Calibrating Water Budgeting Procedures for Non-Tidal Mitigation Wetlands in Virginia

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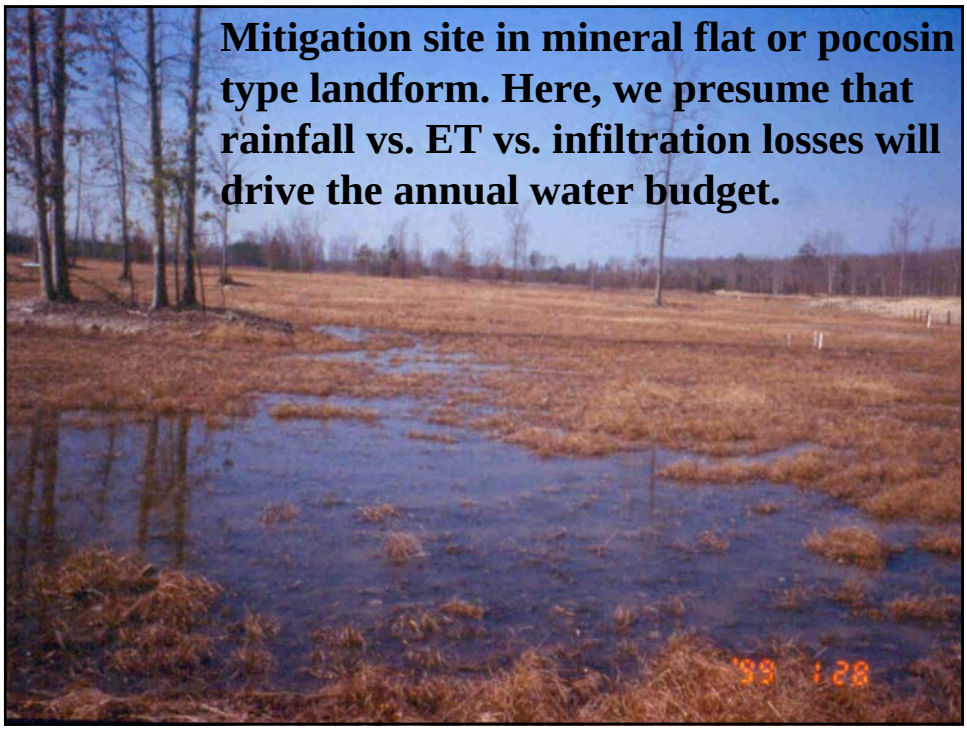


Non-tidal forested mitigation site under construction in early 1990's.

General Research Goals

Evaluate a wide range of proposed and recently constructed mitigation sites with respect to water budgeting procedures vs. observed on-site conditions.

Recommend optimal procedures and necessary adjustments to VDOT for future utilization.

Mitigation Water Budgeting

- Wide variation in water budgeting approaches among agencies and consultants
- Many agencies follow and/or recommend variations of the "Pierce Approach" whereby ground water flux is presumed minimal, ET is estimated via Thornthwaite, runoff additions are estimated via SCS Runoff Curves, and water is presumed to be detained over the site via a berm and water level is controlled via an outlet, etc.

Mitigation Water Budgeting

- Rigorous application of this approach does allow for positive/negative ground water flux when sufficient data (2 yr?) are gathered on-site on both ground water level and aquifer characteristics.
- Frequently, designers (1) prescribe a compacted "perching zone" to limit flux to/from the system or (2) assume any net groundwater inputs just make their budgeting "more conservative".

Specific Research Objectives

- **Determine the actual water budget for a non-tidal mitigation site in eastern Virginia**
- **Compare actual water budget data to that used conventionally by VDOT for mitigation planning**

Detailed Study Sites and Reports

Chisman Lakes/Sandy Bottom:

Study of borrow pit area in Hampton, VA

Whittecar and Daniels, 1999*, in Geomorphology*.

Manassas Airport:

Study of existing wetland slated for "expansion"

Fomchenko, 1998, *Va. Tech. M.S. thesis.*

Fort Lee:

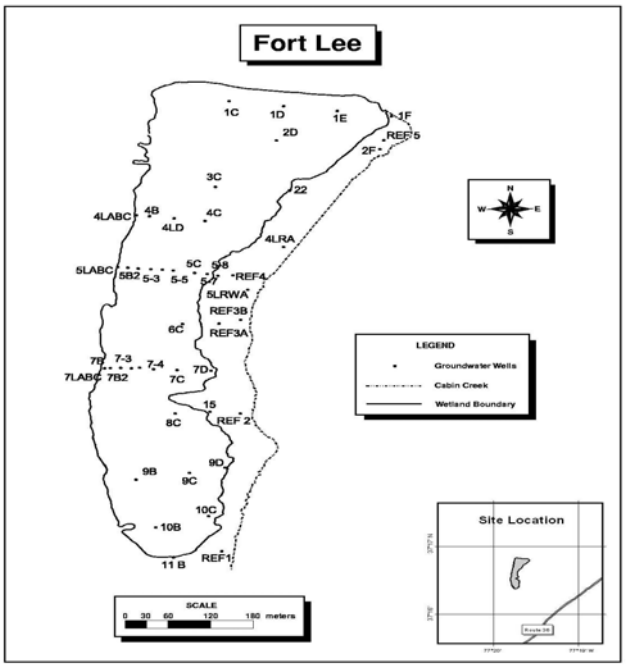
Study reported here; *available as VTRC 01-CR1, August 2000, Evaluation of Methods to Calculate a Wetlands Water Balance. VTRC, Charlottesville.*

Manassas Airport site. Surface water driven system in Triassic. Summary results are also in VTRC report cited earlier.

Fort Lee Mitigation Site

- Constructed in 1991 via excavation of up to 4 m of upland Coastal Plain soils down to presumed “winter high water table”
- Site received approximately 1 foot of upland topsoil
- Approximately 14 ha in size; primarily designed for compensation of forested wetlands

Fort Lee mitigation site in 1994.

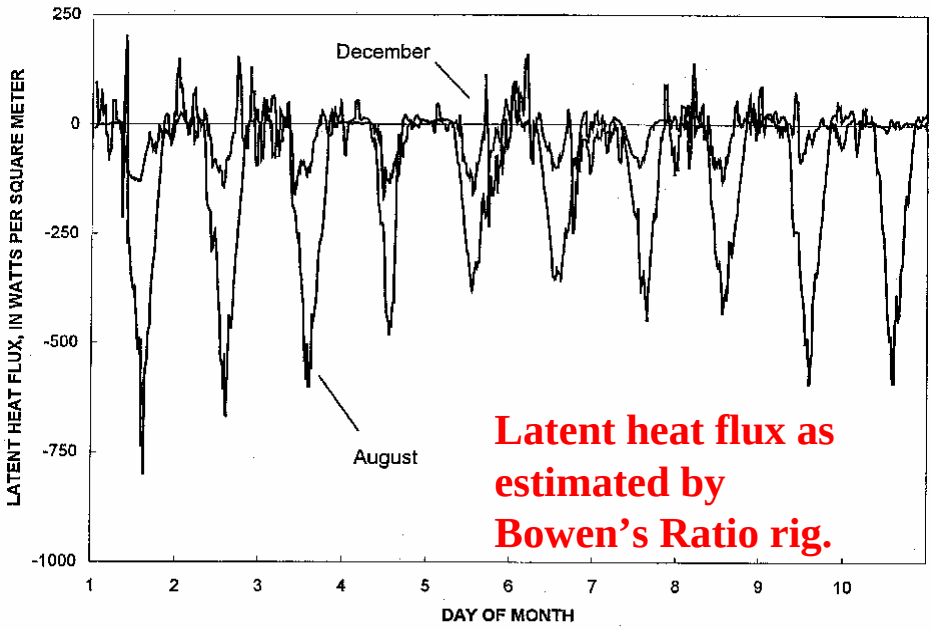


Monitoring Array and Estimation Methods

- **Precipitation** – tipping bucket rain gauge
- **Runoff Additions** – Flows were too low to allow for culvert gauge; SCS Runoff Curve
- **Runoff Losses** – All water above "full pond" was presumed to be lost via limited channel and sheet flow
- **ET** – Bowen Ratio for majority; Blaney-Criddle for "bird-pecked" months.

Bowen's Ratio rig at Fort Lee.

For a cool 20 K $, you can play around with one of these too!



Latent heat flux as estimated by Bowen's Ratio rig.

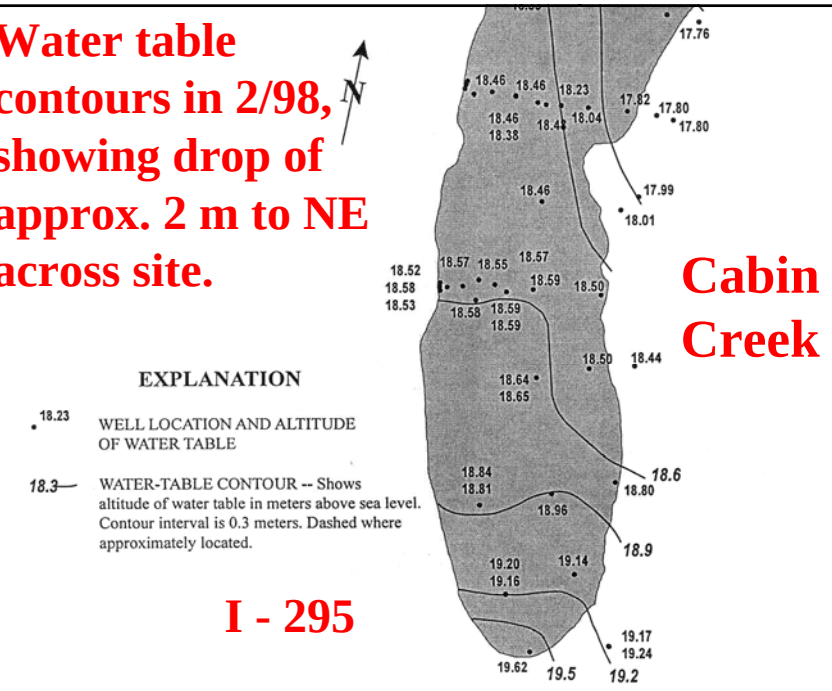
Figure 11. -- Running average (four, fifteen-minute values) of the latent heat flux (negative is toward land surface) at the Fort Lee created wetland, August 1 through 10, 1997, and December 1 through 10, 1997.

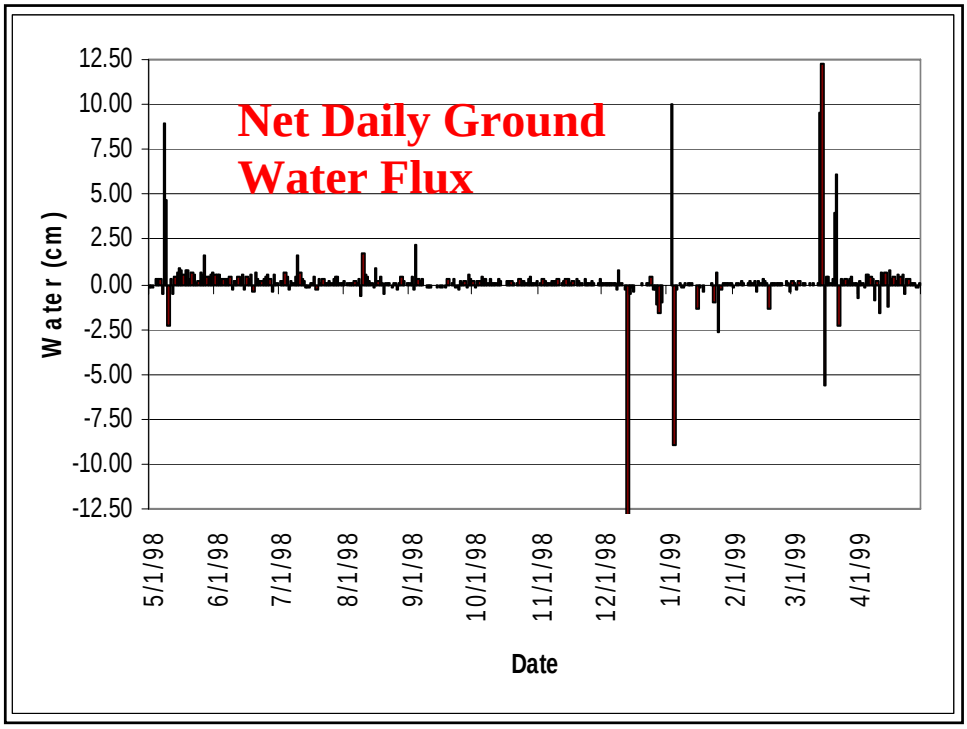
Monitoring Methods

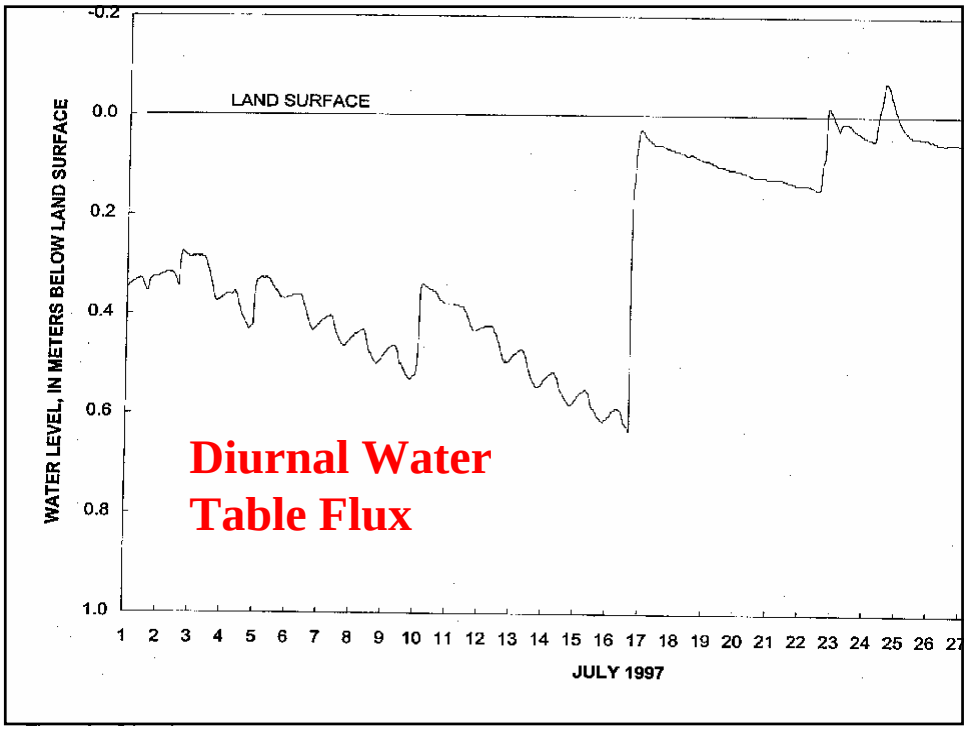
ET – Also estimated via "diurnal water flux" technique of White (1932)

Water levels – Approximately 40 water table observation wells and piezometer nests were monitored monthly. More detailed hourly readings were taken at central Bowen Ratio station

Water table contours in 2/98, showing drop of approx. 2 m to NE across site.




Net Daily Ground Water Flux
12.50
10.00
7.50
5.00
2.50
0.00
-2.50
-5.00
-7.50
-10.00
-12.50
Water (cm)
5/1/98
6/1/98
7/1/98
8/1/98
9/1/98
10/1/98
11/1/98
12/1/98
1/1/99
2/1/99
3/1/99
4/1/99
Date


LAND SURFACE
0.0
0.2
0.4
0.6
0.8
1.0
WATER LEVEL, IN METERS BELOW LAND SURFACE
Diurnal Water Table Flux
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
JULY 1997

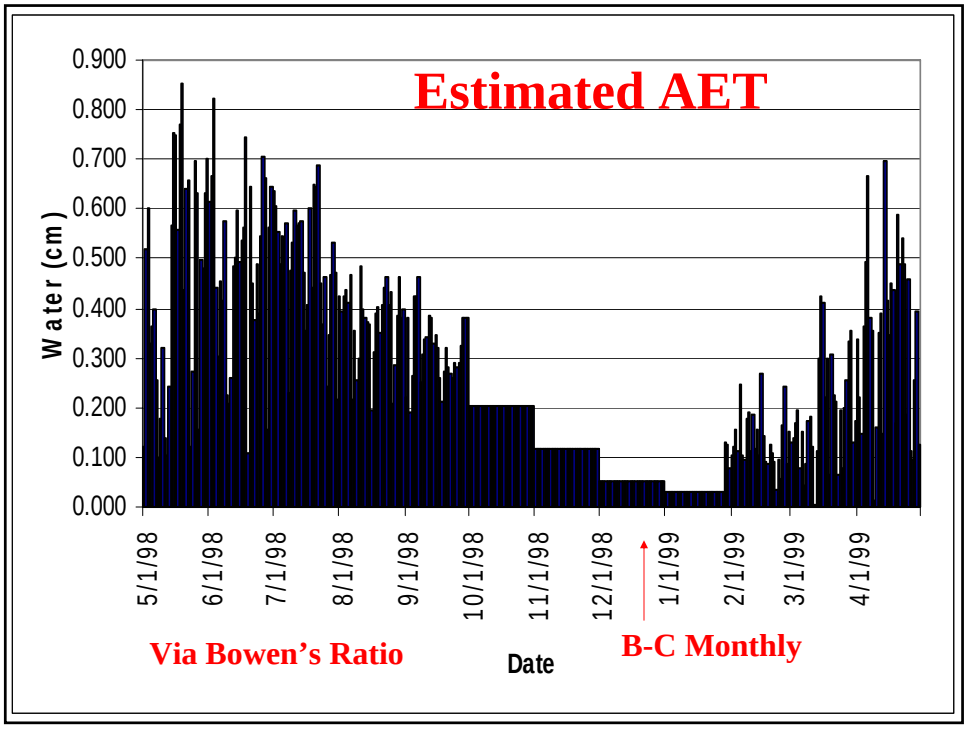
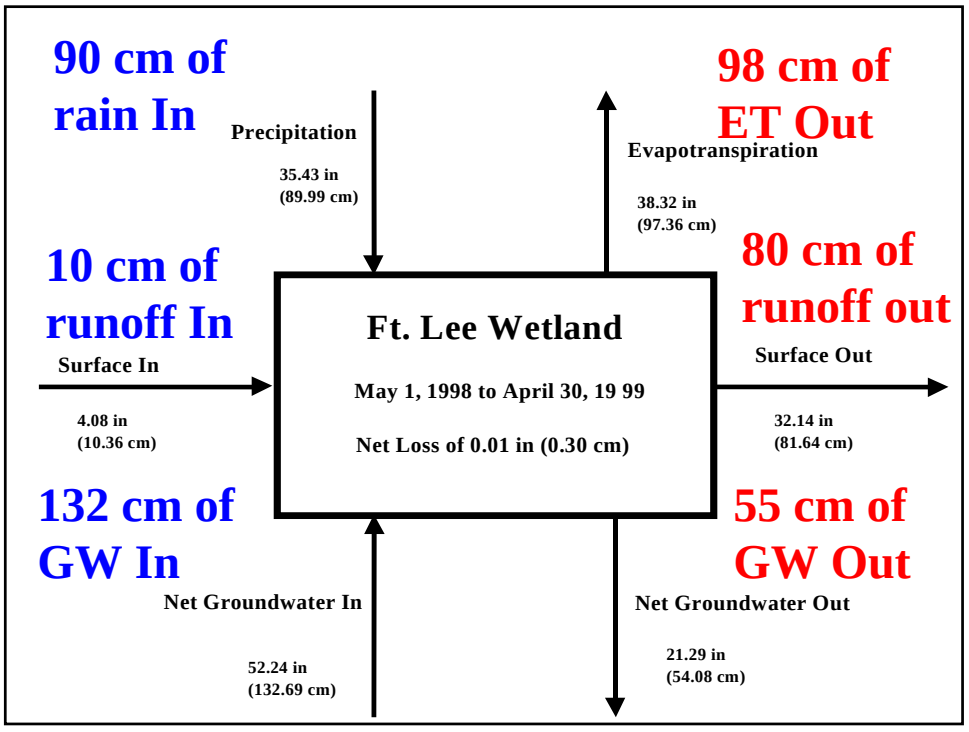


Table 6. Evapotranspiration by three methods for 76 Day Period (6/18/96 - 9/2/96)

Bowen Ratio Method	Water Table Method	Thornthwaite Method
17.5	15.1	11.4

Internal "Calibration" Results

- If we assume that Bowen Ratio AET estimates are accurate, then Thornthwaite critically underpredicts AET by as much as 50% in the early spring and fall months!
- The diurnal water flux method estimates of AET appeared to follow the Bowen Ratio estimates well, *when the water levels were in the appropriate range.*



Conclusions

- Surface water additions and losses to this site were minimal in the dry year monitored
- Ground water additions were significant, and dominated the overall water budget at this site
- The Thornthwaite method significantly underestimated (approx. 35%) AET for the spring and summer months relative to the Bowen Ratio approach

Conclusions

- Obviously, *apriori* water budgeting for a given site is subject to a wide array of potential errors.
- For the system studied, errors in ET valuation via the use of Thornthwaite and any error in ground water addition estimates would have significantly affected a "conventionally derived water budget".

Conclusions

- The diurnal water flux method appears to be an accurate lower-cost alternative for AET estimation, but you must have appropriate water levels and correct aquifer characteristics.
- Detailed site-specific ground water data sets must be obtained to correctly model or budget the water balance of a mitigation site. However, is 2 years of data really necessary?

Practical Implications and Obs. by W&D at Multiple Sites

- Efforts to isolate mitigation wetlands from ground water via the use of impermeable "perching seals" are often counterproductive to the development of a viable plant rooting medium.
- The vast majority of Coastal Plain riparian wetlands that we have studied are net ground water discharge zones. Failure to take this into account in water budgeting procedures can (and frequently does) lead to sites that are "too wet" for intended vegetation.

Some Practical Implications and Field Observations

In reality, we seldom have the luxury or the budget to study actual ground water dynamics at proposed mitigation sites with any level of detail, particularly over multiple growing seasons. Similarly, nobody in their right mind would purchase a Bowen Ratio rig and try to precisely estimate AET! Regardless, we do need to understand the relative levels of error inherent in the overall water budgeting process.

Acknowledgements

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