Summary Minutes of the
U.S. Environmental Protection Agency Science Advisory Board
Lake Erie Phosphorus Objectives Review Panel
Public Meeting
June 21-22, 2016

Date and Time: Tuesday, June 21, 2016, 9:00 a.m. – 5:00 p.m.
Wednesday, June 22, 2016, 8:30 a.m. – 2:00 p.m.

Location: Palmer House Hilton Hotel, 17 East Monroe Street, Chicago, IL 60603

Purpose: To provide advice on development of phosphorus loading targets for Lake Erie.

Participants:

Members of the EPA Science Advisory Board (SAB) Lake Erie Phosphorus Objectives Review Panel (Panel roster is provided in attachment A)

Dr. William Schlesinger
Dr. Merryl Alber
Dr. James Ammerman
Dr. Steven Bartell
Dr. Hunter Carrick
Dr. Celia Chen
Dr. John Connolly
Dr. Richard Di Giulio
Dr. Robert Diaz
Dr. Douglas Endicott
Dr. James Fitzpatrick
Dr. Robert Heath
Dr. Lucinda Johnson
Dr. J. Val Klump
Dr. Douglas McLaughlin
Dr. Ramesh Reddy
Dr. Emma Rosi-Marshall
Dr. Eric Smith
Dr. William Stubblefield

EPA Science Advisory Board (SAB) Staff:

Dr. Thomas Armitage, Designated Federal Officer
Mr. Christopher Zarba, Director SAB Staff Office

EPA Representatives:

Ms. Tinka Hyde, EPA Region 5 Water Division
Dr. Russell Kreis, Jr., EPA Office of Research and Development
Ms. Santina Wortman, EPA Region 5 Water Division

Invited Experts:

Dr. Dr. Jan J.H. Ciborowski, University of Windsor
Dr. Joseph DePinto, LimnoTech
Dr. Jeffrey Reutter, Ohio State University
Dr. Craig Stow, National Oceanic and Atmospheric Administration

Other Attendees (either present at the meeting or listening via audio webcast):

Raj Bejankiwar, International Joint Commission
Jean Chuscicki, EPA Region 5
Abby DeBofsky, EPA Great Lakes National Program Office
Elizabeth Hinchey Malloy, EPA Great Lakes National Program Office
Olga Lyandres, Alliance for the Great Lakes
Peter Regan, EPA Region 5
Alex Shaunae, U.S. EPA Great Lakes National Program Office

Meeting Summary:

Tuesday, June 21, 2016

Convene the Meeting

Dr. Thomas Armitage Designated Federal Officer (DFO) for the SAB Panel, convened the meeting at 9:00 a.m. on Tuesday, June 21, 2016. He stated that the Lake Erie Phosphorus Objectives Review Panel operated as part of the EPA Science Advisory Board which is a chartered Federal Advisory Committee under the Federal Advisory Committee Act (FACA) and is empowered by law to provide advice to the EPA Administrator. He stated that summary minutes of the meeting would be prepared and certified by the Chair. He noted the Panel's compliance with ethics requirements. Dr. Armitage indicated that meeting materials were available on the SAB web site. These meeting materials included: the Federal Register Notice announcing the meeting,[1] meeting agenda,[2] and Panel roster.[3] He noted that time had been included on the agenda to hear oral public comments but no requests to speak had been received.

Mr. Christopher Zarba, Director of the SAB Staff office welcomed the members of the Panel, EPA staff, and members of the public to the meeting. He noted the importance of the advisory topic addressed by the Panel and the depth of expertise on the Panel. Mr. Zarba encouraged members to have thoughtful open-minded discussion of responses to EPA's charge questions as they developed a consensus report of findings and recommendations.

Review of Agenda and Purpose of the Meeting

Dr. William Schlesinger, Chair of the SAB Panel, welcomed members of the Panel and other attendees to the meeting. He indicated that the Panel would be meeting for two days to review the modeling results that informed the development of binational phosphorus reduction targets for Lake Erie. He also indicated that the Panel had been asked to provide advice on future work to support implementation and evaluation of nutrient reduction goals for Lake Erie. He noted that the Panel had been charged with reviewing two documents and responding to EPA's specific charge questions. The two review documents were: (1) a report prepared by the Great Lakes Water Quality Agreement Nutrient Annex 4

Objectives and Targets Task Team modeling subgroup titled *Annex 4 Ensemble Modeling Report,*[4] and (2) a report prepared by the Great Lakes Water Quality Agreement Nutrient Annex 4 Objectives and Targets Task Team titled *Recommended Phosphorus Loading Targets for Lake Erie*.[5]

Dr. Schlesinger noted that a number of invited experts were attending the meeting in addition to Panel members and EPA staff. He indicated that the invited experts were not serving as Panel members but would make presentations, answer questions, and provide information to the Panel during the deliberations. He noted that the invited experts had been involved in Lake Erie nutrient modeling work and the development of phosphorus loading targets.

Dr. Schlesinger asked members of the Panel and the invited experts introduce themselves and state their affiliations. He then reviewed the purpose of the meeting and the agenda. He indicated that the Panel had been given six charge questions and that time had been provided on the agenda to review the questions. He indicated that the goal of the meeting was to begin developing a report of findings and recommendations in response to the charge questions. He stated that the Panel would first hear remarks from Ms. Tinka Hyde, the Water Division Director in EPA Region 5 and next hear presentations from Dr. Russell Kreis of EPA's Office of Research and Development as well as three of the invited experts. He stated that these presentations would focus on development of recommended phosphorus loading targets for Lake Erie and the multi-model approach to evaluating the target phosphorus loads.

Dr. Schlesinger indicated that following the presentations, the Panel would discuss the charge and hear public comments. He noted that no requests had been received from members of the public to provide oral comments, but one set of written public comments had been received. (Written public comments are included in the meeting materials available on the SAB website – see materials cited.[6]) Dr. Schlesinger indicated that after reviewing the charge, the Panel would discuss responses to the charge questions. He noted that lead discussants for each question would begin the discussion of each question. Dr. Schlesinger also indicated that Panel members had been assigned as lead writers for each charge question and they would keep track of the key points discussed. Dr. Schlesinger further indicated that: (1) on the second day of the meeting the Panel would break into subgroups to discuss the key points in the responses to the charge questions, (2) the Panel as a whole would review these key points, (3) following the meeting the lead writers would work with writing subgroups to develop the written responses to the charge questions, and (4) he would work with the Designated Federal Officer to incorporate the written responses into a draft Panel's report which would be sent to members for review and discussion on a public teleconference.

Remarks from EPA Region 5

Ms. Tinka Hyde, Director of the Water Division in EPA Region 5 made a presentation to the Panel. (Ms. Hyde's presentation slides are included in the meeting materials available on the SAB website -- see materials cited.[7]) Ms. Hyde thanked the Panel members and invited experts for participating in the SAB meeting and reviewed work that had been completed under the Great Lakes Water Quality Agreement Annex 4 to develop phosphorus loading targets for Lake Erie. She discussed next steps for Lake Erie phosphorus reduction targets (including work to address nuisance *Cladophora* growth in the Eastern Basin, the binational phosphorus reduction strategy, domestic action plans, and an adaptive management framework). She then reviewed the charge to the SAB Panel.

Panel members asked several questions. A member asked whether the EPA anticipated any future involvement of the SAB in Great Lakes nutrient issues. Ms. Hyde indicated that there may be some need for additional input. In particular, she noted that there was a need for more information to address the

nuisance *Cladophora* issue. A member noted that the Lake Erie phosphorus reduction targets had already been developed and asked why EPA was now seeking advice from the SAB. Ms. Hyde responded that the agency was looking forward and was particularly interested in hearing about what might have to be done in the future.

Presentations from Invited Experts

Dr. Schlesinger next called for presentations from the invited experts. Dr. Joseph DePinto of Limnotec provided an overview of the modeling process for developing phosphorus load-response curves for Lake Erie. (Dr. DePinto's presentation slides are included in the meeting materials available on the SAB website -- see materials cited.[8]) Dr. DePinto indicated that a multiple modeling approach had been used to establish and confirm target phosphorus loads. (A background paper by Scavia et al describing the multiple modeling approach is included in the meeting materials on the SAB website – see materials cited.[9]) Dr. DePinto indicated that this approach was similar to the process previously used to complete work under Annex 3 of the 1978 Great Lakes Water Quality Agreement. Dr. DePinto indicated that the overall approach was to: (1) establish eutrophication response indicators (ERIs); (2) use multiple models to compute the load-response relationships between metrics of the indicators and the loads leading to values of metrics; (3) set targets for measures of the eutrophication response indicators and identify loads that correspond to indicator thresholds; and (4) use models to identify appropriate tributary and in-lake phosphorus concentration objectives associated with load-response values.

Dr. DePinto described the model selection criteria that had been used. He noted that these criteria included: (1) applicability to the ERI metrics; (2) extent and quality of calibration and confirmation for Lake Erie; (3) extent of model documentation; and (4) level of uncertainty analysis available. He noted that a key challenge was that the models had been used for somewhat different purposes. Dr. DePinto then reviewed the models and ERI metrics that had been used in the analysis and the targets adopted for the Western and Central Basins of Lake Erie.

Panel members asked a number of questions. A member asked Dr. DePinto to comment on the differences in the results obtained from the models. Dr. DePinto noted that the results derived from different models were similar. In commenting on the differences in modeling results, he noted that there were sources of uncertainty. In particular, he indicated that it would be beneficial to account for the build-up of phosphorus in sediments in the Western Basin. He noted that, in this regard, it would be useful to have additional data to adjust the models and implement an adaptive management approach. A member asked about the importance of algae in the surficial sediment layer. Dr. DePinto noted that sediments were a source of *Microcystis* seed. Members discussed the depth of the mixed layer and the need to run models for longer periods of time to address sediment flux. Members further discussed the effect of sediment flux on hypoxia and the how models might be adjusted. Members asked questions about *Cladophora* modeling and Dr. DePinto provided additional information.

Dr. Russell Kreis of EPA provided an overview of available phosphorus loading data for Lake Erie and the state of knowledge of nuisance growth of *Cladophora*. (Dr. Kreis' presentation slides are included in the meeting materials available on the SAB website – see materials cited.[10]) Dr. Kries identified sources of historical phosphorus loading data and discussed ongoing efforts to update the loading data. He also provided information about the Lake Erie *Cladophora* Growth Model and summarized the findings of a recent workshop on the state of knowledge about *Cladophora*. (The executive summary of the workshop is included in the meeting materials available on the SAB website – see materials cited.[11] He noted that workshop participants had identified a number of information needs. These included the need to: (1) couple water quality and *Cladophora* modeling, (2) develop a binational coordinated *Cladophora*

surveillance program, (3) establish sentinel time-series concurrent sampling of multiple constituents over a growing season, and (4) convene a small expert panel to review updated *Cladophora* efforts and results and set targets for mitigation of Lake Erie *Cladophora*.

Dr. Jeff Reutter of the Ohio State University Sea Grant Program presented an overview of the nutrient load reduction targets for Lake Erie developed by the Great Lakes Water Quality Agreement Annex 4 Objectives and Targets Task Team. (Dr. Reutter's presentation slides are included in the meeting materials available on the SAB website – see materials cited.[12]) He indicated that the Task Team had developed science-based goals and recommendations to address harmful algal blooms, hypoxia and nuisance *Cladophora* growth in Lake Erie. He noted that there was uncertainty associated with the nutrient load reduction targets so an adaptive management approach had been recommended. He noted that the harmful algae blooms (HAB) goal was to reduce HABS to levels smaller or equal to those observed in years 2004 and 2012 in nine years out of 10. The hypoxia goal was to reduce phosphorus loading to a point where average hypolimnetic dissolved oxygen would be 2.0 mg/l or higher. Dr. Reutter also discussed the load reduction targets developed to accomplish these goals. He noted that a 40% reduction of Maumee River spring total phosphorus load had been recommended to address HABs and a 40% reduction of annual total phosphorus load from Western Basin and Central Basin tributaries had been recommended to address hypoxia. He noted that nutrient reduction targets had not been established to address nuisance *Cladophora* growth. He further indicated that the base year selected for the nutrient reduction targets was 2008 and that flow weighted mean concentrations of phosphorus had been recommended as the indicator to track progress in tracking nutrient reduction targets. Dr. Reutter also described recommendations developed for monitoring, modeling, research, and reporting to support adaptive management.

Following Dr. Reutter's presentation, SAB Panel members asked a number of questions. A member asked for comments on how domestic action plans would be implemented to achieve nutrient reduction targets. Ms. Hyde of EPA responded that the domestic action plans involved the development of Total Maximum Daily Loads, watershed plans, and implementing activities through federal grants. A Panel member asked why the hypoxia goal of 2 mg/l dissolved oxygen had been established instead of a higher value of 4 mg/l. Dr. Reutter responded that the goal had been established with consideration given to a number of issues including fishery management. A member asked whether lack of data was an impediment to establishing goals and nutrient reduction targets. Dr. Reutter responded that more data would be useful to further understand the amounts of nutrients entering Lake Erie from different sources.

Dr. Craig Stow discussed the importance of implementing an adaptive management program. (Dr. Stow's presentation slides are included in the meeting materials available on the SAB website – see materials cited.[13]) He indicated that adaptive management was a well-established concept with an extensive literature to support decision making under uncertainty. He noted that adaptive management enabled: (1) learning by testing hypotheses that were supported by research and monitoring, and (2) updating management actions with new knowledge. He discussed active versus passive adaptive management. He noted that: (1) passive adaptive management involved choosing management options and monitoring and evaluating results; and (2) active adaptive management involved deliberate structured experimentation, choosing management to push the system, developing testable hypotheses and alternative models, and structuring monitoring and research to test hypotheses and differentiate models. Dr. Stow indicated that implementing adaptive management required a defined problem, authorization to address the problem, an institutional framework to support collaboration, defined objectives, a work plan and reporting cycle, performance measures, stakeholder involvement, resources,

and political will. With regard to management of nutrients in Lake Erie, he noted that these elements were present or under development.

Review of the Charge Questions

The Panel reviewed the charge questions. (The charge questions are included in the meeting materials available on the SAB website – see materials cited.[14]) Dr. Schlesinger briefly described the topics addressed by the charge questions. He noted that EPA had given the Panel six questions listed under four topics. The topics were: (1) Approach for developing Lake Erie phosphorus load reduction targets (two questions), (2) *Cladophora* growth (one question), (3) Nitrogen control (one question), and (4) Evaluation of Nutrient Reduction Targets (two questions). Dr. Schlesinger asked Panel members whether any of the charge questions needed clarification and whether any aspects of the charge questions needed further discussion.

Members discussed a number of issues. A member commented that future analyses needed to incorporate climate change interpretation. He noted that this should be considered in responding to the charge questions. A member commented that, with regard to *Cladophora* growth, it was important to understand phosphorus cycling in the Eastern Basin. Another member commented that the effect of nitrogen on the toxicity of cyanobacteria should be discussed. One of the invited experts indicated that a key concern about cyanobacteria was the production of toxins, but there was not a good algorithm to simulate this. He noted that more research will be needed to improve the models to address this issue. Members also commented that eutrophication modeling was a key element to be considered in the discussion of adaptive management. In this regard, a member commented that the importance of winter blooms of diatoms needed further consideration.

Public Comments

Dr. Schlesinger indicated that time had been included on the meeting agenda for public comments but no requests to speak had been received. He therefore moved to the next agenda item which was discussion of the Panel's responses to EPA's charge questions.

Discussion of the Panel's Responses to EPA's Charge Questions

Dr. Schlesinger called for discussion of responses to EPA's charge questions. He noted that Panel members had already developed individual preliminary written responses to the questions. These preliminary responses had been distributed to the Panel and posted on the SAB website[15]. He again noted that lead discussants had been assigned to begin the discussion of each charge question.

Charge Question 1 – Evaluation of the Models to Inform the Interpretation of Results

The Panel discussed the response to charge question 1. The question asked for advice on whether the evaluation of the models was adequate to inform how model results should be interpreted given differences in model complexity and scale. The lead discussant assigned to the question were Drs. Connolly, Di Giulio, Bartell, and Smith.

Panel members commented that the criteria that had been identified for the model evaluation seemed to be adequate. However, members noted that the criteria had been loosely applied. Members noted that the models under consideration differed in complexity. Members noted that a model used for evaluating hypoxia had been judged to be adequate even though calibration and validation had not been conducted,

and uncertainty analysis had not been applied. Members also discussed concerns about model parameterization.

A member commented that all of the models had been used in the analysis but some appeared to be more credible. He commented that the predictions of a subset of models should have been given greater weight. Other members agreed that it was important to pick a subset of the best models and work to develop those.

Members commented that the modeling team had been given a difficult task and had done an admirable job of using available knowledge in the analysis. However, a member expressed concerns about calibration and commented that it was important to link data collection activities with needs for model improvement. He also commented that land use maps and land use change should be considered in the analysis. Another member reiterated the comment that more thought should be given to weighting the results provided by different models to make decisions about the eutrophication response indicator targets and nutrient loads. He noted that the best models should be given more weight. He further indicated that, although the EPA had initially planned to use an ensemble modeling approach, it appeared that the Modeling Subgroup had used a multiple modeling approach.

Individuals who had worked on the modeling analysis responded to Panel members' comments. Some acknowledged that the criticisms about model selection and weighting were valid. They agreed that a multiple modeling effort, not an ensemble modeling effort, had been undertaken. They commented that it would have been useful to apply all of the models to a few data sets. However, they noted that it was difficult to compare the models. They also noted that confounding issues had been identified and future work could be undertaken to address these issues.

A member commented that the use of multiple models in the analysis was a source of uncertainty. Another member commented that it was important consider the effects of climate change and some of the models were better in this regard. Some of the modelers responded that the models had been run with a two-degree increase in the air temperature in the Western Basin and the results showed a higher *Microcystis* bloom peak. However, they noted that it was difficult to project how changes in precipitation would affect loading from the watersheds. The modelers also commented on the uncertainty in forecasting climate change.

A member commented that in the modeling report the discussion of hypoxia focused on carbon dynamics but did not directly link phosphorus loading to hypoxia. Some of the modelers responded that carbon dynamics were linked to phosphorus. They indicated that much of the carbon was autochthonous and there was a good relationship between phosphorus loads and hypoxia in the system. However, modelers commented that cyanobacteria currently appeared to be less sensitive to phosphorus loading than in the past. Modelers note that this was a concern because models had been developed using historical information.

A member commented that a "post mortem" of the modeling analysis should be conducted to understand overestimates and underestimates. He noted that this kind of analysis had been conducted for other systems (e.g., the Chesapeake Bay, Baltic Sea, and Gulf of Mexico).

At 12:30 p.m. the Chair thanked the Panel members and invited experts for their comments and indicated that the Panel would break for lunch. He asked Panel and members and invited experts to return at 1:30 p.m. to continue discussion of the responses to the charge questions.

Charge Question 2 – Recommended Phosphorus Load Targets for Lake Erie

After the lunch break the Panel began its deliberations by discussing the response to Charge Question 2. The question asked the Panel to comment on whether the recommended phosphorus load reduction targets reflected the best available information on the drivers of cyanobacterial growth and seasonal hypoxia in Lake Erie and was appropriate to meet the nutrient lake ecosystem objectives defined in the Great Lakes Water Quality Agreement. The lead discussants assigned to the question were Drs. Klump, Fitzpatrick, and Johnson.

Panel members discussed the consistency of the proposed targets with the nutrient load reductions that had been recommended for other systems. Members commented that the load-response models provided approximations. They commented on the uncertainty in the modeling results and missing or partially missing components in the models. Model components discussed included short term inter-annual variation in physics, internal biogeochemical cycling, and climate impacts. A member commented that short term meteorological information was needed to better understand the variability in hypoxia. A member commented that one purpose of adaptive management was to address uncertainty. Other members commented that setting the same initial conditions each year in the models was problematic. Another member commented that the Lake Erie ecosystem was evolving and may have shifted to a non-steady state.

Members discussed the importance of precipitation as a diver of nutrient loading. They noted that, although some models could incorporate the effects of climate change, precipitation was difficult to predict. A member commented that nutrient loading could increase significantly as a result of climate change. Other members commented that, although there were uncertainties in the nutrient load reductions needed, the proposed reduction targets were defensible. The Panel discussed the effect of proposed nutrient load reduction on fisheries. A member reiterated the comment that the targets were defensible. He noted that anything less than a 40% reduction in phosphorus load would be hard to defend. However, he noted that more data were required to continue developing the models.

A member commented on some of the issues contributing to uncertainty in the nutrient reduction targets. She noted that: (1) the ecological consequences of a 2.0 mg/l versus a 4.0 mg/l dissolved oxygen standard were not completely clear and that there was a need to understand how fundamental rates and processes were affected at these levels of dissolved oxygen; and (2) it was important to understand the consequences of changing precipitation patterns. She noted that in the next round of analyses, model runs should investigate these issues.

Another member commented on the importance of applying an adaptive management approach to understand the effect of changing temperature on cyanobacterial blooms. He noted that cyanobacteria preferred warmer temperatures and that changing climate could offset the effect of phosphorus load reduction. He commented that there was more uncertainty associated with the effect of the nutrient reduction targets on hypoxia than on algae blooms. He commented on the need to consider the effect of sediment oxygen demand. Another member commented on the relative simplicity of the models with regard to phytoplankton biology. He suggested some areas where the models could be further developed. These included incorporation of better information on: the effect of internal nutrient cycling, the role of nitrogen in harmful algae blooms (i.e., co-limitation) and hypoxia, and the effect of winter and spring diatom blooms under ice. He also noted that the lake ecosystem was changing and that the proposed

nutrient reduction targets were reasonable if the models adequately reflected what was happening in the system.

One of the modelers responded. He commented that the more complex models under consideration did consider the effects of nitrogen and silicon. He noted that actions taken to control phosphorus export also limited nitrogen export, and that it was important to understand how phosphorus export control controls nitrogen. Modelers indicated they believed the Lake would benefit from a 40% phosphorus load reduction.

A panelist noted that soluble reactive phosphorus was the fraction of phosphorus that drove phytoplankton growth. He indicated that this should be considered. A modeler responded that soluble reactive phosphorus loading should be targeted along with other forms of phosphorus. A member commented that it may take a long time to reduce internal phosphorus loading to Lake Erie. An invited expert responded that in the Western Basin, the system was driven by external loads. Another invited expert commented that phosphorus in the sediments was a concern, but legacy phosphorus was of greatest concern in watersheds where there where there were high amounts of phosphorus in agricultural fields. He noted that it may take a long time to reduce phosphorus loading from those areas.

A panelist commented that the proposed 40% phosphorus load reduction appeared to be a good target, but he noted that there was no expression of uncertainty. Another member commented that it was important to be as quantitative as possible. A member commented that in the Chesapeake Bay proposed nutrient reduction targets were initially achieved but subsequently the models and targets were improved.

A member commented that the proposed phosphorus load reduction targets did not address toxics. One of the invited experts noted that there appeared to a relationship between cyanobacterial toxicity and nitrogen, but the Modeling Subgroup was most concerned with reduction of cyanobacterial blooms. A modeler indicated that there was uncertainty associated with the prediction of cyanobacterial toxicity. Members discussed explaining this to the public.

Charge Question 3 – Addressing Cladophora Growth

The Panel next discussed the response to Charge Question 3. The question focused on whether scientifically sound phosphorus load reduction recommendations could be developed to address *Cladophora* growth. The lead discussants for the question were Drs. Heath, Carrick, and Rosi-Marshall.

Members discussed nuisance *Cladophora* growth. A member commented that *Cladophora* growth appeared to be most sensitive to cell phosphorus or P-quota. The Panel discussed the concentration of soluble reactive phosphorus that would maximize *Cladophora* growth. A member commented that a major problem associated with *Cladophora* growth was the formation of “beach muck” leading to the bacteria growth and odor. He noted that soluble reactive phosphorus concentrations had been related to total phosphorus concentrations and modeling indicated that a 25% reduction in total phosphorus loading could lower the level of *Cladophora* growth enough to effectively manage the problem. He noted that a 40% reduction of phosphorus loading could therefore be sufficient. The member indicated that there were a number of model caveats to be considered.

The Panel discussed the uncertainties associated with predicting *Cladophora* growth. Members commented that the current state of knowledge of *Cladophora* growth was not adequate to develop scientifically sound phosphorus load reduction targets. In particular, members commented that: (1) the

Great Lakes Cladophora Model had been calibrated and confirmed on Lakes Huron and Michigan and it needed to be confirmed in the Eastern Basin of Lake Erie; (2) *Cladophora* growth depended on soluble reactive phosphorus content which was dependent upon total phosphorus levels in the lake as well as local inputs from nearby tributaries and the presence of dreissenid mussels; (3) the *Cladophora* model needed to account for other nuisance benthic algae species that could cause similar problems; and (4) the processes that lead to sloughing and decay of algae to beach muck needed further investigation. Members commented that further research was needed in these areas in order to develop nutrient load reduction targets to control *Cladophora* growth.

Charge Question 4 – Consideration of Nitrogen Control

The Panel next discussed the response to Charge Question 4. This charge question focused on recommendations for development of an approach to determine whether nitrogen control, in addition to phosphorus, was warranted to prevent harmful algae blooms and manage hypoxia. The lead discussants for the question were Drs. Ammerman, Diaz, and Reddy.

A member commented that a dual nitrogen strategy for Lake Erie may be indicated, but he noted that there were a number of research needs that should be addressed. He commented that some scientists had called for nitrogen control in Lake Erie. A member commented that microcystin toxins were nitrogen rich compounds. Other members commented that nitrogen to phosphorus ratios were important because they could influence the abundance of phytoplankton species. Members noted that *Microcystis* was able to scavenge phosphorus at low concentrations. A member commented that agricultural best management practices to limit phosphorus would help limit nitrogen. However, he commented that because of the solubility of nitrogen compounds, tile drainage was a nitrogen source of particular concern.

A member commented that dual nutrient strategies had been adopted for the Gulf of Mexico, Chesapeake Bay, and Baltic Sea. He indicated that a dual strategy was probably needed for Lake Erie as well. He noted that two important knowledge gaps needed to be filled: (1) total nitrogen loads to Lake Erie (including species of nitrogen) should be determined; and (2) the degree to which nitrogen input will be reduced by controlling phosphorus should be determined. He reiterated the statement that different ratios of phosphorus to nitrogen can drive primary production of different phytoplankton species. The Panel discussed other research needs focusing on: (1) the reliability of the models; (2) the effectiveness and ecological outcomes of nitrogen source control; (3) the possible need for nitrogen control in Lake Ontario and the other Great Lakes.

A panelist agreed that control of both nitrogen and phosphorus was needed. He commented that in Florida's Everglades, phosphorus control had initially been considered but it was recognized that nitrogen would also have to be controlled. He suggested that ammonium and nitrate be monitored and noted that including nitrogen in the models would require considerable effort. The Panel discussed whether the models could incorporate lake-wide denitrification. Members commented that much work would be needed to do this. One of the invited experts commented that nitrogen had been decreasing in the Maumee River but parallel trends had not been observed in phosphorus levels. A member commented that climate change could affect denitrification.

The Panel discussed differences between nitrogen and phosphorus control practices. A panelist commented that nitrogen and phosphorus were fundamentally different and noted that both would probably not be controlled by the same management practices. An invited expert commented that phosphorus control practices focused on erosion control but dissolved reactive phosphorus had been

observed in tile drainage. Members commented that studies of the Mississippi could provide useful best management practices for the Maumee Basin.

The Panel discussed how control of nitrogen could affect cyanobacteria. A member commented that *Microcystis* did not fix nitrogen and therefore required a fixed nitrogen source. Members noted that *Microcystis* became nitrogen limited in late summer in western Lake Erie and that this alga became more toxic when nitrate was abundant in lake water. A member commented that low availability of nitrogen in lake water was associated with a switch between species of cyanobacteria. He noted that if nitrogen concentrations increased, the persistence of *Microcystis* blooms could increase even if phosphorus concentrations were lowered.

The Panel further discussed and identified additional research questions including: (1) how much nitrogen could be removed by internal processes; (2) the consequences of legacy nitrogen and phosphorus in the sediments and the differences in internal cycling; (3) the downstream consequences of not following a dual nutrient strategy; (4) the importance of concentrations and ratios of nitrogen to other nutrients (phosphorus, but also silicon) in directing or controlling ecosystem functions; and (5) the ratio of nitrogen to phosphorus that would be best for ecosystem functioning.

Charge Question 5 – Accounting for Inter-Annual Variability in Hydrology in Assessing Reduction of Tributary Loadings

The Panel discussed the response to Charge Question 5. The charge question asked for comments on the use of flow weighted mean concentrations (FWMC) and other approaches that should be considered to account for inter-annual variability in hydrology when assessing progress in reducing tributary loadings of phosphorus to Lake Erie.

Panel members expressed support for using FWMCs to assess tributary loadings of nutrients. Members commented that FWMCs had been recognized as useful measures to address inter-annual variability because they normalized the tributary phosphorus loading and delivery with respect to flow. The Panel also discussed the need to review the available monitoring outputs (e.g., discharge, flow, concentrations, loads) from significant tributaries and use multiple assessment approaches (including FWMC and flow-adjusted concentrations) for evaluating efforts to control nutrient loadings.

Members commented that it was important to consider uncertainty in the values derived using the flow-weighted or flow-adjusted approaches. Members indicated that uncertainty should be explicitly quantified and presented, and that detailed information on the implementation of phosphorus reduction strategies should be collected to help identify reasons for changes in phosphorus loads delivered to Lake Erie.

Members also discussed the need to monitor land use practices and consider climate change effects when identifying the reasons for changes in phosphorus loads. In particular, members noted that it was important to have detailed information on upstream conditions including: implementation and effectiveness of best management practices; trends in flow weighted mean concentrations; and evidence of changes in the landscape. In addition, members commented that it was important to obtain information showing seasonal changes in concentrations of nutrients, timing of large rain events, and flow relative to land use. An invited expert commented that in the Lake Erie region, the tributaries that contributed large loads were gauged so that flow information was available

Following the discussion of charge question 5 the Chair indicated that the meeting would recess for the day. He indicated that the Panel meeting would reconvene at 8:30 a.m. the following day.

Wednesday, June 22, 2016

Reconvene Meeting

The Designated Federal Officer reconvened the Panel meeting at 8:30 a.m. on Wednesday, June 22, 2016. The Chair summarized issues that had been discussed on the previous day and reviewed the agenda for the day. He indicated that before lunch the Panel would discuss the response to Charge Questions 6 and then the lead discussants and writers for each charge question would break into writing subgroups to discuss the key points to be included in the Panel's report. The Chair noted that after lunch the Panel would discuss these key points. The Chair indicated that that the meeting was scheduled to adjourn at 2:00 p.m. He then called for continued discussion of the responses to the charge questions.

Continued Discussion of the Panel's Responses to EPA's Charge Questions

Charge Question 6 – Evaluation of Nutrient Reduction Goals for Lake Erie

The Panel discussed the response to Charge Question 6. The question focused on: (1) the value of applying the existing eutrophication models on a periodic basis to evaluate phosphorus loading targets and eutrophication response indicators; and (2) elements that should be included in an adaptive management approach to implement and evaluate nutrient reduction goals for Lake Erie. The lead discussants for Charge Question 6 were Drs. Alber, Chen, and Valett.

Panel members discussed elements of an adaptive management approach. Members commented that adaptive management might involve developing and testing alternative hypotheses to explain a current scenario. A member noted that the process of developing and testing alternative hypotheses would require forecasting, determining what should be measured, and determining which models should be used for an evaluation. A member commented that process-based models would be required to evaluate some recommended actions. A member also commented that an adaptive management approach required an ongoing commitment and framework. Members suggested that an adaptive management workgroup be established to implement the approach.

The Panel discussed other elements in an adaptive management approach. A member indicated that an adaptive management approach could include: testing null hypotheses, conducting research, and conducting modeling and monitoring. The member commented that the Lake Erie eutrophication research might involve investigation of: phosphorus loading, the role of dreissenid mussels, and the role of nitrogen and phosphorus. The Panel discussed the importance of monitoring and modeling in an adaptive management approach. A number of potential Lake Erie monitoring and modeling activities were discussed. These activities included: collecting data from additional tributaries, monitoring variables related to climate change, collecting information on wind and currents, measurement of nitrogen loading, monitoring cyanobacteria biomass, monitoring benthic organisms and fish production, and linking landscape and hydrology models. A member commented that it was important to prioritize these activities.

The Panel discussed the need to develop conceptual models. An invited expert indicated that each of the models used to develop the dose-response curves was based on a conceptual model. He suggested that

an adaptive management workgroup examine those conceptual models. The Panel also discussed the importance of assessing the confidence limits associated with monitoring and hypothesis testing. A member commented that data limitations would affect those confidence limits.

The Panel discussed the need for new research, and integration of a body of research, into the adaptive management program. Members commented that models reflected the state of the art and research that had been conducted in the past. Members commented that, in some cases, new research was not needed but better integration of a body of research was needed. A member commented that as the nutrient reduction targets were met, additional information would be collected to inform the models. He noted that this would be an experiment. Another member commented that new information was needed to establish algal toxins as an endpoint in the models. He noted that this information was not currently available.

The Panel further discussed data needed to improve models. A member commented that models themselves could be used as tools to indicate what was not known and identify research priorities. Other members discussed specific data needs. These included the need for: information on cyanobacterial biomass, high quality nutrient loading data from various tributaries (in particular, members discussed the need for additional loading estimates from the Thames watershed), and information on the effectiveness of best management practices.

Writing Session to Develop key points in Response to the Charge Questions

At 10:00 a.m. the Chair asked Panel members to meet in writing subgroups to develop the key points in the responses to each charge question. The subgroup meetings continued through lunch and the Panel came together as a whole at 1:00 p.m. to discuss the key points developed by the writing subgroups.

Discussion of Key Points in the Responses to the Charge Questions

The lead writers for each charge question subgroup summarized the key points in the responses to each question. The Panel then discussed the key points (the key points listed below were discussed).

Points Discussed in the Response to Charge Question 1

Adequacy of the evaluation of the models:

- The model evaluation is important to ensure that the models meet a set of standards.
- In general, the evaluation criteria were loosely applied and accepted.
- The evaluation of model uncertainty was not incorporated into the evaluation of load reduction targets.
- The evaluation of the models did not focus on: the likelihood of achieving target loads, when they could be achieved, and how variations in meteorology would affect the load.
- It was not clear how well the models performed.
- The models were limited by the availability of data – it would be helpful to develop a better understanding of data limitations.
- An ensemble modeling approach was not applied, instead a multiple modeling effort was undertaken.

Analyses to be considered:

- The suite of models to be considered should be reduced.
- Priority should be given to further developing and applying the process-based models.
- Models should evolve and model feedback should support continued development.
- Synaptic monitoring should provide data for model development.
- Additional nutrient loading data should be collected and used for continued model development (consideration should be given to using precision agriculture information to improve loading analyses).
- Consideration should be given to combining model estimates using a Bayesian approach to address loading uncertainty.

Points Discussed in the Response to Charge Question 2

- A range of models was used to develop the 40% phosphorus load reduction target. The target appears to be consistent with what is known about the system.
- Reduction of phosphorus in the system correlates with reduced algal blooms. Achieving the target of a 40% reduction in phosphorus loading is likely to reduce harmful algal blooms (however, blooms could continue to occur in the Western Basin of Lake Erie).
- Reduction of hypoxia is more complicated and uncertain. The entire system is not well modeled.
- Monitoring of tributary loadings should continue. Event-based sampling would provide useful data.
- Nutrient flux from sediment should be modeled. Models should be run in an extended sequence.
- The spatial extent of best management practices should be characterized.

Points Discussed in the Response to Charge Question 3

- Scientifically sound phosphorus load reduction recommendations to address *Cladophora* growth cannot be provided at this time (additional information is needed).
- A nuisance aspect of *Cladophora* growth is the formation, sloughing, and decay of "beach muck." More information is needed about this process.
- *Cladophora* growth is a problem in all of the Great Lakes (associated problems include beach closures, bacteria, and negative effects on property values.)
- The *Cladophora* Growth Model provides useful information but it needs further development and calibration.
- *Cladophora* growth depends on soluble reactive phosphorus. The effects of local nutrient inputs and dreissenid mussels should be further investigated.
- *Cladophora* is not the only nuisance benthic algae in the Great Lakes. The growth of other nuisance benthic algae should be included in a broader whole lake model.

Points Discussed in the Response to Charge Question 4

- Nitrogen input to Lake Erie should not be ignored. A dual nitrogen strategy for Lake Erie may be indicated but there are a number of research needs that should be addressed.
- Research needs include work to provide more information on:
  - Nitrogen loads to Lake Erie (including different species of nitrogen);
  - The effect of nitrogen on toxicity of cyanobacteria;
  - The nitrogen cycle in Lake Erie (including internal cycling) and nitrogen limitation;

  - Best management practices;
  - The degree to which nitrogen input will be reduced by controlling phosphorus; and
  - Effect of ratios of phosphorus to nitrogen on primary production of phytoplankton species.

Points Discussed in the Response to Charge Question 5

- Flow weighted mean concentrations (FWMCs) are useful measures to account for inter-annual variability because they normalize the tributary phosphorus loading and delivery with respect to flow.
- Nutrient inputs for models require data on flow and concentrations.
- All available monitoring outputs (e.g., discharge, flow, concentrations, loads) from significant tributaries and multiple assessment approaches (including FWMC and flow-adjusted concentrations) should be used to evaluate efforts to control nutrient loadings.
- Program information about what is happening in watersheds should be tracked to understand trends in nutrient inputs.
- Nutrient loading data provide estimates of exposure that can be related to endpoints of concern. The spatial and temporal nature of parameters monitored should be meaningful.

Points Discussed in the Response to Charge Question 6

- An adaptive management workgroup should be established and supported.
- The adaptive management workgroup could be charged with coordinating ongoing monitoring and evaluation and developing a research program to investigate alternative hypotheses.
- The adaptive management workgroup needs to address support for a long term monitoring.
- Additional ecological response indicators (e.g., fish and benthic community indicators) should be considered.
- Predictions should be assessed and pulled into an annual audit.
- The adaptive management workgroup should develop alternative hypotheses and conceptual models to guide future monitoring and modeling efforts.
- A number of suggested topics for potential alternative hypotheses were discussed. These focused on:
  - The effects of best management practices phosphorus and nitrogen loading;
  - Nitrogen co-limitation of cyanobacterial blooms;
  - The effects of winter blooms and sediment oxygen demand on hypolimnetic dissolved oxygen;
  - The effects of dreissenid mussels on *Cladophora* growth; and
  - The effects of local hydrodynamics and tributary inputs of phosphorus on *Cladophora* growth.

The lead writer and discussants for Charge Question 6 indicated that other potential hypotheses topics could be considered. They asked Panel members to provide additional input when the Panel's draft report was reviewed and discussed.

Summary of Next Steps

Dr. Schlesinger reviewed action items and the next steps to be completed. He asked the lead writers to develop written synthesis responses for their charge questions and to incorporate comments from the

lead discussants for their questions. He indicated that the lead writers should send the written responses to the DFO by Friday, July 15th. Dr. Schlesinger indicated that he would work with the DFO to incorporate the responses into a draft Panel report which would be sent to the entire Panel for review. He indicated that a Panel teleconference would be scheduled to discuss the draft report. He noted that the DFO would contact members to schedule the call. He further indicated that if there were areas of disagreement on the draft report they would be discussed on the teleconference. He stated that, if necessary, the DFO would schedule a second teleconference for the Panel to discuss the draft report.

Dr. Schlesinger asked members if there were questions or additional issues to be discussed. There were none, so he thanked the members of the Panel for their work and thanked the EPA staff and invited experts for their presentations and responses to the Committee's questions. Dr. Schlesinger then asked the DFO to adjourn the meeting. The DFO reminded Panel members of the specific action items to be completed and adjourned the meeting.

Respectfully Submitted:

/signed/

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Dr. Thomas Armitage
Designated Federal Officer

Certified as Accurate:

/signed/

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

NOTE AND DISCLAIMER: The minutes of this public meeting reflect diverse ideas and suggestions offered by Panel members during the course of deliberations within the meeting. Such ideas, suggestions and deliberations do not necessarily reflect consensus advice from Panel members. The reader is cautioned to not rely on the minutes to represent final, approved, consensus advice and recommendations offered to the Agency. Such advice and recommendations may be found in the final advisories, commentaries, letters or reports prepared and transmitted to the EPA Administrator following the public meetings.

ATTACHMENT A: COMMITTEE ROSTER

U.S. Environmental Protection Agency
Science Advisory Board
Lake Erie Phosphorus Objectives Review Panel

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SCIENCE ADVISORY BOARD STAFF

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Materials Cited

The following meeting materials are available on the EPA Science Advisory Board website, www.epa.gov/sab, on the June 21 - 22 meeting page of the Lake Erie Phosphorus Objectives Review Panel.

https://yosemite.epa.gov/sab/sabproduct.nsf/MeetingCal/CA964916DD47A19585257F500058284A?OpenDocument

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[1] Federal Register Notice

[2] Agenda

[3] Committee Roster

[4] Annex 4 Ensemble Modeling Report (May 2016 Peer Review Draft)

[5] Recommended Phosphorus Loading Targets for Lake Erie: Annex 4 Objectives and Targets Task Team Final Report to the Nutrients Annex Subcommittee. May 11, 2015

[6] Public comments from Laura A. Campbell, Michigan Farm Bureau

[7] Presentation by Tinka Hyde, Binational Phosphorus Load Reduction Efforts to Prevent Lake Erie Hazardous Algal Blooms

[8] Presentation by Joseph DePinto, Annex 4 Load-Response Modeling for Lake Erie

[9] Paper by Scavia et al. titled A Multi-Model Approach to Evaluating Target Phosphorus Loads for Lake Erie

[10] Presentation by Russell Kreis, Jr., Great Lakes Water Quality Agreement Annex 4 –Nutrients Lake Erie Phosphorus Loading and Cladophora Updates

[11] State of Knowledge of Cladophora in the Great Lakes Workshop - Executive Summary, May 10, 2016.

[12] Presentation by Jeffrey Reutter, GLWQA Annex 4

[13] Presentation by Craig Stow, Lake Erie Nutrient Targets: An Imperative for Adaptive Management

[14] Charge for Lake Erie Nutrient Targets and Adaptive Management

[15] Compilation of individual preliminary comments from Panel members (as of 6/16/16)