



DYNAMIC FLOW MODELING REPORT

**CLAYTOR PROJECT
FERC NO. 739**

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January 2009

TABLE OF CONTENTS

INTRODUCTION	1
MODEL DESCRIPTION	1
CALIBRATION.....	2
MODELING.....	7
GRAPHICAL RESULTS	10
FLOW LOOKUP PROGRAM	20

LIST OF FIGURES

Figure 1.	Cross Section Location Map	4
Figure 2.	Historical and Modeled Flows at the Radford USGS gage for November	
2000.	5	
Figure 3.	Historical and Modeled Flows at the Glen Lyn USGS gage for November	
2000.	6	
Figure 4.	Riverview Park Boat Launch 6 hour pulse graphical representation.	11
Figure 5.	Whitethorne Boat Launch 6 hour pulse graphical representation.	12
Figure 6.	Pembroke Boat Launch 6 hour pulse graphical representation.....	13
Figure 7.	Glen Lyn Boat Launch 6 hour pulse graphical representation.	14
Figure 8.	Riverview Boat Launch 6,000 cfs pulse graphical representation.	15
Figure 9.	Whitethorne Boat Launch 6,000 cfs pulse graphical representation.	16
Figure 10.	Pembroke Boat Launch 6,000 cfs pulse graphical representation.	17
Figure 11.	Glen Lyn Boat Launch 6,000 cfs pulse graphical representation.....	18
Figure 12.	Stage vs Flow Relationships for the Riverview, Pembroke, and Glen Lyn	
Boat	Launch Locations.....	19
Figure 13.	FlowLookup example for sites in the upper half of the New River below	
Claytor	dam.	21
Figure 14.	FlowLookup example for sites in the lower half of the New River below	
Claytor	dam	22

LIST OF TABLES

Table 1.	Median seasonal tributary inflow values (cfs).	7
Table 2.	Estimated arrival and peak times for 6 hour releases.	8
Table 3.	Estimated arrival and peak times for 12 hour releases.	9

INTRODUCTION

Appalachian Power Company (Appalachian) is making application to the Federal Energy Regulatory Commission (FERC) for a new license for the Claytor Hydroelectric Project (No. 739), located on the New River in southwestern Virginia. The process selected by Appalachian for applying for a new license is the Integrated Licensing Process (ILP), as defined under FERC's rules and regulations (18 CFR Part 5). As part of this licensing process, Appalachian solicited input from stakeholders, including governmental agencies and non-governmental organizations, to identify potential project-related issues that should be addressed during the licensing process.

Initial instream flow study plan meetings were held with stakeholders on July 19 and 20, 2006. A workgroup, comprising representatives from state resource agencies, universities, non-governmental organizations, and interested citizens, met in August 2006 to address specifics of the instream flow needs study. These meetings resulted in the development of a revised study plan, dated November 21, 2006.

A dynamic flow routing model was developed to estimate the flow attenuation and travel times under different flow releases from Claytor dam. The model used the U.S. Army Corps of Engineers' HEC-RAS program to analyze the flow in the New River for releases from Claytor dam and inflow from tributaries. The downstream extent of the model is the upper reaches of Bluestone Lake below Glen Lyn and extended upstream to Claytor dam.

MODEL DESCRIPTION

Key points of this HEC-RAS model include:

- Cross-section data were obtained from field survey data and USGS topographic mapping, from Claytor dam to the upstream beginning of Bluestone Lake. Field survey data were acquired as part of the Instream Flow Needs Study. These data were collected by acoustic depth sounding Doppler device and traditional survey methods and were used to generate streambed cross-sections between the riverbanks. USGS mapping was used to add data points outside of the riverbanks and to calibrate the field data to a universal vertical datum. Streambed cross-sections were interpolated where cross-sectional data were not available under the water surface.**
- Cross-sections were located at existing stream gage locations, near towns, at boat launches, and at islands and in areas where the river cross-section narrows or widens. Cross-sections were also located to accurately model river bends and inflow points associated with major tributaries. In long reaches without notable cross-sectional changes, sections are spaced at intervals between 0.5 and 1 mile. Bridges were not included as part of the**

waterway features, because modeled flows and water surface levels were not within the proximity of bridge deck elevations in observed flow conditions.

- The hydraulic model was calibrated using existing stream gage data.
- Hydrologic data for the New River and its major tributaries were based on short interval data from USGS gage data and hourly operational data from Claytor dam.

Figure 1 is a map of the New River with cross-section locations for the HEC-RAS model.

CALIBRATION

After completing the cross sectional development of the HEC-RAS model, it was calibrated by using historical release data from Claytor dam and historical 15 minute interval USGS streamflow data at the following gages:

USGS gage no.	Gage Name
• 03171000	New River at Radford (RM 5.5)
• 03176500	New River at Glen Lyn (RM 56)
• 03170000	Little River at Graysontown
• 03173000	Walker Creek at Bane
• 03175500	Wolf Creek near Narrows

During this process, streamflow data from the tributaries were used to determine added base flow along the New River. More importantly, these data were used to pick time periods when inflows from runoff events were not a substantial influence on flows within the New River. Streamflow from the gages at Radford and Glen Lyn were used to check the calibration of the model and to adjust the Manning's n values for the river cross-sections to insure that modeled flow values reasonably represented observed values over the range (750 to 10,000 cfs) of expected flow values. Figures 1 and 2 provide examples of the historical and modeled streamflow at the two USGS gage sites on the New River during a period in November 2000. These figures show that the calibration did not result in an exact match but was reasonably close. An exact match was not feasible due to the heterogeneous and complicated hydraulics, river channel, and flow conditions which are not possible to model exactly under a wide range of circumstances.

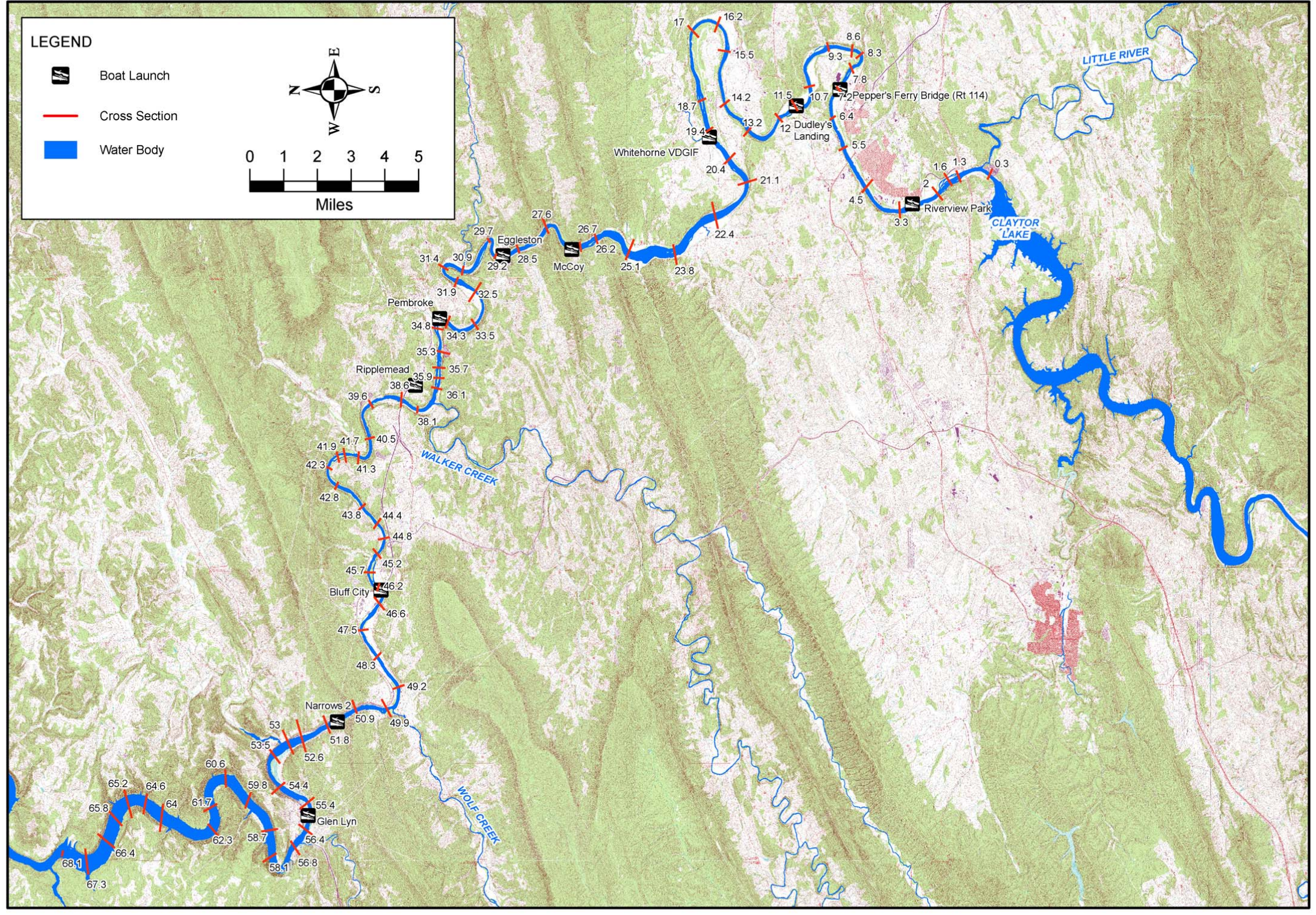


Figure 1. Cross Section Location Map

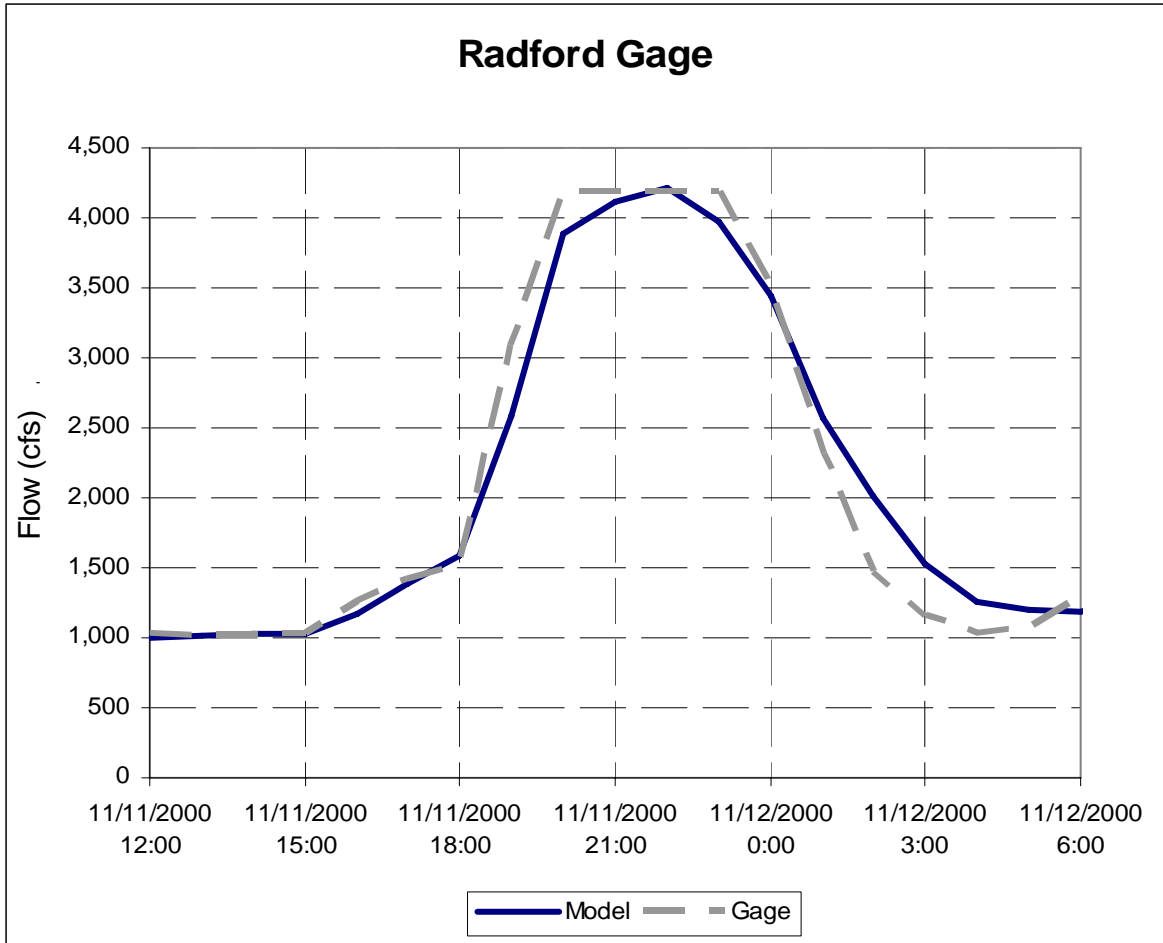


Figure 2. Historical and Modeled Flows at the Radford USGS gage for November 2000.

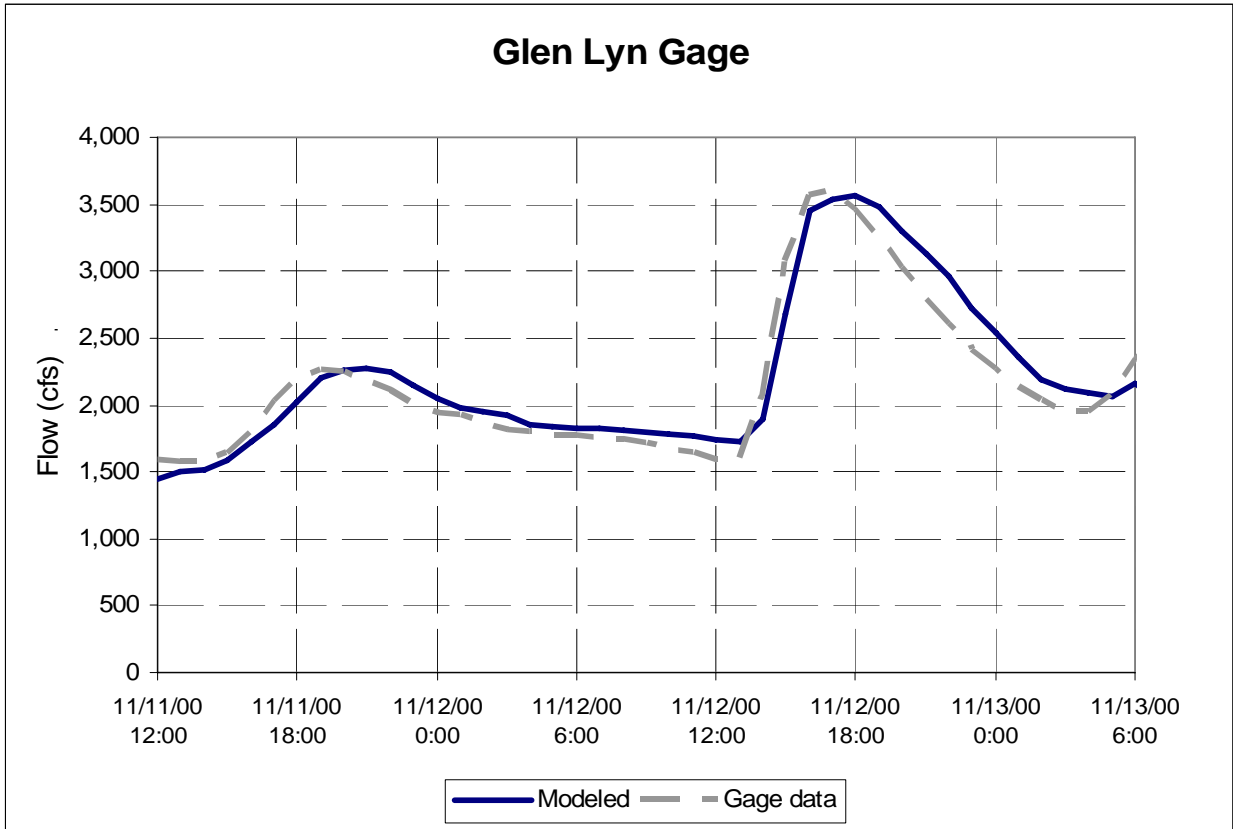


Figure 3. Historical and Modeled Flows at the Glen Lyn USGS gage for November 2000.

MODELING

Tributary inflow shown in table 1, were modeled as the median seasonal inflow from the four inflow location points specified in the HEC-RAS model. In table 1, the ‘Near Whitethrone’ location represents a drainage area of 194 square miles representing small ungaged tributaries including Back, Toms, Stroubles, Crab Creeks with inflows estimated from proration of the USGS gage on the Little River. Similarly, USGS gage data for Wolf and Walker Creeks were prorated to include not only the drainage within their watershed downstream of the gage, but also small tributaries which enter the New River near their confluences.

Table 1. Median seasonal tributary inflow values (cfs).

Location	Period of Record	Dec Jan Feb	Mar Apr May	Jun Jul Aug	Sep Oct Nov
Little River	10/1/1928 to 9/30/2008	473	544	309	274
Near Whitethrone	10/1/1928 to 9/30/2008	238	274	156	138
Walker Creek	4/1/1938 to 9/30/2008	604	732	184	127
Wolf Creek	8/1/1908 to 9/30/2008	520	595	154	99

Model runs were completed for releases of 2000, 4000, 6000, and 8000, with durations of 3, 6, 9, and 12 hours. During non peaking periods the flows released from Claytor dam were modeled with the current minimum flow release of 750 cfs. Based on these parameters, table 2 and 3 provides a summary of the arrival time and peak times for 6 and 12 hour releases for 11 key sites on the New River. Arrival times were estimated as the beginning of an increase in the flow in the New River as a result of releases from Claytor dam.

Table 2. Estimated arrival and peak times for 6 hour releases.

Location	River Mile	Estimated arrival time (hours) for 6 hour releases from Claytor Dam			
		2,000 cfs	4,000 cfs	6,000 cfs	8,000 cfs
Riverview Park Boat Launch	2.7	1 or less	1 or less	1 or less	1 or less
Dudley's Landing	7.5	1	about 1	about 1	about 1
DGIF boat launch, Peppers Ferry Bridge: Rt 114	11	2	2	1	1
DGIF boat launch; Whitethorne, (Toms Creek)	19.5	5	4	3	3
New River Campground: Goodwin Ferry McCoy Boat Launch	27.5	8	7	6	5
Eggleston Boat Launch	29.4	9	8	6	5
DGIF boat launch: Pembroke	35	11	9	8	7
460 bridge boat launch Ripplemead	38	12	10	9	8
Bluff City boat launch	46	15	13	11	10
Narrows Town Park Boat Launch	50	16	14	12	11
Glen Lyn Town Park / Boat Launch	56	18	16	14	13

Location	River Mile	Estimated peak time (hours) for 6 hour releases from Claytor Dam			
		2,000 cfs	4,000 cfs	6,000 cfs	8,000 cfs
Riverview Park Boat Launch	2.7	4	3	2	2
Dudley's Landing	7.5	5	4	3	3
DGIF boat launch, Peppers Ferry Bridge: Rt 114	11	6	5	4	3
DGIF boat launch; Whitethorne, (Toms Creek)	19.5	9	7	6	5
New River Campground: Goodwin Ferry McCoy Boat Launch	27.5	12	11	9	9
Eggleston Boat Launch	29.4	13	12	11	10
DGIF boat launch: Pembroke	35	15	13	12	11
460 bridge boat launch Ripplemead	38	17	14	12	11
Bluff City boat launch	46	19	16	14	13
Narrows Town Park Boat Launch	50	20	17	15	14
Glen Lyn Town Park / Boat Launch	56	22	19	17	16

Table 3. Estimated arrival and peak times for 12 hour releases.

Location	River Mile	Estimated arrival time (hours) for 12 hour releases from Claytor Dam			
		2,000 cfs	4,000 cfs	6,000 cfs	8,000 cfs
Riverview Park Boat Launch	2.7	less than 1	less than 1	less than 1	less than 1
Dudley's Landing	7.5	1	about 1	about 1	about 1
DGIF boat launch, Peppers Ferry Bridge: Rt 114	11	2	2	1	1
DGIF boat launch; Whitethorne, (Toms Creek)	19.5	5	4	3	3
New River Campground: Goodwin Ferry McCoy Boat Launch	27.5	8	7	6	5
Eggleston Boat Launch	29.4	9	8	6	6
DGIF boat launch: Pembroke	35	11	9	8	7
460 bridge boat launch Ripplemead	38	12	10	9	8
Bluff City boat launch	46	15	13	11	10
Narrows Town Park Boat Launch	50	16	14	12	11
Glen Lyn Town Park / Boat Launch	56	18	16	14	13

Location	River Mile	Estimated peak time (hours) for 12 hour releases from Claytor Dam			
		2,000 cfs	4,000 cfs	6,000 cfs	8,000 cfs
Riverview Park Boat Launch	2.7	4	3	2	2
Dudley's Landing	7.5	5	4	3	3
DGIF boat launch, Peppers Ferry Bridge: Rt 114	11	6	6	5	5
DGIF boat launch; Whitethorne, (Toms Creek)	19.5	10	9	9	9
New River Campground: Goodwin Ferry McCoy Boat Launch	27.5	17	16	15	15
Eggleston Boat Launch	29.4	18	16	16	15
DGIF boat launch: Pembroke	35	20	18	17	16
460 bridge boat launch Ripplemead	38	21	19	17	16
Bluff City boat launch	46	23	21	18	17

Narrows Town Park Boat Launch	50	24	22	19	18
Glen Lyn Town Park / Boat Launch	56	25	23	21	20

GRAPHICAL RESULTS

Figures 4 through 7 are graphical representations of 6 hour flow releases at four locations downstream of Claytor dam. The solid lines represent spring baseflow conditions and the pale colored lines lower summer base flow conditions. Similarly, figures 8 through 11 are graphically representations of flow releases of 6,000 cfs for varying durations at the same locations. Figure 12 is an approximate stage versus flow graph for the Riverview, Pembroke, and Glen Lyn boat launch locations and shows a 2 foot increase in water level between flows of 2,000 and 8,000 cfs.

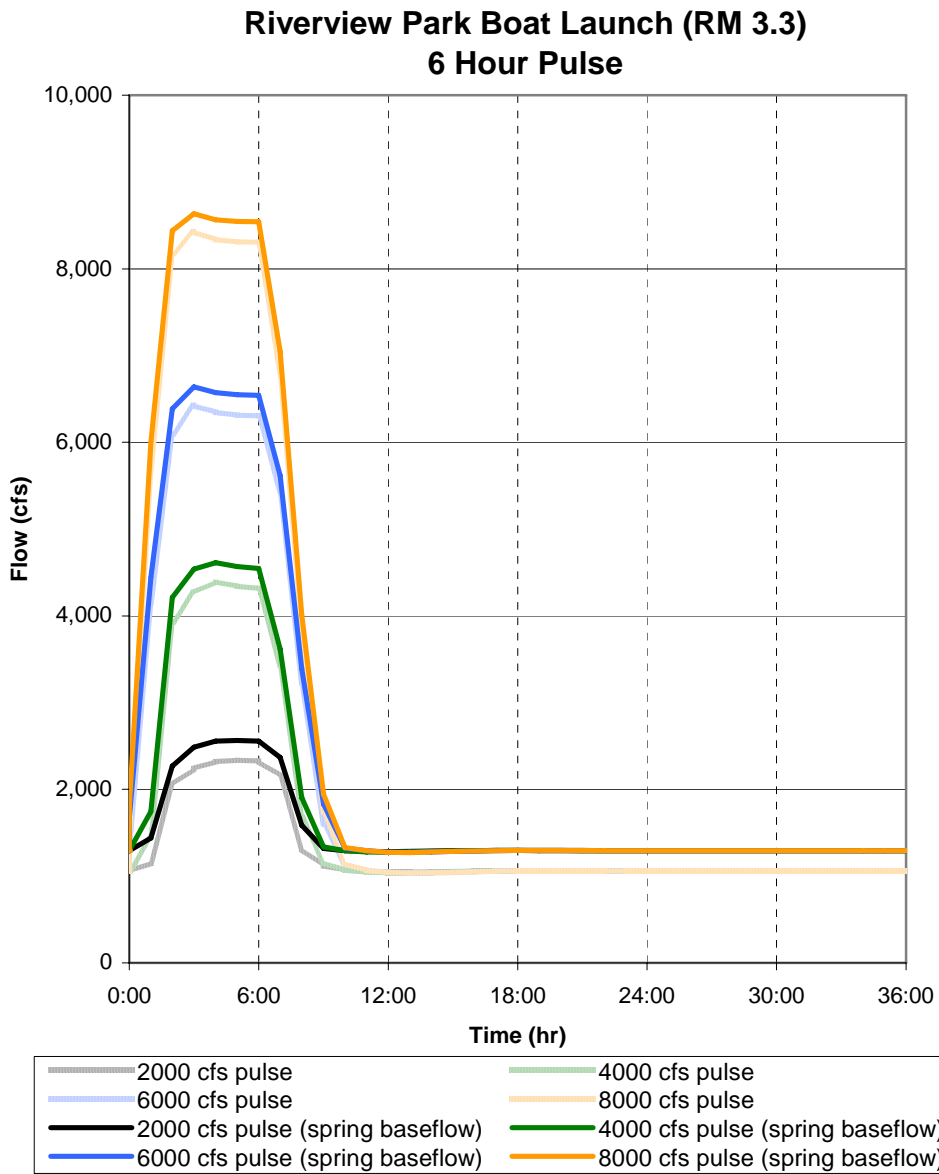


Figure 4. Riverview Park Boat Launch 6 hour pulse graphical representation.

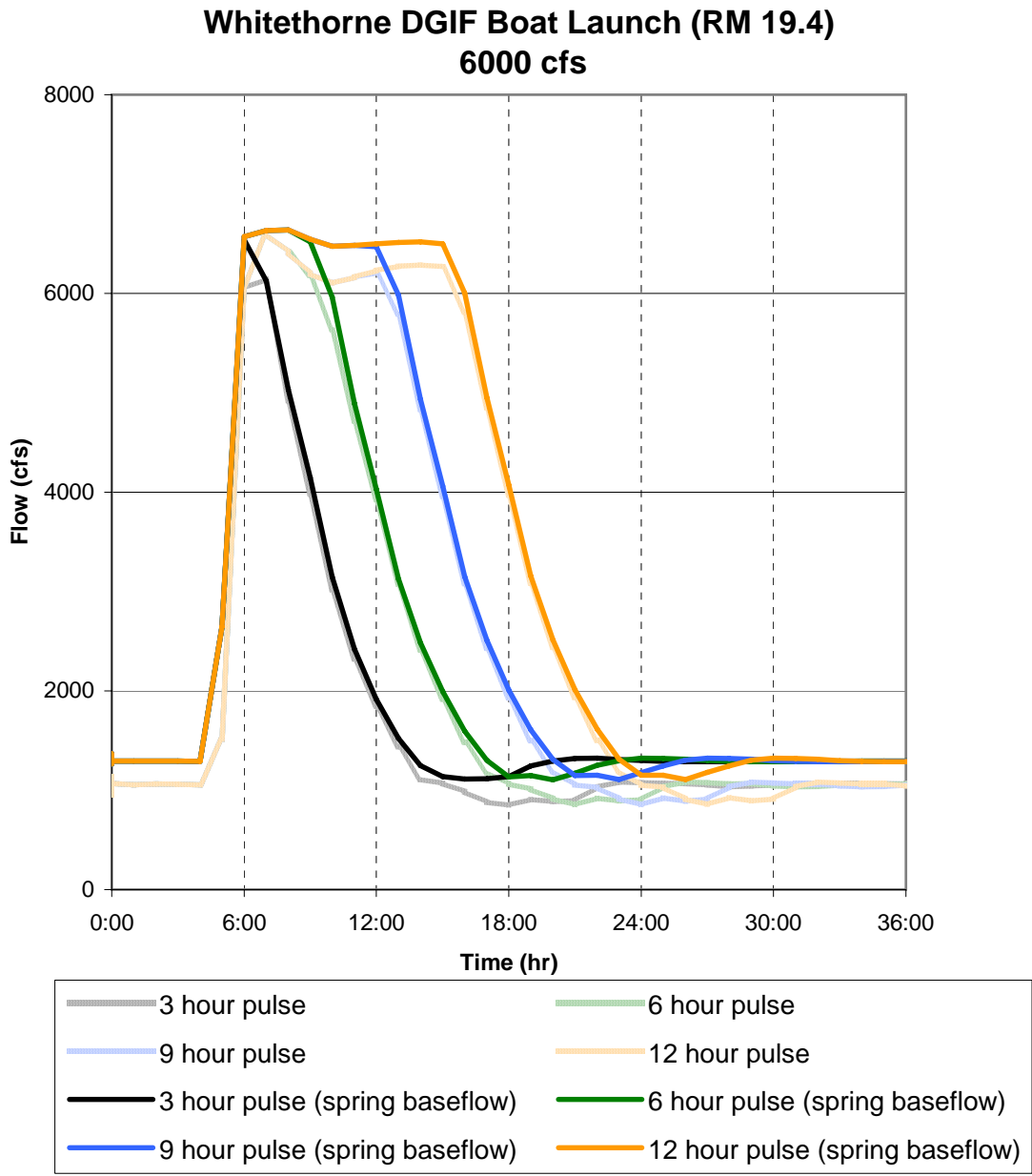


Figure 5. Whitethorne Boat Launch 6 hour pulse graphical representation.

**Pembroke DGIF Boat Launch (RM 35.3)
6 Hour Pulse**

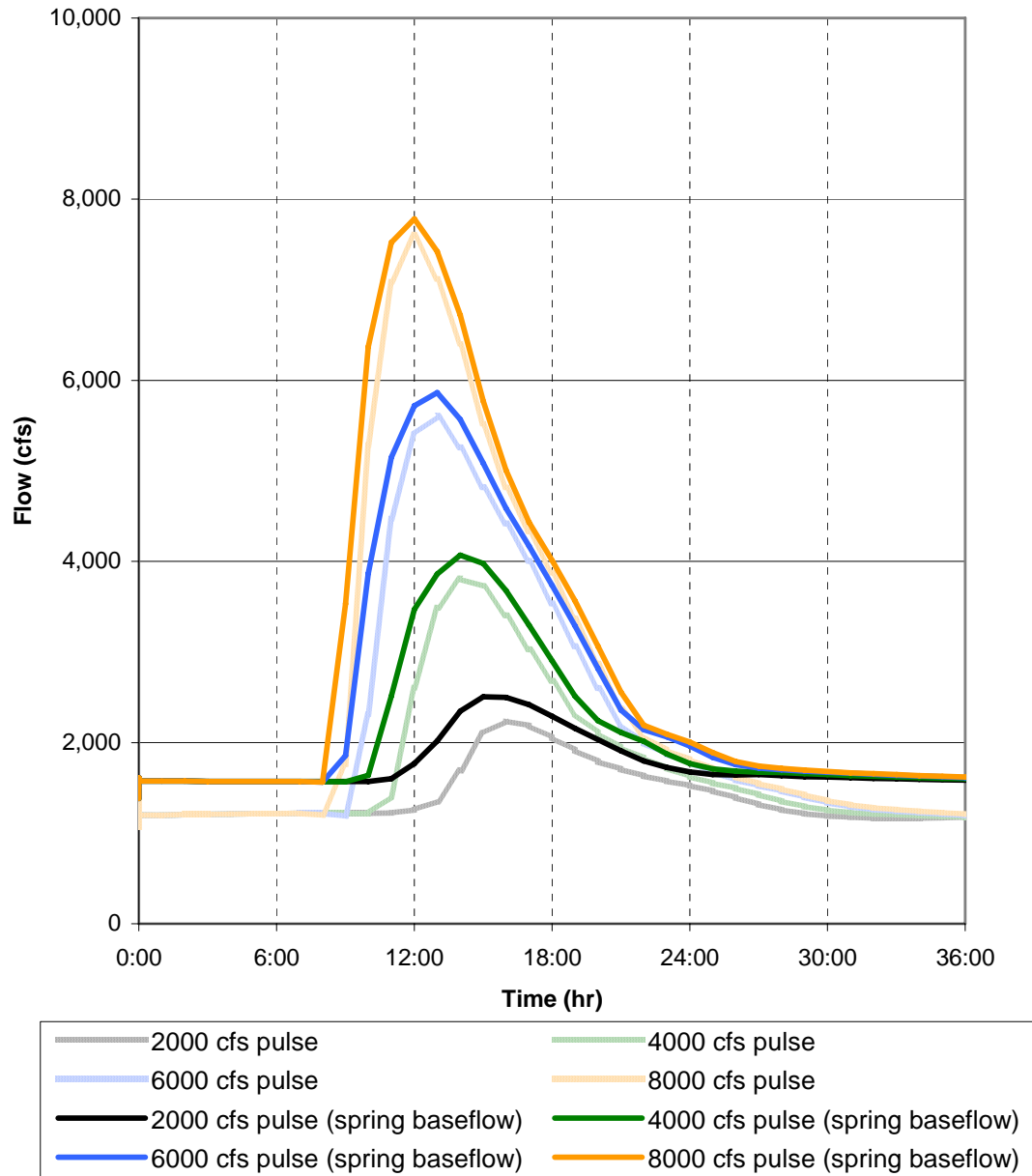


Figure 6. Pembroke Boat Launch 6 hour pulse graphical representation.

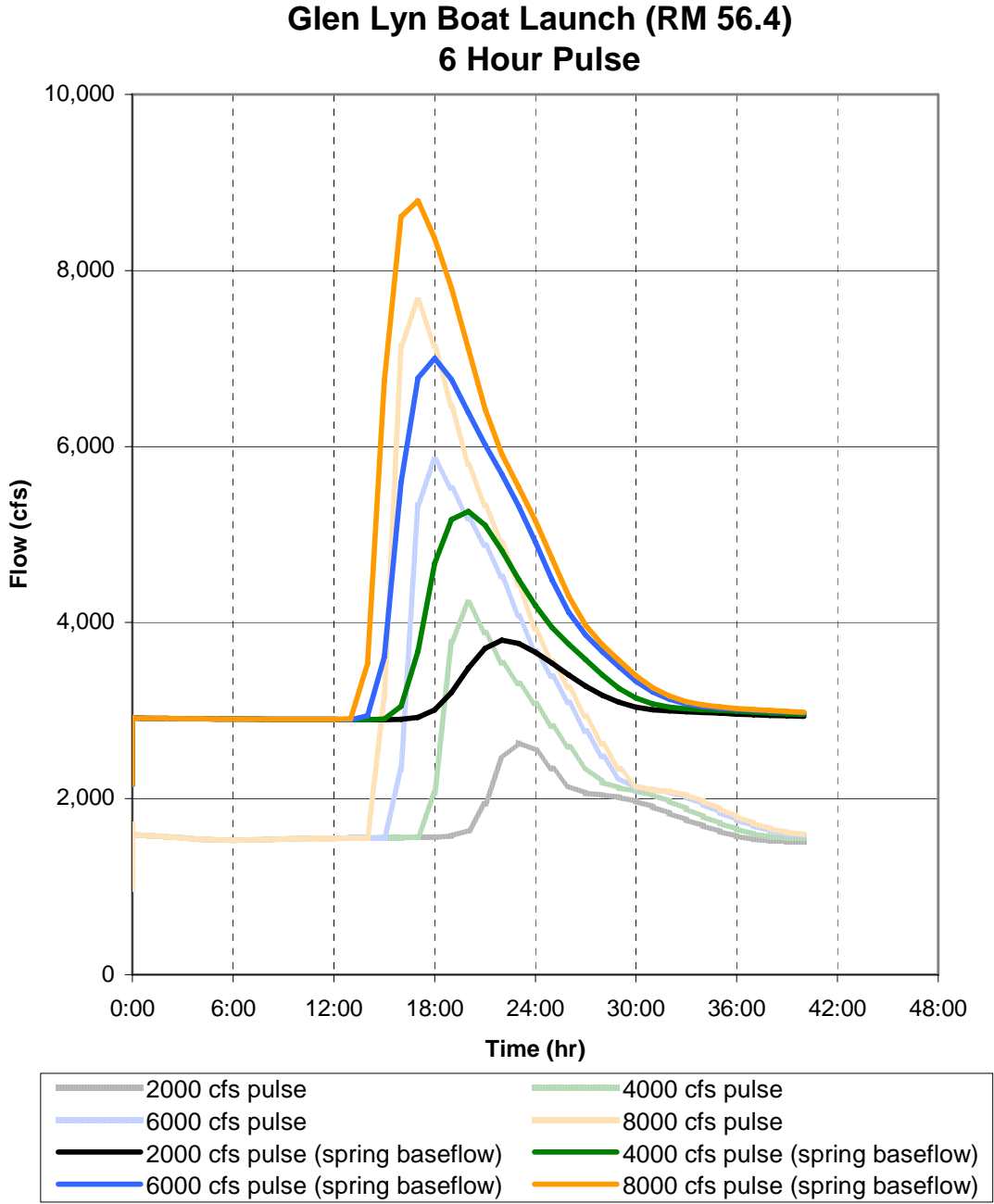


Figure 7. Glen Lyn Boat Launch 6 hour pulse graphical representation.

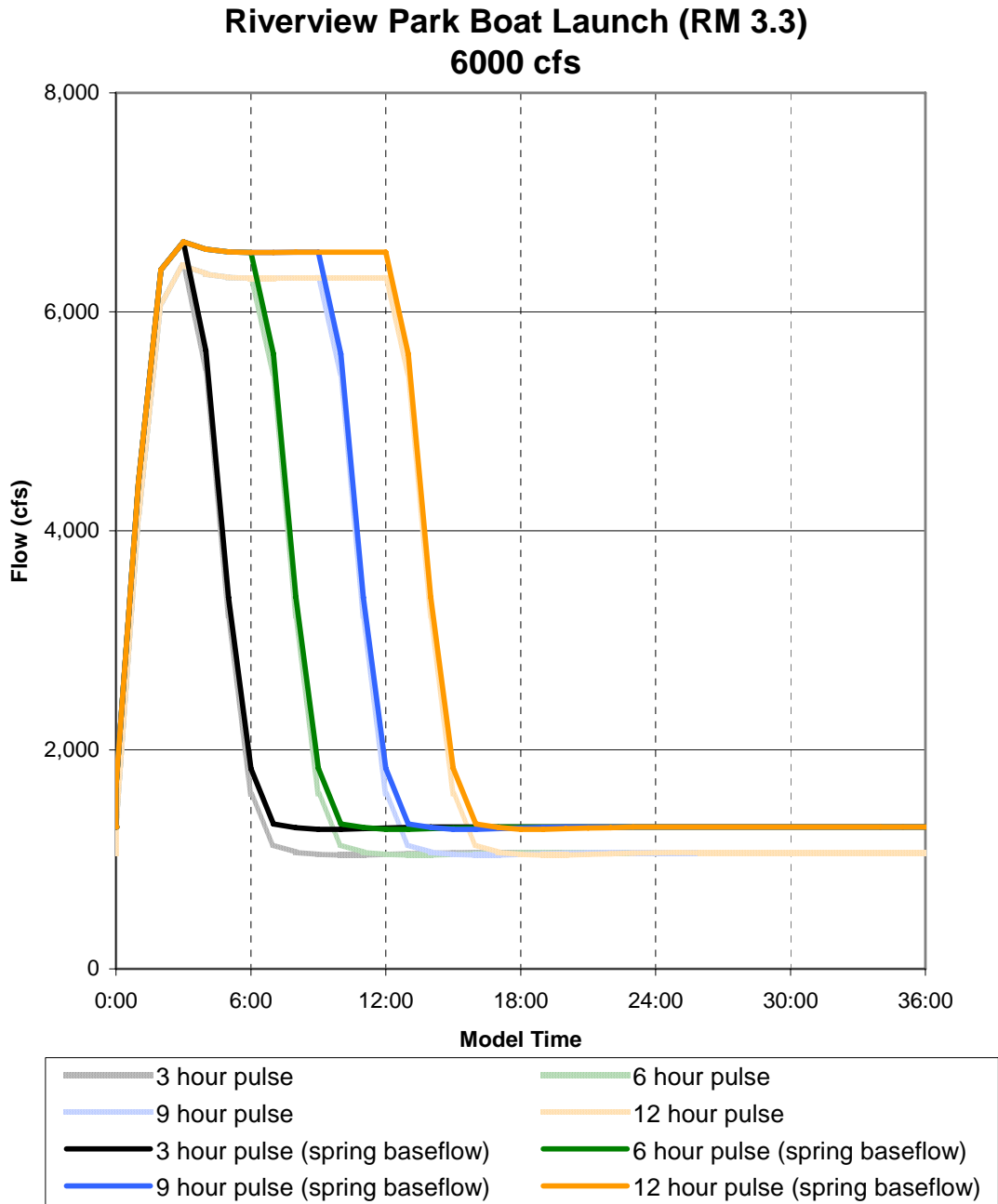


Figure 8. Riverview Boat Launch 6,000 cfs pulse graphical representation.

**Whitethorne DGIF Boat Launch (RM 19.4)
6000 cfs**

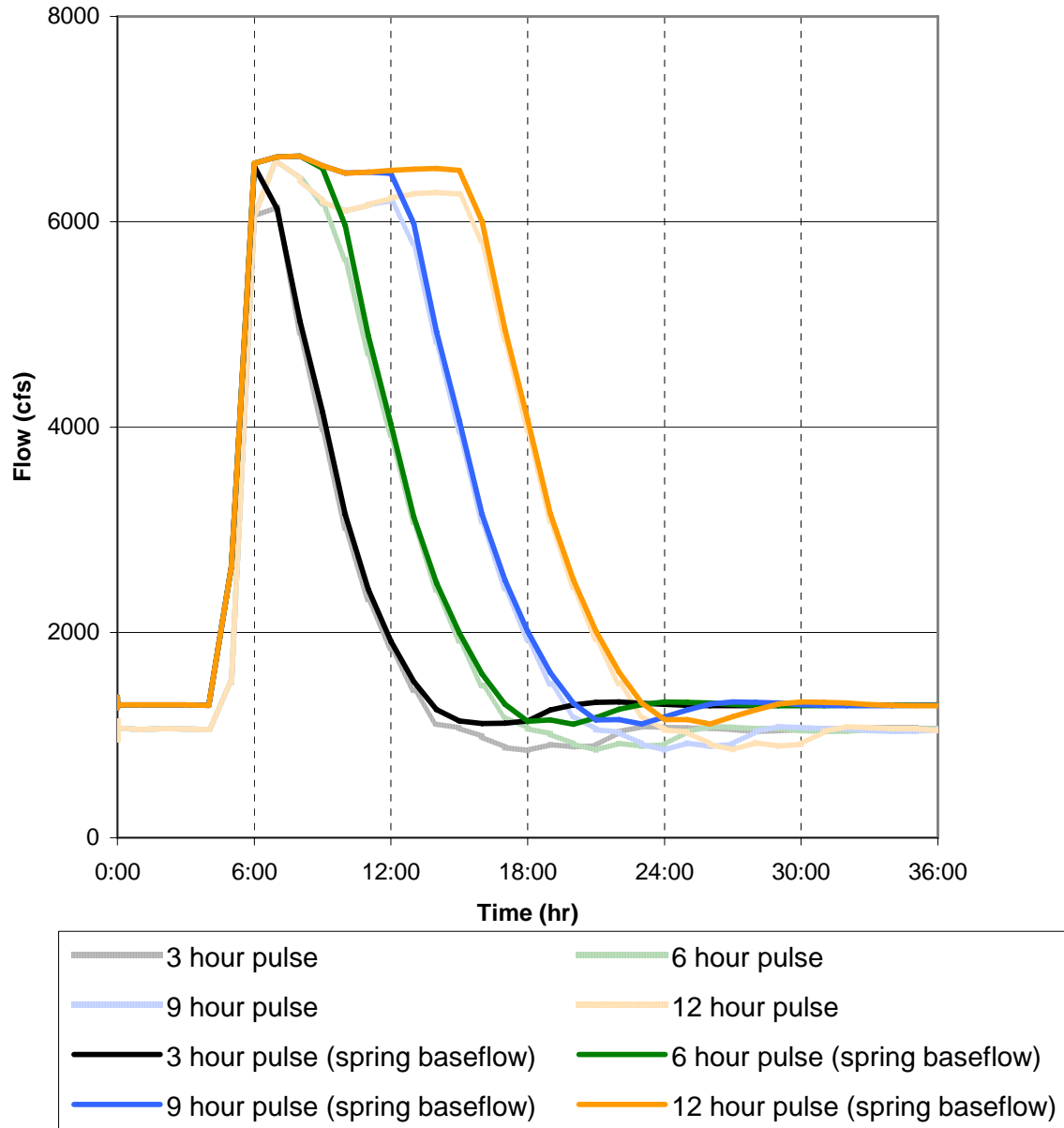


Figure 9. Whitethorne Boat Launch 6,000 cfs pulse graphical representation.

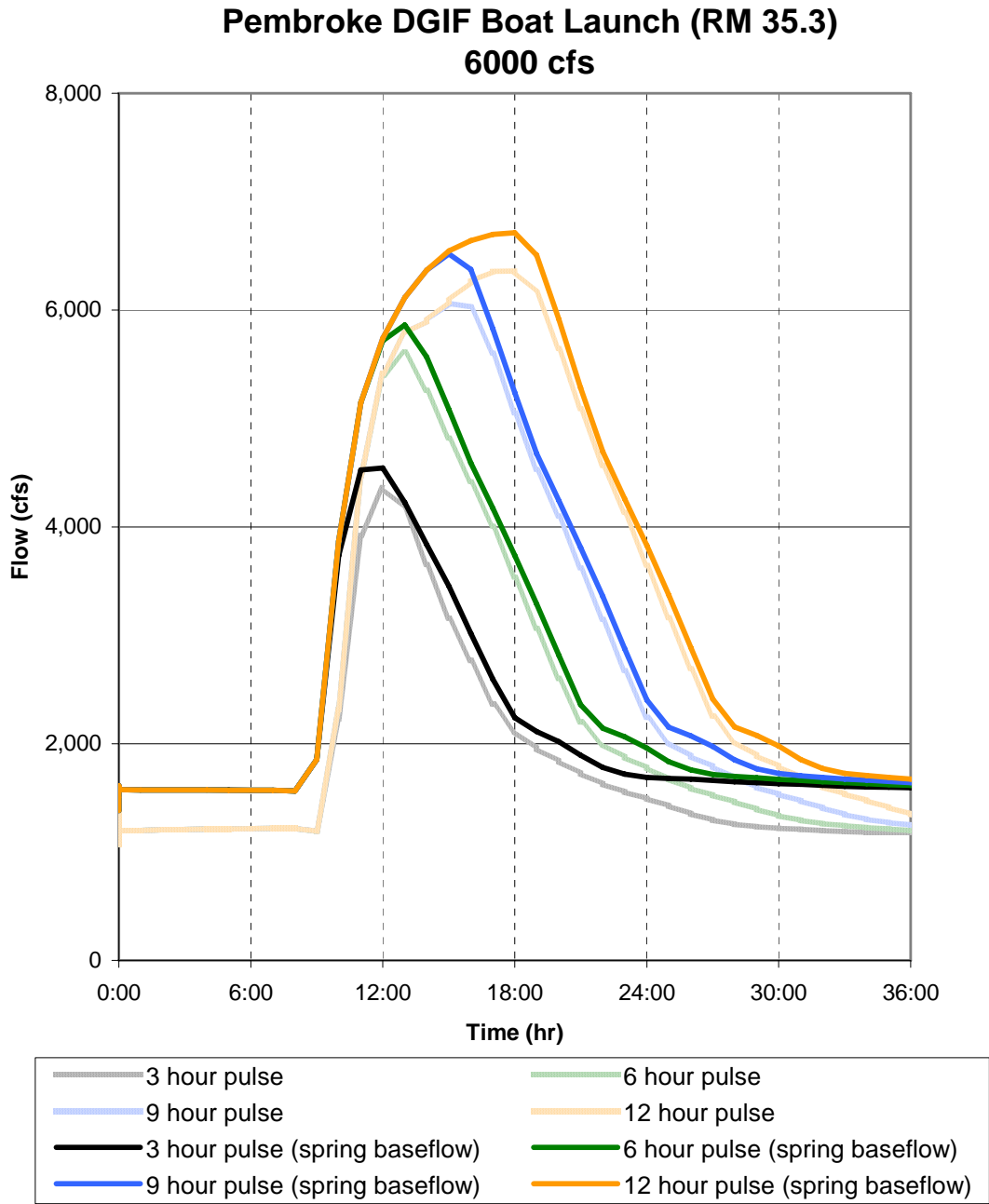


Figure 10. Pembroke Boat Launch 6,000 cfs pulse graphical representation.

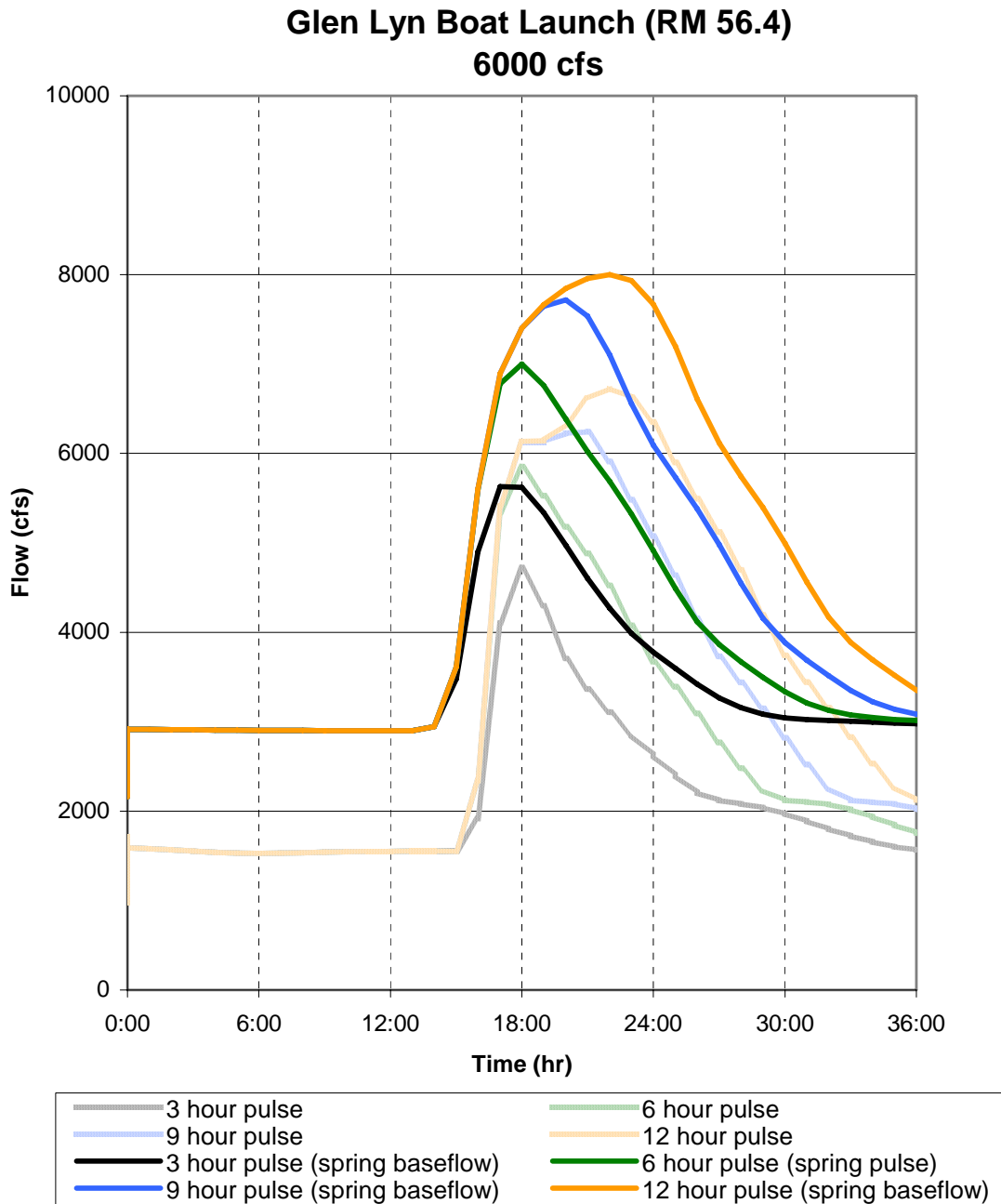


Figure 11. Glen Lyn Boat Launch 6,000 cfs pulse graphical representation.

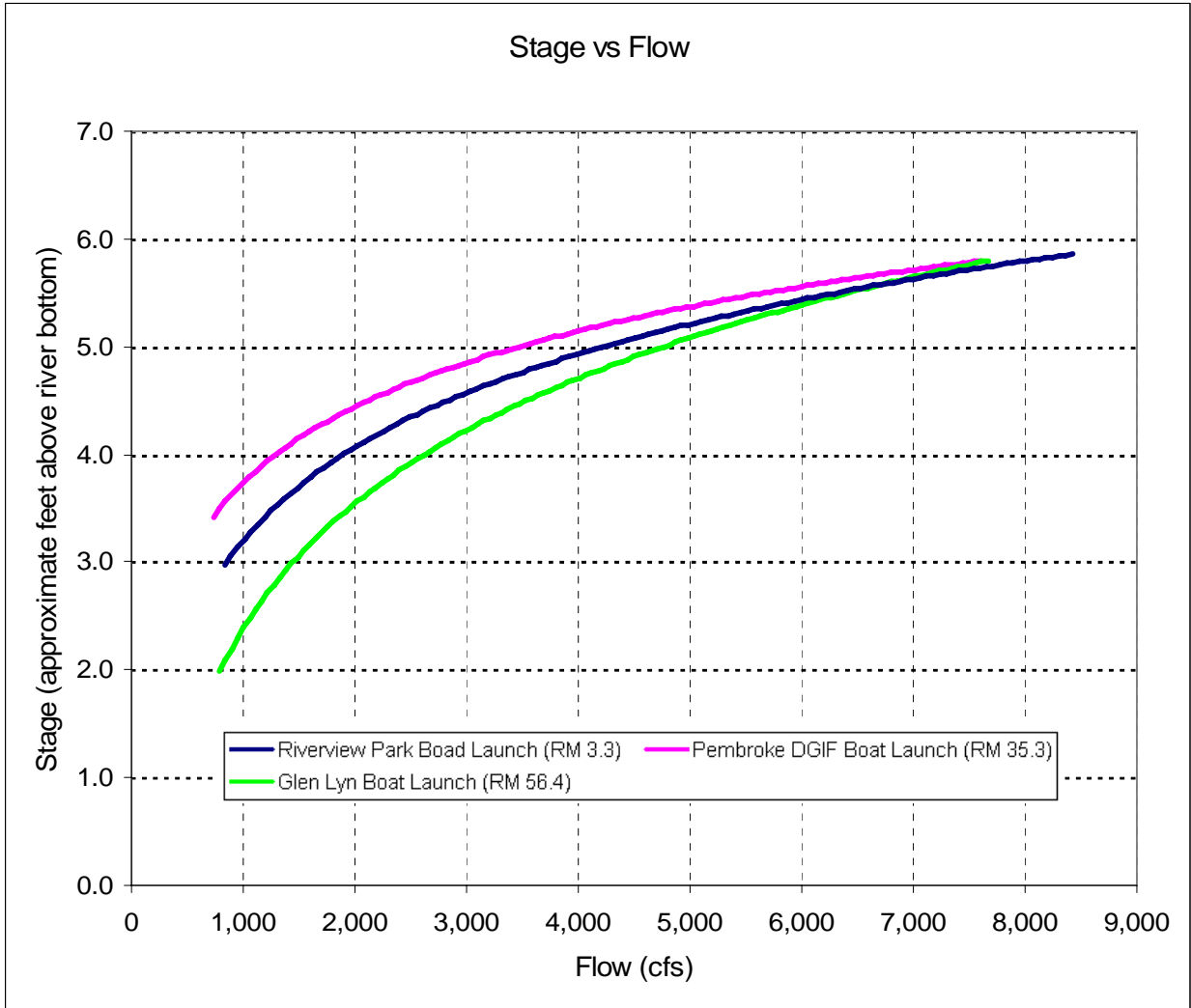


Figure 12. Stage vs Flow Relationships for the Riverview, Pembroke, and Glen Lyn Boat Launch Locations

FLOW LOOKUP PROGRAM

The Excel file ‘Flow lookup.xls’ is included with this report to provide results from the dynamic flow routing model.

Two boxes are used for selecting the model results based on site location (figures 13 and 14). The left side box is used for downstream sites (RMs 29.7 to 56.4); the right side box is used for upstream sites (RMs 3.3 to 27.6). After determining which box contains the desired site, the following parameters may be specified using dropdown menus: peaking flow (2,000, 4,000, 6,000, and 8,000 cubic feet per second), duration (3, 6, 9, or 12 hours), and cross-section location.

Use this side for sites in the upper half of the New River below Claytor Dam:

Ferry McCoy Boat Launch	Dudley Landing
Whitethorne Boat Launch	Riverview Park Boat Launch
Route 114 Bridge	

Flow (cfs)	2000
Duration (hours)	6
Location	Dudley Landing

Location num.	91
Column num.	146

River Mile	7.8
Peak flow (cfs)	2461.1
Peak flow arrival delay	5:00
36 hr flow sum (cfs)	45632
Arrival delay (after generation, hrs)	1:00

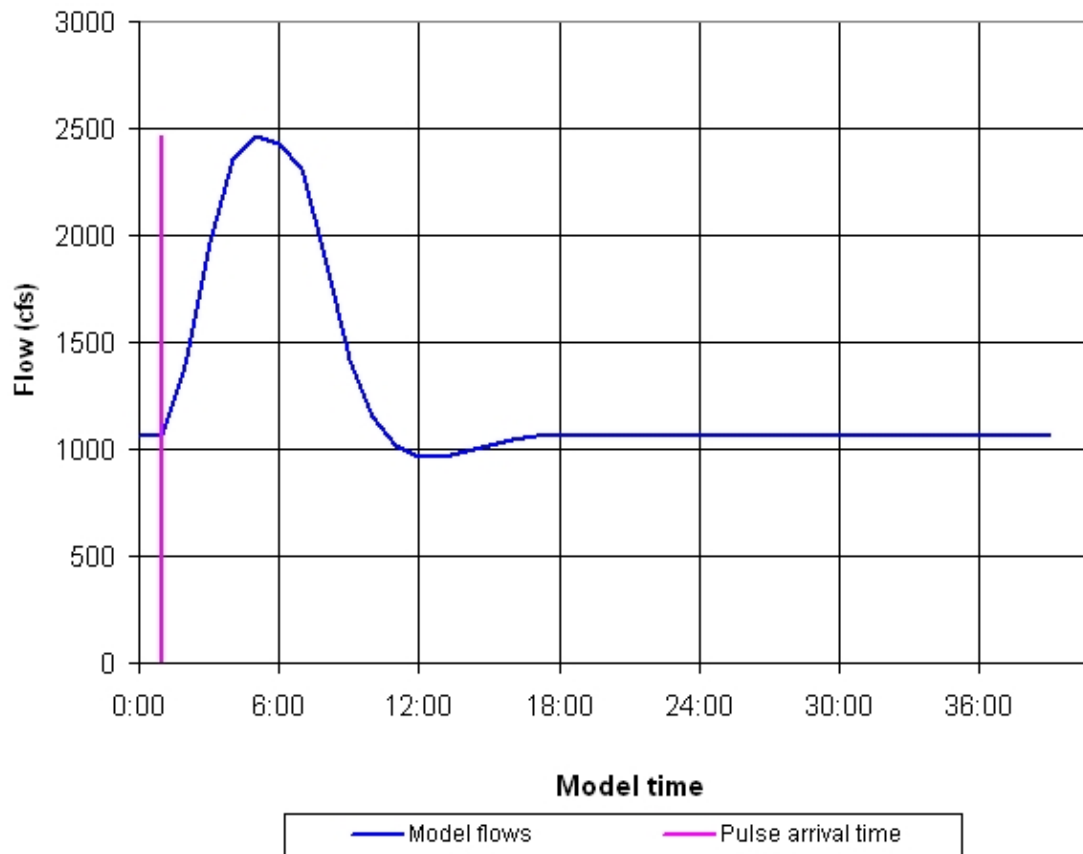


Figure 13. FlowLookup example for sites in the upper half of the New River below Claytor dam.

Use this side for sites in the lower half of the New River Below Claytor Dam:

Glen Lyn Boat Launch	Ripplemead Route 460
Narrows Boat Launch	Pembroke Boat Launch
Bluff City Boat Launch	Eggleston Boat Launch

Flow (cfs)	4000
Duration (hours)	9
Location	Pembroke Boat Launch

Location num.	59
Column num.	71

River Mile	35.3
Peak flow (cfs)	4109.1
Peak flow arrival delay	15:00
36 hr flow sum (cfs)	73214.2
Arrival delay (after generation, hrs)	9:00

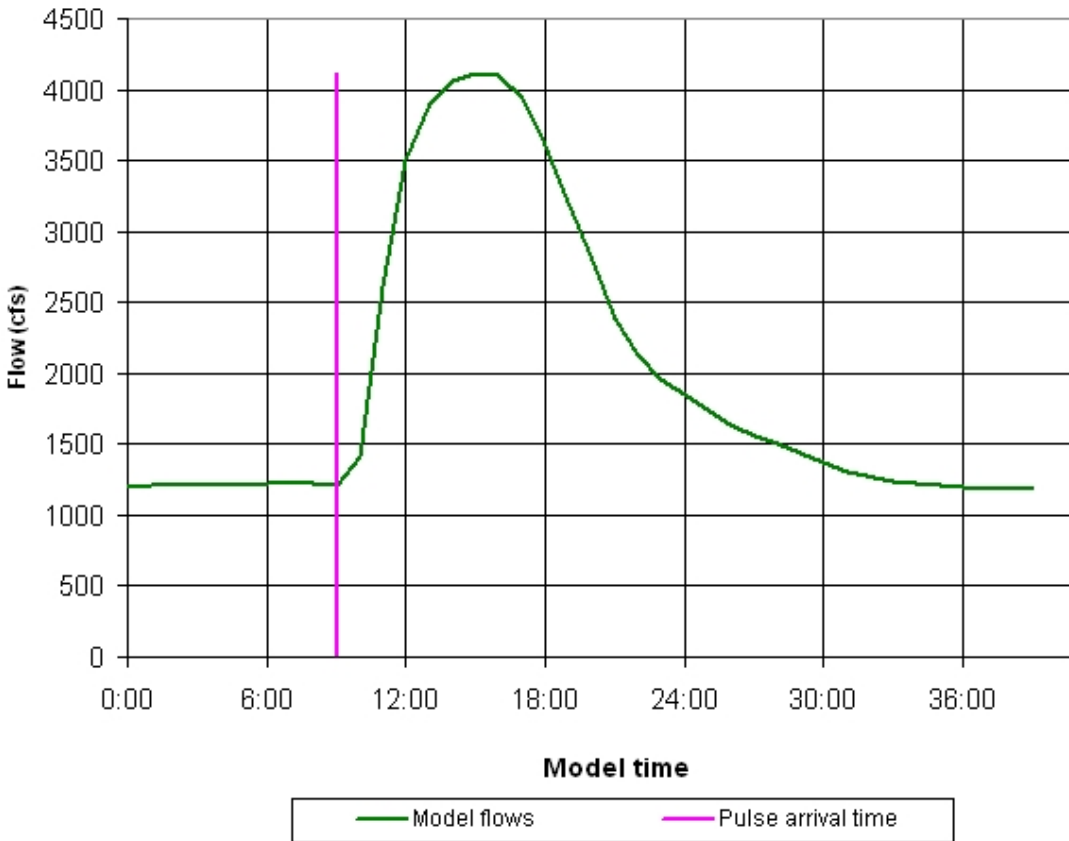


Figure 14. FlowLookup example for sites in the lower half of the New River below Claytor dam

The following results are displayed in the cells highlighted blue:

- 1. River mile – The river mile location of the modeling results.**
- 2. Peak flow – Maximum discharge in cubic feet per second (cfs).**
- 3. Peak flow arrival delay – Length of time between flow release from Claytor dam and the peak flow arriving at the specified location.**
- 4. 36 hr flow sum – The total river discharge at the specified location over the 36 hour period after flow release from Claytor dam in cfs.**
- 5. Arrival delay - Length of time between flow release from Claytor dam and the pulse arriving at the specified location.**

In addition to these parameters, a hydrograph displays modeling results starting at the time of Claytor dam flow release. The hydrograph includes a pink line signifying the pulse arrival time.