Jim Woodruff Dam

Lessons Learned

Basis for Revised IOP

Hydrological Modeling Technical Workshop II

12 July 2006

ESA-listed species on Apalachicola River

Gulf sturgeon

Fat threeridge

Purple bankclimber

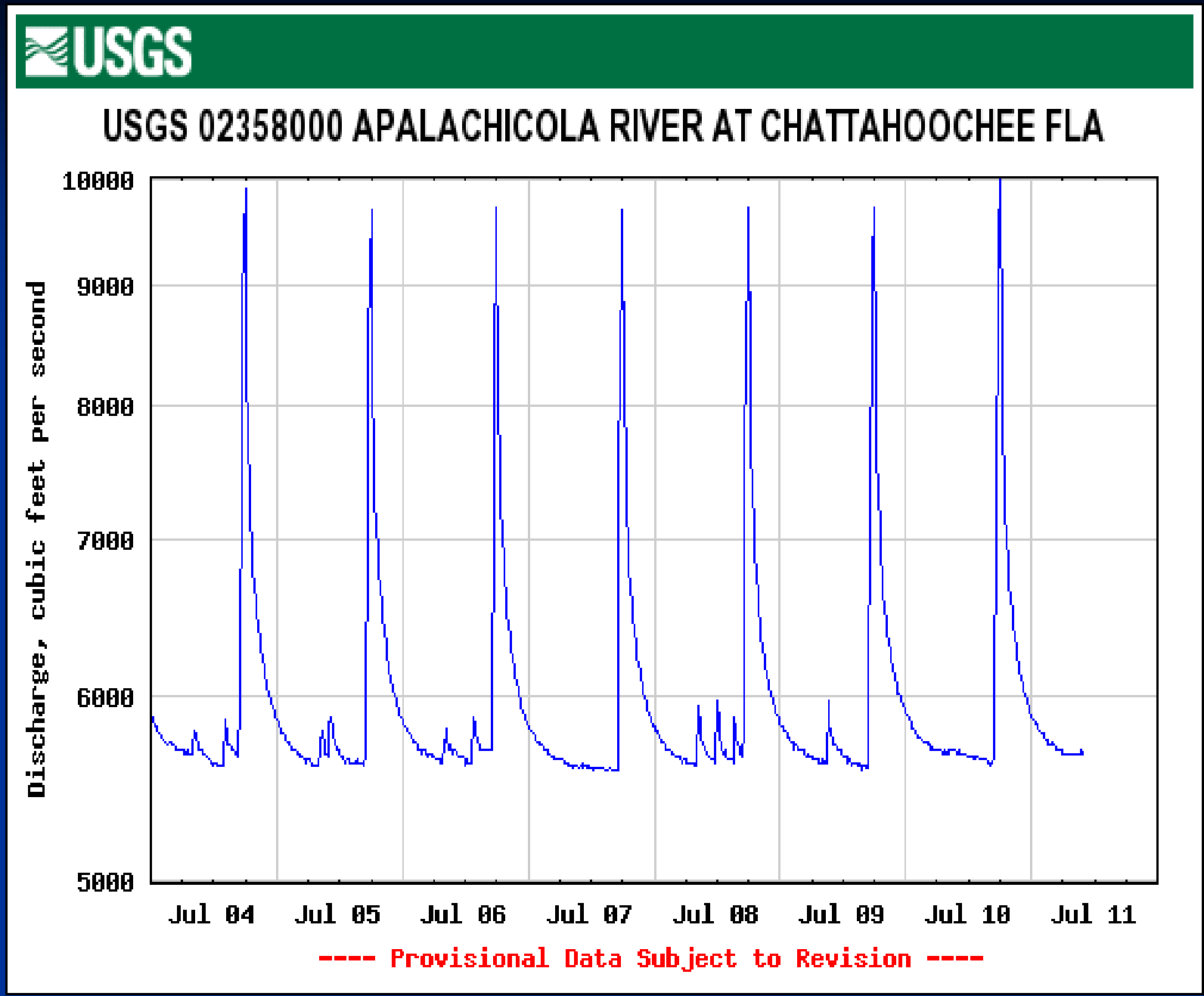
Adjustments to IOP Submitted to USFWS on 12 June 2006

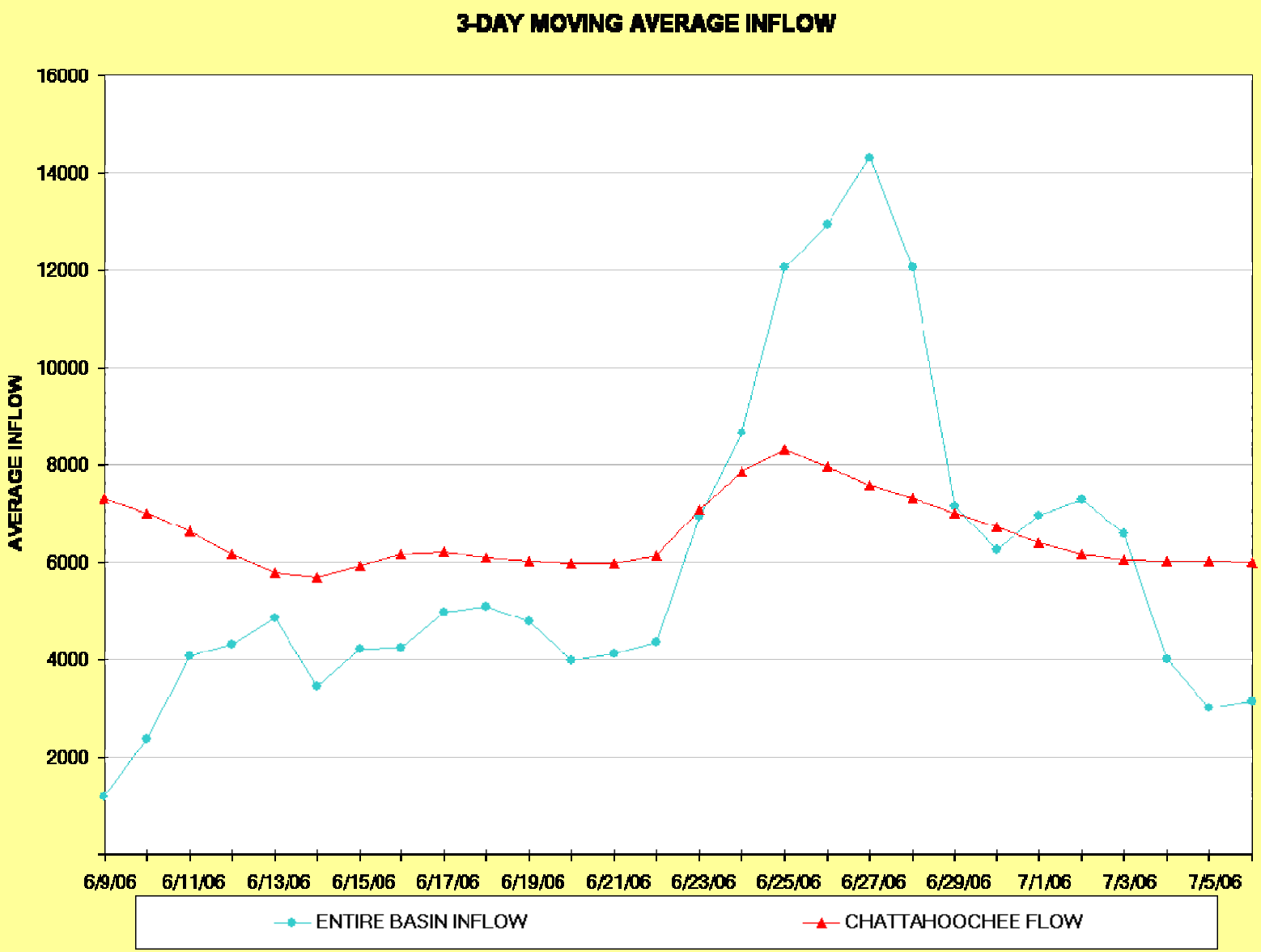
Based on "Lessons Learned"

1. Use Chattahoochee gage, 7-day average and volume computations to measure Basin Inflow and Releases to smooth releases and minimize over-releases
2. Include "mini-peaking" operations at JWD
3. Adjust upper flow threshold Jun-Feb to provide for more opportunities for storage
4. Clarify flood control flows and ramping rates

1. Use of Chattahoochee Gage

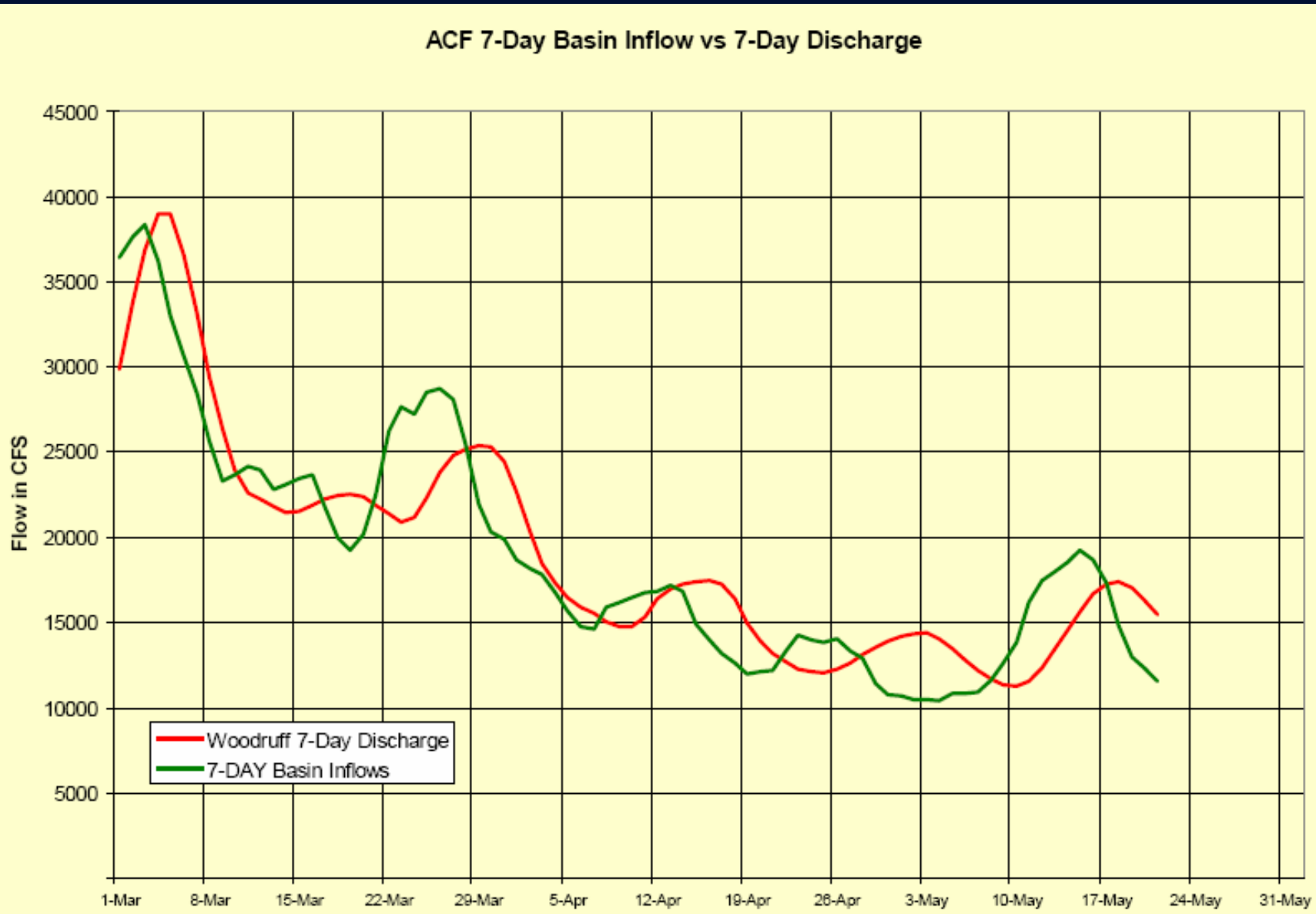
- Documented variation in flows between USGS Chattahoochee gage number 02358000 and Jim Woodruff Outflow
- May be result of differences in spillway and turbine ratings, as well as other flow movements beneath the dam
- Chattahoochee gage is universally accepted point-of-measurement; part of Unimpaired Flow Data Set


USGS
USGS 02358000 APALACHICOLA RIVER AT CHATTAHOOCHEE FLA
Discharge, cubic feet per second
10000
9000
8000
7000
6000
5000
Jul 04
Jul 05
Jul 06
Jul 07
Jul 08
Jul 09
Jul 10
Jul 11
---- Provisional Data Subject to Revision ----


3-DAY MOVING AVERAGE INFLOW
AVERAGE INFLOW
16000
14000
12000
10000
8000
6000
4000
2000
6/9/06
6/11/06
6/13/06
6/15/06
6/17/06
6/19/06
6/21/06
6/23/06
6/25/06
6/27/06
6/29/06
7/1/06
7/3/06
7/5/06
ENTIRE BASIN INFLOW
CHATTAHOOCHEE FLOW

1. 7-Day Average Inflows

- As much as 7-10 day lag for rain in upper basin to reach Jim Woodruff
- Difficult to predict basin response to rainfalls of short durations and intensities
- Allows for smoother transitions of releases
- Better prediction of when to begin ramp down
- Minimize use of storage


ACF 7-Day Basin Inflow vs 7-Day Discharge
Flow in CFS
45000
40000
35000
30000
25000
20000
15000
10000
5000
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
17-May
24-May
31-May
Woodruff 7-Day Discharge
7-DAY Basin Inflows

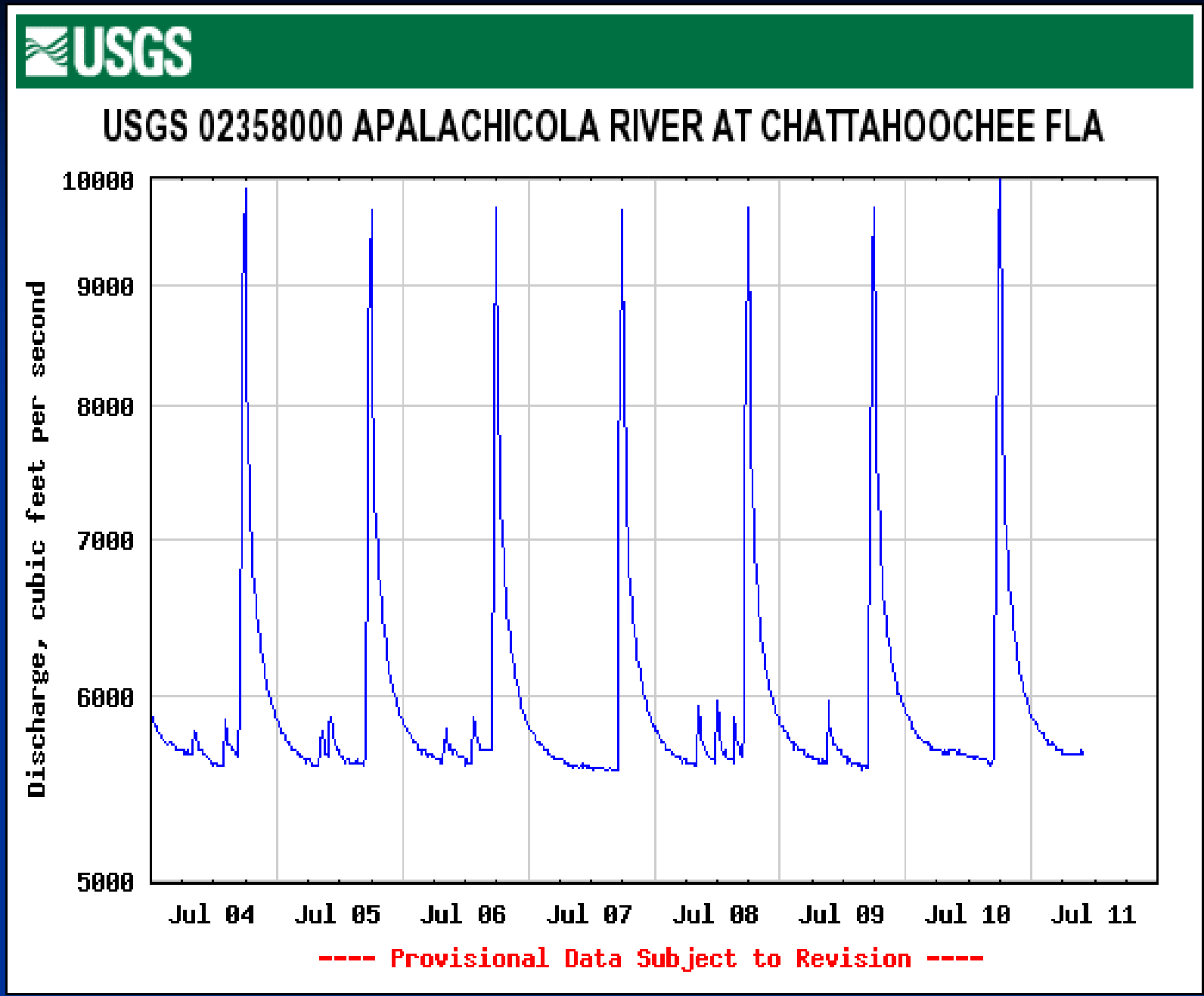
1. Volume Computations

- Better for species:
  - Maintain a steady flow for longer periods vs. numerous fluctuations in attempt to match BI
  - Ramp down rates perhaps more critical
- Maintain continuous record of BI vs. Releases
- Temporary Imbalance? Periodic adjustments
- Greater than 5% - Readjust flows consistent with other features of IOP

DATE	Inflow Volume	Outflow Volume	Difference
3/1/2006			
3/2/2006			
3/3/2006			
3/4/2006			
3/5/2006			
3/6/2006	1,965,369,600	2,308,233,600	342,864,000
3/7/2006	1,984,608,000	2,135,433,600	150,825,600
3/8/2006	1,788,249,600	2,093,472,000	305,222,400
3/9/2006	1,617,177,600	1,938,585,600	321,408,000
3/10/2006	2,070,374,400	1,803,139,200	-267,235,200
3/11/2006	2,501,856,000	1,775,145,600	-726,710,400
3/12/2006	2,541,686,400	1,817,452,800	-724,233,600
3/13/2006	1,976,601,600	1,877,097,600	-99,504,000
3/14/2006	1,479,456,000	1,912,636,800	433,180,800
3/15/2006	1,486,972,800	1,942,675,200	455,702,400
3/16/2006	1,595,001,600	1,955,232,000	360,230,400
3/17/2006	1,724,572,800	1,958,774,400	234,201,600
3/18/2006	1,556,064,000	1,961,049,600	404,985,600

2. Hydropower Peaking

- Required to meet SEPA Contract requirements
- One hour of generation at peak plant capacity each day
- Outflows for remainder of day adjusted to insure mean daily flow target met
- During ramp down, mean daily water surface elevations at Chattahoochee gage used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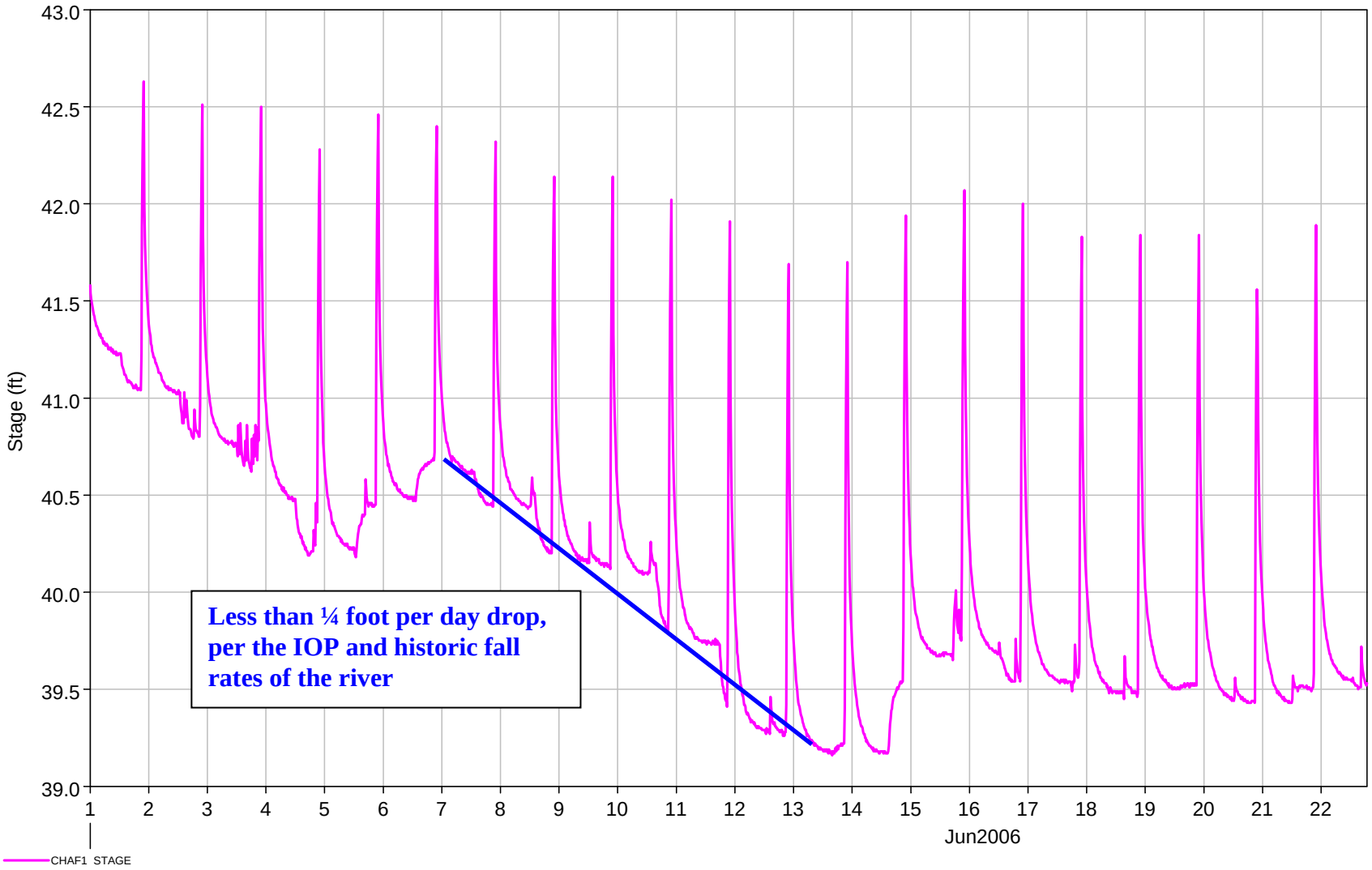
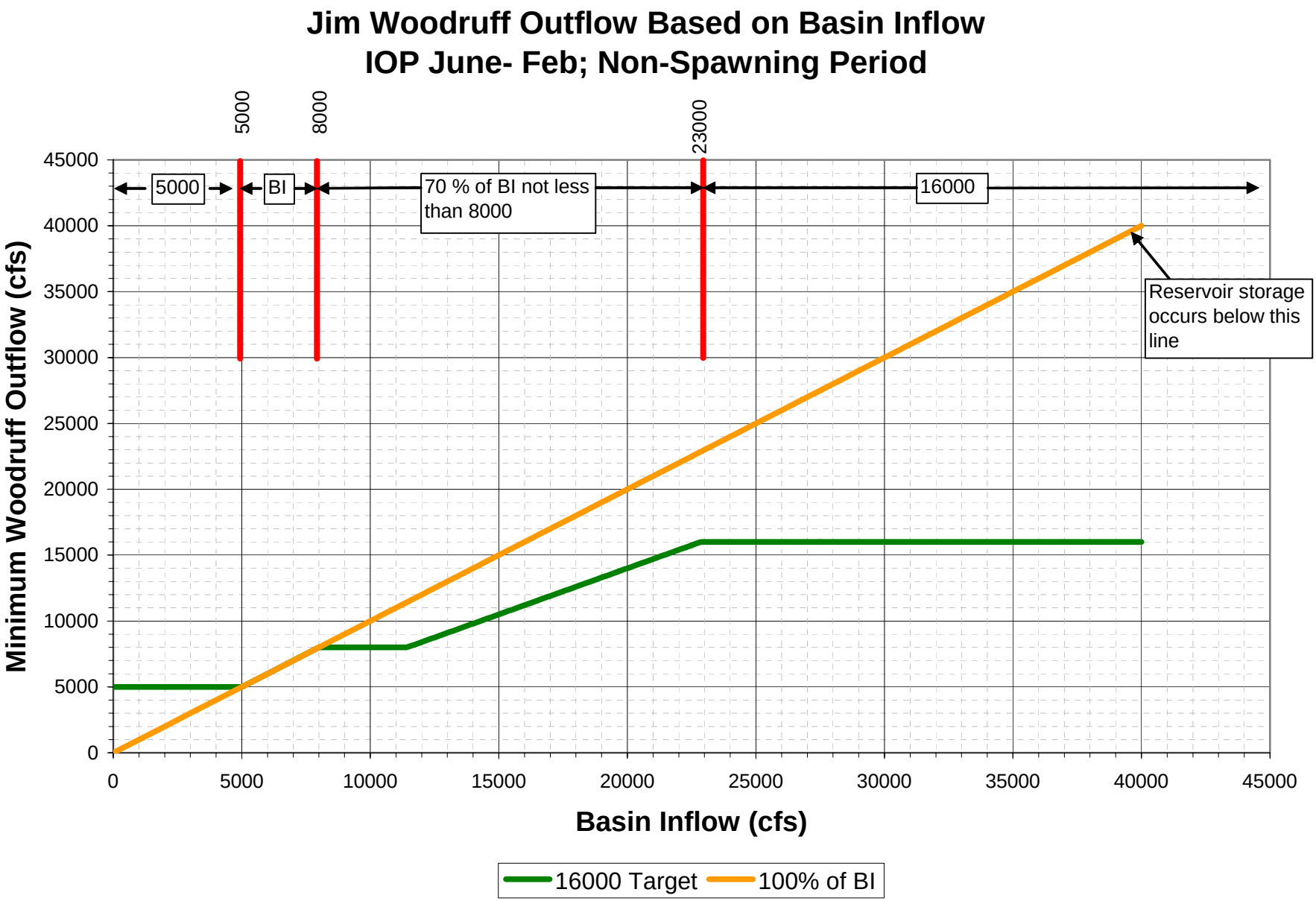

43.0
42.5
42.0
41.5
41.0
40.5
40.0
39.5
39.0
Stage (ft)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
Jun2006
Less than ¼ foot per day drop, per the IOP and historic fall rates of the river
CHAF1 STAGE

3. Proposed Adjustment to Jun-Feb Upper Threshold

- Intent to provide sufficient flows when available for access to the adjacent floodplain by host fish for mussels
- Average monthly flows for Jun – Aug approximately 16,000 cfs
  - Approximately 7,000 acres of adjacent floodplain connected at 16,000 cfs
  - Approximately 3,000 acres of adjacent floodplain connected at 14,000 cfs
  - Only a few hundred acres of adjacent floodplain connected at 8,000 cfs flow
- Provides some restriction on storage when basin inflows are 23,000 cfs or less to provide for gradual reductions for flows on the river of 16,000 cfs or less


Jim Woodruff Outflow Based on Basin Inflow
IOP June- Feb; Non-Spawning Period
5000
8000
23000
5000
BI
70 % of BI not less than 8000
16000
Reservoir storage occurs below this line
Minimum Woodruff Outflow (cfs)
Basin Inflow (cfs)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
16000 Target
100% of BI

	January	February	March	April	May	June	July	August	September	October	November	December	Totals
Average	27213	33238	40638	34143	21680	16637	17316	15115	12327	12416	13343	20083	
Minimum	5980	8280	8260	7010	5210	4540	4530	4430	4530	5010	3900	5150	
Maximum	165000	127000	291000	158000	126000	71300	203000	60800	65900	86800	102000	137000	
99.9% exceedence	6163	8378	8298	7082	5404	4580	4578	4498	4671	5080	4160	5393	
99% exceedence	6785	8980	11386	9661	6939	5076	5367	4689	5461	5290	5280	6252	
95% exceedence	9700	11600	13600	12200	8883	7470	7205	5953	6120	5690	5730	7350	
90% exceedence	11600	13700	16500	14400	10400	8660	8620	7900	6910	6307	6460	8800	
80% exceedence	13600	17800	20300	17700	12600	10500	10100	9542	8480	7604	8110	9952	
75% exceedence	15000	19700	22000	18700	13400	11500	11000	10500	9000	8300	8688	10700	
50% exceedence	22200	28400	33400	27800	18000	14600	14000	13500	11350	10800	11200	14900	
25% exceedence	34275	43575	50400	41300	25100	19300	18900	17400	14000	13500	15200	23900	
10% exceedence	51300	58390	69900	64400	37280	27200	26800	24240	18500	19300	21400	40330	
1% exceedence	78532	94219	160280	124000	72914	47682	79328	43428	31800	44847	44744	73856	

			MARCH DAYS	%	APRIL DAYS	%	MAY DAYS	%							
Less than 4000	0	0	0	0%	0	0%	0	0%	0	0	0	0	0	3	0	
Less than 5000	0	0	0	0%	0	0%	0	0%	23	11	33	6	0	7	0	80
Less than 14000	527	240	134	6%	201	9%	668	28%	1013	1188	1301	1731	1895	1651	1077	11626
Less than 14970	600	304	184	8%	257	11%	791	33%	1207	1326	1496	1851	1978	1740	1214	12949
Less than 16000	684	347	210	9%	315	14%	899	38%	1353	1488	1648	1943	2043	1807	1330	14068
Less than 17000	790	387	259	11%	400	17%	1034	43%	1472	1603	1756	1999	2091	1893	1421	15106
Less than 18000	894	450	310	13%	491	21%	1188	50%	1599	1705	1833	2041	2133	1948	1499	16092
Less than 21000	1137	645	533	22%	778	34%	1529	64%	1865	1939	2029	2173	2225	2086	1676	18616
Total Days	2418	2182	2387		2310		2387		2310	2387	2387	2310	2418	2340	2418	

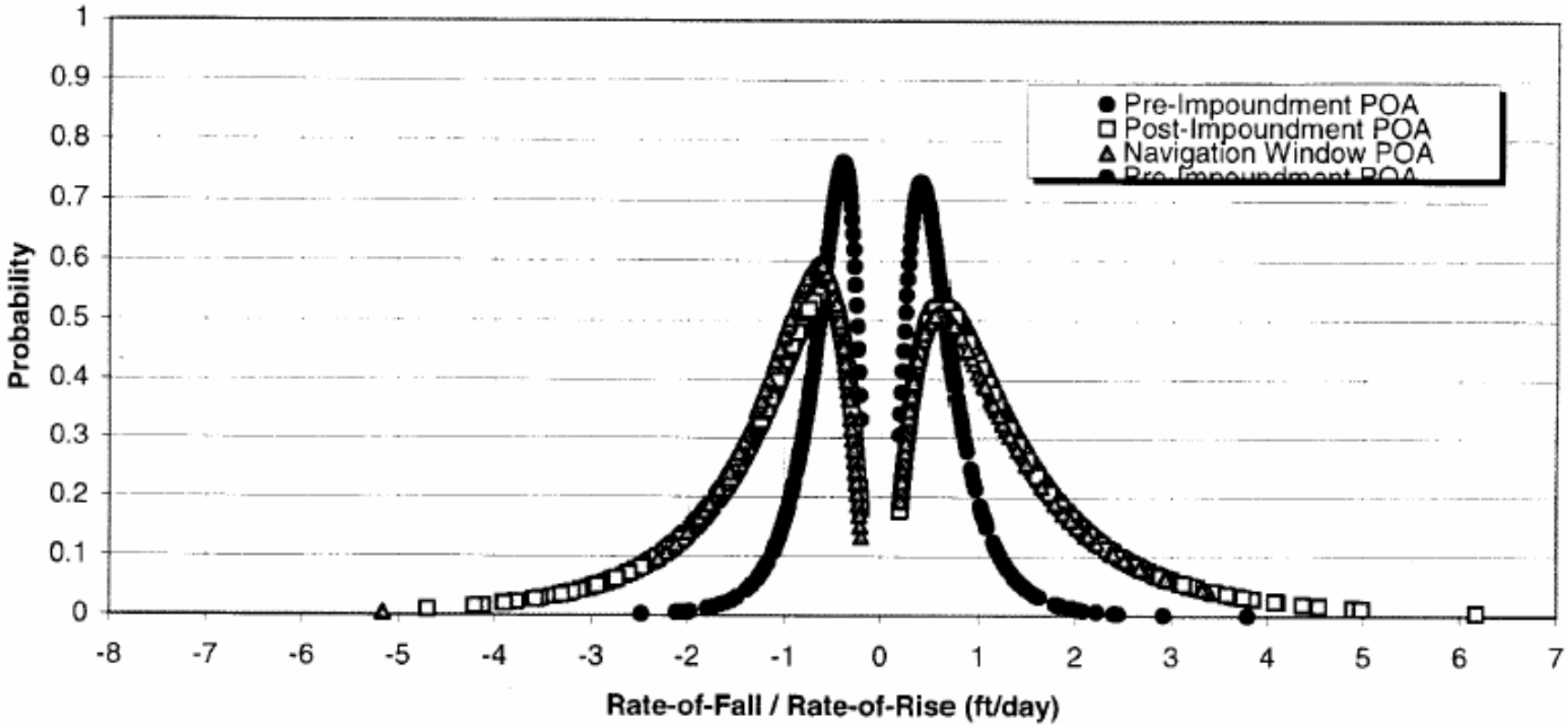
Volatility

1928-1952 Average Day	1515.544264
1953-2006 Average Day	1923.89668

4. Ramping Rates

- Propose to release less than peak, and then match volumes on ramp down – goal of only 100% of Basin Inflow
- Change to 16,000 cfs powerhouse capacity
- Changes for flood control operations

Historical Rate-of-Fall Rates



Original Interim Plan Ramping Rates

- Exceeds Powerhouse Capacity (18,000 cfs)

  0.5 to 1.0 ft/ day*
- Within Powerhouse Capacity and >8,000 cfs

  0.25 to 0.5 ft/day*
- Within Powerhouse Capacity and ≤8,000 cfs

  0.25 ft/day or less*

*Consistent with safety requirements, flood control operations, and equipment constraints – Ramping rates for flood control purposes were clarified in the 12 June 2006 letter to USFWS

Adjusted Ramping Rates*

- No ramping when flows are 30,000 cfs or higher
- Ramp down between 1.0 and 2.0 ft/day when flows are between 20,000 cfs and 30,000 cfs
- Ramp down between 0.5 and 1.0 ft/day when flows are between 16,000 cfs and 20,000 cfs
- Ramp down between 0.25 and 0.5 ft/day when flows are between 8,000 cfs and 16,000 cfs
- Ramp down at 0.25 ft/day or less when flows are less than 8,000 cfs

*Adjusted rates submitted in 12 Jun 06 letter to USFWS

Revised 12 Jun 2006

U.S Army Corps of Engineers, Mobile District
Interim Operations at Jim Woodruff Dam
and Releases to the Apalachicola River
In Support of Listed Mussels and Gulf Sturgeon

Minimum Releases

Months	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)	Justification
March - May	>= 37,400	not less than 37,400	Max. known flow of sturgeon spawning in the Apalachicola, as documented in 2005. All of rock shoal inundated by more than 4.59 ft. Majority of floodplain aquatic habitat (61%) in which mussel fish hosts may spawn is connected to the main channel. Peak flows of this magnitude or greater have occurred in all but 5 out of 85 years of record. No evidence of adverse effects to listed species if Corps stores BI above this level in these months while observing down ramping rates.
	>= 20,400 and < 37,400	>= 70% BI; not less than 20,400	In 2005 successful sturgeon spawning was documented to occur between 20,400 cfs and 37,400 cfs. All of rock shoal habitat at NM 105 is inundated in this range, and most (>73%) innundated with > 4.59 ft (the min. reported depth of Gulf sturgeon spawning in any river). Storing up to 30% of BI (i.e., releasing >= 70% BI) in this flow range would insignificantly affect the area of the rock shoal inundated or other characteristics that may influence its suitability as spawning habitat. During normal to wet periods releases would likely equal or exceed 90% BI. During extended dry or drought periods, if composite storage is less than full, it may be prudent to release less than 90% in order to all some refill for future augmentation flows. Releases of at least 70% BI would still provide inundation of at least approximately 87% of the rock ledge habitat and access for spawning (>4.59 ft depth) would be available to approximately 60% of the rock ledge habitat at NM 105.
	< 20,400	>= BI; not less than 5,000	No discretionary action except flow augmentation and ramping rates. 5000 cfs is the minimum condition to ensure using water stored during discretionary actions in other flow ranges and time periods.

Months	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)	Justification
June - February	>= 23,000	not less than 16,000	A flow of 16,000 cfs is equivalent to the approximate average monthly flow levels for June – August. The 16,000 cfs flow is important because data indicate that it will provide sufficient flow for host fish necessary for mussel reproduction, as well as provide connectivity between the main channel of the Apalachicola River and back channel and floodplain habitat areas used by mussel host fish as well as young Gulf Sturgeon. At this flow level there are still approximately 7,000 acres of floodplain habitat connected to the river channel. The 16,000 cfs release is equivalent to 70 percent of a basin inflow of 23,000 cfs. There is no flow restriction for excess BI above 23,000 cfs, which allows for storage of the excess flow. This additional storage could be used for other project purposes or as future augmentation flows in support of listed mussels. No evidence of adverse effects to listed species if Corps stores BI above this level in these months while observing down ramping rates.
	>= 8,000 and < 23,000	>= 70% BI; not less than 8,000	Max. known stage of listed mussels on the river bed (8000 cfs). Storing up to 30% of BI (i.e., releasing >= 70% BI) in this flow range would not significantly effect habitat features relevant to sturgeon and mussel conservation in these months while observing down ramping rates. No mussels would be exposed. During normal to wet periods releases would likely equal or exceed 90% BI. During extended dry or drought periods, if composite storage is less than full, it may be prudent to release less than 90% (in order to store some water from rain events) in order to allow some refill for future augmentation flows. Releases of at least 70% BI and gradual ramping rates would minimize impacts to host fish necessary for mussel reproduction, by maintaining access to remaining off channel habitat areas. Water stored during these conditions would potentially be available for future augmentation to maintain flows above BI when 8000 cfs >BI >= 5000 cfs, and above 5000 cfs when BI < 5000 cfs.
	< 8,000	>= BI; not less than 5,000	No discretionary action except flow augmentation and ramping rates. 5000 cfs is the minimum condition to ensure using water stored during discretionary actions in other flow ranges and time periods.

Down Ramping Rates

Release Range	Maximum Fall Rate (ft/day), measured at Chattahoochee gage	Justification
Exceeds Powerhouse Capacity* (~16,000 cfs)	0.5 to 1.0 ft/day	Apalachicola River fall rates of greater than 0.5 ft/day were extremely rare prior to construction of the Corps ACF projects (analysis of gage records from the 1920s to present), except during flood pulses. Mussels and early sturgeon life stages have limited mobility to avoid stranding. The Corps ability to control fall rates at less than 0.5 ft/day when releases exceed the powerhouse capacity is very limited, but the stranding risk to listed species at these high flows is also limited (e.g., all of the known sturgeon spawning rock shoal is inundated by flows greater than 18,000 cfs). Previous operations have attempted to produce a fall rate of 0.5 ft/day or less, but not greater than 1.0 ft/day whenever flows are less than 20,000 cfs. These rates represent the best attempt within current capabilities to limit stranding risks of other species in the floodplain, such as potential mussel host fishes. Rates will approximate 0.5 ft/day, but not more than 1 ft/day except in emergency conditions. For flows between 20,000 cfs and 30,000 cfs, ramping down from flood peaks for flood control purposes would likely be within a range of 1.0 to 2.0 ft/day.**
Within Powerhouse Capacity and > 8,000 cfs*	0.25 to 0.5 ft/day	More gradual (lesser) fall rates become a greater conservation concern at flows that approach the stages at which the mussels are found and are achievable when releases are from the powerhouse instead of the spillway gates. 8,000 cfs is the highest stage at which the listed mussels are found. Fall rates of approximately 0.25 ft/day in advance of this stage gives mussels several days to move to lower bed elevations. 9,000 cfs provides approximately 0.5 ft or greater above the highest-stage listed mussels.
Within Powerhouse Capacity and <=8,000 cfs*	0.25 ft/day or less	8,000 cfs is the highest stage at which the listed mussels are found and when the most gradual rates are required if flows decline further. Fall rates of approximately 0.25 ft/day give the mussels several days to move to lower elevations. Rates of less than 0.25 ft/day may be possible when making releases from the powerhouse, but are more difficult to achieve (incremental reduction in releases of 500 cfs/day approximates 0.25 ft/day). Previous operations have been in range of 0.25 and 0.5 ft/day during sustained low flow periods. These rates appear to be within the tolerance of the two species ability to move to lower stages. It is supported mainly by the fact that they are present at stages above 5000 cfs after several years of flows hovering around 5,000 cfs for extended periods during the drought of 1998-2002.

*Consistent with safety requirements, flood control purposes, equipment cabapilities.
**For flows greater than 30,000 cfs, it is not reasonable or prudent to attempt to control down ramping rate, and no ramping rate is required.

Note: These operations are considered sufficient to minimize adverse effects on the listed species to the maximum extent practicable or feasible based on equipment constraints, and safety concerns. Consideration is also given to the need to balance releases to the river with the need to refill or conserve storage in upstream reservoirs in the interest of having adequate storage in later months when augmentation flows may be necessary to protect listed mussel species. Any of the numbers in this table are subject to revision based on better information that may be developed during the Section 7 consultation process. FWS has recommended the release of 90% of BI as the degree to which the Corps could store water during intermediate flow ranges (i.e., March through May when BI is between 37,400 cfs and 20,400 cfs; and June through February when BI is less than 16,000 cfs and greater than 8,000 cfs) such that the amount of flow depletion would not measurably alter habitat quality features in those flow ranges (e.g., temperature, DO, channel area inundated, etc.). Although this requirement can be met during normal to wet periods, it may not be reasonable or prudent during extended dry or drought periods. Therefore, the Corps proposes a minimum percentage of 70 BI that would be released during extended dry or drought periods. The goal would be to release 90% BI. In the event this was not feasible or prudent (i.e. would prevent sufficient refill or conservation of storage to guarantee future augmentation flows for mussels or to meet other critical project purpose needs), then informal consultation discussions would be conducted with FWS to determine the appropriate percentage release and the justification for the reduced percentage release. The release to the Apalachicola River would be at least 70% BI. The 70% BI release would assure that at least approximately 60% of the rock ledge spawning habitat at NM 105 would be submerged to a depth of 4.59 ft or greater during spawning periods during these intermediate flows during this discretionary action. No mussels would be exposed during these intermediate flows due to discretionary action. Any reduction in releases would represent a trade-off of minimal impact on spawning habitat or host fish habitat requirements in order to provide future augmentation flows as required to prevent or minimize mussel mortality due to exposure.