Effects of Reservoir Operations on Water Quality and Fish Habitat in Lake Murray and Saluda Releases

Andy Sawyer and Jim Ruane, REMI

August 7, 2007

Relicensing Issues Identified by the Water Quality Technical Working Committee

- The causes of striped bass fish kills reported in previous years, especially factors related to Saluda Hydro operations
- The effects of Unit 5 operations on entrainment of blue-back herring
- Determination of operational changes that might increase habitat for striped bass and blue-back herring
- Track any impacts that could occur to the tailwater cold-water fishery due to potential operational changes

Factors Considered to Address Relicensing Issues

- Annual flow regimes
- Pool level management
- Unit 5 operations
- In-lake and release water quality
- Habitat for striped bass and blue-back herring
- Water quality, meteorological, and operations data over the period 1990-2005
- Emphasis will be placed on section of reservoir from Blacks Bridge to Saluda Dam

Plan for Using CE-QUAL-W2 to Address the Water Quality TWC Relicensing Issues

1. Analyze water quality, meteorological, flow, and operations data for the period of study

2. Set up CE-QUAL-W2 for the years when major striped bass fish kills occurred

3. Run models to identify the causes that apparently contributed to the fish kills

4. Use the models to explore ways to avoid such fish kills in the future

Preliminary Findings Reported in March

- High flow, especially during March-August, is the primary cause for fish kills
- Higher flows cause the bottom of the lake to warm which in turn increases the rate of DO depletion
- Meteorological conditions can affect striper habitat
- Model results indicate that the temperature and DO range of tolerable striper habitat in Lake Murray is approximately:

$$T < 27^{o}C \text{ and } DO > 2.5 \text{ mg/l}$$

- Preferential use of Unit 5 helps preserve colder bottom water and was predicted to improve DO and increase striper habitat

Preliminary Conclusions Reported in May

- Nutrients are the single dominant factor that can enhance striped bass habitat
- Flow is a dominant factor, but cannot be controlled to avoid fish kills
- Met conditions can be a periodic factor that alleviates otherwise dominant factors like flow
- Striped bass habitat conditions can be improved in some years by maintaining high summer pool levels (~ elev. 358 ft)
- Unit 5 preferential operations can improve striped bass habitat in some years

Next Steps Selected at May Meeting

1. **For selected years, finalize assessment (i.e., assess changes in releases) of operating guide for U5 preference for “first on, last off” operation using the hourly releases**

2. **For selected years, finalize assessment of maintaining summer pool levels at 358**

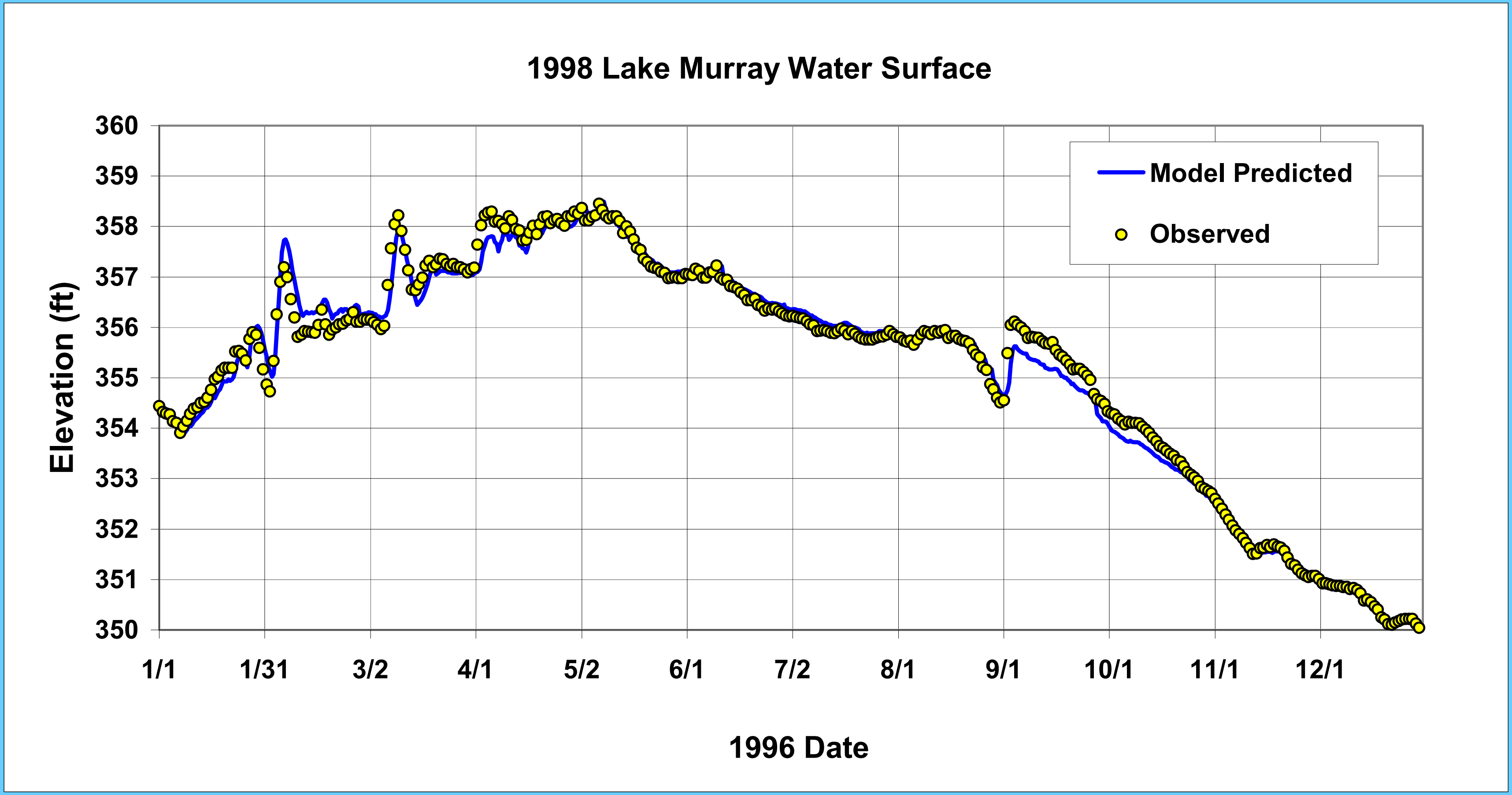
3. **For selected years, finalize assessment of the combination of maintaining summer pool levels at 358 with U5 preference for “first on, last off” operation using the hourly releases**

4. **Analyze additional years, especially a low flow year**

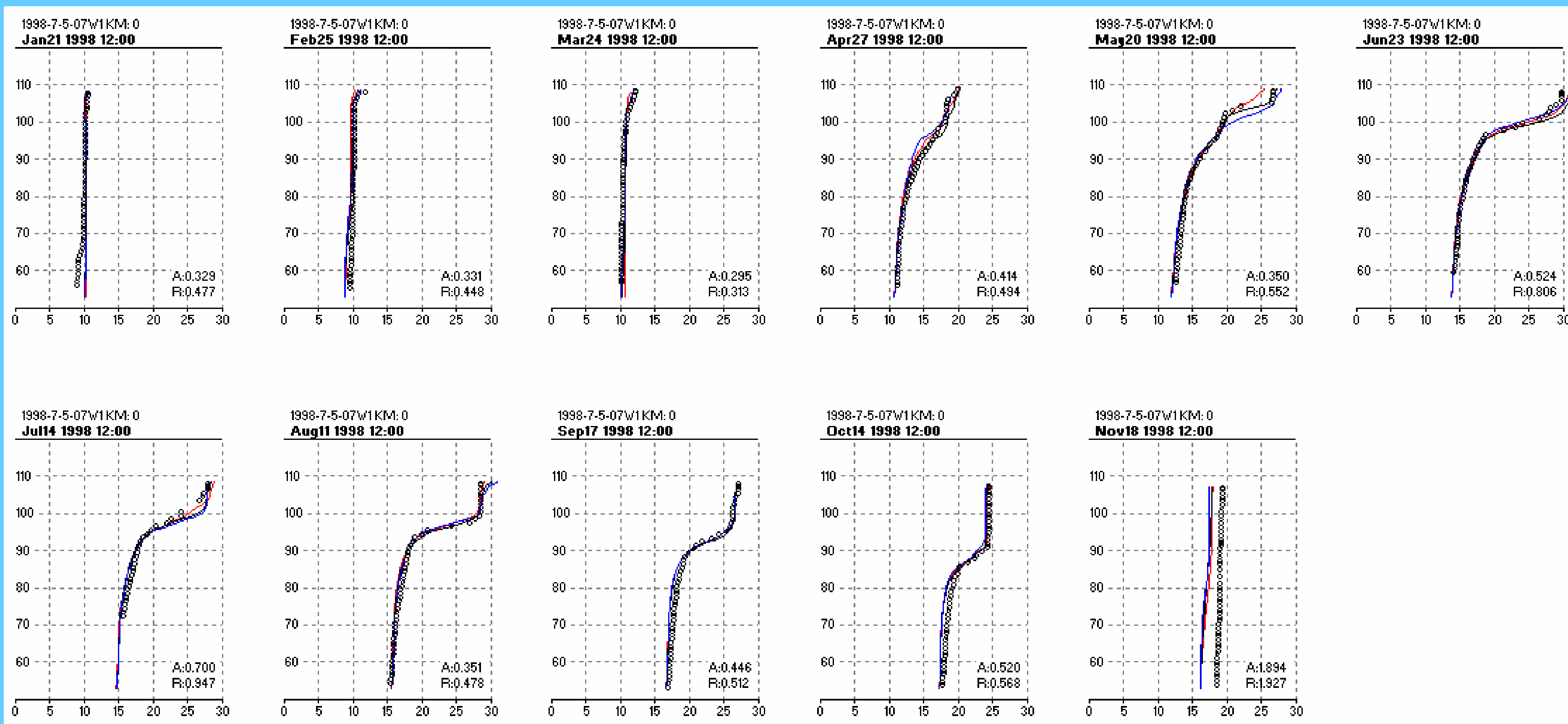
5. **Assess effects of minimum winter pool level, including effects on Little Saluda embayment, increased SOD, internal nutrient cycling, aquatic plants, sedimentation in coves**

1998 Model Calibration

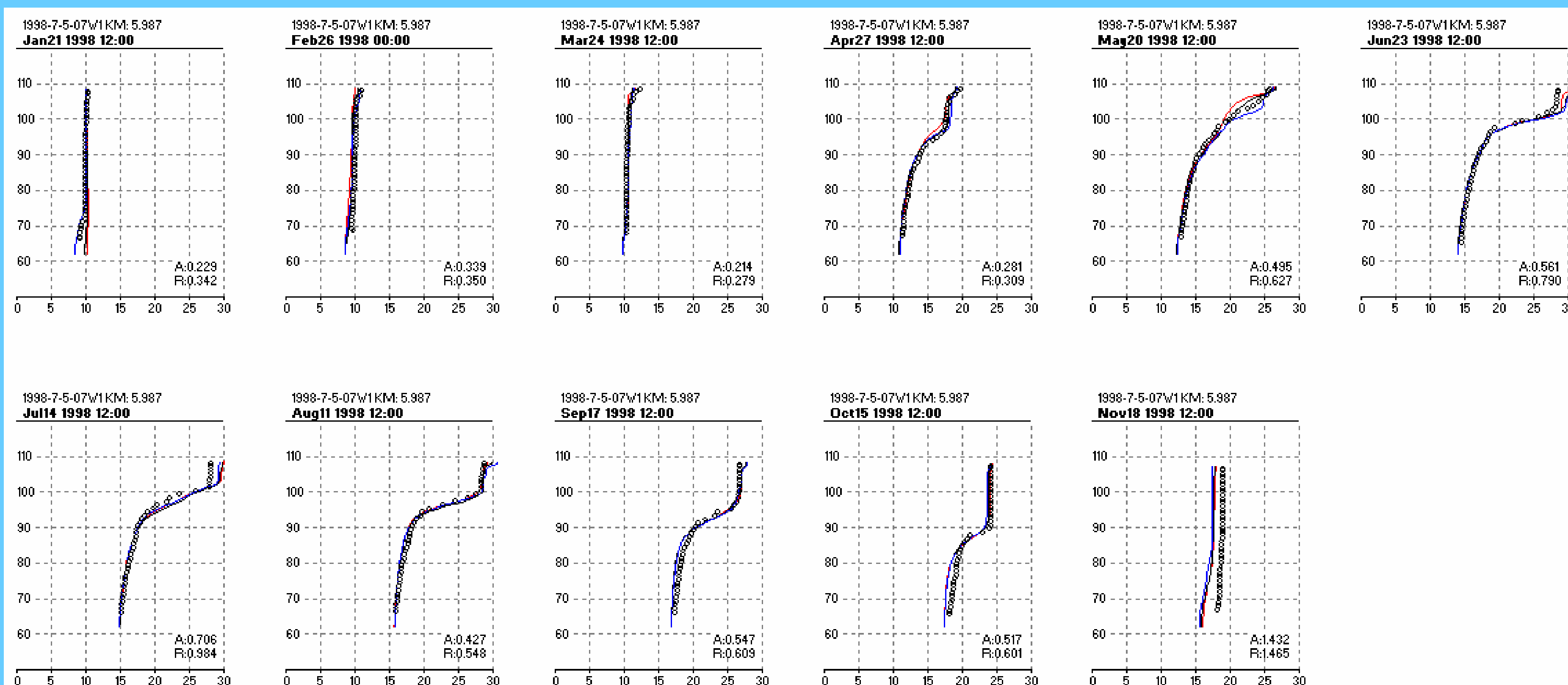
1998 Lake Murray Water Surface
Model vs. Data



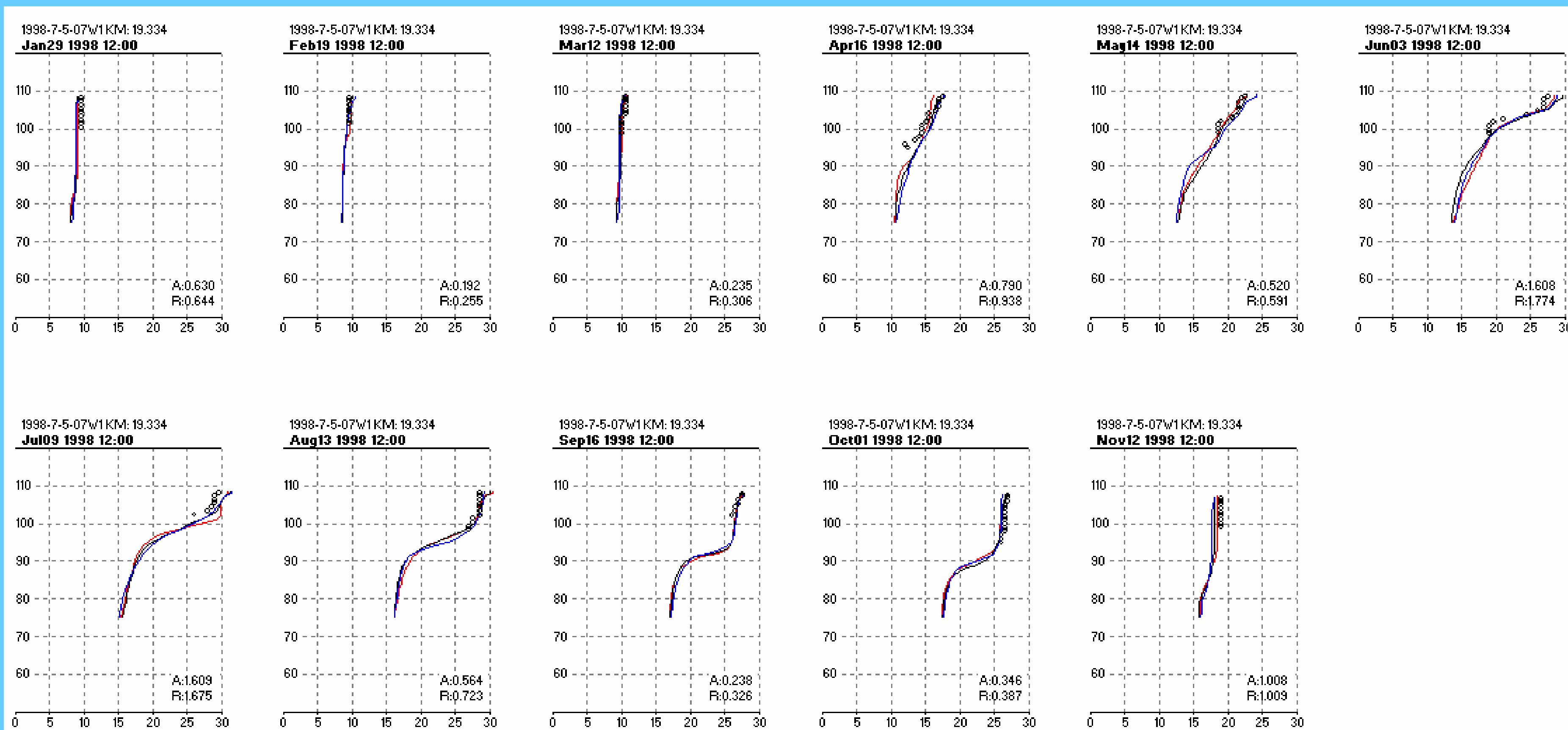
1998 Lake Murray Temperature Profiles
Forebay
Model vs. Data



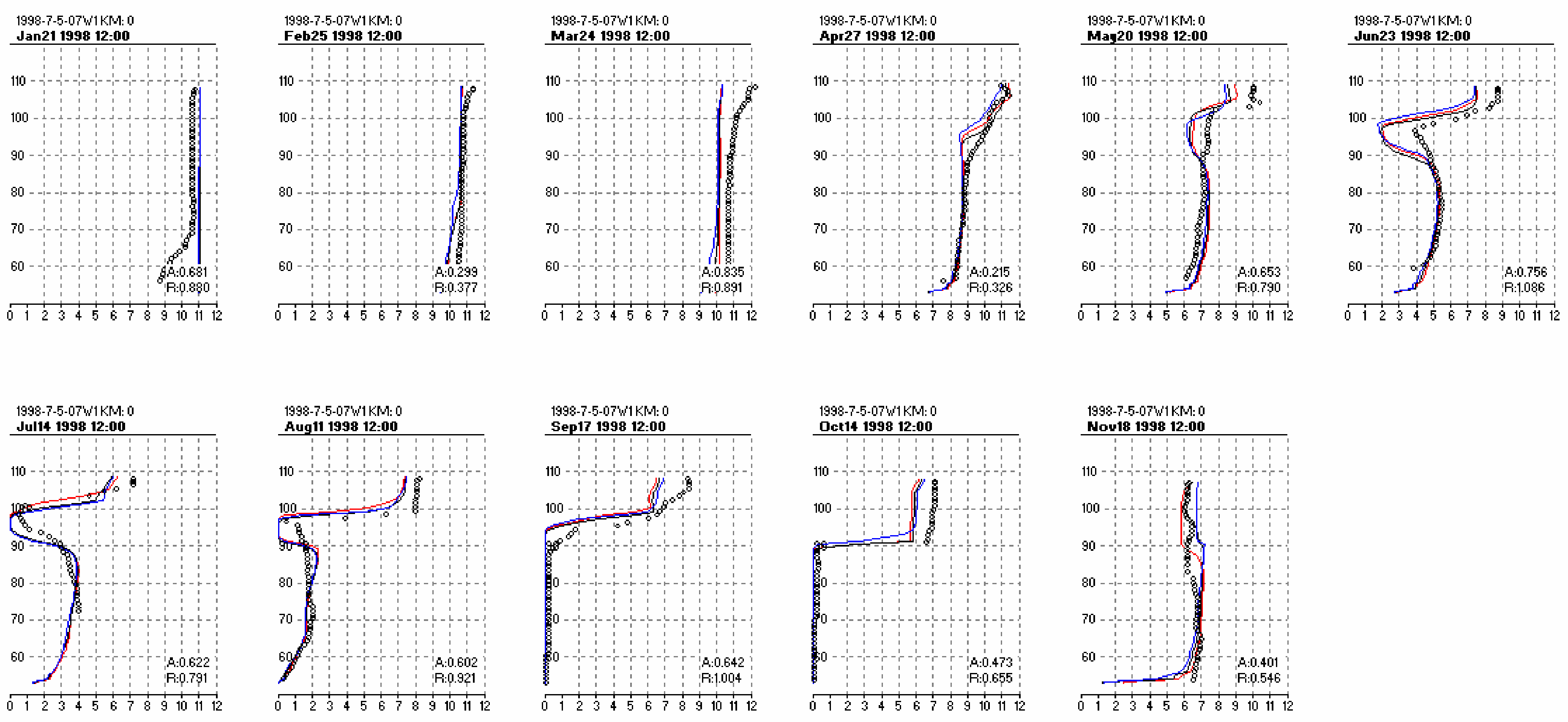
1998 Lake Murray Temperature Profiles
6 Kilometers Upstream of Dam
Model vs. Data



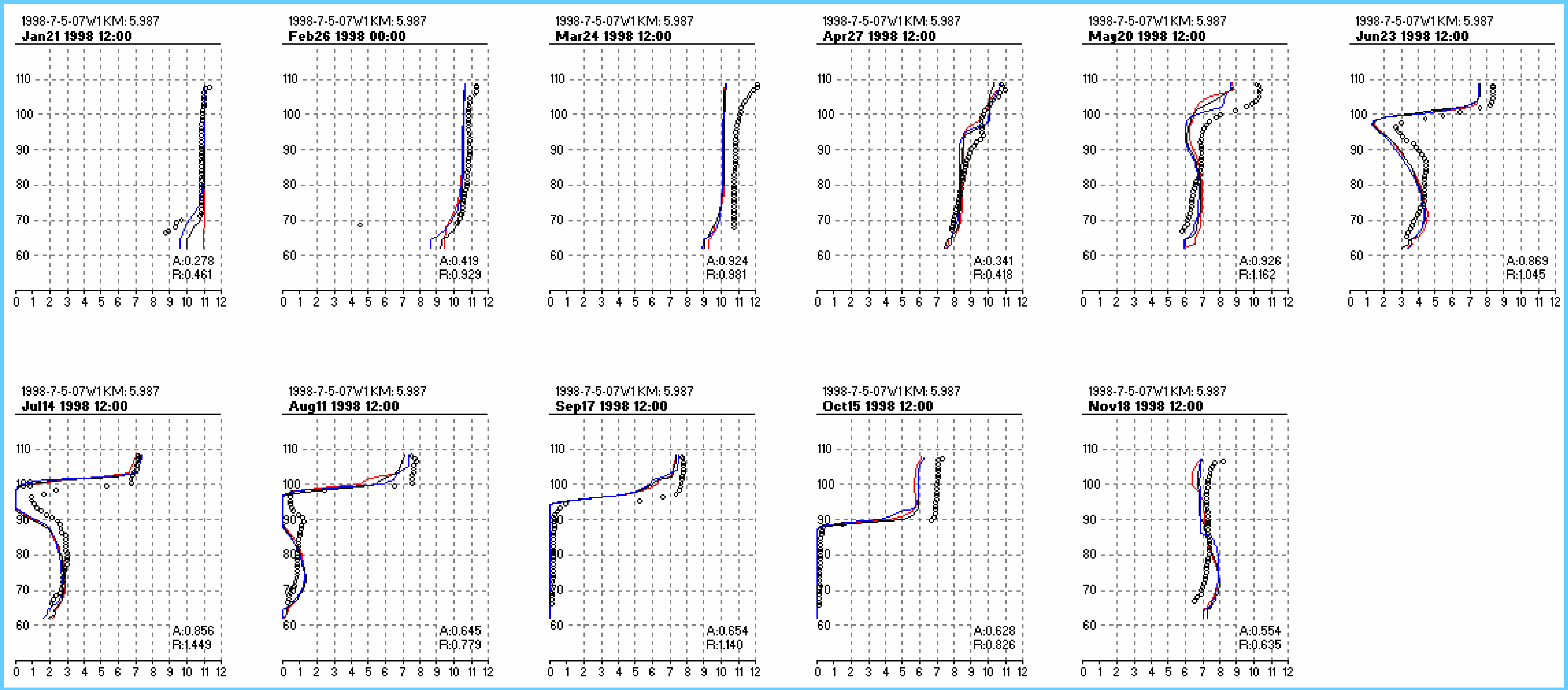
1998 Lake Murray Temperature Profiles
19 Kilometers Upstream of Dam
Model vs. Data



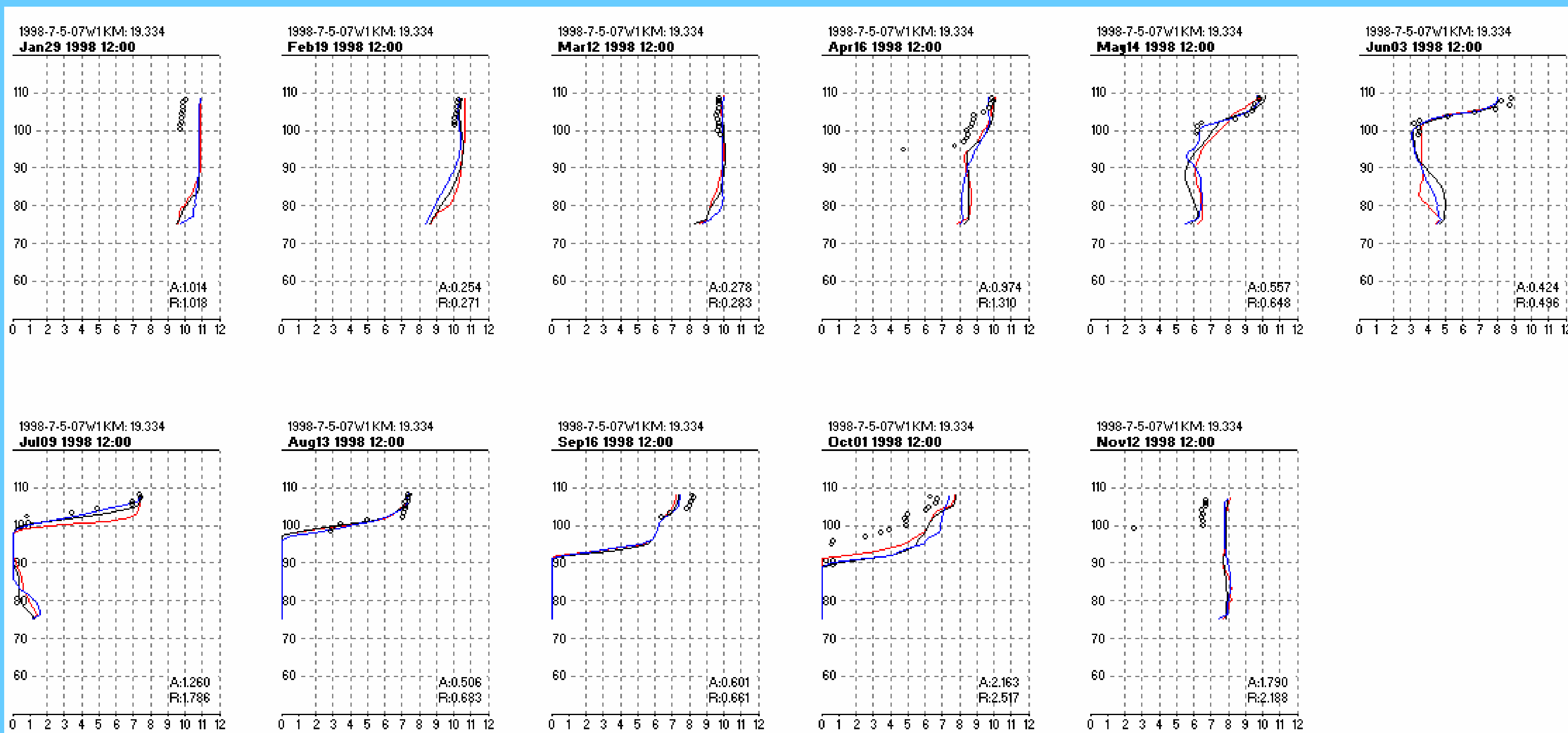
1998 Lake Murray DO Profiles
Forebay
Model vs. Data



1998 Lake Murray DO Profiles
6 Kilometers Upstream of Dam
Model vs. Data



1998 Lake Murray DO Profiles
19 Kilometers Upstream of Dam
Model vs. Data



Calibration Statistics for Temperature and DO Profiles

Temperature

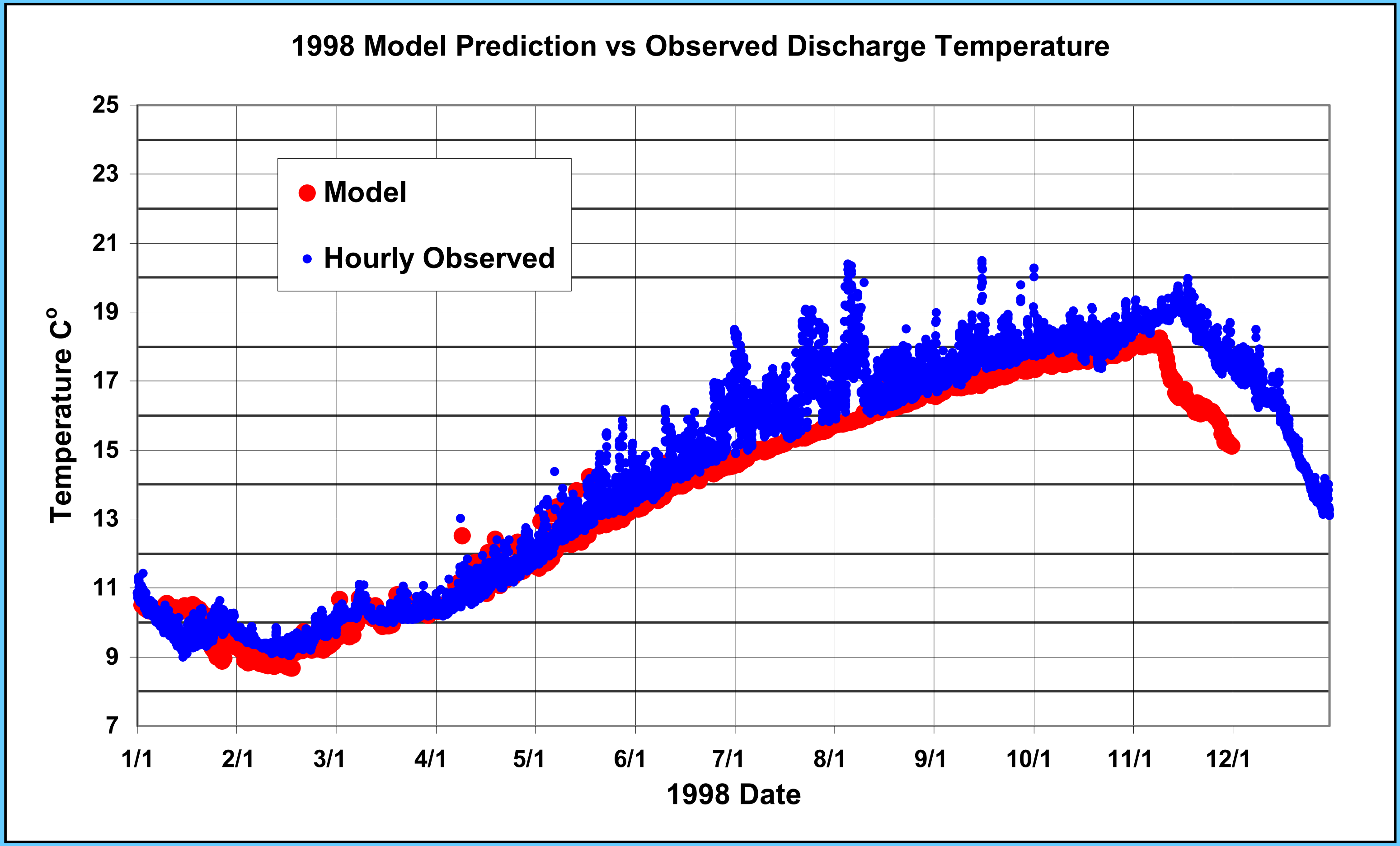
	Kilometers From Dam									
	0.0		6.0		19.3		Little Saluda Embayment		Mean	
Year	AME	RMS	AME	RMS	AME	RMS	AME	RMS	AME	RMS
1991	0.55	0.75					1.05	1.27	**0.80**	**1.01**
1992	0.81	1.11	0.79	1.18	0.65	0.78	1.45	1.96	**0.93**	**1.26**
1996	0.44	0.68	0.52	0.78	0.64	0.90	0.80	1.11	**0.60**	**0.87**
1997	0.45	0.67	0.44	0.61	0.70	0.96	1.23	1.60	**0.70**	**0.96**
1998	0.56	0.80	0.52	0.71	0.69	0.91	0.83	1.08	**0.65**	**0.88**
2000	0.54	0.73	0.58	0.77	0.79	1.02	1.21	1.65	**0.78**	**1.04**
2001	0.54	0.72	0.67	0.83	0.79	0.89	1.23	1.53	**0.81**	**0.99**
2005	0.53	0.73	0.57	0.70	0.58	0.74	1.03	1.23	**0.68**	**0.85**
Mean	**0.55**	**0.77**	**0.59**	**0.80**	**0.69**	**0.89**	**1.10**	**1.43**	**0.73**	**0.97**

DO

	Kilometers From Dam									
	0.0		6.0		19.3		Little Saluda Embayment		Mean	
Year	AME	RMS	AME	RMS	AME	RMS	AME	RMS	AME	RMS
1991	0.83	1.44					1.51	2.00	**1.17**	**1.72**
1992	0.60	0.95	0.67	0.95	0.89	1.20	1.66	2.13	**0.95**	**1.31**
1996	0.59	0.95	0.71	1.04	0.58	0.75	0.81	1.08	**0.67**	**0.95**
1997	0.89	1.38	0.87	1.27	0.86	1.16	1.86	2.58	**1.12**	**1.60**
1998	0.56	0.79	0.65	0.94	0.93	1.35	1.24	1.66	**0.84**	**1.18**
2000	0.87	1.22	1.14	1.48	0.99	1.24	1.69	2.17	**1.17**	**1.53**
2001	0.70	1.18	0.89	1.38			1.76	2.17	**1.12**	**1.58**
2005	0.84	1.53	0.76	1.16	0.94	1.42	1.87	2.37	**1.10**	**1.62**
Mean	**0.73**	**1.18**	**0.81**	**1.17**	**0.86**	**1.19**	**1.55**	**2.02**	**0.99**	**1.39**

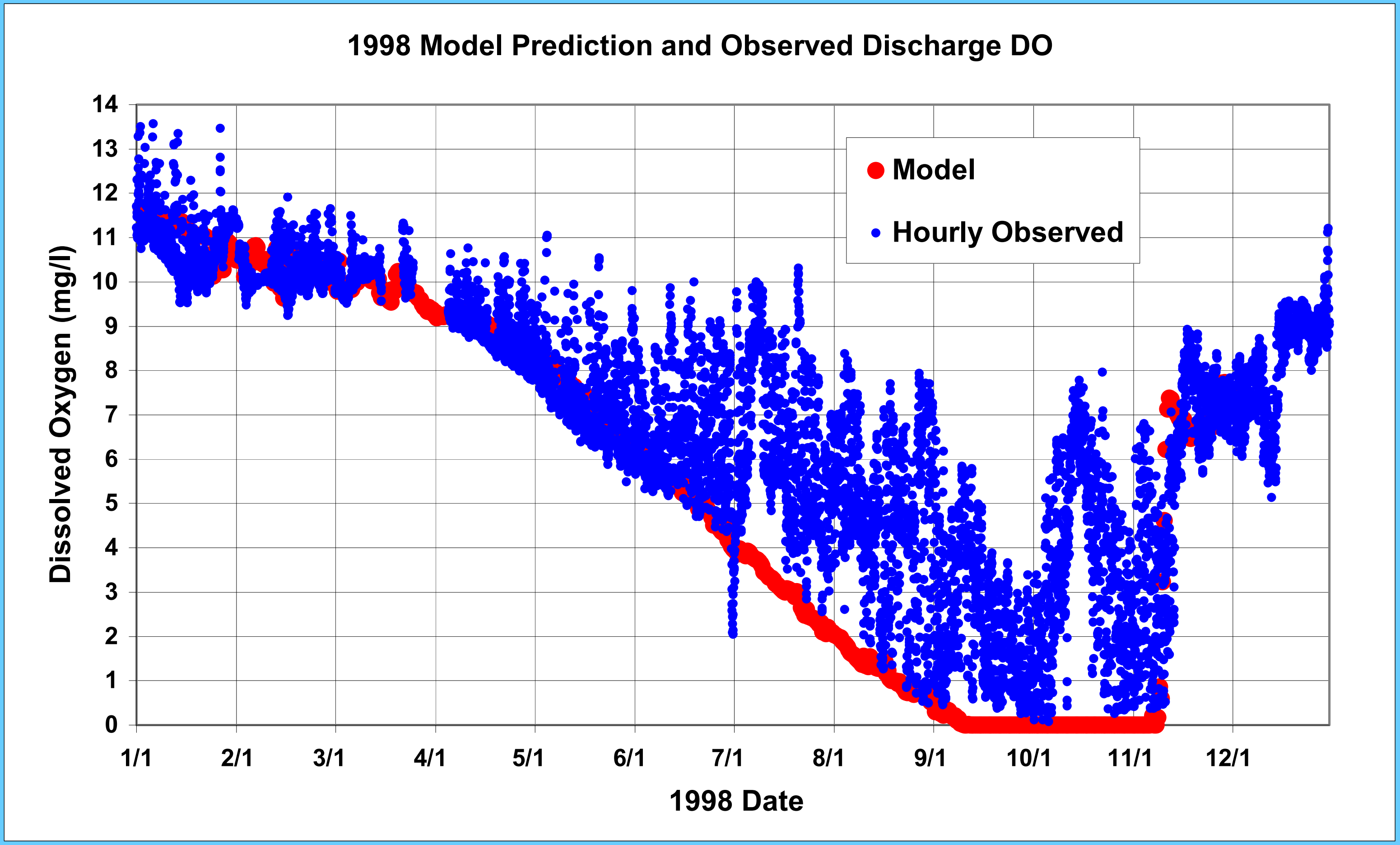
Release Temperature

Model vs. Data



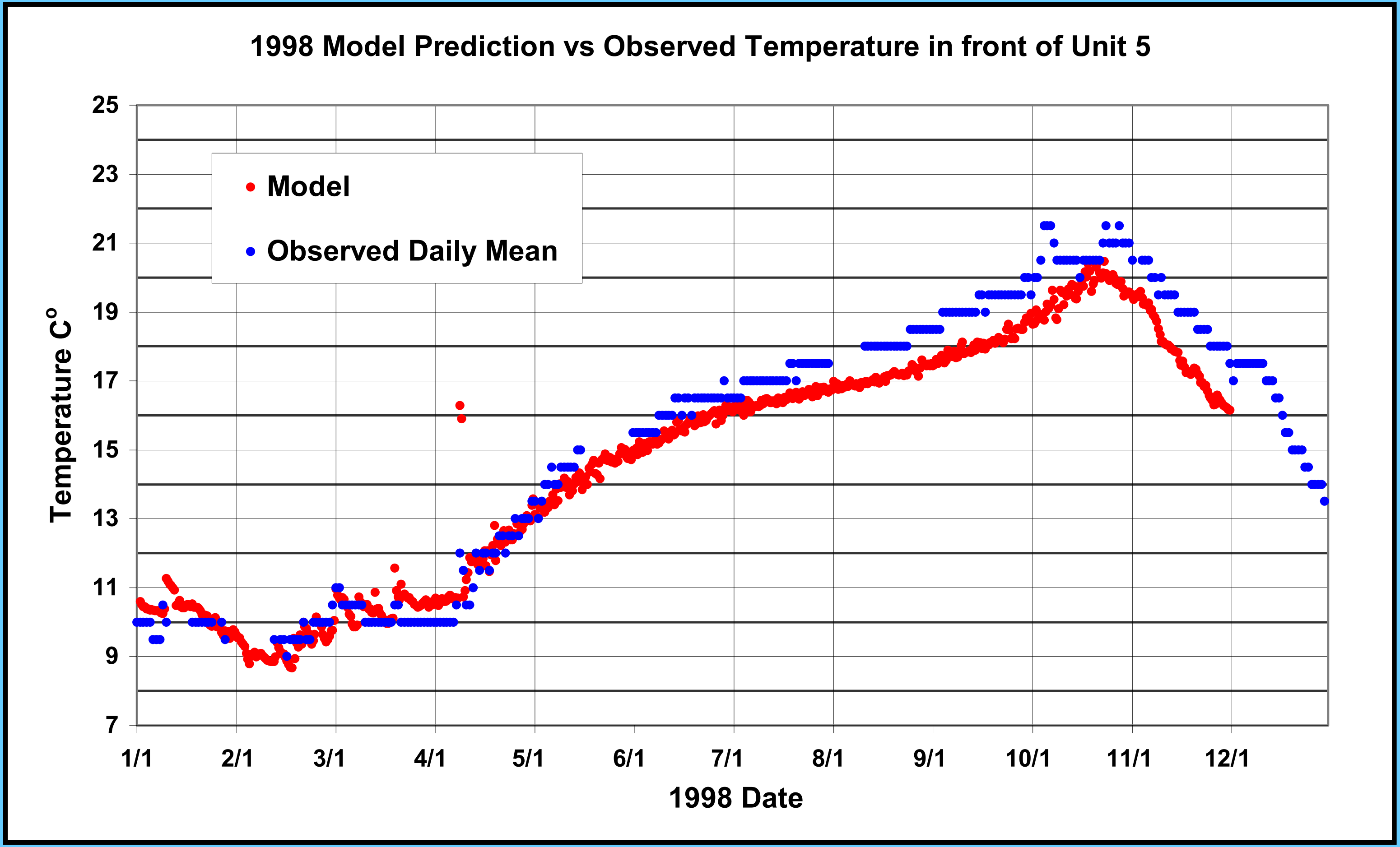
Release DO

Model vs. Data



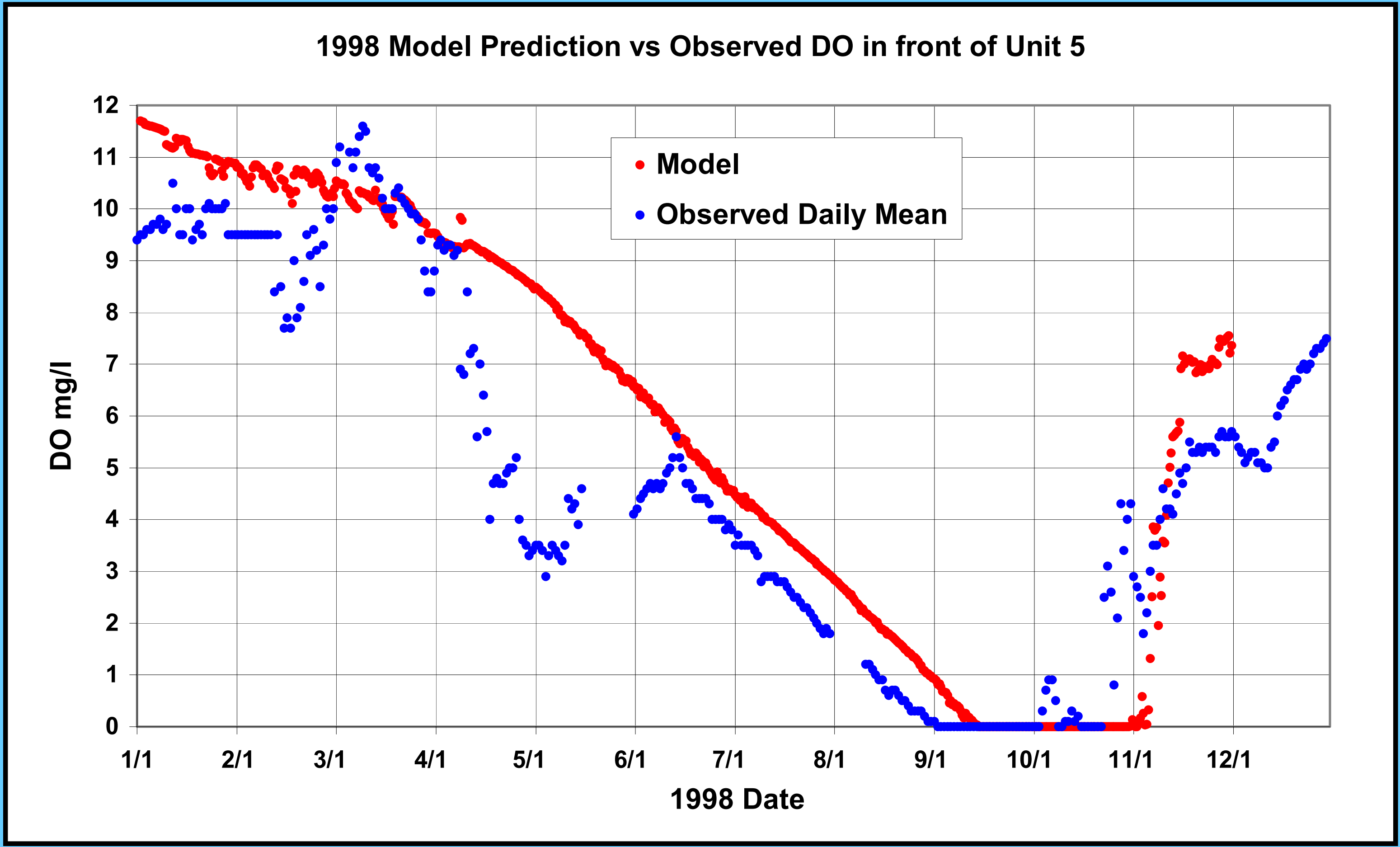
Temperature in Front of Unit 5

Model vs. Data

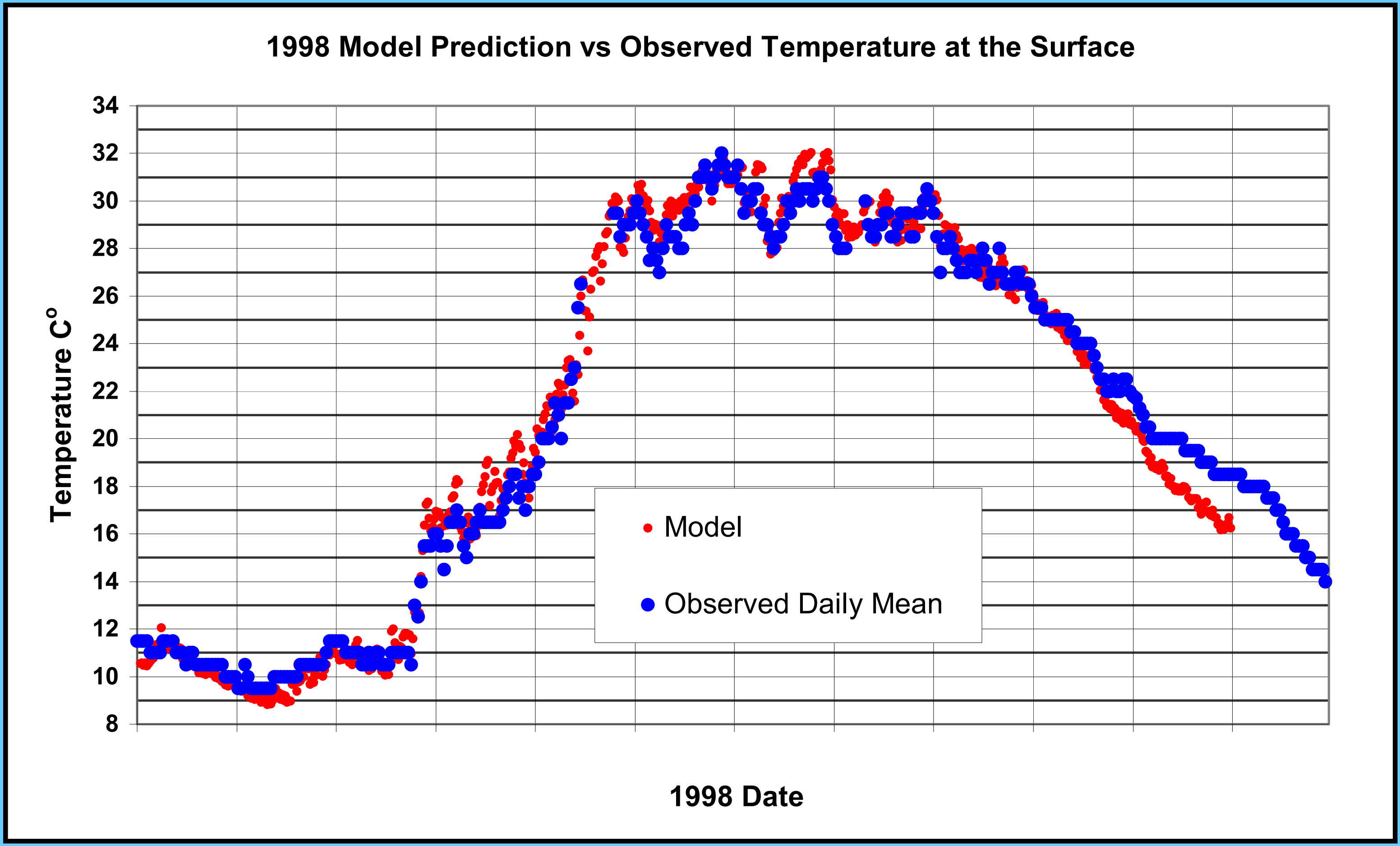


DO in Front of Unit 5

Model vs. Data

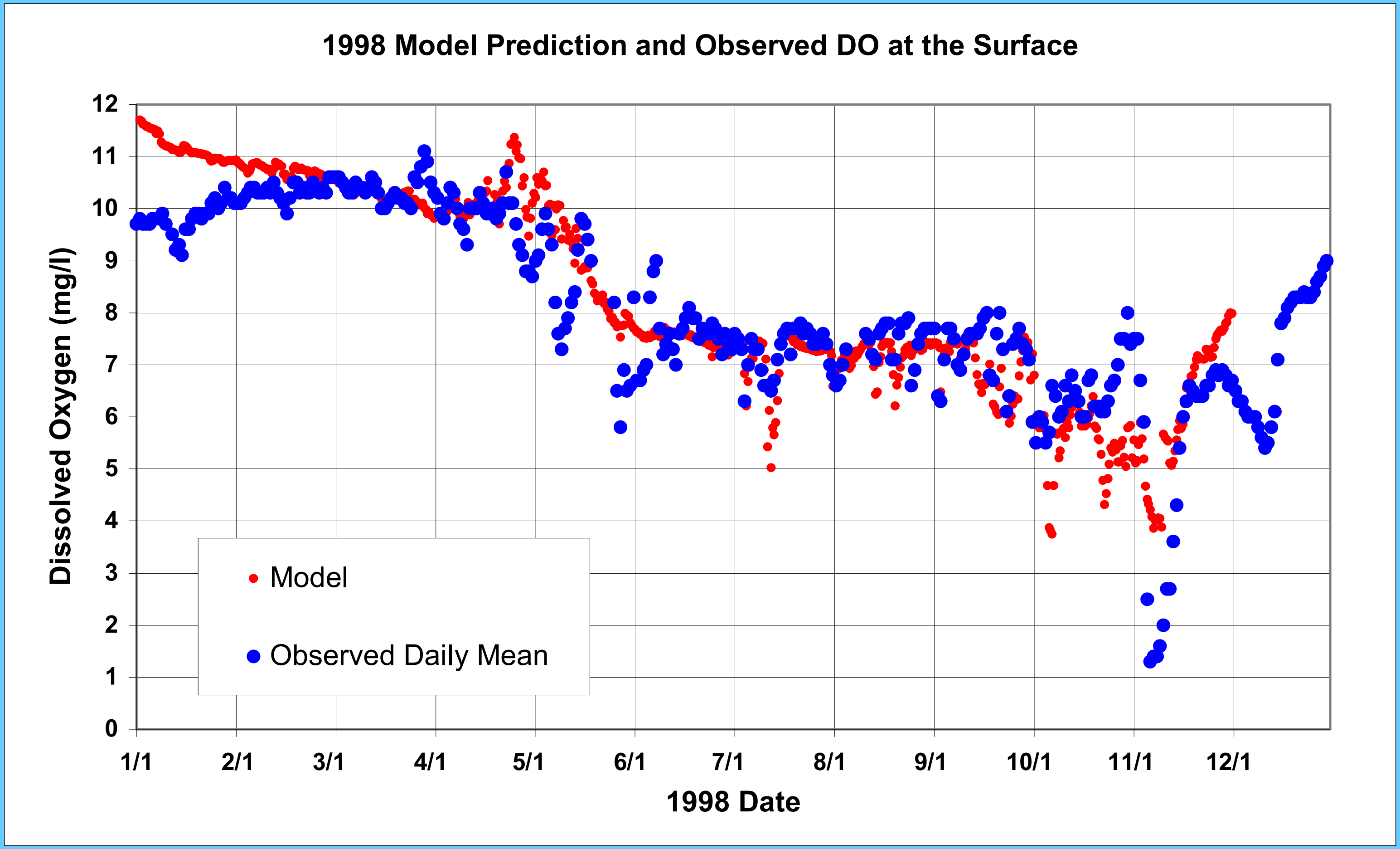


Temperature at the Surface
Model vs. Data

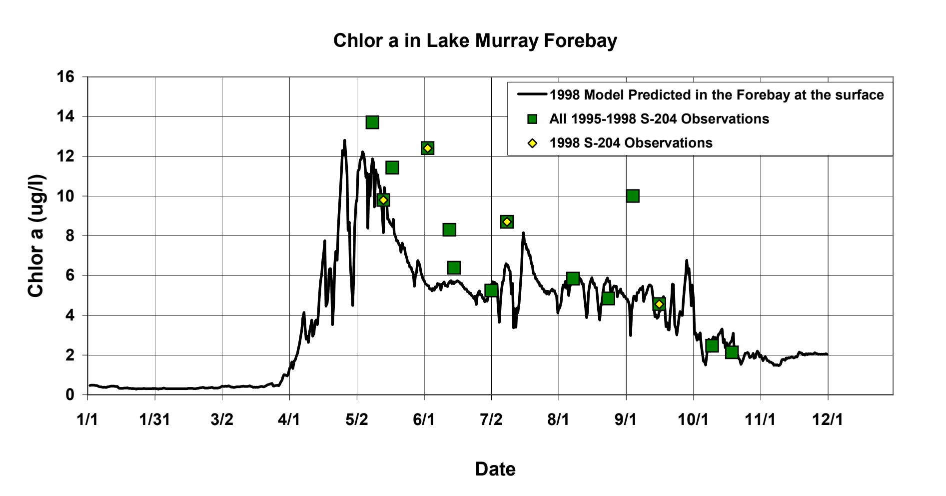


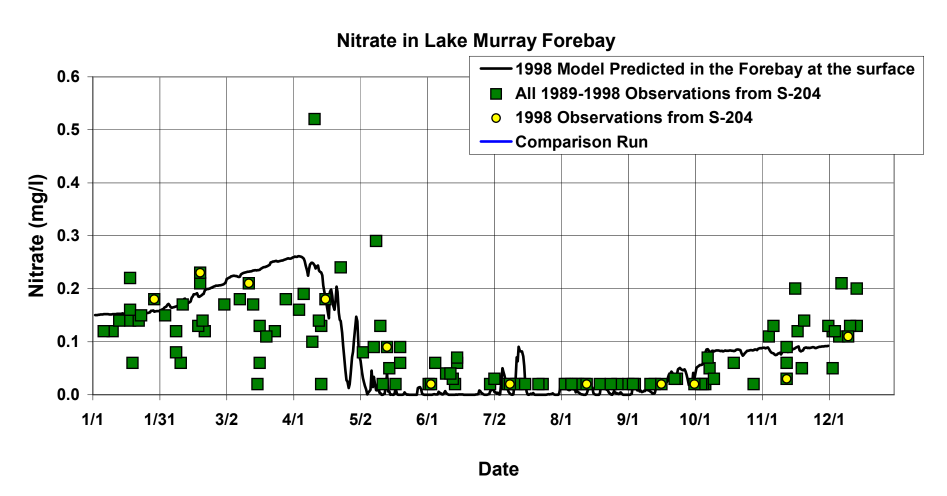
DO at the Surface

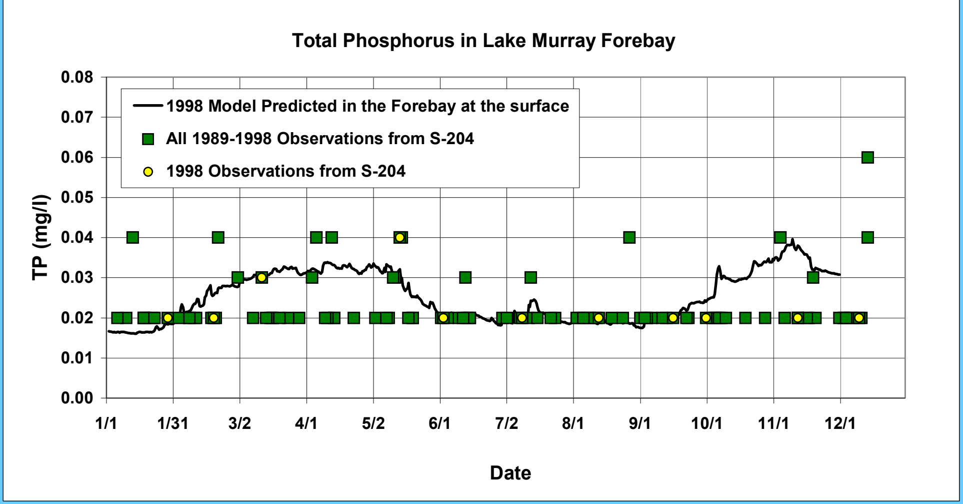
Model vs. Data

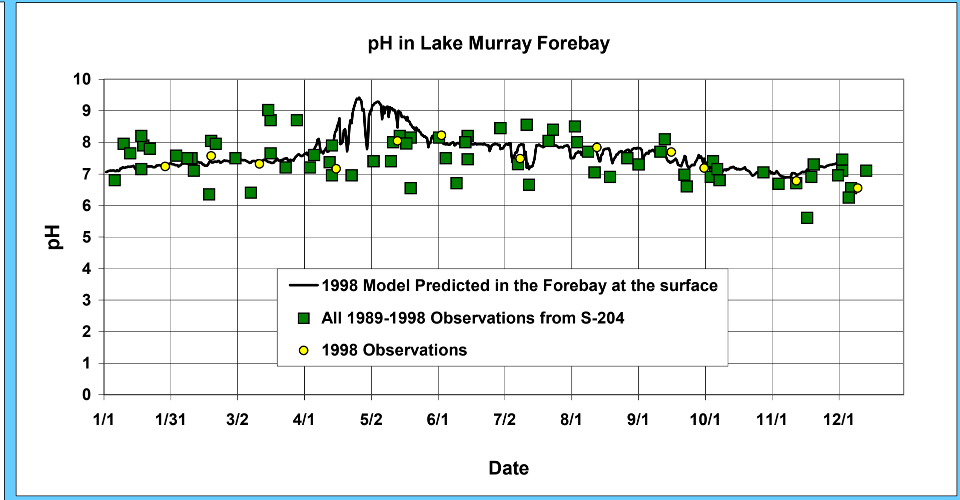


1998 - Other Water Quality Constituents
Forebay Surface
Model vs. Data



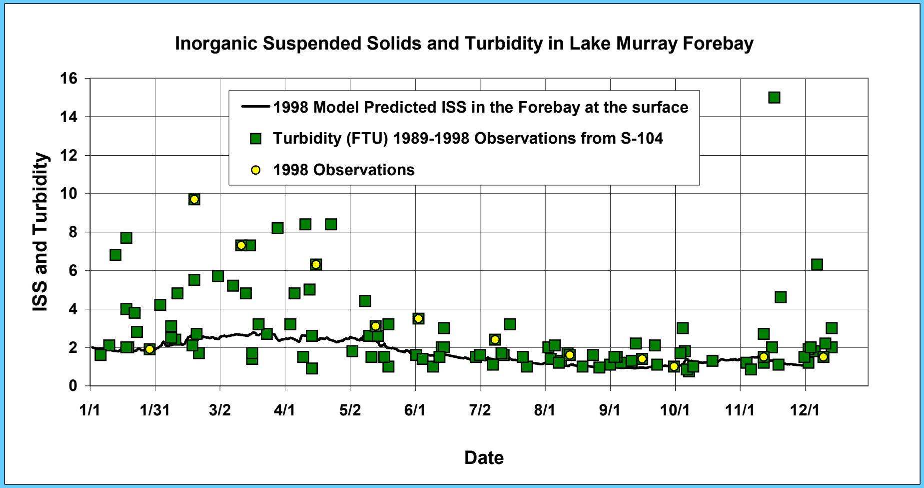


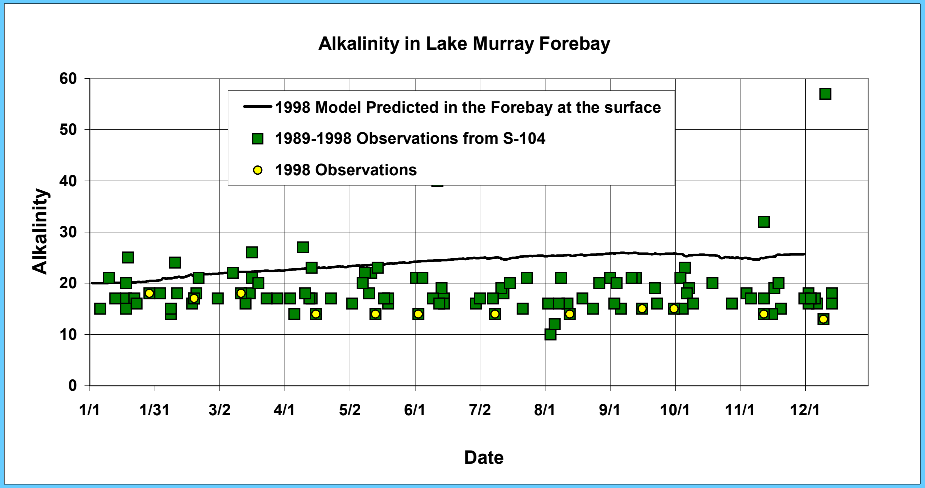


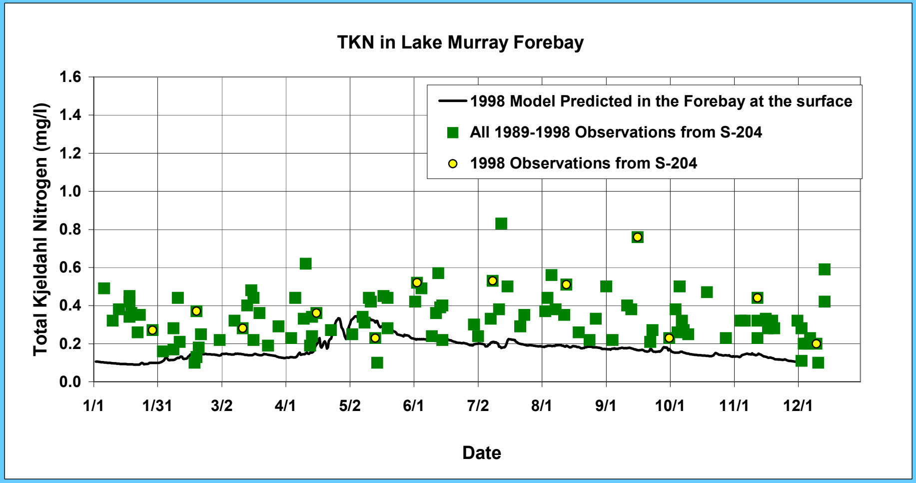


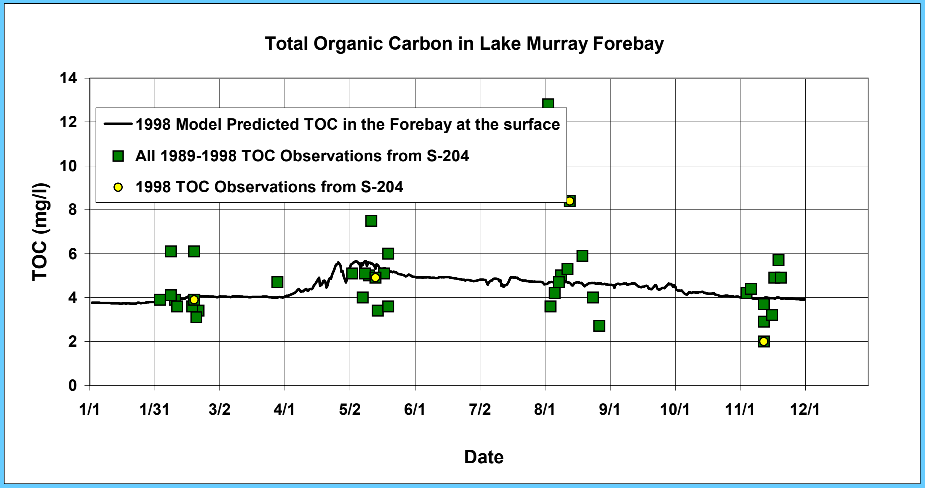
1998 - Other Water Quality Constituents

Model vs. Data









Evaluation of Raised Pool Levels

Scenarios Considered:

- 354(Jan1) to 358(May1⇨Sept1) to 354(Dec 31)
- 350(Jan1) to 358(May1⇨Sept1) to 350(Dec 31)

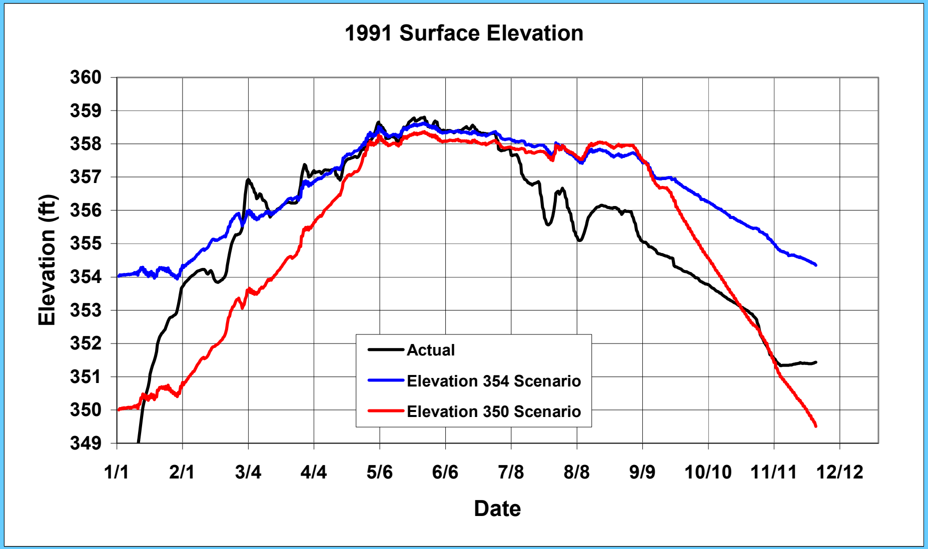
Assumptions:

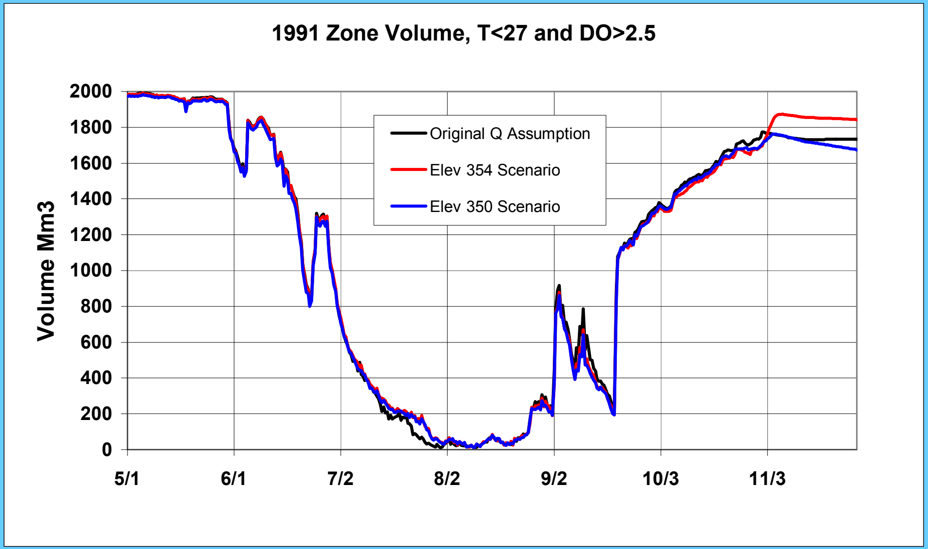
- Assumed 500 cfs for minimum release
- Assumed reserve generation averaged 3hr every two weeks at 18,000 cfs
- Balance of releases were assumed to be used to supplement system demand

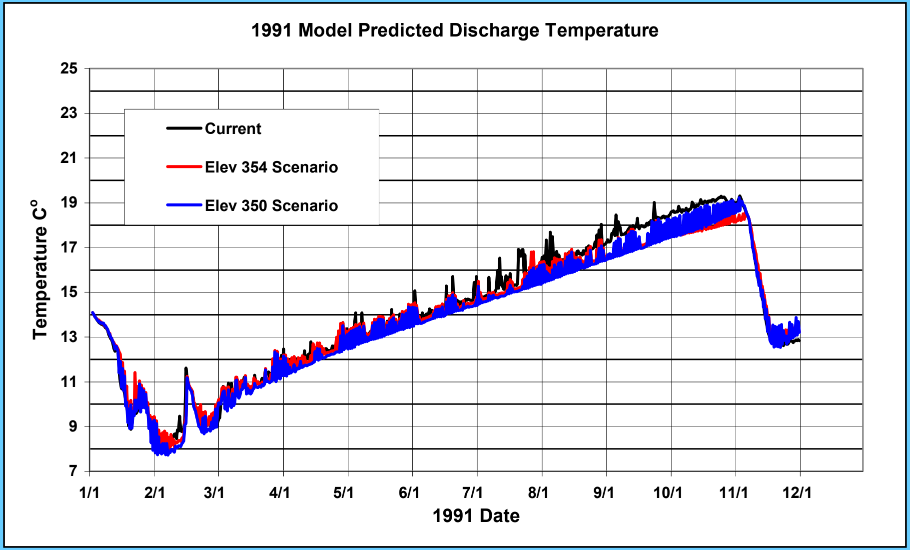
Approach:

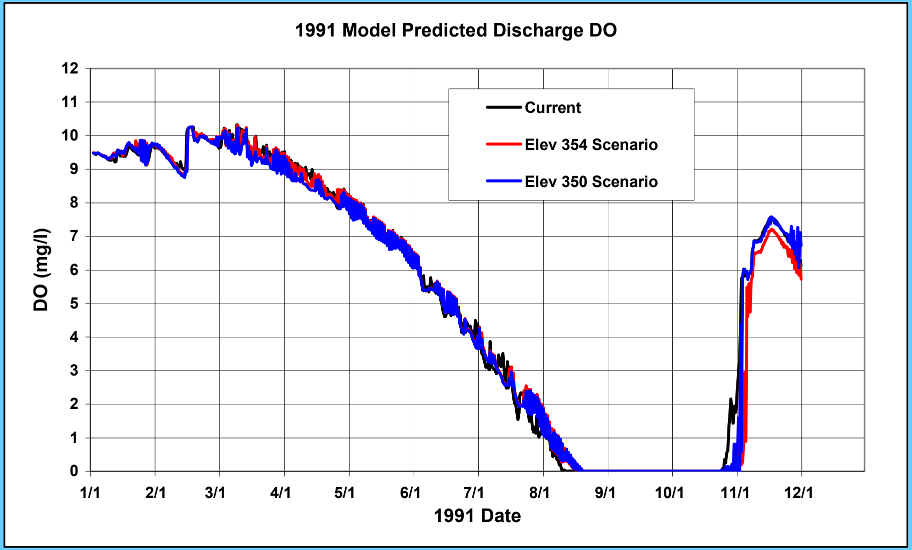
- The above scenarios were developed by KA using daily average flows using HEC-ResSim
- CE-QUAL-W2 was run using daily average flows and release flows were adjusted so that target pool levels were attained
- Using the daily average flows that were adjusted using the CE-QUAL-W2 model the hourly flows for each day were developed using the assumptions above

1991 Surface Elevation, Volume of Striper Habitat and Discharge Temperature and DO

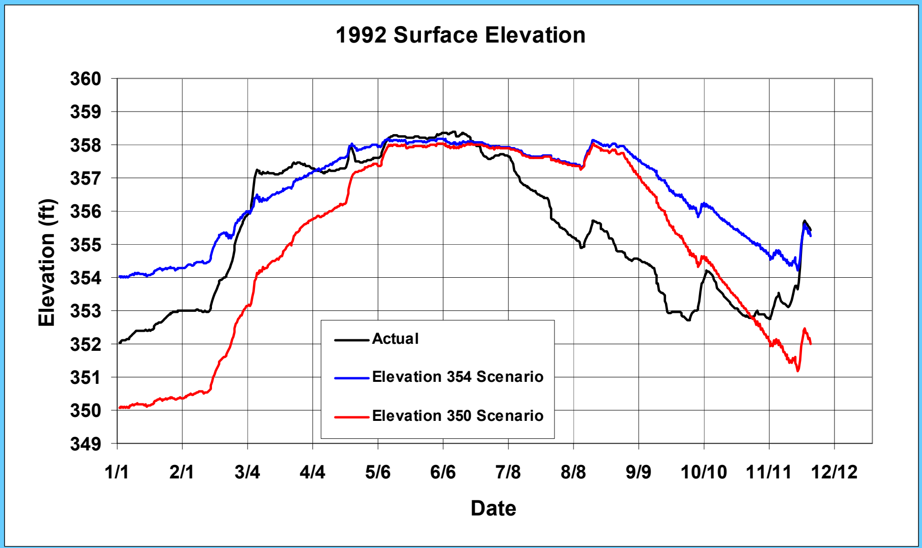


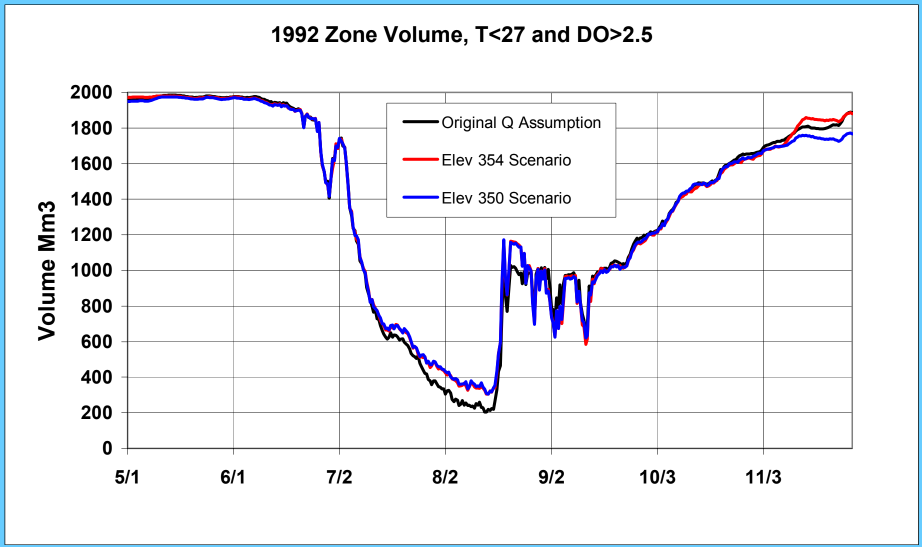


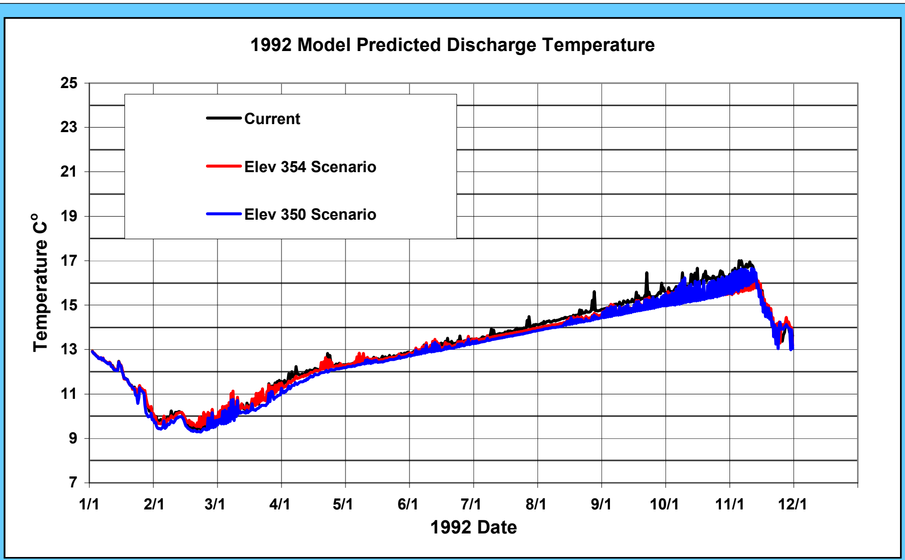


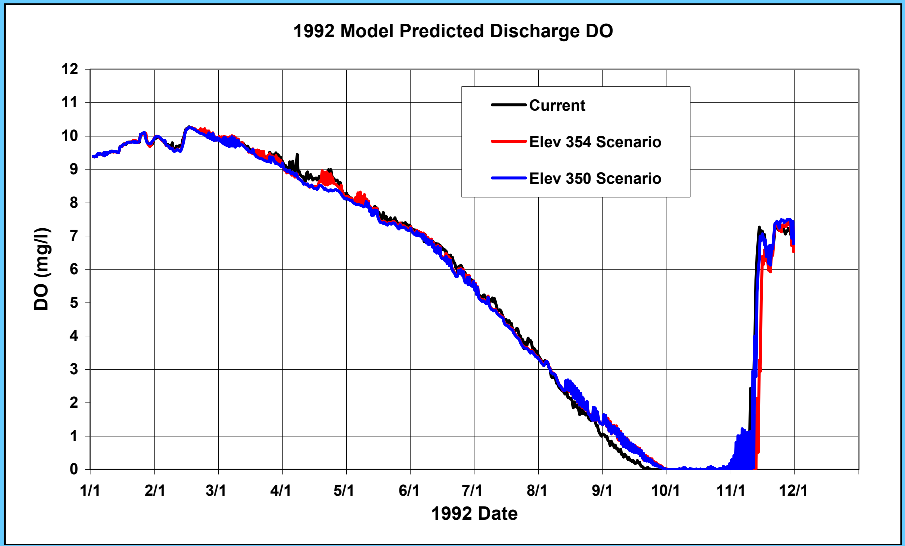


1992 Surface Elevation, Volume of Striper Habitat and Discharge Temperature and DO

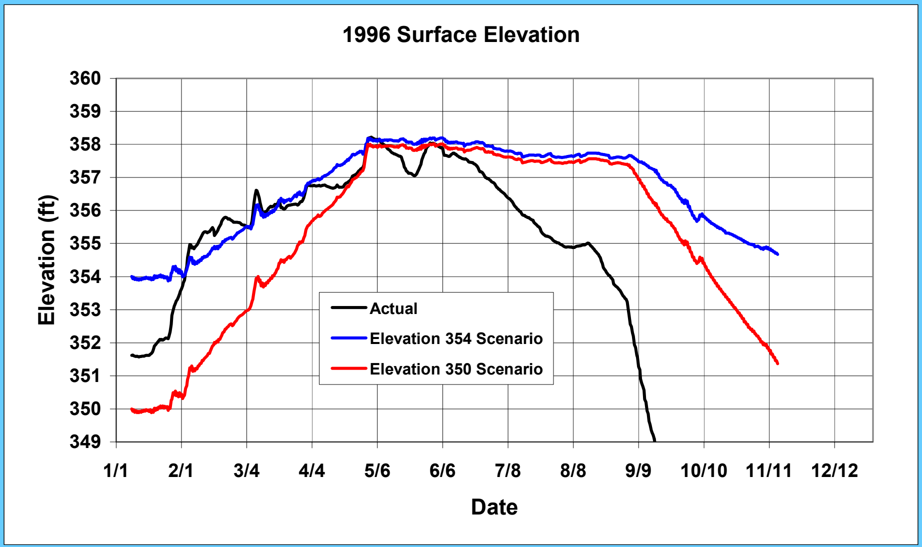


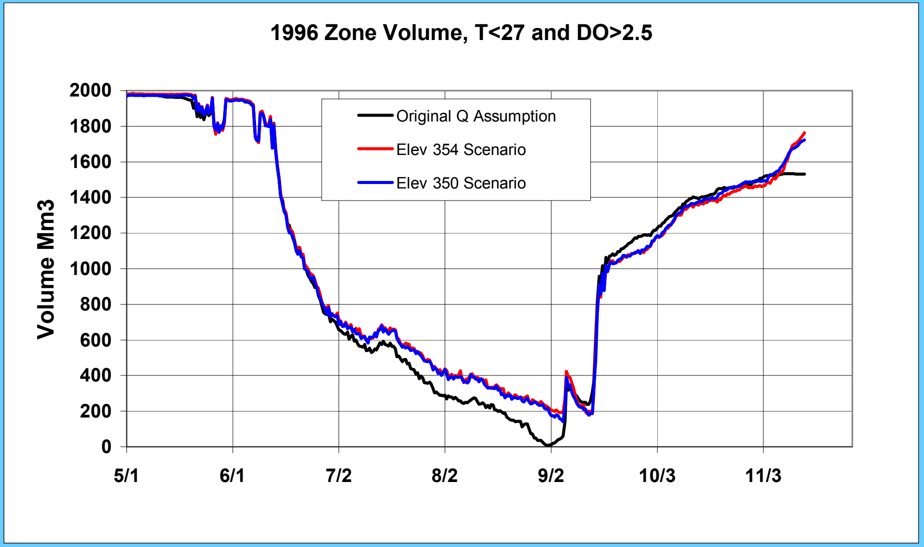


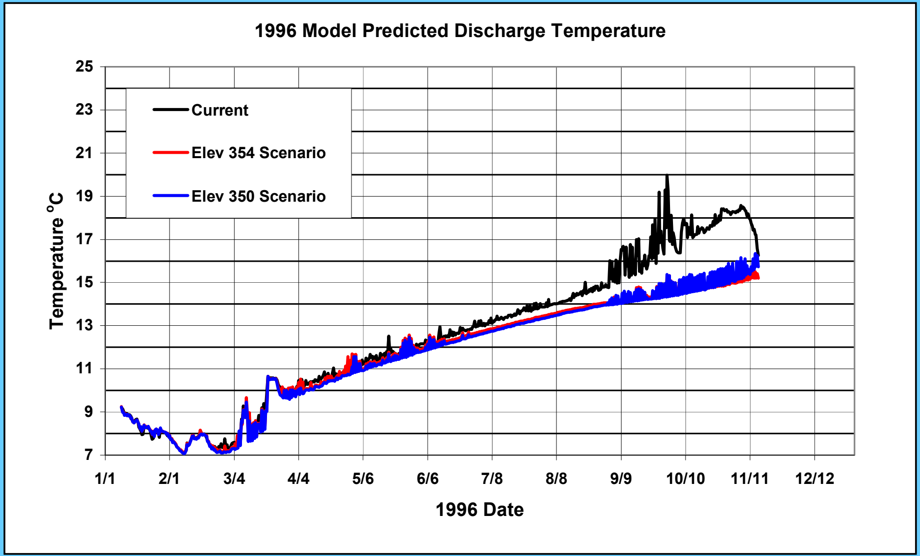


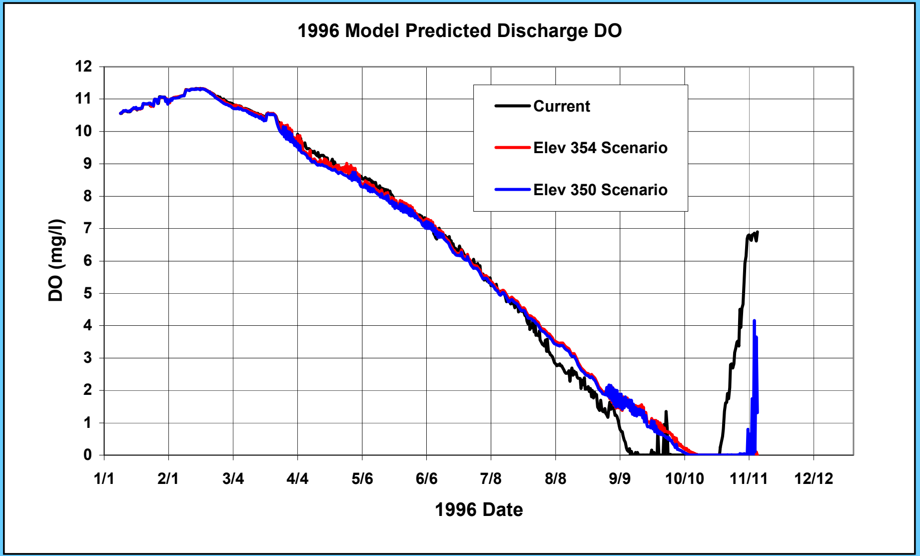


1996 Surface Elevation, Volume of Striper Habitat and Discharge Temperature and DO

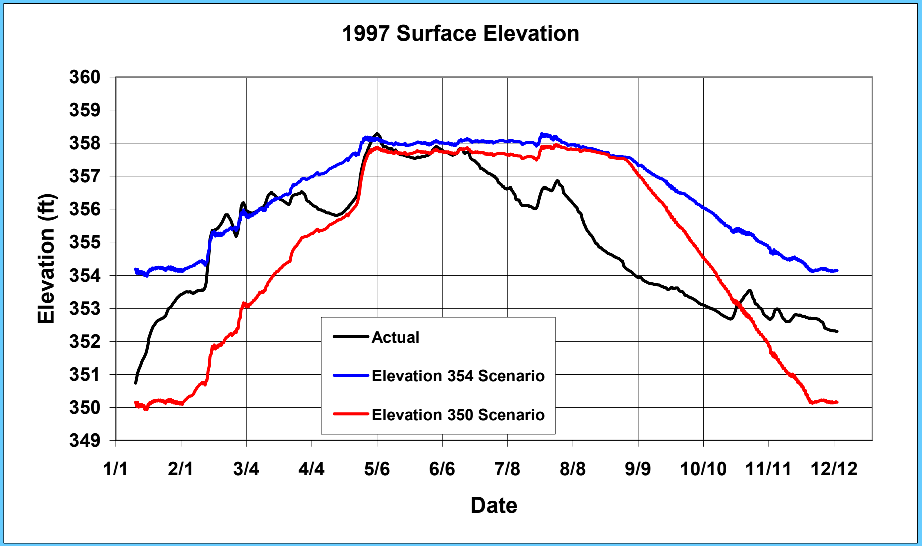


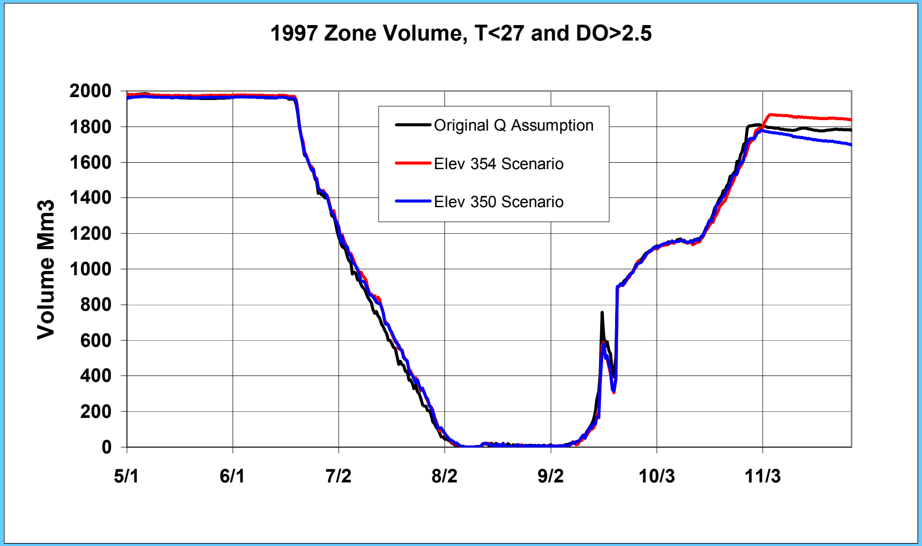


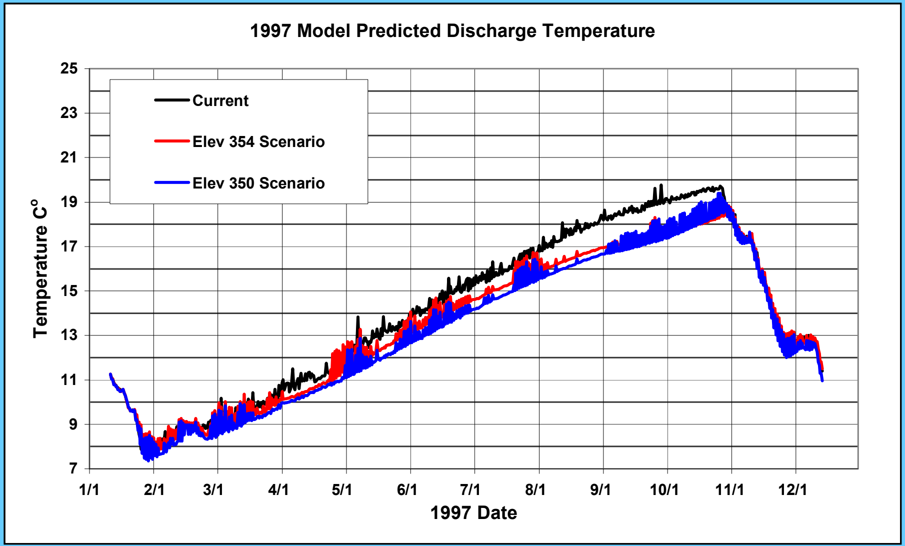


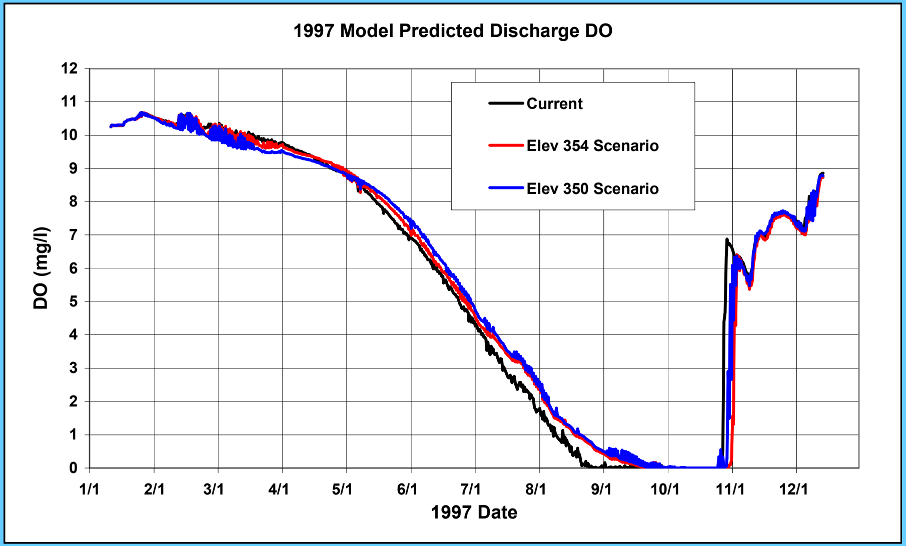


1997 Surface Elevation, Volume of Striper Habitat and Discharge Temperature and DO

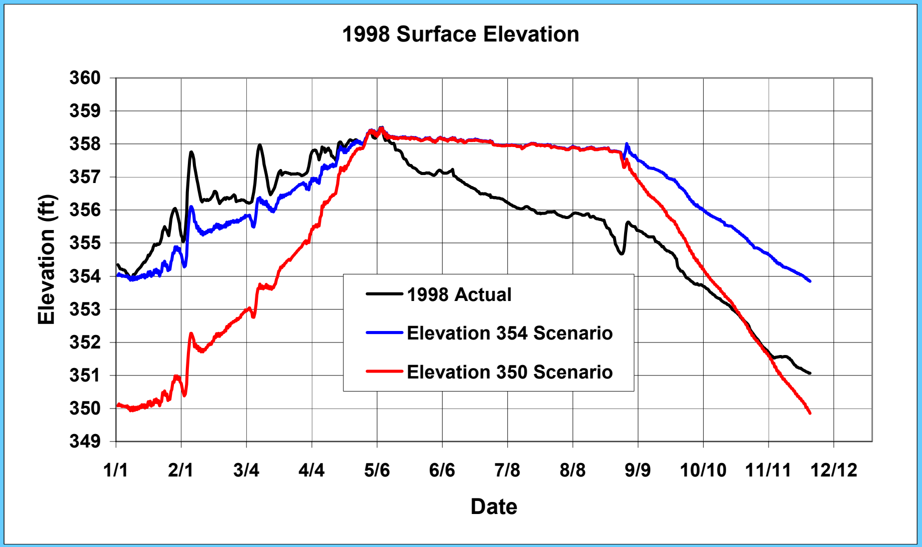


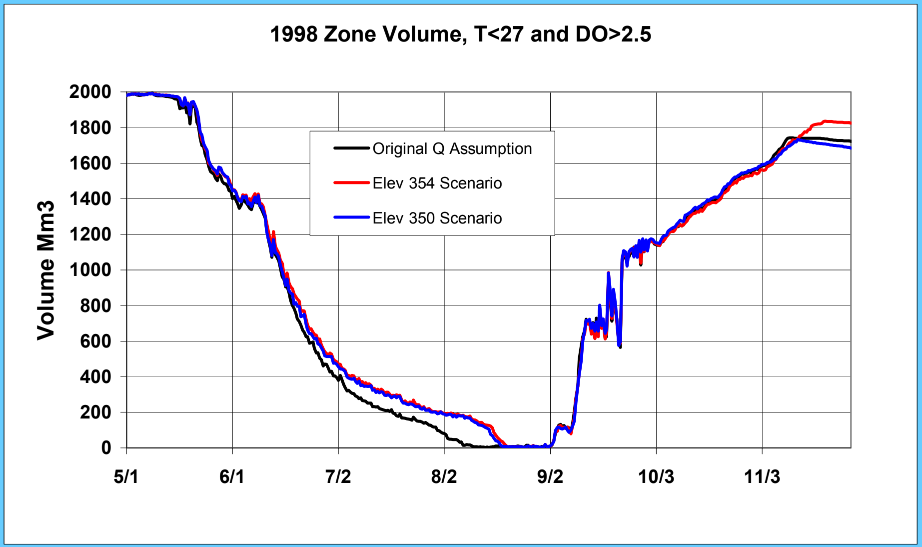


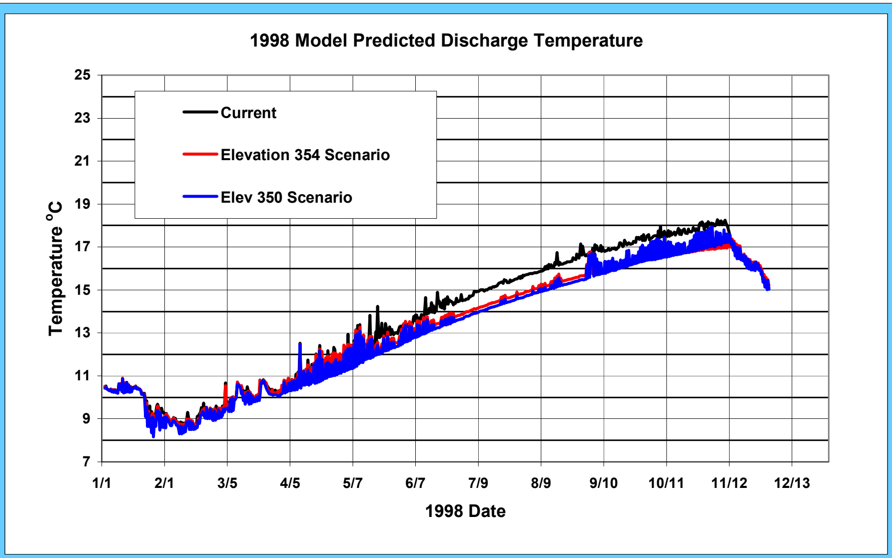


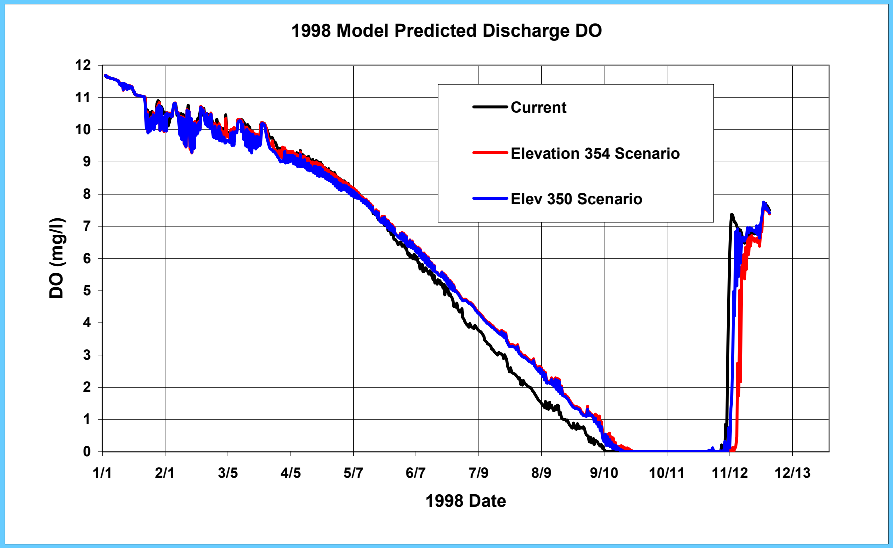


1998 Surface Elevation, Volume of Striper Habitat and Discharge Temperature and DO

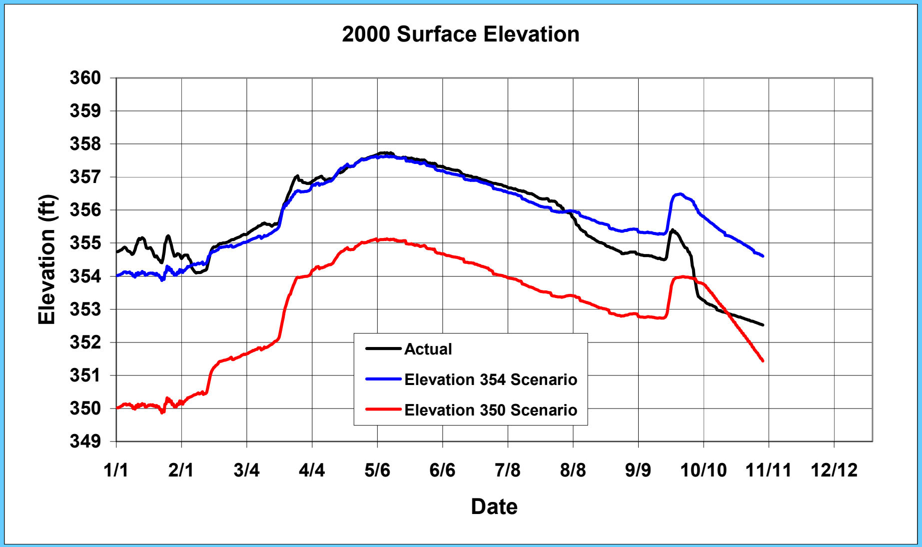


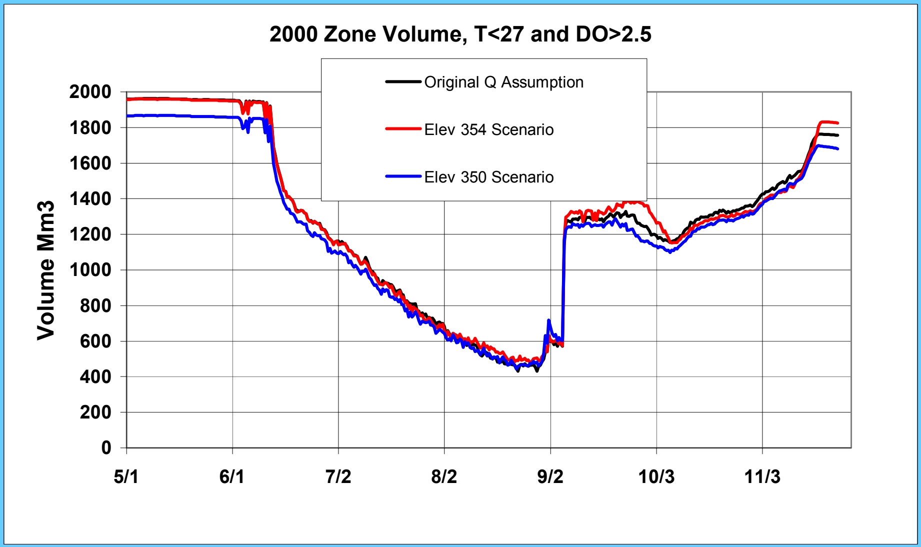


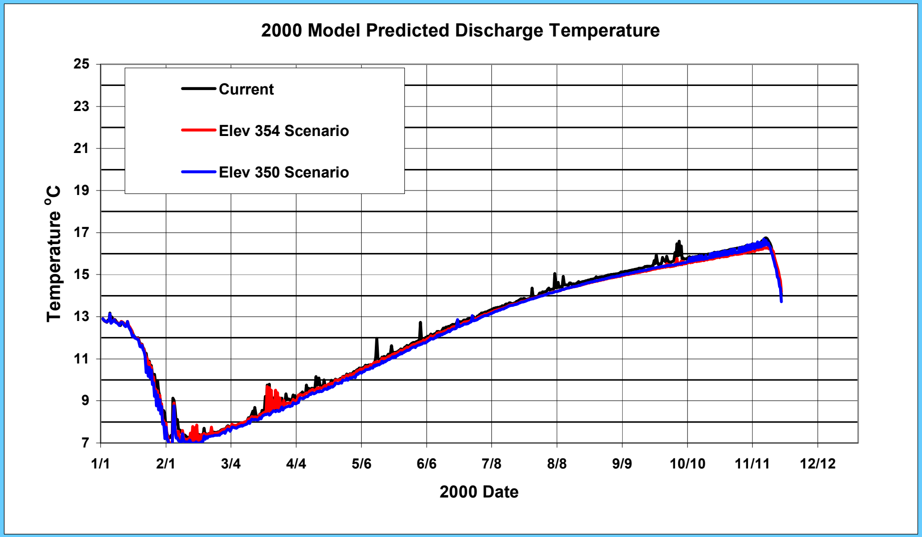


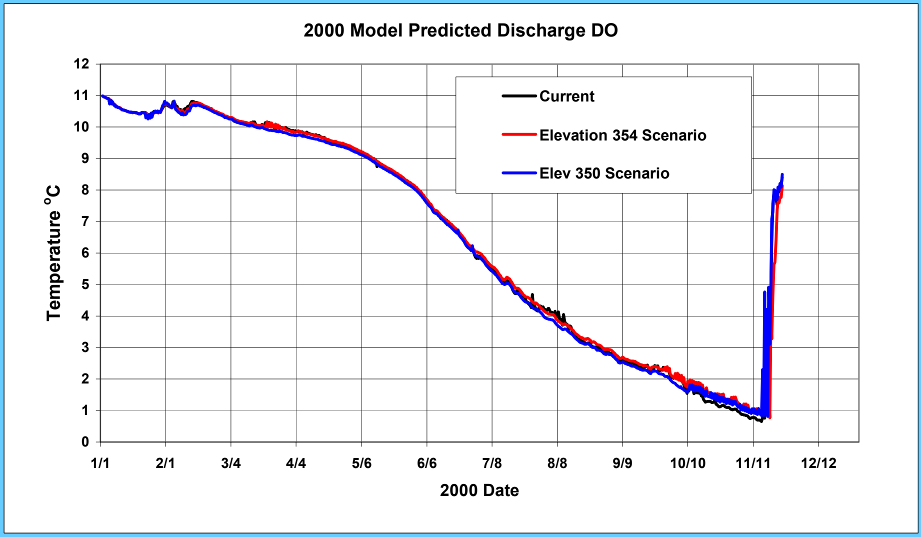


2000 Surface Elevation, Volume of Striper Habitat and Discharge Temperature and DO

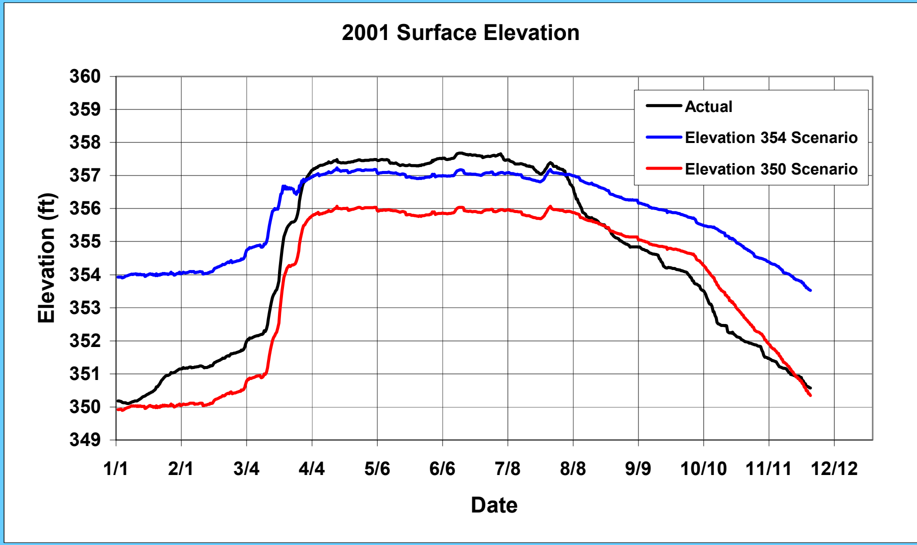


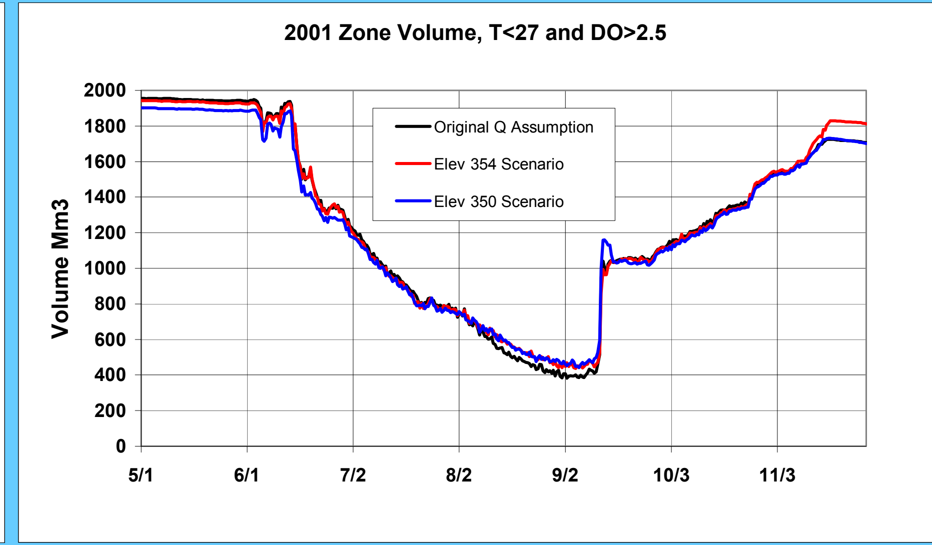


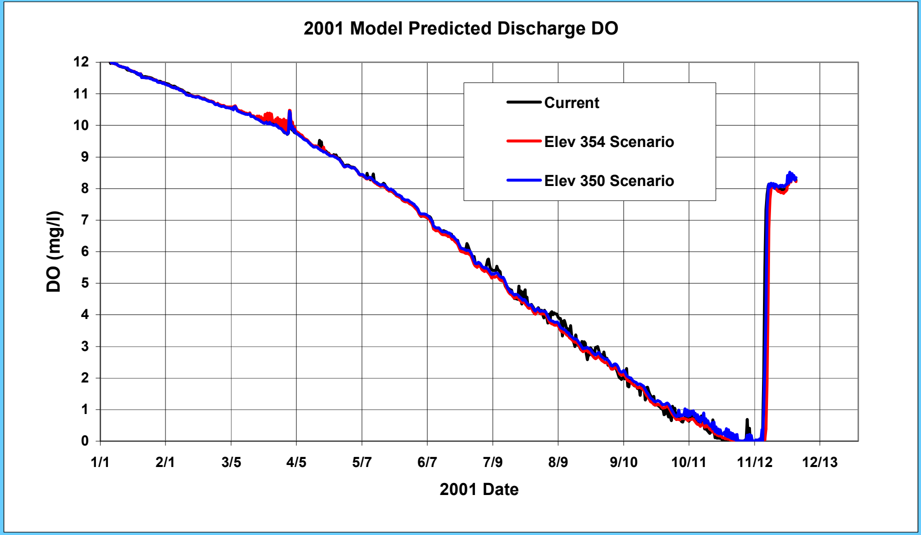


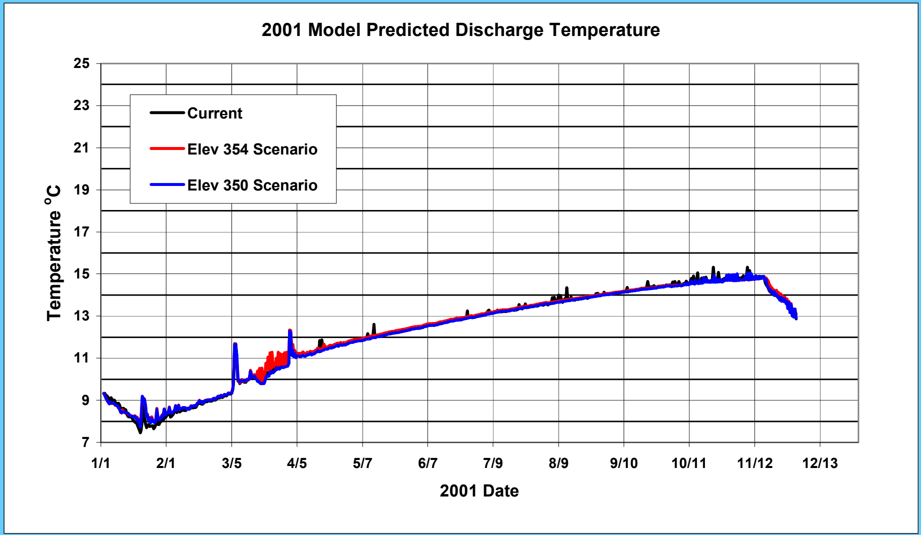


2001 Surface Elevation, Volume of Striper Habitat and Discharge Temperature and DO

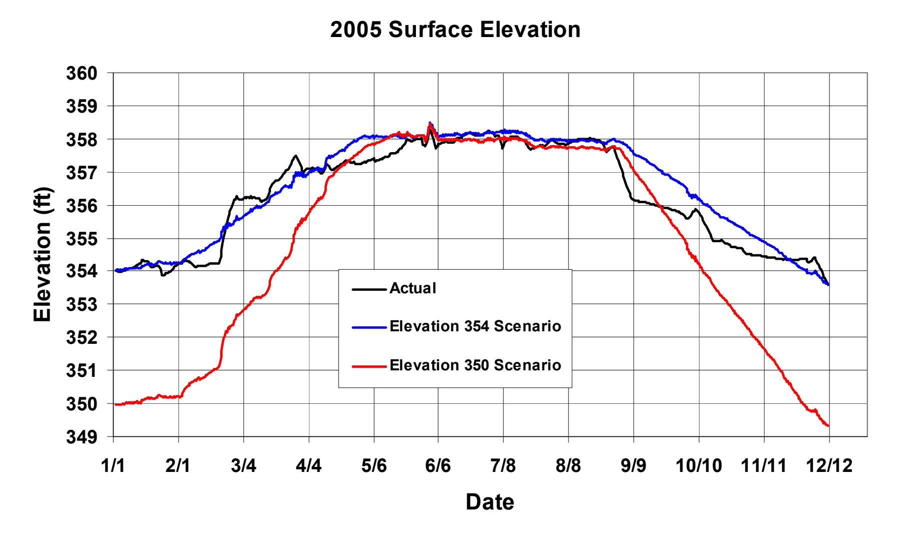


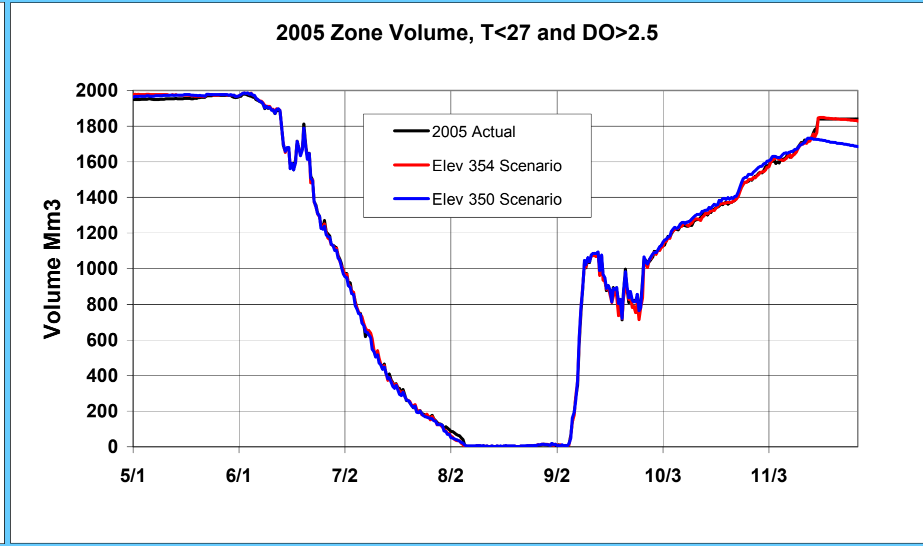


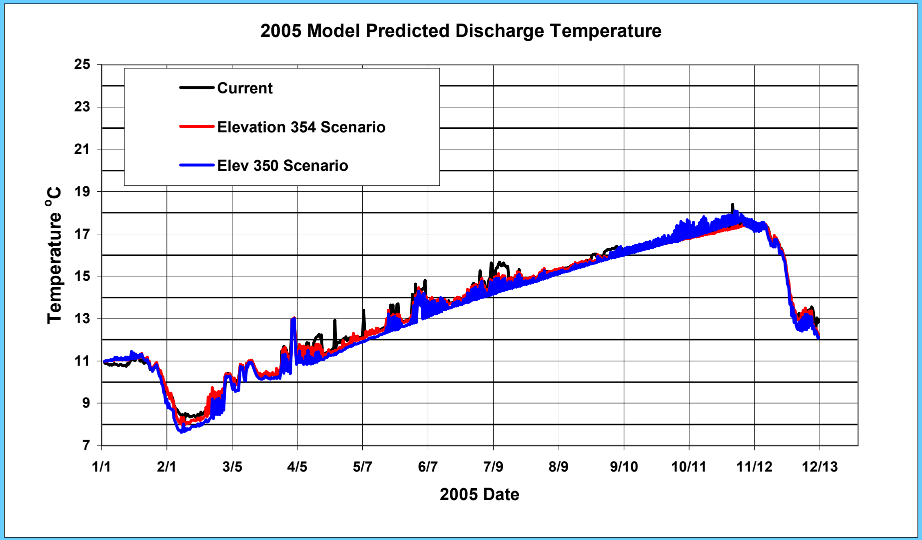


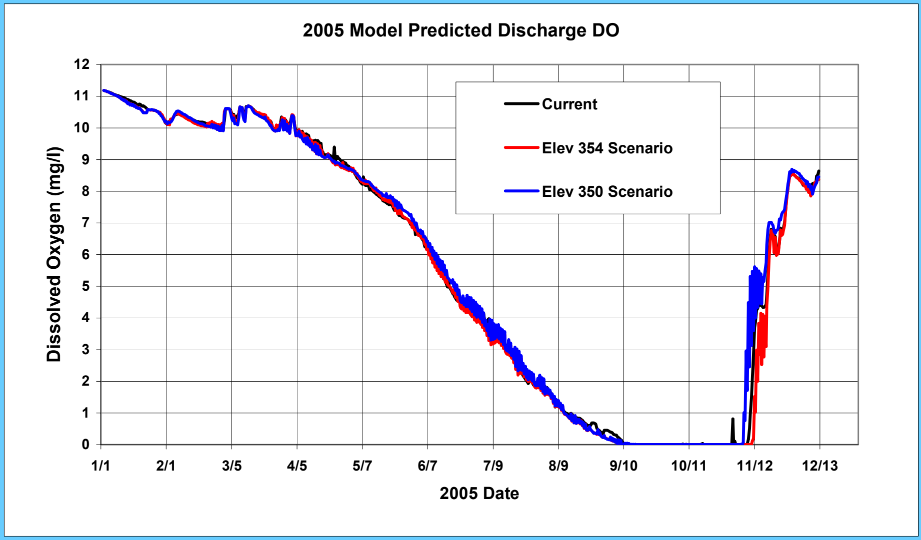


2005 Surface Elevation, Volume of Striper Habitat and Discharge Temperature and DO

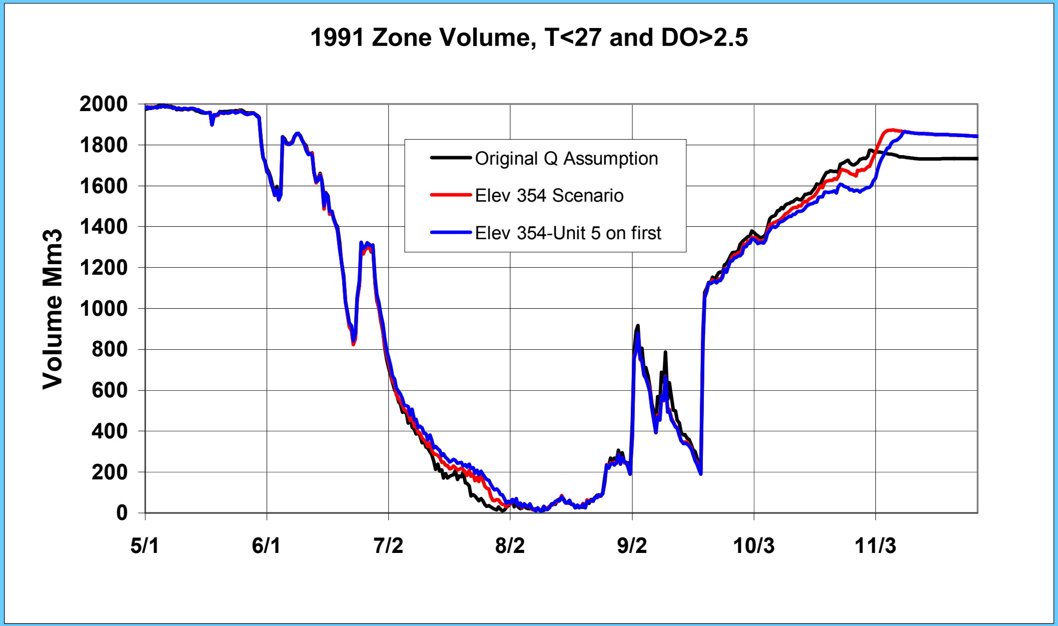


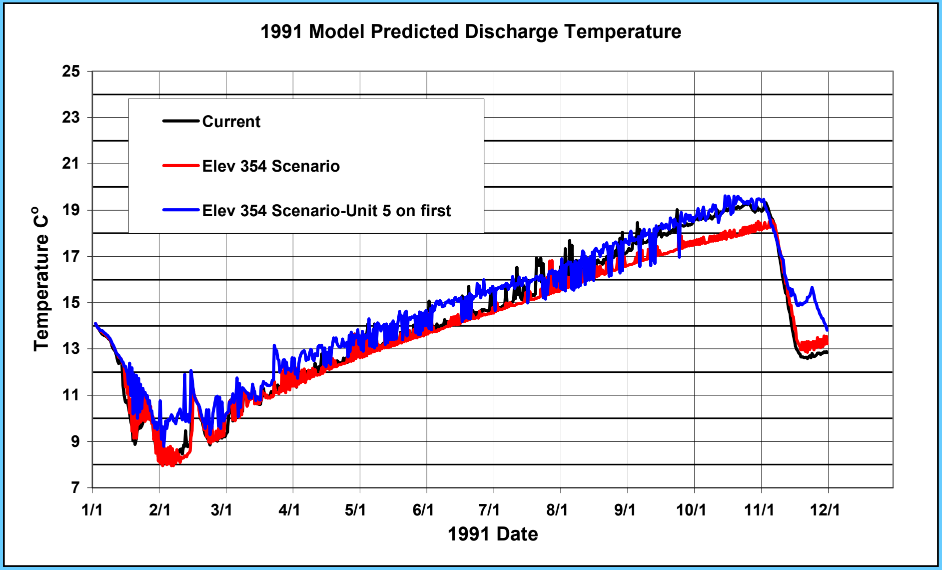


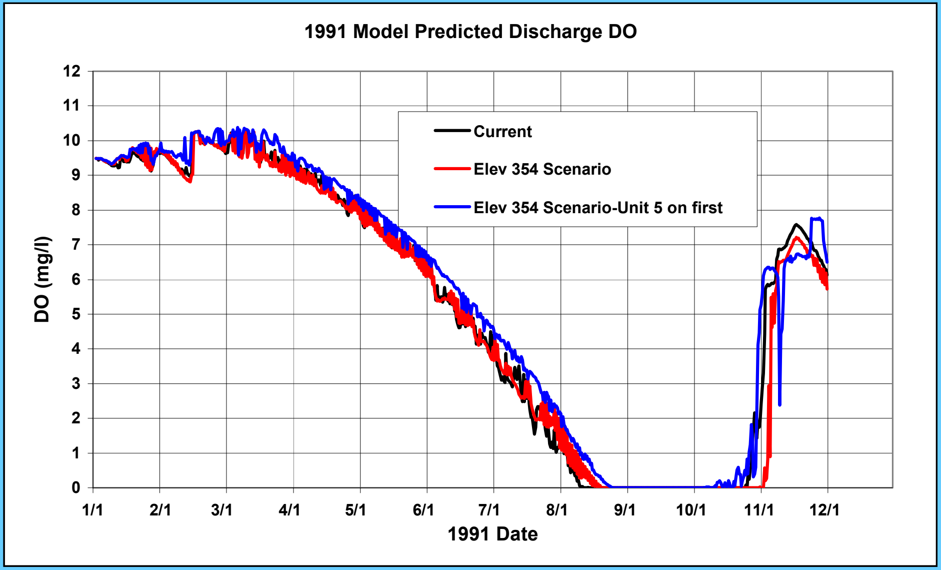




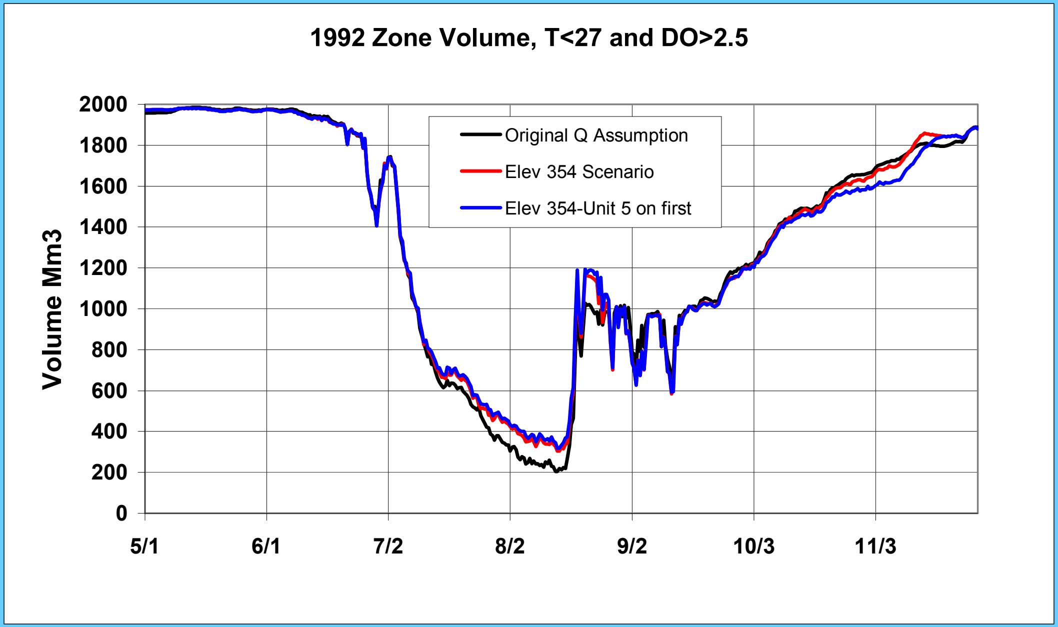
1991 Pool Level Management and Unit 5 on First

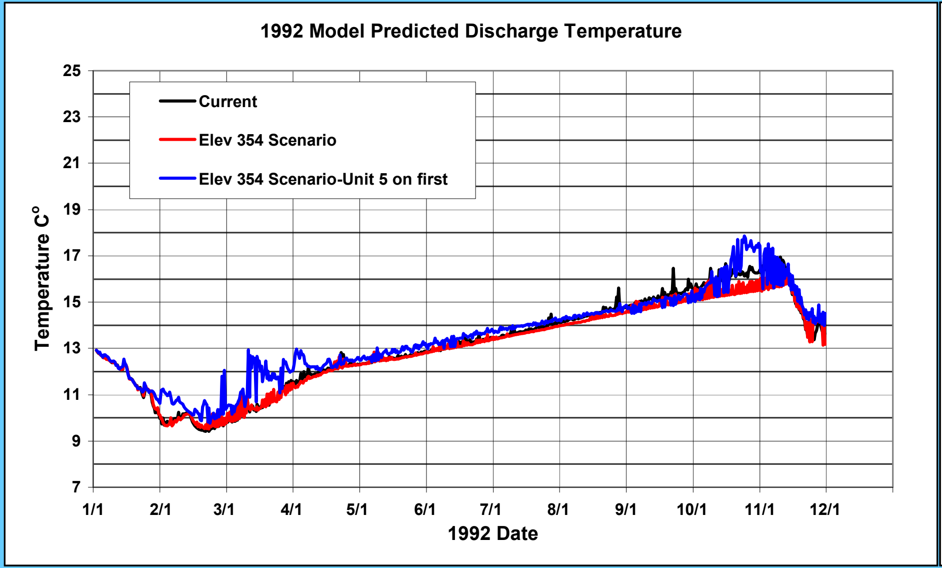


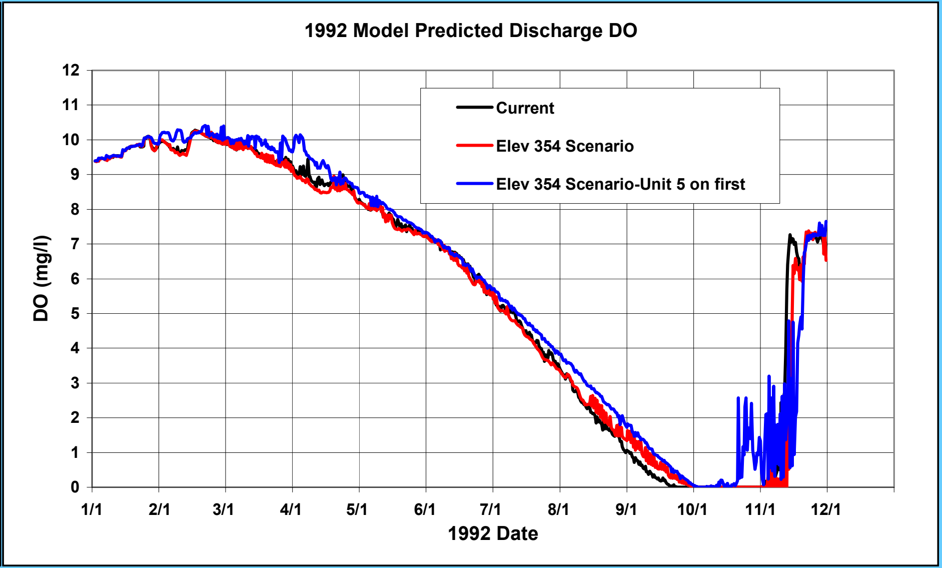




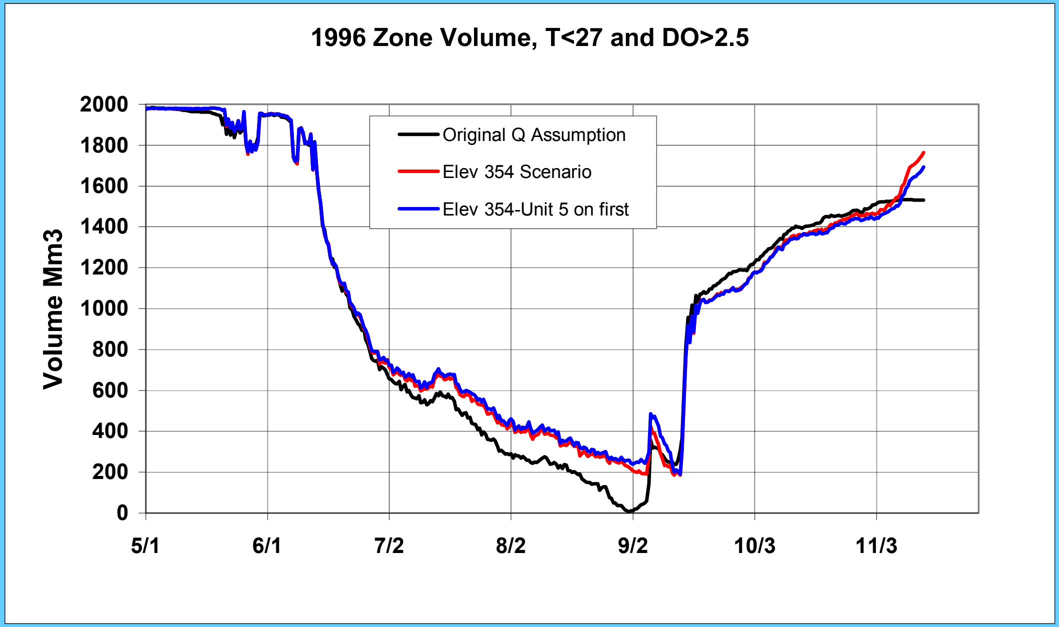
1992 Pool Level Management and Unit 5 on First

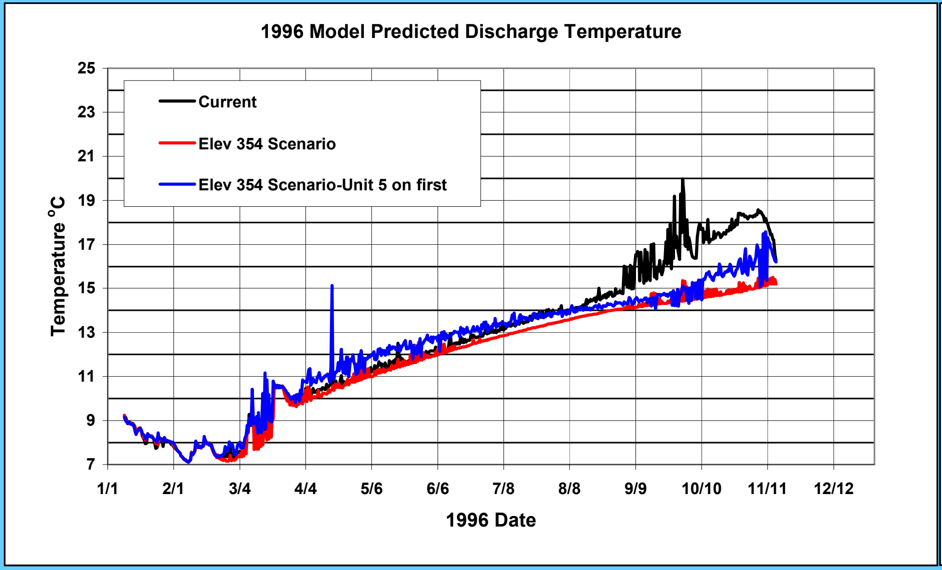


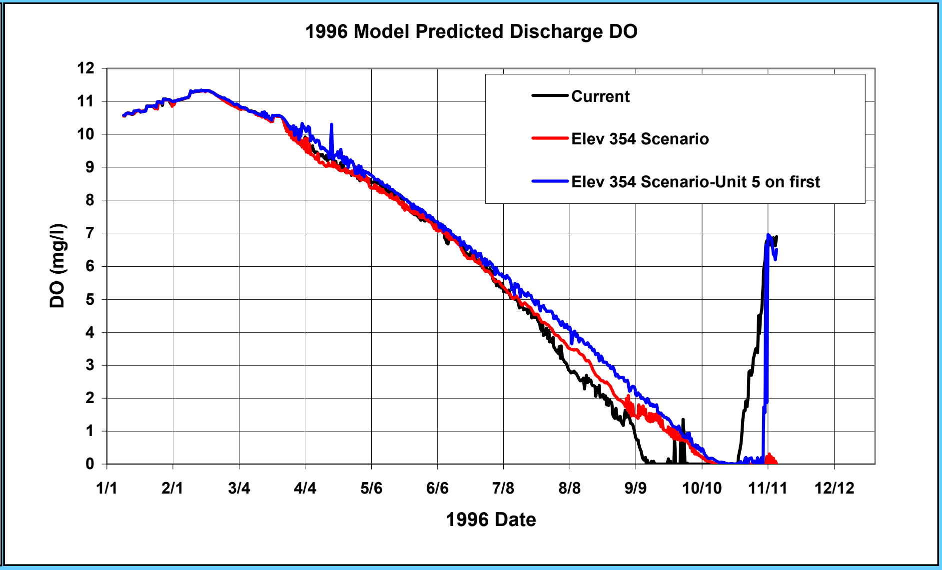




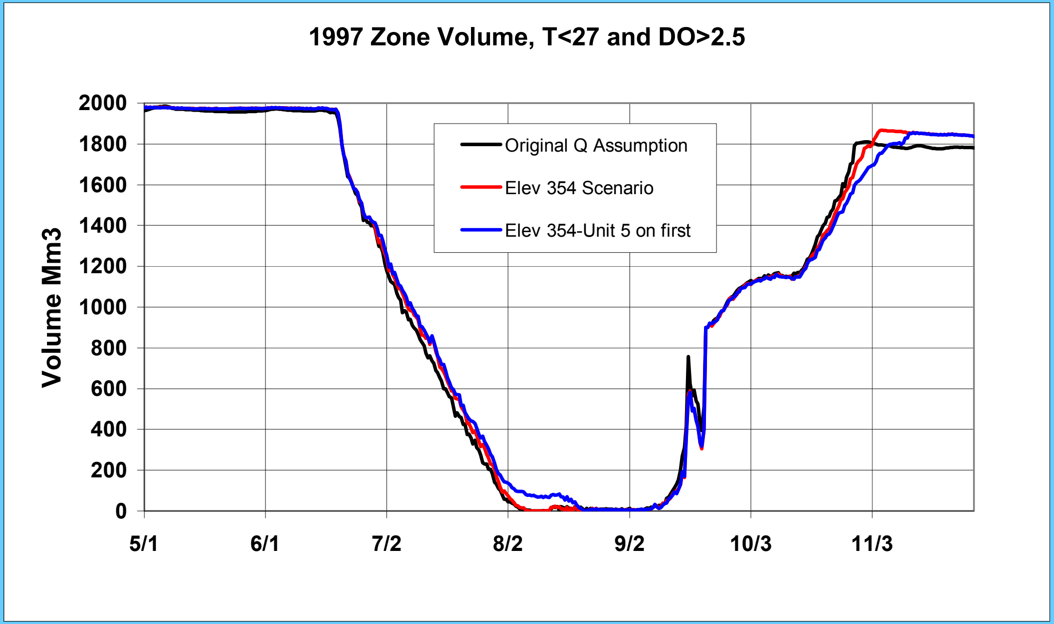
1996 Pool Level Management and Unit 5 on First

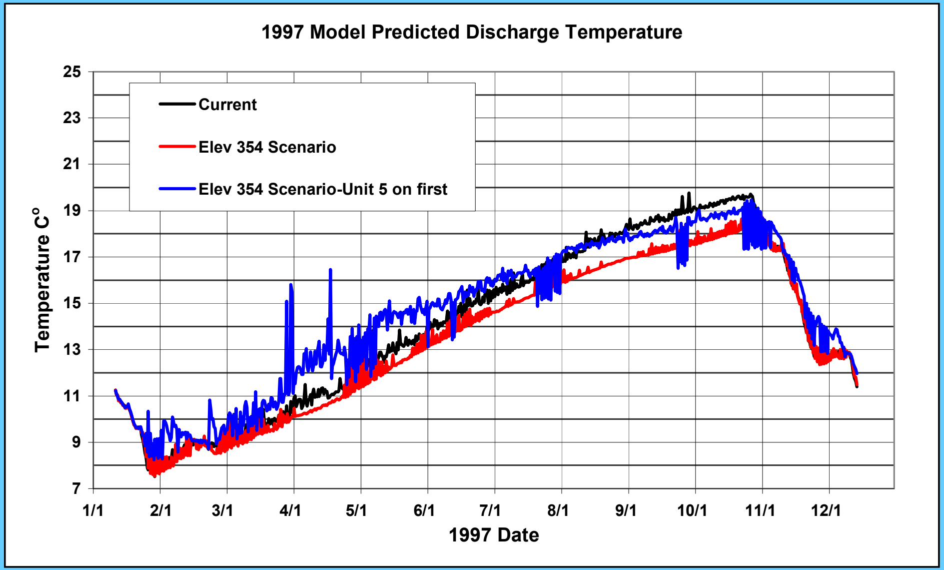


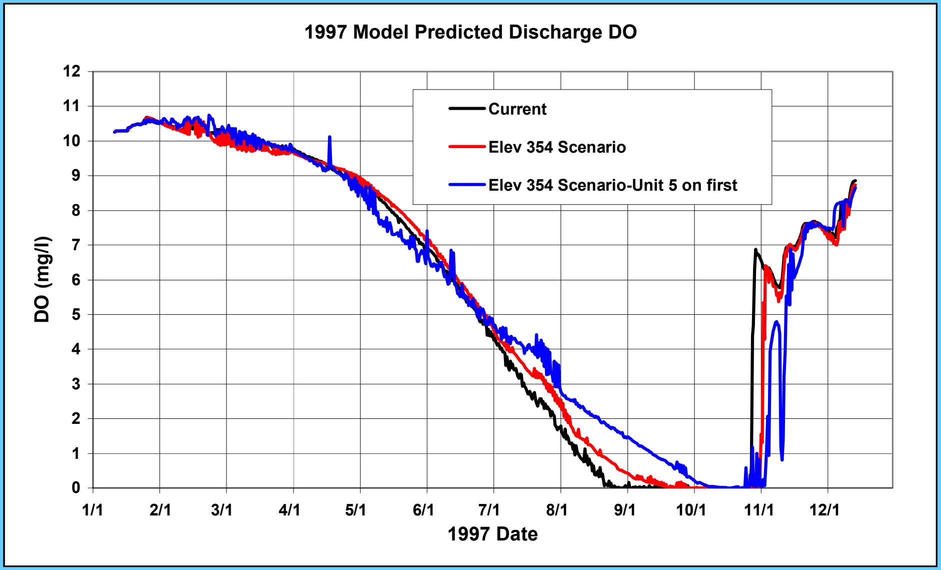




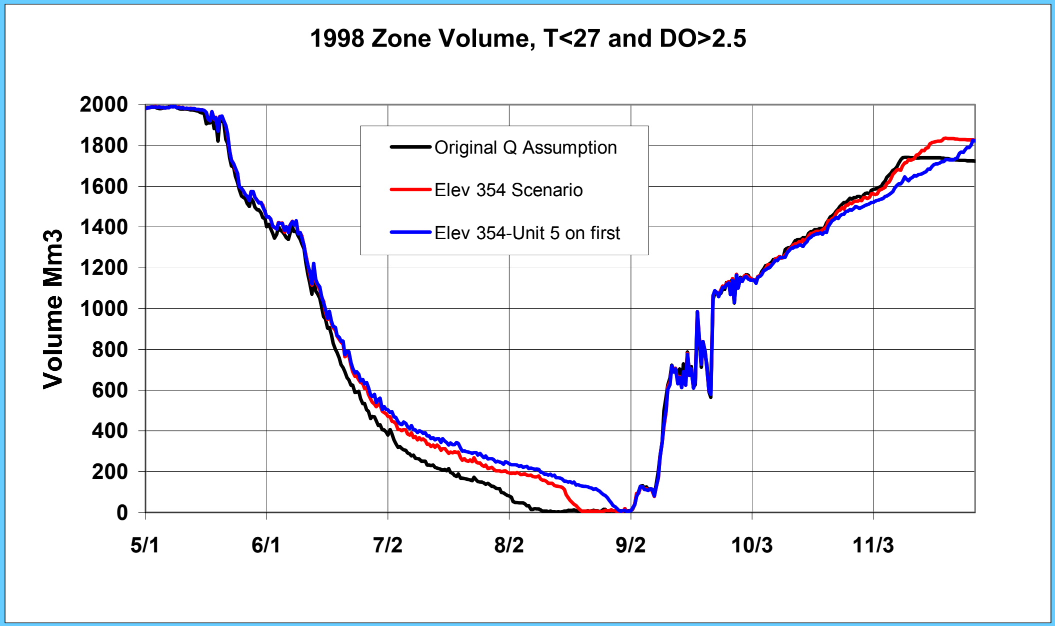
1997 Pool Level Management and Unit 5 on First

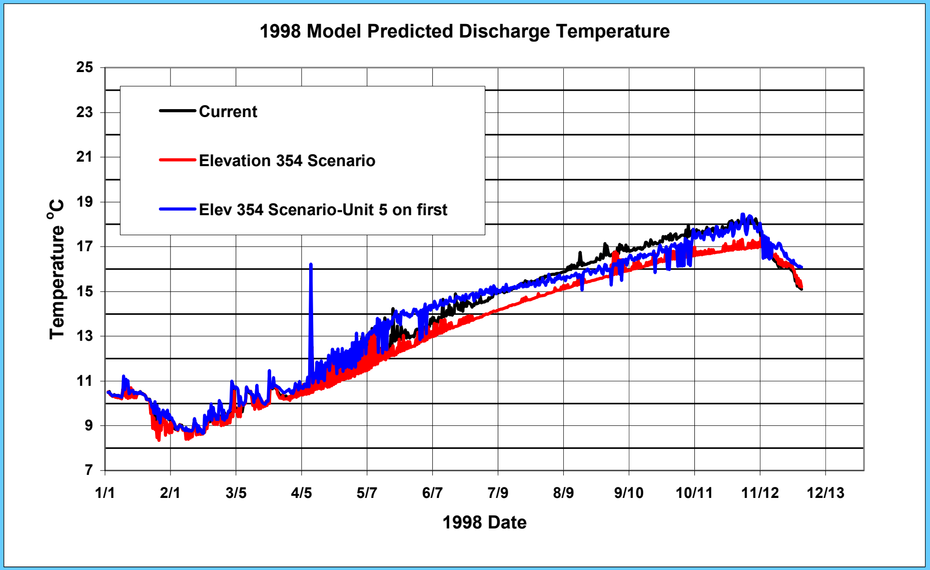


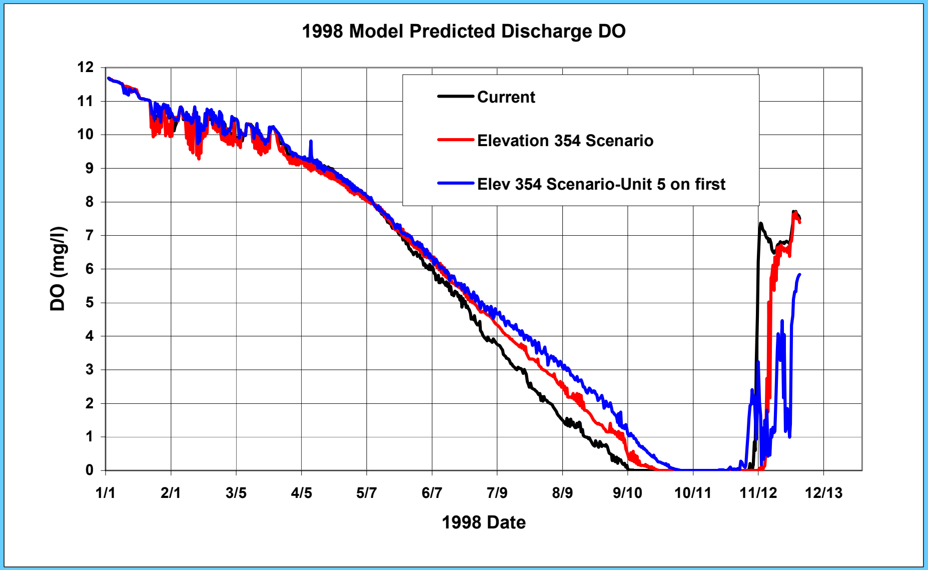




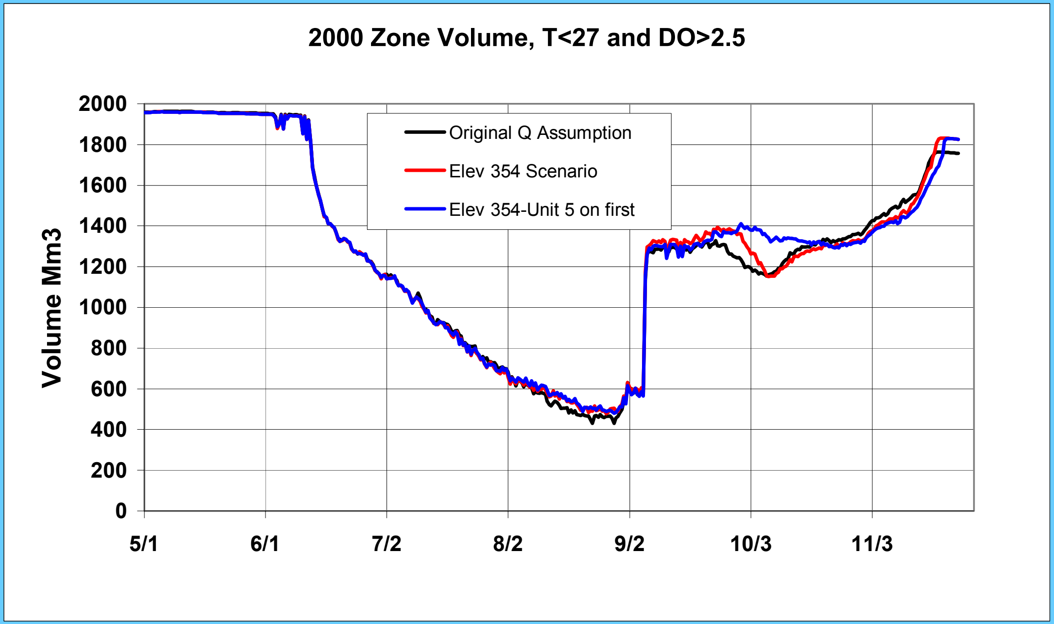
1998 Pool Level Management and Unit 5 on First

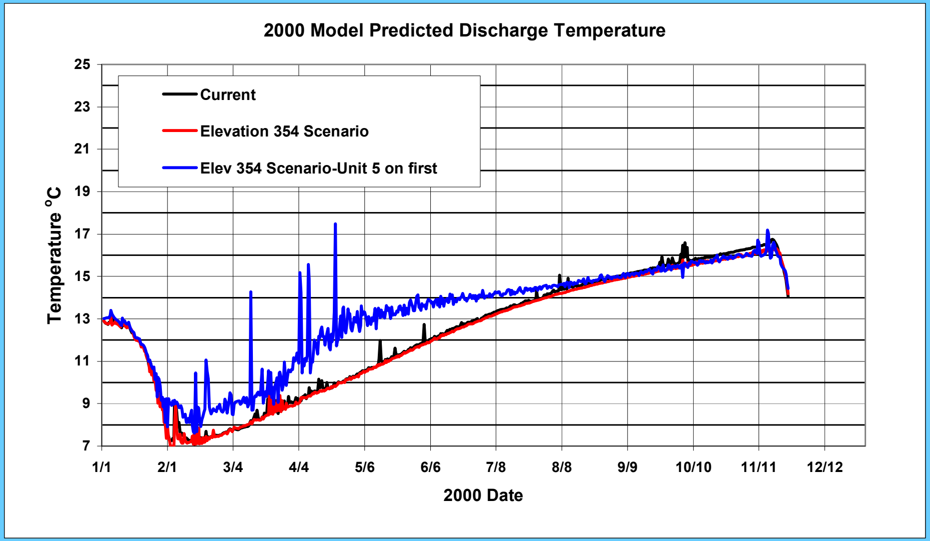


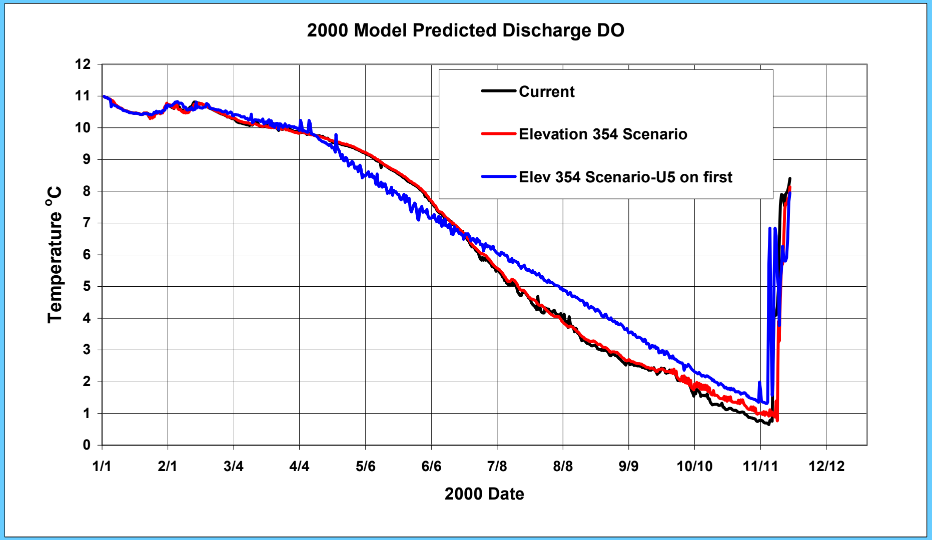




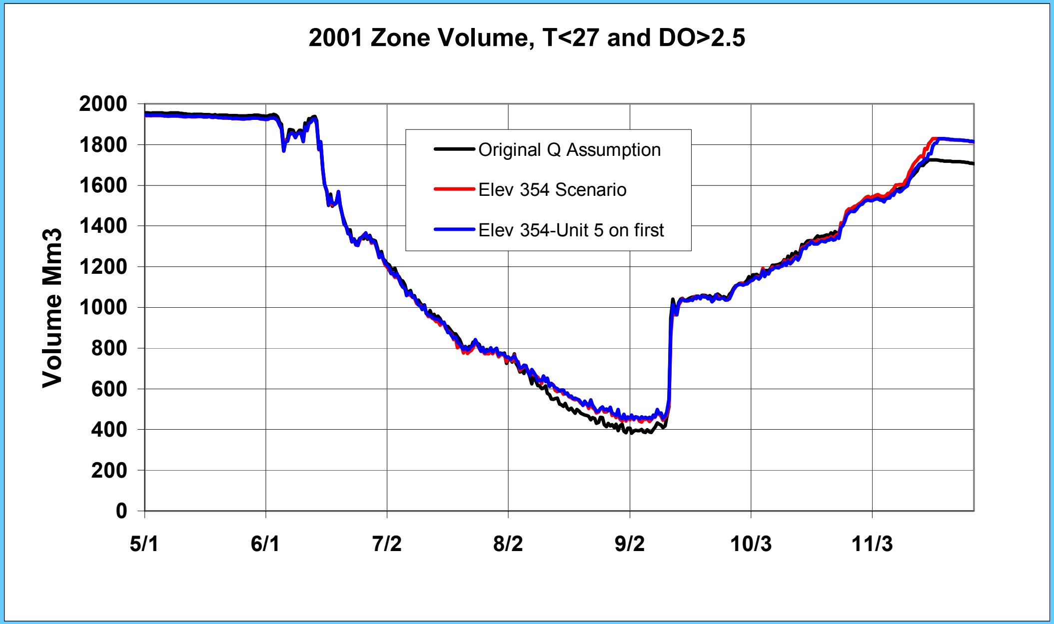
2000 Pool Level Management and Unit 5 on First

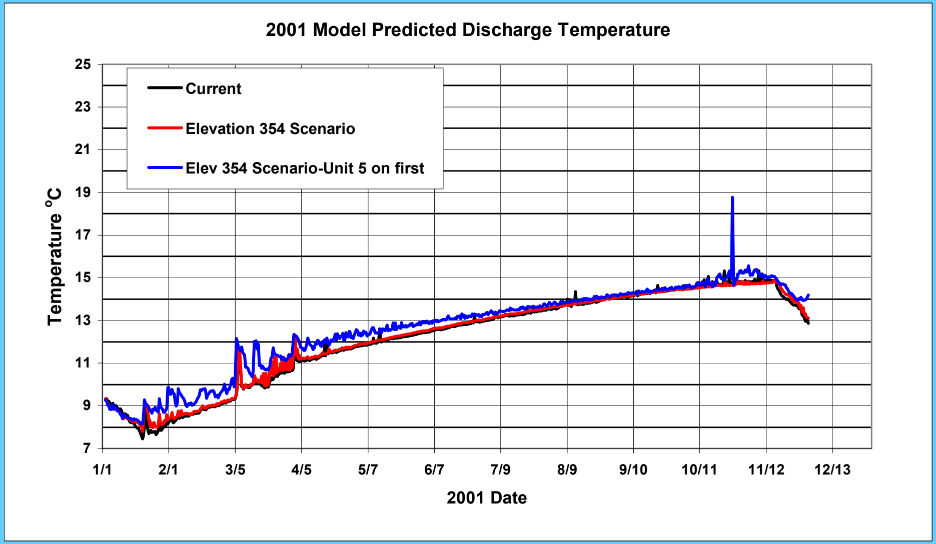


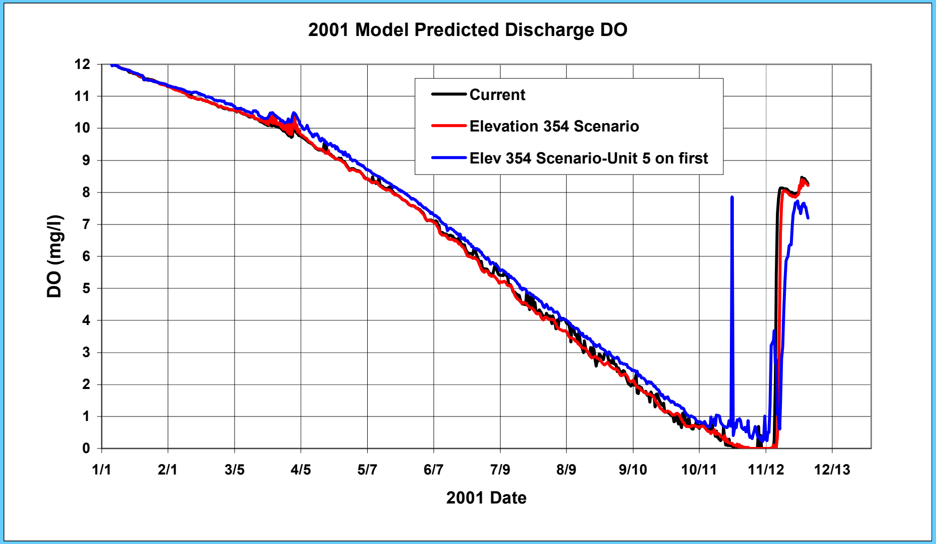




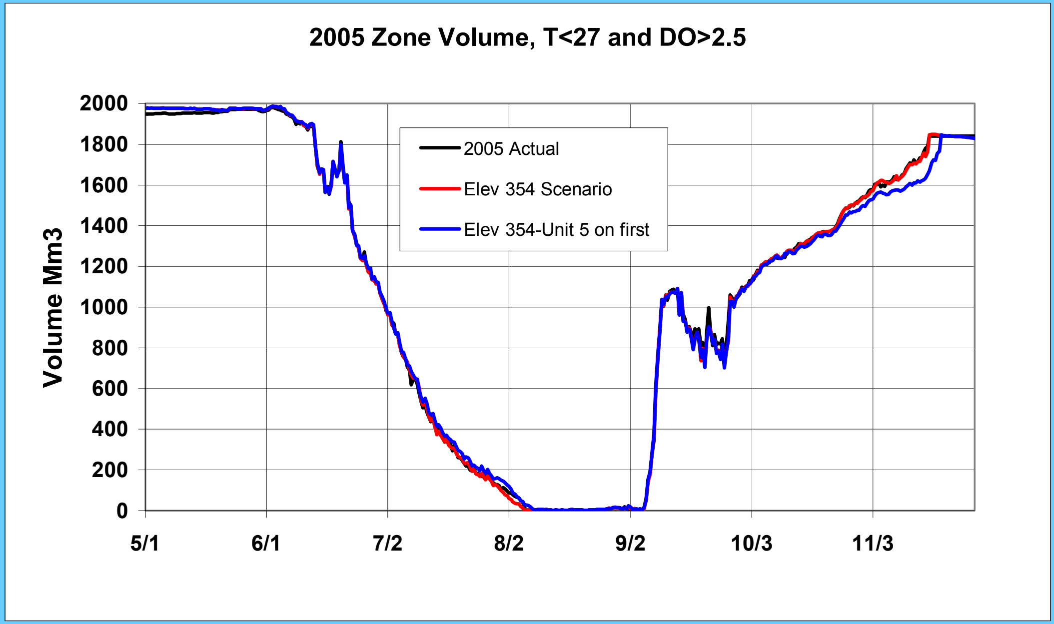
2001 Pool Level Management and Unit 5 on First

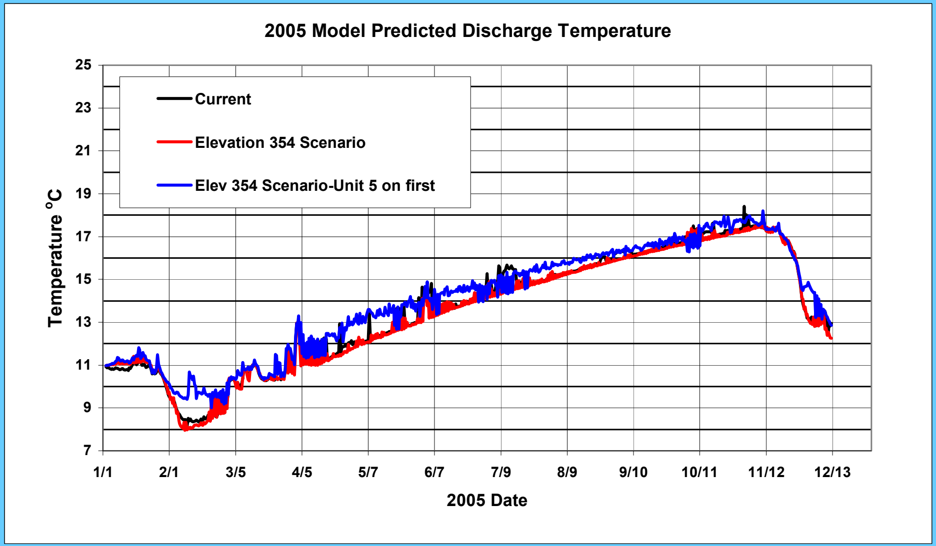


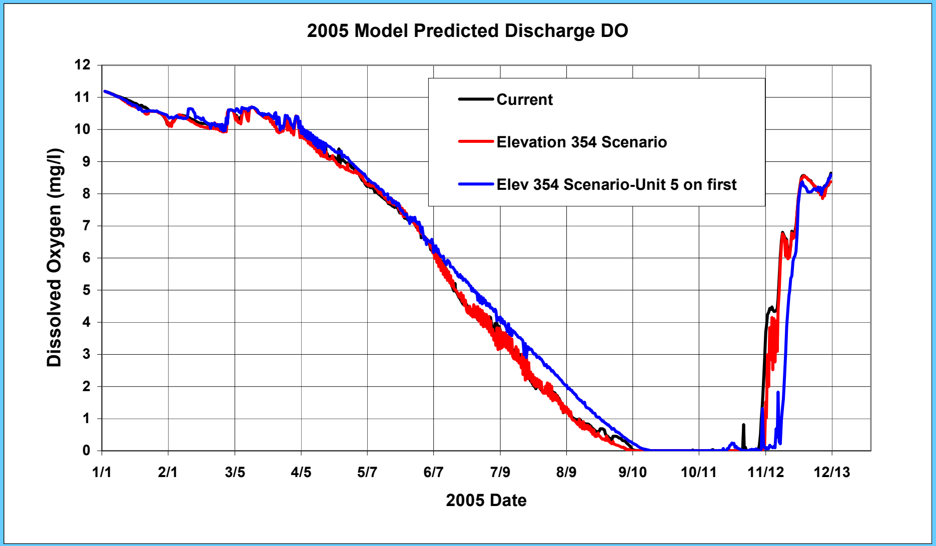




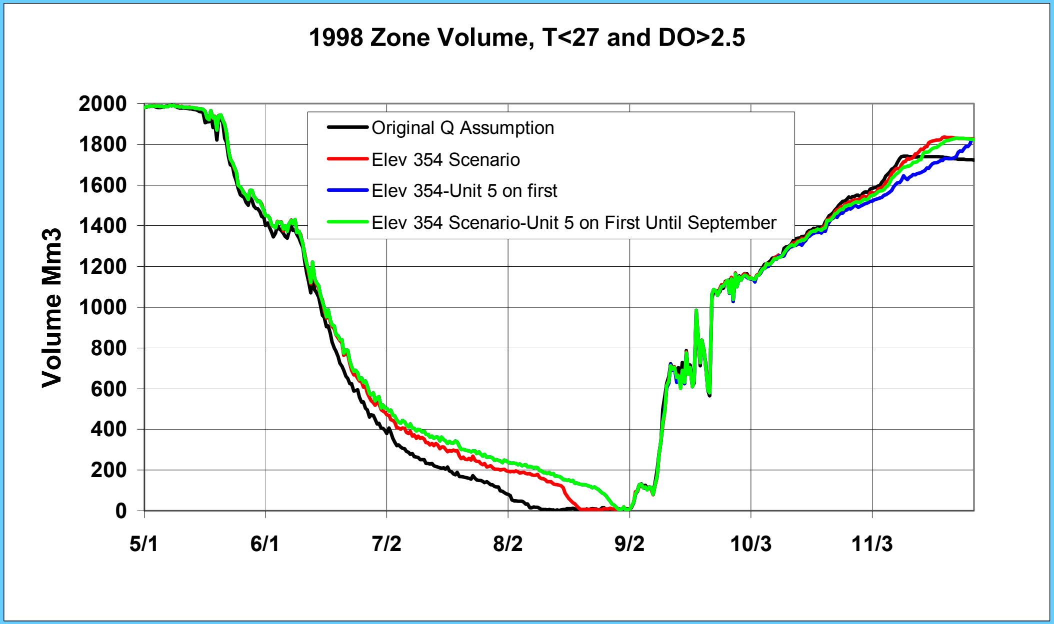
2005 Pool Level Management and Unit 5 on First

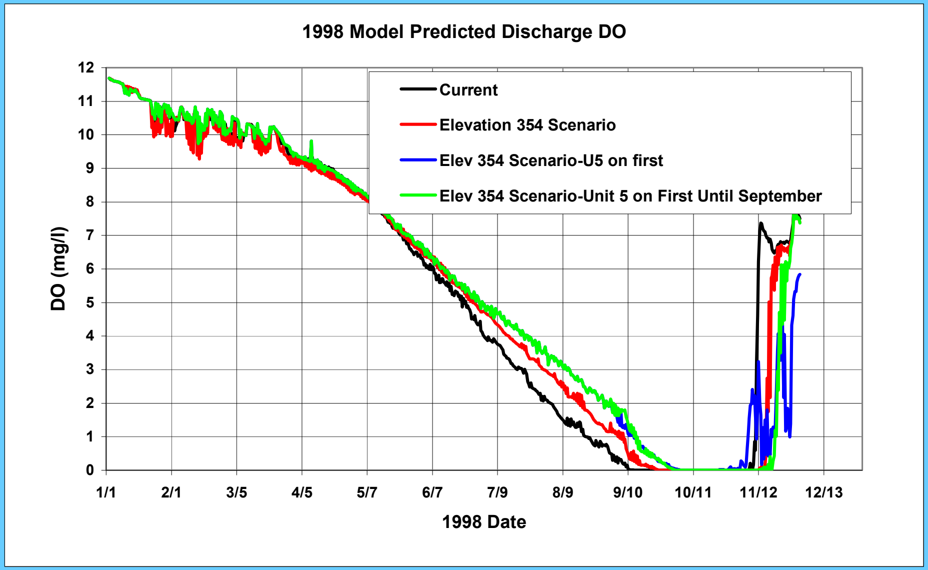


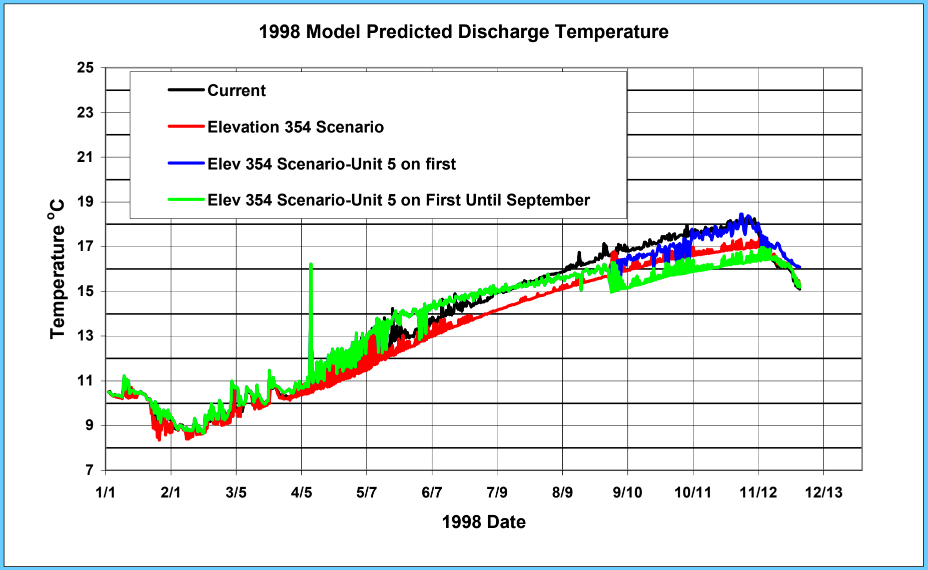




1998 Pool Level Management and Unit 5 on First Until September When the Bottom Units are used for the first 12,800 cfs







Conclusions

- Unit 5 preferential operations can improve striped bass habitat in some years.
- Maintaining the summer pool level at 358 increases striped bass habitat in some years.
- The combination of Unit 5 preferential operations and maintaining the summer pool level at 358 can further increase striped bass habitat in some years. It can also improve water quality in the releases.
- When the discharge temperature from Unit 5 reaches 15^{o} C, the minimum flow should be released through a bottom unit.
- Unit 5 operations after August or September do not effect striped bass habitat.