Daily Reservoir Operations Models for Exploring Increased Multi-Purpose Benefits

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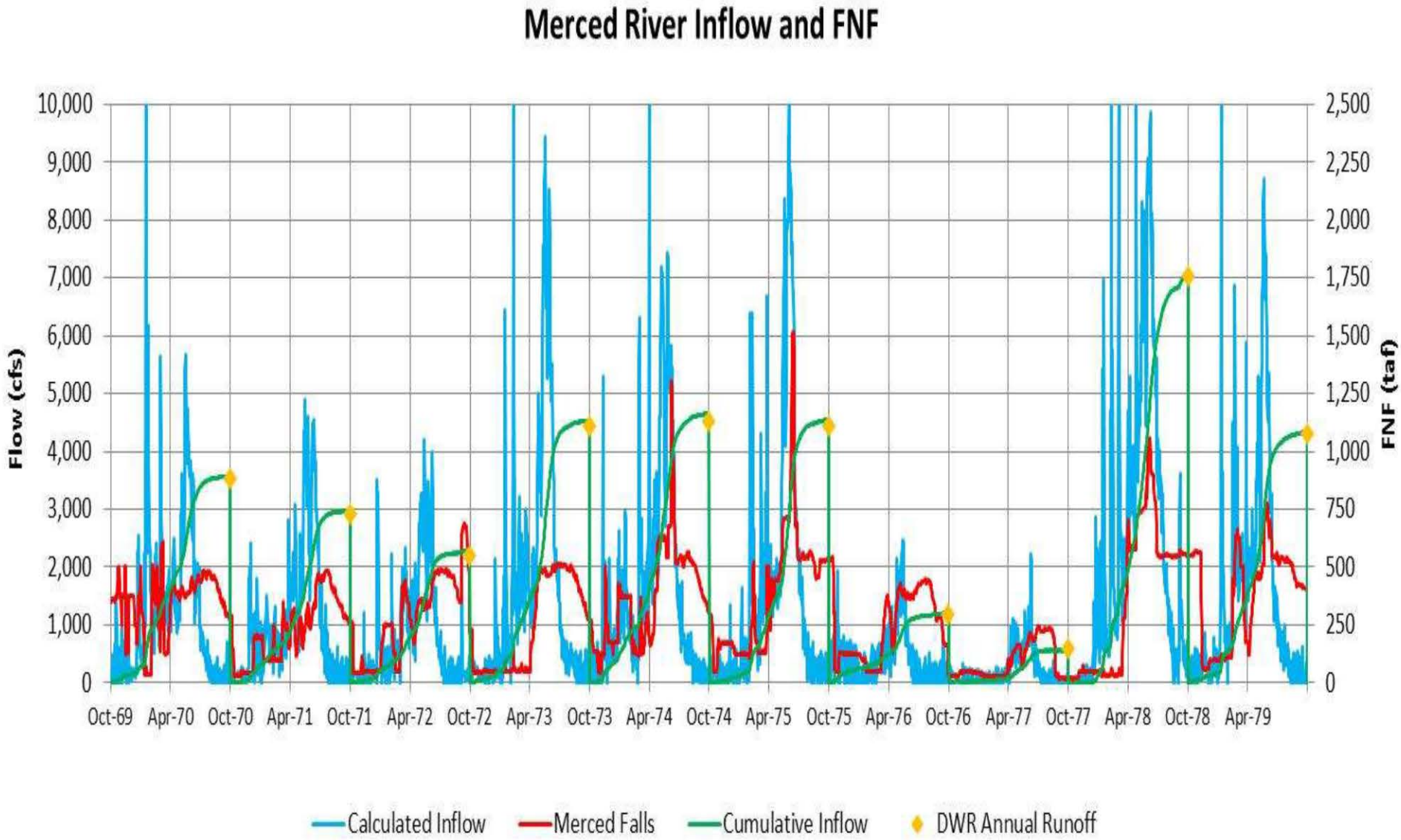
Daily Reservoir Model Ingredients

- Inflow-Full Natural Flow or Upstream Reservoir Releases
- Reservoir Geometry (Elevation-Area-Volume)
- Maximum Flood-Control Storage and Release Flows
- Water Supply Diversion Targets (Seasonal x Allocation)
- Minimum Release Flow Targets (Fish Flows and Downstream Diversions)
- Downstream Flow Benefits (Energy, Temperature, Inundation)
- Carryover Storage Benefits for drought protection and cool temperatures (Minimum storage, maximum drawdown)
- Daily Historical Reservoir Operations Data for Calibration and Comparison

Daily Inflow Patterns (storm events)



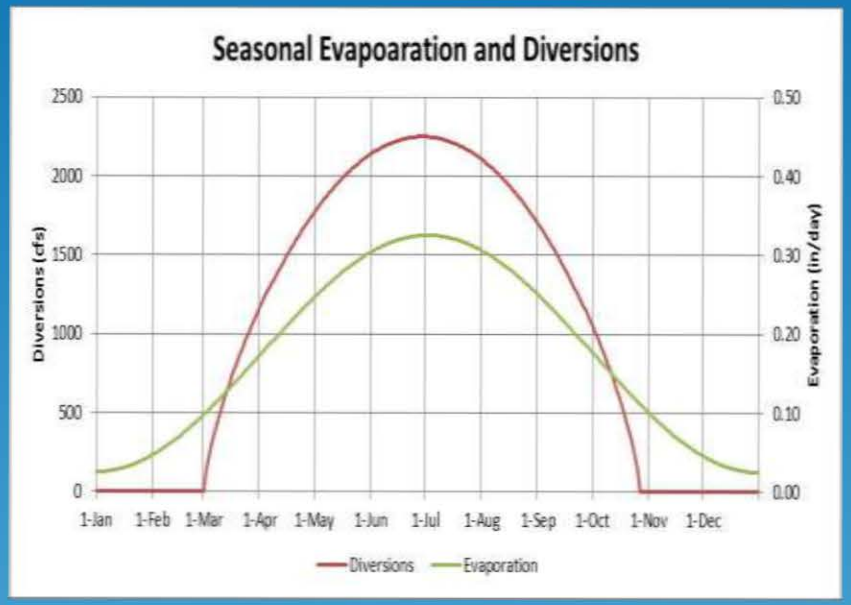
Parameters that can be Specified in the Daily Reservoir Operations Model:

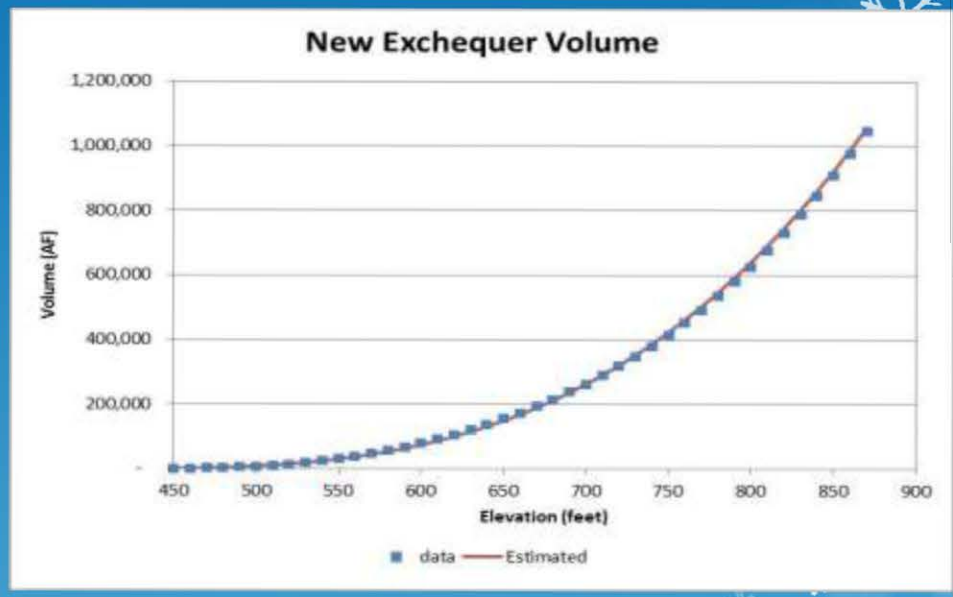
- Maximum flood-control storage (4 date-storage points)
- Maximum release and days for release (above FC)
- Water-Year Index (5 year-types by runoff)
- Minimum releases (month x year-type)
- Percent of full natural flow releases (month x year- type)
- Reservoir evaporation (daily maximum, shape)
- Seasonal Diversion targets (begin, end, min, max, shape)
- Monthly Downstream Riparian Diversions
- Minimum carryover storage
- Water allocation (%target) forecast (March 1) as fraction of runoff and available storage (above minimum carryover)
- Flood control storage buffer (taf) and fish habitat target flow (for extended inundation benefits)

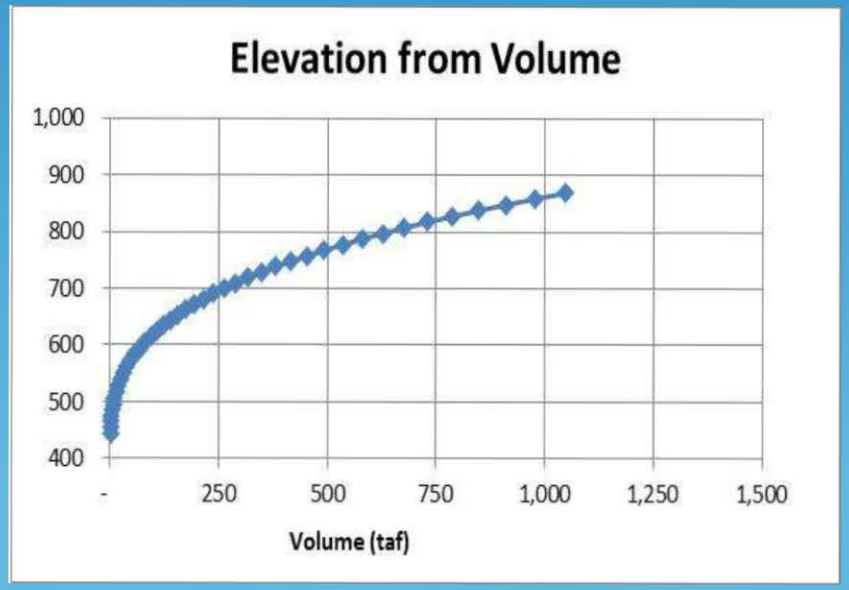
Here are the Model Controls

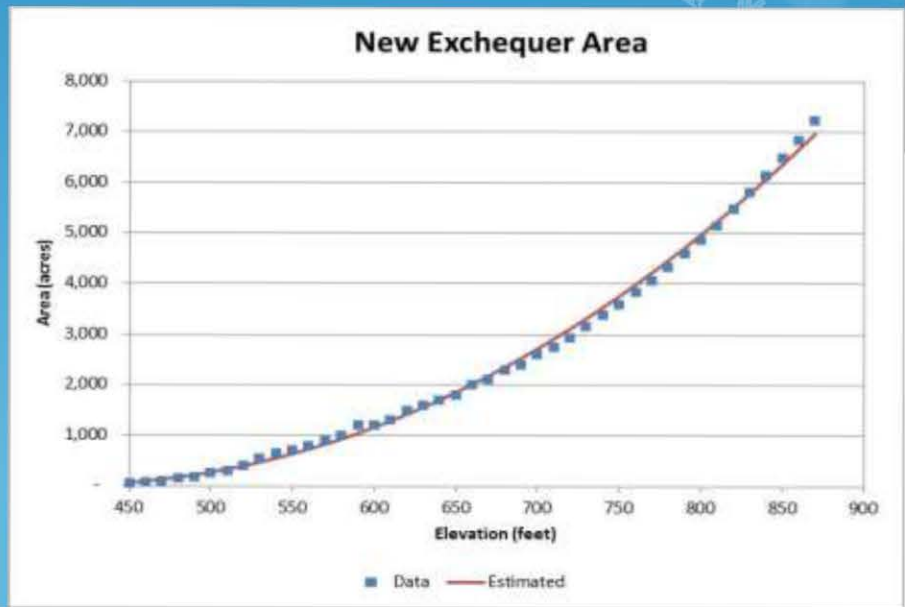
Target Fish Flows			Switch year type in march			Flow at Shaffer Bridge or Stevinson						Maximum Flow		C-H to
Fraction of Unimpaired Flow (Range=FRUN)						**Minimum Flow (Range = MinQ)**						**(Range = MaxQ)**		**Shaffer**
Month	C	D	BN	AN	W	Month	C	D	BN	AN	W	Month	Maximum	Diversions
1	0	0	0	0	0	1	150	150	150	150	150	1	1500	0
2	0	0	0	0	0	2	150	150	150	150	150	2	1500	0
3	0	0	0.4	0.4	0.4	3	150	150	150	150	150	3	1500	25
4	0	0	0.4	0.4	0.4	4	150	150	150	150	150	4	1500	100
5	0	0	0.4	0.4	0.4	5	150	150	150	150	150	5	1500	125
6	0	0	0	0	0	6	150	150	750	750	750	6	1500	150
7	0	0	0	0	0	7	150	150	150	150	150	7	1500	150
8	0	0	0	0	0	8	150	150	150	150	150	8	1500	125
9	0	0	0	0	0	9	150	150	150	150	150	9	1500	100
10	0	0	0	0	0	10	300	300	300	300	300	10	1500	25
11	0	0	0	0	0	11	150	150	150	150	150	11	1500	0
12	0	0	0	0	0	12	150	150	150	150	150	12	1500	0
13	1	1	1.25	1.25	1.25	13	0	0	0	0	0			
	Starting Volume (af)						118	118	154	154	154			48
	700,000						taf/yr	taf/yr	taf/yr	taf/yr	taf/yr			taf/yr
	Day for allocation				Spill (af)									WSE2 includ
	60		Canals		1025000		Flow Objective Location							
	Min Delivery Fraction		Maximum		Flood		1							
	0.25		2000		Release		0=Shaffer		This case has no additional target flow in C and D years.					
			begin day		6000		1=Stevinson		and no target flow in Feb; 750 in June of BN AN and W years.					
			60		Buffer				Additional delivery in BN AN and W if Delivery fraction is > 0.8					
	Carryover (af)		end day		Release				[Specified in Model cell O6] Delivery Fraction is in row 13 of FRUN (above					
	300,000		300		1500									
	Delivery Target (af)		Total Delivery		Buffer (af)									
	584,089		606,104		25000									
	Annual Drawdown		Northside		Days for Release									
	0.50		0.05		10	(Used for flood release and buffer release)								
	Year Type Basis		Main Canal		Fish Flows									
	3		0.95		1									
					1=Based on combination of monthly minimum flows and percent unimpaired									
	1=SJ Valley Index				2=Based on daily NMFS RPA requirements									
	2=Index based on SJ Valley unimpaired flow													
	3=Index based on Merced unimpaired flow													
	4=Mar 1 Storage + Mar through Sep unimpaired flow - Carryover													

Examples of Daily Variations Calculated from Model Parameters

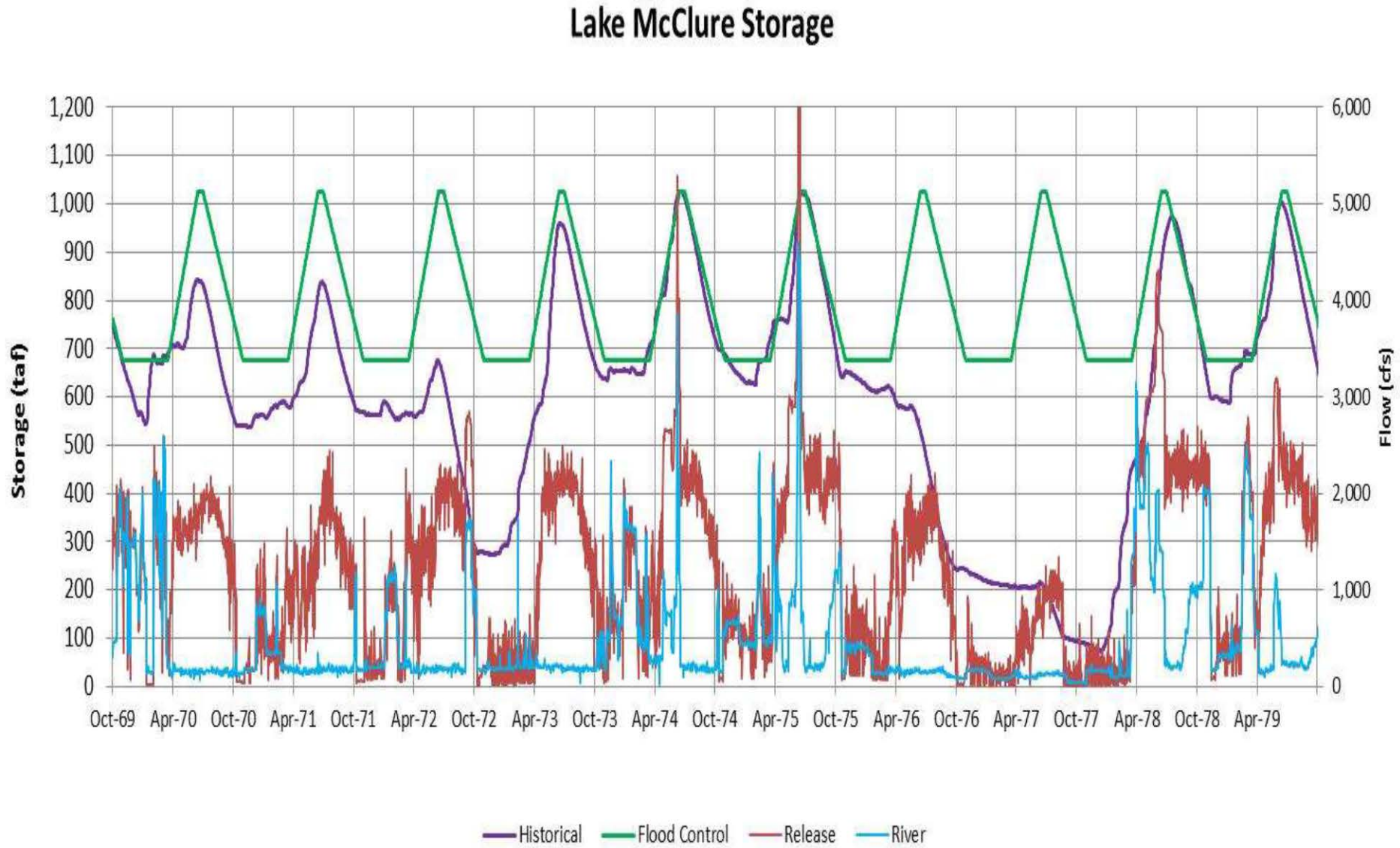




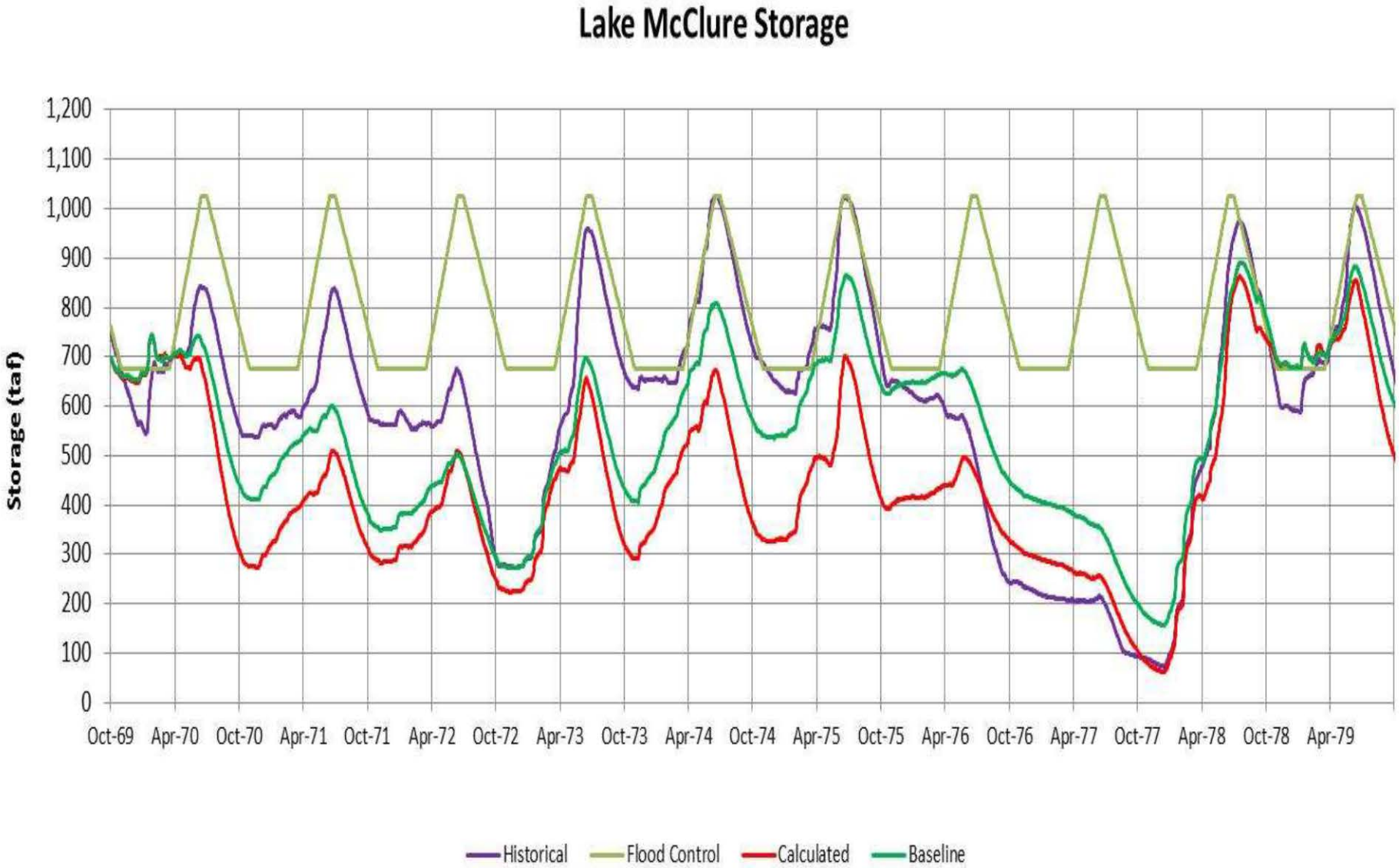




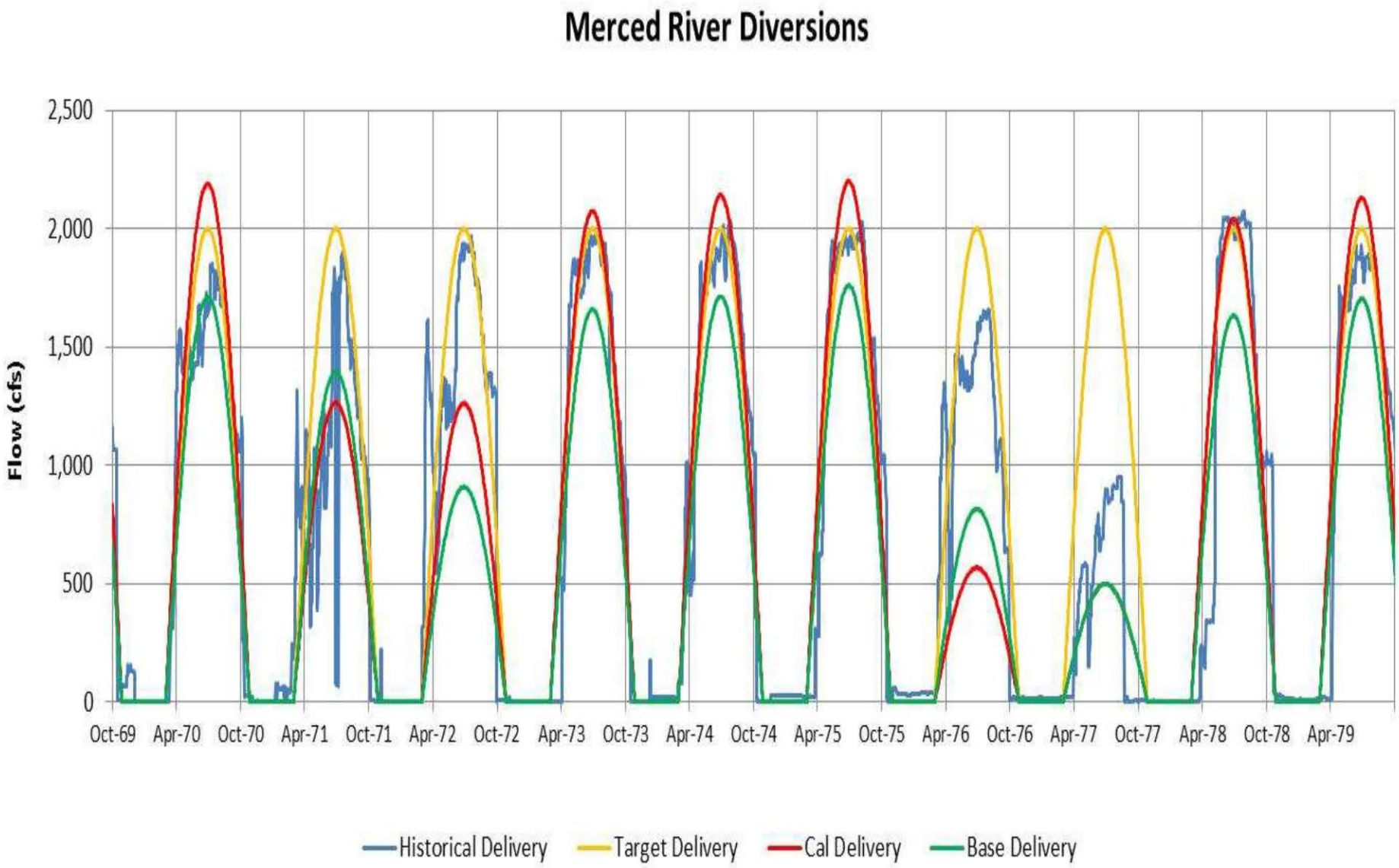
Reservoir Operations are a Daily Decision-Making Process



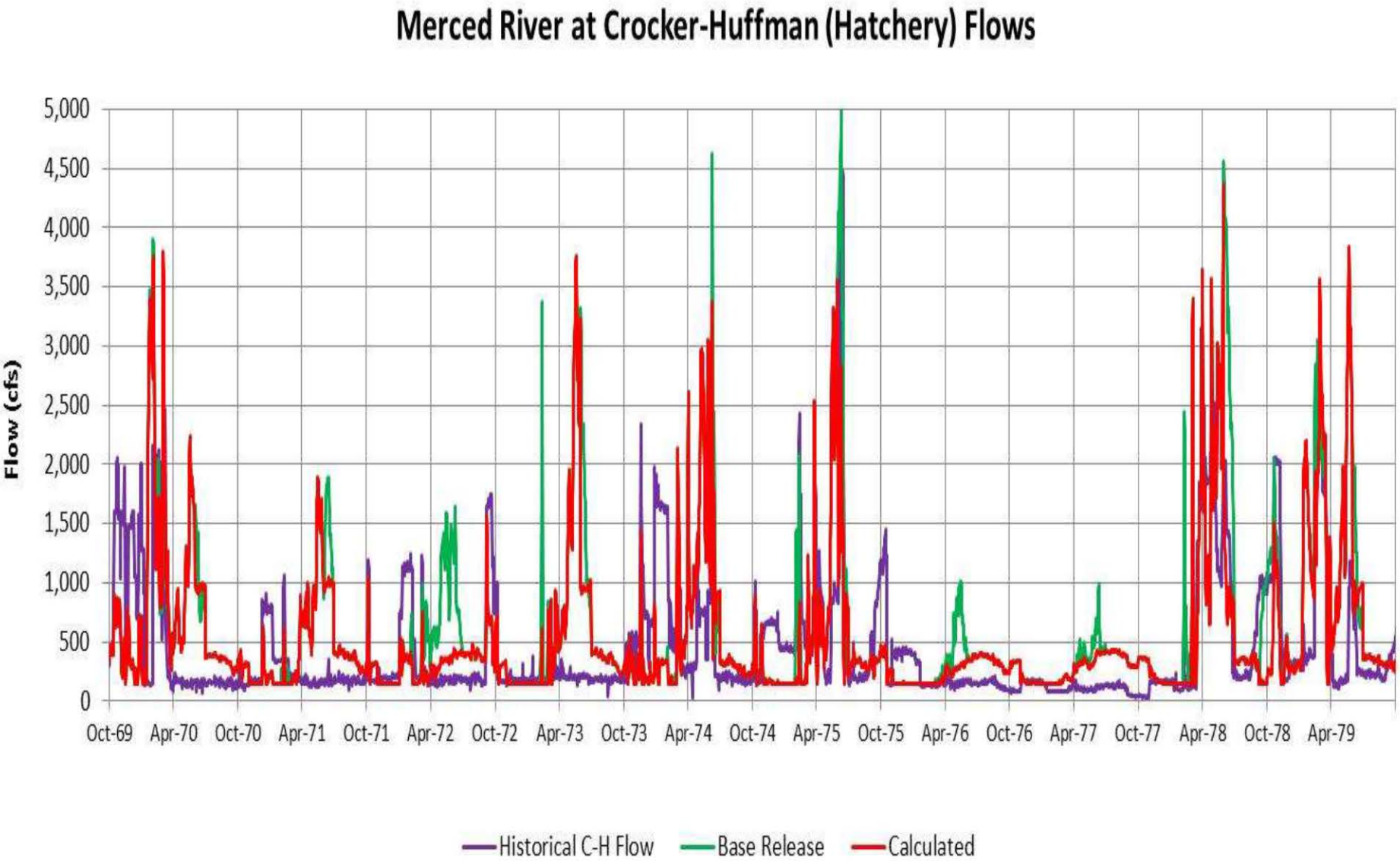
Improved Reservoir Operations are based on a Comparison of Storage Benefits



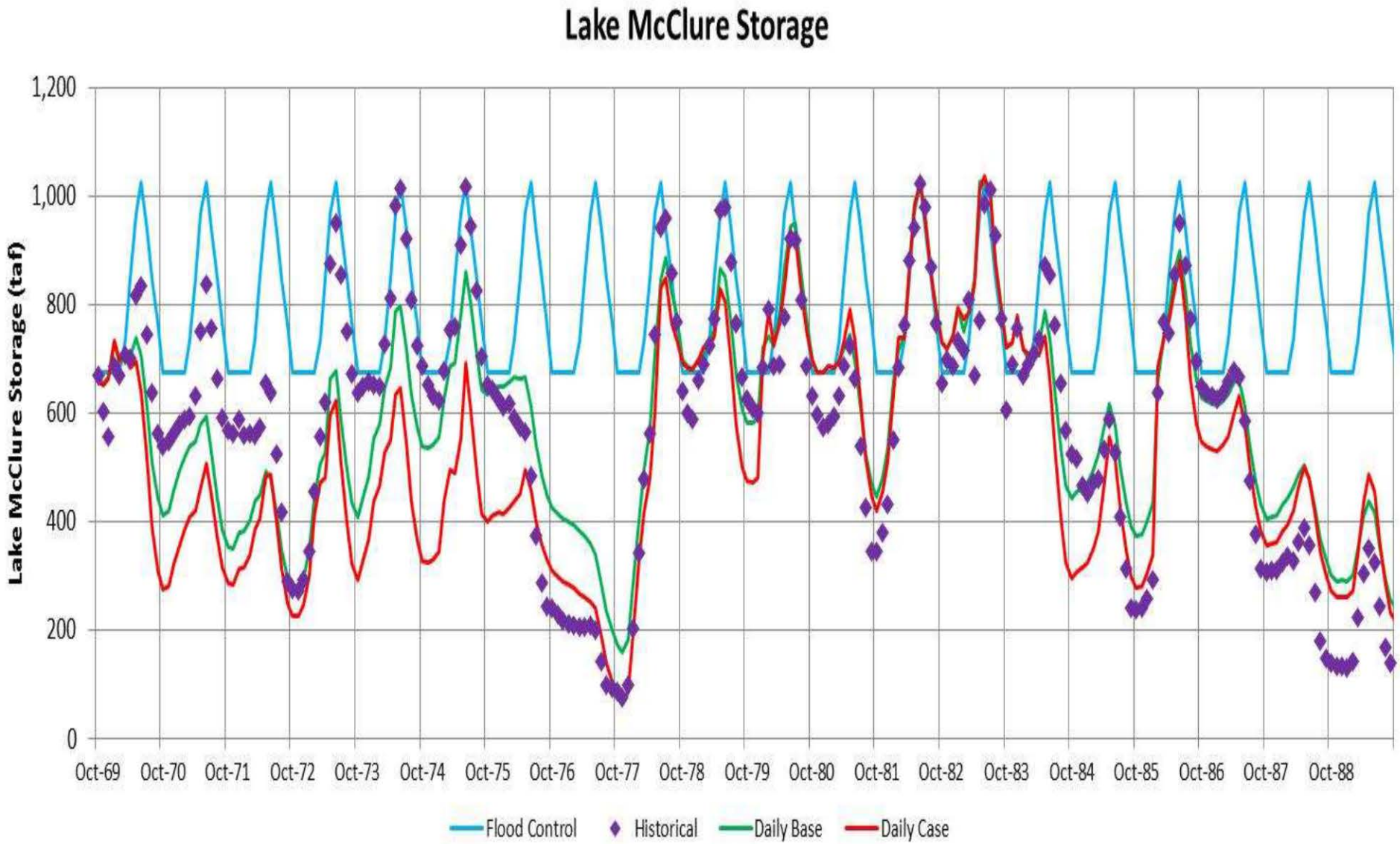
Improved Reservoir Operations are based on a Comparison of Water Supply Benefits



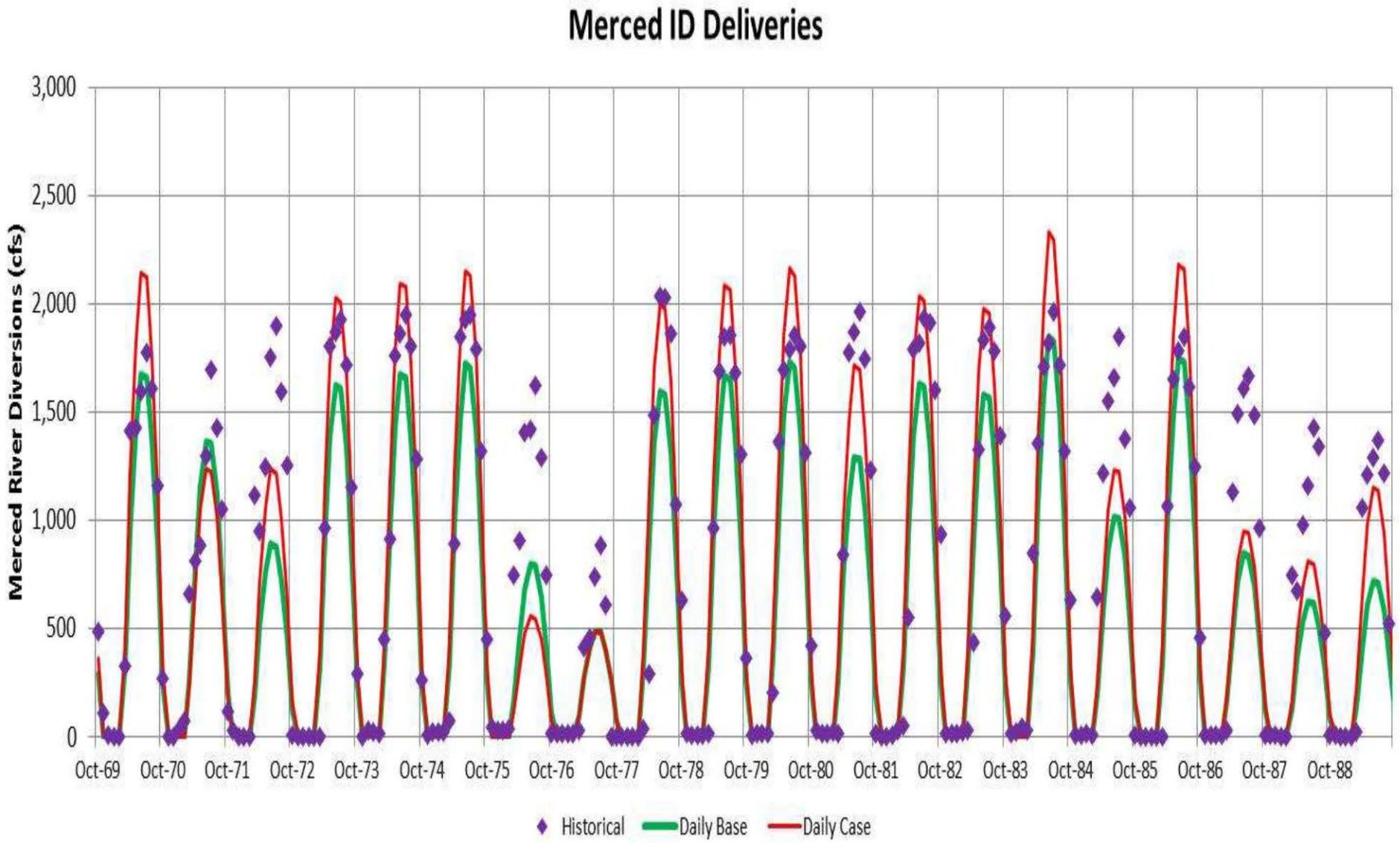
Improved Reservoir Operations are based on a Comparison of River Flow Benefits



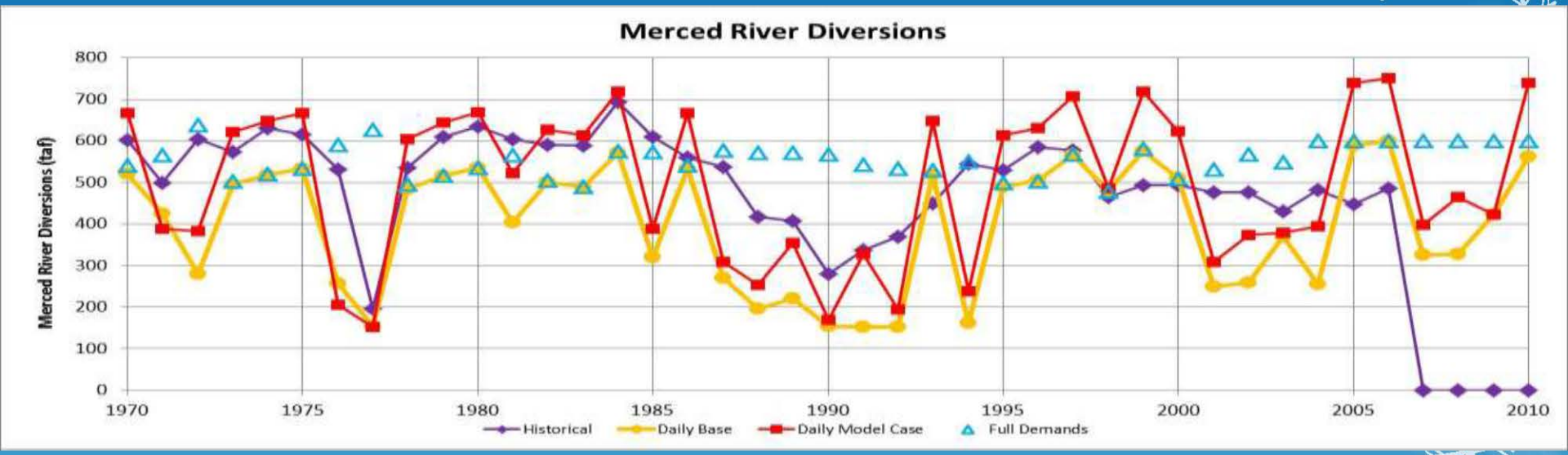
Monthly Storages are a good way to Summarize Daily Reservoir Operations

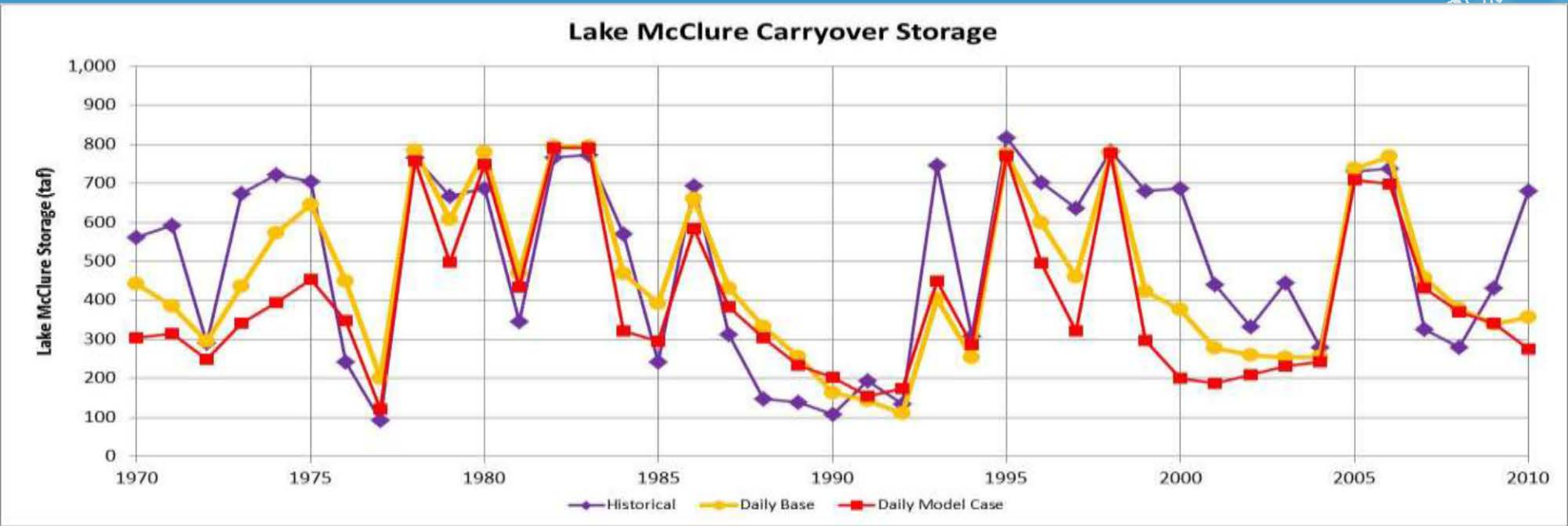


Monthly Deliveries are a good way to Summarize Daily Reservoir Operations



Annual Summary of Daily Reservoir Model Results- with historical data

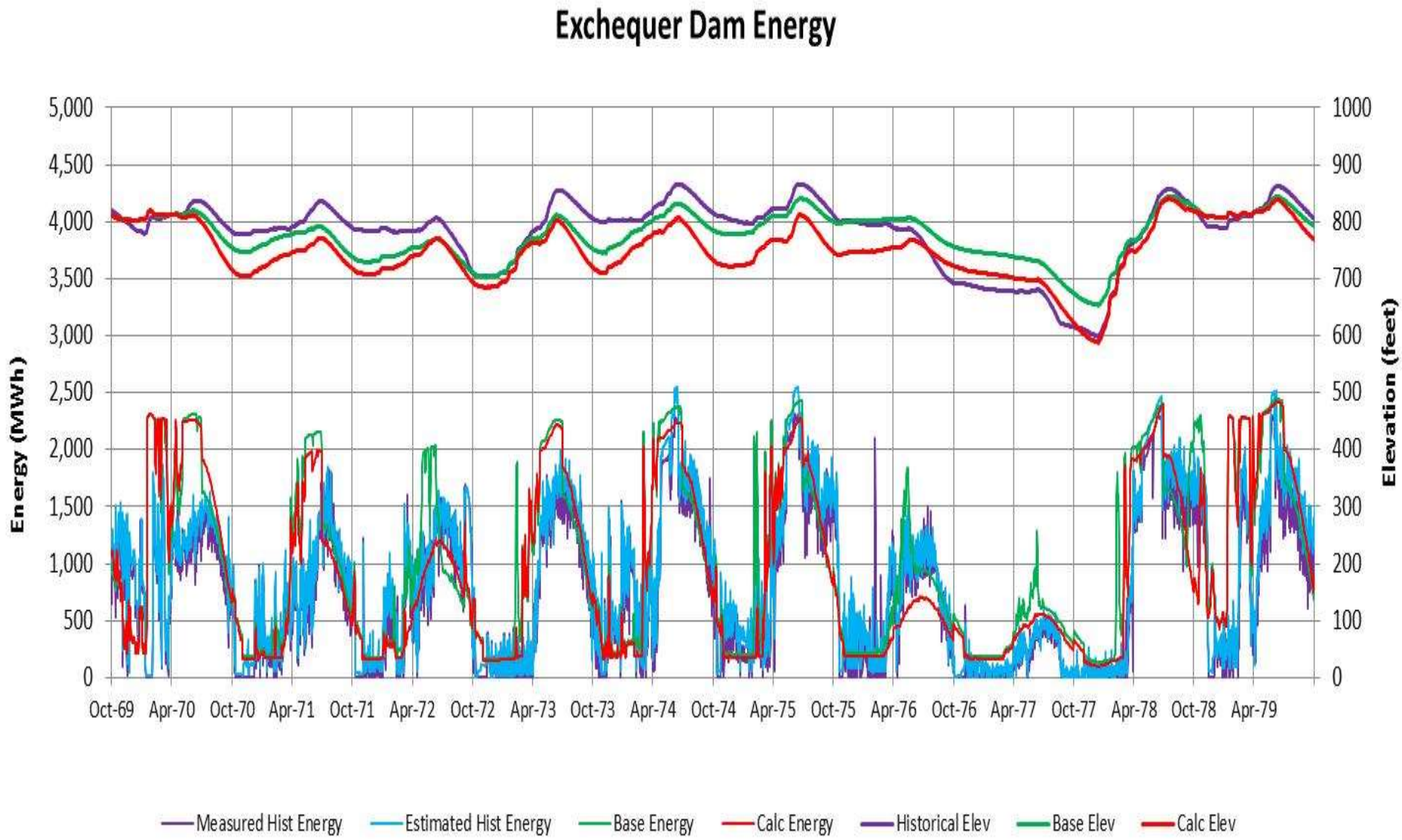




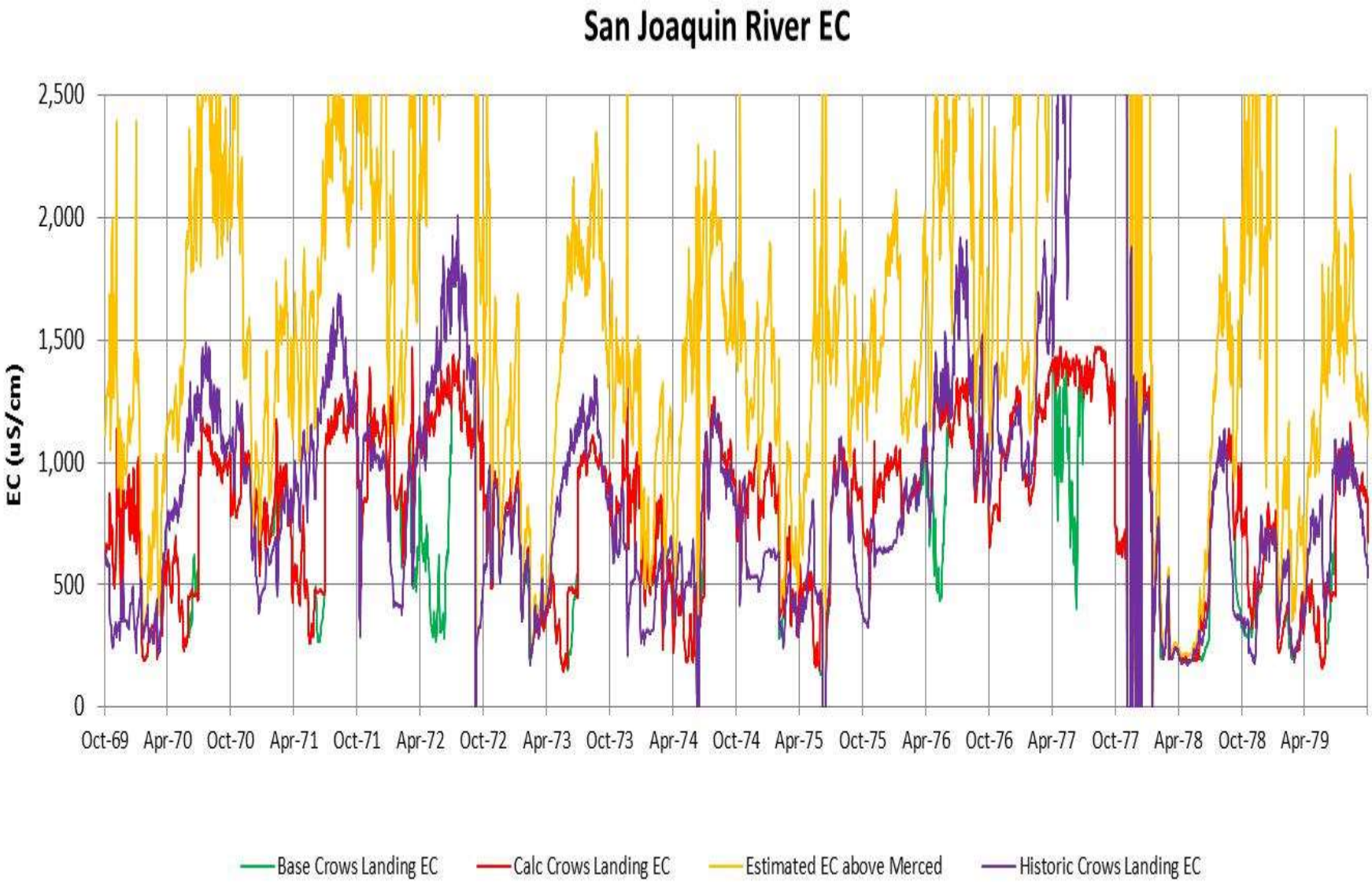
Reservoir and River Benefits can be Estimated using Simple Relationships with Storage and Flow

- Hydropower energy is calculated from reservoir elevation and release flow (maximum capacity)
- Recreation benefits are calculated from reservoir elevations and river flows [and fish abundance for fishermen!]
- Salinity benefits are calculated from Merced river flow and upstream San Joaquin River flow and EC conditions
- Fish benefits are calculated from river inundation area and velocity [growth, survival, habitat capacity]
- Fish benefits and impacts are calculated from reservoir release temperatures and downstream temperatures (warming) effects on eggs, growth, smoltification, survival

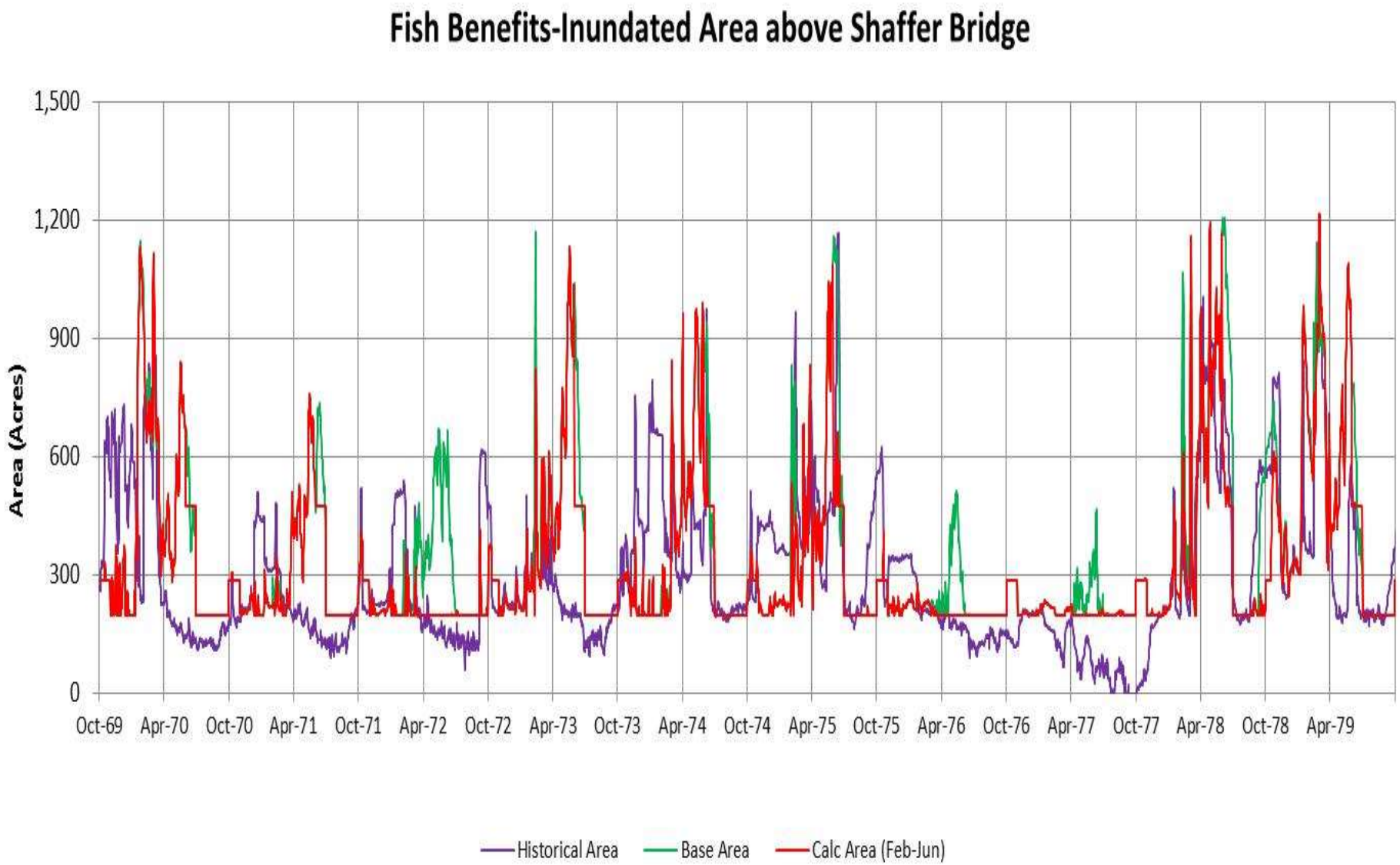
Hydro-Electric Energy Generation is a Substantial Reservoir Benefit



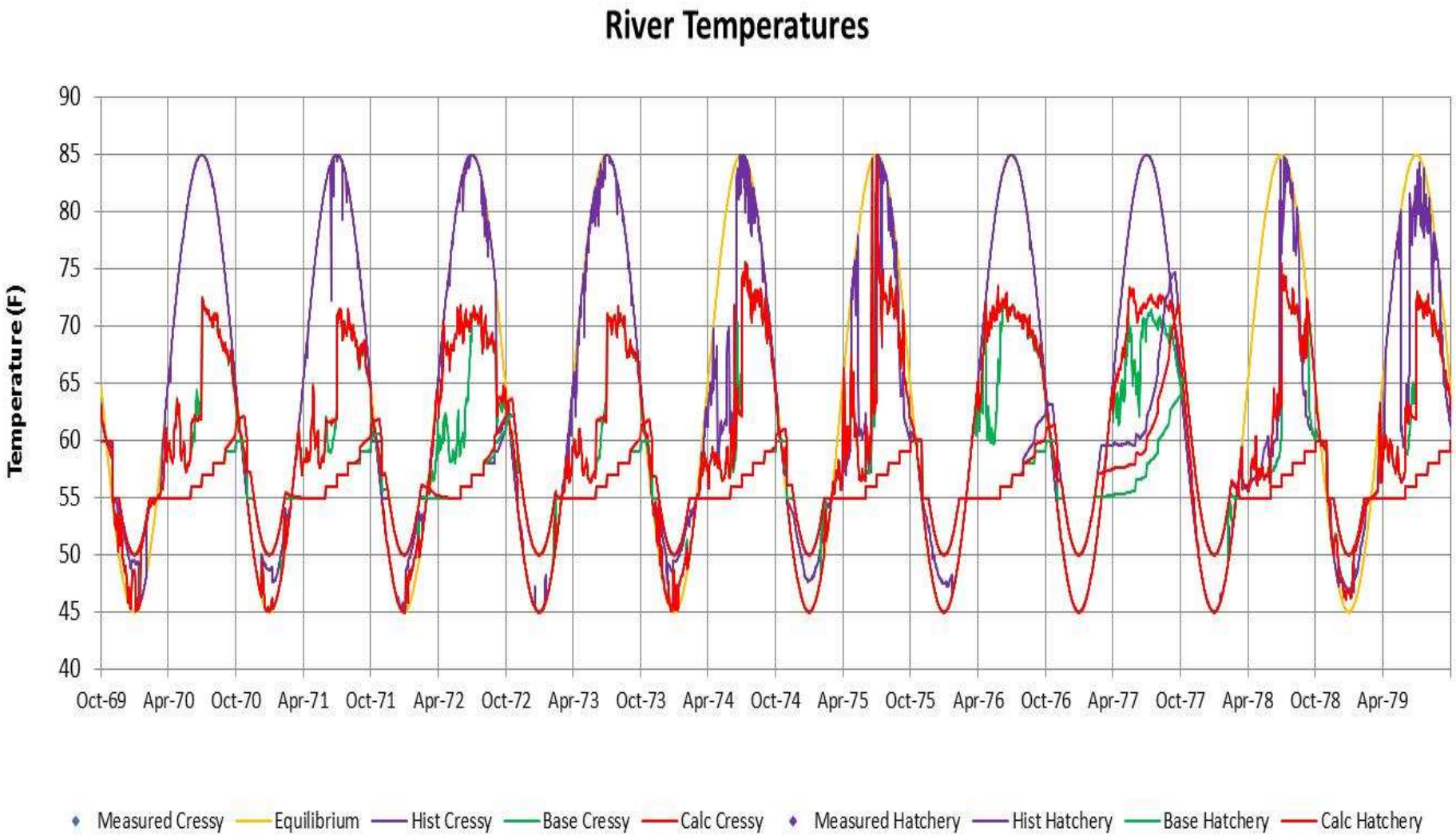
Salinity Benefits Contribute to Real-Time Management for the SJR Salinity TMDL



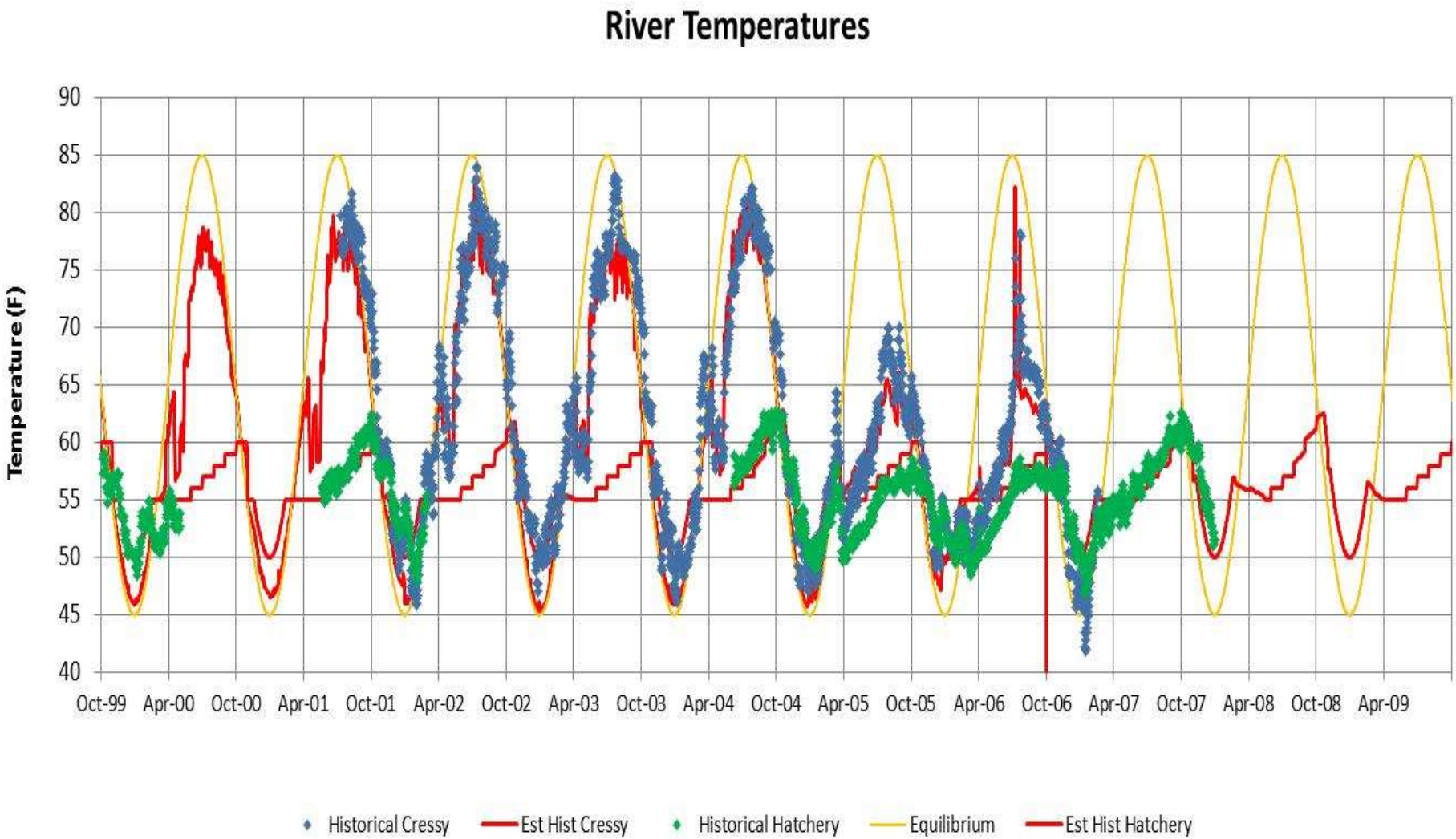
Riparian Habitat Inundation is a Major Juvenile Fish Benefit in January-June



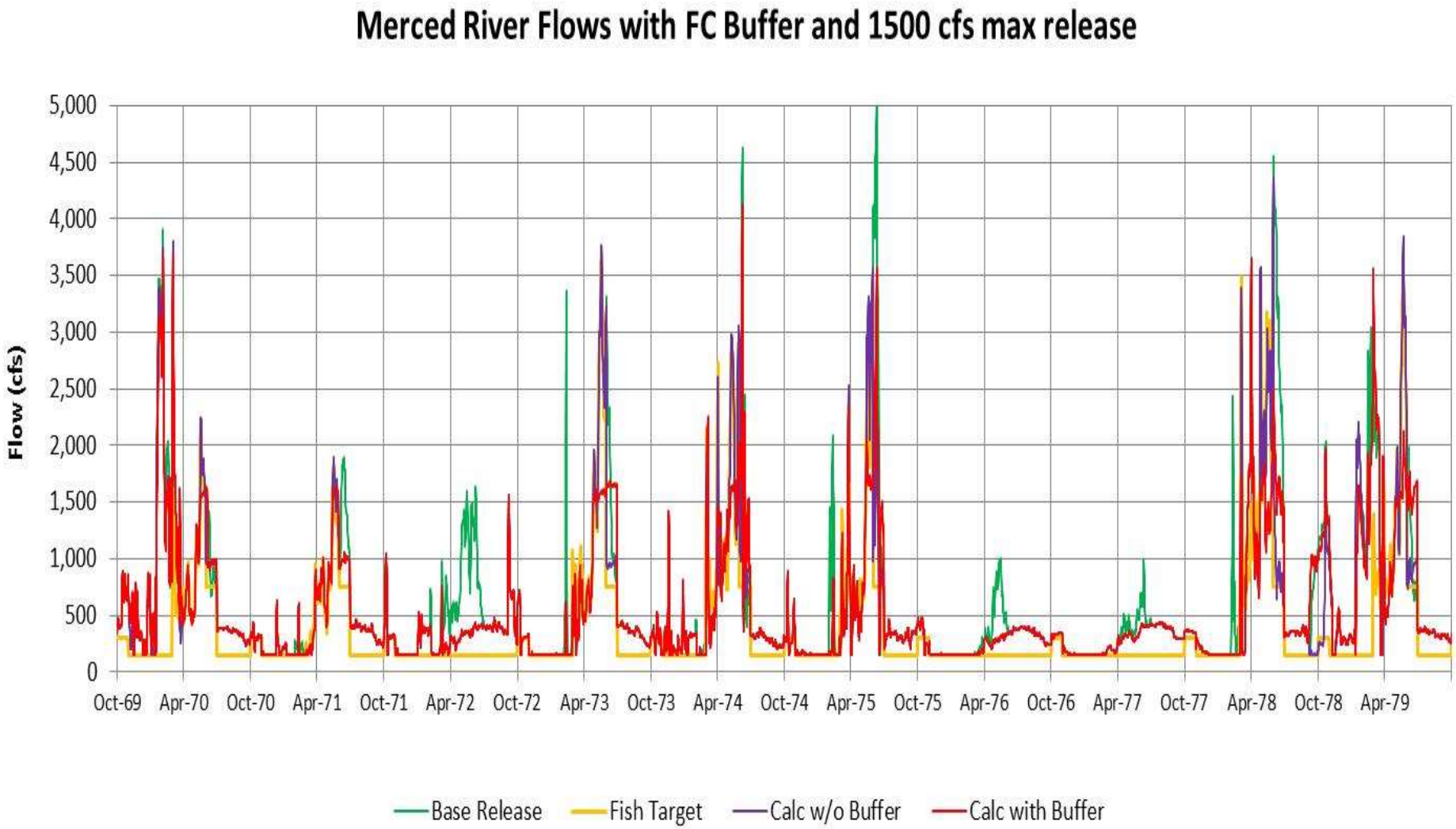
Water Temperatures are important habitat conditions controlling several fish life-stage benefits



Water Temperature calculations can be confirmed (calibrated) with measured data



Flow benefits might be increased by using an "inundation flow" target of 1,500 cfs and a flood control buffer of 25 taf



Conclusions and Recommendations for Daily Reservoir Operations Models

- Daily reservoir operations models for the Merced, Tuolumne, and Stanislaus Rivers can be used to explore adaptive management for alternative SJR flow objectives
- Daily reservoir operations Models provide more accurate and more flexible operations that can be adjusted to explore increased fish flow benefits while preserving the important beneficial uses for flood control, irrigation, energy generation and recreation.
- Daily reservoir operations models should be developed for all Central Valley rivers with major reservoirs that flow to the Delta. A daily operations model for the Delta (including San Luis and Los Vaqueros reservoirs) should also be developed. Upstream reservoir operations should be included for rivers with >100 taf of upstream storage.
- Additional development of calculations for fish benefits using daily tracking of fish life-stage (age, length) effects from river flows and water temperatures should be encouraged.
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