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Drip Irrigation from Elevated Barrels: Emitter Performance at Substandard Pressure

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Introduction

Rainwater Catchment Systems

- According to The Texas Manual on Rainwater Harvesting, there are more than 100,000 residential rainwater harvesting systems in use in the U.S. and its territories.
- Because of the potential to conserve domestic, treated water, several cities in the SW US (e.g., Albuquerque, Austin, Oakland, San Antonio, San Diego, Santa Fe, Tucson) provide incentives for installation of rainwater harvesting systems.
  - Includes rebates or tax breaks on costs of rain barrels and tanks
- In many systems, runoff water from rooftops is channeled into elevated barrels or tanks and is used to irrigate landscape plants or small gardens.

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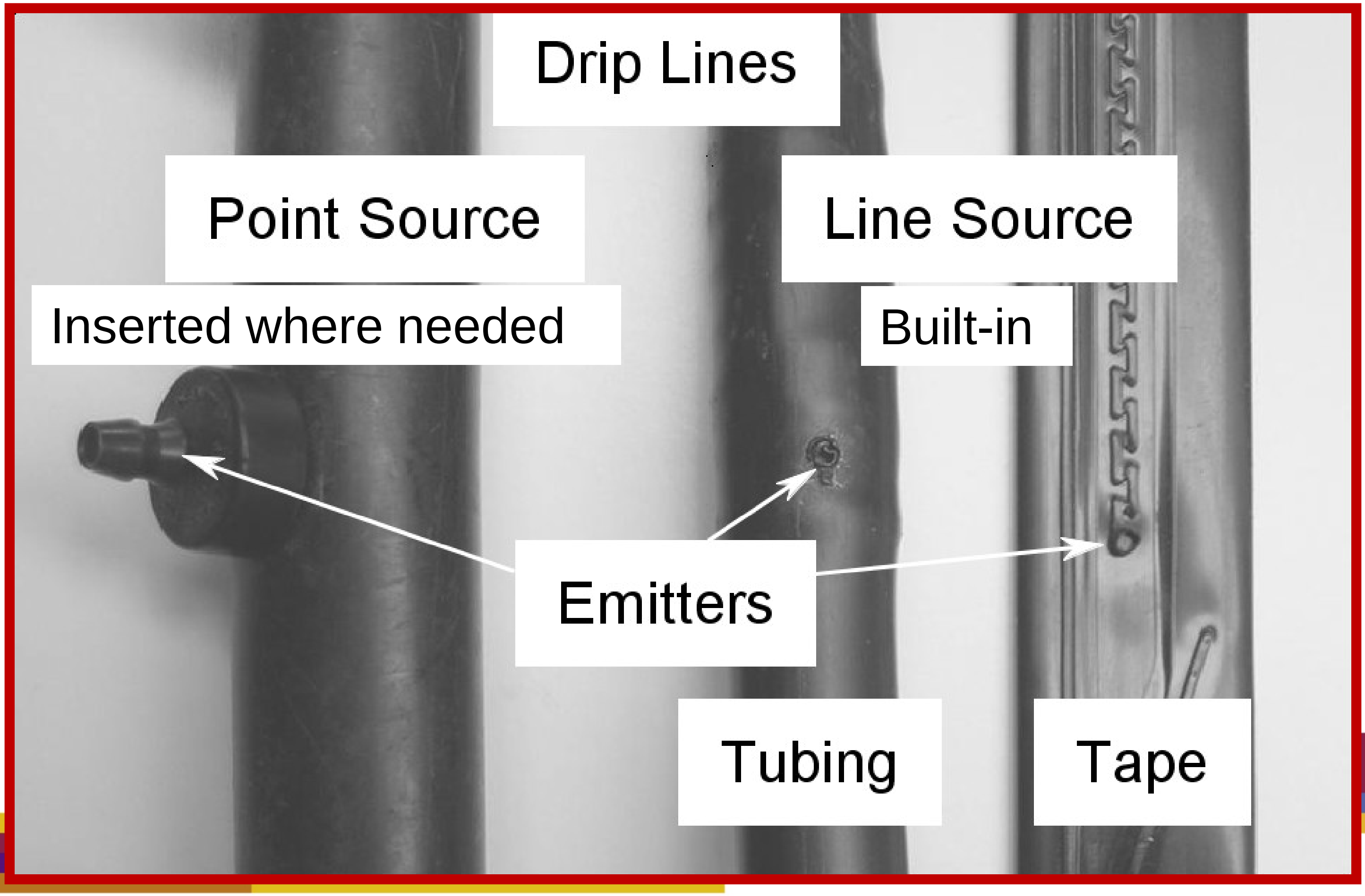
Examples



San Juan College – Farmington, NM

- Point-source drip irrigation is a convenient, water-conserving method of distributing water from elevated tanks to individual plants in a landscape.



Potential problems:

- The pressure provided to an emitter by the height of the water level (head) above the emitter in a rainwater catchment vessel (RCV) is usually lower than that recommended by the drip emitter manufacturer.
  - Pressure (psi) = height of water level above emitter (feet) x 0.433

    (or 2.31 feet of head provides 1 psi of pressure)
  - Typical head range from a RCV = 2 to 8 feet (0.9 to 3.5 psi)
  - Typical manufacturer recommended pressure > 10 psi (23 ft of head)
- What will be the effect on emitter flow rate and water distribution uniformity of these lower than standard pressures?

Specific Objectives of our Study

- Evaluate the effect of low (substandard) water pressures on:
  - Flow rate (FR)
  - Water application uniformity (WAU)

  of various models of drip emitters that are readily available from US distributors.

Materials and Methods

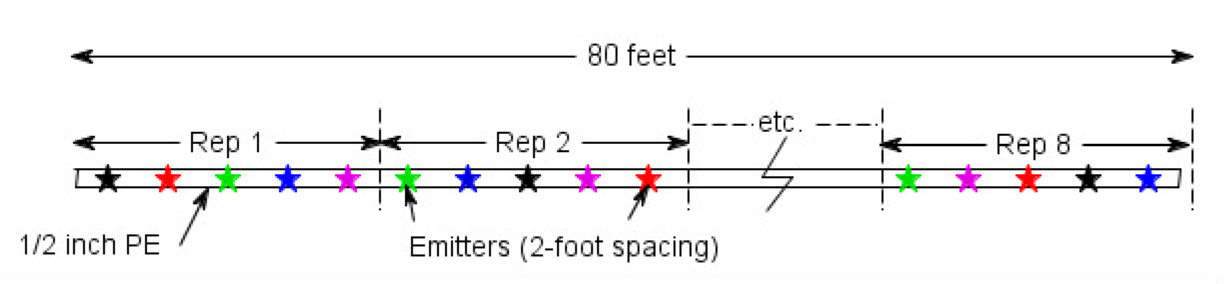
20 different point source emitter models were evaluated.

Specified FR range: 0.5 – 4 gallons per hour (gph)

Recommended pressure range: 10 – 50 psi

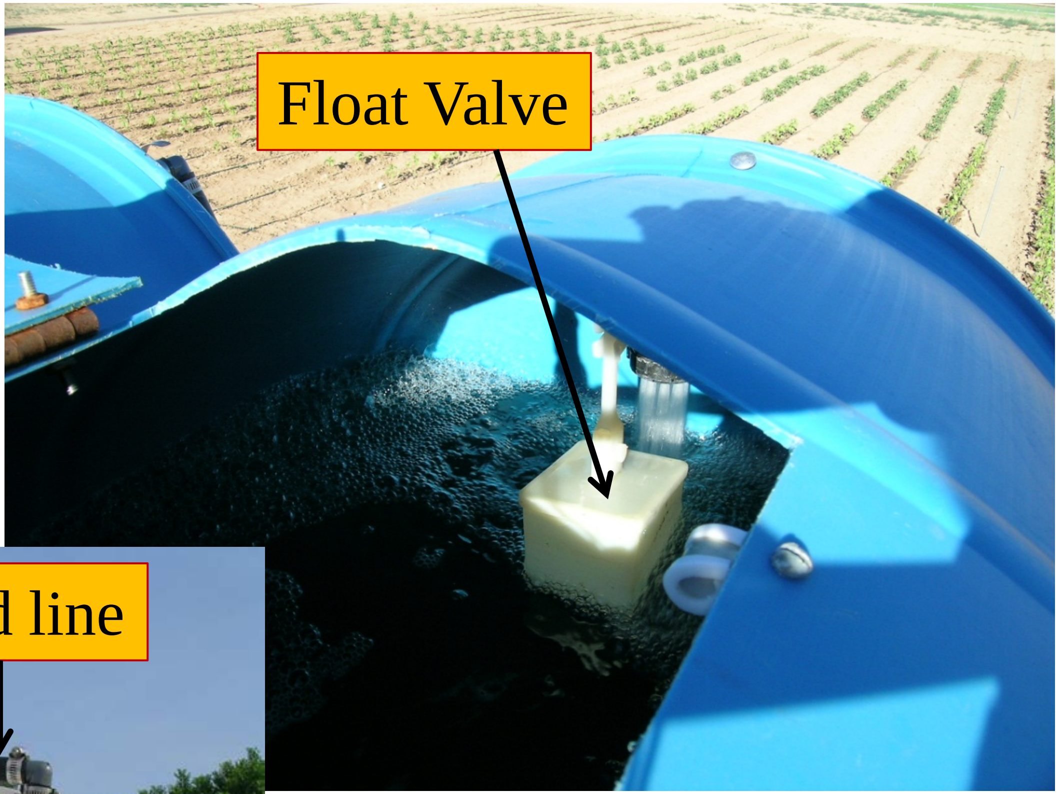
Many were pressure compensating (within a specified pressure range)

- Emitters were inserted into a ½ inch ID polyethylene (PE) lateral at a spacing of 2 feet in 8 sets (replicates) of 5 emitter models in each of 4 separate laterals.



- Total length of each lateral = 80 feet (40 emitters)

Water level in barrels elevated above the laterals was maintained at 5.5 feet (study 1) and 3.5 feet (study 2) using a pressurized line and float valve.



Laterals were hung on a level wire fence for ease in measuring emitter FR.

Graduated cylinder, timer, and catch cup & stand were used to measure FR from each emitter.

Calculation of Flow Rate (FR) and Water Application Uniformity (WAU)

- FR (gph) = ml/min x 60 ÷ 3785
- WAU
  - How uniformly water is delivered from all emitters on a drip line (lateral)
  - Ideally, for efficient irrigation scheduling, each emitter along a lateral should have the same flow rate

Water Application Uniformity

- In this study:

  WAU = 1 – cv (coefficient of variability)

  - cv = standard deviation / mean (average)

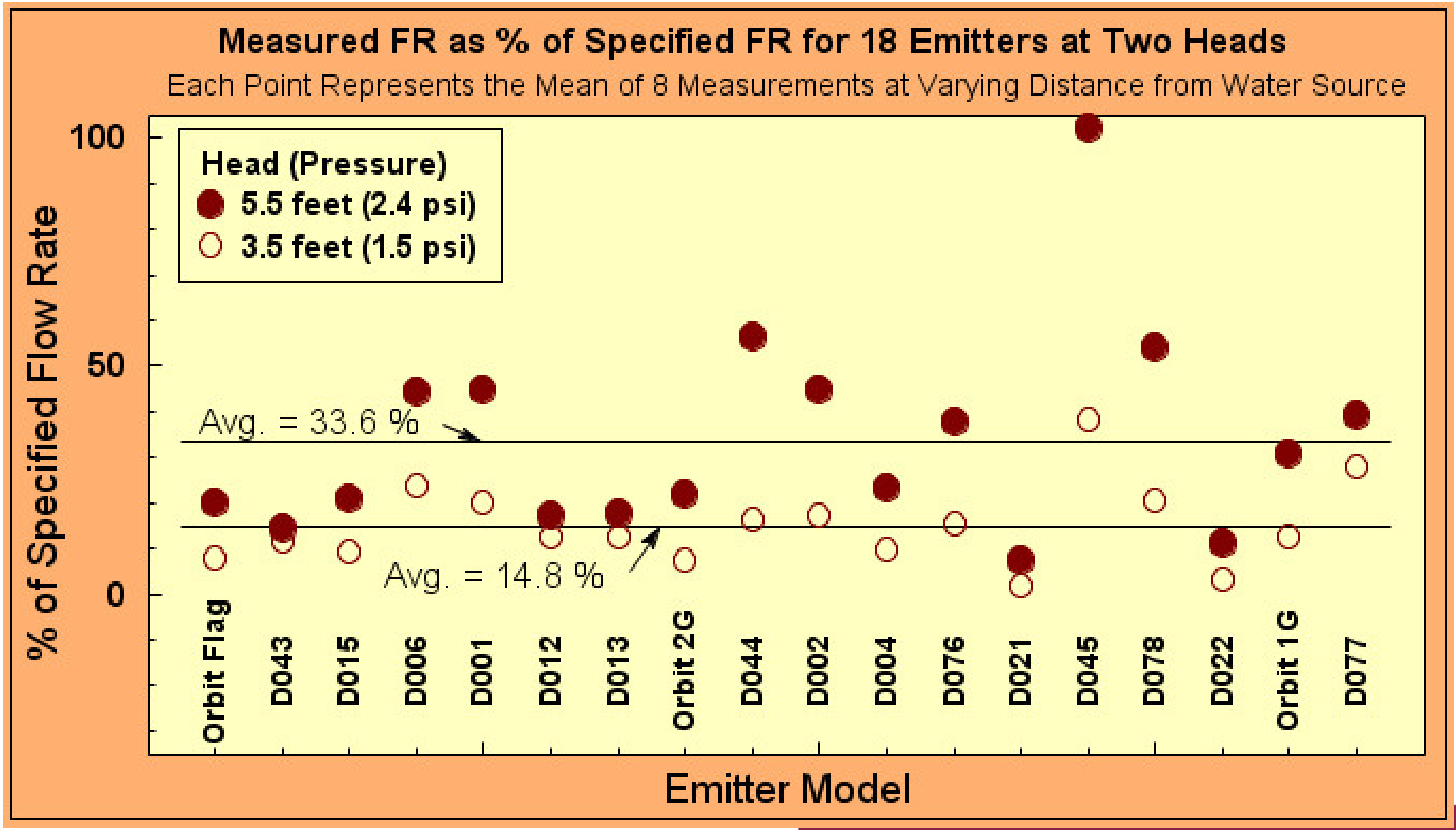
    of 8 measurements for each emitter model

  A WAU of 1.0 indicates perfect uniformity.

- A WAU of > 0.85 generally considered acceptable (in drip irrigation)

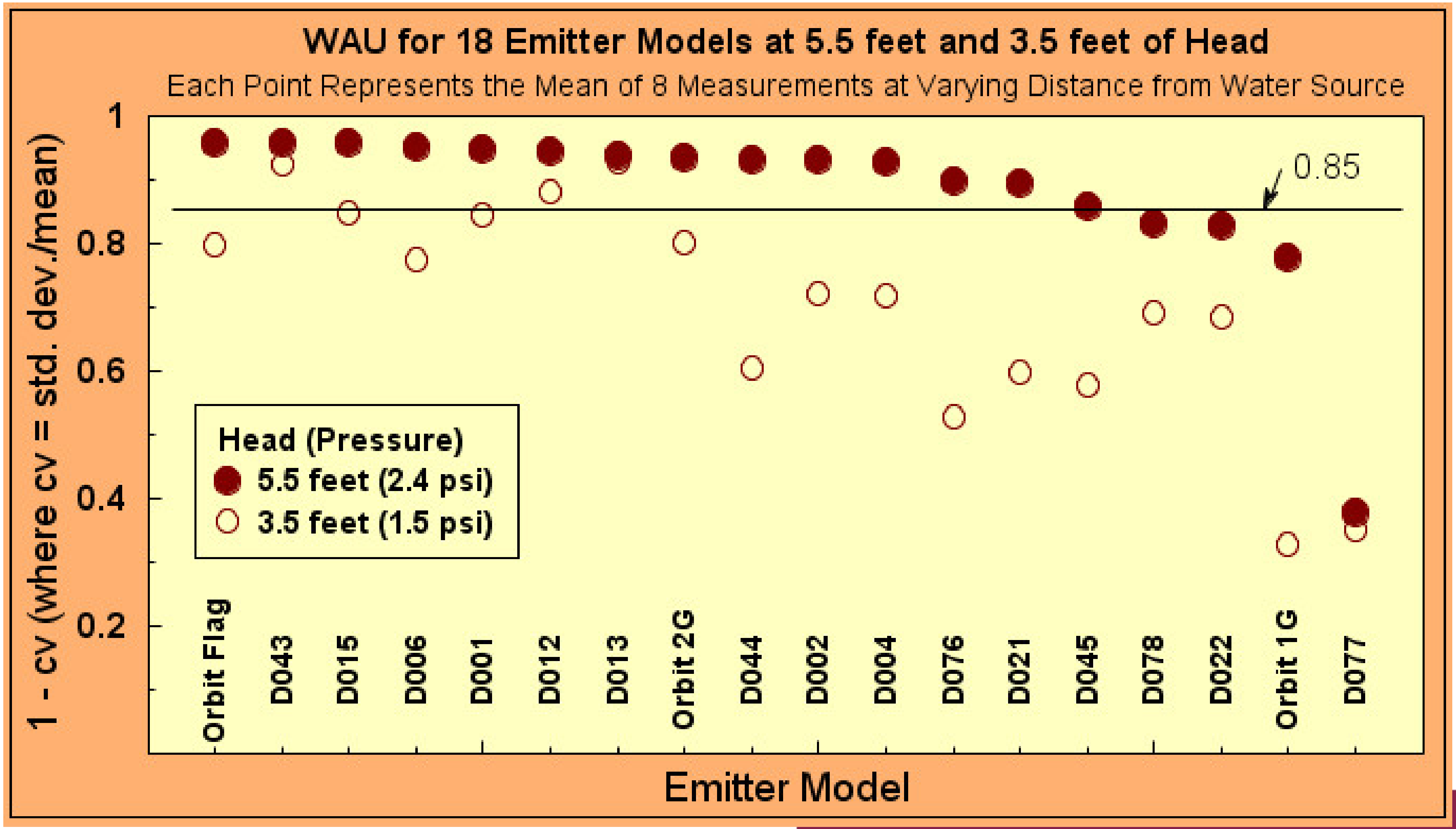
Results

Flow Rate as % of Specified



Note: Avg. FR not shown for emitters D079 and D080 due to zero flow in some units

Water Application Uniformity



Note: Avg. WAU not shown for emitters D079 and D080 due to zero flow in some units

Summary – Flow Rate

- Overall, measured emitter FR at heads of 5.5 feet and 3.5 feet averaged 33.6 % and 14.8 % of manufacturer specified FR, respectively.
- The average FR of one emitter (D045) at 5.5 feet of head (2.4 psi) was about equal to the specified FR of 1 gph at the recommended head range of 23 to 115 feet (10 to 50 psi).

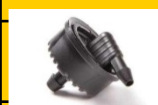
Summary – Water Application Uniformity

- 14 of the 20 emitters exhibited WAUs of > 0.85 at a head of 5.5 feet.
- But only 3 of the 12 (D043, D012, and D013) exhibited WAUs > 0.85 at a head of 3.5 feet.

Summary/Recommendations

- The actual flow rate of a point source emitter at substandard pressure will usually be less than that specified by the manufacturer and this must be considered when designing, setting up, and scheduling irrigations with a low pressure drip irrigation system.
- Foremostly, the irrigator should select an emitter that exhibits a high water application uniformity (i.e. > 0.85) and then consider a flow rate that will satisfy the plant's peak water requirement based on the desired irrigation schedule.

Emitters exhibiting water application uniformities of > 0.9 and flow rates (FR) of > 0.3 gph at 5.5 ft of head (and WAUs of > 0.9 at 3.5 ft of head)

Emitter*		**FR (gph)**	**WAU**	**FR/WAU @ 3.5 feet**
Orbit 4G (nc)		0.79	0.96	
D 043 (pc)		0.48	0.96	0.38/0.92
D 006 (pc)		0.44	0.95	
D 001 (pc)		0.45	0.95	
D 013 (nc)		0.35	0.94	0.25/0.93
Orbit 2G		0.44	0.93	
D 044 (pc)		1.12	0.93	
D 002 (pc)		0.89	0.93	
D 004 (pc)		0.76	0.93	

*nc – non-pressure compensating; pc – pressure compensating
Orbit models from Home Depot; ‘D’ model numbers from ‘The Drip Store’

Conclusions

- While the results of our study provide an indication of emitters that may perform well at low pressure, the irrigator should measure the actual flow rate of the selected emitter after setting up their systems. This is because even slight differences in lateral lengths, emitters per lateral, height of water level (head) above emitters, etc., between the actual system and the system that generated the tabular values in our study may affect flow rate.
- Irrigations cannot be scheduled effectively if the actual flow rate is unknown.

Irrigation Scheduling

Once the emitter flow rate is identified, irrigations can be scheduled accordingly after calculating the irrigation requirement (IR).

Example (xeriscape):

$IR = ET_r \times 0.3 \times D^2 \times 0.49$

Where:

IR = irrigation requirement per plant (gals)

ET_r = accumulated reference ET since previous irrigation based on weather (e.g. 0.3 to 0.35 inch per day – peak avg. in summer)

0.3 – average K_L (adjustment factor) for xeriscape plants

D = plant canopy diameter in feet

0.49 = constant to convert D to canopy area and inches to gallons (0.785 x 0.623)

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For example, suppose you are irrigating an 8-foot diameter desert willow once per week in the summer and average daily ET_r is 0.30 inch:

$$IR = (0.30 \times 7) \times 0.3 \times 8^2 \times 0.49$$

$$IR = 2.10 \times 0.3 \times 64 \times 0.49 = 19.8 \text{ gals}$$

Then:

Irrigation runtime = IR/FR

Suppose the emitter FR is found to be 0.89 gph, then irrigation runtime = 22 hours (19.8/0.89)

Further Information

- For details related to these studies and more, please visit our website:

  http://farmingtonsc.nmsu.edu
- Or contact Dan Smeal: dsmeal@nmsu.edu