Turfgrass ET from Small Weighing Lysimeters in Colorado: First Full Year Results

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Abstract. *Small weighing lysimeters were planted in 11 different turfgrass species or mixes in 2010. Only one of the selections was warm-season turfgrass, the remaining 10 were cool-season turf grasses. There are four replicates of each turfgrass. Results are compared to ETos calculated from an adjacent weather station using the standardized Penman-Monteith equation. The first full season results from 44 small weighing lysimeters are presented. Each lysimeter is centered in a 4-ft by 4-ft plot of the same grass variety. The lysimeters each consist of a PVC shell containing a 12-inch diameter, free-draining sandy loam soil core having a 20-inch rooting depth. The lysimeters are continuously weighed in-place by electronic load platforms connected to a data logger. Irrigation is applied via high uniformity sprinklers and measured through a flow meter monitored by a data logger. All turfgrasses are irrigated on the same schedule and are managed to avoid soil moisture induced stress – each is brought back to field capacity at the time of irrigation. All grasses are mowed to the same height. The purpose of the study is to quantify evapotranspiration of several varieties of turfgrass, under wel- watered conditions and with adequate fertility. The average ratio of measured turfgrass evapotranspiration to calculated ETos are graphically presented in the Summary. Quantification of turfgrass ET with increased accuracy is especially important in regards to water conservation, programming of weather-based SMART irrigation controllers, agricultural to urban water transfers, and water rights administration.*

Keywords. Turgrass ET, weighing lysimeter

Introduction and Background

Interest in different varieties of turfgrasses and their water usage has increased in recent years. Although general statements of lower water requirements are readily attached to some turfgrasses, quantitative assessments based on ETos from the standardized Penman-Monteith equation are rare. The use of lysimeters to directly measure turfgrass ET provides a defensible basis for quantifying and comparing actual water use. This information will assist in the programming of weather-based SMART controllers to account for reduced plant water use in the Spring and Fall. It can provide municipalities with information necessary in developing landscaping standards in support of efficient water use and conservation. It should also assist in more accurate quantification of irrigation return flows from urban landscapes and the in-stream flow credits claimed by Colorado municipalities under water rights administration.

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A previous paper by Crookston, et al. (2010) included an overview of several previous studies regarding turfgrass ET. Although many of these previous studies are in relatively close agreement for ET from well-irrigated cool-season turfgrass with adequate fertility, quantification of differences between cool-season turfgrasses is lacking. Additionally, the difference in mowing height and lack of reference to ETos from the standardized Penman-Monteith equation curtails their transferability from one region to another. The Northern Water lysimeter study will compare ET from turfgrasses - mowed to the same height and under the same climate conditions - to standardized Penmen-Monteith ETos at Berthoud, Colorado.

Methods

In 2009, Northern Water commenced construction and installation of a 30-ft x 30-ft study plot for turfgrass lysimeters within its Conservation Gardens at its headquarters in Berthoud, Colorado. The turfgrasses were seeded starting May 28, 2010, and finishing June 2, 2010. However frequent sprinkler irrigations for establishment of the turfgrasses continued through most of July 2010. The tops of most lysimeters were still clearly visible and the effective diameter of the lysimeters did not fill the small gap surrounding all lysimeters until after that time. Consequently, the 2011 season is the first full season for evaluation of ET from established turfgrasses.

The lysimeter plot was divided into 4-ft x 4-ft sub-plots, separated by 1-inch x 6-inch PVC plastic composite decking/edging material. This edging clearly delineates the subplots and helps prevent the spread of one grass variety into another subplot. It also provides support for foot traffic by study technicians without damage to turf or compaction of the soil. Turfgrasses were planted into 44 of the 49 sub-plots, with the four corners and center sub-plots excluded from the study, but planted to a bluegrass blend to maintain fetch. The lysimeter plot was divided into four blocks, with each block containing 11 randomized sub-plots with lysimeters, one of each turfgrass variety included in the study. Consequently, the study includes four replicates of each of the following 11 turfgrasses:

Table 1. Turfgrasses.

Blue gramma – buffalograss mix	70% - Blue Gramma 30% - Buffalograss
Drought hardy Kentucky bluegrass	33% - Rugby 33% - America 33% - Moonlight
Ephraim crested wheatgrass	
Fine fescue mix	25% - Covar Sheep 25% - Intrigue Chewings 25% - Cindy Lou Creeping Red 25% - Eureka Hard

Kentucky bluegrass blend	50% - Rampart 25% - Touchdown 25% - Orfeo
'Low Grow' mix	29% - Creeping Red fescue 27% - Canada bluegrass 24% - Sheep fescue 16% - Sandburg bluegrass
'Natures Choice' - Arkansas Valley mix	70% - Ephraim Crested wheatgrass 15% - Hard fescue 10% - Perennial ryegrass 5% - Kentucky bluegrass
Perennial ryegrass	Playmate blend
Reubens Canada bluegrass	
Tall fescue	Major League blend
Texas hybrid bluegrass blend	50% - Reveille 50% - SPF 30

Equipment

The weighing platform for each lysimeter includes a Revere PC6-100kg-C3 load cell transducer. Each load cell is connected to one of three AM 16/32 multiplexers, each connected to a Campbell Scientific CR10X data logger. Figure 1 is a diagram of the small turfgrass lysimeters and their arrangement within the lysimeter plot.

Every three seconds a measurement is taken from each load cell. These measurements are averaged every 60 seconds. This 1-minute average is time-stamped and stored in the data logger at the end of each 15-minute period. Stored data is automatically downloaded every 15 minutes to a desktop PC via an RF401 spread-spectrum radio. Differences in lysimeter weight are calculated as the difference in the measurement at the end of each hour. These hourly values are compared to calculated ETos obtained from the REF-ET software v.3.1 (http://www.kimberly.uidaho.edu/ref-et/) utilizing data from the adjacent Campbell Scientific ET-106 weather station. The weather instruments are each calibrated annually.

The weighing platforms for each lysimeter were calibrated in-place (without the lysimeter) in September 2009 over their full load range using steel weights. The platforms were again re-calibrated in-place during 2010, but only over their operational range (from dry soil to wet soil). In-place re-calibration was again performed in early March 2011. No problems were identified during the re-calibrations, and all weighing platforms were measuring lysimeter weights properly.

The entire lysimeter plot is on a single irrigation zone using MP Rotator 2000 sprinklers on 15-ft spacing. A DLJ ¾-inch x ¾-inch brass flow meter with pulse output is connected to a Campbell

Scientific data logger which measures all irrigation applications to the lysimeter plot. In addition, 15 Texas Electronics tipping bucket rain gauges are installed flush with the turf height throughout the lysimeter plot to measure net irrigation application as well as rainfall.

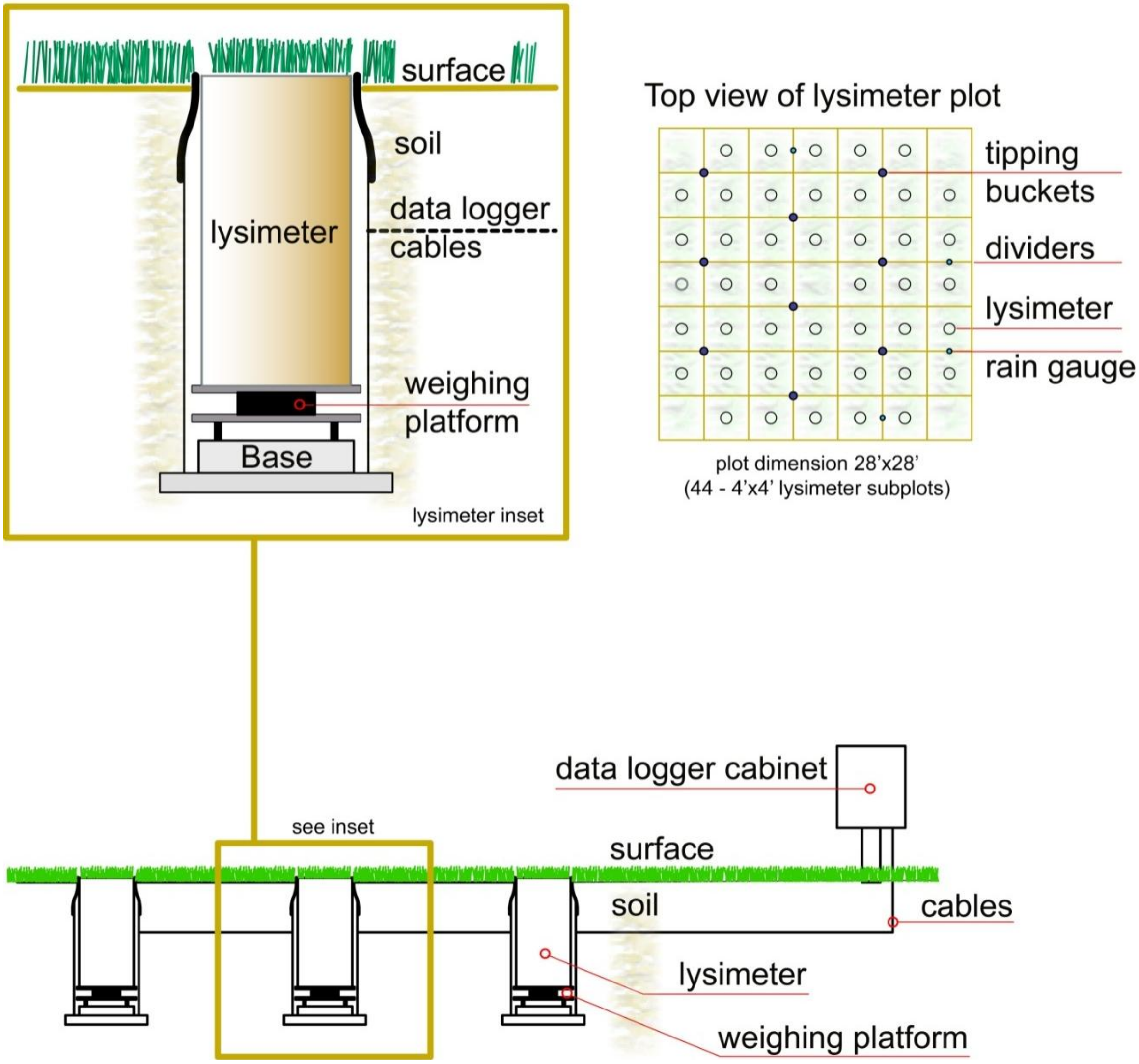

Figure 1. Diagram of Small Turfgrass Lysimeters.

A photograph of the site location, surrounding gardens, and weather station location is provided in Figure 3 at the end of this paper.

Deep Percolation Calculations

Deep percolation through the lysimeters was not directly measured. Deep percolation from irrigation was calculated as the difference between applied irrigation less the increase in lysimeter weight after free drainage. Beginning in late July 2010, all sprinkler irrigations were scheduled for after sundown and before midnight. Because the lysimeters are free-draining with sandy loam soil only 20-inches deep, any deep percolation from irrigation was generally assumed to be completed before sunrise. Turf water use during this nighttime drainage period was considered negligible. However, hand watering to bring each individual lysimeter grid up to field capacity did occur during daytime hours–either earlier the same day as the sprinkler irrigation, or the following day. The majority of the data during daytime irrigation events was excluded from the comparison to calculated ETos. Any excessive percolate that ponded below a lysimeter was removed through a manually-controlled vacuum extraction system as needed.

Deep percolation from rain was calculated similarly as for irrigation. However, special considerations were required – particularly for significant daytime rain events. Deep percolation from rain was calculated as the difference between measured rainfalls less the increase in lysimeter weight (after stabilization). A few periods of extended deep percolation were observed during 2011 following lengthy rain periods, generally in excess of 3 to 4 days. If these rainy drainage periods occurred during daytime hours, the data were generally excluded from the comparison to calculated ETos.

Results and Discussion

Figure 2 graphically presents the average ratio of measured turfgrass evapotranspiration to calculated ETos during the 2011 season for each of the 11 selected turfgrasses. As expected, these data clearly indicate reduced water use in the Spring and Fall with peak water use occurring during mid-Summer. Although some differences between different turfgrasses are evident, these data are preliminary and should not be relied upon until further seasons of data are included for evaluation.

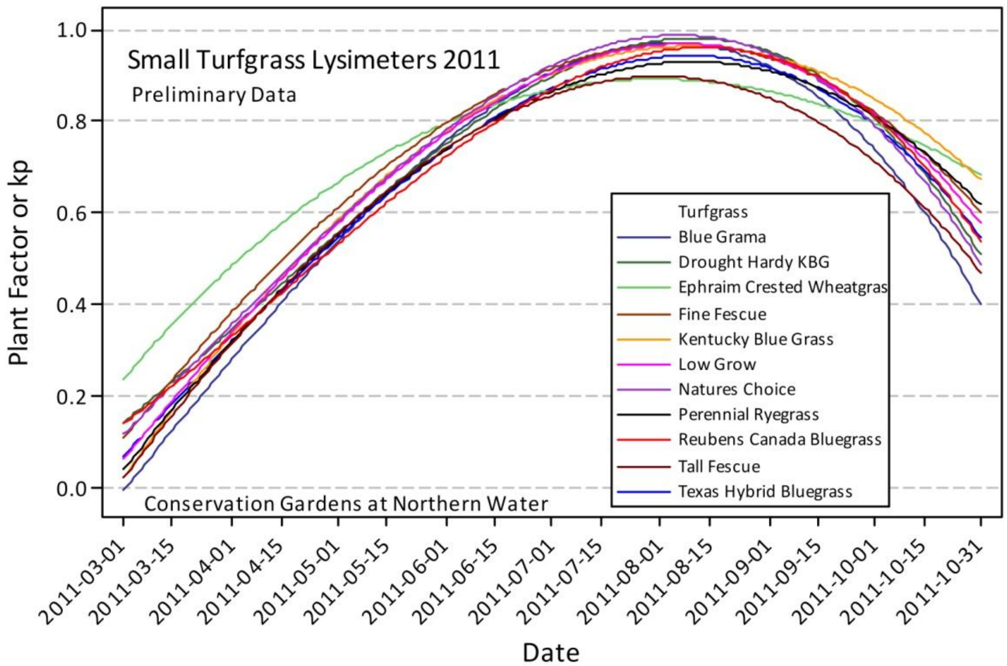

Figure 2. Small Turfgrass Lysimeters 2011 - Preliminary Data (graph of 2011 plant factors)

Conclusions

Additional seasons of data collection are necessary to fully establish the plant water use coefficients for the various turfgrasses. Future plans include study of turf water use under deficit or reduced irrigation management. It is anticipated this information will be of particular value in programming and adjusting irrigation controllers to adjust for the reduced water use of turfgrasses in Spring and Fall and to better maintain turfgrass vigor and health during the mid-summer period of greatest water need. Previous approaches utilizing a constant turfgrass coefficient all season can be readily improved, resulting in potential for increased water conservation and improved landscape appearance.

References

Crookston, M.A. and M. Hattendorf 2010. Turfgrass ET from Small Lysimeters in Northeast Colorado, USCID 2010 Fort Collins Conference, September 28 – October 1, 2010. Abstract on page 51 (full paper on accompanying CD).

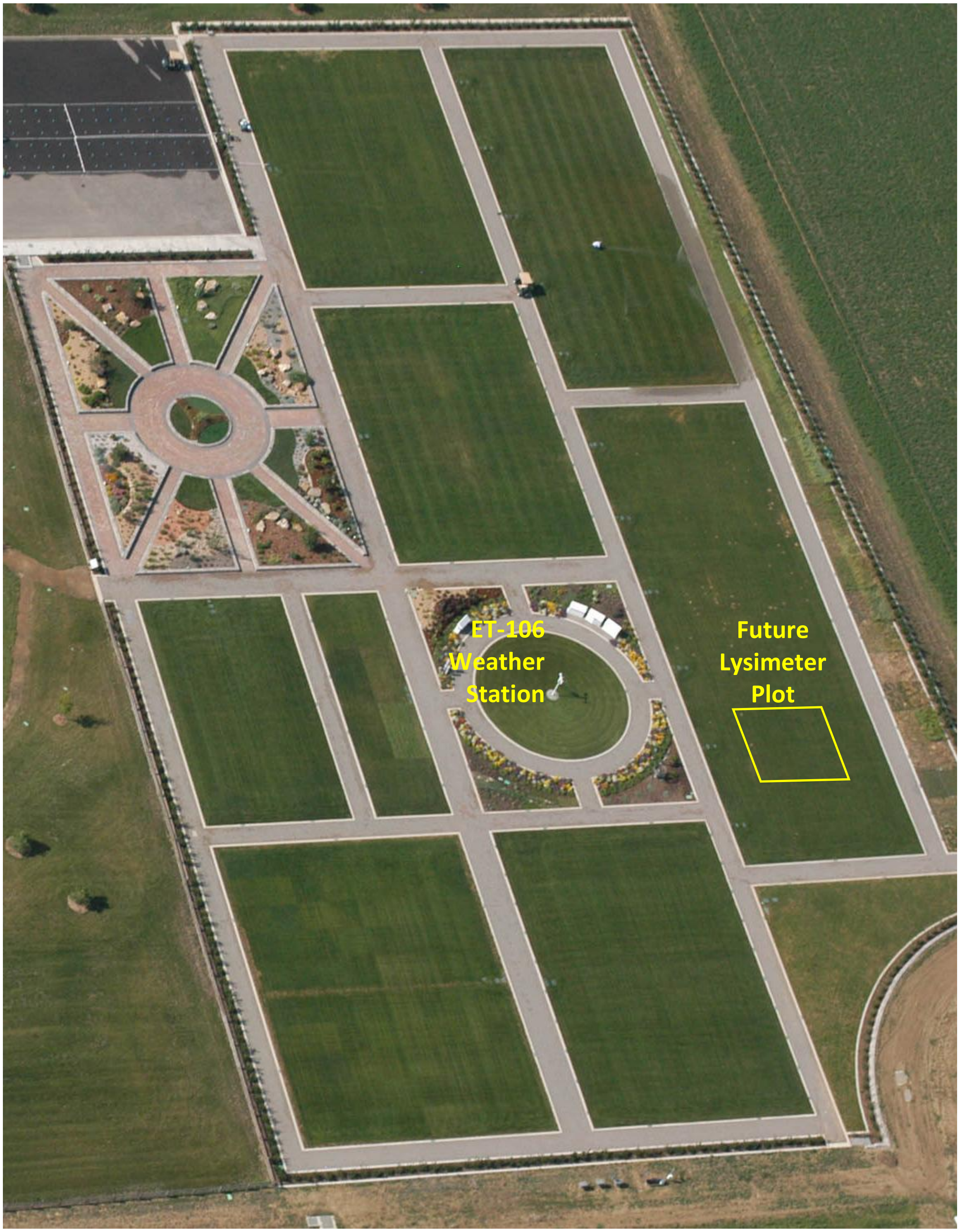

Figure 3. Aerial View of Conservation Gardens at Northern Water – before construction of lysimeter grid.