

Comparative Study of Methods for Determining Consumptive Use of Water in the Delta

This is an interim summary of an on-going study aimed at clarifying how much water is consumed within the Delta (the “Study”). Because of the importance of—and confusion about—consumptive use of water (“CU”) in the varying and evolving conditions in the Delta, there are a large number of state and federal agencies as well as a large number of water users inside and outside of the Delta interested in accurately and routinely measuring CU. Therefore, the Delta Watermaster has convened a large community of interest¹ to jointly sponsor a rigorous comparative investigation of:

- the several methods for measuring CU;
- the calibration of and among these methods in the unique settings within the Delta; and
- the cost, effort and reliability of applying each method.

THE PROBLEM

Measuring CU in primarily agricultural areas is an inherently complicated challenge, but the challenge is generally more difficult and in many ways more critical within the Delta. While researchers have demonstrated reliable methods for determining CU through the application of computer analyses of remote images,² the methods have been applied mostly to less complex settings than are found in the Delta. Within the Delta, the variety of topography, wind corridors, water channels, cropping patterns, temperatures and other factors in relatively close proximity makes reliable measurement more difficult than in more homogeneous upland farming sites. But measuring and understanding CU within the Delta is important not only to farmers but also to water facility managers, to water rights regulators and to those seeking to protect the Delta’s human and natural ecosystem. As a result of the challenge and importance of measuring CU in the Delta, there are conflicts—exacerbated by drought conditions—about assumptions, data and points of view that confound development and implementation of sound water administration and use policies.

BACKGROUND

To address the problem on an integrated basis, the Watermaster convened the interested agencies and parties in late February, 2015 to confirm the need for a study and to develop a strategy for managing the Study to (1) avoid duplication of efforts already underway, (2) identify the gaps in data, understanding, findings, and scientific consensus, and (3) efficiently organize the large number of potential contributors and funders. Following that first meeting,

¹ Among the study participants are: The State Water Resources Control Board, the Department of Water Resources, the Delta Stewardship Council, the Delta Conservancy, the Delta Protection Commission, the North Delta Water Agency, the Central Delta Water Agency, the South Delta Water Agency, the Local Agencies of the North Delta, the United States Department of Agriculture, the National Aeronautics and Space Administration, the Jet Propulsion Lab, several public universities, several State Water Contractors, several Central Valley Project Contractors, several reclamation Districts, and several engineering/consulting firms.

² For a recent overview of this maturing science, see [The View from Above: the Promise of Remote Sensing](#) in the March/April 2015 edition of *Western Water* published by The Water Education Foundation.

the parties established Study objectives, organized into task-oriented committees and began gathering data from a host of prior and on-going efforts.

SCOPE OF STUDY

- **Geographic:** The entire legal Delta plus a small amount of surrounding areas functionally associated with the Delta (approximately 740,000 acres).
- **Crop Types:** Twenty crop classes plus fallowed land, riparian vegetation, open water and aquatic weeds (accounting for virtually all CU within the Delta).
- **Duration:** The land use survey and preliminary field campaign were completed during the 2015 growing season; a preliminary report and refinement of inquiry will be presented in March 2016; additional field work and crop change analysis will be conducted during 2016 growing season; the final peer-reviewed report of the Study will be available in early 2017.
- **Total Cost:** Two major contracts for the Study total approximately \$1 million; in-kind contributions and independently funded and contributed research are expected to total an additional \$500 thousand, for total estimated cost of \$1.5 million.³

2015 PHASE 1: INITIAL DATA CAPTURE

After the initial “all volunteer” phase of the Study, the participants decided to engage the Center for Watershed Science at the University of California at Davis (“UC Davis”) to lead the scientific investigation. Acting as project lead, the Watermaster worked with the UC Davis team to establish the scope, schedule and budget for intensive data gathering during the 2015 growing season, when the entire California water system was constrained by the on-going drought. The resulting contract (amounting to \$200,000) was funded entirely by the State Water Resources Control Board (“Water Board”). Serendipitously, a large group of farmers in the Central and South Delta proposed a voluntary water conservation program among riparian water rights claimants which aimed, in light of the drought, to cut surface water diversions to their lands by 25% compared with 2013. As a result, the data gathered in the Study has been augmented by and can be correlated with insight and information derived from implementation of more than 200 discrete in-Delta diversion reduction plans.

Recognizing that we lack reliable, localized, consistent weather data, the North, Central and South Delta Water Agencies (collectively, “Delta Water Agencies”) pooled resources to purchase five new weather stations to be permanently located within the Delta and integrated into the California Irrigation Management Information System (“CIMIS”) network. The Delta Water Agencies have also been helpful in finding host sites for the new stations which will be

³ A detailed Study budget and cost breakdown is available for review by any Study participant.

deployed over the next two months. Once the stations are in place, they will transmit localized wind, precipitation, temperature and other weather data which will be web-accessible on the CIMIS network. These new data will provide a more reliable and localized basis for determining reference evapotranspiration (“ET”), an important element in determining CU.

The last comprehensive survey of land use within the Delta was completed in 2007. Because of changes in land use since then, the Study participants determined that an updated survey is needed to provide an accurate and consistent set of land use data with which to compare CU measurement methods. One of the Study committees established accuracy criteria, geographic scope, and other specifications for the survey. Ultimately, the Department of Water Resources (“DWR”) agreed to fund a contract to perform the 2015 survey of Delta land use. The survey has been completed, but the resulting data have not yet been analyzed and summarized for use in the Study.

At the same time that these systematic data capture efforts were underway, many of the Study participants continued their independent efforts to refine and apply various methods for measuring CU. Several of the Study participants independently funded extensions of their on-going research projects to cooperate and coordinate with the Study. As a result, 2015 phase of the Study has accumulated significant data about water use in the Delta during the most recent growing season. Because a significant subset of that data derives from analysis of satellite images, the 2015 data can be readily compared with prior (and future) satellite images. So, careful interpretation and use of the 2015 data holds the promise of examining CU over an extended sequence of conditions: wet and dry years; high and low temperatures; windy and calm conditions; field crops and orchards; etc.

2016 PHASE 2: DATA ANALYSIS AND REPORT

In early October, UC Davis hosted a conference of academic researchers to develop and adopt protocols for the use of the 2015 data as the consistent basis for applying eight different methods⁴ for measuring CU in the Delta. These methods range from those relying on field

⁴ The methods/models being compared within the Study include:

1. **Cal-SIMETAW and DETAW** (the traditional crop coefficient and reference ET approach currently used by DWR);
2. **METRIC** (estimates ET based on energy balance and the partition of sensible and latent heat flux using satellite data);
3. **ITRC-METRIC** (modifies METRIC by applying semi-automated internal calibration and a different reference crop);
4. **NASA Ames ET Method** (uses the NASA Terrestrial Observation and Prediction System to integrate satellite and meteorological observations to map basal crop coefficients and ET);

measurements to those relying on computer analysis of remote sensors including satellite images. The researchers agreed upon a “blind test” regime for generating CU estimates using each of the eight methods. Different subgroups among the research team will be responsible for developing estimates using the method with which each of the subgroups has specific expertise. Following submission of these estimates, the researchers will collaborate to compare and evaluate the estimates, not only for accuracy and consistency, but also for cost, ease of application, replicability, intrusiveness and other practical characteristics.

The research will then be the subject of a report allowing the findings and conclusions to be peer-reviewed by independent experts in the field prior to publication.

EXPECTED OUTCOMES

Through the Study, the participants expect to adapt each of the CU measurement methods to application in the Delta—among the most complex and internally varied agricultural landscapes in the world. Thus, each of the methods can be expected to become more useful in the Delta than it has been heretofore. Inevitably, however, the comparative study will identify strengths and weaknesses among each of the methods for use in the Delta and for serving specific purposes. This Study is not an attempt to force rank the various methods based on specific objective criteria. Instead, the Study should (1) allow users to choose appropriate methods for future use based on improved understanding of their individual characteristics; (2) provide a basis for interpreting results through improved understanding of those relative characteristics; (3) reduce confusion with respect to CU among different audiences relying on data based on different measurement methods; (4) promote consistency of data and interpretation among different users (farmers, water system operators, regulators, scientists, environmental advocates, etc.); and (5) improve resource management policies and inform adaptive management strategies critical to the continued evolution of the Delta.

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5. **UC Davis ET Approach** (uses the optimized semi-empirical Priestly-Taylor equations to estimate ET, net radiation, ground heat flux; adds coefficients derived from satellite data);
 6. **Jet Propulsion Lab Approach** (uses remote sensing to quantify plant stresses and applies an algorithm to translate potential to actual ET);
 7. **SEBAL** (estimates ET as a residual of the energy balance, with all the other energy components derived from remote sensing data); and
 8. **DisALEXI** (uses a special disaggregation technique to derive higher resolution ET estimates from thermal satellite data).

2016 BUDGET

Although Study participants will continue to independently fund aspects of the Study, the main research contract with UC Davis has been “fronted” by the Water Board. The 2016 budget is approximately \$400,000. Of that total, the Water Board will directly fund approximately \$100,000 (bringing the Water Board’s 2015 and 2016 commitment to \$300,000). The rest of the 2016 contract is currently funded by borrowing from internal fund accounts accessible to the Water Board. However, the Water Board has tasked the Watermaster with developing other funding to repay the roughly \$300,000 borrowed from the internal funds. As noted earlier, the Delta Water Agencies and DWR have already funded significant parts of the Study with cash, in-kind contributions, and dedication of technical personnel. Similarly, several of the Study participants have directly and independently funded Study-related data collection and research. Additional State and local agencies and associations are also contributing funding and expertise.

The consolidated budget for the Study is over \$1.5 million.