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ENVIRONMENTAL PROTECTION INDICATORS FOR CALIFORNIA: A FRAMEWORK FOR CAL/EPA'S ENVIRONMENTAL INDICATOR SYSTEM

CHAPTER 1. INTRODUCTION

The directive

Secretary Winston Hickox set forth a new direction for the California Environmental Protection Agency (Cal/EPA) in the *Strategic Vision*[1] document, released in July 2000. This new agency orientation is based on a recognition of the need to utilize novel strategies to address the complex environmental challenges of the twenty-first century. In the *Strategic Vision*, a commitment is made to focus on measurable environmental results to guide the State's environmental protection programs. To support this commitment, the adoption of environmental indicators as part of the Agency's planning and decision-making processes was established as a priority.

Recognizing the need to address environmental protection issues in tandem with resource management issues, Secretary Hickox and Resources Secretary Mary Nichols agreed to collaborate in the development of environmental indicators for areas of overlapping responsibility.

Environmental indicators present scientifically-based information on the status of, and trends in, environmentally-related parameters. They convey complex information in a concise, easily understood format, and have a significance extending beyond that directly associated with the measures from which they are derived. Environmental indicators will support the development and implementation of a "results-based management system" for Cal/EPA. The indicators, as part of the strategic planning process, will be considered in formulating policy, allocating resources, and adjusting priorities. In addition, environmental indicators will be used in communicating information about the status of, and trends in, California's environment to the public.

Environmental indicators will help track progress toward meeting the following goals specified in the *Strategic Vision* document:

- Air that is healthy to breathe, and sustains and improves our ecosystems, and natural and cultural resources.
- Rivers, lakes, estuarine, and marine waters that are fishable, swimmable, support healthy ecosystems and other beneficial uses.
- Groundwater that is safe for drinking and other beneficial uses.

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- Communities that are free from unacceptable human health and ecological risks due to exposure from hazardous substances and other potential harmful agents.

- Ensure the efficient use of natural resources.

- Eliminate the disproportionate impacts of pollution on communities.

The Office of Environmental Health Hazard Assessment (OEHHA) has been directed to lead a collaborative effort to develop and maintain environmental indicators. The Environmental Protection Indicators for California or "EPIC" Project was created to carry out this directive. Over the past year, OEHHA has been working closely with others to develop a process for identifying and selecting environmental indicators, and to generate an initial set of indicators. Collaborators in the project include technical staff from the boards and departments of Cal/EPA, the Resources Agency, the Department of Health Services, and Region 9 of the U.S. Environmental Protection Agency (U.S. EPA).* Input into the project is provided by an Interagency Advisory Group of policy-level representatives from various State agencies and U.S. EPA, and by an External Advisory Group consisting of representatives of non-profit environmental/public interest groups, local governments, the private sector, and academia.

The process for the identification and selection of environmental indicators, and the initial set of indicators, are the subject of this document. This process is intended to guide for ongoing and future work in maintaining and developing environmental indicators, and may be revised as needed.

Overview of Environmental Indicators

Increasing concern over environmental issues in recent decades has prompted efforts to develop environmental indicators. These indicators provided a means of simplifying environmental data for decision-makers and the public[2]. The early work of the Organisation for Economic Co-operation and Development (OECD), an international organization charged with promoting policies to achieve sustainable economic growth, was most notable in the field. In 1989, the OECD Council called for further work to integrate environment and economic decision-making[3], a charge which was echoed in a request to OECD by the Group of Seven economic powers after its Economic Summit in the same year[4]. The OECD had also launched a program of environmental performance reviews to help improve the individual and collective performance of its member countries in environmental management.

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* See Appendix A for a list of collaborators.

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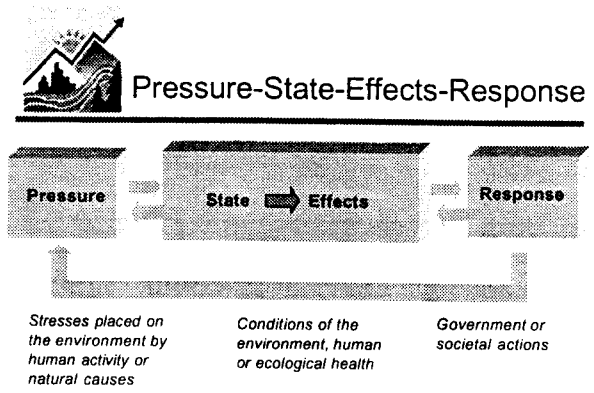
Environmental indicators are used by international organizations (such as OECD and the United Nations[5,6]), by many countries (most notably The Netherlands[7], Canada[8], New Zealand[9], and Australia[10]), by the federal government (U.S. EPA), by other states (such as New Jersey[11] and Florida[12]), and by governmental and non-governmental organizations at the regional and local levels (such as the City of Santa Monica[13] and the Silicon Valley Environmental Partnership[14]). Uses of environmental indicators by these various entities range from the communication of information about the state of the environment to providing specific considerations for strategic planning, goal-setting, and policy-making.

Conceptual model for environmental indicators

Most environmental indicator systems are built around the "pressure-state-response" (PSR) model developed by OECD, or a variation thereof, such as the "pressure-state-effects-response" (PSER) developed by the U.S. EPA's Office of Policy, Planning and Evaluation[15].

The PSER model is based on a concept of causality (see Figure 1). Human activities (as well as natural causes) exert ***pressures*** on the environment. For example, the use of leaded gasoline in vehicles until the 1970's resulted in lead emissions in vehicle exhaust. These pressures can change the quality and quantity of natural resources, the ***state***. In the example given, the lead emissions would result in increased concentrations of lead in air, which can result in elevated human blood lead levels. Changes in the state can then result in one or more adverse ***effects*** on human and ecological health: e.g., reduced IQ in children, in



Adapted from: Organisation for Economic Cooperation and Development, 1993

Figure 1

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the case of lead. Society may then react to these changes by enacting new policies and regulations, the ***response***. The banning of lead as a gasoline additive is an example. In principle, the new policies or guidelines should reduce the pressure, thus relieving pressure on the state and reducing the effect. Certain responses may also be directed at the ***state***, such as efforts to clean up sites contaminated with leaded gasoline. In some cases, the ***state*** may affect the pressure.

A further refinement of the PSER model is used by the Chesapeake Bay Program, a partnership of federal, state and local governments, as its "hierarchy" of indicators[16] (Figure 2).

The indicators in this model can be characterized by their position in the hierarchy on a six-level scale, as follows:

Level 1: Actions by regulatory agencies
(example: issuance of a discharge permit)
Level 2: Responses by the regulated and nonregulated community
(example: compliance with allowable pollutant discharge limits)
Level 3: Changes in discharges/emission quantities
(example: discharge of a pollutant)
Level 4: Changes in ambient conditions
(example: water concentrations of a pollutant)
Level 5: Changes in uptake and/or assimilation
(example: uptake of pollutant by aquatic organisms)
Level 6: Changes in health, ecology or other effects
(example: changes in population of aquatic organisms)

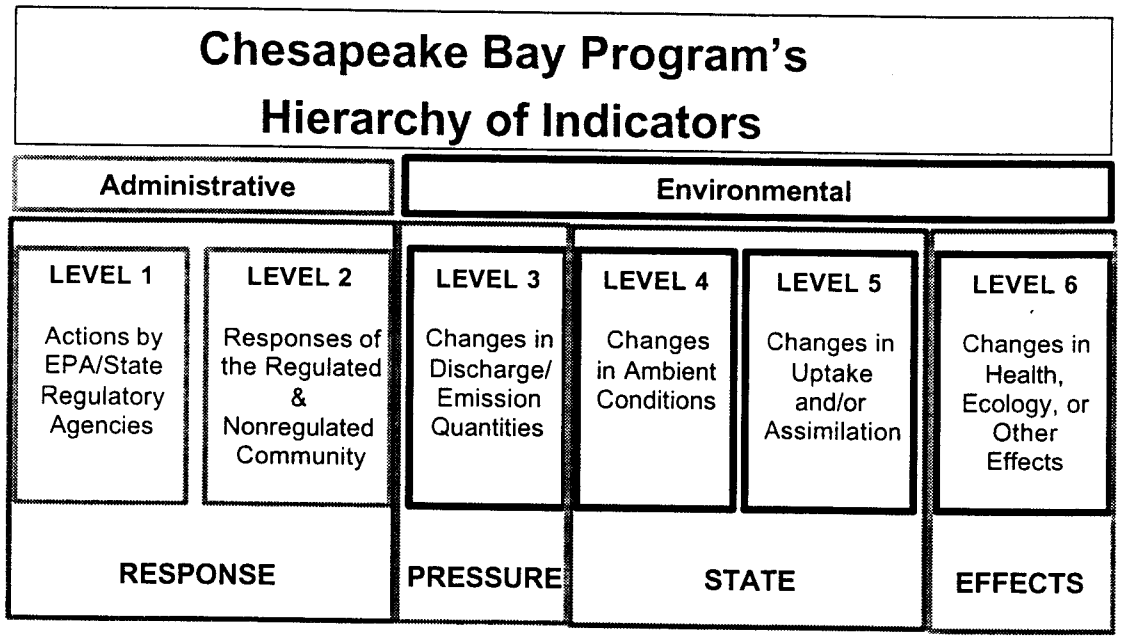

Figure 2

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Although the indicators toward the higher end of the continuum (levels 4 through 6) portray a clearer, more direct image of the environmental condition, indicators at the lower levels (levels 1 through 3) are needed to establish a link between the actions taken and effects observed. It is important to maintain indicators along the continuum in order to demonstrate the linkage between human activities and responses in the natural system.

The focus of the EPIC Project is on the environmental indicators, Levels 3 through 6. Administrative indicators, Levels 1 and 2, are addressed by the Cal/EPA boards and departments in their strategic plans and work plans.

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CHAPTER 2.
A FRAMEWORK FOR THE ENVIRONMENTAL PROTECTION INDICATORS FOR CALIFORNIA (EPIC) SYSTEM

Scope of the EPIC Project

The EPIC Project develops and maintains an environmental indicator system that:

- Reflects an issue that affects California, or a global or transboundary issue of interest to California.
- Relates to the missions of Cal/EPA and its boards, department and office. To the extent that these missions overlap with those of the Resources Agency, the Department of Health Services and other State agencies, those areas will be addressed by the project.
- Measures pressures exerted on the environment by human activities, ambient environmental conditions, or effects on human or ecological health. Measures of program performance, activity, efficiency or outputs are not within the scope of the project*.

These qualifying considerations will guide the determination of important environmental issues and sub-issues from which indicators are developed.

The Indicator Identification and Selection Process

The process of first identifying, then selecting indicators under the EPIC Project is illustrated in the flowchart in Figure 3 on Page 10.

Identification of environmental issues. The identification of significant environmental ***issues*** for California provides a focus for indicator development. Whenever possible, components of the issues, or sub-issues, are identified. Related issues and sub-issues are organized into an ***issue structure***. The issue structure provides a starting point for the identification of possible environmental indicators. The issue structure is intended be flexible to allow the addition, removal or modification of issues and sub-issues in the future.

During the first year of the EPIC Project, issues were identified based on input from internal staff, as well as from participants at a two-day conference (*Environmental Protection Indicators for California: Building an Environmental*

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* Appendix B provides information on the range of indicators that can be used to assess an organization's performance.

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Definition of Terms Used in EPIC

Parameter: A property (e.g., pollutant concentration, pollutant discharge quantities, chemical body burden, etc.) that is measured or observed.

Measure: Raw or analyzed data obtained from monitoring, surveys and other valid data collection methods. Measures form the basis for environmental indicators.

Environmental indicator: A value that presents scientifically based information on the status of, and trends in, environmentally-related parameters. An indicator conveys complex information in a concise, easily understood format, and has a significance extending beyond that directly associated with the measure(s) from which it is derived.

Integrative Indicator: An indicator which a captures multiple aspects of a given issue or system in such a way that its significance extends beyond the measure(s) from which it is derived to a greater degree than other available indicators.

Index: A type of environmental indicator derived from a set of aggregated or weighted indicators or measures.

Indicator suite: A group of indicators that collectively present information on major environmental issues, such as climate change, toxic contamination, biological diversity, hazardous waste, pesticides, ecosystem health, and use of natural resources (energy, fisheries, forests, public lands, soil and water).

Issue: A topic of environmental concern to California, including its components or dimensions, or sub-issues. Environmental issues can exist on a local to statewide scale, and provide the foundation for identifying environmental indicators.

Issue structure: The organization of issues and sub-issues that are used to guide the development of environmental indicators.

Indicator System for Cal/EPA, held January 18 and 19, 2001 in Sacramento), and the Interagency and External Advisory Groups. Similar issues were grouped into issue categories (i.e., air quality, water, land/waste/materials management, pesticides, human health, ecological health, and transboundary issues). Although various ways of organizing issues were explored, the issue categories chosen paralleled areas of authority in Cal/EPA. This facilitated the identification of possible indicators and data sources.

Identification of relevant parameters. Each issue is examined to determine whether relevant properties or ***parameters***, which can then be used to derive candidate indicators, can be identified. The inability to identify a parameter usually

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reflects a lack of understanding of the issue. Further investigation will be necessary to establish the relevant parameters for that issue.

Identification of candidate indicators. Where one or more parameters can be identified for an issue, various ways of presenting these, individually, or in combination with other parameters, will be identified.

Example of parameters and associated candidate indicators:

For ozone as a criteria air pollutant, parameters can include:

- emissions of ozone precursors (i.e., nitrogen oxides and volatile organic compounds);
- ambient ozone concentrations;
- number of exceedances of certain regulatory standards; and,
- vehicle-miles traveled.

Candidate indicators can include:

- total Statewide ozone precursor emissions per year;
- Statewide ozone precursor emissions per year per vehicle-mile traveled;
- maximum Statewide ozone concentration per year; and,
- total number of days of exceedances of California standard.

Evaluation of Candidate Indicators based on Primary Criteria. To ensure that EPIC indicators are of consistently high quality, candidate indicators are evaluated to verify that they meet all primary criteria. An assessment is made regarding whether the data for the candidate indicator are collected using methods that are scientifically acceptable and that they support sound conclusions about the state of the system or issue being studied. In addition, the candidate indicators must closely represent the issue, be sensitive to changes in the issue being measured, and provide a meaningful basis for decision-making.

Ideally, an indicator should, at a minimum, meet all these criteria. However, there are special circumstances when the only available data set does not meet all primary criteria, but could nevertheless be used to develop a reasonably valid indicator. These guidelines allow for the selection of such indicator with the expectation that better quality data will be generated in the future. In these cases, the limitations of the data set(s) used for indicator development should be clearly documented in the narrative for the indicator.

When a candidate indicator does not meet the primary criteria and there is no prospect for the development of new data sets that would meet the criteria, the indicator is dropped from further consideration.

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Guidelines for Indicator Selection: Primary Criteria

The indicator should meet all of the following criteria:

Data quality: Data are/will be collected to yield measures that are scientifically acceptable and support sound conclusions about the state of the system being studied.

Representative: The indicator is designed to reflect the environmental issue it is selected to characterize.

Sensitivity: The indicator should be able to distinguish meaningful differences in environmental conditions with an acceptable degree of resolution.

Decision support: The indicator should provide information appropriate for making policy decisions.

Characterization of data availability. Candidate indicators meeting primary criteria are further evaluated as to whether data are available at the present time to present a status or trend for the issue in question. Where the data are available, the indicator is designated as a ***Type I indicator***.

On the other hand, when the data does not show a status or trend, either because a full cycle of data has not yet been collected, or the data require further analysis or management, the indicator is classified as a ***Type II indicator***.

There are instances when a determination as to whether a candidate indicator meets primary criteria cannot be made because of insufficient data or because the data are from a one-time study. These indicators are classified as ***Type III indicators***. Type III indicators reveal a need for resources to either develop a plan and/or implement a program for data collection.

Classification of indicators based on data availability

Type I indicators: Adequate data are presently available and can be used to support the development of the indicator.

Type II indicators: The collection or management systems for these indicators are currently being developed; or data are currently being collected but not enough measurements have been made to sufficiently present the indicator.

Type III indicators: Indicators that are hypothetical or have not been developed beyond one-time studies that provide only a snapshot in time. Indicators in this class are useful in revealing data gaps that may need to be filled in order to provide quantitative information on certain significant environmental issues.

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Indicator Identification and Selection Process

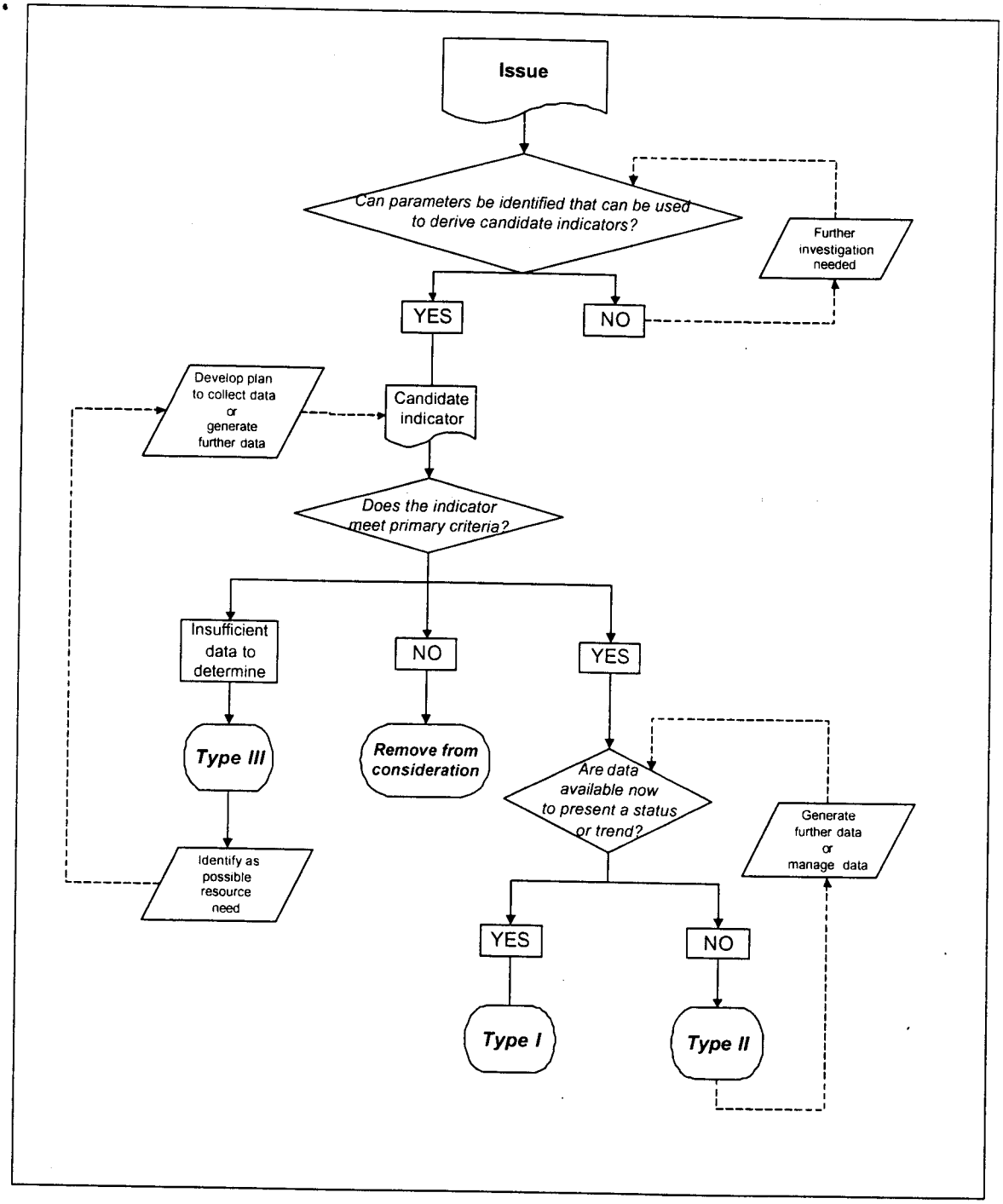

Figure 3

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Evaluation of Type I indicators based on secondary criteria. Secondary criteria reflect other desirable, but non-essential, attributes of an environmental indicator. These criteria address whether an indicator can be used to anticipate changes, can be compared to indicators in other programs or systems, is cost effective, and is based on, or can be compared to, a benchmark value. These characteristics are noted in the indicator sheets whenever appropriate.

Guidelines for Indicator Selection: Secondary Criteria

It is desirable, but not essential, that Type I indicators meet the following criteria:

Anticipatory: The indicator can provide an early warning of environmental change.

Data comparability: The indicator can be compared to indicators in other state, regional, national or international systems.

Cost-effective: The information for an indicator can be obtained at a reasonable cost and effort and provide maximum information per unit effort.

Benchmark value: The indicator is based on, or can be compared to, a benchmark value or point of reference, so that users can assess its significance.

Indicators integrate multiple aspects of a given issue or a system. Certain indicators can synthesize a considerable degree of information. These are termed ***integrative indicators***. The level of dissolved oxygen in a river or stream is an example of an integrative indicator. Oxygen is both produced by plants and used by bacteria, invertebrates, and vertebrates. Its concentration in water reflects many interrelated processes within an aquatic ecosystem.

In certain cases, indicators can be combined, in a weighted or non-weighted fashion, into a single ***index*** to integrate a greater degree of information than the individual indicators.

Collectively, all the indicators that present information on an environmental issue comprise an ***indicator suite.***

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CHAPTER 3.
THE ENVIRONMENTAL INDICATORS

CHAPTER 4.
CONCLUSIONS AND RECOMMENDATIONS

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