Enhancing reservoir evaporation loss estimates: *a multi-pronged approach to monitor surface water evaporation in Texas**

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AMS Annual Meeting, Boston, MA
15 January 2020

**Unless specifically noted, this presentation does not necessarily reflect official Board positions or decisions.*

Outline

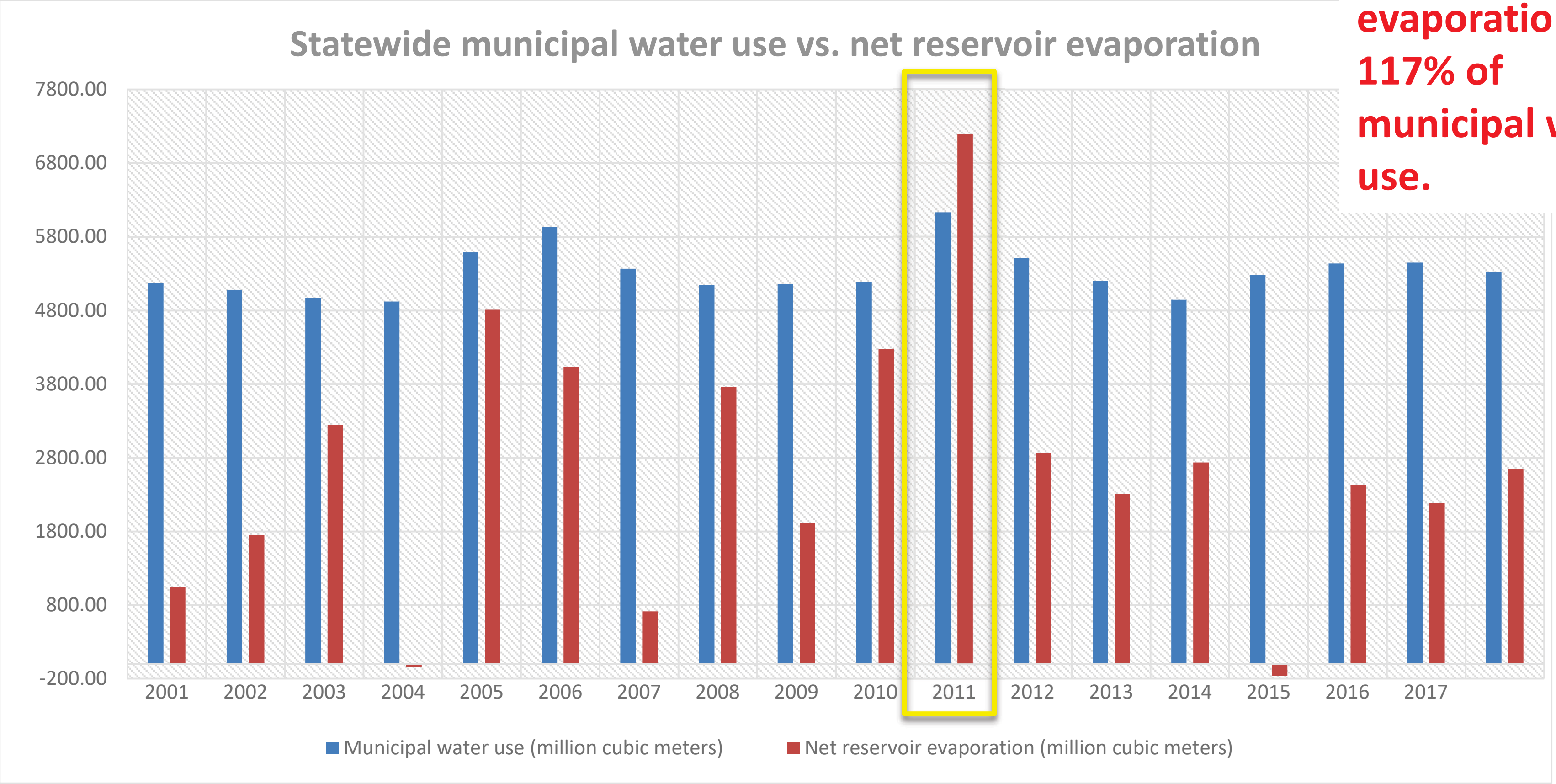
- Why monitor reservoir evaporation?
- Current monitoring network and challenges
- Planned enhancements to monitoring network
- Long-term evaporation monitoring plan
- Questions

Why monitor reservoir evaporation?

"…, in dry periods, when water supplies are already reduced, evaporation rates are higher and the effect of the evaporation loss becomes a significant item in any Texas water-supply analysis."

- Bulletin 6006, Texas Board of Water Engineers, May 1960

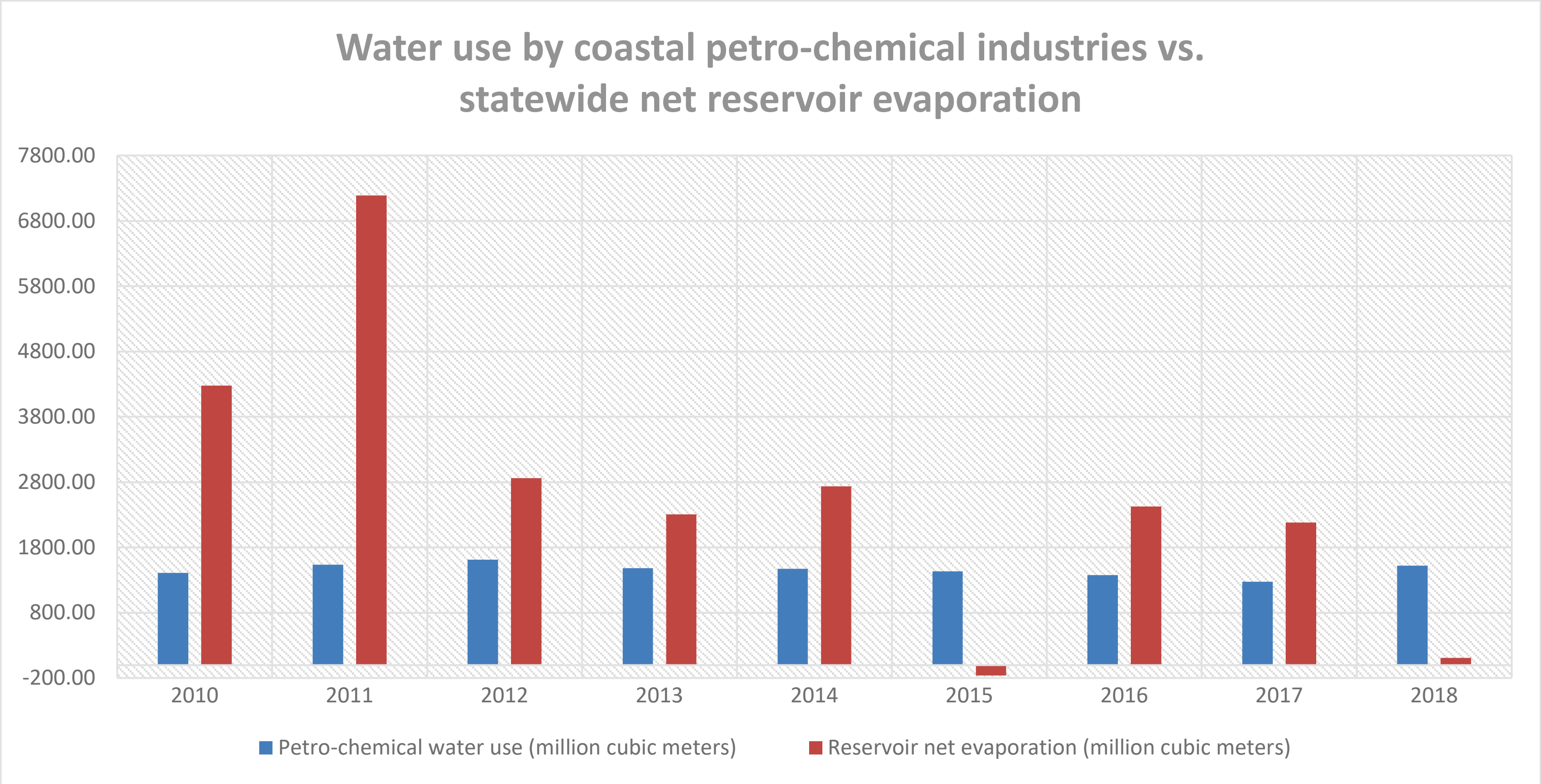
Evaporative loss and water use



Net reservoir evaporation was 117% of municipal water use.

Reservoir evaporative water loss (188 reservoirs, TWDB internal report) vs. statewide municipal water use data (http://www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/data/2017TexasWaterUseEstimatesSummary.pdf?d=7692.909999983385)

Coastal petro-chemical industry: *surface water use*



- Average statewide net reservoir evaporation (2010–2018): 2660 million m^3
- Average annual (2010–2018) surface water diversions (use) by petro-chemical industries on the Texas energy coast: ~1460 million m^3. (~50% of evap. loss!)

Statutory requirements and data use

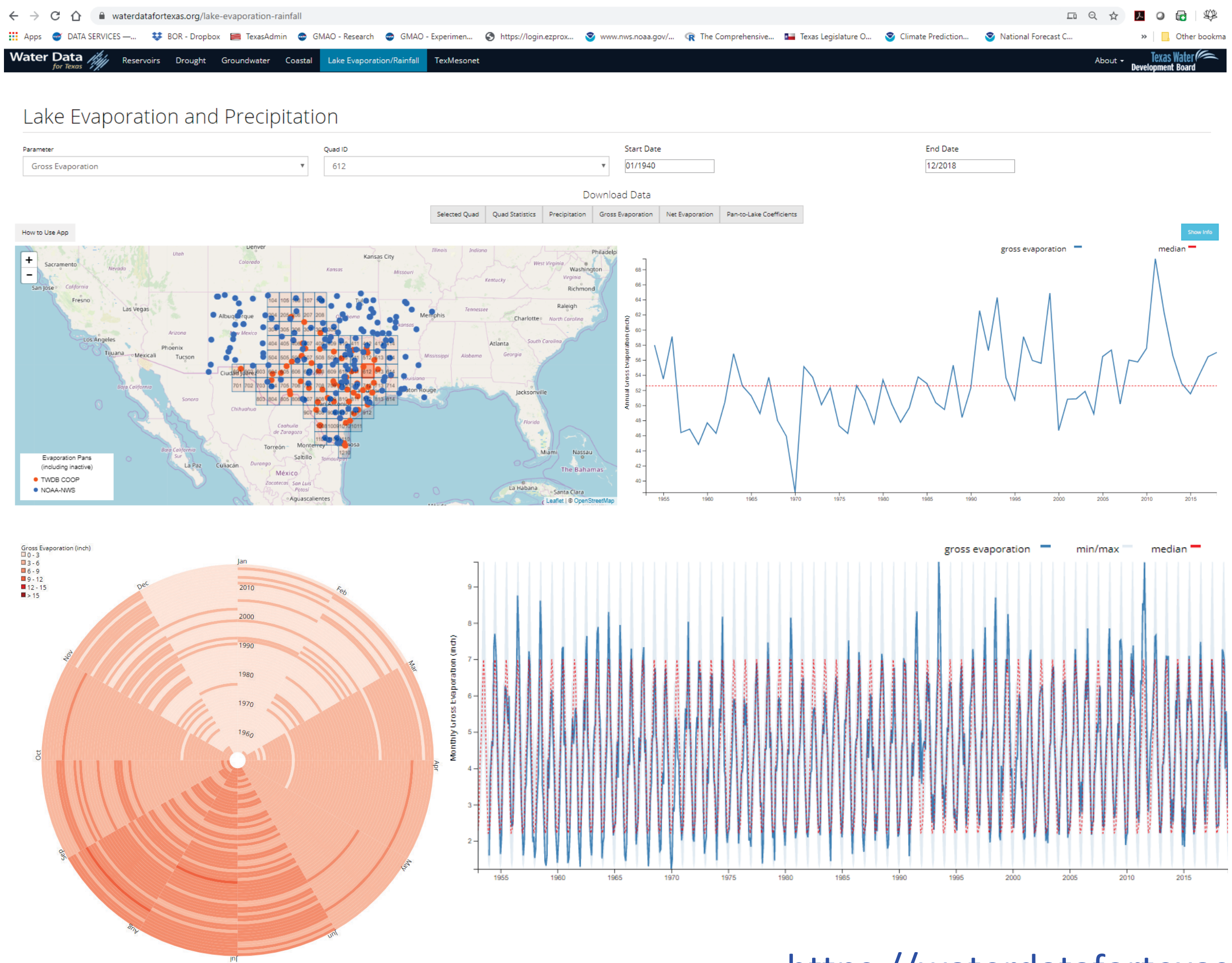
Relevant statutes

- **Texas Water Code (TWC) 16.012** – studies, investigations, surveys
- **TWC 16.051 and TWC 16.053** – state and regional water planning

Data application

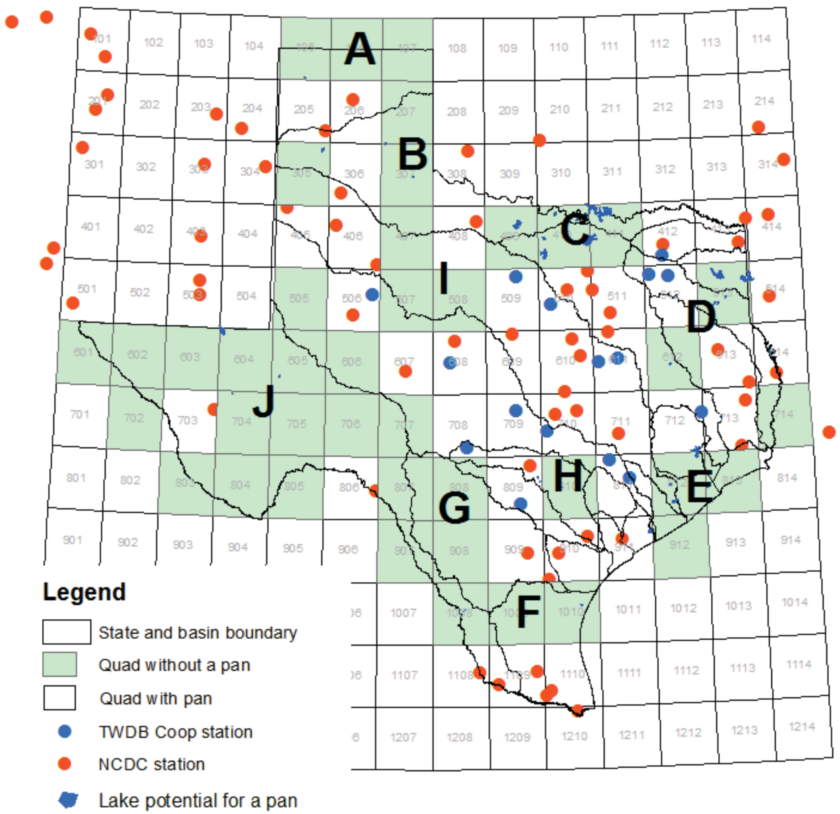
- Texas Water Availability Models (.EVA input file)
  - Water rights permitting
  - Regional water planning (50-year water availability assessment)
- Specialized studies
  - Feasibility of lake evaporation suppression – Lake Arrowhead (2014–2015)
  - Statewide evaporative water loss
- Engineering designs and Reservoir operation

Reservoir evaporation data provision



https://waterdatafortexas.org/lake-evaporation-rainfall

Current monitoring network and challenges

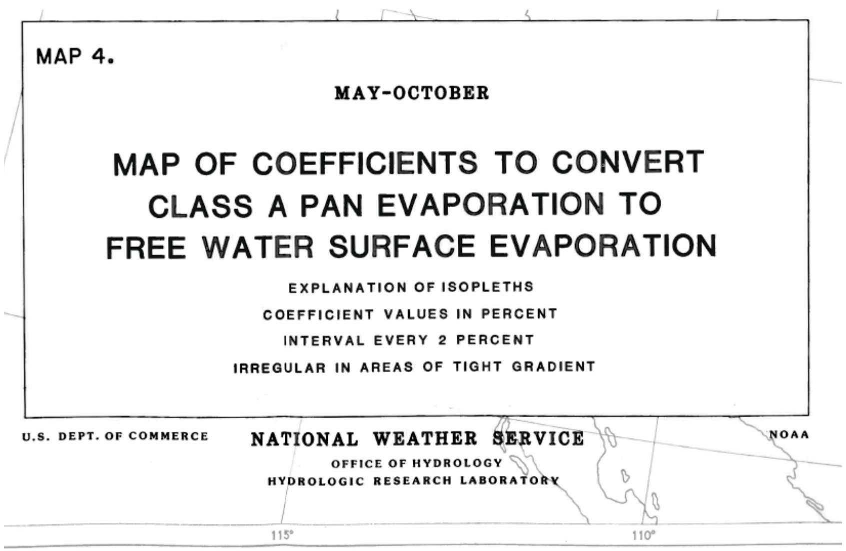


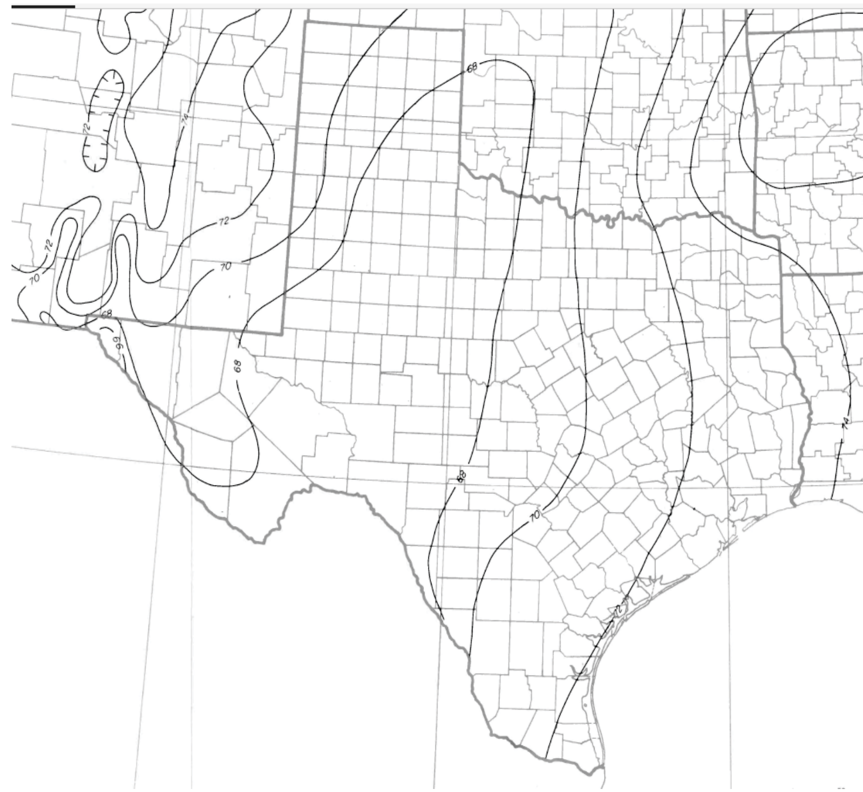
Based on 2018 data:

- 18 TWDB coop sites
- 82 NCEI/NWS sites

Challenge: pan-to-lake coefficients

- Coefficients are based on a few isopleths of mean seasonal evaporation over Texas
- Season: May–October





Uncertainty in evaporation estimates

Causes

- Technology used (i.e., Class A pans)
- Gaps in spatial coverage
- Issues with QA/QC of the NCEI data
- Spatial data interpolation

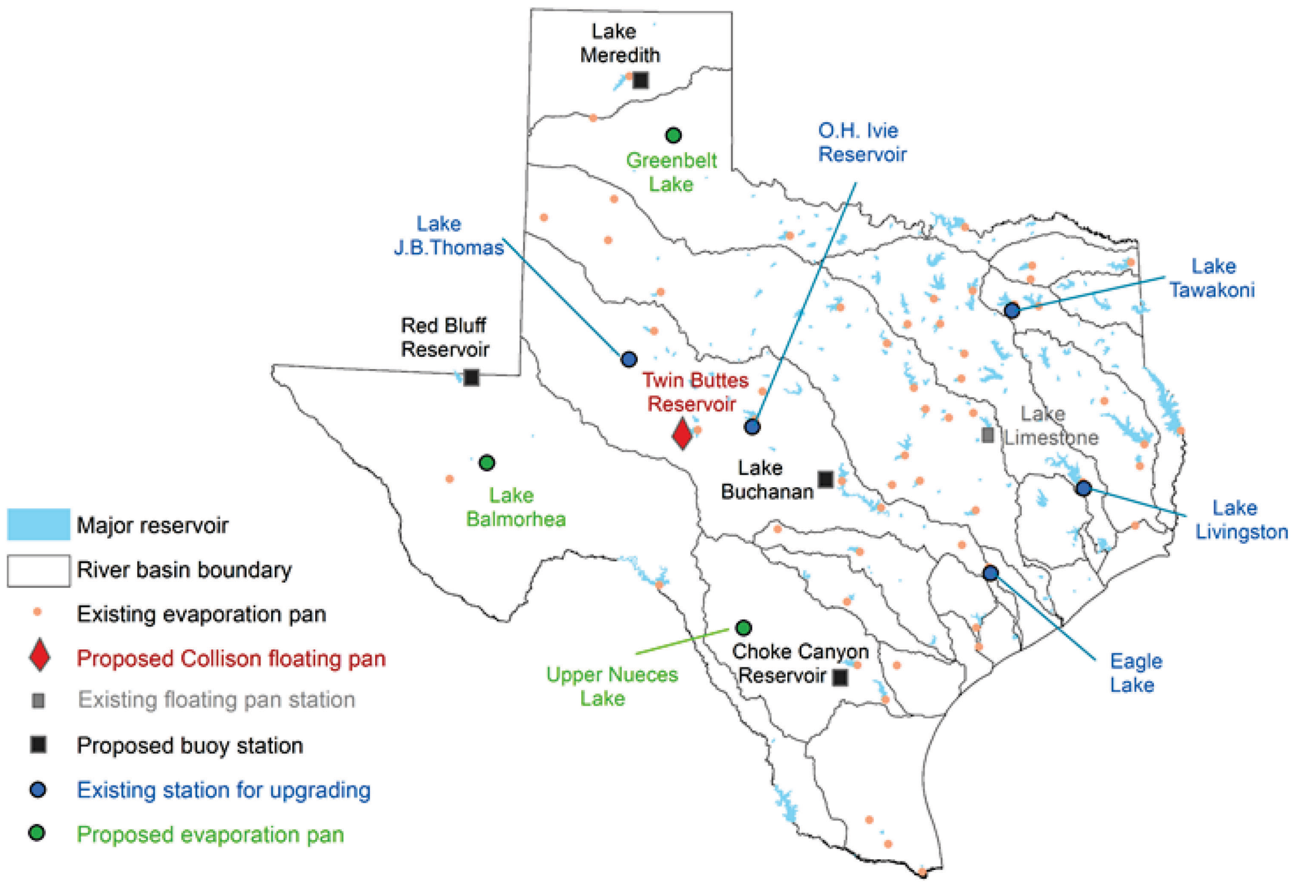
Implication

- Estimates of water availability included in regional and state water plans have large uncertainty.

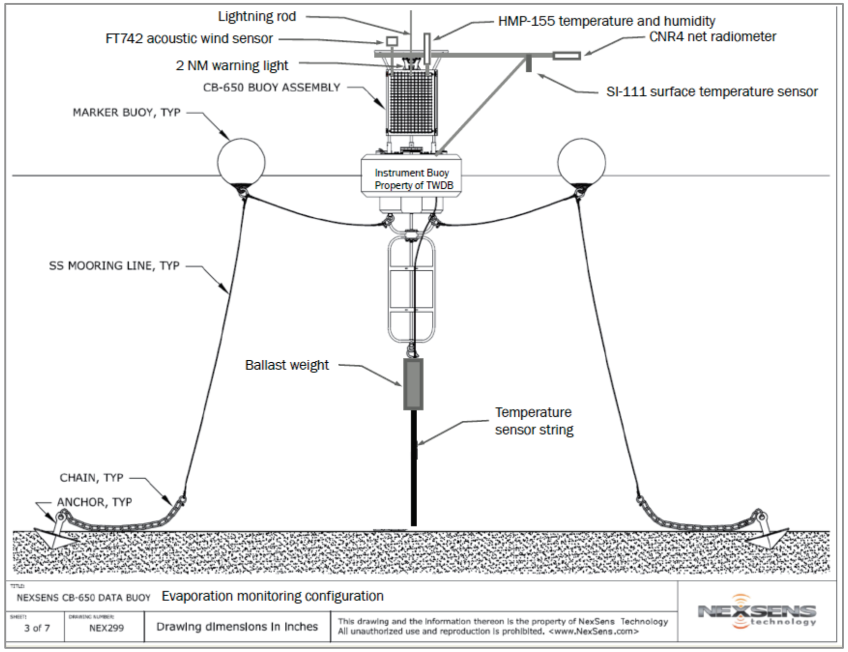
Planned enhancements to network (2020–2022)

- Directly measure open water evaporation
  - 4 buoy stations *(Desert Research Institute)*
  - 1 Collison Floating Evaporation Pan *(Agua del Sol Consultants, LLC)*
- QC buoys with floating pan stations and floating eddy covariance station
- Upgrade and improve existing network of Class A pans
- Install new Class A pans in monitoring "holes"
- Develop new pan-to-lake coefficients
- Compute reservoir evaporation from meteorological data at Class A pans and TexMesonet (www.texmesonet.org) sites
- Provide near real-time evaporative loss estimates for monitored reservoirs and provide data at http://www.waterdatafortexas.org/reservoirs/statewide

Planned enhancements to network: *cont.*



Buoy stations: *configuration and locations*



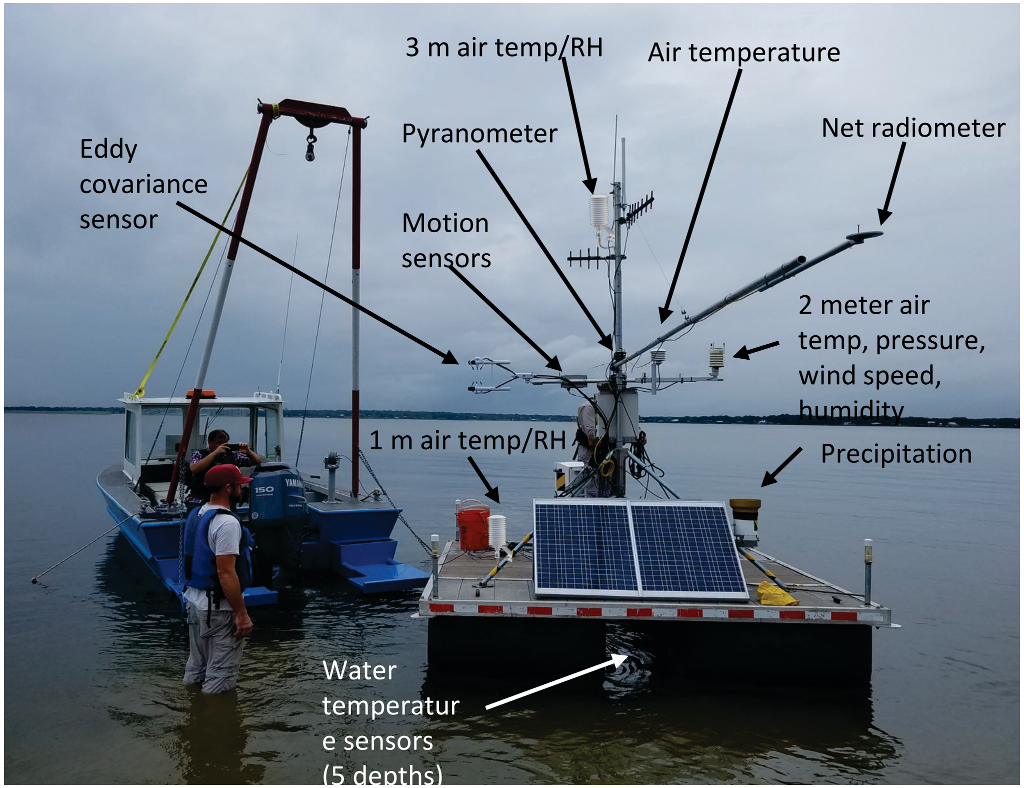
Data

- Air temperature/humidity
- Wind speed/direction
- Net radiation
- Barometric pressure
- Water surface temperature
- Water column temperature

Locations

- Lake Meredith (Canadian, *USBR*)
- Lake Buchanan (Lower Colorado, *LCRA*)
- Red Bluff Reservoir (Pecos, *Red Bluff Water Power Control District*)
- Choke Canyon (Nueces, *USBR*)

QC for open water evaporation



Deployment

- Collison Floating Evaporation Pan at Twin Buttes (USBR) reservoir
  - Quarterly flux chamber measurements
  - Meteorological instrumentation
- Eddy covariance system (left) at rotating locations
  - Lake Limestone (Brazos, *BRA*) current deployment

Long-term evaporation monitoring plan

- Add in a few more buoy stations to capture hydroclimatic and topographic variability.
- Maintain new buoy stations to obtain a 5-year minimum data record.
- Continue partnership with the OpenET network > provide *in-situ* buoy data to measure lake energy balance and validate remotely-sensed lake temperature estimates.
- Compute evaporation using TexMesonet observations and meteorological data from Class A pan sites.
- Collaborate with NASA-JPL to utilized SWOT hydrology products to estimate evaporation from unmonitored reservoirs.
- Develop a finer resolution gridded near real-time reservoir evaporation dataset for the state.

Acknowledgements

- Sincere thanks to TWDB cooperators for data sharing over the years.
- U.S. Department of the Interior – Bureau of Reclamation/Drought Response Program (R19AP00112, FY 2019)

Questions?

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Additional slides

Evaporation data collection over the years

TEXAS BOARD OF WATER ENGINEERS

Durwood Manford, Chairman
R. M. Dixon, Member
O. F. Dent, Member

BULLETIN 6006

MONTHLY RESERVOIR EVAPORATION RATES
FOR TEXAS
1940 THROUGH 1957

Prepared by
The late Robert L. Lowry, Jr.
Consulting Surface Water Hydrologist
for
Texas Board of Water Engineers

May, 1960

Price $1.25

(To Those Not Entitled to Free Distribution)
Those entitled to free distribution are governmental agencies and officials.

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Bulletin 787 *November 1954*

Water Evaporation Studies In Texas

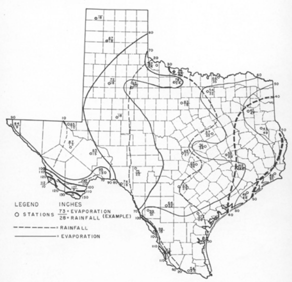


Diagram showing the relationship and comparison of evaporation losses from free-water surfaces and rainfall in Texas.

in cooperation with the
TEXAS BOARD OF WATER ENGINEERS
and the
U. S. DEPARTMENT OF AGRICULTURE

TEXAS AGRICULTURAL EXPERIMENT STATION - - - TEXAS AGRICULTURAL EXTENSION SERVICE
College Station, Texas

TEXAS WATER DEVELOPMENT BOARD

REPORT 64

MONTHLY RESERVOIR EVAPORATION RATES
FOR TEXAS
1940 THROUGH 1965

By
John W. Kane

Revised edition of Texas Board of Water Engineers Bulletin 6006, May 1960, with evaporation rates for 1958 through 1965 added

TEXAS WATER DEVELOPMENT BOARD

REPORT 192

EVAPORATION DATA IN TEXAS

Compilation Report
January 1907–December 1970

By
John P. Dougherty

June 1975

1907: first pan evaporation station in Amarillo operated by the USDA

1928: first COOP station

1954 about 44 stations in 1954 (various pans)

1954: National Weather Service Class A Pan adopted as standard in Texas

1960: publication of 1º x 1 º quadrangular evaporation dataset for 1940–1957, and first statewide annual lake evaporation map.

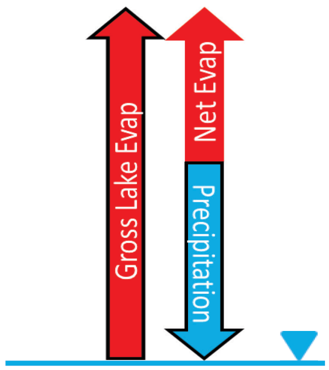
1967: Report 64 on Monthly Reservoir Evaporation Rates for Texas from 1940 through 1965.

1975: Report 192 on Evaporation data in Texas: Compilation Report from January 1907– December 1970.

Statewide lake evaporation loss

- Statewide lake evaporation loss = sum of evaporative loss for all lakes
- For each monitored lake in each month,

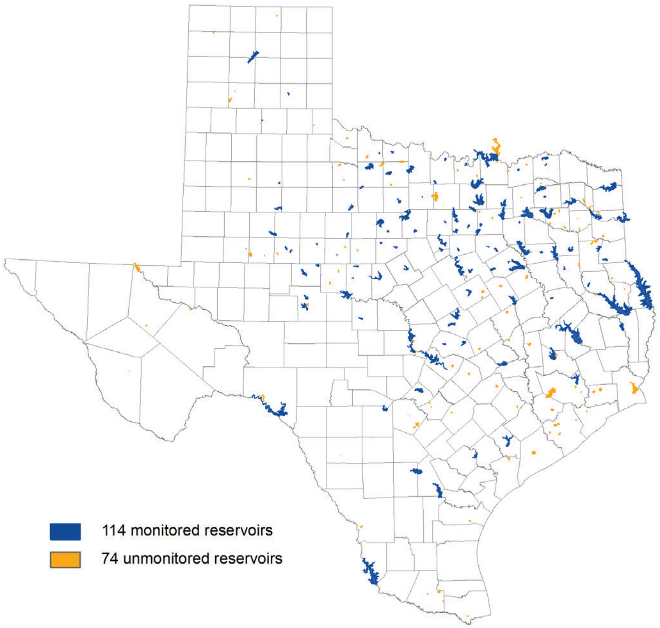
  Volume of Gross Evap. (GE) = GE rate * Surface Area



- Algorithm:
  - Year loop (2001 – 2017)
    - Month loop (1 – 12)
      - Reservoir loop (114 Reservoirs)
        1. Retrieve mean daily water level (WL) -> mean monthly WL -> mean monthly water surface area
        2. Retrieve lake evaporation rate for each month
        3. Retrieve precipitation rate for each month
        4. Compute gross and net lake evaporation losses for each month for each lake

Annual evaporative loss: *188 water supply reservoirs including those monitored*

Number of Reservoirs	Method	Type	Average Annual	Minimum Annual	Maximum Annual
114	computed	gross	6.89	5.85 (2013)	7.96 (2015)
		net	2.02	gain 0.12 (2015)	5.42 (2011)
188	estimated*	gross	7.41	6.29	8.56
		net	2.17	-0.13	5.83



(million acre feet per year)
*Calculated from 114 Reservoir's losses by dividing by 0.93

On average, approximate 6.17 million acre-feet net loss from all state water bodies