Impact of Hurricane Harvey on the State's Transportation Infrastructure in the Houston-Galveston Metropolitan Area and Recommendations on How Best to Rebuild Assets Efficiently and Effectively

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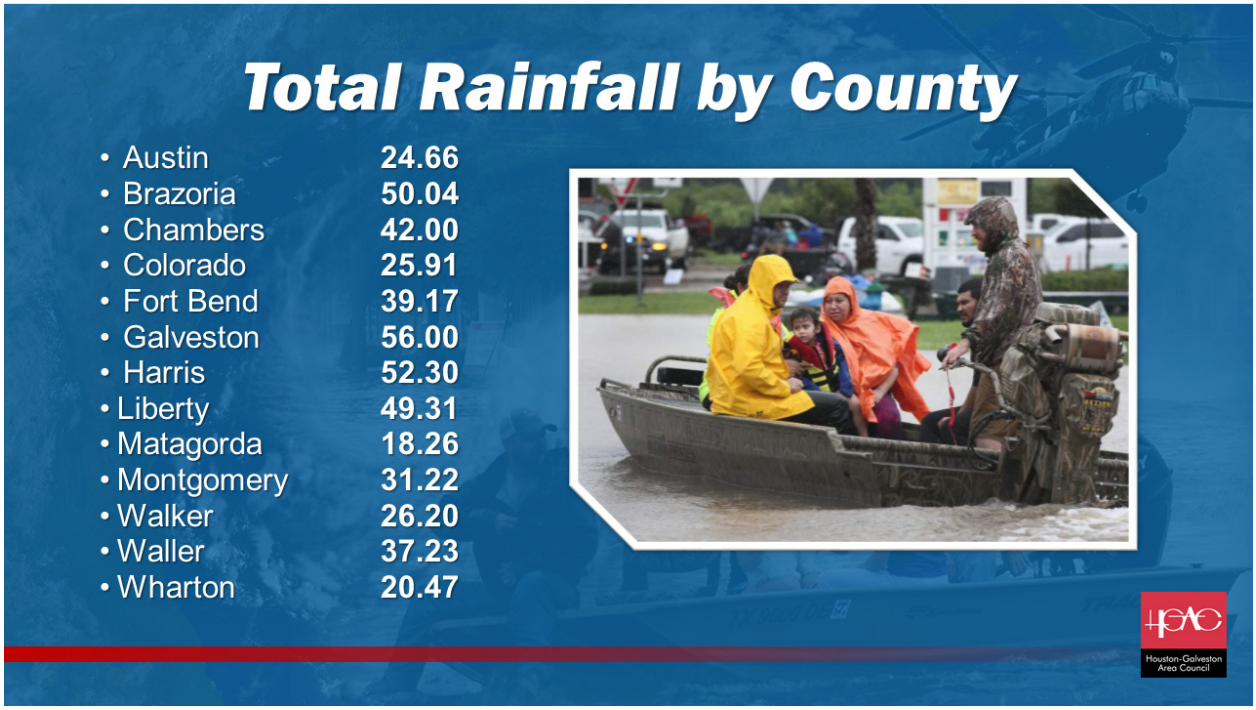
Alan C. Clark
Director Transportation Planning
Houston-Galveston Area Council

Summary of Hurricane Harvey on Transportation Infrastructure

Over the seven-day length of Hurricane Harvey, the 13 counties served by the Houston-Galveston Area Council experienced record rainfall as did much of Southeast Texas. As shown in Figure 1, rainfall of over 50 inches was experienced in Harris, Brazoria and Galveston counties with more than 30 inches of rainfall in Fort Bend, Waller, Montgomery, Liberty and Chambers counties. These eight counties comprise the metropolitan region for which H-GAC is the Metropolitan Planning Organization and will be the focus of this report.

Figure 1. Seven Day Hurricane Harvey Rainfall in the H-GAC Region



Source: National Weather Service

As a consequence of Harvey's rainfall, passenger and freight movement across the region was severely disrupted for much of the seven-day period. This report summarizes impacts on the state and local highway infrastructure and illustrates some of the impact on freight movement across the region and state. As described in this report, the Texas Department of Transportation (TxDOT) and local governments have, as resources and ground conditions permit, restored operational functionality to much of the region's critical roadway infrastructure damaged by Harvey. Due to the frequency and severity of recent flood events, over $3.1 billion in potential investment has been identified to substantially mitigate the flood risk to critical regional and local highways.

Impact on State Roadways - TxDOT Houston District

At the September meeting of the Houston Galveston region's Metropolitan Planning Organization (MPO), TxDOT's Houston District reported that 486 high water locations had been identified during Harvey within its six counties. 300 local TxDOT employees as well as employees from other TxDOT Districts unaffected by Harvey responded during recovery efforts.

TxDOT crews also performed disaster debris removal on local roads in Harris and Montgomery Counties and City of Houston. Other recovery efforts included:

- 4 emergency maintenance contracts awarded to restore operations of TxDOT system;
- 3 emergency change orders negotiated to repair critical damages;
- Emergency Contracts of $8M;
- Emergency change orders of an additional $4M;
- TxDOT FHWA Emergency Relief $3M;
- FEMA debris removal and a FHWA Emergency Relief assessment were underway.

Emergency repairs completed or underway at the time of the meeting included:

- San Jacinto River at I-69 concrete barrier displacement;
- Washout at FM 762 of culvert system;
- Repair of Beltway 8 frontage Road at Boehme Drive (sinkhole under the frontage roads and water pumped out of Beltway 8 main lanes to restore service); and
- Repairs to 1000 signal systems.

Impact on State Highways: Beaumont District

Maintenance, operation and construction of State roadways in Liberty and Chambers Counties is performed by TxDOT's Beaumont District. During Harvey, 92 roadway sections closed or flooded in the two counties. The Harvey impacts included:

- 35-37 miles of I-10 closed in Chambers County;

- FM 787 at Trinity River sheet piling damage but no right-of-way above water to perform repairs;
- Flooding of Hwy 146 in Mount Belvieu;
- FM 2090 at county line pavement washout;
- Multiple locations on all major arterials experienced more than 18-inches of standing water;
- A "portable dam" was used to re-open I-10 at Cedar Bayou (51.9 inches of rain) during the event; and the
- TxDOT Anahuac Maintenance Section flooded and was relocated to Chambers County Airport.

Repair costs by TxDOT in Liberty and Chambers Counties were estimated to include:

- FM 562 (cave in, closed) –$200k;
- FM 787 (Trinity River migration/erosion, one way traffic) - $40 million to extend bridge;
- FM 1985 (bridge abutment damage, closed) - $250k; and
- FM 2090 (bridge approach damage, closed) - $300k.

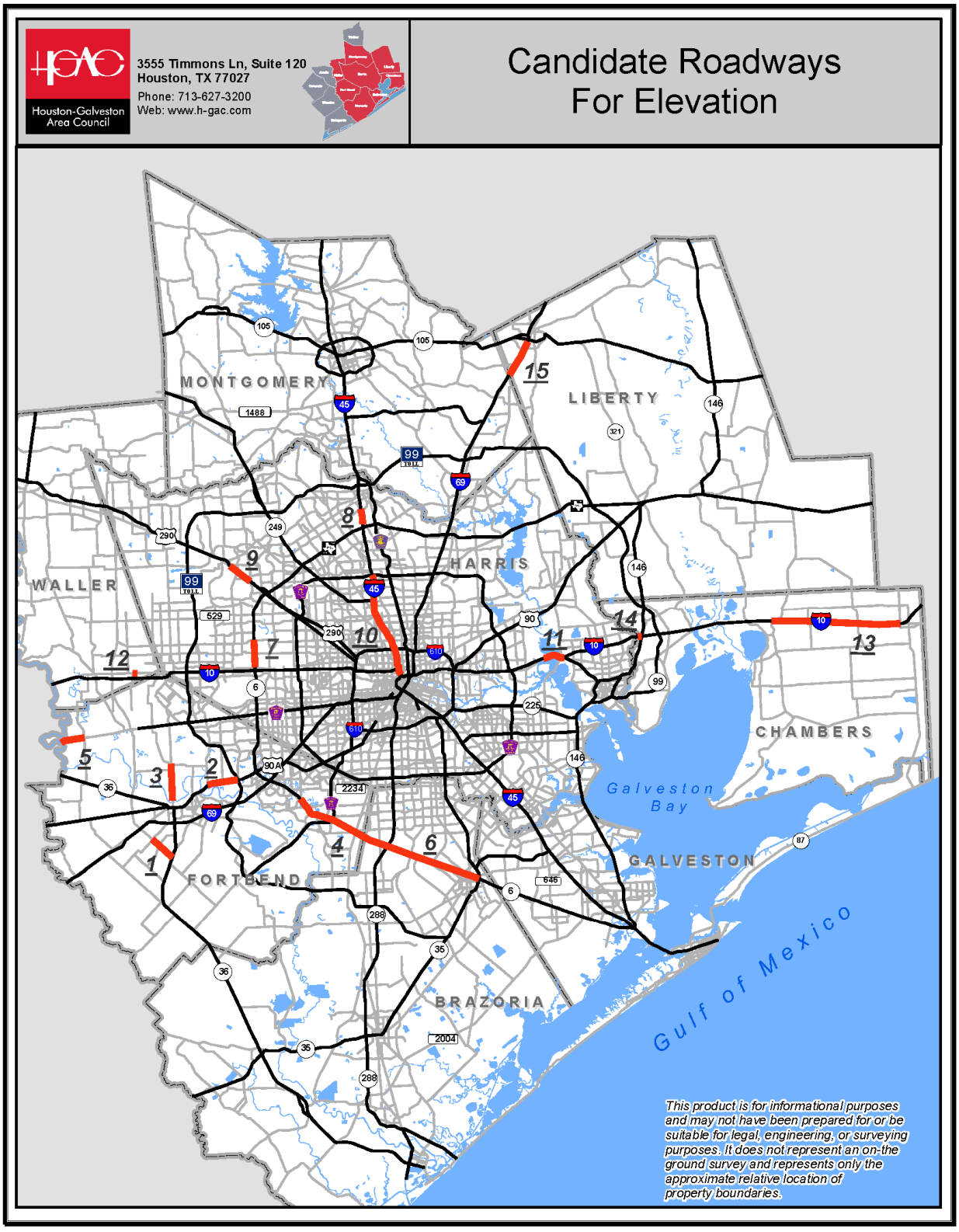
Candidate State Roadways for Elevation

Because of their importance to public safety, mobility and the state and region's economy, TxDOT has identified a list of roadways which should be considered for additional flood mitigation (shown in Table 1). Many of these roadway segments were also flooded by one or more recent flood events (Tax Day flood, Memorial Day Flood, Hurricane Ike, Tropical Storm Allison, etc.).

The cost estimates shown in Table 1 reflect the potential cost to elevate the identified state roadway segments above flood levels. At a value of almost $2.6 billion, it should be noted that roadway elevation may not be the only, best or preferred strategy for mitigation of flooding on these critical roadways. Improved capacity for regional and/or localized flood detention, improvements to reservoir capacity, reservoir management and other flood control strategies should be examined as well.

Table 1.	State Roadways Identified by TxDOT as Candidates for Repair, Elevation or Other Flood Prevention Treatments				
Proj #	County	Roadway	Limits	Estimates	Description
1	Fort Bend	Spur 10	SH 36 to Cottonwood School	60,000,000	elevate pavement
2	Fort Bend	US 90 A	FM 359 to SH 99	50,000,000	elevate pavement and replace bridges
3	Fort Bend	FM 723	Brazos River to FM 359	100,000,000	elevate pavement
4	Fort Bend	SH 6	Fort Bend County Line to FM 1092	250,000,000	elevate pavement and replace bridges
5	Fort Bend	FM 1093	Brazos River to FM 1489	75,000,000	elevate pavement
6	Brazoria	SH 6	SH 35 to Fort Bend County Line	450,000,000	elevate pavement and replace bridges
7	Harris	SH 6	Addicks Dam to Clay Road	200,000,000	bridge roadway through reservoir
8	Harris	I 45 N	Cypresswood to Parramatta	250,000,000	elevating pavement and rebuild two intersections
9	Harris	US 290	Skinnner Road to Telge Road	200,000,000	elevating pavement and rebuild two intersections
10	Harris	I 45 N	I 10 to BW 8		elevate pavement and replace bridges
11	Harris	I 10 E	Monmouth to Spur 330	2,000,000	elevate pavement and replace bridges
12	Waller	I 10	1000' East and West Petterson Road	75,000,000	replace and build urban intersection
13	Chambers	I 10	SH 61 to FM 1406	635,000,000	elevate pavement and replace bridges
14	Chambers	I 10	0.75 mi West of SH 146 to SH 146	32,000,000	elevate pavement
15	Liberty	US 59	SL 573 to Montgomery Co/L	180,000,000	elevate pavement and replace bridges
			Total Estimate	$ 2,559,000,000	
	Source: Texas Department of Transportation Houston and Beaumont Districts				

Map 1.


Houston-Galveston Area Council
3555 Timmons Ln, Suite 120
Houston, TX 77027
Phone: 713-627-3200
Web: www.h-gac.com
Candidate Roadways For Elevation
MONTGOMERY
LIBERTY
HARRIS
WALLER
CHAMBERS
FORT BEND
BRAZORIA
GALVESTON
Galveston Bay
Gulf of Mexico
1
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Additional Roadway Infrastructure Impacts Identified by Local Governments and Other Transportation Agencies

Table 2 summarizes some of the additional roadway infrastructure impacts of Hurricane Harvey identified by cities and counties in the eight-county metropolitan region. The estimated additional cost of almost $560 million include both infrastructure repairs and replacement, particularly replacement and elevation of bridges and their approaches. Needs identified in Table 2 are exclusive of those identified in Table 1. Therefore, the total estimate of flood related highway needs identified by TxDOT, cities and counties in the eight metropolitan counties is in excess of $3.1 billion.

In addition to the items described in Table 2, the following comments were received by local governments and other transportation agencies:

City of Houston:

- More than 200 traffic signals were out of order following Harvey and many have or must be replaced;
- Many traffic signal cabinets have been replaced thanks to additional cabinets from Austin and Fort Worth (similar recognition of assistance with replacement traffic control equipment from local governments in less affected Texas cities and counties was made by other local governments attending the September MPO meeting);
- 1400 bridges have been inspected; no major structural damage
- Some sanitary sewer lines beginning to collapse post Harvey and will need repair/replacement;
- Yale Street Bridge over the White Oak Bayou flooded.

Metropolitan Transit Authority of Harris County (METRO)

- Moved 15,000 people and medical personnel to and from shelters;
- Used preventive measures to forestall as much damage to buses as possible;
- Losses and costs of about $17 million to METRO.

Port of Houston/Port of Freeport

- Emergency procedures in place ahead of storm; Ports were prepared and moved commerce and vessels out of the harbors in coordination with the Coast Guard and Corps of Engineers
- Ceased operations on August 24;
- Not a wind event for the ports, so minimal damages to facilities;
- Coordinated order of vessel sailings as improvements happened;
- Experienced lots of shoaling, requiring additional dredging;
- Channels were checked for submerged vessels and debris.

Table 2.	Roadways Identified by Local Governments as Candidates for Repair, Elevation or Other Flood Prevention Treatments				
Local Government	**County**	**Roadway**	**Limits**	**Estimates**	**Description**
City of Arcola	Brazoria	Various		330,000	Street repair
City of Baytown	Harris, Chambers	TBD	New Cedar Bayou Crossing	40,000,000	Create additional roadway crossing over Cedar Bayou
City of Dickinson	Galveston	Various	Repair roadways, drainage features	36,360,000	
Fort Bend County	Fort Bend	McCray Rd.	FM 76s/US 90A north to SH 99	172,000,000	Create addition bridge crossing of Brazos River
Fort Bend County	Fort Bend, Wharton	US 90A	US 90A @ San Bernard River	80,000,000	Elevate current Bridge Cossing of San Bernard River
Fort Bend County	Fort Bend	FM 359	US 90A to Mason Road (Segments)	27,840,000	Elevate segments of roadway
Galveston County	Galveston	San Louis Pass Bridge	Replace Bridge	135,000,000	Replace Bridge
Galveston County	Galveston	Various	FM 518 @ Wesley; SH 96 @ Walker; SH 3 @ Walker; FM 646 @ Bay Colony; IH 45 @ Bay Colony; IH 45 @ Clear Creek	15,000,000	Elevate roadways and/or improve drainage
Galveston County	Galveston	Pelican Island Bridge	Supplemental funding to replace Pelican Island Bridge	12,125,000	Supplements funding already committed to repair/replacement of Pelican Island Bridge
Harris County	Harris	Various	Repairs to 190 roads and bridges damaged by Harvey	27,000,000	Repair and reconstruct as needed
City of Iowa Colony	Brazoria	Pursley Rd	Replace 2.28 miles damaged by Harvey	2,310,000	Reconstruct 2.28 miles of roadway
City of Iowa Colony	Brazoria	County 48W	Replace timber bridge on County Road 48W @ Hayes Creek	500,000	Bridge Replacement
City of Iowa Colony	Brazoria	County 62	Replace timber bridge on County Road 62 @ Hayes Creek	500,000	Bridge Replacement
City of Katy	Fort Bend	First Street	Repalce First Street bridge at Victoria Lakes and and elevate bridge approaches	1,025,430	Repalce First Street bridge at Victoria Lakes and and elevate bridge approaches
Liberty County	Liberty	CR 2307	Repair bridge at Gator Creek to mitigate erosion	300,000	Repair bridge at Gator Creek to mitigate erosion
Liberty County	Liberty	CR 2305	Repair bridge at Gator Creek to mitigate erosion	200,000	Repair bridge at Gator Creek to mitigate erosion
City of Pinehurst	Montgomery	Various	Base repair and reconstruction of submerged streets	5,167,007	Base repair and reconstruction of submerged streets
City of Seabrook	Harris	Baywood Dr.	Replace Baywood Dr. Bridge East of Todville Rd.	716,000	Replace Baywood Dr. Bridge East of Todville Rd.
City of Stagecoach	Montgomery	Silver Spur	Replace Bridge	120,000	Replace ridge
City of Surfside Beach	Brazoria	Bluewater Highway	Repair damage from storm surge	1,000,000	Repair damage from storm surge
City of Clear Lake Shores	Harris	Clear Lake Road	Elevate Road	1,000,000	Elevate Road
			Total Estimate	**$ 558,493,437**	
	Source: Request for Federal Funding Assistance Citical Infrastructure Projects, October 31, 2017				
	Grand Total: Tables 1 and 2			**$ 3,117,493,437**	
	Note: Duplicative projects removed from Table 2.				

Union Pacific Railroad:

Harvey impacted freight rail lines from Beaumont to Brownsville, west to Giddings, north to Palestine:

- UP is self-sufficient; no federal assistance requested;
- As seen in Figure 2, numerous rail yards were submerged by flood waters, including:
    - Rail yards near University of Houston Downtown;
    - Englewood Yard;
    - Eureka Yard.
- Railroad near Lufkin;
- By Aug. 28: 12 terminals under water; 150 outage locations;
- Quiet zones out of order because signals were out of order;
- Employees, rail cars, customer cars evacuated and moved out of flooded area;
- UP Rail facilities fully open as of Sept. 22.

Fig. 2. Union Pacific RR Harvey Flooding

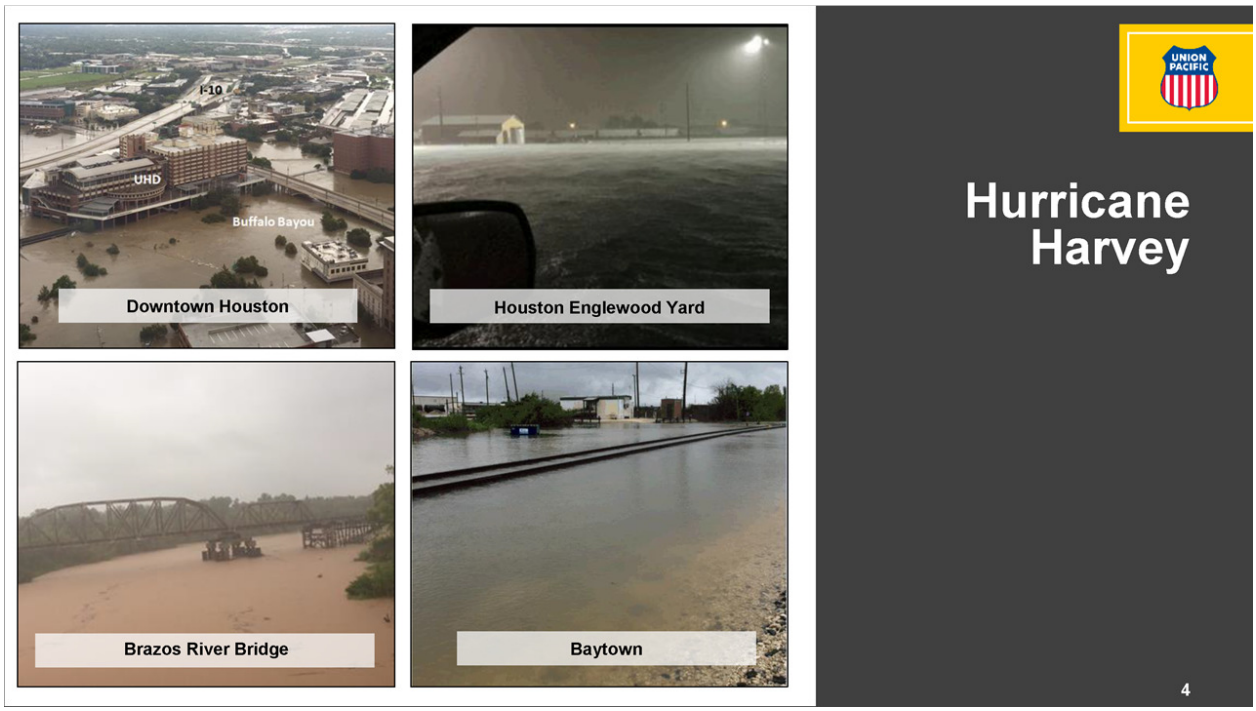
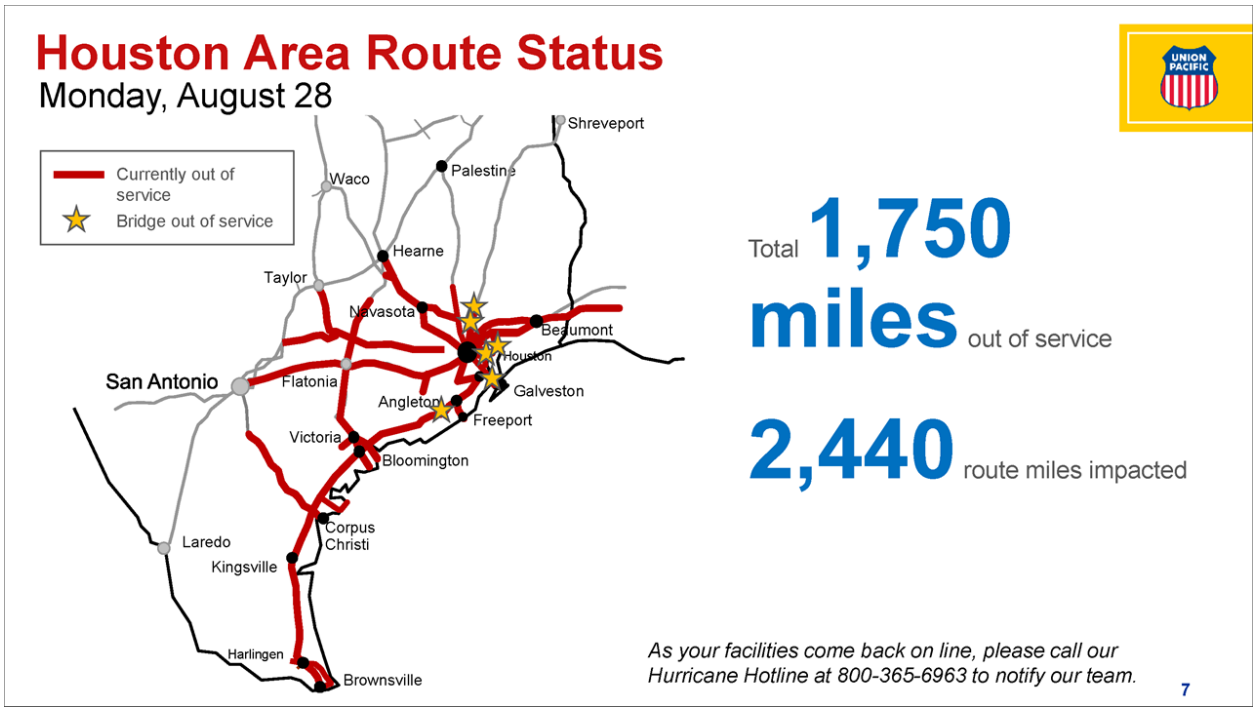


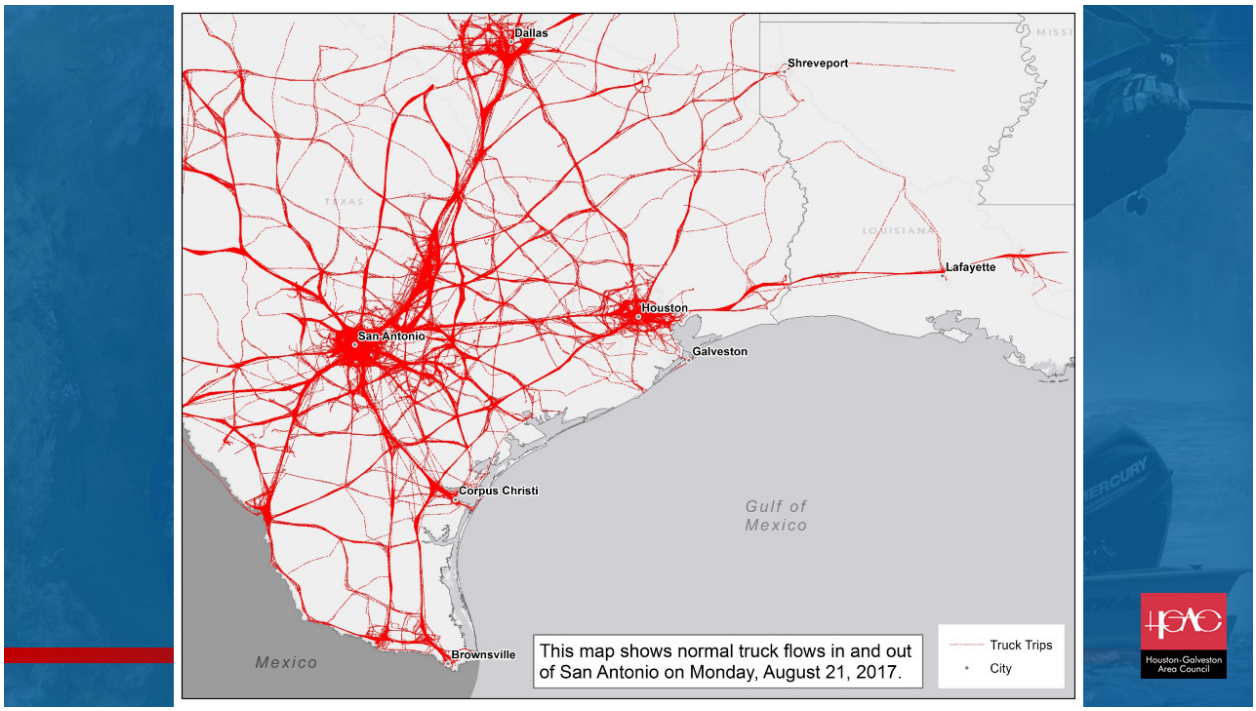
Fig. 3 UP RR Routes Out of Service Aug. 28th

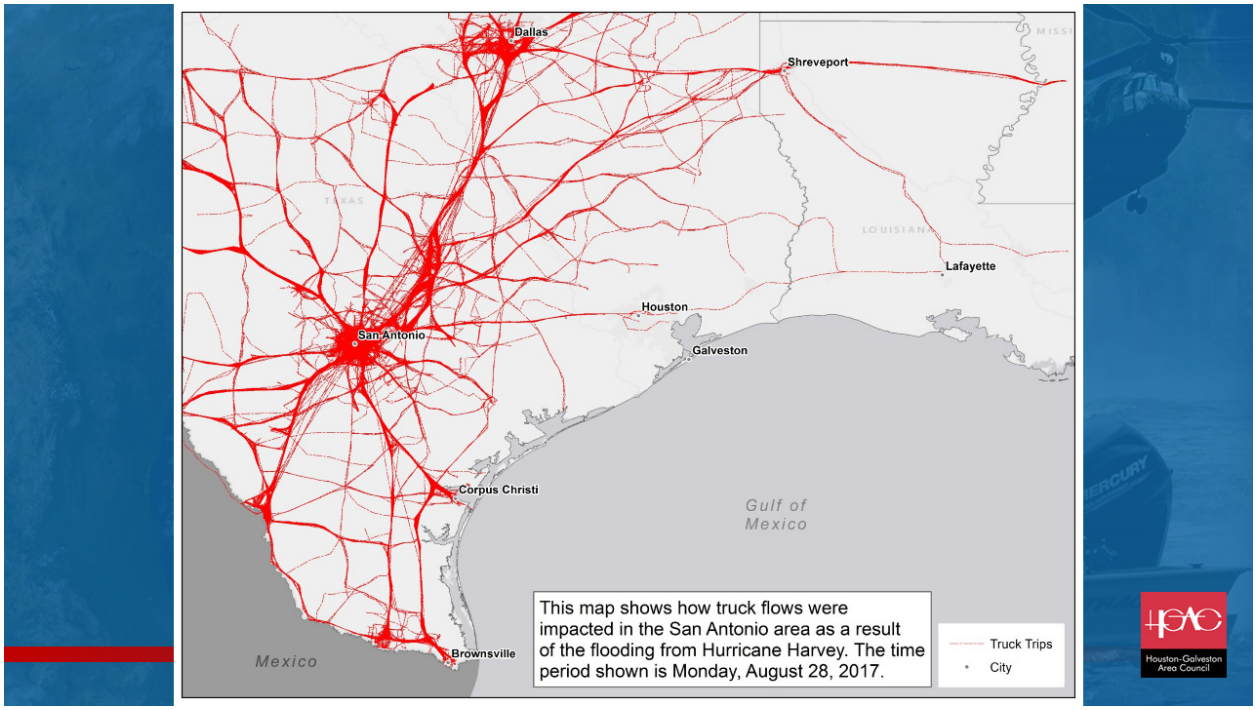


Texas Truck Traffic

By August 20, truck traffic in region completely shut down. The impact on state and national economy was dramatic. Figures 4 and 5 illustrate the impact of Hurricane Harvey on truck movements comparing GPS truck movement data compiled by the American Transportation Research Institute. Although truck travel in Southeast Texas ceased during Hurricane Harvey and was reduced across much of Texas, the impact of diverted truck travel on facilities like Interstate 20 east of Dallas/Fort Worth can be clearly seen.

Figs. 4 and 5 Harvey Impact on Texas Truck Travel





How Best to Rebuild Assets Efficiently and Effectively

Addressing the flood risks on the highways identified in this report efficiently and effectively will require careful consideration of the potential benefits from:

- working with federal, state and local partners to reduce regional flood risk through improved capacity for regional and/or localized storm water detention;
- developing of additional reservoir management options;
- increasing storm water detention and drainage capacity on high flood risk roadway segments;
- revising development standards and incentives to encourage open space preservation that decreases storm water runoff; and
- elevation of high flood risk roadway segments, bridges and bridge approaches where adjacent land uses and access to them can be maintained or acquired at reasonable cost.

Where elevation of existing or proposed roadways appears to be the most cost-effective solution, opportunities may exist to modify plans already under development so that the accommodation adds only an incremental cost and tolerable delay to a planned project letting. Because of the potential visual, noise, drainage and right of way impacts to adjacent land uses, early discussions with affected residents and businesses will be essential to achieving a timely solutions. In locations where the flood risk has led to a determination that acquisition and removal of existing land uses from the flood plane is necessary, however, conflicts with existing land uses may be mitigated.

Many strategies may significantly reduce flood risk individually or in combination. Because of its cost and potential for undesired impacts, selective use of roadway elevation may be necessary and should be applied where possible in coordination with larger flood management and mitigation strategies.