Supplemental Table 1. Weather stations

Abbreviation	Weather gage COOP ID[a]	Station name
	Edwards aquifer sites	
W1	410428	Austin - Camp Mabry
W2	410902	Boerne
W3	411215	Bulverde
W4	411398	Camp Wood
W5	412585	Dripping Springs 6 E
W6	413038	Fair Oaks Rch
W7	414088	Henly
W8	414254	Hondo
W9	414256	Hondo_Municipal_Airport
W10	414780	Kerrville
W11	417628	Riomedina
W12	417706	Rockspring 1s
W13	417712	Rockspring 18 SW
W14	417717	Rockspring 26ssw
W15	417873	Sabinal
W16	418845	Tarpley
N1	--	NEXRAD@Boerne
N2	--	NEXRAD@Rocksprings 26ssw
N3	--	NEXRAD@Tarpley
	Madison aquifer sites	
W17	399347	Wind Cave National Park
W18	394834	Lead
W19	392087	Custer station
W20	393572	Hardy Rs
W21	392228	Deerfield 4 NW
W22	391246	Buskala Rch
W23	397227	Rochford 2 WNW
W24	397222	Rochford
W25	392231	Deerfield_3_SE
W26	392234	Deerfield_dam
W27	395858	Mtn Meadow Resort
W28	393069	Ft Meade
N4	--	NEXRAD for Beaver Creek Watershed

[a] Weather gage COOP ID from National Climatic Data Center (2012)

Supplemental Table 2. Weather stations used for simulation of each site. All precipitation data are from the National Climatic Data Center (2012)

Site label (fig. 2)	Weather stations used (Abbreviation from Supplemental Table 4)[a]
Edwards aquifer sites	
FM1796	W8, W9, (W16, W15, W11, W15)
Bxr	W8, W9, (W11, W15, W16), N3
HCV	W2, N1, (W3, W6, W10)
Bud	W5, (W1, W7)
Dow	W5, (W1, W7)
BARsp	W5, (W1, W7)
LVL	W5, (W1, W7)
COMsp	W14, N2, W13, (W4, W12)
Madison aquifer sites	
FALr	W19, N4
RFsp	(W20, W21, W22, W23, W24, W25, W26, W27), W18[g]
LScr	W18
SPFcr	W18
WCL	W19, N4
RG	USGS 6407500[b]
Tilf	W28
LA88C	W18
Cave drip	
CTD	W17, N4
RmDr	W17, N4
Fractured-rock watershed	
BEVcr	W17, N4

[a] Data from first station listed are used when avaiable, and subsequent stations are used when necessary in the order listed. Arithmetic averages were computed for stations in parentheses, except for site RFsp for which an inverse-distance-weighted average was used.

[b] Streamflow streamgage used to estimate sinking-stream recharge

Supplemental Table 3a. Optimized parameter values for sites with exponential and lognormal IRFs. Parameters are dimensionless unless otherwise specified. [--, not applicable]

Parameter	Description	Period	HCV	LVL	FM1796	Bxr	Dow	Bud	BARsp	COMsp	LA88C	Tilf	RG	RFsp	FALr	WCL[a]
λ	Exponential IRF shape parameter	Wet	--	--	--	0.002	0.004	0.005	0.004	0.002	0.001	0.001	0.003	0.014	0.001	--
a	Exponential IRF curve area	Wet	--	--	--	92.766	123.941	85.919	12.663	38.442	219.898	627.055	21.401	0.058	3.638	--
ω	Lognormal IRF shape parameter	Wet	6.454	5.452	8.782	8.224	--	--	--	--	7.299	6.818	--	6.885	9.274	10.360
ε	Lognormal IRF shape parameter	Wet	1.359	0.363	4.048	0.540	--	--	--	--	0.169	0.379	--	0.759	0.097	3.624
b	Lognormal IRF curve area	Wet	341.416	128.100	1635.499	208.555	--	--	--	--	61.343	295.074		1.364	33.073	574.426
λ	Exponential IRF shape parameter	Dry	--	--	0.000	0.002	0.001	0.003	0.002	0.002	0.004	0.003	0.003	0.013	0.001	--
a	Exponential IRF curve area	Dry	--	--	952.244	92.766	68.607	21.867	10.932	38.442	111.052	142.171	21.401	0.150	0.876	--
ω	Lognormal IRF shape parameter	Dry	6.454	5.452	--	8.224	--	--	--	--	6.117	--	--	6.302	9.317	6.799
ε	Lognormal IRF shape parameter	Dry	1.359	0.363	--	0.540	--	--	--	--	0.227	--	--	0.579	0.037	0.428
b	Lognormal IRF curve area	Dry	341.416	128.100	--	208.555	--	--	--	--	115.831	--	--	0.851	21.436	8.544
c	Soil moisture parameter	--	0.013	0.082	0.020	0.111	0.052	0.050	0.046	0.014	0.022	0.017	--	0.025	0.071	0.051
κ	Soil moisture parameter	--	244.954	19.938	115.919	34.512	217.666	500.000	131.496	291.427	453.650	100.099	--	46.668	0.034	36.545
S_f	Sublimation fraction	--	0.977	0.585	0.475	1.000	1.000	0.300	0.300	1.000	0.710	1.000	--	1.000	1.000	0.800
f	Soil moisture parameter ($°C^{-1}$)	--	0.008	0.998	-0.052	0.608	0.706	0.056	1.000	0.000	0.532	-0.102	--	0.133	0.313	1.000
h_0	Hydraulic-head datum (m)	--	626.838	135.344	156.374	155.384	153.999	170.191	--	--	1084.413	1085.483	320.584	--	--	1089.198
s initial	Initial value of s	--	0.30	0.77	0.00	0.30	0.30	0.30	0.37	0.68	0.30	0.99	0.99	0.93	0.90	0.92
T_s	Snow precipitation threshold (°C)	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_m	Snowmelt threshold (°C)	--	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0

[a]Impulse-response function for sinking-stream recharge also is included, with λ = 0.00015 and ω = 181.

Supplemental Table 3b. Optimized parameter values for sites with only exponential IRFs. Parameters are dimensionless unless otherwise specified. [--, not applicable]

Parameter	Description	Period	LScr	SPFcr	BEVcr
λ	Exponential IRF shape parameter	Wet	0.043	0.234	0.003
a	Exponential IRF curve area	Wet	0.238	6.135	1.648
λ	Exponential IRF shape parameter	Wet	0.001	0.001	0.050
a	Exponential IRF curve area	Wet	6.123	37.885	1.299
λ	Exponential IRF shape parameter	Dry	0.260	0.234	0.149
a	Exponential IRF curve area	Dry	0.060	6.135	0.112
λ	Exponential IRF shape parameter	Dry	0.002	0.001	--
a	Exponential IRF curve area	Dry	5.114	37.885	--
c	Soil moisture parameter	--	0.030	0.019	0.026
κ	Soil moisture parameter	--	7.579	6.281	0.566
S_f	Sublimation fraction	--	0.762	0.273	0.998
f	Soil moisture parameter (°C^{-1})	--	0.188	0.345	0.167
h_0	Hydraulic-head datum (m)	--	--	--	--
s initial	Initial value of s	--	0.30	0.30	0.00
T_s	Snow precipitation threshold (°C)	--	0.0	0.0	0.0
T_m	Snowmelt threshold (°C)	--	9.0	9.0	9.0

Supplemental Table 4. Impulse-response function (IRF) metrics quantified for all sites (dimensionless)

Site	skw-w	skw-d	kurt-w	kurt-d	SDMn-w	SDMn-d	SDMm-w	SDMm-d	MnMm-w	MnMm-d	MdMm-w	MdMm-d	PHA-w	PHA-d	WDA
HCV	3.68	3.68	21.54	21.54	1.40	1.40	0.39	0.39	0.28	0.28	3.8E-02	3.8E-02	3.9E-01	3.9E-01	1.00
LVL	2.11	2.11	10.66	10.66	0.66	0.66	0.29	0.29	0.44	0.44	2.6E-01	2.6E-01	1.2E+00	1.2E+00	1.00
FM1796	1.79	1.74	5.64	6.65	1.28	0.98	0.32	0.32	0.25	0.33	2.6E-03	7.7E-05	8.4E-02	8.4E-02	1.72
Bxr	2.01	2.01	8.50	8.50	1.06	1.06	0.34	0.34	0.32	0.32	9.2E-05	9.2E-05	2.3E-01	2.3E-01	1.00
Dow	1.95	1.90	8.40	7.94	0.99	0.99	0.33	0.33	0.33	0.33	1.3E-03	4.6E-04	1.4E+00	5.0E-01	1.81
Bud	1.96	1.94	8.46	8.33	0.99	0.99	0.33	0.33	0.33	0.33	1.6E-03	1.1E-03	1.8E+00	1.2E+00	3.93
BARsp	1.95	1.93	8.43	8.20	0.99	0.99	0.33	0.33	0.33	0.33	1.5E-03	8.0E-04	1.6E+00	8.7E-01	1.16
COMsp	1.92	1.92	8.10	8.10	0.99	0.99	0.33	0.33	0.33	0.33	6.3E-04	6.3E-04	6.9E-01	6.9E-01	1.00
LA88C	1.37	1.25	5.61	5.72	0.86	0.74	0.32	0.31	0.38	0.42	3.9E-04	1.1E-03	3.6E-01	7.1E-01	1.24
Tilf	2.08	1.94	9.08	8.30	0.93	0.99	0.32	0.33	0.35	0.33	1.4E-01	1.0E-03	2.2E-01	1.1E+00	6.49
RG	1.93	1.93	8.25	8.25	0.99	0.99	0.33	0.33	0.33	0.33	8.9E-04	8.9E-04	9.7E-01	9.7E-01	1.00
RFsp	2.78	2.52	14.41	13.25	1.03	0.98	0.34	0.34	0.34	0.35	1.1E-01	5.6E-04	2.4E-01	7.4E-01	1.42
FALr	0.00	-1.03	3.64	6.38	0.43	0.26	0.25	0.19	0.59	0.72	5.5E-01	7.1E-01	4.2E-02	6.7E-02	1.65
WCL	1.21	3.42	3.53	16.69	0.99	1.59	0.31	0.36	0.31	0.22	1.6E-02	4.9E-02	2.8E-02	7.8E-02	5.65
LScr	1.91	1.93	7.94	8.19	1.03	1.01	0.33	0.33	0.32	0.33	4.3E-04	7.7E-04	1.0E+00	1.9E+00	1.23
SPFcr	1.94	1.94	7.93	7.93	1.15	1.15	0.34	0.34	0.30	0.30	3.1E-04	3.1E-04	1.2E+01	1.2E+01	1.00

Supplemental Table 5. Correlation matrix for metrics. Values are Pearson's rho calculated from log transformed and standardized values (Helsel and Hirsch, 1992)

	skw-w	skw-d	kurt-w	kurt-d	SDMn-w	SDMn-d	SDMm-w	SDMm-d	MnMm-w	MnMm-d	MdMm-w	MdMm-d	PHA-w	PHA-d	WDA	WDD
skw-w	1.00															
skw-d	0.62	1.00														
kurt-w	0.60	0.51	1.00													
kurt-d	0.34	0.92	0.49	1.00												
SDMn-w	0.82	0.62	0.48	0.35	1.00											
SDMn-d	0.85	0.80	0.37	0.53	0.90	1.00										
SDMm-w	0.82	0.61	0.72	0.42	0.90	0.81	1.00									
SDMm-d	0.94	0.76	0.54	0.50	0.92	0.97	0.90	1.00								
MnMm-w	-0.76	-0.58	-0.33	-0.29	-0.98	-0.87	-0.78	-0.86	1.00							
MnMm-d	-0.78	-0.80	-0.26	-0.54	-0.86	-0.99	-0.74	-0.92	0.85	1.00						
MdMm-w	-0.41	0.10	0.08	0.38	-0.51	-0.42	-0.46	-0.43	0.50	0.40	1.00					
MdMm-d	-0.56	0.05	-0.15	0.37	-0.66	-0.47	-0.55	-0.53	0.67	0.43	0.73	1.00				
PHA-w	0.45	-0.01	0.45	-0.17	0.27	0.22	0.44	0.32	-0.17	-0.15	-0.45	-0.34	1.00			
PHA-d	0.46	0.03	0.45	-0.11	0.24	0.24	0.44	0.35	-0.12	-0.16	-0.31	-0.31	0.90	1.00		
WDA	-0.07	0.15	-0.35	0.11	-0.06	0.15	-0.20	0.03	-0.02	-0.22	0.33	0.11	-0.41	-0.26	1.00	
WDD	-0.25	-0.26	-0.42	-0.24	-0.18	-0.17	-0.29	-0.22	0.11	0.14	0.20	-0.04	-0.38	-0.31	0.60	1.00

Supplemental Table 6. Results of principal component analysis showing (a) score values[a] and (b) loading values[b]

a. Score values

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13	PC14	PC15	PC16
HCV	3.779	2.248	-2.850	-0.909	0.808	0.390	-0.547	0.250	-0.327	0.361	0.016	-0.024	-0.003	0.000	0.000	0.000
LVL	-2.039	-0.025	-3.239	0.455	-0.567	-0.496	0.790	-0.644	-0.266	-0.034	-0.095	0.012	-0.006	-0.001	0.000	0.000
FM1796	0.326	0.403	2.648	-1.261	1.037	-0.497	-0.298	-0.961	-0.239	0.075	-0.070	0.020	0.000	0.000	0.000	0.000
Bxr	1.255	-0.784	0.503	-1.917	-0.022	-0.492	0.290	0.697	0.114	-0.343	-0.131	-0.008	-0.019	0.000	0.000	0.000
Dow	0.501	-0.546	0.756	0.521	0.286	0.378	0.123	0.090	-0.420	-0.428	0.193	0.001	0.001	-0.007	0.000	0.000
Bud	0.550	-0.212	0.780	1.578	-0.187	0.008	-0.248	0.433	-0.560	-0.166	-0.203	0.121	0.008	0.003	0.000	0.000
BARsp	0.584	-0.845	0.295	0.400	0.244	0.756	0.194	-0.245	-0.103	-0.242	0.178	-0.110	-0.010	0.007	0.000	0.000
COMsp	0.730	-1.099	-0.287	-0.986	-0.428	-0.430	0.110	0.165	0.050	-0.021	0.083	-0.033	0.021	0.000	0.000	0.000
LA88C	-1.456	-1.670	1.236	-0.034	0.266	0.390	0.651	0.268	-0.001	0.753	0.077	0.103	-0.005	0.000	0.000	0.000
Tilf	-0.144	1.201	0.737	2.037	0.403	-1.210	-0.152	0.286	0.148	0.224	0.074	-0.123	-0.006	0.000	0.000	0.000
RG	0.787	-1.176	-0.508	-0.737	-0.513	-0.373	0.019	0.064	0.054	0.025	0.098	-0.019	0.019	0.002	0.000	0.000
RFsp	1.067	1.124	-0.892	0.639	1.614	0.146	0.229	-0.079	0.704	-0.290	0.000	0.127	0.006	0.000	0.000	0.000
FALr	-9.535	0.468	-0.553	-0.554	0.146	0.251	-0.598	0.182	0.071	-0.070	0.004	-0.010	0.000	0.000	0.000	0.000
WCL	0.575	4.625	1.489	-0.223	-1.804	0.343	0.211	-0.076	0.170	0.000	0.030	0.029	0.000	0.000	0.000	0.000
LScr	0.806	-1.047	0.503	0.477	-0.007	0.822	0.101	-0.086	0.257	0.114	-0.290	-0.164	0.007	-0.002	0.000	0.000
SPFcr	2.262	-2.661	-0.629	0.530	-1.283	0.027	-0.902	-0.315	0.339	0.042	0.036	0.077	-0.012	-0.001	0.000	0.000

b. Loading values

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13	PC14	PC15	PC16
skw-w	0.322	-0.036	-0.005	0.134	0.059	-0.242	0.687	-0.276	-0.200	0.148	-0.127	0.209	-0.020	-0.379	0.014	-0.005
skw-d	0.253	0.350	-0.190	-0.015	-0.141	0.104	0.031	-0.075	0.088	-0.379	-0.236	-0.138	0.716	-0.029	0.004	-0.006
kurt-w	0.209	-0.039	-0.417	0.126	0.551	-0.133	0.011	0.251	-0.198	-0.175	-0.233	-0.432	-0.232	0.128	-0.005	0.003
kurt-d	0.160	0.418	-0.324	-0.043	-0.052	0.272	-0.047	0.096	0.198	-0.158	-0.187	0.551	-0.449	-0.026	-0.001	0.003
SDMn-w	0.331	0.013	0.134	-0.112	0.164	0.020	-0.347	-0.152	-0.118	0.204	-0.079	0.076	0.041	-0.029	0.693	-0.372
SDMn-d	0.331	0.133	0.103	0.018	-0.203	0.021	0.075	0.007	0.075	-0.010	0.247	-0.243	-0.172	0.111	0.375	0.711
SDMm-w	0.328	-0.051	-0.063	0.001	0.245	0.197	-0.152	0.478	0.013	0.341	0.353	0.162	0.283	-0.353	-0.221	0.119
SDMm-d	0.344	0.065	0.039	0.055	-0.030	-0.008	0.252	0.044	0.020	0.191	0.229	0.115	0.073	0.773	-0.175	-0.265
MnMm-w	-0.309	-0.043	-0.218	0.158	-0.113	0.066	0.414	0.439	0.172	-0.124	0.280	-0.028	0.065	-0.060	0.496	-0.266
MnMm-d	-0.313	-0.172	-0.140	0.006	0.303	-0.038	0.036	0.017	-0.106	0.134	-0.252	0.457	0.327	0.309	0.229	0.448
MdMm-w	-0.168	0.351	-0.292	0.276	0.280	-0.316	-0.171	-0.436	0.176	0.046	0.500	0.036	0.052	-0.046	0.001	0.000
MdMm-d	-0.201	0.280	-0.368	0.039	-0.298	0.298	0.012	-0.076	-0.453	0.542	-0.079	-0.236	-0.001	0.010	0.000	0.000
PHA-w	0.148	-0.414	-0.205	0.340	-0.216	0.206	-0.184	-0.160	-0.468	-0.405	0.272	0.209	-0.004	0.019	-0.001	0.000
PHA-d	0.145	-0.356	-0.208	0.510	-0.220	0.001	-0.142	-0.077	0.534	0.297	-0.308	-0.081	0.007	-0.003	0.000	0.000
WDA	-0.033	0.347	0.320	0.521	-0.176	-0.417	-0.188	0.387	-0.267	-0.011	-0.163	0.128	0.011	-0.002	0.000	0.000
WDD	-0.110	0.157	0.419	0.445	0.379	0.623	0.146	-0.148	0.032	-0.048	-0.044	-0.093	-0.016	0.005	0.000	0.000

[a]Score values are the plotting positions of the sites in principal component space (Davis, 2002)

[b]Loading values are the plotting positions of the metrics in principal component space (Davis, 2002)