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Real-Time Operations of the Busse Reservoir

Presenters: John Wills, PE, CPESC; Scott La Vanne, PE, CFM

Flooding Frustrations

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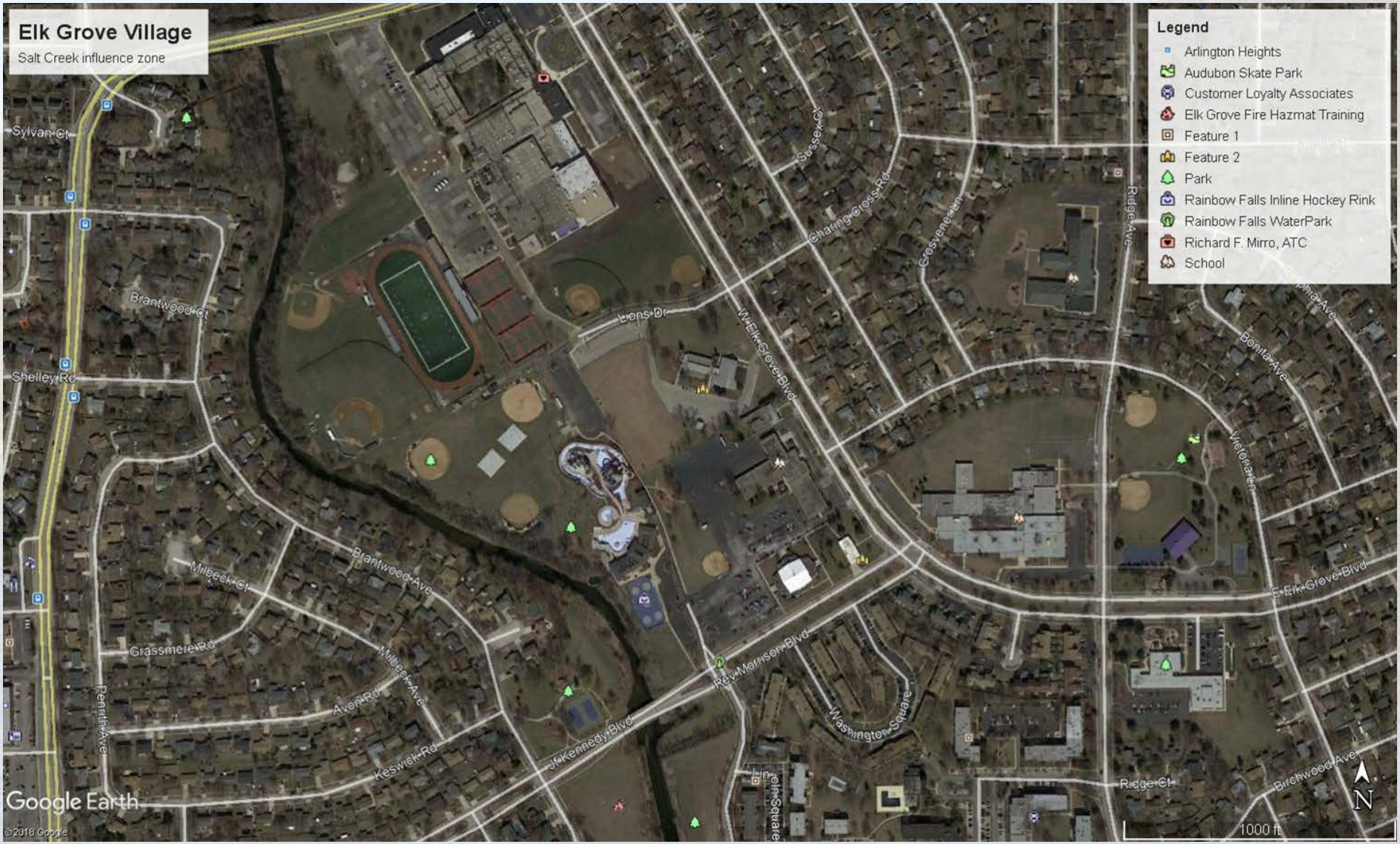

Flooding Frustrations

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Watershed & Location

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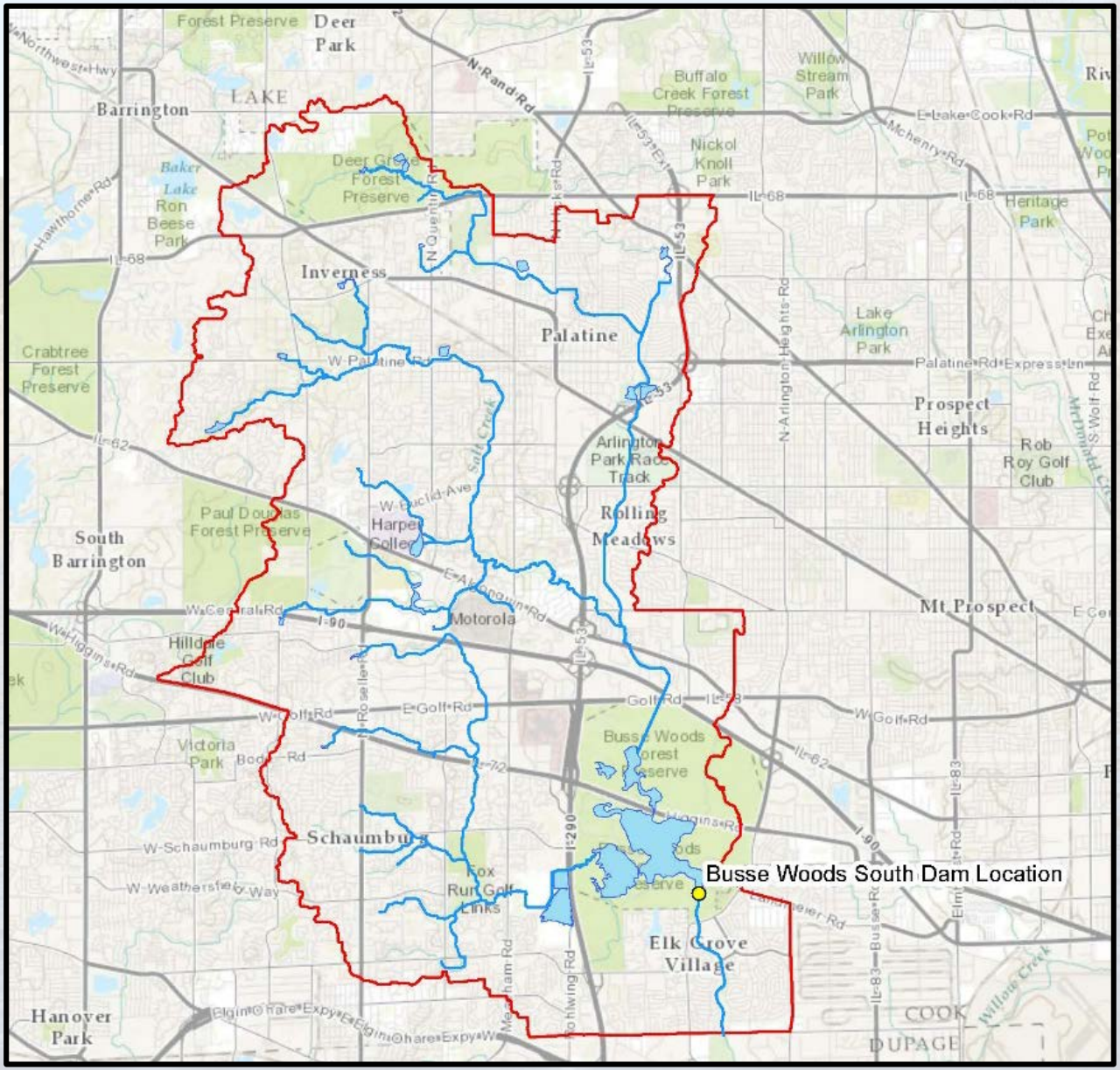
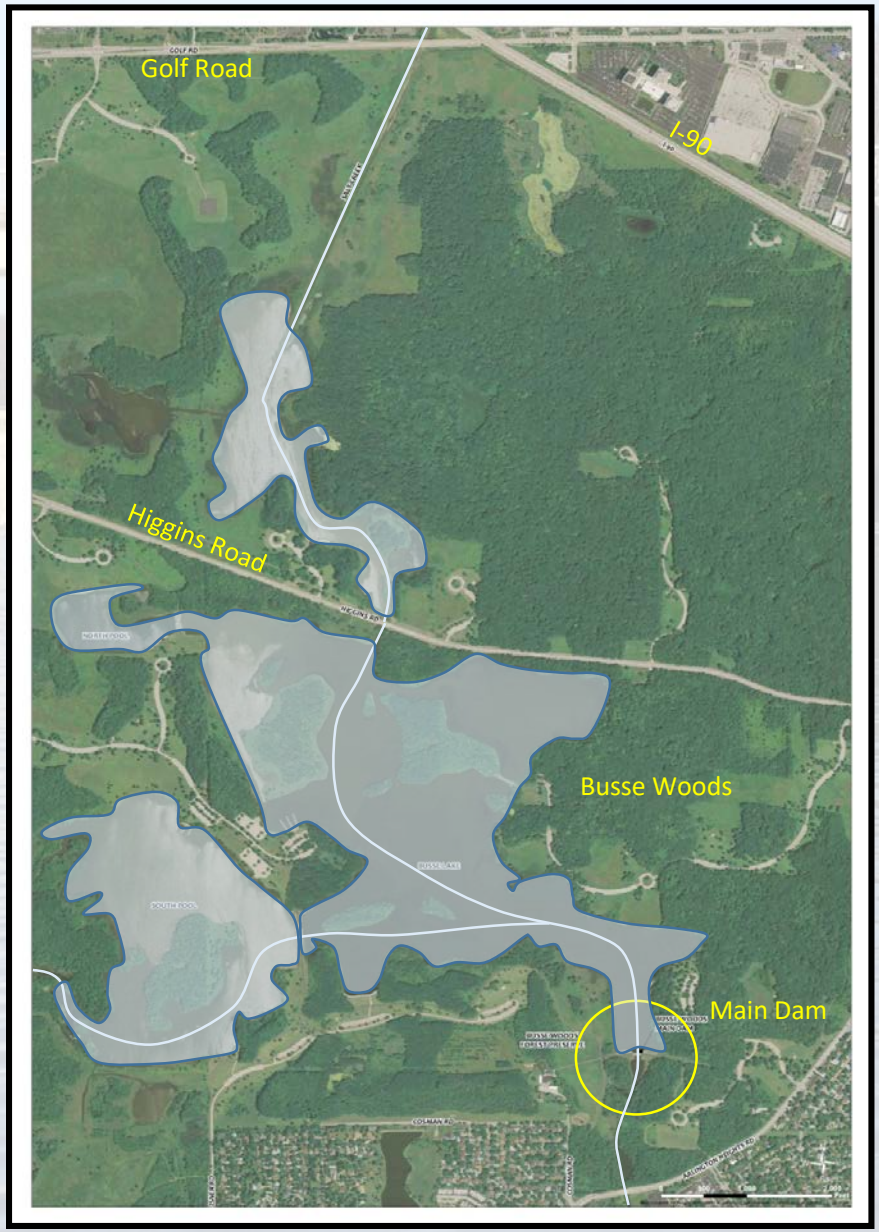


Watershed & Location



Busse Dam Original Weir

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Busse Dam Original Weir

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Busse Dam New Gate

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Busse Dam New Gate

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Busse Dam New Gate

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Sensor Locations

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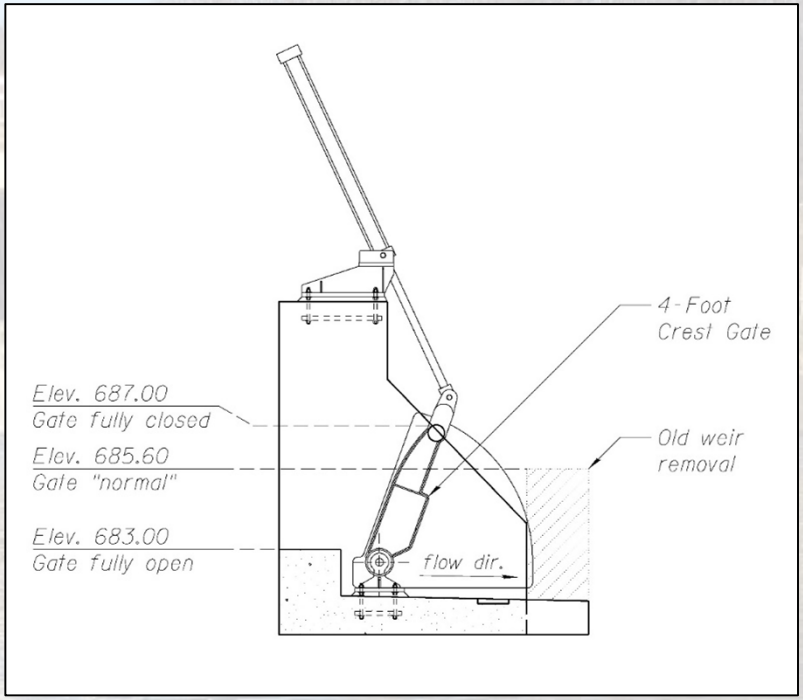
Busse Operations

- Operational Limitations
  - Physical Constraints
  - Flood Definitions
  - IGA
  - Management Resources
- Design Operating Scheme
- Implemented Operating Scheme



Design Operations (10-yr event)

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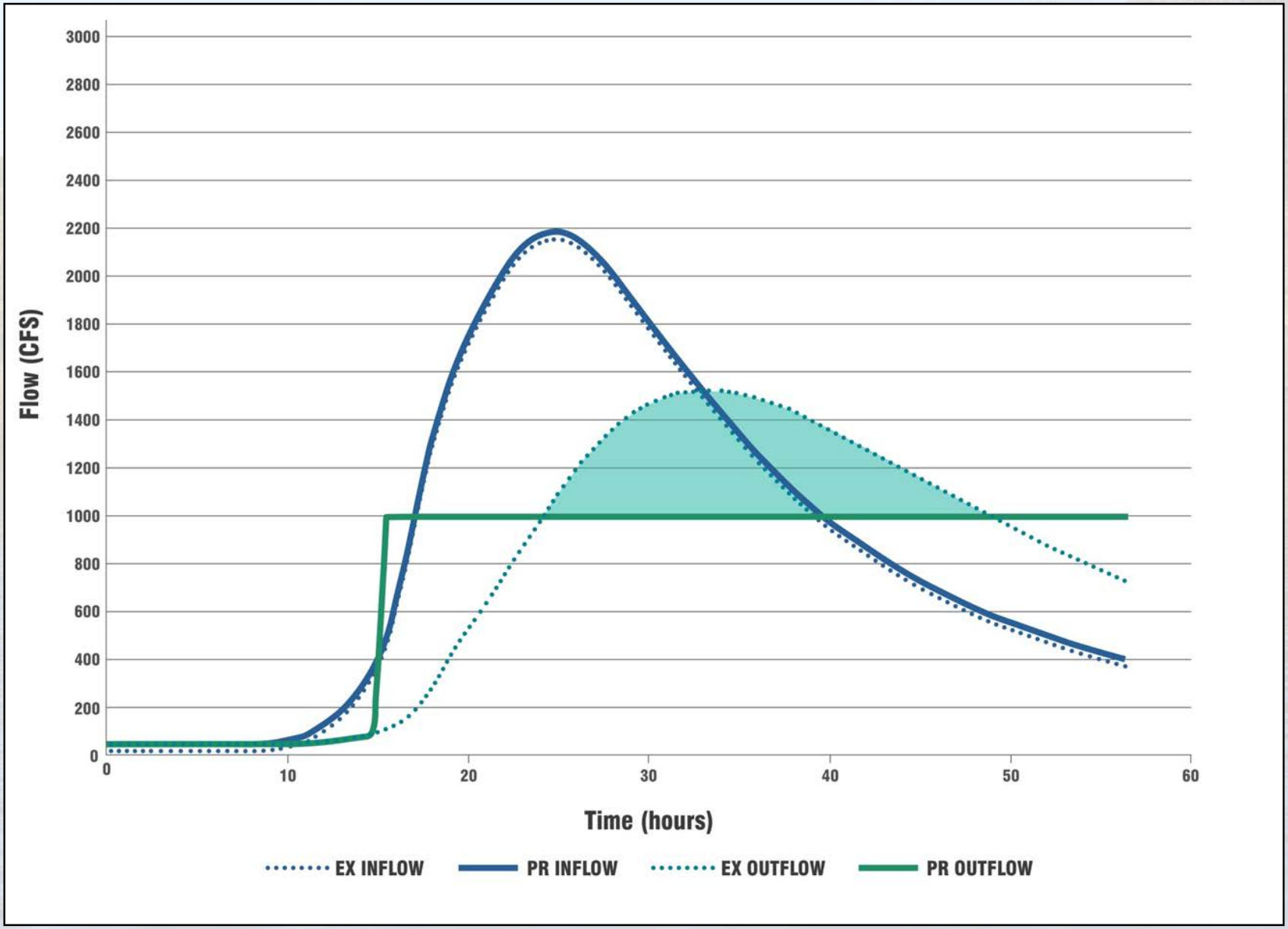
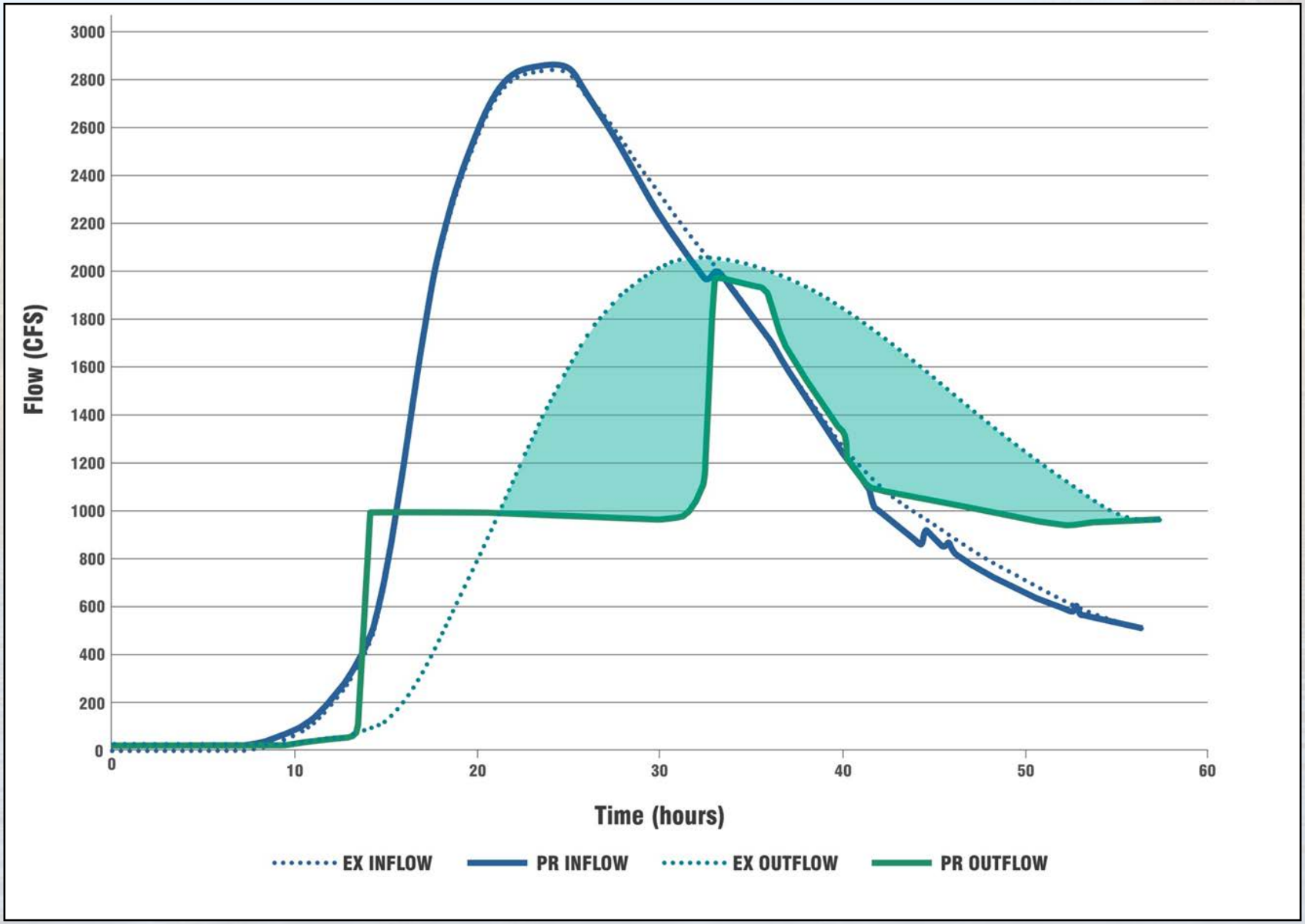
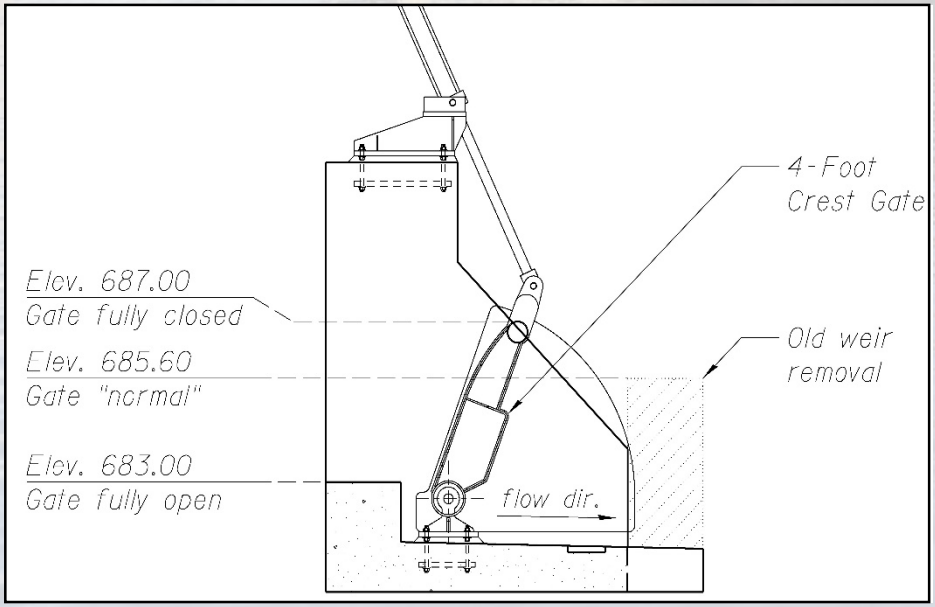


Design Operations (25-yr event)



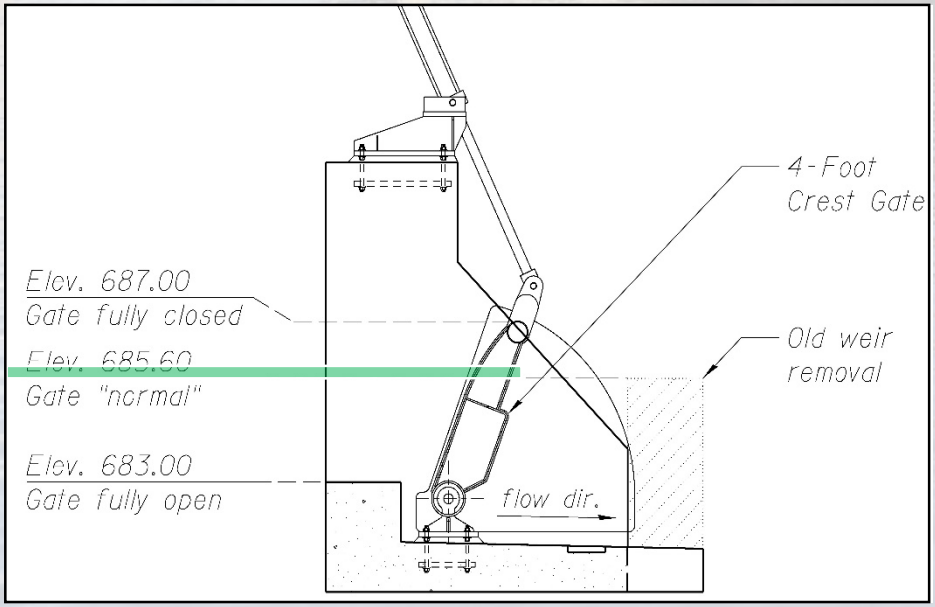
Operations Implemented

Operational Level:	Level 1	Level 2	Level 3	Level 4	Level 5
Attempt to Maintain reservoir elevation of:					
by opening (lowering) gate up to:					
to achieve a maximum flow rate of:					
Continue until reservoir stage is:					
Downstream effect:					



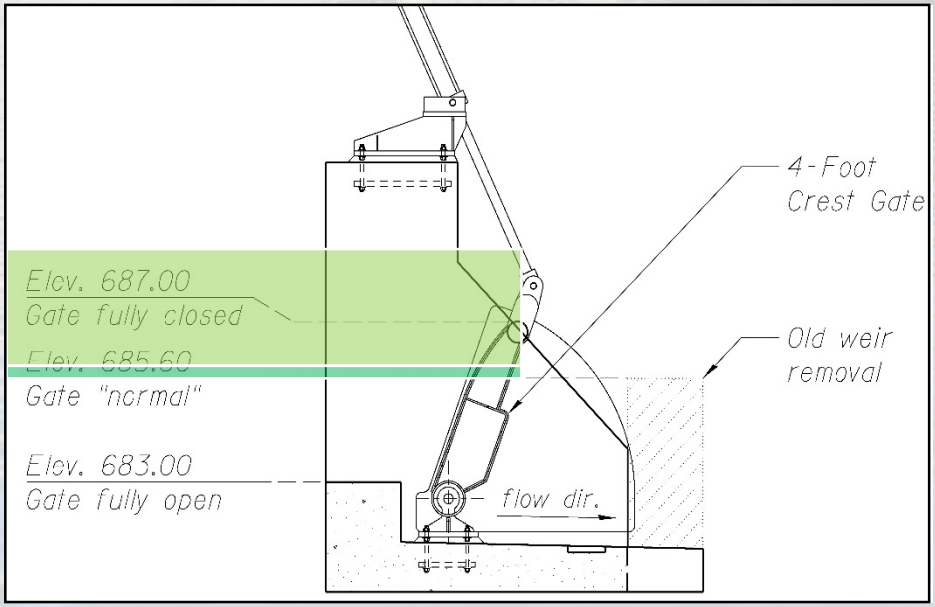
Operations Implemented

Operational Level:	Level 1	Level 2	Level 3	Level 4	Level 5
Attempt to Maintain reservoir elevation of:	685.6				
by opening (lowering) gate up to:	1.1'				
to achieve a maximum flow rate of:	300 CFS				
Continue until reservoir stage is:	685.8				
Downstream effect:	Flow is just below bankful				



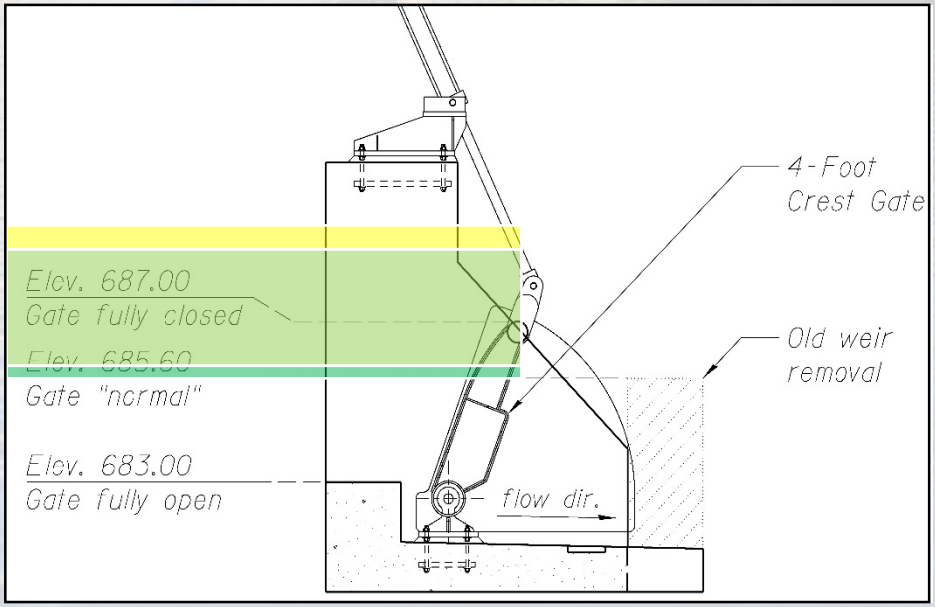
Operations Implemented

Operational Level:	Level 1	Level 2	Level 3	Level 4	Level 5
Attempt to Maintain reservoir elevation of:	685.6	685.8			
by opening (lowering) gate up to:	1.1'	1.5'			
to achieve a maximum flow rate of:	300 CFS	500 CFS			
Continue until reservoir stage is:	685.8	688.0			
Downstream effect:	Flow is just below bankful	Low-laying baseball fields and pedestrian trail inundated			



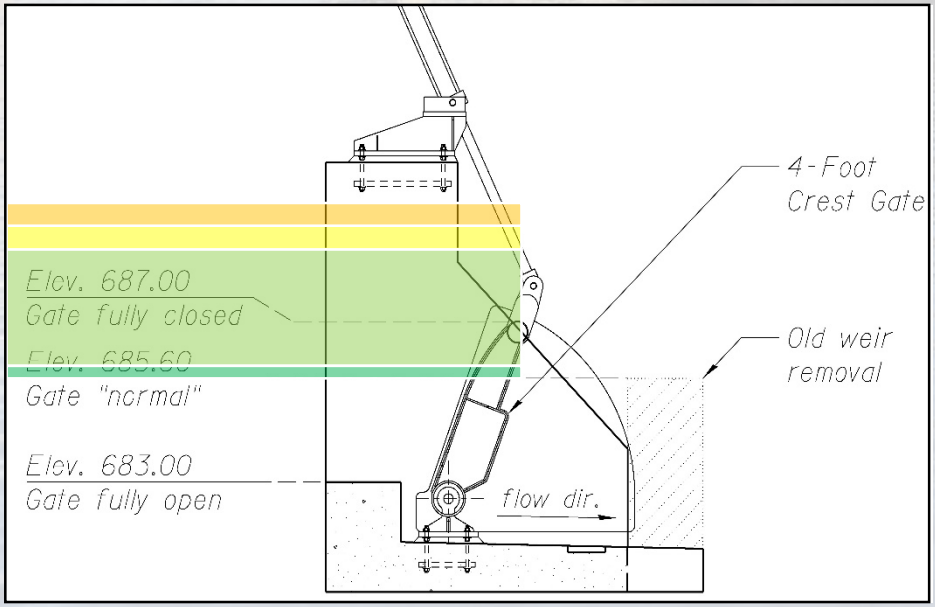
Operations Implemented

Operational Level:	Level 1	Level 2	Level 3	Level 4	Level 5
Attempt to Maintain reservoir elevation of:	685.6	685.8	688.0		
by opening (lowering) gate up to:	1.1'	1.5'	2.0'		
to achieve a maximum flow rate of:	300 CFS	500 CFS	700 CFS		
Continue until reservoir stage is:	685.8	688.0	688.5		
Downstream effect:	Flow is just below bankful	Low-laying baseball fields and pedestrian trail inundated	Some water on pavement – road passable		



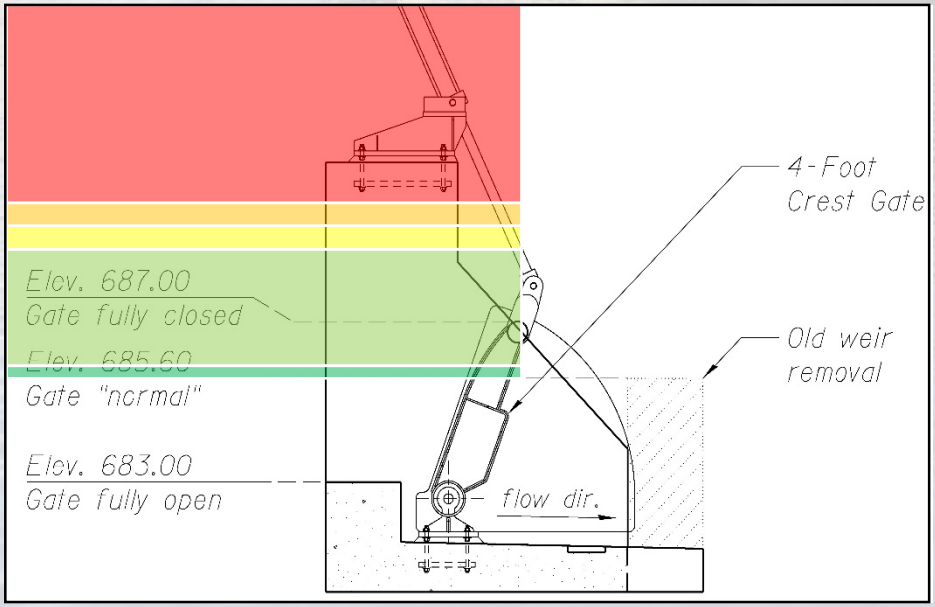
Operations Implemented

Operational Level:	Level 1	Level 2	Level 3	Level 4	Level 5
Attempt to Maintain reservoir elevation of:	685.6	685.8	688.0	688.5	
by opening (lowering) gate up to:	1.1'	1.5'	2.0'	2.4'	
to achieve a maximum flow rate of:	300 CFS	500 CFS	700 CFS	1000 CFS	
Continue until reservoir stage is:	685.8	688.0	688.5	689.0	
Downstream effect:	Flow is just below bankful	Low-laying baseball fields and pedestrian trail inundated	Some water on pavement – road passable	Additional water on pavement – one lane closed	



Operations Implemented

Operational Level:	Level 1	Level 2	Level 3	Level 4	Level 5
Attempt to Maintain reservoir elevation of:	685.6	685.8	688.0	688.5	689.0
by opening (lowering) gate up to:	1.1'	1.5'	2.0'	2.4'	Normal (685.6)
to achieve a maximum flow rate of:	300 CFS	500 CFS	700 CFS	1000 CFS	>1000 CFS
Continue until reservoir stage is:	685.8	688.0	688.5	689.0	< 689.0
Downstream effect:	Flow is just below bankful	Low-laying baseball fields and pedestrian trail inundated	Some water on pavement – road passable	Additional water on pavement – one lane closed	Storm dependent



Operations Level Real Time Data

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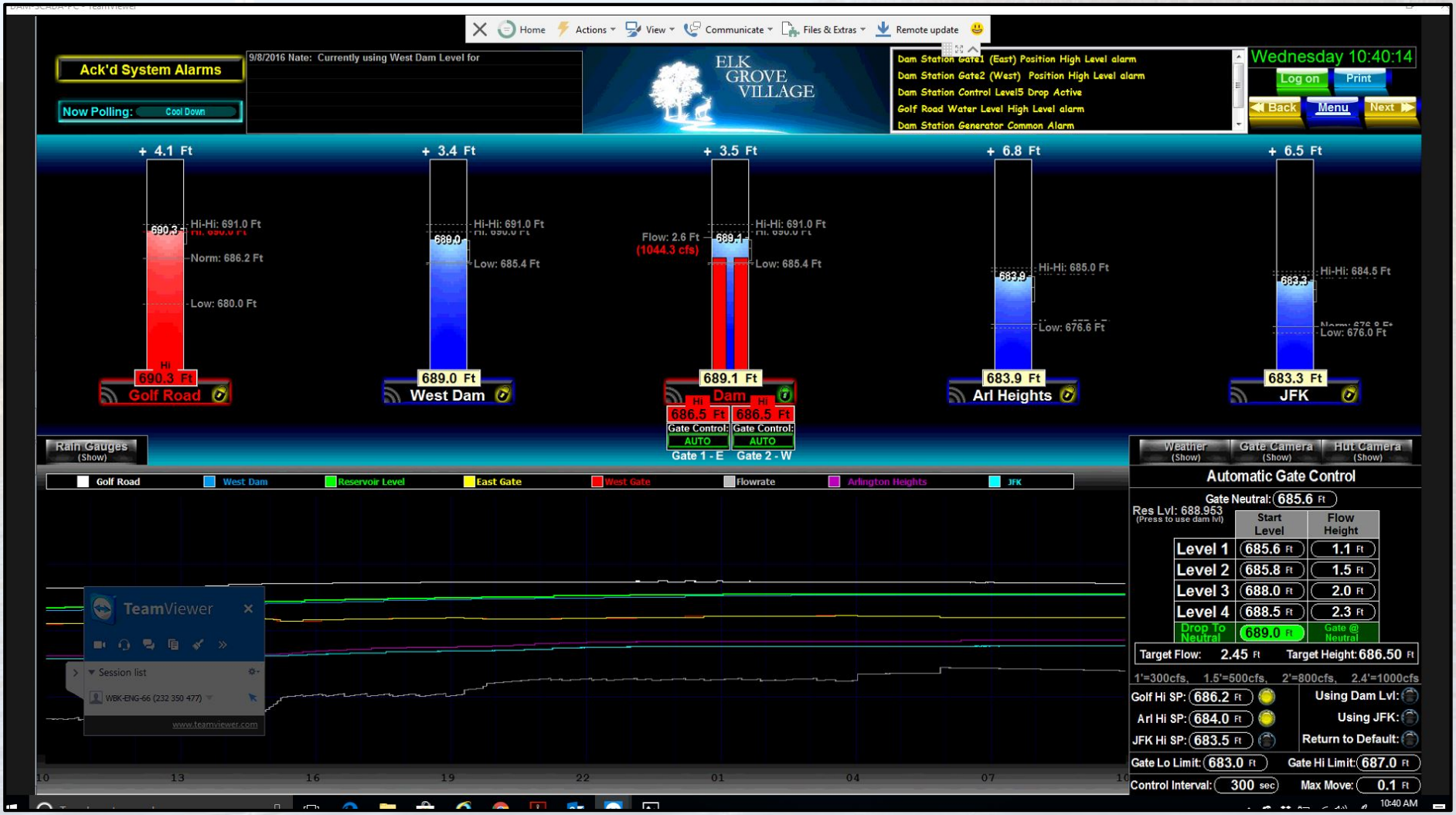
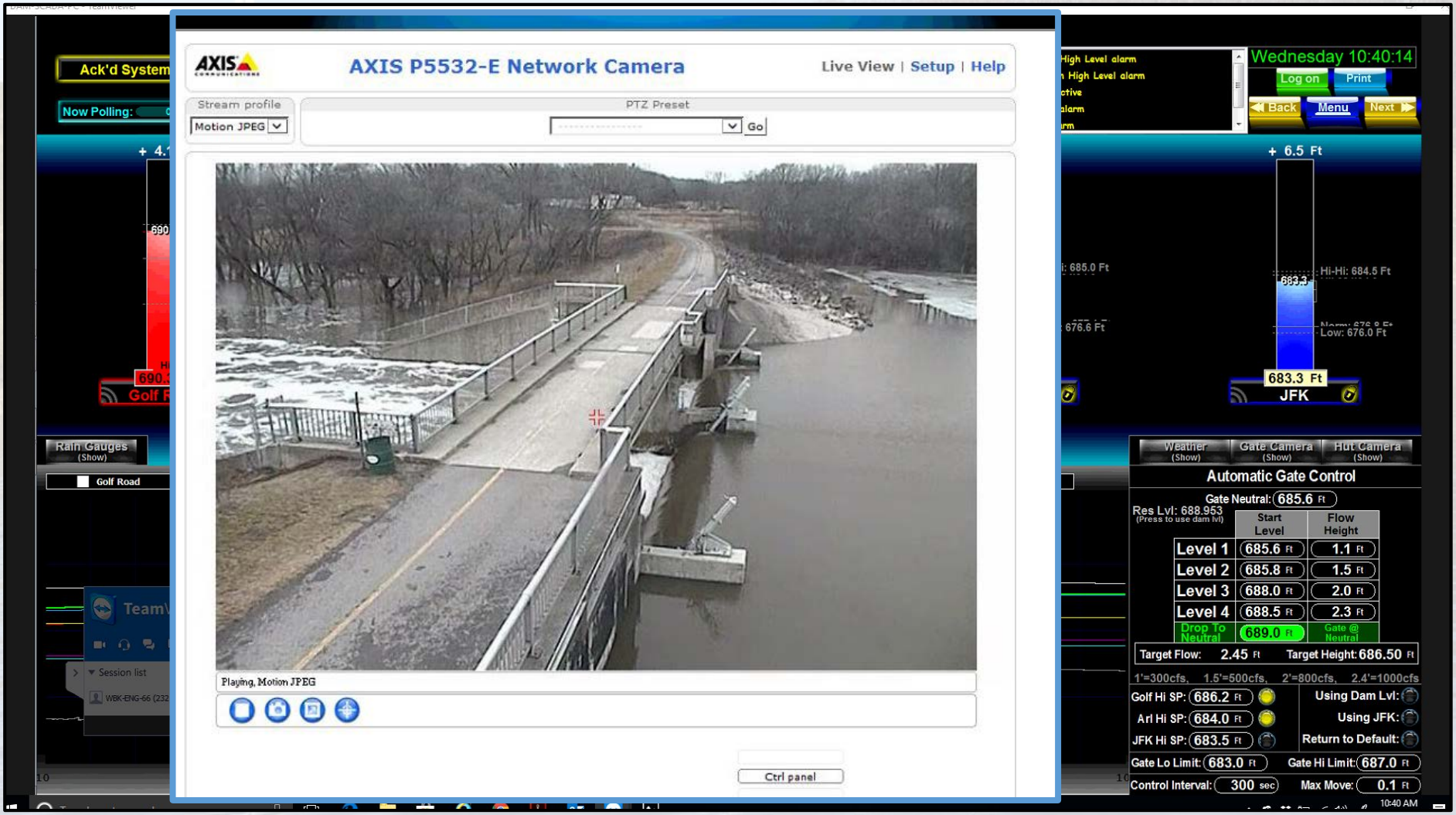


Operations Level Real Time Data



Operations Level Real Time Data

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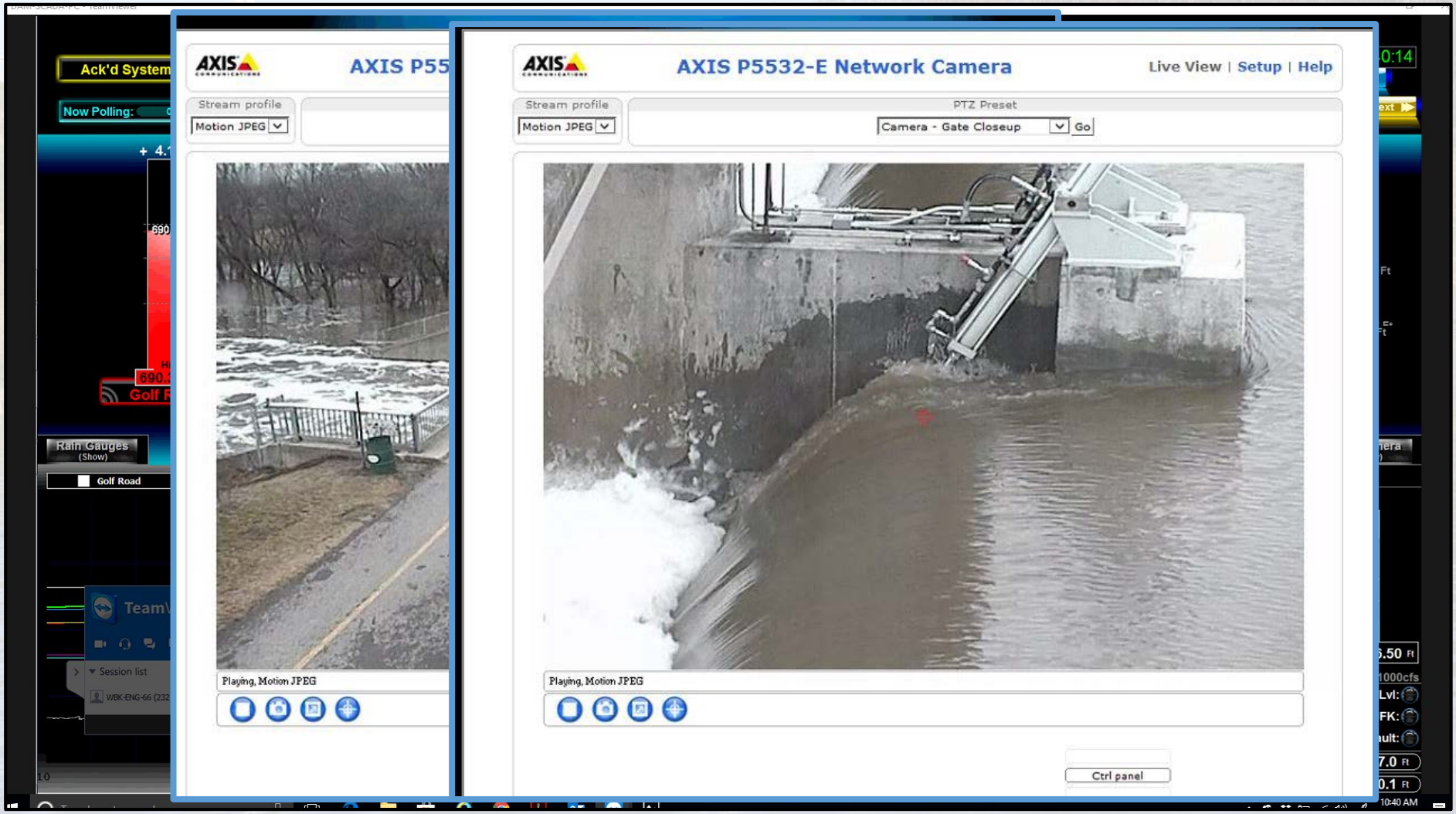

Real Time Data-Trends Overview

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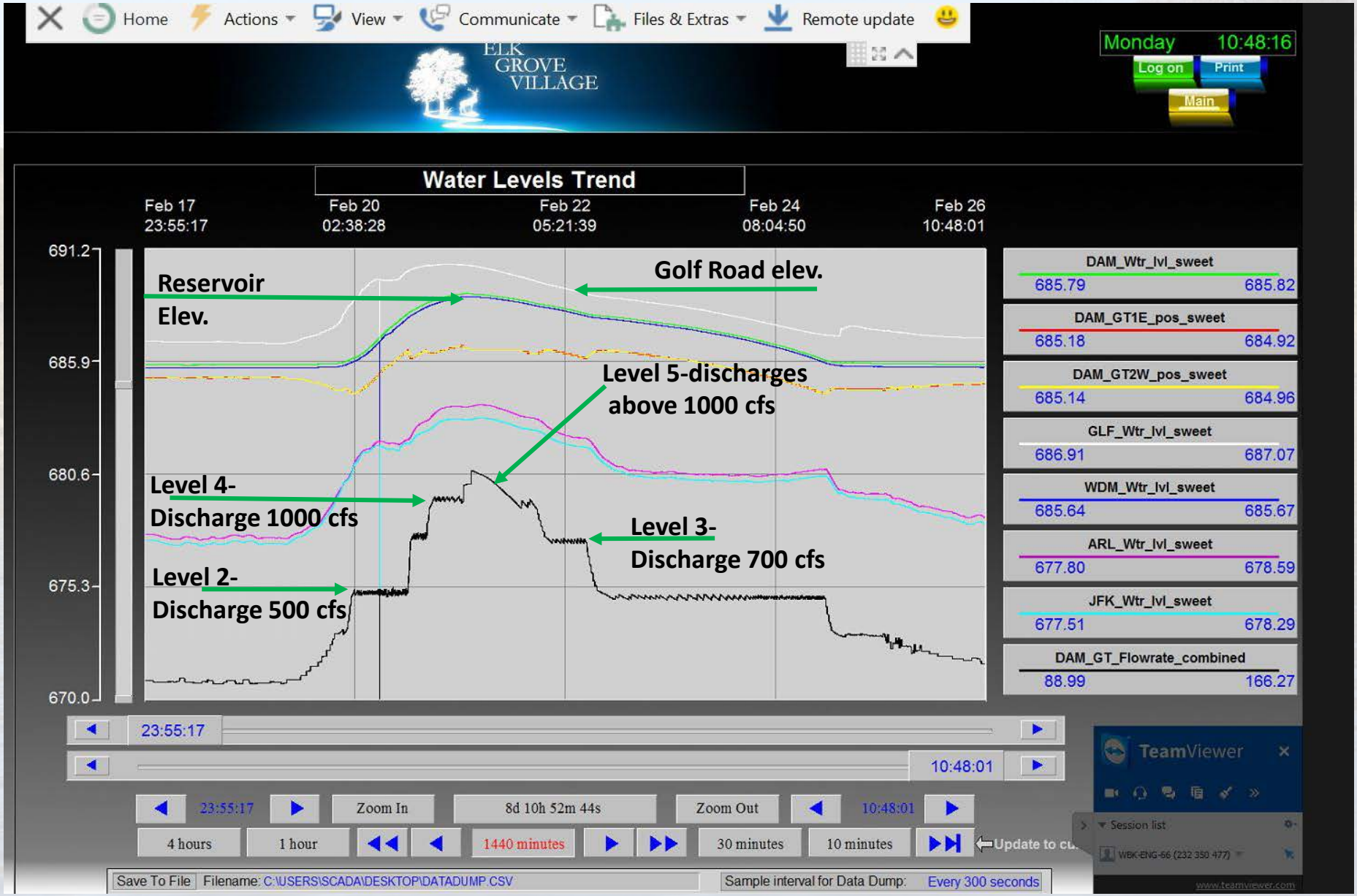
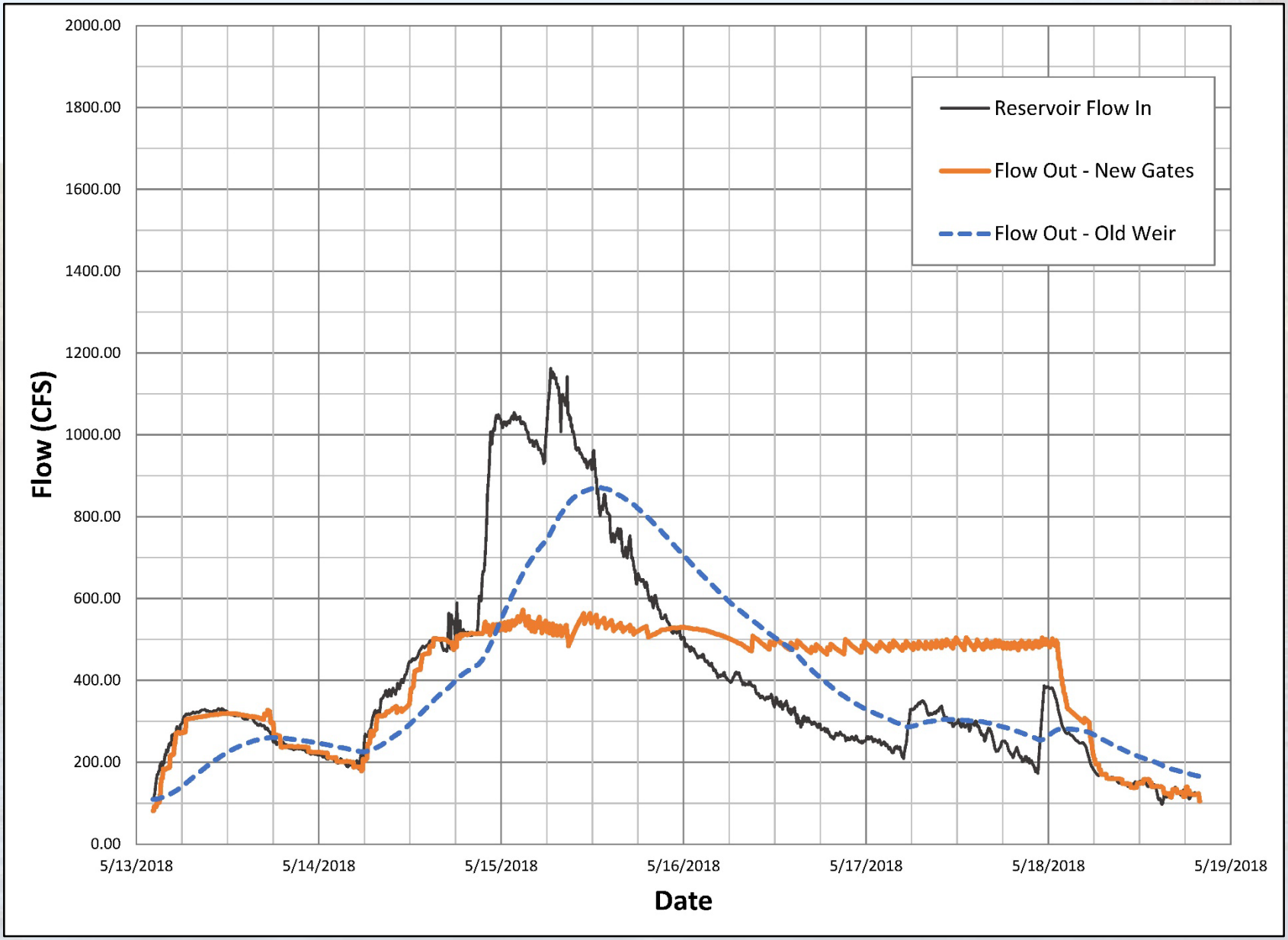
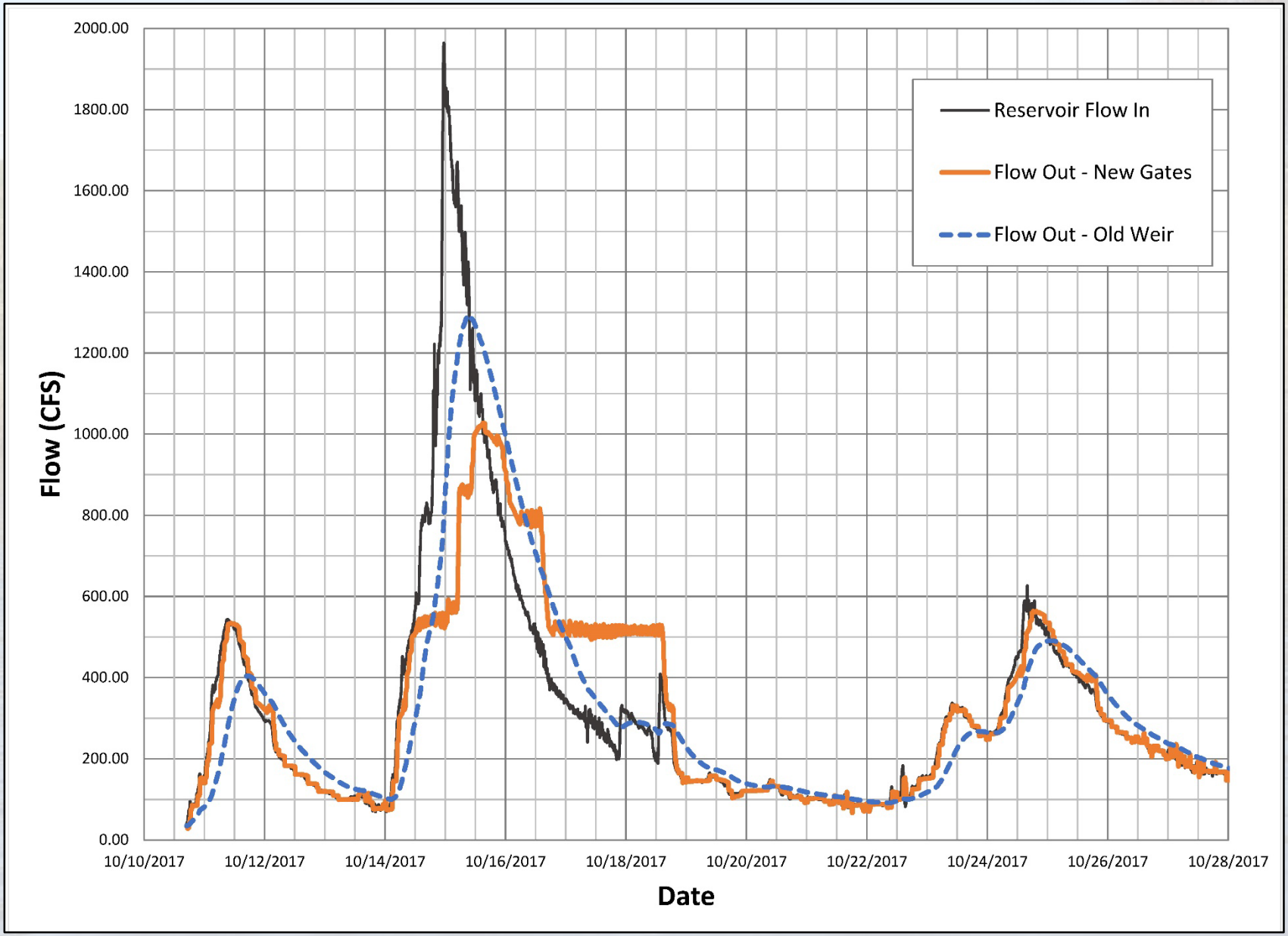


Level 2 Operation



Level 4 Operation-multiple storms-matching inflow/outflow



Level 4 Operation-multiple storms-matching inflow/outflow

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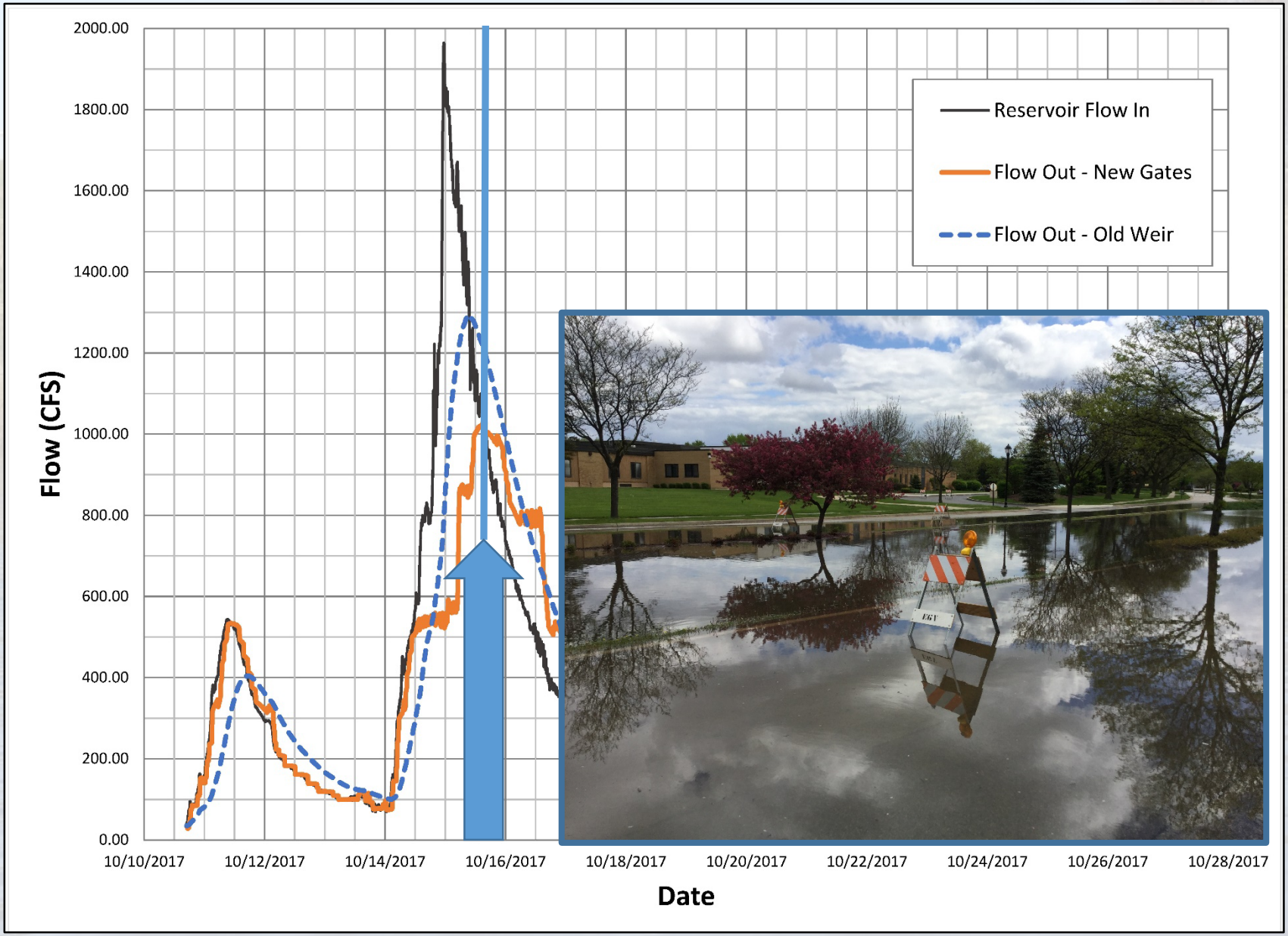
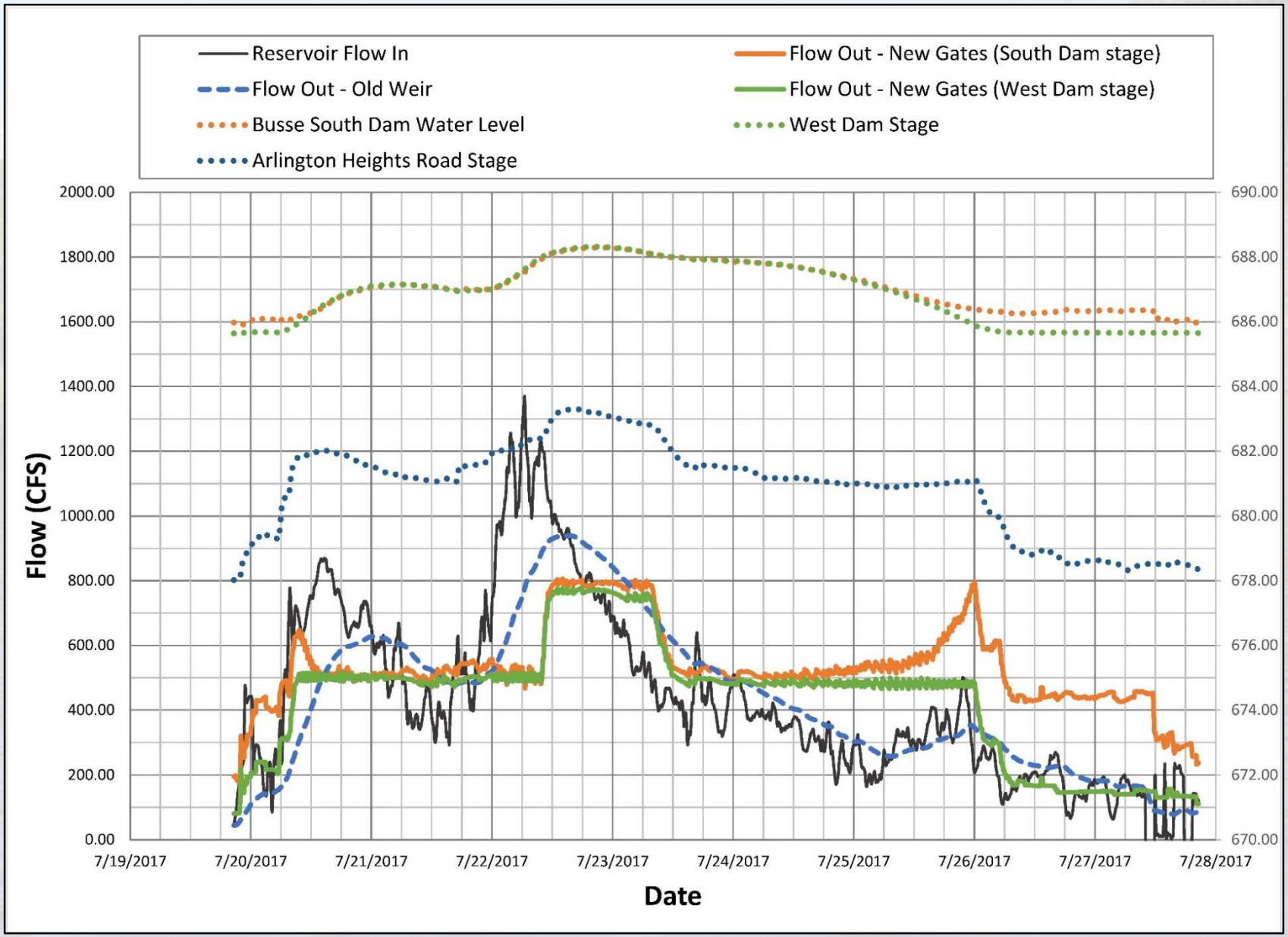
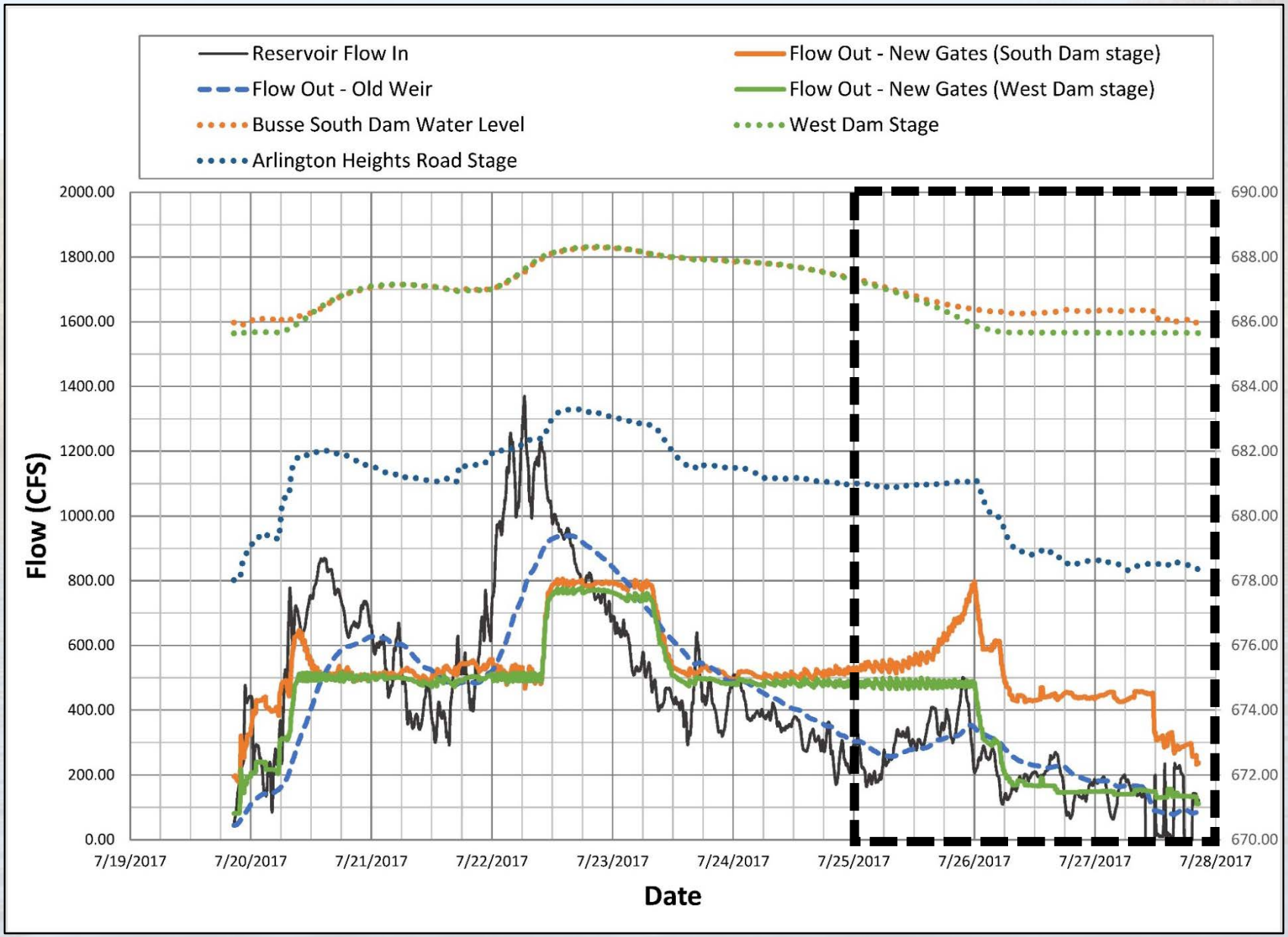


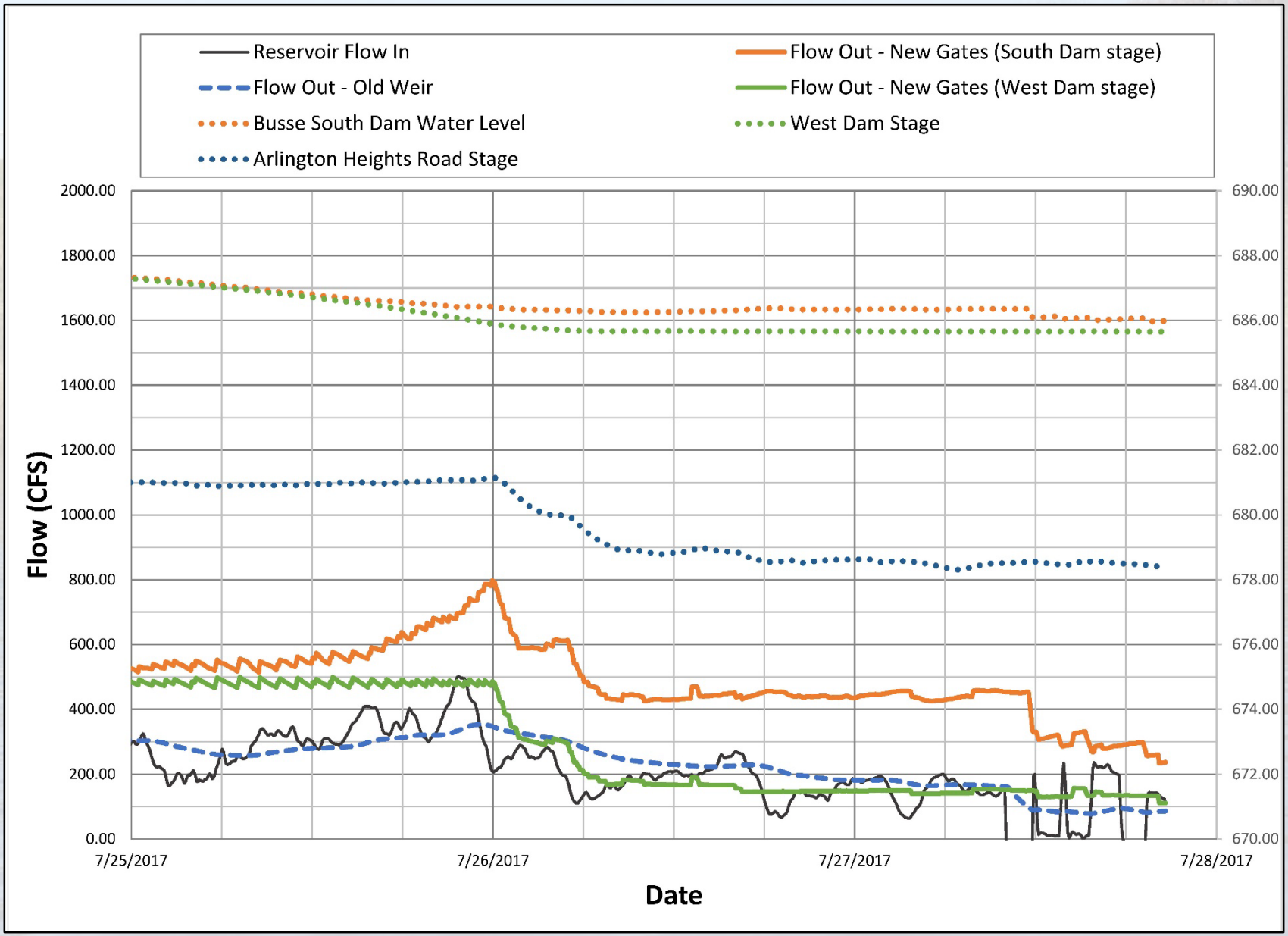
Level 3 Operation—Sensor Mismatch at the Dam



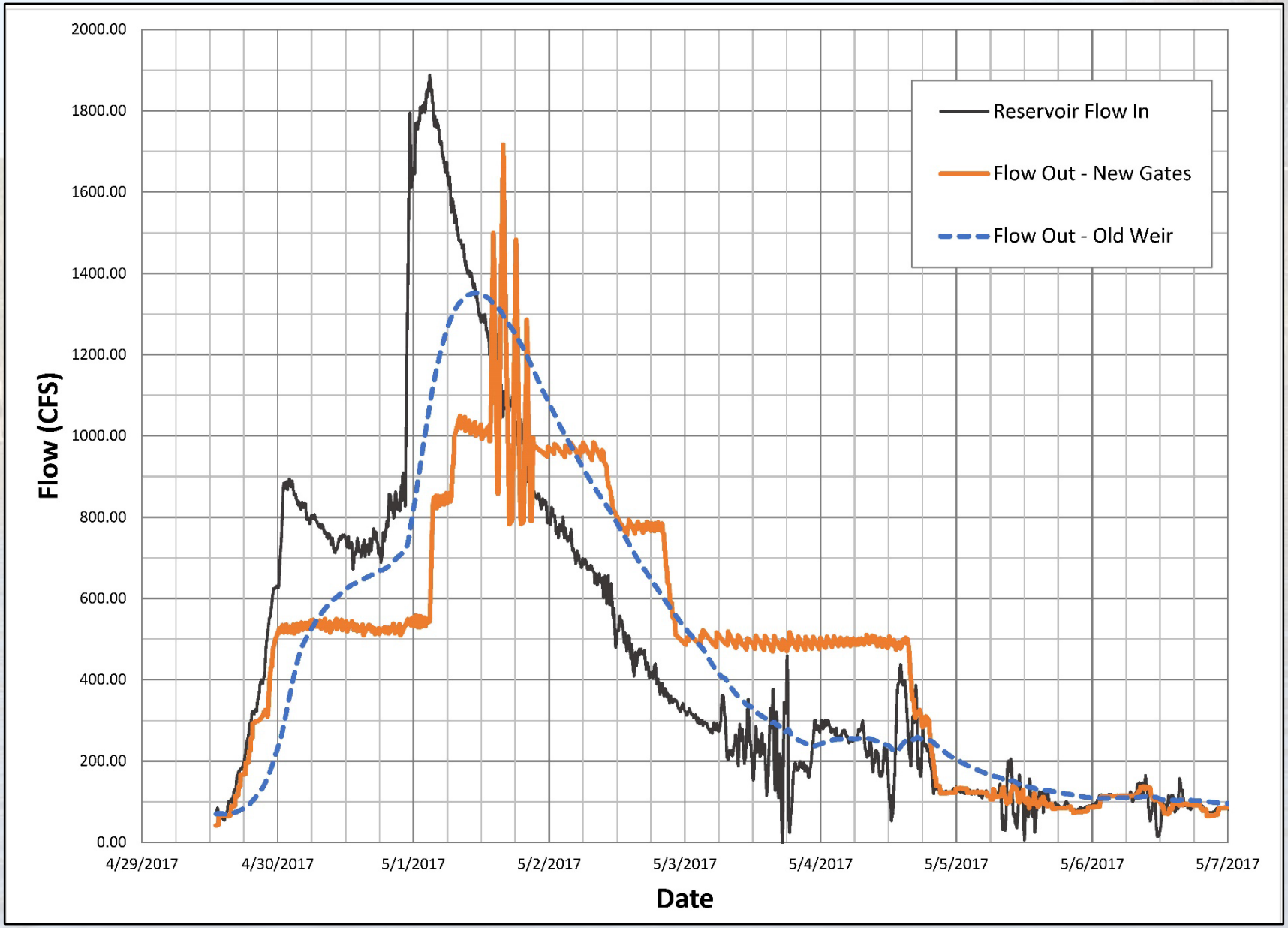
Level 3 Operation—Sensor Mismatch at the Dam



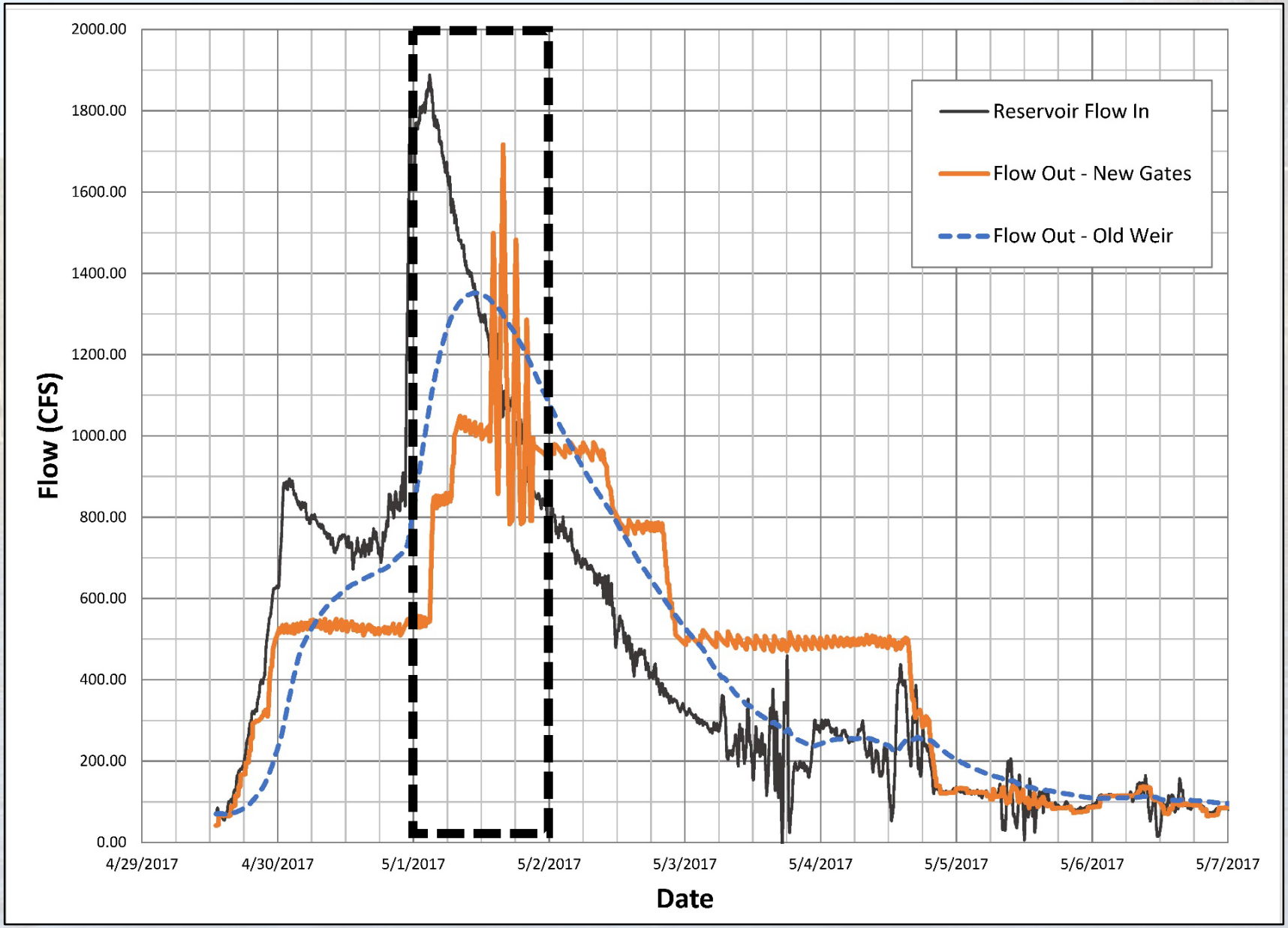
Sensor Mismatch—backup Operations



First Level 5 Operation-2017



First Level 5 Operation-2017



First Level 5 Operation-2017

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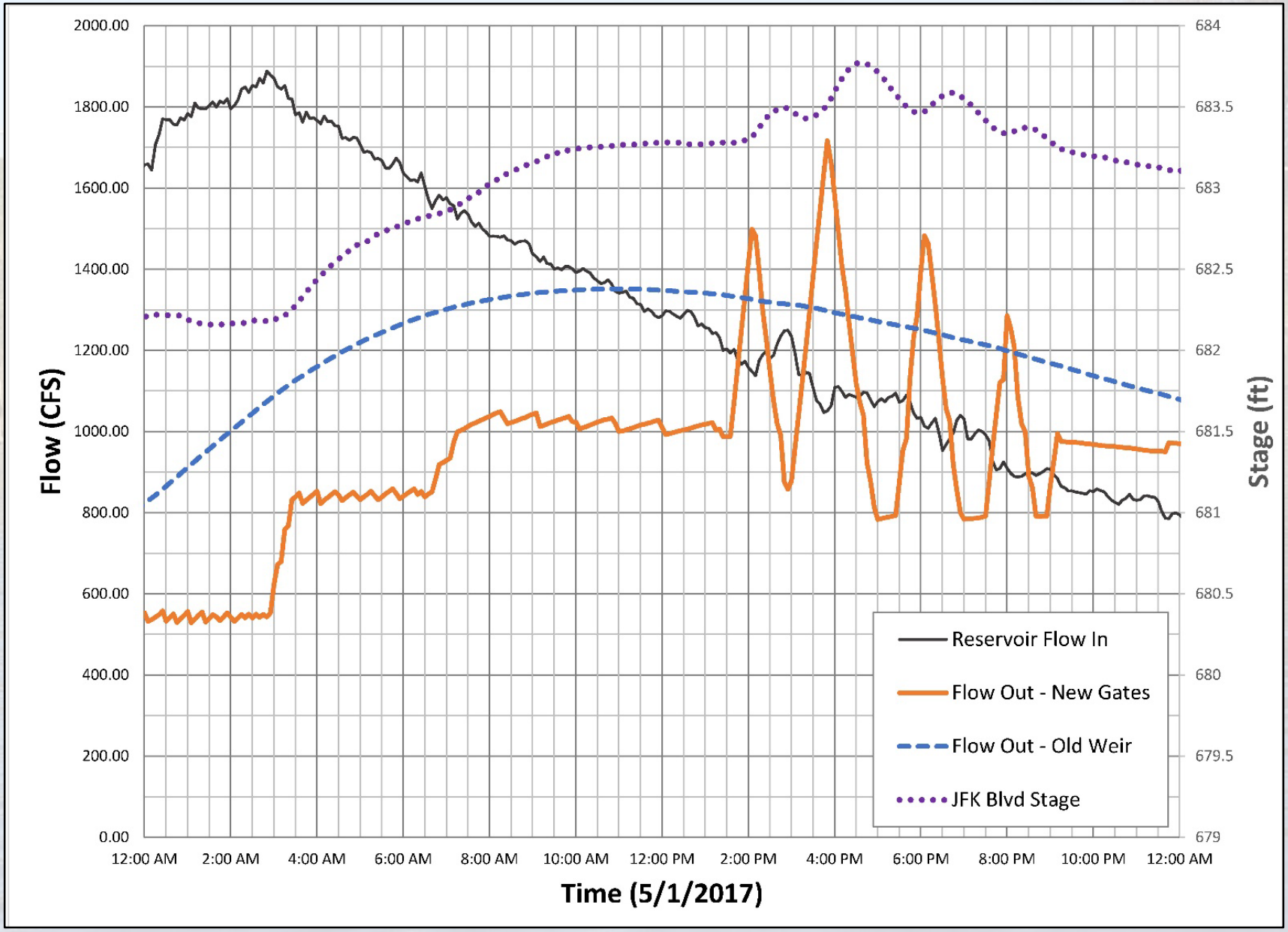
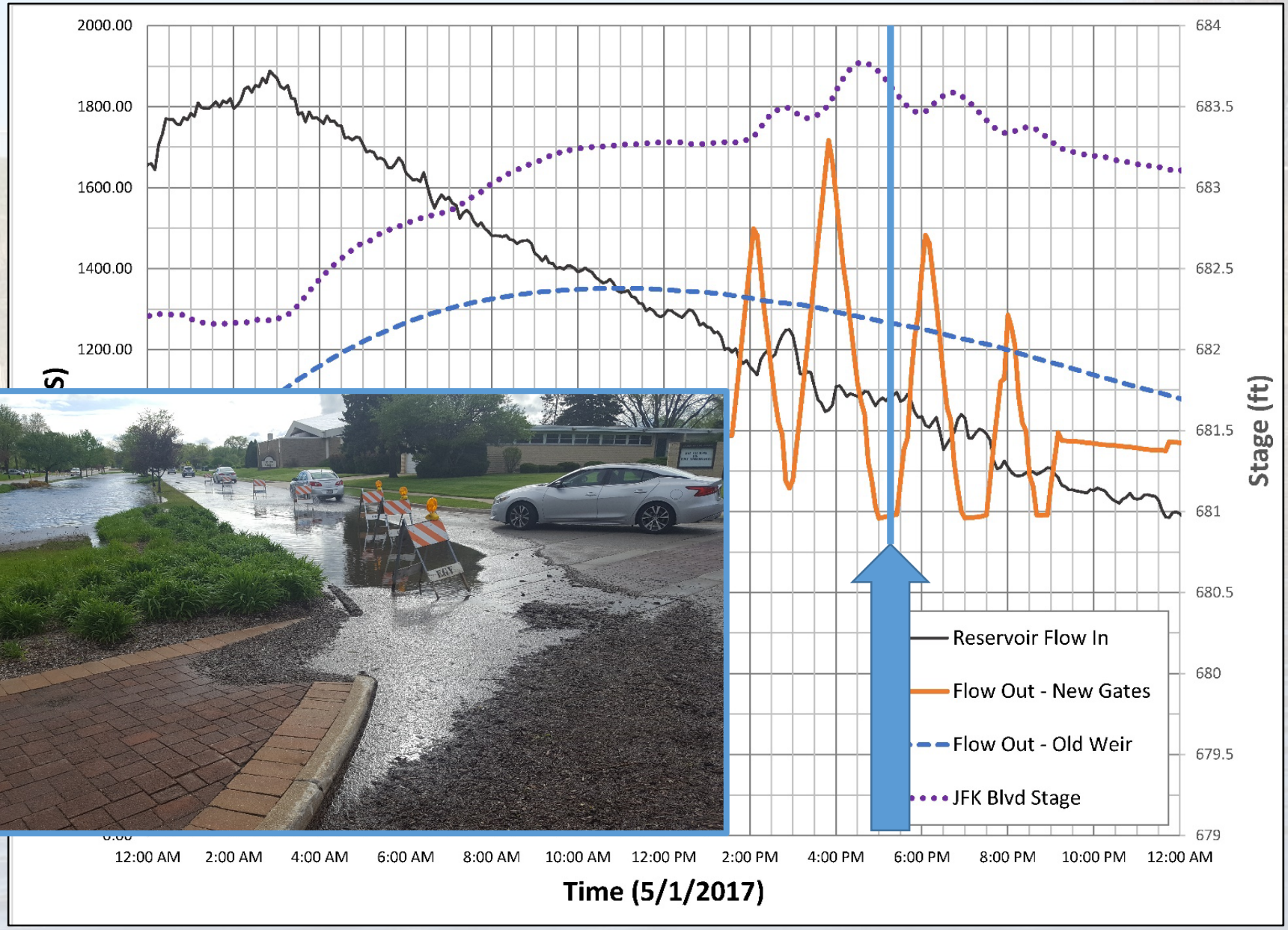


First Level 5 Operation-2017

WBK engineering



Level 5 Operation 2018

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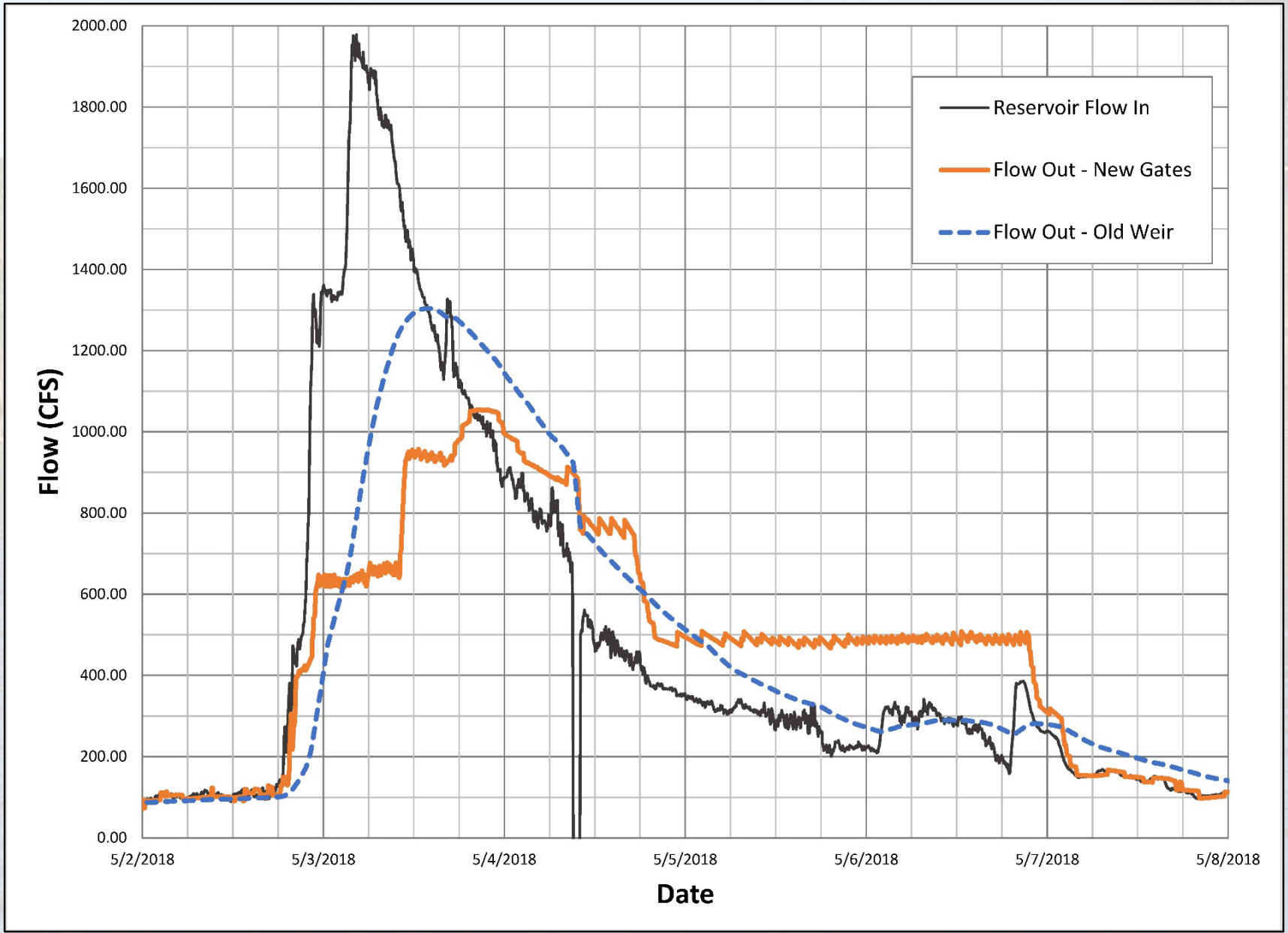

Lessons Learned

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The Three-Year take aways

- We can improve on earlier thinking in flood mitigation strategy.
- Need to translate rules from available data into physical and practical consequence
- Communication and translation between rules and PLC program
- Stay curious about rules
- Coordination between operations and maintenance
- It’s mechanical – things will break!

Future World—*AI in flood control*

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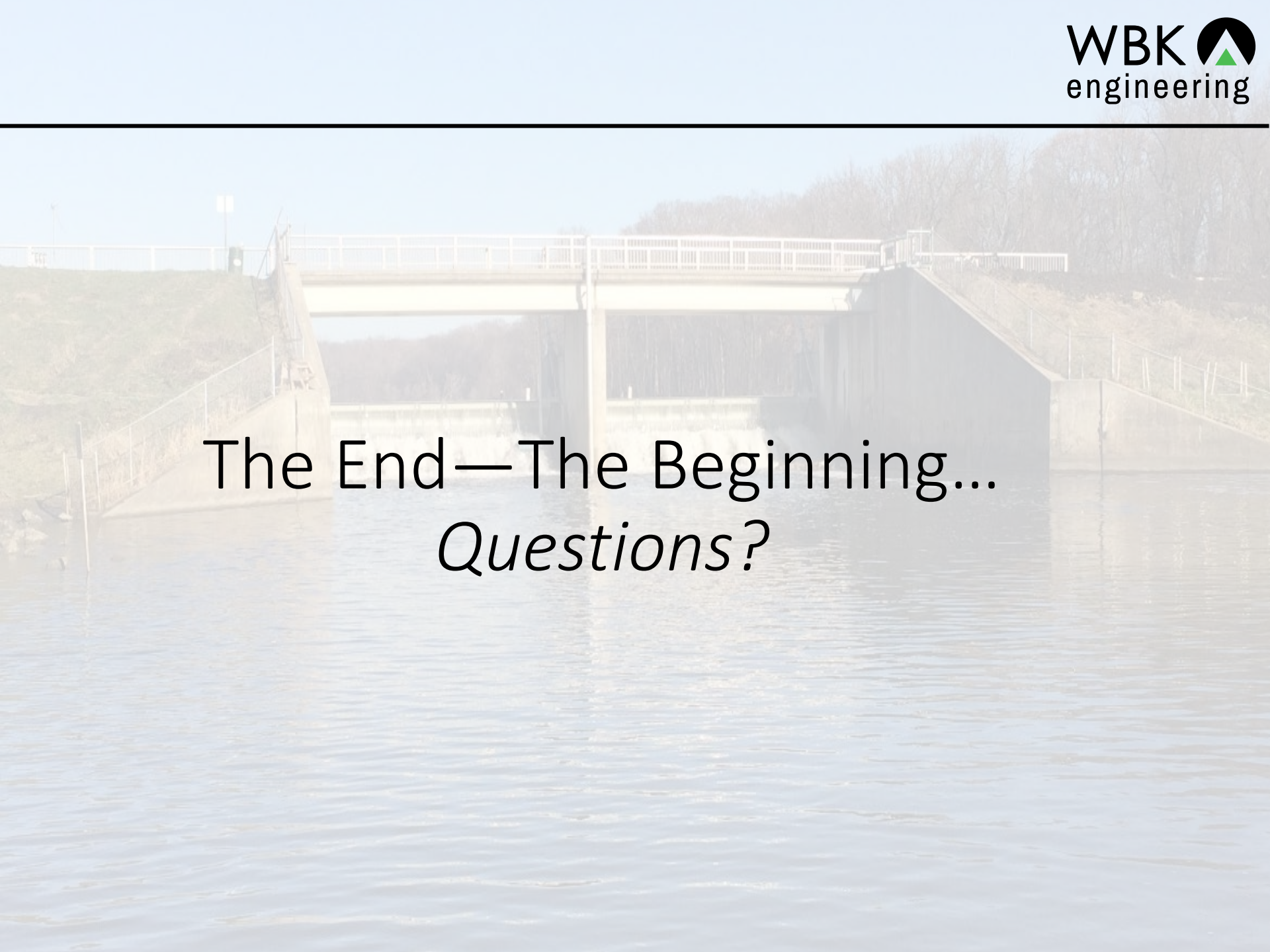
Reactive Systems

- Data Driven
- Rule Bound

Predictive Application

- Mining Weather Data
  - Rain cell change and movement
  - Hydrologic model to convert to runoff-inflow hydrograph
- Multiple reactive schemes as a first step
- Feedback loop and learning



The End—The Beginning…
Questions?