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Supporting Information for “Predictions of household water affordability under conditions of climate change, demographic growth, and fresh groundwater depletion in a southwest US city indicate increasing burdens on the poor”

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Supporting Information for
Predictions of household water affordability under conditions of climate change, demographic growth, and fresh groundwater depletion in a southwest US city indicate increasing burdens on the poor

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Introduction

The Supporting Information contains (a) table of annual volumes for each water supply source and by year for each scenario; (b) table of annual costs for each water supply source and by year for each scenario; (c) census tract numbers used in the analysis of incomes spent on water; (d) the correlation matrix for the demographic variables in Table 3 in the main article and the lowest quintile mean annual income; and (e) shapefiles for the El Paso Water utility service area boundaries.

Projected water supply availability volumes for 2020 to 2070 were taken from the 2016 Far West Texas Water Plan (FWTWP) (Texas Water Development Board, TWDB, 2016). The FWTWP projects future water supply availability from existing sources, plans for new sources, and reductions in per capita demand, to compensate for the deficit between projected demand and current water supply availability. However, we suggest that the FWTWP estimates of water availability from two primary current sources, Hueco Bolson freshwater and the Rio Grande, are overly optimistic. First, given current freshwater pumping rates from the Hueco Bolson aquifer by El Paso, Ciudad Juárez, and agricultural irrigators (approximately 188,000 AF/yr together), estimates of aquifer recharge rates (approximately 33,000 AF/yr), and remaining freshwater storage in the aquifer (approximately 6,500,000 AF), freshwater is expected to be completely depleted in 42 years (Mayer et al., in review). It is likely that pumping rates in Ciudad Juárez will increase substantially in the meantime, as populations in this city may increase as much as 1.02% per year, for a total increase of 66% by 2070. Given current aquifer recharge rates and expected increases in pumping by Ciudad Juárez, we estimate, using our water balance model (https://swim.cybershare.utep.edu/en/wb-intro), that EPW's current rate of pumping of freshwater from the Hueco Bolson will need to be reduced from the amounts predicted in the FWTWP by 50% by 2070 to extend the aquifer life past 2070.

Second, climate change in the headwaters of the Rio Grande are expected to substantially decrease downstream supplies, with flows into Elephant Butte reservoir declining 5%, averaged across a series of climate change scenarios (Townsend and Gutzler, 2020). Using a pessimistic climate change scenario associated with the Access85 climate model projection, inflows into

Elephant Butte will decline by 39% on average over the period 2020-2070, effectively reducing average water availability for EPW from the Rio Grande by the same fraction. Using projected annual Elephant Butte reservoir inflows from Townsend and Gutzler (2020) for the Access85 climate model projection, the declines in Rio Grande water availability by year will be 37%, 56%, 60%, 41%, and 23% in the years 2030, 2040, 2050, 2060, and 2070, respectively. These declines were calculated using the water balance model.

Four scenarios for future supply volumes by source were determined (Table S1) based on the expected impacts of climate change and groundwater depletion and how these decreases will be compensated by increases in desalinated Hueco Bolson brackish groundwater versus imported groundwater. While depletion of Hueco Bolson fresh groundwater is expected to occur in a matter of a few decades, less is known about the availability of Hueco Bolson brackish groundwater over the next 50 years. To contend with this uncertainty, we incorporate into the scenarios the possibility that reductions in Rio Grande supply and Hueco Bolson freshwater pumping will be compensated by either 100% from desalinated Hueco Bolson brackish groundwater or 100% from imported groundwater.

The four water supply scenarios are: (1) “Base Case,” which is based the FWTWP expectations for meeting supply deficits; (2) “Climate Change + Desalination,” in which the Rio Grande water supply is reduced according to the Access85 climate model predictions and the reduction is compensated by increasing desalinated brackish groundwater from the Hueco Bolson; (3) “Climate Change + Imported GW,” in which the Rio Grande water supply is reduced according to the Access85 climate model predictions and the reduction is compensated by increasing imported groundwater; and (4) “Climate Change + Imported GW + Reduction in HB Pumping,” in which the Rio Grande water supply is reduced according to the Access85 climate model predictions, freshwater pumping from the Hueco Bolson (HB) is reduced by 50%, and the two supply reductions are compensated by increasing imported groundwater. Table S1 in the supplementary information shows the annual volumes for each water source by scenario and by year.

The 2016 FWTWP identifies costs associated with expansion of water supply sources. However, we use updated costs of sources directly obtained from EPW (Lisa Franklin Rosendorf, personal communication). These unit costs are cost of supply in 2020 per volume of water supplied and are assumed to include amortized capital and operation and maintenance (O&M) costs. Interest rates for bonds from TWDB to pay for capital water supply improvements are usually low, on the order of 2-3% over the lifetime of the bond. We do not inflate the unit costs from 2020 to 2070, because we take the approach involving the simplest possible assumptions that inflation in unit water supply costs will be matched by increases in household incomes, effectively canceling out increases in water supply costs due to inflation. See Table S2.

The Census Tract numbers in Table S3 are for all of the census tract within the El Paso Water service area boundary and relate to the tract numbers used in the 2020 US Census and American Community Survey. The census tracts within the El Paso Water service area boundary were determined in ArcGIS by overlaying a layer of the service area boundaries on a layer of US census tracts in El Paso County and applying a join tool. All census tracts with overlap of at least 15% were selected.

Table S4 is the correlation matrix for the demographic variables in Table 3 in the main article and the lowest quintile mean annual income. The correlation matrix is used to determine if there is correlation between the socio-economic variables in Table 3 and between those variables and lowest quintile incomes. Because our primary dependent variable (fraction of households paying 5% or more of income for water) already contains income and the socio-economic variables may tend to correlate with income, correlations between the primary dependent variable and the socio-economic variables may be spurious. The correlation matrix shows relatively high inverse correlations (values < -0.5) between the variables in Table 3 in the main article and the lowest quintile income. These high negative correlations imply that there is a strong relationship between the independent variables and income, which is problematic when comparing fraction of households paying 5% or more of income for water, which already has income factored into it, and the socioeconomic variables in Table 3 in the main article.

The shapefiles for the El Paso Water service area boundaries are included in this data package in the folder “boundary11.24.21.gdb.”

Table S1. Annual volumes for each water source by scenario and by year (AF = acre feet)

Base Case

Supply by source (AF)	2020	2030	2040	2050	2060	2070
Mesilla GW	26860	26948	27036	27124	27212	27300
Hueco GW	60040	56852	53664	50476	47288	44100
Rio Grande	63200	64000	64800	65600	66400	67200
Desal	7900	10520	13140	15760	18380	21000
Imported GW	0	5460	10920	16380	21840	27300
AWPF+ASR	0	4620	9240	13860	18480	23100
Total	158000	168400	178800	189200	199600	210000

Access RG + makeup with Desal

Supply by source (AF)	2020	2030	2040	2050	2060	2070
Mesilla GW	26860	26948	27036	27124	27212	27300
Hueco GW	60040	56852	53664	50476	47288	44100
Rio Grande	63200	40320	28512	26240	39176	51744
Desal	7900	34200	49428	55120	45604	36456
Imported GW	0	5460	10920	16380	21840	27300
AWPF+ASR	0	4620	9240	13860	18480	23100
Total	158000	168400	178800	189200	199600	210000

Access RG + makeup with Imported GW

Supply by source (AF)	2020	2030	2040	2050	2060	2070
Mesilla GW	26860	26948	27036	27124	27212	27300
Hueco GW	60040	56852	53664	50476	47288	44100
Rio Grande	63200	40320	28512	26240	39176	51744
Desal	7900	10520	13140	15760	18380	21000
Imported GW	0	29140	47208	55740	49064	42756
AWPF+ASR	0	4620	9240	13860	18480	23100
Total	158000	168400	178800	189200	199600	210000

Table S1. Annual volumes for each water source by scenario and by year, continued

Access RG + makeup with AWPF+ASR

Supply by source (AF)	2020	2030	2040	2050	2060	2070
Mesilla GW	26860	26948	27036	27124	27212	27300
Hueco GW	60040	56852	53664	50476	47288	44100

Rio Grande	63200	40320	28512	26240	39176	51744
Desal	7900	10520	13140	15760	18380	21000
Imported GW	0	5460	10920	16380	21840	27300
AWPF+ASR	0	28300	45528	53220	45704	38556
Total	158000	168400	178800	189200	199600	210000

Access RG + 50% decrease in HB + makeup with Imported GW

Supply by source (AF)	2020	2030	2040	2050	2060	2070
Mesilla GW	26860	26948	27036	27124	27212	27300
Hueco GW	60040	51167	42931	35333	28373	22050
Rio Grande	63200	40320	28512	26240	39176	51744
Desal	7900	34200	49428	55120	45604	36456
Imported GW	0	29140	47208	55740	49064	49350
AWPF+ASR	0	4620	9240	13860	18480	23100
Total	158000	186395	204355	213417	207909	210000

Table S2. Annual costs for each water source by scenario and by year

Base Case

Cost by source ($1,000)	2020	2030	2040	2050	2060	2070
Mesilla GW	4,029	4,042	4,055	4,069	4,082	4,095
Hueco GW	9,006	8,528	8,050	7,571	7,093	6,615
Rio Grande	18,960	19,200	19,440	19,680	19,920	20,160
Desal	3,950	5,260	6,570	7,880	9,190	10,500
Imported GW	-	13,104	26,208	39,312	52,416	65,520
AWPF+ASR	-	5,544	11,088	16,632	22,176	27,720
Total	35,945	55,678	75,411	95,144	114,877	134,610

Access RG + makeup with Desal

Cost by source ($1,000)	2020	2030	2040	2050	2060	2070
Mesilla GW	4,029	4,042	4,055	4,069	4,082	4,095
Hueco GW	9,006	8,528	8,050	7,571	7,093	6,615
Rio Grande	18,960	12,096	8,554	7,872	11,753	15,523
Desal	3,950	17,100	24,714	27,560	22,802	18,228
Imported GW	-	13,104	26,208	39,312	52,416	65,520
AWPF+ASR	-	5,544	11,088	16,632	22,176	27,720
Total	35,945	60,414	82,669	103,016	120,322	137,701

Table S2. Annual costs for each water source by scenario and by year, continued

Access RG + 50% decrease in HB + makeup with Imported GW

Cost by source ($1,000)	2020	2030	2040	2050	2060	2070
Mesilla GW	4,029	4,042	4,055	4,069	4,082	4,095
Hueco GW	9,006	7,675	6,440	5,300	4,256	3,308
Rio Grande	18,960	12,096	8,554	7,872	11,753	15,523
Desal	3,950	17,100	24,714	27,560	22,802	18,228
Imported GW	-	69,936	113,299	133,776	117,754	118,440
AWPF+ASR	-	5,544	11,088	16,632	22,176	27,720
Total	35,945	116,393	168,150	195,209	182,822	187,314

Table S3. Census tract codes (El Paso County, Texas)

Census Tract 1.01	Census Tract 11.13	Census Tract 34.04	Census Tract 43.16	Census Tract 103.28
Census Tract 1.06	Census Tract 11.14	Census Tract 35.01	Census Tract 43.17	Census Tract 103.29
Census Tract 1.07	Census Tract 11.15	Census Tract 35.02	Census Tract 43.18	Census Tract 103.30
Census Tract 1.08	Census Tract 12.01	Census Tract 36.01	Census Tract 43.19	Census Tract 103.31
Census Tract 1.09	Census Tract 12.02	Census Tract 36.02	Census Tract 43.20	Census Tract 103.33
Census Tract 1.10	Census Tract 12.03	Census Tract 37.01	Census Tract 102.07	Census Tract 103.36
Census Tract 1.11	Census Tract 13.01	Census Tract 37.02	Census Tract 102.10	Census Tract 103.37
Census Tract 1.12	Census Tract 13.02	Census Tract 38.01	Census Tract 102.11	Census Tract 103.38
Census Tract 2.04	Census Tract 14	Census Tract 38.03	Census Tract 102.12	Census Tract 103.39
Census Tract 2.05	Census Tract 15.01	Census Tract 38.04	Census Tract 102.13	Census Tract 103.41
Census Tract 2.06	Census Tract 15.02	Census Tract 39.01	Census Tract 102.14	Census Tract 103.42
Census Tract 2.07	Census Tract 16	Census Tract 39.02	Census Tract 102.15	Census Tract 103.46
Census Tract 2.08	Census Tract 17	Census Tract 39.03	Census Tract 102.16	Census Tract 104.01
Census Tract 3.01	Census Tract 18	Census Tract 40.02	Census Tract 102.17	Census Tract 104.05
Census Tract 3.02	Census Tract 19	Census Tract 40.03	Census Tract 102.18	Census Tract 106
Census Tract 4.01	Census Tract 20	Census Tract 40.04	Census Tract 102.19	
Census Tract 4.03	Census Tract 21	Census Tract 41.03	Census Tract 102.20	
Census Tract 4.04	Census Tract 22.01	Census Tract 41.04	Census Tract 102.21	
Census Tract 6	Census Tract 22.02	Census Tract 41.05	Census Tract 102.22	
Census Tract 8	Census Tract 23	Census Tract 41.06	Census Tract 103.03	
Census Tract 9	Census Tract 24	Census Tract 41.07	Census Tract 103.07	
Census Tract 10.01	Census Tract 25	Census Tract 42.01	Census Tract 103.11	

Census Tract 10.02	Census Tract 26	Census Tract 42.02	Census Tract 103.12
Census Tract 11.04	Census Tract 28	Census Tract 43.03	Census Tract 103.16
Census Tract 11.07	Census Tract 29	Census Tract 43.07	Census Tract 103.17
Census Tract 11.09	Census Tract 30	Census Tract 43.09	Census Tract 103.22
Census Tract 11.10	Census Tract 31	Census Tract 43.10	Census Tract 103.23
Census Tract 11.11	Census Tract 32	Census Tract 43.11	Census Tract 103.24
Census Tract 11.12	Census Tract 33	Census Tract 43.12	Census Tract 103.25

Table S4. Correlation Matrix

	Pct Pop Under 18 years	Pct Pop Over 65	Pct Pop Disability %	Pct Pop Less than Bachelor's degree	Pct HH Female Headed	Pct HH Receiving SNAP	Pct Pop Foreign Born	Pct Pop Non US Citizen	Pct Pop Not Speak Only English at	Pct Rent of HH Gross Income	Pct Civilian Pop Unemployed	Pct Pop Black or African American	Pct Pop Hispanic or Latino	Pct Pop Uninsured	Annual Public Assistance Income	Lowest Quintile
Pct Pop Under 18 years	1.000															
Pct Pop Over 65	-0.534	1.000														
Pct Pop Disability %	-0.328	0.655	1.000													
Pct Pop Less than Bachelor's degree	0.028	0.283	0.657	1.000												
Pct HH Female Headed	-0.267	0.447	0.563	0.507	1.000											
Pct HH Receiving SNAP	0.001	0.365	0.704	0.779	0.638	1.000										
Pct Pop Foreign Born	-0.328	0.329	0.535	0.452	0.382	0.659	1.000									
Pct Pop Non US Citizen	-0.266	0.249	0.530	0.466	0.380	0.695	0.930	1.000								
Pct Pop Not Speak Only English at Home	-0.201	0.369	0.586	0.639	0.487	0.694	0.772	0.686	1.000							
Pct Rent of HH Gross Income	0.114	0.114	0.166	0.162	0.231	0.319	0.171	0.202	0.179	1.000						
Pct Civilian Pop Unemployed	0.069	0.180	0.282	0.380	0.353	0.468	0.183	0.248	0.203	0.139	1.000					
Pct Pop Black or African American	0.130	-0.307	-0.115	-0.063	-0.173	-0.179	-0.355	-0.249	-0.589	-0.122	0.015	1.000				

Pct Pop Hispanic or Latino	-0.075	0.308	0.501	0.664	0.438	0.647	0.609	0.535	0.914	0.193	0.176	-0.643	1.000			
Pct Pop Uninsured	-0.190	0.179	0.477	0.653	0.500	0.706	0.685	0.717	0.654	0.178	0.332	-0.234	0.614	1.000		
Annual Public Assistance Income per capita	0.100	0.024	0.082	0.183	0.174	0.204	-0.014	0.014	0.010	0.151	0.125	0.107	0.046	0.053	1.000	
Lowest Quintile Annual Average Income	0.200	-0.401	-0.545	-0.572	-0.666	-0.700	-0.496	-0.542	-0.532	-0.349	-0.377	0.181	-0.510	-0.643	-0.115	1.000