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EPA-SAB-12-xxx

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

Subject: Science Integration for Decision Making at the U.S. Environmental Protection Agency

Dear Administrator Jackson:

With your support, the Science Advisory Board (SAB) undertook a study to evaluate the extent to which science integration for decision making occurs at EPA and how EPA might strengthen science integration practices. In EPA's context, science integration means scientific assessments that integrate information and analysis from the many scientific and technical fields appropriate to address the complex environmental problems facing the agency. Such analyses and assessments integrate input from EPA program and regional offices, the public, and interested and affected parties. Successful science integration provides information clearly to decision makers and the public.

The Presidential commission that recommended the establishment of the EPA in 1970 explicitly called for EPA to use science to address the interrelated nature of pollution problems, and science integration remains essential to support credible decisions today. The concept of science integration resonates with the public and is consistent with your vision of "One EPA," where the agency transcends historical barriers of program and region to use relevant scientific and technical information to help solve environmental problems. It is also consistent with recommendations in the National Research Council's recent report, *Sustainability and the U.S. EPA.*

To understand the practice of science integration at the EPA, members of an SAB committee conducted interviews with EPA program offices, all ten EPA regions, the Office of Research and Development and other offices supporting decision making. Insights from those interviews give rise to the findings and recommendations in the enclosed report.

The SAB's interviews confirmed that science assessment is perceived across the EPA as an important function because the EPA is both a scientific and regulatory agency. Nevertheless, no EPA program has fully implemented the science integration framework previously recommended by the SAB. Program and disciplinary "silos" remain significant barriers to science integration and science integration practices vary across the agency. There is a critical need for high quality assessments of existing science on a broad range of topics important to decision making at EPA. While some managers actively promote science integration, more could be done in most program and regional offices to share best practices and make science integration a more consistent priority.

The SAB views science integration as a foundation for meeting EPA's goals of protecting human health and the environment. Achieving these goals requires the highest quality science to inform environmental

decisions. The SAB recommends that the EPA's senior leadership communicate to agency personnel that science integration is needed and expected to support the EPA's decisions.

The SAB has three principal recommendations for strengthening science integration at the agency. First, EPA should explicitly plan for science integration to support environmental decisions. Second, managers should be accountable for making science integration happen, starting with problem formulation and science assessment, in their own organizations and across EPA. Finally, EPA should increase support and training for scientists across EPA, especially in programs and regions, to strengthen the agency's capacity for science integration and recognize scientists' contributions in this area.

We thank the many EPA personnel who participated in the SAB's science integration interviews for their time and insights. We look forward to receiving your response regarding our recommendations.

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. Mention of trade names of commercial products does not 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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Committee on Science Integration for Decision Making

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Science Integration for Decision Making at the U.S. Environmental Protection Agency (EPA)

Scope of the Study

In October 2008, the Science Advisory Board (SAB) was asked by then-Administrator Stephen L. Johnson to develop advice on how the EPA can strengthen scientific assessments for decision making (Appendix A). After conferring with Administrator Lisa P. Jackson in the spring of 2009 to receive support for the effort, the SAB undertook this study to evaluate EPA's processes for integrating scientific assessment into environmental decision making, as previously recommended by the National Research Council (NRC) (NRC 2009) and the SAB (U.S. EPA SAB 2000). To implement this broad charge, the SAB conducted extensive fact finding to examine barriers to implementing NRC and SAB recommendations. This report identifies immediate and future actions to further develop and institutionalize integrated environmental decision making at the EPA. Areas of consideration include scientific leadership, scientific practices, scientific collaboration across disciplines, and scientific expertise and workforce.

For the purpose of this report, the SAB defines "science" broadly as any enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the world. In the context of the EPA's work, science involves knowledge and data that help the agency answer environmental protection questions. Science integration for EPA means scientific assessments that combine information and analysis from different scientific and technical fields, as appropriate to address the complex environmental problems our nation faces. These analyses and science assessments need to address problems as they occur in the real world with integrated input from EPA program and regional offices, the public, and interested and affected parties. Such science integration was part of the initial vision for EPA and has been important for EPA Administrators since the agency began.

The SAB defines integrated decision making as the deliberate inclusion of integrated science in the process of decision making. Although the concepts of science integration and integrated decision making are distinct, they are logically connected. The SAB described integrated environmental decision making (U.S. EPA SAB 2000) as:

> a broad conceptual way of thinking about environmental problems that responds to criticisms of the fragmented approaches that dominate current national strategies for protecting human health and the environment. At the core of this concept is integrated thinking about complex environmental problems, integrated resources and analyses to address the problems as they occur in the real world, and integrated input from the public and interested and affected parties…Integrated decision making approaches should draw upon concepts and methods originating in many different scientific, technical, and scholarly fields (e.g., physical and biological sciences, public health, environmental engineering, political science, social science, philosophy, and economics), as appropriate for any given case. Integrated environmental decision making is not just a series of methodologies, but rather is a way of thinking, in a whole and complete way, about any environmental problem in order to maximize the efficient reduction of aggregate risk to populations or ecological systems.

Figure 1 presents the three-phase framework for science integration recommended by the SAB (U.S. EPA SAB 2000).

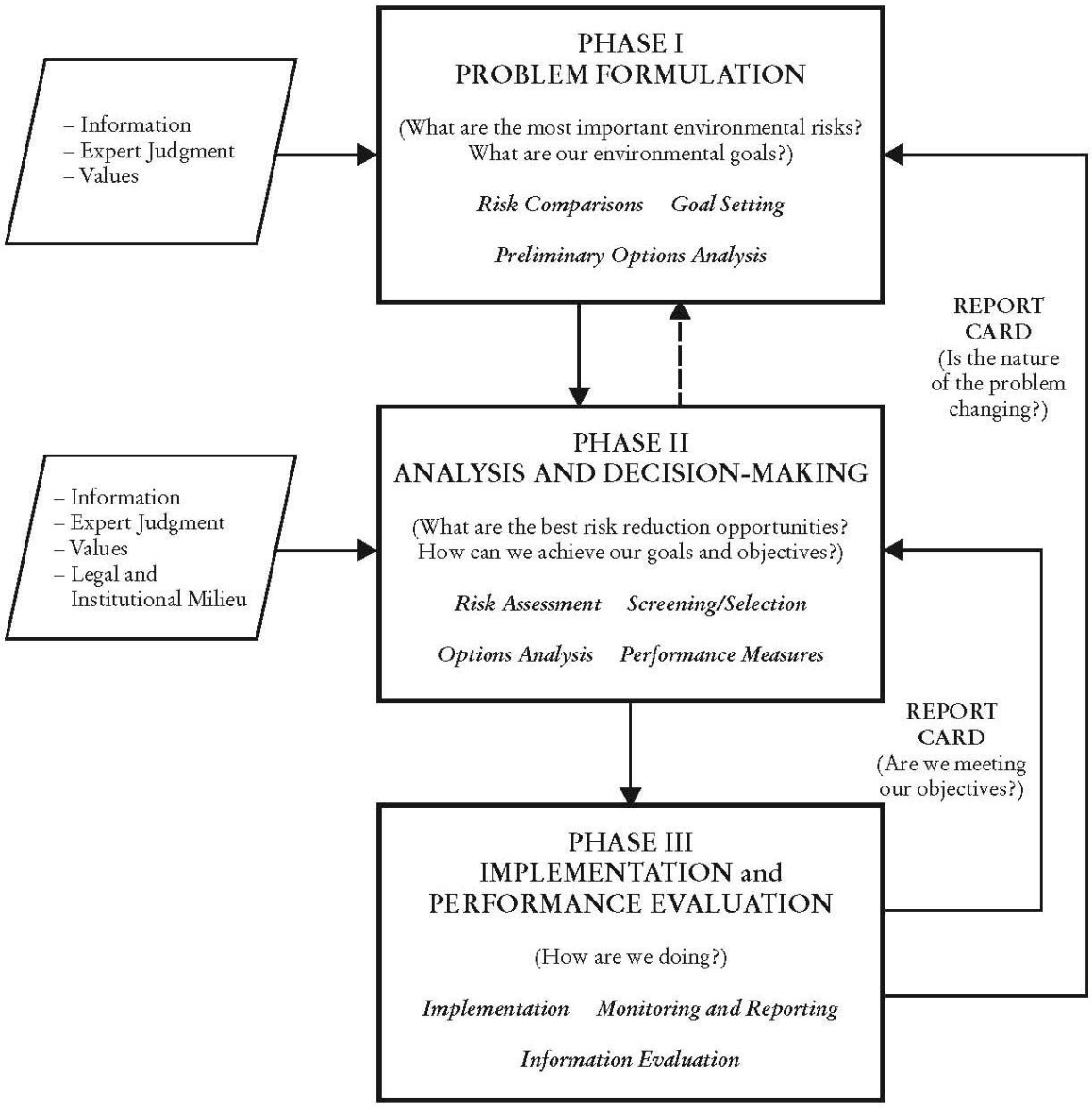

Figure 1. Framework for Integrated Environmental Decision-making (Source: U.S. EPA SAB 2000)

To understand science integration at the EPA, members of an SAB committee conducted interviews between October 26, 2009, and February 4, 2010, in all major program offices and all ten EPA regions. They also interviewed managers and scientific staff in EPA's Office of Research and Development (ORD) and other offices that support decision making. In all, members of the committee held 72 interviews with more than 450 individuals (Appendix B).

EPA offices selected the managers and staff to participate in the interviews, and interviewees received a draft interview protocol and questions in advance (Appendix C). Interviewees were asked to comment on the current and recent past practice of science integration in their organization based on their personal experience. Interviewers stressed their interest in whether and how the EPA actually practiced science integration, not the "nominal" or official approach. The SAB interviewers received extensive background materials from each of the programs and regions prior to the interviews. After the interviews, interviewees were provided a draft interview summary for review and comment. A compilation of interview summaries[1] and the background information provided by regional and program offices[2] are available on the SAB website.

The interviews provided qualitative information that varied in detail from one interview to another and focused on issues of particular concern at the time of the interviews. While the interviews were necessarily limited in scope, the conversations gave the SAB insights about EPA science integration practices and the concerns of EPA managers and staff across the agency. This information provides the foundation for the findings and recommendations in this report.

The SAB recognizes ORD's important role in EPA research and notes that the SAB's interviews were conducted during a time of change. In 2010, ORD initiated new approaches to integrated transdisciplinary research with an emphasis on sustainability and innovation (Anastas 2010). The SAB supports (U.S. EPA SAB 2010 and 2011) ORD's initial steps to implement this new direction. ORD's new focus on systems thinking, problem solving and involving EPA programs and regions in research planning has the potential to improve science integration practices at EPA. Although the SAB conducted interviews with ORD personnel and ORD research was discussed in many interviews, this study focuses on EPA science as a whole and not on ORD research efforts to generate new science. A full discussion of ORD's new strategic research directions and its relevance for program and regional needs is outside the scope of this effort and will be addressed in future SAB advisory reports.

This report reaches beyond ORD to consider science integration for EPA's program and regional offices. Over 6,000 EPA employees are involved in scientific assessments, research, and related activities, with approximately 1,300 full-time scientific staff in ORD and approximately 4,700 full-time scientific staff in program and regional offices. These program and regional offices, together with ORD, are responsible for integrating science to support the environmental decisions made by the EPA Administrator. Program and regional offices also play a primary role in integrating science to support the environmental decisions delegated to them.

Although the findings and recommendations below concern science integration for decision making, this report does not assume that science is the sole input for environmental decision making. The SAB acknowledges that other factors (such as law, politics, policy and values) play important roles (Bipartisan Policy Center 2009) in agency decision making. Because the SAB interviews focused on EPA *processes* that promote or impede science integration, the findings reported here are not an evaluation of the quality of the EPA's decisions or the quality of the science supporting them.

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[1] *Science Integration Fact-finding Discussion Summaries 2009-2010 ar*e available at: http://yosemite.epa.gov/sab/sabproduct.nsf/9E24AF9BA24B1BBE85257860007626C3/$File/SciIntSummaries-02.03.11+with+TOC.pdf (accessed 11/21/11).

[2] SAB Committee on Science Integration for Decision Making Discussion of Preliminary Fact Finding, Meeting Materials, agency-provided background materials are available at: http://yosemite.epa.gov/sab/sabproduct.nsf/MeetingCal/266562906BCF3B0B852576DD0067F2E3?OpenDocument (accessed 11/21/11).

Findings

The SAB has identified the findings below based on major themes from the science integration interviews.

Science integration, including assessment of existing scientific knowledge and information to support decision making, is an important function at the EPA because the EPA is both a scientific and regulatory agency. The SAB interviews confirmed that agency staff and managers view science as an important component of decision making at the EPA, whether decisions involve regulatory, enforcement or voluntary programs. Nationally significant regulatory decisions involving science are addressed at the level of the Administrator. For these actions and other significant actions to be taken by senior managers, the agency's Action Development Process and associated Analytical Blueprint Process provide a structure that could encourage science integration.[3] Some regional and site-specific decisions and routine decisions involving science, however, are not part of the Action Development Process and are made by senior managers, mid-level program managers, permit writers, enforcement personnel and branch chiefs.

No EPA program has fully implemented the science integration framework recommended by the SAB in 2000. The framework for science integration recommended by the SAB (U.S. EPA SAB 2000) (Figure 1) and supported by the NRC (NRC 2009) has three major components: problem formulation; analysis and decision making; and implementation and performance evaluation. The first step, problem formulation, may be the most important. Problem formulation is a systematic planning step, linked to the regulatory and policy context of an environmental problem, which identifies the major factors to be considered, developed through interactions among policy makers, scientists and stakeholders. The problem formulation process should result in a conceptual model that identifies the sources, environmental stressors or health hazards, exposed populations and the relationships among them (U.S. EPA 2004). Problem formulation also includes initial consideration of the options for interventions or risk management.

The NAAQS review process for criteria air pollutants comes closest to full implementation of the SAB's vision for science integration (see text box below). It involves the most effective science integration process among the EPA programs discussed in the SAB interviews.

[3] EPA's Action Development Process (U.S. EPA 2011) requires EPA programs and regions developing significant agency actions (e.g., significant regulations or decisions) to generate an analytical blueprint to identify plans for data collection and analysis. These blueprints are to describe how information from multiple disciplines will be collected, peer reviewed and used to develop the action. The process is to be multi-disciplinary, collaborative, cross-office and cross-media to ensure that a variety of perspectives are integrated for decision making. EPA has developed supplemental guidance on consideration of environmental justice (U.S. EPA 2010) and children's health protection (U.S. EPA 2006) in action development.

Science Integration and the NAAQS Review Process

The NAAQS review for a criteria air pollutant follows a structured process that facilitates science integration.

At the start of a new review cycle for a criteria air pollutant, ORD convenes a public workshop at the start of each review cycle to identify key new science published since the last review. EPA's Office of Air and Radiation (OAR) then prepares an Integrated Science Plan to identify how EPA will review the new science in light of the EPA's statutory mandate to determine whether current standards protect public health and public welfare from known or anticipated adverse effects with an adequate margin of safety. ORD prepares an Integrated Science Assessment reviewing the new science. OAR prepares a Risk and Exposure Assessment related to key aspects of regulating the pollutant and a Policy Assessment that reviews the science as it relates to key aspects of regulations. The goal of the Policy Assessment is to provide a transparent staff analysis of the scientific basis for alternative policy options for consideration by senior EPA management prior to rulemaking. Such an evaluation of policy implications is intended to help ''bridge the gap'' between the agency's scientific assessments and the judgments required of the EPA Administrator in determining whether it is appropriate to retain or revise the NAAQS.

The reviews are iterative, since the EPA must conduct NAAQS reviews for each of the six criteria pollutants every five years and reconsider the science supporting the NAAQS. As a result, the EPA has refined the assessment process over time, identifying risks more precisely and identifying key uncertainties for research to address. NAAQS reviews allow for multiple opportunities for public comment and for peer review by the Clean Air Scientific Advisory Committee, a federal advisory committee dedicated to providing review and advice for the NAAQS process.

ORD also developed the Health and Environmental Research Online (HERO) database as a publicly accessible repository for peer reviewed literature used to develop Integrated Science Assessments.

Even the NAAQS process, however, does not fully implement the SAB's recommended approach because the NAAQS process has been limited in two ways. First, NAAQS reviews have focused primarily on single-pollutant air quality issues, with limited consideration of multi-pollutant impacts and impacts of criteria pollutants on water quality-related ecological impacts. Second, NAAQS reviews by law focus on human health and ecological impacts. Health and ecological assessments are not integrated with assessments of benefits and costs and, as a result, decision makers do not have the benefit of an integrated assessment that would help them evaluate the marginal benefits of additional health or ecological protection.

Program and disciplinary "silos" remain significant barriers to science integration. The need to decide and implement actions to protect human health and the environment through individual regulatory programs, as authorized by Congress, complicates the quest for innovative or sustainable ways to achieve the Agency's mission to protect human health and the environment. Managers and staff in many interviews, especially in program offices, defined success in terms of meeting statutory requirements and court-ordered deadlines for their programs. Although meeting legal mandates is important, EPA needs a broader perspective that extends beyond specific program objectives to achieve science integration and broader protection goals such as sustainability. A narrow focus on "program silos" and defensibility can be a barrier to formulating and responding to problems as they occur in the real world. Such a limited approach can hinder integration of new scientific information into decisions and new applications of science to develop innovative, effective solutions to environmental problems. Rigidity within scientific disciplines also can pose an obstacle to science integration. Interdisciplinary work is difficult; experts often use different terminology and have different assumptions. These

differences can become intellectual silos when the EPA does not implement procedures requiring science integration.

Science integration practices vary across the agency. Despite a general recognition among those interviewed that science is critical for decision making, science integration practices vary across the EPA. Some programs, e.g., the National Estuary Program (U.S. EPA 2005) and the Superfund Program[4], appear to have well established processes to integrate science into decision making through a problem formulation exercise; other programs do not. Some programs, such as the Drinking Water Program or the National Ambient Air Quality Standard (NAAQS) program, rely on ORD science and assessments. Other programs, such as the Hazardous Waste Program, rely on other federal agencies, such as the Department of Energy and Department of Defense, for key science support.

To meet decision makers' needs for scientific information and assessments, program and regional scientists turn to a variety of sources (e.g., contractors, local colleges and universities, other federal agencies, states, Potentially Responsible Parties, and non-governmental organizations). One region has used a highly structured approach, the Multicriteria Integrated Resource Assessment (MIRA) Process and associated logic models,[5] as a framework to help stakeholders and decision makers understand the relationships between relevant scientific data and decision options (Stahl et al. 2002). Other programs and regions take a less structured approach. The Office of Solid Waste and Emergency Response maintains a website[6] as a key communication tool used actively across and beyond EPA to facilitate science integration. The site hosts seminars, offers podcasts, provides a portal for databases and tools related to clean-up technology, and serves as a central place to share information among EPA scientists and scientists outside the agency. Other EPA programs lack such a resource to foster exchange and integration of a wide variety of scientific information supporting decision making. These few examples convey a sense of the wide variety of approaches and mechanisms used at the EPA and the different experiences the public can have when engaging with the EPA on science integration.

There is a critical need for high quality assessments of existing science on a broad range of topics important to decision making at EPA. Interviewees in regional and program offices emphasized the importance of science assessments that evaluate the state of existing science relevant to the agency's decision needs. Interviewees noted that scientific literature reviews published in peer-reviewed journals generally do not provide assessment information that meets the EPA's regulatory or environmental protection needs. As one regional interviewee noted, "Published literature is out there but it is passive. The question is 'how do you apply it to a practical problem?'" Program and regional decisions can be delayed or questioned when the agency lacks current and credible assessments of available science.

Although the Integrated Risk Information System (IRIS) program, which provides assessments of chronic human health effects used widely by EPA programs and regions, was discussed in many SAB interviews, this SAB report will not specifically comment on IRIS beyond underscoring the importance of this information to EPA decisions. IRIS has been the topic of several recent reports (U.S. Government Accountability Office 2008, 2011a; NRC 2009, 2011a) and recent management attention at the EPA.[7]

[4] For information about problem formulation in the Superfund Program, see http://www.epa.gov/ttn/naaqs/review.html (accessed 10/26/2011) and http://www.epa.gov/oswer/riskassessment/superfund_eco_planning.htm (accessed 10/26/11).
[5] For more information about MIRA and its applications, see http://www.epa.gov/reg3esd1/data/mira.htm (accessed December 12, 2011).
[6] Hazardous Waste Clean-Up Information (CLU-IN). http://www.clu-in.org/ (accessed 11/18/2011).
[7] For EPA information about the IRIS process, see http://www.epa.gov/IRIS/process.htm (accessed 11/4/11).

IRIS is only one type of important chemical-specific science assessment at the EPA. Program and regional offices also generate chemical assessments, but few of these assessment activities are marked by a combination of robust scientific staff, resources and an institutional and legal history that facilitates science assessment at the desired quality and rate needed for decision making. EPA's Pesticide Program provides an example of a program with a well-defined regulatory mission, a large scientific staff, a dedicated peer review mechanism (the Scientific Advisory Panel), legal authority to require pesticide registrants to generate key data when needed, and an iterative process for reviewing pesticide active ingredients. Most other EPA programs and regions lack the infrastructure required to generate all assessments needed to support their own activities. Scientists in these offices work within statutory constraints, often on an extremely short time-table and with limited budgets. Within those constraints they either assess available scientific information themselves or rely on ORD, other parts of EPA or other federal or state agencies for the science assessments needed to support decision making.

In addition to chemical-specific assessments, the program and regional interviewees called for science assessments for other kinds of environmental topics. During SAB interviews, scientists and managers across the agency called for additional assessments of existing scientific knowledge to apply to the practical problems they faced. As examples, they noted a need for assessments of existing scientific knowledge about the environmental impacts of pharmaceuticals and personal care products; nutrients; ecological impacts that can guide clean-up efforts; underground injection; hydraulic fracturing; and climate change at temporal and spatial scales useful for regional decisions.

Some managers actively promote science integration, but more could be done in most program and regional offices. Time and resource constraints are important barriers to science integration across the EPA, but notably some leaders and managers make science integration a priority and implement mechanisms within their organizations despite these constraints. As one manager noted, leadership requires that managers be "committed to listening to staff and supporting science needs… managers must demand such planning for high quality science. They should not expect that good science will 'happen organically'--that things will come together by themselves." Effective leadership for science integration emphasizes the importance of problem formulation to allow the EPA to step "out of the box" of narrow programmatic concerns. One manager explicitly noted that "There is a need to recruit, nurture and guide people to make decisions outside the box, while still making timely decisions." Some leaders and managers interviewed provided scientists and managers with training about the potential of programs across the Agency to be used, in conjunction with their own, to achieve the EPA's health and environmental protection goals. They were willing to explore the flexibility of specific statutes and to look for collateral ways to achieve environmental goals.

EPA organizations with successful science integration efforts devote attention to the institutional mechanisms required. Some examples are: (1) explicit problem formulation activities that involve managers, scientists and the public in decision science models or model building exercises;[8] (2) a program-office plan that identifies the research needed to achieve its goals, meet statutory obligations and fulfill court mandates (U.S. EPA 2009); (3) cross-media or cross-disciplinary project teams;[9] (4)

[8] For examples in two EPA regions, see *Science Integration Fact-finding Discussion Summaries 2009-2010*, pp. 9, 22-25.
[9] Several EPA regions and programs described examples, see *Science Integration Fact-finding Discussion Summaries 2009-2010*, pp. 25-26; 121-125; and 128-130.

effective program and regional-office science policy councils;[10] and (5) meetings where project teams present their integrated science to decision makers in forums open to program or regional staff.[11] These mechanisms increase the transparency of (and remove the mystery from) science integration and make it more understandable and accessible to agency staff and managers.

An overarching barrier to consistent science integration is a lack of strong, coordinated management to support the scientists in the regional and program offices. As noted above, the vast majority of the EPA's scientific workforce is employed in EPA regions and program offices. These program and regional scientists play key roles in the integration of science into decisions and in defining needs for research, science assessment and technical assistance. Support for science in the EPA's regional and program offices has long been recognized as a priority (U.S. EPA Expert Panel 1992). Others have called for the appointment of a top science official who would have responsibility and authority for all the research, science and technical functions at the agency (e.g., NRC 2000; U.S. Government Accountability Office 2011b). Currently, EPA does not have a single entity responsible for managing and strengthening EPA's scientific workforce so that it functions as a resource for the agency as a whole. ORD principally focuses on supporting ORD scientists, although it supports several small but important programs in the regions, such as the Regional Science Liaison Program, Regional Research Partnership Program and the Regional Applied Research Effort Program. Program and regional offices manage their scientific workforces relatively independently, with some organizations providing stronger support than others. EPA leadership in science integration requires the recruitment, retention, and development of leading scientists from many fields across EPA programs and regions, as well as in ORD. EPA has not developed a coordinated human resource strategy for building this science base within ORD and beyond.

Recommendations

The SAB provides the recommendations below as the most significant actions for EPA to take to strengthen science integration.

EPA should explicitly plan for science integration to support environmental decisions. EPA's mission to protect public health and the environment requires a difficult balancing of policy and science considerations. The complexity of environmental decisions and growing emphasis on sustainability as an environmental goal requires integration of scientific input from diverse fields of the natural, public health, social, behavioral and decision sciences. The SAB reiterates its recommendation made in 2000 (U.S. EPA SAB 2000) that the EPA implement the framework for science integration depicted in Figure 1 to support decisions agency-wide.

The SAB recommends that the EPA's senior leadership communicate that science integration is needed and expected to support the EPA's decisions. It should be a priority for managers to plan for the research and science assessments needed for decisions and then train, encourage, and expect staff to collaborate so that science integration for decision making is realized.

[10] An effective internal EPA science policy council in a program or regional office would have a charter, clear responsibilities and operating rules, and strong support from senior managers. Science policy councils can facilitate science integration by tracking emerging environmental issues and the science integration actions needed; helping to prioritize research needs for development of science to integrate into future decisions; encouraging communication and collaboration across programs and disciplines; and facilitating training and information exchange to strengthen science integration. For two examples, see *Science Integration Fact-finding Discussion Summaries 2009-2010,* pp. 1-3, 123.

[11] See *Science Integration Fact-finding Discussion Summaries 2009-2010,* pp. 2-3.

For each decision requiring scientific information, science integration will require an initial problem formulation step, with the following components:

- Involvement of the responsible decision-maker to define the initial questions that will look broadly at the physical, economic, and social context of specific environmental problems to seek a management decision with the broadest environmental benefits;
- Identification of options for intervention and risk management;
- An assessment plan that: discusses the appropriate level of science required for the decision; the type of science; and where one might find the science that is needed, who is involved and their roles and responsibilities;
- Expectations regarding the required timeline and resources; and
- An appropriate balance of public and stakeholder engagement, with clear expectations for the roles of each and how the EPA will address public input, as recommended by the SAB and NRC (EPA SAB 2001; NRC 2008).

The problem formulation step should inform the data analysis and decision-making phase, where science assessments will provide key information. Once decisions are made, the EPA should evaluate the use of integrated science for decision making with the goal of improving future decision making.

Managers should be accountable for making science integration happen, starting with problem formulation and science assessment, in their own organizations and across EPA. The SAB recommends that EPA managers consistently devote attention to implementing all the components of science integration. Management should be accountable for problem formulation to martial integrated thinking about complex environmental problems as they occur in the real world. They should also be accountable for generating the science assessments and analyses needed by EPA's programs. Appendix D suggests for EPA consideration several mechanisms to help implement this recommendation. These suggestions have a common goal: more consistent integration of science to strengthen environmental decision making.

EPA should increase support and training for scientists across EPA, especially in programs and regions, to strengthen EPA's capacity for science integration and recognize scientists' contributions in this area. Traditional rewards and recognition for scientific excellence focus on discovery, peer reviewed publication, and national and international recognition by peers. As a result there are few professional incentives for scientists to focus on support of regulatory decision making. The SAB recommends that scientists throughout the agency be encouraged to participate actively in developing improved approaches to integrate science into agency decisions and be rewarded for their valuable contributions.

The EPA should increase the incentives (e.g., awards, performance evaluations, developmental assignments, career opportunities) for scientists throughout the Agency to support the translation and integration of science into decision making. Programs to encourage exchanges of ORD scientists with program and regional offices, and *vice versa*, also would facilitate the development of this culture. The EPA should develop an agency-wide human resource plan to attract, develop and retain highly qualified staff scientists in the regions, programs and ORD so that EPA scientists overall will set the international standard for excellence in integrating science to support decision making. The SAB recommends that this plan receive coordinated review by the SAB, the ORD Board of Scientific Councilors, and the National Advisory Committee on Environmental Policy and Technology.

Conclusion

Effective environmental policy making requires the integration of science from many disciplines to inform the decision process. This concept is fundamental to the identity of the EPA. The presidential commission that called for the establishment of the EPA in 1970 noted that "The environment, despite its infinite complexity, must be perceived as a unified, interrelated system." The Ash Commission stated that an environmental protection agency was needed and must have capabilities "to conduct research on the adverse effects of pollution, to gather information on environmental conditions and use it in modifying programs or recommending policy changes" (Ash et al. 1970). The commission proposed an organizational structure for EPA that would:

- Recognize the interrelated nature of pollution problems;
- Address the fact that pollutants cut across media lines;
- Encourage balanced budget and priority decisions between component functions; and
- Permit more effective evaluations of total program performance.

This concept of science integration resonates with the public and is consistent with the vision of "One EPA," where the agency transcends historical barriers of program and region to use relevant scientific and technical information to help solve environmental problems. It is consistent with recent guidance on advancing the EPA's use of science in a variety of fields (NRC 2009; SAB 2009; NRC 2011a), as well as with the NRC report on sustainability (NRC 2011b), which observed that "Meeting the goal of sustainable development requires an integration of social, environmental, and economic policies, necessitating interdisciplinary coordination among federal agencies with varying missions to address this goal."

Strengthening science integration at the EPA will require change: change in agency culture, change in how the agency works, and increased support for scientists and managers in program and regional offices responsible for science integration. The SAB views science integration as a foundation for meeting the EPA's goals of protecting human health and the environment. These goals require integration of the best available science to inform environmental decisions.

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Attachment A: Request for the Study

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OCT 20 2008

THE ADMINISTRATOR

MEMORANDUM

SUBJECT: Request for a Science Advisory Board Study

TO: Dr. Deborah Swackhamer
Chair, Science Advisory Board

At the U.S. Environmental Protection Agency, sound decision-making depends on getting the best available science. During its 30-year history of advising EPA Administrators, the Science Advisory Board has emphasized the need for anticipating future environmental threats and investing in emerging research and science critical for informing decisions. As our understanding of complex environmental problems improves, integrated approaches for delivering the best science need to be developed and implemented.

The SAB's 2000 report *Toward Integrated Environmental Decision-Making* suggested an integrated decision-making framework for evaluating and responding to environmental problems. I ask that the SAB initiate a study that builds on its 2000 study to develop independent advice on how EPA can strengthen scientific assessments for decision making. The SAB might consider EPA's organizational structure and functions in light of how they influence the development and application of science assessments in different decision-making contexts. It would also be valuable for the SAB to recommend how to strengthen EPA's approaches for integrating traditional human health and ecological science assessments with socioeconomics analyses, decision sciences, and technology development and assessments to better support policy development. Finally, as EPA continues to plan for human capital needs, I would like the SAB to provide advice on ways to attract and retain the best diverse technical workforce.

Attached is a brief description of the proposed study. Please feel free to tailor the scope and depth of the study as appropriate. I ask the study be completed in a timely manner for the next EPA Administrator's consideration and implementation.

Stephen L. Johnson

Attachment

Effective human health and environmental protection requires a strong foundation of scientific knowledge. Scientific information often includes considerable uncertainty resulting in a diversity of scientific interpretations. The development and application of scientific knowledge in identifying potential threats, characterizing risks, formulating technological solutions, and evaluating the benefits and costs of U.S. Environmental Protection Agency actions are major science functions at EPA. The scope and depth of such science assessments greatly vary under different legislation and policies.

These functions are carried out by scientists, engineers, and economists with specialized program knowledge. They, in turn, rely on technical support by outside experts procured through Agency's interagency agreements or contracts. In addition, EPA's National Center for Environmental Assessment in the Office and Research Development develops technical assessments for EPA's Integrated Risk Information System which are used throughout the Agency. Summaries of the potential human health effects information that may result from exposure to chemicals in the environment, along with the supporting Toxicological Reviews, are made available electronically on IRIS for use by EPA, states, and tribal governments.

Over the years, reports from the National Research Council, the General Accountability Office, and other organizations point out that, while EPA has knowledgeable experts, the Agency's policies and regulations are too often perceived to lack a strong scientific foundation and EPA's science is of uneven quality. To address these issues, EPA established several science coordinating bodies. For instance:

- the Risk Assessment Forum consists of Agency senior scientists that develop Agency-wide technical guidelines for human health risk assessment, ecological risk assessment, and exposure assessment;
- the Science Policy Council develops Agency position papers on cross-cutting and emerging issues (e.g. peer review practices, data quality guidelines, genomics, nanotechnology); and
- the Council on Regulatory Environmental Modeling guides the development and use of environmental models.

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Staff support for these coordinating bodies is now centralized in the newly created EPA Office of the Science Advisor. In addition to these groups, the National Regional Science Council promotes communication and collaboration of regional scientists to identify common regional needs.

Nonetheless, scientists, engineers, economists, and other technical professionals, by necessity, continue to be spread throughout the Agency and have limited opportunity to interact with their peers in other organizational units. Such segregation can result in duplication of effort as well as conflicting scientific approaches to the evaluation of similar environmental agents by different offices. While the Agency has tried to minimize such occurrences through its science and science policy coordinating bodies, existing coordination processes can be slow and tend to occur in the later phases of assessment development and approval. Furthermore, the environmental problems of today are more complex, often cross state and national boundaries, and require consideration of difficult trade-offs and integration of socioeconomic and technological solutions. EPA's existing science and science policy coordinating bodies primarily address immediate scientific needs of the Agency and may miss a longer-term strategic viewpoint.

Proposal

The SAB has provided scientific advice and recommendations to the Agency on a wide variety of scientific issues for more than 30 years. Because of the SAB's unique perspective, it would be of value for the SAB to evaluate the Agency's current organizational structures and functions concerning the development and application of science assessments in different EPA decision-making contexts. The evaluation would result in advice and recommendations on how the Agency might strengthen scientific assessments, communication of uncertainties of the assessments, and how the results are used. Areas for consideration may include: scientific leadership; consistent scientific practices; scientific collaboration within and between disciplines; and multi-disciplinary approaches for integrating natural science assessments with economic and social science assessments.

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Appendix B: List of SAB "Science Integration for Decision Making" Interviews, 2009-2010

Region 1 Fact-finding Discussions, October 28, 2009
- With Region 1-New England Acting Regional Administrator
- With Region 1-New England Managers
- With Region 1 New England Scientific and Technical Staff

Region 2 Fact-finding Discussions, December 17, 2009
- With Region 2 Managers
- With Region 2 Deputy Regional Administrator
- With Region 2 Technical Staff

Region 3 Fact-finding Discussions, January 19, 2010
- With Region 3 Managers
- With Region 3 Scientific and Technical Staff
- With Region 3 Deputy Regional Administrator

Region 4 Fact-finding Discussions, October 26, 2009
- With Region 4 Senior Managers: Director, Science and Ecosystem Support Division and Director, Resource Conservation and Recovery Act (RCRA) Division
- With Region 4 Managers
- With Scientific and Technical Staff

Region 5 Fact-finding Discussions, January 25, 2010
- With the Acting Regional Administrator and Acting Deputy Regional Administrator
- With Region 5 Senior Managers
- With Region 5 Scientific Staff

Region 6 Fact-finding Discussions, December 9, 2009
- With Region 6 Senior Managers
- With the Region 6 Regional Administrator and Deputy Regional Administrator
- With Region 6 Scientific and Technical Staff:

Region 7 Fact-finding Discussions, December 16, 2009
- With Region 7 Managers
- With Region 7 Scientists
- With the Region 7 Acting Regional Administrator
- With the Region 7 Agricultural Team

Region 8 Fact-Finding Discussions, December 15, 2009
- With the Region 8 Scientific and Technical Staff
- With Region 8 Managers
- With the Region 8 Acting Regional Administrator

Region 9 Fact-finding Discussions, January 6, 2010
- With the Region 9 Deputy Regional Administrator and Senior Managers
- With Region 9 Managers
- Region 9 Scientific and Technical Staff

Region 10 Fact-finding Discussions, December 8, 2009
- With Region 10 Scientists (first group)
- With Region 10 Scientists (second group)

- With the Region 10 Regional Economist
- With Region 10 Scientists (third group)
- With the Region 10 Executive Team
- With the Region 10 Acting Regional Administrator and Acting Deputy Regional Administrator

Office of Air and Radiation, Office of Atmospheric Programs (OAP) Climate Control Division Fact-finding Discussions, November 19, 2009

- With OAP Climate Control Division scientific staff
- With OAP Climate Control Division managers

Office of Air and Radiation, Office of Air Quality Planning and Standards (OAQPS) Fact-finding Discussions, January 12, 2010

- With OAQPS Managers
- With OAPQS Scientists

Office of Air and Radiation, Office of Transportation and Air Quality (OTAQ) Fact-finding Discussions, November 19, 2009

- With the OTAQ Director
- With OTAQ Staff Scientists

Pesticides and Toxic Substances (OPPTS) Fact-Finding Discussions, January 26, 2010

- With the Office of Pollution Prevention and Toxics Acting Director, Managers, and Scientific Staff
- With the OPPTS Deputy Assistant Administrator
- With the Director and Scientific Staff, Office of Science Coordination and Policy
- With the Acting Office Director, Managers, and Scientific Staff, Office of Pesticide Programs

Office of Solid Waste and Emergency Response Principal Deputy Assistant Administrator Fact-finding Discussion, December 1, 2009

Office of Solid Waste and Emergency Response, Office of Resource Conservation and Recovery (ORCR) Fact-Finding Discussions, November 24, 2009

- With the Economics and Risk Analysis Staff
- With the ORCR Director

Office of Solid Waste and Emergency Response, Office of Superfund Remediation and Technology Innovation (OSRTI) Fact-finding Discussions, November 24, 2009

- With the OSRTI Deputy Director
- With the Assistant Director of the Technology Innovation and Field Services Division, Science Policy Branch Chief and Staff

Office of Water, Office of Ground Water and Drinking Water Fact-finding Discussions, January 20, 2010

- With the OGWDW Office Director and Director, Standards and Risk Management Division
- With OGWDW Managers and Scientific Staff (

Office of Water, Office of Science and Technology (OST) Fact-Finding Discussions, January 28, 2010

- With OST Scientific Staff
- With the OST Deputy Office Director and Managers

Office of Water, Office of Wastewater Management Fact-Finding Discussion, January 20, 2010, with the Office Director and Management Team

Office of Water, Office of Wetlands Oceans and Watersheds (OWOW) Fact-Finding Discussions, January 20 & 28, 2010

- With the OWOW Deputy Office Director and Management Team
- With OWOW Scientific Staff

Office of Environmental Information Toxic Release Inventory (TRI) Program Fact-finding Discussions, December 24, 2009

- With TRI Managers
- With TRI Staff

Office of Research and Development Fact-Finding Discussion, January 29, 2010, with the Assistant Administrator and Deputy Assistant Administrator for Science

Office of Research and Development, National Center for Environmental Assessment (NCEA) Fact-finding Discussion, November 30, 2009, with National Center for Environmental Assessment (NCEA) Director and NCEA managers and scientists

Office of Research and Development, National Health and Environmental Effects Research Lab (NHEERL) and National Exposure Research Lab (NERL) Fact-Finding Discussions, January 25, 2010

- With NHEERL Director and Management Team
- With NHEERL Scientists
- With NERL Director and Management Team
- With NERL Scientists

Office of Research and Development, National Homeland Security Research Center (NHSRC) Fact-finding Discussion, November 30, 2009, with NHSRC Managers and Staff

Office of Research and Development, National Risk Management Laboratory (NRMRL) Fact-finding Discussion, November 30, 2009, with NRMRL Managers and Staff

Office of Research and Development, Office of Science Policy (OSP) Fact-finding Discussion, January 28, 2010, with Managers and Staff

Office of Research and Development, Fact-Finding Discussion, February 4, 2010, with National Program Directors and Program Leads

Office of the Science Advisor Fact-Finding Discussions, January 21, 2010

- With OSA Scientific Staff
- With the OSA Chief Scientist and Managers

Office of the Administrator

- Office of Children's Health Protection Fact Finding Discussion, January 21, 2010, with the Director and Staff
- Office of Policy, Economics, and Innovation National Center for Environmental Assessment Fact-Finding Discussion, January 21, 201, with the NCEE Director and Technical Staff

Appendix C: Interview Protocol and Advance Questions

The SAB conducted interviews with EPA Offices and Regions that use science to support decision making. Two or more committee members were involved in each interview. The SAB Staff Office Director or Deputy Director provided introductions, and the Designated Federal Officer (DFO) for the committee took notes and assisted the SAB committee in consolidating and summarizing information gleaned from the interview sessions. The interviews were held at the designated location of EPA Offices.

The SAB requested separate interview sessions with decision makers, policy makers, and scientific and technical staff. SAB members used the following questions as a guide for the interviews. The SAB recognized that not all questions will be relevant and appropriate for all EPA offices. The interview questions cover topics such as 1) practices for integrating science to support decision making; 2) consideration of public, stakeholder, external scientific, and other governmental input in science assessment for decision making; 3) drivers and impediments to implementing past recommendations[*] for science integration; 4) ways EPA receives feedback on how science is used in decision-making; and 5) the EPA workforce related to science integration supporting decision making.

The SAB committee asked interviewees to review the questions below the interviews and to describe one or two important and representative examples of science-based decisions specific to their organization. The committee expressed interest in learning what interviewees viewed as what is and is not working well, and what changes are needed to improve science integration to support environmental decision making. The SAB DFO provided draft summaries of the interviews to the interviewees for comment.

Advance questions for Policy and Decision Makers:

1. **Practices for integrating science to support decision making**
   - 1.1. What kinds of decisions does your organization make?
   - 1.2. What is (are) your role(s) in the decision-making process?
   - 1.3. For each type of decision please describe the process by which it is made. What types of assessments do you include to inform your decisions?
   - 1.4. Do the decision-making processes used by your office employ planning and scoping, and problem formulation phases? If yes, how are planning and scoping, and problem formulation conducted? What kinds of preliminary assessments are conducted?
   - 1.5. Has your organization applied any of the processes and approaches recommended by the SAB and NRC for integrating science supporting decision making? Has it used other models and approaches? If so, has it been useful to apply these models/approaches?
   - 1.6. As applicable, discuss a particular past recommendation that relates to the example(s) of science-based decisions you have described for the committee. Did the recommendation affect your decision(s)? If it affected the decisions, in what ways did this occur?
   - 1.7. How do you assess the level of analysis needed for a particular science assessment, and when is the analysis judged to be sufficiently completed to allow decision making?

[*] With special consideration of decision-making processes and approaches described in the *Toward Integrated Environmental Decision-Making*. (SAB, 2000) and *Science and Decisions* (NRC, 2009) and recommendations related to public participation in science and environmental protection in *Improved Science-Based Environmental Stakeholder Processes* (SAB, 2001) and *Public Participation in Environmental Assessment and Decision Making* (NRC, 2008).

1.8. Is the science assessment and decision-making process altered to accommodate different locations in the United States or different spatial scales? Do science assessment and decision-making processes change to address short-term and long-term needs?

1.9. What scientific data or information do you need to support decisions? Do you have the data/information that you need, when you need it? If not, what do you do? Are you constrained from using all available scientific information in decisions or generating new data and information to support decisions?

1.10 How are different assessments in different disciplines (including social and decision sciences) integrated as part of the science decision-making process?

1.11 How do you like information about the uncertainties in scientific assessments presented? What are some examples of presentation of uncertainties in scientific assessments that have helped you understand the science related to a decision and had an impact on that decision?

2. Consideration of public, stakeholder, external scientific, and other governmental input in science assessment for decision making

2.1. What role do the regulated community; non-governmental organizations; and the general public play in your organization's science assessment process? If involvement occurs, how is it accomplished? At what steps in the process are these groups involved?

2.2. To what degree and how do you coordinate scientific assessments with international organizations, other federal agencies, states and tribes? How does this coordination happen?

2.3. What role does the external scientific community play in integrating science to support decision-making in your organization? How does your organization engage the external scientific community to help your decision makers get the science needed to support decisions?

2.4. Has your organization applied any of the SAB's or NRC's recommendations relating to public participation in science supporting environmental decision-making? Have these reports influenced how public/stakeholder input has been used in your organization's science assessments? If so, has it been useful to apply these models/approaches?

3. Drivers and impediments to implementing past recommendations for science integration

3.1. Are there perceived or actual barriers for developing and/or implementing new or existing decision-making processes or frameworks that integrate the best available science? If yes, what are they?

4. Ways EPA receives feedback on how science is used in decision-making

4.1. How does your organization determine the effectiveness of implemented decisions (whether the decision resulted in reduced risk and improvement to public health and the environment)?

4.2. Does your organization use feedback on decisions to detect emerging science, influence future policy, set priorities? If so, how?

5. EPA workforce related to science integration supporting decision making

5.1. How does your organization's scientific and technical workforce adapt to shifts in priorities and resources?

5.2. How do scientists stay current in their areas of expertise, or expand their expertise based on current and future scientific needs?

5.3. What is the current balance between near-term program support research and longer-term research to advance the science?

6. Are there other questions we should ask that would help us understand how science and scientific assessments are integrated to support your decisions?

Questions for Scientific and Technical Staff:

1. Practices for integrating science to support decision making

1.1. What kinds of decisions are made in your organization and what is your role(s) in the decision-making process?

1.2. What types of science assessments are done to support your organization's decisions (e.g., technology, benefits, human health, ecological, behavioral/social/economic, etc.)?

1.3. Who actually conducts science assessments (e.g., your organization's staff, contractors, other EPA offices/personnel)?

1.4. How are assessments in different disciplines (including social and decision sciences) integrated as part of the science decision-making process?

1.5. How do you work within your own office, and with other EPA Offices and Regions to coordinate analyses needed for decision-making? What science data, models, analyses, etc. do you obtain from other units to support decision making in your unit?

1.6. Do you conduct formal uncertainty analyses? How are analyses matched to the needs of decision makers? How is uncertainty communicated to decision makers, stakeholders and the public?

1.7. What roles do computational models have in science integration for decision making in your organization. Do you make use of EPA's Council for Regulatory Environmental Modeling or the Models Knowledge Base, and if so, how?

1.8. What improvements are needed to integrate science assessments to support decision-making processes?

1.9. What are current interactions among your organization and the Agency's laboratories (e.g., ORD, Regional, Program-specific)?

2. **Consideration of public, stakeholder, external scientific, and other governmental input in science assessment for decision making**

2.1. To what degree do you coordinate development of your organization's scientific assessments with international organizations, other federal agencies, states and tribes? How does this coordination happen?

2.2. What role do the regulated community, non-governmental organizations, other international, federal, state or tribal governments and the general public play in your organization's science assessment process? If involvement occurs, how is it accomplished? At what steps in the process are these groups involved?

2.3. What role does the external scientific community play in integrating science to support your organization's decision-making? How does your organization engage the external scientific community in getting the science needed to support environmental decisions?

3. Drivers and impediments to implementing past recommendations for science integration

3.1. Are there perceived or actual barriers for developing and/or implementing new or existing decision-making processes or frameworks that integrate the best available science? If yes, what are they?

4. Ways EPA receives feedback on how science is used in decision-making

4.1. How does your organization determine the effectiveness of implemented decisions (whether the decision resulted in reduced risk and improvement to public health and the environment)?

4.2. Does your organization use feedback on decisions to detect emerging science, influence future policy, set priorities? If so, how?

5. EPA workforce related to science integration supporting decision making

5.1. How do you stay current in their areas of expertise, or expand their expertise based on current and future scientific needs?

6. Are there other questions we should ask that would help us understand how science and scientific assessments are integrated in support of your organization's decisions?

Appendix D: Strengthening Management Engagement and Accountability - Specific Suggestions for Consideration

1. The EPA's Action Development and analytical blueprint process should:
   - Be structured to include a problem formulation step for every new action, as described in this report;
   - Encourage scientists and decision makers to identify environmental management options that can achieve multiple environmental protection goals;
   - Include a new requirement that action plans include a plan for inclusion of stakeholder science perspectives, from problem formulation through evaluation of decisions; and
   - Include a new requirement for science integration evaluations for major agency actions.
2. The EPA should commission case studies in each region and program office documenting a problem formulation process, as described in this report. Reports of the case studies should be made available for discussion at a public workshop to study the practical implications of the problem formulation approach across EPA.
3. Senior managers and scientists from programs and regions should continue to participate in planning ORD research activities ***and*** ORD should regularly inform them about and involve them in research at key stages of development.
4. Regions and program offices should develop regular plans to identify the science needed to support upcoming environmental decisions. These assessments would identify needs to be met by internal program or regional scientists and science needs to be met by sources outside the region or program. These plans should be independently peer reviewed.
5. The EPA should build on Superfund's communication and training infrastructure to support cross-disciplinary exchange of information across all of EPA programs and between EPA and external scientists.
6. The EPA should pilot ways to build on Superfund's public involvement infrastructure to strengthen involvement in science integration across EPA programs and regional offices.
7. The EPA's programs and regions should identify and implement mechanisms to strengthen transparency and documentation of how science is integrated into decisions.
8. The EPA should review EPA's 1995 Risk Characterization Policy[1] and 2003 guidance on assessment factors[2] to identify how they might be updated in light of current needs for science integration.
9. The EPA should design and deliver training to managers and scientists about the potential of programs across the agency, in conjunction, to achieve EPA's protection environmental goals.
10. The EPA should implement a mechanism for reviewing SAB and NRC reports with a broad agency scope, communicating their possible implications for EPA programs and regions, and engaging EPA program and regional scientists in responding to recommendations from these science advisory bodies.
11. The EPA should seek opportunities to engage the SAB and NRC more actively in fostering science integration throughout the agency, including advisory activities at the regional and program level.

[1] U.S. Environmental Protection Agency. 2001. *Risk Characterization Handbook*. EPA 100-B-00-002. http://www.epa.gov/spc/pdfs/rchandbk.pdf (accessed 11/04/11).

[2] U.S. Environmental Protection Agency. 2003, A *Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information*, EPA 100/B-03.001. http://www.epa.gov/spc/pdfs/assess2.pdf (accessed 11/176/11).