



Mitigating Thermal Stress in the Upper Delaware River:

What we know and where we are.

Peter Kolesar, Columbia Water Center

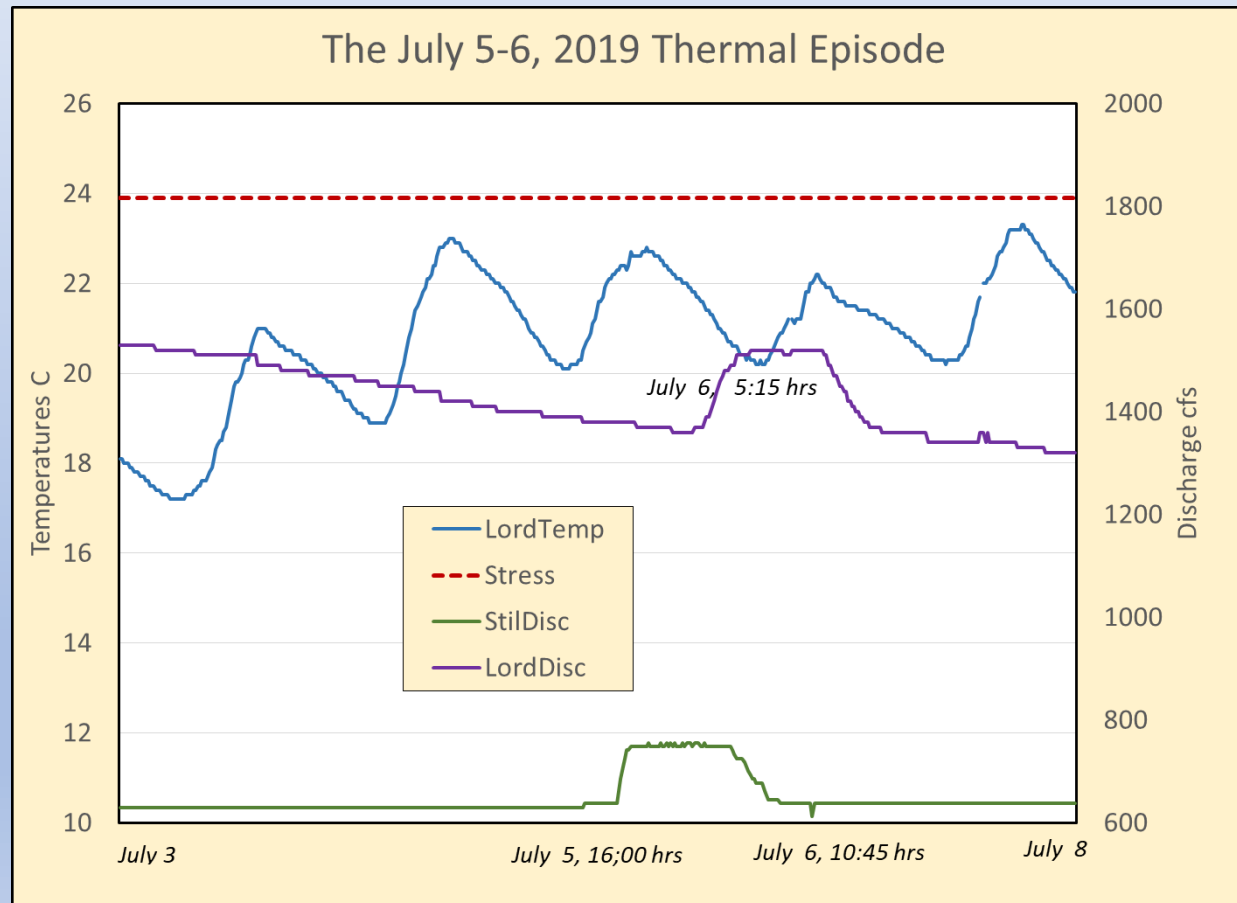
For the Friends of the Upper Delaware River

July 10, 2019

Hancock, NY

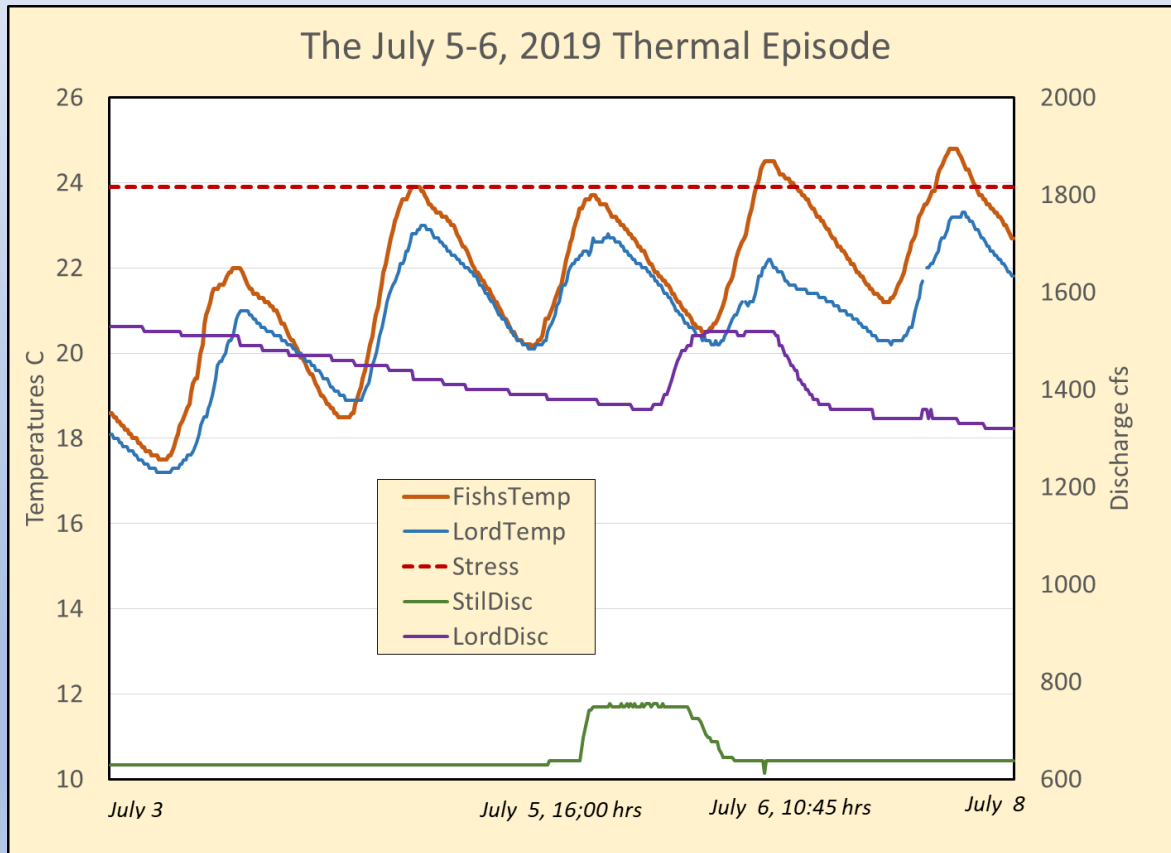
What happened at Lordville over the weekend?

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The pulse was about 119 cfs and lasted about 12 hours. Including ramp-up and ramp-down about 90 cfs-days of water was expended.

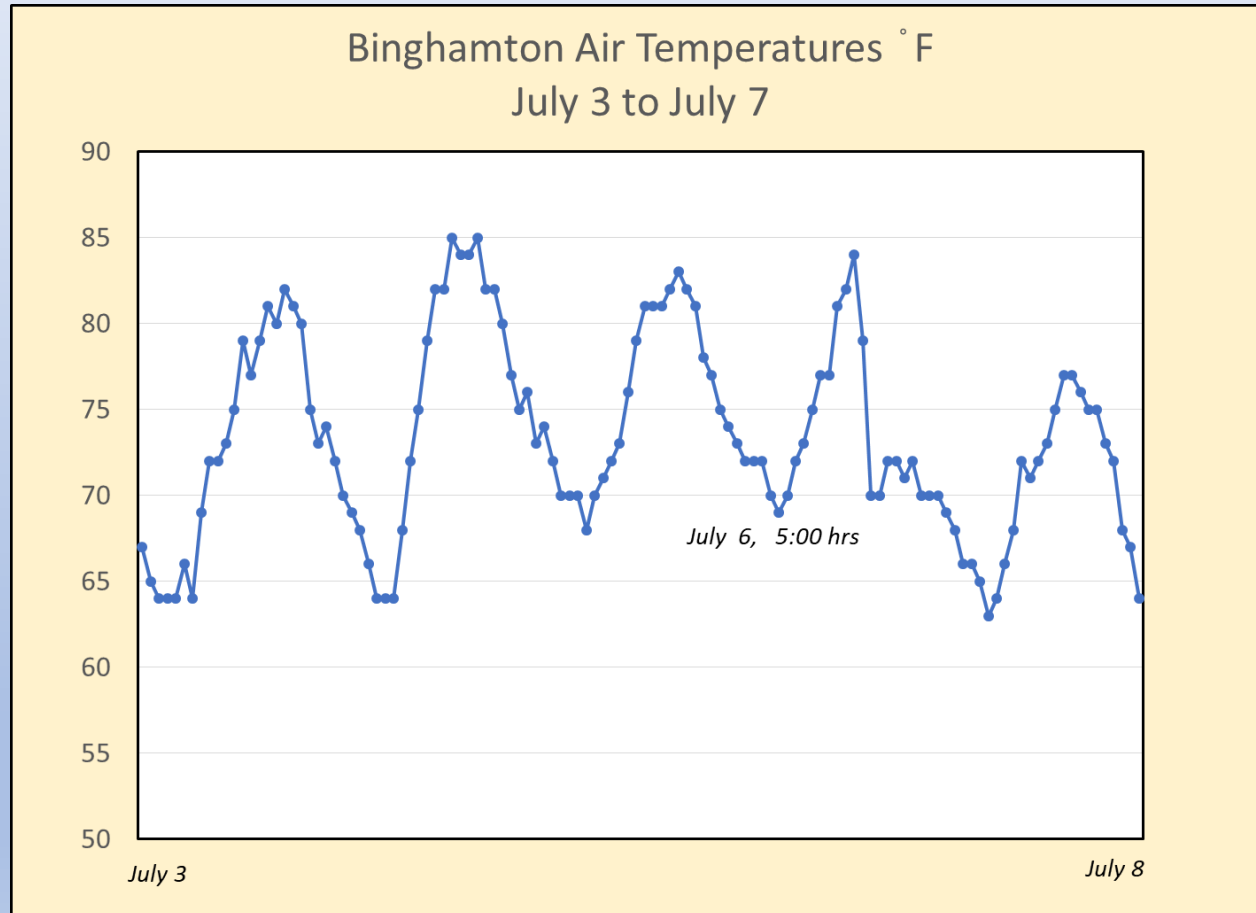
After the pulse reached Lordville regional air temperatures also lowered.

However, relative to Fishs Eddy, the pulse appears to have reduced Lordville temperatures by about 1.3 °C, which is in the ballpark predicted by my regression model

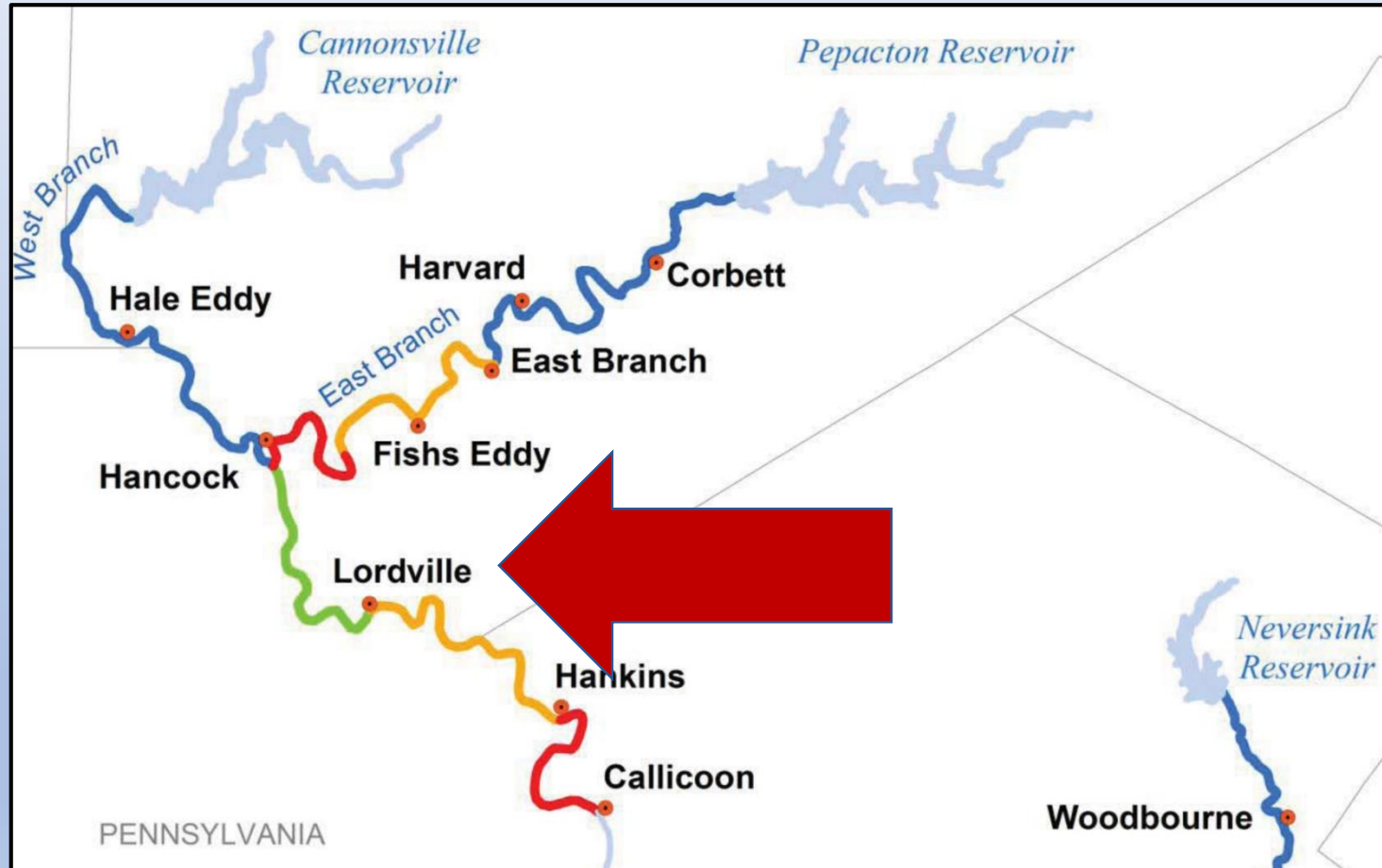
How far we have come....

- On July 25, 2005 with the reservoirs at 95 % capacity, and ir temperatures at 86 F, the release from Cannonsville was 125 cfs.
- No one in charge of the Delaware releases thought there was a problem! We did. This event kick-started the research that led to the FFMP.

*Why impact assessment is complex:
The confounding effect of weather changes*



The Goal: Mitigating high river temperatures from Hancock to Lordville.



Source: Joint Fisheries White Paper, January 2010

Current Thermal Mitigation Status

- FFMP 2017, in effect until 2023, includes a bank of 2,500 cfs-days of water to be administered by NYS-DEC to mitigate thermal events in the upper Delaware.
- The original Decree Party proposal (**The Interim Protocol**), focused on Lordville, included a complex set of stress criteria including a daily 75° F maximum early in the season, and a multiple-day at 75° F or a single day at 77° F maximum later in the season.
- Following recent analysis and a recommendation from the Subcommittee on Ecological Flows (SEF), the Decree Parties have modified the criterion to a single day at 75° F max throughout the season (**The Simple 75 F Protocol**) – for the summer 2019.
- The possibility of adding a daily 72° F average criterion in 2020 is under investigation by SEF, as is the size of the bank.

A Still Perplexing Question: What are appropriate temperature constraints?

- Referring to the Hancock to Lordville reach, Appendix A of FFMP 2017, consistent with the Joint Fisheries White Paper of 2010 states that *“Summer water temperatures will occasionally exceed a daily maximum of 75 °F for short periods and water temperatures greater than 68 °F [will] occur more frequently than with the Excellent protection level. Elevated temperatures will occasionally be an issue.”*
- It is widely documented in the technical literature that trout are stressed at temperatures above 68 °F. But, it is not known what specifically happens to trout in the Hancock to Lordville reach at temperatures above 68 °F, or above 75 °F, for that matter.
- Previous Delaware Releases rules, e.g. Rev 1 of 1983 and Rev 7 of 2004 included temperature criteria further down-river at Hankins or Callicoon for both a daily maximum of 75 °F and a daily average of 72 °F. Use of the 75 °F maximum and 72 °F average criteria has long precedent on the Delaware (Sheppard 1980).
- The original FFMP (2007) did not include any temperature targets

Why/When does Lordville go into thermal stress?

There were 78 thermal stress days (75 ° F max) grouped into 26 stress episodes between 2008 and 2018. There are a complexity of contributing factors but the primary drivers are:

- High Regional Air Temperatures (Binghamton) Median 85 ° F.
- Low River Flows Lordville Median 900 cfs; Cannonsville Median 378 cfs.
- Sequences of high air temperatures – heat waves – are problematic, but are generally well forecasted by the NWS.

History of Thermal Stress at Lordville Under the FFMP

Thermal Events at Lordville		
May through September 2008 to 2018		
Criteria	Days Exceeded	Percent of Season
68 Max	582	34.6
75 Max	78	4.6
77 Max	20	1.2
72 Avg	98	5.8
72 Avg or 75 Max	106	6.3
72 Avg, not 75 Max	28	1.7

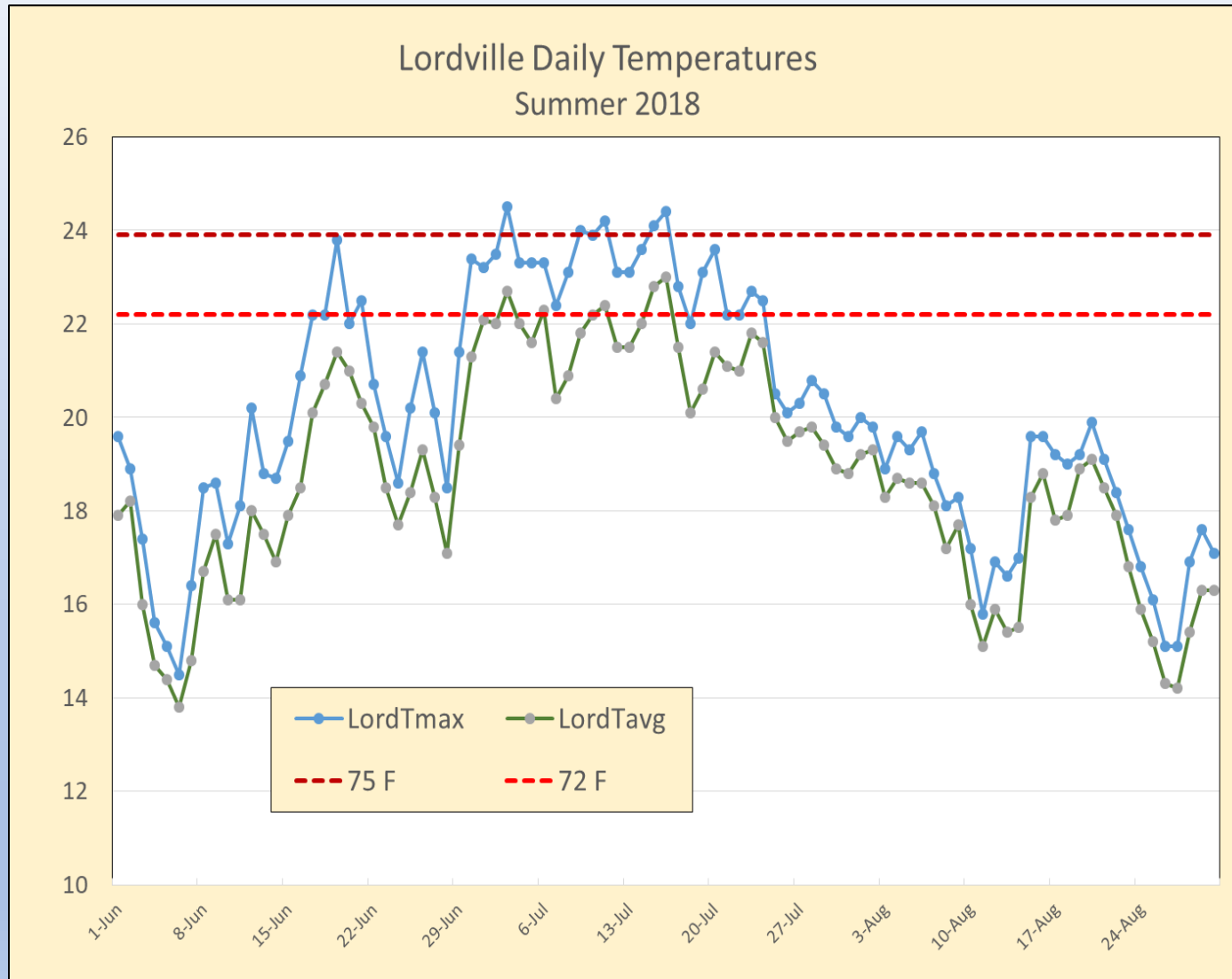
Notes:

- Thermal stress was more frequent in the early years of the FFMP when conservation releases were lower. Had FFMP 2017 been in effect throughout, we estimate that 75 F exceedences would drop from 78 to 41 days.
- Nine thermal mitigation releases were made between 2008 and 2018, so the actual stress 'burden' was about 11days higher than indicated above -- for a total of about 52 days.

The Temporal Pattern of 75 °F Stress Days at Lordville:

Number of Days Above 75°F						
Lordville USGS Gage # 1427207: Summers 2008 to 2018						
Month	May	June	July	August	September	Summer
2008	0	8	9	1	0	18
2009	0	0	0	0	0	0
2010	4	2	15	1	2	24
2011	0	0	3	0	0	3
2012	0	1	5	8	0	14
2013	0	0	2	0	0	2
2014	0	0	0	0	0	0
2015	0	2	0	0	0	2
2016	4	0	4	1	0	9
2017	0	0	0	0	0	0
2018	0	0	6	0	0	6
Average	0.7	1.2	4.0	1.0	0.2	7.1

What Happened Last Summer, 2018?

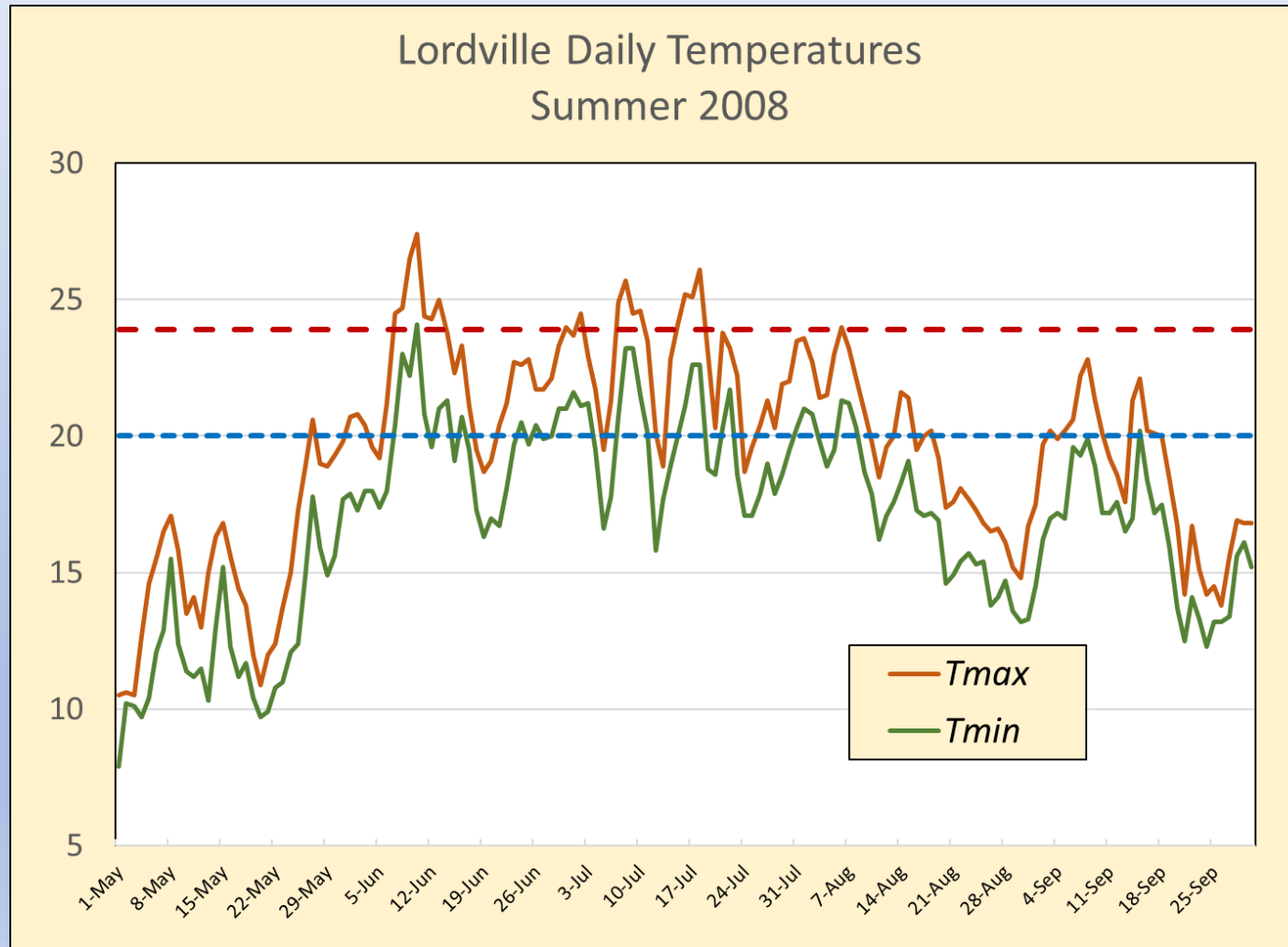


Despite three thermal releases on June 17, June 30 and July 15, there were 6 stress days above 75 F.

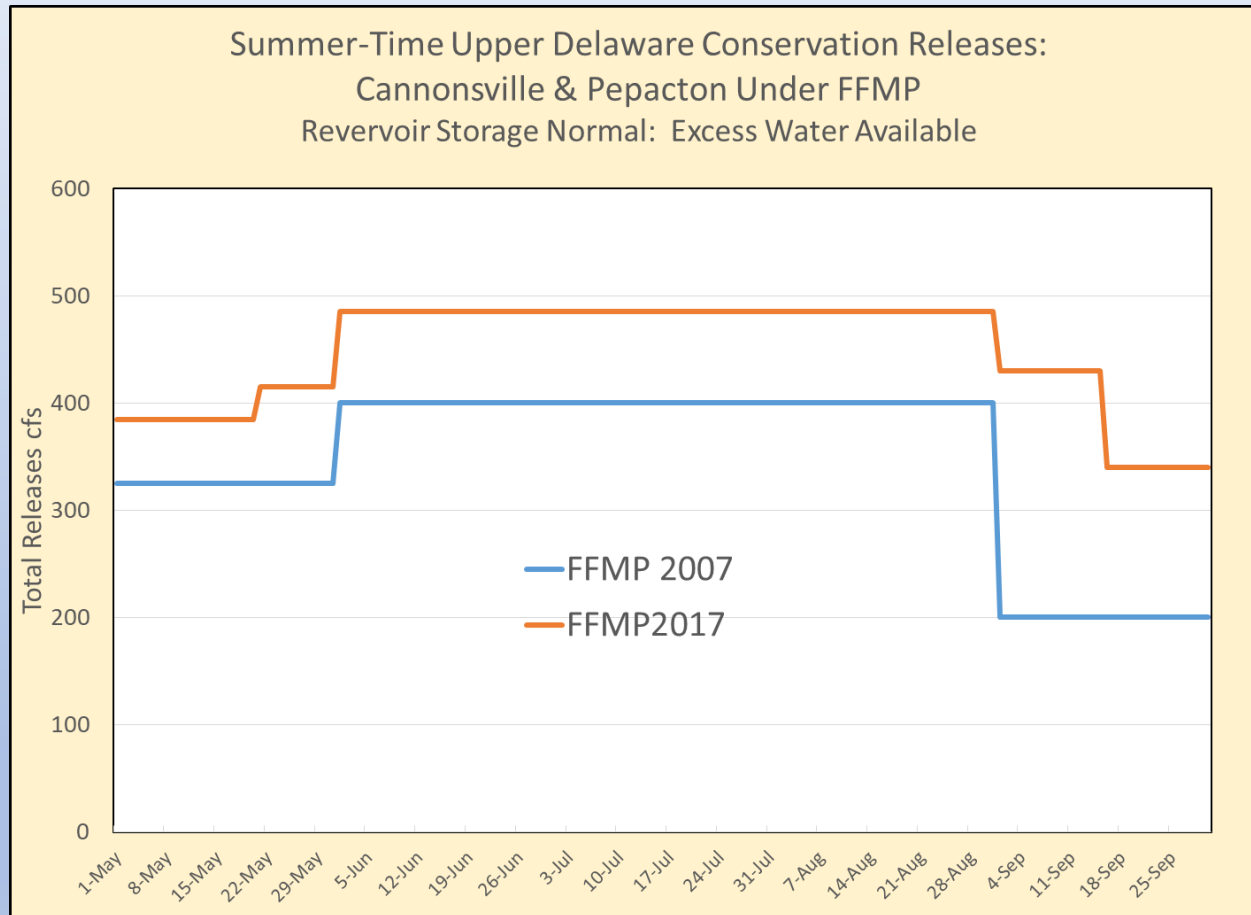
About 1760 of the 2500 cfs-day bank was used.

Due to much heavier than normal precipitation in August, no stress was experienced late in the summer

By contrast in 2008, the first year of the FFMP, there were 18 stress days, 7 of them extreme. A thermal release about 370 cfs was made on June 8, using about 550 cfs-days and mitigating one 75 F stress day.



Improvements in Conservation Releases: FFMP 2007 to FFMP 2017

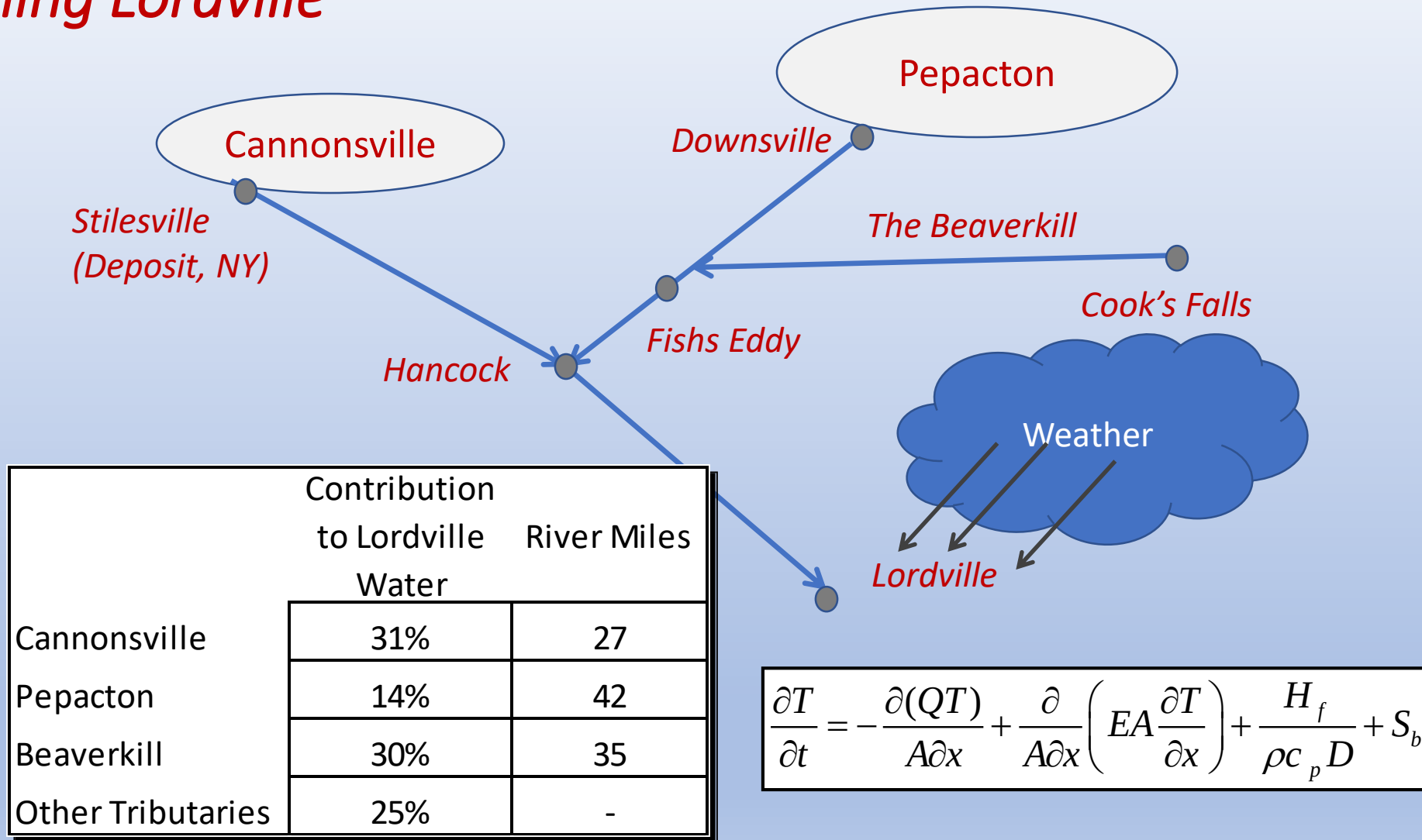


An OASIS simulation of FFMP 2017 rules applied in years 2008 to 2012 showed increased base releases which would have resulted in substantially fewer stress days.

For example, in 2008 the number of stress days was 18 under FFMP 2007, while under FFMP 2017 it would have been 4.

How much Cannonsville water does it
take to cool Lordville?

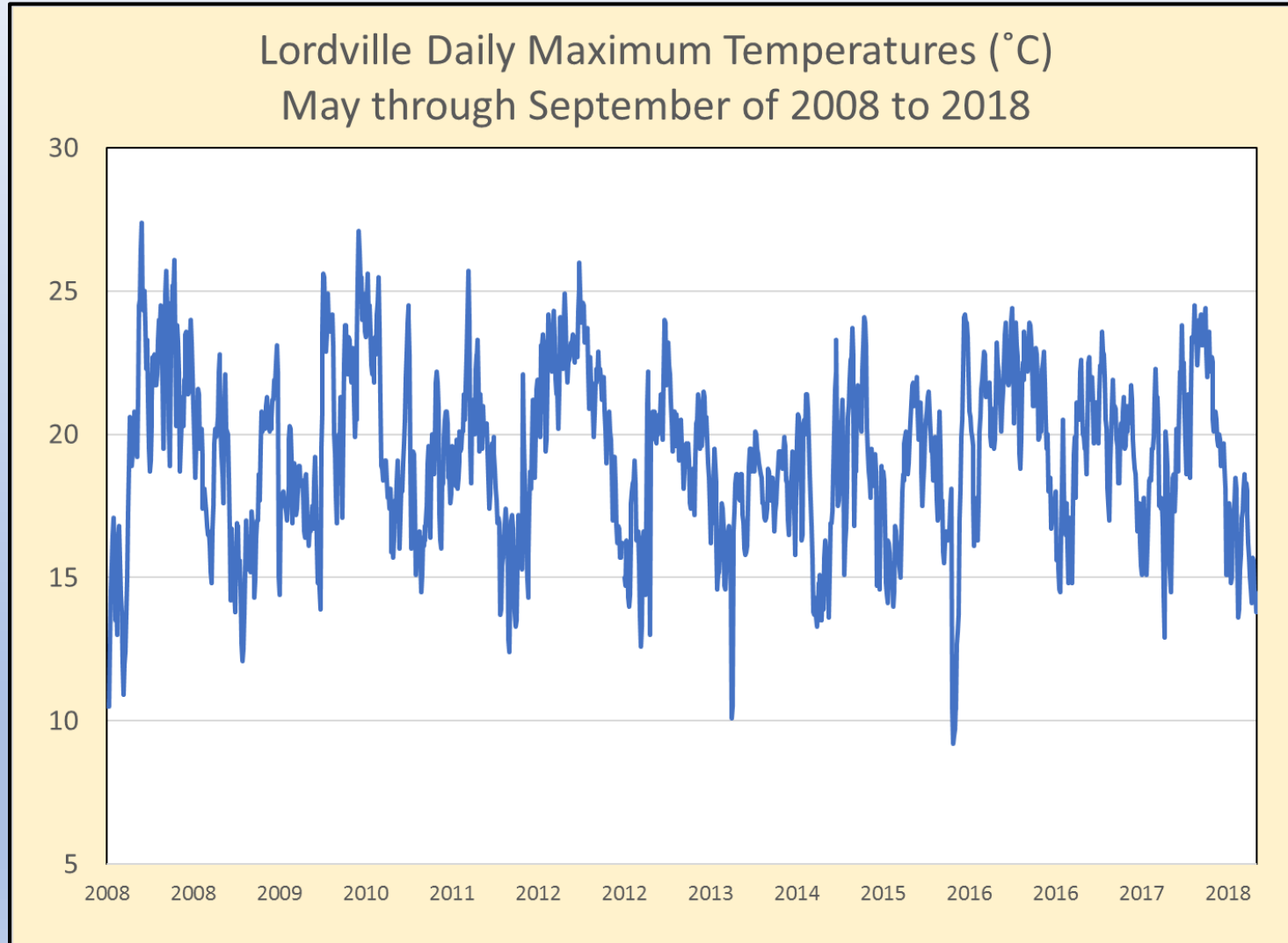
An Engineering/Thermodynamic Approach to Cooling Lordville



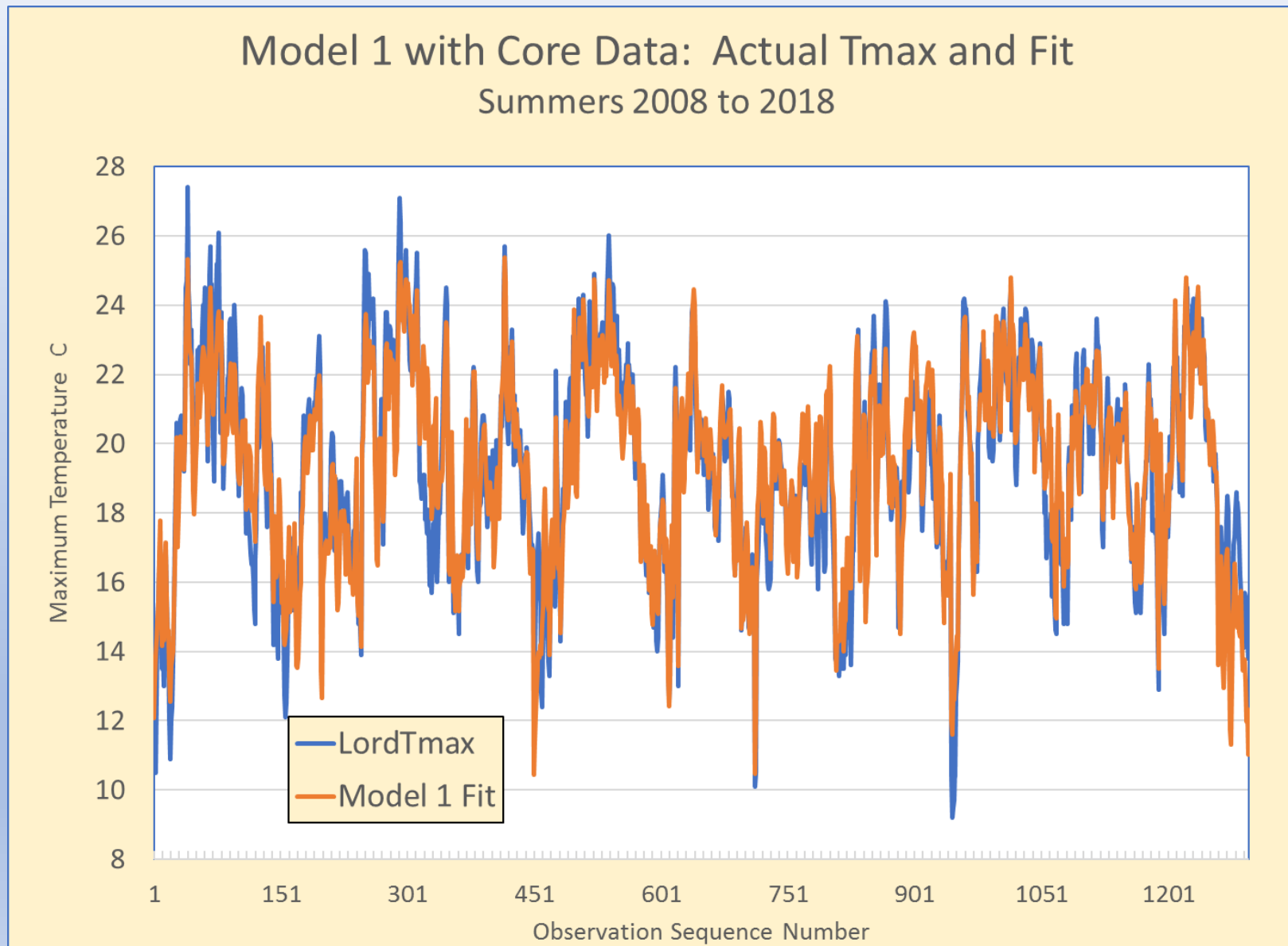
Three approaches to estimating the cooling impact of Cannonsville Releases

- **Statistical (Regression)** analysis to fit an equation to river history estimating the reduction in Lordville water temperatures per cfs of release from Cannonsville. (Done)
- **Direct evaluation** of the observed impact, if any, of the nine thermal releases made by NYS-Dec since the FFMP was instituted. (Done)
- **Thermodynamic modeling** of the impact of mixing cold Cannonsville water with warmer East Branch and Beaverkill water at Lordville (Underway)

Our Challenge: Understand the Lordville thermograph and quantify the role of Cannonsville releases in its “ups and downs”.



Regression “Model 1” : Fit over 11 Summers



Findings to Date

Via Regression Analysis:

Averaged over typical summer-time river and weather conditions on days when thermal stress could occur, it takes about 145 cfs to reduce Lordville temperatures by 1 °C.

Via direct observation of the results of nine thermal releases made since 2008

Eight of the nine actual releases produced some thermal mitigation. The average thermal pulse was 331 cfs, the average amount of additional water used, including ramp-ups and ramp-down, was 608 cfs-days. A pulse of less than 200 cfs does not appear effective.

Simulation Assessment of Policy Implications

The four most important of SEF's simulations of the summers 2008 to 2018, were driven by estimates of Lordville maximum daily temperatures as if the FFMP 2017 release rules had been in effect from 2008 to 2012:

- **Triggering Protocols**

- Interim Protocol (including a post July 6 phase with multi-days at 75° F and single day at 77° F constraint.
- Simple 75° F max constraint, no phases.

- **Releases Quantities**

- Release exactly according the regression estimates (145 cfs/° C) assuming perfect forecasting and perfect calibration
- Release 331 cfs per day in stress regardless of conditions with perfect forecasting of stress days.

Simulation Results Presented to the Decree Parties

		Regression	Observed
		145 cfs/ ° C	331 Per Diem
Interim Proposal	Years Bank Exhausted	0	0
	Stress Days Unmitigated	0	14
	Average Bank Usage	640	962
Simple 75 Policy	Years Bank Exhausted	0	2
	Stress Days Unmitigated	0	5
	Average Bank Usage	714	1474

SEFs Observations:

The 331 per diem simulation is likely to be closer to actual water use. The Regression based simulation unrealistically assumes perfect forecasting and release calibration.

The simple 75 Policy uses more water, but also mitigates more stress days

What about the good old days?

Thermal Stress at the Hankins

Under Rev 7 there was a 72 F average and a 75 F maximum target at the Hankins gage and 6000 cfs-day bank for thermal mitigation. How well did it work?

Hankins USGS Gage: Count of Stress Days @ 75 F Max or 72 F Tavg						
	May	Jun	Jul	Aug	Sep	Season
1994	0	1	13	0	0	14
1995	0	6	15	7	0	28
1996	0	0	2	7	1	10
1997	0	9	6	0	0	15
1998	2	3	10	0	0	15
1999	0	0	0	0	0	0
2000	0	0	3	7	1	11
2001	0	12	9	0	0	21
2002	0	6	19	2	0	27
2003	0	0	12	0	0	12
2004	0	5	1	2	0	8
2005	0	13	21	0	0	34
2006	0	0	13	8	0	21
Average 13 Years	0.2	4.2	9.5	2.5	0.2	16.6

A close-up photograph of two rainbow trout lying horizontally in a black mesh fishing net. The fish are wet, with water droplets visible on their scales. They have silvery bodies with a prominent pinkish-red lateral stripe and dark spots. The text "The End" is written in a large, red, italicized serif font across the middle of the image, overlapping both fish.

The End