Estimating Turfgrass Water Use With AZMET

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ABSTRACT

The Arizona Meteorological Network provides weather-based estimates of reference evapotranspiration (ETo) for much of southern, central and western Arizona. A simple 3-step procedure to convert ETo data into reliable estimates of turfgrass water use is described. The procedure requires that AZMET ETo values be multiplied by a correction factor known as a crop coefficient (Kc). The selection of the Kc depends on the type and height of the turfgrass as well as desired turf quality. The procedure is well adapted for use on computers.

INTRODUCTION

Successful production of turfgrass in Arizona requires an effective irrigation management program. Failure to adhere to proper irrigation management principles can lead to: 1) poor quality turf; 2) higher input costs for water, fertilizer and pesticides; and 3) annual water applications in excess of limits presently imposed by the Arizona Department of Water Resources (DWR).

The goal of an effective turf irrigation management program is to maintain soil moisture at levels that ensure suitable turfgrass performance. Achievement of this goal requires that soil moisture losses resulting from evapotranspiration (evaporative losses from a turf surface, also referred to as turf water use) and leaching (if necessary) be offset by applications of irrigation water.

Information on evapotranspiration (ET), therefore, can assist the irrigation manager in making the decision of how much water to apply. Evapotranspiration can be estimated quite accurately using weather parameters such as solar radiation, temperature, humidity and wind; however, until recently, acquisition of such data was a slow and cumbersome process.

Recent advances in computer-based data acquisition systems and computer processing power now make acquisition of weather data, and therefore, generation of turf-ET estimates a feasible proposition. Arizona Cooperative Extension has recently developed a weather information system known as AZMET that provides weather-based estimates of ET. The following paper describes the AZMET system and the procedures required to convert AZMET information into estimates of turfgrass ET.

THE ARIZONA METEOROLOGICAL NETWORK (AZMET)

The Arizona Meteorological Network (AZMET) is a near-real time information system that provides weather-based information to Arizona's agricultural and horticultural producers. In simple schematic form (Figure 1), AZMET consists of a network of remote, automated weather stations that are linked via phone lines to a data processing center located on The University of Arizona Campus in Tucson. The weather stations utilize state-of-the-art, computer-based data logging systems to continuously monitor key environmental parameters, including air and soil temperature, humidity, solar radiation, wind, and precipitation. Once each day, data are transferred from the remote weather station network to the data processing center where computers convert the incoming data into information summaries. The information summaries are subsequently made available to the public via the local extension office, the mass media and a computer dissemination link located at the Tucson data processing center. At present, AZMET has stations located throughout southern, central and western Arizona, including the Phoenix and Tucson metropolitan areas (Figure 2).

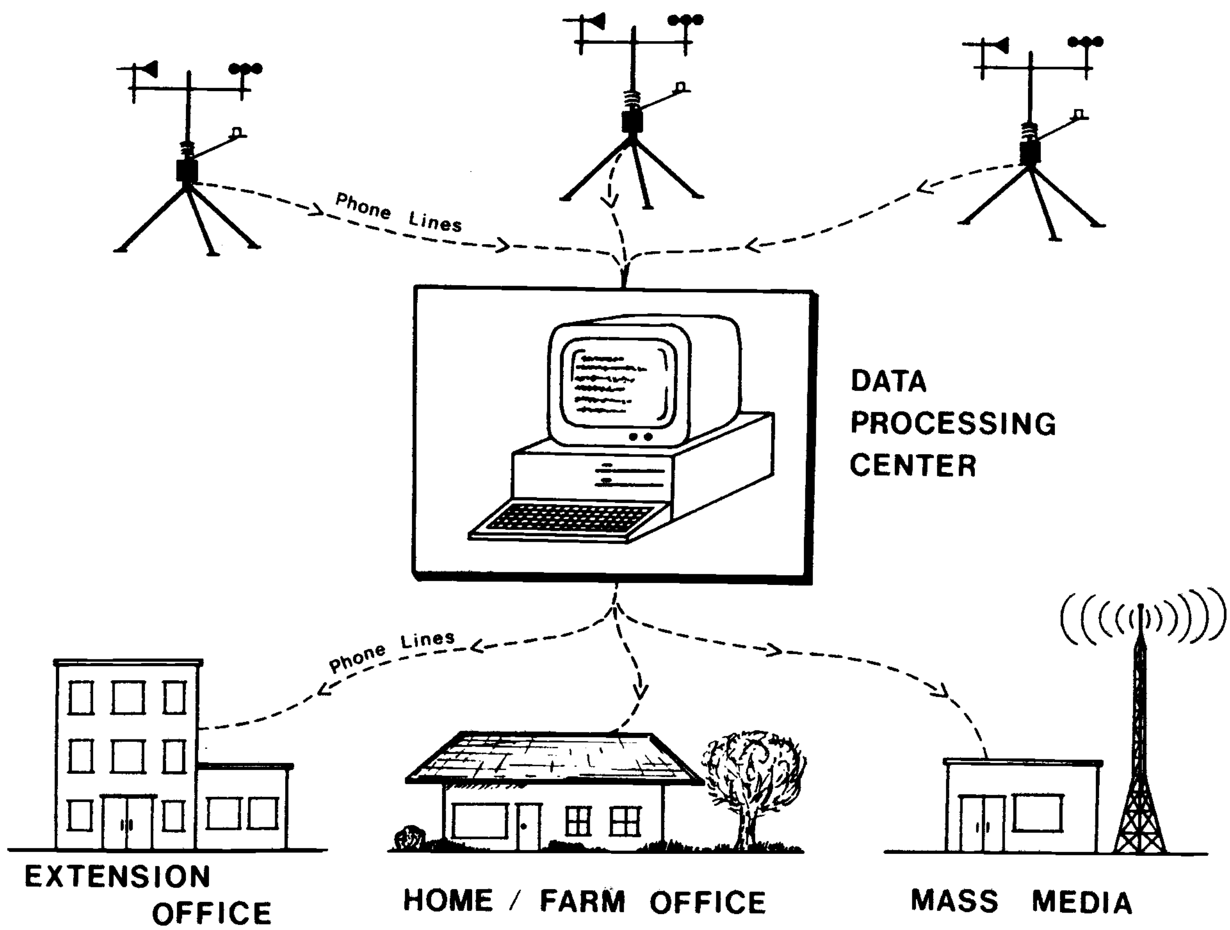

Figure 1. The Arizona Meteorological Network (AZMET) in simple schematic form. Automated weather stations, which continuously monitor key environmental parameters, are linked by phone lines to a data processing center. Data from the stations are converted to informational summaries that are made available to the public through the local extension office, a public access computer link (home/farm office) and the mass media.

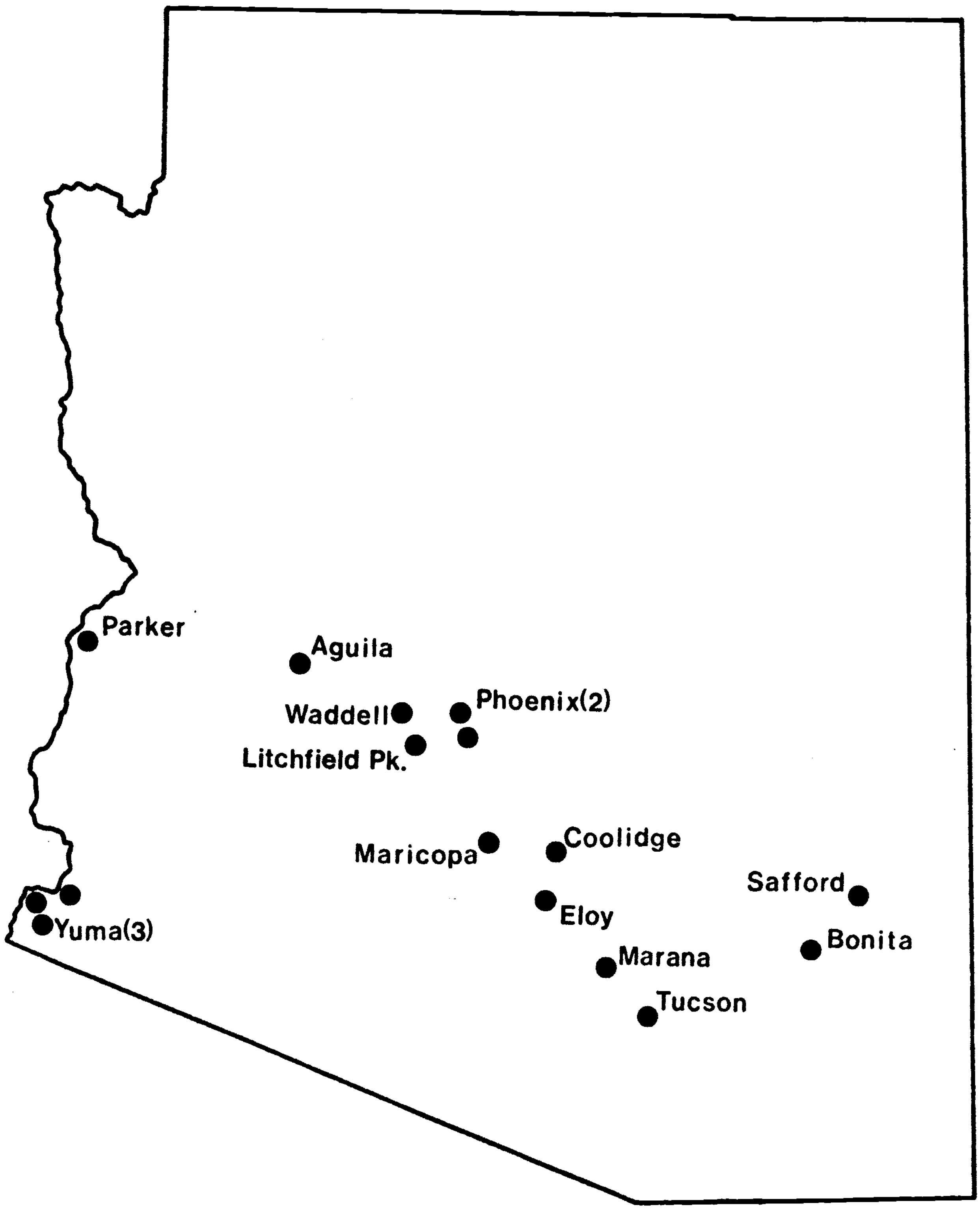

Figure 2. Map showing the locations of AZMET weather stations.

EVAPOTRANSPIRATION

As previously mentioned, knowledge about the evaporative losses from a turf surface are necessary to effectively manage turfgrass irrigation. Evapotranspiration (ET) is the formal term used to describe these evaporative losses. By definition, ET is the loss of water from a vegetated surface through the combined processes of soil evaporation and plant transpiration (ET is frequently referred to as consumptive use). Both environmental and biological factors affect ET. Important environmental factors include solar radiation, temperature, atmospheric dryness (vapor pressure deficit--derived from temperature and humidity), wind and soil moisture. Biological factors include the type of plant, foliage geometry and foliage density.

Research over the past 50 years has resulted in the development of numerous methods of estimating ET. Most functional methods combine weather data with some empirically or theoretically derived equation to generate estimates of reference crop (or potential) ET. Reference crop ET (ETo) is defined as the loss of water from a well watered, full-cover grass surface, 8-15 cm in height (the reference crop). The Arizona Meteorological Network determines ETo on a daily basis for all locations served by network weather stations. AZMET ETo values are determined using a ET model known as the Penman Equation (Figure 3). Weather parameters utilized in the Penman calculation include solar radiation, temperature, vapor pressure deficit and wind speed.

Reference crop ET must be modified to provide ET estimates for vegetated surfaces other than that of the reference crop (a tall, grass surface). A simple multiplicative factor, known as a crop coefficient (Kc), is typically employed to convert ETo to a "crop-specific" ET (ETa):

$$ETa = Kc \times ETo$$

For turfgrass, the Kc value is dependent on three main factors: 1) the type of turfgrass (warm or cool season), 2) the height of the turfgrass and 3) the overall turfgrass quality desired. Crop coefficients developed from University of Arizona studies on turf water use are presented in Table 1.

Table 1. Crop coefficients for use in estimating turfgrass water use.

Turf Type	Turf Quality	Turf Height	Kc Value
Warm Season	Acceptable*	1.5-2.0"	0.65
Warm Season	High (Golf)	0.75-1.75"	0.8-0.83**
Cool Season	High (Golf)	1.50-1.75"	0.85

*Should provide acceptable turf for park areas with low levels of human and vehicular traffic.

**Higher Kc pertains to higher turf height.

Note that Kc values provided in Table 1 are for turfgrass maintained within a given height range. Turfgrass maintained at heights significantly below that indicated may use less water, resulting in a slightly lower Kc. On the other hand, turfgrass maintained at heights above those listed may use slightly more water and demand a higher Kc value.

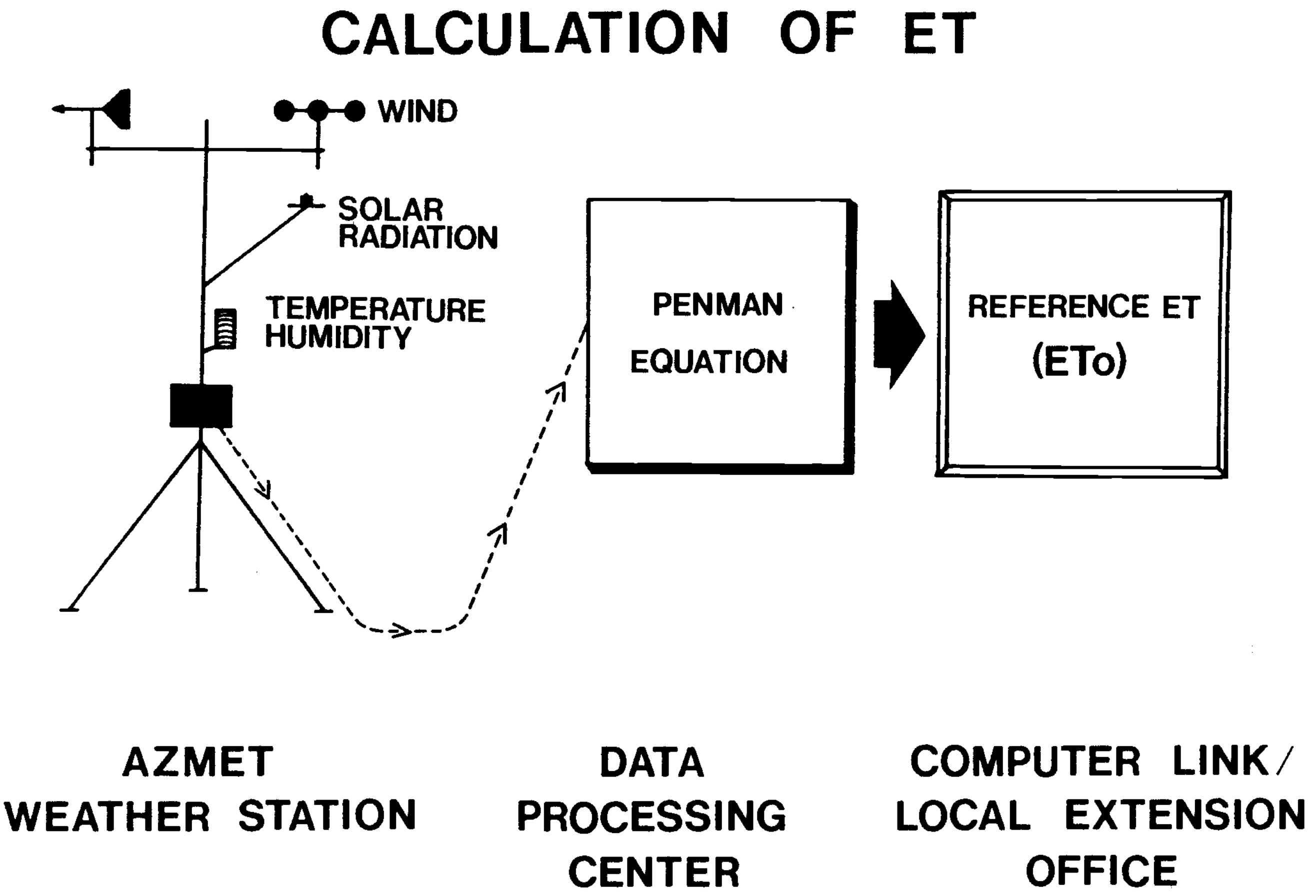

Figure 3. Schematic depicting how AZMET calculates ET. Data on wind, solar radiation, temperature and humidity received from a remote weather station are used as inputs to an ET model known as the Penman Equation. The Penman Equation generates the ETo value that is made available for public dissemination.

ESTIMATING TURFGRASS WATER USE WITH AZMET

The procedure for converting AZMET ETo values into estimates of turfgrass water use can be divided into 3 simple steps. The following examples clarify this procedure.

Example 1. Calculate daily ET for high quality bermuda turf: Phoenix.

Step 1. Obtain the AZMET ETo estimate from an AZMET Daily Weather Summary.

From Figure 4, the AZMET ETo value for Phoenix-Greenway is 0.30".

Step 2. Select the Kc value for high quality bermudagrass turf.

From Table 1, the Kc value is 0.80.

Step 3. Determine turf ET using: ETa = Kc x ETo.

ETa = Kc x ETo
= 0.8 x 0.3"
= 0.24" for the day

AZMET DAILY WEATHER SUMMARY: PHOENIX-GREENWAY
JUL 27 1988

	MAX.	MIN.	MEAN	TOTAL	UNITS
TEMPERATURE	103.2	82.8	91.5		DegF
RELATIVE HUMIDITY	47.5	25.1	35.7		%
VAPOR PRESS. DEF.			3.3		KPas
SOLAR RADIATION				567.2	Langleys
PRECIPITATION				0.53	Inches
SOIL TEMP. 2 IN	97.7	72.9	82.0		DegF
SOIL TEMP. 4 IN	99.9	77.4	85.7		DegF
WIND SPEED	21.7		5.9		MPH
WIND VECTOR MAG.			2.5		MPH
WIND VECTOR DIR.			216		Degrees
REF. EVAPOTRANSPIRATION				0.30	Inches

HEAT UNITS	86/55F		86/50F		86/45F	
----------	DAY	CUM	DAY	CUM	DAY	CUM
INTEGRATED	30.7	3195	35.7		40.7	
SINE CURVE	30.5	3190	35.5	4047	40.5	4990

DAY : Daily Heat Unit Total
CUM : Heat Units Accumulated Since Jan 1

Figure 4. AZMET Daily Weather Summary for Phoenix-Greenway. The AZMET ETo value is labeled "REF. EVAPOTRANSPIRATION" and is 0.30" on this day.

Example 2. Calculate weekly ET for cool season turf: Tucson.

Step 1. Obtain weekly total AZMET ETo from an AZMET Weekly Summary.

From Figure 5, the weekly ETo for Tucson is 0.88".

Step 2. Select the Kc for cool season turf.

From Table 1, the Kc value is 0.85.

Step 3. Determine the turf ET.

ETa = Kc x ETo
= 0.85 x 0.88"
= 0.75" for the week

Example 3. Calculate daily ET for park quality bermudagrass turf: Phoenix.

Step 1. Obtain AZMET ETo estimate from an AZMET Daily Summary.

From Figure 4, the AZMET daily ETo value for Phoenix-Greenway is 0.30".

Step 2. Select the Kc value for park quality turf.

From Table 1, the Kc value is 0.65

Step 3. Determine the turf ET.

ETa = Kc x ETo
= 0.65 x 0.30"
= 0.20" for the day

The examples above show the ease with which estimates of turfgrass ET can be obtained using AZMET ETo data. Individuals with computers will find that various spreadsheet and database management programs can be easily programmed to handle the 3-step procedure, thus alleviating the need to calculate the ET values by hand. The AZMET summaries presented in Figures 4 and 5 are available via AZMET's public access computer link. Access to the computer link requires a personal computer, modem, communications software and access to a phone. Additional details on the use of the computer link may be obtained by requesting Extension Report 8733 from Agricultural Sciences Communications at the University of Arizona, or by requesting the publication "User's Guide To The Arizona Meteorological Network" from the City Of Phoenix Water Conservation and Resources Division.

ARIZONA METEOROLOGICAL NETWORK WEEKLY SUMMARY

TUCSON
1988

DATE	AIR TEMP MX	AIR TEMP MN	AIR TEMP AV	REL HUM MX	REL HUM MN	REL HUM AV	SOIL TEMP 2" AV	SOIL TEMP 4" AV	WIND SPEED MX	WIND SPEED AV	SOLAR RAD	RAIN	ETo	HEAT UNITS 55	HEAT UNITS 50	HEAT UNITS 45
JAN 24	70	28	46	92	16	50	44	45	16	3.4	353	0.00	0.11	4	6	9
JAN 25	68	28	46	70	15	39	44	45	18	4.0	361	0.00	0.13	3	5	8
JAN 26	75	29	52	77	13	39	46	46	13	4.5	355	0.00	0.15	6	8	11
JAN 27	76	47	60	49	14	23	52	51	16	5.8	260	0.00	0.14	8	12	17
JAN 28	83	42	58	55	12	34	53	52	9	3.8	317	0.00	0.13	10	14	18
JAN 29	77	44	59	74	33	49	54	54	11	3.4	328	0.00	0.12	8	12	16
JAN 30	71	44	56	93	29	65	55	55	11	3.6	314	0.00	0.10	6	9	13
AVERAGE	74	37	54	73	19	43	50	50		4.1	327					
TOTALS												0.00	0.88	45	66	90

ANNUAL & SEASONAL TOTALS

HEAT UNITS^	CHILL INFOMATION^^
86/55F = 103	HOURS OF TEMP BELOW 45F = 805
86/50F = 165	HOURS OF TEMP BELOW 32F = 145
86/45F = 246	HOURS OF TEMP ABOVE 68F = 244

ABBREVIATIONS AND UNITS

- MX : MAXIMUM FOR DAY
- MN : MINIMUM FOR DAY
- AV : AVERAGE FOR DAY
- WIND SPEED : IN MILES/HOUR
- RAIN : RAINFALL IN INCHES
- AIR TEMP : AIR TEMPERATURE IN DEGREES F
- REL HUM : RELATIVE HUMIDITY IN %
- SOLAR RAD : SOLAR RADIATION IN LANGLEYS
- SOIL TEMP : SOIL TEMPERATURE AT 2 AND 4 INCHES IN DEGREES F
- ETo : REFERENCE CROP EVAPOTRANSPIRATION IN INCHES

: MISSING DATA
55 : TEMPERATURE LIMITS = 86/55F
50 : TEMPERATURE LIMITS = 86/50F
45 : TEMPERATURE LIMITS = 86/45F
^ : ACCUMULATED SINCE JAN 1
^^ : ACCUMULATED SINCE NOV 1

Figure 5. AZMET Weekly Weather Summary for Tucson. The ETo total for the week (0.88") is presented at the bottom of the ETo column.

PRECAUTIONS

Appropriate caution should be exercised when initiating an irrigation management program that incorporates AZMET ET estimates. Users of AZMET need to be aware that ET will vary with location due to differences in wind and cloudiness. To accommodate for these local variations in weather, the Kc values in Table 1 may need some adjustment. The authors suggest that Kc adjustments be made on the basis of turfgrass performance. Increase the value of the coefficients if unacceptable turf quality results. Alternatively, you may wish to reduce the coefficients if the resulting turf quality is higher than deemed necessary, or water applications are in excess of ceilings imposed by DWR.

Finally, while AZMET ETo estimates provide a convenient means of determining turf ET, irrigation managers must be cognizant of the fact that irrigation system efficiency and water quality must also be taken into consideration when determining the final amount of water to apply. Use of inefficient irrigation systems and/or irrigation water with a high salt content will require applications of water over and above that lost by ET.