Comparison of Computed and Measured Reservoir Evaporation in the Lower Colorado River Basin in Texas

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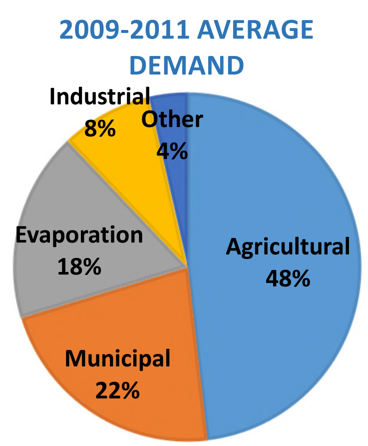
Background

- The lower Colorado River in Texas supplies water for municipal, industrial and agricultural users, and environmental flows for the river and Matagorda Bay.
- LCRA operates six lakes – known as the Highland Lakes – along the Colorado River upstream of Austin.
- Over 1.2 million people and 71,000 acres of agricultural productions rely on the lakes and river for water supply.
- Downstream of Austin, LCRA is constructing the Lane City Reservoir and planning a second off-channel reservoir – the Prairie Conservation Reservoir
- Water loss to evaporation represents a significant loss of water storage.
- LCRA maintains four evaporation pan stations with decades of daily observations..
- Typical gross evaporation ranges from 71 inches in the upper watershed to 55 inches in the lower watershed.
- While computational methods often are used in the region for evapotranspiration estimation, there is no history of use for reservoir evaporation.



Approach

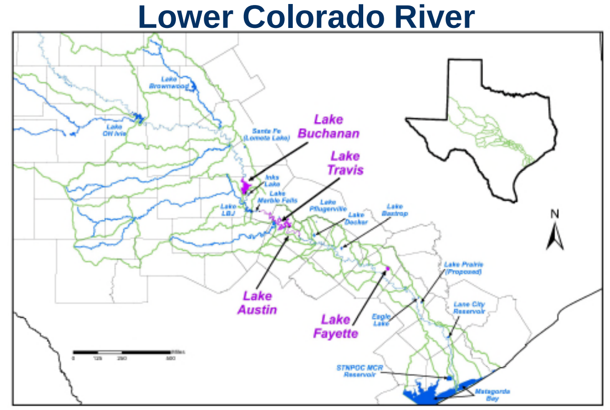
- LCRA began continuous daily computational evaporation measurement in 2015.
- LCRA evaluates both daily Penman-Monteith and hourly Van Bavel methods.
- LCRA's Hydromet and the National Weather Service provide real-time climatic data.
- Real-time water surface temperature data is sparse, but good relationships can be established from 60 days of air temperature data.
- LCRA automates data acquisition and daily computation online using Google sheets, scripts and timers.

Daily Computation of Reservoir Evaporation Rate Using Penman-Monteith Method for Jan. 9, 2017

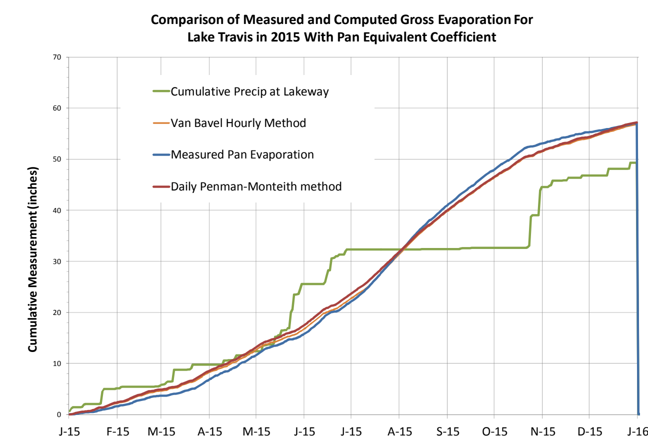
Reservoir	Water Surface Elev. (ft-msl)	Water Surface Elev. (m-msl)	Lattitude(degrees)	Lat	Longitude (degrees)	Date	Elevation (ft-msl)	AirTemp Max (C)	AirTemp Min (C)	AirTemp Avg (C)	RH Max (%)	RH Min (%)	RH Avg (%)	BP Avg (mb)	Wind Speed Avg (m/s)	Precip Total (mm)	Solar Radiation MJ/day)	Water Temp Avg (C)
Travis	682.8	208	30.416	0.53086	-97.882	1/9/2017	682.8	9.58	-5.68	1.74	57	19	39	1029	0.9	0.0	0	15.00
Buchanan	1018.0	310	30.789	0.53737	-98.413	1/9/2017	1018.0	9.44	-7.22	1.39	74	18	47	1028	2.0	0.0	0	11.40
Brownwood	1424.7	434	31.857	0.55601	-99.029	1/9/2017	1424.7	10.00	-7.78	1.45	86	19	48	1026	2.0	0.0	0	11.40
O H Ivie	1517.5	463	31.512	0.55000	-99.678	1/9/2017	1517.5	10.00	-7.78	1.45	86	19	48	1026	2.0	0.0	0	11.40
Lometa	1391.0	424	31.229	0.54504	-98.420	1/9/2017	1391.0	10.00	-6.67	1.64	76	21	47	1027	0.1	0.0	0	11.40
Inks	887.3	270	30.731	0.53636	-98.385	1/9/2017	887.3	9.44	-7.22	1.39	74	18	47	1028	2.0	0.0	0	13.70
LBJ	820.7	250	30.556	0.53331	-98.352	1/9/2017	820.7	9.44	-7.22	1.39	99	19	54	1028	2.0	0.0	0	13.50
Marble Falls	736.3	224	30.557	0.53331	-98.256	1/9/2017	736.3	10.35	-6.52	2.15	99	19	54	1028	2.0	0.0	0	15.70
Austin	485.9	148	30.294	0.52873	-97.786	1/9/2017	485.9	10.56	-6.42	1.43	89	16	52	1029	0.9	0.0	0	15.60
LadyBird	427.0	130	30.267	0.52826	-97.759	1/9/2017	427.0	10.56	-6.42	1.43	89	16	52	1029	0.9	0.0	0	15.00
Decker	530.0	162	30.285	0.52857	-97.598	1/9/2017	530.0	11.11	-8.33	2.18	88	17	48	1029	2.2	0.0	0	6.65
Pflugerville	650.0	198	30.439	0.53126	-97.571	1/9/2017	650.0	11.11	-8.33	2.18	88	17	48	1029	2.2	0.0	0	15.00
Lk Bastrop	450.0	137	30.155	0.52631	-97.292	1/9/2017	450.0	11.11	-8.33	2.18	88	17	48	1029	2.2	0.0	0.00	19.20
Lk Fayette	394.0	120	29.929	0.52237	-96.738	1/9/2017	394.0	12.22	-6.67	3.32	92	35	67	1029	0.8	0.0	0.00	22.30
Eagle Lake	170.0	52	29.556	0.51585	-96.340	1/9/2017	170.0	11.67	-6.11	3.10	88	30	64	1030	1.2	0.0	0.00	15.00
Prairie	174.0	53	29.574	0.51617	-96.390	1/9/2017	174.0	11.67	-6.11	3.10	88	30	64	1030	1.2	0.0	0.00	15.00
Lane City	108.5	33	29.193	0.50951	-96.070	1/9/2017	108.5	12.78	-5.56	3.69	88	30	64	1030	1.2	0.0	0.00	15.00

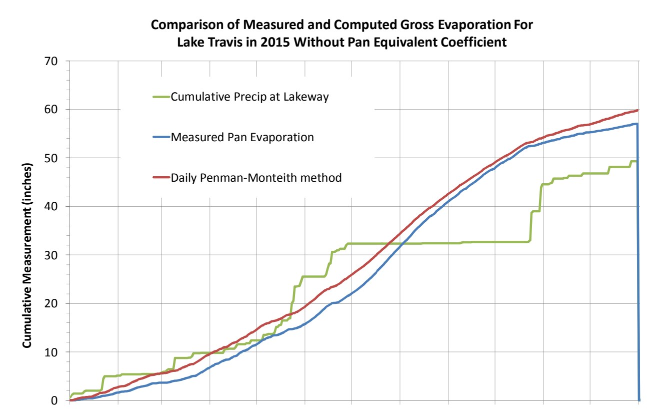
Reservoir	Julian date	InverseE-S dist	Solar Declination	sunset hour angle	Extraterrestrial Rad (MJ/m2/day)	Clear Sky rad (MJ/m2/day)	Latent heat of vaporization (MJ/kg)	Psychrometric const (kPac/C)	Sat Vapor Pressure (kPA)	Slope of eo (kPa/C)	Act Vapor P (kPa)	Vapor P deficit (kPa)	Net longwave (MJ/m2/day)	Calculated Net Rad w/albedo (MJ/m2/day)	F1p	F2p	PET with calculated net radiation (mm/day)	Gross evaporation (inches)	Net Evap (inches)
Travis	9	1.03	-0.39	1.33	20.27	15.29	2.47	0.07	0.80	0.05	0.23	0.57	-2.70	2.70	0.42	2.23	1.22	0.05	0.05
Buchanan	9	1.03	-0.39	1.33	20.04	15.16	2.47	0.07	0.77	0.05	0.24	0.53	-2.65	2.65	0.42	3.16	1.45	0.06	0.06
Brownwood	9	1.03	-0.39	1.32	19.40	14.72	2.47	0.07	0.78	0.05	0.26	0.52	-2.62	2.62	0.42	3.14	1.43	0.06	0.06
O H Ivie	9	1.03	-0.39	1.32	19.61	14.89	2.47	0.07	0.78	0.05	0.26	0.52	-2.62	2.62	0.42	3.14	1.43	0.06	0.06
Lometa	9	1.03	-0.39	1.32	19.78	15.00	2.47	0.07	0.80	0.05	0.27	0.53	-2.63	2.63	0.42	1.55	0.94	0.04	0.04
Inks	9	1.03	-0.39	1.33	20.08	15.17	2.47	0.07	0.77	0.05	0.24	0.53	-2.65	2.65	0.42	3.17	1.46	0.06	0.06
LBJ	9	1.03	-0.39	1.33	20.18	15.24	2.47	0.07	0.77	0.05	0.29	0.48	-2.59	2.59	0.42	3.17	1.35	0.05	0.05
Marble Falls	9	1.03	-0.39	1.33	20.18	15.23	2.46	0.07	0.82	0.05	0.31	0.51	-2.60	2.60	0.43	3.11	1.41	0.06	0.06
Austin	9	1.03	-0.39	1.33	20.34	15.32	2.46	0.07	0.83	0.05	0.27	0.56	-2.65	2.65	0.42	2.25	1.20	0.05	0.05
LadyBird	9	1.03	-0.39	1.33	20.36	15.32	2.47	0.07	0.83	0.05	0.27	0.56	-2.65	2.65	0.42	2.25	1.20	0.05	0.05
Decker	9	1.03	-0.39	1.33	20.35	15.33	2.49	0.07	0.82	0.05	0.26	0.57	-2.64	2.64	0.43	3.24	1.56	0.06	0.06
Pflugerville	9	1.03	-0.39	1.33	20.25	15.27	2.47	0.07	0.82	0.05	0.26	0.57	-2.64	2.64	0.43	3.27	1.58	0.06	0.06
Lk Bastrop	9	1.03	-0.39	1.33	20.42	15.37	2.46	0.07	0.82	0.05	0.26	0.57	-2.64	2.64	0.43	3.29	1.58	0.06	0.06
Lk Fayette	9	1.03	-0.39	1.33	20.56	15.47	2.45	0.07	0.90	0.05	0.42	0.48	-2.50	2.50	0.44	2.11	1.06	0.04	0.04
Eagle Lake	9	1.03	-0.39	1.34	20.78	15.61	2.47	0.07	0.88	0.05	0.38	0.50	-2.54	2.54	0.44	2.39	1.18	0.05	0.05
Prairie	9	1.03	-0.39	1.34	20.77	15.60	2.47	0.07	0.88	0.05	0.38	0.50	-2.54	2.54	0.44	2.39	1.18	0.05	0.05
Lane City	9	1.03	-0.39	1.34	21.00	15.76	2.47	0.07	0.94	0.06	0.40	0.54	-2.55	2.55	0.45	2.35	1.23	0.05	0.05

Water Bodies on the Lower Colorado River



Lake Austin Evaporation Pan





Seasonal Pan Equivalent Coefficients

Period	Travis Coefficients	Buchanan Coefficients
Jan. 1 to July 31	0.6	0.6
Aug. 1 to Nov. 15	1.0	1.0
Nov. 16 to Dec. 31	1.0	0.8

Findings

i. The daily Penman-Monteith and hourly Van Bavel methods produced nearly identical results.
ii. Pan evaporation measurements can be replicated using the Penman-Monteith method with a seasonal pan equivalent coefficient.
iii. The pan equivalent coefficient is stable across years and reservoirs.
iv. It is unclear if the pan methods are under evaluating evaporation or the computation methods are overestimating evaporation.
v. Differences without the coefficient adjustment are mostly in the months of January to July, and amount to a 5 percent annual increase at Lake Travis and a 12 percent increase at Lake Buchanan.
vi. Evaluation with eddy covariance methods in 2017 will provide additional data to validate the use of computation or pan methods in the future.
vii. Over time, adoption of computation methods would reduce operating costs.

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