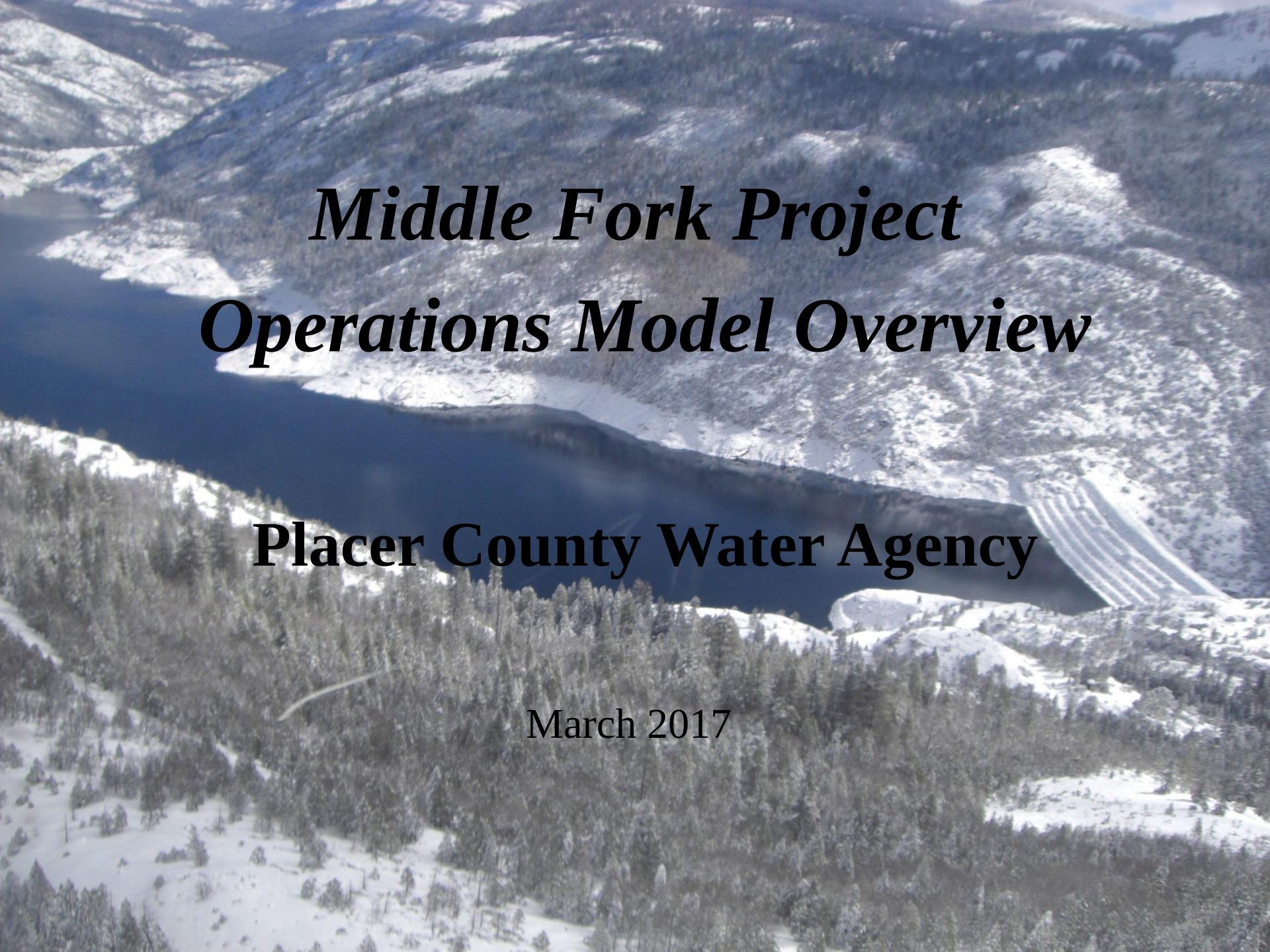

Middle Fork Project Operations Model Overview

Placer County Water Agency

March 2017

MFP Operational Overview

- Middle Fork Project Overview
- Oasis Model Introduction
- Hydrology
- Operations Model Structure and Priorities
- Operational Criteria
- Operational Constraints
- Other Operational Considerations
- Model Operation
- Post-processing metrics

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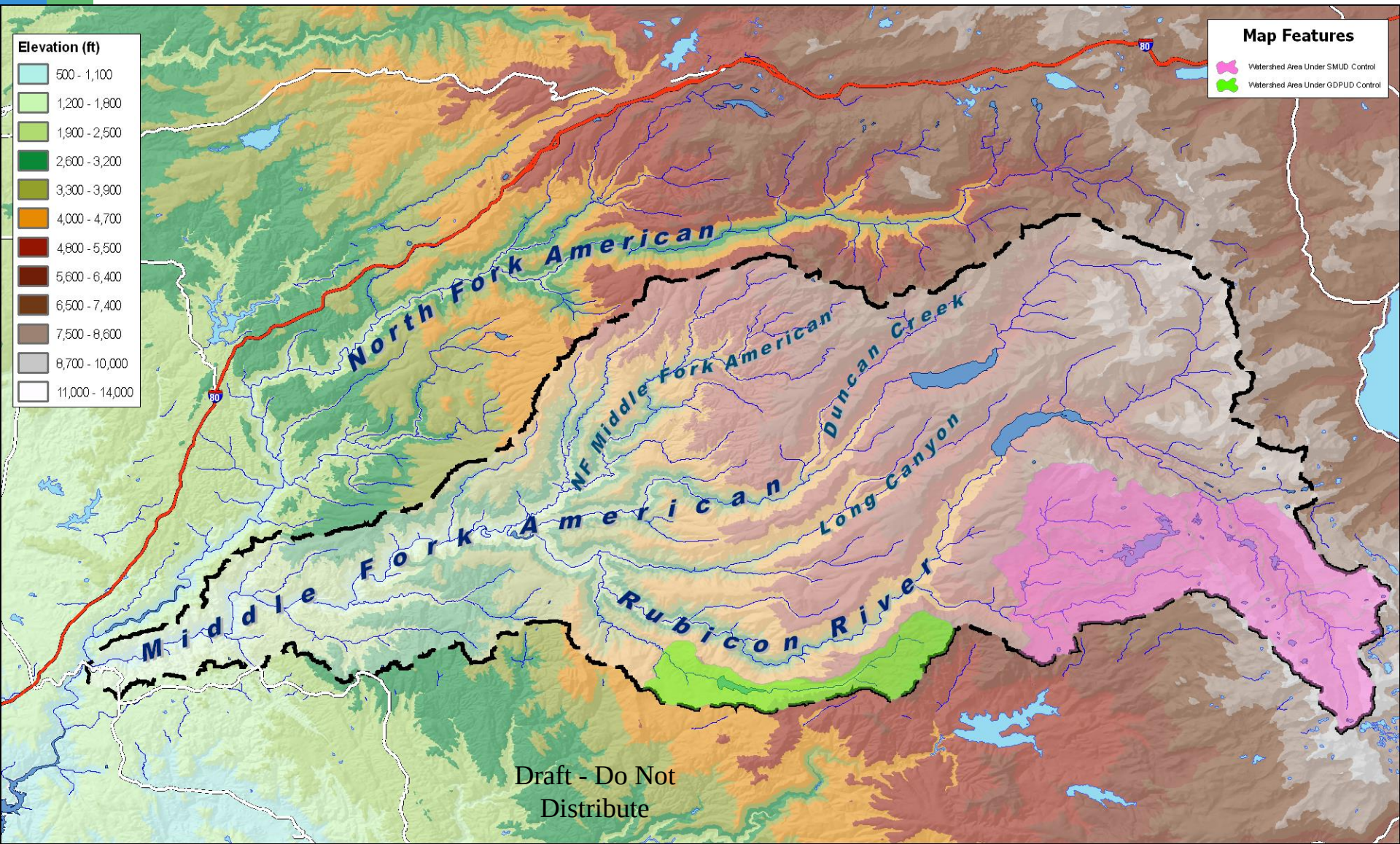
Overview of Basin



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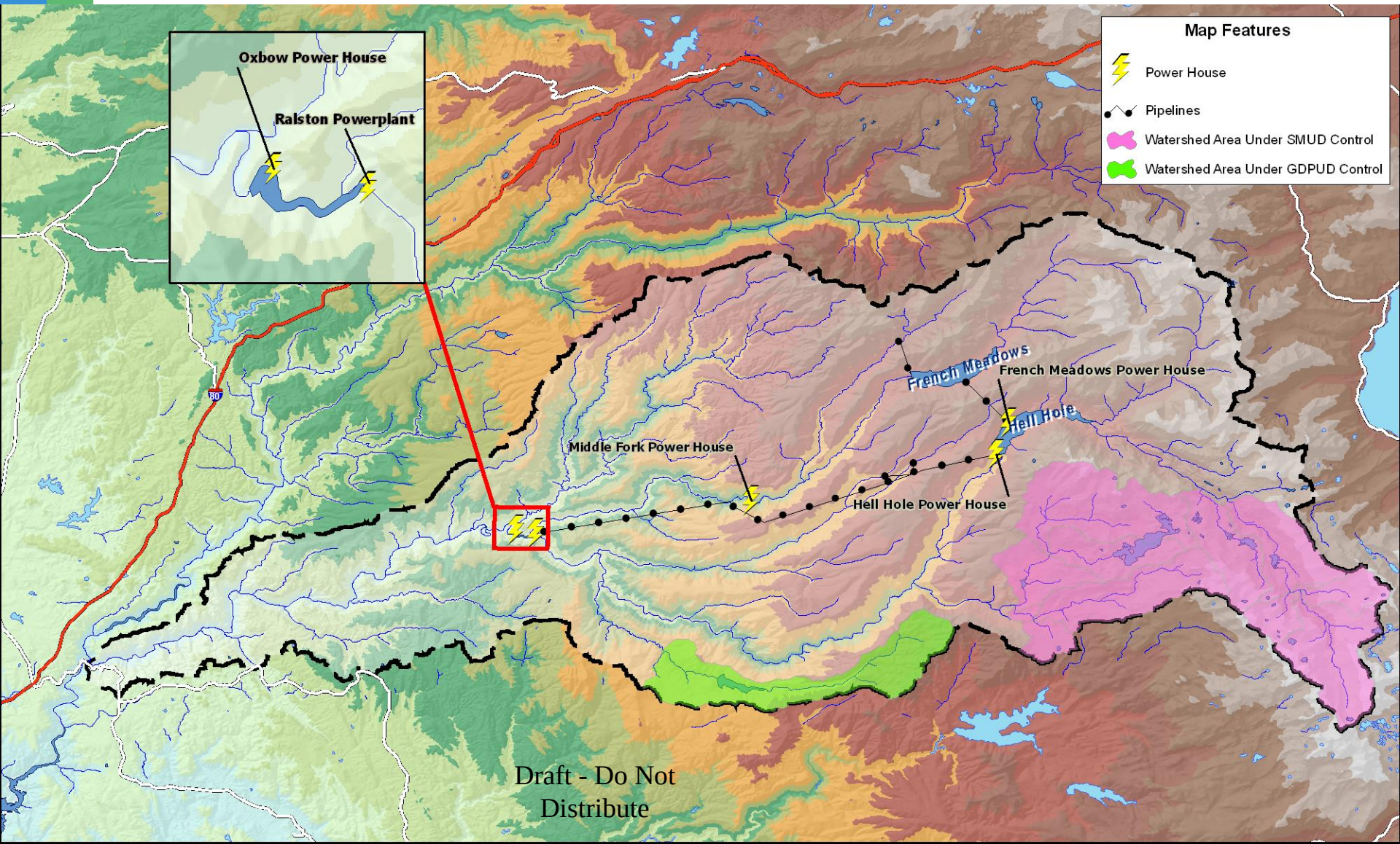
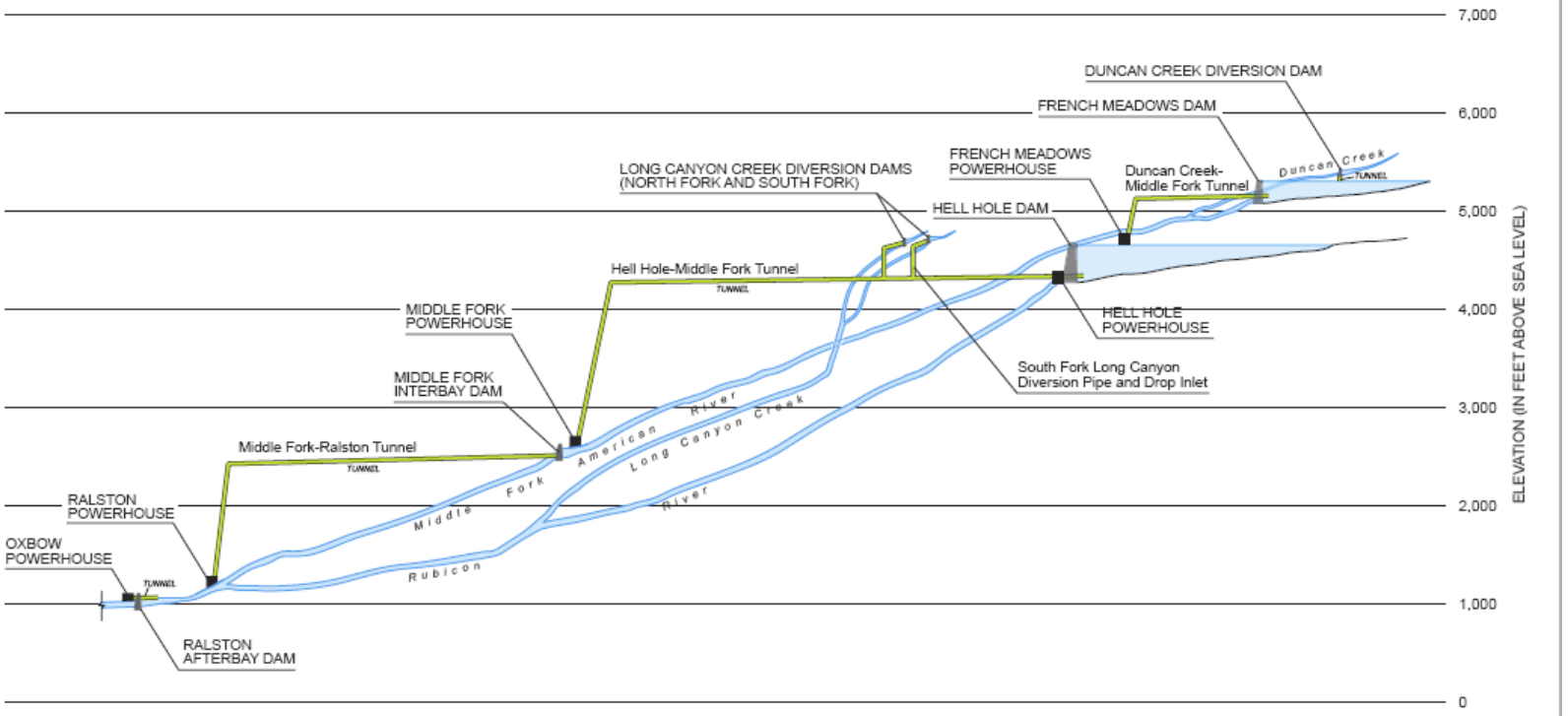
Project Facilities



Project Section View



Horizontal dimension and size of facilities not to scale

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Middle Fork American River Project

Figure SD B-1

MFP Facilities - Elevation Profile

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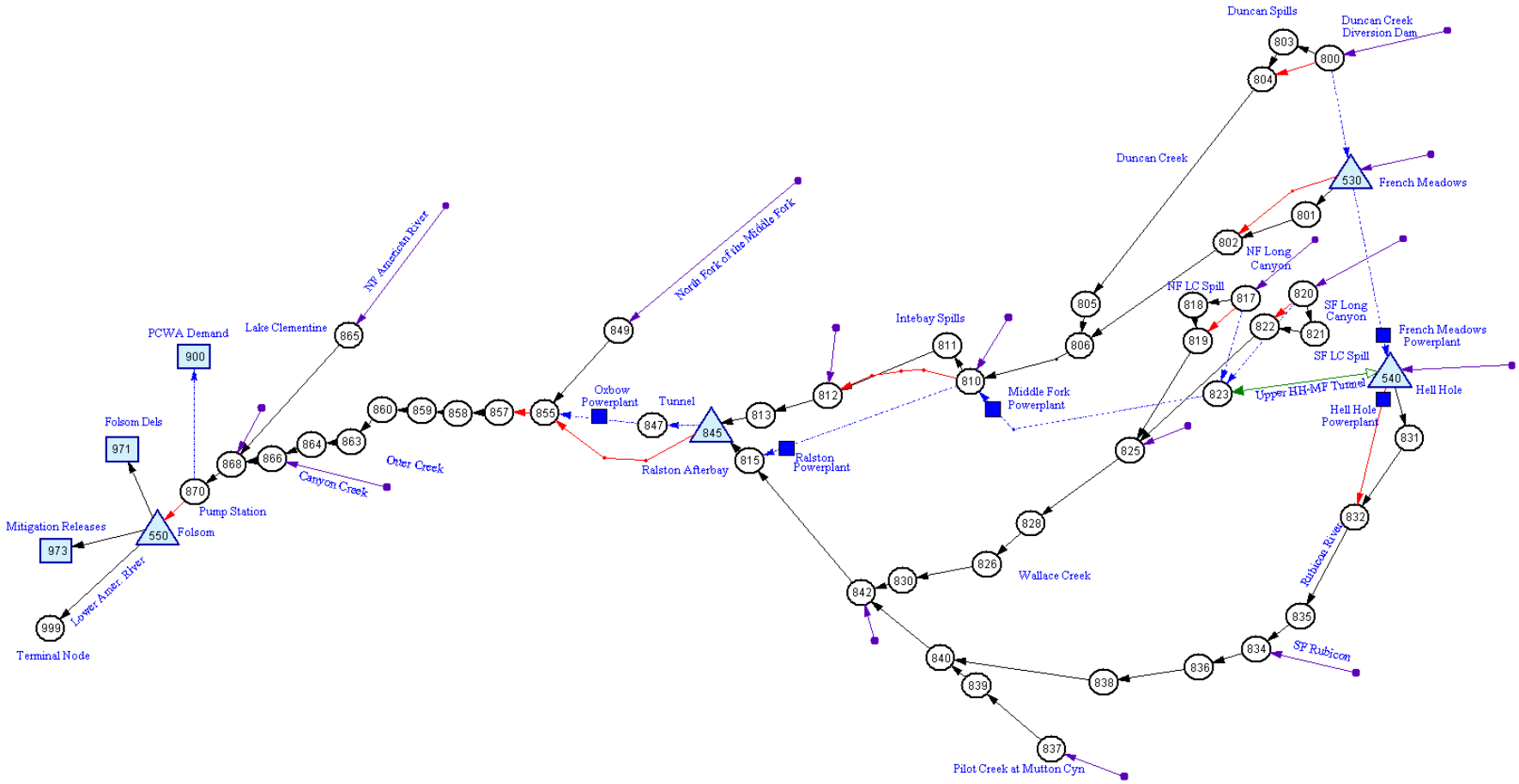
Project Model Schematic



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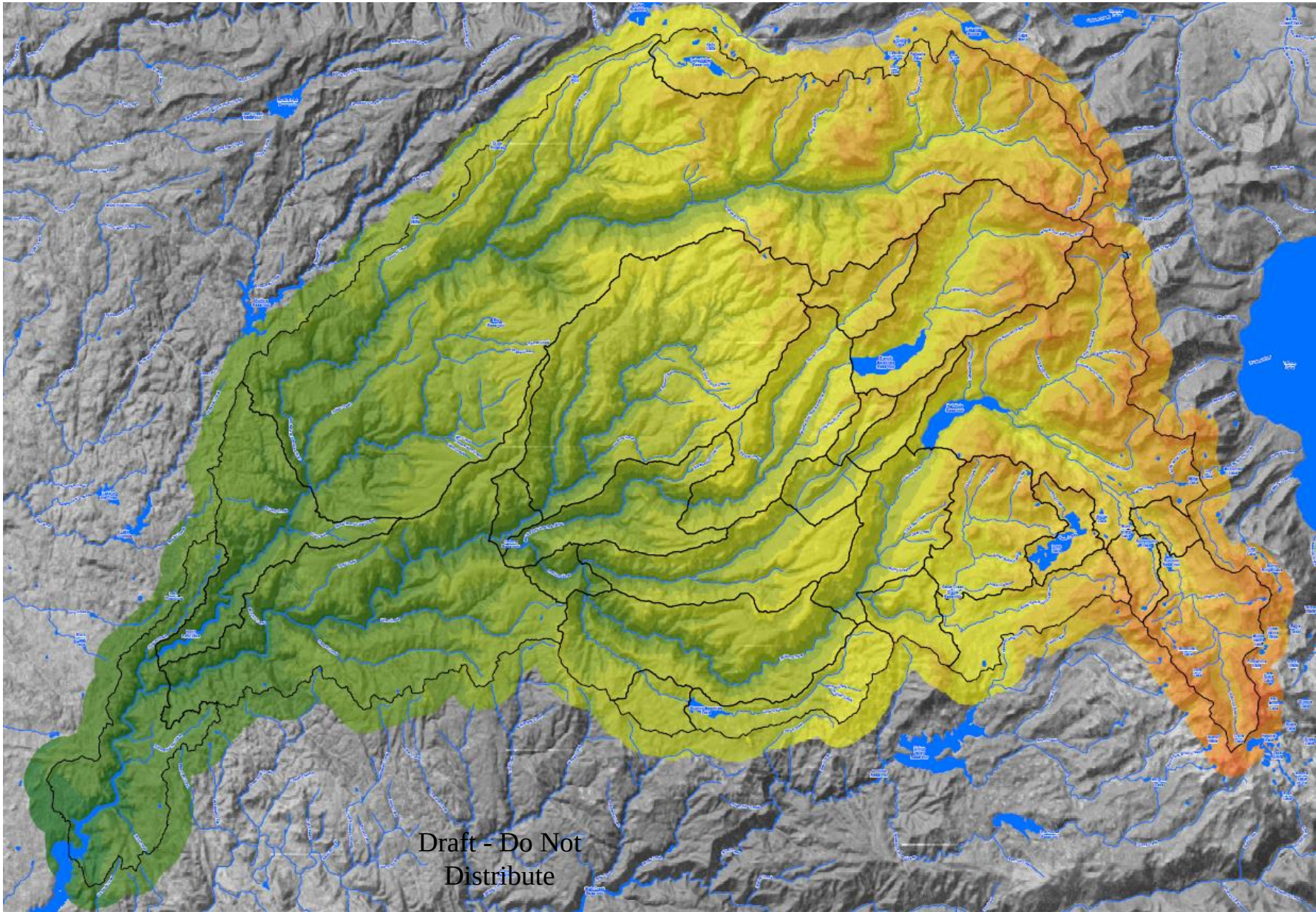
Hydrology



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Hydrology

- Monthly unimpaired hydrology, 1922 - 2011
- Daily unimpaired hydrology, 1975 - 2011
- Rubicon River, South Fork Rubicon, Pilot Creek, and North Fork American are impaired by upstream operators (SMUD, GDPUD, FPUD, PG&E)
- Historic releases on the North Fork from FPUD and PG&E are preserved in the hydrology
- A small spreadsheet model was built for Pilot Creek to estimate Pilot Creek outflows throughout the 1922-2011 hydrology with current operations.
- An Oasis model of the Upper SMUD system was run with the unimpaired hydrology to develop SMUD outflows on the Rubicon and SF Rubicon Rivers.

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Water Balance Model - Structure

- Mass balance tracking tool
  - Daily time step according to a set of operational rules
  - Limited by the physical capacities of the Project facilities
  - Uses unimpaired inflow calculated based on historic hydrology records
- Inflow into Project facilities is either:
  - Routed into storage
  - Released through MFP generation facilities
  - Bypassed to downstream reaches
  - Spilled
- Diversions to and from storage and generation change daily in response to a set of programmed priorities

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Water Balance Model - Priorities

- MFP Water Balance Model priorities include:
  - Operating within water rights restrictions
  - Meeting all minimum release requirements
  - Meeting all minimum storage requirements
  - Meeting consumptive water supply demands
  - Meeting Water Forum Agreement committments
  - Filling reservoirs without spilling
  - Arriving at an end of year carryover storage target
  - Taking a maintenance period each year
  - Generating electricity during periods of highest energy demand

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Water Year Indices

- Middle Fork Project Water Year Types
  - Based on Water-Year Unimpaired Inflow to Folsom Reservoir
  - Used to set minimum reservoir storage and minimum instream flow requirements
  - Six water year types (Wet, Above Normal, Below Normal, Dry, Critical, Extreme Critical)
  - Monthly updates (February through May) based on DWR Bulletin 120 Folsom Unimpaired Inflow forecast
- American River Water Forum Index
  - March through November Unimpaired Inflow to Folsom Reservoir
  - Used to determine environmental releases and consumptive demand levels

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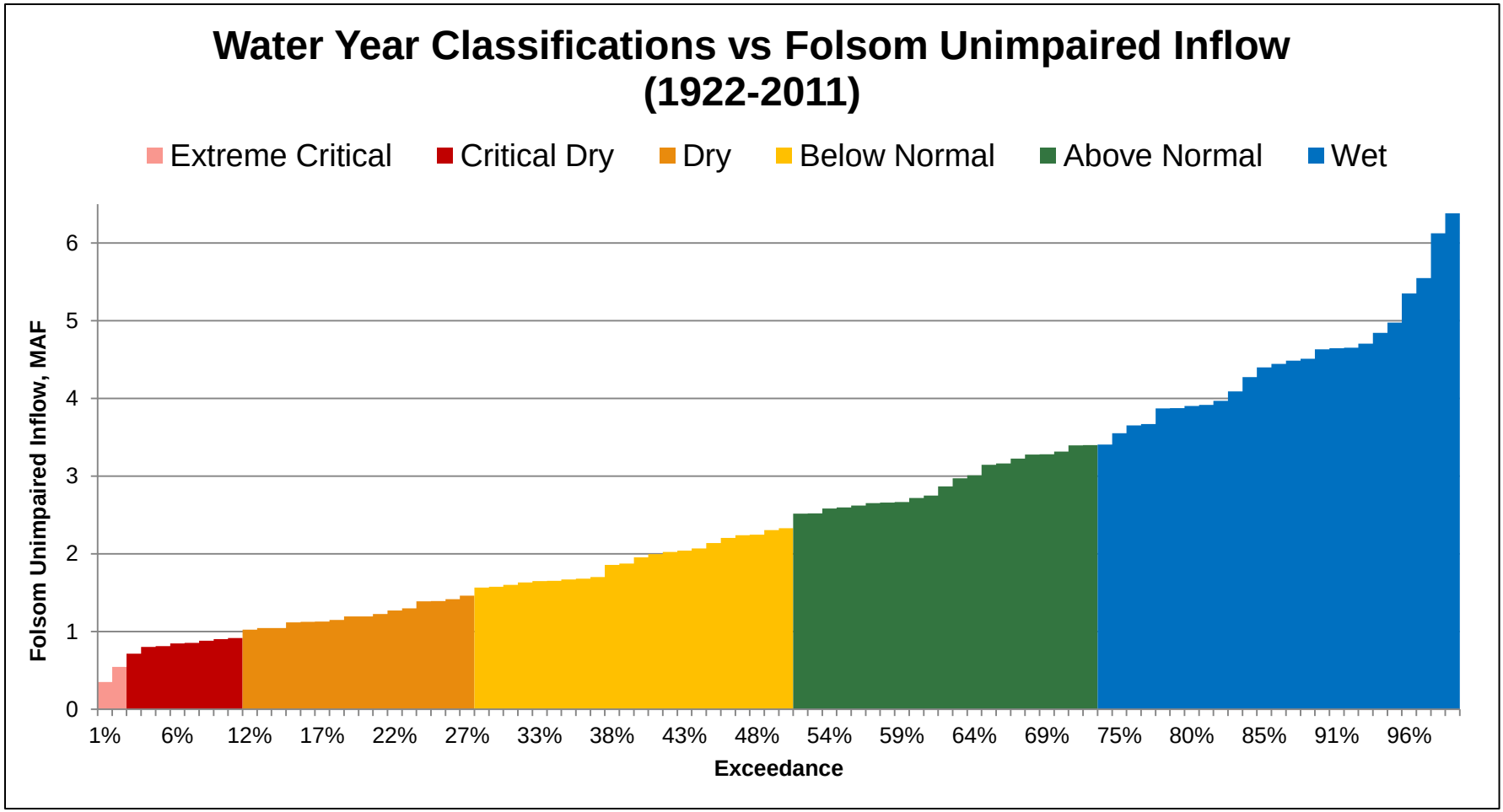
Water Year Types



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Physical Capacities

Facility	Capacity
French Meadows Reservoir	134,993 AF
Hell Hole Reservoir	215,178 AF
Ralston Afterbay	2,782 AF
Duncan Creek Diversion Tunnel	400 cfs
SF Long Canyon Diversion Tunnel	100 cfs
NF Long Canyon Diversion Tunnel	200 cfs
French Meadows Powerhouse	400 cfs
Middle Fork Powerhouse	924 cfs
Ralston Powerhouse	940 cfs
Oxbow Powerhouse	1000 cfs
Hell Hole Powerhouse	80 cfs
American River Pump Station	200 cfs

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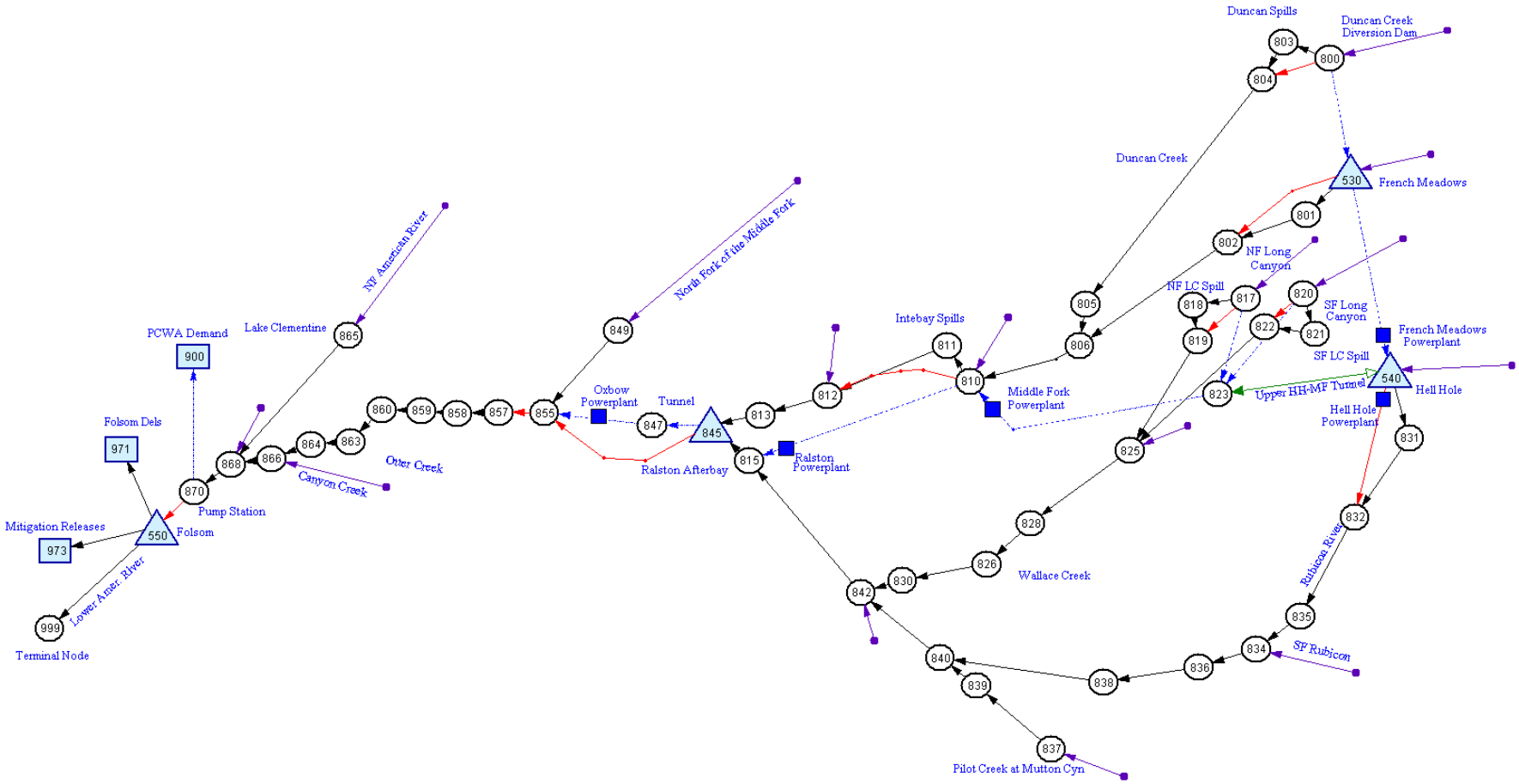
Water Rights Limitations

- Consumptive direct diversions from North Fork American River are only allowed November through June. July through October consumptive deliveries come from rediversion only.

Instream Flow Requirements

- The MFP is currently required to maintain minimum instream flow at 9 locations as a condition of the new MFP FERC license
- Required flows vary by water year type and time of year
- The MFP has Pulse Flow Requirements at 5 of these locations.
- The MFP has recreational release requirements below Oxbow Powerhouse.

Instream Flow Requirements



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Instream Flow Requirements - Example

Duncan Creek Below Duncan Diversion Dam						
	Month	Minimum Streamflow by Water Year (cfs)				
		EC/C	DRY	BN	AN	WET
	OCT	4 or NF	8 or NF	8 or NF	8 or NF	8 or NF
	NOV	4 or NF	8 or NF	8 or NF	8 or NF	8 or NF
	DEC	4 or NF	8 or NF	8 or NF	8 or NF	8 or NF
	JAN	4 or NF	8 or NF	8 or NF	8 or NF	8 or NF
	FEB	4 or NF	8 or NF	8 or NF	8 or NF	8 or NF
	MAR 1-14	4 or NF	8 or NF	8 or NF	8 or NF	8 or NF
	MAR 15-31	9 or NF	11 or NF	13 or NF	16 or NF	16 or NF
	APR	13 or NF	14 or NF	17 or NF	24 or NF	24 or NF
	MAY	13 or NF	14 or NF	17 or NF	24 or NF	24 or NF
	JUNE	7 or NF	7 or NF	9 or NF	12 or NF	12 or NF
	JULY	No Div[2]	No Div[2]	No Div[2]	No Div[2]	No Div[2]
	AUG	No Div[2]	No Div[2]	No Div[2]	No Div[2]	No Div[2]
	SEPT	No Div[2]	No Div[2]	No Div[2]	No Div[2]	No Div[2]

[1]NF: Natural Flow

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Minimum Storage Levels

Reservoir	Water Year Type (based on American River Unimpaired Flow Below Folsom Lake (ac-ft) Bulletin 120 Forecast[1]	Date Range	WSE[2] (ft)	Date Range	WSE (ft)
French Meadows Reservoir	Wet	6/1–9/15	5,220	9/16–5/31	5,152
	Above Normal	6/1–9/15	5,220	9/16–5/31	5,152
	Below Normal	6/1–9/15	5,220	9/16–5/31	5,152
	Dry	6/1–9/1	5,200	9/2–5/31	5,152
	Critical	6/1–9/1	5,175	9/2–5/31	5,152
	Extreme Critical	6/1–9/1	5,175	9/2–5/31	5,120
Hell Hole Reservoir	Wet	6/1–Labor Day	4,530	After Labor Day–5/31	4,451
	Above Normal	6/1–Labor Day	4,530	After Labor Day–5/31	4,451
	Below Normal	6/1–Labor Day	4,530	After Labor Day–5/31	4,402
	Dry	6/1–9/1	4,485	9/2–5/31	4,402
	Critical	6/1–9/1	4,455	9/2–5/31	4,402
	Extreme Critical	6/1–9/1	4,404	9/2–5/31	4,341

[1] Unimpaired run-off of American River to Folsom Lake for current year, October 1 through September 30, as estimated by the DWR Bulletin 120 on or about the beginning of May.
[2] WSE: water surface elevation

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Maintenance Periods

- French Meadows Powerhouse Maintenance
  - 9 Days, beginning first Monday in May
- Middle Fork Powerhouse, Ralston Powerhouse, Oxbow Powerhouse, and Ralston Afterbay Maintenance
  - 30 Days, beginning first Monday in October.

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Consumptive Demand

- The Middle Fork Project has two points of diversion for consumptive water
  - American River Pump Station
  - Folsom Reservoir
- Monthly pattern based on recent observation
  - Daily pattern is represented by equally distributing the monthly demand
- Existing consumptive demand is 42 TAF
- Build-out demand is 120 TAF

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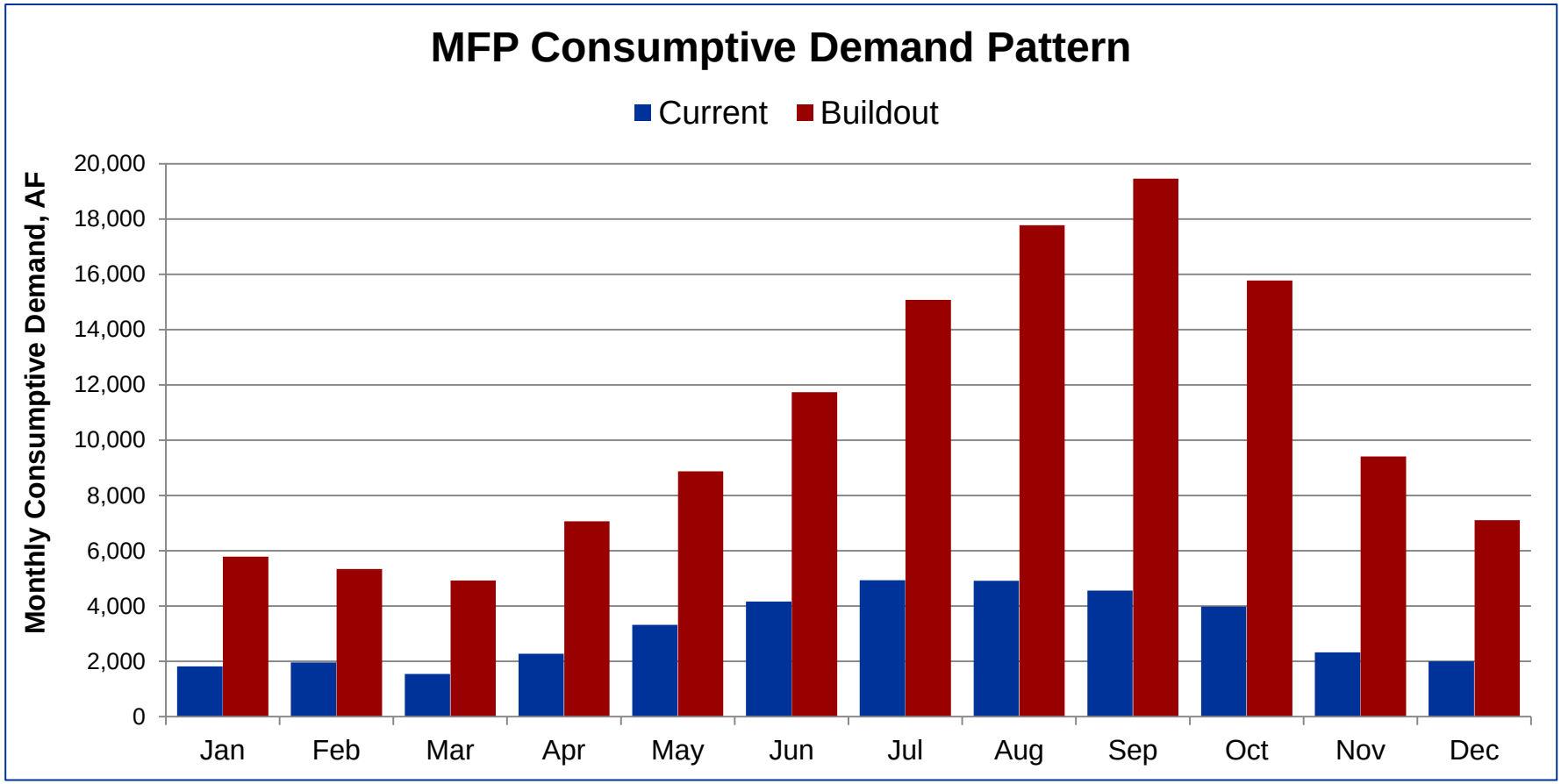
Consumptive Demand



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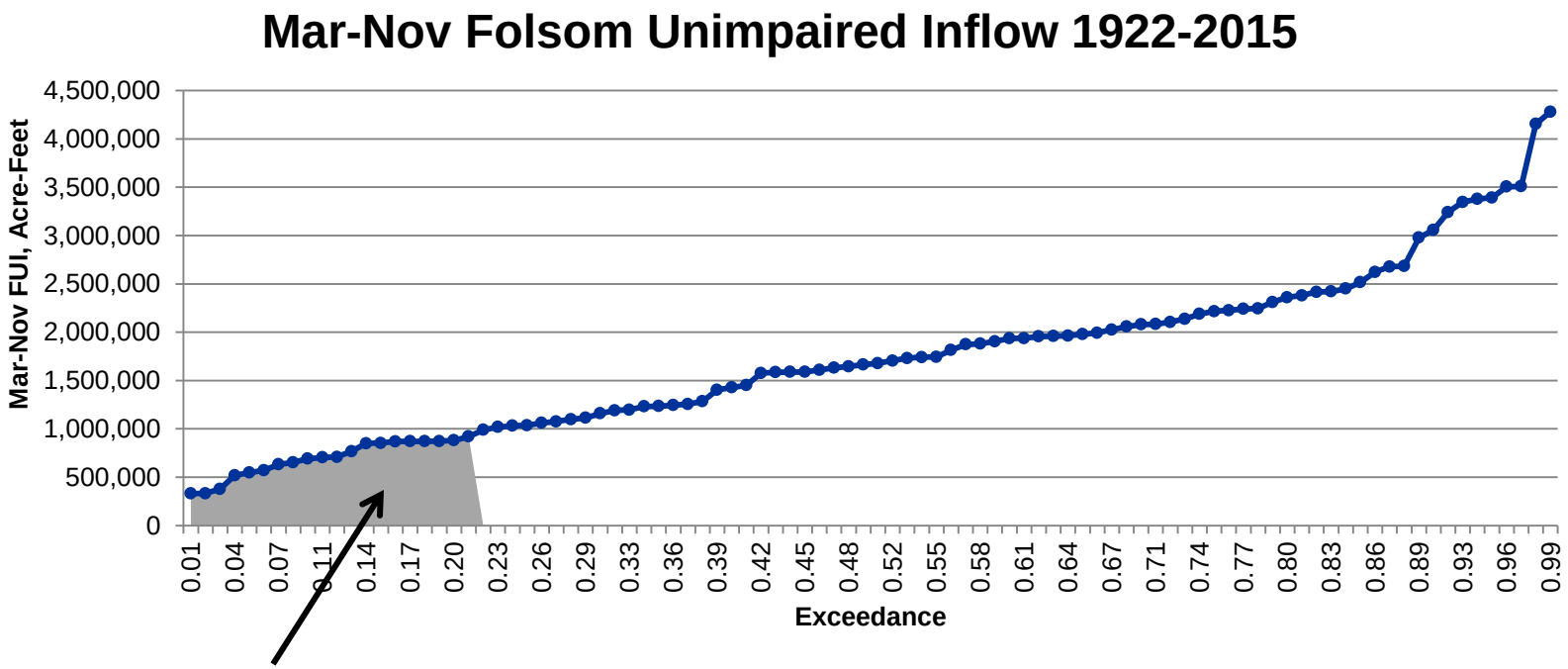
American River Water Forum Releases

- American River Water Forum actions are taken when Mar-Nov Folsom Unimpaired Inflow is less than 950,000 AF



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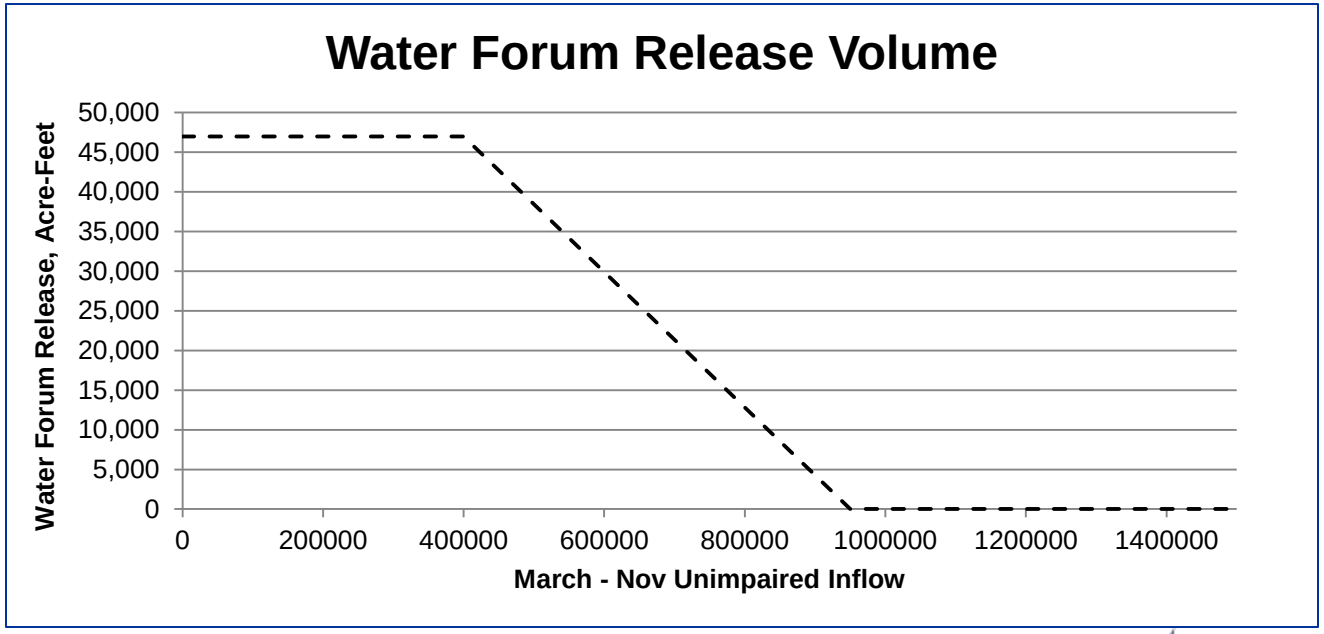
American River Water Forum Releases

- PCWA Releases up to 47,000 AF of environmental releases in the driest years
- Environmental Releases are spread evenly over May through September



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Other Water Transfers

- Historically, PCWA has done several one-time water transfers to various buyers
- Potential water transfer years are identified based on available Delta export capacity and CVP allocations
- These water transfers are sometimes included in long term planning studies

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Reservoir Operations Overview

- Diversion Dam Operations
- Runoff Forecasts
- Carryover Storage Targets
- Reservoir Fill Logic
- Reservoir Dispatch Logic
- Afterbay Operations
- American River Pump Station Operations
- Consumptive Deliveries

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Diversion Dam Operations

- Diversion Dams are mostly passive systems
- During spills at French Meadows, Diversions from Duncan are shut off
- During Spills at Hell Hole, Diversions from NF and SF Long Canyon are shut off

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Runoff Forecasts

- To avoid using perfect knowledge of inflow, the model can use DWR Bulletin 120 runoff forecasts

- B120 runoff forecasts are only available beginning 1975, so longer period simulations use actual inflow as a proxy for Bulletin 120 runoff forecasts

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Carryover Storage Targets

- The Model is operated to an end-of-year (December 31) combined storage target
- The combined storage target is intended to ensure that the MFP carries over sufficient water to meet the following year's demands in the event of a dry year, but also ensure sufficient vacant reservoir capacity to allow runoff to be captured in the event of a wet year
- Historic combined carryover storage targets have ranged from over 165 TAF to less than 100 TAF
- The combined storage target is set at 150 TAF in the model

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Carryover Storage Targets

- The carryover storage target is reduced from the normal-year target by the amount of any Water Forum mitigation releases or water transfers and held at the reduced level until Folsom Reservoir refills

- Every mitigation release and transfer assumes a refill agreement with USBR similar to recent PCWA-USBR refill agreements

Reservoir Fill Logic

- Operating goal is to fill Middle Fork Project reservoirs without spilling
- Runoff forecasts are incorporated to estimate inflow
- Drier year fill date is May 31, wetter year fill date is June 30
- Model will generate electricity during the spring (fill period) when projections indicate that there is more water available than needed to fill the reservoir and meet downstream obligations

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Reservoir Dispatch Logic

- During the dispatch cycle, the model looks ahead to the end-of-year carryover storage target to assign a volume of water which is needed to meet requirements and consumptive demands

- Remaining water in excess of other obligations is available to be used to generate electricity at the times of highest demand

- Volume available for generation is updated bi-monthly

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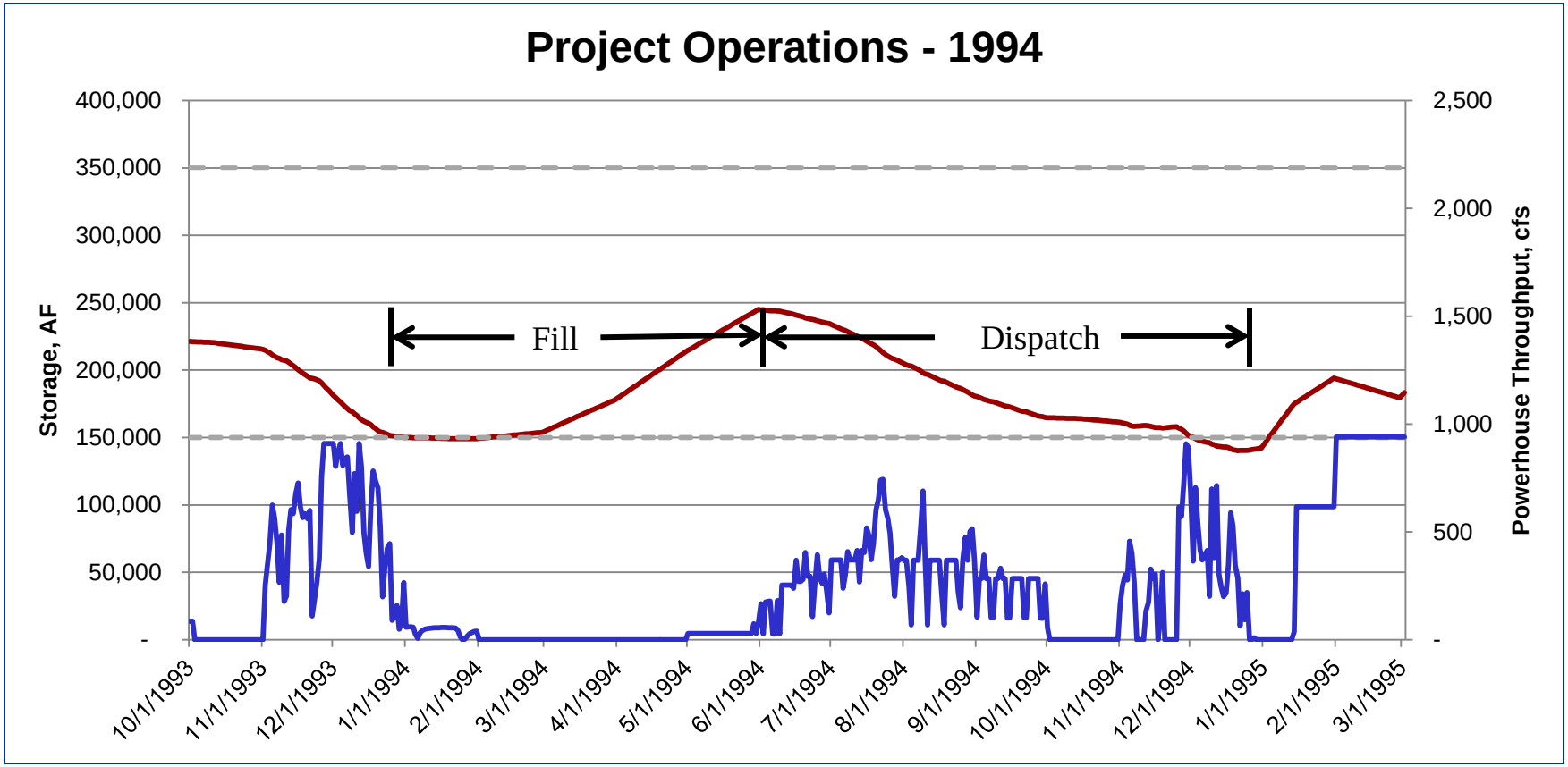
Model Fill-Dispatch Cycles

- Dry Year



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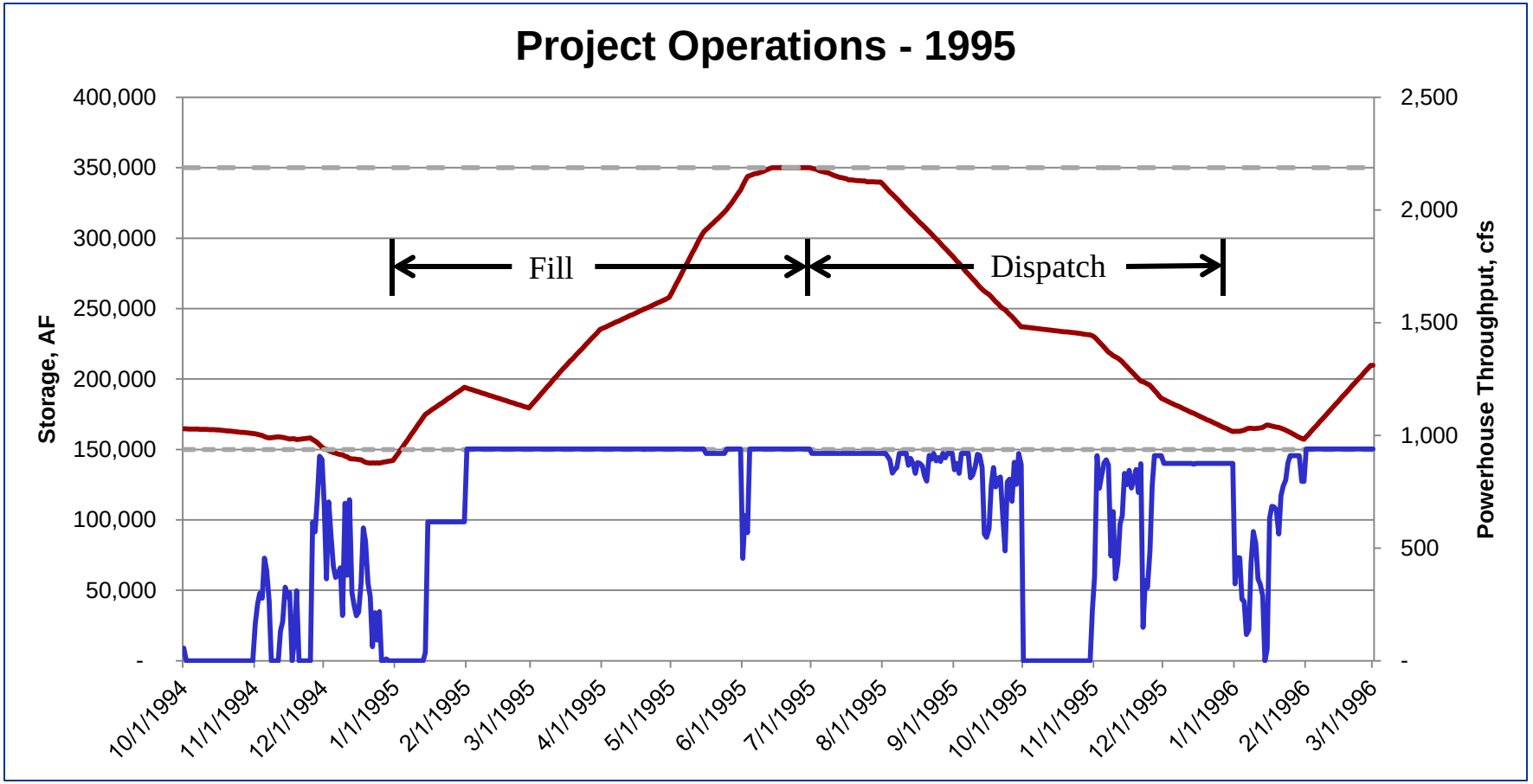
Model Fill-Dispatch Cycles

- Wet Year



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Hydro Generation Demand

- The Model uses generation dispatch curves to determine the volume of water per day of generation given a volume of water available for the season
  - Based on 2006 Cal ISO Electricity Prices as a proxy for electricity demand
- The dispatch curve shapes seasonal generation releases to days with higher overall energy demand
- The Model operates the powerhouses during days that have the highest value

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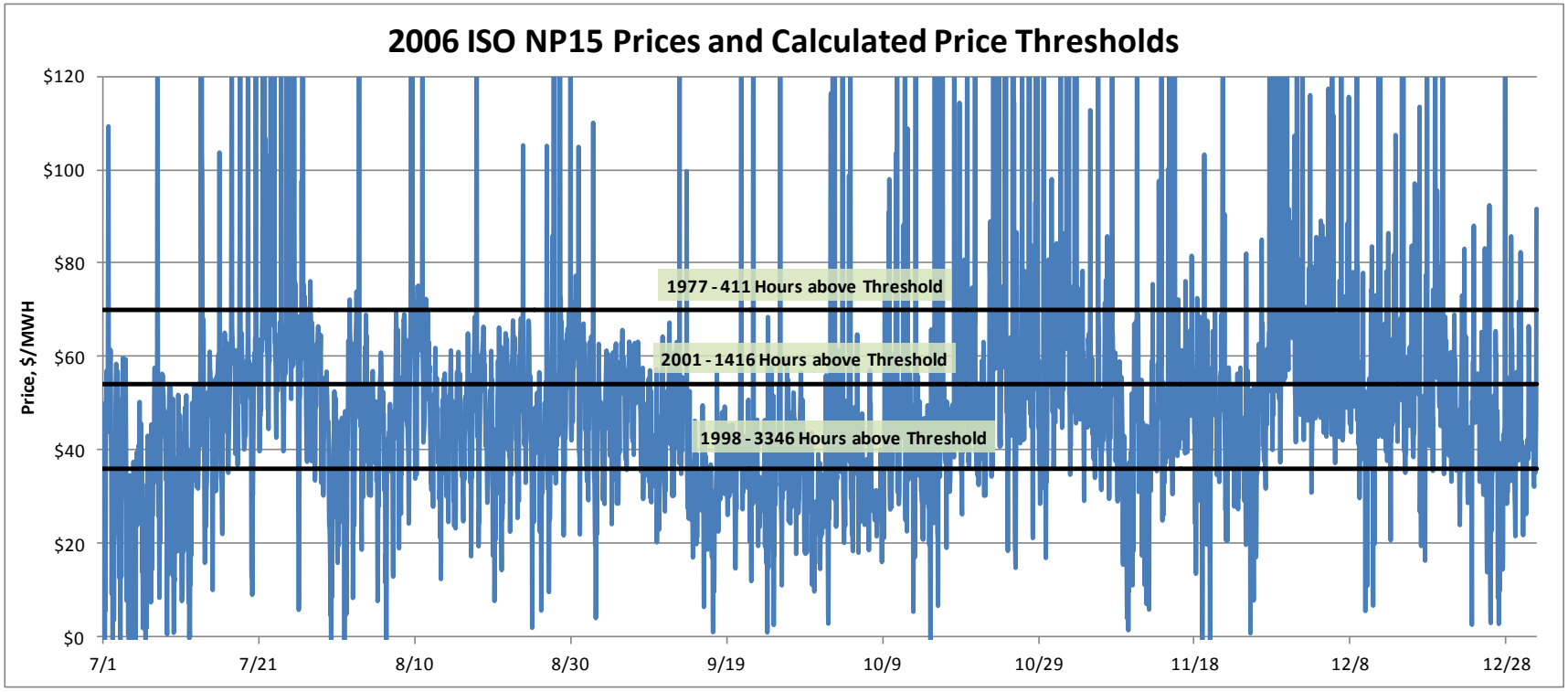
Hydro Generation Demand



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Interbay / Afterbay Operations

- Ralston and Middle Fork powerhouses are operated synchronously
  - Middle Fork Interbay modeled with no storage capacity
  - Middle Fork powerhouse is occasionally curtailed to take advantage of accretion flows into Interbay
- In the daily model, generally there is no net change in Afterbay storage
- Detailed Afterbay operations are captured in the hourly model

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Hourly Model

- Used to evaluate Oxbow powerhouse and Ralston Afterbay operations effects on the peaking reach
- Daily and hourly models run sequentially, changes to the hourly model can require changes to daily model
- Redistributes the daily model output, using an hourly power demand index
- Includes travel time in the peaking reach

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Hourly Model

- Ralston powerhouse and Oxbow powerhouse may not operate synchronously
- Afterbay storage fluctuations allow disconnected operations
- Afterbay has limited storage volume

- “Dead band” at top of active storage prevents overtopping
- “Dead band” at bottom of active storage prevents vortex formation

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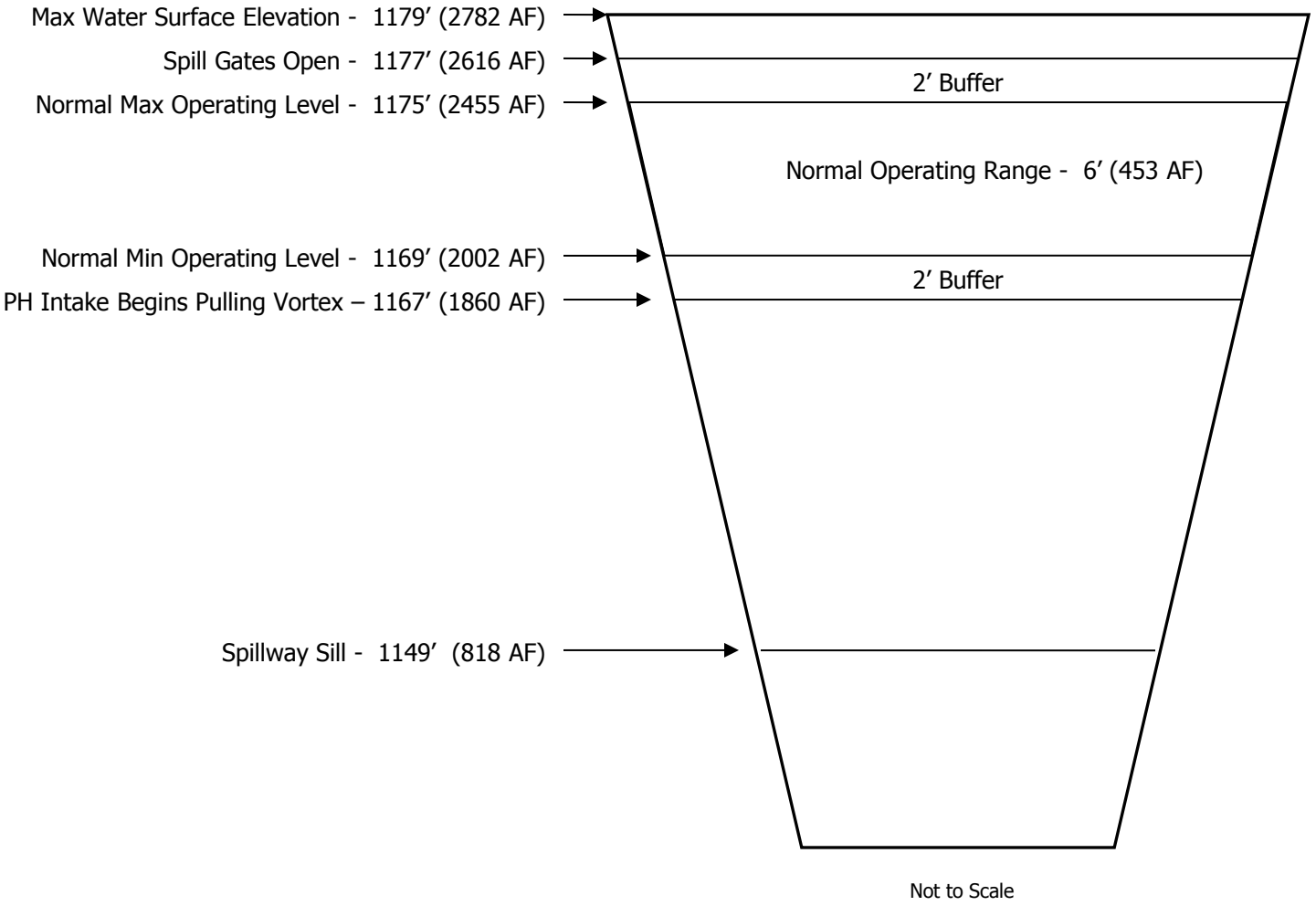
Afterbay Constraints



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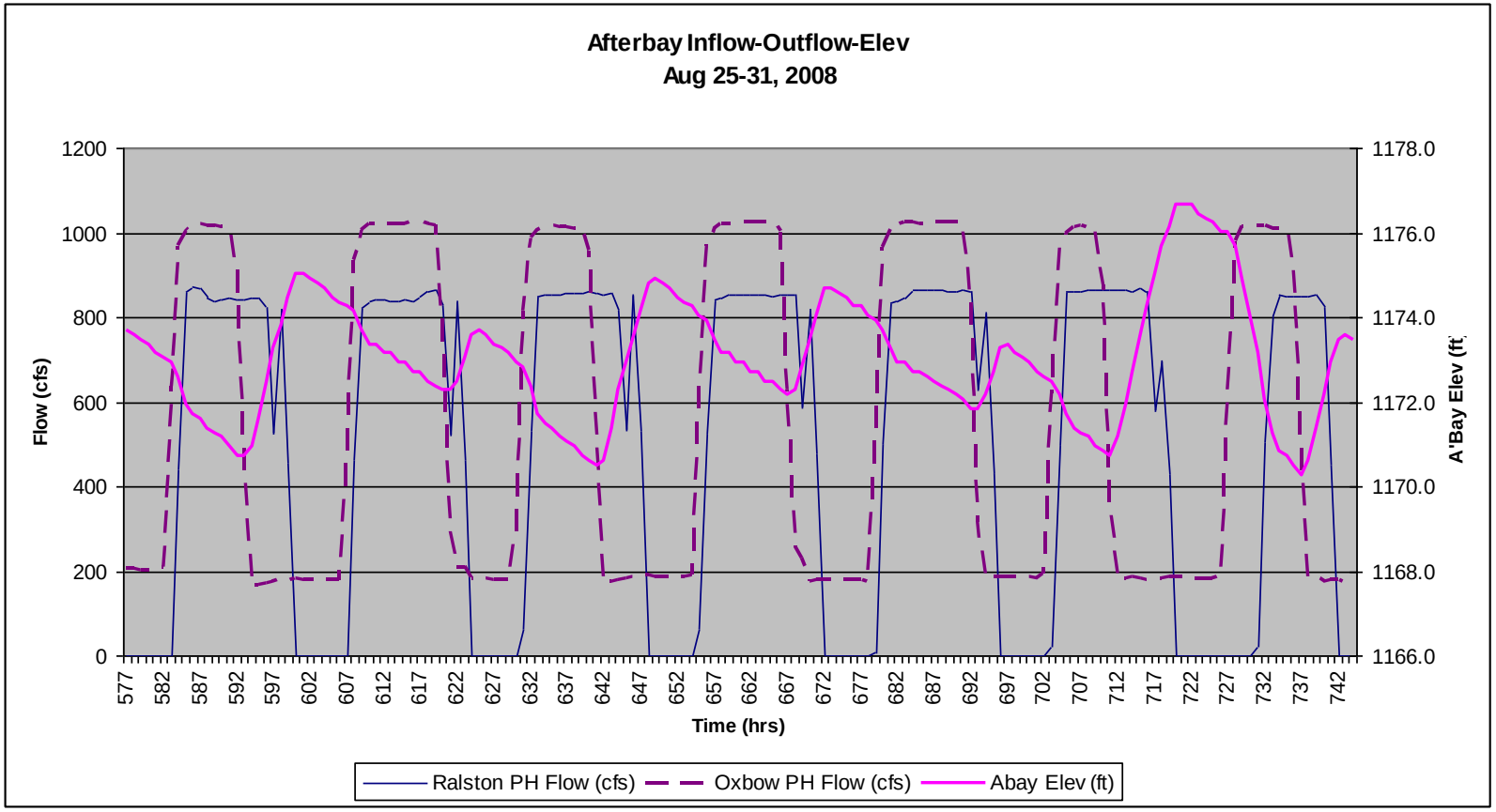
Hourly Model



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American River Pump Station

- American River Pump Station (ARPS) diverts from the North Fork American just below the confluence with the Middle Fork
- 75 cfs minimum flow requirement below the ARPS
- Model ensures that flow into Folsom Reservoir is at least equal to PCWA consumptive demands at Folsom for each day of simulation (no storage or ponding at Folsom)

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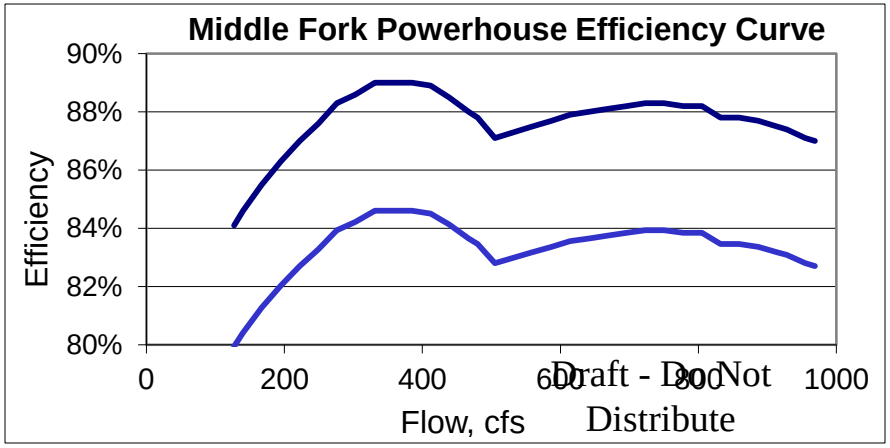
Output Metrics

- The model computes generation at each facility using
  - Generation = Flow * Head * Efficiency
- Efficiency vs Flow relationships at each PH
- Tunnel Head Losses vs Flow relationships at each PH



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Output Metrics

- The model prepares output of the North Fork American formatted for inflow to Calsim
- The model prepares storage output formatted for use in Calsim Folsom Flood Control Pool calculations
- Model Deliveries can used as consumptive demands in Calsim

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The End

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