Bubbler irrigation scheduling

Calculating a bubbler irrigation schedule requires the following steps:

- **Calculate plant water use (LPD)**
  - **Where LPD = Liters per day used by the plant.**
- **Calculate soil water storage (S)**
  - **Where S = volume of usable water (liters) in soil.**
- **Calculate days between irrigation (S/LPD)**
- **Calculate irrigation run time (S/Q)**
  - **Where Q = bubbler or emitter flow rate (LPM)**

Details on how to calculate plant water use are found at
http://ag.arizona.edu/research/DIRT/Measuring landscape irrigation uniformity.pdf

Calculate the soil water storage, S, based on soil texture, root zone, allowable soil water depletion for specific plants, and the diameter of the basin.

$$S = \left(\frac{\pi D_b^{\,2}\ m^2}{4}\right)(Z\ m)\left(\frac{AWHC}{100\ \%}\right)(MAD)\left(\frac{1{,}000\ L}{m^3}\right) = 8 * Z * AWHC * MAD * D_b^{\,2} \qquad (1)$$

where

S	=	Volume of water storage in soil available to the plant, L.
Z	=	root zone depth, m (1.0 m for trees and 0.5 m for shrubs),
AWHC	=	available water holding capacity, % (see table 2),
MAD	=	management allowable depletion (1.0 for desert plants, 0.5 for other plants),
D_b	=	diameter of the basin, m.

The available water holding capacity (the percent of soil volume that holds water that is available for the plant) for different textured soils is shown in table 1. Assume that depth of the root zone, Z, is 0.5 m for shrubs and 1.0 m for trees unless better information is available.

Table 1. Available water holding capacity for several soil textures.

Soil texture	AWHC %
Sand	8
Sandy loam	12
Loam	17
Clay loam	18
Silty clay	20
Clay	23

The management allowable depletion is the fraction of total available water in the soil that is available for a specific plant species. Very drought tolerant, moderately drought tolerant, and nondrought tolerant plants might have MAD's of 0.8, 0.45, and 0.2, respectively.

The number of days between irrigations (Days) is the Liters of storage divided by the Liters used per day.

$$\text{Days} = S / \text{LPD} \qquad (2)$$

The irrigation cycle run time (Minutes) is the soil water storage divided by the application rate (LPM)

$$\text{Minutes} = S / \text{LPM} \qquad (3)$$

Example 1. Calculate the watering schedule for a 5 m diameter maple tree (high water use plant) in Northern Arizona during late summer with the following parameters.

Canopy diameter = 3 m.
The basin diameter, D_b, is 1.2 m.
The soil is clay loam.
Bubbler flow rate, Q, is 8 LPM.
Late summer reference evapotranspiration, ET_0, is 5 mm/day
Species crop coefficient, K_s, is 0.5.
Microclimate and density crop coefficients are 1.0

Calculate plant water use (LPD)

$$\text{LPD} = ET_0 * K_L * D^2$$

$$\text{LPD} = 5 * 0.5 * 3^2 = 22.5 \text{ LPD}$$

Calculate soil water storage (S)

Assume that the MAD for a maple tree is 0.5.

AWHC for a clay loam soil is 18 %
Root zone depth, Z, for a tree is 2.0 m.

$$S = 8 * Z * AWHC * MAD * D_b^{\,2} = 8 * 2 * 18 * 0.5 * 1.2^2 = 207\ L$$

Calculate days between irrigation (S/LPD)

$$\text{Days} = S / \text{LPD} = 207 \text{ L} / 22 \text{ LPD} = 9.5 \text{ days}$$

Calculate irrigation run time (S/Q)

$$\text{Minutes} = S / \text{LPM} = 207 \text{ L} / 8 \text{ LPM} = 26 \text{ minutes}$$

A larger basin would also encourage root growth.

Redo the example with 3 m diameter basin.

Calculate plant water use (LPD)

Same as above = 22 LPD

Calculate soil water storage (S)

$$S = 8 * Z * AWHC * MAD * D_b^{\ 2} = 8 * 2.0 * 18 * 0.5 * 3^2 = 1{,}296\ L$$

Calculate days between irrigation (S/LPD)

Days = S / LPD = 1,296 L / 22 LPD = 59 days

Calculate irrigation run time (S/Q)

Minutes = S / LPM = 1,296 L / 8 LPM = 162 minutes

A bubbler may not fill a 3 m basin, so redo the example with a 2 m basin.

Calculate plant water use (LPD)

Same as above = 22 LPD

Calculate soil water storage (S)

$$S = 8 * Z * AWHC * MAD * D_b^{\ 2} = 8 * 2.0 * 18 * 0.5 * 2^2 = 576\ L$$

Calculate days between irrigation (S/LPD)

Days = S / LPD = 576 L / 22 LPD = 26 days

Calculate irrigation run time (S/Q)

Minutes = S / LPM = 576 L / 8 LPM = 72 minutes

The 2 m diameter basin is probably the best choice because there is a long period between irrigations and because the basin is not too large to be irrigated with one bubbler.