

Clark Fork Hourly Operations

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AVISTA

Riverside Technology, inc.

Introduction



 **Riverside Technology, inc.**

Introduction



Noxon Rapids Dam



Introduction



Cabinet Gorge Dam



Project Goals

Planning tool to grade alternative operations

Avista plans big upgrade at Noxon dam

Four generators will get new turbine runners in \$35 million project

[Journal of Business](#), [May 29, 2008](#) by [Ripley, Richard](#)

Project Goals

Planning tool to grade alternative operations

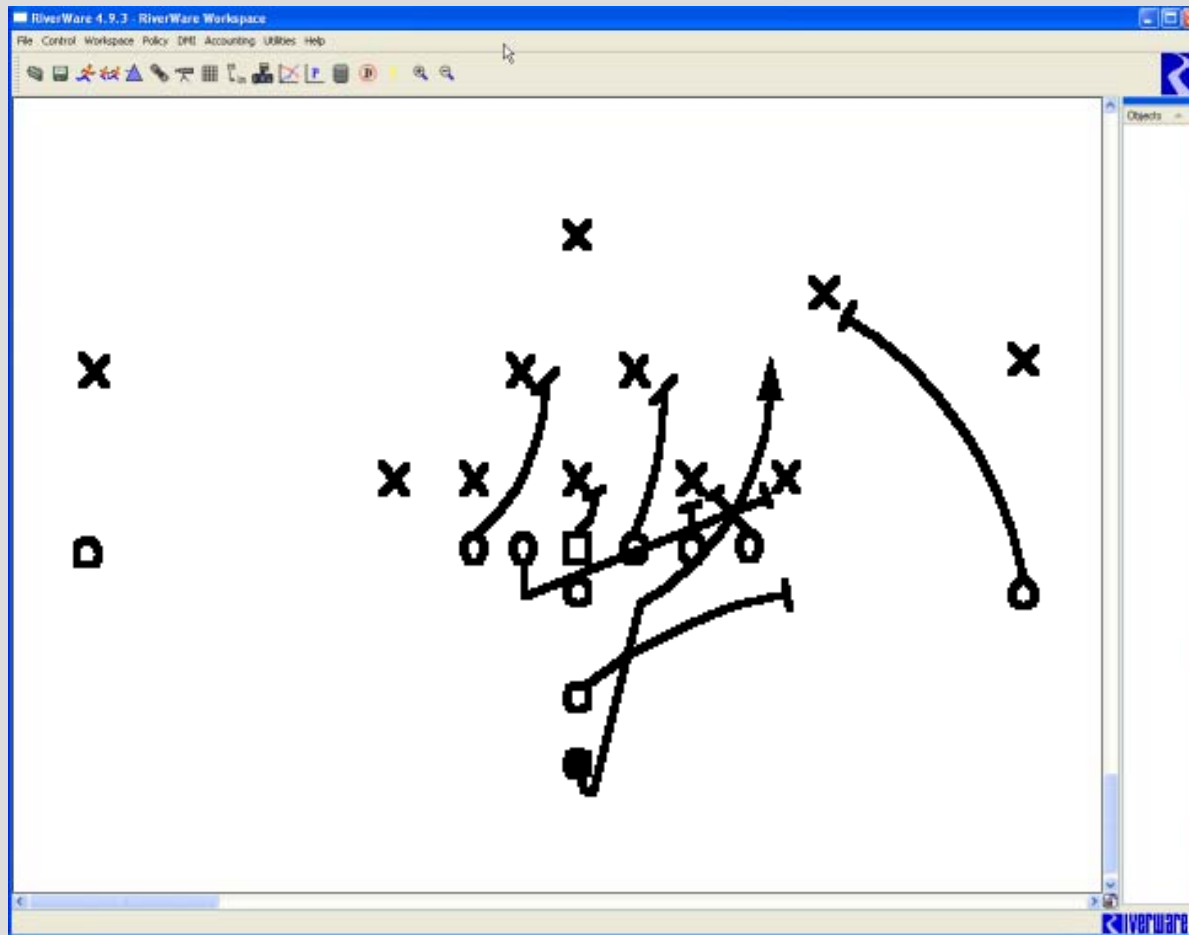
- Provide realistic hourly operation
- Model turbine capacity changes
- Construction times versus cost
- Model pool elevation changes
- Retain sufficient simplicity avoiding the need for ongoing consultant expertise
- Look forward to optimization

Approach—Phases

- Review and Strategic Design

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- Review and Strategic Design



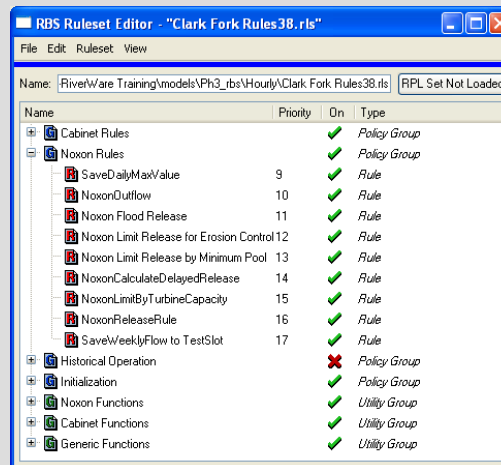
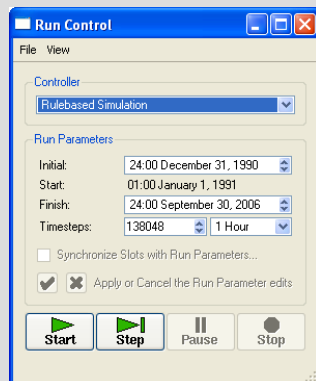
Approach—Phases

- Review and Strategic Design
- Collaborative Development



Approach—Phases

- Review and Strategic Design
- Collaborative Development
- Model Enhancement and Support



Open Object - Noxon Rapids dialog box showing a table of slot names, values, and units. The table includes slots like 'Best Hydro Capacity', 'Canal Flow', 'Convergence', 'Diversion', etc.

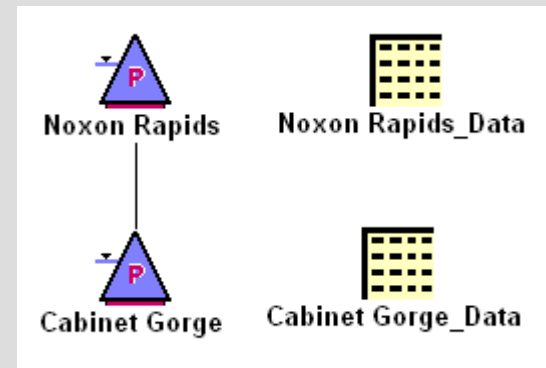
Slot Name	Value	Units
Best Hydro Capacity	NaN	MW
Canal Flow	NaN	cfs
Convergence		
Diversion	NaN	cfs
Diversion Capacity	NaN	cfs
Elevation Volume Table		
Energy	NaN	MW/H
Flow FROM Pumped Storage	NaN	cfs
Flow TO Pumped Storage	NaN	cfs
Hydro Capacity	NaN	MW
Inflow	0.00	cfs
Max Iterations		
Minimum Power Elevation		
Operating Head	NaN	ft
Outflow	0.00	cfs
Plant Power Limit	NaN	MW
Plant Power Table		
Pool Elevation	2330.25	ft
Power	NaN	MW
Power Coefficient	NaN	MW/cfs
Power Curvature Tolerance	NaN	NONE
Power Plant Cap Fraction	NaN	decimal
Regulated Spill	NaN	cfs
Regulated Spill Drift Index	NaN	NONE
Regulated Spill Index Table		
Regulated Spill Table		
Return Flow	NaN	cfs
Spill	NaN	cfs
Storage	113300.00	cfs-day
Tailwater Base Value	2172.70	ft
Tailwater Elevation	NaN	ft
Stage Flow Tailwater Table		
Total Inflows	NaN	cfs
Tail Water Reference Elevation		
Turbine Release	NaN	cfs

Model Design

- Simulation Model
- Physical and operational constraints
- Power market
- Rule development
- Model results

Simulation Model

- Match physical and historical operations
 - Hourly operation – 16 years of data
 - Cabinet pool elevation affects tailwater of Noxon Rapids
 - Power operation at both locations using plantEfficiencyCurve
 - Rulebased Simulation



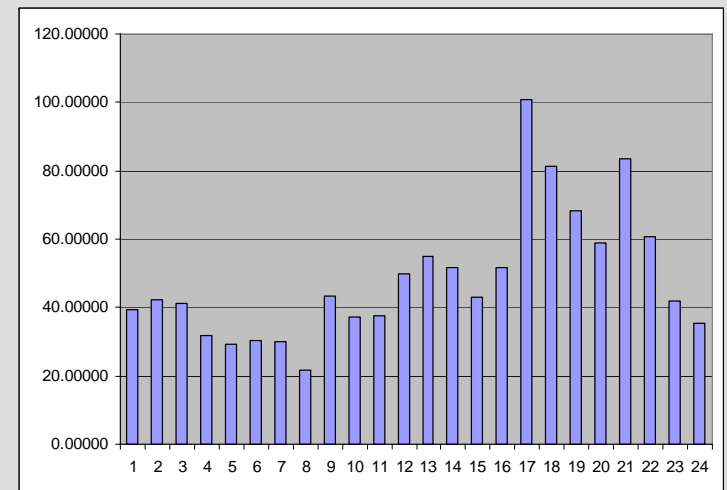
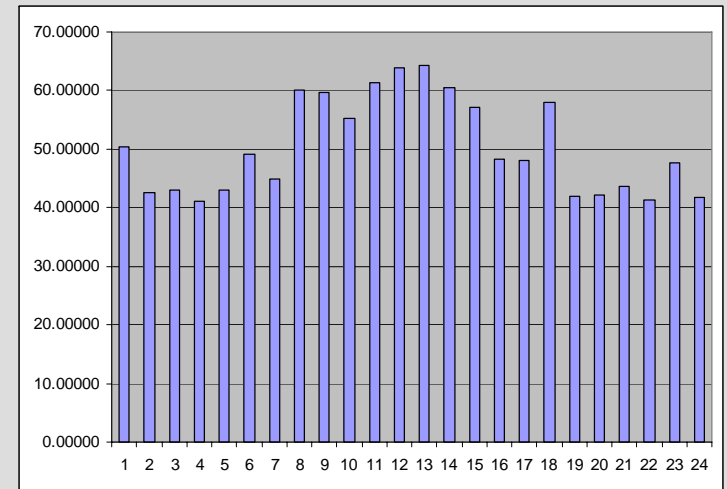
Constraints

- Erosion control
 - Cannot decrease pool more than 2 ft / day or 5 ft / week
- Turbine capacity
 - Available capacity can change based on construction schedule
- Maximum/Minimum Pool Elevation
- Minimum stream flow below Cabinet

Power Market

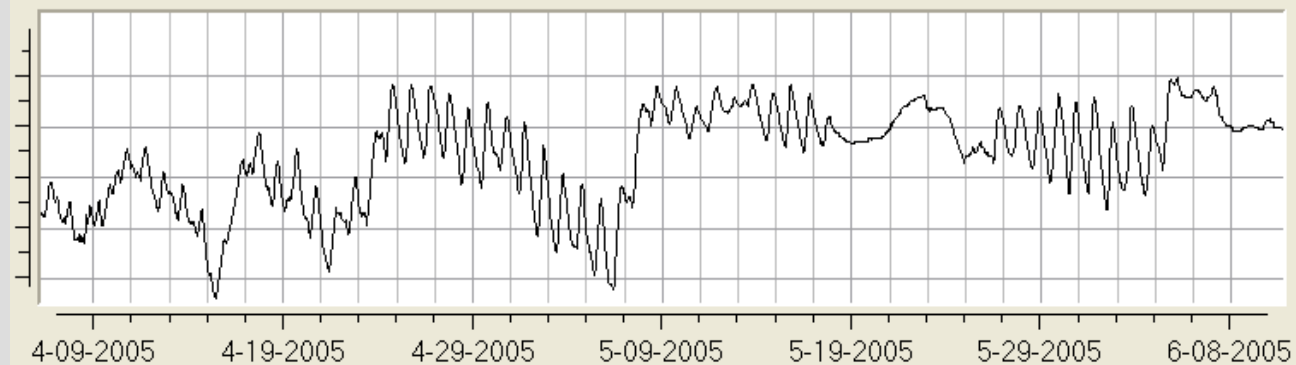
- Hourly fluctuation in prices based on
 - Temperature
 - Day of week
 - Time of day
 - Season
 - External factors
- Operate to maximize benefit of hydropower
- Hourly prices could be used with optimization

Relative Prices per Hour
Spring and Summer Days



Power Releases

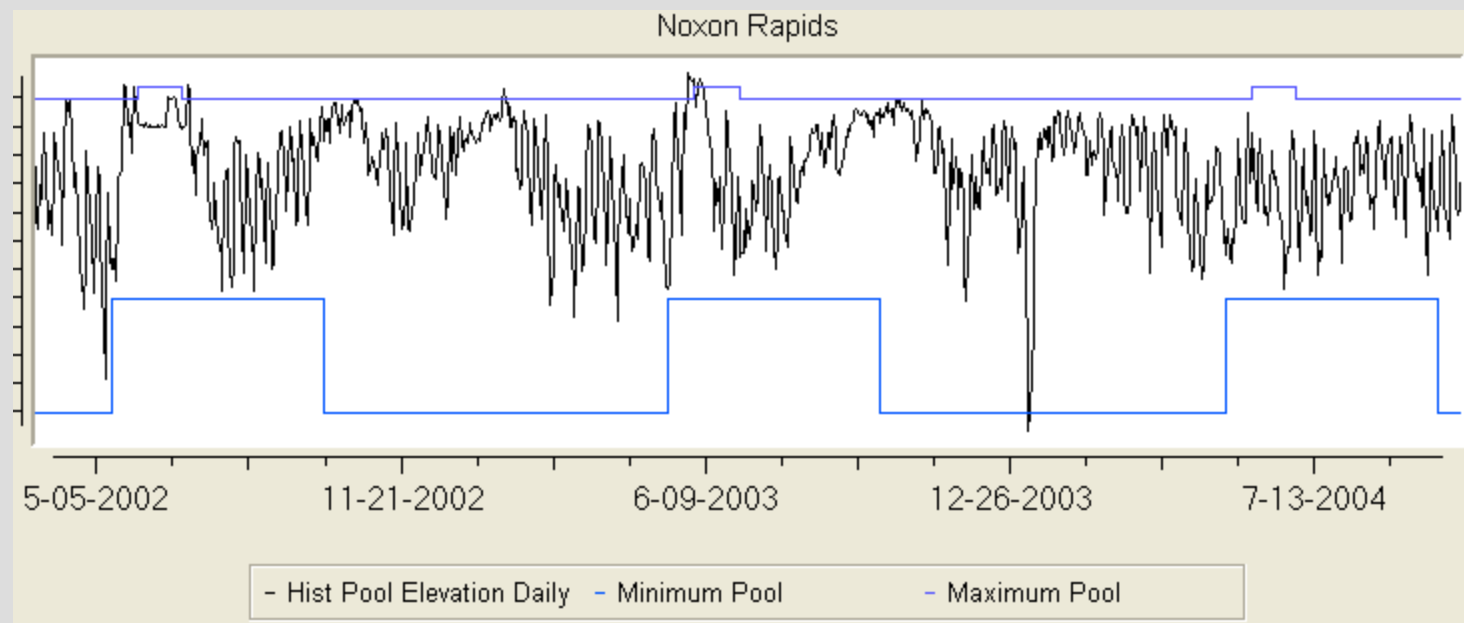
- Correlation between releases and the hourly power price was low
 - Total water available
 - Physical constraints, such as starting or stopping individual units



- Noxon Rapids_Data.Pool Elevation

Pool Limits

- Maximum / Minimum
 - Provided as a seasonal pattern (periodic)
 - Particularly helpful for maximum storage
 - Provided limits for the release rule



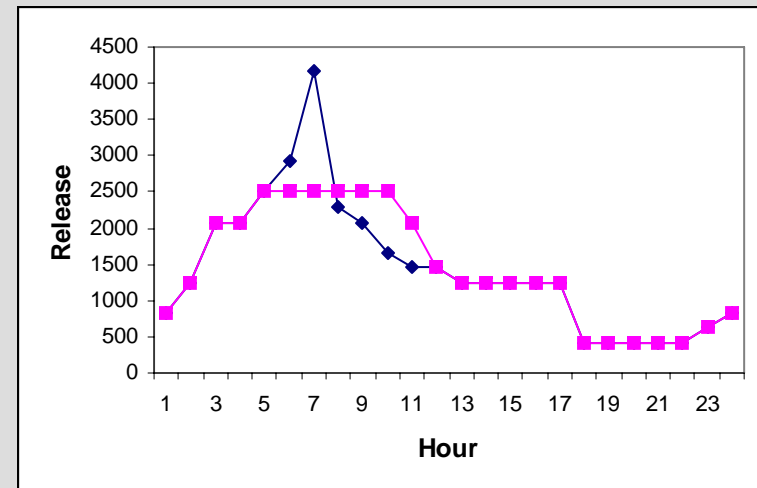
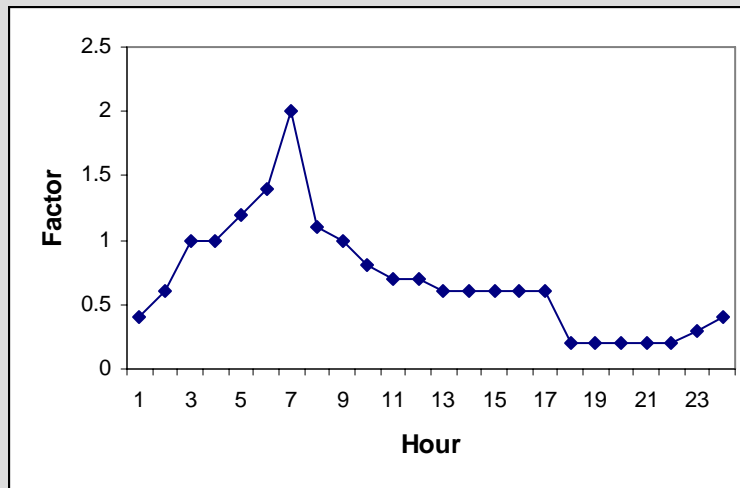
Typical Release

- Release is a function of:
 - Weekly inflow
 - Date
 - Turbine capacity
 - Minimum pool
 - Maximum pool
 - Erosion limits
 - Minimum release

Name	Priority	On	Type
[-] Cabinet Rules		✓	Policy Group
[-] CabinetOutflow	1	✓	Rule
[-] Cabinet Minimum Outflow	2	✓	Rule
[-] Cabinet Flood Release	3	✓	Rule
[-] Cabinet Limit Release by Minimum Pool	4	✓	Rule
[-] CabinetCalculateDelayedRelease	5	✓	Rule
[-] CabinetLimitByTurbineCapacity	6	✓	Rule
[-] CabinetReleaseRule	7	✓	Rule
[-] SaveWeeklyFlow to TestSlot	8	✓	Rule
[-] Noxon Rules		✓	Policy Group
[-] SaveDailyMaxValue	9	✓	Rule
[-] NoxonOutflow	10	✓	Rule
[-] Noxon Flood Release	11	✓	Rule
[-] Noxon Limit Release for Erosion Control	12	✓	Rule
[-] Noxon Limit Release by Minimum Pool	13	✓	Rule
[-] NoxonCalculateDelayedRelease	14	✓	Rule
[-] NoxonLimitByTurbineCapacity	15	✓	Rule
[-] NoxonReleaseRule	16	✓	Rule
[-] SaveWeeklyFlow to TestSlot	17	✓	Rule
[+] Historical Operation		✗	Policy Group
[+] Initialization		✓	Policy Group
[+] Noxon Functions		✓	Utility Group
[+] Cabinet Functions		✓	Utility Group
[+] Generic Functions		✓	Utility Group

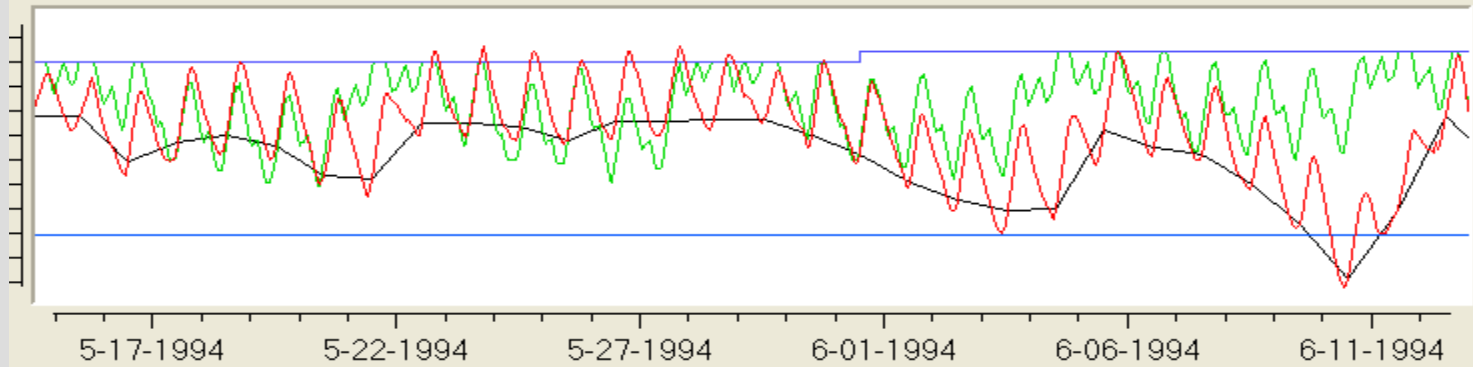
Turbine Capacities

- Reduction in turbine capacity
 - Daily release variation is maintained
 - Excess release is stored
 - Pool elevation limits are enforced

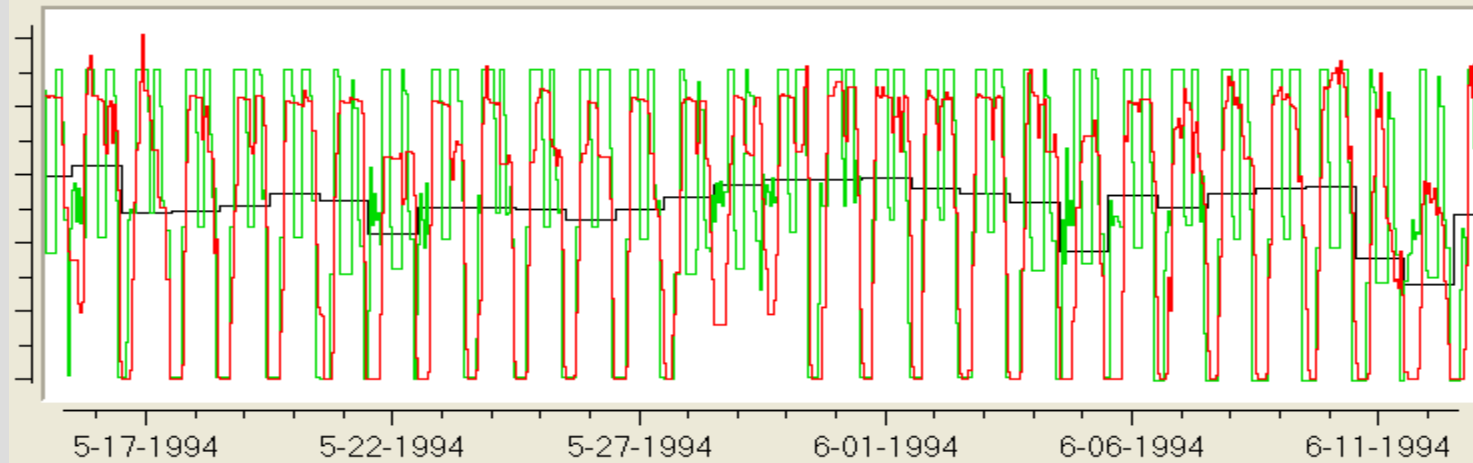


Results

Noxon Rapids



- Hist Pool Elevation Daily - Simulated Pool Elevation - Minimum Pool - Maximum Pool
- Hist Pool Elevation Hourly



- Hist Release Daily - Simulated Release - Hist Release Hourly

Conclusion

- The model and training were successfully delivered with project objectives fully met
- Avista currently runs the model
- Modeling results used for:
 - Construction / Maintenance timing
 - Estimating the benefits of planned improvements



Spokane River,
Downtown Spokane, WA

Questions?