Virginia Concepts in Water Quality Trend Analysis.

The Virginia Department of Environmental Quality's Concepts in Water Quality Trend Analysis, have been applied across the Commonwealth, and piloted in a few other waters. The 2012 Virginia Draft Integrated Report, included trend analysis of both individual long term monitoring stations (Section 4.5), as well as waterbody analyses associated with grouping of monitoring stations (Section 4.6). Section 4.6, describes the grouping approach also known as the IWQ (Integrated Water Quality) analysis, and will be described here. The IWQ approach allows the inclusion of multiple monitoring stations from varying time periods, changing water quality analytical methods and even changes to water quality standards.

The IWQ measures suggested here provide a mechanism for documenting interim changes in water quality variables that could easily be summarized in visual / graphical form to identify apparent changes or trends in water quality. The first chart is in the form of a color coded histogram with no confidence intervals associated with annual summaries. The second plot is in the form of a regression of annual scores that does provide an approximate significant probability.

We believe that the IWQ methodology responds to the specific requirement of the OW EPA guidance on page 31, "Integration of statistical survey and targeted monitoring designs to assess the condition of all water resources over time…"

Such summaries could conceivably be presented on a statewide basis (across all seasons) or stratified by aggregated ecological region, waterbody type, or basin.

1. For the first example, we used DEQ monitoring results in Virginia to establish baseline for comparisons, using the following procedure:

a. Reference time period – Most recent ten year block of data, e.g. for the 2012 Integrated Report the reference period is 2001-2010.

b. Include all appropriate ambient data.

c. Evaluate selected dataset for each parameter of interest (total Nitrogen, total Phosphorus, total suspended solids, bacteria; others such as dissolved Oxygen, pH, flow, and temperature could be included.)

d. Establish reference values within the reference time period for each watershed, waterbody type, season, and water quality parameter. For example a selection of stratum might include, 5th order NWDB hydrologic unit, stream / surface sample, season, and variable. In the following examples we selected a 10-digit HUC level of resolution, 0301020512 VAHU5=AS-C ON5=North Landing River, with a STREAM depth of 1.0 meters or less, six two month seasons, and total suspended solids (SOLIDS).

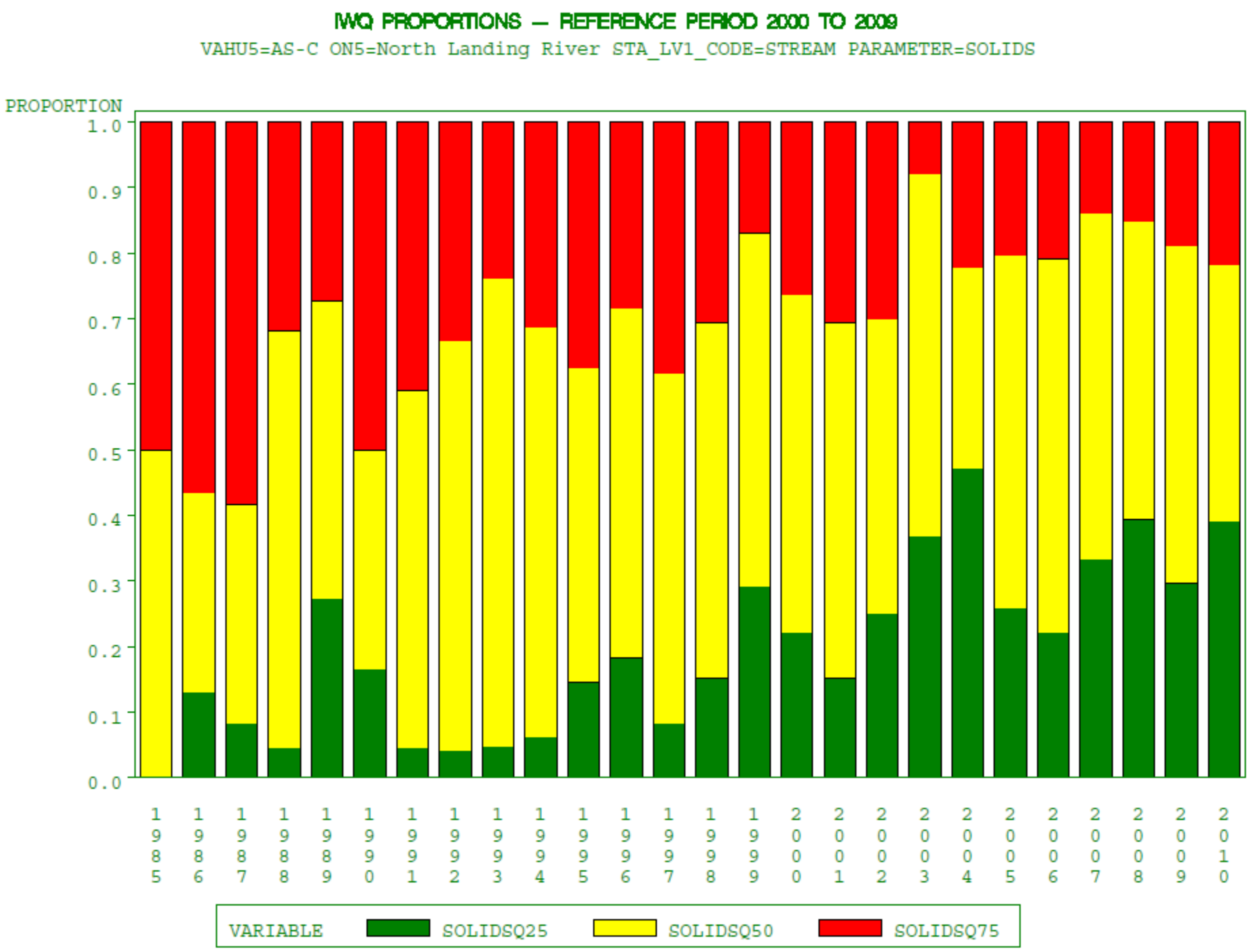
i. Determine 75th percentile reference value: upper quartile values considered "lower water quality" within each level of stratum as described above (25% of reference dataset).

ii. Determine 25th percentile reference value: lower quartile values considered "higher water quality" (25% of reference dataset).

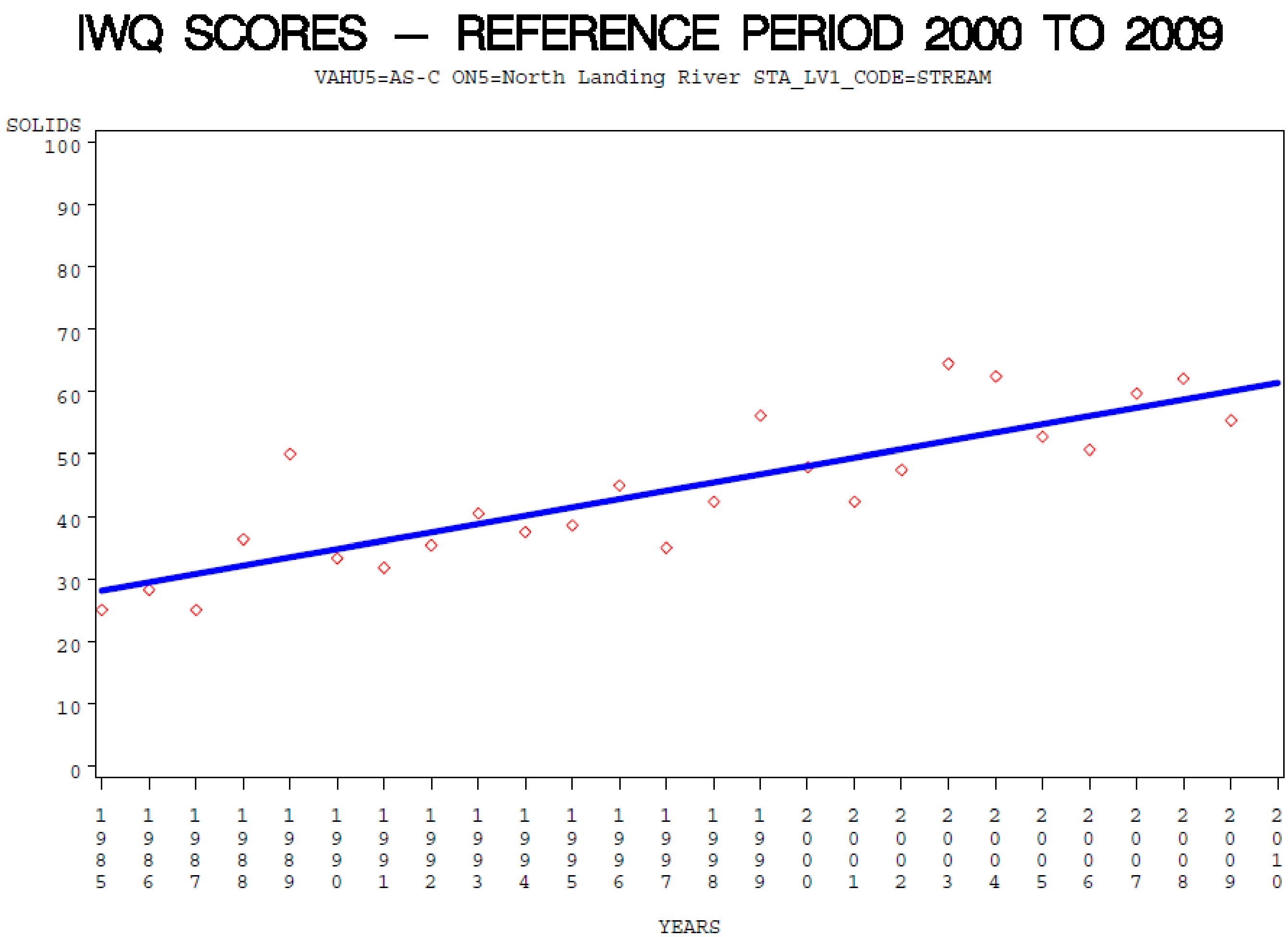
iii. The inter-quartile values are considered "moderate" (50% of reference dataset).

e. Compare individual water quality measurements within each stratum to the 25th and 75th percentile reference values. Assign a score of 100 to each individual measurement that is less than or equal to the 25th percentile. Assign a score of 50 to each individual measurement that is greater than the 25th percentile and less than or equal to the 75th percentile. Assign a score of zero to each measurement that is greater than the 75th percentile.

A bar plot of the stacked annual proportions in each of the categories follows. Higher water quality is indicated by green, lower water quality by red, and intermediate by yellow.



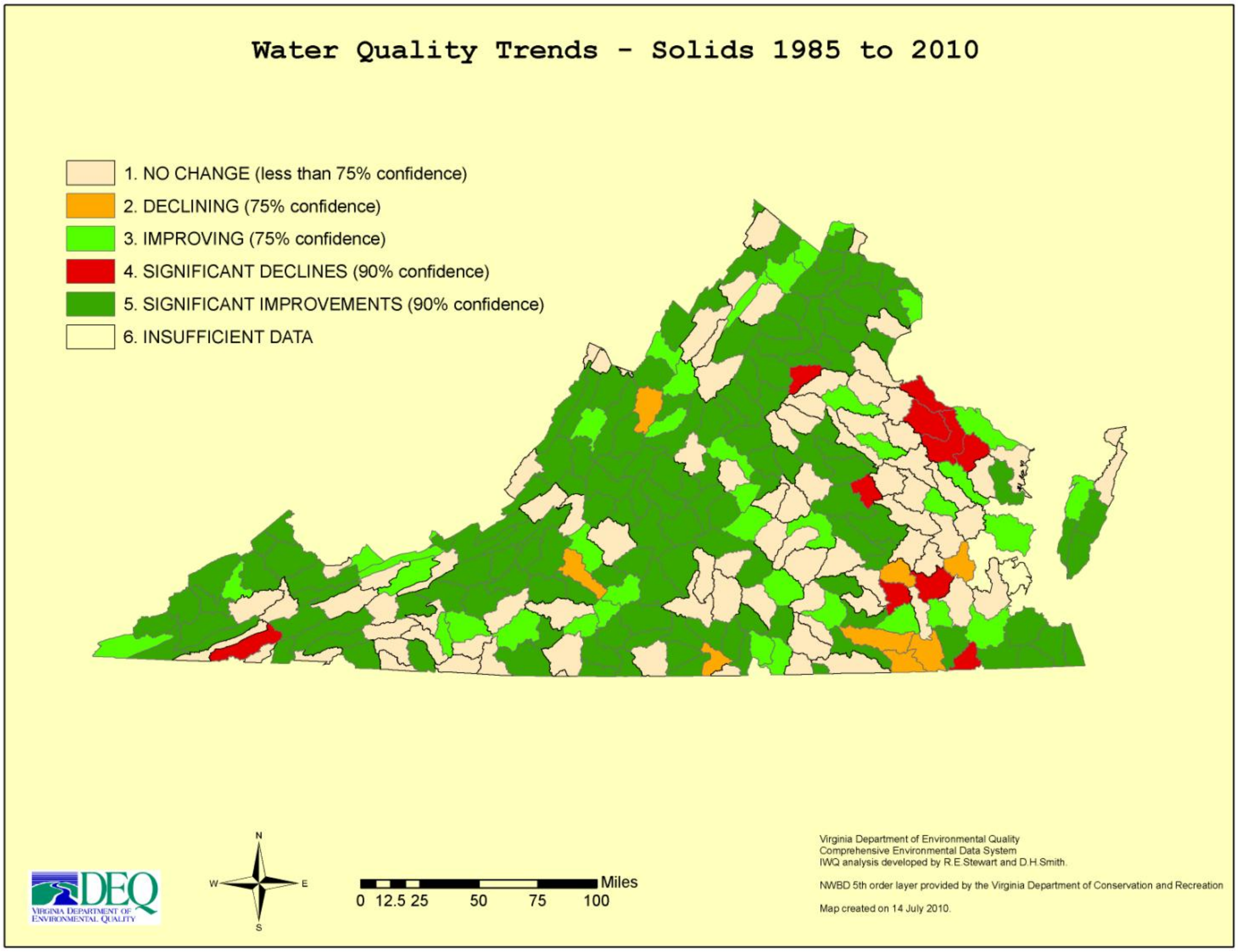
f. Calculate the mean score by year. To interpret changing water quality conditions over time calculate a linear regression of the mean annual score versus year, including the p value for the regression. Linear regressions with positive slopes indicate improving water quality conditions; those with negative slopes indicate declining water quality conditions. An example of improving water quality for solids in the North Landing River watershed in the Albemarle Sound basin follows.



Regression Equation:
SOLIDS = -5.180804 + 0.003647*YEARS

p value < 0.0001

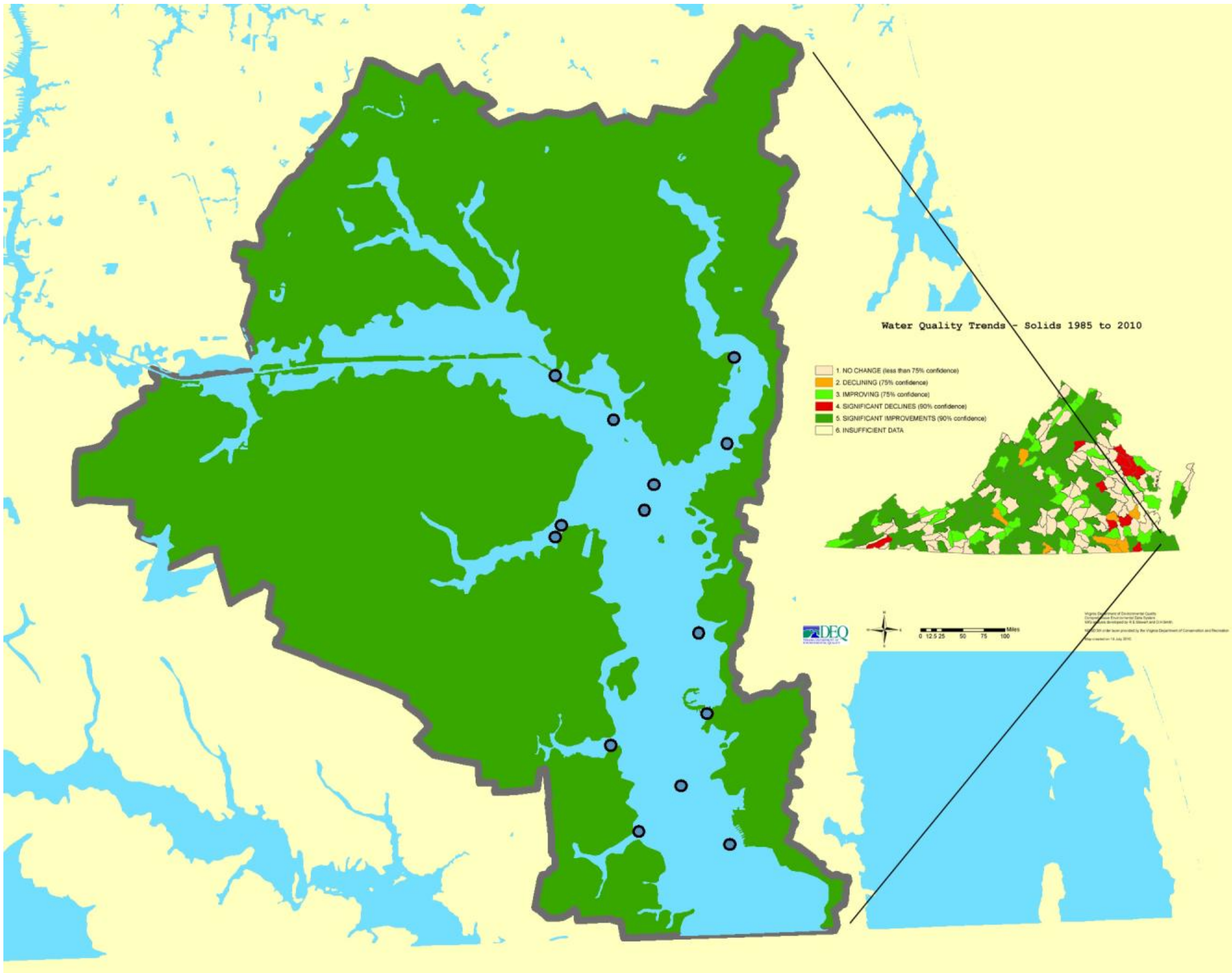
g. Assigning categories to the trend detected in each regression and linking the category to the geospatial stratum used in the analysis allows for visual representation of the integrated water quality score in the form of a map. For example the Statewide integrated solids trend in streams for each watershed are displayed on the following map.



Categories are assigned as follows:

1. NO CHANGE (less than 75% confidence) WHERE PVALUE > 0.25.
2. DECLINING (75% confidence) WHERE SLOPE <0.0 AND PVALUE > 0.10 AND PVALUE <=0.25.
3. IMPROVING (75% confidence) WHERE SLOPE >0.0 AND PVALUE > 0.10 AND PVALUE <=0.25.
4. SIGNIFICANT DECLINES (90% confidence) WHERE SLOPE <0.0 AND PVALUE <= 0.10.
5. SIGNIFICANT IMPROVEMENTS (90% confidence) WHERE SLOPE >0.0 AND PVALUE <= 0.10.
6. INSUFFICIENT DATA WHERE PVALUE IS NULL.

h. From the statewide Solids map above users can zoom to a 5th order watershed of interest. The North Landing River watershed has an improving trend in water quality for total suspended solids (00530) since 1985. Stations used in the analysis are indicated by the blue circles.

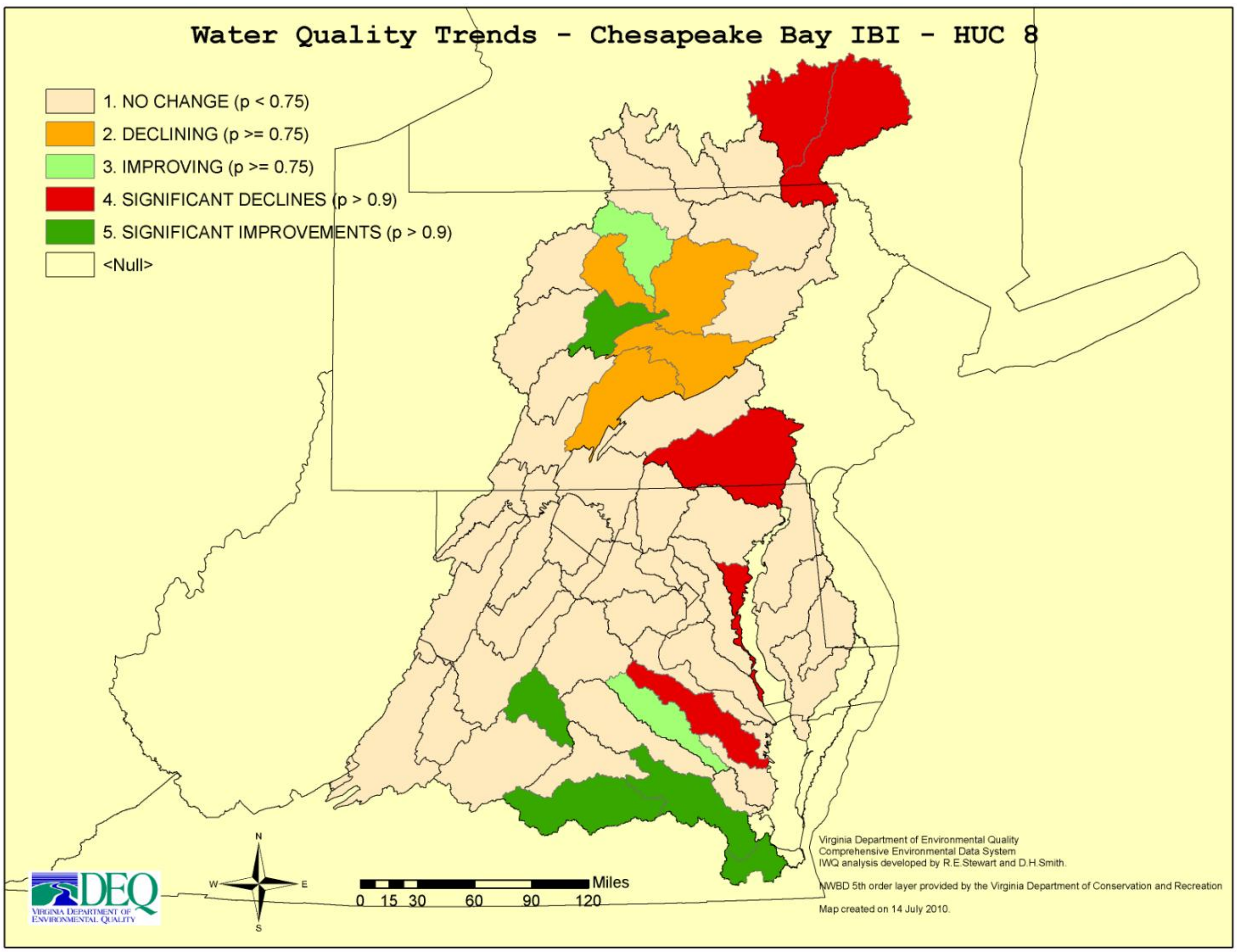


DISCUSSION

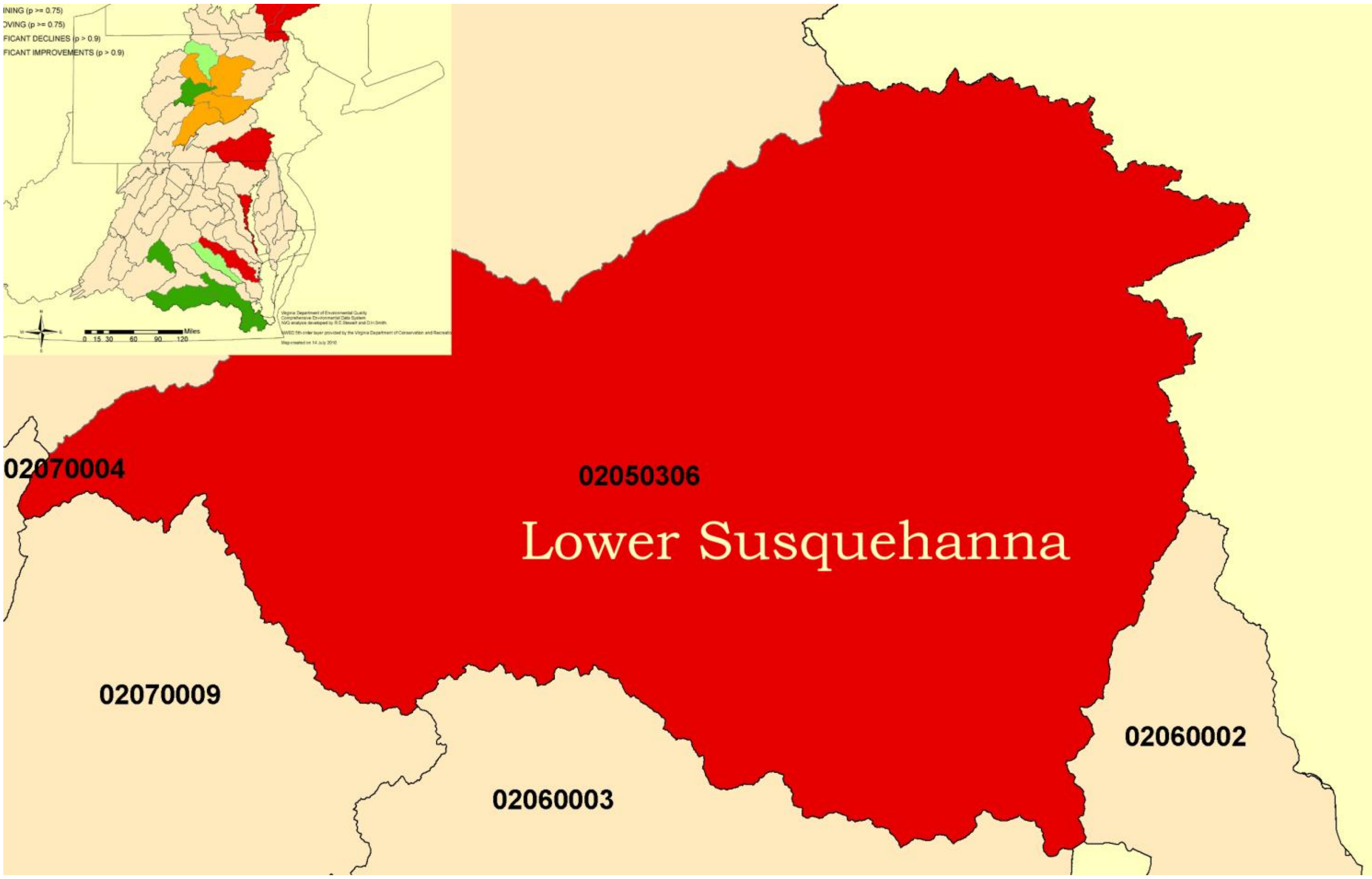
Standardization of the reference distributions by aggregated level III ecological regions or by water resource types (low order streams, higher order streams, lakes and reservoirs, and estuaries) could facilitate resource characterizations and permit more representative characterizations when the results are integrated across resource types and/or geographic regions (e.g., by river basin, ecological region, EPA region, Chesapeake Bay watershed. etc).

The IWQ approach has been recognized by EPA as a candidate for interim measure. Pilot studies have been performed with several waterbodies, regions, or states. Kansas volunteered as a pilot project. Kansas adapted Virginia's IWQ method to evaluate Kansas' waters, including a lakes analysis. The integrated water quality scoring methodology described above can be applied to pooled data from various data sources as long as the scores are derived from reference values of the individual data sources prior to regression. For example Maryland and Virginia use different methodologies to calculate a benthic macro invertebrate numeric value for stream conditions in the Potomac River basin. To understand the overall trend in the benthic community health in the Potomac basin over time it is desirable to include data from these two sources. By including the data source, in this case Virginia and Maryland, in the strata, numeric values are reduced to scores based on each state's reference conditions. Once these numeric values are reduced to a standardized score they can be combined to produce an overall score for the basin.

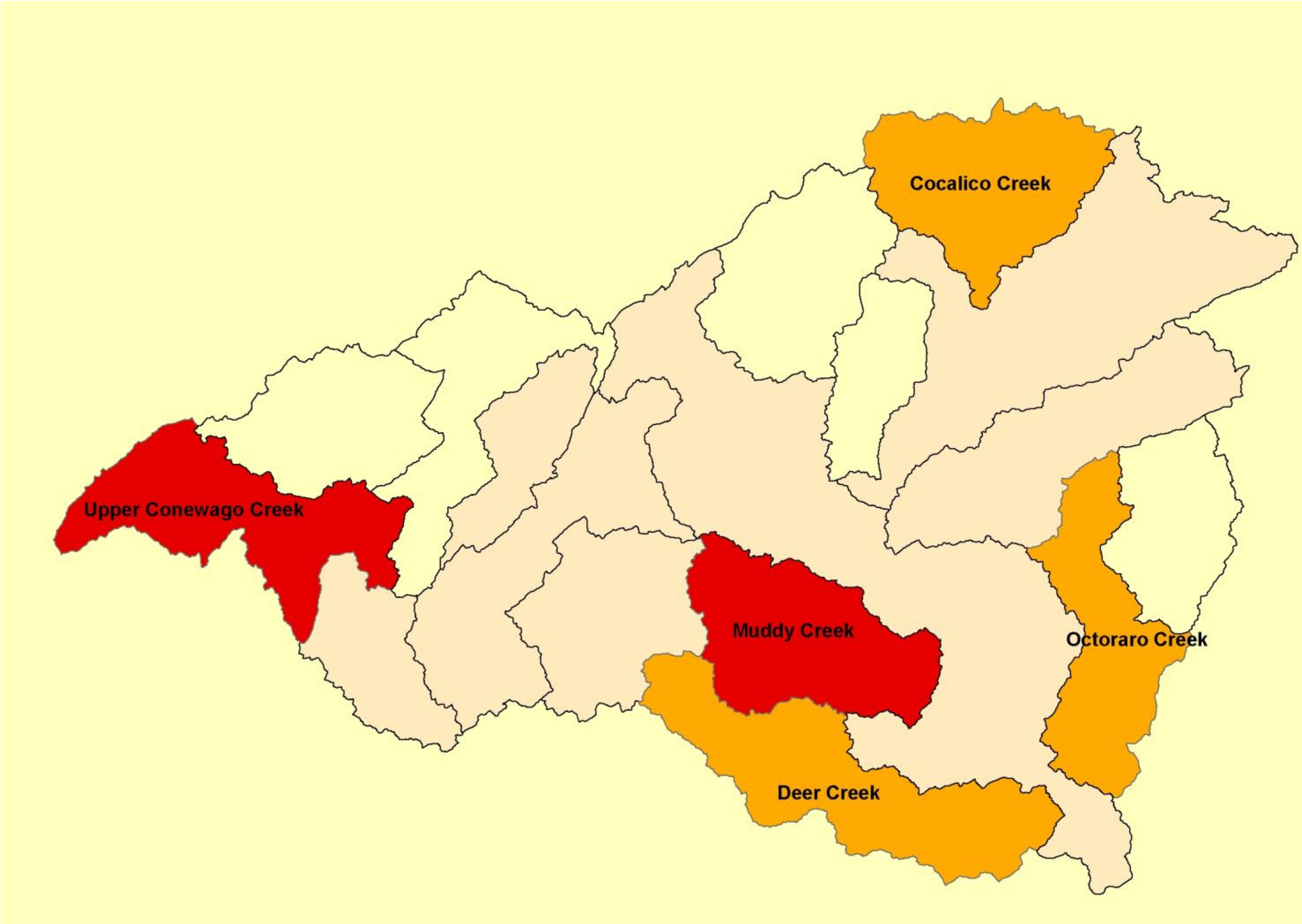
Data for the following maps of the Chesapeake Bay stream macroinvertebrate IBI were provided by Katie Foreman of the Chesapeake Bay Program. These data illustrate how water quality trends across various states can be integrated.



Furthermore the IWQ can be used to identify sub watersheds that may contribute to declining scores. At the HUC 8 level the Lower Susquehanna, 02050306, shows a declining score for the CB stream macroinvertebrate IBI.



When drilling down from the HUC 8 to the HUC 10, five sub watersheds, Upper Conewago Creek, Muddy Creek, Cocalico Creek, Octoraro Creek and Deer Creek, indicate declining IBI scores. These five would be candidates for closer investigation.



Virginia is using trend analyses to develop a more strategic planning approach to prioritize the implementation of existing and future water quality management plans. Additionally, this approach has helped Virginia to prioritize permitted point source management in favor of implementation of at least one TMDL for a watershed with bacterial declines. Strategic planning tools such as the IWQ can enable watershed management to avoid unnecessary costs, target efforts, and prioritize each dollar to have the greatest impacts.

Analyses developed by Don Smith and Roger Stewart. Document prepared by Roger Stewart, Don Smith, and Craig Lott. Special thanks to Larry Merrill, EPA Region 3, for support and encouragement. Questions regarding these analyses may be directed to Craig Lott.

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