

Orange Trees & Oil Wells: Imagining a Decarbonized California

**A Thesis Submitted to the Department of Urban Planning and Design,
Harvard University Graduate School of Design**

by

Duke Dunham

In Partial Fulfillment of the Requirements for the Degree of

Master of Architecture in Urban Design

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Student

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Thesis Advisor

ORANGE TREES & OIL WELLS

IMAGINING A DECARBONIZED CALIFORNIA

1120:—Orange Groves and Oil Wells, Santa Fe Springs, Calif.



IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE
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URBAN DESIGN

BY: DUKE DUNHAM
ADVISORS: PETER ROWE & ALEX YUEN

TABLE OF CONTENTS

INTRODUCTION

DECARBONIZED CALIFORNIA	7
CONTEXT	11
ANALYSIS	23
REMEDIATION	29
SYSTEMS TRANSITION	47
PHASING	59
CHEVRON EL SEGUNDO 2045	63

DECARBONIZED CALIFORNIA

California is the most valuable state in the United States, with its real estate valued at more than \$10 trillion or 20% of the US real estate market.¹ Supporting this real estate market California has become the largest exporter of agriculture in the nation, valued at \$55.8 million.² California is also the third largest oil refiner in the country, refining 1.8 million barrels per day.³ California today is facing extreme climate stress expecting a 40% decline in crop yields by 2050.⁴ Industrialized agriculture relies on fossil fuels to support the world's food supply. Starting in 2030 demand for oil is expected

1 Lea, Sazuki. "Where San Francisco Ranks on 'Most Valuable' Real Estate Markets List." San Francisco Chronicle. Accessed January 30, 2024. <https://www.sf-chronicle.com/realestate/article/most-valuable-home-markets-california-data-18392040>.

2 Western Farm Progress. "What US States Produce the Most Food? (Ranking 1-50)." Farm Progress, January 6, 2023. <https://www.farmprogress.com/management/what-us-states-produce-the-most-food-ranking-1-50-#>.

3 OGJ. "2022 Worldwide Refining Capacity Summary." Oil & Gas Journal, March 20, 2023. <https://www.ogj.com/ogj-survey-downloads/worldwide-refining/document/14291248/2022-worldwide-refining-capacity-summary>.

4 Brillinger, Renata. "Climate Threats to Agriculture." CalCAN, December 7, 2021. <https://calclimateag.org/climatethreatstoag/>.

to drop from 93 million barrels to 25 million barrels a day by 2050.⁵ Based on these predictions oil prices are going to rise drastically creating global food instability. In addition to the phased decommissioning of 629 oil refineries by 2050.⁶

California's AB1757 leads the nation as the most aggressive climate policy. This phased decarbonization strategy will transform the world's 4th largest economy into a carbon free economy.⁷ The city affected the most by these policies is Los Angeles, a city defined by its infrastructure. LA has used these tools for the past century to extract resources and bring value to the barren Los Angeles Basin. What happens when the price of carbon is no longer the determining factor for development but instead development is guided by the impact of carbon on the environment?

Los Angeles currently has five refineries within the county limits. Current pressure at the state and local level has banned oil extraction and is making it increasingly difficult to refine oil in the city, with Chevron the state's largest refiner withdrawing future investment in the state. The Chevron El Segundo refinery is 1,200 acres of prime coastal property that produces 40% of

5 IEA. "Net Zero by 2050 – Analysis." IEA, May 2021. <https://www.iea.org/reports/net-zero-by-2050>.

6 IEA. "Transformation – Key World Energy Statistics 2020 – Analysis." IEA, 2020. <https://www.iea.org/reports/key-world-energy-statistics-2020/transformation>.

7 Sample, Brooke. "California to Have World's Fourth-Largest Economy, Topping Germany." Bloomberg.com, October 29, 2022. <https://www.bloomberg.com/opinion/articles/2022-10-29/california-to-have-world-s-fourth-largest-economy-topping-germany?embedded-checkout=true>.

the jet fuel and 20% of the gasoline in Southern California.⁸ The withdrawal of the oil industry is inevitable, but can we imagine a new use for these sites that assist in our transition to a more sustainable future?

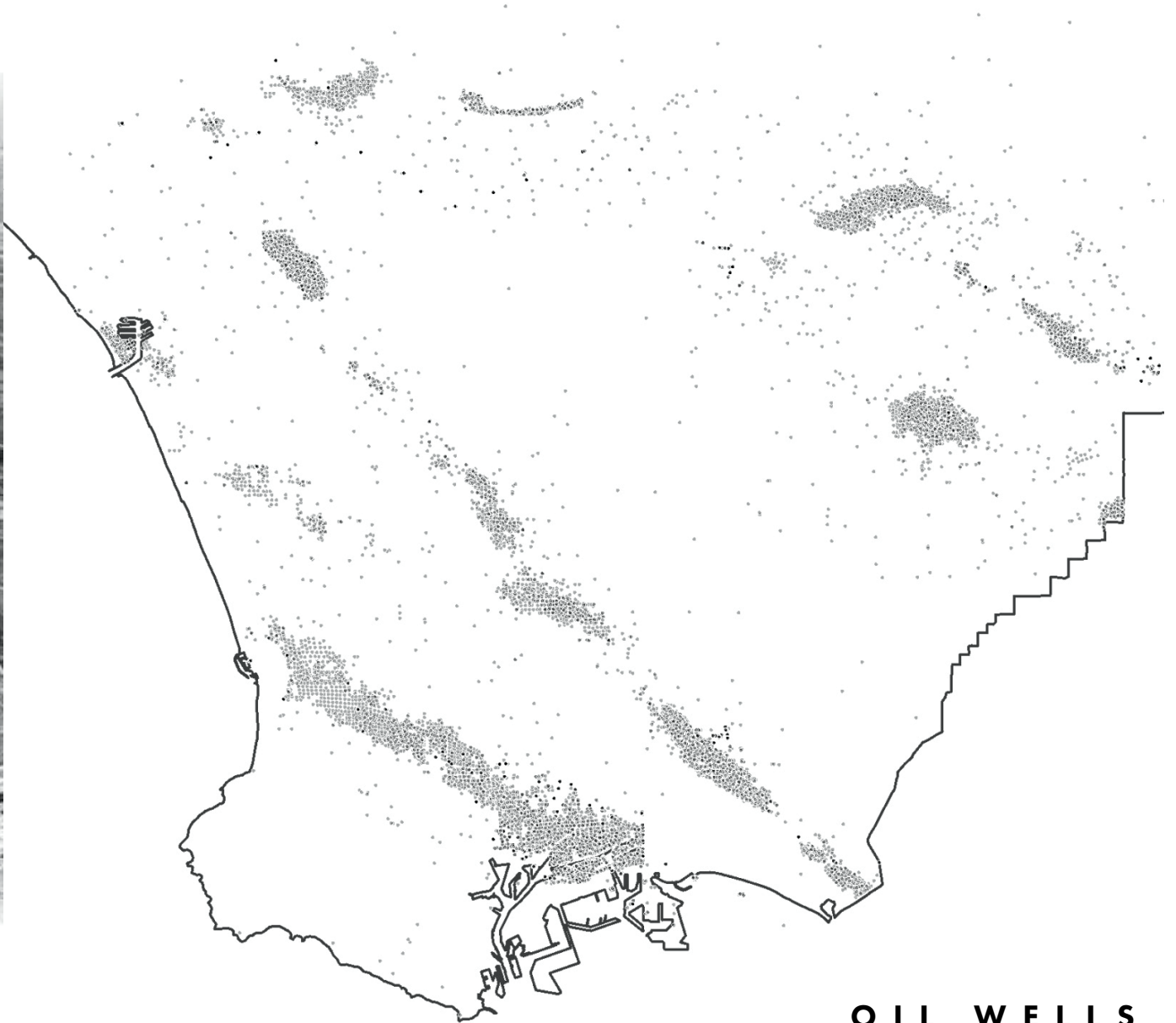
As the world is facing this trifecta of a climate crisis, energy crisis, and food crisis solutions need to be looking at their capacity to create change. the adaptation of oil refineries provides an opportunity in the midst of a crisis to rethink the value of heavy industrial land use types as a way to provide more resilience and stability to urban centers.

8 Chevron Policy, Government and Public Affairs. "About." chevron.com, December 12, 2022. <https://elsegundo.chevron.com/about>.

The Invisible **Ecology** of Los Angeles

Networked Infrastructure of Oil



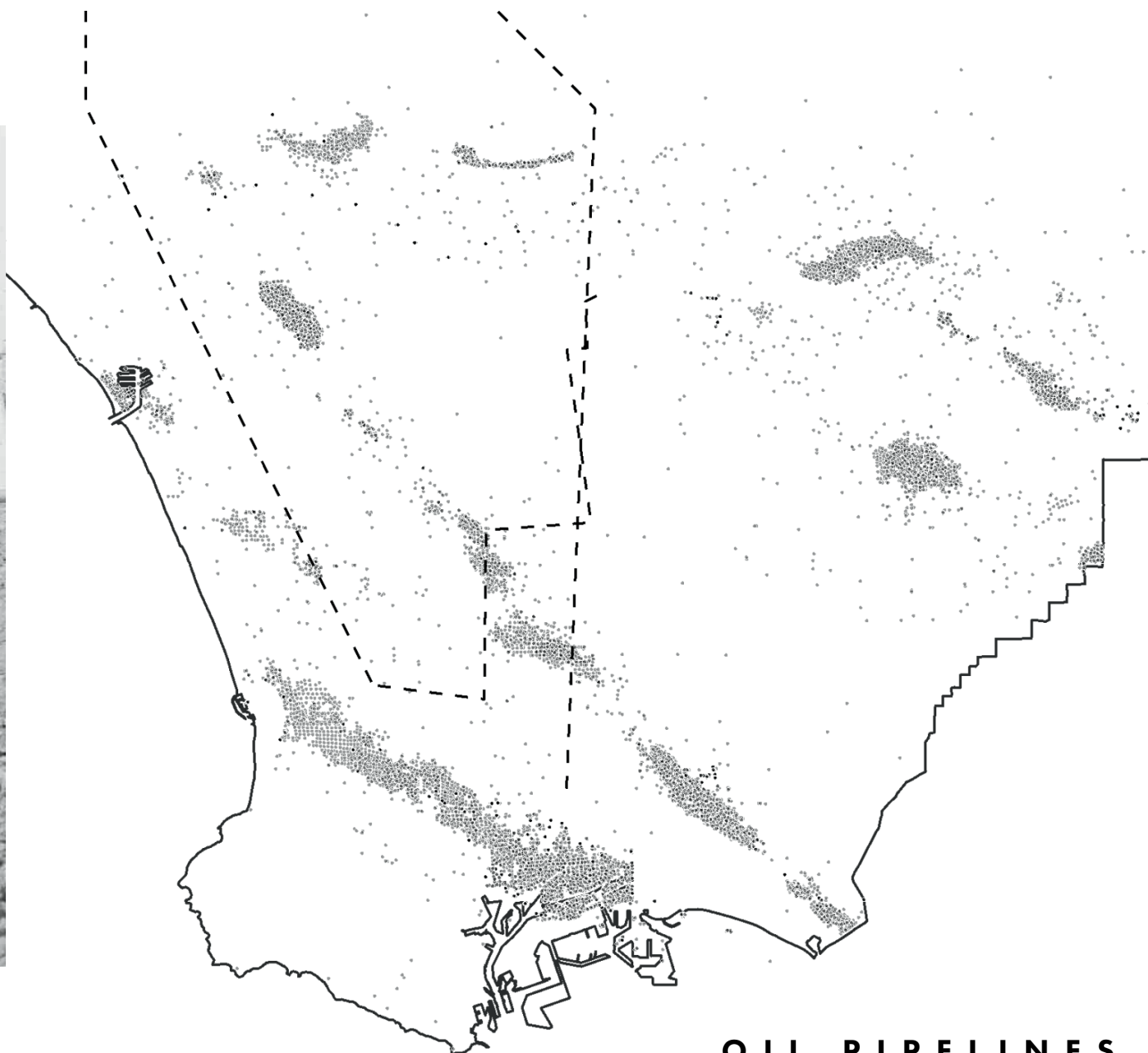


**OIL WELLS
(ACTIVE)**

The Invisible **Ecology** of Los Angeles

Networked Infrastructure of Oil



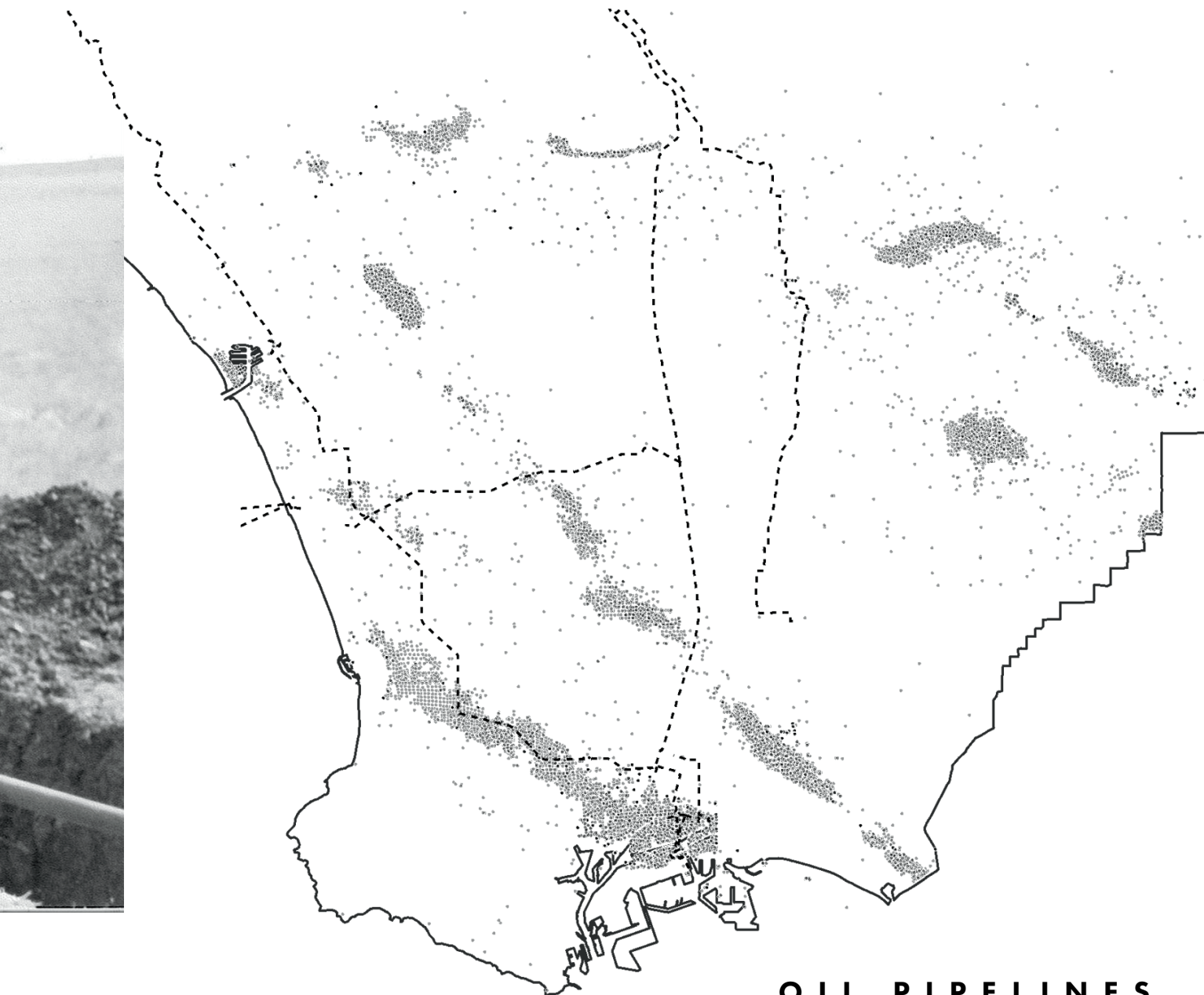


**OIL PIPELINES
(IMPORT)**

The Invisible **Ecology** of Los Angeles

Networked Infrastructure of Oil



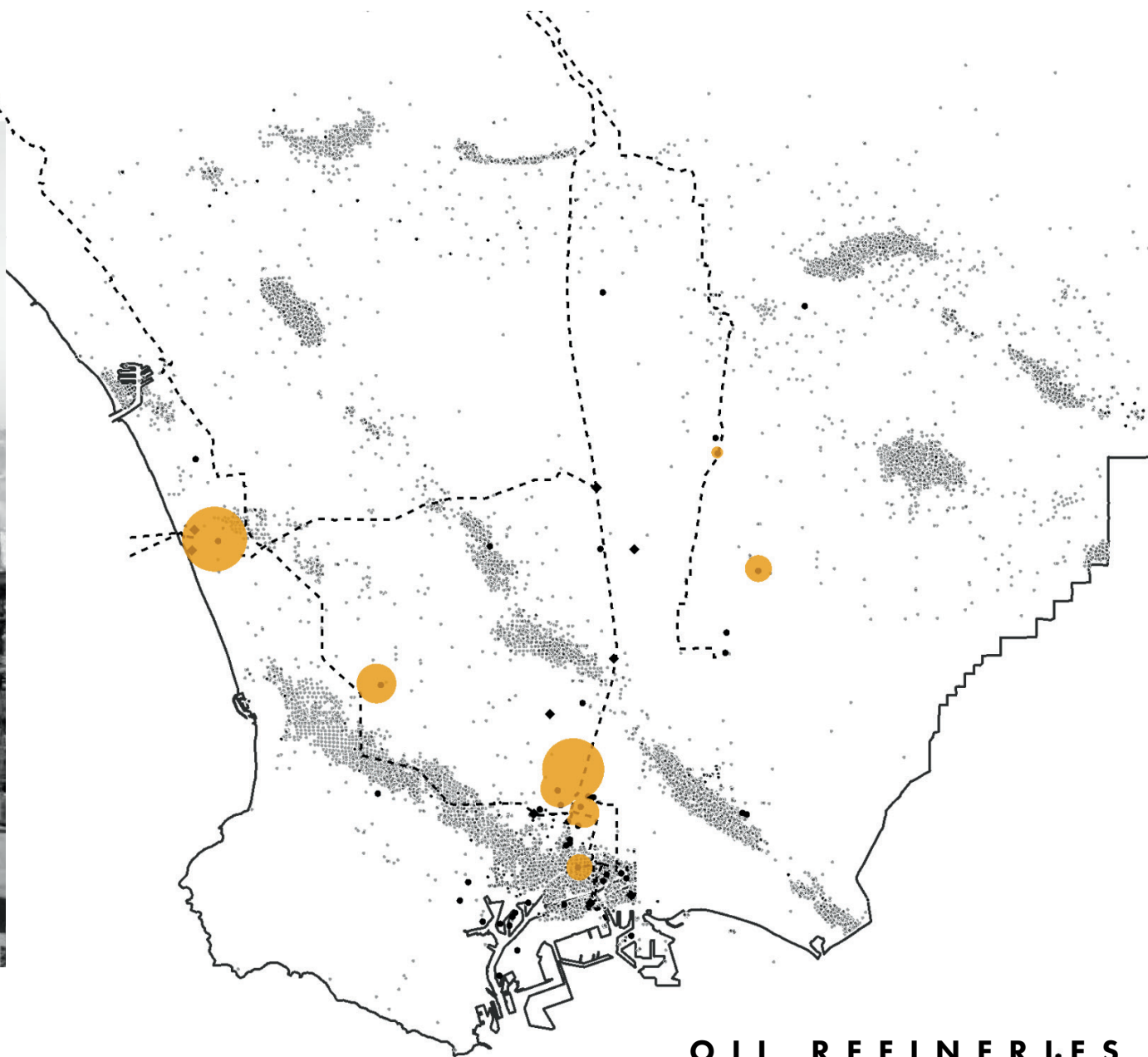


**OIL PIPELINES
(EXPORT)**

The Invisible **Ecology** of Los Angeles

Networked Infrastructure of Oil



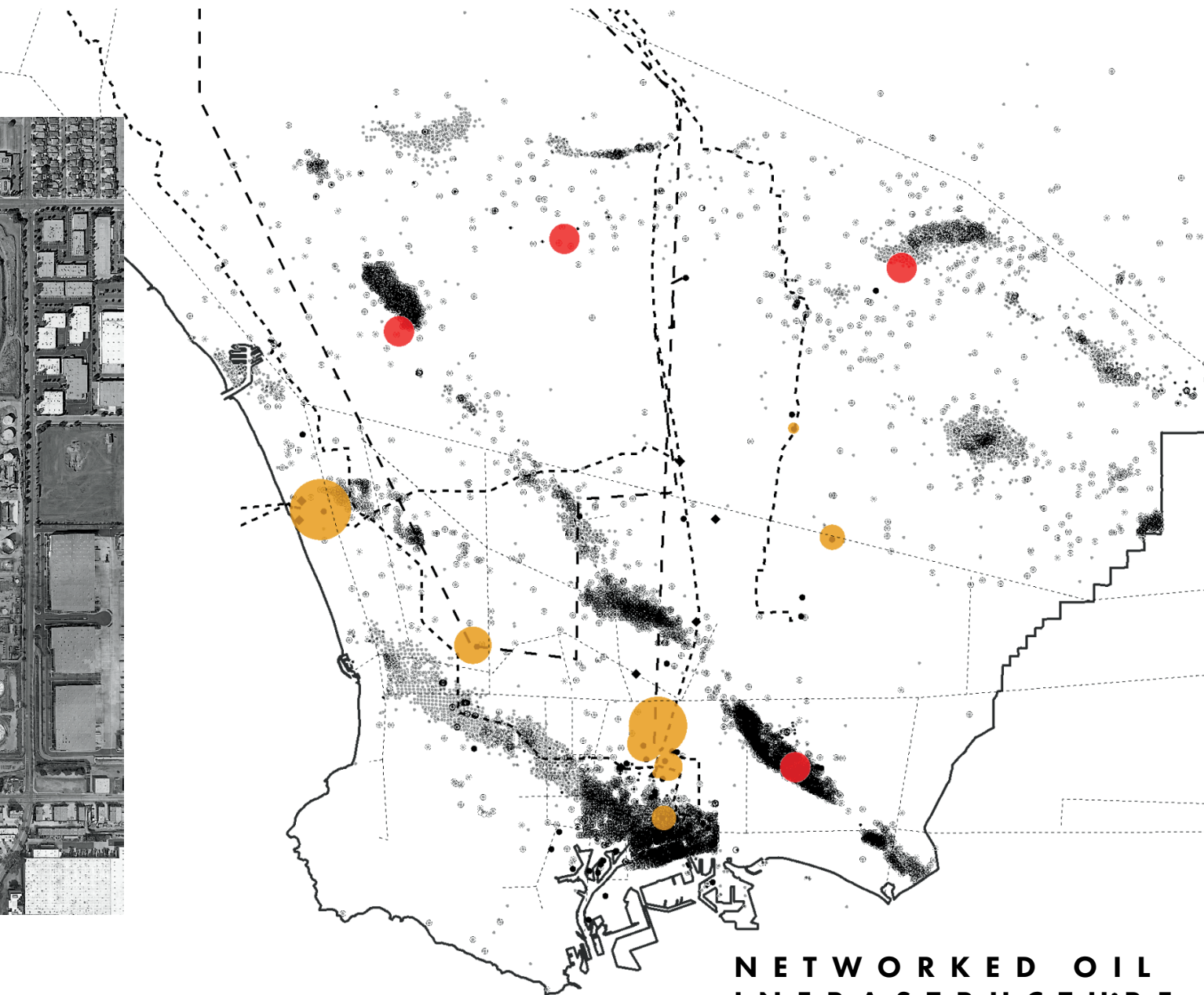


OIL REFINERIES

The Invisible **Ecology** of Los Angeles

Networked Infrastructure of Oil





NETWORKED OIL INFRASTRUCTURE



Roadmap to Decarbonization

CRUDE OIL | 15%

SB-1137

CA | Oil and Gas Restrictions

New Oil Well Ban (within 3,200')

New Oil Drilling Permit Ban

NO-187709 LA | Oil & Gas Drilling Ordinance

New Oil Drilling Ban

Existing Oil Drilling Phase Out

DIESEL | 15%

N-79-20

ADVANCED CLEAN TRUCKS REGULATION

Diesel Municipal Vehicle Ban

Diesel Drayage Truck Ban

Diesel Engine Sales Ban

Diesel Truck Ban

GASOLINE | 45%

N-79-20

ADVANCED CLEAN CARS II

50% Zero-Emission Vehicle Sales

100% Zero-Emission Vehicle Sales

Average Salvage Period (12.5yrs)

POLLUTANTS

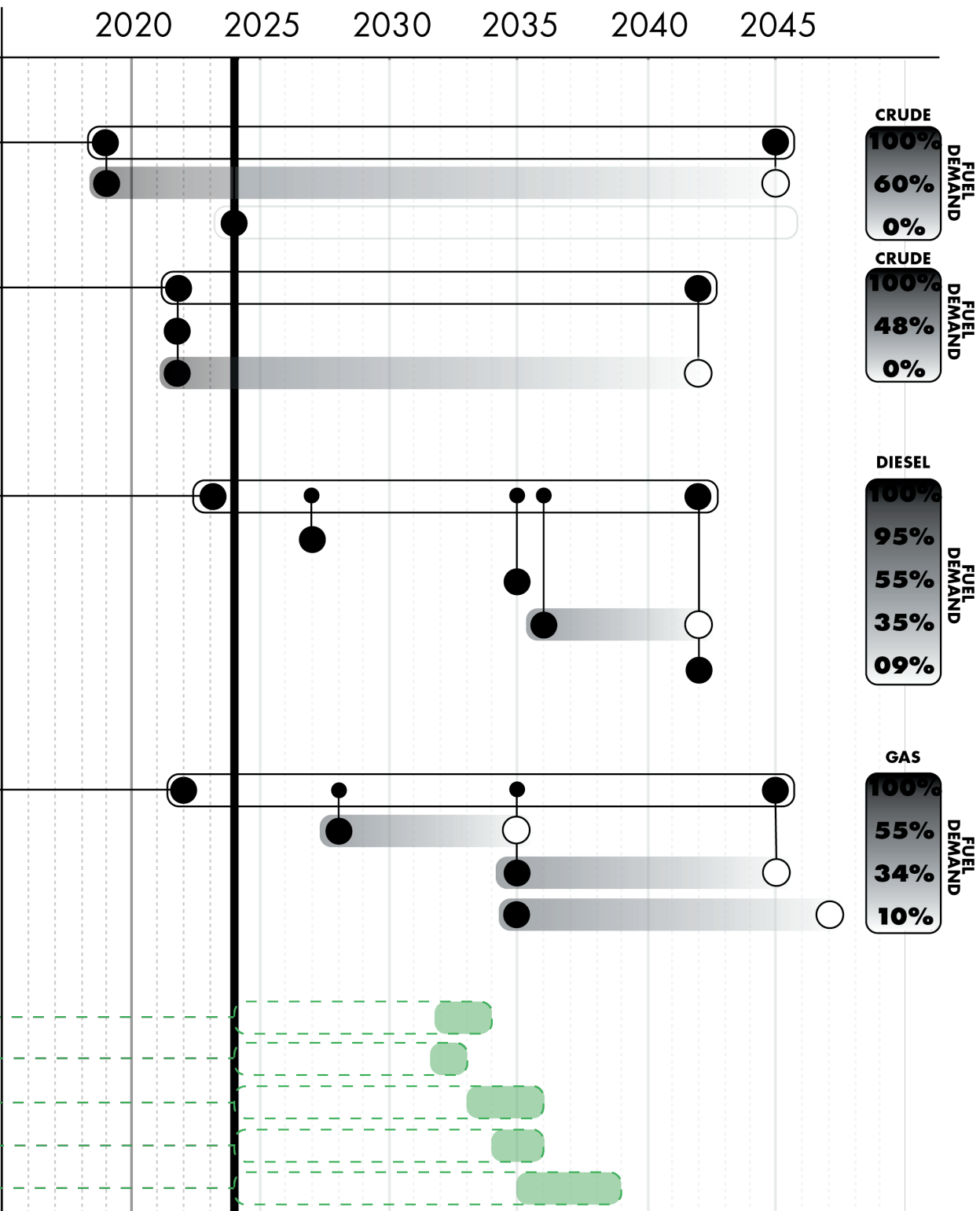
MTBE

ALPHATICS

PETROLEUM

PAH'S

BTEX

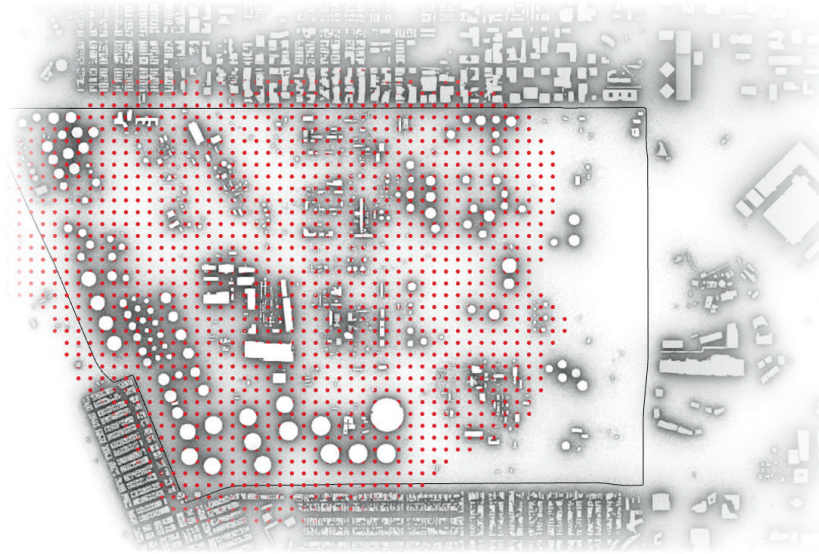


CONTAMINANTS

BTEX

BENZENE | TOLUENE | ETHYLBENZENE | XYLENES

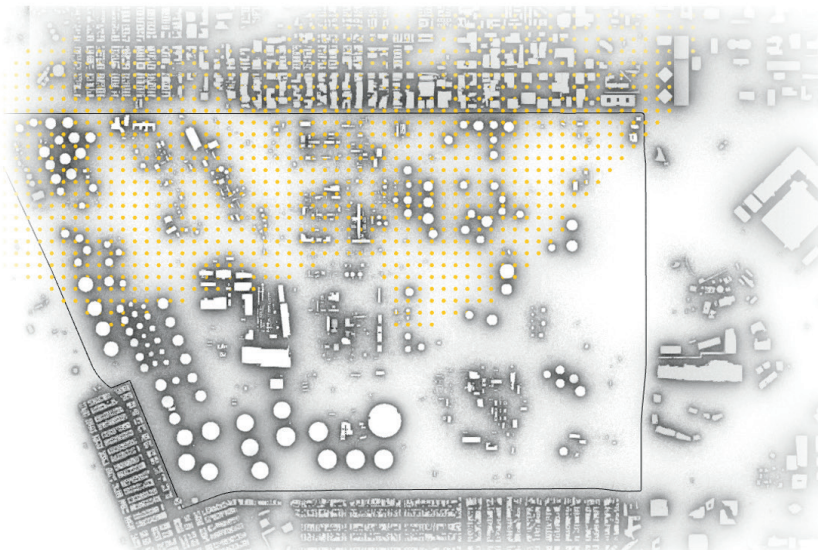
DISPERSES THROUGH STORMWATER RUNOFF



TPH

TOTAL PETROLEUM HYDROCARBONS

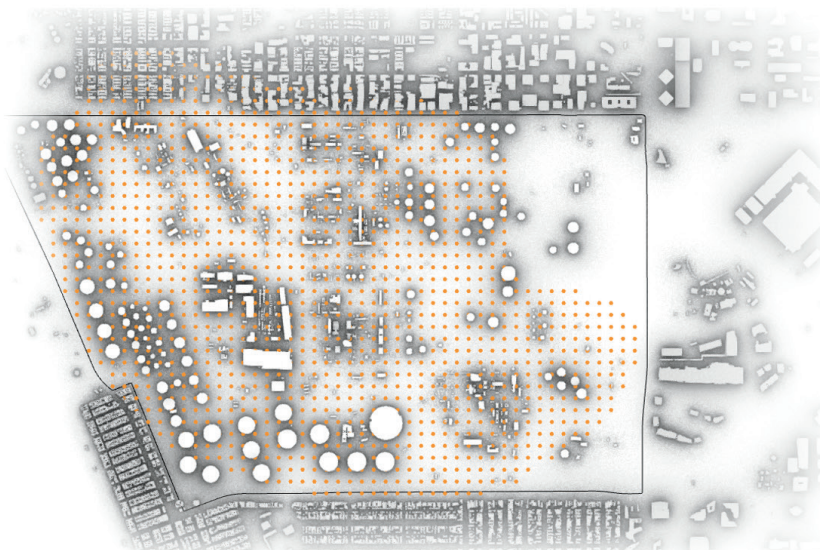
DISPERSES THROUGH GROUNDWATER INFILTRATION



PAH
POLYCYCLIC AROMATIC HYDROCARBONS
DISPERSES THROUGH AIR

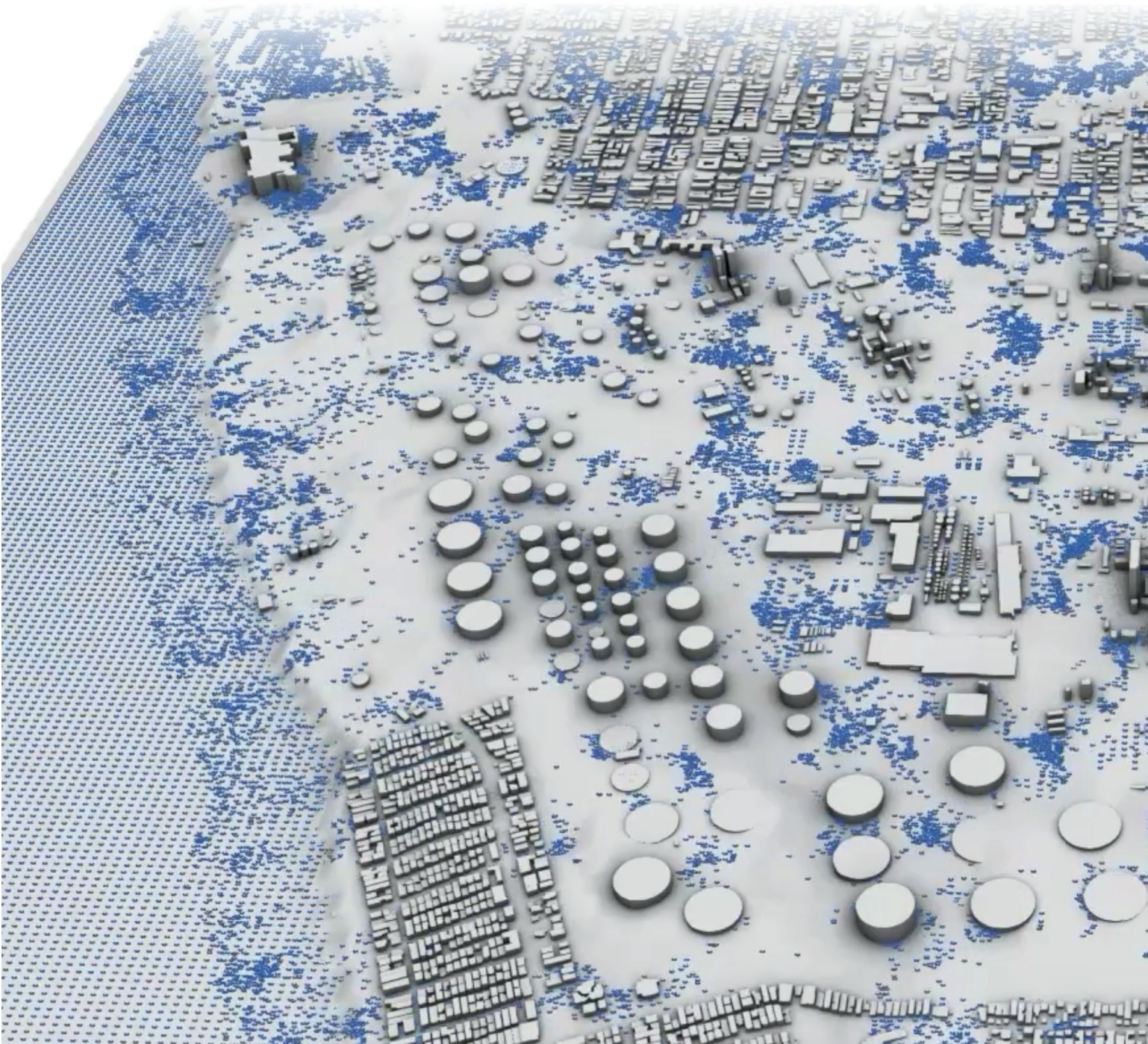


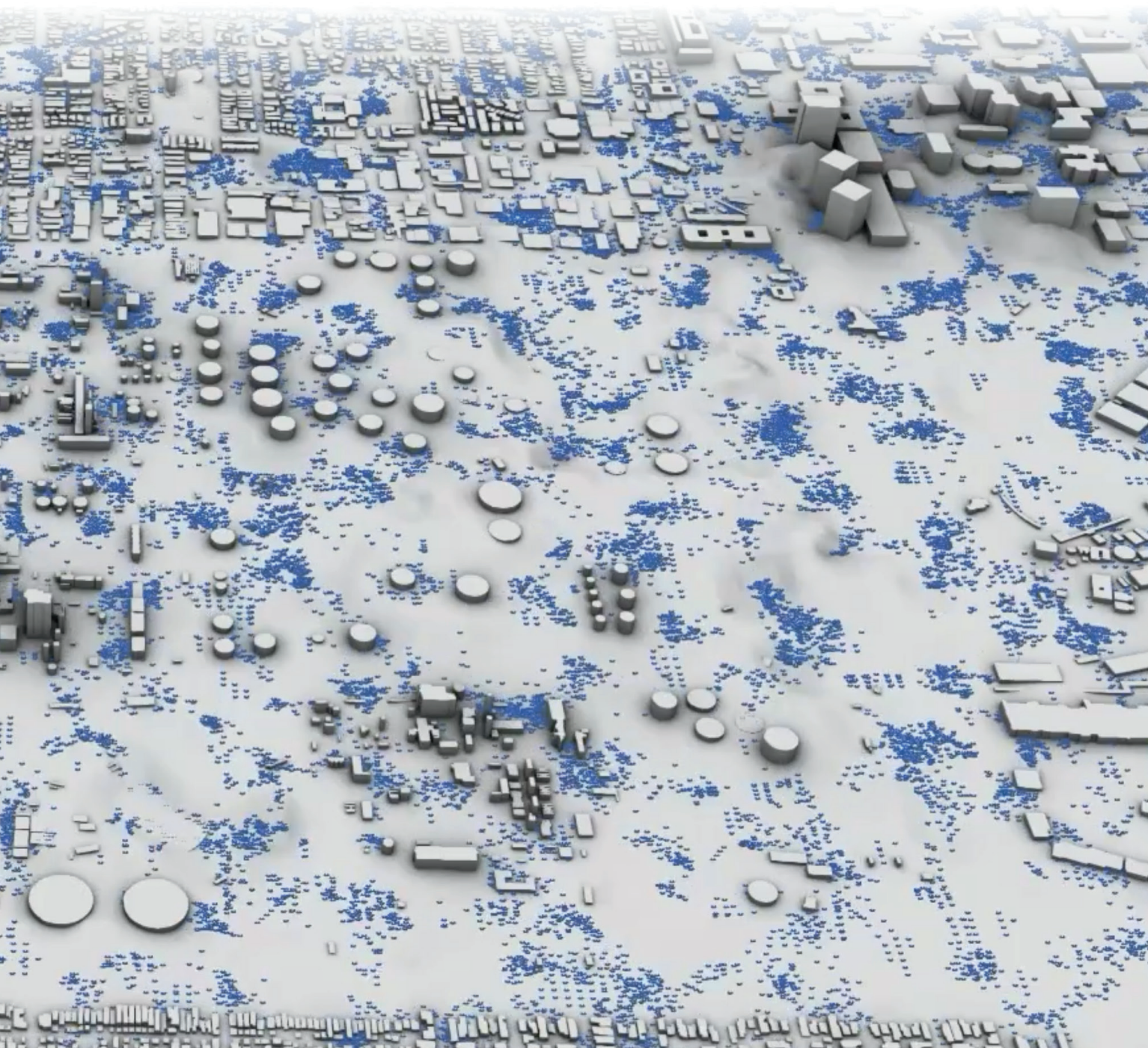
MTBE
METHYL TERT-BUTYL ETHER
DISPERSES THROUGH SOIL INFILTRATION



Pollution Dispersion

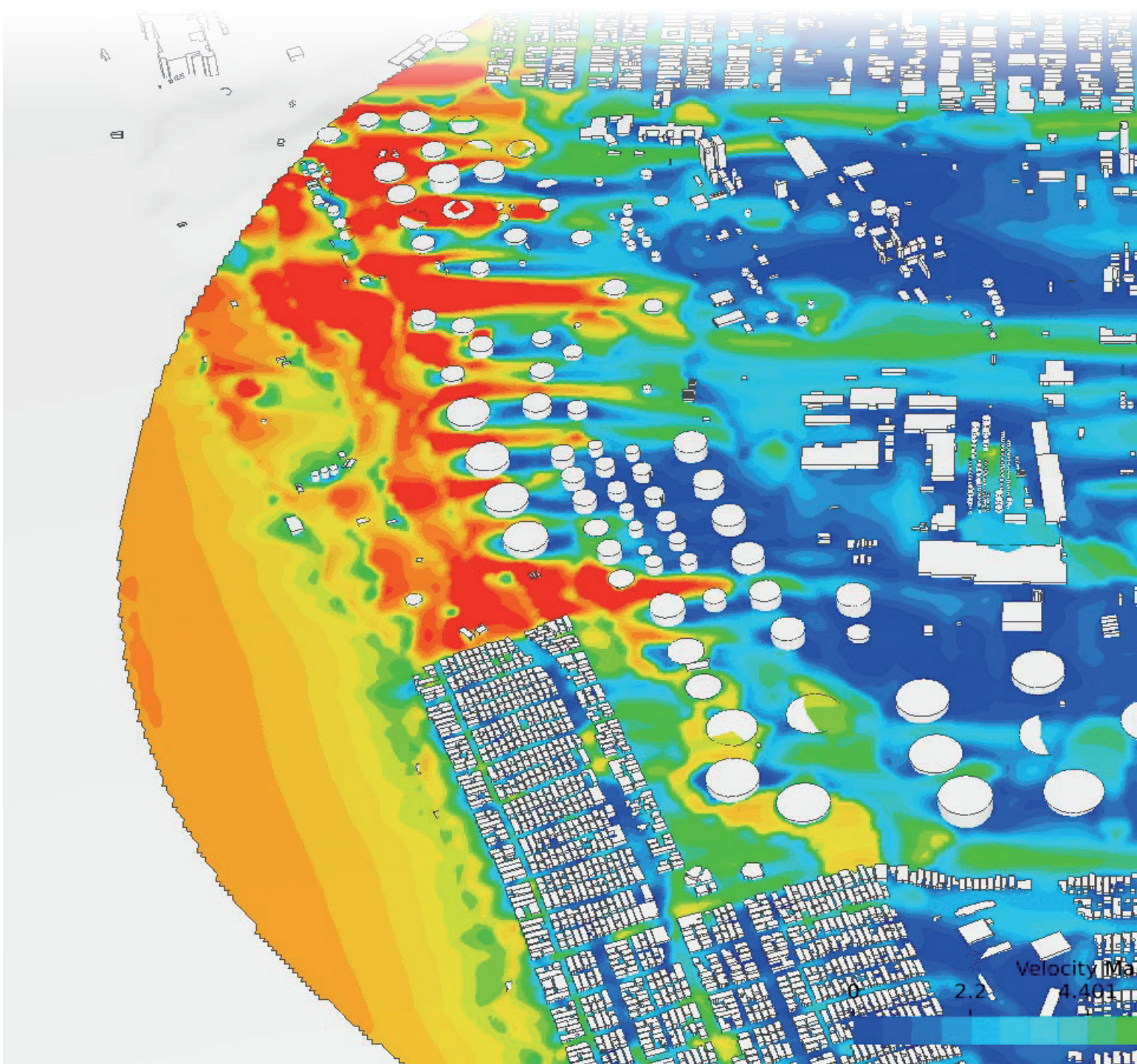
Runoff

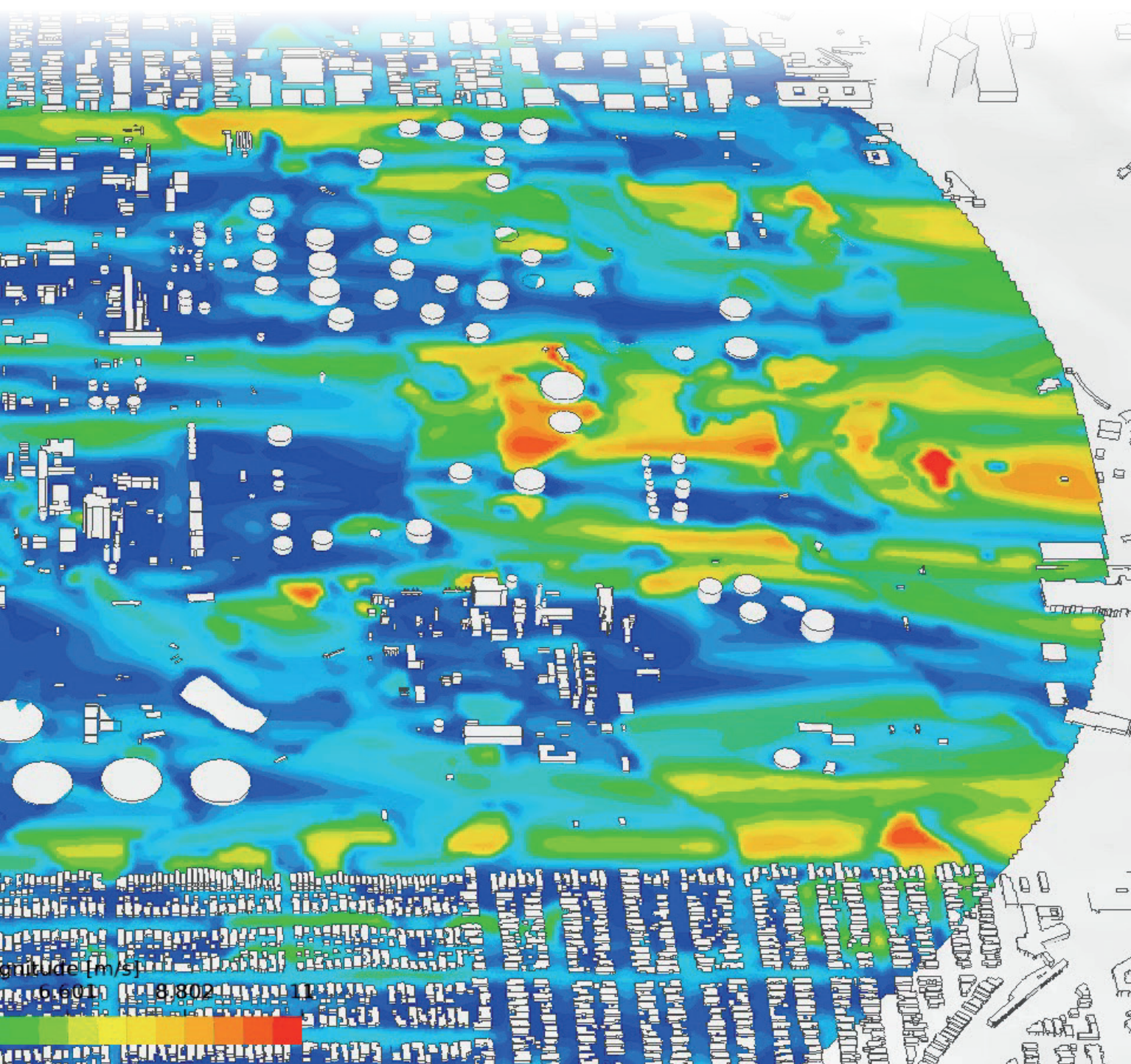




Pollutant Dispersion

Wind





Remediation | Zones

HARD **HEAVILY CONTAMINATED** TREES CANNOT GROW



EASY

LIGHTLY CONTAMINATED

TREES CAN GROW

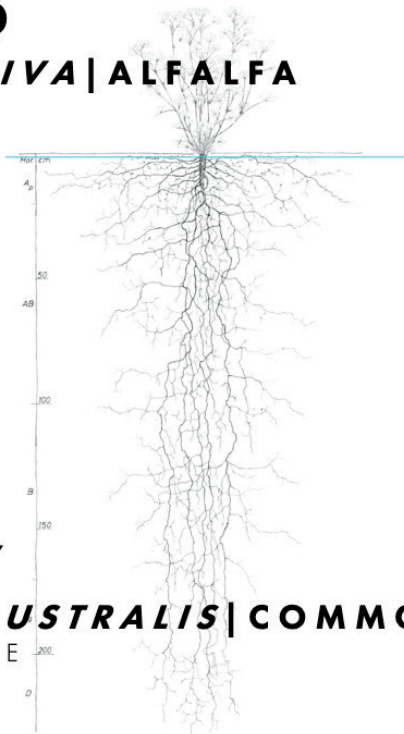


MTBE | ZONE

MTBE | HARD

MEDICAGO SATIVA | ALFALFA

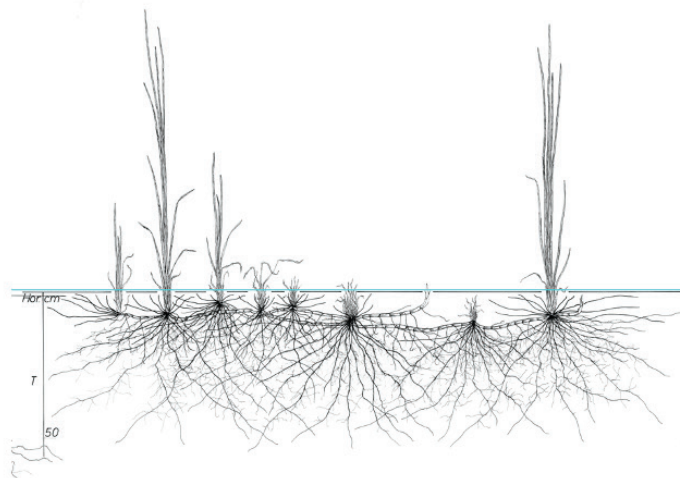
1.5' SPACING

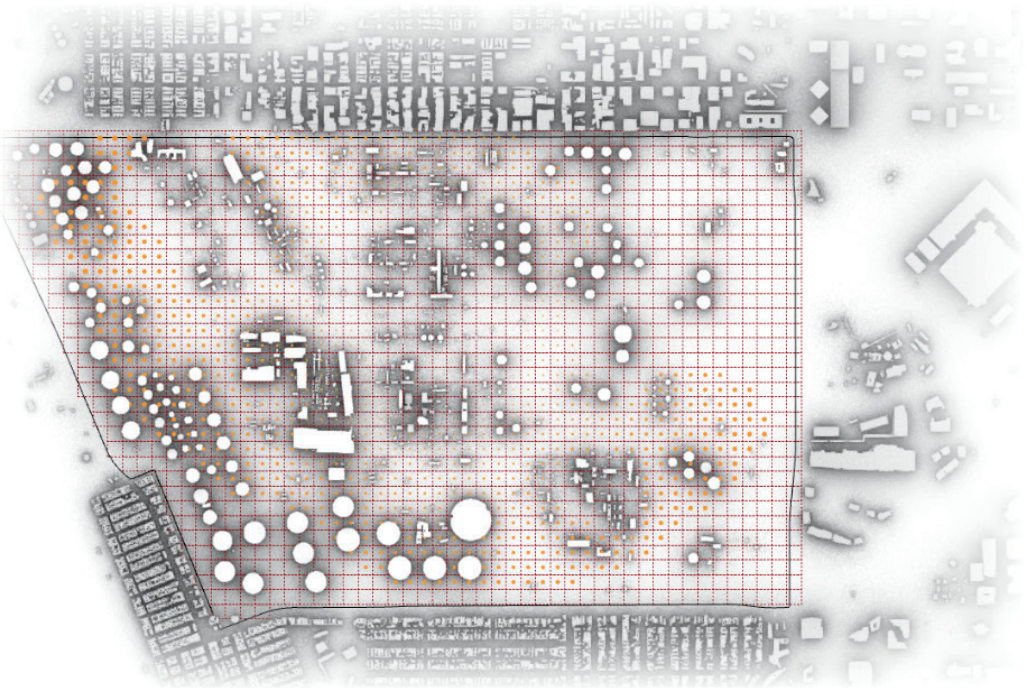
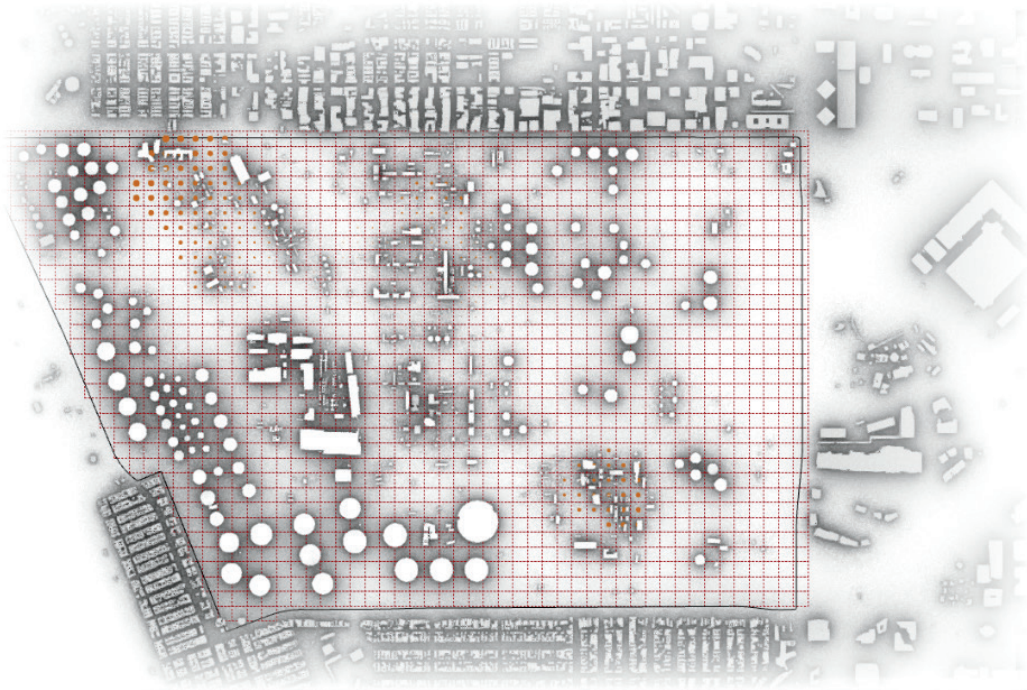


MTBE | EASY

PHRAGMITES AUSTRALIS | COMMON REED

HYDROPHYTIC ZONE





BTEX | ZONE

BTEX | HARD

CELTIS OCCIDENTALIS | HACKBERRY

18' SPACING

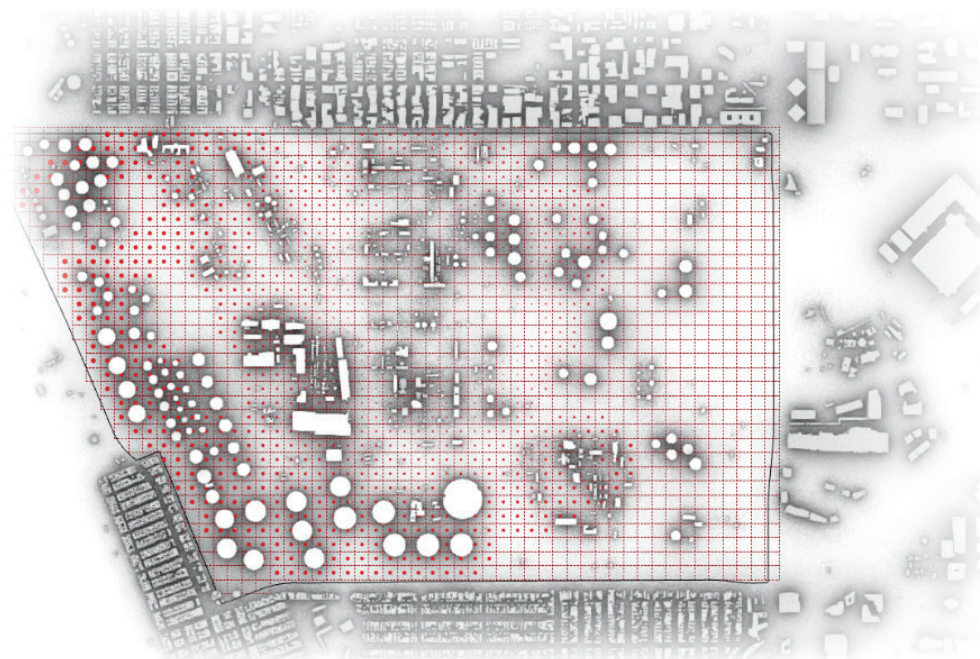
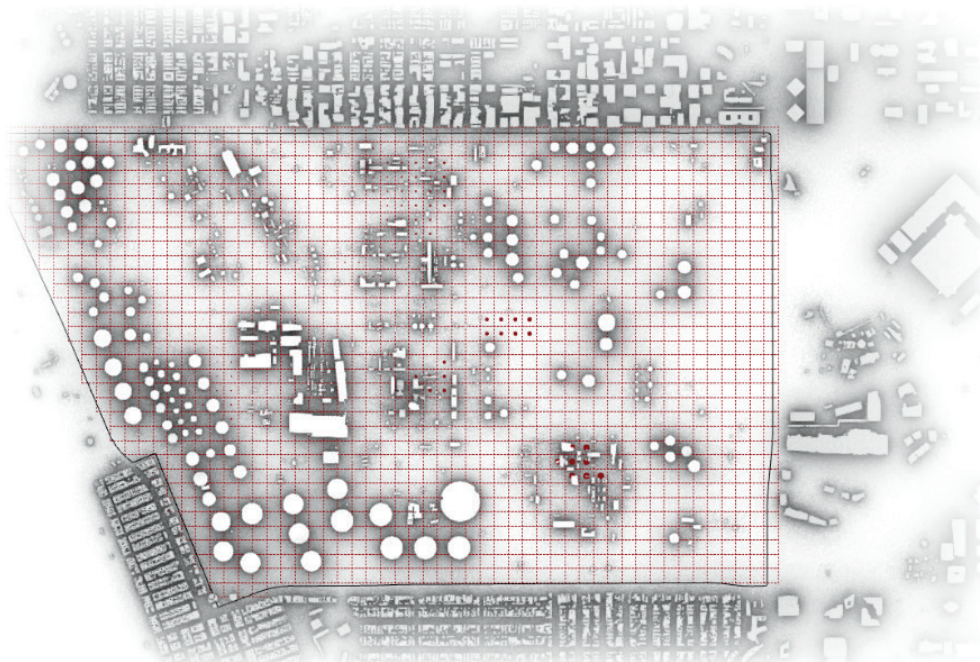


BTEX | EASY

ACER PLATANOIDES | MAPLE TREE

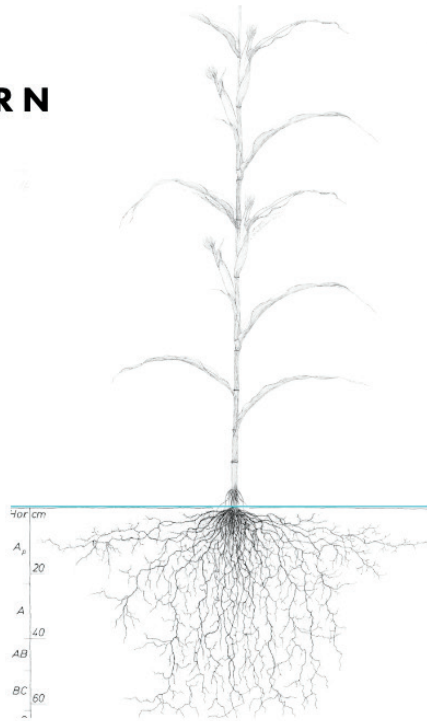
15' SPACING





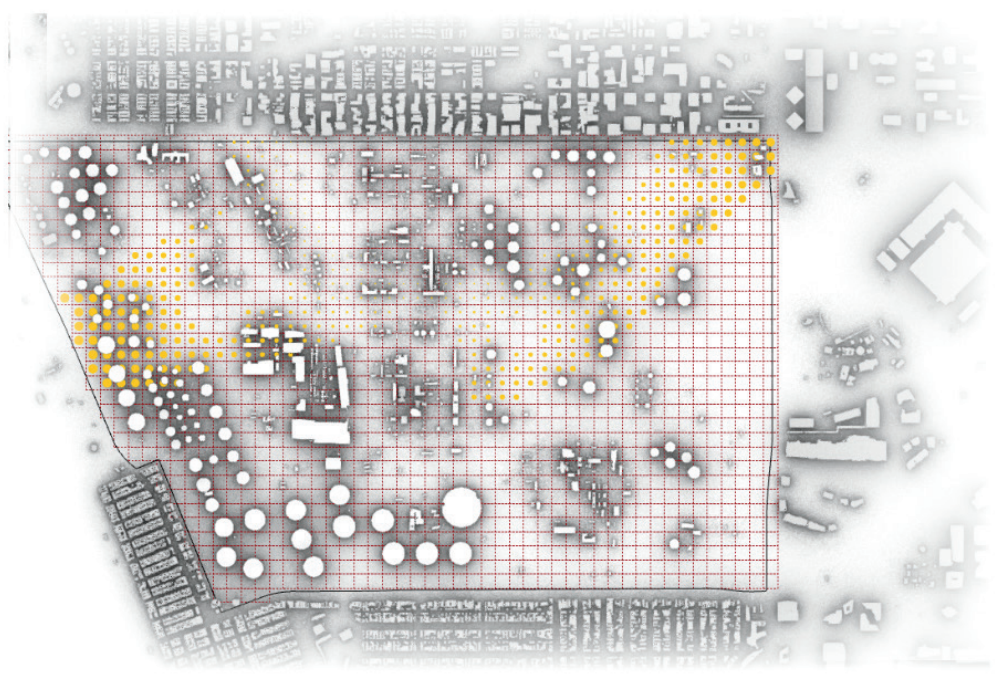
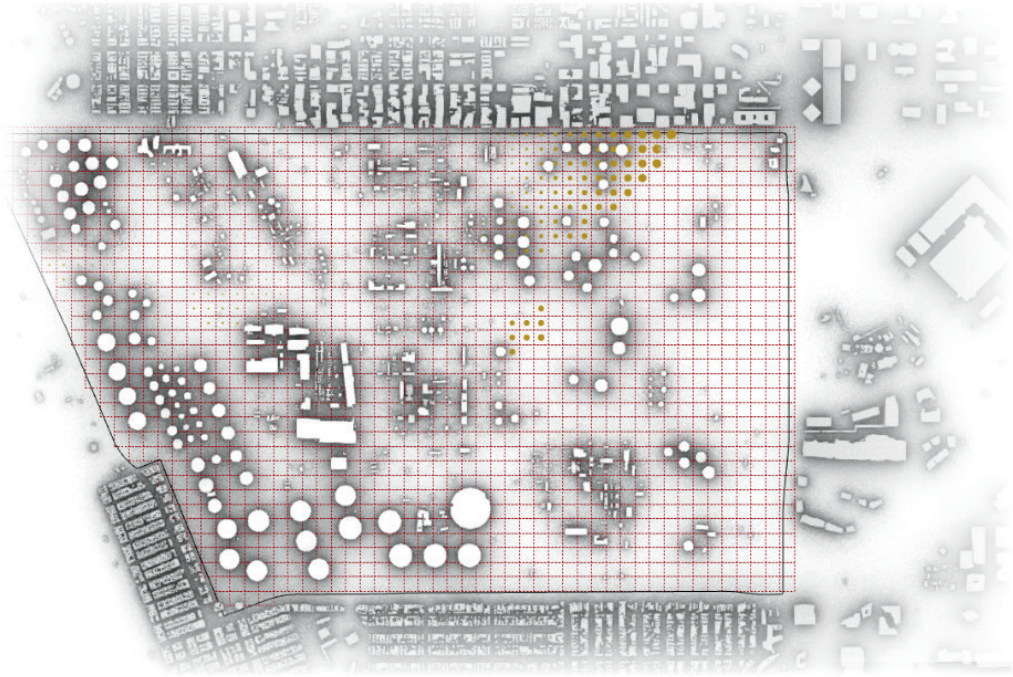
TPH | ZONES

TPH | HARD *ZEA MAYS* | CORN 1' SPACING



TPH | EASY *SALIX EXIGUA* | WILLOW TREE 30' SPACING



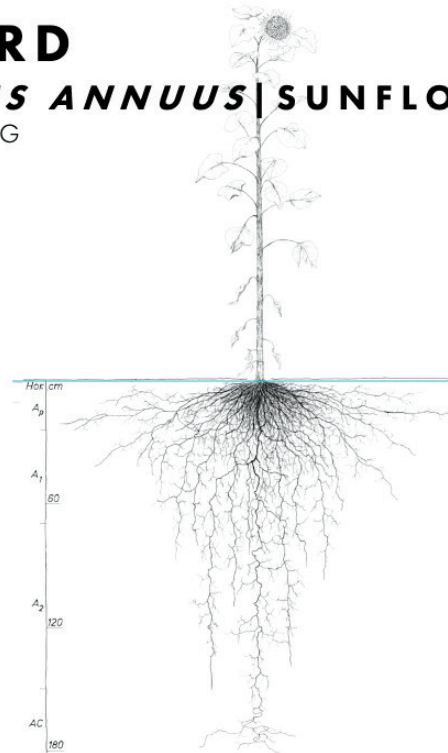


PAH | ZONE

PAH | HARD

HELIANTHUS ANNUUS | SUNFLOWER

.5' x 3' SPACING

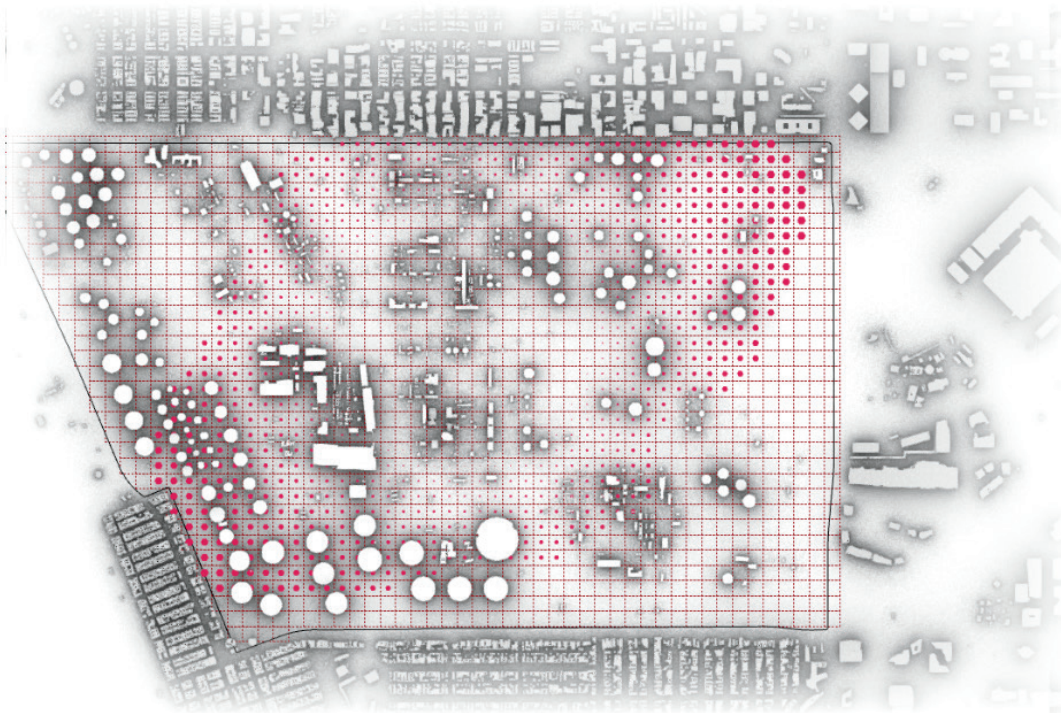
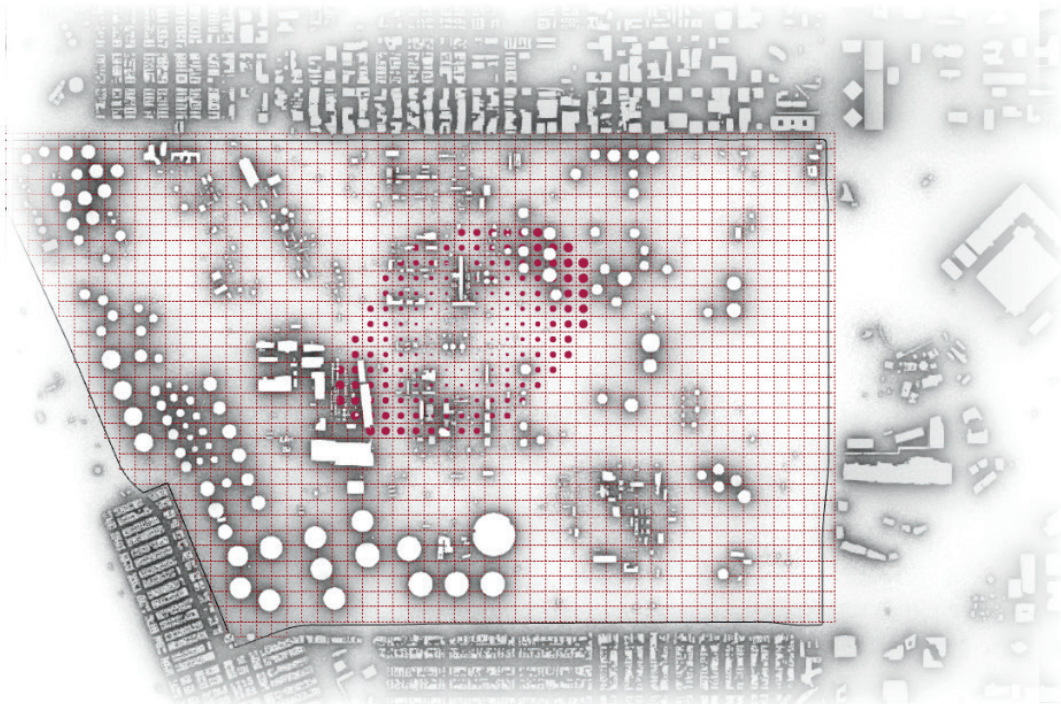


PAH | EASY

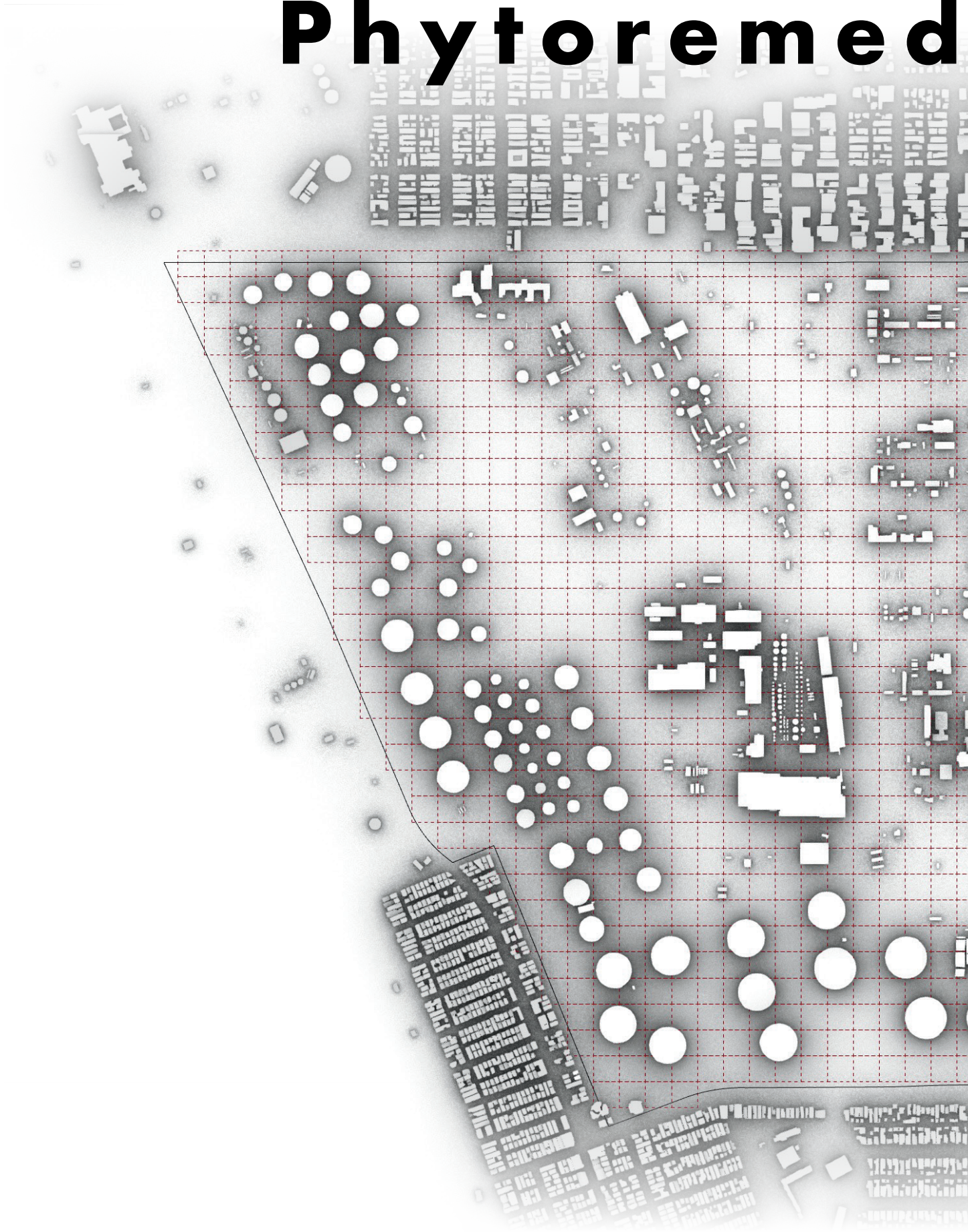
ROBINIA PSEUDOACACIA | BLACK LOCUST

20' SPACING

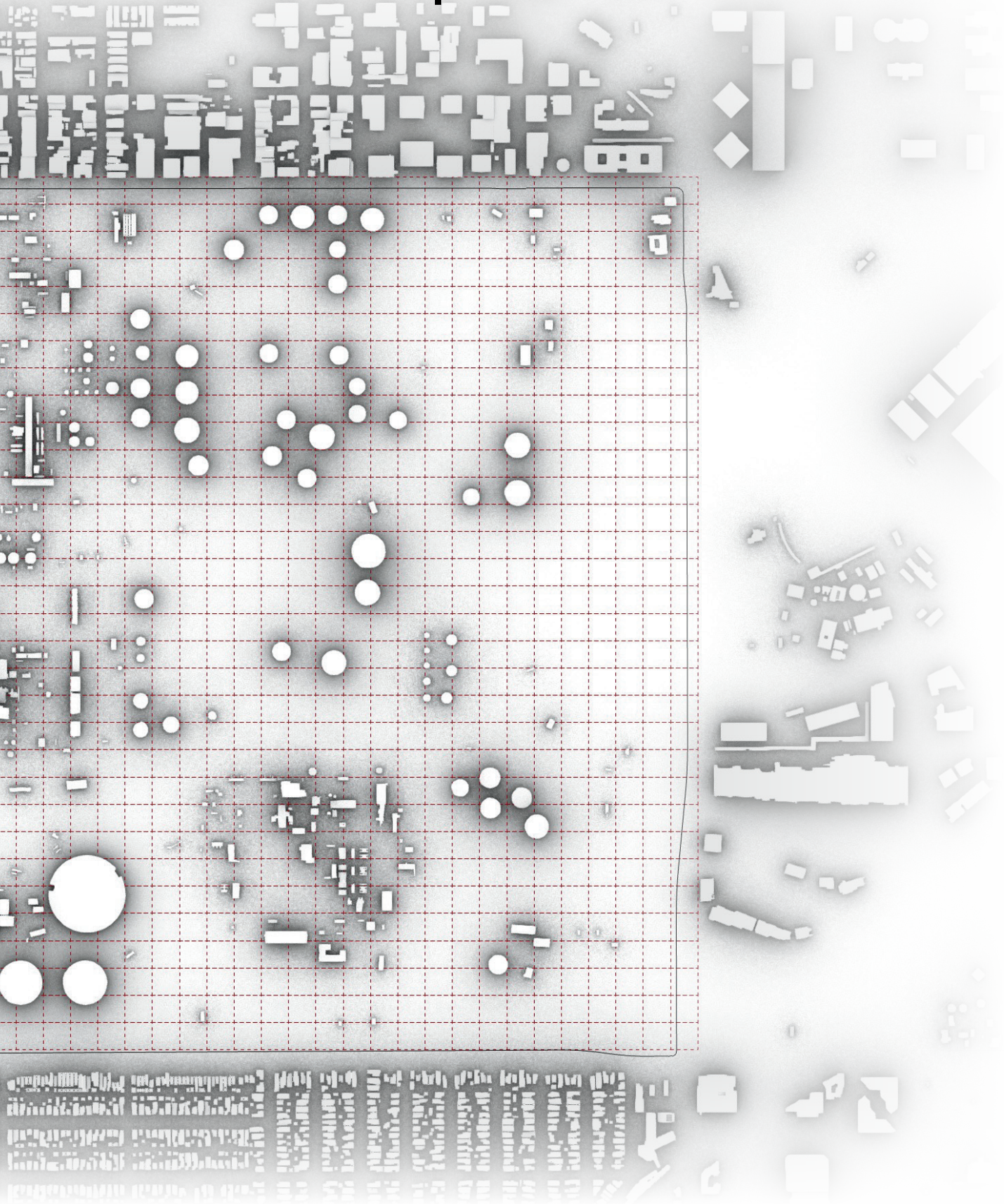




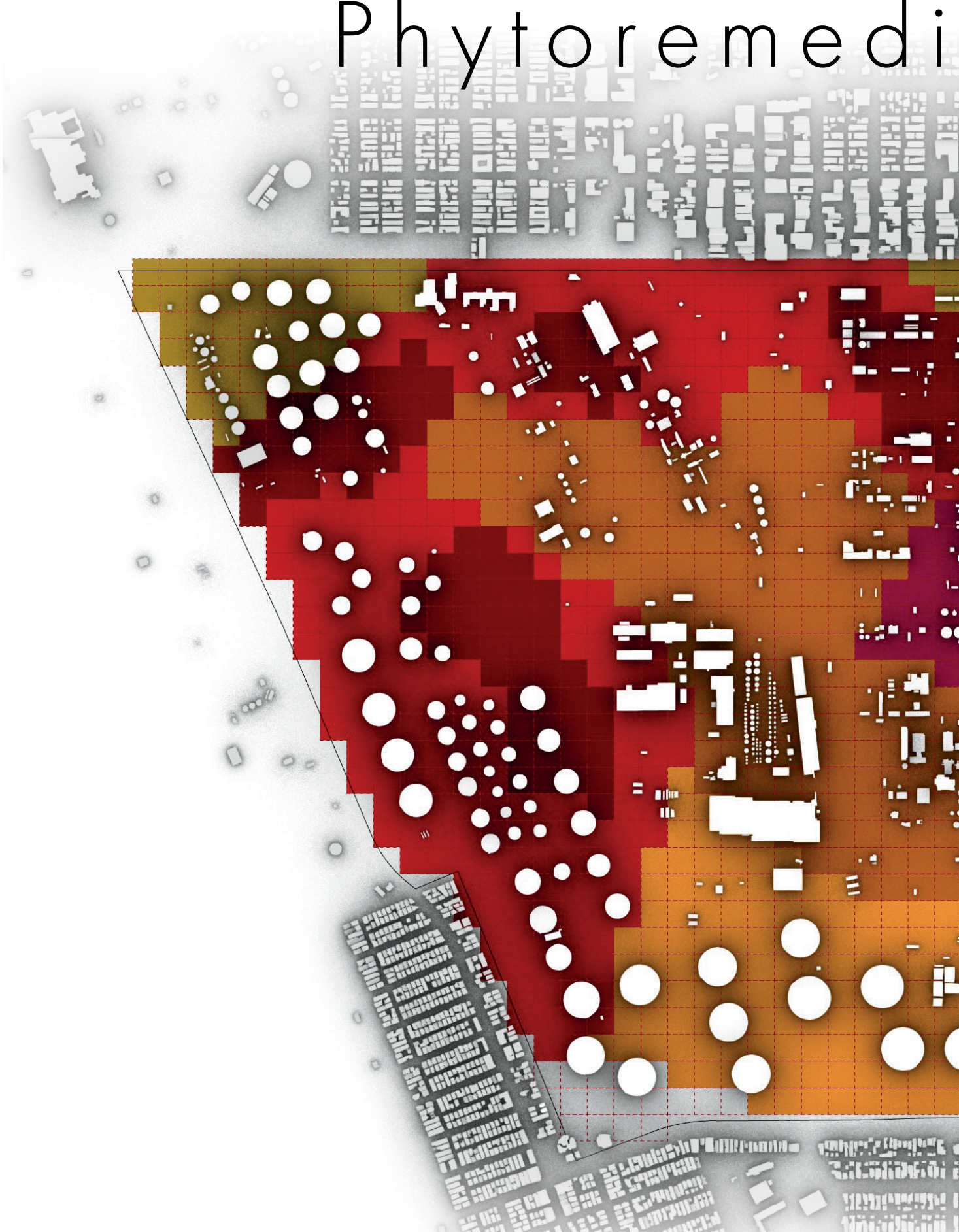
Phytoremed



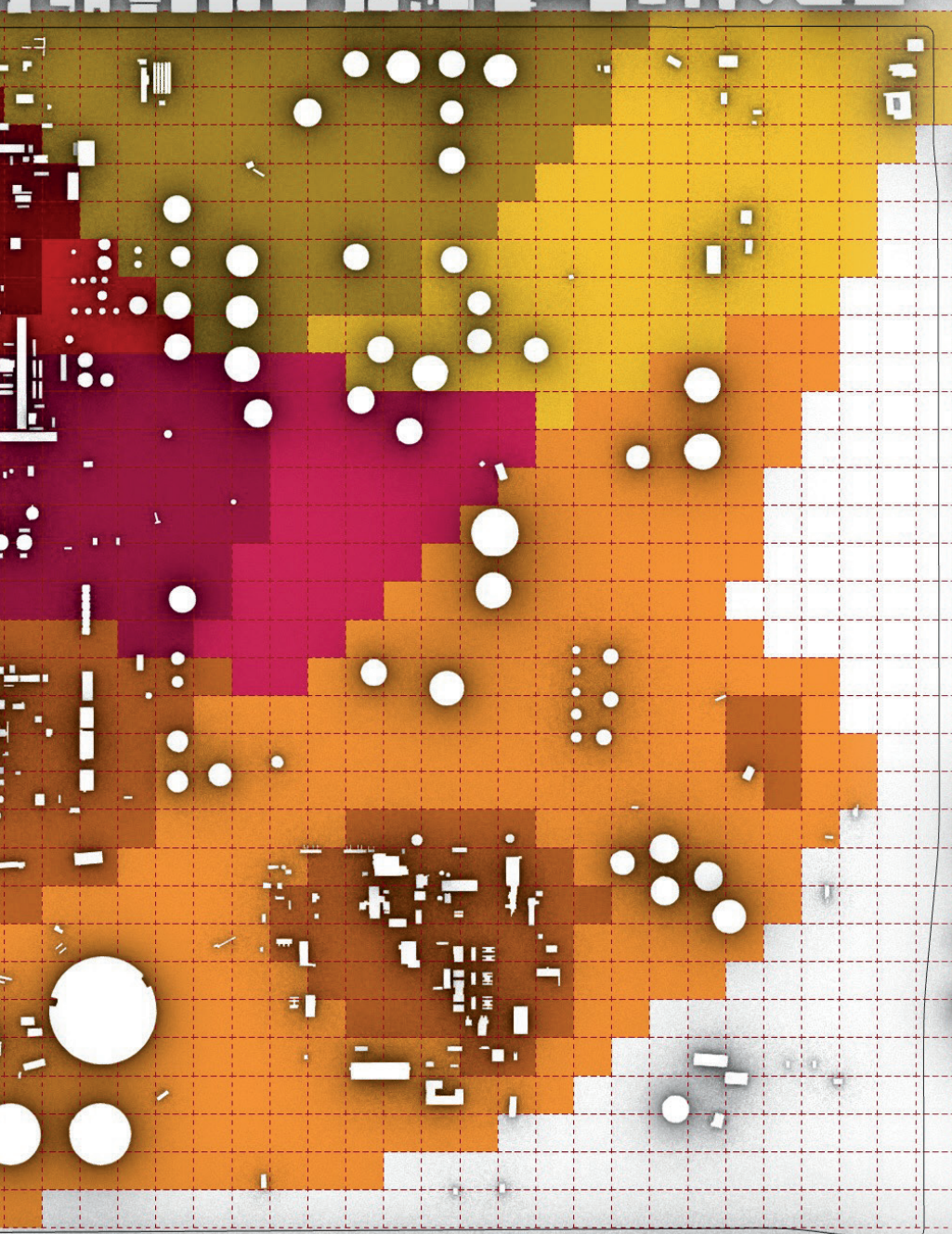
iation | Grid



Phytoremediation



ation | **Plots**



Decarbonization Potential

Per Acre CO2 Emissions

<u>Refinery</u> - 796,666 lbs/yr	<u>Residential</u> + 34,108 lbs/yr	<u>Commercial</u> + 56,426 lbs/yr	<u>Agriculture</u> + 199,845 lbs/yr
			<u>Organic</u> - 10,890 lbs/yr
			<u>Salt Marsh</u> - 476,198 lbs/yr

Per Acre Remediation Cost

<u>Remediation</u> \$ 50,000	<u>Phyto-Remediation</u> \$ 14,310
---------------------------------	---------------------------------------

Decarbonization | Potential

Per Acre CO2 Emissions

<u>Refinery</u>	<u>Refinery + Agriculture (Organic)</u>	<u>Conventional</u>
+796,666 lbs/yr	+34,168 lbs/yr	+199,845 lbs/yr

CO2 Emission Reduction
=-330,026,076 lbs/yr
(34.52%)

Remediation Cost Reduction
=-\$46,397,000
(-71.38%)

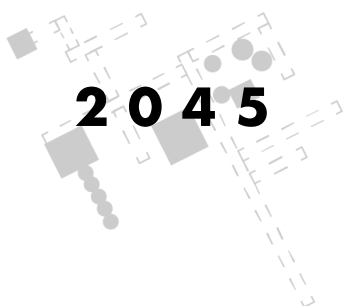
Per Acre Re-Development Cost

<u>Remediation</u>	<u>Residential</u>	<u>Commercial</u>	<u>Planting</u>
\$50,000	\$16,800,000	\$11,352,000	\$954

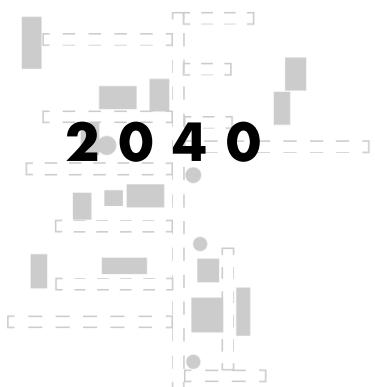
Refinery - Transitions

OIL - DIST

MARINE FUEL

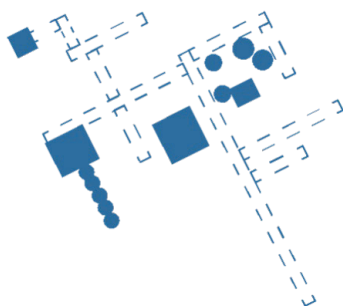


JET FUEL

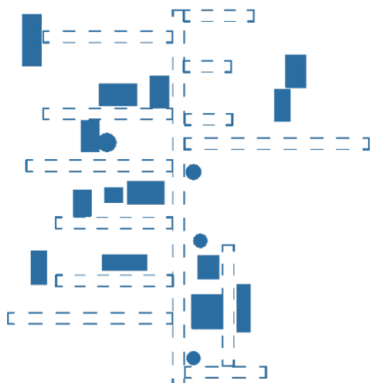


CARBON - DI

Power Plant

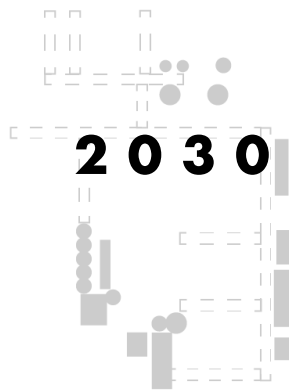


Lithium Plant

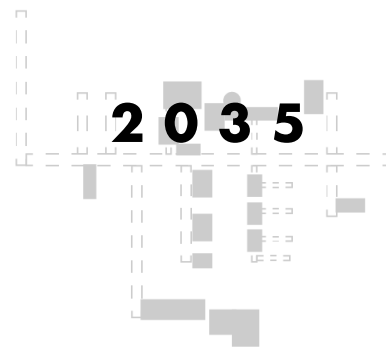


ILLATION

D I E S E L

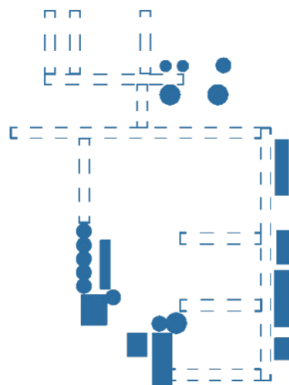


G A S O L I N E

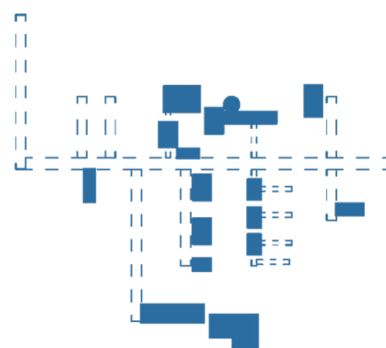


STILLATION

D e s a l i n a t i o n
P l a n t

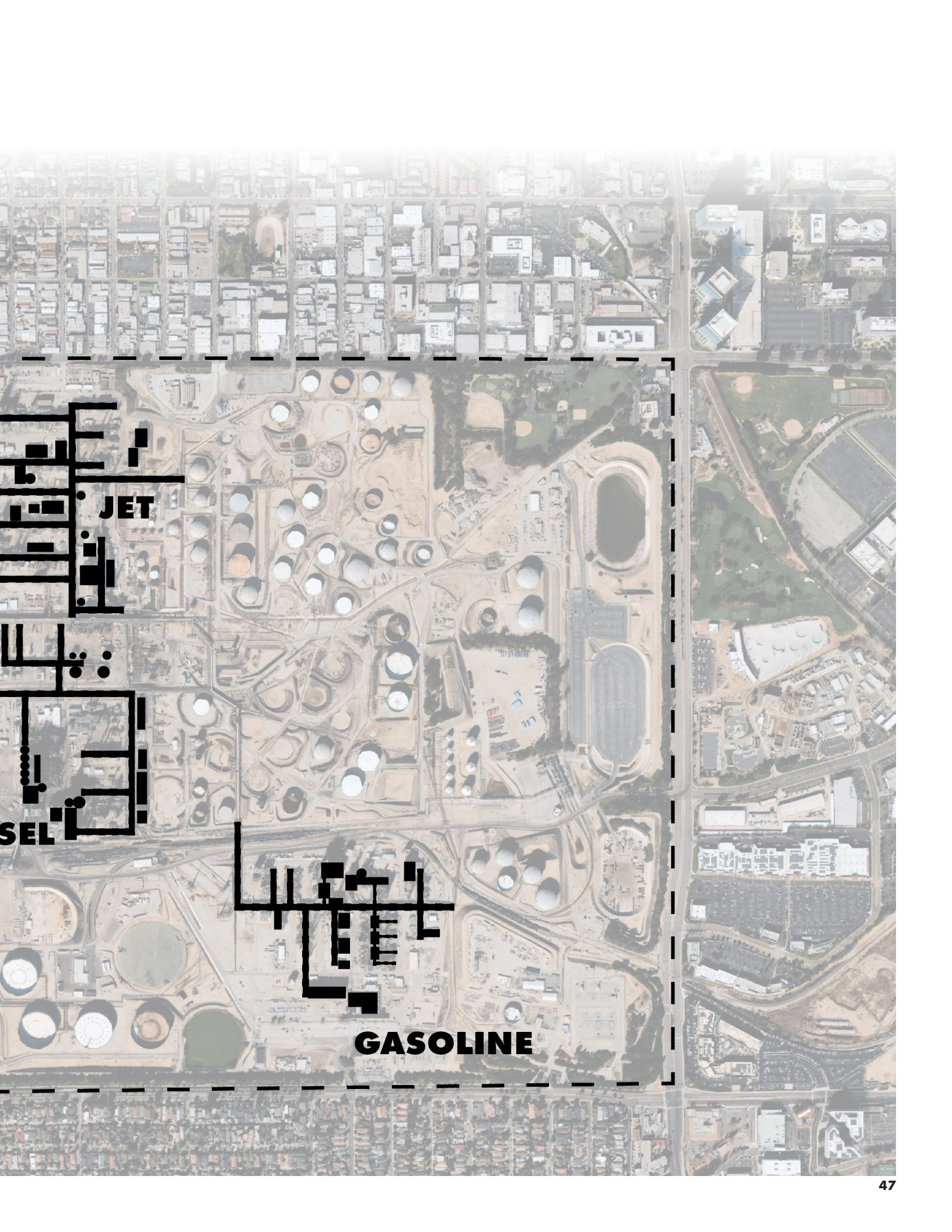


B i o f u e l
P l a n t



Refinery Typologies



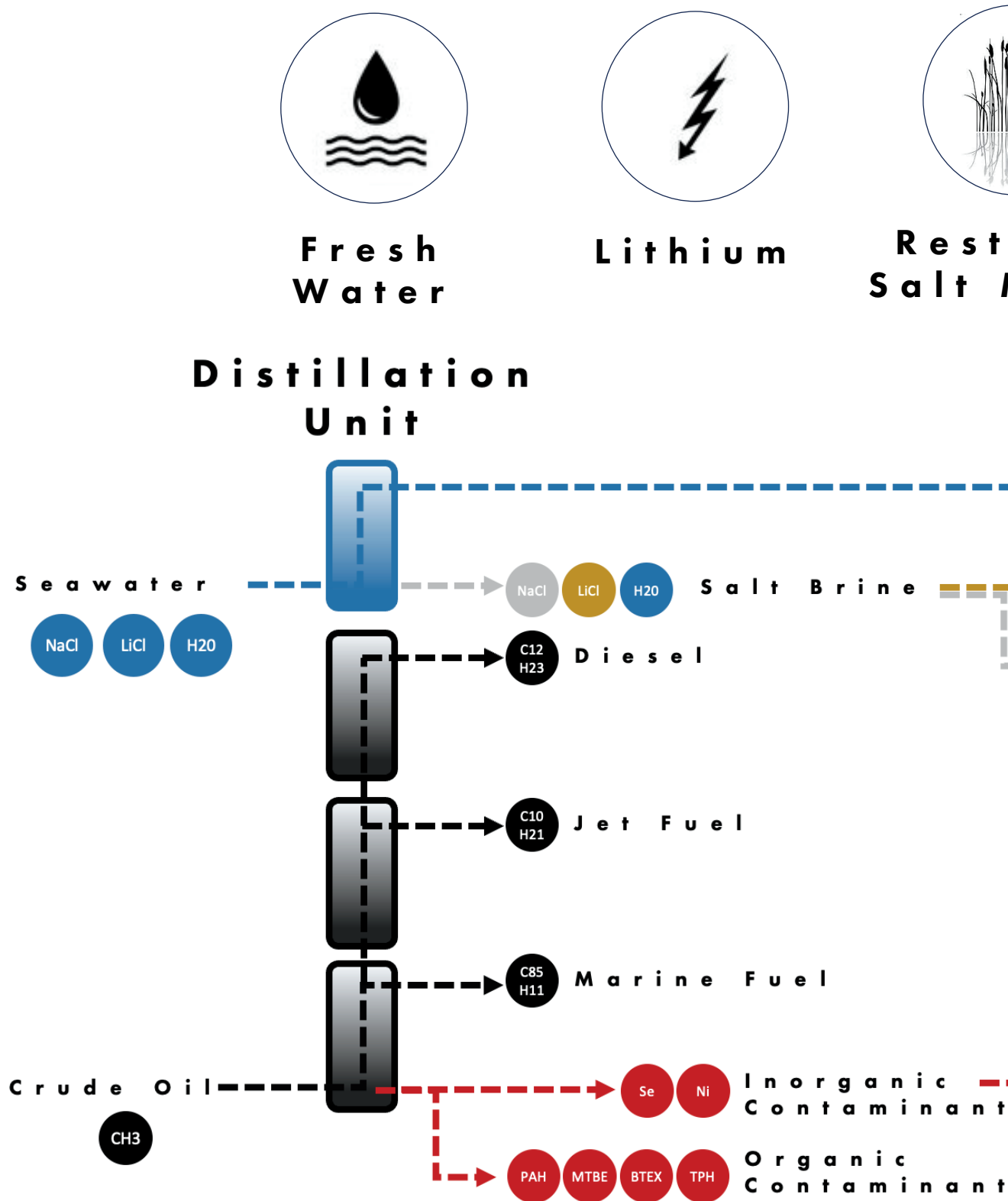


JET

SEL

GASOLINE

Regenerative Refinery

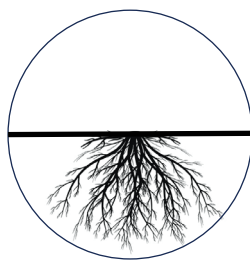




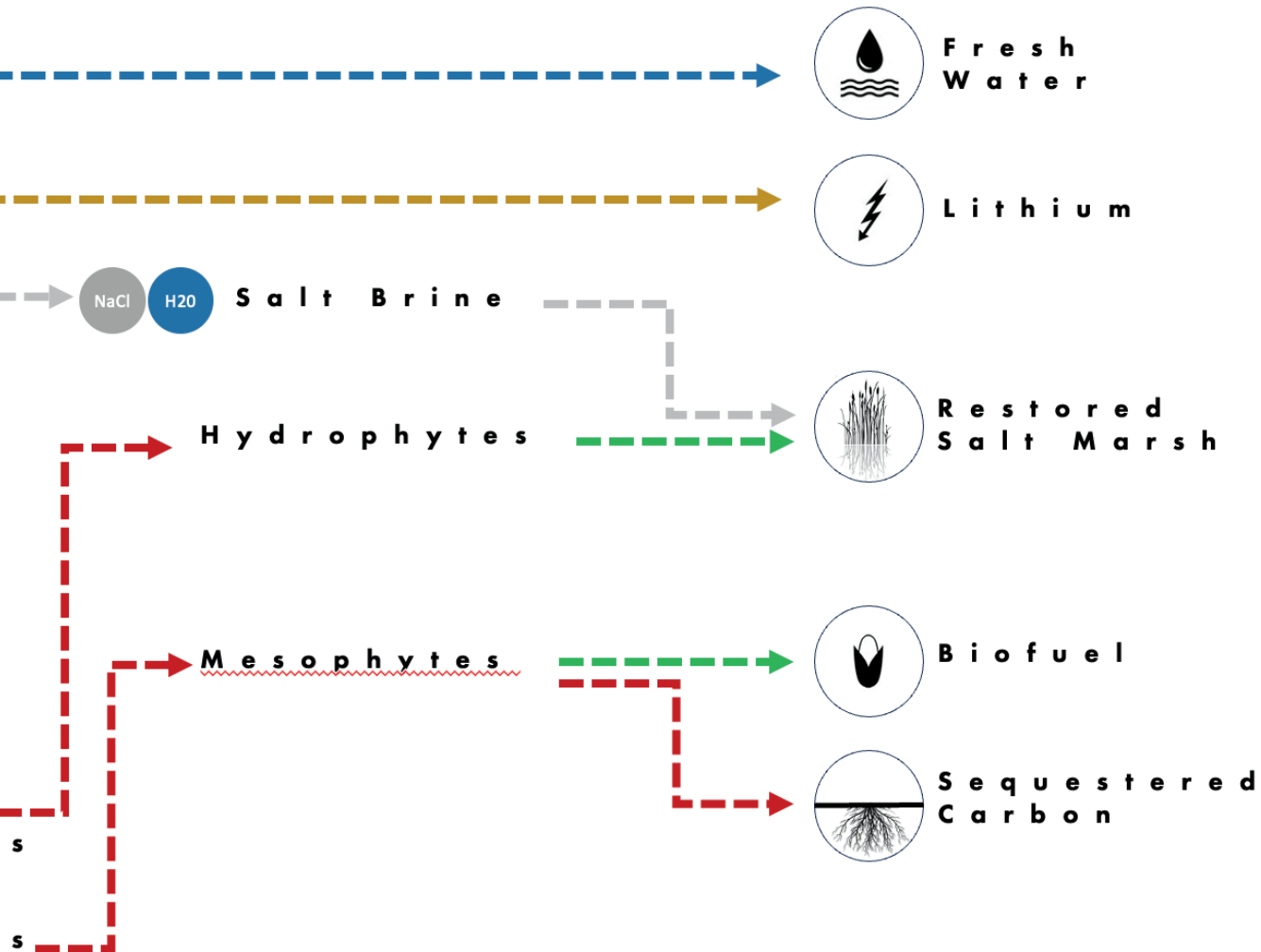
ored
Marsh



Biofuel

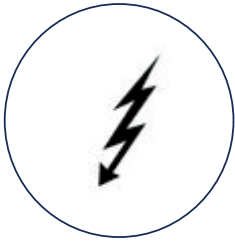


Sequestered
Carbon





**F r e s h
W a t e r**



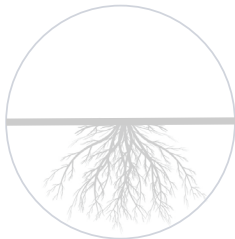
L i t h i u m



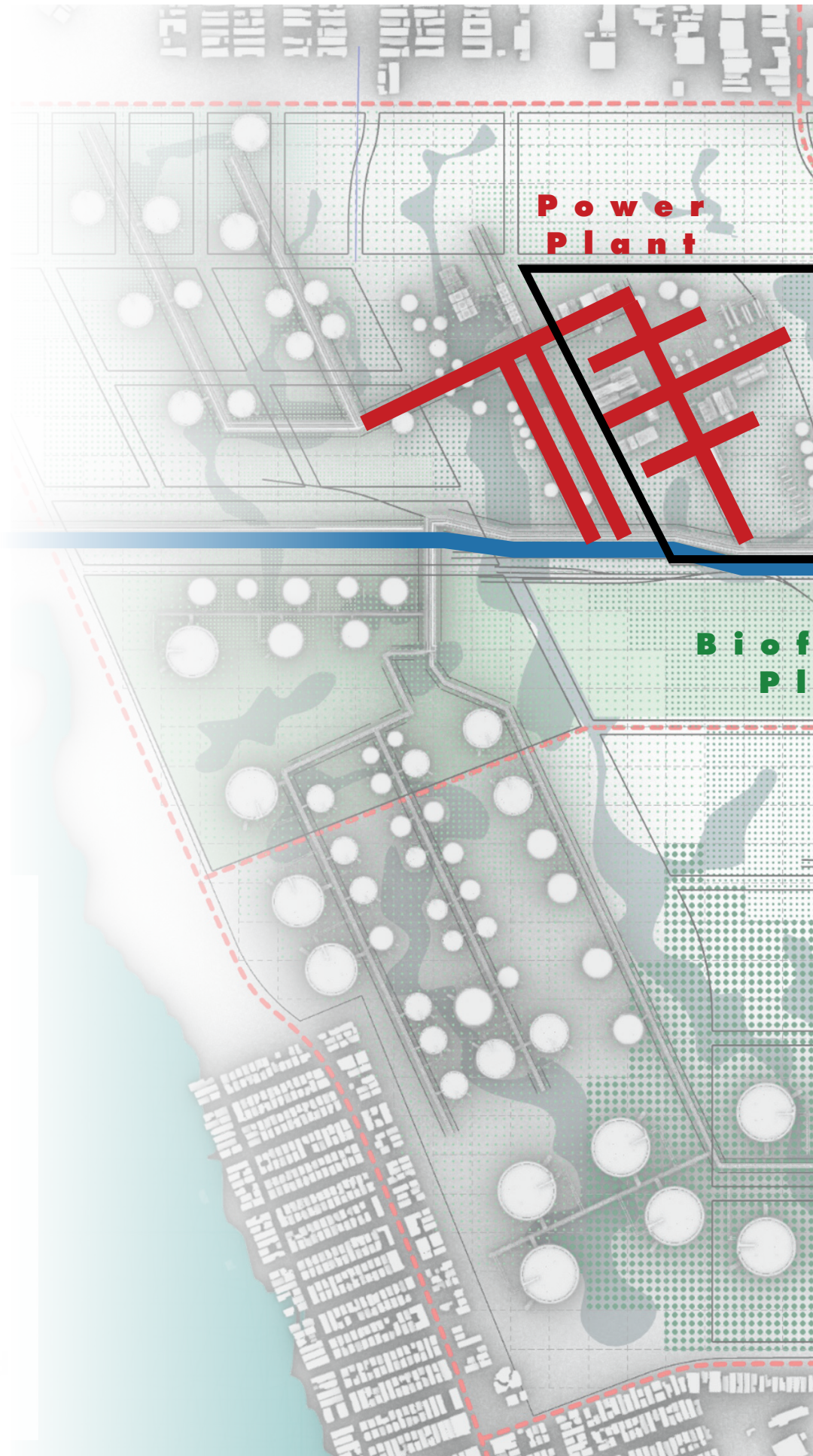
B i o f u e l

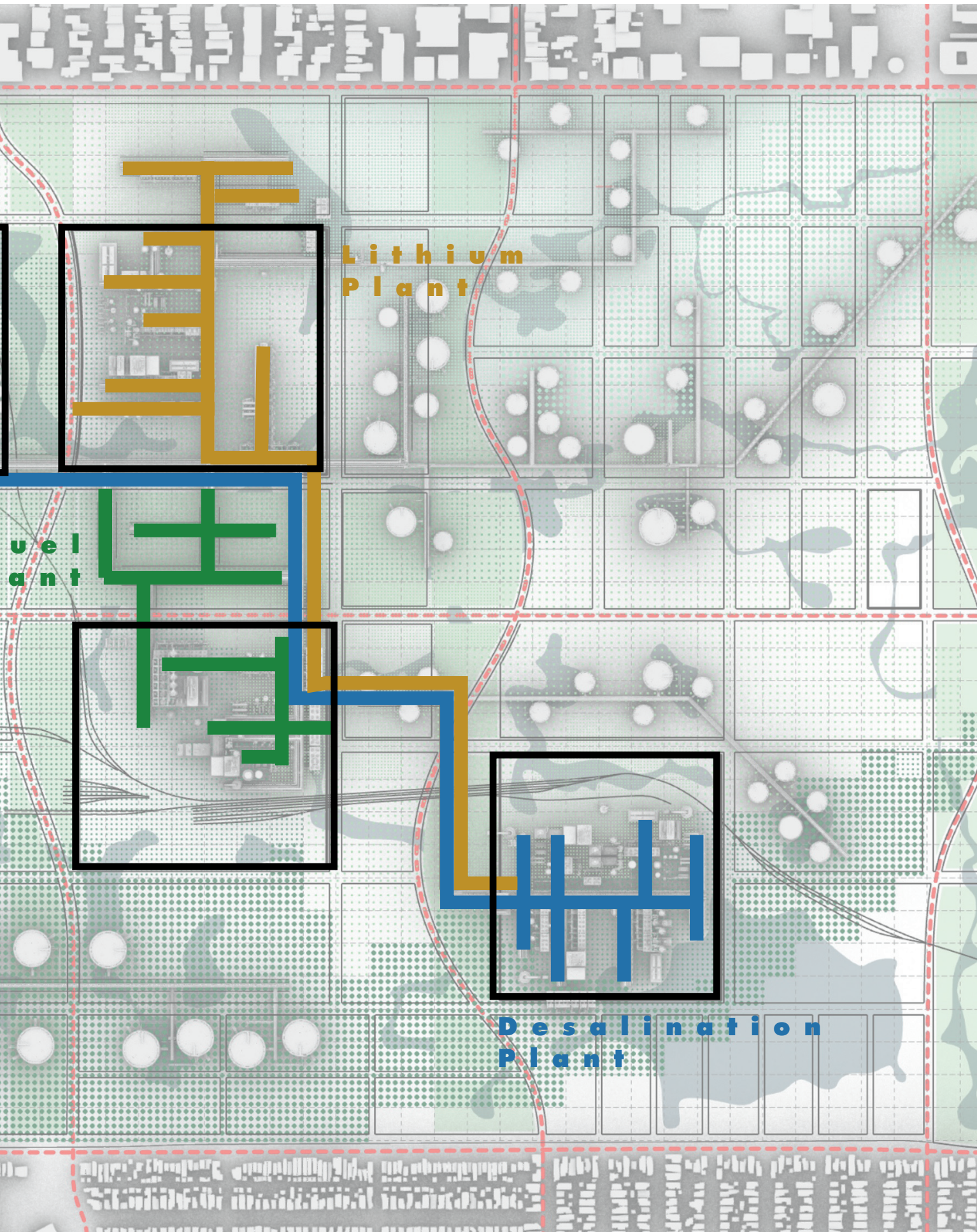


**R e s t o r e d
S a l t M a r s h**



**S e q u e s t e r e d
C a r b o n**





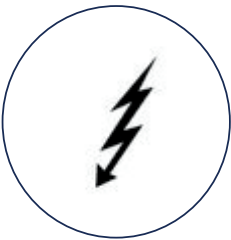
Lithium
Plant

Desalination
Plant

Fuel
Plant



**F r e s h
W a t e r**



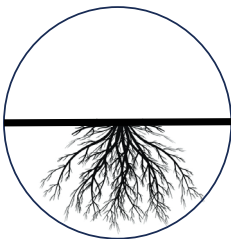
L i t h i u m



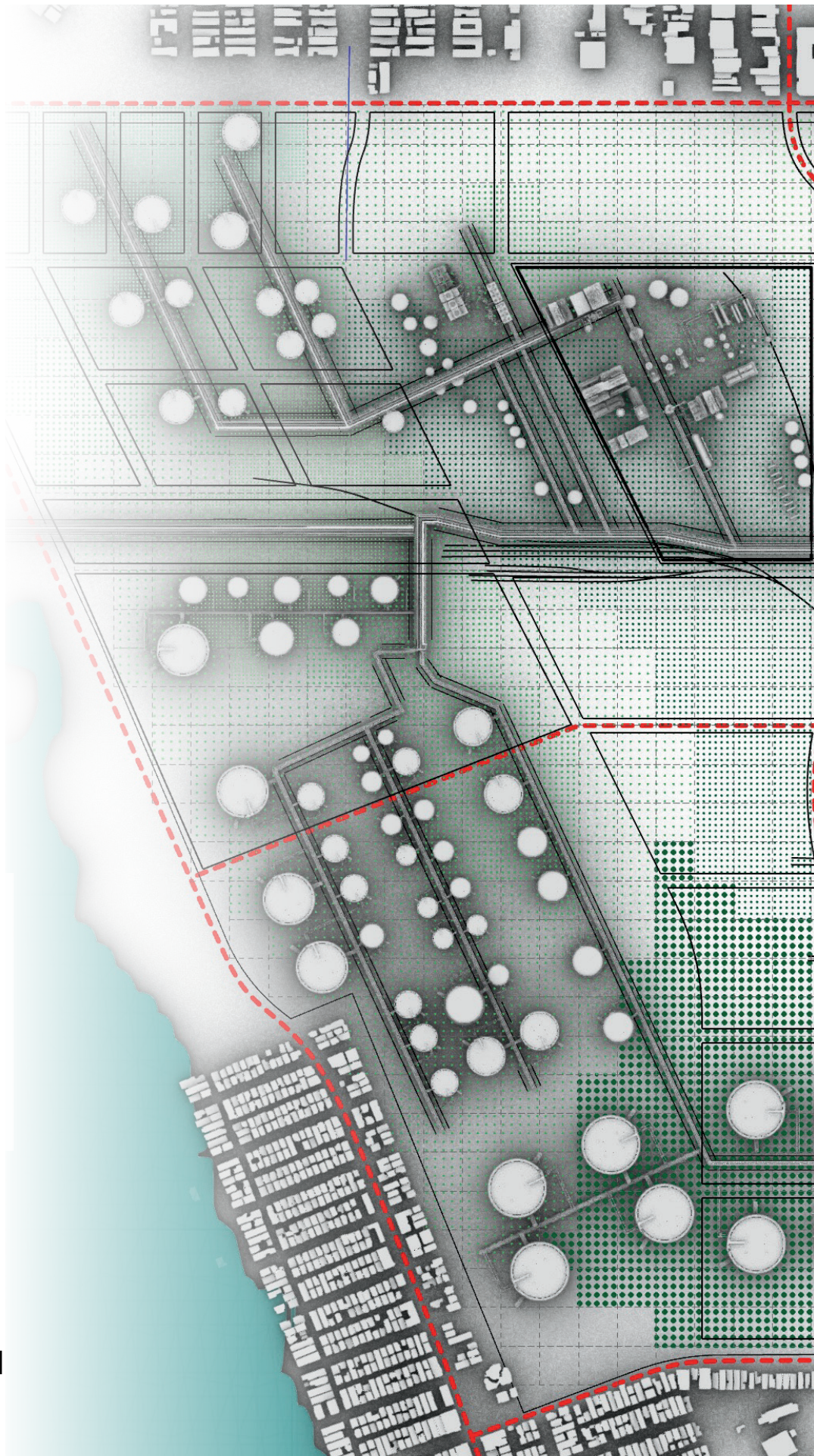
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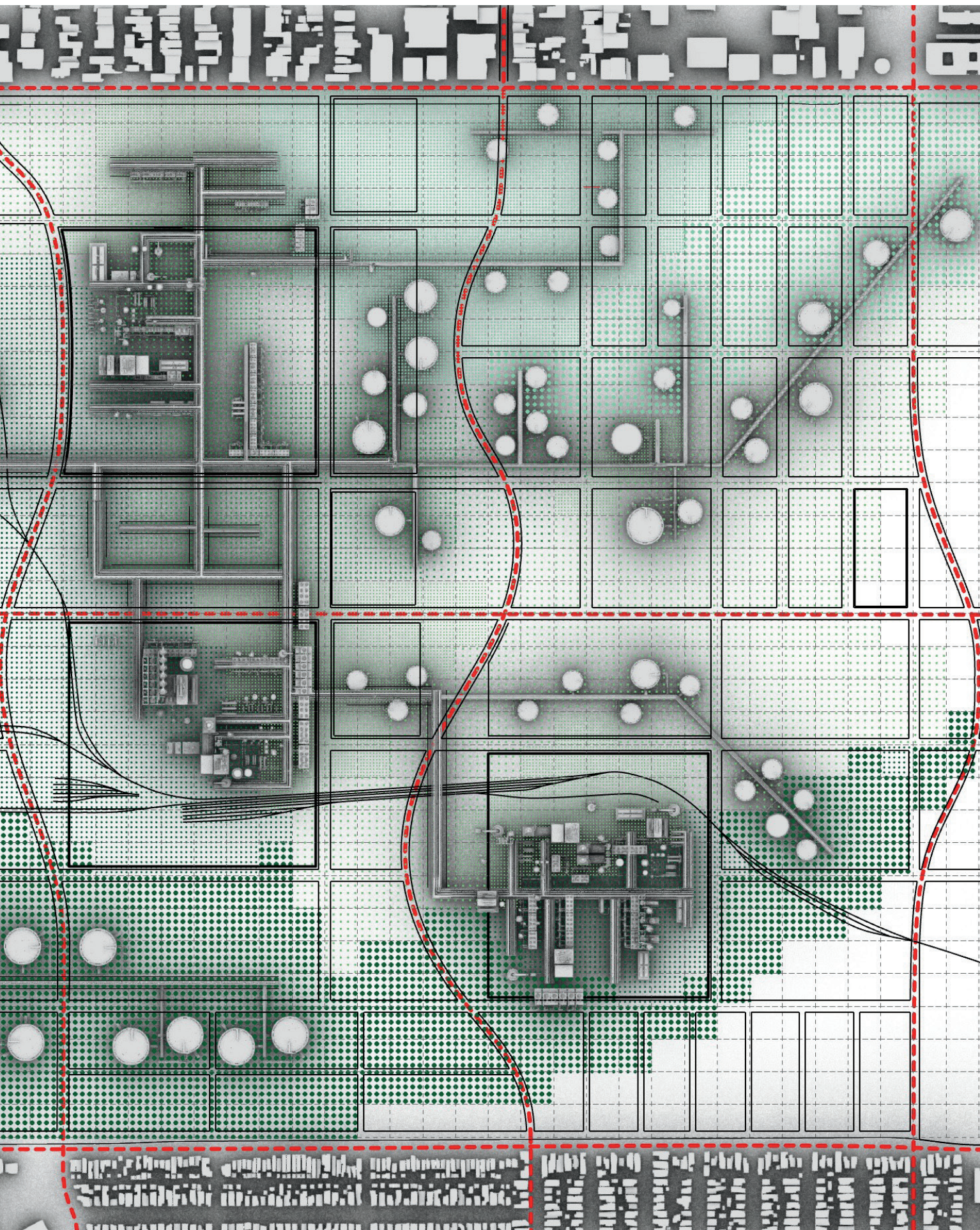


**R e s t o r e d
S a l t M a r s h**



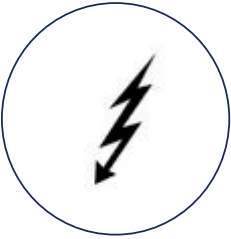
**S e q u e s t e r e d
C a r b o n**







**F r e s h
W a t e r**



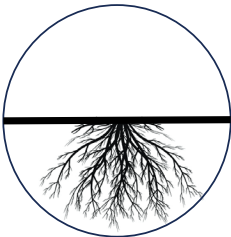
L i t h i u m



B i o f u e l



**R e s t o r e d
S a l t M a r s h**



**S e q u e s t e r e d
C a r b o n**

