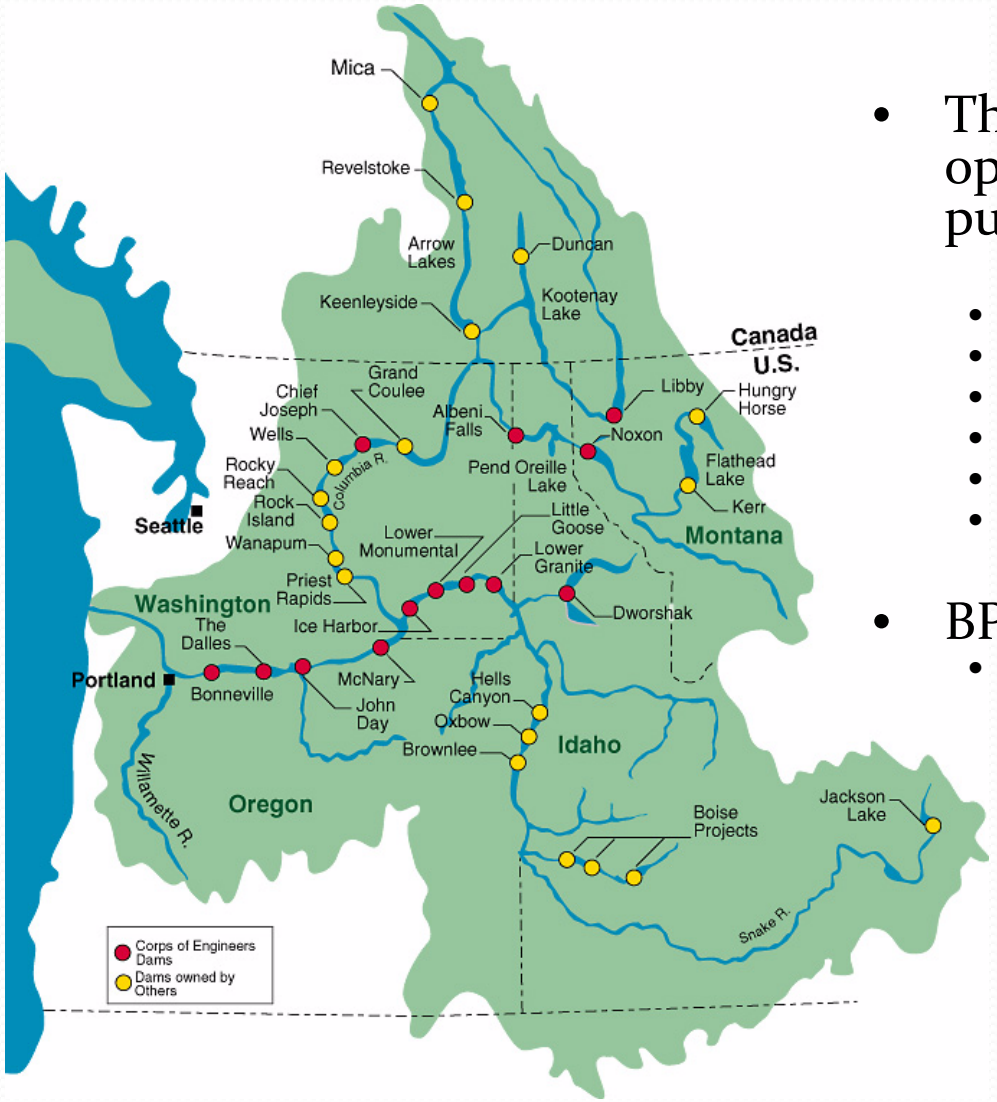
Operational Scheduling on the Columbia River

Anna Stermer
Bonneville Power Administration
February 1, 2018

Federal Columbia River Power System



- The Corp and the Bureau own and operate the federal dams for multiple public purposes:
  - Flood Control
  - Navigation
  - Fish protection operations
  - Irrigation
  - Recreation
  - Power production
- BPA's Role
  - Markets the power produced from the federal dams within the constraints and requirements for other river purposes

How RiverWare is used at BPA

- Realtime Operations
  - Studies run using the Rule Based Simulator
  - Model operations for current day (possibly a couple days)
- ShortTerm Planning
  - All studies run using the Optimizer
  - Planning Study
    - Expected case for next 2-3 weeks
    - Options to do alternative min/max studies as well
  - Capacity and Light Load Hour Studies
    - Single day studies 1-4 days into future pushing operations to limits
    - Used to provide guidance to marketing group for trading

Benefits of RiverWare for Realtime

- Quickly verify plan or see flaws with plan
- Communication tool between Schedulers
  - Provide plan across shift transitions
  - Very useful for special operations that require multiple shifts to position reservoirs
  - Helps ensure special operations aren't missed in plan
- Ability to do "what-if" scenarios for different marketing options
- Exploring use of Optimizer

Benefits for ShortTerm Planning

- Visibility into Optimizer and goal priority order
  - Ability to change order
- Hourly model that can capture details of special operations and demonstrate issues that may arise
- Allows us to fulfill requirements to provide hourly model results (forecasted generation and capacity)
- Demonstrate when operational constraints are in conflict
- Support and quick turn around for production issues

Benefit to BPA – Foresight to better plan reservoir operations and avoid spill

Lower Granite

Little Goose

Lower Monumental

Ice Harbor

Lower Snake Operations

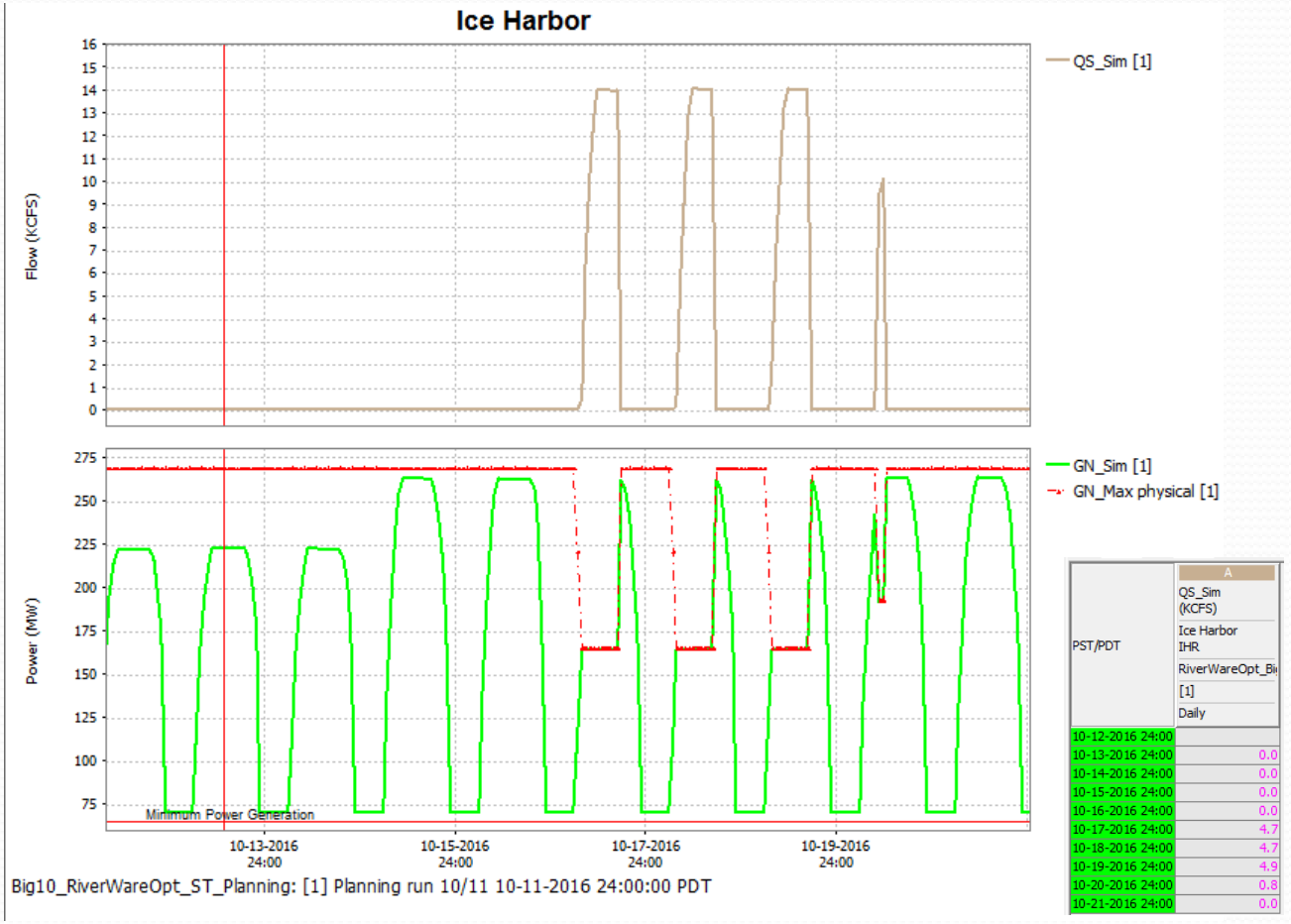
- Relatively small projects with limit storage
- Short (1 hr) travel time between projects
- When conditions allow, operators tend to shape projects with generation on HLH, drafting during the day and refilling over night.
- On a planning basis we try to provide a smooth and predictable operation to help support our obligations to provide data to downstream consumers (Slice)

“Standard” operation shows spill

Ice Harbor had daily outages which limited the max generation Oct 17-19.

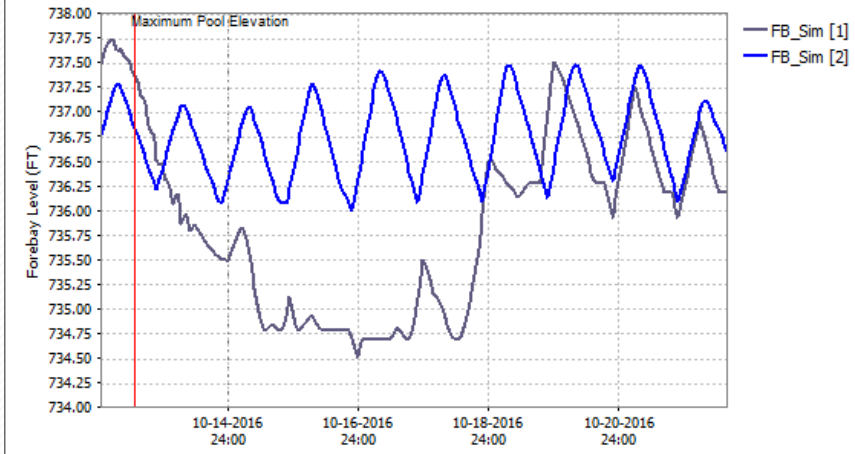
Using the normal modeling process for operations, this resulted in spill.

Using the RiverWare model, this spill was obvious a week in advance, giving us time to come up with a better plan.



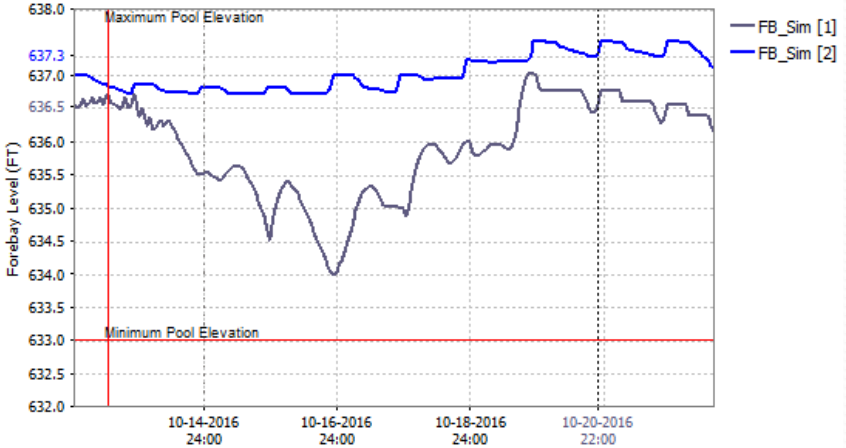
Blue = Original Run Black = Revised Run

Lower Granite



Big10_RiverWareOpt_ST_Planning: [1] Planning run 10/14 10-14-2016 24:00:00 PDT
Big10_RiverWareOpt_ST_Planning: [2] Planning run 10/11 10-11-2016 24:00:00 PDT

Little Goose



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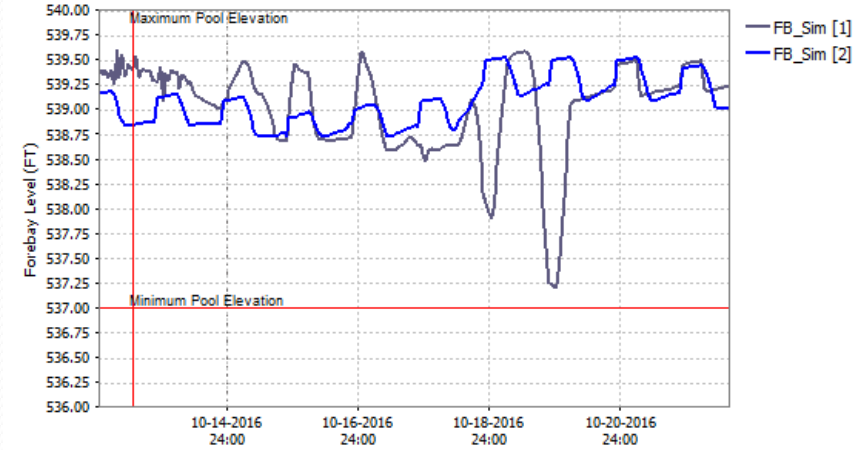
Lower Monumental



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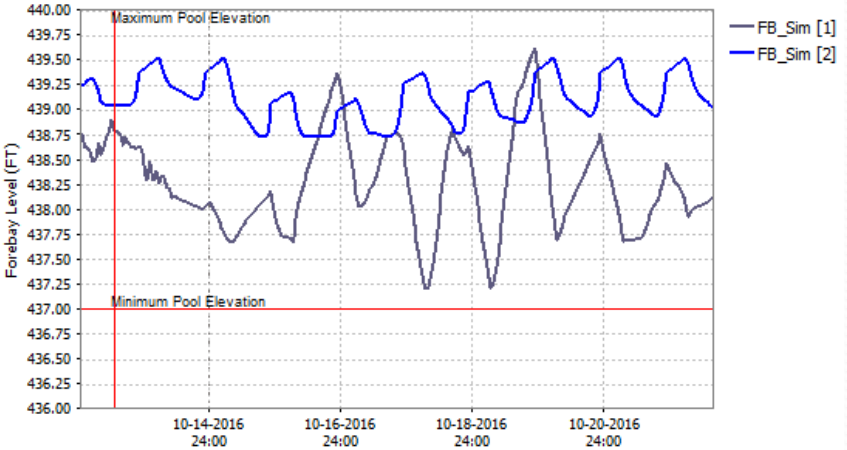
Ice Harbor



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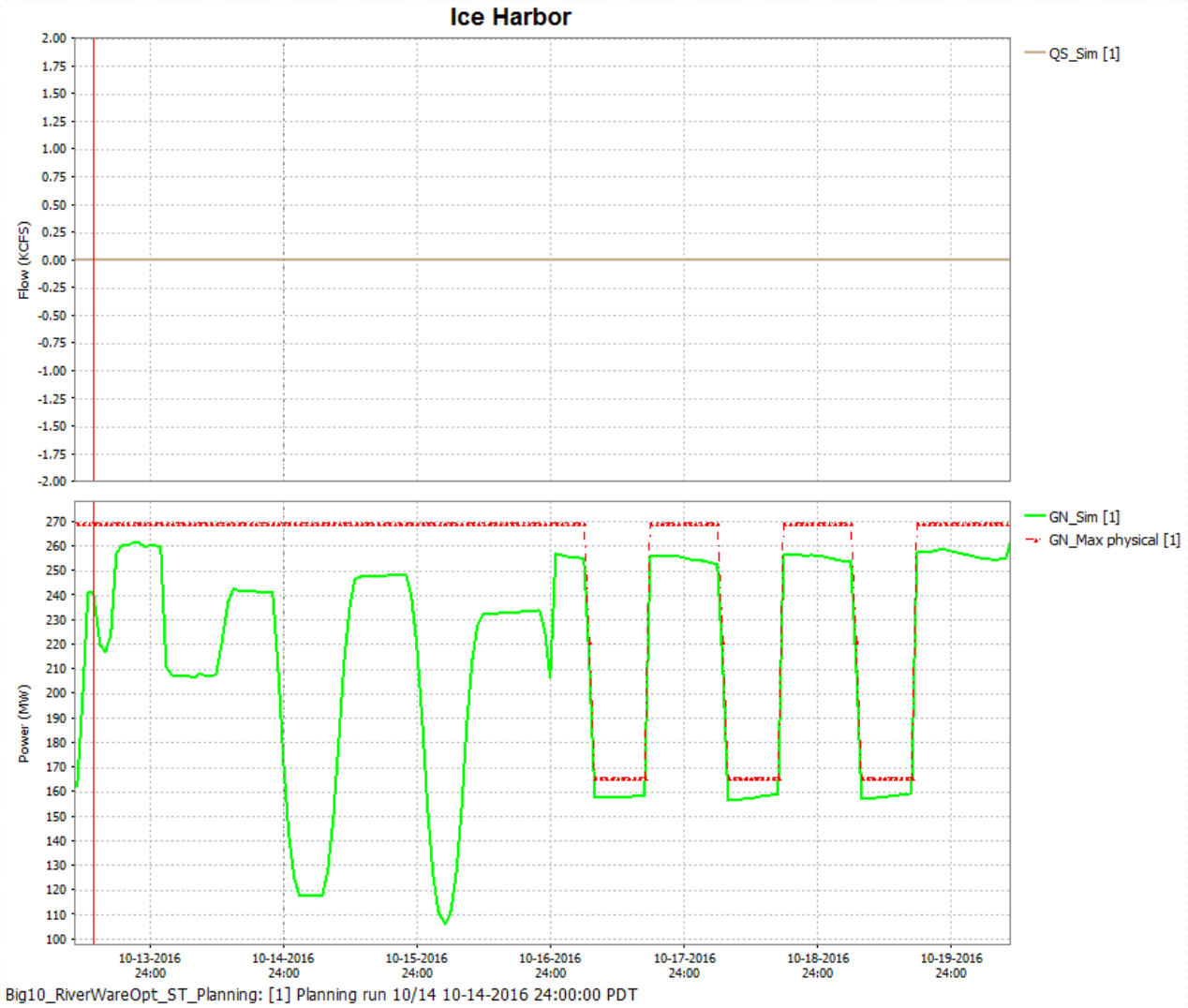
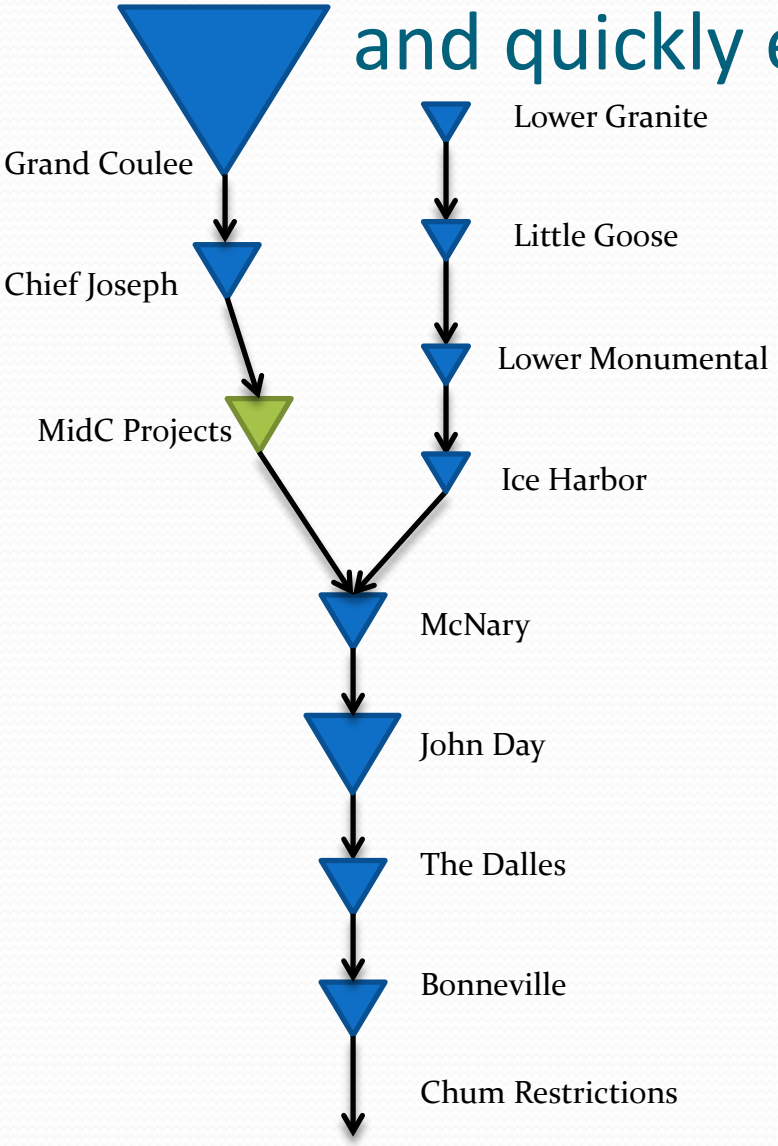
Revised operation avoids all spill at Ice Harbor



How RiverWare Helped

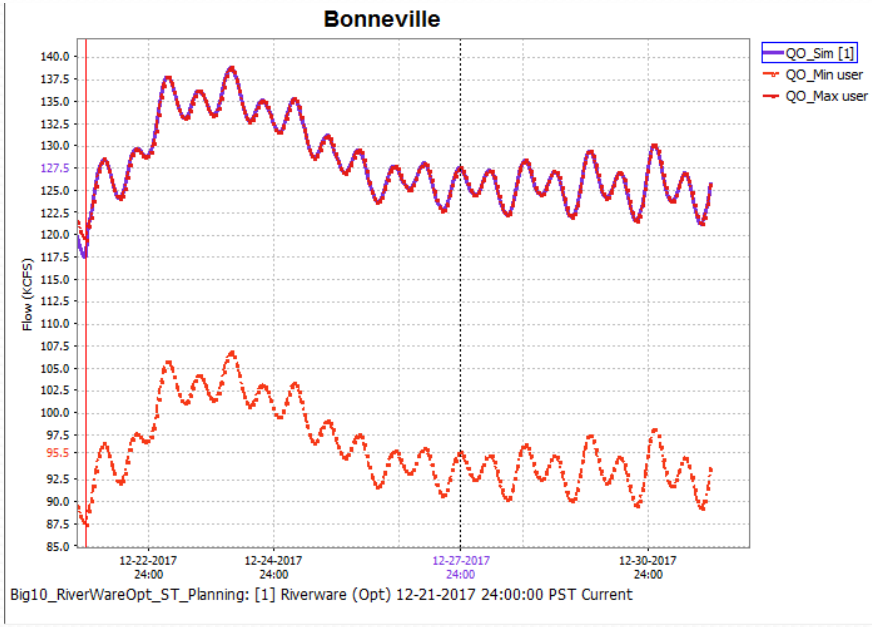
- Having a hourly model for the next two weeks makes it easy to spot issues while there is still time to act
- RiverWare gave duty schedulers a clear display of potential problem and allowed them a tool to find solution
- Using the RBS model, a duty scheduler was able to enter Forebay requests to guide the projects through an operation that would eliminate spill at Ice Harbor.
  - Clear communication tool across shifts
  - “Proof” that the plan would work
- Given initial estimate of spill, foresight and better planning saved $125k.

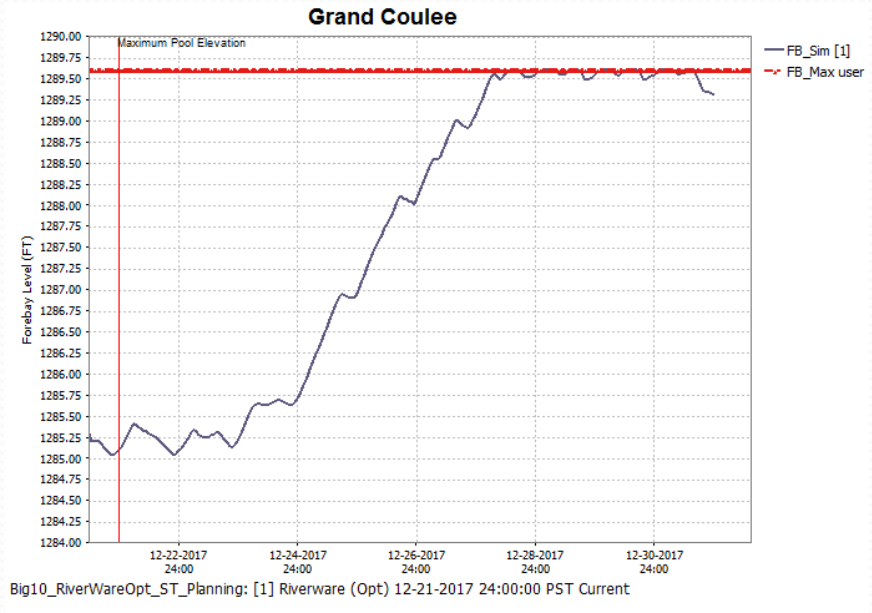
Benefit to BPA – Ability to see pinch points and quickly evaluate changing conditions



Operating Grand Coulee to manage flows below Bonneville

- During November – Late December Chum are spawning below Bonneville dam
- Chum protection level based on max tailwater level during spawning period, this becomes minimum Bonneville tailwater until April 10
- Grand Coulee is main storage reservoir on our system
- Grand Coulee fills in an attempt to keep Chum protection level as low as possible, but often these end up in conflict
- Complicating factors:
  - Outflow/tailwater relationship varies
  - Incremental flows and Snake River flows can change daily and affect how much Grand Coulee can discharge


Bonneville
Flow (KCFS)
140.0
137.5
135.0
132.5
130.0
127.5
125.0
122.5
120.0
117.5
115.0
112.5
110.0
107.5
105.0
102.5
100.0
97.5
95.5
92.5
90.0
87.5
85.0
12-22-2017 24:00
12-24-2017 24:00
12-27-2017 24:00
12-30-2017 24:00
QO_Sim [1]
QO_Min user
QO_Max user
Big10_RiverWareOpt_ST_Planning: [1] Riverware (Opt) 12-21-2017 24:00:00 PST Current


Grand Coulee
Maximum Pool Elevation
Forebay Level (FT)
1290.00
1289.75
1289.50
1289.25
1289.00
1288.75
1288.50
1288.25
1288.00
1287.75
1287.50
1287.25
1287.00
1286.75
1286.50
1286.25
1286.00
1285.75
1285.50
1285.25
1285.00
1284.75
1284.50
1284.25
1284.00
12-22-2017 24:00
12-24-2017 24:00
12-26-2017 24:00
12-28-2017 24:00
12-30-2017 24:00
FB_Sim [1]
FB_Max user
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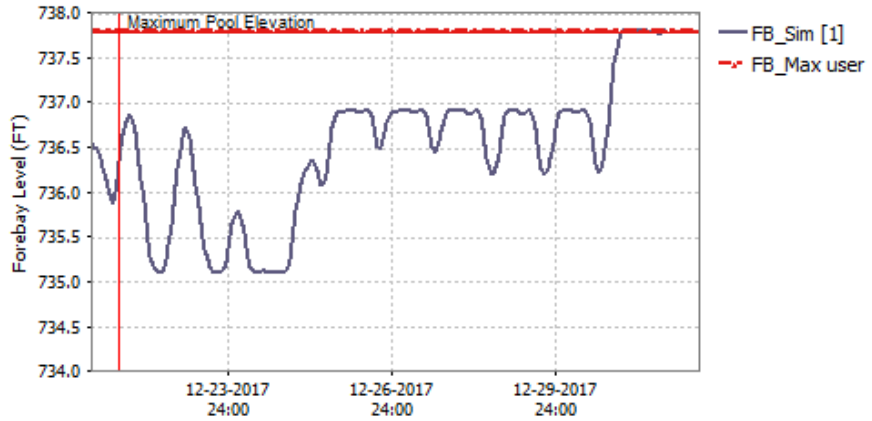
Lower Granite



Big10_RiverWareOpt_ST_Planning:
[1] Riverware (Opt) 12-21-2017 24:00:00 PST Curren

Little Goose

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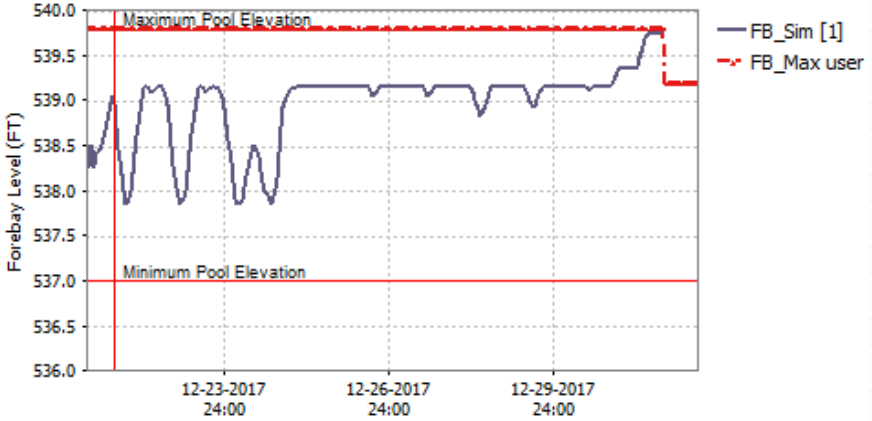
Lower Monumental



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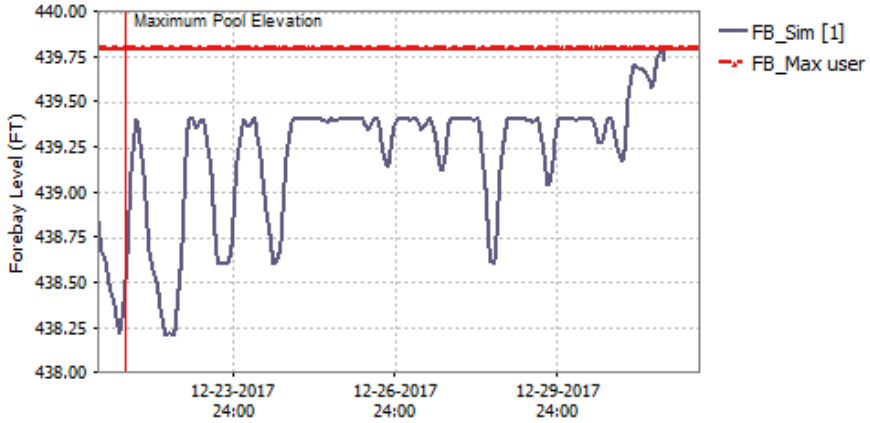
Ice Harbor



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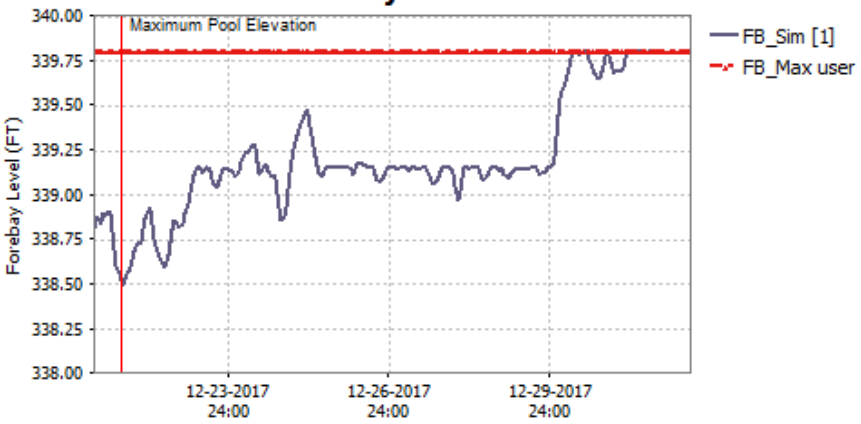
McNary



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John Day

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The Dalles

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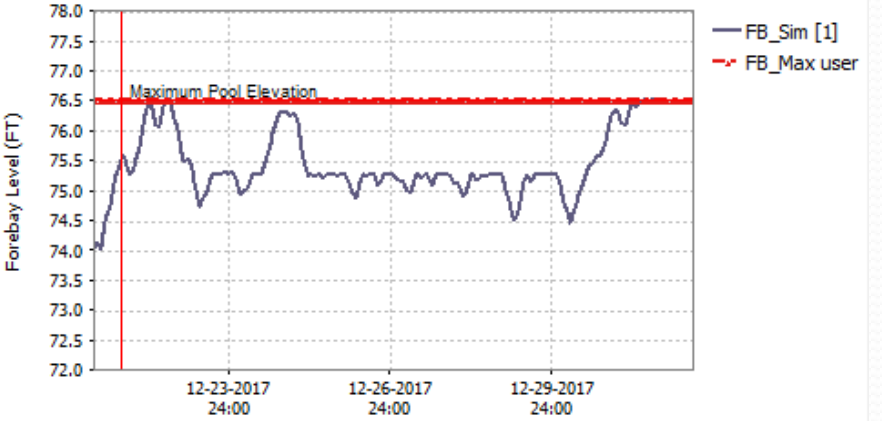
Bonneville



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How RiverWare helps

- Easily see pinch points and affects of relaxing constraints slightly (or more than slightly)
- Quickly update our studies each day as conditions change
- By planning ahead we can minimize magnitude of violations by spreading them out over a longer period
- More confidence in decisions/plans

Questions?