Summary Report: Recovery Potential Screening of Massachusetts Watersheds in Support of Nutrients Management

INTRODUCTION

The US Environmental Protection Agency's (EPA's) Total Maximum Daily Loads (TMDL) Program, in cooperation with state water quality programs, released a long-term TMDL Vision document in December 2013. Part of the TMDL Vision involves increasing states' identification of priority watersheds for restoration and protection efforts over a several-year time frame, and better linkage of TMDLs to these priorities. Previously, a 2011 Office of Water policy memorandum on nutrients had also recommended systematic watershed analysis, comparison and priority setting to obtain better results. EPA's TMDL program has provided watershed data, comparative assessment tools and state technical assistance for the past ten years through the Recovery Potential Screening (RPS) approach and tools (see Attachment 1). In support of state requests for assistance in nutrients-related prioritization, the TMDL program has partnered with several states, including Massachusetts, to jointly carry out RPS assessments and develop results to help states consider their watershed nutrients management options systematically with consistent data. These RPS assessments were designed to address primary nutrients issues identified by each state using state-specific indicators and data relevant for watershed comparison. This report summarizes the Massachusetts project approach and findings, and identifies multiple additional products (e.g., RPS Tools and data files) that were developed along with this overview document.

Background

Recovery Potential Screening (RPS) is a systematic, comparative method for identifying differences among watersheds that may influence their relative likelihood to be successfully restored or protected. The RPS approach involves identifying a group of watersheds to be compared and a specific purpose for comparison, selecting appropriate indicators in three categories (Ecological, Stressor, Social), calculating index values for the watersheds, and applying the results in strategic planning and prioritization. RPS was developed to provide states and other restoration planners with a systematic, flexible tool that could help them compare watershed differences in terms of key environmental and social factors affecting prospects for restoration success. As such, RPS provides water programs with an easy to use screening and comparison tool that is user-customizable for the geographic area of interest and a variety of specific comparison and prioritization purposes. The RPS Tool is a custom-coded Excel spreadsheet that performs all RPS calculations and generates RPS outputs (rank-ordered index tables, graphs and maps). It was developed several years ago to help users calculate Ecological, Stressor, Social, and Recovery Potential Integrated index scores for comparing up to thousands of watersheds in a desktop environment using widely available and familiar software. RPS Tools with embedded indicator data have been developed for each of the conterminous states and other selected geographic areas of interest.

Massachusetts Department of Environmental Protection (MassDEP) requested assistance from EPA in 2010 due to their interest in a more systematic, data-supported comparison of watersheds for restoration investments in their 303d/TMDL program and 319/Nonpoint Source program. An RPS assessment project was jointly undertaken by EPA's TMDL program, the Cadmus Group (EPA contractor), MassDEP, and MassDEP collaborators. 115 base, ecological, stressor, and social indicators were initially measured from State and federal data sources at the HUC12 and/or the smaller (e.g., catchment-size) Sustainable Watershed Management Initiative (SWMI) watershed scale provided by the USGS. All indicators were compiled in a Massachusetts statewide RPS tool (an Excel file). The 2011 workshop marked the completion and delivery of the State's first RPS tool and enabled MassDEP to begin routine use. An ensuing series of RPS workshops, round tables, and other events enabled MassDEP to build experience with the RPS tool among themselves and other MassDEP water programs, State and federal agencies, and non-governmental collaborators. In 2014, MassDEP requested follow-on assistance in RPS tool enhancement and application as one of several state nutrients demonstration projects using RPS. New national-scale data made available in 2014 in addition to datasets from the State enabled development of the current (2015) Massachusetts statewide RPS Tool for this project. This RPS tool contains 341 indicators with full statewide coverage at HUC12, HUC8, and/or SWMI scales. The assessment findings and most of the figures in this document were generated by the Massachusetts RPS Tool.

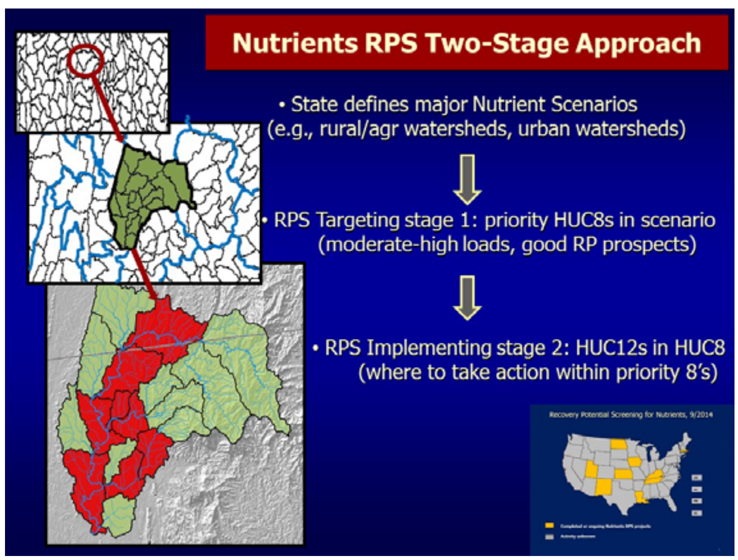
APPROACH

As a starting point, each RPS nutrients project was designed to apply recommendations from the EPA Office of Water 2011 nutrients policy memorandum, which reads in part:

> *Prioritize watersheds on a statewide basis for nitrogen and phosphorus loading reductions*
>
> *A. Use best available information to estimate Nitrogen (N) & Phosphorus (P) loadings delivered to rivers, streams, lakes, reservoirs, etc. in all major watersheds across the state on a Hydrologic Unit Code (HUC) 8 watershed scale or smaller watershed (or a comparable basis.)*
>
> *B. Identify major watersheds that individually or collectively account for a substantial portion of loads (e .g. 80 percent) delivered from urban and/or agriculture sources to waters in a state or directly delivered to multi-jurisdictional waters .*
>
> *C. Within each major watershed that has been identified as accounting for the substantial portion of the load, identify targeted/priority sub-watersheds on a HUC 12 or similar scale to implement targeted N & P load reduction activities. Prioritization of sub-watersheds should reflect an evaluation of receiving water problems, public and private drinking water supply impacts, N & P loadings, opportunity to address high-risk N & P problems, or other related factors.*

The two-stage approach implicit in the text above fits well with the RPS Tool, which easily supports comparing HUC8 watersheds in a first, targeting stage and then focuses on screening and comparing HUC12s in a second, implementation-oriented stage. All the RPS nutrients projects utilized the same general two stage approach (HUC8 or similar larger-scale unit in Stage 1, HUC12 or similar subwatershed unit in Stage2), while encouraging state-specific customizing of the approach in identifying stage 1 scenarios, establishing state approaches for priority watershed identification, and selection and weighting of the most nutrients-relevant indicators for use in both stages. In this project, the data sources and indicators compiled in the RPS tool, the selections of indicators, choice of demonstration watersheds, and weighting of indicators in the nutrients-related screening runs all took place collaboratively among MassDEP, EPA and its contractor. Nevertheless, this technical project's findings and outputs are not meant to represent decisions or policies of MassDEP, EPA, or other entity.

Figure 1: Two-stage conceptual approach utilized in RPS projects for supporting state nutrients management.



Stage 1

Identifying Nutrient Scenarios. The RPS Tool is most effective in comparing groups of watersheds that have something in common, such as generally similar landscapes, nutrient sources, impacts and possible management options; for this reason, Stage 1 begins by engaging the state in defining specific types or groups of watersheds with something in common regarding their primary nutrients management challenges. The term "scenario" is used here to describe these sets of shared characteristics that provide a basis for groups of similar watersheds to be compared and contrasted with one another effectively. Nutrient management challenges in any given state can be complex and involve multiple scenarios. Breaking down a large group of watersheds statewide into smaller, more similar groups and focusing on scenarios most relevant to each group enables a narrower focus on nutrient issues and possible solutions. At a minimum, nutrients scenarios usually differentiate between groups of watersheds with primarily agricultural/rural loading sources and groups of more urban-suburban watersheds with wastewater and urban runoff nutrient sources. Screening these scenarios separately enables selection of indicators that can be more specific to each scenario.

For Massachusetts, two scenarios identifying similar subsets of interest from the State's 20 HUC8s were initially selected in a conference call between EPA, MassDEP, and Cadmus:

Rural-agricultural watersheds scenario. Watersheds in this scenario contain a mixed land use pattern typically including cropland, grazing land, low-density residential areas and forested land. At the HUC8 scale in a state with a long history of intensive land use and high population density, this scenario is not purely rural and agricultural but often contains a significant amount of urbanization and suburban spread. This characteristic suggests that some urban-oriented indicators be included in this primarily agriculture-oriented screening. Contiguous cropland areas are more frequent on the larger low-gradient areas, and thus may occur near the moderate to larger rivers and streams, but smaller cropland patches also are common and limited in extent by adjacent steep slopes. Grazing and pasture areas are not as slope-limited as cropland and may include moderately steep areas as well as areas near rivers and streams. Human population and typically urban/suburban nutrients sources probably are secondary to agriculture in this scenario's watersheds, but rural residential patterns in or near the stream corridors might be capable of a significant effect on loading at more local, subwatershed scales.

Urban-suburban watersheds scenario. Watersheds in this scenario contain a substantial urban and suburban presence, but typically are not urbanized over a majority of area. Urbanization may comprise a small percentage of HUC8 scale watersheds due to their relatively large watershed area, but can still be the source of significant nutrient loads. Few Massachusetts HUC8s contain large, high-density urbanized areas, but several more do contain extensive suburban and smaller high-density urban components. With urbanization seldom dominating, a mosaic of cropland, pasture, forest and other uses makes up the remainder of this watershed scenario. Indicator selection favors the urban and suburban nutrient source-related elements that typify this scenario, but the presence of agriculture in the outskirts of many urban watersheds suggests including indicators that help discern between watersheds with exclusively urban-suburban nutrient sources and those with more mixed sources.

Selection of Stage 1 indicators. Because the two scenarios differ fundamentally in land use patterns, nutrient source types and exposure pathways, watersheds within each scenario can be compared to one another with more scenario-specific indicator selections. Indicators for Stage 1 need only to be sufficient for generally comparing watersheds across the state, identifying which watersheds to include in each scenario, and revealing major differences in condition and estimated nutrient loading magnitude as a state selects its first watersheds to assess within each scenario. Using the RPS Tool, two different (scenario-specific) selections of recovery potential indicators weighted according to MassDEP request (see indicator lists in Table 1 and definitions in Attachment 2) were used to screen all the Massachusetts HUC8s.

Selecting Stage 1 demonstration watersheds. Typically, several Stage 1 watersheds in each scenario are selected by the state as an initial 'focus group' in which to demonstrate the RPS assessment approach. Identifying a demonstration group may target early adopters or high-interest watersheds, but is not meant to assign priority or preclude a state's assessment of their remaining watersheds over time. Selections can be based on a Stage 1 screening, expert opinion, or a combination of both. The Stage 1 approach allows inclusion of specific watersheds that did not fully meet these scenario criteria if a compelling reason existed for their inclusion (e.g., significant progress in planning or addressing nutrient issues typical of the scenario). Ideally, Stage 1 indicators, criteria and expert judgment combine to identify watersheds that not only have loading issues, but also show traits relevant to better restorability.

For each scenario, Massachusetts's Stage 1 selections were made by MassDEP and validated with a Stage 1 screening. These statewide screenings each provided an independent (from MassDEP selection) basis to identify the group of

HUC8s that best fit the defining characteristics of each scenario. These two groups of scenario-specific 'best fit' watersheds were identified by applying threshold criteria (e.g., % instate, % specific land use categories, N or P loading > state median) to further refine the two statewide scenario screenings.

Table 1. Stage 1 RPS indicator selections and weights for screening and comparing HUC8 watersheds for the Rural-Agricultural Scenario (upper) and the Urban-Suburban Scenario (lower) in Massachusetts. See Attachment 2 for indicator definitions.

Stage 1 Rural-Agricultural Scenario

Ecological Indicators	wt	Stressor Indicators	wt	Social Indicators	wt
% NEF2001, National Ecological Framework, WS	3	% Human Use, U-index 2 (2006) in Watershed	3	% of HUC8 Instate	1
% Natural Cover, N-index1 (2006) in HCZ	2	Empower Density 2001, Mean Value in Watershed	2	Nutrient TMDL Count	2
% Woody Vegetation (2006) in Riparian Zone	3	% Agriculture (2006) in Riparian Zone	2	ADOPT Watershed Groups Count	3
Ratio of Natural to Recycled N Inputs	1	Agricultural water use WS	1	Percent GAP status 1, 2, and 3 WS	3
Ratio of Natural to New N Inputs	1	Domestic water use WS	1	Anthropogenic Recycled N Effort (Inverse)	2
		SPARROW Predicted Incremental Agr N Yield (2012)	3	Anthropogenic New N Effort (Inverse)	2
		SPARROW Predicted Incremental Agr P Yield (2012)	3	Percent Drinking Water Source Protection Area WS	3
		Anthropogenic Recycled N Effort	1		
		Anthropogenic New N Effort	1		
		Nutrient Impaired Segment Count	2		
		Watershed Likely N/P NPDES Discharger Count	1		

Stage 1 Urban-Suburban Scenario

Ecological Indicators	wt	Stressor Indicators	wt	Social Indicators	wt
% NEF2001, National Ecological Framework, WS	3	% Human Use, U-index 2 (2006) in Watershed	2	% of HUC8 Instate	1
% Natural Cover, N-index1 (2006) in HCZ	2	Empower Density 2001, Mean Value in HCZ	2	Nutrient TMDL Count	3
% Woody Vegetation (2006) in Riparian Zone	3	% Agriculture (2006) in Watershed	1	ADOPT Watershed Groups Count	3
Ratio of Natural to Recycled N Inputs	1	% Urban (2006) in HCZ	3	Percent GAP status 1, 2, and 3 WS	2
Ratio of Natural to New N Inputs	1	Watershed Likely N/P NPDES Discharger Count	3	Anthropogenic Recycled N Effort (Inverse)	2
		Domestic water use WS	1	Anthropogenic New N Effort (Inverse)	2
		SPARROW Predicted Incremental Agr P Yield (2012)	2	Percent Drinking Water Source Protection Area WS	3
		Anthropogenic Recycled N Effort	3	% of HUC8 Instate	1
		Anthropogenic New N Effort	3		
		Nutrient Impaired Segment Count	3		
		Empower Density 2001, Mean Value in Watershed	1		
		Centralized Sewage N Input	1		

Stage 2

Selection of Stage 2 Indicators. Stage 2 assessment is intended to compare smaller subwatersheds (HUC12s in this report) for a more specific planning purpose (i.e., considering where best to implement control efforts) than Stage 1. Stage 2 continues Stage 1's orientation toward scenarios, as different sets of Stage 2 indicators are selected for assessing the HUC12s within the rural-agricultural HUC8s and the urban-suburban HUC8s. Indicator selection at this second, more detailed stage can draw from the much lengthier and varied set of indicators compiled statewide at the HUC12 scale, and thus is capable of being tailored to address more specific land use settings or control practices. Indicator selections and weights assigned by MassDEP (see Table 2) were used for screening the HUC12s within the HUC8s of each scenario.

Within-HUC8 Comparison of HUC12s. In addition to the difference in purpose, a second important difference between Stage 2 and Stage 1 is in geographic scope. Stage 1 compared larger watersheds statewide using rather general indicators and criteria at statewide scales, thus Stage 1 results were meaningful in the context of the State. In contrast, Stage 2 compared subwatersheds (meaning HUC12s in this document) in the context of their larger HUC8 watershed alone, not in the context of the State's entire group of HUC12s. This difference means that Stage 2 screening identifies subwatersheds that may influence the health and future of the larger watershed, as well identifying opportunities for action within these subwatersheds individually. Comparison of all HUC12s statewide is appropriate for some purposes, but within-HUC8 comparisons of HUC12s are frequently more useful because they reveal HUC12 relative differences within the context of a smaller, more homogeneous setting rather than a highly variable statewide setting.

Potential Stage 2 priority watersheds. RPS Tool screening runs performed on each demonstration HUC8 identify a gradient of conditions among the HUC12s within the HUC8. Each screening run generates an Ecological, Stressor, Social and Integrated Index score for every HUC12; those four indices, and even single indicators of exceptional interest, may be used in contrasting differences among a HUC8's subwatersheds and thus helping to inform strategies for where to invest nutrient management and control resources. As the purpose of this report is to demonstrate procedures and alternatives for identifying potential watershed priorities that states may follow and adapt to their planning, the Stage 2 results presented in this document should be considered a demonstration of alternatives rather than final selections.

Table 2. Stage 2 RPS indicator selections and weights for screening and comparing HUC12 watersheds within HUC8s from the Rural-Agricultural Scenario (upper) and the Urban-Suburban Scenario (lower) in Massachusetts. See Attachment 3 for indicator definitions.

Stage 2 Rural-Agricultural Scenario

Ecological Indicators	wt	Stressor Indicators	wt	Social Indicators	wt
% Woody Vegetation (2006) in Watershed	3	Stream Corridor (30.5M) % Crop (ISO)	3	% Watershed Streamlength Assessed	1
% Woody Vegetation (2006) in Riparian Zone	2	Stream Corridor (30.5M) % Pasture (ISO)	3	% Watershed Waterbody Area Assessed	1
Watershed % Wetland (ISO)	2	Open Water Buffer (30.5M) % Crop (ISO)	3	Watershed Count Ratio TMDLs to Impairments	1
% Natural Cover, N-index 2 (2006) in HCZ	1	Open Water Buffer (30.5M) % Pasture (ISO)	3	Watershed Segments with Nutrient TMDLs Count	1
HCZ mean soil stability	3	% Developed, Open Space (2006) in Riparian Zone	2	NRCS Obligated Projects (#/sq. mi.) (ISO)	1
CNFI (ISO)	2	% Developed, Low intensity (2006) in Riparian Zone	2	Protected Land Index (ISO)	3
Mean Index of Ecological Integrity (ISO)	3	% Contiguous Agriculture (2006) in Watershed	3	PWS Intakes (#/sq. mi.) (ISO)	3
NFHAP HCI (ISO)	2	% U-Index06 Contiguous H2O, in Watershed	1	PWS Wells (#/sq. mi.) (ISO)	3
		Empower Density 2001, Mean Value in RZ	1	% ACEC (ISO)	3
		Total nitrogen deposition WS	3	% Water-based Recreation (ISO)	3
		Synthetic N fertilizer application (kg N/ha/yr) WS	3		
		N Yield (lb/sqmi) (ISO)	3		
		P Yield (lb/sqmi) (ISO)	1		
		Road Density 2003, Mean Value (mi /sq mi) RZ	2		
		% Watershed Streamlength 303d-Listed Nutrients	1		
		Watershed Nutrients 303d-Listed Segments Count	1		
		Watershed 303d + TMDL Impairment Causes Count	1		

Stage 2 Urban-Suburban Scenario

Ecological Indicators	wt	Stressor Indicators	wt	Social Indicators	wt
% Woody Vegetation (2006) in Watershed	3	Watershed % Urban1 (ISO)	3	% Watershed Streamlength Assessed	1
% Woody Vegetation (2006) in Riparian Zone	2	% Developed, Low intensity (2006) in Watershed	3	% Watershed Waterbody Area Assessed	1
Watershed % Wetland (ISO)	2	% Developed, Medium intensity (2006) in Watershed	3	Watershed Count Ratio TMDLs to Impairments	1
% Natural Cover, N-index 2 (2006) in HCZ	1	% Agriculture (2006) in Watershed	2	Watershed Segments with Nutrient TMDLs Count	1
Infiltration BMP Suitability (Ksat um/s) (ISO)	3	Stream Corridor (61M) % Impervious (ISO)	2	% Area not in MS4 (ISO)	1
CNFI (ISO)	2	Open Water Buffer (61M) % Impervious (ISO)	2	CC Score (ISO)	1
Mean Index of Ecological Integrity (ISO)	3	Empower Density 2001, Mean Value in RZ	1	Protected Land Index (ISO)	3
NFHAP HCI (ISO)	2	Total nitrogen deposition WS	3	PWS Intakes (#/sq. mi.) (ISO)	3
		Synthetic N fertilizer application (kg N/ha/yr) WS	3	PWS Wells (#/sq. mi.)v	3
		N Yield (lb/sqmi) (ISO)	3	% ACEC (ISO)	3
		P Yield (lb/sqmi) (ISO)	1	% Water-based Recreation (ISO)	3
		PCS (#/sqmi) (ISO)	1		
		Sediment (ISO)	2		
		Road Density 2003, Mean Value (mi /sq mi) RZ	2		
		% Watershed Streamlength 303d-Listed Nutrients	1		
		Watershed 303d + TMDL Impairment Causes Count	1		

STAGE 1 RESULTS

Rural-Agricultural Watersheds Scenario

This scenario identified HUC8s with significant rural and agricultural sources of nutrients that are of higher interest for rural nutrient management efforts. A copy of the RPS Tool populated with this scenario's screening results is among project deliverables. HUC8 watersheds were included in this scenario based on the following criteria:

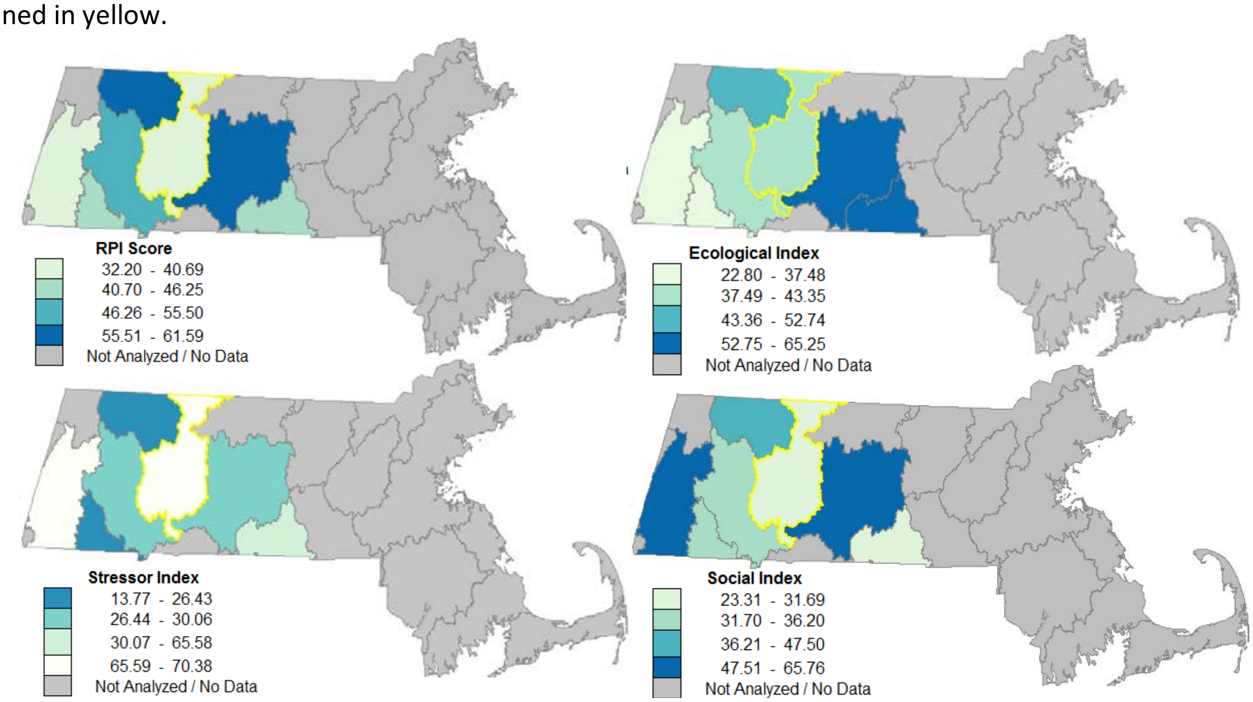
- ≥20% instate
- ≥ Statewide median SPARROW-predicted agricultural nitrogen (N) or phosphorus (P) loads

Seven of 20 HUC8s met scenario criteria from the Stage 1 screening; five (bolded) also qualified as urban-suburban scenario HUC8s. One HUC8 watershed in this scenario (Middle Connecticut, asterisked) was specifically requested by MassDEP as a rural-agricultural demonstration watershed for Stage 2.

- **Chicopee**
- Deerfield
- Westfield
- **Quinebaug**
- **Housatonic**
- **Farmington**
- **Middle Connecticut***

Recovery Potential Integrated (RPI) index scores for the rural scenario are displayed in map form in Figure 2, showing the scenario watersheds cluster in the western half of the State. RPI scores are a composite of scores for the Ecological, Stressor, and Social Indices. Top scoring HUC8s include the Chicopee, Quinebaug, and Deerfield. The Middle Connecticut's RPI score is low compared to the other HUC8s; this implies that it may have higher nutrient loads from agriculture and other stressors, and thus may require more effort than other scenario HUC8s to manage. The low RPI score should never be interpreted as being unrestorable or undesirable for restoration, but viewed as a relative measure of likely needed effort compared with other watersheds. Maps of Ecological, Stressor, and Social Index scores for the rural-agricultural scenario are also displayed in Figure 2. The Ecological Index map shows a gradient of high to low Ecological Index scores from mid-State east to west. Stressor and Social Index scores are more varied geographically.

Figure 2. Index scores for the rural-agricultural scenario. The most intense colors in RPS maps denote the "best" scores for traits likely to be more favorable to restoration efforts. The HUC8 requested by MassDEP for Stage 2 is outlined in yellow.



The bubble plot in Figure 3 enables additional comparison and contrast of the demonstration HUC8 to other scenario HUC8s and also against conditions statewide. It displays the relative value differences among HUC8s in Ecological, Stressor and Social Index scores by each bubble's size and position on the graph, also showing how these compare to statewide medians (the horizontal and vertical median lines). Further, this figure enables the scenario (dark green and red) and demonstration (red with label) HUC8s to be compared with the rest of the State's HUC8s. Most of the scenario HUC8s have average or below average (i.e., better) Stressor scores than the State overall, and the group varies markedly in Ecological score with several well above the State median. Generally the most promising watersheds for restoration appear in the upper left quadrant of the plot (low stressors and high ecological), and some scenario HUC8s appear there. This may imply that, despite moderately extensive agricultural land use, the rural-agricultural scenario contains several of the State's better-scoring HUC8s overall. The demonstration HUC8 for this scenario (Middle Connecticut) is about average in Ecological score and has a slightly higher than average Stressor score statewide, but represents the highest Stressor index within the rural scenario. One HUC8 (Quinebaug) in the scenario has an Ecological Index score that is well above average and an average Stressor Index score. This HUC8 was not selected as a demonstration HUC8 but may be a good candidate for future screening because it appears to have positive ecological features despite the stressors present.

Figure 3. Bubble plot for all Massachusetts HUC8s based on RPI score derived from the rural-agricultural scenario indicators. This plot highlights rural-agricultural scenario watersheds (dark green and red) and the Stage 2 demonstration watershed (red with name label). Axes are set to statewide median Ecological index and Stressor index scores.

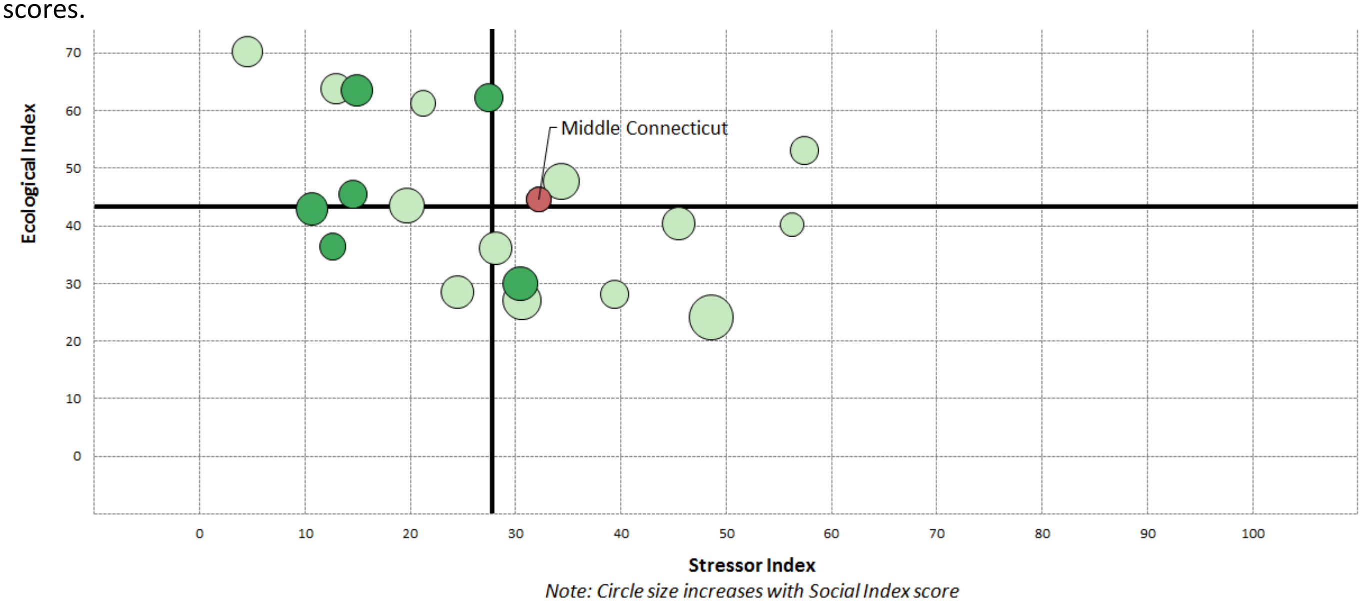


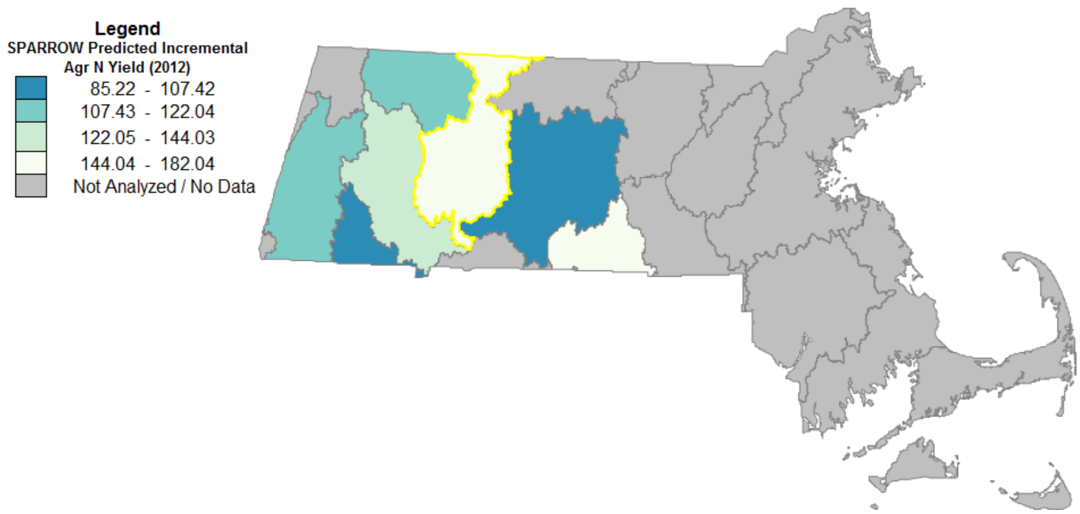
Table 3 contains Ecological, Stressor, Social, and RPI scores for the rural-agricultural scenario HUC8s, in order of descending RPI score and color-coded by quartile per RPS index. This tabular format is another option for presentation of Stage 1 results that can be used to compare and contrast HUC8s for rural nutrient management efforts. In interpreting this table, preferred HUC8s for rural nutrient management do not necessarily have to be those with the highest RPI scores but instead could consider one or more of the component index scores. For example, the Quinebaug HUC8 ranks outside the top 50th percentile in RPI score but has the second highest Ecological Index score, and its high Stressor Index may suggest emerging risks to its ecological positives.

Table 3. Index and RPI scores for the rural-agricultural scenario. HUC8s are ordered by RPI score. Cells are shaded according to rank (green = 76 -100th percentile; yellow = 51-75th percentile; orange = 26-50th percentile; pink = 0-25th percentile). The demonstration HUC8 requested by MassDEP for the rural-agricultural scenario is marked with an asterisk (*). Scores and quartiles derived from screening rural-agricultural scenario HUC8s only.

Watershed ID	Watershed Name	Ecological Index	Stressor Index	Social Index	RPI Score
01080204	Chicopee	65.25	28.19	47.69	61.59
01080203	Deerfield	50.00	13.77	47.31	61.18
01080206	Westfield	43.35	30.06	36.20	49.83
01080207	Farmington	31.69	24.68	31.74	46.25
01100001	Quinebaug	55.49	61.20	31.64	41.98
01100005	Housatonic	22.80	70.38	65.76	39.39
01080201	Middle Connecticut*	43.28	69.98	23.32	32.21

Figure 4 displays a map of a single indicator used in the rural-agricultural scenario, agricultural nitrogen yields for each HUC8 predicted by the USGS SPARROW model. Individual indicators can be mapped and explored within the RPS tool in conjunction with index scores to further refine the selection of HUC8s of interest for additional screening.

Figure 4. Agricultural nitrogen yields for HUC8s in the rural-agricultural scenario predicted by the USGS SPARROW model. The most intense colors in RPS maps denote the "best" scores for traits likely to be more favorable to restoration efforts. The HUC8 requested by MassDEP for Stage 2 is outlined in yellow.



Urban-Suburban Watersheds Scenario

This scenario is intended to identify HUC8s with significant urban and suburban sources of nutrients that are of higher interest for urban nutrient management efforts. A copy of the RPS Tool populated with this scenario's screening results is among project deliverables. Twelve HUC8 watersheds are included in this scenario based on the following criteria:

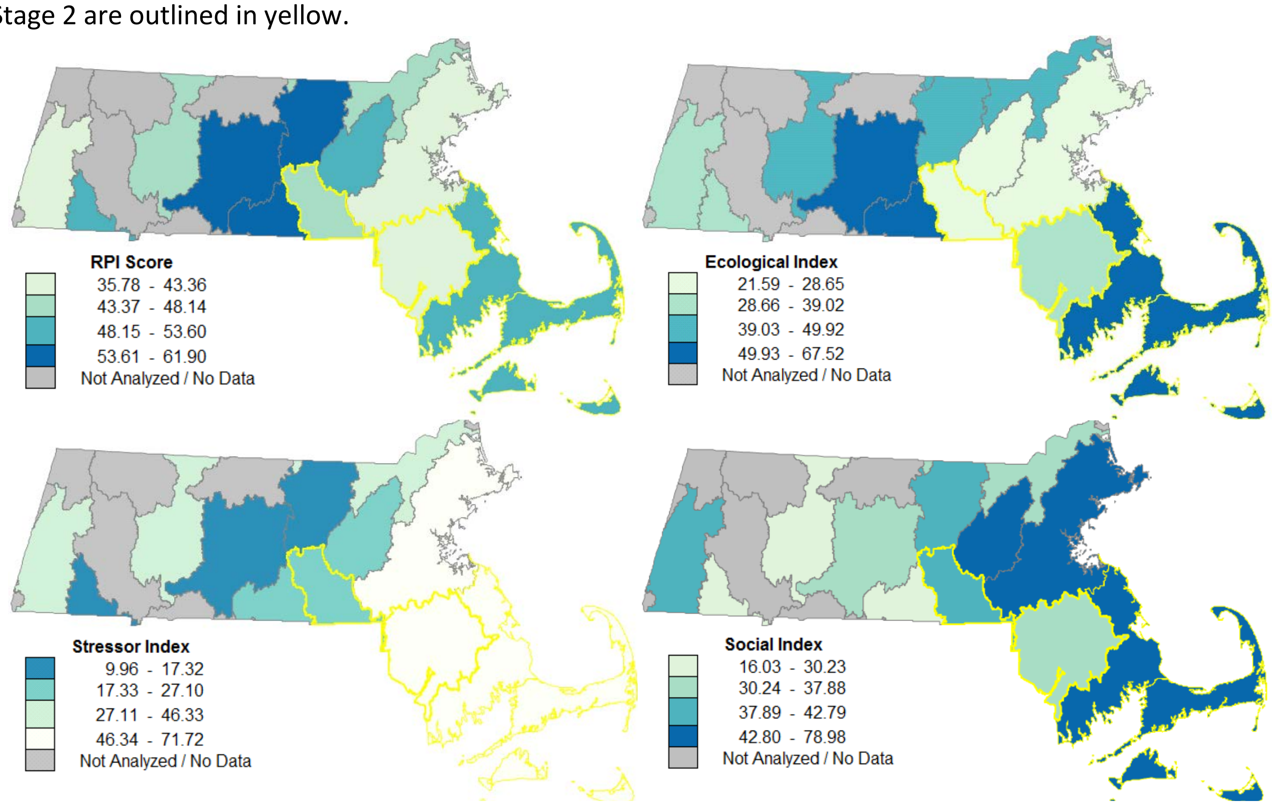
- ≥20% instate
- ≥10% developed land cover in watershed

Twelve of 20 HUC8s met all scenario criteria from the Stage 1 screening; five (bolded) also qualified for the rural-agricultural scenario HUC8s. Three HUC8 watersheds in this scenario (asterisked) were specifically requested by MassDEP as demonstration watersheds for Stage 2:

- **Chicopee**
- Nashua
- **Quinebaug**
- Cape Cod*
- Blackstone*
- **Middle Connecticut**
- Merrimack River
- Charles
- Concord
- **Farmington**
- **Housatonic**
- Narragansett*

Recovery Potential Integrated (RPI) index scores for the urban-suburban scenario are displayed in map format in Figure 5. RPI scores are a composite of scores for the Ecological, Stressor, and Social Indices based on the urban-suburban scenario's indicator selection and weighting. As a State with a long history of widespread development, most of the Massachusetts HUC8s appear in this scenario but the eastern half of the state predominates. Top scoring HUC8s based on RPI score from the urban-suburban indicators and screening include Chicopee, Nashua, and Quinebaug. HUC8s with the lowest RPI scores include the Charles, Housatonic, and Narragansett. Maps of Ecological, Stressor, and Social Index scores for the urban-suburban scenario are also displayed in Figure 5. HUC8s with high Ecological Index scores occur throughout the State. Social Index scores are generally highest along the Atlantic coast, but frequently co-occur with poor Stressor scores.

Figure 5. Recovery Potential index scores for the urban-suburban scenario. The most intense colors in all RPS maps denote the "best" scores for traits likely to be more favorable to restoration efforts. HUC8s requested by MassDEP for Stage 2 are outlined in yellow.



The bubble plot for the urban-suburban scenario (Figure 6) reflects the relative value differences among HUC8s in Ecological, Stressor and Social Index scores by each bubble's size and position on the graph, also showing how these compare to statewide medians (the horizontal and vertical median lines). Further, this figure enables the scenario (dark blue and red) and demonstration (red with labels) HUC8s to be compared with the rest of the State's HUC8s. For these scenario and demonstration HUC8s, Ecological Index scores vary widely above and below the statewide median. Stressor Index scores of demonstration as well as scenario HUC8s also vary widely from below average to the highest in the State; this broad range of conditions among demonstration HUC8s may imply differences in degree of difficulty in urban-suburban nutrient management efforts from place to place. The combined particularly high Stressor Index scores and low Ecological Index scores of several scenario members suggests that, in Massachusetts, urban-suburban impacts can be extreme relative to HUC8s statewide. In contrast, like the rural-agricultural scenario, this scenario's members still include some HUC8s with both Indexes better than statewide medians.

Figure 6. Bubble plot for all Massachusetts HUC8s based on RPI score derived from the urban-suburban scenario indicators. This plot highlights the urban-suburban scenario watersheds (dark blue and red) and demonstration watersheds (red with name labels). Axes are set to statewide median Ecological and Stressor index scores.

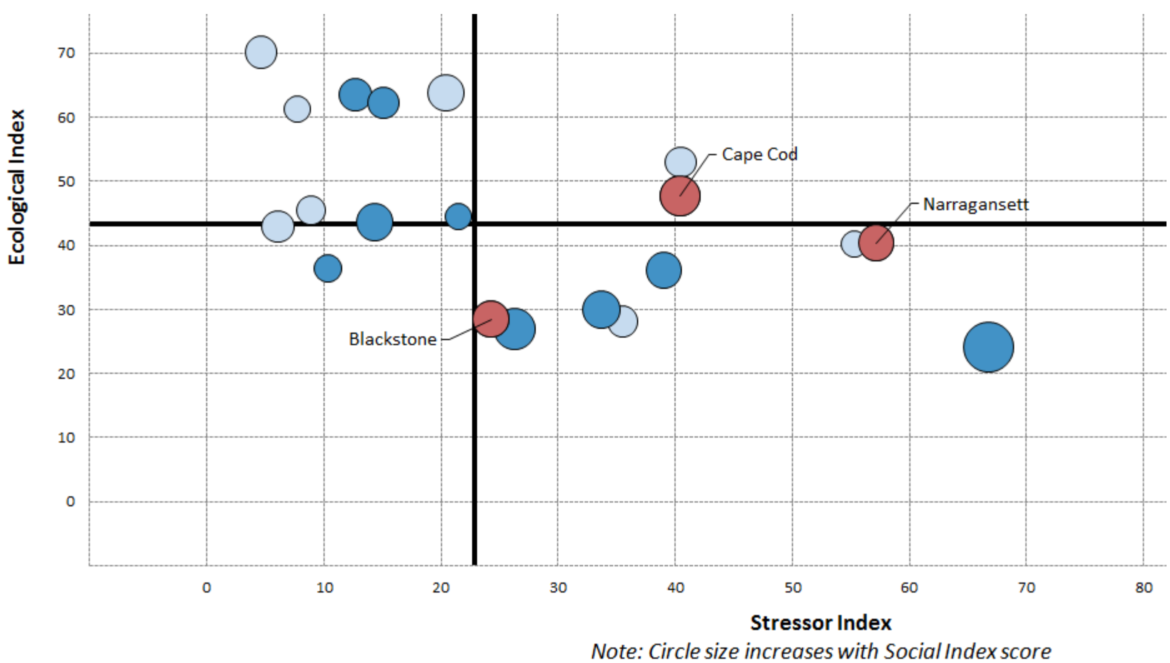


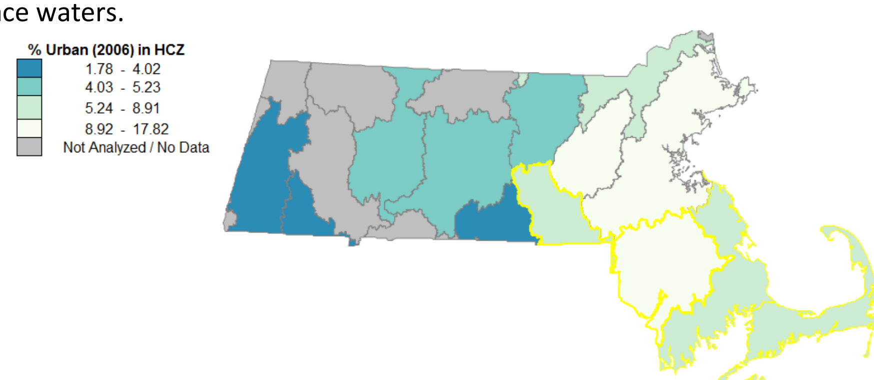
Table 4 contains Ecological, Stressor, Social, and RPI scores for the urban-suburban scenario, in order of descending RPI score and color-coded by quartile per RPS index. This tabular format is another option for presentation of Stage 1 results that can be used to compare and identify HUC8s for urban-suburban nutrient management efforts. Demonstration HUC8s for nutrient management do not necessarily have to be those with the highest RPI scores, but could consider one or more of the component index scores. For example, some HUC8s within the urban scenario do appear to have relatively good ecological scores and moderate stressor levels. Other considerations such as prior nutrient management activity or the extent of nutrient impairments might also help to identify HUC8s of higher interest for urban nutrient management.

Table 4. Index and RPI scores for the urban-suburban scenario. HUC8s are ordered by RPI score. Cells are shaded according to rank (green = 76 -100th percentile; yellow = 51-75th percentile; orange = 26-50th percentile; pink = 0-25th percentile). HUC8s requested by MassDEP for the urban-suburban scenario are marked with an asterisk (*). Scores and quartiles derived from screening urban-suburban scenario HUC8s only.

Watershed ID	Watershed Name	Ecological Index	Stressor Index	Social Index	RPI Score
01080204	Chicopee	67.52	12.91	31.09	61.90
01070004	Nashua	48.25	13.96	39.94	58.08
01100001	Quinebaug	63.48	18.44	27.68	57.57
01090002	Cape Cod*	54.91	48.34	50.24	52.27
01070005	Concord	23.26	25.78	53.81	50.43
01080207	Farmington	36.45	9.97	18.19	48.22
01090003	Blackstone*	27.59	22.99	39.58	48.06
01080201	Middle Connecticut	46.21	28.41	16.03	44.61
01070006	Merrimack River	39.80	45.41	36.11	43.50
01090001	Charles	21.59	71.71	78.98	42.95
01100005	Housatonic	29.00	45.66	40.31	41.22
01090004	Narragansett*	38.25	67.09	36.18	35.78

Figure 7 displays a map of a single indicator used in the urban-suburban scenario, the percentage of urban land cover in the Hydrologically Connected Zone (HCZ) of each HUC8. Individual indicators can be mapped and explored within the RPS tool in conjunction with index scores to further refine the selection of HUC8s of interest for additional screening.

Figure 7. Percentage of urban land cover in the Hydrologically Connected Zone (HCZ) of each HUC8 in the urban-suburban scenario. The most intense colors in all RPS maps denote the "best" scores for traits likely to be more favorable to restoration efforts. The HCZ is a topographically-derived estimate of areas with greater hydrologic connectivity to surface waters.



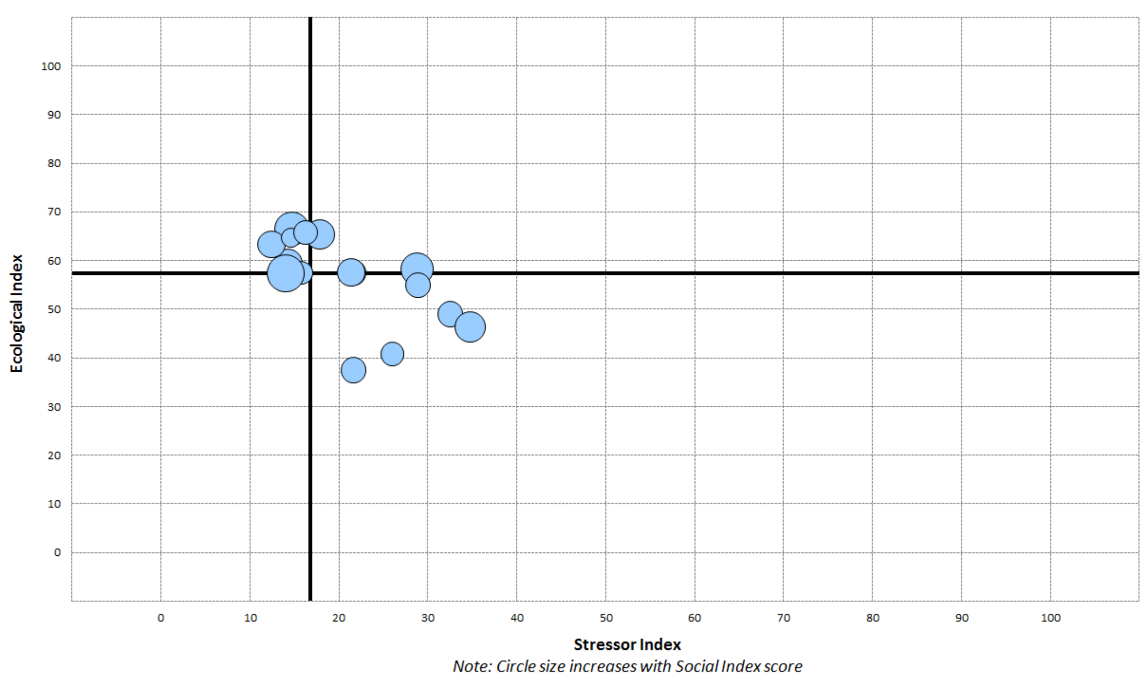
STAGE 2 RESULTS

As described in the Approach section, Stage 2 screening is performed on HUC8s individually and compares the HUC12s or other small-scale watershed within a single HUC8 to each other. The much more extensive array of indicators available at HUC12 scale (300 metrics) enabled more varied and specific targeting of indicators relevant to implementing nutrient management activities, thus Stage 2 utilized the HUC12 rather than SWMI data. These indicator selections and weights (see indicators in Table 2 and definitions in Attachment 3) were finalized by MassDEP and used in the Stage 2 screenings carried out by EPA and Cadmus. Stage 2 screenings were completed on all rural-agricultural and urban-suburban demonstration HUC8s. These HUC8 screenings are briefly summarized below, and a single HUC8 from each scenario is included in this document to serve as an example of Stage 2 methods and results. As with the Stage 1 screenings, a separate copy of the RPS tool for each of the 4 demonstration HUC8s in the two scenarios has been archived for delivery to MassDEP with other products (see Attachment 4).

<u>General Observations about Rural-Agricultural Scenario Stage 2 Screening</u>

The demonstration HUC8 for this scenario was screened individually, enabling the comparison of the HUC12 subwatersheds within this HUC8 based on selected rural-agricultural indicators and weights submitted by MassDEP. Figure 8 shows the bubble plot from the Middle Connecticut. It is important to note that the median lines on the HUC8 plot are the statewide median values for the Ecological and Stressor indices, not the median values for the individual subwatersheds in the Middle Connecticut alone. This was done to provide context for the user to generally observe how each HUC12's index scores compare not only to this HUC8's own subwatersheds, but also how they compare to all HUC12s statewide. The RPS Tool provides the option to bubble-plot a subset of watersheds by themselves (i.e., showing scores and median lines only relative to the subset) or to bubble-plot the subset but with reference to statewide scores (i.e., showing the statewide median lines and the subset's scores relative to all statewide watersheds). This enables the user to note situations where most or all of the subwatersheds are extremely higher or lower scoring than usual in the state, which could be missed if the Indexes and median scores of the HUC8's subwatersheds only are observed.

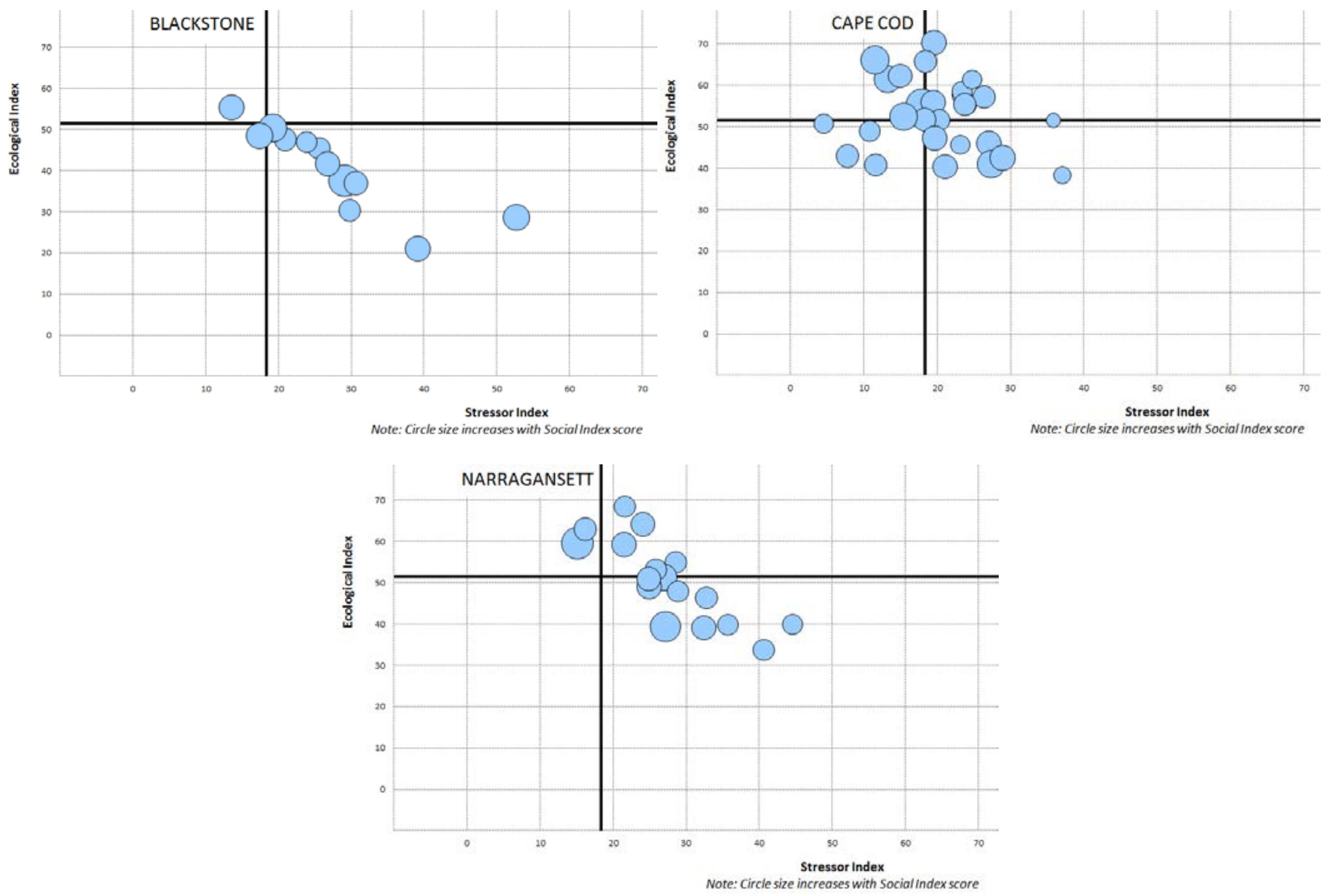
Figure 8. Bubble plot comparing the HUC12s within the demonstration HUC8 (Middle Connecticut) from the rural-agricultural scenario. Vertical and horizontal axes on the plot represent the Stressor and Ecological Index median values for all HUC12s statewide, respectively. Generally, most HUC12s in this HUC8 have average or above-average Stressor scores and average or below average Ecological scores.



<u>General Observations about Urban-Suburban Scenario HUC8 Screenings</u>

Three HUC8s from this scenario were screened individually, enabling the comparison of the HUC12 subwatersheds within each HUC8 based on selected urban-suburban indicators and weights submitted by MassDEP. Figure 9 shows the bubble plots from all three demonstration HUC8s together. It is important to note that the median lines on each HUC8 plot are the statewide median values for the Ecological and Stressor indices, not the median values for the individual HUC8's subwatersheds. This was done to provide context for the user to generally observe how each HUC12's index scores compare not only to the HUC8's other subwatersheds, but also how they compare to all HUC12s statewide.

Figure 9. Bubble plots comparing the HUC12s within each demonstration HUC8 from the urban-suburban scenario. Vertical and horizontal lines on each plot represent the Stressor and Ecological Index median values for all HUC12s statewide, respectively. Comparison to statewide medians reveals that these HUC8s vary markedly in what proportion of their HUC12s have higher than median ecological and stressor scores. Most HUC12s in the Blackstone and Narragansett HUC8s have consistently higher than median stressor scores, with many more below median stressor scores in the Cape Cod HUC8. Ecological scores are mostly below the statewide median in the Blackstone HUC8 but many HUC12s in the Cape Cod and Narragansett HUC8s have above median ecological scores.



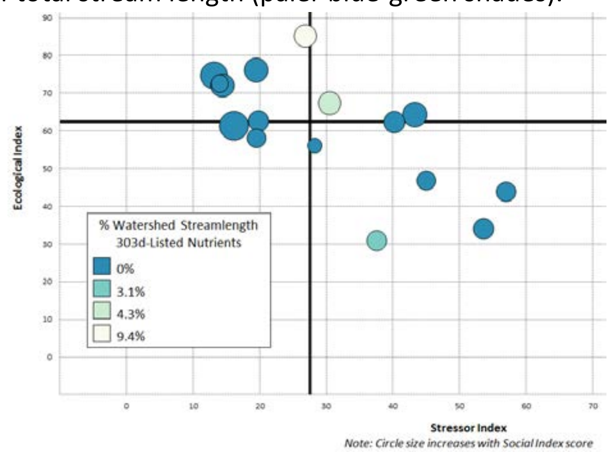
Stage 2 Rural-Agricultural Scenario Screening: Middle Connecticut

The Middle Connecticut HUC8 was selected as the demonstration HUC8 from the rural-agricultural scenario analysis of Stage 1. Compared with all HUC8s statewide (see again Figure 3), this watershed displays a moderately high stressor score while still retaining a mid-range ecological index score. Reexamining Figure 8 further contrasts the Middle Connecticut HUC8's subwatersheds with statewide median ecological index and stressor index scores. For example, almost all of the Middle Connecticut HUC12s fall in the upper left and lower right quadrants of the plot (quadrants formed by median lines). HUC12s in the lower right quadrant have above average stressor scores and below average ecological scores and may be of lower interest for management actions relative to HUC12s with higher ecological scores.

The variety of conditions across the Middle Connecticut HUC12s is thought provoking and invites further analysis as to how they differ, and what these differences may suggest regarding strategies from place to place. An example series of further analytical steps is offered below. Note that the Stage 2 screening plots below include Middle Connecticut, not statewide, medians.

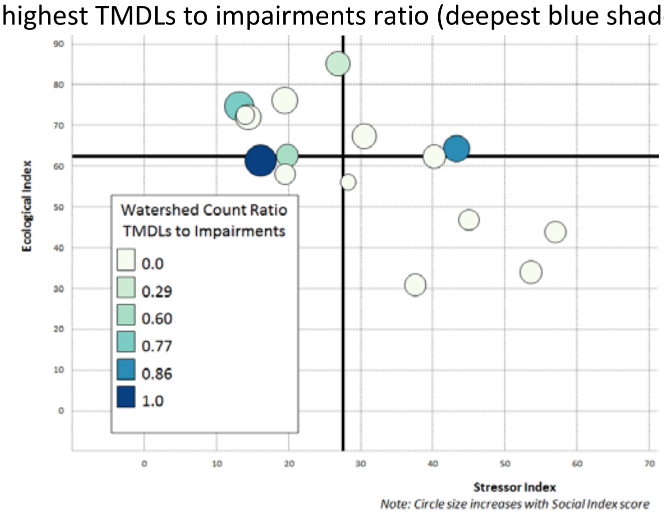
<u>Where are the impairments relative to how the HUCs scored</u>? Regardless of which indicators are used in a screening, the RPS Tool can color-assign a value gradient for any indicator in the data table and use this to gain insights into the bubble plot or map results. In Figure 10, the bubble plot result from the Middle Connecticut screening is further enhanced to display relative percent of stream length listed as nutrient-impaired. Three of the 16 HUC12s have at least 1% of stream miles listed for nutrients. Stressor, social and particularly ecological scores vary widely among these watersheds with listings. Two HUC12s in particular with more listings are at or higher than the median ecological score and the median stressor score of the group. If further study continues to reveal positive traits, these HUC12s might be good choices for implementing nutrient management because both have documented nutrient issues and yet maintain high ecological scores that might suggest better resilience and response to restoration efforts.

Figure 10. Middle Connecticut HUC12s nutrients screening output, highlighting HUC12s with the highest nutrients listings as % of total stream length (paler blue-green shades).



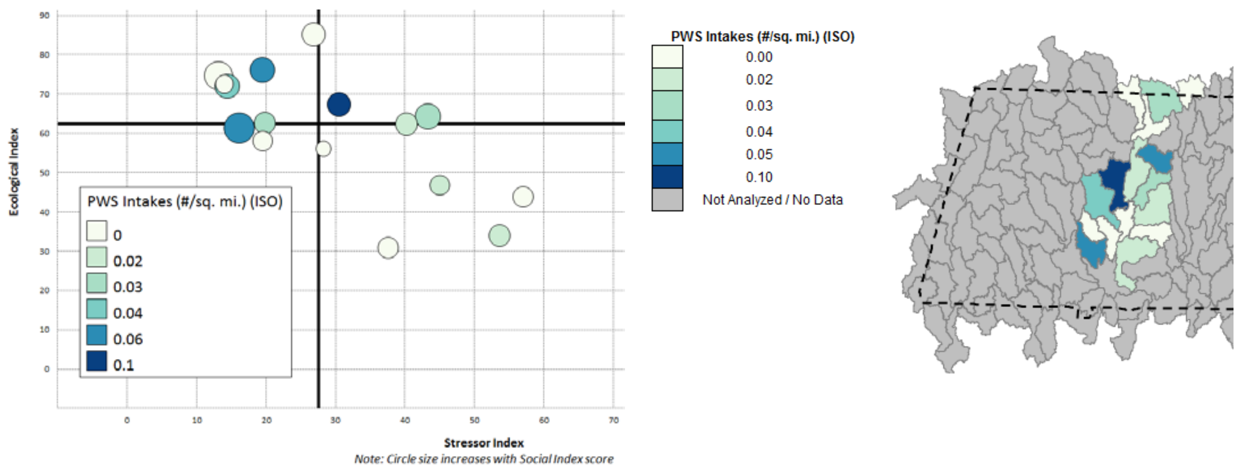
<u>Where are we better prepared for action</u>? In addition to where the impairments are found, the existence of TMDLs and other forms of technical information or plans can be displayed as a factor in RPS bubble plots. Figure 11 shows the Middle Connecticut plot output with color assignment based on the ratio of TMDLs to listings across all HUC12s. Note that one of the HUC12s discussed above as having nutrient listings also has some existing TMDLs. Further study might seek to verify whether these are nutrients-relevant TMDLs, and

Figure 11. Middle Connecticut output highlighting HUC12s with the highest TMDLs to impairments ratio (deepest blue shades).



whether other studies or activities (e.g., Nonpoint Source control projects) exist in any HUC12s and might add to their readiness for carrying out implementation actions.

Figure 12. Middle Connecticut bubble plot and map outputs highlighting HUC12s with the highest density of public water supply surface intakes (deepest blue shades).



Are there specific community motivators for some watersheds? Another technique for interpreting screening results is to compare index scores in conjunction with a selected social indicator of high importance to local communities. In Figure 12, the Middle Connecticut HUC12s are color-assigned by density of public water supply surface intakes. As drinking water protection is easily communicated to most communities, this may be a factor in increasing the likelihood of community support for nutrient management control actions in specific watersheds. This comparison reveals that nine HUC12s contain some drinking water intakes. Some of these nine HUC12s contain TMDLs and one contains nutrients listings (see again Figures 10 and 11). Further, it is noteworthy that several scored relatively high on the Stressor Index.

Where would specific types of control practices be appropriate, or effective? Building on questions like the above, continuing analysis may want to use the RPS Tool results to consider in which HUC12s might specific families of control practices be most appropriate while relating this observation to other recovery potential factors. Given that Middle Connecticut is the rural-agricultural scenario demonstration watershed, it would be most relevant to compare its HUC12s' values for selected agricultural and low-density residential indicators as well as ecological metrics that may also influence management strategies and practices. In Table 5, selected indicator values of all the Middle Connecticut HUC12s are compared via a data table with five selected indicators from the RPS screening. Each indicator is color-assigned in quartiles from highest to lowest value (in this case, not necessarily highest to lowest recovery potential) in the order green, yellow, orange, and pink.

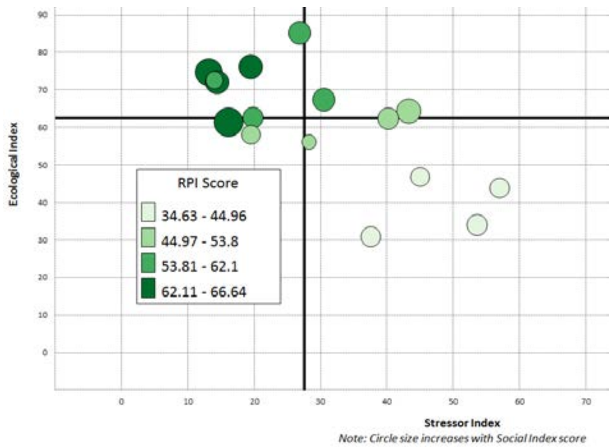
For the four stressor metrics (names in red), the highest scores (green cells) help identify HUC12s with the greatest amount of specific activities that may be nutrient sources. Note that, in this usage of the RPS data, the highest stressor quartile is being used to identify greatest magnitude of the stressors rather than recovery potential (which would favor the lowest stressor scores). High quantities of low density residential in the riparian zone, for example, helps identify which HUC12s may be most likely to have loading contributions from leaky septics and residential lawn care runoff. Percent agriculture contiguous with surface waters provides insight into the HUC12s with greater amounts of cropland and pasture that may be appropriate for a variety of nutrient runoff management approaches. Two additional indicators – synthetic Nitrogen fertilizer application and percent human use index – integrate the agricultural and urban contributions and provide an alternative way of comparing the HUC12s. For Table 5's one ecological metric, the values imply HUC12 differences in erosion potential as an additional consideration along with the stressor factors above. These are selected examples of how, due to the ease of data retrieval from the RPS tool, any indicators for any set of watersheds can be compared in numerous ways with little effort in the desktop environment.

Table 5. HUC12 values for five selected indicators from the Middle Connecticut screening that may be useful in choice of management strategies and targeted subwatersheds. Each indicator is color-assigned in quartiles from highest to lowest value in the order green, yellow, orange, red. For stressor metrics (red names), the highest scores help identify HUC12s with the greatest amount of specific activities that may be nutrient sources. For the ecological metric, the values imply HUC12 differences in erosion potential as an additional consideration.

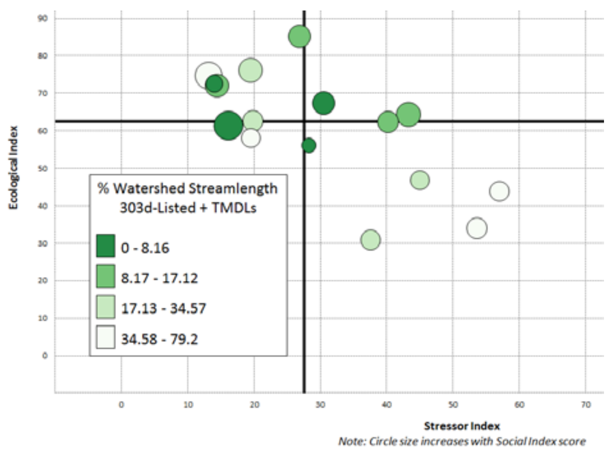
Watershed Name	**Mean Soil Stability in HCZ**	**% Developed, Low Intensity in RZ**	**% Agriculture Contiguous H2O in WS**	**Synthetic N Fertilizer Application in WS**	**% U-Index Contiguous H2O in WS**
Dry Brook-Connecticut River	0.77	2.11	10.57	27.12	50.51
Russellville Brook-Connecticut River	0.68	1.38	16.45	19.84	33.96
Doolittle Brook-Mill River	0.77	1.52	12.65	15.44	32.63
Fort River	0.72	0.95	9.24	12.68	24.77
Lower Manhan River	0.56	2.53	4.59	9.86	32.96
West Brook-Mill River	0.67	1.83	7.79	9.74	22.92
Upper Manhan River	0.77	0.58	3.57	8.79	15.60
North Branch Manhan River	0.76	0.55	4.48	7.85	11.67
Batchelor Brook	0.74	1.58	3.37	7.30	15.00
Stony Brook-Connecticut River	0.73	2.80	3.85	7.27	60.48
Dry Brook-Connecticut River	0.76	1.09	0.61	6.09	20.74
Pauchaug Brook-Connecticut River	0.73	0.95	4.66	6.00	18.45
Mill River	0.73	0.84	2.12	5.41	14.89
Fall River	0.75	1.37	3.33	4.99	18.03
Sawmill River	0.67	0.72	2.02	2.97	9.75
Mirey Brook	0.73	0.34	1.37	1.03	8.74

Figure 13. Options for identifying possible HUC12s for protection as part of a Middle Connecticut RPS screening to inform nutrients management (darkest green are best candidates). A: the RPI Index score from the nutrients screening; B: percent stream length with listings or TMDLs; C: percent natural cover in watershed. All point to many of the same HUC12s (upper left quadrant).

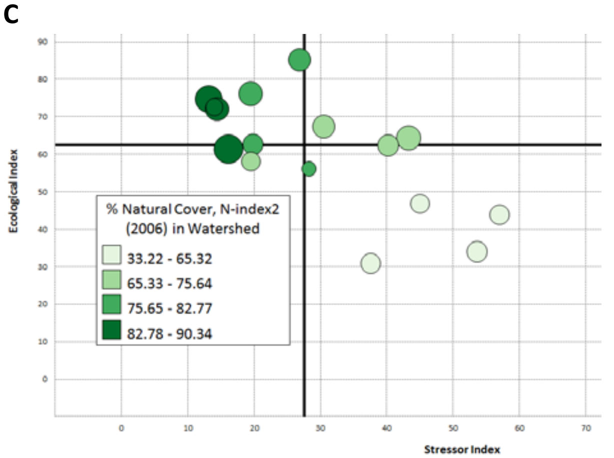
A



B



C



__Which HUC12s should be protected while others are restored__? Although the RPS Tool is most often used to assist restoration planning, it is used to identify watershed protection candidates as well. The HUC12s in the Middle Connecticut ultimately all contribute to the same drainage, and thus targeted HUC12 protection affects the condition of this HUC8 just as targeted HUC12 restoration efforts do. The healthier HUC12s likely play an important role in attenuating nutrient loads from upstream or contributing cleaner flows that may dilute loads from other HUC12s downstream. When available, healthy watersheds identified from a statewide assessment will provide a highly useful data source for selecting protection priorities. Absent a healthy watersheds assessment and using currently available data, the HUC12s in relatively better condition for protection in a nutrients setting can be found using the RPI score or a selected indicator related to absence of impairment or presence of ecological attributes associated with ability to process nutrients.

Three such options appear in Figure 13, and all are color-assigned to highlight the best prospects (top quartile) with the darkest shade of green. The first is the RPI Index score, an integrator of ecological, stressor and social factors chosen for this screening to be relevant to nutrients management, whose high end scores may serve as a single predictor of protection candidates given a broad range of considerations. Although most HUC12s with high RPI scores cluster in or near the upper left quadrant of the plot where low stressor and high ecological scores combine, one HUC12 with an above average Stressor index score but an average Ecological Index score is evident, probably aided by its high Social index score (large dot). This HUC12 may merit protection with the others despite its moderate Ecological score as it may have a good social context to support action.

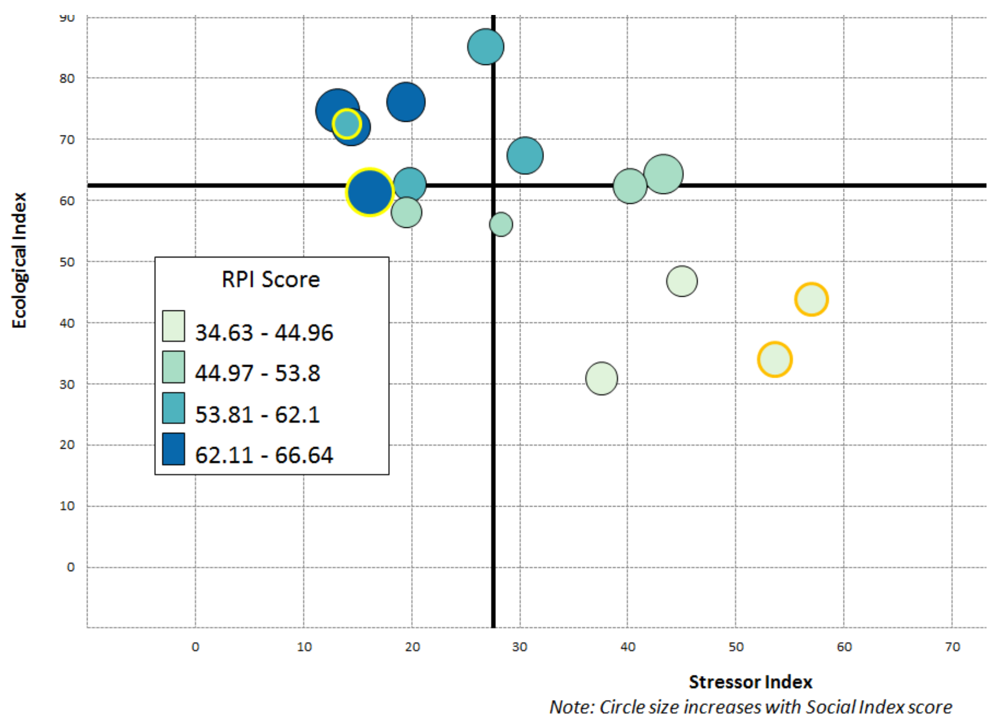
A second option uses a stressor indicator, percent stream length with listings and/or TMDLs, to detect the reportedly less-impaired HUC12s. This indicator was not used in the screening, but any indicators in the dataset are available for displaying with the screening results in the RPS Tool. Best prospects for protection based on this indicator are spread throughout the upper left and upper right quadrants. A third option offered in Figure 13 examines one ecological indicator, the percent natural cover in the watershed, as a determinant for protection potential. This metric as well points to many of the same prospects as the others discussed above.

<u>*Does the screening make sense overall*</u>? Although all RPS indicators are QA/QC'ed during and after compilation individually, it is appropriate to test any RPS screening result as the product of selected indicators and formulae together. The usefulness of any screening is dependent on the relevance of the indicators selected to the purpose of the screening. If the indicators for a given screening purpose are performing as intended, 'good reference' HUC12s and 'poor reference' HUC12s from the 16 Middle Connecticut HUCs being screened should have predictably good and poor index scores, respectively. To test the screening result in this manner, indicators preferably independent from those in the screening but likely associated with relatively good or poor reference condition are selected and compared with the Middle Connecticut screening output.

Identifying suitable 'good reference' HUCs from the 16 involved in the screening relied on the percent of forest in the watershed and the percent National Ecological Framework (NEF). Impaired stream miles were also reviewed but few HUC12s in the Middle Connecticut have had significant stream miles assessed. Two potential 'good-reference' HUC12s were selected for this demonstration. Two potential 'poor reference' HUCs were identified through the same set of indicators. In practice, additional indicators/data should be considered when selecting appropriate reference watersheds.

Figure 14 shows the results of plotting both types of reference HUC12s against the full set of Middle Connecticut HUC12s. Generally, the relative scores of reference HUC12s appear as expected, with higher scores for good reference HUCs and lower scores for poor reference HUCs. Avoiding use of indicators already used in the screening may have prevented the identification of stronger (or additional) good and poor reference HUC12s but improved the independence of this verification step.

Figure 14. Testing 'good reference' (yellow outline) and 'poor reference' (orange outline) HUC12s in association with the Middle Connecticut RPS screening results. Selection of good and poor reference HUCs was made only from HUC12s within the Middle Connecticut HUC8, and was based on indicators not used in the Stage 2 screening. Thus, 'good' and 'poor' are relative to this subset of HUC12s only.



Stage 2 Urban-Suburban Scenario Screening: Cape Cod

The Cape Cod HUC8 was one of three demonstration HUC8 selections from the urban-suburban scenario analysis of Stage 1. Compared with all HUC8s statewide (see again Figure 6) and other scenario and demonstration HUC8s, this watershed displays a higher stressor score but with a moderately higher median ecological index score. Reexamining Figure 9 further contrasts the Cape Cod HUC8's HUC12s with those of other HUC8s from this scenario. For example, the Cape Cod HUC12s as a group combine a particularly wide range of both ecological scores and stressor scores.

Looking closer at Figure 9, a few of the 29 Cape Cod HUC12s scored 'better' (i.e., high eco, low stressor) than statewide medians in both the Ecological and Stressor Indices (upper left quadrant of plot). Approximately one-half of Cape Cod HUC12s display high stressor scores compared with statewide conditions. Some of these scored above the Ecological Index statewide median (horizontal line), and Social Index scores among these HUC12s may present added insights on relative ease or difficulty of taking action.

The variety of conditions across the Cape Cod HUC12s invites further analysis as to how they differ, and what these differences may suggest regarding strategies for action. An example series of further analytical steps is offered below. Note that the Stage 2 screening plots below include Cape Cod HUC12s, not statewide, medians.

Where are the impairments relative to how the HUCs scored? In Figure 15, the bubble plot result from the Cape Cod HUC8 screening is further enhanced to display the relative percent of stream length listed as nutrient-impaired. Five HUC12s contained greater than 10% nutrients-listed stream length. These include two in the lower right quadrant of the plot (very high stressor and low ecological scores), but the other three HUC12s that met this criterion exhibit Ecological index scores at or above the median. As an early impression, these three HUC12s may be more promising candidates for taking action based on their ecological positives; on the other hand, if the two highly stressed HUC12s at the far right of the plot are shown to have downstream effects on other HUC12s, these might also be worth targeting despite probable difficulty restoring these two HUC12s specifically,

Where are we better prepared for action? In addition to where the impairments are found, the existence of TMDLs and other forms of technical information or plans can be displayed as a factor in RPS bubble plots. Figure 16 shows the Cape Cod HUC8 plot output with color assignment based on the ratio of TMDLs to listings across all HUC12s. Note that TMDL availability to guide action is extensive and includes some of the HUC12s noted in Figure 15 as having more extensive listings. Further study might seek to verify whether these are nutrients-relevant TMDLs, and whether other studies or activities (e.g., Nonpoint Source control projects) exist in any HUC12s and might add to their readiness for carrying out implementation actions.

Figure 15. Cape Cod HUC12s nutrients screening output, highlighting HUC12s with the highest nutrients listings as % of total stream length (paler blue shades).

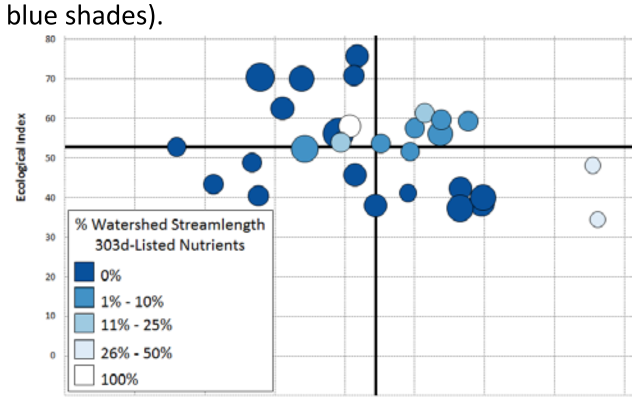
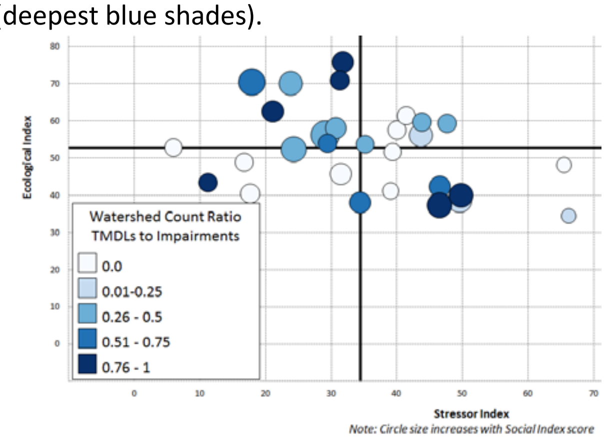
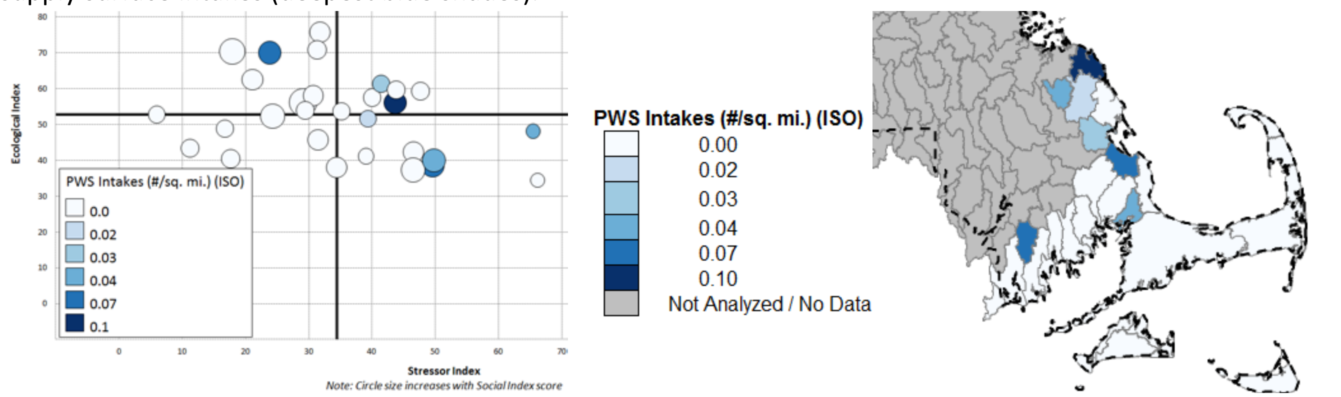


Figure 16. Cape Cod RPS output highlighting HUC12s with the highest TMDLs to impairments ratio (deepest blue shades).



<u>*Are there specific community motivators for some watersheds*</u>? Another technique for interpreting screening results is to compare index scores in conjunction with a selected social indicator of high importance to local communities. In Figure 17, the Cape Cod HUC12s are color-assigned by density of public water supply surface intakes. As drinking water protection is easily communicated to most communities, this may be a factor in increasing the likelihood of community support for nutrient management control actions in specific watersheds. This comparison reveals that seven Cape Cod HUC12s have surface intakes. As one of these has nutrient listings and TMDLs, its role in drinking water protection may be an important asset in developing community support for nutrient management efforts.

Figure 17. Cape Cod bubble plot and map outputs highlighting HUC12s with the highest density of public water supply surface intakes (deepest blue shades).



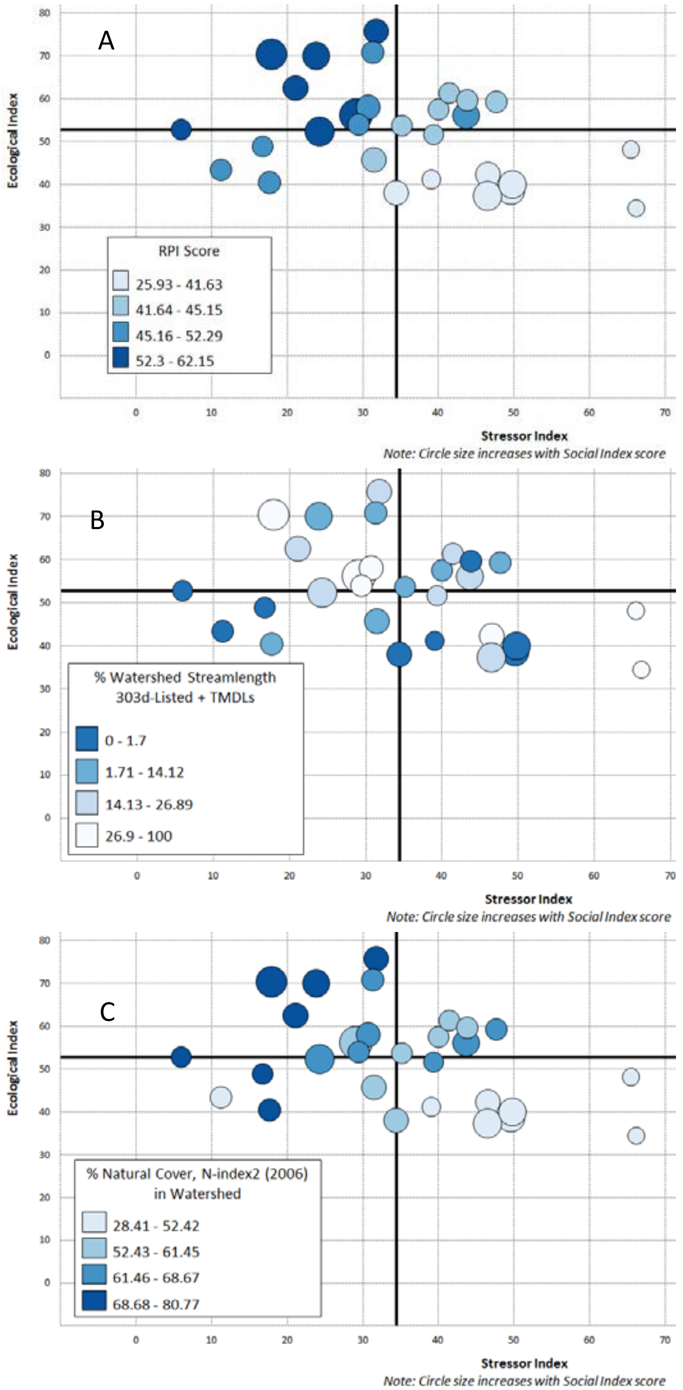
<u>*Where would specific types of control practices be appropriate, or effective*</u>? Building on questions like the above, continuing analysis can apply the RPS Tool results to consider where specific types of control practices might be most appropriate while relating this observation to other recovery potential factors. Given that Cape Cod is one of the urban-suburban scenario demonstration watersheds, it would be most relevant to compare its HUC12s' values for selected stressor indicators as well as ecological metrics that may also influence management strategies and practices. In Table 6, selected indicator values of all the Cape Cod HUC12s are compared via a data table with selected indicators from the RPS screening. Each indicator is color-assigned in quartiles from highest to lowest value in the order green, yellow, orange, and red.

For the stressor metrics (names in red), the highest scores (green cells) help identify HUC12s with the greatest amount of specific activities that may be nutrient sources worth addressing. These included low intensity development close to streams, the proximity of impervious cover that may accelerate and deliver urban runoff, the percent agriculture in the watershed (still a contributing factor in the urban-suburban scenario), and two integrative metrics (percent human use index contiguous with surface waters, and synthetic fertilizer application) that further clarify where specific control practices might best be applied to address significant nutrient sources. The ecological metric, percent woody vegetation in the riparian zone, offers insight into HUC12s with better bank stability and runoff filtration than urban lawns or impervious cover as an added consideration when planning management approaches.

Table 6. HUC12 values for five selected indicators from the Cape Cod screening that may be useful in choice of management strategies and targeted subwatersheds. Each indicator is color-assigned in quartiles from highest to lowest value in the order green, yellow, orange, red. For stressor metrics (red names), the highest scores help identify HUC12s with the greatest amount of specific activities that may be nutrient sources. For the ecological metric, the values imply HUC12 differences in woody vegetation near streams as an additional consideration associated with better bank stability and runoff filtration than urban lawns or impervious cover.

Watershed Name	% Woody Vegetation in RZ	% Developed, Low Intensity in WS	% Agriculture in WS	% U-Index06 Contiguous H2O, in WS	Stream Corridor (61M) % Impervious	Synthetic N fertilizer application in WS
Headwaters Indian Head River	34.45	2.98	1.56	55.04	1.33	1.17
North River	39.01	1.85	2.89	31.86	0.67	2.20
Bound Brook-Frontal The Gulf	33.59	2.00	1.14	34.03	0.83	0.79
Duck Hill River-Frontal Duxbury Bay	29.39	1.90	3.09	34.30	0.50	2.40
Jones River-Frontal Kngston Bay	36.08	2.11	6.04	36.38	0.83	4.60
Eel River-Frontal Plymouth Bay	9.54	2.06	3.53	44.44	2.00	2.69
Great Herring Pond-Frontal Cape Cod Bay	14.91	1.96	5.67	32.85	0.83	4.40
Pilgrim Lake	9.64	0.65	0.00	12.77	0.00	0.00
Pamet River	36.72	1.42	0.00	18.94	0.67	0.00
Herring River	45.72	0.95	0.00	15.52	0.50	0.00
Nauset Bay	23.82	2.57	0.38	30.97	0.50	0.30
Long Pond	19.19	2.76	1.40	39.64	0.83	1.28
Wequaquet Lake	10.77	3.00	1.35	42.29	0.83	1.23
Sippican River	52.43	0.64	17.40	24.87	0.83	13.22
Weweantic River	29.52	1.19	21.12	35.83	1.00	16.11
Red Brook-Frontal Cape Cod Canal	14.88	2.52	6.50	41.43	1.17	5.10
Agawam River-Frontal Buzzards Bay	17.03	0.99	10.91	26.49	1.00	8.33
Aucoot Creek-Frontal Sippican Harbor	49.13	1.54	1.82	25.79	0.83	1.41
Mattapoisett River-Frontal Buzzards Bay	45.69	1.18	7.36	26.32	0.67	5.14
Acushnet River-Frontal Buzzards Bay	17.19	2.04	5.19	57.66	1.33	2.95
Paskamanset River-Frontal Buzzards Bay	30.26	1.04	8.28	34.42	1.17	4.51
Noquochoke Lake	42.49	0.72	4.19	14.45	0.50	2.26
Westport River-Frontal Rhode Island Sound	34.19	0.79	9.74	21.80	0.50	5.73
Sakonnet Point-Frontal Rhode Island Sound	38.10	0.71	19.05	28.28	0.17	11.56
Eastern Island-Frontal Nantucket Sound	11.72	2.11	3.13	35.63	0.67	1.82
Tisbury Great Pond-Frontal Atlantic Ocean	9.94	0.35	2.41	14.26	0.50	1.25
Squibnocket Pond-Frontal Vineyard Sound	25.81	0.27	0.02	10.40	0.50	0.01
Elizabeth Islands	30.41	0.00	0.43	0.00	0.33	0.23
Nantucket Island	29.48	1.43	2.50	22.63	0.83	2.33

Figure 18. Options for identifying possible HUC12s for protection as part of a Cape Cod RPS screening to inform nutrients management (darkest blue are best candidates). A: the RPI Index score from the nutrients screening; B: percent stream length with listings or TMDLs; C: percent natural cover in watershed. All point to many of the same HUC12s (upper left quadrant).



<u>*Which HUC12s should be protected while others are restored*</u>? Although the RPS Tool is most often used to assist restoration planning, it is used to identify watershed protection candidates as well. The HUC12s in the Cape Cod HUC8 ultimately all contribute to the same drainage, and thus targeted HUC12 protection affects the condition of this HUC8 just as targeted HUC12 restoration efforts do. The healthier HUC12s likely play an important role in attenuating nutrient loads from upstream or contributing cleaner flows that may dilute loads from other HUC12s downstream. When available, healthy watersheds identified from a statewide assessment will provide a highly useful data source for selecting protection priorities. Absent a healthy watersheds assessment and using currently available data, the HUC12s in relatively better condition for protection in a nutrients setting can be found using the RPI score or a selected indicator related either to absence of impairment or presence of ecological attributes associated with greater ability to process nutrients. In an urban-suburban dominated watershed, truly healthy subwatersheds (e.g., HUC12s well into the low stressors – high ecological quadrant of the RPS bubble plot) may not exist or be the focus of protection efforts, yet protection of the relatively best HUC12s remains crucial for the recovery of the larger watershed even in impacted scenarios.

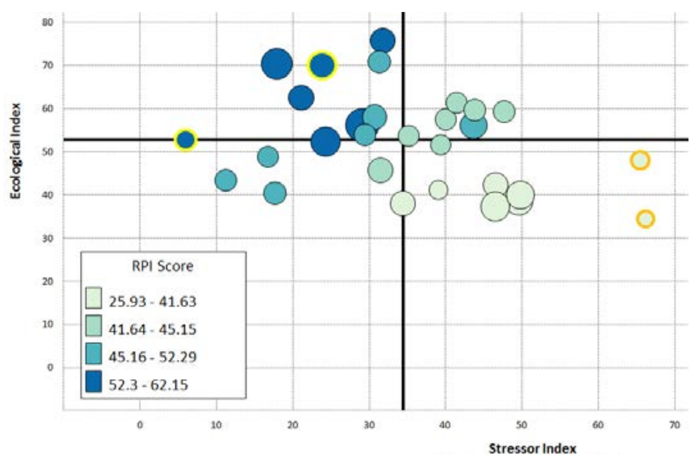
Three such options for considering protection priorities appear in Figure 18, and all are color-assigned to highlight the best prospects (top quartile) with the darkest shade of blue. The first is the RPI Index score, an integrator of ecological, stressor and social factors chosen for this screening to be relevant to nutrients management, whose high end scores may serve as a single predictor of the best protection candidates given a broad range of considerations. In the Cape Cod HUC8, one promising feature is the co-occurrence of high Ecological and Social index scores in several HUC12s. These watersheds may be good protection prospects.

A second option uses a stressor indicator, percent stream length with listings and/or TMDLs, to detect the less-impaired HUC12s. This indicator was not used in the screening, but all indicators are available for displaying the screening results in the RPS Tool. Several HUC12s denoted by dark blue in Figure 18B have lower proportions of stream length impaired, providing another possible basis for protection choices.

A third option offered in Figure 18 examines an ecological indicator, the percent natural cover in the watershed, as a determinant for protection potential. Few HUC12s in this urban-suburban HUC8 would be expected to have substantial natural cover, but these should be recognized for their contribution to the HUC8's overall health and prospects for nutrient management and recovery.

__Does the screening make sense overall__? As discussed in the Middle Connecticut screening example, it is appropriate to test any RPS screening result as the product of selected indicators and formulae together. The usefulness of any screening is dependent on the relevance of the indicators selected to the purpose of the screening. If the indicators for a given screening purpose (urban-suburban nutrients management) are performing as intended, 'good reference' HUC12s and 'poor reference' HUC12s from the 29 Cape Cod HUC12s being screened should have predictably good and poor index scores, respectively. To test the screening result in this manner, indicators preferably independent from those in the screening but likely associated with relatively good or poor reference condition are selected and compared with the Cape Cod screening output. An example result, presented in Figure 19, shows the expected position of good and poor reference watersheds on the bubble plot. Avoiding use of indicators already used in the screening may prevent the identification of stronger good and poor reference HUC12 candidates but can improve the independence of this verification step.

Figure 19. Testing potential 'good reference' (yellow outline) and 'poor reference' (orange outline) HUC12s in association with the Cape Cod RPS screening results. Most intensely colored dots in each plot are the reference HUCs. Selection of good and poor reference HUCs was made only from HUC12s within the Cape Cod HUC8, and was based on indicators not used in the Stage 2 screening. Thus, 'good' and 'poor' are relative to this subset of HUC12s only.



SUMMARY AND RECOMMENDATIONS

This document summarizes the usage of Recovery Potential Screening (RPS) to compare watersheds at two scales (HUC8 and HUC12) for purposes of informing possible watershed management options and priorities for nutrient management. Utilizing georeferenced data provided primarily by MassDEP, EPA and additional sources, this project compiled over 300 indicators (base, ecological, stressor and social) at one or both watershed scales that were used to screen and compare watersheds in a two-stage process. In the first stage, Massachusetts's 20 HUC8s were screened with two separately developed sets of indicators selected to identify initial focus groups of rural-agricultural watersheds and urban-suburban watersheds with nutrient management challenges. Based on these first stage screenings and other criteria, one rural-agricultural watershed and three urban-suburban watersheds were selected as demonstration HUC8s for further analysis in the second stage.

Stage two screenings were performed on each of the four demonstration HUC8s, and scored and compared each HUC8's component HUC12s using more detailed sets of indicators that drew from HUC12-scale metrics. Whereas the purpose of Stage 1 was to compare and recognize like groups of scenario watersheds at the larger scale, Stage 2's purpose was to examine and reveal potential opportunities for nutrient management action at the more localized HUC12 scale. As a demonstration of the RPS Tool, no priorities among HUC12s were selected in this project but numerous alternatives and analytical techniques were presented in one Stage 2 screening from each of the two Stage 1 demonstration groups. Products include this summary report, a master RPS Tool file, and six separate screening files that archived the results from the two Stage 1 screenings, the Stage 2 rural-agricultural watershed screening, and the three Stage 2 urban-suburban watershed screenings. Opportunities for MassDEP and other users from this point forward may include:

Become adept at RPS Tool desktop use. Despite the extensive amount of data it holds and the wide variety of comparisons among watersheds that these data can support, the RPS Tool is actually a fairly simple spreadsheet tool. As novice users of Excel far outnumber GIS specialists, for many more people this tool opens the door to simple but useful forms of spatial data analysis, systematic comparisons among watersheds, and a variety of visualization tools – on their own desktops. A wider circle of users will be able to perform quick 'what-if' screenings to compare watersheds on the spur of the moment and gain insights on what may be worth a greater investment of time and effort with more technical analytical tools.

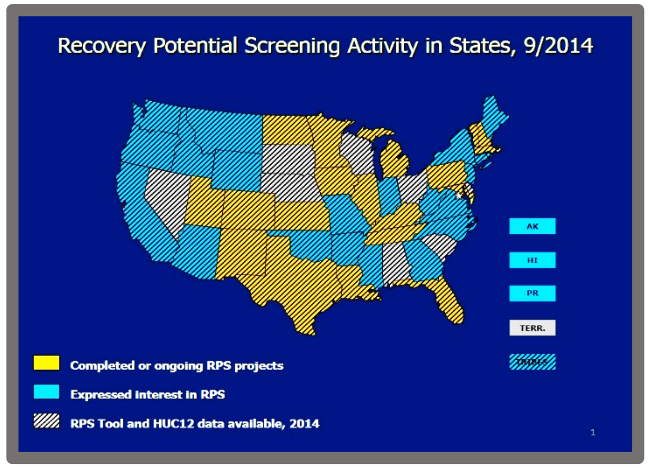
Apply the RPS Tool to other screening topics. Although this effort focused on a nutrients application of RPS, the Massachusetts dataset would support numerous other screening themes and purposes that can be explored in the interest of long-term priority setting for restoration and protection. Other screening topics might include sediment, metals, pathogens, or any other prominent cause of impairment. Or in contrast, screenings might focus on a valued resource such as watersheds with drinking water sources or major outdoor recreational sites. The RPS Tool might be used to develop a first-cut identification of healthy watersheds for protection, or rank likely eligibility for specific types of pollution control incentives. With both the TMDL Program and the Non-Point Source Control Program promoting watershed priority-setting, the range of opportunities is widespread.

Refine the available data and selection of indicators. Even within this nutrients application of RPS, opportunities always exist to add more relevant data or refine previous screenings as new insights are gained. The RPS Tool is structured to accept additional indicator data from a user that can then be made part of future screenings. New data needn't be statewide, and a local user may still use the tool after adding new data for a limited set of their local subwatersheds. Further, previous analyses can be refined by structured group processes to assign consensus weights to indicators, or by correlation analyses designed to narrow down indicator selections and better differentiate watersheds. For example, varying Massachusetts's available HUC8 indicators and re-screening would allow for considering nutrient delivery to coastal areas as well as comparing HUC8s based on instate effects only. Further, the SWMI scale watershed data table (114 indicators) has been embedded in the RPS tool along with HUC8 and HUC12 data as a third scale of application of RPS. Stage 2 analyses could be repeated using SWMI's within each HUC8, if HUC12-based Stage 2 data are seen as too coarse for certain purposes.

Galvanize state/local restoration and protection dialogue and partnering. RPS offers a mechanism for state agency to agency and state-local collaboration that was already realized in MassDEP's RPS roundtables and other meetings. Rather than assume that the RPS indicators are a static dataset, or that the HUC8 screenings shouldn't be additionally adjusted or customized, further tailoring indicators to the circumstances and data of each locale and additional collaborating agency or organization is appropriate and encouraged. Some HUC8s may host watershed groups, researchers and other sources of continued analysis and refinement of the available indicators and techniques that can be accommodated by this versatile tool. Further, if local organizations do engage with MassDEP and enhance their RPS Tool copies, they may provide valuable dialogue on addressing local as well as statewide interests in watershed priority-setting and improved nutrient management. In this sense, RPS has been called a "discussion support tool" as well as a decision support tool.

Attachment 1

RECOVERY POTENTIAL SCREENING: SUMMARY



- Recovery Potential Screening (RPS) is a systematic, comparative method for identifying differences among watersheds that may influence their relative likelihood to be successfully restored or protected. The EPA Office of Wetlands, Oceans and Watersheds (OWOW) created RPS jointly with the EPA Office of Research and Development (ORD) in 2004 to help states and others use limited restoration resources wisely, with an easy to use tool that is customizable for any geographic area of interest and a variety of specific comparison and prioritization purposes.

- The main programmatic basis for RPS includes the TMDL Program (e.g., prioritized schedule for listed waters; where best to implement TMDLs; Integrated Reporting of Priority waters under the TMDL Vision) and the Nonpoint Source Program (e.g., annual program strategies; prioritization to aid project funding decisions; collaboration with Healthy Watersheds), but several other affiliations also exist.

- Since 2005, several hundred RPS indicators have been incrementally compiled through literature review, identifying states' indicator needs and preferences, and collaboration with others (ORD EnviroAtlas, Region 4 Watershed Index). Most have been applied in a series of statewide RPS projects. In 2009, an RPS paper was published in the refereed journal *Environmental Management*. The one-stop RPS Website hosts a library of indicators, RPS tools, case studies and step by step RPS instructions.

- As of September 2014, RPS projects and statewide databases have been either initiated or completed in 20 states (**see figure**). Approximately that many additional states have expressed interest in RPS usage, but Branch resources have not previously been able to support these requests.

- The RPS Tool is key to RPS' ease of use, widespread applicability and speed. This tool is an Excel spreadsheet that contains all watershed indicators, auto-calculates key indices, and generates rank-ordered tables, bubble plot graphics and maps that can be user-customized. Any novice Excel user can quickly become fluent in using the RPS Tool.

- Statewide RPS Tools and data have now been developed for each of the lower 48 states. These contain 207 indicators measured for every HUC12, and enable customizable desktop screening, rank ordering, graphics plotting and mapping without advanced software or training. Individual, state-specific RPS Tools were distributed to every lower 48 state and all EPA Regions in July 2014 (HI and AK in planning).

- RPS is playing/may soon play a pivotal role in each of the following:
  - Prioritizing watersheds for nutrient management (projects in 9 states)
  - Identifying state priority watersheds for TMDL Vision/Integrated Reporting 2016-2022
  - Improving state/local interactions in states with RPS projects
  - Enabling Tribes to screen and compare their watersheds for purposes similar to states
  - Helping the Healthy Watersheds program by providing a national preliminary assessment
  - Jointly (OW and EPA Region 4) creating the Watershed Index Online (WSIO) interactive tool

- Contact: Doug Norton, WB/AWPD/OWOW at norton.douglas@epa.gov or 202-566-1221.

Attachment 2: MA Stage 1 Rural-Agricultural and Urban-Suburban Scenario Indicator Descriptions

(Note: Green denotes ecological, red is stressor, blue is social. WS in indicator name always means based on watershed; HCZ always means based on hydrologically connected zones in the watershed; RZ always means based on 100-meter per side riparian zones in the watershed.)

HUC8 METRIC	DESCRIPTION
% NEF2001, National Ecological Framework, WS	Watershed percent of total area within Region 4 Watershed Index's National Ecological Framework (NEF) of hydrologically significant and connected natural cover hubs and corridors.
% Natural Cover, N-index1 (2006) in HCZ	Hydro connected zone percent of total HUC area in natural land cover categories (land and water) including NLCD06 water and ice 11, 12; forested 41, 42, 43; shrub 52; grassland 71; wetlands 90 and 95. Differs from NINDEX2 by not including barren/rock/desert/mining; NINDEX1 is appropriate for use when mining cover types are a significant proportion of non-vegetated cover.
% Woody Vegetation (2006) in Riparian Zone	Percent of total HUC riparian zone area in NLCD06 forested or woody (e.g. shrub) land cover categories 41, 42, 43, 52 and 90.
Ratio of Natural to Recycled N Inputs	The ratio of pre-European N inputs (natNfix + Nat_OxN) to recycled anthropogenic N inputs. Inverse of original ORD metric.
Ratio of Natural to New N Inputs	The ratio of pre-European N inputs (natNfix + Nat_OxN) to new anthropogenic N inputs. Inverse of original ORD metric.
% Human Use, U-index 2 (2006) in Watershed	Percent of total HUC area in human-managed land cover, as represented by NLCD06 urban land cover categories 21,22,23, 24 plus agricultural categories 81 and 82. This version of UINDEX includes category 21, which is an assortment of urban open space categories such as schools and hospitals with extensive lawn and maintained grounds.
Empower Density 2001, Mean Value in Watershed	Watershed: Values of transformities have been worked out for very many processes in the environment. Based on these values, we can calculate the emergy flow (empower) and emergy flow per unit area (empower density) for the land use characteristics of various landscape types. The non-renewable emergy flow (primarily from fossil fuels) drives our economy and structures our built infrastructure. By applying the transformities of various land use types, we can assign an empower density to the National Land Cover Database. When this is mapped, it gives a good idea of human disturbance on the landscape.
Empower Density 2001, Mean Value in HCZ	Hydro connected zone: Values of transformities have been worked out for very many processes in the environment. Based on these values, we can calculate the emergy flow (empower) and emergy flow per unit area (empower density) for the land use characteristics of various landscape types. The non-renewable emergy flow (primarily from fossil fuels) drives our economy and structures our built infrastructure. By applying the transformities of various land use types, we can assign an empower density to the National Land Cover Database. When this is mapped, it gives a good idea of human disturbance on the landscape.
% Agriculture (2006) in Watershed	Watershed % of total area in cropland or pasture according to 2006 National Land Cover Dataset
% Agriculture (2006) in Riparian Zone	Riparian zone % of total area in cropland or pasture according to 2006 National Land Cover Dataset
% Urban (2006) in HCZ	Hydro connected zone % of total area in low, medium and high density urban use according to 2006 National Land Cover Dataset
Watershed Likely N/P NPDES Discharger Count	From EPA's NPDAT website, the HUC8's number of NPDES-permitted dischargers whose permits contained terms related to nutrient discharge limits
Agricultural water use WS	From EPA/ORD EnviroAtlas, agricultural usage estimates aggregated from HUC12 scale data

Domestic water use WS	From EPA/ORD EnviroAtlas, domestic water usage estimates aggregated from HUC12 scale data
SPARROW Predicted Incremental Agr N Yield (2012)	Recalculation of SPARROW results for N incremental yield estimation developed in 2012-2013 at HUC12 scale using newer data; HUC12 data aggregated to HUC8 scale.
SPARROW Predicted Incremental Agr P Yield (2012)	Recalculation of SPARROW results for P incremental yield estimation developed in 2012-2013 at HUC12 scale using newer data; HUC12 data aggregated to HUC8 scale.
Anthropogenic Recycled N Effort	The value of TOTRECYCNEFFORT adjusted to consider HUC8 size; calculated by HUC8 area times TOTRECYCNEFFORT, then adjusted for better area reporting units. This metric estimates effort to achieve recycled N reductions for the whole HUC8 as influenced by both effort per unit area and size.
Anthropogenic New N Effort	The total new N rate (TOTNEWNRATE) times the HUC8 area, then adjusted for better area reporting units.
Nutrient Impaired Segment Count	From EPA's NPDAT website, the number of waterbody segments in the HUC8 reported under section 303(d) as impaired by listing causes grouped under the Parent Category Nutrients.
Centralized Sewage N Input	Estimated nitrogen load from centralized sewage treatment systems per HUC8 per year. Derived by multiplying sewage input rate (kg N per HA per year) from EPA ORD nitrogen study times the HUC8 area in square meters.
% of HUC8 Instate	Proportion of HUC8 by total area found within the state being assessed; allows for setting higher state priorities on watersheds fully or mostly within their borders as well as identifying watersheds for multi-state cooperation.
Nutrient TMDL Count	From EPA's NPDAT website, the number of waterbody segments in the HUC8 with TMDLs developed for pollutant targets grouped under the Parent Category Nutrients.
ADOPT Watershed Groups Count	Number of active watershed organizations identified as in any way connected geographically with the HUC8, based on the EPA ADOPT website.
Percent GAP status 1, 2, and 3 WS	Percent of HUC8 by total area that is in GAP analysis program's protection and conservation status categories 1, 2, and 3
Anthropogenic Recycled N Effort (Inverse)	A weighted average overall degree of difficulty based on the proportion of each N input source and its individual degree of difficulty, for recycled N sources per HUC. Does not consider HUC size. Based on values assigned by the specific state water program personnel as their best professional judgment whether the HUC's anthropogenic N sources require high (3), medium (2) or low(1) effort to reduce loads. Original rankings were inverted in this metric to be directionally consistent with other (higher=better) social metrics.
Anthropogenic New N Effort (Inverse)	A weighted average overall degree of difficulty based on the proportion of each N input source and its individual degree of difficulty, for new N sources per HUC. Does not consider HUC size. Based on values assigned by the specific state water program personnel as their best professional judgment whether the HUC's anthropogenic N sources require high (3), medium (2) or low(1) effort to reduce loads. Original rankings were inverted in this metric to be directionally consistent with other (higher=better) social metrics.
Percent Drinking Water Source Protection Area WS	Representative of the relative amount of source water protection area (SPA) in the watershed. Original source data are available at HUC12 scale as SPA total % of HUC12 area; every SPA's percent area is summed to get the HUC12 total. Thus, due to multiple SPAs per HUC, it is possible to have values >100%. The HUC8 indicator is the mean of the HUC12 values.

Attachment 3: MA Stage 2 Rural-Agricultural and Urban-Suburban Scenario Indicator Descriptions

RURAL INDICATORS	WEIGHT	DESCRIPTION
% Woody Vegetation (2006) in Watershed	3	% of HUC12 with woody vegetation (2006 National Land Cover Dataset version 1; Land classes 41, 42, 43, 52, 90)
% Woody Vegetation (2006) in Riparian Zone	2	Percent of total HUC riparian zone area in NLCD06 forested or woody (e.g. shrub) land cover categories 41, 42, 43, 52 and 90.
Watershed % Wetland (ISO)	2	Forested Wetlands, Non-forested Wetland, Salt Marsh, Cranberry Bog, Saltwater Sandy Beach, Saltwater Wetland categories from MA Land Use 2005
% Natural Cover, N-index 2 (2006) in HCZ	1	% of HUC12 with natural cover (not barren, urban or agriculture) in the Hydrologically Connected Zone (2006 National Land Cover Dataset version 1; Land classes 41, 42, 43, 52, 71, 90, 95)
HCZ mean soil stability	3	Average soil stability in HCZ. Calculated as one minus average K factor in HCZ (HCZ_KFACTOR).
CNFI (ISO)	2	Combined Natural Flow Index - Higher score = ecologically better flow conditions. Based on USGS metrics
Mean Index of Ecological Integrity (ISO)	3	Mean Index of Ecological Integrity score from CAPS data
NFHAP HCI (ISO)	2	Habitat Condition Index from National Fish habitat Action Plan Assessment
Stream Corridor (30.5M) % Crop (ISO)	3	Cropland, Orchard, Nursery categories from MA Land Use 2005
Stream Corridor (30.5M) % Pasture (ISO)	3	Pasture category from MA Land Use 2005
Open Water Buffer (30.5M) % Crop (ISO)	3	Cropland, Orchard, Nursery categories from MA Land Use 2005
Open Water Buffer (30.5M) % Pasture (ISO)	3	Pasture category from MA Land Use 2005
% Developed, Open Space (2006) in Riparian Zone	2	% of HUC12 with developed, open space cover in the Riparian Zone (2006 National Land Cover Dataset version 1)
% Developed, Low intensity (2006) in Riparian Zone	2	% of HUC12 with developed, low intensity cover in the Riparian Zone (2006 National Land Cover Dataset version 1)
% Contiguous Agriculture (2006) in Watershed	3	% of HUC12 with Agriculture that is contiguous with water
% U-Index06 Contiguous H2O, in Watershed	1	% of HUC12 that is agricultural or urban and is contiguous with water
Empower Density 2001, Mean Value in RZ	1	Mean value of non-renewable emergy flow per year in Riparian Zone
Total nitrogen deposition WS	3	Estimated total annual deposition of nitrogen within each HUC12 in kilograms per hectare. Includes both dry and wet deposition of oxidized and reduced nitrogen.
Synthetic N fertilizer application (kg N/ha/yr) WS	3	The mean rate of synthetic nitrogen fertilizer application to agricultural lands within each HUC12 in kg N/ha/yr.
N Yield (lb/sqmi) (ISO)	3	USGS SPARROW Incremental Model Results for Nitrogen Yield
P Yield (lb/sqmi) (ISO)	1	USGS SPARROW Incremental Model Results for Phosphorus Yield
Road Density 2003, Mean Value (mi /sq mi) RZ	2	Mean Road Density (mi / sqmi) in Riparian Zone
% Watershed Streamlength 303d-Listed Nutrients	1	Percent of stream features in HUC12 listed as impaired due to nutrient-related causes and requiring a TMDL under Section 303(d) of the Clean Water Act. Calculated as length of 303(d) listed nutrient impaired streams (STREAMLGTH_303D_NUTRIENTS) divided by total stream length (STREAMLGTH_NHD + STREAMLGTH_303D_CUSTOM).
Watershed Nutrients 303d-Listed Segments Count	1	Count of waters listed as impaired due to nutrients and requiring a TMDL under Section 303(d) of the Clean Water Act in HUC12. Calculated as the number of unique state-assigned water segment IDs in the EPA Office of Water "303(d) Listed Impaired Waters" NHD-indexed dataset with "Nutrients", "Organic Enrichment/Oxygen Depletion", "Algal Growth", or "Noxious Aquatic Plants" listed as a parent cause of impairment.
Watershed 303d + TMDL Impairment Causes Count	1	Count of causes of impairment for waters with TMDLs or waters listed as impaired and requiring a TMDL under Section 303(d) of the Clean Water Act in HUC12. Calculated as the number of unique parent

		(grouped) causes of impairment in the EPA Office of Water "Impaired Waters with TMDLs" and "303(d) Listed Impaired Waters" NHD-indexed datasets.
% Watershed Streamlength Assessed	1	Percent of stream features in HUC12 assessed under Section 305(b) of the Clean Water Act. Calculated as length of assessed streams (STREAMLGTH_305B) divided by total stream length (STREAMLGTH_NHD + STREAMLGTH_305B_CUSTOM).
% Watershed Waterbody Area Assessed	1	Percent of lakes, estuaries, and other areal water features in HUC12 assessed under Section 305(b) of the Clean Water Act. Calculated as area of assessed waterbodies (WBAREA_305B) divided by total waterbody area (WBAREA_NHD + WBAREA_305B_CUSTOM).
Watershed Count Ratio TMDLs to Impairments	1	Ratio of number of TMDLs to impairments in HUC12. Calculated from TMDL count (CNT_TMDLS) and count of impairments for 303(d) listed waters/waters with TMDLs (CNT_303DTMDL_IMPAIRMENTS).
Watershed Segments with Nutrient TMDLs Count	1	Count of waters with a nutrient-related TMDL in HUC12. Calculated as the number of unique state-assigned water segment IDs the EPA Office of Water "Impaired Waters with TMDLs" NHD-indexed dataset with "Nutrients", "Organic Enrichment/Oxygen Depletion", "Algal Growth", or "Noxious Aquatic Plants" listed as a parent TMDL pollutant.
NRCS Obligated Projects (#/sq. mi.) (ISO)	1	Fully funded USDA Farm Bill Projects
Protected Land Index (ISO)	3	Percent of watershed protected with the following designations: Wwater supply protection, habitat protection, flood control, and conservation lands
PWS Intakes (#/sq. mi.) (ISO)	3	Number of public water supply intakes in surface waters per square mile
PWS Wells (#/sq. mi.) (ISO)	3	Number of public water supply wells per square mile
% ACEC (ISO)	3	Percent of Watershed containing Areas of Critical Environmental Concern
% Water-based Recreation (ISO)	3	% Water-based Recreation from MA Land Use 2005

URBAN INDICATORS	WEIGHT	DESCRIPTION
% Woody Vegetation (2006) in Watershed	3	% of HUC12 with woody vegetation (2006 National Land Cover Dataset version 1; Land classes 41, 42, 43, 52, 90)
% Woody Vegetation (2006) in Riparian Zone	2	Percent of total HUC riparian zone area in NLCD06 forested or woody (e.g. shrub) land cover categories 41, 42, 43, 52 and 90.
Watershed % Wetland (ISO)	2	Forested Wetlands, Non-forested Wetland, Salt Marsh, Cranberry Bog, Saltwater Sandy Beach, Saltwater Wetland categories from MA Land Use 2005
% Natural Cover, N-index 2 (2006) in HCZ	1	% of HUC12 with natural cover (not barren, urban or agriculture) in the Hydrologically Connected Zone (2006 National Land Cover Dataset version 1; Land classes 41, 42, 43, 52, 71, 90, 95)
Infiltration BMP Suitability (Ksat um/s) (ISO)	3	Area-weighted average saturated hydraulic conductivity (Ksat) from SSURGO database
CNFI (ISO)	2	Combined Natural Flow Index - Higher score = ecologically better flow conditions. Based on USGS metrics
Mean Index of Ecological Integrity (ISO)	3	Mean Index of Ecological Integrity score from CAPS data
NFHAP HCI (ISO)	2	Habitat Condition Index from National Fish habitat Action Plan Assessment
Watershed % Urban1 (ISO)	3	Mining, Participatory Recreation, Golf Course, Spectator Recreation, Multi-family Residential, High-density Residential, Medium-density Residential, Low-density Residential, Very Low-density residential, Commercial, Industrial, Urban Open, Transitional, Cemetery, Transportation, Waste Disposal, Junk Yard, Water-based Recreation,

		Powerline/Utility, Marina, Urban Public categories from MA Land Use 2005
% Developed, Low intensity (2006) in Watershed	3	% of HUC12 with developed, low intensity cover (2006 National Land Cover Dataset version 1)
% Developed, Medium intensity (2006) in Watershed	3	% of HUC12 with developed, medium intensity cover (2006 National Land Cover Dataset version 1)
% Agriculture (2006) in Watershed	2	% of HUC12 with agricultural (crops + hay/pasture) cover (2006 National Land Cover Dataset version 1; Land classes 81, 82)
Stream Corridor (61M) % Impervious (ISO)	2	% Impervious area from MA dataset (1M resolution)
Open Water Buffer (61M) % Impervious (ISO)	2	%Percent Impervious area from MA dataset (1M resolution)
Empower Density 2001, Mean Value in RZ	1	Mean value of non-renewable emergy flow per year in Riparian Zone
Total nitrogen deposition WS	3	Estimated total annual deposition of nitrogen within each HUC12 in kilograms per hectare. Includes both dry and wet deposition of oxidized and reduced nitrogen.
Synthetic N fertilizer application (kg N/ha/yr) WS	3	The mean rate of synthetic nitrogen fertilizer application to agricultural lands within each HUC12 in kg N/ha/yr.
N Yield (lb/sqmi) (ISO)	3	USGS SPARROW Incremental Model Results for Nitrogen Yield
P Yield (lb/sqmi) (ISO)	1	USGS SPARROW Incremental Model Results for Phosphorus Yield
PCS (#/sqmi) (ISO)	1	Number of outfalls from EPA PCS Dataset divided by watershed area
Sediment (ISO)	2	Intensity of road sediment production in the watershed weighted by road class; a surrogate for road sediment production rates.
Road Density 2003, Mean Value (mi /sq mi) RZ	2	Mean Road Density (mi / sqmi) in Riparian Zone
% Watershed Streamlength 303d-Listed Nutrients	1	Percent of stream features in HUC12 listed as impaired due to nutrient-related causes and requiring a TMDL under Section 303(d) of the Clean Water Act. Calculated as length of 303(d) listed nutrient impaired streams (STREAMLGTH_303D_NUTRIENTS) divided by total stream length (STREAMLGTH_NHD + STREAMLGTH_303D_CUSTOM).
Watershed 303d + TMDL Impairment Causes Count	1	Count of causes of impairment for waters with TMDLs or waters listed as impaired and requiring a TMDL under Section 303(d) of the Clean Water Act in HUC12. Calculated as the number of unique parent (grouped) causes of impairment in the EPA Office of Water "Impaired Waters with TMDLs" and "303(d) Listed Impaired Waters" NHD-indexed datasets.
% Watershed Streamlength Assessed	1	Percent of stream features in HUC12 assessed under Section 305(b) of the Clean Water Act. Calculated as length of assessed streams (STREAMLGTH_305B) divided by total stream length (STREAMLGTH_NHD + STREAMLGTH_305B_CUSTOM).
% Watershed Waterbody Area Assessed	1	Percent of lakes, estuaries, and other areal water features in HUC12 assessed under Section 305(b) of the Clean Water Act. Calculated as area of assessed waterbodies (WBAREA_305B) divided by total waterbody area (WBAREA_NHD + WBAREA_305B_CUSTOM).
Watershed Count Ratio TMDLs to Impairments	1	Ratio of number of TMDLs to impairments in HUC12. Calculated from TMDL count (CNT_TMDLS) and count of impairments for 303(d) listed waters/waters with TMDLs (CNT_303DTMDL_IMPAIRMENTS).
Watershed Segments with Nutrient TMDLs Count	1	Count of waters with a nutrient-related TMDL in HUC12. Calculated as the number of unique state-assigned water segment IDs the EPA Office of Water "Impaired Waters with TMDLs" NHD-indexed dataset with "Nutrients", "Organic Enrichment/Oxygen Depletion", "Algal Growth", or "Noxious Aquatic Plants" listed as a parent TMDL pollutant.
% Area not in MS4 (ISO)	1	Areas eligible for 319 funds
CC Score (ISO)	1	Commonwealth Capital Score spatially weighted average from all towns within each HUC watershed

Protected Land Index (ISO)	3	Percent of watershed protected with the following designations: Wwater supply protection, habitat protection, flood control, and conservation lands
PWS Intakes (#/sq. mi.) (ISO)	3	Number of public water supply intakes in surface waters per square mile
PWS Wells (#/sq. mi.) (ISO)	3	Number of public water supply wells per square mile
% ACEC (ISO)	3	Percent of Watershed containing Areas of Critical Environmental Concern
% Water-based Recreation (ISO)	3	% Water-based Recreation from MA Land Use 2005

Attachment 4: MA RPS Tool file names and contents
(note that the 6 digit date beginning each file name may change with subsequent updates)

The following are RPS Tool files completed during this project and delivered to MassDEP for statewide and HUC8-specific use. Except for MASTER MA RPS, all these files contain archived results for each geographic area and scenario as named. Other than differences in their screening results, these files are otherwise identical to the master file.

RPS Tool File Name	Content
MA RPS –Scoring-Tool-051915.xlsm	MA RPS Tool with all HUC8 and HUC12 data, no screening content saved (master copy for all new screening statewide or on HUC subsets)
150519 ST1RURAL MA RPS-Scoring-Tool-051915.xlsm	MA RPS Tool with screening results for HUC8 Stage 1 rural-agricultural scenario
150519 ST1URBAN MA RPS-Scoring-Tool-051915.xlsm	MA RPS Tool with screening results for HUC8 Stage 1 urban-suburban scenario
150519 RURST2 MIDCONN MA RPS –Scoring-Tool-051915.xlsm	MA RPS Tool with Stage 2 results for HUC12 rural-agricultural scenario screening within Middle Connecticut HUC8
150519 RURST2 DEERFIELD MA RPS –Scoring-Tool-051915.xlsm	MA RPS Tool with Stage 2 results for HUC12 rural-agricultural scenario screening within Deerfield HUC8
150519 RURST2 CHICOPEE MA RPS –Scoring-Tool-051915.xlsm	MA RPS Tool with Stage 2 results for HUC12 rural-agricultural scenario screening within Chicopee HUC8
150519 URBST2 BLSTONE MA RPS –Scoring-Tool-051915.xlsm	MA RPS Tool with Stage 2 results for HUC12 urban-suburban screening within Blackstone HUC8
150519 URBST2 CPCOD MA RPS –Scoring-Tool-051915.xlsm	MA RPS Tool with Stage 2 results for HUC12 urban-suburban screening within Cape Cod HUC8
150519 URBST2 NARR MA RPS –Scoring-Tool-051915.xlsm	MA RPS Tool with Stage 2 results for HUC12 urban-suburban screening within Narragansett HUC8
150519 URBST2 CHICOPEE MA RPS –Scoring-Tool-051915.xlsm	MA RPS Tool with Stage 2 results for HUC12 urban-suburban screening within Chicopee HUC8
150519 URBST2 MIDCONN MA RPS –Scoring-Tool-051915.xlsm	MA RPS Tool with Stage 2 results for HUC12 urban-suburban screening within Middle Connecticut HUC8