July 27, 1999

EPA-SAB-EPEC-99-014

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

Subject: Second Review of the Index of Watershed Indicators

Dear Ms. Browner:

On October 14-15, 1998, the Ecological Processes and Effects Committee of the Science Advisory Board (SAB) conducted a second review of the Office of Water's Index of Watershed Indicators (IWI), a web site that uses easily understandable maps to depict the condition of all watersheds in the United States. By using a common set of indicators for every watershed, the web site and its companion printed materials allow members of the public not only to gain information about particular watersheds, but also to compare their local watersheds to others across the nation.

The primary strengths of the IWI lie in its use of watershed units to organize and present data from a variety of sources, the high quality presentation on an Agency web site of both the composite information and the underlying data, and its ability to highlight data gaps through map presentations and thereby to stimulate improved data collection and reporting. The Committee continues to feel that the IWI concept is a good one and worth building upon. By providing public access to important, but disparate, types of environmental data in a systematic and organized manner, the IWI should facilitate local discussion and decision-making regarding watershed issues.

The IWI used indicators that were readily available, enabling it to provide a great deal of useful information in a short amount of time. However, those readily available indicators are not necessarily optimal for achieving IWI's goal of "measuring progress toward EPA's goal that all watersheds will be healthy and productive places." Most of the existing IWI indicators measure chemical stressors, but not their biological or ecological **effects**. Just as one would not assume that her child had lead poisoning simply because lead paint was discovered on the walls of the house, nor assume that her child was completely healthy just because she did not exhibit lead poisoning, conclusions about the health (or illness) of organisms and ecosystems should not be drawn solely on the basis of ambient chemical measures in water and sediments. Indicators are needed that more directly measure ecological health.

In most instances (and in IWI's defense), there are no nationwide measurements of ecological health that can be easily taken "off the shelf" and added as IWI indicators. Although the Committee has made specific suggestions in this report for the development of indicators from existing data, in many cases the basic monitoring needed to assess ecological health doesn't exist, or exists only in some states. Thus, although the conclusions of the report are directed at our specific charge questions, this review raises a larger issue of ecological monitoring that the Agency may want to address across media and target organisms: "what data are needed to assess watershed health?"

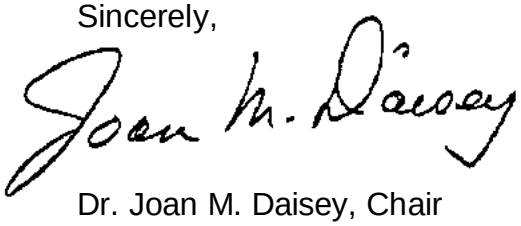
Specific to IWI, the Committee recommends that the Agency develop a strategic plan to articulate IWI's goals and objectives, identify target audiences and clientele, define terms, and identify data gaps. The Agency should also develop a conceptual model to guide the selection of additional data layers and refinements to the integrating algorithm.

In lieu of direct measures of ecological health, the IWI has adopted surrogate indicators from readily available data, but has not yet evaluated indicator performance to demonstrate that changes in the indicator correspond to meaningful changes in environmental quality. This evaluation is crucial, and should be undertaken for the IWI as it currently exists as well as for the expanded IWI planned for the future. The Agency should also undertake research to refine the composite index that combines the individual indicators, which currently falls short of the goal of characterizing watershed condition and vulnerability. The Agency should determine the sensitivity of the composite index to variation of the composite indicators, conduct analyses to assign differential weights to the individual indicators based on their relative importance as predictors of watershed integrity, and ensure that the composite index does not reward (or punish) organizations just because they collected and reported a lot of data.

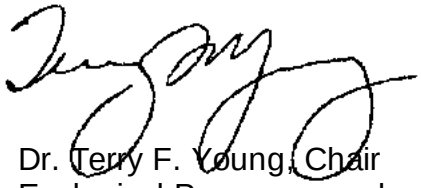
We commend the Agency for taking a very positive step in making watershed information available in such a user-friendly format on the IWI web site (accessed through *Surf Your Watershed*). The Committee feels, however that the time has come to put the IWI on a more sound scientific footing. In some cases, this will require longer term effort to develop additional data layers in cooperation with the Office of Research and Development, other federal and state data gathering organizations, and public and private researchers.Because the IWI has the potential to serve as a nexus, both within and outside of the Agency, for a wide variety of data on watershed condition and vulnerability, the Committee encourages the Office of Water and other Agency program

offices to push ahead with proposed improvements. We hope these comments are helpful to the Agency in working toward that end, and we look forward to your response.

Sincerely,



Dr. Joan M. Daisey, Chair
Science Advisory Board



Dr. Terry F. Young, Chair
Ecological Processes and
Effects Committee

Dr. Carol Johnston, Acting Chair
for the IWI Review
Ecological Processes and
Effects Committee

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U.S. ENVIRONMENTAL PROTECTION AGENCY
SCIENCE ADVISORY BOARD
ECOLOGICAL PROCESSES AND EFFECTS COMMITTEE

Review of the Index of Watershed Indicators
October 13-14, 1998

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1. EXECUTIVE SUMMARY

On October 13-15, 1998, the Ecological Processes and Effects Committee of the Science Advisory Board met to review and comment on the Index of Watershed Indicators (IWI) developed by the Office of Water. The stated purpose of the IWI is to provide available data on aquatic resources in a Geographic Information System (GIS) format to interested parties, including state and tribal governments and members of the public, for assessing the condition and vulnerability of watersheds. Phase I of the IWI, released in 1997, consisted of information on 15 indicators (or data layers) presented individually and in aggregate. In a previous review (EPA-SAB-EPEC-ADV-97-003), the Committee supported in concept Agency plans to include 6 additional indicators (i.e., biological integrity, habitat, groundwater, coastal condition indicator, air deposition, and downstream effects) and further recommended that land use change and other indicators of terrestrial condition be considered. The Committee also recommended that the algorithm used to calculate composite scores for watershed condition and vulnerability be examined prior to the Agency's release of a revised version of the IWI.

The primary focus of this second EPEC review, as reflected in the Charge to the Committee, is to follow up on the previous Committee recommendations by providing comments on IWI strategic directions, further evaluation of individual indicators, and the integrating algorithm. The Committee applauds early Agency efforts on the IWI, but recommends strengthening the scientific basis of IWI .

The IWI currently highlights watersheds with low water quality, as defined by the state water quality standards. This approach does not capture other reliable indicators of poor water quality, such as biological indices, because only a handful of states include biological criteria in their water quality standards. More importantly, the IWI does not characterize watershed condition (i.e., "health") and vulnerability as claimed. The Committee supports the Office of Water's efforts to incorporate new indicators and adjust the integrating algorithm to achieve the stated goals of the IWI. To this end, the Committee recommends the following:

a) The Agency should develop a strategic plan to articulate IWI's goals and objectives, identify its target audiences and clientele, define terms, and identify data gaps in order to assure that the IWI can be updated efficiently with additional data layers and provide an improved assessment of condition. A Quality Assurance/Quality Control (QA/QC) plan should be included in the strategic plan.

b) The Agency should develop a conceptual model for the IWI that can be used to guide the selection of additional data layers and refinements to the integrating algorithm.

c) The Agency should add more indicators of biological and ecosystem effects to the IWI.

d) The Committee reiterates its previous recommendation to include terrestrial indicators, but recommends waiting until the Multi-Resolution Land Characteristics (MRLC) data set becomes available to develop indices related to land use. The Agency should develop better riparian habitat indicators to replace its proposed riparian indicators (Indicator 16 - Forest Riparian Habitat and Indicator 18 - Agricultural/Urban Habitat).

e) The Agency should evaluate each existing and proposed indicator to demonstrate that changes in the indicator correspond to meaningful changes in environmental quality. The Agency should better document data sufficiency and other sources of indicator uncertainty and describe sensitivity of the composite index to variation of the component indicators.

f) The Agency should revisit the current integrated index, which falls short of the goal of characterizing watershed condition and vulnerability. As part of this exercise, the Agency should undertake the appropriate analyses to assign differential weights to the individual indicators based on their relative importance as predictors of watershed integrity.

g) The integration algorithm must be flexible with respect to the amount of data used to compile composite indicators, so as not to reward (or punish) organizations just because they collected and reported a lot of data.

h) Watershed quality and vulnerability are individual measures that should be reported separately.

2. INTRODUCTION

On October 13-15, 1998, the Ecological Processes and Effects Committee of the Science Advisory Board met to review and comment on the Index of Watershed Indicators (IWI) developed by the Office of Water. The stated purpose of the IWI is to provide available data on aquatic resources in a Geographic Information System (GIS) format to interested parties, including state and tribal governments and members of the public, for assessing the condition and vulnerability of watersheds. Phase I of the IWI, released in 1997, consisted of information on 15 indicators (or data layers) presented individually and in aggregate. In a previous review (EPA-SAB-EPEC-ADV-97-003), the Committee supported in concept Agency plans to include 6 additional indicators (i.e., biological integrity, habitat, groundwater, coastal condition indicator, air deposition, and downstream effects) and further recommended that land use change and other indicators of terrestrial condition be considered. The Committee also recommended that the algorithm used to calculate composite scores for watershed condition and vulnerability be examined prior to the Agency's release of a revised version of the IWI.

The primary focus of this second EPEC review, as reflected in the Charge to the Committee, is to follow up on the previous Committee recommendations by providing further evaluation of individual indicators and the integrating algorithm. The Committee also provides recommendations for future directions for the IWI. The Charge to the Committee (attached) from the Office of Water contains 13 questions in three general areas: a) the strategic plan for the IWI; b) the algorithm used to calculate watershed scores; and c) the proposed indicators of terrestrial condition. The Committee's response to these questions is contained in the sections that follow.

3. GENERAL COMMENTS

The primary strengths of the IWI lie in its use of watershed units to organize and present data from a variety of sources, the high quality presentation on an Agency web site of both the composite information and the underlying data, and its ability to highlight data gaps through map presentations and thereby to stimulate improved data collection and reporting. The Committee continues to feel that the IWI concept is a good one and worth building upon. By providing public access to important, but disparate, types of environmental data in a systematic and organized manner, the IWI should facilitate local discussion and decision-making regarding watershed issues.

The Committee commends the Agency for its continuing efforts to develop and refine the IWI. The Agency has responded to several concerns raised previously by EPEC (EPA-SAB-EPEC-ADV-97-003) by including new terrestrial indicators, improving data documentation, and increasing coordination with other offices and agencies. At present, however, efforts to improve the IWI are hampered by the absence of a strategic plan and future vision for the IWI, and a clear conceptual basis to guide the selection and weighting of indicators for the composite index. Our responses to many of the charge questions relate back to these two critical issues.

4. STRATEGIC PLAN FOR THE IWI

4.1 Essential Components

Charge Question 1. Does the strategic plan for IWI include the critical development activities, and are the time frames envisioned appropriate/adequate?

Although the IWI initially was launched with a relatively narrow focus (i.e., presentation of water quality-related measures organized by watersheds), its popularity with the public and its potential future value as a nexus of watershed management information strongly suggest that this focus should be expanded. The potential evolution of the IWI from primarily a vehicle for presenting information reported under Clean Water Act (CWA) Section 305(b) to a source of more comprehensive information on watershed condition will be more effective if guided by a strategic plan. The strategic plan should articulate the IWI's goals and objectives, identify its target audiences and clientele, and maintain continuity during the long-term evolution of the program. Although a draft of the strategic plan was not available for Committee review, we understand that such a plan is currently under development. The Committee urges the Agency to consider the issues outlined below as it drafts the strategic plan for the IWI.

4.1.1 Goals and Objectives

One essential component of the strategic plan should be an articulation of the goals and objectives of the program. During the course of the Agency's presentation to the Committee, two distinct goals were presented regarding the type of information that the IWI seeks to present:

a) Identify the watersheds where water quality goals, as represented by numerical water quality standards adopted pursuant to the Clean Water Act, are not being met; and

b) Characterize the overall health of each watershed and the country's watersheds as a group.

These two goals are mirrored in the introduction to the printed version of the IWI provided to the Committee (U.S. EPA, 1997a). The Committee agrees that both goals are important, but is particularly supportive of the latter goal because it will be far more valuable in the long term to inform watershed management and educate the public. As currently implemented, IWI accomplishes the goal of identifying non-attainment of 305(b) water quality goals, but does not accomplish the goal of characterizing watershed health. The IWI strategic plan should provide the vision for making a

smooth transition between the two goals. This transition would involve identifying watershed characteristics related to ecological health for which data layers would ultimately be developed, such as water quality, habitat quality and landscape characteristics, and hydrology. It would also require developing an improved algorithm that mathematically groups the measures so that each group carries an appropriate weight (see Section 6).

The strategic plan also should address the **audience and clientele** for IWI both inside and outside the federal government. The popularity of the IWI web site is a measure of its success in reaching a variety of clients and users and may lead IWI developers to attempt to be all things to all people. However, some of those clients are more important to the success of IWI than others. The strategic plan should identify and prioritize clients based on IWI objectives so that the needs and desires of high priority clients can be addressed before those of other users. Clients within EPA (e.g., Assistant Administrators or staff from other EPA offices), as well as external clients, should be included in the identification/prioritization process. Such a prioritization will help the Office of Water to sort out the myriad requests and suggestions that it may receive from users, so as to focus its energy and resources on those changes that will further IWI and broader Agency objectives.

Identification of the audience will also guide the selection and presentation of information in the IWI. For example, if one of the main audiences is local watershed management groups, then presenting the broader picture of overall watershed health will be essential. In addition, the ability to incorporate locally developed information (that meets quality control standards, but is not available from a national database) also will be important. If one of the main audiences is EPA internal management or Congress, for whom a progress report on national water quality improvement is important, then the IWI should be capable of showing changes for water quality indicators , both individually and in aggregate, over time. The ability to showcase gradual improvements or declines is important to the general public, as well, and is not currently incorporated into the IWI; this aspect of the IWI should be discussed in the strategic plan.

4.1.2 Clarification of Index Classification: "Condition" and "Vulnerability"

IWI indicators are currently grouped into "condition" and "vulnerability" categories. However, the description of these terms in the IWI printed materials (U.S. EPA, 1997a) is confusing. "Condition" is defined as "existing water quality," but **none** of the original 15 IWI indicators shows existing water quality. For example, there are no maps showing average chemical concentrations in stream water or sediments, only exceedences above national criteria. Rather, most of the IWI indices (1, 3a, 3b, 5, 9, 10) measure **compliance** (e.g., violations of NPDES permits, non-attainment of 305(b) designated uses), which is not the same as condition or vulnerability. A watershed may be perfectly compliant with established thresholds, yet still have water quality

problems (i.e., poor condition) or contain ecosystems susceptible to pollution (i.e., high vulnerability). Compliance indices are a measure of regulatory success and reporting, and reflect the Agency's role as water quality regulator, rather than indicate ecological condition or vulnerability *per se.*

"Vulnerability," as defined in the IWI printed materials (U.S. EPA 1997a), is designed to show "where discharges and other stressors impact the watershed and could, depending on the natural and manmade factors present in the watershed, cause future problems to occur." This definition is not clear. What constitutes vulnerability? Is an ecosystem more vulnerable when a given stressor increases (increased exposure) or when a sensitive assemblage of organisms is present, or both? How does vulnerability equate to risk (which relates exposure to effects)? In general, we believe vulnerable systems are those that require significantly less unit change in the stressor to cause an effect. Based on the Committee's interpretation, only indices 8 and 15 indicate ecosystem vulnerability.

Several of the IWI indicators are measures of exposure to pollution or other stressors, more commonly called **pressure** indicators (U.S. EPA 1998a). Indices 3c, 4, 6, and 14 are indices of current measured exposure; indices 11, 12a, 12b, and 12c are indices of potential (modeled) exposure; and indices 7a, 7b, and 13 are indices of past exposure trends (measured).

Three of the new IWI indices that appear in Enviromapper (16 - Forest Riparian Habitat, 18 - Agricultural/Urban Riparian Habitat, and 20 - Soil Permeability Index) provide background information about the **state** of the resource, but are not classified as indicators of condition nor vulnerability. These indices provide useful background information. Also, there are appropriate links via the MapLibrary to the Center for Environmental Information and Statistics (CEIS) Water Atlas (http://www.epa.gov/ceisweb1/ceishome/atlas/nationalatlas/wateratlas.html) and other web sites (e.g., NRCS, USGS) with good background information. The Committee applauds these links to related sites.

The strategic plan and IWI documentation in general should better define the terms "condition" and "vulnerability," and clarify the relationship of pressure and compliance indices to condition and/or vulnerability.

4.2 Data Gaps

Charge Question 2. Does the plan include a mechanism for IWI users and developers to communicate data needs and gaps to those responsible for data collection?

An important secondary purpose of the IWI, acknowledged repeatedly during the presentation to the Committee, is to **highlight data gaps**. The IWI partially accomplishes this goal by including "insufficient data" designations on IWI maps, and according to Agency staff, early IWI maps have already stimulated several states to come forth with new, improved data. However, some types of data are missing from the IWI; there are no maps showing biological effects of chemical contaminants; and, more importantly, there are no maps showing information about other essential aspects of watershed condition, such as native biota, habitat quality, and hydrology. The strategic planning process should identify the highest priorities among those missing pieces.

The strategic plan also should describe mechanisms for ongoing feedback to EPA administrators, state producers of 305(b) reports, and other data gatherers within and outside of EPA about the data needs. In developing IWI, the staff already has gained substantial collective knowledge about specific data sets that would be desirable, but do not currently exist or would be prohibitively expensive to develop into watershed indicators. That knowledge is valuable, and should be channeled back to those who can support appropriate data gathering efforts.

Data providers other than states are an important data source that often has been disregarded by developers of the IWI and should be cultivated. The strategic plan should address ways that the Agency can reach out to potential data suppliers who are not yet aware of the IWI.

When non-EPA data sources are used, it is an important professional courtesy to inform database owners (particularly listed contact persons) about how their data are being used. These contacts may provide reciprocal benefits: the producers of the data may be able to help IWI to interpret and use the data and, conversely, the IWI may be able to help the data producers to improve the utility of their data in the future. The strategic plan should identify mechanisms to inform database owners (particularly listed contact persons) about how their data are being used.

A related issue is quality assurance procedures for existing data. At present, the IWI seems dependent on users or state agencies to communicate problems or mistakes found in the data by, for example, phoning to report problems. However, many dissatisfied users may simply leave the web site. The IWI Strategic Plan should include a quality assurance/quality control (QA/QC) plan that addresses the sources of uncertainty described in Section 5.3 of this review, as well as such issues as locational

accuracy of data, potential for errors in data transfer from original sources (e.g., data entry from hardcopy 305(b) reports, downloading digital data), and procedures for resolving data conflicts where watersheds cross state boundaries.

5. WATERSHED CHARACTERIZATION

Charge Question 3. Are the IWI indicators (current and proposed), taken as a whole, adequate to characterize watershed condition and vulnerability? Are there redundancies among indicators?

The Committee concludes that the current set of IWI indicators, even when augmented by some of the proposed indicators, is not adequate to characterize watershed condition and vulnerability. However, the following sections provide suggestions on how the Agency can broaden the utility of the IWI and move in the direction promised in the IWI documentation of providing information on watershed condition and vulnerability.

5.1 Developing a Conceptual Model

Selecting the most appropriate indicators of watershed condition (and vulnerability) requires an assessment of the types of ecological characteristics that should be represented, an understanding of the relationship between an indicator and the ecological characteristic, and knowledge of the manner in which the indicator will respond to a change in an environmental stressor(s) (see, e.g., U.S. EPA, 1998a). This understanding can be used to construct a conceptual model that depicts the interrelationships among the ecological characteristics and relates changes in stressors to changes in the indicators to changes in environmental condition/vulnerability. Such a conceptual model would provide a unifying framework for selecting and interpreting the many types of environmental information (e.g., pressure, state, and compliance indicators) that are available about watersheds, while highlighting areas where indicators or data should be developed.

The Committee recommends that the Agency develop a conceptual model for the IWI that can be used to guide the selection of additional data layers and refinements to the integrating algorithm. This need not be an overly time-consuming exercise, but at a minimum should identify a list of ecological characteristics to be included, and their indicators. A statement of the physical basis for each indicator, i.e., what it measures, and its relationship to watershed condition/vulnerability also should be included. General ecosystem models (see, e.g., Odum, 1994; McIntire and Colby, 1979) or conceptual models developed for watershed risk assessments (e.g., U.S. EPA, 1996a-d) may provide a good starting point. A conceptual model that relates changes in indicators to changes in environmental conditions/vulnerability also would be an important public education tool. Once the conceptual models are in place, further refinements could be attempted by the use of mathematical ecosystem, watershed, and landscape models, specifically those capable of being linked with spatial frameworks (e.g., see the variety of approaches reported in Goodchild et al., 1993; NCGIA, 1996).

5.2 Evaluation of Index Performance

Once the hypothesized relationships between multiple indicators and watershed condition are described, it is necessary to evaluate the resulting index by demonstrating that changes in the index correspond to meaningful changes in watershed quality. We strongly recommend, therefore, that the Agency provide information on how well the indicators used in the IWI monitor the health of the watersheds. This evaluation of the IWI is particularly important because the IWI results may be used by the states as the basis of corrective actions. Ideally, evaluation should be undertaken for the IWI as it currently exists as well as for the expanded IWI planned for the future.

Index evaluation could be done in any of the following three ways. First, IWI indicators could be evaluated for watersheds for which there are biological indicators of watershed health. Comparison of the two sets of indices (IWI vs. biological indicators) would be very helpful in assessing the performance of the current approach, as well as addressing the broader issue of how to assess watershed health. Watershed data collected as part of the Office of Research and Development's Mid-Atlantic Integrated Assessment (MAIA) project might be useful in this regard. Second, a semi-quantitative sensitivity analysis could be performed to determine the ability of the current indicators and the integrating algorithm to detect small to moderate changes in the environment. In other words, can the current index be used to detect improvement in watershed conditions, and if so, what are its detection limits (i.e., how much improvement would have to occur before it could be detected by the index)? Third, a retrospective comparison of IWI indicator changes to watershed improvement as measured biologically and chemically at one or more sites could be used to answer the question of whether or not watershed quality improvements are reflected in the IWI approach.

5.3 Sources of Uncertainty

Distinct from the question of which indicators have a sound ecological basis is the issue of **indicator uncertainty** and the related question of **data sufficiency thresholds** (e.g., what sample size or temporal and spatial coverage of data points is necessary before a data layer is included in the Index.) A misleading or incorrect sense of watershed condition or vulnerability may result where indicator methods differ from state to state (e.g., Indicator 1 - Designated Uses); where indicators are adopted with limited data (e.g., Indicator 2 - Fish and Wildlife Consumption Advisories); where a few, scattered measurements are used to represent the entire watershed (e.g., Indicator 4 - Contaminated Sediments); where a statewide or basinwide measurement is assigned to all watersheds within that larger geographic unit (e.g., Indicators 7a and 7b - Wetland Loss); or where the indicator is measured in a portion of the watershed that is not representative of the conditions in general (e.g., Indicator 5 - Ambient Water Quality, metals). Although the IWI document (U.S. EPA, 1997a) provides some qualitative information about indicator uncertainty and data sufficiency thresholds, more

quantitative information would improve indicator interpretation. For example, the statement for Indicator 7b that "all available data were used" implies low uncertainty, but the fact that the data set used (Dahl, 1990) contains only 48 values for the conterminous United States (one value per state) indicates a much higher level of uncertainty.

This discrepancy suggests the need for some indication of the limits and uncertainties associated with reported indicator values. The IWI document should characterize the uncertainty associated with assignments of watershed conditions and vulnerability in the very beginning of the document. Attempts should be made to identify the major sources of uncertainty in IWI calculations. These sources of variation include: a) variation in sample size across different indicators and within indicators across states; b) measurement and reporting errors across data sets; and c) the loss of information associated with moving from fine-scaled spatial data to coarser-scaled averaged data (e.g., in spatial data that are highly aggregated, the average value almost never occurs).

The Committee thus recommends that IWI provide some indication of the error associated with indicator values. This recommendation was made in the previous EPEC review of the IWI, but has yet to be addressed adequately. As a first approximation, error tends to decrease with increasing sample sizes used to arrive at indicator values. Consequently, we recommend that sample size distributions accompany each map and that a measure of variability in indicator values be given along with the integrated watershed score.

In addition, data sufficiency thresholds vary widely among the current indicators. For example, Indicator 5 (Cu, Cr, Ni, and Zn) has a higher threshold than others, requiring 20 observations representing a minimum of five sites, and therefore most of the map is in the "insufficient data" category. This is in contrast to other maps (e.g., Indicators 7a, 7b, and 12a), where no data sufficiency thresholds are applied. The rationale for selecting sufficiency thresholds should be made explicit and the relationship of this selection to the uncertainty of the indicator should be clarified. Additional uncertainty is introduced by combining heterogeneous variables into a single indicator, as was done for Indicator 6 (Ammonia, Dissolved Oxygen, Phosphorus, and pH). These four conventional pollutants have vastly different anthropogenic sources, and combining them obscures their individual contribution to water quality.

5.4 Redundancies Among Indicators

There are several reasons why it may be important to identify redundancies among indicators included in the IWI (i.e., where multiple data layers are in fact providing information about the same stressor or effect). The first is the concern, given that the current algorithm gives equal weight to all indicators except Indicator 1, that some stressors or effects may be "double counted" in the integrated watershed score if more than one data layer relates to that stressor or effect. This concern would be moderated if the algorithm were modified so that indicators providing information about the same ecological characteristic are clustered and weighted as a group. A second issue associated with redundancy is the desirability of providing the maximum amount of information with the minimum required data.

Redundancies among indicators could be evaluated using the conceptual model recommended in Section 5.1 to relate the indicators to ecological condition in order to define a parsimonious set of indicators. Another approach would be to conduct statistical analysis of the indicators and combinations of them. For example, as a first step, pairwise scatter diagrams and simple regressions of indicators would reveal whether some of these indicators may be redundant. Multivariate methods could be used after potential relationships are uncovered by these simple bivariate methods. Multivariate analysis is a method to reduce the number of variables in a data set, and also could be used to design weighting scores for redundant variables. An additional benefit of conducting these exercises would be that descriptive characteristics of the indicators can be compared for consistency.

5.5 Recommended Additional Indicators

Charge Question 4. Are the priorities for development of additional indicators appropriate?

In the Committee's view, watershed characterization requires information not only on the presence of environmental stressors (e.g., concentrations of chemical contaminants and measures of landuse change), but also on environmental effects or responses. In short, characterizing watershed condition (or **state** of health) requires assessment of information about several attributes relating to structure, function, and composition of the ecological resource. In order to determine whether the priorities for development of additional indicators are appropriate, therefore, the Committee recommends that the IWI identify the set of major ecological attributes that should be included in a watershed assessment, determine which of these are not reflected in the current IWI data layers, and identify which missing attributes can be added most efficiently in the near term. The following sections provide suggestions for additional high-priority indicators and offer recommendations for improving the relevance of existing IWI information. In particular, indicators of biological effects should be added,

because the numbers, types, and condition of organisms living in a watershed provide a strong indication of watershed conditions.

When selecting new indicators, the Office of Water should take greater advantage of the wealth of published information available on ecological indicators, much of which has been produced by EPA (e.g., McKenzie et al., 1992; Jones et al., 1997; U.S. EPA, 1998a, 1998b). The IWI has used numerous EMAP products, but could use the results from the Office of Research and Development's Ecological Indicators Research to a greater extent.

5.5.1 Indicators of Effects

The Committee is concerned that the majority of the IWI indicators are based upon chemical measurements either in the water or the sediments without providing complementary information on ecological effects. In addition, the current IWI assessment is "blind" to many problems not associated with the four conventional pollutants and heavy metals. For example, although "potential for agriculture runoff" and "fish advisories" have the potential for identifying insecticide problems, it would be more useful to have actual chemical concentrations and measures of ecological effects (e.g., biotic integrity).

While the present set of indicators provides a useful screening level measure of watershed condition, these measures are predominately exposure measures and not biological effects measures. This reflects the regulatory bias towards these data by the federal government and the states in implementing the Clean Water Act and regulating point sources. The condition of a given watershed should not be measured solely as a function of water quality (i.e., chemistry), but also by its biological integrity/quality. The Agency has released guidance documents on biological assessment and biocriteria (e.g., U.S. EPA 1996e; 1998c) and has begun to place more emphasis upon collection of biological data at the state level with a view towards providing these data in the 305(b) state reports. We support this action and recommend that biological indices be incorporated in the IWI. Biological data supplied in 305(b) reports or from other sources should constitute a separate data layer in the IWI to complement chemical water quality assessment information. When assessing biotic integrity, preference should be given to indices that include measured biological conditions, rather than an index that is an indirect surrogate for biotic integrity (e.g., lack of heavy metals, no exceedences of pH or dissolved oxygen reference levels).

5.5.2 Terrestrial Indicators

Charge Question 10. Are the data sets that underlie the proposed terrestrial indicators used appropriately? How can the proposed indicators be improved for purposes of the IWI?

Charge Question 9. Are there other available data sets or indicators of terrestrial condition that the Agency should evaluate for use in the IWI?

The Committee reiterates its previous recommendation that a valid watershed-scale assessment must identify and integrate both terrestrial and aquatic environmental indicators (EPA-SAB-EPEC-ADV-97-003) and encourages the Agency to continue to work in that direction. Efficient development of terrestrial indicators will be facilitated by clear articulation of management goals and objectives, recognition that terrestrial indicators may need to vary on a regional basis, and a strategy to organize watersheds into larger landscape units. Management goals and objectives must be clearly presented, since there is no statutory requirement for comprehensive monitoring of terrestrial systems analogous to CWA 305(b) reporting. Terrestrial management goals can be based on benefit flows (products or services) from ecosystems to society, or on inherent ecosystem condition (i.e., system integrity and sustainability). The alternative (benefit flows versus system integrity) chosen to guide terrestrial indicator selection should be consistent with the definition of "condition" developed for the overarching strategic plan.

Terrestrial indicators may differ from the aquatic indicators that are used to characterize watershed condition in at least two respects. First, relevant indicators will vary among watersheds because different terrestrial ecosystem types (e.g., forest, rangeland, and agroecosystems) cannot be reflected by the same descriptors. Second, in order to organize and identify specific terrestrial ecosystem types, watersheds must be integrated into larger units (e.g., ecoregions) than the USGS hydrologic units that form the basis of IWI data layers. Addressing these issues up front in the strategic plan will allow for smoother additions of data layers in the future.

The Committee understands that a number of the previously proposed terrestrial indicators have been set aside due to problems encountered with the available data. The Committee agrees with the Agency's decision to table the Partners in Flight (Terrestrial Indicator B), Diversity of Natural Land Cover Types (Terrestrial Indicator A3), Agriculture (Terrestrial Indicator A2), and Human Use (Terrestrial Indicator A1) indicators. The latter three may be reconsidered when the MRLC data set becomes available (see below).

The "Conterminous U.S. Land Cover Characteristics Data Set " database (Loveland et al., 1991), which served as the basis for Terrestrial Indicators A, C, and D, is not optimal for this application because of its generalization of land cover types, coarse spatial resolution (1 km pixels), and the use of mixed classifications (forest/agriculture). A better alternative will be the Multi-Resolution Land Characteristics (MLRC) data, which are available now for states east of the Mississippi River, and which will be available by January 2000 for the entire conterminous U.S. The Committee recommends, therefore, that the Agency utilize the MRLC data as they are released, rather than continuing with use of the Conterminous U.S. Land Cover Characteristics Data Set to compute terrestrial indices requiring land cover data. If the Agency decides that it is more important to release the information quickly than to wait for national coverage, then terrestrial indices could be released for multi-state geographic regions as MRLC data become available.

The Agency derived several of its proposed terrestrial indicator maps from the Conterminous U.S. Land Cover Characteristics Data Set by interpreting the proportion of urban, agricultural, and forested land from their original legend descriptions (Jones et al., 1997). Pixels containing mixed forest/agricultural land were counted as having 100% cover in <u>both</u> categories, leading to overestimation of total land cover. This assumption also generated serious errors in Indicator 18 - "Agricultural/Urban Riparian Habitat", resulting in gross over-representation of riparian agricultural land cover in the states of Maine, Massachusetts, New Hampshire, Vermont, and northern Minnesota. These errors are evident when Indicator 18 is compared with NRCS's "Percent of Non-Federal Area in Cultivated Cropland" (http://www.nhq.nrcs.usda.gov/land/lgif/m2081l.gif). Pending its revision, we strongly recommend that Indicator 18 be removed from the IWI web site.

The data sets used to compute the "Roads Crossings Streams" map (Terrestrial Indicator E) are the 1:1,000,000 scale USGS Digital Line Graphs (DLGs) for rivers and roads. Line density on these 1:1,000,000 DLGs is greatly influenced by cartographic convention (e.g., rivers and roads are not shown where they are too dense to map). Thus, the 1:100,000 scale USGS Transportation DLGs and joint EPA-USGS National Hydrography Data set, already available in digital form, would be more appropriate. Also, EPA may wish to consider the Federal Highway Administration's "Highway Statistics Information Retrieval System" to weight roads by usage, because a bridge crossed by only a few cars a day will have much less impact on aquatic life than one that is crossed by thousands of cars a day.

In selecting or developing terrestrial indicators, the Office of Water will have to consider how much of the terrestrial data are available in the immediate (1-2 year) time frame and what might be useful, but would only be available on a longer time frame. The Agency also should consider additional sources of information on watersheds, including Appendix B of the recently released National Research Council pre-publication report, *New Strategies for America's Watersheds*, which can be viewed

online in the “Reading Room” of the National Academy Press (www.nap.edu), and a recent USDA publication entitled *America’s Private Land, A Geography of Hope* (NRCS, 1996). The latter contains watershed information on nationwide maps, including the following:

a) Dominant Land Uses;
b) Patterns of Agricultural Diversity;
c) Net Gains and Losses in Irrigated Cropland Acreage;
d) Sediment Delivered to Rivers and Streams from Sheet & Rill Erosion (shows pattern similar to IWI Indicator 12c);
e) Confined Livestock Concentration;
f) Potential Nitrogen and Phosphate Loss from Farm Fields (Nitrogen loss data shows patter similar to IWI Indicator 12b);
g) Pesticide Runoff Potential for Field Crop Production (used in IWI Indicator 12a);
h) Pesticide Leaching Potential for Field Crop Production (this is the potential for groundwater contamination from pesticides, and the spatial distribution is MUCH different than that for runoff); and
i) Freshwater Consumption as a Percentage of Local Average Precipitation.

There are also many relevant spatial data sets for water that can be downloaded from the USGS Water Resources web page (http://water.usgs.gov/lookup/getlist), including agricultural chemical uses and "Risk of Nitrate Contamination in Groundwaters of the United States."

The IWI has already used the output from simulation models to predict pollutant loadings (Indices 12a, 12b, 12c), and should also consider their use to predict ecological response to environmental stressors. For example, the EPA **P**esticides and **I**ndustrial chemical **R**isk **AN**alysis and **H**azard **A**ssessment (PIRANHA) model (developed by the EPA Environmental Research Laboratory in Athens, GA) could be used to predict aquatic organism risks from toxic chemicals.

5.5.3 Riparian Habitat Indicators

The fundamental importance of riparian vegetation to the structure and function of stream ecosystems has been well documented (e.g., Cummins et al., 1989, Gregory et al., 1994). Two of the Terrestrial Indicator maps distributed to EPEC in July 1998 that remain on the IWI web site (http://www.epa.gov/surf2/iwi) as of January 1999 are riparian indicators: Indicator 16 - “Forest Riparian Habitat" and Indicator 18 - "Agricultural/Urban Riparian Habitat" (Terrestrial Indicators C and D, respectively, in the materials received by the Committee). The renaming of these maps is an improvement, as it more correctly reflects their contents than the former names ("Riparian Habitat Integrity" and "Riparian Habitat Vulnerability", respectively). However, "Forest Riparian Habitat" is an inappropriate measure of riparian condition in the prairie and desert

states because riparian areas were never forested there, and "Agriculture/Urban Riparian Habitat" overestimates agricultural influences in the northern U.S. states (see Section 5.5.2). The Committee strongly urges, therefore, that the Agency work to develop better riparian habitat indicators. Because riparian habitats have been shown, in essentially all carefully studied watersheds, to be major regulators of in-stream biotic resources, very significant effort should be expended to incorporate their characteristics into the IWI.

Stream density (i.e., length of stream per unit area of watershed) is a simple yet powerful indicator that could be added. Studies have shown that there is an inverse relationship between stream order (or width) and riparian influence on in-stream ecology. In other words, the smaller the stream (i.e., the lower the order), the greater the influence of the riparian zone. In any given drainage basin, stream orders 1 to 3 will be maximally influenced by riparian cover, and will also dominate stream density. At the watershed scale, the result is a direct relationship between stream density and potential riparian influence; the higher the stream density, the greater the proportion of the watershed potentially under direct riparian control of biological integrity. At the cumulative watershed level, high drainage density, and its coupled proportionally large riparian control, would infer greater resilience in the face of disturbance to headwater tributary riparian areas. However, a fixed percent removal of riparian cover would involve a much greater area of channels in high drainage density watersheds than in those having low drainage density.

An additional riparian indicator, the **percent of intact riparian cover**, would be a reliable predictor of overall in-stream biotic condition. The intact nature of riparian cover can be inferred from the condition of the general vegetation cover. For example, complete watershed cover by old or second growth forest would almost always include good riparian cover. A profitable way to develop the indicator would be to intersect a stream map with a map of potential terrestrial plant cover (e.g., potential vegetation types listed by Omernik, 1987). The combination of these two factors provides a basis for assessing the potential influence of riparian habitat on the aquatic resources of the watershed. The ecoregion vegetation cover type for the watersheds provides an indication of expected riparian cover. Thus, high drainage density watersheds in minimally disturbed terrestrial or grassland ecoregions would be indicative of high quality watersheds. Further, estimates of removal of vegetation cover, even at 1 square km resolution, in high drainage density areas should reliably predict watershed impairment at the level of aquatic biotic resources. This information could be obtained from NRCS's "Percent Change in Forested Land Cover, 1982-1992" (http://www.nhq.nrcs.usda.gov/land/sgif/m2310s.gif) and EPA's North American Landscape Characterization (NALC) program (U.S. EPA, 1993).

Additional resolution could be achieved by designating climax and pioneer riparian vegetation cover types characteristic of each ecoregion. For example, for most watersheds in forested and grassland ecoregions, some species of alder would be

expected to be dominant in both deciduous and conifer forested areas as well as grassland areas in second growth (re-growth) condition. Although riparian condition (i.e., percent intact riparian habitat) might be inferred from run-off data from the USGS National Water Information System (http://waterdata.usgs.gov/nwis-w/US/), other riparian inventory data bases would need to be sought. In the long-term, a national riparian inventory, similar to the wetlands inventories that have been introduced, will be required. A significant research question for the future will be the most efficient (cost-effective) way to accomplish this, for example through the use of a volunteer/intern work force in collaboration with USDA, especially USFS. A critical point will be designation of percent intact riparian habitat in agricultural lands, in as much as watershed condition could be noted good if riparian coverage is high.

5.5.4 Lake Indicators

In addition to the general call for the inclusion of indicators of biological effects, the Committee recommends that IWI be expanded to include indicators for lakes and reservoirs. Lakes are important ecosystems which are highly valued for human use, and for which there are abundant chemical and biological data suitable for indicator development (e.g., Kanciruk et al., 1986; Omernik et al., 1988; U.S. EPA 1998c). Because lakes are not uniformly distributed nationwide, lake indicators might be developed for only a subset of watersheds, comparable to the approach already used for estuaries (Indicator 15).

5.6 Research Needs

Charge Question 5. What additional steps, including additional research, could be undertaken to improve watershed assessments?

The primary focus of the IWI developers has been on utilizing existing indicators and watershed assessment information. This focus is appropriate for the initial IWI goal of providing water resource information on a watershed basis for citizens and resource managers. In this report, the Committee suggests expanding the IWI effort to truly report on watershed condition by evaluating ecological attributes in addition to water quality. In order to accomplish this purpose, additional existing databases and classes of indicators (e.g., biological indicators) should be considered. There are a number of areas, however, where additional research will be needed to develop new indicators and additional environmental data will need to be collected. Important research areas underlying watershed assessment include: development and validation of terrestrial and landscape indicators; measures of ecological processes, such as organic matter turnover rates in streams in the form of riparian-derived vascular plant litter; techniques for aggregating individual indicators into representative indices that take into account biotic and abiotic variables, and missing values in data sets; weighting methods that incorporate community differences expected in different habitats or biomes; and understanding the transport, fate, and effects of atmospheric

contaminants on watersheds.

Further effort should be devoted to continuing improvement of the IWI methodology, with particular attention to issues discussed in this report, including the use of conceptual and simulation models to support the integration algorithm, sensitivity analysis to identify “key” indicators and to assess known or hypothetical changes in water quality or biological integrity, uncertainty estimation, and evaluation methods. The IWI strategic plan provides an opportunity to describe and prioritize key additional information that needs to be developed, as well as to indicate ways in which the information may be generated (e.g., ORD research activities, STAR grant program, programs underway at other federal agencies). Many improvements to the IWI, however, including most of those suggested in this report are possible with existing information.

6. INTEGRATION ALGORITHM

Charge Question 6. Is the algorithm used to integrate the individual indicators into a watershed score appropriate, given the objectives of the IWI?

Charge Question 7. How should the proposed additional indicators be incorporated into the integrated index?

The algorithm used in Phase I of the IWI calculates a watershed score by summing the point contributions for the seven "condition" indicators (to produce a watershed condition score) and for the eight "vulnerability" indicators (to produce a vulnerability score). Within the condition score, the greatest weight (6x, with a maximum contribution of 18) is accorded to Indicator No. 1 (state 305(b) assessments of the extent to which surveyed surface waters meet Water Quality Standards and designated uses). The remaining six condition indicators can contribute a total of 12 points.

While noting that the current approach is inherently subjective and not based on science, the Committee emphasizes that the selection of the most appropriate algorithm will depend on the goals of the IWI as stated in the strategic plan. In general, a good algorithm should have the following qualities:

a) Respond to the overall objectives of the project;
b) Be amenable to the inclusion of new indicators; and
c) Be transparent.

As noted earlier, in order for the algorithm to respond to the objectives of the project, those objectives must be well defined. For example, if the main objective is to highlight the watersheds with low water quality as defined exclusively by CWA Section 305(b), then the present algorithm may be sufficient with minor modifications. If, however, the objective is to characterize watersheds with respect to overall water quality, then the present algorithm is insufficient. That is, it would not capture indicators of poor water quality that are not explicitly captured by 305(b) water chemistry data, such as biological indicators. Finally, if the objective of the IWI, as stated in the documentation provided to the Committee, is to characterize watersheds with respect to overall conditions and vulnerability, then the current algorithm falls far short of this goal.

The algorithm must be flexible with respect to the amount of data used to compile the composite indicators. That is, since the data sets from individual watersheds will be widely disparate across the country, the algorithm must have built-in functionality to handle differing amounts of data without skewing the resulting composite indicator. The present algorithm assigns a score that is equivalent to better

water quality when there are insufficient data, skewing the composite to favor watersheds with few data sets. The composite score of a watershed should not degrade solely because a larger data set is available for its calculation; in other words, the algorithm should be designed to reward (not punish) organizations just because they have collected and reported a lot of data.

It is crucial that any algorithm used to compile data and produce an overall composite indicator be easily understandable to those who may utilize the composite data. A truly transparent algorithm would allow the user to independently judge the usefulness of the resulting parameter and make informed decisions about the appropriate application of such results.

The Committee has a number of specific recommendations for improvement of the algorithm. First, the Committee believes that watershed condition and watershed vulnerability (or susceptibility) are individual measures that should be reported separately. This would avoid the awkwardness associated with some of the presently applied descriptors, e.g. “more serious water quality problems, low vulnerability.” Second, as mentioned earlier, indicators should be grouped into composites that represent broad measures of watershed condition that could then be weighted (if desired) to achieve an overall quantitative descriptor of watershed quality and a separate descriptor of watershed vulnerability. This exercise would be greatly aided by the development of a conceptual model, as discussed in Section 5.1. A consistent intellectual framework for the selection and integration of multiple indicators would allow orderly inclusion of additional indicators as they are developed.

Appropriate composites for watershed condition, most of which would have both aquatic and terrestrial components, would include: water quality, habitat quality and extent, hydrology, energy and nutrient flows, and native biota. Composites for watershed vulnerability would include sensitive biological communities, landscape change, and critical habitats (including, e.g., percent intact riparian habitat). Within these composite categories, it would be important to include indicators of potential stressors and measures of biotic integrity as they apply to keystone, rare and endangered, and commercially important species. Development of vulnerability composites will be complicated somewhat by the fact that the factors contributing to vulnerability will often be stressor specific (e.g., watershed and surface water characteristics that describe sensitivity to acid deposition are given by Marcus et al., 1983).

Individual indicators should be used to calculate composites in a manner that would be amenable to inclusion or exclusion of available indicators. Efforts should be made to ensure that results would not change simply due to choice of indicator sets but would actually be tied to additional information. For example, instead of summing individual indicator scores to arrive at a composite, individual scores could be normalized then averaged, thereby allowing any number of indicators to be easily

incorporated without skewing the data. Insufficient data sets would therefore not be assigned any value and would not be included in the average.

Arbitrarily chosen calculation methods that are used solely to spread the composite scores more evenly across the watersheds should be avoided. Specifically, in the current algorithm, if insufficient 305(b) data are available then other data are summed and tripled. A more logical, quantitative, and defensible method for incorporating additional data sets should be applied (see above).

In any case, the Committee feels that the assignment of weights in the integrating algorithm requires validation. As noted above, we recommend that IWI undertake a sensitivity analysis of the Index calculations to determine which indicators are the most robust indicators of response in watershed quality. In this way, the indicators could be weighted according to their relative sensitivities. The Committee recognizes that this would require additional effort and may take some time. However, a sensitivity analysis will lead to a more natural weighting and remove any biases associated with an arbitrary over-weighting of selected indicators.

Finally, it is essential that whatever method is chosen to assign composite scores to watersheds be made explicit. Both the web site and printed documents associated with the IWI should include not only a description of the algorithm, but worked examples illustrating actual calculations.

7. PRESENTATION AND DOCUMENTATION ISSUES

7.1 Map Data Intervals

Charge Question 8. Should different map intervals/data breakpoints (see hard copy of map legend for example) be used for any of the individual indicators or the roll-up index?

The data breakpoints or intervals are not consistent across the various IWI indicator maps. For example, terciles are used for several indicators whereas a different number of intervals is used in other indicators. The selection of breakpoints is not always clear and needs to be better documented since decisions about breakpoints for narrative categories can greatly influence the message portrayed by a map. (For discussion of this and other presentation issues, see Monmonier, 1996). One way of addressing the question of breakpoints is to provide a histogram of the data distribution together with the map, as done in several figures (e.g., Figures 2.3, 2.4, 2.5) of "An Ecological Assessment of the United States Mid-Atlantic Region" (Jones et al., 1997). It may also be important to provide some examples of how the maps change if different breakpoints are selected.

7.2 IWI Presentation

Charge Question 11. Are the IWI results presented in an understandable manner? Are the methods used to disseminate the results (i.e., published map reports and the web site) appropriate?

As highlighted early in this report, the Committee feels that the presentation of IWI results on the web site and in published hardcopy maps has been very effective. The large number of visitors to the IWI web site is a testimony to the interest that has been generated by the effort. While issues still remain about the clarity of the integration algorithm and issues associated with individual data layers, we continue to feel that the Agency has taken a very positive step in making watershed information available in such a user-friendly format.

7.3 IWI Documentation

Charge Question 12. Are the algorithms used in the IWI (e.g., to generate data layers from source data, and to integrate multiple indicators) clearly documented?

Charge Question 13. Are there adequate metadata available to users to describe the content, quality, condition and other characteristics of the IWI indices and their source data? Do the metadata meet applicable Federal Geographic Data Committee (FGDC) content standards?

As discussed in Section 6, documentation of the algorithms used in the IWI requires further improvement so that IWI users can more easily trace the assumptions and decision rules used to transform source data to data layers to composite indicators to calculation of IWI scores. With regard to metadata, documentation about the IWI data layers is provided by links to ORD's Environmental Information Management System (EIMS). This documentation was hard to find on the Web page at the time of the EPEC review meeting, but the links have since been made more prominent. The use of EIMS is a good start, but there should be additional efforts to provide metadata that meet applicable Federal Geographic Data Committee (FGDC) content standards. When an IWI data set is derived from another data set within EIMS, there should be a link to that EIMS page. For example, the description of the IWI indicator "Ambient Water Quality Data - Four Conventional Pollutants" should have a link to the EIMS description of EPA's STOrage and RETrieval System (STORET) data set from which it was derived. When an IWI data set is derived from a data set from a federal source outside of EPA, there should be links to Web pages of those data providers (e.g., the NRCS Natural Resources Inventory (NRI), the Fish and Wildlife Service Wetlands Status and Trends data, the U.S. Census Bureau). Not only will this supply information about data lineage, it will also simplify the task of writing metadata for IWI products, because the metadata may already have been written for the source data set.

8. CONCLUSIONS AND RECOMMENDATIONS

The presentation of IWI results on the web site and in published hardcopy maps has been very effective. While issues still remain about the clarity of the integration algorithm and the quality of individual data layers, we continue to feel that the Agency has taken a very positive step in making watershed information available in such a user-friendly format. The scientific basis of IWI, however, should be improved.

The IWI currently highlights watersheds with low water quality, as defined by the state water quality standards. This approach does not capture other reliable indicators of poor water quality, such as biological indices, because only a handful of states include biological criteria in their water quality standards. More importantly, the IWI does not characterize watershed condition (i.e., "health") and vulnerability as claimed. The Committee supports the Office of Water's efforts to incorporate new indicators and adjust the integrating algorithm to achieve the stated goals of the IWI. To this end, the Committee recommends the following:

a) The Agency should develop a strategic plan to articulate IWI's goals and objectives, identify its target audiences and clientele, define terms, and identify data gaps in order to assure that the IWI can be updated efficiently with additional data layers and provide an improved assessment of condition. A Quality Assurance/Quality Control (QA/QC) plan should be included in the strategic plan.

b) The Agency should develop a conceptual model for the IWI that can be used to guide the selection of additional data layers and refinements to the integrating algorithm.

c) The Agency should add more indicators of biological and ecosystem effects to the IWI.

d) The Committee reiterates its previous recommendation to include terrestrial indicators, but recommends waiting until the Multi-Resolution Land Characteristics (MRLC) dataset becomes available to develop indices related to land use. The Agency should develop better riparian habitat indicators to replace its proposed riparian indicators (Indicator 16 - Forest Riparian Habitat and Indicator 18 - Agricultural/Urban Habitat).

e) The Agency should evaluate each existing and proposed indicator to demonstrate that changes in the indicator correspond to meaningful changes in environmental quality. The Agency should better document data sufficiency and other sources of indicator uncertainty and describe sensitivity of the composite index to variation of the component indicators.

f) The Agency should revisit the current integrated index, which falls short of the goal of characterizing watershed condition and vulnerability. As part of this exercise, the Agency should undertake the appropriate analyses to assign differential weights to the individual indiators based on their relative importance as predictors of watershed integrity.

g) The integration algorithm must be flexible with respect to the amount of data used to compile composite indicators, so as not to reward (or punish) organizations just because they collected and reported a lot of data.

h) Watershed quality and vulnerability are individual measures that should be reported separately.

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APPENDIX A. CHARGE TO THE COMMITTEE

The Office of Water will be developing additional IWI data layers and library maps as time goes on. The goal is to release information on a quarterly basis, and to build the IWI with more current data. As part of this ongoing effort to improve the scientific quality of the integrated watershed information provided by the IWI, the Office of Water requests that EPEC provide peer review and advice on the strategic plan for IWI, the algorithm used to calculate watershed scores, and the proposed indicators of terrestrial condition. Specifically, the Agency requests the SAB to consider the following questions:

Strategic Plan for IWI:

1. Does the strategic plan for IWI include the critical development activities, and are the time frames envisioned appropriate/adequate?

2. Does the plan include a mechanism for IWI users and developers to communicate data needs and gaps to those responsible for data collection?

Watershed Characterization:

3. Are the IWI indicators (current and proposed), taken as a whole, adequate to characterize watershed condition and vulnerability? Are there redundancies among indicators?

4. Are the priorities for development of additional indicators appropriate?

5. What additional steps, including additional research, could be undertaken to improve watershed assessments?

Roll-Up Algorithm:

6. Is the algorithm, used to integrate the individual indicators into a watershed score, appropriate, given the objectives of the IWI?

7. How should the proposed additional indicators be incorporated into the integrated index?

8. Should different map intervals/data breakpoints (see hard copy of map legend for example) be used for any of the individual indicators or the roll-up index?

Terrestrial Indicators:

9. Are there other available data sets or indicators of terrestrial condition that the Agency should evaluate for use in the IWI?

10. Are the data sets that underlie the proposed terrestrial indicators used appropriately? How can the proposed indicators be improved for purposes of the IWI?

Presentation and Documentation:

11. Are the IWI results presented in an understandable manner? Are the methods used to disseminate the results (i.e., published map reports and the web site) appropriate?

12. Are the algorithms used in the IWI (e.g., to generate data layers from source data, and to integrate multiple indicators) clearly documented?

13. Are there adequate metadata available to users to describe the content, quality, condition and other characteristics of the IWI indices and their source data? Do the metadata meet applicable Federal Geographic Data Committee (FGDC) content standards?

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AN SAB REPORT: REVIEW OF THE INDEX OF WATERSHED INDICATORS

PREPARED BY THE ECOLOGICAL PROCESSES AND EFFECTS COMMITTEE OF THE SCIENCE ADVISORY BOARD