

**Science Advisory Board (SAB) Draft Report (February 10, 2015)
for Quality Review-- Do Not Cite or Quote –**

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4 EPA-SAB-15-xxx

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6 The Honorable Gina McCarthy
7 Administrator
8 U.S. Environmental Protection Agency
9 1200 Pennsylvania Avenue, N.W.
10 Washington, D.C. 20460

11
12 Subject: Early Advice on an Ensemble Modeling Approach for Developing Lake Erie
13 Phosphorus Objectives

14
15 Dear Administrator McCarthy:

16
17 The U.S. Environmental Protection Agency's Region 5 requested a consultation with the Science
18 Advisory Board (SAB) regarding the development of preliminary phosphorus objectives, loading targets
19 and allocations for Lake Erie. These binational phosphorus objectives are being updated to achieve the
20 nutrient objectives for Lake Erie, pursuant to the Annex 4 of the 2012 Great Lakes Water Quality
21 Agreement (GLWQA). The SAB reviewed the methodology presented in EPA's Draft *Technical*
22 *Approach for Lake Erie Phosphorus Load-Response Modeling* (2014) to provide early advice on the
23 agency's approach. The document describes the framework that the EPA will use to model indicators of
24 eutrophication, the ensemble of models relevant to Lake Erie, and the available data to develop, calibrate
25 and validate the models.

26
27 The SAB was asked to comment on the eutrophication response indicators, the models chosen to
28 evaluate the eutrophication response in Lake Erie, the ensemble modeling approach and the efficacy of
29 setting phosphorus loads and concentration targets. The charge questions are attached. The SAB Lake
30 Erie Phosphorus Objectives Review Panel met in Chicago on December 10, 2014, to receive briefings
31 from EPA Region 5 staff, presentations by invited technical experts from Canada, and comments from
32 the public. Brief responses to the charge questions are provided below.

33
34 ***Eutrophication Response Indicators***

35 The SAB was asked whether the proposed eutrophication response indicators provide a scientific
36 foundation for the Lake Erie Ecosystem Objectives. The EPA identified four eutrophication indicators
37 and selected models that will provide an ensemble of results to compare the indicators and phosphorus
38 levels in Lake Erie. The four indicators are:

- 39
- 40 • phytoplankton as represented by chlorophyll-*a*,
 - 41 • cyanobacteria blooms in the western basin of Lake Erie,
 - 42 • hypoxia in the central basin of the lake, and
 - 43 • phosphorus content stored in *Cladophora*

44 Phytoplankton as represented by chlorophyll-*a*, cyanobacteria blooms in the western basin of Lake Erie,
45 and hypoxia in the central basin of the lake are reasonable indicator choices, have a foundation in the
46 available science concerning Lake Erie nutrient dynamics, and can be estimated from the models. In

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1 contrast, the SAB found that there may not be a sufficient history of reliable data collection to develop
2 models based on the phosphorus content of *Cladophora*.

3
4 The traditional indicators of eutrophication (focusing on phosphorus concentrations, total phytoplankton
5 biomass and chlorophyll-*a*) should be supplemented by monitoring changes in the composition of the
6 biological communities in the ecosystem. The agency should also be mindful that factors such as
7 nutritional status and physical environment can add uncertainty to predictions for chlorophyll-*a* to
8 predict cyanobacterial biomass.

9
10 There is evidence that the total phosphorus loading in Lake Erie has not changed markedly during the
11 past couple of decades, but the response of the lake's biology has changed in ways that are undesirable
12 (e.g., toxic blooms and hypoxia), poorly understood and difficult to predict. Specifically, the biological
13 communities in the lake have changed and thus altered the patterns, rates, and amounts of phosphorus
14 cycling internally in the ecosystem, including its regeneration from sediments. For example, the agency
15 should consider the rapid recycling of phosphorus between the bacterial and phytoplankton communities
16 and release from sediments. The regional climate is changing and the temperature of the lake waters,
17 degree of stratification, and length of the ice-free season have increased. Also, there appears to be an
18 increase in the fraction of total phosphorus that is dissolved and therefore more bioavailable. Thus, the
19 traditional dose-response assumptions of models, based solely on total phosphorus, may be insufficient
20 to develop the phosphorus objectives.

21
22 ***Selection of Models and the Ensemble Modeling Approach***

23 The SAB was asked whether the models chosen to evaluate the eutrophication response in Lake Erie are
24 appropriate and reflect the best available science. The SAB finds that ecosystem simulation models and
25 an ensemble modeling approach are appropriate and powerful tools to address the problem of
26 phosphorus pollution in Lake Erie and to make predictions for the future state of the Lake Erie
27 ecosystem. However, some of the models chosen for the ensemble assume that the productivity of Lake
28 Erie is limited solely by phosphorus. The direct relation of phosphorus concentration in lake waters to
29 the productivity of phytoplankton is still robust but other factors in addition to phosphorus (i.e., possible
30 co-limitation by nitrogen) may need to be considered to minimize hypoxia and algal blooms. Increased
31 loading of nitrogen has shifted the available nitrogen in lake water, the nitrogen-to-phosphorus ratio, and
32 the nutrient uptake from the changing composition of the biota.

33
34 Although the ensemble approach is reasonable, there are questions about how the models will be
35 combined. Providing more detail on this topic should be a priority for the EPA. Also, there are questions
36 about the efficacy of the specific models included in the ensemble, some of which do not include much
37 of the lake's biology. The SAB notes that recent published literature in ecology speaks of major
38 changes in the biology of ecosystems as representing a "regime shift"; it is possible that Lake Erie has
39 undergone a major regime shift that may be addressed in the process models but is not captured in the
40 empirical or statistical models.

41
42 The SAB notes that the current response indicators are relatively simple and easy to measure. The
43 agency will need to determine if they are sufficient to address the eutrophication problems of Lake Erie.
44 The draft *Technical Approach* did not provide sufficient detail to assess how the agency will evaluate
45 the similarities and differences among the models to develop preliminary phosphorus loadings to Lake
46 Erie. The SAB notes that there are methods to conduct uncertainty and sensitivity analyses individually

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1 and across the models, yet at this stage, there was insufficient information available to the SAB to
2 provide specific recommendations about the efficacy of individual models.

3
4 ***Developing Preliminary Phosphorus Loads and Concentration Targets***

5 The SAB was asked whether the models included in the ensemble, used singly or in combination,
6 provided a scientifically grounded basis for the required update of phosphorus load targets for Lake Erie.
7 The SAB notes that monitoring the loading of nitrogen and phosphorus to Lake Erie is appropriate to
8 understand the lake's nutrient regime and implement management practices. However, the biology in
9 the lake responds to concentrations, not loadings.

10
11 The EPA and the GLWQA Annex 4 work group will “apply an adaptive management approach in which
12 the phosphorus concentrations and loading targets are revisited periodically” to develop the phosphorus
13 objectives. The SAB agrees that an adaptive management approach is appropriate given the complexity,
14 changing biology and shifts in the physical dynamics of Lake Erie. The SAB encourages the EPA to
15 expand on its plans to implement adaptive management. For example, the 2011 *Lakewide Action and*
16 *Management Plan for Lake Erie* includes a plan to revisit and revise on an annual basis. The EPA
17 should include more detail on the monitoring, data, and analyses needed to implement an adaptive
18 management strategy for the phosphorus objectives.

19
20 The SAB appreciates the opportunity to provide the EPA with early advice on the modeling approach
21 for developing phosphorus targets for Lake Erie and looks forward to the agency's response. More
22 detailed comments from individual panel members are available on the [SAB website](#).

23
24 The SAB anticipates a subsequent review of the preliminary phosphorus targets to provide advice on (1)
25 whether the process used to develop the targets was appropriate to meet the nutrient Lake Ecosystem
26 Objectives as defined in the GLWQA and (2) whether the recommended targets are derived from the
27 best available information on the phosphorus sources and trophic status of Lake Erie.

28
29 Sincerely,

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34 Dr. Peter S. Thorne
35 Chair
36 Science Advisory Board

Dr. William H. Schlesinger
Chair
SAB Lake Erie Phosphorus Objectives Review
Panel

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39 Enclosures

- 40
41 (1) Roster of Lake Erie Phosphorus Objectives Review Panel Members
42 (2) Roster of SAB Members
43 (3) Charge to the SAB for the Consultation of Lake Erie Phosphorus Objectives

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This report has been written as part of the activities of the EPA Science Advisory Board (SAB), a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The SAB is structured to provide balanced, expert assessment of scientific matters related to problems facing the agency. This report has not been reviewed for approval by the agency and, hence, the contents of this report do not represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the federal government, nor does mention of trade names of commercial products constitute a recommendation for use. Reports of the SAB are posted on the EPA website at <http://www.epa.gov/sab>.

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**U.S. Environmental Protection Agency
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Lake Erie Phosphorus Objectives Review Panel**

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**Charge to the Science Advisory Board for the Consultation of
Lake Erie Phosphorus Objectives
Prepared by the EPA Region 5 Water Division
November 4, 2014**

Background

The U.S. Environmental Protection Agency (EPA) Region 5 is co-leading a binational workgroup to develop and implement the Nutrients Annex (“Annex 4”) of the 2012 Great Lakes Water Quality Agreement (GLWQA) in accordance with Article 3(b) of the GLWQA. Under Annex 4, the U.S. and Canada (herein referred to as “the Parties”) are charged with establishing binational Substance Objectives for phosphorus concentrations, loading targets and allocations for the nearshore and offshore waters of Lake Erie by February 2016. While the Annex applies to all Great Lakes, only Lake Erie has time-bounded commitments, reflecting the Parties’ commitment and understanding of the need for prompt action to combat the algae issue there.

Lake Ecosystem Objectives

Pursuant to Article 3(1)(b)(i), the Parties adopted the following Lake Ecosystem Objectives related to nutrients for Lake Erie:

1. minimize the extent of hypoxic zones associated with excessive phosphorus loading,
2. maintain the levels of algal biomass below the level constituting a nuisance condition;
3. maintain algal species consistent with healthy aquatic ecosystems in the nearshore;
4. maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health; and
5. maintain mesotrophic conditions in the open waters of the western and central basins of Lake Erie, and oligotrophic conditions in the eastern basin of Lake Erie.

The Annex 4 workgroup has adopted the following general approach for establishing new/revised Substance Objectives and loading targets for Lake Erie:

- 1) establish eutrophication response indicators and metrics related to the nutrient Lake Ecosystem Objectives (LEOs);
- 2) use multiple models to compute appropriate load-response relationships and attribute these to the eutrophication response indicators of concern;
- 3) synthesize and interpret the results of the ensemble of models to derive phosphorus concentrations and loading targets needed to meet the nutrient LEOs, taking into account the bioavailability of various forms of phosphorous, related productivity, seasonality, fisheries productivity requirements, climate change, invasive species and other factors, such as downstream impacts, as necessary;
- 4) apply an adaptive management approach in which the phosphorus concentrations and loading targets are revisited periodically.

Due to the complexity of the issue and the need to rely on existing information in the short term, we anticipate refinements in response to peer review and stakeholder feedback. Ongoing monitoring and evaluation will be critical as we track the changes in phosphorus concentrations and loads, in addition to other drivers like hydrology and climate, and the ecological response.

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Additional Resources: The EPA identified several reports as supplementary material on the efforts taken in the Lake Erie basin to better understand the background and context of this work. These three reports provide additional background information on the efforts to understand and manage excess nutrients in Lake Erie and the preliminary work on approaches to develop phosphorus objectives:

- [Lake Erie Binational Nutrient Management Strategy: Protecting Lake Erie by Managing Phosphorus.](#) Prepared by the Lake Erie LaMP Work Group, 2011.
- [Status of Nutrients in Lake Erie Basin.](#) Prepared by the Lake Erie LaMP Work Group, 2009.
- [An Approach for Determination of Phosphorus Objectives and Target Loads for Lake Erie.](#) Discussion paper prepared by LimnoTech for Environment Canada, May 2013.

Charge to SAB:

The EPA requests the Science Advisory Board (SAB) provide early advice on the approach (Phase I consultation) and subsequent review (Phase II Peer Review) of preliminary binational phosphorus objectives, loading targets and allocations for the nearshore and offshore waters to achieve the Lake Ecosystem Objectives related to nutrients for Lake Erie, pursuant to the Annex 4 of the 2012 GLWQA.

The objective of the SAB consultation is to obtain early advice on the modeling approach being applied to inform the updated phosphorus targets for Lake Erie. The purpose of the subsequent review of the preliminary phosphorus targets will be to obtain advice on (1) whether the process used to develop the targets was appropriate to meet the nutrient Lake Ecosystem Objectives as defined in the GLWQA and (2) whether the recommended targets reflect the best available information on the phosphorus sources and trophic status of Lake Erie. EPA and Environment Canada are particularly interested in advice pertaining to future applicability of this work as we develop a phosphorus reduction strategy for Lake Erie and begin evaluating phosphorus targets for other Great Lakes.

Document for Review: The SAB will review the methodology presented in EPA's *Draft Technical Approach for Lake Erie Phosphorus Load-Response Modeling*. The document describes the framework approach the EPA will use to model eutrophication response indicators, the ensemble of models relevant to Lake Erie, and the available data to develop, calibrate, and validate the models.

Phase 1 Consultation Questions:

1. Please comment on whether the eutrophication response indicators proposed sufficiently address and provide the scientific foundation for the Lake Ecosystem Objectives for Lake Erie. During your evaluation of the eutrophication response indicators, identify other metrics appropriate for measuring eutrophication response in Lake Erie and other Great

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Lakes that should be considered, and whether there is a method (model) available to measure this response.

2. Please comment on each of the models chosen to evaluate the eutrophication response in Lake Erie? Are the models appropriate for representing the eutrophication response indicators? Do the models reflect the best available scientific knowledge?
3. Please comment on the appropriateness of the ensemble modeling approach to examine the suite of eutrophication response indicators. Are the models included in the ensemble, when used either singly or combined, sufficient to provide a scientifically grounded basis for the required update of phosphorus load targets for Lake Erie?

An anticipated outcome of the modeling exercise is to better understand and quantify what types of conditions would be expected in the lake based upon different levels of phosphorus loading, and to use that information to inform selection of phosphorus loading targets needed to meet the nutrient Lake Ecosystem Objectives. The phosphorus loading targets could be converted to concentration targets, particularly for river mouths/nearshore zones. Please comment on efficacy and value of establishing target values for both phosphorus loads and concentrations in order to meet to the Lake Ecosystem Objectives. How can we ensure the phosphorus concentration and loading targets are internally consistent with respect to the eutrophication response indicators of concern?