UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

January 24, 2012

EPA-SAB-12-002

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Review of Great Lakes Restoration Initiative Action Plan

Dear Administrator Jackson:

The EPA, with its federal partners, developed the *Great Lakes Restoration Initiative Action Plan FY 2010 - 2014.* The Action Plan is a multi-year plan that identifies goals, objectives, ecological targets, and specific actions for five major focus areas. Restoration efforts, measures of progress, and principal actions have been developed to address toxic substances, Areas of Concern, invasive species, nearshore health, nonpoint source pollution, habitat restoration and wildlife protection. The Action Plan identifies the need to monitor and evaluate the GLRI's progress and ensure its accountability. It also addresses the need to educate the public, to enhance collaboration among its partners, and to ensure public participation. In response to an EPA Region 5 request, the Science Advisory Board formed an ad hoc panel, the Great Lakes Restoration Initiative Action Plan Review Panel, to provide advice through the chartered SAB.

The SAB acknowledges the EPA's thoughtful effort and leadership that guided the development of the *Great Lakes Restoration Initiative Action Plan FY 2010- 2014.* The SAB supports the premise that enough is known about the issues confronting the Great Lakes, as well as the underlying causes and potential remedies, to initiate action, and agrees that the Action Plan identifies most of the important actions that should be undertaken. The SAB notes that an integrated, science-based framework that provides input and justification for actions is lacking within the GLRI, but finds that the Action Plan is largely consistent with previous plans and strategies, reflecting a continuation of collaborative planning in the region. This continuity is good, but it does not guarantee sufficiency and the SAB has a number of comments and recommendations to improve future efforts.

The SAB supports the primary emphasis on implementing the extensive backlog of restoration projects in the Great Lakes region. The SAB also notes that this 5-year Action Plan is well underway and the plan itself recognizes that as these projects are completed, an evaluation and reprioritization of efforts will be needed using an adaptive management framework. This evaluation will require that a solid, science-based framework be in place to drive the restoration plan. The SAB recommends that the agency

create this integrated framework to bolster the Action Plan, to organize the current efforts, and to identify future directions to develop and implement new restoration technologies, methods and approaches.

Another important organizational tool that is missing is a standing science panel. The SAB recommends the agency create a well-integrated panel that could influence the program's evolution by providing assessments of progress in key areas. The science panel's input on design, implementation, monitoring, and evaluation efforts would provide a scientific basis for setting priorities across disparate actions. In addition to natural and physical scientific expertise, the panel should include the social science disciplines. Behavioral, social, and decision scientists can provide many kinds of insights and advice needed for a program as wide ranging as the GLRI. A diverse panel will offer assistance in targeting education and outreach efforts, and critical insights into the likely workability of particular institutional arrangements

The SAB notes that climate change is not explicitly addressed in the each of the focus areas of the Action Plan. Restoration efforts of this magnitude and complexity will likely change in the future as alterations in air and lake temperature, amount and patterns of precipitation, ice cover and lake levels may significantly impact restoration efforts.

The SAB agrees with the agency's goal to develop an accountability system and recognizes that the current Great Lakes Accountability System is a work in progress. The SAB also notes that a great deal of effort will be necessary in order to upgrade the current system from an accounting system to one that provides transparency, tracks project outcomes as well as outputs, and provides a solid basis for programmatic evaluation needed for an adaptive management framework. In developing such an accountability system, the SAB urges the agency to develop metrics of progress that are more in line with the underlying science of restoring the Great Lakes rather than only the Government Performance Results Act measures that currently comprise the Action Plan. Robust monitoring programs are essential and a key element of adaptive management. Therefore, they should be continued and/or developed to measure the status and progress of restoration. Monitoring will also be needed to assess impacts on the Great Lakes and to assess how global, regional, and subwatershed factors interact. The SAB recommends that sufficient funding be allocated to monitoring and the subsequent programmatic evaluation to determine the eventual success (or lack thereof) of the Action Plan's projects.

The Action Plan continues to build on the considerable history and experience studying and controlling toxic chemicals in the Great Lakes. This is a sound approach. However, the agency should carefully consider whether the current focus on priority "legacy" contaminants addresses the totality of the restoration required, or whether the focus should be tailored to account for other contaminants of concern. Additionally, as the agency addresses emerging contaminants, it should rely on the strong science and protocols developed by scientists in the Great Lakes region to identify which contaminants occur at levels of concern and should therefore be priority contaminants for action. The SAB also notes that the goal of delisting five areas of concern by 2014 is laudable, but is an extremely aggressive goal given historical rates of de-listing, program logistics and system response times.

There are a number of admirable long-term goals and objectives to eliminate the introduction of invasive species in the Action Plan. Several parallel activities are under way to address specific invasive species (i.e., Asian carp) and vectors (i.e., ballast water controls) in addition to the recommendations on surveillance programs the agency requested. The SAB finds these issues important and timely, and recommends that these parallel efforts be evaluated together to develop a comprehensive invasive species program. The SAB endorses developing a basin-wide invasive species surveillance program and

recommends that surveillance and rapid response protocols be coordinated to ensure that the various states, provinces, and other participating organizations use the same methodology and protocols to provide meaningful information and effective rapid response.

The Action Plan's intent to identify, map, and target the highest priority Great Lakes subwatersheds to protect nearshore health is the best strategy for producing measurable positive outcomes and provides a unique opportunity to form the basis for a long-term restoration vision. In order to sustain that vision, strategic planning that includes mechanisms for assuring sound science and measurement of progress must be performed. Reducing soluble reactive phosphorus loads is one of the more important measures of progress as it is a key stressor throughout the Great Lakes ecosystem. However, this and other metrics must be developed with targets that are statistically significant and scientifically meaningful.

Protecting and restoring habitat and wildlife will require the development and application of a range of critical management actions and sound decision-making. The SAB agrees that restoring resiliency is an appropriate goal for this focus area. However, the Action Plan does not clearly articulate the concept of resiliency in the context of this plan. In addition, adequate information was not presented to judge whether the actions associated with habitat and wildlife protection and restoration would be effective at attaining enhanced ecosystem resilience in the face of disturbances. A clear, working definition of resiliency should be developed along with metrics that can be used to track changes in the resiliency over time as restoration measures are implemented. While most of the actions presented in the Action Plan are "restoration" actions, the SAB questions whether the noted actions will enable the attainment of the objectives under this important focus area.

The SAB agrees that accountability, education, monitoring, evaluation, communication, and partnerships are important to the success of the GLRI, but concludes that the monitoring and other elements in this focus area may be better addressed in the specific focus areas rather than as a combined focus area. Instead, under this capstone focus area; EPA should develop a strategic assessment and management plan that implements monitoring, synthesis, and integration across the focus areas to bolster the accountability goals of the GLRI. Without a science-based accountability framework, the GLRI will do little to advance coordination and collaboration among Great Lakes partners to address key scientific issues. There is also a need to enforce the incorporation of educational and outreach activities as an overarching theme for all projects in the GLRI. Outreach and education activities provide highly respectable goals, but overall the Action Plan lacks a strategic approach to achieve the stated objectives.

Finally, the SAB recommends that the EPA and its partners consider explicit peer review criteria, in parallel with the peer-review process of the National Science Foundation, for all activities (internally and externally funded), including those focused on education and outreach. The criteria should advance the knowledge and understanding of Great Lakes issues, promote teaching, increase participation of underrepresented groups, and broadly disseminate information to enhance the scientific and technological understanding of the public.

In closing, the SAB encourages EPA to continue efforts under the GLRI and collaborate with its interagency partners to develop the best available science to support remediation and restoration efforts and develop a sustainable program. We appreciate the opportunity to provide advice on this important effort and look forward to your response.

Sincerely,

/Signed/

Dr. Judith Meyer
Acting Chair
Science Advisory Board

/Signed/

Dr. James Sanders
Chair
SAB Panel on the Great Lakes Restoration Initiative Action Plan Review

Enclosure

NOTICE

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 necessarily 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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Great Lakes Restoration Initiative Action Plan Panel

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Acronyms and Abbreviations

AOC	Areas of Concern
BMP	Best Management Practices
BWMS	Ballast Water Management Systems
DNA	Deoxyribonucleic acid
EPA	Environmental Protection Agency
GPRA	Government Performance and Results Act
GLAS	Great Lakes Accountability System
GLRI	Great Lakes Restoration Initiative
IATF	Great Lakes Interagency Task Force
IJC	International Joint Commission
LaMP	Lake Management Plan
NGO	Non-Governmental Organizations
NIS	Non-indigenous invasive species
NSF	National Science Foundation
OMB	Office of Management and Budget
PAH	Polycyclic aromatic hydrocarbons
PBT	Persistent, bioaccumulative and toxic
PCB	Polychlorinated biphenyls
SAB	Science Advisory Board
SAV	Submerged aquatic vegetation
SOLEC	State of the Great Lakes Ecosystem Conference

1. EXECUTIVE SUMMARY

In 2009, President Obama announced and Congress later appropriated $475 million in new funding for the Great Lakes Restoration Initiative (GLRI) to "protect and restore the chemical, biological, and physical integrity of the Great Lakes." To guide the efforts of the GLRI, the Environmental Protection Agency (EPA) and its Federal partners, through the Great Lakes Interagency Task Force (IATF)[1] developed a comprehensive multi-year Action Plan that identifies goals, objectives, ecological targets, and specific actions for five major focus areas.

The *Great Lakes Restoration Initiative Action Plan FY 2010 - 2014*, hereafter referred to as the Action Plan, describes the measures of progress and principal actions to address toxic substances, Areas of Concern, invasive species, nearshore health, nonpoint source pollution, habitat restoration, and wildlife protection and restoration. The Action Plan also provides a fifth focus area to address the GLRI's effort to improve accountability, education, monitoring, evaluation, communication, and partnerships.

In response to the Department of the Interior, Environment, and Related Agencies Appropriations Act of 2010, EPA as the lead agency for the GLRI requested that the Science Advisory Board (SAB) review the Action Plan. The SAB formed an ad hoc panel, the Great Lakes Restoration Initiative Action Plan Review Panel, to conduct the review and provide advice through the chartered SAB. The SAB responded to eleven charge questions in its deliberations. Charge questions were organized to address the overall structure of the Action Plan and the five Focus Areas. The SAB recognizes that the five-year Action Plan is well underway and is providing advice to guide future decisions for the GLRI. In this Summary, an excerpt of the charge questions provides context to the SAB recommendations and advice on each of the topics addressed in the Action Plan.

Overall Structure of the Action Plan

> *Are the principal actions proposed in the Action Plan consistent with the actions and/or recommendations of the previous collaborative plans and strategies for the Great Lakes (e.g. Great Lakes Regional Collaboration Strategy)? Are there other actions that we should consider for inclusion in the Action Plan that will better achieve the goals of the Action Plan?*

The SAB supports the basic premise that enough is known about the issues confronting the Great Lakes, as well as the underlying causes and potential remedies, to implement initial remedial activities, and agrees that the Action Plan identifies the important actions that should be undertaken. Although a transparent framework describing the scientific justification for the Action Plan is lacking, the SAB notes that the Action Plan is consistent, for the most part, with previous plans and strategies and reflects a continuation of collaborative planning in the region. This continuity in planning is good, but such consistency does not guarantee sufficiency. The SAB provides recommendations for improvement in a number of areas.

The SAB recognizes there is an extensive backlog of restoration projects in the Great Lakes region that need to be pursued, and supports the agenda of putting primary emphasis on implementing those

[1] The Great Lakes Interagency Task Force (IATF) brings together eleven U.S. cabinet and Federal agency heads to coordinate restoration of the Great Lakes. Created by Executive Order from President Bush on May 18, 2004, the IATF is to focus on environmental outcomes like cleaner water and sustainable fisheries, and target measurable results. The IATF helps coordinate GLRI implementation.
http://www.epa.gov/greatlakes/iatf/index.html

projects. The Action Plan recognizes that as these projects are completed, evaluation and reprioritization of efforts will need to be accomplished, using an adaptive management framework. Implementation of an adaptive management framework will require systematic and continual integration of design, management, and monitoring, which would enable EPA and the IATF to make informed adjustments and adaptations in the restoration efforts in the Great Lakes. The SAB notes that a solid, science-based framework that provides input and justification for actions will be necessary to support restoration decisions, track the restoration plan's progress, and document the GLRI's success.

> *The Great Lakes Accountability System (GLAS)[2] [is] the primary mechanism for collecting information to monitor and report on GLRI progress. GLAS is still a work-in-progress at this time and it is not ready for external review. However, given the scope of the Action Plan and the nature and types of projects funded under the GLRI, [EPA is] interested in the SAB's recommendations on how best to track the progress and accountability for a large ecosystem restoration program. What critical environmental elements, endpoints, or other measures would you include to those identified in the Action Plan?*

The SAB agrees with the agency's goal to develop an accountability system and recognizes the current Great Lakes Accountability System (GLAS) is a work in progress. However, much work will need to be done to upgrade the current system from an accounting system to one that provides transparency, is able to track project outcomes as well as outputs, and provides a solid basis for programmatic evaluation across the focus areas. In addition, the SAB notes that the ability to integrate outcomes across hundreds of projects, essential for evaluation at the theme (e.g., toxics), Lake, or system level and at the overall GLRI program level, is lacking. GLAS may not be an appropriate vehicle for this type of integration, as it appears designed to function at the project level, and the diversity and granularity of those projects would make integration within GLAS difficult. An effective integrative assessment will require additional effort, perhaps building from GLAS inputs. Therefore, the SAB recommends a new, focused, and perhaps independent, scientific evaluation process.

> *Please comment on the overall scope and framework of the Action Plan and its ability to organize environmental issues in a way that directs restoration actions. Does the SAB have any specific recommendations on how to improve or clarify the Action Plan?*

While the Action Plan is consistent with previous efforts in the Great Lakes region, there appears to be a serious disconnect in that very few of the research, monitoring, and integrative assessment needs identified in the earlier documents (e.g., the State of the Great Lakes Ecosystem Conferences, www.epa.gov/solec/) are carried through to the Action Plan. SAB findings on the adequacy of the identified endpoints and measures are addressed in each section below, but overall the measures often appear naïve or narrow, and without proper context or benchmarking. Measures should be cognizant of historical context and variability. Metrics to identify change or progress toward restoration should be developed such that they can be detected statistically. Otherwise, it is not clear if, or when, a metric is met. This requires an understanding and explicit documentation of both historical baselines and their variability, and the universe within which the metric is couched.

When developing and implementing a program as large, expansive, and hopefully as sustained as the GLRI will be, scientific investment to increase the understanding of critical ecological functions and

[2] Available online at http://glri.us/projects.html

pathways is needed to ensure effective restoration, improve restoration methods, and to monitor, track, and evaluate progress. The SAB is concerned that the Action Plan is not placing enough emphasis on programmatic evaluation and synthesis across focus areas of the GLRI to successfully employ adaptive management. Indeed, evaluations of programs and projects, and their success, should be considered as important as the other actions. Robust monitoring programs are essential and a key element of adaptive management. Therefore, they should be continued and/or developed to measure the status and progress of restoration. Monitoring will also be needed to assess impacts on the Great Lakes and to assess how global, regional, and subwatershed factors interact. The SAB recommends that sufficient funding be allocated to assessing the eventual success (or lack thereof) of the Action Plan.

To achieve success, the SAB notes that an integrated science-based framework that provides input and justification for actions taken is necessary to transparently link goals to outputs and outcomes and that such a plan is lacking. Creating this framework, herein referred to as a science plan, will not only support the current efforts, but also lay out future directions that can support and take advantage of development of new restoration technologies, methods, and approaches. The SAB recommends that EPA work with natural and social scientists and engineers from government, academia, non-government organizations (NGOs) and industry to create this science plan that, when coupled with the Action Plan, creates a framework for adaptive management. This science plan also should explicitly consider potential impacts of climate change on restoration.

The Action Plan suggests that restoration and protection can be accomplished through natural science and engineering processes alone. This is rarely the case in environmental decision-making. Significant roadblocks to action can come from social, economic, political, and other human dimensions. Investments in behavioral, social and decision science analysis of the science-policy interfaces in the region can provide important information to avoid implementation pitfalls and overcome impediments to action. Therefore, the SAB recommends that behavioral, social and decision sciences are included in the science plan.

One important organizational tool that seems to be missing is a standing science panel, and the SAB recommends that one be established. A well-integrated panel could influence the program's evolution providing assessments of progress in key areas. The science panel's input on design, implementation, monitoring, and evaluation efforts would provide a scientific basis for setting priorities across disparate actions and implementing an adaptive management framework. Members should be independent experts drawn from universities and other research institutions, the private sector, and government agencies, but selected for their expertise and not to represent their agencies. Such a panel could make substantial contributions to the development of both robust monitoring efforts and the adaptive management plan that would rely heavily on well-designed monitoring. In addition to natural and physical scientific expertise, the panel should include the social science disciplines. Behavioral, social, and decision scientists can provide many kinds of insights and advice needed for a program as wide ranging as the GLRI. A diverse panel will offer assistance in targeting education and outreach efforts, and critical insights into the likely workability of particular institutional arrangements
The SAB also recommends the agency explore existing efforts, such as the Puget Sound Institute, the Scientific and Technology Advisory Committee of the Chesapeake Bay Program and the Delta Science Program in the Sacramento-San Joaquin Delta. These efforts serve as potential models for innovative ways to engage scientists in developing and implementing the science plan; supporting and managing scientific assessments and syntheses of critical restoration issues; funding critical gap-filling research; and integrating scientific efforts across projects, focus areas, and themes. The SAB recommends this

approach so that the EPA and IATF may identify and incorporate elements from other plans to tailor a panel and plan that address the needs of the GLRI.

Toxic Substances and Areas of Concern

> *Please comment on the Action Plan's approach for addressing so-called "legacy" contaminants through sediment remediation and toxics reduction efforts. Please comment on whether the Action Plan addresses the reduction of "legacy" contaminants at all geographic scales sufficiently to restore the Great Lakes ecosystem. Are there other actions that we should consider?*

The Action Plan builds on the considerable history and experience studying and controlling toxic chemicals in the Great Lakes, and the Action Plan is clearly directed towards continuing this effort. This is a sound approach.

A major strategy for addressing so-called "legacy" contaminants is the accelerated clean-up of areas of concern (AOCs). Contaminated sediments are often a continuing chronic source of persistent chemicals to Great Lakes biota; therefore, a strategy based on cleaning up contaminant "hot spots" has a high probability of reducing pollutant levels and effects to biota on a regional basis and may have similar success on a basin wide basis. However, as noted in the GLRI, there are a number of other possible impacts from a wide range of chemical contaminants, and the SAB cautions the agency to favor an approach that balances the need to remediate known problems (e.g., polychlorinated biphenyls (PCBs) in sediments) while systematically addressing previously under studied "legacy" contaminants. The SAB notes that the goal of delisting five AOCs by 2014 is laudable but extremely aggressive given historical rates of de-listing, program logistics and system response times.

Performance management of the AOC restoration program is critical, and needs to go beyond program tracking to include scientifically defensible metrics of success that indicate progress of restoration. These evaluation mechanisms are lacking from the Action Plan. The SAB notes that such efforts will require resources that might otherwise go to additional site cleanup actions, and that these resources may be required for many years after the cleanup operations are completed. However, assessing success, partial success, or failure of these AOC clean-up programs is essential to the overall Great Lakes restoration and making future remediation decisions.

> *Please comment on [the Action Plan] approach for assessing and managing the risks posed by chemicals of emerging concern. Are there other actions or specific chemicals of emerging concern that we should consider?*

The Action Plan briefly covers emerging contaminants in a single principal action by coordinating national chemical programs with progress of AOC cleanups and assessing new toxic threats. The choice of which emerging contaminants to focus upon must be led by their potential to affect aquatic species and human health at the levels found or anticipated in the Great Lakes. The SAB notes that the Great Lakes science community has made significant progress to prioritize emerging contaminants, but that further research will be necessary, as few ecotoxicological data exist for these contaminants. Further, recommendations made by the International Joint Commission Work Group on Chemicals of Emerging Concern should be incorporated into the Action Plan.

Invasive Species

> *What are the key scientific data needed in an early detection surveillance network to provide up-to-date critical information for evaluating rapid response options? Does the SAB have any recommendations on demonstrated preventative and control technologies that could be applied to invasive species in the Great Lakes? Are there other actions that we should consider?*

This section of the Action Plan sets out a number of laudable long-term goals and objectives. On the other hand, relatively few specific details are provided to explain what exactly will be done regarding surveillance, and especially about the technologies to contain and/or control invasive species. While the charge to reviewers notes that there are parallel actions under way to address specific invasive species (i.e., Asian carp) and vectors (i.e., ballast water controls) and that the Action Plan focuses on other methods to control invasive species, the SAB finds these parallel issues important and timely. Therefore, the SAB cites some examples developed under these efforts that may be important to consider in developing an early detection surveillance program.

One of the Action Plan's objectives is to develop methodology and protocols for a basin-wide invasive species surveillance program. The SAB agrees with this action and recommends that surveillance and rapid response protocols be coordinated to ensure that the various states, provinces, and other participating organizations use the same methodology and protocols to provide meaningful information exchange and effective rapid response. However, the Action Plan did not provide information about prevention and control technologies for invasive species that are under consideration by the agency. In addition, the charge requested the SAB provide technologies that could be applied to invasive species in the Great Lakes. This is a difficult task given the paucity of information provided. The SAB discussed technologies to control invasive species and provides some general guidance and bibliographic citations. The SAB encourages the agency's consideration. The SAB recommends the EPA develop criteria to evaluate these and additional studies to develop preventative and control technologies. The SAB also recommends that the agency assess known and probable invasive species and prioritize which species present the greatest threats to the Great Lakes.

Nearshore Health and Nonpoint Sources

> *Please comment on the adequacy of the principal actions to address the impacts associated with nearshore soluble reactive phosphorus, Cladophora biomass, and dreissenid biomass. Are there other actions that we should consider? Please comment on the Action Plan's intent to target Great Lakes subwatersheds that show severe signs of stress for focused restoration activities as opposed to a broader approach that targets all watersheds (stressed and currently unstressed).*

While the Action Plan is a five-year plan, it provides a unique opportunity to form the basis for a long-term restoration vision that could guide subsequent renewals of the Action Plan. In order to sustain that long-term vision, strategic planning that includes mechanisms for assuring sound science and measurement of progress must be performed in order to meet the goal to restore nearshore health and reduce impacts from nonpoint source pollution. How future development and climate change will affect the Action Plan targets needs to be considered in more detail. Global climate change needs to be added as a major driving force. The Action Plan does not address this in an integrated fashion, and further detail acknowledging this important new factor and how restoration may be affected is needed.

The Action Plan's intent to identify, map, and target the Great Lakes subwatersheds that show severe signs of stress for focused restoration activities is the best strategy for producing measurable positive outcomes. Overall, severely stressed systems usually respond positively and measurably to stressor relief. This is particularly true for stresses associated with excess nutrient loadings. While the focus on stressed watersheds and subwatersheds is good, the SAB notes that the selection process needs to be more understandable and transparent and recommends that, at a minimum, a complete list of stressed watersheds by Lake be included.

Reducing soluble reactive phosphorus loads is one of the more important measures of progress as it is a key stressor throughout the Great Lakes ecosystem. However, this and other metrics must be developed with targets that are statistically significant and scientifically meaningful. Within this focus area, it is not clear, how metrics and their target quantities were developed, or if the quantities reflect significant or scientifically meaningful or measurable improvement. A critical evaluation of what is a significant target to achieve in restoration is needed here, and in other focus areas. The SAB recommends EPA engage in strategic planning to develop mechanisms that assure sound science, performance measures and rigorous monitoring to provide an understanding of how changing climate, water level variation and nonpoint sources of stresses impact the Great Lakes.

As identified in the objectives for this focus area, monitoring programs apparently will be a strong part of this part of the Action Plan as restoration progress can best be measured by status and trend analysis. The adaptive management approach proposed by the Action Plan also requires adequate and timely monitoring, to enable subsequent evaluation and justify course corrections for program priorities. Monitoring will also be needed to assess global change impacts on the Great Lakes and how global, regional, and subwatershed factors interact. The SAB recommends that sufficient funding be allocated to monitoring the eventual success (or lack thereof) of the Action Plan's projects.

Habitat and Wildlife Protection and Restoration

> *Does the SAB have any recommendations on actions to increase "resiliency"? Are there additional ecological elements or measures that should be considered to better improve resiliency or buffering capacity and our progress in habitat restoration and ecosystem protection projects? What about actions in the other focus areas?*

Achieving the five goals of this focus area will require the development and application of a range of critical management actions and sound decision-making. The SAB finds that restoring resiliency is an appropriate goal for this focus area. However, the Action Plan does not clearly articulate the concept of resiliency in the context of the GLRI. In addition, adequate information was not presented to judge whether the actions associated with Habitat and Wildlife Protection and Restoration would be effective at attaining enhanced ecosystem resilience in the face of disturbances. The SAB recommends that a clear, working definition of resiliency be developed along with metrics that can be used to track changes in the resiliency over time as restoration measures are implemented.

The SAB was asked to identify additional ecological elements and measures to improve resiliency that the agency should consider as it evaluates the progress of the Action Plan and plans next steps. The SAB notes that there are certain ecosystem characteristics that have been shown to contribute to ecosystem capacity to resist state changes in the face of disturbances. This capacity is frequently what is meant by resilience. Restoration actions that enhance these ecosystem characteristics, therefore, should contribute

to resilience. The SAB urges the agency to consider the recommendations presented in this section of the Advisory Report and incorporate them as appropriate.

> *The Action Plan broadly defines "restoration" to encompass physical, biological, and chemical functions and processes. Are the actions listed in the Action Plan "restoration" actions?*

Most of the actions listed under this focus area are "restoration" actions. The more relevant question for the GLRI is whether these actions will enable the attainment of the Action Plan's objectives. The SAB finds that the italicized parts of the principal actions may be more appropriate as goals for the protection and restoration of habitat and wildlife. Actions that are more specific would further describe the efforts to achieve these goals. This change would represent the first step towards addressing the ambiguity in the links between vision, long-term goals, objectives, and principal actions in the Action Plan. The SAB recommends the formal integration of an adaptive management program with clearly articulated goals and explicit statements of what the program seeks to accomplish.

Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships

> *Does the SAB have any recommendations of critical data gaps for which programs or tools should be implemented in the other focus areas? Please comment on the Action Plan's approach for enhancing coordination and collaboration among Great Lakes partners to address key scientific issues.*

The topics addressed under this diverse and disparate focus area in the Action Plan are important to the success of the GLRI. The SAB concurs that overall assessment and a management framework are necessary for the GLRI, and provides recommendations on how best to achieve this in Section 3.1. In order to develop the information needed to evaluate the GLRI, EPA and the IATF must have sufficient information to conduct analyses of the success of individual projects and across the focus areas. The SAB concludes that the monitoring and other elements of this focus area may be better addressed in the specific focus areas noted above, rather than as a combined focus area. The SAB also recommends that, instead, a strategic assessment and adaptive management plan to implement monitoring, synthesis and integration across the focus areas be included in the Action Plan in this focus area to bolster the accountability goals of the GLRI. The SAB further provides recommendations to achieve greater accountability, considerations to increase collaboration among partners, and to enhance educational and outreach opportunities.

Combining the accountability, monitoring and evaluation actions together into a single section may come at the cost of them being developed separately from the focus area or in a cursory manner. The Action Plan addresses a wide variety of management activities and seeks to coordinate them through an adaptive management process. Without an explicit representation of the management layer, however, the GLRI faces substantial challenges implementing performance evaluation based on principles of adaptive management. Monitoring and evaluation in this focus area should provide for the analyses of focus area integration and synthesis of actions to achieve overarching goals and the accountability of the GLRI as a whole. These analyses should also address uncertainties or data gaps. Additionally, measures of progress need to identify benchmarks for expected outputs and outcomes. The GLRI should consider using an overall framework to evaluate the integration, synthesis and coordination of all program elements across all the focus areas. This type of analysis can be used to identify hotspots, areas of improvement, or highlight the success or failure of best management practices (BMP), both in terms of location or scale.

Without an accountability framework, the GLRI will do little to advance coordination and collaboration among Great Lakes partners to address key scientific issues.

The Action Plan lists the federal department level members of the Interagency Task Force and Regional Working Group that developed the Action Plan. It also alludes to approximately 200 organizations at the federal, state and sovereign tribal nation levels. While it is clear that a great many stakeholder organizations are involved in the program, it is not apparent which are the key parties, or what their interests and their roles are within the Action Plan. A functional approach to explicit partnerships needs to be described; what they are (e.g., science or outreach), and where they fit within the other focus areas is needed.

> *The Action Plan identifies the need to educate future generations to extend restoration efforts. Please comment on the Action Plan's approach to incorporate Great Lakes stewardship into environmental education curricula.*

The SAB agrees that there is a need to enforce the incorporation of educational and outreach activities as an overarching theme on all projects. Outreach and education activities provide highly laudable goals, but overall the Action Plan lacks a strategic approach to achieve the stated objectives. Measures of progress were ambiguous and will be difficult to track. Currently, there are no specific indications in the Action Plan of the amount or type of resources allocated to these aspects of the program. The SAB recommends that EPA and its partners should consider explicit peer review criteria, in parallel with the peer-review process of the NSF, for all activities (internally and externally funded) that include education and outreach with significant weighting as it implements projects under the GLRI. The criteria should advance the knowledge and understanding of Great Lakes issues, promote teaching, increase participation of underrepresented groups, and broadly disseminate information to enhance scientific and technological understanding of the public.

2. INTRODUCTION

In 2009, President Obama proposed the Great Lakes Restoration Initiative (GLRI) to "protect and restore the chemical, biological, and physical integrity of the Great Lakes," and Congress appropriated $475 million in new funding for the effort. To guide the GLRI, U.S. Environmental Protection Agency (EPA) and its Federal partners, through the Great Lakes Interagency Task Force (IATF), developed a comprehensive multi-year Action Plan that describes how the Initiative will be executed from 2010 through 2014. The GLRI Action Plan identifies goals, objectives, ecological targets, and specific actions for five major focus areas:

- Toxic Substances and Areas of Concern – focus on pollution prevention and cleanup of the Areas of Concern (AOCs) and Beneficial Use Impairments (BUIs) in the Great Lakes;
- Invasive Species – develop and implement measures to control invasive species to maintain the health of the Great Lakes ecosystem;
- Nearshore Health and Nonpoint Source Pollution – identify priority watersheds for reduction in polluted runoff from urban, suburban and agricultural sources;
- Habitat and Wildlife Protection and Restoration – provide an assessment of Great Lakes coastal wetlands and strategically target restoration and protection efforts for wetlands and other habitat restoration; and
- Accountability, Education, Monitoring, Evaluation, Communication and Partnerships - implement goal- and results-based accountability measures, learning initiatives, outreach and strategic collaborative partnerships.

The GLRI, through EPA, conducted two rounds of requests for grant proposals to select restoration projects and related activities. As of March 2011, over $418 million in projects to restore the Great Lakes was awarded. In addition to federal partners, 286 grantees represent state, local and tribal government, nonprofits, and universities. EPA is currently preparing for a third round of proposals based on the Action Plan.

In the 2010 Department of the Interior, Environment, and Related Agencies Appropriations Act, Congress specified, "conferees expect [EPA] to establish a process that engages an independent, scientific panel to review the scientific credibility of the Action Plan to optimize the likelihood of successful restoration at appropriate scales." In order to meet this requirement, the EPA Great Lakes National Program Office has requested that the Science Advisory Board (SAB) review the *Great Lakes Restoration Initiative Action Plan FY 2010- 2014* (US EPA 2010), hereafter referred to as the "Action Plan."

The SAB formed an ad hoc panel, the Great Lake Restoration Initiative Action Plan Review Panel, to conduct the review. The Panel met on July 12-13, 2011, to hear EPA technical presentations and public comments, and to discuss responses to the Charge to the SAB (Appendix A). The Panel held a follow-up public teleconference on September 16, 2011, to discuss an initial draft report. The chartered SAB conducted a quality review of the Panel's report on December 6, 2011. Public comments were received and considered throughout the advisory process.

The Charge to the SAB included questions on the overall framework of the Action Plan and specific questions on each of the five focus areas. The EPA requested recommendations and advice to further develop the Action Plan and increase the collaborations among members of the Great Lakes community

to meet GLRI goals as progress was made on focus area projects. The full charge is included as Appendix A and relevant charge questions are included within each section of this report.

The SAB reviewed the charge questions, available information from the GLRI, and projects initiated at the time of the review. Projects initiated in the first two rounds of the GLRI were still underway and not yet near completion. The agency is developing additional mechanisms and tools to evaluate the progress of restoration described in the Action Plan. The SAB recognizes that the GLRI is well underway at this point (approximately two years into a five-year plan) and that it is a dynamic program that needs to account for a changing physical, social, geographic, and environmental landscape at vast scales. GLRI Projects are in different stages of completion simultaneously across the focus areas. Projects completed in one focus area may create an opportunity or need for a restoration project in another focus area. The size and complexity of the GLRI preclude a program-wide stop, evaluate and restart management approach. These considerations necessitate a programmatic ability within the GLRI to reprioritize efforts as needed when information becomes available from individual projects without impeding the progress of restoration in the Great Lakes.

Based on the status of projects, the project information available, and the charge questions the SAB is providing advice to guide future decisions and provide direction for the next steps in the GLRI. The SAB responses are geared toward assisting the EPA and IATF to evaluate the results of the restoration projects as they are completed and synthesize the data and information across the wide-ranging program. The recommendations identify tools, mechanisms, approaches and the types of information needed to make decisions on future restoration projects and apply adaptive judgment to change priorities to meet the GLRI goals. The SAB encourages the agency to move forward using the best available science to restore the Great Lakes and develop the tools and mechanisms needed to guide the program on a successful course based on the advances made under the GLRI.

3. RESPONSE TO CHARGE QUESTIONS

3.1. Overall Structure of the GLRI Action Plan

Charge questions 1, 2, and 3 address overarching issues and request that the SAB comment on the overall scope of the Action Plan. The SAB provides comments and recommendations on (1) the consistency of Action Plan with previous plans and their science, (2) how to identify methods to enhance the accountability of the program, and (3) actions the agency could take to improve and clarify the GLRI and the Action Plan as it implements further actions. The specific questions and SAB responses are detailed below.

3.1.1. Consistency with Other Great Lakes Collaborative Plans and Science

Question 1 - As presented in the scientific background document, the goals, objectives, measures, and actions of the Action Plan are based on the best available scientific analysis of environmental challenges and are consistent with the multitude of strategic plans and governing structures for the Great Lakes. Since the Action Plan is an "action driver," we are most interested in the SAB's recommendations on the identified principal actions to achieve progress.

Question 1a: Are the principal actions proposed in the Action Plan consistent with the actions and/or recommendations of the previous collaborative plans and strategies for the Great Lakes (e.g. Great Lakes Regional Collaboration Strategy) as identified in scientific background document and other information of which you are aware?

In their current form, it is not possible for the SAB to determine if the Action Plan and Scientific Background document provided to the SAB (U.S. EPA 2011) are based on best available science or that they are fully consistent with other strategic plans. The Action Plan was written for a general audience, and does not contain the breadth or detail that would be required to make such a determination. Similarly, the Scientific Background document cites previous collaborative plans and strategies but does not provide direct linkage between projects in the Action Plan and those citations. SAB expertise and understanding of issues facing the Great Lakes, examination of past strategic plans, and familiarity with regional workshop reports identified the scientific bases and foundations of many of the Action Plan's principal actions and goals. Therefore, the SAB supports the conclusion that enough is known about the issues confronting the Great Lakes, as well as the underlying causes and potential remedies, to take initial action and agrees that the Action Plan identifies the important first steps to be undertaken.

On the surface, the Action Plan appears consistent with previous plans and strategies, reflecting a continuation of collaborative planning in the region. While continuity in planning is good, such consistency does not guarantee sufficiency and, in some cases, it fails to promote the innovation that comes from strong connections between research and action – a connection that is not evident in the Action Plan. In addition, while the actions are consistent with many aspects of previous efforts, very few of the research, monitoring and integrative assessment needs identified in the earlier documents (e.g., SOLEC 2009) are carried through to the Action Plan. Some of the more important gaps are addressed in more detail in the following sections.

The SAB also concludes that the relationship between the Action Plan and lake-specific goals developed through the EPA-facilitated Lake Management Plan (LaMP) processes and the Great Lakes Fishery Commission-facilitated Lake Technical Committee processes is unclear. Specific

water-quality, fishery and habitat goals have been established through extensive stakeholder processes (i.e., scientific community, policy makers and members of the public) and it is important that the Action Plan support achieving those goals. Based on the material provided to the SAB, it is not clear whether or how the Action Plan will support these goals.

The SAB recommends that EPA outline explicitly how the Action Plan supports the Lake-wide goals and objectives established by the LaMPs and Fishery Technical committees, including their research, monitoring, and assessment recommendations.

Question 1b: Are there other actions that we should consider for inclusion in the Action Plan that will better achieve the goals of the Action Plan?

While science is only one basis for taking particular action (e.g., others can include availability of matching funds, state and local priorities, and partner development), evaluation of the effectiveness of actions taken is a scientific process and needs to be included more explicitly within the Action Plan. For a program as large, complex, and hopefully sustained as the GLRI, it is critical to understand, measure, and track the impacts of initial actions and make adjustments as needed within an adaptive management framework. However, the SAB notes that, while monitoring appears to exist for some projects, overall there is insufficient monitoring, assessment, and evaluation to support adaptive management. Science-based tracking and evaluation should be considered as important as direct "restoration actions," and such efforts should be considered integral to the Action Plan.

Adaptive management is a well-established concept in environmental management. Implementation of an adaptive management framework will require systematic and continual integration of design, management, and monitoring, which would enable EPA and the IATF to make informed adjustments and adaptations in the restoration efforts in the Great Lakes. The SAB recommends that EPA reframe the Action Plan using an adaptive management framework that includes support for measuring progress and making midcourse corrections, if necessary. This is discussed further below in the recommendation related to the need for an integrated, science-based framework that will bolster the Action Plan and a science advisory panel.

The SAB also notes that climate change is not addressed in the Action Plan. Restoration efforts at this magnitude and with the attending complexities will play out over time scales where changes in air and lake temperature, amount and patterns of precipitation, ice cover and lake levels are likely to occur and could significantly alter restoration effectiveness. Further, it is not clear if decadal trends of these properties have been taken into account while developing the actions. Therefore, the SAB recommends that EPA include efforts to explicitly consider the potential impacts of climate change on restoration over the lifetime of the projects in the Action Plan.

3.1.2. Tracking GLRI Projects and Accountability

<u>Question 2</u> – As presented in the scientific background document, we have developed and currently operate the Great Lakes Accountability System (GLAS)[3] as the primary mechanism for collecting information to monitor and report on GLRI progress. GLAS is still a work-in-progress at this time and it is not ready for external review. However, given the scope of the Action Plan

[3] Available online at http://glri.us/projects.html

and the nature and types of projects funded under the GLRI, we are interested in the SAB's recommendations on how best to track the progress and accountability for a large ecosystem restoration program. What critical environmental elements, endpoints, or other measures would you include to those identified in the Action Plan?

The SAB recognizes GLAS is a work in progress, but notes that the current system appears to be primarily an accounting – as opposed to accountability – system; that is, a system that tracks where the funding is going and who will be responsible for those projects. This is important information and the SAB appreciates the transparency. However, it should be noted that at the time of the review, less than half the agencies had entered information into the system. Some of the entries with multiple organizations appear to lack specificity on which organizations are the recipients of funding and ultimately responsible for the action.

There is a potential to track outcomes and outputs for the projects in this system, and if pursued carefully GLAS could provide a solid basis for programmatic evaluation across the focus areas. However, the SAB finds it is likely not possible to integrate outcomes across hundreds of projects, essential for evaluation at the theme (e.g., toxic substances), lake, or system level, and for evaluation of the overall GLRI program. GLAS is probably not an appropriate vehicle for this type of integration, as it appears designed to function at the project level, and the diversity and granularity of those projects would make integration within GLAS difficult. An effective integrative assessment will require additional effort, perhaps building upon information reported in GLAS.

Comments on the adequacy of the identified endpoints and measures will be addressed more specifically in responses to focus area charge questions below, but overall the measures often appear naïve or narrow, and without proper context or benchmarking. Measures should be cognizant of historical context and variability. Metrics to identify change or progress toward restoration should be developed such that they can be detected statistically, are scientifically significant, and attributed to management actions. Otherwise, it will not be clear when or if a measure of progress is achieved. This requires an understanding and explicit documentation of both historical baselines, the variability in the metric, the universe within which the metric is couched and the expected effect of the management action.

Most metrics identified in the Action Plan measure outputs as opposed to outcomes. These distinctions are important for reporting under the Government Performance and Results Act. However, the agencies have an opportunity to be innovative in environmental outcome evaluation and reporting. The agencies should consider continuing to report the more typical project-level outputs through GLAS, but also outline for the Office of Management and Budget (OMB) an innovative program for evaluating and reporting environmental outcomes integrated across projects at the theme, Lake, and program level. By investing a modest portion of the overall budget on an innovative, science-based, integrated outcome evaluation program, there is the potential for the GLRI to move toward its restoration goals, and provide a new path toward evaluation and reporting restoration goals at more meaningful levels.

The SAB recommends that EPA implement a new, focused, and perhaps independent scientific and integrative outcome evaluation process. This is discussed further below in the recommendation related to the need for a science plan, review panel, and a new independent entity.

3.1.3. Recommendations to Improve or Clarify the Action Plan

Question 3 – Please comment on the overall scope and framework of the Action Plan and its ability to organize environmental issues in a way that directs restoration actions. Does the SAB have any specific recommendations on how to improve or clarify the Action Plan?

Bolster the Action Plan with a Science-based Framework

The overall scope and framework of the Action Plan addresses many of the important issues and problems. However, the SAB is concerned that, while EPA may be able to report on project-specific outputs and some outcomes, it will not be in a position to effectively measure and report on progress toward the overall goal of restoring the Great Lakes. The actions are organized primarily around stresses and mostly narrow geographies, as opposed to being organized at basin- or lake-scale goals that take into account multiple stresses. This is not to say that the specific actions will not add up to larger-scale restoration. Rather, because the GLRI is not organized around these larger goals (see above) and because there is not sufficient funding for monitoring and scientific evaluation at those scales, the GLRI will not know if those goals are being approached effectively. The GLRI lacks a larger-scale framework and a scientific evaluation plan to accompany the Action Plan.

Overall, the GLRI and its Action Plan would be greatly improved by a comprehensive science-based framework that provides a foundation of past and current scientific understanding, integrates restoration across focus areas, and documents the scientific basis to evaluate GLRI actions. Herein, we refer to this framework as a "science plan." This science plan will identify restoration goals, how projects may meet those goals and guide the development of future iterations of the Action Plan past 2014. A science plan should also demonstrate and ensure the following key elements are addressed:

- Provide the logic supporting how selected projects support the Action Plan;
- The timely availability of monitoring data; and
- Assessment of project outcomes, both positive and negative.

The SAB recommends that EPA work with natural, physical, and social scientists and engineers from government, academia**,** NGOs, and industry to create a forward-looking science plan that, when coupled with the Action Plan, creates a conducive framework for adaptive management.

A science plan for the GLRI would outline a plan and funding requirements for (1) integrating across stresses and projects; (2) creating opportunities for restoration innovation and increases in efficiency and effectiveness; (3) identifying and overcoming key impediments to progress; (4) monitoring, assessment, and evaluation at project, Lake, and system levels; and (5) increasing transparency of decision making processes. Each element is described briefly below.

- *A Need for Integration* – While the symbolic notion of thinking of the Great Lakes as one ecosystem is often helpful, from the perspective of understanding, managing, and protecting them – the "Great Lakes" is not an ecosystem. As currently constructed, the Action Plan is focused around stress issues (e.g., toxic substances) and most of the language suggests the Great Lakes can be viewed as a single ecosystem. The individual Lakes are as different from each other as the Everglades, Chesapeake Bay, Puget Sound, and Georges Bank are from each other, and it would not be logical to think of managing them as a single ecosystem. Each Lake has unique characteristics, stresses, and likely

restoration goals, and it would be more effective, especially in terms of measuring and reporting progress, if the goals and objectives were lake-specific. There already is a basis for this approach. Each Lake has a Lake-wide Management Plan (LaMP) or the equivalent (Lake Huron is treated differently). LaMPs are developed through stakeholder engagement, focused on water quality, and have shown a recent movement toward broader ecosystem goals. Each Lake also has a set of fisheries goals, established through the Lake Technical Committees facilitated by the international Great Lakes Fishery Commission and engaging all appropriate stakeholders. Recent efforts have also moved toward habitat and broader ecosystem contexts. A science plan developed for each Lake would be helpful in focusing the Action Plan at lake scales.

Organizing a science plan around individual Lakes also may help provide a better overall context for actions to restore the Great Lakes. A set of clearly defined objectives should be developed to understand and assess the collective impacts of the myriad projects. Meeting those objectives would constitute progress in the restoration of the Great Lakes. The Action Plan currently addresses a series of critical stresses (e.g., toxic substances, nonpoint source pollution, and habitat loss) with limited recognition of the potential for synergistic or antagonistic actions among the silos potentially created by the focus areas. It may also make sense to reshape the Action Plan such that "habitat restoration" becomes an overarching goal and strategy, and each of the remaining stress-focus areas is redesigned to support habitat restoration. This would be more consistent with the ecosystem management paradigm often discussed in Great Lakes management circles and cited in the Great Lakes Water Quality Agreement, and would allow for integration across the focus areas (IJC 1988 and 2006).

- *An Opportunity for Innovation* – The SAB recognizes there is an extensive backlog of restoration projects in the Great Lakes region that need to be pursued, and supports the agenda of putting primary emphasis on implementing those projects. However, the level of sustained funding that is in place and anticipated provides the agencies with an opportunity to be revolutionary, as opposed to evolutionary, in its implementation. This level of funding should not only satisfy the myriad long-standing needs, but also provide a new model for how large-scale restoration can be effected – an opportunity for innovation. This argues for a place in the science plan for modest investments in improving the understanding of the ecosystems that are being restored and developing new restoration technologies, methods, and approaches.

- *Understanding and Overcoming Impediments* – The current plan suggests that restoration and protection can be accomplished through natural science and engineering processes alone. This is rarely the case in environmental decision-making. Significant roadblocks to action can come from social, economic, political, and other human dimensions. Investments in behavioral, social and decision science analysis of the science-policy interfaces in the region can provide important information on avoiding implementation pitfalls and overcoming impediments to action. Therefore, the behavioral, social and decision sciences should be included explicitly in the science plan.

- *Scientific monitoring, assessment, and evaluation* – The science plan should review and refine environmental outcome measures for each project. It should outline the requirements for and approaches to monitoring, assessing, and evaluating those projects

in the context of the goals developed at large scales. While efforts at the project scale should be retained and funded within each project, the science plan also should develop an approach for monitoring, assessing, and evaluating efforts across projects, focus areas, and perhaps Lakes.

- *Increasing Transparency* – While GLAS provides a transparent identification of the funding allocation and projects selected, it is not clear to the SAB how priorities among focus areas or projects were established. A technically sound prioritization process that considers the ecological value of potential restoration efforts is essential to program success. While it is clear that ecological value is only one metric that needs to be considered in assigning priority and that social, economic and political elements also must be factored, the lack of a clear description of the process used for generating relative ecological values for the GLRI projects underlines the need for the science plan. In addition, the EPA should peer review all project proposals using criteria such as those employed by the National Science Foundation (2011a and 2011b).

Independent Science Advice and Implementation

The SAB recommends that EPA establish a science advice and implementation structure that ensures routine expert advice from government, academic, industry, and NGO sectors on the science plan, as well as an external entity for implementing key elements of the science plan.

- *Independent Science Advisory Panel* – This panel would be comprised of senior level natural, physical, and social scientists and engineers from government, academia, industry, and NGOs without conflicts of interests or stakes in particular projects. This advisory panel would be convened every 1-2 years to review the science plan and restoration progress, evaluate new scientific findings, and recommend appropriate adjustments to the action plan and science plan. Government and other scientists to staff the science advisory panel is an additional consideration. Support to develop the science plan, manage scientific assessments and syntheses of topics of management and restoration concern, fund critical gap-filling research identified in the science plan, and coordinate scientific efforts to integrate across projects, focus areas, and themes could come from EPA, the IATF, or a support staff could be created outside government.

The SAB is familiar with and supportive of advisory structures and institutes established to provide the scientific foundation for restoration efforts. The Puget Sound Institute, the Scientific and Technology Advisory Committee of the Chesapeake Bay Program and the Delta Science Program in the Sacramento-San Joaquin Delta are some examples. These efforts serve as potential models for innovative ways to engage scientists in developing and implementing the science plan; supporting and managing scientific assessments and syntheses of critical restoration issues; funding critical gap-filling research; and integrating scientific efforts across projects, focus areas, and themes. The SAB recommends that EPA consider aspects of these models in implementing this approach so that the EPA and IATF may identify and incorporate elements from other plans to tailor a panel and plan that addresses the needs of the GLRI.

In addition, in response to an early draft of this report, EPA requested advice on the level of funding that would be appropriate for supporting scientific monitoring, assessment, and evaluation. In other major restoration efforts, the percentage of funding dedicated to support

monitoring, assessment, and evaluation of individual projects appears to range between 5 and 50 percent depending on the scope, effort, and parameters monitored.

While it is difficult *a priori* to determine the right value for the GLRI, and since at least some scientific monitoring, assessment, and evaluation is imbedded in the individual focus areas, the SAB recommends that a sufficient percentage of the overall GLRI budget explicitly be allocated annually for these tasks. In addition, the SAB urges that funds be made available to implement the recommendations for a science plan, science advisory panel and to provide the resources needed to support and manage tasks assigned to the science advisory panel.

3.2. Toxic Substances and Areas of Concern

Focus Area 1 of the Action Plan addresses toxic substances, with emphasis on continuing or enhancing long-term declines in legacy pollutants (Question 4) and on managing emerging contaminants (Question 5). The Action Plan builds on the considerable history and experience studying and controlling toxic chemicals in the Great Lakes, and the Action Plan is clearly directed towards continuing this effort. This is a sound approach. However, as discussed above, the SAB finds that both the overall GLRI and the toxic substances focus area would benefit greatly from a strategic science plan that prioritizes actions and assists in choosing remediation sites. Actions linked to the goals and objectives within the strategic planning for the toxics focus area should be based on a risk characterization that reflects current and anticipated future conditions in the Great Lakes.

3.2.1. Legacy Contaminants

Question 4 – The presence, significance, and trends of many historically-regulated (or "legacy") contaminants in the Great Lakes are well-documented. Through the Action Plan, we are working to fully implement and enhance existing programs to eliminate releases of many of these contaminants. For example, the GLRI is working to accelerate the rate of sediment remediation in Areas of Concern (AOCs) through the Great Lakes Legacy Act[4] among other programs. Similarly, the Action Plan calls for initiating strategic pollution prevention and toxics reduction efforts to minimize releases and emissions of many of these same contaminants.

Question 4a: Please comment on the Action Plan's approach for addressing so-called "legacy" contaminants through sediment remediation and toxics reduction efforts.

The Action Plan's stated goal of delisting five AOCs by 2014 is commendable but extremely aggressive given historical rates of de-listing, program logistics, and system response times. The SAB recommends that this measure of progress in the Action Plan should be clarified – is the goal to delist five AOCs by 2014 or is it to complete the management actions thought necessary to lead to a delisting? Both are stated in the Action Plan. Some quantitative analysis should be included on the implications for other GLRI toxics measures of progress if the goal is not met by 2014. Stated another way, what is the incremental benefit to the Great Lakes derived from each successive AOC delisting, and what extent of AOC clean-up (number of sites, intensity of clean-up at each site) will be required to meet the toxics goals? Further analysis is needed to explore how the toxics measures of progress work together – for example how does delisting a given AOC contribute to the goal of reducing fish tissue PCB concentrations and therefore the number and frequency of fish consumption advisories?

[4] Funding under the Great Lakes Legacy Act is now part of the GLRI.

Over the past decades, the record of delisting Great Lakes AOCs is poor, with only four AOCs cleaned up in approximately 20 years, due in part to the large cost of implementing source controls and dredging, disposing, and capping of contaminated sediments. Even with the resources available through the GLRI, not all Great Lakes AOCs can be addressed immediately, and a rational method to prioritize and rank sites is needed. The Action Plan and supporting documents should provide further detail describing how the GLRI prioritizes the order of clean-up activities. Prioritization of AOCs should be clearly linked to the remedial action plans already established for each AOC in a manner that integrates the stated objectives in the Action Plan. The SAB recognizes that the selection of AOC projects is often driven by factors beyond science, and includes the availability of willing local partners and matching funds. However, there should be an independent, science-based ranking of AOCs to determine which site clean-ups will best assist in meeting the GLRI toxics goals.

Question 4b: Please comment on whether the Action Plan addresses the reduction of "legacy" contaminants at all geographic scales sufficiently to restore the Great Lakes ecosystem.

A major strategy for addressing so-called legacy contaminants is the accelerated clean-up of AOCs. Contaminated sediments are often a continuing chronic source of persistent chemicals to Great Lakes biota. Therefore, a strategy based on cleaning up contaminant hot spots has a high probability of reducing pollutant levels and effects to biota on a regional basis and may have similar success on a basin wide basis. However, as noted in the Action Plan there are a number of other possible impacts from a wide range of chemical contaminants, and the SAB cautions that the agency favor an approach that balances the need to remediate known problems (e.g., polychlorinated biphenyls (PCBs) in sediments) while systematically addressing previously understudied legacy contaminant issues. Such balance could be achieved by conducting a rigorous hazards evaluation within an adaptive management framework.

Question 4c: Are there other actions that we should consider?

The SAB identified several additional actions the agency should consider as it implements the Action Plan. Rigorous analysis of the anticipated and realized ecological benefits of proposed AOC cleanups should be conducted using established methods in a transparent manner. This includes both evaluative models relating the magnitude of benefit to the extent of proposed clean-up before the restoration as well as a post-clean up effectiveness assessment. These evaluations should include the anticipated and realized benefits to the AOC area itself as well as the adjacent Great Lakes open water. Both types of evaluation should include estimations of the links between reduced sediment concentrations and biological endpoints (e.g., tissue residues or biological effects), and the overall impact of the AOC delisting on contaminant body burdens in Great Lakes fish (and therefore fish consumption advisories).

Performance management of the AOC restoration program is critical, and needs to go beyond program tracking to include scientifically defensible metrics of success. The SAB recognizes that this work will require resources that might otherwise go to additional site clean-up actions, and that these resources may be required for many years after the clean-up operations are completed. Nonetheless, assessing success, partial success, or failure of these AOC cleanup programs is essential to improving the Nation's ability to clean up the Great Lakes.

The Action Plan has few biologically based indicators and the current SOLEC (2009) analysis includes external lesions in fish as the sole biologically based effects indicator. Development of

additional, biologically-based effects monitoring is required. Many human health indicators and environmental health indicators were not evaluated in the 2009 SOLEC report due to lack of data and this gap must be addressed by GLRI-supported projects. The toxics measures of progress are focused on PCBs and seem to underemphasize the role of mercury despite the greater contribution of the latter to fish consumption advisories across the Great Lakes basin **(**IJC 2004; U.S. EPA 2003; IJC 2009a). Polycyclic aromatic hydrocarbons (PAHs) also warrant more defined actions in the GLRI, given recent findings showing the effects of low levels of these compounds on early life stages of a wide variety of fish species (Incardona et al. 2004; Carls et al. 2008; Incardona et al. 2009; Hicken et al. 2011; Turcotte et al. 2011). The SAB recognizes that focusing on PCBs will likely have a "multiplier effect" for other compounds (e.g., they too will be reduced) and that other initiatives exist to address some of the other persistent, bioaccumulative and toxic (PBT) compounds in the Great lakes. However, the Action Plan does not address the nature of these efforts in any detail.

3.2.2. Chemicals of Emerging Concern

Question 5 – The Action Plan also acknowledges the threats posed to the ecosystem by chemicals of emerging concern, such as flame retardants, surfactants, pharmaceuticals and personal care product constituents. To devise and implement effective control strategies, EPA and the other federal agencies are coordinating efforts to identify significant sources and impacts of new toxics to the Great Lakes ecosystem through robust surveillance and screening.

Question 5a: Please comment on our approach for assessing and managing the risks posed by chemicals of emerging concern.

The Action Plan briefly considers emerging contaminants in a single principal action. This action links measuring progress of AOC clean ups and assessing new toxic threats. The Action Plan states that the program will develop an approach of comprehensive monitoring and assessment to identify significant sources and impacts of new toxic substances to the Great Lakes. Based upon this surveillance, the agency will "devise and implement effective control strategies" and coordinate with efforts to update the Toxic Substances Control Act (page 21). The SAB agrees that leveraging multiple statutes and regulatory mechanisms is an appropriate action under which to consider emerging contaminants. However, the SAB cannot determine if these actions are sufficient given the presentation in the Action Plan and provides additional commentary in its response to Question 5b.

Question 5b: Are there other actions or specific chemicals of emerging concern that we should consider?

The SAB notes that the Great Lakes science community has made significant progress towards prioritizing emerging contaminants by using the Muir and Howard (2006) analysis. Further details about how this work is influencing basin-wide monitoring and risk assessment programs are needed in the Action Plan. GLRI requires a scientifically sound framework to address and prioritize emerging contaminants, in order to avoid pursuing an unwieldy number of chemicals. The SAB notes that the approach developed by the U.S. EPA Midwest Ecological Research Laboratory for personal care products and pharmaceuticals (Ankley et al. 2005**)** is an example of such a framework. The choice of which emerging contaminants to focus upon must be led by the contaminants' effects on aquatic species and human health at the levels found or anticipated in the Great Lakes. With a few important exceptions (brominated flame retardants, fluorinated surfactants), consumption of Great Lakes fish is not likely to be a major health risk exposure

pathway for emerging contaminants. Unfortunately, for many of these chemicals there is little or no ecotoxicological information, making a ranking of emerging contaminants difficult. Further research with Great Lakes species, coupled with biological effects-monitoring, will be required.

Recommendations made by the International Joint Commission Work Group on Chemicals of Emerging Concern (IJC 2009b) should be incorporated into the GLRI Action Plan. These include:

- Improved bi-national cooperation and coordination on the underlying principles and processes by which emerging chemicals will be prioritized and then on the design and implementation of monitoring programs that set common objectives;
- Development of appropriate tools to adequately assess the exposures and impacts of emerging chemicals in the Great Lakes;
- Targeted studies to resolve significant gaps in the current state of the science;
- Further emphasis on moving upstream and adopting sustainable solutions to the design, production and consumption of chemicals of emerging concern;
- Strengthening pre-manufacturing notification and transparency in chemical production and use; and
- Adopting innovative approaches to chemical management in the Great Lakes that go beyond one-by-one chemical approaches.

Finally, the Action Plan and associated documents should recognize the interplay between all current and emerging stressors, including physical stressors such as increased UV penetration and those resulting from climate change (e.g., timing and magnitude of annual water temperature cycles, and acidification).

3.3. Invasive Species

Focus Area 2 of the Action Plan sets out a number of laudable long-term goals and objectives designed to eliminate and control invasive species. However, the Action Plan offers relatively few specific details as to what exactly will be done regarding surveillance, and, in particular, about the technologies that will be developed, refined, and employed to contain and/or control invasive species. The Charge to the SAB notes that there are separate, parallel actions under way to address specific invasive species (i.e., Asian carp) and vectors (i.e., ballast water controls), and seeks recommendations on additional technologies for detection and surveillance of invasive species. The SAB finds these parallel issues important, timely, and of value to the Action Plan. Therefore, the SAB cites some examples developed under these parallel efforts, as well as others, that may be important to consider while developing an early detection surveillance program or implementing other actions for early detection and species removal.

Question 6 – Invasive species have dramatically altered the Great Lakes ecosystem. New species continue to threaten the Great Lakes. The Action Plan identifies a set of actions intended to eliminate new introductions, control the spread, and minimize the risks of invasive species. EPA has initiated separate reviews for some of the principal actions in this focus area. Ballast water technology is being reviewed by a separate SAB panel. The Asian Carp activities are being addressed through the Asian Carp Control Strategy Framework that is being elevated to a program unto itself in coordination with GLRI. Therefore, we are asking the SAB's for advice and recommendations on the remaining actions to address invasive species.

3.3.1. Early Detection and Response

Question 6a: What are the key scientific data needed in an early detection surveillance network to provide up-to-date critical information for evaluating rapid response options?

One of the Action Plan's objectives is to develop consistent methodology and protocols for a basin-wide invasive species surveillance program. The SAB supports this objective and recommends that surveillance and rapid response protocols be coordinated to ensure that the various states, provinces, and other participating organizations use the same methodology and protocols to provide meaningful information and effective rapid response. This coordination will be necessary to make the program effective.

In order to know which species are potential invaders, information is needed on what has occurred recently in the Great Lakes region and similar regions. Literature reviews and risk assessments that evaluate potential invaders in the Great Lakes, those that have become invasive elsewhere, and the vectors by which they could arrive will be critical sources of information (Johnson et al. 2001; Kolar and Lodge 2002; Anderson et al. 2004). The quality and quantity of these risk assessments will be the major determinants of the success of prevention and rapid response efforts. Data on the transport and sale of live organisms for bait, food, and pets (including backyard ponds) also should help inform these risk assessments and further identify which species are potential invaders in the Great Lakes. Indeed, as ballast water comes under control, other vectors, such as those cited above, may become the most likely sources of new invaders.

It is important to recognize that climate change is likely to facilitate invasion by many invasive species, including pathogens (Walther et al. 2002; Holzapfel and Vinebrooke 2005). Potential impacts of climate change include altered transport of invasive species, climatic constraints on invasive species, altered distributions of existing invasive species, impacts of existing invasive species, and altered effectiveness of management strategies (Hellman et al. 2008). In freshwater ecosystems, climate change is expected to cause warmer temperatures, reduced duration of ice cover, and altered stream flow patterns, which can affect pathways by which non-native species enter aquatic systems. Climate change will affect the likelihood of new species becoming established by eliminating cold temperatures that currently prevent survival. Conversely, some invasive coldwater species may not persist under warmer conditions. Ecological impacts of invasive species are expected to increase through enhanced competitive and predatory effects on native species, and increased virulence of some diseases (Rahel and Olden 2008).

It is also important to recognize that the adjustment of species' ranges is an important mechanism through which ecosystems will adapt to climate change. Many native species will shift their geographic distributions northward, moving into areas where they were previously absent. As these shifts occur, the distinction between native and invasive species becomes blurred.

Recent and emerging technologies for measuring deoxyribonucleic acid (DNA) have great potential for surveillance, but probes must be developed for the different species that are of concern. Jerde et al. (2011) located the Asian carp invasion front using a technique called environmental DNA or "eDNA." They analyzed over 1,000 water samples from the Chicago Sanitary & Ship Canal and other water bodies in the area. Using genetic tools, they screened the samples to find traces of eDNA from species, including Asian carp. In addition to showing that the invasive fish were much closer to the Great Lakes than people believed, the research

demonstrated that eDNA is an effective tool for locating and monitoring aquatic species invasions. Assessment and, if warranted, adoption of this technology should move forward as rapidly as possible.

The availability of taxonomic expertise to identify and recognize many potentially invasive species may constrain efforts at early detection, especially for plankton and microscopic organisms. The SAB notes that there is currently a scarcity of taxonomic expertise and an aging taxonomic workforce that will be available for species identification, especially considering surveillance of such diverse ecosystems requires expertise in many different types of organisms. This may be an additional consideration for the outreach and education programs discussed under Focus Area 5.

Rapid detection and then response to invading organisms are complicated tasks, and must be supported by an intensive monitoring program in order to detect nonindigenous invasive species (NIS) (unless they are large and conspicuous) before they become very abundant. However, such a program can also serve other purposes such as ecosystem monitoring, thus providing multiple benefits.

A single, rapid response plan should be adopted by all states and provinces that will provide for collective effort and will cut through jurisdictional barriers in advance. Otherwise, there will be excessive delays in responding and possibly shortfalls in resources, reducing the chance of successful eradication when there is still time to do so.

3.3.2. Prevention and Control Technologies

Question 6b: Does the SAB have any recommendations on demonstrated preventative and control technologies that could be applied to invasive species in the Great Lakes?

The Action Plan did not provide prevention and control technologies that are under consideration by the agency and requested that the SAB provide technologies that could be applied to invasive species in the Great Lakes. The SAB discussed some technologies and is providing general techniques for the agency to consider, with references and bibliographic citations. The SAB encourages the EPA to consider these technologies and recommends the agency develop criteria to evaluate these and additional studies to develop preventative and control technologies.

- *Selective Piscicides* -- It is vital that selective poisons are truly selective for the invasive species under consideration. It is difficult to find a chemical that is toxic to certain fishes and not to others. Conover et al. (2007) provide information on selective poisons for Asian carp. Another important consideration is some of the fishes most sensitive to piscicides are among the most endangered fish species (e.g., sturgeons and native lampreys) in the Great Lakes basin (Boogard et al. 2003; McLaughlin et al. 2003). Therefore, while such an approach may have merit, care must be taken to guard against unwanted consequences.

- *Pheromones* --Pheromones to attract or scatter the Asian carp appear to be more promising in terms of not harming non-target species. Improvements to lamprey control, such as more effective traps using pheromone attractants (Sorensen and Hoye 2007; Li et al. 2007), are being developed, as are repellants (Wagner et al. 2011). These are an improvement over existing chemical control, since lampricides are not entirely selective (Boogaard et al. 2003).

- *Ballast Water Technologies*– There are plans to test the performance of the many technologies that have already been developed to treat ballast water. This lab work should lead to bench and pilot-scale testing providing additional information. Genomic techniques could be used for monitoring the ballast water to see if it needs treatment. The report, *Efficacy of Ballast Water Treatment Systems: a Report by the EPA Science Advisory Board*, provides advice on technologies and systems to minimize the impacts of invasive species in vessel ballast water discharge (SAB 2011). The SAB notes the following as germane to the Action Plan, and recommends careful consideration of the report:

  > [The SAB's] overarching recommendation is that the EPA adopt a risk-based approach to minimize the impacts of invasive species in vessel ballast water discharge rather than relying solely on numeric standards for discharges from shipboard [ballast water management systems (BWMS)]. The [SAB] found that insufficient attention has been given to integrated sets of practices and technologies that could be used to systematically advance ballast water management. These practices include managing ballast uptake to reduce the presence of invasive species, reducing invasion risk through operational adjustments and changes in ship design to reduce or eliminate the need for ballast water, development of voyage-based risk and/or hazard assessments, and treatment of ballast water in onshore reception facilities. The [SAB] recommended that a comprehensive analysis be done to compare biological effectiveness, cost, logistics, operations and safety associated with shipboard BWMS and onshore reception facilities. These practices include managing ballast uptake to reduce the presence of invasive species, reducing invasion risk through operational adjustments and changes in ship design to reduce or eliminate the need for ballast water, development of voyage-based risk and/or hazard assessments, and treatment of ballast water in onshore reception facilities. The [SAB] recommended that a comprehensive analysis be done to compare biological effectiveness, cost, logistics, operations and safety associated with shipboard BWMS and onshore reception facilities.

- *Management of NIS Flora* – Management activities for *Phragmites australis* provide an example of how management of plant species may need to consider a wider array of factors and biological or chemical control options. For wetland plants (and other species), one should evaluate the actual damage that they do, as well as the possible positive ecosystem services the species may provide before starting wide-scale eradication (Hershner and Havens 2008). The capacity of invasive species to provide valued ecosystem services should be considered in the management of NIS flora. For example, contributions to food webs (Wainwright et al. 2000; Weis et al. 2002), improved habitat (Weis and Weis 2001; Yuhas et al. 2005), and sequestration of pollutants (Windham et al. 2001, 2003; Windham and Meyerson 2003,) have been associated with *Phragmites* in tidal marshes. In addition, it is critical that a biological control agent be well-studied and highly specific to the desired invasive species, and not attack other plants (Tewksbury et al. 2002). Other control methods for invasive plants involve the use of large amounts of herbicides, which, like piscicides, tend to be harmful to other species beyond the target

species. One commonly used herbicide, glyphosate (Roundup®), is toxic to a wide variety of plants, to various aquatic animals (Tsui and Chu 2003), and to soil microbes that perform important ecosystem services (Busse et al. 2001).

- *Physical Separation Technologies* – The separation study for the Mississippi River and Great Lakes system provides considerations for the agency. Fences are being used to provide physical separation between the river and Lake Michigan in order to keep Asian carp out of the lake (Rasmussen et al. 2011). However, during spring high water, fish may be able to go through wetland areas to access lakes Erie and Michigan (Hochanadel 2010; U.S. ACOE 2010). In general, erecting barriers could impair any migrations of native species as well, although this is not a concern for the manmade connection between the Mississippi River and Great Lakes.

- *Education and Outreach programs* – Well-considered education programs (not just "contact") for the general public about releasing pets, and anglers releasing bait fish, are crucial. In addition, surveillance for juvenile carp and other invasive fishes among bait fish is needed. Target groups for intensive training should include field technicians, commercial fishermen, naturalists, subsistence fishers, and others already involved in observing, sampling, and handling of Great Lakes fauna and flora. People involved with GLRI should work together with the Sea Grant Extension staff in all Great Lakes states on these education programs in order to avoid duplication of efforts.

Finally, the SAB also recommends that the agency assess potential and current invasive species and prioritize which species present the greatest problem(s) for the Great Lakes. The SAB concludes it would be wise to spend most of the effort and money on the most problematical species, and avoid reactions to all non-native species (Davis et al. 2011; Schlaepfer et al. 2011).

3.3.3. Other Possible Actions

Question 6c: Are there other actions that we should consider?

In general, a better understanding of which ecosystem characteristics increase susceptibility or resistance to invasions is needed (Milbau and Nijs 2004; Kuhn and Klotz 2007; Bulleri et al. 2008). This understanding should be applied to manage the Great Lakes. Focus Area 4, Habitat and Wildlife Protection and Restoration, has a goal that includes restoring access of migratory fish species at fish passage barriers. While generally a positive goal, this may exacerbate problems with movement of problematic non-native species from the Great Lakes into their drainage basins. Therefore, the positive and negative impacts of barrier removal should be considered in each instance.

As noted generally above (Section 3.1), more meaningful and measurable metrics of ecological improvement are needed. Some of the metrics in the Action Plan are not practical. For example, how can one measure if an average of 1.4 or 1.3 new species arrive? While the SAB recognizes that averages can be calculated over the longer term, such a measure is of little value in assessing whether the threat from invasions has been reduced. In addition, some measures need further specificity. For example, removing "5,000 lbs." of invasive species is not a helpful measure, when one could be addressing either microbes, water fleas or Asian carp.

The positive and negative impacts of developing a fishery for Asian carp in the Mississippi should be evaluated. Once a species has proliferated and prevention is no longer possible, other management options must be considered, and for carp, this may include commercial and recreational fishing. While it is not likely that a fishing effort will eliminate the Asian carp, it could keep them at a lower population density in the rivers and thereby reduce the probability of their invasion of the Great Lakes. An Asian Carp Marketing Summit was convened in Illinois in the fall of 2010 to identify opportunities to market the fish as a way to reduce their numbers, and recommended that eating bighead and silver carp may be a feasible approach. Representatives from restaurants, commercial fishing, processing and related businesses, government agencies and academic institutions attended the summit and agreed that high value Asian carp fillets marketed to restaurants and retailers could provide a financial incentive for extensive harvesting of these fish. They further recommended that the harvested fish be exported to Asian markets where they are popular food fish, and that carp by-products be converted into pet food to eliminate waste and maximize efficiency and profit. Representatives also felt it was important for people with different expertise, for example, natural resource professionals and entrepreneurs, to work together to successfully market Asian carp. When the final summit report is completed, a summary of recommendations will be available online and updated as information progresses (From: ACES News (http://www.aces.uiuc.edu/news/stories/news5449.html).

An ecosystem context is desirable for management of invasive species (Arkema et al. 2006; Schlaepfer et al. 2011) and management plans for ecosystems should include possible new invasive species. Wise management of such an approach requires the integration of data and information with modeling results when measured data are not available.

3.4. Nearshore Health and Nonpoint Sources

Key elements of any restoration plan for the Great Lakes will have to target the principal sources of stress to reduce their effect on the Lake ecosystems, and the Action Plan does address these key elements. The SAB's responses to Charge question 7 address the adequacy of the principal actions proposed for the Nearshore Health and Nonpoint Sources Focus Area and evaluate how, if implemented, these actions would improve the Great Lakes and lead to a successful restoration. Many of the comments made relative to this charge question also can be applied to other focus areas as many of the issues raised are crosscutting.

The SAB's responses to the specific charge questions address the adequacy of actions and impacts associated with key stressors in the nearshore region that the agency should consider as it evaluates the GLRI and applies adaptive management to identify priorities. As identified in the Action Plan, the primary environmental stressors include excessive nutrient loadings from both point and nonpoint sources; bacteria and other pathogens responsible for outbreaks of avian botulism and beach closures; development and shoreline hardening that disrupt habitat and alter nutrient and contaminant runoff; and urban agricultural practices that increase nutrient and sediment loadings. The primary targets of restoration are aquatic living resources and human use.

3.4.1. Impacts from Phosphorus Loading

Question 7 - The report State of the Great Lakes 2009 has documented that "phosphorus loads may be increasing after a long period of decrease, and that an increasing proportion of the phosphorus is an available, dissolved form." The increased phosphorus loads along with other stressors are degrading nearshore water quality as evidenced by eutrophication, harmful algal blooms (e.g. Cladophora and Microscystis) and avian botulism. To address these problems, the

Action Plan identified a set of principal actions to improve the health of the nearshore areas and reduce nonpoint source pollution to levels that do not impair nearshore waters of the Great Lakes. These principal actions include identifying sources and reducing loadings of nutrients and soil erosion and targeting watershed plan implementation in high priority watersheds.

Question 7a: Please comment on the adequacy of the principal actions to address the impacts associated with nearshore soluble reactive phosphorus, Cladophora biomass, and dreissenid biomass.

As stated above, while the Action Plan is a five-year plan, it provides a unique opportunity to form the basis for a long-term restoration vision that could guide subsequent renewals of the Action Plan. To sustain that long-term vision, the SAB recommends strategic planning that includes mechanisms for assuring sound science and performance measures that would assess progress (see response to Question 3 in Section 3.1).

Reducing soluble reactive phosphorus loads is one of the more important measures of progress as it is a key stressor throughout the Great Lakes ecosystem. However, it is not clear if the proposed reduction targets will, as a whole, be large enough to make a measurable difference based upon the information provided. In addition, water quality will be an important part of assessing nearshore health but water quality measurements are highly variable in space and time. Performance assessment of the GLRI program should include statistically significant reductions in targeted measures, yet the monitoring program may not be sufficient for this purpose. This could lead to bias or a large degree of uncertainty in assessing performance if sufficient attention is not given to development of deliberate, science-based sampling designs. Failure to develop and implement sound sampling designs for targeted projects and long-term monitoring increases the likelihood that the Action Plan will not reach its goals.

The SAB found that there was a lack of reference to dreissenids and *Cladophora* in this section of the Action Plan; however, there is some detail in the Scientific Background document (US EPA 2011). The International Joint Commission (IJC) Work Group on Eutrophication (2009c) addressed this issue and came to a similar conclusion. There is substantial evidence that phosphorus loads are contributing to nuisance and harmful algal blooms (*Cladophora* and cyanobacteria), but that there is weak evidence to support claims that a reduction in phosphorus loading will reduce the current problems in the nearshore. Given this uncertainty, the SAB recommends that the GLRI Action Plan address the need for rigorous monitoring and experimentation to separate and understand the effects of changing climate, water level variation, and invasion of dreissenids (see response to Question 3 in Section 3.1).

It is not clear how metrics and their target quantities were determined. While the SAB recognizes that the targets were developed as first-cut policy measures (e.g., in response to GPRA), the SAB recommends thorough analysis and documentation to explain how the metric and target quantities relate to restoration. It is not clear if the quantities reflect significant or measurable improvement. For example, the increase in the percentage of good beach days seems very small. In the table on measures of progress (page 29 of the Action Plan), percentage of beaches meeting bacteria standards 95% or more of beach days has a 2006 baseline of 86%. The target for 2010 was 86%, then 87% for 2011 and 2012. The target increases to 88% for 2013 and 89% for 2014. These are small changes in the targets for such an important measure of human health and restoration progress, and it is not clear if they are meaningful changes in terms of reducing human health risks. Bacterial problems in the nearshore appear to be acute and can lead to

serious human health problems. A critical evaluation of what is a significant target to achieve in restoration is needed for this measure, in particular, and for other targets.

The baseline for the target parameters is provided in the Action Plan tables but the universe for these parameters is not always defined**.** It is very important that data on the parameter's universe be given so readers can assess the magnitude of change associated with restoration efforts. The SAB recommends inclusion of the parameters range of values for all baselines. In addition, discussion of the relative size of target numbers to universe is needed in the Scientific Background document (U.S. EPA 2011). For example, the U.S. Department of Agriculture conservation practice acreage baseline is 165,000 acres. This represents about 0.4% of the total agricultural land in the U.S. Great Lakes watersheds (38,629,000 acres). The target percent increases out to 2014 would raise this percentage to 0.6%. While this change represents a 50% increase in conserved acreage, it is not clear if this is meaningful to the system. Details on where and how this percentage improvement will potentially result in positive restoration would be helpful.

The SAB could not assess if real ecological benefit will result from achieving the target numbers. For soluble reactive phosphorus, the Action Plan calls for a small, across-the-board reduction in all of the targeted watersheds. If this is achieved, it may result in different ecological benefits within individual watersheds, ranging from no impact to some change in biological activity. Understanding how and why different systems responded the way that they did would be important information for planning future restoration efforts. No such mention of this complexity is made in the Action Plan.

The SAB recommends that currently unexplained connections among actions and measures need to be addressed. For example, it is not clear how actions to "Identify sources and reduce loadings of nutrients and soil erosion" (the second principal action to achieve progress on page 30) will lead to a reduction in "the number and severity of incidences of ecosystem disruptions, including *Cladophora*, harmful algal blooms, [avian] botulism and other issues associated with eutrophication." It is not clear if the target reductions will be enough to result in any improvement in the ecosystems and reduction in stress. While this is a weakness in the Action Plan, this is one place where the Action Plan recognizes the difficulty of setting complex targets and imbeds research and modeling efforts as part of the principal actions. The SAB considers research and modeling to establish the linkage between actions, measures, and targets to be a strength in the Action Plan and an essential strategic activity. The SAB recommends that the research and modeling effort be clearly identified and highlighted in the Action Plan as a separate activity (see response to Question 3 in Section 3.1).

3.4.2. Other Recommended Actions

Question 7b: Are there other actions that [EPA] should consider?

The SAB recommends that greater consideration be given to how future development within the watersheds and how climate change will affect the Action Plan targets. From the establishment of Detroit in the early 1700's to the present, human development has been the major driving force in altering the Great Lakes ecosystems. In particular, Lake Erie is prone to development of hypoxia (Delorme 1982). Now, global climate change needs to be added as a major driving force. Acknowledging climate change issues and how restoration efforts may be affected should be integrated throughout the Action Plan.

The Action Plan was released in February 2010. However, the tables in the Action Plan, prepared for a 2009 start, have not been updated since the release. The SAB recommends a column be added to the tables showing what was accomplished in 2010 and 2011 relative to target figures. Hundreds of projects have been funded and it is necessary to include some information on what has been accomplished. Footnote 19 notes that targets for selected subwatersheds were still under development in 2010 and not included in the Action Plan (page 29 of the Action Plan). This a prime example of why the Action Plan will need to be updated or revised and tables reset for 2012. The agency should consider developing a separate mechanism to update the public and interested members of the scientific community, perhaps by using a status update or an annual report card.

3.4.3. Targeting Stressed Subwatersheds

Question 7c: Please comment on the Action Plan's intent to target Great Lakes subwatersheds[5] that show severe signs of stress for focused restoration activities as opposed to a broader approach that targets all watersheds (stressed and currently unstressed).

The Action Plan's intent to identify, map, and target the highest priority Great Lakes subwatersheds that show severe signs of stress for focused restoration activities is the best strategy for producing measurable positive outcomes. Overall, severely stressed systems respond positively and measurably to stressor relief. This is particularly true for stresses associated with excess nutrient loadings. Rabalais et al. (2010) documented at least 50 cases where hypoxia was reduced or eliminated by reductions in nutrient or organic matter loading. An approach that targets a broader range of watersheds in the Great Lakes likely would require significantly more resources.

While it is appropriate to implement projects at the subwatershed level based on severity of stressed habitats, restoring physical habitat also will require attention to stressors acting outside the subwatershed that may keep the restored habitat from functioning. For example, restoring headwater habitat for anadromous fish may be irrelevant if their access to the habitat is blocked by degraded water quality down river. Thus, the SAB recommends that the subwatershed approach be backed by a sound plan for the entire watershed that considers how the ecosystem functions as a whole.

The SAB concurs that targeting BMPs is also a very good idea and may demonstrate the value of targeting to a broader community. In particular, the Action Plan should mention how agricultural BMP performance can be assessed. Some portion of the implementation resources needs to be targeted towards accounting for agricultural BMP performance, including selective monitoring and evaluation. The GRLI is not the first program developed to improve the Great Lakes' degraded ecosystems. Some mention of previous and ongoing programs needs to be included so external observers can assess progress. One example would be to integrate the ongoing efforts on TMDL development and implementation with the recommended activities.

The focus on stressed watersheds and subwatersheds is good, but the selection process for the subwatersheds needs to be more understandable and transparent. In support of the selection discussions, the SAB recommends that at a minimum a complete list of stressed watersheds by Lake be included. It is likely that the value of this approach, to focus on the most stressed systems, can be made by the GLRI by 2014, if recommendations for outreach and monitoring are

[5] These include the targeted geographic watersheds identified on pages 16 and 28 of the Action Plan and other Areas of Concern

implemented. As the GLRI evolves and selects the next group of watersheds it will be important to demonstrate successful restoration and positive trends in metrics. Overall the Action Plan's vision, goals, actions, and performance assessment need to be made clearer.

3.5. Habitat and Wildlife Protection and Restoration

Focus Area 4 seeks to contribute to the improved health of the Great Lakes ecosystems through the restoration of key habitats. The goal is to implement these restorative measures in a manner that achieves five overarching goals in an environmentally sensitive manner:

- Improve aquatic ecosystem resiliency;
- Maintain, improve or enhance populations of native species;
- Enhance wetlands, wetland-associated uplands, and high priority coastal upland and island habitats;
- Identify, inventory and track progress on Great Lakes habitats including coastal wetlands restoration; and
- Restore habitat functioning in areas of concern.

Achieving the five goals of the focus area will require the development and application of a range of critical management actions and sound decision-making to protect and restore critical habitats and species. This focus area also addresses the restoration of habitat functions in, and native species use of, AOCs where contaminant remediation actions will be implemented.

3.5.1. Aquatic Ecosystem Resiliency

Question 8 – One of the Action Plan's principal actions to protect and restore habitat and wildlife is aimed at improving "aquatic ecosystem resiliency." "Resiliency" is loosely defined in the Action Plan as providing an ecosystem with the capability to buffer the impacts of potential problems such as climate change.

Question 8a: Please comment on the concept of "resiliency" in restoring and protecting aquatic habitats in the Great Lakes ecosystem. Does the SAB have any recommendations on actions to increase "resiliency?"

Restoring resiliency is an appropriate goal for this focus area. However, the Action Plan does not clearly articulate the concept of resiliency in the context of this Action Plan. In addition, adequate information was not presented to judge whether the actions associated with Focus Area 4 would be effective at attaining enhanced ecosystem resilience in the face of disturbances.

The SAB recommends that a clear, working definition of resiliency be developed along with metrics that can be used to track changes in the resiliency over time as restoration measures are implemented. The topic of resilience of ecosystems is wide-ranging, and often misunderstood (Holling 1973; Walker et al. 2002). It has received very little attention with respect to habitat restoration. It is critical that the Action Plan strive not just for resilience, but also for resilience associated with desirable future ecosystem conditions. Resilience can be high in systems dominated by invasive species (e.g., *Phragmites*) and low in some pristine systems (e.g., some oligotrophic lakes). Therefore, resilience alone does not define a desirable ecosystem condition. The resilience of an ecosystem condition that supports habitats of native and desirable aquatic and terrestrial species should be the goal.

Ecosystems often appear to be resilient until a level of perturbation occurs that exceeds a tipping point (Ellis et al. 2011). Once a tipping point is reached, the ecosystem undergoes a dramatic change in condition. Such altered systems often have little resiliency as they cannot return to their original condition without intervention; in some cases restoring ecosystem conditions is not feasible. An example of a tipping point is increased turbidity in a shallow lentic habitat that reduces light reaching the lakebed enough to prevent the growth of submerged aquatic vegetation (SAV). The changes associated with the SAV loss can include alterations in nutrient cycling, trophic organization and a shift in the animals occupying the site. Once such a change in system condition occurs, return to the original condition is unlikely without restoration actions. In the example above, reducing turbidity would represent the initial step and may require nutrient and sediment abatement actions. Even when light conditions are again appropriate to support SAVgrowth, revegetation of the site may occur very slowly if a source population of the plants is not proximate to the site. In some cases, moving vegetation from a donor site to the affected site may be required. Identifying these tipping points and implementing corrective actions before they are reached should be a component of any process to enhance ecosystem resilience. It is far more efficient and effective to identify and avoid these tipping points rather than attempt to restore conditions after they have shifted.

A variety of stressors have challenged the resiliency of the Great Lakes over the past century. Excess nutrients, invasive species and toxic chemicals have caused fundamental changes in ecosystem characteristics. Climate change will affect the Great Lakes with increasing severity over the next century. Focus Area 4 is the only place in the Action Plan where climate change is explicitly identified as an issue, yet climate change also will affect efforts to achieve the objectives of the other focus areas. As noted earlier, the effect of climate change should be considered, as appropriate, for all focus areas of the Action Plan. Climate-forced changes in conditions over the next few decades may negatively influence the effectiveness of actions implemented to address Focus Area 4 objectives. Some potential effects of climate change include increased frequency and severity of major storms, increased temperature and elevated evapotranspiration. The increase in evapotranspiration may contribute to a drop in water level, threatening coastal wetlands and other aquatic habitats. The SAB recommends that, as a first step, the program evaluate climate change model predictions for the region and use this information to develop a habitat restoration strategy that will enhance the resiliency of the Great Lakes ecosystem to climate change. This strategy should include the consideration of the extent to which climate change may compromise the effectiveness of proposed restoration projects, the identification of particularly vulnerable key habitats and the development of methods to secure these vulnerable areas.

3.5.2. Restoration Principles

Question 8b and 8c: Are there additional ecological elements or measures that should be considered to better improve resiliency or buffering capacity and our progress in habitat restoration and ecosystem protection projects? What about actions in other focus areas?

Questions 8b and 8c of the Charge are closely related. The SAB's responses equally apply to both questions and are presented together. The SAB concludes that these recommendations may increase the resiliency of an ecosystem and identify additional ecological elements and measures the agency should consider as it evaluates the progress of the Action Plan and plans next steps. Resiliency is not explicitly discussed in the other focus areas of the Action Plan. The SAB finds that it should be a key consideration in the program. The general principles and concepts

provided in the response to Question 8a, 8b and 8c are applicable to the other four focus areas and should be incorporated in the decision framework as appropriate.

There are certain ecosystem characteristics that have been shown to contribute to ecosystem capacity to resist state changes in the face of disturbances. This capacity is frequently what is meant by resilience. Restoration actions that enhance these ecosystem characteristics, therefore, should contribute to resilience. The SAB urges the agency to consider these following recommendations as appropriate to restoration actions:

- Reconnect the landscape elements (e.g., remove hydrological barriers) to enhance the flow of energy, materials and species throughout the ecosystem.
- Consider natural habitat complexity as a key feature to enhance resilience. Use reference sites as models where appropriate (Bisson et al. 1997).
- Utilize buffers of appropriate size and quality to mitigate impacts from various stressors (Lowrance et al. 1995).
- Protect areas that currently support quality habitat and high levels of native biodiversity. Locating restoration projects near these high-quality protected sites can enhance the effectiveness of restoration actions (Doppelt et al. 1993).
- Cluster restoration projects in a manner that will contribute to the development of a restored landscape. Restoring ecological function at a landscape scale will greatly enhance ecosystem resilience (Naiman et al. 1997).
- Establish recovery goals for populations of species of interest that specify abundance, density or productivity required to achieve a reasonable probability of persistence in the face of natural variation (McElhany et al. 2000). Restoration efforts can then be designed to re-create habitat to meet these demographic targets for focal species.
- Select restoration projects with some understanding of the "return time" of disturbances. Some understanding of the frequency and severity of disturbance events a restored site is likely to experience provides useful information regarding project design and effectiveness (Bisson et al. 1997).

The SAB concludes that considering and incorporating these elements, as appropriate, in the Action Plan will enhance ecosystem resilience and therefore, contribute to long-term sustainability of habitat conditions and improved levels of native of biodiversity.

3.5.3. Restoring Resilience and Measuring Progress

Question 9 – The Action Plan broadly defines "restoration" to encompass physical, biological, and chemical functions and processes. Are the actions listed in the Action Plan "restoration" actions?

The simple answer to this question is that most of the actions listed under Focus Area 4 are "restoration" actions. The more relevant question for the GLRI is whether these actions will enable the attainment of the Focus Area 4 objectives. The SAB finds that the italicized principal actions (page 34 of the Action Plan) may be more appropriate as goals for the protection and restoration of habitat and wildlife. Actions that are more specific would further describe the efforts to achieve these goals. This change would represent the first step towards addressing the ambiguity in the links between vision, long-term goals, objectives, and principal actions in the Action Plan. Additionally the SAB recommends that the Action Plan tie monitoring elements

more directly to goals. The more clearly and transparently the agency can communicate the connection between the monitoring metrics and the goals, the easier it will be to document how well the actions are working to meet the goals.

The Action Plan includes stocking native fish and other aquatic species as a critical management activity under long-term goal 2 of this Focus Area. The SAB notes that fish stocking programs as a tool for restoration may have unintended consequences. There are many examples where stocking has hurt native populations, and generally degraded ecosystem conditions (Evans and Wilcox 1991; Fitzsimmons et al. 2007; Chilcote et al. 2011; Carpenter et al. 2011). Although the SAB understands the need for this type of action, application of fish stocking programs requires careful evaluation.

The SAB acknowledges the unprecedented scale of the GLRI, which bounds on intractable in terms of size and complexity. For this reason, the SAB recommends that specific actions that are implemented have at least a moderate probability of working at a scale and in locations where they have the potential greatest positive impact on the ecosystem. In order to determine the potential of a specific action to succeed at an appropriate scale, the SAB provides a list of considerations (Appendix B) to stimulate discussion by the participating agencies as actions or projects are solicited, implemented, and evaluated. These considerations include a systematic approach to evaluating actions, locations, and uncertainties relative to the goals for the program.

Measuring Progress Toward Goals

It is important to develop a transparent method and set of metrics to measure net ecosystem improvement that is sustained by building resilient systems. Some methods and attributes for doing this include sources and levels of evidence, detectable signals in the broader ecosystem, and quantification of cumulative effects of multiple actions.

The SAB recommends the formal integration of an adaptive management program with clearly articulated goals and explicit statements of what the program seeks to accomplish. This involves the development of a system-level model, which identifies and prioritizes all factors (natural and anthropogenic) that could potentially affect attainment of the stated goal(s). Once the goals are clearly articulated, the current management efforts are assessed to identify gaps and/or overlaps in the management programs addressing the priority factors affecting goal attainment. A management strategy is then developed in coordination with implementation planning by stakeholders.

A monitoring program can only be designed after the goals and management strategy have been determined. Assessing management performance is the first priority to support adaptive management. The criteria for success and/or failure of management efforts should be known when the strategy is developed and the monitoring program is designed. This analysis informs adaptation. It involves defining uncertainties around intermediate targets and establishes decision thresholds that trigger a change in management actions. Based on the monitoring assessment, the system-level model for goal attainment is amended and monitoring strategies revised to improve performance and reduce uncertainty (Hershner 2011).

Products and Tools for the GLRI

Outcomes from an effective adaptive management approach may include model runs to predict outcomes of future actions based on what has been learned, recommendations for improvements

and research to reduce uncertainty of actions, and annual reports or report cards that summarize progress and provide recommendations, define the decision process, and develop action recommendations.

3.6. Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships

Question 10 – Focus Area 5: Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships, is intended to provide the "necessary backbone" of the entire GLRI through oversight, monitoring and assessment, education and outreach, and partnerships. This focus area is intended to implement assessment and evaluation actions to address gaps in knowledge and an inadequate understanding of complex and emerging issues.

The topics addressed under Focus Area 5 are important to the overall success of the GLRI. Question 10 focuses on critical data gaps and tools to increase collaboration and implement the GLRI focus areas. Question 11 addresses outreach and education to incorporate Great Lakes stewardship into curricula across the Great Lakes region. As previously discussed, the SAB concludes that the monitoring and other elements presented in this focus area may be better addressed in each of the specific focus areas rather than a combined focus area and notes that monitoring, synthesis and integration across the focus areas should be included in the Action Plan to bolster the accountability goals of the GLRI. The SAB further provides recommendations to provide greater accountability, increase collaboration among partners, and enhance educational and outreach opportunities.

3.6.1. Integrated Assessment, Evaluation and Accountability

Question 10a: Does the SAB have any recommendations of critical data gaps for which programs or tools should be implemented in the other focus areas?

The SAB concurs that overall assessment and a management framework are necessary for the GLRI, and provides recommendations on how best to achieve this in Section 3.1. In addition, the SAB has discussed data gaps, tools, and other implementation recommendations for each of the focus areas in the response to the charge questions. Monitoring is a concern in each of the other focus areas, and the SAB endorses efforts to include sufficient monitoring to allow meaningful assessment and evaluation of individual project activities. In contrast, monitoring and evaluation in Focus Area 5 should be broader in order to assess integration and synthesis of actions to achieve overarching goals and the accountability of the GLRI as a whole. This assessment requires measures of progress based on benchmarks for expected outputs and outcomes relative to attainment of Action Plan objectives.

The SAB notes that a framework and important tools to develop a holistic approach to evaluation of the effectiveness of Action Plan are missing. The SAB has previously noted the lack of a science-based, integrated outcome evaluation program in the Action Plan. Future iterations of the GLRI would benefit from the inclusion of a section that explicitly addresses synthesis and integration. Synthesis and integration are relevant to the Great Lakes effort in many ways. Identifying how efforts in one action area may be synergistic or antagonistic with goals in other areas, how well the missions and mandates of different managing entities line up, and how efforts under one LaMP or a case study on one AOC can provide "lessons learned" for others.

The SAB also notes there is no discussion of management and the arrangements by which key commitments are established and maintained to achieve Action Plan goals. For example, identifying which entities, projects, or actions most contribute to the achievement of which goals and how progress is being measured can only be evaluated through integration and synthesis using metrics that examine trends and meaningful change. Monitoring and evaluation is a key ingredient of accountability, and the LaMP framework seems to be a good place to focus development of monitoring efforts and accountability reporting. The SAB notes that EPA and Environment Canada, through the Great Lakes Water Quality Agreement, have made extraordinary efforts to use LaMPs to develop common ecosystem objectives for each of the Great Lakes and to identify Beneficial Use Impairments. The LaMP process has grown to include lake committees of the Great Lakes Fishery Commission, water quality managers, and other stakeholders who participate in public Forums, and the LaMP framework is thus potentially suitable for science-based integration of monitoring and accountability of the Action Plan.

The Action Plan addresses a wide variety of management activities and seeks to coordinate them through an adaptive management process. Without an explicit representation of management, however, the GLRI faces substantial challenges implementing performance evaluation based on principles of adaptive management. Management of the stressors affecting the heath of the Great Lakes involves direct and indirect actions. Some regulatory policies address stressors indirectly and depend upon various management agencies for implementation. Other management activities, such as fisheries regulation and regulation of point source discharges of contaminants, address stressors directly. Management decisions concerning remediation action fall in between. Oversight of the Action Plan ultimately depends upon attribution of changes in state of a Great Lake's ecosystem(s) to a management action through a scientifically defensible monitoring and assessment framework. In its present form, the Action plan lacks both an explicit representation of management activities and a science-based, comprehensive evaluation framework. The need for overall program management that provides program integration, monitors and evaluates outputs/outcomes, drives an adaptive management process, identifies uncertainties and data gaps, and examines trade-offs in management decisions is thus unmet. Without an accountability framework, the GLRI will do little to advance coordination and collaboration among Great Lakes partners to address key scientific issues.

The SAB recommends that EPA initiate four actions to provide greater accountability for GLRI projects and results:

- Place all project decisions in an explicit management accountability framework. The framework should identify the goal or objective addressed by the project, stressors affected and scale of effects, and specific management actions and responsible parties. A revised version of GLAS could provide a central repository for this information.
- Improve the logical connection of goals, objectives, actions, and metrics for evaluation across focus areas to permit an integrative assessment of the effectiveness of funded projects.
- Create a formal mechanism for overall program evaluation of the GLRI Action Plan that is explicitly linked to adaptive management.
- Fund a specific monitoring and assessment effort to evaluate progress at the project level.

3.6.2. Coordination and Collaboration Among Partners

Question10b: Please comment on the Action Plan's approach for enhancing coordination and collaboration among Great Lakes partners to address key scientific issues.

The Action Plan lists the federal department-level members of the IATF and Regional Working Group that developed the Action Plan. It also alludes to approximately 200 organizations at the federal, state, local, and sovereign tribal nation levels. While it is clear that a great many stakeholder organizations are involved in the program, the key members among this complex constellation of interests and the roles they play are not apparent. There is little information on the participation at the international or state level. How is intergovernmental cooperation directed at Great Lakes recovery and how is it sustained? How does the current program build on existing efforts of the federal agencies, the states, and activities carried out under treaty agreements with Canada? A functional approach to partnerships needs to be described, what they are (e.g., science or outreach) and where they fit within the other focus areas.

Given the lack of specifics, it is difficult for the SAB to determine whether there are missing organizations. One important organizational tool that seems to be missing, however, is a standing science panel integrated into the management system discussed in the response to Charge Question 3. A well-integrated panel could influence the program's evolution by providing assessments of progress in key areas. The science panel input on design, implementation, monitoring, and evaluation efforts would provide a scientific basis for setting priorities across disparate actions. Members should be independent experts drawn from universities and other research institutions, the private sector, and government agencies, but selected for their expertise and not to represent their agencies. Such a panel could make substantial contributions to the development of both robust monitoring efforts and the adaptive management plan that would be a logical outgrowth of well-designed monitoring. This panel should have social as well as natural and physical scientific expertise, and the social science represented should go beyond economics. Behavioral, social, and decision scientists can provide many kinds of insights and advice, ranging from assistance in targeting education and outreach efforts to identifying critical insights into the likely workability of particular institutional arrangements. It is likely that there are significant gaps in scientific understanding that will impede progress in the program, and a science panel would be instrumental in identifying those gaps and providing advice on how they can be addressed. The science panel should develop a strategic science plan and update it on a regular (e.g., biennial) basis.

Increased coordination and collaboration could be achieved by employing social media and increasing the availability of data and information from GLRI projects. For example, web-based GIS or other tools can be used to provide public access to site-specific data and data analyses at different scales. The GLRI could be informed by the experiences of other large restoration efforts (e.g., Chesapeake Bay, Puget Sound) and smaller efforts (e.g., Sacramento –San Joaquin Delta, Tahoe Basin).

3.6.3. Outreach and Education

Question 11 - Outreach and education are crucial in the effort to restore the Great Lakes. The Action Plan identifies the need to educate future generations to extend restore efforts. Please comment on the Action Plan's approach to incorporate Great Lakes stewardship into environmental education curricula.

The Action Plan contains highly laudable goals for outreach and education, but generally lacks a strategic approach to achieve the stated objectives. Measures of progress were ambiguous and will be difficult to track. Currently, there are no specific indications in the Action Plan of the amount or type of resources allocated to these aspects of the program. The EPA needs to describe allocation of resources to educational efforts, and take a systematic approach to building new efforts and tapping into existing efforts (the NSF-funded regional Centers for Ocean Sciences Education Excellence are one example**)** to further the GLRI goals.

It is not clear if any education planners were involved in developing the Action Plan. If not, then educators and planners need to be engaged early in the process to help ensure that education materials developed under the GLRI are incorporated into the curriculum. For example, the Action Plan did not address the reality that new curricula in K-12 are difficult to introduce unless they help teachers meet assessment standards or state mandates. If environmental education about the Great Lakes is not part of a district's or State's Graduation Test, chances are that new modules will not be incorporated into the curriculum. Thus, the Action Plan should include a benchmarking effort on State(s) guidelines to determine how Great Lakes activities could be included in State electives or requirements.

The emphasis in this focus area seems to be on K-12 education and outreach, with the assumption that these activities will extend into higher education and graduate education. In terms of curriculum development, the initial focus should be teaching the teachers so that they are equipped to use the information. In addition, the development of human capital – the scientists, engineers, managers, and educators of the future – is an essential part of this program and should be explicitly considered. During presentations of the Action Plan at the July 2011 SAB panel meeting, EPA stated that they use cooperative agreements to accomplish many of these activities using graduate students and postdoctoral researchers, but this is not indicated as a goal or measure of progress in the Action Plan. The SAB recommends that the Action Plan include a specific goal to develop human capital within the higher education network.

The SAB discussed the need for explicit requests for activities within the program to enhance educational and outreach opportunities. The SAB notes that in the 2010 round of funding, there were a number of funded outreach activities, but only one curriculum development project was listed. The EPA should consider targeted outreach and curriculum development projects that include activities from not only the natural sciences, but also behavioral and social sciences and humanities. For example, modules could be developed to incorporate ethical frameworks (i.e., European vs. Tribal worldviews) or environmental justice concepts into eco-curriculum or into history or philosophy programs (e.g., in an American and World Cultures classes). In addition, good opportunities exist within this framework for service learning and citizen science, especially in monitoring efforts (e.g., NSF's Science Education for New Criteria Engagements and Responsibilities program).

The SAB agrees that there is a need to incorporate educational and outreach activities as an overarching theme in all projects. During the July meeting, EPA stated that education and outreach activities are considered in peer-review, but this is not indicated as a goal or measure of progress in the Action Plan. The SAB recommends that EPA and its partners consider explicit peer review criteria for all activities (internally and externally funded) that include education and outreach with significant weighting**.** This is parallel with the peer-review process of the NSF (2011a and b.). The NSF's statement (NSF 1999) on the integration of research and education is:

> One of the principal strategies in support of NSF's goals is to foster integration of research and education through the programs, projects and activities it supports at academic and research institutions. These institutions provide abundant opportunities where individuals may concurrently assume responsibilities as researchers, educators, and students, and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the diversity of learning perspectives.

The SAB agrees with this principle and recommends that the Action Plan incorporate and utilize the same or similar criteria in its funded projects. These criteria involve a review of (1) Intellectual Merit, (2) Broader (i.e., societal) Impacts, (3) Project Assessment Plan, and (4) Project Data Management Plan. As discussed, the SAB underscores the importance of explicitly incorporating all of these criteria into the review process of all project proposals, both internal and external to the agencies.

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APPENDIX A: CHARGE TO THE SAB

Great Lakes Restoration Initiative Action Plan
Science Advisory Board Review

Charge to the SAB panel reviewing the GLRI Action Plan

I. Scope of Review

The SAB panel is charged with reviewing the Great Lakes Restoration Initiative's (GLRI or Initiative) Action Plan. A separate scientific background paper was developed to provide the review panel with an overview of the key ecological problems in the Great Lakes, and help the panel navigate through the extensive literature, strategies, and plans that informed the GLRI Action Plan. The SAB panel is requested to use the scientific background paper (and other relevant documentation cited in the background paper) in the review of the Action Plan.

II. Introduction

In 2010, President Obama announced and Congress appropriated $475 million in new funding for the GLRI to protect and restore the chemical, biological, and physical integrity of the Great Lakes. The Great Lakes contain 20 percent of the world's surface freshwater, accounting for 95 percent of the surface freshwater in the United States. The watershed includes two nations, eight U.S. States, two Canadian provinces, more than 40 tribes, and more than one-tenth of the U.S. population. Led by the United States Environmental Protection Agency (EPA), the GLRI targets some of the most serious threats to the Great Lakes including toxic substances and contaminated sediment, invasive species, non-point source pollution, and habitat degradation.

To guide the efforts of the GLRI, EPA and our Federal partners, through the Great Lakes Interagency Task Force (IATF)[6] chaired by EPA Administrator Lisa Jackson, developed a comprehensive multi-year Action Plan. The GLRI Action Plan identifies goals, objectives, measurable ecological targets, and specific actions for five major focus areas:

- Toxic Substances and Areas of Concern
- Invasive Species
- Nearshore Health and Nonpoint Source Pollution
- Habitat and Wildlife Protection and Restoration
- Accountability, Education, Monitoring, Evaluation, Communication and Partnerships

III. Directive for Review of the GLRI Action Plan

The Congressional Conference Report accompanying H.R. 2996[7] further specifies the need for EPA to "engage an independent, scientific panel to review the scientific credibility of the Action Plan to optimize the likelihood of successful restoration at appropriate scales."

[6] The Great Lakes Interagency Task Force (IATF) brings together eleven U.S. cabinet and Federal agency heads to coordinate restoration of the Great Lakes. Created by Executive Order from President Bush on May 18, 2004, the IATF mission is to focus on environmental outcomes like cleaner water and sustainable fisheries, and target measurable results. The IATF helps coordinate GLRI implementation. http://www.epa.gov/greatlakes/iatf/index.html

[7] Public Law 111-88, the Department of the Interior, Environment, and Related Agencies Appropriations Act, 2010.

IV. Charge Questions on the overall structure of the GLRI Action Plan

Question 1 - As presented in the scientific background document, the goals, objectives, measures, and actions of the Action Plan are based on the best available scientific analysis of environmental challenges and are consistent with the multitude of strategic plans and governing structures for the Great Lakes. Since the Action Plan is an "action driver", we are most interested in the SAB's recommendations on the identified principal actions to achieve progress. Are the principal actions proposed in the Action Plan consistent with the actions and/or recommendations of the previous collaborative plans and strategies for the Great Lakes (e.g. Great Lakes Regional Collaboration Strategy) as identified in scientific background document and other information of which you are aware? Are there other actions that we should consider for inclusion in the Action Plan that will better achieve the goals of the Action Plan?

Question 2 – As presented in the scientific background document, we have developed and currently operate the Great Lakes Accountability System (GLAS)[8] as the primary mechanism for collecting information to monitor and report on GLRI progress. GLAS is still a work-in-progress at this time and it is not ready for external review. However, given the scope of the Action Plan and the nature and types of projects funded under the GLRI, we are interested in the SAB's recommendations on how best to track the progress and accountability for a large ecosystem restoration program. What critical environmental elements, endpoints, or other measures would you include to those identified in the Action Plan?

Question 3 – Please comment on the overall scope and framework of the Action Plan and its ability to organize environmental issues in a way that directs restoration actions. Does the SAB have any specific recommendations on how to improve or clarify the Action Plan?

V. Charge Questions on Toxic Substances and Areas of Concern

Question 4 – The presence, significance, and trends of many historically-regulated (or "legacy") contaminants in the Great Lakes are well-documented. Through the Action Plan, we are working to fully implement and enhance existing programs to eliminate releases of many of these contaminants. For example, the GLRI is working to accelerate the rate of sediment remediation in Areas of Concern (AOCs) through the Great Lakes Legacy Act[9] among other programs. Similarly, the Action Plan calls for initiating strategic pollution prevention and toxics reduction efforts to minimize releases and emissions of many of these same contaminants. Please comment on the Action Plan's approach for addressing so-called "legacy" contaminants through sediment remediation and toxics reduction efforts. Please comment on whether the Action Plan addresses the reduction of "legacy" contaminants at all geographic scales sufficiently to restore the Great Lakes ecosystem. Are there other actions that we should consider?

Question 5 – The Action Plan also acknowledges the threats posed to the ecosystem by chemicals of emerging concern, such as flame retardants, surfactants, pharmaceuticals and personal care product constituents. To devise and implement effective control strategies, EPA and the other federal agencies are coordinating efforts to identify significant sources and impacts of new toxics to the Great Lakes ecosystem through robust surveillance and screening. Please comment on our approach for assessing and managing the risks posed by chemicals of emerging concern. Are there other actions or specific chemicals of emerging concern that we should consider?

[8] Available online at http://glri.us/projects.html

[9] Funding under the Great Lakes Legacy Act is now part of the GLRI.

VI. Charge Question on Invasive Species

Question 6 – Invasive species have dramatically altered the Great Lakes ecosystem. New species continue to threaten the Great Lakes. The Action Plan identifies a set of actions intended to eliminate new introductions, control the spread, and minimize the risks of invasive species. EPA has initiated separate reviews for some of the principal actions in this focus area. Ballast water technology is being reviewed by a separate SAB panel. The Asian Carp activities are being addressed through the Asian Carp Control Strategy Framework that is being elevated to a program unto itself in coordination with GLRI. Therefore, we are asking the SAB's for advice and recommendations on the remaining actions to address invasive species. What are the key scientific data needed in an early detection surveillance network to provide up-to-date critical information for evaluating rapid response options? Does the SAB have any recommendations on demonstrated preventative and control technologies that could be applied to invasive species in the Great Lakes? Are there other actions that we should consider?

VII. Charge Question on Nearshore Health and Nonpoint Sources

Question 7 - The report *State of the Great Lakes 2009* has documented that "phosphorus loads may be increasing after a long period of decrease, and that an increasing proportion of the phosphorus is an available, dissolved form." The increased phosphorus loads along with other stressors are degrading nearshore water quality as evidenced by eutrophication, harmful algal blooms (e.g. *Cladophora* and *Microscystis*) and avian botulism. To address these problems, the Action Plan identified a set of principal actions to improve the health of the nearshore areas and reduce nonpoint source pollution to levels that do not impair nearshore waters of the Great Lakes. These principal actions include identifying sources and reducing loadings of nutrients and soil erosion and targeting watershed plan implementation in high priority watersheds. Please comment on the adequacy of the principal actions to address the impacts associated with nearshore soluble reactive phosphorus, *Cladophora* biomass, and dreissenid biomass. Are there other actions that we should consider? Please comment on the Action Plan's intent to target Great Lakes subwatersheds[10] that show severe signs of stress for focused restoration activities as opposed to a broader approach that targets all watersheds (stressed and currently unstressed).

VIII. Charge Questions on Habitat and Wildlife Protection and Restoration

Question 8 – One of the Action Plan's principal actions to protect and restore habitat and wildlife is aimed at improving "aquatic ecosystem resiliency". "Resiliency" is loosely defined in the Action Plan as providing an ecosystem with the capability to buffer the impacts of potential problems such as climate change. Please comment on the concept of "resiliency" in restoring and protecting aquatic habitats in the Great Lakes ecosystem. Does the SAB have any recommendations on actions to increase "resiliency"? Are there additional ecological elements or measures that should be considered to better improve resiliency or buffering capacity and our progress in habitat restoration and ecosystem protection projects? What about actions in the other focus areas?

Question 9 – The Action Plan broadly defines "restoration" to encompass physical, biological, and chemical functions and processes. Are the actions listed in the Action Plan "restoration" actions?

IX. Charge Question on Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships

[10] These include the targeted geographic watersheds identified on pages 16 and 28 of the Action Plan and other Areas of Concern

Question 10 – Focus Area 5: Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships, is intended to provide the "necessary backbone" of the entire GLRI through oversight, monitoring and assessment, education and outreach, and partnerships. This focus area is intended to implement assessment and evaluation actions to address gaps in knowledge and an inadequate understanding of complex and emerging issues. Does the SAB have any recommendations of critical data gaps for which programs or tools should be implemented in the other focus areas? Please comment on the Action Plan's approach for enhancing coordination and collaboration among Great Lakes partners to address key scientific issues.

Question 11 - Outreach and education are crucial in the effort to restore the Great Lakes. The Action Plan identifies the need to educate future generations to extend restore efforts. Please comment on the Action Plan's approach to incorporate Great Lakes stewardship into environmental education curricula.

APPENDIX B: CONSIDERATIONS FOR AN ECOSYSTEM RESTORATION PROGRAM

The SAB recognizes and acknowledges the unprecedented scale of the GLRI. It bounds on intractable in terms of size and complexity. For these reasons, the SAB recommends that specific actions that are implemented have at least a moderate probability of working at a scale and in locations where they have the potential greatest positive impact on the ecosystem. In order to determine the specific action potential to succeed at an appropriate scale the SAB provides considerations across the definition, implementation and evaluation steps of the Action Plan that are intended to stimulate discussion by the participating agencies as actions or projects are solicited, implemented, and evaluated. These considerations include a systematic approach to evaluating actions, locations, and uncertainties relative to the goals for the program.

Defining Restoration Goals

- What is wrong, where and why? Answering this question is fundamental to developing a plan. The SAB assumes that answers are reasonably well developed, but it was not apparent in the review of the Action Plan and Scientific background documents, whether this was the case.
- At what scale are damages and stressors active, and potentially limiting restoration? This comment is related to responses provided to the questions above and involves a more in depth investigation of problems in the ecosystem.
- What are the specific characteristics of a "restored" Great Lakes ecosystem? Program objectives that clearly articulate the desired future condition for the ecosystem should be developed. The National Research Council (1992) defined "restoration of aquatic ecosystems" as returning an ecosystem to a close approximation of what it was like prior to disturbance by humans. This goal may not be appropriate for the Great Lakes given their current condition. However, the Action Plan does not specifically define a set of goals. The scientific literature on restoration has developed some generic restoration goals, that are provided below. The SAB encourages EPA to review the generic goals and identify and define goals for the GLRI. It is likely that the restoration goals for the Great Lakes will vary spatially, include elements for most of the broad strategies below and should be fully developed specific to the GRLI . An overarching set of program goals will greatly help in setting priorities for restoration projects (Thom et al. 2010).
    - Restore to prehistoric conditions – conditions before man was present.
    - Restore to historic conditions – man was present but had a minimal impact on natural ecosystems.
    - Enhance selected attributes – improve conditions of habitat and landscapes by enhancing ecological attributes of the systems.
    - Conserve biodiversity – some disturbance can be present but the native biodiversity is intact.
    - Protection – all human-related disturbances and stressors are barred from the system. Protection differs from restoration in that there is no net gain associated from protection alone. However, protection of areas of the ecosystem can support other restoration projects through supplying materials and species to restored sites, and by preventing future habitat loss.
    - Habitat creation – Constructing a habitat that is different than what existed historically or pre-historically in an area. In cases where there are considerable levels of disturbance on the landscape and site scales, creation may be the only viable

option. In general, maintenance of created habitats requires expenditures of energy and funds because the processes that would normally maintain them are not present or are poorly developed.

- How sure are predictions of the response of the ecosystem and populations to specific actions? There is a need to specify the uncertainties associated with the goals. In the long run, identifying key uncertainties will aid in developing directed research questions that will help guide the restoration program in the future.

Prioritizing Actions

What are specific links between actions and goals? This element needs clarification, and more specific information because it helps develop more robust restoration plans that clearly target specific actions.

The process that will be used to determine what actions need to be accomplished and where those actions should be deployed was not clearly explained in the Action Plan. The SAB expressed concerned about the lack of detail as to how projects would be prioritized and suggests the following recommendations for the agency to consider:

- Define and identify priority areas of the ecosystem where actions would have the greatest benefit. This analysis forms the foundation of a comprehensive restoration plan that identifies best actions and best locations.
- As opportunities arise, these opportunities can be assessed against the comprehensive plan maps to determine if actions are high priority.
- Clearly articulate the restoration strategy that will be deployed in each action.
- Develop a set of case studies for each of the types of restoration actions that will be implemented to develop some understanding of effectiveness. This understanding will help design subsequent projects.
- Clearly define elements and criteria of prioritization process such as,
    - Habitat forming processes
    - Landscape features
    - Site condition
    - Adjacent site conditions
    - Self-maintenance
    - Resilience potential
    - Time frame for development toward goal.
- Develop a *Project Proposal Template* that articulates goals, performance metrics. The template should address project criteria, location, size, time period to attain goal, effectiveness monitoring, uncertainties, and direct relationship to prioritization criteria.

Measuring Progress Toward Goals

- Develop a transparent method and set of metrics to measure net ecosystem improvement that is sustained by building resilient systems. Some methods and attributes for doing this include sources and levels of evidence, detectable metrics in the broader ecosystem, and quantification of cumulative effects of multiple actions.
- Formalize an integrated adaptive management program with the following elements-
    - Clearly articulate the goal - everything hinges on a clear and explicit statement of what the program seeks to accomplish.

- Develop a system-level model for goal attainment - identify all factors (natural and anthropogenic) that could potentially affect goal attainment and rank their relative importance.
- Assess the current management efforts - which will identify gaps and/or/overlaps in existing management programs addressing the important factors affecting goal attainment.
- Develop management strategy - through coordination and implementation planning by stakeholders.
- Develop monitoring program(s)- monitoring can only be designed after the goals and management strategy are determined. Assessing management performance is the first priority to support adaptive management.
- Assess performance - the criteria for success/failure of management efforts should be known when the strategy is developed and the monitoring program is designed. This analysis informs adaptation and involves defining uncertainties around intermediate targets and establishes decision thresholds that trigger a change in management actions.
- Manage adaptively - based on the monitoring assessment, the system-level model for goal attainment is amended and monitoring strategies revised to improve performance. (Hershner 2011)

Products and Tools for the GLRI

Outcomes from an effective adaptive management approach may include:

- Report cards
- Model runs to predict outcomes of future actions based on what has been learned
- Recommendations for improvements and research to reduce uncertainty of actions
- Annual report that summarizes progress and provides recommendations, defines the decision process, and develops action recommendations

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