Resilience through regeneration:

The economics of re-purposing vacant land with green infrastructure

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Resilience through regeneration: The economics of repurposing vacant land with green infrastructure

Overview

Nearly 17% of each large U.S. cities' land area is vacant; this has increased by 1.3% since 1998. When floods strikes, vacancies catapult. The Texas coast is one of the most frequently flood impacted areas globally. Houston, TX has one of the highest numbers of flood-related fatalities in the past 50 years. From 2001 to 2017, Harris County incurred 20 billion dollars in flood-related damages. Houston reports nearly 11% of its land as vacant, many concentrated in marginalized communities, which are highly vulnerable to flooding. Many underserved urban areas affected by flood disasters are also becoming increasingly ecologically and socially fragmented due to the accumulation of vacant properties. These unused lots can potentially provide land for ecological/hydrological land uses. Despite overall population in-migrations in flood prone regions, many marginalized neighborhoods are characterized by excessive amounts of vacancies. Rather than chasing development-based incentives for regenerating vacant lots in these areas, a balance should be sought between new developmental land uses and green infrastructure (GI) to help counteract stormwater runoff and flood effects, or *resilience through regeneration*. This research examines the costs and benefits of retrofitting green infrastructure into vacant lands in underserved, flood prone communities using landscape performance models across three master plans in Houston, Texas. The research asks, what are the economic costs and benefits of retrofitting GI into underserved communities as a strategy for vacant land regeneration? It uses landscape performance measures across three master plans for lower-income, minority dominant, flood-prone neighborhoods in Houston, Texas, USA to evaluate the economic and hydrologic impacts of GI regeneration projects. Results suggest that, when using this approach, 1) flood risk significantly decreases, 2) short term, upfront economic costs increase, and 3) the long-term economic return on investment is much higher.

Narrative

Resilience through regeneration is an approach to flood mitigation that focuses repurposing efforts of vacant lots around green infrastructure (GI). This research examines the costs and benefits of GI as a strategy for vacant land regeneration, evaluating the performance of three community plans in Houston: South Park, Manchester, and Sunnyside. Each plan was created following a participatory design approach between research personnel and residents. The economic and hydrologic benefits of each design was then evaluated utilizing a landscape performance models the Center for Neighborhood Technology's National Green Values Calculator (GVC).

South Park's flood vulnerability is mostly due to its ineffective open ditch infrastructure. While the vacancy rate of Houston decreased by 9% from 2006 to 2017, South Park maintained a rate near 16%. The land value is 85% lower than the Houston average, over 90% of the residents are minority, and 30% do not have high school degree. Performance models project that 85% of the site's vacant lots will be regenerated, 90% of abandoned structures will be managed, and 17 acres of new GI will be added. The plan increases permeable area by 15%, captures more than 45% of the runoff volume, and can capture 66 million ft3 of runoff, creating $2.6 million in annual GI benefits.

Manchester is surrounded by industries, and has one of the lowest water qualities in TX. Local authorities provide 'Toxic Tours' for visitors to raise awareness of the conditions in the neighborhood. Manchester is over 80% Hispanic and 1/3 of the residents live below poverty line. The site is 16% vacant parcels/abandoned structures and 68% of the neighborhood's surface is impervious. The plan regenerates a majority of the sites underutilized parcels. The amount of green space increases nearly 7 times its current amount; percent pervious surface increases from by 20%. Over 40 million gallons of stormwater can be retained and over $5 million in GI benefits, annually.

Sunnyside has one of its most socially vulnerable populations and is 93% minority, with many residents making less than $25,000 annually. Fifty percent of the design site is within the 100-year floodplain. New construction in the site is built at a high elevation, leading to increased flooding for existing housing. The GVC shows that the plan can increase total runoff volume capture from 49.6% to 190.7%; 143 acres of vacant space is regenerated, four times more walkable space is created, and dense canopy coverage increases from by 16%.

When comparing GVC outputs across sites, results show that 95% of vacant lands were regenerated, on average. Second, the plans called for an average of over 11% of increase in green space, resulting in over 22 million gallons of stormwater retained annually. Third, the economic benefits created by the increase in GI over a 100-year life cycle greatly outweigh the upfront construction/maintenance costs. With an average total cost of 34.5 million dollars but an 87.8 million dollar economic benefit, over 53 million more dollars are produced in life cycle benefits. These benefits generally take around 40 years to produce a return. Green roofs have the highest overall costs to construct while rain gardens provide the most benefits for the least amount of cost efficiency. While upfront economic costs increase in the short term, the long-term return on investment is much higher and the GI pays itself off through time.

Literature Review

Vacant land is a ubiquitous urban phenomenon. A small amount can be an indicator of economic growth, while larger proportions of typically indicate symptoms of urban decline. The vacancy condition has grown to the extent that scholars and designers have now developed an agenda to begin to regenerate such properties through both temporary and permanent uses. Alan Berger describes the global accumulation of vacant lands as a ‘Drosscape’ – a design framework utilized for the redesign and adaptive re-use of nonproductive landscapes. Other various taxonomic efforts have also been made to research vacant lands, describing them as “dead space,” “TOADS – Temporarily Obsolete Abandoned or Derelict Sites,” “Zombie Properties,” and “Urban Shrapnel.”

The ratio of vacant land to city size has increased by 1.3% since 1998, indicating a growing problem. While regional variations exist in both the amount and type of urban vacancies, many vacant parcels are small, odd shaped, and disconnected, making them difficult to repurpose. Disinvestment, suburbanization, and disaster events such as floods are reported as the primary causes of increases in vacant land supply.

Flood research is predominantly focused on the paradigm of resilience. Conceptually, disaster resilience is both a set of capacities for adaptation and a process of adaptation; when a disaster strikes, vacancies can catapult and communities work to restore functioning and rebuild in ways that improve their capacities for the next event. Disaster events can exacerbate the vacancy condition, resulting in massive increases in vacant parcels and abandoned structures until recovery can occur. The Texas coast is one of the most frequently impacted areas by coastal storms globally. Houston, TX, is one of the fastest growing U.S. cities, and has one of the highest numbers of flood-related fatalities in the past 50 years. Houston, despite being one of the fastest growing cities in the U.S., reports nearly 11% of its land as vacant. Many of the its vacant properties are concentrated in marginalized communities, which are also typically characterized as highly vulnerable to flooding. Vacant land, however, does not always need to be viewed as a problem and, if managed or repurposed correctly, can contribute to increasing flood resilience. Vacant land can presents valuable opportunities for urban transformations as well as a potential solution for the flooding issues.

Despite the challenges associated with the flood vulnerability, social conditions and disconnected typology of urban vacant land, careful research and design efforts toward regenerating vacant land prove to be a huge opportunity for cities. The idea of “sponge city” has raised attention to adaptive water management as a critical part of urban planning and policy-making (Chan et al., 2018; Yu, 2016). However, retrofitting urban areas with green infrastructure often requires additional land area secured for stormwater infiltration. This often competes with developer’s or property owner’s interest to maximize the amount of buildable land or the right-of-way along public streets. Therefore, the effectiveness of sponge city practice depends largely on how public and private sectors address the challenges in the contested arena. Although large-scale, regulatory efforts are usually effective in the planning of new towns and new districts, incremental changes with carefully planned phasing would reduce the physical, regulatory, and financial barriers for existing cities.

Vacant land regeneration offers a prototype of incremental planning practice to achieve the sponge city principles. Specifically, according to the sponge city concept, a city should perform like a sponge with elasticity in absorbing, storing, purifying and releasing water in responding to changes (Wang, Ding, and Wang, 2018). For a sponge to absorb and hold water, the composition of numerous small pores is essential. For cities that have been built based on traditional grey infrastructure to get water off site as soon as possible, siting and implementing these pores are often difficult without impeding the economic, social and other functions. Therefore, for existing cities that are either growing or shrinking, urban vacant land regeneration presents great suitability and feasibility to serve as the pores to enhance the water adaptive capacity of cities. Rather than creating conflicting environmental and economic objectives, as noted with literature outlining the challenges of sponge city, transforming vacant land offers unprecedented opportunities for ecosystem services, as well as a variety of economic and social co-benefits.

Participants

A collection of scholars, professionals, and community members collaborated to solve local issues through evidence-based design and planning. The Center for Housing and Urban Development, the Institute for Sustainable Communities, the Hazard Reduction and Recovery Center, and Texas Target Communities work with faculty and students within the Department of Landscape Architecture and Urban Planning and School of Public Health at Texas A&M University to conduct engaged service learning projects for communities. These organizations work with community members, stakeholders, and local organizations to develop community-scaled participatory-based master plans. The process for this project utilized interdisciplinary affiliates from these centers and institutes in conjunction with local stakeholders, residents and organizations to conduct in-depth site analyses using multisystem input and layering approach, quantitative comparisons of spatial and temporal phenomena, participatory design feedback, and design alternative development. Local organizations such as Texas Environmental Justice Advocacy Services, Charity Productions, and Jones Future Academy were engaged partners Upon initiation of the project, the design team held community meetings to introduce the project and identify problems, as well as to acquire local knowledge of issues. A second meeting communicated the site analysis findings and synthesized information gathered through public engagement, and collected ideas on design programing options. A third and fourth meeting involved presenting a series of master plan scenarios and getting feedback from community stakeholders. The final master plan that incorporated the critiques and ideas from the previous meetings were developed, which reflected the desired functions and programs for proposed open space, and repurposed new growth opportunities. A final presentation to community members ensured the final design outcome was communicated and evaluated by locals, and that the master plan spurred long-term community-driven efforts in regeneration beyond the project timeline. This process was enacted within each neighborhood involved in the research.

Methodology

This work was conducted from August of 2016 to October of 2019. Each sites full process took around one year to complete. The design process utilizes consistent landscape performance tools to capture the hydrologic and economic impacts across all the three master plans. Landscape Performance tools provide the ability to measure the effectiveness with which existing or designed/planned solutions fulfill their intended purpose and a broad range of calculators exist to analyze the social, hydrologic, and economic impacts of designs and plans. The economic rationale of green infrastructure is emerging as an essential component of flood provision strategies. The Center for Neighborhood Technology's (CNT) National Stormwater Management Calculator, also known as the National Green Values Calculator (GVC) is an interactive tool for comparing the performance, costs, and benefits of green infrastructure to conventional stormwater practices. Through 1) determining the average precipitation of the site under investigation, 2) selecting a stormwater runoff volume reduction goal, 3) defining the impervious areas under development with no green infrastructure, and 4) inputting the types of green infrastructure utilized within the site plan, the GVC can be used to determine the cost-efficiency of runoff volume reduction. In this research, the GVC, was used to compare costs, benefits, and performance of green infrastructure compared to conventional stormwater management practices, This tool has been used to assist in assessing the effectiveness of stormwater management practices on water quality, flood proofing, predict runoff capture, and evaluate stormwater runoff storage. For the purposes of this research, the performance evaluation included the land cover change and increased amount of green space for utilitarian and recreational purposes, the amount of stormwater retention, and economic benefits. The economic benefits are evaluated based on stormwater retention, carbon dioxide sequestration, reduced air pollutants, compensatory value of trees, groundwater replenishment, reduced energy use, and reduced treatment benefits.

Results

Results show three key findings. First, the ability to regenerate vacant properties is much easily performed, as less developmental expenses are necessary; 95% of pre-design vacant lands were regenerated, on average across all three sites. Because a large proportion of the repurposed vacant properties were not based on developmental pursuits, there is room for development in these areas in the future. The green spaces can provide temporary or permanent functions to assist with social or hydrological needs. These newly created nodes spur diverse interactions, and create new resources and activities, which will contribute to urban vitality and land use optimization. Second, the increase in green space significantly assists in increasing stormwater retention. Across all sites, the plans called for an average of over 11% of increase in green space, resulting in over 22.2 million gallons of stormwater retained annually, Third, the economic benefits created by this increase in green space over a 100 year life cycle greatly outweigh the upfront construction and maintenance costs. With an average total cost (including construction and maintenance) of 34.5 million dollars but an 87.8 million dollar economic benefit across all three sites, findings suggest over 53 million more produced in life cycle benefits than upfront costs. These benefits generally take around 40 years to produce a return on investment. Construction costs appear to claim a bulk of the overall cost total, green roofs have the highest overall costs to construct while rain gardens provide the most benefits for the least amount of cost efficiency. When using green infrastructure to regenerate vacant properties, flood risk continually decreases, Also, while upfront economic costs increase in the short term, the long-term return on investment is much higher and the green infrastructure pays itself off through time. It should be noted that this cost-benefit comparison total, however, does not include jobs created, local economy increases, social and public health savings, and savings from flood recovery costs.

Although all three designs explore the strategy of regenerating vacant land with green infrastructure and stormwater management, they propose different strategies for regeneration, based on the pre-design vacant land conditions and design priorities identified by residents. Future designers can draw lessons from three prototypes.

The South Park Prototype: The South Park design represents a solution for an inland neighborhood that faces severe challenges in high percentages of vacant land (more than 35%). The design provides a toolkit for assigning programming elements based on the typology and locations of vacant lots, featuring diverse functions including multi-purpose open space for recreation, socialization and flood management, community gardens, and residential, commercial, and cultural infill development.

The Manchester Prototype: The Manchester design demonstrates a solution for a riverfront neighborhood that is impacted by flooding and low physical and mental health. With a medium vacancy rate of 16%, Manchester's design focuses on repurposing vacant land into functional green space for mitigating floods and promoting healthy lifestyles. This prototype offers implications for neighborhoods with a medium rate of vacant land that would also benefit from healthier environments.

The Sunnyside prototype: The Sunnyside design provides an example for a neighborhood that has an outdated open ditch drainage system, one which caused inland flooding during excessive rainfall. Based on its current medium vacancy condition (16%), the proposal features a green infrastructure system that connects rain gardens, bio-swales, riparian corridors, detention/retention ponds, and pixelates parking areas to increase pervious surface ratios and raise water retention capacities. Lessons learned from this prototype are particularly relevant for neighborhoods with a medium amount of disconnected vacant lots that could be integrated and regenerated into a green infrastructure system.

Based on the improved hydrological and economic performance across three different projects, it is indicated that this prototype has the potential to be applied in cities that face similar challenges in increased vacancy rate and flood hazard.

Impact

South Park's flood vulnerability is due to its ineffective open ditch infrastructure. While the vacancy rate of Houston decreased by 9% from 2006 to 2017, South Park maintained a rate near 16%. The land value is 85% lower than the Houston average, over 90% of the residents are minority, and 30% do not have high school degree. Performance models project that 85% of the site's vacant lots will be regenerated, 90% of abandoned structures will be managed, and 17 acres of new GI will be added. The plan increases permeable area by 15%, captures more than 45% of the runoff volume, and can capture 66 million ft3 of runoff, creating $2.6 million in annual GI benefits.

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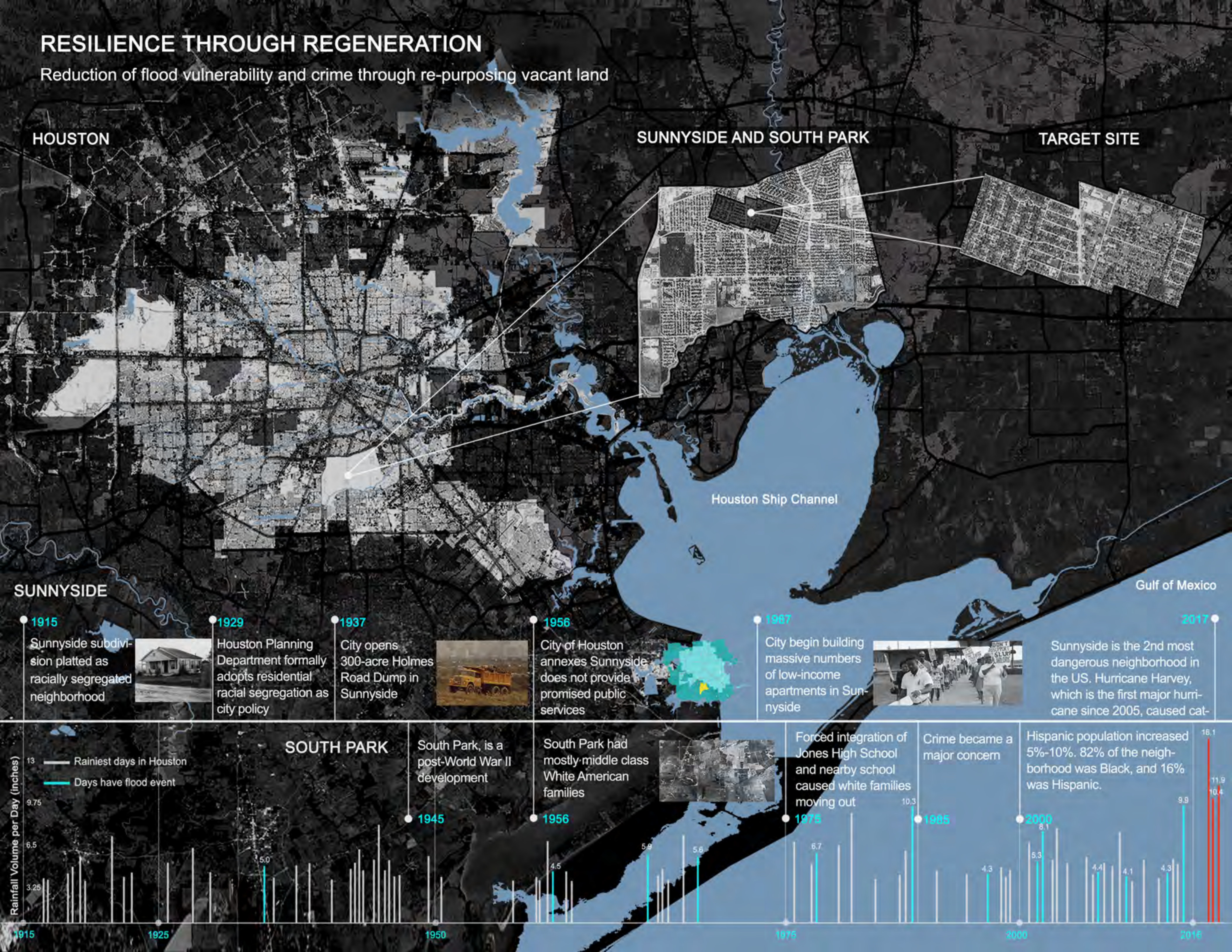
Implication of findings

Never before have repercussions from storm events driven by both surge and rainfall been so damaging to local communities. Urban decline to structural abandonment and underutilized properties is also a global crises in many cities and neighborhoods. Both flood mitigation and vacancy crises can only be understood and eventually reduced through integrated investigation across multiple disciplines, cultures, and boundaries. Coastal flooding and urban vacant lots are both worldwide problems and there is still a lack of comprehensive research on the strategies, methods, and design program for increasing community resiliency across countries. This research is broad-ranging by combining transdisciplinary inquiries which a focus on case sites within three marginalized communities. Through this approach, experts from multiple disciplines worked together to understand and solve common flood problems leading to transformative findings on 1) flood risk reduction through built environmental and infrastructural alteration, 2) methods in which to use technologies to measure and quantify potential design impacts, and 3) innovative strategies for mitigating flood impacts and reusing unused lots in marginalized and socially vulnerable areas.

The presence and density of green infrastructure as part of the urban built environment can influence the reliance of communities and individuals. Simultaneously, the duration and amount of vacant land can also be indicative of neighborhood decline levels. Evidence-based urban planning and designs are increasingly integrating GI elements into master plans for cities and communities to address various urban problems (e.g., urban heat islands, stormwater management, vacancy/abandonment, etc...). Landscape performance – the ability to measure the effectiveness with which designed/planned solutions fulfill their intended purpose – is increasingly being utilized to evaluate the effectiveness of GI. As a result, the Landscape Architecture Foundation (LAF) has developed a series of Landscape Performance Tools (LPTs) to help designers and planners assess the impacts of existing GI on community conditions. The LAF's LPTs measure economic, ecological, and social performance of urban GI, but fail to apply these tools to mater plans as they are utilized primarily as post occupancy evaluation tools for built designs. Currently available LPTs are also not fully applicable to the evaluation of GI impacts at a community scale and are rarely applied in underserved neighborhoods. This interdisciplinary team deployed instruments and tools cross three sites experiencing similar issues to directly measure the effects of green infrastructure on hydrologic and economic conditions. This research shows that while implementation costs are higher in the short term, increased green infrastructure pays itself off in the long term and results in multiple direct and indirect benefits for residents. The knowledge gained will allow cities to be (re)built in ways that enhance public health, mitigate flooding, reduce urban heat islands, support land use change, and prepare cities for population migrations. It also sets the stage for new performance models to be developed which measure green infrastructure impacts on other issues such as public health.

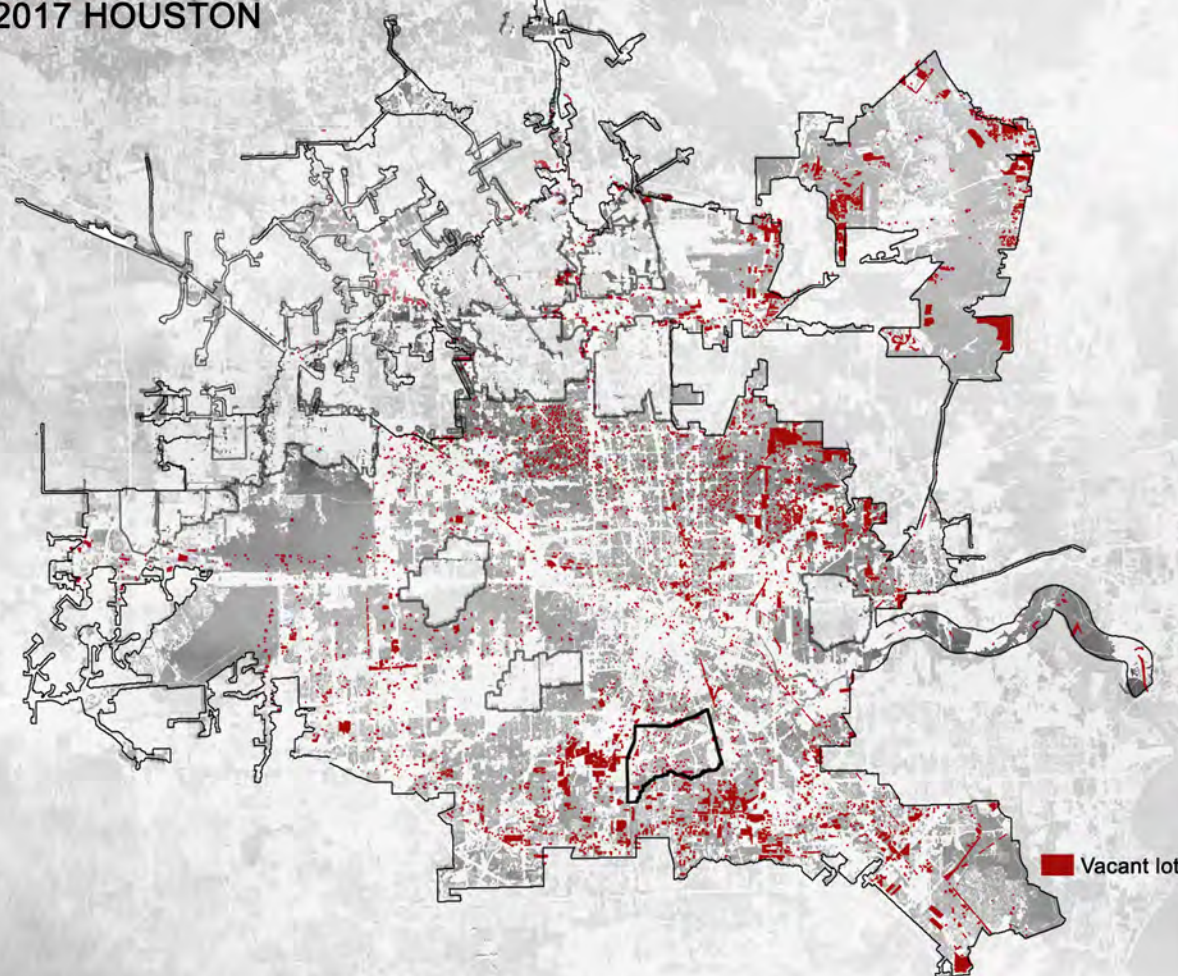
RESILIENCE THROUGH REGENERATION

Reduction of flood vulnerability and crime through re-purposing vacant land



VACANCY RATE CHANGE

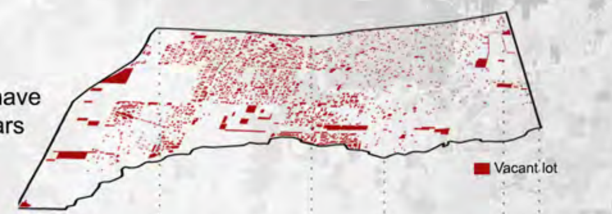
11% VACANCY RATE
2017 HOUSTON



16.3% VACANCY RATE
2017 SITE

Vacant Lot

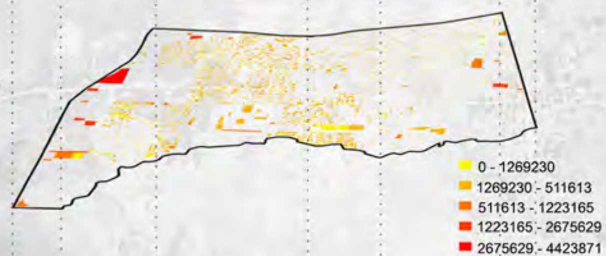
99% Vacant lots have been more than 3 years



Land Value

84.9% Lower than Houston Average

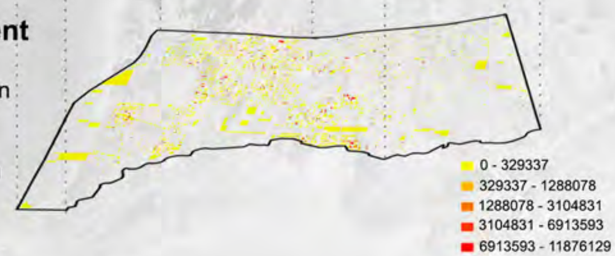
51% Lower than Houston Median



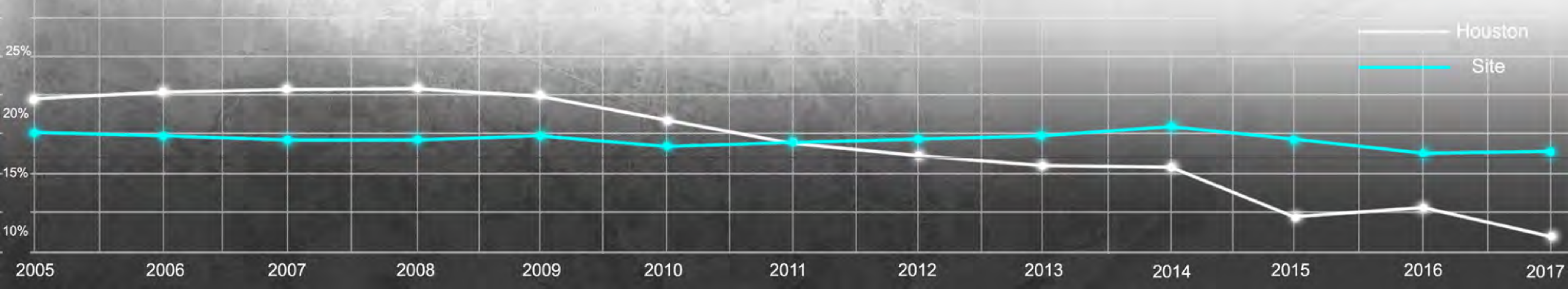
Land Improvement

96.3% Lower than Houston Average

100% Lower than Houston Median



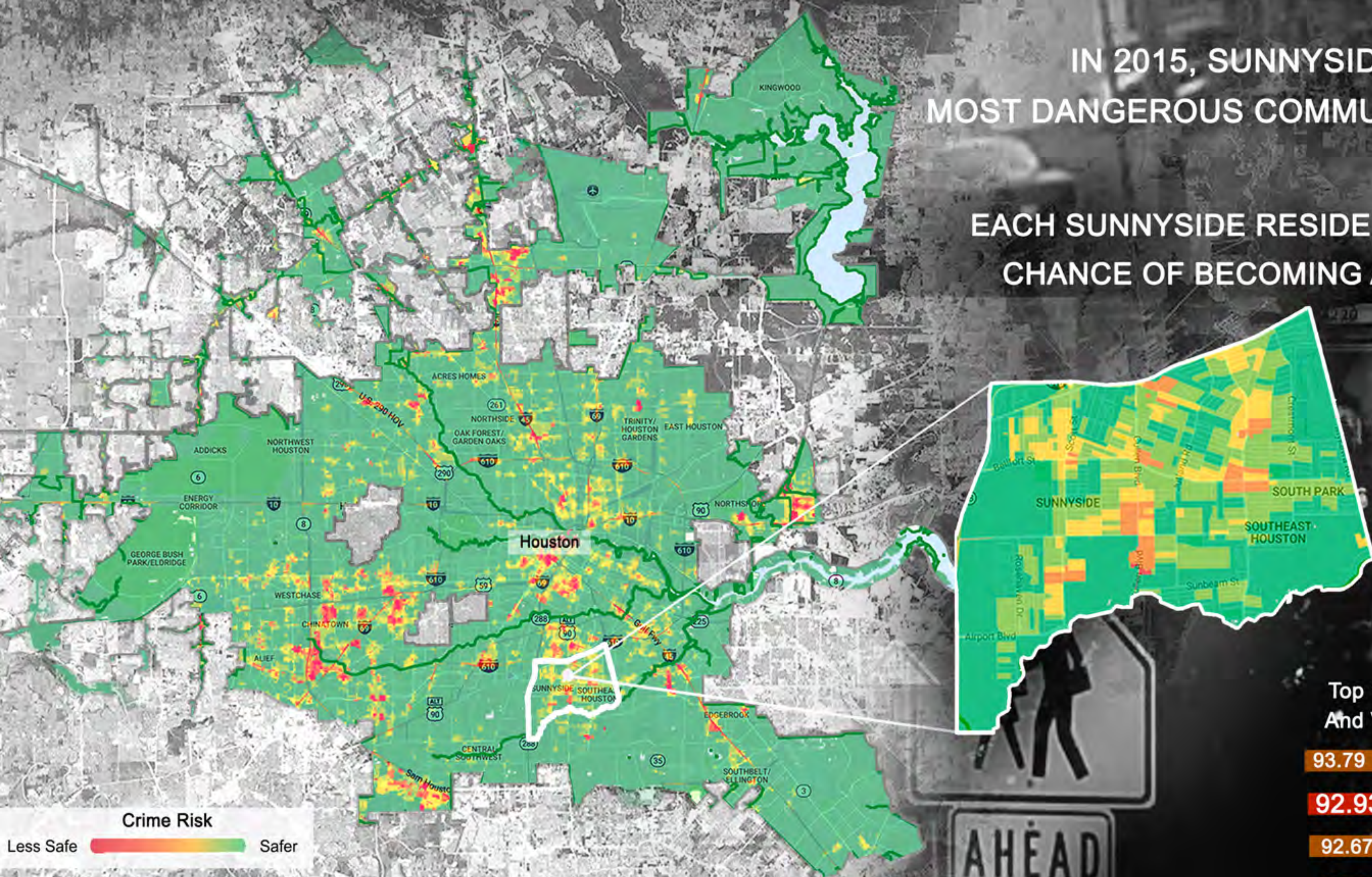
2005 -2017 Vacancy Rate Change

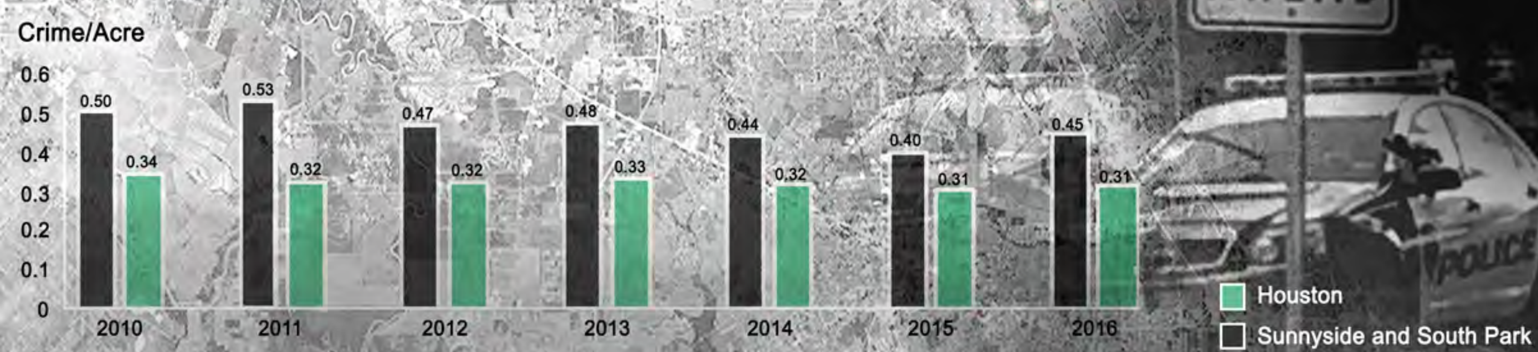


CRIME RATE

IN 2015, SUNNYSIDE WAS THE 2ND MOST DANGEROUS COMMUNITY IN AMERICA

EACH SUNNYSIDE RESIDENT HAD A 1 IN 11 CHANCE OF BECOMING A VICTIM OF CRIME



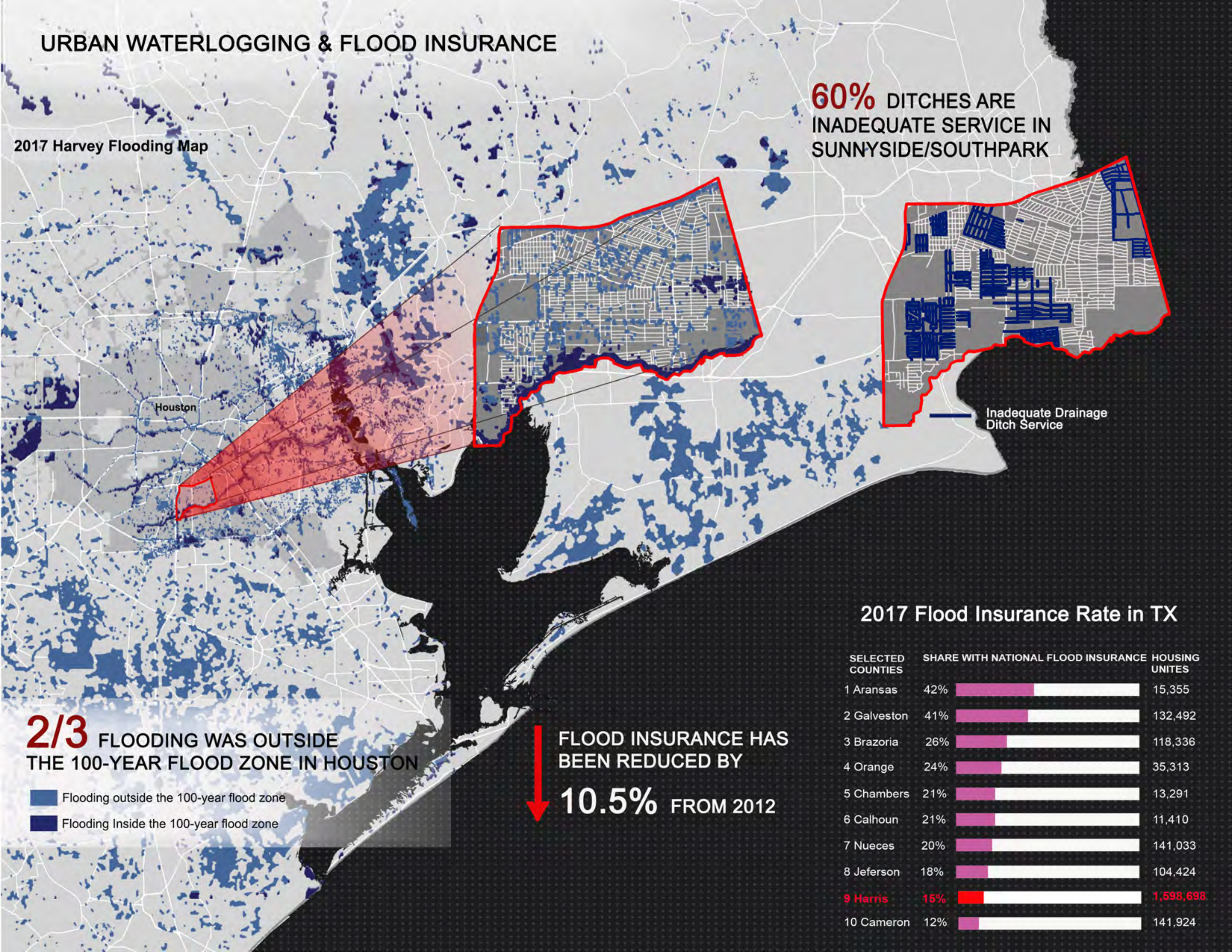


https://www.trulia.com/real_estate/Houston-Texas/crime/

Top 10 Dangerous Neighborhoods And Violent Crime Rate (per 1,000)

93.79	Lexington Terrace, Baltimore
92.93	SUNNYSIDE, HOUSTON, TX
92.67	Northview Heights, Pittsburgh, PA
88.98	TRIGG, Memphis, TN
87.02	Ferry Ave, Camden, NJ
85.35	Gaston Park, Memphis, TN
83.06	Upton, Baltimore, MD
79.99	City Center, St. Louis, IL
78.86	E Mohawk BLVD,Tulsa, OK
77.60	Core City, Detroit, MI

URBAN WATERLOGGING & FLOOD INSURANCE



60% DITCHES ARE INADEQUATE SERVICE IN SUNNYSIDE/SOUTHPARK

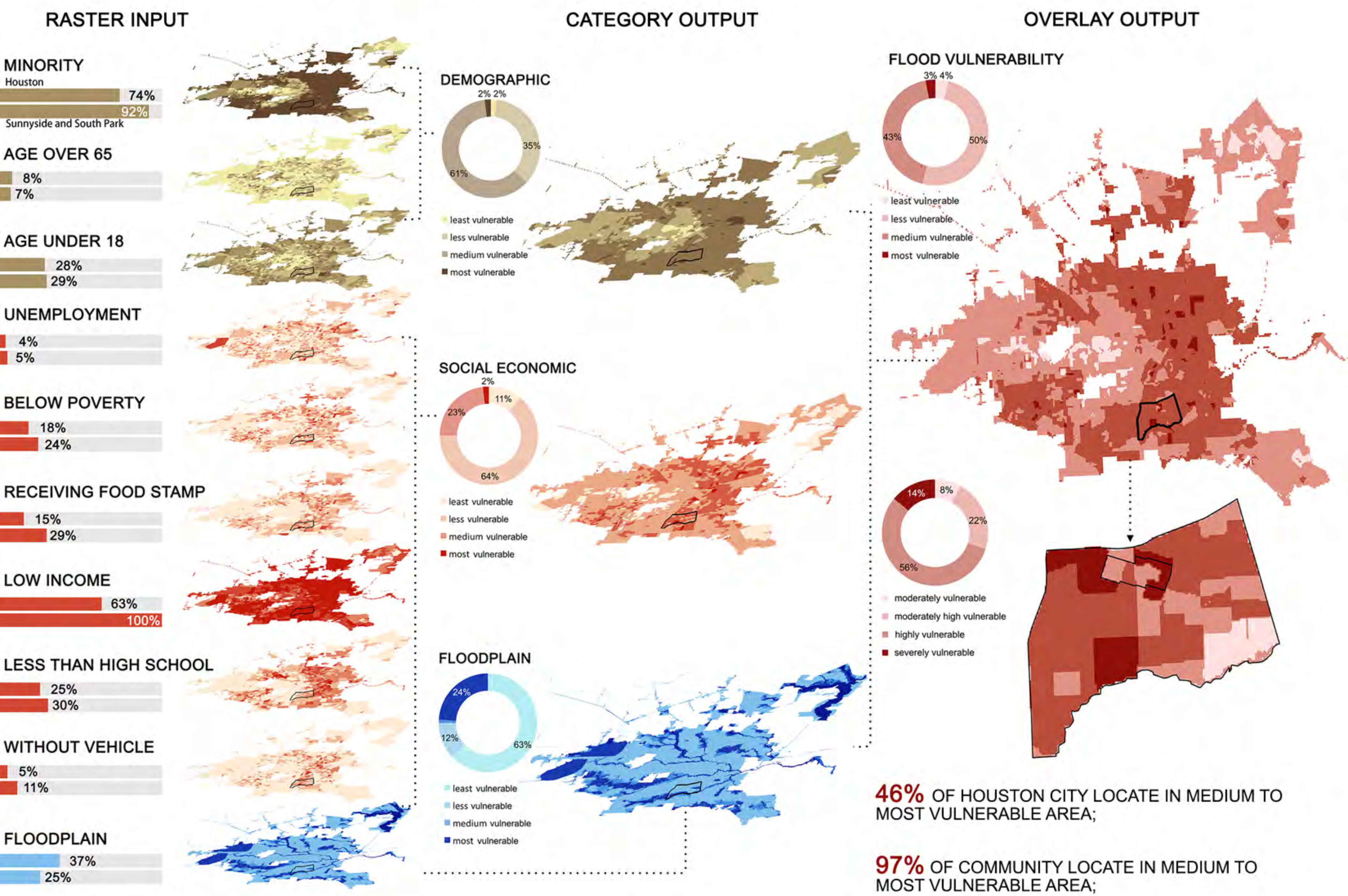
2/3 FLOODING WAS OUTSIDE THE 100-YEAR FLOOD ZONE IN HOUSTON

FLOOD INSURANCE HAS BEEN REDUCED BY **10.5%** FROM 2012

2017 Flood Insurance Rate in TX

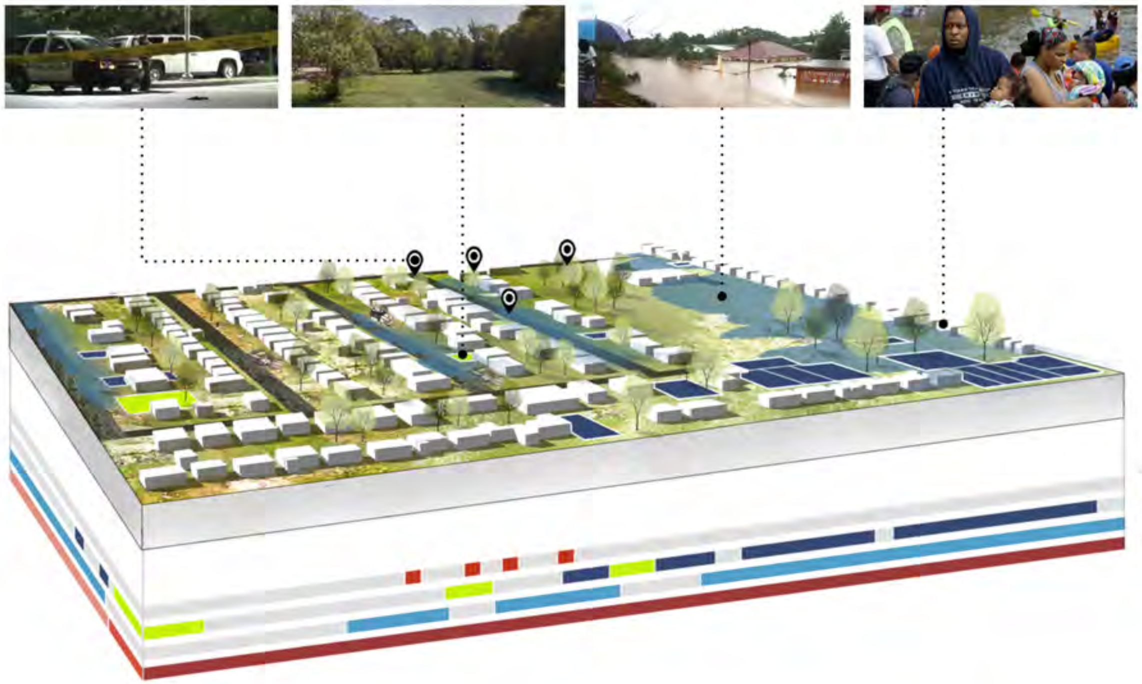
SELECTED COUNTIES	SHARE WITH NATIONAL FLOOD INSURANCE	HOUSING UNITES
1 Aransas	42%	15,355
2 Galveston	41%	132,492
3 Brazoria	26%	118,336
4 Orange	24%	35,313
5 Chambers	21%	13,291
6 Calhoun	21%	11,410
7 Nueces	20%	141,033
8 Jeferson	18%	104,424
9 Harris	15%	1,598,698
10 Cameron	12%	141,924

FLOOD VULNERABILITY MODELING



TARGET SITE LIVABILITY ANALYSIS

DARNAY DRIVE



- Concentration of Crime
- Scrub Space
- Flood Potential
- Ponding Areas
- Moderately High Vulnerable
- Highly Vulnerable
- Severely Vulnerable

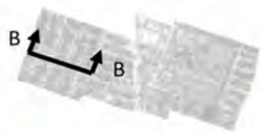
30% VACANCY RATE

40% FLOODING POTENTIAL RATE (PONDING AREA/ACRE)

20% CRIME RATE (CRIME/ACRE)

Concentration of Crime
Vacant Lot
Ponding Areas
Flood Vulnerability

RED BUD STREET



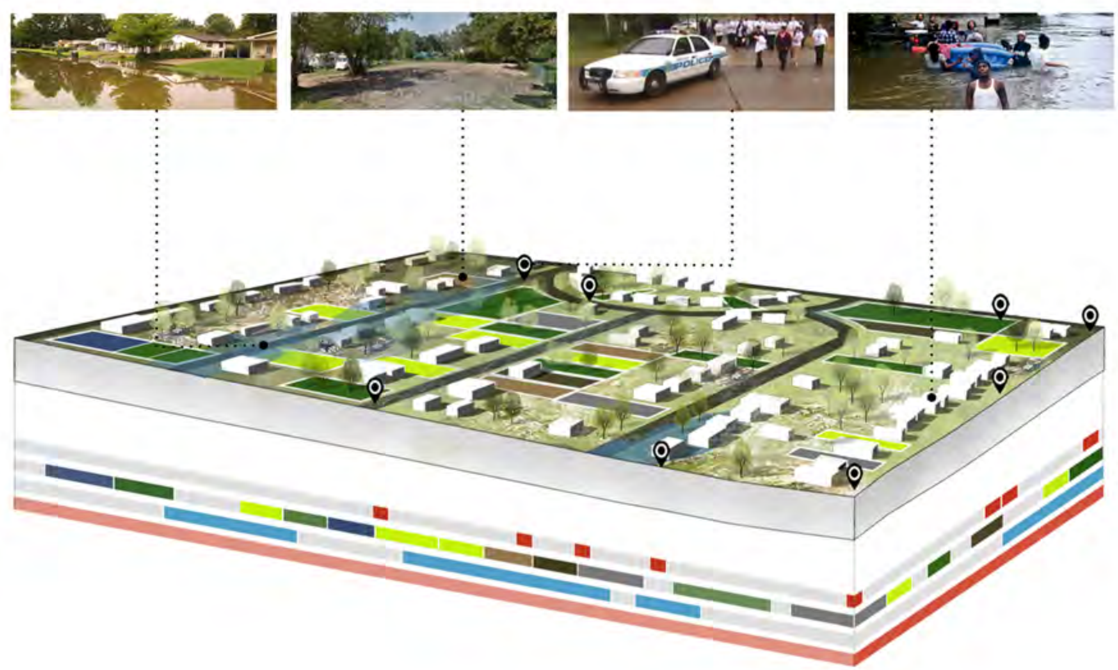
- Concentration of Crime
- Underutilized
- Obsolete
- Derelict
- Woody Area
- Scrub Space
- Flood Potential
- Ponding Areas
- Moderately High Vulnerable
- Highly Vulnerable

42% VACANCY RATE

20% FLOODING POTENTIAL RATE (PONDING AREA/ACRE)

10% CRIME RATE (CRIME/ACRE)

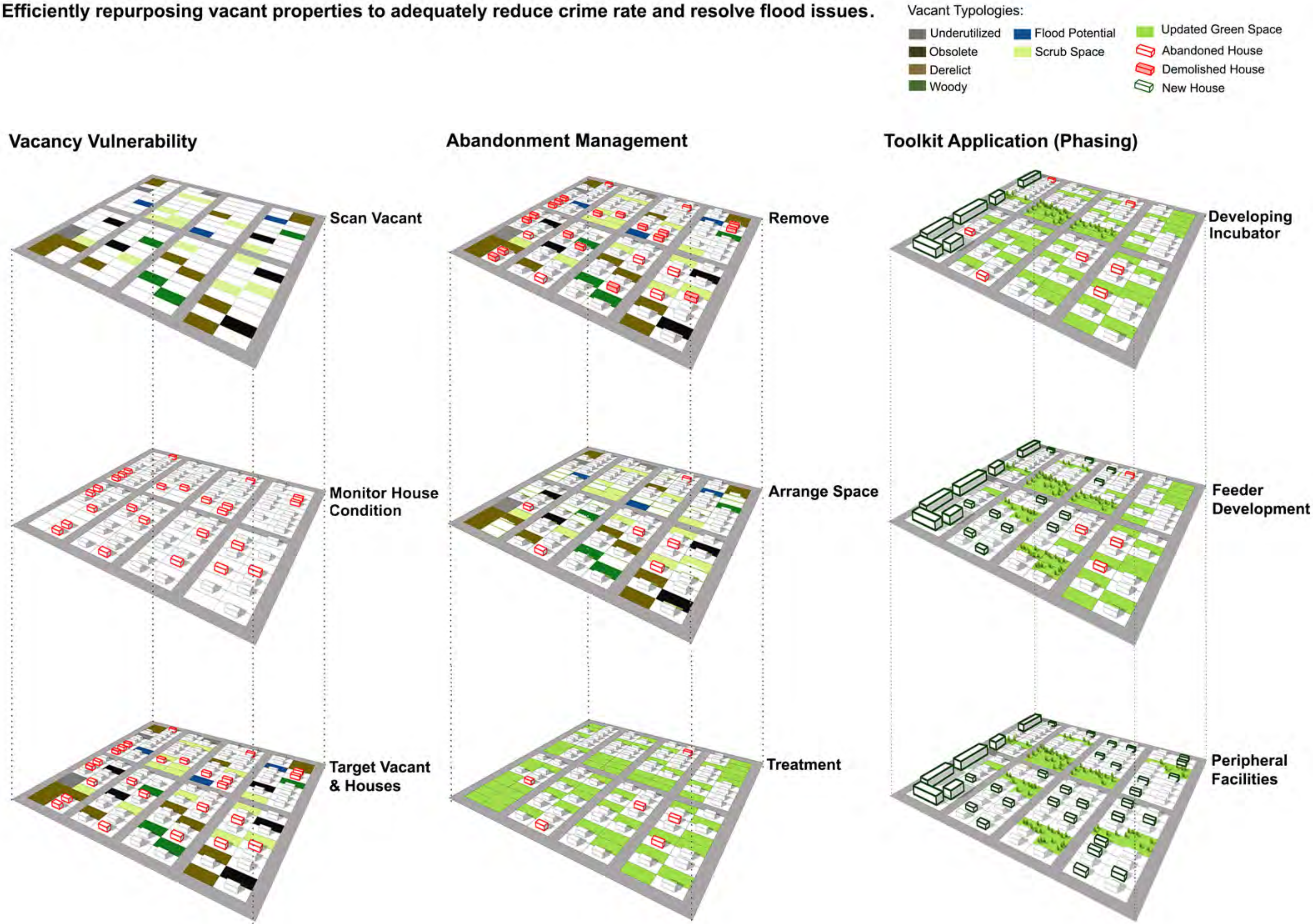
Concentration of Crime
Vacant Lot
Ponding Areas
Flood Vulnerability



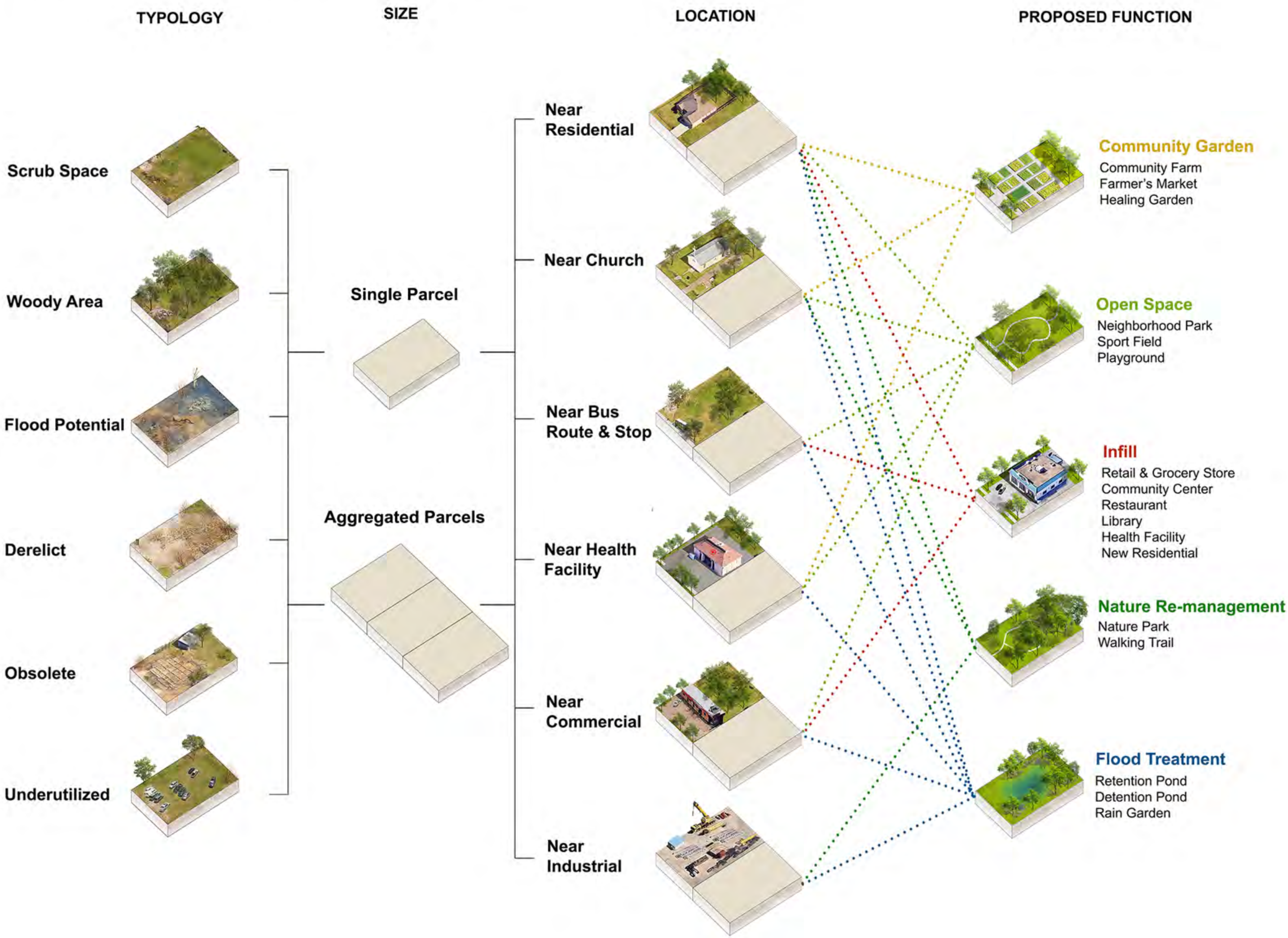
OVERALL, THE TARGET SITE HAS **36%** VACANCY RATE, **30%** PONDING AREA/ACRE FLOODING POTENTIAL RATE, **15%** CRIME/ACRE CRIME RATE.

STRATEGY

Efficiently repurposing vacant properties to adequately reduce crime rate and resolve flood issues.



VACANCY TYPOLOGY PROGRAM TOOLKIT



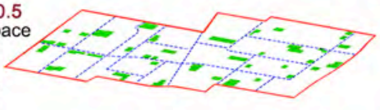
AFFORDABLE HOUSING

Low-income Housing are provided to 500 families

Low-income Housing

COMMUNITY GREEN SPACE

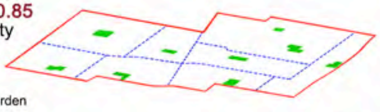
50-70 families share at least 0.5 acres green space



Service Area
Green Space

COMMUNITY GARDEN

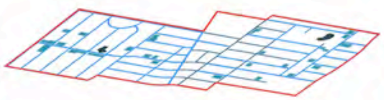
100-125 families share one 0.7-0.85 acres community garden



Service Area
Community Garden

STORMWATER MANAGEMENT

Open Ditch
Curb Drainage
Retention Pond
Rain Garden



PHASING (TOOLKIT APPLICATION)

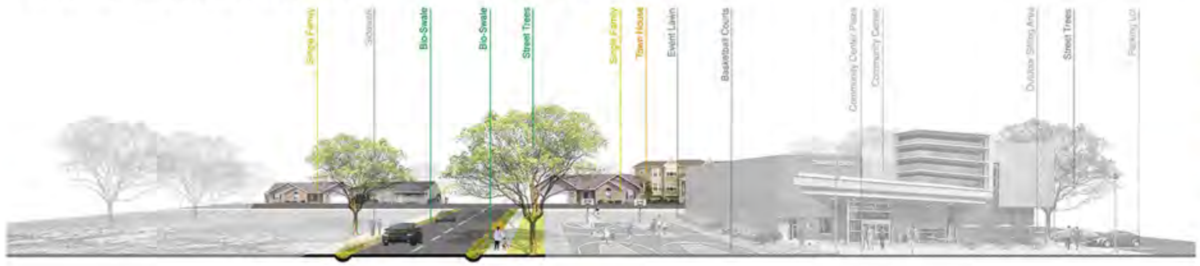
PHASE 1: DEVELOPING INCUBATORS (5 YEARS)

Regenerated Vacant Land
20% (22 acres)

Managed Abandonment:
23% (50 units)

Jobs Produced:
487-641

PHASE 2: FEEDER DEVELOPMENT (5-10 YEARS)

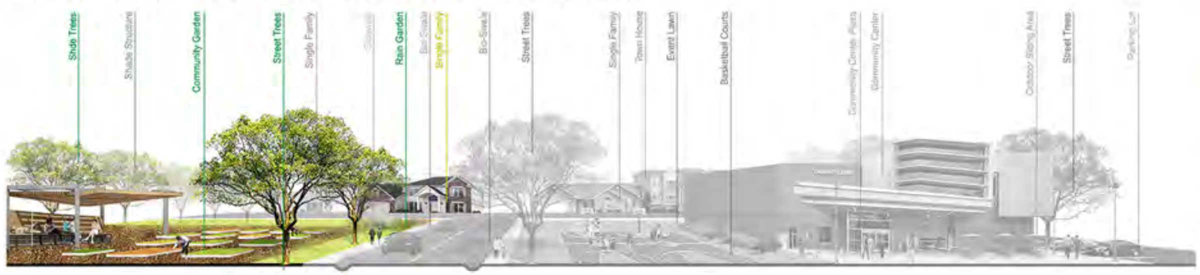


Regenerated Vacant Land
37% (43 acres)

Managed Abandonment:
45% (77 units)

Jobs Produced:
173-259

PHASE 3: PERIPHERAL FACILITIES (10-20 YEARS)

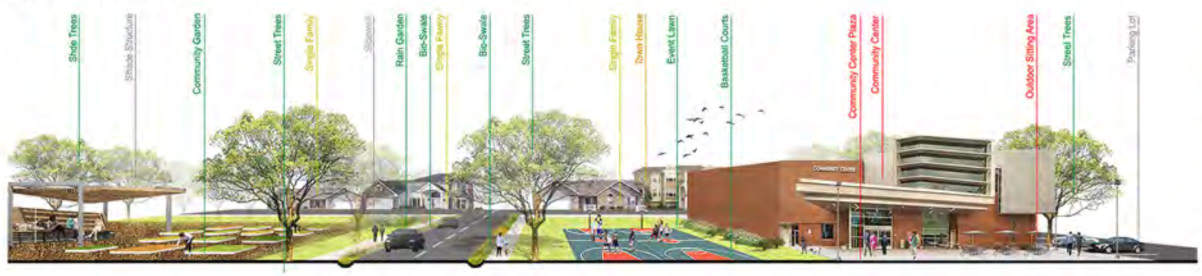


Regenerated Vacant Land
28% (32 acres)

Managed Abandonment:
12% (38 units)

Jobs Produced:
14-21

FINAL VISION



TOTAL

Regenerated Vacant Land
85% (97 acres)

Managed Abandonment:
90% (168 units)

Jobs Produced:
674-921

PHASE 1 DEVELOPING INCUBATORS (0-5 YEARS)

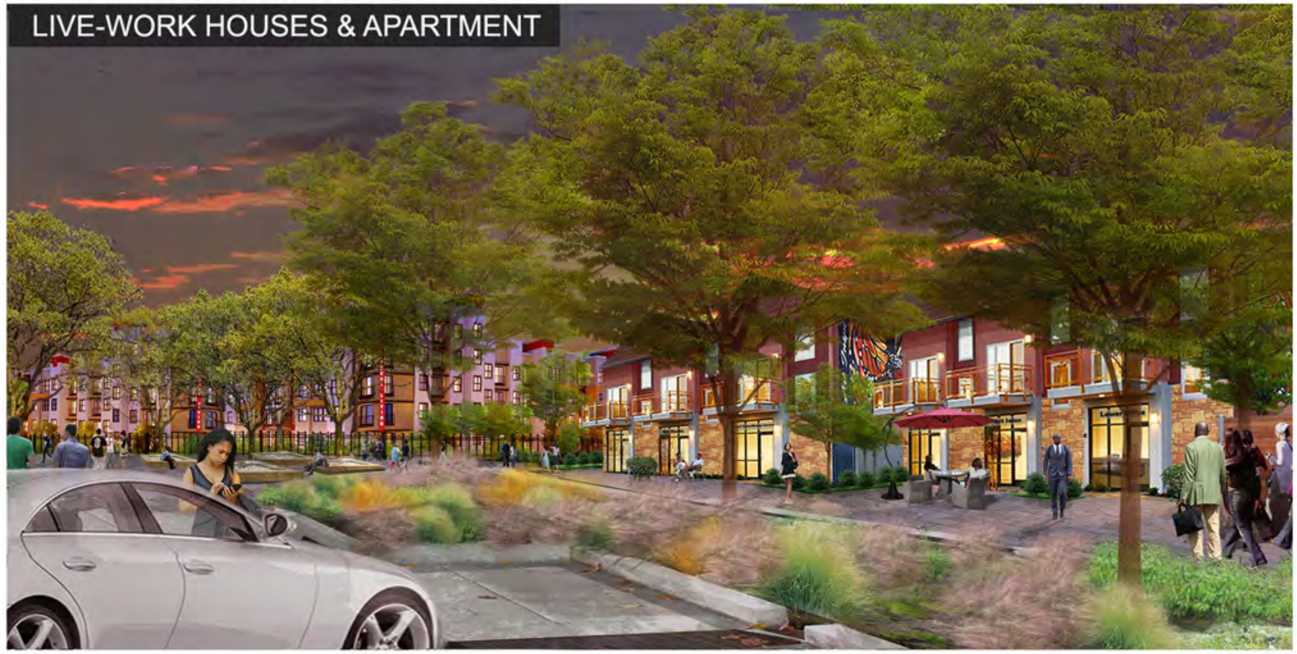
VACANT LOTS ALONG MAIN STREET

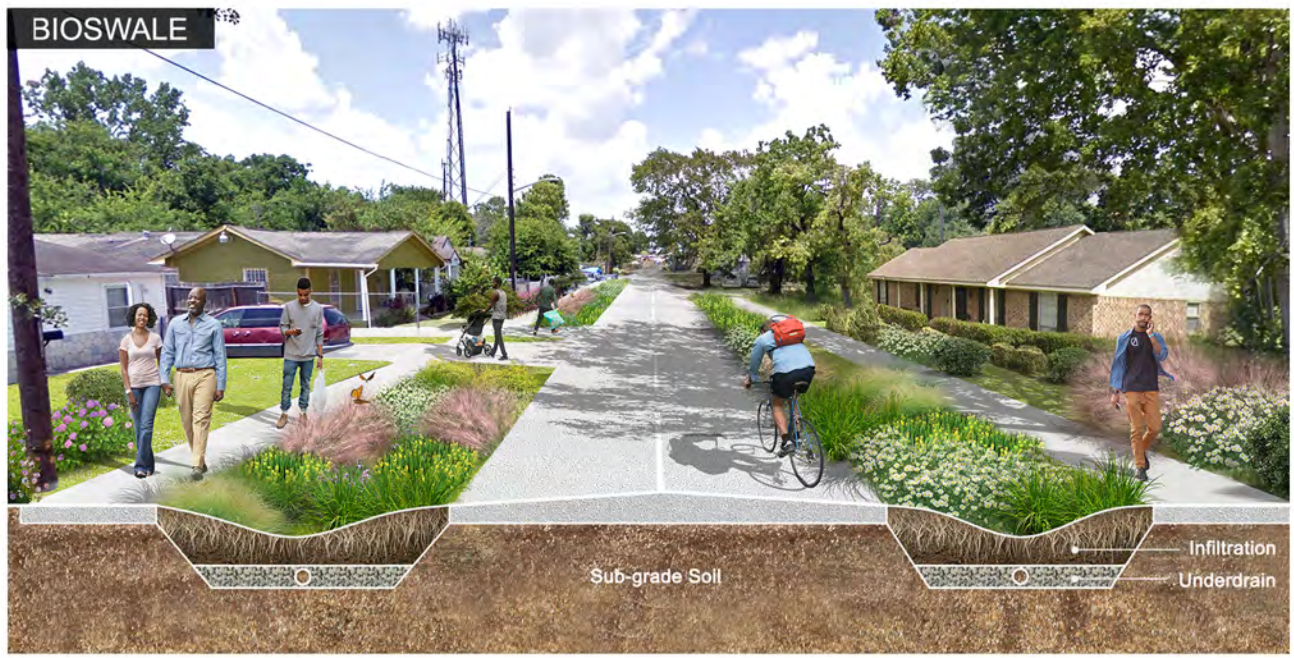
COMMUNITY CENTER & MIXED USE

ABANDONED HOUSING AT FLOODING AREA

DETENTION POND

PHASE 2 FEEDER DEVELOPMENT (5-10 YEARS)





PHASE 3 PERIPHERAL FACILITIES (10-20 YEARS)


INTERSTITIAL VACANT LOT


COMMUNITY GARDEN


RESIDENTIAL FLOOD POINT

RAIN GARDEN & EDUCATIONAL TRAIL

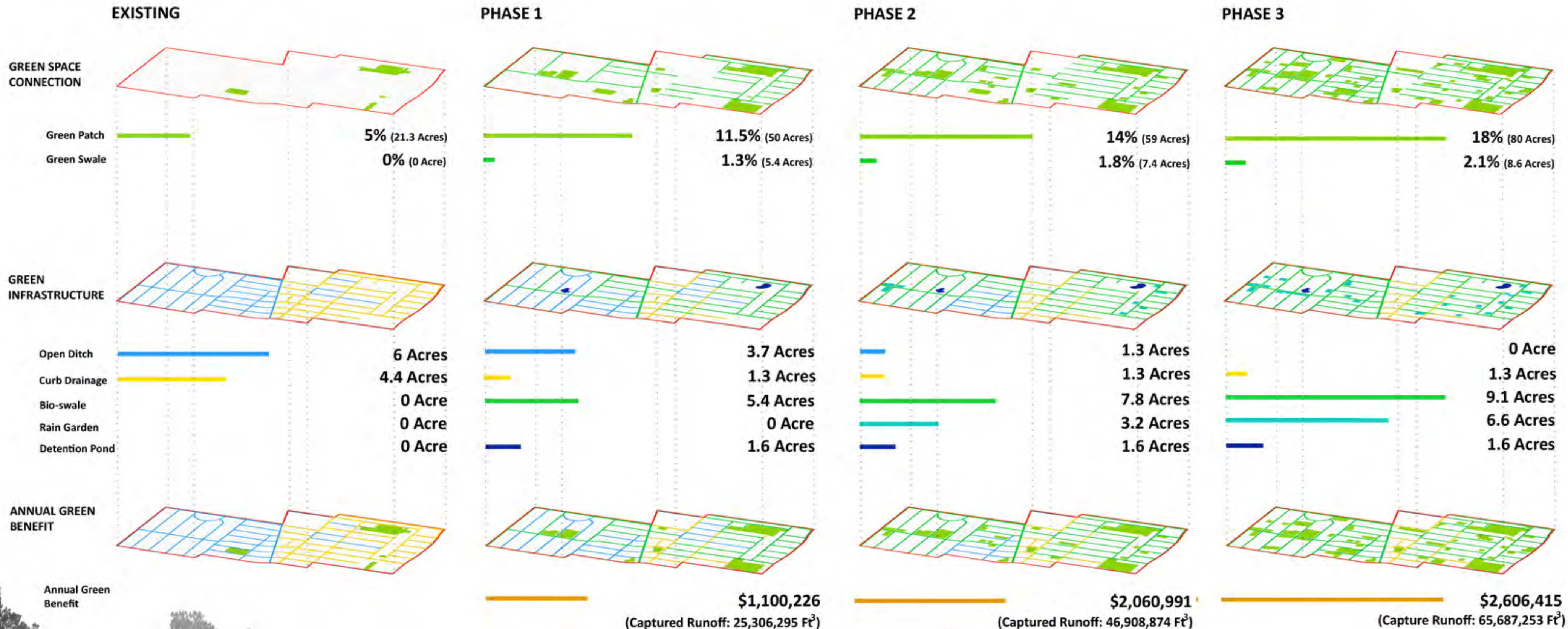
DESIGN IMPACT

	EXISTING	PHASE 1	PHASE 2	PHASE 3
ABANDONMENT TREATMENT				
Neglected	186 Units	-22.5% (136 Units)	-68% (59 Units)	-90% (19 Unit)
Refurbish	0 Unit	+7% (13 Units)	+38% (72 Units)	+52% (97 Units)
Rebuilt	0 Unit	+15% (28 Units)	+17% (31 Units)	+20% (37 Units)
Demolish	0 Unit	+0.5% (9 Units)	+13% (24 Units)	+18% (33 Units)
REPURPOSED HIGH CRIME AREA				
Crime	30 Crimes	-26%	-56%	-72%
Vacant	114 Acres	-19.7% (92 Acres)	-57% (49 Acres)	-85% (17 Acres)
LAND USE				
Mixed Use	1.52% (7.4 Acres)	2.16% (11.7 Acres)	2.16% (11.7 Acres)	2.16% (11.7 Acres)
Multi Family	1.9% (7.9 Acres)	4.2% (18 Acres)	4.7% (20 Acres)	4.7% (20 Acres)
Single Family	34.2% (146 Acres)	29% (125 Acres)	33.2% (144 Acres)	57% (247 Acres)

STRUCTURAL ABANDONMENT DECREASED BY **90%**

REGENERATED **85%** OF VACANT LOTS IN CLOSE PROXIMITY TO CRIME OCCURRENCE

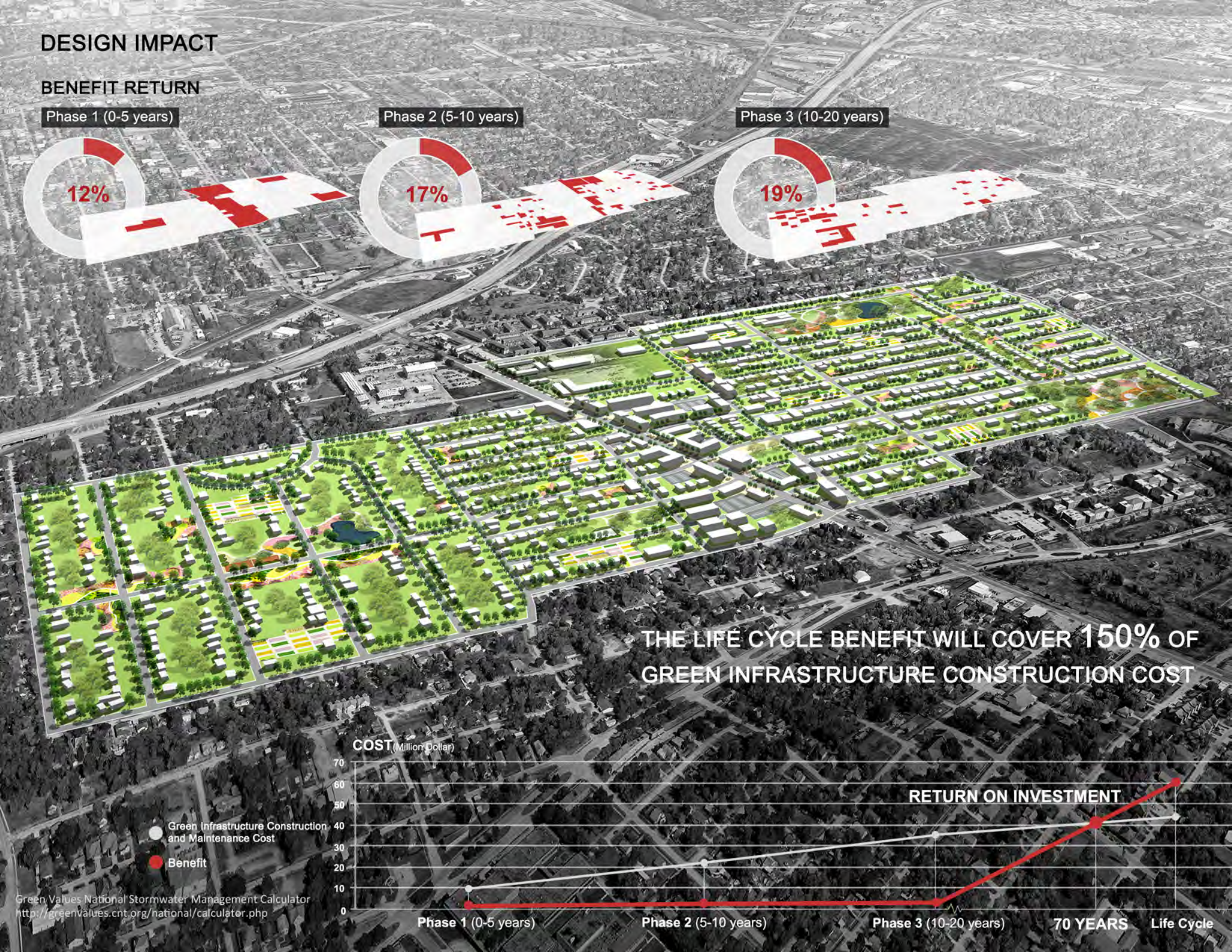
DESIGN IMPACT



INCREASED GREEN SPACE BY **15%**

INCREASED GREEN INFRASTUCTURES AREA BY **17 ACRES**

THE TOTAL ANNUAL GREEN BENEFIT IS **$2,606,415**


DESIGN IMPACT
BENEFIT RETURN
Phase 1 (0-5 years)
12%
Phase 2 (5-10 years)
17%
Phase 3 (10-20 years)
19%
THE LIFE CYCLE BENEFIT WILL COVER 150% OF GREEN INFRASTRUCTURE CONSTRUCTION COST
COST(Million Dollar)
70
60
50
40
30
20
10
0
RETURN ON INVESTMENT
Green Infrastructure Construction and Maintenance Cost
Benefit
Phase 1 (0-5 years)
Phase 2 (5-10 years)
Phase 3 (10-20 years)
70 YEARS
Life Cycle
Green Values National Stormwater Management Calculator
http://greenvalues.cnt.org/national/calculator.php