Optimatics

optimizing water systems

City of Bend Chooses Optimized Decision Support for Master Plan Update

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Introductions

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The City of Bend

- Central Oregon, east of Cascade Mountains
- Population of ~81,000
- Explosive Growth from 1990 to 2005
- City serves approximately 60,000 residents
- Water and wastewater services

The City of Bend – Water Supply

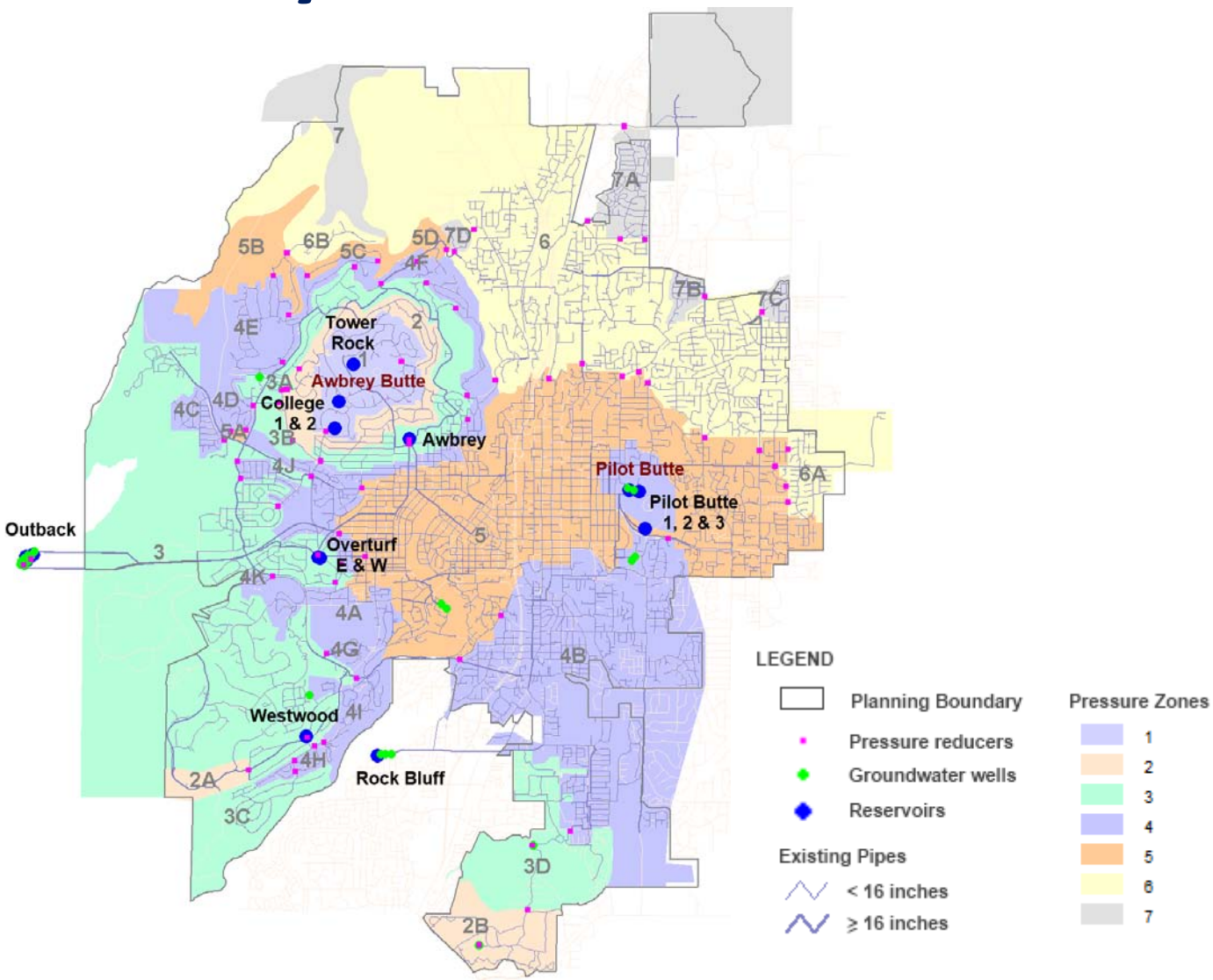
- Surface water
  - Collected 13 miles from the City limits
  - Delivered to system via the Outback facility

- Groundwater
  - Extracted from 25 wells at nine locations spread across the City

The City of Bend - Water System Facts

- 15 finished water storage reservoirs
- 6 booster pump stations
- 420 miles of mains
- 11 primary pressure zones

Bend Water System



Bend & Optimization

- City attempted coordinating a WMCP and a Water Master Plan Update in 2004
- Resulted in a good WMCP, but a weak WMP
- City did a new WMP in 2006, but had poor data to give to the consultants and many inputs from City were not coordinated with operations
- Resulted in a good WMP in 2007, but more work needed to be done

Why Optimatics vs Traditional Modeling?

- Economy crashed in 2007, resulting in much tighter budgets to perform work (SDC funds were especially hard hit)
- City needed a defensible and better decision making tool to defend needed expenditures (It needed to stand up to public scrutiny and all the what if scenarios)
- Goal was to prioritize needed CIP work and reduce needed CIP expenditures for future system improvements
- City needed to understand how the system performance changed under dynamic conditions

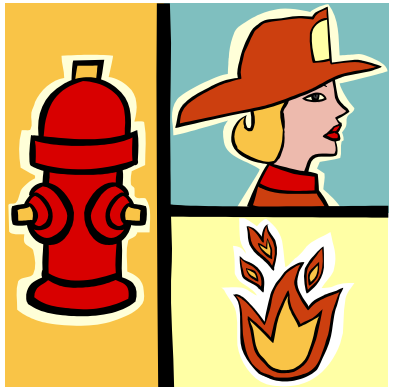
Study Scope

- Bend Water System Master Plan Update Optimization Study
  - Pipe Criticality Analysis
  - Typical Summer & Winter Operations
  - Build-out Master Plan Optimization

Pipe Criticality Analysis

Consequences of Pipe Failure

- Potential impacts include
  - Reduction in system pressure
  - Reduced fire fighting capacity
  - Loss of supply to critical customers, medical facilities, dialysis machines
  - Property damage
  - Traffic disruption
  - Safety of public and City personnel
  - Harm to reputation



Pipe Criticality Analysis – Objectives

Determine where system is vulnerable to

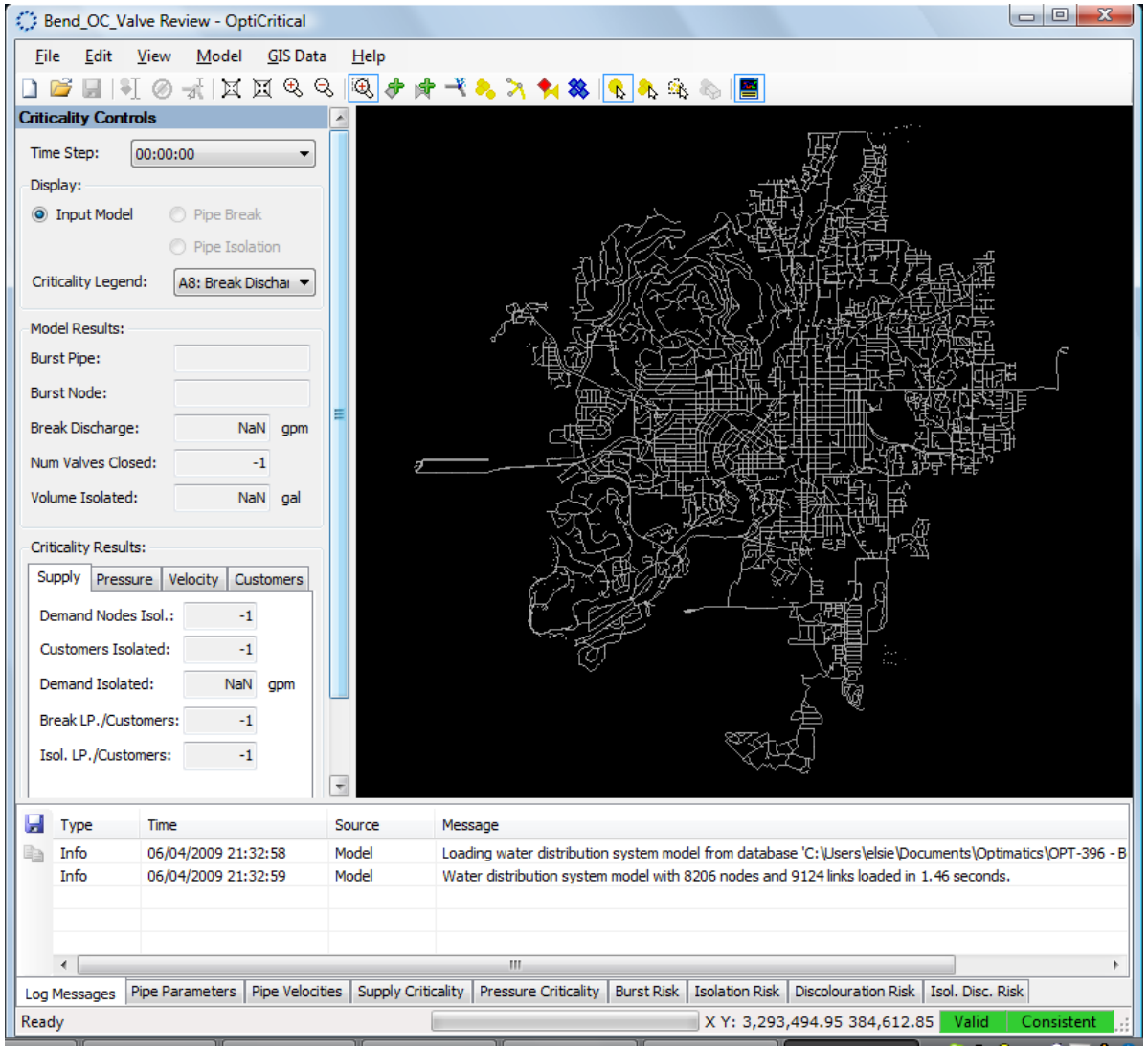
a) Pipe break events

b) Isolation of a pipe for repair

Pipe Criticality Analysis – Objectives

- Prioritize areas based on the relative impact of break or isolation events
  - Provide operators with an understanding of higher risk areas
  - Identify improvements to reduce impact

Pipe Criticality Analysis – Setup



- Updated and calibrated hydraulic model
- System shutoff valves imported (8,889 valves)
- Analysis breaks and isolates every pipe (9,980 pipes),
  - System pressures
  - Flow velocities
  - Supply to customers

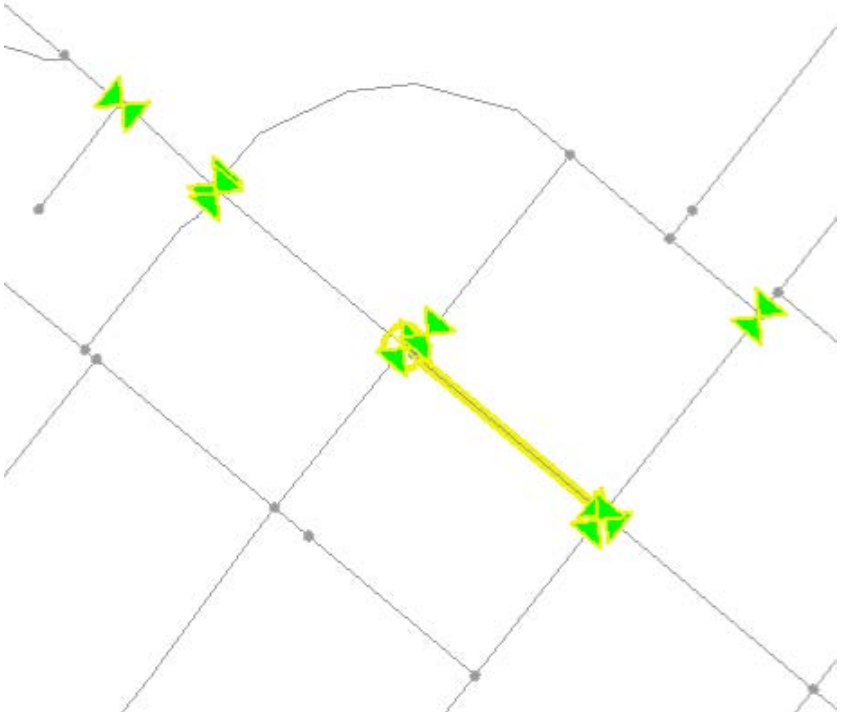
Pipe Criticality Analysis

- Most important metrics for Bend:
  - loss of supply (number customers affected)
  - hydraulic performance (low pressures)
  - maintenance (valves required to isolate a break)

- Bend system not vulnerable to water discoloration due to excessive velocities or reverse flows

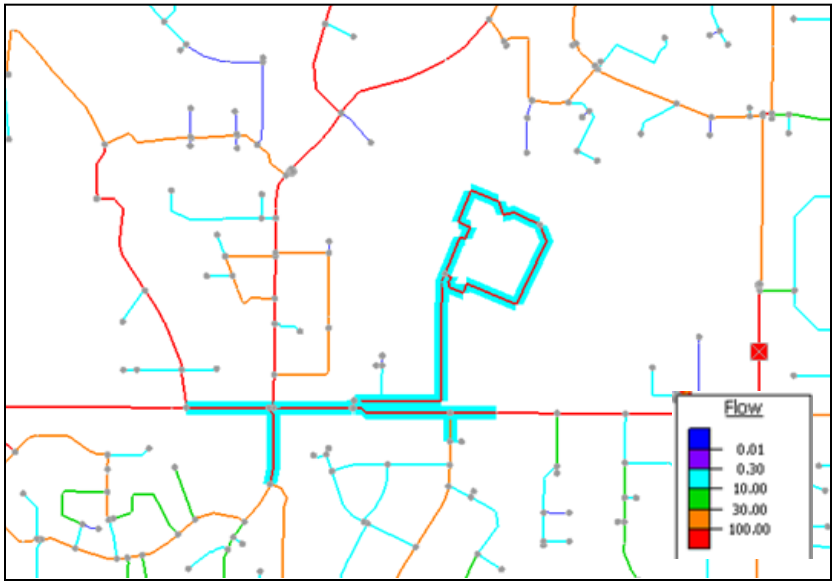
Pipe Criticality Analysis – Results

- Number of valves required to isolate break
  - 96% of the pipes in the system can be isolated by closing 4 or fewer valves
  - Two locations require 7 or 8 valves to isolate

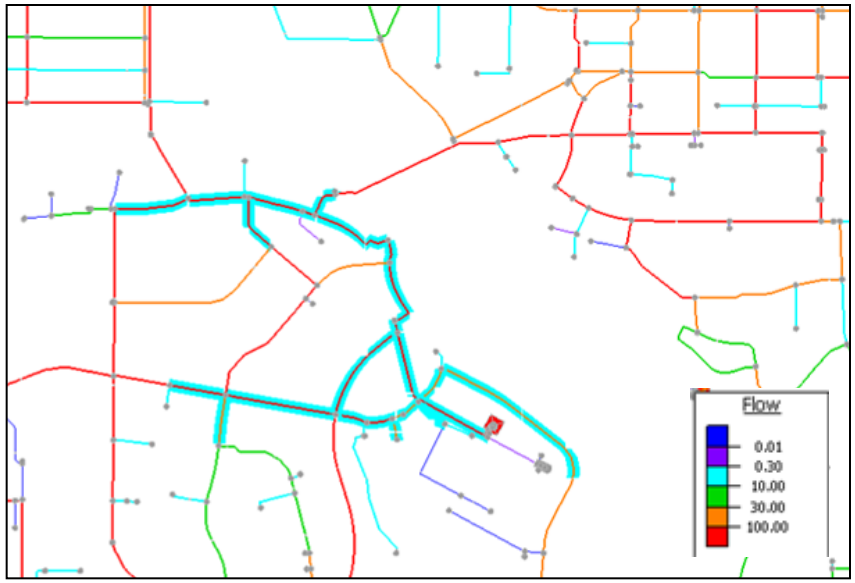


Critical Customers

- Two high risk customers identified
  - Hospital and adjacent medical area
  - Brewery (equipment relies on sustained pressure)

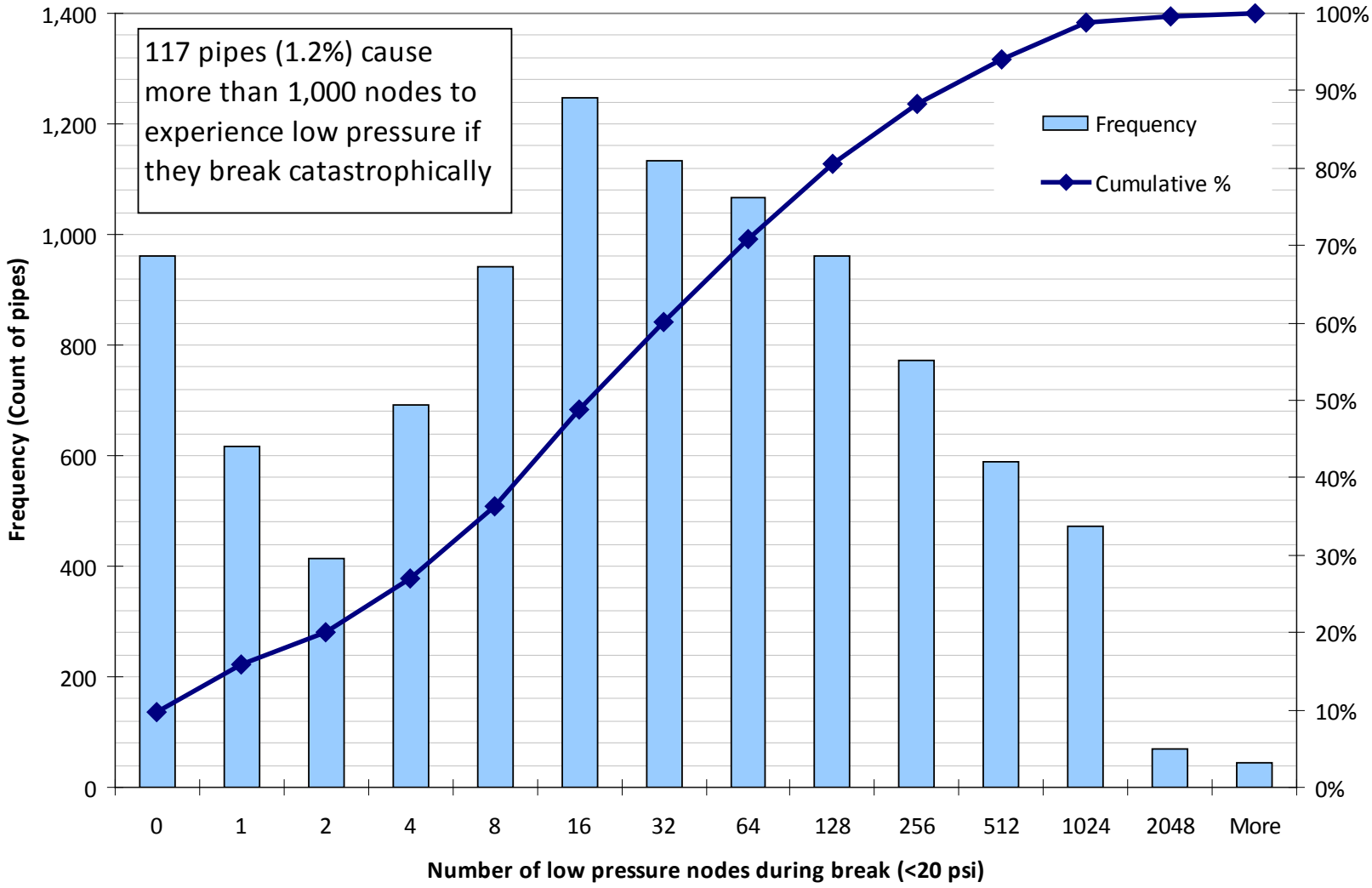


St Charles Medical Center

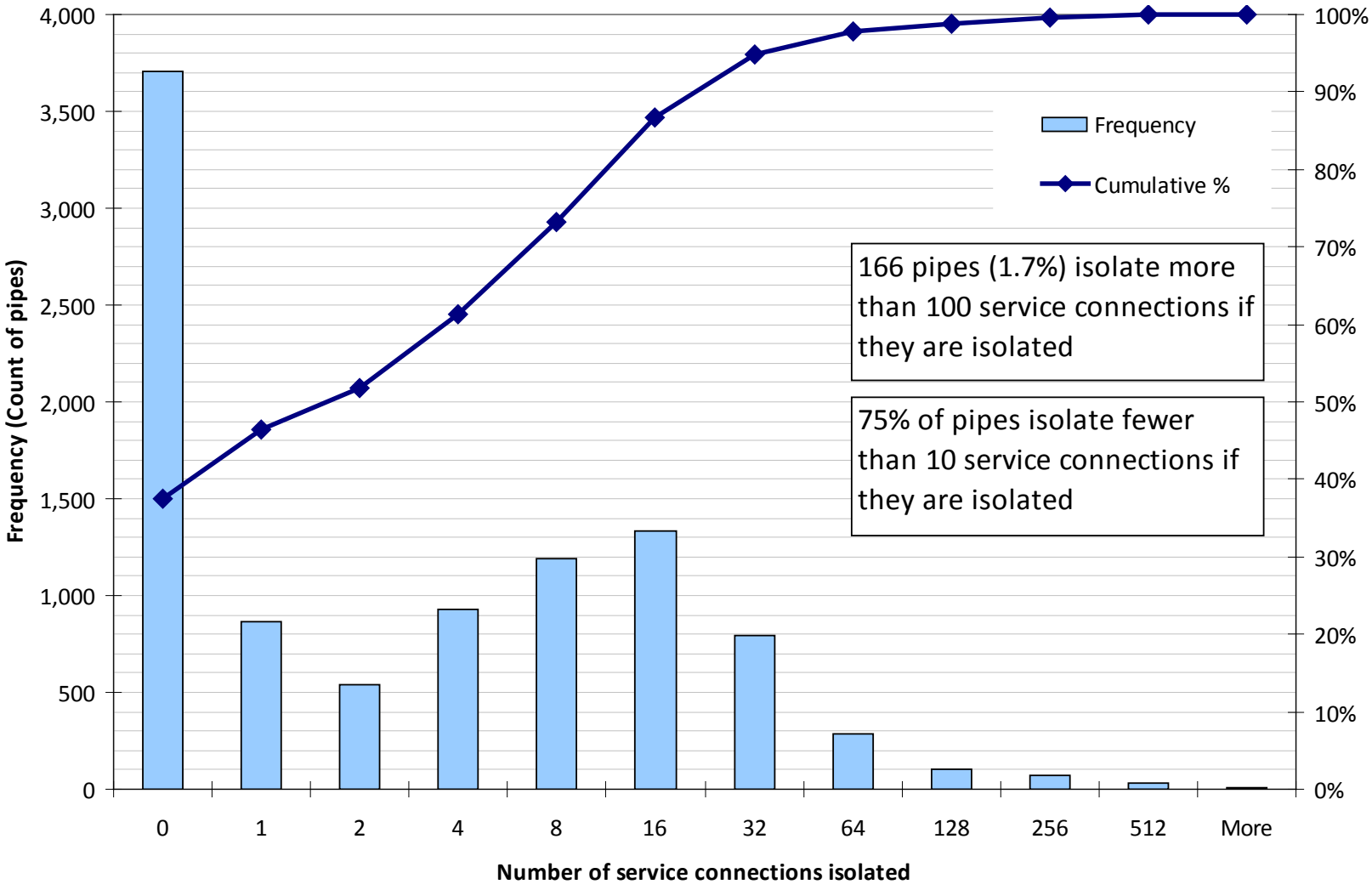


Deschutes Brewery

Low System Pressure during a break



Service Connection Isolation



Prioritization

Rank areas based on consequence of failure

Priority Number	Location	Affects St. Charles Medical Center	Affects Brewery	Low system pressure during break	# Customers isolated during break or isolation
1	Zone 5 - Medical Center	✓		✓	✓
2	Zone 5 - Key Customer		✓	✓	
3	Zone 4B - North			✓	
4	Zone 3 - South			✓	✓
5	Zone 3C			✓	✓
6	Zone 4B - South			✓	
7	Zone 3 - North				✓

OptiCritical™ – Pipe Failure Risk

PIPE FAILURE RISK

Probability

Factors input to predictive model:

- Break history
- Pipe age
- Pipe material
- Soil type
- Pressure
- Year of construction
- Location
- Ground movement

Consequence

Hydraulic Factors

- Loss of supply
- Water quality issues
- Flooding

Economic Costs

- Repair costs
- Compensation
- Fines
- Loss of reputation

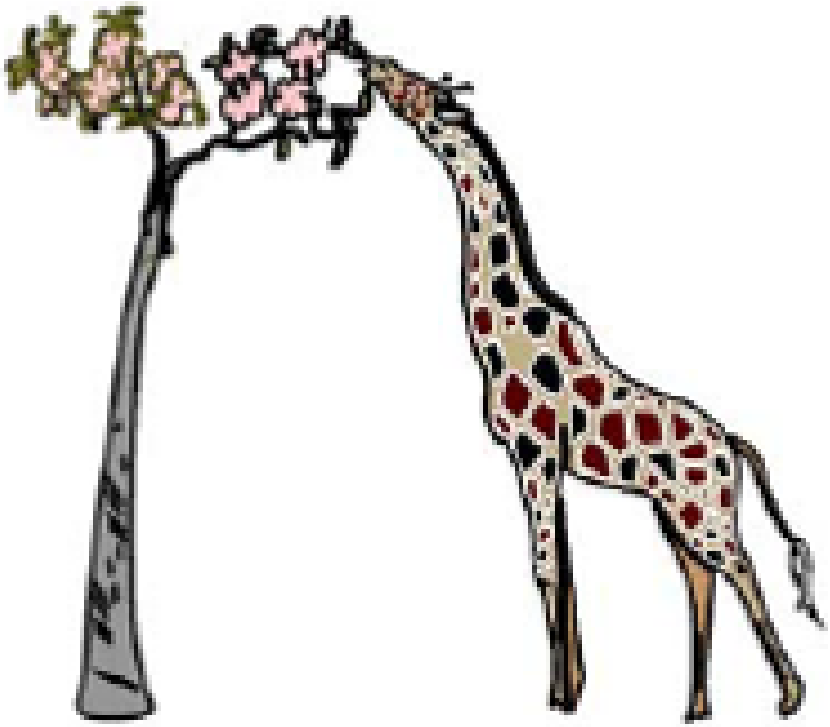
Optimization applied to Water Systems for Planning and Operations

Managing a Water Utility is Complex

Genetic algorithm optimization

Evolutionary search

Only the fittest solutions survive



Genetic algorithm optimization

Objective ?

Decisions ?

Options ?

Constraints ?

Near optimal solutions…

Seasonal Operations Optimization

Seasonal Operations Optimization

- Bend system operation varies significantly throughout the year:
  - Summer
    - Mixture of surface and groundwater supply
    - Base scenario: Calibrated July 2009 model
  - Winter
    - Primarily surface water supply
    - Base scenario: January 2009 model

Optimization Goals

- Minimize energy costs
- Summer: Maximize surface water use
- Winter: Improve reservoir turnover
- Make best use of existing infrastructure

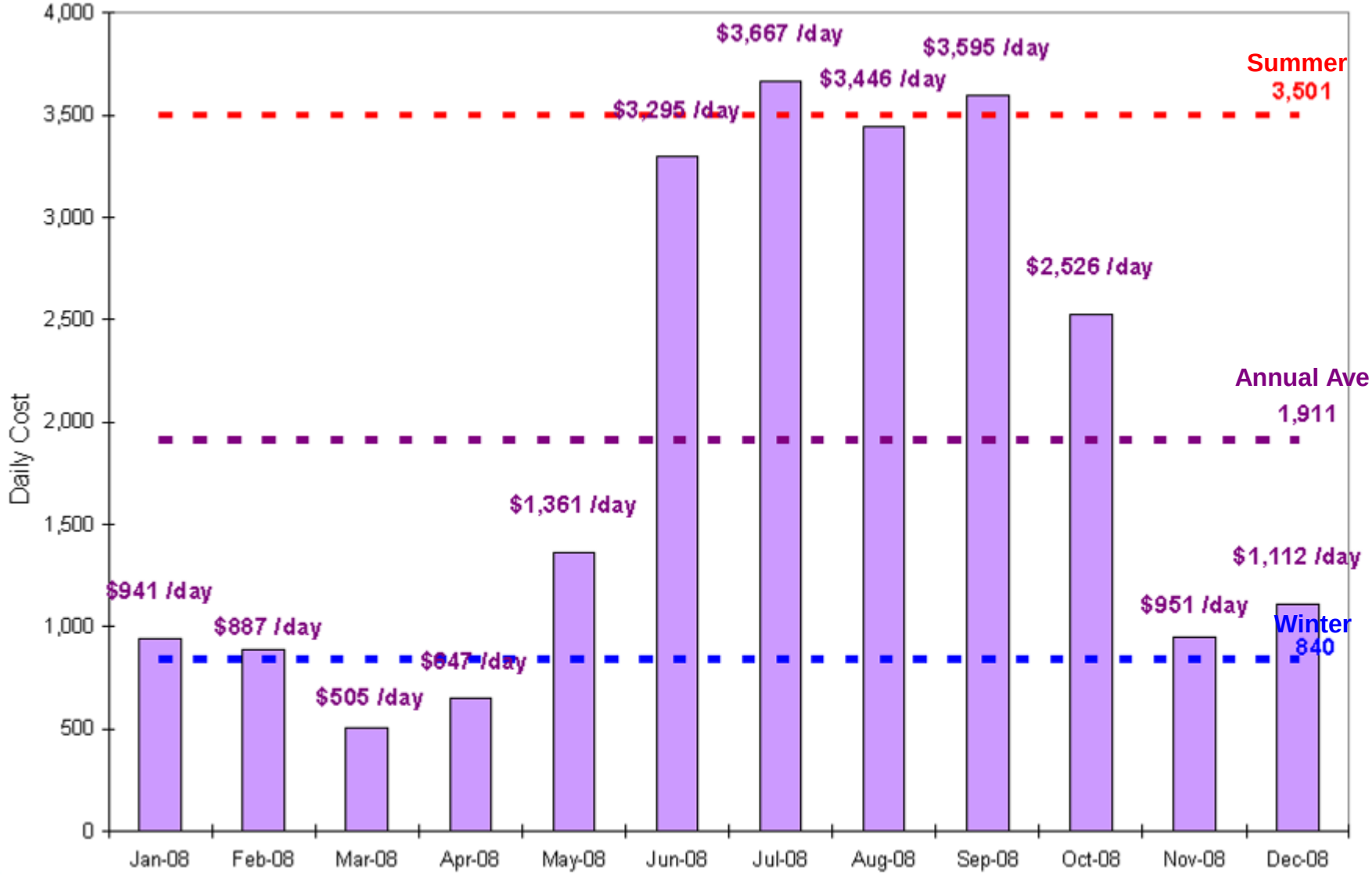
- Operations and Planning staff involved in review of proposed recommendations

Review of Past Annual Power Costs

Year	Average Annual Daily Production (MGD)	Pacific Power Costs[1]
2006	11.55	$660,000
2007	13.84	$740,000
2008	12.84	$700,000

1) Represents the sum of charges under four accounts: water delivery pumping systems, watershed surface water, water wells and water production disinfection. Includes all charges (energy and demand/load size).

System-wide daily costs by month – 2008

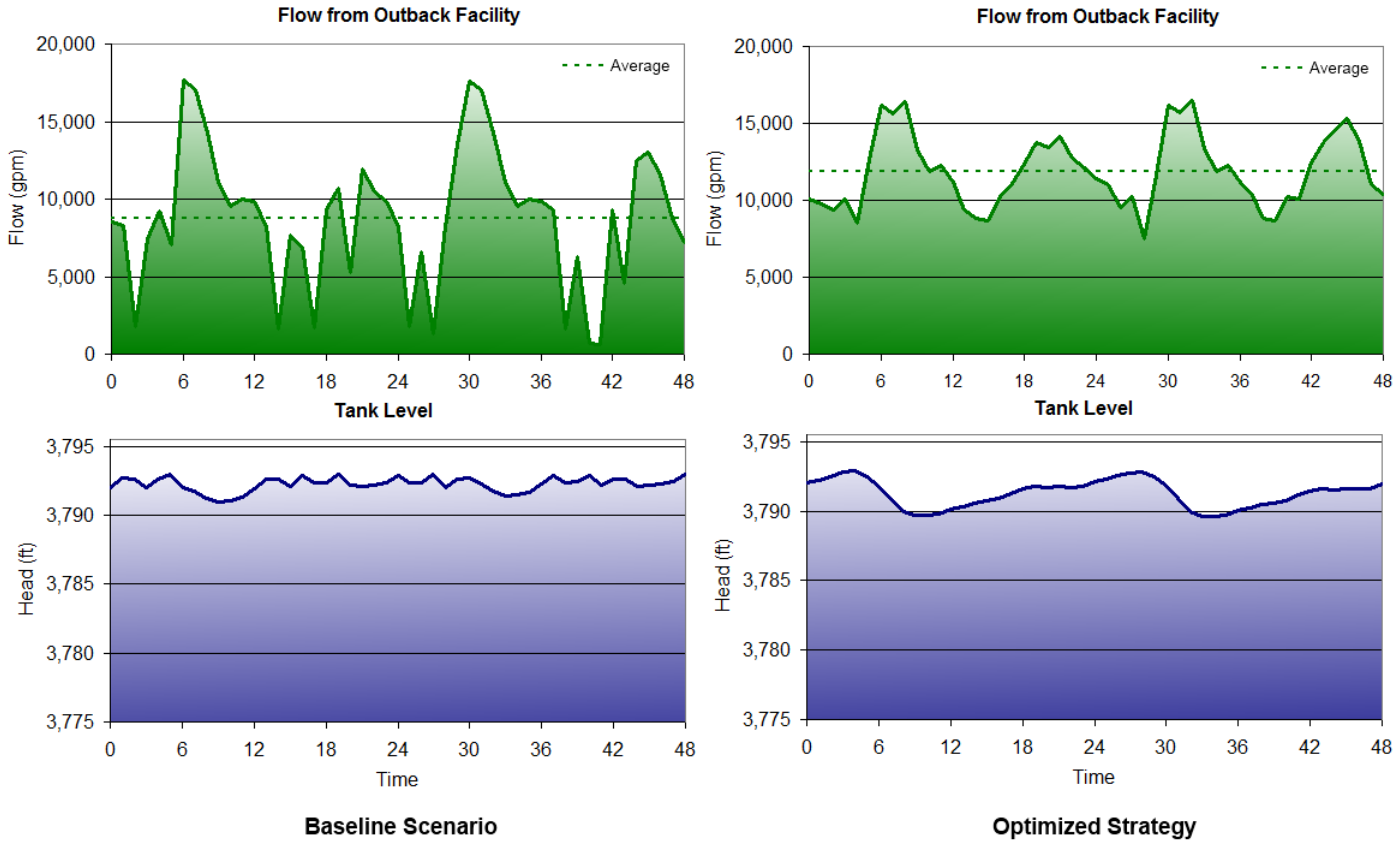


Formulation – Options

- Selection of which facilities to operate
- Adjustment of pumping controls
- Adjustment of control valve settings
- Modifications to zone boundaries
- Elimination of small sub-zones
- Minor capital improvements
  - Pipe connections
  - New booster pumps

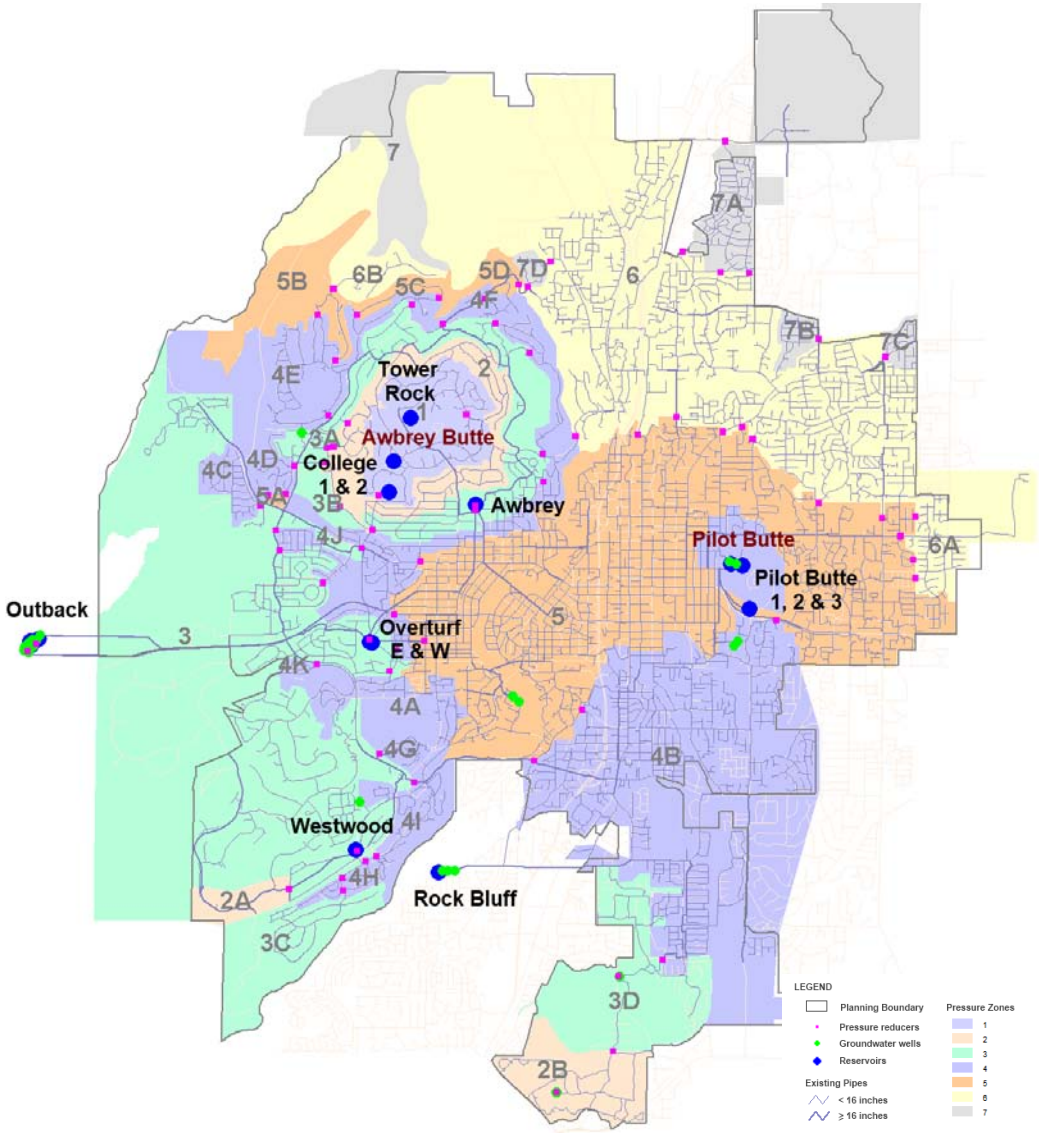
Summer – Recommendations

- Increased transmission, adjusted flow into Awbrey Reservoir



Summer – Recommendations

- Transmission and Supply
  - Increased surface flow from west to east
  - Reduced well pumping
  - Utilization of booster pumps to transfer supply



Summer – Cost Savings

Estimated Costs	Baseline	Strategy #1 (Long-term)	Strategy #2 (Short-term)
		River Wells	No River Wells
Annual	$378,000	$290,750	$289,340
Daily	$1,895	$1,458	$1,451
Savings		**23 %**	**23 %**

Costs represent estimated annual energy costs for key water facilities only, using $0.05/kWh. Do not include other power costs such as demand charges/load size charges or costs associated with reservoirs, valve stations, buildings, disinfection, etc.

Operations Optimization Recommendations

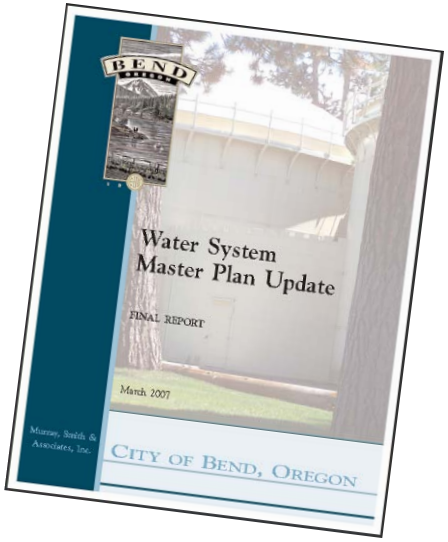
- Minor capital improvements
- Modified control valve settings
- System control strategy for summer and winter provided to operators:

	A	B	C	D	E	F	G	H	I	J	K	L
1		Table 5.3 – Current and modified controls recommended based on optimized strategies										
2			*Current Summer Strategy*		*Optimized Summer Strategy #1*		*Optimized Summer Strategy #2*		*Current Winter Strategy*		*Optimized Winter Strategy*	
3	**Facility**	**Looks to:**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**
20	**Outback**				Settings for these wells were not considered in the optimization						Settings not considered in the optimization	
21	Outback 1	Manual	Manual - Off		Manual - Off		Manual - Off		Manual - Off		Manual - Off	
22	Outback 2	Manual	Manual - Off		Manual - Off		Manual - Off		Manual - On		Manual - On	
23	Outback 3	Outback 3 Level	26	28	26	28	26	28	26	28	26	28
24	Outback 4	Outback 3 Level	24	27	24	27	24	27	24	27	24	27
25	Outback 5	Outback 3 Level	23	26	23	26	23	26	23	26	23	26
26	Outback 6	Outback 3 Level	20	24	20	24	20	24	20	24	20	24
27	**Westwood Well**	Westwood Level	20	28	19	26	19	26	18	26	19	26
28	**Westwood PS**		Maintain 78 psi		Maintain 78 psi		Maintain 78 psi		Maintain 78 psi		Closed	
29	**Bear Creek**				Lowered settings		Lowered settings					
30	Bear Creek 1	Pilot Butte 2 Level	36	38	33	35	33	35	Off		Off	
31	Bear Creek 2	Pilot Butte 2 Level	35	37	33	35	33	35	Off		Off	
32	**Scott St PS**				Raise to share load with Bear Creek, less pumping than Strategy #2		Raise to lead from Bear Creek				Does not operate, no change to settings	
33	Scott Street 1	Pilot Butte 2 Level	27	30	31	34	31	33	22	26	22	26
34	Scott Street 2	Pilot Butte 2 Level	25	29	33	35	34	35	21	24	21	24
35	Scott Street 3	Pilot Butte 2 Level	23	28	30	32	27	32	20	22	20	22
36	**Rock Bluff**										Do not operate	
37	Rock Bluff 1	Rock Bluff Level	35	37	34	36	35	37	33	35	33	35
38	Rock Bluff 2	Manual	Manual - Off		Manual - Off		Manual - Off		Manual - Off		Manual - Off	
39	Rock Bluff 3	Rock Bluff Level	36	38	36	38	36	38	34	36	34	36
40	**River Wells**						Do not operate					
41	River Well 1	Awbrey Level	Manual - On		15	17	14	16	Manual - Off		Manual - Off	
42	River Well 2	Awbrey Level	Manual - Off		14	16	10	16	Manual - Off		Manual - Off	
43	**Pilot Butte Wells**											
44	Pilot Butte 1	Manual	Manual - On		Manual - On		Manual - On		Manual - Off		Manual - Off	

Build-out System Master Plan Optimization

Build-out System Optimization

- Previous Master Plan updated in 2007



- Optimization study:
  - Updated, calibrated hydraulic model
  - Updated demand projections
  - Changes to surface water supply assumptions

Traditional vs Optimization Approach

Optimization fits in with traditional approach:

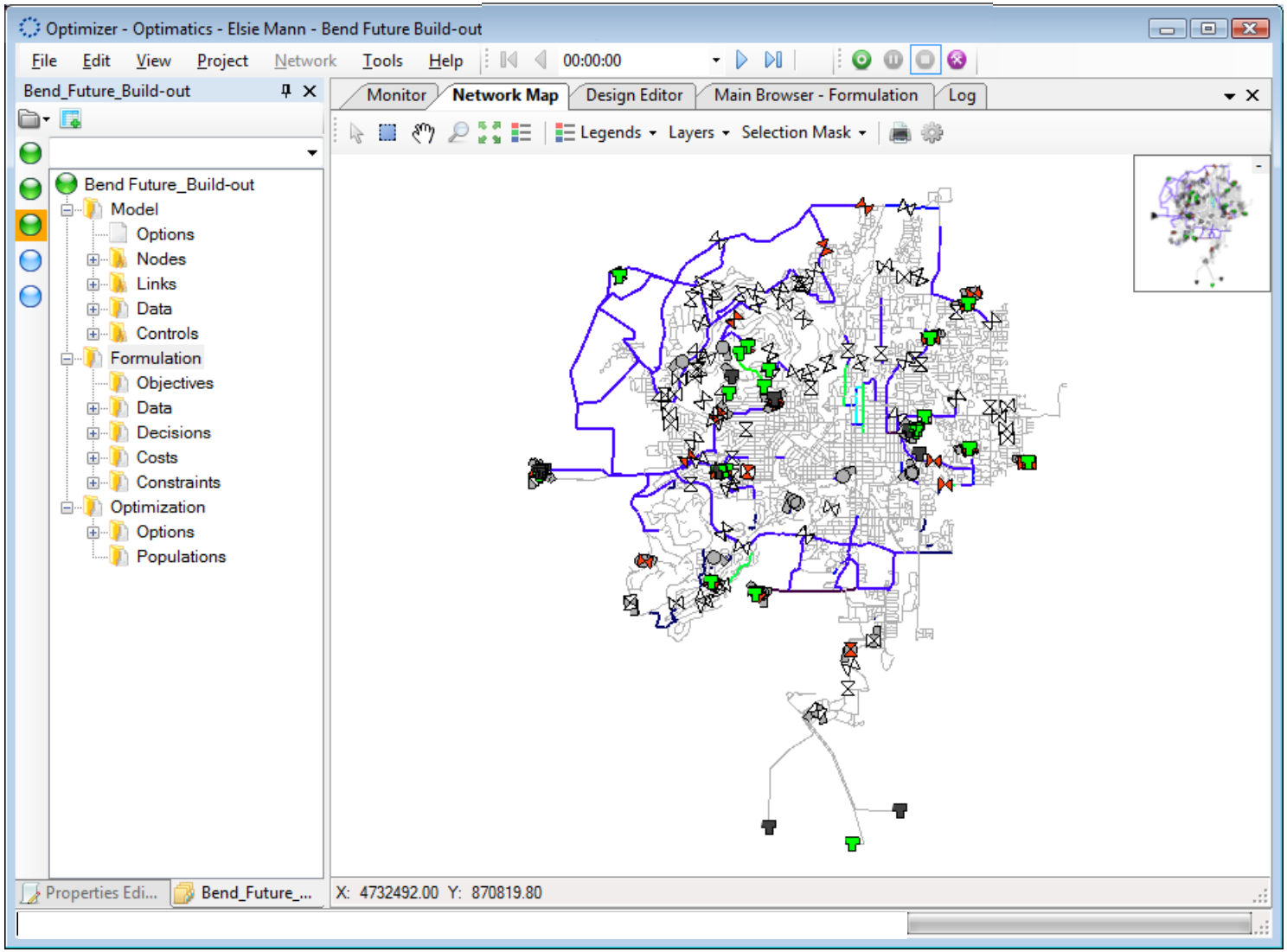
1. Develop and calibrate hydraulic model
2. Project water demands and establish design criteria
3. Evaluate a number of trial designs
4. Review and revise recommendations
5. Finalize recommendations

- Identify potential decision options
- Formulate optimization model
- Interim runs, feedback
- Final runs

Optimization Formulation

- Location of new supply wells to supplement expanded surface water source
- Transmission and distribution pipe
- New and upgraded pump stations
- Storage capacity upgrades and operation
- Pressure zone settings
- Incorporation of new development areas

Build-out System Optimization



Optimization Challenges

- Challenges faced in all planning activities
  - Uncertainties with future growth
  - Need for good quality model

- Some challenges specific or more critical in an optimization study:
  - More intensive data needs, costs for all options
  - Understanding all the drivers, stakeholders
  - Defining the design criteria and constraints (optimization needs to know limits)

Optimization Benefits

- Wide range of options evaluated
- Ability to analyze multiple scenarios
- Results have relevance to near-term planning
- Confidence on path forward meeting future needs

Conclusions

- Optimized decision support links to
  - Asset management
  - Existing operations
  - Capital improvements
  - Significant return on investment (ROI)

Conclusions

- Hydraulic modeling + power of optimization = millions of potential solutions evaluated
- Engineering judgment always important
- Wide range of options evaluated enables Bend to be confident in future infrastructure upgrades

Optimatics

optimizing water systems

Thank you – Questions

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