CITY OF HOUSTON
HOUSING AND COMMUNITY DEVELOPMENT

DRAFT ACTION PLAN FOR DISASTER RECOVERY

2024 DERECHO

+

HURRICANE BERYL

CITY OF HOUSTON | **HOUSING AND COMMUNITY DEVELOPMENT DEPARTMENT**

Change Log

Table 1: Change Log

Version (Date)	Summary of Changes Made
Version 1 (July 20, 2025)	

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Executive Summary

Overview

The U.S. Department of Housing and Urban Development (HUD) announced that the City of Houston (the City) will receive $314,645,000 in funding to support long-term recovery efforts following qualifying major disasters that occurred in 2023 or 2024, through the Office of the Assistant Secretary for Community Planning and Development, HUD. Community Development Block Grant-Disaster Recovery (CDBG-DR) funding is designed to address remaining needs after all other assistance has been exhausted. This plan details how funds will be allocated to address various unmet needs in the City.

To meet disaster recovery needs, the statutes making CDBG-DR funds available have imposed additional requirements and authorized HUD to modify the rules that apply to the annual CDBG program to enhance flexibility and allow for quicker recovery. HUD has allocated $314,645,000 in CDBG-DR funds to the City in response to the 2024 windstorm derecho and Hurricane Beryl (2024 Storm) (FEMA DR-4781 & FEMA DR-4798) through the publication of the Federal Register, FR-6512-N-01, on Thursday, January 16, 2025. This allocation was made available through the Disaster Relief Supplemental Appropriations Act, 2025 (Pub. L. 118-158) approved December 21, 2024.

Table 1: CDBG-DR Allocation Overview

Allocation Type	Amount
Unmet Need	$273,604,000
Mitigation	$41,041,000
Total Allocation	**$314,645,000**

Table 1 Source: Federal Register (FR-6512-AAN-01)

On January 8, 2025, HUD published the Community Development Block Grant Disaster Recovery Universal Notice: Waivers and Alternative Requirements (the Universal Notice), which outlines the rules and requirements governing the $12 billion of CDBG-DR funding appropriated by Public Law 118-158. On March 19, 2025, HUD issued a memo updating the guidance provided by the Universal Notice. The Action Plan for Disaster Recovery – 2024 Derecho and Hurricane Beryl (the Plan) has been developed as prescribed by HUD in accordance with the guidance provided by the Universal Notice.

The Plan contains the following sections:

- Executive Summary
- Unmet Needs Assessment
- Mitigation Needs Assessment
- Connection of Proposed Programs and Projects to Unmet Needs and Mitigation Needs
- Allocation and Award Caps/Funding Criteria
- General Information
- Appendix

Proposed Use of Funds

The City of Houston will use 100% of the CDBG-DR allocation in the HUD-identified MID area (Houston, TX) as shown in Table 3 below:

Table 2: CDBG-DR Program Allocations

Eligible Cost Category	CDBG-DR Allocation Amount	% of CDBG-DR Total Grant Award	Amount of CDBG-DR Allocation for LMI Benefit
Administration	$15,732,250.00	5.00%	N/A
Planning	$200,000.00	0.06%	N/A
Housing	$0.00	0.00%	0.00%
Infrastructure	$160,091,150.00	50.88%	77.25%
Public Services*	$97,580,600.00	31.01%	86.82%
Economic Revitalization	$0.00	0.00%	0.00%
Mitigation	$41,041,000.00	13.04%	0.00%
Total	**$314,645,000.00**	**100%**	

Table 2 Source: HUD's Unmet Need Justification Memo

**Public Services allocation amount does not include the public service program under Mitigation. The total amount budgeted for Public Service activities exceeds the 15% cap, however, the City is seeking a waiver to allow for this based on guidance from HUD.

Disaster Overview/Impacts

In the spring and summer of 2024, Houston faced two catastrophic events: the Derecho and Hurricane Beryl. At a national scale, "the total damage and economic loss from Beryl is $28 billion to $32 billion nationwide, including damage to homes, infrastructure, job and wage losses, and government cleanup expenses."[1]

Derecho

A powerful derecho windstorm swept through Houston, causing widespread destruction and leaving a significant portion of the city without power. The storm, characterized by sustained straight-line winds of up to 100 mph, brought with it intense thunderstorms, heavy rain, and damaging wind gusts that caused havoc across the region. The fast-moving storm resulted in significant damage to buildings, uprooted trees, and widespread infrastructure disruptions. The derecho was considered the worst damaging wind event to affect Houston in nearly 25 years. The strong winds in Downtown Houston blew out the windows of many high-rise buildings in the area, littering the streets below with broken glass. A brick building occupied by a bar near the intersection of Congress Street and Travis Street suffered the collapse of a wall.

The Derecho affected most of Houston's population, with many facing severe impacts to their homes and businesses. The storm downed power lines across the City, leaving over a million customers without electricity at the height of the event. The strong winds caused extensive damage to the city's power grid, delaying restoration efforts. More than 24 hours later, almost 555,000 customers remained without power, and by Wednesday of the following week (seven days later), when repairs were initially expected to be finished, nearly 60,000 homes, businesses, and schools in the worst-hit areas of the City were still without power. Eight people were confirmed to have died in Greater Houston as a result of the storm.

In addition to power outages, the storm caused substantial property damage. Large trees were uprooted, crashing into homes and blocking major roadways. Many neighborhoods reported extensive roof damage, broken windows, and flooding due to heavy rains accompanying the winds. The storm also damaged several public buildings and schools, prompting temporary closures.

[1] Patel, Shafaq, "Hurricane Beryl's estimated damage is in the billions." AXIOS Houston, 7/18/2024. https://www.axios.com/local/houston/2024/07/18/beryls-estimated-damage-in-the-billions

Emergency services were quickly deployed, focusing on clearing blocked roads, responding to calls for assistance, and helping residents affected by the storm. Shelters were set up to house those displaced, and efforts to repair homes and clear debris began almost immediately after the storm had passed.

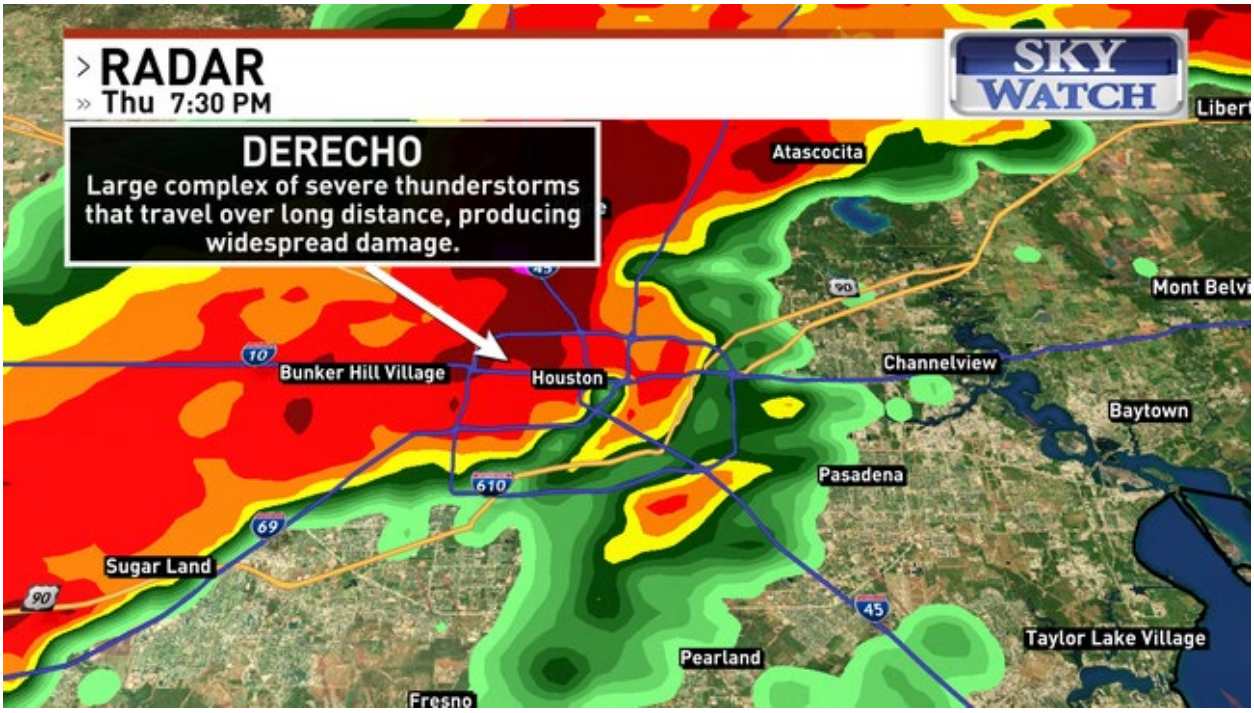

Figure 1: Derecho Radar
Source: https://wlos.com/news/nation-world/explainer-derecho-hits-houston-with-large-swath-of-severe-weather

Hurricane Beryl

Hurricane Beryl was a deadly and destructive tropical cyclone that impacted parts of the Gulf Coast of the United States. It made landfall in Houston on July 8, 2024, and struck the City as a powerful Category 1 storm, bringing with it sustained winds of 95 mph, heavy rains, and dangerous storm surges. Rainfall of 16.88 in (429 mm) was measured at a point 2.7 miles NNE of Hillshire Village, while parts of the Greater Houston area received 13.55 in (344 mm) of rain. The hurricane caused widespread damage and significant disruption across the City, impacting infrastructure, homes, businesses, and essential services. As Beryl made landfall, areas across Houston experienced extensive flooding and property damage, with some neighborhoods submerged due to heavy rainfall.

Hurricane Beryl was also significant for causing over 2.7 million households and businesses near the Gulf Coast, primarily in the Houston metropolitan area, to suffer from prolonged power outages during high temperatures and high humidity. The combination of downed power lines, fallen trees, and damaged electrical infrastructure left large parts of the City in the dark. Efforts to restore power were delayed due to severe flooding and extensive debris, with some areas remaining without power for up to seventeen days after the storm. The post-storm power outages played a contributing factor in at least ten deaths related to excess heat or nonfunctional medical equipment. Tragically, 42 fatalities were reported as a result.

In terms of infrastructure, the city also saw major roads rendered impassable and significant damage to homes and public buildings. The overall cost of the destruction is estimated to be between $2.5 billion to $4.5 billion in property damage, infrastructure repairs, and economic losses.

Texas declared a severe weather disaster declaration for 121 of its 254 counties. Houston's NRG Stadium suffered from roof damage, with strong winds causing a hole to form between a groove in the retractable roof. Severe weather forced George Bush Intercontinental Airport to delay 117 flights and cancel another 312 flights, while William P. Hobby Airport delayed 56 flights and canceled eight. At least one break room and one elevator were damaged during the storm at George Bush Intercontinental Airport.

Hurricane Beryl left Houston with long-lasting challenges as the City worked to rebuild. Despite the damage and disruption, Houston's community has shown resilience as it faces the recovery process and works to return the city to normalcy.

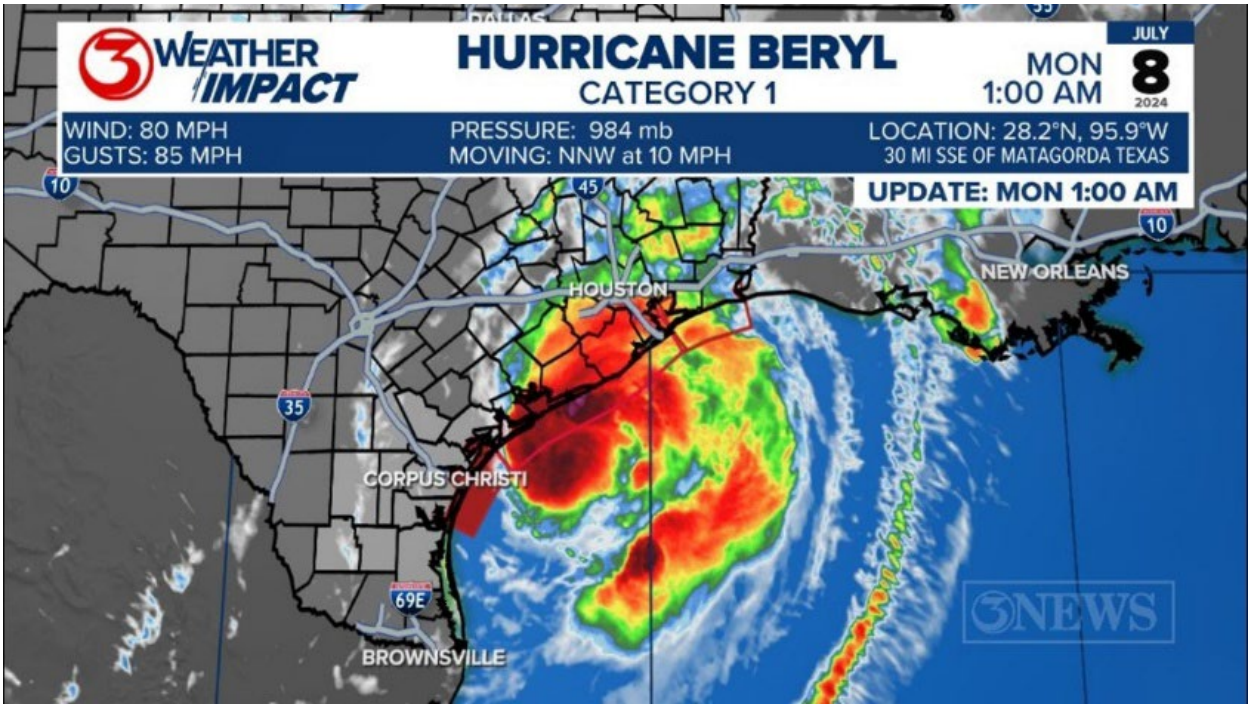

Figure 2: Hurricane Beryl Radar
Source: https://www.kiiitv.com/article/weather/hurricane/beryl-expected-to-make-landfall-near-matagorda-bay/503-2edce95e-c63c-470c-88b2-1e770b604287

Housing Impact

Figure 3: Housing Disaster Damage – Trees Uprooted
Source: https://www.fox26houston.com/news/trees-topple-onto-homes-and-vehicles-in-cypress-during-powerful-storm-system

Infrastructure Impact

Figure 4: Infrastructure Damage – Destroyed Power Towers
Source: https://abc13.com/post/houston-severe-weather-storms-damage-after-in-my-area/14828941/

Figure 5: Infrastructure Damage – Downed Powerlines
Source: https://www.khou.com/article/weather/hurricane/beryl/beryl-utility-poles/285-9adcc3ab-069c-46ad-9a04-0909da151866

Economic Impact

Figure 6: Economic Impact – Businesses Destroyed
Source: https://www.inc.com/araceli-crescencio/derecho-devastation-underscores-need-disaster-preparation.html

Table 3: Disaster Overview

Disaster Summary	
Qualifying Disaster	DR-4781-TX, DR-4798-TX
Grantee-Identified MID Areas	Houston, TX (Citywide)
HUD-Identified MID Areas	Houston, TX (Same as HUD-Identified MID Area)

Table 3 Source: Federal Register (FR-6512-AAN-01)

The following Federal Emergency Management Agency (FEMA) maps illustrate the federally declared disaster areas, and the type of FEMA funding approved for each impacted county from the 2024 Derecho and Hurricane Beryl. The entire City of Houston is within counties that FEMA designated for FEMA Individual Assistance (FEMA IA). FEMA IA designation allows the individuals and households in these counties to apply for financial and direct services after a federally declared disaster.

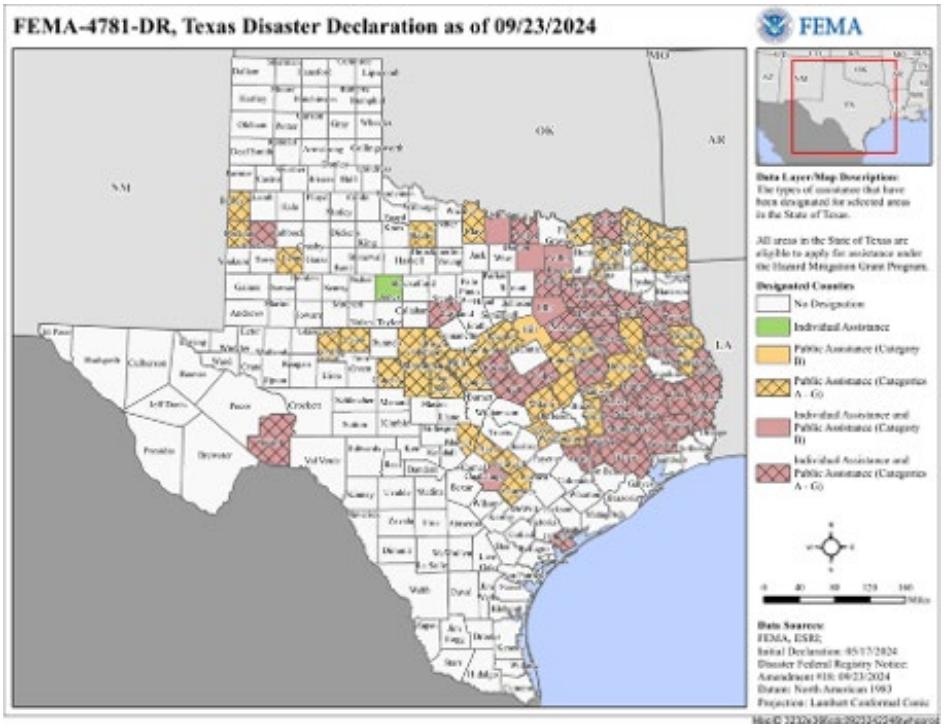

Figure 7: FEMA Map of DR-4781 Disaster Declaration Areas

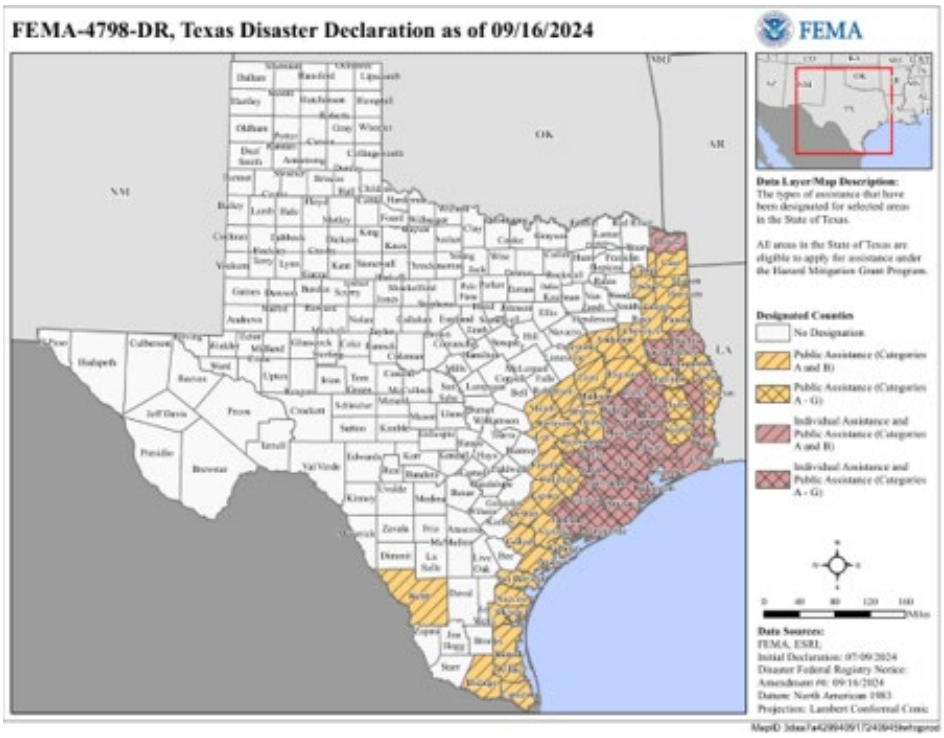

Figure 8: FEMA Map of DR-4798 Disaster Declaration Areas

Most Impacted and Distressed Areas

HUD identified MID Areas

HUD has designated Houston, TX as a "Most Impacted and Distressed" area (MID area). The City will spend 100 percent of the CDBG-DR funds on the HUD-designated MID area.

Grantee-identified MID Areas

N/A

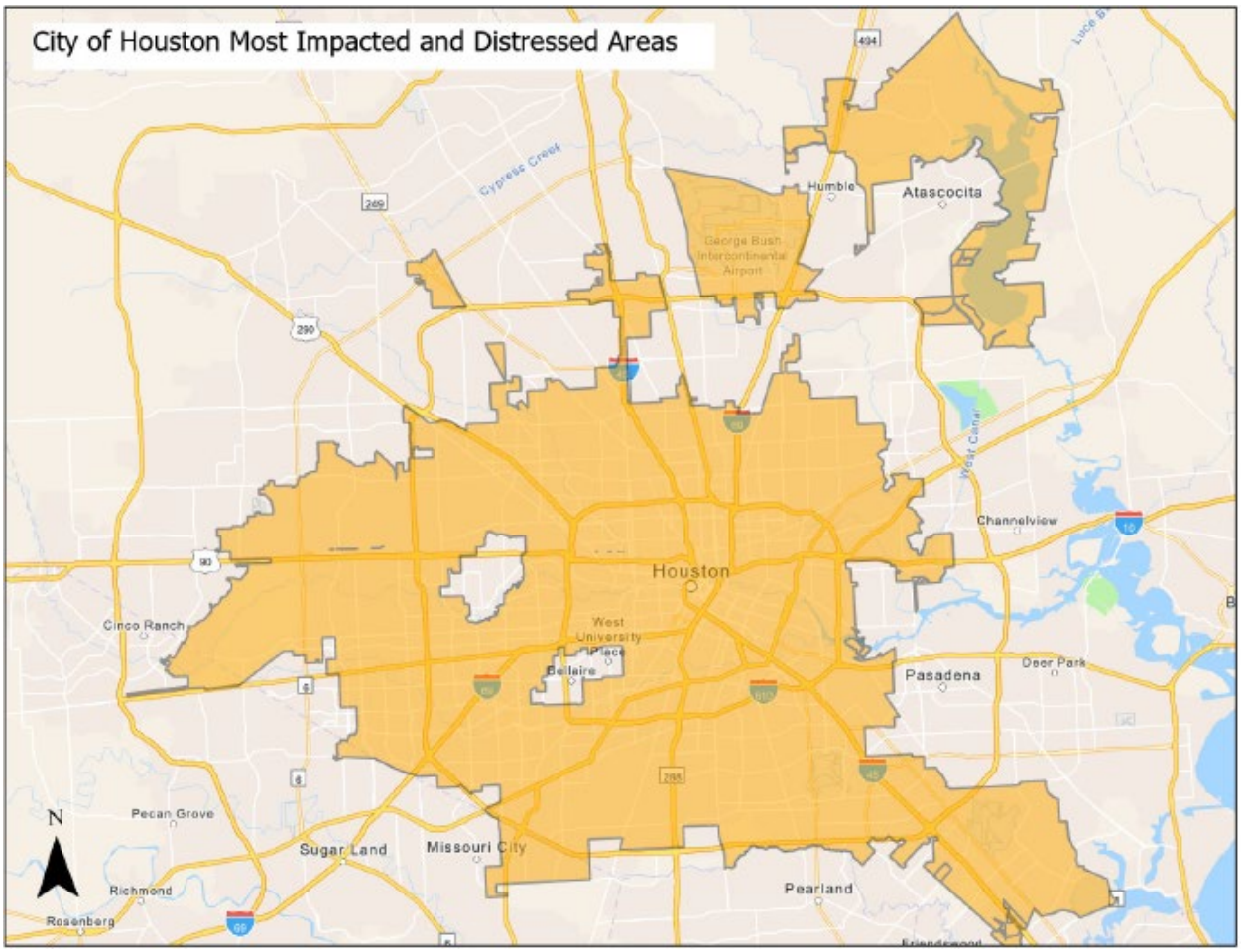

Figure 9: City of Houston Most Impacted and Distressed Areas

Unmet Needs and Mitigation Needs Summary

Given the disruption and damage caused by the 2024 Derecho and Hurricane Beryl and the compounding impacts from previous disasters, unmet needs for housing, infrastructure, economic revitalization, public services, and mitigation in the City of Houston remain significant. The unmet need assessment found that there are significant gaps/needs in every category.

- Housing: The largest unmet need, with over $229 million in estimated post-disaster housing repair, reconstruction, and personal property lost. Overcrowding and cost-burden, especially for LMI individuals and families, remain a key challenge. Disasters create additional financial burdens and may jeopardize individuals' and families' lives. Renters disproportionately receive significantly less assistance and approvals from FEMA.
- Infrastructure: Approximately $135 million in public infrastructure damages, with nearly $7.65 million in unmet needs, especially in the areas of emergency power resiliency and debris management.
- Economic Development: Power outages have caused significant disruptions in various industries, especially small businesses. An unmet need of over $186 million has been calculated from SBA data.
- Public Services: Public services were disrupted all over Houston, including senior care, youth programs, public health, and homeless services, due to power outages. At least $70 million is needed to maintain current levels of public services for individuals and families experiencing homelessness.

- Mitigation: Mitigation projects that are in dire need of funding and upgrades. While the Hazard Mitigation Plan details the risks, priorities, and likelihood of various disaster types, it does not quantify an amount of funding that would be needed to fully mitigate such disasters.

The City is committed to supporting a disaster recovery process that leverages a variety of strategies and resources to support the recovery effort. While the City acknowledges the significant unmet needs in housing and economic revitalization, the City cannot continue to ignore the long-needed infrastructure upgrades and will prioritize the City's disaster response and resilience efforts, in accordance with the proposed allocations shown in Table 4 below.

The primary objectives for CDBG-DR24 funding are to assist Houston residents by creating more resilient neighborhood facilities that can support residents before, during, and after a disaster. The activities outlined in this Plan will be funded using CDBG-DR24.

Given the disruption and damage caused by the 2024 Derecho and Hurricane Beryl and the compounding impacts from previous disasters, unmet needs in the City of Houston remain significant. The City is committed to addressing these needs and supporting a disaster recovery process that leverages other resources to support the recovery effort. The City acknowledges the unmet needs in housing, economic revitalization, and infrastructure; however, the City cannot continue to ignore… and must prioritize the City's disaster response and resilience efforts.

The following table provides a summary of disaster impacts from the 2024 Derecho and Hurricane Beryl (FEMA DR-4781 & FEMA DR-4798), with the program allocation amounts. The City may update the information below if information becomes available.

Table 4: Unmet Needs and Proposed Allocations

Category	Unmet Need	Percent of Total Unmet Need	Program Allocation Amount	Percent of Program Allocation Amount
Housing	$229,415,935.00*	46.5%	$0.00	0.0%
Infrastructure	$7,649,487.74	1.6%	$160,091,150.00	53.6%
Economic Revitalization	$186,350,706.00*	37.8%	$0.00	0.0%
Public Services**	$70,000,000.00	14.2%	$97,580,600.00	32.7%
Mitigation	Unavailable	0.0%	$41,041,000.00	13.7%
Total	**$493,416,128.74**	**100.0%**	**$298,712,750.00****	**100.0%**

Table 4 Source: HUD's Unmet Need Justification Memo

*This number may increase or decrease based on the timing of the determination of verified loss vs when the claim is paid out

**The Public Services allocation amount does not include the public service program under Mitigation. The total amount budgeted for Public Service activities exceeds the 15% cap, however, the City is seeking a waiver to allow for this based on guidance from HUD.

***Numbers exclude $15,932,250.00 (5.1%) distributed among Planning and Administration, not part of Unmet Needs

Unmet Needs Assessment

The needs assessment includes specific details about unmet needs within the City of Houston. Unmet needs are divided into housing, infrastructure, and economic revitalization sections. The assessment takes into consideration pre-disaster needs in addition to unmet recovery needs resulting from the 2024 Derecho and Hurricane Beryl. It discusses additional types of assistance that may be available for affected communities.

According to HUD's unmet need justification memo, the City received on 4/14/2025, the unmet needs for the two disasters across the state of Texas were approximately $825 million, with the majority of the unmet needs pointing to housing, and serious unmet needs. The City accounts for approximately 34% of HUD-calculated unmet need for the State of Texas. Unmet need plus mitigation set-aside totaled over $318 million. This amount was reduced by a 1.2488% pro-rata reduction, with the City receiving a final allocation amount of over $314.6 million.

Table 5 shows the state allocation and unmet need, and Table 6 shows the City's allocation and unmet need.

*Note: While this Plan is being drafted, additional data is coming in and being analyzed. The City will continue to evaluate updated data from FEMA and SBA and will update this section, as appropriate, based on the pending results of this analysis for the final Plan.

Table 5: Components of Unmet Need for the State of Texas by Disaster

Disaster Number	Disaster Description	Homes with Serious Unmet Needs	Housing Serious Unmet Needs	Business Serious Unmet Needs	Infrastructure Unmet Needs	Total HUD Formula Unmet Needs
4781	Flood	5,350	$333,277,069.00	$33,327,707.00	$38,586,676.00	$405,191,452.00
4798	Hurricane	5,452	$350,394,711.00	$35,039,471.00	$35,039,471.00	$420,473,653.00

Table 5 Source: HUD's Unmet Need Justification Memo

Table 6: Components of Unmet Housing Need for Houston, TX

Grantee	Disaster Number	Homes with Serious Unmet Housing Needs	Percentage of State	Housing Unmet Need	Business / Infrastructure Unmet Need*	Mitigation (15% of Total Unmet Need)	Disaster Total (Unmet Need + Mitigation)
Houston, TX	4781; 4798	3,965	34%	$229,415,935	$47,648,065.00	$41,560,000.00	$318,624,000.00

Table 6 Source: HUD's Unmet Need Justification Memo
*HUD did not break down this amount between Business and Infrastructure

Table 7: Allocation Table

Grantee	Disaster Number	Housing	Business Serious Unmet Needs /	Total Unmet Need	Mitigation (15% of Total Unmet Need)	Total Allocation
Houston, TX	4781; 4798	$226,550,989.00	$47,053,036.00	$273,604,025.00	$41,041,000.00	$314,645,025.00

Table 7 Source: HUD's Unmet Need Justification Memo

Evaluate the Impacts of the Three Core Aspects of Recovery

Housing

Pre-Disaster Housing Market Conditions

Between 2010 and 2023, the number of occupied housing units in Houston's three-county region increased by 35%, more than two times the national growth rate of 15%. The substantial increase in Houston area rentals (41%) is the primary driver of the overall increase in occupied housing, though the number of housing units occupied by homeowners increased by 32% during this period.

According to a report by the Kinder Institute, new home sales have substantially increased in all three of the biggest counties in the Houston metro area: Harris, Fort Bend, and Montgomery. Comparing the single years of 2011 and 2023, the number of new homes sold increased almost 50% in Fort Bend (from 2,474 to 3,685), more than doubled in Harris (from 4,720 to 9,733), and increased almost sixfold in Montgomery (1,046 to 6,076).

Although growth has been observed for market-rate homes, the availability of affordable housing units has not met the needs of low-income Houstonians. The City consistently sees high rates of severe cost burden, meaning households pay more than 50% of their monthly income for housing costs. Overcrowding is also a problem.

Using the most recent Comprehensive Housing Affordability Strategy (CHAS) data from 2017 to 2021 provided by HUD, it became apparent that approximately 58% of renters are paying more than 30% of their gross income towards rent, which could mean that their ability to effectively address their housing needs may be severely impeded by financial resources. Approximately 12% (41,355) of renter households earning below 80% area median family income have overcrowding issues. The persistence of both housing problems indicates that the available housing stock is not meeting the needs of the residents.

The data also showed that out of all Houston households in all income categories, 24.1% of the owner-occupied households had at least one housing problem, and 52.3% of renter households had at least one housing problem. For homes that were experiencing housing problems and repetitive flooding in the last five years, financial resources addressing housing concerns may be an even bigger challenge. The lack of available, accessible, and quality affordable housing in Houston only amplifies the need for housing recovery, restoration, and resilience.

The median new home price in Harris County in 2023 was roughly $357,365, almost 20% higher than the median price of an existing home ($300,000) compared to 5 years ago. In 2011, the median existing home sold for $130,000. At the same time, most residents living in Houston are renters, representing 58% of the occupied housing. The majority (81.4%) of Houston homeowners live in housing units that consist of 3 or more bedrooms.

Table 8: Housing Problems by Number of Households

	Renter			Owner		
	0-80% AMI	Over 80 % AMI	Total	0-80% AMI	Over 80 % AMI	Total
Housing Problems	**NUMBER OF HOUSEHOLDS**					
Substandard Housing - Lacking complete plumbing or kitchen facilities	6,155	510	**6,665**	1130	235	**1365**
Severely Overcrowded - With >1.51 people per room (and complete kitchen and plumbing)	12,470	1,785	**14,255**	1015	345	**1360**
Overcrowded - With 1.01-1.5 people per room (and none of the above problems)	24,330	2,770	**27,100**	4860	1405	**6265**
Housing cost burden greater than 50% of income (and none of the above problems)	104,270	775	**105,045**	30,220	1495	**31715**
Housing cost burden greater than 30% of income (and none of the above problems)	85,570	10,140	**95,710**	26,040	4675	**30715**
Zero/negative Income (and none of the above problems)	62,000	35,350	**97,350**	58,550	26610	**85160**

Table 8 Source**:** 2017-2021 CHAS, Table 3

Emergency Shelters, Interim, and Permanent Housing

The annual Point-in-Time Homeless Count & Survey (PIT Count) is a requirement of the U.S. Department of Housing and Urban Development (HUD) for the local Continuum of Care (CoC) known as The Way Home. The PIT Count illustrates trends over time (increases or decreases) in homelessness and provides insights into the effectiveness of

a community's housing programs and homeless services. The Coalition for the Homeless of Houston/Harris County serves as the Lead Agency to The Way Home and coordinates the PIT Count as part of those responsibilities. The Way Home encompasses Houston, Pasadena, Harris, Fort Bend, and Montgomery Counties, Texas.

A PIT Count of sheltered (i.e., those in emergency shelters, transitional housing, or safe haven) and unsheltered persons experiencing homelessness in the Houston, Pasadena, Harris County, Fort Bend County, and Montgomery County area was held on the night of January 22, 2024, with the unsheltered portion of the count conducted over three days from January 23-25, 2024.

Table 9: Homeless Needs Table – 2024 PIT Count

Population	Estimate the # of persons experiencing homelessness on a given night*		Total
	Sheltered	Unsheltered	
Persons in Households with Adult(s) and Child(ren)	738	0	738
Persons in Households with Only Children	9	0	9
Persons in Households with Only Adults	1,426	1,107	2,533
Chronically Homeless Individuals	176	318	494
Chronically Homeless Families	19	0	19
Veterans	163	50	213
Unaccompanied Youth (24 and under)	142	33	175
Persons with HIV	60	17	77
*2024 PIT, as reported to HUD HDX. Also, the chronically homeless status is self-reported.			

Table 9 Source: Coalition for the Homeless, Houston/Harris County

At the time of the 2024 PIT count, prior to both Derecho and Hurricane Beryl, there was a total of 3,280 individuals experiencing homelessness.

The majority, 66% (2,173 people) of the homeless population were sheltered in our CoC (the City of Houston, Harris County, Fort Bend, and Montgomery County). The breakdown of unsheltered vs. sheltered homeless individuals by county is as follows:

- Harris County – 1,046 unsheltered and 1,893 sheltered
- Fort Bend County – 11 unsheltered and 41 sheltered
- Montgomery County – 50 unsheltered and 239 sheltered
- Total Count: 3,280 – 1,107 unsheltered and 2,173 sheltered

All homeless households with children were sheltered, 26% of the sheltered population experiencing homelessness were under the age of 18, and 8% were between 18 to 24 years old. Three-quarters (76%) of Veterans were in a sheltered situation.

Among the unsheltered population, 41% had been homeless for three years or longer, similar to the percentage found in 2022 (38%). This year's findings of 12% newly homeless (0-3 months) were also similar to last year's findings of 14%. The chronically homeless comprised almost one-fourth of the total population, an increase over 2022's findings (17%), with a higher percentage among the unsheltered. An interview with those who are unsheltered revealed that one of the main reasons for homelessness was due to a natural disaster, most commonly Hurricane Harvey, even though this occurred more than five years ago. The Way Home and the CFTH are working to find and help those individuals, as they are a priority population for housing.

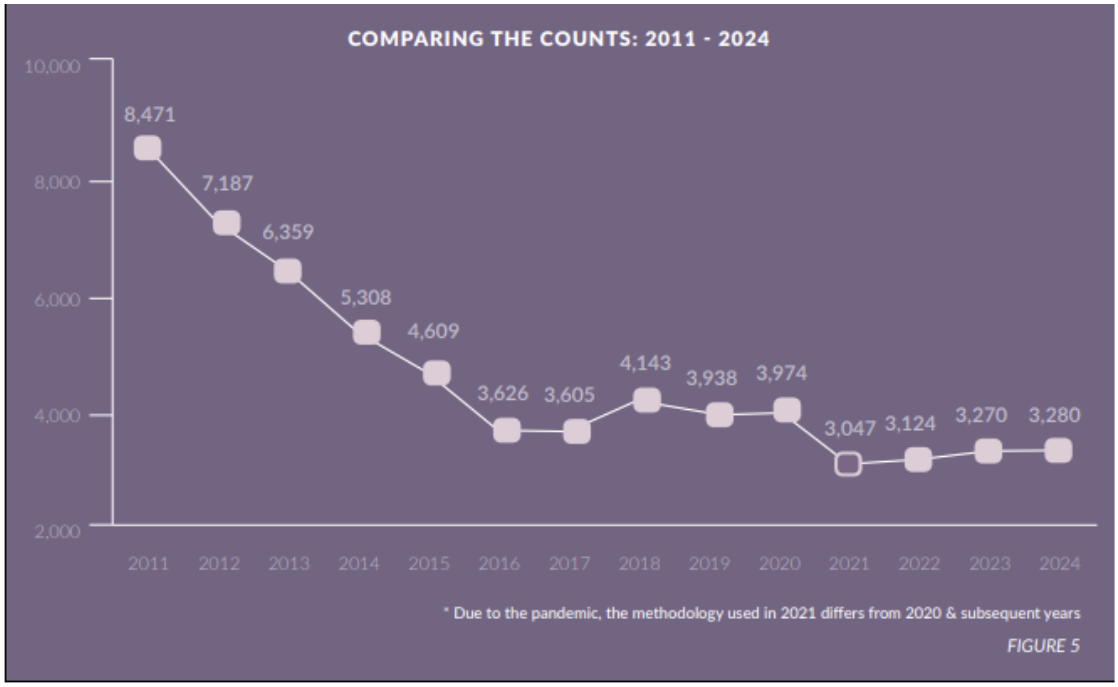

Figure 10: Comparing the Counts: 2011-2024

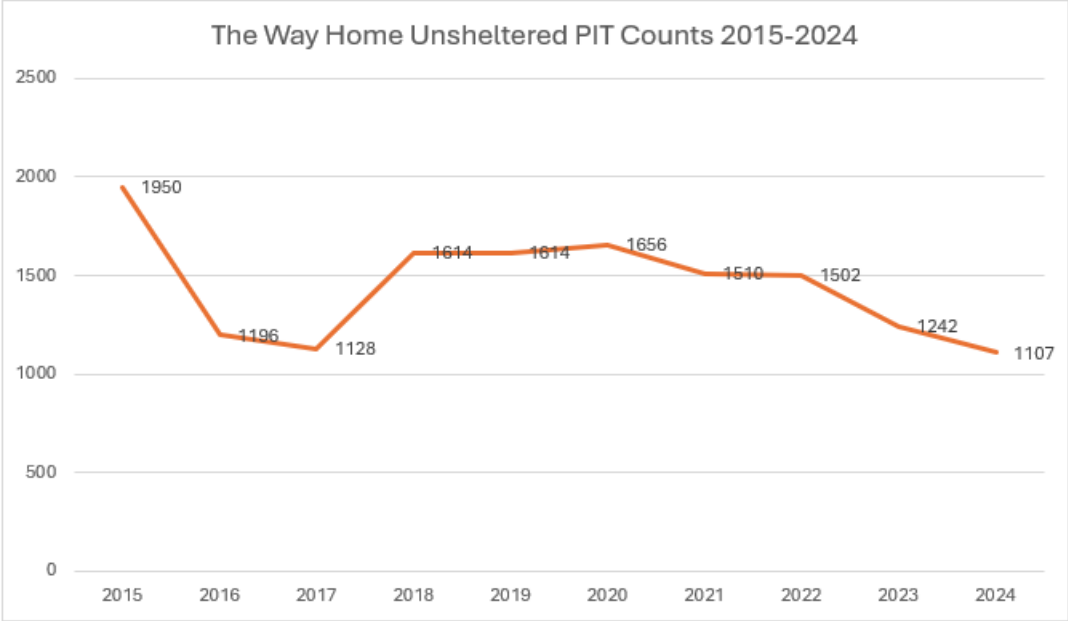

Figure 11: The Way Home Unsheltered PIT Counts 2015-2024

The City, partnering with the County and other partners, has housed over 32,000 people and significantly reduced homelessness since 2011. The City is dedicated and committed to leveraging available resources, including federal dollars, in providing public services, shelters, and rehousing of homeless individuals and families. As COVID and federal funding are set to expire, additional funding and resources are needed to house more homeless persons.

Although it is hard to quantify the actual damage due to the Derecho and Hurricane Beryl related to public services, disasters severely affect survivors who are experiencing homelessness or are at risk of experiencing homelessness because of impacts to housing, shelters, and homeless services. These impacts to homeless service providers and the people they serve include: 1) Disrupting lives and support networks of individuals and families experiencing homelessness resulting in increased need for assistance and increased work for homeless providers, 2) Damaging or rendering unusable homeless shelters or other facilities for programs that serve individuals and families experiencing homelessness, and 3) Significantly increasing the number of people experiencing homelessness or at risk of homelessness because homes become damaged or unlivable.

Although permanent supportive housing has been a successful solution to homelessness for the most vulnerable, continuous investments and upgrades must be made at public facilities and service providers so that they are able to deploy personnel and resources to bring vulnerable individuals into a safe environment and provide needed help and services.

As the service level needs of people experiencing homelessness vary based on their circumstances, it remains crucial that all options and assistance are open and available, even during and after a natural disaster, for those people needing longer-term rental assistance and services support to achieve stability. An effective homeless response system can identify and quickly connect people who are experiencing or are at risk of experiencing homelessness to housing assistance and other services, as it works because it aligns a community, its programs, and services around one common goal: to make homelessness rare, brief, and nonrecurring.

As of 5/23/2025, the 2025 PIT count is not yet available. The City will provide any updates, as appropriate, based on the release of the 2025 report.

Rental and Owner-Occupied Single Family and Multifamily Housing

Cities rely on the FEMA Individual Assistance (IA) Program as a primary indicator when establishing housing unmet recovery needs for disaster recovery funding. The FEMA data provides useful and important information about applicants who ask for assistance from FEMA. However, some households do not register with FEMA, or landlords do not file for claims, deflating the impact reflected in the data and the true impact of the disaster. Despite these limitations, it is the best indicator to identify individual and household disaster unmet needs for housing recovery.

The table below shows the distribution of FEMA IA Applicants (owner and renter) by Housing Type. The vast majority of applications came from single-family houses and duplexes, followed by apartments, then town homes. However, when it came to renters vs owners, single family homeowners and apartment/multifamily renters had the greatest number of claims.

Table 10: FEMA IA Applicants by Household Type

Residence Type	Total Applicants	% of Total	Owner-Occupied	Owner-Occupied %	Renter Occupied	Renter Occupied %
House/Duplex	342,938	54.14%	229,621	84.92%	113,201	30.70%
Apartment	211,269	33.36%	60	0.02%	211,151	57.27%
Mobile Home	11,425	1.80%	7,127	2.64%	4,289	1.16%
Townhouse	24,326	3.84%	13,623	5.04%	17,258	4.68%
Travel Trailer	1,459	0.23%	256	0.09%	596	0.16%
Condo	9,532	1.50%	4,784	1.77%	4,746	1.29%
Other	32,435	5.12%	14,927	5.52%	17,467	4.74%
Total	**633,384**	**100.00%**	**270,398**	**100.00%**	**368,708**	**100.00%**

Table 10 Source: FEMA IA

Per the Federal Register, the following consist of the calculation methodology of unmet needs.
To calculate the level of damage for owner-occupied households, HUD categorized the FEMA inspected owner units into one of five categories:

- Minor-Low: Less than $3,000 of FEMA inspected real property damage.
- Minor-High: $3,000 to $7,999 of FEMA inspected real property damage.
- Major-Low: $8,000 to $14,999 of FEMA inspected real property damage and/or more than one foot of flooding on the first floor.
- Major-High: $15,000 to $28,800 of FEMA inspected real property damage and/or 4 to 5.9 feet of flooding on the first floor.
- Severe: Greater than $28,800 of FEMA inspected real property damage or determined destroyed and/or six or more feet of flooding on the first floor.

Rental household damage is calculated based on personal property damage, because FEMA does not inspect rental units for real property damage. To calculate the level of damage for rental households, HUD categorized the FEMA inspected owner units into one of five categories:

- Minor-Low: Less than $1,000 of FEMA inspected personal property damage.
- Minor-High: $1,000 to $1,999 of FEMA inspected personal property damage.
- Major-Low: $2,000 to $3,499 of FEMA inspected personal property damage or one to 3.9 feet of flooding on the first floor or determination of “Moderate” damage by the FEMA inspector.
- Major-High: $3,500 to $7,499 of FEMA inspected personal property damage and/or four to 5.9 feet of flooding on the first floor or determination of “Major” damage by the FEMA inspector.
- Severe: Greater than $7,500 of FEMA inspected personal property damage and/or determined destroyed and/or six or more feet of flooding on the first floor or determination of “Destroyed” by the FEMA inspector.

The calculation of unmet needs only include application types that are in the Major-Low, Major-High, or Severe category. The table below shows the distribution of owners and renters who were placed in the 3 categories. Across all damage categories, homeowners had greater impacts from the 2024 Disasters than renters in each damage category.

Out of 4,687 total applications, a significant majority (82.6%) fell in the major-low category. About 3 times more owners received/qualified for FEMA assistance compared to renters. Also, the number of renters excludes those above 50% AMI, who may also have had losses; hence, the number of renters who may need assistance may be greater than what is shown in the table.

Table 11: FEMA Damage Categories

Residency Type	Major-Low	Major-High	Severe	Total
Owners	3,010	391	92	3,493
Renters*	865	298	34	1,194
Total	**3,872**	**689**	**126**	**4,687**

Table 11 Source: FEMA IA
*Based on HUD, landlords are expected to have insurance unless their rental unit is occupied by a tenant with income below 50% AMI. Hence, the table only includes renters who are below 50% AMI.

Finally, HUD applies a disaster-specific multiplier based on the incident type that each FEMA IA applicant falls into. DR-4781 (Derecho) was designated as a “Flood,” and DR-4798 (Beryl) was designated as a “Hurricane”.

Table 12: FEMA IA Unmet Need Multiplier by Damage Category

Disaster	Major-Low	Major-High	Severe
FEMA-DR-4781-TX	$47,074	$57,856	$64,513
FEMA-DR-4798-TX	$36,800	$45,952	$45,952

Table 12 Source: Federal Register (FR-6512-AAN-01)

Table 13: Category of Unmet Need by Owner-Occupied and Renter

Damage Category	Count	Total Unmet Need
Major-Low	3,872	$155,106,072
Major-High	689	$34,494,080
Severe	126	$6,569,514
Total	**4,687**	**$196,169,666**

Table 13 Source: FEMA IA

The FEMA results show that there is an unmet need of $196,169,666, which is different from the amount provided by HUD and mentioned in the executive summary. However, as noted above, the actual amount of unmet need is likely higher because, renters above 50% AMI are excluded, FEMA has not fully gone through all of the applications, individuals did not put in a claim request (or did not know how to), and/or errors were made in the application resulting in a denial/delay. The City will continue to evaluate updated data from and will update this section, as appropriate, based on the pending results of this analysis for the final Plan.

Public Housing (Including HUD-assisted Housing) and Other Affordable Housing

The Houston Housing Authority (HHA) provides affordable housing and services to more than 60,000 low-income individuals throughout the City of Houston, serving families, elderly persons, and persons with disabilities. HHA currently operates 21 developments, which include Public Housing, mixed-income (LIHTC), RAD, and Section-8 PBV developments.

According to HHA, capital needs for the public housing portfolio were estimated at over $250 million or $147,000 per unit in 2024. Based on the existing capital funds allocated to HHA of $8 million in 2024, it would take 31 years to address the anticipated capital needs of the public housing properties. Although HHA and the City have worked together to increase the availability of public and affordable housing, it comes with many challenges. Continued disasters only amplify the needed repairs, reconstruction, and capital expenditures needed in our communities.

Both the Derecho and Hurricane Beryl caused damage to the City's Public Housing developments, as summarized below.

Table 14: HHA Damaged Units - Derecho

County / Municipality	Total # PHAs Developments	Total PHA Units	Total PHA Developments Damaged	Total PHA Development Power Loss	# of Units Damaged	Remaining Unmet Need
HHA Units (includes PH/LIHTC/RAD)	21	3,900	10	5	3	$26,055

Table 14 Source: Houston Housing Authority

According to HHA, during Derecho, seven HHA communities/developments sustained damage, which included downed trees, water leaks, loss of power, loss of water, and roof damage. Five developments experienced power

loss during and after the storm. Three units experienced broken doors, and two windows were shattered as a result of the strong wind. HHA estimates that costs/damages are $26,055, with repairs/removals still needed for some developments

Table 15: HHA Damaged Units – Hurricane Beryl

County / Municipality	Total # PHAs Developments	Total PHA Units	Total PHA Developments Damaged	Total PHA Development Power Loss	# of Units Damaged	Remaining Unmet Need
HHA Units (includes PH/LIHTC/RAD)	21	3,900	18	5	72	$2,504,554

Table 15 Source: Houston Housing Authority

On the other hand, Hurricane Beryl had a greater impact, causing over 72 units across 18 of the 21 HHA communities to sustain damage, which included window damage, roof damage, siding/fencing/structure damage, property damage (such as cars and other vehicles), and power/water loss. HHA estimates damages to be over $2.5 million.

HHA also administers the Housing Choice Voucher (HCV) - Section 8 program. However, voucher holders live across the city. Therefore, it is difficult to determine the number of HCV holders affected by either/both events unless individuals and homeowners self-report to HHA that their unit/home has been damaged. Additionally, FEMA data does not classify whether the individual(s) making a claim for personal property loss are voucher holders. So, it is possible that many voucher holders were also affected by both events.

Although no permanent relocation was needed from either event, some residents had to seek temporary shelter or another place as water/power loss occurred during the summer, which resulted in health and safety hazards/risks for many HHA program participants. The City will continue working with HHA and other affordable housing providers to address unmet needs that have been exacerbated by compounding disasters.

Infrastructure

The City of Houston is a sprawling city, and therefore, public infrastructure and improvements are often in need of enhancement. At the same time, Houston's infrastructure is aging and may require replacement.
Both the Derecho and Hurricane Beryl exposed vulnerabilities in Houston's infrastructure, particularly regarding power outages and flooding, prompting calls for improvements and increased resilience.

The City of Houston's Capital Improvement Plan (CIP) addresses the infrastructure needs in Houston. The plan primarily focuses on the need to invest in infrastructure to meet the city's short and long-term needs for streets, storm drainage, water, and wastewater systems. In 2024, the plan outlined prioritizing improvements to the wastewater and drinking water infrastructure, along with large projects, including airport renovations.

Unlike previous disasters, the 2024 events occurred within two months of one another. In both events, power outages led to much of the subsequent damage or infrastructure systems failures, like impacting the availability of drinking water, cooling centers, air conditioning, and city services. The City's preparation and post-disaster assistance provided to residents relies heavily on electricity, which may be subject to outages during a disaster. The loss of power can potentially leave residents stranded or in unsafe conditions in their homes, but it can also impact emergency responders' and the City's ability to provide critical public safety services and other general services that are necessary before, during, and after a disaster. During both 2024 events, the critical infrastructure across the city experienced challenges in power generation reliability.

There have been eight (8) presidentially declared disaster declarations in Houston since 2015. The most common natural disasters that result in a federal disaster declaration are floods and hurricanes. The City of Houston is still rebuilding from previous disasters, including Hurricane Harvey and Winter Storm Uri. Much of the damage from recent disasters includes damage to buildings and infrastructure, like water system facilities, roads, and bridges, due to flooding. In addition to direct damage to infrastructure caused by flooding, infrastructure that is aging or undersized can also lead to flooding in residential homes and other buildings.

Cities rely on the FEMA Public Assistance (PA) Program as a primary indicator when establishing infrastructure unmet recovery needs for disaster recovery funding. The FEMA PA data provides useful and important information about applicants who ask for this assistance from FEMA.

Table 16 shows the estimated FEMA PA Cost by each category made available to the City of Houston through the program, and Table 17 shows Total Cost vs Cost Share Total.

Table 16: Total Cost and Need by PA Category

PA Category	Estimated PA Cost	Local Cost Share*	Total Need
A – Debris	$105,248,472.00	$26,312,118.00**	$78,936,354.00
B – Emergency Measures	X	X	X
C – Roads and Bridges	-	-	-
D – Water Control Facilities	-	-	-
E – Building and Equipment	$21,687,486.68	$5,421,486.72	$16,265,999.96
F – Utilities	$2,145,080.60	$536,269.50	$1,608,811.10
G - Other	$6,765,384.25	$1,691,346.06	$5,074,038.19
Total	**$135,846,423.53**	**$33,961,220.28**	**$101,885,203.25**

Table 16 Source: City of Houston

*Typically, FEMA covers 75%, with the remaining 25% being the responsibility of local governments or other entities involved for Category A.

** Local cost share for Category A - Debris will be submitted for coverage by the State of Texas.

Table 17: FEMA PA Total Cost vs Cost Share Total

Disaster Number	FEMA PA Total Cost	Cost Share Total
4781	$4,259,637.21	$1,064,909.30
4798	$26,338,313.76	$6,584,578.44
Total	**$30,597,950.97**	**$7,649,487.74**

Table 17 Source: FEMA PA

After both events, the City of Houston assessed damage to City-owned buildings and facilities. The estimated damage was $135 million, and the City will seek state funds to repair and address damage related to Category A ($26,312,118.00), leaving a remaining unmet need of $7,649,487.74 from the Derecho and Hurricane Beryl.

Economic Revitalization

Overview

During the last five years, the Houston Metropolitan Statistical Area (MSA) enjoyed continuous economic growth. The Houston MSA was recently ranked as the seventh-largest economy in the nation.[2] Growth has been especially strong since the COVID-19 pandemic began to subside in 2021. In the two years from 2021 to 2023, Houston's GDP grew by 25.1 percent, which was faster than the U.S. overall, where GDP grew by 16.0 percent during the same period. In

[2] *Houston Economic Highlights 2024*, Greater Houston Partnership (June 2024).

fact, among the 20 most populous U.S. metro areas, Houston has had the fastest-growing economy since 2021, as measured by GDP.

Historically, much of Houston's economy has been based around energy businesses, and this continues today. Five industries- manufacturing, professional/business services, real estate, government, and healthcare/ education- have been the leading drivers of this growth. Together, they made up more than 50 percent of Houston's GDP in 2023. However, in recent years, digital technology and innovation have also continued to grow, with over 60 organizations supporting tech start-ups in Houston. This innovation has also led to many small businesses to flourish in the City.

Small Business Administration Loans

Table 18: Economic Revitalization Unmet Need

Application Status	Count	Median	Amount
SBA declined applicants with verified losses < $12,000	1,008	$0.00	$0.00
SBA declined applicants with verified losses between $12,000 and $29,999	199	$21,392.00	$4,257,008.00
Subtotal (not included in unmet need)	1207		$4,257,008.00
SBA declined applicants with verified losses between $30,000 and $64,999	261	$45,000.00	$11,745,000.00
SBA declined applicants with verified losses between $65,000 and $149,999	255	$95,040.00	$24,235,200.00
SBA declined applicants with verified losses > $150,000	286	$525,771.20	$150,370,506.00
Unmet Need	**802**		**$186,350,706.00**

Table 18 Source: SBA Data

HUD provides a methodology for calculating the unmet need for economic revitalization by using the following categories:

- Category 1: real estate + content loss = below $12,000
- Category 2: real estate + content loss = $12,000–$29,999
- Category 3: real estate + content loss = $30,000–$64,999
- Category 4: real estate + content loss = $65,000–$149,999
- Category 5: real estate + content loss = $150,000 and above

Then, for properties with real estate and content loss of $30,000 or more, HUD calculates the estimated amount of unmet needs for small businesses by multiplying the median damage estimates for each of the categories above by the number of small businesses denied an SBA loan in that category. Using the methodology described, the City determined the estimated unmet need for economic revitalization to be **$186,350,706.00.**

Note: As the data provided from the US Small Business Administration was based on a point in time changes in the number of claims and claim status can affect the determination of unmet need for economic revitalization. The city will continue to evaluate the SBA data and provide an update when more recent data is retrieved.

Unemployment

As described in the previous section, both events significantly impacted the Houston economy. Across the United States, the Derecho caused an estimated $9-11 billion in total economic loss and damage, and Hurricane Beryl caused an estimated $28-32 billion in total economic loss and damage, including significant business losses in Houston. The storm caused wind damage and power outages, leading to temporary and permanent shutdowns of many businesses, resulting in job and income losses.

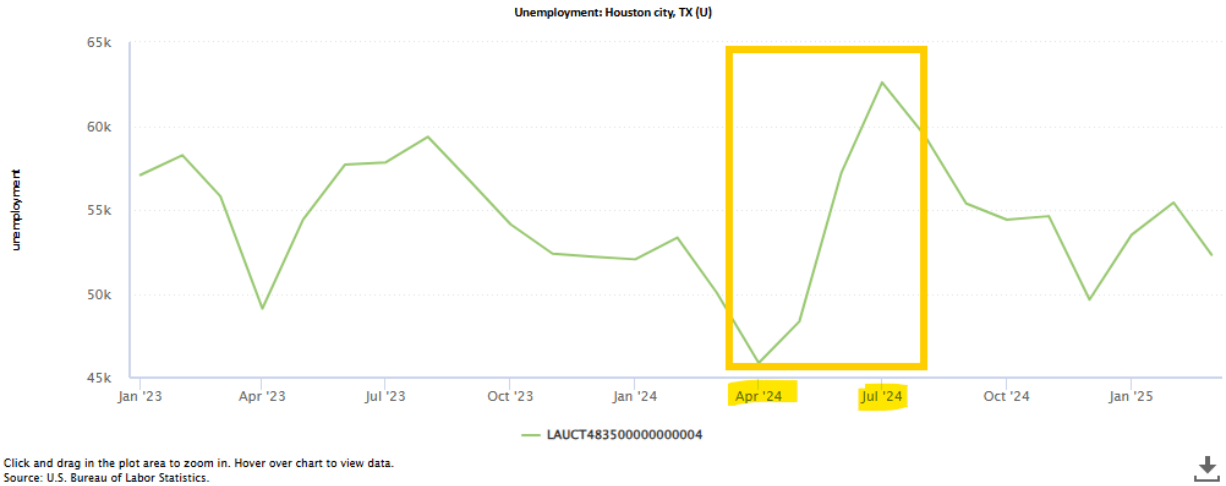

Figure 12: Unemployment: Houston City, TX

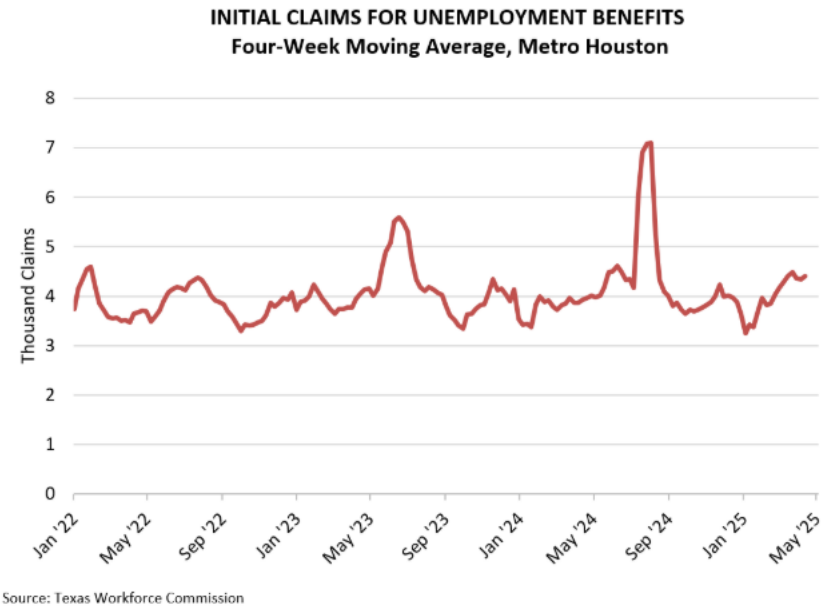

Figure 13: Initial Claims for Unemployment Benefits (4WK AVG) Metro Houston

Figures 12 and 13 show the impact of both events. As the graph shows, the number of unemployed person(s) significantly jumps from May to July 2024, which coincides with the occurrence of the Derecho and Hurricane Beryl. Initial claims for unemployment benefits also jumped significantly in July. Unemployment not only affects people who have lost jobs, but businesses as well, especially small businesses that require employees. Although many people were able to find jobs after the storms, unemployment remains higher than it was pre-disaster (April of 2024).

On top of unemployment, the storms had a significant impact on many people and businesses, as food, products, and other materials sold at many stores were destroyed. Downtown Houston's infrastructure suffered significantly, with multiple high-rise buildings sustaining extensive damage from the derecho's straight-line winds, which also contributed to the supply chain and transportation delays. Lastly, there was a spike in burglary reports in Houston following Hurricane Beryl, with businesses being targeted during and after the storm, adding more to the unaccounted indirect damage many businesses suffered.

Mitigation Needs Assessment

As required by HUD, the City of Houston developed a mitigation needs assessment based in part on the *City of Houston Hazard Mitigation Plan (*https://www.houstontx.gov/2023-2028-Hazard-Mitigation-plan.pdf). To develop the mitigation needs assessment, the City reviewed: the FEMA Local Mitigation Plan Handbook, Department of Homeland Security (DHS) Office of Infrastructure Protection, FEMA Lifelines Implementation Toolkit (2023), resources about wildfires from the U.S. Forest Service, the National Interagency Coordination Center (NICC), the CDBG-MIT Action Plan, and HUD's CPD mapping tool. This assessment addresses current and future risks, including hazards, vulnerability, and impacts of disasters and identifies appropriate mitigation actions to reduce the highest risks that Houston faces. This mitigation needs assessment informs the use of the 15% CDBG-DR mitigation set-aside and helps to build resilience and mitigation measures into recovery programs and projects.

Overview of the City of Houston Hazard Mitigation Plan

The goal of the *Hazard Mitigation Plan* is to minimize or eliminate long-term risks to human life, property, operations, and the environment from known hazards by identifying risks and implementing cost-effective hazard mitigation actions. The planning process is an opportunity for the City of Houston, stakeholders, and the general public to evaluate and develop successful hazard mitigation actions to reduce future risk of loss of life and damage to property resulting from a disaster in the City of Houston.

The Mission Statement of the *Hazard Mitigation Plan* is, "Maintaining a secure and sustainable future through the revision and development of targeted hazard mitigation actions to protect life and property." Hazard mitigation activities are an investment in a community's safety and sustainability. It is widely accepted that the most effective hazard mitigation measures are implemented at the local government level, where decisions on the regulation and control of development are ultimately made. Throughout the planning process, and in partnership with the Texas Division of Emergency Management, members of community groups, local businesses, neighboring jurisdictions, schools and universities, hospitals, consulates, non-profit organizations, and local media organizations were invited to participate in the plan's development. Elements of the Hazard Mitigation Plan have been used to inform this assessment, including hazard identification, risk assessment, and the identification of potential projects.

Hazard Analysis and Lifeline Assessment

Upon a review of the full range of natural hazards suggested under the FEMA planning guidance, the City of Houston identified 12 hazard types, shown in Table 24 (Hazard Descriptions) below. These 11 natural hazards and 1 quasi-technological hazard (dam failure) have created or have the potential to create significant losses to justify inclusion in the *City of Houston Hazard Mitigation Plan*.

Table 19: Hazard Descriptions

HAZARD	DESCRIPTION
ATMOSPHERIC	
Extreme Heat	Extreme heat is the condition whereby temperatures hover ten degrees or more above the average high temperature in a region for an extended period of time.
Hail	Hailstorms are a potentially damaging outgrowth of severe thunderstorms. Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and subsequent cooling of the air mass.
Hurricane / Tropical Storm	A hurricane is an intense tropical weather system of strong thunderstorms with a well-defined surface circulation and maximum sustained winds of 74 mph or higher.
Lightning	Lightning is a sudden electrostatic discharge that occurs during an electrical storm. This discharge occurs between electrically charged regions of a cloud, between two clouds, or between a cloud and the ground.
Thunderstorm Wind	A thunderstorm occurs when an observer hears thunder. Radar observers use the intensity of the radar echo to distinguish between rain showers and thunderstorms. Lightning detection networks routinely track cloud-to-ground flashes, and therefore thunderstorms.
Tornado	A tornado is a violently rotating column of air that has contact with the ground and is often visible as a funnel cloud. Its vortex rotates cyclonically with wind speeds ranging from as low as 40 mph to as high as 300 mph. The destruction caused by tornadoes ranges from light to catastrophic, depending on the location, intensity, size, and duration of the storm.
Winter Storm	Severe winter storms may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Blizzards, the most dangerous of all winter storms, combine low temperatures, heavy snowfall, and winds of at least 35 miles per hour, reducing visibility to only a few yards. Ice storms occur when moisture falls and freezes immediately upon impact on trees, power lines, communication towers, structures, roads, and other hard surfaces. Winter storms and ice storms can down trees, cause widespread power outages, damage property, and cause fatalities and injuries to human life.
HYDROLOGIC	
Drought	A prolonged period of less than normal precipitation such that the lack of water causes a serious hydrologic imbalance. Common effects of drought include crop failure, water supply shortages, and fish and wildlife mortality.

HAZARD	DESCRIPTION
Flood	The accumulation of water within a body of water, which results in the overflow of excess water onto adjacent lands, usually floodplains. The floodplain is the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that is susceptible to flooding. Most floods fall into the following three categories: riverine flooding, coastal flooding, and shallow flooding.
OTHER	
Expansive Soils	Expansive soils are soils and soft rock that tend to swell or shrink due to changes in moisture content. Changes in soil volume present a hazard primarily to structures built on top of expansive soils.
Wildfire	A wildfire is an uncontrolled fire burning in an area of vegetative fuels such as grasslands, brush, or woodlands. Heavier fuels with high continuity, steep slopes, high temperatures, low humidity, low rainfall, and high winds all work to increase the risk for people and property located within wildfire hazard areas or along the urban/wildland interface. Wildfires are part of the natural management of forest ecosystems, but most are caused by human factors.
TECHNOLOGICAL	
Dam Failure	Dam failure is the collapse, breach, or other failure of a dam structure resulting in downstream flooding. In the event of a failure, the energy of the water stored behind even a small dam is capable of causing loss of life and severe property damage if development exists downstream of the dam.

Table 19 Source: City of Houston Hazard Mitigation Plan Update 2023- Section 4: Risk Overview

The methodologies utilized to develop the Risk Assessment are a historical analysis and a statistical approach. Both methodologies provide an estimate of potential impact by using a common, systematic framework for evaluation.

Records retrieved from the National Centers for Environmental Information (NCEI) and National Oceanic and Atmospheric Administration (NOAA) were reported for the City of Houston. Remaining records identifying the occurrence of hazard events in the planning area and the maximum recorded magnitude of each event were also evaluated. The four general parameters that are described for each hazard in the Risk Assessment include frequency of return, approximate annualized losses, a description of general vulnerability, and a statement of the hazard's impact.

Frequency of return was calculated by dividing the number of events in the recorded time period for each hazard by the overall time period that the resource database was recording events. The frequency of return statements is defined in Table 20, and impact statements are defined in Table 26 below.

Table 20: Frequency of Return Statements

PROBABILITY	DESCRIPTION
Highly Likely	Event is probable in the next year.
Likely	Event is probable in the next three years.
Occasional	Event is probable in the next five years.
Unlikely	Event is probable in the next ten years.

Table 20 Source: City of Houston Hazard Mitigation Plan Update 2023 - Section 4: Risk Overview

Table 21: Impact Statements

POTENTIAL SEVERITY	DESCRIPTION
Substantial	Multiple deaths. Complete shutdown of facilities for 30 days or more. More than 50 percent of property destroyed or with major damage.
Major	Injuries and illnesses resulting in permanent disability. Complete shutdown of critical facilities for at least two weeks. More than 25 percent of property destroyed or with major damage.
Minor	Injuries and illnesses do not result in permanent disability. Complete shutdown of critical facilities for more than one week. More than 10 percent of property destroyed or with major damage.
Limited	Injuries and illnesses are treatable with first aid. Shutdown of critical facilities and services for 24 hours or less. Less than 10 percent of property destroyed or with major damage.

Table 21 Source: City of Houston Hazard Mitigation Plan Update 2023 - Section 4: Risk Overview

Hazard Ranking

During the 2023 planning process the Planning Team determined that certain hazard rankings need to be updated from the 2018 rankings due to changes in priorities in the City of Houston and recent hazard events. Drought was ranked as “moderate” in 2018 and increased to “high” in 2023. Similarly, expansive soils, dam failures, and winter storm rankings were increased from “low” in 2018 to “moderate” in 2023. Lightning was ranked as “moderate” in 2018 but ranking decreased in 2023 to “low.”

Table 22 portrays the results of the risk assessment analysis for the frequency of occurrence and potential severity and the City’s self-assessment for hazard ranking, based local knowledge of past hazard events and impacts for each of the identified hazards.

Table 22: Hazard Risk Ranking

HAZARD	FREQUENCY OF OCCURENCE	POTENTIAL SEVERITY	RANKING
Flood	Highly Likely	Substantial	High
Hurricane/Tropical Storm	Highly Likely	Substantial	High
Extreme Heat	Highly Likely	Substantial	High
Drought	Highly Likely	Minor	High
Thunderstorm Wind	Highly Likely	Substantial	High
Dam Failure	Unlikely	Substantial	Moderate
Expansive Soils	Likely	Limited	Moderate
Tornado	Likely	Substantial	Moderate
Winter Storm	Highly Likely	Limited	Moderate
Wildfire	Highly Likely	Limited	Low
Lightning	Highly Likely	Substantial	Low
Hail	Highly Likely	Limited	Low

Table 22 Source: City of Houston Hazard Mitigation Plan Update 2023-2028

FEMA defined Community Lifelines for incident response, allowing the federal government a better understanding of the impacts of hazards and disasters in state and local jurisdictions. Although FEMA does not require a comprehensive Community Lifelines assessment in hazard mitigation planning guidance, the City of Houston does use these constructs during emergency response and recovery efforts. The assessment below includes an overview of the FEMA-defined Community Lifeline Components (shown in Figure 17), which were updated in 2023.

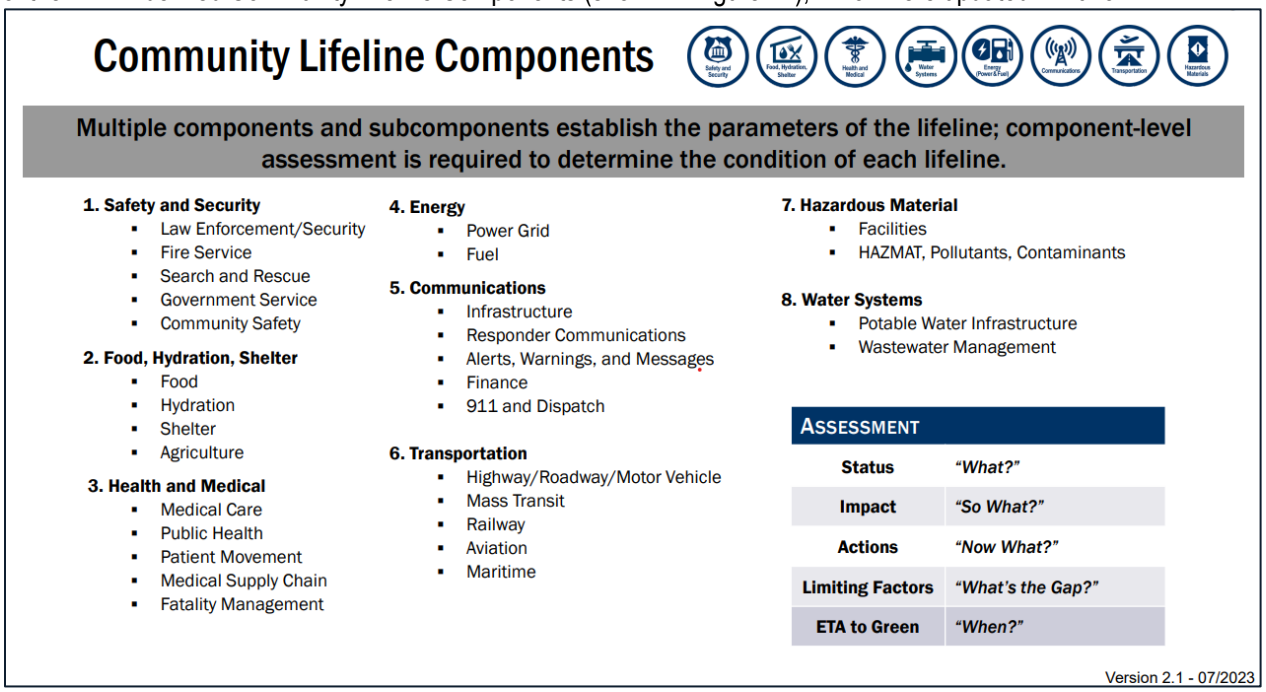

Figure 13: Community Lifeline Components
Source: FEMA Community Lifelines Toolkit 2.1/2023
(https://www.fema.gov/sites/default/files/documents/fema_lifelines-toolkit-v2.1_2023.pdf)

Ensuring the resilience of Community Lifelines is an important concept in all phases of emergency management. To quantitatively assess lifelines, the City of Houston is evaluating known facilities and infrastructure to support each lifeline and conducting geographic assessments of each with known hazard zones. The quantitative assessment is limited to flood risks (both inland and coastal). A preliminary assessment of each lifeline by hazard is provided in this

section using vulnerability and consequence/impact assessments for each of the seven community lifelines. The classifications of vulnerability and consequences are shown in the following Tables 23 and 24, respectively. These assessments are presented at the end of each hazard section. Consequence analysis may include all components of a lifeline or be isolated to one or two components or subcomponents that are critical in each hazard condition.

Table 23: Vulnerability Classifications

Vulnerability	Description
High Vulnerability	Geographically widespread exposure of facilities and systems to the damaging effects of a hazard AND the lifeline has low resilience to a hazard.
Moderate Vulnerability	The geographic exposure of facilities and systems to a hazard is widespread OR the lifeline has a low resilience to a hazard and the hazard is geographically isolated.
Low Vulnerability	Exposure of facilities and systems related to a community lifeline are geographically isolated OR the system itself has significant resilience to the hazard.

Table 23 Source: City of Houston OEM

Table 24: Consequence Classifications

Consequence	Description
Significant Impact to Lifeline/Services	In the worst, most probable hazard situation, services and infrastructure are fully functioning within weeks of onset of the hazard condition.
Moderate Impact to Lifeline/Services	In the worst, most probable hazard situation, services and infrastructure are fully functioning within days of onset of the hazard condition.
Low Impact to Lifeline/Services	In the worst, most probable hazard situation, services and infrastructure are fully functioning within hours of onset of the hazard condition.

Table 24 Source: City of Houston OEM

The sections below provide an overview of the hazards affecting Houston, including information related to previous occurrences and their magnitude and impacts, as well as the probability of future hazard events.

Flood

Flooding is the foremost hazard that threatens the City of Houston, generally resulting from excessive precipitation. The severity of a flood event is determined by a combination of several major factors, including: stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; and the degree of vegetative clearing and impervious surface. Typically, floods are long-term events that may last for several days.

The primary types of general flooding are inland and coastal flooding. Due to the City of Houston's inland location, only inland flooding is profiled in this section. Inland or riverine flooding is a result of excessive precipitation levels and water runoff volumes within the watershed of a stream or river. Inland or riverine flooding is overbank flooding of rivers and streams, characteristically resulting from large-scale weather systems that generate prolonged rainfall over a wide geographic area, thus it is a naturally occurring and inevitable event. Some river floods occur seasonally when winter or spring rainfalls fill river basins with too much water, too quickly. Torrential rains from decaying hurricanes or tropical systems can also produce river flooding. The City of Houston area residents are subject to a tremendous amount of rainfall, which often occurs over an extremely short period. This is generally due to unstable tropical storms or hurricanes, and rain events which results in a substantial flooding problem. Floods are a natural and recurrent event. Floods take place every year and, in all seasons.

The Harris County Flood Control District (HCFCD) and FEMA are currently partnering on a flood hazard assessment project to produce a comprehensive set of maps that will include previously unmapped urban flood hazards, due to be released in 2025. Current maps do not account for all the complexities of drainage patterns in a rapidly developing environment and are an incomplete snapshot of flood risk in the Houston area. This assessment will incorporate the National Oceanic and Atmospheric Administration's (NOAA) Atlas 14 results, which include increased estimates of the precipitation amounts in a standard return period (i.e., 100-year interval).[3] HCFCD's project will culminate in the development of new FEMA Flood Insurance Rate Maps (FIRMs), which are used to regulate new development and to control the improvement and repair of substantially-damaged buildings, and other flood risk projects.

HCFCD has reviewed recent storms within the new parameters outlined by the Atlas 14 study. Flood risks are likely to be greater than previously thought. The figure below shows the intensity of repetitive flood losses in Houston. According to a report by the Baker Institute for Public Policy at Rice University, Atlas 14 substantially increased the 100-year and 500-year storm amounts for the Houston area, raising the 100-year event for 24 hours (the time period used for floodplain mapping purposes) from 13 inches to 17-18 inches and the 500-year event from 18.9 to 25.4 inches. Details are provided in Table 25.

Table 25: Comparison of NOAA Atlas 14 Rainfall Amounts to Previous Amounts

Duration	100 Year Rain Event	500 Year Rain Event	NOAA Atlas 14 100 Year	NOAA Atlas 14 500 Year	Imelda Sept. 2019	Harvey Aug. 2017	Tax Day April 2016	Allison June 2001	October 1994
1-hr	4.3	5.5	4.8	6.4	6.4	6.8	4.7	5.7	3.7
2-hr	5.7	7.6	7.0	9.7	9.2	11.9	7.3	9.9	4.7
3-hr	6.7	9.2	8.6	12.4	10.9	14.8	8.3	13.5	5.3
6-hr	8.9	12.8	11.4	17.0	14.3	18.9	13.9	21.2	7.2
12-hr	10.8	15.5	14.1	21.2	17.9	20.9	16.7	28.3	12.0
24-hr	13.2	18.9	17.0	25.4	21.1	25.6	17.4	28.4	20.9
2 days	14.5	20.0	20.5	29.6	29.1	35.2	17.5	28.5	23.1
4 days	15.9	21.1	23.1	32.5	29.7	47.7	N/A	38.5	28.9

Table 25 Source: Rice University's Baker Institute for Public Policy, data from Harris County Flood Control District

A property's vulnerability to a flood depends on its location and proximity to the floodplain. Structures that lie along banks of a waterway are the most vulnerable and are often repetitive loss structures. The City of Houston encourages development outside of the floodplain, and the impact for flood for the entire planning area is "Minor" as facilities and services would be shut down for one week, more than 10 percent of property destroyed or with major damage, and injuries or illness that would not potentially result in permanent disability. However, with nine reported fatalities and three injuries, the impact is considered "substantial", with multiple deaths possible depending on the size and magnitude of the flood event. The City of Houston identified some critical facilities as assets that are considered the most important to the planning area and are susceptible to a range of impacts caused by flood events. Considering 69 flood events over 27 years, the frequency is approximately two to three events every year.

While all citizens are at risk to the impacts of a flood, forced relocation and disaster recovery processes drastically impact low-income residents who lack the financial means to travel, afford a long-term stay away from home, and to rebuild or repair their homes. An estimated 19.5 percent of the planning area population lives below the poverty level.

[3] Source: Harris County Modeling Assessment and Awareness Project. http://www.maapnext.org/

Similarly, renters tend to be more vulnerable to the impacts of flooding events. Their ability to recover after a flood is often disproportionately impacted by limited affordable replacement housing, financial constraints, and they often do not carry flood insurance to cover losses. Within the City, 58 percent of housing units are renter-occupied. While warning times for these types of hazard events should be substantial enough for these individuals to seek shelter, individuals who work and recreate outside are also vulnerable to the potential impacts of a flood event.

The severity of a flooding event varies depending on the relative risk to citizens and structures located within the city. Table 31 depicts the level of impact for the City of Houston.

Table 26: Level of Impact Summary

Jurisdiction	Impact	Description
City of Houston	Substantial	While it is anticipated that the City of Houston could anticipate an impact of "minor" with critical facilities shut down for a week or more, and more than 10 percent of property would be destroyed or damaged, the historical injuries and fatalities resulting from flood indicate a "substantial" impact.

Table 26 Source: City of Houston OEM

Worsening flood conditions can be frequently associated with a variety of impacts, including:

- Flood-related rescues may be necessary at swift and low-water crossings or in flooded neighborhoods where roads have become impassable, placing first responders in harm's way.
- Evacuations may be required for entire neighborhoods because of rising floodwater, further taxing limited response capabilities and increasing sheltering needs for displaced residents.
- Health risks and threats to residents are elevated after the flood waters have receded due to contaminated flood waters (untreated sewage and hazardous chemicals) and mold growth typical in flooded buildings and homes.
- Significant flood events often result in widespread power outages increasing the risk to more vulnerable portions of the population who rely on power for health and/or life safety.
- Extended power outage can result in an increase in structure fires and/or carbon monoxide poisoning as individuals attempt to cook or heat their home with alternate, unsafe cooking or heating devices, such as grills.
- Floods can destroy or make residential structures uninhabitable, requiring shelter or relocation of residents in the aftermath of the event.
- 265 buildings and sites in the City are on the National Register of Historic Places. These structures would typically be built at lower elevations and may be more susceptible to flooding.
- First responders are exposed to downed power lines, contaminated and potentially unstable debris, hazardous materials, and generally unsafe conditions, elevating the risk of injury to first responders and potentially diminishing emergency response capabilities.
- Emergency operations and services may be significantly impacted due to damaged facilities.
- Significant flooding can result in the inability of emergency response vehicles to access areas of the community.
- Critical staff may suffer personal losses or otherwise be impacted by a flood event and unable to report for duty, limiting response capabilities.
- City departments may be flooded, delaying response and recovery efforts for the entire community.
- Private sector entities that the jurisdiction and its residents rely on, such as utility providers, financial institutions, and medical care providers may not be fully operational and may require assistance from neighboring communities until full services can be restored.
- Damage to infrastructure may slow economic recovery since repairs may be extensive and lengthy.
- Some businesses not directly damaged by the flood may be negatively impacted while utilities are being restored or water recedes, further slowing economic recovery.

- When the community is affected by significant property damage it is anticipated that funding would be required for infrastructure repair and restoration, temporary services and facilities, overtime pay for responders, and normal day-to-day operating expenses.
- Displaced residents may not be able to immediately return to work, further slowing economic recovery.
- Residential structures substantially damaged by a flood may not be rebuilt for years and uninsured or underinsured residential structures may never be rebuilt, reducing the tax base for the community.
- Large floods may result in dramatic population fluctuation, as people are unable to return to their homes or jobs and must seek shelter and/or work outside of the affected area.
- Businesses that are uninsured or underinsured may have difficulty reopening, which results in a net loss of jobs for the community and a potential increase in the unemployment rate.
- Flooding may cause significant disruptions of clean water and sewer services, elevating health risks and delaying recovery efforts.
- The psycho-social effects on flood victims and their families can traumatize them for long periods of time, creating long term increases in medical treatment and services.
- Extensive or repetitive flooding can lead to decreases in property value for the affected community.
- Flood poses a potential catastrophic risk to annual and perennial crop production and overall crop quality leading to higher food costs.
- Flood related declines in production may lead to an increase in unemployment.
- Large floods may result in loss of livestock, potentially increased livestock mortality due to stress and water borne disease, and increased cost for feed.
- Recreation activities at areas such as Buffalo Bayou and Hermann Park may be unavailable and tourism can be unappealing for years following a large flood event, devastating directly related local businesses and negatively impacting economic recovery.
- Vegetation in the City's urban parks may become destroyed or oversaturated from flood waters, impacting air quality and public health.
- Parks, recreational areas and nature preserves, such as the Armand Bayou Nature Center may suffer significant wildlife mortality during and following a flood due to damaged or destroyed ecosystems and water contamination.

The overall extent of damages caused by floods is dependent on the extent, depth and duration of flooding, and the velocities of flows in the flooded areas. The level of preparedness and risk reduction planning done by the City, local businesses, and residents will contribute to the overall economic and financial conditions in the aftermath of a flood event.

A summary assessment of flood hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 27: Flood Vulnerability and Consequence Summary by Lifeline

Flood	Vulnerability	Consequence
Safety and Security	High Vulnerability	Moderate Impact to Lifeline/Services
Food, Hydration, Shelter	High Vulnerability	Significant Impact to Lifeline/Services
Health and Medical	Moderate Vulnerability	Significant Impact to Lifeline/Services
Energy (Power and Fuel)	High Vulnerability	Significant Impact to Lifeline/Services
Communications	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Transportation	High Vulnerability	Significant Impact to Lifeline/Services
Hazardous Material	High Vulnerability	Significant Impact to Lifeline/Services
Water Systems	High Vulnerability	Significant Impact to Lifeline/Services

Table 27 Source: City of Houston OEM

Hurricane

The location of the City of Houston near the coast makes the planning area vulnerable to threats directly and indirectly related to a hurricane event, such as high-force winds and flooding. While the City is not located along the Gulf coast, the southeast jurisdictional boundary is located approximately 20 miles from the Gulf of Mexico coast, making it susceptible to hurricanes. Hurricanes and/or tropical storms can impact the City of Houston from June to November, the official Atlantic U.S. hurricane season.

As a hurricane develops, the barometric pressure (measured in millibars or inches) at its center falls, and wind increases. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name, and closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. Hurricanes are categorized according to the strength and intensity of their winds using the Saffir-Simpson Hurricane Scale (Table 33). A Category 1 storm has the lowest wind speeds, while a Category 5 hurricane has the highest. However, a lower category storm can inflict greater damage than higher category storms depending on where they strike, the amount of storm surge, other weather they interact with, and how slow they move.

Table 28: Extent Scale for Hurricanes Saffir-Simpson Scale

Category	Maximum Sustained Wind Speed (MPH)	Minimum Surface Pressure (millibars)	Storm Surge (feet)
1	74 – 95	Greater than 980	3 – 5
2	96 – 110	979 – 965	6 – 8
3	111 – 130	964 – 945	9 – 12
4	131 – 155	944 – 920	13 – 18
5	155 +	Less than 920	19+

Table 28 Source: National Hurricane Center, https://www.nhc.noaa.gov/HAW2/english/basics/saffir_simpson.shtml

Previous occurrences include storms that had a direct path through the City of Houston study area, as well as large storms that impacted the planning area without directly passing over the City. Historical hurricane data for the City of Houston is provided on a countywide basis per the NCEI and NOAA databases.

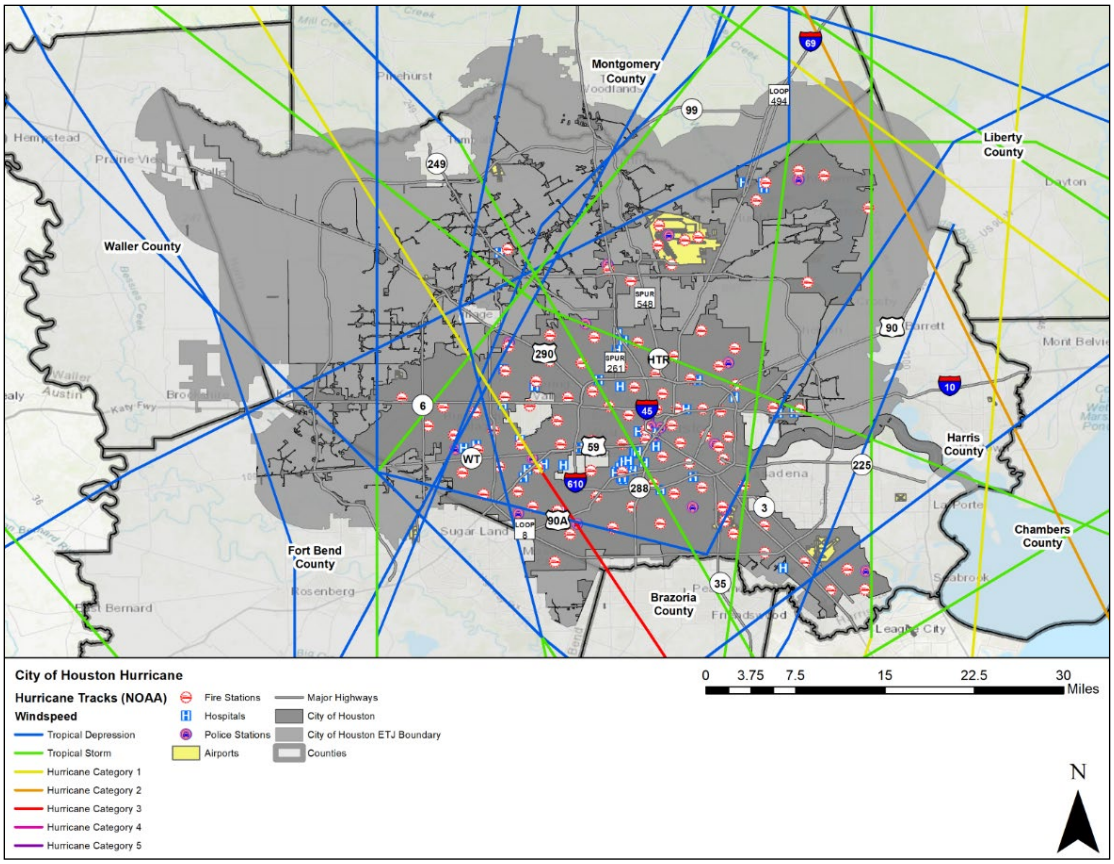

Figure 14: Location of Historic Hurricane Tracks 1854-2023
Source: https://coast.noaa.gov/hurricanes/

Vulnerability and Impact

Hurricane and tropical storm events can cause major damage to large areas; hence, all existing buildings, facilities, and populations are equally exposed and vulnerable to this hazard and could potentially be impacted. The City of Houston planning area features multiple mobile or manufactured home parks throughout the planning area. These parks are typically more vulnerable to hurricane events than typical site-built structures. In addition, manufactured homes are located sporadically throughout the planning area. These homes would also be more vulnerable. The US Census data indicates a total of 9,450 manufactured homes located in the City of Houston planning area. In addition, 51.0 percent of the single family residential (SFR) structures in the City of Houston were built before 1980.[4] These structures would typically be built to lower or less stringent construction standards than newer construction and may be more susceptible to damage during significant events.

In addition, renters tend to be more vulnerable to the impacts of hurricane events. Their ability to recover after a hurricane is often disproportionately impacted by limited affordable replacement housing, financial constraints, and lack of insurance to cover losses. Within the City, 58 percent of housing units are renter-occupied

[4] Source: U.S. Census Bureau data estimates for 2022.

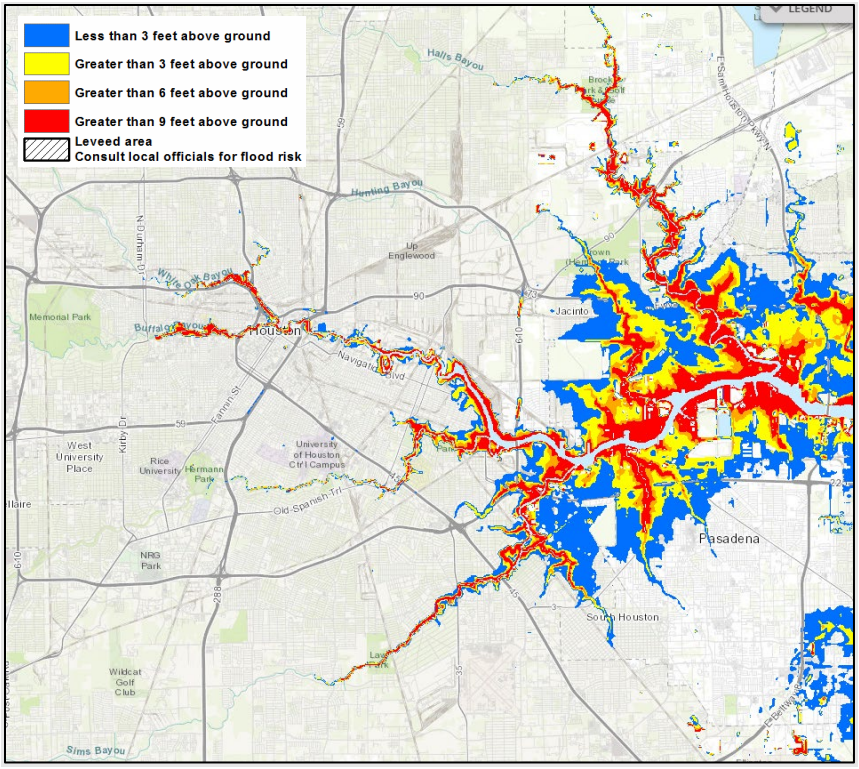

Figure 15: Hurricane Storm Surge Risk in Houston
Source: NOAA, National Storm Surge Hazard Maps: https://noaa.maps.arcgis.com/home/index.html

Figure 15 presents the risk associated with storm surge produced by a hurricane. It should be noted that storm surge is not entirely dependent on the strength of the storm but can vary depending on the size or speed of the storm.

Hurricane events have the potential to pose a significant risk to people and can create dangerous and difficult situations for public health and safety officials. The impact of climate change could produce larger, more severe hurricane events, exacerbating the current hurricane impacts. Impacts to the planning area can include:

- Individuals exposed to the storm can be struck by flying debris, falling limbs, or downed trees, causing serious injury or death.
- Structures can be damaged or crushed by falling trees, which can result in physical harm to the occupants.
- Driving conditions in the planning area may be dangerous during a hurricane event, especially over elevated bridges, elevating the risk of injury and accidents during evacuations if not timed properly.
- Emergency evacuations may be necessary prior to a hurricane making landfall, requiring emergency responders, evacuation routing, and temporary shelters.
- Significant debris and downed trees can result in emergency response vehicles being unable to access areas of the community.
- Downed power lines may result in roadways being unsafe for use, which may prevent first responders from answering calls for assistance or rescue.
- During hurricane landfall, first responders may be prevented from responding to calls as the winds may reach a speed in which their vehicles and equipment are unsafe to operate.
- Hurricane events often result in widespread power outages, increasing the risk to more vulnerable portions of the population who rely on power for health and/or life safety.
- Extended power outages can also result in an increase in structure fires and carbon monoxide poisoning as individuals attempt to cook or heat their homes with alternative, unsafe cooking or heating devices, such as grills.

- Extended power outages can also be deadly for individuals reliant on electricity to live independently in their homes.
- Extreme hurricane events may rupture gas lines and down trees and power lines, increasing the risk of structure fires during and after a storm event.
- Extreme hurricane events may lead to prolonged evacuations during search and rescue, and immediate recovery efforts requiring additional emergency personnel and resources to prevent entry, protect citizens, and protect property.
- First responders are exposed to downed power lines, unstable and unusual debris, hazardous materials, and generally unsafe conditions.
- Emergency operations and services may be significantly impacted due to damaged facilities and/or loss of communications.
- Critical staff may be unable to report for duty, limiting response capabilities.
- City departments may be damaged, delaying response and recovery efforts for the entire community.
- Private sector entities that the City and its residents rely on, such as utility providers, financial institutions, and medical care providers, may not be fully operational and may require assistance from neighboring communities until full services can be restored.
- Economic disruption negatively impacts the programs and services provided by the community due to short- and long-term loss in revenue.
- Some businesses not directly damaged by the hurricane may be negatively impacted while roads are cleared and utilities are being restored, further slowing economic recovery.
- Older structures built to less stringent building codes may suffer greater damage as they are typically more vulnerable to hurricane damage. 51 percent of homes in the City were built before 1980. 265 buildings and sites in the City are on the National Register of Historic Places, many of which pre-date modern building codes.
- Vegetation in the City's urban parks may become flattened or oversaturated from high winds and heavy rains.
- Large scale hurricanes can have significant economic impact on the affected area, as it must now fund expenses such as infrastructure repair and restoration, temporary services and facilities, overtime pay for responders, as well as normal day-to-day operating expenses.
- Businesses that are more reliant on utility infrastructure than others may suffer greater damages without a backup power source.
- As the City of Houston continues to add population, the number of people and housing developments exposed to the hazard increases. Continued public education on the City's risks to hurricane events will continue to be key to the city's overall mitigation strategy.

The economic and financial impacts of hurricane events on the area will depend on the scale of the event, what is damaged, and how quickly repairs to critical components of the economy can be implemented. The level of preparedness and pre-event planning done by the county, communities, local businesses, and citizens will also contribute to the overall economic and financial conditions in the aftermath of any hurricane event.

Based on historical occurrences of significant hurricane events, the probability of future events is highly likely with the frequency of occurrence of one event, every year for the City of Houston. A summary assessment of hurricane hazard vulnerability and impacts to the community lifelines is presented in the table below.

Hurricane and tropical storm events have the potential to pose a significant risk to people and property. Such events can create dangerous situations for public health and safety officials and cause catastrophic damages. The impact of climate change could produce larger, more severe hurricane events, exacerbating the current hurricane impacts. The economic and financial impacts of hurricanes and tropical storms will depend entirely on the scale of the events, what is damaged, and how quickly repairs to critical components of the economy can be implemented.

Table 29: Hurricane Vulnerability and Consequence Summary by Lifeline

Hurricane	Vulnerability	Consequence
Safety and Security	High Vulnerability	Significant Impact to Lifeline/Services
Food, Hydration, Shelter	High Vulnerability	Significant Impact to Lifeline/Services
Health and Medical	Moderate Vulnerability	Significant Impact to Lifeline/Services
Energy (Power and Fuel)	High Vulnerability	Significant Impact to Lifeline/Services
Communications	High Vulnerability	Significant Impact to Lifeline/Services
Transportation	High Vulnerability	Significant Impact to Lifeline/Services
Hazardous Material	High Vulnerability	Significant Impact to Lifeline/Services
Water Systems	High Vulnerability	Significant Impact to Lifeline/Services

Table 29 Source: City of Houston OEM

Extreme Heat

Extreme heat is a prolonged period of excessively high temperatures and exceptionally humid conditions. Extreme heat during the summer months is a common occurrence throughout the State of Texas, and the City of Houston is no exception. The City typically experiences extended heat waves or an extended period of extreme heat and is often accompanied by high humidity. In addition, the City also has urban heat islands or areas where there is a concentration of structures such as buildings and pavement and a limited amount of greenery causing higher temperatures relative to outlying areas.

Although heat can damage buildings and facilities, it presents a more significant threat to the safety and welfare of citizens. The major human risks associated with extreme heat include heat cramps; sunburn; dehydration; fatigue; heat exhaustion; and even heat stroke. The most vulnerable population to heat casualties are children and the elderly or infirmed who frequently live on low fixed incomes and cannot afford to run air-conditioning on a regular basis. This population is sometimes isolated, with no immediate family or friends to look out for their well-being.The National Weather Service (NWS) initiates alerts based on the Heat Index as shown in Table 30.

Table 30: Heat Index and Warnings

Category	Heat Index	Possible Heat Disorders	Warning Type
Extreme Danger	125°F and higher	Heat stroke or sun stroke likely.	An Excessive Heat Warning is issued if the Heat Index rises above 105°F at least 3 hours during the day or above 80°F at night.
Danger	103 – 124°F	Sunstroke, muscle cramps, and/or heat exhaustion are likely. Heatstroke possible with prolonged exposure and/or physical activity.	
Extreme Caution	90 – 103°F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.	A heat advisory will be issued to warn that the Heat Index may exceed 105°F.
Caution	80 – 90°F	Fatigue is possible with prolonged exposure and/or physical activity.	

Table 30 Source: City of Houston OEM

There is no defined geographic boundary for extreme heat events. While the entirety of the City of Houston is exposed to extreme temperatures, existing buildings, infrastructure, and critical facilities are not likely to sustain significant damage from extreme heat events. Therefore, any estimated property losses associated with the extreme heat hazard are anticipated to be minimal across the area.

Every summer, the hazard of heat-related illness becomes a significant public health issue throughout much of the United States. Mortality from all causes increases during heat waves, and excessive heat is an important contributing factor to deaths from other causes, particularly among the elderly. Extreme temperatures present a significant threat

to life and safety for the population of the City as a whole. Heat casualties, for example, are typically caused by a lack of adequate air conditioning or heat exhaustion.

The most vulnerable population to heat casualties is the elderly or infirmed who frequently live on low fixed incomes and cannot afford to run air-conditioning on a regular basis. This population is sometimes isolated, with no immediate family or friends to look out for their well-being. Children may also be more vulnerable if left unattended in vehicles. Students are also susceptible as sporting events and practices are often held outside during early fall or late spring when temperatures are at their highest. In addition, populations living below the poverty level are unable to run air-conditioning on a regular basis and are limited in their ability to seek medical treatment. Another segment of the population at risk is those whose jobs consist of strenuous labor outdoors.

The population over 65 in the City of Houston is estimated at 11 percent of the total population, and children under the age of 5 are estimated at 7 percent, or an estimated total of 420,297 potentially vulnerable residents in the planning area based on age. In addition, an estimated 19.5 percent of the planning area population lives below the poverty level. Underprivileged populations; disproportionately impacted by extreme heat events, as they are less likely to be able to afford air conditioning during the hot summer months, as well as less likely to have access to medical care. The greatest risk from extreme heat is to public health and safety. The impact of climate change could produce longer, more severe heat waves, exacerbating the current impacts. Extreme heat conditions can be frequently associated with a variety of impacts, including:

- Vulnerable populations, particularly the elderly (11 percent of total population) and children under 5 (7 percent of total population), can face serious or life-threatening health problems from exposure to extreme heat including hyperthermia, heat cramps, heat exhaustion, and heat stroke (or sunstroke).
- Response personnel including utility workers, public works personnel, and any other professions where individuals are required to work outside, are more subject to extreme heat related illnesses since their exposure would typically be greater.
- High energy demand periods can outpace the supply of energy, potentially creating the need for rolling brownouts, which would elevate the risk of illness to vulnerable residents.
- Highways and roads may be damaged by excessive heat causing asphalt roads to soften and concrete roads to shift or buckle.
- Vehicle engines and cooling systems typically run harder during extreme heat events, resulting in increases in mechanical failures.
- Extreme heat events during times of drought can exacerbate the environmental impacts associated with drought, decreasing water and air quality, and further degrading wildlife habitat.
- Extreme heat increases ground-level ozone (smog), increasing the risk of respiratory illnesses.
- Negatively impacted water suppliers may face increased costs resulting from the transport of water resources or development of supplemental water resources.
- Tourism and recreational activities predominant in the City of Houston may be negatively impacted during extreme heat events, reducing seasonal revenue.
- Outdoor activities may see an increase in school injury or illness during extreme heat events.
- Food suppliers can anticipate an increase in food costs due to increases in production costs and crop and livestock losses.
- Fisheries may be negatively impacted by extreme heat, suffering damage to fish habitats (either natural or man-made), and a loss of fish and/or other aquatic organisms due to decreased water flows or availability.

The economic and financial impacts of extreme heat will depend on the duration of the event, demand for energy, drought associated with extreme heat, and many other factors. The level of preparedness and the amount of planning done by the jurisdiction, local businesses, and citizens will impact the overall economic and financial conditions before, during, and after an extreme heat event.

Climate change is expected to lead to an increase in average temperatures as well as an increase in frequency, duration and intensity of extreme heat events. With no reductions in emissions worldwide, the state of Texas is projected to experience an additional 30 to 60 days per year above 100°F than what is experienced now. A summary assessment of extreme heat hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 31: Extreme Heat Vulnerability and Consequence Summary by Lifeline

Extreme Heat	Vulnerability	Consequence
Safety and Security	Moderate Vulnerability	Low Impact to Lifeline/Services
Food, Hydration, Shelter	Moderate Vulnerability	Low Impact to Lifeline/Services
Health and Medical	Low Vulnerability	Low Impact to Lifeline/Services
Energy (Power and Fuel)	High Vulnerability	Moderate Impact to Lifeline/Services
Communications	Moderate Vulnerability	Low Impact to Lifeline/Services
Transportation	Low Vulnerability	Low Impact to Lifeline/Services
Hazardous Material	Moderate Vulnerability	Low Impact to Lifeline/Services
Water Systems	Moderate Vulnerability	Moderate Impact to Lifeline/Services

Table 31 Source: City of Houston OEM

Thunderstorm Wind

Thunderstorms create extreme wind events including straight-line winds. Wind is the horizontal motion of the air past a given point, beginning with differences in air pressures. Pressure that is higher at one place than another sets up a force pushing from the high toward the low pressure: the greater the difference in pressures, the stronger the force. The distance between the area of high pressure and the area of low pressure also determines how fast the moving air is accelerated.

Straight-line winds are responsible for most thunderstorm wind damages. One type of straight-line wind, the downburst, is a small area of rapidly descending air beneath a thunderstorm. A downburst can cause damage equivalent to a strong tornado and make air travel extremely hazardous.

Thunderstorm wind events can develop in any geographic location and are considered a common occurrence in Texas. Therefore, a thunderstorm wind event could occur at any location within the City of Houston's planning area, as these storms develop randomly and are not confined to any geographic area within the City. It is assumed that the entire City of Houston planning area is uniformly exposed to the threat of thunderstorm winds.

Vulnerability is difficult to evaluate since thunderstorm wind events can occur at different strength levels, in random locations, and can create relatively narrow paths of destruction. Due to the randomness of these events, all existing and future structures and facilities within the City of Houston planning area could potentially be impacted and remain vulnerable to possible injury and property loss from strong winds.

Trees, power lines and poles, signage, manufactured housing, radio towers, concrete block walls, storage barns, windows, garbage receptacles, brick facades, and vehicles, unless reinforced, are vulnerable to thunderstorm wind events. More severe damage involves windborne debris; in some instances, patio furniture and other lawn items have been reported to have been blown around by wind and, very commonly, debris from damaged structures in turn have caused damage to other buildings not directly impacted by the event. In numerous instances roofs have been reported as having been torn off buildings. The portable buildings typically used at schools and construction sites would be more vulnerable to thunderstorm wind events than typical site-built structures and could potentially pose a greater risk for wind-blown debris.

While all citizens are vulnerable to the impacts of thunderstorm wind, forced relocation and disaster recovery drastically impacts low-income residents who lack the financial means to travel, afford a long-term stay away from home, and to rebuild or repair their homes. An estimated 19.5 percent of the planning area population lives below the poverty level. Renters also tend to be more vulnerable to the impacts of wind events and their ability to recover after an event. Within the City, 58 percent of housing units are renter-occupied. While warning times for these type of hazard events should be substantial enough for these individuals to seek shelter, individuals who work and recreate outside are also vulnerable to potential impacts of a thunderstorm wind event.

Thunderstorm wind events have the potential to pose a significant risk to people and can create dangerous and difficult situations for public health and safety officials. The impact of climate change could produce larger, more severe thunderstorm wind events, exacerbating the current thunderstorm wind impacts. Thunderstorm wind conditions can be frequently associated with a variety of impacts, including:

- Individuals exposed to the storm can be struck by flying debris, falling limbs, or downed trees, causing serious injury or death.
- Structures can be damaged or crushed by falling trees, which can result in physical harm to the occupants.
- Significant debris and downed trees can result in emergency response vehicles being unable to access areas of the community.
- Downed power lines may result in roadways being unsafe for use, which may prevent first responders from answering calls for assistance or rescue.
- During exceptionally heavy wind events, first responders may be prevented from responding to calls, as the winds may reach a speed in which their vehicles and equipment are unsafe to operate.
- Thunderstorm wind events often result in widespread power outages, increasing the risk to more vulnerable portions of the population who rely on power for health and/or life safety.
- Extended power outages often result in an increase in structure fires and carbon monoxide poisoning, as individuals attempt to cook or heat their homes with alternate, unsafe cooking or heating devices, such as grills.
- First responders are exposed to downed power lines, unstable and unusual debris, hazardous materials, and generally unsafe conditions.
- Emergency operations and services may be significantly impacted due to damaged facilities and/or loss of communications.
- Critical staff may be unable to report for duty, limiting response capabilities.
- City or county departments may be damaged, delaying response and recovery efforts for the entire community.
- Private sector entities that the City and its residents rely on, such as utility providers, financial institutions, and medical care providers may not be fully operational and may require assistance from neighboring communities until full services can be restored.
- Economic disruption negatively impacts the programs and services provided by the community due to short- and long-term loss in revenue.
- Some businesses not directly damaged by thunderstorm wind events may be negatively impacted while roads are cleared and utilities are being restored, further slowing economic recovery.
- Older structures built to less stringent building codes may suffer greater damage as they are typically more vulnerable to thunderstorm winds. 51 percent of homes in the City were built before 1980. 265 buildings and sites in the City are on the National Register of Historic Places, many of which pre-date modern building codes.
- Large-scale wind events can have a significant economic impact on the affected area, as it must now fund expenses such as infrastructure repair and restoration, temporary services and facilities, overtime pay for responders, as well as normal day-to-day operating expenses.
- Businesses that are more reliant on utility infrastructure than others may suffer greater damages without a backup power source.

- Recreational areas and parks may be damaged or inaccessible due to downed trees or debris, causing temporary impacts to area businesses.
- Thunderstorm wind events could impact tourism and recreational activities, placing visitors in imminent danger, potentially requiring emergency services or evacuations.

The economic and financial impacts of thunderstorm winds on the area will depend entirely on the scale of the event, what is damaged, and how quickly repairs to critical components of the economy can be implemented. The level of preparedness and pre-event planning done by the community, local businesses, and citizens will also contribute to the overall economic and financial conditions in the aftermath of any thunderstorm wind event.

Most thunderstorm winds occur during the spring and fall seasons and during the months of March, April, May, and September. Based on available records of historic events, there have been 188 events in a 72-year reporting period, which provides a probability of three events every year. Even though the intensity of thunderstorm wind events is not always damaging for the City of Houston, the frequency of occurrence for a thunderstorm wind event is highly likely. This means that an event is probable within the next year for the City of Houston planning area. A summary assessment of thunderstorm wind hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 32: Thunderstorm Wind Vulnerability and Consequence Summary by Lifeline

Thunderstorm Wind	Vulnerability	Consequence
Safety and Security	Low Vulnerability	Low Impact to Lifeline/Services
Food, Hydration, Shelter	Moderate Vulnerability	Low Impact to Lifeline/Services
Health and Medical	Low Vulnerability	Low Impact to Lifeline/Services
Energy (Power and Fuel)	Moderate Vulnerability	Significant Impact to Lifeline/Services
Communications	High Vulnerability	Moderate Impact to Lifeline/Services
Transportation	Low Vulnerability	Moderate Impact to Lifeline/Services
Hazardous Material	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Water Systems	Moderate Vulnerability	Moderate Impact to Lifeline/Services

Table 32 Source: City of Houston OEM

The impacts on the frequency and severity of severe thunderstorm wind events due to climate change are unclear. According to the Texas A&M 2021 Climate Report Update, changes in severe thunderstorm reports over time have been more closely linked to changes in population than changes in the hazard event. At this time there is low confidence of an ongoing trend in the overall frequency and severity of thunderstorm events, due to the lack of climate data records for severe thunderstorms. Based on climate models that are available, the environmental conditions needed for severe thunderstorms are estimated to become more likely, resulting in an overall increase in the number of days capable of producing a severe thunderstorm event.

Lightning

Lightning is a discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm, creating a “bolt” when the buildup of charges becomes strong enough. This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning rapidly heats the sky as it flashes but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes the thunder which often accompanies lightning strikes. While most often affiliated with severe thunderstorms, lightning often strikes outside of heavy rain and might occur as far as 10 miles away from any rainfall.

According to the National Weather Service (NWS), the 10-year (2012–2021) average for fatalities is 23 people with an average of 300 injuries in the United States each year by lightning. Lightning can occur as cloud to ground flashes or as intra-cloud lightning flashes. Direct lightning strikes can cause significant damage to buildings, critical facilities, infrastructure, and communication equipment affecting emergency response. Lightning is also responsible for igniting wildfires that can result in widespread damages to property before firefighters have the ability to contain and suppress the resultant fire.

Based on historical records and input from the planning team the probability of occurrence for future lightning events in the City of Houston planning area is considered highly likely, or an event probable in the next year. The planning team stated that lightning occurs regularly in the area. According to NOAA, the City of Houston planning area is located in an area of the country that experiences approximately twelve to twenty-one lightning flashes per square mile per year (approximately 7,980 to 13,965 flashes per year). Given this estimated probability of events, it can be expected that future lightning events will continue to threaten life and cause minor property damages throughout the planning area. Impacts of climate change are not expected to increase the average frequency of lightning events but may lead to an increase in the intensity of events when they do occur. See additional information on climate change at the end of this section.

Vulnerability is difficult to evaluate since lightning events can occur at different strength levels, in random locations, and can create a broad range of damages depending on the strike location. Due to the randomness of these events, all existing and future structures and facilities in the City of Houston planning area could potentially be impacted and remain vulnerable to possible injury and property loss from lightning strikes. The City of Houston planning area has 25 reported lightning events, since 1996 per the NCEI, however the City is vulnerable and could be impacted by lightning.

The direct and indirect losses associated with these events include injury and loss of life, damage to structures and infrastructure, agricultural losses, utility failure (power outages), and stress on community resources. The entire population of the City of Houston is considered exposed to the lightning hazard. The peak lightning season in the State of Texas is from June to August; however, the most fatalities occur in July. Fatalities occur most often when people are outdoors and/or participating in some form of recreation. The population located outdoors is considered at risk and more vulnerable to a lightning strike compared to being inside a structure. Moving to a lower risk location will decrease a person's vulnerability.

The entire general building stock and all infrastructure of the City of Houston planning area are considered exposed to the lightning hazard. Lightning can be responsible for damages to buildings, cause electrical, forest and/or wildfires, and damage infrastructure such as power transmission lines and communication towers.

While all citizens are at risk to the impacts of lightning, forced relocation and disaster recovery drastically impacts low-income residents who lack the financial means to travel, afford a long-term stay away from home, and to rebuild or repair their homes. An estimated 19.5 percent of the planning area population live below the poverty level. In addition, renters tend to be more vulnerable to the impacts of lightning events. Their ability to recover after a lightning event is often disproportionally impacted by limited affordable replacement housing, financial constraints, and lack of insurance to cover losses. Within the City 58 percent of housing units are renter-occupied.

Lightning events have the potential to pose a significant risk to people and can create dangerous and difficult situations for public health and safety officials. The impact of climate change could produce more frequent and severe lightning events, exacerbating the current lightning impacts. Additional impacts to the planning area can include:

- The City of Houston features 39,501 acres of total park space including 382 developed parks and 167 green spaces. Lightning events could impact recreational activities, placing residents and visitors in imminent danger, potentially requiring emergency services or park evacuation.

- Older structures built to less stringent building codes may suffer greater damage from a lightning strike as they are typically built with less fire-resistant materials and often lack any fire mitigation measures such as sprinkler systems. 51 percent of homes in the City were built before 1980. 265 buildings and sites in the City are on the National Register of Historic Places, many of them similarly lack fire mitigation materials or measures.
- Vegetation in the City's urban parks may be destroyed by lightning caused brush fires, impacting air quality and public health.
- Individuals exposed to the storm can be directly struck, posing significant health risks and potential death.
- Structures can be damaged or crushed by falling trees damaged by lightning, which can result in physical harm to the occupants.
- Lightning strikes can result in widespread power outages, increasing the risk to more vulnerable portions of the population who rely on power for health and/or life safety.
- Extended power outages often result in an increase in structure fires and carbon monoxide poisoning, as individuals attempt to cook or heat their homes with alternate, unsafe cooking or heating devices, such as grills.
- Lightning strikes can be associated with structure fires and wildfires, creating additional risk to residents and first responders.
- Emergency operations and services may be significantly impacted due to power outages and/or loss of communications.
- City departments may be damaged, delaying response and recovery efforts for the entire community.
- Lightning events could impact recreational activities, placing residents and visitors in imminent danger, potentially requiring emergency services or park evacuation.
- Economic disruption due to power outages and fires, negatively impacts the programs and services provided by the community due to short and long-term loss in revenue.
- Some businesses not directly damaged by lightning events may be negatively impacted while utilities are being restored, further slowing economic recovery.
- Businesses that are more reliant on utility infrastructure than others may suffer greater damages without a backup power source.

The economic and financial impacts of lightning will depend entirely on the scale of the event, what is damaged, and how quickly repairs to critical components of the economy can be implemented. The level of preparedness and pre-event planning done by the community, local businesses, and citizens will also contribute to the overall economic and financial conditions in the aftermath of any lightning event.

A summary assessment of lightning hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 33: Lightning Vulnerability and Consequence Summary by Lifeline

Lightning	Vulnerability	Consequence
Safety and Security	Moderate Vulnerability	Low Impact to Lifeline/Services
Food, Hydration, Shelter	Moderate Vulnerability	Low Impact to Lifeline/Services
Health and Medical	Moderate Vulnerability	Low Impact to Lifeline/Services
Energy (Power and Fuel)	High Vulnerability	Moderate Impact to Lifeline/Services
Communications	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Transportation	Low Vulnerability	Low Impact to Lifeline/Services
Hazardous Material	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Water Systems	Moderate Vulnerability	Low Impact to Lifeline/Services

Table 33 Source: City of Houston OEM

Tornado

Tornadoes are among the most violent storms on the planet. A tornado is a rapidly rotating column of air extending between, and in contact with, a cloud and the surface of the earth. The most violent tornadoes are capable of tremendous destruction and have wind speeds of 250 miles per hour or more. In extreme cases, winds may approach 300 miles per hour. Damage paths can be in excess of one mile wide and 50 miles long

The most powerful tornadoes are produced by "supercell thunderstorms." Supercell thunderstorms are created when horizontal wind shears (winds moving in different directions at different altitudes) begin to rotate the storm. This horizontal rotation can be tilted vertically by violent updrafts, and the rotation radius can shrink, forming a vertical column of very quickly swirling air. This rotating air can eventually reach the ground, forming a tornado.

Tornadoes do not have any specific geographic boundary and can occur throughout the City uniformly. It is assumed that the entire City of Houston planning area is susceptible to a potential tornado event. The entire City of Houston planning area is located in Wind Zone III where tornado winds can be as high as 200 mph, refer to Figure 16.

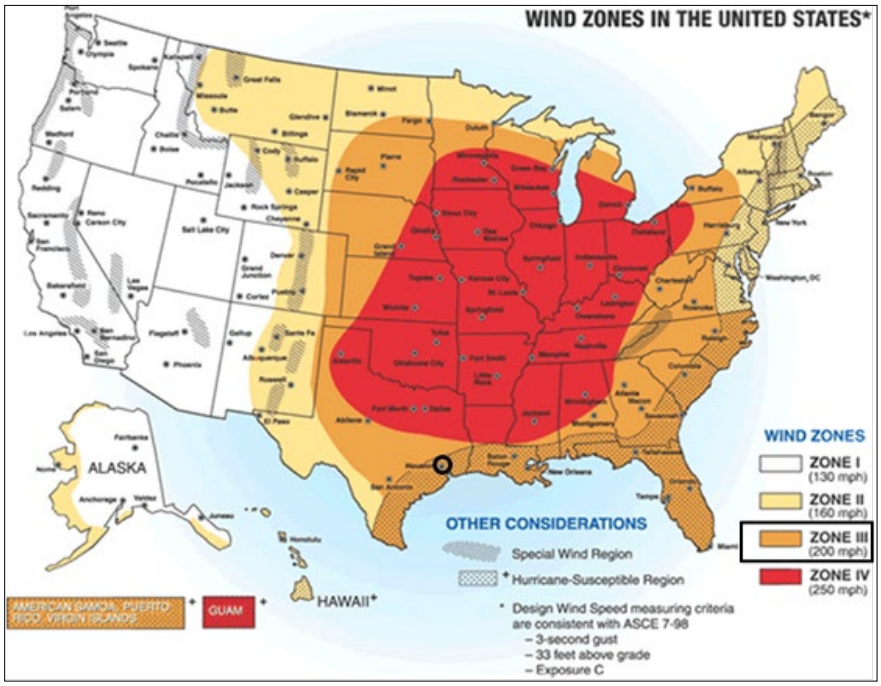

Figure 16: FEMA Wind Zones in the United States

The destruction caused by tornadoes ranges from light to inconceivable, depending on the intensity, size, and duration of the storm. Typically, tornadoes cause the greatest damage to structures of light construction, such as residential homes (particularly mobile homes).

Tornado magnitudes prior to 2005 were determined using the traditional version of the Fujita Scale. Since February 2007, the Fujita Scale has been replaced by the Enhanced Fujita Scale (Table 39), which retains the same basic design and six strength categories as the previous scale. The newer scale reflects more refined assessments of tornado damage surveys, standardization, and damage consideration to a wider range of structures. For the purposes of this plan, those tornadoes that occurred prior to the adoption of the EF scale will still be mentioned in the Fujita Scale for historical reference.

Table 34: Enhanced Fujita Scale for Tornadoes

STORM CATEGORY	DAMAGE LEVEL	3 SECOND GUST (MPH)	DESCRIPTION OF DAMAGES	PHOTO EXAMPLE
EF0	Gale	65 – 85	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.	
EF1	Weak	86 – 110	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads; attached garages may be destroyed.	
EF2	Strong	111 – 135	Considerable damage; roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.	
EF3	Severe	136 – 165	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.	
EF4	Devastating	166 – 200	Well-constructed homes leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.	
EF5	Incredible	200+	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles flying through the air in excess of 330 yards; trees debarked; steel reinforced concrete badly damaged.	

Table 34 Source: City of Houston Hazard Mitigation Plan

Both the Fujita Scale and Enhanced Fujita Scale should be referenced in reviewing previous occurrences since tornado events prior to 2007 will follow the original Fujita Scale. The largest magnitude reported within the planning area is F4 on the Fujita Scale, a “Devastating Tornado.” Based on the planning area’s location in Wind Zone III, the planning area could experience anywhere from an EF0 to an EF5 depending on the wind speed. The events in the City of Houston (converted from the Fujita Scale) have been between EF0 and EF5 (Figure 17). This is the strongest event the planning area can anticipate in the future.

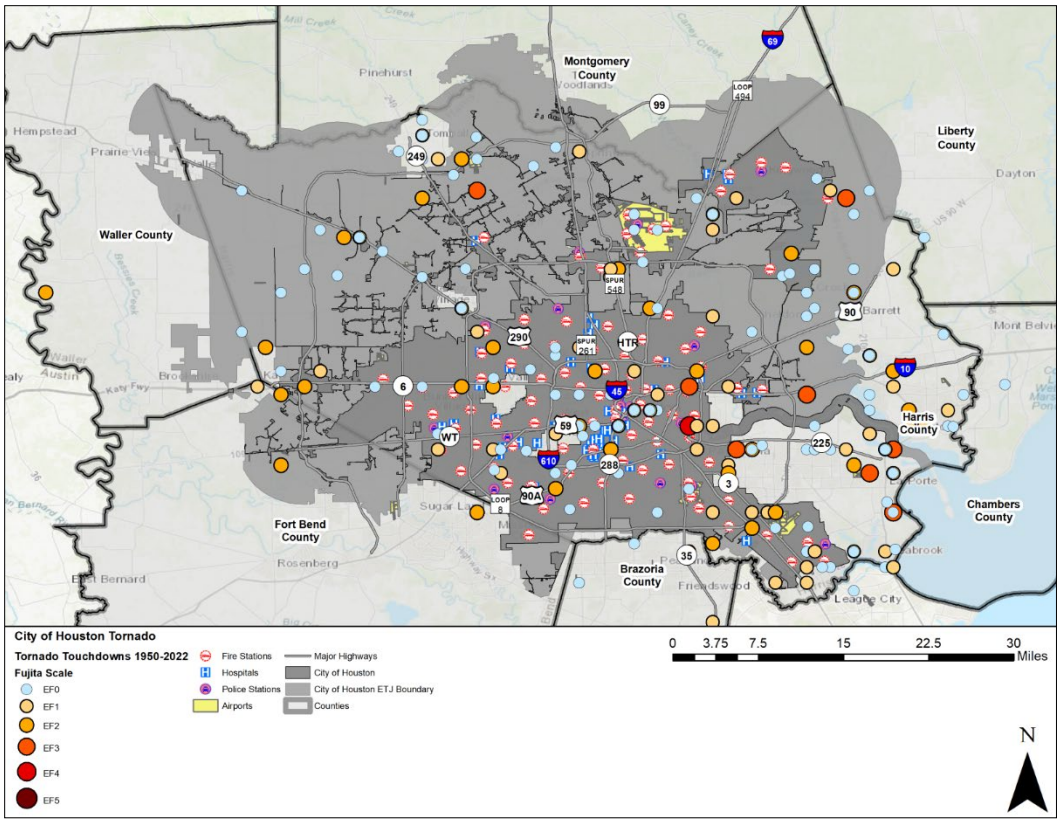

Figure 17: Historical Tornado Events, 1950-2022
Source: City of Houston Hazard Mitigation Plan Update 2023

Due to the randomness of tornado events, all existing and future buildings, facilities, and infrastructure in the City of Houston planning area are considered to be exposed to this hazard and could potentially be impacted. The damage caused by a tornado is typically a result of high wind velocity and wind-blown debris.

The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. Consequently, the vulnerability of humans and property is difficult to evaluate since tornadoes form at different strengths, in random locations, and create relatively narrow paths of destruction. Although tornadoes strike at random, making all buildings vulnerable, three types of structures are more likely to suffer damage:

- Manufactured homes;
- Homes on crawlspaces (more susceptible to lift); and
- Buildings with large spans, such as shopping malls, gymnasiums, and factories.

Tornadoes can cause a significant threat to people as they could be struck by flying debris, falling trees or branches, utility lines, and poles. Blocked roads could prevent first responders from responding to calls. Tornadoes commonly cause power outages, which could cause health and safety risks to residents and visitors, as well as to patients in hospitals.

The City of Houston planning area features mobile or manufactured home parks throughout the planning area. These parks are typically more vulnerable to tornado events than typical site-built structures. In addition, manufactured homes are located sporadically throughout the planning area, which would also be more vulnerable. U.S. Census data indicates a total of 9,450 (1 percent of the total housing stock) manufactured homes located in the City of Houston, a 16 percent increase in this housing type since 2018. Another factor of manufactured homes that may

increase vulnerability is the age of installation. Inspection of manufactured home installations changed in 2011 when the process was revised statewide; therefore, manufactured homes installed prior to 2011 may be more vulnerable to damage from tornado events. In addition, 51 percent (approximately 504,772 structures) of the housing structures in the City of Houston were built before 1980. These structures would typically be built to lower or less stringent construction standards than newer construction and may be more susceptible to damage during significant tornado events.

While all citizens are at risk to the impacts of a tornado, forced relocation and disaster recovery drastically impacts low-income residents who lack the financial means to travel, afford a long-term stay away from home, and to rebuild or repair their homes. An estimated 19.5 percent of the planning area population lives below the poverty level. Renters also tend to be more vulnerable to the impacts of wind events and their ability to recover after an event. Within the city 58 percent of housing units are renter-occupied. While warning times for these type of hazard events should be substantial enough for these individuals to seek shelter, individuals who work and recreate outside are also vulnerable to the potential impacts of a tornado event.

Tornadoes have the potential to pose a significant risk to the population and can create dangerous situations. Often, providing and preserving public health and safety is difficult following a tornado event. The impact of climate change could produce larger, more severe tornado events, exacerbating the current tornado impacts. More destructive tornado conditions can be frequently associated with a variety of impacts, including:

- Individuals exposed to the storm can be struck by flying debris, falling limbs, or downed trees, causing serious injury or death.
- Structures can be damaged or crushed by falling trees, which can result in physical harm to the occupants.
- Manufactured homes may suffer substantial damage as they would be more vulnerable than typical site-built structures.
- Significant debris and downed trees can result in emergency response vehicles being unable to access areas of the community.
- Downed power lines may result in roadways being unsafe for use, which may prevent first responders from answering calls for assistance or rescue.
- Tornadoes often result in widespread power outages, increasing the risk to more vulnerable portions of the population who rely on power for health and/or life safety.
- Extended power outages can result in an increase in structure fires and/or carbon monoxide poisoning, as individuals attempt to cook or heat their home with alternate, unsafe cooking or heating devices, such as grills.
- Tornadoes can destroy or make residential structures uninhabitable, requiring shelter or relocation of residents in the aftermath of the event.
- First responders must enter the damage area shortly after the tornado passes to begin rescue operations and to organize cleanup and assessments efforts. Therefore, they are exposed to downed power lines, unstable and unusual debris, hazardous materials, and generally unsafe conditions, elevating the risk of injury to first responders and potentially diminishing emergency response capabilities.
- Emergency operations and services may be significantly impacted due to damaged facilities, loss of communications, and damaged emergency vehicles and equipment.
- City departments may be damaged or destroyed, delaying response and recovery efforts for the entire community.
- Private sector entities that the City and its residents rely on, such as utility providers, financial institutions, and medical care providers may not be fully operational and may require assistance from neighboring communities until full services can be restored
- Economic disruption negatively impacts the programs and services provided by the community due to short and long-term loss in revenue.
- Damage to infrastructure may slow economic recovery since repairs may be extensive and lengthy.

- Some businesses not directly damaged by the tornado may be negatively impacted while roads and utilities are being restored, further slowing economic recovery.
- When the community is affected by significant property damage it is anticipated that funding would be required for infrastructure repair and restoration, temporary services and facilities, overtime pay for responders, as well as normal day-to-day operating expenses.
- Displaced residents may not be able to immediately return to work, further slowing economic recovery.
- Residential structures destroyed by a tornado may not be rebuilt for years, reducing the tax base for the community.
- Large or intense tornadoes may result in a dramatic population fluctuation, as people are unable to return to their homes or jobs and must seek shelter and/or work outside of the affected area.
- Businesses that are uninsured or underinsured may have difficulty reopening, which results in a net loss of jobs for the community and a potential increase in the unemployment rate.
- Recreation activities may be unavailable, and tourism can be unappealing for years following a large tornado, devastating directly related local businesses.

The economic and financial impacts of a tornado event on the community will depend on the scale of the event, what is damaged, costs of repair or replacement, lost business days in impacted areas, and how quickly repairs to critical components of the economy can be implemented. The level of preparedness and pre-event planning done by government, businesses, and citizens will contribute to the overall economic and financial conditions in the aftermath of a tornado event.

Tornadoes can occur at any time of year and at any time of day, but they are typically more common in the spring months during the late afternoon and evening hours. A smaller, high frequency period can emerge in the fall during the brief transition between the warm and cold seasons. According to historical records, the City of Houston can experience a tornado touchdown approximately twice every year or 46 percent annual chance of a tornado event. This frequency supports a “Highly Likely” probability of future events. A summary assessment of tornado hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 35: Tornado Vulnerability and Consequence Summary by Lifeline

Tornado	Vulnerability	Consequence
Safety and Security	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Food, Hydration, Shelter	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Health and Medical	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Energy (Power and Fuel)	High Vulnerability	Significant Impact to Lifeline/Services
Communications	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Transportation	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Hazardous Material	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Water Systems	Moderate Vulnerability	Moderate Impact to Lifeline/Services

Table 35 Source: City of Houston OEM

Expansive Soils

Expansive soils are soils and soft rocks with a relatively high percentage of clay minerals that are subject to changes in volume as they swell and shrink with changing moisture conditions. Expansive soils contain minerals such as smectite clays that are capable of absorbing water. When these clays absorb water, they increase in volume and expand. The change in soil volume and resulting expansion can exert enough force on a building or other structure to cause damage.

Expansive soils will also lose volume and shrink when they dry. Drought conditions can cause soils to contract in response to a loss of soil moisture. A reduction in soil volume can affect the support to buildings or other structures and result in damage. Fissures in the soil can also develop and facilitate the deep penetration of water when moist conditions or runoff occurs. This produces a cycle of shrinkage and swelling that place repetitive stress on structures. The effect of expansive soil is most prevalent in regions prone to prolonged periods of drought followed by periods of moderate to high precipitation. Expansions in soil of 10 percent or more are not uncommon in the City of Houston planning area.

In Texas the most expansive soils are in a band 200 miles west from the coastline, stretching approximately from Beaumont down to Brownsville. These areas receive the most moisture and are also vulnerable to droughts, which can cause the soil to contract. In the City of Houston planning area, the problems associated with expansive soil typically occur during drought periods. Expansive soils (bentonite, smectite, or other reactive clays) expand when the soil particles attract water and can shrink when the clay dries.

Damages from expansive soils are typically associated with droughts, previous occurrences for expansive soils can be correlated with previous occurrences for drought, which are typically negligible. The City of Houston has experienced three known events. During a wet period in the summer of 2012, the ground expanded and led to cracks in the streets. Drought conditions in 2011 and 2022 caused the clay soil underground to contract and shift leading to thousands of broken water pipes. In total the City experienced 700 main water breaks a day in the summer of 2011, an increase of 200 breaks on a typical summer day.

The amount and depth of potential swelling that can occur in a clay material are, to some extent, functions of the cyclical moisture content in the soil. In drier climates where the moisture content in the soil near the ground surface is low because of evaporation, there is a greater potential for extensive swelling than in the same soil in wetter climates where the variations of moisture content are not as severe. Volume changes in highly expansive soils range between 7 and 10 percent, however under abnormal conditions, they can reach as high as 25 percent.

The City of Houston is primarily (89%) comprised of 4 major soil types. These soils present an expansion index (plasticity index) from low to moderate ranges as described in Table 41.

Table 36: Primary Soils and Associated Plasticity Index – City of Houston

SOIL TYPE	PLASTICITY INDEX
Lake Charles Urban Land Part	12-20
Bernard Urban Land Part	12-30
Midland Urban Land Part	12-20
Beaumont Urban Land Part	12-30

Table 36 Source: City of Houston OEM

The effects of expansive soils are most prevalent when periods of moderate to high precipitation are followed by drought and then again by periods of rainfall. Other cases of damage result from increases in moisture volume from such sources as broken or leaking water and sewer lines. Dry clays are capable of absorbing water and will increase in volume in an amount proportional to the amount of water absorbed. Soils capable of changes in volume present a hazard to structures built over them and to the pipelines buried in them. Houses and one-story commercial buildings are more apt to be damaged by the expansion of swelling clays than are multi-story buildings, which are usually heavy enough to counter swelling pressures. However, if constructed on wet clay, multi-story buildings may also be damaged by clay shrinkage when moisture levels are substantially reduced.

Cracked foundations and floors, jammed windows and doors, and ruptured pipelines are typical types of damage resulting from swelling soils. Damage to the upper floors of larger buildings can occur when motion in the structure is

significant. While all infrastructure within the City of Houston planning area is minimally vulnerable, slabs on grade structures are more likely to suffer damage from expansive soils. In addition, older structures built to less stringent building codes may also be more susceptible to damage than new construction.

Expansive soil can directly impact infrastructure and as a result indirectly create impacts on residents. The impact of climate change could produce more severe expansive soils events, exacerbating the current expansive soils impacts. The following are a summary of impacts frequently associated with expansive soils:

- Expansive soils are influenced by the seasonal precipitation-drought cycle. Most impacts on the City of Houston typically occur during extended periods of drought.
- Impacts to lightweight buildings and other infrastructure are most likely to occur. Impacts include uneven settling and shifting in structures; cracks in foundations, walls, streets, driveways, and sidewalks; ruptured pipes; and windows and doors that do not open and close properly.
- 51 percent of homes in the City of Houston were built before 1980 leading them to more susceptible to damages from expansive soils. 265 buildings and sites in the City are on the National Register of Historic Places, many of which pre-date modern building codes.
- Highways (IH-10, IH-45, US-290, US-59, IH-37, and US-83/US-284) and mass transit (METRORail) can be affected by expansive soils.
- Economic impacts are limited to uninsured damages.
- Impacts on people are indirect, with impacts related to disruption in city services such as water and sewer.
- As population grows and development increases in the City the potential risk to expansive soils will also increase.
- Limited impact anticipated to the natural environment other than changes in soil characteristics.

The impact of expansive soils experienced in the City of Houston has resulted in no injuries and fatalities, supporting a “limited” severity of impact meaning injuries and/or illnesses are treatable with first aid, shutdown of facilities and services for 24 hours or less, and less than 10 percent of property is destroyed or with major damage.

A summary assessment of expansive soils hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 37: Expansive Soils Vulnerability and Consequence Summary by Lifeline

Expansive soils	Vulnerability	Consequence
Safety and Security	Low Vulnerability	Low Impact to Lifeline/Services
Food, Hydration, Shelter	Moderate Vulnerability	Low Impact to Lifeline/Services
Health and Medical	Moderate Vulnerability	Low Impact to Lifeline/Services
Energy (Power and Fuel)	Low Vulnerability	Low Impact to Lifeline/Services
Communications	Low Vulnerability	Low Impact to Lifeline/Services
Transportation	Moderate Vulnerability	Low Impact to Lifeline/Services
Hazardous Material	Moderate Vulnerability	Low Impact to Lifeline/Services
Water Systems	Moderate Vulnerability	Low Impact to Lifeline/Services

Table 37 Source: City of Houston OEM

Hail

Hailstorm events are a potentially damaging outgrowth of severe thunderstorms. During the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere

and the subsequent cooling of the air mass. Frozen droplets gradually accumulate into ice crystals until they fall as frozen masses of round or irregularly shaped ice typically greater than 0.75 inches in diameter. The size of hailstones is a direct result of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a by-product of heating on the Earth's surface. Higher temperature gradients above Earth's surface result in increased suspension time and hailstone size.
According to the National Insurance Crime Bureau (NICB), between 2018 and 2020 the State of Texas had the greatest number of hail loss claims in the United States with 605,866 loss claims (23 percent of total hail claims in the U.S.) due to hail events. In this two-year period Texas experienced a total of 584 severe hail days. In 2021, 6.8 million properties in the U.S. experienced one or more damaging hail events, resulting in a total of $16.5 billion in insured losses. Texas had the highest number of properties affected by hail with over 1.5 million properties or 17 percent of total properties in the state affected; an increase of 80,000 properties affected between 2020 and 2021. Texas hailstorms accounted for almost a quarter of total U.S. properties affected by hail in 2021, with Harris County experiencing the most damages with an estimated 169,579 properties affected by hailstorms.

Hailstorms are an extension of severe thunderstorms that could potentially cause severe damage. As a result, they are not confined to any specific geographic location and can vary greatly in size, location, intensity, and duration. Therefore, the entire City of Houston planning area is equally at risk to hail events.

The National Weather Service (NWS) classifies a storm as "severe" if there is hail three-quarters of an inch in diameter (approximately the size of a penny) or greater, based on radar intensity or as seen by observers.

Vulnerability and Impact

Much of the damage inflicted by hail is to crops. Even relatively small hail can shred plants to ribbons in a matter of minutes. Vehicles, roofs of buildings and homes, and landscaping are most commonly damaged by hail.

Utility systems on roofs of City buildings and critical facilities would be vulnerable and could be damaged. Hail could cause a significant threat to people as they could be struck by hail and falling trees and branches. Outdoor activities and events may elevate the risk to residents and visitors when a hailstorm strikes with little warning. Portable buildings typically utilized by schools and commercial sites such as construction areas would be more vulnerable to hail events than the typical site-built structures.

The City of Houston planning area features mobile or manufactured home parks throughout the planning area. These parks are typically more vulnerable to hail events than typical site-built structures. In addition, manufactured homes are located sporadically throughout the planning area which would also be more vulnerable

Hail events have the potential to pose a significant risk to people and can create dangerous situations. The impact of climate change could produce larger, more severe hail events, exacerbating the current hail impacts. Worsening hail conditions can be frequently associated with a variety of impacts, including:

- Hail may create hazardous road conditions during and immediately following an event, delaying first responders from providing for or preserving public health and safety.
- Individuals and first responders who are exposed to the storm may be struck by hail, falling branches, or downed trees resulting in injuries or possible fatalities.
- Residential structures can be damaged by falling trees, which can result in physical harm to occupants.
- Large hail events will likely cause extensive roof damage to residential structures along with siding damage and broken windows, creating a spike in insurance claims and a rise in premiums.
- Automobile damage may be extensive depending on the size of the hail and length of the storm.
- Hail events can result in power outages over widespread areas, increasing the risk to more vulnerable portions of the population who rely on power for health and/or life safety.

- Extended power outages can result in an increase in structure fires and/or carbon monoxide poisoning, as individuals attempt to cook or heat their home with alternate, unsafe cooking or heating devices, such as grills.
- First responders are exposed to downed power lines, damaged structures, hazardous spills, and debris that often accompany hail events, elevating the risk of injury to first responders and potentially diminishing emergency response capabilities.
- Downed power lines and large debris, such as downed trees, can result in the inability of emergency response vehicles to access areas of the community.
- Hazardous road conditions may prevent critical staff from reporting for duty, limiting response capabilities.
- Economic disruption negatively impacts the programs and services provided by the community due to short- and long-term loss in revenue.
- Some businesses not directly damaged by the hail event may be negatively impacted while roads are cleared and utilities are being restored, further slowing economic recovery.
- Businesses that are more reliant on utility infrastructure than others may suffer greater damages without a backup power source.
- Hazardous road conditions will likely lead to increases in automobile accidents, further straining emergency response capabilities.
- Depending on the severity and scale of damage caused by large hail events, damage to power transmission and distribution infrastructure can require days or weeks to repair.
- A significant hail event could significantly damage agricultural crops, resulting in extensive economic losses for the community and surrounding area.
- Hail events may injure or kill livestock and wildlife.
- A large hail event could impact the accessibility of recreational areas and parks due to extended power outages or debris clogged access roads.

The economic and financial impacts of hail will depend entirely on the scale of the event, what is damaged, and how quickly repairs to critical components of the economy can be implemented. The level of preparedness and pre-event planning conducted by the community, local businesses, and citizens will contribute to the overall economic and financial conditions in the aftermath of any hail event. The frequency of historic events supports a highly likely probability of future events for the Houston area. A summary assessment of hail hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 38: Hail Vulnerability and Consequence Summary by Lifeline

Hail	Vulnerability	Consequence
Safety and Security	Moderate Vulnerability	Low Impact to Lifeline/Services
Food, Hydration, Shelter	Moderate Vulnerability	Low Impact to Lifeline/Services
Health and Medical	Moderate Vulnerability	Low Impact to Lifeline/Services
Energy (Power and Fuel)	Moderate Vulnerability	Low Impact to Lifeline/Services
Communications	Low Vulnerability	Moderate Impact to Lifeline/Services
Transportation	Moderate Vulnerability	Low Impact to Lifeline/Services
Hazardous Material	Moderate Vulnerability	Low Impact to Lifeline/Services
Water Systems	Moderate Vulnerability	Low Impact to Lifeline/Services

Table 38 Source: City of Houston OEM

Hail has been known to cause injury to humans and occasionally has been fatal. Overall, the average loss estimate of property and crops in the planning area is considered $35,431,998 with an average annualized loss of $528,836. Based on historic loss and damages, the impact of hail damages on the City of Houston planning area can be considered “Limited” severity of impact, meaning minor quality of life lost, critical facilities and services shut down for 24 hours or less, and less than 10 percent of property destroyed or with major damage.

Wildfire

A wildfire event can rapidly spread out of control and occurs most often in the summer when the brush is dry and flames can move unchecked through a highly vegetative area. Wildfires can start as a slow burning fire along the forest floor, killing and damaging trees. The fires often spread more rapidly as they reach the tops of trees with wind carrying the flames from tree to tree. Usually, dense smoke is the first indication of a wildfire. A wildfire event often begins unnoticed and spreads quickly, lighting brush, trees, and homes on fire. For example, a wildfire may be started by a campfire that was not doused properly, a tossed cigarette, burning debris, or arson.

Texas has seen a significant increase in the number of wildfires in the past 30 years, which included wildland, interface, or intermix fires. Wildland fires are fueled almost exclusively by natural vegetation, while interface or intermix fires are urban/wildland fires in which vegetation and the built environment provide the fuel.

A wildfire event can be a potentially damaging consequence of drought conditions, lightning, or wind events if the conditions allow. Wildfires can vary greatly in terms of size, location, intensity, and duration. While wildfires are not confined to any specific geographic location, they are most likely to occur in open grasslands. The threat to people and property from a wildfire event is greater in the fringe areas where developed areas meet open grass lands, such as the Wildland Urban Interface (WUI) (Figure 22). It is estimated that 14.3 percent of the total population in the City of Houston live within the WUI. However, the entire City of Houston planning area is at some risk for wildfires.

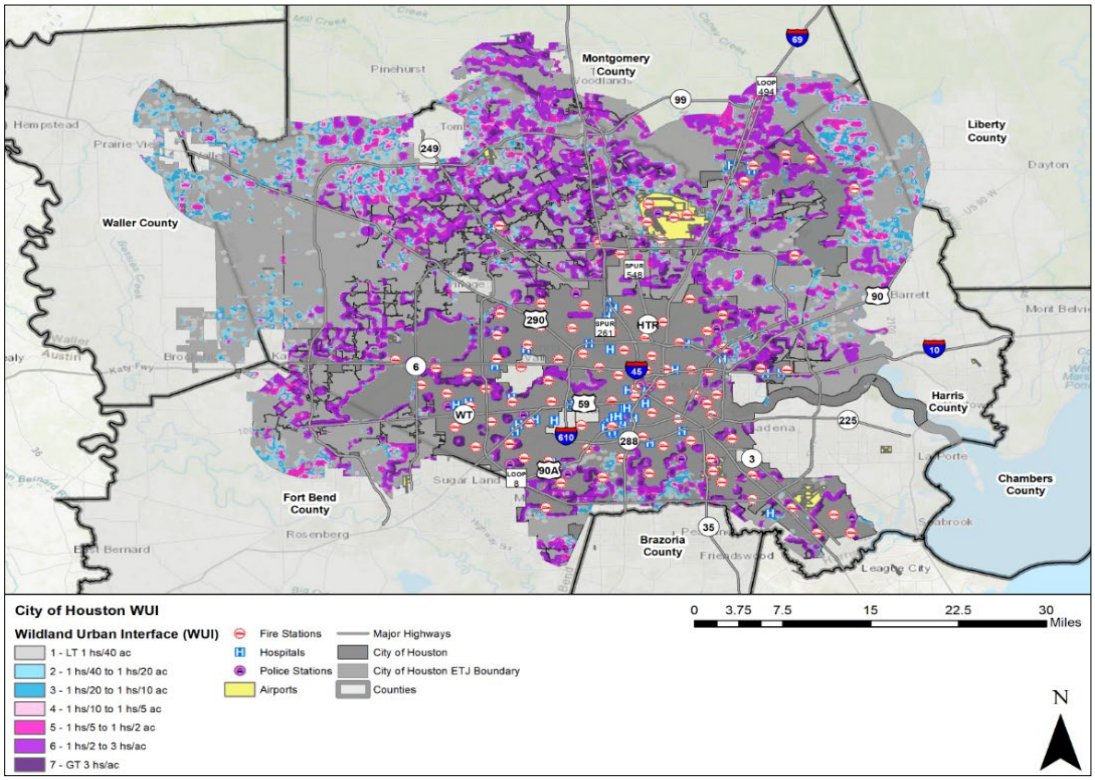

Figure 18: Windland Urban Interface Map - City of Houston

The Texas Forest Service reported 830 wildfire events between 2005 and 2021. The National Centers for Environmental Information (NCEI) did not include any wildfire events from 1996 through 2022. The Texas Forest Service (TFS) started collecting wildfire data reported by volunteer fire departments in 2005. Due to a lack of

recorded data for wildfire events prior to 2005, frequency calculations are based on a seventeen-year reporting period, using only data from recorded years.

Table 39: Historical Wildfire Events Summary, 2005 - 2021

JURISDICTION	NUMBER OF EVENTS	ACRES BURNED
City of Houston	830	2,391

Table 39 Source: City of Houston Hazard Mitigation Plan

Table 40: Historical Wildfire Events by Year

JURISDICTION	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
City of Houston	2	0	1	1	0	1	26	4	3	3	2	0	2	0	265	216	304
																	Total: 830

Table 40 Source: City of Houston Hazard Mitigation Plan

Periods of drought, dry conditions, high temperatures, and low humidity are factors that contribute to the occurrence of a wildfire event, as was experienced in 2011. Areas along railroads and people whose homes are in woodland settings have an increased risk of being affected by wildfire.

The heavily populated, urban areas of City of Houston are not likely to experience large, sweeping fires. Unoccupied buildings and open spaces that have not been maintained have the greatest vulnerability to wildfire. The overall level of concern for wildfires is located mostly along the perimeter of the study area where wildland and urban areas interface. Areas along major highways in the City have an increased vulnerability where empty lots and unoccupied areas are located.

Diminished air quality is an environmental impact that can result from a wildfire event and pose a potential health risk. The smoke plumes from wildfires can contain potentially inhaling carcinogenic matter. Fine particles of invisible soot and ash that are too small for the respiratory system to filter can cause immediate and possibly long-term health effects. The elderly or those individuals with compromised respiratory systems may be more vulnerable to the effects of diminished air quality after a wildfire event.

For the City of Houston planning area, the impact from a wildfire event can be considered “Limited," meaning injuries and/or illnesses are treatable with first aid, shutdown of facilities and services for 24 hours or less, and less than 10 percent of property is destroyed or with major damage. Severity of impact is gauged by acreage burned, homes and structures lost, injuries and fatalities.

Table 41: Impact for City of Houston

JURISDICTION	IMPACT	DESCRIPTION
City of Houston	Limited	City of Houston has an estimated 330,159 people or 14.3% of the total population that live within the Wildland Urban Interface (WUI). Average housing density is most commonly 3 houses per 1 acre. City of Houston citizens may suffer minor injuries that can be treated with first aid. Critical facilities could be shut down for 24 hours or less, and less than 10 percent of total property could be damaged.

Table 41 Source: City of Houston Hazard Mitigation Plan

A Wildfire event poses a potentially significant risk to public health and safety, particularly if the wildfire is initially unnoticed and spreads quickly. The impacts associated with a wildfire are not limited to direct damage. The impact of climate change could produce larger, more widespread wildfire events, exacerbating the current wildfire impacts. Significant wildfire events can be frequently associated with a variety of impacts, including:

- The City of Houston's urban parks include 39,501 acres of open space. Community assets including places like Memorial Park or the Armand Bayou Nature Center are vulnerable to the impacts of wildfire events. Recreation and tourism can be unappealing for years following a large wildfire, devastating directly related businesses.
- Recreation activities throughout the City's parks may be unavailable and tourism can be unappealing for years following a large wildfire event, devastating directly related local businesses and negatively impacting economic recovery
- Persons in the area at the time of the fire are at risk for injury or death from burns and/or smoke inhalation.
- First responders are at greater risk of physical injury since they are near the hazard while extinguishing flames, protecting property or evacuating residents in the area.
- First responders can experience heart disease, respiratory problems, and other long term related illnesses from prolonged exposure to smoke, chemicals, and heat.
- Emergency services may be disrupted during a wildfire if facilities are impacted, and roadways are inaccessible, or personnel are unable to report for duty.
- Critical city departments may not be able to function and provide necessary services depending on the location of the fire and the structures or personnel impacted.
- Non-critical businesses may be directly damaged, suffer loss of utility services, or be otherwise inaccessible, delaying normal operations and slowing the recovery process.
- Displaced residents may not be able to immediately return to work, further slowing economic recovery.
- Roadways in or near the WUI could be damaged or closed due to smoke and limited visibility.
- Older homes are generally exempt from modern building code requirements, which may require fire suppression equipment in the structure. 51 percent of homes in City were built before 1980. 265 buildings and sites in the City are on the National Register of Historic Places, many of which pre-date modern building codes.
- Vegetation in the City's urban parks may be destroyed in a wildfire, impacting air quality and public health.
- Some high-density neighborhoods feature small lots with structures close together, increasing the potential for fire to spread rapidly.
- Air pollution from smoke may exacerbate respiratory problems of vulnerable residents.
- Charred ground after a wildfire cannot easily absorb rainwater, increasing the risk of flooding and potential mudflows.
- Wildlife may be displaced or destroyed.
- Historical or cultural resources may be damaged or destroyed.
- Tourism can be significantly disrupted, further delaying economic recovery for the area.
- Economic disruption negatively impacts the programs and services provided by the community due to short and long- term loss in revenue.
- Fire suppression costs can be substantial, exhausting the financial resources of the community.
- Residential structures lost in a wildfire may not be rebuilt for years, reducing the tax base for the community.
- Direct impacts to municipal water supply may occur through contamination of ash and debris during the fire, destruction of aboveground delivery lines, and soil erosion or debris deposits into waterways after the fire.
- Tourism and recreational activities could be impacted and can be unappealing for years following a large wildfire, devastating directly related businesses.

The economic and financial impacts of a wildfire event on local government will depend on the scale of the event, what is damaged, costs of repair or replacement, lost business days in impacted areas, and how quickly repairs to critical components of the economy can be implemented. The level of preparedness and pre-event planning done by government, businesses, and citizens will contribute to the overall economic and financial conditions in the aftermath of a wildfire event.

A summary assessment of wildfire hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 42: Wildfire Vulnerability and Consequence Summary by Lifeline

Wildfire	Vulnerability	Consequence
Safety and Security	Low Vulnerability	Moderate Impact to Lifeline/Services
Food, Hydration, Shelter	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Health and Medical	Low Vulnerability	Moderate Impact to Lifeline/Services
Energy (Power and Fuel)	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Communications	Low Vulnerability	Significant Impact to Lifeline/Services
Transportation	Low Vulnerability	Significant Impact to Lifeline/Services
Hazardous Material	Low Vulnerability	Moderate Impact to Lifeline/Services
Water Systems	Low Vulnerability	Moderate Impact to Lifeline/Services

Table 42 Source: City of Houston OEM

Wildfires require the alignment of several factors, including temperature, humidity, and the lack of moisture in fuels, such as trees, shrubs, grasses, and forest debris. All these factors have strong direct or indirect ties to climate variability and climate change. Research shows that changes in climate create warmer, drier conditions, leading to longer and more active fire seasons. Increases in temperatures and the thirst of the atmosphere due to human-caused climate change have increased aridity of forest fuels during the fire season. Extreme heat and extended periods of drought contribute to wildfire risk in the planning area. Extreme temperatures and periods of drought destroy vegetation in the area, contributing to available fuels that spread wildfires.

Drought

Drought is a period of time without substantial rainfall that persists from one year to the next. Drought is a normal part of virtually all climatic regions, including areas with high and low average rainfall. Drought is the consequence of anticipated natural precipitation reduction over an extended period, usually a season or more in length. Droughts can be classified as meteorological, hydrologic, agricultural, and socioeconomic. Table 48 presents definitions for these different types of droughts.

Droughts are one of the most complex of all natural hazards as it is difficult to determine their precise beginning or end. In addition, droughts can lead to other hazards such as extreme heat and wildfires. Their impact on wildlife and area farming is enormous, often killing crops, grazing land, edible plants, and even in severe cases, trees. A secondary hazard to drought is wildfire because dying vegetation serves as a prime ignition source. Therefore, a heat wave combined with a drought is a very dangerous situation.

Table 43: Drought Classification Definitions[5]

Meteorological Drought	The degree of dryness, as measured as departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales.
Hydrologic Drought	The effects of precipitation shortfalls on stream flows and reservoir, lake, and groundwater levels.
Agricultural Drought	Soil moisture deficiencies relative to water demands of plant life, usually crops.
Socioeconomic Drought	The effect of demand for water exceeds the supply as a result of a weather-related supply shortfall.

Table 43 Source: City of Houston OEM

Droughts occur regularly throughout Texas and the City of Houston and are a normal condition. However, they can vary greatly in terms of their intensity and duration. The U.S. Drought Monitor, produced through a partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, U.S. Department of Agriculture and the National Oceanic and Atmospheric Administration, shows the planning area is currently not experiencing drought conditions but has experienced a range of conditions from abnormally dry to exceptional drought conditions over the last decade. There is no distinct geographic boundary to drought; therefore, it can occur throughout the City of Houston planning area equally.

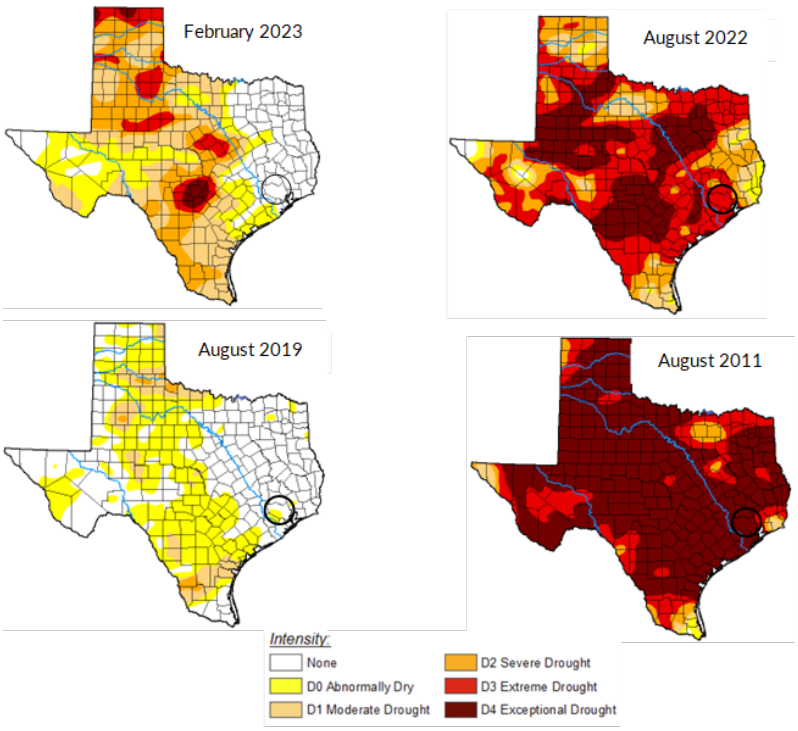

Figure 19: U.S. Drought Monitor, February 2023, August 2022, August 2019, August 2011

The City of Houston has a combination of over 1.2 billion gallons per day of reliable surface water rights and over 200 million gallons per day of available groundwater supplies.16 Houston's Drinking Water Operations (DWO) is responsible for operating and maintaining three water purification plants and 56 ground water plants. Houston's water

[5] Source: Multi-Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy, Federal Emergency Management Agency (FEMA).

system serves approximately 2.2 million citizens each day and spans over 600 square miles serving four counties, therefore, making it one of the most complex water systems in the nation.

Local lakes and rivers supply the City of Houston's surface water resources. The City of Houston's water supply flows from the Trinity River into Lake Livingston, and from the San Jacinto River into Lake Conroe and Lake Houston, making up 87 percent of Houston's water supply. Deep underground wells drilled into the Evangeline and Chicot aquifers currently provide the other 13 percent of the City's water supply. While the planning area relies on multiple water resources, high demand can deplete these resources during extreme drought conditions. As resources are depleted, potable water is in short supply and overall water quality can suffer, elevating health concerns for all residents but especially vulnerable populations – typically children, the elderly, and the ill. In addition, potable water is used for drinking, sanitation, patient care, sterilization, equipment, heating and cooling systems, and many other essential functions in medical facilities.

The average person will survive only a few days without potable water, and this timeframe can be drastically shortened for those people with more fragile health – typically children, the elderly, and the ill. Population over 65 in the City of Houston planning area is estimated at 11 percent of the total population and children under the age of 5 are estimated at 7 percent, or an estimated total of 420,297 potentially vulnerable residents in the planning area based on age. In addition, an estimated 19.5 percent of the planning area population live below the poverty level which may contribute to the overall health impacts of a drought.

This population is also vulnerable to food shortages when drought conditions exist, and potable water is in short supply. Potable water is used for drinking, sanitation, patient care, sterilization, equipment, heating and cooling systems, and many other essential functions in medical facilities. All residents in the City of Houston planning area could be adversely affected by drought conditions, which could limit water supplies and present health threats. During summer drought, or hot and dry conditions, elderly persons, small children, infants and the chronically ill who do not have adequate cooling units in their homes may become more vulnerable to injury and/or death.

The economic impact of droughts can be significant as they produce a complex web of impacts that spans many sectors of the economy and reach well beyond the area experiencing physical drought. This complexity exists because water is integral to our ability to produce goods and provide services. If droughts extend over a number of years, the direct and indirect economic impact can be significant.

Crop production can also suffer greatly during extreme drought conditions, limiting fresh local food supplies, driving up costs, and negatively impacting the local economy. The City of Houston has embraced community food production, from rooftop gardens to urban schoolyards. Drought conditions could adversely affect urban farming projects throughout the city

Habitat damage is a vulnerability of the environment during periods of drought for both aquatic and terrestrial species. The environment also becomes vulnerable during periods of extreme or prolonged drought due to severe erosion and land degradation. The city's tree canopy and urban parks are also vulnerable to prolonged drought conditions as was experienced during the 2011 drought. Impact of droughts experienced in the City of Houston planning area, have not resulted injuries or fatalities supporting a " Minor" severity of impact meaning injuries and/or illnesses do not result in permanent disability, shutdown of facilities and services for more than one week, and more than 10 percent of property is destroyed or with major damage.

Drought has the potential to impact people in the City of Houston planning area. While it is rare that drought, in and of itself, leads to a direct risk to the health and safety of people in the U.S., severe water shortages could result in inadequate supply for human needs. The impact of climate change could produce longer, more severe droughts, exacerbating the current drought impacts. Severe drought conditions can be frequently associated with a variety of impacts, including:

- Dry clay soil can lead to water main lines shifting and break. Often repair to water lines includes shutting off water to multiple homes at one time.
- The number of health-related low-flow issues (e.g., diminished sewage flows, increased pollution concentrations, reduced firefighting capacity, cross-connection contamination), will increase as the drought intensifies.
- Public safety issues from forest/range/wildfires will increase as water availability and/or pressure decreases.
- Respiratory ailments may increase as the air quality decreases.
- There may be an increase in disease due to wildlife concentrations (e.g., rabies, Rocky Mountain spotted fever, Lyme disease).
- Jurisdictions and residents may disagree over water use/water rights, creating conflict.
- Residents may disagree with the City over water use/water rights, creating conflict.
- Political conflicts may increase between municipalities, counties, states, and regions.
- Water management conflicts may arise between competing interests.
- Increased law enforcement activities may be required to enforce water restrictions.
- Severe water shortages could result in inadequate supply for human needs as well as lower quality of water for consumption.
- During drought, there is an increased risk for wildfires and dust storms.
- The community may need increased operational costs to enforce water restrictions or rationing.
- Prolonged drought can lead to increases in illness and disease related to drought
- Firefighters may have limited water resources to aid in firefighting and suppression activities, increasing risk to lives and property.
- Utility providers can see decreases in revenue as water supplies diminish.
- Utilities providers may cut back energy generation and service to their customers to prioritize critical service needs.
- Hydroelectric power generation facilities and infrastructure would have significantly diminished generation capability. Dams simply cannot produce as much electricity from low water levels as they can from high water levels.
- Fish and wildlife food and habitat will be reduced or degraded over time during a drought and disease will increase, especially for aquatic life.
- Wildlife will move to more sustainable locations, creating higher concentrations of wildlife in smaller areas, increasing vulnerability and further depleting limited natural resources.
- Severe and prolonged drought can result in the reduction of a species or cause the extinction of a species altogether.
- Plant life will suffer from long-term drought. Wind and erosion will also pose a threat to plant life as soil quality will decline. The urban tree canopy, including city parks, are vulnerable to the impacts of prolonged drought.
- Dry and dead vegetation will increase the risk of wildfire.
- Recreational activities that rely on water may be curtailed, such as canoeing at the Armand Bayou Nature Center, resulting in fewer tourists and lower revenue.
- Drought poses a significant risk to annual and perennial crop production and overall crop quality, leading to higher food costs.
- Drought related declines in production may lead to an increase in unemployment.
- Drought may limit livestock grazing resulting in decreased livestock weight, potential increased livestock mortality, and increased cost for feed.
- Negatively impacted water suppliers may face increased costs resulting from the transport of water or developing supplemental water resources.
- Long-term drought may negatively impact future economic development.
- Unlikely to have an impact on continuity of operations until prolonged severe or extreme levels are reached.
- Government functionality may be questioned and challenged if planning, response, and recovery are not timely and effective, impacting public confidence.

The overall extent of damage caused by periods of drought is dependent on its extent and duration. The level of preparedness and pre-event planning done by the government, businesses, and citizens will contribute to the overall economic and financial conditions in the aftermath of a drought event.

A summary assessment of drought hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 44: Drought Vulnerability and Consequence Summary by Lifeline

Drought	Vulnerability	Consequence
Safety and Security	High Vulnerability	Low Impact to Lifeline/Services
Food, Hydration, Shelter	High Vulnerability	Low Impact to Lifeline/Services
Health and Medical	Moderate Vulnerability	Low Impact to Lifeline/Services
Energy (Power and Fuel)	High Vulnerability	Low Impact to Lifeline/Services
Communications	Low Vulnerability	Low Impact to Lifeline/Services
Transportation	Low Vulnerability	Low Impact to Lifeline/Services
Hazardous Material	Low Vulnerability	Low Impact to Lifeline/Services
Water Systems	Moderate Vulnerability	Low Impact to Lifeline/Services

Table 44 Source: City of Houston OEM

With the range of factors influencing drought conditions, it is impossible to make quantitative statewide projections of drought trends; however, many factors point toward increased drought severity. Drought will continue to be driven largely by precipitation variability over multiple decades, with long-term precipitation trends expected to be relatively small. Other factors affecting drought impacts, such as increased temperatures and improved plant water use efficiency, decrease water availability but will cause drought impact trends to be highly sector-specific, with the impacts possibly smaller for agriculture than for surface water supply.

According to the Houston Climate Impact Assessment 2.0, the City of Houston will experience an increased likelihood of droughts in the future due to an estimated increase in the number of dry days in the City of Houston area. In addition, it is projected that future changes to the City of Houston will include increased temperatures, longer multi-day heatwaves and greater variability in precipitation, with an expected decrease in precipitation in the summer and increase in the fall.

Dam Failure

Dams are water storage, control, or diversion structures that impound water upstream in reservoirs. Dam failure can take several forms, including a collapse of or breach in the structure. While most dams have storage volumes small enough that failures have few or no repercussions, dams storing large amounts can cause significant flooding downstream. Dam failures can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding, which cause most failures;
- Inadequate spillway capacity, resulting in excess overtopping of the embankment;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees, repair internal seepage problems, or maintain gates, valves, and other operational components; Improper design or use of improper construction materials;
- Failure of upstream dams in the same drainage basin;
- High winds, which can cause significant wave action and result in substantial erosion;
- Destructive acts of terrorism; and,

- Earthquakes, which typically cause longitudinal cracks at the tops of the embankments, leading to structural failure.

Benefits provided by dams include water supplies for drinking; irrigation and industrial uses; flood control; hydroelectric power; recreation; and navigation. Dams in Texas serve many purposes, some of which include recreation, flood mitigation, irrigation, water supply, and fire protection

Texas has 7,413 dams, all regulated by the Texas Commission on Environmental Quality (TCEQ). The National Dam Safety Review Board (in coordination with FEMA) and the National Inventory of Dams (NID) lists a total of five dams that pose a risk to the City of Houston planning area including one dam three miles outside of the city limits that is owned by the City of Houston. Each of these dams were analyzed individually by location, volume, elevation, and condition (where available) when determining the risk, if any, for each dam. Each dam site was further analyzed for potential risks utilizing FEMA's National Flood Hazard Layer (where available) to map locations and fully understand development near the dam and topographical variations that may increase risk.

Two of the dams listed were embankments for typically dry detention drainage areas. These types of structures are utilized for flood control and do not pose a dam failure risk. Dams that were deemed to pose no past, current, or future risk to the planning area are not profiled in the plan as no loss of life or impact to critical facilities or infrastructure is expected in the event of a breach. Based on this analysis, the planning team was able to determine that only 3 of the 5 dams identified pose a risk to the planning area (Table 45). Figure 20 illustrates general locations for each dam posing a potential risk to the planning area.

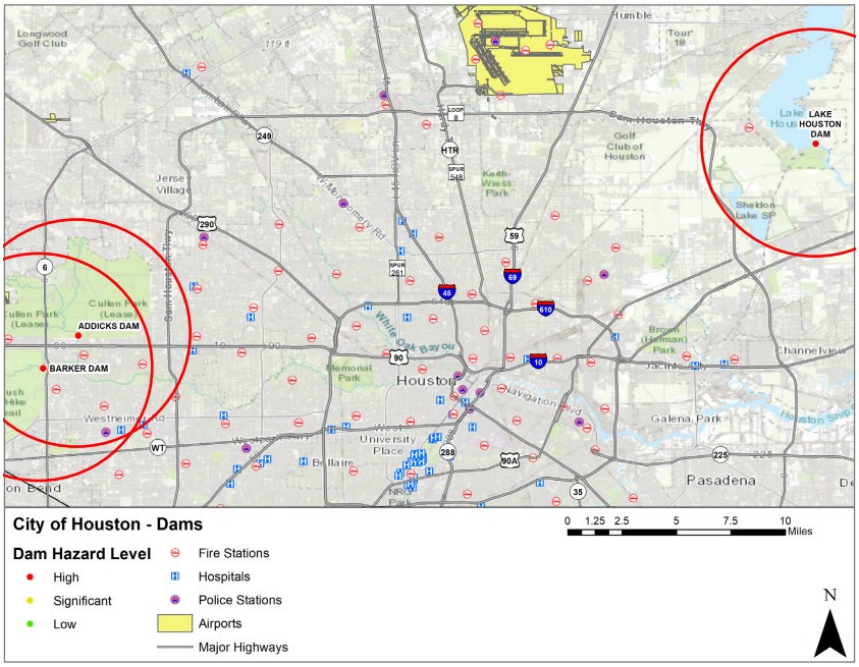

Figure 20: Dams with Potential Risk to the City of Houston

Table 45: City of Houston Dam Survey

Location	Dam Name	Classification	Height (Ft.)	Max Storage (Acre Ft.)	Dam Type	Condition	Owner	EAP	Profiled
Houston	Barker Dam	High	42	209,000	Earth	Unsatisfactory	Federal	Yes	Yes
Houston	Addicks Dam	High	52	200,800	Earth	Unsatisfactory	Federal	Yes	Yes
Magnolia Gardens	Lake Houston Dam	Not Available	66	281,800	Earth	Satisfactory	City of Houston	Yes	Yes

Table 45 Source: City of Houston OEM

While inundation maps are not available for the profiled dams, an estimated inundation radius has been included on the location map for each profiled dam (indicated by the red circle). For dams with a maximum storage capacity of 100,000 acre-feet or more, all structures within five miles are considered to be at risk to potential dam failure hazards. For dams with a maximum storage capacity between 10,000 and 100,000 acre-feet, all structures within three miles are considered to be at risk to potential dam failure hazards. For dams with a maximum storage capacity of less than 10,000 acre-feet, all structures within one mile are considered to be at risk to potential dam failure hazards.

Table 46: Extent Summaries Per Profiled Dam

PROFILED DAM	EXTENT (Flow Depth)	LEVEL OF INTENSITY TO MITIGATE
Barker Dam	0-15 Feet	While extensive damages and impacts to critical facilities or infrastructure are not anticipated in the event of a failure, as a High Hazard classified dam the consequences of a potential failure will likely cause loss of life as a result of a failure event.
Addicks Dam	0-15 Feet	While extensive damages and impacts to critical facilities or infrastructure are not anticipated in the event of a failure, as a High Hazard classified dam the consequences of a potential failure will likely cause loss of life as a result of a failure event.
Lake Houston Dam	0-25 Feet	While extensive damages and impacts to critical facilities or infrastructure are not anticipated in the event of a failure, as a High Hazard classified dam the consequences of a potential failure will likely cause loss of life as a result of a failure event.

Table 46 Source: City of Houston OEM

There have been no major dam failures that have affected the City of Houston planning area in the past. However, Hurricane Harvey did have impacts on the dams within the City. In the aftermath of Hurricane Harvey, it was determined to allow a controlled release of both Addicks and Barker Dams. According to Harris County Flood Control District the combined rate of controlled release was 4,000 cubic feet per second. Water was released into concrete-armored spillways which is preferable to overtopping the dams. Neighborhoods both upstream and downstream experienced additional flooding as a result from this controlled release. Upstream experienced flooding because of the overflow in the reservoirs that were backing up behind the dams. Downstream the water was released into Buffalo Bayou which was already experiencing flooding.[6]

The Texas Tribune states the Army Corp of Engineers believes if there was a failure the damage could exceed 60 million dollars and nearly 1 million residents could be impacted. While homes and business flooded, the damage sustained was less than what an over capped dam would do to the community of Houston. Evacuations were considered voluntary and were not mandated during the controlled release. Approximately 53 neighborhoods are located within the Addicks Watershed and 40 within Barker Dam.[7]

There are 5 dams in the City of Houston planning area (including one dam three miles outside of the City limits that is owned by the City of Houston). All dams were evaluated in-depth to determine the risk, if any, associated with each dam. This analysis indicated 3 of the dams identified present a risk to structures or infrastructure in the planning area. These dams will be revaluated in the next planning process to confirm if risk has changed. As development increases in the City there is the potential for dams classified as low hazard to be reclassified as development and populations near these dams increase.

[6] Source: Harris County Flood Control District https://www.hcfcd.org/hurricane-harvey/flooding-impacts-in-connection-with-the-reservoirs/
[7] Source: Texas Tribune: https://www.texastribune.org/2017/08/29/q-why-houstons-reservoirs-arent-going-fail/

Flooding is the most prominent effect of dam failure. If the dam failure is extensive, a large amount of water would enter the downstream waterways forcing them out of their banks. There may be significant environmental effects, resulting in flooding that could disperse debris and hazardous materials downstream that can damage local ecosystems. If the event is severe, debris carried downstream can block traffic flow, cause power outages, and disrupt local utilities, such as water and wastewater, which could result in school closures.

Any individual dam has a very specific area that will be impacted by a catastrophic failure. Dams identified as high or significant hazard can directly threaten the lives of individuals living or working in the inundation zone below the dam. The impact from any catastrophic failure would be similar to that of a flash flood. The impact of climate change could produce greater risk of dam failure due to larger more frequent floods, exacerbating the current dam failure impacts. Dam failure threats can be associated with a variety of impacts, including:

- Addicks and Barker Dams are classified as high hazard potential dams and would result in lives lost in the event of a failure.
- Future development downstream of dams has the potential to increase dam classification to significant or high hazard potential.
- Injuries from debris carried by the floodwaters are possible.
- Swift-water rescue of individuals trapped by the water puts the immediate responders at risk for their own lives.
- Individuals involved in the cleanup may be at risk from the debris left behind.
- Continuity of operations for any jurisdiction outside the direct impact area could be very limited.
- Roads and bridges downstream of a dam failure could be destroyed.
- Homes and businesses downstream of a dam could be damaged or destroyed.
- Emergency services may be temporarily unavailable.
- Disruption of operations and the delivery of services in the impacted area.
- A large dam with a high head of water could effectively scour the terrain below it for miles, taking out all buildings and other infrastructure.
- Scouring force could erode soil and any buried pipelines.
- Scouring action of a large dam will destroy all vegetation in its path.
- Wildlife and wildlife habitats caught in the flow will likely be destroyed.
- Fish habitat will likely be destroyed.
- Topsoil will erode, slowing the return of natural vegetation.
- The destructive high velocity water flow may include substantial debris and hazardous materials, significantly increasing the risks to life and property in its path.
- Debris and hazardous material deposited downstream may cause further pollution of areas far greater than the inundation zone.
- Destroyed businesses and homes may not be rebuilt, reducing the tax base and impacting long term economic recovery.
- Historical or cultural resources may be damaged or destroyed. There are 265 buildings and sites in the City that are listed on the National Register of Historic Places.
- Recreational activities and tourism may be temporarily unavailable or unappealing, slowing economic recovery.

The economic and financial impacts of dam failure on the area will depend entirely on the location of the dam, scale of the event, what is damaged, and how quickly repairs to critical components of the economy can be implemented. The level of preparedness and pre-event planning done by the government, community, local businesses, and citizens will also contribute to the overall economic and financial conditions in the aftermath of any dam failure event.

A summary assessment of dam failure hazard vulnerability and impacts to the community lifelines is presented in the following table.

Table 47: Dam Failure Vulnerability and Consequence Summary by Lifeline

Dam Failure	Vulnerability	Consequence
Safety and Security	Moderate Vulnerability	Significant Impact to Lifeline/Services
Food, Hydration, Shelter	Moderate Vulnerability	Significant Impact to Lifeline/Services
Health and Medical	Moderate Vulnerability	Significant Impact to Lifeline/Services
Energy (Power and Fuel)	Moderate Vulnerability	Significant Impact to Lifeline/Services
Communications	Moderate Vulnerability	Significant Impact to Lifeline/Services
Transportation	Moderate Vulnerability	Significant Impact to Lifeline/Services
Hazardous Material	Moderate Vulnerability	Significant Impact to Lifeline/Services
Water Systems	Moderate Vulnerability	Significant Impact to Lifeline/Services

Table 47 Source: City of Houston OEM

Winter Storms

A severe winter storm event is identified as a storm with snow, ice, or freezing rain. This type of storm can cause significant problems for area residents. Winter storms are associated with freezing or frozen precipitation such as freezing rain, sleet, snow, and the combined effects of winter precipitation and strong winds. Wind chill is a function of temperature and wind. Low wind chill is a product of high winds and freezing temperatures.

Winter storms that threaten the City of Houston planning area usually begin as powerful cold fronts that push south from central Canada. Although the City is at risk to ice hazards, extremely cold temperatures, and snow, the effects and frequencies of winter storm events are generally mild and short-lived.

Winter storm events are not confined to specific geographic boundaries. Therefore, all existing and future buildings, facilities, and populations in the City of Houston are considered to be exposed to a winter storm hazard and could potentially be impacted.

While the entire City of Houston is vulnerable to winter storm events, the areas of the City that reported the highest percentage of damages after Winter Storm Uri in February 2021, were concentrated in the central and eastern areas of the city. The hardest-hit areas tended to be in low-income neighborhoods with older homes built before 1985 and higher shares of renter households.

Vulnerability and Impact

During periods of extreme cold and freezing temperatures, water pipes can freeze and crack, and ice can build up on power lines, causing them to break under the weight or causing tree limbs to fall on the lines. These events can disrupt electric service for long periods. An economic impact may occur due to increased consumption of heating fuel, which can lead to energy shortages and higher prices. House fires and resulting deaths tend to occur more frequently from increased and improper use of alternate heating sources. Fires during winter storms also present a greater danger because water supplies may freeze and impede firefighting efforts.

People and animals are subject to health risks from extended exposure to cold air. Elderly people are at greater risk of death from hypothermia during these events, especially in the neighborhoods with older housing stock. Of all occupied housing units in the city, 65 percent depend on electricity to heat their homes.

The population over 65 in the City of Houston is estimated at 11 percent of the total population or an estimated total of 255,52211, potentially vulnerable residents in the planning area based on age. An estimated 19.5 percent of the planning area population live below the poverty level. Older homes tend to be more vulnerable to the impacts of winter storm events. Half of all housing units (51 percent) in the City were built before 1980. Of occupied housing units, 58 percent are renter occupied. Renters can face more challenges with recovery following an event including home repairs or implementing personal mitigation measures before an extreme cold event.

Table 48: Populations at Greater Risk of Winter Storm Events

JURISDICTION	YOUTH (UNDER 5)	ELDERLY (OVER 65)	POPULATION BELOW POVERTY LEVEL
City of Houston	164,775	255,522	453,395

Table 48 Source: City of Houston Hazard Mitigation Plan

The greatest risk from a winter storm hazard is public health and safety. The impact of climate change could produce longer, more intense winter storm events, exacerbating the current winter storm impacts. Worsening winter storm conditions can be frequently associated with a variety of impacts, including:

- Vulnerable populations, particularly the elderly (11 percent of total population) and children under 5 (7 percent of total population), can face serious or life-threatening health problems from exposure to extreme cold including hypothermia and frostbite.
- Loss of electric power or other heat sources can result in increased potential for fire injuries or hazardous gas inhalation because residents burn candles for light and use fires or generators to stay warm.
- Response personnel, including utility workers, public works personnel, debris removal staff, tow truck operators, and other first responders are vulnerable to injury or illness resulting from exposure to extreme cold temperatures.
- Response personnel would be required to travel in potentially hazardous conditions, elevating the life safety risk due to accidents, and potential contact with downed power lines.
- Operations or service delivery may experience impacts from electricity blackouts due to winter storms.
- Power outages are possible throughout the City of Houston due to downed trees and power lines and/or rolling blackouts.
- Critical facilities without emergency backup power may not be operational during power outages.
- Emergency response and service operations may be impacted by limitations on access and mobility if roadways are closed, unsafe, or obstructed.
- Hazardous road conditions will likely lead to increases in automobile accidents, further straining emergency response capabilities.
- Depending on the severity and scale of damage caused by ice and snow events, damage to power transmission and distribution infrastructure can require days or weeks to repair.
- A winter storm event could lead to tree, shrub, and plant damage or death.
- Severe cold and ice could significantly damage agricultural crops.
- Older structures built to less stringent building codes may suffer greater damage as they are typically more vulnerable to impacts of winter storm events. 51 percent of homes in City were built before 1980. 265 buildings and sites in the City are on the National Register of Historic Places, many of which pre-date modern building codes.
- Schools may be forced to shut early due to treacherous driving conditions.
- Exposed water pipes may be damaged by severe or late season winter storms at both residential and commercial structures, causing significant damages.

The economic and financial impacts of winter weather on the community will depend on the scale of the event, what is damaged, and how quickly repairs to critical components of the economy can be implemented. The level of

preparedness and pre-event planning done by government, businesses, and citizens will also contribute to the overall economic and financial conditions in the aftermath of a winter storm event.

Climate change is expected to reduce the number of extreme cold events statewide but increase in the variability of events. Extreme cold events will continue to be possible but overall winters are becoming milder, and the frequency of extreme winter weather events are decreasing due to the warming of the Arctic and less extreme cold air coming from that region. A trend that is expected to continue with winter extremes estimated to be milder by 2036 compared to extremes in the historic record.

A summary assessment of winter storm hazard vulnerability and impacts to the community lifelines is presented in the table below.

Table 49: Winter Storm Vulnerability and Consequence Summary by Lifeline

Winter Storm	Vulnerability	Consequence
Safety and Security	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Food, Hydration, Shelter	High Vulnerability	Significant Impact to Lifeline/Services
Health and Medical	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Energy (Power and Fuel)	High Vulnerability	Significant Impact to Lifeline/Services
Communications	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Transportation	High Vulnerability	Significant Impact to Lifeline/Services
Hazardous Material	Moderate Vulnerability	Moderate Impact to Lifeline/Services
Water Systems	High Vulnerability	Significant Impact to Lifeline/Services

Table 49 Source: City of Houston OEM

Sea Level Rise

According to NOAA, the sea level around Galveston, Texas has risen 18 inches since 1950. The speed of rise has accelerated over the last 10 years and is now rising by nearly 1 inch every year. Scientists have determined these figures by measuring the sea level every 6 minutes using equipment like satellites, floating buoys off the coast, and tidal gauges to accurately measure the local sea level as it accelerates and changes.

By 2050, the Galveston Pleasure Pier can expect to see up to 22 inches of additional rise. The NOAA sea level rise viewer, a web-mapping tool designed to view potential impacts from coastal flooding or sea level rise, provides a range of local scenarios. One of these scenarios is an intermediate-high scenario for Galveston that shows increased water levels in the San Jacinto River and Buffalo Bayou watersheds, as well as severe impacts in the far southeastern reaches of Houston.

The City of Houston considers sea level rise in climate action planning as well as mitigation planning, though it often appears in conjunction with hurricane and flood hazard mitigation due to the inland nature of most of the City.

A summary assessment of hazard vulnerability and impacts to the community lifelines related to sea level rise is presented the table below.

Table 50: Sea Level Rise Vulnerability and Consequence Summary by Lifeline

Sea Level Rise	Vulnerability	Consequence
Safety and Security	Low Vulnerability	Significant Impact to Lifeline/Services
Food, Water, Sheltering	Low Vulnerability	Significant Impact to Lifeline/Services
Communications	Low Vulnerability	Low Impact to Lifeline/Services
Transportation	Low Vulnerability	Moderate Impact to Lifeline/Services
Health and Medical	Low Vulnerability	Significant Impact to Lifeline/Services
Hazardous Material (Mgmt)	Low Vulnerability	Significant Impact to Lifeline/Services
Energy (Power and Fuel)	Low Vulnerability	Significant Impact to Lifeline/Services

Table 50 Source: City of Houston OEM

Mitigation Needs Assessment Conclusion

This mitigation needs assessment reviewed the characteristics and impacts of current and future hazards. The risk of thunderstorm winds and hurricanes in Houston is high, and the potential severity of the risk is substantial, which was fully realized after the Derecho in mid-May and Hurricane Beryl in early July.

Connection of Proposed Programs and Projects to Unmet Needs and Mitigation Needs

Allocating limited long-term recovery resources when unmet needs far surpass available funding can be challenging. Many factors from the various assessments and available data help to guide these decisions, however there are other factors that must be considered.

Houston is no stranger to disasters. It is not a question of "if" but rather, a question of "when" the next disaster will impact the City. Houston's geography and proximity to the Gulf of Mexico, combined with climate change increase the City's vulnerability. Since 2008, there have been 10 presidentially declared disasters. There have also been other localized events that did not rise to the level of a presidentially declared disaster, but nonetheless impacted many residents and businesses in the City.

The City's allocation of CDBG-DR resources related to disasters in 2008, 2015, 2016, 2017, and 2021 favored a housing centered response approach (with more than 80% of awarded funding and nearly $775MM invested in housing-related programs). Failure to consider and address the City's capacity to mount an effective disaster response and recovery strategy and ensure the appropriate resources to do so has left the City vulnerable and this poses a risk to all Houstonians.

The 2024 Derecho and Hurricane Beryl exposed existing challenges that informed the City's approach to preparing for disaster events and reducing this risk for all residents. In the City's assessment of disaster response deficiencies following these disasters, it became evident that the City must strengthen its capacity. The City submitted a detailed request to its federal delegation outlining the resources needed to address critical capability gaps in the identified areas below:

- Emergency power generation to support critical public facilities
- Disaster response and public safety operations
- Pre-disaster vegetation management
- Post-disaster debris removal operations
- Homeless services and supports

Congress responded by directly allocating funding to the City, ensuring a more efficient deployment of resources where they are most needed. This plan describes how the City will utilize CDBG-DR funding to enhance the City's preparedness and resilience.

The CDBG-DR Program Allocations below reflect the City's strategy to ameliorate deficiencies in its capacity to meet the needs of Houston residents before, during, and after disasters. The City will use 100% of the CDBG-DR allocation in the HUD-identified MID area (Houston, TX) as shown in Table 51 below:

Table 51: CDBG-DR Program Allocations

Eligible Cost Category	CDBG-DR Allocation Amount	% of CDBG-DR Total Grant Award	Amount of CDBG-DR Allocation for LMI Benefit
Administration	$15,732,250.00	5.00%	N/A
Planning	$200,000.00	0.06%	N/A
Housing	$0.00	0.00%	0.00%
Infrastructure	$216,631,150.00	68.85%	77.25%
Public Services	$41,040,600.00	13.04%	100.00%
Economic Revitalization	$0.00	0.00%	0.00%
Mitigation	$41,041,000.00	13.04%	0.00%
Total	**$314,645,000.00**	**100%**	**70.00%**

Table 51 Source: City of Houston HCD

Programs have been designed to mitigate the impacts of future disasters, in consideration of hazard risks identified in the mitigation needs assessment. Information on proposed programs and connection to needs are described below.

Power Generation Resilience Program

Loss of power during and following these events has been a significant barrier to initiating an effective response and recovery strategy that this program will help to mitigate. Ensuring the continuity of critical public safety functions/services continues to be a challenge in the immediacy and aftermath of these events when widespread power outages occur.

With the 2024 Derecho, more than 1 million customers lost power in the greater Houston area, and with Hurricane Beryl, this number rose to more than 2.7 million customers (many without power for 10 days or more. These power outages impacted critical City public facilities and residential customers alike.

During Hurricane Beryl, a significant number of heat-related illnesses were reported. Of those who died during Hurricane Beryl, a significant portion of these deaths were attributed to heat-related causes associated with the loss of power and lack of air conditioning in homes. Not only does this accounting of residents in distress highlight the need for emergency power generation for critical fire and police services but it also highlights the need for accessible public facilities throughout the City where residents can seek temporary respite and access resources.

The City of Houston owns and operates the largest municipal water utility system in country. It serves over 5.6 million people, stretching over 7 counties, with 7200 miles of drinking water pipes and 6,100 miles of wastewater pipes.

- With the lack of power supporting the City's water utility system, the City experienced trouble keeping waste water moving through the system. All 44 of the City's wastewater operation locations were impacted during these disasters. Due to the lack of power, these operations were

forced to relocate and adjust back up power generators throughout the system to power the 44 wastewater lift stations and treatment plants. Despite these efforts, 55 public sanitary sewer overflows occurred due to loss of power during Hurricane Beryl and another 16 were reported due to the Derecho

- With the lack of power supporting the City's water utility system, the City experienced trouble keeping water moving through the system to maintain adequate line pressure which is regulated by the Texas Commission on Environmental Quality. Drinking water operations faced significant vulnerability and risk associated with outdated diesel generators. This shuffling of generators from one repump station to the next (7 total), was done to avoid a boil water notice for 5.6 million people already experiencing a lack of power during the summer months. There was a consistent state of fuel insecurity as many were competing for the same fuel supply. Logistics of getting fuel to the drinking water re-pump stations were also made more challenging due to storm damage and debris. Additionally, these systems were only designed to meet a minimum back-up power generation requirement of 72 hours, not the 10+ days of power loss during Hurricane Beryl. Houston's repump stations not only support residents, but also critical businesses such as the Texas Medical Center (world's largest) and the Houston Ship Channel (with 44% of the US petrochemical refining capacity).

The COH's 12 Multi-Service Centers serve many needs during a disaster such as cooling/warming centers, and points of distribution for supplies. During the Derecho and Hurricane Beryl, none of the City's Multi-Service Centers had backup power to be able to properly function in those roles. With no power at these facilities, their usefulness was greatly diminished. Similarly, Libraries, which can also serve these functions lack back-up power to do so.

The City of Houston currently has 90 fire stations and 5 police stations that do not have back up power generation. These facilities house our public safety officials and provide critical services to our communities during a disaster. Fire and Police stations left without power during both the Derecho and Hurricane Beryl put our public safety officials and the City's residents at an elevated risk by not having appropriate emergency response capacity. The Power Generation Resilience Program is intended to address emergency/back-up power generation needs at this City facilities.

Emergency Response/Public Safety Program

During Hurricane Beryl, the city and county set up a triage facility for those leaving hospitals that didn't yet have power in their homes. Having ambulances at the ready, especially in times of disaster, is critical to supporting our residents. The lack of power during and after a disaster put a strain on the emergency response and public safety network. While most hospital systems are connected to an emergency power grid, the patients that they are providing care to during or after a disaster do not have emergency power at home. Due to these circumstances, patients who needed to be in a stable environment were not released from hospitals because of the lack of power in their homes. This situation caused a large buildup of Houston Fire Department ambulances waiting to deliver patients to emergency rooms and hospitals across the city, putting a strain on the ability of the department to respond to new emergencies where life-saving care was needed. Increasing capacity in the Houston Fire Department's ambulance fleet which will allow them to provide critical emergency response during or after a disaster.

The Derecho and Beryl both impacted the City of Houston by causing power outages for multiple days, in most instances for 5 days or longer. The issue placed a strain on our Houston Police Department and their ability to patrol an entire city without power. The threats of increased crime and looting were a serious concern that prompted the City to call in off-duty police officers and force others to work overtime so that a constant law enforcement presence could be felt throughout the city. With the lack of power, the Houston Police Department also had to deal with a traffic grid that had no working traffic lights. Officers had to be dispatched and stationed at major intersections to prevent accidents and traffic deaths. All these

circumstances left the Houston Police Department with a shortage of available vehicles to respond to emergencies. Adding capacity to the Houston Police Department vehicle fleet, will provide necessary public safety coverage for the city during and after a disaster.

During a disaster, often times public safety needs to respond to an emergency in any situation. Many disasters in Houston, including Beryl, have brought about flash or continued flooding that impacts public safety's ability to respond to emergency situations. Additional high water vehicles or other lifted 4-wheel drive options are needed to help traverse challenging conditions during a disaster.

The lack of power during and after a disaster can have negative effects on communications infrastructure used to support the City of Houston's emergency response network. With extended periods of time without power during both the Derecho and Beryl, the City of Houston's emergency communications network experienced issues related to connectivity and service. Portable communications solutions are needed during and after a disaster.

FEMA Public Assistance Local Cost Share
FEMA's Public Assistance (PA) program includes assistance for both short-term "Emergency Work" undertaken to respond to a disaster or an emergency, and long-term "Permanent Work" undertaken to recover from a major disaster. With FEMA PA, the non-federal cost-sharing arrangement for local governments involves a share, or "match," which is 25% of the total eligible project costs. This will cover this local cost share for eligible CDBG-DR activities undertaken as a result of the disasters.

Homeless Services Program
The City is expanding strategy beyond permanent housing, e.g., to include shelter and “specialty beds,” to be able to offer different levels of care as a steppingstone for those acute needs. Nightly, 3,280 individuals face homelessness, with 1,100 unsheltered. Houston strives to help homeless neighbors with immediate access to supportive services, ensuring there is no more waiting on the streets. Expanding outreach, shelter, and streamlined housing access for individuals and front-line teams. Moving all remaining individuals experiencing unsheltered/street homelessness into housing with supportive services. And finally, to establish hubs across the region to offer immediate support and services, facilitating a seamless transition from the streets to stable, permanent housing. This public services program will address these needs.

Debris Repository Acquisition and Development Project
High wind events like the Derecho and Beryl often have tremendous impacts on Houston's vegetation and tree canopy. Debris from uprooted trees, broken tree limbs, and other vegetation that is damaged by high winds often impacts not only residential and commercial property, but public infrastructure like roads and traffic signals. During these two Presidentially Declared Disasters, over 4.5 million cubic yards of storm debris were collected. Debris depository sites are set up throughout the City to collect and sort the debris for appropriate disposal methods. Often those sites are selected on a temporary and needs basis, limiting opportunities to select the most appropriate site for a debris depository. This project is intended to address the need for permanent debris repositories to support vegetation management and debris removal operations.

Vegetation Management/Debris Removal Program
To aid in reducing damage from the impacts of high wind events on critical infrastructure and property and reduce the financial burden on both constituents and the government when dealing with disasters. Preventative and mitigative vegetation/tree-cutting and debris removal operations will provide for reduced levels of storm-generated debris that can lead to hazards, damage, and flooding along main streets and thoroughfares. Overgrown vegetation can encroach on right-of-way areas such as roads, highways and

bicycle pathways. This overgrowth can have dangerous consequences pre- and post-disaster, such as traffic accidents, fires, and power outages. This program will address both mitigative and post disaster needs.

While the City has prioritized deployment of the CDBG-DR resources as described in the Plan, the City does estimate that other federal funding, including annual CDBG (50%) and HOME (90%) allocations are estimated to contribute $106 million to housing-related programs over the next five years. In addition, the City was a co-applicant with the Houston Housing Authority in bringing in a $50 million Choice Neighborhoods Implementation Grant to support the development of affordable rental housing (Cuney Homes) and spur investment in the surrounding community. The City will continue to seek opportunities for collaboration and leveraging to prioritize housing needs as it makes decisions on how to best utilize the limited federal funding the City receives annually.

Displacement of Persons or Entities

To minimize the displacement of persons and other entities that may be affected by the activities outlined in this action plan, the City of Houston will coordinate with all agencies and entities necessary to ensure that all programs are administered in accordance with the amended RARAP, Uniform Relocation Assistance and Real Property Acquisition Policies Act (URA) of 1970, as amended (49 CFR Part 24,) and Section 104(d) of the Housing and Community Development Act of 1974, as amended, and the implementing regulations at 24 CFR Part 570.496(a) to minimize displacement. Should any proposed projects or activities cause the displacement of people, the following policy has been adopted to ensure the requirements of the Uniform Relocation Assistance and Real Property Acquisition Act of 1970 (URA), as amended are met.

The City of Houston does not plan to administer activities that will cause a direct or indirect displacement of persons or entities. Should any proposed projects or activities cause the displacement of persons or entities, the City of Houston plans to amend the current Residential Anti-displacement and Relocation Assistance Plan (RARAP) to reduce any hardship of a displaced person or entity and increase oversight to ensure the requirements of Uniform Relocation Assistance and Real Property Acquisition Act of 1970 (URA), as amended are met. The amended RARAP will set the minimum standard for, but not limited to, planning efforts, Relocation Plan, relocation schedule, accommodations for displaced persons with disabilities, relocation budget, and project the number of staff needed to carry out URA requirements. If relocation is applicable, a program or project must demonstrate it has met the latest RARAP requirements before and activity can be approved and implemented. Relocation activities will be planned for and budgeted within the applicable CDBG-DR program. CDBG-DR funds may not be used to support any federal, state, or local projects that seek to use the power of an eminent domain unless eminent domain is employed only for public use (e.g., mass transit, railroad, airport, seaport, highway, and utility projects). None of the currently planned projects under this Action Plan anticipate the use of eminent domain.

Allocation and Award Caps/Funding Criteria

Table 52: CDBR-DR Program Allocations

Eligible Cost Category	CDBG-DR Allocation Amount	% of CDBG-DR Total Grant Award	Amount of CDBG-DR Allocation for LMI Benefit
Administration	$15,732,250.00	5.00%	N/A
Planning	$200,000.00	0.06%	N/A
Housing	$0.00	0.00%	0.00%
Infrastructure	$160,091,150.00	50.88%	77.25%
Public Services	$97,580,600.00	31.01%	100.00%
Economic Revitalization	$0.00	0.00%	0.00%
Mitigation*	$41,041,000.00	13.04%	0.00%
Total	**$314,645,000.00**	**100%**	**70.00%**

Table 52 Source: City of Houston HCD
*Mitigation includes a public service program this amount and the amount of Public Services results in total public services budgeted in excess of the 15% cap. However, the City is seeking a waiver to allow for this, based on HUD guidance.

Administration

Table 53: Grantee Administration Activity(ies) Overview

Eligible Cost Category	CDBG-DR Allocation Amount	% of CDBG-DR Grant Award
Administration	$15,732,250.00	5.00%
Total	**$15,732,250.00**	**5.00%**

Table 53 Source: City of Houston HCD

Planning

Table 54: Grantee Planning Activity(ies) Overview

Eligible Cost Category	CDBG-DR Allocation Amount	% of Total CDBG-DR Grant Award
Planning	$200,000.00	0.06%
Total	**$200,000.00**	**0.06%**

Table 54 Source: City of Houston HCD

Housing

Housing Programs Overview

Table 55: Grantee Housing Programs Overview

Housing Programs	CDBG-DR Allocation Amount	% of CDBG-DR Allocation for LMI Benefit	% of CDBG-DR Allocation for Urgent Need
N/A	$0.00	0.00%	0.00%
Total	**$0.00**	**0.00%**	**0.00%**

Table 55 Source: City of Houston HCD
No Housing programs budgeted from CDBG-DR24 funds.

Infrastructure

Infrastructure Programs Overview

Table 56: Grantee Infrastructure Programs Overview

Infrastructure Programs	CDBG-DR Allocation Amount	Estimated % of CDBG-DR Allocation for LMI Benefit	Estimated % of CDBG-DR Allocation for Urgent Need
Power Generation Resilience Program	$151,291,150.00	77.25%	22.75%
FEMA Public Assistance Local Cost Share	$8,800,000.00	77.25%	22.75%
Total	**$160,091,150.00**	**77.25%**	**22.75%**

Table 56 Source: City of Houston HCD

Infrastructure Program 1: Power Generation Resilience Program

Program Title: Power Generation Resilience Program

Amount of CDBG-DR Funds Allocated to this Program: $151,291,150.00

Eligible Activity(ies): Public Facilities and Improvements

National Objective: Benefit to Low- and Moderate-Income Persons (LMI), Urgent Need (UN)

Lead Agency and Distribution Model: This program will be administered by the City of Houston, Housing and Community Development Department, as the lead agency, in coordination with other City departments. Contractor(s) will be selected through a request for proposal (RFP) process and funding will be awarded to selected contractor(s) according to the outcome of this process and the needs of the program.

Program Description: This program will fund improvements to a variety of public facilities by adding resilience measures that mitigate the impacts of protracted power outages during extreme weather events, including presidentially declared disasters, and enable effective disaster response and recovery efforts. Such measures may include the installation of permanently affixed full-site standby/emergency power generation and distribution options at these facilities to allow them to continue to deliver critical public safety services and/or to be a resource to the surrounding community in the event of future disasters.

This program will strengthen and improve public facilities to:

- Protect critical infrastructure such as drinking water and wastewater operations
- Ensure capacity to deliver critical public safety services such as those provided by fire or police stations
- Ensure the availability of public facilities such as community/multiservice centers and/or libraries to serve as cooling/heating centers, shelters, and/or distribution points during or immediately following a disaster

Costs under this program may include engineering/design services; purchase and installation of natural gas generators; related modifications to facility infrastructure, including resilient platform construction, establishing power connection/switching mechanisms, and other site-specific modifications; ongoing operation/maintenance considerations; activity delivery; and administration.

Eligible Geographic Areas: The City of Houston **(**HUD Identified MID area).

Other Eligibility Criteria: Essential City-owned and operated public facilities without permanent emergency back-up power generation will be prioritized.

Maximum Amount of Assistance Per Beneficiary: N/A

Maximum Income of Beneficiary: N/A

Mitigation Measures: This activity meets HUD mitigation activity definition.

Reducing Impediments for Assistance: N/A

Infrastructure Program 2: FEMA PA Local Cost Share

Program Title: FEMA PA Local Cost Share

Amount of CDBG-DR Funds Allocated to this Program: $8,800,000.00

Eligible Activity(ies): Public Facilities and Improvements

National Objective: Benefit to Low- and Moderate-Income Persons (LMI); Urgent Need (UN)

Lead Agency and Distribution Model: This program will be administered by the City of Houston, Housing and Community Development Department, as the lead agency, in coordination with other City departments.

Program Description: FEMA's Public Assistance (PA) program includes assistance for both short-term "Emergency Work" undertaken to respond to a disaster or an emergency, and long-term "Permanent Work" undertaken to recover from a major disaster. With FEMA PA, the non-federal cost-sharing arrangement for local governments involves a share, or "match," which is 25% of the total eligible project costs. Costs under this program may include the local cost share for CDBG-DR eligible FEMA PA submissions and activity delivery.

Eligible Geographic Areas: The City of Houston (HUD Identified MID area).

Other Eligibility Criteria: FEMA PA cost share for CDBG-DR eligible Public Facilities projects only.

Maximum Amount of Assistance Per Beneficiary: N/A

Maximum Income of Beneficiary: N/A

Mitigation Measures: N/A

Reducing Impediments for Assistance: N/A

Economic Revitalization

Economic Revitalization Programs Overview

Table 57: Grantee Economic Revitalization Programs Overview

Economic Revitalization Programs	CDBG-DR Allocation Amount	% of CDBG-DR Allocation for LMI Benefit	% of CDBG-DR Allocation for Urgent Need
N/A	$0.00	0.00%	0.00%
Total	**$0.00**	**0.00%**	**0.00%**

Table 57 Source: City of Houston HCD

No Economic Revitalization programs budgeted from CDBG-DR24 funds.

Public Services

Public Services Programs Overview

Table 58: Grantee Public Services Program Overview

Public Services Programs	CDBG-DR Allocation Amount	Estimated % of CDBG-DR Allocation for LMI Benefit	Estimated % of CDBG-DR Allocation for Urgent Need
Emergency Response/Public Safety Program	$56,540,000.00	77.25%	22.75%
Homeless Services Program	$41,040,600.00	100.00%	0.00%
Total	**$97,580,600.00**	**86.82%**	**13.18%**

Table 58 Sources: City of Houston HCD

Public Services Program 1: Emergency Response/Public Safety Program

Program Title: Emergency Response/Public Safety Program

Amount of CDBG-DR Funds Allocated to this Program: $56,540,000.00

Eligible Activity(ies): Public Services (Public Service Cap Waiver)

National Objective: Benefit to Low- and Moderate-Income Persons (LMI); Urgent Need (UN)

Lead Agency and Distribution Model: This program will be administered by the City of Houston, Housing and Community Development Department, as the lead agency, in coordination with other City departments. Vendor(s) will be selected for this program through a competitive solicitation process and funding will be awarded to selected vendor(s) according to the outcome of this process and the needs of the program.

Program Description: The program will support the purchase of equipment (such as emergency communications systems, mobile cell sites, public safety and other related specialized equipment) and vehicles (such as ambulances, police vehicles, high-water or other lifted vehicles, etc.) necessary for effective emergency response and the maintenance of public safety during and following disasters. Having sufficient ambulances at the ready is especially critical to supporting our residents in times of disaster. Also critical is ensuring sufficient public safety vehicles are available for the City to deploy an effective emergency response and public safety strategy. Crucial to this strategy is ensuring the availability of portable communications solutions to maintain connectivity, coordination, and continuity of services in disaster response efforts.

Based on guidance from HUD, the City will be seeking a waiver for this program.

Costs under this program will include the purchase of emergency response equipment and public safety vehicles, portable communication equipment and related services, and activity delivery.

Eligible Geographic Areas: The City of Houston (HUD Identified MID area).

Other Eligibility Criteria: Equipment purchased will only support City-owned and operated public facilities performing emergency response and public safety activities.

Maximum Amount of Assistance Per Beneficiary: N/A

Maximum Income of Beneficiary: N/A

Mitigation Measures: N/A

Reducing Impediments for Assistance: N/A

Public Services Program 2: Homeless Services Program

Program Title: Homeless Services Program

Amount of CDBG-DR Funds Allocated to this Program: $41,040,600.00

Eligible Activity(ies): Public Services

National Objective: Benefit to Low- and Moderate-Income Persons (LMI)

Lead Agency and Distribution Model: This program will be administered by the City of Houston, Housing and Community Development Department, as the lead agency, in coordination with other City departments. Sub-recipients may be designated directly or selected through a competitive solicitation process, as allowable.

Program Description: The services provided will be those needed to prevent or address homelessness. This may include financial support to nonprofits that provide essential services such as shelter operations, case management, and other services to meet the needs of homeless individuals. Costs may include public services and activity delivery.

Eligible Geographic Areas: The City of Houston **(**HUD-identified MID area).

Other Eligibility Criteria: N/A

Maximum Amount of Assistance Per Beneficiary: N/A

Maximum Income of Beneficiary: N/A

Mitigation Measures: N/A

Reducing Impediments for Assistance: N/A

CDBG-DR Mitigation Set-Aside

CDBG-DR Mitigation Set-Aside Programs Overview

Table 59: Grantee CDBG-DR Mitigation Set-Aside Programs Overview

Mitigation Programs	CDBG-DR Allocation Amount	Estimated % of CDBG-DR Allocation for LMI Benefit	Estimated % of CDBG-DR Allocation for Urgent Need
Debris Repository Acquisition / Development Project	$32,791,000.00	0.00%	100.00%
Vegetation Management / Debris Removal Program	$8,250,000.00	0.00%	100.00%
Total	**$41,041,000.00**	**0.00%**	**0.00%**

Table 59 Source: City of Houston HCD
Mitigation Set-Aside = $41,041,000.00

Mitigation Set-Aside Program 1: Debris Repository Acquisition/Development Project

Program Title: Debris Repository Development Project

Amount of CDBG-DR Funds Allocated to this Program: $32,791,000.00

Eligible Activity(ies): Mitigation

National Objective: Urgent Need (UN)

Lead Agency and Distribution Model: This project will be administered by the City of Houston, Housing and Community Development Department, as the lead agency, in coordination with other City departments. Contractors or vendors may be selected pursuant to 2 CFR 200 procurement requirements, as needed.

Program Description: This project will develop two large-scale regional depositories that would facilitate self-help and department-assisted debris collection operations post-disaster. Before and during the aftermath of a disaster, it is critical for the City to safely isolate hazardous materials from the environment and human contact. As a result, the regional debris repositories will protect the public health and the local ecosystem. These repositories will also service the City's proposed *Vegetation Management/Debris Removal Program.*

Costs for this Public Improvements and Facilities project would include land acquisition, site preparation, related construction or modifications, security measures, and activity delivery.

Eligible Geographic Areas: The City of Houston **(**HUD Identified MID area).

Other Eligibility Criteria: Identified city-owned and operated public facilities without permanent emergency back-up power generation.

Maximum Amount of Assistance Per Beneficiary: N/A

Mitigation Measures: This activity meets HUD mitigation activity definitions.

Reducing Impediments for Assistance: N/A

Mitigation Set-Aside Program 2: Vegetation Management/Debris Removal Program

Program Title: Vegetation Management/Debris Removal

Amount of CDBG-DR Funds Allocated to this Program: $8,250,000.00

Eligible Activity(ies): Mitigation

National Objective: Urgent Need (UN)

Lead Agency and Distribution Model: This program will be administered by the City of Houston, Housing and Community Development Department, as the lead agency, in coordination with other City departments. Sub-recipient(s) may be designated directly or selected through a competitive solicitation process, as allowable

Program Description: The City will develop and operate a strategic Vegetation Management/Debris Removal Program. This will include implementing preventative/mitigative vegetation management practices to reduce damage and post-disaster debris. The planned debris repository project will assist in the disposal of vegetation and debris collected.

Costs for this vegetation management/debris collection public service may include the purchase and maintenance of equipment necessary to perform vegetation management and debris collection, and activity delivery.

Eligible Geographic Areas: The City of Houston **(**HUD-identified MID area).

Other Eligibility Criteria: N/A

Maximum Amount of Assistance Per Beneficiary: N/A

Mitigation Measures: This activity meets the HUD mitigation activity definition.

Reducing Impediments for Assistance: N/A

General Information

Citizen Participation

The City ensured that all disaster-impacted residents had opportunities to engage and participate through various methods throughout the drafting of this plan. The participation of citizens, stakeholders, and communities was essential to inform the priorities and needs of residents affected by the disasters. The City, as outlined in the Citizen Participation Plan (Appendix), conducted public hearings, deployed surveys to residents and stakeholder agencies, and consulted with various partners to complete this plan in compliance with HUD's Revised Universal Notice requirements.

Consultation on Developing the Action Plan

During the development of the Action Plan for Disaster Recovery – 2024 Derecho and Hurricane Beryl, the City consulted with relevant government and local agencies and other stakeholders listed in the table below to ensure consistency with applicable regional development plans and identify opportunities for leveraging funding.

Table 60: Partner Consultation

Partners Consulted	Describe Consultation
Federal Partners (FEMA, SBA)	FEMA and SBA were consulted and provided data to support impact and needs analysis in the Plan, FEMA was also consulted regarding recovery resources, including FEMA Public Assistance (PA), to ensure alignment and leveraging of FEMA PA funding with CDBG-DR funding. FEMA and SBA contacts were invited to complete the Agency disaster recovery survey.
Local/State Government	The state government was consulted regarding coverage of local cost share for FEMA PA Category A, to ensure appropriate leveraging of available recovery resources. The City also engages in regular consultation with state and county partners.
Indian Tribes	Not Applicable
Nongovernmental organizations	The City engages with a variety of NGOs, who were invited to participate in both the Resident/Agency disaster recovery surveys as well as a variety of public engagement opportunities, including the two virtual public hearings for this Plan.
Private sector	The City has engaged with private sector partners to inform recovery and resilience discussions/planning efforts. Many private sector parties are included on our mailing list and were invited to complete the Resident or Agency disaster recovery survey.
State and local emergency management agencies that have primary responsibility for the administration of FEMA funds	The City, through the Urban Area Security Initiative (UASI) Urban Area Working Group (UAWG), the Regional Collaboration Committee, Health and Medical Committee, and Community Preparedness Committee engages with partners across the Houston-Galveston region, to analyze threats and hazards, identify gaps in capability, and invest time and resources in solutions to ensure our communities are ready for our worst days. Also, the Harris County Long-Term Recovery Committee (HCLTRC) engages over 120 organizations and departments (Harris County Recovers) to share information and resources and to collaborate on long-term resilience and recovery solutions. The HCLTRC meets for steady-state objectives quarterly, and after emergencies, the group meets more frequently to problem-solve and collaborate on recovery-specific challenges.
Agencies that manage local Continuum of Care	City meets regularly with the lead agency, the Coalition for the Homeless of Houston/Harris County (CFTH), for the local CoC (The Way Home) to discuss a variety of issues surrounding homelessness, including the needs of the homeless during times of

Partners Consulted	Describe Consultation
	emergency/disaster. CFTH was also invited to participate in the Agency disaster recovery survey.
Public Housing Agencies	HHA – monthly meetings to discuss ongoing public housing, housing voucher programs, and collaborate to implement the Choice Neighborhoods Initiative, Project Based Vouchers, and to participate in the Agency disaster recovery survey to determine the impacts of the 2 disasters.
HUD-approved housing counseling agencies	The City partners with many Housing Counseling Agencies through its homebuyer assistance programs. These agencies were invited to participate in the Agency disaster recovery survey.
State Housing Finance Agencies	TDHCA – the City holds ongoing conversations with TDHCA to discuss various affordable housing issues and challenges around tax credits and state housing guidelines, as well as issues surrounding disaster and long-term recovery.
Other Stakeholders	The City is in collaboration with the Texas Housing Group (THG), made up of the 6 largest Texas cities and participates in monthly meetings to discuss various housing issues/needs in the state of Texas.

Table 60 Source: City of Houston HCD

Public Comments

A public notice that included the budget and how to access and comment on the draft Plan as well as dates and times of the virtual public hearings was published in the Houston Chronicle and La Voz on May 23, 2025, and the draft Action Plan for Disaster Recovery – 2024 Derecho and Hurricane Beryl. This information was also posted on the City's disaster recovery website. The 30-day public comment period began on May 23, 2025, and ended on June 22, 2025. Public comments and responses will be summarized and included in the final version of the Plan. Additionally, a summary of public comments received during virtual Public Hearings and responses will also be included.

Public Hearings

The City conducted two virtual public hearings in accordance with requirements in HUD's Revised Universal Notice (I.C.2.b).

These meetings included:

- Presentation on Action Plan for Disaster Recovery
- Formal public comment
- Question and answer session

The table below provides details regarding the public hearings held.

Table 61: CDBG-DR24 Public Hearing Information

Public Hearing Date	Public Hearing Times	Public Hearing Format	Number of Attendees
Tuesday, June 10, 2025	11:00 AM – 1:00 PM	Virtual Public Hearing	TBD
Thursday, June 12, 2025	3:00 PM – 5:00 PM	Virtual Public Hearing	TBD

Table 61 Source: City of Houston HCD

Access to Public Hearings

Public hearings were advertised through a variety of methods – social media, email, newspaper (public notice), and the City's disaster recovery website. Information included how people with disabilities could request accommodation. To ensure effective communication, Communication Access Real-time Translation (CART) services were provided, and meetings were held in both English and Spanish.

Consideration of Public Comments

The following provides a summary of public comments received for the Draft Action Plan for Disaster Recovery 2024 Derecho and Hurricane Beryl Storm in response to the public comment periods that began from May 23, 2025, through June 22, 2025. In addition, this section contains a summary of the information received through other methods of community engagement throughout the development of this Action Plan. The City of Houston implemented several strategies to receive feedback regarding long-term recovery and funding strategies related to this Action Plan. Opportunities for the community to give feedback about their disaster impacts, remaining community recovery needs, and priorities for funding, included:

- Stakeholder interviews
- 2 Surveys: resident and agency
- 30-day public comment period
- 2 virtual public hearings

Table 62: Public Comments

Comment Received	Grantee's Response
Add additional rows as needed.	…

Table 62 Source: City of Houston HCD

Note: This table will be filled out once the public hearings and public comment period have been completed.

Citizen Complaints

Complaints and Appeals

To promote transparency and partnership with communities where HCDD operates, HCDD responds to all complaints and appeals in a timely and equitable manner consistent with HUD requirements. An appeal is a communication from an applicant of any of HCDD's programs who wishes to overturn a decision made regarding either the applicant's application or the resulting case. A complaint is a communication from a member of the public to a City official or employee that includes a concern or grievance regarding the operations of the City or any party acting on behalf of the City.

Complaints
Complaints alleging violation of fair housing laws will be directed to HUD or the Texas Workforce Commission for immediate review.

HCDD maintains a dedicated website (https://houstontx.gov/hcdrecovery/fraud.html) that provides information about identifying, reporting fraud, waste, and abuse. Complaints regarding fraud, waste, or abuse can be reported through the following methods to ensure accessibility and convenience.

HUD OIG Fraud Hotline
1-800-347-3735
hotline@hudoig.gov

City of Houston Office of the Inspector General Fraud Hotline
832-393-3542
Secure Online Portal

City of Houston Housing and Community Development Department
housingfraud@houstontx.gov

HCDD program areas will make concerted efforts to resolve concerns at the earliest stage, if possible. However, anyone may file a complaint at any time, in writing or verbally. Complaints may be filed in-person, by mail or email, or through HCDD's dedicated hotline for complaints.

Housing & Community Development Department.
ATTN: Complaints and Appeals
2100 Travis Street, 9th Floor
Houston, TX 77002
Hotline: 832-394-6200 ext. 2
hcddcomplaintsappeal@houstontx.gov
Business Hours: Monday – Friday, 8:00 AM – 5:00 PM

All complaints related to this Action Plan (or its amendments), QPRs, or the City's activities or programs funded with CDBG-DR24 will receive careful consideration and will be responded to in writing within 15 business days, as practicable. For more information, please refer to the HCDD website, https://houstontx.gov/hcdrecovery/complaints.html.

Appeals
All program applicants have the right to appeal a determination made by HCDD. Applicants have the right to appeal decisions made on their program file based on the following:

- Denial of services or award through any of HCDD's programs
- Program eligibility determination
- Program award calculation
- Program determination of Moderate or Substantial damage leading to Rehabilitation or Reconstruction
- Procedural error where the application was not processed by program staff in accordance with the program guidelines
- Affirmatively Furthering Fair Housing

Appeal requests are accepted in writing via email at HCDDComplaintsAppeal@houstontx.gov, mailed or delivered letter, online Appeal Request form, or using the paper form at the HCDD office.

Appeal Requests must be submitted within 30 days of the notice of determination. To be considered complete, an appeal request must contain the following information:

- Name
- Property Address
- Mailing Address (if different from Property Address)
- Phone
- Application number (if applicable)
- Email Address
- Reason for Appeal

Appeals will be responded to in writing within 30 calendar days. Appeals are accepted in writing via email, mailed or delivered letter, or online submission form.

For more information regarding the Appeal Submission or Appeal Review process, please refer to the HCDD website at https://houstontx.gov/hcdrecovery/appeals.html or call 832-394-6200 ext. 2.

Modifications to the Action Plan

A substantial amendment will be required when any of the following occurs:

- Additional needs have been identified
- Additional resources are being added
- A change is made to the program benefit or eligibility criteria
- An activity is being added or deleted
- The overall benefit requirement is being reduced
- A new allocation or reallocation increase or decrease of *more than 25 percent in an activity's program budget*
- The original Action Plan submission was incomplete, and an update is required

Substantial amendments are subject to a citizen participation process and require formal action by the City Council and submission to HUD. The City announces substantial amendments to the public through a public notice published in one or more newspapers of general circulation for 30 days, to provide an opportunity for public review and comment regarding proposed substantial amendments. Notices will be available in English and may also be available in Spanish and other languages, as feasible. The City will consider all written and/or oral comments or views concerning proposed substantial amendments that are received during the comment period in accordance with 24 CFR 91.105(c)(3). A summary of these comments and views, including comments or views not accepted, and the reason why, shall be submitted with each Substantial Amendment.

In conjunction with a substantial amendment, the City will evaluate the need to update the impact and unmet needs assessment section of the Plan, as required by HUD.

When the City of Houston pursues the substantial amendment process, the amendment will be posted here at https://houstontx.gov/hcdrecovery/dr24/ for a 30-day public comment period. The City of Houston will review and respond to all public comments received and submit them to HUD for approval.

Non-Substantial Amendment

A non-substantial amendment is an amendment to the plan that includes technical corrections, clarifications, and budget increases or decreases by less than twenty-five percent (25%). These require the signature of the City's HCD Director or designated representative, but do not require a public comment period or City Council approval. The City will notify HUD five (5) business days before the change is effective. All amendments will be numbered sequentially and posted to the website as one final, consolidated plan.

Performance Reports

In onboarding new DRGR reporting requirements for this grant, the City of Houston (City) will assess all budgeted programs/projects proposed for implementation in determining appropriate performance measures and/or beneficiary demographics that will be required for quarterly reporting. This information is used to inform the design of data collection templates that will be incorporated into program/project management procedures, as well as contracts/agreements with sub-awardees, and will provide the framework for a coordinated monthly data collection process. Records of sub-awardee monitoring visits, audits, and technical assistance visits performed during the performance period will also be collected and reviewed to further inform performance reporting content. Integral to the report development process is a multi-step data validation/review process in conjunction with periodic reconciliation actions, as needed, to ensure the accuracy and completeness of each Quarterly Progress Report (QPR) prior to its timely submission in DRGR.

In accordance with HUD requirements, the City will submit each QPR through the HUD Disaster Recovery Grant Reporting (DRGR) system no later than thirty (30) days following the end of each fiscal quarter commencing with the first full quarter after execution of the grant agreement. QPRs will be posted to the City's Disaster Recovery website (houstontx.gov/hcdrecovery) within three (3) calendar days following HUD approval. Quarterly performance reporting will continue throughout the lifecycle of the grant until all funds have been expended, related accomplishments have been reported and required closeout materials have been submitted. Thereafter, the City will report on any program income received following the closeout of the grant, annually in DRGR.

Appendix

CITY OF HOUSTON

CITIZEN PARTICIPATION PLAN FOR DISASTER RECOVERY

2024 DERECHO AND HURRICANE BERYL

Introduction

The purpose of the Citizen Participation Plan for Disaster Recovery - 2024 Derecho and Hurricane Beryl (CPP-DR24) is to establish a means by which residents of the City of Houston (City), public agencies, and other interested parties can actively participate in the implementation and assessment of documents related to CDBG-DR24 activities and reflects the alternative requirements as specified by the Universal Notice 90 FR 1754 and Federal Register 90 FR 4759 and is implemented according to federal regulations (US Department of Housing and Urban Development (HUD) Regulations 24 CFR Part 91.105).

The CPP-DR24 is a separate, distinct, and tailored plan based upon and consistent with the City's Citizen Participation Plan, which describes public participation related to the consolidated planning process and entitlement grants. The City encourages citizen participation that emphasizes the involvement of low- and moderate-income residents, minority populations, persons with limited English proficiency, and persons with disabilities.

Availability and Accessibility of Documents

During the term of the CDBG-DR24 grant, the City will provide citizens and other interested parties with reasonable and timely access to information and records relating to the Action Plan and the grantee's use of grant funds. This Action Plan for Disaster Recovery – 2024 Derecho and Hurricane Beryl and associated amendments and performance reports will be made available on HCD's website, and upon request, from HCD. In addition, these documents are available in a form accessible to persons with disabilities, and those with limited English proficiency upon request.

Public Website

The City of Houston will maintain a public website that provides information accounting for how all grant funds are used, managed, and administered, including links to all disaster recovery action plans, action plan amendments, program policies and procedures, performance reports, citizen participation requirements, and activity and program information described in this plan, and details of all contracts and ongoing procurement processes.

These items are made available through https://houstontx.gov/hcdrecovery/dr24/. Specifically, the City of Houston *will make the following items available:*

- the Action Plan for Disaster Recovery – 2024 Derecho and Hurricane Beryl (including all amendments)
- each Quarterly Performance Report (as created using the DRGR system)
- the Citizen Participation Plan for Disaster Recovery – 2024 Derecho and Hurricane Beryl; procurement policies and procedures
- all executed contracts that will be paid with CDBG-DR funds as defined in 2 CFR 200.22 (including subrecipients' contracts)
- a summary including the description and status of services or goods currently being procured by the grantee or the subrecipient (e.g., phase of the procurement, requirements for proposals, etc.)

Contracts and procurement actions that do not exceed the micro-purchase threshold, as defined in 2 CFR 200.67, are not required to be posted to a grantee's website.

In addition, the City will maintain a comprehensive website regarding all disaster recovery activities assisted with these funds. The website will be updated on time to reflect the most up-to-date information about the use of funds and any changes in policies and procedures, as necessary. At a minimum, updates will be made monthly.

Amendments

Over time, recovery needs will change. Thus, the City of Houston will amend the disaster recovery action plan as often as necessary to best address our long-term recovery needs and goals. This plan describes proposed

programs and activities. As programs and activities develop over time an amendment may not be triggered if the program or activity is consistent with the descriptions provided in this plan.

Amendments to this Action Plan are divided into two categories: Substantial amendments and non-substantial Amendments. As amendments occur, both types of amendments are numbered sequentially and posted on HCD's Disaster Recovery webpage, https://www.houstontx.gov/hcdrecovery/. Copies of amendments are available upon request to: hcdd@houstontx.gov or 832.394.6200. Changes in amendments will be identified at the beginning of each amendment.

The most current version of the entire Action Plan will be accessible for viewing as a single document. Each amendment will have highlighted changes, and the beginning of the amendment will include:

- Section identifying exactly what content is added, deleted, or changed
- Revised budget allocation table that reflects all funds and illustrates where funds are coming from and moving to, as amended and applicable
- Description of how the amendment is consistent with the mitigation needs assessment

Substantial Amendment

A change to this action plan is a substantial amendment if it meets the following criteria:

- A change in program benefit or eligibility criteria,
- The addition or deletion of an activity,
- A proposed reduction in the overall benefit requirement,
- A new allocation or reallocation increase or decrease of more than 25 percent in an activity's program budget, and/or
- An update to the submitted initial Action Plan, if the original submission was incomplete.

Substantial amendments are subject to a citizen participation process and require formal action by the City Council and submission to HUD. The City announces substantial amendments to the public through a public notice published in one or more newspapers of general circulation for 30 days, to provide an opportunity for public review and comment regarding proposed substantial amendments. Notices will be available in English and may also be available in Spanish and other languages, as feasible. The City will consider all written and/or oral comments or views concerning proposed substantial amendments that are received during the comment period in accordance with 24 CFR 91.105(c)(3). A summary of these comments and views, including comments or views not accepted, and the reason why, shall be submitted with each Substantial Amendment.

When the City of Houston pursues the substantial amendment process, the amendment will be posted here at https://houstontx.gov/hcdrecovery/dr24/ for a 30-day public comment period. The City of Houston will review and respond to all public comments received and submit them to HUD for approval.

Non-Substantial (Minor) Amendment

A non-substantial (minor) amendment is an amendment to the plan that includes technical corrections, clarifications, and budget increase or decrease by less than twenty-five percent (25%). These require the signature of the City's HCD Director or designated representative, but do not require a public comment period or City Council approval. The City will notify HUD five (5) business days before the change is effective. All amendments will be numbered sequentially and posted to the website as one final, consolidated plan.

Public Hearings and Comments

Public hearings will be held at times and locations convenient to potential and actual beneficiaries, with accommodation for persons with disabilities and appropriate auxiliary aids and services to ensure effective communication, by providing CART services and advertising that accommodation is available upon request. If a significant number of non-English speaking residents are expected at a public hearing or an interpreter is requested

within a reasonable time, HCD will make interpretation services available. Additional accommodation may be made upon advance request. Public hearings shall be held after a minimum fourteen (14) day notice, where practicable, in at least one newspaper of general circulation. Notices will be available in English and may also be available in Spanish and other languages, as feasible.

Public comments will be published in the Action Plan for Disaster Recovery – 2024 Derecho and Hurricane Beryl and/or any substantial amendments after the conclusion of a public comment period and public hearings.

Application Status and Transparency

As applicable, the City of Houston will provide multiple methods of communication to provide applicants with timely information to determine the status of their application for assistance, including by phone, by mail, and in person. Written complaints from the public related to the Action Plan for Disaster Recovery – 20924 Derecho and Hurricane Beryl (or its amendments), QPRs, or the City's activities or programs funded with CDBG-DR24, will receive careful consideration and will be answered in writing, or other effective methods of communication, within 15 business days, where practicable.

Complaints and Appeals

To promote transparency and partnership with communities where HCDD operates, HCDD responds to all complaints and appeals in a timely and equitable manner consistent with HUD requirements. An appeal is a communication from an applicant of any of HCDD's programs who wishes to overturn a decision made regarding either the applicant's application or the resulting case. A complaint is a communication from a member of the public to a City official or employee that includes a concern or grievance regarding the operations of the City or any party acting on behalf of the City.

Complaints

Complaints alleging violation of fair housing laws will be directed to HUD for immediate review.

HCDD maintains a dedicated website (https://houstontx.gov/hcdrecovery/fraud.html) that provides information about identifying, reporting fraud, waste, and abuse. Complaints regarding fraud, waste, or abuse can be reported through the following methods to ensure accessibility and convenience.

HUD OIG Fraud Hotline

1-800-347-3735

hotline@hudoig.gov

City of Houston Office of the Inspector General Fraud Hotline

832-393-3542

Secure Online Portal

HCDD

housingfraud@houstontx.gov

HCDD program areas will make concerted efforts to resolve concerns at the earliest stage, if possible. However, anyone may file a complaint at any time, in writing or verbally. Complaints may be filed in-person, by mail or email, or through HCDD's dedicated hotline for complaints.

Housing & Community Development Department.

ATTN: Complaints and Appeals

2100 Travis Street, 9th Floor

Houston, TX 77002

Hotline: 832-394-6200 ext. 2

hcddcomplaintsappeal@houstontx.gov

Business Hours: Monday – Friday, 8:00 AM – 5:00 PM

All complaints related to this Action Plan (or its amendments), QPRs, or the City's activities or programs funded with CDBG-DR21, will receive careful consideration and will be responded to in writing within 15 business days, as practicable. For more information, please refer to the HCDD website, www.houstontx.gov/housing/complaints.html or https://houstontx.gov/hcdrecovery/complaints.html.

Appeals

All program applicants have the right to appeal a determination made by HCDD. Applicants have the right to appeal decisions made on their program file based on the following:

- Denial of services or award through any of HCDD's programs
- Program eligibility determination
- Program award calculation
- Program determination of Moderate or Substantial damage leading to Rehabilitation or Reconstruction
- Procedural error where the application was not processed by program staff in accordance with the program guidelines
- Affirmatively Furthering Fair Housing

Appeal requests are accepted in writing via email at HCDDComplaintsAppeal@houstontx.gov, mailed or delivered letter, online Appeal Request form, or using the paper form at the HCDD office.

Appeal Requests must be submitted within 30 days of the notice of determination. To be considered complete, an appeal request must contain the following information:

- Name
- Property Address
- Mailing Address (if different from Property Address)
- Phone
- Application number (if applicable)
- Email Adrees
- Reason for Appeal

Appeals will be responded to in writing within 30 calendar days. Appeals are accepted in writing via email, mailed or delivered letter, or online submission form.

For more information regarding the Appeal Submission or Appeal Review process, please refer to the HCDD website at https://houstontx.gov/housing/complaints.html or https://houstontx.gov/hcdrecovery/appeals.html or call 832-394-6200 ext. 2.