



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

**OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD**

April 18, 2008

EPA-SAB-08-007

Honorable Stephen L. Johnson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: SAB Advisory on EPA's Draft *Report on the Environment 2007:
Science Report*

Dear Administrator Johnson:

EPA's Office of Research and Development requested that the Science Advisory Board (SAB) review the Agency's draft *Report on the Environment 2007: Science Report* (ROE). The ROE is an update of EPA's draft 2003 Report on the Environment which was reviewed by the SAB in 2004. In response to the Agency's advisory request, an SAB panel conducted a peer review of the draft 2007 ROE. The enclosed advisory report provides the advice and recommendations of the Panel.

The ROE is intended to present status and trend information for indicators that reflect the condition of human health and ecosystems in the United States. The SAB commends the Agency for its initiative in preparing this unique but ambitious report, and is pleased that prior SAB advice has been incorporated into the document. While the draft 2007 ROE represents an evolutionary advancement over the earlier 2003 version, the current draft still does not fully meet its intended purpose. Although the ROE presents status information to establish baselines for reporting future trends, the lack of long-term trend information in the document precludes trend analysis for many indicators. The rigid application of indicator selection criteria has resulted in the exclusion of valuable and relevant information that could be used to further analyze trends. The ROE is also limited because it contains little data interpretation and no conclusions supported by statistical analysis. In addition, the ROE lacks a framework describing the scientific understanding of relationships between indicators and the basis for including them in the Report. The SAB has provided recommendations to improve the draft 2007 ROE and strongly recommends that they be incorporated prior to releasing the final Report. In addition, the SAB has provided recommendations to improve future Reports on the

Environment with the expectation that those recommendations will require a longer time frame to implement.

The ROE has the potential to replace the sorely missed annual reports on the state of the environment once published by the Council on Environmental Quality. The value and importance of the ROE will continue to grow as pressures of population, energy use, urbanization, and climate change lead to continued stress on environmental quality and impacts on health and ecosystems. Therefore, as recommended in its review of the 2003 ROE, the SAB again strongly urges EPA to fully support and permanently embed the ROE into its core mission-directed activities. This will require an investment of resources beyond those currently devoted to the ROE.

Sincerely,

/Signed/

Dr. M. Granger Morgan, Chair
Science Advisory Board

/Signed/

Dr. Deborah Swackhamer, Chair
Panel for the Review of EPA's
2007 Report on the Environment

Attachments

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Mr. Thomas Miller, Designated Federal Officer, U.S. Environmental Protection Agency, Washington, DC

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1.0 EXECUTIVE SUMMARY

The Science Advisory Board (SAB) Panel for the Review of EPA's 2007 Report on the Environment has reviewed the Agency's draft *Report on the Environment 2007: Science Report* (ROE 2007 Science Report or Report). The ROE 2007 Science Report compiles and reports on scientific indicators of status and trends in human health and ecological condition in the United States. EPA initially presented this information in a draft *Report on the Environment Technical Document* released in 2003 and reviewed by the SAB. Since then, EPA has revised the Report in response to feedback from the SAB and stakeholders. The ROE 2007 Science Report will be used by EPA to inform strategic planning, priority setting, and decision making across the Agency, and to communicate with the general public.

In developing the ROE 2007 Science Report, EPA compiled indicators to help answer twenty-six policy-relevant questions deemed to be critically important to the Agency's mission and national interest. EPA sought the SAB's review of the adequacy of the formulation and scope of the questions posed in the Report; the appropriateness of the indicators in answering the questions; the accuracy of the characterization of indicator data gaps and limitations; the degree to which the data gaps and limitations of the indicators limit ability to answer the questions; the appropriateness of regionalization of national indicators; the utility of regional indicators in the Report; and the overall quality of the Report with respect to technical accuracy, clarity, and appropriateness of the level of communication. In this advisory report, the SAB provides specific comments and recommendations in response to the charge questions.

The Panel emphasizes the tremendous value of the ROE 2007 Science Report and concurs with the statement in the previous SAB review of the 2003 Report that there is an urgent need for this kind of assessment. The Report is unique in providing a comprehensive assessment of the time-varying quality of the environment including air, land, and water in relation to human and ecological health. Such an assessment becomes increasingly important as environmental pressures of population, urbanization, climate change, and energy use grow. The Panel therefore strongly urges EPA to fully support and permanently embed the Report on the Environment into its core mission-directed activities. This will require an investment in resources well beyond those currently devoted to the ROE 2007 Science Report.

The Panel finds that the ROE 2007 Science Report is a valuable collection of data and impact indicators. The Panel commends EPA for incorporating many of the SAB's recommendations from the 2004 review to improve the organization and scope of the Report. EPA has structured the ROE 2007 around questions central to the Agency's mission to protect human health and ecological condition. Generally, the SAB finds that the questions in the Report are well developed. However, a conceptual framework should be constructed and used as the basis for further developing appropriate questions. In the Report, EPA has effectively identified many of the key indicator data gaps and limitations; and regional analyses have made the Report more meaningful. However, as discussed below, the Panel has identified shortcomings in the document that limit its

usefulness in fulfilling its stated purposes. **While the Report may help inform strategic planning and priority setting, its value is limited because the Report contains little data interpretation and no conclusions supported by statistical analysis.**

Recommendations for improvements in the Report are provided in response to EPA's specific charge questions and to generally strengthen the document. The Panel provides recommendations at two levels, i.e., those to be considered before finalization of the Report, and longer-term recommendations to be considered in subsequent reports. These recommendations are listed as bullets throughout this advisory report and presented in summary tables in Appendices F and G respectively. Additional comments and suggestions are also provided in the text of this advisory report, and detailed comments pertaining to specific indicators and technical issues are included in Appendix A.

Overarching “higher level” findings and recommendations that pertain to all chapters

- **The scientific underpinnings of the final Report should be strengthened to make it a “science report,” as indicated by its title, rather than simply a data report.** As discussed below, this can be accomplished by including greater synthesis, interpretation, statistical analysis, and discussion related to the literature. An alternative would be to remove “science” from the title of the final Report so it is characterized as a status and trends report. When work is completed to strengthen the scientific underpinnings of future Reports, “science” could be included in the title.
- **The final Report should contain a greater degree of integrated discussion across the indicators and chapters.** The organization of the Report into individual media chapters (air, water, and land) and chapters on human health and ecosystem condition is consistent with EPA's programmatic configuration, and asking key scientific questions about the environment is a highly effective approach for organization and presentation. However, the Panel recommends that the final Report contain a greater degree of integrated discussion across the indicators and chapters than currently exists. **A conceptual framework that illustrates the connectedness between the media chapters and the human health and ecological condition chapters should be added to the introduction of the final Report. In addition we recommend that a final synthesis chapter be added to future Reports. The synthesis chapter should fully integrate the entire Report and discuss health and ecosystem status, trends, and effects from a holistic perspective.** The synthesis chapter should include a discussion that interprets the observed trends, connects the trends seen in the various indicators with cause/effect to the extent possible, and also connects the indicators with each other. EPA should add a brief section to the final Report outlining how a synthesis chapter could be developed in future Reports.
- **An approach to statistical analysis should be incorporated into future Reports on the Environment.** The ROE 2007 Science Report states that, due to time and resource limitations, statistical analyses of uncertainty and trends in indicators were not included. The Panel finds that this has limited the usefulness of the Report, and that a statistical approach to analysis and presentation of the data is needed to add rigor to the Report. The Panel notes that the Report provides a large amount of

valuable data and information that can be interpreted by readers, but it contains few clear conclusions and statements of significance of the findings. Future Reports on the environment should provide such conclusions and statements of significance.

The Panel therefore recommends that EPA incorporate into future Reports on the Environment an approach to statistical analysis and reporting across all indicators. This should be part of the results presentation for each indicator. In some cases, this may involve formal statistical analyses, whereas in other cases it may involve the inclusion of additional information such as error bars around mean values. When there are insufficient data available for robust quantitative analyses, such statistical limitations should be reported. Without such information, the ROE cannot fully meet its intended purpose of reporting scientifically established trends in human health and environmental condition.

- **All questions in the final Report should address status and trends.** The Panel was asked to comment on the adequacy of the formulation and scope of questions posed in the ROE 2007 Science Report. Although the scope of the questions posed in the Report is generally appropriate, questions are asked only about trends. Most of the information presented in the Report reflects indicator status rather than trends. **The Panel recommends that all questions in the final Report address both status and trends.** The discussions of “what the data show” should clearly reflect cases where trends cannot be presented because only status information is available. In addition, it is recommended that in the final Report, EPA should clarify whether trends are defined qualitatively or quantitatively. The word “trend” has a specific meaning in statistical science. The definition of trend can cover both statistical and qualitative assessment of change over time as long as the intended meaning in a particular situation is indicated. It is also recommended that EPA explicitly state how each question is related to the conceptual framework of the Report.
- **The Report on the Environment can be strengthened by selecting additional indicators to inform the stated questions.** The Panel was asked to comment on whether the indicators presented were used appropriately to answer questions contained in the Report. Indicators were selected against a set of specified criteria. The Panel finds that, with some exceptions, appropriate indicators were selected. However, the rigid application of indicator selection criteria, particularly national representativeness, has resulted in the exclusion of valuable and relevant information. **As discussed in various sections of this advisory report, the Report on the Environment can be strengthened by relaxing the restrictive indicator selection criteria to enable the use of additional indicators to inform the stated questions. In this regard, it will be useful to select additional regional indicators and case studies by applying clear and transparent criteria.** Indicators should also be included to show the response of more integrated components of the system or address missing issues. For example, indicators should capture the status of and trends in ecosystem services. This will provide important information on how changes in environmental condition directly affect human well being. **In addition, the Panel recommends that for each indicator in the final Report, EPA provide a clear description of why the indicator is important, what it tells, and the**

documented relationship between the indicator and human health and ecological condition.

- **Discussion of the indicator gaps, limitations, and challenges should be clarified in the final Report.** Each question contained in the Report is accompanied by a discussion of the most critical indicator gaps, limitations, and challenges that prevent the question from being fully answered. The Panel was asked to comment on the adequacy, objectiveness, and transparency with which the indicator gaps and limitations were characterized. In general, the Panel finds that most of the critical indicator data gaps and limitations have been identified. However, to improve the final Report, additional clarification is required to differentiate data gaps (e.g., where indicator data are not available) from limitations (e.g., where limited data are available). In addition, various kinds of indicator data limitations could be grouped (e.g., geographic limitations, statistical limitations, and limitations in coverage of ecosystem types or components). In addition, the Panel recommends that in the final Report, the discussion of data gaps and limitations should be strengthened by including: 1) a discussion of the need for a transparent set of indicator metrics that can be well justified, 2) additional information, at the end of each chapter, on emerging issues such as chemicals of concern and invasive species, and 3) further justification of limitations associated with the intervals of time used to establish trends. The Panel also recommends that the indicator gaps discussion in the final Report be expanded to identify some of the more prominent available data sets that were excluded, and the reasons for their exclusion. It is also recommended that in the final Report, EPA should identify the status of the monitoring programs (e.g., extant, on hold, or expired) that have provided indicator data used in the Report. This will enable readers to determine whether additional trend information will be available in the future.
- **In future Reports on the Environment, regional analyses of indicator data should be presented by relevant geographic units such as ecoregions, airsheds, and watersheds.** The Report has broken out national-level data for some of the indicators by EPA region and provided ten regional indicators. The Panel was asked to comment on the utility of these approaches. The Panel finds that regional analysis of data makes the Report more meaningful. The Panel also recognizes the pragmatic appeal of using EPA administrative regions for this purpose. However, the use of EPA administrative regions to scale national data has little ecological justification and does not provide particularly informative geographic descriptors of human health. **Therefore, the Panel recommends that in future Reports on the Environment, indicator data be presented by relevant geographic units such as ecoregions, airsheds, and watersheds.** This would be a useful approach for presenting both ecological and human health data. The Panel supports the use of regional indicators that can reflect important information for gauging the state of the U.S. environment. Key regional issues such as the ecological health of the Great Lakes or the Everglades should also be addressed in a national report on the environment, and the use of state and county data could increase the resolution for reporting the health indicators in future Reports. In this regard, some states generate and publish their own reports on

the environment. Such reports may provide useful data on indicators of human health as well as ecological condition.

- **More regional indicators and case studies with long-term, well-supported data sets could be used in future Reports on the Environment to illustrate trends when national data sets are not available.** It is disappointing that the lack of available long-term data for many indicators precludes trend analysis and limits the usefulness of the Report. **Regional data are not a substitute for national or even representative national data.** However, the Panel notes that with appropriate caveats, more regional indicators and case studies with long-term, well-supported data sets could be used in future Reports on the Environment to illustrate trends when national data sets are not available. Some regional case studies are included in the Report, and it should be clearly stated that the specific case studies presented may not be representative of a general or national situation. However, this concern should not constrain the use of additional regional studies to demonstrate important examples of national importance or particular significance to local populations. In Section 5.0 of this advisory report, the Panel suggests criteria that might be applied to identify useful regional indicators and case studies.

In addition to overarching findings and recommendations pertaining to all chapters of the ROE 2007 Science Report, the Panel has provided specific recommendations pertinent to individual chapters of the Report.

Air chapter findings and recommendations

Although the questions in the air chapter of the Report are generally appropriate, a science framework is needed to show interaction within, between and among media, as well as between and among indicators. The Panel also notes that a short historical section should be included in the air chapter of the final Report to provide background information on the criteria pollutants. This information is needed to provide an understanding of the importance of these pollutants as indicators, how they have been tracked, and their relationship to other indicators in the Report. As discussed in Section 6.0 of this advisory report, the Panel has identified a number of missing air indicators that should be added to the final Report because they represent important trends in air quality or present a more holistic picture of atmospheric chemistry. These include SO₂ concentration and air toxics information. The Report should also discuss key trends in the understanding of the atmosphere, such as the clear reduction of primary pollutants (CO, SO₂, and Pb) and much flatter trends in secondary pollutants (O₃ and PM_{2.5}).

Most of the gaps and limitations of air indicators have been appropriately identified in the Report. However, the Panel finds that the pollutant-by-pollutant recounting approach used in the air chapter does not show the interplay of the various criteria and toxic pollutants with one another or the role of stratospheric ozone depletion and climate change with respect to air quality. In addition, the pollutant information in the Report does not demonstrate the relationship to human health. An integrative description of

these air pollutants is needed in the final Report to provide public or other policy makers with a full picture of the state of the atmospheric environment.

Water chapter findings and recommendations

The Panel finds that some of the questions in the water chapter inappropriately call for information on trends in both the extent and condition of certain indicators. Therefore, it is recommended that in the final Report, EPA refine the differentiation between extent and condition for indicators where inclusion of both extent and condition measures does not make sense. For example, it is not meaningful to refer to the extent of coastal waters because the issue of importance is condition. In addition, questions should be incorporated into the water chapters of future Reports on the Environment to provide information on critical habitats and missing thematic elements such as trends in water availability and usage of water for human activities.

The Panel finds a lack of acceptable water indicators in the Report to answer some of the questions posed. The following additional types of indicators are recommended to answer questions in future Reports on the Environment. 1) The freshwater indicators in the Report have a strong lotic bias, and equal attention should be devoted to indicators relevant to lentic systems. 2) EPA should identify and use indicators that have relevance to human health as well as to ecology. Pathogen indicators should be included in the future Reports. The Panel notes that in the Report, concentrations of chemical indicators have been inappropriately compared to drinking water maximum contaminant levels. The comparison is inappropriate because people do not generally drink water from agricultural streams where pesticide concentrations were measured for the comparison. The data should be evaluated to assess toxicity to biota living in the streams. 3) EPA should identify indicators of important ecosystem processes such as denitrification, decomposition, and primary production. In this regard, data on biogeochemical processes in wetlands such as organic matter decomposition and accretion, denitrification, and sulfate reduction can provide early indications of impending ecological changes. 4) EPA should identify indicators that will aid in evaluating the impact of emerging issues such as biofuel feedstock production on the quality and quantity of water. 5) Some chemical indicators, such as pesticides in agricultural streams, should be based on measured concentrations in sediments and biota, if available, rather than the water column where concentrations may be low but biota may be impacted by elevated levels in sediments.

Land chapter findings and recommendations

The questions in the land chapter address land resource management and land contamination. The questions are appropriate although somewhat peripheral to EPA's mission. It is recommended that in future Reports on the Environment EPA consider adding a question that addresses the important issue of soil quality and conservation. In future Reports on the Environment EPA should also 1) consider a range of available land-cover classification schemes with different levels of resolution (this is necessary because the resolution of the data in the current draft of the Report is too coarse to completely answer the questions); 2) extend land cover characterization to all major ecosystem types,

not just the forest land characterized in the current draft of the Report; and 3) adopt standard approaches for land-use and land-cover analysis to evaluate information and document trends across a range of available data sets. Moreover, as further discussed in Section 8.0 of this advisory report, the Panel finds that the questions in the land chapter are not completely answered by the indicators presented, and the range of indicators in the land chapter is not at the same overall level of development as in the water and air chapters. For example, few land indicators provide direct measures of effects on human health. Some additional resources and an expanded set of disciplines are needed to bring the land chapter to the level of evaluation provided in other chapters. To more completely answer the questions posed in the land chapter, the Panel recommends that EPA include the following additional indicators in the final Report: 1) a pesticide use indicator (this would be particularly important from the standpoint of human exposure); and 2) indicator data for persistent bioaccumulative toxics (PBTs) and mining wastes (e.g., Toxics Release Inventory derived information), radioactive wastes, and animal and other wastes applied on agricultural land.

Human health chapter findings and recommendations

The questions in the human health chapter are comprehensive, appropriate, and well-developed. However, the Panel notes that they encompass both human health and exposure. It is therefore recommended that in the final Report, the chapter be more descriptively renamed “Human Exposures and Health.” In addition, the questions in the human health chapter of the final Report should be reordered to be consistent with the event sequence in the environmental health paradigm as depicted in Figure 5.1 of the Report. The indicators used in the human health chapter are appropriate, but the Panel recommends that in future Reports on the Environment, EPA consider using an expanded suite of human health indicators that include National Health Interview Survey (NHIS) and Behavioral Risk Factor Surveillance System (BRFSS) information (Centers for Disease Control and Prevention, 2008a,b), hospital and emergency room admission data available in National Hospital Discharge Survey reports (Centers for Disease Control and Prevention, 2008c), and reports of infectious disease maintained by the Centers for Disease Control and Prevention (Centers for Disease Control and Prevention, 2007). These indicators would more effectively capture important health concerns such as effects related to indoor air quality, use of pesticides, and exposure to pathogens.

In addition, the Panel finds that there is a critical need to expand the indicator discussion in the final Report to address indicator relevance to the stated questions. Such discussion is needed because the relevance of the indicators to the questions can be wide ranging and it is important that the Report provide a characterization of the value or importance of the indicator to the question. Strong epidemiologic evidence is available in the literature to support many of the indicators EPA has chosen (i.e., cancer incidence, childhood cancer incidence, cardiovascular disease, chronic obstructive pulmonary disease, asthma, infectious disease, birth defects, low birth weight, and preterm delivery), and it is recommended that a qualitative or quantitative description of such information be provided in the final Report. To further strengthen the scientific credibility of the Report, the Panel recommends that the discussion of indicator gaps and limitations also

be expanded in the final Report to include a more quantitative description of indicator relevance by relying on the epidemiologic literature. The discussion might be further expanded to address how the limitations and gaps affect the interpretations of the indicators.

Ecological condition chapter findings and recommendations

The questions posed in the ecological condition chapter of the Report are generally appropriate, but the Panel recommends that in the final Report the chapter be reorganized to reflect an integrated focus on ecosystem health. Some revision of the questions may be needed as the chapter is reorganized. It is recommended that the chapter be organized hierarchically according to 1) major ecosystem type, 2) ecosystem processes and services, and 3) ecosystem components (physical, chemical, biological). In addition, the Panel finds that the scope of indicators in the ecological condition chapter needs considerable broadening to cover all ecosystem types and fill specific gaps in the indicator coverage (i.e., missing ecosystems, missing populations, and missing processes). Specific indicators and indicator types have been suggested in Section 10.0 and Appendix A of this advisory report to broaden the coverage and fill gaps. Easily accessible data may be available for some of these indicators, and they could be included in the final Report, while others should be included in future Reports on the Environment. It is recognized that EPA cannot develop an unlimited set of indicators but should select those that address key ecological issues.

2.0 INTRODUCTION

This report transmits the advice of the U.S. Environmental Protection Agency Science Advisory Board (SAB) Panel for the Review of EPA's 2007 Report on the Environment. The Panel conducted a peer review of EPA's draft *Report on the Environment 2007: Science Report* (ROE 2007 Science Report or Report). The draft ROE 2007 Science Report compiles and updates scientific indicators of status and trends in human health and ecological condition in the United States. EPA released its first draft Report on the Environment in 2003. That report was reviewed by the SAB (U.S. EPA Science Advisory Board, 2004), and the SAB's advice was used to develop the improved and updated ROE 2007 Science Report. A second SAB Panel was formed to review the 2007 Report. EPA intends to use the ROE 2007 Science Report to inform strategic planning, priority setting, and decision making across the Agency. The ROE 2007 Science Report is also intended to provide information that will enable the public to assess whether EPA is succeeding in its overall mission to protect human health and the environment.

In developing the ROE 2007 Science Report, EPA identified twenty-six policy-relevant questions about environmental and human health deemed to be critically important to the Agency's mission and national interest. The Agency selected a suite of indicators to answer these questions. The ROE 2007 Science Report consists of chapters developed to answer status and trend questions concerning air, water, land, human health, and ecological condition. In each of these five chapters, EPA described the scope of the priority questions to be answered; provided a set of indicators to answer the questions; and discussed indicator data gaps, limitations, and challenges that prevented questions from being fully answered. In the ROE 2007 Science Report, EPA established an explicit indicator definition and six indicator selection criteria. The metadata for indicators used in the Report are available on EPA's website (U.S. Environmental Protection Agency, 2008). The metadata include EPA's evaluation of the extent to which procedures for quality assurance and quality control of the data have been documented. The Report presents indicator status information to establish baselines for reporting future trends, but it does not provide long-term trend information for many indicators. EPA stated that the ROE 2007 Science Report was written for a target audience of environmental professionals. The Agency developed a less detailed ROE 2007 "Highlights Document" for the more general audience of concerned citizens, and a web-based "e-ROE" to facilitate electronic access to materials in the Report and provide timely updates in the future. The SAB Panel was asked to review only the ROE 2007 Science Report.

The Panel emphasizes the tremendous value of EPA's Report on the Environment. This is a unique report with the objective of providing an assessment of changes in environmental quality over time as related to human and ecological health. We concur with the statement in the SAB's review of EPA's draft 2003 Report that there is an urgent need for this kind of assessment. It can have an important impact on improving the state of the environment by synthesizing relevant information from many sources for the development of effective environmental monitoring, policy, and protection programs. EPA's Report on the Environment can also provide the public with essential information about environmental status and trends and their relevance to public health and ecological

condition. **The Panel therefore strongly urges EPA to fully support and permanently embed the Report on the Environment in its core mission-directed activities.** This will require an investment in resources beyond those currently devoted to the ROE 2007 Science Report. The EPA staff that produced the ROE 2007 Science Report are commended for their remarkable productivity and output; however, a sustained and increased investment in staff and expertise for the Report on the Environment is essential and strongly recommended. The Panel offers recommendations for improvements in the ROE 2007 Science Report to make it more useful to EPA and other intended audiences.

3.0 CHARGE TO THE REVIEW PANEL

EPA gave the following six charge questions to the SAB Panel for its review of the ROE 2007 Science Report.

Charge Question 1. Please comment on the adequacy of the formulation and scope of the questions in the Chapters of the *Report on the Environment 2007: Science Report*. Does the SAB have any specific recommendations on how to improve or clarify the formulation of the questions? Does the SAB have recommendations on changing the scope of the questions to better reflect EPA's mission?

Charge Question 2. Please comment on whether all of the relevant indicators in the Report have been used appropriately to answer the questions. Please comment on whether the integrity of the material in the indicator write-up is preserved in the chapter narrative.

Charge Question 3. Please comment on the adequacy, objectivity, and transparency of the identification and communication of gaps and limitations of the indicators in answering the Report on the Environment questions.

Charge Question 4. Please comment on the utility, comparability, and objectivity of the regionalization of the national Report on the Environment indicators. Does the use of EPA Regions to scale national data accurately reflect, or does it inappropriately distort the problem domain?

Charge Question 5. Please comment on the utility of the regional indicators in *Report on the Environment 2007: Science Report* in answering the questions. Does the SAB have recommendations for whether and how to build on this base in future versions of the report?

Charge Question 6. Please comment on the overall quality of the *Report on the Environment 2007: Science Report* with respect to technical accuracy, clarity, and appropriateness of the level of communication.

4.0 REVIEW PROCESS

The Panel's review of EPA's ROE 2007 Science Report was structured to develop responses to all of the charge questions for each chapter of the Report. Panel subgroups were assigned lead responsibility for reviewing individual chapters of the Agency's draft Report. The Panel then discussed the subgroup responses and developed specific findings and recommendations concerning the air, water, land, human health, and ecological condition chapters. The Panel has also provided "higher level" overarching recommendations that pertain to all chapters of the ROE 2007 Science Report. The overarching findings and recommendations in Section 5.0 of this advisory report address EPA's specific charge questions as well as general improvements needed to make the ROE 2007 Science Report a more effective assessment of status and trends in human health and ecological condition. The Panel has recommended revisions that should be incorporated into the final Report as well as improvements that will require a much longer time frame to implement, and thus should be incorporated in future Reports on the Environment. These recommendations are listed as bullets throughout this advisory report and presented in summary tables in Appendices F and G respectively. Additional comments and suggestions are also provided in the text of this advisory report, and detailed comments pertaining to specific indicators and technical issues are included in Appendix A. The Panel strongly recommends that EPA make the suggested near-term changes prior to releasing the final Report.

5.0 OVERARCHING RECOMMENDATIONS

The Panel finds that the ROE 2007 Science Report is a valuable collection of data and impact indicators and strongly endorses continued development and dissemination of the Report. The Panel finds that the Report is an improvement over EPA's draft 2003 Report on the Environment and commends the Agency for addressing many of the SAB's comments and recommendations on the 2003 Report. As recommended by the 2004 SAB Review Panel, the ROE 2007 is free from conclusions about the impacts of specific policies or government initiatives, regional indicators have been incorporated into the Report, and some key missing indicators have been added. The 2007 SAB Review Panel notes, however, that some recommendations of the previous SAB review panel were not addressed. Additional funds and personnel have not been allocated to sustain development of the Report on a continuing basis, and analyses of greater statistical rigor have not been included in the Report. Generally, the formulation and scope of the questions in the ROE 2007 Science Report are adequate, narratives in the text have captured information about the indicators presented in the document, EPA has effectively identified many of the key indicator data gaps and limitations, and regional analyses have made the Report more meaningful. However, as discussed below, the Panel has identified numerous shortcomings in the document that limit its usefulness in fulfilling its stated purposes. While the Report may help inform strategic planning and priority setting, its value is limited because the Report contains data with little interpretation and no conclusions supported by statistical analysis. Recommendations for improvements in the Report are provided to make it more useful to EPA and other intended audiences.

Organization of the ROE 2007 Science Report

The organization of the Report into individual media chapters (air, water, and land) and chapters on human health and ecological condition is consistent with EPA's programmatic configuration, and asking key scientific questions is a highly effective approach for presenting the information in the Report. However, the Panel finds that the introduction of the Report should be revised to clearly articulate EPA's objectives in developing the document and to more fully describe the structure of the document. As further discussed below, the introduction should also provide a conceptual framework that illustrates the connectedness between the media, human health, and ecological condition chapters. To articulate EPA's objectives and describe the structure of the Report, the Panel recommends the following changes in the introduction:

- **In the final Report, the introduction should be revised to clearly indicate that the first three chapters are intended to address status and trends using specific indicators for the individual “media” of air, water, and land, and that the next two chapters are intended to provide integrated assessments of status and trends in human health and ecosystem condition.**
- **In the final Report, the introduction should also clearly state its purpose for intended audiences and EPA. The introduction should discuss how the Agency plans to use the Report and its analyses and how the Agency wants the Report to be used by the broader public. In this regard, the final Report should state that the current version of the Report provides status information to establish baselines for reporting future trends, but does not yet include long-term trend information for many indicators.**

Strengthened scientific underpinnings

The Panel finds that the scientific underpinnings of the final Report should be strengthened to make it a “science report,” as indicated by its title, rather than simply a data report. As discussed below, this can be accomplished by including greater synthesis, interpretation, statistical analysis, and discussion related to the literature. An alternative would be to remove “science” from the title so that the report is characterized as a status and trends report. If work is completed to strengthen the scientific underpinnings of subsequent versions of the Report, “science” could again be included in the title.

Incorporation of a conceptual framework and synthesis chapter

The Panel finds that the final Report needs a greater degree of integrated discussion across the indicators and chapters. Each chapter of the Report is currently designed to be a stand-alone document for readers interested in the particular subject areas of land, water, air, health, and ecology. Consequently, the interconnections among these areas are not well established or discussed. For example, the relationship between waste management and chemical uses (addressed in Chapter 4) and water quality (addressed in Chapter 3) is mentioned in the introduction of the water chapter, but this relationship is

not obvious from the presentations of the individual indicator data. In addition, the possible links between greenhouse gas emissions (in Chapter 2) and global sea level and temperature changes (in Chapter 6) are not discussed. The Report currently contains a discussion section after each question and related series of indicators, but there is not a corresponding synthesis discussion across the questions to tie the document together and make the whole greater than the sum of its parts. The Panel also notes that, although the Report provides a large amount of valuable data and information that can be interpreted by readers, it contains few clear conclusions and statements of significance of the findings. In future Reports on the Environment, EPA should provide such conclusions and statements. The Panel also urges that the following recommendations be implemented.

- **In the final Report, EPA should incorporate a conceptual framework into the introduction to illustrate the connectedness between the media, human health, and ecological condition chapters.** Development of the conceptual framework will enable selection of better indicators by identifying the key stressors (drivers), responses, and outcomes that should be tracked to understand trends in the condition of air, water, land, human health, and ecosystems. The conceptual framework could be a short but comprehensive description and figure that demonstrates scientific understanding of relationships between the stressors, responses, and outcomes to human health and ecosystem condition. An example conceptual framework figure is provided in Appendix C of this advisory report. The conceptual framework should address relationships between source, transport, and fate of human and environmental health hazards, as well as exposure to receptors, dose, and impact. The description of the conceptual framework might discuss efforts underway to develop so-called linked indicators of environmental hazards and human health, such as the Environmental Public Health Tracking Project (National Association of County and City Health Officials, 2007). The figure could be included in the introduction with appropriate similar figures at the beginning of each chapter to provide overall context for the chapter and illustrate how the chapters are connected. For example, in each chapter the relevant parts of the figure that show the role and importance of a given chapter could be highlighted in the graphic. This would provide the clear basis for the use and prioritization of specific indicators, the choice of scale and boundaries in regional indicators, and selection of metrics (i.e., thresholds, benchmarks, etc.) The choice in scale and metrics would provide the appropriate context for future monitoring and assessment of status and trends.
- **In appropriate places in the final Report, interconnections between the indicators should be established by cross-referencing the discussion of indicators in different chapters.** EPA should elaborate wherever possible on the relationships between indicators and the outcomes with respect to human health and ecological condition
- **In future Reports on the Environment, a synthesis chapter should be included to fully integrate the Reports and to provide an overall assessment of health and ecosystem status, trends and effects.** The synthesis chapter in future reports could

also analyze and discuss in more detail the connections among various related indicators as well as relationships among the media and health and ecology chapters. For example, the relationship between nitrogen and phosphorus in agricultural watersheds (in Chapter 3) and fertilizer use (in Chapter 4) could be discussed. In this regard, a number of questions could be addressed, such as, Is there any evidence that indicators are correlated? Is it possible to use the indicator data for such an analysis? EPA should add a brief section to the final Report outlining how a synthesis chapter could be developed in future Reports.

- **In future Reports on the Environment, a summary section should be included after each media chapter to summarize information presented in the chapter and identify relevant emerging issues that could potentially affect human health and the environment.**

Statistical analysis

The ROE 2007 Science Report states that, due to time and resource limitations, statistical analysis of uncertainty and trends in indicators was not included. The Panel finds that this has limited the usefulness of the Report, and that a statistical approach to analysis and presentation of the data is needed. Without such information, the Report on the Environment cannot fully meet its intended purpose of reporting scientifically established trends in human health and environmental condition. The Panel understands that EPA has begun this work for some indicators and that the analysis for those indicators will be included in the final Report. It is our further understanding that this work will eventually be completed for all indicators. The Panel understands that some of the most important indicators are not well developed and few high quality data sets may be available for these indicators. The Panel suggests that these indicators could be used with the explanation that a higher level of statistical analysis and reporting will be developed in the future. We encourage the effort to develop statistically established trends and recommend that:

- **In the final Report, EPA should clarify whether the document refers to qualitative or quantitative trends, or both (i.e., “trend” as used in the document needs to be defined). The word “trend” (used in the questions) has a specific meaning in statistical science.** The definition of trend used in the Report can cover both statistical and qualitative assessment of change over time, as long as the intended meaning in a particular situation is indicated. The Panel suggests that trend information be developed wherever possible, and that EPA use both qualitative as well as quantitative data to generate trend information for all indicators.
- **In future Reports on the Environment, EPA should incorporate statistical analysis and interpretation in the reporting of all indicators.** This should be part of the results presentation for each indicator. In some cases, this may involve formal statistical analyses, whereas in other cases it may involve the inclusion of additional information such as error bars around mean values. The Panel notes that this approach should be developed taking into consideration the need for statistical

accuracy as well as the importance of using available information to report on indicators of human health and environmental condition.

Charge Question 1. Adequacy of formulation and scope of questions in the ROE 2007 Science Report

The Panel was asked to comment on the adequacy of the formulation and scope of questions posed in the ROE 2007 Science Report. The Panel notes that in the ROE questions are asked only about trends. The scope of the questions should be broadened in the final Report to focus on status as well as trends. This will reflect the importance of capturing information to represent a baseline established as an initial step to evaluate trends when more data become available. To help readers understand the importance of the questions and associated indicators, it is also important to explain the relationship between the questions and the conceptual framework in the final Report. The Panel therefore recommends that:

- **In the final Report, all questions should be broadened to ask, “What are the status and trends...” rather than focusing only on trends.** In some chapters of the Report, a few long-term data sets are presented. However, the information in the Report is focused more on status than trends. The questions should therefore address both status and trends. In cases where a trend cannot be presented because only status information is available, this should be clearly reflected in the discussion of what the data show.
- **In the final Report, EPA should explicitly state how each question in the Report is related to a conceptual framework.** The Panel recognizes that in the Report EPA has included “policy relevant” questions that are important to the Agency’s program offices. However, the conceptual framework that demonstrates understanding of the relationships between stressors, responses, and outcomes to human health and ecosystem condition should be the basis for developing questions to be answered in the report. Once the appropriate questions are developed, EPA can consider their relevance to Agency policy.

Charge Question 2. Use of indicators to answer questions in the ROE 2007 Science Report and presentation of indicator data in the chapter narratives

The Panel was asked to comment on whether the indicators presented in the ROE 2007 Science Report were used appropriately to answer questions in the Report, and whether narratives in the text accurately captured indicator information. The Panel has responded to this question and has also identified a number of missing but appropriate indicators (discussed in Sections 6.0 – 10.0 and Appendix A of this advisory report). In particular, as discussed in Section 10.0 below, indicators should be included in the final Report to represent the status of and trends in ecosystem services. In addition, the Panel recommends that the final Report contain further discussion of the relationships between the indicators and human health and ecological condition.

EPA established a set of criteria that were used to drive the process of selecting the indicators in the Report. The criteria included rigorous data requirements for selection of indicators. The Panel finds that, with some exceptions, the narratives in the text of the Report have accurately captured the indicator data. However, the high data standards established by the indicator selection criteria are restrictive, and this has resulted in the exclusion of many important indicators of status and trends in human and ecological health. As further discussed in other sections of this advisory report, future Reports on the Environment can be strengthened by including indicators and data sets that may not meet the current selection criteria. The Panel specifically recommends the following:

- **In the final Report, EPA should provide a clear description of why each indicator is important, the rationale for selecting the indicator, what it tells, and the documented relationship between the indicator and human health and ecological condition. An example indicator description is provided in Appendix C of this advisory report.** For each indicator, the description could be provided in an introductory section that refers to the conceptual model or framework. This is critical in order to enable the reader to interpret the meaning of the indicator relative to the question. The primary stressors (e.g., air emissions data) are important indicators but the Report should more fully explain how these stressors contribute to answering questions in the Report.
- **In the final Report, additional indicators (identified in various sections of this advisory report) should be included to show the response of more integrated components of the system or address missing issues. For example, indicators should be included to capture the status of and trends in ecosystem services.** This will provide important information on how changes in environmental condition directly affect human well-being. For information on this topic, EPA is referred to Meyerson et al., 2005. Ecosystem services classification and indicators are further discussed in Section 10.0 of this advisory report.
- **In the final Report, additional trend data (classified as either qualitative or quantitative) should be included for as many indicators as possible.** This is recommended as a revision for the final Report if data are available and certainly as a revision for future Reports on the Environment.
- **In the final Report, EPA should identify the status of the monitoring programs (e.g., extant, “on hold,” or expired) that have provided indicator data used in the Report.** This will enable readers to determine whether additional trend information will be available in the future.
- **In future Reports on the Environment, the indicators selected should be clearly related to the “big picture” fundamental questions, and not chosen just because of data availability or compliance with indicator criteria (i.e., they are the only indicators left after others have been eliminated).**

- In future Reports on the Environment, EPA should consider relaxing the restrictive indicator selection criteria so that additional indicators can be included.** The use of restrictive indicator criteria resulted in selection of indicators supported by nationally representative data. However, long-term data were not available for many of these indicators, and thus trend analysis was not possible. Relaxing the restrictive criteria will enable EPA to use additional indicators in order to better evaluate trends and answer questions in the Report. In this regard, regional indicators supported by long-term data sets may be particularly useful. The Panel appreciates that EPA's indicator selectivity is in response to the 2004 SAB review, but the Panel feels the selection criteria have been made too restrictive and rigid such that useful data have been excluded. One way to revise the selection criteria in order to identify useful regional indicators and data sets would be to classify indicators according to completeness or rigor. This could supplement the current approach of classifying the data as national or regional. For example, indicators could be classified as high, medium, or low with respect to confidence in the ability to detect trends based on data continuity. Although this is recommended as a revision for future Reports on the Environment, some regional trend data may currently be available and easily obtained. In these cases, revision of the final Report is recommended to use the available data. On page 12 of this advisory report, the Panel has provided some additional guidance for selecting useful regional indicators, and a number of specific indicators that should be considered are identified in various sections of this advisory report. For example, a coral reef indicator and National Oceanographic and Atmospheric Administration status and trends data could be included if restrictive selection criteria were relaxed.

The Panel recognizes that it is not a simple task to change the indicator selection criteria to take into account the importance of additional long-term data sets and key indicators in various media and systems. However, the conceptual framework of the Report should drive the design of criteria that will enable selection of the best indicators to answer questions posed in the Report.

Charge Question 3. Discussion of indicator data gaps and limitations in the ROE 2007 Science Report

Each question in the ROE 2007 Science Report is accompanied by a discussion of the most critical indicator gaps, limitations, and challenges that prevent the question from being fully answered. The Panel was asked to comment on the accuracy of characterization of the indicator gaps and limitations, and the degree to which they limit the ability to answer questions in the Report. In general, the Panel finds that most of the critical indicator data gaps and limitations have been identified and clearly explained in the Report. However, the Panel is troubled by the frequency of statements indicating that long-term data were not available for many indicators and that this precluded trend analysis. The Panel appreciates this transparency but finds that there are too many indicators in the ROE 2007 Science Report that use "snapshot" data. The Panel acknowledges that baseline data are essential but, as noted above, in future Reports on the

Environment EPA should consider relaxing the indicator criteria, especially on a regional basis, to allow the use of data sets that are amenable to trend analysis.

It is somewhat problematic that many of the indicators in the Report aggregate data over a prolonged period of time. While this may be the result of the sampling methodology, it should be mentioned and discussed as a weakness. For example, in the presentation of the indicator “nitrogen and phosphorus in streams in agricultural watersheds,” the data are aggregated over nearly 10 years, but it is safe to assume that agricultural practices and land cover in each of the watersheds have changed over that time. The Panel notes that these changes in agricultural practice may be a confounding effect.

The Panel also notes that it is not always clear which bullets in the Report refer to “indicator limitations” or to “data gaps.” This should be clarified in the final Report, and in future Reports on the Environment it may be useful to subdivide the data gaps and limitations section into different types of limitations instead of providing a laundry list after each indicator. For example, the limitations could be grouped based on: 1) geographic limitations; 2) statistical limitations; 3) data coverage limitations; etc. The following specific recommendations are provided to amplify and clarify the discussion of indicator data gaps and limitations in the Report:

- **In the final Report, EPA should clarify whether specific bullets in the indicator limitations sections refer to indicator limitations or data gaps.**
- **In the final Report, the discussion of gaps and limitations should be expanded to identify some of the more prominent available data sets that were excluded and the reasons for their exclusion (e.g., technical concerns, lack of statistical power, or other specific reasons).** This discussion should refer to the indicator selection criteria and might identify indicators that could effectively narrow data gaps but may not meet specific stringent criteria (e.g., older data sets that can be used to show trends in important indicators, regional data sets that are of national interest or case studies demonstrating a framework for discussion or national applicability). This would help address questions about some omissions, such as fish advisories issued by states and birth defect data.
- **In the final Report, the discussion of data gaps and limitations should be strengthened by adding or expanding existing information in several areas.** These areas include: 1) discussion of the need for a transparent set of indicator metrics that can be well justified (the current choices of metrics and benchmarks are not well justified); 2) the need to provide additional information at the end of each individual chapter on emerging issues such as chemicals of emerging concern, exotic wildlife diseases or invasive species (the Panel specifically notes that perfluorinated chemicals should be added to the list of emerging contaminants of importance in Chapter 7 of the ROE 2007); and 3) further justification and discussion of limitations associated with the intervals of time used to establish trends. To understand and account for such potential confounding effects, the description of each indicator

should include a discussion of the relevant time periods that can be aggregated without losing integrity.

- **In the final Report, the implications of each indicator limitation should be discussed, and the uncertainties associated with each limitation should be quantified to the extent feasible.** One possible approach to address uncertainty would be to assign a level of confidence to the inferences that can be drawn from the data sets. Even a subjective evaluation would provide helpful information.
- **In future Reports on the Environment, each of the sections that address data gaps and limitations should be separated into clear discussions of types of limitations (e.g., geographic, statistical, data coverage, etc.)**

Charge Question 4. Regionalization of national indicators in the ROE 2007 Science Report

The ROE 2007 Science Report has broken out national-level data for some of the indicators by EPA region, and the Panel was asked to comment on the utility of this approach. The panel notes that national-level indicators are by themselves insufficient for gauging the state of the U.S. environment. Nationally aggregated data cannot reflect local and regional environmental trends that are important to the quality of life and health of the residents living in these areas. Exposures to environmental contaminants may be relevant at three scales: national (e.g., mercury emissions), regional (e.g., contaminants in lake fish), and local (e.g., contaminated land sites). Moreover, disasters such as Hurricane Katrina and “9/11” taught us that while the immediate direct effects of such events are regional or local in scale, the overall long-term effects reverberate through the nation. Similarly, a decline in the health of one region’s environment could affect the entire nation. Therefore, national indicator data should be presented at the finest spatial resolution that can be scientifically supported. For example, it would be valuable to examine national trends in air quality as well as regional, state, and/or county trends.

The disaggregation of the national indicator data in the Report by EPA administrative regions is useful for some purposes. For example, indicator data for individual EPA regions could be used for goal setting and performance evaluation. However, this should be done independently from the primary environmental assessments because the use of EPA administrative regions to scale national data has little ecological justification and does not provide particularly informative geographic descriptors of human health. Appendix D of this advisory report provides further discussion of how ecoregionally derived indicator information could be used for action and decision making by EPA regional offices. The Panel finds that a preferable approach would be to analyze the air, water, land, human health, and ecological condition indicators using appropriate airshed, watershed, and ecoregional units. A useful approach to regionalization of indicators may be to include two subcomponents for each indicator: 1) a national metric of some kind, with the obvious caveat that data aggregation can lead to masking of local trends; and 2) a consistent (whenever possible) approach to showing regional data, preferably based on

ecologically justifiable regions, not EPA administrative regions. The following specific recommendations are provided regarding this approach.

- **In the final Report, if EPA administrative regions continue to be used as the basis for regionalizing data, the Panel recommends that this process be better explained.** For example, it is unclear why the data are not presented consistently for each Region. Presenting these data consistently for each EPA Region would at least provide more comparability, although it will not address the bigger issue of ecological validity. The strengths and limitations of using EPA administrative regions to regionalize data should also be discussed.
- **In future Reports on the Environment, EPA should analyze the air, water, land, human health, and ecological condition indicators using appropriate airshed, watershed, and ecoregional units.** However, the appropriate scaling for indicator analysis and reporting should be considered on an indicator-by-indicator basis. This is true also for temporal scaling issues and the appropriateness of data aggregation over time and space.

Charge Question 5. Utility of regional indicators in the ROE 2007 Science Report

EPA has included ten regional indicators in the ROE 2007 Science Report. The Panel was asked to comment on the utility of regional indicators in answering the questions in the Report. The Panel finds that regional indicators and case studies should be used in future Reports on the Environment when they may be of particular value for use in trend analysis, or provide information that is vital to the nation's interest (e.g., topsoil preservation in the central Midwest). Examples will be most valuable if they can be replicated across the U.S. In addition, important regional issues, such as the ecological health of the Great Lakes or the Everglades, should be addressed in a national report on the environment. The Panel notes, however, that the justification for the inclusion of particular regional indicators is not clear in the current draft of the Report on the Environment and therefore appears somewhat arbitrary. It is difficult to understand why the current regional indicators have been chosen, as they do not appear to provide value for replication elsewhere.

The Panel finds that the use of regional examples is particularly useful in cases where:

- They present the successful application of an approach, model or tool that may have wider application. For example, the conceptual approach used for Biscayne Bay may have application to a wide range of problems in quite different environments, and the connectivity analyses done for EPA Region 4 may have broader applications.
- They serve to explain the functioning of the ecosystem and help build understanding of a conceptual framework of wider application. Diagrams of conceptual models or frameworks might be linked (especially in the web version of the "e-ROE") to regional examples that demonstrate processes or cause and effect relationships.

- They have wider applicability to areas within the same ecologically relevant region or type. Case examples can be very effective if the Report is built around natural systems (for example, tidal wetlands, dunes, tundra).
- They have long-term data sets that permit explanation of trends. This would be especially useful where nationwide data sets have limited time series.
- They represent an issue of national importance and deserve illumination even if they fail to meet the other criteria. Significance may stem from its natural resource value (e.g., Great Lakes), or from its importance as an emerging issue (nanotechnology, pharmaceuticals).
- They provide a higher resolution example of a nationwide indicator.

The following specific recommendations are provided concerning the use of regional data sets and indicators:

- **In future Reports on the Environment, it is recommended that EPA identify and use, with appropriate caveats, more regional indicators and data bases to illustrate trends when national data sets are not available.** The Panel notes, however, that such regional data are not a substitute for national or even representative national data and can be misleading if not carefully presented. Regional indicators should also be used in future Reports on the Environment when they have national importance or are of particular significance to local populations. Long-term, well-supported data sets are available for such regional indicators. Examples include data available from the National Science Foundation's Long-term Ecological Research Program sites, U.S. Geological Survey (USGS) groundwater basins, state agencies, and data collected on Lake Tahoe, Lake Mendota, and the Great Lakes.
- **In future Reports on the Environment, it is recommended that EPA develop clear and transparent criteria that are uniformly used for the selection of regional indicators and case studies, with the recognition that not all data will meet the criteria for these regional indicators.** For example, regional indicators should have long-term well supported data sets, be of particular national or local significance, or represent an assessment approach that that could be replicated.

6.0 AIR CHAPTER COMMENTS

Charge Question 1. Adequacy of formulation and scope of questions in the air chapter

In general, the Panel finds that the scope of questions in the air chapter of the Report is appropriate. However, it is problematic that the indicator data in the chapter are presented in isolation. A science framework consisting of a process model and discussion is needed in the final Report to provide context for the components by showing the interaction within, between, and among media and indicators as well as the effects on human health and ecosystem condition. The lack of such a framework is a significant problem. It is critically important for EPA to understand that data presented

in isolation are not science. It is only when the data are explained as well as appropriately interrelated across factors and chapters that one gains the scientific understanding of what the data mean. The following recommendations are provided to improve the formulation and scope of the questions in the air chapter.

- **In future Reports on the Environment, the discussion provided in the response to the indoor air quality question should be expanded.** The Panel finds that the discussion of indoor air and related indicators is too limited considering the importance of the indoor environment and the amount of time spent by the population indoors. While indoor environments do not fall within the statutory mandate of EPA, exclusion of available and relevant data makes the Report incomplete. Because of the importance of consumer products (e.g. solvents, paints, glues, and building materials) as a determinant of indoor air quality and exposure, we encourage EPA to consider whether there are appropriate consumer product data available that satisfy the criteria for uses as an indicator. For example, data regarding changes in the benzene content of gasoline, paints, and varnishes with time would provide a powerful indicator of human exposure. Similarly, data concerning changes in formaldehyde content of particle board and other building materials would be relevant and informative of indoor air quality and human exposure.

Charge Question 2. Use of indicators to answer questions in the air chapter of the ROE 2007 Science Report and presentation of indicator data in the chapter narrative

Overall, the Panel finds that the integrity of the indicator information is maintained in the air chapter narrative, but as noted above, the indicators are not adequately linked to information across the various other Report chapters. A short historical section containing background information on the criteria pollutants is needed in the final Report to provide an understanding of the importance of these pollutants as indicators, how they have been tracked, and their relationship to other indicators in the Report. Because the Report contains no history of the air indicators, there is no indication of how long the air monitoring networks have been in place. This knowledge would give the reader a sense of the importance that EPA places on the air monitoring networks. Further, it would provide the opportunity for the reader to learn about the various types of air monitoring networks. The air chapter then can have a discussion of questions that integrate across the pollutants. In addition, it is important to discuss conceptual links between trends in climate (e.g., increased radiation from stratospheric ozone depletion) and secondary pollutant¹ problems. There is a clear need to look at the air chapter from the whole atmosphere perspective instead of simply isolated atmospheric components.

The most significant shortcoming in the air chapter is the fact that the pollutant-by-pollutant recounting approach does not show the interplay of the various criteria and toxic pollutants with one another or the role of stratospheric ozone depletion and climate change on air quality. Put another way, a holistic picture of the chemistry of the atmosphere is missing. The Panel notes that substantial gains have been made in limiting

¹ A “secondary pollutant” is not emitted directly. Rather, it forms in the air when directly emitted pollutants react or interact.

the emissions of specific primary pollutants¹. Additional research on the health effects of air pollutant mixtures versus single substances is needed, however, because it has become increasingly recognized that air pollutant mixtures are also playing an important role in the impact of air pollutants on human health. Human activities have made the atmosphere more oxidizing through increases in NO_x emissions. This leads to greater ozone, more rapid conversion of SO₂ to SO₄²⁻, NO_x to NO₃⁻, and biogenic and anthropogenic volatile organic compounds (VOCs) to secondary organic aerosols. Thus, one cannot really look at the problem of ozone and fine particulate matter without considering SO₂ and NO_x emissions all together. NO_x has been controlled to the point where average ambient concentrations of NO₂ no longer violate the primary national ambient air quality standard (NAAQS), but that approach fails to achieve control of O₃ and PM_{2.5} (Particulate Matter less than 2.5 micrometers in diameter). The discussion of VOCs in the air chapter is almost entirely focused on anthropogenic VOCs, but it is now recognized that for many parts of the U.S., biogenic VOCs dominate and it is necessary to think very differently about how to bring about continuing improvements in air quality. Thus, the pollutant-by-pollutant evaluation or “stove piping” within the air chapter does not really provide a clear picture of the current status of air quality and what should be done in the future to continue the gains made over the past 35 years. Local sources have been or are being controlled through either air quality state implementation plan (SIPs) processes or maximum achievable control technology (MACT) and residual risk. New conceptualization of the problems is needed. Recitation of pollutant-by-pollutant gains without a truly integrative description of their interplay fails to provide the public or other policy makers of the full picture of the state of the atmospheric environment.

The Panel notes that the Report contains some discussion of trends in air indicators, but it is unfortunate that there is neither mention nor discussion of the possible direction of trends in air indicators 10 to 20 years into the future. Such a discussion would provide the reader with the rationale for the suggestion that improving air indicator trends will continue into the future. It should be made clear to the reader that EPA views air quality management as an ongoing process. The Panel also notes that EPA used data from sites going back to 1990 to demonstrate declining trends, but it is not clear that the same data for these sites during the past 5 years would provide the same understanding of trends. The issue of base year and site selection bias should be considered and a transparent description of the analysis should be provided. In addition, the Panel notes that when regional indicators are considered the picture of air quality may change. It is important for EPA to consider whether all of the available relevant information is being used in the Report.

A number of missing air indicators have been identified below and in Appendix A of this advisory report. These indicators should be added to the future Reports on the Environment because they represent important trends in air quality, or present a more holistic picture of atmospheric chemistry. The Panel also notes that the acid deposition discussion in the air chapter should be cross referenced and further discussed in the water and land chapters. It is not unreasonable for given indicators to appear in different

¹ A “primary pollutant” is directly emitted from a process, such as ash from a volcanic eruption or the carbon monoxide gas from a motor vehicle exhaust.

chapters as long as there is a clear cross-reference across the chapters and the reason for the cross-reference is clearly explained.

The following specific recommendations are provided to improve the air indicators in the final Report.

- **As stated in the overarching recommendations, a science framework should be incorporated into the air chapter of the final Report to show the interaction within, between and among media as well as between and among indicators.** The data presented should be explained because data presented in isolation are not science. In addition, the health/environmental relevance of the air indicators should be better documented with more extensive reference to the epidemiologic evidence as well as the environmental evidence.
- **In the final Report, a short historical section should be added to the air chapter to provide background information on the criteria pollutants.**
- **In the final Report, SO₂ concentration should be added to the air chapter as an indicator.** The Panel notes that this is a “good news” story for both EPA and the environment. SO₂ emissions controls have resulted in significant reductions in ambient SO₂ concentrations. This has also resulted in a reduction in the amount of acidic deposition attributable to SO₂ emissions.
- **In the final Report, the air toxics indicator should be expanded in the air chapter.** This is an important and rapidly emerging human and environmental health issue and it should be more completely addressed in the Report. Currently the air chapter presents an air toxics emissions indicator as an aggregate of 188 compounds. A more informative description could be presented to provide additional information concerning specific toxics (see also the following recommendation concerning the National Emissions Inventory). The Panel also notes a disconnect in data between 1990 and 1999 and suggests that the Agency could look at the possibility of using estimates to determine trends. Trends in ambient concentrations of toxics could be developed by looking beyond the regional scale to the local level where additional monitoring data are available. While it is true that in the current network the benzene data are the most robust, it should be anticipated by EPA that in the future the network will be more robust for additional chemicals of concern.

Further, it is not clear in the text what the difference is between Persistent Organic Pollutants (POPS), Persistent Bioaccumulative and Toxic chemicals (PBTs), and Hazardous Atmospheric Pollutants (HAPS). Sometimes the terms air toxics and HAPS are used as synonyms. Since the ROE 2007 Science Report is to be read by the general public, it is essential that all of the terms used in the text be clearly and unambiguously defined and used consistently. This becomes an important integration issue when chemicals and the responses to those chemicals appear in different media chapters. Reference is made in the water chapter, for example, to compounds also found in the air chapter but no cross-referencing is evident.

- **In the final Report, a broader explanation of what is in the National Emissions Inventory (NEI) should be added to the air chapter.** This is important because there is reference in the text to the Toxic Release Inventory (TRI) and Persistent Bioaccumulative and Toxic (PBT) chemicals.
- **In the final Report, further analysis of the trends in air indicators should be added to the air chapter.** While it is important to know whether air indicator trends are increasing or not, it is important for the reader to understand the reason for the direction of indicator trends. The Report should state where have we been, where we are now, and where we are going. As it stands, there is no history provided on how the air indicators were developed or evolved, or what may have influenced a certain trend (e.g., banning lead from gasoline resulted in a precipitous decline in atmospheric lead concentrations).
- **In the final Report, an indicator should be added to the air chapter to focus on the clear reduction of primary pollutants (CO, SO₂, and Pb) but much flatter trends in secondary pollutants (O₃ and PM_{2.5}), reflecting the growing importance of secondary air pollutants.** These pollutants are becoming increasingly important as regulatory efforts have resulted in reductions of major primary pollutants. Such an indicator would allow EPA to show the interaction of the atmospheric components and would help pull the pieces together conceptually. It also allows one to discuss more complex issues such as climate and ozone.
- **In the final Report, a small section should be added to the air chapter to discuss how climate change is affecting aerosols.** A paragraph would be appropriate. This paragraph would create the opportunities in the text to emphasize the interactions among pollutants, the importance of secondary pollutants, and the complexity of the atmospheric chemistry.

Charge Question 3. Identification of gaps and limitations of the air chapter indicators

Overall, the Panel finds that most of the critical gaps and limitations of air chapter indicators have been identified. That being said, the Panel provides a number of suggestions for informational improvements to the gaps and limitations to provide a better understanding of the meaning and relevance of the indicators. The Panel finds that indicator limitations are presented in a generally pro forma and mechanical fashion. There is virtually no discussion of whether, and how, these limitations should affect the reader's interpretation of the estimates with regard to magnitude of point estimates or shape of trends. With the exception of the ambient concentration indicators for criteria pollutants, benzene, and manganese in Region 5, quantitative estimates of uncertainty are lacking, leaving unanswered questions concerning the robustness of the majority of the indicators.

The Panel also finds that in the discussion of gaps and limitations of the air indicators, more emphasis should be placed on how limitations fit into the "big picture," or how

changes in outdoor concentrations may have increased or decreased the importance of other contributors to exposure and health risk. For example, given what is known, information should be provided to indicate how decreases or increases in ambient contaminant concentrations are reflected in total exposure and human and ecosystem health. It is important to know whether the trends in decreasing ambient concentrations for certain contaminants are reflected to the same extent in bio-measurements (human and other organisms) beyond Lead (Pb). These are questions that require thinking more comprehensively than the media-by-media presentation. The Panel also notes that in the air chapter, as well as other chapters, the final Report should offer approaches and/or solutions to filling gaps and limitations. The following specific recommendations are provided to improve the discussion of indicator limitations in the air chapter.

- **In the final Report, EPA should acknowledge and discuss the limitations of a single pollutant, local source approach to pollution control in the context of the marked reductions in individual pollutants documented by the indicators, and as exemplified by continuing challenges with regard to ozone and PM_{2.5}.** The significance of temporal trends viewed in the light of the importance of primary vs. secondary pollutants (specifically with respect to PM and ozone) should be discussed.
- **For the final Report, EPA should view the PM speciation network as the vehicle to provide the needed information on PM composition.**
- **In the final Report, the bias that may result from the choice of base year for trends for a given air indicator should be discussed, as this has implications in the interpretation of the air indicator data.**
- **In the final Report, the effects of trends in ambient concentrations of air pollutant indicators on exposure and dose should be discussed.**

Charge Question 4. Regionalization of the national Report on the Environment indicators in the air chapter

The Panel finds that the concept of having “national” as well as “regional” air indicators would be very informative if an appropriate approach were used. The main problem with the approach currently used in the air chapter is that the EPA regions are artificial administrative units that do not reflect airsheds. In addition, the national air quality data are dominated by data from urban air quality monitoring stations. Presentation of national data at the scale of EPA regions and subregions (e.g., states and cities) could be extremely misleading unless the inherent limitations of the data are clearly understood.

Charge Question 5. Utility of the regional indicators in answering the questions in the air chapter

The Panel finds that regional air indicators would be very useful as long as their application has a sound scientific basis. Unfortunately, this is generally not the case in

the air chapter. As noted above, the EPA regions do not correspond to airsheds but rather artificial administrative units. That being said, the Agency could get around this dilemma by carefully defining the “region” according to an air issue. While two examples of regional indicators are provided in the chapter (Manganese within Region 5 and PM along the U.S.-Mexico border), the basis for the selection of these indicators is not evident. This illustrates the need for EPA to consider developing and providing air indicators for ‘hot-spot’ locations/areas. For future Reports on the Environment, more conceptual development is required by EPA with respect to applying regional and sub-regional (i.e., hot spot) air indicators.

Charge Question 6. Overall quality of the air chapter with respect to technical accuracy, clarity, and level of communication

The Panel finds that the air chapter fails to provide the critical links between the observed changes in concentrations of pollutants and the understanding of the functioning of the atmospheric environment. The air chapter benefits from a long record of atmospheric monitoring that provides a wealth of data. Data are an essential part of science because they provide the basis for developing an understanding of the sources, processes and fate of the measured constituents. However, the final Report should do more than report data. The pollutant-by-pollutant presentation does not adequately reflect the understanding of the interrelationships among the measured species. As mentioned above, there are key trends in the understanding of the atmosphere that should be addressed in the final Report, such as the clear reduction of primary pollutants (CO, SO₂, lead) but much flatter trends in secondary pollutants (O₃, PM_{2.5}). NO_x has been controlled to the point where average concentrations of NO₂ do not exceed the primary NAAQS, but concentrations permit formation of O₃ and PM_{2.5} that lead to air quality violations. As mentioned above, the discussion of VOCs in the air chapter is almost entirely focused on anthropogenic VOCs. However, it is now recognized that for many parts of the U.S., biogenic VOCs dominate. In addition, the relationships between climate change and stratospheric ozone depletion, and tropospheric chemistry that enhances key pollutants (O₃ and PM_{2.5}), provide an important link between these currently isolated aspects of the chapter and other air pollutants which the EPA monitors. Thus, to improve understanding of atmospheric processes and achieve continuing improvements in air quality, indicator data such as those currently presented in the air chapter should be treated as a valuable resource but not an end in themselves. More attention needs to be paid to the “one atmosphere” concept that EPA has been trying to implement, and to using the data to demonstrate how they have improved our understanding of the atmospheric system in the U.S. The “one atmosphere” concept incorporates the dynamic complexities of emissions and their chemistry in the atmosphere to predict air pollution and guide program implementation.

7.0 WATER CHAPTER COMMENTS

Charge Question 1. Adequacy of formulation and scope of questions in the water chapter

The Panel finds that the overall broadness and consistency of the questions in the water chapter of the ROE 2007 Science Report are appropriate given EPA's mission and the scope of the Report. However, the questions in the water chapter do not adequately address the interconnectedness of different water systems and both land-water and air-water interactions. The Panel also finds that additional questions are needed to incorporate missing information on critical habitats and thematic elements. The following specific recommendations are provided to improve the formulation and scope of the questions.

- **In the final Report, the questions in the water chapter should be expanded to focus on the interconnectedness of different systems (both within the different water types and across media).**
- **In the final Report, additional questions should be included in the water chapter to incorporate missing information on availability and usage of water for human activities, especially with respect to both ground water and surface water withdrawals (see data in Roy et al., 2005 and Solley et al., 1995).**
- **In the final Report, EPA should examine the relevance of measures of “Extent and Condition” across all aquatic ecosystem types.** In this regard, the Panel finds that the question on the “extent” of coastal waters is not meaningful because for coastal waters, the issue of importance is their condition not their extent.
- **In future Reports on the Environment, additional questions should be included in the water chapter to incorporate missing information on critical habitats or thematic elements such as:**
 - Extent and condition of coral reefs;
 - Wastewater management information (it is recommended that EPA review available National Pollution Discharge Elimination System data for possible useful indicators);
 - Extent and condition of, and trends in, riparian zones and lake shoreline (i.e., land-water interface, where much of the biological activity occurs), and their effects on human health and the environment; and
 - More national indicators and analyses providing data and information on non-indigenous invasive species.
- **In future Reports on the Environment, some key model aquatic systems should be identified in several ecoregions of the U.S. and data collected from these systems should be mined and analyzed in the context of questions presented in the Report.**
- **For future Reports on the Environment, EPA should examine the 2004 National Research Council Report on national and global water resources and water infrastructure problems, and the importance of research in addressing them (National Research Council, 2004).** In this regard, relevant questions to be

considered include: (1) Will drinking water be safe? (2) Will there be sufficient water to support both the environment and future economic growth? (3) Can effective water policy be made? (4) Can water quality be maintained and enhanced? (5) Will our water management systems adapt to climate change? While the Panel recognizes that some, if not most, of these questions are outside the narrowly defined scope of the ROE 2007 Science Report, EPA should consider addressing these questions because they help place the water media chapter into the context of the rest of the report.

Charge Question 2. Use of indicators to answer questions in the water chapter of the ROE 2007 Science Report and presentation of indicator data in the chapter narrative

In general, the Panel finds that the narratives in the water chapter of the ROE 2007 Science Report have accurately captured the indicator data. However, there is a lack of acceptable water indicators to provide answers to the questions in the chapter. In this regard, the following concerns are noted.

- The indicators selected to address freshwater issues are all based on streams and rivers. It is problematic that there is no mention of any indicators for lakes, ponds, and reservoirs.
- The section in the water chapter on wetlands provides minimal analysis of available data. The Panel finds that addressing only loss or gain in wetland acreage as an indicator is not adequate. A measure of wetland quality should be incorporated into the final Report to improve this indicator.
- Only total nitrogen and phosphorus are used as nutrient indicators in the water chapter. Other nutrient indicators mentioned below should be considered.
- The drinking water section of the water chapter needs additional critical analysis to consider the implications of drinking water quality to human health. For example, the water chapter indicator dealing with "drinking water" covers only the number of systems that have not reported exceedances of maximum contaminant levels (MCLs). The Panel finds that it would be more informative to report this indicator in the final Report as the number of systems that have had exceedances, and include data on which contaminants were present and the degree to which they exceeded the MCL.
- The lack of microbial indicators in the water chapter makes it difficult if not impossible to ascertain human health implications and impairment of water resources due to fecal pathogen contamination, regulated contaminants, or EPA Contaminant Candidate List elements. In the case of pathogens, this is an unfortunate void (as implied in the water chapter limitations and gap analysis) given that there is a non-ambiguous (etiological) link between pathogen exposure and disease, albeit an unclear dose-dependent relationship. In earlier U.S. EPA Water Quality Inventory Reports to Congress (U.S. EPA, 2000), pathogen data were evaluated and used to classify contributions to pollution of water resources. It was noted that pathogens were either the first or second primary pollutant contributing to non-attainment of water quality standards for estuaries, coastal shoreline, and rivers and streams. These data, once obtainable from the states, are apparently no longer accessible or have been judged statistically or probabilistically unreliable for accurate trend analysis.

EPA should look for ways to obtain these data again (perhaps collaboratively with states).

- It appears that many of the indicators used in the water chapter are composite or multi-metric in nature. These indicators are useful, but the Panel recommends that they be complemented with single metric indicators that are easier to understand and require fewer caveats and assumptions.
- In the water chapter there is very limited inclusion of data on specific toxic industrial chemicals and contaminants, of either a regulated or an unregulated nature, for which EPA has statutory responsibility under the Clean Water Act. Analysis of specific toxic and bioaccumulating chemicals, other than pesticides, is largely confined to fish tissue contaminant concentration. The lack of such information for streams, rivers, and sediments makes it difficult to discriminate sources of contamination and impairment (e.g., urban/industrial vs. agricultural).
- The water chapter data on “pesticides in agricultural streams” are comprised of measurements of concentrations in the water only. However, the Panel notes that many of these chemicals are hydrophobic and are better analyzed in the sediments and biota rather than in the water column, where they may appear low even in situations where biota may be impacted by their elevated levels in the sediments. It is also unclear why these concentrations were compared with EPA’s MCLs for drinking water. People are not generally drinking water out of agricultural streams, so the focus on pesticide concentrations should be their toxicity to biota living in the streams, not to human consumers of drinking water.
- The section of the water chapter on “coastal fish tissue contaminants” includes analyses of many species of fish, and indicates that 22% of the sites showed high contamination. However, the contaminant data are pooled from many different species of fish and shellfish from different habitats, trophic levels, and age classes. The Panel notes that these factors strongly influence the degree to which a particular species bioaccumulates various contaminants.

The Panel suggests that in the water chapter of future Reports on the Environment it should be possible to develop internally consistent local or regional indicators (covering individual environmental units or ecological provinces) in those cases where data for national indicators are not available or do not meet the criteria for inclusion in the ROE 2007 Science Report. Indicator data from different watersheds or hydrological basins may not be directly comparable with each other, but the local or regional sets of data can provide meaningful temporal trends.

The Panel also finds that the final Report should contain better justification for some of the schemes used to grade indicators in the water chapter. In some instances (e.g., trophic state of coastal waters) the grading of “high, medium and low” quality are quite understandable. On the other hand, the low, medium, and high grading of “nitrogen and phosphorus in wadeable streams” presented on pages 3-22 and 3-23 is confusing. It is hard to understand why the grading is “low” when it is below the 75th percentile for the reference. It appears this system was used because of statistical analyses that are not discussed in the Report. Providing only qualitative indication (such as low nitrogen, medium nitrogen, and high nitrogen or low flow and high flow) is not adequate for those

who would like to use this report as a guide to determine the state of these systems. The Panel suggests that it might be better to provide a range of values in the final Report for each of these parameters presented. The following specific recommendations are provided to address the concerns noted above.

- **In the final Report, data for the indicator “pesticides in agricultural streams” should not be compared to human health benchmarks.** In future Reports on the Environment, data should reflect pesticide toxicity to stream biota (e.g., sediment concentrations of pesticides could be considered).
- **In future Reports on the Environment, EPA should include appropriate indicators of condition of lakes, ponds, and reservoirs.**
- **In future Reports on the Environment, EPA should consider including the following important specific indicators:**
 - **Snow pack (extent, condition, and volume)**
 - **Pathogens (coliforms, enteric viruses, toxins, etc.)**
 - **Storm water and wastewater (contaminant effects)**
 - **Drinking water primary contaminants (e.g., microbial indicators and pathogens: bacterial, viral or protozoan)**
 - **Contaminants of emerging concern such as pharmaceutical and personal care products, perfluorinated chemicals, brominated flame retardants, nanoparticles, and others.**
- **In future Reports on the Environment, additional wetland data should be used.** In many areas, wetlands will indicate more efficiently the ecological integrity of the entire watershed than will any other portion of the landscape. New data on basic wetland soil, vegetation, and periphyton characteristics are now emerging in various ecoregions. These data can provide important information. In addition, some of the possible complementary or alternative wetland indicators may include biogeochemical processes, such as organic matter decomposition and accretion, denitrification, phosphorus saturation, sulfate reduction, and indices of biotic integrity (IBIs), which can provide early indications of impending ecological changes.
- **For future Reports on the Environment, EPA should evaluate whether nutrient indicators based on bioavailable nitrogen and phosphorus or nitrogen:phosphorus ratios may be more useful.**
- **For future Reports on the Environment, EPA should develop drinking water indicators based on the available data from the Agency’s own databases and the consumer confidence reports released to the public annually by community water systems.** Based on these data, EPA could formulate indicators that can delineate trends in drinking water quality. The water chapter should include source water monitoring data in addition to treated water quality data.

- **For future Reports on the Environment, pathogen monitoring should be investigated as a primary indicator for water quality trends and human health effects across various water sources.** This recommendation would encourage more cooperation with states in providing data for analysis for longer term trends.
- **In future Reports on the Environment, composite or multi-metric indicators should be complemented with single metric indicators that are easier to understand and require fewer caveats and assumptions.** For example, the coastal benthic communities indicator could be supplemented with data on the abundance of key reference organisms that are particularly important to ecosystem function in each region (i.e., keystone species), or species that have special value to the stakeholders of the region (e.g., manatees in Florida or Coho salmon in Pacific Northwest).
- **In future Reports on the Environment, EPA should incorporate more information on specific toxic industrial chemicals for which the Agency has statutory responsibility under the Clean Water Act.**
- **In future Reports on the Environment, EPA should analyze fish tissue contaminant data by different species, or at least conduct separate analyses of fish from different trophic levels or different habitats (as was done for the “lake fish tissue” indicator) to see which species (e.g., piscivores) are more likely to have higher levels of contaminants than others.**

Additional technical comments and recommendations concerning the specific indicators in the water chapter are provided in Appendices A and B of this report.

Charge Question 3. Identification of gaps and limitations of the water chapter indicators

In general, the Panel finds that EPA has effectively identified and communicated the gaps and limitations of the indicators in answering questions posed in the water chapter of the ROE 2007 Science Report. However, it is disappointing that many of the indicators used in the chapter are recent and do not include many years of prior monitoring to show trends, so this gap/limitation is cited frequently. This is in striking contrast to the air chapter of the Report in which numerous graphs with downward trends are presented showing the overall improvement in release and ambient concentrations of various air pollutants (with the exception of greenhouse gases which are going up). The Panel finds it hard to understand why the data collected for the last three decades on various water systems are not adequate to determine status of and trends in the ecological condition of water systems. The gaps identified in the water chapter (e.g., on page 3-40) for freshwater systems highlight the need for more data. The Panel notes that more data will not necessarily answer the questions presented in Report, but it may be helpful to use additional data from well-planned and consistent monitoring of representative systems.

In several instances the “indicator limitations” discussion in the water chapter addresses or provides recommendations on how to interpret indicators. In these instances the discussion is most often focused on interpretation of indicators to show human health

effects. The Panel finds that the discussion of how to interpret indicators or, show what they mean, would fit better in the section of the water chapter titled, “what the data show.” Alternatively, to address the need for cross-media linkages, it is suggested that EPA could add a separate section titled, “what does this mean for human health.” An example of such a limitation is on page 3-27 in the discussion of the nitrate in streams indicator. The text states that, “Drinking water treatment can significantly reduce concentrations of nitrate, so the level of contaminants reported in this indicator is not necessarily representative of exposures to people when these waters are used as public water supplies.” The Panel notes that this is a separate issue from the sample design and temporal limitations of the data set, concerns that most commonly appear in the indicator limitations list. The interpretation statement included on page 3-27 raises important human health questions that could well be addressed by providing additional information. These include questions such as: How many communities rely on these streams for their water supply? How many communities rely on the streams that had nitrates above the MCL? How many communities treat their water for nitrate? The Panel notes that while treatment can reduce nitrate levels, it is often cost prohibitive and communities must find an alternate water supply. In addition, a high percentage of residents in rural areas depend on private water wells which have no treatment capability. Because surface water contamination in streams often has a direct bearing on ground water quality, how are the exposures of these people affected? A similar issue is apparent in the limitations discussion of the “pesticide in streams” indicator on page 3-32. Important human health questions that could be addressed include: How practical is it to treat a community water supply for pesticides? and How many communities do this?

The Panel recognizes that the "Survey of the Nation's Lakes" will provide a valuable database in the future for assessing conditions of ponds and reservoirs that are representative of all lakes in the United States. However, in the interim, usable data that already exist should not be overlooked. For example, there is a wealth of information (and associated data) available on nutrients, especially for rivers, lakes, and coastal waters. The Panel recommends that staff visit (or revisit) EPA guidance manuals for lakes, rivers, coastal waters, and wetlands for potential data sets, if they have not already done so. In addition, long-term monitoring programs of EPA (e.g., Environmental Monitoring and Assessment Program - EMAP) and other Federal Agencies (e.g., the U.S. Geological Survey's National Water Quality Assessment Program, the National Oceanic and Atmospheric Administration's Status and Trends and Mussel Watch Programs, and the National Science Foundation's Long-term Ecological Research and Long-term Research in Environmental Biology programs), and of states or universities should be examined. Indicator criteria should be relaxed (within reason) to enable the use of important trend data. It is important to be able to see the trends with appropriate caveats about methodologies used. This was done for the “SAV in the Chesapeake” indicator discussed on pages 3-74 to 3-75. In this case, data were adjusted to account for methodological inconsistencies. A similar approach should be adopted for other parameters (e.g., sediment contamination, tissue contaminants, benthic communities, etc.), if feasible. The following specific recommendations are recommended to address indicator gaps and limitations in the water chapter.

- **For future Reports on the Environment, EPA should visit (or revisit) the Agency's guidance manuals for lakes, rivers, coastal waters, and wetlands for potential data sets to fill identified data gaps.**
- **For future Reports on the Environment, long-term monitoring programs of EPA (e.g., Environmental Monitoring and Assessment Program - EMAP) and other Federal Agencies (e.g., the U.S. Geological Survey's National Water Quality Assessment Program, and the National Oceanic and Atmospheric Administration's Status and Trends and Mussel Watch Programs), and of states or universities should be examined. Indicator criteria should be relaxed (within reason) to enable use of important trend data.**

Charge Question 4. Regionalization of the national Report on the Environment indicators in the water chapter

The Panel finds that regionalization of national indicators is an important component of the water chapter of the ROE 2007 Science Report. However, as noted previously, the Panel is concerned that the use of EPA administrative regions will distort true ecological patterns or gradients. If possible, in future Reports on the Environment the data should be analyzed at more appropriate scales. For surface water, a more appropriate approach may be to use watersheds or established hydrologic units that also account for altitudinal gradients. For groundwater, EPA should evaluate the validity of using U.S. Geological Survey (USGS) groundwater basins as regional units. Contributing watersheds may be used as a scaling unit for estuaries.

The Panel notes that a regional approach will also aid in evaluating indicators to be used for various water systems during extreme events such as hurricanes, drought, and possibly bioterrorism. As noted previously, it is important for EPA to mine existing data and find ways to use these data to develop indicators for different ecoregions. For example, an enormous amount of data is collected by the five Water Management Districts in Florida on various water systems. Similar data sets exist for various ecoregions. For future Reports on the Environment, these data can be used to identify indicators.

Charge Question 5. Utility of the regional indicators in answering the questions in the water chapter

The Panel finds that there is considerable utility in using regional indicators to answer questions in the water chapter of the ROE 2007 Science Report. The regional indicators used in the water chapter answer parts of the questions to one degree or another but certainly do not address all aspects of the questions. The Panel suggests that additional regional indicators could be used to answer questions in the water chapter. One indicator used in the Report to respond to the question of the condition and extent of coastal waters and their effects on human health and the environment is the occurrence of dinoflagellate blooms on the west coast of Florida (e.g., *Karina brevis*). The Panel notes that dinoflagellate blooms (*Pfiesteria*) have been strongly linked to nutrient input in the bays

of North Carolina and Virginia and could be possible regional indicators. In addition, recurrent harmful algal blooms (HABs) of *Alexandrium* off the coast of New England, brown tide (*Aureococcus*) in the middle Atlantic, and *Pseudonitzschia* off the coast of the Pacific Northwest are being monitored, among others. The Panel questions why harmful algal blooms in fresh waters and invasive species have not been included as indicators in the discussion of extent and condition of fresh surface waters. The Panel notes that a regional indicator would seem to make sense here, either based on Great Lakes or Everglades long-term data (National Oceanic and Atmospheric Administration, 2007; South Florida Water Management District, 2007). Occurrences of freshwater HABs such as *Microcystis* could also be used as indicators. In future Reports on the Environment, EPA should consider incorporating these and other monitored blooms into the HAB indicator in the water chapter. In the water chapter, there are seven other indicators listed in response to the question of the condition and extent of coastal waters and their effects on human health and the environment. Even taken collectively, these indicators do not answer all aspects of the question, although each indicator illuminates some facet of the problem posed. If EPA continues to use regional indicators in answering this question in future Reports on the Environment, it would be helpful to explicitly identify the benefits and limitations associated with each regional indicator vis-à-vis national indicators.

The Panel finds that for future Reports on the Environment, development of regional indicators focusing on individual water systems would be a useful way to identify common indicators across regions. For example, separate water systems could be divided into groups: lakes and reservoirs, streams and rivers, ground water aquifers, wetlands, estuaries, and coastal waters. Indicators used in each of these groups could be evaluated across ecoregions and climatic gradients. Regional EPA offices, in collaboration with USGS and state agencies in the region, could identify data sources and transform data into useable information for the Report on the Environment.

The Panel notes that as indicators are developed, there are a multitude of processes that must be integrated, some of which can be described in deterministic/mechanistic equations (e.g., water flux, sediment and contaminant transport) or stochastic models (e.g., climate change). In contrast, other complex processes that affect water resources, such as the behavior of population groups, are more difficult to incorporate into quantitative models. The process of indicator development will require transdisciplinary research and education to synergize expertise from various domains and develop holistic approaches or models that are modular, scalable, and flexible in order to link land and water resources to internal and external forcing functions. The following specific recommendations are provided to strengthen the use of regional indicators in the water chapter of the Report:

- **In future Reports on the Environment, EPA should utilize and build on existing databases that have been collected and existing local expertise that has been developed at benchmark sites in various ecoregions.** Some specific examples are provided in the discussion above and in the following recommendations. This effort should focus on addressing water quality and quantity issues that could potentially

affect human, economic, and ecological health. The specific proposed goals of such an effort should be to:

- Identify attributes of land and water resources that can serve as indices of sustainability, and develop field and laboratory methodologies to determine these attributes in space and time within different benchmark water systems;
 - Investigate the sensitivity and dependence of basin factors to internal and external forcing functions such as climate change, extreme events, water law, land use policies, and social customs;
 - Develop predictive tools that will aid in determining the interactions and linkages between hydrologic processes, biogeochemical processes and socio-economic factors; and
 - Expand institutional collaborations through partners and maximize the utilization of available resources to promote interdisciplinary research and educational activities in benchmark water systems.
- **In future Reports on the Environment, EPA should give state data sets much closer scrutiny for possible inclusion.** Some states have a wealth of area-specific data. For example, private well testing data are available in states with a high proportion of private wells, cf. the “Wellogic” system in Michigan (Michigan Department of Environmental Quality, 2008) and local sport fish testing in states with strong recreational fisheries may mesh well with the existing national indicators. Highlighting what some states have done might help advance interest in expanding the efforts to develop a national surveillance system.
 - **For future Reports on the Environment, the Panel recommends that EPA consider the following as an example potential local/regional indicator for use in the water chapter.** The State Water Resources Control Board of California is funding USGS to lead and conduct a Groundwater Ambient Monitoring and Assessment (G.A.M.A.) program (U.S. Geological Survey, 2008) under which groundwater samples from public and private water supply wells from California are analyzed for water quality. The data collected will be integrated with existing water quality data (such as the public supply well water quality data of the California Department of Health Services). The monitoring program is scheduled to repeat the collection and analyses once every ten years and therefore it will provide the badly needed information for temporal trends. Although this type of data set may not be useful in developing a national water quality indicator, it is nevertheless meaningful and very useful in answering many of the questions in the regional context.
 - **In future Reports on the Environment, the Panel recommends that, in addition to the Gulf of Mexico and Long Island Sound, other places where hypoxic conditions tend to occur and are well monitored (such as Chesapeake Bay, the coastal waters off Oregon, and parts of Lake Erie) should be added to the hypoxia indicator.**

- **For future Reports on the Environment, EPA should develop indicators for arid regions.** In this regard the Agency should draw upon the numerous studies and data collection efforts conducted by various federal and state agencies in the western states where the climate is arid. Most areas in these states (EPA Region 9: California, Arizona, Nevada) can be classified as desert or semi-desert, and water resources issues (related to both water quality and quantity) are highly contentious.

Charge Question 6. Overall quality of the water chapter with respect to technical accuracy, clarity, and level of communication

The Panel generally finds that the water chapter is technically accurate and that the level of communication is appropriate. As noted above, additional indicators are needed to answer the questions in the water chapter. The following specific recommendation is provided to strengthen the overall quality of the water chapter and other parts of future Reports.

- **In future Reports on the Environment, EPA should consider identifying the following emerging issues in the summary section of the water chapter:**
 - **Effect of climate change on water quantity and quality**
 - **Emerging pathogens associated with climate change**
 - **Chemicals of emerging concern**
 - **Nanoparticle waste products**
 - **Water availability and sustainability**
 - **Invasive species**
 - **Algal toxins.**

8.0 LAND CHAPTER COMMENTS

Charge Question 1. Adequacy of formulation and scope of questions in the land chapter

In the land chapter of the ROE 2007 Science Report, indicators are presented to address fundamental questions about the state of the nation's land and its effect on human health and the environment. The five questions in the chapter focus on trends in: the extent of land cover, land use, wastes, chemicals used on land, and contaminated land. The questions in the land chapter are appropriate although somewhat peripheral to the mission of the EPA. The first two questions (addressing land cover and land use) relate to land resource management, while the last three questions relate to land contamination. The Panel finds that an additional question is needed to address the important issue of soil quality and conservation. In addition, the Panel finds that, while the inclusion of the phrase "and their effects on human health and the environment" in each question is understandable given the mission of EPA, there are few land indicators in the Report that directly measure effects on human health. The following specific recommendations are provided to improve the overall formulation and scope of the questions in the land chapter.

- **In the final Report, EPA should consider the following suggested revisions of the land chapter questions to improve their clarity.**
 - The waste deposition addressed in Question 3 (wastes) could be considered a “land use” issue and included as a subtopic of Question 2 (land use). However, the separation of waste management is understandable, as it is recognized that the hazardous and solid waste management programs run by EPA are large and important land media activities for the agency.
 - Waste deposition on land has impacts on groundwater that are likely of equal or greater significance than the direct impacts on land. Thus, the topic encompassed by Question 3 has overlap with the fundamental question regarding groundwater in Chapter 3, and in the introduction there is a need for an explanation of integration among components of the Report.
 - The indicators presented in relation to Question 4 (addressing chemicals used on land) focus on agriculture. The agency may wish to explicitly identify agriculture as the focus of Question 4. An alternative would be to include agricultural land indicators under Question 2 (addressing land use), considering agriculture as a specific land use.
 - Question 5 (addressing contaminated land) has some overlap with Questions 3 and 4. The “contaminated land” issue that is addressed by Question 5 (e.g., from pesticide use, industrial waste disposal, etc.) can be viewed as subsidiary to Questions 3 and 4. The factors distinguishing Question 5 (addressing contaminated land) from Questions 3 and 4 should be explained more fully.
- **In future Reports on the Environment, EPA should consider adding a fundamental question on soil quality and conservation to the land chapter.** The structure of the question could be parallel to the others in the chapter. While it could be argued that soil quality is covered conceptually under one of the existing questions, it is not obvious which one, and the Panel believes that soil quality and conservation is at the same level of importance as land cover, land use, etc. A variety of indicators could be established in relation to this fundamental question, including soil properties such as ability to hold nutrients (as measured by cation exchange capacity [CEC] or organic matter content), soil nutrient inventory (e.g., to assess loadings of nutrients and legacy phosphorus inventory), soil salinity (e.g., to assess long-term effects of irrigated agriculture), and others.

Charge Question 2. Use of indicators to answer questions in the land chapter of the ROE 2007 Science Report and presentation of indicator data in the chapter narrative

The Panel finds that the five fundamental land chapter questions are not completely answered by the indicators presented, and in some cases are answered only in very small part. Further, most of the indicators do not by themselves represent a direct causal

relationship to human and environmental health. However, the Panel recognizes that presently it may not be possible to define land indicators that are directly linked to health effects.

The following recommendations are provided to improve the use of indicators to answer questions in the land chapter. Additional specific technical comments concerning the land chapter indicators are provided in Appendix A.

- **In the final Report, EPA should include more direct indicators of effects in the land chapter.** For example, stream water quality associated with particular land uses could be used as an indicator. In addition, as in other chapters, a better explanation of the reasons for choosing the indicators used should be provided.
- **In the final Report, EPA should consider adding indicators for mining wastes as well as animal and other wastes applied on agricultural land.** The Panel finds that the two waste indicators in the land chapter are appropriate, but adding these additional indicators would provide important information about waste on land.
- **In the final Report, EPA should add an indicator based on the generation and disposal of civilian radioactive waste.** This will fill an important data gap. The Panel recognizes that some data on defense radioactive waste may not be publicly available. However, it is recommended that EPA staff work with the U.S. Nuclear Regulatory Commission to obtain statistical information on status and trends concerning civilian radioactive waste generation, disposal, and management (U.S. Nuclear Regulatory Commission, 2007).
- **In the final Report, a pesticide use indicator should be added to the land chapter.** This could be done by renaming the existing indicator, “fertilizer applied for agricultural purposes,” as “fertilizer and pesticide applied” and adjusting the type of data used to populate the indicator. In this regard, one possible indicator that could be used is pesticide sales. Pesticide sales could likely be parsed into agricultural and residential/commercial landscape applications. The latter would provide a suburban/urban indicator, which is important from the standpoint of human exposure. It is noted, however, that pesticide sales alone will not capture the complex interrelationships between agricultural chemical use and human health and environmental condition. Sales of pesticides should be evaluated in the context of ecological and human health risks as well as benefits of pesticide use such as changes in crop yields (affecting land use), changes in food quantity and quality (e.g., price and availability of food), contamination of foods with natural toxins, changes in agricultural practices such as no-till farming which is dependent upon herbicide use, and other factors such as seasonal changes in weather which affect pesticide use.
- **In the final Report, the pesticide residues in food and reported pesticide incident indicators should be moved to the human health chapter.** The Panel finds that the decline in reported pesticide incidents has a direct relationship with human health. However, the link between reported pesticide incidents and the human health impacts

of land management practices is tenuous. Reported pesticide incidents cover all sorts of uses of pesticides, and are based on calls to poison control centers. Many of these incidents are related to misuse of household products and activities far removed from land management. Pesticide residues in food may have a direct relationship to human and environmental health. However, the linkage of this indicator to land use is weak and this information should be included in the human health chapter.

- **In future Reports on the Environment, with respect to the land chapter indicators the Panel recommends that EPA should: 1) consider a range of land cover classification schemes with different levels of resolution.** This is necessary because the resolution of the data in the current Report is too coarse to completely answer the questions; **2) characterize land cover of all major ecosystem types, not just the forest land cover characterized the current draft of the Report; and 3) adopt standard, established approaches for land use and land cover analysis to evaluate information and document trends across a range of available data sets.**

Charge Question 3. Identification of gaps and limitations of the land chapter indicators

The Panel finds that the discussions of indicator information gaps and limitations in the land chapter are objective, honest and insightful. In many cases, these sections point out why particular indicators do not provide the comprehensive picture that is needed or are “not ready for prime time.” However, with respect to data gaps, much more could be said for each question. The data gap topics chosen for discussion seem somewhat arbitrary, though the data gaps discussions do uniformly address the lack of measures needed to directly assess the relationship of the indicator values to human health. Therefore the Panel recommends that:

- **In the final Report, the discussions of the data gaps in the land chapter should be modified to make it clear that the gaps mentioned are the highest priority gaps determined by the agency, and that the list is not intended to be comprehensive.**

Charge Question 4. Regionalization of the national Report on the Environment indicators in the land chapter

Concerns about the use of EPA administrative regions to regionalize national data have been noted previously. The Panel also notes that for future Reports on the Environment, the Agency may wish to consider the utility of the land chapter for cross-media evaluations if EPA regions were keyed to important environmental factors. The Panel notes that no single regionalization approach fits all evaluation needs. In the age of geographic information systems (GIS) there is no need to oversimplify. Therefore, in evaluating the condition of land, for example, EPA could select a particular level of USGS Hydrologic Units and overlay an ecoregionalization scheme. Bailey’s U.S. Forest Service (USFS) Ecoregions of the U.S. (Bailey, 1995) or Omernik’s Ecoregional schema (Omernik, 1987) would be appropriate because these combine soil, elevation, moisture, vegetation, and other factors.

- **In future Reports, different types of regional groupings could be used to show the location and extent of features in various chapters of the ROE.** For example, as further discussed in Section 10 of this advisory report, ecologically relevant units such as watersheds, climatic provinces, and major coastal realms could be used to regionalize data. At the beginning of a future Report, it would be useful to discuss how the indicators have been regionalized (i.e., an ecologically relevant regionalization scheme has been selected based on a type of indicator).

Charge Question 5. Utility of the regional indicators in answering the questions in the land chapter

As further discussed in Appendix A of this advisory report, the Panel does not find the one regional example in the land chapter (the Puget Sound/Georgia Basin example given in the Land Cover subsection) to be very useful. It is sufficiently unique that it is not seen as providing much value as a national model or case study. The Panel could not determine why this example was included, nor was it clear how this example could be standardized for use in other regional analyses. However the Puget Sound case study exemplifies how an indicator (impervious cover) in one medium (land) has clear implications in another medium (water). Unfortunately, there is no explicit linkage to the water chapter of the ROE. As discussed above, a conceptual model could be used to illustrate such linkages. It would also be useful to include examples from more than one region in the Report. Examples and case studies of significant national importance (e.g., from the Great Lakes region) should be given preference.

Charge Question 6. Overall quality of the land chapter with respect to technical accuracy, clarity, and level of communication

The Panel finds that the land chapter is generally clearly written and technically accurate. The data presented are interesting and will be useful for multiple purposes. However, in most cases, the fundamental questions in the land chapter are far from completely answered by the indicators and indicator data available, and the big picture understanding that the public may expect is not achieved. The data gap discussions are brief and the Panel recommends that they be reviewed and expanded where appropriate. In addition, while the Report writers clearly made strong efforts to avoid statements regarding influence of programs, some such statements have made their way into the Report and should be removed. For example, the Report states that recycling efforts related to municipal solid waste have increased “most likely due to the increased awareness about the benefits of recycling and the implementation of policies by state and local governments tying waste generation directly to the cost of waste services.”

The Panel also finds that the range of indicators in the land chapter is not at the same level of development as indicators in the water and air chapters. This is understandable given that EPA does not have a land program comparable to its water and air programs. The modest level of development of the land chapter must ultimately be addressed through direction of additional resources and an expanded set of disciplines in the Agency.

9.0 HUMAN HEALTH CHAPTER COMMENTS

Charge Question 1. Adequacy of formulation and scope of questions in the human health chapter

The panel generally finds the questions in the human health chapter of the ROE 2007 Science Report to be comprehensive, appropriate, and well developed. There is strength in the simplicity and clarity of the questions. However, the Panel recommends the following specific revisions to improve the scope and clarity of the questions.

- **In the final Report, the questions in the human health chapter should be reordered to be consistent with event sequence in the environmental health paradigm as depicted in Figure 5.1 of the Report** (i.e., exposure precedes the health effect).
- **In the final Report, the human health chapter should be more descriptively renamed as “Human Exposures and Health.”** This change is needed because the questions contained in the chapter encompass both human health and exposure. In addition to being more descriptive, the inclusion of “exposure” within the chapter title offers the following advantages:
 - It appropriately elevates exposure assessment within the ROE as a central and critical domain within EPA;
 - It is a key tenet of the ROE to link environmental change to human and ecological change; and
 - It provides a more appropriate place to include National Health and Nutrition Examination Survey (NHANES) pesticide body burden measurements as well as the pesticide residues in food and pesticide incident information that is currently out of place in the land use chapter.

There were differing opinions among panelists regarding the adequacy and scope of the first question in the chapter, “What are the trends in health status in the United States?” Some panelists thought that because the environmental factors considered in the Report play relatively small roles in the epidemiology of major U.S. health trends (i.e., general mortality, life expectancy, and infant mortality), such broad health-related conditions would have limited utility as environmental health indicators *per se*. Others felt that this question was appropriate in highlighting EPA’s health mission. There was some consensus around a compromise suggestion to eliminate this question in the final Report but retain the content as introductory text to the subsequent, more specific health question, “What are the trends in human disease and conditions for which environmental contaminants may be a risk factor, including across population subgroups, and geographic regions?” In contrast to the previous more general question, there is strong justification for the inclusion of this question in the final Report.

Charge Question 2. Use of indicators to answer questions in the human health chapter of the ROE 2007 Science Report and presentation of indicator data in the chapter narrative

The Panel finds that the indicators used in the human health chapter of the ROE 2007 Science Report are appropriate. However, as discussed below, additional indicators are recommended to more completely answer the questions. In addition, there is a critical need to expand the discussion of the health indicators' relevance to the questions. This discussion can appropriately stem from the following indicator criterion on page 1-7 of the Report.

“The indicator is useful. It answers (or makes an important contribution to answering) a question in the Report on the Environment.”

Although there is strong epidemiologic evidence that supports the indicators chosen (cancer incidence, childhood cancer incidence, cardiovascular disease, chronic obstructive pulmonary disease, asthma, infectious disease, birth defects, low birth weight, preterm delivery) the Panel finds that the Report fails to take advantage of this literature to provide either a qualitative or quantitative description of the environmental contribution. For example, what is the estimated fraction of cardiovascular disease that can be attributed to air pollution? Although the Report acknowledges that the health questions are complex and have multiple causes, it fails to provide a quantitative or even qualitative assessment of the relevance of the indicator to the question. This is an important consideration in providing the reader with the necessary context for understanding the meaningfulness of the indicator in the context of the health question. For example, there are scientifically credible estimates for the contribution of the environment to various cancers (Doll and Peto, 1981; Lichtenstien et al., 2000) and such information should be provided in the Report. There are similar estimates of air pollution contributions to asthma and cardiovascular morbidity and mortality (U.S. Environmental Protection Agency, 2005). The Panel therefore recommends that:

- **For the final Report, if credible quantitative impact estimates are available** (e.g., estimates of the mortality or morbidity impacts of particulate air pollution in selected locations in the U.S.), **they should be included.** Establishing the relevance of the indicator grounded in the literature will go a long way toward strengthening the science of the Report.
- **In future Reports on the Environment, EPA should consider using an expanded suite of human health indicators** that would include the following:
 - The National Health Interview Survey (NHIS) (Centers for Disease Control and Prevention, 2008a) and Behavioral Risk Factor Surveillance System (BRFSS) (Centers for Disease Control and Prevention, 2008b). This is a population-base survey administered by states and includes the relevant domains of Secondhand Smoke Policy (Module 10), Indoor Air Quality (Module 11), and the Home Environment (Module 12). These modules include salient indicators for indoor air quality: 1) the use of gas appliances; 2) use of a coal stove, fireplace, or

- kerosene heater; 3) use of pesticides; 4) whether smoking is allowed indoors at home and at work. Because these data are collected at a state level, there is sufficient resolution to the data for use as a regional as well as a national indicator (this recommendation also is relevant to the air chapter).
 - Hospital and emergency room discharge data available in the National Hospital Discharge Survey reports (Centers for Disease Control and Prevention, 2008c).
 - Reports of infectious disease maintained by CDC (Centers for Disease Control and Prevention, 2007).
- **In future Reports on the Environment, EPA needs to adopt the suites of indicators that other agencies have developed, but present them in relation to environmental factors.**

Charge Question 3. Identification of gaps and limitations of the human health chapter indicators

The Panel finds that the identification and communication of gaps and limitations of the indicators in the health chapter are adequately addressed with some potential areas for improvement. The following recommendations are provided to improve the identification of gaps and limitations:

- **In the final Report, the discussion of gaps and limitations should be expanded to include a more quantitative description of indicator relevance by relying on the epidemiologic literature** (this is also addressed in the indicator discussion above). The discussion might be further expanded to address how the limitations and gaps affect the interpretations of the Report on the Environment indicators, or the larger framework of the disease state or indicator.
- **In the final Report, the concept statements in the indicator limitations sections such as “the measurement of mercury or any other environmental chemical in a person’s blood or urine does not by itself mean that the chemical has caused or will cause harmful effects in that person” should be removed** from each discussion of indicator gap and instead be placed in the conceptual framework section of the chapter.

Charge Questions 4 and 5. Regionalization of the national indicators and utility of the regional indicators in answering the questions in the human health chapter

As noted previously, the Panel finds that regional analysis will make the Report on the Environment richer and more meaningful. Nationally aggregated data cannot reflect local and regional environmental or health trends that are important to the quality of life and health of the residents living in these areas. Regional indicators as presented by EPA administrative regions are not particularly informative geographic descriptors of health. The Panel notes that geographic units such as ecoregions and watersheds are far more useful for presenting regional information. Using such units to present health data would be a novel approach that would set the Report on the Environment apart from the already

existing health data presentations. The finer the spatial scale of this analysis, the more valuable it becomes. The finest spatial resolution contained in the Report is at the EPA regional level and trend analysis is shown simplistically as line graphs. The Panel notes that even for this relatively simple analysis, and certainly as the Report on the Environment is developed to include indicators with greater spatial resolution, more sophisticated and innovative means of analysis and presentation will be required.

For some of the indicators, resolution can go down to the state and even the county level (indicators derived from birth and death certificates) thus making it possible to aggregate the data in many geographic patterns. The NHIS survey data and the Survey Epidemiology and End Results (SEER) cancer data (National Cancer Institute, 2008) only have national resolution. However, state-based surveys such as the BRFSS can provide much of the same disease prevalence data as the NHIS with resolution at the state level. State cancer reporting registries are available in nearly all states and, while not as rigorous as the SEER program, provide credible cancer incidence data widely used by states without SEER registries. In addition, some states periodically publish cancer and other disease reports that provide data on county and/or major metropolitan areas. It would be helpful for EPA to provide “regional” reports that were integrative and coherent. The current approach does not provide much benefit. Therefore the Panel specifically recommends that:

- **In the final Report, EPA should build on the higher geographic resolution theme by presenting individual or multiple state data which could inform the gross national estimates presented and point toward the future.** This should be done if possible, given the time constraints of revising this version of the ROE.
- **For future Reports on the Environment, EPA should consider making use of county-level data available from the states.** All of the vital statistic data presented and used for the EPA Regional indicators can and have been scaled to the county level and excellent maps have been generated and already published in books. Geographic differences in disease have been identified. Virtually every state provides tables and maps of their vital statistics by county and they are used to identify local priorities to allocate targeted interventions and funding, yet on page 5-68 of the ROE 2007 Science Report it is stated that “underlying data for most ROE indicators ...do not enable extensive analysis of disease trends within or across geographic regions.” The Panel notes that this statement only pertains to the NHIS survey data. Certainly cardiovascular disease, stroke, and chronic obstructive pulmonary disease mortality can be presented at the county level or certainly the state level. Data sets can be found in the National Vital Statistics Reports (Centers for Disease Control and Prevention, 2008d).

Charge Question 6. Overall quality of the human health chapter with respect to technical accuracy, clarity, and level of communication

The Panel finds that the human health chapter is generally technically accurate although limited in its assessment and synthesis. As with the Report in general, there is a

need to further develop the chapter from its current form, which can be characterized as a data report, to a more sophisticated scientific document that includes assessment based on the primary literature and appropriate statistical analysis. The following specific additional recommendations are provided to improve the overall quality of the human health chapter.

- **In the final Report, Bullet #2 on page 5-5 should be rewritten to include biological agents.** The following sentence should be added: “Infectious diseases associated with environmental exposures or conditions are also addressed.”
- **In the final Report, expanded health indicator information should be provided for sensitive populations.** Expanded information is needed because these populations are important in considerations of environmental health. Although the current draft of the Report does discuss the importance of health indicator information for at-risk populations, more information should be provided to understand trends in diseases such as asthma or autism in these populations. Moreover, information is not provided to relate the contribution of environmental hazards to these diseases.

10.0 ECOLOGICAL CONDITION CHAPTER COMMENTS

The ecological condition chapter of the ROE 2007 Science Report addresses an extremely complex topic. The Panel recognizes that developing the chapter has been a difficult task, as it covers millions of species as well as populations, biological communities, and ecosystems, all of which interact with each other and are differentially affected by environmental factors. EPA is to be commended for tackling this important task. Compiling this information and pointing out the gaps and limitations is a very useful project for the Agency, the scientific community, and the general public. However, the Panel finds that reorganization of the chapter is needed to reflect an integrated focus on ecosystem health. The ecological condition chapter should be reorganized hierarchically according to: 1) major ecosystem type, 2) ecosystem processes and services, and 3) ecosystem components (physical, chemical, biological). This is discussed in more detail below.

Structuring the chapter as recommended above will involve reorganization of material presently covered in the chapter and the inclusion of additional indicators discussed below. The Panel recognizes that many of the comments and recommendations provided below in response to the specific charge questions probably cannot be addressed in the final Report, but should be considered for future Reports on the Environment. However, the Panel recommends that EPA complete as much of the reorganization as possible for the final Report. The Panel also suggests that in the final Report, the ecological condition chapter include a synthesis of the independent indicators, and that it emphasize the connections between ecosystems and stressors.

Charge Question 1. Adequacy of formulation and scope of questions in the ecological condition chapter

In general, the Panel finds that the questions in the ecological condition chapter are formulated appropriately, although some revision of the questions may be needed as the chapter is reorganized as recommended below. An exception is the biomarker question addressing the level of exposure of specific plant and animal species to different forms of pollution and toxic chemicals. The Panel suggests that in the final Report, rather than focusing on trends in biomarkers, the question should refer to trends in exposure and effects of contaminants in organisms. Biomarker data are collected to analyze the trends. In addition, the Panel notes that it is important to show the linkages between the effects seen in the ecological condition chapter and the indicators discussed in the media chapters. For example, EPA should strengthen the link between sea temperature and sea level rise discussed in this chapter and greenhouse gases in the air chapter. The Panel therefore recommends that:

- **In the final Report, the climate indicator trends in the ecological condition chapter should be placed in a paleoclimatic context to distinguish between human induced changes and other long-term changes.** References to the Report of the Intergovernmental Panel on Climate Change (IPCC, 2007a,b) should be included.
- **The Panel recommends that in the final Report, a question should refer to trends in exposure and effects of contaminants in organisms** rather than focusing on trends in biomarkers.

Although most of the questions in the ecological condition chapter appear to be germane, the associated indicators in the chapter seem to have been chosen because of the availability of data, not always because of their appropriateness to answer the questions. In some cases there are significant gaps between the questions and the corresponding indicators. As recommended previously for other chapters of the final Report, EPA should provide the rationale for selection of these particular indicators. This rationale may be that for many desired indicators of ecological condition the needed data simply are not available. If a desired indicator has no data, the final Report should contain a statement of the need for data.

As further discussed below, the Panel also notes that the scope of indicators used to answer questions in the chapter needs considerable broadening to cover more ecosystem types, with the recognition that EPA cannot develop an unlimited set of indicators but should select those that address key ecological issues. **Easily accessible data may be available for some of these indicators and could be included in the final Report, while others will have to wait for future Reports on the Environment.** A critical issue to be considered is whether data must meet some test that many ecological studies may not achieve. The final Report will be more useful if it includes more information, and then discusses caveats about the methodology. Specific gaps in coverage (missing ecosystems, missing populations, and missing processes) in the ecological condition chapter of the ROE 2007 Science Report are identified in Appendix A.

Charge Question 2. Use of indicators to answer questions in the ecological condition chapter of the ROE 2007 Science Report and presentation of indicator data in the chapter narrative

In reviewing indicators used in the ecological condition chapter, the Panel considered the charge question in two parts: “Are the current indicators appropriately used to answer the questions?” and “Are these the correct indicators to answer the questions?” The Panel finds that the indicators in the ecological condition chapter provide relevant and useful information as an initial attempt to answer the general questions posed, but many of the indicators are not transparent. The limited number of acceptable indicators in the ecological condition chapter can offer only a narrow perspective or a snapshot, and many do not show temporal trends. They are hardly adequate. This argues for an introductory discussion of each indicator along with a conceptual process diagram so that the reader can better understand the role of each indicator and its importance relative to the questions asked. The Panel’s specific recommendations to address these concerns are as follows:

- **In the final Report, EPA should reorganize the ecological condition chapter to focus on three major indicator categories: Ecosystems, Ecological Processes and Services, and Ecosystem Components.**
- **In the final Report, appropriate indicators should be included in the ecological condition chapter to provide information on the ecosystem extent** (e.g., land cover, land use, urbanization) **and quality /condition** (e.g., landscape integrity, connectedness, fragmentation, and contamination) **of major ecosystem types.** Examples of major ecosystem types include: forests, grasslands, shrublands, arid lands, wetlands, farmlands, freshwater, and coastal, marine, and urban ecosystems.
- **In the final Report, indicators should be included in the ecological condition chapter to represent important ecosystem processes and services such as: provisioning** (e.g., timber, fuel, minerals, and other services); **regulating** (e.g., disease, climate, and flood processes); **cultural** (e.g., spiritual and aesthetic services); **and supporting** (e.g., soil formation, primary productivity, pollination, decomposition, disturbance, nutrient cycling, hydrological/chemical cycling, carbon sequestration processes, and services such as clean air, clean water, and net production). These ecosystem services classifications were developed by the Millennium Ecosystem Assessment (2005). Potential indicators relevant to the ecosystem processes listed above include: fire frequency, floods, drought, algal blooms, invasive species, carbon storage, soil salinity, nutrients, and erosion.
- **In the final Report, indicators should be included in the ecological condition chapter to represent physico-chemical components of ecosystems** (e.g., soils, water, chemicals, snow pack, and physical habitats). Some physico-chemical indicators are already included in the Report (e.g., mean temperature and precipitation, sea surface temperature, sea level, stream flows, and nitrogen and phosphorus discharge into rivers and streams). It is also noted that an indicator of

light pollution is not currently included in the Report. Because artificial light may adversely affect some species that depend upon darkness as a physical attribute of habitat, it is specifically recommended that in future Reports, EPA consider including an indicator of light pollution. Noise pollution can also affect ecological condition. EPA should therefore consider including an indicator of noise pollution in future Reports.

- **In the final Report, indicators should be included in the ecological condition chapter to represent biological components of ecosystems ranging from the genome to the community level of organization.** Such components include biodiversity, endangered species, invasive species, keystone species, and communities. Specific examples of biological component indicators include: the extent and range of communities (e.g., land cover, coastal benthic communities, and coral reefs) and particular taxa (e.g., birds, fish, macroinvertebrates, and submerged aquatic vegetation); the protection status of biological components (e.g., management policy and zoning information relevant to understanding status and future vulnerability); and threats. The Panel finds that the current indicators in the ecological condition chapter have too much reliance on vertebrates and not enough emphasis on small organisms (e.g., microbes, invertebrates, and flora).

In Appendix A the Panel has provided specific technical comments and suggested improvements concerning individual indicators currently used in the ecological condition chapter.

Charge Question 3. Identification of gaps and limitations of the ecological condition chapter indicators

The Panel finds that, in general, the limitations and gaps are assessed fairly and objectively, and are presented in a clear and transparent way in the ecological condition chapter. As in other chapters of the Report, it may be useful to subdivide this section into different types of limitations, such as geographic limitations, statistical limitations, data coverage limitations, etc. Limitations are often based on inadequate data or inability to interpret data because they are “incomplete.” Often gaps or limitations are discussed with an inadequate understanding of relationships between the indicator and the environment. This concern can be addressed by including a conceptual model in the chapter as recommended above. The conceptual model should indicate how stressors (drivers), responses and outcomes are perceived by the scientific community. As previously discussed, this will improve interpretation and discussion and help the reader understand the importance of the indicators.

As in other chapters of the Report, it is disappointing that so many of the indicator data are recent and prior monitoring data are not available to see temporal trends. As noted previously, there are many monitoring programs of EPA, other federal agencies, and states that have long-term data sets. These data sets may not be based on probabilistic surveys and the statistical approaches that meet the indicator selection criteria. However, they may provide good long-term data and, if appropriate, should be

incorporated into future Reports on the Environment. The sampling deficiencies associated with the data should be discussed in the section on gaps and limitations. Ignoring decades of prior monitoring information because methodologies were not “up to” current standards results in the inability to see trends in many important parameters. The Panel notes that it is important to show trends and include caveats about methodology. As methods, indices, and statistical design continue to improve, EPA should not discard the present measurements in favor of the new and improved indices. When methods are changed, there should be a time when both the old and new methods are used in order to establish their comparability.

The Panel provides the following specific recommendations to improve the discussion of indicator limitations in the Report.

- **In the final Report, the discussion of “trends in diversity and biological balance of the nation’s ecological systems,” (on page 6-29) should acknowledge that some systems inherently have different numbers and variety of species, making comparisons between these systems inappropriate.**
- **In the final Report, the discussion of “fish faunal intactness,” should explain why 1970 is chosen as the reference year.**
- **In the final Report, trend data should be adjusted to account for methodological inconsistencies.** For example, in the discussion of “SAV in the Chesapeake” which shows trends since 1978, the Report on the Environment states that “methods changed over the course of this study. However, data have been adjusted to account for any methodological inconsistencies.” The same should have been done with other parameters that are presented as a snapshot at one time but could have been used to show trends with adjustment. The Panel recognizes that not all data sets will lend themselves to this type of adjustment, but when possible, EPA should calibrate or adjust data from different periods that use different methodologies to allow comparability over time.
- **In future Reports on the Environment, EPA should use available information from the Agency’s water quality criteria guidance manuals.** As noted in the water chapter discussion, EPA has previously conducted a detailed review of current information to develop water quality criteria guidance manuals for lakes, rivers, and coastal waters. It is not clear whether this information was used in addressing some of the questions raised in the Report.

Charge Question 4. Regionalization of the national Report on the Environment indicators in the ecological condition chapter

As discussed previously, regionalization is an important element in the Report on the Environment. However, the EPA regions, while important for administrative purposes, are not relevant for representation of regional indicators in the ecological condition chapter. The separation of data into the ten EPA regions may inadvertently convey

inaccurate ecological information to readers. For example, Exhibit 6-2 shows the changes in acreage in the extent of forested land in the U.S. broken down by EPA regions. However, the Report fails to recognize the differences in climate, biomes, and the amount of total area among these ecologically distinct units. The Panel finds the basis of the division to be misleading. Ecologically relevant units, such as watersheds, climatic provinces, major coastal realms, forests, etc. provide a scientifically sound basis for conceptual and statistical analyses. Results from ecoregional analysis could easily be reported in the final Report for EPA administrative units by using current GIS technology. It could be mentioned early in the final Report that some indicators will be regionalized based on the type of indicator (e.g., one that relates to large watersheds, such as nutrient discharge to oceans; or to major climatic zones, such as forest indicators). In this way objectivity of regionalization is addressed. Because there is little comparison across indicators in the Report, comparability across regions is limited. This suggests a future need for some kind of cross-reference table or section in the final Report that addresses the issue of comparability of indicators, questions and regions.

Charge Question 5. Utility of the regional indicators in answering the questions in the ecological condition chapter

The Panel finds that regional indicators in the ecological condition chapter have value and should be retained but with qualifications. Although regional examples have value for the national report, caution should be used in applying interpretation of regional examples on a national basis. As discussed above, the shortage of acceptable national large-scale indicators can be remedied by developing regional or local indicators. However, the justification of the inclusion of these particular indicators in the chapter is not clear. The use of a region to demonstrate some trend or change is useful if it represents scaling of similar national data. Some of the data sets are sufficiently complete to support useful regional subdivision, while others are not. Scaling decisions should be made on an indicator-by-indicator basis. If a regional indicator has been included in the Report only because a particular EPA region developed the methodology and collected the data (e.g., ecological connectivity in EPA Region 4), the indicator should be tested in another region that is not geographically or physiognomically equivalent. If the indicator represents an “interesting” region (e.g., Puget Sound area) where analysis of changes has been completed, it should be pointed out that the uniqueness of the study may make it difficult to duplicate across the nation.

The following recommendations are provided to improve the use of regional indicators in the ecological condition chapter.

- **In the final Report, it should be clearly stated that specific case studies in the Report may not be representative of a general or national situation.** These concerns should not constrain the use of regional examples if developed in a fashion similar to other indicators with emphasis on the importance and applicability of the example.

- **In future Reports on the Environment, specific case studies using regional indicators should be selected for their ability to demonstrate the long-term trends that cannot be accomplished at the national level.** It would be useful to pick well-studied sites (e.g., Lake Mendota, Lake Tahoe) where there are long-term data sets available for each region.
- **For future Reports on the Environment, some of the regional indicators should be expanded to become national indicators** (e.g., SAV, invasive species, harmful algal blooms).

Charge Question 6. Overall quality of the ecological condition chapter with respect to technical accuracy, clarity, and level of communication

As noted above, the ecological condition chapter provides relevant, accurate, and useful information, but it is far too limited in scope. The nation's ecosystems and key ecosystem processes are far more extensive than represented in the Report. One problem is the immense difference between the objectives and base questions for the Report and the availability of applicable information to meet these objectives. The ecological condition chapter of the final Report would benefit from improved organization, as mentioned previously. The general introduction of the final Report should include a description of how all the themes are or can be integrated. To improve integration it would be possible to take a regional approach (e.g., large watershed) and show how each theme can be integrated within the region. This is something that should be considered for future Reports on the Environment. The Report also makes scaling difficult. Regional data need to be scaleable to a larger region or nationally, and national data need to be scaled to regional levels for application and understanding of the data. A more consistent and defensible approach is needed in future Reports on the Environment to deal with regionalization of indicators.

There is no easy way to develop ecological condition indicators, populate them with data, and then interpret the results. One approach requires use of conceptual models that show how indicator selection was achieved and how the indicator actually "indicates" the consequences of changing stressors, processes and outcomes. The authors should be commended for their ecological condition paradigm diagram Exhibit 6-1. A conceptual model of flows between stressors and outcomes will look quite different from this general interactive model but, as discussed previously, this type of diagram showing interactions among many processes and attributes should be placed at the beginning of the document. The ecological condition paradigm is an excellent conceptual framework, but not well used in discussions of the indicators. The interconnections of human health and ecological condition with each other and with the media chapters should be discussed and expanded. This approach would greatly improve the level of communication. For example, the schematic that the SAB provided in its prior advisory report to demonstrate interconnections should be consulted because it is still germane and would improve the Report on the Environment. The inclusion of a statistical approach to analysis of the data, and consistent use of metric measures would also add rigor and are needed in a scientific document.

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Appendix A: Specific Technical Comments and Corrections

General

- In the final Report, EPA should identify, perhaps by using a letter (e.g., “H”), those indicators that explicitly relate to human health. Such identification will help differentiate those indicators from others that relate more to ecological health. For example, indicators presented on pages 3-32 (pesticides in agricultural watersheds), 3-44 (nitrate and pesticides in shallow ground water in agricultural watersheds), 3-90 (population served by community water systems with no reported violations of health-based standards), and 3-103 (coastal fish tissue contaminants) include a health component because of health based standards.
- In some cases, data are presented for each of the 9 ecoregions (e.g., Exhibit 3-3). The type of panel in Exhibit 3-3, showing a map of the 9 ecoregions, with stacked bars emanating from each region, should be more frequently used in the Report because it is much more informative than aggregated data. This is recommended as a revision for future Reports on the Environment.

Air chapter

Ambient Concentrations of Lead (Figure B on page 2-22)

- The caveat regarding the lead trend sites above the NAAQS is not really useful since the last year with a concentration above the NAAQS was 1982. The description in the narrative is sufficient for describing this event and the Figure is not necessary. It is not clear if excluded sites could be useful for establishing trends in more recent years. In the final Report, perhaps the X axis in Figure B could be modified in a manner similar to the NO_x or other NAAQS emission trends as presented in Figure A on page 2-24 or SO₂ on page 2-54.

NAAQS for PM_{2.5}

- Exhibit 2-26 on page 2-48 of the ROE indicates that the 24-hour PM_{2.5} NAAQS is 65 ug/m³. The NAAQS is now set at 35 ug/m³.

Particulate Matter (PM)

- With regard to PM, a significant fraction of the 2.5 size range results from secondary formation. The Report on the Environment does not mention the potential use of the PM characterization sites (which also provide data on elemental composition and elemental carbon/organic carbon [EC/OC]). These sites have been operational for several years and it would be worth considering in future Reports on the Environment. At a minimum, there is probably enough data to provide a snapshot of regional differences in broad ranges of composition (North American Consortium for Atmospheric research in Support of Air Quality Management – NARSTO data, for example).

Acid Deposition Data

- The presentation of acid deposition data is visually attractive but the format is discordant with how data are presented for other pollutants (i.e., charts). The graphical format on pages 2-59 and 2-60 is difficult to follow in its detail as compared with the chart (bar graph, pie chart). Thus it would seem for added clarity in understanding national and regional trends, in the final Report it would be advisable to follow the format used for the other pollutants in the air chapter.

Water Chapter

Presentation of Data

- On rare occasions, the discussion text in the water chapter is not consistent with the data being presented. For example, in the discussion of “coastal benthic communities” on pages 3-71 to 3-73 it is shown that 17% of area of all the U.S. coastal waters have low index values, and that 27% of the area in U.S. EPA Region 3 has a low index value. The Panel notes that a substantial portion the area of U.S. coastal waters (20 to 25% of the area) has a low index, and in addition there are extensive areas with “moderate” rather than “high” condition. However, in the discussion on page 3-85 of the water chapter, the Report states that, “Benthic communities in the nation’s estuaries are largely intact in terms of species diversity... which is critical because these organisms are a fundamental link in the coastal food web.” While the second part of the sentence is true, the first part is the statement is not supported by the data. The Panel recommends that in the final Report this misrepresentation of the data be corrected.

High and Low Stream Flows

- “High and low stream flows” is not an accurate characterization of this indicator. The data also address timing, but this is not intuitive from this heading. A more accurate title is recommended for the final Report.
- Page 3-15 lines 5-11: The text is confusing in this section. First, the word “substantially” is vague, perhaps intentionally, and lacks rigor. Second, what does substantially “larger low flows” mean? Is this an increase in volume for low flows? A greater number of streams experiencing low flows? Or does it mean something else? This should be clarified in the final Report.
- 3-15/24-32: It might be instructive to know if the change in timing showed any type of pattern. Was there more often a delay or an acceleration, or was there no distinct pattern? Distinct patterns may be useful to identify, as they may be related to withdrawal patterns or climate change influences.
- Since this indicator comes directly from the Heinz Center Report, EPA should look into how Heinz has modified its data.

Nitrogen and Phosphorus in Wadeable Streams

- 3-22/1: This indicator should be labeled Total N and P, not just N and P, to be accurate.
- Although there are geographic limits to the data, much of the land cover that sends waters to the oceans is covered. Limitations on what is not included are explained. It might be mentioned in the final Report that many if not most of the

rivers in the Southwest do not discharge into the ocean, or if they do, much of the river has already been diverted for other purposes.

Nitrogen and Phosphorus in Agricultural Watersheds

- 3-25/10: The important point is not that nitrite and ammonium are not *present*—rather, they are present but in low concentrations.
- 3-25/20: Clarify in the final Report that it is the decomposition of the excess algae that can deplete oxygen in water. Also, include internal P loading from sediments as a potential P source, especially in shallow lakes.
- 3-26/3: The low range for phosphorus is still quite high, and indicates eutrophic conditions for most systems. It is unclear why such a high threshold was chosen for the low end of this indicator. It is not surprising that such a high percentage fell into this low category, but its significance is debatable. Clarify this in the final Report.
- 3-26/10: Flow-weighting makes considerable sense, given the aggregation of data. However, it would be very instructive if the data were analyzed for base flow and storm event periods, assuming the data set allows this type of analysis.

Nitrogen and Phosphorus Discharge from Large Rivers

- 3-28/1: In the final Report replace “Discharge” with “Load”
- Exhibit 3-9: As noted in the text, load is a function of both discharge and concentration—in the final Report it would be instructive to have discharge data also included in this figure, to see how much of the change in load is a function of discharge vs. concentration. While both drive load, changes driven by the former are more climate related, while changes driven by the latter are more a function of land use practices, and therefore more related to human activities. This is an important distinction.
- In future Reports on the Environment statistical analysis (trend analysis) is recommended for these data to determine if these trends are significant or not.

Pesticides in Streams in Ag Watersheds

- Exhibit 3-11: There is considerable value in disaggregating the data into at least a few key pesticides. In the present format, there may be considerable improvement or declines in a key pesticide, but the trend would be masked. While there is presentation value in aggregated data, it also can lead to misinterpretations—if the aggregated data need to be retained, they should be enhanced in the final Report by adding trends on a few key pesticides.
- 3-33/25: Include a map of the watersheds in the final Report to show explicit geographic distribution of the data collection.

Benthic Macroinvertebrates in Wadeable Streams

- 3-36: The explanation of the O/E model will be difficult for many readers to follow. This may be an acceptable limitation, especially if the intended audience of the Report on the Environment is scientists, but others will balk at the non-intuitive narrative.

- What is the justification for the inclusion of these 3 ecoregions? Why not more, less, others?
- Exhibit 3-13: Why are the O/E data not shown in a geographic context as well?
- Data from the wadeable stream sampling are suspect, not because of the sampling technique but rather the timing. Samples are taken from April to November and then treated equally. Certainly streams change considerably over this time, both in physical and chemical characteristics.

3.2.3 Discussion

- 3-39/30: These indicators do not reveal the role of precipitation—the load indicators don’t provide any precipitation information, and in fact, as currently presented, mask the role of precipitation.
- 3-39/33: This should be rephrased in the final Report—the chemical and physical indicators are proxies, at best, for the biological condition of the fresh surface waters. The Report on the Environment provides a very limited picture, not a mixed picture, of biological conditions, simply because there are so few biological indicators to this point. The only trophic level discussed for surface fresh waters in the entire U.S. is benthic invertebrates—nothing about bacteria, algae, macrophytes, fish, or waterfowl. Hence, it is misleading to state the biological condition index is mixed—there simply are insufficient data to draw any conclusions about the overall state of the nation’s surface fresh water biology.
- The final Report should include something on waterborne pathogens in this section; even if it is not an indicator, perhaps there can be cross-references to other sections where this indicator is discussed.

Nitrate and Pesticides in Shallow Ground Water in Ag Watersheds

- The indicator “nitrate and pesticides in shallow groundwater in agricultural watersheds” does not match well with the question it addresses in the Report because as it fails to inform on “extent.” The Panel therefore suggests that it may be appropriate to restrict the question in the final Report to just “condition of groundwater”
- See comments on the pesticides in streams indicator—they apply here, as well.

3.3.3 Discussion

- There is a dire need for a national monitoring program to address groundwater extent; this is within the domain of the USGS and hopefully funding can be obtained to start this work. In the interim, why not use groundwater contribution to stream base flow as a measure? Gauging stage data from appropriate streams across the nation might serve this purpose.
- 3-48/15: Changes in water table elevations are available in many groundwater basins. For example, California Department of Water Resources maintains the water table data. Over-drafting groundwater resources is a major concern and pressing environmental issue in the central and western states. Regional indicators should be developed to address the question of “extent.”

Wetland Extent, Change, and Sources of Change

- 3-54/19: An important limitation of these data, which is not stated, is that extent does not equate to quality—the increase in freshwater ponds results in a very different quality of habitat than an increase in wetlands.
- If possible, the data should also be shown in the final Report by region within the U.S.
- Exhibit 3-19: More attention should be paid in the final Report to the “other” category; relative to the identified land use categories, this change is very large and needs better classification.

Trophic State of Coastal Waters

- The Panel recommends that in the final Report the water chapter indicator called “trophic state of coastal waters” be renamed “nutrients” or “eutrophication” in coastal waters. Trophic state is a larger concept that would encompass, for example, depleted stocks of large piscivores such as cod in New England that have altered food webs and the trophic state of the waters through top-down cascading effects. As written, the focus of this section of the water chapter is only on bottom up, nutrient-related issues. In future Reports on the Environment it would be useful to include considerations of the state of all trophic levels but the name of the indicator could be changed immediately.
- 3-62/2: It appears from the exhibits that this indicator does not include the Great Lakes coastal regions; this should be denoted in the final Report.
- 3-62/7: Note that algal blooms can also include attached, macroscopic algae, such as *Cladophora* or *Enteromorpha* blooms.
- 3-62/12: If the definition of algal blooms stays strictly planktonic, this sentence is correct as is; however, if it is extended to include benthic algae, then this sentence will need amending to reflect that reduction of chlorophyll *a* by filtering activity is restricted to water column chlorophyll *a*.
- 3-62/27: It may be instructive to include a table in the final Report that lists the reference conditions for each region; this gives readers an idea of the thresholds, and how they vary with region.
- 3-62/34: It does not appear that the composite U.S. score is weighted in any fashion. Is that correct? Given the very different lengths of coastal areas in each Region, what is the rationale for giving them equal weights?
- Exhibits 3-20 to 3-25:
 - A) In the final Report, a more effective graphic display would be to show the regional map of the U.S. in the center of the Exhibit (now in the bottom footnote), and have each region blown up as a pie chart, radiating out from the U.S. map. The pie chart would show the four water quality categories.
 - B) As noted earlier, ecoregions are a much more scientifically defensible geographic approach for showing regional data than EPA regions.
 - C) There may be value in applying statistical tests to determine if there are differences among regions; one would need to know more about the data computation and distribution, a Chi-square test may work.
- 3-63/9: The indicator should be accurately defined in the final Report—this is dissolved inorganic nitrogen (DIN), *not* nitrogen, *per se*.

- 3-64/1: As above, in the final Report this should be called dissolved inorganic phosphorus (DIP), not “phosphorus”, which could mean a lot of different things to readers.

Dissolved Oxygen

- It is unclear when dissolved oxygen (DO) measurements were taken; because DO concentration is dependent on time of day, this point should be reflected in the discussion in the final Report.

Coastal Sediment Quality

- 3-67/2: It is unclear why this indicator was not applied to fresh water systems, as well. This does not invalidate its merit for coastal systems, but readers may wonder why there is an apparent inconsistency among systems.
- Exhibits 3-26 and 3-27: See comments above regarding 1) using a different graphic for these exhibits, using pie charts from each region emanating from a map of the U.S.; 2) revising composite U.S. score to weight based on coastline within each region; and 3) statistical analysis for differences among regions.

Coastal Benthic Communities

- Exhibit 3-28: See comments above for Exhibits 3-26 and 3-27.

SAV in Chesapeake Bay

- 3-74/2: In the final Report, EPA may want to generalize the importance of SAV beyond just Chesapeake Bay, similar to what is done for the introduction in the Hypoxia Indicator.
- 3-74/28: In the final Report, it would be useful, either here or in indicator limitations, to identify what percent of total area was estimated based on prior years' surveys for those years with incomplete coverage. Is this a small amount (<10%) or something more significant where the uncertainties have more significance?
- 3-74/32: The data show two distinct trends – increasing from 1984 to 1992 and leveling from 1992 to 2005. These trends should be discussed.
- 3-75/25: Species composition is also an important variable, as not all SAV species provide the same ecosystem functions.

Hypoxia in Gulf of Mexico and Long Island Sound

- This was a very well structured indicator.

HAB Outbreaks Along the Western Florida Coastline

- Other potential limitations to this indicator include: 1) cell density does not necessarily equate to toxicity; and 2) biovolume may be a better indicator than density, although this may be too labor-intensive to compute.
- The selection of an indicator such as HAB should not be restricted to *coastal waters*; rather, the question is more appropriately aimed at surface waters—for future Reports on the Environment consideration should be given to reorganizing

the questions in the water chapter around surface water (including both fresh and marine coastal), ground water, and drinking water.

- The HAB indicator is site specific. Perhaps the algal blooms are more common along the Florida coastline, but they are not unique to that region.

3.5.3 Discussion

- 3-84/28: In the final Report the “location of a large city” should not be characterized as a human *activity*—the Report on the Environment is confusing state variables and flows. This should be reworded to identify the relevant activities (e.g., runoff from impervious surfaces, combined sewer overflows, etc.).

Population Served by Community Water Systems (CWS) with no Reported Violation

- It is unclear why the indicator is not the inverse of what is presented—i.e., the number of CWS with reported violations. This seems the more direct measurement.
- 3-90/39: The value of reporting the number of regions above the national percentage of systems with no reported health based violations is unclear. Aren’t the regional data used to develop the national percentage? What is the point of including this information?

3.7.3 Discussion

- Why not have a regional indicator based on number of beach closings (number of beaches or number of days)? This information is currently being collected in the Great Lakes, as part of the EPA Beach Act.

Coastal Fish Tissue Contaminants

- Exhibit 3-38: See comments given above regarding 1) using a different graphic for these exhibits, using pie charts from each region emanating from a map of the U.S.; 2) revising composite U.S. score to weight based on coastline within each region; and 3) statistical analysis for differences among regions.

Contaminants in Lake Fish Tissue

- Exhibits 3-40/41: In the final Report, it would be more instructive to represent these data by Region to show geographic differences.
- 3-109/4: In the final Report, the absence of Great Lakes data should be noted earlier in this section, not just as an indicator limitation bullet. This is important given the historical legacy of contaminants in this region, so the exclusion of these data may result in an underreporting of the degree of contamination.

Land Chapter

Land Cover

- The Panel’s issues of concern for the land cover indicator are that: a) the data are old, b) the classification categories for land cover are too coarse, and c) to date there is no time series (trend) information, though EPA reports that time series

information is under development. There are a number of regional and national products; including the National Land Cover Data Set (NLDC), Landscape Fire and Resource management Planning Tools (LandFire), and others. These would provide greater resolution and time series for these analyses.

- The Panel recommends that in future Reports on the Environment, EPA consider using a range of land cover classification schemes with different levels of resolution based on what is most appropriate to answer specific questions.
- In the land chapter there is no discussion regarding the relationship between the status/trends in land cover and the effects on human health and the environment. In the final Report, it would be helpful to elucidate what data collection and analysis will be required to answer these questions and steps that need to be taken to make this a practical and useful indicator.

Forest Extent and Type

- The Panel believes that EPA needs to characterize land cover of all major ecosystem types. Therefore it is unclear why the Agency chose to only report on forest extent and type over other types of land cover. Other land cover types are distinguishable from existing imagery products data sets, the data presented for the land use indicator show trends in many different land cover (use) types. The rationale for only using forest extent and type needs to be clarified in the final Report.
- The forest extent and type indicator that is presented in Chapter 6 (ecosystem condition) only represents timberland. This presents only one category of forest land and others should be included in future Reports on the Environment.

Land Cover in the Puget Sound/Georgia Basin

- The land chapter regional example on Puget Sound using the National Oceanic and Atmospheric Administration Coastal Change Analysis Program (CCAP) data has very coarse classification information that translates to a low sensitivity indicator instrument. The reference point of 10% impervious surface becomes an important metric to make a statement regarding what the indicator means, whether things are falling apart or improving, and when action needs to be taken. There are many changes brought up in this section that may be better suited to the land use indicator category.
- There is no good explanation why the Puget Sound example was chosen to be representative of “land cover.” Such an explanation should be included in the final Report. The area encompasses many watersheds that have many different types of land cover, but the data only assess changes to forest and urban classes. The example does not provide much useful information or methodology that would describe an approach that should be used for assessment of land condition outside of the immediate area covered by the case study. The Panel suggests that regional indicators should provide this use through inclusion in this Report. The Panel supports the inclusion of regional examples, but believes that they should present data or methods that can be applied across the U.S. An example or case study should be chosen to demonstrate particular aspects of the conceptual model underlying the set of indicators and their linkage to the fundamental questions.

Land Use

- The Panel suggests that in future Reports on the Environment, EPA evaluate and adopt widely-used standardized approaches to classify land uses that have been developed through the National Resource Inventory and the Forest Inventory and Analysis programs as well as the National Agricultural Statistics Service and Economic Research Service. The Panel finds that much of the introductory material in the land chapter discusses the differences between approaches rather than interpreting what they can tell us about the status of land resources. The Panel is pleased to see that this indicator provides a beginning of a time series that can be used to document trends. The usefulness of the discussion will be improved by elaboration of what specific land uses changed from one class to another.
- The Panel notes differences between national and EPA regional data for land use in the Report. The discussion regarding the land use indicator is inconsistent concerning the inability to obtain data for land cover and the data available for land use. The land use data sets imply that there are trend data available for land cover. If this is not the case because the land use and land cover data are different in nature, this will need further explanation. For future Reports on the Environment the agency should work to adopt standard approaches for land use and land cover analyses. Standardized land use and land cover analysis and reporting at national and regional scales ultimately will benefit from a higher level of classification and mapping consistency across all federal agencies.
- For future Reports on the Environment, the Panel recommends that EPA consider adding road density (which can be measured directly just like stream density) as an indicator for land use. Accurate road density data are readily available in electronic, Geographic Information System (GIS) format (e.g., as Topographically Integrated Geographically Encoded Referencing System [TIGER] files). Since TIGER is a U.S. Census Bureau product, its limits and accuracy are well documented (<http://tiger.census.gov/>). Nationwide data are available, and changes over time can be mapped and measured. Density can be determined for specified regions of interest. There are other sources of road network data, but a 1990-2000 TIGER would be a good start.

Urbanization and Population Change

- The Panel finds that the urbanization and population change indicator in the land chapter presents much good information regarding the relationship between these factors. However, the chapter provides limited and indirect examination of the relationship between the available information and the resulting affect on human and environmental health.
- The Panel finds that the urbanization and population change indicator actually measures a stressor of land use in addition to one type of land use (developed land). The Panel questions whether population is a land use indicator or part of a group of indicators considered to be major drivers (stressors) of most indicators.

- In the final Report, the developed land data set that is used in the land chapter to represent urbanization and population change needs to be clearly described in the introductory text for this indicator. EPA should evaluate whether a more useful indicator might be “population density by land use type,” not by EPA region. Exhibit 4-11 on page 4-33 shows population density in the U.S. by EPA Region but the EPA Regional averages do not capture the aggregation of population density. Data aggregation is a major issue and EPA needs to be cautious that this does not misrepresent the extent and intensity of environmental impact.
- The discussion for the land use indicator addresses human residential and commercial uses. The Panel suggests that more could be said in the final Report about other land changes (e.g., changes in agricultural land and associated fertilizer and pesticide use), beyond just identifying them as gaps.

Quantity of Municipal Solid Waste Generated and Managed

- The data used to represent this indicator are well defined and consistently collected. However, the connection to human health and the environment is missing and should be discussed in the final Report.
- In the discussion of indicator limitations it is stated that the available information is model driven. The Panel recommends that more information be provided in the final Report about sources of uncertainty associated with the modeled estimates. If the estimated waste generation is based on a model that uses materials utilized, these changes and thus the quality and quantity of the waste is not “consistent from year to year” as stated. The Panel also notes that this indicator does not appear to meet EPA’s indicator acceptance criteria. The Panel does not recommend omission of the indicator, but more discussion of the quality of the estimate is needed in the final Report.
- In the discussion of indicator limitations, a gap concerning landfill capacity is identified. The Panel notes that landfill capacity is not a nationally limited resource (only cheap landfill space near some very large cities is in short supply). Therefore, landfill capacity should probably not be listed as a gap in the final Report.
- Some discussion regarding the influence of programs on trends in this indicator is not well linked to the data and should be avoided in the final Report. For example, on page 4-46 it is stated that, “Recycling efforts related to municipal solid waste have increased over the four decades showing the steepest increases between 1980 and 2000, most likely due to the increased awareness about the benefits of recycling and the implementation of policies by state and local governments tying waste generation directly to the cost of waste services.”

Quantity of RCRA Hazardous Waste Generated and Managed

- The data used to represent this indicator are well defined and consistently collected. However, the connection to changing levels of exposure and the resulting impact to human health and the environment is missing and should be discussed the final Report. This is an indirect land use issue, especially when deep well injection is a major method of getting rid of the RCRA waste.

Fertilizer Applied for Agricultural Purposes

- There is good information presented in the land chapter discussion of this indicator, but it is again not related to human and environmental health. The “delta” between fertilizers applied, that taken up by the crops, and that which is released to the environment is the most relevant indicator.
- The Panel notes that this indicator is limited to three crops and questions how well it represents fertilizer application in cropping across the U.S. The Panel also notes that separation of data for this indicator by EPA regions could be helpful since nitrogen and phosphorus drain into rivers, and large watershed regions might be more appropriate.
- The Panel recommends that a pesticide use indicator be added to the land chapter of the final Report. This could be done by renaming the indicator as “Fertilizer and Pesticide Applied.” In this regard, one possible indicator that could be used is pesticide sales, which could likely be parsed into agricultural and residential/commercial landscape applications. The latter would provide a suburban/urban indicator, which is important from the standpoint of human exposure.

Toxic Chemicals in Production-Related Wastes Released, Treated, Recycled, or Recovered for Energy Use

- The Panel notes that the title for the indicator should perhaps be modified in the final Report so that it does not appear that only toxic chemicals related to energy use are being considered.
- Reductions in toxic chemical releases can benefit human health and ecological condition. The indicator limitations section clearly points out the gaps in our knowledge and reporting base. In the final Report, this indicator might be more appropriately placed in a section dealing with toxic and harmful chemicals.
- In the final Report it would be helpful to weight the amounts of toxic chemicals by toxicity (e.g., the un-normalized weights given in Exhibit 4-18 on page 4-55), but this is addressed under limitations.
- The Panel recommends that in the final Report indicator data (e.g., Toxics Release Inventory [TRI] derived) be included for persistent bioaccumulative toxics (PBTs) and mining wastes, even if the available data are limited, such as is apparently the case for PBTs. The Panel notes that PBT data are available for some aquatic ecosystems such as the Great Lakes. This indicator therefore provides an opportunity for integrating land the land and water chapters. The Panel suggests that EPA consult PBT data available in the draft 2007 State of the Great Lakes report ([http://www.solecregistration.ca/documents/4201%20Contaminants%20in%20Sport%20fish%20\(SOLEC%202006\).pdf](http://www.solecregistration.ca/documents/4201%20Contaminants%20in%20Sport%20fish%20(SOLEC%202006).pdf)).

Pesticide Residues in Food

- The Panel notes that reductions in pesticide residues in food may have net positive health benefits. However, the linkage of this indicator to land use is weak and the Panel recommends that in the final Report the indicator be moved to Chapter 5 (Human Health).

- The indicator limitations section clearly points out that we should be monitoring the detections that exceed established tolerance levels in addition to what our instruments are able to detect.

Reported Pesticide Incidents

- The Panel finds that the decline in reported pesticide incidents has a direct relationship with human health. However, the link between reported pesticide incidents and the human health impacts of land management practices is tenuous. Reported pesticide incidents cover all sorts of uses of pesticides, and are based on calls to poison control centers. Many of these incidents are related to misuse of household products and activities far removed from land management. The Panel recommends that in the final Report the indicator be moved to Chapter 5 (Human Health).

High Priority Cleanup Sites with No Human Contact to Contamination in Excess of Health-Based Standards

- The Panel finds that this indicator has a direct connection to human health and addresses whether people are being kept away from hazardous sites. It may be useful to include some RCRA Corrective Action sites in the analyses in the final Report. In addition, it may be useful to provide an indicator that would address the number of sites that have been taken off the high priority site list.
- The Panel recommends that EPA consider including in the final Report an indicator for the number and associated land area of sites of this type that have been cleaned up.

High Priority Cleanup Sites where Contaminated Groundwater is Not Continuing to Spread Above Levels of Concern

- The Panel finds that this indicator also has a direct connection to human health as it addresses whether contaminated waters are being contained. It would appear that there are many additional CERCLIS listed sites and other RCRA Corrective Action sites that could also be included in these analyses. It may also be useful in this case to provide an indicator in the final Report that would address the number of sites that have been taken off the high priority list. EPA should also consider including an indicator of the number and associated land area of sites of this type that have been cleaned up.

Human Health Chapter

Health Effects of Air Pollutants

- In describing health effects associated with air pollutants, authors should be careful to include in the final Report those effects associated with low-level exposure as occurs in the ambient environment. For example, ambient carbon monoxide is described as having effects including cardiovascular, neurological, visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, and difficulty performing complex tasks. The Panel questions whether these effects are associated with low level exposures.

Ecological Condition Chapter

Need for Additional Indicators

- Indicators are provided in the ecological condition chapter to answer the question: “What are the trends in the diversity and biological balance of the nation’s ecological systems?” The Panel notes that the concept of biological balance includes complex interrelationships for which clear indicators are not easily selected. Those indicators selected are either population states or events which are difficult to translate into “balance.” Very few biological taxa indicators are included. At present, it is a good start but inadequate. Far more indicators of floral and faunal groups as well as biological communities should be included in future Reports on the Environment.

Ecosystems are Missing

- Western continental issues. In the ROE 2007 Science Report there is little or no attention paid to the arid ecosystems in the Great Basin and the desert southwest. Grassland/prairie, shrublands, rangelands, and chaparral are important ecosystems in terms of biodiversity. It is important to include information on these ecosystems in future Reports on the Environment.
- Coral reefs. Coral reefs have been in serious decline due to eutrophication, overfishing, siltation, disease, and climate, among other factors. Many of the factors affecting coral reefs are germane to EPA regulatory programs. Much monitoring data are available on these ecosystems. The Panel notes that earlier reviews recommended that coral reef cover, which had been proposed as an indicator, not be included in the 2007 ROE Science Report because it lacked calibration between methods, lacked an explanation of how sites were selected, and lacked a consistent analytical framework to adjust for bias in geographic distribution and sampling method. We think that, because of their ecological, economic, and recreational value, the benefits of including corals in the Report outweigh these problems. Many coral reef monitoring programs use transects, and data from these monitoring programs could be used in the Report. A regional coral reef indicator could be developed, using only those that reefs that were sampled appropriately. Problems with the data could be described in the limitations and gaps section. The Panel recommends that coral reef information could be added to future Reports on the Environment.
- Soil ecosystems. Soils are one of the key drivers that cut across all terrestrial ecosystems. Soil is a fragile and finite resource that plays a unique role in maintaining air and water quality. Use and management of native, agricultural, forested, range, and urban lands play an integral part in influencing soil and water quality within a watershed. Protecting soil quality is important for ecosystem productivity and water quality. Soil morphological, physical, chemical, and biological properties can serve as indicators. Spatial data in various ecoregions are currently available on range of soil properties and should be included in future Reports on the Environment.

Populations are Missing

- Marine/estuarine fish. The Panel recommends that in future Reports on the Environment, the ecological condition chapter include considerations of marine/estuarine fish populations. There are numerous long-term data on these populations available from NOAA Fisheries. Many species are in decline due to overfishing; this has received considerable attention. The depletion of predatory fish can have ramifications through the food web via trophic cascades that can result in reduced numbers of grazers, and subsequent algae blooms, that can exacerbate eutrophication. The depletion of filter feeders such as oysters can also lead to reduced water quality. While fisheries are not EPA's responsibility, the depletion of upper trophic level species can have major effects on the ecosystem and environmental quality.
- Amphibians. The Panel recommends that in future Reports on the Environment EPA include in the ecological condition chapter an indicator dealing with amphibians. There have been many studies documenting the precipitous decline and loss of populations of amphibians, and some of those could be used to construct an indicator. While the reasons for the disappearance of amphibians are not all understood, some factors involved appear to be climate change, ultraviolet radiation, and pesticides, all of which are relevant to EPA. If development of a national indicator is not possible, a regional one could be developed.
- Invasive species. The Panel recommends that in future Reports on the Environment EPA include data on non-indigenous invasive species in a variety of terrestrial and aquatic ecosystems. There are numerous data sets that could be used to develop indicators, at least for some regions. For example, SERC (Smithsonian Environmental Research Center) has data sets for marine/estuarine invasive species. Additional sources of information are the Global Invasive Species Database of the Global Invasive Species Information Network (<http://www.invasivespecies.net/>), and the National Invasive Species Information Center hosted by the U.S. Department of Agriculture (<http://www.invasivespeciesinfo.gov/>).
- Taxa containing massive diversity. The Panel recommends that in future Reports on the Environment indicators be developed for taxa such as microflora and microfauna, and non-vascular and vascular plants, which have very high biodiversity. Ecosystems host complex microbial communities, including bacteria, fungi, protozoa, and viruses. The size and diversity of microbial communities are directly related to quality and quantity of resources available. Microbial processes and populations have more rapid turnover than higher trophic levels and are often more responsive to environmental change. These characteristics make microbes good indicators of ecosystem condition because they are potentially very sensitive to perturbations such as nutrient loading, hydrologic alterations, and fire. New information is now emerging about these indicators and the Panel hopes this information will be added in future reports.

Processes are Missing

- Denitrification. The Panel recommends that in future Reports on the Environment the ecological condition chapter include an indicator of the natural denitrification

- process which is important for nutrient balance in ecosystems, for example, the denitrification of nitrate from atmospheric deposition. Ecological processes in low order streams are important in processing excess nutrients (e.g., denitrification of N from atmospheric deposition).
- Soil processes. Another issue of importance is the trend in the extent and condition of the nation's soil resources. As noted above, soils are one of the key drivers that cut across all terrestrial ecosystems. Soil quality and associated processes can have major influences on ecosystem productivity and nutrient cycling. Loss of topsoil due to erosion and other processes can influence ecosystem productivity and long-term assimilative capacity as well as stream water quality. Assimilative capacity is important as ecosystems have finite capacity to provide services before they are drastically altered. For example, long-term application of nutrients via fertilizers or organic wastes may ultimately saturate a system. This is evident through accumulation of phosphorus in soils and increased levels of nitrate in ground waters. Salination of irrigated farmland soil is an urgent issue in the arid Southwest. Potential soil quality indicators include: carbon storage, organic matter, nutrient inventory, phosphorus index, extent and soil type, soil quality, salinity, soil erosion. The Panel recommends that future Reports on the Environment consider these indicators.
 - Acidification. The Panel notes that there are long-term data sets available on responses to acidification and its reduction (National Acid Precipitation Assessment Program [NAPAP]) that should be included in future Reports on the Environment.
 - Disturbance. Disturbance is a critical process in all ecosystems and should be included in future Reports on the Environment. The Report discusses its importance but has no indicator of disturbance or response to it (e.g., resilience). Disturbance processes can be used as indicators of anthropogenic effects on the environment. For example, maps showing how fire cycles have changed in relation to the health of forests can provide important information on a critical issue

Trends in Diversity and Biological Balance of the Nation's Ecological Systems

- On page 6-29, the final Report should acknowledge that some systems inherently have different numbers and variety of species, making it inappropriate to make comparisons among systems.

Choice of Forests, Wetlands, and Land Use as Indicators in Chapter 6

- While there is nothing wrong with these categories, it is unclear to readers why these were chosen and not other equally appropriate categories. A conceptual framework would be very helpful in the final Report to place these categories and indicators into some type of context.

Forest Extent and Type

- This indicator is limited to "timberlands" which is misleading. This is nearly equivalent to using corn and wheat fields in order to describe the extent of grasslands. The Panel notes that this indicator is based on productive capacity,

and therefore a statement in the Report concerning the limits of indicators that have excluded production does not apply. However, the discussion of indicator limitations does recognize some of the limits of using timberland data.

- 6-16/15: What percent of forest land is not being captured in this analysis? In the final Report this percent should be explicitly noted as part of the uncertainty.

Forest Fragmentation

- The Panel understands the value of using forest fragmentation as an indicator but questions why a fragmentation indicator is not equally important for the other ecosystems. The Panel questions whether this is because of the availability of data. The Panel finds that in the final Report, a schematic diagram graphically showing the four degrees of forest cover would be helpful to complement the narrative, as would a presentation of the absolute area of forested lands identified for each region.

Wetland Extent, Change, and Source of Change

- Development of artificial wetlands, ponds etc. may skew data for this indicator.

Ecological Connectivity (Region 4)

- The Panel notes that development of this indicator is an exercise demonstrating how to show connectivity, but since it is regional it does not tell much about connectivity either nationally or in major ecoregions. The distinction between hub and corridor should be better defined and shown in the map in the final Report. If the methodology is relatively simple and uses just National Land Cover Data Set (NLCD) data, then a major effort should be made to see if it is applicable to non-forested regions.

Relative Ecological Condition of Undeveloped Land (Region 5)

- The Panel finds that this is a case where a tool has been developed for one EPA region but it does not tell the story about the landscape in general or its usefulness. The indices used have the potential to display a lot of information, but it is not stated what exact data layers are included in each index. This tool used only NLCD data to generate three indices, two of which use species diversity or rarity. The Panel questions whether it is possible to go to species level with NLCD satellite data. If models were used for the diversity and rarity indices, they should be explained. In the discussion in the final Report it should be noted that increases in developed land affect habitat and impact physical and chemical processes such as runoff from impervious surfaces, reduced groundwater recharge, and increased stream temperatures.
- Shades of green are extremely difficult to distinguish in Exhibit 6-8.
- Undeveloped is a relative term and appears to be confounded with population density, making it inappropriate to draw conclusions or causative associations (as on page 6-27, "The potential for future land use changes with increasing urbanization is the major determinant for judging potential fragmentation of ecological systems in EPA Region 5...")

- In the final Report EPA should clarify the interpretation or importance of the cover types mentioned: maple-beech-birch, spruce and pine. Is this simply a descriptive statement or should the reader be able to infer something about a trend of ecological significance?

6.2.3 Discussion

- It is unclear why forests, wetlands, and land development, of all available indicators, are the three worth highlighting for the nation's ecological condition. This should be clarified in the final Report.
- 6-27/1-3: It may also be worth noting that these increases in developed land affect not only habitat loss for biota, but also impact physical and chemical factors, such as more runoff from impervious surfaces, leading to greater loading of nutrients and contaminants, a more unstable hydrology, reduced groundwater inputs, and increased stream temperatures.

6.3 Discussion

- 6-30/25-31: It is helpful to know about the absence of a systematic biodiversity initiative in the U.S., but there is still a need to explain in the final Report the rationale behind including those indicators that are found in the Report.

Bird Populations

- The limitations on the data set should not detract from the usefulness of this indicator. It is one of the most consistent, long-term sets of ecological measures in the whole Report.
- In the final Report, EPA may want to note that the significant increases or decreases are of observations, not population size.

Fish Faunal Intactness

- The discussion in the ecological condition chapter states a concern over the inability to show magnitude of loss. The Panel notes that this could be remedied by using a map of number of species lost. With such a small number of species to begin with, the percent decline figure can be misleading. The Panel questions whether using 1970 as a reference year potentially confounds comparisons from regions that were heavily polluted at that time. The Panel recommends that data from estuarine fish should be included in future Reports on the Environment.

Non-indigenous Species in the Estuaries of the Pacific Northwest

- The limitation one area implies that non-indigenous species are less important in other estuaries. The Panel notes that the restriction to species captured in a grab sample suggests that this is how most invasive species can be sampled. However, this is not true. More estuarine invasive species tend to be epibionts that attach to surfaces. Some invasive species cause greater disruption of ecosystems than others, so it may make sense to use indicators that address those species that are most ecologically or economically problematic. The Panel finds the preliminary classification of estuaries as "exposed" or "background" depending upon the assumed amount of ballast water or aquaculture releases is naïve, since estuarine

biota disperse, and currents aid their spread, particularly in the planktonic stages. There is no need to pre-classify estuaries. Once the data on non-indigenous species are collected, then estuaries can be classified according to their percentage of non-indigenous species. The Panel recommends that in future Reports on the Environment this indicator be expanded to other estuaries as well as other aquatic and terrestrial ecosystems.

6.3.3 Discussion

- 6-40/18: Chesapeake Bay SAV may not be a representative example for wider-spread phenomena.
- 6-40/24: It may not be possible to statistically defend this claim with the available data sets.
- Good regional long-term data sets may be available to address above ground plant richness and diversity (e.g., Long-term Ecological Research Programs, Harvard Forest data)
- 6-42/25: Perhaps a useful template for the type of exhibit on this page would be a map of the U.S. subdivided into regions, with more detailed maps of each region showing data for different representative species. For invasive species, this may be an autotroph or a heterotroph, or aquatic vs. terrestrial, depending upon which species provides the best information for the region.

6.4 Discussion

- Perhaps the Millennium Ecosystem Assessment (MEA) model could be used for identifying ecological processes that sustain the nation's ecological systems (i.e., provisioning, regulating, cultural, and supporting).
- There is a fundamental problem in the indicator chosen for this question. The question deals with processes, but the indicator deals with a state variable, not a process. This can be resolved by changing the question or choosing an indicator that answers the question, such as primary productivity, decomposition rates, or nutrient uptake/cycling rates. Long Term Ecological Research Program sites should provide a rich source of data for these types of information.

Carbon Storage in Forests

- The Panel notes that carbon storage in forests is not an ecological process *per se*, but a condition representing the net balance between the processes of photosynthesis and decomposition. This indicator can show trends. However, many more processes need to be covered in future Reports on the Environment. The use of several geographic regions is more logical here than the use of EPA regions elsewhere. Unfortunately, the data in the chapter represent only "timberlands" which include many highly managed forests and this should be pointed out in the limitations section. Use of this indicator should be expanded in future Reports on the Environment to carbon storage reservoirs, such as grasslands, especially below ground (soil) storage which holds a significant portion of the total carbon.

Photosynthesis and Decomposition

- Photosynthesis and decomposition are the two most important ecological processes. Carbon storage is described as an indicator representing the net balance between these two processes. Restricting the indicator to forests and excluding grasslands greatly weakens this indicator. In the final Report this needs to be discussed in the limitations section on page 6-46.

6.4.3 Discussion

- 6-48/4: The indicator does not provide data on trends in primary production; this process is a rate. The indicator provides data on a stock, which is different.
- 6-49/1: Another limitation, assuming carbon storage is used as the proxy indicator for this question, is that carbon storage from many other important terrestrial ecosystems is missed.

U.S. Temperature and Precipitation, Sea Surface Temperature, Sea Level

- These are very good time series data. They are all physical attributes that have impacts on biota and on ecological processes. These indicators, and their links to greenhouse gas emissions discussed in the air chapter, should be included in the ecological condition chapter discussion in the final Report.

Sea Surface Temperature

- 6-59/4: Why not include statistical information?

Sea Level

- Although not technically “sea” level, one limitation is the lack of data reported for Great Lakes levels. These data are available from the U.S. Army Corps of Engineers (Detroit District), and should be considered for inclusion in future Reports on the Environment.

Appendix B: Editorial Comments

General

- Throughout the Report there is generous use of acronyms, which may be confusing, but perhaps unavoidable. Thus, including a list of acronyms and abbreviations (e.g., units of measurements) would be an improvement.
- As this version of the Report is intended for scientists rather than the general public, it would be helpful to use metric system units throughout for measurements (e.g. °C rather than °F for temperature).

Introduction

1-4: Identify explicitly the philosophy behind choosing indicators.

Water Chapter

3-7/14: Replace “like” with “such as”.

3-7/42: Move “only” to after “meet”.

3-9: Should N and P discharge be load?

3-9: Delete “wetland extent...” from the coastal waters box.

3-11/37: Seems that NPS paragraph also should include affects of land cover, such as impervious surfaces.

3-12/1-3: Air deposition should include nutrients, as well (N and P).

3-12/12-18: It is not just extent of the fresh waters, but also their configuration in the landscape that matter. This should be noted.

3-15: Exhibit 3-1: Clarify caption: “Relative percentages of rivers and streams in terms of their changes of high and low flow ...”

3-17/3: Are any estimates available of the percentage increase of dammed rivers between 1949 and 1970?

3-26/10: Suggestion--briefly explain the weighting scheme used.

3-28/24: Change to “have a broad geographic distribution”.

3-36: Needs enumeration of rows 1-45.

3-42/19: Add: Groundwater accretions in agricultural watersheds may also increase contaminant loads of rivers and streams.

3-50/17: This is not a *location* classification—it is salinity of media.

3-53/4: Insert “and other types of coastal” after “Estuarine”.

3-53/7: Insert ‘, chemical’ after “biological”.

3-53/14: Insert “These conversions reduce the area of the relatively unique systems such as forested swamps and bogs and increase the area of the ubiquitous ponds and marshes.” after “pond.”

3-54/19: Insert “although still much less in absolute terms than the other wetland types” before “Panel D”.

3-54/40; 3-55: Exhibit 3-19--Please clarify the meaning of describe the process of “deepwater conversion”.

3-57: Insert “and continue to be lost” after “1990s”.

3-57/29: Insert “and some wetland types such as forested swamp and bogs are difficult or even impossible to create or restore.” after “lost”.

3-57/32: Insert “using a logistically plausible” after “estimate” and Remove “without an impractical”.

3-58/3: Insert “function and” before “condition”.

3-63/9; Exhibit 3-21: Include quantitative information for nitrogen concentrations.

3-64: Exhibit 3-32: Include quantitative information for phosphorus and chlorophyll.

3-67/3: May want to define what is meant by “adverse”.

3-71: Exhibit 3-28 is missing letters and a dash in the label within the text box.

3-79: Exhibit 3-32 is missing data in Panel A.

3-71: Exhibit 3-38--Fix caption number.

3-72/19: Address the possible effect of the weighting scheme and methodology on the results.

3-79: Exhibit 3-32--- Include missing data in graphic.

3-82/6: Limitations---the temporal trend is limited by the short time span (only 5 years of data).

3-84/30: Comment---How much different? Many times higher or less?

3-87/5: Suggestions---Include brief definitions of surface water and ground water.

3-103/17: Suggestion---Include brief description of health risk basis of guideline.

3-104: Exhibit 3-38---Indicate that the values are percentages. Add: “Percent” to caption.

3-108/10: Briefly explain toxic equivalents (TEQ). MDLs have no direct relations to health risk.

3-109/2: Comment---Imported seafood accounts for 70% of consumption. Perhaps it is also an FDA issue.

Land Chapter

4-61: Consider an outline to the bars in Exhibit 4-6, 4-7 (pp. 4-26, 4-27) to make them more visible, such as in Exhibit 4-23.

4-31: legend is incomplete in Exhibit 4-8.

4-50: NPK are identified as pounds per acre; are these the desired units?
Are these values devoid of inert ingredients (i.e., just element)?

Human Health Chapter

5-7: Figure 5-1 can be enhanced by depicting susceptibility factors including genetics, diet, etc. described in the paragraph starting on line 28 of page 5-6. Furthermore, this figure might more effectively appear within the introduction as a way to provide both a conceptual framework for the Report on the Environment as well as the organizing principle. The figure and text would need to be modified to include ecological effects and to show increased uncertainty as indicators move from left to right.

5-7 and 5-8: In the introduction, terms such as “definitive proof” and “conclusive evidence” are used. It might be better to omit the adjectives.

Ecological Condition Chapter

6-14: In Exhibit 6-2 add black outline bars to make it easier to see light colors.

6-14: In Exhibit 6-2, indicate the percentage changes rather than absolute changes because forest coverage and sizes differ from region to region.

6-15: Clarify that emphasis in Exhibits 6-3 and 6-4 is on economically important species.

6-15: In Exhibits 6-3 and 6-4, indicate percentage changes rather than absolute changes because covering and sizes differ from region to region.

6-18: On line 13 explain “degree of connectivity.” Can a quantitative definition be used?

6-21: In Exhibit 6-6, a different color scheme should be used. The map does not show clearly the difference in the greens.

6-22: On lines 22-24, please specify the twelve layers and the four layers if possible. Are any weighting factors used?

6-25: On line 15 clarify “decreases in Regions 6 and 9” and “increases in Regions 3 and 5.” The data in Exhibit 6-2 show discrepancies from the general statement in the text. Region 9 has increased during 1977-2002.

6-30: Insert acknowledgement that nutrient enrichment can also be considered a “pollutant” and be responsible for community shifts toward invasive species.

6-30: On line 1 the following suggested change in the wording is provided: “...by global events such as large meteor impacts...” or “...bolide collisions...”

6-32: With regard to bird populations, delete the following debatable statement, “are among the most visible and important biological components of ecological systems and”

6-32: Note whether abundances in Exhibit 6-9 are standardized by numbers of observers.

6-32: On line 22 discuss the possible causes for the decrease in grassland species.

6-34: With regard to fish faunal intactness, explain why 1970 is chosen as the reference.

6-35: Expand the legend in Exhibit 6-10 to explain the pie chart (i.e., reduction areas expressed as % total land area).

6-37: On line 12 replace “>=” with “≥”.

6-38: In Exhibit 6-12, illustrate where the “exposed” and “minimally exposed” estuaries are located on the map and provide an idea of the sampling intensity.

6-40: On line 24, the following statement needs supporting data and justification: “...fewer blooms in recent years as compared to 1996...”

6-45: The key in Exhibit 6-13 is missing the color codes. Letters are missing in the title of the exhibit.

6-45/32: The word “somewhat” understates the trend. Inspection of the data indicates a decline in the 1990’s of approximately 33%, which is more substantial than “somewhat.”

6-46: In Exhibit 6-14, indicate in the captions and on the labels that the values are net changes of storage, not total storage.

6-46: On line 31, can an estimate of carbon storage (e.g., % of total) in soils be provided? How significant is this omission?

6-46: In Exhibit 6-14, add outlines to fill in order to increase the visibility and acknowledge that the net carbon storage is affected by climate and soils.

6-48: On line 9, the dates in the discussion do not correspond to the dates presented in the indicator.

6-49: On line 2 include estimates of carbon storage in soils.

6-53: On line 41, what is the confidence level or statistical significance of the regression?

6-54: In Exhibit 6-16, add negative signs on the temperature scale.

6-55: On line 14, include the names of the three climate regions.

6-56: In Exhibit 6-18, the graphs as presented do not clearly show support for the discussion. Please modify the graphic data to show statistical significance.

6-56: In Exhibit 6-18, the Y axis scales should be changed to appropriate values to better show trend data.

6-57: On line 2, a limitation should be added indicating that the empirical debiasing models used to adjust the data may themselves introduce non-climatic biases.

6-61: On line 33 the following change in wording is suggested: “subsidence or uplift caused by tectonic movements of landmasses.” Delete “changes in natural land accretion.”

6-64: On line 6, the following change in wording is suggested: “...due to changes in sea level or land elevation caused by tectonic movements.”

Appendix C: Example Conceptual Framework

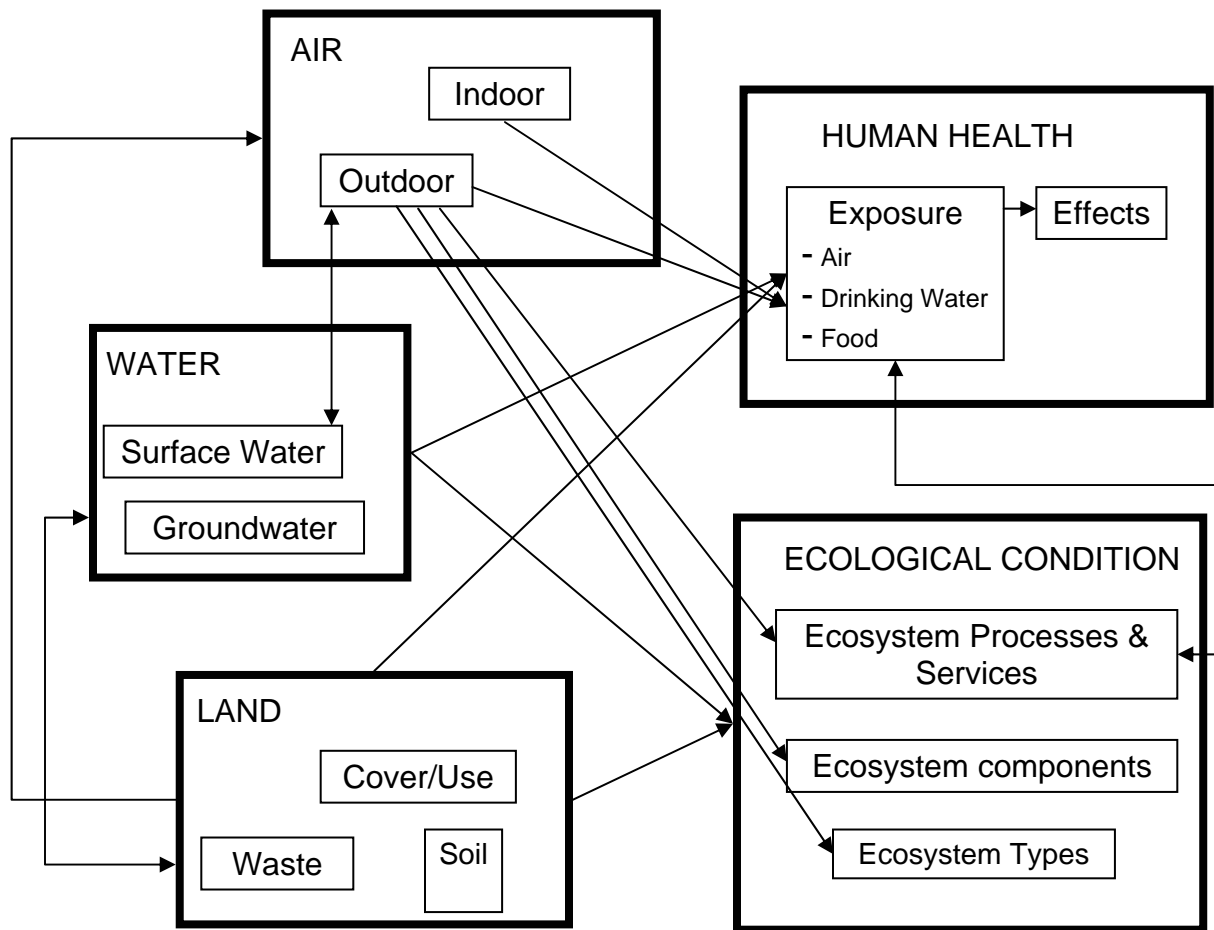
A synthesis chapter is needed to pull together the findings of EPA's Report on the Environment. The findings reported through the questions and indicators show status and trends of many different environmental parameters. These parameters have been placed in two types of chapters: 1) media (i.e., air, water and land), and 2) health and ecological condition. However, it is important to indicate that parameters are linked through attributes and processes that control the parameters as well as attributes and processes that the parameters influence. Consequently, to demonstrate the integration and synthesis of the Report, three components need to be added 1) a conceptual framework, 2) a synthesis discussion, and 3) a simple and clear description of each indicator, with a discussion providing a rationale of why it was selected, and what it should tell. It is recommended that the conceptual framework and the description of each indicator be added to the final Report, and the synthesis chapter be added to future Reports.

Conceptual Framework Component: We suggest that this be included as part of the suggested introductory chapter and possibly part of the introductions to the human health and ecological condition chapters. An example conceptual diagram is shown in the accompanying figure, which has the compartments of air, water, and land, and shows their connection to each other and their impacts and linkages to human health and ecological condition through physical, chemical and biological processes. Any such diagram that EPA develops for this purpose should show the flows, influences or connections among the many parameters selected to be used in the ROE 2007 (see figure). The figure is provided as an example. A more specific and detailed conceptual framework could be developed to represent relationships among indicators and media.

Synthesis Discussion: A discussion of the interactions among the many parameters selected to assess the state of the environment should include a commentary on the importance of status and trends of selected parameters within a particular medium. The commentary should draw upon the observations of status and trends within each indicator discussion. The synthesis should indicate how status and trends in one parameter might influence other parameters within the same and other media. This cross media discussion then should demonstrate how status and trends in media parameters might influence status and trends of parameters within the integrative chapters (human and ecological health and/or condition). The status and trends within the human health and ecological condition chapters should each be discussed to describe the importance of the findings relative to "well being" and/or "sustainability" of each attribute (i.e., humans and ecosystems). The synthesis discussion should not put values (e.g., good, bad, inconsequential) on status and trend data but rather focus the discussion on the importance of the magnitude or "direction" of the status or trend and its implications for other factors.

Importance of Indicator: Each indicator should have a clear explanation of why it is important based upon a scientific (perhaps conceptual) fundamental understanding of drivers and processes that if changing will alter the status of the indicator over time. An example indicator description is provided in Appendix D.

Example Conceptual Framework Diagram



Appendix D: Example Indicator Description

The indicators should all have a consistent description and presentation to the reader. We recommend that each indicator have a description and/or definition of the indicator, and a clear justification and explanation for its selection. Secondly, we recommend that each of the metrics used to report the indicator be described. The following example is based on information contained in the SAB report, a Framework for Assessing and Reporting on Ecological Condition (U.S. EPA Science Advisory Board, 2002)

Example indicator: Landscape Condition

Landscape is an area composed of a mosaic of interacting ecosystems or habitat patches. A change in the size and number of natural habitat patches, or a change in the connectivity between habitat patches, affects the probability of local extinction and loss of diversity of native species, and can affect regional species persistence. At the landscape scale, the extent of broad land cover classes (e.g., forest, agriculture, urban/suburban, surface waters) can serve as surrogates of habitat extent for broad classes of species.

Landscape indicators are reported in the following three categories: extent of ecological system type, landscape composition, and landscape pattern/structure. The extent of ecological system type is an important indicator because it is correlated with species decline. Landscape composition information provides insight into long-term population viability because populations are unlikely to persist in landscapes where the largest patch of habitat type is smaller than that species' home range. Landscape pattern and structure provides a measure of habitat fragmentation that may isolate vulnerable species restricted to specific habitat types.

Metrics used to measure the indicator:

- Extent of the ecological system/habitat type: (e.g., habitat area, perimeter-to-area ratio, core area, elongation, etc.)
- Landscape composition: (e.g., number of habitat types, number of patches of each habitat, size of the largest patch, presence/absence of native plant communities, measures of topographic relief, slope, and aspect, etc.)
- Landscape pattern/structure: (e.g., dominance, distance between patches, longitudinal and lateral connectivity, juxtaposition of patch types, width of habitat adjacent to wetlands, etc.).

Appendix E: The Use of Ecoregionally Derived Indicator Information for Action and Decision Making at the EPA Regional Offices

All indicators need to be developed, analyzed and reported within an appropriate ecoregional context. This context includes important dimensions of scale and boundary, and should be driven by the intended uses for the indicator information. The formulation of the indicator parameters will be constructed from knowledge regarding their relationship to regional-scale ecological processes. The mapping of indicator values will be dictated by the amount of relevant data available for spatial analysis.

Environmental protection and resource management agencies are administered through hierarchical regional structures. These regionalizations are agency specific, and were developed through a complicated historical set of administrative and mission driven factors. Knowing that many environmental management and protection actions will be implemented by the regional offices, it is a common error to use these administrative regions as a surrogate for ecoregions for all ecological indicators. These administrative regions often do not represent the boundaries of resources that are being protected and managed by the Agency. These administrative regions should not be used as a framework for indicator analysis.

A two-step process is required to use environmental indicators to inform priority management and protection actions within an administrative region. First, the indicators should be developed within an appropriate ecoregionalization framework, and the analytical results should be generated for each indicator within each ecoregion in that framework. Second, the indicator results should be spatially parsed to provide relevant management directives to the regional offices.

As an illustrative example, let us consider the use of freshwater mussels as an indicator of water quality factors and biological intactness. The current distribution of mussel species represents a combination of hydrological connectivity, geochemical, land use and pollution factors. The logical ecoregional context for this indicator would be a hydrologic watershed framework that is represented at an appropriate scale that captures the relevant geochemical regimes and associated land-use patterns. Time series data on the composition and distribution of these species within these ecoregions relative to land use, exotic introductions and pollution sources would provide the desired indicators of ecological health.

Any administrative region could contain either entire watersheds or parts of watersheds. When a watershed is completely contained in one regional jurisdiction, that region would take responsibility to respond when the indicator demonstrates the need for intervention. When a watershed is shared by multiple jurisdictions, a decision must be made to lay out a formula for a) responsibility sharing, or b) designating full responsibility for management and protection decisions across the entire watershed to a particular administrative region. The designation of full responsibility could either be based on the relative percentage of geographic intersection between watersheds and

administrative regions, or by capacity and expertise factors within the different administrative regions. The critical point is that responsibility must be assigned and accepted to ensure the appropriate management response.

Appendix F: Table of Recommendations to be Considered Before Finalizing the 2007 Draft Report

Table F-1 in this appendix presents a summary of recommendations to be considered before finalizing the 2007 Report. The second column of the table provides page numbers where recommendations may be found this advisory report. Additional comments and suggestions are provided in the text of the report. Detailed comments pertaining to specific indicators are included in Appendix A.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Overarching	4	The introduction should be revised to clearly indicate that the first three chapters are intended to address status and trends using specific indicators for the individual “media” of air, water, and land, and that the next two chapters are intended to provide integrated assessments of status and trends in human health and ecosystem condition.
Overarching	4	The introduction should clearly state its purpose for intended audiences and EPA. The introduction should discuss how the Agency plans to use the Report and its analyses and how the Agency wants the Report to be used by the broader public. In this regard, the final Report should state that the current version of the Report provides status information to establish baselines for reporting future trends, but does not yet include long-term trend information for many indicators..
Overarching	5	EPA should incorporate a conceptual framework into the introduction to illustrate the connectedness between the media, human health, and ecological condition chapters.
Overarching	5	In appropriate places of the final Report, interconnections between the indicators should be established by cross-referencing the discussion of indicators in different chapters.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Overarching	6	EPA should clarify whether the document refers to qualitative or quantitative trends, or both (i.e., “trend” as used in the document needs to be defined). The word “trend” (used in the questions) has a specific meaning in statistical science.
Overarching	7	All questions should be broadened to ask “What are the status and trends...” rather than focusing only on trends.
Overarching	7	EPA should explicitly state how each question in the Report is related to a conceptual framework.
Overarching	8	EPA should provide a clear description of why each indicator is important, the rationale for selecting the indicator, what it tells, and the documented relationship between the indicator and human health and ecological condition
Overarching	8	Additional indicators (identified various sections of this report) should be included to show the response of more integrated components of the system or address missing issues. For example indicators should be included to capture the status of and trends in ecosystem services.
Overarching	8	EPA should identify the status of the monitoring programs (e.g., extant, “on hold,” or expired) that have provided indicator data used in the Report.
Overarching	8	Additional trend data (classified as either qualitative or quantitative) should be included for as many indicators as possible.
Overarching	10	EPA should clarify whether specific bullets in the indicator limitations sections refer to indicator limitations or data gaps.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Overarching	10	The discussion of gaps and limitations should be expanded to identify some of the more prominent available data sets that were excluded and the reasons for their exclusion (e.g., technical concerns, lack of statistical power, or other specific reasons).
Overarching	10	The discussion of data gaps and limitations should be strengthened by adding or expanding existing information in several areas. These include: 1) Discussion of the need for a transparent set of indicator metrics that can be well justified. The current choices of metrics and benchmarks are not well justified. 2) The need to provide additional information on emerging issues such as chemicals of emerging concern, exotic wildlife diseases or invasive species (the emerging issues should be discussed at the end of each individual chapter). The Panel specifically notes that perfluorinated chemicals should be added to the list of emerging contaminants of importance in Chapter 7 of the ROE 2007. 3) Further justification and discussion of limitations associated with the intervals of time used to establish trends.
Overarching	11	The implications of each indicator limitation should be discussed, and the uncertainties associated with each limitation should be quantified to the extent feasible.
Overarching	12	If EPA administrative regions continue to be used as the basis for regionalizing data, the Panel recommends that this process be better explained.
Air	16	A science framework should be incorporated into the air chapter of the final Report to show the interaction within, between and among media as well as between and among indicators.
Air	16	A short historical section should be added to the air chapter to provide background information on the criteria pollutants.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Air	16	SO ₂ concentration should be added to the air chapter as an indicator.
Air	16	The air toxics indicator should be expanded in the air chapter.
Air	17	A broader explanation of what is in the National Emissions Inventory (NEI) should be added to the air chapter.
Air	17	Further analysis of the trends in air indicators should be added to the air chapter. While it is important to know whether air indicator trends are increasing, it is important for the reader to understand the reason for the direction of indicator trends. The Report should state where have we been, where we are now, and where we are going.
Air	17	An indicator should be added to the air chapter to focus on the clear reduction of primary pollutants (CO, SO ₂ , and Pb) but much flatter trends in secondary pollutants (O ₃ and PM _{2.5}), reflecting the growing importance of secondary air pollutants.
Air	17	A small section should be added to the air chapter to discuss how climate change is affecting aerosols.
Air	18	EPA should acknowledge and discuss the limitations of a single pollutant, local source approach to pollution control in the context of the marked reductions in individual pollutants documented by the indicators, and as exemplified by continuing challenges with regard to ozone and PM _{2.5} .
Air	18	EPA should view the PM speciation network as the vehicle to provide the needed information on PM composition.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Air	18	The bias that may result from the choice of base year for trends for a given air indicator should be discussed, as this has implications in the interpretation of the air indicator data.
Air	18	The effects of trends in ambient concentrations of air pollutant indicators on exposure and dose should be discussed.
Water	20	The questions in the water chapter should be expanded to focus on the interconnectedness of different systems (both within the different water types and across media).
Water	20	Additional questions should be included in the water chapter to incorporate missing information on availability and usage of water for human activities, especially with respect to both ground water and surface water withdrawals (see data in Roy et al., 2005 and Solley et al., 1995).
Water	20	EPA should examine the relevance of measures of “Extent and Condition” across all aquatic ecosystem types. In this regard, the Panel finds that the question on the “extent” of coastal waters is not meaningful because for coastal waters, the issue of importance is their condition not their extent.
Water	23	Data for the indicator “pesticides in agricultural streams” should not be compared to human health benchmarks.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Land	30	EPA should consider the following suggested revisions of the land chapter questions in order to improve their clarity. 1) The Panel suggests that trend information be developed wherever possible, and that EPA use both qualitative as well as quantitative data to generate trend information for all indicators. 2) The waste deposition addressed in Question 3 (wastes) could be considered a “land use” issue and included as a subtopic of Question 2 (land use). 3) The topic encompassed by Question 3 has overlap with the fundamental question regarding groundwater in Chapter 3, and there is a need for an explanation of integration among components of the Report in the introduction. 4) The agency may wish to list agriculture explicitly as the focus in Question 4. An alternative would be to include agricultural land indicators under Question 2 (addressing land use), considering agriculture as a specific land use. 5) The factors distinguishing Question 5 (addressing contaminated land) from Questions 3 and 4 should be explained more fully.
Land	31	EPA should include more direct indicators of effects in the land chapter.
Land	31	EPA should consider adding indicators for mining wastes as well as animal and other wastes applied on agricultural land.
Land	31	EPA should add an indicator based on the generation and disposal of civilian radioactive waste.
Land	31	A pesticide use indicator should be added to the land chapter.
Land	31	The pesticide residues in food and reported pesticide incident indicators should be moved to the human health chapter.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Land	32	The discussions of the data gaps in the land chapter should be modified to make it clear that the gaps mentioned are the highest priority gaps determined by the agency, and that the list is not intended to be comprehensive.
Human Health	34	The questions within the human health chapter should be reordered to be consistent with event sequence in the environmental health paradigm as depicted in Figure 5.1 of the Report (i.e., exposure precedes the health effect).
Human Health	34	The human health chapter should be more descriptively renamed as “Human Exposures and Health.” This change is needed because the questions contained within the chapter encompass both human health and exposure.
Human Health	35	If credible quantitative impact estimates are available (e.g., estimates of the mortality or morbidity impacts of particulate air pollution in selected locations in the U.S.), they should be included.
Human Health	36	The discussion of gaps and limitations should be expanded to include a more quantitative description of the indicator’s relevance by relying on the epidemiologic literature.
Human Health	36	The concept statements in the indicator limitations sections such as “the measurement of mercury or any other environmental chemical in a person’s blood or urine does not by itself mean that the chemical has caused or will cause harmful effects in that person” should be removed from each discussion of indicator gap and instead be placed in the conceptual framework section of the chapter.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Human Health	37	EPA should build on the higher geographic resolution theme by presenting individual or multiple state data which could inform the gross national estimates presented and point toward the future. This should be done if possible, given the time constraints of revising this version of the ROE.
Human Health	38	Bullet #2 on page 5-5 should be rewritten to include biological agents. The following sentence should be added: “Infectious diseases associated with environmental exposures or conditions are also addressed.”
Human Health	38	Expanded health indicator information should be provided for sensitive populations. Expanded information is needed because these populations are important in considerations of environmental health.
Ecological Condition	39	The climate indicator trends in the ecological condition chapter should be placed in a paleoclimatic context to distinguish between human induced changes and other long-term changes. References to the Report of the Intergovernmental Panel on Climate Change (IPCC, 2007a,b) should be included.
Ecological Condition	39	A question should refer to trends in exposure and effects of contaminants in organisms rather than focusing on trends in biomarkers.
Ecological Condition	40	EPA should reorganize the ecological condition chapter to focus on three major indicator categories: Ecosystems, Ecological Processes and Services, and Ecosystem Components.
Ecological Condition	40	Appropriate indicators should be included in the ecological condition chapter to provide information on the ecosystem extent (e.g., land cover, land use, urbanization) and quality /condition (e.g., landscape integrity, connectedness, fragmentation, and contamination) of major ecosystem types.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Ecological Condition	40	Indicators should be included in the ecological condition chapter to represent important ecosystem processes and services such as: provisioning (e.g., timber, fuel, minerals, and other services); regulating (e.g., disease, climate, and flood processes); cultural (e.g., spiritual and aesthetic services); and supporting (e.g., soil formation, primary productivity, pollination, decomposition, disturbance, nutrient cycling, hydrological/chemical cycling, carbon sequestration processes, and services such as clean air, clean water, and net production).
Ecological Condition	40	Indicators should be included in the ecological condition chapter to represent physico-chemical components of ecosystems (e.g., soils, water, chemicals, snow pack, and physical habitats).
Ecological Condition	41	Indicators should be included in the ecological condition chapter to represent biological components of ecosystems ranging from the genome to the community level of organization. Such components include biodiversity, endangered species, invasive species, keystone species, and communities.
Ecological Condition	42	The discussion of “trends in diversity and biological balance of the nation’s ecological systems,” (on page 6-29) should acknowledge that some systems inherently have different numbers and variety of species, making it inappropriate to make comparisons between systems.
Ecological Condition	42	The discussion of “fish faunal intactness,” should explain why 1970 is chosen as the reference year.

Table F-1. Recommended Changes in the Final Report		
Chapter	Page	Recommendation
Ecological Condition	42	Trend data should be adjusted to account for methodological inconsistencies. For example, in the discussion of “SAV in the Chesapeake” which shows trends since 1978, the Report on the Environment states that “methods changed over the course of this study. However, data have been adjusted to account for any methodological inconsistencies.” The same should have been done with other parameters that are presented as a snapshot at one time that could have shown trends.
Ecological Condition	43	It should be clearly stated that specific case studies in the Report may not be representative of a general or national situation.

Appendix G: Table of Recommended Improvements for Future Reports on the Environment

Table G-1 presents a summary of recommendations that should be considered to improve future Reports. The second column of the table provides page numbers where recommendations may be found in this advisory report. Additional comments and suggestions are provided in the text of this advisory report. Detailed comments pertaining to specific indicators are included in Appendix A.

Table G-1. Recommended Improvements for Future Reports on the Environment		
Chapter	Page	Recommendation
Overarching	5	A synthesis chapter should be included to fully integrate the Reports and to provide an overall assessment of health and ecosystem status, trends and effects. The synthesis chapter in future reports could also analyze and discuss in more detail the connections among various related indicators.
Overarching	6	A summary section should be included after each media chapter to summarize information presented in the chapter and identify relevant emerging issues that could potentially affect human health and the environment.
Overarching	6	EPA should incorporate statistical analysis and interpretation in the reporting of all indicators. This should be part of the results presentation for each indicator. In some cases, this may involve formal statistical analyses, whereas in other cases it may involve the inclusion of additional information such as error bars around mean values.
Overarching	8	The indicators selected should be clearly related to the “big picture” fundamental questions, and not chosen just because of data availability or compliance with indicator criteria (i.e., they are the only indicators left after others have been eliminated).
Overarching	9	EPA should consider relaxing the restrictive indicator selection criteria so that additional indicators can be included. This will enable EPA to better evaluate trends and answer questions in the Report.

Table G-1. Recommended Improvements for Future Reports on the Environment		
Chapter	Page	Recommendation
Overarching	11	Each of the sections that address data gaps and limitations should be separated into clear discussions of types of limitations (e.g., geographic, statistical, data coverage, etc.)
Overarching	12	EPA should analyze the air, water, land, human health, and ecological condition indicators using appropriate airshed, watershed, and ecoregional units.
Overarching	13	EPA should identify and use, with appropriate caveats, more regional indicators and data bases to illustrate trends when national data sets are not available. The Panel notes, however, that such regional data are not a substitute for national or even representative national data and can be misleading if not carefully presented.
Overarching	13	EPA should develop clear and transparent criteria that are uniformly used for the selection of regional indicators and case studies, with the recognition that not all data will meet the criteria for these regional indicators. For example, regional indicators should have long-term well supported data sets, be of particular national or local significance, or represent an assessment approach that that could be replicated.
Air	14	The discussion provided in the response to the indoor air quality question should be expanded. The discussion of indoor air and related indicators is too limited considering the importance of the indoor environment and the amount of time spent by the population indoors. While indoor environments do not fall within the statutory mandate of EPA, exclusion of available and relevant data makes the Report incomplete.

Table G-1. Recommended Improvements for Future Reports on the Environment		
Chapter	Page	Recommendation
Water	20	Additional questions should be included in the water chapter to incorporate missing information on critical habitats or thematic elements such as: 1) Extent and condition of coral reefs; 2) Wastewater management information (it is recommended that EPA review available National Pollution Discharge Elimination System data for possible useful indicators); 3) Extent and condition of, and trends in, riparian zones and lake shoreline (i.e., land-water interface, where much of the biological activity occurs), and their effects on human health and the environment; and 4) More national indicators and analyses providing data and information on non-indigenous invasive species.
Water	20	Some key model aquatic systems should be identified in several ecoregions of the U.S. and data collected from these systems should be mined and analyzed in the context of questions presented in the Report.
Water	20	EPA should examine the 2004 National Research Council Report on national and global water resources and water infrastructure problems, and the importance of research in addressing them (National Research Council, 2004).
Water	23	EPA should include appropriate indicators of condition of lakes, ponds, and reservoirs.
Water	23	EPA should consider including the following important specific indicators: 1) Snow pack (extent, condition, and volume); 2) Pathogens (coliforms, enteric viruses, toxins, etc.); 3) Storm water and wastewater (contaminant effects); 4) Drinking water primary contaminants (e.g., microbial indicators and pathogens: bacterial, viral or protozoan); 5) Emerging contaminants such as pharmaceutical and personal care products, nanoparticles, and others.
Water	23	Additional wetland data should be used. In many areas, wetlands will indicate more efficiently the ecological integrity of the entire watershed than will any other portion of the landscape.

Table G-1. Recommended Improvements for Future Reports on the Environment		
Chapter	Page	Recommendation
Water	23	EPA should evaluate whether nutrient indicators based on bioavailable nitrogen and phosphorus or nitrogen:phosphorus ratios may be more useful.
Water	23	EPA should develop drinking water indicators based on the available data from the Agency's own databases and the consumer confidence reports released to the public annually by community water systems. Based on these data, EPA could formulate indicators that can delineate trends in drinking water quality. The water chapter should include source water monitoring data in addition to treated water quality data.
Water	24	Pathogen monitoring should be investigated as a primary indicator for water quality trends and human health effects across various water sources.
Water	24	Composite or multi-metric indicators should be complemented with single metric indicators that are easier to understand and require fewer caveats and assumptions.
Water	24	EPA should incorporate more information on specific toxic industrial chemicals for which the Agency has statutory responsibility under the Clean Water Act.
Water	24	EPA should analyze fish tissue contaminant data by different species, or at least conduct separate analyses of fish from different trophic levels or different habitats (as was done for the "lake fish tissue" indicator) to see which species (e.g., piscivores) are more likely to have higher levels of contaminants than others.
Water	26	EPA should visit (or revisit) the Agency's guidance manuals for lakes, rivers, coastal waters, and wetlands for potential data sets to fill identified data gaps.

Table G-1. Recommended Improvements for Future Reports on the Environment		
Chapter	Page	Recommendation
Water	26	Long-term monitoring programs of EPA (e.g., Environmental Monitoring and Assessment Program - EMAP) and other Federal Agencies (e.g., the U.S. Geological Survey's National Water Quality Assessment Program, and the National Oceanic and Atmospheric Administration's Status and Trends and Mussel Watch Programs), and of states or universities should be examined. Indicator criteria should be relaxed (within reason) to enable use of important trend data.
Water	27	EPA should utilize and build on existing databases that have been collected and existing local expertise that has been developed at benchmark sites in various ecoregions.
Water	28	EPA should give state data sets much closer scrutiny for possible inclusion. Some states have a wealth of area-specific data.
Water	28	EPA should consider the following as an example potential local/regional indicator for use in the water chapter. The State Water Resources Control Board of California is funding USGS to lead and conduct a Ground-Water Ambient Monitoring and Assessment (G.A.M.A.) program (U.S. Geological Survey, 2008) under which groundwater samples from public and private water supply wells from California are analyzed for water quality.
Water	28	In addition to the Gulf of Mexico and Long Island Sound, other places where hypoxic conditions tend to occur and are well monitored (such as Chesapeake Bay, the coastal waters off Oregon, and parts of Lake Erie) should be added to the hypoxia indicator.
Water	29	EPA should develop indicators for arid regions. In this regard the Agency should draw upon the numerous studies and data collection efforts conducted by various federal and state agencies in the western states where the climate is arid.

Table G-1. Recommended Improvements for Future Reports on the Environment		
Chapter	Page	Recommendation
Water	29	EPA should consider identifying the following emerging issues in the summary section of the water chapter: 1) Effect of climate change on water quantity and quality, 2) Emerging pathogens associated with climate change, 3) Chemicals of emerging concern, 4) Nanoparticle waste products, 5) Water availability and sustainability, 6) Invasive species, and 7) Algal toxins.
Land	30	EPA should consider adding a fundamental question on soil quality and conservation to the land chapter. The structure of the question could be parallel to the others in the chapter.
Land	32	EPA should: 1) consider a range of land cover classification schemes with different levels of resolution. This is necessary because the resolution of the data in the current Report is too coarse to completely answer the questions; 2) characterize land cover of all major ecosystem types, not just the forest land cover characterized the current draft of the Report; 3) adopt standard, established approaches for land use and land cover analysis to evaluate information and document trends across a range of available data sets.
Land	33	Different types of regional groupings could be used to show the location and extent of features in various chapters of the Report. For example, ecologically relevant units such as watersheds, climatic provinces, and major coastal realms could be used to regionalize data.
Human Health	35	EPA should consider using an expanded suite of human health indicators (discussed in Section 9.0).
Human Health	36	EPA should adopt the suites of indicators that other agencies have developed, but present them in relation to environmental factors.

Table G-1. Recommended Improvements for Future Reports on the Environment		
Chapter	Page	Recommendation
Human Health	37	EPA should consider making use of county-level data available from the states. All of the vital statistic data presented and used for the EPA Regional indicators can and have been scaled to the county level and excellent maps have been generated and already published in books.
Ecological Condition	42	EPA should use available information from the Agency's water quality criteria guidance manuals. The Panel notes that EPA has previously conducted a detailed review of current information and developed water quality criteria guidance manuals for lakes, rivers, and coastal waters.
Ecological Condition	44	Specific case studies using regional indicators should be selected for their ability to demonstrate the long-term trends that cannot be accomplished at the national level. It would be useful to pick well-studied sites (e.g., Lake Mendota, Lake Tahoe) where there are long-term data sets available for each region.
Ecological Condition	44	Some of the regional indicators should be expanded to become national indicators (e.g., SAV, invasive species, and harmful algal blooms).