

US EPA ARCHIVE DOCUMENT

Streamflow Management Alternatives for Aquatic Habitat and Herring Restoration in a Small Public Water Supply Reservoir System, First Herring Brook, Scituate, Massachusetts

Margaret Kearns
MA Div. of Ecological Restoration
(formerly Riverways Program)

Colin Apse & Mark P. Smith
The Nature Conservancy

Brian Joyce
Stockholm Environment Institute



NEAEB
March, 2010

Acknowledgements

Project Team:

Colin Apse & Mark P. Smith, The Nature Conservancy

Brian Joyce & Jack Sieber, Stockholm Environment Institute

Margaret Kearns & Joanna Carey, Massachusetts Div. of Ecological Restoration
Town of Scituate, MA

Stakeholder Workgroup:

Including representatives from state agencies, federal agencies, Scituate Water Dept, North and South Rivers Watershed Association, First Herring Brook Watershed Initiative and local citizens

Support From:

Richard Vogel, Stacey Archfield & Yongxuan Gao, Tufts University

Tara Moberg, Yale University

Primary Funding Provided By:

U.S. Environmental Protection Agency

Collaborative Science and Technology Network for Sustainability

EPA Grant # X3-83238601-0

Water Situation in Scituate

Current Water Sources: Surface water ~ 40%, Ground Water ~60%

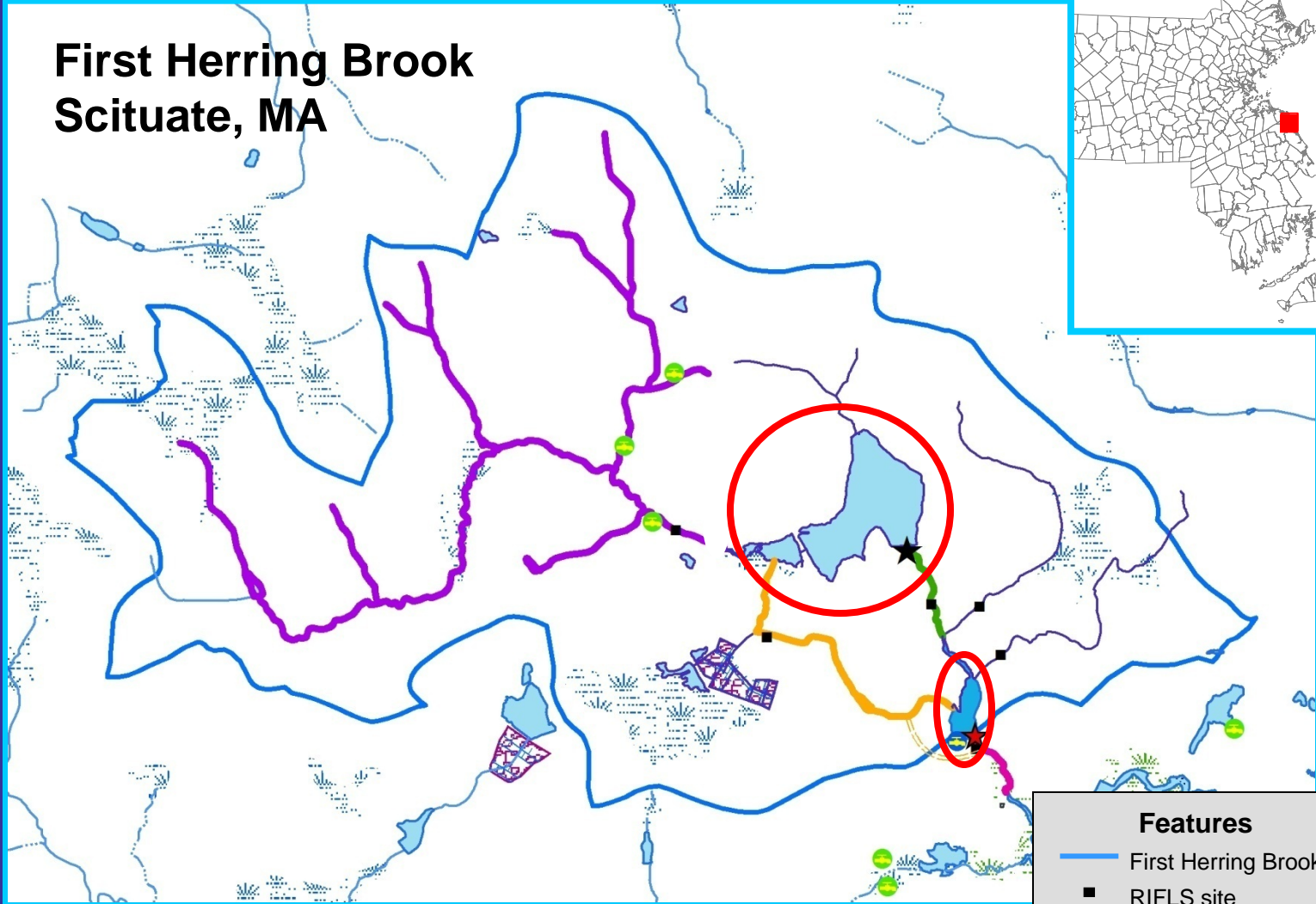
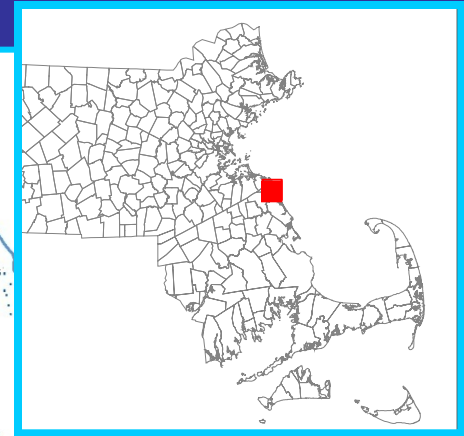
Surface Water Management: “The Reservoir” used for storage & releases downstream to smaller Old Oaken Bucket Pond which connects directly to supply treatment facility

Last Water Management permit –

- Increased permitted extraction to 1.85 MGD
- Required investigations into restoration of habitat for fish migration
- Selectmen made a strong commitment to pursuing restoration of habitat

Scituate Water Supply System

**First Herring Brook
Scituate, MA**



Features

- First Herring Brook watershed
- RIFLS site
- Public Water Supply

Water Resource Limitation

- Current sources used at or near permitted yields
- Shuttling water between reservoirs creates periods of zero flow and rapid rates of change
- Some seasonal shortages for fish migration needs
- Water use ~ 66 gal/person/day (at state guidelines)
- Summer to winter water use ratio is 2.05 : 1, with minor summer population increase
- Project team had little specific information on new sources, so used hypothetical new sources to explore the benefit of different options.

The Reservoir



Very high, August 2009



Very low, September 2007

The Town of Scituate was already looking for new water sources and wanted to know how large a source would be needed to restore aquatic habitat and herring migration in First Herring Brook.

Project Purpose

Examine the feasibility of improving environmental conditions between the two impoundments and downstream of Old Oaken Bucket pond in support of restoring aquatic habitat for river herring and other native river species

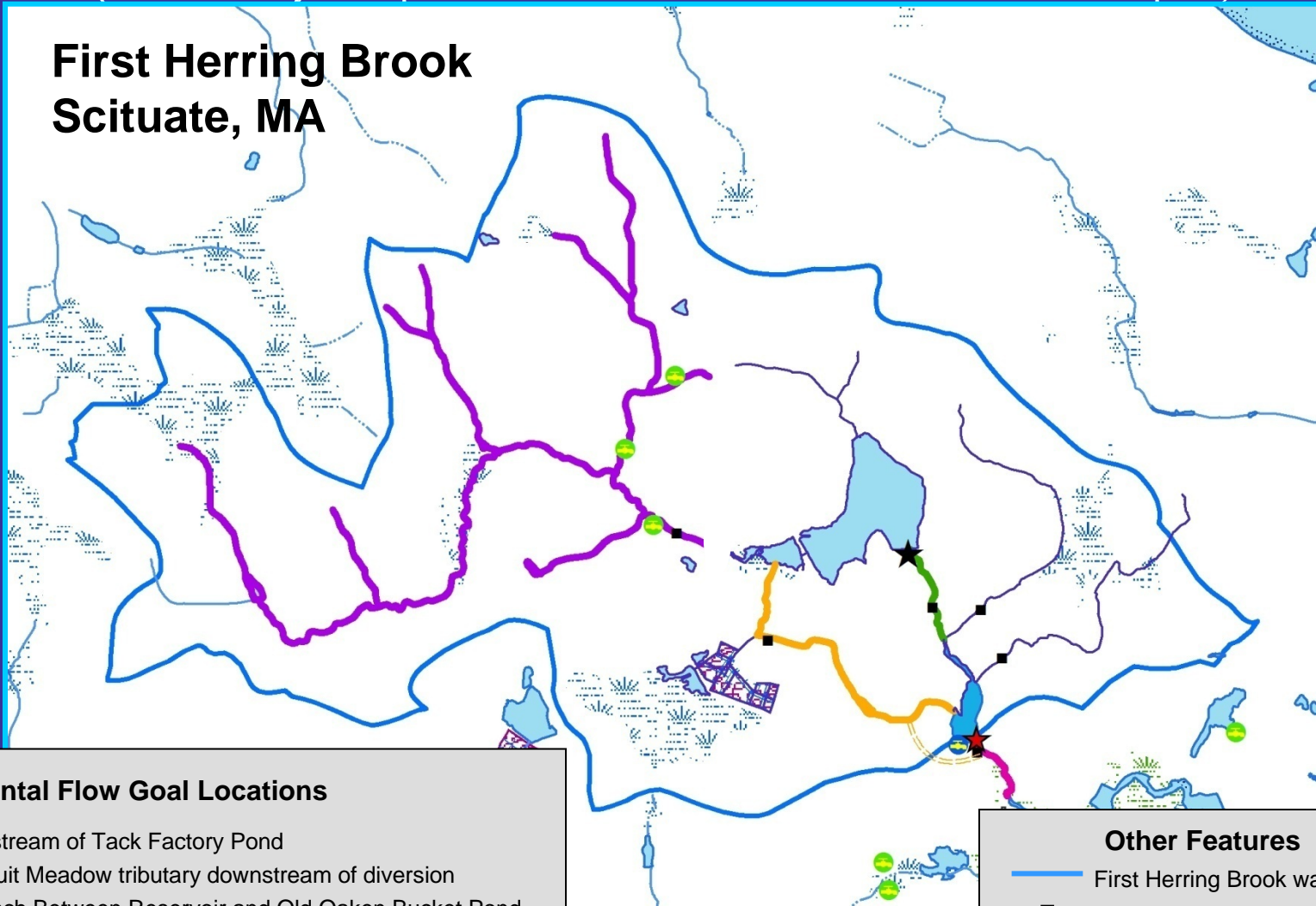
Hydrologic modeling examines existing & potential future conditions, providing an understanding of:

- how much water is necessary to restore adequate flows at the outflows of the Reservoir and Old Oaken Bucket Ponds
- measures that may be necessary to ensure passage of anadromous fish (alewife and smelt)
- the feasibility of several water management alternatives to attain adequate flows and passage while providing for the Town's water needs

Environmental Flow Goals

(Generally bioperiod medians, not less than 6" depth)

First Herring Brook Scituate, MA



Environmental Flow Goal Locations

- Upstream of Tack Factory Pond
- Satuit Meadow tributary downstream of diversion
- Reach Between Reservoir and Old Oaken Bucket Pond
- Downstream of Old Oaken Bucket Pond to tidal
- ★ Fish ladder for Reservoir
- ★ Ladder for Old Oaken Bucket Pond

Other Features

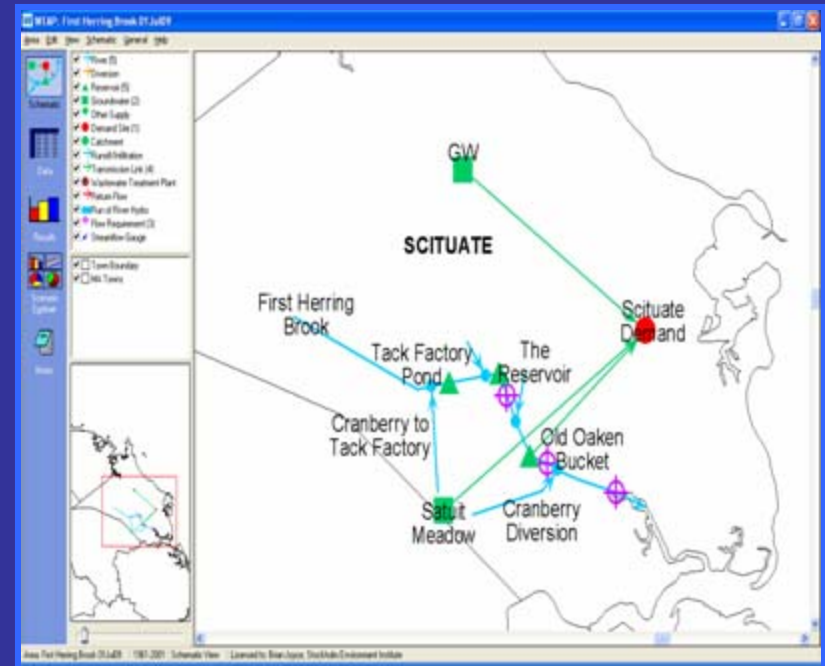
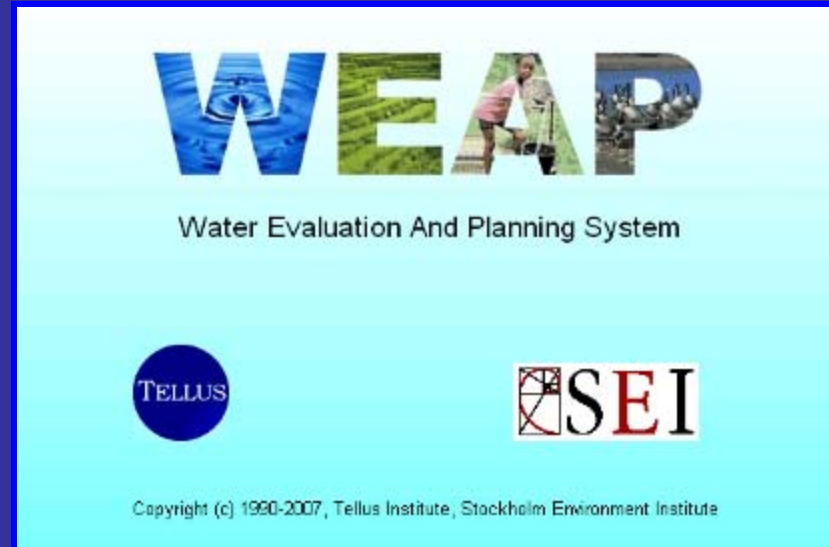
- First Herring Brook watershed
- RIFLS site
- Public Water Supply

Modeling Platform: Water Evaluation And Planning system

Developed and maintained by the Stockholm Environment Institute

Constructed WEAP model essentially matches known system yield (1.77 vs. 1.79mgd)

A copy has been made available to the town of Scituate for future modeling and improvements



All Models Are Wrong





Some Models Are Useful!

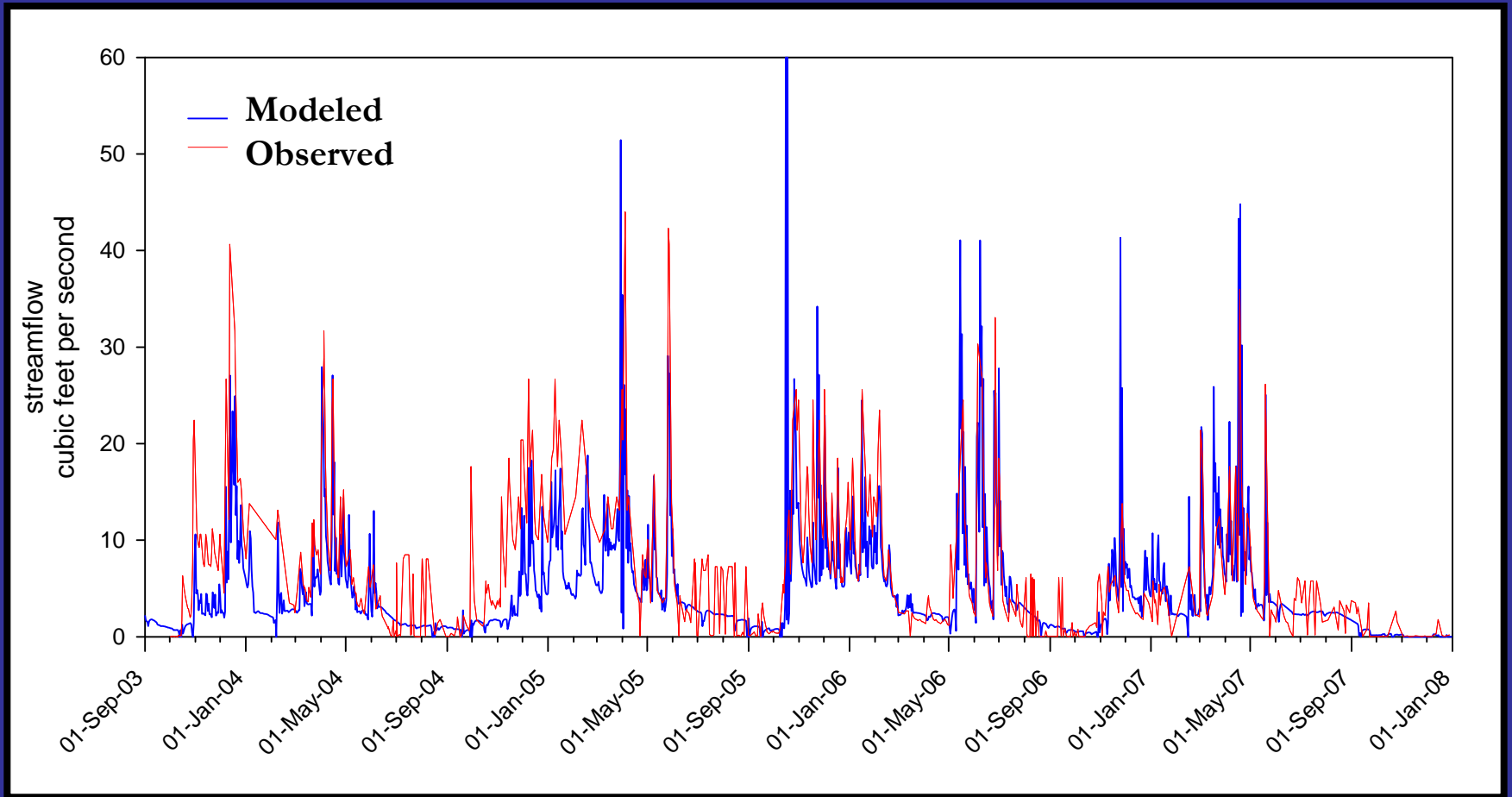
Model Input & Validation: Streamflows

Used reference USGS gage and MA Firm Yield Methodology to generate unregulated streamflow records at 7 points within the basin

Validated model under current operations & conditions using MA Riverways (RIFLS) streamflow data and Scituate water level data



It works!
(as well as any model...)



Alternatives Analysis in WEAP

Improve Environmental Conditions

- Improve fish ladders (existing ladders essentially non-functional)
- Create and operate downstream migratory fish passage weirs
- Improve streamflow releases for year-round habitat

Increase Water System Capacity

- Expand impoundment storage capacity
- Develop a new groundwater source
- Implement demand management



Core Performance Metrics

Reservoir Performance

- Reservoir levels during extreme drought levels (95th percentile)
- Achievement of Habitat Elevation Goals

Streamflow Conditions

- Zero flow days
- Achievement of Environmental Flow Goals



Herring Passage Performance

- Percentage of days over period of record meeting ladder/weir goals
- Percentage of effective up and downstream passage years
- Percentage of days with adequate channel depth for fish passage

Water Supply

- Sustainable yield

Also: flow duration curves and boxplots of streamflow/reservoir results

River Flows Below Old Oaken Bucket Pond

WEAP Model Results	Exceedance of Flow Goal				
	% of Bioperiod Exceeding the Flow Goal				
	>30				
	20-30				
	< 20				
	Mar-Apr	May	Jun-Aug	Sep-Nov	Dec-Feb
Number of days in bioperiod for period of record	2379	1209	3588	3549	3510
Natural	50	50	50	50	50
Current Ops + Current Ladders (1.77)	40	44	12	23	40
Current Ops (1.54)	43	36	10	30	39
Dredge Both (1.75)	43	35	10	28	39
Satuit 0.75 (2.18)	37	32	17	34	37
BioQ90 (1.2)	41	36	10	25	34
BioQ90 + Satuit 0.75 (1.82)	42	30	13	43	35
Bio Q90 + Satuit 0.35 + Dredge Both (1.63)	43	30	11	31	37
Bio Q90 + Satuit 0.35 + Drought Mgmt (1.65)	39	25	9	33	33
Bio Q90 + Satuit 0.35 + Dredge OOB + Drought Mgmt (1.68)	44	31	10	27	38

River Flows Below the Reservoir

WEAP Model Results	Exceedance of Flow Goal				
	% of Bioperiod Exceeding the Flow Goal				
	>30				
	20-30				
	< 20				
	Mar-Apr	May	Jun-Aug	Sep-Nov	Dec Feb
Number of days in bioperiod for period of record	237 9	1209	358 8	354 9	351 0
Scenario (yield, mgd):					
Natural	72	63	50	67	50
Current Ops + Current Ladders (1.77)	61	96	68	32	39
Current Ops (1.54)	73	93	84	24	38
Dredge Both (1.75)	69	93	84	24	38
Satuit 0.75 (2.18)	61	25	17	46	40
BioQ90 (1.2)	79	88	78	20	32
BioQ90 + Satuit 0.75 (1.82)	66	52	79	30	37
Bio Q90 + Satuit 0.35 + Dredge Both (1.63)	66	90	71	26	36
Bio Q90 + Satuit 0.35 + Drought Mgmt (1.65)	67	87	63	26	36
Bio Q90 + Satuit 0.35 + Dredge OOB + Drought Mgmt (1.68)	67	71	56	29	38

River Flows Below the Reservoir, part 2

WEAP Model Results	Number of Zero Flow Days			
	(Number of 0 flow days in bioperiod)			
	0			
	1-180 (0 to ~5% of days)			
	> 180 (> ~5% of days)			
	Mar-May	Jun-Aug	Sep-Nov	Dec- Feb
<i>Number of days in bioperiod for period of record</i>	3588	3588	3549	3510
SCENARIO				
Natural Flow Conditions	0	0	0	0
1. Current Operations + Current Ladders	15	48	591	163
2. Current Operations + New Passage	32	83	857	416
3. Dredge Both + New Passage	32	71	770	332
4. Satuit 0.75mgd Withdrawal + New Passage	3	74	965	55
5. Bio Q90 Release + New Passage	0	0	0	0
6. Bio Q90 Release + Satuit 0.75 + New Passage	0	0	0	0
7. Bio Q90 Release + Satuit 0.35 + Dredge Both + New Passage	0	0	0	0
8. Bio Q90 + Satuit 0.35 + Drought Management + New Passage	0	0	0	0
9. Bio Q90 + Satuit 0.35 + Dredge OOB + Drought Mgmt + New Passage	0	0	0	0

Old Oaken Bucket Fish Ladder Performance

WEAP Model Results	Percent of Days Achieving Fish Ladder Flow Target	Frequency of Years with Effective Fish Ladder Flows
	% of days within April-May migration period that flows in ladder exceed passage flows across period of record	% of years within April-May migration period in which 50 or more of days exceed passage flows
	>80%	>75%
	50-80%	60-75%
	<50%	< 60%
	Apr-May %	Apr-May %
<i>Natural</i>	n/a	n/a
1. Current Ops + Current Ladders	0	0
2. Current Ops + New Passage	95	90
3. Dredge Both + New Passage	93	85
4. Satuit 0.75 + New Passage	99	97
5. BioQ90 + New Passage	85	74
6. BioQ90 + Satuit 0.75 + New Passage	95	95
7. Bio Q90 + Satuit 0.35 + Dredge Both + New Passage	93	87
8. Bio Q90 + Satuit 0.35 + Drought Mgmt + New Passage	96	95
9. Bio Q90 + Satuit 0.35 + Dredge OOB + Drought Mgmt + Passage	82	67

Old Oaken Bucket Weir Performance

WEAP Model Results	1. Percent of Days Equal or Exceeding Weir Flow Target Across Period of Record	2. Frequency of Adequate Years for Out-migration
	% of days within Sept-Oct outmigration period that flows over weir exceed performance flows across period of record (1962-2000)	% of years within Sept-Oct outmigration period in which more than 20 days exceed weir performance flows
	> 33%	> 50%
	10 - 33%	20 - 50%
	< 10%	< 20%
Scenario (yield)		
Natural	n/a	n/a
1. Current Ops + Current Ladders (1.77)	n/a	n/a
2. Current Ops (1.54)	31	38
3. Dredge Both (1.75)	28	33
4. Satuit 0.75 (2.18)	59	77
5. BioQ90 (1.2)	25	33
6. BioQ90 + Satuit 0.75 (1.82)	51	77
7. Bio Q90 + Satuit 0.35 + Dredge Both (1.63)	31	36
8. Bio Q90 + Satuit 0.35 + Drought Mgmt (1.65)	37	51
9. Bio Q90 + Satuit 0.35 + Dredge OOB + Drought Mgmt (1.68)	23	33

Other Flow & Habitat Findings

- The virtual installation of ladders and weirs drastically improves the likelihood of upstream fish passage, can make it slightly more challenging to meet flow goals
- Environmental flow goals (based on medians) are difficult to meet below the Reservoir in the summer and below both impoundments in the fall without additional water capacity – but minimum flows can be achieved
- Reservoir habitat condition goals are typically met, with the primary challenge being dry fall conditions when a release is required

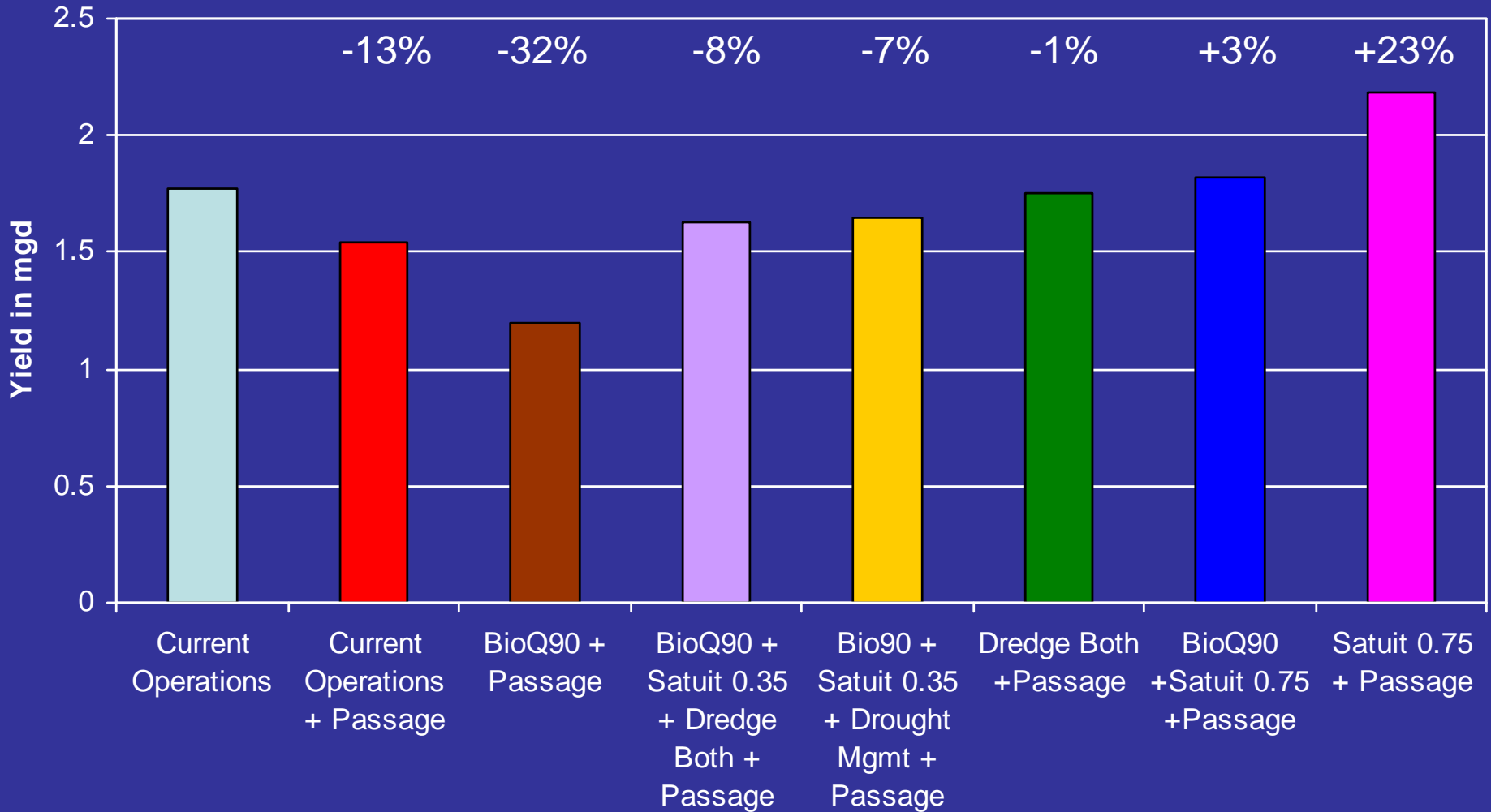


Other Passage Findings

- Reservoir upstream fish passage is greatly improved, with results lagging when only a Bioperiod Q90 release is included
- Weir performance below the Reservoir is fair to poor, with significant additional water (i.e. Satuit 0.75) or an aggressive combination of measures (BioQ90 + Satuit 0.35 + Dredge OOB + Drought Mgmt) necessary to allow for downstream passage $\frac{1}{4}$ of time
- Directed release is critical for maintaining adequate depth for fish passage below OOB year round (6 inch over riffles). Maintaining adequate depth is challenging in fall below the Reservoir (except for BioQ90 + Satuit 0.75)



Impacts on Yield from Example Alternatives



Conclusions

- Difficulty in meeting both the water supply and environmental goals is limited to certain months and weeks during the year
- No single scenario modeled to date met all the goals defined by the group - yet results provide the pieces necessary to develop a system design and operations plan to meet all goals
- Objectives and water needs may be met or partially met by infrastructure modification and improvements, including:
 - Improved fish ladders
 - Modifications of dams to allow more effective management of current surface water supplies
 - Increased storage capacity for source waters
 - New source outside the basin



Conclusions

- Model results indicate that additional water sources are likely to be needed to restore herring and improve overall aquatic condition while maintaining drinking water supplies.
- A range of alternatives not studied are promising for future WEAP modeling & exploration, including:
 - Active management of flows for downstream passage
 - Modified release rules: e.g., change release values or “share the pain” cutbacks during drought/dry period
 - Alternate design of weirs or ladders
 - Additional water conservation measures



Next Steps



- Town has been provided with a calibrated WEAP model with a range of coded scenarios that can be used for future planning and analysis of options
- Project partners provide final documentation of results to the town and a report to U.S. EPA and others for consideration as collaborative model for water management
- Additional water conservation and fish ladder/weir changes are being modeled to more closely define the volume of new source needed.
- Town is pursuing new sources and water conservation options

Questions?

