

Rock River Flood Monitoring and Evaluation

Summary Presentation

February 5, 2021

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We conducted this monitoring and analysis project for Steve Folkman and Tim Cargill, both of whom own land on the Rock River in the Town of Lebanon. They, and many other property owners in this reach of the Rock River, have been negatively impacted by high, extended water levels on the Rock River. Since the early 80's they have seen a steady increase in flooding in both water levels and duration. Flooding has gone from being associated with spring thaws and rainstorms to being persistent for as long as 11 months a year, particularly in the last several years (since 2018).

For example, Steve Folkman has lost the use of over 20% of his land due to flooding, with over 50 acres of crop, pasture, and woods affected with major tree and crops loss. Existing drainage ditches and berms have become ineffective due to the volume and levels of water backed up due to Rock River flooding. Waterfowl hunters traversing their lands when flooded has increased due to the increased duration and height of flooding from the Rock River, which is a concern due to the value of the livestock they own that are kept in proximity to the hunters and potential injury from stray shots.

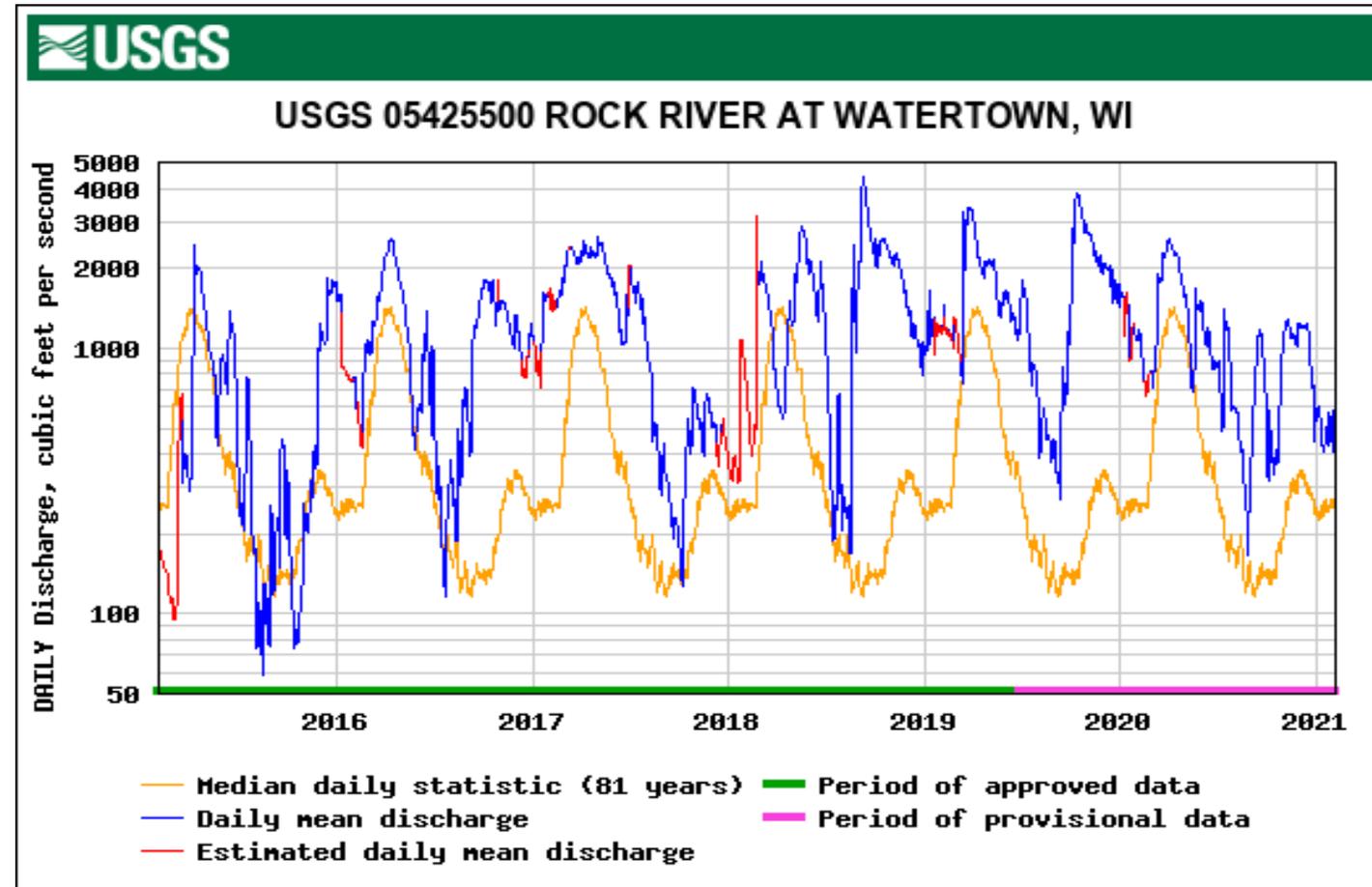
The issues our clients are experiencing are not unique to them – this has become an issue for riparian landowners adjacent to the Rock River along its path through the Town of Lebanon as well as riparians upstream (Town of Hustisford) and downstream (Town of Ixonia) who live along this very flat section of the Rock River. Property devaluation, loss of usable land (agriculture and recreational) and land access, loss of mature trees and floodplain forest wetland habitat, are all impacts of sustained high water to landowners. We also recognize that there are downstream water quality concerns due to frequent flooding of agricultural operations (feed lots, fertilized lands, etc.), and that high water becomes a public safety issue when flooded roadways restrict emergency vehicle access.

In addition to public safety concerns, road closures due to flooding have also been a burden on municipalities. The specific cases we know of are in the Town of Lebanon including Monroe, Upham, and LaFollette Roads. The town sends an employee out weekly, or more frequently during high water, to determine if they need to physically close Monroe Road.

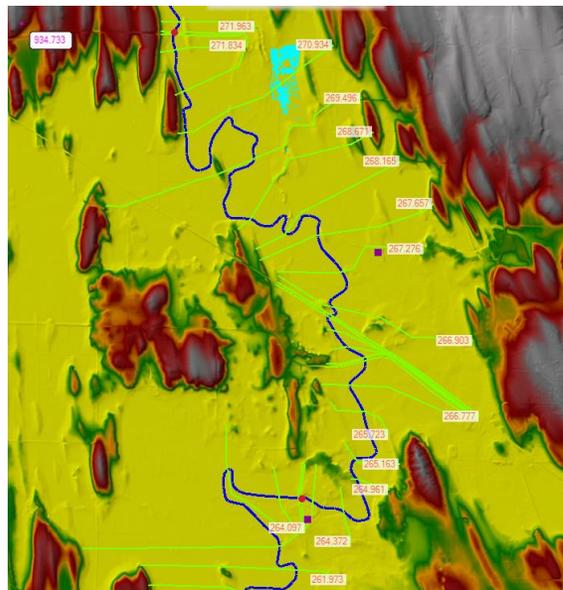
The objective of this study has been to analyze the increased flood durations and to identify potential causes and effects. Part of this project included a water level monitoring study which was conducted from August 2020 to December 2020. This report summarizes our data collection study, analysis, possible remedies, and action plan to resolve these issues.

The graphics on this and the next slides quantify the extent of the flooding in this area of the Rock River that has occurred in the last several years. This graph shows the discharge of the Rock River measured at the US Geological Survey gage at Watertown over the past five years- in blue. The long-term average discharge rate is shown in orange. This graph illustrates that flooding since 2016 has had far higher flow rates and longer duration than flows that typically occurred over the past 85 years.

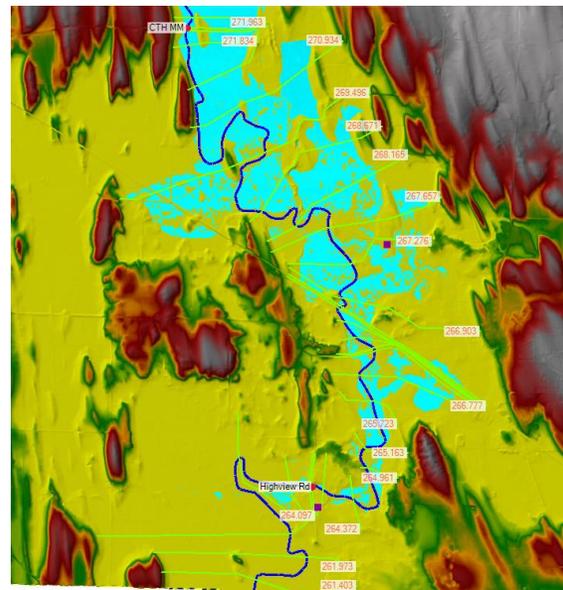
Note the discharge has substantially exceeded 1000 CFS for a large percentage of the year after 2016. In 2018 and 2019 flows exceeded 1000 CFS for all but a few months of the year.



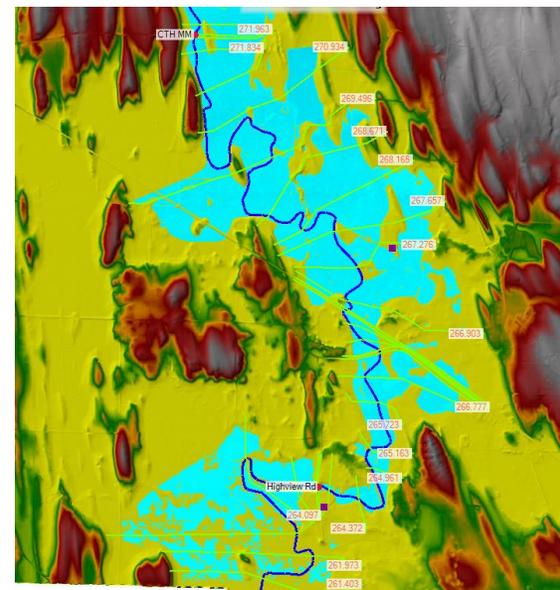
The Rock River in the Town of Lebanon is very flat, with an average slope of only 0.25 ft / mile (0.005%) including sections of adverse slope (the riverbed actually rises moving downstream). This slope causes the river to drain slowly, and when there is more flow in the river than the main channel can convey water spreads out across the broad, flat floodplains and recedes very slowly. The images below, from the DNR's steady flow HEC-RAS model of the river, illustrate the extent of out-of-channel water (cyan) as flows increase.



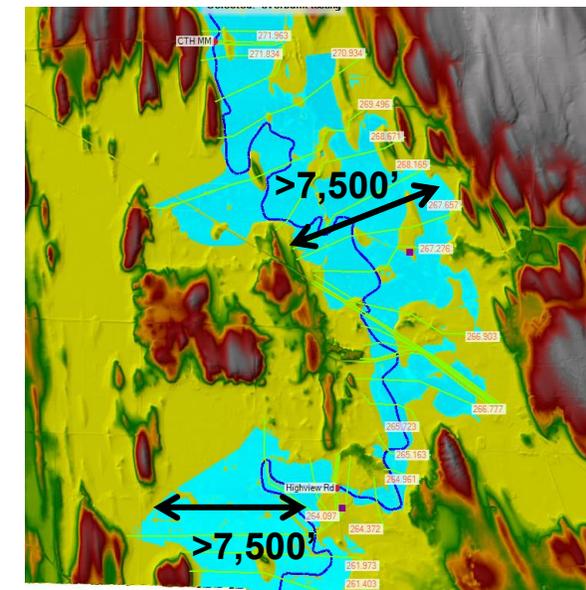
500 cfs - river between banks



750 cfs – pockets of water in floodplain, some wider inundation



1,000 cfs



1,250 cfs – extensive water in floodplain, >1 mile wide

Using the HEC-RAS model, we determined the total out-of-channel flooded area for each flow rate. The table below shows this relationship between flow and out-of-channel flooding area from downstream of Hustisford Dam to CTH P near Ixonia.

Flow Rate	Out-of-channel wet area	Area increase (compared to 500 cfs)
500 cfs	15,500 acres	-
750 cfs	18,400 acres	+ 19%
1000 cfs	23,350 acres	+ 51%
1250 cfs	25,400 acres	+ 64 %

These data illustrate two points:

1. Impacts from out-channel flooding is not unique to our clients, or for only a small portion along the Rock River in the Town of Lebanon. The out-of-channel wet areas at 500 cfs are likely wetlands or other naturally wet areas, but when flows increase from 500 cfs to 1250 cfs it causes 9,900 additional acres (15.5 square miles) of land to be flooded and water depths to increase by over 2'. This wide, deep inundation is what impacts residents of the Town of Lebanon, and these high flow rates have been seen frequently, and for extended periods, over the last several years.

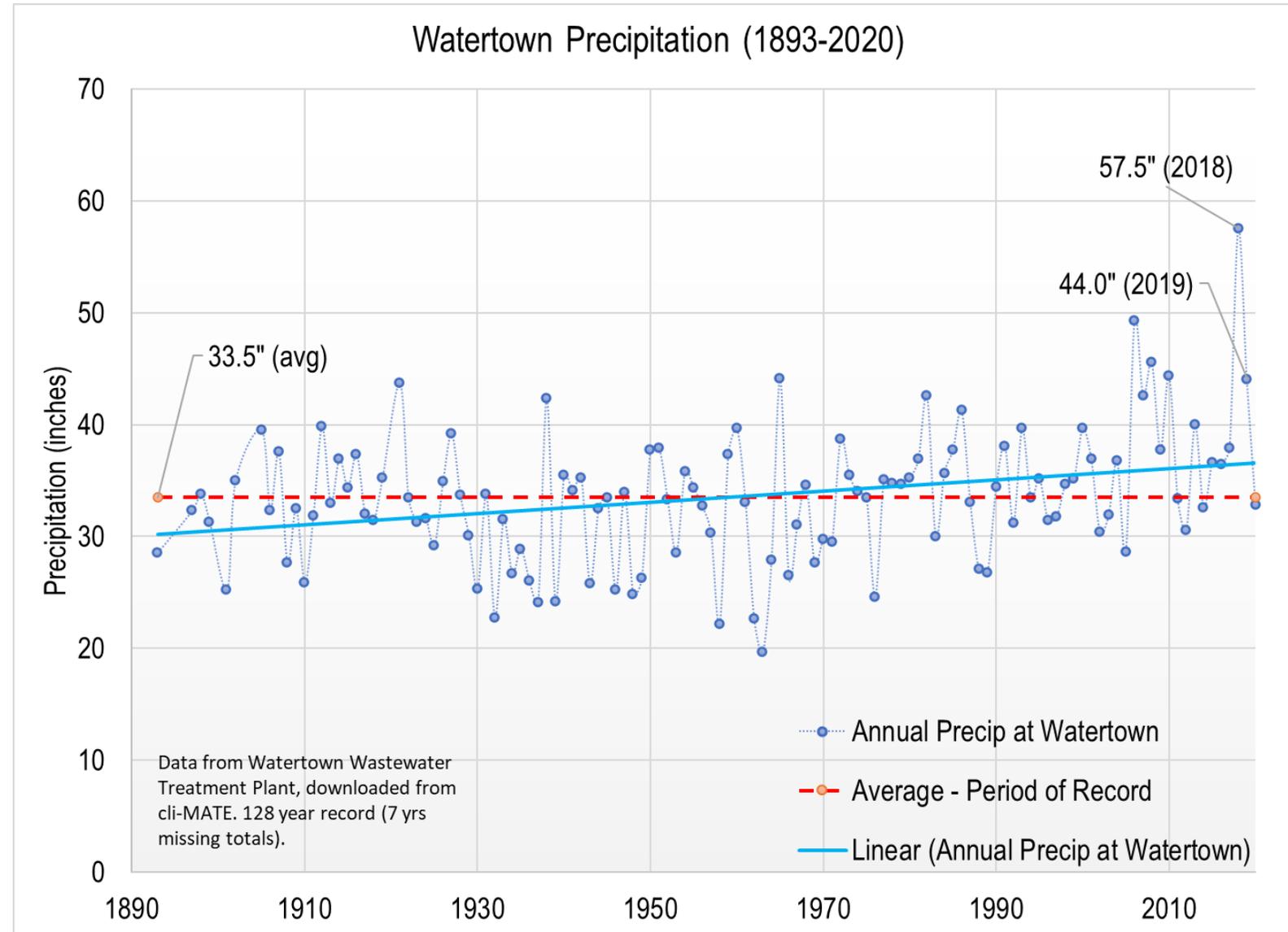
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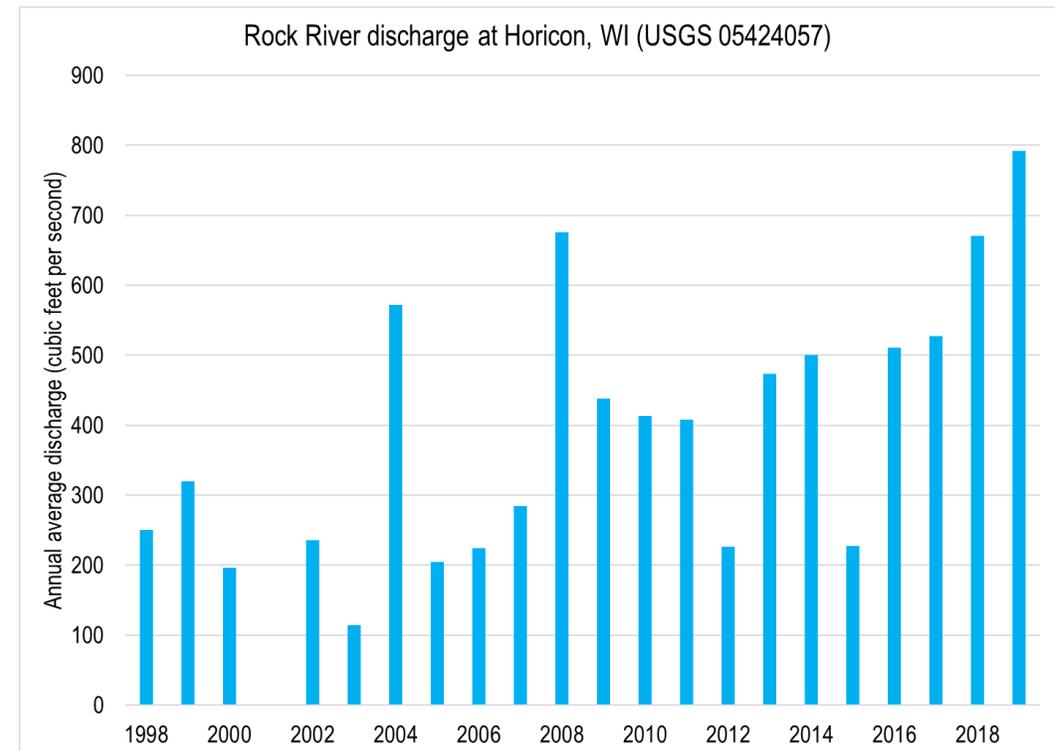
2. There seems to be a threshold, between 750 cfs and 1000 cfs, where flood extents increase rapidly in response to increased flows. In the analysis above, 50% (~5,000 acres) of the total flooded area increase occurred between 750 and 1000 cfs.

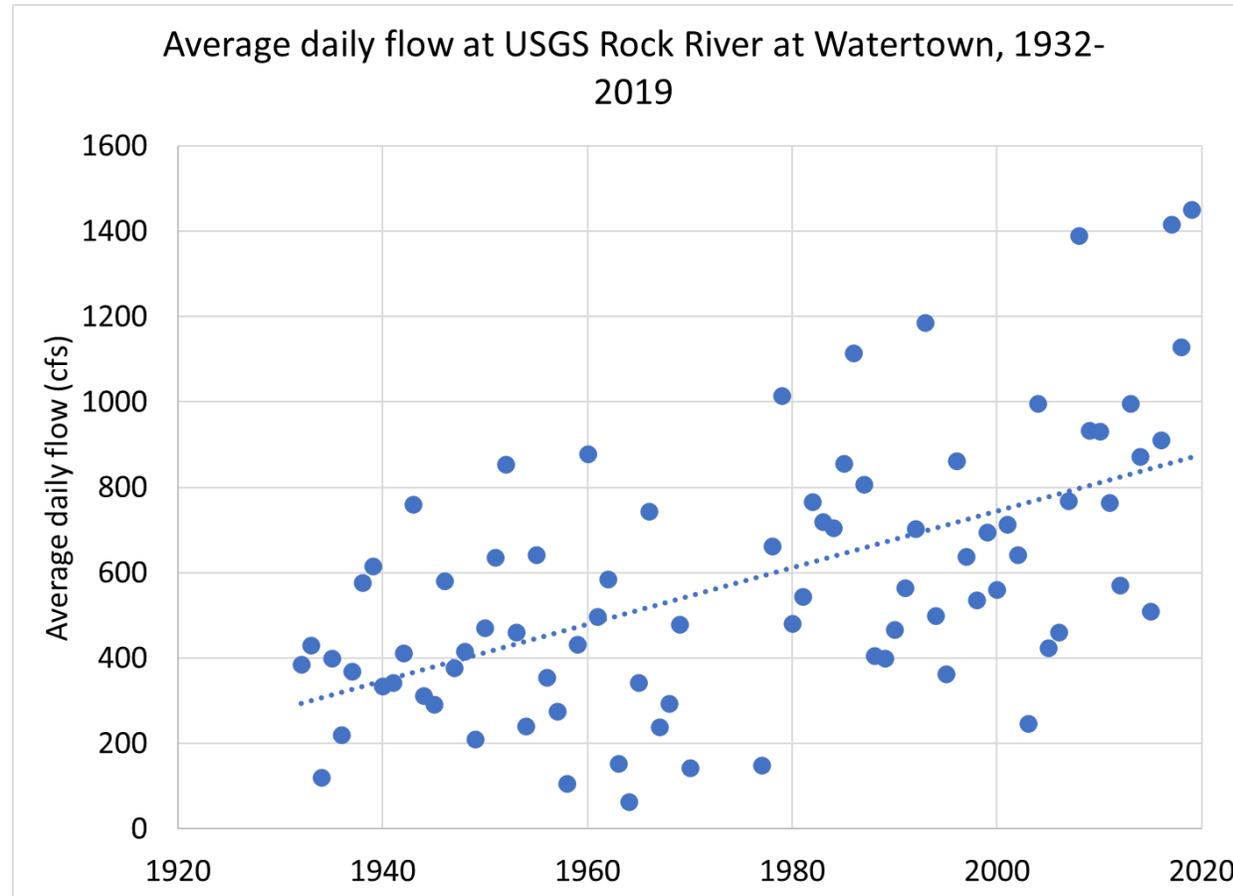
One obvious source of recent flooding is that higher rainfall amounts that have been observed across Wisconsin, and particularly during the last several years. This plot shows annual precipitation in recent years at Watertown, the nearest rain gage with the longest period of record. 2018 was by far the wettest year on record – annual precipitation was 24” above the long-term average – and was followed by a wet 2019 (10.5” above average).



This increased precipitation has led to year-round high base flows in many river systems across Wisconsin over the past few years. Additionally, an increase in average streamflow across the upper Midwest over the past decades has been well-researched and documented, with many rivers seeing a sharp increase (often doubling) of average flow when comparing the period after the 1980s to the previous conditions. The increase in discharge has been attributed to a combination of increased precipitation and land use changes (agricultural drainage, urban development, etc.).

Discharge leaving Horicon Marsh shows this trend in the Rock River. Annual flows have generally increased over the gage record and have been particularly high recently, with average daily flow in 2019 exceeding that seen during the last major regional flood event (2008).



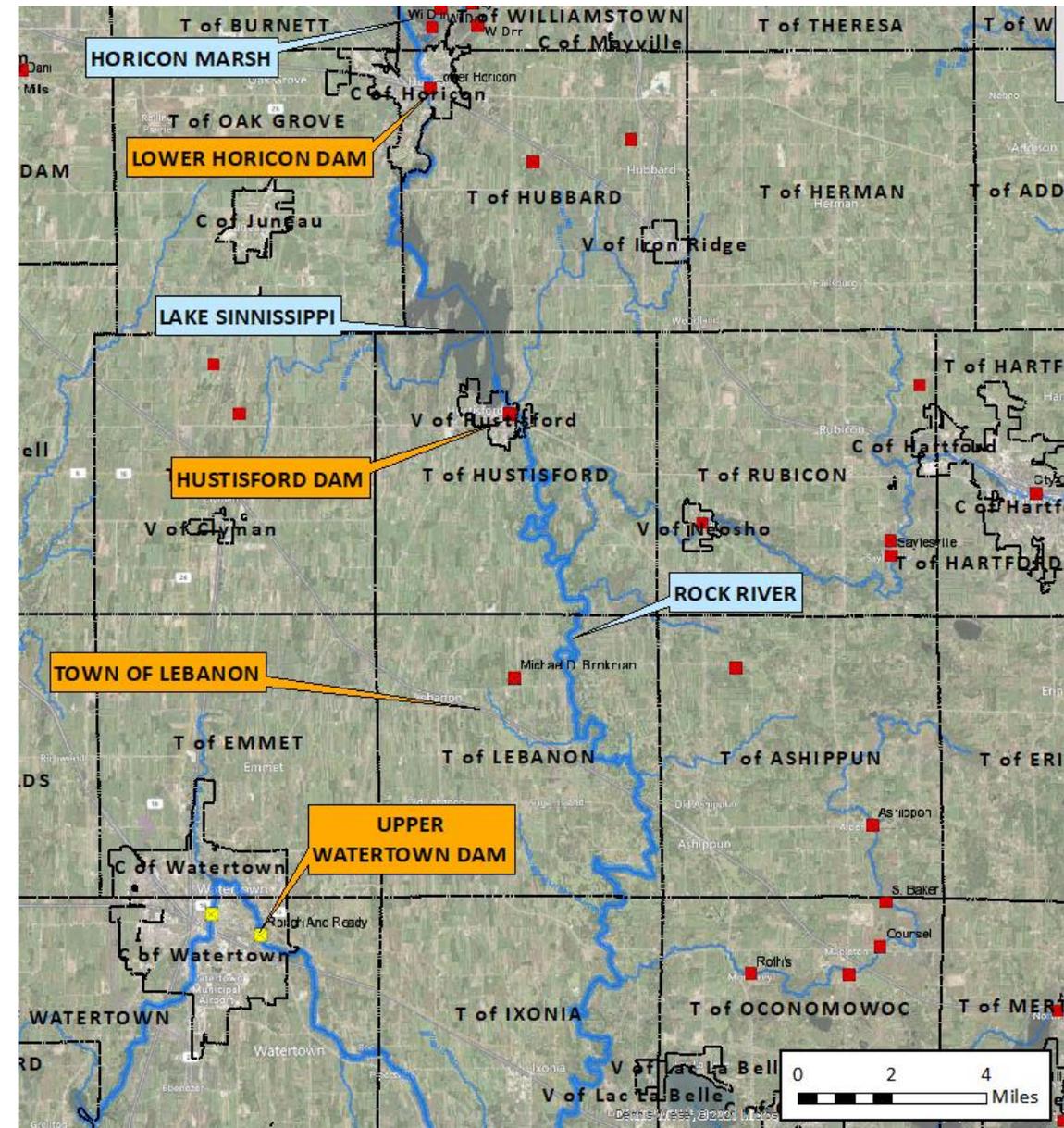


The same streamflow increase is evident at the USGS gage on the Rock River in Watertown. The flow data show a steady increase over the period of record, to nearly triple the average flow observed in the 1940s.

Summary of the Issue (cont.)

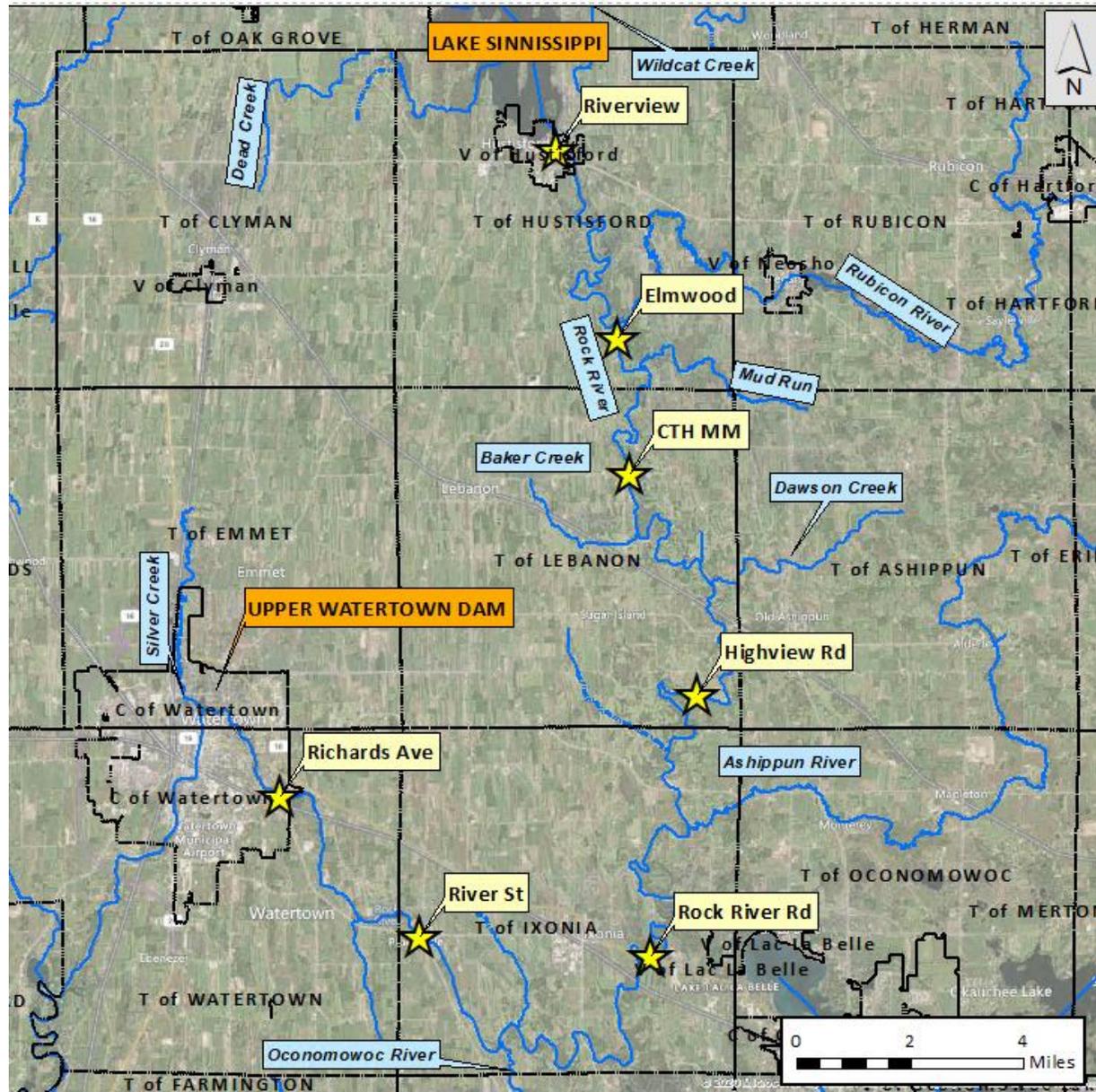
There are many dams on the Rock River upstream and downstream of the Town of Lebanon, with the nearest upstream dams being Lower Horicon and Hustisford, which are connected by Lake Sinnissippi. Upper Watertown is the next dam downstream.

Part of the objective of this study was to better understand how dam operation impacts Rock River flow and timing, and to learn if there are any management strategies that could provide relief to the many riparian landowners in this stretch. We are also evaluating if there are any physical restrictions contributing to high water levels in this area.



We developed a water level monitoring program, in cooperation with the dam operators at upper Watertown, Hustisford and Lower Horicon to collect data that will help understand the hydraulics of the system. We established water level monitoring locations at 7 sites along the Rock River between Hustisford and the Upper Watertown Dam. These locations were based on previous watershed and RAS model analysis and access opportunities. At 6 sites we installed edge-of-river wells using fence posts and PVC pipe, and at the “Riverview” site in Hustisford we re-established a former USGS gage site. Well locations are shown on the following slide.

HOBO or Solinst water level loggers reading at 15-minute increments were placed at each site. Loggers were installed on August 13, 2020 and removed on December 17, 2020. We established local benchmarks and surveyed the top of PVC with a level and took periodic depth-to-water measurements from nearby bridges to translate water level readings to estimated river stage elevations.



7 monitoring locations (upriver to downriver):

- Riverview (old USGS Hustisford site)
- Elmwood
- CTH MM
- Highview Rd
- Rock River Rd
- River St
- Richards Ave

Other data sources:

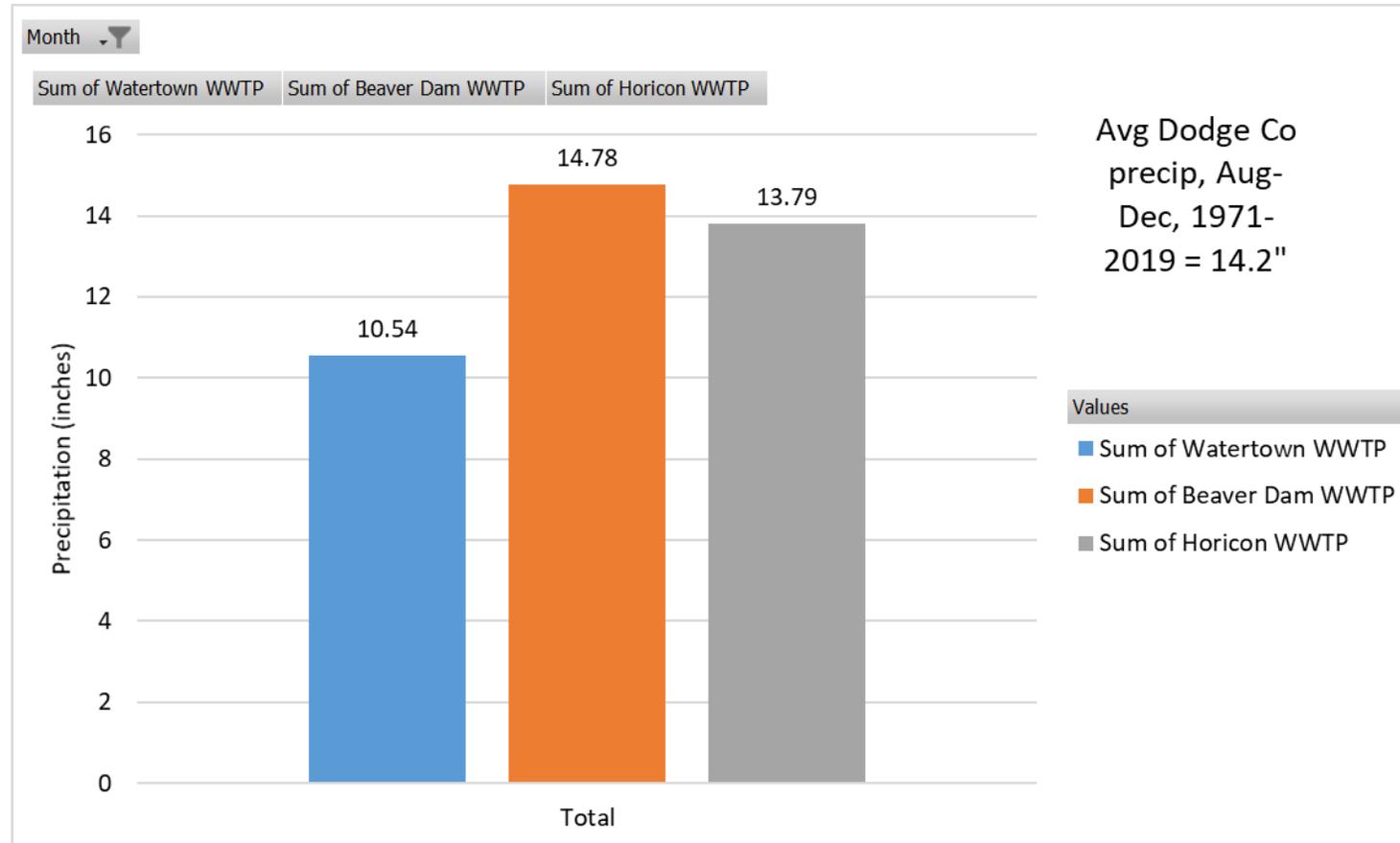
- USGS gages (lower Horicon, Watertown)
- Hustisford Dam operations data
- NOAA weather stations

We used spreadsheet tools to process and analyze the water level, flow, and rainfall data. We conducted more detailed hydraulic analysis using the Rock River HEC-RAS model (WDNR, 2013). Key analyses included:

- Evaluated rainfall and flow records
- Assessed dam operations during monitoring period
- Compared HEC-RAS model predicted water levels to previous WDNR measurements and our data
- Identified flow rates that cause out-of-bank flow in the Town of Lebanon
- Modeled impacts of dam operations on water levels (steady flow model)
- Modeled impacts of downstream constrictions on water levels (steady flow model)
- Summarized and analyzed key events during monitoring program (large rainfalls, dam operation manipulations)
- Converted the HEC-RAS model to unsteady flow to investigate selected events

- Rainfall
- River flow and stage
 - Streamflow
 - Stage data
 - Gate manipulations
 - Prolonged high flows
- Effects of upstream & downstream controls

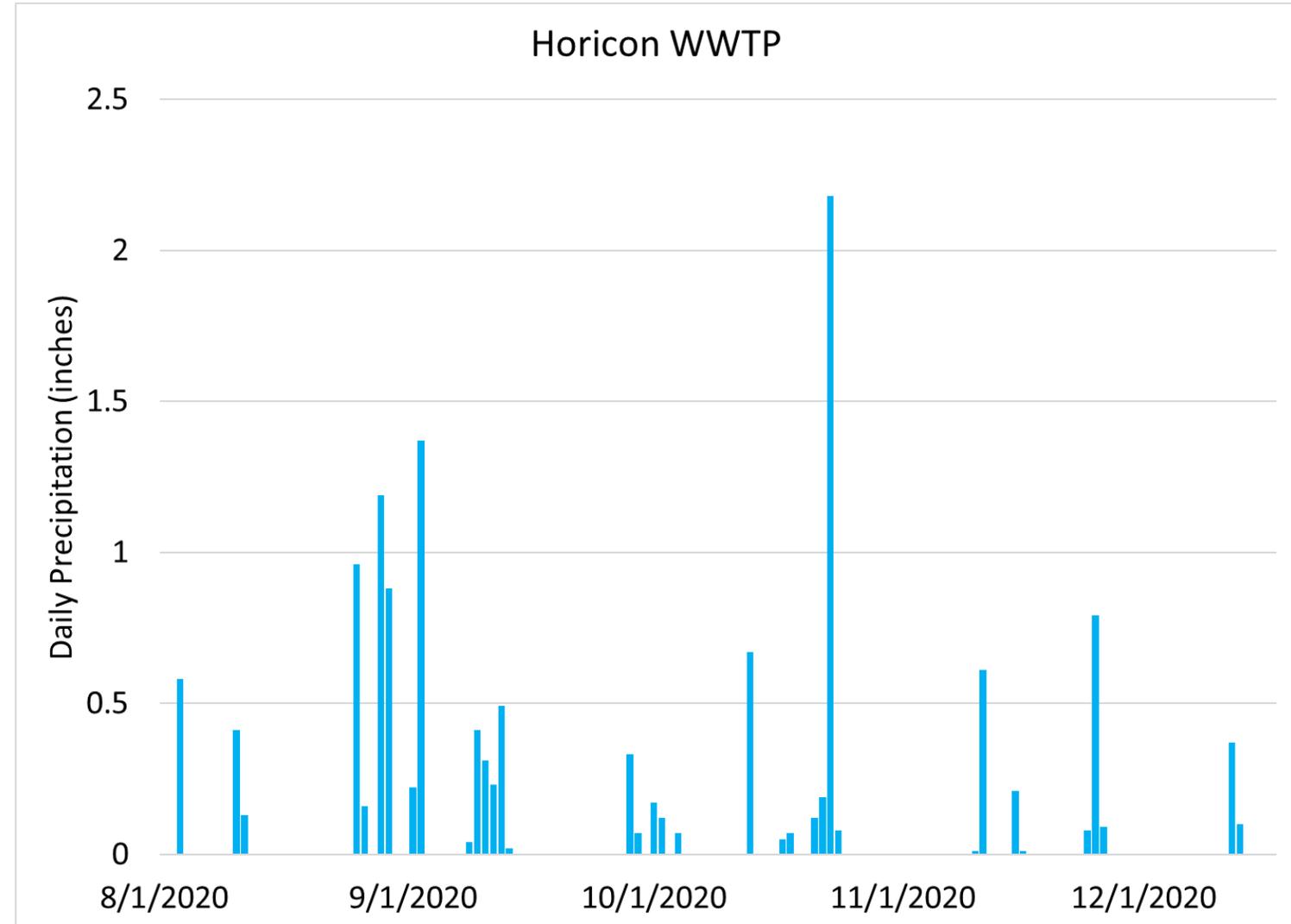
Rainfall during monitoring period



The upper watershed (Horicon and Beaver Dam stations) received ~ 14" of rain during the monitoring period, while the lower watershed (Watertown station) received ~10.5". The average August through December rainfall for Dodge County is ~14.2" based on the last 50 years of data at the Horicon wastewater treatment plant, meaning that overall watershed rainfall during our monitoring period was slightly below the long-term average.

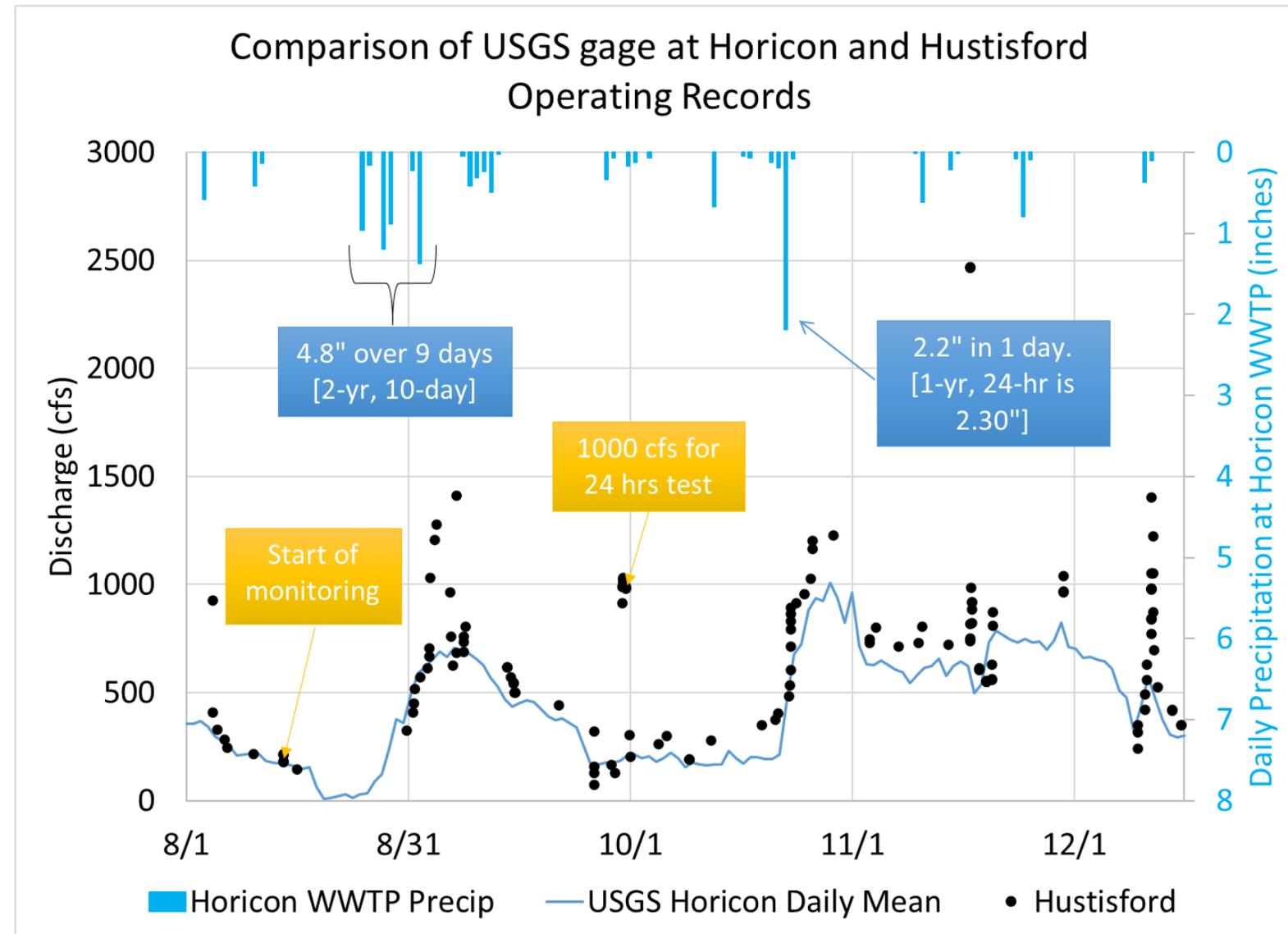
Rainfall events during monitoring period

- The period leading up to the test through late August was relatively dry
- Horicon measured 4.8" of rain from August 25 – Sep 2, with an additional 1.5" from Sep 8 – Sep 13. The 10-day, 2-yr rainfall for Horicon is 4.8".
- The other significant runoff producing event was the 2.2" of rain in a single day on October 23. The NOAA Atlas 14 24-hour, 1-yr rainfall for Horicon is 2.3".
- The southern part of the watershed received less rain on Oct 23 (1.33" in Watertown)



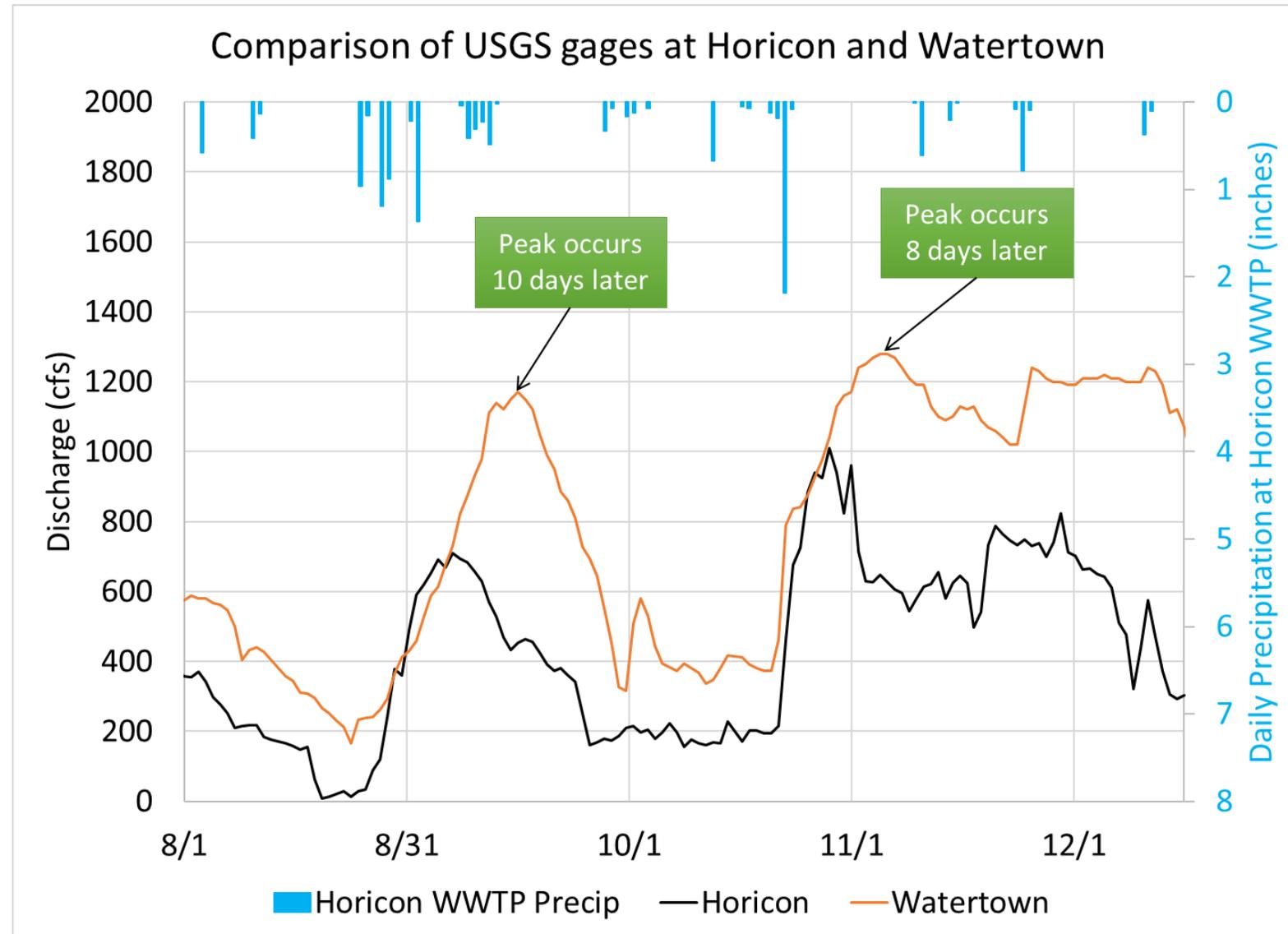
River flow during monitoring period – Horicon vs. Hustisford

- At the start of monitoring the lower Horicon dam was closed to try and raise their water levels
- The multi-day rainfall in late Aug – early Sep increased flows up to 750 cfs, and flows stayed high for several weeks
- Note that the rainfalls were not unusually large – the largest series of storms at the end of August had a return period of approximately 2-years
- We coordinated a 1-day test of 1,000 cfs release from Hustisford on Sep 30 – Oct 1
- The heavy rains on Oct 23 raised flows from 200 cfs to 1,000 cfs, and these high flows persisted for nearly six weeks up to the very end of our monitoring period



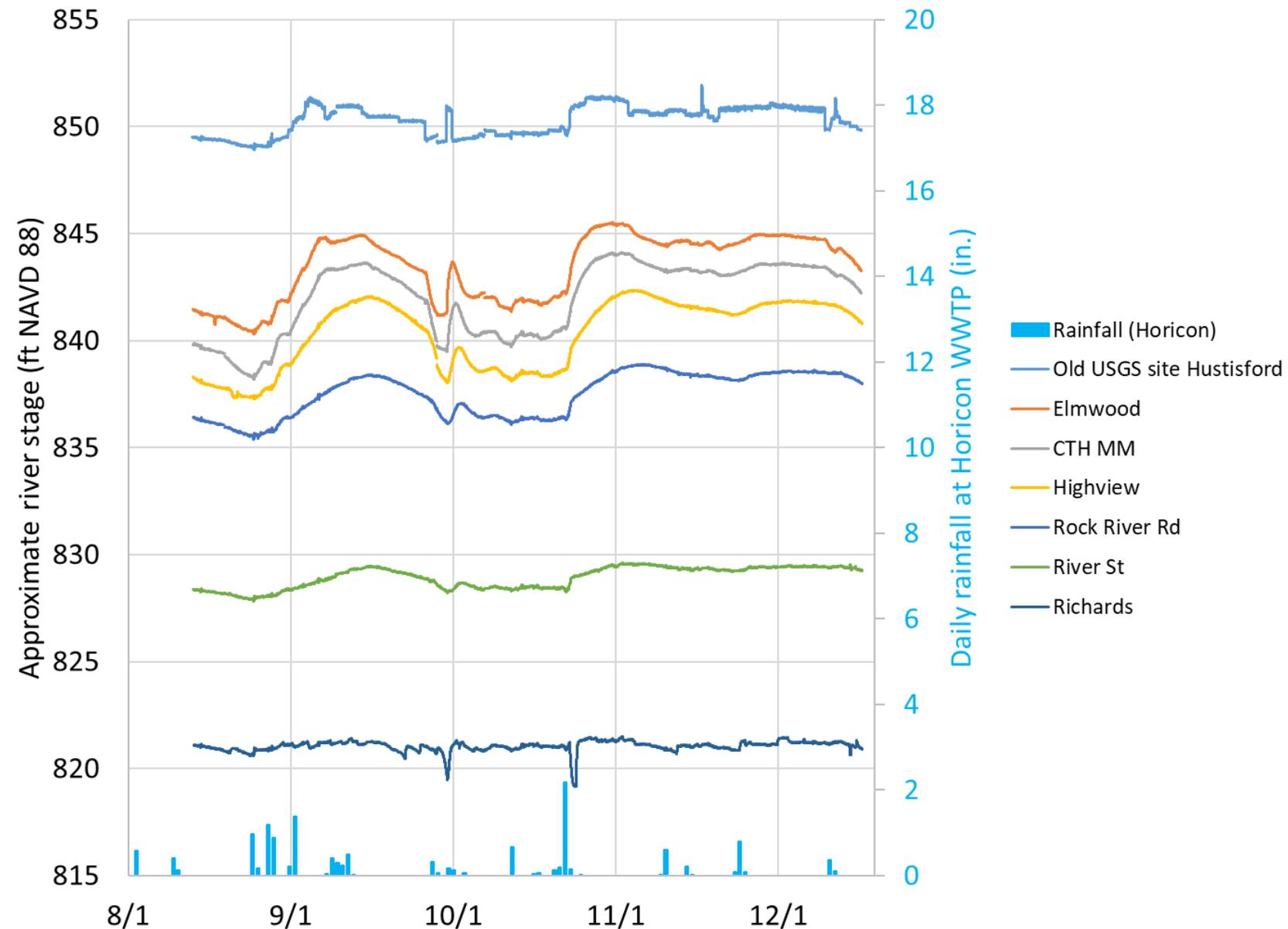
River flow during monitoring period – Horicon vs. Watertown

- The downstream peaks occur over a week later than at Horicon.
- Discharge at Watertown is typically 50-100% higher than at Horicon.
- This increased discharge is consistent with the increasing watershed area from 456 square miles at Horicon to 969 square miles at Watertown, meaning that the river is gaining both storm runoff flow and groundwater baseflow between these locations.



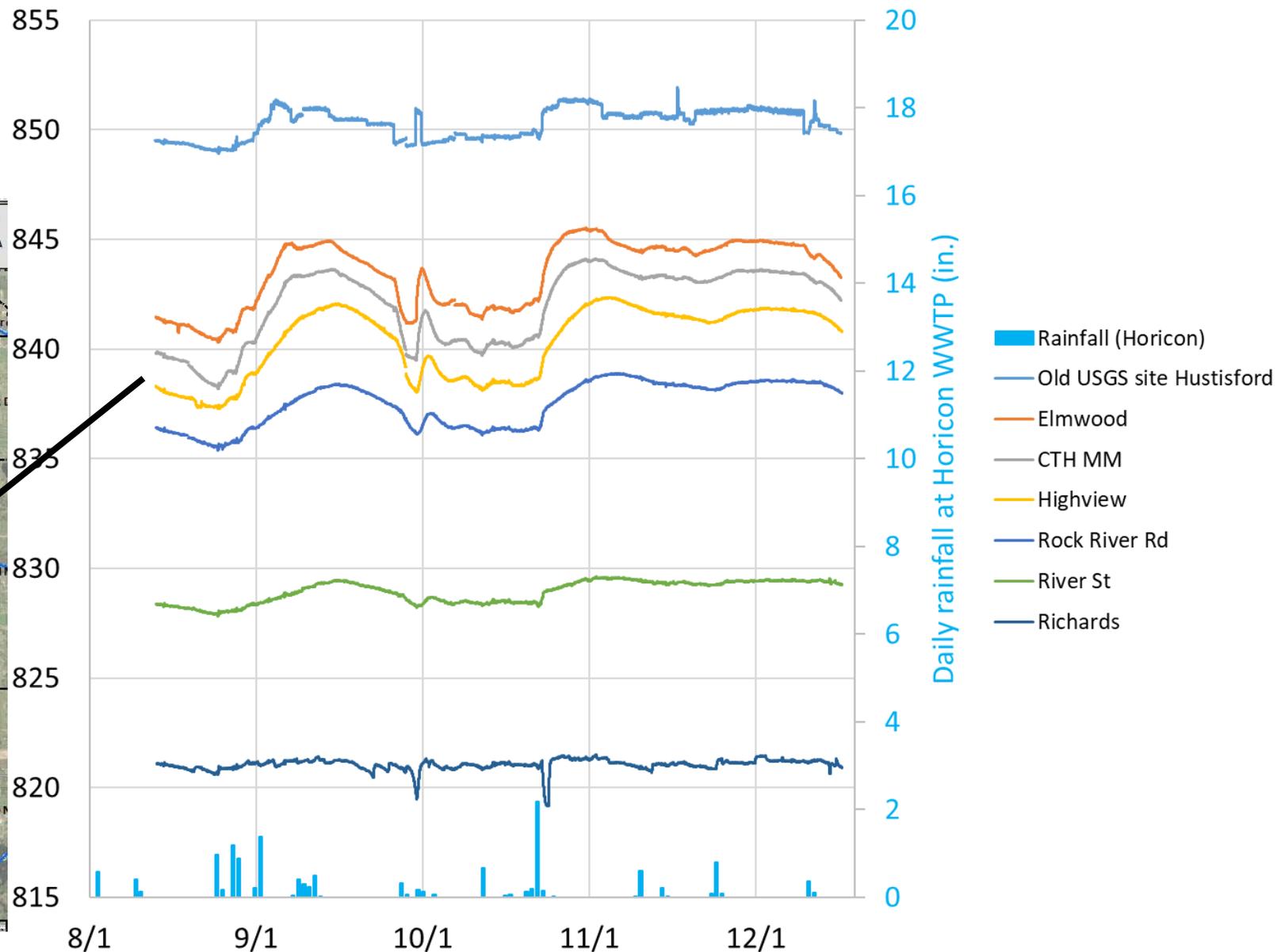
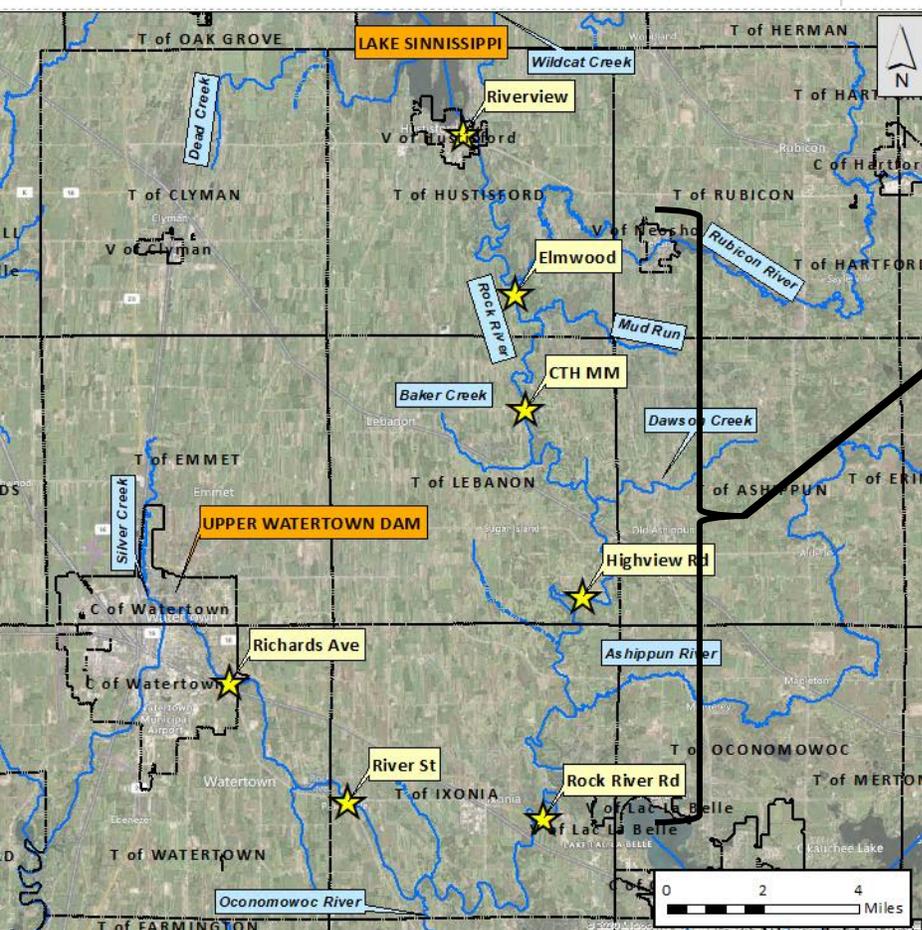
River stages during monitoring period

- The Riverview (old USGS site) location reflects flow from Hustisford Dam and changes abruptly based on gate operations. The levels don't change too much because the river channel is steep.
- The 4 middle loggers (Elmwood, CTH MM, Highview and Rock River Rd.) are in the very flat portion of the Rock River which includes the Town of Lebanon. These gages will be referred to as the "Town of Lebanon gages".
- The 2 downstream loggers are at locations with lower riverbed elevations and are closer to Watertown. The Richards logger is in the pool behind the Upper Watertown dam.



River stages during monitoring period

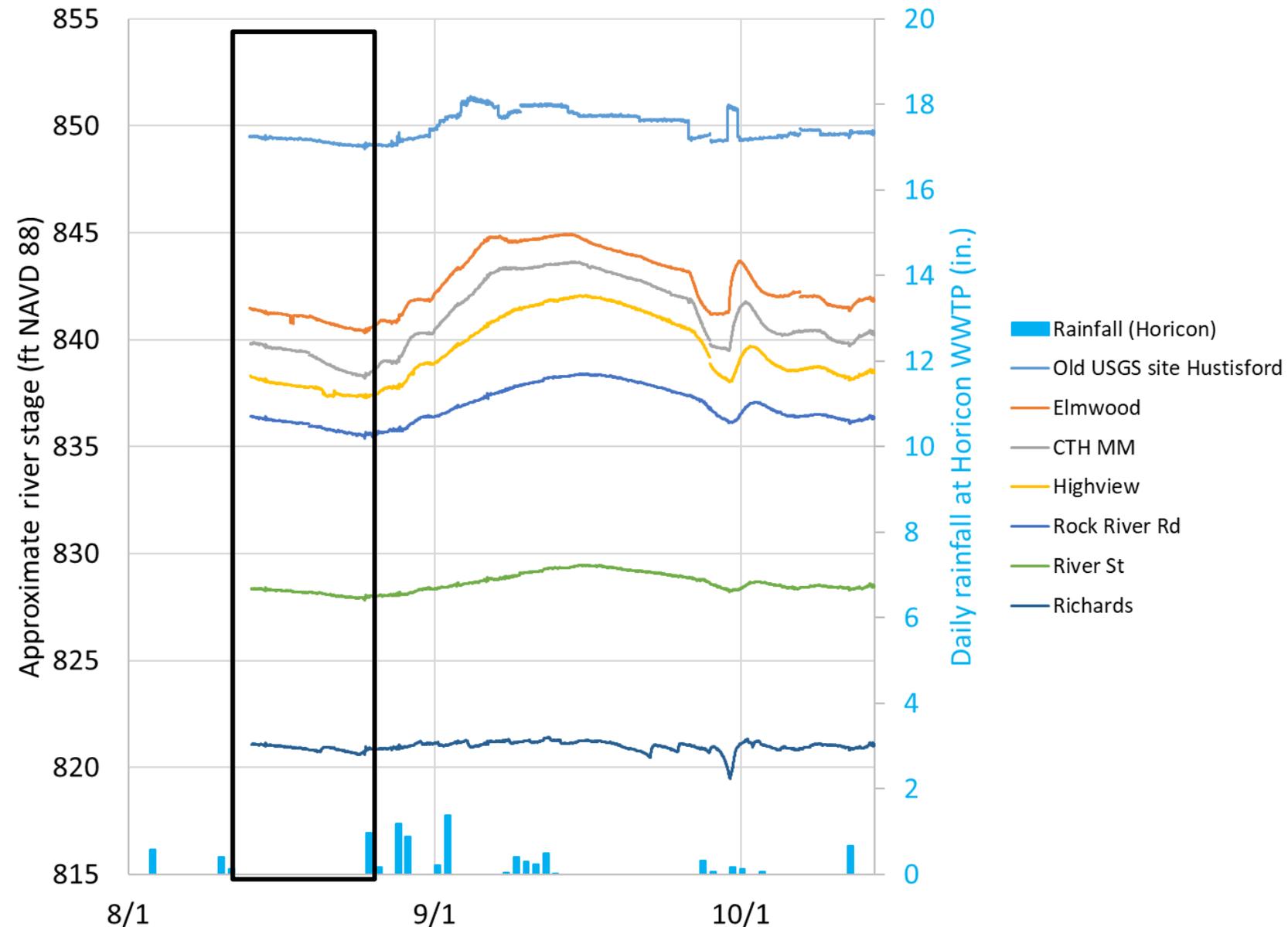
With the map again for reference.
Very little elevation drop over 35
river miles in middle section.



Early portion of monitoring period

There was no rainfall in the first two weeks of monitoring and lower Horicon dam was mostly closed to raise the pool to their target level.

Downstream water levels in the Town of Lebanon fell approximately 1 foot during this dry period when flows leaving the Horicon gage were below 200 cfs.



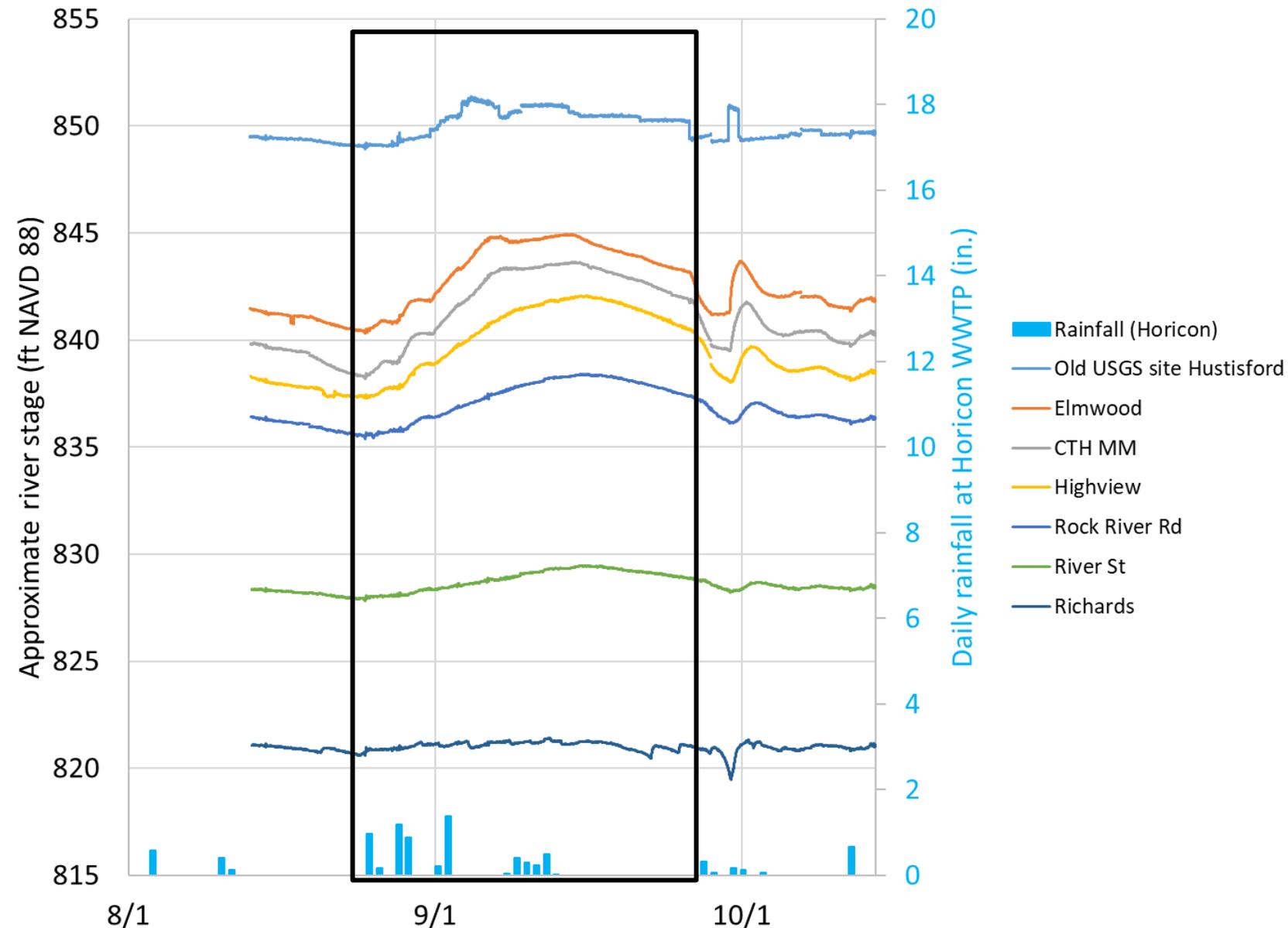
Large, extended rainfall late Aug – early Sep

Lower Horicon and Hustisford increased discharge following the 4.8” of rain over 9 days (Aug 25 – Sep 2).

Following the rains, the water level in lower Horicon marsh stabilized near the target of ~7.2’ on September 6th.

River levels in the Town of Lebanon rose upwards of 5 feet and remained high for over a month (until our test Sep 30).

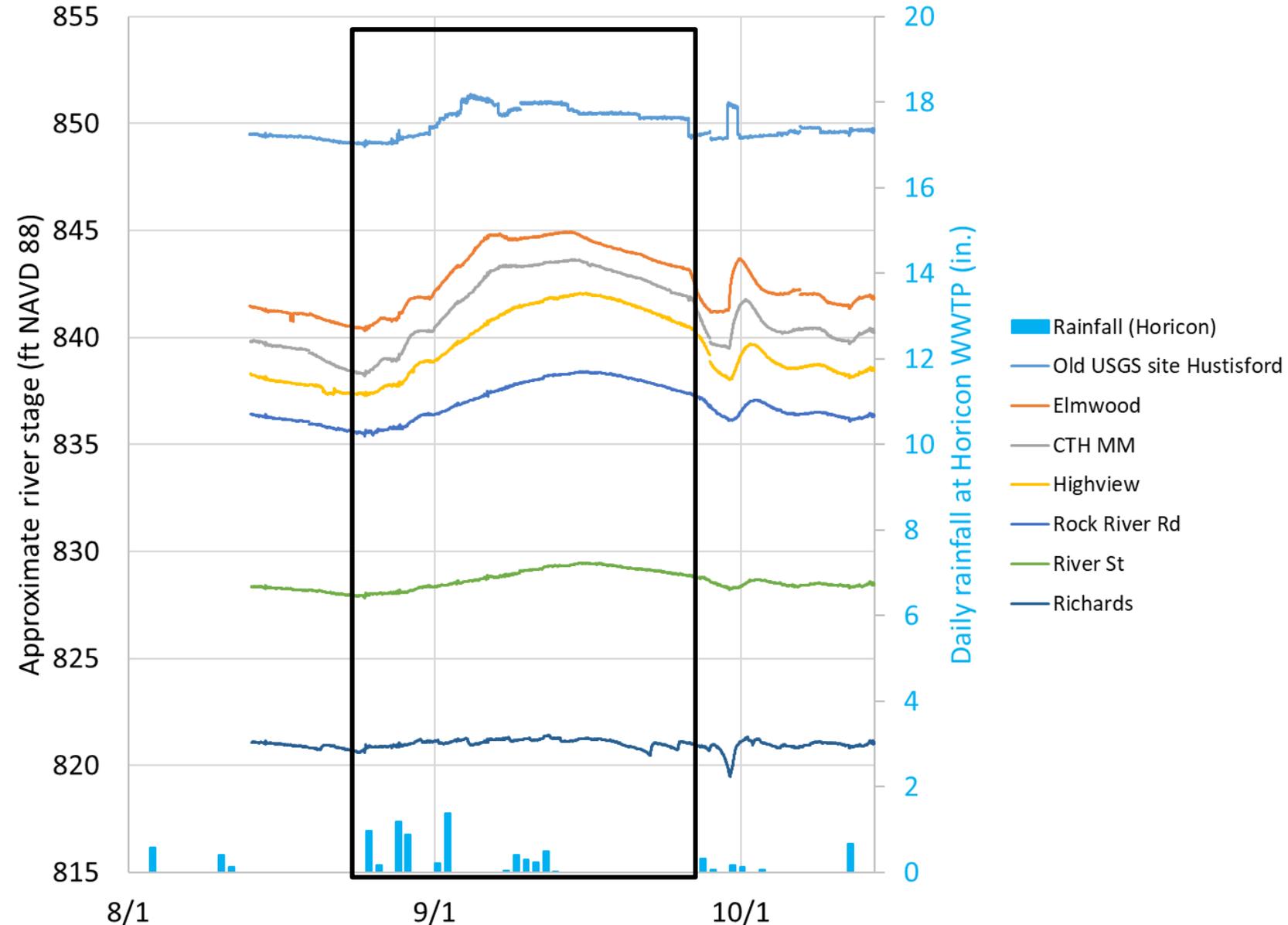
The downstream gages showed a much smaller water level change. The Upper Watertown pool was very steady during this time.



Large, extended rainfall late Aug – early Sep (cont.)

OBSERVATIONS:

- The downstream peak at River St occurred ~ 10 days after the peak at Elmwood.
- The magnitude of change was MUCH greater in the Town of Lebanon than elsewhere. This reach is very sensitive to higher flows and very slow to drain. Some of these higher flows are due to tributary watersheds downstream of Hustisford.
- Levels at the Upper Watertown dam remained steady, and the water surface is 15-20 ft lower at the dam than in the Town of Lebanon.

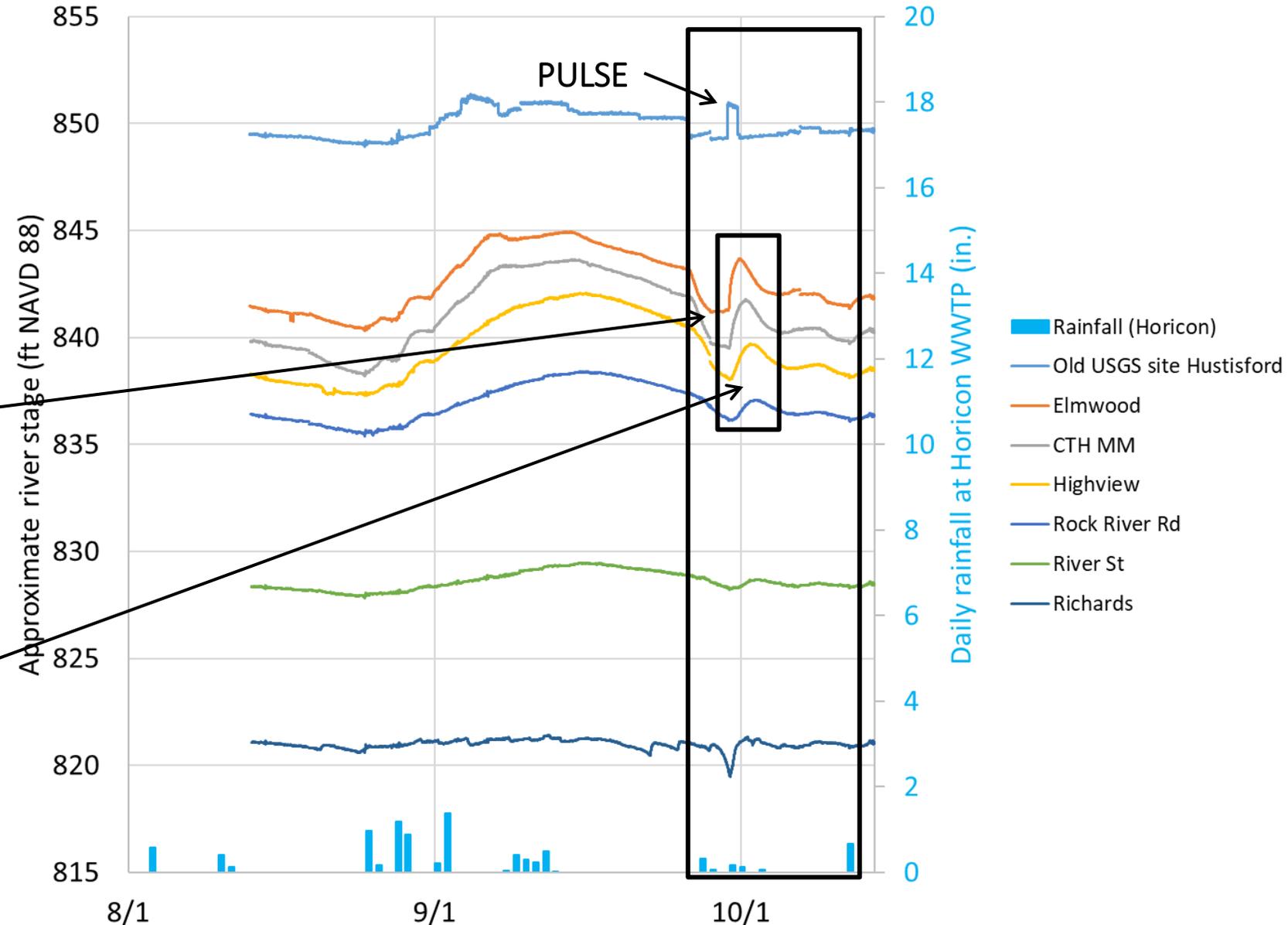


Hustisford 1000 cfs pulse test

We coordinated a 24-hour, 1,000 cfs pulse from Hustisford to study river behavior at the flow rate downstream, including the timing and magnitude of river level changes.

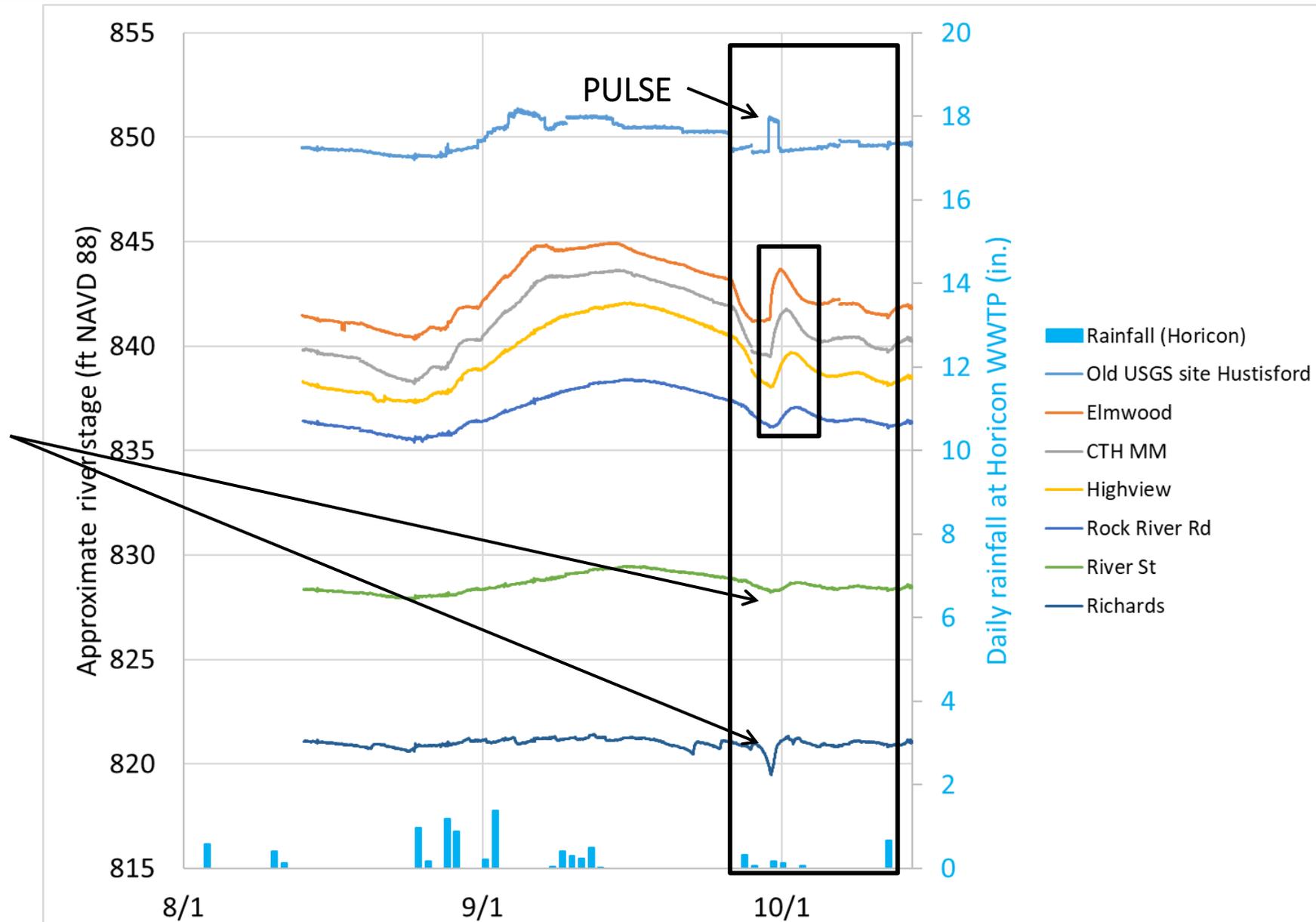
Leading up to the test Hustisford closed their gates, and water levels fell downstream ~ 1.5 ft over 3 days.

The test raised levels at Elmwood over 2 feet but had less impact downstream, and levels subsided fairly quickly - within a few days - after the 1-day test.



Hustisford 1000 cfs pulse test (cont.)

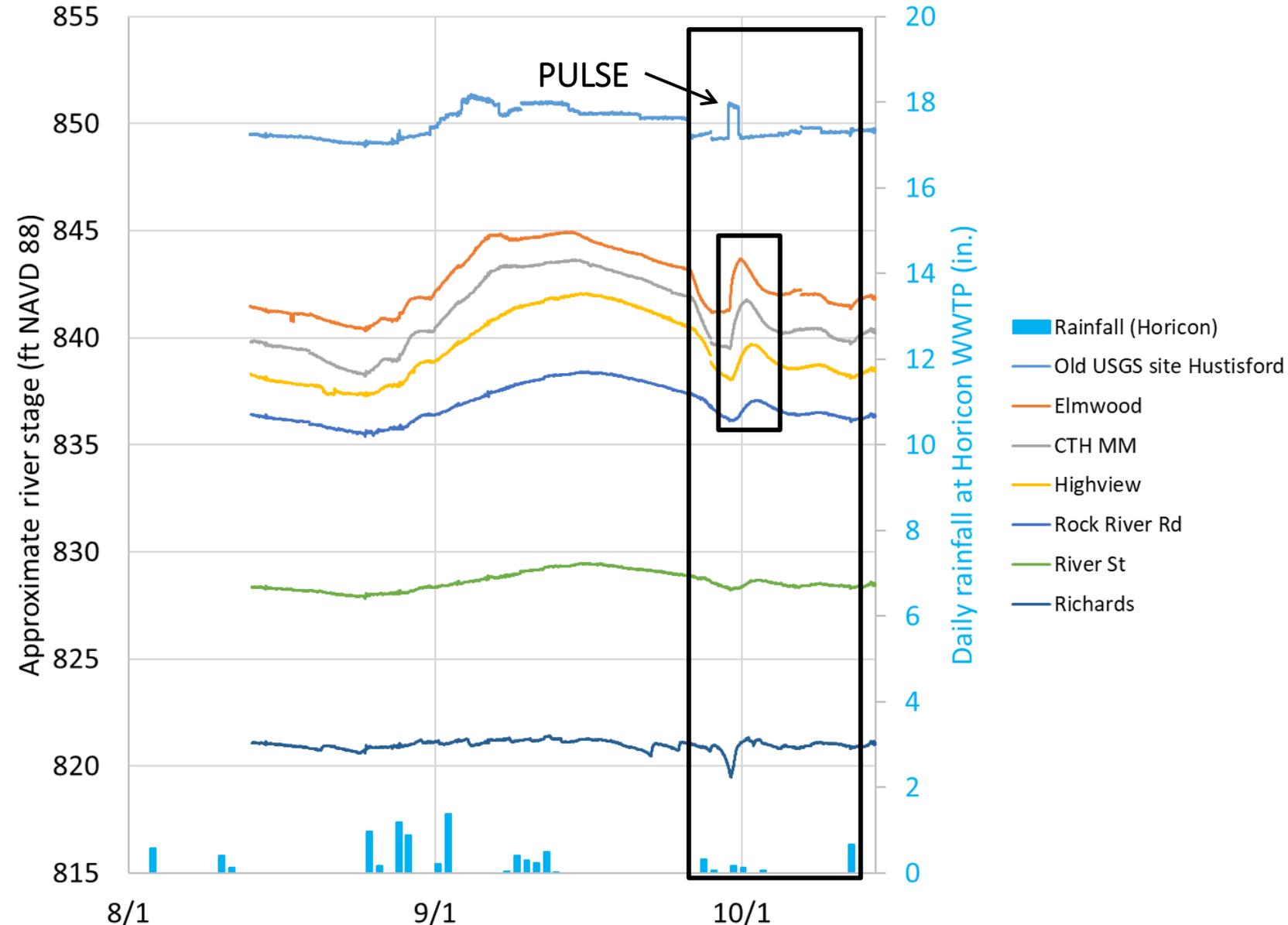
During this same time, the Upper Watertown dam gates were briefly opened, as seen in the Richards logger. The River Street logger, 4 miles upstream from Richards, doesn't show any impact from this opening. This brief lowering of the Upper Watertown pool provided useful data on the hydraulics of the steeper downstream portion of the study reach – discussed further below.



Hustisford 1000 cfs pulse test (cont.)

OBSERVATIONS:

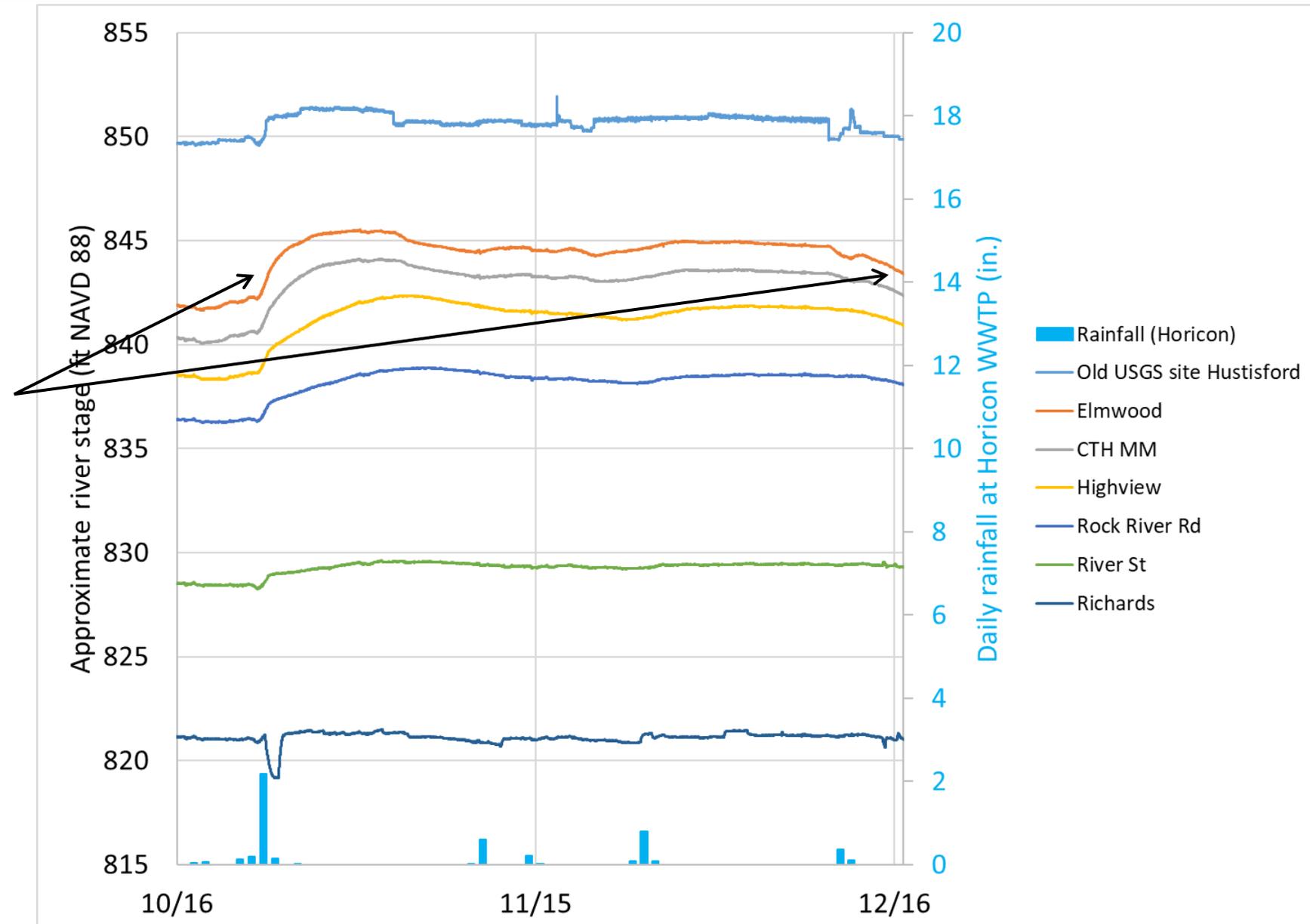
- Despite the slow timing of flood flow peaks moving downriver, the Town of Lebanon gages were fairly quick to respond to decreases in flow coming from Horicon and Hustisford.
- When the river isn't already high, there seems to be enough storage in this section of river to handle this higher flow (1,000 cfs) for a limited duration.



Heavy rain and long duration high water

The 2.2" of rain (an approximately 1-year storm) measured at Horicon on October 23 (possibly more in the upper watershed) had a significant impact on water levels for the remainder of the monitoring period.

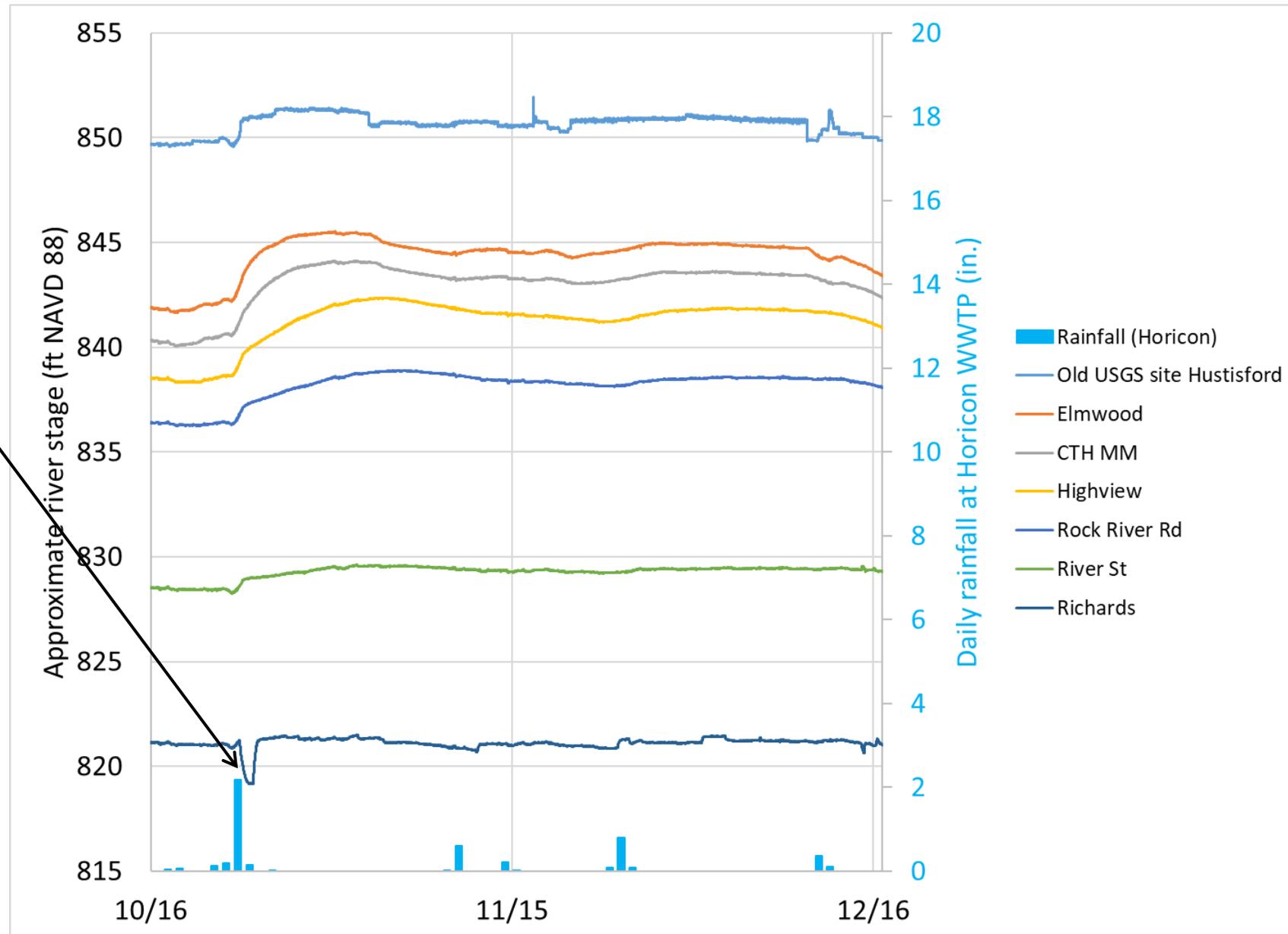
Water levels increased by ~3 feet at Elmwood and remained high until the very end of the monitoring period when Horicon outflow dropped from 600-800 cfs down to ~200 cfs and the river dropped quickly. We recorded ~1.5 feet of drop before pulling loggers due to ice, but our clients reported the river continued to drop down to about 3 ft lower than it had been.



Heavy rain and long duration high water (cont.)

On the day of heavy rain (Oct 23), Upper Watertown opened gates based on locally high runoff. Instead, the river upstream of the dam dropped enough to expose mud flats and the pool fell almost 2 feet below the minimum elevation. The operator received many complaints from the City during this event regarding low water levels upstream, and promptly closed the gates to restore water levels.

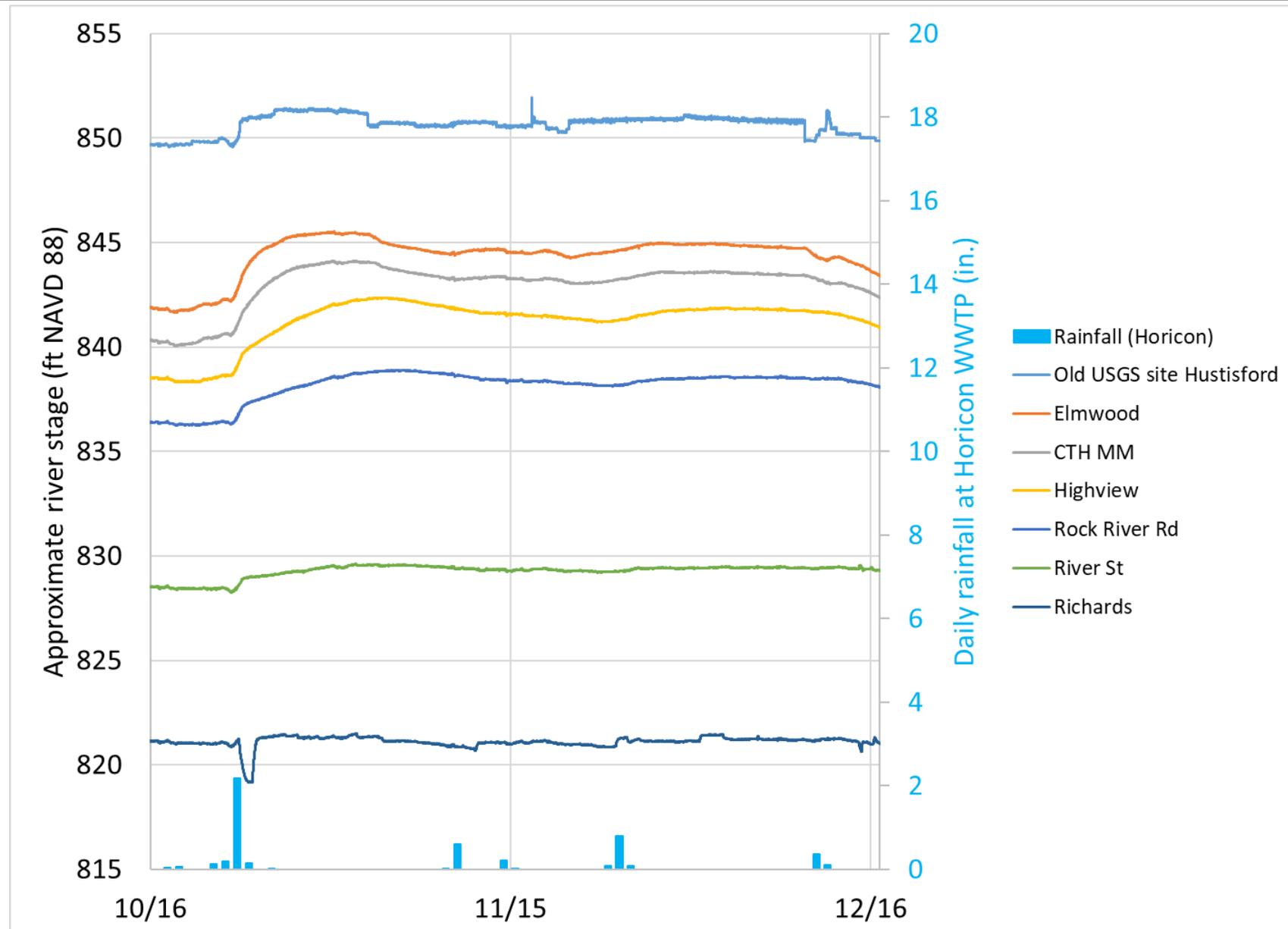
Despite this sudden lowering, no water level change is seen upstream at River St – instead levels there continue to slowly rise, similar to upstream.



Heavy rain and long duration high water (cont.)

OBSERVATIONS:

- The sustained flow of 600-800 cfs was too high to allow flood waters to recede in the Town of Lebanon. Once the river is out-of-bank, it seems that inflow needs to be ~400 cfs or lower to allow water to drain from the floodplain and for the water levels to drop.
- The Upper Watertown dam does not impact river levels very far upstream of its pool. Opening gates doesn't provide storage for upstream flow or drop water levels in the Town of Lebanon.



- We recorded data during one targeted Hustisford pulse test (9/30) and two occasions of sudden lowering of the Upper Watertown dam pool (9/30 and 10/23). These events helped capture river behaviors relating to upstream flow and the downstream control of the Upper Watertown dam.
- We also observed two periods of long, extended flows that continued long after precipitation events. These are the types of flow situations that have frustrated residents in the Town of Lebanon and elsewhere along the Rock River, which is likely confounded by lack of information about what is going on upstream at the many dams and reservoirs, and lack of information on inflow to the river from the watershed downstream of Hustisford. The long timing lag, and the potential for rainfall totals to vary widely over a watershed this large, add to this disconnect.
- The sustained high water levels in the Town of Lebanon appear to be caused by inflows from upstream, and not by the operations of the Upper Watertown dam. This confirms steady-state HEC-RAS modeling of the Upper Watertown dam. While the flow coming from Horicon and Sinnissippi seems to be control behavior in the river here, there is certainly inflow from the Rubicon River and other tributaries that fills up floodplain storage during high flows and may also contribute to long, sustained high flows.
- There is limited storage volume and hydraulic capacity in the flat middle section, and once a certain flow rate is exceeded for a duration of time there are problems for residents and communities in this section. Based on October and November records, it seems that flows in excess of 400-600 cfs coming from Horicon/Hustisford are near the threshold of flows that cause flooding issues.

During the monitoring work we also requested information on operating orders for dams upstream and downstream of the Town of Lebanon. WDNR provided the following:

- Upper Horicon / Pool 1 (Federal): normal pool level of 77.0 local datum; no minimum or maximum. The conversion of the local datum to vertical datums referenced to sea level is not known. According to the DNR operator downstream, there is some storage in the side pools, and the main pool sometimes does drawdowns in late summer (to encourage macroinvertebrates, reptiles and amphibians to burrow)
- Lower Horicon dam (DNR): Ordered max is 75.3 local, which according to the field file can be converted to NGVD29 by adding 781.06 to get 856.36 (NGVD29). The standard Dodge County shift from NGVD29 to NAVD88 is -0.2 ft, so the NAVD88 max is approximately 856.16. The DNR operator said that the target water level is 7.20 on the USGS gage, and this does not vary seasonally. There is no winter drawdown because they don't want to freeze out burrowed animals (food supply for waterfowl production area).

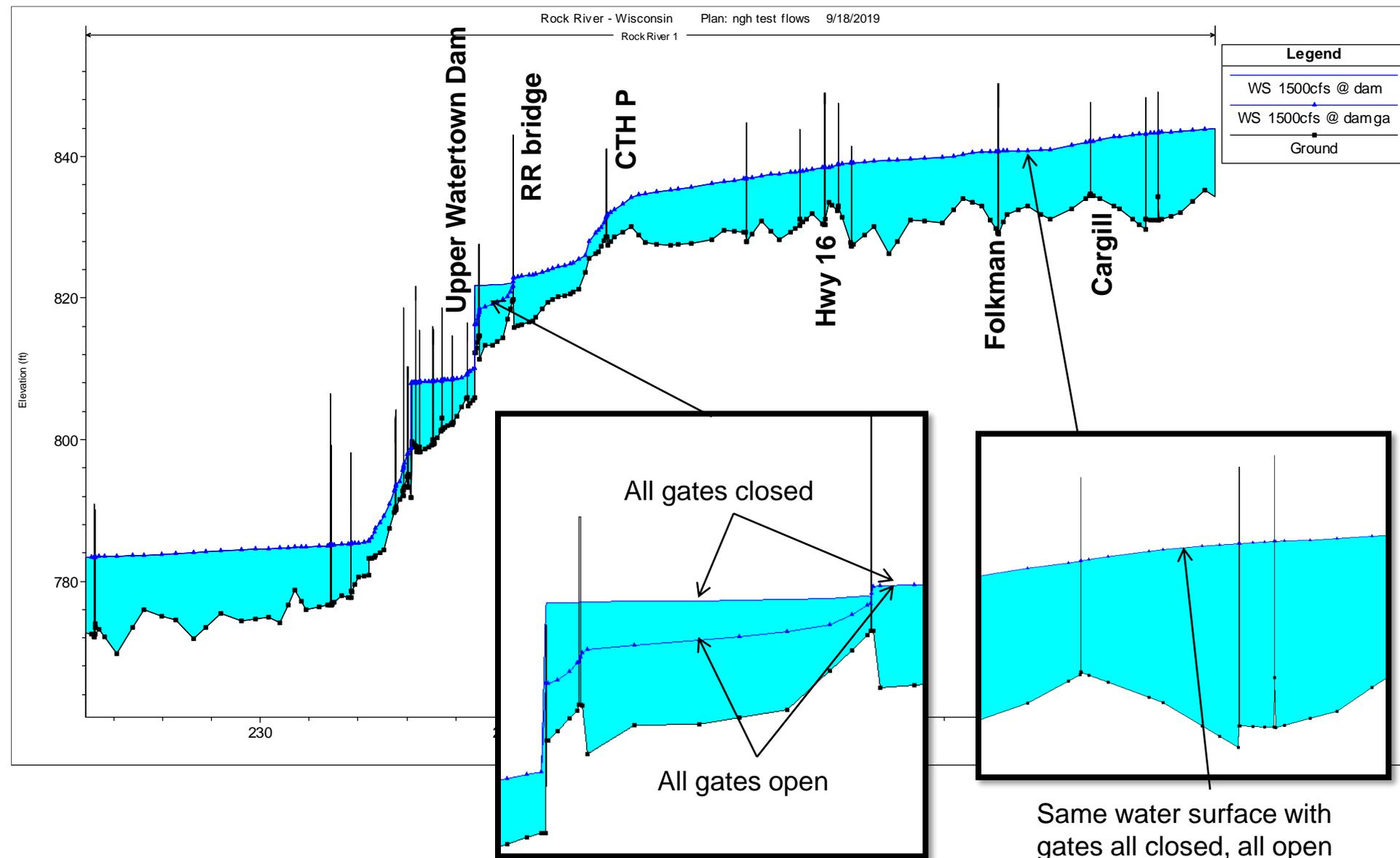
- Hustisford dam: The ordered maximum is 99.5 local, which transcribes to “855.77” in a datum described in records only as “USGS” that is usually interpreted as NGVD29, but may not precisely match. There are two minimums, based on season – for most of the year, the minimum is 98.28 (854.55 USGS); starting February 15 they are authorized to lower another 6” to 97.78 local (854.05 USGS) through the spring melt. If the “USGS” datum is truly NGVD29, then the NAVD88 max is ~855.57 and the min is ~ 854.35 (853.85 late winter)
- Upper Watertown dam: The normal pool target is 820.58 NAVD88, with a min of 820.48 and a max of 821.28. There is no seasonal drawdown that we are aware of.

Prior to monitoring, we conducted several HEC-RAS based analyses to better characterize the system. We have also done some analysis of the monitoring data using the model. We expect to use the HEC-RAS model to further evaluate management solutions as the project proceeds. The following slides illustrate some of the work to date, including:

- Lower Watertown dam impacts
- Model “validation”
- Unsteady modeling
- Downstream channel obstructions

Upper Watertown dam impacts - modeled

With a steady flow set at 1,500 cfs, drastically changing the gate operations at Upper Watertown to be wide open lowers the upstream pool drastically but impacts dissipate above the railroad bridge and are imperceptible above CTH P.



Upper Watertown dam impacts - modeled

The steeper downstream river slope and separation between downstream (Upper Watertown dam) and upstream (above CTH P) hydraulics can be observed in-person at CTH P, the RR bridge, and near the River St logger. The velocity in those locations is much higher here than upstream of the CTH P bridge and throughout the Town of Lebanon.



CTH P bridge

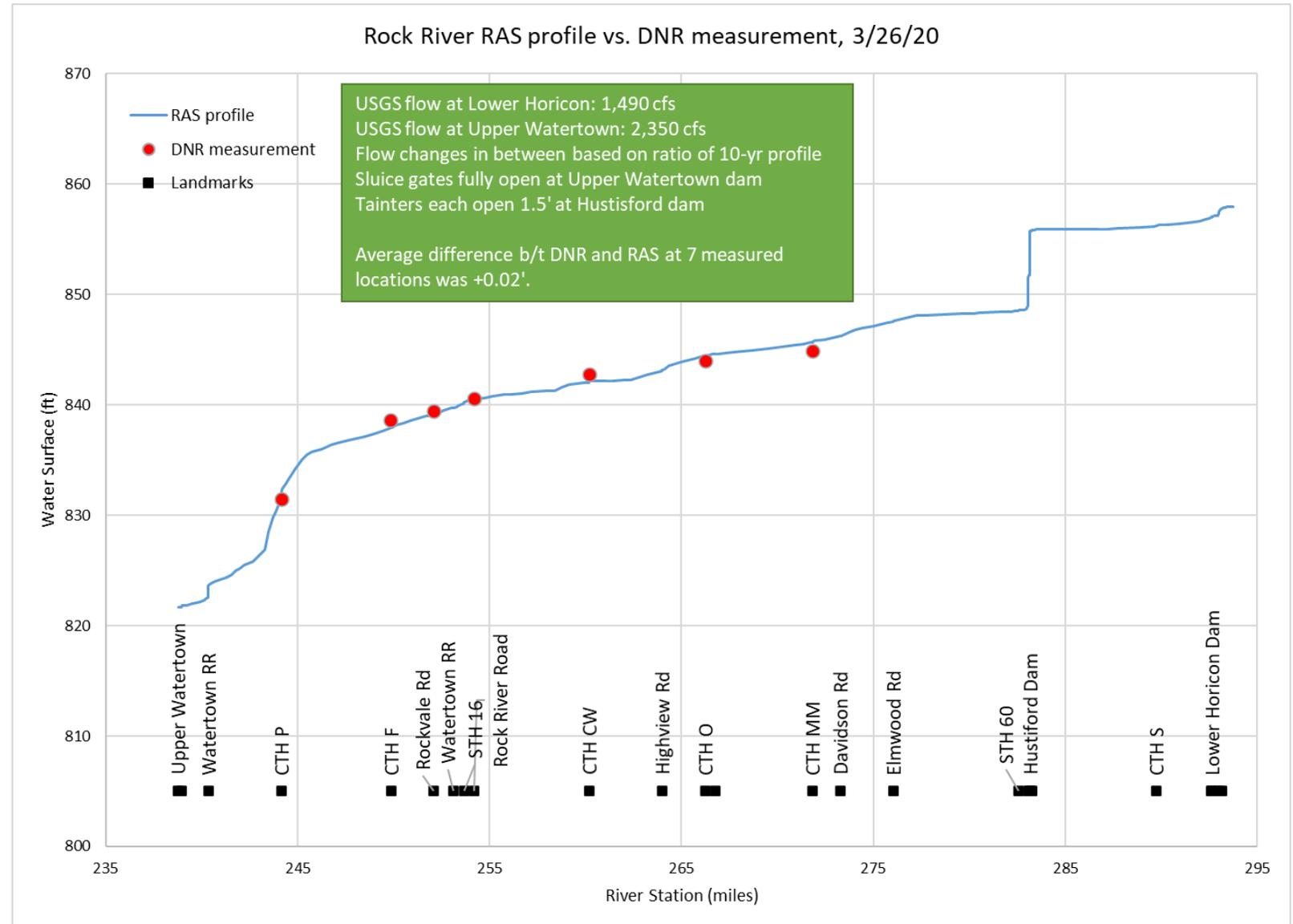
Higher velocity,
surface ripples



Slack water
upstream of
CTH P bridge

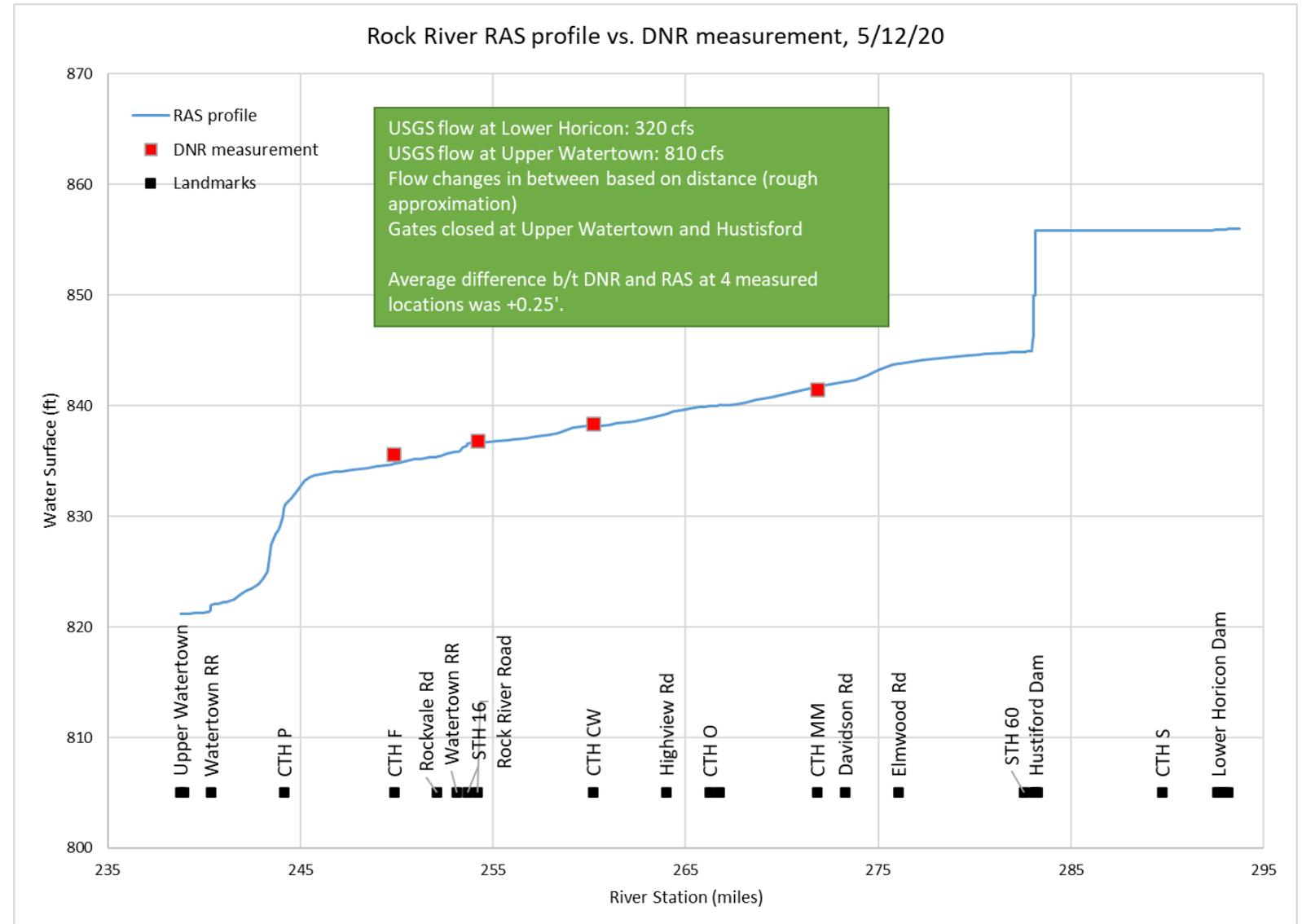
We used available data to evaluate whether the HEC-RAS model is sufficiently accurate to be useful in analyzing management alternatives in the reach of the Rock River.

The DNR provided water surface measurements from 2 separate dates in spring 2020. We ran the estimated flows on those days in the model and compared the water surface elevations predicted to those measured. The difference between model and measurements were generally well under 1 foot and weren't consistently biased.



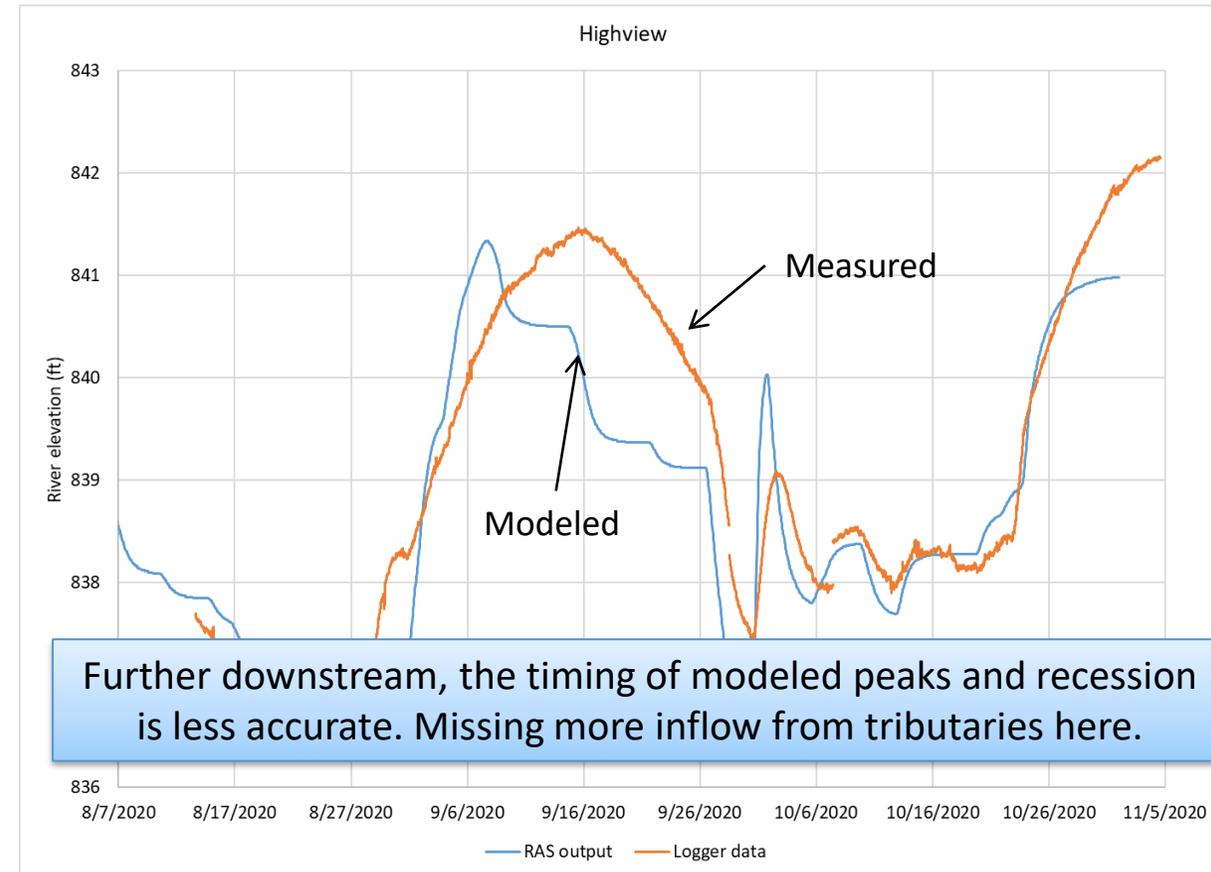
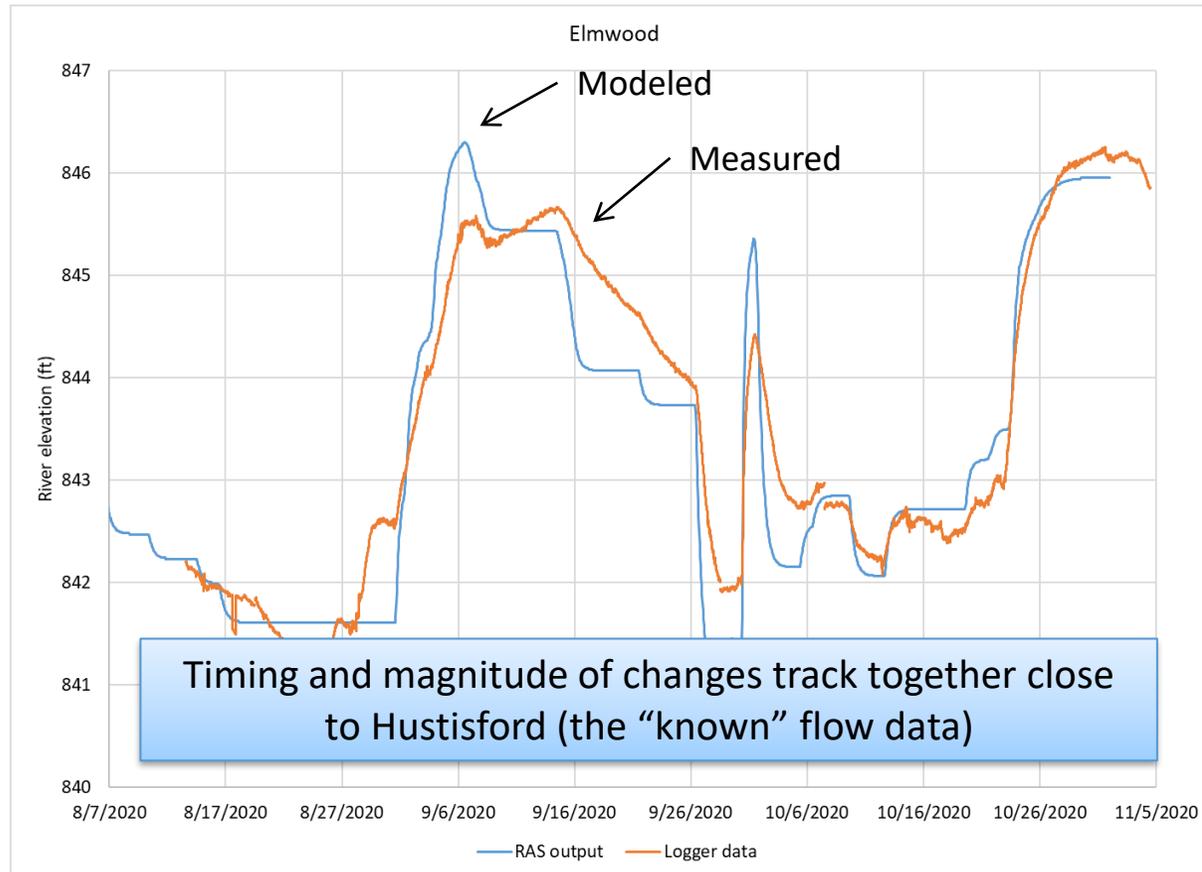
Model validation (cont.)

The HEC-RAS seemed to represent water surface levels well and this confirmed its utility as an analysis tool.



Model validation (conclusion)

We also ran the model in unsteady mode with some of the monitoring data. Unsteady flow requires more assumptions about dam operations and tributary inflow. We compared observed and modeled river stage at Elmwood and Highview in the Town of Lebanon. The model results indicate that the model reasonably replicates observed data and will be useful in evaluating management alternatives.



1. Moderation of gate operations upstream.

As demonstrated by the dam operation data and monitoring data, the areas along the river controlled by dams maintain a relatively stable (within 1 foot) water surface even during large rainfalls. During these same events, the river in the Town of Lebanon can rise by 5 ft or more and these high water levels persist for many weeks to months and impact residents and adjacent landowners. We understand that Horicon and Sinnissippi are providing some peak flood attenuation, that they have their own management and public safety objectives, and that there is a large upstream watershed (including other storage areas) that flows into these dams. Nevertheless, we would like to discuss any potential ways to moderate the flows entering the river downstream of Hustisford with the cooperation of the operators at these facilities.

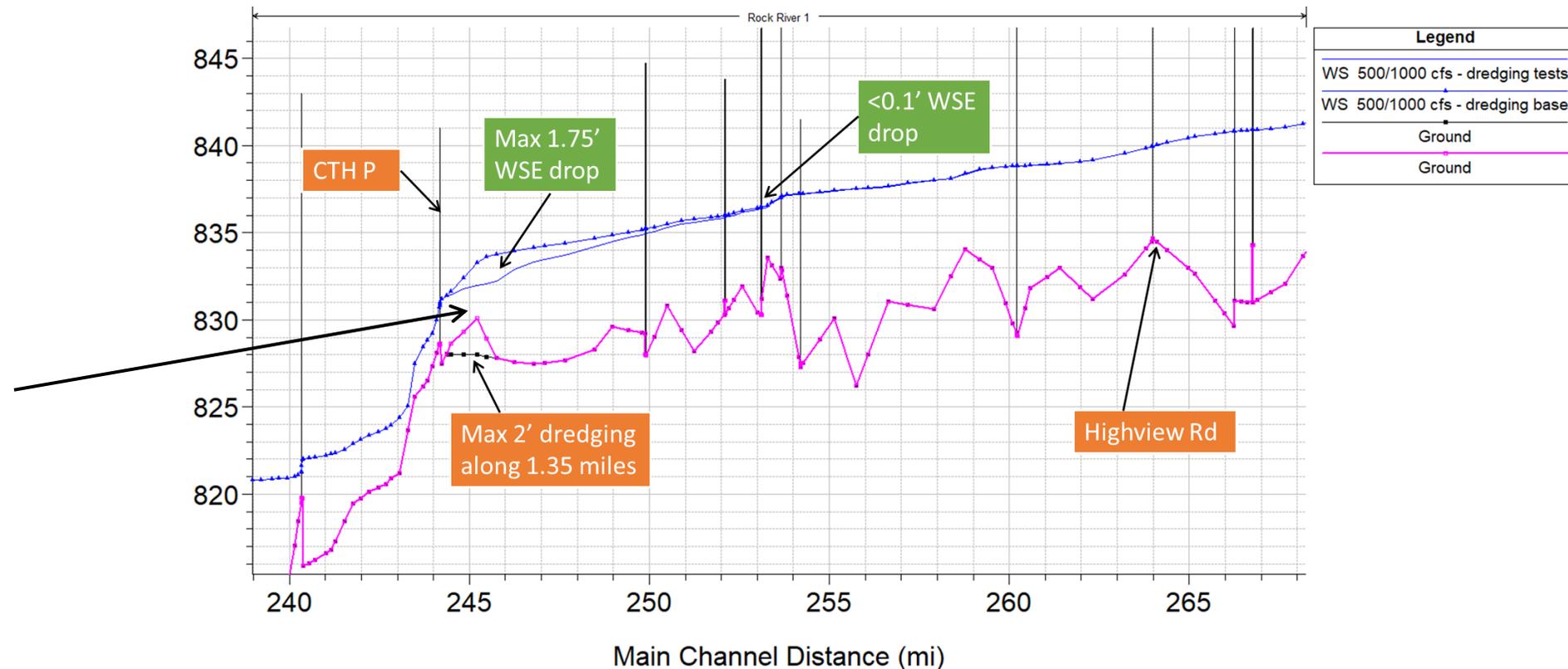
2. Channel improvements downstream

The downstream area, particularly at bridge crossings, should continue to be monitored / assessed for obvious channel obstructions. Increasing flow capacity through bridges should also be considered as bridges along this stretch need replacement. The Rock River Road bridge is an example that visually seems to constrict the channel and appears to be old.

Initial Evaluation on POSSIBLE actions: Downstream channel obstruction removal

There is an island of sediment and logs upstream of CTH P that appears to be blocking flow through the bridge. There are also many “high points” seen in the model’s channel profile along the river sections within the Town of Lebanon that likely slow flow and raise water levels. We briefly analyzed the potential for improving drainage by removing obstructions or otherwise enhancing channel capacity. The purpose of this analysis is not necessarily to say these are feasible or permanent solutions – it is to assess if increasing channel capacity by some means (dredging, bridge widening, blasting rock ledges, etc.) would have an impact, and how far upstream the impact would extend.

Removing the high point upstream of CTH P dropped local upstream water levels considerably (1.75 ft), but the impacts tapered off upstream

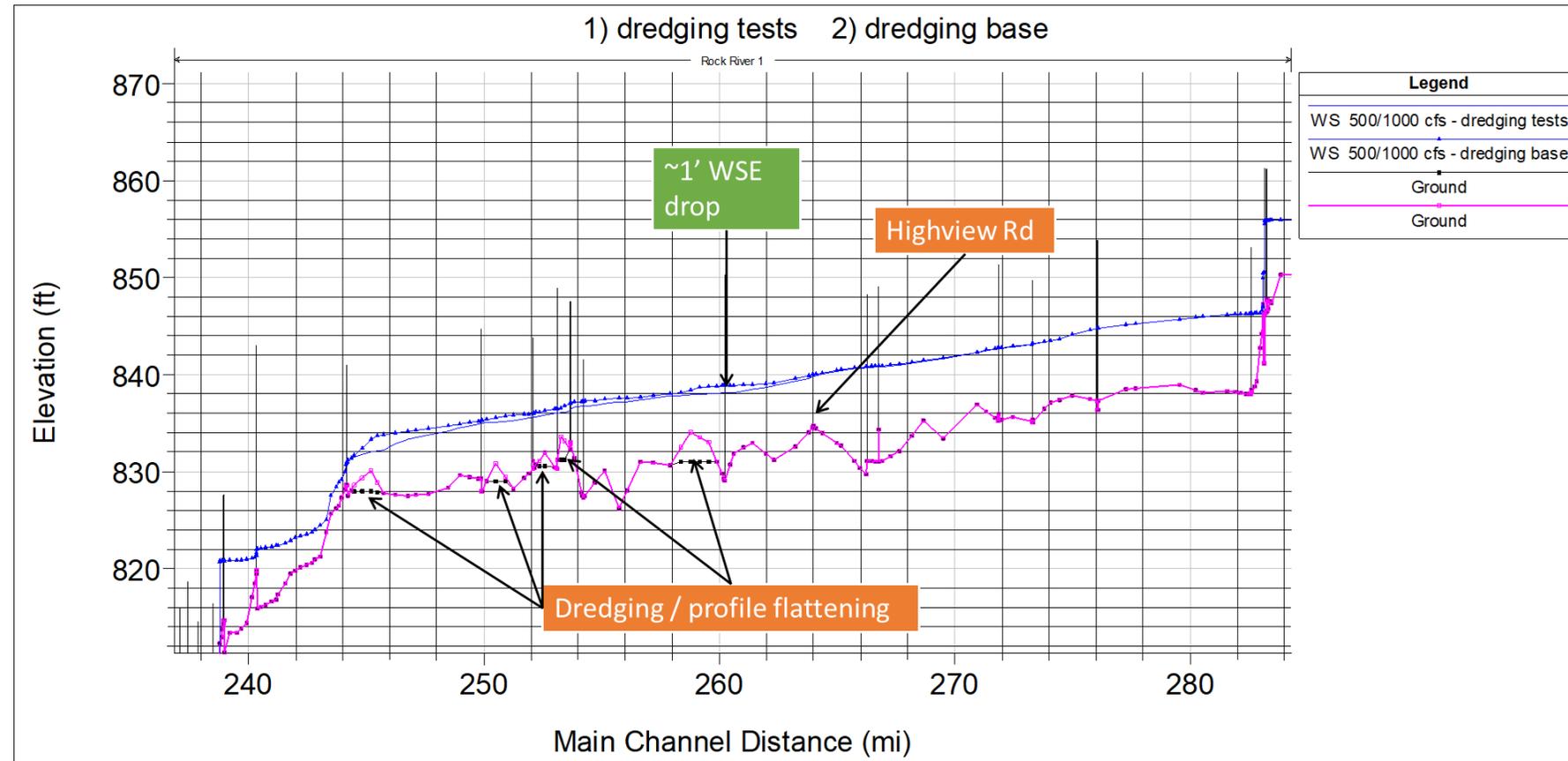


Initial Evaluation on POSSIBLE actions: Channel obstruction removal (cont.)

We removed more channel high points upstream, but impacts were still usually local and did not result in a substantial cumulative lowering throughout the river section.

It doesn't seem that identifying a single bridge constriction or channel obstruction will solve the problem, since the channel overall will still have a very low slope.

But there may be opportunities, like removing obstructions near bridges or designing any bridge replacement projects to have more low-flow capacity, that could start to provide cumulative improvements.



1. Upstream and local tributary watershed flows are causing the long duration flooding in the Town of Lebanon, not downstream management of the Upper Watertown dam.
2. Although a substantial area of local tributary watershed drains directly into the Rock River downstream of Hustisford, we believe that runoff from the upper watershed, flowing through Horicon Marsh and Lake Sinnissippi, is the primary source of these high, sustained flows. We conclude this because our Town of Lebanon gages include flow from tributaries (including the Rubicon River) but their patterns during periods with no rainfall are remarkably consistent with each other and the upstream-most logger, and when the gates at Sinnissippi close the entire system downstream starts to drop.
3. If flows from Horicon and Sinnissippi could be moderated, with a maximum target for these long, sustained releases being somewhere in the 500 cfs range, water in the Town of Lebanon could likely recede following rain events rather than stay flooded for 2 months following a 2" rain as we saw this fall.

4. A way to moderate these upstream flows could be to operate the upstream storage areas (marshes and lakes) differently. One strategy is lowering water levels to provide available storage. Another would be to draw down more slowly following runoff events (once there's no immediate flood risk on the lake / marsh). Both have tradeoffs including wildlife production, recreational use, upstream flood risk, etc. Slower draw-downs in particular may be risky since available storage volume would take longer to recover following storms, which might cause problems both locally and downstream if another large storm hits the watershed.
5. Based on initial draft calculations, changing the upstream operation strategies could incrementally help the situation by lowering flow rates or shortening the long periods of higher flow, but there is not nearly enough available storage volume in Lake Sinnissippi, Horicon Marsh, or other surface water bodies in the upper watershed to truly control flows and drastically reduce flooding in the Town of Lebanon.
6. Likewise, channel improvements downstream could improve the situation incrementally in local areas.

7. We think some relief from the flooding problems is possible with these strategies, but the dramatic increase in watershed runoff volume that started decades ago and has been particularly extreme in the last several years is an enormous challenge. A realistic objective would be to reduce – but probably not eliminate – the flood duration problem.
8. We recommend an action plan that includes both near-term and long-term strategies. These action plan items are detailed on the following pages.

1. Establish forum for coordination of dam operations.

We would like to meet with the DNR and dam operators to share study results and to discuss possible means of moderating the flows entering the river at Hustisford.

We also think that creating an easily-accessed information website providing current water level, flow and dam operations data would help residents in the Town of Lebanon understand current river conditions. This might help to alleviate some of the frustrations that arise over persistent high water level conditions in the Town of Lebanon when it hasn't rained locally for several weeks. Integrating this resource with rainfall measurements and creating an easy way to access this information (web site, app) should be pursued.

2. Install additional monitoring stations.

We propose seeking funding for one or more additional permanent monitoring stations. A water level gage in the Town of Lebanon would inform locals as well as provide upstream operators with a real-time status of river conditions. This would also provide data for additional model and study of river behavior.

The USGS provided the following estimate for a river gage station:

- Flow and water level - \$12k to install, \$12k / year O&M
- Water level only - \$12k to install, \$6k / year O&M

There may be grants available and municipalities interested in contributing to a permanent gage in this section, especially since it would inform road closures due to high water in the area.

Additionally, it may be helpful to have stage recorders in Horicon Marsh to provide data for studies and to approximate storage available in the marsh.

3. Discussion with municipalities and stakeholders about a comprehensive analysis of alternatives.

After initial discussions with the DNR and dam operators, we suggest meeting with municipalities and other stakeholders to further discuss potential management alternatives, as well as seeking funding for a more comprehensive analysis of these issues. The Corps of Engineers or the Wisconsin DNR – via several programs – could possibly support this effort. Note that to date, this study has been entirely funded by two landowners on the Rock River. Additional parties providing constructive solutions and funding will help make commissioning of additional stream monitoring and alternative analysis possible.