stac Chesapeake Bay Program's
Scientific and Technical Advisory Committee

Harry R. Hughes Center for
AGRO-ECOLOGY, INC.

Explaining Management Effects On Water Quality Trends

STAC Workshop Outcomes and Next Steps

June 22, 2015
CBP Water Quality Goal Implementation Team Conference Call

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Management Effects On Water Quality Trends

Challenges

What makes this effort so difficult? Complex and interacting factors:

- Natural climatic variability
- Diversity of environmental settings
- Diversity and broad distribution of management actions
- Effects of uncontrolled changes in land use and behavior

Management Effects On Water Quality Trends

Why Have A Workshop?

- **To share the current state of the science** on quantifying and explaining water quality trends among a broader community of watershed and estuarine researchers;

- **To identify promising technical approaches to advance the science** of explaining effects of management actions on water-quality in the watershed and estuary;

- **To promote discussion and generate recommendations** on three primary topics:
  1. Enhancing trend detection methods;

  2. Developing an integrated approach to explain trends in both tidal and non-tidal waters of the watershed;

  3. Identifying information that is needed to better explain trends.

Organizations Represented

About 20 different organizations:

- Baltimore County Department of Environmental Protection and Sustainability
- Maryland Department of the Environment
- Maryland Department of Natural Resources
- Virginia Department of Environmental Quality
- West Virginia Department of Environmental Protection
- Metropolitan Washington Council of Governments (double-check)
- Bay Journal
- Johns Hopkins University
- University of Maryland Baltimore County
- University of Maryland Center for Environmental Science (UMCES) Appalachian Laboratory
- UMCES Chesapeake Biological Laboratory
- University of Maryland Wye Center
- University of Michigan
- Virginia Commonwealth University
- Virginia Institute of Marine Sciences
- Virginia Tech
- Smithsonian Environmental Research Center
- EPA
- USDA Agricultural Research Service
- USGS

Management Effects On Water Quality Trends

Breakout Discussions

Trend Detection

- Are existing methods adequate to characterize trends in water quality?
- Are there additional trend detection methods or variables that should be considered?
- What near-term and long-term enhancements should be developed to better characterize water quality trends?

Information Needed to Better Explain Trends

- What data are currently available on the physical setting in the Chesapeake Bay and watershed to enhance trend explanation?
- What new research and information (data collection) is needed about physical settings to better explain trends?
- What new or improved research and information (data collection) is needed on changes in pollutant sources and associated management practices data?

Integrated Approaches For *Explaining* Trends

- What are the most promising descriptive and quantitative approaches available for developing an integrated explanation of trends in the estuary and watershed?
- At what scale(s) can these approaches be applied (i.e. entire Bay/watershed; major river systems; smaller sites)?

Findings and Recommendations for Trend Detection

Finding 1:

- The Weighted Regressions on Time, Discharge, and Season (WRTDS) method is appropriate for estimating medium- to long-term trends (i.e., greater than 5 years) in N, P, and sediment loads at a majority of the non-tidal sites in the Chesapeake Bay watershed.

Recommendation 1:

- The CBP should prioritize work that adds the ability to estimate uncertainty to the WRTDS method.

Finding 2:

- Methods (such as General Additive Models, or GAMs) for detecting and describing trends in estuarine waters require further development. The inability to automate interpretation of GAM results currently limits its utility.

Recommendation 2:

- The CBP should continue to develop and apply GAMs to the appropriate response variables in tidal waters, and should develop a process of ‘artificial intelligence’ that enables automated application of GAMs.

Management Effects On Water Quality Trends

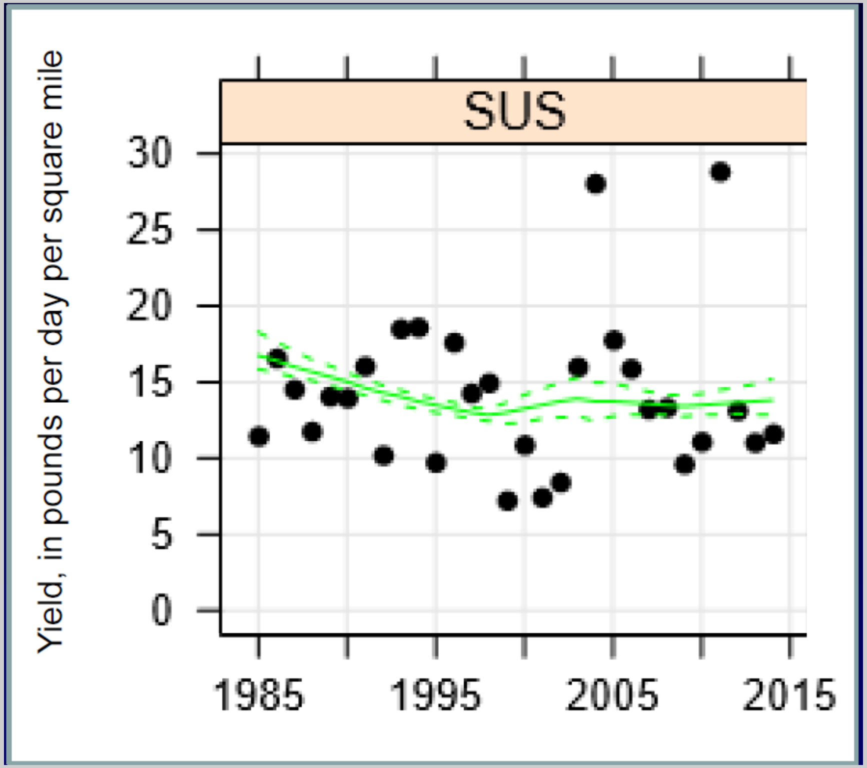
Activities Supporting Trend Detection

Recommendation 1:

- The CBP should prioritize work that adds the ability to estimate uncertainty to the WRTDS method.

Relevant supporting activities:

- STAC member Robert Hirsch and colleagues have developed an uncertainty estimation method for WRTDS and have submitted a journal article describing the method and recommending management applications.
- In anticipation, the CBP has begun to discuss the application of this capability.
- Additionally, the CBP Office (CBPO) has made computing resources available to the U.S. Geological Survey (USGS) to facilitate the extensive calculations involved in uncertainty estimation.



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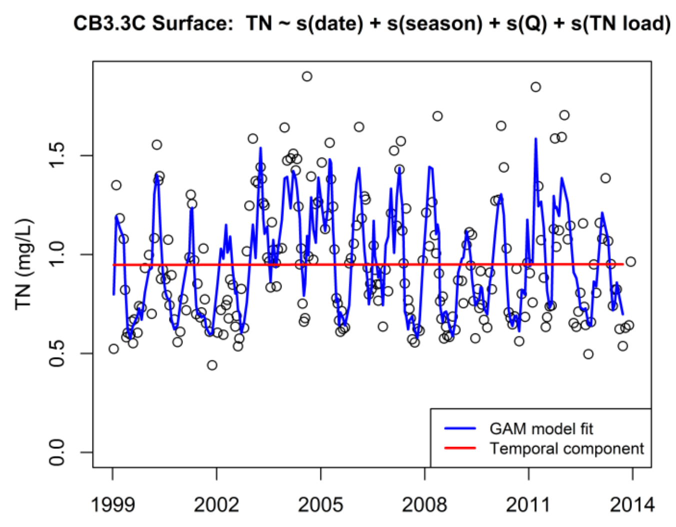
Activities Supporting Trend Detection

Recommendation 2:

- The CBP should continue to develop and apply GAMs to the appropriate response variables in tidal waters, and should develop a process of ‘artificial intelligence’ that enables automated application of GAMs.

Relevant supporting activities:

- The CBPO is devoting significant resources to further the development of GAMs for analysis of water quality trends in tidal waters of Chesapeake Bay, led by Rebecca Murphy (UMCES-CBPO) and Jeni Keisman (USGS) in collaboration with MD DNR and VA DEQ, and supported by additional CBPO staff



- In 2015, the CBPO is providing additional statistical consulting and statistical programming resources to enable the implementation of GAMs by MDDNR and VADEQ technical staff for their standard annual trends analyses.

Findings for Information Needs

Finding 1:

- Incomplete and/or inaccurate reporting of BMPs continues to constrain the partnership's ability to quantify BMP impacts .
- Some practices are not well tracked.
- Reporting of some practices is suspect; lacks necessary geographic resolution.
- Assumptions and decision rules that must be applied in order to process BMP datasets constrain its interpretability.

Finding 2:

- Understanding BMP effectiveness requires more edge-of-field, farm-scale flow and concentration data, including a more complete inventory of all pollutant sources (such as livestock populations) and encompassing a greater number and variety of watersheds.

Finding 3:

- Additional continuous monitoring of water quality parameters would reduce uncertainty and improve assessment of trends in water quality*.
- In non-tidal waters, continuous monitoring of P and sediment loads may be more valuable than that of N.

* Participants recognized that the Chesapeake Bay and watershed dataset is among the most robust in the world

Recommendations for Information Needs

Recommendation 1:
- The CBP should continue to improve reporting and tracking of BMPs
- The CBPO should work with partners to ensure that assumptions and decision rules applied to BMP data are effectively communicated to the recipients of these datasets

Recommendation 2:
- The CBP should prioritize more comprehensive and improved monitoring of BMP effectiveness.
- This includes assessing BMP effectiveness over time, both with and without proper operation as well as required periodic maintenance.

Recommendation 3:
- The CBP partnership should implement continuous monitoring for locations, times, and constituents that maximize utility for improving assessment of effectiveness of management actions.

* Participants recognized that the Chesapeake Bay and watershed dataset is among the most robust in the world

Management Effects On Water Quality Trends

Recommendations for Information Needs

Recommendation 1:

- The CBP should continue to improve reporting and tracking of BMPs.

- The CBPO should work with partners to ensure that assumptions and decision rules applied to BMP data are effectively communicated to the recipients of these datasets.

Relevant supporting activities:

- The CBP partnership understands that this issue is priority for both the management and scientific community.

- STAC has appropriately raised this issue on several occasions and this continued involvement has been helpful in motivating activity in this area.

- A full response to this question was given in the management board response to STAC's workshop report on lag times. The management board response can be accessed at the following link:

http://www.chesapeake.org/stac/presentations/214_MB%20Response%20to%20STAC%20Workshop%20Report%20Incorporating%20Lag-Times%20into%20the%20Chesapeake%20Bay%20Program.pdf

Recommendations for Information Needs

Recommendation 2:

- The CBP should prioritize more comprehensive and improved monitoring of BMP effectiveness.

- This includes assessing BMP effectiveness over time, both with and without proper operation as well as required periodic maintenance.

Relevant supporting activities:

- The CBP has recently devoted substantial resources to institute a basin-wide BMP verification framework program across all source sectors and jurisdictions to reduce multiple counting of BMPs in reporting; clean historical BMP databases used in CBP modeling tools; better account for the useful life of BMPs; track and report more specific information for each restoration project; assess degrees of meeting design standards; and evaluate and update Quality Assurance Project Plans for each agency submitting environmental data to EPA.

- A wealth of information regarding this effort to verify both the existence and functionality of BMPs on the ground and reported for model purposes can be found under “Projects and Resources” under the CBP BMP Verification Committee site:

http://www.chesapeakebay.net/groups/group/best_management_practices_bmp_verification_committee

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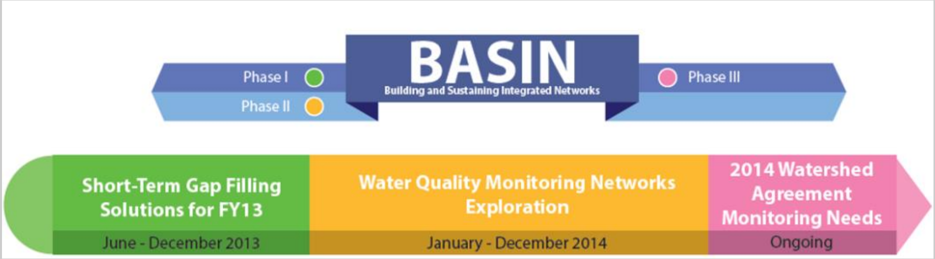
Recommendations for Information Needs

Recommendation 3:

- The CBP partnership should implement continuous monitoring for locations, times, and constituents that maximize utility for improving assessment of effectiveness of management actions.

Relevant supporting activities:

- As part of the Building And Sustaining Integrated Networks (BASIN) Phase II initiative, the CBP and STAC are engaged in an ongoing effort to identify and implement optimal monitoring strategies for the Chesapeake Bay watershed and estuary.


BASIN
Building and Sustaining Integrated Networks
Phase I
Phase II
Phase III
Short-Term Gap Filling Solutions for FY13
June - December 2013
Water Quality Monitoring Networks Exploration
January - December 2014
2014 Watershed Agreement Monitoring Needs
Ongoing

- The “Building Environmental Intelligence” (BEI) component of BASINS II is directly assessing opportunities for continuous monitoring the Chesapeake Bay watershed and estuary.

- Continuous monitoring can improve load estimates of some nutrients and sediment to the Bay and should be considered for the major rivers entering into the Bay (such as the Susquehanna, Potomac and James or all of the RIM stations).

- Learn more about BASIN II here: http://www.chesapeakebay.net/groups/group/building_and_sustaining_integrated_networks_basin

Management Effects On Water Quality Trends

Findings for Explaining Trends

Finding:

Explaining trends in small watersheds:

- Often more feasible because of the limited numbers of influencing factors and pollutant transport processes relative to larger watersheds. Also addresses citizens' concerns regarding local water quality.

Explaining trends in large watersheds/regionally:

- Assesses the collective benefit of many different types of practices on downstream water quality.

Linking findings at small and large scales:

- Efforts to link management actions with trends in water quality at the scale of small watersheds must incorporate and be complemented by studies that aim to discern trends and their drivers at regional and basin-wide scales

- Isolating the effects of management actions on water quality in the watershed and estuary within and across both spatial and temporal scales will require novel approaches and the application of new analytical techniques.

- A number of techniques hold promise for application at a range of scales and for integrating across scales

Management Effects On Water Quality Trends

Recommendations for Explaining Trends

Recommendation:

- The CBP should engage in a concerted effort to energize the academic and federal research communities to conduct collaborative studies using the most capable and feasible techniques from among those suggested in this report.

- Multiple tools and approaches were suggested both for small watershed studies and regional analysis. These approaches need to be evaluated and the most promising techniques applied to explain observed water quality changes.

Relevant supporting activities:

- A new CBP STAR team – the Integrated Trends Analysis Team (ITAT) – has been formed to serve as a forum for researchers to discuss results of their ongoing and recent activities

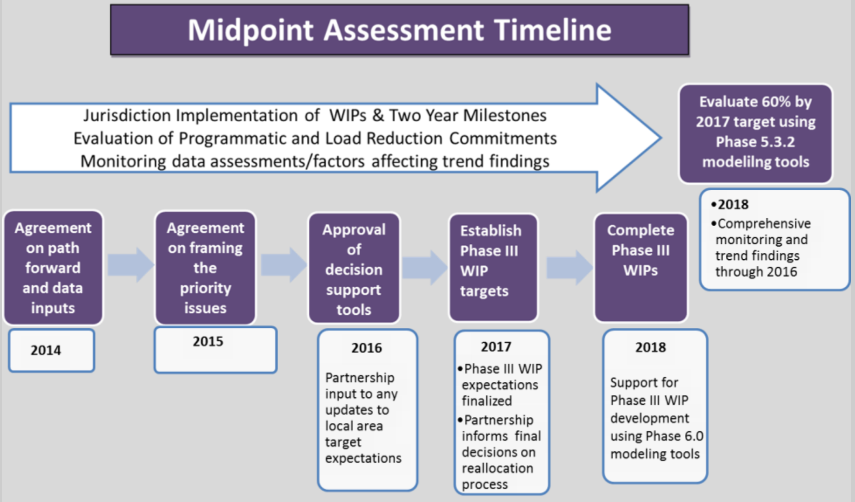
- The CBP has committed to provide support for a small number of focused synthesis efforts to be completed between now and March, 2017.

- Requests for funding of synthesis efforts will be open to ITAT participants and researchers who have demonstrated a commitment both to explaining trends in water quality in the Chesapeake Bay watershed and estuary, and to the application of their research to inform management strategies in the region.

Management Effects On Water Quality Trends

Next Steps: Through 2017

What can we accomplish between now and the 2017 TMDL Mid-Point Assessment?



Midpoint Assessment Timeline

Jurisdiction Implementation of WIPs & Two Year Milestones
Evaluation of Programmatic and Load Reduction Commitments
Monitoring data assessments/factors affecting trend findings

Evaluate 60% by 2017 target using Phase 5.3.2 modeling tools

- 2018
- Comprehensive monitoring and trend findings through 2016

Agreement on path forward and data inputs
2014

Agreement on framing the priority issues
2015

Approval of decision support tools
2016
Partnership input to any updates to local area target expectations

Establish Phase III WIP targets
2017
- Phase III WIP expectations finalized
- Partnership informs final decisions on reallocation process

Complete Phase III WIPs
2018
Support for Phase III WIP development using Phase 6.0 modeling tools

- Further develop and apply WRTDS and GAM techniques to quantify trends in fluxes from the watershed and responses in the estuary

- Report results of trend detection analyses, including estimates of uncertainty, for analyses conducted with both the WRTDS and GAM approaches.

- Identify sub-watersheds where sufficient reporting of BMPs, existing knowledge of land use changes, and a robust time series of water-quality monitoring can support an immediate effort to apply one or more of the recommended analytical approaches for explaining the drivers of observed trends in water quality.

- Conduct targeted SPARROW modeling activities to help inform development of the Phase 6 CBWM.

- Identify projects already under way that can provide findings in time to inform the MPA and Phase III WIPs.

Next Steps: Beyond 2017

Longer-Term Enhancements for Explaining Trends through 2025 and beyond

- Improve quality of, and access to, BMP data need to help explain trends.
- Implement more continuous monitoring of nutrients and sediment to improve the capacity to detect and explain trends in water quality
- Determine support for collection of additional parameters (such as groundwater source tracers) critical to linking landscape characteristics to water quality
- Continue to develop and apply the most promising of the statistical techniques recommended here to better distinguish effects of BMPs in river basins and downstream estuary waters.

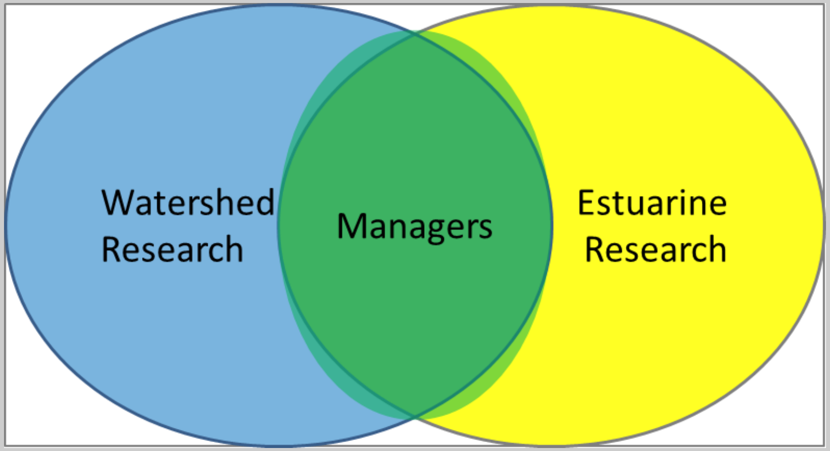
Management Effects On Water Quality Trends

Science For Decision Support

Enhance Collaboration → Enhance Integration → Enhance Relevance

Watershed Science Questions

- What do our WRTDS analyses tell us about long-term and recent changes in nutrient and sediment loads from the watershed?
- How can we use these new insights to determine role of management actions on observed changes?



Estuarine Science Questions

- What do our new GAMs results tell us about changes in estuarine water quality?
- How do management actions/changes in nutrient loads affect estuarine water quality and ecosystem health?

Managers' Questions

How do we use what you've learned to adjust our strategies and increase the impact of our investments in improving the water quality and ecosystem health of the Bay?

Management Effects On Water Quality Trends

Science For Decision Support

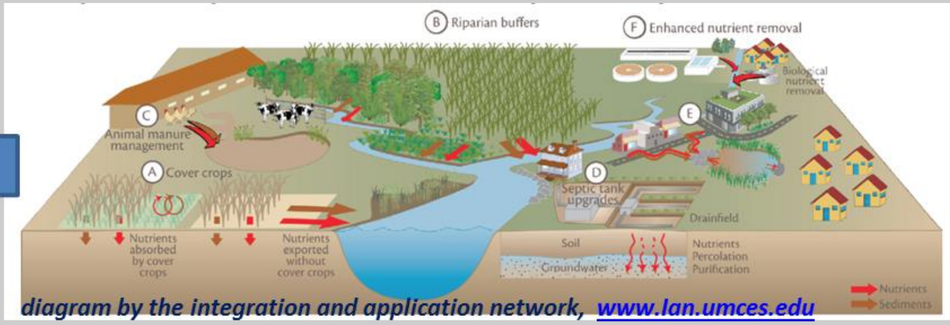
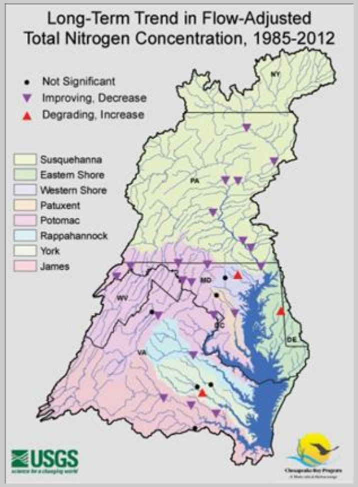

B Riparian buffers
F Enhanced nutrient removal
Biological nutrient removal
C
Animal manure management
E
A Cover crops
D
Septic tank upgrades
Drainfield
Nutrients absorbed by cover crops
Nutrients exported without cover crops
Soil
Groundwater
Nutrients Percolation Purification
Nutrients
Sediments

diagram by the integration and application network, [www.Ian.umces.edu](http://www.ian.umces.edu)

Implement water quality management practices

Monitor



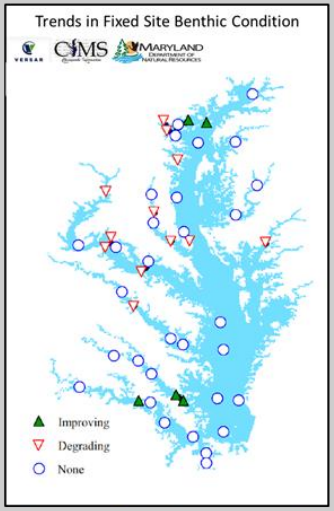
Long-Term Trend in Flow-Adjusted Total Nitrogen Concentration, 1985-2012

● Not Significant
▼ Improving, Decrease
▲ Degrading, Increase
Susquehanna
Eastern Shore
Western Shore
Patuxent
Potomac
Rappahannock
York
James
NY
PA
MD
WV
VA
DC
DE
USGS

Quantify trends of N, P, and sediment in the watershed

Explain Change

Enhance Models



Trends in Fixed Site Benthic Condition

VERSAR
CBMS
MARYLAND DEPARTMENT OF NATURAL RESOURCES
▲ Improving
▽ Degrading
○ None

Quantify changes in estuarine water quality

Inform Strategies

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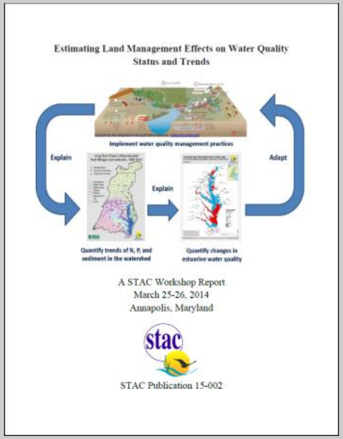
Thank You



Estimating Land Management Effects on Water Quality
Status and Trends

Implement water quality management practices
Explain
Adapt
Explain
Quantify trends of N, P, and sediment in the watershed
Quantify changes in estuarine water quality

A STAC Workshop Report
March 25-26, 2014
Annapolis, Maryland

STAC Publication 15-002

Questions?

The full MEOWQT report can be accessed at:

http://www.chesapeake.org/pubs/336_Keisman2015.pdf

Report Citation:

Keisman, J., J. Blomquist, S. Phillips, G. Shenk, E. Yagow. Estimating land management effects on water quality status and trends. Proceedings of the March 25-26, 2014 workshop. STAC Publication Number 15-002, Edgewater, MD. 33 pp.

Learn more about the CBP Integrated Trends Analysis Team (ITAT) here:

http://www.chesapeakebay.net/groups/group/integrated_trends_analysis_team