Building Resilience to Flooding and Climate Change in the Moonlight Brook Watershed

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DOWNPOURS AND DROUGHT, Climate Adaption Workgroup
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NOAA Office for Coastal Management
NH Department of Environmental Services Coastal Program

PROJECT TEAM

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MAY 16, 2006 MOTHERS DAY STORM


ARKING FOR
ERICAN LEGION
TRONS ONLY
HERS WILL BE TOWED
IR OWNERS EXPENSE
SPEED
LIMIT
20
NO
PARKING

15 Highest Events –

Daily Discharges on Lamprey River near Newmarket

Rank	Date	Discharge (cfs)
1	**16-May-06**	**8400**
	15-May-06	*7600*
2	**18-Apr-07**	**7590**
	17-Apr-07	*7410*
3	**7-Apr-87**	**7360**
	8-Apr-87	*5920*
	6-Apr-87	*5460*
4	**16-Mar-10**	**6550**
	17-Mar-10	*5610*
	15-Mar-10	*4810*
5	**22-Oct-96**	**6310**
	23-Oct-96	*6150*
6	**17-May-06**	**6240**
7	**20-Mar-36**	**5270**
	21-Mar-36	*4690*
8	**1-Apr-10**	**5240**
	31-Mar-10	*4600*
9	**19-Apr-07**	**4830**
10	**27-Feb-10**	**4640**
11	**15-Mar-77**	**4620**
12	**3-Apr-04**	**4550**
13	**16-Jun-98**	**4500**
	15-Jun-98	*4400*

Of 15 largest events since 1934:
- 11 have occurred in last 25 years
- 10 have occurred in last 15 years
- 7 have occurred in last 5 years

Primary Causes of Runoff Increase

CAUSES

- Land Use Changes→Increase in impervious cover
- Changes in storm depth, duration, and frequency→Increased rainfall depth and runoff volume

SOLUTIONS

- Land use management strategies to mitigate runoff volumes

The New Orleans Hurricane Protection System: What Went Wrong and Why-- **10 Lessons Learned from Katrina** by the ASCE Hurricane Katrina External Review Panel and the USACE Interagency Performance Evaluation Task Force

1. Failure to think globally and act locally-We must account for climate change
2. Failure to absorb new knowledge
3. Failure to understand, manage, and communicate risk-Need to take rigorous risk based approach,
4. Failure to build quality in
5. Failure to build in resilience
6. Failure to provide redundancy
7. Failure to see that the sum of many parts does not equal a system
8. The buck couldn't find a place to stop--Poor organization, lack of accountability
9. Beware of interfaces: materials and jurisdiction
10. Follow the money-People responsible for design and construction had no control of the monies.

OBJECTIVES

1. Study flood risk associated with climate change and how future development and build-out of the community affect these risks,

2. Design green infrastructure (GI) practices within the watershed to help reduce the risk of flooding while reducing pollutant load

OUTCOMES

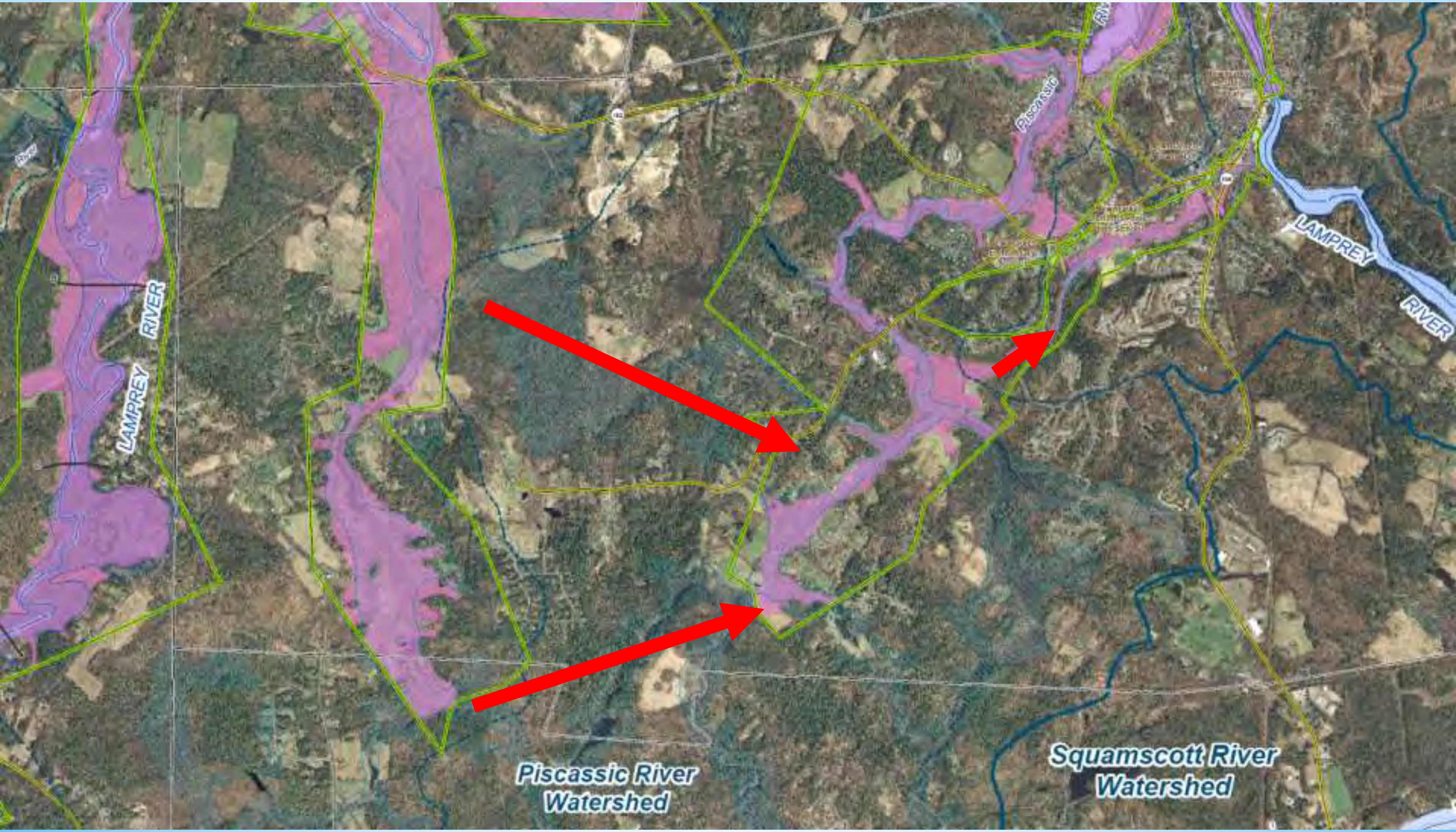
1. To provide an illustration of the types and quantities of BMPs that could be used to reduce flooding.

2. Provide cost performance on BMPs for cost effectiveness, unit costs ($/ft3 reduced), total minimum optimized cost, flood mapping for volume and the duration.

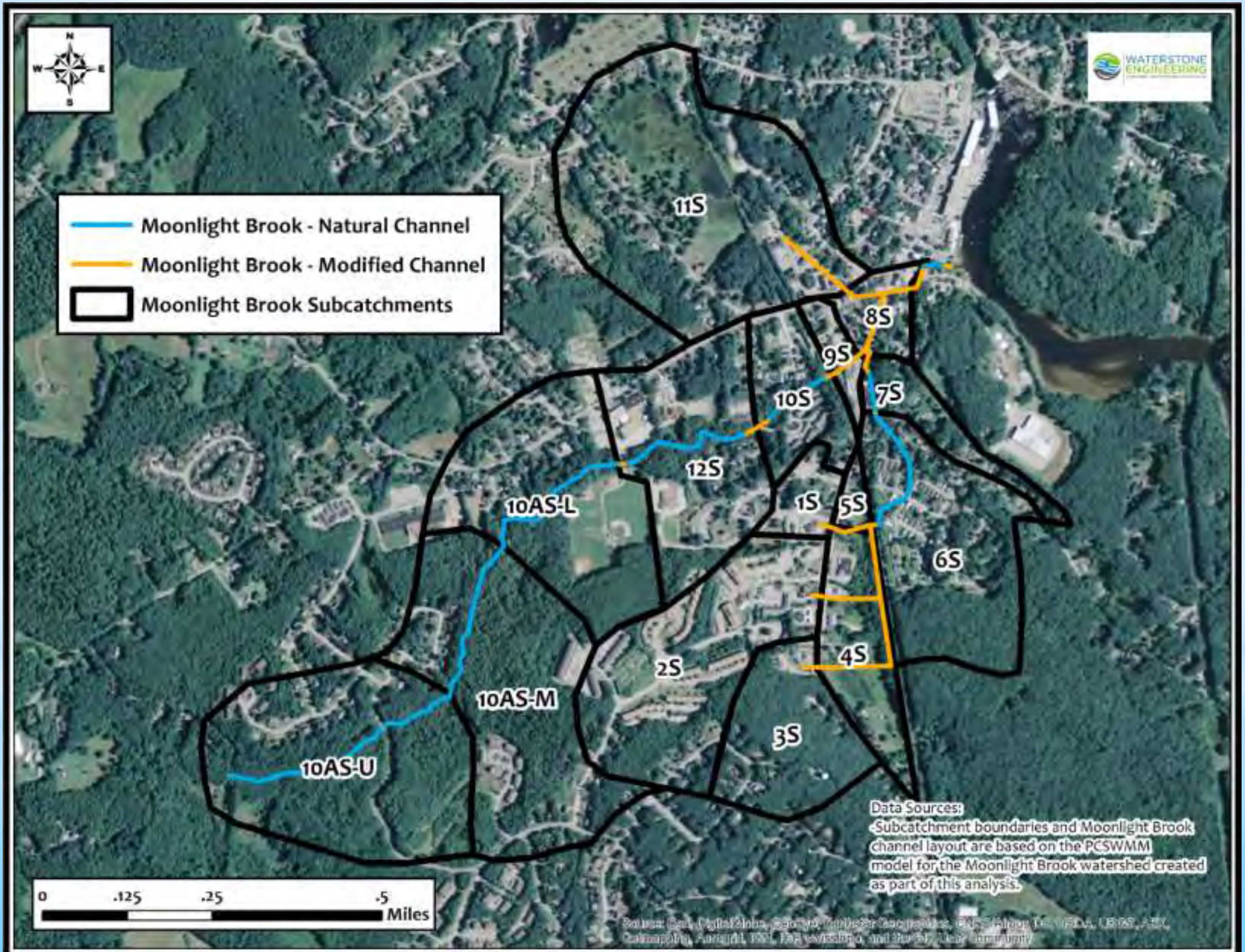
3. Develop a GI final design that can be used for construction.

4. Green Infrastructure will also provide water quality benefits to:
   a. promote groundwater and stream recharge,
   b. maintain stream water temperatures and
   c. reduce nutrient, sediment and bacterial pollution

LAMPREY STUDY OF 2100 CONDITION



MOONLIGHT BROOK

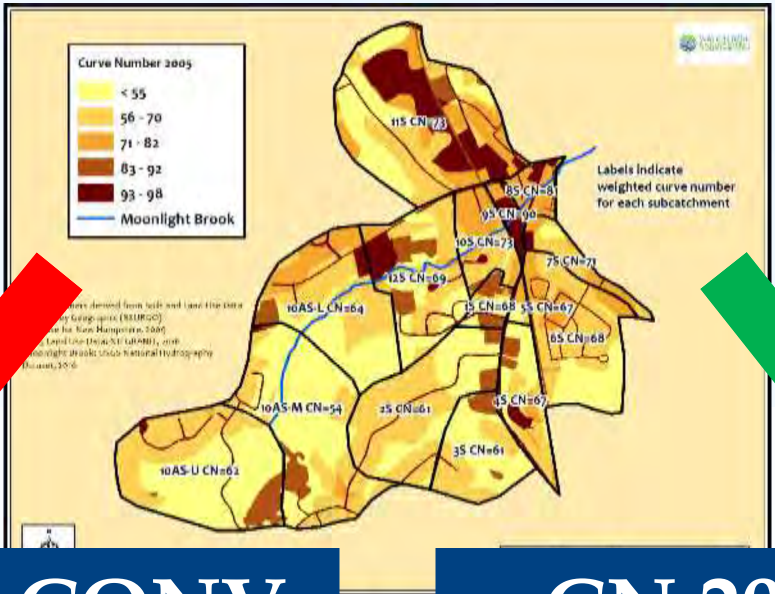


SCENARIOS

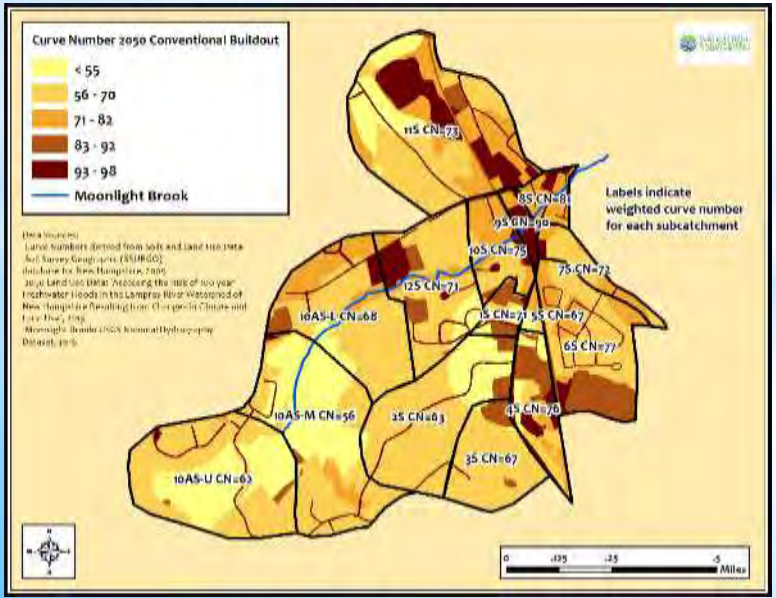
	No-Piscassic	With Piscassic Bypass	Design Storm Depth (Inches)
2005/2015	Current	Current +307 CFS	8.75
2005/2015	Current without New Road	Current with New Road +307 CFS	8.75
2050	LID/Conventional	LID/Conventional +307 CFS	8.75
2050	LID/Conventional	LID/Conventional +612 CFS	10.06*

*CRHC Recommendation for +15% of existing

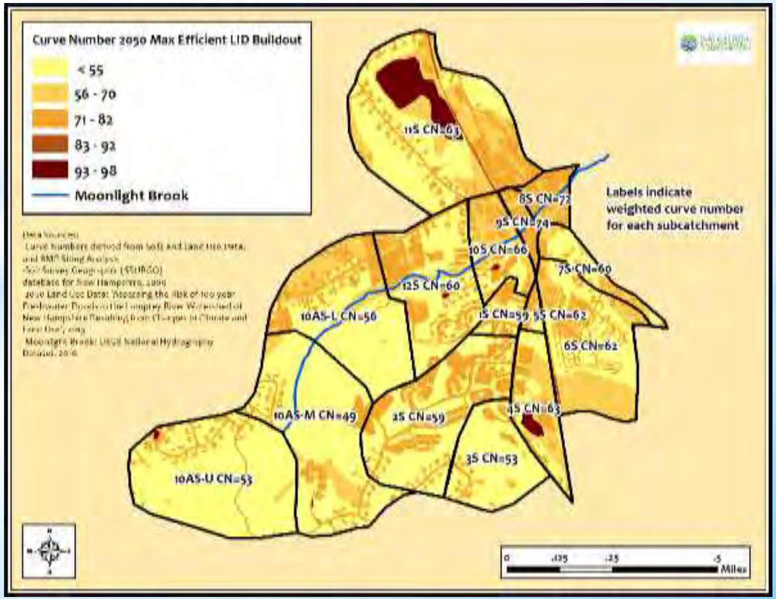
CURVE NUMBER CURRENT



CN 2050 CONV

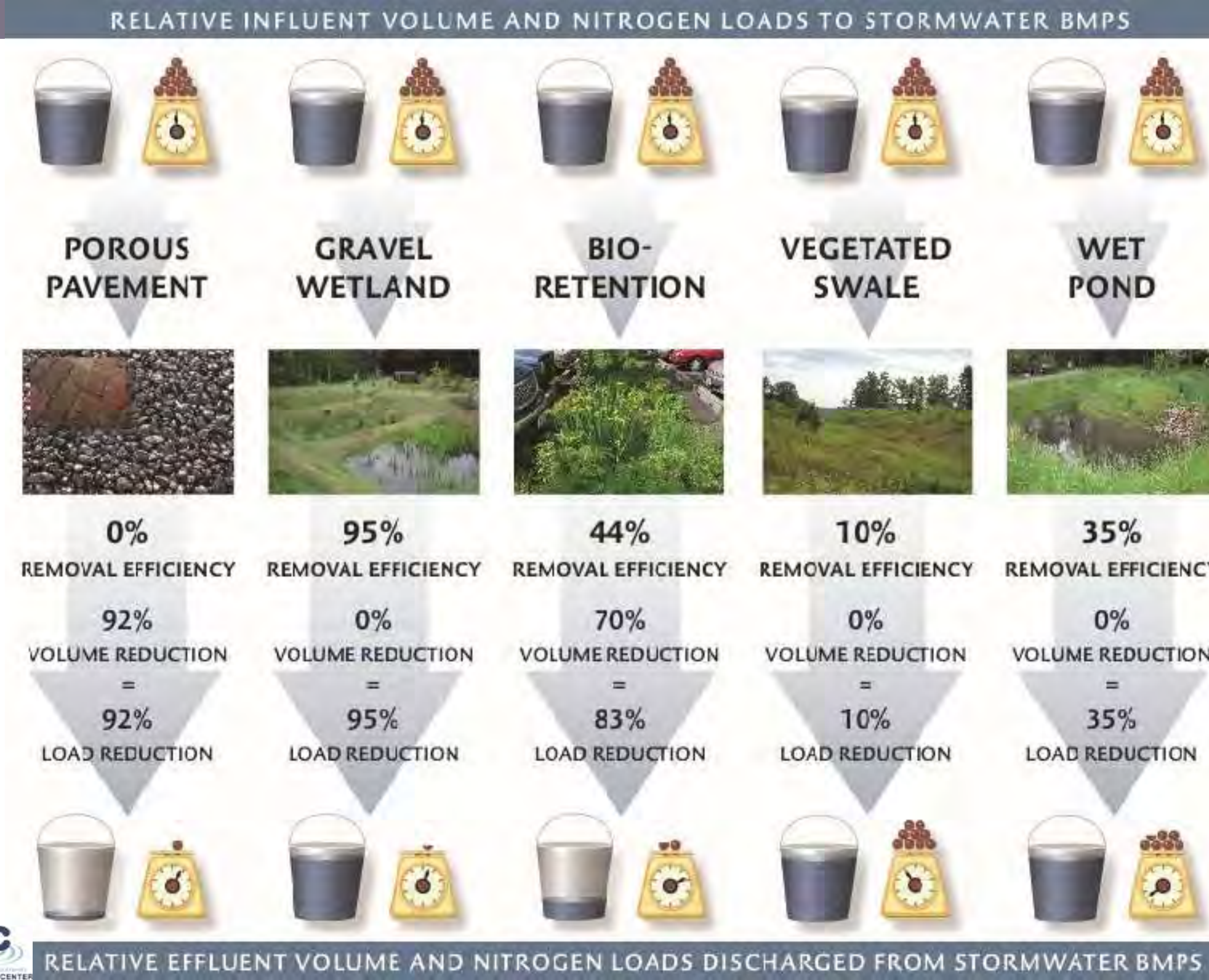


CN 2050 LID



FLOOD MITIGATION STRATEGIES AND BENEFITS

LID as a Climate Adaptation Tool

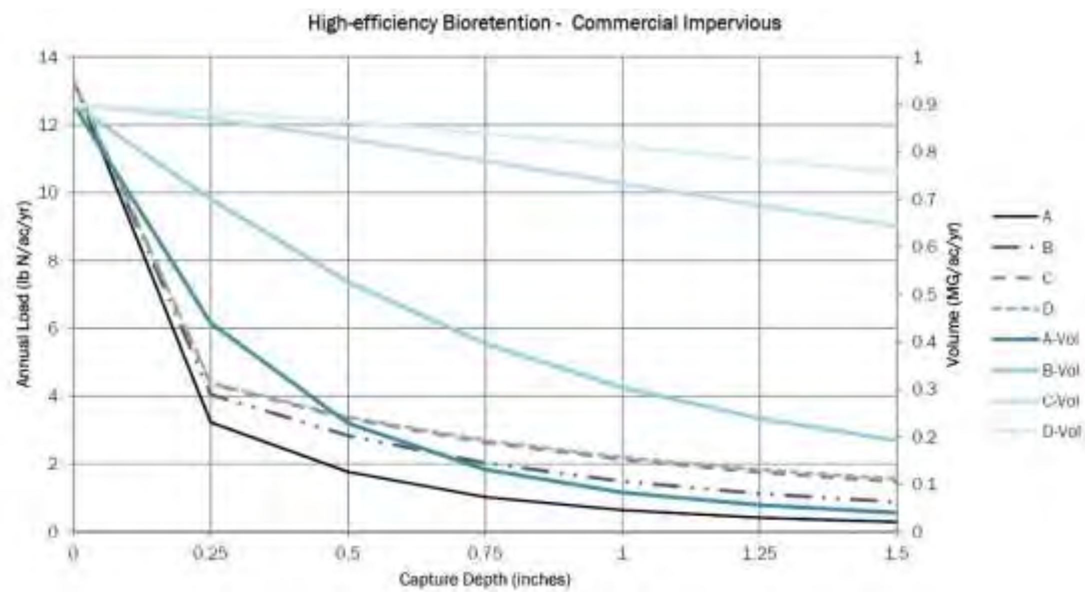


RELATIVE INFLUENT VOLUME AND NITROGEN LOADS TO STORMWATER BMPS
POROUS PAVEMENT
0% REMOVAL EFFICIENCY
92% VOLUME REDUCTION
=
92% LOAD REDUCTION
GRAVEL WETLAND
95% REMOVAL EFFICIENCY
0% VOLUME REDUCTION
=
95% LOAD REDUCTION
BIO-RETENTION
44% REMOVAL EFFICIENCY
70% VOLUME REDUCTION
=
83% LOAD REDUCTION
VEGETATED SWALE
10% REMOVAL EFFICIENCY
0% VOLUME REDUCTION
=
10% LOAD REDUCTION
WET POND
35% REMOVAL EFFICIENCY
0% VOLUME REDUCTION
=
35% LOAD REDUCTION
RELATIVE EFFLUENT VOLUME AND NITROGEN LOADS DISCHARGED FROM STORMWATER BMPS

BMP OPTIMIZATION

•1 system treating a 1” water quality volume for 1 acre will reduce runoff volume by approximately 0.83 MG/acre/year.

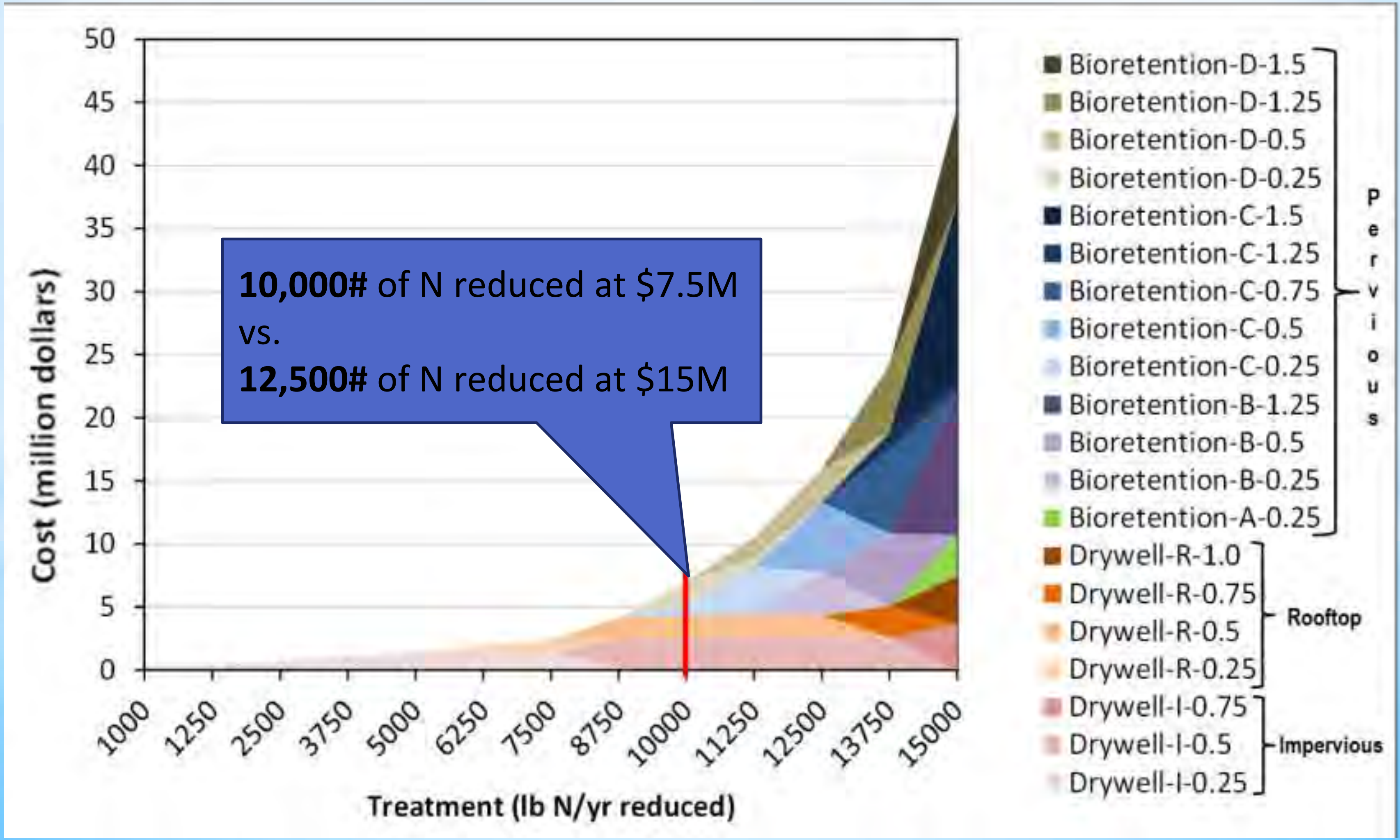
•4 smaller systems treating ¼” WQV from 4 acres will each reduce runoff volume by 0.44 MG/acre/year for a total of 1.76 MG per year

•At nearly equivalent costs, you will get approximately 212% increase in volume reduction.

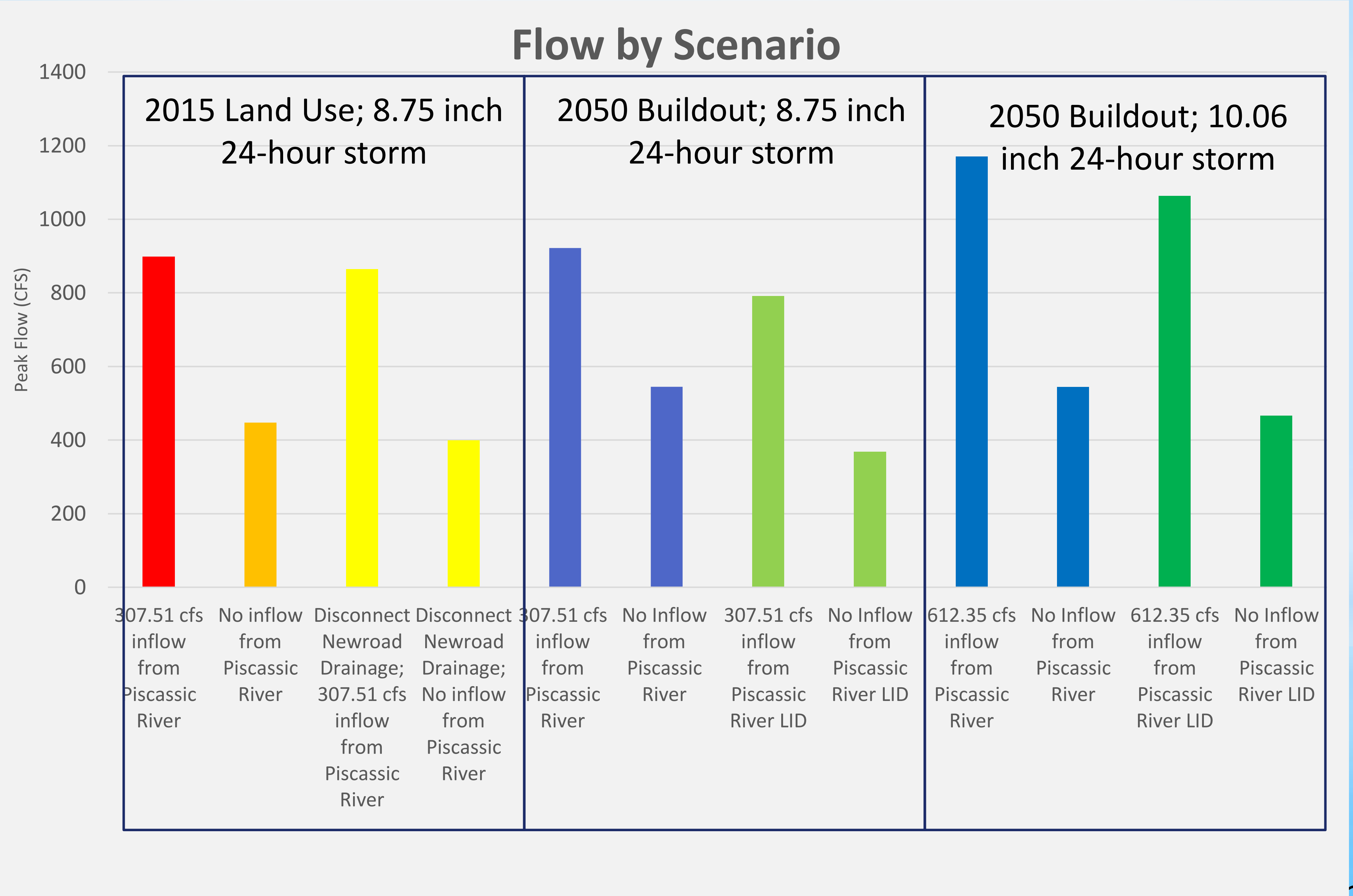


LAND USE SCALE OPTIMIZATION

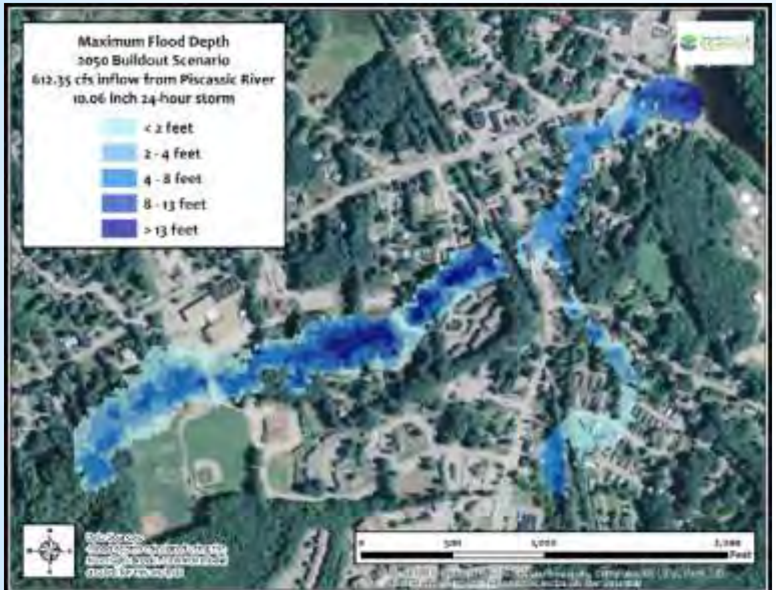
This process enables the identification of the **maximum extent practicable (MEP)**, or the point at which cost effectiveness is greatest and feasibility begins to decline.

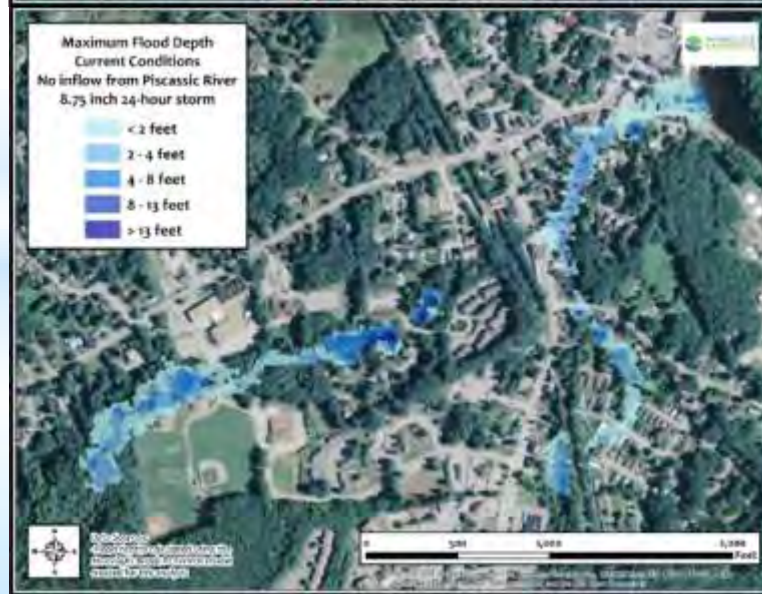


PEAK FLOW AND % REDUCTION



FLOOD CONDITIONS FOR CURRENT, W/ AND W/O PISCASSIC AND FUTURE





KEY FINDINGS

- **Piscassic Bypass is significant--No bypass increases flood elevation 0.3- 1.0 ft in Piscassic and reduces peak flows by 50% in MB**
- **LID benefit reduces runoff volume within watershed by 21% and peak flows by 12%**
- **Combined reduction from Piscassic, New Road, and LID exceeds 80%**
- **LID benefits could be accomplished in part with rezoning through redevelopment with a combination of new and redevelopment with BMPs targeted for a capture depth of 0.25-0.5 inches**
- **Approximately 50% covered by the municipality and 50% covered by private sector redevelopment.**

APPLICATIONS

- **New MS4 permits for NH and Final MA include a requirement for**
  - **BMP optimizing, and**
  - **Ranking of retrofits opportunities and target areas.**
- **Optimization at the watershed scale can significantly reduce costs for achieving load reduction targets for nitrogen, phosphorous, and other pollutants.**
- **“Small Systems” can be a tremendous way to increase the cost effectiveness**

Thank you for your time

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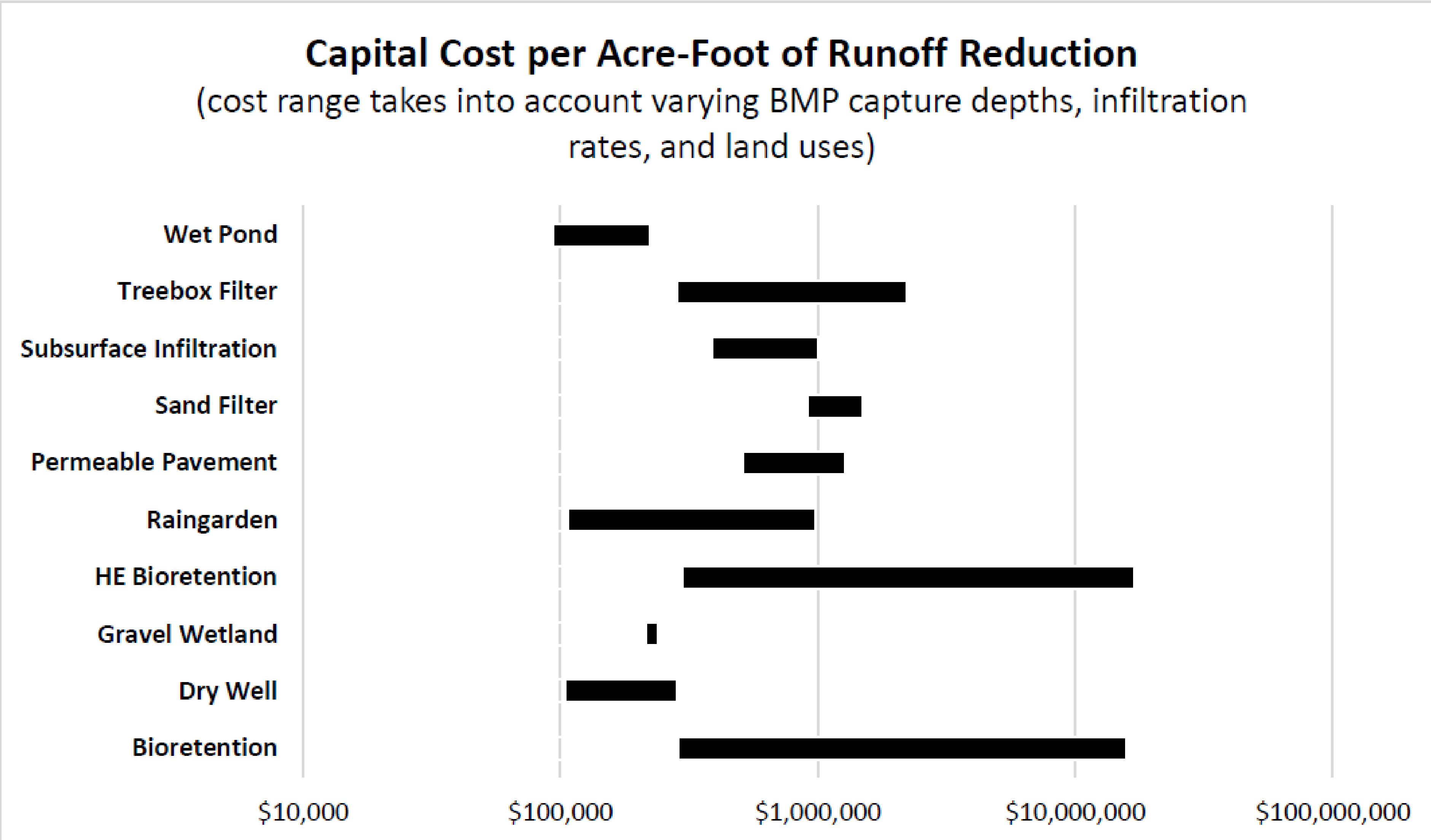
Waterstone Engineering

SCENARIO RESULTS

Modeled Scenarios		Total Runoff (MG)	Total Inflow from Piscassic River (MG)	Peak Outflow into Lamprey River (cfs)		Total Outflow into Lamprey River (MG)	
				CFS	% Reduction	MG	% Reduction
2015 Land Use; 8.75 inch 24-hour storm	307.51 cfs inflow from Piscassic River	66.15	199	898.93	0	225	-
	No inflow from Piscassic River	66.15	0	446.8	50.3%	62.53	72.2%
	Disconnect Newroad Drainage; 307.51 cfs inflow from Piscassic River	66.15	199	775.11	13.8%	207.2	7.9%
	Disconnect Newroad Drainage; No inflow from Piscassic River	66.15	0	276.33	69.3%	42.59	81.1%
2050 LID Buildout; 8.75 inch 24-hour storm	307.51 cfs inflow from Piscassic River LID	52.46	199	791.97	11.9%	214.12	4.8%
	No Inflow from Piscassic River LID	52.46	0	369.31	58.9%	50.25	77.7%
2050 Buildout; 10.06 inch 24-hour storm	612.35 cfs inflow from Piscassic River	84.38	396	1171.39	-30.3%	366.36	-62.8%
	No Inflow from Piscassic River	84.38	0	544.61	39.4%	79.44	64.7%
2050 LID Buildout; 10.06 inch 24-hour storm	612.35 cfs inflow from Piscassic River LID	71.57	396	1064.43	-18.4%	355.48	-58.0%
	No Inflow from Piscassic River LID	71.57	0	467.12	48.0%	67.16	70.2%

*CRHC Recommendation for +15% of existing


Newmarket -
Town Hall
152
108
Newmarket
Junior/Senior
High School

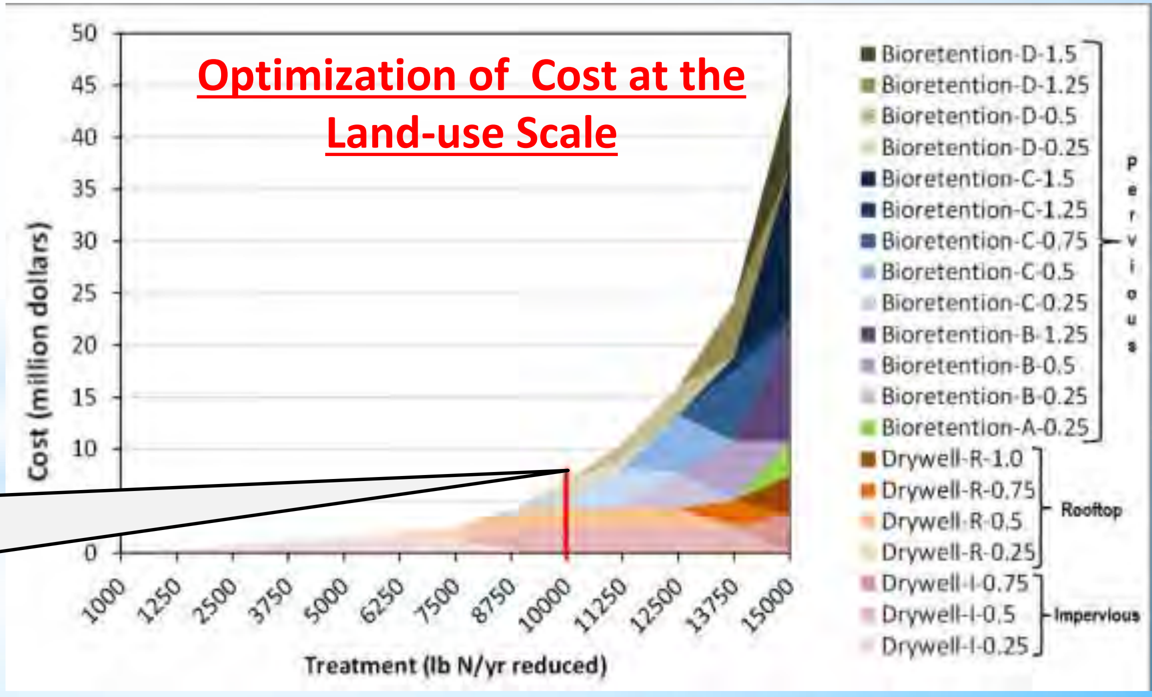

Capital Cost per Acre-Foot of Runoff Reduction
(cost range takes into account varying BMP capture depths, infiltration rates, and land uses)
Wet Pond
Treebox Filter
Subsurface Infiltration
Sand Filter
Permeable Pavement
Raingarden
HE Bioretention
Gravel Wetland
Dry Well
Bioretention
$10,000
$100,000
$1,000,000
$10,000,000
$100,000,000

LAND USE SCALE OPTIMIZATION

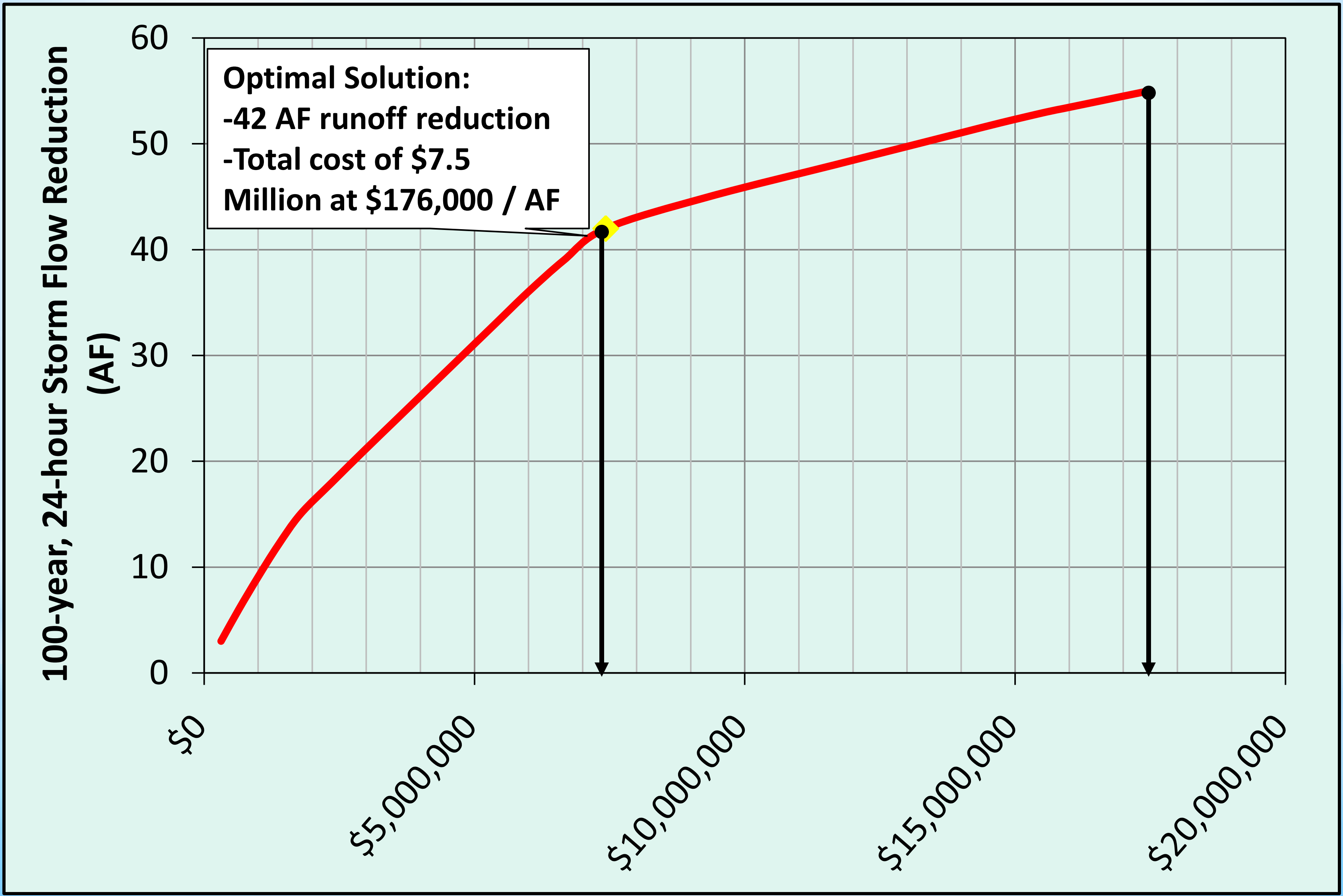
This process enables the identification of the **maximum extent practicable (MEP)**, or the point at which cost effectiveness is greatest and feasibility begins to decline.

To achieve **10,000 lbs** of reduction by treating residential land, use a mix of:

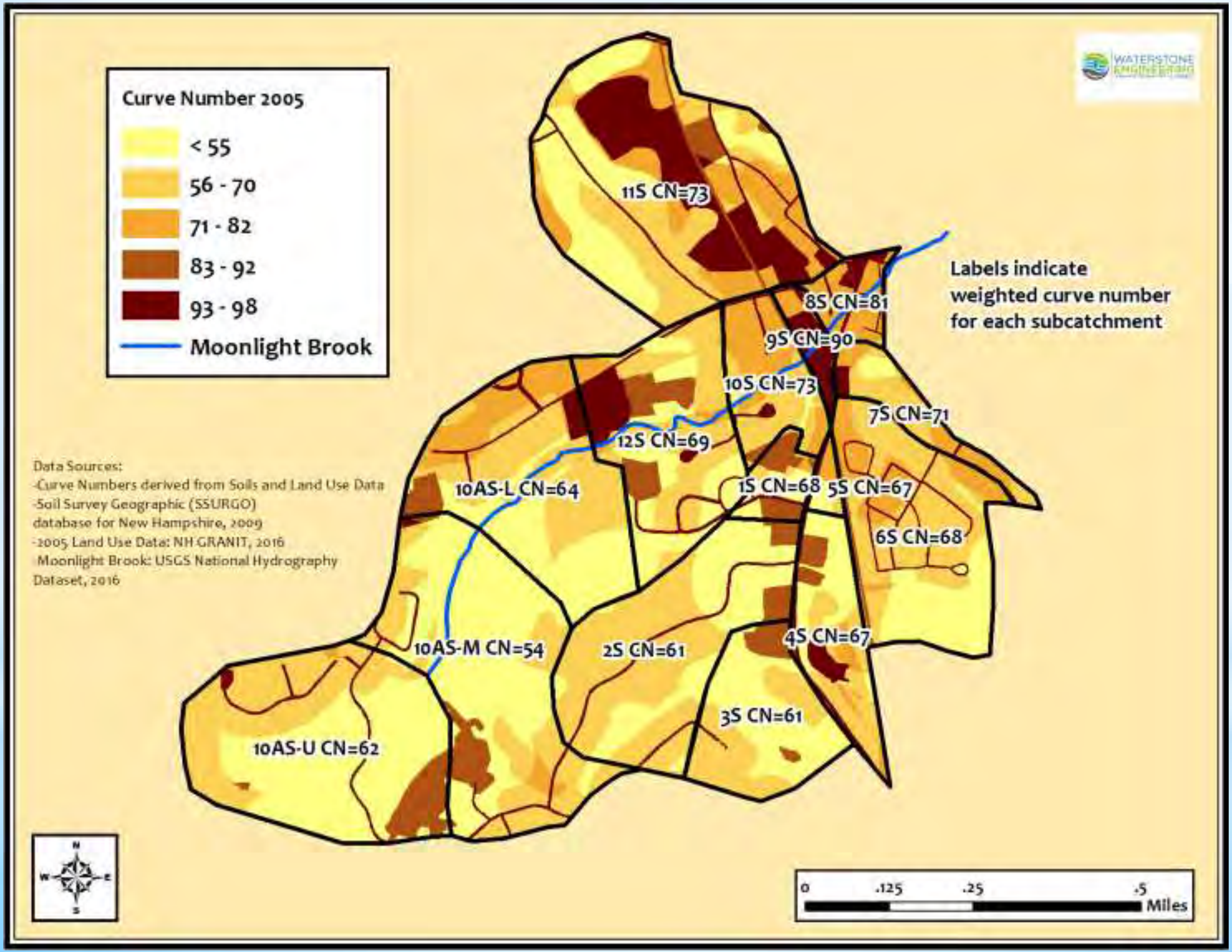
- Drywell/Infiltration trenches, 0.5” capture depth, treating runoff from driveways/sidewalks
- Drywells, 0.5” capture depth, treating roof runoff
- Bioretention (rain gardens), 0.25” capture depth, treating runoff from pervious C soils
- Bioretention (rain gardens), 0.25” capture depth, treating runoff from pervious D soils



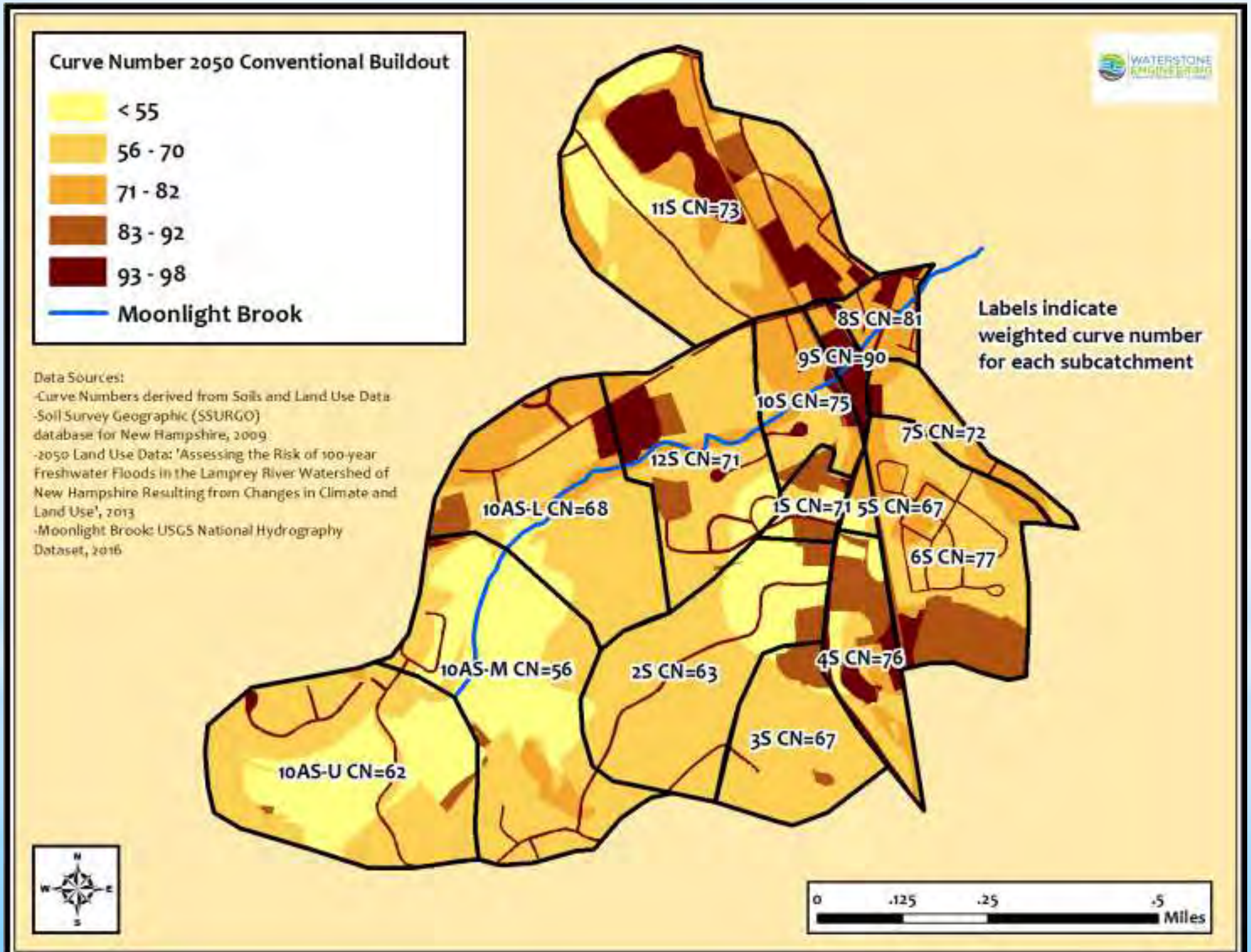
WATERSHED OPTIMIZATION



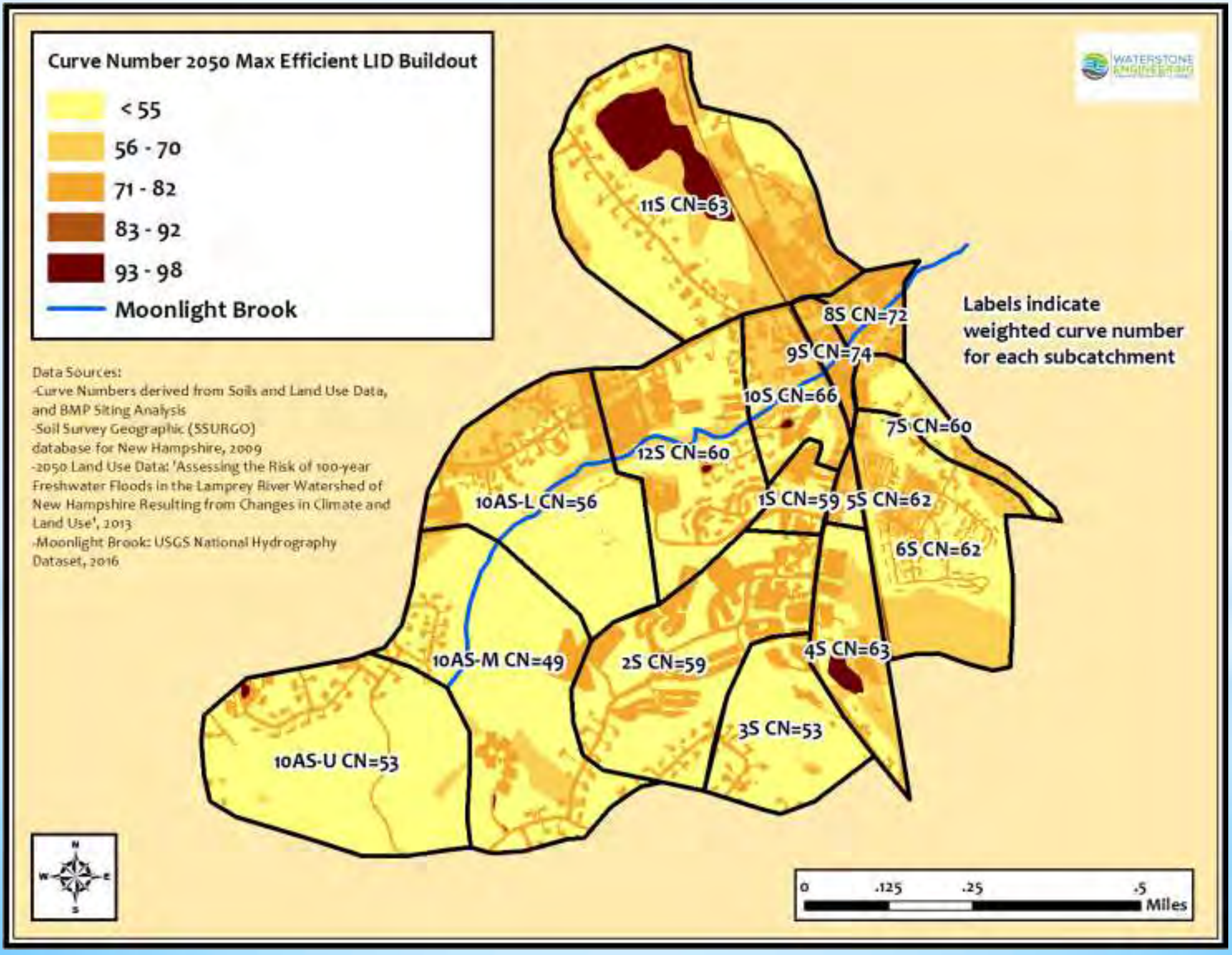
CURRENT CURVE NUMBER



CHANGES IN CURVE NUMBER BY 2050



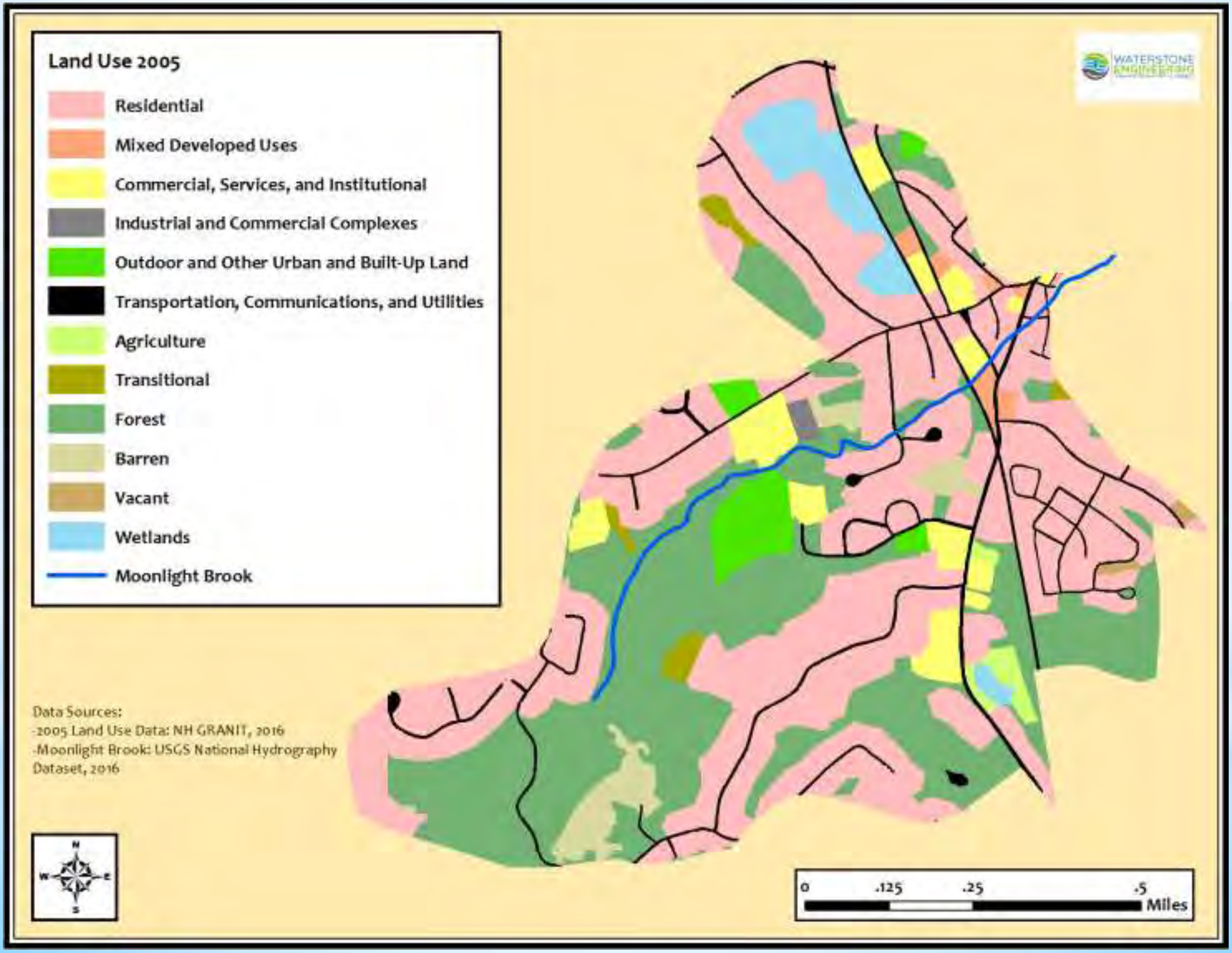
CHANGES IN CURVE NUMBER BY 2050 W/ LID



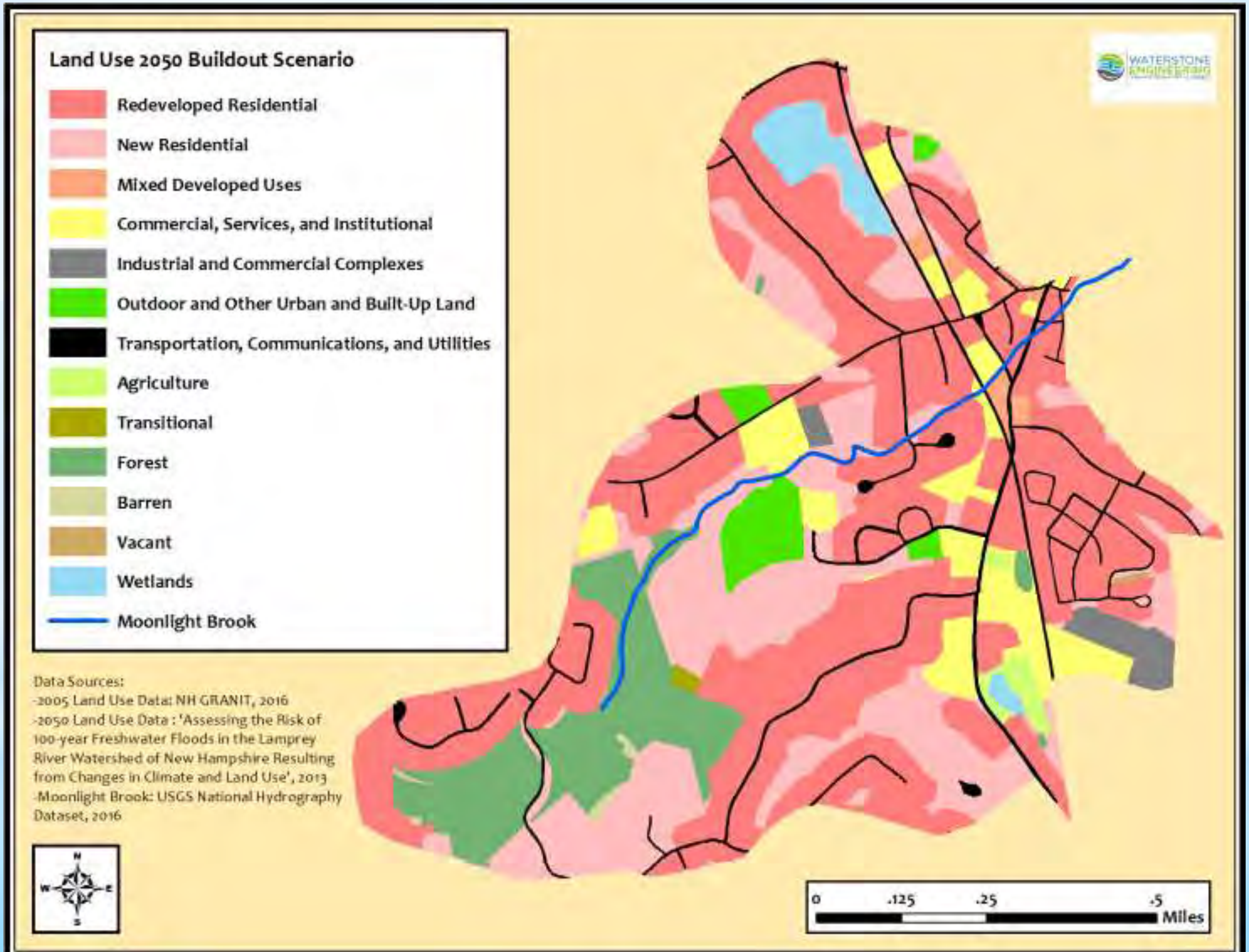
CHANGES IN CURVE NUMBER BY 2050

		Weighted Curve Number		
Subcatchment	Area (acres)	2005 (Current Conditions)	2050 Conventional Buildout	2050 Efficient LID Buildout
10AS-L	50	65	69	57
10AS-M	62	55	57	50
10AS-U	62	62	62	54
10S	18	74	76	66
11S	80	73	73	63
12S	41	69	71	61
1S	7	68	71	60
2S	50	62	63	60
3S	27	62	67	54
4S	20	68	76	64
5S	3	68	68	62
6S	44	68	77	62
7S	11	71	73	61
8S	8	82	82	72
9S	5	90	90	75
Total MB Watershed	486	66	69	59

CURRENT LAND USE



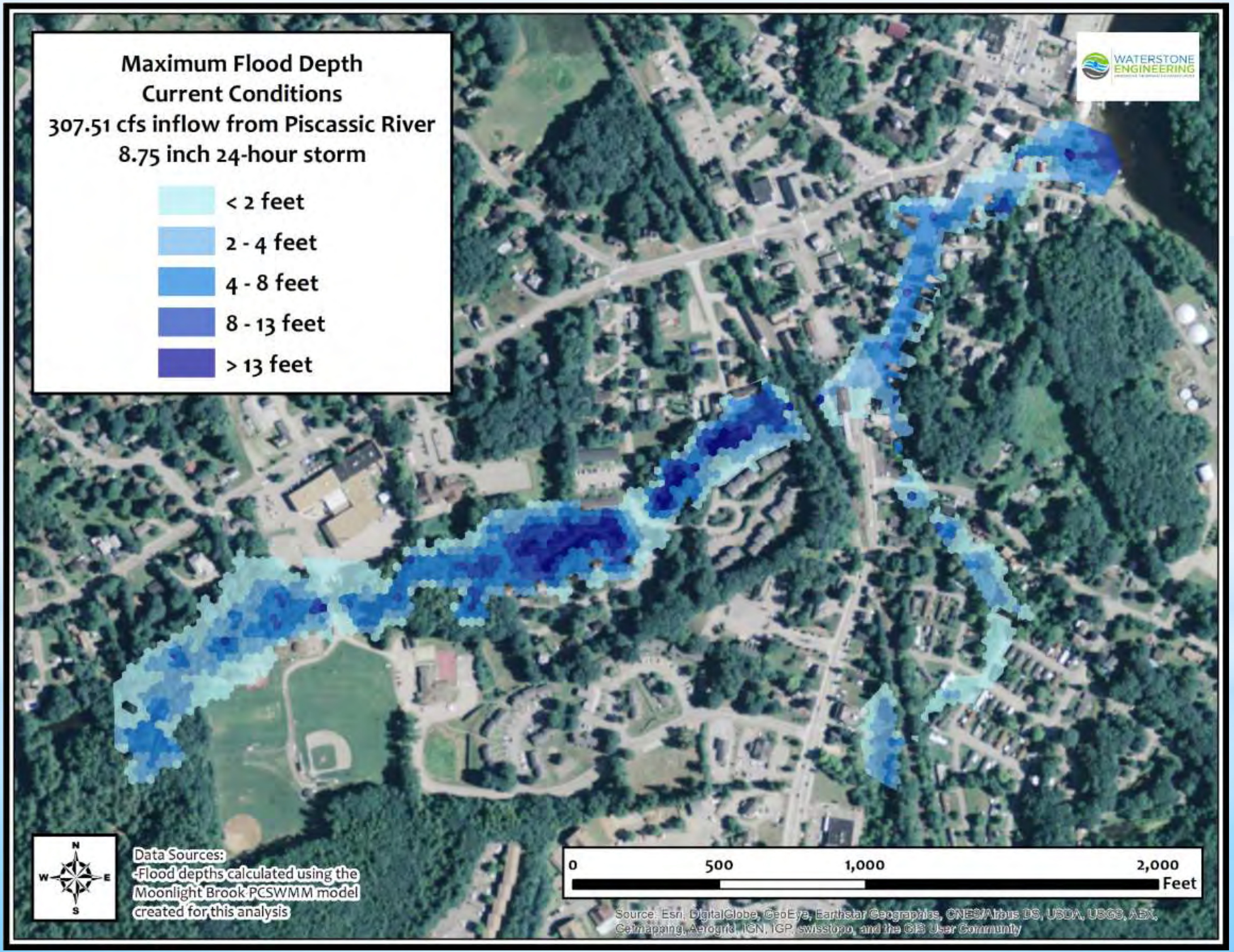
CHANGES IN LAND USE BY 2050



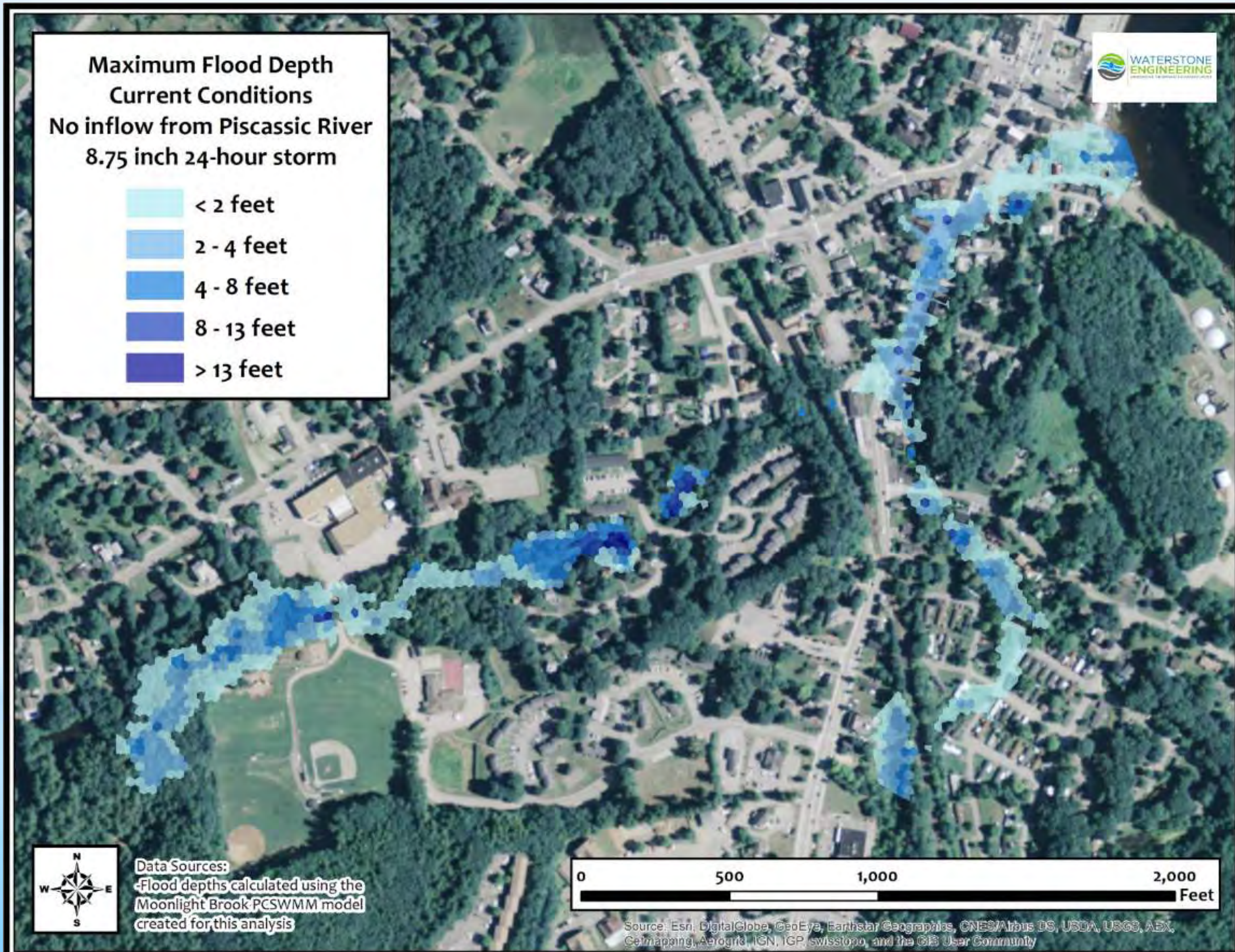
CHANGES IN LAND USE BY 2050

	Acreage	
Land Use Type	**2005 (Current Conditions)**	**2050 Buildout Scenario**
Redeveloped Residential	N/A	228.53
New Residential	228.53	106.92
Mixed Developed Uses	3.91	3.91
Commercial, Services, and Institutional	22.7	35.39
Industrial and Commercial Complexes	1.33	7.66
Outdoor and Other Urban and Built-Up Land	12.4	12.4
Transportation, Communications, and Utilities	24.12	24.12
Agriculture	3.72	3.72
Transitional	4.47	0.71
Forest	155.13	50.03
Barren	12.59	1.11
Vacant	1.08	0.26
Wetlands	15.9	11.12
Moonlight Brook Watershed	485.88	485.88
1. All of 2005 commercial and industrial land use is redeveloped for 2050		

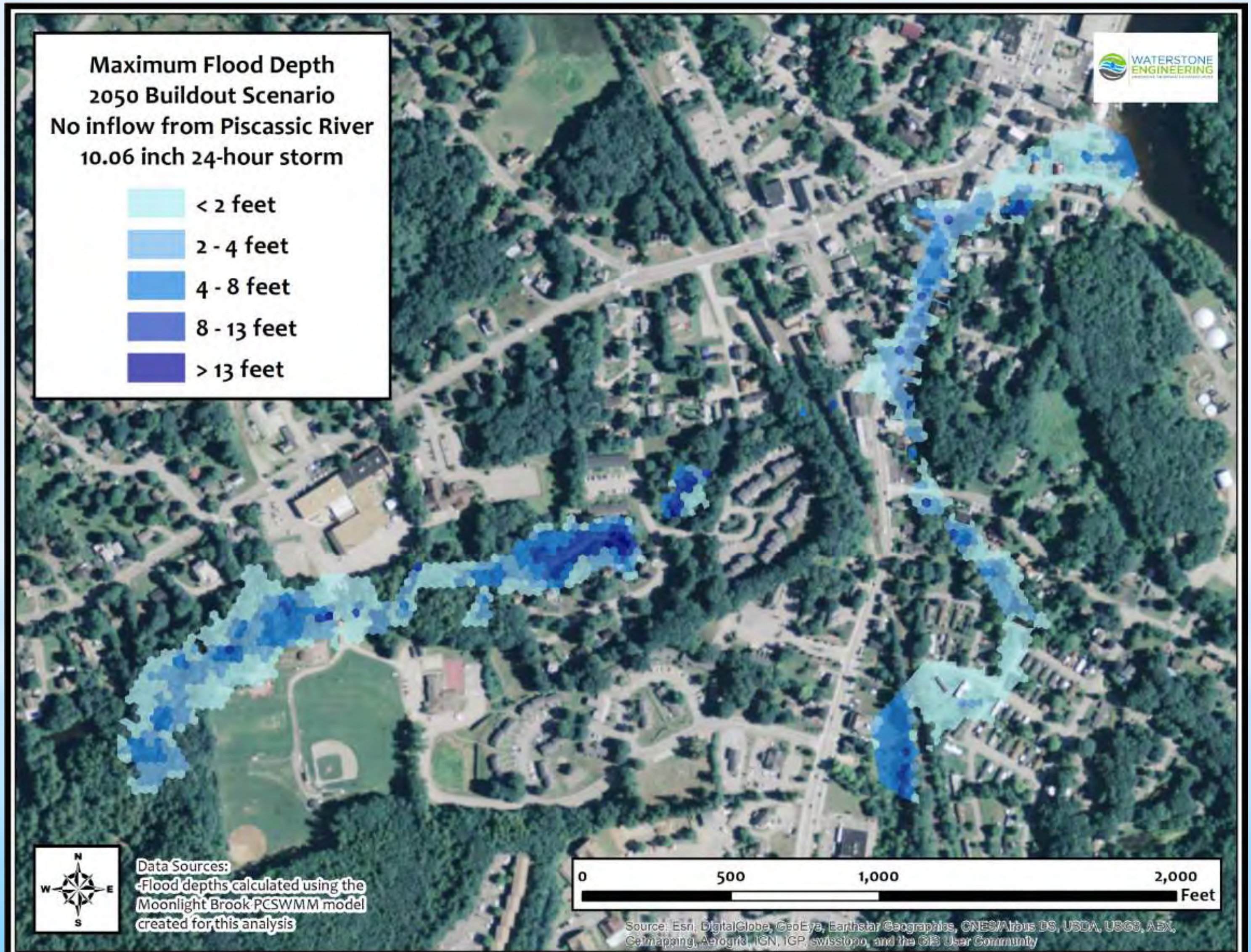
CURRENT FLOOD CONDITIONS W/ PISCASSIC



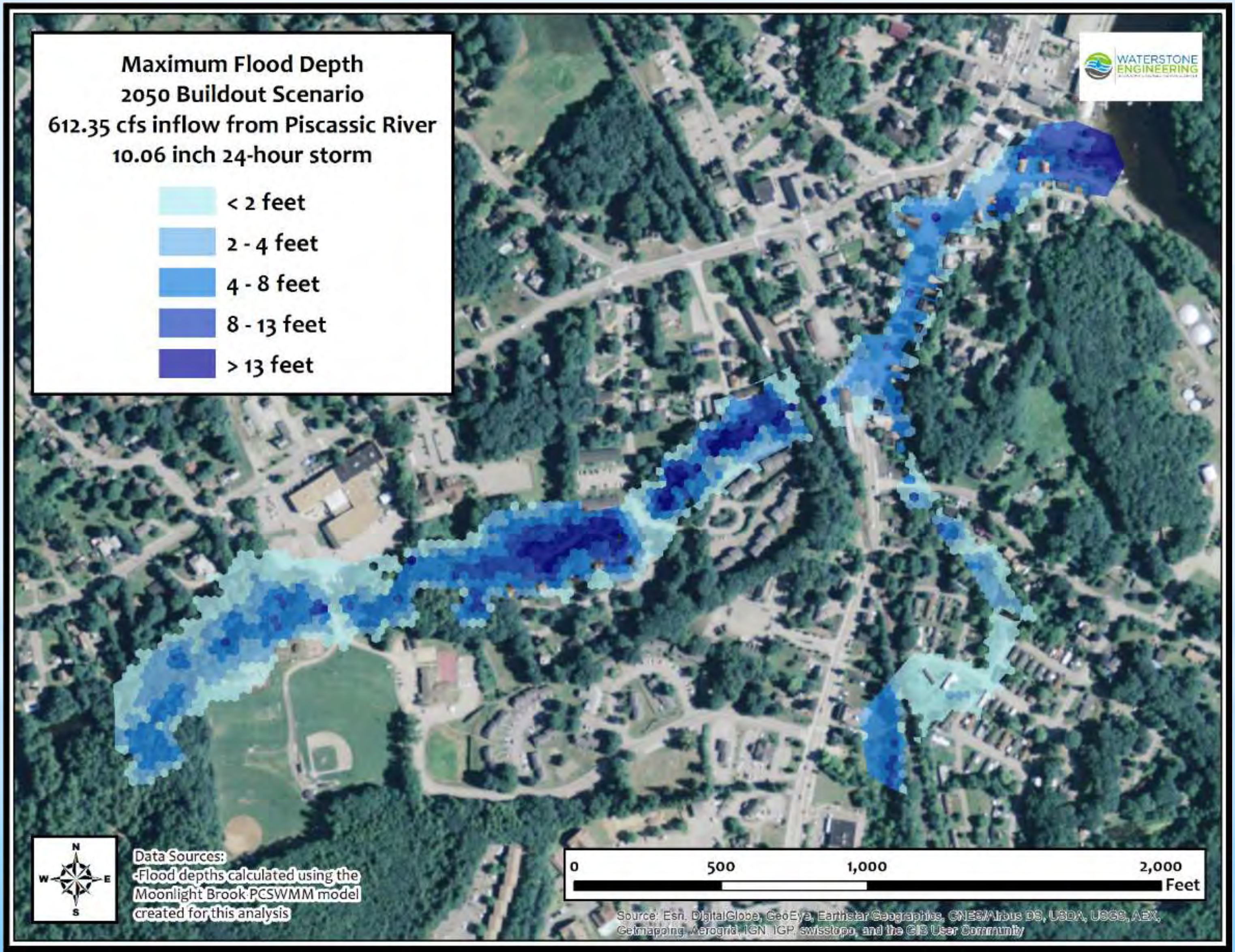
CURRENT FLOOD CONDITIONS W/O PISCASSIC +371CFS



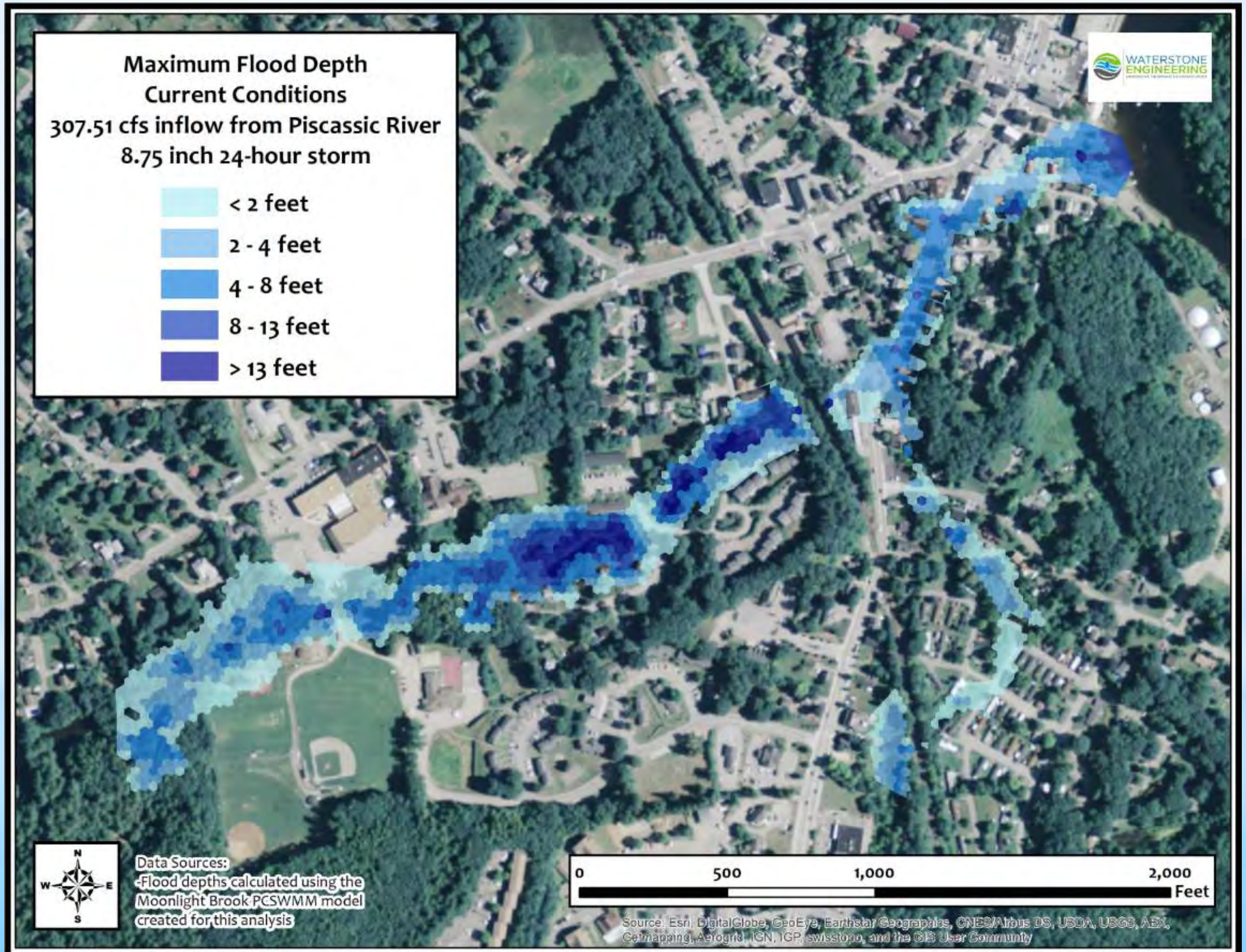
CHANGES IN FLOODING BY 2050 W/ O PISCASSIC



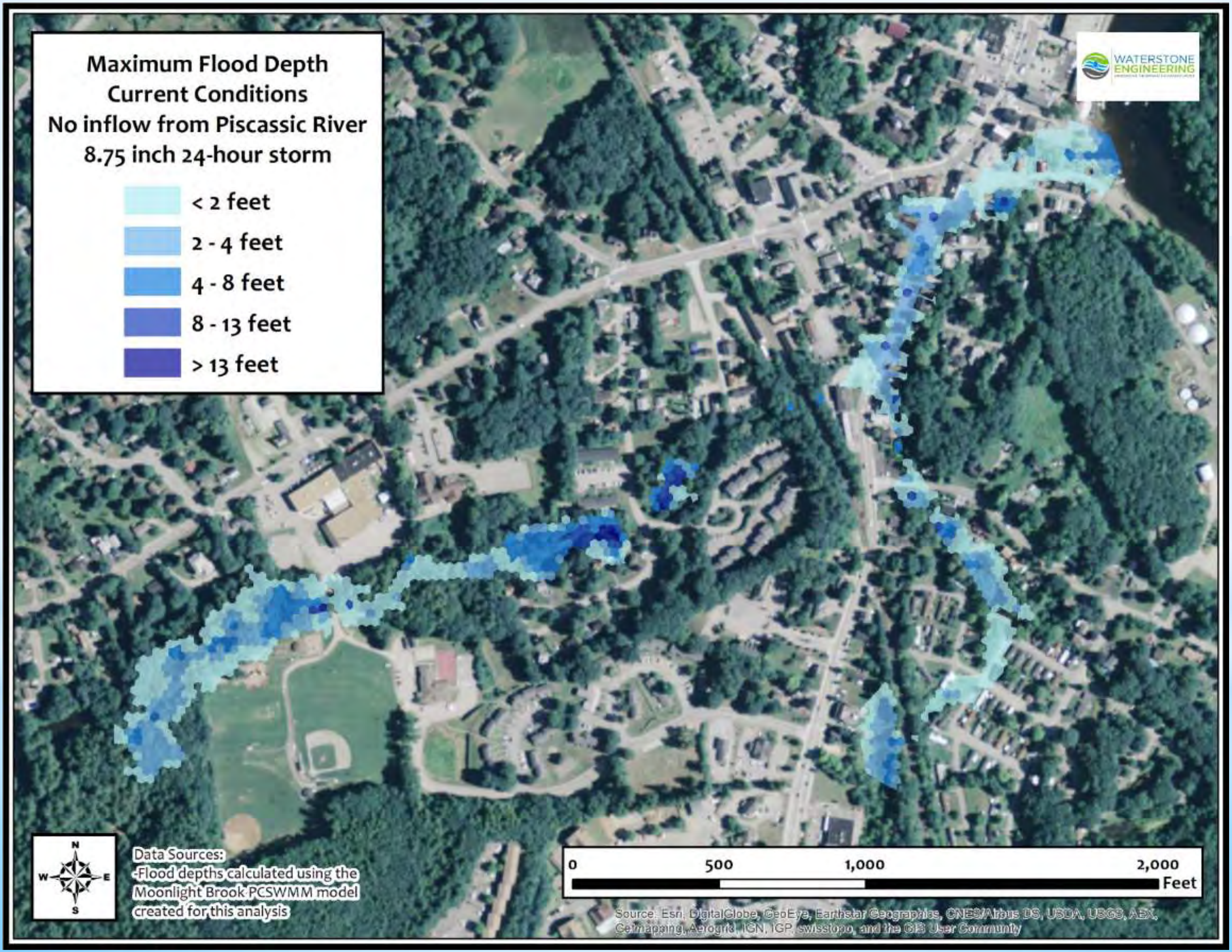
2050 W/ PISCASSIC + 612 CFS



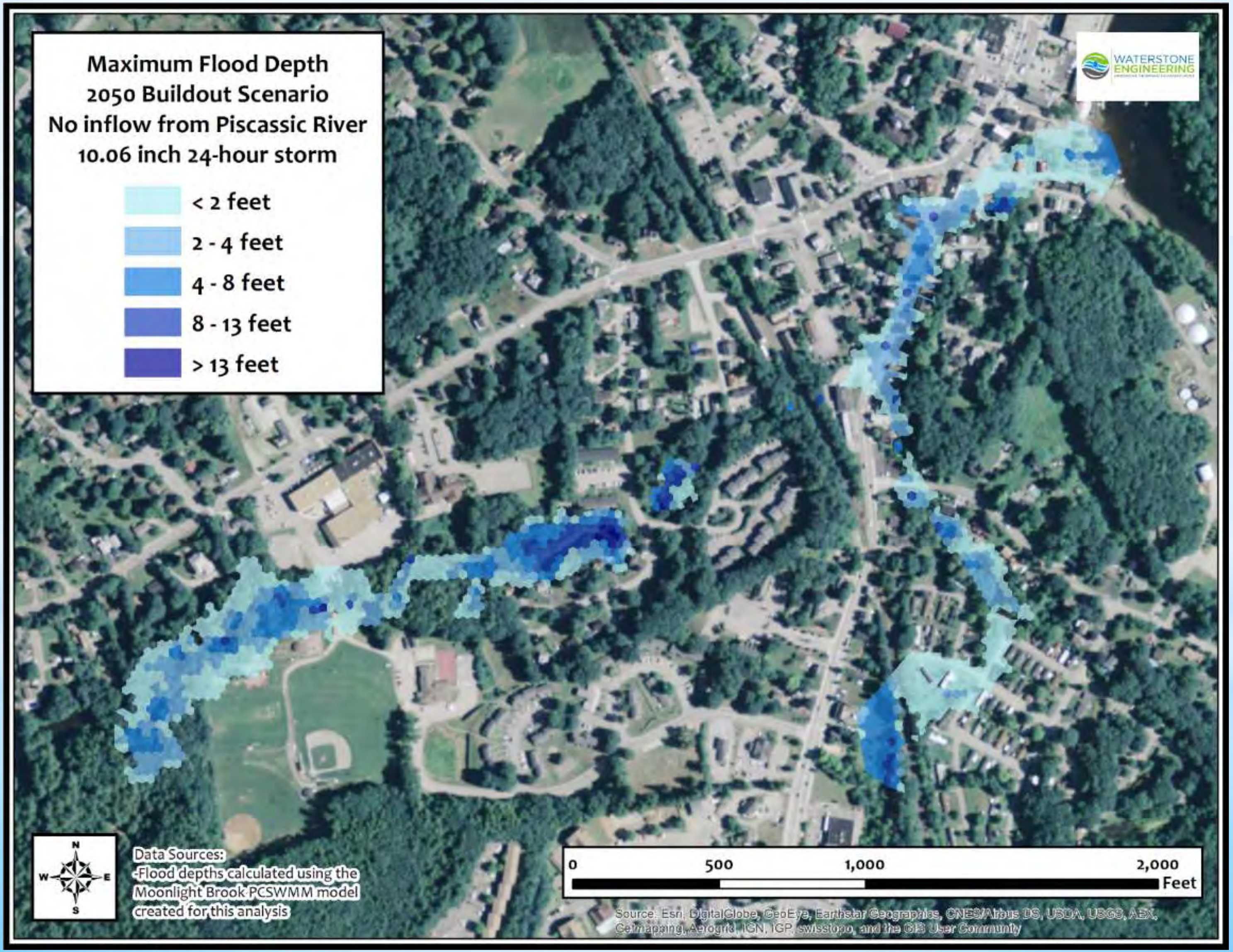
CURRENT FLOOD CONDITIONS W/ PISCASSIC



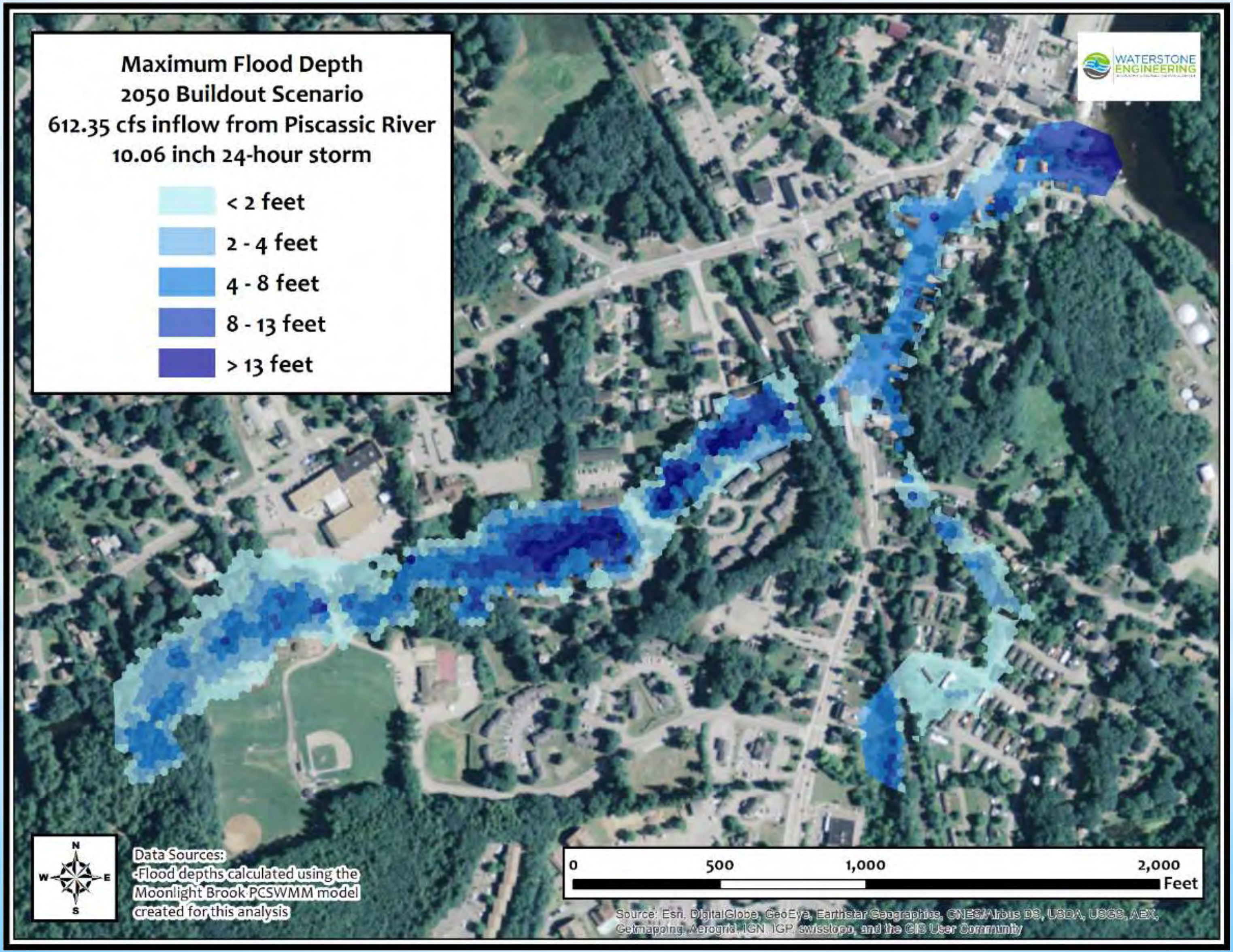
CURRENT FLOOD CONDITIONS W/O PISCASSIC +371CFS



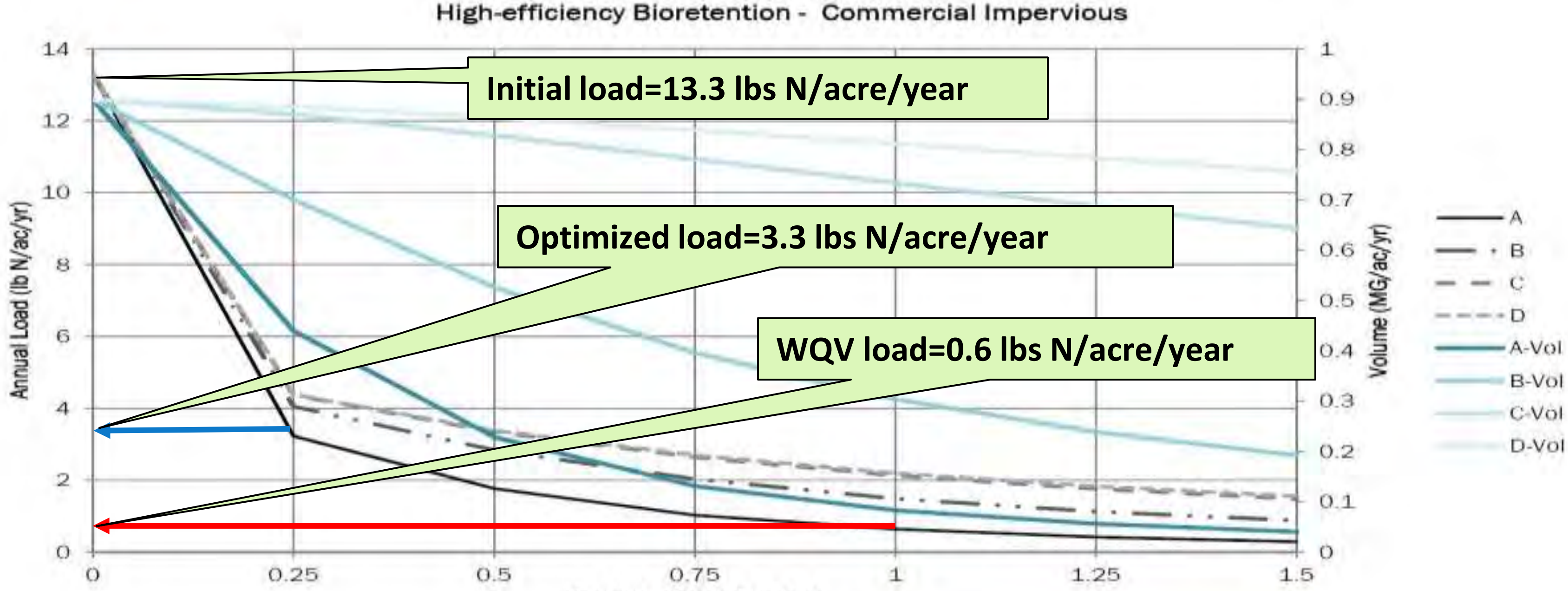
CHANGES IN FLOODING BY 2050 W/ O PISCASSIC



2050 W/ PISCASSIC + 612 CFS



BMP OPTIMIZATION--WQ



BMP Sizing Example:

•1 system treating a 1" water quality volume for 1 acre will remove approximately 12.7 lbs N/acre/year.

•4 smaller systems across 4 acres designed to treat 0.25" WQV/acre/yr will each remove 10 lbs N/acre/year for a total of 40 lbs N per year.

•An additional 27 lbs of nitrogen per year at nearly equivalent costs, or approximately 315% increase.

RECOMMENDED BMPS

Total Present Value of NPS Management (including O&M): $7.5 M
Total Volume Reduction from NPS Management: 13.7 Million Gallons
Total Acres Treated: 417

Land Cover	BMP Type	BMP Size	Unit Runoff Reduction (MG / acre)	Recommended Acreage	Construction Cost ($/acre)	Unit Cost ($/MG)	Total Potential Runoff Reduction (MG)	Cost by Land Use ($$)
ROAD I	RAINGARDEN	1.5	0.029	189.31	$ 18,000	$ 621,000	5.49	$ 3,408,000
ROAD I	RAINGARDEN	1.5	0.03	44.86	$ 18,000	$ 600,000	1.35	$ 808,000
RESIDENTIAL R	RAINGARDEN	1.5	0.0325	41.73	$ 18,000	$ 554,000	1.36	$ 752,000
RESIDENTIAL I	RAINGARDEN	0.5	0.009	29.63	$ 7,000	$ 778,000	0.27	$ 208,000
RESIDENTIAL R	WET POND	1.5	0.063	18.85	$ 22,400	$ 356,000	1.19	$ 423,000
RESIDENTIAL C	RAINGARDEN	0.75	0.02275	16.95	$ 10,000	$ 440,000	0.39	$ 170,000
RESIDENTIAL D	RAINGARDEN	1.5	0.0325	12.02	$ 18,000	$ 554,000	0.39	$ 217,000
RESIDENTIAL B	GRAVEL WETLAND	1.5	0.049	9.04	$ 35,300	$ 721,000	0.44	$ 319,000
RESIDENTIAL A	WET POND	1.5	0.063	7.07	$ 22,400	$ 356,000	0.45	$ 159,000
OUTDOOR I	RAINGARDEN	1.5	0.03	6.23	$ 18,000	$ 600,000	0.19	$ 113,000
				417			13.7	$ 7,428,000

*Showing only areas totaling greater than 5 acres

BIORETENTION AT HIGH SCHOOL

BIORETENTION AT HIGH SCHOOL

BIORETENTION AT HIGH SCHOOL