627 8851

~~F1-314~~
I1-090

I. Inquiry Submittal (Group 3)

a. Delta Island Water Budget
Michael R. Simpson, U.S. Geological Survey (USGS)

b. Objectives:
It is estimated that there are more than 1,800 unmeasured diversions from the Sacramento and San Joaquin Rivers and their tributaries on and off the delta islands for agricultural purposes. The delta island lowlands have been historically classified as riparian (California Department of Water Resources (DWR) bulletin 106). Because riparian-right water use is unregulated, no record of water consumption, diversion quantities or discharge is maintained by the water user or is available to water management agencies. Flows on and off the delta islands are very hard to estimate because they must be quantified from multiple siphon and drain flows as well as seepage and evapo-transpiration (ET) data. Existing water use estimates are done using areal photographs linked with crop ET estimates (DWR bulletin 106), and may lack the accuracy needed for water budget studies.

On- and off-island water flow, ET rates, and seepage quantities are crucial elements needed for the accurate estimate of off-island contaminant, nutrient and carbon transport as well as delta island water budget calculations. Off-island contaminant and nutrient transport may play an important role in the vitality of threatened or endangered aquatic organisms that inhabit or traverse the delta island river network, especially during low-flow periods.

Although water budget measurements on all the delta islands would be ideal, the instrumentation required to measure diversion flows, ET, and seepage is expensive and difficult to install:

- Of the myriad pipe flow meters that are commercially available, only a few have the accuracy required for water budget studies (appendix A, section 1). Some types of flow meters may require accuracy testing prior to installation.

- Accurate ET measurement equipment is usually constructed by customizing commercially available instrumentation, is sometimes completely hand-crafted, and is often specifically designed for the target environment. ET measurements are difficult at best and are manpower intensive (appendix A, section 2).

- Seepage flows, at a minimum, require the installation of nested monitoring wells in a pattern which transects the study island in both length and width. Monitoring wells of this type are manpower intensive and require the installation of expensive, temperature compensated pressure transducers in each of the wells (appendix A, section 3).

Even in the unlikely event that all of the delta island farmers would allow water budget measurement equipment to be installed on their property, the task (and expense) of instrumenting, calibrating and maintaining such a large network would be monumental.

c. Approach:
A more cost effective approach is proposed that would limit the initial water budget study to *two* delta islands; Twitchell Island (because of on-going collateral studies) and an additional island (possibly Bacon or Bradford). Data from this study could be used in future efforts to more accurately characterize the un-measured delta islands (see appendix A, section 8). The proposed two and ½ year study would embody the following features:

Evaluation / Implementation phase : nine months:

The proposed study would begin by the identification of one additional test island (appendix A section 4). Pipe flow and ET measurement equipment would be evaluated from each of the above-mentioned categories (appendix A sections 1 and 2). Instrumentation, shelters and test wells would be installed and properly calibrated at all of the test Island diversions and transects. A senior Instrumentation specialist and two hydrologic technicians would direct the instrument installation and perform the calibration. A contractor would be hired to install the invasive flow meters, and instrument shelters. The Instrumentation specialist and a Plant Biologist advisor would position and calibrate ET measurement equipment.

Data collection phase: one year

The data collection portion of the study would be done for a full year, through the entire delta island growing season. Flow , ET and seepage data would be collected on a bi-monthly basis (appendix A, section 5).

Analysis/report phase: Nine months

Data analysis and report preparation would begin prior to the close of the data collection period. A detailed water budget for the test islands would be prepared as well as on and off island flow hydrographs developed and presented in a data report. ET rates and seepage estimates would be included in the report as well as results of the equipment evaluation.

d. Justification for project funding

Results of this project (in conjunction with on-going water quality studies) would provide the ability to calculate off-island contaminant, nutrient, and organic carbon fluxes that effect water quality in the delta basin river tributaries. The products of this project would also be invaluable tools for the planning of wetlands habitat restoration.

e. project costs

Projected project costs:	Salaries	$301,657.00
	Contractor	$75,000.00
	Report publishing	$14,500.00
	Equipment	$460,000.00
	Total	$851,157.00

f. Applicant qualifications:

The project leader is a senior instrumentation specialist with 23 years experience in the design of Hydrologic instrumentation. He developed a moving-boat acoustic Doppler discharge measurement system used Nation-wide by the USGS, and has helped design and calibrate a network of ultrasonic flow meters in the Sacramento/San Joaquin River Delta. He also designed and built Bowen ratio measurement equipment used for ET studies in Owens Valley, California. The project leader would have an experienced crop biologist (with ET measurement experience) as a project advisor as well as support and resources of the USGS organization.

Coordination with other programs:

Water budget measurements would directly benefit ongoing USGS water quality/wetland restoration studies on Twitchell Island as well as other proposed studies. Equipment evaluation and island characterization would enable future water budget efforts (appendix A, section 8).

Appendix A.

Michael R. Simpson
U.S. Geological Survey, WRD
Placer Hall
6000 J Street
Sacramento, CA 95819-6129
(916)-278-3130.. msimpson@usgs.gov

Section 1 - Flow metering equipment.

IMPELLER FLOW METERS: Impeller style flow meters, use a mechanical cup or impeller device which is moved or rotated by the water providing a mechanical indication of the flow rate. Water velocity is provided at one point in the pipe cross section and the pipe must be rated to provide an accurate flow measurement. Impeller flow meters, although inexpensive, are subject to fouling and require weekly (possibly daily) maintenance for accurate flow measurement.

ELECTROMAGNETIC FLOW METERS: Electromagnetic flow meters use the Faraday principle to measure the perturbation of an electromagnetic field by adjacent flowing water. The amount of perturbation is proportional to the water velocity. Electromagnetic flow meters are more expensive than impeller style flow meters, are also subject to fouling and must be cleaned on a weekly basis to ensure accuracy. Again, the pipe must be properly rated to ensure accurate measurement of water velocity.

ACOUSTIC FLOW METERS: Acoustic flow meters (Doppler and travel-time) use an acoustic sensor array to measure water velocity in the pipe cross section. Both types are expensive and difficult to install, but require less maintenance than the other types when installed.

- Travel-time flow meters: The travel-time method measures the time-of-flight of an acoustic pulse first one direction and then the other in a diagonal path across the pipe width. The water velocity aids the acoustic pulse in the direction of flow and hinders the acoustic pulse in the reverse direction. The acoustic travel time difference is proportional to the velocity along the acoustic path. Because the travel-time flow meter measures velocity along an acoustic path that traverses the pipe cross-section, it can be a better indicator of velocity than the other methods discussed, but it must be expertly installed (as well as rated) to ensure accurate flow measurement. With the addition of depth sensors, this method can be used to measure flow in partially filled pipes.

- Doppler flow meters: Doppler flow meters use the Doppler principle to gage the velocity of small particles or bubbles moving with the water. The acoustic signal is bounced off the moving particles and is shifted in frequency (relative to the transmitter) proportional to the water velocity. Doppler meters measure a small portion of the water in the pipe cross-section (more than the impeller and electromagnetic meters, but less than the travel-time flow meters) and the pipe must be rated to ensure accurate flow measurement. Some of these meters can be used to directly measure partially filled pipes.

All of the flow meters described above are expensive, either from an acquisition cost standpoint or from a maintenance cost standpoint. None of the above described meters can be easily installed by an inexperienced person, and all must be rated properly to ensure accurate flow measurement.

Section 2.-- ET measurement equipment.

ET measurements on the targeted Delta Islands will be done with three suites of ET measurement equipment:

- Modified Penman weather stations each consisting of a Net radiometer, Air temperature sensor, Relative humidity (RH) probe, Wind speed and direction, pyronometer, soil heat flux plates, soil moisture sensors, and a rain gage.

- Bowan ratio measurement sites at the same locations consisting of two high accuracy RH probes separated by a distance of 1 meter. Positions of the RH probes are reversed each measurement series to eliminate systematic error using a specially designed mechanism. Alternatively, a chilled mirror hygrometer could be used with properly spaced intake arms.

- A mobile eddy correlation measurement suite consisting of a high speed datalogger (CR-7), a sonic anemometer, a lyman-alpha hygrometer, Two back-to-back Epply pyronmeters, and soil heat flux plates.

Section 3 -- seepage measurement equipment.

The nested well sites on the Island must be placed along transects that run in two orthogonal directions across the island (at a minimum). Additional transects may be required for an island that is rectangularly shaped. Nested wells must be placed at increasingly smaller spatial intervals as the transect approaches the island levee. Water depth in each test well must be measured within .01 foot for an accurate water surface slope determination. Temperature compensated transducers must be used in such cases. Drilling costs will not be excessive because the well nests will probably be no deeper than 10 or 15 feet.

Section 4 -- selection of the additional island..
The initial selection would be determined by farm owner cooperation, crop types represented, diversion point locations and ease of instrumentation.

Section 5 -- data collection.
The flow meter, ET rate, and seepage data would be logged on Cr-10 data loggers with sm-192 storage modules and data would be collected bi-monthly. Critical portions of the data network would be monitored by cellular phone modems. Such stations could be included in the existing bay-delta hydrodynamics automated data collection network.

Section 6 -- study products..
A data report would be prepared documenting the on and off island yearly water budget for both test islands. On and off island hydrographs would be included in the report as well as ET rates and Seepage measurements. During the evaluation phase of the study, flow measurement equipment would be selected and evaluated for use in different diversion scenarios. The diversions would also be characterized by type (full pipe siphons, pumped, partially filled culverts, and so on). ET and well monitoring equipment would also be evaluated. Equipment evaluation and calibration observations would included in the data report and if new equipment were developed, it may be presented in a journal article. During the evaluation portion of the study, the equipment would be calibrated and procedures developed so that nontechnical personnel could install, calibrate and maintain the equipment while still ensuring accurate flow measurement. Calibration checkouts would also identify hard to calibrate, temperamental equipment.

Section 7 – cost breakdown:
Because the costs for contractor time and equipment will vary depending upon the Island chosen, costs are estimated for a typical delta island (Bacon Island) even though it may not be the Island chosen for the study. Salaries could also vary somewhat.

Section 8 – Future studies
A team could be assembled with the task of characterizing the delta islands. Predominant crop

types (or non crop types) would be identified and linked to ET rates of crop varieties on the test islands. The team would include an element devoted to remote imagery. Delta island surface temperatures/ infrared filtered images (from areal overflights) would be collected in an attempt to define a filtered light profile of each Island. During the data collection period of the study, these data could be tested for correlation to irrigation volume, plant/crop types and ET rates. Much land use data already exists as part of the update to DWR bulletin 106 and could be included into the Island characterization data. Delta Island farmers could be canvassed about possible participation in future flow measurement studies. They would also be queried about possible incentives that could facilitate their inclusion in the study (Tax breaks, power subsidies, levee repair funds, and so on.)

Characterization of the delta islands could reap many benefits during the initial phase as well as later phases of the data collection program. Flows on and off the unmeasured Islands could be more readily estimated.

At the conclusion of the 2-year study, the types of instrumentation required as well a detailed set of calibration and maintenance procedures would have been developed. The Instrumentation of other delta islands could proceed without difficulty. Perhaps only spread of Islands having differing characteristics would require further water budget studies.