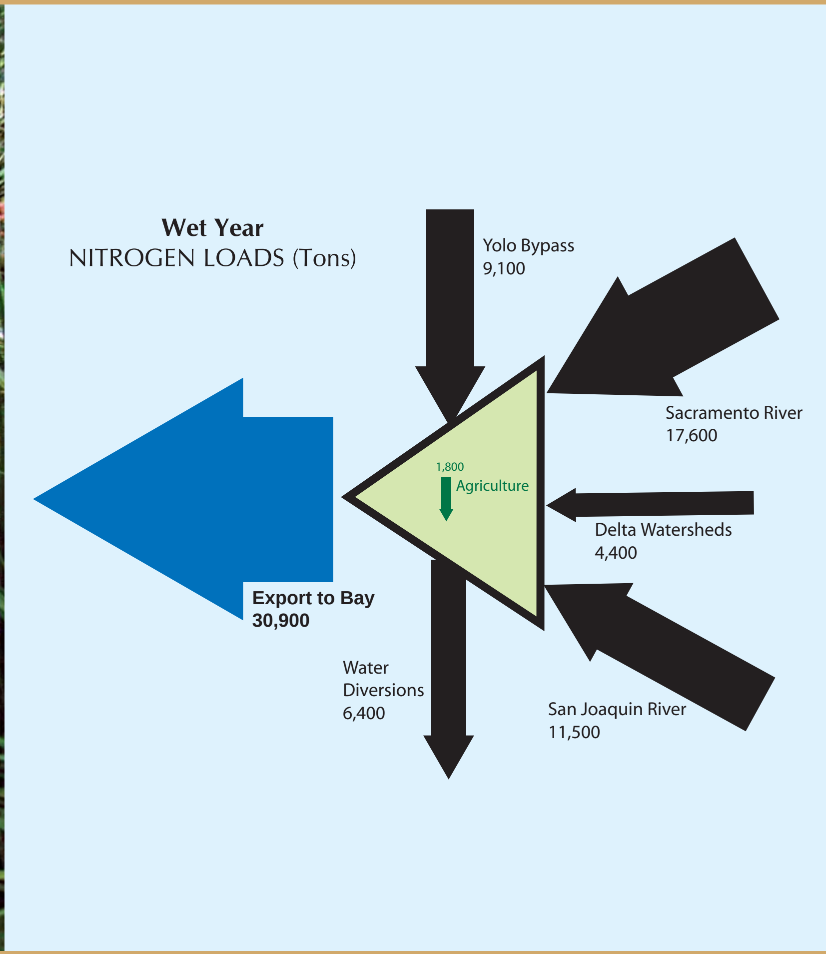
Conceptual Model For

Nutrients in the Central Valley and Sacramento – San Joaquin Delta

Final Report

September 20, 2006



Prepared for:

US Environmental Protection Agency, Region IX

Central Valley Drinking Water Policy Workgroup

Prepared by:

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Prepared by

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LIST OF ACRONYMS & ABBREVIATIONS

CDF FRAP	California Department of Forestry and Fire Protection Fire and Resource Assessment Program
CVDWPWG	Central Valley Drinking Water Policy Workgroup
cfs	Cubic feet per second
DFG	Department of Fish and Game
DICU	Delta Island Consumptive Use
DIN	Dissolved inorganic nitrogen
DO	Dissolved oxygen
DON	Dissolved organic nitrogen
DOP	Dissolved organic phosphorus
DSM	Delta Simulation Model
DWR	Department of Water Resources
gal/year	Gallons per year
GIS	Geographical Information Systems
kg/person/yr	Kilograms per person per year
μg/l	Micrograms per liter
mg/l	Milligrams per liter
MGD	Million gallons per day
MIB	2-Methylisoborneol
MWQI	Municipal Water Quality Investigations
NEMDC	Natomas East Main Drainage Canal
NO3+NO2-N	Nitrate plus nitrite expressed as nitrogen
NO3-N	Nitrate expressed as nitrogen
NWIS	National Water Information System
PN	Particulate nitrogen
PON	Particulate organic nitrogen
TKN	Total Kjeldahl nitrogen
TN	Total nitrogen
TP	Total phosphorus
USGS	United States Geological Survey
WY	Water year

EXECUTIVE SUMMARY

This report presents a conceptual model of nutrients for the Central Valley and the Sacramento-San Joaquin Delta. The conceptual model was based on previously collected data from a variety of sources and can be used to direct future investigations to improve understanding of nutrients sources, transport, and impacts.

Although nutrients are not directly toxic (with the exception of nitrate and nitrite), nutrient levels in water bodies are important for drinking water supply for several reasons. The presence of nutrients in aquatic systems promotes primary productivity through algal and macrophyte growth which adds to the levels of dissolved and total organic carbon in water. Organic carbon in source waters is a constituent of drinking water concern, primarily due to the formation of carcinogenic byproducts during disinfection at water treatment facilities (discussed in greater detail in the organic carbon conceptual model report, prepared as part of this larger study; Tetra Tech, 2006).

In addition to being a source of organic carbon, some species of algae are associated with compounds, such as geosmin and 2-methylisoborneol (MIB) that produce objectionable odors and tastes. Species of cyanobacteria (blue-green algae), such as Microcystis, produce toxins that may be harmful to humans. Recent algal blooms in the Delta have produced measurable levels of microcystin, a common toxin produced by cyanobacteria. There are not currently any drinking water standards for these algae, but cyanobacteria, other freshwater algae, and their toxins are on EPA's Drinking Water Contaminant Candidate List (CCL) for consideration of regulation adoption. The presence of algae in source waters may also decrease filtration efficiency. Finally, the presence of nitrate and nitrite, components of total nitrogen, can exceed current drinking water standards (10 mg/l nitrate as nitrogen and 1 mg/l nitrite as nitrogen) in some of the waste streams that are discharged to surface waters.

From the standpoint of quality of drinking water supplies, low nutrient levels are desirable. However, when other beneficial uses of water bodies are considered, specifically those that relate to ecosystem health, the role of nutrients is more complex. A certain level of nutrients is necessary for biological production and is therefore vital for ecosystem functioning. Excessive nutrients, however, can cause too much production and lead to other adverse impacts. There are no applicable water quality standards for nutrients in general, and appropriate nutrient levels for maintaining a variety of beneficial uses will vary by location and water body characteristics.

Nutrient concentrations across the Central Valley were estimated by averaging time series data at many sampling locations and are represented schematically in Figure ES-1 for nitrogen and ES-2 for phosphorus. The data show substantially higher concentrations in the San Joaquin River basin compared with the Sacramento River basin. Across seasons, the San Joaquin River did not exhibit large variability for either total nitrogen or total phosphorus. The Sacramento River exhibited higher total nitrogen concentrations in the wet months, and total phosphorus concentrations did not show significant inter-seasonal trends. Overall, nutrient concentrations in the San Joaquin Rivers and the Delta are high, and both could be classified as eutrophic waters. The San Joaquin River exhibits many classic symptoms of eutrophication such as low dissolved oxygen levels in deeper waters that adversely affects many beneficial uses. Given the abundance of nutrients, primary productivity in the Delta is fairly low suggesting that factors other than nutrients are limiting, specifically light limitation caused by suspended solids. However, when waters from the Delta are pumped out in aqueducts for transport, or stored in reservoirs along the way, other limiting factors may disappear and high levels of algal growth may result.

In general, average nutrient concentrations at the Banks Pumping Plant, one of the largest diversions from the Delta, lie between average concentrations in the Sacramento and San Joaquin Rivers, except for ammonia-N and total Kjeldahl nitrogen (TKN), where average concentrations at Banks are lower than both Sacramento and San Joaquin River average concentrations. Figure ES-1 and ES-2 illustrate that average total nitrogen (TN) and total phosphorus (TP) concentrations from all water diversions lie between average concentrations in the Sacramento and San Joaquin Rivers.

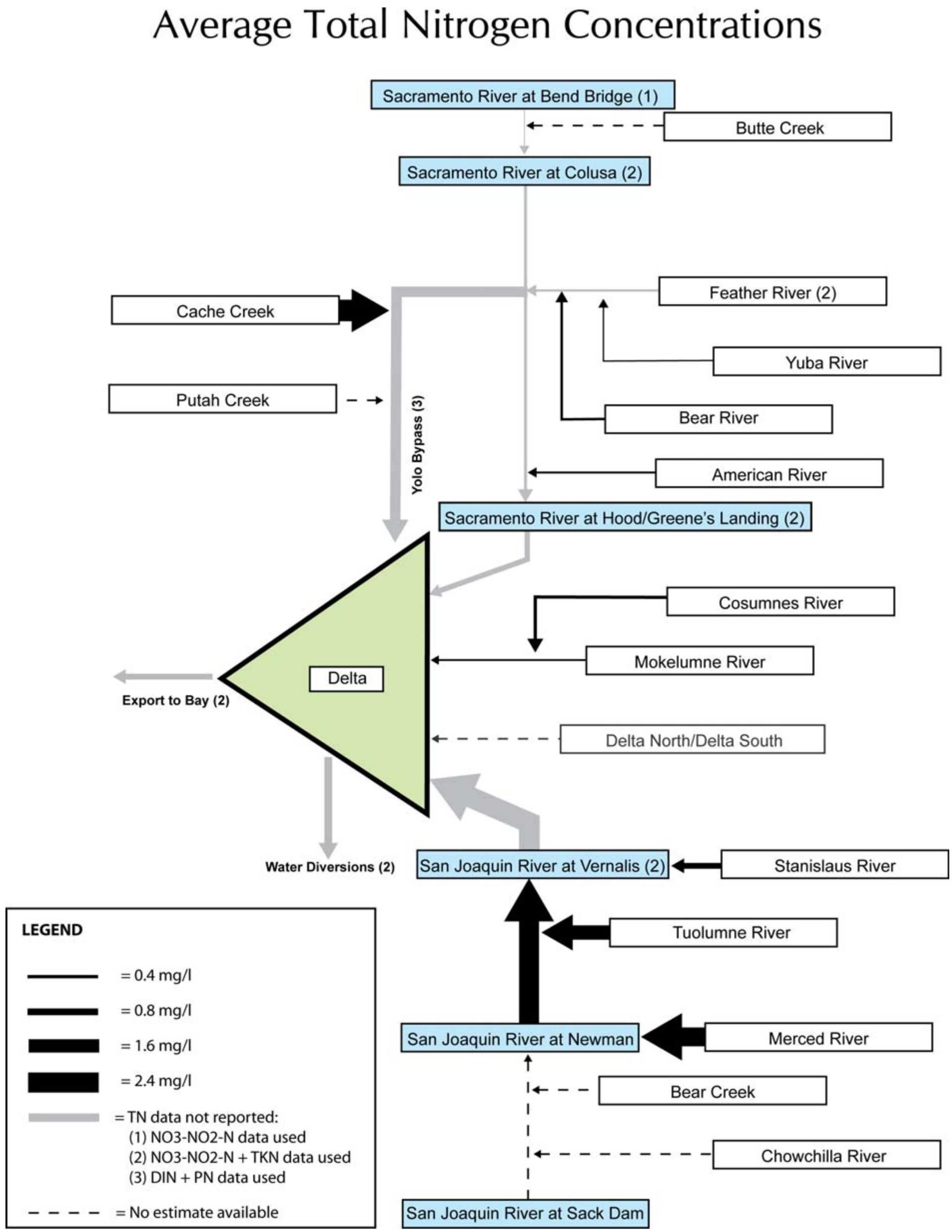

Figure ES-1. Average concentrations of total nitrogen in the Central Valley and Delta. Other important tributary sources of nutrient loads (Mud Slough, Salt Slough) are discussed further in Chapter 4.

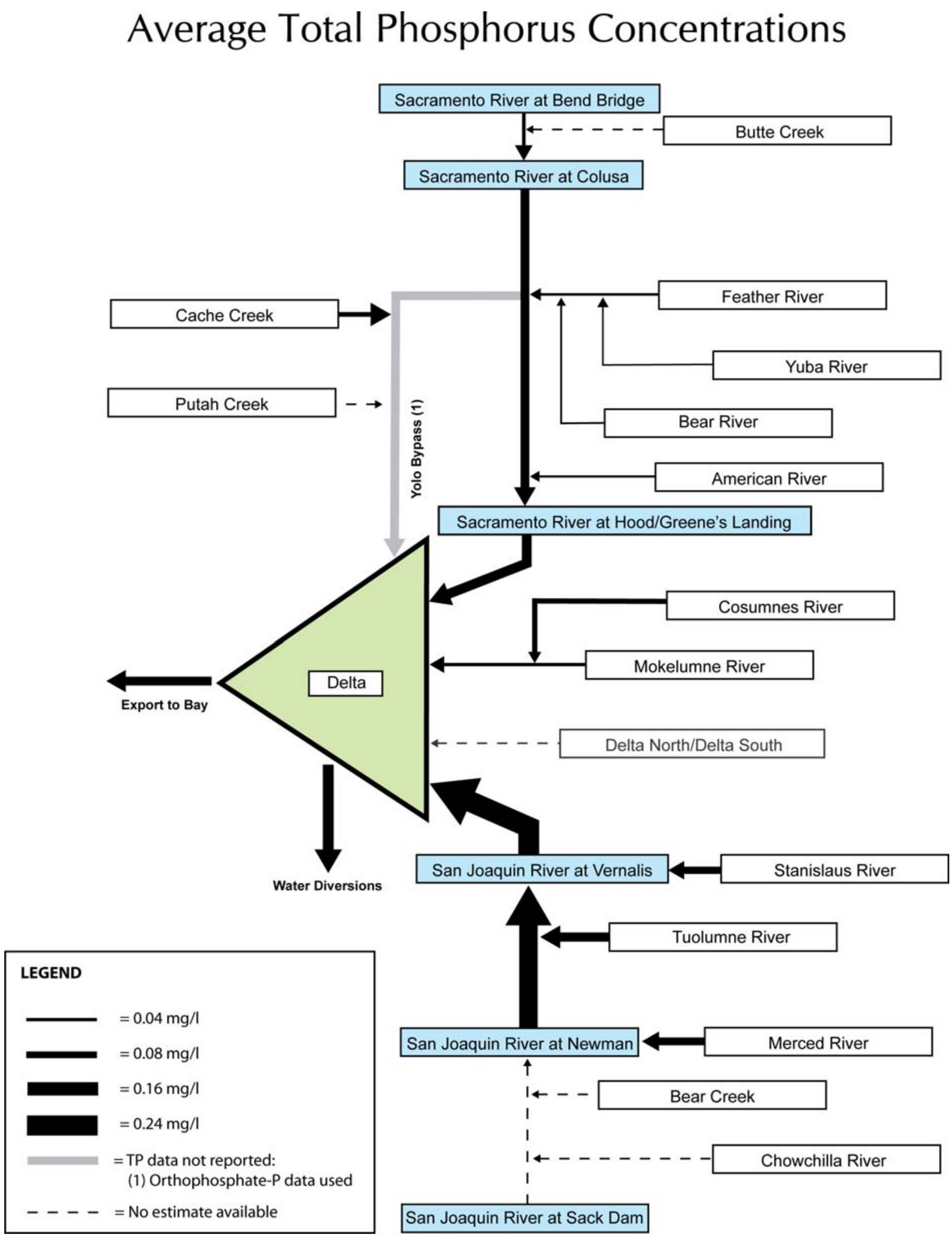

Figure ES-2. Average concentrations of total phosphorus in the Central Valley and Delta. Other important tributary sources of nutrient loads (Mud Slough, Salt Slough) are discussed further in Chapter 4.

Although water quality impacts are usually related to concentrations of constituents of concern, load estimates that aggregate concentrations and flows allow identification of important sources. Nutrient loads at various locations were estimated using historical monthly average flow data and average monthly concentrations (Figure ES-3 and ES-4 for nitrogen and phosphorus, respectively). Tributary loads were found to vary significantly between wet and dry years, with loads from the Sacramento River exceeding the San Joaquin River loads by nearly a factor of two or greater, especially in dry years. Despite the higher concentrations found in the San Joaquin River Basin (Figures ES-1 and ES-2), average annual runoff is up to 10 times higher in the Sacramento River, which contributes to higher loads from the Sacramento River compared to the San Joaquin River.

The loads transported in streams were compared to estimated nitrogen and phosphorus export rates from different land uses (Figures ES-3 and ES-4). Export rates (mass of either nitrogen or phosphorus transported in streams per unit area per year) were computed for key land uses: urban land, agricultural land, wetlands, and natural areas (including forests, shrubland, and rangeland). Preliminary conclusions based on the export rates are as follows. For nitrogen, forest/rangeland loads may dominate the overall loads for the Sacramento Basin and agricultural loads may dominate in the overall loads to the San Joaquin Basin, particularly for wet years. Point source loads from wastewater discharges may contribute nearly half or more of the overall nitrogen and phosphorus loads during dry years in both basins, and possibly during wet years for phosphorus in the San Joaquin Basin.

The calculated total watershed exports matched well with the stream loads at key locations (such as Sacramento River at Hood/Greene's Landing and San Joaquin River at Vernalis) although not at all locations considered. These differences highlight the need for greater data collection, both to characterize stream loads and to better understand the sources of nutrients in the watersheds of the Central Valley and Delta.

Current estimates for in-Delta contribution of nutrients from agriculture on the Delta islands are small compared to tributary sources. The nutrient export loads in water diversions are relatively uniform from year to year, particularly when compared with the tributary loads, and are of the same magnitude as those loads estimated from the immediate watershed of the Delta. In dry years, the export loads of nitrogen and phosphorus in water diversions are similar in magnitude to their export to the Bay (Figure ES-5).

Uncertainties exist in the data used to calculate the loads presented herein. Data at some tributary locations are sparse, especially at upstream locations. Due to a lack of monitored data representing a single landuse type, export rates used to calculate loads are uncertain. In-delta sources of nutrients, primarily agricultural drainage, are not well quantified. Nutrient loads from fish hatcheries and nutrient concentrations in reservoirs are unknown. Data gaps can be addressed in future work, primarily through targeted monitoring.

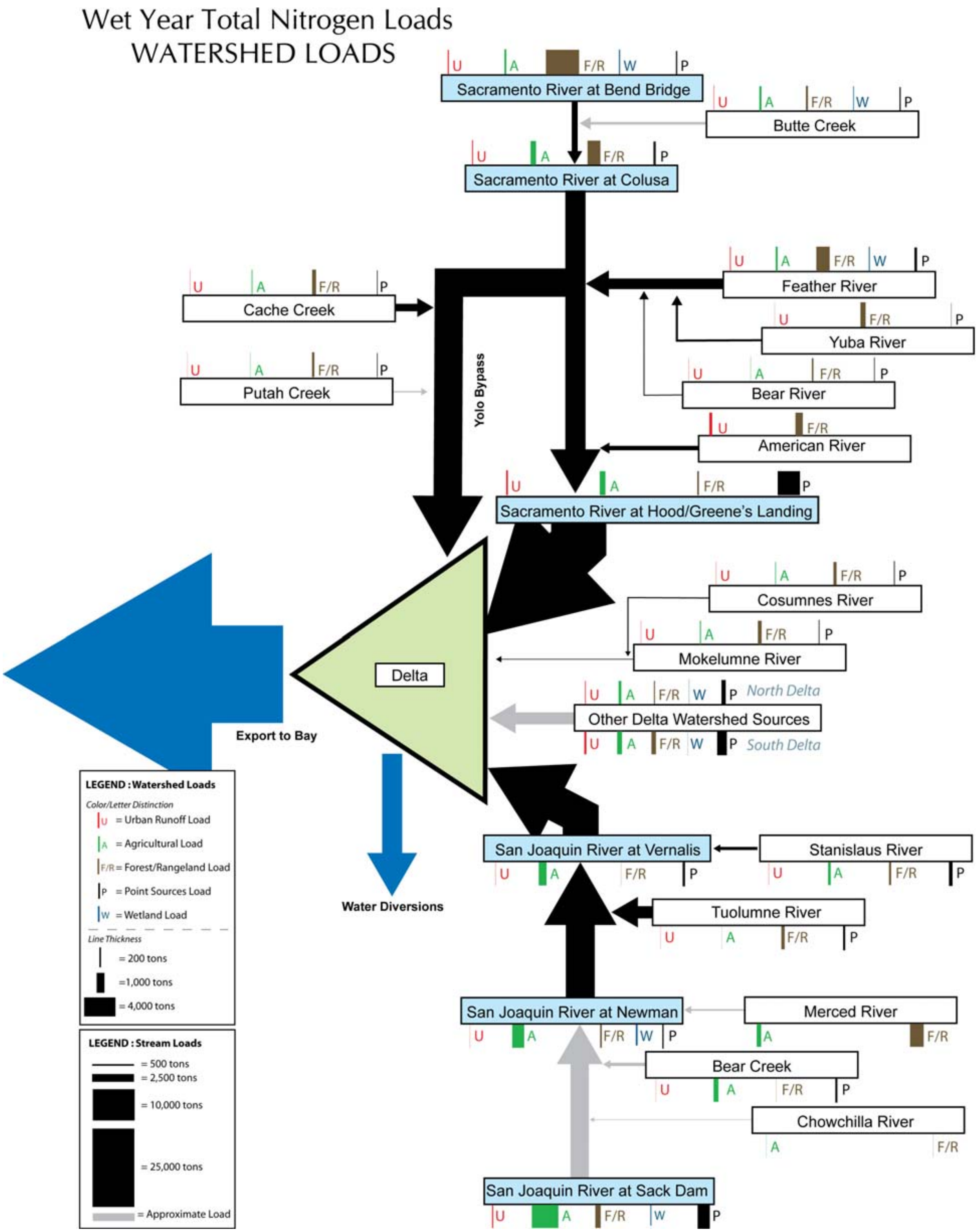

Figure ES-3. Watershed and outflow loads for the Central Valley and Delta for average wet years for total nitrogen. Arrow thicknesses are proportional to stream loads. See Chapter 4 for dry year loads.

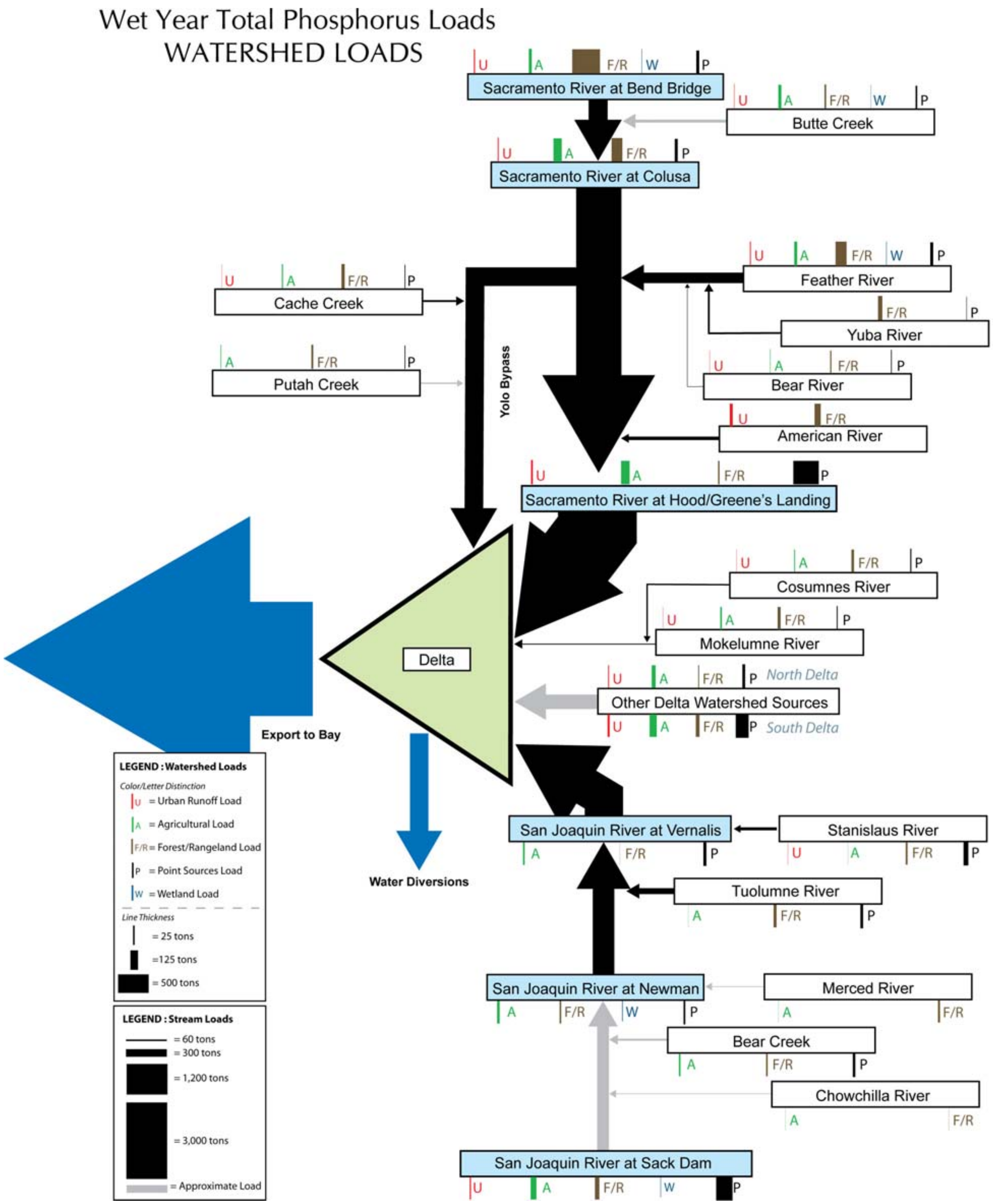

Figure ES-4. Watershed and outflow loads for the Central Valley and Delta for average wet years for total phosphorus. Arrow thicknesses are proportional to stream loads. See Chapter 4 for dry year loads.

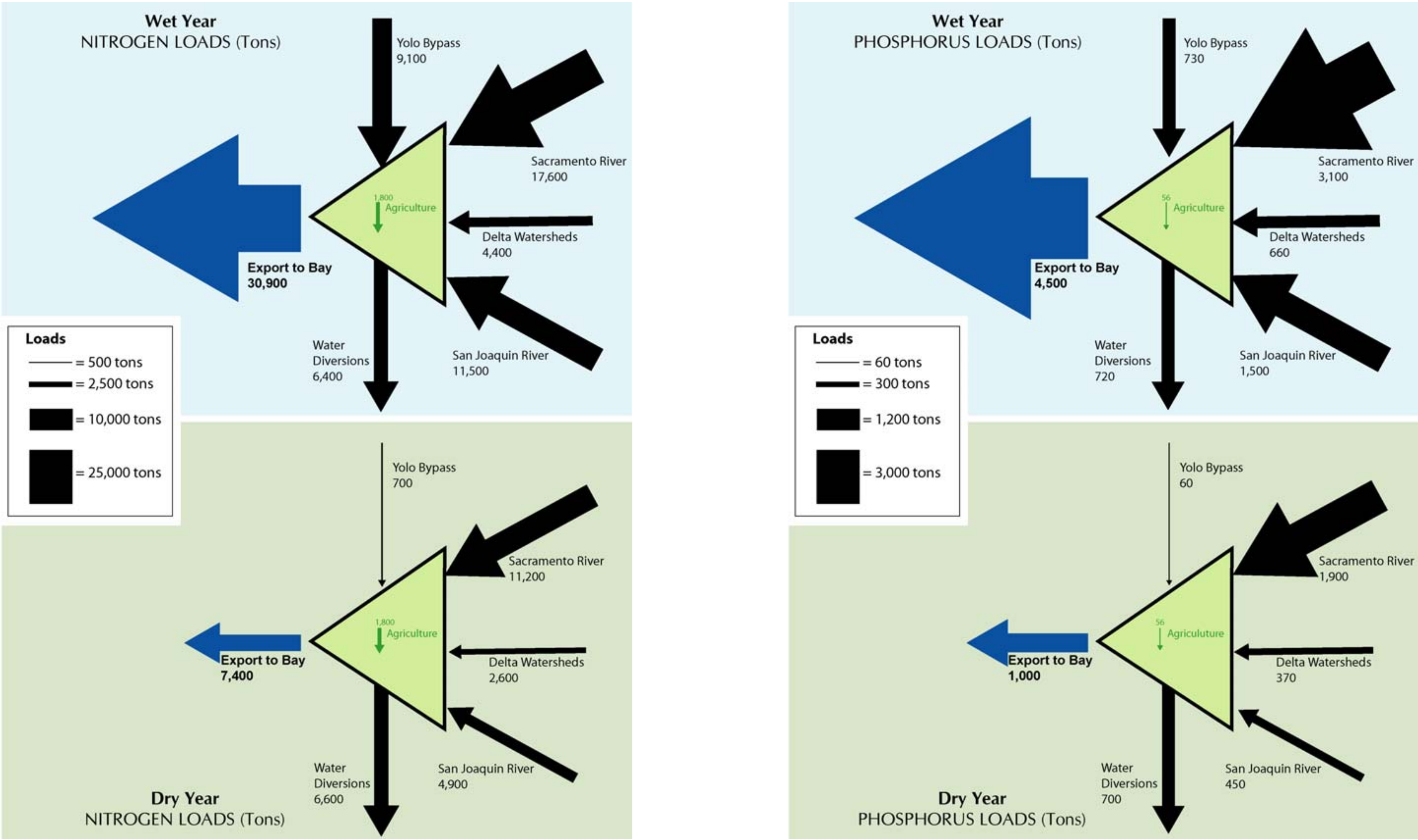

Figure ES-5. The major tributary loads for total nitrogen and total phosphorus shown in Figure ES-3 and ES-4, along with the internal loads from in-Delta sources and exports from the Delta into San Francisco Bay and into the aqueducts.