TECHNICAL NOTE

WATER USE AND TRANSPIRATION

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Water needs for any plant can be divided into two categories a) the water needed to provide the **physical content** of water in the roots, stems, leaf structure tissue itself; and b) the water that is lost by **transpiration** activities of the plant. A succulent plant like a cactus stores a lot of water in its structure, but transpires very little. Grass and most leafy plants on the other hand provide minimal storage in structure, but transpire a lot of water by transpiration. Transpiration is the invisible physical activity of growing plants where water absorbed at the root level is transferred through the supporting stems and out to the surrounding atmosphere from leaf openings called “stomata”.

Turf grasses may transpire as little as **0.10** gallons per square foot per day during cool night time periods, or over **0.40** gallons per square foot per day during hot, dry windy conditions. On the other end of the spectrum desert plants like cactus have evolved with structures that minimize transpiration to nearly undetectable levels. Water loss by **transpiration** is a **variable rate** that will be dependent on a combination of all of the following factors:

- Plant species
- Leaf area (of growing tissue)
- Humidity
- Temperature
- Wind speed
- Sun exposure (cloudiness)
- Health of the plant

To illustrate this biological variability several testing scenarios were documented in regard to water usage in EPIC systems.

EPIC TRANSPIRATION TESTS

13” Deep, 11.25” diameter (0.69 sq.ft.) Sand based grass bucket with
Established Kentucky Blue Grass Sod.
Water capacity (dry) 6500 ml. (0.92 gal.) per 0.667 cu ft. (1.38 g/cf)
3784 ml.= 1gal.
Temperature in F, Reno Gazette logs
Humidity air saturation < 10%

DATE	TIME	ML	T.ML	GAL	T.GAL	TEMP	GSF/d	COMMENT
8/1/01	5:00 P	160	160	0.042	0.042			Mahogany
8/2/01	8:00 A	210	370	0.055	0.097	96-59		Sunny/no wind
	5:00 P	180	550	0.047	0.144		0.21	area
8/3/01	8:00 A	190	740	0.050	0.194		0.11	
	7:00 P	230	970	0.061	0.256	92-60	0.19	
8/4/01	8:00 A	140	1,110	0.037	0.293		0.10	
8/6/01	7:00 A	680	1,790	0.180	0.473		0.13	
	6:00 P	320	2,110	0.085	0.558	98-56	0.27	
8/7/01	8:00 A	200	2,310	0.053	0.610		0.13	
	6:00 P	320	2,630	0.085	0.695	100-61	0.30	
8/8/01	8:00 A	160	2,790	0.042	0.737	98-67	0.10	
8/9/01	8:00 A	320	3,110	0.085	0.822		0.12	
	8:00 P	250	3,360	0.066	0.888	96-62	0.19	0.17 Av.
8/10/01	7:00 A	150	3,510	0.040	0.927	99-67	0.09	
8/11/01	9:00 A	420	3,930	0.111	1.038		0.15	
	7:00 P	390	4,320	0.103	1.141	95-55	0.36	
8/12/01	9:00 A	160	4,480	0.042	1.183		0.10	
	5:00 P	220	4,700	0.058	1.241	96-62	0.25	
8/13/01	7:00 A	220	4,920	0.058	1.299	95-65	0.14	
8/14/01	7:00 A	330	5,250	0.087	1.387		0.13	
	6:00 P	240	5,490	0.063	1.451	98-64	0.20	
8/15/01	7:00 A	210	5,700	0.055	1.506	99-54	0.15	
8/16/01	7:00 A	410	6,110	0.108	1.615		0.16	
	8:00 P	240	6,350	0.063	1.678	100-55	0.17	
8/17/01	8:00 A	170	6,520	0.045	1.723		0.13	
	6:00 P	280	6,800	0.074	1.797	99-57	0.26	
8/20/01	1:00 P	Full						
	4:30 P	230	230	0.061	0.061		0.61	Beaumont
8/21/01	7:00 A	150	380	0.040	0.100		0.10	High wind,

DATE	TIME	ML	T.ML	GAL	T.GAL	TEMP	GSF/d	COMMENT
	6:30 P	330	710	0.087	0.188	86-53	0.26	Full sun area
8/22/01	7:00 A	230	940	0.061	0.248		0.17	
	7:00 P	240	1180	0.063	0.312	86-54	0.18	
8/23/01	7:00 A	230	1410	0.061	0.373		0.18	
	6:30 P	200	1610	0.053	0.425	86-48	0.16	0.22 Av.
8/24/01	7:00 A	230	1840	0.061	0.486		0.17	
	7:30 P	260	2100	0.069	0.555	89-51	0.19	
8/25/01	7:30 A	300	2400	0.079	0.634		0.23	
	7:00 P	240	2640	0.063	0.698	98-53	0.20	
8/26/01	7:00 A	210	2850	0.055	0.753		0.16	
	6:30 P	490	3340	0.129	0.882	98-56	0.39	
8/27/01	6:50 A	140	3480	0.037	0.920		0.11	
	6:50 P	340	3820	0.090	1.010	97-57	0.26	
8/28/01	6:50 A	200	4020	0.053	1.062		0.15	
	5:00 P	360	4380	0.095	1.158	99-59	0.33	
8/29/01	8:00 A	210	4590	0.055	1.213		0.13	
	8:10 P	350	4940	0.092	1.305	93-58	0.27	
8/30/01	7:20 A	190	5130	0.050	1.356		0.15	
	6:15 P	430	5560	0.113	1.469	93-59	0.36	0.24 Av.
8/31/01	6:25 A	160	5720	0.042	1.512		0.12	
9/1/01	7:15 A	490	6210	0.129	1.641	93-57	0.18	
9/2/01	6:15 A	580	6790	0.153	1.794		0.23	
	4:45 P	460	7250	0.122	1.916		0.40	
9/3/01	6:50 A	330	7580	0.087	2.003		0.22	
	5:40 P	460	8040	0.122	2.125	92-59	0.39	
9/4/01	7:20 A	230	8270	0.061	2.185		0.15	
	7:30 P	360	8630	0.095	2.281	90-57	0.28	
9/5/01	7:00 A	260	8890	0.069	2.349		0.21	
	5:30 P	360	9250	0.095	2.444	87-57	0.32	

In conventional sprinkler (overhead) irrigation an estimate of water need is distributed at the surface with the anticipation the water will find itself to the roots and satisfy the transpiration needs of the turf. A temporary reservoir is created in the root/soil structure such that enough water will be available until the next application. If we apply too much water and/or the soils are compacted, excess water is lost by runoff. If it is windy, water is lost from the target area, and there may also be insufficient water available until the next cycle. Inefficiency arises from:

- Difficulty of predicting the exact transpiration needs due to the just mentioned changing variables.

- Variability of distribution coverage due to the mechanical state and nature of the sprinkler head or overhead watering volume, time, and speed.
- Slope and compaction levels of soils that influence drainage and water loss.

In EPIC, irrigation can be **100% efficient** not that plants are forced to use less water, but because EPIC eliminates the above inherent problems of overhead irrigation. Properly constructed, **EPIC systems will match the transpiration needs of the plant** by simply providing a stable underground reservoir, and the plants themselves determine the water uptake they need.

Textbooks on a national level may chart water requirements as indicated in the table below:

Climatic Region	In./day	Gal/sq.ft/day
Coastal climates having considerable fog	0.10 - 0.15	0.06 - 0.09
Northern temperate regions having moderate summer temperatures and humidities	0.12 - 0.15	0.07 – 0.09
Midtransitional region having high summer temperatures	0.15 - 0.27	0.09 – 0.17
Interior continental climate of the plains and interior valleys having hot, dry summers	0.25 - 0.35	0.16 – 0.22
Dry desert areas	0.30 – 0.45	0.19 – 0.28

These numbers are however averages and have been adjusted by not incorporating runoff waste due to slopes or inefficient irrigation practices. Microclimates within a general region may also show variations due to specific variables. As an example to that effect, in a high desert area, during the summer Hidden Valley Golf course (Reno,NV) puts out by sprinkler irrigation approximately 0.23 GPSF/day while the higher altitude and windier Redhawk Golf course puts out 0.62 GPSF/day. The differences may be due to different wind conditions or just a judgment on the part of the superintendent.

The EPIC display aquarium (highly controlled tool) at our office in the last days of July when temperatures soared to the high 90's consumed 0.25 – 0.31 GPSF/day. Although it is exposed to very hot windy conditions in the afternoon, it enjoys being in the shade for most of the morning.

Data on our longest standing installation is attached for review, as EPIC expands additional data is being gathered from various sources. In general EPIC systems (if not leaking) will supply the exact plant requirements in a particular area of the installation, as runoff and air evaporation of droplets are eliminated (problems inherent in sprinkler systems.)

EPIC

UNR Practice Field Water Consumption Data

> Total affected Field Area 200,000 sq.ft.

Date	Time	Meter	Gallons used	GPSF/day	Comment
07/26/00	3:00 P	1,345,400			Sod Completion
07/27/00	6:00 A	1,375,200	29,800	0.09	Sod Dormant
08/03/00	4:00 P	1,656,400	281,200	0.19	Top Watering of Clay based sod
08/06/00	7:30 A	1,764,265	107,865	0.20	
08/06/00	5:00 P	1,780,700	16,435	0.20	
08/08/00	8:00 A	1,847,200	66,500	0.21	Valve adjustments
08/08/00	6:00 P	1,862,540	15,340	0.18	
08/09/00	7:00 A	1,863,400	860	0.01	First night time data
08/10/00	7:00 A	1,888,880	25,480	0.13	
08/10/00	5:00 P	1,900,300	11,420	0.14	
08/11/00	7:30 A	1,923,720	23,420	0.19	
08/12/00	8:30 A	1,949,420	25,700	0.12	August
08/13/00	10:00 A	1,976,720	27,300	0.13	0.158 Average
08/14/00	8:00 A	1,998,660	21,940	0.12	
08/15/00	7:00 A	2,022,940	24,280	0.13	
08/17/00	7:30 A	2,105,400	82,460	0.20	
08/20/00	9:00 A	2,242,500	137,100	0.22	
08/21/00	8:00 A	2,285,410	42,910	0.22	
08/22/00	8:00 A	2,329,690	44,280	0.22	Top watering/Fertilizing
08/24/00	8:00 A	2,358,490	28,800	0.07	
08/28/00	8:00 A	2,476,160	117,670	0.14	
08/29/00	7:30 A	2,510,370	34,210	0.18	
08/31/00	2:00 P	2,565,510	55,140	0.12	
09/01/00	9:00 A	2,585,960	20,450	0.13	
09/03/00	11:00 A	2,637,720	51,760	0.12	
09/05/00	7:30 A	2,657,690	19,970	0.12	
09/14/00	3:00 P	2,929,500	271,810	0.15	
09/15/00	7:30 A	2,955,430	25,930	0.19	September
09/17/00	11:00 A	3,038,510	83,080	0.19	0.134 Average
09/19/00	8:00 A	3,090,000	51,490	0.14	
09/21/00	2:00 P	3,135,990	45,990	0.10	
09/22/00	8:00 A	3,160,200	24,210	0.16	

Date	Time	Meter	Gallons used	GPSF/day	Comment
09/23/00	2:00 P	3,199,040	38,840	0.16	
09/27/00	8:00 A	3,298,120	99,080	0.13	
09/28/00	8:00 A	3,302,300	4180	0.02	
10/03/00	8:00 A	3,450,200	147,900	0.15	Aerating 10/2/00
10/04/00	8:00 A	3,475,770	25,570	0.13	
10/05/00	8:00 A	3,499,370	23,600	0.12	See average next page
10/06/00	8:00 A	3,523,580	24,210	0.12	
10/09/00	8:00 A	3,659,010	135,430	0.23	Valves Fully Open
10/10/00	8:00 A	3,678,840	19,830	0.10	
10/11/00	8:00 A	3,699,400	20,560	0.10	
10/12/00	8:00 A	3,717,910	18,510	0.09	October
10/13/00	8:00 A	3,737,430	19,520	0.10	0.117 Average
10/14/00	8:00 A	3,753,010	15,580	0.08	
10/16/00	5:00 P	3,795,550	42,540	0.09	
10/17/00	8:00 A	3,806,520	10,970	0.09	
03/15/01	4:00 P	4,004,000	197,480		Intermittent Winter Use +
03/16/01	2:00 P	4,076,020	72,020	0.39	Initial Charging Sequence
03/20/01	10:00 A	4,144,620	68,600	0.09	
03/24/01	11:00 A	4,210,590	65,970	0.08	March
03/26/01	2:00 P	4,247,670	37,080	0.06	0.133 Average
03/27/01	2:00 P	4,265,140	17,470	0.09	
03/30/01	3:00 P	4,318,260	53,120	0.09	
04/02/01	3:00 P	4,369,630	51,370	0.09	
04/05/01	10:00 A	4,427,040	57,410	0.10	April
04/16/01	4:00 P	4,607,120	180,080	0.08	0.088 Average
04/24/01	9:00 A	4,688,600	81,480	0.05	
04/30/01	3:00 P	4,833,040	144,440	0.12	
05/03/01	2:00 P	4,953,860	120,820	0.20	
05/07/01	8:00 A	5,042,450	88,590	0.12	May
05/10/01	11:00 A	5,108,503	66,053	0.10	0.151 Average
05/16/01	12:00 P	5,297,870	189,367	0.16	
05/18/01	7:00 P	5,386,150	88,280	0.19	
05/30/01	9:00 A	5,704,400	318,250	0.14	
06/11/01	8:00 A	6,107,800	403,400	0.17	June
06/18/01	12:00 P	6,327,790	219,990	0.15	0.16 Average
07/11/01	4:00 P	6,890,350	562,560	0.12	
07/12/01	4:00 P	6,912,240	21,890	0.11	New Sand Based Sod Primary F.

Date	Time	Meter	Gallons used	GPSF/day	Comment
07/19/01	5:00 P	7,098,200	185,960	0.13	Top watering to soften clay areas
07/23/01	4:00 P	7,213,370	115,170	0.14	As such 0.13 Av. For July not
07/24/01	5:00 P	7,242,970	29,600	0.14	Accurate due to outside water
07/30/01	1:00 P	7,419,300	205,930	0.15	
08/07/01	8:00 A	7,667,900	248,600	0.16	Fertilizing + Top watering today
08/08/01	9:00 A	7,687,150	19,250	0.09	
08/13/01	8:00 A	7,824,880	137,730	0.14	
08/17/01	11:00 A	7,961,320	136,440	0.16	0.15 Av. August
08/20/01	11:00 A	8,035,170	73,850	0.12	
08/23/01	8:00 A	8,129,340	94,170	0.16	
08/27/01	8:00 A	8,262,820	133,480	0.17	
08/31/01	9:00 A	8,393,730	130,910	0.16	
09/04/01	9:00 A	8,514,600	120,870	0.15	
09/05/01	2:00 P	8,574,960	60,360	0.25	Bi-pass valves left open (flooded)
09/11/01	5:00 P	8,717,130	142,170	0.12	
09/13/01	4:00 P	8,767,840	50,710	0.13	0.13 Av. September
09/17/01	5:00 P	8,876,200	108,360	0.13	
11/02/01	12:00 P	9,626,680	750,480	0.08	0.08 Av. October
04/01/02	3:00 P	10,160,100	533,420	0.02	Winter shut down loss,recharge
05/17/02	1:00 P	10,681,610	521,510		Water shut off one week

Metered studies on a comparative residential lot in the Reno that incorporated standard sprinkler design and the EPIC system showed that EPIC water usage was **58%** less than conventional irrigation when based on a square foot basis. The seasonal averages over a four year period demonstrated a water demand for sprinklers at **0.33 gallons per square foot per day** versus **0.15 gallons per square foot per day for the EPIC area.**

Very accurate comparative studies at New Mexico State University that studied water usage between overhead sprinklers, subsurface drip and EPIC systems on 12 golf course greens showed **water savings of 50% on EPIC systems** as well as better turf quality.

In highly controlled and independent party studies on Al-Sammalia Island in Abu Dhabi, UAE where August temperatures exceeded 120 deg. F. short cropped Bermuda grass grown in an EPIC profile showed a water demand to be **78.9% less** than a similar area served by conventional sprinklers. Recorded data illustrated water usage at 0.686 gal./sq.meter/day (**0.06 gal/sq.ft/day**) for EPIC versus 3.250 gal./sq.meter/day (**0.30 gal/sq.ft./day**) for conventional Sprinklers.