Statistical Evaluation of Proposed Modifications to the AMP Sampling Schedule for Tributary Macroinvertebrates

Prepared for

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The Onondaga Lake Ambient Monitoring Program (AMP) was designed to provide information supporting future decisions on wastewater and watershed management (Onondaga County, 1998). These decisions are based in part upon measured responses in the Lake, its tributaries, and Seneca River as specific point and non-point source control measures are implemented over the 2000-2020 period. Decisions will also rely upon comparisons of monitored conditions with water quality standards, indices of ecosystem health, and other management goals. Specific hypotheses have been formulated to track the progress of the program, guide data collection, and guide statistical analysis.

Previous reports (Walker, 1998; 1999; 2000a; 2002ab; 2007) describe a statistical framework (AMPSF) with the following functions:

- Identifying and quantifying sources of variability in the data;
- Evaluating precision of yearly summary statistics, expressed as relative standard
- errors, RSE = standard error / mean);
- Evaluating power for detecting long-term trends, expressed as likelihood of
- detecting hypothetical trends or step changes of specific magnitudes;
- Refining monitoring program designs;
- Developing methods for testing hypotheses regarding trends or compliance.

The framework uses a statistical model that expresses precision and power with a common set of numerical indices. The APSF reports supplement the statistical analyses and interpretations of each dataset in the AMP yearly monitoring reports. The analytical approach to support biological and limnological interpretation of the data varies with monitored component and metric.

The cumulative database for each water quality and biological metric provides a good basis for continued refinement of the program to increase cost-effectiveness. Review of the data analyses in the AMP reports suggests that that designs have provided a good basis for detecting trends and establishing baselines. Stable signals, high precision, and redundancy in some of the data suggest that spatial and/or temporal sampling intensity could be scaled back without compromising objectives. The statistical framework provides a basis for adjusting to the program to increase cost-effectiveness.

This report analyzes the cumulative database for tributary macroinvertebrate data collected at two year intervals between 2000 and 2010 (Figure 1). The AMP design calls for biennial sampling at 10 stations starting in 2000 (Figure 1). Four replicates are collected at each site. A variety of indices have been used over the years to express the organism counts in terms that reflect the health of the stream community. The previous AMPSF report (Walker, 2007) developed precision and power estimates for four indices (Species Richness, HBI Score, DEC Index Score, and % Oligocheates).

The Biological Assessment Profile (BAP) is computed from the four individual indices and is currently the primary metric for expressing organism counts in terms that reflect the health of the benthic community and sensitivity to ambient water quality. Ecologic (2012) provided summaries and interpretations of the cumulative database thru 2010 (Figure 2). Seven sampling events between 2000 and 2010 provide a good baseline for measuring changes in the as the CSO controls and other watershed management measures are implemented over the next several years.

This report evaluates the potential impacts of omitting the 2012 survey on the precision of the baseline and power for measuring future changes in the BAP score in response to management measures. The measurements are costly because counting the organisms is labor intensive and requires considerable expertise. Omitting the 2012 survey would allow reallocation of funds to other AMP efforts. If this adjustment can be made without significantly reducing the baseline precision, the overall cost-effectiveness of the program could be improved.

Simple inspection of the data (Figure 2) suggests that the monitoring program design has provided a good basis for categorizing each site, establishing baseline conditions, detecting trends, and characterizing spatial variations across sites within and among the three tributaries. Most sites exhibit relatively stable signals with respect to the index score and the pollution tolerance category.

The same data are re-plotted in Figure 3 expressed as follows:

- Means by site and sampling event. The standard errors are computed from an average of 4 replicates per site.

- Cumulative baseline by site and sampling event. The cumulative baseline is defined as the period-of-record mean at a given site. Baseline values are shown starting in 2004 (2000-2004 mean) and ending in 2010 (2000-2010 mean). Standard errors are computed from the distribution of the individual event means.

- 3-Year rolling baselines by site and sampling event. The first value for each site represents the 2000-2004 mean and the last represents 2006-2010 mean.

At most sites, the 2000-2004 data provided a solid baseline for measuring changes. Adding 2006, 2008, and 2010 data did not have a significant impact on the cumulative baseline mean or standard error. The standard errors are sufficiently low to provide high statistical power for detecting changes relative to the overall range of values and to the classification increment (~2.5 BAP units, Figure 2).

Based upon linear regression analysis, trends are indicated at 4 sites: Harbor-2 (-0.06 units/yr, $p < 0.06$), Ley-2 (+0.07 units/yr, $p < 0.08$), Onondaga-2 (-0.08 units/yr, $p < 0.01$), and Onondaga-5 (+0.06 units/yr, $p < 0.11$). The Ley-2 data are suspect because of substrate characteristics (Ecologic, 2012). Most of the changes at the other sites occurred after the first two sampling events (2000-2002). Linear regression slopes have been used to adjust the cumulative baseline to 2010 conditions (Figure 4). Stable signals are also evident in the adjusted data.

Barring unforeseen site disturbances, it is reasonable to expect that omitting the 2012 survey would not significantly compromise the objectives of the program for detecting changes in the BAP values in response to implementation of CSO and other nonpoint control measures over the next several years. In the event of a major site disturbance, such as a toxic chemical spill or scouring event, it is hypothetically possible that the BAP baseline established in the previous decade could be dramatically lowered. This may call for an additional stream survey to re-establish a limited baseline, depending on the specific circumstances and best professional judgment.

It is likely that solid baselines have also been established for other AMP water quality and biological metrics. A similar analysis is recommended for future updates of the AMPSF. It would also provide a basis for enhancing the program to focus on metrics and locations currently considered to be most important for measuring status and restoration progress in the lake and tributaries.

References

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NYSDEC. "Standard Operating Procedure: Biological Monitoring of Surface Waters New York State", New York State Department of Environmental Conservation, Division of Water. 159 pp., 2009.

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Figure 1 Site Map and HBI Results for 2000-2010 Baseline (Ecologic, 2012)

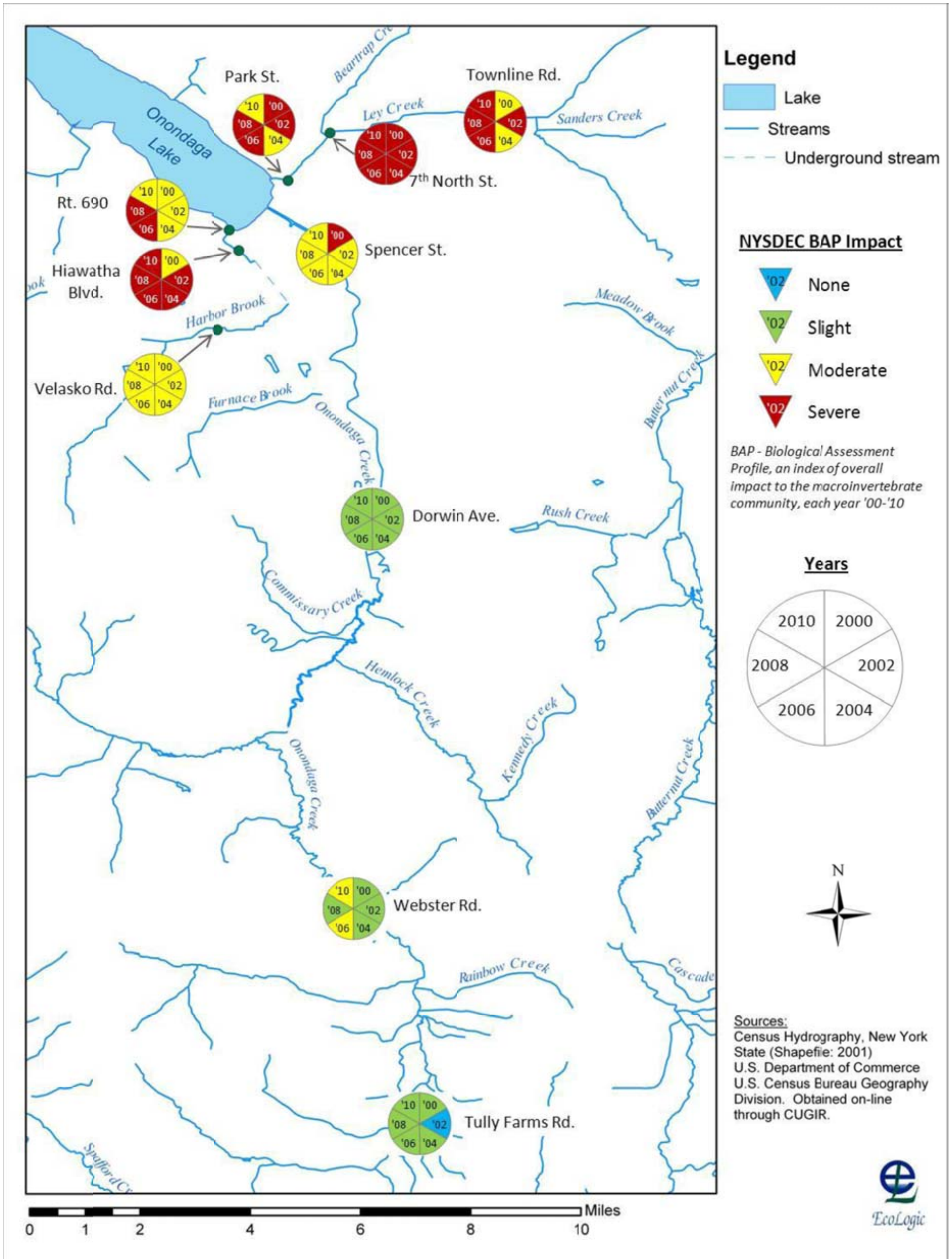


Figure 2 Biological Assessment Profiles, 2000-2010 (Ecologic, 2012)

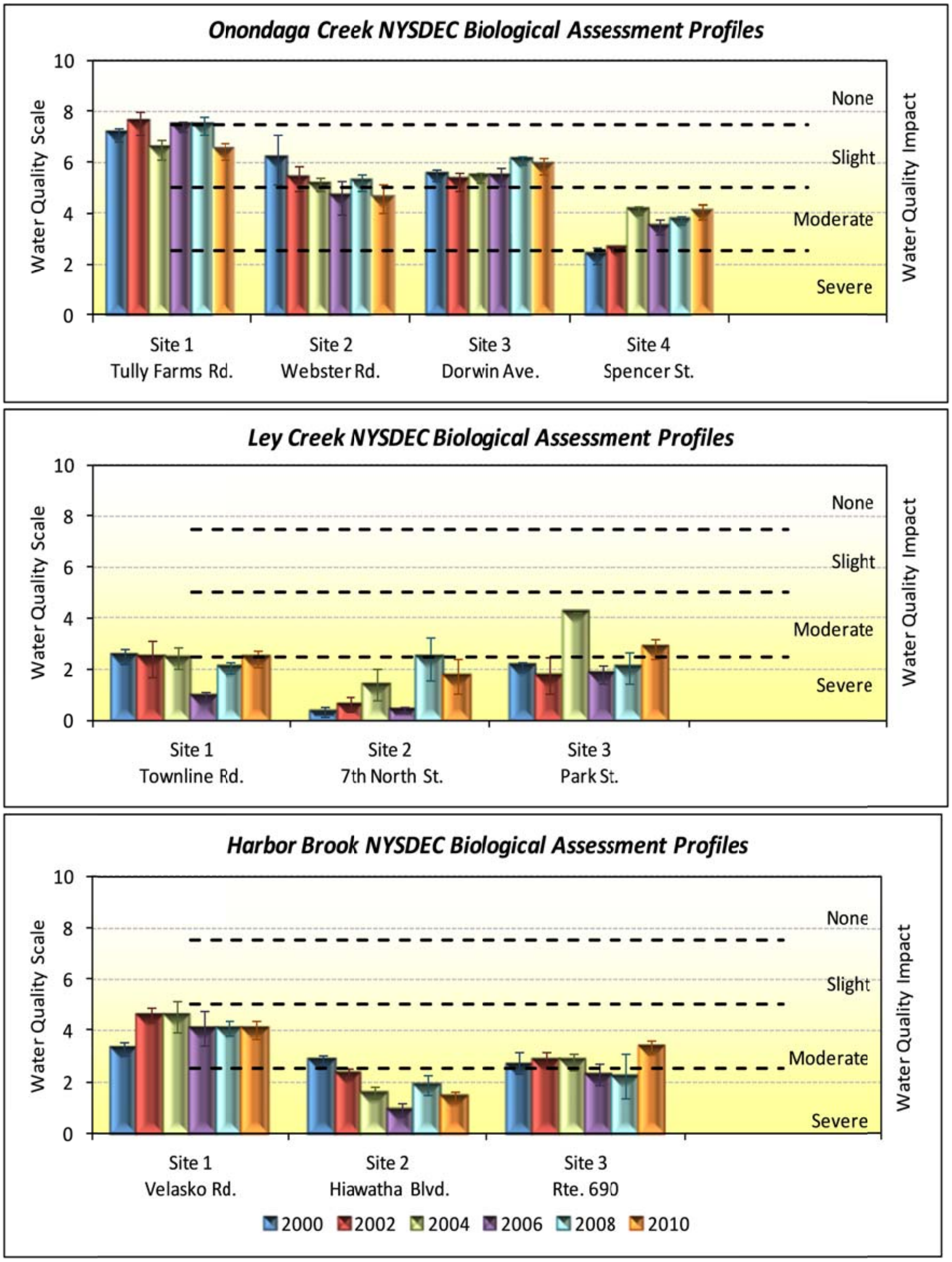
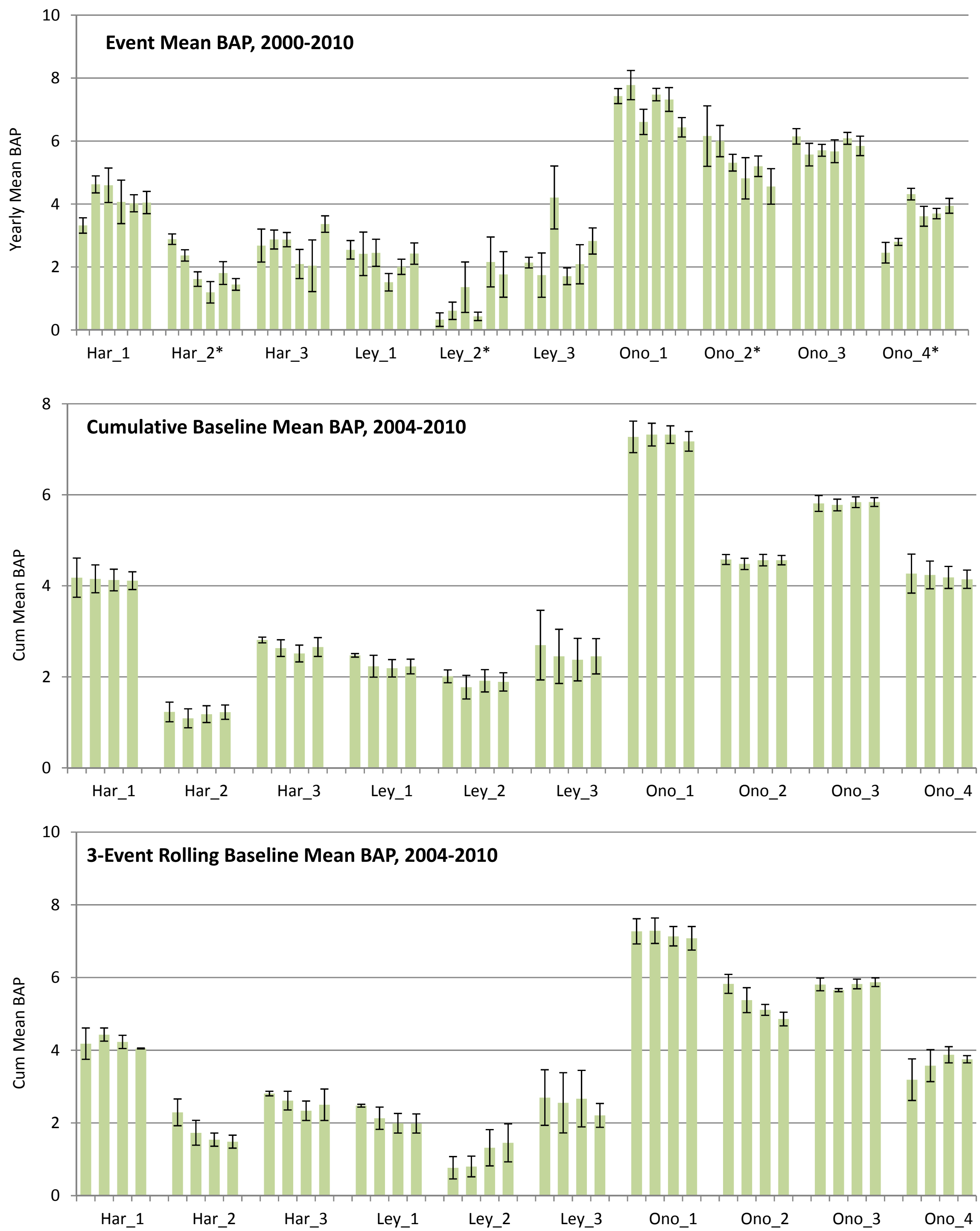
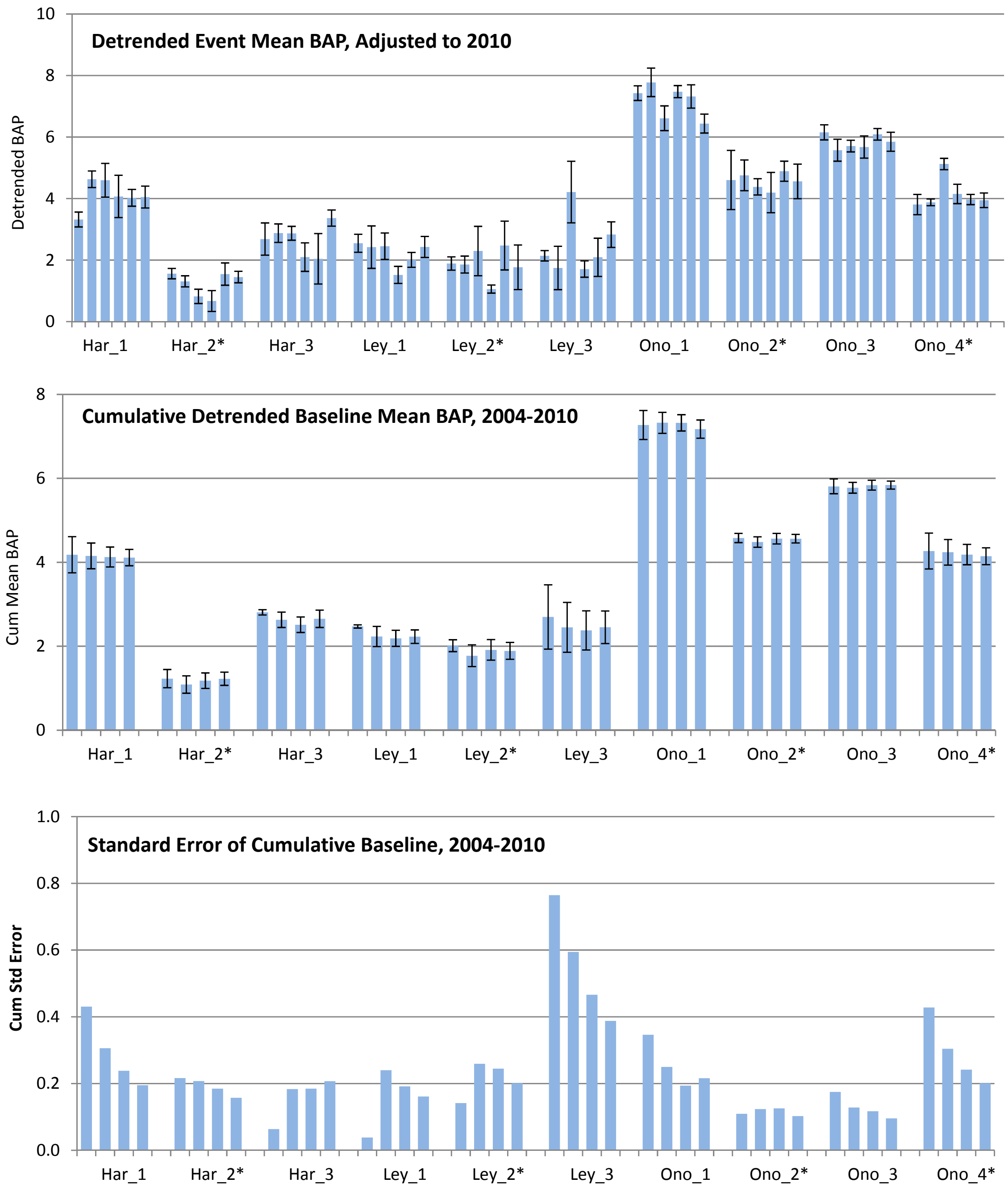


Figure 3 BAP Scores by Sampling Event and Site



* Significant linear trend, $p < 0.12$

Figure 4 Detrended BAP Scores by Sampling Event and Site



* significant yearly trend (p<.1) adjusted to 2010