Memorandum

Date:	April 18, 2016
To:	Independent Review Panel, 2016 California WaterFix Aquatic Science Peer Review
From:	Marin Greenwood, ICF
Subject:	**Request for graphical representation of the effects on Sacramento flow of the rules for water diversion and the amount of water that will be diverted from the North Delta (Specific panel request #1)**

Introduction

This memorandum addresses the following specific request for information and materials:

1. *Request for graphical representation of the effects on Sacramento flow of the rules for water diversion & the amount of water that will be diverted from the North Delta.*
    a. *The long tables in Ch. 3 are too complicated to easily grasp.*
    b. *Request for hydro period graphs that simply capture the differences in relative water diversion from the Sacramento by the dual conveyance facility*
        i. *For a dry, average, wet, and extremely dry water year, provide the amount (cfs) of water that will be diverted each month. This should be presented in a series of graphs with month on the x-axis. A range in the diversion should be presented to reflect the various decisions that affect water diversion.*
        ii. *On the same hydrograph, show the diversion as a percentage of total water available in the Sacramento River at the diversion site*
    c. *For the same scenarios as the diversion at the dual conveyance facility, provide hydrographs for the Sacramento River below the diversion site, such as at Rio Vista or in the Cache Slough complex*
    d. *If reasonable, for the same scenarios above, show the position of X2?*

The memorandum includes information regarding the bypass flows as proposed and modeled, in addition to the above specific hydro period requests.

Bypass Flow Criteria

The Independent Science Panel found the tables explaining North Delta Diversion (NDD) bypass flow criteria (i.e., Tables 3.3-1 and 3.3-2 in the working draft Biological Assessment) challenging to interpret. As an example graphical representation of these criteria, Figure 1 illustrates the potential diversions that would be possible based on the bypass flow criteria during December-April, which is a period of particular management importance for outmigrating juvenile salmonids (e.g., Winter-Run Chinook Salmon). Note that other regulatory constraints affect the actual bypass flows (e.g., downstream water quality requirements), so that the actual percentage of flow diverted does not necessarily correspond to the amount allowable from the bypass flow criteria alone. This is illustrated in Figure 2 below. The regulatory criteria often controlling Delta operations are contained in the State Water Resources Control Board's (SWRCB) 2006 Water Quality Control Plan (WQCP) for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary , commonly referred to as D-1641 for the SWRCB's Water Right Decision 1641 from which the objectives were derived.[1] Among these criteria, which are intended to benefit a variety of in-Delta user groups, are flow and operational criteria intended to provide reasonable protection of fish and wildlife beneficial uses. It is important to note that the California WaterFix proposes to adhere to these objectives, as described in Chapter 3 of the working draft BA. Select important flow-based criteria from the WQCP are shown in Table 1. These provide important context for the specific hydro period graphs included in response to the Independent Science Panel's request.

Requested Hydro Period Graphs

The Independent Science Panel's request for representative hydro period graphs is addressed below based on CalSim-II modeling outputs of the proposed California WaterFix action scenario (proposed action, or PA) and, for context, the no action alternative (NAA). As described in the presentation to the panel, caution should be applied when examining individual years from CalSim-II outputs, for the purpose of the model is to provide longer term, planning-level comparisons (e.g., averages by water year types). In addition to the material requested by the panel, it is important to provide context for overall operational changes under WaterFix by also considering the role of south Delta exports. This is shown below in additional plots.

The selected example years were chosen by examining the mean water year (February-January, per the CalSim-II modeling) Sacramento River at Freeport flow. The following years were selected:

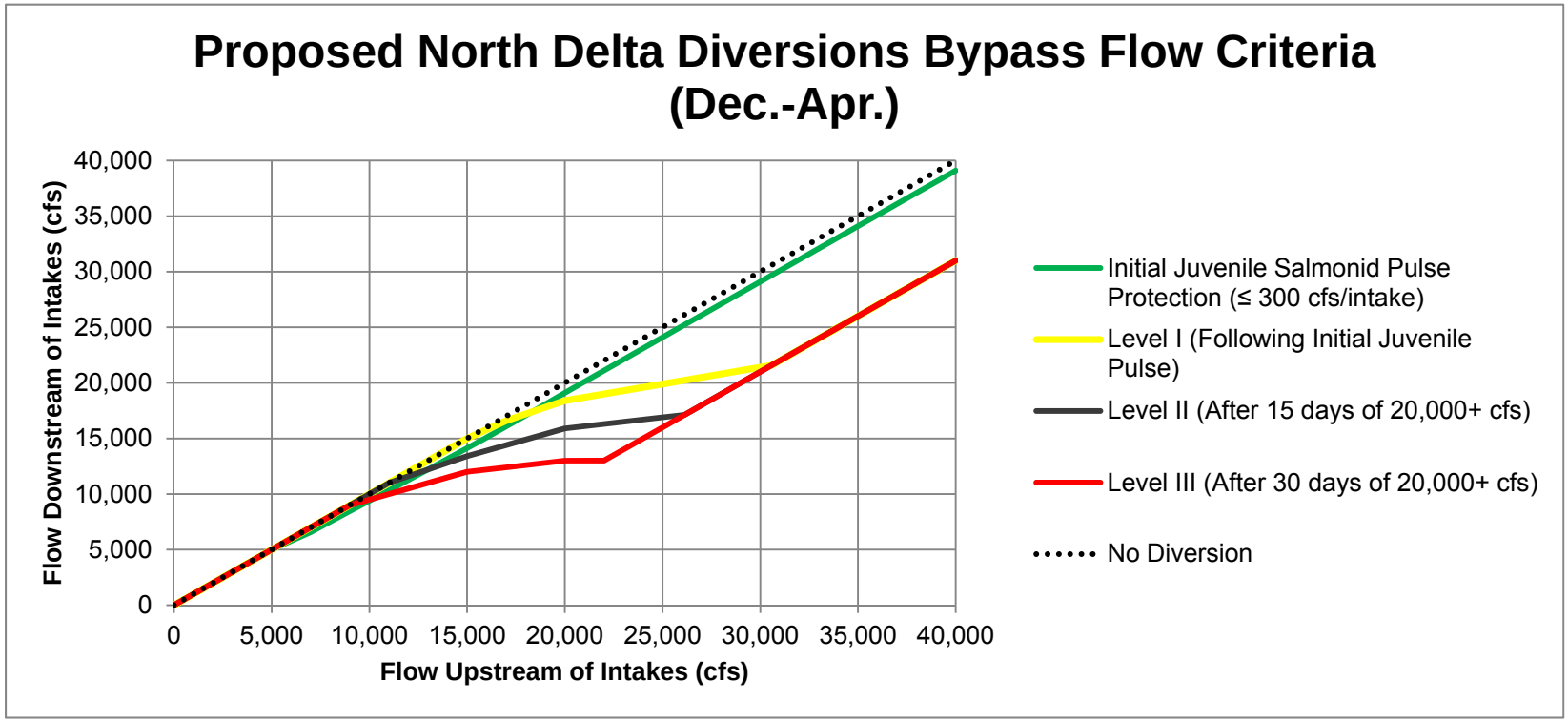
- Extremely dry year: the critically dry year of 1924 (mean Freeport flow = 9,345 cfs) (Figures 3 and 4)

[1] State Water Resources Control Board. 2006. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. December 13. Division of Water Rights, State Water Resources Control Board, Sacramento, CA. Available: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/wq_control_plans/2006wqcp/index.shtml

- Dry year: 1989 (mean Freeport flow = 16,003 cfs) (Figures 5 and 6)
- Average year: the below normal year of 1968 (mean Freeport flow = 21,927 cfs) (Figures 7 and 8) and the above normal year of 1980 (mean Freeport flow = 21,768 cfs) (Figures 9 and 10)
- Wet year: 1996 (mean Freeport flow = 36,368 cfs) (Figures 11 and 12)

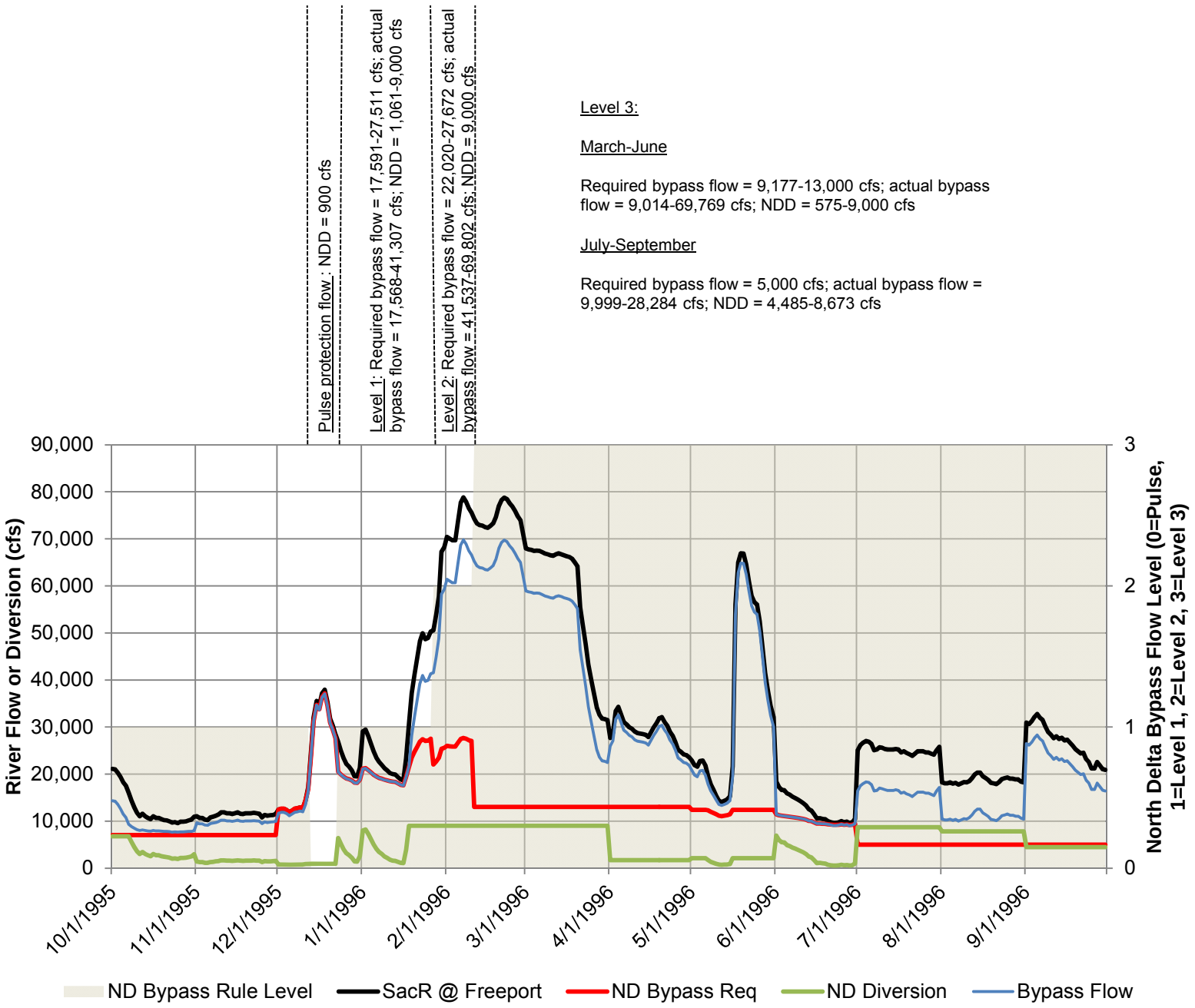
Each example year has two plots below, per the panel request and also to provide the important context for the effects of dual conveyance operations. The first plot includes the mean monthly water flow exported by the NDD, in addition to the percentage of Sacramento River flow upstream of the NDD (at Freeport) that this flow represents. The first plot's export flow axis is scaled to 10,000 cfs in order to allow the different years to be easily compared, in relation to the maximum possible 9,000-cfs diversion. Also included on the first plot is the export to inflow (E:I) ratio, which is a measure of water exported divided by water inflowing to the Delta. This ratio is included to recognize that with implementation of dual conveyance, a certain amount of export pumping would be shifted from the south Delta to the north Delta, so that south Delta exports under the PA would appreciably less than under the NAA. As noted on the first plot, the inflow (I) term for the PA is the Sacramento River downstream of the NDD (i.e., accounting for the water exported by the NDD); NDD exports are not included in the export (E) term for the PA (Figures 3,5,7,9,11).

The second plot for each example year includes the mean monthly flow in the Sacramento River at Rio Vista (for PA, as requested) and X2, the position of the 2-ppt near-bottom isohaline, with X2 shown for both the PA and NAA scenarios in order to emphasize that X2 is dependent on both south and north Delta exports. SWRCB WQCP outflow-based objectives occur year-round for the reasonable protection of fish and wildlife beneficial uses (Table 1); these are met under the PA and NAA (Figures 4, 6,8,10, 12).



Source: Adapted from Greenwood and Chilmakuri (2014: http://www.eposters.net/pdfs/habitat-restoration-and-water-diversion-effects-of-the-proposed-bay-delta-conservation-plan-on-the.pdf)

Figure 1. Proposed North Delta Diversions Bypass Flow Criteria (December-April example).

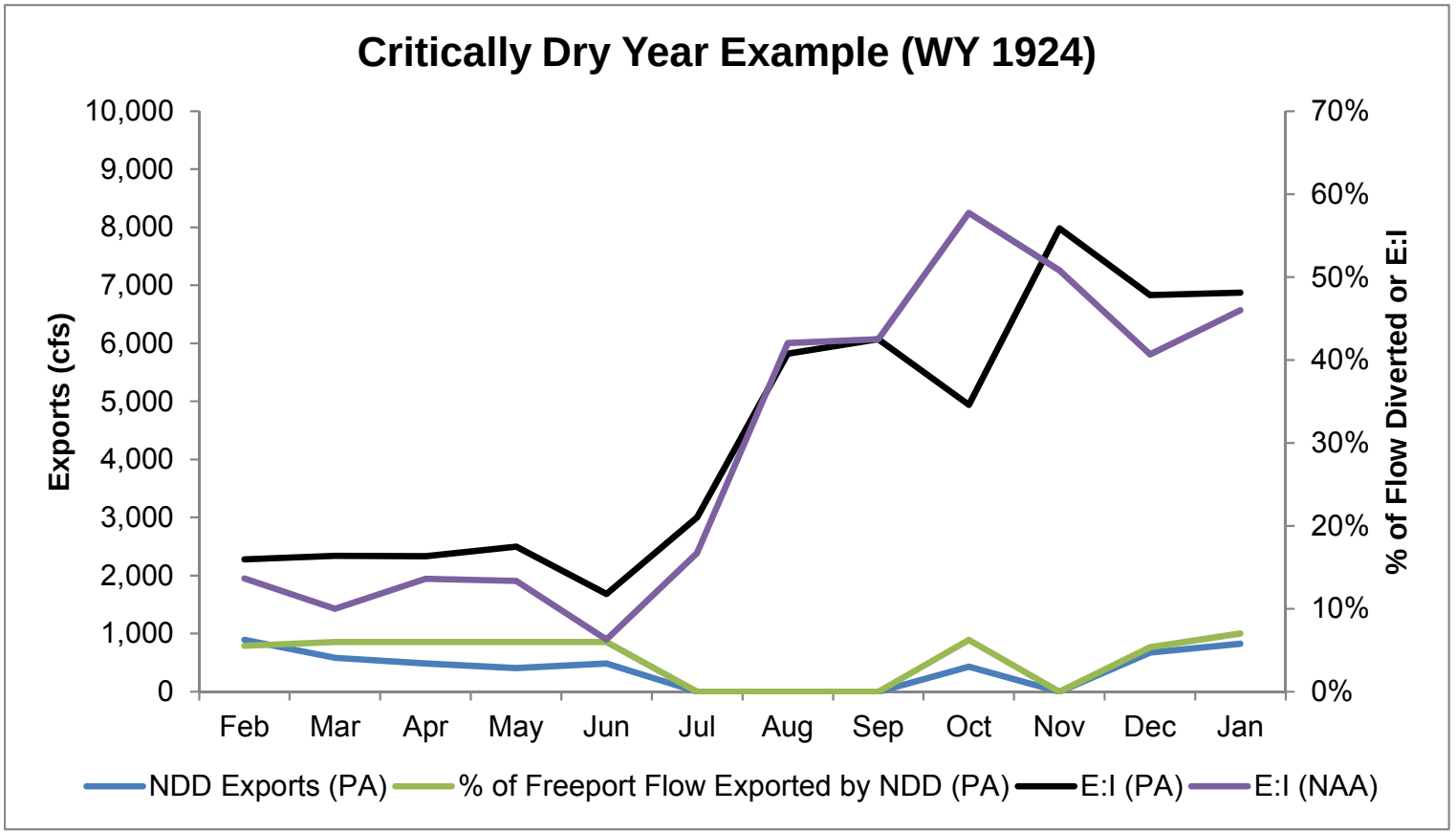


Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: the grey shading indicates the bypass rule (0=pulse/low level pumping, 1=level I, 2=level II, and 3=level III). 'SacR @ Freeport' = flow upstream of the NDD. 'ND Bypass Req' = the required bypass flow based on the criteria/rules (see Tables 3.3-1 and 3.3-2 in the working draft Biological Assessment). 'ND Diversion' is the water exports by the NDD. 'Bypass Flow' is the flow that was modeled to have been bypassed (i.e., occurred just downstream of) the NDD.

Figure 2. Example Year Daily Patterns and Operation of the North Delta Diversions

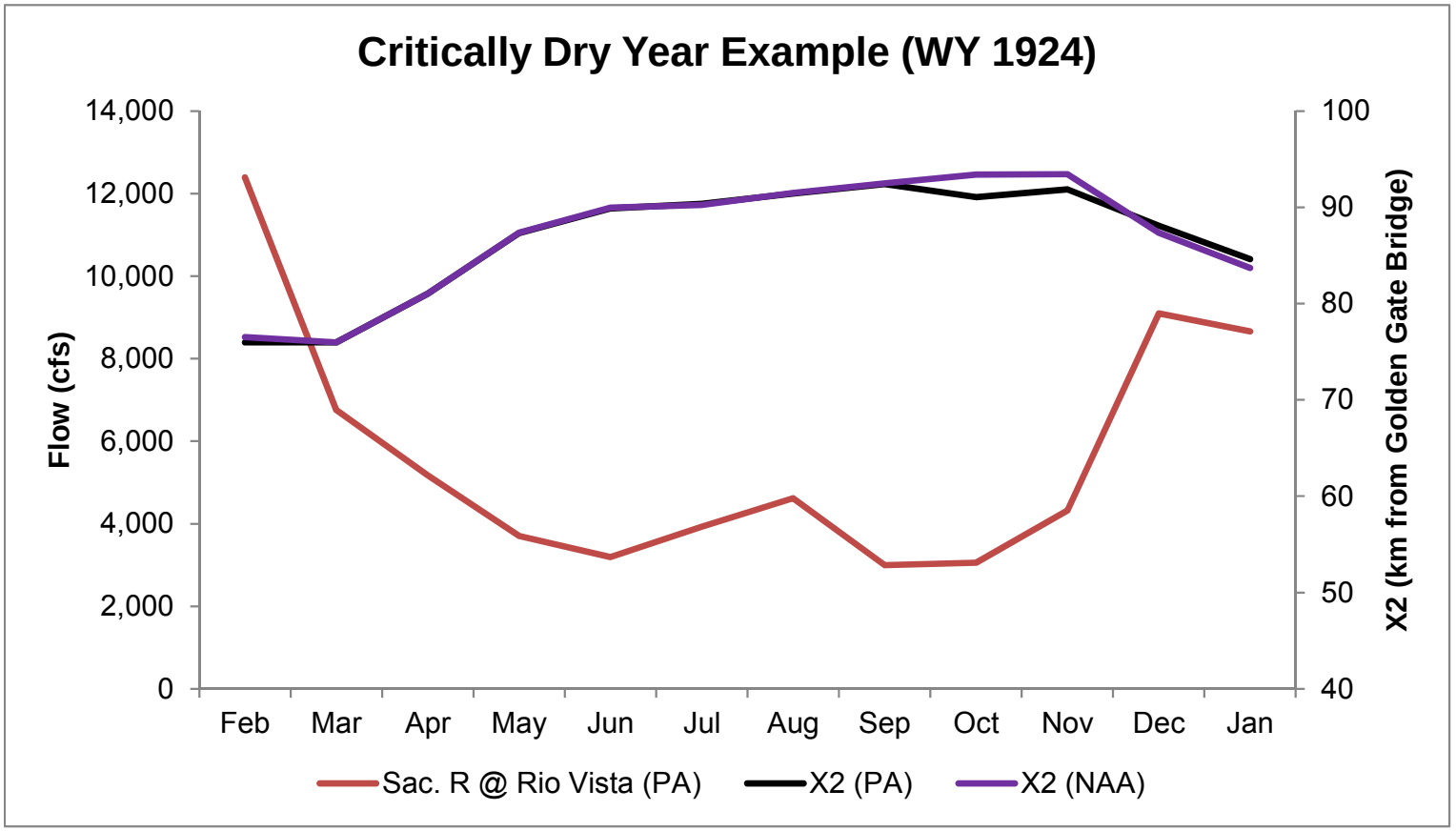
Table 1. Selected Flow-Related Water Quality Objectives for Fish and Wildlife Beneficial from the SWRCB (2006) Bay-Delta Water Quality Control Plan.

Objective	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SWP/CVP Export Limits					1,500 cfs							
Export/Inflow (E:I) Ratio	0.65	0.35					0.65					
Min. Delta Outflow	4,500-6,000 cfs						3,000-8,000 cfs					
Habitat Protection Outflow		7,100-29,200 cfs										
Rio Vista Flows									3,000-4,500 cfs			



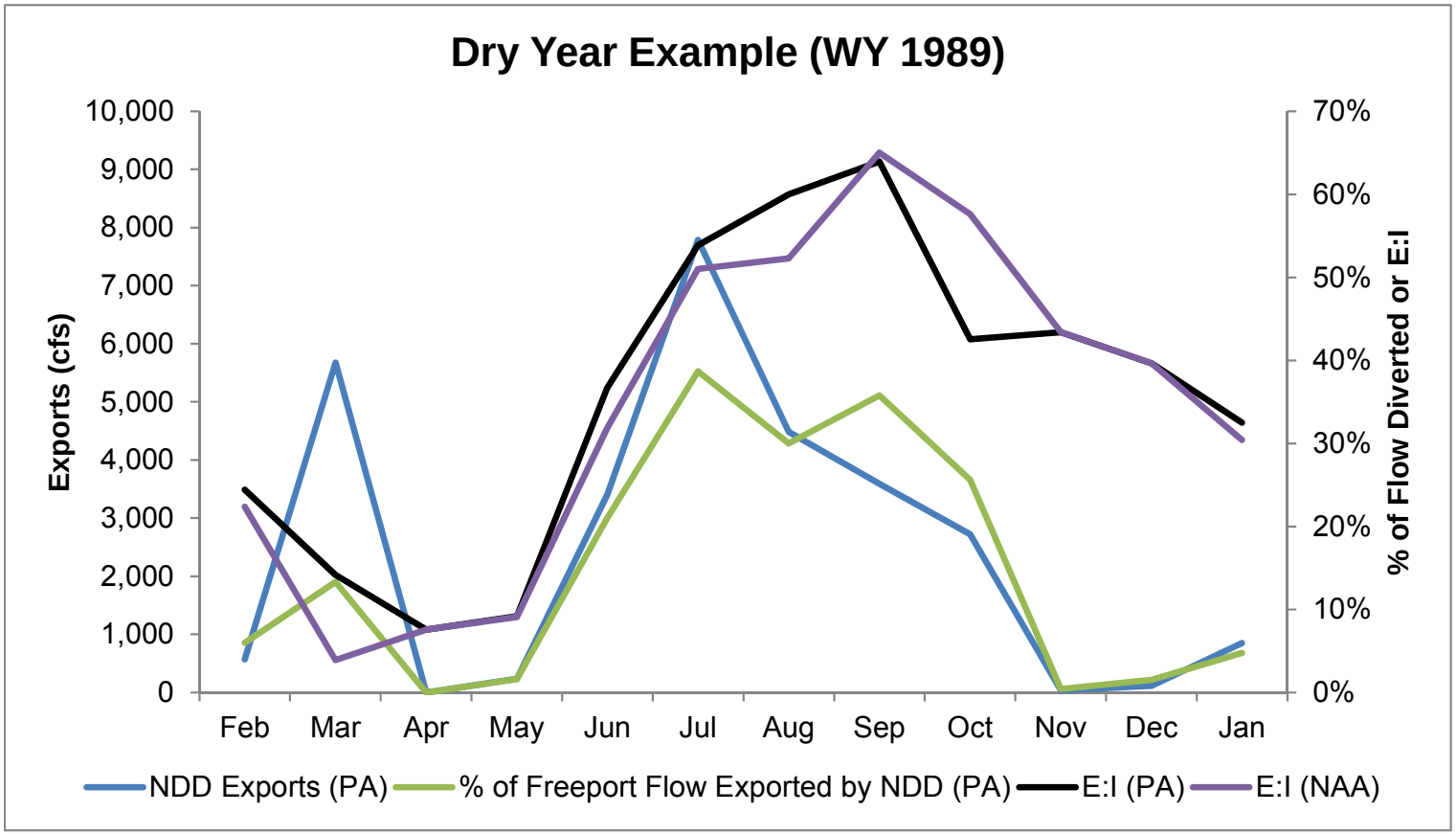
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 3. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1924.



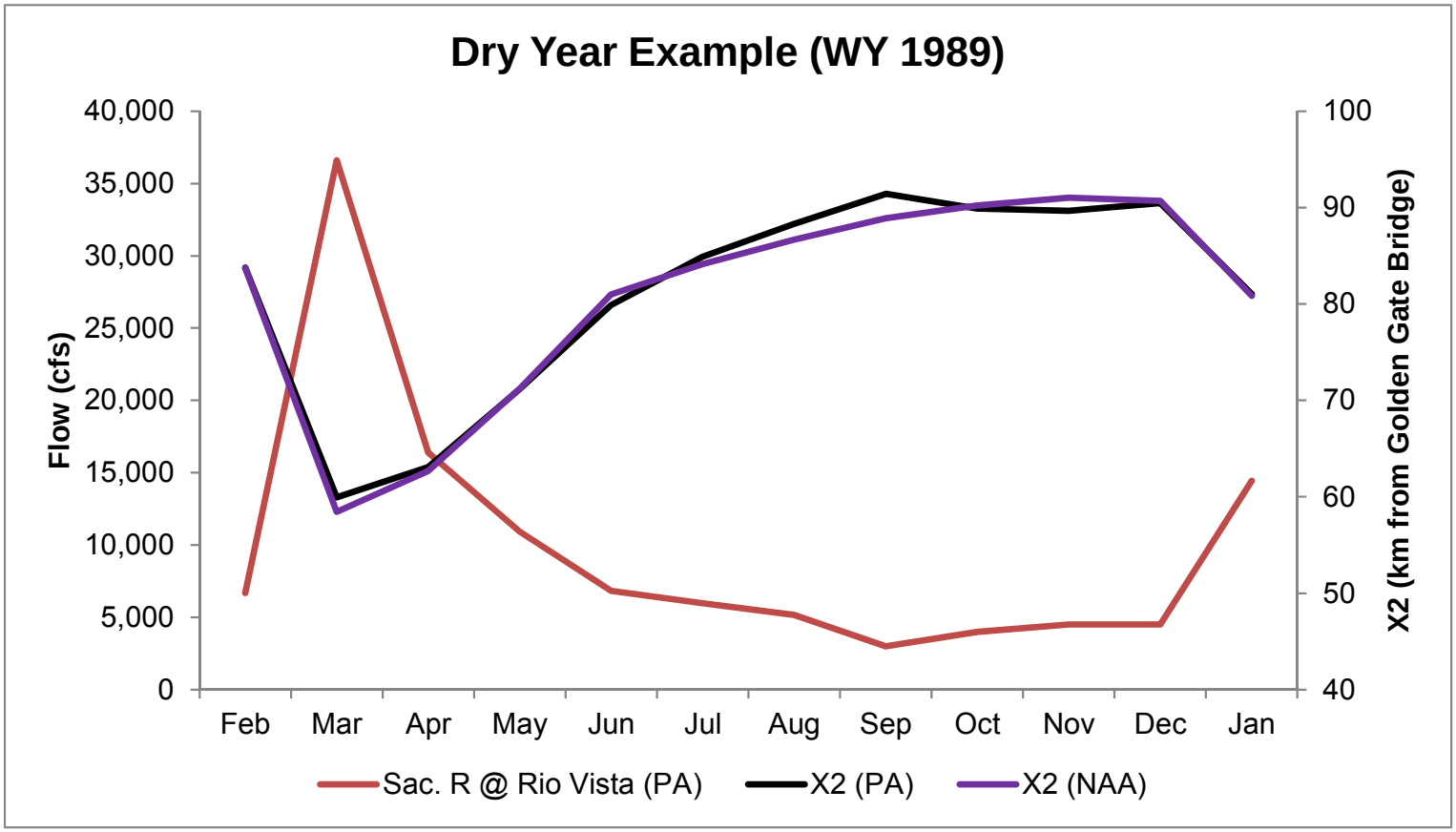
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 4. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1924.



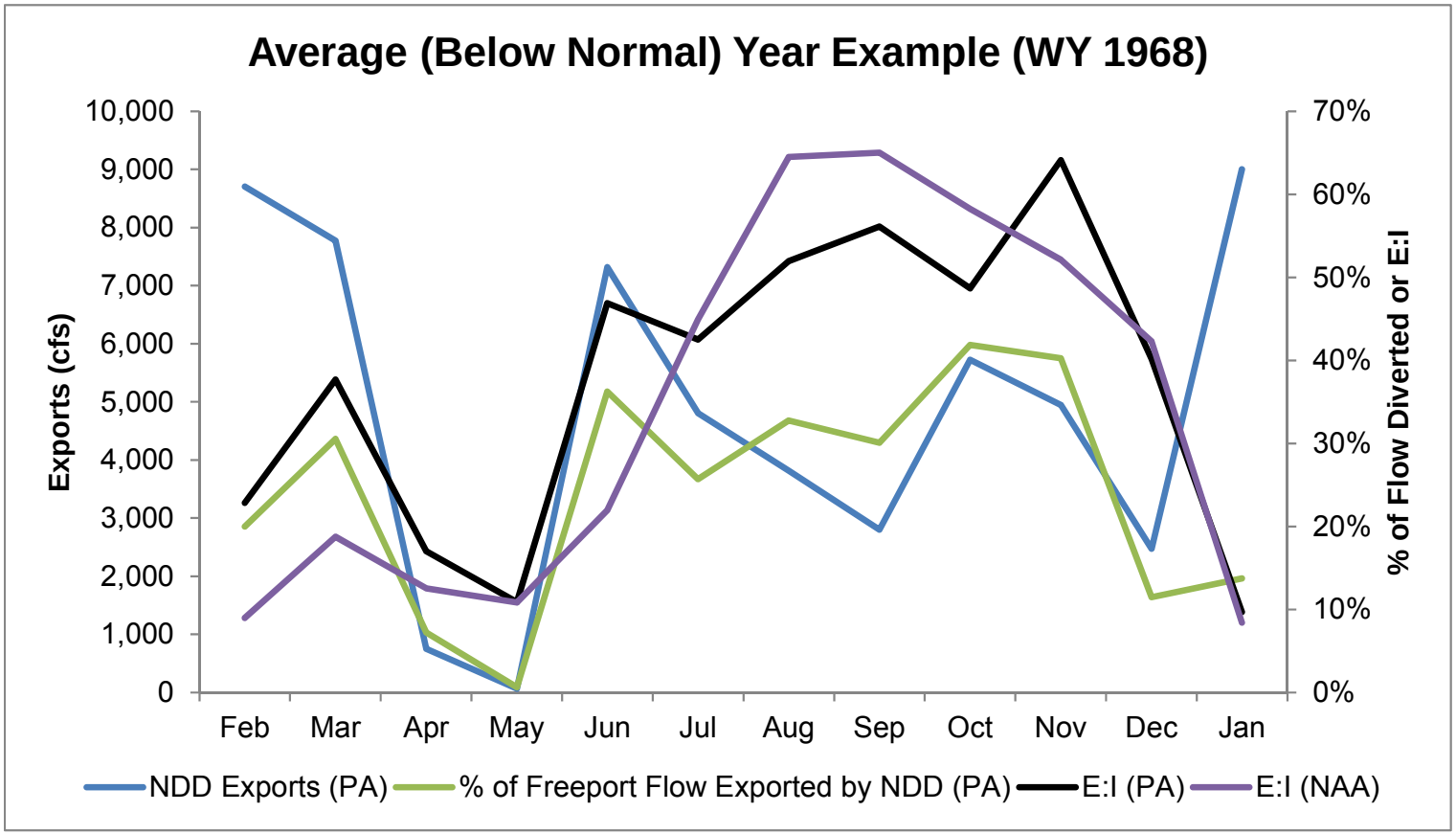
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 5. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1989.



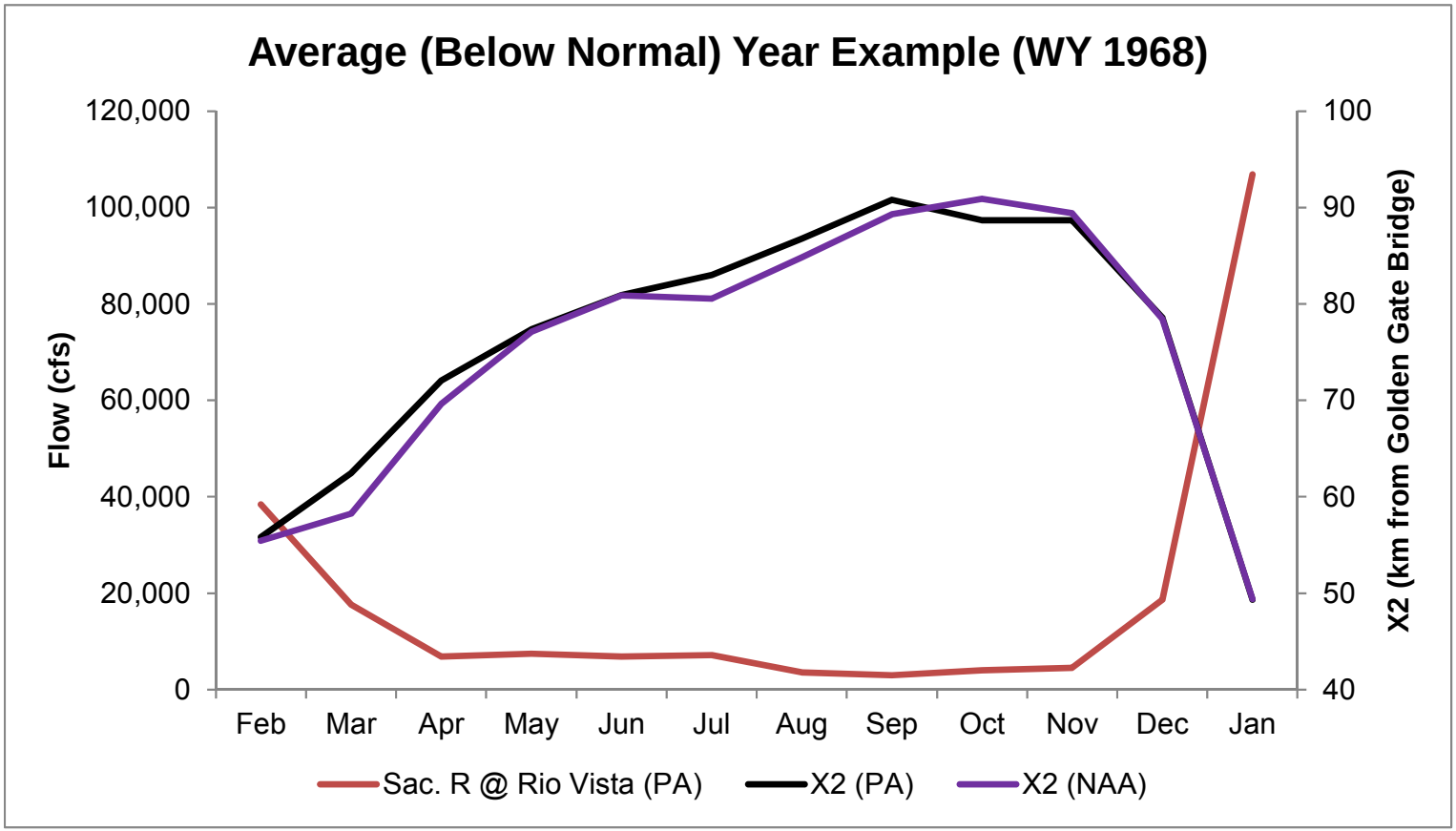
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 6. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1989.



Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 7. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1968.



Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 8. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1968.

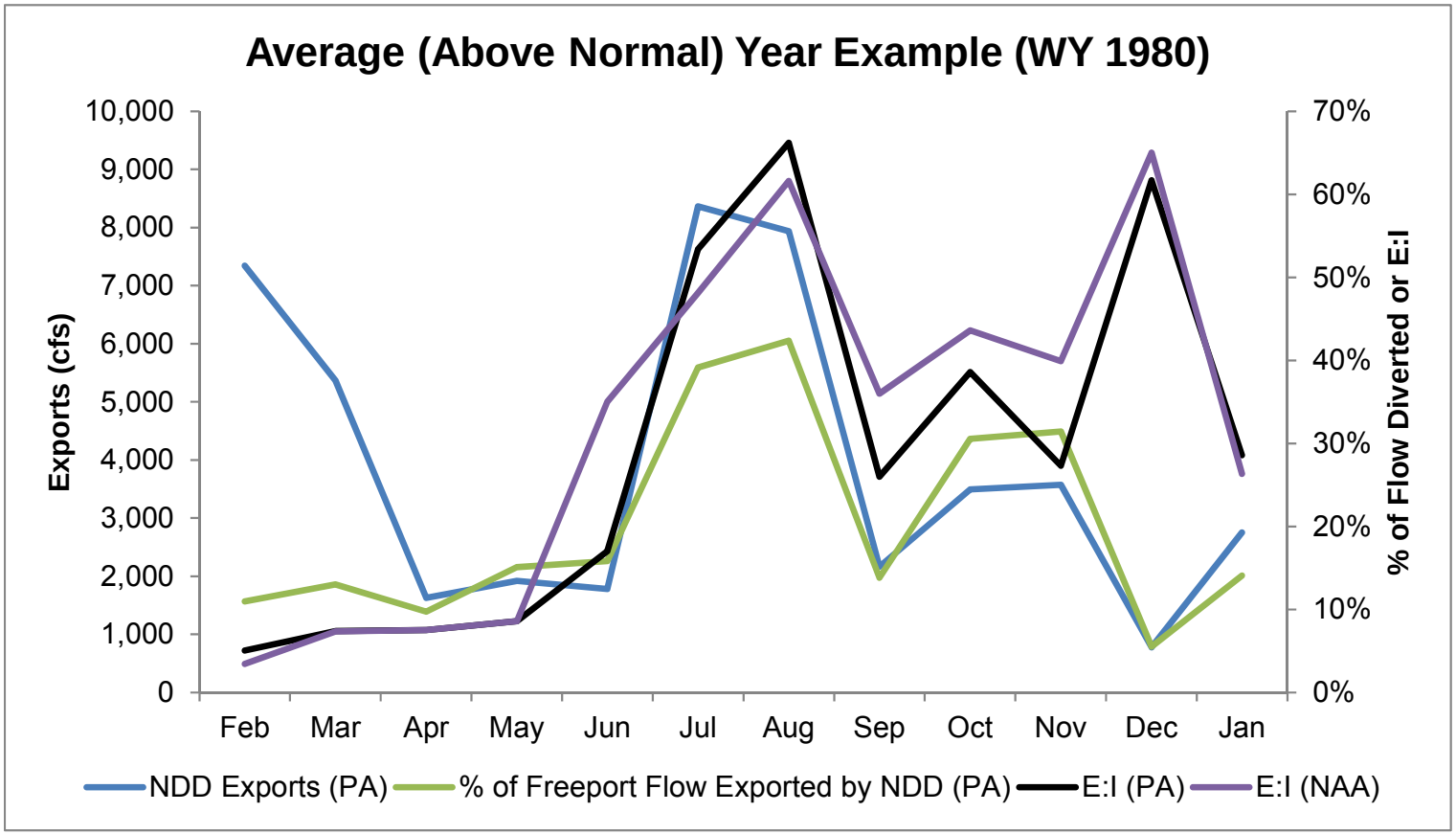


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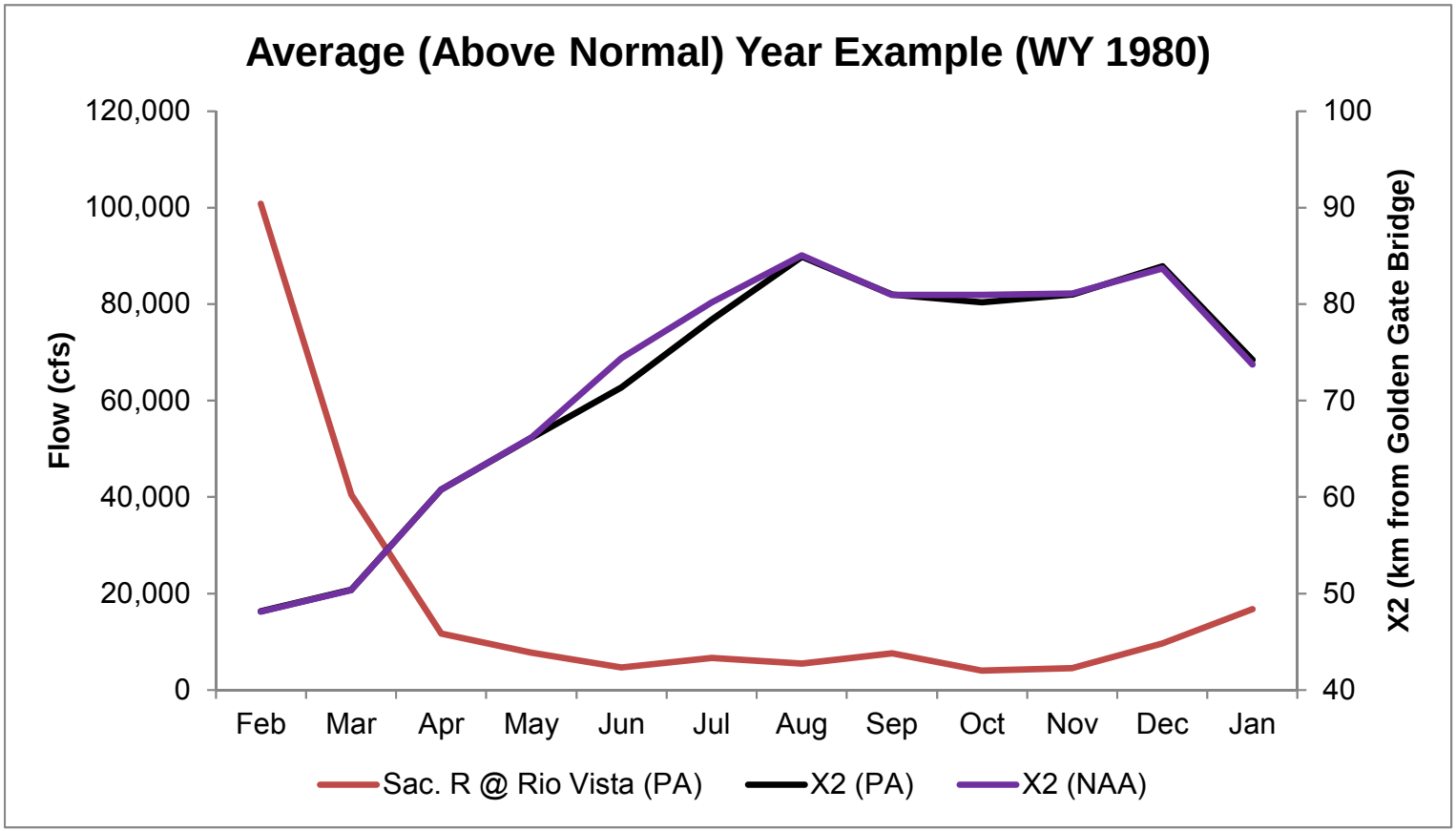
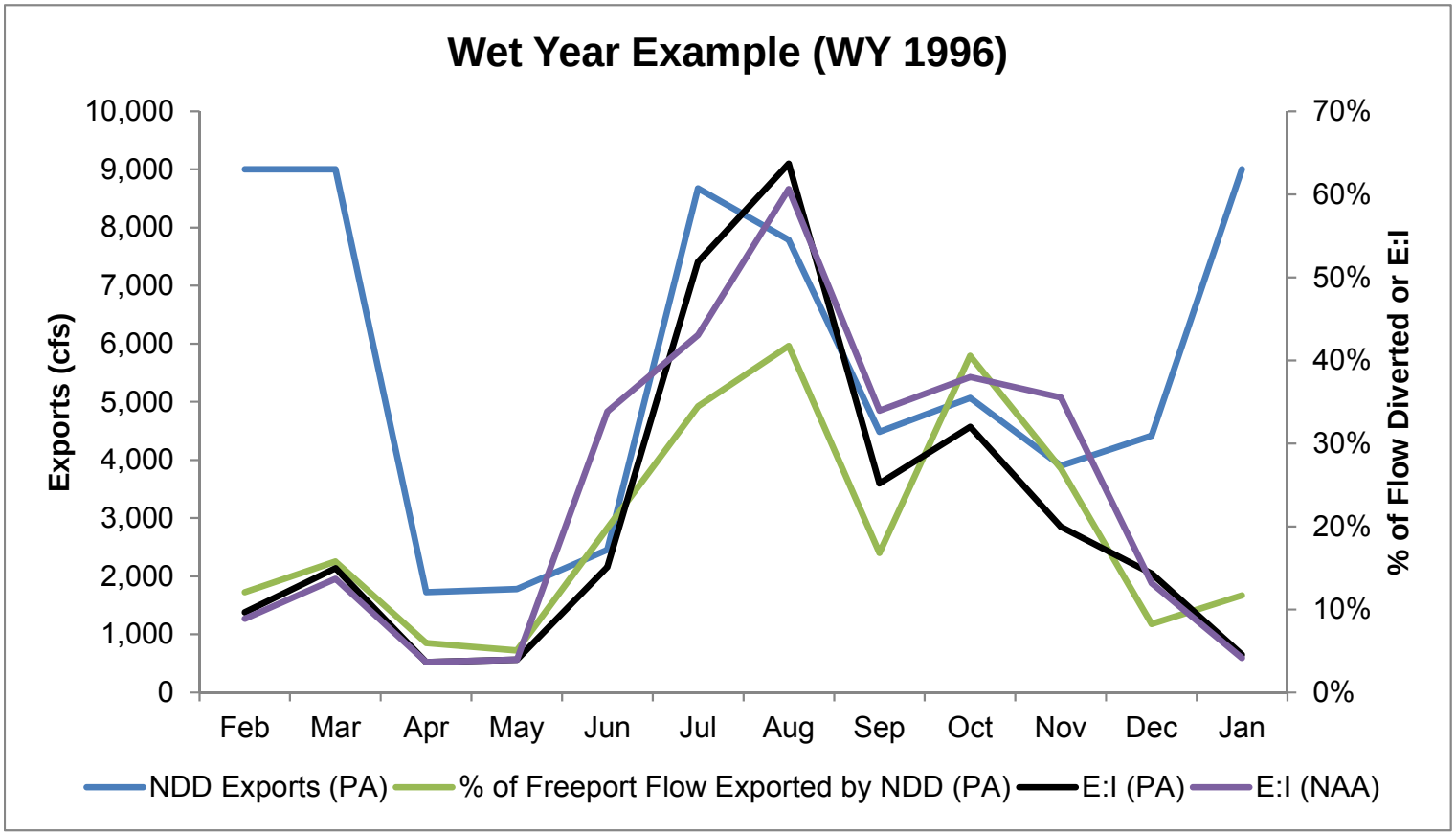
Figure 9. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1980.



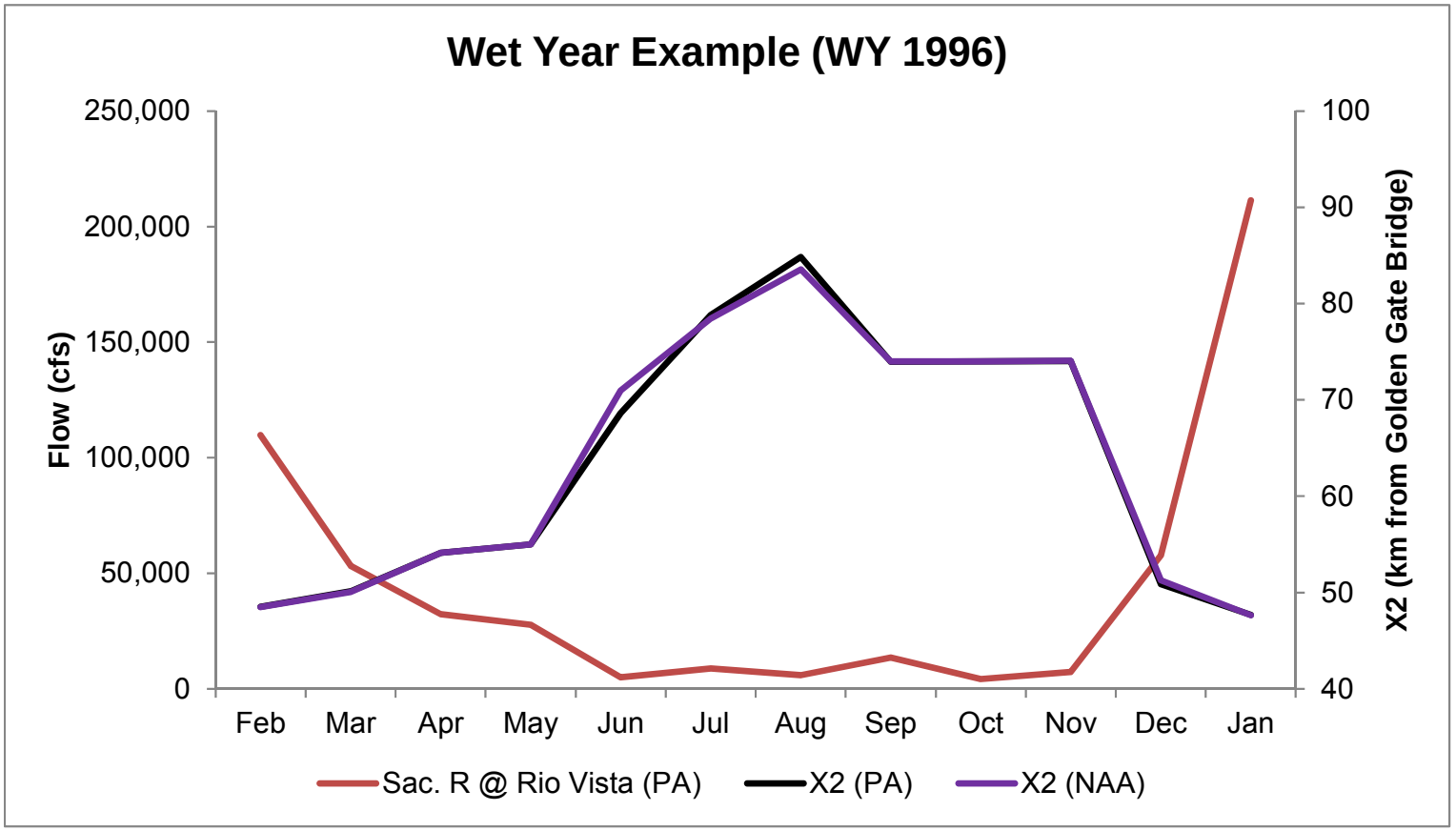
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 10. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1980.



Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 11. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1996.



Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 12. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1996.