# A Critical Analysis of Indicators of Community-based Watershed Initiatives

Monica R. Lipscomb

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Maria Papadakis, Chair
John Randolph
David Trauger

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(ABSTRACT)

Community-based watershed initiatives (CBWIs) are commonly cited as an effective solution to cross-jurisdictional environmental management issues. However, the efficacy of this approach has not been proven. This study provides a method and example for planners to analyze the potential for CBWI indicators to be used in performance monitoring. This major paper includes a compilation of the criteria often cited in the literature as fundamental aspects of successful indicators. These criteria were operationalized using dichotomous variables, which allow qualitative traits to be quantified. This method was applied to the evaluation of EPA-recommended environmental indicators and indicators used by two CBWI case studies. The critical analysis of indicators was carried out according to the literature criteria for each category of indicator effectiveness, including scientific validity, practicality and programmatic considerations. Indicators were classified as condition, stress, activity or organization indicators. The strengths and weaknesses of each indicator were evaluated according to each category of indicator effectiveness and each indicator classification scheme. Based on the findings from these analyses, the indicators commonly used in these case studies are not sufficient for performance measurement of CBWI activities. By adopting the methodology outlined in this research, planners can determine specific weaknesses in the range of watershed indicators collected by various associations. In addition, this evaluation framework can enable planners to determine what measurements are needed to complement those collected so they can better support their environmental decision-making needs.

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Sincerely,

Monica R. Lipscomb

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# Acronyms

| | |
|---|---|
| **AWS** | Anacostia Watershed Society |
| **CBEP** | Community-based Environmental Protection |
| **CBWI** | Community-based Watershed Initiative |
| **EPA** | Environmental Protection Agency |
| **ERMS** | Environmental Results Monitoring Systems |
| **FCPM** | Florida Center for Public Management |
| **IRB** | Internal Review Board |
| **ITFM** | Intergovernmental Taskforce on Monitoring |
| **NepRWA** | Neponset River Watershed Association |
| **NRC** | National Research Council |
| **TSS** | Total Suspended Solids |
| **USGS** | U.S. Geological Survey |

# Introduction

This major paper explores the extent to which Environmental Protection Agency- (EPA) recommended environmental indicators and commonly used indicators of community-based watershed initiatives (CBWIs) adhere to academic criteria of successful indicators, and determines whether indicators used in practice are sufficient for performance monitoring of community-based watershed efforts.

CBWIs are commonly cited as an effective solution to cross-jurisdictional environmental management issues (Steel and Weber, 2001; EPA, 1997; John, 1994; Korfmacher 1998 and 2000). However, the efficacy of this approach has not been proven (Koontz and Korfmacher, 2000; Nickelsburg, 1998; Kenney, 1997; Agrawal and Gibson, 1999; Coggins, 1998; Shannon and Anytpas, 1996). Thus, an evaluation of the effectiveness of CBWI is a timely endeavor. Development of indicators of effective CBWIs is a first and key step in performance evaluation/monitoring. While there is much literature pertaining to the development of indicators and selection criteria, these criteria have not yet been directly applied to indicators of CBWI (ERMS, 2000; Virginia Tech Department of Urban Affairs and Planning, 2000; Hart, 1998; NRC, 2002). There are various reports (primarily in the gray literature, such as EPA, 2002;reports by each state's Department of Environmental Quality; or Reports from EPA's Index of Watershed Indicators) that use indicators to measure watershed health, but these documents often do not measure how current practices and initiatives are affecting change in the watershed. Therefore, this paper aims to contribute to both the indicator development literature and the practice of developing effective indicators for CBWI performance evaluation. The objective of this paper is to evaluate the strengths and weaknesses of indicators recommended by EPA and those used in practice. This evaluation and methods used in this research aims to improve researchers' ability to determine the efficacy of these watershed efforts.

This major paper includes a compilation of criteria often cited in the literature as fundamental aspects of successful indicators. These criteria were operationalized in a way that allows these qualitative traits to be quantified. This method was then applied to the evaluation of EPA-recommended environmental indicators (1999) and indicators that are used in practice by two CBWI case studies. The critical analysis of indicators was carried out according to the literature criteria for each category of indicator effectiveness, including scientific validity, practicality, and programmatic considerations. Indicators were classified as condition, stress, activity, or organization indicators relating to the level of impact that these indicators measure. A list of recommended indicators cited in the Environmental Protection Agency's (EPA's) *Framework for Community-Based Environmental Protection* (1999) was analyzed according to the literature's criteria. The strengths and weaknesses for each category of indicator effectiveness was discussed and compared to those used in practice. Based on the conclusions from these analyses, the sufficiency of CBWI indicators for performance measurement was assessed.

# Review of the Literature

Federal and state environmental protection strategies have in the past been very reliant on traditional "command and control" regulations (Rosenbaum, 1998). Command and control environmental protection uses a one-size-fits-all type of strategy to counter pollutants from a variety of industrial sources. These strategies have played a critical role in advancing environmental conditions from their dire state in the 1970s when they were initiated. However, the lack of flexibility in these strategies has sometimes been self-defeating in terms of environmental protection. Critics of the command-and-control approach assert that these tactics offer regulated parties few economic incentives to comply rapidly and efficiently with mandated pollution standards (Rosenbaum, 1998). Traditional approaches require the government to specify which technologies and methods should be used in every situation, rather than situation-specific alternatives (Rosenbaum, 1998).

In the wake of these disputes about how to most effectively direct the efforts of environmental protection agencies, citizens have taken matters into their own hands and are attempting to abate environmental problems themselves through collaborative efforts (Brosius et al., 1998; Steelman and Carmin, 2002). Collaboration in environmental management has occurred over the past three decades, but emphasized community inclusive strategies, rather than community-based activities (Koontz and Korfmacher, 2000). Community-based environmental management approaches emerged as a new forum for dealing with environmental problems in the 1980s, and empowered communities to effect change in environmental and social conditions directly, rather than relying on government officials to solve environmental problems (Steelman and Carmin, 2002).

## Community-Based Environmental Protection

EPA defines community-based environmental protection (CBEP) as action that local individuals and groups take to address their environmental concerns. CBEP includes a variety of activities, for example, technical assistance to farmers, environmental education, environmental monitoring, and rebuilding habitat. Bottom-up initiatives differ from the traditional command and control model of environmental protection in four ways, because they:

- focus on a different set of environmental problems
- use different tools
- seek to overcome fragmentation
- search for alternatives to confrontation (EPA, 1999).

CBEP acts not as a replacement, but a complement to command and control because the efforts are nourished by new values and knowledge (John, 1994; Getches, 2000). Although current writings frequently assert that involving community is central to resource management, the literature has paid little attention to explaining how community affects outcomes (Agrawal and Gibson, 1999). In fact, little attention has been paid to the environmental impact of community involvement in protecting the environment. EPA's plan for 2001-2005 heavily emphasizes the agency's increased need for innovative strategies to improving the environment, and CBEP is among these alternatives. Therefore, if the agency is to invest in promoting such approaches, it is necessary to evaluate the environmental impact of CBEP beyond traditional environmental regulatory enforcement. By ranking the relative efficacy of certain community-based efforts, it may be possible to ascertain which elements of these programs lead to their success or failure. Such information is crucial not only for the development of effective CBEP in the future, but to assist environmental planners in developing more effective stakeholder involvement in other environmental approaches.

This study focuses on a subset of CBEP—community-based watershed initiatives (CBWIs). Watersheds are land areas delineated by ridgelines that catch precipitation and drain to specific marshes, streams, rivers, lakes, or groundwater (McGinnis et al., 1999). CBWIs are CBEP efforts that are focused toward the improvement of a specific watershed system. Watershed-based planning can be considered a comprehensive and integrated approach to protect or improve ecosystem health (McGinnis et al., 1999).

## Watershed Approach

The idea of watershed-based environmental protection efforts is not new. In 1878, John Wesley Powell, first director of the U.S. Geological Survey (USGS), urged that communities needed to collectively control their own water and land resources through watershed commonwealths (Powell, 1879). Watersheds represent a geographically delineated space where monitoring stations can be easily associated with community-based efforts, and environmental protection efforts are narrowed to more comparable types of issues, such as water quality and biodiversity. Taking a watershed approach requires that environmental managers involve the public and private sector in addressing problems within hydrologically-defined geographic areas. Watersheds are defined by natural hydrology and represent a local basis for managing water resources. Emphasis on water quality improvement has traditionally focused on point source pollution, but this approach ignores other chronic problems leading to watershed decline such as habitat destruction or polluted runoff.

A community-based watershed approach enhances environmental benefits and leads to cost savings by building upon the financial and human resources of those interested in watershed protection. Due to the transboundary nature of water resources, water protection efforts have realized an unusually high level of intergovernmental experimentation and innovation (Kenney, 1997). Watershed management responsibilities have been devolving from federal to state, from legislative and executive to judicial, and from public to private control (Kenney, 1997).

## CBWI in an Urban Planning Context

Urban planners cannot promote development as if no other jurisdiction exists downstream, because overall water quality will continue to deteriorate. However, the system of political boundaries that limit the decision and development power of every planner is not likely to change in the near future. One method that planners can utilize to link jurisdictions is the promotion of community-based watershed initiatives whose efforts can span across cities, townships, counties, and stream quarters. Agencies can play a central role in guiding collaborative initiatives (Wondolleck and Yaffee, 2000). In order for localities to invest in empowering local watershed groups—by supplying technical resources and assisting in federal and state grant writing—the effectiveness of this approach should be assessed and effective aspects of successful efforts need to be defined.

Urban watersheds are degraded extensively by automobile-related development (Hough, 1995). Roadside storm drains carry oil and other chemicals straight to nearby stream channels, and impervious roadways increase flooding due to the increased volume and speed of runoff. The environmental effects of increased watershed imperviousness include adverse impacts on water quantity, water quality, erosion, microclimate changes, habitat degradation and destruction, and landscape aesthetics (Fairfax County, 2001). Habitat quality and biological integrity in stream systems are significantly decreased when an area's percentage of impervious surfaces reach or exceed levels of 10 to 20 percent impervious surface cover (Schueler, 1994). Storm water carried across hot impervious surfaces and lack of vegetation surrounding urban streams can raise water temperatures by up to 10 degrees, killing many aquatic communities (Schueler, 1994). Due to these impacts, many species of wildlife have difficulty thriving in urban streams (Schueler, 1994; Booth and Reinelt, 1993).

To address these impacts within a community, acknowledgement of public values and interests in development decisions is necessary. Planners can utilize collaborative processes to build from a common ground such as a place, goal, or fear. The collaborative efforts in CBWI encapsulate and serve as the underpinnings of the various goals of community-based activities. Planners can play a role in fostering these collaborative efforts to advance watershed quality within their jurisdictions. The major uses of collaborative processes in environmental management include:

- building understanding and developing an exchange of information and ideas;
- assisting in effective decision making by focusing on common problems;
- fostering joint activities and expanding current resources; and
- developing the capacity of agencies, organizations, and communities (Wondolleck and Yaffee, 2000).

## CBWI Activities

Natural systems, left to their own devices, typically have a built-in self-maintenance system as a result of thousands of years of responding to gradual environmental forces. However, the natural environment cannot adapt quickly enough to keep pace with the rapid urbanization that is changing the modern-day landscape (Bugliarello, 2002). Therefore, natural resources must be managed and new development must be constructed with natural systems in mind (Jackson and Steiner, 1985). CBEP efforts often aim to achieve substantive outcomes. These activities frequently include research on water quality, watershed health, community education, watershed restoration, or protocol development to achieve environmental goals (Steelman and Carmin, 2002). There are a variety of watershed management strategies that community-based groups can promote and actively engage in. A few of these items are listed in Table 1.

**Table 1. Watershed management strategies and their associated actions**

| Watershed Management Strategies | Specific Actions |
|---|---|
| Habitat Preservation and Restoration | • Improve stream connectivity<br>• Channeled stream daylighting (i.e., the uncovering of streams that were once diverted into underground channels for development)<br>• Improve slope and dimensions of stream channels<br>• Stabilization with riparian plantings |
| Watershed Management Programs/Plans | • Public awareness promoted |
| Storm Water Management Strategies | • Structural BMPs including: ponds, wetlands, infiltration, filtering systems and open channels. |
| Aquatic buffer conservation | • Monitoring of buffers<br>• Active restoration<br>• Limits on mowing and boating |
| Reduction of Impervious Surfaces | • Clustered development<br>• Shared and multistory parking<br>• Gutter cisterns<br>• Raingardens |
| Erosion and sediment control | • Decrease clearing<br>• Stabilize drainage ways and steep slopes |
| Countering point source pollution | • Repairing failed septic systems<br>• Stream monitoring<br>• Reporting discharge violators |
| Countering nonpoint-source pollution | • Promotion of nonphosphoric fertilizer<br>• Proper disposal of pet waste<br>• Drain stenciling |

It is important that jurisdictions begin to consider watershed management approaches to water quality because upstream negligence can lead to downstream degradation. The importance of collaboration within resource management cannot be overstated. New environmental problems, due to their complexity, are said to not be conducive to centralized decision making (Dryzek, 1997). Lay people and experts have different perspectives regarding risk. Even with the most technical tools in environmental decision making—risk assessment and cost benefit analysis—rely on subjective judgment, which may not be in line with public values (NRC, 1996). Therefore, many communities feel the need to influence the reduction of environmental risks, because they (perhaps not the decision makers or expert consultants) are the recipients of any resulting consequences of these risks. Although Table 1 is not a comprehensive list, it provides an overview of the many roles that communities can play in improving their local environment.

Despite the perceived advantages of community-based environmentalism, there has been little evaluation of how effective these activities have been in improving environmental outcomes (Kenney, 2000). The first step in environmental monitoring is to build measurable objectives, which provide data for decision making and specific agenda items for adapting activities (ERMS, 2000). To do so, it is necessary to determine which measurable indicators exist or should be collected that are capable of demonstrating current conditions, activity input, and outcomes of intervention. Thus, in order to determine whether CBWIs are contributing to improved environmental quality, environmental indicators must be developed strategically to allow for an assessment of CBWI activities.

## Environmental Indicators

> *The use of a limited number of environmental indices, by aggregating and summarizing available data, could illustrate major trends and highlight the existence of significant environmental conditions. It could also provide the Congress and the American people measures of success of Federal, State, local, and private environmental protection activities.*
>
> *The process of developing dependable environmental quality indices will be a long one.*
>
> --President's Council on Environmental Quality, 1972

### What are Environmental Indicators?

An indicator is a tool that can help an organization understand its status and trends with respect to its goals (Virginia Tech Department of Urban Affairs and Planning, 2001). Environmental indicators are direct or indirect measures of environmental quality that can be used to determine current conditions and trends (Bernard, 1998). For example, water quality is impossible to measure directly, but measuring indicators such as dissolved oxygen content or toxic chemicals in parts per million *indicates* the state of water quality. Environmental indicators are key to environmental management; in 1996, 71 percent of surveyed state environmental management agencies stated that they were measuring environmental indicators (Bernard, 1998). Measuring environmental indicators shifts the focus of environmental practice to environmental results, rather than administrative indicators such as number of permits issued. Developing and monitoring these indicators can allow those who are involved in environmental protection to see the results of their efforts (or the outcome of their inactivity).

Performance measurement should include a balanced set of measures, target setting, benchmarking, and objective-setting collaborations (Gore, 1997). Measurement information can be used to set goals and standards; determine problems; improve processes; and record accomplishments (Gore, 1997). However, these objectives cannot be achieved by measurement alone, but only by integrating monitoring, target setting and benchmarking into the organization's performance measurement plan. Developing a balanced set of measures is a first step in this process.

Environmental indicators can be useful in showing the condition of a resource and the changing condition of the resource when measured over a period of time (Bernard, 1998; Jones, 2000). A variety of organizations use performance-focused systems to improve outcomes and strengthen program accountability (Metzenbaum, 1997). These outcomes are achieved by sharpening organizational focus, motivating improved performance, facilitating organizational learning and increasing flexibility in methodologies. Three general uses for indicators include:

- defining and describing the magnitude of environmental problems
- providing the basis for setting goals
- showing progress (or lack there of) toward achieving those goals (Jones, 2000)

"Many environmental planners are considering the use of environmental indicators to monitor results-oriented policy and to better communicate information about the environment,"(Jones, 2000). Public sector managers can use performance measurements to benchmark one organization's activities against another, evaluate overall effectiveness, and to designate management priorities (Metzenbaum, 1997). For example, Minnesota's water-quality program organized a task force to establish benchmarks for the activities of the program. As a result, the state recognized the need for increased funds for the water quality program, and also identified specific weaknesses in the program (Metzenbaum, 1997).

Currently, many states, cities and smaller localities are developing indicators to measure their economic and social health and to set future goals (Andrews, 1996). Environmental planners can draw upon community indicator projects. Community indicators are useful to monitor progress, understanding sustainability, educating community members on the issues, describing linkages, and motivating and focusing action (Hart, 1998). Community indicators are place-based and developed with local stakeholder input. Community indicator projects, such as Sustainable Seattle, do not use watersheds as a unit of analysis for their indicator projects (Atkisson, 1996). Similarly, CBWIs do not always incorporate community indicator principles into their indicator development and performance measurement plans.

## Indicator Classification Levels

There are various classification systems that distinguish types of environmental indictors. EPA's Framework for Community-Based Environmental Protection outlines a variety of examples of activity-measure categories (EPA, 1999). The indicators listed are sensitive to the many different goals of community-based environmental planning activities (EPA, 1999). However, the classification scheme of indicators assessed is based on Jones (2000). The primary reason for the differences in the EPA framework and that in Jones is the EPA categories were designed to reflect the various goals of community-based environmentalism, whereas Jones is specific to environmental indicators.

Jones (2000) established the primary to tertiary classification schemes:

1) Primary indicators communicate an environmental condition, e.g., nitrate levels in streams

2) Secondary indicators provide information on environmental stressors, e.g., percent impervious surface
3) Tertiary indicators measure the activities that address the environmental problem, e.g., number of hours spent removing invasive species

For the purposes of clarity, these classification levels have been renamed for this analysis as condition, stress, and activity indicators, respectively. An additional classification—organization indicators, providing information about the organizational elements of the CBWI itself, e.g. number of members—was used here to supplement the Jones classification scheme. The classification scheme used in this analysis is described below:

1) **Condition indicators** provide information on the environmental state, e.g., nitrate levels in streams
2) **Stress indicators** provide information on activities that are detrimental to the environmental condition, e.g., percent impervious surface
3) **Activity indicators** provide information on an organization's mitigation efforts, e.g., number of hours spent removing invasive species
4) **Organization indicators** provide information about an organization's processes, e.g., number of members

In order to understand causal relationships between various CBWI activities, processes, and environmental outcomes and stressors, all four indicator categories need to be incorporated into the initiative's performance measurement plan. Condition and stress indicators are outcome indicators. These indicators can demonstrate the result of CBWI. Activity and organization indicators are input indicators, and provide information about the CBWI activities and organizational style. Stress indicators can also be input indicators if measuring the impact of a specific stress on the environment, rather than the impact of the organization's activities or processes that reduce these stresses (outcome).

To determine a causal relationship between CBWI activities and environmental results, both input and outcome indicators must be collected. For example, a causal relationship might exist between number of trees planted (activity indicator) and total suspended solids (TSS) (condition indicator); or number of voting members of an organization (organization indicator), and percent of population driving to work (secondary indicator). Collecting a mixture of condition, stress, activity and organization indicators can allow planners a better understanding of what types of CBWI organizations lead to improved environmental results, and whether contributing to CBWI efforts is beneficial to watershed health. Despite the usefulness of such a mixture, CBWIs may be more likely to collect solely activity or organization indicators because they are less expensive and require less expertise to collect; it is much more difficult to collect measurements that demonstrate the impact of CBWI activities. Beyond a mixture of classes of indicators, there are criteria that can be used to evaluate potential environmental indicators that can be tied into a constructive performance measurement plan.

## Criteria for Good Environmental Indicators

The Intergovernmental Task Force on Monitoring Water Quality identifies three major categories of indicator effectiveness (ITFM, 2002). These include:

- scientific validity
- practical considerations
- programmatic considerations

Criteria lists compiled from other literature can be assigned to these three major categories, except that "sustainable considerations" are a noted subset of criteria that have been given some attention in the literature.

Criteria have been compiled from a variety of sources in the literature (ITFM, 2002; FCPM, 1995; Metzenbaum, 1997; Hart, 1998; and NRC, 2000). These sources offer a broad perspective on indicator use. ITFM (2002) is a consensus document that incorporates the needs and opinions of various federal agencies. FCPM (1995) provides indicator guidance to the Florida state government. Metzenbaum (1997) was written by a nonprofit organization, the Brookings Institute, and addresses building a large environmental monitoring system based on devolved data collection responsibilities. Hart (1998) focuses on sustainability and community measures. NRC (2000) is written by a consensus committee and recommends specific indicators that address U.S. environmental indicator needs overall. These reports were selected because they offer national, state, and local perspectives and represent the government and nonprofit sectors. The compilation of indicator selection criteria from these various perspectives provides a broad view on good indicator metrics.

These criteria can be organized into four major categories including scientific validity, practicality, programmatic considerations, and sustainability.

1) **Scientific validity criteria** include measurability, sensitivity, integrative of effects/exposures, validity/accuracy, data quality, reliability, reproducibility, representivity, scope/applicability, data comparability, appropriate scale, and anticipatory.
2) **Practical consideration criteria** include timeliness, affordability, cost effectiveness, difficulty level, and data availability.
3) **Programmatic consideration criteria** include relevance, understandability, importance, trend applicability, decision supportive, and archived data.
4) **Sustainability consideration criteria** include addressing carrying capacity, community usability, adopting long-term view, and linking environment, society, and economics.

These criteria make up an integral part of the design for this research. They were used in an evaluation framework in concert with the indicator classification levels to determine the strengths and weaknesses of EPA-recommended indicators and those used in practice.

# Methods

This research analyzes EPA-recommended (1999) and commonly-used indicators of CBWI using the criteria cited in the literature as fundamental aspects of successful indicators. A list of recommended indicators cited in the EPA's *Framework for Community-Based Environmental Protection* (1999) was analyzed according to the literature's criteria. These indicators include, for example, biological integrity, species at risk, and financial resources. Two community-based watershed initiatives—the Anacostia Watershed Society (AWS) and the Neponset River Watershed Association (NepRWA)—were investigated, and their indicator usage was examined. The AWS indicators include, for example, tons of debris collected and number of tires removed from the river. The NepRWA indicators include metrics such as total nitrogen and pH.

The critical analysis of indicators was carried out according to the literature criteria for each category of indicator effectiveness (scientific validity, practicality, and programmatic considerations). The strengths and weaknesses for each category of indicator effectiveness was evaluated, so that the sufficiency of EPA- recommended and commonly-used indicators of CBWI could be determined.

## Operationalization of Evaluation Criteria

In order to evaluate CBWI indicators using the literature criteria, it was necessary to establish an evaluatory framework with which to conduct this analysis. The indicator classification levels and evaluation criteria were operationalized using dichotomous variables, which are used to distinguish between the presence and absence of specified traits. A series of yes-no questions were constructed to create dichotomous variables representative of the dimensions of each evaluation criteria.

For example, the operationalization of the indicator category "condition" is "Does this indicator communicate an environmental condition?" This series of questions was used to determine the classification level for each evaluated indicator. An example of operationalizing the "sensitivity" criterion is described below to clarify the process. The concept of "sensitivity" was described as an attribute of an indicator that responds to broad range of conditions or perturbations within an appropriate frame and geographic scale, and is sensitive to potential impacts being evaluated (ITFM, 2002). Using this information, the following dichotomous variable question was constructed: *Are changes in conditions reflected in the measurement scale for this indicator?* This operationalization was carried out for the 4 indicator classes and 23 criteria for successful indicators. See Table 2 for a list of the operationalized indicator classification categories. See Tables 3 to 6 for a list of operationalized literature-cited criteria. These tables are clustered to represent the four evaluation criteria categories:

1. scientific validity
2. practicality
3. programmatic considerations
4. sustainability considerations

**Table 2. Indicator classification category operationalization questions**

| Indicator class | Operationalization |
|---|---|
| Condition | Does this indicator communicate an environmental condition? |
| Stress | Does this indicator provide information on environmental stressors? |
| Activity | Does this indicator measure activities that address the environmental problem? |
| Organization | Does this indicator measure programmatic elements of CBWIs? |

**Table 3. Operationalization of scientific validity criteria**

| Criteria | Operationalization |
|---|---|
| **Measurability:** the indicator measures a feature of the environment that can be quantified simply using standard methodologies with a known degree of accuracy and precision[2] | Is it quantifiable? Y=1; N=0 |
| **Sensitivity**: responds to broad range of conditions or perturbations within an appropriate frame and geographic scale; sensitive to potential impacts being evaluated[1] | Are changes in conditions reflected in the measurement scale for this indicator? Y=1; N=0 |
| **Integrative of effects/exposures:** the indicator integrates effects of exposures over time and space and responds to the cumulative impacts of multiple stressors. It is broadly applicable to many stressors and sites[2, 3] | Does this indicator respond to the cumulative impacts of multiple stressors? Y=1; N=0 |
| **Validity/accuracy:** parameter is a true measure of some environmental condition within constraints of existing science[1] | Is the indicator representative of the environmental conditions that it operationalizes? Y=1; N=0 |
| **Data quality:** the data supporting the indicators are adequately supported by sound collection methodologies, data management systems, and quality assurance procedures to ensure that the indicator is accurately represented. The data should be clearly defined, verifiable, scientifically acceptable, and easy to reproduce[2] | A: Are there quality assurance procedures? Y=1; N=0<br>B: Are analytical methods documented?Y=1; N=0<br>A*B |
| **Reliability:** experience or evidence demonstrates the indicator's reliability[4] | Is there evidence that supports the indicator's reliability? Y=1; N=0 |
| **Reproducibility:** reproducible within defined and acceptable limits for data collection over time and space[1] | Is this indicator likely to reproduce the same results if measured a second time under the same conditions or by a different person? Y=1; N=0 |
| **Representivity:** changes in parameter/species indicate trends in other parameters they are selected to represent[1] | Do the changes in this indicator reflect trends in the parameter it was selected to represent? Y=1; N=0 |
| **Scope/applicability:** responds to changes on a geographic and temporal scale appropriate to the goal or issue[1] | Is this indicator appropriate for a watershed scale? Y=1; N=0 |
| **Comparability:** can be compared to existing data sets/past conditions[1] | Are the definitions of this indicator and its units of measure comparable to (or can they be converted to) others collected in past and/or by other organizations? Y=1; N=0 |
| **Scale appropriate:** the indicator responds to changes on an appropriate geographic (e.g., national or regional) and/or temporal (e.g., yearly) scale[2] | Does the indicator aim to show a local trend? Y=1; N=0 |
| **Anticipatory:** the indicator is capable of providing an early warning of environmental change[4] | Does this indicator show an early warning sign? Y=1; N=0 |

1. ITFM, 2002; 2. FCPM, 1995; 3. Metzenbaum, 1997; 4. NRC, 2000.

**Table 4. Operationalization of practical consideration criteria**

| PRACTICAL CONSIDERATIONS | Operationalization |
|---|---|
| **Timeliness:** data need to be assembled, analyzed, presented, and disseminated within a time period that users need it[3] | Does it take less than 3 months to assemble and analyze data? Y=1; N=0 |
| **Affordability:** data collection, analysis, and presentation take time and cost money. Measures too costly do not help anyone[3] | Is the cost of acquiring this indicator less than 10 percent of this budget? Y=1; N=0 |
| **Cost effectiveness:** the information for an indicator is available or can be obtained with reasonable cost and effort and provides maximum information per unit of effort[2] | Is [(Total of all considerations marked yes – practical considerations) / percent of total budget consumed by measurement] greater than 1? Y=1; N=0 |
| **Difficulty level:** ability to obtain expertise to monitor[1] | A. Is a college education not required to collect this data Y=1; N=0<br>B. Is a college education not required to analyze and interpret this data? Y/N |
| **Availability:** good information dissemination is key[3] | Is this indicator measure readily available? |

1. ITFM, 2002; 2. FCPM, 1995; 3. Metzenbaum, 1997; 4. NRC, 2000.

**Table 5. Operationalization of programmatic consideration criteria**

| PROGRAMMATIC CONSIDERATIONS | Operationalization |
|---|---|
| **Relevance:** the indicator should be relevant to a desired significant policy goal, issue, legal mandate, or agency mission (e.g., contaminated fish fillets for consumption advisories, species of recreational or commercial value) that provides information of obvious value that can be easily related to the public and decisionmakers[2] | Does this indicator provide information relevant to the mission of the organization? Y=1; N=0 |
| **Understandability:** the indicator should be simple and clear, and sufficiently nontechnical to be comprehensible to the general public with brief explanation. The indicator should lend itself to effective and appealing display and presentation[2] | Are the units of measure of this indicator commonly used by the general public or explainable in everyday nontechnical language? Y=1; N=0 |
| **Importance:** The indicator must measure some aspect of environmental quality that reflects an issue of major national importance to states and to federal government in demonstrating the current and future conditions of the environment[2] | Does this indicator measure an aspect of environmental quality of national importance? Y=1; N=0 |
| **Trend applicability:** the data for the indicator should have been collected over a sufficient period of time to allow some analysis of trends or should provide a baseline for future trends. The indicator should show reliability over time, bringing to light a representative trend, preferably annual[2] | Are changes in this indicator expected? Y=1; N=0 |
| **Decision supportive:** the indicator should provide information to a level appropriate for making policy decisions. Highly specific and special parameters, useful to technical staff, will not be of much significance to policy staff, will not be of much significance to policy staff or management decisionmakers[2] | Will trends in this indicator potentially be used to determine effectiveness? Y=1; N=0 |
| **Archived data:** archive needs to save record of measurements to track ecological indicators[4] | Have plans been made to keep these measures? Y=1; N=0 |

1. ITFM, 2002; 2. FCPM, 1995; 3. Metzenbaum, 1997; 4. NRC, 2000.

**Table 6. Operationalization of sustainability consideration criteria**

| SUSTAINABILITY CONSIDERATIONS | Operationalization |
|---|---|
| **Addresses carrying capacity:** an indicator of sustainability needs to address the carrying capacity[1] | Is carrying capacity included in this indicator? Y=1; N=0 |
| **Community usability:** If indicators are not used by the community, they will not have any effect on what people do. Indicators need to help people see how they can change their behavior to have a positive effect on community sustainability[1] | Does this indicator easily connected with human behavior? Y=1; N=0 |
| **Adopting long-term view:** sustainability is a long-term goal. We need long term indicators. This means 25 or 50 years in the future, not 5 or 10 years[1] | Will the indicator display long-term impacts be important 50 years in the future? Y=1; N=0 |
| **Linking environment, economics and society**[1] | Does it incorporate a link between two of the following: environment, economics and society? Y=1; N=0 |

1. Hart, 1998

Every question for which the answer is "yes" receives a score of "1," while every question for which the answer is "no" receives a score of "0." This dichotomous variable system allows for a very simple quantification of how well each indicator is meeting the literature-recommended criteria for good metrics. In the case of the indicator classification categories (Table 2), this analysis determined the classification for each indicator based on which category was marked "1," where answering "yes" to the operationalization question. The determination of "yes" or "no" is subject to the judgment of the researcher. The questions were constructed so that the response "yes" means that the indicator meets the criterion. In some cases, this leads to an awkward question such as for operationalizing "difficulty level." The two questions used are:

*Is a college education not required to collect this data?*
*Is a college education not required to analyze and interpret this data?*

While these questions are awkward, phrasing them this way ultimately simplifies the quantification, where a score of "1" always means "yes" to the operationalized criteria question and conveys that the indicator meets the criteria. In the case of the indicator criteria listed in Tables 3 to 5, the series of "0" and "1" scores are averaged for each category of indicator effectiveness—scientific validity, practicality, and programmatic considerations—and overall ranking. The sustainability considerations were not calculated for each indicator, but applied to the CBWI indicators in practice as a whole, across each organization. Specific examples of how these operationalized criteria are applied are illustrated in sections below.

## Evaluation of EPA Metrics

The EPA-recommended indicators were analyzed using the operationalized criteria listed in Tables 3 to 5. The sustainability criteria are not used in the EPA evaluation because these criteria are less useful in evaluating individual indicators than in evaluating how an organization's blend of indicators complement each other. No organization could possibly acquire and use all of the EPA-recommended indicators—it would not be practical. So a determination of how these indicator complement one another for sustainability was not appropriate.

The list of EPA-recommended indicators can be viewed in the first column of Tables 7 to 10. Each indicator was scored separately in each table to evaluate the strengths and weaknesses in each category. This analysis was conducted by marking each criterion with a score of "1" or "0." In instances where two questions are required, such as "difficulty level," the response scores for each question are multiplied times the other. Thus, if the response to the sensitivity operationalization, "Is a college education not required to collect this data?" gets a score of "0," while the other question, "Is a college education not required to analyze and interpret this data?" gets a score of "1," the total score is "0" (because 0 x 1 = 0).

The average criteria met in the categories of scientific validity, practicality, and programmatic considerations were provided in Table 12 to 15. The average score across all three categories was also calculated. The tables list the indicators in ranked order from highest to lowest average percentage of criteria met in all three categories. A strong indicator should have high scores in each category of indicator effectiveness. The most common strengths and weaknesses found in this analysis are discussed in more detail in the results section.

## Evaluation of the CBWI Indicators in Practice

To assess how well indicators in practice reflect the criteria set in the literature, two case studies of community-based watershed initiatives were examined. The first case study examines the indicators used by the Anacostia Watershed Society (AWS), which runs many community-based programs to clean up the Anacostia River and collects indicators that report on program delivery. The second case study examined the indicators used by the Neponset River Watershed Association (NepRWA), which focuses on collecting indicators for environmental advocacy.

The different usage of indicators in these case studies was particularly intriguing given the similarity between their respective missions:

- the mission of the AWS is to work to ***protect and restore*** the Anacostia River and its watershed
- the mission of the Neponset River Watershed Association (NepRWA) is to ***protect and restore*** the natural resources of this watershed for the present and future generations.

These case studies are both urban watersheds located in comparable watershed regions of the U.S. (The Northeastern and Mid-Atlantic coast have similar watershed concerns focusing on population growth, agriculture, and urbanization, as opposed to water scarcity concerns that face midwestern and western CBWIs). These CBWIs were selected as the case studies for this research because, while they were comparable given their common goals and similarity in regional issues, their contrasting use of indicators allowed for a more comprehensive assessment of various indicators used in practice. More detailed background on each of the case studies is provided in the following sections.

## Anacostia Watershed Society

The Anacostia Watershed Society (AWS) has a variety of activities that aim to improve this watershed. The Anacostia watershed is located in Maryland and Washington, D.C. (See Figure 1). The mission is to work to protect and restore the Anacostia River and its watershed (http://www.anacostiaws.org/). AWS seeks to make the Anacostia a swimmable and fishable river through its programs of education, action, and advocacy. The Anacostia River Manifesto outlines various strategies by which the AWS wants to clean the watershed, recover its shores, and honor the heritage of the Anacostia river.

The group hosts several education and restoration events. These include operating a wetland nursery, tree plantings, river cleanups, storm-drain stenciling, and tours of the river. The wetland nursery project allows children to raise and grow wetland plantsand transplant them in the Anacostia River. These plantings are proposed to serve a variety of functions such as flood prevention, water pollution control, soil erosion, sediment control, maintenance of stream baseflows, provision of wildlife habitat, and aesthetic value (http://www.anacostiaws.org/). By shading tributaries, tree plantings prevent erosion and slow and cool run-off. The AWS has organized river cleanups that have removed much debris and used tires from the streambanks. The goal of storm-drain stenciling is to educate the public about the destination of storm drains to reduce the dumping of toxics into these drains. The river tour program allows students to participate in water quality monitoring and learn more about the value of watershed preservation.

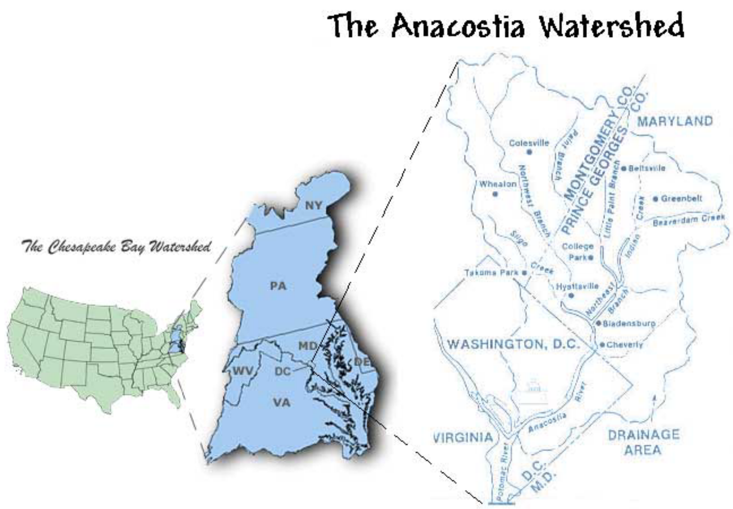


**Figure 1. Location of Anacostia watershed. Courtesy of Anacostia Watershed Society.**

The AWS uses indicators to measure their activities.  A preliminary list of indicators used by this group include:

- number of volunteers
- number of trees planted
- number of storm drains stenciled
- tons of debris removed
- number of tires removed
- number attending educational presentations

All of these indicators fall within activity or organization indicator categories.  Some of the goals—"reduce run-off," "create linked wildlife habitat," "thread pathways throughout the watershed connecting points of interest"—would require extensive political advocacy efforts. While the AWS's grassroots organizing efforts are focused on educational activities to "promote the healing of the Anacostia River," the waterhsed's "healing" is not monitored by this organization.  AWS was selected for its action-oriented approach in improving watershed health. A preliminary list of indicators used by another CBWI is provided in the following section.

## Neponset River Watershed Association

The Neponset River Watershed Association (NepRWA) is a nonprofit organization that aims to protect and restore the natural resources of this watershed for the present and future generations.  This watershed covers the waterbasin that is southwest of the Boston, Massachusetts, and is a subwatershed within the Boston Harbor watershed.

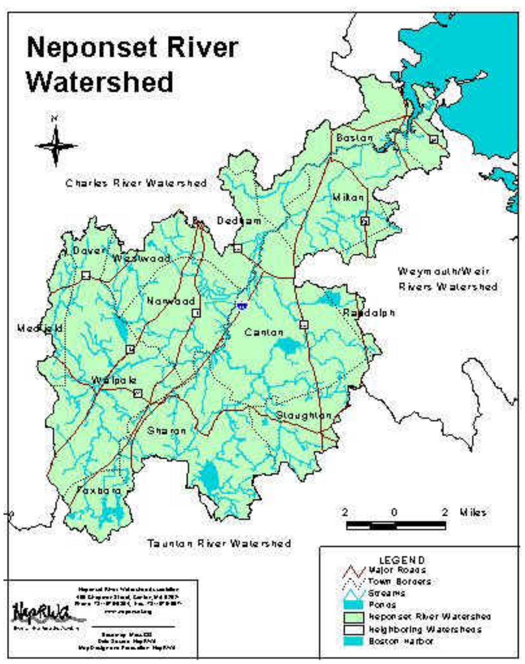


**Figure 2.  Location of the Neponset River watershed.  Courtesy of Neponset River Watershed Association.**

The association was founded in 1967 and works to facilitate the active participation of citizens, municipalities, and businesses in making decisions that affect watershed health. The association has organized citizen monitoring since 1990. The goal of the association is to "achieve fishable, swimmable (Class B) water quality, and ensure that the public is able to gain access to and enjoy their local waterways and wildlife" (http://www.neponset.org/).

The association implemented the Citizen Water Monitoring Network, which is the only organization within the watershed that continuously monitors water quality at 40 sites around pollution "hotspots" (http://www.neponset.org/). Indicators of water quality that are collected by the volunteer monitors include:

- levels of fecal coliform bacteria
- total suspended solids
- total nitrogen
- nitrate plus nitrite
- ammonia
- total phosphorous
- orthophosphate
- pH
- temperature
- dissolved oxygen

All of these indicators fall into the condition indicator category. It is surprising that no stress indicators are included in this list given the Association's focus on improving development decisions with respect to watershed health.

By measuring these indicators at the specified "hotspots," the association has worked with local officials to coordinate clean-up, redevelop existing facilities, and develop innovative wastewater and stormwater technologies. The association bases its advocacy efforts on scientific understanding of environmental interrelationships and provides decision makers with analytical and organizational tools. This CBWI effort was selected for this study because of its extensive collection of environmental indicators.

Indicators of water quality that are collected by the volunteer monitors include levels of fecal coliform bacteria, total suspended solids, total nitrogen, nitrate plus nitrite, ammonia, total phosphorous, orthophosphate, pH, temperature, and dissolved oxygen. All of these indicators fall into the condition indicator category.

## Case Study Process

Tentative lists of indicators listed above were collected from the Anacostia Watershed Society and the Neponset River Watershed Association websites (http://www.anacostiaws.org/; http://www.neponset.org/). Because a list of collected indicators was made readily available via the Internet for each case study, it was evident from very early stages of this research process that the indicators collected by these organizations did not overlap. An interview with a responsible person from each watershed initiative was used to determine whether the list was complete and what methods were used to collect these indicators; a formal interview protocol is included in Appendix A. This interview also aimed to collect information required to answer the operationalization questions for certain criteria, such as collection methods (including quality assurance mechanisms), data documentation, data storage, funding requirements, and resource information (i.e., time and money spent collecting and analyzing data, and the total budget for the organization). This interview was carried out so that the organization's total list of indicators could be evaluated for their comprehensiveness and completeness. The interview protocol was exempted from a review by the Virginia Polytechnic Institute and State University's Internal Review Board (IRB). A copy of this letter of exemption can be viewed in Appendix B.

The responsible person for each watershed initiative was identified by calling the main number listed on its web site. The Anacostia Watershed Society representative was James Connelly, Executive Director. The Neponset River Watershed Association representative was Wendy Parisi, Environmental Scientist. These representatives were contacted and an interview was set up. The protocol was emailed to these representatives in advance so that they could be prepared for the more complex questions, such as their total list of indicators and budget.

After a complete list of indicators and a description of collection techniques was obtained, the indicators were evaluated based on the previously outlined criteria. The strengths and weaknesses are compared to those highlighted in the EPA (1999) framework for community-based environmental protection (Table 7, 8, 9, and 10). Since each category has a different number of criteria, the results for each indicator displayed in Tables 7 to 10 show the percentage of criteria met for each indicator in each category of indicator effectiveness—scientific validity, practicality, and programmatic considerations.

# Findings and Analysis

The first set of results described below refer to the adequacy of the EPA-recommended indicators. Next, the results of the interview are discussed. Third, the case study indicators are evaluated according to the effectiveness criteria are carried out, and the strengths and weaknesses of these indicators are discussed.

## Evaluation of EPA-recommended Indicators

Each of the EPA-recommended indicators was evaluated against the literature-cited criteria for effective metrics. The average score for each EPA-recommended indicator, organized by indicator type, was ranked and is listed in Table 7, 8, 9, and 10. The complete scoring information and primary analysis for these indicators is available upon request from the author. In order to demonstrate how this analysis was carried out, the evaluation of EPA-recommended indicator "number of fish kills and fish killed" are described in detail. The indicator provides information on an environmental condition, not a stressor, environmental protection activities, or organizational structure. Thus, the indicator is classified as a condition indicator. Next the indicator is evaluated against the list of criteria. A sample of the scores of this indicator in the category of scientific validity can be seen below:

Measurability: Is "number of fish killed" quantifiable? Yes (1)
Sensitivity: Are changes in conditions reflected in the measure "number of fish killed?" (1)
Anticipatory: Does "number of fish killed" show an early warning sign of environmental change (0) (fish have already been killed)

This question was answered for the remaining nine scientific validity criteria. The indicator "number of fish killed" met 83 percent of the criteria in the scientific validity category.

A sample of the scores that evaluate this indicator's practicality can be seen below:
Timely: Does it take less than 3 months to assemble and analyze the "number of fish killed?" Yes (1); this information is not complicated to assemble or analyze.
Level of Difficulty: Is a college education not required to collect the "number of fish killed?" Yes (1); this is a simple measure to acquire.
Is a college education not required to analyze and interpret the "number of fish killed?" Yes (1); this is a simple measure to analyze.

Operationalized questions were answered for the remaining three practicality criteria. The indictor "number of fish killed" met 100 percent of the practicality criteria.

A sample of the scores that evaluate this indicator's programmatic considerations can be seen below:
Relevance: Does "number of fish killed" provide information relevant to the mission of the organization? Yes (1); protecting fish is part of EPA's mission.
Understandable: Are the units of measure of "number of fish killed" commonly used by the general public or explainable in everyday nontechnical language? Yes (1); the general public is quite comfortable with this unit.

Operationalized questions were answered for the remaining four programmatic consideration criteria. The indicator "number of fish killed" met 100 percent of the programmatic criteria.

These percentages for criteria met listed above are included in Table 12 because "number of fish killed" is a condition indicator. The overall score for the indicator is 94 percent, the average of 83 (scientific validity), 100 (practicality), and 100 percent (programmatic consideration) in each category.

**Table 7. Average percent criteria met for EPA recommended condition indicators**

| Condition Indicators | Scientific validity | Practicality | Programmatic considerations | Overall |
|---|---|---|---|---|
| 1. Number of fish kills and fish killed | 83 | 100 | 100 | 94 |
| 2. Nonpoint-source sediment loadings from cropland | 92 | 100 | 83 | 92 |
| 3. Water meeting designated uses | 83 | 80 | 100 | 88 |
| 4. Number and percent of people with access to adequate sanitation | 75 | 100 | 83 | 86 |
| 5. Biological integrity | 92 | 60 | 100 | 84 |
| 6. Species at risk | 83 | 60 | 100 | 81 |
| 7. Population served by community drinking water systems violating health-based requirements | 75 | 60 | 100 | 78 |
| 8. Population served by community water system exceeding lead action levels | 75 | 60 | 100 | 78 |
| 9. Fish consumption advisories | 75 | 60 | 100 | 78 |
| 10. Contaminated sediments | 50 | 100 | 83 | 78 |
| 11. Number of native species at risk | 83 | 40 | 100 | 74 |
| 12. Percent of assessed water bodies with healthy biological communities | 83 | 40 | 100 | 74 |
| 13. Average seasonal soil nutrient content by location | 83 | 40 | 100 | 74 |
| 14. Number of species experience reduced range | 67 | 40 | 100 | 69 |
| 15. Ground and surface water pollutants | 75 | 40 | 83 | 66 |
| 16. River and stream miles designated as healthy, using Biological Integrity Assessments | 75 | 40 | 83 | 66 |
| 17. Biotic/ecosystem assessment indices (e.g. Index of biological Integrity) | 75 | 40 | 83 | 66 |
| 18. Number and percent of people exposed to toxins, by ethnicity and income | 50 | 40 | 100 | 63 |
| 19. Eutrophication conditions in estuaries, lakes and reservoirs | 64 | 40 | 83 | 62 |
| 20. Number and percent of population of served by wastewater treatment | 50 | 100 | 33 | 61 |
| 21. Number and level of pesticide residues found in food | 42 | 60 | 67 | 56 |
| 22. Number and percent of residents who consider their community beautiful | 58 | 40 | 67 | 55 |
| 23. Number and percent of people who express pride in their community | 58 | 40 | 67 | 55 |
| 24. Perceived quality of life | 42 | 40 | 83 | 55 |

**Table 8. Average percent criteria met for EPA-recommended stress criteria**

| Stress Indicators | Scientific validity | Practicality | Programmatic Considerations | Overall |
|---|---|---|---|---|
| 25. Wetland acreage | 83 | 100 | 100 | 94 |
| 26. Ratio of timber harvest to timber growth | 75 | 100 | 100 | 92 |
| 27. Total and per capita water supply withdrawal | 83 | 100 | 83 | 89 |
| 28. Rate of topsoil loss per year | 91 | 40 | 100 | 77 |
| 29. Land use/cover | 83 | 40 | 100 | 74 |
| 30. Degree and rate of fragmentation in watershed | 100 | 40 | 83 | 74 |
| 31. Transportation fuel consumption per capita (also social) | 58 | 80 | 67 | 68 |
| 32. Number of jobs dependent on resource extraction (also social) | 50 | 100 | 50 | 67 |
| 33. Miles of maintained walking, hiking, biking trails per 1,000 residents | 50 | 60 | 83 | 64 |
| 34. Number of people engaging in outdoor activities | 50 | 60 | 83 | 64 |
| 35. Energy consumption by use, per capital (also social) | 67 | 40 | 83 | 63 |
| 36. Materials used per capita, per output (also social) | 67 | 40 | 83 | 63 |
| 37. Percent of population within ½ mile of green space | 58 | 60 | 67 | 62 |
| 38. Marine debris | 42 | 60 | 83 | 62 |
| 39. Vehicle miles traveled per capita per year (also social) | 58 | 60 | 67 | 62 |
| 40. Percent of commuters within 30 minutes of work (also social) | 58 | 60 | 67 | 62 |
| 41. Pesticide use | 42 | 40 | 83 | 55 |
| 42. Percent of development within five minutes of stores, transit | 58 | 40 | 67 | 55 |
| 43. Modes of transportation to work (also social) | 33 | 80 | 33 | 49 |
| 44. Ratio of amount of raw resources exported vs. value-added exports | 50 | 40 | 50 | 47 |
| 45. Human migration and dispersal patterns (also social) | 25 | 40 | 50 | 38 |

**Table 9. Average percent criteria met for EPA-recommended activity indicators**

| Activity Indicators | Scientific validity | Practicality | Programmatic Considerations | Overall |
|---|---|---|---|---|
| 46. Number of users of CBWI tools | 50 | 100 | 83. | 77 |
| 47. Projects for which innovative organizational structures or cross-program or cross-division partnerships were established | 33 | 100 | 33 | 55 |
| 48. Amount of class time in environmental curriculum devoted to watersheds in local school | 41 | 80 | 33 | 51 |

**Table 10. Average percent criteria met for EPA-recommended organization indicators**

| Organization Indicators | Scientific Validity | Practicality | Programmatic Considerations | Overall |
|---|---|---|---|---|
| 49. Government spending on environmental issues | 58 | 100 | 67 | 75 |
| 50. Hours of CBWI-related training for the EPA staff and management | 50 | 100 | 67 | 72 |
| 51. Percentage of projects delineated by watershed | 58 | 100 | 50 | 69 |
| 52. Percentage of projects involving federal, state/tribal, local government, and community stakeholders | 50 | 100 | 50 | 67 |
| 53. Percentage of cross-media projects | 50 | 100 | 50 | 67 |
| 54. Percentage of projects involving economic and sociocultural goals | 50 | 100 | 50 | 67 |
| 55. Percentage of projects pursuing goals established by collaborative processes | 50 | 100 | 50 | 67 |
| 56. Partnerships developed with non-agency organizations | 42 | 100 | 50 | 64 |
| 57. Number of participants in environmental volunteer activities | 50 | 100 | 33 | 61 |
| 58. Resources and expertise | 25 | 100 | 50 | 58 |
| 59. Number and characteristics of projects | 25 | 100 | 50 | 58 |
| 60. Number of public/private partnership efforts to protect the environment | 42 | 100 | 33 | 58 |
| 61. Number of joint projects among municipal, county and state governments | 42 | 80 | 50 | 57 |
| 62. Number of CBWI-related staff | 33 | 100 | 33 | 55 |
| 63. Customer satisfaction with tools and information systems | 42 | 40 | 83 | 55 |
| 64. Number of art exhibits/shows that feature nature and wildlife | 42 | 80 | 33 | 52 |
| 65. Number and percent of environment-related articles in local media | 33 | 80 | 33 | 49 |
| 66. Number and percent of residents who list environmental health as a component of a better quality of life | 33 | 40 | 33 | 36 |

## Findings in the Evaluation of EPA-Recommended Indicators

The EPA-recommended indicators that rated most strongly across these criteria were those in the condition and stress indicator classes. This result is most likely a reflection of bias in the criteria toward outcome-related indicators. Activity and organization indicators were ranked much higher in the area of practicality because they are typically cheaper to obtain and often readily available. However, activity and organization indicators were much lower in the area of scientific validity, and programmatic considerations.

Despite the strength of the practicality associated with the activity indicators, EPA (1999) recommended only three activity indicators. It is surprising that more of these indicators are not suggested by EPA because activity indicators are direct indicators of activities carried out by the CBWI, and provide an easy way for any CBWI to keep track of its activities. However, activity indicators need to be specific to the chosen activities of an initiative and may not be as appropriate for EPA to prescribe.

Strong Indicators. The condition indicators scored higher than stress indicators in meeting the compiled criteria used in this analysis. The top indicators (scoring higher than 80 percent overall in all criteria categories) in the condition indicator group included:

- number of fish kills and fish killed (94 %)
- nonpoint-source sediment loadings from cropland (92 %)
- water meeting designated uses (88 %)
- number and percent of people with access to adequate sanitation (86 %)
- biological integrity (84%)
- species at risk (81 %)

The top ranking indicator "number of fish kills and fish killed" had a perfect score in the area of 100 percent in the two of the categories of indicator effectiveness: practicality and programmatic considerations. This indicator is already collected by the EPA and relates directly to EPA's mission to protect the environment. This indicator scored lower than "nonpoint-source sediment loadings from cropland" in the area of scientific validity. Sediment loadings were found to be stronger in the area of scientific validity than did the fish kills indicator, and was 100 percent in the area of practicality (because fish killed is not anticipatory). However, the major weakness of the "nonpoint-source sediment loadings from cropland" is that the indicator is not readily understood by the general public.

The top stress indicators were (over 80 percent ranking):

- wetland acreage
- ratio of timber harvest to timber growth
- total and per capita water supply withdrawal

The top ranking EPA-recommended activity indicator was "number of users of CBWI tools." The top ranking EPA-recommended organization indicator was government spending on environmental issues.

Over 80 percent of the EPA-recommended indicators met the following criteria: reproducibility, understandability, data archiving, data quality, reliability, data quality, reliability, affordability, and cost effectiveness. The EPA-recommended indicators as a whole can be referred to as being strong in these areas. The frequently achieved criteria for EPA-indicators span the three categories of indicator effectiveness (scientific validity, practicality, and programmatic considerations). Nine EPA-recommended indicators met over 80 percent of the literature-cited criteria including:

- number of fish kills and fish killed
- nonpoint-source sediment loadings from cropland
- water meeting designated uses
- number and percent of people with access to adequate sanitation
- biological integrity
- species at risk
- wetland acreage
- ratio of timber harvest to timber growth
- total and per capita water supply withdrawal

All but one of these strong indicators (water meeting designated uses) is weak in the area of scope and applicability because they are not specifically appropriate for a watershed scale. Many of these indicators failed the scope and applicability criteria. The only EPA-recommended indicators that consistently met these criteria were those recommended in the "range of issues" category (a category recommended by the EPA, but not used in this analysis). These indicators included such measures as "percentage of projects delineated by watershed" and "degree and rate of fragmentation in watershed." Such indicators can more easily be traced to a specific watershed. Other common weaknesses for these otherwise strong indicators included the criteria: anticipatory, timeliness, integrative of effects, and level of difficulty.

Weak Indicators. Criteria that were met by less than 50 percent of the EPA-recommended indicators included timeliness, importance, and availability. These weaknesses are not necessarily comparable to the indicators used in practice. State environmental protection agencies provide environmental reports on quarterly, bi-annual, or annual basis. Thus, timeliness of acquired data can be more of a problem in a large organization rather than a small CBWI. Importance was assessed based on the indicators' relevance to the EPA mission; EPA's mission is to protect human health and to safeguard the natural environment — air, water, and land— upon which life depends. Thus, an indicator that has a weakness in the area of importance at EPA, may not necessarily be weak in a CBWI, depending on the CBWI's mission. The types of indicators that meet the availability criteria are typically indicators that are already mandated (such as number of fish consumption advisories), or those that are already counted because counting is required for regular business (such as number of volunteers). A CBWI could potentially rely on EPA-collected data and the indicator would meet the "availability" criteria.

Importance and availability criteria were met by all of the strongest EPA-recommended indicators discussed above.

Weak EPA-recommended indicators, which met less than 50 percent of the evaluation criteria include:

- Modes of transportation to work (49 %)
- Number and percent of environment-related articles in local media (49 %)
- Number and percent of residents who list environmental health as a component of a better quality of life (36 %)

No condition indicators met less than 50 percent of the criteria. Again, this result illustrates the criteria's bias towards environmental results indicators. The weak indicators mentioned above are indicators that also measure social well-being. While the EPA-recommended indicators are not analyzed for sustainability considerations, the indicators above are the types of indicators that demonstrate a linkage between economics, environment, and social equity, and allow citizens to consider how their actions might affect the environment. The evaluation of the indicators used in practice includes a section that evaluates the indicators strengths and weaknesses in sustainability considerations.

## Evaluation of CBWI Indicators in Practice

An interview was conducted with James Connelly, AWS Executive Director, to verify that the list of collected indicators provided on-line was complete. The AWS reported five other indicators that were not included on their web site. These included:

- number of students attending environmental educational presentations
- number of adults attending environmental educational presentations
- number of wetland plants planted in river
- feet of streambanks stabilized
- fecal coliform

The interview with Wendy Parisi, Environmental Scientist, found that NepRWA also collected "conductivity" in addition to the indicators included in the preliminary list.

In addition to verifying the completeness of the indicator list, these interviews provided information on quality assurance processes, data archiving, and the organizations' financial and labor resources. Both organizations reported that they do not rely on much outside data, such as those produced by the USGS or EPA, to carry out their activities. NepRWA does not collect data pertaining to their advocacy efforts to measure the effectiveness of their labors.

Interview data were required to answer whether the programmatic consideration criteria question "Are these measures saved in an archive or database?" AWS reported that they maintain an ongoing tally of their activity data and provide the data in bulletins and on-line. Their *E. coli* data are maintained according to EPA standards. However, data that students collect on science field trips are not maintained because they are not considered to be scientifically sound—they are not collected at specific spots or at specific times, and the measurement instrumentation for these activities is not very sensitive. NepRWA maintains their scientific database of measurements and includes the data in reports that are provided on-line.

Both organizations go to great lengths to ensure the validity of their data. AWS follows EPA quality assurance standards in their *E. coli* measurements. There is no rigorous quality control for their activity measures, but indicators are frequently double-checked by an additional volunteer or staff person. NepRWA data are also checked by a second person. Each person collecting samples is required to take field duplicate samples. Duplicate samples must not exceed a certain "relative percent" difference from one another. This relative percent differs for each parameter measured. NepRWA also checks the quality of the laboratory analysis by sending blind samples with known nutrients to check on the labs. If there is a problem, it is noted in the records. They have a Quality Assurance Program document that has been approved by the EPA and state officials. Federal and Massachusetts EPA approve of their data analysis and data archiving procedures.

Information on these organizations' financial and labor resources was also required to complete the analysis below. NepRWA indicators require about 150 hours every two months on collection, and analysis requires a total of 24 hours every two-month period. Most of the indicator cost is covered by in-kind analysis donated by the laboratories. It costs about $100 per event to verify that meters are operating properly, a small percentage of NepRWA's $275,000 budget. AWS requires 3 hours per weekday for *E. coli* sample collection. The analysis is not carried out on-site, but after the results are received, another hour is used to call the boat centers and inform them of the day's results. The most expensive indicator to collect is the fecal coliform data. The activity indicators require about 10 or 15 minutes a day. Posting the data on-line each month costs about $5000, primarily in staff time. Total budget for AWS is $800,000 per year. Thus, the expense of indicator collection for each of these organizations is affordable and cost effective.

NepRWA is specifically funded to collect the condition indicators that they measure. AWS sponsors do not require specific indicators. Their sponsors are said to be interested in supporting public involvement, education, and advocacy work. Collecting data is not the mission of the AWS; the society is "more action oriented" (James Connelly, Executive Director, Anacostia Watershed Society, personal communication, February 2002). The exception is the collection of fecal coliform data, which the association is specifically funded to collect. The AWS started collecting the activity indicators to document their activities, demonstrate that their work is impressive, and provide "tangible" illustrations of their work.

The statements offered by the AWS demonstrate the dichotomy between initiatives that focus on volunteer monitoring and those that focus on volunteer mitigation efforts. The statement that AWS is "more action oriented," rather than scientifically oriented, implies that volunteer monitoring efforts are not about action. Meanwhile, NepRWA primarily collects indicators so that it can affect government decisions in the watershed, but does not collect data on its advocacy activities. If these two initiatives existed in the same watershed, a researcher could possibly investigate the relationship between feet of streambanks stabilized and total suspended solids; the relationship between trees planted and water temperature; the relationship between the number of storm drains stenciled and conductivity. These examples illustrate the potential power of collecting related condition and activity indicators within the same unit of analysis.

The majority of well-documented CBWI cases are normally characterized as successful; however unsuccessful efforts are typically not well documented (Kenney, 1997). Most researchers report that efforts are successful if they increase the level and quality of communication, but these efforts eventually must be evaluated in terms of improved resource conditions (Kenney, 1997). Communication appeared to be the primary reason that these CBWIs were collecting this data. However, beyond communication, these indicators can be used to support environmental planners in the development of three major steps for performance monitoring of cross jurisdictional management, including (1) defining the magnitude of environmental problems, (2) providing information for setting goals, and (3) establishing the basis for showing progress (Jones, 2000). These three steps would need to be developed so that CBWIs can demonstrate effectiveness in terms of impact on resource conditions.

The analysis below evaluates the extent to which commonly used indicators of CBWIs adhere to the criteria of effective indicators, so that a determination can be made as to whether they are sufficient for performance monitoring of community-based watershed efforts. The strengths and weaknesses of these indicators are assessed. Determination of whether these indicators are sufficient to support decision making is important for understanding the role of CBWIs and the use of effective indicators in environmental planning.

## NepRWA Indicator Assessment

All of NepRWA's indicators are condition indicators. The results of this evaluation are illustrated in Table 11. Almost all of the indicators met 100 percent of the scientific validity criteria. The exception was the *E. coli* measurements. These criteria were not considered to be anticipatory because they do not provide an early warning sign. These measures indicate that a problem has occurred rather than showing a steady increase that should be slowed.

**Table 11. Average criteria met by Neponset Watershed and River Association Indicators**

| NepRWA Indicators | Scientific Validity | Practicality | Programmatic Considerations | Overall |
|---|---|---|---|---|
| **Condition Indicators** | | | | |
| Temperature | 100 | 80 | 100 | 93 |
| PH | 100 | 80 | 83 | 88 |
| Total suspended solids | 100 | 80 | 83 | 88 |
| Total nitrogen | 100 | 80 | 83 | 88 |
| Nitrate plus nitrite | 100 | 80 | 83 | 88 |
| Ammonia | 100 | 80 | 83 | 88 |
| Total phosphorous | 100 | 80 | 83 | 88 |
| Orthophosphate | 100 | 80 | 83 | 88 |
| Dissolved oxygen | 100 | 80 | 83 | 88 |
| Conductivity | 100 | 80 | 83 | 88 |
| *E. coli* | 92 | 80 | 83 | 85 |

The indicators collected by NepRWA are not strong in the area of practicality because they require a high level of expertise to analyze, and they are not readily available. However, this association is funded for the sole purpose of collecting these indicators. As a result, the impracticality of collecting these difficult-level indicators cannot be a limiting factor to this association. Analysis of these indicators requires considerable expertise, which under common circumstances would be unaffordable to such an association. However, the association relies heavily on the in-kind laboratory services, which makes these indicators a lot more practical to this organization than they might be under different circumstances.

All of the indicators collected by NepRWA met many of the programmatic consideration criteria because these condition indicators are measures of important environmental quality parameters and very much a part of the mission of the association. Temperature and pH measures rated slightly higher than the other indicators because temperature degrees and pH values are more readily understandable to the public at large.

NepRWA indicators were weak in meeting the criteria for understandability, difficulty level, and availability. The vast majority of NepRWA indicators were strong in all but three categories. Although the collection of the highly scientific indicators is difficult, NepRWA takes many steps to ensure data accuracy and quality in creating their measures—contributing to the organization's high ranking in the category of scientific validity.

All of NepRWA's indicators are chemical parameters. Most of the indicators were weak only in the area of "understandability," except for temperature. Scientific indicators that are commonly reported in chemical micrograms or parts per million can potentially intimidate lay people when reading about water quality. Such measures can be balanced out with more understandable indicators such as "number of fish killed," "species at risk," or "water meeting designated uses." Level of difficulty in obtaining these indicators is a criterion that affects the activities of this organization less than other organizations. NepRWA receives in-kind services to provide the analytic expertise necessary to produce these scientific indicators, so they are indeed practical even though the collection requires a high degree of difficulty. This association exists for the purpose of collecting these indicators, so the fact that they are not readily available is not actually a practical consideration for the association.

NepRWA relies heavily on its volunteer monitoring program to create the information needed for their advocacy and outreach efforts. The goal of the association is to "achieve fishable, swimmable (Class B) water quality, and ensure that the public is able to gain access to and enjoy their local waterways and wildlife. However, the organization only maintains informal records of the results of their advocacy efforts. There are no activity indicators that are collected to keep track of these efforts. For example, NepRWA could maintain records of number of hours spent giving presentations to government decision-makers. This effort would allow researchers to realize relationships between the associations activities and the outcomes that it is currently measuring. NepRWA seems to regard their indicator collection as a tool to affect change, rather than a tool to measure the outcomes of their efforts. However, without monitoring their advocacy activity input, the organization will not be able to contribute any improvements in watershed health as a result of their actions.

## AWS Indicator Assessment

Most of the indicators collected by the AWS are activity. The results of this indicator evaluation can be seen in Table 12. There are only a few organization and one condition indicators among those measured by this initiative. The condition indicator measured is not related to measuring the outcomes of the AWS activities. The indicator that met the highest number of criteria is "feet of streambanks stabilized." "Number of trees planted" and "numbers of wetland plants planted" are close seconds.

**Table 12. Average criteria met by Anacostia Watershed Society Indicators**

| AWS Indicators | Scientific Validity | Practicality | Programmatic Considerations | Overall |
|---|---|---|---|---|
| **Condition Indicators** | | | | |
| Fecal coliform | 92 | 60 | 83 | 78 |
| **Activity Indicators** | | | | |
| Feet of streambanks stabilized | 83 | 100 | 100 | 94 |
| Number of trees planted | 75 | 100 | 100 | 92 |
| Number of wetland plants planted in river | 75 | 100 | 100 | 92 |
| Tons of debris removed | 67 | 80 | 83 | 77 |
| Number of tires removed | 58 | 100 | 50 | 69 |
| Number of storm drains stenciled | 58 | 100 | 33 | 64 |
| **Organization Indicators** | | | | |
| Number of adults attending environmental educational presentations | 58 | 100 | 50 | 69 |
| Number of students attending environmental educational presentations | 58 | 100 | 50 | 69 |
| Number of volunteers | 58 | 100 | 33 | 44 |

As opposed to the NepRWA indicators, most of these measures are highly understandable to the public at large. Half of the indicators appear to be strong in the area of programmatic considerations such as "tons of debris moved". However, "number of tires removed," "number of storm drains stenciled," and the organization indicators—"number of students attending environmental educational presentations," "number of adults attending environmental educational presentations," and "number of volunteers"—did not rate very high in the programmatic area.

All of the indicators (except for the *E. coli* levels) were very practical to collect. However, the AWS indicators (except for the *E. coli* levels) did not prove to be very high in the area of scientific validity. The criteria related to scientific validity tend to be outcome oriented. Mr. Connelly indicated that the AWS was more interested collecting measures to indicate what the organization had done, rather than what impact these activities had on the watershed.

More than 80 percent of AWS indicators met the criteria categories availability, difficulty level, understandability, measurability, reliability, reproducibility, representation, timeliness, affordability, cost effectiveness, and data archiving. The AWS indicators are strong in these areas primarily because this organization does not collect very complicated measures. All of the practicality criteria are met by all AWS indicators, except fecal coliform and tons of debris removed. The reason that these measures are less practical than the others is that they are not readily available; a member must specifically collect and analyze the coliform data and tons of debris must be weighed.

AWS indicators met less than 50 percent of the criteria in the areas of validity/accuracy and importance. The AWS indicators were fairly weak in the areas of scientific validity and programmatic considerations. The major exceptions to these weaknesses are their condition indicators of “feet of streambanks stabilized,” “trees planted,” and “number of wetland plants planted.” The primary reason for the common weaknesses in the AWS indicators is that the society views itself as “more action oriented” than concerned with collecting environmental quality indicators. The AWS collects indicators primarily to demonstrate their work in a “tangible” form to the sponsors and excite members about their work. However, without maintaining records of improvements in watershed health, they cannot prove to their sponsors that their efforts are resulting in improved environmental conditions.

## Sustainability Considerations

In order for an initiative to assess its effectiveness in addressing sustainability considerations, it must measure impacts in a more integrative way. Each specific indicator does not necessarily need to reflect economic, environmental, and social issues itself, but an initiative’s set of indicators should touch on all four of the sustainability criteria outlined previously—address carrying capacity, be usable by the community, provide a long-term view, and show links between environmental, economic, and societal considerations. Overall, NepRWA’s set of indicators meet 25 percent of the sustainability criteria, consistently providing information on long-term impacts. The remaining sustainability considerations (carrying capacity, usability by the community and crosscutting linkages) are not addressed at all by the NepRWA indicators. AWS meets 50 percent of the sustainability consideration criteria. These indicators provide information on long-term impacts, but also are usable to the community.

AWS met twice as many sustainability considerations as were met by NepRWA. This result is due to the fact that AWS indicators can be considered to be more usable to the community as operationalized in this context. In the context of sustainability, usability means that the indicator provides information that could potentially alter human behavior. AWS indicators on number of tires and tons of debris collected could inform a community on how human littering habits can accumulate and impact watershed aesthetics substantially.

While NepRWA and AWS both collect information that can provide information on longterm environmental impacts, neither organization addresses carrying capacity or crosscutting measures. Crosscutting measures show linkage between society, environment and economics. In the long run, environmental degradation will lead to a declining economy (NRC, 2002).

Examples of crosscutting measures include vehicle miles traveled or percentage of recyclables used. Such measures can be contrasted to traditional measures such as the water quality parameters collected by NepRWA.

As stated previously, no organization could practically acquire and use all of the EPA-recommended indicators, and as a result, the sustainability analysis was not carried out for the EPA indicator set. However, some of these indicators are illustrative of the types of crosscutting measures that prescribe to the sustainability criteria. Examples of these include:

- Modes of transportation to work (49 %)
- Ratio of amount of raw resources exported vs. value-added exports (47 %)
- Human migration and dispersal patterns (38 %)

Such indicators demonstrate a linkage between economics, environment, and social equity, and allow citizens to consider how their actions might affect the environment. These indicators provide an example to community-based watershed initiatives as to the types of creative indicators that can be used to integrate sustainability considerations into their performance measurement plans.

## Methodological Considerations

The study methodology used in this study was developed to assess indicators in an objective way. However, the operationalization questions still allow a degree of subjectivity because the scoring was based on researcher judgment. For example, does the indicator "Percent of commuters within 30 minutes of work" measure an aspect of environmental quality of national importance?" The question was marked as "No" in this analysis. The rationale was that commuters within 30 minutes of work gives no information regarding how each person gets to work—do they walk, do they bike, do they fly, or drive a vehicle with low gas mileage? The answer to this operationalization question illustrates the difficulty of answering complicated questions with a simple yes or no question. A more complex scoring system could potentially be developed to better accommodate such issues. However, 23 criteria were used to assess each indicator. Any difficulty in answering these yes-no questions would result in only a 4 percent change. Four percent may be enough to affect an indicator's relative ranking to another, but the range of strongly ranked indicators is 80 to 100 percent. In addition, specific weaknesses of the strongly ranked indicators were discussed.

A focus group could be called upon to evaluate the author's judgment in this research. This focus group could include experts in related fields such as natural resources management, urban planning specialists, and experts in indicator development. Such a panel would be well-suited to evaluate the operationalization of each of the criteria compiled for this analysis. The panel would also be able to validate and reify the judgment of the author for each of the yes-no questions answered in this analysis. Finally, this panel would be able to determine whether any of these criteria are more important than others and determine a weighting strategy to weight more important criteria more heavily than those deemed less important.

This analysis does not provide an indication of how well each indicator scores across the entirety of the criteria for successful indicators. Applying the balanced score-card approach to this research would provide a basis to understand how well each indicator is addressing these criteria overall. This study is open for further validation with more refined statistical analysis.

Finally, this evaluation of indicators used in practice considered two case studies. A more extensive sample of cases may reveal that some CBWIs are adept at measuring a variety of useful indicators for performance monitoring. Alternately, a more extensive study may provide a stronger case for the need to advise CBWIs on the importance of performance monitoring to demonstrate their effectiveness. A future study could potentially apply this study methodology to evaluate a wider range of CBWIs and their indicators. Using a well-recognized case study selection guide such as R. K. Yin's *Case Study Research, Design and Methods (*1994) would provide a good reference to develop the next set of case studies with which to apply this method.

# Conclusions

The objective of this research was to evaluate the strengths and weaknesses of indicators recommended by EPA and those used in practice. This major paper includes a compilation of literature-cited criteria for effective indicators, and explores the extent to which EPA-recommended environmental indicators and CBWI case study indicators adhere to these academic criteria. These criteria were operationalized in a way that allows these qualitative traits to be quantified, in the construction of an evaluatory framework for this analysis.

This method was applied to recommended indicators cited in the EPA's *Framework for Community-Based Environmental Protection* (1999), and these indicators were analyzed according to the literature's criteria. Only 9 of 66 EPA-recommended indicators met over 80 percent of the literature-cited criteria. Most of the indicators were frequently strong in the areas of reproducibility, understandability, data archiving, data quality, reliability, data quality, reliability, affordability, and cost effectiveness. The majority of these indicators were lacking in the areas of timeliness, importance, and availability. The weakest EPA-recommended indicators emphasized social relevance. This result illustrates a bias in the criteria toward environmental impacts, rather than social or economic impacts and the need for sustainability analysis as component of this evaluation.

The EPA-recommended criteria tended to be quite strong in terms of scientific validity and emphasized condition indicators. However, there was not as much emphasis on activity indicators. While CBWIs, planners, and CBWI sponsors might be able to use this list of indicators to recommend strong condition, stress and organization indicators, it is recommended that these groups consider the evaluation criteria and community indicator principles in developing activity indicators for use in practice.

Although some of the indicators evaluated in this research may score high, it does not necessarily mean that the indicator will be effective in every context. The criteria used in this analysis, "relevance," is operationalized as "Does this indicator provide information relevant to the mission of the organization?" Because the concept of performance monitoring requires addressing a specific set of goals, this criterion is especially important for an organization to address with their indicators.

Performance measurement should be a part of an organization's management plan and relate directly to its goals. A framework for performance assessment should include a balanced set of measures, target setting, benchmarking, and objective-setting collaborations (Gore, 1997). Using the methodology and applying a balanced score-card approach would provide a basis for an organization to determine a balanced set of measures. Based on the goals of the organization, it would be necessary for the organization to develop targets for each of these indicators to reach in order to monitor progress. Measurement information can be used to set goals and standards; determine problems, improve processes, and record accomplishments (Gore, 1997). However, these objectives can be achieved by measurement alone, but by integrating monitoring, target setting and benchmarking into the organization's performance measurement plan.

When organizational input and outcome indicators are monitored over a period of time, a determination can be made as to whether an organization's inputs have been effective. By making this determination, it is possible to redesign an organization's activities to improve outcomes or soundly decide to continue operating as usual. This approach is called "adaptive management," and is one of the major operating principles defined by the Ecological Society of American (Christensen et al, 1996) in their Guide to Ecosystem Management. The Lake Tahoe Regional Planning Agency has been successful in protecting its watershed as it has set specific threshold measures, monitors these measures, and practices adaptive management strategies based on the outcomes of these measures (Murphy and Knopp, 2000). Without performance measurement and adaptive management strategies, CBWIs cannot be sure that their efforts are effective as they can be.

The Anacostia Watershed Society reported that the Anacostia Watershed Network collected condition indicator data. These data—such as sediment, toxics, and debris—are made available as information in a report, but not as raw data. Future research could entail acquiring these data to examine potential cause-effect relationships of CBWI activities, e.g., feet of streambanks stabilized in relation to sediment loadings. Such a study might provide a basis for assessing the effectiveness of CBWIs. Another future study could include an analysis of CBWI funding institutions to gain a better understanding of why performance monitoring is not commonly required.

This research set out to determine whether commonly used indicators obtained by community-based watershed initiatives were sufficient for performance monitoring of their efforts. Based on the analysis of indicators used by two case studies, CBWI in-practice indicators can be considered insufficient for performance monitoring. Many of the indicators used by these case study initiatives met the majority of the literature criteria for indicator effectiveness. However, the indicators failed to span the indicator categories necessary to determine cause and effect relationships. Additionally, the two case studies did not rely on outside data acquisition to attempt to prove the effectiveness of their activities. The case studies used their indicators primarily as a means to communicate with their sponsors, not as a means to evaluate the impact of their efforts.

The method developed for the purposes of the analysis in this paper is significant for several reasons. First, it provides a simple platform by which to quantify qualitative characteristics. Second, this method allows inherent biases in the literature-cited criteria to be recognized because different indicator classification levels and categories of indicator effectiveness are easily sorted. Third, the method allows provides a way to rank indicators relative to one another in specific categories of indicator effectiveness. Finally, this method provides information not only on overall trends in the sets of indicators, but allows specific weaknesses in each indicator to be readily apparent.

This method can be adopted by CBWIs to develop their initial set of indicators within their performance measurement plan. There is no magic bullet set of indicators that will apply to all CBWIs because sensitivity to context and organizational goals is necessary for indicators to be considered strong. CBWIs can, however, use the analysis of the EPA-recommended indicators to find indicators that are strong in the context of their organizational goals. In addition, CBWIs should strive to measure a collection of indicators that meet as many of these criteria as possible. Finally, a variety of indicator classes is necessary to determine the efficacy of CBWI activities in each organizational context and these efforts as a whole.

# SUMMARY

There is increasing pressure on federal agencies to demonstrate the effectiveness of their program investments. The Government Performance Results Act of 1993 (Section 5501 of Title 15, PL 103-62) requires agencies to "establish performance indicators to be used in measuring or assessing the relevant outputs, service levels, and outcomes of each program activity." While this mandate is not new, technology is now enabling the performance of agency investments to become more transparent through the recently passed E-gov Act (Public Law 107-347) which aims to improve the effectiveness and efficiency throughout the federal government.

These federal mandates and required investment transparency will also affect state and local investments that are supported by federal funds. As state and local planners grapple with the need to demonstrate the effectiveness of their investments, how will they be able to justify sponsoring community-based efforts that offer no proof of effectiveness? In both case studies, the indicators were collected either for the benefit of their sponsors or specified by the sponsor. Thus, funding sources have a potential role to play in informing these CBWIs on the importance of performance monitoring.

CBWIs and community-based environmental protection efforts are assumed to be effective in much of the literature on the topic. This study provides a method and example for planners to analyze the potential for CBWIs indicators to be used in performance monitoring. By adopting such a methodology, planners can determine specific weaknesses in the array of indicators collected by various associations on a watershed basis. In addition, this evaluation framework can enable planners to determine what measurements are needed to complement those collected, so they can better support their environmental decision making needs.

Based on the conclusions from these analyses, the insufficiency of commonly used indicators cannot provide a basis for performance measurement of CBWI activities. This study is an important assessment of the underlying measures that currently support decision making in environmental and community planning. CBWIs can take advantage of this methodology to improve their ability to demonstrate the effectiveness of their activities. This evaluation and methods used in this research are a first step to improve researchers' ability to determine the efficacy of these watershed efforts.

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# Appendix A
# Interview Protocol

Interview for Anacostia Watershed Society and Neponset River Watershed Association

I. Opening:
Hello. This is Monica Lipscomb and I am a graduate student in Virginia Tech's Department of Urban and Regional Planning. I am working on a major paper concerning the strengths and weaknesses of indicators used by community-based watershed initiatives. I have selected this organization as one of the case studies that I am evaluating in this paper. I would like a few minutes of your time to discuss indicators used by the Anacostia Watershed Society/ Neponset River Watershed Association. I would also like to have permission to use your name in this paper.

II. Indicators used by AWS

A. I have gathered a list of indicators used by AWS that were available on your Web site and I'd like to verify whether the list is complete. These include the following:
   - number of volunteers,
   - number of trees planted,
   - number of storm drains stenciled,
   - tons of debris removed,
   - number of tires removed,
   - and number attending educational presentations.

   Is this a complete list of the indicators collected by AWS?

B. Does the AWS maintain the water monitoring data collected during its educational programs? What data are collected?

C. Are there any other indicators that AWS uses from other organizations or agencies to measure the progress or impacts of its activities?

D. What indicators are required by your funding organizations?

II. Indicators used by NepRWA

A. I have gathered a list of indicators used by the Neponset River Watershed Association that were available on your Web site and I'd like to verify whether the list is complete. These include the following:
   - fecal coliform bacteria,
   - total suspended solids,
   - total nitrogen,
   - nitrate plus nitrite,
   - ammonia,
   - total phosphorous,
   - orthophosphate,
   - pH,
   - temperature,

- and dissolved oxygen.

Is this a complete list of the indicators collected by NepRWA?

B. Are there any other indicators that NepRWA uses from other organizations or agencies to measure the progress or impacts of its activities?

C. Does NepRWA keep a record of the changes in development patterns that occur as a result of its advocacy efforts?

D. What indicators are required by your funding organizations?

III. Indicator collection methods

A. What is the method used to obtain these indicators?
B. How are these data stored?
C. What kind of documentation is included with these records?
D. How are the data verified for accuracy? Is there a double-checking?

IV. Resources

A. How many hours are spent on data collection per month?
B. How much time is required to analyze these data?
C. How much money is spent on collecting indicators?
D. Which indicators cost the most money to collect and why?
E. What is the total budget for the organization?

V. Thank you very much for your time. If you wish, I will provide a copy of this paper to you after the report is completed. What is your address, so that I can mail it to you?

# Appendix B
# IRB Exemption Letter

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

**Institutional Review Board**
Dr. David M. Moore
IRB (Human Subjects) Chair
Assistant Vice Provost for Research Compliance
CVM Phase II - Duckpond Dr., Blacksburg, VA 24061-0442
Office: 540/231-4991; FAX: 540/231-6033
e-mail: moored@vt.edu

22 January 2003

**MEMORANDUM**

TO: Maria Papadakis UAP 0113
Monica Lipscomb UAP 0113

FROM: David M. Moore

SUBJECT: IRB EXEMPTION APPROVAL – "A Critical Analysis of Indicators of Effective Community-based Watershed Initiatives" – IRB # 03-029

I have reviewed your request to the IRB for exemption for the above referenced project. I concur that the research falls within the exempt status. Approval is granted effective as of January 21, 2003.

cc: file

# Vita

Monica R. Lipscomb was born in Tucker, Georgia on September 26, 1974. In 1991, she was an exchange student in Helsinki, Finland in the Youth for Understanding Program. When she returned to the U.S., she moved with her family to New York City. After graduating from the Peddie School in Hightstown, New Jersey, she earned B.S. in Environmental and Forest Biology from the State University of New York, College of Environmental Science and Forestry in Syracuse, New York. She moved to Washington, D.C. in 1997 to work as a biologist at the National Cancer Institute's Laboratory of Molecular Biology. In 2000, she served as a Peace Corps volunteer in Côte d'Ivoire, where her service was interrupted by a coups d'etat. She currently works as a Research Assistant for the National Research Council's Board on Earth Sciences and Resources in Washington, D.C. This major paper completes her Master of Urban and Regional Planning degree with a concentration in Environmental Planning from Virginia Polytechnic Institute and State University.