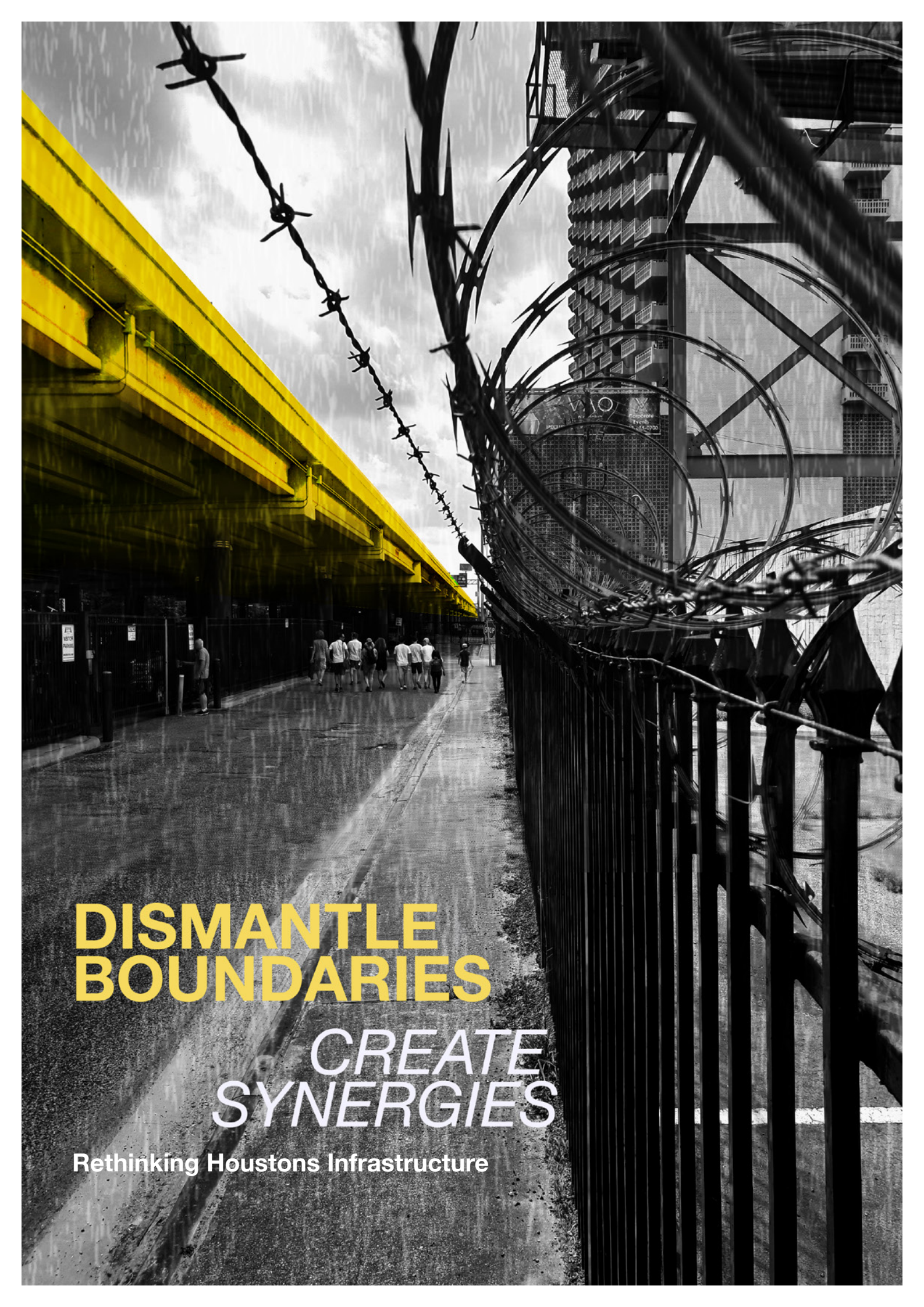




**DISMANTLE
BOUNDARIES**

*CREATE
SYNERGIES*

Rethinking Houston's Infrastructure

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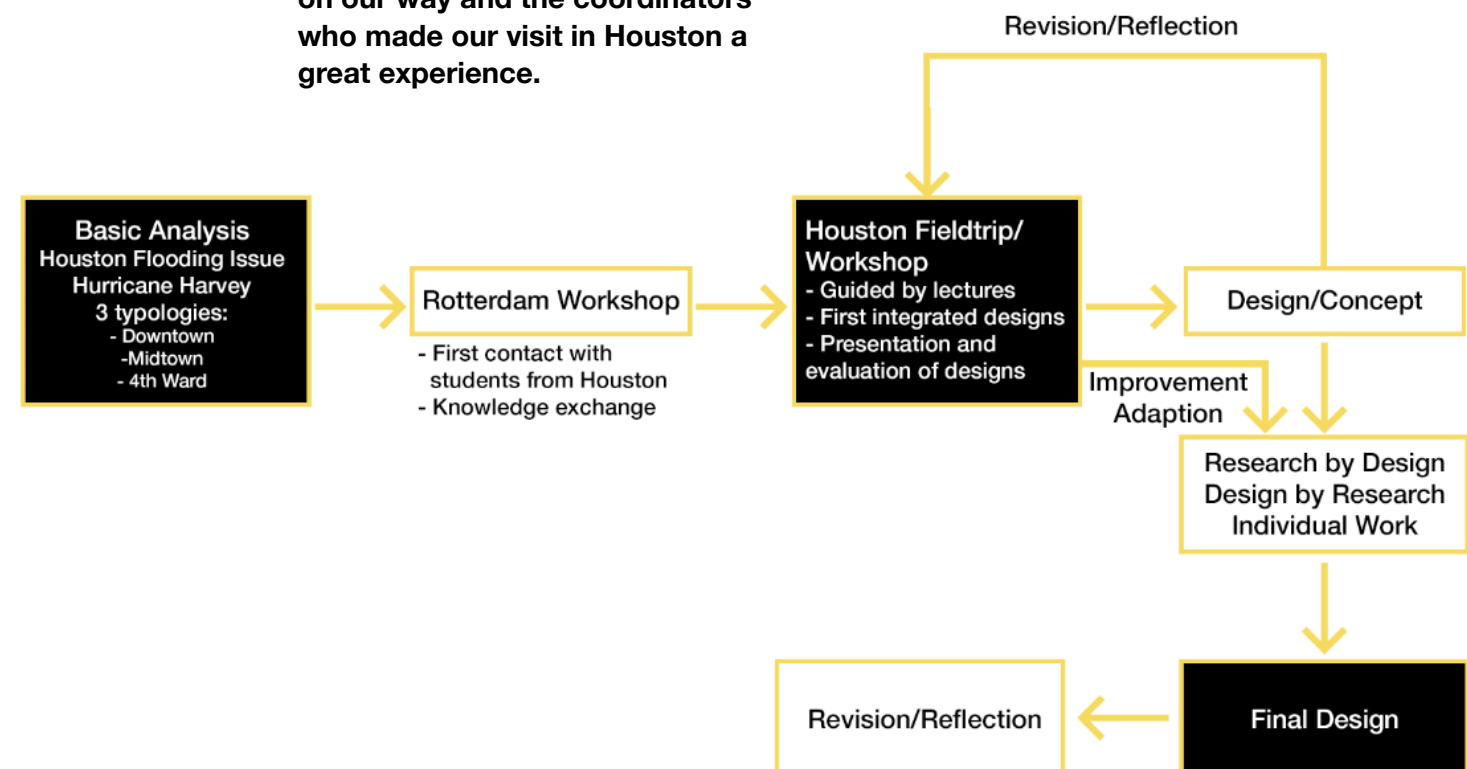
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01 INTRODUCTION

This report is not only the final result of the design made for the Infrastructure and Environment Design course (Q4 - Urbanism) but considerably more a representation of the entire learning process and the path towards the goal itself. The aim of this course was to investigate water related urban- and engineering designs in delta metropolises. The international context of the Bayou City of Houston (Texas, USA), its long flooding history, but also the contemporary state of the city made it a very interesting but also challenging task.

We would like to thank everyone involved in the process, the amazing and friendly people we met on our way and the coordinators who made our visit in Houston a great experience.



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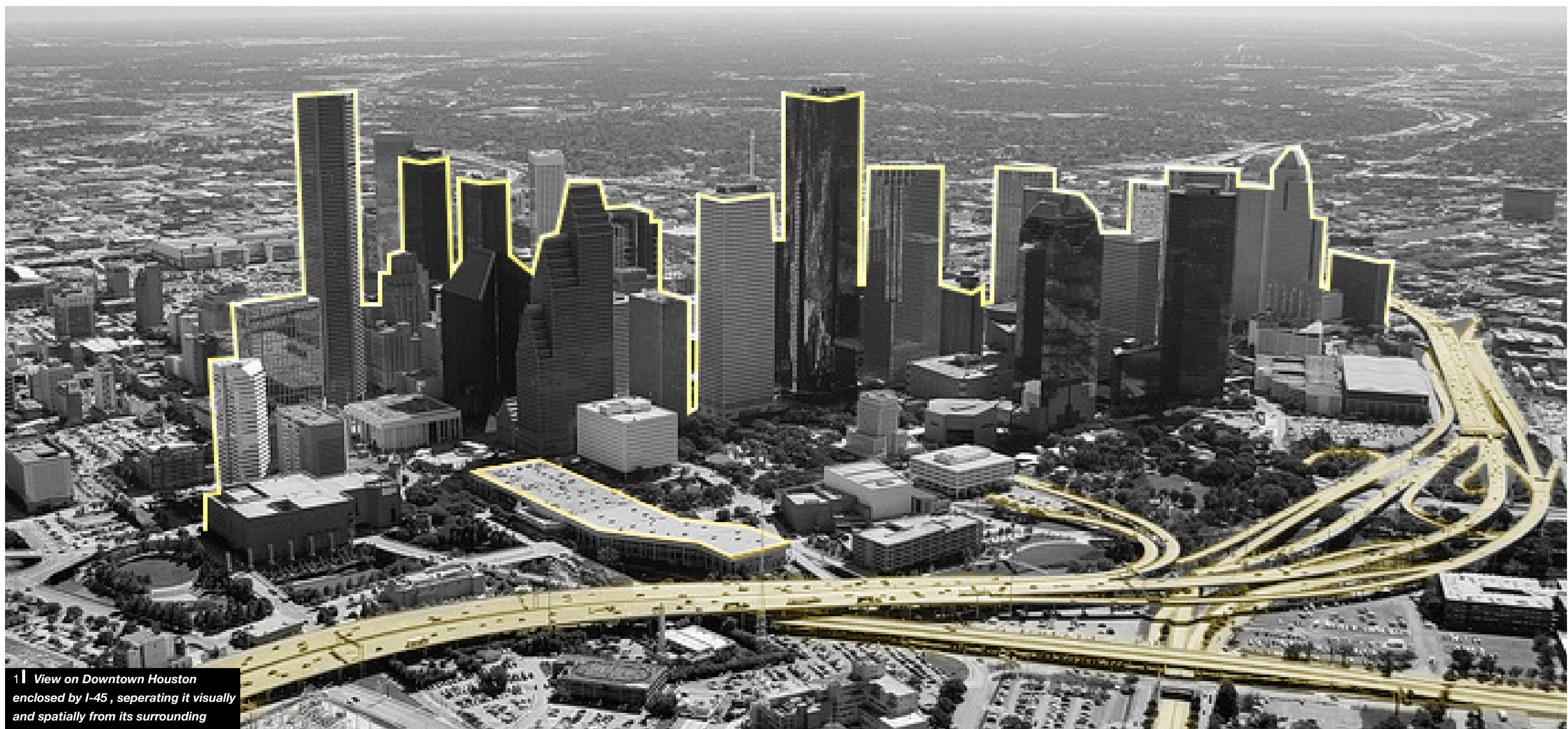
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Duration of Project:
April 2019 - July 2019

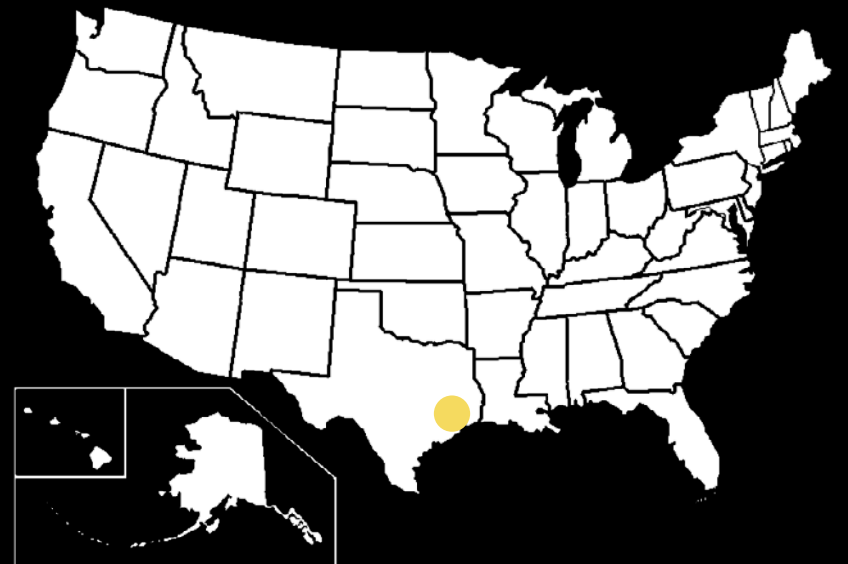
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02 ANALYSIS



1 | View on Downtown Houston enclosed by I-45, separating it visually and spatially from its surrounding

2.1 HOUSTON DEVELOPMENT



2 | *Historic view on Buffalo Bayou with its unique and undisturbed riparian vegetation and wetlands, Houston, Texas (1908)*

2.1 DEVELOPMENT

“Houston is a cruel, crazy town on a filthy river in East Texas with no zoning laws and a culture of sex, money and violence. It’s a shabby, sprawling metropolis ruled by brazen women, crooked cops and super-rich pansexual cowboys who live by the code of the West - which can mean just about anything you need it to mean, in a pinch.”

PARODY ON HOUSTON BY HUNTER S. THOMPSON



3 | Bird's Eye View of the City of Houston, Texas, 1873

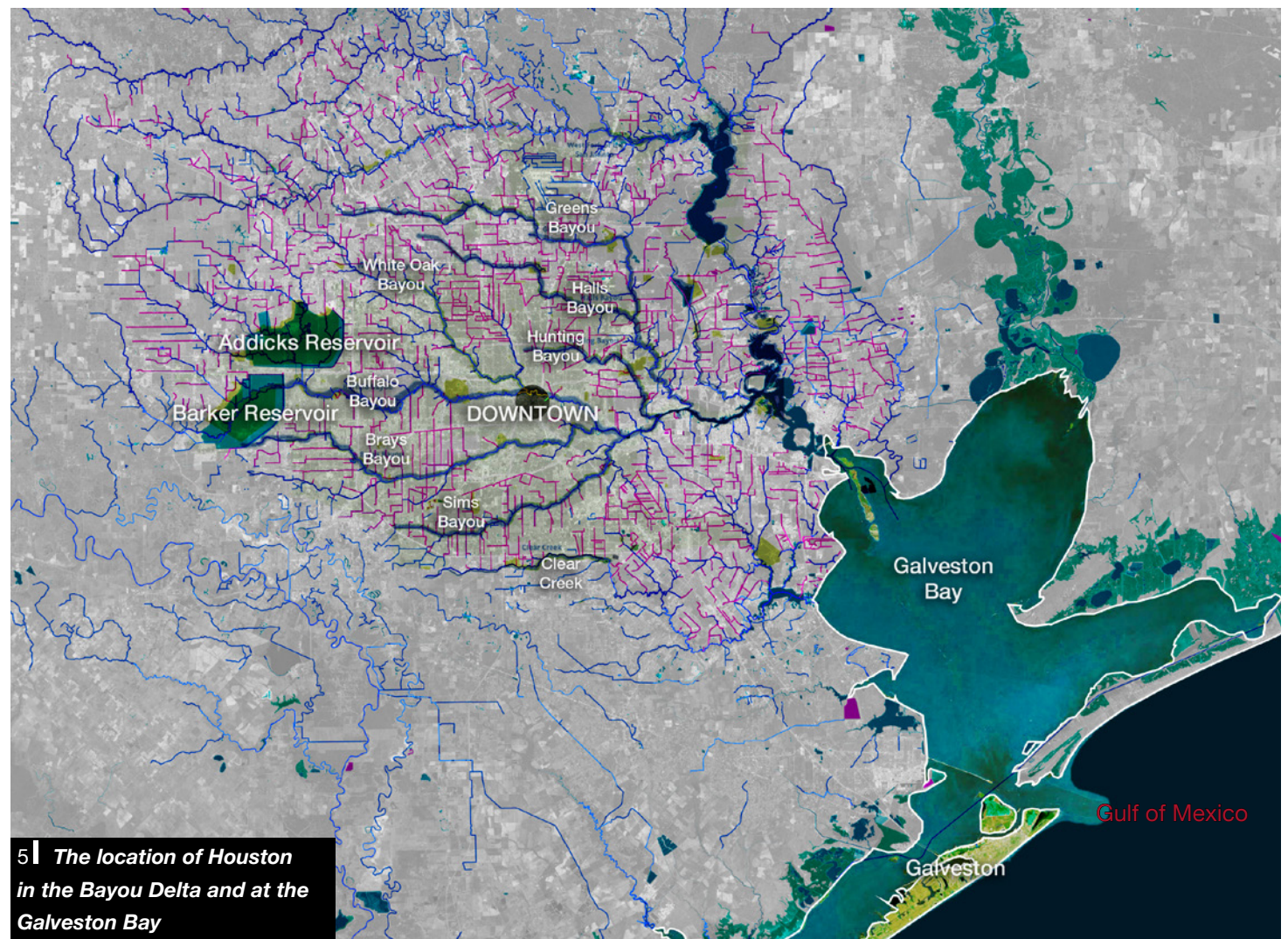
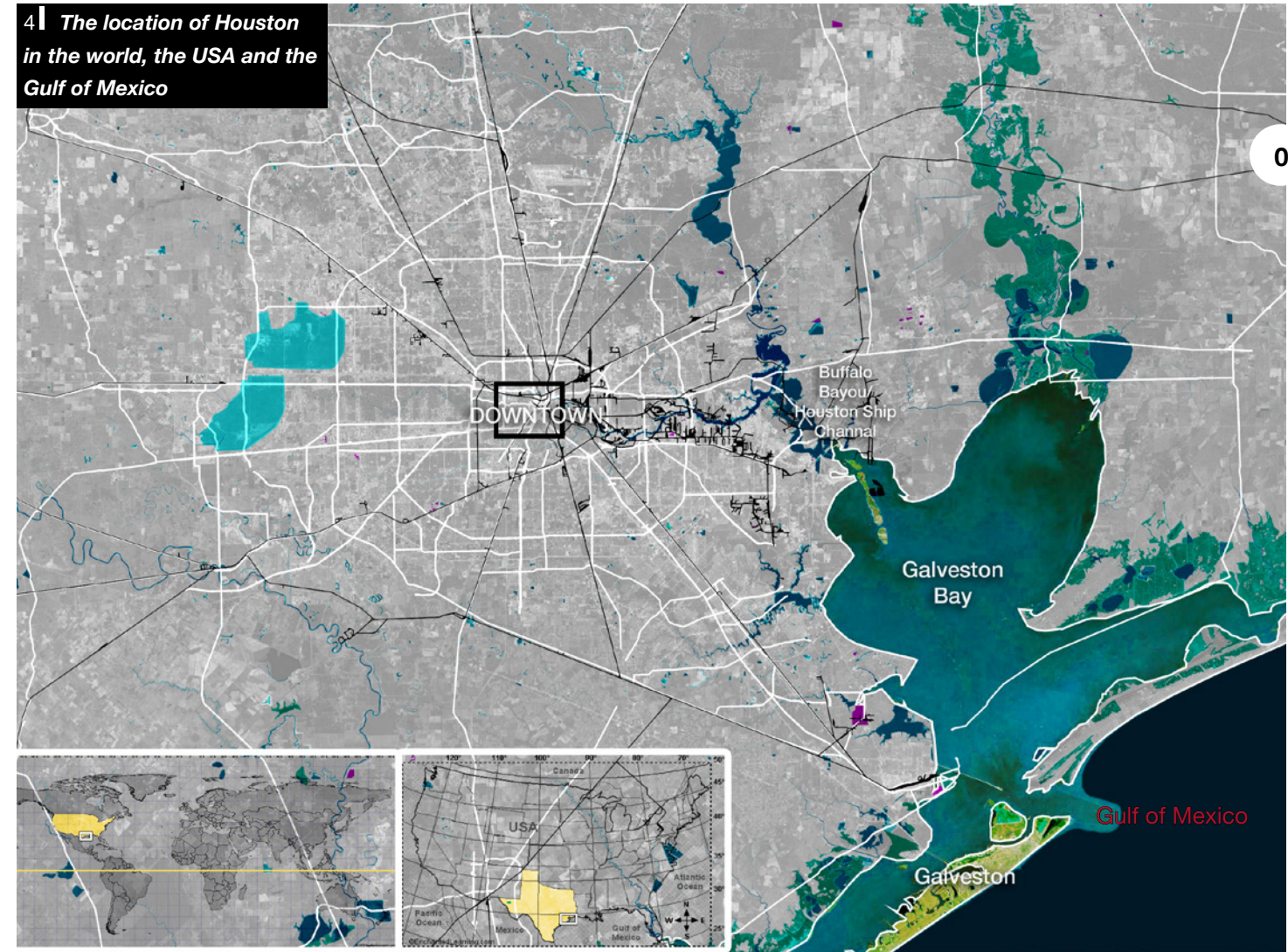
Houston is the 4th most populated city of the United States of America and therefore also one of the biggest metropolitan areas and economic drives of the region. Houston, also known as the Bayou City is located in the south east of Texas and is situated close to the Galveston Bay (Gulf Coast Plain) and lies between four major bayous (Buffalo Bayou and Houston Shipping Channel, White Oak Bayou, Brays Bayou as well as Sims Bayou).

In 1836 the brothers August and John purchased land within a swampy area today known as the City of Houston along the southside of the Buffalo Bayou.

Around 50 miles inland from the coast of Galveston the brothers placed the first settlement between the two slow moving, tidal rivers Buffalo and White Oak Bayou. Eventhough the area was struck by several disease and epidemics, Houston grew towards a railway distribution hub for local ressources by 1870. Nonetheless before Houston gained the status as the 4th most populated city in the US, Galveston was still the economic driver in this region due to its port and location at the gulf coast. (McComb, n.d.)

Galveston was shattered by a catastrophic hurricane in 1901 (followed by another one in 1915), therefore people started to look for a less exposed location for the port and financial ressources, business and residents started to move to Houston. Together with the finalization of the Houston Shipping Channel in 1914 and the discovery of oil, Houston's path towards the Boomtown of today was settled.

4 | The location of Houston in the world, the USA and the Gulf of Mexico

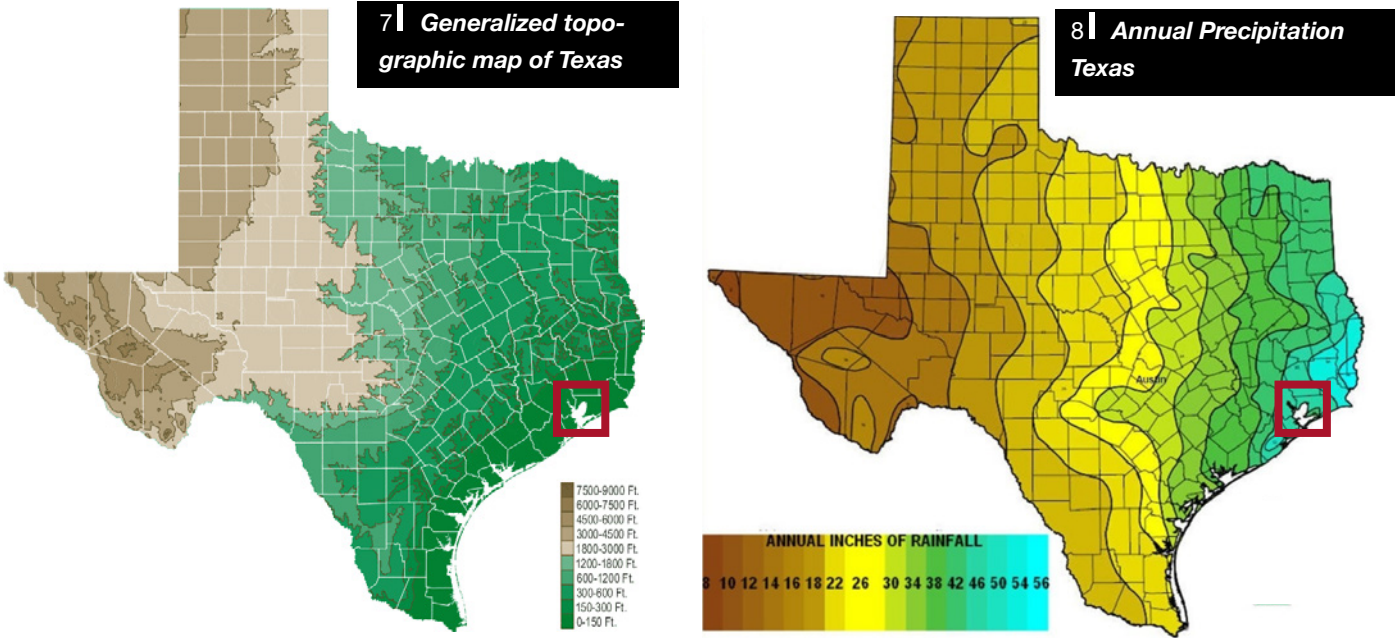
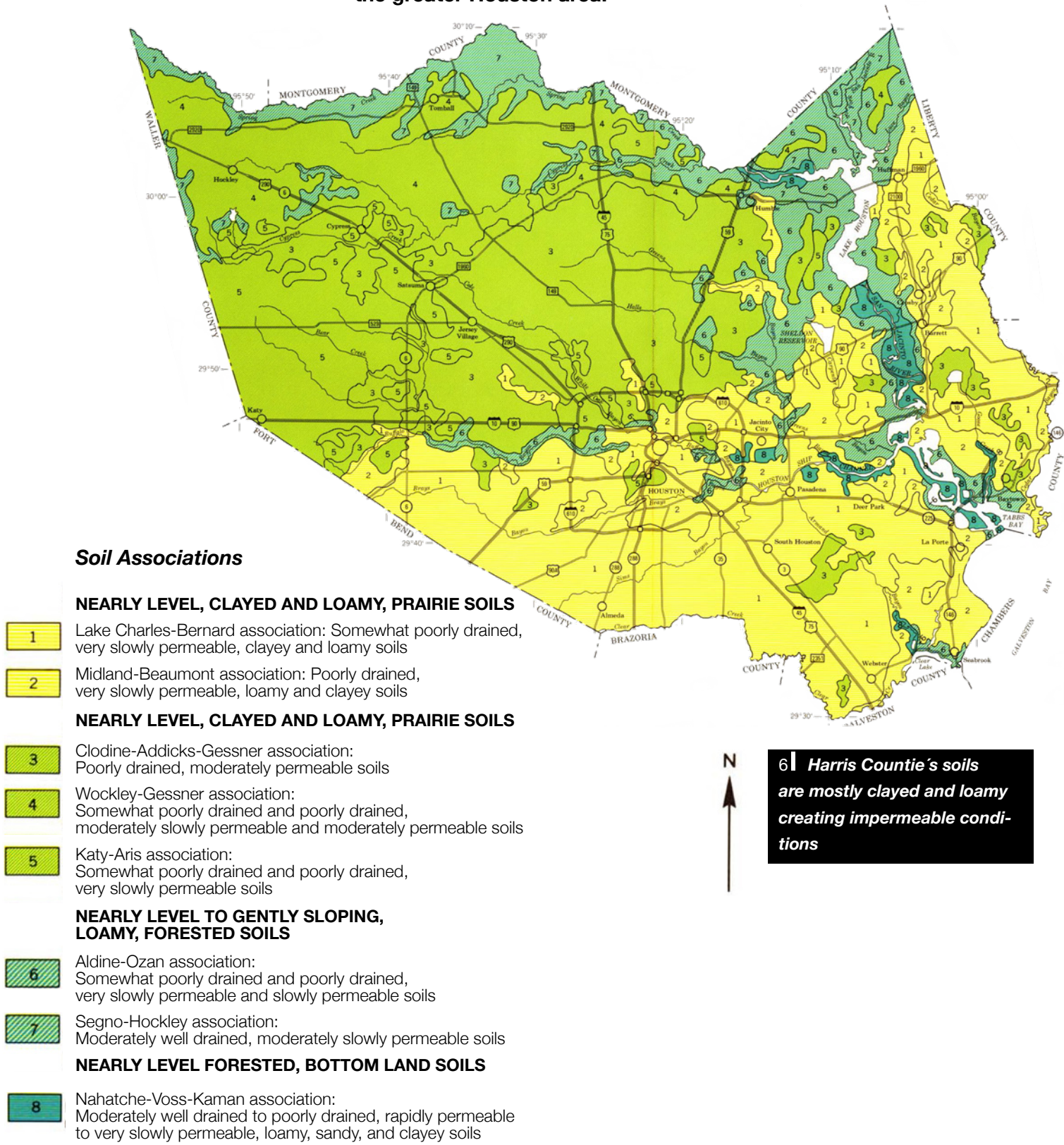


5 | The location of Houston in the Bayou Delta and at the Galveston Bay

2.1 DEVELOPMENT

GEOGRAPHIE

Houston is located in the south east of Texas, around 50 miles inland of the Galveston Coast. For the upcoming chapters about Houston's flooding issue due to high precipitation and flashfloods caused by Hurricanes and Tropical Storms, it is important to gather a brief overview of the overall, basic geographic and climatic conditions of the greater Houston area.



Climate:

The area of Houston can be defined as a humid subtropical zone with tropical influences. The warmest month with an average temperature of around 104 degrees F (40 degrees C) is August and the coldest month with around 43 degrees F (6 degrees C) in January. (National Oceanic and Atmospheric Administration)

Topography and Geography:

Most of the city was built on former marsh and swamp/prairie land. The major part of the underlying soil is clay and loam based, which makes the unpermeable surface unsuitable for draining water into the soil quickly. (U.S. Department of Agriculture Soil Conservation Service)

Looking at the topography of Texas, Houston is located in a very shallow area in the Gulf Coast biome. Not many extreme elevations can be seen in and around the area of the city. With an average height of 50 feet (15m) above sealevel and a maximum elevation of around 90 feet (27m) Houston is basically flat. (United States Coast Guard Air Station Houston; Abbott, 2001)



Additionally recent studies show that the areas within and outside the city limits are subsiding due to groundwater and oil withdrawal which caused from 1979, as much as 10 feet (3m) of subsidence in the Houston-Galveston region. (United States Geological Survey)

Precipitation and Rainfall:

Rainfall is the most occurring form of precipitation in Houston. Compared to other parts of Texas, the annual rainfall in Houston with around 50-56 inches is quite high.

9 | Armand Bayou Nature Center

2.1 DEVELOPMENT

POPULATION

As already stated at the beginning, Houston is the 4th biggest city on the United States of America concerning population. The population of the Greater Region of Houston in 2014 was 5,399,338, increasing at an average annual rate of 2.7% since 2000. Metro Houston added nearly 92,000 residents last year, boosting the region's population to nearly 7.0 million. Since 2010, the Houston area has added nearly 1.1 million residents. Houston's population should exceed 7.1 million by the end of the decade.

Jankowski, 2019

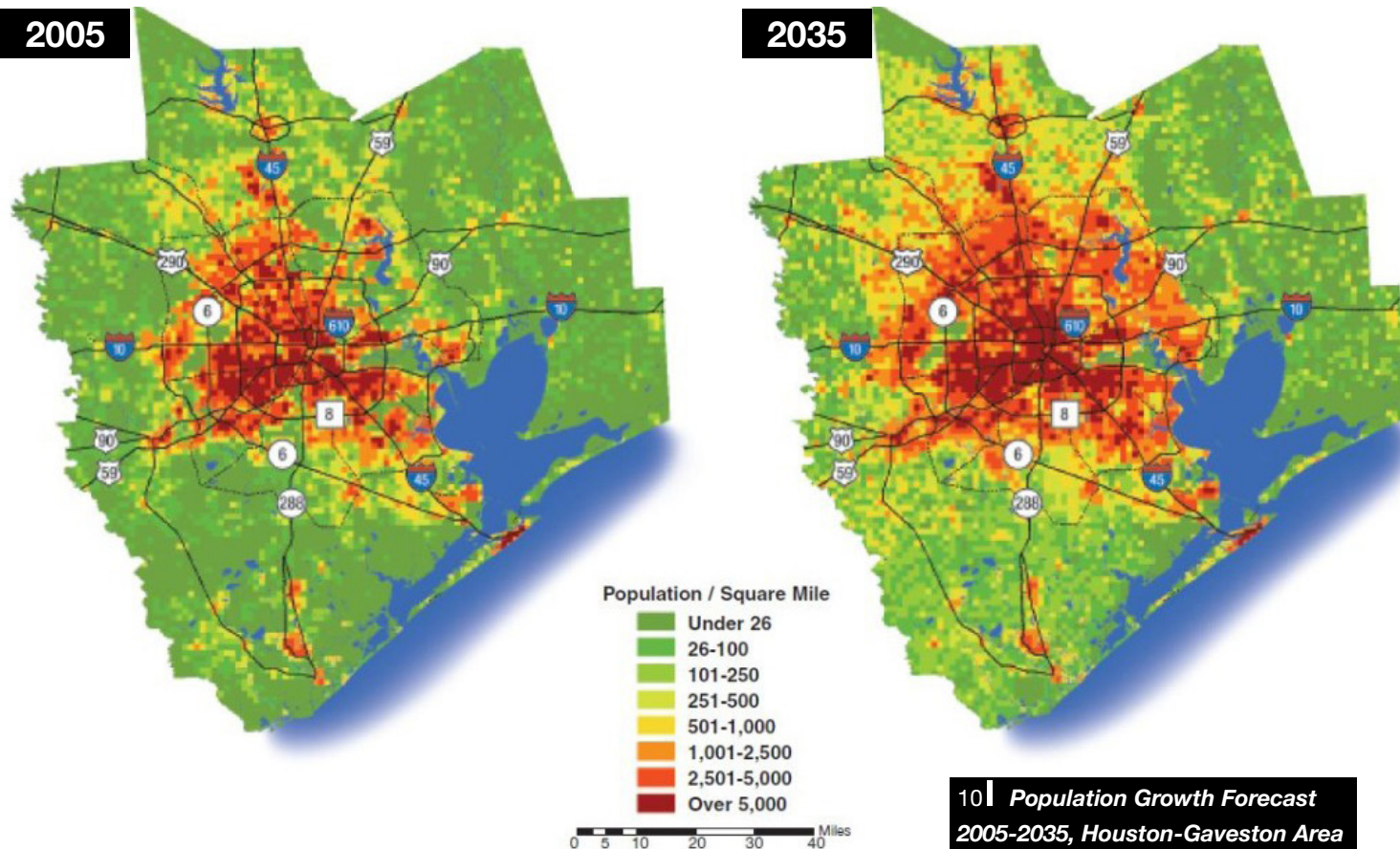
But not only the population of Houston will grow, also the built environment itself and therefore as well the amount of impermeable areas like streets, plots parking space and other kinds of infrastructure. Taking a look back in history analysis shows that land development is integrally linked to highway and interstate construction.

Residential areas occurred as soon as or even before the planning process for new highways began.

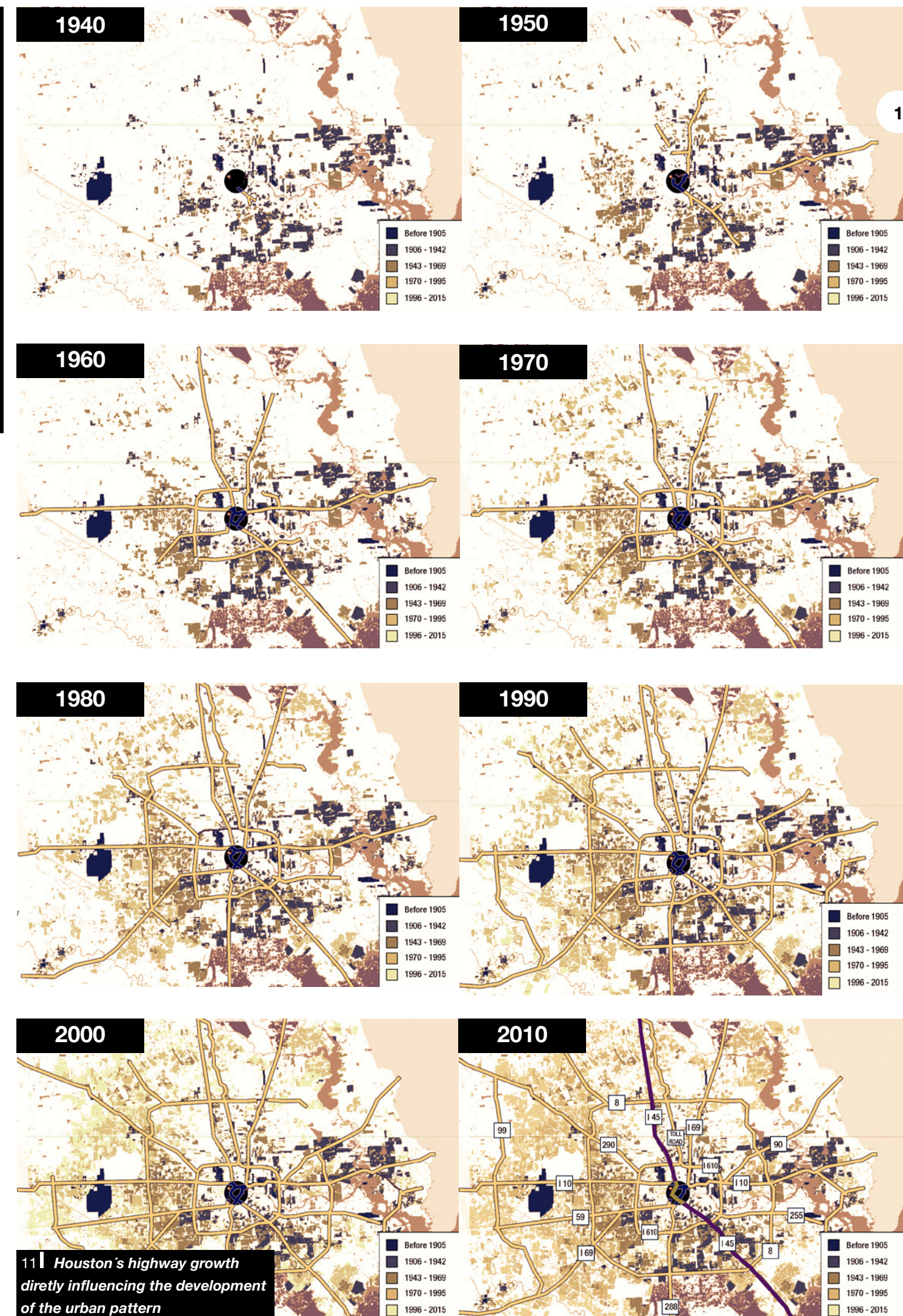
Those highways, freeways and interstates, that were promoted as solutions against congestion, basically promoted (similar to other American metropolises) sprawl and were and are still the driving force behind outward development (*see sequence of maps on the right*).

2014 the urban extend of Houston was around 420,000 hectare, which is an increase of 2,8% compared to the year 2000. (*Atlas of Urban Expansion, Houston*)

Is sprawl, the lack of density and the absence of zoning the reason why Houston floods? Houston can be seen as a medium dense city. Compared to New York or Chicago, Houston seems like a sheer sprawl. Nonetheless compared to other urbanized areas in the States the city is more dense than some urban planners may think. (*see results of Ybarra, 2017*)



10 | Population Growth Forecast 2005-2035, Houston-Gaveston Area



2.1 DEVELOPMENT

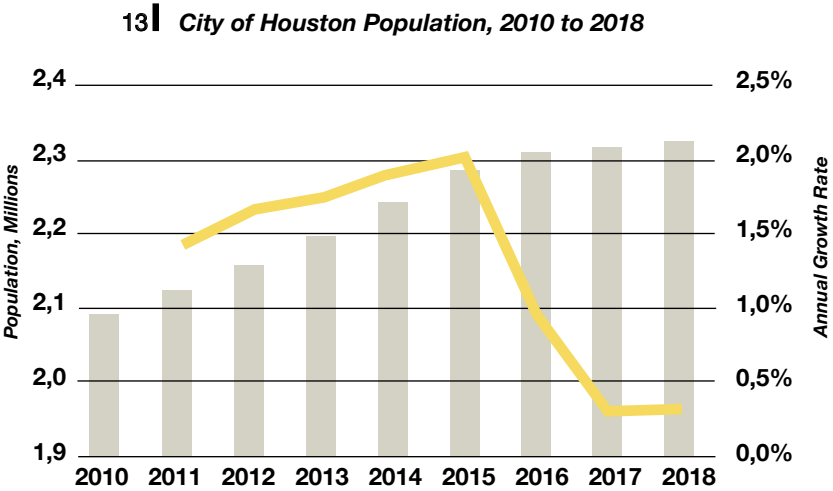
URBAN SPRAWL

“When you have a less dense urban fabric, you’re going to have more impervious surface and you’re going to have more runoff ... That’s clearly an important consideration in Houston.”

The chair of Georgia Tech’s School of Regional and City Planning argued on CNN
Source: CATO INSTITUTE

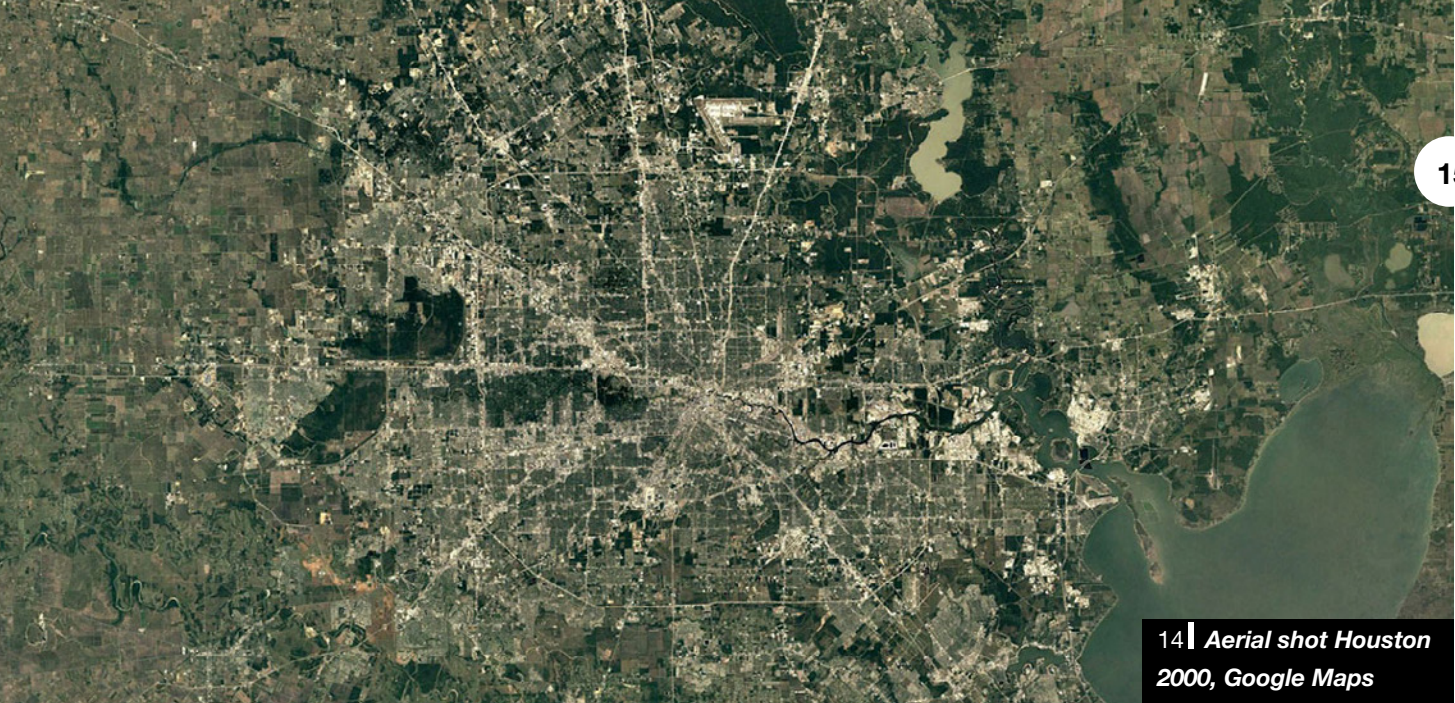
12 | Most Populous U.S. Cities, 2018

Rank	City	Residents July 1, 2018	Residents added 7/1/2017 to 7/1/2018	Percent Change (%)
1	New York, New York	8,398,748	-39,523	-0,5 %
2	Los Angeles, California	3,990,456	8,454	0,2 %
3	Chicago, Illinois	2,705,994	-7,073	-0,3 %
4	Houston, Texas	2,325,502	8,057	0,3 %
5	Phoenix, Arizona	1,660,272	25,288	1,5 %
6	Philadelphia, Pennsylvania	1,584,138	3,917	0,2 %
7	San Antonio, Texas	1,532,233	20,824	1,4 %
8	San Diego, California	1,425,976	11,549	0,8 %
9	Dallas, Texas	1,345,047	1,960	0,1 %
10	San Jose, California	1,030,119	-2,017	-0,2 %
11	Austin, Teas	964,254	12,504	1,3 %
12	Jacksonville, Florida	903,889	12,153	1,4 %
13	Fort Worth, Texas	895,008	19,552	2,2 %
14	Columbus, Ohio	892,533	10,770	1,2 %
15	San Francisco, California	883,305	4,139	0,5 %
16	Charlotte, North Carolina	872,498	13,151	1,5 %
17	Indianapolis, Indiana	867,125	5,235	0,6 %
18	Seattle, Washington	744,955	15,354	2,1 %
19	Denver, Colorado	716,492	11,053	1,6 %
20	Washington, District of Columbia	702,455	6,764	1,0 %

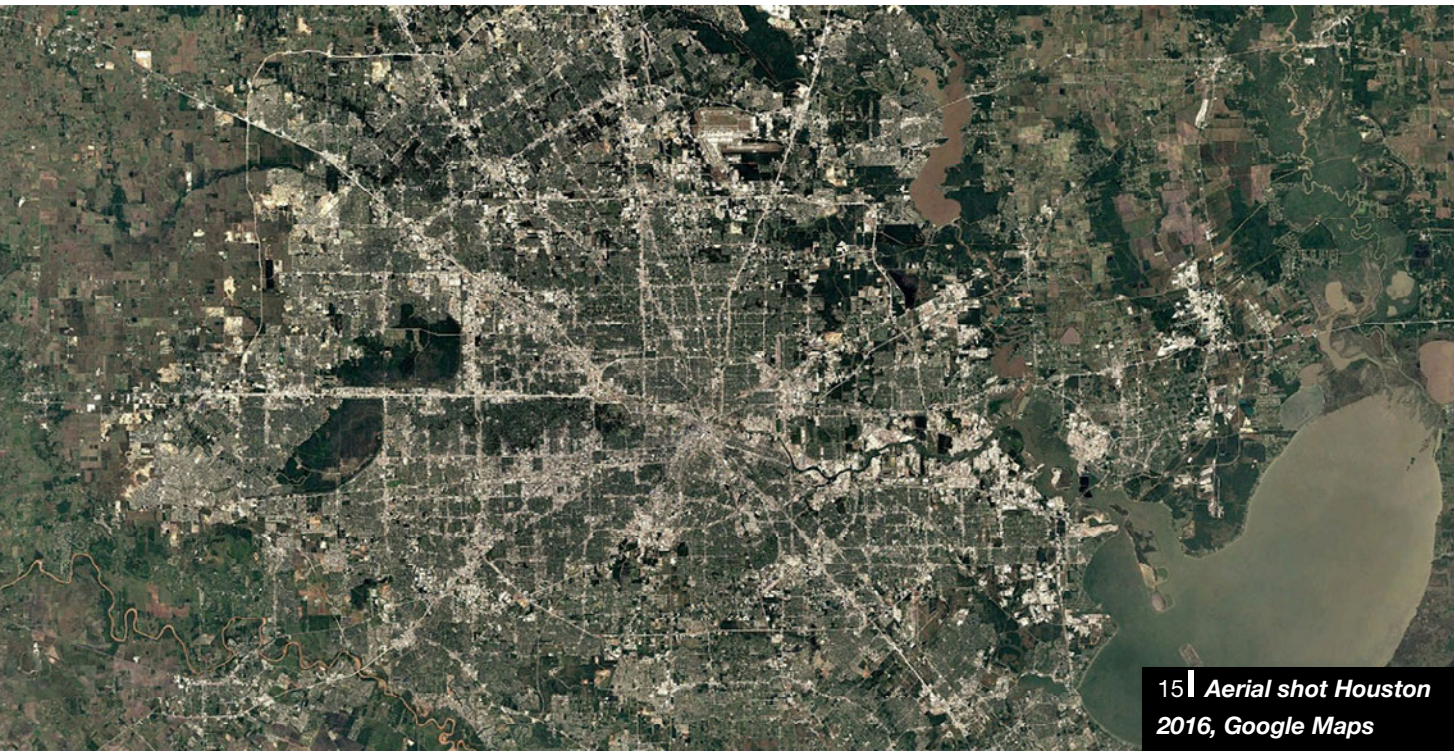


In fact, a map of Houston indicates that the city has a lower level of impervious surface cover across more than 90% of the city. Most of the remaining 10% falls under the “average” impervious/pervious surface ratio category, and hardly any falls under the “high levels of pavement” category (*Calder, 2017*).

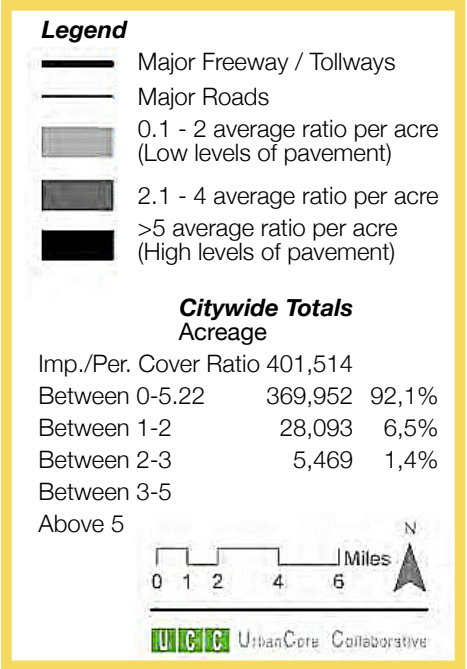
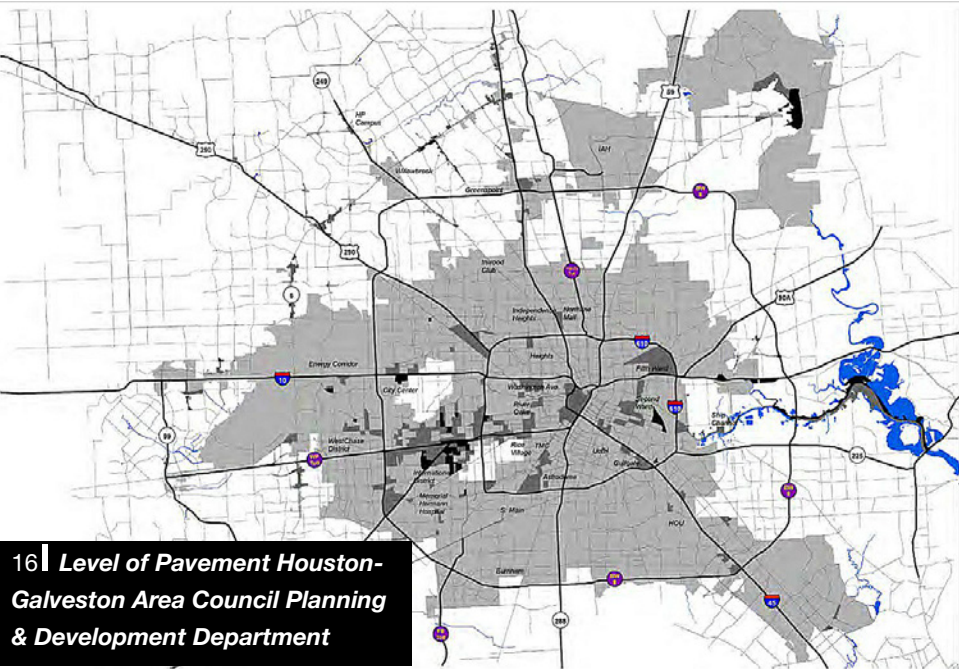
Nonetheless, the rapid development and high urban dynamics as well as the lack of zoning brought something negative with it. Houston is the only major city in the US promoting fast urban dynamics which are only regulated by municipal policies. Urban development depicts a traditional market philosophy, where zoning would violate the value of the private property and personal freedom. No zoning law encouraged the enormous cities footprint as well as the phenomena of exurbanism and sprawl (*Qian, 2009*). Houston may be not as sealed as thought but unsuitable development in vulnerable areas, for example densification and the emergence of impervious surface within floodplains and watersheds brings a highly negative effect with it (*Brody et al. 2008*). The consequences of unregulated densification within the path of draining water can be seen in the chapter about flooding.



14 | Aerial shot Houston 2000, Google Maps



15 | Aerial shot Houston 2016, Google Maps



“The rain in Harris County was worse than the previous worst-case scenario. If Houston had gotten the equivalent of the worst storm in history, and if it had targeted Harris County like an expert marksman, it still would have fallen several inches shy of Harvey.”

JOHN NIELSEN-GAMMON, PH.D.
Regents Professor of Atmospheric Sciences
at Texas A&M University and Texas State Climatologist

16

17

2.2 HOUSTON FLOODING



17 | People walk through the flooded waters of Telephone Road in Houston on Sunday as the city battles with tropical storm Harvey and resulting floods.

2.2 FLOODING

FLOODING IS HARRIS COUNTY'S NO.1 NATURAL DISASTER

20 | Harris County 22 Watersheds

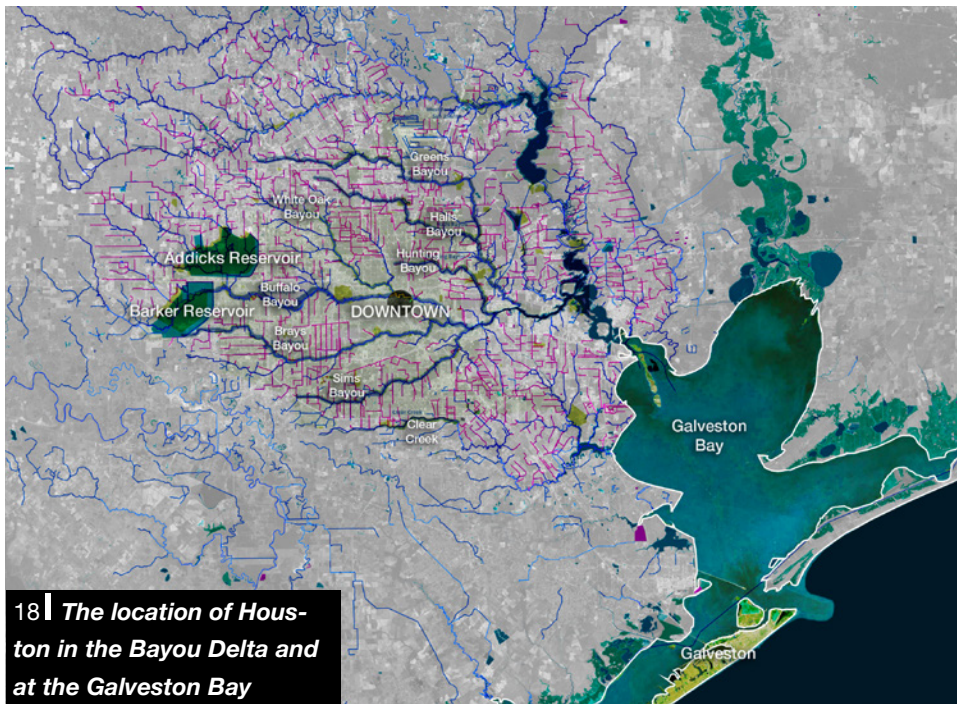
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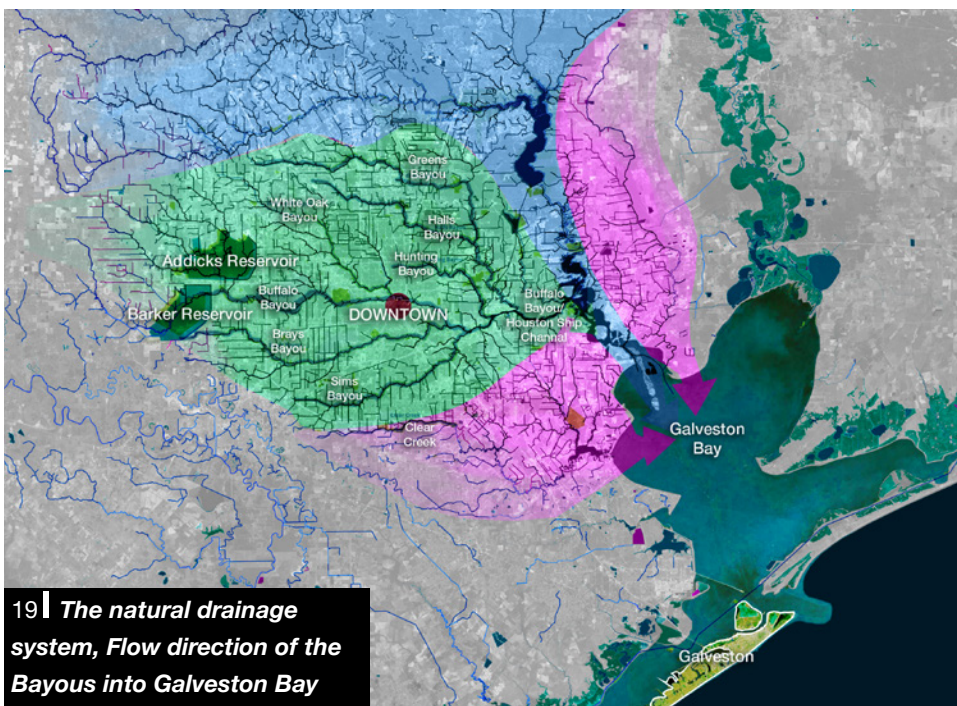
The 22 bayou systems and waterways in the greater Houston region:

- 1) Addicks Reservoir, 2) Armand Bayou, 3) Barker Reservoir Drainages, 4) Brays Bayou, 5) Buffalo Bayou, 6) Carpenters Bayou, 7) Cedar Bayou Clear Creek / Clear Lake, 8) Cypress Creek, 9) Dickinson Bayou, 10) Goose Creek/Spring Gully, 11) Greens Bayou / Halls Bayou, 12) Hunting Bayou, 13) Jackson Baou, 14) Lake Houston Drainage, 15) Little Cypress Creek, 16) Lower San Jacinto River, 17) Sims Bayou, 18) Spring Creek, 19) Upper Galveston Bay, 20) Shoreline Tributaries, 21) White Oak Bayou, 22) Willow Creek

(Bayou Preservation Association)



18 | The location of Houston in the Bayou Delta and at the Galveston Bay



19 | The natural drainage system, Flow direction of the Bayous into Galveston Bay

Harris County Drainage System and Watersheds

As the third largest county in the US, Harris County covers around 1700 square miles (4400 square kilometer) with a around 1500 channels and ditches of water with a total length of 2500 miles (4000 kilometer) within 22 waterheds defined by the 22 bayous.

Originally only 800 miles (1300 kilometer) of those streams and drainage systems are natural. Most of them are either human-made and improved for a more efficient storm-water management (**Harris County Flood Control Distric, HCFCD**).

A watershed can be defined as an area that drains rainfall runoff ans stormwater from the surface towards a common body of water. They are mostly devided in big, major main-watersheds as well as sub-watersheds formed by smalles branches bayous, creeks and gullies, which then can have their own sub-watersheds again.

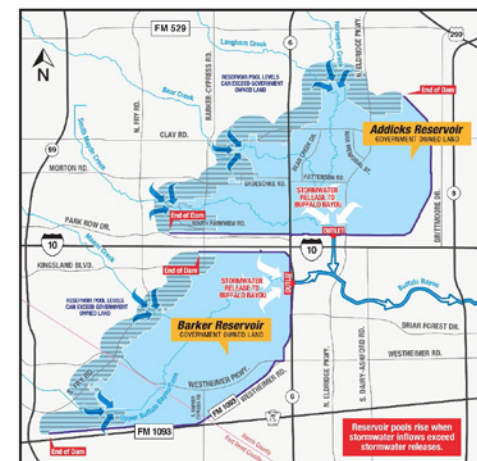
The 22 watersheds are defined as „natural“ drainage areas that lead the water in one of the 22 bayous. They come in all forms and shapes and are determined by topography and „lay of land“ which brings each area its individual and unique flooding issue (**HCFCD**).

Addicks and Baker Reservoirs

The Addicks and Baker reservoir are the only two, large scale storm-water storages in Harris County. In the 1940s, those two basins have been constructed to collect precipitationand run-off from upstream locations, to reduce the pressure on Buffalo Bayou as well as prevent Houston Downtown and other down stream areas from flooding (**HCFCD**). During Hurricane Harvey, the two emergency reservoirs started to fail, due to densification and intense residential development within the Addicks and Baker watersheds. Many of the houses located behind the reservoirs started to flood. To prevent even bigger damage, the US Army Corps decided to release water from the dams into Buffalo Bayou, which originally should be supported by the reservoirs. The unusual big amount of stormwater created flooding of many downstream areas, including Houston Downtown as a result (**Brussee, van der Doef, Jansen, Oostrum, 2017**).



21 | Flooding of Sesquicentennial Park and Franklin St. during Harvey, Houston 2018



22 | Addicks and Baker Reservoir

Drains to Galveston Bay through San Jacinto River

Drains to Galveston Bay through Buffalo Bayou and Houston Shipping Channel

Drains to Galveston Bay

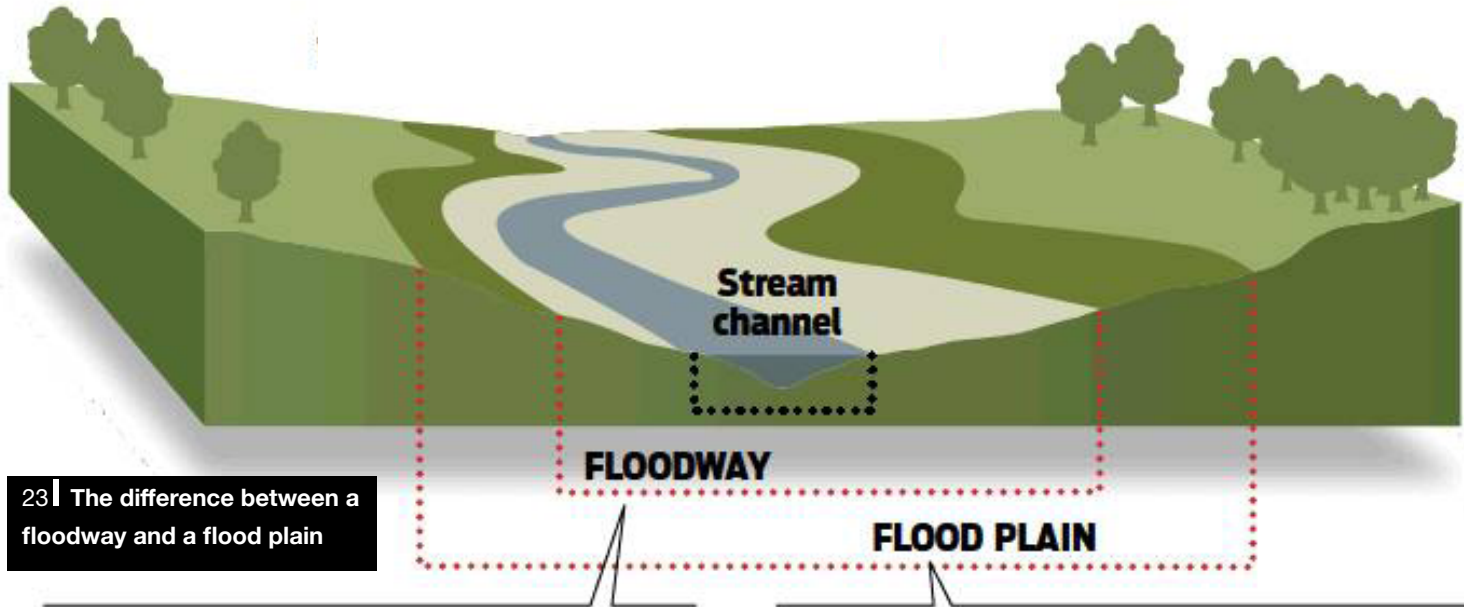
Addicks and Baker Reservoir

2.2 FLOODING

Floodplains:
Next to the watersheds, each bayou and creek has its own including area called floodplain, where water collects, ponds and flows during a storm event. To be able to identify those areas, so called FIRMs or Flood Insurance Rate Maps have been created by the Harris County Flood District Control. These maps show properties and areas of individuals and the county which are at risk for flooding during different situation.

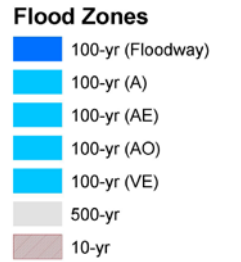
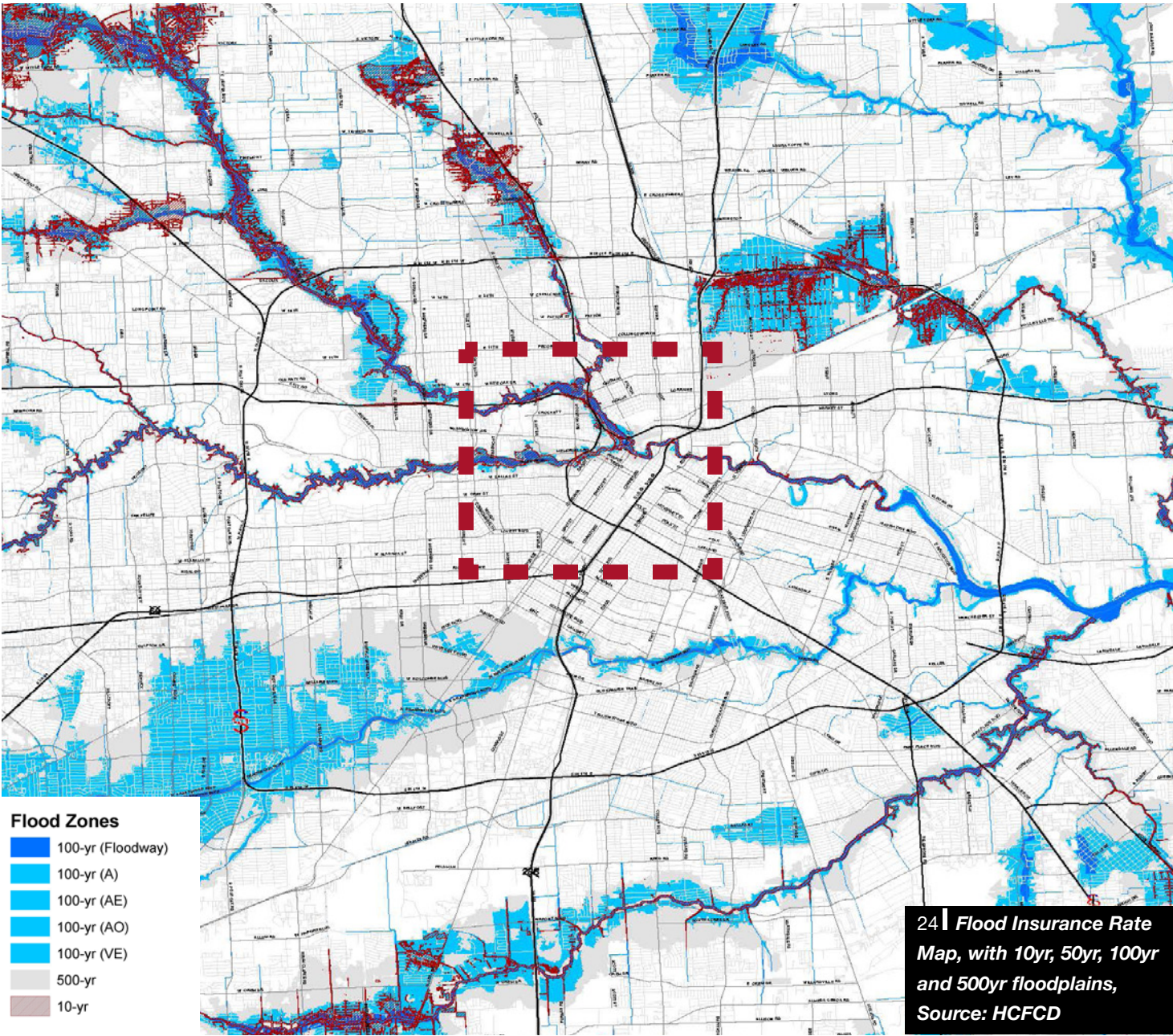
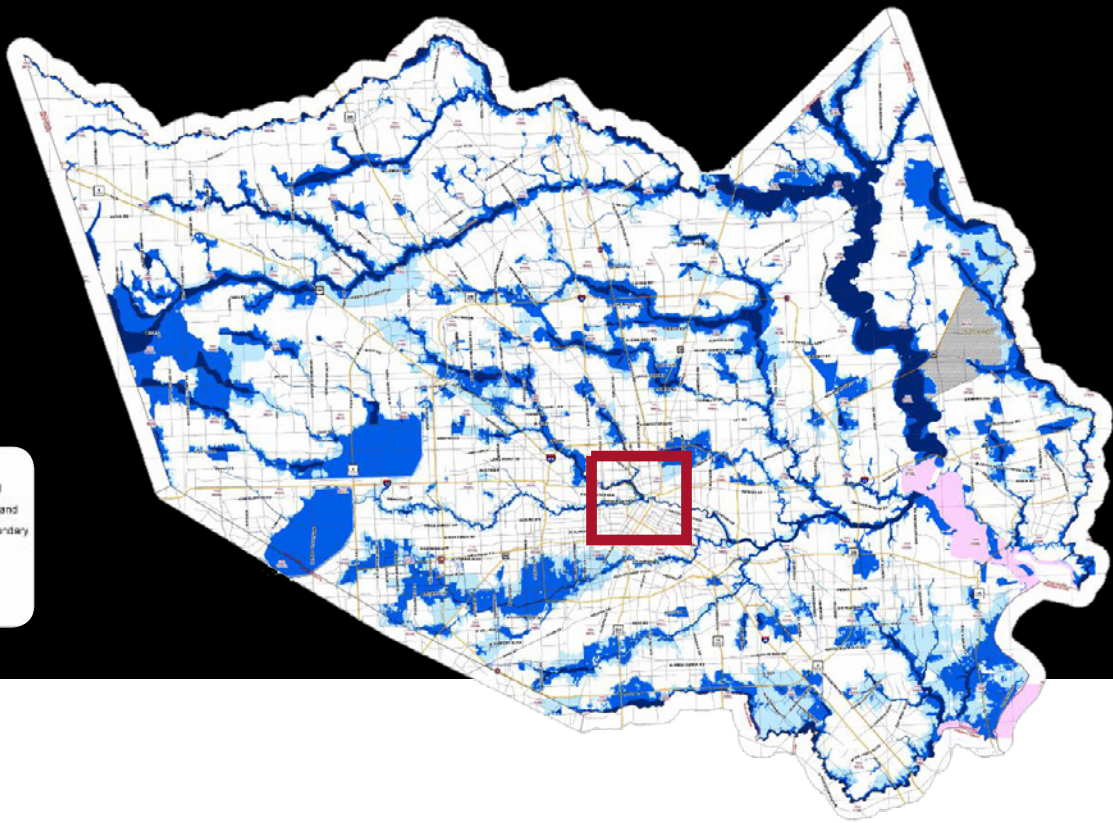
Based on the FIRMs the residents but also developers, engineers and communities can or better say „could“ make better decisions in protecting their properties with insurance. A floodplaine is defined as any land area susceptible to being inundated by water. They are classified in so called SFHA, Special Flood Hazard Areas, which are located within a 100-year flood zone (HCFCF).

100 year flood-zone:
Different than the name, a 100 year flood-zone does not flood approximately every 100 years. Instead those areas have a 1% chance to reach or exceed a certain elevation of flood-water every year. Similar to that, also 50 and 10 years flood zones are predicted by those maps. The highest category are 500 years floodplains, that tend to flood with a chance of 0.2% every year (HCFCF).



A **Floodway** is the channel of a river or stream, plus the adjacent land needed to carry away floodwaters. It has some of the fastest-moving water during a flood.

The **100-year flood plain** is a broader area surrounding the floodway. It would be inundated during a storm that has a 1 percent chance of occurring in a given year.



24 | Flood Insurance Rate Map, with 10yr, 50yr, 100yr and 500yr floodplains, Source: HCFCF

2.2 FLOODING

DEVASTATING FLOOD EVENTS

Houston is a city predestined to flood due to extensive rainfall during the hurricane season. Especially in the last few years, devastating flood events like the Memorial Day Flooding, Tax Day Flooding and ofcourse Hurrican Harveys rampaged in and around Houston. Nonetheless history shows that flooding in Houston is not a new phenomena.

1900
September - Major hurricane hits Galveston. The "Great Galveston Storm" is the worst natural disaster to date in U.S. history. Loss of life reported to be 6,000 to 8,000 citizens. Harris County experiences widespread flooding, with property damage at \$30 to \$40 million.

1907
Major storm floods much of Houston and Harris County.

1900

1908
First drainage district created in Harris County in Brays Bayou watershed.

1911-1914
Houston Ship Channel construction begins.

1913
December - Major Brazos River storm spreads to Harris County. Entire area is hard hit. Buffalo, White Oak, Brays and Greens Bayous are all out of banks. Many citizens evacuate.

1910

1914
Houston Ship Channel opens.

1915
August - Another Galveston hurricane causes major damages throughout Harris County. Buffalo Bayou and widespread areas of Houston experience heavy flooding. Damage estimated at \$56 million.

1916
The United States Geological Survey publishes topographic maps for Harris County.

1929
April - Enormous gulf storm descends on Houston and Harris County and lasts 14 hours. Many areas of county report rainfall close to 10 inches. Extensive damage sustained to structures in almost all of Harris County. All bayous are reported to be out of banks.

1920

1929
May - As the area is still reeling from the last storm, another major storm hits Harris County. Structural damage, heavy street flooding and widespread crop damage reported. San Jacinto River 30 feet above normal.

1930
May - Large rainstorm cell remains stationary over Harris County for 3 days. Rainfall amounts reported as high as 12.5 inches. Entire area averages 8 inches.

1930

1935
December - Massive storm inundates Houston and Harris County. Buffalo Bayou 52 feet above normal. Overwhelming devastation leads to creation of the Harris County Flood Control District in 1937.

1940
November - Heavy rains last for 5 days in Northeast Harris County. 10,000 head of cattle lost.

1940

1943
July - Hurricane near Galveston creates extensive flooding for Harris County. \$16.5 million in damages.

1943
October - Hurricane near Freeport. More than 11,000 structures flood in Harris County.

1945
August - Area hurricane produces heaviest rainfall ever recorded in Harris County. More than 15 inches in 24 hours. Flooding reported on all bayous.

1950
February - Thunderstorm precedes cold front, resulting in Greens Bayou running out of banks. Area residents evacuate. Baytown also reports flooding.

1950

1955
May - Major thunderstorm hits northern portion of Harris County. Structure flooding reported in the area.

1957
June - Hurricane Audrey crosses the Louisiana/Texas coast. Flooding is reported in Harris County.

1959
October - Thunderstorm floods more than 100 structures in Houston area.

1960
June - Thunderstorm inundates many areas throughout Harris County. Cypress Creek, Spring Creek and San Jacinto River experience flooding. Over 200 families evacuate.

1960

1969
February - Thunderstorm precedes cold front, flooding more than 250 area structures. Damages exceed \$3.3 million.

1972
March - Thunderstorm precedes cold front and floods much of northern Harris County. More than 700 families evacuate.

1973
June - Major storm hits Harris County and brings 10-15 inches of rain. Sims and Greens bayous are reported out of banks. 10 lives are lost and damages exceed \$50 million.

1970

1979
July - Tropical Storm Claudette brings record rainfall amounts to the area. A U.S.-record of 43 inches of rain in 24 hours falls in Alvin. Total damages exceed \$700 million.

1983
May - Large thunderstorm floods areas along several bayous. Damages exceed \$14 million.

1983
August - Hurricane Alicia strikes Galveston and Harris County. Damages approach \$1 billion, mostly due to wind.

1980

1983
September - Nine inches of rain falls south of downtown. More than 1,000 structures flood along Brays Bayou. Damages top \$38 million.

1984
October - Thunderstorm in northern Harris County floods more than 200 structures. Total damages exceed \$32 million.

1989
May & June - Two separate storms result in two back-to-back presidential disaster declarations.

1992
March - Major storm floods more than 1,500 structures and many bayous are out of banks. Much of I-10 is under water.

1994
October - Major storm hits Harris County. Twice as many structures flood than in the 1992 storm. Most bayous are out of banks.

1990

1998
September - Tropical Storm Frances causes extensive flooding along White Oak Bayou and other bayous. More than 1,300 structures flood.

1998
October & November - Adding insult to injury, two more major storms flood hundreds more structures, mainly in north Harris County.

2001
June - Tropical Storm Allison strikes first on June 5; returns three days later for a second round of storms. Texas Medical Center essentially shut down. North Downtown Houston decimated. Two million people impacted; 22 lives lost. More than 70,000 structures flood. Damages top \$5 billion.

2006
June 19 - Rainfall on already saturated ground floods 3,370 homes, 561 apartments and one nursing home, mostly along Berry and Sims bayous. Rainfall 8-10 inches in three hours.

2000

2008
September - Hurricane Ike, 3rd costliest in U.S. history, strikes Galveston Island. Eleven deaths in Harris County. Storm surge swamps 2,500 structures; rainfall causes 1,200 more structures to flood. More than \$28 billion in damage.

2009
April 17-28 brings extensive flooding; five children drown when a car goes into a Greens Bayou tributary. Some highways close; record high water on Bear, Langham, Mayde creeks. 2,305 structures flood on Langham Creek and Buffalo Bayou. HCFCD records one-hour rainfall of 6.9 inches at Clear Creek.

2012
July - High water rescues along Cypress, Little Cypress and Willow creeks after several days of heavy rainfall beginning July 9. More than 70 structures flood in northern Harris County.

2014
August - Slow-moving rains drench portions of Harris County with 3.5-4.5 inches. In the Greens Bayou watershed, 109 structures flood.

2015
May 25-27 - Memorial Day Flood. More than 6,000 structures flood. Seven fatalities. Highest rainfall recorded in Buffalo and Brays watersheds. Nearly 11 inches in 3 hours on Brays Bayou.

2010

2016
April 17-18 - Tax Day Flood. Historic flood over northern and western Harris County results in seven fatalities. Average 12-16 inches of rain in 12 hours countywide; record pool levels in Addicks and Barker reservoirs. Estimated 9,820 structures flood in Harris County.

2016
May 26-27 - Memorial Day Flood. North and northwest Harris County hit with 8-13 inches of rain. Overbank and structural flooding along Spring, Willow, Little Cypress and Cypress creeks, San Jacinto River. More than 400 structures flood in Harris County and more than 900 in the Spring Creek watershed in Montgomery County.

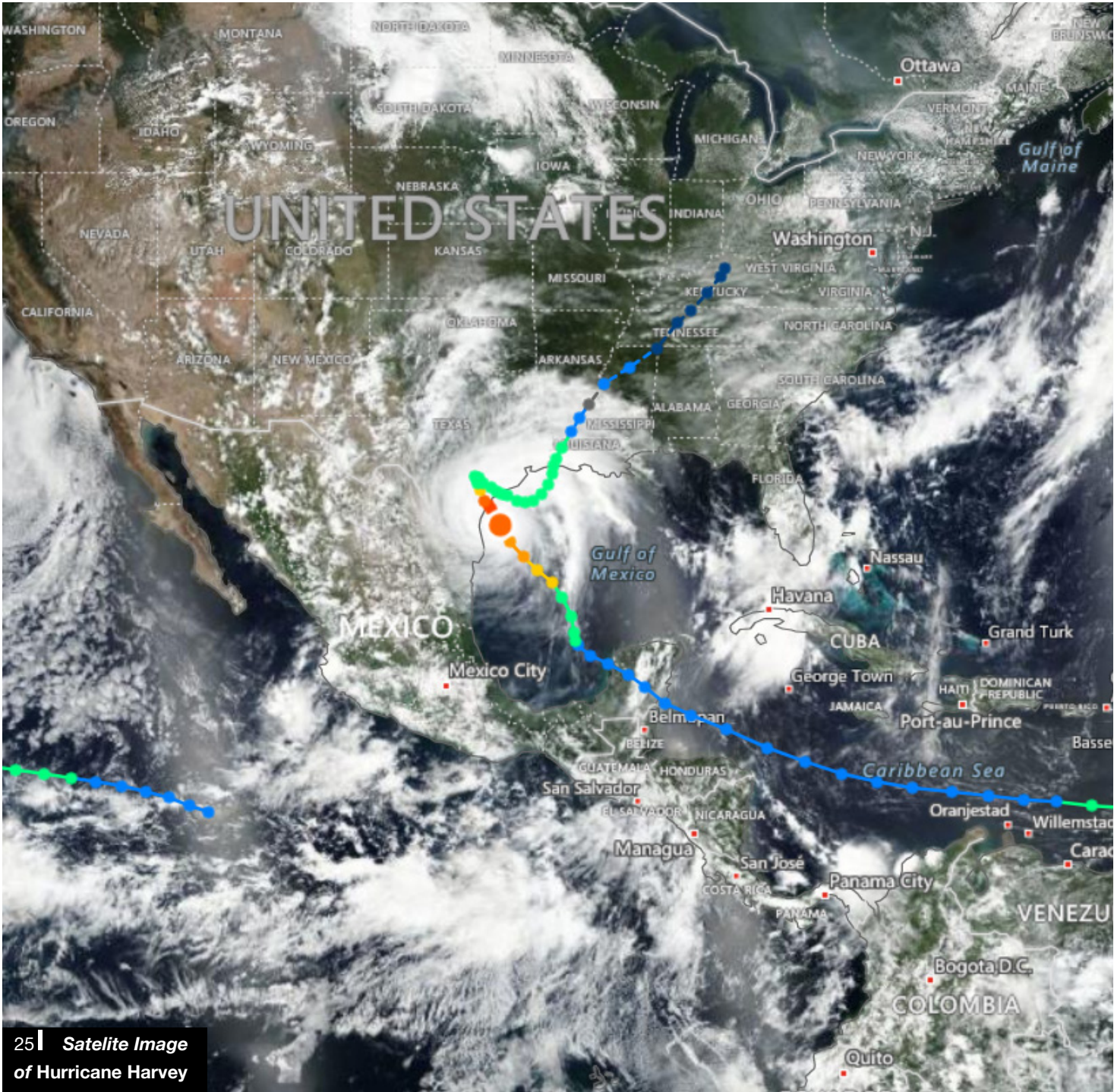
Graphic adapted by author, HCFDC, Harris County Texas, 2018)

2.2 FLOODING

HURRICANE HARVEY

An Unprecedented Storm Event: On August 17, 2017, Harvey became the eighth named storm of the 2017 Atlantic hurricane season.

- Initial Formation: August 14, 2017
- Tropical Storm: August 17, 2017
- Cat. 1 Hurricane: August 24, 2017
- Cat. 4 Hurricane: August 25, 2017
- First U.S. Landfall: August 25, 2017, Rockport, TX
- First rain bands reach Harris County: August 26, 2017
- Total Time Over Harris County: 4 days



25 | Satellite Image of Hurricane Harvey



26 | Interstate highway 45 is submerged from the effects of Hurricane Harvey seen during widespread flooding in Houston on August 27, 2017

In late August 2017 Hurrican Harvey, one of the eight storms of that years hurricane season rampaged over Houston. The Category 4 Storm spent a total of 4 days over the city and flooded big parts of the area. Due to over 47 inches of rain in average all of the 22 Bayous burst its banks and cause one of the biggest natural disasters of Houstons history.

On August 14th the storm started to form itself above the Gulf of Mexico. High sea temperatures cause the water to evaporate in big amounts. As the water rises, it cools down. We know this effect from common cloud formation and thunderstorms. Under certain circumstances this effect can lead to the emergence

of Hurricanes. Is the energy to big, surrounding air heats up even more causing further evaporation and the atmospheric preasure above sea to drop. Together with suitable wind conditions and the present rotation of the earth the formation of evapo-rated water in form of clouds and thunderstorms starts to build up and eventually turn into a Hurricane. (Sebastian et al. 2017)

Duration	Harvey August 2017	Allison June 2001	Tax Day April 2016	October 1994
1-hr	6.8	5.7	4.7	3.7
2-hr	11.9	9.9	7.3	4.7
3-hr	14.8	13.5	8.3	5.3
6-hr	18.9	21.2	13.9	7.2
12-hr	20.9	28.3	16.7	12.0
24-hr	25.6	28.4	17.4	20.9
2 days	35.2	28.5	17.5	23.1
4 days	47.7	38.5	N/A	28.9

27 | Harvey Rainfall compared to offer record events

2.2 FLOODING

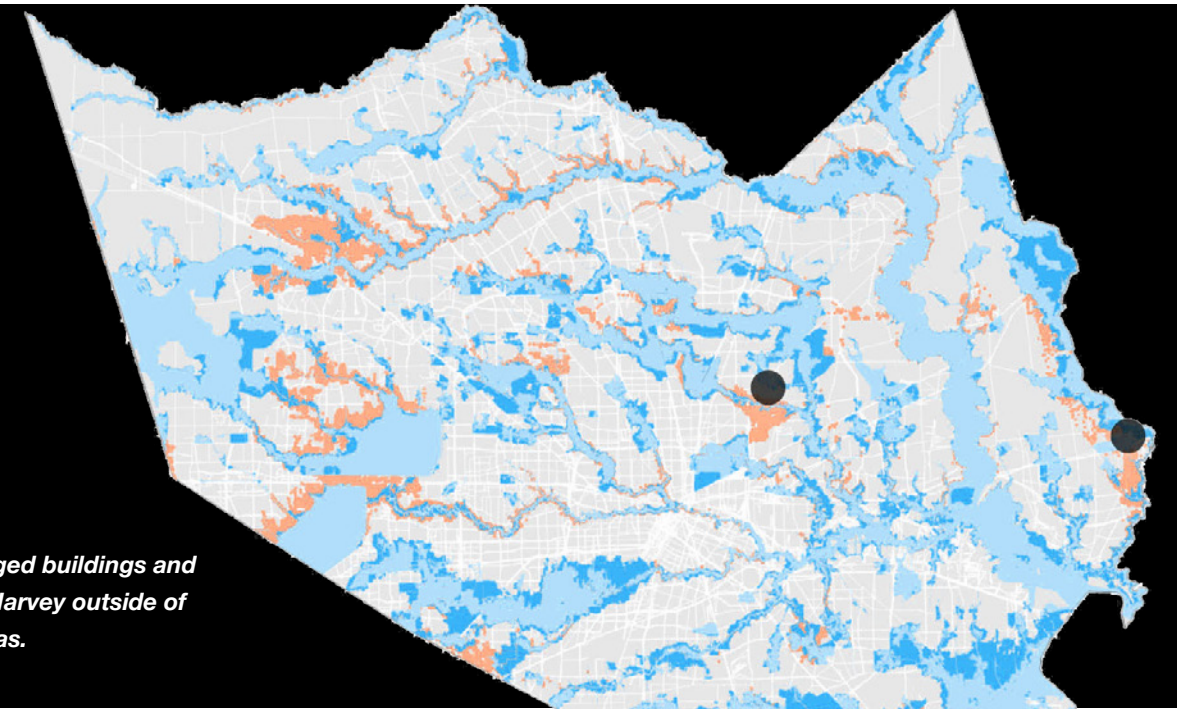
A SLEFMADE PROBLME ?

“Other flood-prone areas around the world like the Netherlands are planning for 10,000-year storms. In Houston, officials are still allowing new construction in the path of a 100-year storm.

I’m often the butt of jokes in meetings all over the country.”

SAM BRODY / Professor of Marine Sciences,
Texas A&M University at Galveston
Director, Center for Texas Beaches and Shores

32 | **Map of damaged buildings and propertie during Harvey outside of the floodplain areas.**



29

Harris County Floodplain Remapping

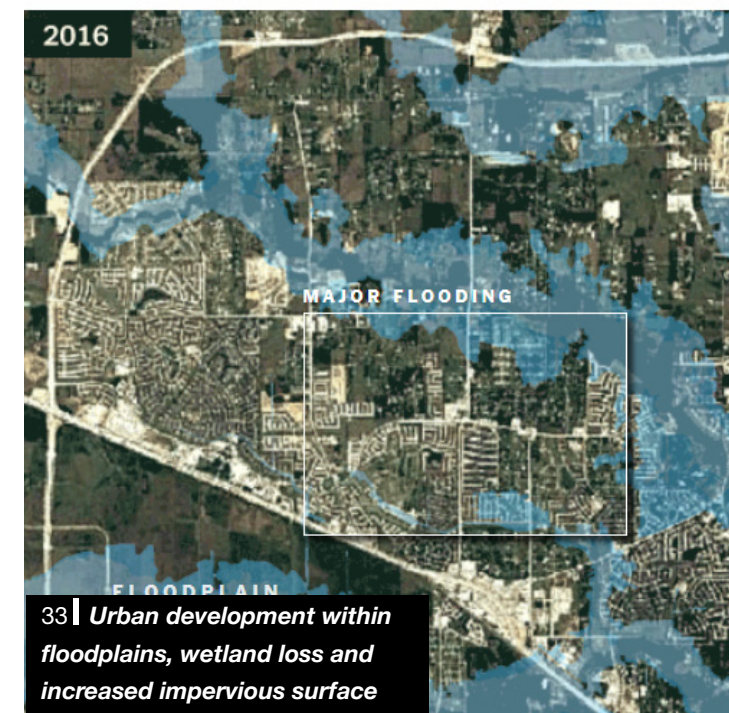
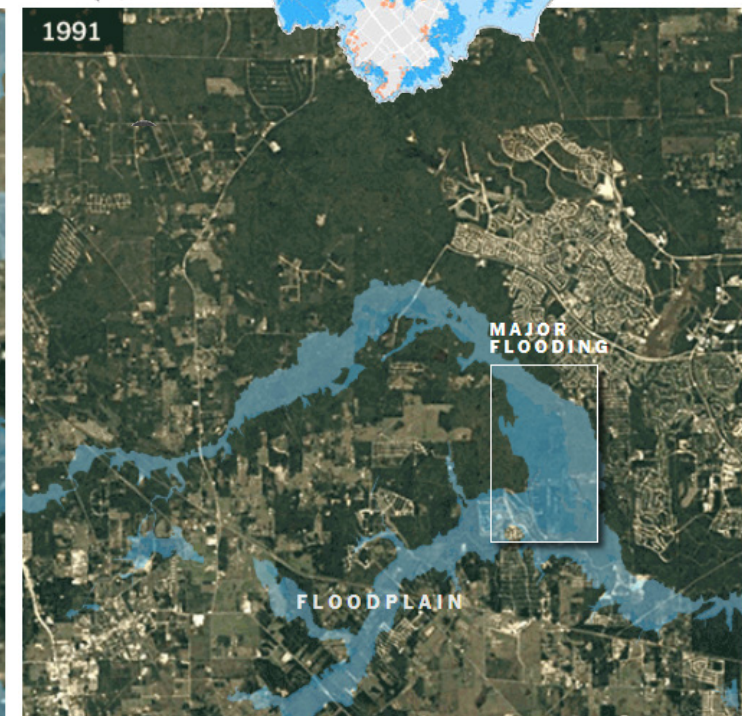
A lot of the previous mentioned damage could have been avoided. Many homes outside of the marked floodplanes also flooded during Hurricane Harvey’s rampage. The previous mentioned physical characteristics have not been the only reason for that.

Another potential reason for this devastating flood event is also Houstons development. Due to the lack of a regulating zoning law, missing restrictions and guidelines, many areas within floodplains and watersheds have been developed towards residential and commercial use. This so calles land use change has drastic consequences for the intensity of flooding especially when they occure in upper stream areas (**Sebastian et al. 2017**).

The fact that the the FEMA flood insurance maps have been developed only in one point of time and have not taken the changing use of land into account, the predicted flood areas have been drastically inaccurate.

An increasing amount of impervious surface, eg. buildings, parking lots, streets, as well as deforestation and the displacement of natural vegetation and wetlands cause an increase in speed and amount of runoff into the often already overloaded and sometimes badly maintained storm-water drainage systems.

The sequence of maps on the right shows this so called land use change. Areas in major floodplains have been heavily densified over the last decades. This has not only the flooding of many of those houses and areas as a result but also creates flooding in areas where those events never happened before.



2.3 PROJECT AREA



34 | Area of special interest:
4th Ward, Buffalo Bayou
and Interstate 45

2.3 PROJECT AREA

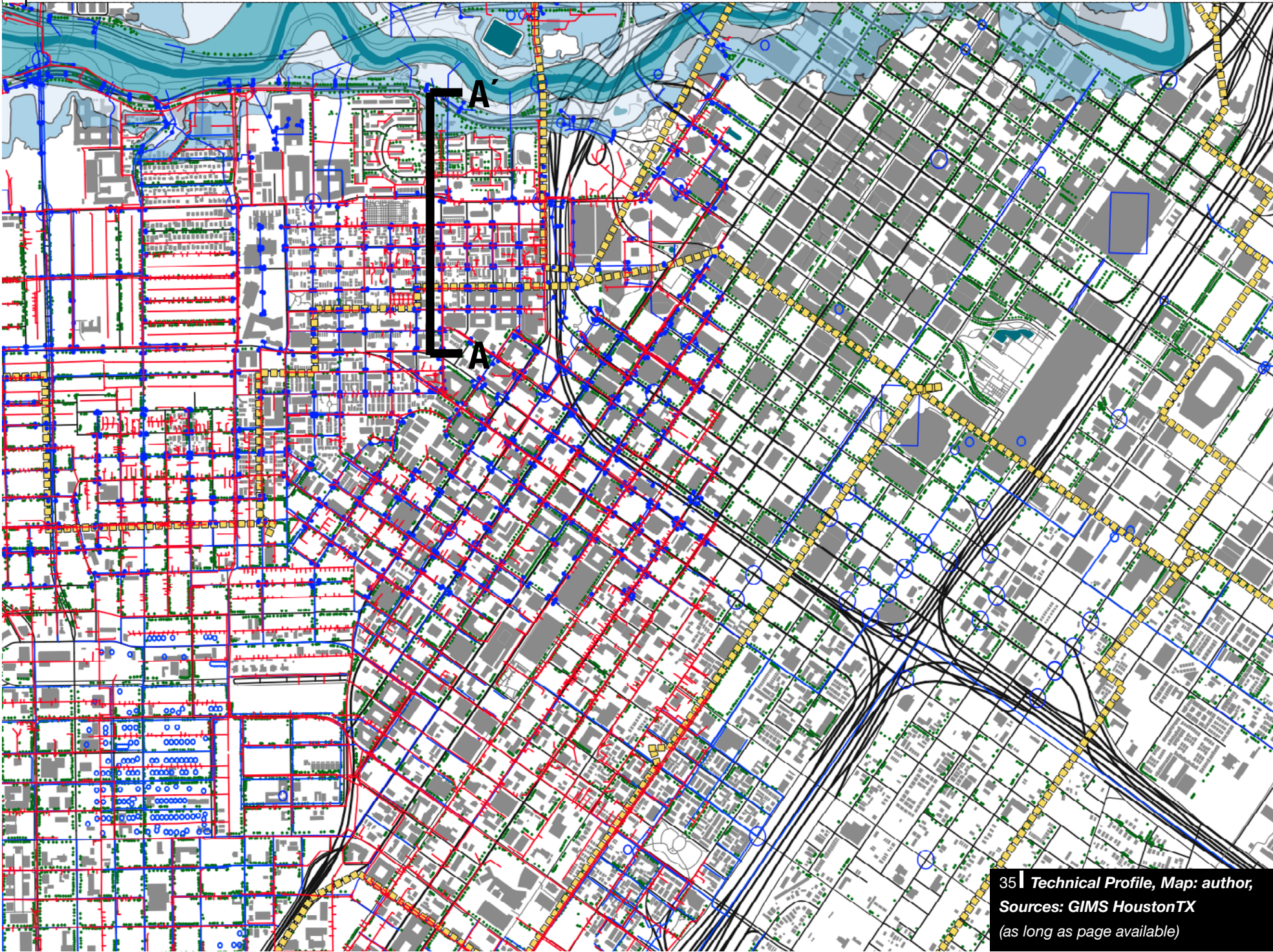
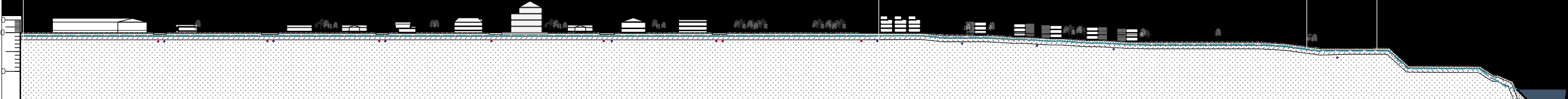
Section A - A' 1km

Historic 4th Ward
- Bernard Urban Land Complex

Allen Park Village
- Gated Community

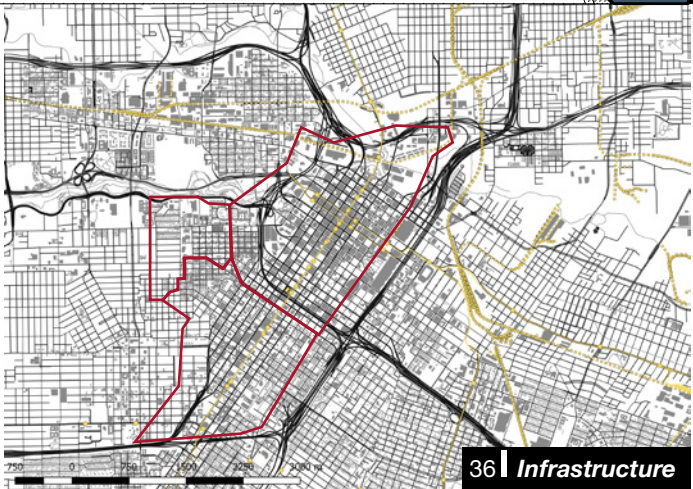
Allen
Parkway

Buffalo Bayou Promenade
- Vamont Urban Land

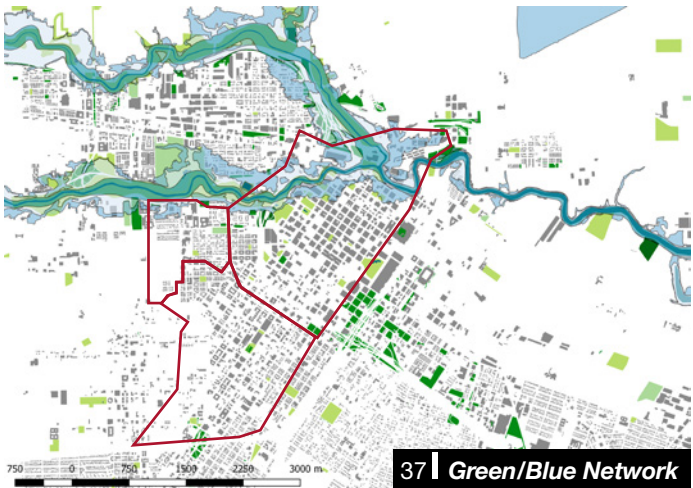


LEGEND

- Buildings
- Car Infrastructure
- Pedestrian/Bike Infrastructure
- Open Water
- 100 yr Floodplain with elevation
- 500 yr Floodplain with Stormwater Sewer
- Drainage Gravity Main
- Wastewater Sewer
- Main Electricity
- Trees, Vegetation



36 | Infrastructure



37 | Green/Blue Network

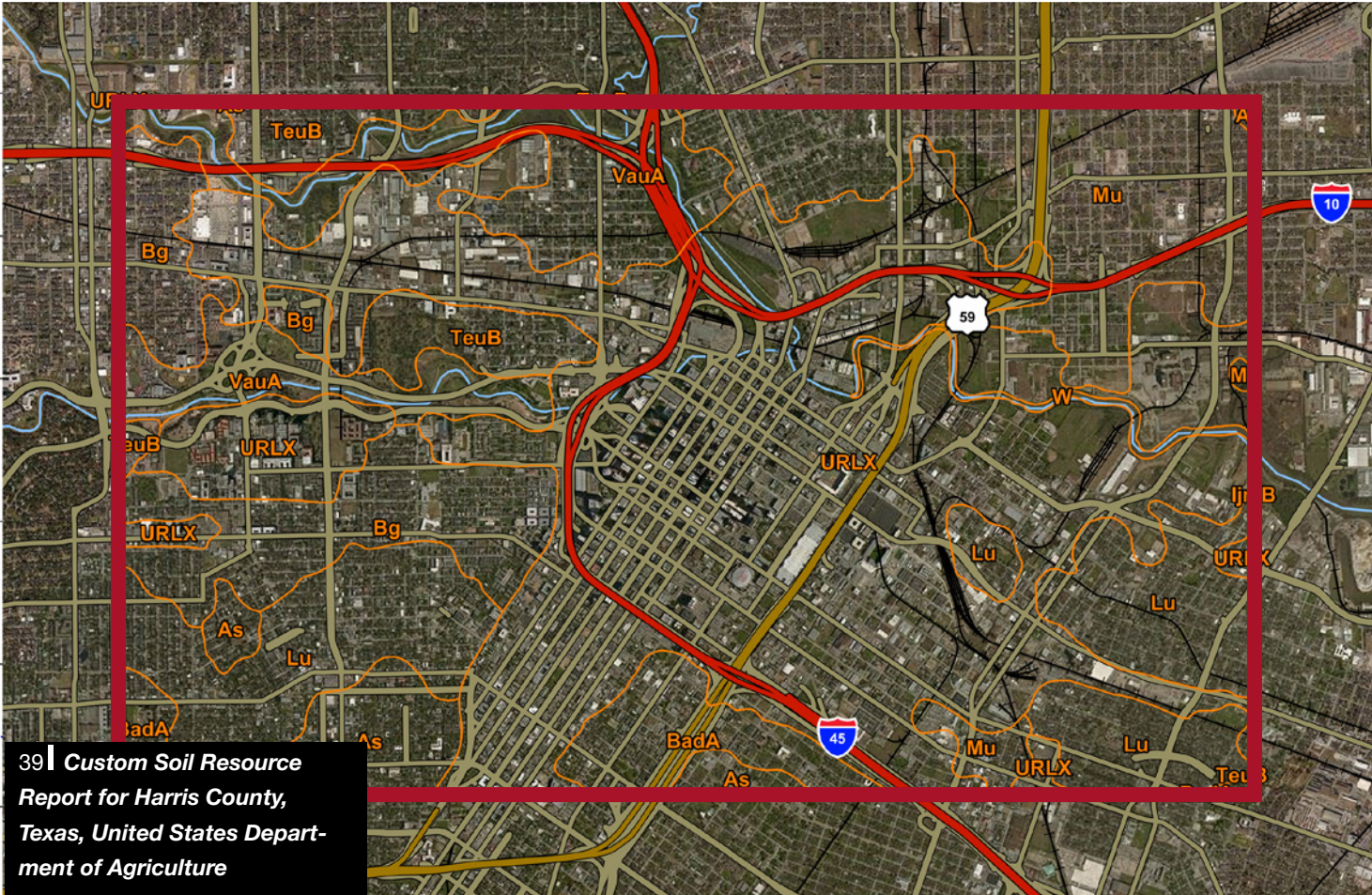


38 | 2 Feet Elevation

35 | Technical Profile, Map: author,
Sources: GIMS HoustonTX
(as long as page available)

2.3 PROJECT AREA

SOIL



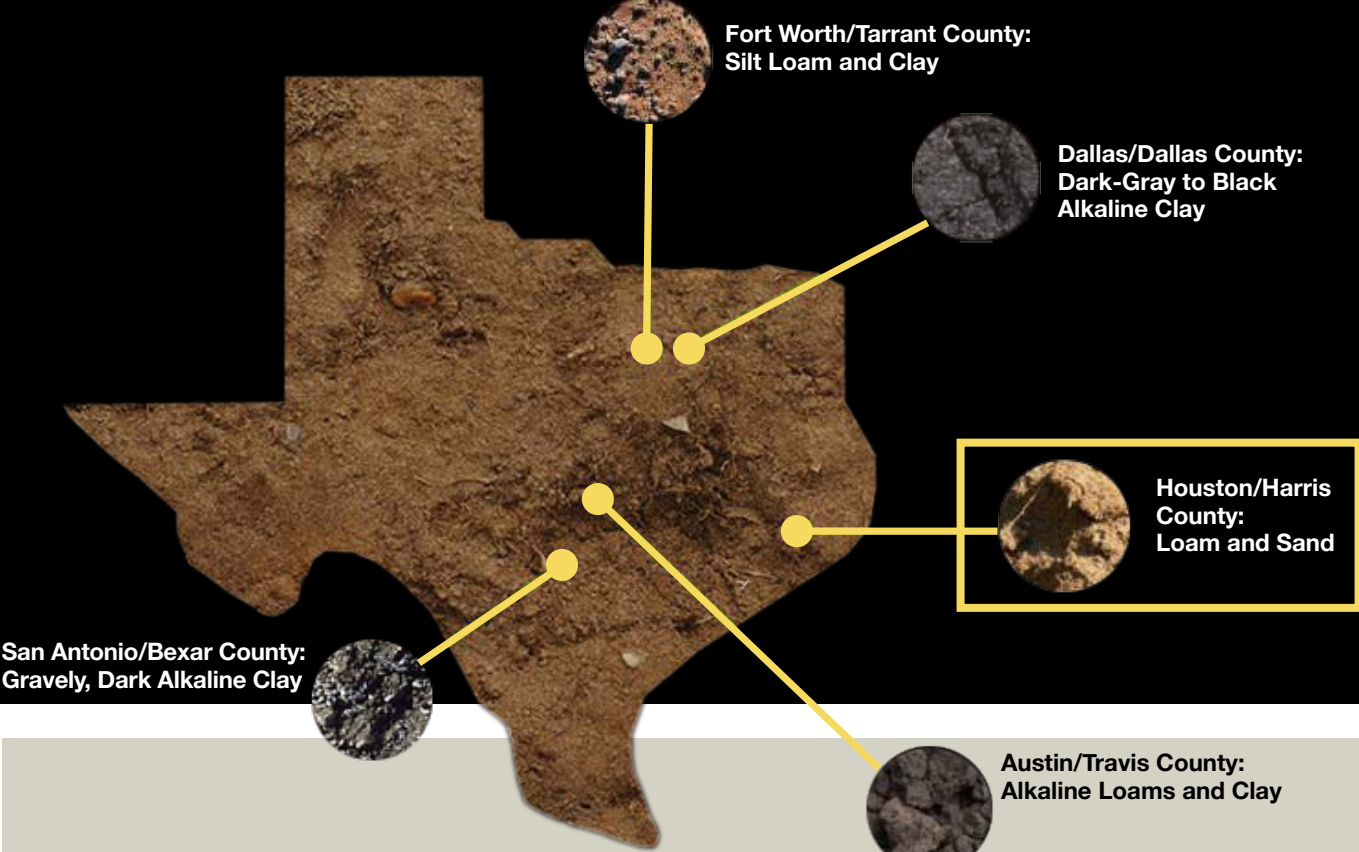
39 | Custom Soil Resource Report for Harris County, Texas, United States Department of Agriculture

Soil Project Area

As already mentioned at the beginning of the general analysis of Hosuton and its greater surrounding, most of its soils are clay based and therefore only badly drain the water into the soil. The project areas consist basically out of three different soil types (Bernard- Urban land complex located in ther area of the 4th Ward, Vamont-Urban land complex located along Buffalo Bayou and the Urban

land complex in Downtown and Midtown), which are characterized on the next page. Together with a relatively high and fluctuating water table, those data are crucial when it comes to the planning of stormwater de- and retention measurements within the site. But also the choice of vegetation is highly influenced by the clayay soil. Unsuitable trees suffer from 1) the

high water table. The roots of most trees only reach as deep as the unsaturated zone in the soil. A high water table forces trees to build a very weak, and shallow root system. Problem 2) is the fact, that also with so called root-boxes, most of the trees´ roots will start to rott, because of waterlogging.



Description of Bernard, Bg

Landform: Meander scrolls
Landform position: Linear
Across slope shape: Linear
Parent material: Clayey fluviomarine deposits derived from igneous, metamorphic and sedimentary rock
Typical profile: H1- 0 to 6 inches clay loam
H2 - 6 to 34 inches clay
H3 - 34 to 65 inches clay
Properties and qualities:
Slope: 0-1 percent
Depth to restrictive feature: more than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: high
Depth to watertable: 18 to 30 inches
Available water storage in profile: High (9.9 inches)

Description Vamont-Urban VauA

Landform: Flats
Landform position: Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey fluviomarine deposits derived from igneous, metamorphic
Typical profile: A-0 to 4 inches: silty clay
Bss-4 to 20 inches: clay
Bssg1-20 to 60 inches: clay
Bssg2-60 to 80 inches: clay
Properties and qualities:
Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: High
Depth to water table: About 14 to 37 inches
Available water storage in profile: Moderate (about 7.0 inches)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
As	Aris-Urban land complex, 0 to 1 percent slopes	349.9	3,6%
BadA	Bacliff-Urban land complex, 0 to 1 percent slopes	339.4	3,5%
Bg	Bernard-Urban land complex,	785.5	8,1%
ljmB	ljam clay, 0 to 2 percent slopes, frequently flooded, tidal	3.2	0,0%
Lu	Lake Charles-Urban land complex	1,244.8	12,8%
Mu	Verland-Urban land complex	1,123.1	11,5%
TeuB	Texla-Urban land complex, 0 to 2 percent slopes	357.0	3,7%
URLX	Urban land	4,594.8	47,1%
VauA	Vamont-Urban land complex, 0 to 1 percent slope	911.8	9,3%
W	Water	45.4	9,5%
Totals for Area of Interest		9,755.8	100,0%

2.3 PROJECT AREA

TPOLOGY AND FUNCTIONS

The first area which is going to be investigated further is the intersection of the 4th Ward in the west and Downtown in the east. Both areas are separated by the large scale infrastructural barrier of the Interstate 45. The two maps show a more detailed and zoomed in technical profile as well as a short overview of the different typologies and functions located on this site.



41 | Impressions 4th Ward

4TH WARD/DOWNTOWN

Morphology:

This sequence of pictures (on the left) captures the clash of new and historic development within the fourth ward. The top picture shows parts of the old, in some cases abandoned shotgun houses. The historic development and characteristic of the fourth ward will be explained later in this chapter. The picture in the middle represents the uprising gentrification going on in this area. Dense, similar stamps

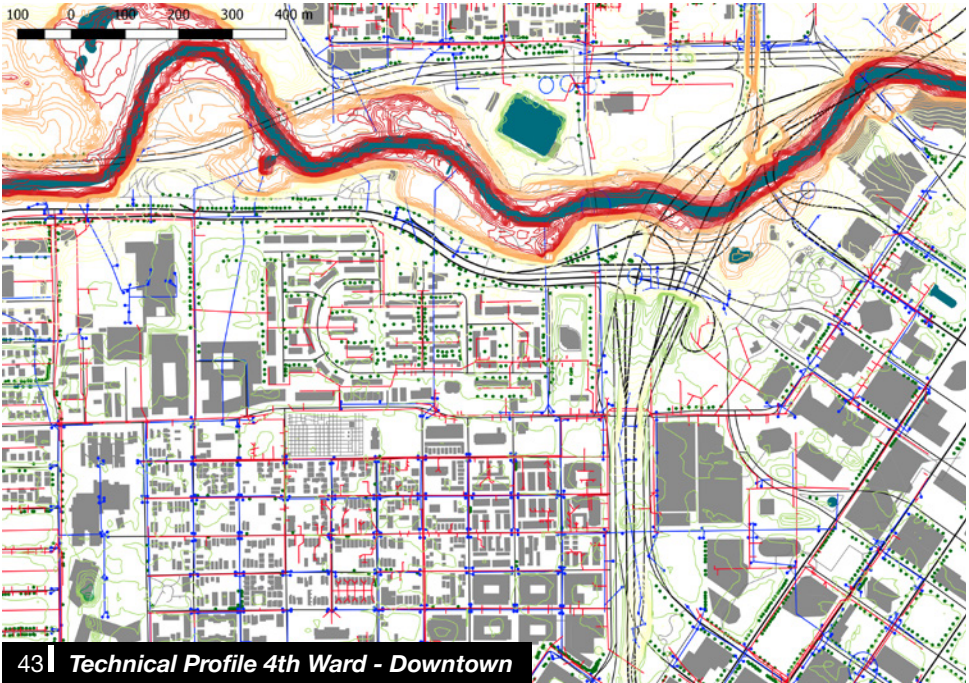
of mid-rise development spreading from the west side of Downtown, starts to replace big parts of the historic character. The last picture shows the amount of vacant plots, where sooner or later new residential projects will arise. Another typology within this area, which creates this juxtaposition of different styles and characters is the Allen Parkway Village in der north. The gated community with mostly post-war buildings outlines the end and therefore a boundary towards the Buffalo Bayou which lies accross the Allen Parkway Street.



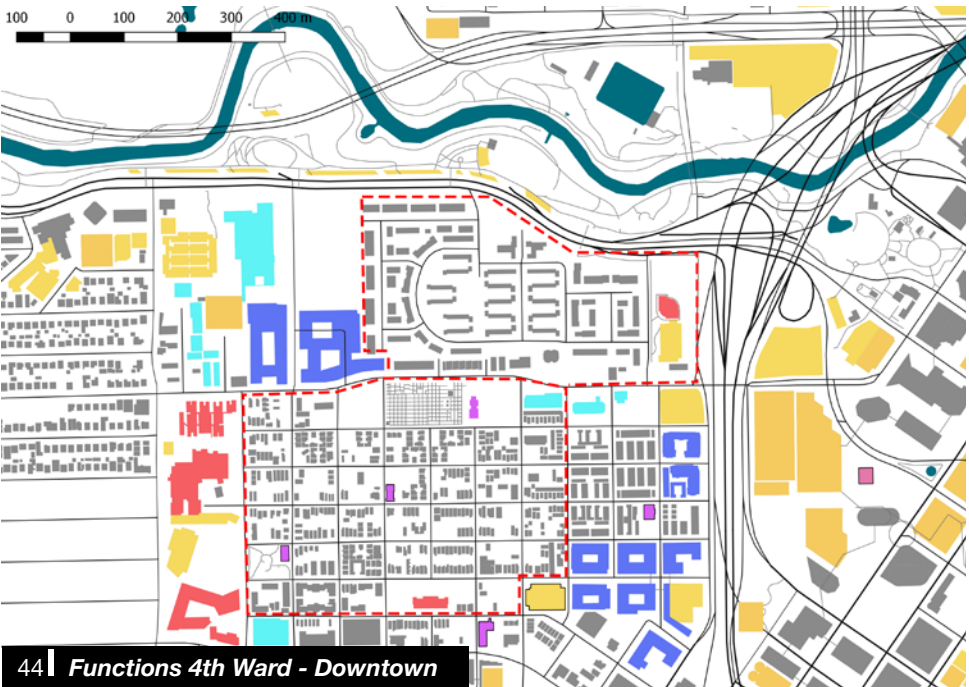
42 | CBD Downtown



40 | New development at Midtown-Park Houston



43 | Technical Profile 4th Ward - Downtown



44 | Functions 4th Ward - Downtown

Functions:

The area is mostly characterized by residential development. In the west, the site is framed by a school district and other different business and retail developments. Together with the Interstate 45, the area gets separated by large scale car-parking from the Downtown in the east.

Legend:

- Residential
- New, Mid-dense Residential
- Business / Retail
- School / Library / Culture
- Religion
- Car Parking

2.3 PROJECT AREA

TYPOLOGY AND FUNCTIONS



45 | Impressions along I-45

DOWNTOWN, MIDTOWN, I45

The second area that is investigated further is the intersection of Downtown and Midtown. Similar to the first location also those parts of Houston are divided by the Interstate 45 infrastructure, but with more permeable connections and streets.

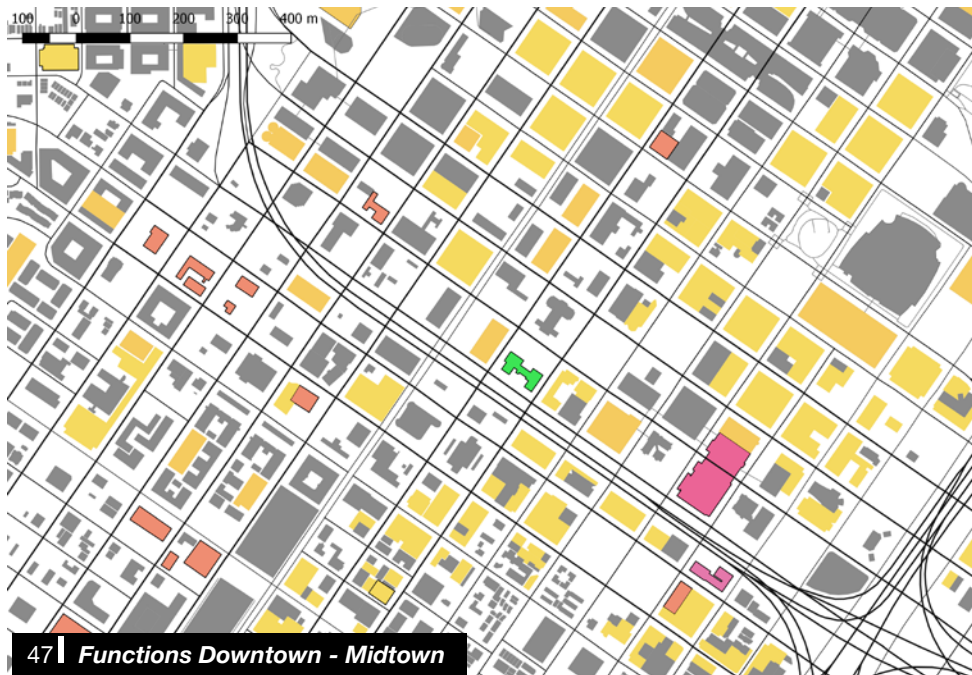
Morphology:

As seen on the map, the grid structure is more homogenous and does

not chance as much as in the area of the 4th Ward. The typology of the buildings changes as soon as both areas get segregated by the freeway. In the north east we can see the typical Downtown typology with large vertical office and business towers, whereas in Midtown the same typology of medium dense residential and retail buildform as the one pushing towards the 4th Ward starts to spread and develop.



46 | Technical Profile Downtown - Midtown



47 | Functions Downtown - Midtown

Functions:

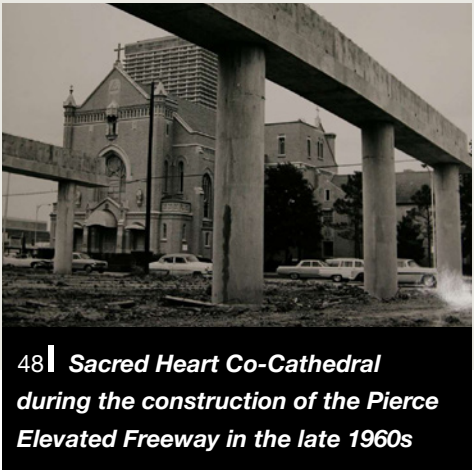
Both areas are connected by one of the few public transport lines existing in Houston. The rest of the functions surrounding and underneath the Interstate 45 is mainly car-parking. (marked as yellow in the map to the left)

2.3 PROJECT AREA

INTERSTATE 45

The Interstate 45 which includes a connection between Houston and Galveston was the first Interstate Highway contract to be let in Texas and was authorized by the Texas State Highway Commission in 1956. The construction of the North Freeway segment in Houston started in 1959 and was completed in February 1963.

(Interstate Guid, n.d.)



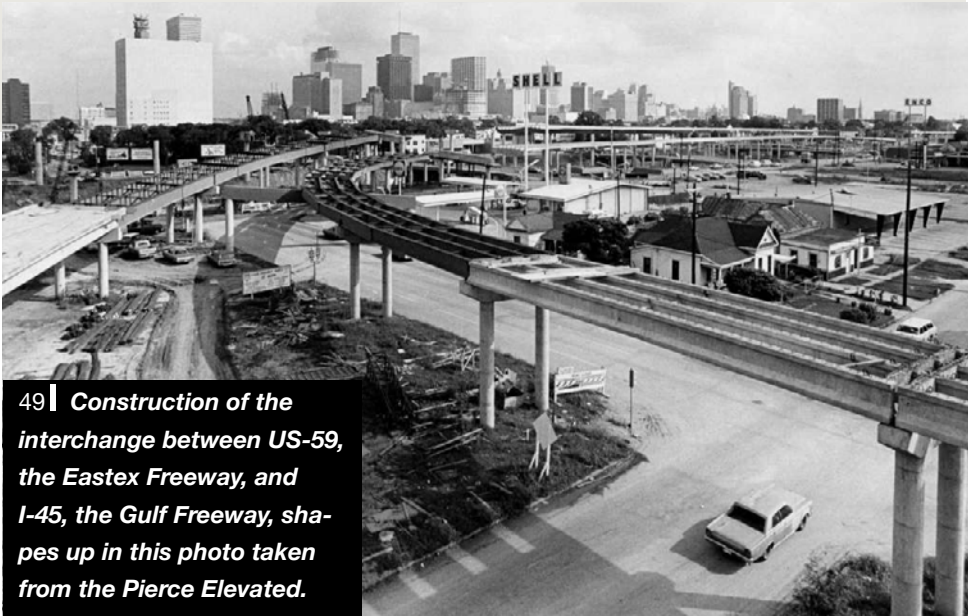
48 | Sacred Heart Co-Cathedral during the construction of the Pierce Elevated Freeway in the late 1960s

A very important part of the construction within Houston City was the Pierce Elevation, which is now separating Downtown from Midtown. The intentional thought of the planners was to frame the CBD of the boomtown by offering views of the skyline when entering and exiting the city by car.

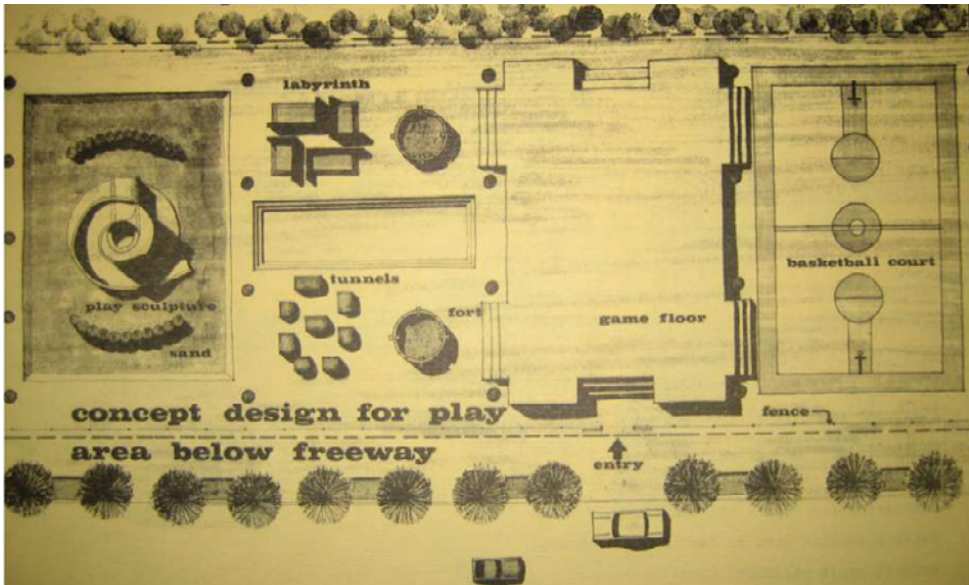
Already during the time of planning and constructing, many experts but also residents saw a big, negative impact within the cities former, homogenous gridsystem aswell its face. In 1966, Patrick Horsburgh called the space beneath the elevated „psychologically intolerable“ and doubted that any real form of urban life could occur beneath it.

(Shelton, 2015)

Today many if not all of the negative predictions became reality. The area next and beneath the Interstate has become a wastescape of sealed unmaintained and segregating parking lots and infrastructures for cars. The permeable (in the meaning of crossable) but unattractive linear and vertical wall of concrete creates not only a visual boarder but also shows the age of failing infrastructure in Houston.



49 | Construction of the interchange between US-59, the Eastex Freeway, and I-45, the Gulf Freeway, shapes up in this photo taken from the Pierce Elevated.

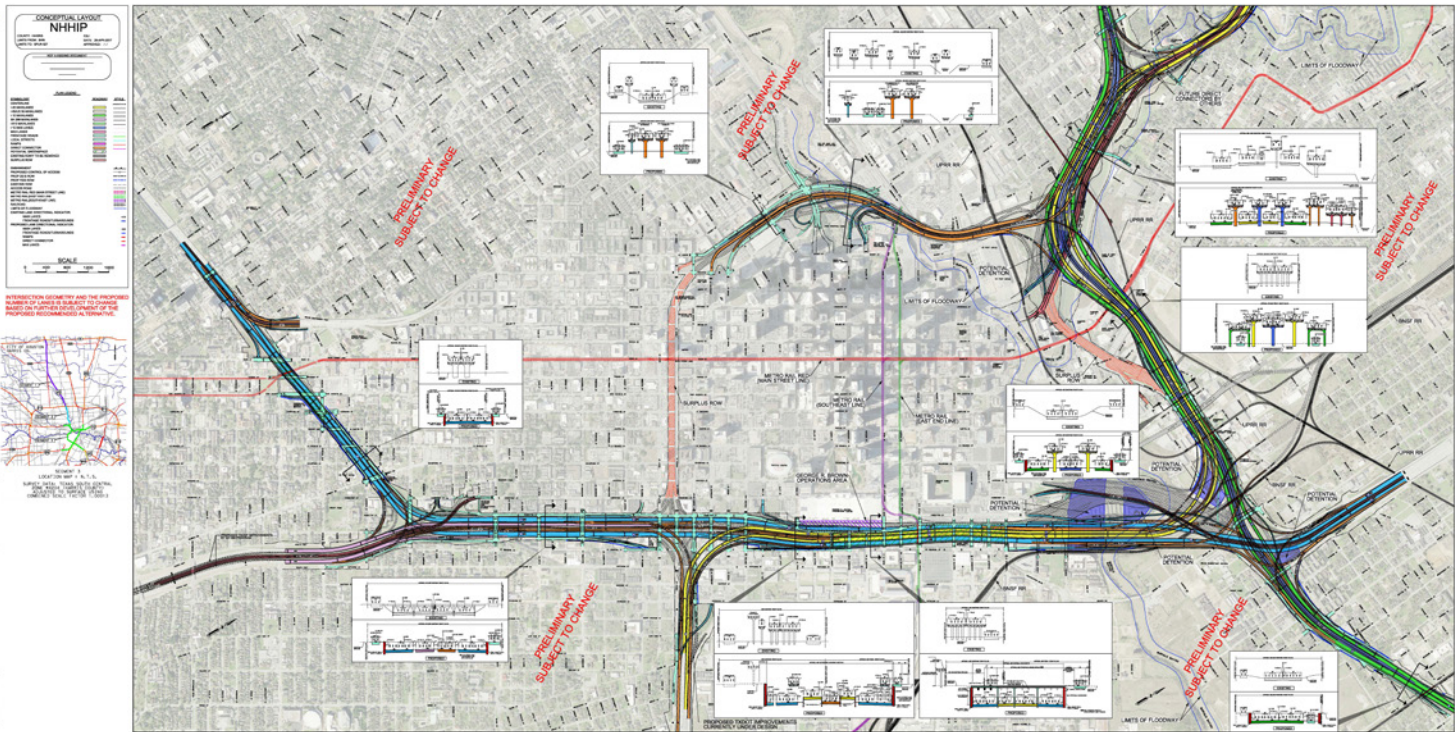


50 | Response of the City and Houston Art Commission: Study of possible activities (Recreation, Greenspace) beneath the Interstate 45 elevation

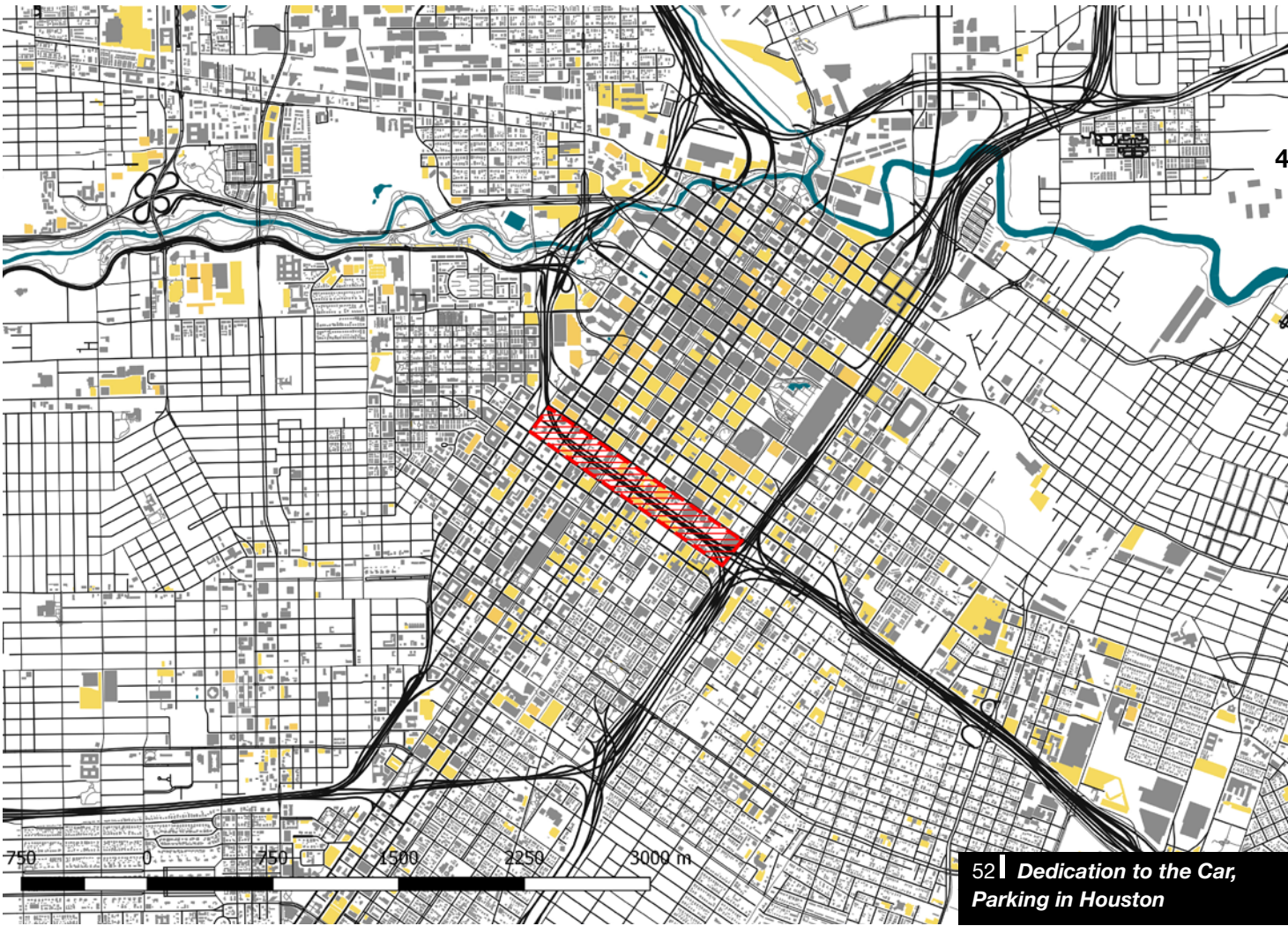
2.3 PROJECT AREA

INTERSTATE 45

Together with the Federal Highway Administration (FHWA), the Texas Department of Transport (TxDOT) elaborate on improvements of the Interstate 45 in the norther part of Houston area. The plans below show the proposed changes of the freeway layout around the Houston Downtown area as well as impressions of the changing face of the area. Important are especially the new Downtown connection, the elevation of the section close to Buffalo Bayou, between 4th Ward and Downtown and the deconstruction of the Pierce Elevation between Downtown and Midtown.



51 | Official Plans and Illustrations of the improvements of the Interstate 45 along Houston Downtown



Current Situation:

As already briefly described in the analysis of the typology and functions of the project area, most of the infrastructure but also the built environment in and around Downtown, Midtown and the 4th Ward is dedicated to cars. The upper map shows the huge loss of space due to car parking which forms over 1/3 of the actual build environment of Downtown.

Different then the proposed illustrations by the Houston Art Commission, almost the entire space underneath the Pierce elevation is space for parked cars. In addition most of the lots are in private hand and therefore secured with either walls or fences creating an even bigger boundary then it already is.

New Plans:

In several articles and news pages, the redevelopment of the I45 is described as one of the most ambitious and innovative plans of the TxDOT since the actual construction of the infrastructure in the 1960s. Especially the removal of the Pierce Elevation (marked as red in the upper map) at the south side of Downtown is seen as a huge opportunity to reconnect former separated parts by green and open spaces and as well as reconquer large amounts of valuable construction land for all kind of developments and amaniities contamporary occupied by cars. The process of the redevelopment already goes on for several years. The reason for this is the involvement of many stakeholders and residents and the resulting and time intensive negotiation process.



53 | Parking along I-45

2.3 PROJECT AREA

FOURTH WARD HISTORY

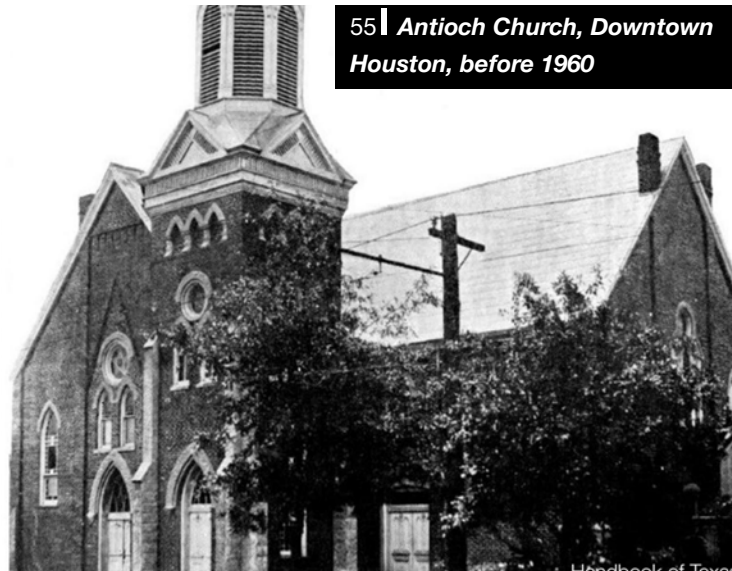
For many Houstoniens the 4th Ward stands for a well thriving, vital and and cultural African American Culture in the heart of the city. Today not much is left from the layout and history of the former settlement of freed slave that formed to a cultural center for the African American community in Houston.

(STROM, 2010)



54 | *Frontporch in Alabama 1937*

55 | *Antioch Church, Downtown Houston, before 1960*



56 | *Antioch Church, Downtown Houston, today*

The series of pictures displays the former character of this historic area of Houston. In 1839 the city started to subdivide its area into so called wards. The ward system, compareable to todays City Council Districts, was a legal political tool during those times. The Fourth Ward started as a agglomeration of freed african amerian slaves at around the same time the system got incooperated. For many decades the district developed

towards one of the most prominent centers of african american culture, art, education and religion. 1910 almost 17000 people lived within the wards borders. Compared to its original outlines of the early 1900s todays Fourth Ward lost most of its area to other districts. In 1930s many white institutions as well as parts of the CBD encroached on the Fourth Ward. Black residents were partly replaced. One example is the still existing Allen Parkway Village in

the north of the district. A large scale residential development for white veterans disrupted the original pattern of the so called shotgun houses of the african american community. Also the construction of the Interstate 45, which diverges right through former connected parts of the Ward, seperated the residents from important institutions. Big parts are now incooperated within Downtown Houston.

(Strom 2010, Texas State Historical Association, The Archive)

58 | *Rainbow Theatre, 4th Ward, 1934*



57 | *Location of the former Rainbow Theatre today*



Houston Lost and Unbuilt

The first Before/After comparison shows the Antioch Baptist Church. During the legal existence of the Fourth Ward the church was an important religious institution before it got seperated from the coherrent area by the construction of the I45.

Nowadays the church is lost and displaced between large Downtown typologies and concrete streets. The second series shows the Rainbow Theatre along todays West Dallas Street. Today it got replaced by a money and profit driven hotel complex.

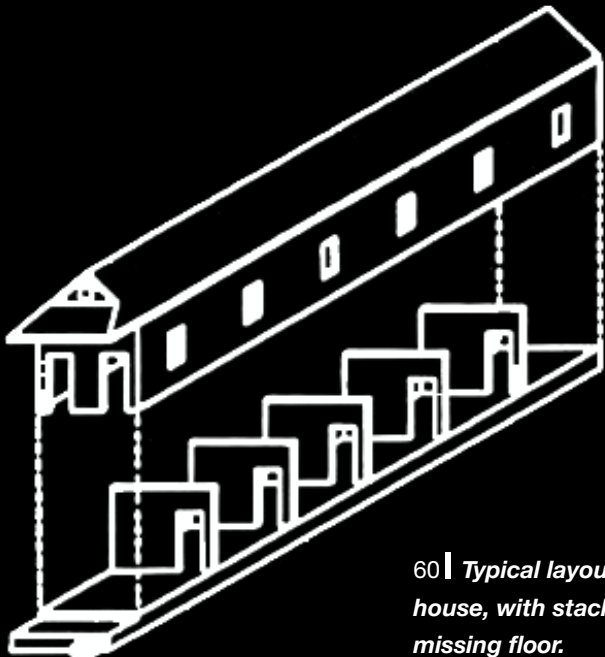


59 | *historic shotgun architecture, demolished*

2.3 PROJECT AREA

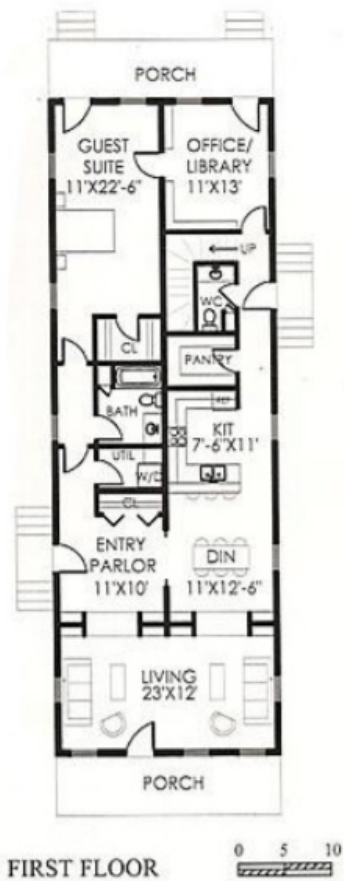
SHOTGUN HOUSES

It is an urban legend that the name „shotgun house“ derived from the fact that architectural characteristic of this typology would allow a shotgun bullet to travel all the way through the house and exits at the back when fired into the entrance of the building.



60 | Typical layout of a shotgun house, with stacked rooms and missing floor.

61 | Example of a standard, traditional four-bay single barrel, camelback shotgun house in plan and elevation

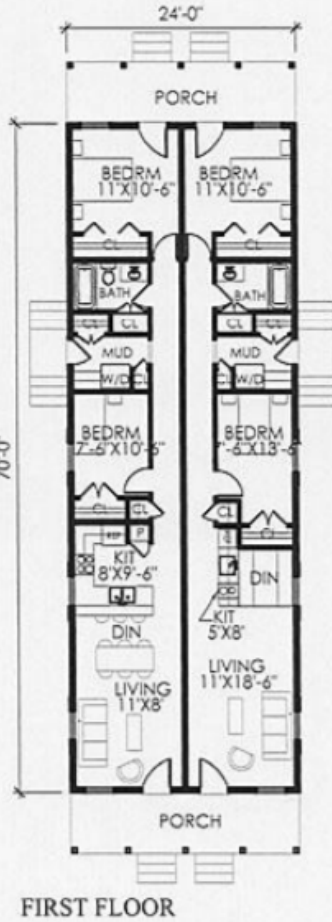
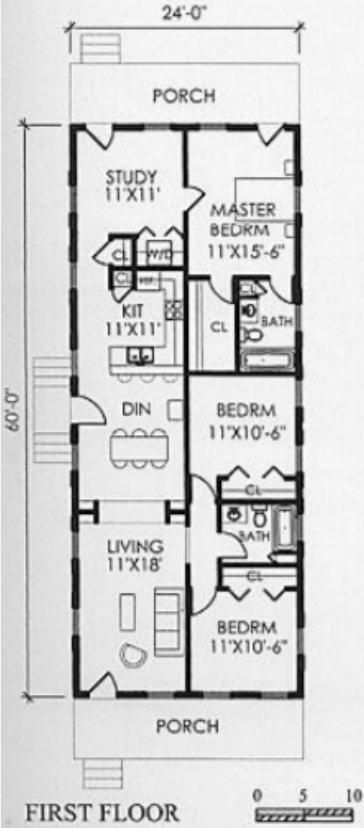
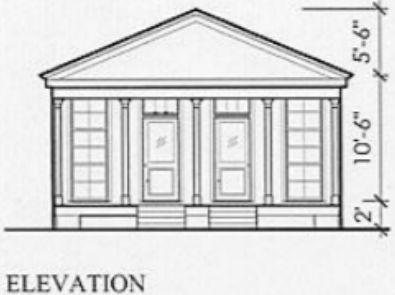


The shotgun typology was a wide spread type of architecture especially in the south of the United States. There are different theories of its origin.

One theory concludes that the „shotgun“ originated in New Orleans between the 1830s-40s. Due to the further and further subdivision of plots, the existing buildings were adapted. To be more space efficient the narrow end of the structures which used to have their longer site towards the street turned and the small site became the front entrance that faced the street (McRae, 2012 p.14).

John Michael Vlach on the other-hand states that the shotgun typology derived from Haitii. Similiar architecture can be found in those regions. "Togun", the Yoruba word meaning "house" or "gathering place" is related with the fact that the front porch became a popular asset to those housings (Vlach 1979). Traditionally the typology is defined as being a one room wide and several (three to four) rooms long, which are stacked behind each other without an existing floor. Especially in times of rapidly growing population and a changing mindset towards sustainable and reuseable constructions, this very inexpensive, easy and adaptive form of building celebrates its renaissance.

62 | Examples of a standard, traditional four bay single barrel (right) and double barrel shotgun house (left) in plan and elevation



CONCLUSION

The complexity of the bayou and its watershed, the large scale and long-time period, but especially the incalculable additivity and synergy between all the impacts make it close to impossible to identify a direct source-effect relationship. It is the overall cumulative picture of the impacts urbanization had and still has on the ecosystem and its services that emerge, which can be identified by looking at the past as well as present urban development.

- 1) Rising population in the form of sprawl and densification (driven by unregulated zoning and a lack of policies) are accompanied with an increasing amount of impermeable surfaces like streets, pavements and also buildings.
- 2) The increase of population leads to more people being affected by floods (**Eigenbrod et al. 2011**).

Urban Ecology and Flooding Issue

The transformation of former wetlands and the rising amount of inter-connected impervious surface within the watershed area lead to higher runoff speeds, detaining water from rainfall-events not only faster but also more frequent and often into the bayou. The already decreased capacity and modified physical structure of the bayou increase the problematic. Channelization, straightening and damming of former meandering parts of the bayou not only lead to a decrease of the natural flood-plain area and natural water capacity but also increased the speed of water flow within the aquatic system. Quick and rapid water-level changes and higher amounts of run-off, finally lead to a collapse of the natural limit of the system draining the stormwater. This increased quantity of water previously was drained into wetlands. However, floodplains are close to non-existent anymore in Houston, resulting in



63 | Pedestrian Sign, implying the priority of cars within the daily urban live in Houston

more frequent bank-overflows. The alteration of the hydrological system of the bayou and its watersheds, the reduced capacity of the system to hold and store surface run-off on an effective and natural way results in more and more substantial flooding events causing increased damage in areas at risk as well as in locations which were never impacted by flooding issues before.

Mobility and Built Environment

Car-driven development is present everywhere in Houston. The dependency on automobiles is not only main driver for the city's sprawling character, but also decreases urban ecology to a minimum. Large infrastructure like streets, highways and parking facilities increase run-off, create unwalkable condition, which separate and disconnect neighbourhoods and occupy space, which could be used for integrative and sustainable development within the heart of the city.

Nonetheless analysis also shows that there is a lot of potential in Houston to find synergy between the ecosystem and the built environment.

- The redevelopment plans for the Interstate 45 bring huge possibilities for a more sustainable and multi-functional development
- Traditional architecture like the shotgun houses in the fourth ward depict a constant, adaptable urban pattern, within the otherwise incoherent and rapid urban development in Houston

It is not specifically a matter how much is built within the city, but it is important where within an essential ecological system development unfolds and how the built environment can be a part of the system rather than representing it.

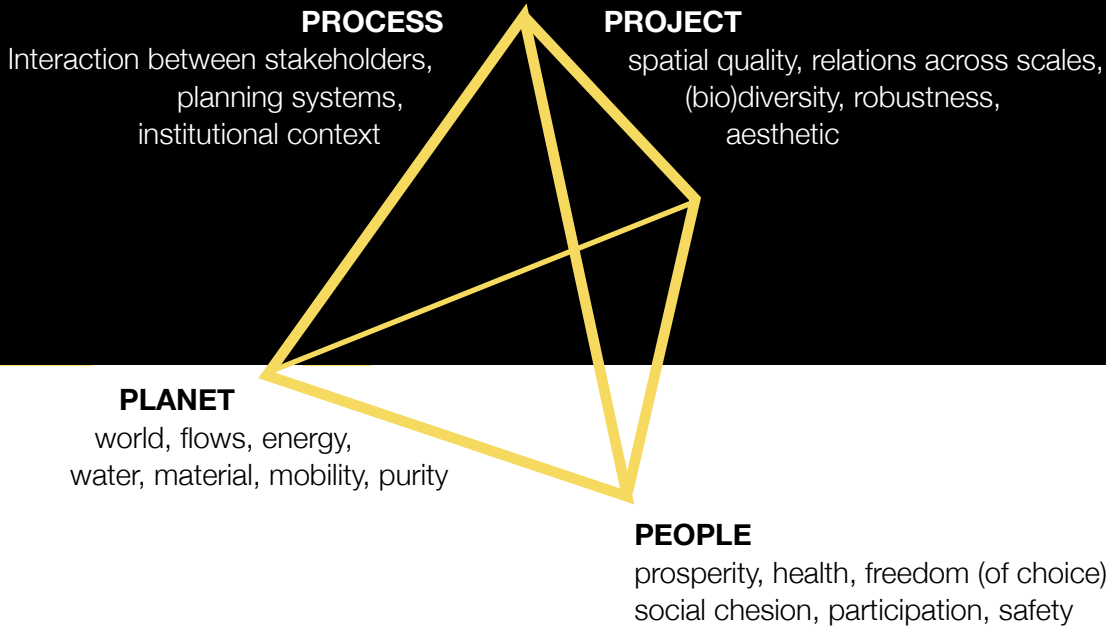
03 WORKSHOP



64 | Closed sequence of the Intertate 45 close to Houston Downtown

3.1 SCOPING

The tetragon of sustainable construction
(van Dorst and Duijvestein, 2014)



Between the end of May and the beginning of June, the team of Urbanists and Transport, Infrastructure and Logistic Planners visited Houston for a fieldtrip.

After arriving, the first weekend has been used to acclimatize and get to know each other and the different professions closer.

After the group was complete the first day of the workshop was used to explore the project area. A side visit, especially within a interdisziplinary group is always a very positive experience.

It is important to get a feeling for the scale, the conditions and the general vibe, which can hardly be grasp by only looking at maps and street-views.

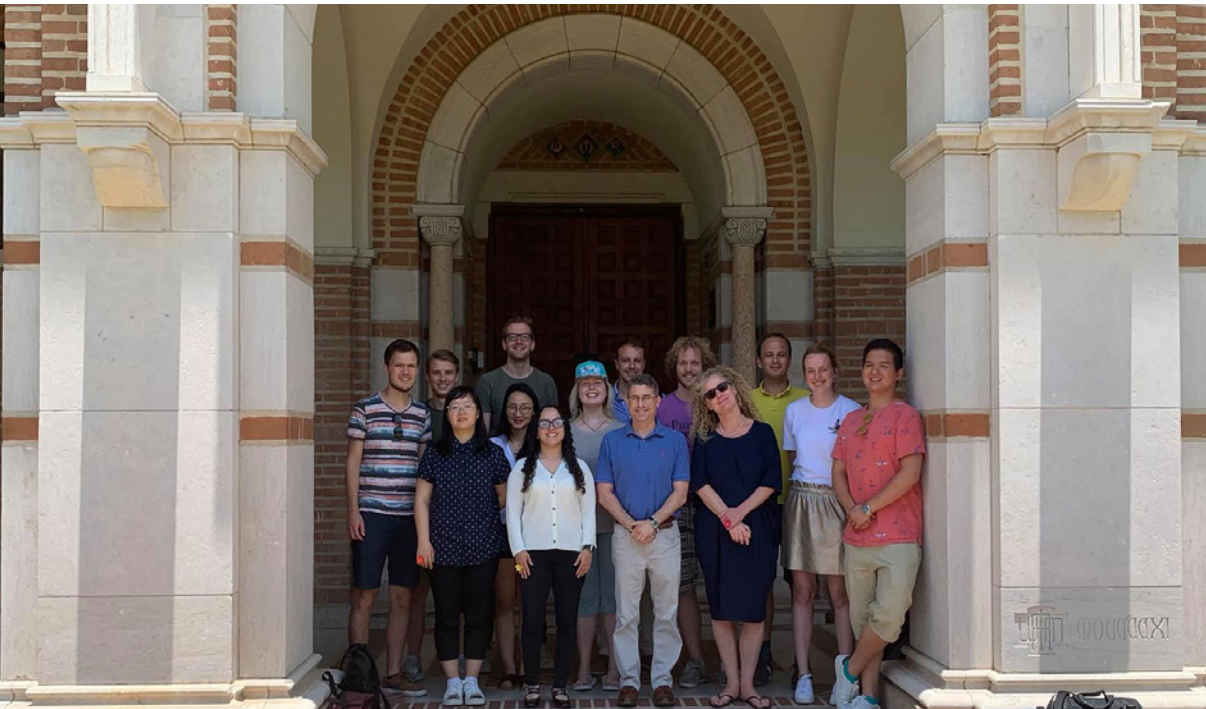
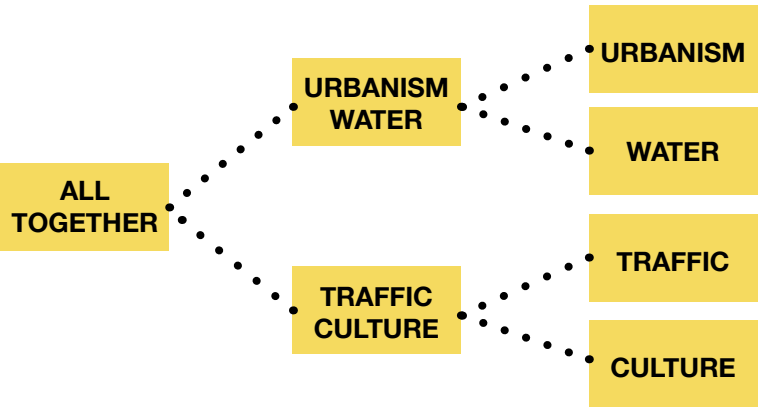
On the second day, the actual workshop started. The big group has been divided in three subgroups each with the opportunity to define their own way of approaching the project.

To gather an holistic view on the conditions and problematics, as well as collecting a broad field of solutions and concepts, the area was scoped in three rounds.

In the first round Urbansim, Water, Traffic and Culture Experts were forming groups in which they discussed three different concepts within the framework of the „tetragon of sustainable construction“.

- Disciplinary scope:**
- What do we know?
 - What questions do we have?
 - What examples do we have?
 - What concepts can we define, as with its own strategy and set of measures?

As a result each group came up three different concepts, which are explained in the following chapter.



65 | Project Group visiting Rice University

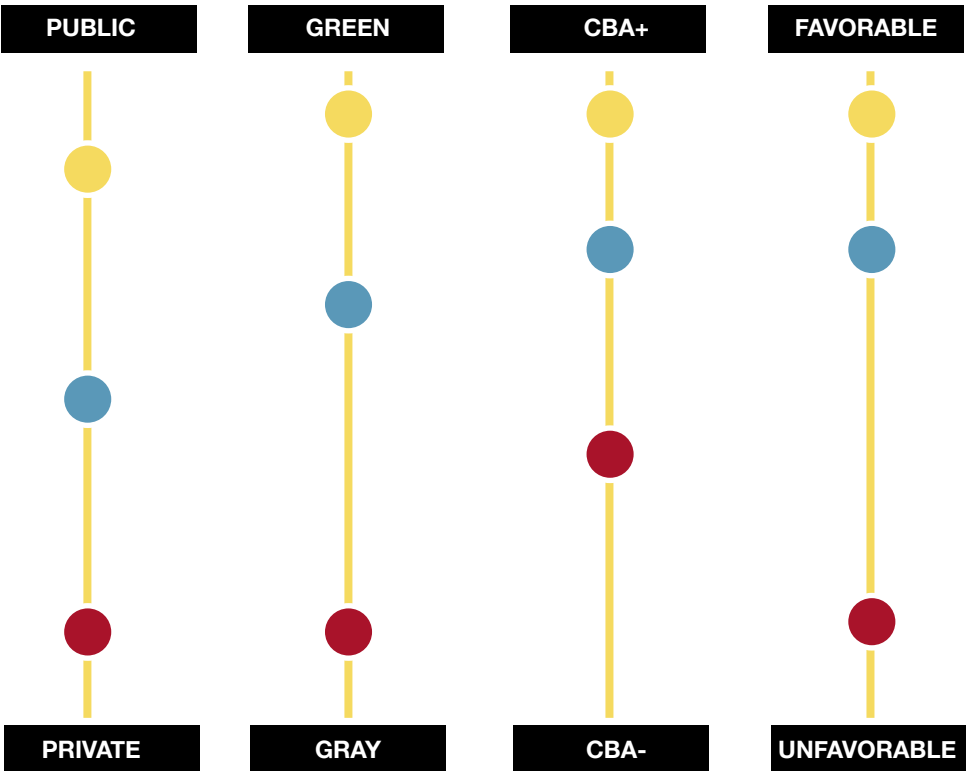
SCOPING

CULTURE:

Concept 1: Profit driven
This concept stirs towards an individualistic and egoistic approach, which is especially money and profit driven. The current state of mind has not changed, people insist on their right of property, which promotes a car and sprawl orientated development. Changes are seen as too complex or scary wherefore no measures or only minimal changes can be realized.

Concept 2: Prosperity driven
Main goal of this concept is to create more awareness of the current problematics within the city. Changes are facilitated in a positive way as well as in small steps. Compared to Concept 1, people don't think only about themselves but rather care about the bigger picture. This results in alternative concepts like more active ways of transport and a mixed use, dense build environment.

Concept 3: Purpose driven
People start to question the current way of development, lifestyle and society. This can lead towards a more sustainable development for a better future. Money and profit are not the main drivers anymore. This szenario can be reached by the help of governmental and/or municipal regulations.



3.1 SCOPING

HOUSTON, MAY 2019



66 | Workshop at Rice University

TRAFFIC:

Concept 1: Do minimal

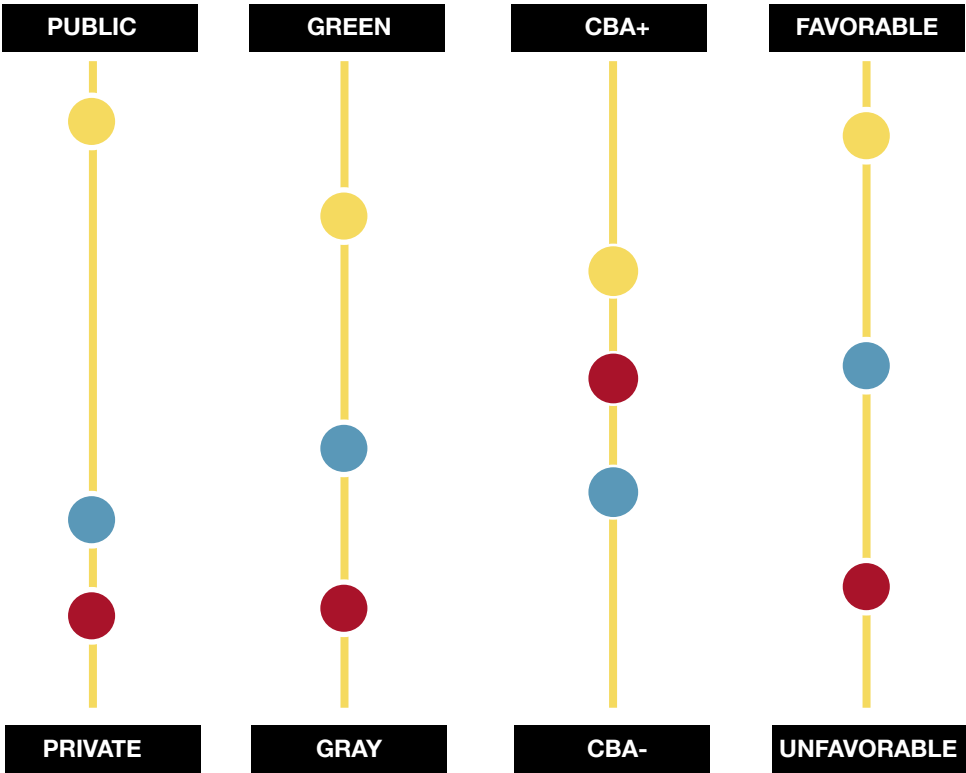
In this baseline proposal the I-45 will be torn down and through traffic will be redirected to the enhanced I-10&69 corridor. No additional regulations will be implemented though. The mass transit line will be expanded by building a new line in the form of a light rail vehicle system. These measures will provide a solid basis for the area to prosper. Additional property development will rely on private incentives. They will be very interested with the considering the raised quality of the area however.

Concept 2: Optimising the current system

Current traffic lights have fixed timings. This system can be fine tuned however. An intelligent traffic management system will be installed in the entire city to increase flow and thus facilitate future traffic levels. The traffic lights will predict traffic better with the help of ground loop detectors and other optical/electrical detectors. Big data will be used to analyse flow patterns and provide detailed traffic predictions on which the traffic management system can anticipate on. Accelerated expansion and build of new LRV mass transit lines with multiple convenient and centrally located park and ride facilities that will ease car traffic demand to downtown.

Concept 3: Houston satellite city

Houston will be transformed into a polycentric urban city. Multiple districts have areas with a higher concentration of commercial areas. These will be developed into worthy alternatives to the current CBD or sprawled out locations. These polycentric centres will be linked with a lot of public transit lines, with both LRV and metro rapid transit lines. This will lead to a modal shift to the CBD and less travel need to the centralised core overall. This will ease congestion.



WATER:

Concept 1: A small step for men but a giant step for mankind

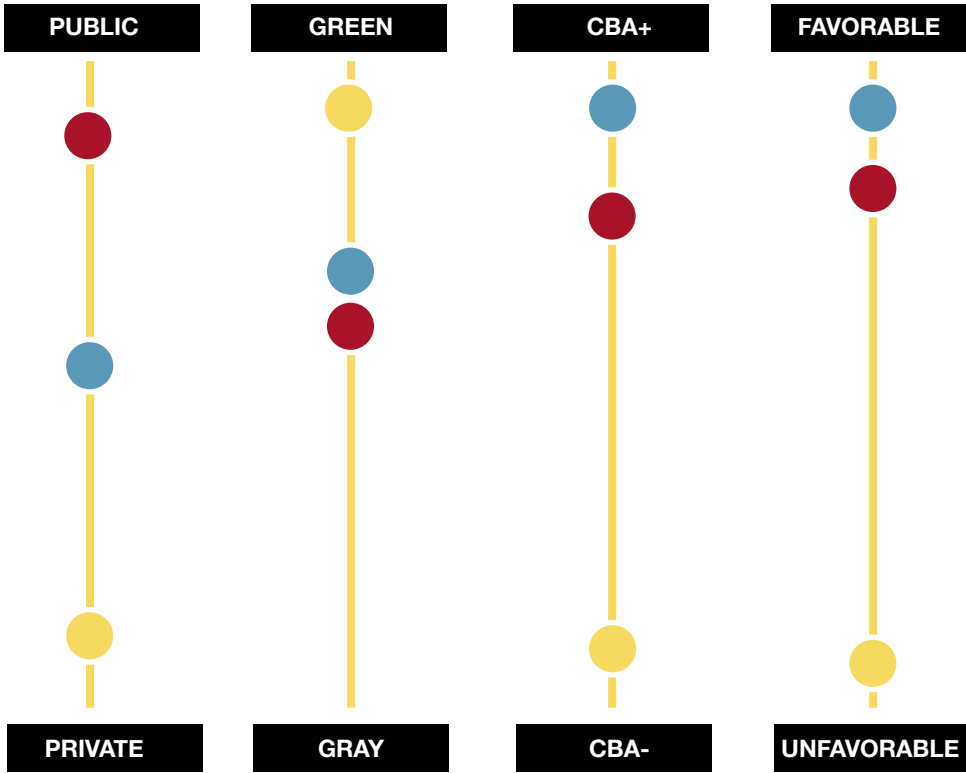
The firsts concept focuses on small scale measurements and implementations like creating more green spaces instead of impermeable surfaces as well as improve the already existing detention areas. Collective and city wide initiatives for stormwater collection and storage on roofs and private lots can make a big difference. Focus is also set on the maintainance of the existing ditch and sewer system, to prevent the from clogging and failing during emergency. Last but not least, it is important to create awareness and educate people about their possibilities but also duties to keep the city dry.

Concept 2: Forcing difference

Remove/Redevelope impermeable infrastructure on a big scale. Together with more strict and precise rules and guidelines for planners and developers on a city scale, (especially in areas at risk, like floodplains or ponding locations) more green and permeable areas can be implemented within the urban tissue. Together with large scale projects similar to the „Room for the River“ initiative, where canals are widened and renatured again, the forcing the difference concept has the power to set the basics for further sustainable developments within Houston.

Concept 3: Surrender

The last and most extreme concept focuses on telling people to leave and move the city together with its inhabitants towards a more suitable place in the USA. In a softer version, this concept could also suggest to atleast remove buildings and people from the floodplains and find more suitable areas for densification within the city.



3.2 FIRST RESULTS

BRINGING THE CONCEPTS TOGETHER

URBANISM:

Concept 1: Frank Lloyd Wright Broadacre City

This concept is evolved from the contemporary form and shape of Houston. Similar to Frank Lloyd Wrights idea of a sprawled city, where every person/family lives on there own plot in a suburban kind utopia in which the car but also futuristic modes of transport play an important role, also Houston is characterized by an endlessly seaming sprawl promoted by the lack of zoning and rules. The only difference is, that in the concept of Broadacre City, the main driver for development is based on demoratic desicions made by the inhabitnats themselfe, which is leading to a wishfull agglomeration of nature and city. In Houston nonet-helss the main driver is money and profit which seems to restric the on-goin development to stir towards a more sustainable and resilient one.

Concept 2: LeCorbusier

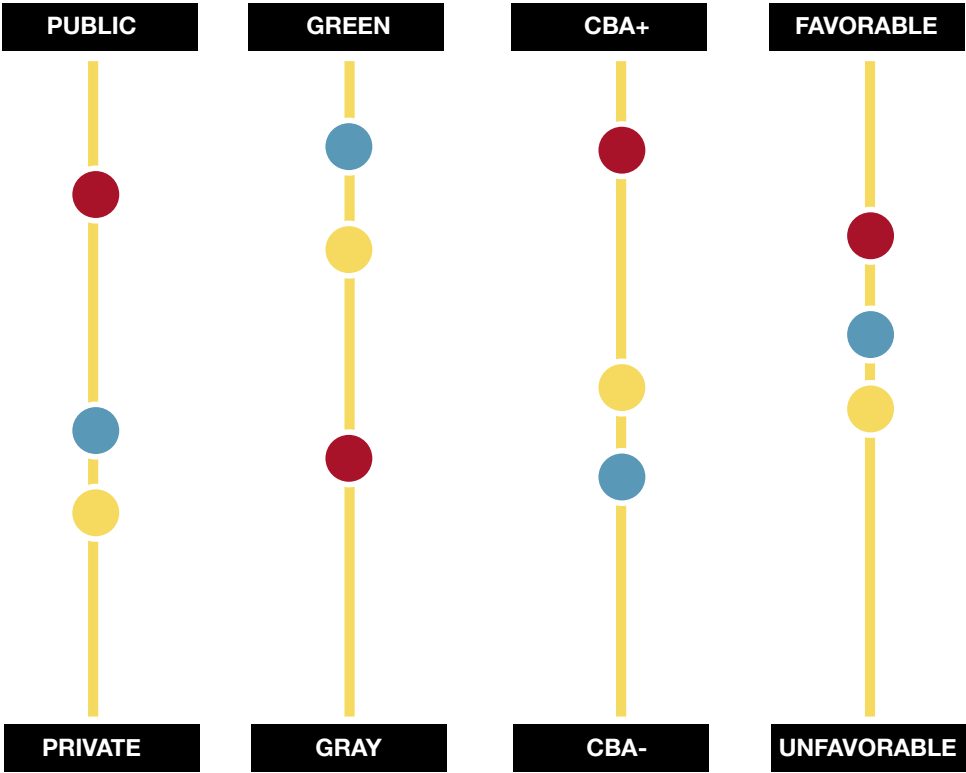
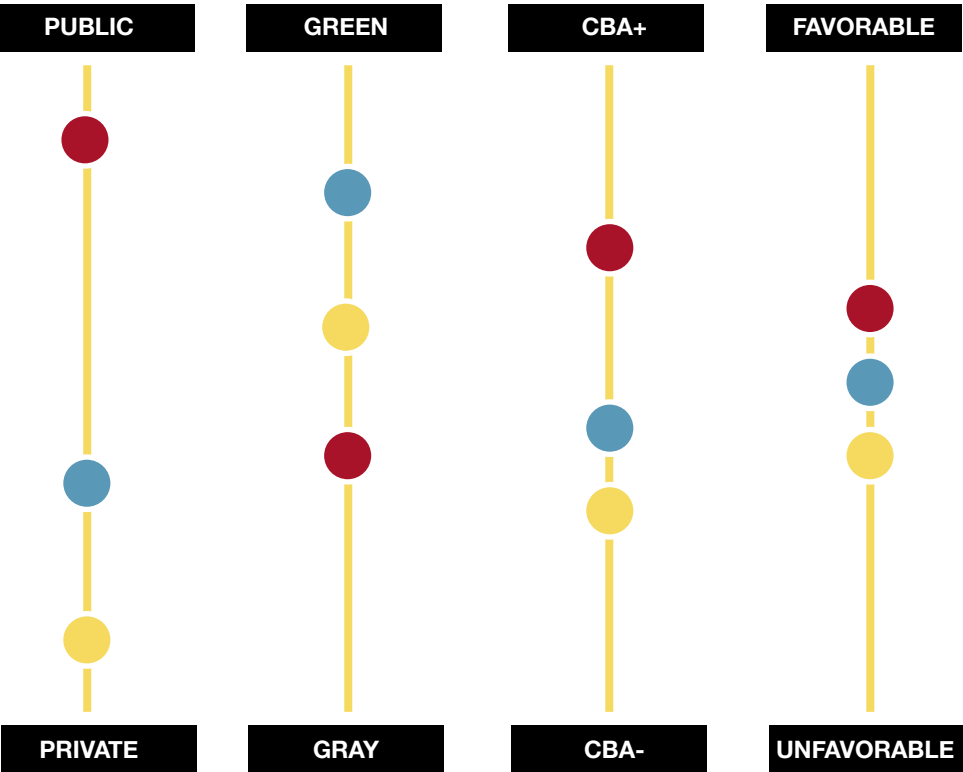
The next concept was called that way, because it maily focuses on a development of large scale residen-tial complexes placed in nature. This gives the opportunity to put future development within a sustainable and resilient framework of large open spaces that are adapted to the flood-ing issue, function as detention areas and create rereational as well as eco-logical corridors for its inhabitants.

The negative side of this concept is the seperation of the different func-tions and flows of the city, making it condradicting to the proposed goal of integrity and synergy.

Concept 3: Extreme Densifica-tion, Manhattan/Hong Kong

The third urban concept focuses on intense densification of suitable areas within the city. This creates the opportunity to dedicate vulnera-ble areas, like floodplaines back to

nature. Moreover densification can justify alterntive modes of transport, like trams, biking but also autono-mouse vehicles. Negative about this concept is the fact, that it needs a complete restructuring of the exist-ing layout of the city as well as an enormouse amount of time money and planning.



As a next step, the two concepts of Culture and Traffic as well as Urba-nism and Water have been fused together. The desicions have been made on a round table together with the members of the specialized teams. During the discussions the individual concepts have been adap-ted and improved.

URBANISM AND WATER:

Concept 1: a small step for men but a giant step for mankind plus Frank Lloyd Wright/Broadacre City

The implementation of many small scale improvements of the flood-defense system can be success-fully combined with the idea of the bottom up approach of the urban concept. The inhabitants are the main driver of this development and are responsible for a more sustaina-ble and resilient city.

Concept 2: Forcing difference plus LeCorbusier

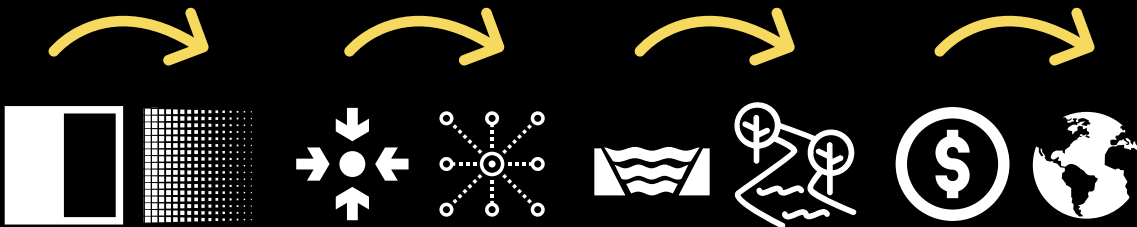
The idea behind this combined concept is to integrate big scale improvements of the Houstons water infrastructure within large and dense developments. This would result in new, mixed use residential complexes which are situated on a wide field of renaturized openspaces adapted to flooding.

Concept 3: Forcing difference plus Surrender plus Extreme Densification, Manhattan/Hong Kong

The last combination of water and urbansim concepts promotes inten-se densification within sutiable areas, making room for large scale adap-tions within critical areas as well as creates the opportunity to surrender in specific areas and dedicate this space back to nature.

3.2 FIRST RESULTS

BRINGING THE CONCEPTS TOGETHER

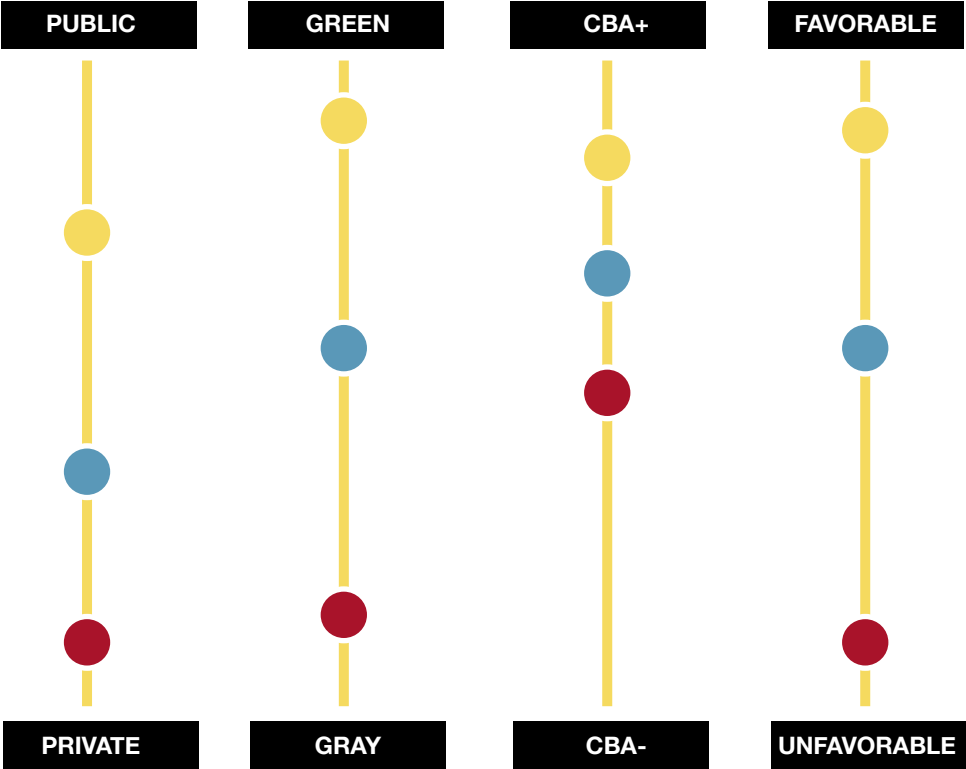


CULTURE AND TRAFFIC:

Concept 1: Individualistic approach
The flooddefense system can be successfully combined with the idea of the bottom up approach of the urban concept. The inhabitants are the main driver of this development and are responsible for a more sustainable and resilient city.

Concept 2: Awareness for energy consumption
The idea behind this combined concept is to integrate big scale improvements of the Houstons water infrastructure within large and dense developments. This would result in new, mixed use

Concept 3: Polycentric /Transit and active modes



At the end of the three days workshop the single groups presented their first ambitions and goals, as well as finding answers to following questions:

- **For the larger scale of the area:** what do you think the replacement of the highway can improve challenges of the area on the larger scale?
- **For the district in relation to the highway area:** how can the new dynamic on the highway positively affect the district?

CONCEPT:	URBANISM	TRAFFIC	WATER	CULTURE
Fourth Ward	Freedom Town	Do minimal	Small Steps Regulation for Plots	Creating Awareness/ Community driven Enforcing: Regulations
Downtown	Manhattan Concept	Optimizing / enable active Modes & PT	Small Steps	
Midtown	Moderate Densification/ Mixed Use	Transit Station		
I-45 Corridor	Gradient Densification	Connect for active Modes & PT	Emergency Retention	Facilitating: Cycling Corridor
Buffalo Bayou	Living in Park/ Le Corbusier	Allen Parkway as Boulevard	Room for the River	Facilitating: Cycling Corridor

DOWNTOWN:

Creating a diverse and multilayered space with an extensive public transportation network and space to walk in a green area. Floodplains are respected and sustainability is achieved by densification and less car usage.

MIDTOWN:

Providing a solid basis for the area to prosper in a sustainable manner. Society will benefit from better transportation links, while profiting from a better walkable and recreational neighborhood. Enhanced climate resilience provides a safeguard for the future.

FOURTH WARD:

From controlling variables to complex systems with a shift from segregating boundaries towards gradient transitions to create synergies between neighbouring areas.

3.3 VISIONS

DISMANTLE BOUNDARIES – CREATE SYNERGIES

As a result of the workshop, each team came up with first drafts, ideas and prototypes of the overall concept we wanted to use on the way towards the final design.



68 | Workshop result, 4th-Ward Group, showing first ideas of creating synergy and connections between neighbourhoods and networks



67 | Modell: Broadacre City, 1932

Dismantle Boundaries – Create Synergies

This slogan was already created during the workshop and later became the title of this report. Our conclusion of four days of lectures, designing, scoping and observing, was that the city, its infrastructure and build environment has to shift from segregating boundaries towards a gradient transition to create synergies of networks.

Especially Houston's failing infrastructure can be one part of making the city more resilient, sustainable and multifunctional. The ongoing rapid changes within the build environment and the need for adaption to flooding gives the opportunity to reshape the fabric of the city.

Three main focus points have been set

The reuse of the existing and soon obsolete structure of the I45:

Instead of demolishing the Interstate re-purposing it can not only help to reduce wasted material but also sets a framework of „how to work“ with the existing construction.

Mobility:

We see the need for Houston to change its mobility concept. A car-oriented development brought many of today's problems and only a rethinking of mobility and infrastructure can be a suitable way of creating new synergies between failing systems.

Flood-adaptive typologies:

Especially the analysis of the Fourth Ward, with its traditional shotgun typology and a deeper insight into amphibious architecture were the main driver in experimenting with new and more suitable structures within the existing urban fabric.



69 |



70 |



71 |



72 |



73 |



74 | Parking spot in the heart of Houston Downtown, showing the large amount of impervious surface, increasing run-off and repressing urban ecology



76 | Flood waters block the I-45 and I-10 interchange north of downtown Houston, Saturday, June 9, 2001, after rains from the remnants of Tropical Storm Allison dumped an estimated 28 inches of rain on the area. (AP Photo/Houston Chronicle, Dave Einsel)



75 | Unused, wasted and sealed open space under Interstate 45

How can we imagine a **FUTURE FOR HOUSTON** where its strengths

high **URBAN DYNAMICS**, the rethinking of **URBAN INFRA-STRUCTURE** and the growing awareness **OF FLOOD ISSUES**

are mobilized to make its urban fabric **MORE RESILIENT** to flooding, **ADAPTIVE TO** new and alternative mobilities as well as ecologically **SUSTAINABLE?**

04 CONCEPT



77 | View from I45 towards Houston Downtown and 4th Ward in the background

4.1 CREATING SYNERGY

AREAS

From this perspective it is the aim to create the **CONDITIONS** for a **HEALTHY, SECURE** and **LIVEABLE HABITANT** for its **RESIDENTS**. (Humans, Flora, Fauna)

HOUSTON SYNERGY

FLOWS

Flows can be seen as **INPUTS AND OUTPUTS** within **AREAS** that function as **OPEN SYSTEMS**. The **AIM** for the decision making on flow management, is to **GENERATE ACTIVITIES** that have internalized the **RESPONSIBILITY FOR FLOWS**.

ACTORS

The **GOAL** here is to **INCREASE** the **PARTICIPATION** of different **ACTORS** (using different/similar flows within certain areas as well as **INVOLVEMENT** for the **RESPONSIBILITY OF FLOWS** in the **AREA**).

4.1 CREATING SYNERGY

THE EMERALD NECKLACE IN BOSTON

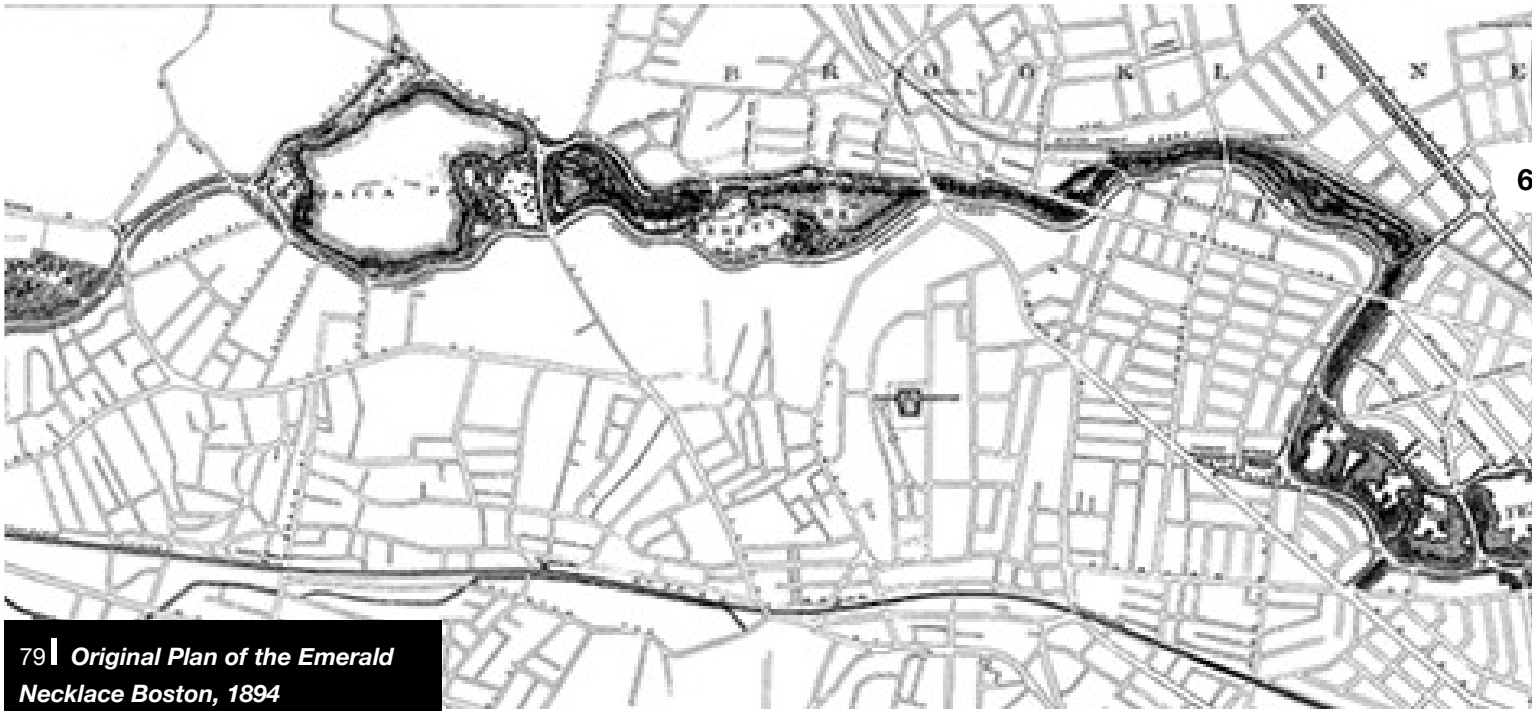
Late plan of the Boston Park System by Olmsted in 1894, which shows his approach to the park as a system with a contiguous NETWORK of amenity spaces from Franklin Park down to the Charles River.

Back in the Netherlands we tried to refine the raw concepts of synergy, which was developed in the workshop in Houston.

From the beginning on, it was the goal to redefine project area from a juxtaposition of non-communicating, monofunctional and devided spaces and infrastructures into a coherent network of different flows and functions working together in synergy and creating a new multi-functional, sustainable and resilient center of Houston.

As one of the first landscape architects/urban planners, Frederick Law Olmsted designed the Emerald Necklace Parksystem in Boston under the focus of connecting different systems, located in this areas. Blue and green infrastructure combines the flows of ecology (open space, flora and fauna) with the system of hydrology (eg. functional issues of urban stormwater management on tidal rivers). By creating synergy between those systems and using their characteristics as a foundation to plan with, instead of against na-

ture, this project became a breakthrough in urban planning (Marks, Wescoat Jr., Noiva, Rawoot, 2015). To be able to emerge synergy between different system, not only knowledge and analysis is required, but also synergy between the different professions being experts within the different fields is an essential factor. As a collaborative and interdisciplinary course/project, we tried to find a way to bring the different approaches of Transport, Infrastructure and Logistic (TIL) and



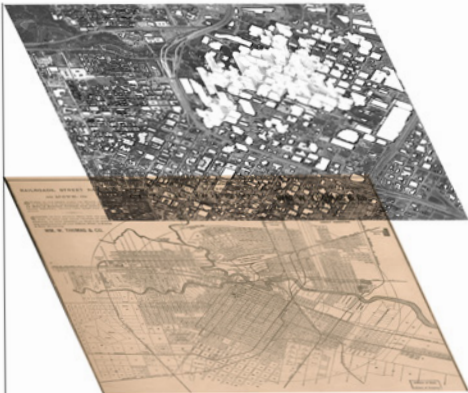
79 | Original Plan of the Emerald Necklace Boston, 1894

Urbansim (Urb) together. We figured out that we need to understand the different perspectives of each other.

The refined concept is based on Tjallingii's S2N (Synergy 2 Networks) principle (Tjallingii, 1996). In Houston the two networks of hydrology (including ecology, and recreation) as well as the flows of mobility are the biggest drivers for the city's development (Built Environment) but also main-reason for causing today's problems. To set a flexible, interdisciplinary and expandable framework it is important to:

1. understand the interrelated characteristics of different networks within a system as a whole. By overlapping the three layers (layer-approach) of built environment, mobility and green-blue ecology those cumulative relationships can be identified, which helps to develop and define spatial solutions (Hooimeijer & Maring, 2018).

2. set guiding principles that help with concrete decision making. The single design decisions adapted from Tjallingii, are based on the already explained flows (hydrology and mobility), areas and actors. The specific explanations of them will be elaborated on the next page.



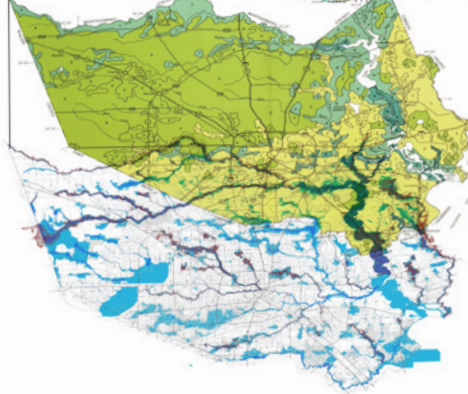
The Build Environment

Today's and past characteristics, emergence and development, grown structures, borders and boundaries



Mobility

Today's and past characteristics, emergence and development, changes in structures, now possibilities



Ecology Green - Blue

Hydrology, Subsoil, Flora, Fauna and natural processes within the area

Layers of the different Flows in the project area

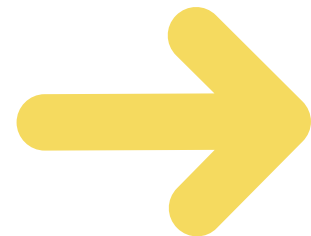
78 | Perspectives, aims and products of the different disciplines (Tjallingii 1996 p. 101)

	1. empirical sciences	2. problem-oriented sciences	3. design-oriented sciences
disciplines			
aim	<i>the true explanatory (general)</i>	<i>the good effective, efficient (categorical)</i>	<i>the good appropriate, legitimate (specific)</i>
product	hypothesis prognosis	solution, standard	plan, policy

4.1 CREATING SYNERGY

S2N SYNERGY 2 NETWORKS

For the three different areas (Highline, Living Machine and Fourth Ward) we picked the most suitable principles to strengthen design decisions with theory but to also keep the focus.



AREAS

The space for synergy principle

The plan creates spatial conditions for synergy between different sustainable flows and creates involvement/negotiation between different actors/users.

The sublayer principle

The design for this principle is controlled by the sublayer, formed by nature and culture of the existing environment (work with nature).

FLOWS

The synergy with areas and actor's principle

Creating conditions for synergy of activities in an area and the interests of actors. Prevent nuisance and conflicts, make flows visible.

The economical use principle

Create conditions for economical use ('reduce, reuse, recycle')

ACTORS

The planning as learning principle

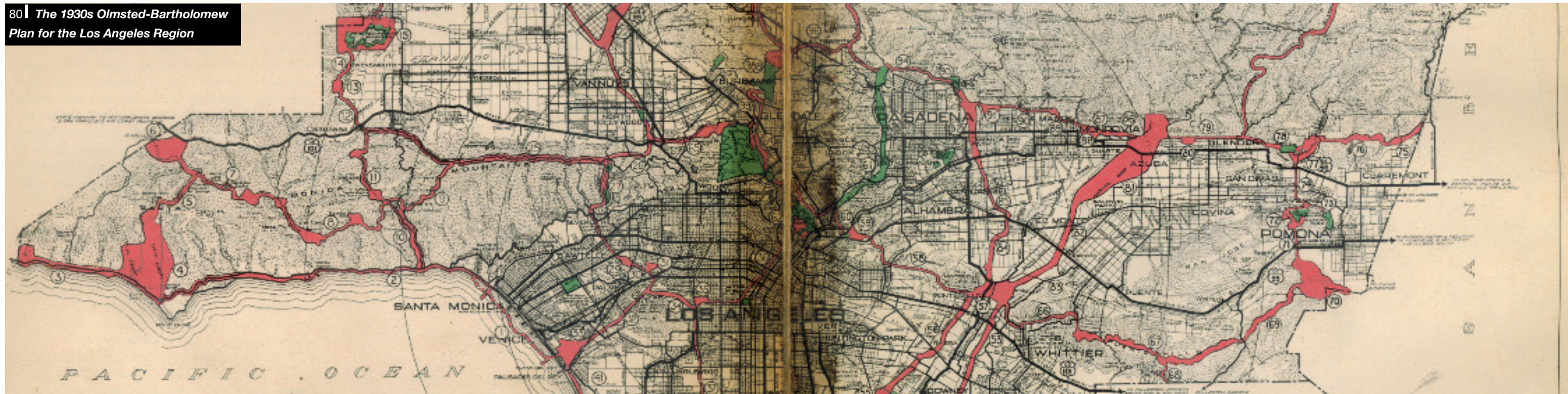
In a learning process of practice and theory, find the synergy of interests and activities in the perspective of innovative developments.

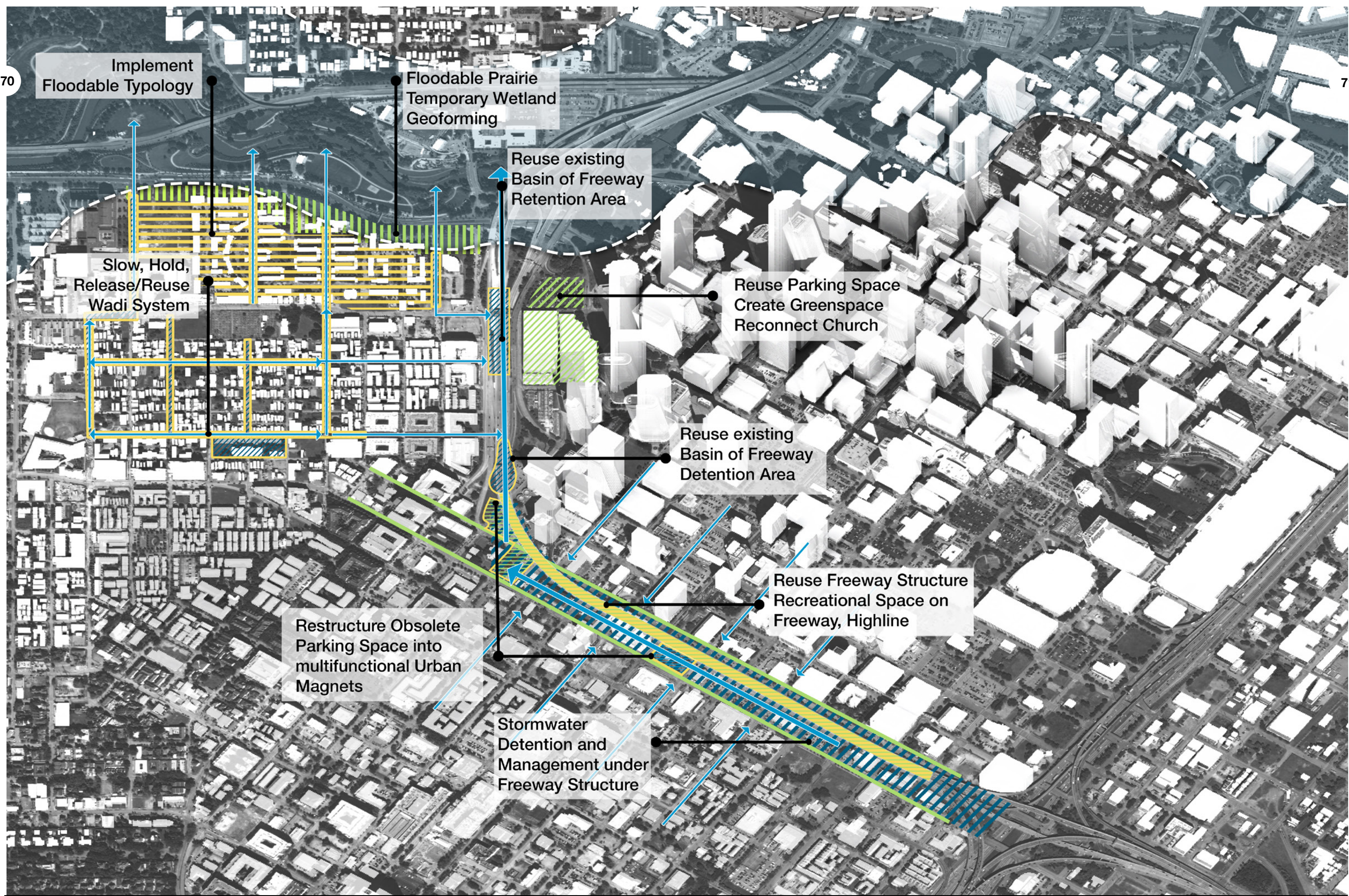
The making visible principle

Work with visible flow management and involvement in natural processes in the landscape. Make use of visible pilot projects of pioneers who are already working innovatively in the area.

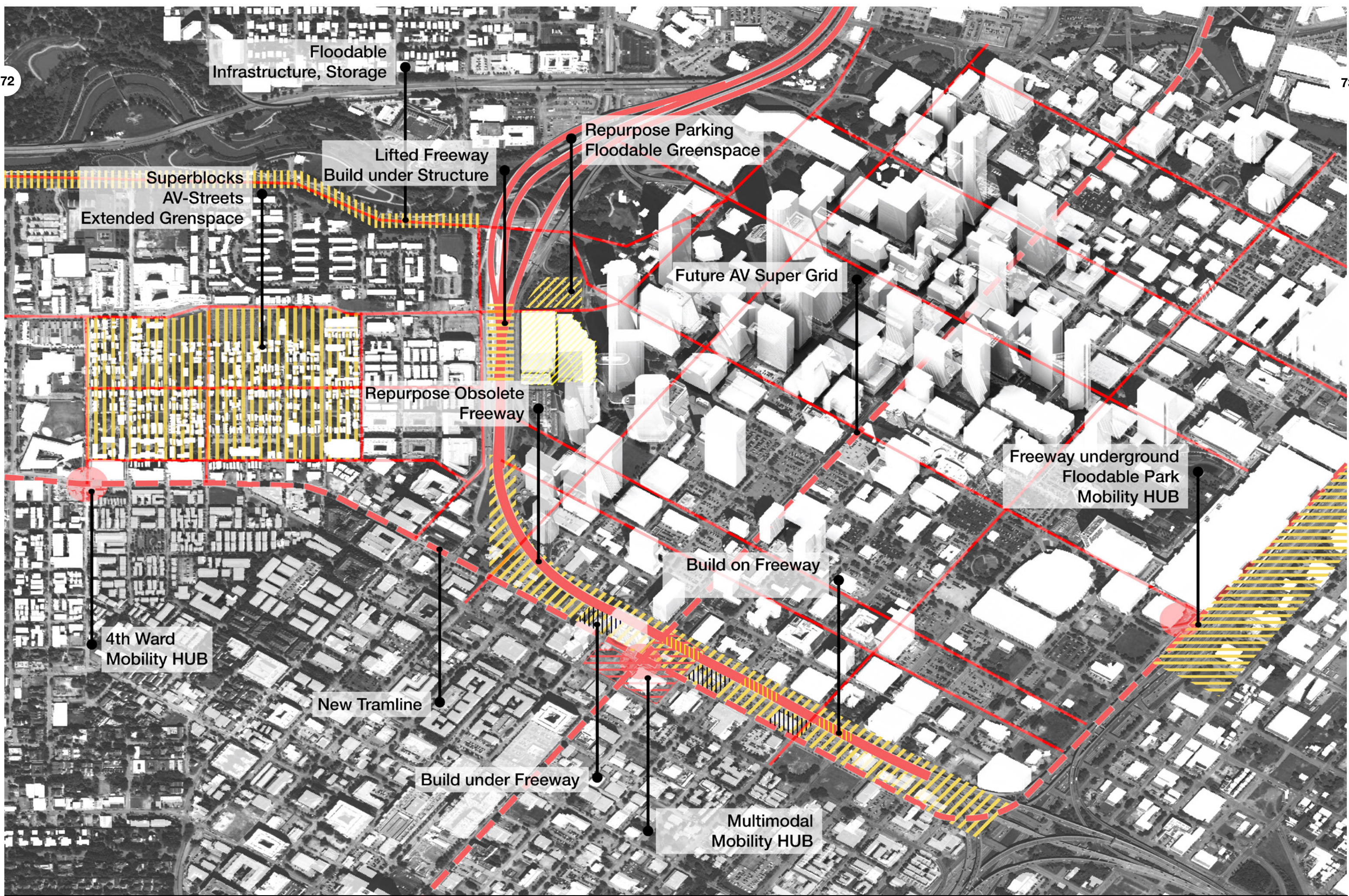
Overview of guiding principles, (Tjallingii & Jonkhof, 2011 in Stehouder, 2018)

80 | The 1930s Olmsted-Bartholomew Plan for the Los Angeles Region





4.2 GREEN / BLUE CONCEPT



4.3 MOBILITY CONCEPT

4.3 MOBILITY CONCEPT

COMPLEMENTARY ESSAY
THIJS VAN DE WIEL | TIL

Houston Mobility Program

Within the Houston Highline plan special attention is given to mobility. It is obvious that Houston is quite a car-oriented city. In this section, mobility aspects, especially considering future transportation, are examined to improve and complement the overall design. Firstly, three goals are set. They all address problems which are important to keep Houston and especially the 4th ward and downtown area a liveable and accessible area.

Goals

- Mobility vs. Liveability
From (motorised) mobility restraining liveability, towards (active) mobility enhancing liveability in Houston. From living environment clashing with infrastructure towards creating synergy.
- The right to exist as a pedestrian in Houston.
From a fully car oriented city towards a liveable urban system where everyone regains the right to exist as a pedestrian in the streets of Houston. This is better for environment and health.
- Facilitating future mobility
The car will remain having a dominant role in Houston: promote alternatives while facilitating future mobility to improve the city. From car as only option towards a MAAS concept.

Mobility program

Most people do not live where they work. They also don't shop work they work. Therefore, people need transportation to perform their activities. This is also true for Houstonians. Houston is a city characterized by suburbia. Urban sprawl results in more transport demand. At large distances, active modes (like walking and cycling) are no longer attractive and public transit not viable. So, in dispersed areas the only option remaining is the personal car. It is the car that drove sprawl and it is the same car that ensures people remain dependent of it. This car-dependency together with Houston's car-oriented city design clashes with the urban quality and liveability. The Highline project aims at creating synergy between mobility, water and the living environment. By giving space to both pedestrians and water, while using the existing infrastructure it is possible to improve the city. We cannot ignore the fact that cars will remain to have a dominant role within a city like Houston, but we can have a look into the future of automotive transportation. Since many believe we are now at the verge of a new age of personal transportation: the autonomous vehicle (AV). In this mobility program the goal is to examine how AVs can help improving the spatial quality in Houston.

Future mobility

There is discussion about the effects automation will have on personal transportation and its spatial consequences in cities. Nevertheless, it is clear that technologies in Automated personal vehicles are developing rapidly and many believe that AVs will come sooner to our cities than we think (**Howell, 2019**). Because these new vehicles will have (like traditional cars) their negative side effects, we need to carefully think ahead to overcome these (**Smolnicki & Soltys, 2016**). This is especially true for the spatial consequences AVs can have on cities. In order to steer towards a situation where AVs can help improve the living environment instead of increasing the car dominance and urban sprawl, future scenarios are created by Gruel & Stanford (2016). Something very relevant for a car-oriented city like Houston. These scenarios can be considered as stages of adaptation to automation. The most important stages are identified:

First: vehicle ownership will remain private

The most important consequences in this stage are the increased comfort of driving and the decreased travel times (congestion decrease). This is a driver towards more urban sprawl and more vehicle kilometres.

Large scale

Small scale

Table 1: Potetial spatial impacts AVs

Positive

- + **Densification:**
Viable PT & justifying active modes
- + **Less need for parking spaces:**
space available for public space, water or active travel
- + **Potential for speed limits:**
more attractive streets

Negative

- **Increased vehicle kilometres**
- **More space in street design for AVs**
- **Travel substitution**
- **Mode segregation**

Although this scenario might seem the most realistic for a city where owning a car is deeply embedded in the culture, private ownership will probably not remain as obvious if innovations in automated transportation will be further developed. Since automated vehicles will be much more expensive, it is likely that private ownership will decrease anyhow. The services from these vehicles are expected to be cheaper than taxis, shared vehicles services and cars nowadays (**Litman, 2018**).

Later: Pooled Automated Vehicles
A later scenario assumes that AV's will become increasingly shared. Personal transport will be just a service which can be ordered. Shared (or pooled) AVs will be most efficient in areas where ridership is highest. In densely populated areas shared AVs are most efficient and cheapest to operate. Hence there is a tendency to densify the urban area.

Spatial consequences

If private ownership of vehicles will decrease and pooled ridership becomes the norm it will have many spatial consequences. The first trend is densification of the city. Public transport needs certain amount of travelers per stop to operate in a viable condition. Therefore, densification is

justifying forms of public transport. Also active travel modes become better alternatives in densified areas because distances between different activities are decreasing.

Pooled AVs will not only have impacts on the larger scale, but also have small scale consequences. Due to the real-time availability of AVs on the basis of a Mobility As A Service (MAAS) concept there is less need for parking spaces. There is virtually no parking space needed in areas where land values are high (e.g. the densified areas). Considering that many plots in downtown Houston are dedicated for car parking, land values will increase (due to increased densification) and parking lots will become obsolete due to the shared AVs, there will be a lot of yet to develop space. This 'new' space can be used for pedestrians, cyclists, water storage or public space.

In contrast to saving space, AVs may also need more space in the street design. In the future, drop-off and collection of passengers could be dominating the streets (**Stead, 2018**). This extra space is likely to be taken from the sidewalk, which is valuable pedestrian space. The alighting of passengers could also create conflicts with cyclists.

Another potential negative effect is decrease of active travel due to the substitution of last mile travel by a pre-ordered AV. Also, since self-driving cars don't perform well in chaotic streets where lots of interaction with other road users is happening, mode segregation is likely to happen (**Stead, 2018**). This creates less vibrant and liveable streets (**Alexander, Ishakawa, & Silverstein, 1977**). Lastly, the travel demand might increase due to increased comfort/less disutility of travelling by car and a decrease of congestion (**Gruel & Stanford, 2016**). An increase in vehicle kilometres is therefore likely and undesirable.

4.3 MOBILITY CONCEPT

COMPLEMENTARY ESSAY
THIJS VAN DE WIEL | TIL

Policy program for Houston

Since the first scenario of automation will probably lead to more negative spatial side effects it is important to steer towards a development of pooled automated vehicles where other modes needless connect to each other. A strong policy scheme towards a shared organization of AVs, on the other hand, will have economic, social and environmental benefits for the city.

(Gruel & Stanford, 2016).

The best conditions to make AV's support the use of active travel modes is when their use is restricted in cities and used pooled (Stead, 2018). Firstly, this can be done by policies which only allow shared AVs to be in the downtown area of Houston. Secondly, measures like mobility hubs, to facilitate needles connections with other modes of transport should be taken. To prevent alighting passengers from vehicles becoming a dominant part of the streets, designated 'drop off & collection places' have to be created. This also enhances the use of other travel modes for the last and first mile connections.

AV corridors

To accommodate the pooled AV policy we want to emphasize not to remove all cars and change the grid structure, but rather use the existing environment. In downtown Houston only AVs that are pooled will be allowed in the future. To create more space in the streets, AVs will only run along a limited number of 'special AV corridors' (Figure 1). In residential neighbourhoods (like 4th ward) there will also be lower hierarchy roads. Here, the space is predominantly designed for pedestrians. The speeds can be lowered in such a way the vehicles blend with slow travel modes (Dijkstra & Ionescu, 2018). This way, mode segregation and its negative consequences will be prevented.



Figure 1: AV Corridors

Consequently, the use of active modes will also be encouraged, which is better for health and environment. Freed up parking space is used for the pedestrians and cyclists, water storage or used as public space. Future mobility can now enhance spatial quality and water resilience in the city of Houston. Synergy is created between mobility, spatial quality and water resilience. Designated drop off (&collection) zones are placed at places where all modes meet. Preferably, these zones are also served by high-quality Public transit. Furthermore, mobility hubs are created to facilitate needles connections with other modes of transport.

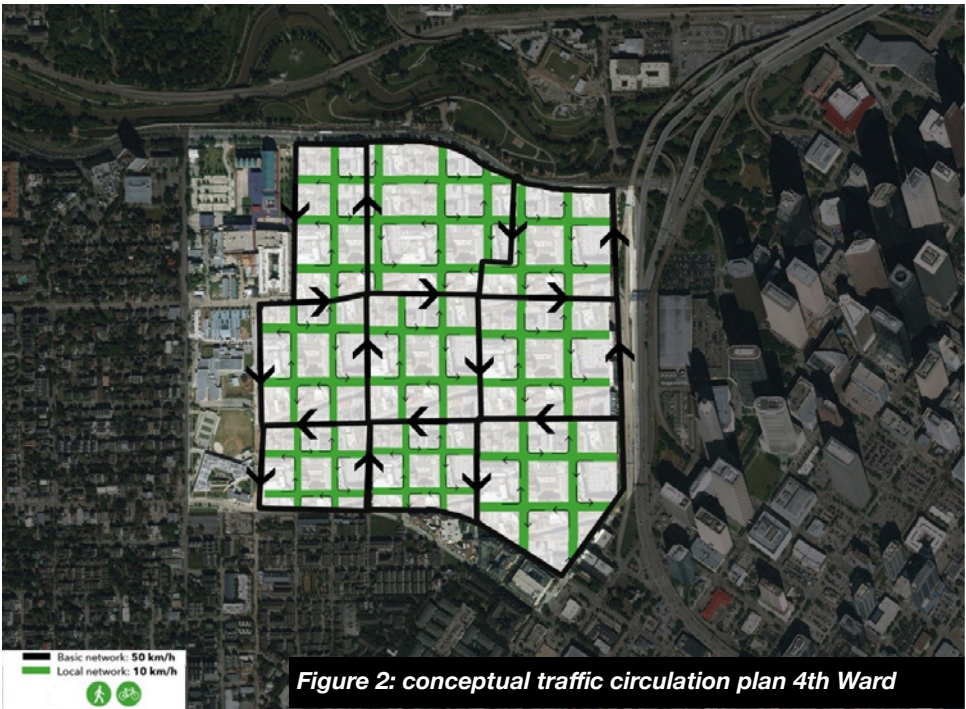


Figure 2: conceptual traffic circulation plan 4th Ward

Superblocks

Within in the AV corridors the idea of Superblocks is used (Agencia de Ecología Urbana de Barcelona, 2012). In Superblocks a grid structure is used to prioritize pedestrian traffic and public space. Faster traffic is redirected around the superblock. Within the superblock AVs are only able to drive at walking pace. This concept will perfectly fit into the realm of automated vehicles, because they don't need parking places. The main problem of implementing the concept in present days, is the lack of parking spaces (Rueda, 2018). In order to keep every destination easily accessible by foot, a guideline for the distances between the corridors of 4 blocks is used. Within the superblocks space for pedestrians and public space is key. Within the 4th ward there also wadi streets created to prevent excessive surface water runoff during heavy rainfall.

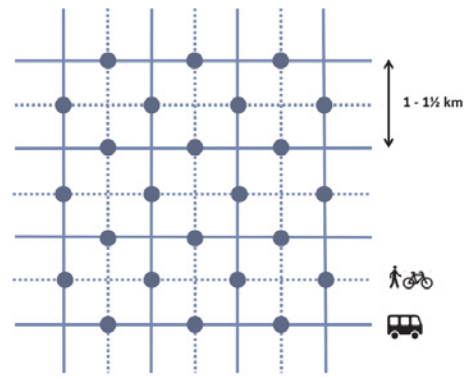


Figure 3: Superblocks

Street design

Because AVs are controlled by computer software they can guide themselves very accurately. Therefore, they need less (impermeable) surface to drive on. Only a small guideway is needed for these cars. The saved space is again used for pedestrian, cyclists and water storage or drainage. Figure 4 shows how a street will look like.

Tramline

Because the new mobility plan for Houston is aiming towards mobility used as a service rather than predominantly car use, different modes of transport also need to be incorporated. The tramlines will serve as important transfers from or towards AVs. Therefore, a new tramline (or light rail line) is proposed (figure 5 & 6). This new (yellow) tramline is connecting the west of Houston with downtown. It runs alongside the 4th

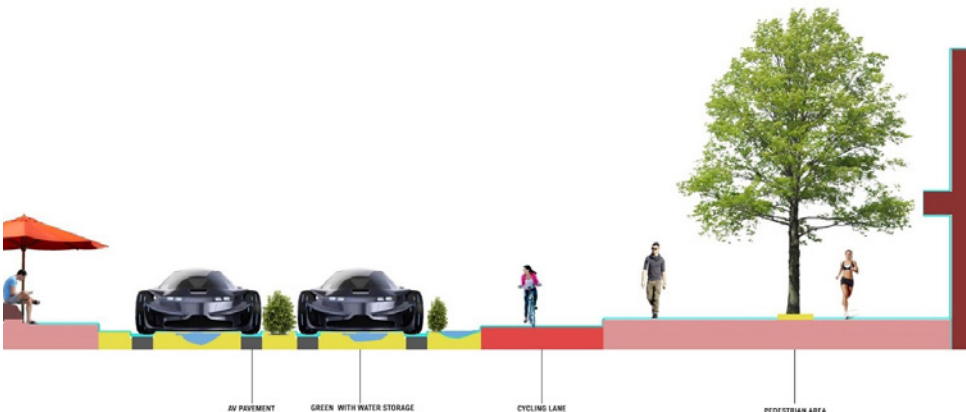


Figure 4: Section AV Corridor

ward (south side) and the highline. It is connected with the existing north-south line (red-main street) line at the new transfer & mobility hub located adjacent to the highline in midtown. The yellow tramline continues alongside the highline and follows the contours of downtown until it is connected to the east end line near the convention centre. This new tramline ensures a better coverage of high quality public transport in downtown Houston and therefore an increased use. Because the new line makes the tram network circular around downtown it also makes the network more robust for disruptions. Lastly, it ensures that last mile trips from AVs to destinations are possible by public transport.

4.3 MOBILITY CONCEPT

COMPLEMENTARY ESSAY
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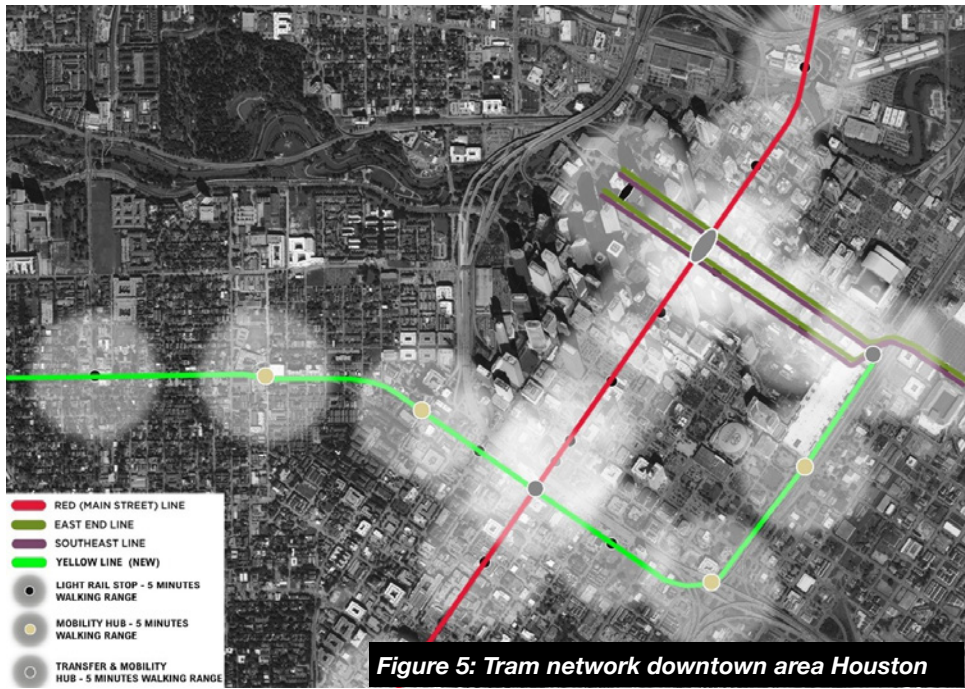


Figure 5: Tram network downtown area Houston

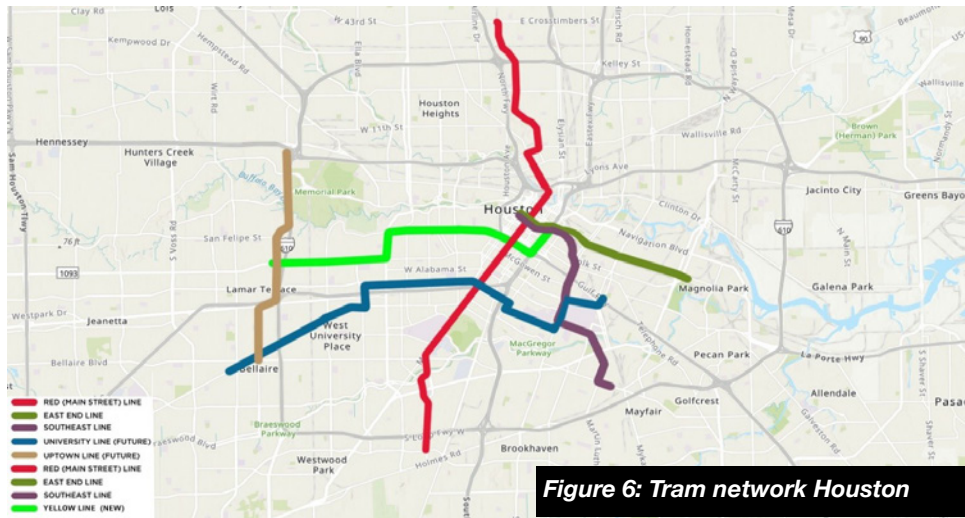


Figure 6: Tram network Houston

Mobility hubs

To create needless connections between AVs and other modes high quality transfer stations are created. These so called ‘mobility hubs’ facilitate the drop off & collection zones for AVs, public transport stops and other modes of transport like shared bikes and scooters. They are strategically placed alongside the tramlines and function as activity nodes in the necklace concept of the wider plan. Two of the mobility hubs are highlighted in this report. The first one is the tram station which is located near the place where the red tram line crosses the highline (mobility hub #1 in figure 7). This tram stop is already in place, but will be improved to facilitate the functions mentioned. A real ‘central station’ for public transport will be created at the edge of downtown which will be accessible from the highline above. Around the station higher density buildings will be built. This fits in the concept of Transit Oriented Development (TOD) where higher building density is used because of the high accessibility of the area (by Public Transport) to attract companies and reduce car commuting.

(Dittmar, Belzer, & Autler, 2004)

This enhances the use of public transport and together with the highline also active modes. The second stop that is highlighted is



Figure 8: Impression mobility hub

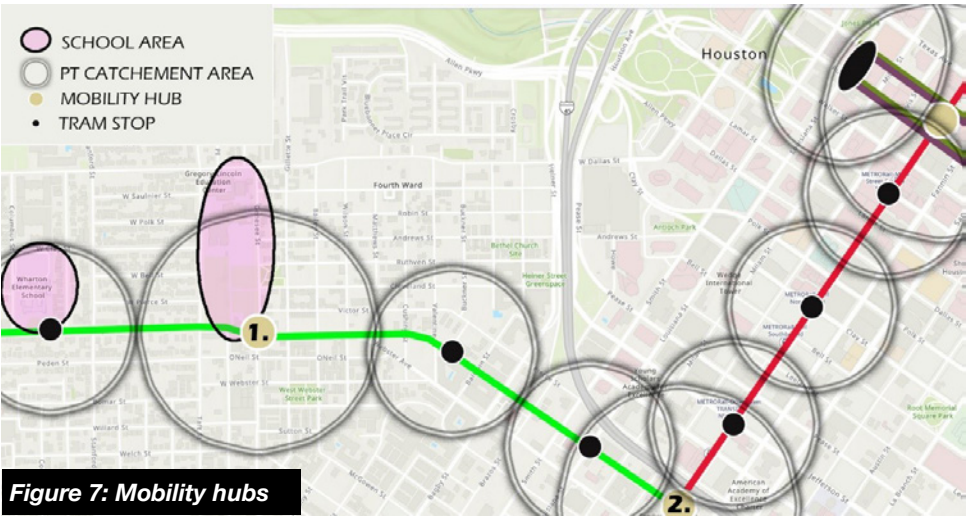


Figure 7: Mobility hubs

the hub at the south west tip of the 4th Ward neighbourhood (mobility hub #2 in figure 7). It serves both the schools which are located directly next the mobility hub and the whole 4th area. It also needs to be able to facilitate the school busses. Figure 8 shows an impression.

Active modes

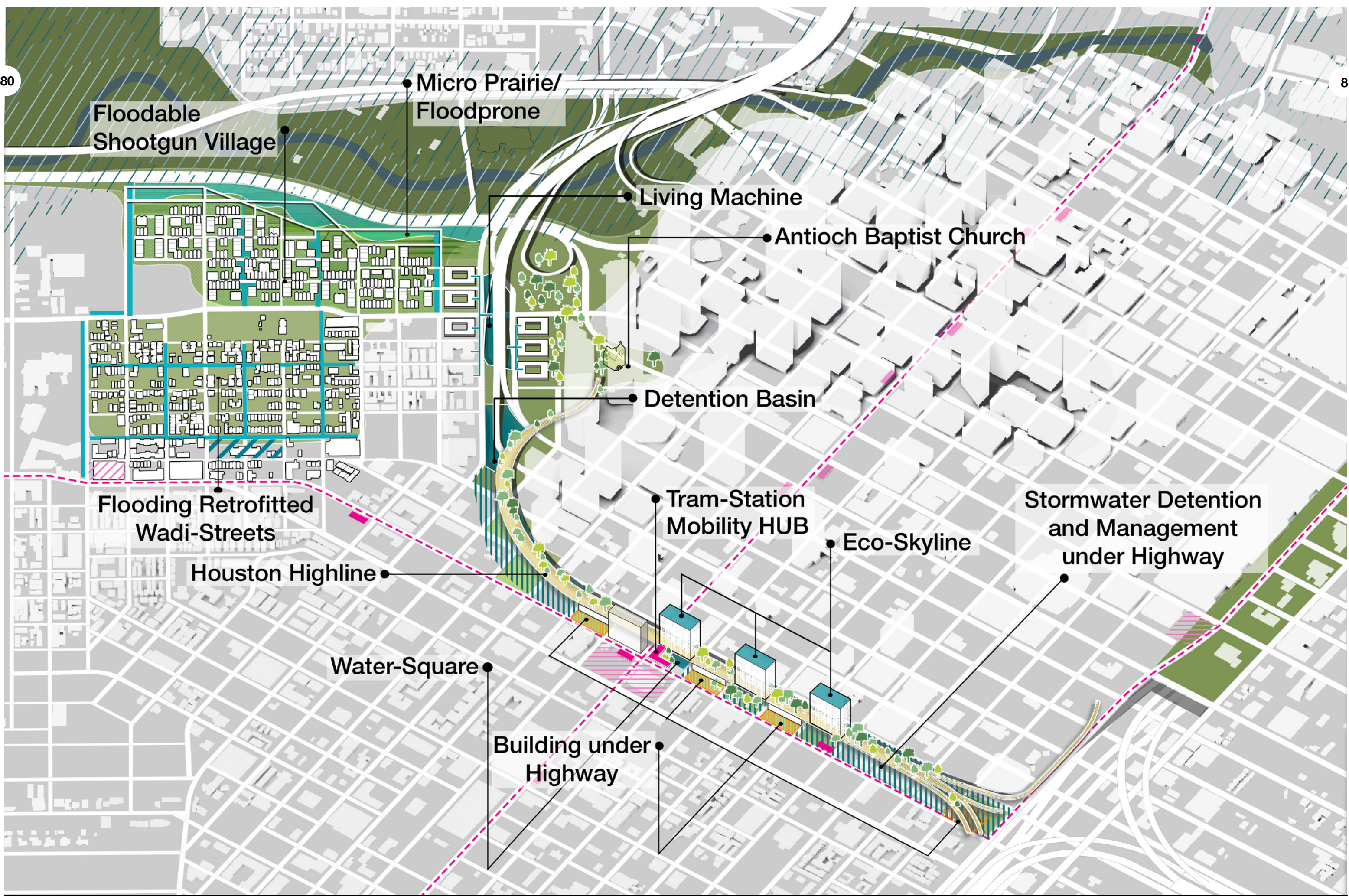
Another goal for the mobility program is to promote active modes. Right now, it is feels not ‘natural’ at all to walk in Houston. This is mainly due to the dominance of the car use and the street design that enhances this. It is clear that Houstonians like to be in the outside though. Along the Buffalo bayou there are lots of people recreating. Only, this rare and precious peace of pedestrian friendly land is cut off of by two barriers, the Allen parkway (figure 9) and a gated



Figure 9: Allen Parkway (Cohen, 2016)

community. In order to make the bayou accessible by foot and increase interaction with the 4th ward these barriers are removed. (Ancieas, Jones, & Mindell, 2016)

The highline creates an important new pedestrian and cycling friendly corridor towards and alongside downtown. The redesign of the



4.4 NECKLACE CONCEPT

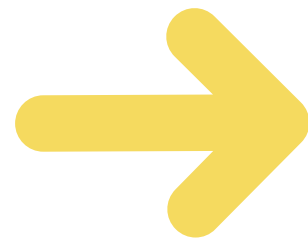
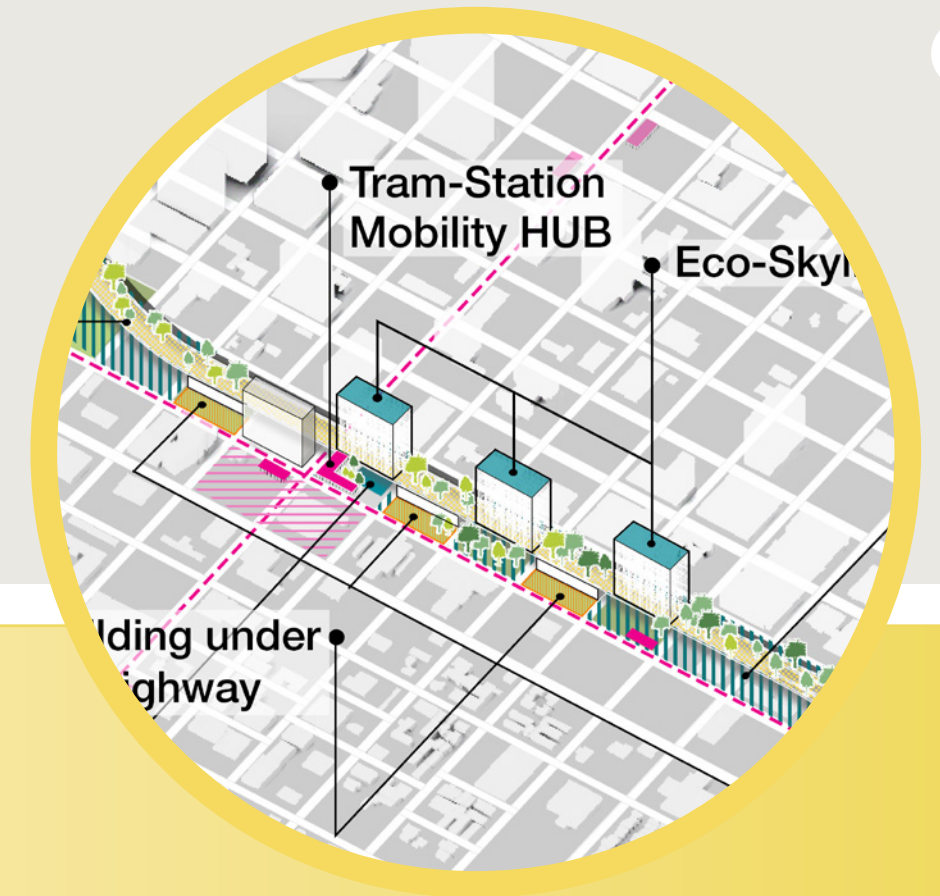
4.5 HIGHLINE



81 | *The layered character of the Interstate 45 and its potential as a repurposed structure for urban mobility, recreation and ecology*

4.5 HIGHLINE

S2N SYNERGY 2 NETWORK



AREAS

The space for synergy principle

The plan creates spatial conditions for synergy between the flows of alternative mobility and urban ecology and creates involvement/negotiation between today's and future actors.

FLOWS

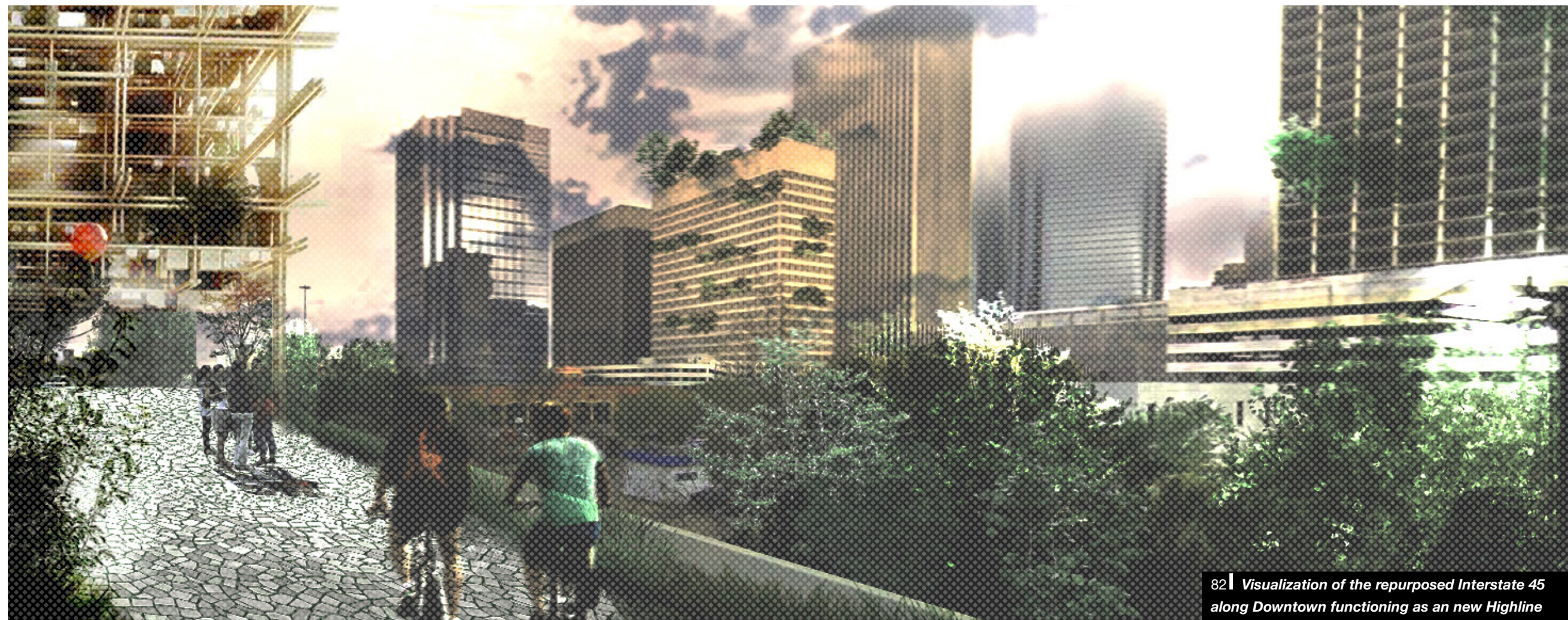
The synergy with areas and actor's principle

Creating conditions for synergy of different activities like watermanagement, mobility, recreation, commerce and residential development.

ACTORS

The planning as learning principle

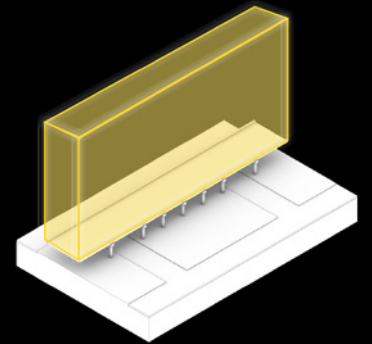
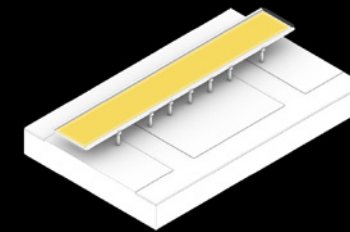
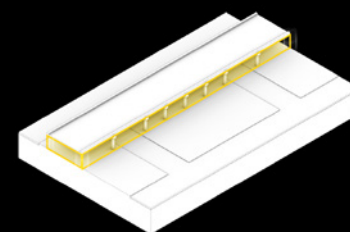
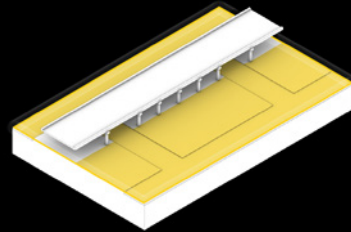
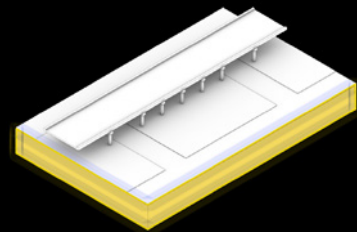
Finding synergy between interests and activities in the perspective of innovative developments along the new Highline can be a best practice for future developments within Houston.



82 | Visualization of the repurposed Interstate 45 along Downtown functioning as an new Highline

4.5 HIGHLINE

LAYERED CHARACTER



SUBSOIL

STREETSCAPE

UNDER FREEWAY

HIGHLINE

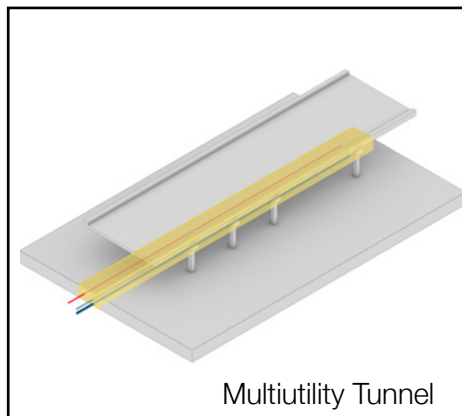
ONTOP FREEWAY

LAYERED CHARACTER

The subsoil underneath the structure will function as space for managing and accomodating utilities like electricity, storm- and wastewater pipes. During the deconstruction of many parking lots, the subsoil can be filled with water-storage boxes, holding back the rainwater and let the city function like a sponge.

The streetscape can be redefined on many different ways. Public spaces like watersquares and pocket parks can occure on former concrete desserts and wastescapes. Pre-fabricated buildings and constructions can be implemented between surface and elevated Freeway. Thorough a mix of recreation, shops, bars, restaurants and parks a walkable/bikeable version of a sustainable stripmall occures between Mid- and Downtown. The area on top of the Interstate will transform into a second layer of a bikeable and walkable „Highline“.

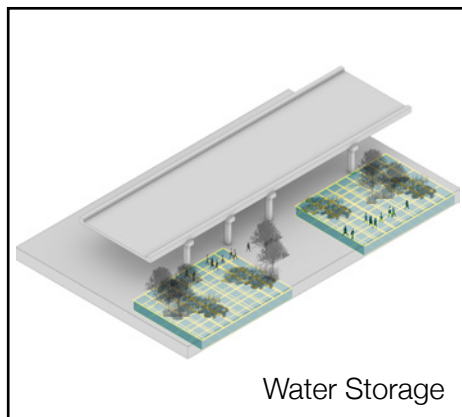
Last but not least, an „Eco-Sky-line with residential and business development will appear on top of some segments of the Highline, attracting incestors and developers.



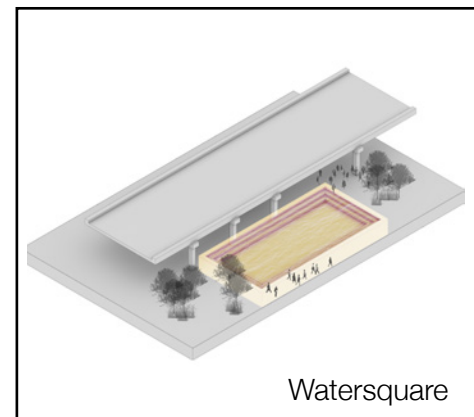
Multiutility Tunnel



83 | *Mobility Hubs*



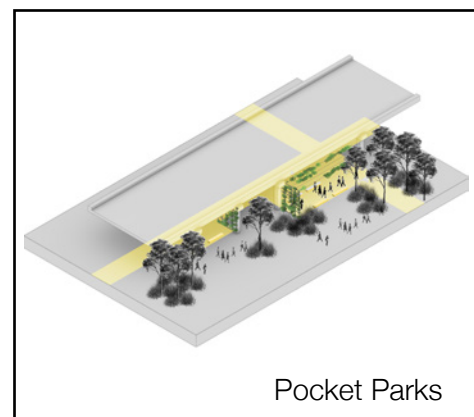
Water Storage



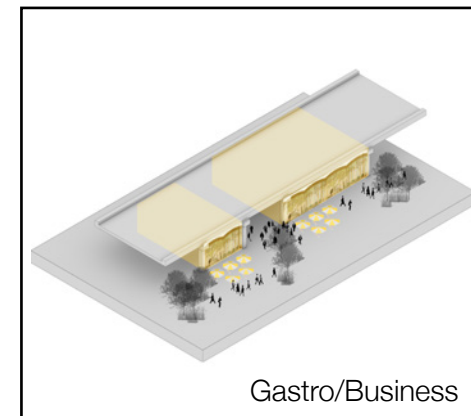
Watersquare



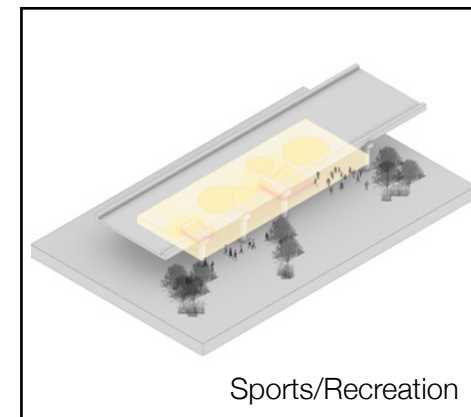
84 | *Car Parking*



Pocket Parks



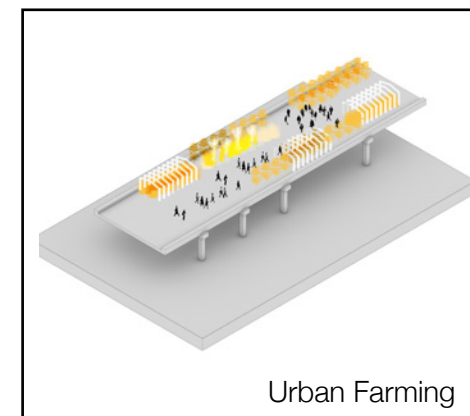
Gastro/Business



Sports/Recreation



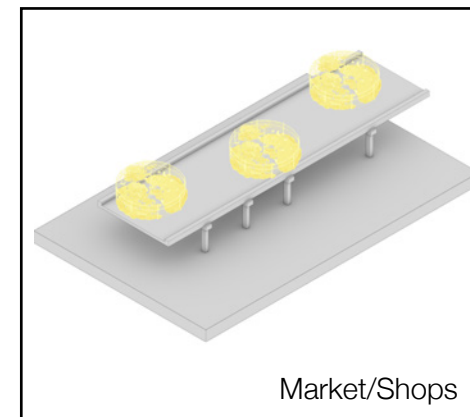
87 | *Open Air Cinema*



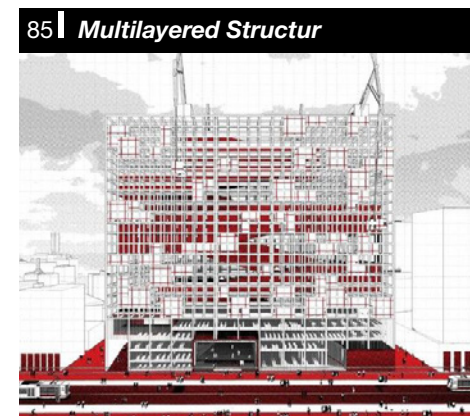
Urban Farming



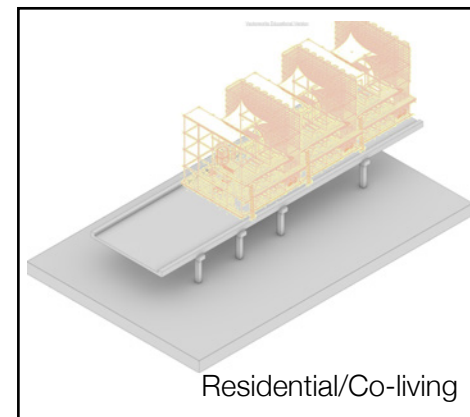
86 | *Connecting Elements*



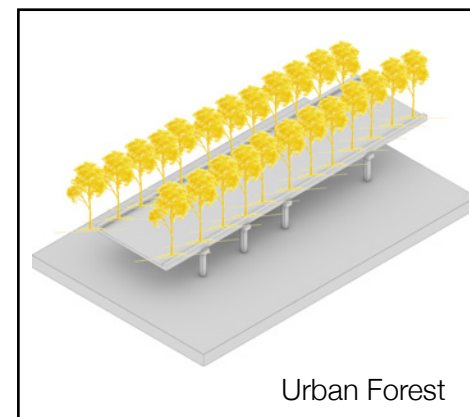
Market/Shops



85 | *Multilayered Structur*



Residential/Co-living



Urban Forest

4.5 HIGHLINE

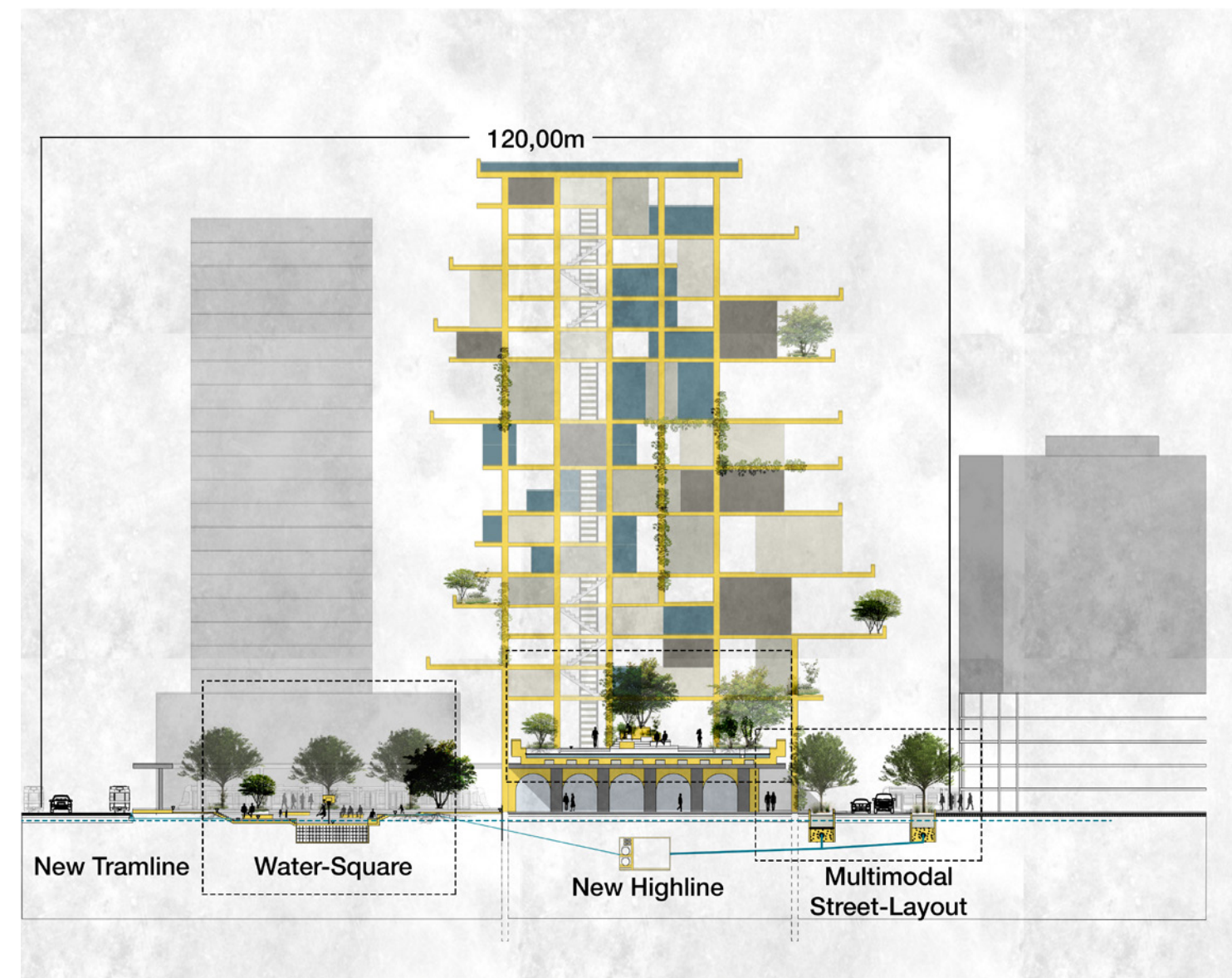
SECTIONS



88 | Visualization of the Eco-Skyline on top of the repurposed I-45



BEFORE: A section of the I45 between Downtown and Midtown showing the space dedicated to cars on different layers. The unwalkable and unattractive area creates a barrier between different neighbourhoods. A high level of impervious surface increases run-off and intensifies the risk of flooding.

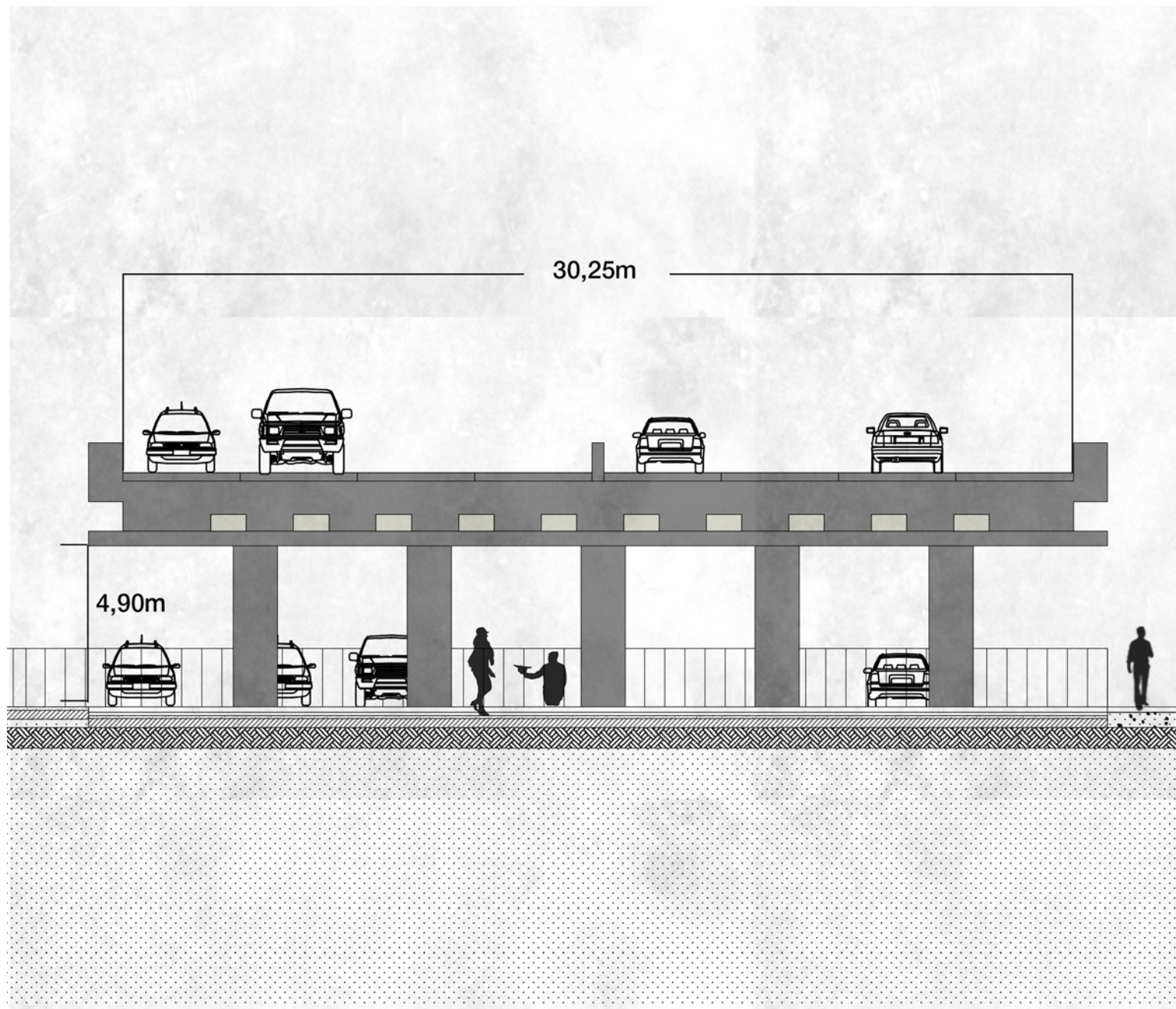


AFTER: The repurposing of the I-45 brings back a vibrant and liveable public space. Different layers of walkability as well as bikefriendly infrastructure reconnects former seperated areas. Interventions, from simple urban greenery to complex water-storage facilities and recreational implementations increase the quality of urban live and ecology.

4.5 HIGHLINE

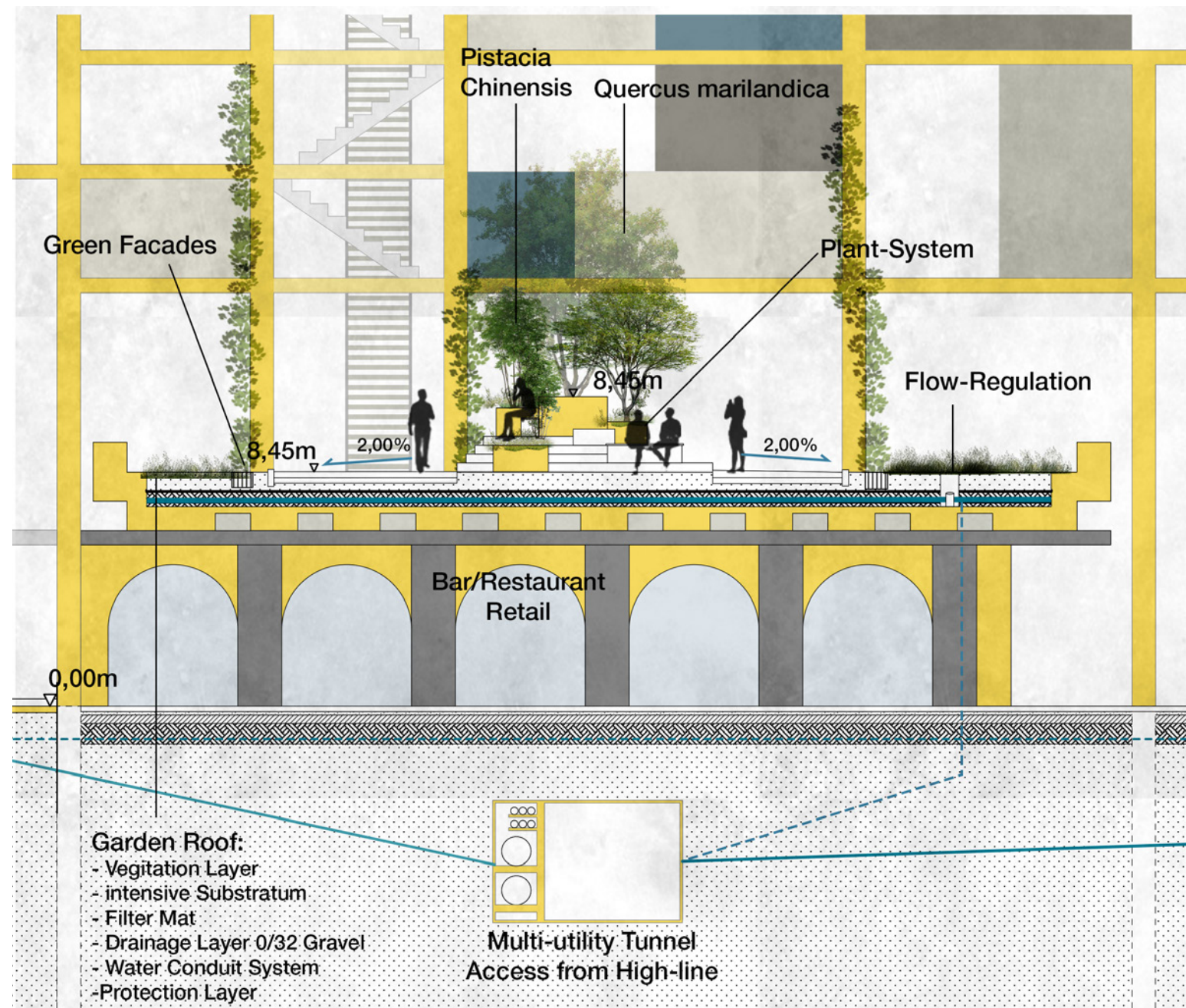
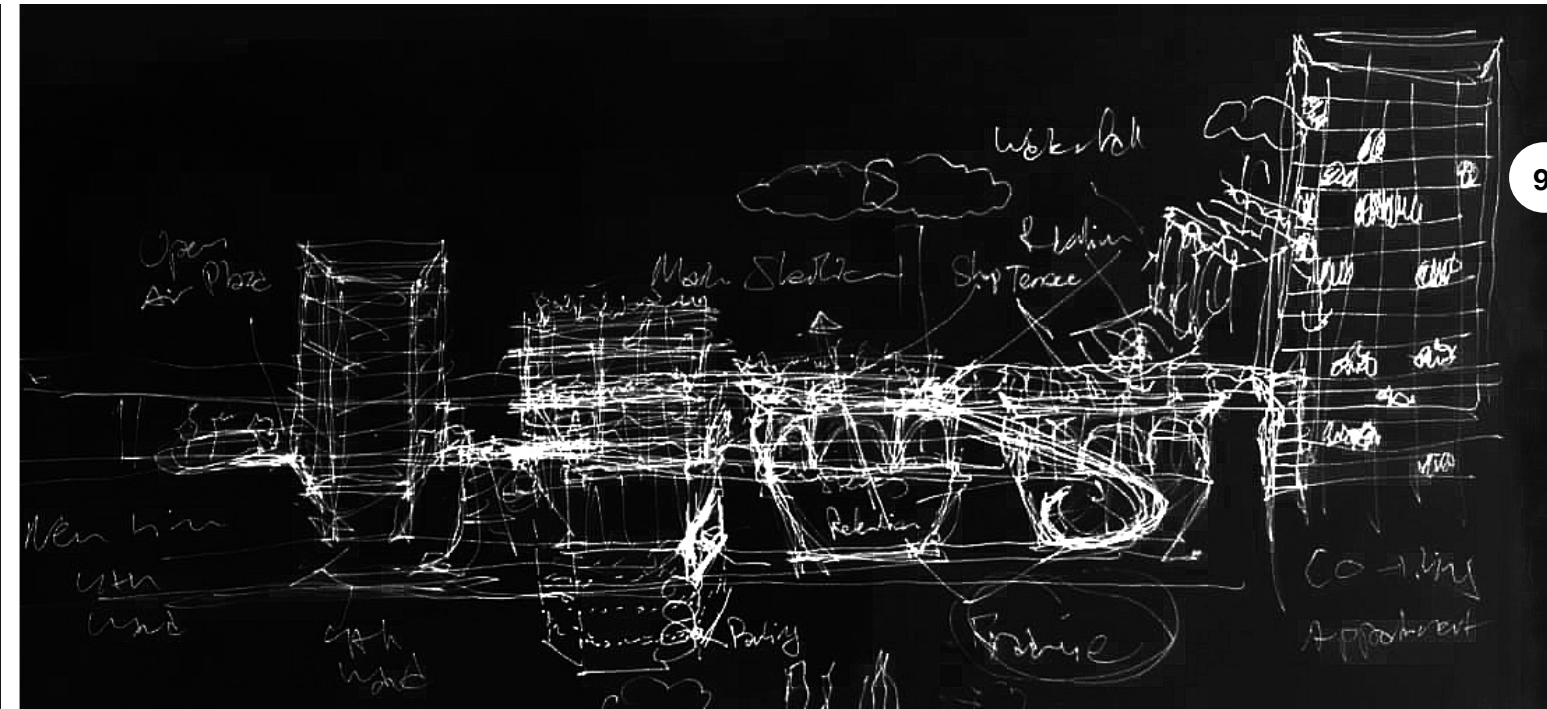
SECTIONS

90



BEFORE: Detailed/zoomed-in section of the actual Interstate and its car-orientated infrastructure/facilities

91

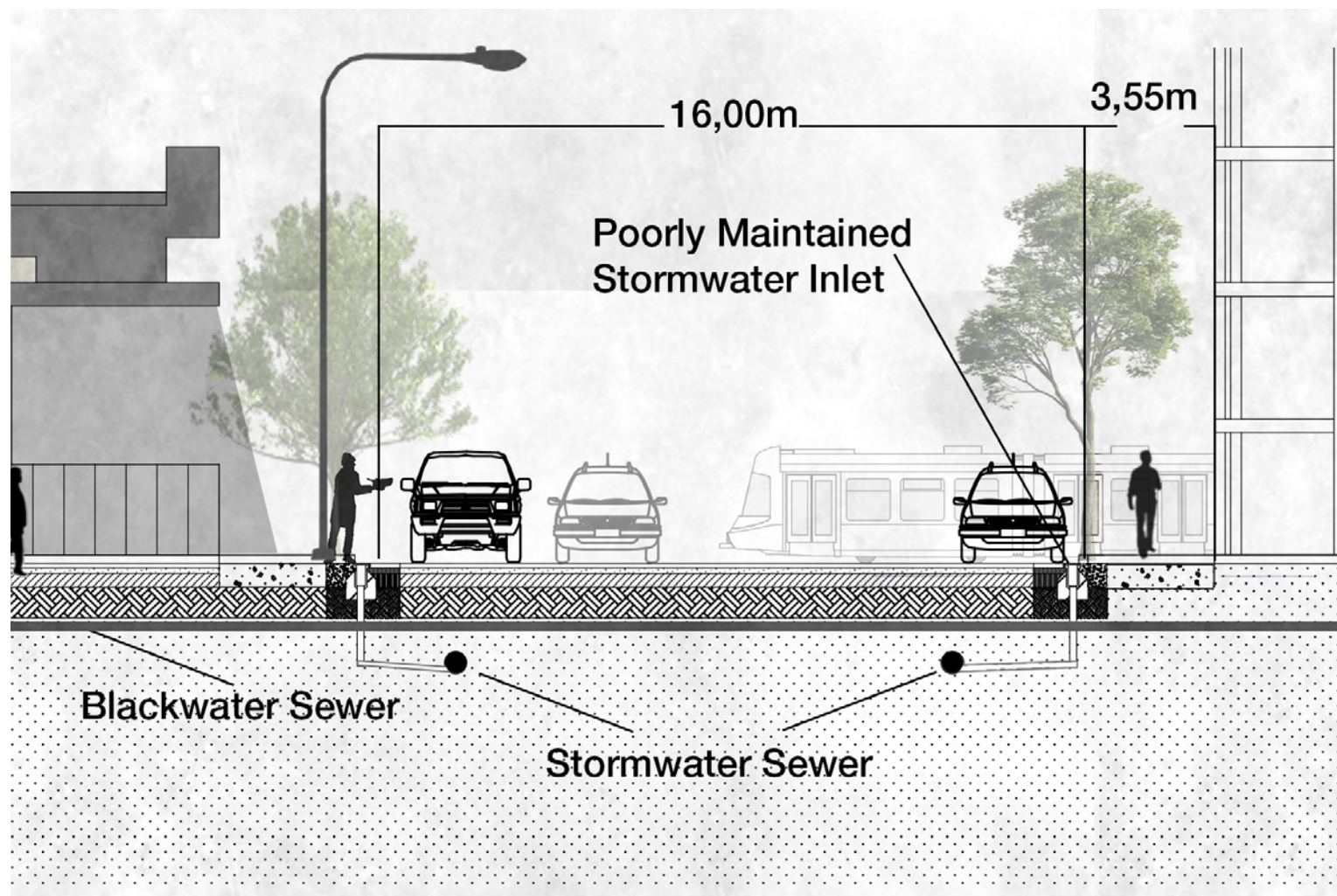


AFTER: Detailed/zoomed-in section the new Highline, combined with new residential development on top, as well as various potentials underneath the structure

4.5 HIGHLINE

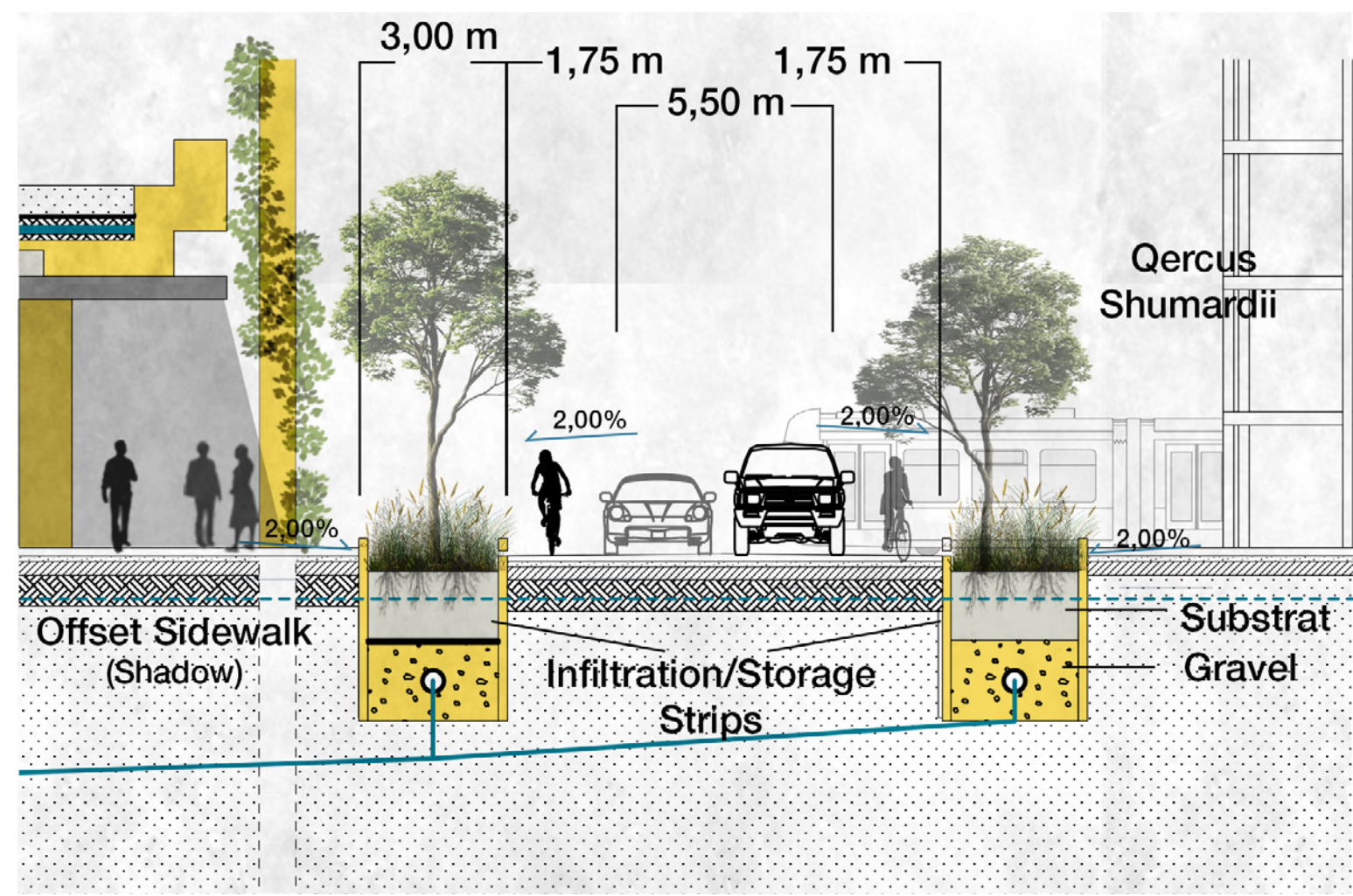
SECTIONS

92



BEFORE: Detailed/zoomed-in section of the current street-level situation along I-45

93

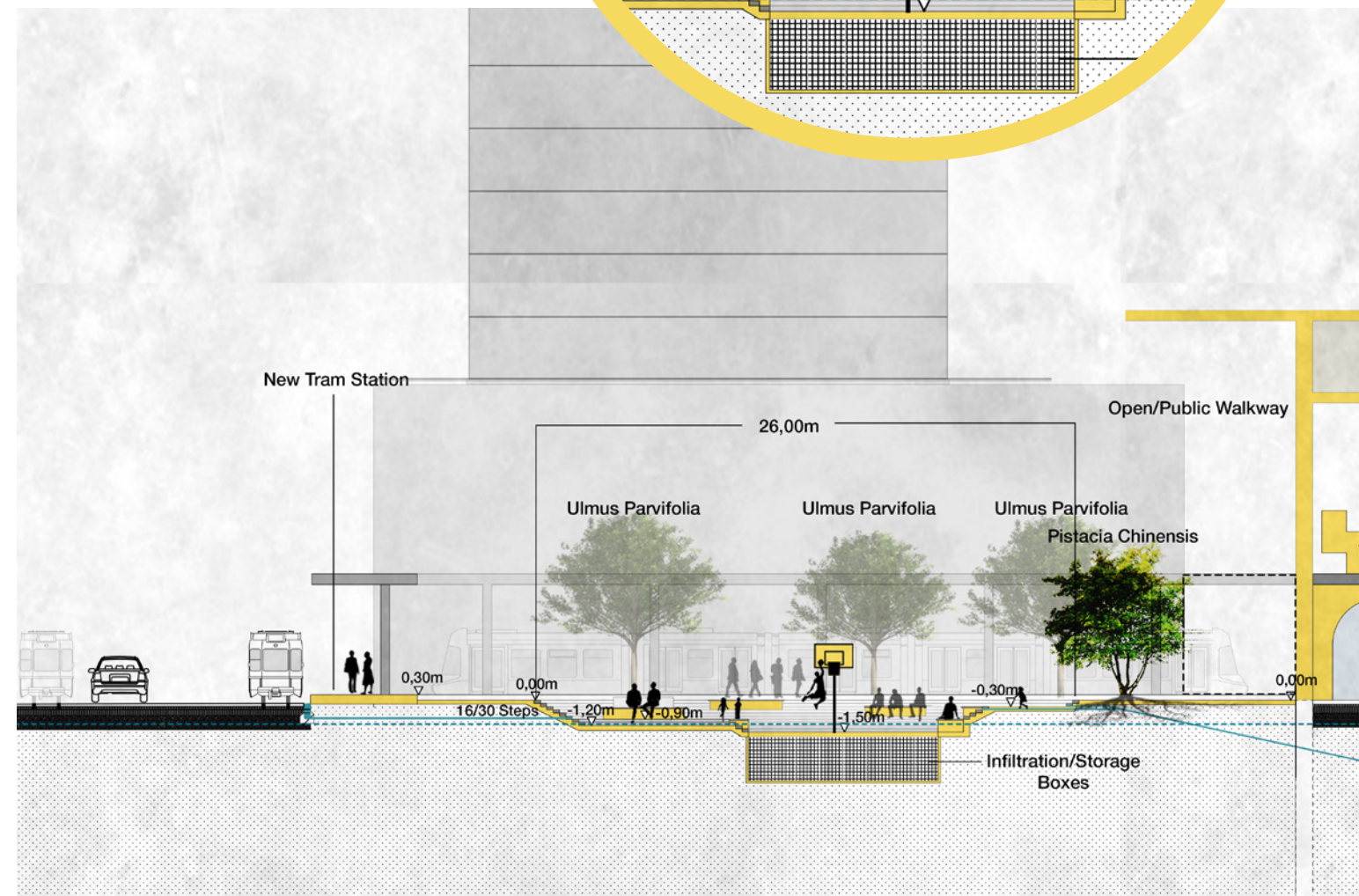


AFTER: Detailed/zoomed-in section of the current street-level situation along I-45. Reduction of the car-dedicated space creates new room for alternative mobility, like bikes, as well as adequate ecologic storm-water facilities, decreasing the run-off from paved areas.

4.5 HIGHLINE SECTIONS



BEFORE: Detailed/zoomed-in section of functions and activities along I 45.



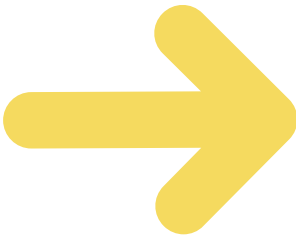
AFTER: Detailed/zoomed-in section of new potential public amenities purposing different functions like, recreation, mobility and storm-water management.

4.6 LIVING MACHINE



89 | *Constructed Wetlands Renaissance Park, Chattanooga, Tennessee*

4.6 LIVING MACHINE



AREAS

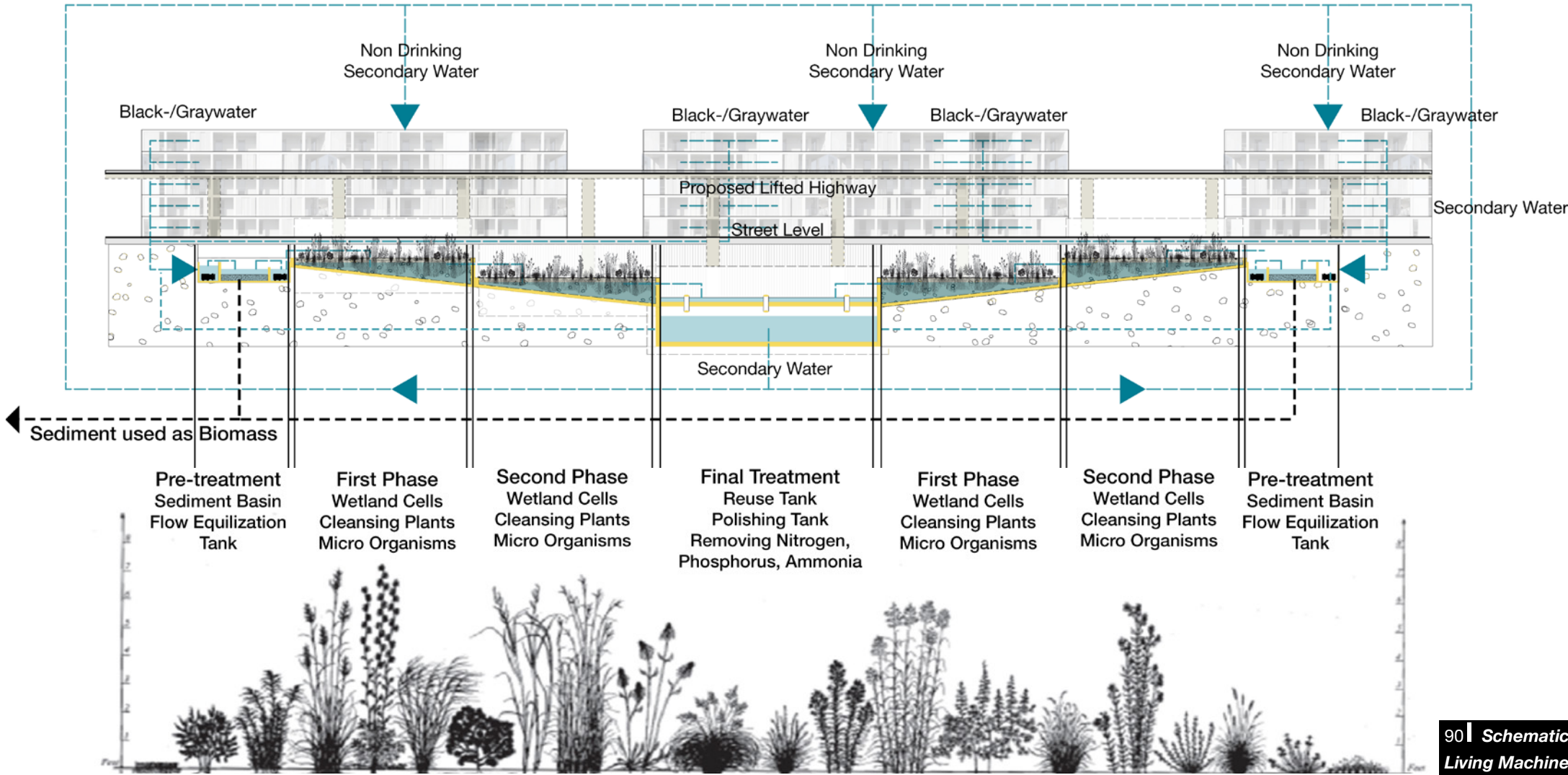
The sublayer principle
Already existing, natural as well as man-made structures and processes set the base for the design.

FLOWS

The economical use principle
The reduction, reuse and recycling of water can give great economic benefits, but also creates awareness about more sustainable lifestyles.

ACTORS

The making visible principle
Visible flow management and involvement in natural processes in the landscape can function as pilot projects, to educate and create awareness, for further sustainable developments.

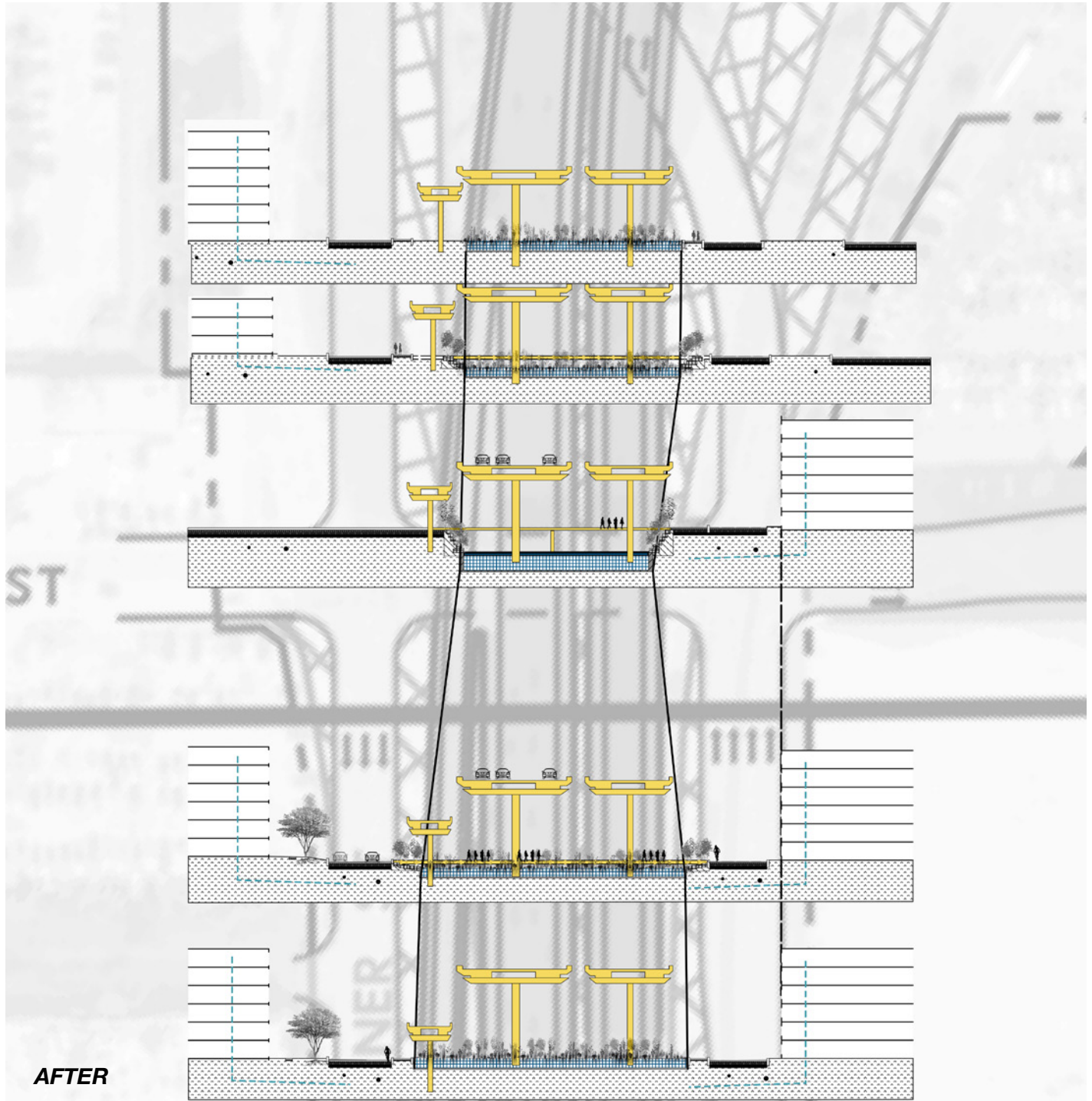
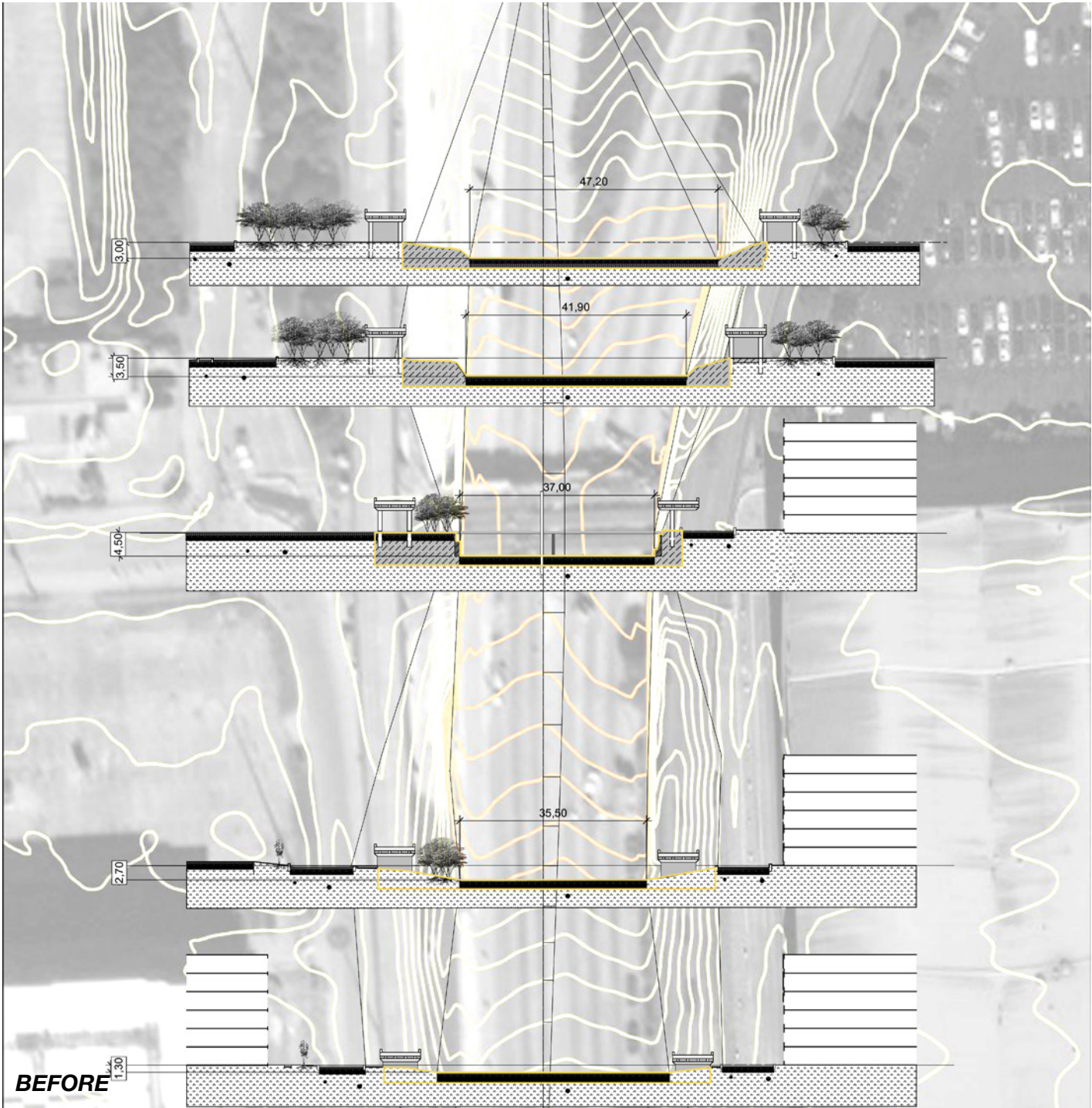
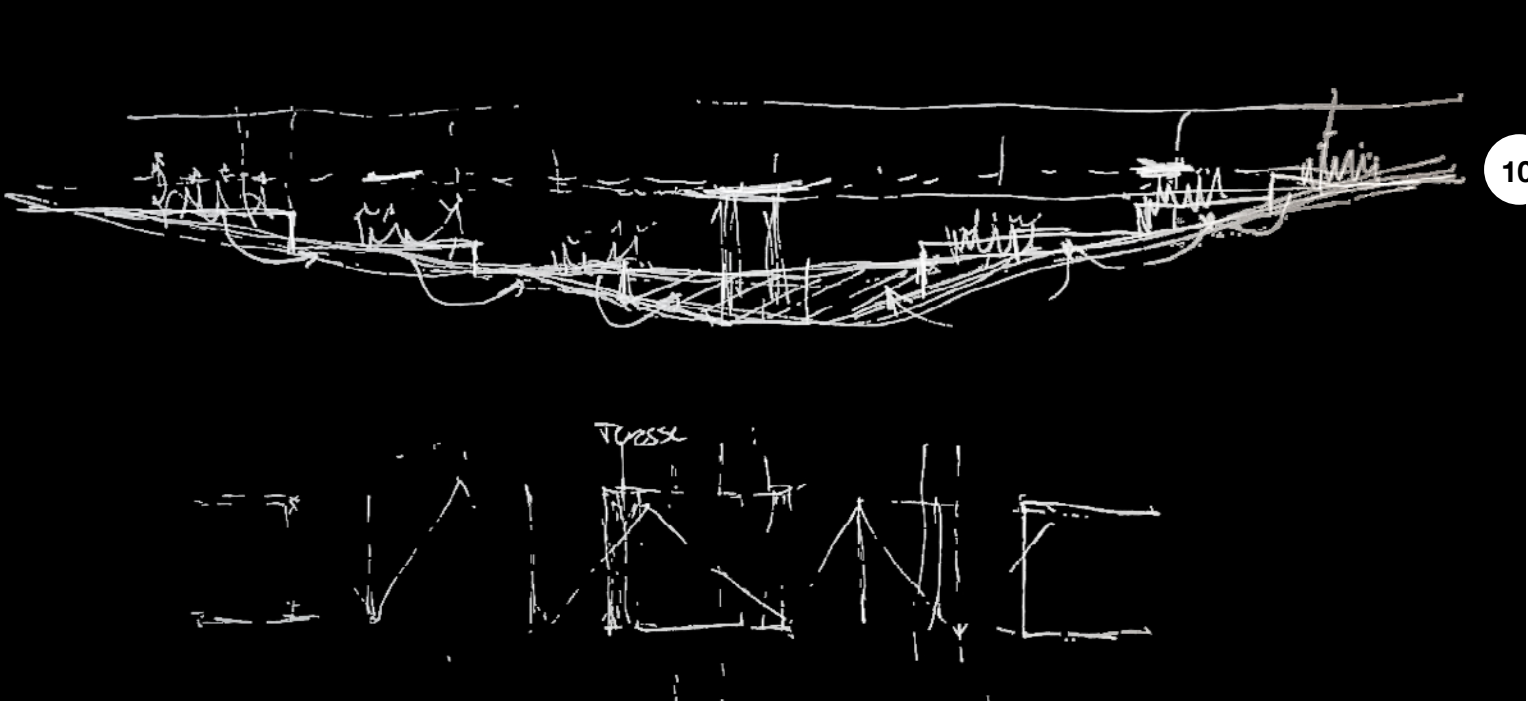


90 | Schematic Section
Living Machine under Highway

4.6 LIVING MACHINE

TECHNICAL SECTIONS

From analyzing the topography of the built environment as well as by studying the new proposals for the redevelopment of the Interstate 45, we found out, that some of the former sunken parts of the obsolete I45 can be reused and refunctioned. Their topography will be used for different ways of water-storage. This specific part of the Interstate divides the 4th Ward and Downtown from each other. Due to a planned elevation of the street, space on the surface area becomes free. We want to use this space for creating a multifunctional area where the slope is redesigned into a large scale living machine, where recreation, connection and education are integrated parts of the new development.



4.6 LIVING MACHINE

TECHNICAL SECTIONS

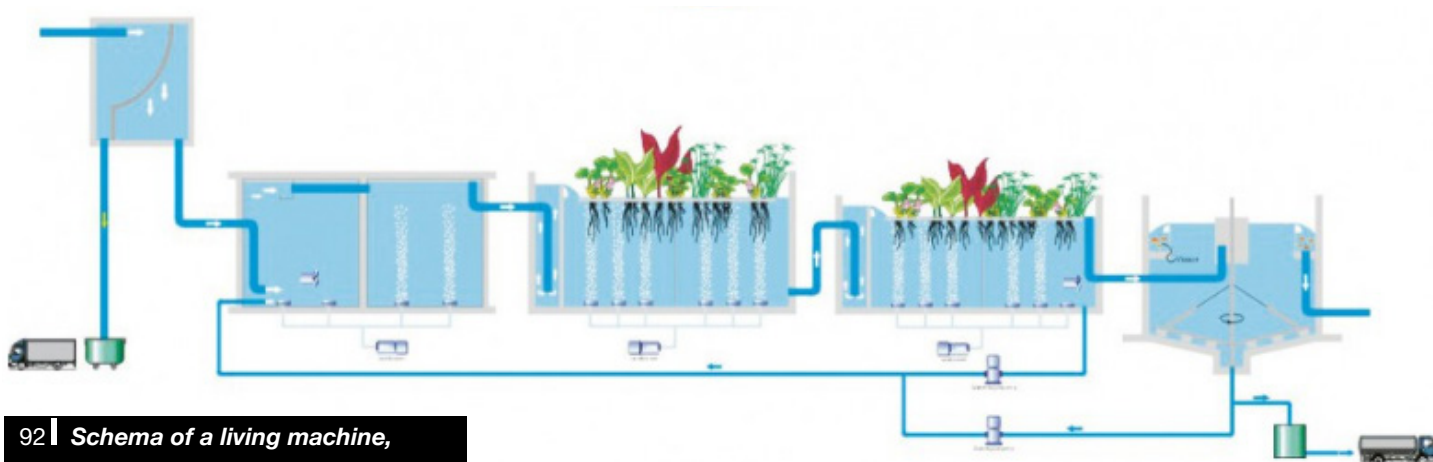
Living Machine, Eco Machine or somehow similar, are human-made, nature based systems, where black- and greywater from houtholds or offices is retreated in a biological process.



91 | **Eco-Machine- Omega Institute Center for Sustainable Living**

Saving valuable drinking water is a big task in the city of Houston. During the dry months, many sprinkling systems, fed by fresh water, can be seen in frontlawns all over the city. But also the fact, that a large amount of waste water is mixed with freshwater inside the large scale, centralized water treatment plants and groundwater wells, is reason enough to think about smarter, more ecological friendly and decentralized ways of treating and reusing black- and greywater in Houston.

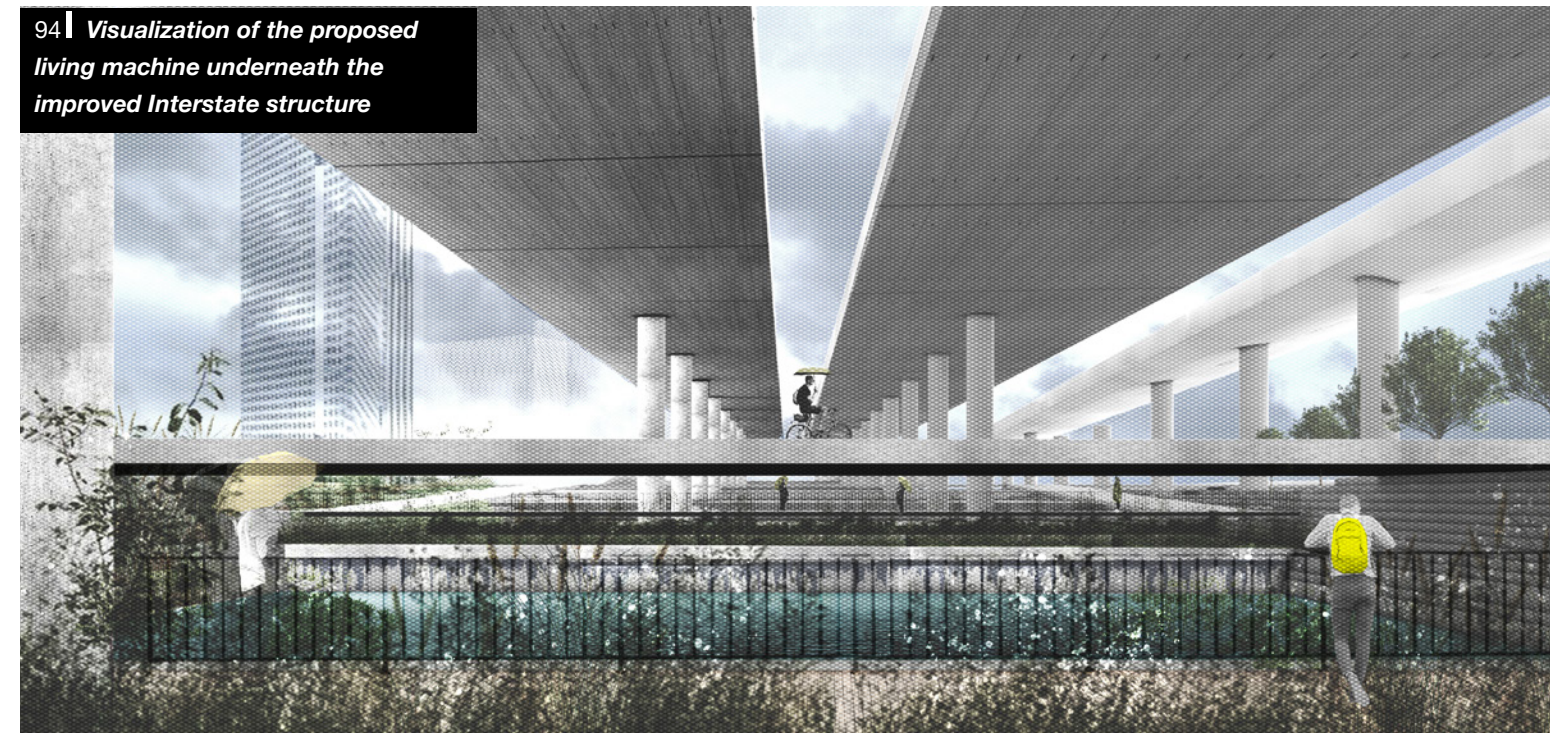
Right now, Houston treats most of its waste water with chlorine, to kill harmful bacteria. Eventhough the chemicals are approved for use in drinking water, a more ecological and sustainable solution could be implemented and function as a pilot project to realize decentralized wastewater treatment systems in the city. As the schematic section shows, black- and greywater is pumped from the neighboring residential areas towards the living machine.



92 | **Schema of a living machine, Emmen Zoo, Netherlands**



93 | **Current situation of the I-45**



94 | **Visualization of the proposed living machine underneath the improved Interstate structure**

In a first step the water stays inside a sediment basin, where bigger particles settle, sink to the ground and can be reused as biomass. During this anaerobic process, microorganism start to pre-treat the waste water. The so called flow equalization tank guarantees a steady flow of water which is important for the further treatment. In phase one water travels along the the length of the former freeway into the first constructed wetland. This kind of basin is filled with gravel and plants like bull rush and cattail. Microorganisms

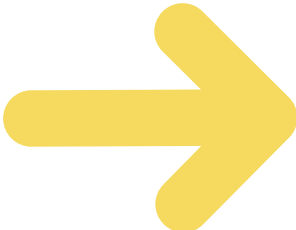
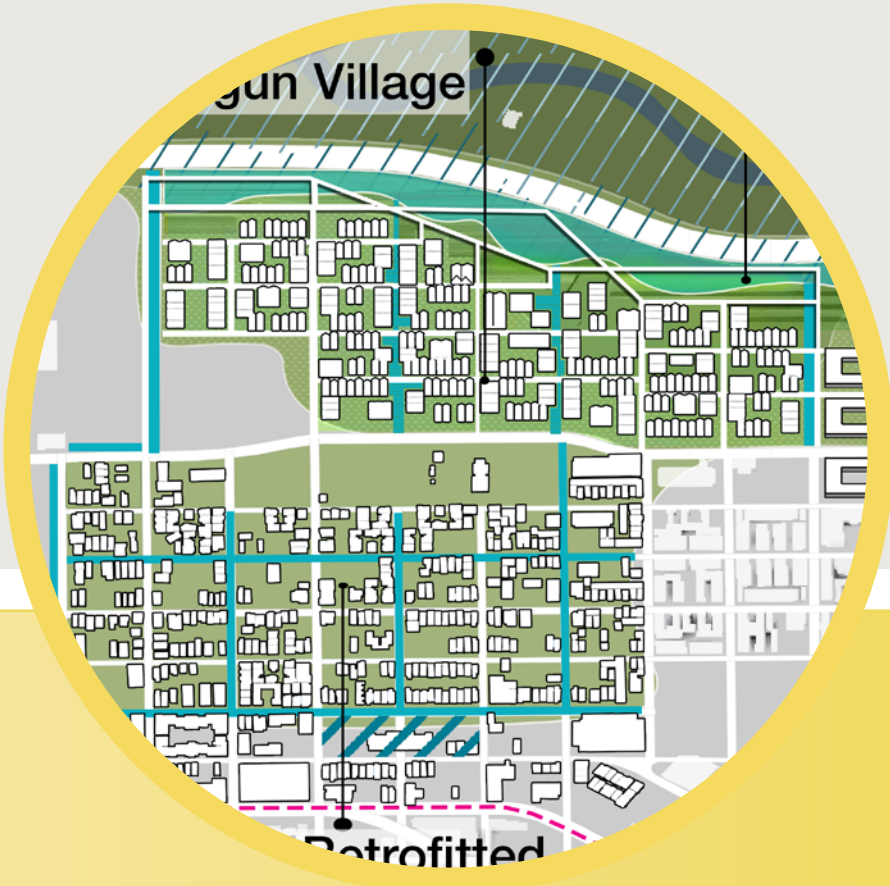
start digesting bacteria and particles. Roots clean the water from nutrients using them for their growth. Thorough gravity, water flows from one end of the wetland to the other. As the water starts to clarify it flows into a second phase, where the same process gets repeated. Finally the water ends up in a basin where the quality is controlled. If the cleaning process was successfull, the former waste- and greywater will be reused for secondary processes, like flushing the toilet, cleaning, or watering the garden.

4.7 FOURTH WARD



95 | Abandoned Shotgun houses, 4th Ward

4.7 FOURTH WARD



AREAS

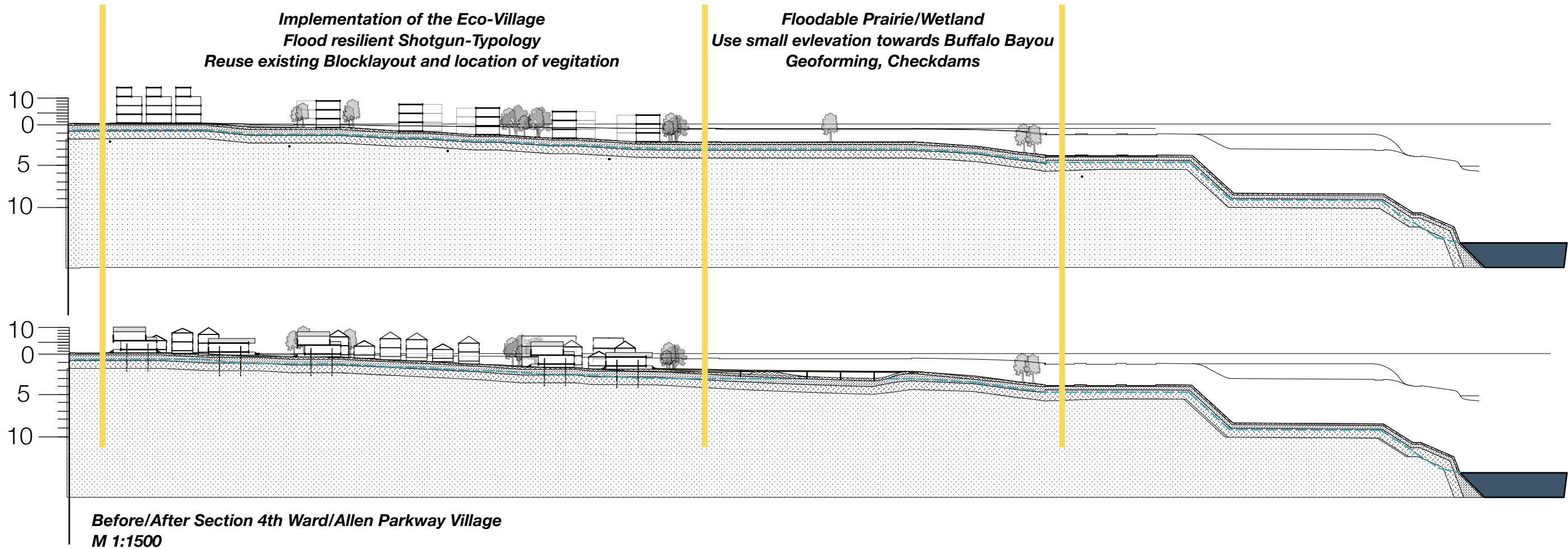
The sublayer principle
Already existing, natural as well as man-made structures and processes set the base for the design.

FLOWS

The economical use principle
Storing and reusing run-off water can not only prevent those areas from flooding but also creates economic benefits within the neighborhood.

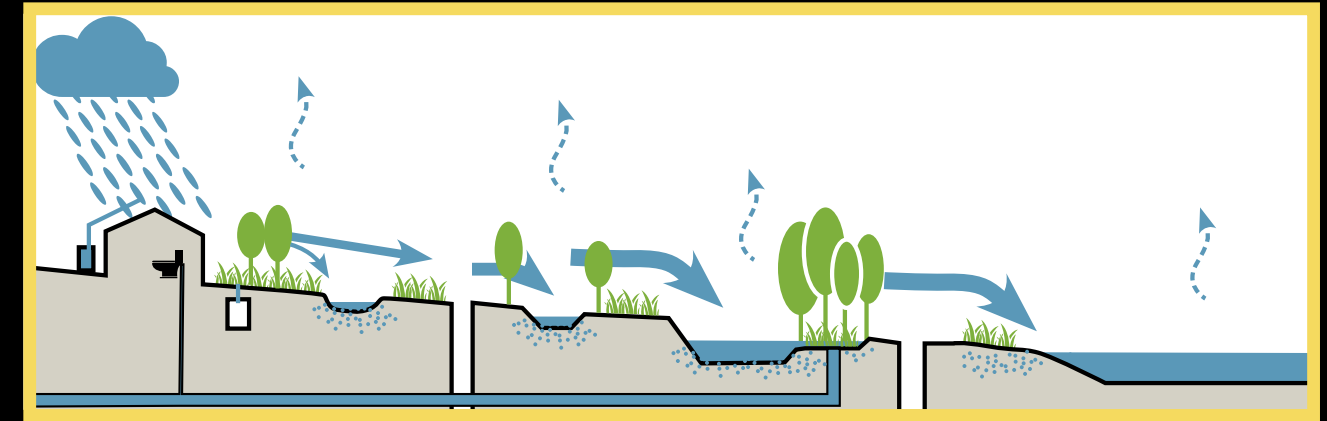
ACTORS

The making visible principle
Visible flow management and involvement in natural processes in the landscape can function as pilot projects, to educate and create awareness, for further sustainable developments.



4.7 FOURTH WARD

PLANNING WITH NATURE



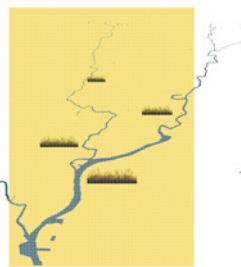
WATER

PROGRAMM

ECOLOGY

ENGINEERING

EDUCATION



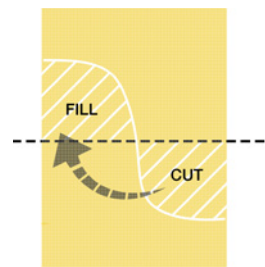
Create Wetlands



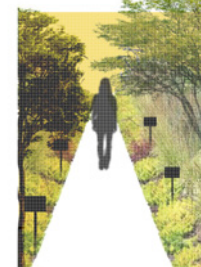
Accessible for all



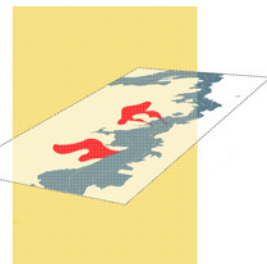
Urban Agriculture



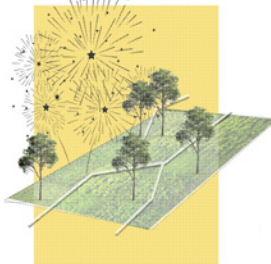
Reuse Materials



Arboretum



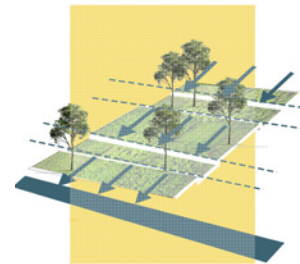
Controlled flooding



Event Space



Regreenation



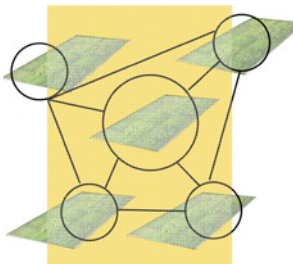
Create Topography



Involve Residents



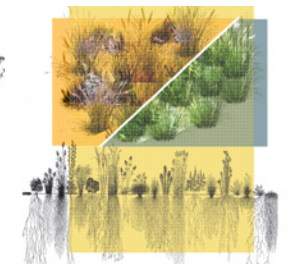
Visible Water



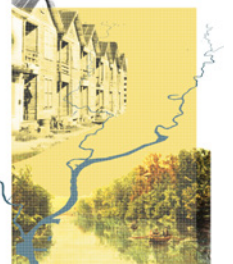
Pilotproject



Pollinators



Smart Vegetation



Involve History

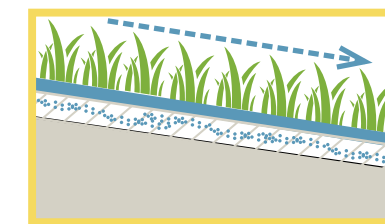
The main vision for the area of the Fourth Ward is to reshape the environment towards a ecologically sustainable town-village, that values not only its connection to natural processes in the city but also refocuses on its historic characteristics.

Due to adaptations in the aspect of **WATER, PROGRAMM, ECOLOGY, ENGINEERING AND EDUCATION** the new Fourth Ward becomes a water resilient neighborhood in which people live with water and nature instead of keeping it out.

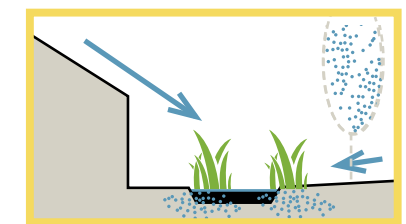
The principle of a city functioning as a sponge (**Slow Down, Store/Reuse and Drain**) slowly into the close by Buffalo Bayou) reduces the stress on the Bayou during heavy precipitation (*Chan et al. 2018*).

The build environment is going to change and adapt. Especially the redevelopment of the former gated community "Allen Parkway Village" can be seen as a experiment of "how to build in floodplains". But also in parts of the historic Fourth Ward already existing structures will be retrofitted.

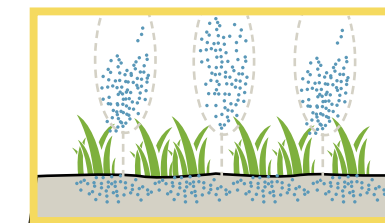
SLOW



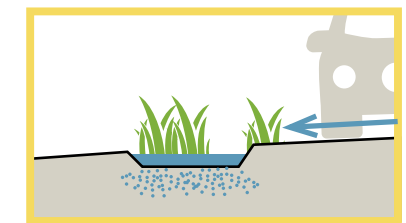
Green Roof



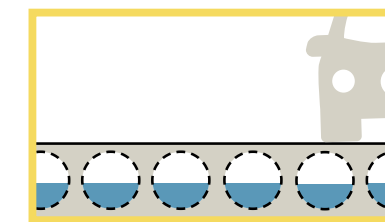
Rain Garden



Plants

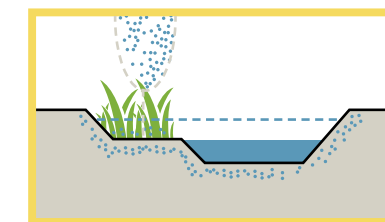


Bioswale

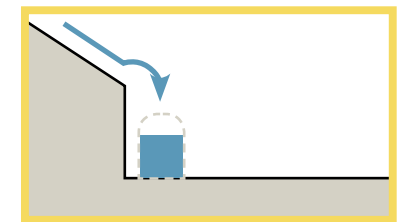


Subsurface Storage

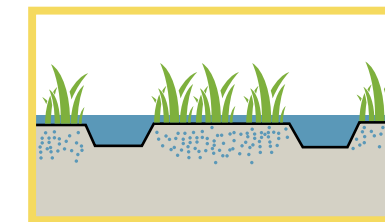
STORE & USE



Improved Canal



Harvesting



Internal Wetlands

4.7 FOURTH WARD

BUOYANT FOUNDATION

Different to buildings that are constructed permanent on to of stilts, amphibious houses sit on dry land like ordinary buildings. Only in times of flooding, special mechanisms give them the capeability to rise with the waterlevel and float until the flood recedes. This type of flood adaptive construction works in synergy with the natural characteristics of floodprone areas, instead of obstructing them.



96 | Construction of a prototype Buoyant Foundation

The Buoyant Foundation

Borrowed from Dutch boie (a floating and anchored object) the Buoyant Foundation is a specific type of amphibious foundation that is specially designed for retrofitting already existing, slightly raised houses. Especially in the Fourth Ward still some of the elevated shotgun houses still exist and can be adapted to flooding. As the schematic drawing on the right page shows, the system consists mainly of

- 1) the buoyancy block underneath the existing building structure (light expanded polystyrene) which will rise the construction together with the house
 - 2) vertical guiding posts, that keep the building in place and guarantee up and down movement
 - 3) a special frame that connects the construction parts with each other.
- Due to the fact that now horizontal movement is possible, this foundations are not suitable for coastal adaption or within areas of high flow velocity. However floodings in Houston oc-cure on shallow flat and large flood-plains where the water stays long and drains slow due to the impermeable soil and other surfaces.

The benefits of implementing such a typology especially within floodplain areas in Houston are:

- The houses are only temporarily risen, which means that the city at eye-level remains and now new adapted infrastructure like pipes and cables but also paths and stairs are needed. Especially for elderly people homes that are elevated permanent are hard to reach and use.
- The construction accomodates the flooding issue but also soil subsidence
- The vertical mechanism makes it flexible for low and high flooding events
- It preserves and favours historic and traditional architecture
- Construction costs are very low compared to permanent elevated houses and compared to damage repair because of flooding.

Cost comparison Buoyant foundation and flood repair costs:

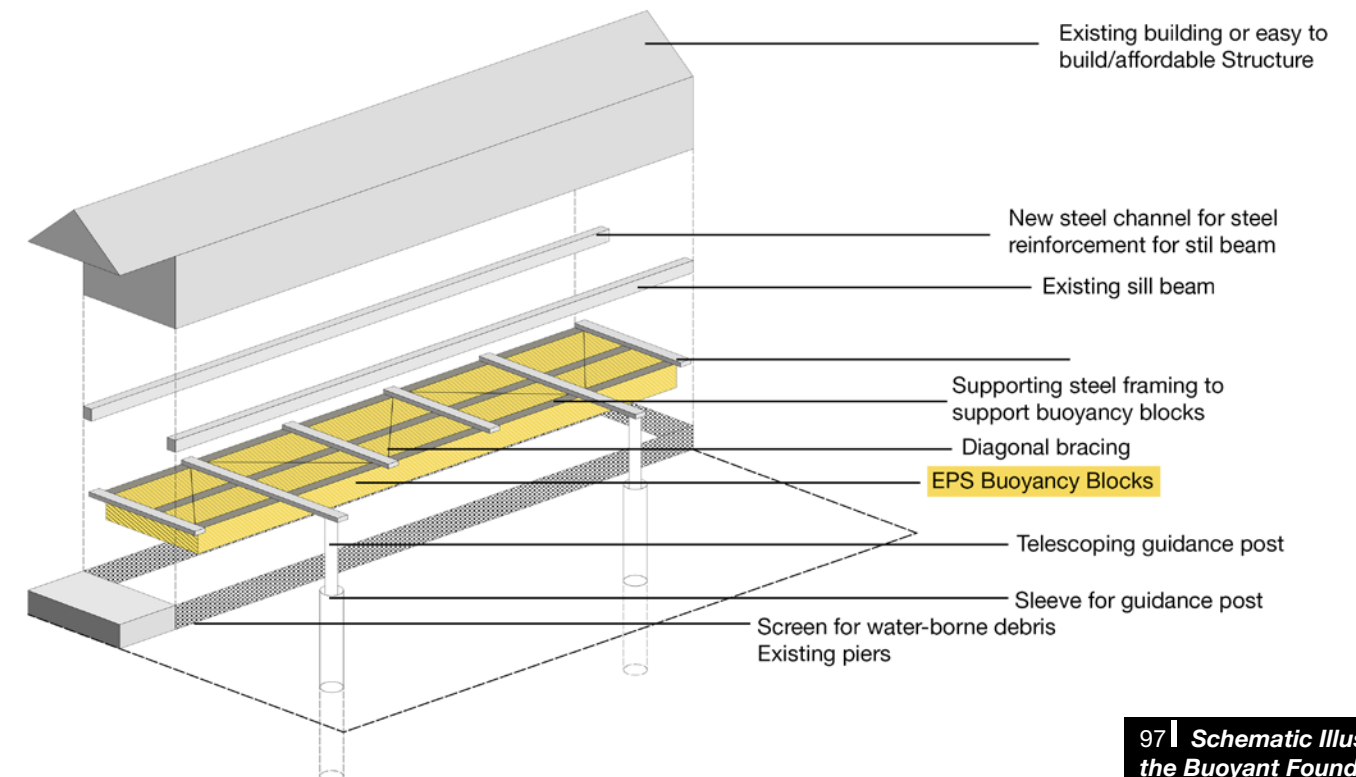
Those calculations have been made for a case-study object in Louisiana:

Vertical Guidance Posts = \$ 8,600
 Dock floats = \$ 14/sq.ft
 Marine Plywood = \$ 5.5/sq.ft
 Hurricane ties and fasteners = \$ 0.5/sq.ft (costs include installation labour)
 So, the cost of retrofitting this house with a Buoyant Foundation might be \$ 30,280

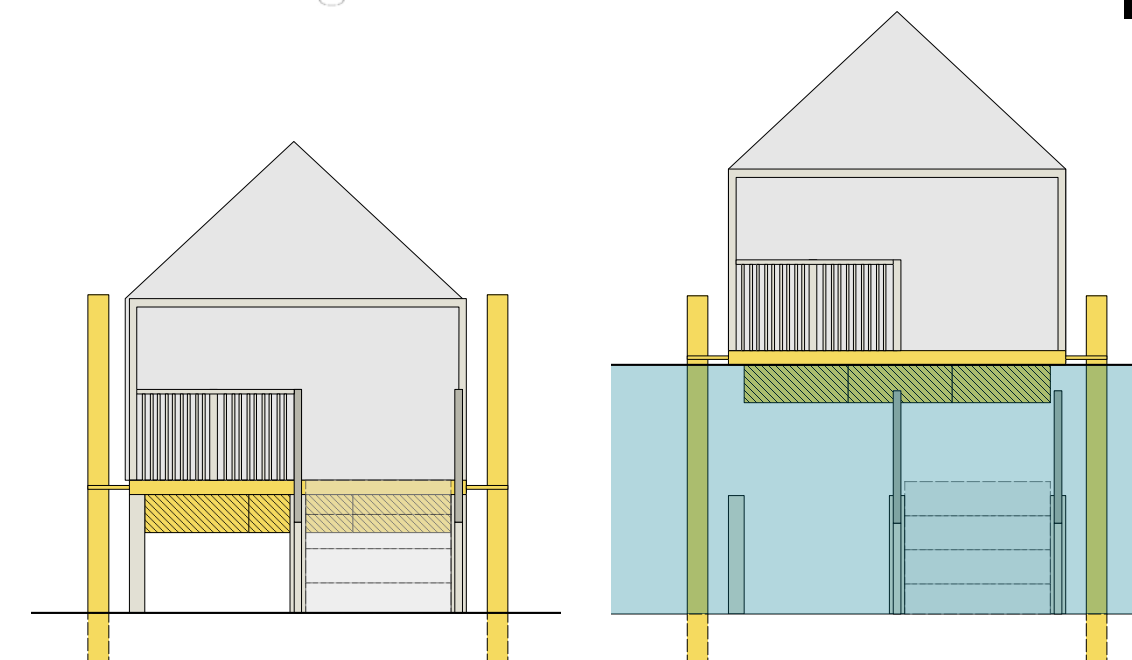
LAS (Loss Avoidance Study) looks at three categories of losses that could be avoided, if the houses were to be retrofitted with a buoyant foundation instead:

- Building Repair Costs: \$70,000.
- Contents Damage Costs \$21,000.
- Displacement Costs: 220.30/day for 2,5 people

(English, Turner, Klink 2016)



97 | Schematic Illustration of the Buoyant Foundation

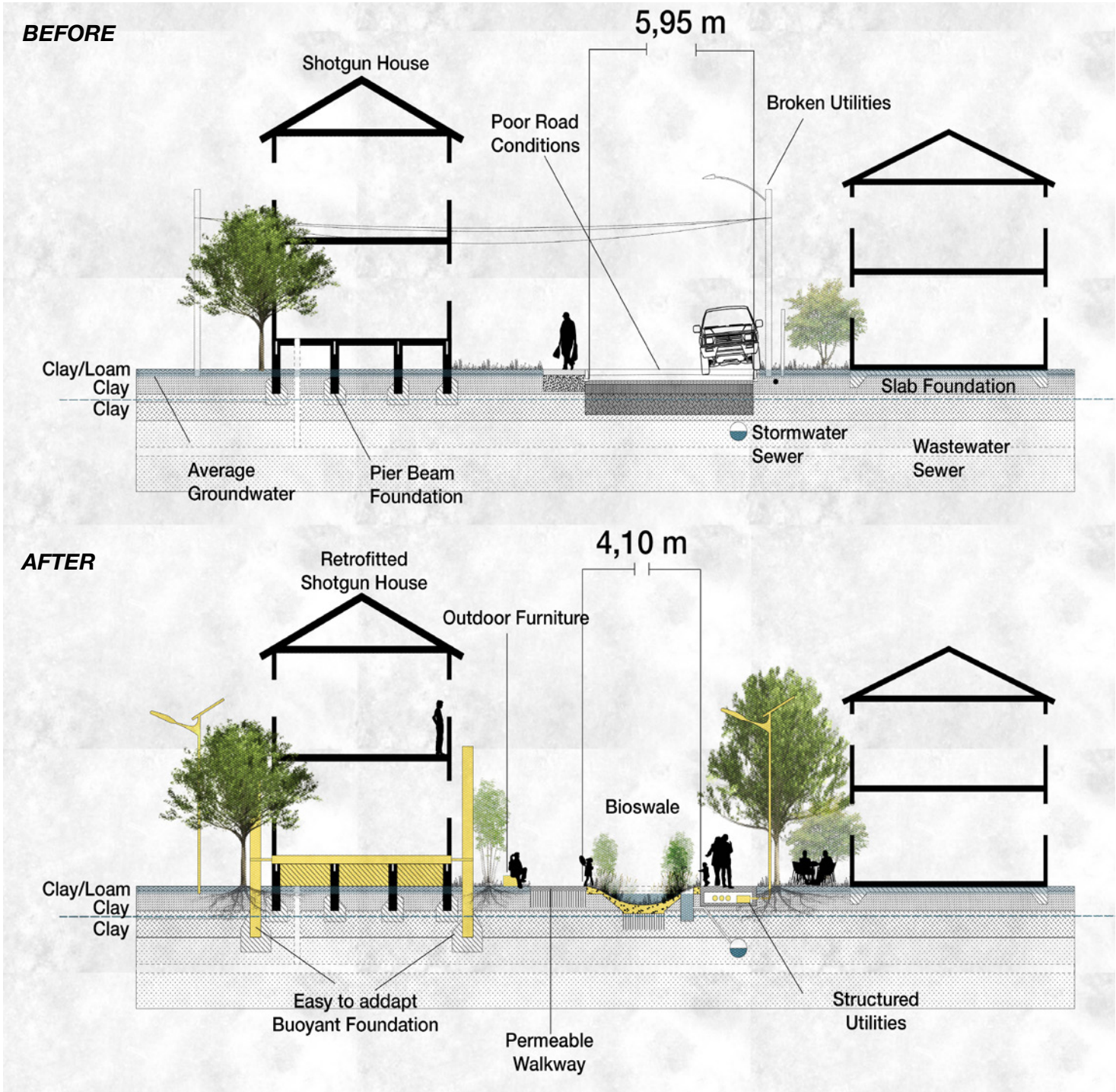


4.7 FOURTH WARD

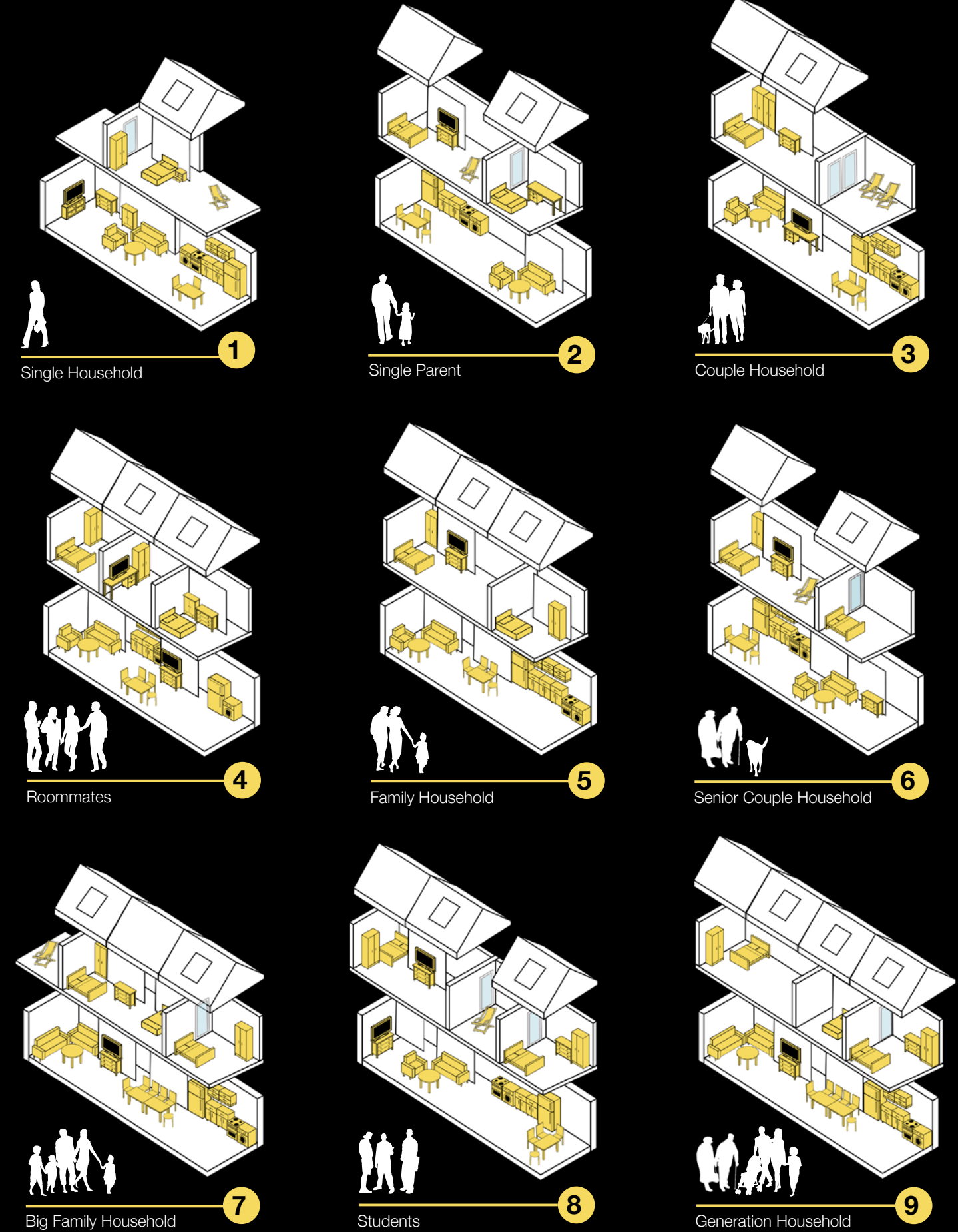
SHOTGUN HOUSES

The shotgun typology is not only adaptable to flooding, as already discussed in depth, but this form of traditional architecture is also suitable for constructing affordable and flexible living space for different

target groups. Especially in metro-politan areas like Houston, that are characterized by high urban dyna-mics and fast population growth, multifunctional and suitable typolo-gies can make the difference.



LIVING TYPES



4.7 FOURTH WARD

PLANNING WITH NATURE

“Synergy - the bonus that is achieved when things work together harmoniously.”

MARK TWAIN

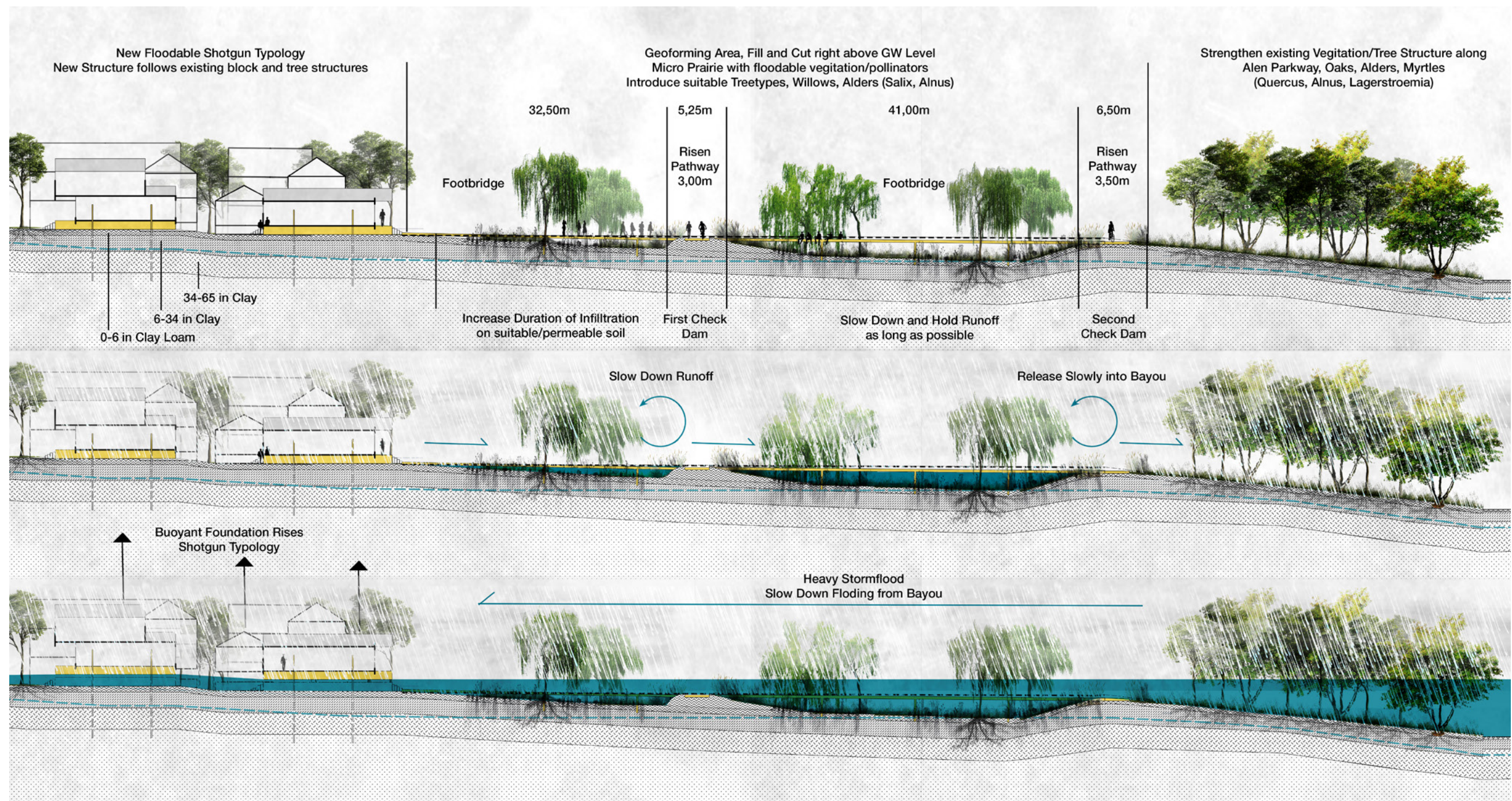
115

98 | Buoyant Foundation while flooding in Port Maria, Jamaica

The south area of the former Allen Parway Village will be transformed into a floodable prairie/wetland which is partly accessible by platforms and elevated pathways. The small change in topography towards the Buffalo Bayou will be used and transformed into small checkdams, storing and holding the rainwater before slowly draining it into Buffalo Bayou.

The section on the right shows 3 different scenarios:

- 1) most of the time the prairie/wetland will be free from surface water. The area is used for recreation and functions as habitats for flora and fauna.
- 2) The relief of deepened locations and the elevated checkdams will hold stormwater coming from the 4th Ward.
- 3) The checkdams will slow down extrem stormwater flooding coming from the Bayou. The refitted typology will flood in worst case scenario.



4.7 FOURTH WARD

PLANNING WITH NATURE

The variety of native grasses, shrubs and trees suitable for the implementation of the Prairie/Wetland would be too long to intensively discuss in this report. Nonetheless some suitable plants are listed on this page. All of them are native and origine from the area where they will be reimplemented. It is important to focus on a mixture of plants that have enough surface to slow down run-off, can handle dry and wet periods and increa-se biodiversity.



Arrowfeather threeawn
(*Aristida purpurascens*)



Texas goldentop
(*Euthamia gymnospermoides*)



Bushy bluestem
(*Andropogon glomeratus*)



Gulf muhly
(*Muhlenbergia capillaris*)



Bush's sedge
(*Carex bushii*)



Maryland meadow-beauty
(*Rhexia mariana*)



Plains coreopsis (*Coreopsis tinctoria*)



Black willow (*Salix nigra*)



99 | Visualization of the 4th Ward,
as a new ecological neighbourhood

05

5.1 REFLECTION

THIJS VAN DE WIEL

As part of the policy specialisation in my master's program of Transport, Infrastructure & Logistics I followed the course Infrastructure and Environment Method Module. I chose the policy specialisation very consciously and was curious about the courses at the faculty of architecture that are mostly concentrated in quarter 4. I am interested in mobility and transport, but also in urban planning and the interactions between these subjects.

First of all, the whole quarter was together with this course rather messy. The courses at the faculty of Architecture were all very differently organised than the rest of our program. This was also the case for the AR0093 course. I didn't know very well what to expect from it in the beginning. But when I received the news that I was able to go to Houston for the project I became excited for the course. After the nice experience (and results) from the intensive one week Urban Sustainability course I was also more looking forward to this project.

In Houston, with my bachelor's background in spatial planning, it was especially very interesting to experience how the city's planning procedures are organised. Or maybe I should say, not organised. The project itself was at first sight some-

what disappointing to me to be honest. It didn't seem as if we were really were solving an issue. But as I learned in meantime at Architecture, projects are often more aimed at problem seeking rather than problem solving. Also, the process seemed a little unstructured to me. I was more used to a clear structure of analysis, concept and design. Moreover, it was hard for me to think and write in abstract terms instead of immediately concrete measures. I definitely widened my scope of thinking. I think it is especially useful for myself to understand other disciplines' way of thinking and their approaches to problems.

Although I had great help from my project mate Lukas, it was hard for me to really dive into the project. It was another way of approaching a project than I was used to and I was insecure about the way I could contribute to the overall project. After a meeting with our tutor in Rotterdam it became more clear how my part could look like and how to approach it. That is when my mobility program started to have some shape.

5.1 REFLECTION

LUKAS HÖLLER

To beginn with, I took this course mainly to strengthen my skills and widen my interests in the field of urban metabolism and flows. Coming from a landscape architectural background I'm very curious about urban concepts like, Planning with Nature (McHarg), Landscape as Infrastructure (Belanger) or Flow-scapes (Nijhuis). The combination of different urban flows (mobility, urban ecology and floodmanagement), but also the possibility to plan within a for me new cultural and urban context made me choose the Houston project. The combination with the Ecology and Morphodynamics in Catchments Course has been very interesting for me as well. Even though we didn't learn much about hydrologic engineering, the basics of understanding certain processes, synergetic and additive effects of man made impacts on the environment has been very helpfull also for the Houston case.

The overall set-up of this course gave us a very large amount of freedom. To admit, at the beginning of the course the freedom given to us was a bit too much. It seemed that the vague instructions at the start influenced especially the TIL students throughout the project. During the workshop in Houston, which was very interesting, particulary because of its structure of scooping, asses-

sing and coming up with first ideas and visions (which was also new for me), I had the feeling that the TIL students, but also we (the Urbanism students) still weren't able to grasp the „real“ task/goal of the project. Seen from todays perspective, I think the goal was to create this kind of experimental/free environment, to come up with creative and innovative ideas, driven by the cooperation of engineers and urbansist. Maybe it could be a possibility to already create collaboration between the two disciplines before the actual fieldtrip. Additionally the big difference of ECTS between urbanists and engineers made it sometimes feel, that this course (5ECTS) is only one of the many minors the TIL students had to take, whereas this course is the urbanists major for Q4 (9 ECTS). Nonetheless I really enjoyed the whole project as well as the collaboration with the TIL students very much. Next to the fact that I made many new contacts, I learned a lot about the different style of approaching a task, other than we do in urbanism. It once more brought to light, how important the interdisciplinary collaboration is, but also that it sometimes needs more time, preperation and practice to create a base for synergy and communcation between those disciplines.

Finally I want to write about the new experience of working within the U.S. american context. I really learned a lot about difference of planning in the U.S. compared to what we are used in Europe. The interesting workshops and discussions we had with the students from Texas, while they visited Rotterdam, but also the presentations we had during our stay at Rice University, Texas, helped me a lot in understanding how urban planning works, or may not work in Houston. However, I wished for more collaboration with the students and hydrology experts from Texas during our stay in Houston.

The fact that even professionals, dealing with urban planning in Houston every day felt helpless, made the project feel like a fantasy task. In the end this was not the case and I hope that our interdisciplinary project contains ideas which can help to overcome the issues present in the city of Houston. At least I can say, that next to new impressions, skills and contacts, learned a lot for my personal but also professional future as an urbanist.



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**FREEDOM
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ELSE BUT A
CHANCE TO
BE BETTER.**

ALBERT CAMUS