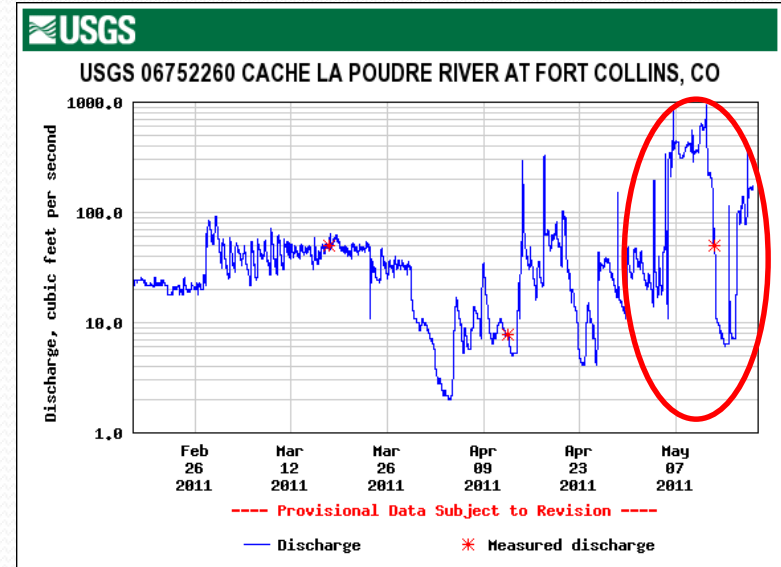
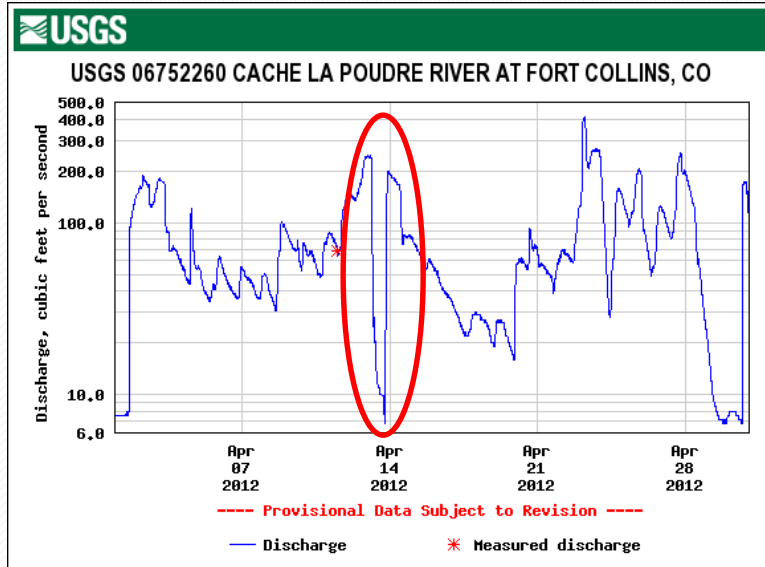
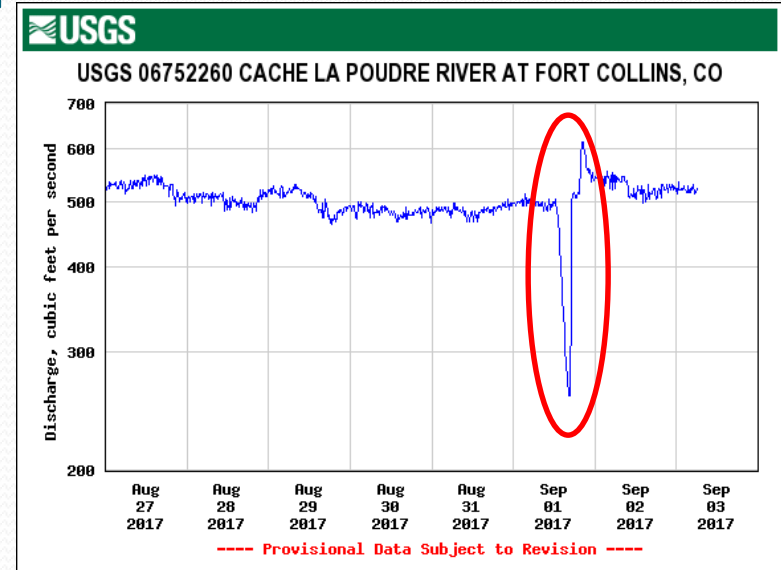
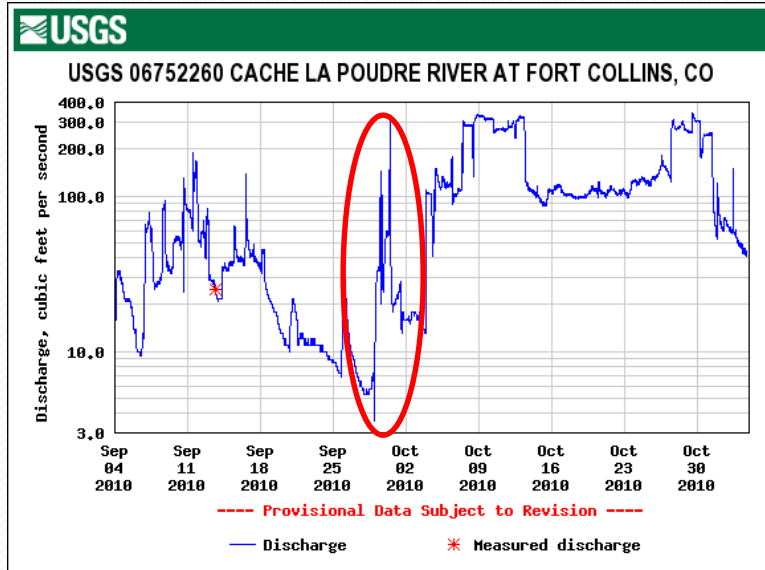


Transient Explorer's Progress Report

John Bartholow
PRTI, January, 2017

Why?

Documented Abrupt Flow Events



Note logarithmic scales

Initial Goals

- **Understand** the likely causes of flow fluctuations that are **Transient**:
 - Abrupt – begin and end rather suddenly
 - Short-lived
 - Represent a large percentage or absolute flow change
 - Occur in the Poudre, primarily through the Fort Collins reach
- **Understand** how transients may impact aquatic organisms, public safety, sediment management and/or water temperature (positively or negatively)

And Also...

- **Brainstorm** promising opportunities for further exploration that might:
 - Reduce the magnitude / frequency / length of river / or avoid certain times of the year of large transients
 - Opportunities could include:
 - Structural changes
 - Operational changes
 - All directed toward a healthier working river and acceptable to all parties

Abrupt Flow Plunges

- Can dewater channels (especially side channels) leading to fish stranding if long lasting



Abrupt Flow Spikes

- Can disrupt brown trout spawning in October



Biological 'Guidance'

- Scientific literature is scarce and incomplete:
 - Especially for warm water species
- Stranding is worse when:
 - Water is cold ($< 40-44^{\circ}\text{F}$)
 - Substrate is coarse and gradients low
 - Ramping rate (rate of change) is greater than $\sim 1/3$ to $1/2$ foot per hour in a low flow range
 - Example: At McMurry Bridge, a 100 cfs change = 0.36 feet when flows are low
- Abrupt fluctuations are associated with higher energetic costs, lower growth rates, reduced spawning and rearing success

Recreation and Safety

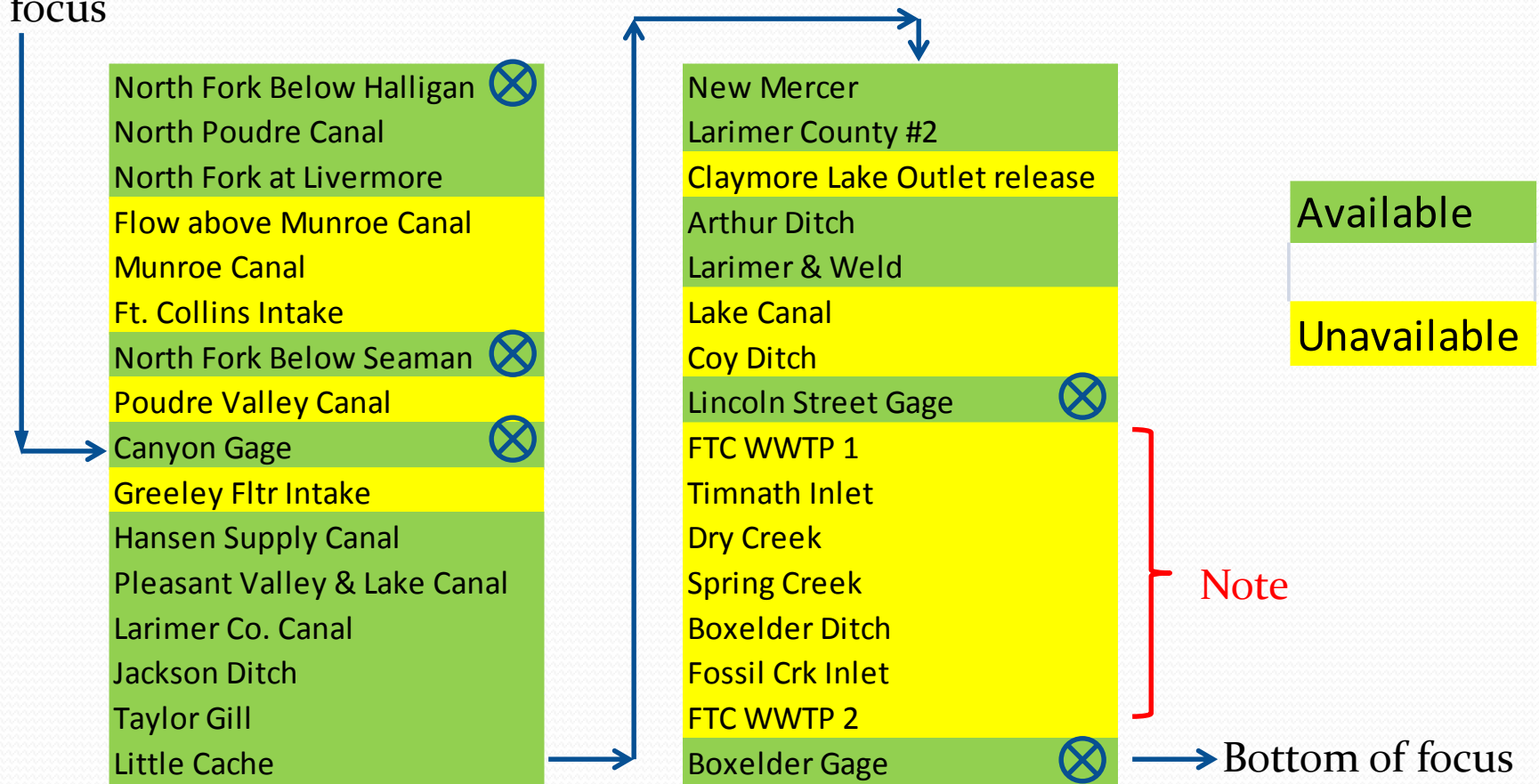
- Both abrupt flow increases and decreases can affect quality and safety of river-based recreation
- There is no way for public to anticipate sudden changes
 - Flows that are safe for a young child for tubing at 10 am could become unsafe by noon

Data Used

- November 2015 through October 2016, i.e., WY 2016
 - Telemetry was added to many diversion points for 2016
 - 15-minute data only
 - No QA/QC; obvious data gaps and bad values
 - Inflows (Mainstem, North Fork & Hansen Supply Canal)
 - Many, but not all, diversions

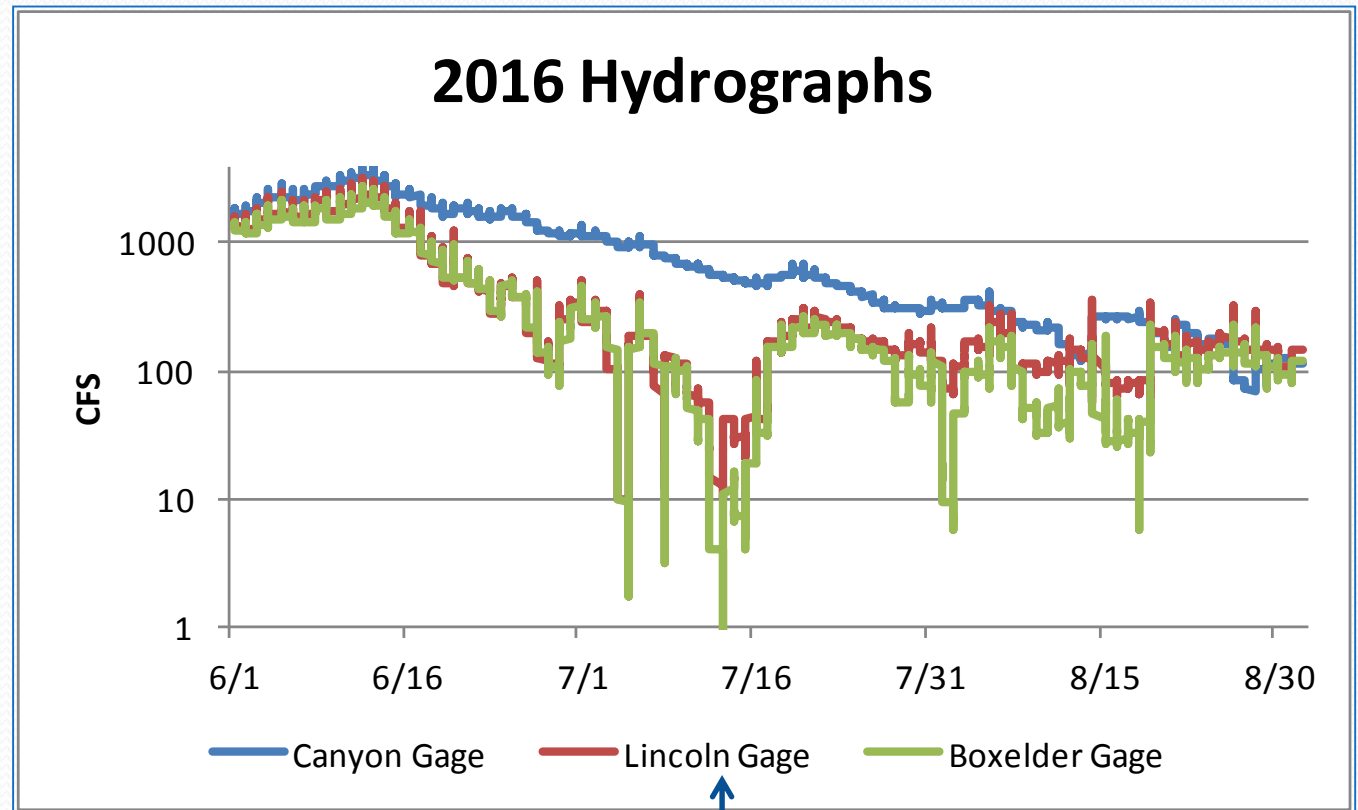
Data Used, cont.

Top of main focus



Starting Point – Gage Data

- Logarithmic scale use to highlight differences
- Only part of year shown here



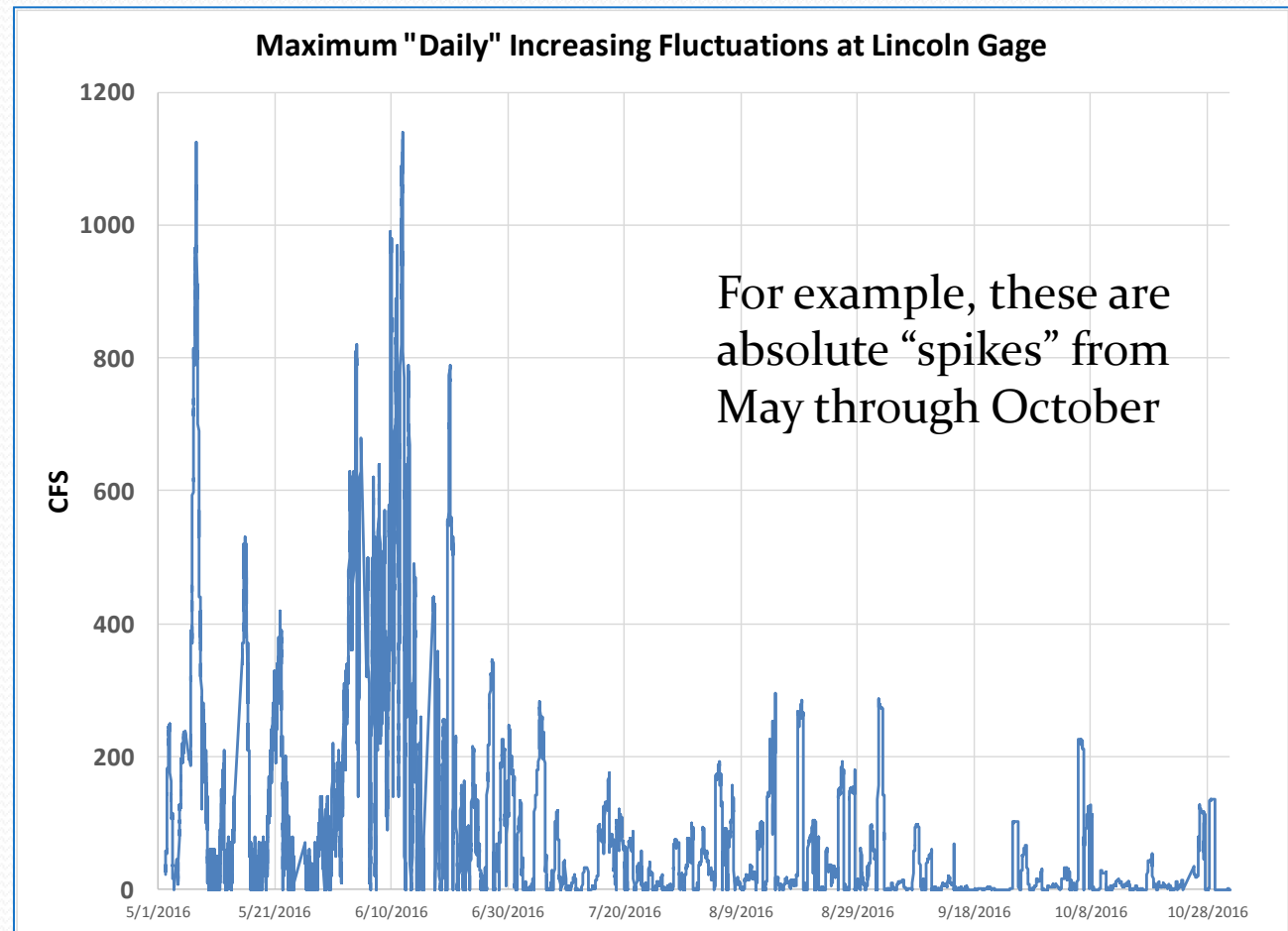
Primary Focus

Approach

- Calculated the maximum positive or negative flow changes within 24-hours following each 15-minute data point
 - **Absolute**, i.e., maximum – minimum cfs, & vice-versa
 - **Percentage** (Relative) change in cfs
 - Each may have utility in exploring impacts
- Sampled largest transient events to identify major contributing factors

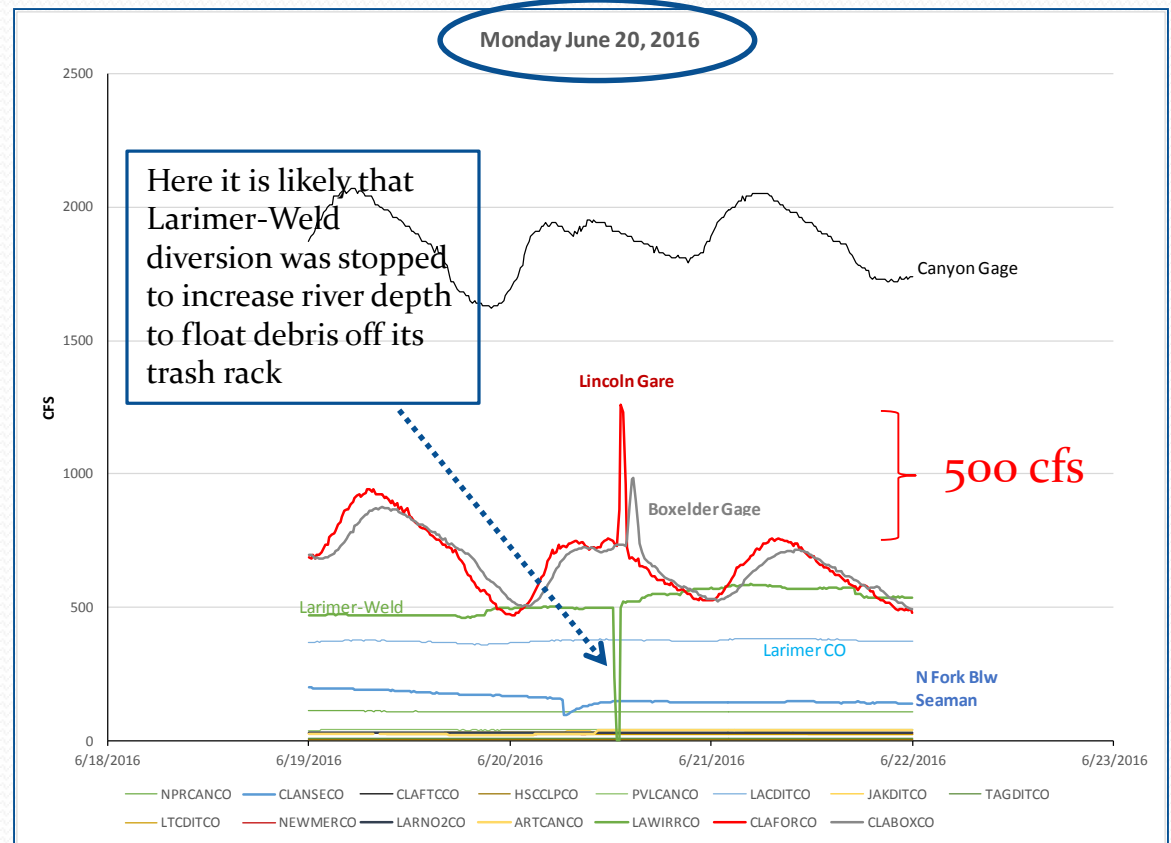
Selected Findings – 1

- Large transients, both absolute and percentage, occur year-round
- But mostly occur during the irrigation season, June through October



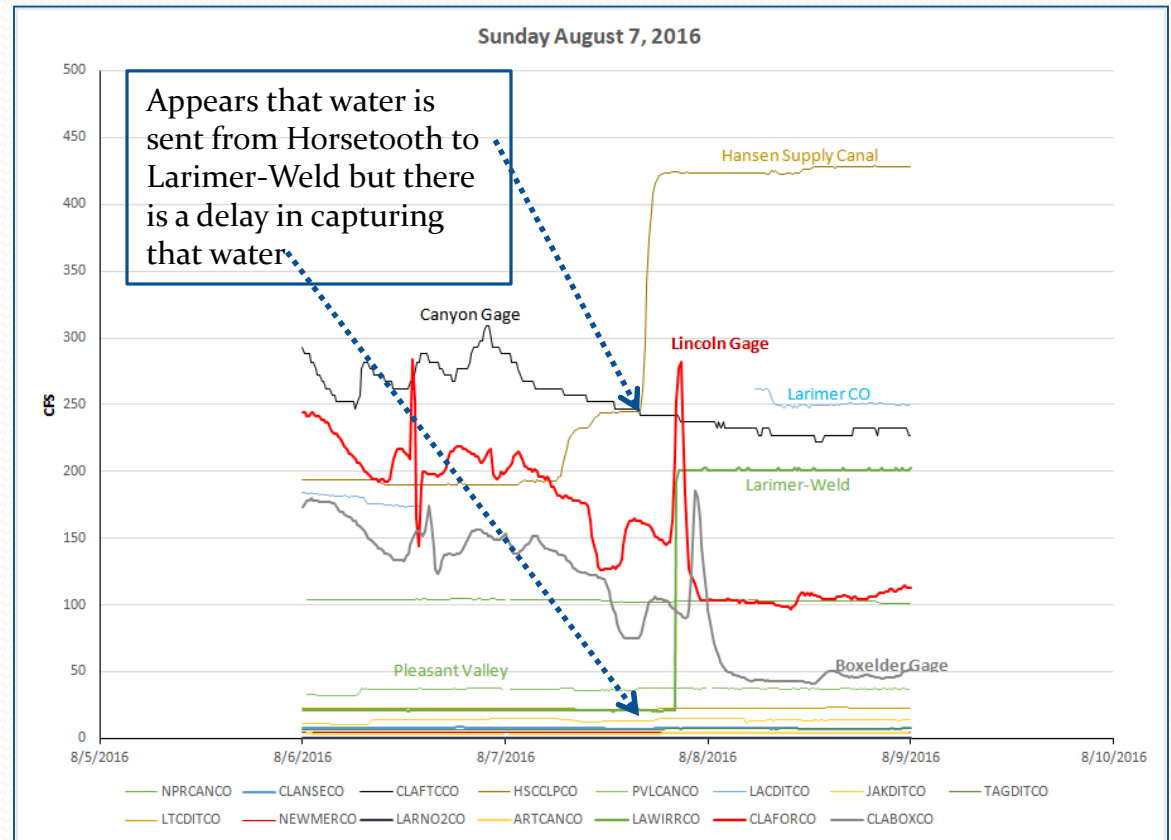
Selected Findings – 2

- Some events are straightforward resulting from day-to-day operations
- For example a canal headgate must be cleared or tended



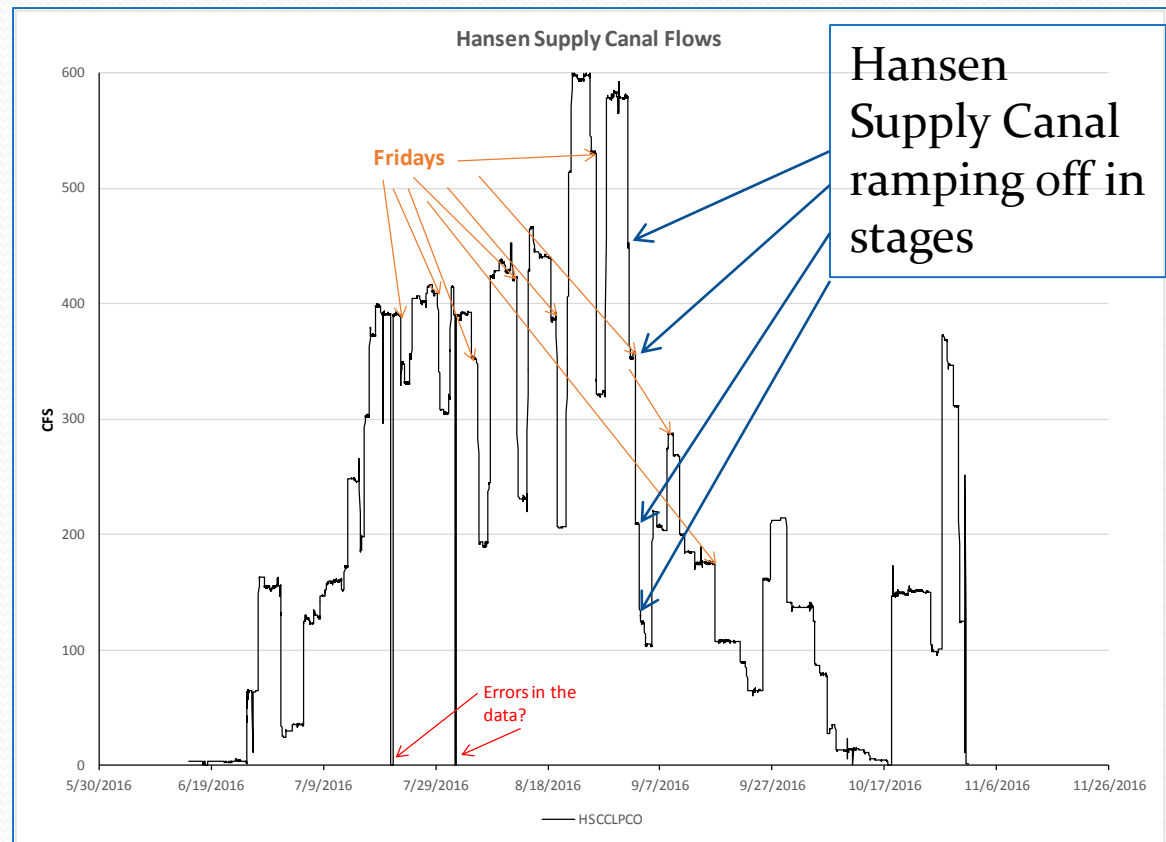
Selected Findings – 3

- Some events are more complex timing or coordination issues
- Commissioner prefers to see “bumps” rather than “holes”



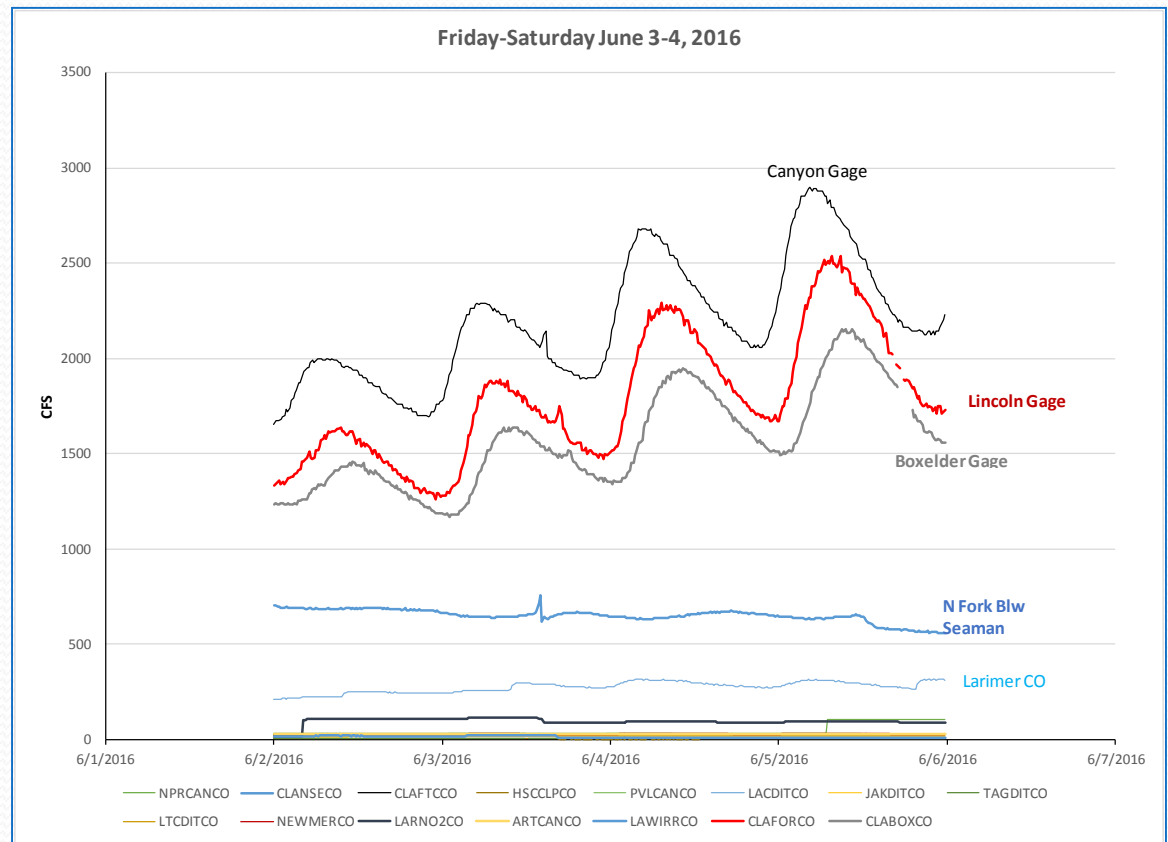
Selected Findings – 4

- Transients often observed Thursday to Monday
- Shown is a common 'shut-down' pattern – small Thursday drops followed by larger Friday drops



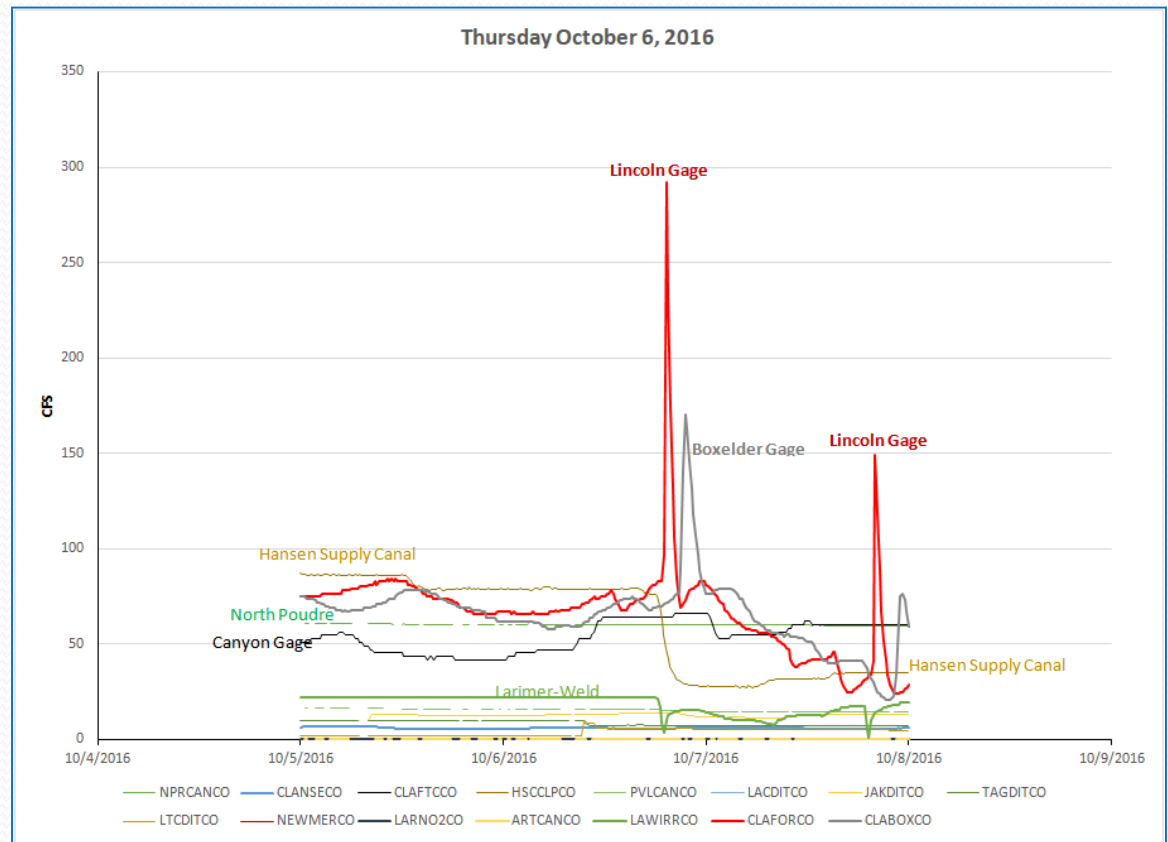
Selected Findings – 5

- Diurnal fluctuations during peak snowmelt can be large but are rarely abrupt
- Here we see ± 400 cfs variation from a high daily mean flow



Selected Findings – 6

- Often no obvious explanation for magnitude of transients
- Could be rainfall, ice, bad or misleading gage data, ...

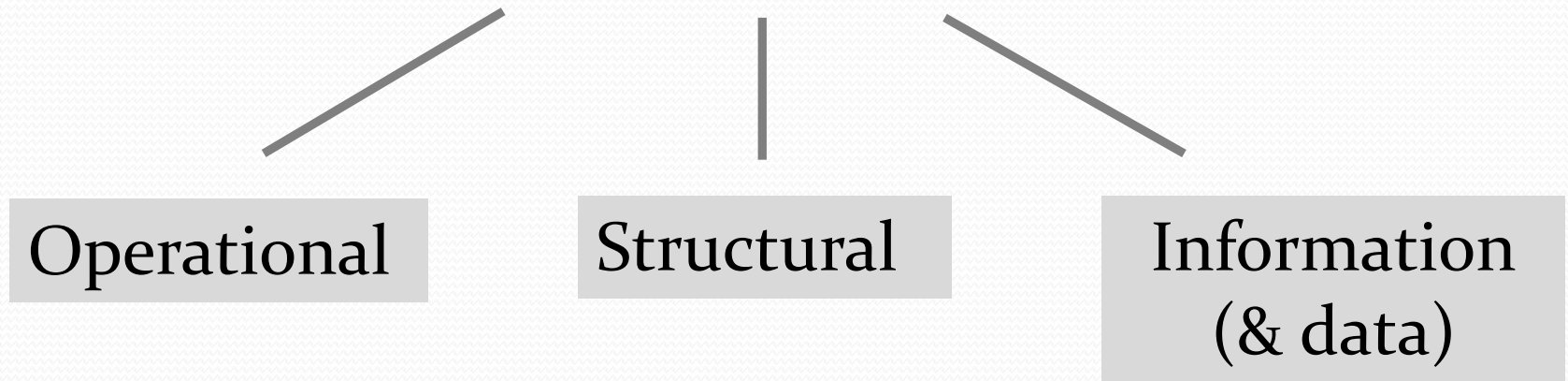


Looking Ahead

- There may be fewer large transients in the future
 - C-BT deliveries to the Poudre will likely decline as downstream agricultural deliveries convert to upstream municipal withdrawals
- But if less water is in the river, there may be more large percentage flow changes from river operations
 - Less “buffering” capacity
- Time will tell

Brainstorming

Opportunities



Operational Opportunities - 1

- Meet with large diverters to better understand their operations, explore possibilities, and brainstorm incentives for all parties
- Potential operational examples:
 - Tweak the ‘normal’ Hansen ramping rate guidelines
 - Use more but smaller step changes when large flow changes are scheduled and automated receipt of water is, or becomes, possible

Operational Opportunities - 2

- If a weekly water users coordination conference should come to pass to discuss multiple objectives, keep transient issues in mind
- If new water development projects are built, explore possibilities to further minimize detrimental transients without injecting any new ones

Structural Opportunities

- Continue to look for funds to automate diversion headgates and maximize working-river coordination
- Continue to support Flows Initiative and fish passage retrofit since base flows help buffer large percentage flow changes and likely mitigate stranding
- Support redesign of large capacity headgates to minimize needs to abruptly “flush” debris from diversion pools

Information Needs - 1

- Continue to explore adding more real-time measurements to diversions
 - Though many have been added recently, many remain
 - Priorities are largest diversions and municipal intakes & outfalls
 - Data will benefit multiple objectives such as the Flow Augmentation Initiative
- Support local scientific studies that may shed light on the biological implications of abrupt flow fluctuations, e.g., fish movement

Information Needs - 2

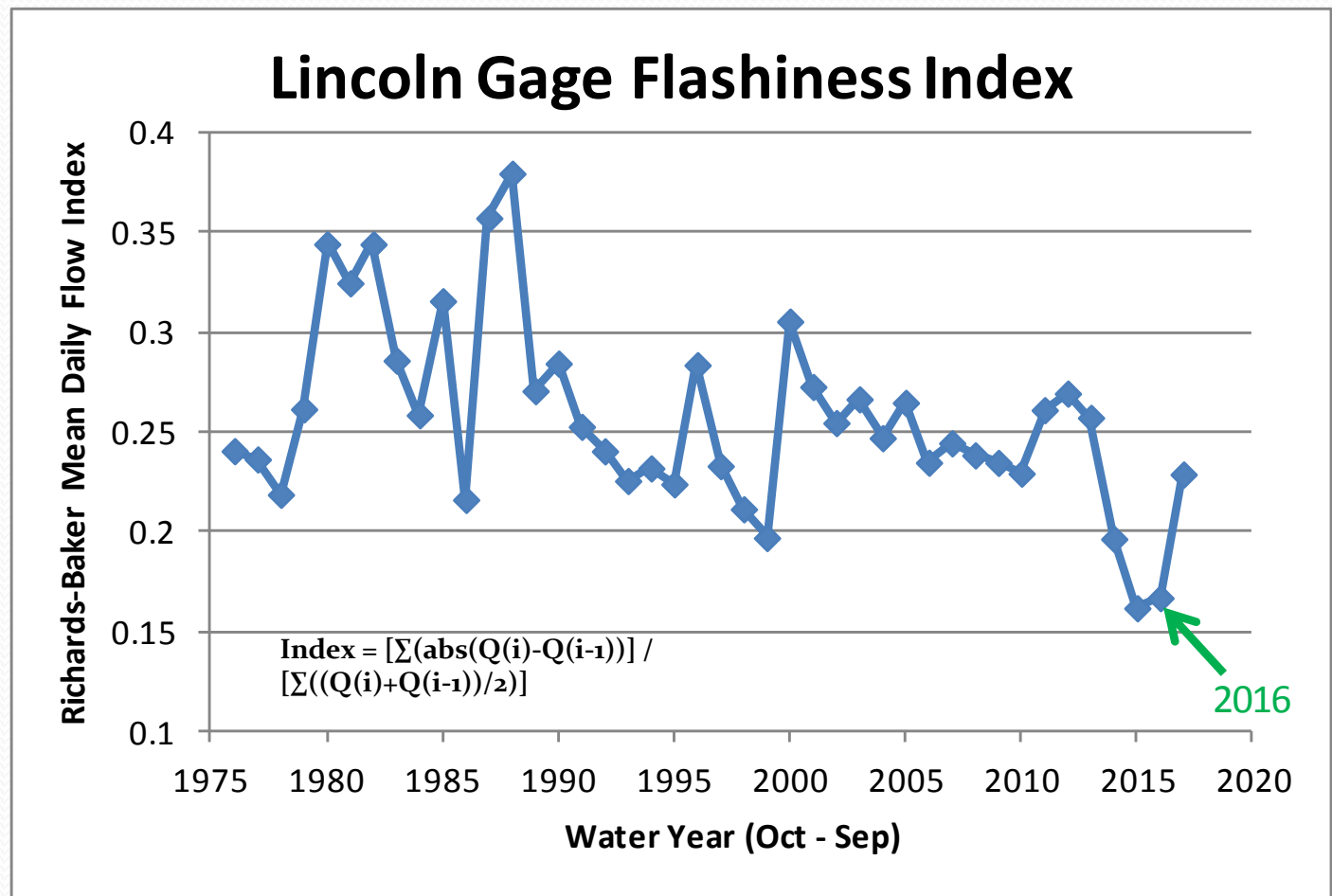
- For "educational" purposes only, consider Smartphone app to display real-time flow data with warnings on likely flow changes along the river
 - OWF oversee development with grant from Fort Collins
 - App could present other geo-referenced data
 - Must consider any liability issues

Caveats

- Existing operations system has been established over almost 150 years
 - Few incentives to change operations or infrastructure
 - Some reasons not to change:
 - Transit loss, expense, extra responsibilities, possible benefits of flow spikes

Data Limitation?

- Additional years of more complete data may reveal other issues and opportunities



Progress Report Summary

- Identified at least some mechanisms causing large transient flow events
- Identified several potential opportunities
 - Operational
 - Structural
 - Information needs
 - Ranging from easy and inexpensive to harder, long-term and expensive
- More work to do!

Many Thanks To Many Advisors and Helpers:

Scott Hummer, Ken Kehmeier, Steve Malers,
Andy Pineda, Jen Shanahan, Luke Shawcross,
Kristin Swaim, Reagan Waskom, Brad Wind
(and Mark Simpson)

