Comparison of Measured ET from Turfgrass Lysimeters

To Calculated ET During Drought Conditions

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Abstract

The Northern Colorado Water Conservancy District (NCWCD) has a network of weather stations throughout its service area to provide reliable crop water use information for both turf irrigation managers and agricultural producers. It also has four small turfgrass weighing lysimeters to compare measured ET to calculated ET. During 2002, Colorado experienced one of its worst droughts and less frequent irrigations were mandated at the location of the lysimeters. The results from comparison of measured ET to calculated ET using the ASCE Standardized Reference Evapotranspiration Equation[3] are presented. The measured ET from the lysimeters agrees well with the ET calculated from weather station data. The knowledge gained is useful in helping irrigation managers make decisions about irrigation practices, including how much water reduction can be achieved without causing severe injury to the turf area in the landscape during periods of drought or water shortages.

Background

The NCWCD constructed four turfgrass weighing lysimeters during the 1998 season. Each lysimeter was 18 inches in diameter and had a 24-inch depth. Three electronic load cells supported each lysimeter. Details on the construction of the lysimeters were presented at the 20th Annual International Irrigation Show of the Irrigation Association[4]. Two lysimeters (LysB and LysC) were filled with a sandy loam soil and two lysimeters (LysA and LysD) were filled with a silty clay soil. All four were established from sod to the same varietal mix of Kentucky bluegrass. It received about three pounds of nitrogen in split applications over the growing season. Mowing occurred weekly at a 3 inch cutting height.

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[3] The ASCE Standardized Reference Evapotranspiration Equation, Environmental and Water Resources Institute of the American Society of Civil Engineers, Standardization of Reference Evapotranspiration Task Committee, December 21, 2001, revised July 9, 2002, Draft

[4] 1999 Proceedings, International Irrigation Show, Irrigation Association

Beginning in 2001, the lysimeters were all installed adjacent to the NCWCD weather station at its former headquarters site in Loveland, Colorado. This site was a 120-ft by 120-ft irrigated plot, surrounded by a hedge of Three-leaf Sumac (Rhus trilobata). This weather station site was in the middle of a field of dry land grasses. The character of the area was urban with office buildings and residences on adjoining properties. Irrigation at the location was accomplished by an automated sprinkler system, typically beginning at 11:00 pm. Seven tipping bucket rain gauges were installed to record rainfall and irrigation information with the top of their collectors flush with the surface of the turf. Their locations were arrayed immediately around and between the four lysimeters. A single tipping bucket beneath each lysimeter was intended to record drainage data but was not fully reliable. Two electronic data loggers were utilized to collect data continuously, recording at 15-minute intervals.

The on-site weather station included sensors for air temperature, relative humidity, rainfall, wind speed, solar radiation and rain. The normal schedule for instrumentation maintenance was to clean, service and re-calibrate each sensor annually or more frequently if needed. Additionally, data loggers were returned to the manufacturer for cold-temperature testing and re-calibration on a five-year or less schedule to insure accuracy and reliability.

The typical growing season starts April 1 and ends October 31 with average grass reference evapotranspiration totaling 33 inches. The time periods selected for this paper were June 24th through July 21st of 2001 and 2002. This four-week period is generally the peak ET time of each season in northeastern Colorado. In addition, data was limited to the time period starting at 5:00 a.m. through 10:00 p.m. Nighttime data was discarded because calculated ET was negligible and it eliminated lysimeter data during periods of irrigation and also when most drainage losses occurred. This simplified and cleaned up the data set.

The 2001 season was characterized by daily watering of the irrigation zone containing the four lysimeters. Lysimeters were well watered during 2001 and soil moisture was consistently maintained near field capacity. In contrast, severe drought conditions precipitated irrigation changes for 2002. Irrigation during the 2002 season was limited to twice weekly watering and soil moisture levels were maintained lower than the previous year. In summary 2001 was representative of well-watered conditions with negligible moisture stress using daily irrigations. The 2002 season represents controlled moisture stress conditions with irrigations occurring every 3 to four days. Turfgrass health and appearance in all lysimeters was excellent both years.

Calculated ET

ET was calculated from the on-site weather station with the ASCE Standardized Reference Evapotranspiration Equation for hourly intervals using both a NCWCD developed computer program and REF-ET[5]. These two Penman-Monteith calculations compared very closely, both hour-by-hour and their 28-day sums as shown in Table 1. However the NCWCD developed program provided

[5] Reference Evapotranspiration Calculation Software, version 2.01.17, University of Idaho and Dr. Richard G. Allen

hourly ET to the thousandth of an inch while the output from REF-ET was rounded to the hundredth of an inch. This proved significant as calculated peak hourly ET was only 0.034 inches. Consequently, data from the NCWCD in-house program was utilized for the comparison with lysimeter measured ET.

Table 1

	Year	Sum (inches)	Maximum Difference (inches/hour)	Minimum Difference (inches/hour)
REF-ET	**2001**	**6.06**	**n/a**	**n/a**
NCWCD	**2001**	**6.079**	**+0.007**	**-0.007**
REF-ET	**2002**	**6.47**	**n/a**	**n/a**
NCWCD	**2002**	**6.452**	**+0.005**	**-0.007**

Weighing Lysimeter Data

To eliminate data outliers, the weighing lysimeter data was filtered hour-by-hour using upper and lower limits.

Primarily to eliminate outliers from un-measured drainage events, the upper limit was set to 0.05 inches per hour. This upper limit was nearly 50 percent higher than the 0.034 inches per hour maximum calculated by the ASCE Standardized Reference Evapotranspiration Equation. LysC in 2002 especially had trouble with longer than normal drainage delays, often continuing for several hours after irrigation was completed. The effects of delayed drainage could have been minimized with a quicker draining soil medium and/or more reliable operation of the tipping buckets beneath each lysimeter.

Primarily to eliminate outliers caused by under-measured rainfall, a lower limit of -0.005 inches per hour was set. Measurable rainfall occurred five times in 2001 and once in 2002 during the study periods.

The following figures summarize the data obtained from the turfgrass lysimeters for the selected study periods. Figure 1 and Figure 2 show the lysimeter weights during the study periods. Note the higher frequency of irrigations in 2001 versus 2002. Additionally, the lysimeter weights are significantly higher in 2001 than in 2002 indicative of higher soil moisture. Figure 3 and Figure 4 show running sums of lysimeter measured ET versus calculated ET from weather station data during each study period. The lysimeter sums are generally at or above the calculated ET sum in 2001 and below calculated ET in 2002, indicative of more normal soil moisture levels with some controlled water stress.

Figure 1 - Turfgrass Lysimeters at Loveland, CO
June 24 - July 21, 2001

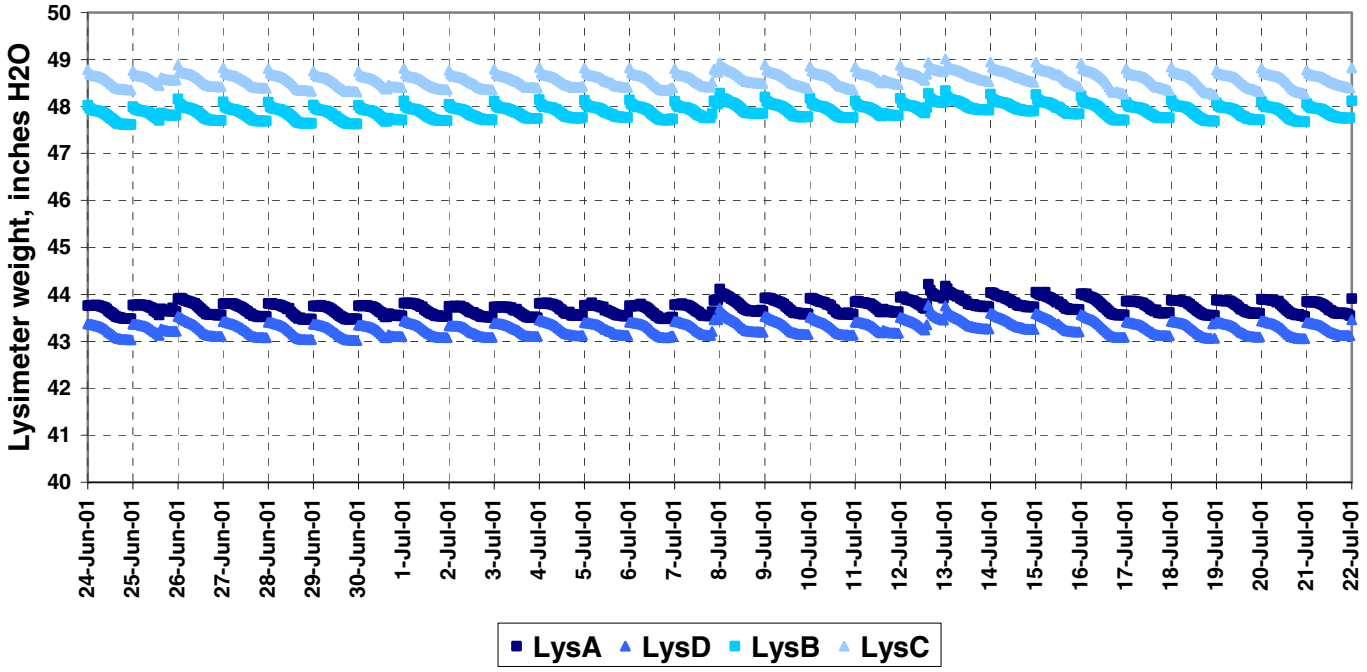


Figure 2 - Turfgrass Lysimeters at Loveland, CO
June 24 - July 21, 2002

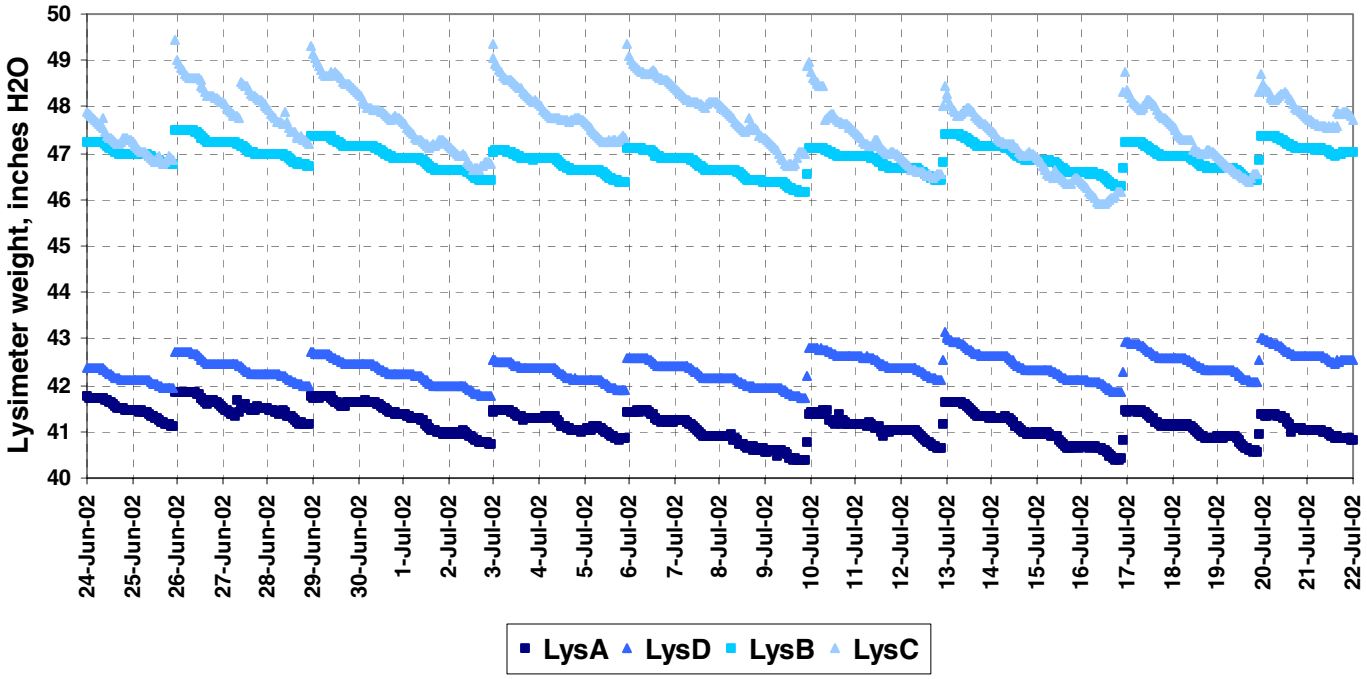


Figure 3 - Turfgrass Lysimeters at Loveland, CO
June 24 - July 21, 2001

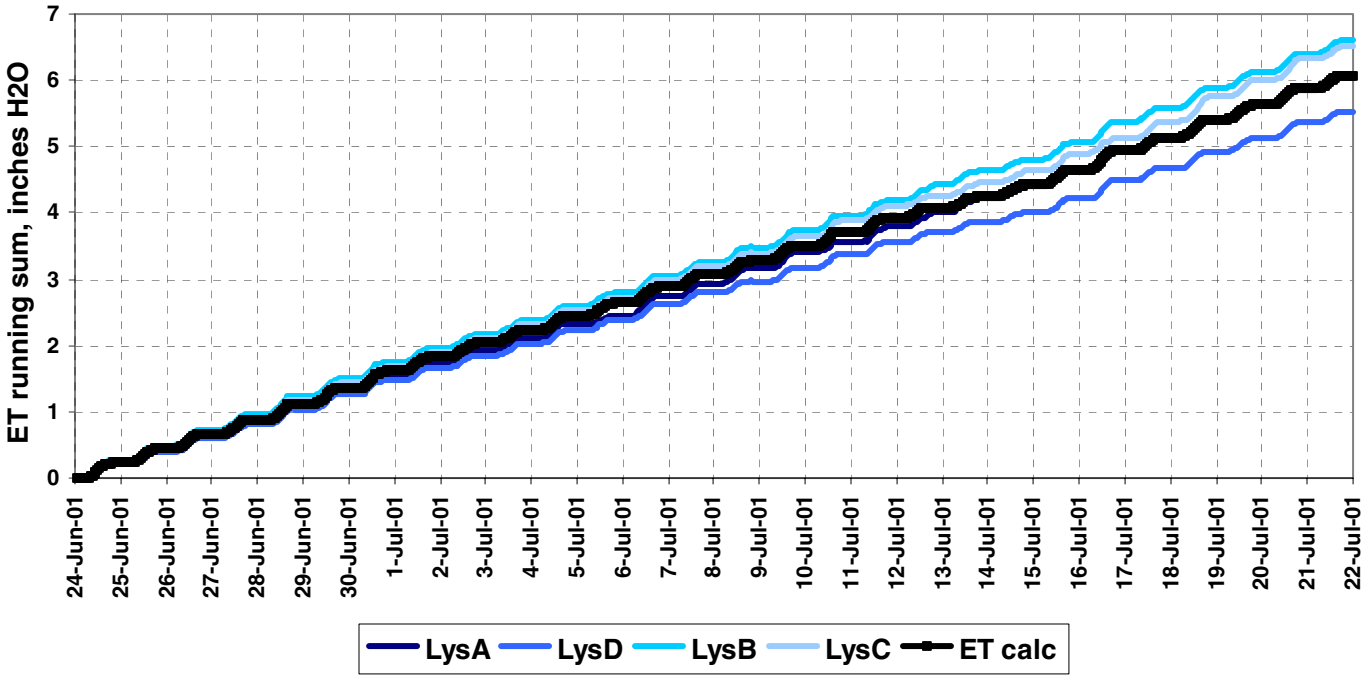
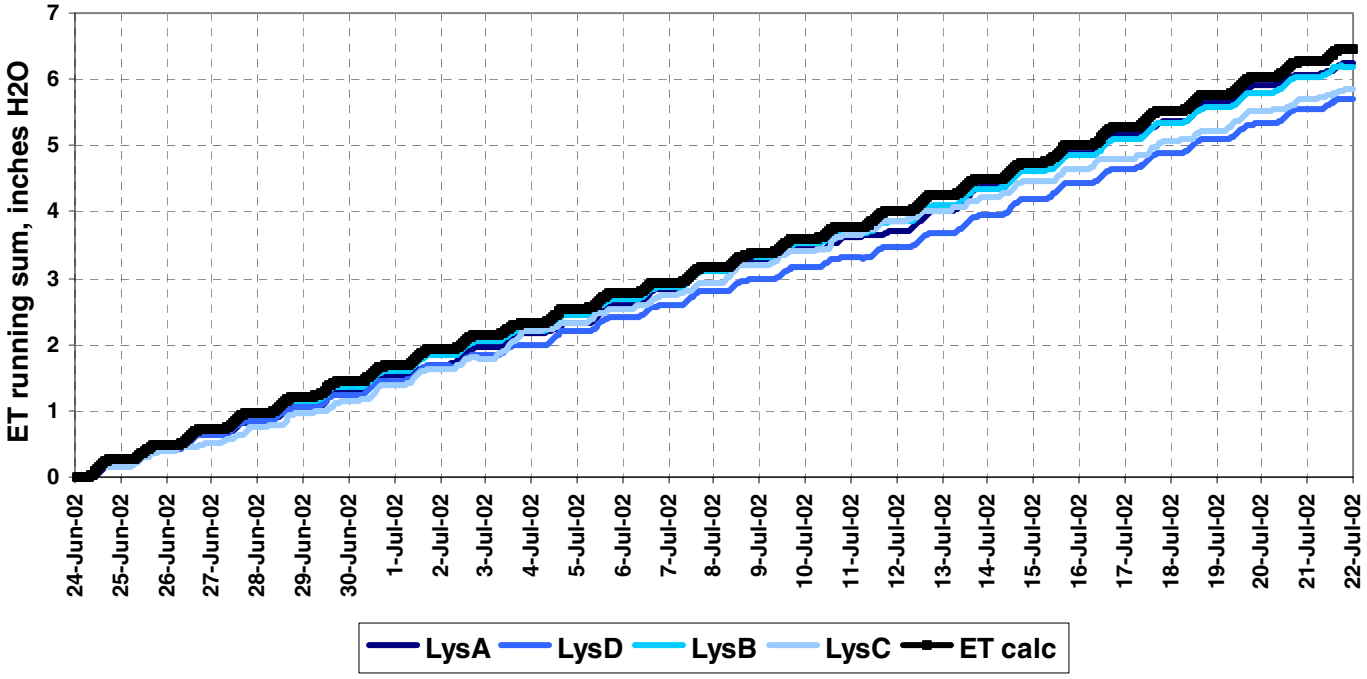


Figure 4 - Turfgrass Lysimeters at Loveland, CO
June 24 - July 21, 2002



Average daily KC ratios were calculated by dividing the measured ET from each lysimeter by the calculated ET from the NCWCD program of the ASCE Standardized Reference Evapotranspiration Equation. The results are summarized in Table 2.

Table 2

	2001 Sum ET (inches)	2001 Avg Daily KC	2002 Sum ET (inches)	2002 Avg Daily KC
Calculated ET	**6.079**	**n/a**	**6.452**	**n/a**
LysA	**6.084**	**1.00**	**6.244**	**0.97**
LysD	**5.526**	**0.91**	**5.705**	**0.88**
LysB	**6.595**	**1.08**	**6.199**	**0.96**
LysC	**6.527**	**1.07**	**5.844**	**0.91**
Avg Lysimeter Difference	**+2%**		**-7%**	

Conclusions

It was anticipated the measured ET from the turfgrass lysimeters would be 90 percent of the ET calculated using the ASCE Standardized Reference Evapotranspiration Equation and data from the adjacent weather station. This reduction was expected due to the lower mowing height. The lysimeter site was cut to 3 inches weekly while the ASCE Standardized Reference Evapotranspiration Equation assumes a turf height of 0.12 meters or nearly 5 inches.

The more frequent irrigation interval and higher soil moisture levels during 2001 resulted in increased measured ET from turfgrass lysimeters. Measured ET was 2 percent higher than calculated ET, a minor difference.

The less frequent irrigations of 2002 and lower soil moisture levels did not appear to significantly decrease the measured ET from the turfgrass lysimeters. Measured ET was 7 percent lower than calculated ET from weather station data, reasonably close to the anticipated 10 percent reduction due to mowing height.

Further analysis of the available data sets from the NCWCD weighing lysimeters should provide additional information regarding turf water use and appropriate irrigation management strategies.