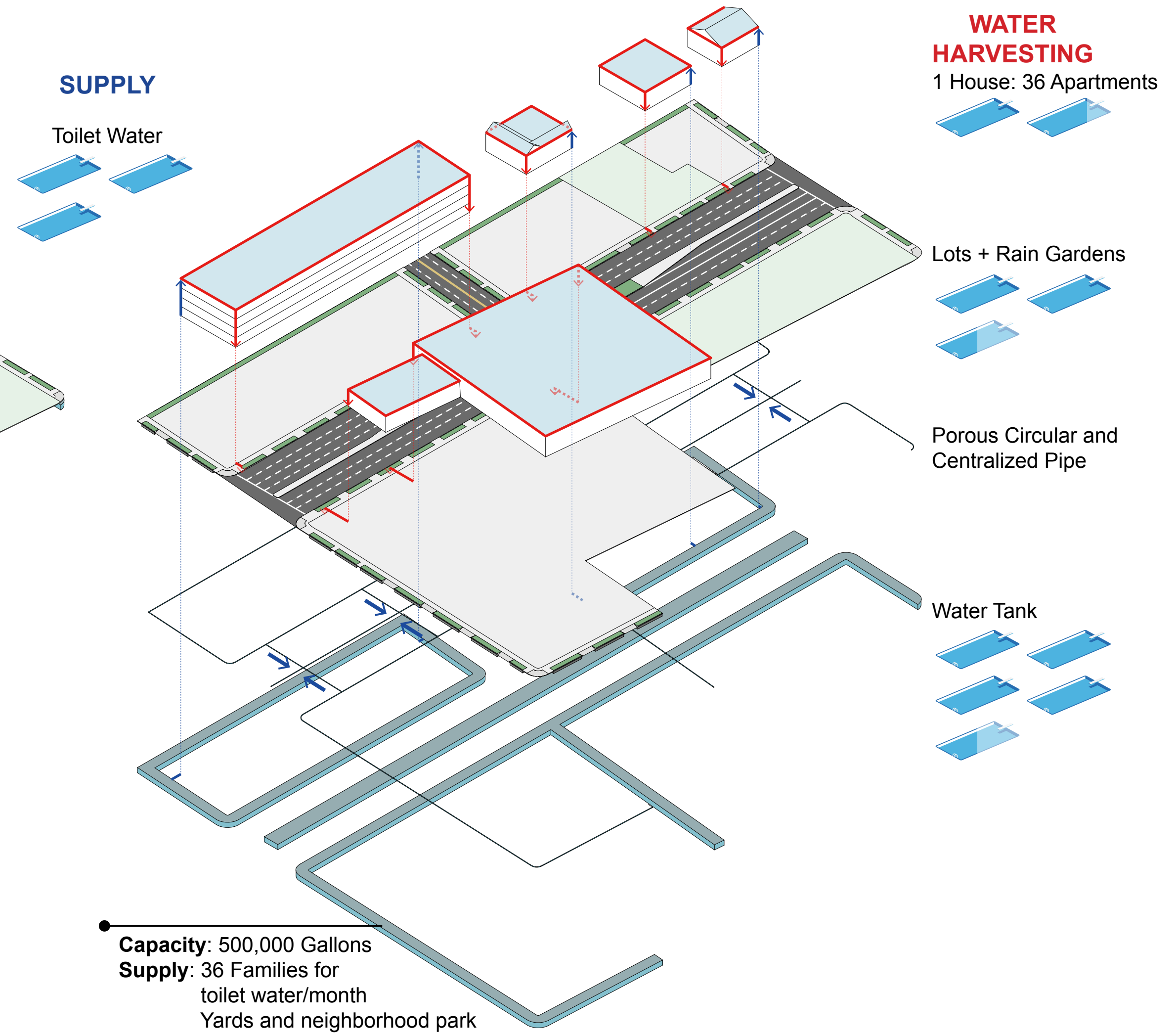


There are four layers in the system for a block unit. According to the toilet and irrigation water needed for different residence districts, the volume of water tank has varieties.

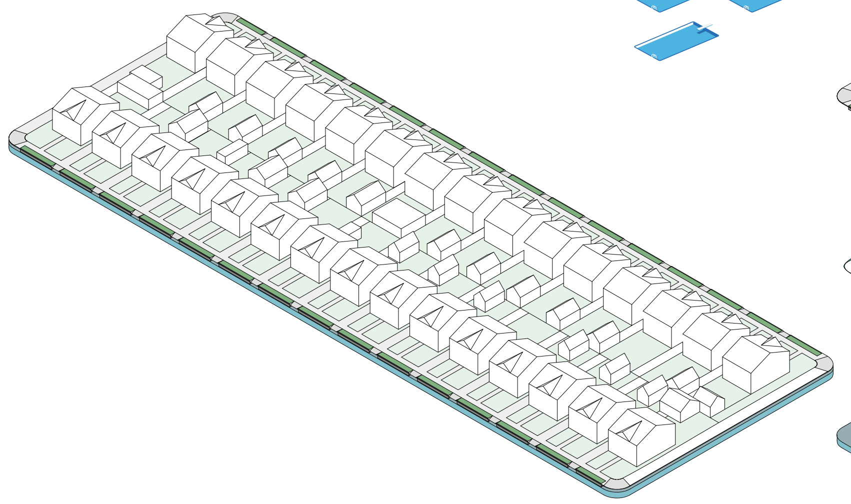


Phase 3 Residence District Prototypes

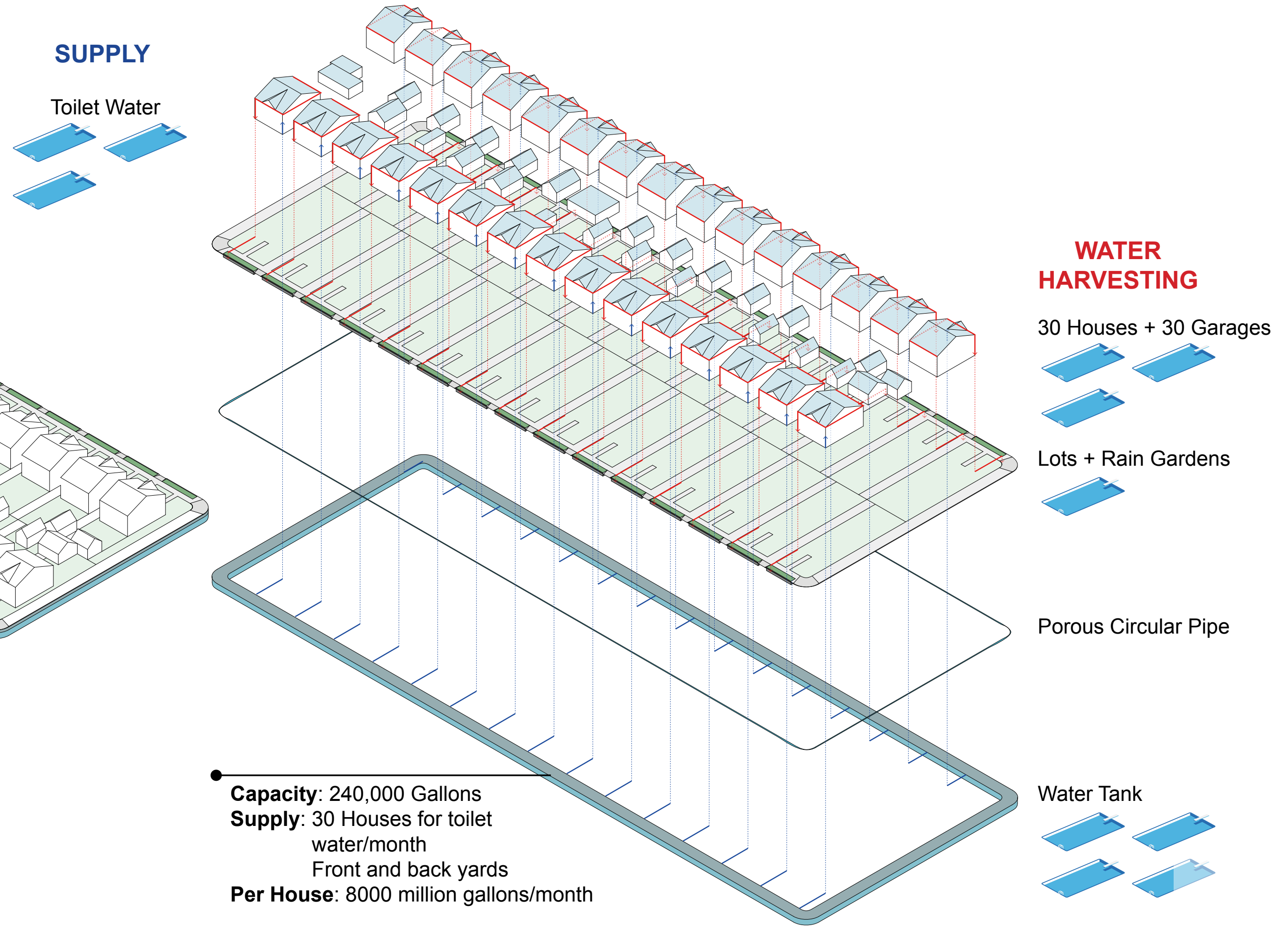




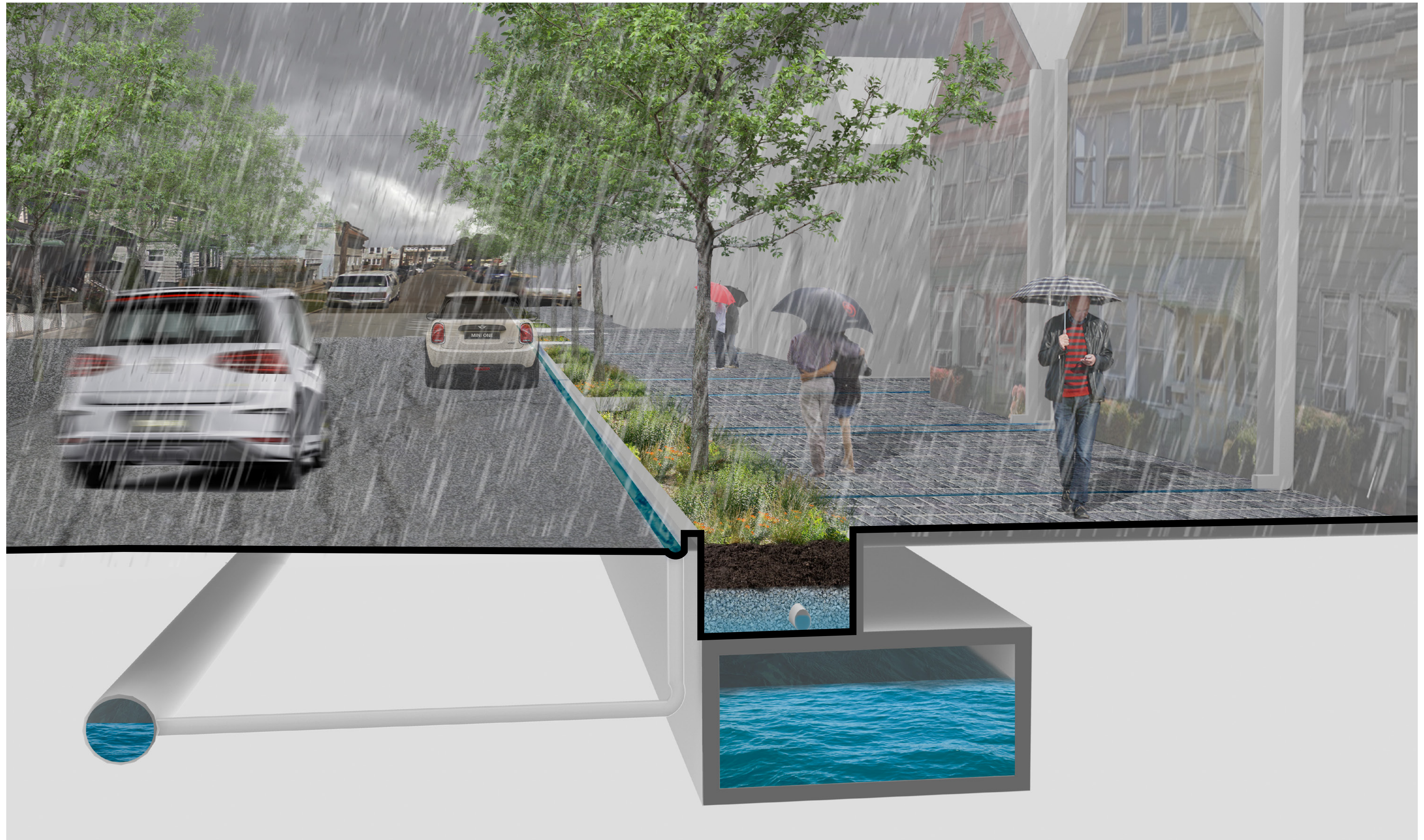
R5 / R6 Moderate-density, Multi-family Houses
Save $1,390,144 for 30 years
Reduces peak discharge by 64%



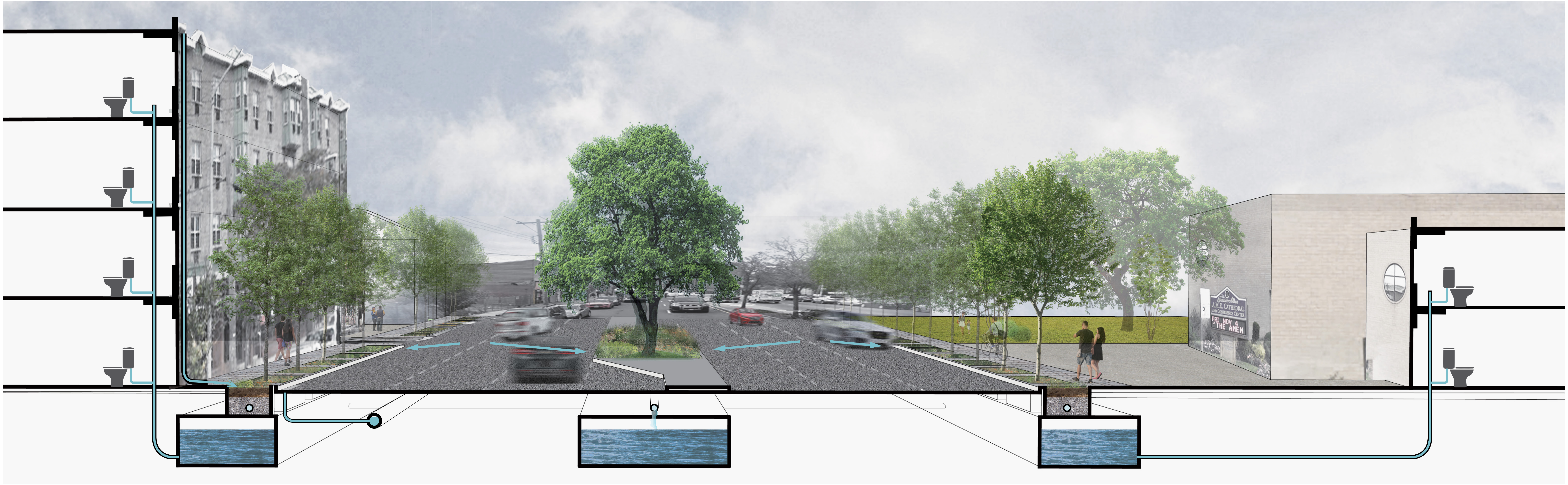
R2 Large Single-family Detached Houses
Save $156,714 for 30 years
Reduces peak discharge by 52%



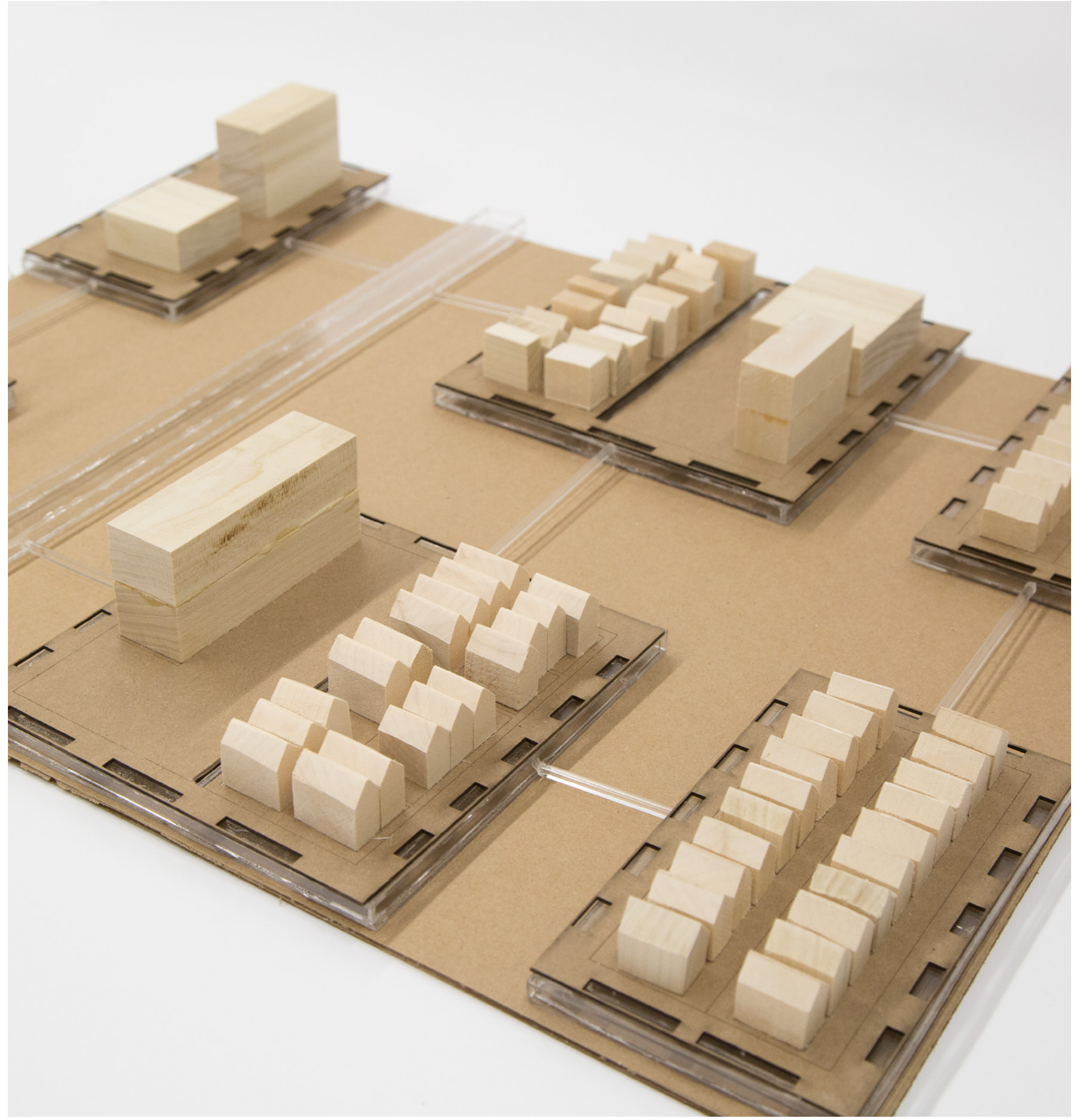
Phase 3 Surface Interaction

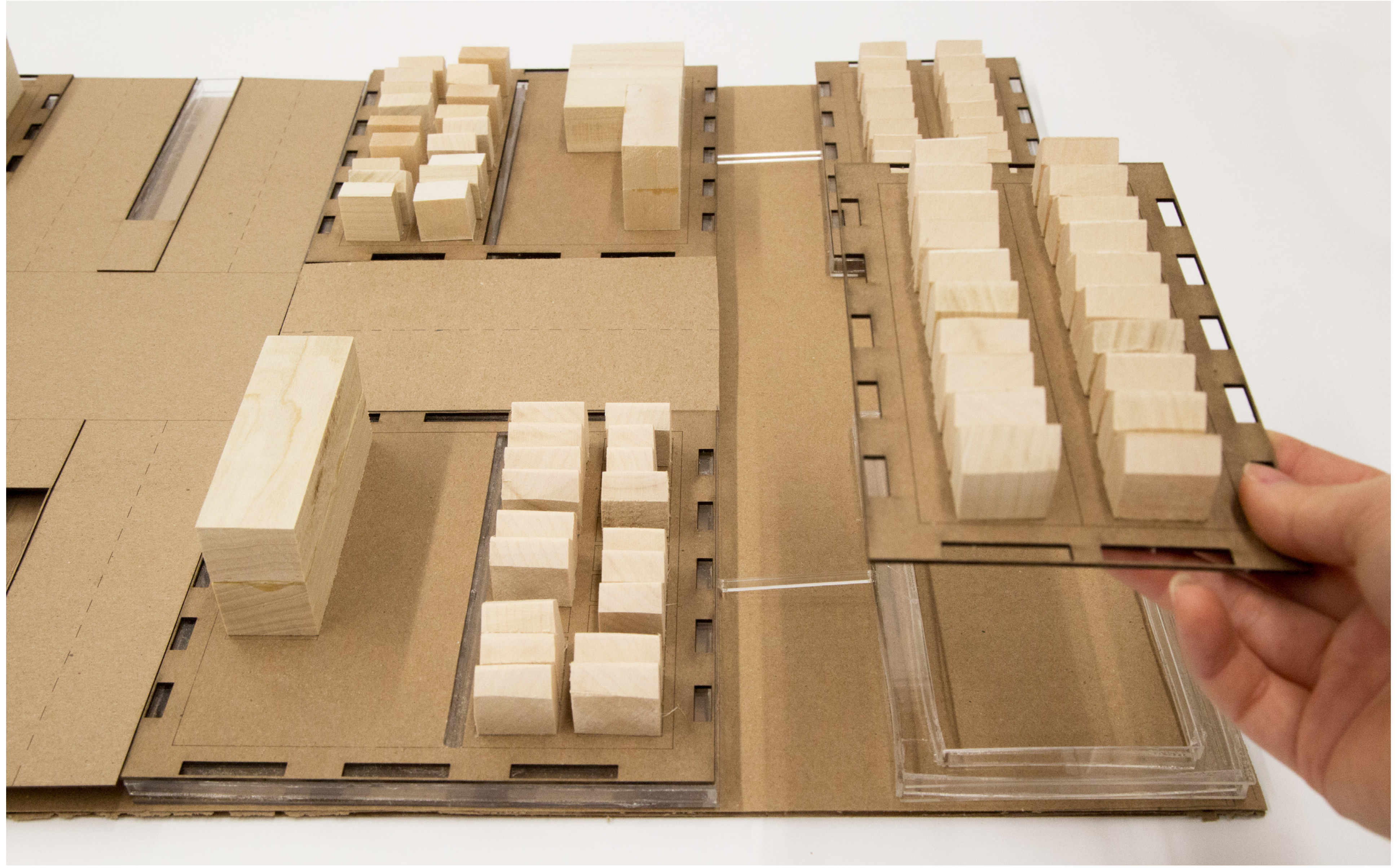


Phase 3 Surface Interaction



Phase 3 Concept Model





Pilot project is based on a block as a unit. According to different characteristic of various residence districts, there always is a structure that fits the block.

Findings + Conclusions

According to the rainfall and groundwater usage data, in Queens, the aquifer displacement drains 144 million gallons per day from Nassau County, which causes the lower water table in Nassau County. However, the rainfall in Queens is enough for recharging the groundwater, yet under utilized. Because of a great amount of impermeable surface, most of the rainwater goes directly into the sewage system. After sewage treatment, it is discharge to the ocean directly.

In order to solve the problem of draining 141 million gallons of water per day from Nassau County, 1.5 times of area of central park to store water for one day is needed. The volume of 141 million gallons of water can fill in 4,270 Olympic standard swimming pools.

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Toilet water requires lower quality of freshwater than drinking water. Through certain simple greywater treatment, rainwater can be reused for flushing toilet.

A 4-people household requires 7000 gallons for toilet water per month.
If most rainwater could be collected effectively for supplying toilet water, it will reduce 28% of freshwater use.

The new system starts from a block as a unit and expand to centralized main streets in the neighborhood, finally to a citywide scale. There are 4 layers at each unit: houses (roofs), ground plane, porous pipe, and water tank. Each water tank under the sidewalk is able to store 7000-8000 gallons of water for each house per month according to water need from different types of residence districts. During the heavy rain, overload will flow to the central spines for public space irrigation.

By establishing the new system and applying it to the whole city, 218 million gallons water per day will be reduced, which considerably mitigates the problem of overpumping and groundwater migration.

Assessment

Phase 3 settles down a large-scale problem into a small-scale solution and responses to specific circumstances in Queens. Two areas of advancement are needed to think about.

First, resilient solutions are usually layered and multi-functional, not singular in approach, which requires expanding the possibility of other functions more than just saving water. On the other hand, a landscape architecture project is to combine problem solving with cultural expression, to celebrate water engineering at the same time they are highly functional. Activating and engaging with water flow could be rooted into people’s daily lives.

More varieties for the system is needed to test how to react to the more complicated details in a real neighborhood in Queens. There is an opportunity to develop an idea into a spatial and experiential landscape, or to tackle the technical problem of incorporating street tree planting into a stormwater system and to take an idea set out by engineers and turn it into a landscape.

Overall Assessment

Final Conclusions

Long Island's aquifer system, including the Lloyd, Magothy, Jameco, and upper glacial aquifers, it is susceptible to lower water table and saltwater intrusion, which threatens the sole-source for 2.8 million people. Running short of groundwater in certain area does not influence its groundwater supply in Queens even when overpumping, because groundwater has a tendency to flow from Nassau County to Queens based on the potentiometric contours at each aquifer layer. Water from precipitation that is not evapotranspired or that does not run off in storm drains or streams infiltrates the permeable soil and moves both downward and horizontally through the porous rocks in response to gravitational or withdrawal-induced gradients. For Lloyd and Magothy aquifer, which are two thickest aquifers on Long Island, there is a basin at Queens groundwater supply area on the potentiometric map. The tendency of water flowing from Nassau County to Queens could make the freshwater supply in Nassau County run short.

A potential way to protect the groundwater source and ensure freshwater supply in Nassau County is to move more water from upstate watersheds in New York state. Since NYC is already draining current in-use watersheds, finding another water source from watersheds up north is needed. However, the topography of being high in central New York state increases the difficulty and price to construct new aqueducts for conveying more water for 1.352 million of people at Nassau County. Therefore, it is necessary to review the problem and seek for a local solution on Long Island if possible.

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Final Assessment

In Phase 1, the large-scale aquifer study clarified the understanding of underground geology and groundwater movement. The analysis in this phase is informational, but not synthetic yet. Multi-scale analysis could have been done to connect the large-scale problem to a granular-scale individual. This phase only reveals one aspect of the issue and leaves the potential direction too open to consider.

The criteria for Phase 2 address the issue of transitional concept from regional scale to neighborhood scale. The lack of clarity about specific strategy about design leaves some questions that could be potentially answered in Phase 3. The assessment for this phase should have spent more time on multi-scale analysis and water behavior to better understand the specific strategies being considered for execution. Explorations of multiple design alternatives and its impacts on the adjacent neighborhood could have strengthened the potential prototype and spatial strategy.

Phase 3 settles down the design development in a granular scale, which synthesizes the conceptual ideas and design principles explored in earlier phases. The transitional concept from the analysis of residence districts to strategy in react to various conditions of water use takes on the significance for proposing a system. Integrating more functions and cultural expression would have been done to reveal the richness of a system being highly functional and beautiful.

Overall, scale is always the issue in this research topic. Each phase explored the topic and guided principle at a comprehensive and detailed scale. The boundary between the abstract and physical addressed the significance of understanding water behaviors, infrastructure tectonic and community engagement. However, there are still missing answers regarding to the relationship between problem solving and culture expression. It would have been better if each phase researched about the cultural meaning of water engagement parallel with current studies. This holds potential in weaving together all layers into an integrated system with functions and beauty.

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