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Hydrogeologic Data from a Shallow Flooding Demonstration Project, Twitchell Island, California, 1997—2001

U.S. GEOLOGICAL SURVEY
Open-File Report 03-378

Prepared in cooperation with the
CALIFORNIA DEPARTMENT OF WATER RESOURCES

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Sacramento, California
2003

U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS

Multiply	By	To obtain
acre	0.4047	hectare
acre-foot (acre-ft)	0.001233	cubic hectometer
cubic foot (ft^3)	0.02832	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
gallon (gal)	3.785	liter
gallon per minute (gal/min)	0.06309	liter per second
inch (in.)	2.54	centimeter
inch per hour (in/hr)	2.54	centimeter per hour
inch per year (in/yr)	2.54	centimeter per year
square foot (ft^2)	0.09290	square meter
square inch (in^2)	6.452	square centimeter

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

ABBREVIATIONS AND ACRONYMS

CIMIS	California Irrigation Management Information System
DOC	dissolved organic carbon
DWR	(California) Department of Water Resources
EM	electromagnetic
ET	evapotranspiration
HPIA	hydrophilic acid
NWIS	National Water Information System
PVC	polyvinyl chloride
TDS	total dissolved solids
THM	trihalomethane
THMFP	trihalomethane formation potential
USGS	U.S. Geological Survey
c/s	counts per second
mS/m	millisiemens per meter

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ABSTRACT

Data were collected during a study to determine the effects of continuous shallow flooding on ground-water discharge to an agricultural drainage ditch on Twitchell Island, California. The conceptual model of the hydrogeologic setting was detailed with soil coring and borehole-geophysical logs. Twenty-two monitoring wells were installed to observe hydraulic head. Ten aquifer slug tests were done in peat and mineral sediments. Ground-water and surface-water temperature was monitored at 14 locations. Flow to and from the pond was monitored through direct measurement of flows and through the calculation of a water budget.

These data were gathered to support the development of a two-dimensional ground-water flow model. The model will be used to estimate subsurface discharge to the drainage ditch as a result of the pond. The estimated discharge will be used to estimate the concentrations of DOC that can be expected in the ditch.

INTRODUCTION

Dissolved organic carbon (DOC) originating in the Sacramento-San Joaquin Delta (Delta) is increasingly present in water transferred to southern California. The DOC may form trihalomethanes (THMs) at concentrations that exceed the U.S. Environmental Protection Agency's limit of 0.100 milligrams per liter in drinking water (U.S. Environmental Protection Agency, 2002) when the water is chlorinated (Fujii and others, 1998). Drinking water for two-thirds of California's population of more than 20 million people passes through the Delta (California Department of Water Resources, 1993). The Delta is a 738,000-acre tidal marsh of islands and interlaced channels that has been developed for agricultural use (fig. 1). Agricultural practices throughout the Delta promote the dissolution and flushing of carbon from peat beds through the decomposition (microbial oxidation) of organic matter. In addition to eluting DOC from the peat, the decomposition of organic matter causes land subsidence. As a result of subsidence, many of the Delta islands that once were at sea level now lie as deep as 20 feet (ft) below sea level. As the surface subsides, pumping from the agricultural drainage ditches is increased to maintain arable land. More aggressive pumping increases the proportion of drainage ditch water (and DOC) in Delta surface waters and increases the hydraulic pressure on the levee system. The increased pressure could increase the chances of levee failure.

From 1980 to 1981, approximately 7.8 million acre-feet of the surface water flowing through the Delta was diverted to water purveyors for drinking, municipal, and agricultural purposes (California Department of Water Resources, 1993). Organic carbon in the peat is dissolved and then transferred to the surface water through the island drainage systems. Island drainage water is a combination of irrigation water that seeps through the peat or flows overland across the peat, direct precipitation, and ground-water discharge through the peat. The drainage water is pumped from the islands into adjacent rivers and sloughs.

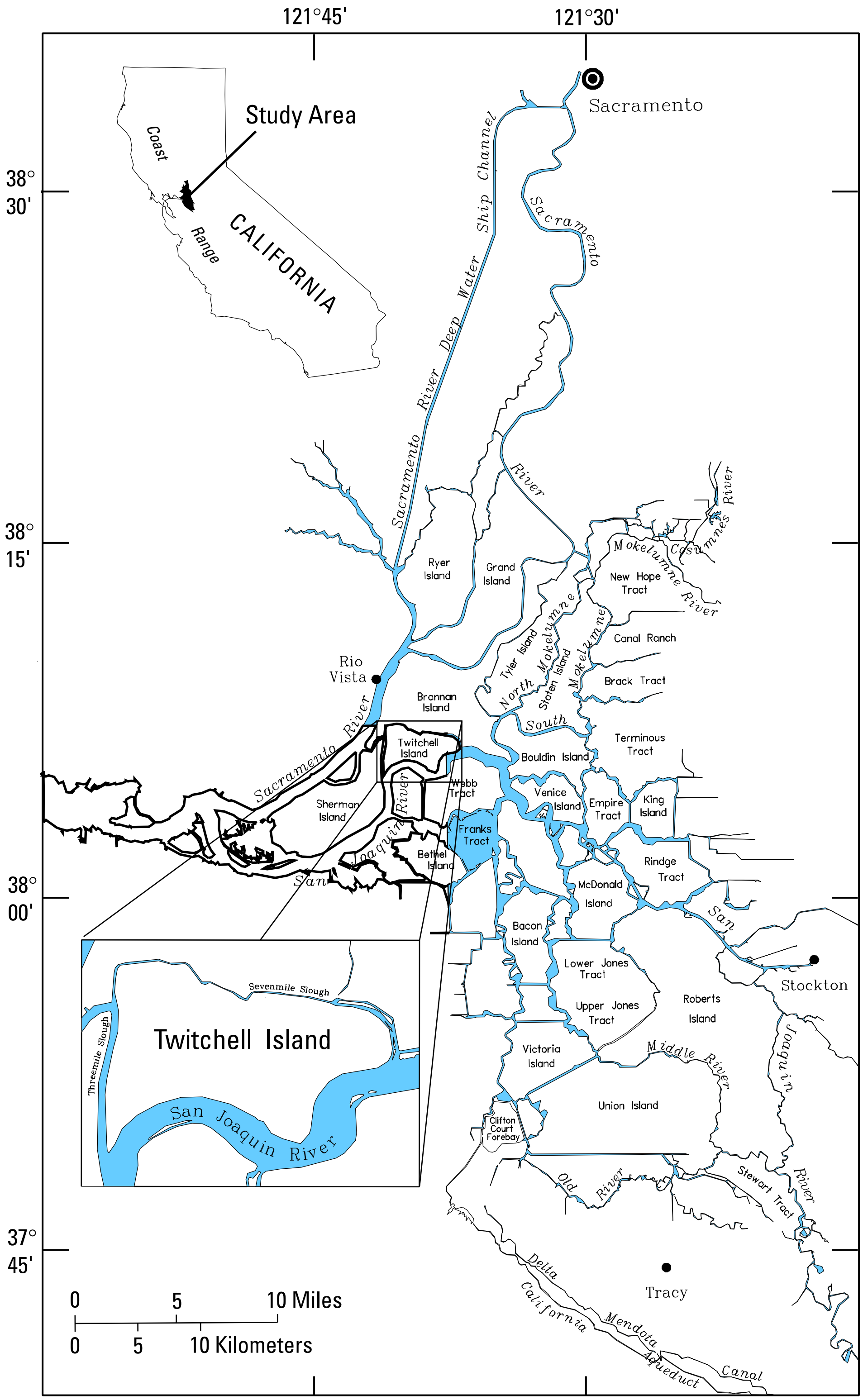

Figure 1. Location of Twitchell Island in the Sacramento–San Joaquin Delta, California.

Because of the increased probability of levee failure caused by subsidence, the cause and prevention of land subsidence has been a concern in the Delta since the 1920’s and has been the subject of several studies. Collectively, the studies show that subsidence occurs almost exclusively in the peat layer (Rojstaczer and others, 1991) at an average rate of 3 inches per year (Weir, 1950; Rojstaczer and others, 1991). These studies also show that draining and cultivating the islands creates a surface environment that promotes the microbial oxidation of the peat (Deverel and Rojstaczer, 1996; Deverel and others, 1998).

Microbial digestion of organic matter in the aerobic environment of the unsaturated zone and the anaerobic environment of the saturated zone liberates carbon to the aqueous phase, generating DOC and causing loss in land elevation. Differences in metabolic processes between the oxygen-rich and oxygen-poor environments produce varying proportions of different forms of DOC in the saturated and unsaturated zones. For example, Deverel and others (1998) and Fujii and others (1998) found that greater concentrations of the hydrophilic acid (HPIA) variety of DOC were present in the aerobic environment of the peat and that the anaerobic zone had relatively less of the HPIA form. Fujii and others (1998) demonstrated that the different varieties of DOC have different THM formation potential (THMFP).

Current Delta management practices change the environment in the peat through the course of a year, promoting or inhibiting microbial oxidation through the cyclical wetting and draining of the upper few feet of the peat. In general, moisture contents near and equal to saturation, combined with low temperatures, inhibit microbial oxidation of the peat (Deverel and Rojstaczer, 1996). The oxidation-limiting role of saturation and its accompanying anaerobic conditions were observed by Miller and others (2000), who found that perennial flooding as shallow as 35 centimeters (13.8 inches) produced anaerobic conditions and a net gain of organic material in a small test plot. Perennial shallow flooding currently is seen as a promising technique to alleviate subsidence and possibly to recover some land-surface elevation. However, the effect of shallow flooding on DOC loading to the drainage ditches is unclear.

Purpose

This study is designed to characterize the shallow aquifer structure and to estimate hydraulic conductivity and hydraulic gradients to quantify the contribution of water and DOC from a continuously flooded demonstration pond to an adjacent drainage ditch on Twitchell Island in the Sacramento-San Joaquin Delta. To date, research has concentrated on the processes and conditions that generate DOC and the form of DOC that has the greatest THMFP. Researchers have speculated on the relative contribution from the aerobic and anaerobic zones by comparing DOC concentration data from each zone within the peat to DOC concentrations measured in the drainage ditch water. However, these studies were not designed to estimate loading and, therefore, no attempt was made to quantify subsurface flow.

This report presents hydrogeologic data (lithologic and geophysical logs), data to support calculation of a water budget and the water-budget calculations, and the data-collection methods for a cooperative study between the U.S. Geological Survey (USGS) and the California Department of Water Resources (DWR). These data were gathered to support the development of a two-dimensional ground-water flow model. The model will be used to predict the travel times and concentrations of DOC expected in the drainage ditch.

Study Site

The study site is on Twitchell Island in the northwestern part of the Sacramento-San Joaquin Delta (fig. 1). Two 7-acre ponds, identified as East and West Pond, have been maintained since September 1997 (fig. 2). East Pond is a flow-through wetland constructed by enclosing the area with a berm of native soils. Water from the nearby San Joaquin River flows continuously into the pond and usually tops the spillways. Water enters East Pond from the south using a gravity siphon, filling the pond to a depth of about 2 ft. Spillways along the northern edge of the pond control the water depth. The spillways lead to pipes that convey the water away from East Pond toward the drainage ditch. The pond water level typically is above that in the ditch, creating a hydraulic gradient toward the ditch. A schematic cross section of pond construction and conceptualized flow is presented in figure 3.

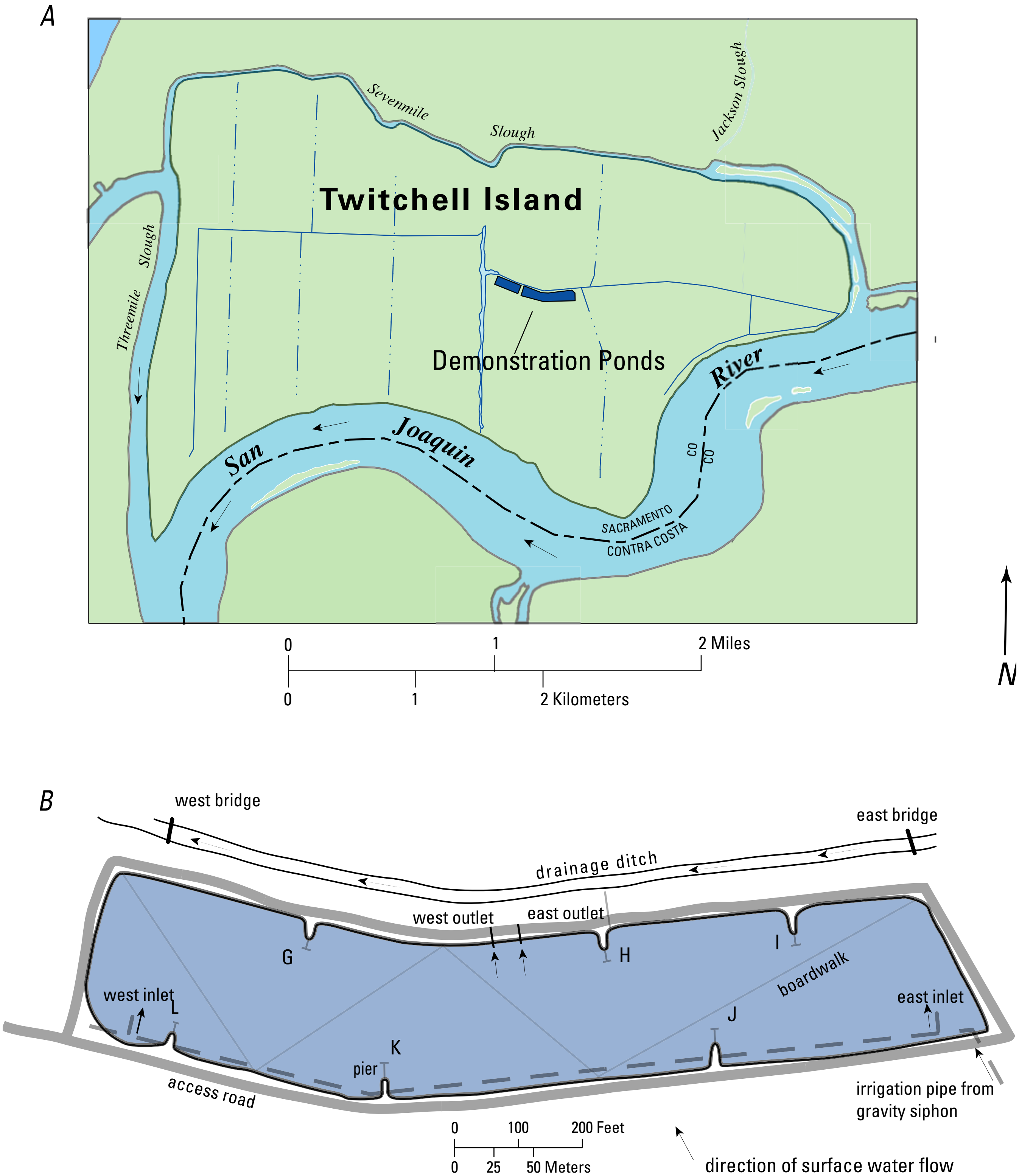

Figure 2. Demonstration ponds location and layout.

A, Map of Twitchell Island showing the location of the demonstration ponds relative to the network of drainage ditches. *B*, Diagram of east pond showing general layout.

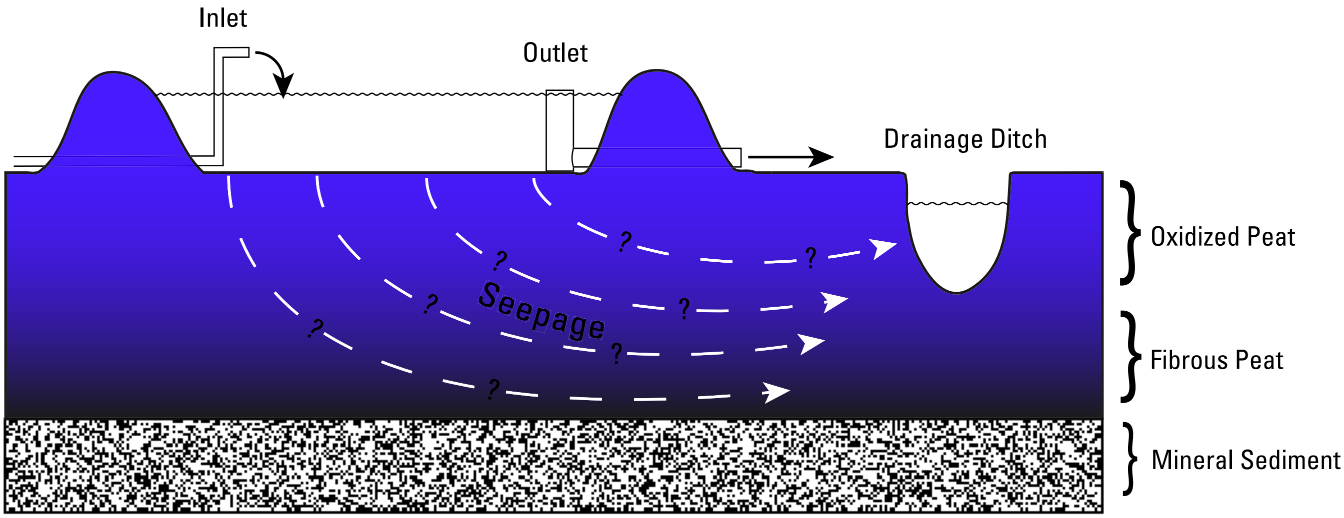

Figure 3. Conceptualized flow from the demonstration pond to drainage ditch on Twitchell Island.

The hydrogeologic characterization of the subsurface for this study was done at East Pond and is the focus of this report. West Pond is operated the same as East Pond, but is flooded to a depth of about 1 ft. East Pond is roughly rectangular in shape and is about 200-feet wide and 1,300-feet long. It is oriented in an east-west direction along a drainage ditch in the central part of the island. To access wells installed within the perimeter of the pond, six piers, labeled G-L, are spaced apart relatively evenly around the edge and extend perpendicular from the berm about 20 ft into the pond. A boardwalk crisscrosses the pond extending from three locations on the north berm to two locations on the south berm (fig. 2*B*).

The general geologic framework of Twitchell Island and the Delta is fluvial sands, silts, and clays overlain by peat. Historically, the seasonal growth of tules, bulrush, reeds, sedge, and grasses accreted the Delta surface at the rate of sea level rise, 0.1 to 0.2 centimeters per year (0.04 to 0.08 inches per year) for the past 8,000 years (Atwater and others, 1977). The slow accretion process resulted in peat beds as much as 60-ft thick (California Department of Water Resources, 1993). The peat beds generally are thickest near the Coast Range Mountains, and they thin to the east towards the cities of Sacramento and Stockton. Draining of the peat islands for agriculture began in 1850 and essentially was complete by 1921 (Weir, 1950).

DATA COLLECTION METHODS

Soil Coring

Prior to flooding, the peat layer was characterized, in part, through the collection of eight continuous soil cores on May 12 and 13, 1997. Cores were collected from the six pier locations, G–L, as well as from the middle of the pond at the locations labeled GM and JM (fig. 4). Continuous core samples were collected from the land surface to a depth of 9 to12 ft. Samples were obtained by pushing a 48-inch-long core barrel into the soft peat layer with a hydraulic rig. Core barrels were advanced to their maximum depth and then retrieved. Samples were extruded from the core barrels for measurements of recovery and for description. Soil-core recovery varied depending upon the degree of saturation and cohesion of the material. Saturated, noncohesive material yielded recovery rates of less than 10 percent, while more cohesive material yielded up to 100-percent recovery. Soil descriptions included lithology, color, layering, degree of saturation, and degree of visible fibrous material that persisted through handling.

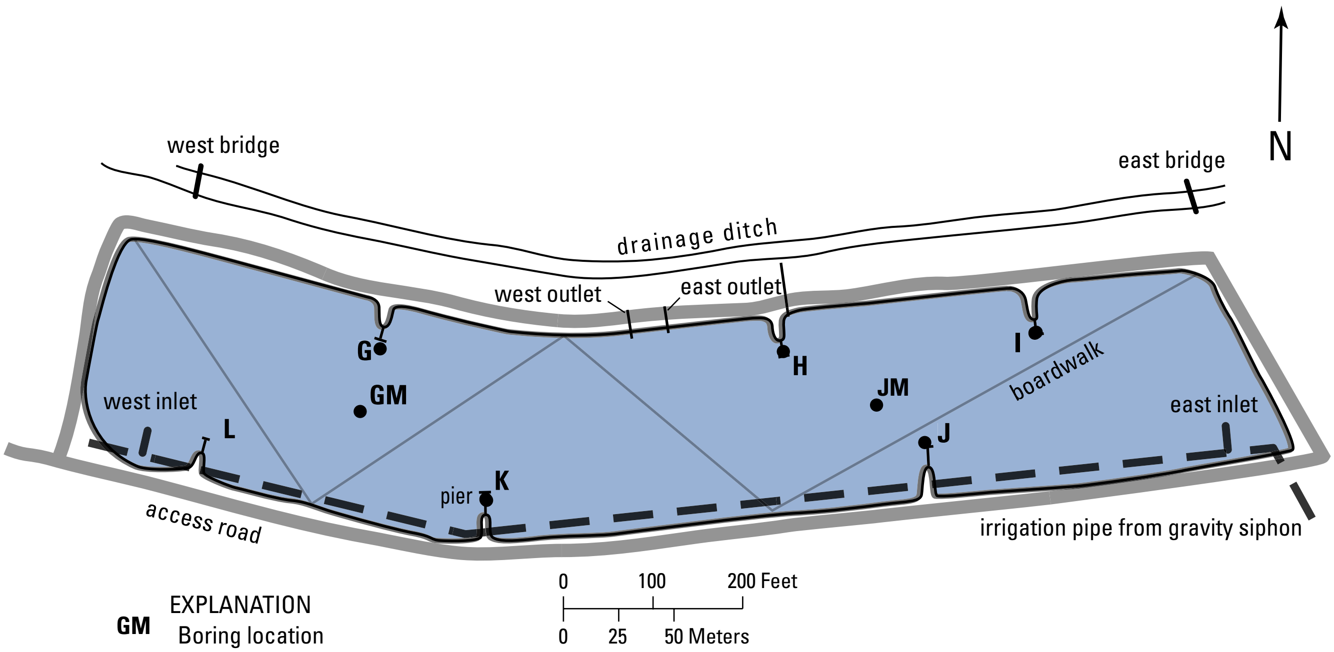

Figure 4. Twitchell Island demonstration pond boring locations.

Borehole-Geophysical Data

Wells were logged at locations H, I, J, and K with an electromagnetic (EM) induction tool and a natural-gamma tool. The EM-induction tool measures the electrical conductivity of the materials surrounding the borehole. Total dissolved solids (TDS) concentration in ground water and the presence of silt and clay affect the electrical conductivity of sediments measured by an induction logger. A high response is interpreted in this report as an indication of relatively more silt and clay in the formation.

Natural gamma logs record the amount of gamma radiation emitted by geologic materials. The gamma-emitting radioisotopes that occur naturally in geologic materials are potassium-40 and products of the uranium and thorium decay series. Generally, clay-rich sediments emit relatively higher gamma radiation than do other sediments because of the relative abundance of potassium (decomposition of potassium feldspars) or uranium and thorium (adsorption and ion exchange) in fine-grained materials (Keys, 1990).

Monitoring Wells

East Pond was outfitted with a network of 22 monitoring wells (fig. 5) to monitor water quality, water levels, and water temperature. Monitoring stations were installed at four pier locations, H–K. Wells at each location were identified with a three- or four-letter well identification beginning with the station designation. The second letter designates the relative depth being monitored by the well. Shallow wells (S) were screened at 0.5–2 ft below land surface. Deep wells (D) were screened at 8–10 ft below land surface. Several wells (O) were screened at 23–27 ft below land surface. The deepest wells (HMOW and HDOW) were screened at 52–55 ft below land surface and 80–83 ft below land surface, respectively. In addition, a group of four drive-point wells were located between the pond and the drainage ditch, adjacent to station H (fig. 5). These drive-point wells were designated as DPH1–4. Table 1 (at back of report) details well-construction information for each of the wells in this study. The rotary method indicates that the wells were drilled using hydraulic rotary methods with bentonite mud as the drilling fluid. The 10-foot-deep wells were drilled using water as the drilling fluid. Wells HMOW and HDOW were sealed from the land surface down to the top of the sand pack with cement grout. The remaining wells were sealed with bentonite chips.

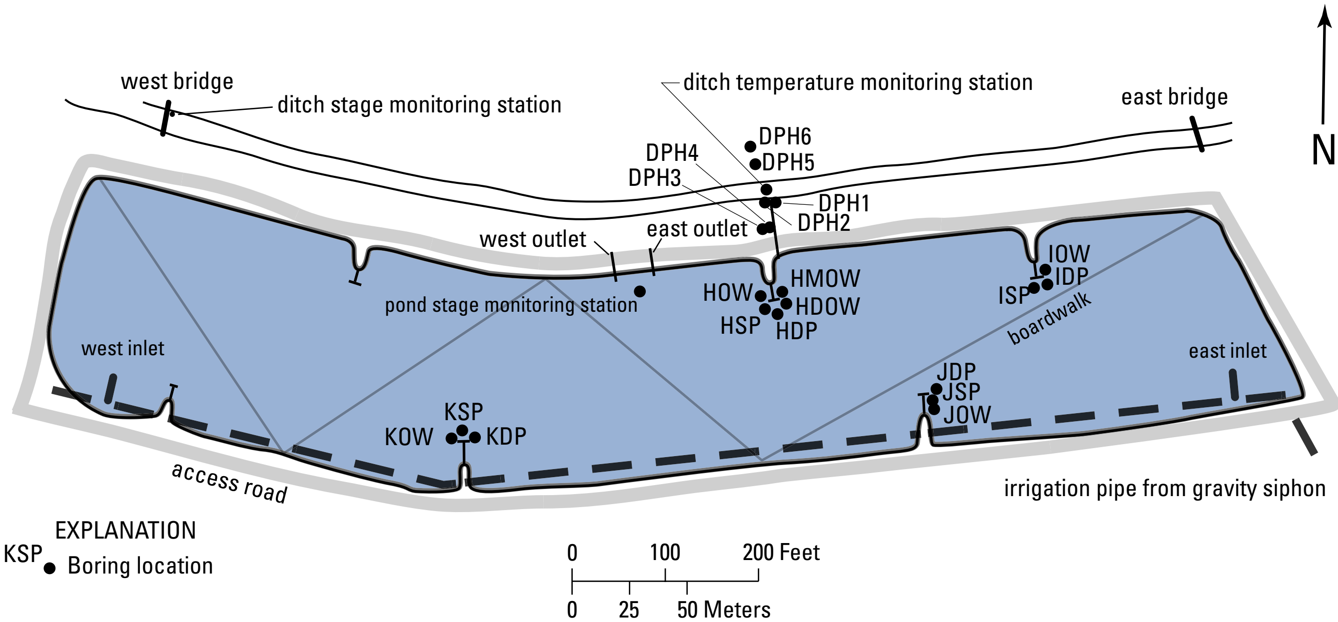

Figure 5. Twitchell Island demonstration pond well locations.

Water levels were measured monthly at 23 locations. The monitoring included water levels in the drainage ditch and in the monitoring wells (HSP, ISP, JSP, KSP, DPH1, DPH2, DPH3, DPH4, DPH5, DPH6, DPI1, DPI2, HDP, IDP, JDP, KDP, HOW, IOW, JOW, KOW, HMOW, and HDOW). Depth-to-water in monitoring wells was measured manually with a steel tape that was graduated in 0.01-foot increments. Measurements were made by coating several feet of the lower end of the tape with blue chalk. The tape then was lowered into the well until the chalked tape intersected the water, creating a wetted chalk line. The upper part of the tape was held at an exact 1-foot mark against the measuring point at the top of the well casing. The tape then was withdrawn until the wetted chalk line is visible. The difference between the wetted chalk line and the point held at the top of the casing represented the depth to water below the measuring point. Depth-to-water measurements were converted to elevations by subtracting them from the surveyed casing elevation at each well. A 5-foot interval of casing was added periodically because of seasonal changes in water levels. The water level in the ditch was read directly from a staff gage on west bridge. Water levels in the pond were measured continuously with a pressure transducer and recorded on a data logger as hourly mean values.

Temperature Monitoring

Ground-water and surface-water temperature was monitored at 14 combined locations as an indicator of ground-water movement. Ground-water temperature was monitored at 12 locations and surface-water temperature was monitored at two locations. Suzuki (1960), Stallman (1963), Sorey (1971), Lapham (1989), Taniguchi (1993), and Constantz and others (1994) used temperature as an indicator of aquifer characteristics or dynamics. Ground-water temperature was monitored at 12 locations along the cross section (J-H) to be modeled with numerical simulations. Wells JSP, JDP, JOW, HSP, HDP, HOW, HMOW, HDOW were equipped with temperature-logging devices called Tidbits. Tidbits also were placed in the pond and ditch to monitor surface-water temperature.

Tidbits are integrated thermistor, data logger, and power-supply units. The manufacturer reports a minimum accuracy of ±0.3°C. The units are programmed by the user to record temperature at regular intervals. Date, time, and temperature were recorded every 30 minutes in peat-layer wells HSP, HDP, JSP, and JDP and every 60 minutes in the remaining locations. Wells DPH1–4 were fitted with thermistors connected to an external data logger that recorded every 60 minutes. These data were stored in the USGS National Water Information System (NWIS) database.

Slug Tests

Ten aquifer-slug tests were used to estimate the hydraulic conductivity and transmissivity of the peat layer and the mineral sediments beneath the peat. Four tests were done in the peat layer in wells HDP, IDP, JDP, and KDP, which were screened from 8 to 10 ft below land surface. Four tests were done in the fine-sand layer in wells HOW, IOW, JOW, and KOW, which were screened between 23 and 27 ft below land surface. One test was done in the silt layer in well HMOW, which was screened from 52 to 55 ft below land surface. One test was done in the fine silty sand layer in well HDOW, which was screened from 80 to 83 ft below land surface.

Before the slug tests began, the transducer and data logger were calibrated over the full range of water levels expected during the test. The instruments were calibrated by comparing the depth to water, as recorded with the transducer and data logger, to the depth-to-water measured using1-foot increments along the transducer cable. The calibration procedure was done at two wells; one with up to 7 ft of water above the transducer and one with up to 25 ft of water. Correlation coefficients between the measured depth below the above the transducer and the known depths indicate that the transducer accurately measured water depth (r^2= 0.996 and 0.999).

Flow Monitoring

Water was supplied to the pond at two metered locations referred to as the eastern and western inlets (fig. 5). The inlets had 4-inch-diameter polyvinyl chloride (PVC) pipes, fitted with ball valves to control flow and McCrometer propeller-type flow meters. The McCrometer flow meters were rated by the manufacturer to have ±2 percent accuracy over their entire rated flow range. The meters installed on the pond inlets at Twitchell Island were rated for flows between 50 and 600 gallons per minute (gal/min). Flow rates measured during this study ranged from 48 to 230 gal/min. The flow rates measured were within the flow range of the meters for 97 percent of days measured. The flow meters produced eight electrical pulses per gallon of water that passed through the meter. The total count of pulses was recorded by the data logger, which wrote mean hourly flow rates to the memory. The hourly flow rates were downloaded periodically and averaged into daily mean values.

The only other supply of water to the pond was direct precipitation and possibly subsurface inflow. The DWR maintained a weather station on Twitchell Island that records hourly precipitation totals with a tipping-bucket rain gage. Records from the weather station were obtained for the study period through the California Irrigation Management Information System (CIMIS) automated data system. The rain gage used on Twitchell Island had a reported accuracy of ±1 percent at 5 centimeters per hour (2 inches per hour) or less (California Irrigation Management Information System, accessed March 1, 2002). Precipitation was converted to a volumetric inflow to the pond by multiplying by the pond area. Inflow from beneath the pond was calculated as discussed in the section on seepage estimates.

Surface discharge from the pond was gaged at two locations referred to as east and west outlets (fig. 5). Water exited the pond through two separate spillways on the north side, which led to separate 24-inch-diameter corrugated PVC pipes. The pipes passed through the pond berm opening toward the ditch. The downstream end of each conduit was fitted with a 3-inch Parshall flume. The flumes were rated for a discharge range of 0.027 cubic feet per second (ft^3/s) to 1.13 ft^3/s. Measured discharge was below the flumes' rated capacity about 14 percent of the time. The low-discharge measurements indicated a period when no water exited the pond. Stage measurements in the flumes were made with a pressure transducer. Druck PDCR1830-8388 pressure transducers used in this study were rated for a pressure range of 0–5 pounds per square inch (lbs/in^2). All measurements recorded during the study were within the rated pressure range for the transducers. Hourly stage measurements for the pond were recorded on a data logger for periodic retrieval. Ditch stage was read from a staff gage and then subtracted from the surveyed elevation. Ditch-stage measurements after October 2000 were measured with a pressure transducer.

Pond loss to evaporation and uptake by plants was computed as evapotranspiration (ET). ET for the plant under consideration was calculated by multiplying a reference value, ETo, by the crop coefficient, Kc. Reference evaporation recorded hourly at the DWR weather station on Twitchell Island was multiplied by a published crop coefficient (University of California Cooperative Extension, 1994) to obtain the ET demand. Hourly ETo values were summed to get daily totals then multiplied by the appropriate Kc value to get the daily total ET demand. The Kc values for rice grown in the San Joaquin Valley (University of California Cooperative Extension, 1994) were used to represent East Pond. The ETo varies daily with weather conditions, and the crop coefficient varies with growth stage of the crop. The coefficient of 0.95 was used from planting to 10 percent ground shading (about 25 days beginning on April 1). The coefficient of 1.25 was used for plant growth between 10 percent and 75 percent ground shading (about 32 days). Then from 75 percent ground shading to harvest (about 90 days) the coefficient of 0.95 was used. Under cultivation, transpiration demand would stop after harvest, however, the plants in East Pond were not harvested and remained standing through their natural maturity. Therefore, a coefficient of 1.00 was used for the days outside the growing season. Open-water Kc is estimated to be a constant value of 1.10 statewide (University of California Cooperative Extension, 1994). A slightly lower value was used to account for the continued shading of the water by standing plant material after the growing season ended. Approximately 68 percent of the pond was covered with standing vegetation and much of the remainder contained water-surface vegetation. Similar to precipitation, the ET estimate was converted to a volumetric outflow from the pond by multiplying by the pond area.

The pond storage was calculated by multiplying water depth by pond area to obtain the volume of water in the pond. The surface area of the pond was assumed to be constant at 260,487 square feet (ft^2). Hourly stage measurements were recorded in a data logger as measured by a pressure transducer. Once again, the transducer was rated to measure within a pressure range of 0–5 lbs/in^2, and all measurements fell within the range. All transducers used during this study were vented to eliminate the need for barometric corrections. The transducer measuring pond stage was installed in a standpipe on the northern side of the pond (fig. 5). Increasing biomass in the pond was not accounted for in the calculation of pond storage because data were not sufficient to estimate a value. Not considering biomass in water balance calculations may have resulted in an overestimation of pond storage.

RESULTS

Lithologic Characterization

Soil corings and borehole geophysical data were used to prepare a generalized lithologic cross section of the pond (fig. 6). In general, the peat was a brownish, red-brown-to-black layer composed of mostly organic matter. The top 2 to 3 ft were unsaturated and occasionally showed soil structures (peds). Under cultivation, the water-table elevation on the island varied through the year; however, the appearance of a more fibrous peat at an average depth of 5 ft below land surface suggested that the water table did not retreat below that level. A more fibrous texture is interpreted here to mean relatively less weathering that may result from perennial saturation. The flooding of the test pond, of course, saturated the peat to the land surface.

One-eighth to one-half-inch-thick gray clay lenses were common throughout the peat but did not appear to collectively make up a significant part of the aquifer material. A gray muck layer was present from 2 to 5 ft below land surface at location J and from 4.8 to 5.2 ft below land surface at location JM. No soil cores could be recovered in the muck layer.

Observations made during the installation of monitoring wells and interpretation of borehole gamma and EM-induction logs were used to describe lithologies below the peat layer. At 15 ft below land surface, the organic peat is underlain by sand and clay in well H. A relatively continuous clay layer (about 5-feet thick) began at 15 ft below land surface in all four boreholes. Alternating layers of fine sand and silt occurred at 20 to 64 ft below land surface. Layer thickness ranged from 4 to 8 ft for silts and from 8 to 16 ft for the fine sands. A silty-clay layer existed from 64 to 79 ft below land surface and was interrupted by a 2-foot-thick sand layer from 74 to 76 ft below land surface. The hole bottomed in sand at 84 ft below land surface.

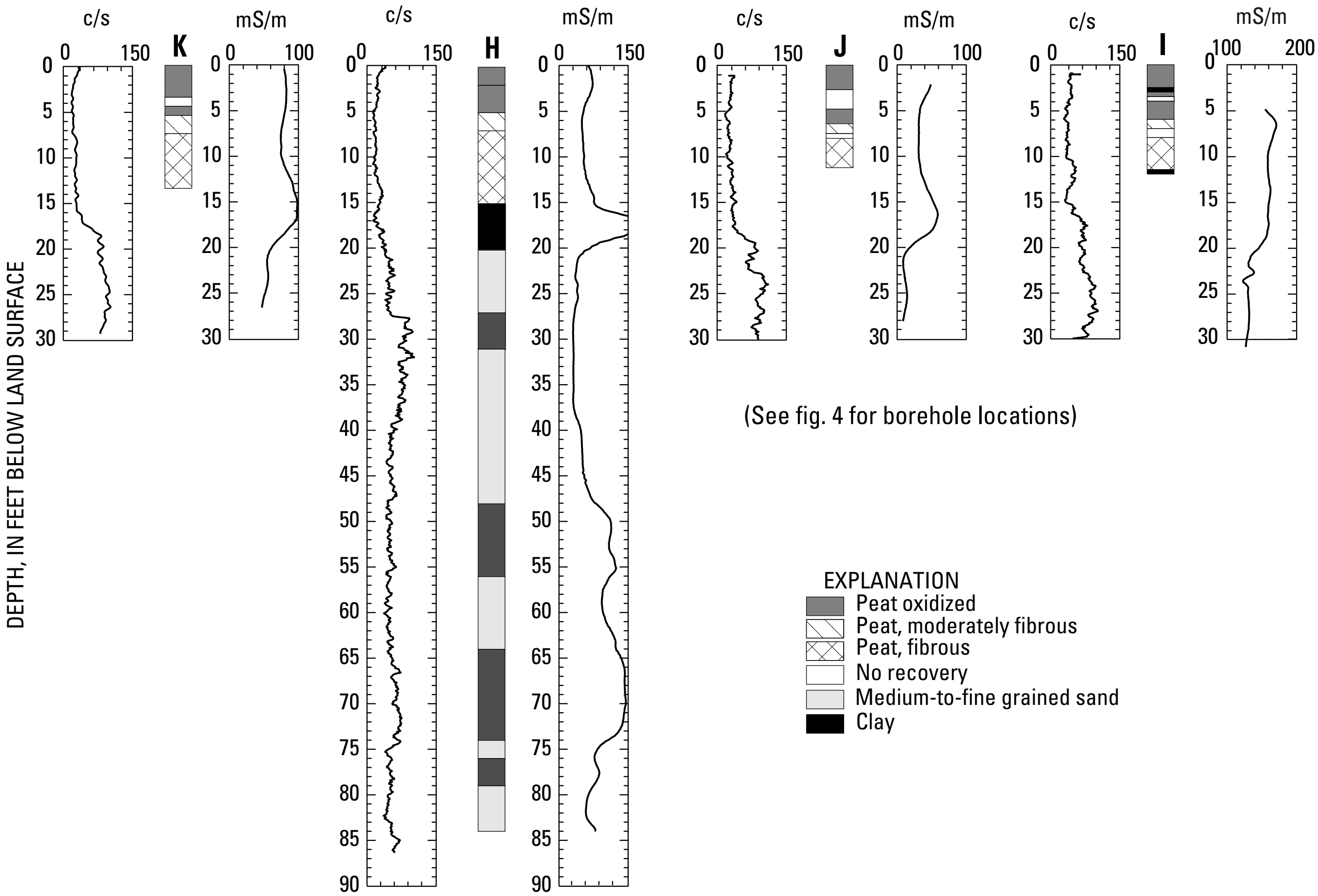

Figure 6. Geologic section and geophysical logs for selected wells on Twitchell Island, California.

Trace to the left of the graphic logs is gamma (in counts per second) and trace to the right is electrical conductivity (in millisiemens per meter). Station numbers are shown at the top of the graphic log. See figure 4 for borehole locations

Water Levels

Water-level elevations at the study site, relative to the NAVD 88, ranged from about –21 ft in the drainage ditch to about –17.5 ft in the peat layer and about –14 ft at about 80 ft below land surface. Horizontal hydraulic gradients in the peat consistently were toward the drainage ditch and averaged about 0.03. Vertical hydraulic gradients from the mineral sediments to the peat were about 0.06 and consistently were oriented upward. The vertical gradients are evident when viewed on graphs of water elevations by screened interval (figs. 7*A* and 8). The degree of connection between the San Joaquin River and the shallow ground-water flow system can be assessed by qualitative comparison between ground-water levels (figs. 7*A*, 8*A*, and 8*B*) and San Joaquin River stage (figs. 7*B*). Statistical comparisons indicated that wells screened in the mineral sediments beneath the peat were best correlated with river stage measurements during this period. Water-level elevations measured at the site between September 1997 and May 2001 are presented in table 2 (at back of report). The USGS surveyed the vertical and horizontal locations of the measuring points with an accuracy of 0.01 foot.

Water Temperatures

Thermistors were installed during May 2000 in the pond, the drainage ditch, and wells DPH1–4. By the end of June 2000, Tidbits (temperature-logging devices) were installed in the remaining locations selected for monitoring. Average daily temperature for each location monitored is shown in figure 9. A few gaps are present in the temperature data due to equipment malfunction. Monitoring was discontinued in wells HDOW and HMOW in March 2001 because there was no response to land-surface temperature changes.

Temperature changes propagated through the system in the remaining wells. The surface-water temperature at the pond (fig. 9*B*) varied from a low of 4.7°C on January 5 and 6, 2001, to a high of 23.1°C on June 15, 2000. Water temperature reached a maximum during summer (June and July) then cooled through the fall and into winter. Beginning in late January 2001, the temperature began to rise steadily through the end of the record presented in this report. The same pattern of temperature change was observed in wells screened in the peat layer, except the magnitude of the change was reduced with increasing depth and the timing was shifted to later in the year. Maximum and minimum water temperatures were present about 30–45 days later than surface-water temperatures in wells screened at depths of 10–11 ft below land surface (fig. 9*A*). Essentially no temperature change was observed in wells screened below 25 ft (fig. 9*B*).

Estimates of Hydraulic Conductivity

Water-level recovery data from the slug tests were analyzed using two different analytical solutions (Papadopulos and others, 1973; Bouwer and Rice, 1976) to obtain estimates of average hydraulic conductivity and transmissivity for each layer tested. Estimates of hydraulic conductivity in the peat varied about two orders of magnitude, from 0.01 foot per day (ft/d) to 0.7 ft/d (table 3, at back of report). The highest estimates, 9 ft/d and 5 ft/d, were obtained in the sand material at about 25 ft below land surface. Most of the estimates for sand and silt varied within one order of magnitude, between 1 ft/d and 9 ft/d. Hydraulic conductivities were estimated from slug test transmissivity values using a saturated thickness of 15 ft in the peat layer, 28 ft in the sand, 56 ft in the silt, and 85 ft in the fine silty sand. Slug test analyses are archived and available for viewing at the USGS District Office in Sacramento, California.

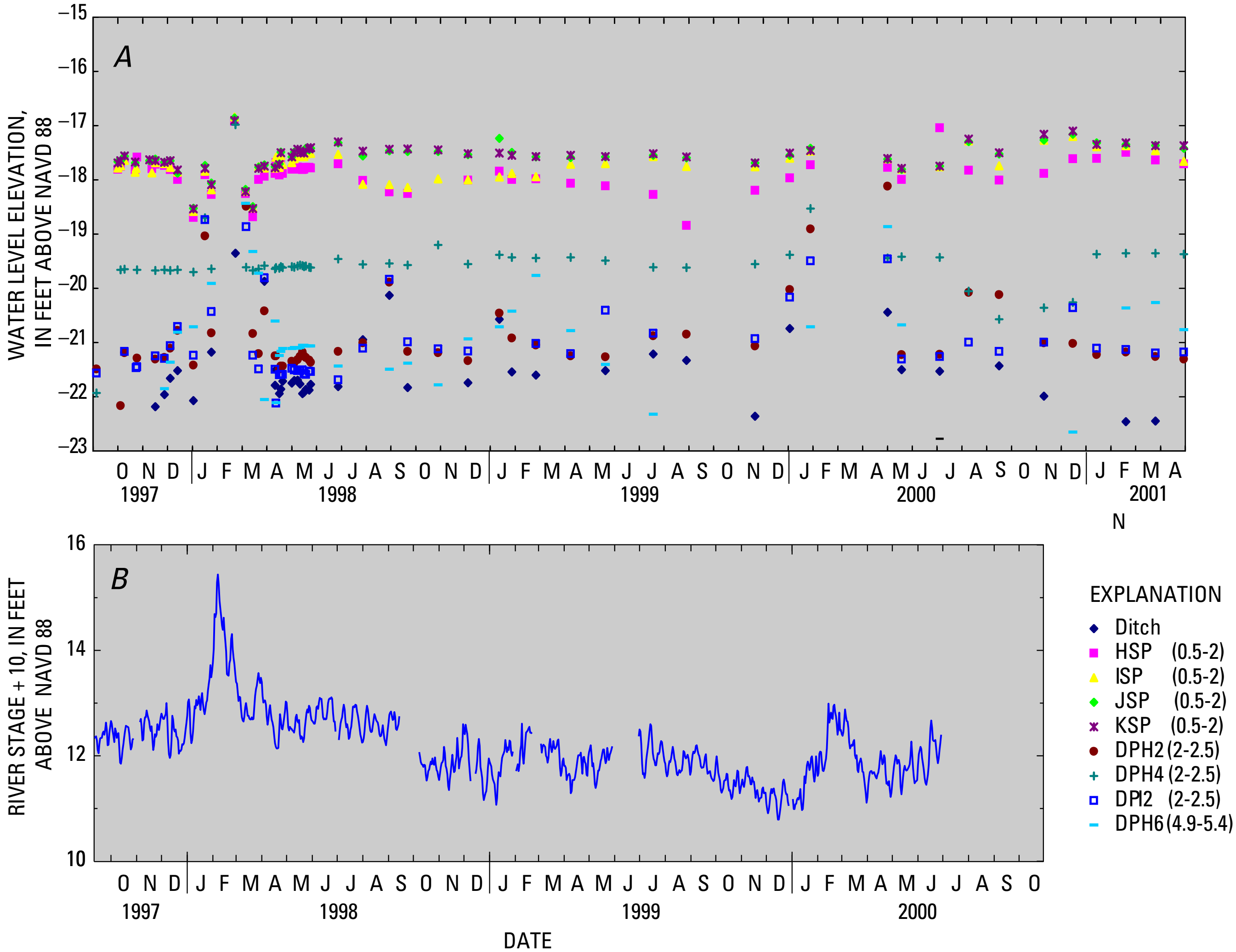

Figure 7. Water level response in shallow wells in relation to the San Joaquin River stage at Twitchell Island, California.

A, Water levels in shallow wells and drive points in upper peat layer. Numbers in parentheses are depth of screened interval, in feet. *B*, San Joaquin River stage at Jersey Point. San Joaquin river stage is tidally corrected using a Godin filter; gaps in curve indicate missing data; NAVD 88, North American Vertical Datum of 1988.

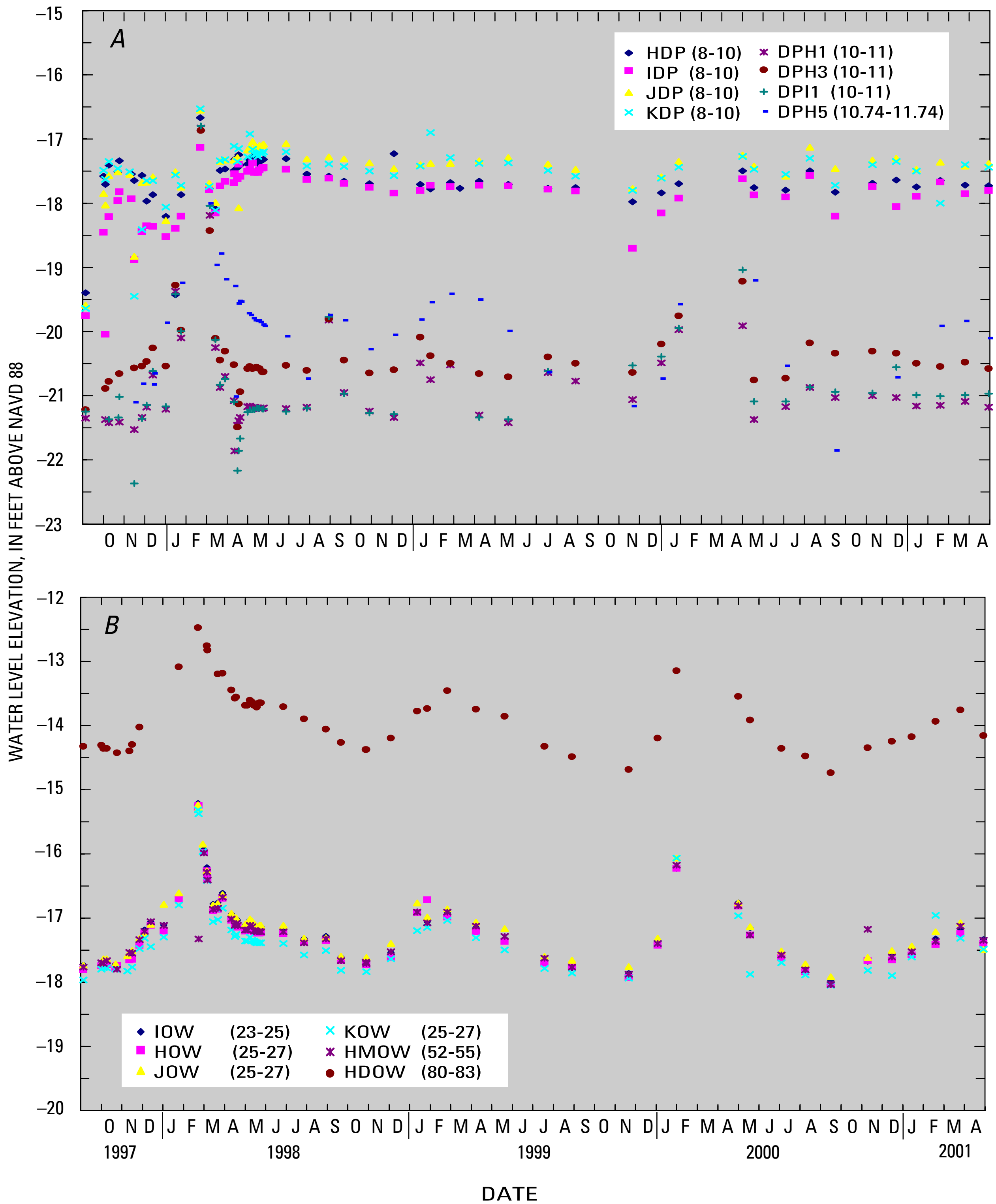

Figure 8. Water level in wells at Twitchell Island, California.

A, Water levels in wells and drive points screened in lower peat layer. *B*, Water levels in wells screened in mineral sediments. Numbers in parentheses are depth of screened interval, in feet; NAVD 88, North American Vertical Datum of 1988.

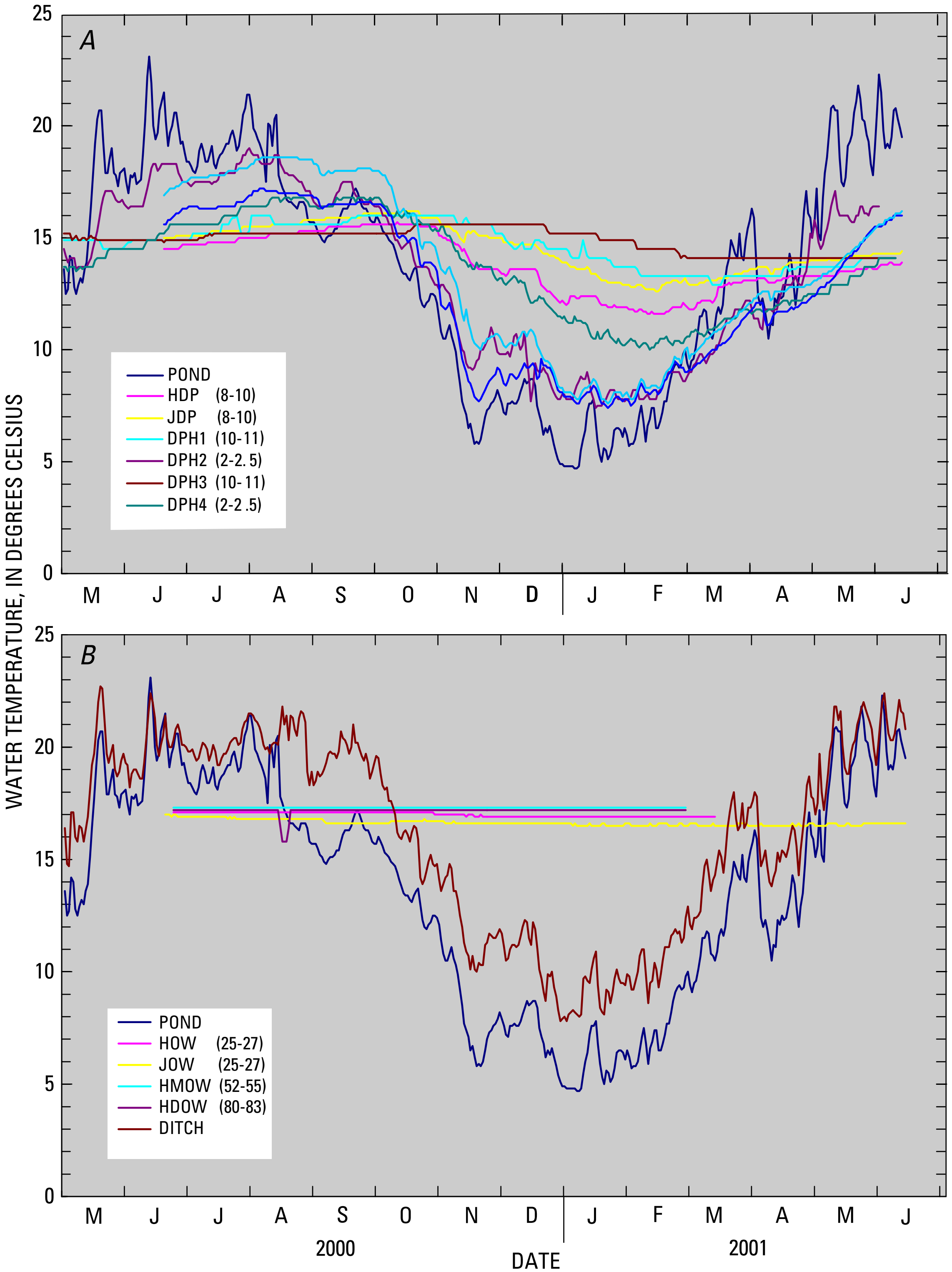

Figure 9. Water temperature in wells on Twitchell Island, California.

A, Water temperature in wells screened in peat layers and pond, May 2000 to June 2001. *B*, Water temperature in wells screened in mineral sediments and in pond and ditch. Numbers in parentheses are depth of screened interval, in feet.

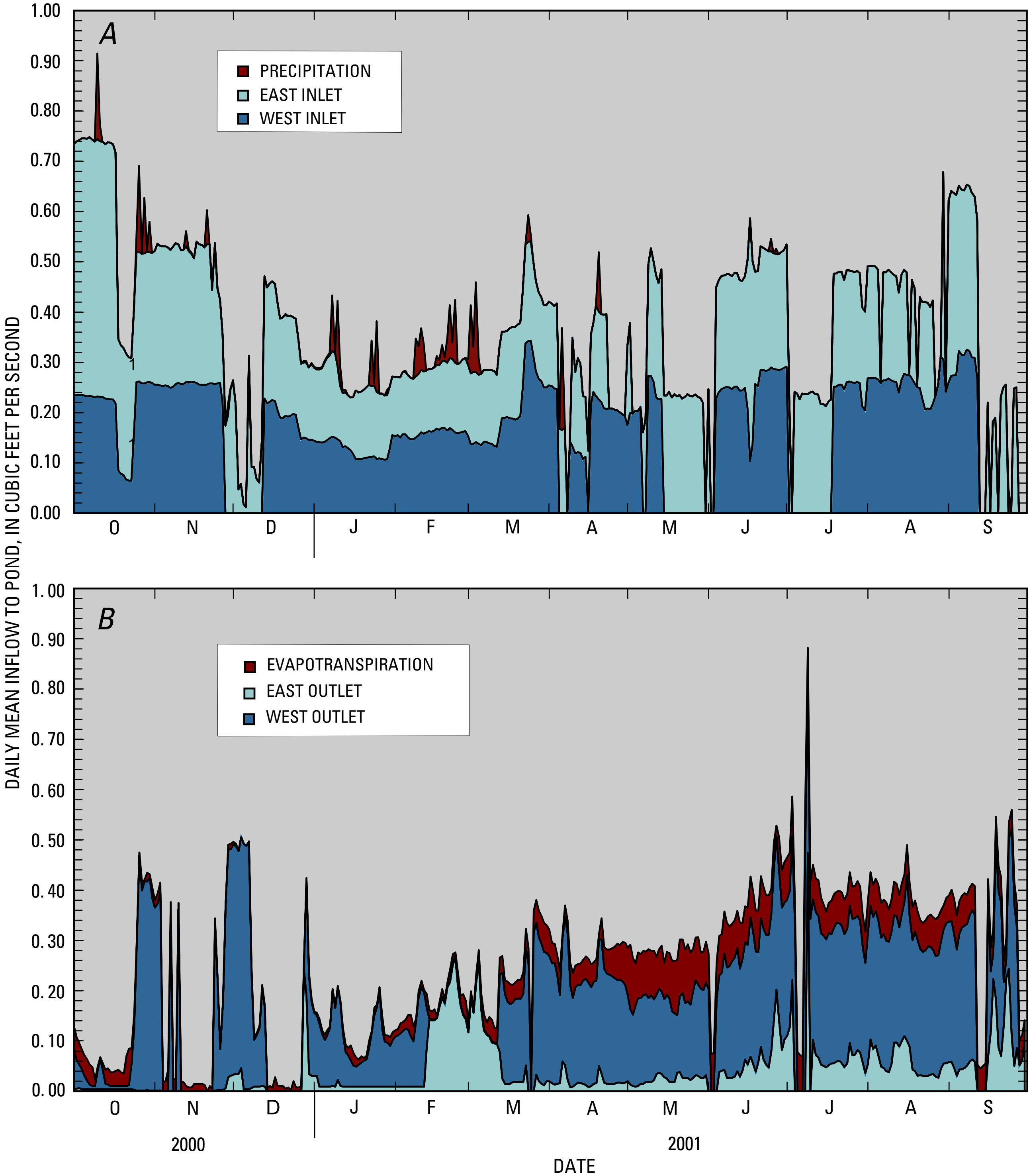

Figure 10. Water budget for East Pond from October 2000 through September 2001 on Twitchell Island, California.

A, Surface water inflow to East Pond. Surfaces are stacked to depict the contribution of each component. *B*, Surface water outflow from East Pond. *C*, Daily mean change in storage in East Pond.

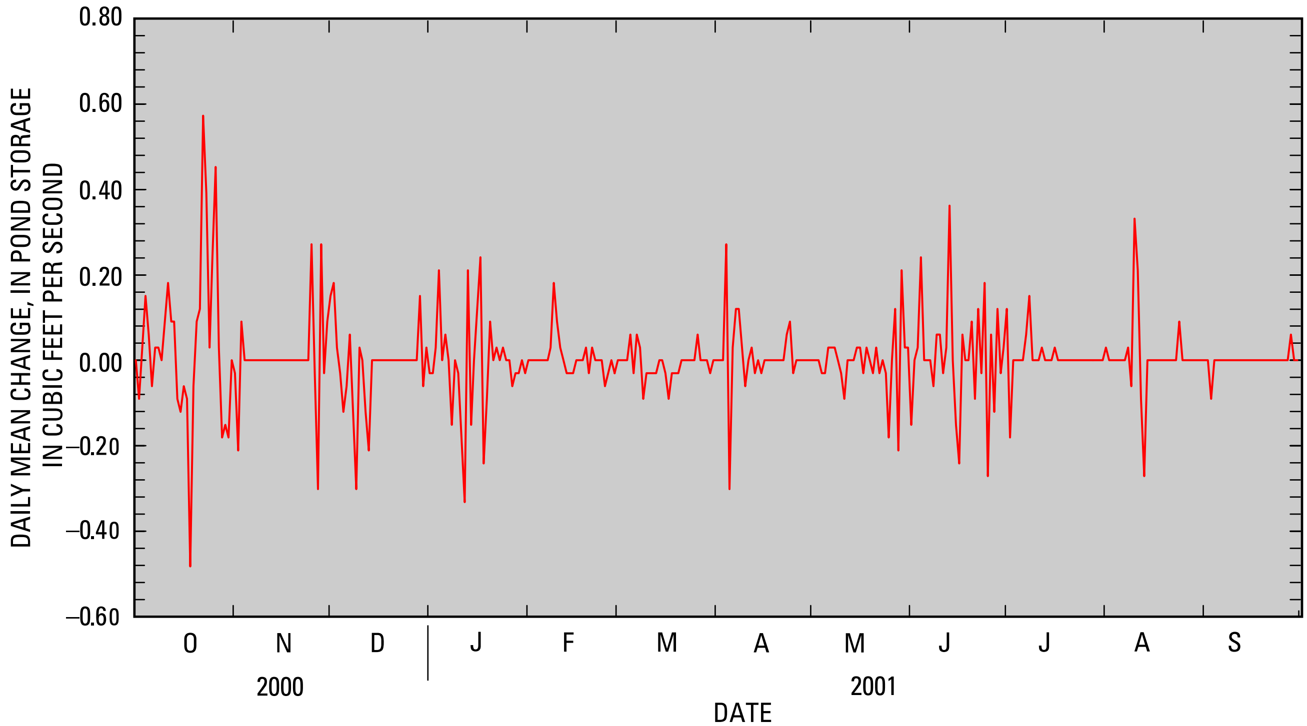

Figure 10.—Continued.

Seepage Estimates

Under continuously flooded conditions, seepage from the flooded area is the primary source of water flowing through the peat and, thus, is the main carrier of DOC to the ditch. Therefore, to estimate DOC loading to the drainage ditch, subsurface discharge from the pond must be determined. Although the seepage from the pond cannot be directly measured, the components of the pond water budget, such as pond inflow and outflow and pond storage were directly measured, and can be used to estimate the net seepage from the pond. Daily mean flow rates are summarized in tables 4 and 5 (at back of report) for eastern and western inlets, respectively. Daily mean discharge for east and west outlets are summarized in tables 6 and 7 (at back of report), respectively. The seepage rate is calculated as the difference between the total of quantifiable flows to and from the system and the change in pond storage (table 8 (at back of report); fig. 10). Zero pond inflow reflects intervals when no water was siphoned from the San Joaquin River. Although some of the flow parameters have been monitored since 1997, only measurements beginning in October 2000 were used in the water budget. Before October 2000, a significant amount of water escaped the pond through a crack beneath the perimeter berm. Repairs to the system were complete in late summer 2000. A bentonite slurry wall was installed to stop the flow beneath the berm and to force the water to exit the pond through the flumes.

Seepage estimates from the water budget ranged from 0.96 ft^3/s to -0.21 ft^3/s (table 8, at back of report). Positive values indicate seepage from the pond. The estimated average seepage during the 1-year period was 0.18 ft^3/s. When data are excluded because, for various reasons, daily mean values did not include 24 hourly measurements or measured flow was outside the instrument range the estimated average seepage was 0.26 ft^3/s.

SUMMARY

This report presents the methods used, and data collected, during the U. S. Geological Survey and California Department of Water Resources study to determine the effects of continuous shallow flooding on ground-water discharge to an agricultural drainage ditch on Twitchell Island. The conceptual model was detailed with soil coring and borehole geophysical logs. Twenty-two monitoring wells were installed to observe hydraulic head. Ground-water and surface-water temperatures were monitored at 14 locations. Flow to and from the pond was monitored through direct measurement of flows and through the calculation of a water budget. Aquifer slug tests were done in peat and mineral sediments to estimate hydraulic conductivity.

These data were gathered to support the development of a two-dimensional ground-water flow model. The model will be used to estimate subsurface discharge to the drainage ditch, and to estimate the concentrations of dissolved organic carbon that can be expected in the ditch.

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Table 1. Well construction details for wells on Twitchell Island, California

[N/A, not applicable. Elevations are in feet, relative to the North American Vertical Datum of 1988]

Well name	State well number	USGS site number	Elevation of top of casing	Drilling method	Well depth	Screened interval	Sand pack interval	Grout interval	Borehole diameter	Casing diameter
					(feet below land surface)				(inches)	
HSP	003N003E16G005M	380626121383505	-14.89	auger	2	0.5–2	0.5–2	0–0.5	8	2.4
HDP	003N003E16G004M	380626121383504	-14.83	rotary	10	8–10	8–10	0–8	6	1.4
HOW[1]	003N003E16G003M	380626121383503	-16.26	rotary	27	25–27	23–27	0–23	6	2.2
HMOW[2]	003N003E16G002M	380626121383502	-21.73	rotary	60	52–55	50–57	0–50	6	2.2
HDOW[3]	003N003E16G001M	380626121383501	-13.96	rotary	88	80–83	78-85	0–78	6	2.2
DPH1	003N003E16G006M	380627121383601	-15.28	driven	11	10–11	N/A	N/A	N/A	1.2
DPH2	003N003E16G007M	380627121383602	-17.32	driven	2.5	2–2.5	N/A	N/A	N/A	1.2
DPH3	003N003E16G008M	380626121383506	-14.59	driven	11	10–11	N/A	N/A	N/A	1.2
DPH4	003N003E16G009M	380626121383507	-16.67	driven	2.5	2–2.5	N/A	N/A	N/A	1.2
DPH5[4]	003N003E16B001M	380627121383603	-14.05	driven	11.74	10.74–11.74	N/A	N/A	N/A	1.2
DPH6[5]	003N003E16B002M	380627121383604	-18.10	driven	5.4	4.9–5.4	N/A	N/A	N/A	1.2
ISP	003N003E16G012M	380626121383203	-14.45	auger	2	0.5–2	0.5–2	0–0.5	8	2.4
IDP	003N003E16G011M	380626121383202	-14.95	rotary	10	8–10	8–10	0–8	6	1.4
IOW[6]	003N003E16G010M	380626121383201	-16.14	rotary	25	23–25	21–25	0–21	6	2.2
DPI1	003N003E16G013M	380627121383201	-14.89	driven	11	10–11	N/A	N/A	N/A	1.2
DPI2	003N003E16G014M	380627121383202	-17.11	driven	2.5	2–2.5	N/A	N/A	N/A	1.2
JSP	003N003E16G017M	380624121383303	-14.78	auger	2	0.5–2	0.5–2	0–0.5	8	2.4
JDP	003N003E16G016M	380624121383302	-15.09	rotary	10	8–10	8–10	0–8	6	1.4
JOW[7]	003N003E16G015M	380624121383301	-16.32	rotary	27	25–27	23–27	0–23	6	2.2
KSP	003N003E16G020M	380624121384003	-14.95	auger	2	0.5–2	0.5–2	0–0.5	8	2.4
KDP	003N003E16G019M	380624121384002	-15.25	rotary	10	8–10	8–10	0–8	6	1.4
KOW[8]	003N003E16G018M	380624121384001	-16.80	rotary	27	25–27	23–27	0–23	6	2.2

[1]Casing elevation was -11.26 after 2/26/98.
[2]Casing elevation was -14.21 from 3/6/98 to 3/28/98, -19.21 from 2/26/98 to 3/5/98, and -19.21 after 3/28/98.
[3]Casing elevation was -8.96 after 1/28/98.
[4]Casing elevation was -17.71 from 1/6/98 to 1/25/99, -18.81 from 12/18/97 to 1/5/98, and -15.66 after 1/28/99.
[5]Casing elevation was -15.99 after 2/26/98.
[6]Casing elevation was -11.14 after 2/26/98.
[7]Casing elevation was -11.32 after 2/26/98.
[8]Casing elevation was -11.80 after 1/28/98.

Table 2. Ground-water elevations on Twitchell Island, California, From Setpember 1997 to September 2001

[--, no measurement was made on that date. Screened interval indicated in parentheses; *, statistical measures shown for information only; values may not be comparable due to missing data]

Upper 5 and one-half feet of peat									
Date	Ditch	HSP (0.5–2.0)	ISP (0.5–2.0)	JSP (0.5–2.0)	KSP (0.5–2.0)	DPH2 (2–2.5)	DPH4 (2–2.5)	DPI2 (2–2.5)	DPH6 (4.9–5.4)
09/11/97	--	dry	dry	dry	dry	-21.49	-21.93	-21.57	--
10/07/97	--	-17.80	-17.78	-17.67	-17.69	--	--	--	--
10/10/97	--	-17.75	-17.74	-17.65	-17.65	-22.17	-19.66	--	--
10/15/97	--	-17.63	-17.64	-17.57	-17.56	-21.19	-19.65	-21.17	--
10/28/97	--	-17.81	-17.86	-17.69	-17.67	--	--	--	--
10/29/97	--	--	-17.79	--	--	--	--	-21.47	--
10/30/97	--	-17.58	--	--	--	-21.29	-19.66	-21.45	--
11/14/97	--	--	--	-17.65	-17.63	--	--	--	--
11/17/97	--	-17.79	-17.87	--	--	--	--	--	--
11/21/97	-22.18	-17.71	-17.68	-17.62	-17.65	-21.31	-19.67	-21.25	-25.12
12/02/97	-21.96	-17.73	-17.70	-17.68	-17.68	-21.28	-19.66	-21.30	-21.85
12/09/97	-21.66	-17.81	-17.77	-17.65	-17.65	-21.11	-19.67	-21.06	-21.36
12/18/97	-21.52	-17.99	-17.86	-17.88	-17.82	-20.78	-19.66	-20.71	-20.81
01/06/98	-22.07	-18.69	-18.58	-18.53	-18.54	-21.42	-19.70	-21.24	-20.71
01/20/98	--	-17.90	-17.84	-17.74	-17.79	-19.04	-18.70	-18.74	--
01/28/98	-21.18	-18.27	-18.18	-18.06	-18.09	-20.83	-19.64	-20.43	-19.91
02/25/98	--	-16.92	-16.84	-16.86	-16.91	--	--	--	--
02/26/98	-19.35	--	--	--	--	--	-16.98	--	--
03/10/98	--	-18.25	-18.21	-18.18	-18.22	--	--	--	-18.43
03/11/98	--	--	--	--	--	-18.49	-19.61	-18.87	--
03/19/98	--	-18.68	-18.52	-18.50	-18.53	-20.84	-19.67	-21.24	-19.32
03/26/98	--	-17.99	-17.76	-17.77	-17.79	-21.21	-19.64	-21.49	-19.72
04/02/98	-19.87	-17.93	-17.78	-17.73	-17.75	-20.42	-19.58	-19.81	-22.05
04/15/98	-21.79	-17.88	-17.78	-17.76	-17.78	-21.25	-19.64	-21.50	-20.60
04/16/98	-21.50	-17.68	-17.58	--	--	-21.25	-19.62	-22.12	-22.11
04/20/98	-21.94	-17.91	-17.77	-17.71	-17.72	-21.50	-19.63	-21.60	-21.24
04/22/98	-21.86	-17.67	-17.55	-17.49	-17.50	-21.44	-19.60	-21.59	-21.16
04/24/98	-21.71	-17.88	-17.72	--	--	-21.44	-19.62	-21.59	-21.11
05/05/98	-21.75	-17.80	-17.68	-17.58	-17.58	-21.35	-19.60	-21.48	-21.11
05/08/98	-21.70	-17.75	-17.61	-17.49	-17.50	-21.38	-19.61	-21.51	-21.09
05/12/98	-21.70	-17.76	-17.55	-17.45	-17.44	-21.32	-19.59	-21.52	-21.10
05/15/98	-21.77	-17.80	-17.57	-17.47	-17.47	-21.26	-19.57	-21.52	-21.09
05/18/98	-21.94	-17.81	-17.57	-17.48	-17.49	-21.18	-19.58	-21.51	-21.05
05/20/98	-21.92	-17.80	-17.57	-17.49	-17.51	-21.25	-19.60	-21.58	-21.05
05/22/98	-21.87	-17.77	-17.53	-17.42	--	-21.28	-19.59	-21.59	-21.06

Table 2. Ground-water elevations on Twitchell Island, California, from September 1997 to September 2001—Continued

Upper 5 and one-half feet of peat									
Date	**Ditch**	**HSP (0.5–2.0)**	**ISP (0.5–2.0)**	**JSP (0.5–2.0)**	**KSP (0.5–2.0)**	**DPH2 (2–2.5)**	**DPH4 (2–2.5)**	**DPI2 (2–2.5)**	**DPH6 (4.9–5.4)**
05/26/98	-21.88	-17.77	-17.50	-17.45	-17.43	-21.33	-19.61	-21.53	-21.06
05/28/98	-21.77	-17.78	-17.51	-17.42	-17.41	-21.37	-19.62	-21.54	-21.06
06/30/98	-21.81	-17.70	-17.53	-17.32	-17.30	-21.17	-19.46	-21.69	-21.43
07/30/98	-20.95	-18.01	-18.08	-17.56	-17.47	-21.01	-19.56	-21.11	-23.88
08/31/98	-20.13	-18.22	-18.09	-17.47	-17.44	-19.89	-19.54	-19.84	-21.49
09/22/98	-21.83	-18.25	-18.14	-17.48	-17.43	-21.17	-19.57	-20.99	-21.38
10/29/98	--	--	-17.98	-17.48	-17.45	-21.19	-19.20	-21.12	-21.78
12/04/98	-21.74	-18.00	-18.00	-17.54	-17.52	-21.34	-19.55	-21.16	-20.93
01/11/99	-20.57	-17.84	-17.95	-17.24	-17.51	-20.46	-19.38	--	-20.71
01/26/99	-21.54	-17.99	-17.88	-17.50	-17.55	-20.92	-19.43	--	-20.42
02/24/99	-21.60	-17.98	-17.94	-17.58	-17.57	-21.05	-19.44	-21.02	-19.76
04/07/99	--	-18.06	-17.71	-17.59	-17.55	-21.25	-19.43	-21.21	-20.78
05/19/99	-21.52	-18.11	-17.70	-17.58	-17.57	-21.27	-19.49	-20.41	-21.40
07/16/99	-21.21	-18.27	-17.57	-17.55	-17.52	-20.88	-19.61	-20.83	-22.32
08/25/99	-21.33	-18.84	-17.75	-17.60	-17.58	-20.85	-19.62	--	--
11/16/99	-22.36	-18.19	-17.76	-17.69	-17.69	-21.07	-19.55	-20.93	--
12/28/99	-20.74	-17.96	-17.60	-17.55	-17.51	-20.03	-19.38	-20.17	--
01/22/00	--	-17.72	-17.47	-17.42	-17.46	-18.91	-18.53	-19.50	-20.71
04/24/00	-20.44	-17.77	-17.61	-17.62	-17.61	-18.12	-19.44	-19.46	-18.86
05/11/00	-21.50	-17.99	-17.80	-17.81	-17.79	-21.23	-19.42	-21.31	-20.67
06/26/00	-21.53	-17.04	-17.76	-17.75	-17.75	-21.22	-19.43	-21.26	-22.77
07/31/00	--	-17.82	-17.28	-17.30	-17.25	-20.08	-20.05	-21.00	--
09/06/00	-21.43	-18.00	-17.74	-17.53	-17.50	-20.12	-20.57	-21.17	--
10/30/00	-21.99	-17.88	-17.27	-17.27	-17.16	-21.01	-20.36	-21.00	--
12/04/00	--	-17.61	-17.20	-17.16	-17.01	-21.02	-20.26	-20.36	-22.65
01/02/01	--	-17.60	-17.39	-17.32	-17.35	-21.23	-19.37	-21.11	--
02/06/01	-22.46	-17.49	-17.37	-17.35	-17.32	-21.18	-19.35	-21.13	-20.36
03/14/01	-22.45	-17.63	-17.46	-17.37	-17.37	-21.26	-19.35	-21.20	-20.26
04/17/01	--	-17.70	-17.66	-17.42	-17.37	-21.31	-19.37	-21.18	-20.76
05/22/01	--	-17.60	-17.79	-17.42	-17.39	-21.31	-19.35	--	-21.08
06/18/01	--	-18.10	-17.81	-17.40	-17.41	-21.02	-19.42	--	-20.99
07/16/01	--	--	--	--	--	--	--	--	--
08/20/01	--	-18.13	-17.88	-17.42	-17.39	-20.97	-19.42	--	-22.12
09/20/01	--	--	--	--	--	--	--	--	--
Minimum*	-22.46	-18.84	-18.58	-18.53	-18.54	-22.17	-21.93	-22.12	-25.12
Median*	-21.71	-17.81	-17.74	-17.55	-17.52	-21.19	-19.59	-21.20	-21.06
Mean*	-21.55	-17.90	-17.74	-17.58	-17.59	-20.92	-19.56	-21.03	-21.21
Maximum*	-19.35	-16.92	-16.84	-16.86	-16.91	-18.12	-16.98	-18.74	-18.43

Table 2. Ground-water elevations on Twitchell Island, California, from September 1997 to September 2001—Continued

Lower seven feet of peat								
Date	**HDP (8–10)**	**IDP (8–10)**	**JDP (8–10)**	**KDP (8–10)**	**DPH1 (10–11)**	**DPH3 (10–11)**	**DPI1 (10–11)**	**DPH5 (10.74–11.74)**
09/11/97	-19.40	-19.75	-19.59	-19.64	-21.35	-21.22	-21.25	--
10/07/97	-17.58	-18.45	-17.85	-17.49	--	--	--	--
10/10/97	-17.71	-20.04	-18.03	-17.63	-21.37	-20.89	--	--
10/15/97	-17.41	-18.21	-17.57	-17.35	-21.42	-20.78	-21.37	--
10/28/97	-17.51	-17.96	-17.51	-17.46	--	--	--	--
10/29/97	--	--	--	--	--	--	-21.34	--
10/30/97	-17.34	-17.82	--	--	-21.41	-20.66	-21.02	--
11/14/97	--	--	-17.55	-17.51	--	--	--	--
11/17/97	-17.55	-17.93	--	--	--	--	--	--
11/21/97	-17.65	-18.88	-18.83	-19.45	-21.53	-20.57	-22.37	-21.10
12/02/97	-17.57	-18.44	-17.68	-18.41	-21.34	-20.54	-21.36	-20.81
12/09/97	-17.97	-18.35	-17.67	-17.65	-21.18	-20.47	-21.15	--
12/18/97	-17.87	-18.36	-17.59	-17.65	-20.68	-20.26	-20.62	-20.82
12/19/97	--	--	--	--	--	--	--	-20.65
01/06/98	-18.21	-18.52	-18.27	-18.06	-21.21	-20.54	-21.17	-19.86
01/20/98	-19.43	-18.39	-17.51	-17.56	-19.37	-19.28	-19.42	--
01/26/98	--	--	--	--	--	--	--	--
01/28/98	-17.87	-18.20	-17.75	-17.72	-20.10	-19.98	-20.00	-19.24
02/25/98	-16.67	-17.13	-16.55	-16.53	--	--	--	--
02/26/98	--	--	--	--	-16.83	-16.87	-16.80	--
03/10/98	-17.77	-17.79	-17.69	-17.74	--	--	--	-18.00
03/11/98	--	--	--	--	-18.19	-18.43	-18.04	--
03/19/98	-18.09	-18.15	-17.99	-18.11	-20.25	-20.11	-20.13	-18.96
03/26/98	-17.49	-17.73	-17.35	-17.34	-20.87	-20.45	-20.83	-18.78
04/02/98	-17.47	-17.66	-17.33	-17.32	-20.70	-20.31	-20.74	-19.18
04/15/98	-17.49	-17.68	-17.33	-17.11	-21.08	-20.52	-21.10	-19.29
04/16/98	-17.32	-17.54	--	--	-21.86	--	--	-21.01
04/20/98	-17.45	-17.62	-17.29	-17.35	-21.46	-21.49	-22.17	-19.56
04/22/98	-17.25	-17.39	-18.07	-17.15	-21.39	-21.13	-21.86	-19.52
04/24/98	-17.41	-17.58	--	--	-21.34	-20.94	-21.67	-19.53
05/05/98	-17.39	-17.50	-17.17	-17.28	-21.17	-20.58	-21.26	-19.71
05/08/98	-17.33	-17.47	-17.12	-16.92	-21.16	-20.55	-21.22	-19.74
05/12/98	-17.27	-17.37	-17.04	-17.16	-21.19	-20.58	-21.22	-19.79
05/15/98	-17.36	-17.52	-17.14	-17.24	-21.18	-20.57	-21.22	-19.82
05/18/98	-17.36	-17.51	-17.13	-17.24	-21.19	-20.56	-21.19	-19.83
05/20/98	-17.38	-17.52	-17.15	-17.27	-21.19	-20.57	-21.20	-19.82
05/22/98	-17.33	-17.48	-17.10	-17.21	-21.20	-20.58	-21.20	-19.85
05/26/98	-17.33	-17.45	-17.10	-17.23	-21.20	-20.63	-21.21	-19.89
05/28/98	-17.32	-17.44	-17.08	-17.20	-21.19	-20.63	-21.21	-19.91
06/30/98	-17.31	-17.47	-17.07	-17.20	-21.20	-20.53	-21.25	-20.07

Table 2. Ground-water elevations on Twitchell Island, California, from September 1997 to September 2001—Continued

Lower seven feet of peat								
Date	**HDP (8–10)**	**IDP (8–10)**	**JDP (8–10)**	**KDP (8–10)**	**DPH1 (10–11)**	**DPH3 (10–11)**	**DPI1 (10–11)**	**DPH5 (10.74–11.74)**
07/30/98	-17.55	-17.63	-17.31	-17.42	-21.18	-20.61	-21.20	-20.73
08/31/98	-17.58	-17.61	-17.28	-17.39	-19.82	-19.81	-19.77	-19.74
09/22/98	-17.66	-17.69	-17.31	-17.43	-20.95	-20.45	-20.97	-19.82
10/29/98	-17.70	-17.75	-17.37	-17.50	-21.24	-20.65	-21.27	-20.27
12/04/98	-17.23	-17.84	-17.46	-17.57	-21.34	-20.60	-21.29	-20.05
01/11/99	-17.71	-17.80	-17.40	-17.42	-20.49	-20.09	--	-19.81
01/26/99	-17.78	-17.72	-17.38	-16.90	-20.75	-20.38	--	-19.54
02/24/99	-17.68	-17.74	-17.38	-17.29	-20.52	-20.50	--	-19.41
03/10/99	-17.77	--	--	--	--	--	--	--
04/07/99	-17.66	-17.72	-17.34	-17.38	-21.30	-20.66	-21.34	-19.50
05/19/99	-17.71	-17.73	-17.29	-17.37	-21.42	-20.71	-21.37	-19.99
07/16/99	-17.77	-17.78	-17.39	-17.49	-20.64	-20.40	-20.62	-20.63
08/25/99	-17.76	-17.81	-17.47	-17.58	-20.77	-20.50	--	--
11/16/99	-17.98	-18.70	-17.77	-17.80	-21.06	-20.64	-20.53	-21.16
12/28/99	-17.84	-18.15	-17.59	-17.61	-20.49	-20.20	-20.39	-20.73
01/22/00	-17.70	-17.92	-17.35	-17.44	-19.97	-19.76	-19.95	-19.57
04/24/00	-17.50	-17.62	-17.25	-17.27	-19.91	-19.22	-19.04	--
05/11/00	-17.76	-17.87	-17.42	-17.47	-21.37	-20.76	-21.09	-19.20
06/26/00	-17.80	-17.90	-17.58	-17.55	-21.17	-20.73	-21.09	-20.53
07/31/00	-17.50	-17.57	-17.13	-17.30	-20.87	-20.18	-20.87	--
09/06/00	-17.83	-18.20	-17.46	-17.72	-21.03	-20.34	-20.94	-21.85
10/30/00	-17.69	-17.74	-17.33	-17.40	-21.00	-20.31	-20.96	--
12/04/00	-17.64	-18.05	-17.30	-17.35	-21.03	-20.34	-20.56	-20.71
01/02/01	-17.75	-17.89	-17.47	-17.50	-21.16	-20.50	-20.99	--
02/06/01	-17.65	-17.67	-17.36	-18.00	-21.15	-20.55	-21.01	-19.91
03/14/01	-17.72	-17.85	-17.42	-17.40	-21.09	-20.48	-20.99	-19.83
04/17/01	-17.73	-17.80	-17.38	-17.44	-21.18	-20.58	-20.97	-20.10
05/22/01	-17.72	-17.69	-17.39	-17.43	-20.89	-20.50	-20.99	-20.34
06/18/01	-17.72	-17.70	-17.31	-17.44	-20.60	-20.39	--	-20.38
06/26/01	--	--	--	--	--	--	--	--
07/16/01	-17.69	-17.63	-17.31	-17.44	-20.63	-20.37	--	-21.60
07/31/01	--	--	--	--	--	--	--	--
08/20/01	-17.79	-17.65	-17.49	-17.52	-20.61	-20.31	--	--
09/20/01	-17.82	-17.69	-17.43	-17.56	-20.75	-20.39	-20.72	--
Minimum*	-19.43	-20.04	-19.59	-19.64	-21.86	-21.49	-22.37	-21.85
Median*	-17.66	-17.74	-17.38	-17.44	-21.16	-20.52	-21.09	-19.85
Mean*	-17.68	-17.92	-17.50	-17.54	-20.88	-20.40	-20.87	-20.04
Maximum*	-16.67	-17.13	-16.55	-16.53	-16.83	-16.87	-16.80	-18.00

Table 2. Ground-water elevations on Twitchell Island, California, from September 1997 to September 2001—Continued

Beneath peat						
Date	**IOW (23-25)**	**HOW (25-27)**	**JOW (25-27)**	**KOW (25-27)**	**HMOW (52-55)**	**HDOW (80-83)**
09/11/97	-17.69	-17.80	-17.74	-17.97	-17.77	-14.33
10/07/97	-17.66	-17.74	-17.71	-17.80	-17.70	-14.31
10/10/97	-17.66	-17.75	-17.64	-17.78	-17.71	-14.36
10/15/97	-17.63	-17.72	-17.64	-17.78	-17.67	-14.36
10/28/97	-17.68	-17.78	-17.72	-17.80	--	--
10/29/97	--	--	--	--	--	--
10/30/97	--	-17.73	--	--	-17.80	-14.43
11/14/97	--	--	-17.59	-17.83	--	--
11/17/97	-17.59	-17.65	--	--	-17.54	-14.40
11/21/97	-17.56	-17.64	-17.51	-17.77	-17.55	-14.30
12/02/97	-17.32	-17.42	-17.32	-17.48	-17.34	-14.03
12/09/97	-17.14	-17.23	-17.24	-17.32	-17.21	--
12/18/97	-17.02	-17.11	-17.10	-17.45	-17.06	--
12/19/97	--	--	--	--	--	--
01/06/98	-17.07	-17.20	-16.79	-17.30	-17.12	--
01/20/98	--	--	--	--	--	--
01/26/98	--	--	--	--	--	--
01/28/98	-16.61	-16.70	-16.61	-16.80	--	-13.09
02/25/98	-15.17	-15.27	-15.24	-15.32	--	-12.48
02/26/98	-15.19	-15.24	-15.29	-15.38	-17.33	--
03/04/98	--	--	-15.85	-15.97	--	--
03/06/98	-15.89	-15.97	--	--	-15.99	--
03/10/98	-16.17	-16.26	-16.27	-16.42	-16.29	-12.76
03/11/98	--	-16.38	--	--	-16.41	-12.83
03/19/98	-16.74	-16.88	-16.80	-17.06	-16.87	--
03/26/98	-16.72	-16.86	-16.78	-17.03	-16.85	-13.20
04/02/98	-16.57	-16.69	-16.64	-16.85	-16.68	-13.19
04/15/98	-16.90	-17.03	-16.93	-17.19	-17.02	-13.45
04/16/98	--	--	--	--	--	--
04/20/98	-17.01	-17.13	-17.02	-17.29	-17.12	-13.58
04/22/98	-16.97	-17.11	-17.00	-17.26	-17.09	-13.56
04/24/98	-17.00	-17.14	--	--	-17.12	--
05/05/98	-17.07	-17.20	-17.01	-17.36	-17.19	-13.69
05/08/98	-17.06	-17.19	-17.09	-17.36	-17.19	-13.69
05/12/98	-16.99	-17.13	-17.02	-17.30	-17.12	-13.61
05/15/98	-17.03	-17.15	-17.05	-17.35	-17.14	-13.64
05/18/98	-17.08	-17.21	-17.01	-17.36	-17.20	-13.69
05/20/98	-17.09	-17.23	-17.11	-17.38	-17.20	-13.69
05/22/98	-17.09	-17.23	-17.14	-17.39	-17.22	-13.72
05/26/98	--	-17.23	-17.12	-17.39	-17.21	-13.65

Table 2. Ground-water elevations on Twitchell Island, California, from September 1997 to September 2001—Continued

			Beneath peat			
Date	**IOW (23-25)**	**HOW (25-27)**	**JOW (25-27)**	**KOW (25-27)**	**HMOW (52-55)**	**HDOW (80-83)**
05/28/98	-17.10	-17.22	-17.12	-17.39	-17.22	-13.65
06/30/98	-17.13	-17.24	-17.12	-17.40	-17.22	-13.71
07/30/98	-17.28	-17.37	-17.32	-17.58	-17.39	-13.90
08/31/98	-17.24	-17.35	-17.31	-17.51	-17.33	-14.06
09/22/98	-17.57	-17.66	-17.60	-17.82	-17.67	-14.27
10/28/98	--	--	--	--	-17.69	-14.38
10/29/98	-17.61	-17.72	-17.62	-17.84	-17.71	-14.38
12/04/98	-17.50	-17.61	-17.40	-17.64	-17.53	-14.20
01/11/99	-16.86	-16.91	-16.77	-17.20	-16.91	-13.78
01/26/99	-17.02	-16.71	-16.99	-17.15	-17.08	-13.74
02/24/99	-16.88	-16.98	-16.86	-17.04	-16.91	-13.46
03/10/99	--	--	--	--	--	--
04/07/99	-17.11	-17.21	-17.07	-17.31	-17.13	-13.75
05/19/99	-17.28	-17.36	-17.17	-17.50	-17.29	-13.86
07/16/99	-17.59	-17.70	-17.60	-17.79	-17.63	-14.33
08/25/99	-17.74	-17.75	-17.66	-17.86	-17.77	-14.49
11/16/99	-17.82	-17.92	-17.76	-17.94	-17.88	-14.69
12/28/99	--	-17.42	-17.32	-17.40	-17.40	-14.20
01/25/00	-16.19	-16.22	-16.07	-16.07	-16.18	-13.15
04/24/00	-16.72	-16.81	-16.77	-16.97	-16.81	-13.55
05/11/00	-17.12	-17.26	-17.14	-17.88	-17.27	-13.92
06/26/00	-17.52	-17.61	-17.52	-17.70	-17.58	-14.36
07/31/00	-17.73	-17.83	-17.72	-17.89	-17.81	-14.48
09/06/00	-17.93	-18.04	-17.92	-18.05	-18.04	-14.74
10/30/00	-17.64	-17.66	-17.62	-17.82	-17.18	-14.35
12/04/00	-17.52	-17.65	-17.51	-17.90	-17.61	-14.25
01/02/01	-17.44	-17.57	-17.44	-17.61	-17.53	-14.18
02/06/01	-17.28	-17.41	-17.22	-16.96	-17.37	-13.94
03/14/01	-17.13	-17.24	-17.08	-17.32	-17.13	-13.76
04/17/01	-17.29	-17.39	-17.49	-17.49	-17.35	-14.16
05/22/01	-17.23	-17.36	-17.24	-17.48	-17.27	-15.06
06/18/01	-17.38	-17.54	-17.37	-17.58	-17.46	-14.08
06/26/01	--	-17.61	--	--	--	--
07/16/01	-17.55	-17.67	-17.57	-17.79	-17.62	--
07/31/01	--	-17.83	--	--	--	--
08/20/01	-17.86	-17.98	-17.89	-18.06	-17.93	-14.53
09/20/01	-17.90	-18.01	-17.90	-18.07	-17.98	-14.67
Minimum*	-17.93	-18.04	-17.92	-18.07	-18.04	-15.06
Median*	-17.13	-17.31	-17.17	-17.40	-17.27	-13.93
Mean*	-17.16	-17.28	-17.17	-17.38	-17.30	-13.95
Maximum*	-15.17	-15.24	-15.24	-15.32	-15.99	-12.48

Table 3. Well construction and estimates of hydraulic conductivity and transmissivity from slug tests for selected wells on Twitchell Island, California

Well name	Well depth	Screened interval	Sand pack interval	Grout interval	Borehole diameter	Casing diameter	Hydraulic conductivity		Transmissivity	
	(feet below land surface)				(inches)		(feet per day)		(square feet per day)	
peat (0–15 feet below land surface)										
HDP	10	8–10	8–10	0–8	6	1.4	[1]0.7	[2]0.01	[1]10	[2]0.2
IDP	10	8–10	8–10	0–8	6	1.4	[1].7	[2].01	[1]10	[2].2
JDP	10	8–10	8–10	0–8	6	1.4	[1].7	[2].01	[1]10	[2].2
KDP	10	8–10	8–10	0–8	6	1.4	[1].7	[2].01	[1]10	[2].2
poorly sorted sand (20–30 feet below land surface)										
HOW	27	25–27	23–27	0–23	6	2.2	[1]9	[2]5	[1]240	[2]150
IOW	25	23–25	21–25	0–21	6	2.2	[1]9	[2]5	[1]240	[2]150
JOW	27	25–27	23–27	0–23	6	2.2	[1]9	[2]5	[1]240	[2]150
KOW	27	25–27	23–27	0–23	6	2.2	[1]9	[2]5	[1]240	[2]150
silt (48–56 feet below land surface)										
HMOW	60	52–55	50–57	0–50	6	2.2	[1]1	[2]0.5	[1]70	[2]30
fine silty sand (79–85 feet below land surface)										
HDOW	88	80–83	78–85	0–78	6	2.2	[1]5	[2]2	[1]500	[2]100

[1]Estimate made using the method developed by Papadopulos and others, 1973.
[2]Estimate made using the method developed by Bouwer and Rice, 1976.

Table 4. Daily mean inflow at eastern inlet of East Pond at USGS site number 380626121383806 on Twitchell Island, California

[Daily mean values are calculated from hourly readings from micrometer installed on inlet valve; all shown in cubic feet per second. Values in bold indicate that one or more hourly readings were not included in the calculated daily mean due to equipment failure; --, missing data; *, statistical measures shown for information only; values may not be comparable due to missing data]

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 1998 to September 1999											
1	--	--	--	--	--	--	--	--	--	0.26	0.25	0.24
2	--	--	--	--	--	--	--	--	--	0.26	0.21	0.25
3	--	--	--	--	--	--	--	--	--	0.26	0.20	0.25
4	--	--	--	--	--	--	--	--	--	0.26	0.25	0.25
5	--	--	--	--	--	--	--	--	--	0.25	0.25	0.25
6	--	--	--	--	--	--	--	--	--	0.25	0.25	0.24
7	--	--	--	--	--	--	--	--	--	0.26	0.20	0.25
8	--	--	--	--	--	--	--	--	--	0.26	0.16	0.25
9	--	--	--	--	--	--	--	--	--	0.26	0.16	0.24
10	--	--	--	--	--	--	--	--	--	0.26	0.15	0.24
11	--	--	--	--	--	--	--	--	--	0.26	0.15	0.24
12	--	--	--	--	--	--	--	--	--	0.26	0.15	0.24
13	--	--	--	--	--	--	--	--	--	0.26	0.16	0.24
14	--	--	--	--	--	--	--	--	--	0.27	0.16	0.22
15	--	--	--	--	--	--	--	--	--	0.27	0.15	0.08
16	--	--	--	--	--	--	--	--	--	0.27	0.14	0.11
17	--	--	--	--	--	--	--	--	--	0.26	0.15	0.36
18	--	--	--	--	--	--	--	--	--	0.25	0.15	0.36
19	--	--	--	--	--	--	--	--	--	0.18	0.15	0.36
20	--	--	--	--	--	--	--	--	--	0.04	0.19	0.36
21	--	--	--	--	--	--	--	--	--	0.15	0.22	0.35
22	--	--	--	--	--	--	--	--	--	0.26	0.22	0.35
23	--	--	--	--	--	--	--	--	--	0.25	0.22	0.34
24	--	--	--	--	--	--	--	--	--	0.25	0.22	0.34
25	--	--	--	--	--	--	--	--	0.26	0.25	0.24	0.34
26	--	--	--	--	--	--	--	--	0.26	0.25	0.25	0.33
27	--	--	--	--	--	--	--	--	0.26	0.24	0.25	0.33
28	--	--	--	--	--	--	--	--	0.26	0.24	0.25	0.34
29	--	--	--	--	--	--	--	--	0.26	0.25	0.25	0.33
30	--	--	--	--	--	--	--	--	0.26	0.25	0.25	0.33
31	--	--	--	--	--	--	--	--	--	0.25	0.24	--
Minimum*	--	--	--	--	--	--	--	--	--	0.04	0.14	0.08
Mean*	--	--	--	--	--	--	--	--	--	0.24	0.20	0.28
Maximum*	--	--	--	--	--	--	--	--	--	0.27	0.25	0.36

Table 4. Daily mean inflow at eastern inlet of East Pond at USGS site number 380626121383806 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 1999 to September 2000											
1	0.33	0.23	0.44	--	--	--	--	--	--	--	--	--
2	0.33	0.39	0.42	--	--	--	--	--	--	--	--	--
3	0.32	0.38	0.42	--	--	--	--	--	--	--	--	--
4	0.32	0.38	--	--	--	--	--	--	--	--	--	--
5	0.31	0.41	--	--	--	--	--	--	--	--	--	--
6	0.32	0.13	--	--	--	--	--	--	--	--	--	--
7	0.32	--	0.40	--	--	--	--	--	--	--	--	--
8	0.32	0.24	--	--	--	--	--	--	--	--	--	--
9	0.32	0.43	0.39	--	--	--	--	--	--	--	--	0.50
10	0.32	0.43	--	--	--	--	--	--	--	--	--	0.50
11	0.32	0.42	--	--	--	--	--	--	--	--	--	0.50
12	0.32	0.27	--	--	--	--	--	--	--	--	--	0.50
13	0.32	0.00	--	--	--	--	--	--	--	--	--	0.50
14	0.33	--	--	--	--	--	--	--	--	--	--	0.50
15	0.33	0.26	--	--	--	--	--	--	--	--	--	0.50
16	0.31	0.42	--	--	--	--	--	--	--	--	--	0.50
17	0.06	0.44	--	--	--	--	--	--	--	--	--	0.50
18	--	0.42	--	--	--	--	--	--	--	--	--	0.49
19	0.16	0.21	--	--	--	--	--	--	--	--	0.37	0.47
20	0.04	--	--	--	--	--	--	--	--	--	0.36	0.50
21	0.15	--	--	--	--	--	--	--	--	--	0.45	0.51
22	0.24	0.23	--	--	--	--	--	--	--	--	0.48	0.50
23	0.08	0.44	--	--	--	--	--	--	--	--	0.49	0.49
24	--	0.44	--	--	--	--	--	--	--	--	0.49	0.49
25	0.18	0.23	--	--	--	--	--	--	--	--	0.49	0.50
26	0.24	0.27	--	--	--	--	--	--	--	--	0.48	0.50
27	0.25	0.27	--	--	--	--	--	--	--	--	0.48	0.50
28	0.26	--	--	--	--	--	--	--	--	--	0.47	0.50
29	0.25	0.25	--	--	--	--	--	--	--	--	0.46	0.50
30	0.03	0.43	--	--	--	--	--	--	--	--	0.45	0.50
31	--	--	--	--	--	--	--	--	--	--	--	--
Minimum*	0.03	--	--	--	--	--	--	--	--	--	--	--
Mean*	0.25	--	--	--	--	--	--	--	--	--	--	--
Maximum*	0.33	--	--	--	--	--	--	--	--	--	--	--

Table 4. Daily mean inflow at eastern inlet of East Pond at USGS site number 380626121383806 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 2000 to September 2001											
1	0.50	0.27	**0.26**	0.15	0.12	0.14	0.17	**0.16**	**0.25**	0.24	0.22	**0.36**
2	0.50	0.28	**0.22**	0.14	0.12	0.14	0.17	**0.18**	--	0.24	0.22	**0.37**
3	0.51	0.28	**0.05**	0.15	0.12	0.14	0.17	--	--	--	0.22	**0.36**
4	0.51	0.28	**0.06**	0.15	0.12	0.14	**0.17**	--	**0.22**	0.24	0.22	**0.36**
5	0.51	0.28	**0.02**	0.16	0.12	0.14	--	--	0.22	0.24	0.22	**0.33**
6	0.51	0.28	**0.01**	0.16	0.12	0.14	--	--	0.23	0.23	--	**0.33**
7	0.52	0.28	**0.31**	0.17	0.12	0.14	**0.22**	**0.16**	0.22	0.24	0.22	**0.33**
8	0.51	0.28	**0.09**	0.17	0.12	0.14	**0.16**	0.19	0.22	0.24	0.22	**0.33**
9	0.51	0.28	**0.09**	0.17	0.12	0.15	**0.19**	0.22	0.23	0.24	0.22	**0.33**
10	0.51	0.28	**0.07**	0.15	0.12	0.15	**0.18**	0.25	0.23	0.24	0.22	**0.33**
11	0.51	0.27	**0.06**	0.11	0.12	0.15	**0.13**	0.24	0.23	0.24	0.21	**0.32**
12	0.51	0.27	**0.15**	0.11	0.12	0.14	0.12	0.24	0.23	0.24	0.21	**0.32**
13	0.51	0.27	**0.24**	0.11	0.12	0.17	0.12	0.23	0.22	0.24	0.20	--
14	0.51	0.26	0.23	0.11	0.12	0.17	0.14	**0.26**	0.22	0.22	0.21	--
15	0.51	0.26	0.24	0.11	0.13	0.17	**0.14**	**0.23**	0.22	0.22	0.21	--
16	0.51	**0.25**	0.24	0.11	0.13	0.17	**0.18**	**0.23**	0.29	0.21	0.20	0.22
17	**0.50**	0.28	0.23	0.14	0.13	0.18	**0.18**	**0.24**	0.48	0.22	--	--
18	**0.26**	0.28	0.21	0.13	0.13	0.18	0.18	**0.23**	0.36	0.23	0.20	0.18
19	0.26	0.28	0.20	0.13	0.13	0.19	**0.19**	**0.24**	0.22	0.23	0.19	0.19
20	0.25	0.27	0.20	0.14	0.13	0.19	**0.19**	**0.23**	0.23	0.23	--	--
21	0.25	0.28	0.20	0.14	0.14	0.19	--	**0.24**	0.25	0.23	0.18	0.23
22	0.25	**0.28**	0.20	0.14	0.14	0.19	--	**0.23**	0.24	0.22	0.19	0.25
23	0.24	**0.19**	0.20	0.14	0.14	0.20	--	**0.23**	0.24	0.22	0.21	0.26
24	0.25	0.28	0.19	0.14	0.14	0.20	--	**0.24**	0.24	0.22	0.21	--
25	0.26	0.19	0.19	0.13	0.14	0.20	--	**0.23**	0.23	0.22	0.20	--
26	0.26	0.17	0.17	0.13	0.14	0.19	--	**0.23**	0.23	0.22	0.21	0.25
27	0.26	**0.14**	0.15	0.13	0.14	0.18	--	**0.24**	0.23	0.22	--	0.25
28	0.26	**0.17**	0.15	0.13	0.15	0.17	--	**0.23**	0.23	0.22	--	0.25
29	0.26	**0.19**	0.15	0.13	--	0.17	--	**0.23**	0.23	0.22	--	0.24
30	0.26	**0.25**	0.14	0.12	--	0.16	--	**0.22**	0.24	0.20	0.37	--
31	0.26	--	0.15	0.12	--	0.16	--	--	--	0.20	--	--
Minimum*	0.24	0.14	0.01	0.11	0.12	0.14	--	--	0.22	0.20	--	0.18
Mean*	0.39	0.25	0.16	0.14	0.13	0.17	--	--	0.25	0.23	--	0.29
Maximum*	0.52	0.28	0.31	0.17	0.15	0.20	--	--	0.48	0.24	--	0.37

Table 5. Daily mean inflow at western inlet of East Pond at USGS site number 380626121383807 on Twitchell Island, California

[Daily mean values are calculated from hourly readings from micrometer installed on inlet valve and are shown in cubic feet per second. Values in bold indicate that one or more hourly readings were not included in the calculated daily mean due to equipment failure; --, missing data; *, statistical measures shown for information only; values may not be comparable due to missing data]

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 1998 to September 1999											
1	--	--	--	--	--	--	--	--	--	0.51	0.50	0.50
2	--	--	--	--	--	--	--	--	--	0.52	0.41	0.51
3	--	--	--	--	--	--	--	--	--	0.52	0.39	0.51
4	--	--	--	--	--	--	--	--	--	0.51	0.51	0.51
5	--	--	--	--	--	--	--	--	--	0.50	0.50	0.51
6	--	--	--	--	--	--	--	--	--	0.50	0.51	0.50
7	--	--	--	--	--	--	--	--	--	0.51	0.39	0.51
8	--	--	--	--	--	--	--	--	--	0.51	0.30	0.51
9	--	--	--	--	--	--	--	--	--	0.51	0.28	0.50
10	--	--	--	--	--	--	--	--	--	0.52	0.27	0.50
11	--	--	--	--	--	--	--	--	--	0.52	0.27	0.50
12	--	--	--	--	--	--	--	--	--	0.52	0.27	0.50
13	--	--	--	--	--	--	--	--	--	0.52	0.28	0.49
14	--	--	--	--	--	--	--	--	--	0.53	0.28	0.45
15	--	--	--	--	--	--	--	--	--	0.53	0.27	0.16
16	--	--	--	--	--	--	--	--	--	0.53	0.25	0.22
17	--	--	--	--	--	--	--	--	--	0.51	0.23	0.75
18	--	--	--	--	--	--	--	--	--	0.49	0.27	0.75
19	--	--	--	--	--	--	--	--	--	0.32	0.26	0.75
20	--	--	--	--	--	--	--	--	--	0.05	0.38	0.75
21	--	--	--	--	--	--	--	--	--	0.31	0.43	0.73
22	--	--	--	--	--	--	--	--	--	0.52	0.44	0.72
23	--	--	--	--	--	--	--	--	--	0.52	0.45	0.72
24	--	--	--	--	--	--	--	--	--	0.52	0.44	0.72
25	--	--	--	--	--	--	--	--	0.51	0.51	0.49	0.71
26	--	--	--	--	--	--	--	--	0.51	0.52	0.51	0.69
27	--	--	--	--	--	--	--	--	0.51	0.47	0.51	0.68
28	--	--	--	--	--	--	--	--	0.51	0.46	0.51	0.70
29	--	--	--	--	--	--	--	--	0.52	0.51	0.51	0.69
30	--	--	--	--	--	--	--	--	0.52	0.51	0.51	0.69
31	--	--	--	--	--	--	--	--	--	0.51	0.50	--
Minimum*	--	--	--	--	--	--	--	--	--	0.05	0.23	0.16
Mean*	--	--	--	--	--	--	--	--	--	0.48	0.39	0.58
Maximum*	--	--	--	--	--	--	--	--	--	0.53	0.51	0.75

Table 5. Daily mean inflow at western inlet of East Pond at USGS site number 380626121383807 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 1999 to September 2000											
1	0.36	0.17	--	--	--	--	--	--	--	--	0.29	0.21
2	0.36	0.24	--	--	--	--	--	--	--	--	0.29	0.22
3	0.35	0.23	--	--	--	--	--	--	--	--	--	0.22
4	0.35	0.23	--	--	--	--	--	--	--	--	--	0.22
5	0.35	0.26	--	--	--	--	--	--	--	--	0.19	0.22
6	0.35	0.07	--	--	--	--	--	--	--	--	--	0.25
7	0.35	--	--	--	--	--	--	--	--	--	--	0.24
8	0.35	0.15	--	--	--	--	--	--	--	--	0.14	0.21
9	0.35	0.22	--	--	--	--	--	--	--	--	--	0.22
10	0.35	0.27	--	--	--	--	--	--	--	--	--	0.21
11	0.35	0.25	--	--	--	--	--	--	--	--	0.20	0.22
12	0.35	0.12	--	--	--	--	--	--	--	--	--	0.22
13	0.34	--	--	--	--	--	--	--	--	--	--	0.22
14	0.35	--	--	--	--	--	--	--	--	--	0.25	0.22
15	0.36	0.12	--	--	--	--	--	--	--	--	0.25	0.22
16	0.34	0.01	--	--	--	--	--	--	--	--	0.25	0.23
17	0.05	0.08	--	--	--	--	--	--	--	--	0.23	0.22
18	--	0.06	--	--	--	--	--	--	--	--	0.15	0.22
19	0.18	--	--	--	--	--	--	--	--	--	--	0.20
20	0.03	--	--	--	--	--	--	--	--	--	--	0.23
21	0.16	--	--	--	--	--	--	--	--	--	0.19	0.22
22	0.26	0.06	--	--	--	--	--	--	--	--	0.22	0.23
23	0.08	0.05	--	--	--	--	--	--	--	--	0.22	0.23
24	--	0.04	--	--	--	--	--	--	--	--	0.22	0.23
25	0.20	0.00	--	--	--	--	--	--	--	--	0.22	0.23
26	0.26	--	--	--	--	--	--	--	--	--	0.22	0.23
27	0.26	--	--	--	--	--	--	--	--	0.28	0.22	0.23
28	0.28	--	--	--	--	--	--	--	--	0.29	0.22	0.23
29	0.26	--	--	--	--	--	--	--	--	0.29	0.21	0.23
30	0.03	--	--	--	--	--	--	--	--	0.29	0.20	0.23
31	--	--	--	--	--	--	--	--	--	0.29	0.20	--
Minimum*	0.03	--	--	--	--	--	--	--	--	--	--	0.20
Mean*	0.27	--	--	--	--	--	--	--	--	--	--	0.22
Maximum*	0.36	--	--	--	--	--	--	--	--	--	--	0.25

Table 5. Daily mean inflow at western inlet of East Pond at USGS site number 380626121383807 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 2000 to September 2001											
1	0.23	0.26	--	0.14	0.15	0.15	0.25	0.18	--	0.29	0.27	0.26
2	0.24	0.26	--	0.14	0.16	0.14	0.25	0.20	--	--	0.27	0.27
3	0.24	0.25	--	0.14	0.15	0.14	0.25	0.20	--	--	0.27	0.27
4	0.24	0.25	--	0.14	0.16	0.14	**0.25**	0.20	**0.23**	--	0.27	0.28
5	0.23	0.25	--	0.14	0.16	0.14	--	0.20	0.24	--	0.27	0.32
6	0.23	0.25	--	0.15	0.15	0.14	--	0.21	0.25	--	0.26	0.32
7	0.23	0.25	--	0.15	0.15	0.14	--	--	0.25	--	0.26	0.32
8	0.23	0.25	--	0.15	0.15	0.14	--	--	0.25	--	0.26	0.33
9	0.23	0.26	--	0.15	0.15	0.14	**0.14**	0.27	0.25	--	0.27	0.32
10	0.23	0.26	--	0.15	0.16	0.14	**0.13**	0.27	0.25	--	0.26	0.31
11	0.23	0.26	--	0.14	0.16	0.13	0.12	0.26	0.25	--	0.26	0.31
12	0.23	0.26	--	0.13	0.16	0.13	0.12	0.23	0.25	--	0.26	0.27
13	0.23	0.26	**0.23**	0.13	0.16	0.16	0.12	0.23	0.24	--	0.24	--
14	0.23	0.26	0.22	0.13	0.16	0.19	0.11	**0.23**	0.24	--	0.27	--
15	0.23	0.26	0.22	0.13	0.16	0.19	**0.11**	--	0.25	--	0.28	--
16	0.23	0.26	0.23	0.12	0.16	0.19	--	--	0.21	--	0.28	--
17	**0.22**	0.26	0.22	0.11	0.17	0.19	**0.22**	--	0.10	--	0.28	--
18	**0.09**	0.26	0.21	0.11	0.17	0.19	0.24	--	0.14	--	0.27	--
19	0.08	0.26	0.19	0.11	0.17	0.19	**0.23**	--	0.26	0.25	0.26	--
20	0.08	0.26	0.19	0.11	0.17	0.19	0.23	--	0.25	0.25	0.25	--
21	0.07	0.26	0.19	0.11	0.16	0.19	**0.22**	--	0.28	0.26	0.25	--
22	0.07	0.26	0.19	0.11	0.17	0.25	0.21	--	0.29	0.26	0.23	--
23	0.07	0.26	0.19	0.11	0.17	0.34	0.21	--	0.28	0.25	0.21	--
24	0.16	0.26	0.20	0.11	0.16	0.34	0.21	--	0.28	0.26	0.21	--
25	0.26	0.26	0.20	0.11	0.16	0.34	0.21	--	0.29	0.26	0.21	--
26	0.26	**0.26**	0.17	0.11	0.16	0.31	0.21	--	0.29	0.26	0.22	--
27	0.26	**0.22**	0.15	0.11	0.16	0.28	0.21	--	0.29	0.26	0.23	--
28	0.26	--	0.15	0.11	0.16	0.27	0.20	--	0.29	0.26	0.26	--
29	0.26	--	0.15	0.11	--	0.26	0.20	--	0.29	0.26	0.31	--
30	0.26	--	0.15	0.13	--	0.25	0.19	--	0.29	0.21	0.31	--
31	0.26	--	0.15	0.16	--	0.25	--	--	--	0.21	0.24	--
Minimum*	0.07	0.22	--	0.11	0.15	0.13	--	--	0.10	--	0.21	--
Mean*	0.20	0.26	--	0.13	0.16	0.20	--	--	0.25	--	0.26	--
Maximum*	0.26	0.26	--	0.16	0.17	0.34	--	--	0.29	--	0.31	--

Table 6. Daily mean outflow at eastern outlet of East Pond at USGS site number 380626121383802 on Twitchell Island, California

[Daily mean values are calculated from hourly readings and are shown in cubic feet per second. Values in bold indicate that one or more hourly readings were not included in the calculated daily mean due to equipment failure; --, missing data; *, statistical measures shown for information only; values may not be comparable due to missing data]

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 1997 to September 1998											
1	--	--	--	0.02	0.43	0.10	0.44	--	0.00	0.15	0.01	0.25
2	--	--	--	0.01	0.41	0.09	--	--	0.00	0.21	0.01	0.37
3	--	--	--	0.02	0.40	0.09	--	--	0.00	0.26	0.01	0.02
4	--	--	--	0.02	0.38	0.08	--	--	0.00	0.03	0.01	0.00
5	--	--	--	0.02	0.37	0.07	--	--	0.00	0.00	0.01	0.00
6	--	--	--	0.02	0.36	0.06	--	--	0.00	0.00	0.01	0.01
7	--	--	--	0.03	0.34	0.06	--	--	0.00	0.00	0.01	0.01
8	--	--	--	0.03	0.33	0.05	--	--	0.00	0.00	0.01	0.01
9	--	--	--	0.03	0.32	0.04	--	--	--	0.00	0.03	0.01
10	--	--	--	0.03	0.30	0.04	--	--	--	0.00	0.15	0.01
11	--	--	--	0.04	0.29	0.03	--	--	0.01	0.00	0.15	0.01
12	--	--	--	--	0.28	0.03	--	--	0.03	0.00	0.50	0.02
13	--	--	--	--	0.27	0.02	--	--	0.04	0.00	0.67	0.02
14	--	--	--	--	0.26	0.02	--	--	0.06	0.00	0.67	0.01
15	--	--	--	--	0.24	0.01	--	--	0.01	0.00	0.67	0.01
16	--	--	--	--	0.23	0.01	--	--	0.00	0.00	0.67	0.01
17	--	--	--	--	0.22	0.01	--	--	0.00	0.00	0.67	0.02
18	--	--	--	--	0.21	0.00	--	--	0.00	0.00	0.49	0.02
19	--	--	--	--	0.20	0.00	--	--	0.00	0.00	0.02	0.01
20	--	--	--	--	0.19	0.01	--	--	0.00	0.01	0.00	0.01
21	--	--	--	--	0.18	0.02	--	--	0.00	0.01	0.10	0.01
22	--	--	--	--	0.17	0.03	--	--	0.00	0.01	0.49	0.01
23	--	--	--	0.57	0.16	0.05	--	0.00	0.00	0.01	0.67	0.01
24	--	--	0.01	0.55	0.15	0.07	--	0.00	0.00	0.01	0.67	0.01
25	--	--	0.01	0.54	0.14	0.09	--	0.00	0.00	0.01	0.16	0.01
26	--	--	0.01	0.52	0.13	0.10	--	0.00	0.00	0.01	0.02	0.00
27	--	--	0.01	0.50	0.12	0.08	--	0.00	0.00	0.01	0.24	0.00
28	--	--	0.01	0.49	0.11	0.05	--	0.03	0.00	0.01	0.37	0.00
29	--	--	0.01	0.47	--	0.03	--	0.01	0.28	0.01	0.52	0.00
30	--	--	0.01	0.46	--	0.03	--	0.00	0.36	0.01	0.59	0.00
31	--	--	0.02	0.44	--	0.17	--	0.00	--	0.01	0.34	--
Minimum*	--	--	--	--	0.11	0.00	--	--	0.00	0.00	0.00	0.00
Mean*	--	--	--	--	0.26	0.05	--	--	0.03	0.02	0.29	0.03
Maximum*	--	--	--	--	0.43	0.17	--	--	0.36	0.26	0.67	0.37

Table 6. Daily mean outflow at eastern outlet of East Pond at USGS site number 380626121383802 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
						October 1998 to September 1999						
1	0.01	0.01	0.01	0.01	0.06	0.03	0.01	0.00	0.17	0.15	0.13	0.09
2	0.01	0.00	0.01	0.01	0.04	0.02	0.01	0.00	0.17	0.15	0.11	0.09
3	0.01	0.00	0.01	0.01	0.04	0.02	0.02	0.00	0.18	0.14	0.05	0.09
4	0.01	0.00	0.00	0.01	0.04	0.02	0.02	0.00	0.18	0.14	0.10	0.09
5	0.01	0.00	0.00	0.01	0.04	0.03	0.05	0.00	0.17	0.15	0.13	0.09
6	0.00	0.00	0.00	0.01	0.09	0.03	0.04	0.00	0.16	0.13	0.14	0.09
7	0.00	0.00	0.01	0.03	--	0.03	0.02	0.00	0.15	0.13	0.12	0.10
8	0.00	0.00	0.01	0.03	--	0.02	0.04	0.00	0.16	0.13	0.05	0.11
9	0.01	0.01	0.01	0.01	--	0.01	0.00	0.00	0.16	0.14	0.03	0.11
10	0.01	0.01	0.01	0.01	--	0.01	0.00	0.01	0.16	0.27	0.03	0.10
11	0.02	0.01	0.01	0.01	0.14	0.00	0.00	0.03	0.15	0.43	0.07	0.12
12	0.02	0.02	0.01	0.01	0.05	0.00	0.00	0.12	0.15	0.23	0.06	0.11
13	0.02	0.01	0.01	0.01	0.05	0.00	0.00	0.15	0.15	0.13	0.04	0.10
14	0.02	0.01	0.01	0.01	0.05	0.01	0.00	0.15	0.15	0.13	0.01	0.09
15	0.02	0.01	0.00	0.01	0.05	0.01	0.00	0.11	0.15	0.14	0.01	0.05
16	0.03	0.01	0.00	0.04	0.05	0.00	0.00	0.02	0.15	0.13	0.01	0.02
17	0.04	0.01	0.01	0.15	0.05	0.00	0.00	0.01	0.16	0.13	0.01	0.02
18	0.02	0.01	0.01	0.14	0.05	0.01	0.00	0.01	0.16	0.12	0.01	0.08
19	0.02	0.01	0.01	--	0.04	0.01	0.00	0.10	0.15	0.07	0.01	0.15
20	0.03	0.01	0.01	0.16	0.04	0.10	0.00	0.17	0.15	0.01	0.01	0.17
21	--	0.01	0.01	0.13	0.03	0.07	0.00	0.19	0.10	0.01	0.01	0.18
22	--	0.01	0.01	0.10	0.03	0.02	0.00	0.18	0.12	0.01	0.01	0.17
23	0.34	0.01	0.01	0.08	0.03	0.06	0.00	0.18	0.15	0.04	0.02	0.15
24	0.26	0.01	0.01	0.07	0.03	0.01	0.00	0.19	0.16	0.11	0.02	0.14
25	0.20	0.01	0.01	0.07	0.06	0.07	0.00	0.20	0.16	0.13	0.05	0.14
26	0.15	0.01	0.01	0.07	0.05	0.01	0.00	0.20	0.16	0.13	0.14	0.13
27	0.10	0.01	0.01	0.04	0.03	0.01	0.00	0.18	0.16	0.12	0.28	0.12
28	0.05	0.01	0.01	0.05	0.02	0.01	0.00	0.18	0.16	0.09	0.34	0.11
29	0.02	0.01	0.01	0.05	--	0.02	0.00	0.18	0.17	0.14	0.12	0.12
30	0.01	0.01	0.01	0.05	--	0.02	0.00	0.18	0.17	0.14	0.10	0.12
31	0.01	--	0.01	0.10	--	0.02	--	0.17	--	0.13	0.09	--
Minimum*	0.00	0.00	0.00	0.01	--	0.00	0.00	0.00	0.10	0.01	0.01	0.02
Mean*	0.05	0.01	0.01	0.05	--	0.02	0.01	0.09	0.16	0.13	0.07	0.11
Maximum*	0.34	0.02	0.01	0.16	--	0.01	0.05	0.20	0.18	0.43	0.34	0.18

Table 6. Daily mean outflow at eastern outlet of East Pond at USGS site number 380626121383802 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 1999 to September 2000											
1	0.12	0.00	0.08	--	--	--	--	0.00	0.02	0.01	0.00	0.00
2	0.12	0.00	0.14	--	--	0.36	--	0.00	0.02	0.01	0.00	0.00
3	0.12	0.00	0.13	0.57	--	--	--	0.00	0.02	0.01	0.00	0.00
4	0.11	0.00	0.08	0.41	--	--	--	0.00	0.02	0.01	0.01	0.00
5	0.13	0.00	0.01	0.46	--	--	--	0.00	0.02	0.01	0.01	0.00
6	0.12	0.01	0.01	0.48	--	--	--	0.00	0.01	0.00	0.01	0.00
7	0.11	0.00	0.01	0.48	--	--	--	0.00	0.01	0.00	0.01	0.00
8	0.10	0.00	0.09	--	--	--	--	0.00	0.01	0.00	0.01	0.00
9	0.10	0.00	0.16	--	--	--	--	0.00	0.01	0.01	0.01	0.00
10	0.09	0.04	0.17	--	--	0.08	--	0.00	0.01	0.01	0.01	0.00
11	0.09	0.01	0.13	--	--	0.18	--	0.00	0.01	0.01	0.01	0.00
12	0.08	0.04	0.02	0.45	--	0.31	--	0.00	0.01	0.01	0.01	0.00
13	0.09	0.00	0.02	0.40	--	--	--	0.00	0.00	0.01	0.01	0.00
14	0.09	0.00	0.03	0.39	--	0.30	--	0.00	0.00	0.01	0.01	0.00
15	0.10	0.00	0.14	0.27	--	0.05	--	0.00	0.01	0.01	0.02	0.00
16	0.08	0.00	0.18	0.03	--	--	--	0.00	0.21	0.01	0.47	0.01
17	0.03	0.01	0.19	0.10	--	--	--	0.00	0.01	0.01	0.11	0.11
18	0.01	0.07	0.12	--	--	0.21	--	0.00	0.00	0.02	0.01	0.37
19	0.00	0.07	0.02	--	--	0.01	--	0.00	0.00	0.03	0.01	0.35
20	0.00	0.00	0.02	0.37	--	0.00	--	0.01	0.00	0.02	0.01	0.00
21	0.00	0.00	0.02	0.37	--	0.01	--	0.01	0.00	0.02	0.01	0.00
22	0.00	0.00	0.13	0.33	--	0.15	--	0.01	0.00	0.02	0.01	0.00
23	0.00	0.00	0.18	0.14	--	0.00	0.26	0.01	0.00	0.02	0.01	0.00
24	0.00	0.00	0.20	--	--	0.00	0.01	0.01	0.00	0.02	0.01	0.00
25	0.00	0.02	0.17	--	--	0.31	0.01	0.01	0.01	0.02	0.01	0.01
26	0.00	0.00	0.11	--	--	--	0.00	0.02	0.01	0.01	0.01	0.00
27	0.00	0.03	0.37	--	--	--	0.00	0.02	0.01	0.00	0.01	0.00
28	0.00	0.01	--	--	--	--	0.00	0.02	0.01	0.00	0.01	0.00
29	0.00	0.01	--	--	--	--	0.00	0.01	0.01	0.00	0.01	0.01
30	0.00	0.01	--	--	--	--	0.00	0.02	0.01	0.00	0.01	0.01
31	0.00	--	--	--	--	--	--	0.02	--	0.00	0.00	--
Minimum*	0.00	0.00	0.01	--	--	--	--	0.00	0.00	0.00	0.00	0.00
Mean*	0.05	0.01	0.11	--	--	--	--	0.01	0.02	0.01	0.03	0.03
Maximum*	0.13	0.10	0.37	--	--	--	--	0.02	0.21	0.03	0.47	0.37

Table 6. Daily mean outflow at eastern outlet of East Pond at USGS site number 380626121383802 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
						October 2000 to September 2001						
1	0.00	0.00	0.03	**0.03**	0.00	0.12	0.02	0.02	--	0.11	0.05	0.06
2	0.01	0.00	0.04	**0.03**	0.00	0.19	0.02	0.01	--	0.13	0.10	0.06
3	0.01	**0.00**	0.04	**0.01**	0.00	0.16	0.01	0.01	--	0.22	0.08	0.05
4	0.00	--	0.05	**0.01**	0.00	0.22	0.02	0.01	--	--	0.09	0.03
5	0.00	--	0.00	0.00	0.00	0.26	0.02	0.01	0.04	--	0.07	0.04
6	0.00	--	0.00	0.00	0.00	0.16	0.06	0.02	0.04	--	0.05	0.04
7	0.00	--	0.00	0.00	0.00	0.12	0.05	0.02	0.04	--	0.05	0.05
8	0.00	--	0.01	0.01	0.00	0.11	0.02	0.02	0.03	--	0.04	0.05
9	0.00	--	0.01	0.00	0.00	0.11	0.01	0.02	0.03	0.47	0.04	0.06
10	0.00	--	0.01	0.02	0.00	0.10	0.01	0.02	0.03	--	0.05	0.06
11	0.00	--	0.01	0.01	0.00	0.10	0.01	0.02	0.03	0.10	0.10	0.06
12	0.00	--	0.01	0.00	0.00	0.09	0.02	0.03	0.04	0.07	0.10	--
13	0.00	--	**0.01**	0.00	0.07	0.08	0.02	0.04	0.03	0.07	0.09	--
14	0.00	--	--	0.00	0.12	0.03	0.02	0.03	0.04	0.05	0.10	--
15	0.00	--	--	0.00	0.12	0.02	0.01	0.03	0.06	0.05	0.11	--
16	0.00	--	--	0.00	0.12	0.02	0.01	0.03	0.05	0.05	0.10	0.07
17	0.00	--	--	0.00	0.12	0.02	0.01	0.02	0.07	0.05	0.09	0.12
18	0.00	--	--	0.00	0.14	0.02	0.02	0.02	0.05	0.06	0.04	0.22
19	0.00	--	--	0.00	0.16	0.02	0.02	0.02	0.04	0.06	0.04	0.18
20	0.00	--	--	0.00	0.15	0.02	0.05	0.04	0.06	0.06	0.03	0.09
21	0.00	--	--	0.00	0.18	0.02	0.04	0.04	0.09	0.06	0.03	0.07
22	0.00	--	--	0.00	0.19	0.02	0.02	0.03	0.06	0.06	0.03	0.13
23	0.00	--	--	0.00	0.22	0.05	0.02	0.03	0.05	0.05	0.03	0.23
24	0.00	**0.00**	--	0.00	0.23	--	0.02	0.03	0.05	0.06	0.03	0.24
25	0.00	0.00	--	0.00	0.18	--	0.02	0.02	0.08	0.10	0.03	0.11
26	0.00	0.00	--	0.00	0.15	--	0.02	0.03	0.14	0.07	0.03	0.05
27	0.00	**0.00**	--	0.00	0.13	0.03	0.02	0.03	0.20	0.07	0.03	0.09
28	0.00	0.01	**0.24**	0.00	0.12	0.02	0.02	0.03	0.14	0.08	0.03	0.05
29	0.00	0.03	**0.19**	0.00	--	0.02	0.02	0.03	0.08	0.08	0.05	0.06
30	0.00	0.03	**0.03**	0.00	--	0.01	0.02	0.03	0.10	0.06	0.06	0.10
31	0.00	--	**0.03**	0.00	--	0.02	--	0.03	--	0.04	0.06	--
Minimum*	0.00	--	--	0.00	0.00	0.01	0.01	0.01	0.03	--	0.03	0.03
Mean*	0.00	--	--	0.01	0.09	0.08	0.02	0.02	0.06	--	0.06	0.09
Maximum*	0.01	--	--	0.03	0.23	0.26	0.06	0.04	0.20	--	0.11	0.24

Table 7. Daily mean outflow at western outlet of East Pond at USGS site number 380626121383801 on Twitchell Island, California

[Daily mean values are calculated from hourly readings and are shown in cubic feet per second. Values in bold indicate that one or more hourly readings were not included in the calculated daily mean due to equipment failure; --, missing data; *, statistical measures shown for information only; values may not be comparable due to missing data]

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 1997 to September 1998											
1	--	--	--	0.00	0.00	--	0.22	--	0.06	0.01	0.25	0.35
2	--	--	--	0.00	0.04	--	--	--	0.08	0.01	0.23	0.37
3	--	--	--	0.01	--	--	--	--	0.13	0.01	0.22	0.34
4	--	--	--	0.01	--	--	--	--	0.17	0.01	0.27	0.31
5	--	--	--	0.01	--	--	--	--	0.18	0.01	0.33	0.32
6	--	--	--	0.01	--	--	--	--	0.22	0.01	0.23	0.32
7	--	--	--	0.01	--	--	--	--	0.25	0.01	0.35	0.31
8	--	--	--	0.01	--	--	--	--	0.28	0.02	0.41	0.28
9	--	--	--	0.01	--	--	--	--	--	0.01	0.43	0.32
10	--	--	--	0.01	--	--	--	--	--	0.02	0.45	0.32
11	--	--	--	0.01	--	--	--	--	0.36	0.05	0.41	0.32
12	--	--	--	0.07	--	--	--	--	0.34	0.25	--	0.31
13	--	--	--	--	--	--	--	--	0.27	0.34	--	0.31
14	--	--	--	--	--	--	--	--	0.22	0.35	--	0.30
15	--	--	--	--	--	--	--	--	0.15	0.34	--	0.32
16	--	--	--	--	--	--	--	--	0.15	0.32	--	0.33
17	--	--	--	--	--	0.10	--	--	0.14	0.20	--	0.32
18	--	--	--	--	--	0.09	--	--	0.12	0.26	0.47	0.33
19	--	--	--	--	--	0.09	--	--	0.20	0.26	0.39	0.35
20	--	--	--	--	--	0.07	--	--	0.20	0.26	0.37	0.34
21	--	--	--	--	--	0.06	--	--	0.21	0.25	0.38	0.34
22	--	--	--	--	--	0.05	--	--	0.22	0.30	0.49	0.34
23	--	--	--	--	--	0.04	--	0.29	0.22	0.22	--	0.34
24	--	--	--	--	--	0.04	--	0.15	0.22	0.10	--	0.34
25	--	--	--	--	--	0.14	--	0.05	0.16	0.16	0.36	0.36
26	--	--	--	--	--	--	--	0.00	0.11	0.28	0.34	0.38
27	--	--	--	--	--	--	--	0.00	0.15	0.28	0.38	0.40
28	--	--	--	--	--	--	--	0.00	0.12	0.26	0.38	0.39
29	--	--	--	0.00	--	--	--	0.00	0.08	0.25	0.42	0.36
30	--	--	--	0.00	--	--	--	0.02	0.02	0.24	0.44	0.36
31	--	--	--	0.00	--	0.14	--	0.03	--	0.28	0.35	--
Minimum*	--	--	--	--	--	--	--	--	0.02	0.01	--	0.28
Mean*	--	--	--	--	--	--	--	--	0.18	0.17	--	0.34
Maximum*	--	--	--	--	--	--	--	--	0.36	0.35	--	0.40

Table 7. Daily mean outflow at western outlet of East Pond at USGS site number 380626121383801 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 1998 to September 1999											
1	0.36	0.40	0.39	0.34	0.26	0.28	0.42	0.02	0.06	0.10	0.06	0.07
2	0.37	0.37	0.35	0.34	0.24	0.23	0.43	0.01	0.06	0.10	0.05	0.08
3	0.36	0.36	0.35	0.34	0.25	0.14	0.45	0.01	0.06	0.09	0.01	0.08
4	0.36	0.33	0.25	0.33	0.25	0.24	0.43	0.00	0.07	0.11	0.04	0.08
5	0.36	0.33	0.32	0.29	0.23	0.27	0.43	0.00	0.06	0.11	0.06	0.09
6	0.39	0.33	0.35	0.21	0.32	0.27	0.46	0.00	0.05	0.10	0.07	0.09
7	0.41	0.49	0.32	0.23	--	0.24	0.41	0.00	0.05	0.10	0.05	0.08
8	0.41	0.48	0.33	0.23	--	0.14	0.47	0.00	0.05	0.10	0.00	0.08
9	0.40	0.35	0.30	0.23	--	0.39	0.43	0.00	0.04	0.10	0.00	0.08
10	0.41	0.34	0.31	0.23	--	0.30	0.40	0.00	0.05	0.22	0.00	0.08
11	0.41	0.35	0.31	0.23	0.24	0.32	0.25	0.01	0.04	0.36	0.03	0.08
12	0.42	0.32	0.33	0.22	0.09	0.32	0.05	0.06	0.05	0.18	0.02	0.07
13	0.44	0.31	0.34	0.24	0.03	0.33	0.03	0.07	0.06	0.10	0.02	0.07
14	0.45	0.31	0.34	0.27	0.03	0.34	0.02	0.07	0.06	0.11	0.00	0.06
15	0.46	0.32	0.34	0.31	0.02	0.32	0.11	0.04	0.07	0.11	0.00	0.03
16	0.43	0.32	0.35	0.34	0.03	0.25	0.11	0.00	0.07	0.12	0.00	0.01
17	0.45	0.35	0.36	0.31	0.13	0.29	0.00	0.00	0.07	0.10	0.00	0.01
18	0.49	0.32	0.36	0.39	0.14	0.32	0.00	0.00	0.06	0.11	0.00	0.05
19	0.52	0.30	0.34	0.30	0.13	0.41	0.00	0.03	0.06	0.06	0.00	0.13
20	0.51	0.27	0.33	0.19	0.16	0.43	0.03	0.07	0.06	0.01	0.00	0.14
21	--	0.28	0.31	0.15	0.18	0.46	0.08	0.08	0.04	0.01	0.00	0.14
22	--	0.29	0.34	--	0.08	0.43	0.01	0.07	0.04	0.01	0.00	0.15
23	0.66	0.30	0.33	0.14	0.07	--	0.11	0.07	0.08	0.02	0.00	0.14
24	--	0.34	0.32	0.17	0.19	0.43	0.01	0.08	0.09	0.07	0.00	0.13
25	--	0.32	0.32	0.18	0.31	0.54	0.08	0.08	0.09	0.08	0.01	0.14
26	0.58	0.32	0.32	0.24	0.29	0.42	0.07	0.07	0.09	0.08	0.06	0.13
27	0.56	0.37	0.32	0.20	0.29	0.39	0.06	0.07	0.10	0.07	0.16	0.12
28	0.53	0.40	0.32	0.22	0.29	0.39	0.05	0.06	0.10	0.04	0.21	0.12
29	0.50	0.37	0.32	0.24	--	0.40	0.04	0.07	0.10	0.06	0.08	0.14
30	0.44	0.44	0.33	0.25	--	0.41	0.03	0.07	0.11	0.06	0.08	0.14
31	0.42	--	0.34	0.35	--	0.43	--	0.07	--	0.05	0.07	--
Minimum*	0.36	0.27	0.25	0.14	--	0.14	0.00	0.00	0.04	0.01	0.00	0.01
Mean*	0.45	0.35	0.33	0.26	--	0.34	0.19	0.04	0.07	0.09	0.03	0.09
Maximum*	0.66	0.49	0.39	0.39	--	0.54	0.47	0.08	0.11	0.36	0.21	0.15

Table 7. Daily mean outflow at western outlet of East Pond at USGS site number 380626121383801 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 1999 to September 2000											
1	0.12	0.00	0.07	--	--	--	--	0.01	0.00	0.00	0.00	0.00
2	0.12	0.00	0.12	0.53	0.39	0.25	--	0.01	0.00	0.00	0.00	0.00
3	0.13	0.00	0.12	0.31	--	0.31	--	0.01	0.00	0.00	0.00	0.00
4	0.12	0.00	0.08	0.18	--	--	--	0.01	0.00	0.00	0.01	0.00
5	0.12	0.00	0.01	0.23	--	--	--	0.01	0.00	0.01	0.01	0.00
6	0.12	0.01	0.01	0.25	--	--	--	0.01	0.00	0.01	0.01	0.00
7	0.11	0.00	0.01	0.26	--	--	--	0.01	0.00	0.01	0.01	0.00
8	0.11	0.00	0.08	0.58	--	--	--	0.01	0.00	0.01	0.01	0.00
9	0.13	0.00	0.15	--	--	--	--	0.01	0.00	0.01	0.01	0.00
10	0.13	0.03	0.17	--	--	0.07	--	0.01	0.00	0.01	0.01	0.00
11	0.13	0.08	0.14	--	--	0.14	--	0.00	0.00	0.00	0.01	0.00
12	0.13	0.03	0.02	0.32	--	0.27	--	0.00	0.00	0.01	0.01	0.00
13	0.13	0.00	0.02	0.30	--	--	--	0.00	0.00	0.00	0.01	0.00
14	0.13	0.00	0.03	0.30	--	--	--	0.00	0.00	0.00	0.01	0.00
15	0.12	0.00	0.13	0.21	--	0.19	--	0.00	0.00	0.00	0.01	0.00
16	0.09	0.00	0.18	0.02	--	--	--	0.00	0.10	0.00	0.28	0.03
17	0.03	0.01	0.19	0.04	--	--	--	0.00	0.00	0.00	0.04	0.09
18	0.01	0.07	0.11	--	--	0.12	--	0.00	0.00	0.00	0.01	0.29
19	0.01	0.07	0.02	0.39	--	0.02	--	0.00	0.00	0.00	0.00	0.29
20	0.00	0.00	0.02	0.33	--	0.11	--	0.00	0.00	0.00	0.00	0.18
21	0.00	0.00	0.02	0.32	--	0.24	--	0.00	0.00	0.01	0.00	0.20
22	0.00	0.00	0.10	0.30	--	0.30	--	0.00	0.00	0.02	0.00	0.18
23	0.00	0.00	0.17	0.11	--	0.28	0.30	0.00	0.00	0.03	0.00	0.13
24	0.00	0.00	0.20	--	--	0.28	0.07	0.00	0.00	0.03	0.01	0.12
25	0.00	0.01	0.17	--	--	0.38	0.04	0.00	0.00	0.03	0.01	0.08
26	0.00	0.00	0.04	--	--	--	0.02	0.00	0.00	0.02	0.01	0.04
27	0.00	0.02	0.22	--	--	--	0.02	0.00	0.00	0.01	0.01	0.02
28	0.00	0.01	0.46	--	--	--	0.02	0.00	0.00	0.02	0.00	0.02
29	0.00	0.01	0.63	--	--	--	0.02	0.00	0.00	0.03	0.00	0.06
30	0.00	0.01	--	--	--	--	0.01	0.00	0.00	0.02	0.00	0.09
31	0.00	--	--	--	--	--	--	0.00	--	0.01	0.00	--
Minimum*	0.00	0.00	0.01	--	--	--	--	0.00	0.00	0.00	0.00	0.00
Mean*	0.06	0.01	0.13	--	--	--	--	0.00	0.00	0.01	0.02	0.06
Maximum*	0.13	0.08	0.63	--	--	--	--	0.01	0.10	0.03	0.28	0.29

Table 7. Daily mean outflow at western outlet of East Pond at USGS site number 380626121383801 on Twitchell Island, California—Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	October 2000 to September 2001											
1	0.08	0.36	0.46	**0.13**	0.10	0.00	0.25	0.17	**0.20**	0.271	0.26	0.28
2	0.06	0.37	0.45	**0.12**	0.10	0.00	0.24	0.15	--	0.271	0.27	0.28
3	0.05	0.39	0.44	**0.13**	0.11	0.00	0.24	0.14	--	0.286	0.26	0.27
4	0.04	0.00	0.46	**0.10**	0.11	0.01	0.22	0.16	**0.18**	0.333	0.27	0.25
5	0.03	0.00	0.49	0.09	0.12	0.01	0.18	0.18	0.19	--	0.27	0.27
6	0.02	0.00	0.48	0.10	0.11	0.00	0.25	0.17	0.20	--	0.26	0.28
7	0.01	**0.34**	**0.49**	0.12	0.10	0.00	0.29	0.18	0.23	--	0.27	0.28
8	0.01	0.00	**0.23**	0.19	0.09	0.00	0.29	0.18	0.22	0.483	0.26	0.28
9	0.01	0.00	0.09	0.16	0.13	0.00	0.20	0.17	0.22	0.332	0.26	0.29
10	0.04	**0.36**	0.10	0.18	0.18	0.00	0.18	0.17	0.23	0.343	0.26	0.30
11	0.06	--	0.12	0.17	0.20	0.00	0.19	0.16	0.24	0.279	0.25	0.29
12	0.04	--	0.19	0.10	0.19	0.00	0.20	0.16	0.25	0.284	0.25	--
13	0.01	--	**0.16**	0.07	0.08	0.15	0.20	0.17	0.22	0.281	0.24	--
14	0.01	--	--	0.06	0.00	0.21	0.21	**0.16**	0.22	0.261	0.25	--
15	0.01	--	--	0.05	0.00	0.18	0.21	**0.16**	0.23	0.259	0.27	--
16	0.01	--	--	0.04	0.00	0.16	0.21	**0.17**	0.24	0.254	0.33	0.30
17	0.01	--	--	0.04	0.00	0.16	0.20	**0.17**	0.28	0.263	0.26	0.12
18	0.01	--	--	0.04	0.00	0.16	0.20	**0.14**	0.26	**0.26**	0.26	0.05
19	0.01	--	--	0.05	0.00	0.17	0.20	**0.14**	0.24	0.27	0.28	0.32
20	0.01	--	--	0.05	0.00	0.17	0.25	**0.11**	0.22	0.28	0.27	0.31
21	0.01	--	--	0.05	0.00	0.17	0.27	**0.15**	0.26	0.27	0.25	0.31
22	0.01	--	--	0.08	0.00	0.18	0.23	**0.17**	0.26	0.27	0.25	0.09
23	0.05	--	--	0.11	0.00	0.23	0.22	**0.15**	0.26	0.26	0.25	0.04
24	0.12	**0.33**	--	0.14	0.01	**0.25**	0.22	**0.15**	0.26	0.27	0.26	0.26
25	0.29	0.22	--	0.16	0.00	--	0.21	**0.15**	0.27	0.27	0.25	0.41
26	0.47	0.08	--	0.19	0.00	**0.32**	0.21	**0.17**	0.30	0.27	0.25	0.32
27	0.40	**0.18**	--	0.12	0.00	0.30	0.20	**0.19**	0.31	0.27	0.24	0.24
28	0.42	0.37	**0.00**	0.09	0.00	0.29	0.21	**0.18**	0.30	0.27	0.24	0.31
29	0.42	0.45	**0.23**	0.09	--	0.28	0.20	**0.18**	0.28	0.26	0.25	0.29
30	0.42	0.45	**0.19**	0.08	--	0.27	0.19	**0.18**	0.27	0.23	0.27	0.18
31	0.38	--	**0.15**	0.09	--	0.26	--	0.18	--	0.22	0.28	--
Minimum*	0.01	--	--	0.04	0.00	0.00	0.18	0.11	0.18	0.22	0.24	0.04
Mean*	0.11	--	--	0.10	0.06	0.13	0.22	0.16	0.24	0.28	0.26	0.25
Maximum*	0.47	--	--	0.19	0.20	0.32	0.29	0.19	0.31	0.48	0.33	0.41

Table 8. Water budget for East Pond, October 2000 to September 2001, on Twitchell Island, California

[Seepage is the sum of inflows, outflows, and change in storage. Negative values indicate subsurface discharge into the pond. Values shown in cubic feet per second; *, statistics calculated only on dates when all daily mean values included 24 hourly readings and all measurements were within instrument range; --, no measurement was made on that date]

Date	Inflow	Outflow	Change in storage	Seepage
10/01/00	0.74	-0.13	--	--
10/02/00	0.74	-0.11	-0.09	0.54
10/03/00	0.74	-0.01	0.03	0.68
10/04/00	0.75	-0.08	0.15	0.81
10/05/00	0.75	-0.07	0.06	0.74
10/06/00	0.75	-0.06	-0.06	0.62
10/07/00	0.75	-0.05	0.03	0.72
10/08/00	0.74	-0.05	0.03	0.73
10/09/00	0.74	-0.02	0.00	0.72
10/10/00	0.91	-0.05	0.09	0.96
10/11/00	0.77	-0.07	0.18	0.89
10/12/00	0.74	-0.06	0.09	0.77
10/13/00	0.73	-0.04	0.09	0.78
10/14/00	0.74	-0.05	-0.09	0.60
10/15/00	0.74	-0.04	-0.12	0.58
10/16/00	0.73	-0.04	-0.06	0.64
10/17/00	0.72	-0.04	-0.09	0.59
10/18/00	0.35	-0.04	-0.48	-0.18
10/19/00	0.33	-0.04	-0.06	0.24
10/20/00	0.33	-0.04	0.09	0.38
10/21/00	0.32	-0.07	0.12	0.37
10/22/00	0.31	-0.08	0.57	0.80
10/23/00	0.31	-0.09	0.39	0.62
10/24/00	0.41	-0.15	0.03	0.28
10/25/00	0.55	-0.30	0.24	0.49
10/26/00	0.69	-0.48	0.45	0.67
10/27/00	0.52	-0.42	0.03	0.13
10/28/00	0.63	-0.42	-0.18	0.03
10/29/00	0.52	-0.43	-0.15	-0.06
10/30/00	0.58	-0.43	-0.18	-0.03
10/31/00	0.52	-0.41	0.00	0.11
11/01/00	0.52	-0.38	-0.03	0.11
11/02/00	0.54	-0.39	-0.21	-0.07
11/03/00	0.53	-0.42	0.09	0.21
11/25/00	0.45	-0.22	0.27	0.50

Date	Inflow	Outflow	Change in storage	Seepage
11/26/00	0.43	-0.08	-0.03	0.31
11/27/00	0.36	-0.18	-0.30	-0.12
12/29/00	0.30	-0.42	0.15	0.03
12/30/00	0.29	-0.23	-0.06	0.00
12/31/00	0.30	-0.18	0.03	0.15
01/01/01	0.29	-0.16	-0.03	0.10
01/02/01	0.29	-0.16	-0.03	0.10
01/03/01	0.29	-0.14	0.03	0.17
01/04/01	0.29	-0.12	0.21	0.38
01/05/01	0.30	-0.11	0.00	0.19
01/06/01	0.31	-0.12	0.06	0.25
01/07/01	0.32	-0.13	0.00	0.19
01/08/01	0.43	-0.20	-0.15	0.08
01/09/01	0.32	-0.17	0.00	0.15
01/10/01	0.42	-0.21	-0.03	0.18
01/11/01	0.29	-0.18	-0.18	-0.07
01/12/01	0.24	-0.13	-0.33	-0.21
01/13/01	0.25	-0.09	0.21	0.36
01/14/01	0.23	-0.09	-0.15	-0.00
01/15/01	0.23	-0.09	0.00	0.14
01/16/01	0.23	-0.08	0.12	0.28
01/17/01	0.24	-0.07	0.24	0.42
01/18/01	0.24	-0.06	-0.24	-0.06
01/19/01	0.24	-0.07	-0.09	0.08
01/20/01	0.25	-0.07	0.09	0.27
01/21/01	0.25	-0.07	0.00	0.18
01/22/01	0.26	-0.10	0.03	0.18
01/23/01	0.34	-0.12	0.00	0.22
01/24/01	0.26	-0.17	0.03	0.12
01/25/01	0.38	-0.17	0.00	0.21
01/26/01	0.24	-0.21	0.00	0.03
01/27/01	0.24	-0.15	-0.06	0.03
01/28/01	0.23	-0.11	-0.03	0.09
01/29/01	0.25	-0.11	-0.03	0.10
01/30/01	0.25	-0.11	0.00	0.14

Table 8. Water budget for East Pond, October 2000 to September 2001, on Twitchell Island, California—Continued

Date	Inflow	Outflow	Change in storage	Seepage	Date	Inflow	Outflow	Change in storage	Seepage
01/31/01	0.27	-0.12	-0.03	0.12	03/17/01	0.37	-0.21	-0.09	0.06
02/01/01	0.27	-0.12	0.00	0.15	03/18/01	0.37	-0.21	-0.03	0.13
02/02/01	0.27	-0.12	0.00	0.15	03/19/01	0.37	-0.22	-0.03	0.12
02/07/01	0.27	-0.15	0.00	0.12	03/20/01	0.38	-0.22	-0.03	0.12
02/08/01	0.27	-0.13	0.03	0.17	03/21/01	0.38	-0.22	0.00	0.16
02/09/01	0.35	-0.14	0.18	0.38	03/22/01	0.45	-0.24	0.00	0.21
02/10/01	0.33	-0.20	0.09	0.22	03/23/01	0.53	-0.32	0.00	0.21
02/11/01	0.37	-0.22	0.03	0.18	03/27/01	0.46	-0.38	0.00	0.08
02/12/01	0.34	-0.20	0.00	0.14	03/30/01	0.41	-0.33	-0.03	0.05
02/13/01	0.28	-0.19	-0.03	0.06	03/31/01	0.41	-0.33	0.00	0.08
02/14/01	0.29	-0.16	-0.03	0.10	04/01/01	0.42	-0.32	0.00	0.10
02/15/01	0.29	-0.16	-0.03	0.10	04/02/01	0.42	-0.29	0.00	0.12
02/16/01	0.29	-0.16	0.00	0.13	04/03/01	0.41	-0.29	0.00	0.12
02/17/01	0.31	-0.15	0.00	0.16	04/04/01	0.42	-0.27	0.27	0.42
02/18/01	0.30	-0.18	0.00	0.13	04/10/01	0.35	-0.24	-0.06	0.05
02/19/01	0.33	-0.20	0.03	0.16	04/11/01	0.28	-0.25	0.00	0.03
02/20/01	0.31	-0.18	-0.03	0.10	04/12/01	0.31	-0.25	0.03	0.09
02/21/01	0.35	-0.22	0.03	0.16	04/13/01	0.30	-0.25	-0.03	0.01
02/24/01	0.42	-0.28	0.00	0.15	04/14/01	0.23	-0.26	0.00	-0.03
02/25/01	0.30	-0.23	-0.06	0.00	04/15/01	0.23	-0.27	-0.03	-0.07
02/26/01	0.30	-0.19	-0.03	0.08	04/17/01	0.36	-0.25	0.00	0.10
02/27/01	0.31	-0.19	0.00	0.11	04/18/01	0.38	-0.26	0.00	0.12
02/28/01	0.31	-0.18	-0.03	0.10	04/19/01	0.41	-0.26	0.00	0.15
03/05/01	0.31	-0.28	0.06	0.09	04/20/01	0.52	-0.31	0.00	0.21
03/06/01	0.28	-0.19	-0.03	0.05	04/21/01	0.40	-0.34	0.00	0.05
03/07/01	0.29	-0.15	0.06	0.19	04/22/01	0.40	-0.29	0.00	0.11
03/08/01	0.29	-0.14	0.03	0.18	04/23/01	0.40	-0.28	0.06	0.17
03/09/01	0.29	-0.15	-0.09	0.05	05/01/01	0.33	-0.29	0.00	0.05
03/10/01	0.28	-0.14	-0.03	0.11	05/02/01	0.38	-0.29	0.00	0.09
03/11/01	0.28	-0.12	-0.03	0.13	05/09/01	0.50	-0.28	0.00	0.21
03/12/01	0.28	-0.13	-0.03	0.12	05/10/01	0.53	-0.28	-0.03	0.22
03/13/01	0.33	-0.27	-0.03	0.03	05/11/01	0.50	-0.28	-0.09	0.13
03/14/01	0.36	-0.27	0.00	0.09	05/12/01	0.47	-0.27	0.00	0.21
03/15/01	0.36	-0.22	0.00	0.14	05/13/01	0.46	-0.28	0.00	0.18
03/16/01	0.36	-0.22	-0.03	0.11	05/14/01	0.49	-0.29	0.00	0.20

Table 8. Water budget for East Pond, October 2000 to September 2001, on Twitchell Island, California—Continued

Date	Inflow	Outflow	Change in storage	Seepage
06/08/01	0.48	-0.33	-0.06	0.08
06/09/01	0.48	-0.33	0.06	0.21
06/10/01	0.47	-0.33	0.06	0.20
06/11/01	0.48	-0.34	-0.03	0.11
06/12/01	0.48	-0.36	0.03	0.15
06/13/01	0.46	-0.33	0.36	0.49
06/14/01	0.46	-0.33	0.00	0.13
06/15/01	0.47	-0.37	-0.15	-0.05
06/16/01	0.50	-0.36	-0.24	-0.10
06/17/01	0.59	-0.43	0.06	0.22
06/18/01	0.50	-0.40	0.00	0.10
06/19/01	0.48	-0.36	0.00	0.12
06/20/01	0.48	-0.36	0.09	0.21
06/21/01	0.53	-0.43	-0.09	0.01
06/22/01	0.53	-0.41	0.12	0.24
06/23/01	0.53	-0.39	-0.03	0.11
06/24/01	0.52	-0.39	0.18	0.31
06/25/01	0.55	-0.40	-0.27	-0.13
06/26/01	0.52	-0.49	0.06	0.08
06/27/01	0.53	-0.53	-0.12	-0.12
06/28/01	0.52	-0.51	0.12	0.13
06/29/01	0.52	-0.44	-0.03	0.05
06/30/01	0.52	-0.46	0.03	0.01
07/01/01	0.54	-0.46	0.12	0.19
08/01/01	0.49	-0.38	0.03	0.14
08/10/01	0.48	-0.38	0.33	0.43
08/11/01	0.47	-0.42	0.21	0.27
08/12/01	0.47	-0.41	-0.09	-0.03
08/13/01	0.44	-0.39	-0.27	-0.22
08/24/01	0.42	-0.35	0.09	0.16
09/03/01	0.64	-0.38	-0.09	0.17
Minimum*	0.23	-0.53	-0.33	-0.21
Mean*	0.47	-0.21	0.01	0.26
Median*	0.47	-0.17	0.03	0.18
Maximum*	0.91	-0.04	0.36	0.96