WMOST v2 Case Study: Monponsett Ponds

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Halifax, MA
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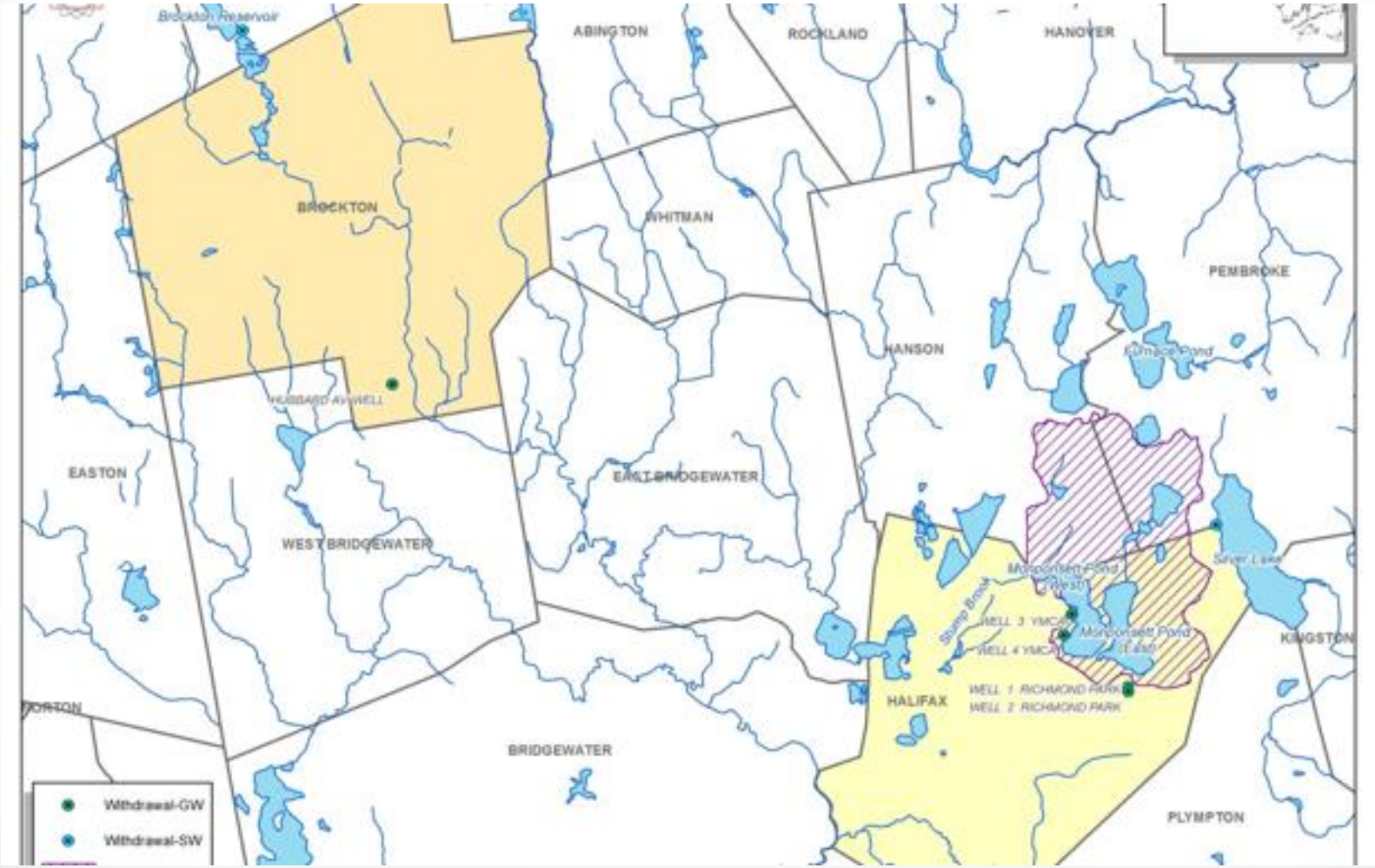
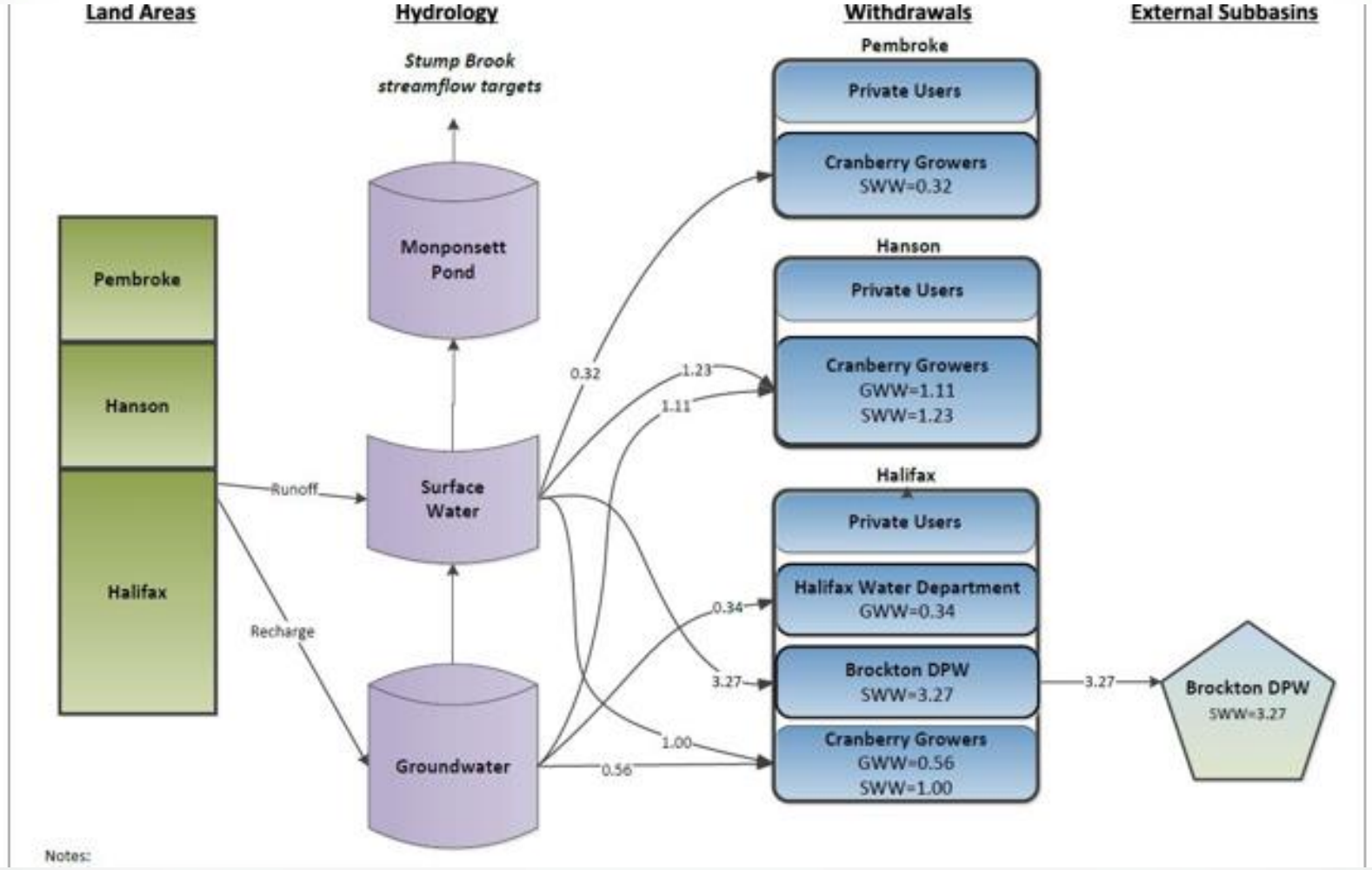
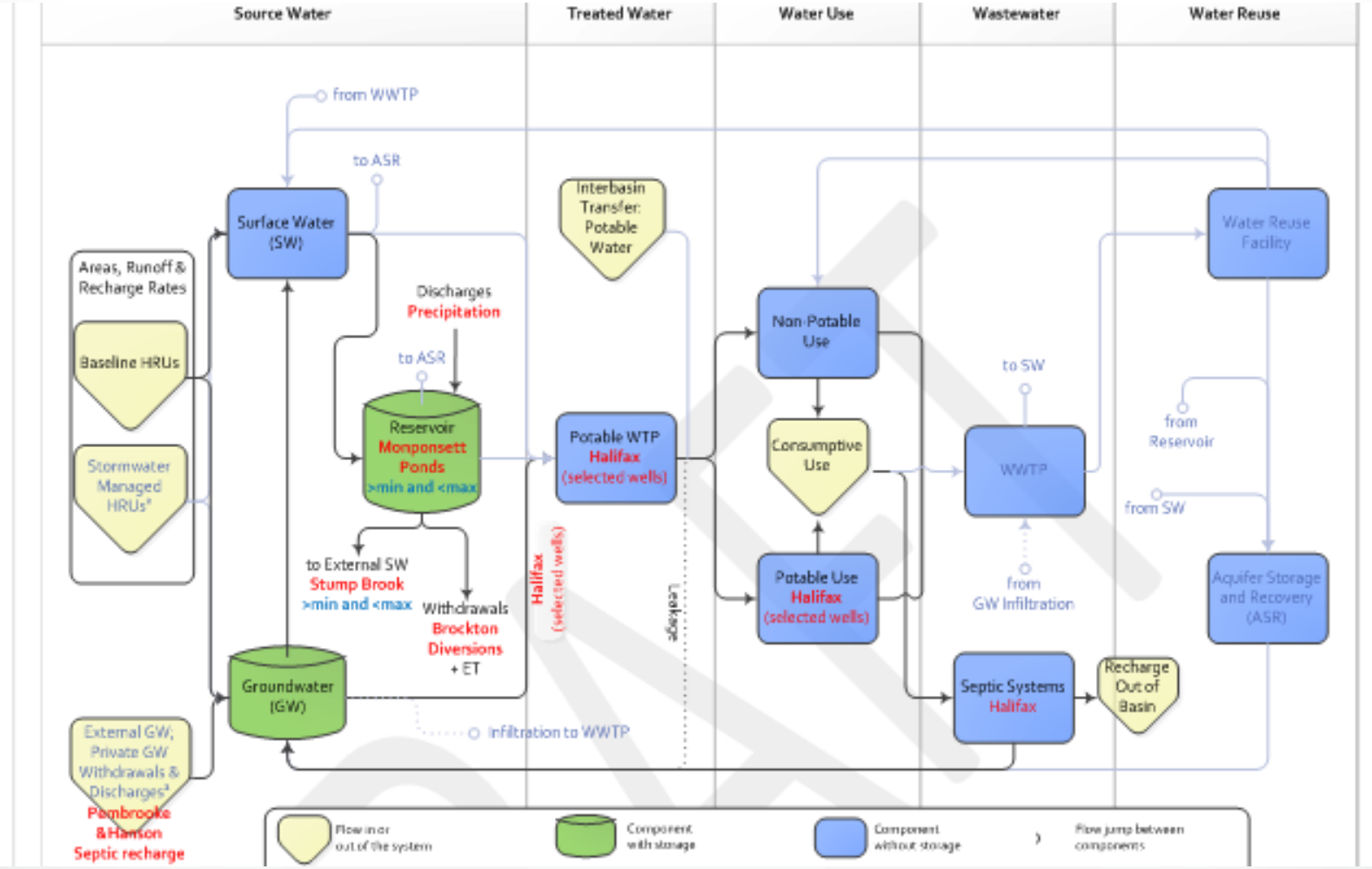
Monponsett Ponds Watershed



Water Balance in Monponsett Pond Subbasin



Selected Model Components for MP Watershed



Baseline Run for WMOST Model Validation

- 2002 – 2006
- Precipitation time series: Daymet
- Land areas, runoff rates, recharge rates for 15 land-use/soil types (HRUs) from HSPF, adjusted for increased precipitation
- Two basins of MP modelled as single basin
- Surface water (SW) withdrawals: Brockton diversions*
- Min, max, initial groundwater (GW) storage, recession coeff't from HSPF
- No private GW withdrawals/discharge or external inflows**
- SW and GW pumping data for Halifax
  - Monthly disaggregated to daily
  - Consumptive use values from literature
- Wastewater: all septic
- Reservoir outflows estimated based on operating rules

*Cranberry bog withdrawals for irrigation not included to avoid double-counting because bogs included as HRUs which have associated evapotranspiration

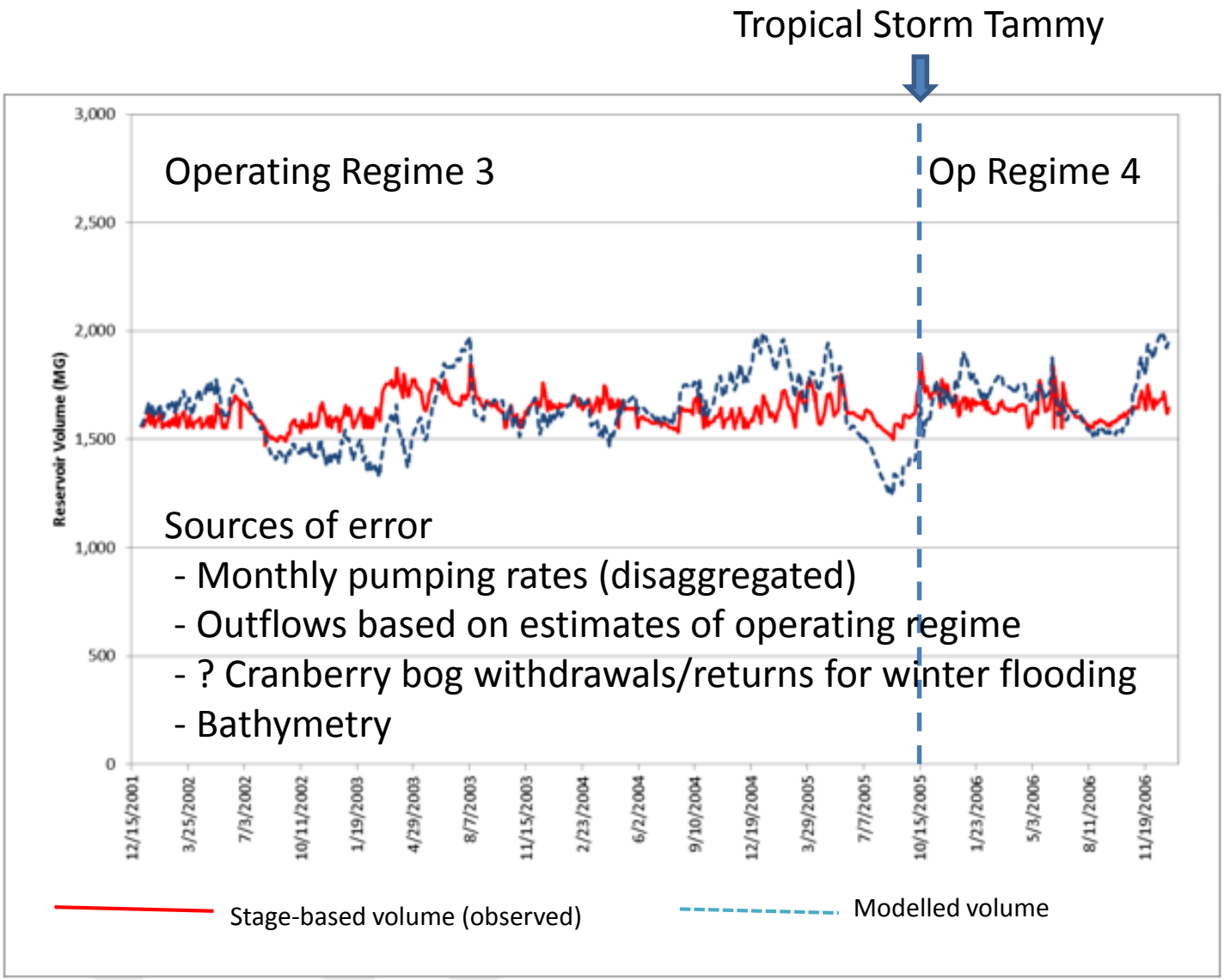
**Carlson and Lyford 2004 estimate net GW recharge from surface water bodies in region

Reservoir Outflow Operating Regimes

- Modified discharge equations from Princeton Hydro (2013) assuming 53.5 ft elevation (dam + flashboard*)
  - Spillway
  - Fishway
- Several operating regime assumptions tested, incl.
  - Operating Regime 3
    - Full spillway discharge when stage > dam flashboard (53.5 ft)
    - Average release of 0.9 MGD (1.39 cfs) through fishway year-round
  - Operating Regime 4 (High water conditions)
    - Full spillway discharge when stage > dam flashboard (53.5 ft)
    - Full fishway discharge if stage > 52.5 ft

* Based on 1964 design with dam application

Observed and Modeled MP Volume (2001-2006)



Monthly Average MP Volume and Residuals

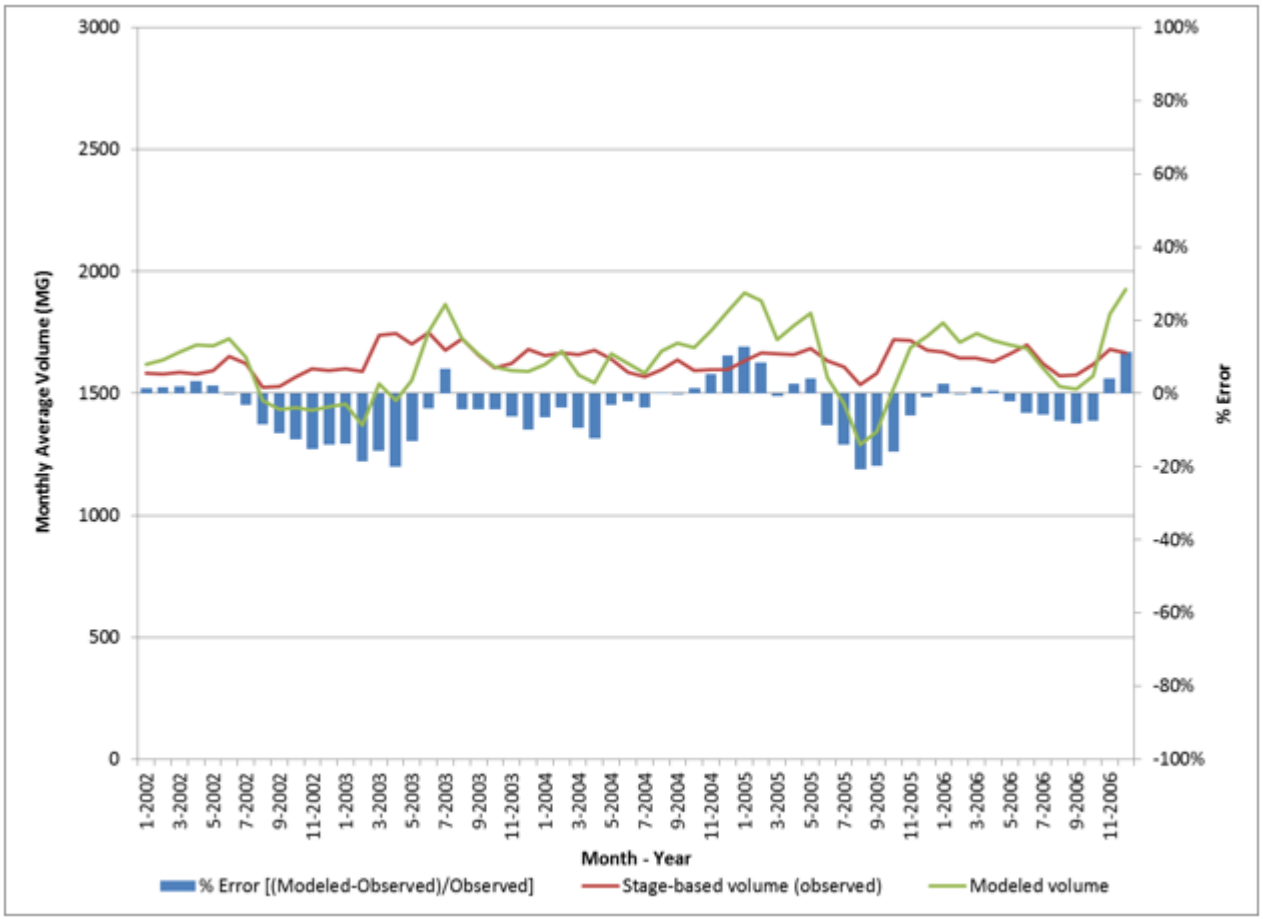


Exhibit 9: Model fit statistics for different time periods.

Fit statistic	Daily	Weekly	Monthly	Annual	Seasonal
Average residual (%)	0%	0%	-4%	0%	0%
Maximum residual (%)	22%	19%	13%	3%	2%
R^2	0.170	0.171	0.162	0.070	0.998

Goal of 10%

Multiple Combinations of Management Scenarios

Menu of model specifications for validation management scenarios				
Model Component	**Validation Scenario**	**Management Scenarios (Select One)**		
Halifax water demand	Historical 2001-2006	Scaled to reflect more recent demand (2009-2013) and meet 10% UAW		
Brockton water diversions	Historical	Scaled to reflect more recent demand (2009-2013)	Scaled to reflect more recent demand (2009-2013) + Aquaria at 3 MGD in November-July	
Reservoir volume (based on stage)	No constraint	52ft - 54.5ft	52ft - 53.5ft	52ft - 53ft
Stump brook flow	No constraint	Uniform target of 1.39 cfs	Monthly target based on 25th percentile (5.58 cfs)	Monthly target based on 75th percentile (13.51 cfs)
Reservoir withdrawals	Specified based on historical record	Scaled diversions based on adjusted demand and historical distribution	Scaled diversions based on adjusted demand and uniform distribution	
Reservoir outflows	Specified based on historical record	Estimated in model		
Management options	None	Stormwater BMPs	Stormwater BMPs and ASR	Stormwater BMPs and IBT

BMP = best management practice, ASR = Aquifer storage and recharge, UAW = unaccounted for water, IBT = “interbasin” (subbasin) transfer from other Halifax wells

Summary of Management Scenarios

- Timing of diversions: uniform distribution yielded more volume deficits than seasonal withdrawals
- Range in stage
  - Historic range (2002-6) supported historic demand but exceeded targets (52.1 - 54.2 ft)
  - Scenarios without volume deficits
    - 52 – 53.5 ft
      - Reduced diversions (2009-2013 levels) - 1.6% UAW, 25%ile SYE flows, Stormwater BMPs + ASR ($9.6M cost)
      - No diversions, 25%ile SYE min stream flows (5.58 cfs)
    - 52 – 54.0 ft
      - No diversions, 25%ile SYE min stream flows (5.58 cfs)
      - Reduced diversions (2009-2013 levels + use of Aquaria@3MGD Nov-July , 1.39 cfs stream flow, IBT from Halifax wells outside MP basin
    - 52 – 54.5 ft
      - Historical diversions, 1.39 cfs stream flow, stormwater BMPs
      - Reduced diversions (2009-2013 levels), 1.39 cfs stream flow
- Streamflow targets: no scenarios met 75%ile SYE flows

BMP = best management practice, ASR = Aquifer storage and recharge, UAW = unaccounted for water, IBT = “interbasin” (subbasin) transfer from other Halifax wells, SYE = Sustainable Yield Estimator

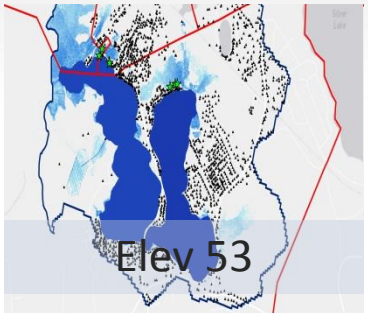
Feasible Management Solutions

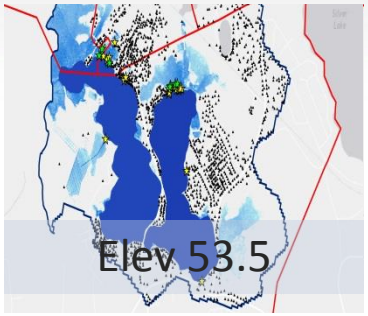
Halifax Water Demand	Basis	Existing 2009-2013	Existing 2009-2013	Existing 2009-2013	Existing 2009-2013	Existing 2009-2013	Existing 2009-2013
	Annual Total (MGY)	120.34	120.34	120.34	120.34	120.34	120.34
	Max (MGD)	0.49	0.49	0.49	0.49	0.49	0.49
Brockton Water Diversions	Basis	None	Adjusted based on 2009-2013 diversions + addl savings	Adjusted based on 2009-2013 diversions + Aquaria	None	Adjusted based on 2009-2013 diversions	Historical
	Magnitude (MG, over 5 years)	-	13,871.3	10,417.4	-	11,297.5	13,871.3
	Pattern	N/A	Historical	Historical	N/A	Historical	Historical
Reservoir volume	Min stage (ft)	52.0	52.0	52.0	52.0	52.0	52.0
	Max stage (ft)	53.5	53.5	54.0	54.0	54.5	54.5
Stump Brook flow	Basis	SYE 25th Percentile	SYE 25th Percentile	DCR	SYE 25th Percentile	DCR	DCR
	Min (cfs)	7.49	7.49	1.39	7.49	1.39	1.39
	Max (cfs)	130.0	130.0	130.0	130.0	130.0	130.0
	Pattern	Monthly Min	Monthly Min	Uniform target	Monthly Min	Uniform target	Uniform target
Reservoir Withdrawals (includes ET)	Basis	No Diversions	Historical, Adjusted	Historical, Adjusted	No Diversions	Modified historical	Historical
	Max (MGD)	37.3	29.8	28.0	37.3	30.4	37.3
	Total (MG)	17,183.4	14,409.1	13,729.4	17,183.4	14,609.6	17,183.4
Reservoir Outflows	Basis	Decision	Decision	Decision	Decision	Decision	Decision
	Min (MGD)	0.6	0.9	0.9	0.6	0.9	0.9
	Max (MGD)	84.0	84.0	84.0	84.0	84.0	84.0
	Average (MGD)					3.7	3.4
	Total (MG)	18,253.0	13,791.0	8,059.2	18,162.1	6,762.2	6,180.8
Management Options	Available	Stormwater BMPs	Stormwater BMPs+ASR	Stormwater BMPs+IBT	Stormwater BMPs	None	Stormwater BMPs
	Selected	SW BMPs: 0 acres	Stormwater BMP (270 acres) and ASR	IBT	SW BMPs: 0 acres	N/A	SW BMPs: 101 acres
Costs	Total costs (Million $)	$0.5	$9.6	$0.5	$0.5	$0.5	$0.5
	Water supply costs ($)	$466,514	$9,631,434	$466,514	$466,514	$466,514	$501,176

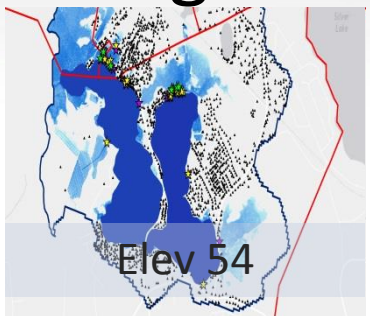
Specified as Input

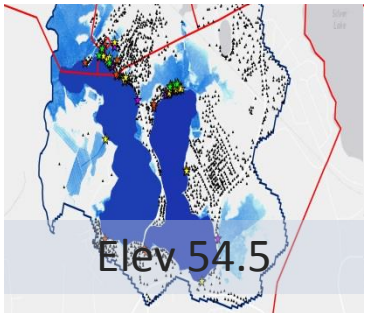
Calculated by Model

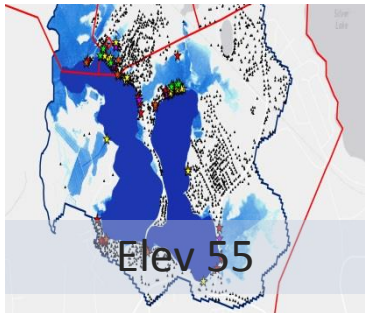
HAZUS - Estimated Flooding Costs*



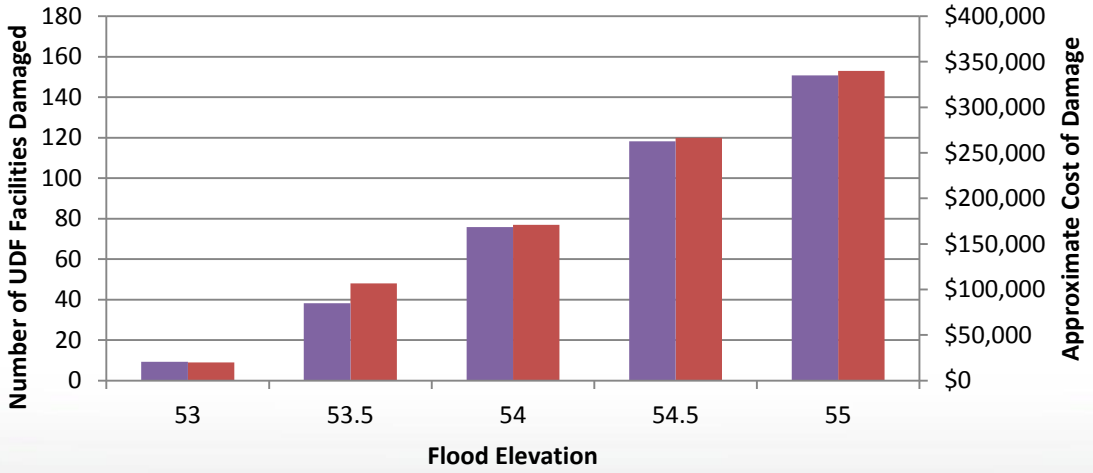








Predicted User Defined Facility (UDF) Damage (wi



*No damages predicted for UDF at elevations under 53

Assuming basements and 1st floor at 4 ft elev above ground

* Not included in cost optimization runs because related to pond stage not flow

Next Steps

- Check results with refined bathymetry based on LIDAR (top of hypsographic curve from PH 2013 ~52 ft)
- More detailed presentation to larger group of stakeholders (Sept. 10)
- Regional analysis for Upper Taunton: Flooding costs versus stormwater BMP implementation costs (could also enhance groundwater supplies outside of MP basin, reducing need for diversions)
- Addition of water quality module

Acronyms

ASR	**Aquifer storage and recharge**
BMP	**Best management practice**
DPW	**Department of Public Works**
EPA	**Environmental Protection Agency**
ET	**Evapotranspiration**
FEMA	**Federal Emergency Management Agency**
GI	**Green infrastructure**
GW	**Groundwater**
HAZUS	**Natural hazards decision support tool developed by FEMA**
HRU	**Hydrologic Response Unit**
IBT	**Interbasin transfer**
LIDAR	**Light Detection and Ranging (fine resolution digital elevation model)**
MGD	**Million gallons per day**
MP	**Monponsett Ponds**
PH	**Princeton Hydro**
SW	**Surface water**
SYE	**Sustainable Yield Estimator**
UAW	**Unaccounted for water**
WMOST	**Watershed Management Optimization Support Tool**

Questions?

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