How to Create an Irrigation Schedule

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Water use – defined

- Water use
  + Metabolism (growth)
  + Transpiration
  + Evaporation

- 1% to 3% in metabolic processes
- > 90% Transpiration

Turgeon, 2004
Lower Rio Grande Valley: Pecan Trees on 27,200 acres
Water Requirement (ET): 48”/yr
(Samani et al., 2009)
NMSU Golf Course:
90 irrigated acres
22 CS & 68 WS

Water Requirement (ET):
CS: 53” WS: 34” = 48”

(Leinauer and Smeal, 2012)
The majority of a tree root system is in the top three feet of soil and extends several feet beyond the canopy.
Canopy die-back (cavitation) of a mature ash tree associated with turfgrass removal and inadequate irrigation
(Photo courtesy of Devitt and Morris [UNLV], 2008)
Factors influencing ET-rates

- Turf species / cultivars
- Soil water availability
- Turf quality
- Climate / weather / season

- Soil type
- Water quality
- Maintenance intensity
  - Fertility
  - Mowing height
  - Plant growth regulators
Evapotranspiration

1) **Actual Evapotranspiration**
   - Lysimeter
   - Moisture Sensors

Courtesy Brian Horgan
## Mean Summer Evapotranspiration Rates of Different Turf Species

<table>
<thead>
<tr>
<th>ET rate</th>
<th>Cool season</th>
<th>Warm season</th>
</tr>
</thead>
<tbody>
<tr>
<td>in/wk</td>
<td>mm/day</td>
<td></td>
</tr>
<tr>
<td>2.0 – 3.5</td>
<td>7.2 – 12.6</td>
<td>Tall Fescue</td>
</tr>
<tr>
<td>1.8 – 3.1</td>
<td>6.6 – 11.2</td>
<td>Perennial ryegrass</td>
</tr>
<tr>
<td>1.7 – 2.2</td>
<td>6.2 – 8.1</td>
<td>Seashore paspalum</td>
</tr>
<tr>
<td>1.6</td>
<td>5.7</td>
<td>Blue grama</td>
</tr>
<tr>
<td>1.5 – 2.0</td>
<td>5.3 – 7.3</td>
<td>Buffalograss</td>
</tr>
<tr>
<td>1.0 – 2.2</td>
<td>4.0 – 8.7</td>
<td>Bermudagrass</td>
</tr>
<tr>
<td>1.3 – 2.1</td>
<td>4.8 – 7.6</td>
<td>Zoysiagrass</td>
</tr>
<tr>
<td>1.1 – 1.8</td>
<td>4.1 – 6.6</td>
<td>Kentucky bluegrass</td>
</tr>
</tbody>
</table>

Gaussoin, 2003
Buffalograss - Water Use
(Stewart et al., 2004)

• No difference in water extraction between buffalograss and Kentucky bluegrass for well watered conditions

Incipient water stress:
• Kentucky bluegrass depleted 50% of soil water to 30 cm depth (6 days)
• Buffalograss depleted 60% of soil water to 90 cm depth (20 days)
Average Daily ET of Cool Season Turf (5 years)

\[ ET = 0.0245 - 0.00331d + 0.000068d^2 - 3.114 \times 10^{-7}d^3 + 4.1 \times 10^{-10}d^4, \quad r^2 = 0.95 \]
Average Daily ET of Warm Season Turf (5 years)

\[ ET = -0.608 + 0.00825d - 0.0000209d^2, \quad r^2 = 0.87 \]

**YEAR**
- 1998
- 1999
- 2000
- 2003
- 2004

**Date (d = day of year)**
- 4/1
- 5/1
- 6/1
- 7/1
- 8/1
- 9/1
- 10/1
- 11/1

**Daily Water Use, in. (ET)**
- 0.2
- 0.1
- 0.0
Evapotranspiration

1) Actual Evapotranspiration
   Lysimeter
   Moisture Sensors

2) Potential or Reference Evapotranspiration

Courtesy Brian Horgan
2) Potential or Reference Evapotranspiration

ET calculated from

- Solar radiation
- Temperature
- Humidity
- Wind speed

\[
ET_o = \frac{0.408 \Delta (R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34 u_2)}
\]
NM Climate Center

You are here: » Home » Weather Data » NM Climate Center » NMSU Turfgrass

NMSU Turfgrass

Latitude: 32.275
Longitude: -106.736
Elevation: 1221.000
County:
Climate Division:

Get Data
- Daily/ Hourly Data List
- Reference ET and GDD
# NMSU Turfgrass ET and GDD Data

**Start Date:** 2014-06-16  
**End Date:** 2014-06-22

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
<th>RH</th>
<th>Wind</th>
<th>Solar Radiation</th>
<th>Reference ET</th>
<th>Growing Degree Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>MPH</td>
<td>Total</td>
</tr>
<tr>
<td>2014-06-16</td>
<td>98.35</td>
<td>67.42</td>
<td>22.68</td>
<td>8.90</td>
<td>3.74</td>
<td>30.78</td>
</tr>
<tr>
<td>2014-06-17</td>
<td>97.57</td>
<td>70.70</td>
<td>35.85</td>
<td>10.41</td>
<td>3.89</td>
<td>25.83</td>
</tr>
<tr>
<td>2014-06-18</td>
<td>93.38</td>
<td>68.05</td>
<td>48.73</td>
<td>13.36</td>
<td>4.80</td>
<td>26.27</td>
</tr>
<tr>
<td>2014-06-19</td>
<td>94.80</td>
<td>66.65</td>
<td>38.52</td>
<td>10.82</td>
<td>2.16</td>
<td>27.90</td>
</tr>
<tr>
<td>2014-06-20</td>
<td>95.88</td>
<td>71.01</td>
<td>45.95</td>
<td>11.92</td>
<td>6.66</td>
<td>30.80</td>
</tr>
<tr>
<td>2014-06-21</td>
<td>96.67</td>
<td>69.26</td>
<td>61</td>
<td>12.72</td>
<td>2.79</td>
<td>27.52</td>
</tr>
<tr>
<td>2014-06-22</td>
<td>101.21</td>
<td>70.41</td>
<td>38.78</td>
<td>8.10</td>
<td>4.53</td>
<td>30.60</td>
</tr>
</tbody>
</table>

**ETh**  Hargreaves and Samani Reference ET  
**ETo**  Penman-Monteith Short Canopy Reference ET  
**ETr**  Penman-Monteith Tall Canopy Reference ET  

2.06
Crop Coefficient (Kc)

\[ Kc = \frac{ET_a}{(ET_p \leftrightarrow ET_o)} \]

- Adjustment factor to calculate irrigation amount from \( ET_p \) or \( ET_o \)
- Several variables need to be considered to adjust irrigation to \( ET_a \) as closely as possible
Cool Season Grasses

K. Bluegrass

Prairie Junegrass (Koeleria macrantha)

Alkaligrass (removed)

Hard Fescue

Crested wheatgrass (Agropyron cristatum)

Courtesy D. Smeal, NMSU
Cool Season Turf Crop Coefficient (Kc), 5 years

\[ K_c = -0.07 + 0.000856G - 3.853 \times 10^{-7}G^2 + 8 \times 10^{-11}G^3 - 6.21 \times 10^{-15}G^4, \quad r^2 = 0.89 \]

ET/PET (Kc)

Cumulative GDD (G)

G = \sum (Mean Daily Temp - 40^\circ F) (with 105^\circ F and 40^\circ F cutoffs)

YEAR
- 1998
- 1999
- 2000
- 2003
- 2004

57
Warm Season Turf Crop Coefficient (Kc), 5 years

\[ Kc = 0.00128G - 1.1065 \times 10^{-6}G^2 + 5.1435 \times 10^{-10}G^3 - 1.111 \times 10^{-13}G^4, \quad r^2 = 0.74 \]

**YEAR**
- ■ 1998
- ○ 2003
- ▲ 2000
- ▲ 2004
- ● 1999

\[ G = \sum (\text{Mean Daily Temp} - 60^\circ \text{F}) \text{ (with 60^\circ \text{F minimum cutoff})} \]

Cumulative GDD (G)
Crop Coefficients

Kryder, 2015

Percentage of Water Needed Each Month Based on ET

January: 22%
February: 29%
March: 53%
April: 68%
May: 84%
June: 100%
July: 86%
August: 80%
September: 60%
October: 49%
November: 30%
December: 22%
Crop Coefficients

Kc values (0.1 – 1.1):

- Bermudagrass: 0.50 – 0.80
- Tall fescue: 0.75 – 0.95
- Perennial ryegrass: 0.80 – 1.0
- Kentucky bluegrass: 0.85 – 1.0
How much of a turf’s ET rate needs to be replaced through irrigation?

It depends almost entirely on your quality expectations.
Turfgrass Water Requirement

1. Determine how much water to apply (Irrigation amount)

Irrigation Scheduling:
1. Determine irrigation system’s run time
2. Determine how often to irrigate (Irrigation frequency)

⇒ Irrigation Audit
Irrigation Frequency

1) Plant
2) Weather
3) Soil
Factors that influence irrigation frequency

<table>
<thead>
<tr>
<th>Plants</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep rooted</td>
<td></td>
</tr>
<tr>
<td>Sparse cover</td>
<td>Dense cover</td>
</tr>
<tr>
<td>Warm season</td>
<td>Cool season</td>
</tr>
<tr>
<td>Less often</td>
<td>More often</td>
</tr>
</tbody>
</table>
## Factors that influence irrigation frequency

<table>
<thead>
<tr>
<th>Weather</th>
<th>Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool</td>
<td>Deep</td>
</tr>
<tr>
<td>Humid</td>
<td>Fine</td>
</tr>
<tr>
<td>Wind still</td>
<td>Low salt</td>
</tr>
<tr>
<td>Hot</td>
<td>Shallow</td>
</tr>
<tr>
<td>Dry</td>
<td>Coarse</td>
</tr>
<tr>
<td>Windy</td>
<td>High salt</td>
</tr>
</tbody>
</table>

- **Less often**
- **More often**
## Infiltration Rates

### BASIC INFILTRATION RATES FOR VARIOUS SOIL TYPES

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Infiltration rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm/hour</td>
</tr>
<tr>
<td>sand</td>
<td>30</td>
</tr>
<tr>
<td>sandy loam</td>
<td>20 - 30</td>
</tr>
<tr>
<td>loam</td>
<td>10 - 20</td>
</tr>
<tr>
<td>clay loam</td>
<td>5 - 10</td>
</tr>
<tr>
<td>clay</td>
<td>1 - 5</td>
</tr>
</tbody>
</table>
Irrigation frequency

• only as frequently as necessary to meet the plant’s need
• from every second day to once a week to every 10 days
• less frequent, heavy irrigations help develop a deeper root system (watch your soil type!)
• plants with shallow roots are much more susceptible to moisture stress
Turfgrass Water Requirement

A. Determine how much water to apply (Irrigation amount)

Irrigation Scheduling:

B. Determine irrigation system’s run time

⇒ Irrigation Audit
How to Perform a Catch Can Irrigation Audit on a Home Lawn Sprinkler System

Guide H-510
Cheryl Kent and Bernd Leinauer

Cooperative Extension Service • College of Agricultural, Consumer and Environmental Sciences

INTRODUCTION
The natural precipitation in New Mexico is not sufficient to grow and sustain turfgrasses and most other landscape plants. Therefore, supplemental irrigation is necessary to maintain turf at an acceptable quality level. Pop-up sprinklers are commonly used to irrigate lawn areas. Understanding the precipitation rate and uniformity of the sprinkler system will allow correct irrigation scheduling for more efficient irrigation and water savings. The step-by-step instructions outlined in this guide will help you perform a catch can irrigation audit on a pop-up sprinkler system. For a complete discussion on all aspects of turfgrass irrigation, refer to NMSU Circular 660, Turfgrass Irrigation (available at http://aces.nmsu.edu/pubs/_circulars/CR660.pdf).

PREPARING FOR THE AUDIT
1. Visually inspect your system for obvious problems.
   In many cases, an initial visual inspection can detect obvious problems that can be corrected, which will greatly improve the performance of the irrigation system. Turn on the system and watch it run. Are there broken sprinklers or obvious adjustments needed (heads not popping up all the way, clogged heads, or heads pointing in the wrong direction with water falling on the sidewalk instead of the lawn)? Are there obstructions preventing water from reaching the intended target (tree trunks, overgrown grass, weeds, or overhanging shrubs)?

PERFORMING THE AUDIT
If possible, perform the audit at the same time of day that irrigation normally takes place. Choose a calm day (winds less than or equal to 5 mph). Use catch cans to collect and measure the water delivered by the irrigation system. Catch cans are receptacles of uniform size placed on the lawn area (Figure 1). A minimum of 24 catch cans are needed for reliable results. Calibrated containers may be purchased from an irrigation supply store (Figure 2).

Figure 1. Calibrated catch can, measuring tape, metal support stake, and graduated cylinder.

http://aces.nmsu.edu/pubs/_h/H510.pdf
Irrigation Audit
Irrigation Audit Procedure

1. Take soil sample for feel
2. Turn on irrigated zone
3. Perform visual inspection of each zone and note problems
   1. Broken pipes and sprinklers
   2. Interference
   3. Rotors and sprays on same zone
   4. Clogged nozzles
   5. Erosion
   6. Exceptional wet or dry spots
   7. Plant conditions
Irrigation Audit Procedure (contd.)

4. Perform irrigation audit
   1. Set catch cans (allow distance to heads)
   2. Turn on zone
   3. Record run time
   4. Take core sample
   5. Collect data
   6. Perform calculations
4. Perform irrigation audit
   1. Set catch cans (allow distance to heads)
      I. Minimum of 12 (better 16 or 24)
      II. 12 to 24 inches in from the edge
      III. Rotor sprinkler heads less than 40 feet apart:
           i. within 2 to 3 feet near the head
           ii. every one third the distance
      IV. Rotor sprinkler heads greater than 40 feet apart:
           i. within 2 to 3 feet near the head
           ii. every one fourth of the distance
      V. Spray heads in irregularly shaped areas
         I. Uniform grid
         II. 5 to 8 feet spacing
Calculations

Data
1. Surface area of catch can
2. Run time
3. Collected irrigation amounts
Irrigation Audit

1. Surface Area:
   \[ A = r^2 \times \pi, \quad r = 2.25" \]
   \[ A = 16 \text{ in}^2 \]

2. Catch can test

   24 cans:
   13, 35, 40, 29, 39, 41, 45, 45, 30, 35, 47, 35, 79, 79, 50, 35, 17, 22, 28, 46, 67, 78, 42, 63,
   Average: 43.3 ml
2. Catch can test  
   Average (Avg.): 43.3 ml  
3. Run time 6 minutes  
4. Irrigated amount $I_a$:  

$$I_a = \frac{\text{Avg. (ml)}}{A(\text{in}^2)}$$  

$$I_a = \frac{43.3 \text{ ml}}{16 \text{ in}^2} = 2.7 \text{ ml/in}^2$$
Irrigation Audit

4. Irrigated amount $I_a$: 
   2.7 ml/in$^2$

5. Convert ml/in$^2$ to in: 
   multiply with 0.06

6. $I_a$: 0.16”

Average irrigation amount gives no information whether there are over and under-watered areas
Irrigation Audit

Low quarter distribution uniformity

1. Catch can test
   13, 35, 40, 29, 39, 41, 45, 45,
   30, 35, 47, 35, 79, 79, 50, 35,
   17, 22, 28, 46, 67, 78, 42, 63

2. Average of lowest 25%
   13, 17, 22, 28, 29, 30

3. Avg \( l_{lq} \) = 23.2

4. DU\(_{lq}\) = \( \frac{23.2}{43.3} = 0.54 = 54\% \)
Irrigation Efficiency

- Average DU of 0.5
Irrigation Audit

Low quarter distribution uniformity

• $DU_{lq} > 75\%$ Goal (Standard!)
• $DU_{lq} 60\%$ to $70\%$ common
• $DU_{lq} < 50\%$ not uncommon
Distribution uniformity rating for sprinklers used in turf irrigation (Mecham, 2004)

<table>
<thead>
<tr>
<th>Sprinkler type</th>
<th>Excellent</th>
<th>Very Good</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Spray</td>
<td>0.75</td>
<td>0.65</td>
<td>0.55</td>
<td>0.50</td>
<td>0.40</td>
</tr>
<tr>
<td>Rotor</td>
<td>0.80</td>
<td>0.70</td>
<td>0.65</td>
<td>0.60</td>
<td>0.50</td>
</tr>
<tr>
<td>Impact</td>
<td>0.80</td>
<td>0.70</td>
<td>0.65</td>
<td>0.60</td>
<td>0.50</td>
</tr>
</tbody>
</table>

- 50” of water is necessary to maintain a cool season turf
- improving the uniformity from 0.55 (which is considered “good” for spray heads) to 0.75
- decreases the water amount from 91” to 67” (182% to 134%)
Calculate Irrigation Run Time

Data
1. Water requirement (ET)
2. Crop Coefficient (Kc)
3. Irrigation application rate
4. Distribution Uniformity
5. Irrigation run times
6. Irrigation intervals
Run Time Modifier (RTM):
How much longer do you have to run the irrigation system to put down adequate amounts of water to the dry areas?

\[ \text{IR} = \frac{\text{ET} \times \text{Kc}}{\text{RTM}} \]

1. Midpoint Modifier (M.M.)
2. Distribution Uniformity (DU)
Irrigation Audit

Midpoint Uniformity

1. Catch can test
   13, 35, 40, 29, 39, 41, 45, 45,
   30, 35, 47, 35, 79, 79, 50, 35,
   17, 22, 28, 46, 67, 78, 42, 63

2. Average of lowest 50%
   13, 17, 22, 28, 29, 30,
   35, 35, 35, 35, 39, 40

3. $\text{Avg}_{\text{mu}} = 29.8$

4. $\text{DU}_{\text{mu}} = 29.8 / 43.3 = 0.69$
Irrigation requirement IR (inches)

Example:
ET for June 16 – June 25: 2.0”
Kentucky bluegrass: Kc = 0.8
Seasonal adjustment: 100%
Option 1: Midpoint Modifier M.M.
IR = (2” x 0.8) / 0.69 = 2.3”
Application rate: 0.16” in 6 minutes
  0.027“/min

Irrigation run time (week)
2.3/0.027 = 85 min
Irrigation requirement IR (inches)

Irrigation run time (week):
2.3/0.027 = 85 min

Irrigation run time (day):
85 min / 7 = 13 min
Irrigation requirement IR (inches)

Example:
ET for June 16 – June 25: 2.0”
Kentucky bluegrass: Kc = 0.8
Seasonal adjustment: 100%
Option 2: Low quarter RTM
IR = (2” x 0.8) / 0.54 = 3.0”

Application rate: 0.16” in 6 minutes
0.027“/min

Irrigation run time (week)
3/0.027 = 111 min
## Daily Irrigation Requirement IR

<table>
<thead>
<tr>
<th></th>
<th>Midpoint Modifier</th>
<th>Low Quarter RTM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weekly Irrigation</strong></td>
<td>2.3 / 0.027</td>
<td>3 / 0.027</td>
</tr>
<tr>
<td></td>
<td>= 85 Minutes</td>
<td>= 111 Minutes</td>
</tr>
<tr>
<td><strong>Daily Irrigation</strong></td>
<td>13 Minutes</td>
<td>16 Minutes</td>
</tr>
</tbody>
</table>
Example:
MP Rotator (Hunter) 0.45 in/hr

Prices for these products are listed on our price sheets.
Irrigation requirement IR (inches)

Example (MP Rotators):
ET for June 16 – June 25: 2.0”
Kentucky bluegrass: Kc = 0.8
Seasonal adjustment: 100%
Irrigation uniformity: 0.8

Irrigation run time (week):
(2/0.45)/0.8 x 60 = 333 min

Irrigation run time (day):
267 / 7 = 48 min
Soil sensor / ET – sensor
Water savings (2013)