# Construction of Three Weighing Lysimeters for the Determination of Crop Coefficients for Improving Water Use Efficiency and Managing Irrigation of Row and Vegetable Crops in the Winter Garden

G. Piccinni, T. Marek, M. Jett, A. Schneider, D. Dusek, T. Howell

## Bottom line

- Improving irrigation application efficiency and distribution uniformity through new technologies could allow for greater total crop water use efficiency.

- Lysimeters, which are essentially large, weighing "flower pots", are used to measure real time water use during the growing season.

### Introduction

In semi-arid regions such as the Winter Garden and High Plains of Texas, ground water levels are declining and farmers are "mining and selling water". These producers, and the industries that support them, realize that their livelihood depends on the continued availability of ground water for crop irrigation. Unfortunately in many of these areas, water resources are limited and competition between urban users, industry, and agriculture is intense and all irrigation water needs to be optimally utilized. With this basis, the Texas Agricultural Experiment Station in Uvalde has taken a leadership role in water management efforts by investigating optimal water use for crops grown within the region.

However, because actual crop water requirements for the Winter Garden region of Texas are not available, many producers often apply significantly more irrigation water than the crop requires. This practice wastes water, and leads to potential problems with soil fertility and plant diseases. Thus there is an immediate need for accurate water use data for Winter Garden crops to maximize utilization of available irrigation water resources. By relating the water use of a specific crop to a well-watered reference crop such as alfalfa or grass, crop coefficients can be developed to assist in predicting accurate crop needs using meteorological data. Irrigation scheduling can then be improved for private consultants and growers to avoid water over use and to more precisely meet the crop water demand to produce greater yields, crop quality, and enhanced water use efficiency.

Crop coefficient curves are currently not available for the Winter Garden region and are not necessarily transferable from a different region. For the Texas High Plains, for example, crop water use has been determined for corn, sorghum, cotton, soybean, and wheat. Recently, networks of weather stations have been established in the Texas High Plains for the purpose of supporting predictions of crop ET. In the northern Texas Panhandle, economists have estimated fuel cost and engine wear savings in the range of 18 million dollars annually, definitively benefitting producers.

### Experimental Approach

Three weighing lysimeters, consisting of undisturbed 60" x 80" area by 84" depth cores of soil, comprise the Uvalde lysimeter facility. Two lysimeters, weighing in the range of 20,000 to 30,000 pounds, are to be placed beneath a linear irrigation system and used in field production. The third lysimeter is to be used to measure reference ET values (ETo) and is to be located in a well-watered grass area located near the field lysimeters. Several aspects of the design required engineering details to ensure acceptable performance.

The soil monolith boxes were constructed of 0.375-inch thickness mild steel plate and fabricated by a commercial steel-manufacturing firm. The above ground, top lip air gap between the inner and outer boxes was designed to be 0.375 inches. All welding on the boxes was alternated to provide minimal distortion in manufacturing. Internal and external reinforcing with 0.375 x 2 inch flat bars were engineered into the design to resist compression "bulges" during the acquisition phase of the soil monoliths. The 0.375 x 2 inch flat bars were also designed to resist clay-swelling forces during wetting cycles of the profile. The soil boxes also had a 0.75-inch flat bar on the interior of the box. This was to serve as an anti-seep collar within the AP soil zone to prevent any free water intrusion down the interior sidewalls as the profile contracted during low moisture periods. The outside boxes also had similar reinforcing flat bars spaced proportionally to resist clay expansion forces from the field side of the facility. During acquisition, the flat bar reinforcing design proved adequate in restricting sidewall deformation. All inner and outer boxes were primed and painted with an epoxy-based paint.

Once the soil monoliths were acquired, each monolith was outfitted with a steel, false top and lifted from the acquisition site using off centered, I beams attached to the sides with high strength, A325 bolts and overturned with the use of 75-ton crane. Once overturned, approximately 4 inches of parent material was excavated from the bottom of the monolith. Each monolith was then outfitted with a partitioned, multi-sintered tube, stainless steel drainage system to allow excavation of percolated water and related soluble compounds once in operation. The drainage system was packed in a uniform, ultra fine sand media. Subsequently, multiple pass welding sealed the bottom of each of the soil monolith boxes with a mild steel plate 0.375 inches in thickness.

Foundations for the lysimeters were established at a depth of nearly 9 feet below ground level. Each foundation was engineered to provide an ultra stable platform for the platform scale to rest on. The minimum nominal thickness of the foundations was 6 inches with supporting areas receiving a minimum of 12 inches of 4,000 pounds per square inch concrete. All reinforcing in the foundations were arranged in minimum grid of 10 inches with stress points receiving a 6 to 8 inch grid spacing. All reinforcing in the concrete was completed with #6 bars. A sloped sump drain was designed in the center of the foundation with a centered gravel base to drain water beneath the foundation in the event of leaks or surface overflows. The scale systems used in the design consist of sensitive platform type scales capable of weighing the entire soil mass and detecting small crop water changes. These scales utilize 4 weight beam mechanisms, which are essentially horizontal load cells with strain gauges. The scales further utilize an electronic accumulator to concatenate the 4 measurements for a central output. Each scale has a total capacity of 40,000 pounds. Preliminary calibrations indicate very good repeatability with coefficients of determination exceeding 0.9999. Detectable resolution values in the range of approximately 0.25 pounds on the 40,000-pound scales have been measured with a precision Campbell scientific CR23X electronic datalogger. The preliminary assessments of the scales are satisfactory for the desired level of accuracy required for use in measuring crop water use. Selected photographs of construction activities are included below.

**Figure 1**: Uvalde technician prepares sealing of soil box.

**Figure 2**: Illustration of pulldown assembly used to acquire soil monolith.

**Figure 3**: Lifting and overturning of soil monolith required the use of a large crane.

**Figure 4**: The desired end result is to have minimal distinction of the field to the soil monolith growth patterns. Shown here is the grass reference lysimeter at the USDA-ARS Bushland facility.