TESTIMONY OF DR. RUSS T. BROWN
Jones & Stokes Associates

Bay-Delta Workshop
May 17, 1994

MODELS FOR ASSESSING EFFECTS OF DELTA STANDARDS AND OPERATIONS

This testimony addresses item no. 3 in the notice for the second workshop to review standards for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary: methods available to analyze water supply and environmental effects of draft standards. Jones & Stokes Associates has recently developed two Delta simulation models that address the workshop topic:

- DeltaSOS, a monthly Delta operations model that simulates Delta water management in the context of specified standards and operations criteria, and
- DailySOS, a similar Delta operations model that simulates Delta water management in compliance with standards specified on a daily basis.

DeltaSOS simulations complement and extend monthly simulations produced by the systemwide planning models, DWRSIM and PROSIM, by providing more complete descriptions of Delta conditions. DailySOS provides simulations of daily hydrologic conditions that are more appropriate to evaluate solutions to Delta fisheries problems.

Jones & Stokes Associates is serving as the consultant to the California State Water Resources Control Board and U.S. Army Corps of Engineers in preparing an environmental impact report/environmental impact statement (EIR/EIS) on a proposed in-Delta water supply facility. To support that EIR/EIS, Jones & Stokes Associates recently developed the two Delta water management planning models. We believe that these analytical tools offer some important advantages for developing Delta water and fisheries management strategies and evaluating Delta environmental effects. These tools were not available during the previous hearings and workshops on proposed D-1630 standards.

DeltaSOS: Delta Standards and Operations Simulation Model

DeltaSOS is built on the following general concepts:

- Each Delta standard of interest can be specified as a monthly equivalent flow for each month of each type of water year.

- An initial monthly Delta water budget can be specified based on historical or simulated (DWRSIM or PROSIM) conditions for the 1922-1991 hydrologic record.

- Incremental changes in Delta operations that are required to meet each specified Delta standard can be estimated.

The DeltaSOS monthly model provides a general analytical tool for evaluating a wide range of possible future Delta standards, operations, facilities, and management options. A complete description of the model has been prepared and is submitted as part of Jones & Stokes Associates' workshop testimony. Copies of the Lotus 1-2-3 spreadsheet model and associated monthly inputs and alternative Delta standards are available from Jones & Stokes Associates.

Basic Features

DeltaSOS provides the following capabilities that are useful for many types of Delta water resource analysis tasks:

- All monthly inputs, coefficients, calculations, assumed Delta standards, and results are directly accessible to the user.

- User-specified Delta standards (e.g., proposed U.S. Environmental Protection Agency [EPA] outflow standards) can be changed easily and rapidly to examine different regulatory scenarios.

- Simulated flows in major Delta channels and diversions are calculated based on hydraulic relationships estimated by Delta hydrodynamic models.

- The model can represent all existing Delta facilities and many possible future Delta facilities (e.g., Georgiana Slough and Old River gates, full State Water Project [SWP] pumping capacity, in-Delta storage reservoirs, and diversions to an isolated transfer facility).

- The model produces complete graphical displays and statistical summaries of simulation results that can be modified as needed.

Potential Applications

DeltaSOS can be used for many practical applications for Delta water resource planning and management. Possible applications (sometimes in conjunction with other models) might include:

- confirming and decomposing results from systemwide planning models (DWRSIM and PROSIM),

- interactively and quickly simulating a wide variety of possible Delta standards for the entire range of hydrological conditions,

- simulating proposed changes in standards or facilities in incremental steps to perform sensitivity analyses of their benefits and impacts (e.g., to provide enhanced fish protection and production),

- estimating likely transport and entrainment of selected fish life stages in response to changes in Delta operations and standards (in conjunction with a Delta fish transport model),

- investigating effects of proposed new facilities on existing Delta operations and on compliance with Delta standards and fish protection measures, and

- identifying possibilities for additional water for export (e.g., possible water transfers) in context of new standards and operations criteria.

Comparison with DWRSIM and PROSIM Models

DeltaSOS does not replace the systemwide planning models, DWRSIM and PROSIM, but rather complements their results by providing a more complete description of Delta hydrologic conditions. DeltaSOS can be used as a screening tool to evaluate a wide range of possible Delta operations prior to systemwide simulations. DeltaSOS can also be used to confirm and decompose systemwide simulation results for Delta conditions (postprocessing).

DeltaSOS does not simulate upstream reservoir operations, nor does it consider south-of-Delta demands and storage capacity. These systemwide constraints must be analyzed with DWRSIM or PROSIM.

DeltaSOS does not simulate Delta salinity and does not replace Delta hydrodynamic and salt transport models such as the Fischer Delta Model, Resources Management Associates (RMA) Delta model, or Department of Water Resources Delta Simulation Model (DWRDSM). Delta channel flows calculated in DeltaSOS are based on hydraulic relationships derived from RMA Delta hydrodynamic model simulations, which are similar to results from other hydrodynamic model simulations.

DailySOS: Daily Standards and Operations Simulation Model

Jones & Stokes Associates recently developed the DailySOS model to evaluate possible effects of daily operations of a proposed in-Delta water storage facility. By simulating Delta flows and operations on a daily time step, DailySOS more accurately depicts potential effects of Delta standards and facilities on Delta channel flows and operations.

Basic Features

DailySOS includes the basic features and capabilities of DeltaSOS but allows the effects of daily fluctuations in Delta hydrology and operations to be more accurately simulated. Additional features of DailySOS include:

- The input data for DailySOS are obtained from files of daily historical Delta inflows and exports for 1967-1992 from the California Department of Water Resources' DAYFLOW database (i.e., 26 years of daily Delta simulation).

- Gate closures (e.g., Delta Cross Channel [DCC] or Old River) and diversion calculations use daily flows, yielding more accurate results than calculations from monthly average flows.

- Calculations of water available for Delta export in context of satisfying specified monthly pumping capacity, QWEST minimum flows, and required Delta outflows are calculated with daily flows, yielding more accurate results than calculations from monthly average flows.

- Graphical display and statistical summaries of the daily results for 1 year or monthly results for a sequence of years can be easily viewed and printed.

Potential Applications

DailySOS can perform many of the applications suggested above for DeltaSOS. In addition, DailySOS can properly perform applications that could not be properly done with a monthly planning model, including the following:

- DailySOS can be used to simulate a selected study year or sequence of years to evaluate the effects of different standards or facilities on daily Delta operations.

- DailySOS can simulate daily flows in the context of Delta outflow standards that require a specified number of days of minimum outflow within a control period (e.g., proposed EPA estuarine habitat standards), yielding more accurate estimates of water required to satisfy the standards than monthly average calculations.

- DailySOS can be used to check Delta channel flow estimates against U.S. Geological Survey measurements of net Delta channel flows from acoustic velocity measurement stations now installed at several key Delta channel locations.

- Effects of Delta channel flows on Delta salinity conditions (including salinity gradient locations) can be more reliably estimated with simulations of daily flows.

- DailySOS can simulate and evaluate effects of "moving-average" standards on Delta operations and compliance monitoring.

- Possible effects of endangered species "take limits" on Delta operations can be simulated with daily flows and assumed daily patterns of species abundance, as estimated from daily salvage records or other fish sampling efforts.

DailySOS Results for Historical 1978 Conditions

Graphical results from DailySOS simulations of 1978 conditions illustrate potential applications of the DailySOS model for Delta operations and environmental management.

Figure 1 shows daily values for historical Sacramento River inflow and DailySOS simulations of DCC and Georgiana Slough diversions for 1978. The DCC was simulated to be closed under the specified 25,000-cubic-feet-per-second (cfs) Sacramento River flow control standard from January through April of 1978, but actual DCC gate operation is often more variable. Daily exports simulated by DailySOS are shown for comparison.

Figure 2 shows daily values for historical San Joaquin River inflow, DailySOS simulations of adjustments to meet the specified 900-cfs San Joaquin River flow standard and Old River diversions for 1978. The simulated gate at the head of Old River would be closed in September-November and in April-May, except when San Joaquin inflow is greater than the specified 8,000-cfs flood limit for the gate structure. The simulated gate remained open throughout April and May of 1978 because the specified flood limit was exceeded.

Figure 2 shows that the hydraulic simulation of Old River diversion of San Joaquin River flow is approximately 60% at high flows but increases to approximately 100% at low San Joaquin River flows (based on the relationship from RMA hydrodynamic model simulations). Daily exports simulated by DailySOS are shown for comparison. The portion of Delta exports that would have been supplied by diversions through Old River can be easily identified.

Figure 3 shows DailySOS simulations of daily QWEST flows for 1978. QWEST calculations with historical exports (with simulated DCC operation) were slightly less than the specified QWEST standards on some days in December-February, requiring reductions in export by DailySOS. The DailySOS simulation indicates that for most of the year, simulated exports were greater than historical exports, causing simulated QWEST flows to be lower than historical QWEST. The DailySOS-calculated exports are shown for comparison.

Figure 4 shows daily values for historical exports and DailySOS simulations of required export adjustments and maximum possible exports (without consideration of south-of-Delta demands and storage capacity) for 1978. Major reductions in historical daily exports were required in June and July to satisfy the specified outflow standards for an above-normal year-type. Increases in historical daily exports were simulated during January-May and September. The historical annual SWP and Central Valley Project exports in 1978

were 4,332 thousand acre-feet (TAF), while DailySOS simulations of maximum possible exports were 5,359 TAF.

Figure 5 shows daily values for minimum Delta outflow requirements, DailySOS simulation of Delta outflow, reductions in export to satisfy outflow requirements, and remaining outflow deficits for 1978. Delta inflow was not sufficient in October and November to meet the specified minimum outflow, even with exports reduced to the specified minimum pumping of 1,500 cfs.

DailySOS Results for 1967-1992

DailySOS can be used to simulate a sequence of years, and the results can be summarized as monthly average channel flows and exports. Monthly averages of DailySOS results for historical 1967-1992 daily inflows with D-1485 standards plus National Marine Fisheries Service (NMFS) winter-run requirements provide an example of a multiple-year DailySOS simulation of daily flows.

Figure 6 shows monthly average values for historical exports for 1967-1992 and the DailySOS simulation of maximum possible Delta exports, assuming the specified standards were met. Maximum possible monthly exports simulated by DailySOS were quite similar to historical monthly exports during the 1987-1992 period. Historical export pumping was much less than the maximum possible exports simulated by DailySOS during the 1967-1986 period.

Figure 6 also shows the DailySOS adjustments to historical exports that were required to satisfy the specified outflow standards and QWEST standards. Some adjustments were required in most years because these currently specified standards were not applicable during historical Delta operations.

Figure 7 shows monthly average values for DailySOS simulations of 1967-1992 outflow and the specified minimum Delta outflow requirement. The monthly average export reductions simulated by DailySOS to satisfy the minimum required outflow and remaining outflow deficits (for 1,500-cfs minimum pumping) are also shown.

Comparison of DailySOS with DeltaSOS Model

DailySOS simulates the same Delta channel flows as DeltaSOS but provides a more accurate simulation of Delta conditions because the effects of daily hydrological variations are properly represented.

More Accurate Simulation of Fish Protection Measures. The effects of fish protection measures in the Delta depend on the combination of net and tidal channel flows, facility operations, salinity gradient location, fish species distribution and abundance, and the transport and entrainment of various fish life stages. Fish habitat and population variables cannot be properly analyzed with monthly average models. DailySOS can simulate

daily hydrologic conditions that are appropriate to evaluate solutions to Delta fisheries problems.

More Accurate Simulation of Water Supply Operations. Differences between DeltaSOS and DailySOS can be illustrated by considering both models' simulations of maximum possible exports using historical 1967-1991 inflows with D-1485 standards and NMFS winter-run requirements. Figure 8 shows annual values of maximum possible exports derived from monthly average flows simulated by DeltaSOS and from daily flows simulated by DailySOS. The results indicate that monthly simulations of Delta exports will overestimate possible Delta exports relative to daily simulations because of the effects of hydrological variations on water supply operations.

Differences in possible exports between daily and monthly simulations can be understood with a couple of examples. Additional allowable SWP pumping capacity in December-March is simulated as a function of San Joaquin River flow. A high monthly average inflow would allow the SWP pumps to export at capacity for the entire month with monthly calculations, but actual daily calculations might show that the full SWP pumping capacity could only be used for 10 days during the month. The monthly model would therefore overestimate allowable export pumping.

A second example pertains to operations of the DCC gates. The DCC gates might be simulated to remain open in a monthly model at an average Sacramento River inflow of 20,000 cfs so that the calculated DCC and Georgiana Slough diversions and QWEST flows might allow full export pumping. A daily model might more accurately simulate, however, that DCC gates would have been closed during the storm event that caused the 20,000-cfs average flow so that the Georgiana Slough diversion and QWEST flows would be much less during the highest flows, with a possible reduction in simulated export pumping.

Potential Improvements in DeltaSOS and DailySOS Models

Jones & Stokes Associates recommends that both DeltaSOS and DailySOS models be used extensively by all interested parties to better describe and understand the Delta and more accurately simulate the effects of Delta standards and operations on Delta environmental conditions.

Jones & Stokes Associates anticipates that as more parties apply these models, possible changes and improvements in the models will be suggested. We would like to initiate this development process by identifying several possible improvements in DeltaSOS and DailySOS that might be pursued:

- incorporate capabilities to specify conditional Delta standards whereby values of flow standards depend on inflow conditions;

- incorporate salinity calculations for important Delta locations having salinity standards so that such standards could be specified and simulated directly (e.g., to allow "carriage water" effects to be simulated more accurately);

- incorporate water transport calculations as input to evaluate potential fish transport effects;

- incorporate spring-neap tidal effects for more accurate estimates of net Delta outflow and provide estimates of tidal flows in major Delta channels; and

- incorporate Delta water budget terms for agricultural diversions and drainage flows to more accurately simulate diversion flows and potential water quality effects.

Jones & Stokes Associates will present additional information at the June Bay-Delta workshop regarding use of available daily data to better understand historical Delta environmental conditions, formulate potential conditional standards for fish protection, and develop flexible environmental management strategies for Delta water management operations.

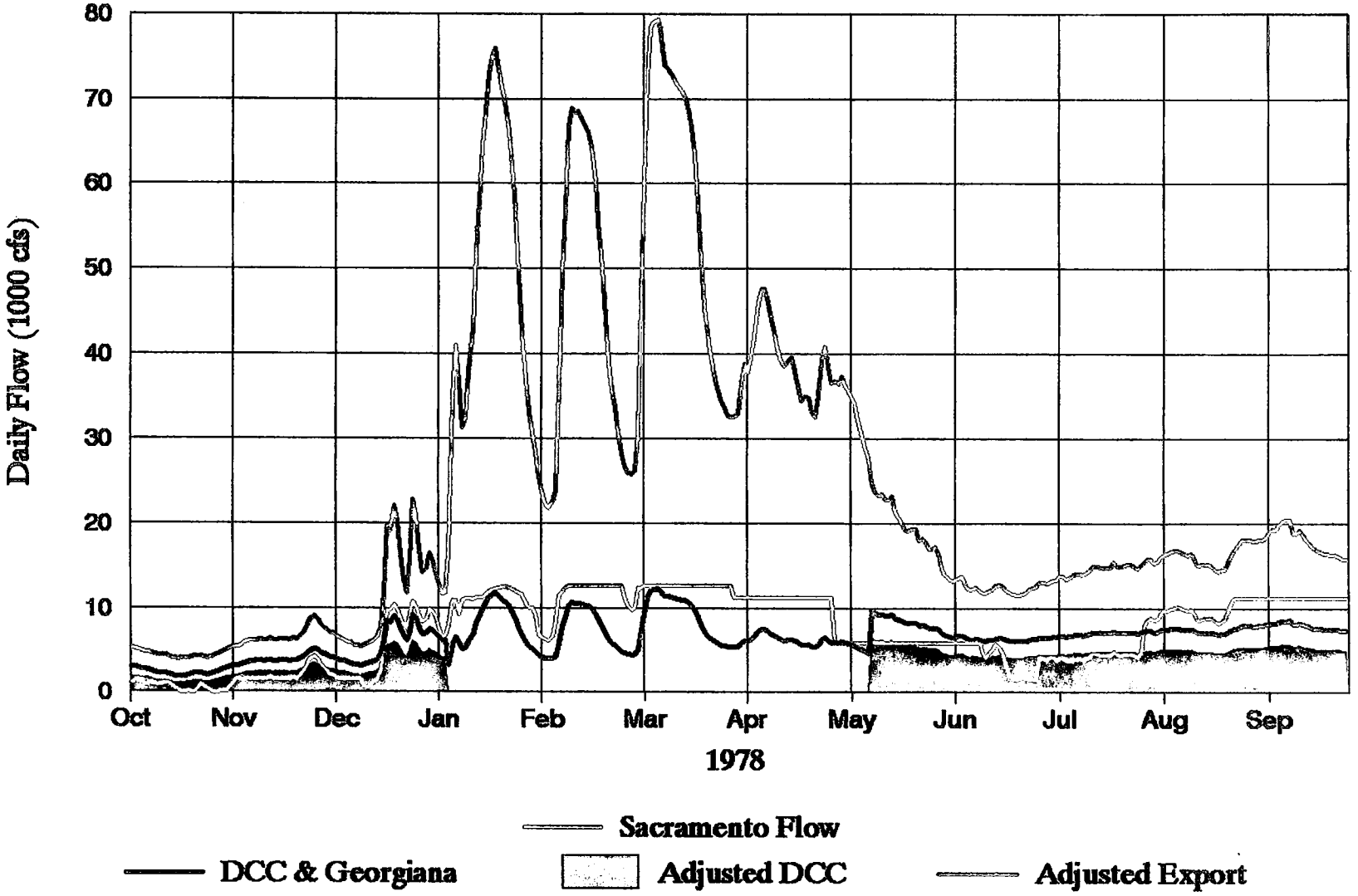

Figure 1. Historical Daily Sacramento River and DailySOS Calculated DCC and Georgiana Slough Diversions and Adjusted Exports for 1978

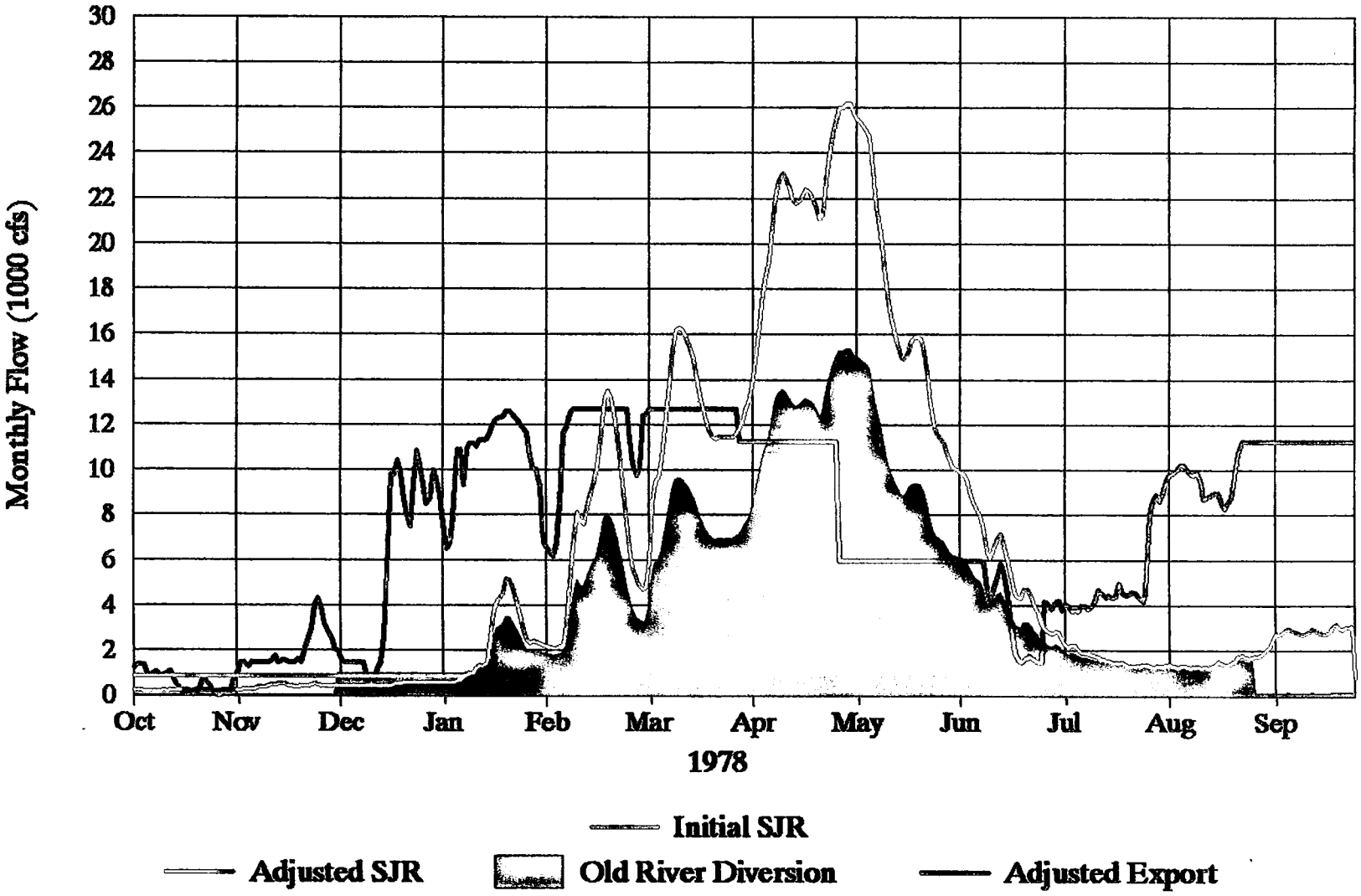

Figure 2. Historical Daily San Joaquin River and DailySOS Calculated Adjusted San Joaquin Flows, Old River Diversions, and Adjusted Exports for 1978

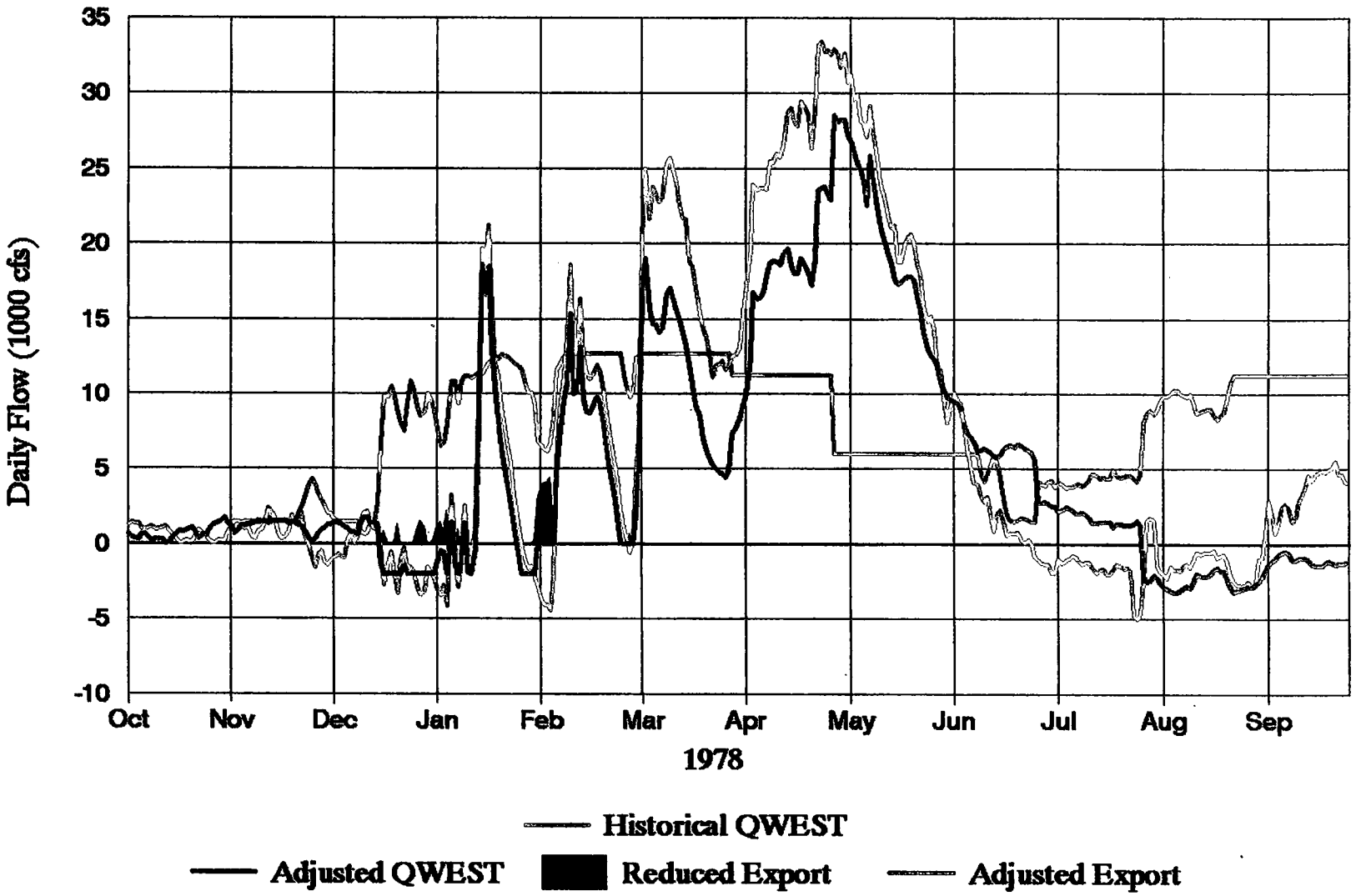

Figure 3. Historical Daily QWEST and DailySOS Calculated QWEST and Export Reductions to Satisfy QWEST Standards for 1978

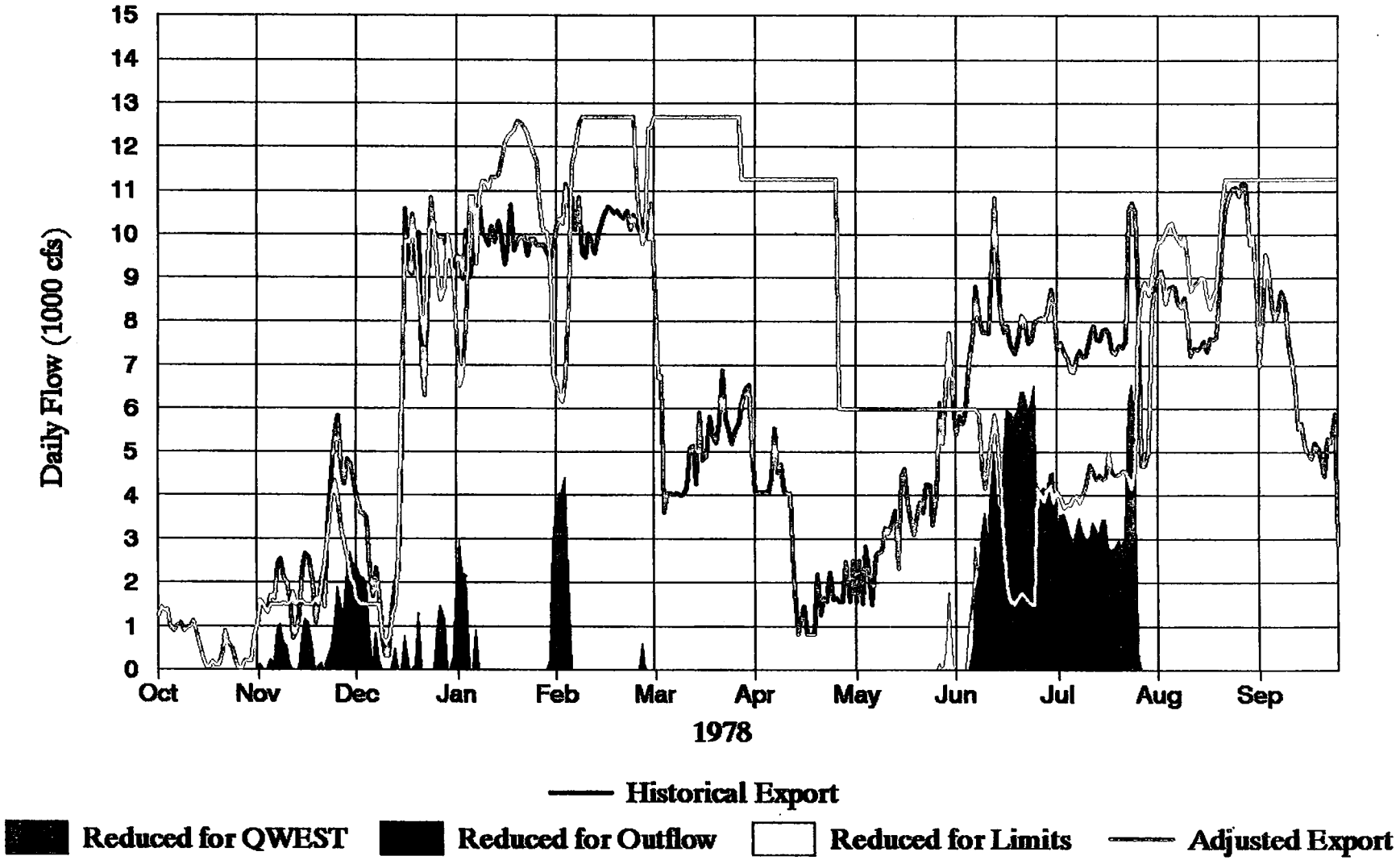

Figure 4. Historical Daily Exports and DailySOS Calculated Export Reduction and Adjusted Exports for 1978

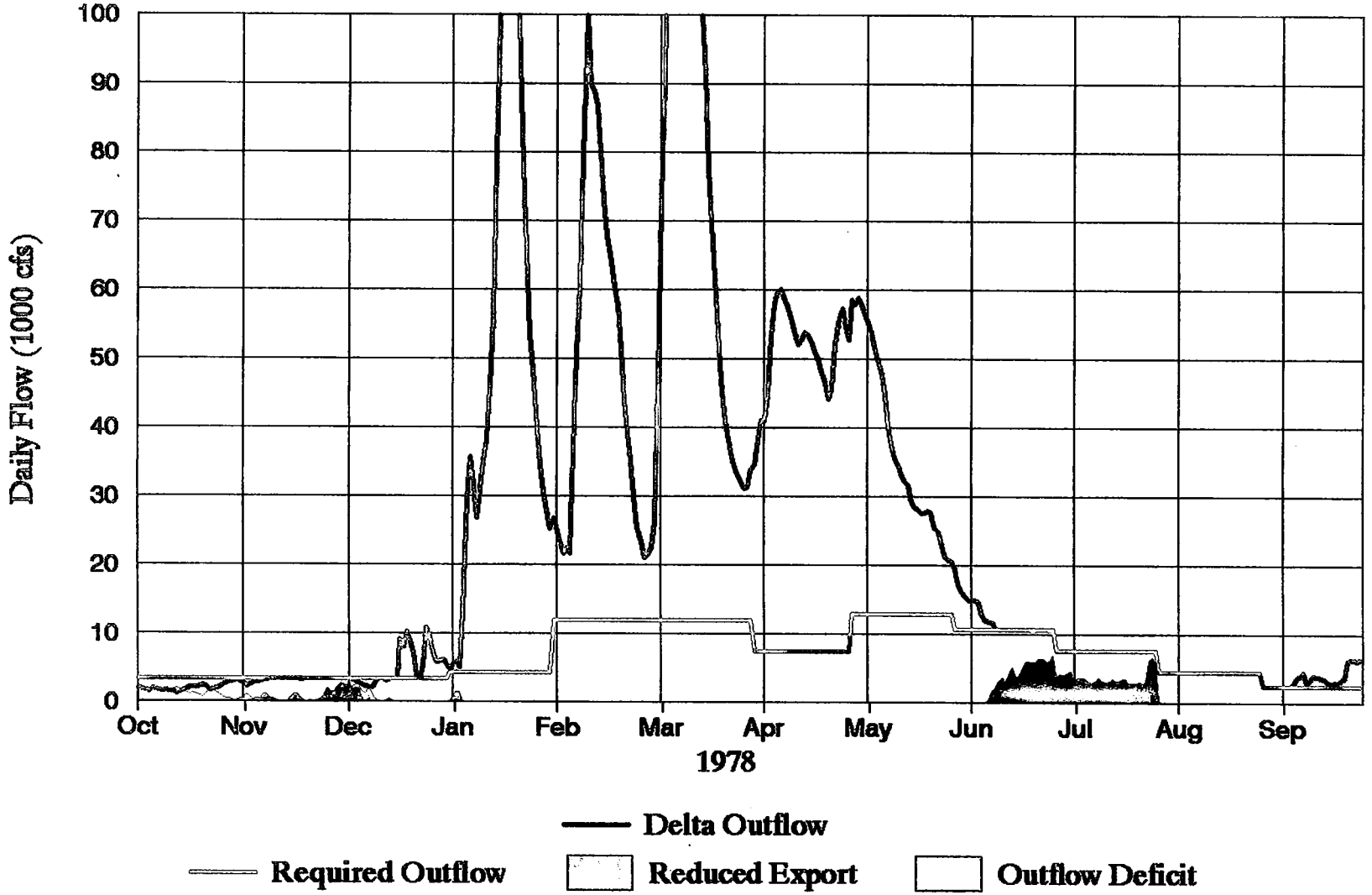

Figure 5. DailySOS Calculated Daily Delta Outflow, Required Outflow, and Export Reductions to Satisfy Outflow Standards and Remaining Outflow Deficit for 1978

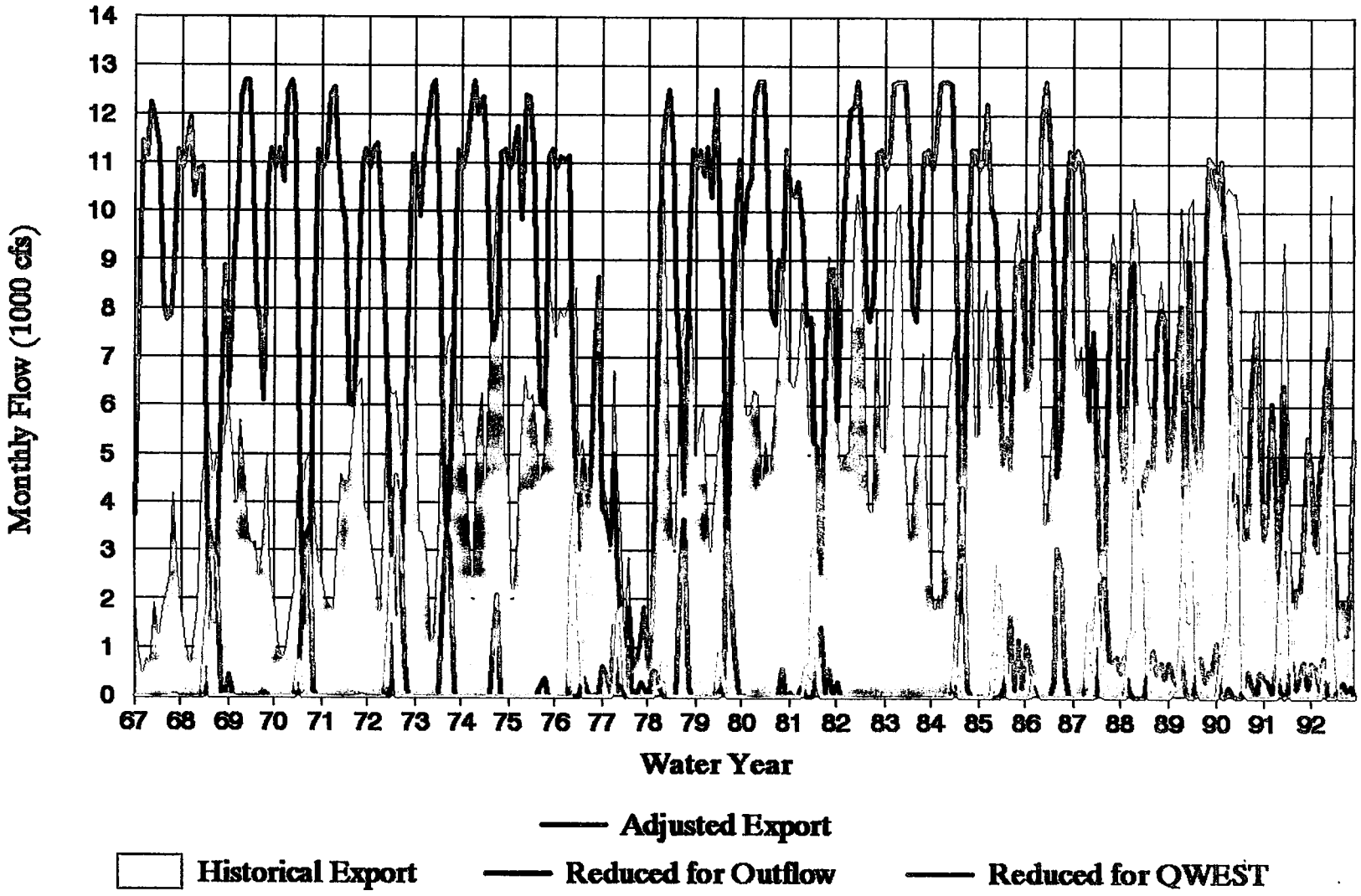

Figure 6. DailySOS Calculated Monthly Maximum Possible Delta Exports for 1967-1991 Historical Inflows with D-1485 and NMFS Delta Standards

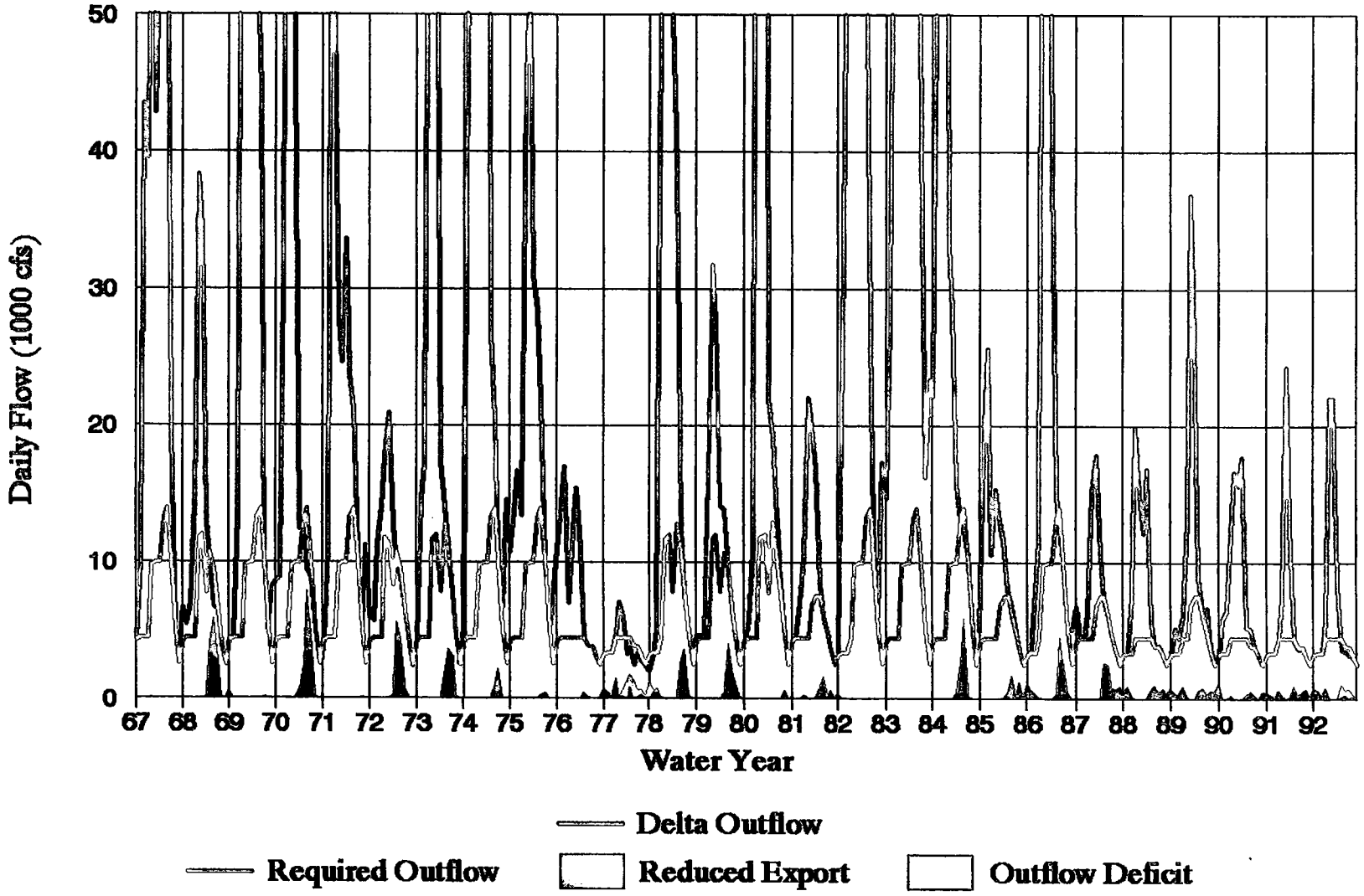

Figure 7. DailySOS Calculated Monthly Delta Outflow and Outflow Deficits for 1967-1991 Historical Inflows with D-1485 and NMFS Delta Standards

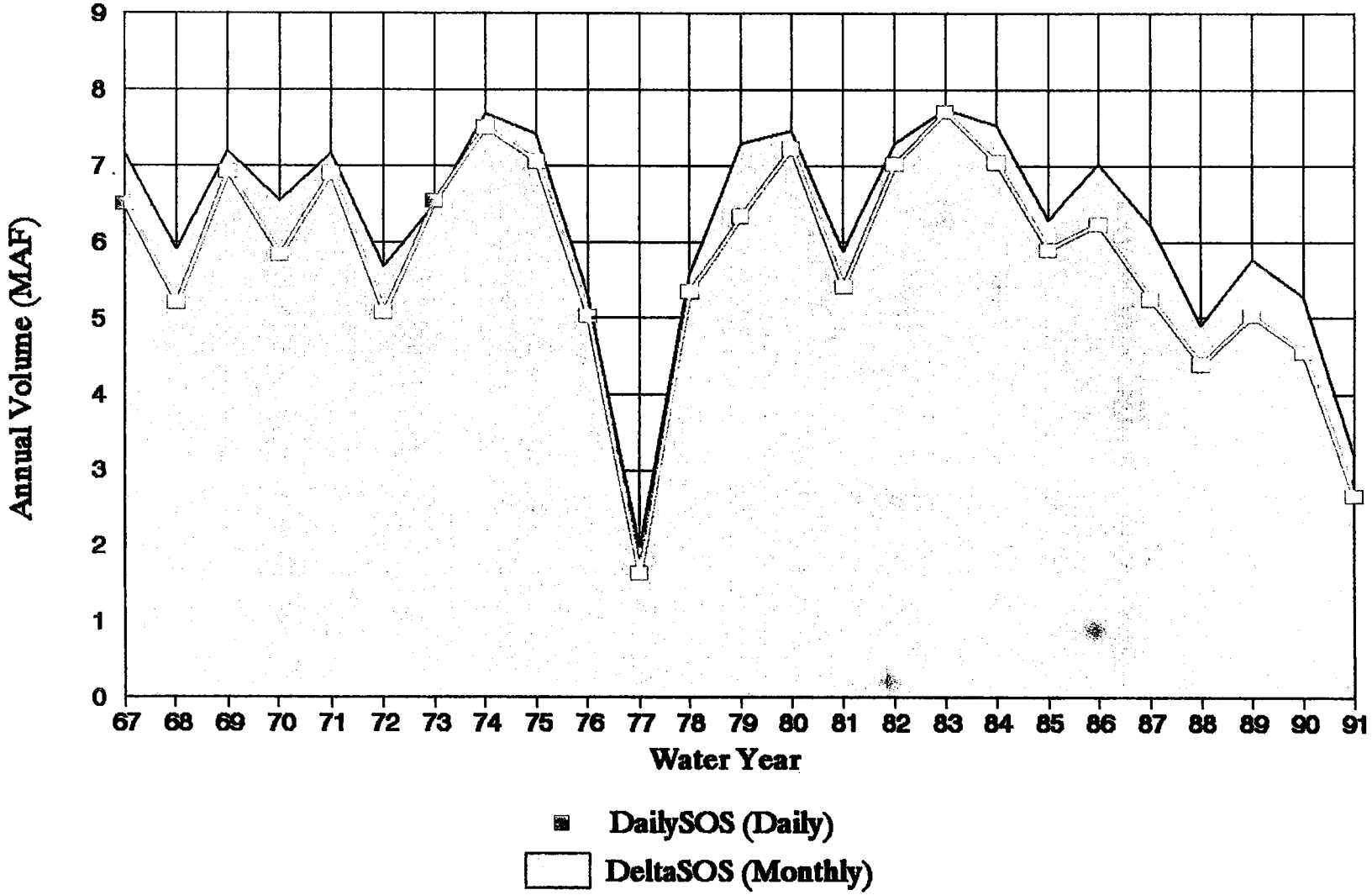

Figure 8. Comparison of DeltaSOS (Monthly Calculations) and DailySOS (Daily Calculations) Estimates of Annual Maximum Possible Delta Exports for 1967-1991 Historical Inflow with D-1485 and NMFS Delta Standards