Supplementary Information for:

Holistic planning of human, water, and environmental impacts for regional flood management: A case study of aging dam infrastructure

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Text S1 – Modeling Assumptions for Alternative Scenarios

Rainfall data for Hurricane Harvey was obtained from NOAA (2017a), shown in *Fig. S1*. Parameterization for the HEC-HMS models is shown in *Table S-S2*. HEC-HMS peak values were used as input for the HEC-RAS hydraulic models. Hydraulic geometries were obtained from HCFCD M3, and steady-state flow analyses were conducted in HEC-RAS Version 5.0.1 with subcritical flow (HCFCD, 2019). The upstream boundary conditions were modeled with a normal depth slope equal to the average of each stream reach. Downstream boundary conditions were set at critical depth. HEC-RAS Mapper was used to create depth and inundation boundaries according to 2018 Harris County LiDAR topography, 10 cm resolution (TNRIS, 2019).

We note here that while the Barker watershed is included within the overall ABRS hydrologic system, most of the mitigation alternatives impact the Addicks and Buffalo Bayou watershed bounds. Per the TWDB (2015) study, approximately 97% of the Cypress Creek overflow enters the Addicks watershed, with only 3% of the flow entering the Barker watershed bounds. We, therefore, incorporated Barker watershed conditions through hydrologic diversion nodes and reservoir releases (*Fig. S2*), but we limited our alternative mitigation strategies to areal conditions within the Addicks and Buffalo Bayou watersheds. Specific modelling assumptions for each of the mitigation alternatives (A1-A8) are summarized below:

- ✓ A1 (Baseline): Models were downloaded from the HCFCD M3 system, updated using latest geospatial datasets, and calibrated to field observations.
- ✓ A2 (Additional Reservoir): Cross-basin overflow from Cypress Creek to the reservoirs was estimated to be 92,000 ac-ft, based on HEC-HMS model simulations (*Fig. S7*). Observed high-water marks (HCFCD, 2017) were also used to estimate the overflow volume for comparison. The water surface elevation was interpolated from high water marks and intersected with the underlying digital elevation model for an estimated overflow volume of 115,000 ac-ft. For purposes of this study, the cross-basin overflow volume during Hurricane Harvey was assumed to be an average of 100,000 ac-ft, with approximately 97% of the volume entering the Addicks watershed, and the remaining flow diverting through Barker and into the Addicks watershed, per (TWDB, 2015).

  We assumed the maximum storage volume of an additional reservoir at the Cypress-Addicks drainage divide was $2.34\text{x}10^8$ m^3 (190,000 acre-foot) with a 56.6 m^3/s (2,000 ft^3/s) outflow near the Bear Creek tributary, per TWDB (2015) and USACE (2020). Using Hurricane Harvey precipitation values, our modelled reservoir captured approximately $1.23\text{x}10^8$ m^3 of flow (100,000 acre-foot). We linked the Cypress Creek hydrological model with the Addicks model by simulating diversion nodes to capture the estimated quantity of cross-basin overflow.

  A2 flood risk calculations were limited to the Addicks Watershed bounds plus the weighted area of ancillary impact (e.g., disturbed prairie habitats), which were spatially averaged using the AHP-derived aggregate weighting for habitat.
- ✓ A3 (Addicks Watershed Buyouts): In this scenario, we assumed approximately 10,000 homes located below the Addicks Reservoir spillway are purchased and reallocated (per USACE, 2020, pg. 25 of 210, assuming an equal split of the proposed 20,000 homes below spillway elevation within the Addicks and Barker watersheds). We therefore adjusted the curve number values in each of the impacted subbasins to account for an increase in open space (*Table S1*).

  Note: The inundation extents for A3 do not change significantly by altering the curve number values. Instead, the amount of water entering the Addicks Reservoir (as a function of storage volume) changes (*Fig. S7*), thus impacting Alternative A6 (optimized releases) within the Buffalo Bayou watershed. As such, the magnitude of population density within A3 buy-out parcels are altered to quantify a shift in social impact between the baseline and mitigated scenarios.
- ✓ A4 (Diversion Levee): Diversion tables for the Cypress Creek overflow were obtained from local basin models (HCFCD M3), extrapolated to accommodate Hurricane Harvey flows, and used as source gauges in the adjacent watersheds. We assumed that one-half of the cross-basin overflow during Hurricane Harvey continued into the Addicks watershed, while the other one-half was diverted to Cypress Creek by a levee. We incorporated assumptions regarding the risk of increased flooding in the lower portions of Cypress Creek

by adopting inundation bounds from (Dunbar et al., 2019), which modeled a diversion levee at the Addicks-Cypress Creek watershed divide.

A4 risk calculations were limited to the Addicks Watershed bounds plus the weighted area of ancillary impact (e.g., increased social vulnerability along Cypress Creek), which were spatially averaged using the AHP-derived aggregate weighting for downstream flooding.

- ✓ A5 (Buffalo Bayou Buyouts): We assumed that 441 structures along Buffalo Bayou were acquired in this scenario (per USACE, 2020, pg. 22 of 210), and modified the associated subbasin parameters to account for these changes. We removed associated land parcels from the composite social risk maps in this alternative.
- ✓ A6 (Increased Storage): USACE (2017) data suggested that 13,300 cfs combined was released from Addicks and Barker into downstream Buffalo Bayou during Hurricane Harvey conditions (*Table S3*), which corresponded well with our calibrated model outputs. We assumed that an increased storage capacity within the existing reservoir bounds would allow for an optimized release strategy into the receiving channel (per USACE, 2010), which was modeled by simulating the overland flow conditions within the Buffalo Bayou watershed using Hurricane Harvey rainfall in HEC-HMS and then assessing the output hydrograph at the USGS Piney Point gauge node to determine when the channel would have naturally reached 113.27 cms (4,000 cfs) under optimized timing of releases (*Fig. S8*).
- ✓ A7 (Enlarged Receiving Channel): We modified the Buffalo Bayou channel geometry within the HEC-RAS model per USACE (2020) to capture an additional 340 m^3/s (12,000 ft^3/s) capacity. In this scenario, the modified channel cut depth averaged 3.0-4.6 m (10-15 ft) with 1V:4H side slopes, daylighting to natural ground. The proposed top widths ranged from approximately 100-160 m (350-540 ft).
- ✓ A8 (Underground Tunnel): Here we assumed no outflows from the Addicks or Barker reservoirs into the receiving channel, thereby removing inflows from the HEC-HMS source nodes for Buffalo Bayou. Per USACE (2020), reservoir storage water would be re-routed around the city and toward Galveston Bay in this mitigation scenario.

Note: The inundation models for A5-A8 were all truncated at the Piney Point gauge.

Text S2 – Modeling Output Observations for Alternative Scenarios

- ✓ A1 (Baseline Conditions): The baseline conditions models for the ABRS watersheds compared well against observed stream gauge heights (described in main manuscript, *Sect. 5.2.1*), with an a Nash-Sutcliffe efficiency (NSE) of 0.995-0.999, RMSE-observed standard deviation ratio (RSR) of 0.037-0.211, and an index of agreement (*d*) of 0.990-0.999. The resulting flood inundation bounds also compared well against manual spot inspection of flooded areas, per NOAA aerial imagery (NOAA, 2017b).
- ✓ A2 (Additional Reservoir): We estimated approximately $1.23E^8$ m^3 (100,000 acre-feet) overflowed from the Cypress Creek watershed into the Addicks watershed during Hurricane Harvey, which corresponded well to observed flooding conditions. An additional reservoir would therefore need to capture at least this amount to minimize cross-basin transfer. The USACE (2020) resiliency study proposed an additional reservoir capacity of $2.34E^8$ m^3 (190,000 acre-feet). Since we assumed a constant outflow from the reservoir into Bear Creek (TWDB, 2015), the majority of flood inundation improvements between A1 and A2 were observed near this confluence. While the addition of a third reservoir improved conditions within the watershed, a significant portion of the flow into the Addicks Reservoir resulted from overland conditions within the watershed and would have occurred irrespective of additional upstream storage capacity.

According to results from *Fig. S7*, an additional reservoir would have needed to store all of the estimated overflow from Cypress Creek to remain below the USACE Emergency Release threshold. Previous studies suggested a Third Reservoir could store approximately one-half of the flows noted in Hurricane Harvey (TWDB, 2015), while the USACE (2020) report suggested a much larger storage volume is possible. Due to the preliminary nature of this study, and the assumptions used within the models, a detailed analysis is necessary to understand the hydrologic impacts of an additional reservoir within the ABRS system. Nevertheless, findings suggest that additional engineered infrastructure should not be the only solution to complex hydrological systems. Soft solutions could also be considered as complementary measures, such as optimized release operations coupled with retaining water on-site through natural infiltration to reduce the amount of overflow reaching the conveyance streams.

- ✓ A3 (Buyouts): When considering the hydrological impacts for buyouts by altering the subbasin loss parameters (*Table S1*), we observed negligible changes to the overall peak flow conditions, primarily due to the location of the buyout parcels near the downstream bounds of the model. Since peak flows were used to drive the HEC-RAS models, the inundated area for A3 was nearly identical to baseline conditions, suggesting an unreasonable improvement to flood risk given the high estimated cost ($5B) when viewed strictly through the lens of a cost-benefit analysis.
- ✓ A4 (Diversion Levee): While the USACE (2020) mitigation report excluded diversions from the focused array due to the adverse flood impacts in adjacent watersheds, we chose to simulate model conditions for purposes of comparison between the CBA and MCDA frameworks. We demonstrated a reasonable reduction in flood inundation area within the Addicks watershed in comparison to baseline conditions. However, these benefits were offset when we considered additional flooded areas within the downstream portions of Cypress Creek. These findings highlight the hydrologically-interconnected nature of cross-basin dams and stress the necessity to consider social impacts as a function of regional space.
- ✓ A5 (Buyouts): Modelling results for A5 were similar to observations for buyout conditions in the Addicks watershed (A3). Specifically, the peak flow outputs differed a negligible amount when altering the subbasin loss parameters (*Table S2*) due to the location of the parcels near the receiving stream. We therefore altered the magnitude of population density within A5 buy-out parcels to quantify a shift in social impact between the baseline and mitigated scenarios.
- ✓ A6 (Increased Storage Capacity + Optimized Timing of Releases): By increasing storage capacity in the existing Addicks and Barker reservoirs, we assumed we could then optimize the timing of releases into the receiving channel in accordance with the USACE (2010) interim report guidelines (see main manuscript, **Appendix B** for further details regarding this option).

  Alternative A6 resulted in a significant reduction of flood inundation area by approximately 64% from baseline conditions (1,456.45 to 519.58 hectares) within the Buffalo Bayou watershed. We noted the USACE (2020) mitigation study did not inherently link the provision of optimized releases by increasing storage capacity. Our findings suggest that additional capacity in the existing reservoirs may have alleviated the need to release surcharged flows into the receiving channel during Hurricane Harvey by allowing stored floodwaters to remain within the reservoirs for a longer period of time.

  The inundated area for each of the modeled scenarios varies according to changes in the hypothetical reservoir releases. Given similar land and climate conditions, the overall risk is influenced by the operation of large-scale flood control reservoirs during an extreme event. While the structural stability of the reservoirs is of paramount importance, this study suggests that a moderate change in the timing of releases could have significantly altered the severity of flooding in the receiving watershed during Hurricane Harvey (e.g., by waiting to release flows until the Piney Point gauge reached 4,000 cfs, *Fig. S8*).
- ✓ A7 (Enlarged Receiving Channel): To achieve adequate storage of the observed releases during Hurricane Harvey, we needed to expand the top width geometry for Buffalo Bayou in our HEC-RAS model to extents much wider than what was proposed by the USACE [~100-160 m in our model vs. 70 m in (USACE, 2020)]. A significantly deeper channel (thus a steeper slope) was not possible within our modeling exercise due to the elevation constrains in downstream portions of Buffalo Bayou. While our study is not intended for detailed design, we suggest that significant displacement of land would be necessary for this alternative scenario, further impacting social and environmental considerations along the banks of the natural stream.
- ✓ A8 (Underground Tunnel): We noted similar improvements to the inundated area for Alternative A8 (560.61 hectares) when compared with A6 (519.58 hectares), highlighting how the receiving watershed is driven primarily by outflows from the dams. The significant costs associated with the tunnels ($6.5-12B) and the comparable flood mitigation benefits with other alternatives led the USACE to drop this option from the focused recommendations (USACE, 2020); however, when we considered regional and ancillary socio-environmental impacts within our analysis, the tunnel alternative warrants further consideration.

Supplementary Tables

Table S1: Parameter values for Addicks HEC-HMS subbasins using SCS Curve Number loss methodology. Values in ()† indicate changes to the curve number and percentage of impervious coverage in each subbasin for Alternative A3 – Proposed Buyouts along Addicks Reservoir.

Subbasin	Curve Number (buyouts)†	% Impervious (buyouts)†	Subbasin	Curve Number (buyouts)†	% Impervious (buyouts)†
U101A	56.08	14.99	U106A	57.18	46.93
U101B	55.91	17.62	U106B	57.67	45.87
U101C	55.76	17.83	U106C	57.42	52.39
U101D	56.23	36.28	U106D	58.13 (51.63)	52.54 (46.66)
U101E	55.79	35.24	U120A	56.22	44.87
U101F	57.65	52.33	U129A	56.15	8.40
U101G	57.89	52.94	U129B	57.06	39.85
U101H	58.12 (55.12)	54.45 (51.64)	U129C	57.47	50.24
U101I	58.81 (54.77)	40.36 (37.59)	U129D	57.56	54.18
U102A	56.28	18.42	U129E	57.94 (52.01)	58.67 (52.67)
U102B	55.41	20.87	U129F	60.33 (57.81)	57.13 (47.07)
U102C	56.60	45.70	W167C	63.13	30.19
U102D	58.30	43.11	W167D	57.01	42.38
U102E	58.31 (57.44)	44.37 (43.71)	W167E	59.21	56.04
U102F	59.49 (58.43)	31.49 (30.93)	W167F	59.64	58.78

Table S2: Parameter values for Buffalo Bayou HEC-HMS subbasins using Green & Ampt loss methodology. Values in ()† indicate changes to the percentage of impervious coverage in each subbasin for Alternative A5 – Proposed Buyouts along the Buffalo Bayou.

Subbasin	Initial Content	Saturated Content	Suction (in)	Conductivity (in/hr)	% Impervious (buyouts)†
W100A	0.01	0.46	10.45	0.33	35 (34.98)
W100B	0.03	0.46	9.52	0.49	35
W100C	0.01	0.48	8.3	0.37	45 (44.82)
W100D	0.01	0.46	12.45	0.74	45 (44.88)
W100E	0.01	0.46	12.45	0.74	45 (44.88)
W100F	0.01	0.48	12.45	0.81	45 (44.92)
W100G	0.01	0.48	12.45	0.81	45 (44.77)
W100H	0.03	0.46	10.03	0.37	40 (39.86)
W100I	0.03	0.46	10.03	0.37	45 (44.88)
W100J	0.03	0.46	10.03	0.37	40 (39.87)
W100K	0.03	0.46	10.03	0.37	45 (44.97)
W100L	0.03	0.46	10.03	0.37	45 (44.98)
W100M	0.03	0.46	10.03	0.37	40 (39.98)
W100N	0.03	0.46	10.03	0.37	50
W100O	0.03	0.46	10.03	0.37	45
W129A	0.03	0.46	10.03	0.37	50
W138A	0.03	0.46	10.03	0.37	50
W139A	0.03	0.46	10.03	0.37	50
W140A	0.03	0.46	10.03	0.37	45.18
W140B	0.03	0.46	10.03	0.37	45
W140C	0.03	0.46	10.03	0.37	45
W140D	0.03	0.46	10.03	0.37	45
W140E	0.03	0.46	10.03	0.37	45
W141A	0.03	0.46	10.03	0.37	45.23
W142A	0.03	0.46	10.03	0.37	55
W145A	0.03	0.46	10.03	0.37	55
W147A	0.01	0.48	12.45	0.81	55
W151A	0.01	0.48	12.45	0.81	50.4 (50.32)

W156A	0.01	0.46	12.45	0.74	55
W156B	0.01	0.46	12.45	0.74	55
W167A	0.01	0.46	9.1	0.37	52.47
W167B	0.01	0.46	9.1	0.37	45
W170A	0.04	0.46	6.8	0.34	43.26
W190A	0.05	0.46	3.31	0.41	4.57
W190B	0.05	0.46	3.31	0.41	3.11
W190C	0.05	0.46	3.31	0.41	16.43

Table S3: Simulated reservoir releases for Addicks HEC-HMS model under Hurricane Harvey conditions for observed releases (per USACE, 2017) and optimized-timing releases (per USACE, 2010).

Time	Addicks Releases (Harvey)	Barker Releases (Harvey)	Optimized Timing Releases, Combined (A6)
August 24, 2017 21:00	0 CFS	0 CFS	0 CFS
August 28, 2017 04:00	800 CFS	800 CFS	0 CFS
August 28, 2017 12:00	3800 CFS	3500 CFS	0 CFS
August 29, 2017 04:00	7300 CFS	6000 CFS	0 CFS
August 29, 2017 09:00	7300 CFS	6000 CFS	4000 CFS
September 3, 2017 00:00	2000 CFS	2000 CFS	4000 CFS

Table S4: Values used to convert the HEC-HMS peak flow outputs at select junction nodes for each Alternative (A1-A8) into steady-state flow data for corresponding HEC-RAS cross-sections (XS). (Top: Addicks Reservoir Watershed, Bottom: Buffalo Bayou Watershed).

			PEAK FLOW (cfs)			
RAS River	**RAS XS**	**HMS Junction**	**A1**	**A2**	**A3**	**A4**
U100-00-00	89149.7	U1000000_0747_J	3205.2	3205.2	3205.2	3205.2
U100-00-00	62234.7	U1000000_0613_J	5918.9	5918.9	5918.9	5918.9
U100-00-00	41734.5	U1000000_0408_J	12090.8	12090.8	12090.8	12090.8
U100-00-00	39144.7	U1000000_0386_J	12660.8	12660.8	12660.8	12660.8
U100-00-00	28751.6	U1000000_0288_J	13795	13795	13771	13795
U100-00-00	27102.1	U1000000_0219_J	22486.8	22486.8	22407.6	22486.8
U100-00-00	19514.7	U1000000_0152_J	22995.6	22995.6	21961.7	22995.6
U101-00-00	101835.6	U1010000_0959_J	22593.8	4000	22593.8	5648.4
U101-00-00	82695.4	U1010000_0828_J	25035.7	3670.2	25035.7	8393.7
U101-00-00	67829.7	U1010000_0660_J	27615.1	7072.7	27615.1	11456.5
U101-00-00	49146.2	U1010000_0484_J	31481.7	11975.9	31481.7	16164.8
U101-00-00	36113.6	U1010000_0361_J	33537.8	15216.7	33537.8	19233
U101-00-00	33216.3	U1010000_0306_J	34623	16650	34613.9	20610.5
U101-00-00	26243.5	U1000000_9902_J	72745.8	56300.5	72605	60625.8
U102-00-00	77737.9	U1020000_0777_J	10048.3	4007	10048.3	4277.5
U102-00-00	58715.1	U1020000_0587_J	12346.8	8820	12346.8	9101.4
U102-00-00	43042.76	U1020000_0427_J	13335.2	10933.7	13335.2	11188.5
U102-00-00	19755.1	U1020000_0198_J	14901.4	13660.9	14817.2	13911.1
U106-00-00	32133.5	U1060000_0300_J	1504.7	1504.7	1504.7	1504.7
U106-00-00	22728	U1060000_0227_J	4751	4751	4751	4751
U106-00-00	17601.8	U1060000_0176_J	7219.4	7219.4	7219.4	7219.4
U106-00-00	6400.5	U1060000_0006_J	10139.8	10139.8	9927.2	10139.8

			PEAK FLOW (cfs)				
RAS River	**RAS XS**	**HMS Junction**	**A1**	**A5**	**A6**	**A7**	**A8**
W100-00-00	248647.7	W1000000_2411_J	6300	6300	3576.3	6300	3694.4
W100-00-00	241079	W1000000_0020_J	13300	13300	3800	13300	6984.3
W100-00-00	232681.7	W1000000_2271_J	16700	16700	4000	16700	8611.2
W100-00-00	239993.6	W1000000_2340_J	16700	16700	6374.6	16700	6359.9
W100-00-00	214669.3	W1000000_2147_J	19000	19000	11703.4	19000	11371.5
W100-00-00	211631.3	W1000000_2116_J	19000	19000	12029.7	19000	11659.9
W100-00-00	205679.6	W1000000_2037_J	19000	19000	12340.6	19000	11928.1
W100-00-00	199440.6	W1000000_1985_J	19000	19000	13626.1	19000	13195.7
W100-00-00	196182.3	W1000000_1879_J	17000	17000	13626.1	17000	14929.5
W100-00-00	128104.6	W1000000_1237_J	24000	24000	13626.1	24000	27523.8
W100-00-00	188903.7	W1000000_1865_J	24000	24000	15401.7	24000	14923.5
W100-00-00	175675.6	W1000000_1757_J	24000	24000	17501.3	24000	17028
W100-00-00	166558.2	W1000000_1663_J	24000	24000	24028	24000	17526.3
W100-00-00	162811.9	W1000000_1646_J	24000	24000	24852	24000	23320.7

Table S5: Summary of survey results denoting levels of perceived importance of various impact factors associated with the ABRS mitigation. Likert survey, 1-9 scale; 1 represented lowest importance, 9 highest importance.

Criterion (j)	**Mean**	**Standard Deviation**	**Variance**
Toxic Release Inventory	7.31	1.38	1.91
Leaking Petroleum Storage Tanks	5.31	2.13	4.52
Wastewater Treatment Plants	6.38	1.73	3.01
Soil Erodibility	5.69	1.64	2.67
Habitat Disruption	5.46	1.91	3.63
Medical Facilities	7.85	1.46	2.13
Population Density	8	1.52	2.31
Inundated Roadway	3.77	1.67	2.79
Flood Insurance	5.69	1.73	2.98
Residential Relocation	4.54	1.60	2.56
Downstream Flooding	6.92	2.06	4.22
Amenity Disruption	4.38	2.59	6.70
Social Vulnerability	6.92	2.02	4.07

Table S6: Detailed survey results for Likert-scale ABRS criteria for n=13 respondents.

		Respondent No.												
	Criterion (j)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**
Environmental	Toxic Release Inventory	7	6	9	6	7	6	8	8	7	6	6	8	7
	Leaking Petroleum Storage Tanks	3	3	8	3	7	6	7	6	3	6	7	7	2
	Wastewater Treatment Plants	6	5	8	5	7	5	8	6	7	4	8	7	4
	Soil Erodibility	3	7	6	7	5	5	6	7	3	6	8	4	6
	Habitat Disruption	4	8	5	4	6	5	6	3	6	7	8	3	4
Social	Medical Facilities	6	6	9	7	8	6	7	7	8	8	9	7	8
	Population Density	5	6	8	8	8	7	8	9	8	8	8	6	7
	Inundated Roadway	2	5	7	5	4	4	3	1	3	1	5	4	5
	Flood Insurance	4	7	7	6	6	9	6	2	6	6	7	4	4
	Residential Relocation	3	3	7	3	7	5	3	4	6	6	6	3	3
	Downstream Flooding	4	9	7	9	6	8	7	5	5	6	9	5	6
	Amenity Disruption	5	5	8	5	5	1	2	8	1	5	6	2	2
	Social Vulnerability	7	5	7	5	8	8	9	9	3	7	6	6	6

Table S7a: AHP-based weightings (in percent, %) for n=13 survey responses for environmental and social impact factors for ABRS Alternative A1 – No Action, Baseline.

		Weight (w_j) - A1													
	Criterion (j)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**Avg.**
Environmental	Toxic Release Inventory	50.4	28.4	21.1	28.4	30	33.3	35.1	45.5	41.7	30	10.9	43.9	49.5	34.5
	Leaking Petroleum Tanks	8.9	7.3	13.2	7.3	30	33.3	18.9	14.1	8.3	30	18.9	24.6	6.1	17.0
	Wastewater Treatment	31.8	17	13.2	17	30	16.7	35.1	14.1	41.7	10	35.1	24.6	13.4	23.0
	Soil Erodibility	8.9	47.3	52.4	47.3	10	16.7	10.9	26.3	8.3	30	35.1	7	31	25.5
	Habitat Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Social	Medical Facilities	26.5	20.6	39.5	25.7	28.1	14.5	16.6	17.8	36.5	32.6	41.9	38.6	41.9	29.3
	Population Density	16.4	20.6	23.4	41.5	28.1	16.7	26.7	37.3	36.5	32.6	26.3	22.5	26.3	27.3
	Inundated Roadway	4.8	10.9	12.4	8.8	5.1	4.7	4	3.1	5.3	3.2	6.2	8.2	9.7	6.6
	Flood Insurance	10.3	36.9	12.4	15.3	10.7	34.4	10.6	4.5	16.3	12.3	16	8.2	6.2	14.9
	Residential Relocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Downstream Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Amenity Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Social Vulnerability	42	10.9	12.4	8.8	28.1	29.8	42.1	37.3	5.3	19.4	9.7	22.5	16	21.9

Table S7b: AHP-based weightings (in percent, %) for n=13 survey responses for environmental and social impact factors for ABRS Alternative A2 – Additional Reservoir.

		Weight (w_j) – A2													
	Criterion (j)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**Avg.**
Environmental	Toxic Release Inventory	44.3	16.4	39	26.3	26	32.8	31.3	40.8	33.6	19.2	8.2	39.8	43.7	30.9
	Leaking Petroleum Tanks	7.3	4.8	23	6.2	26	27.7	17.6	14.6	6.1	19.2	13.8	24	5	15.0
	Wastewater Treatment	28.9	10.3	23	16	26	13.9	31.3	14.6	33.6	7	26	24	11.5	20.5
	Soil Erodibility	7.3	26.5	9.1	41.9	8.2	12.8	9.9	25.2	6.1	19.2	26	7.3	28.3	17.5
	Habitat Disruption	12.3	42	5.9	9.7	13.8	12.8	9.9	4.7	20.5	35.5	26	4.9	11.5	16.1
Social	Medical Facilities	26.5	20.6	39.5	25.7	28.1	14.5	16.6	17.8	36.5	32.6	41.9	38.6	41.9	29.3
	Population Density	16.4	20.6	23.4	41.5	28.1	16.7	26.7	37.3	36.5	32.6	26.3	22.5	26.3	27.3
	Inundated Roadway	4.8	10.9	12.4	8.8	5.1	4.7	4	3.1	5.3	3.2	6.2	8.2	9.7	6.6
	Flood Insurance	10.3	36.9	12.4	15.3	10.7	34.4	10.6	4.5	16.3	12.3	16	8.2	6.2	14.9
	Residential Relocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Downstream Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Amenity Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Social Vulnerability	42	10.9	12.4	8.8	28.1	29.8	42.1	37.3	5.3	19.4	9.7	22.5	16	21.9

Table S7c: AHP-based weightings (in percent, %) for n=13 survey responses for environmental and social impact factors for ABRS Alternative A3 – Property Buyouts, Upstream.

		Weight (w_j) – A3													
	Criterion (j)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**Avg.**
Environmental	Toxic Release Inventory	50.4	28.4	21.1	28.4	30	33.3	35.1	45.5	41.7	30	10.9	43.9	49.5	34.5
	Leaking Petroleum Tanks	8.9	7.3	13.2	7.3	30	33.3	18.9	14.1	8.3	30	18.9	24.6	6.1	17.0
	Wastewater Treatment	31.8	17	13.2	17	30	16.7	35.1	14.1	41.7	10	35.1	24.6	13.4	23.1
	Soil Erodibility	8.9	47.3	52.4	47.3	10	16.7	10.9	26.3	8.3	30	35.1	7	31	25.5
	Habitat Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Social	Medical Facilities	25.1	19.8	34.8	24.5	24.4	13.5	16.8	17.4	32.2	29	37.7	35.2	38.2	26.8
	Population Density	16	19.8	21.1	37.8	24.4	16.2	25.7	34.6	32.2	29	24.3	21.6	25	25.2
	Inundated Roadway	4.3	11.1	11	9.2	4.2	4.2	3.8	2.6	4.3	2.7	5.4	8.2	10.1	6.2
	Flood Insurance	9	33.5	11	15.3	8.7	32.3	11.1	3.6	13.5	10.1	15	8.2	6.4	13.7
	Residential Relocation	7.2	4.7	11	4.1	13.9	6.3	3.8	7.1	13.5	10.2	8.8	5.2	4.3	7.7
	Downstream Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Amenity Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Social Vulnerability	38.3	11.1	11	9.2	24.4	27.6	38.8	34.6	4.3	19.1	8.8	21.6	16	20.4

Table S7d: AHP-based weightings (in percent, %) for n=13 survey responses for environmental and social impact factors for ABRS Alternative A4 – Diversion Levee.

		Weight (w_j) – A4													
	Criterion (j)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**Avg.**
Environmental	Toxic Release Inventory	50.4	28.4	21.1	28.4	30	33.3	35.1	45.5	41.7	30	10.9	43.9	49.5	34.5
	Leaking Petroleum Tanks	8.9	7.3	13.2	7.3	30	33.3	18.9	14.1	8.3	30	18.9	24.6	6.1	17.0
	Wastewater Treatment	31.8	17	13.2	17	30	16.7	35.1	14.1	41.7	10	35.1	24.6	13.4	23.1
	Soil Erodibility	8.9	47.3	52.4	47.3	10	16.7	10.9	26.3	8.3	30	35.1	7	31	25.5
	Habitat Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Social	Medical Facilities	24.5	11.7	34.8	15.7	25.6	10.9	14	16.8	33.2	29.2	29.6	34	36.6	24.4
	Population Density	15.3	11.7	21.1	24.8	25.6	12.6	23.4	34.2	33.2	29.2	18	20.2	23.1	22.5
	Inundated Roadway	4.1	6.6	11	5.9	4.3	3.7	3.3	2.6	4.4	2.6	4.6	6.9	8	5.2
	Flood Insurance	9.2	20	11	9.7	9.5	29.1	8.6	3.5	15	10.7	11.2	6.9	5.2	11.5
	Residential Relocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Downstream Flooding	9.2	43.4	11	38.1	9.5	21	14	8.8	9.8	10.7	29.6	11.7	13.6	17.7
	Amenity Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Social Vulnerability	37.8	6.6	11	5.9	25.6	22.7	36.7	34.2	4.4	17.6	7	20.2	13.6	18.7

Table S7e: AHP-based weightings (in percent, %) for n=13 survey responses for environmental and social impact factors for ABRS Alternative A5 – Property Buyouts, Channel.

		Weight (w_j) – A5													
	Criterion (j)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**Avg.**
Environmental	Toxic Release Inventory	50.4	28.4	21.1	28.4	30	33.3	35.1	45.5	41.7	30	10.9	43.9	49.5	34.5
	Leaking Petroleum Tanks	8.9	7.3	13.2	7.3	30	33.3	18.9	14.1	8.3	30	18.9	24.6	6.1	17.0
	Wastewater Treatment	31.8	17	13.2	17	30	16.7	35.1	14.1	41.7	10	35.1	24.6	13.4	23.1
	Soil Erodibility	8.9	47.3	52.4	47.3	10	16.7	10.9	26.3	8.3	30	35.1	7	31	25.5
	Habitat Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Social	Medical Facilities	25.1	19.8	34.8	24.5	24.4	13.5	16.8	17.4	32.2	29	37.7	35.2	38.2	26.8
	Population Density	16	19.8	21.1	37.8	24.4	16.2	25.7	34.6	32.2	29	24.3	21.6	25	25.2
	Inundated Roadway	4.3	11.1	11	9.2	4.2	4.2	3.8	2.6	4.3	2.7	5.4	8.2	10.1	6.2
	Flood Insurance	9	33.5	11	15.3	8.7	32.3	11.1	3.6	13.5	10.1	15	8.2	6.4	13.7
	Residential Relocation	7.2	4.7	11	4.1	13.9	6.3	3.8	7.1	13.5	10.2	8.8	5.2	4.3	7.7
	Downstream Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Amenity Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Social Vulnerability	38.3	11.1	11	9.2	24.4	27.6	38.8	34.6	4.3	19.1	8.8	21.6	16	20.4

Table S7f: AHP-based weightings (in percent, %) for n=13 survey responses for environmental and social impact factors for ABRS Alternative A6 – Increased Storage, Optimized Releases.

		Weight (w_j) – A6													
	Criterion (j)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**Avg.**
Environmental	Toxic Release Inventory	50.4	28.4	21.1	28.4	30	33.3	35.1	45.5	41.7	30	10.9	43.9	49.5	34.5
	Leaking Petroleum Tanks	8.9	7.3	13.2	7.3	30	33.3	18.9	14.1	8.3	30	18.9	24.6	6.1	17.0
	Wastewater Treatment	31.8	17	13.2	17	30	16.7	35.1	14.1	41.7	10	35.1	24.6	13.4	23.1
	Soil Erodibility	8.9	47.3	52.4	47.3	10	16.7	10.9	26.3	8.3	30	35.1	7	31	25.5
	Habitat Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Social	Medical Facilities	26.5	20.6	39.5	25.7	28.1	14.5	16.6	17.8	36.5	32.6	41.9	38.6	41.9	29.3
	Population Density	16.4	20.6	23.4	41.5	28.1	16.7	26.7	37.3	36.5	32.6	26.3	22.5	26.3	27.3
	Inundated Roadway	4.8	10.9	12.4	8.8	5.1	4.7	4	3.1	5.3	3.2	6.2	8.2	9.7	6.6
	Flood Insurance	10.3	36.9	12.4	15.3	10.7	34.4	10.6	4.5	16.3	12.3	16	8.2	6.2	14.9
	Residential Relocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Downstream Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Amenity Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Social Vulnerability	42	10.9	12.4	8.8	28.1	29.8	42.1	37.3	5.3	19.4	9.7	22.5	16	21.9

Table S7g: AHP-based weightings (in percent, %) for n=13 survey responses for environmental and social impact factors for ABRS Alternative A7 – Expanding Receiving Channel.

		Weight (w_j) – A7													
	Criterion (j)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**Avg.**
Environmental	Toxic Release Inventory	44.3	16.4	39	26.3	26	32.8	31.3	40.8	33.6	19.2	8.2	39.8	43.7	30.9
	Leaking Petroleum Tanks	7.3	4.8	23	6.2	26	27.7	17.6	14.6	6.1	19.2	13.8	24	5	15.0
	Wastewater Treatment	28.9	10.3	23	16	26	13.9	31.3	14.6	33.6	7	26	24	11.5	20.5
	Soil Erodibility	7.3	26.5	9.1	41.9	8.2	12.8	9.9	25.2	6.1	19.2	26	7.3	28.3	17.5
	Habitat Disruption	12.3	42	5.9	9.7	13.8	12.8	9.9	4.7	20.5	35.5	26	4.9	11.5	16.1
Social	Medical Facilities	23.3	18.8	32.3	23.9	26.2	14.4	16.9	13.2	34.3	29.8	37.7	35.4	38.3	26.5
	Population Density	13.8	18.8	18.8	37.4	26.2	17	25.7	30.7	34.3	29.8	24.3	21.9	25.1	24.9
	Inundated Roadway	4	9.9	9.8	8.1	4.4	5.5	4.2	2.5	5.8	2.6	5.4	8.7	10.3	6.2
	Flood Insurance	8.4	32.7	9.8	14.5	10.4	32.3	11.3	3.4	16.8	11.7	15	8.7	6.7	14.0
	Residential Relocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Downstream Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Amenity Disruption	13.8	9.9	15.6	8.1	6.7	2.4	3	19.5	2.9	7.8	8.8	4.2	3.4	8.2
	Social Vulnerability	36.7	9.9	13.6	8.1	26.2	28.3	38.8	30.7	5.8	18.4	8.8	21.2	16.1	20.2

Table S7h: AHP-based weightings (in percent, %) for n=13 survey responses for environmental and social impact factors for ABRS Alternative A8 – Underground Tunnel.

		Weight (w_j) – A8													
	Criterion (j)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**Avg.**
Environmental	Toxic Release Inventory	50.4	28.4	21.1	28.4	30	33.3	35.1	45.5	41.7	30	10.9	43.9	49.5	34.5
	Leaking Petroleum Tanks	8.9	7.3	13.2	7.3	30	33.3	18.9	14.1	8.3	30	18.9	24.6	6.1	17.0
	Wastewater Treatment	31.8	17	13.2	17	30	16.7	35.1	14.1	41.7	10	35.1	24.6	13.4	23.1
	Soil Erodibility	8.9	47.3	52.4	47.3	10	16.7	10.9	26.3	8.3	30	35.1	7	31	25.5
	Habitat Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Social	Medical Facilities	26.5	20.6	39.5	25.7	28.1	14.5	16.6	17.8	36.5	32.6	41.9	38.6	41.9	29.3
	Population Density	16.4	20.6	23.4	41.5	28.1	16.7	26.7	37.3	36.5	32.6	26.3	22.5	26.3	27.3
	Inundated Roadway	4.8	10.9	12.4	8.8	5.1	4.7	4	3.1	5.3	3.2	6.2	8.2	9.7	6.6
	Flood Insurance	10.3	36.9	12.4	15.3	10.7	34.4	10.6	4.5	16.3	12.3	16	8.2	6.2	14.9
	Residential Relocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Downstream Flooding	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Amenity Disruption	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Social Vulnerability	42	10.9	12.4	8.8	28.1	29.8	42.1	37.3	5.3	19.4	9.7	22.5	16	21.9

Table S8: Consistency Ratio (CR) values for each AHP individual matrix, for respondents R1-13.

		CR													
	Alternative (k)	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**Avg.**
Environmental	A1	.010	.019	.045	.019	0	0	.004	.004	0	0	.004	.010	.029	.011
	A2	.012	.022	.012	.015	.002	.006	.003	.016	.008	.004	.002	.015	.020	.011
	A3	.010	.019	.045	.019	0	0	.004	.004	0	0	.004	.010	.029	.011
	A4	.010	.019	.045	.019	0	0	.004	.004	0	.004	.004	.010	.029	.011
	A5	.010	.019	.045	.019	0	0	.004	.004	0	.004	.004	.010	.029	.011
	A6	.010	.019	.045	.019	0	0	.004	.004	0	.004	.004	.010	.029	.011
	A7	.012	.022	.012	.015	.002	.006	.003	.016	.008	.004	.002	.015	.020	.011
	A8	.01	.019	.045	.019	0	0	.004	.004	0	0	.004	.010	.029	.011
Social	A1	.022	.003	.002	.008	.009	.095	.027	.033	.017	.022	.015	.006	.015	.021
	A2	.022	.003	.002	.008	.009	.095	.027	.033	.017	.022	.015	.006	.015	.021
	A3	.019	.009	.001	.017	.009	.061	.025	.042	.017	.023	.011	.010	.020	.020
	A4	.017	.001	.001	.013	.009	.069	.020	.042	.020	.019	.013	.007	.012	.019
	A5	.019	.009	.001	.017	.009	.061	.025	.042	.017	.023	.011	.010	.020	.020
	A6	.022	.003	.002	.008	.009	.095	.027	.033	.017	.022	.015	.006	.015	.021
	A7	.016	.002	.035	.006	.010	.074	.032	.027	.031	.026	.011	.018	.026	.024
	A8	.022	.003	.002	.008	.009	.095	.027	.033	.017	.022	.015	.006	0.15	.031

Supplementary Figures

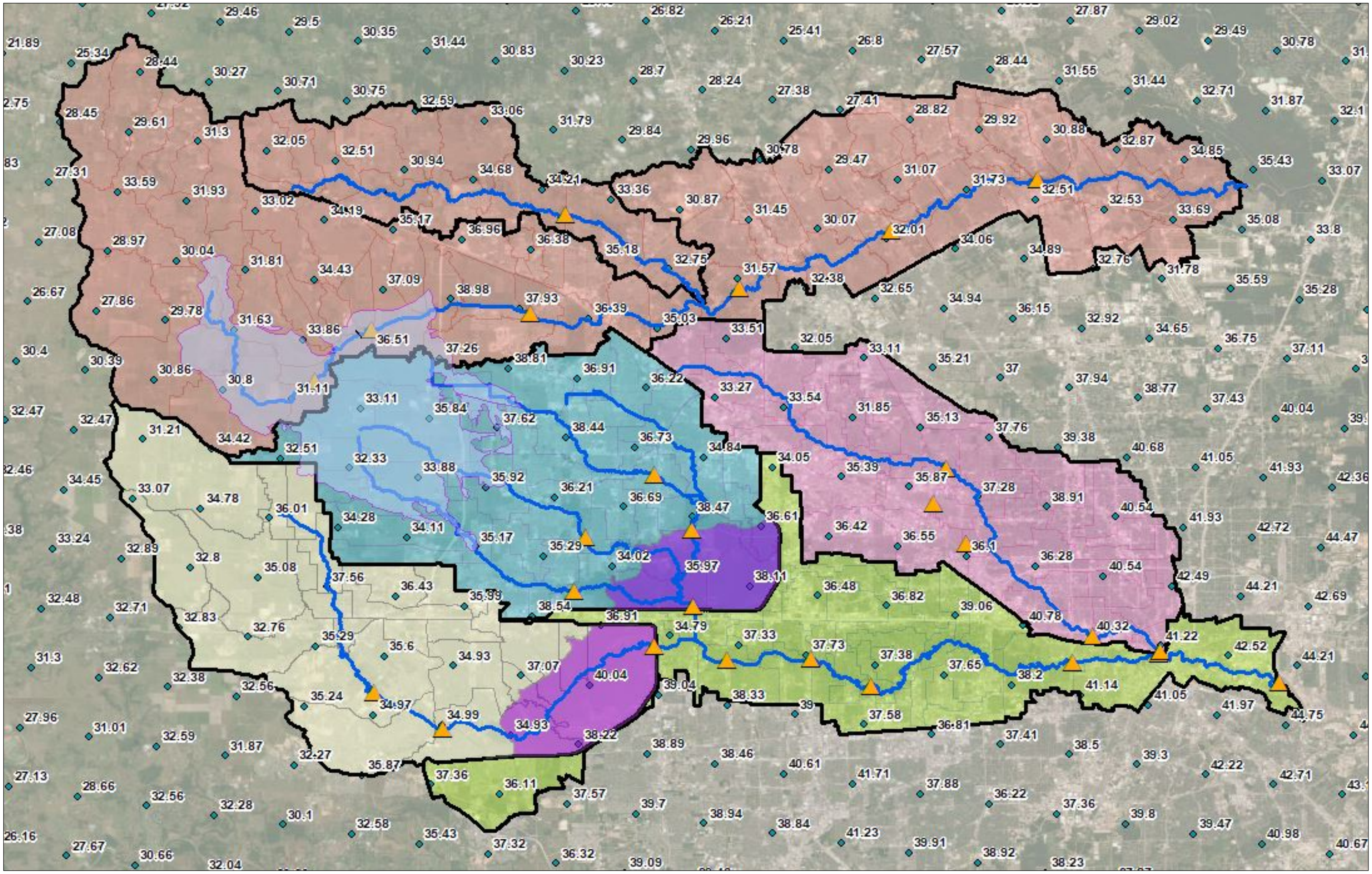
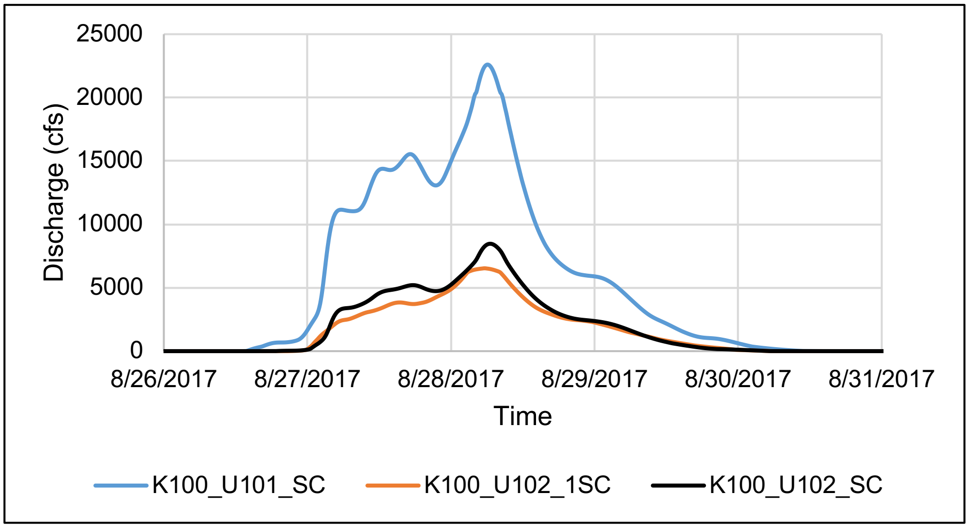
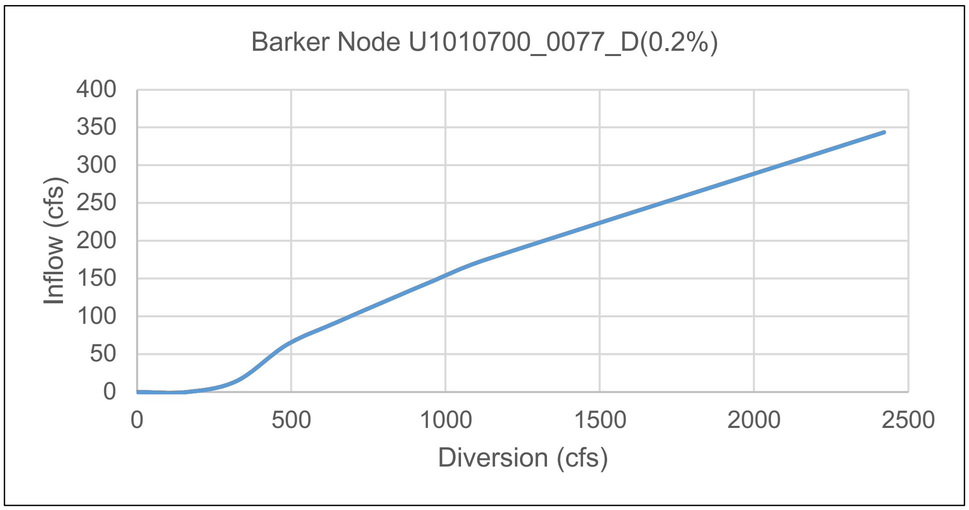


Figure S1: Gridded rainfall maximum values for Hurricane Harvey conditions in the ABRS inter-connected watershed system, from National Oceanic Atmospheric Administration (NOAA, 2017a) for August 24, 2017 21:00 to August 29, 2017 23:00.





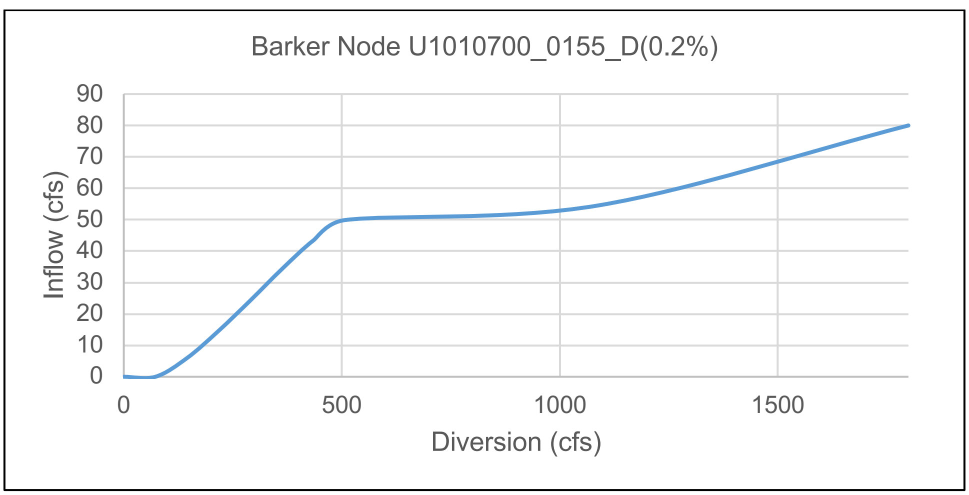


Figure S2: Discharge and diversion node values used to link the Cypress Creek overflow conditions with the Addicks watershed HEC-HMS model.

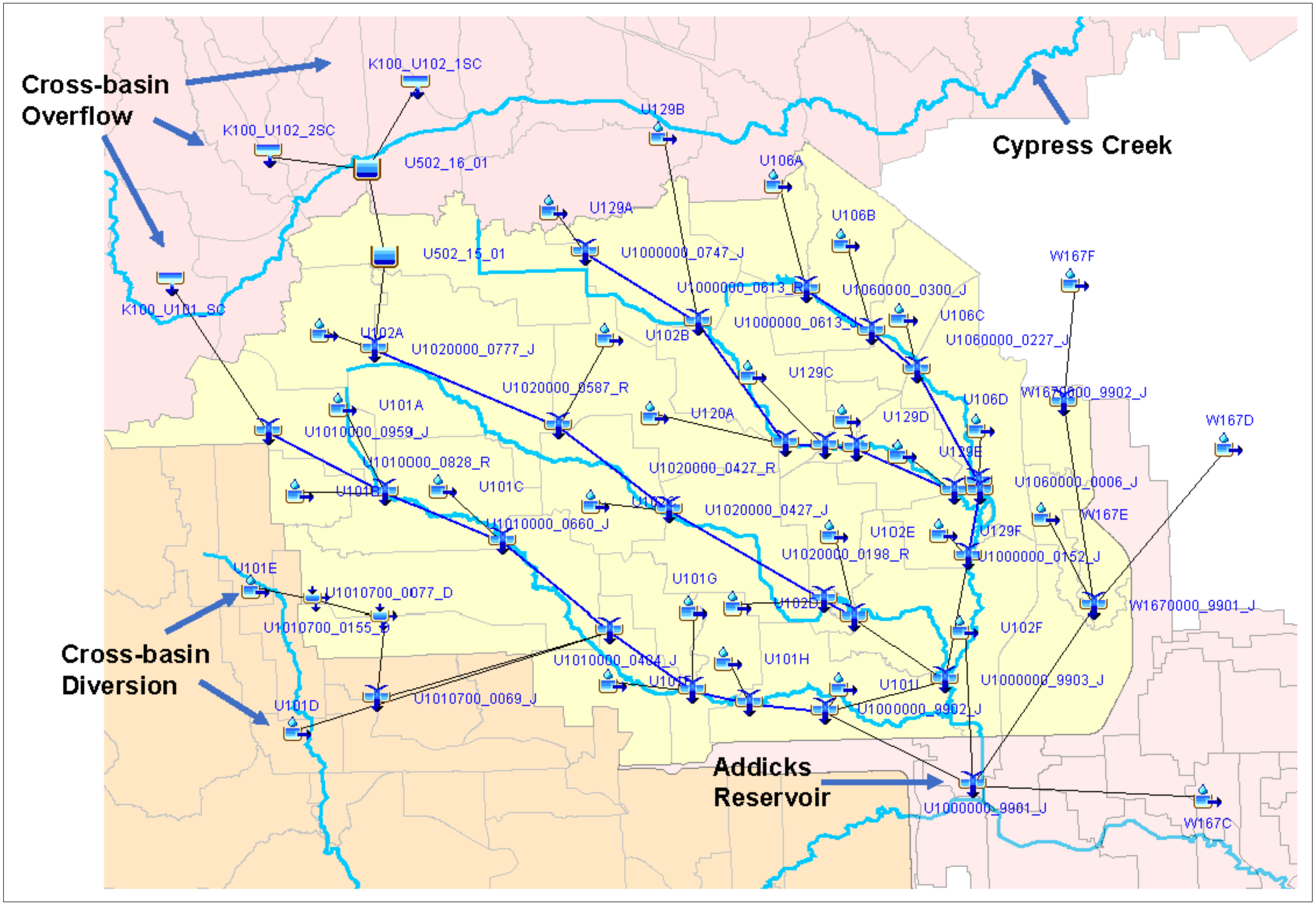


Figure S3: HEC-HMS schematic for Addicks watershed model, showcasing how the cross-basin overflow from Cypress Creek was integrated into model through diversion nodes.

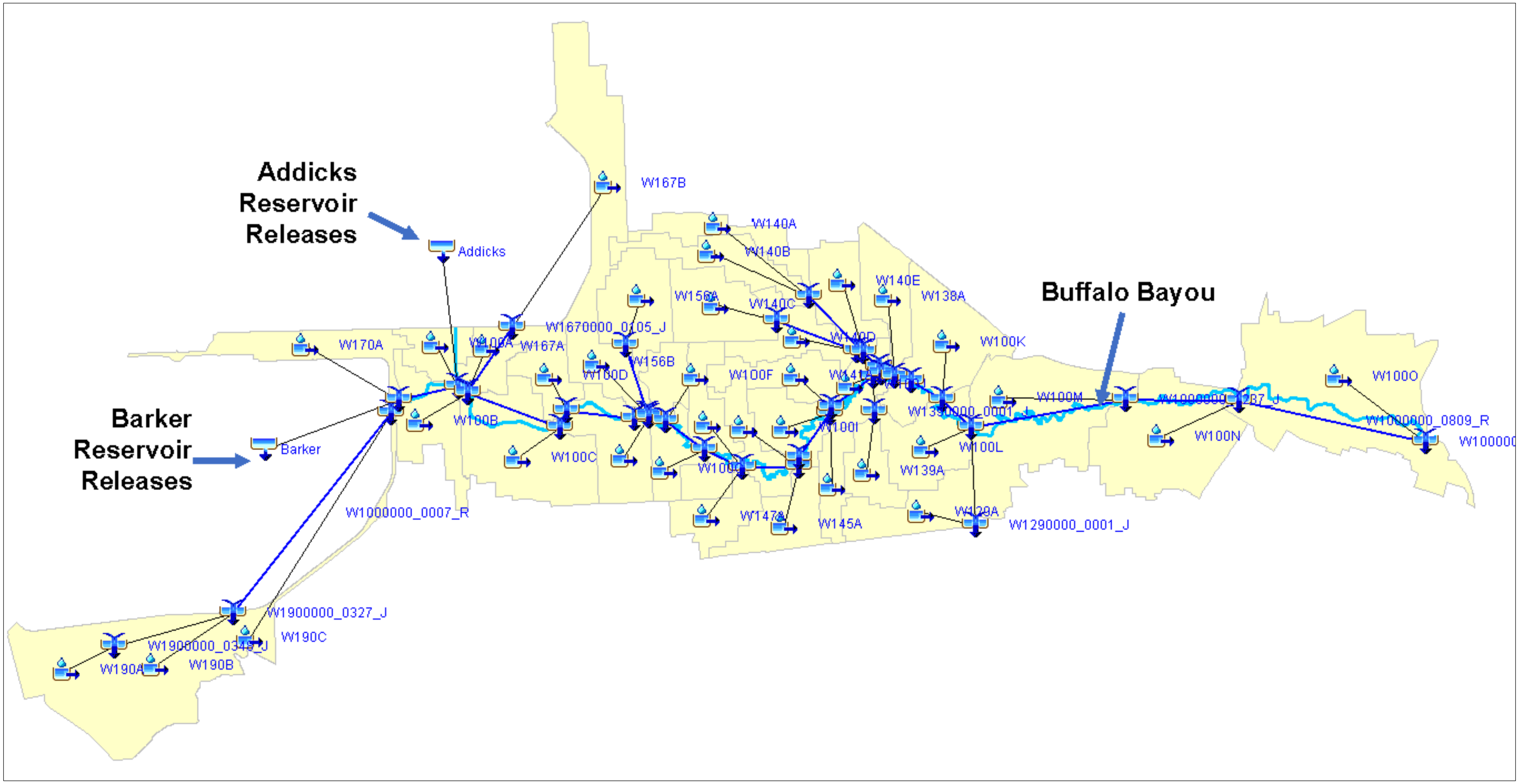


Figure S4: HEC-HMS schematic for Buffalo Bayou watershed model, showcasing how the Addicks and Barker reservoir releases were integrated into the Buffalo Bayou watershed model through source discharge gages.

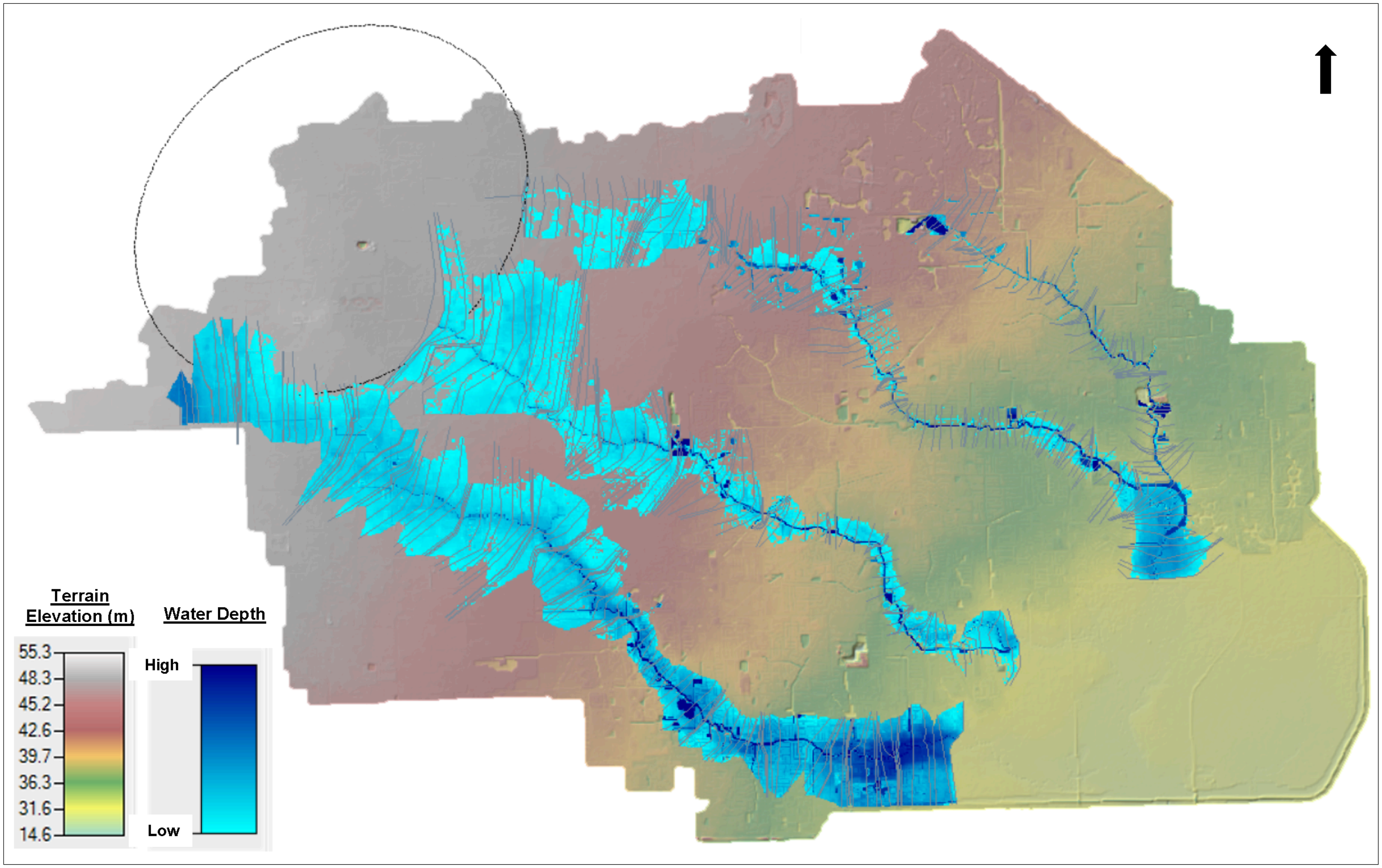


Figure S5: HEC-RAS schematic for Addicks watershed model, showcasing how the various streams within the basin were combined within a single model to estimate flood inundation bounds and water depth under Hurricane Harvey conditions.

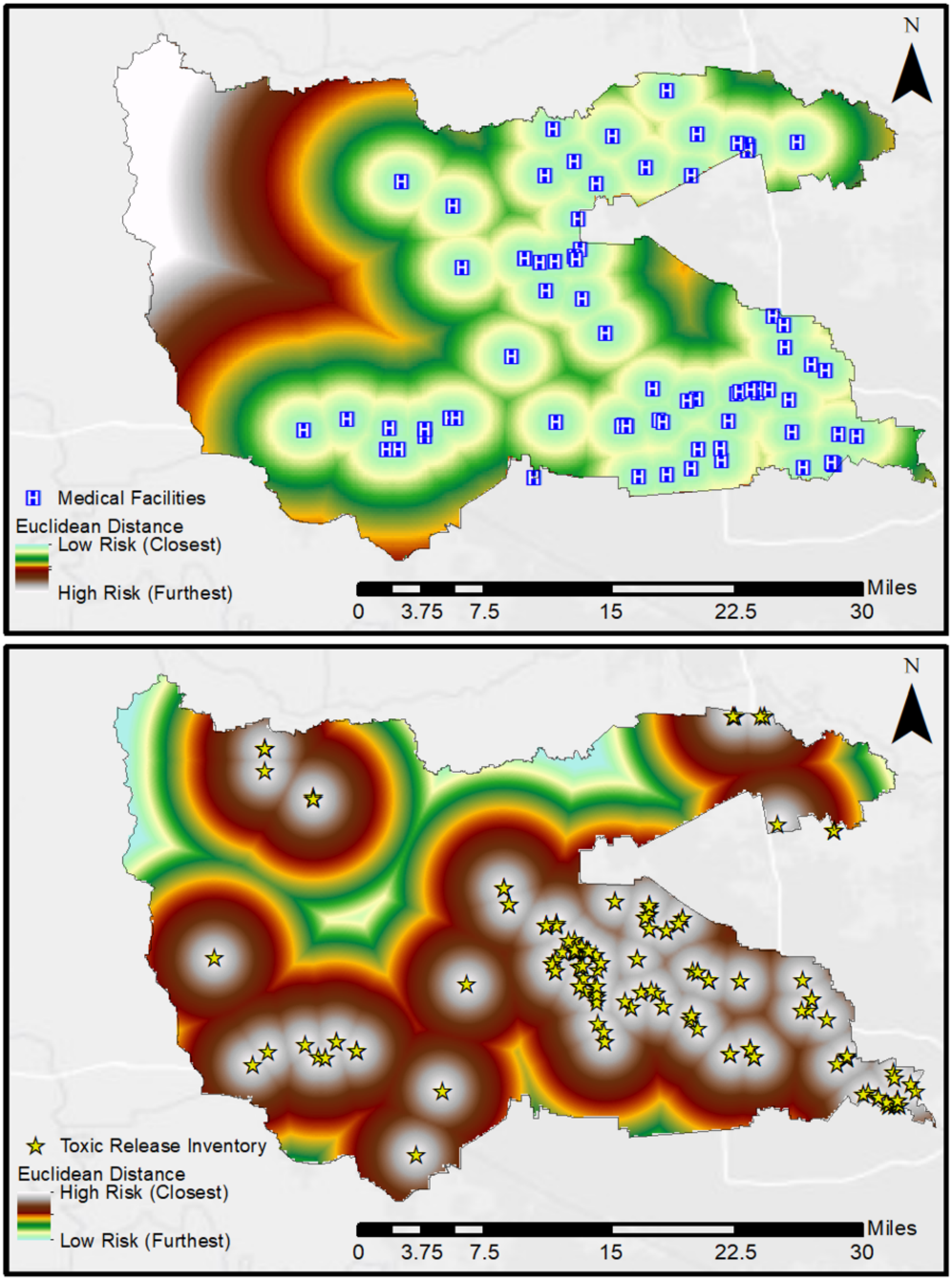


Figure S6: Hotspot map created using ArcGIS *Euclidean Distance* function for the watersheds adjacent to the ABRS case study system for medical facilities (top) and toxic release inventories (TRIs) (bottom).

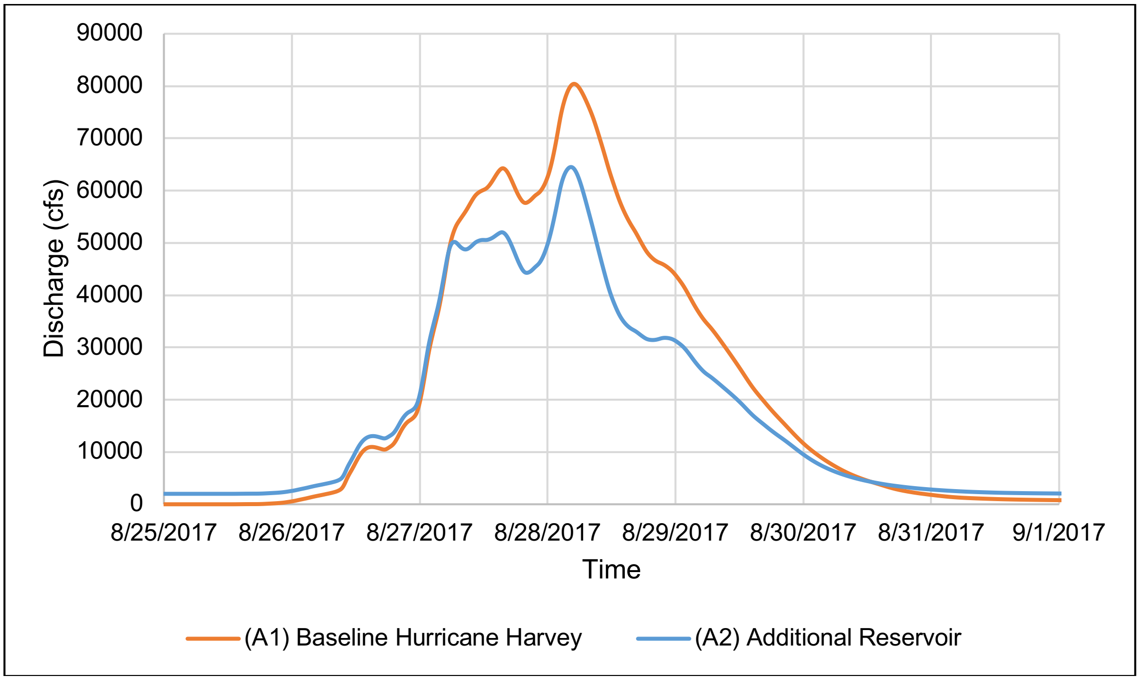


Figure S7: Comparison of HEC-HMS output hydrographs at Addicks Reservoir (HEC-HMS node U1000000_9901_J) for Alternatives A_1 and A_2. The storage volume for A1 is 309,870.1 ac-ft, while the hydrograph volume for A2 is 258,989.6, thereby elucidating the difference in total inflow volume at Addicks Reservoir given the addition of a hypothetical third reservoir.

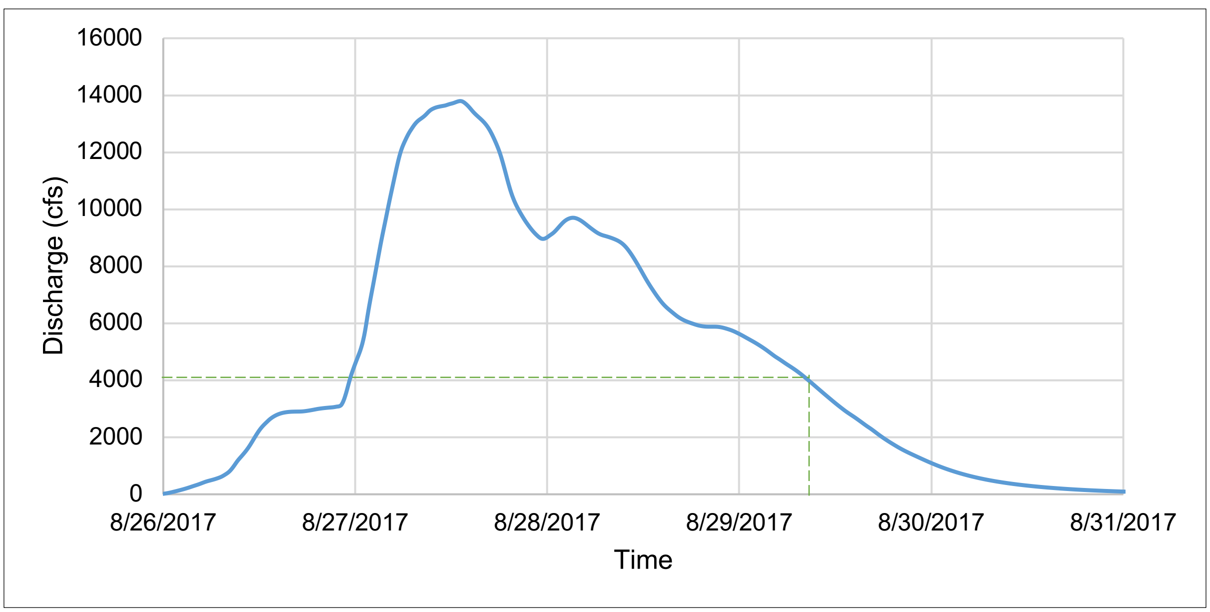
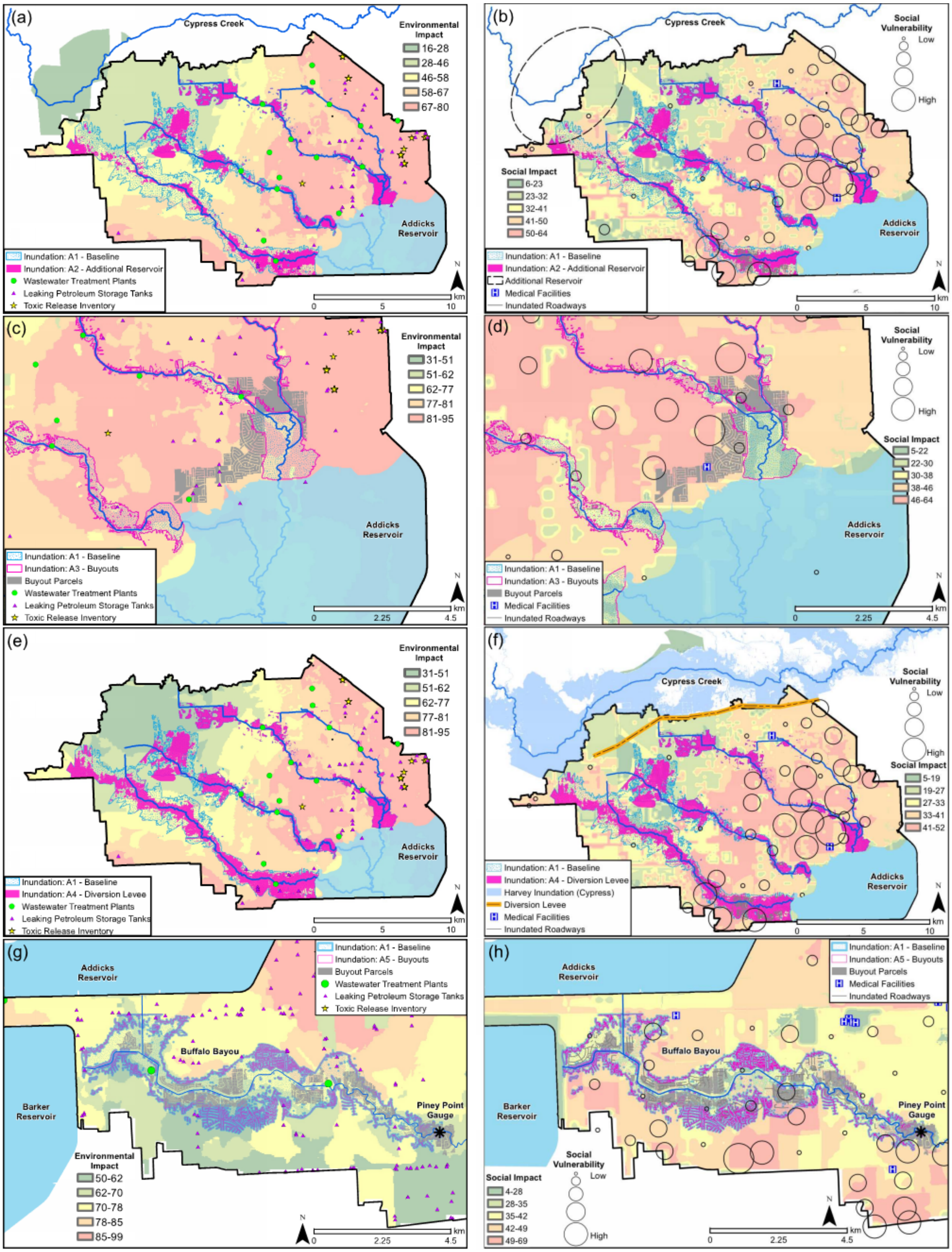


Figure S8: Output hydrograph of USGS Piney Point gauge (HEC-HMS Node W1000000_1985_J) under Hurricane Harvey rainfall conditions with no reservoir releases, used to determine the assumed timing of releases for Alternative A_6 under the Interim Reservoir Control Action Plan conditions (USACE, 2010).

Figure S9: Box plot illustrating variations in stakeholder responses (n=13) for socio-environmental criteria factors considered in the ABRS flood management case study. [Note: Each box represents interquartile range of stakeholder responses, while upper and lower whiskers represent minimum to maximum response, respectively. Points represent outliers. ‘x’ represents mean of data.]



(a)
Cypress Creek
Environmental Impact
16-28
28-46
46-58
58-67
67-80
Addicks Reservoir
Inundation: A1 - Baseline
Inundation: A2 - Additional Reservoir
Wastewater Treatment Plants
Leaking Petroleum Storage Tanks
Toxic Release Inventory
(b)
Cypress Creek
Social Vulnerability
Low
High
Social Impact
6-23
23-32
32-41
41-50
50-64
Addicks Reservoir
Inundation: A1 - Baseline
Inundation: A2 - Additional Reservoir
Additional Reservoir
Medical Facilities
Inundated Roadways
(c)
Environmental Impact
31-51
51-62
62-77
77-81
81-95
Addicks Reservoir
Inundation: A1 - Baseline
Inundation: A3 - Buyouts
Buyout Parcels
Wastewater Treatment Plants
Leaking Petroleum Storage Tanks
Toxic Release Inventory
(d)
Social Vulnerability
Low
High
Social Impact
5-22
22-30
30-38
38-46
46-64
Addicks Reservoir
Inundation: A1 - Baseline
Inundation: A3 - Buyouts
Buyout Parcels
Medical Facilities
Inundated Roadways
(e)
Environmental Impact
31-51
51-62
62-77
77-81
81-95
Addicks Reservoir
Inundation: A1 - Baseline
Inundation: A4 - Diversion Levee
Wastewater Treatment Plants
Leaking Petroleum Storage Tanks
Toxic Release Inventory
(f)
Cypress Creek
Social Vulnerability
Low
High
Social Impact
5-19
19-27
27-33
33-41
41-52
Addicks Reservoir
Inundation: A1 - Baseline
Inundation: A4 - Diversion Levee
Harvey Inundation (Cypress)
Diversion Levee
Medical Facilities
Inundated Roadways
(g)
Addicks Reservoir
Barker Reservoir
Buffalo Bayou
Piney Point Gauge
Inundation: A1 - Baseline
Inundation: A5 - Buyouts
Buyout Parcels
Wastewater Treatment Plants
Leaking Petroleum Storage Tanks
Toxic Release Inventory
Environmental Impact
50-62
62-70
70-78
78-85
85-99
(h)
Addicks Reservoir
Barker Reservoir
Buffalo Bayou
Piney Point Gauge
Inundation: A1 - Baseline
Inundation: A5 - Buyouts
Buyout Parcels
Medical Facilities
Inundated Roadways
Social Vulnerability
Low
High
Social Impact
4-28
28-35
35-42
42-49
49-69

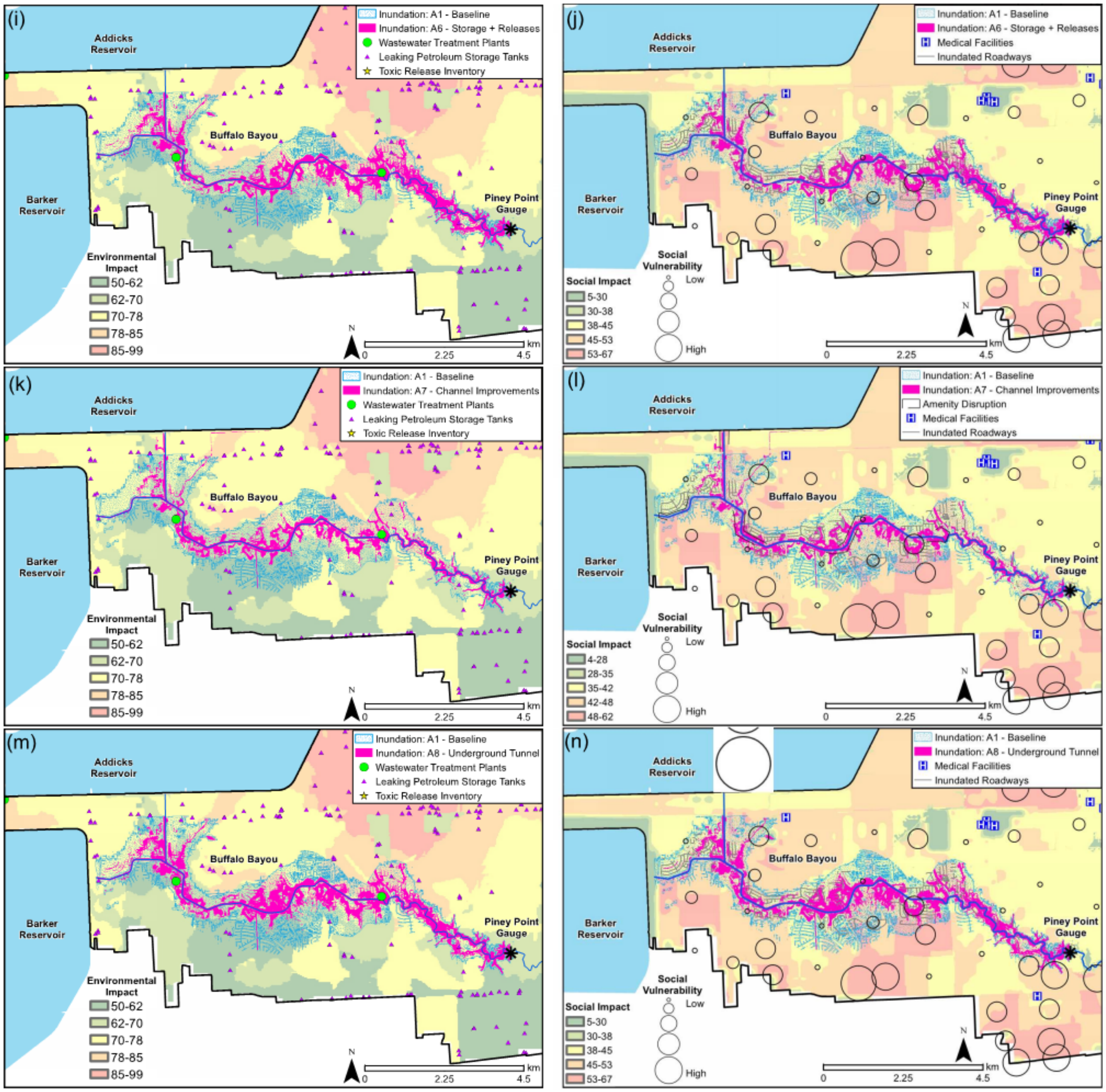


Figure S10: Composite risk maps for the ABRS watershed for each mitigation alternative ($\boldsymbol{A_k}$), for $\boldsymbol{k = 2 - 8}$, and study domain ($\boldsymbol{S}$: social, $\boldsymbol{E}$: environmental): **(a)** $\boldsymbol{A_2}$-*E*; **(b)** $\boldsymbol{A_2}$-*S*; **(c)** $\boldsymbol{A_3}$-*E*; **(d)** $\boldsymbol{A_3}$-*S*; **(e)** $\boldsymbol{A_4}$-*E*; **(f)** $\boldsymbol{A_4}$-*S*; **(g)** $\boldsymbol{A_5}$-*E*; **(h)** $\boldsymbol{A_5}$-*S*; **(i)** $\boldsymbol{A_6}$-*E*; **(j)** $\boldsymbol{A_6}$-*S*; **(k)** $\boldsymbol{A_7}$-*E*; **(l)** $\boldsymbol{A_7}$-*S*; **(m)** $\boldsymbol{A_8}$-*E*; **(n)** $\boldsymbol{A_8}$-*S*.

Supplementary References

Dunbar, L., Garcia, M., Juan, A. and Bedient, P.: CYPRESS CREEK WATERSHED: ANALYSIS OF FLOODING & STORAGE OPTIONS, [online] Available from: https://www.houstonconsortium.com/graphics/GHFMCCypressCreek.pdf, 2019.

HCFCD: Hurricane Harvey high water marks, [online] Available from: https://www.hcfcd.org/Portals/62/Downloads/Hurricane Harvey/HighWaterTables 10.23.17.pdf, 2017.

HCFCD: Model and map management system (M3), Harris Cty. Flood Control Dist. [online] Available from: https://www.m3models.org/, 2019.

NOAA: Hurricane Harvey 1-hourly multi-sensor radar and rain gauge data, 2017a.

NOAA: Hurricane Harvey aerial imagery, [online] Available from: https://storms.ngs.noaa.gov/storms/harvey/index.html#7/28.400/-96.690, 2017b.

TNRIS: Harris County LiDAR 2018, [online] Available from: https://data.tnris.org/collection/b5bd2b96-8ba5-4dc6-ba88-d88133eb6643, 2019.

TWDB: Final Study Report: Cypress Creek Overflow Management Plan, , TWDB Contract Report Number 1248321466 [online] Available from: https://www.twdb.texas.gov/publications/reports/contracted_reports/doc/1248321466_HCFCD.pdf, 2015.

USACE: Buffalo Bayou and Tributaries: Addicks and Barker Dams - Interim Reservoir Control Action Plan, [online] Available from: http://hurricaneharveylawsuithelp.com/wp-content/uploads/2017/09/interim-reservoir-control-action-plan.pdf, 2010.

USACE: USACE Galveston News Releases: Aug 28, Aug 30, Sept 1, Sept 3, Sept 17, 2017, [online] Available from: https://www.swg.usace.army.mil/Media/News-Releases/Year/2017/Month/8/; https://www.swg.usace.army.mil/Media/News-Releases/Year/2017/Month/9/, 2017.

USACE: Buffalo Bayou and Tributaries Resiliency Study, Texas Combined Feasibility Report and Environmental Impact Statement: Review of Completed Projects, , P2-451975 [online] Available from: https://www.swg.usace.army.mil/Portals/26/BBTnT_Interim_Report_202001001_Final_1.pdf, 2020.