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Conceptual Aspects of Environmental Monitoring

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CONCEPTUAL ASPECTS
OF
ENVIRONMENTAL MONITORING

by

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Preface

This report was prepared by the U.S. Army Engineer Institute for Water Resources (IWR), at the request of Dr. John Belshe, Chief, Environmental Program Branch, Planning Division, Office of the Chief of Engineers (OCE), U.S. Department of the Army. The objective was to provide a basis for understanding concepts of auditing and monitoring. The report was prepared for use in planning a new Environmental Impact Research Program (EIRP) work unit entitled "A Monitoring Plan for Evaluating Impact Prediction Accuracy and Mitigation Measure Success."

The report was written by Mary Vincent under the supervision of Mr. James R. Hanchey, Director, IWR, and Mr. Kyle Schilling, Chief, Policy Studies Division, IWR.

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Impetus

The impetus to environmental monitoring comes from two sources: (a) research and conceptual needs for ex post factual analysis, and (b) administrative requirements to compliance to environmental agreements. The concept of conducting an ex post analysis along with comparing observed to predicted impacts, has been discussed among environmental interests since the mid-30's as scientists recognized that natural resources are limited. NEPA focused attention on the idea and environmental monitoring/auditing terminologies and approaches emerged. NEPA specifically recognized the need to develop and to implement techniques for analysis of the environmental effects of project construction. Where NEPA implied the need for monitoring project impacts, EO 11514 (March 1970) required that "monitoring be done by Federal agencies to help ensure that planned mitigation measures are in fact carried out once a project begins." (Bisset, 1980).

Both the concept and the requirement for environmental monitoring were furthered in November 1978 when the Council on Environmental Quality issued regulations for implementing NEPA. These regulations are binding on Federal agencies. They require monitoring and enforcement programs for projects for which an Environmental Impact Statement (EIS) is filed. Agencies are required to issue a "Record of Decision" that specifies all factors considered in reaching a decision on the proposed project, the alternatives considered, the environmentally preferable option, and the factors used in reaching the project decision. Also, the Record "must state whether all practical means of mitigating or preventing environmental harm have been adopted and if not, why not." Finally, to ensure that preventive/mitigating measures are applied, the Record requires that agencies must monitor projects: the lead agency must condition funding of mitigative actions; upon request, agencies must inform other agencies of mitigation progress; and, the lead agency must make environmental monitoring results available to the public (Bisset, 1980).

Project monitoring is required by Federal regulations only to check that mitigation measures are implemented and to assure that criteria to assess the performance of these measures are met. There are no Federal environmental monitoring requirements to perform audits and to improve the quality of future EISs. While evidence is sparse, some cases have surfaced where injunctions were issued against continuing project work until the agreed upon environmental mitigation actions have been achieved; this may encourage agencies to monitor their performance in mitigating or preventing impacts (Bisset, 1980).

During the 1970's, with continued environmental problems and feelings that the regulatory reaction had not been as effective as hoped, the concept of the environmental audit emerged. This concept stems from the recognition that resources are limited and that safekeeping the environment is the responsibility of all segments of society, industry as well as government. Although the environmental audit concept is still new to environmentalists, most feel that it has potential to be a useful tool in shared environmental safekeeping (Golten, 1984). Enforcement alone cannot be relied upon to ensure environmental performance. Industry knows this and welcomes self-auditing as a cost-effective and more reliable compliance technique than can be obtained by external policing (Cutler, 1984). As the environmental monitoring concept emerged, governmental interest in the ability of resources to meet long-term needs resulted in periodic appraisals of most natural resources. Laws such as the Soil and Water Conservation Act of 1976 require periodic appraisals. As the environmental monitoring/auditing concepts mature, they will become standardized, institionalized, and integrated to the mainstream of environmental planning (Cutler, 1984).

Terminology

Those who talk about environmental monitoring as well as those who practice it (in particular, government agencies) use a variety of terms, for example: review, surveillance, survey, assessment, appraisal, evaluation, audit, monitoring, compliance inspection, tracking, mitigation success, environmental management, adaptive management, and inventory, etc. There does not appear to be a commonly held definition for any of the terms although some are used more consistently than others and some, as applied, mean essentially the same thing. Appendix A presents a collection of definitions for various terms.

Collectively, each of these terms applies to an effort for gathering information, and, in a general sense, all fall under an umbrella term: monitoring. What differentiates the terms are: the purpose for which the information is collected and at what stage in the life of the project it is collected. In this regard, the terms appear to fall into these three categories:

1. Auditing: monitoring done (typically during the construction or operations stages) to determine how the status of one or more variables compares with requisite or desired standard(s). A check list is frequently used if several criteria are being audited. In order for the effort to truly be an audit there must be a follow-up enforcement process for variables that did not meet the criteria. Depending on what is being monitored, auditing can be one-time (e.g. grading to a certain contour) or periodic (e.g. for water quality). Similar terms include surveillance and compliance inspection.

2. Impact Assessment: monitoring done during the project planning stage in order to obtain an inventory of data for use in predicting project impacts. The data collected is factored into the decision-making process to design a project with minimal adverse effects.

As an aside to this discussion, it should be noted that the Federal government has traditionally been reluctant to implement auditing/evaluation reserach programs (See Appendix A for definitions). The literature on this (e.g., Weiss, 1973 and Wengert and Hamilton, 1983) should be reviewed by anyone contemplating the design and development of a monitoring program.

3. Monitoring: collection of data during construction or operations stages for one or more of the following purposes:

   a. To determine status or trends, e.g. an inventory or successive inventories.

   b. To determine if expected effects have occurred, i.e. prediction monitoring.

   c. To determine project impacts whether anticipated or not, i.e. impact monitoring, tracking.

   d. To determine if objectives for management are being achieved, if measures were applied and with what effect, i.e. mitigation success monitoring.

In each case, the data collected underlies the decision for some action. Either the data is used as feedback to improve the project it was collected at or to improve the planning or implementation of another project.

Types and Purposes

Several authors have discussed types and purposes of monitoring. Among these are: A.D. Little (no date), Holling (1978), Osburn (1980), Dickson and Dindal (1980), and Bisset (1980). Simply put, environmental monitoring is conducted to obtain information on ecosystem status or trends. As such, the monitoring falls into several broad, though not necessarily mutually exclusive categories:

1. Inventory efforts to determine the quantity, distribution, and rates of loss or gain of various ecosystem types (e.g wetland loss).

2. Inventory efforts to provide information for maintaining a regional or even national data base (e.g. the Soil Conservation Service (SCS) appraisal of soil, water, and related resources of the nation) or for ecologically characterizing an area (e.g. the Nature Conservancy's State Natural Heritage Programs).

3. Assessment and inventory for educational and demonstrational purposes. For example: to set aside and characterize research reference areas, to establish field and laboratory repositories to serve as gene reservoirs, to establish demonstration areas where citizens and specialists can observe the long-term effects of specific factors and the true costs of waste management or environmental management, or to provide an outdoor laboratory for training ecologists.

4. Assessment to detect subtle, including early warning changes or shifts in ecosystems, actually on a regional scale (e.g. effects of acid rain).

5. Ex post assessment efforts to determine the extent, significance, and recovery from specific known contaminants or stresses, usually at a particular site (e.g. effects of sewage discharge into a particular river). This is the most common application of monitoring.

It is into this last broad category that ex post project assessment falls. At the present time, a number of agencies and industries are pursuing or are planning programs to conduct follow-up assessment of the effects of their activities. The reasons for doing so include one or more of the following purposes:

- o To check the validity of predictions, including the determination of any unpredicted impacts occuring.
- o To determine whether or not environmental protection provisions are being implemented and if further protective measures may be required.
- o To detect cause and effect relationships and their significance in order to improve ability to predict impacts.
- o To comply with applicable standards or regulations on environmental quality.
- o To determine that baseline conditions are correctly identified.

These appear to be the major general purposes for ex post project assessment. There are additional, more specific reasons that could be contained within them and that could also be valid for the other main categories of environmental monitoring. For example: (a) to identify organisms and/or ecosystems components that could serve as indicators of environmental quality; (b) to develop mathematical models simulating ecosystems in order to better predict environmental response, to organize information about that environment, and to establish research priorities; (c) to study the interactions of pollutants and environmental conditions; and (d) to study the pathways and sinks of pollutants in the environment.

With respect to ex post project environmental monitoring, one characteristic is prominent: that the information is obtained for feedback, either into that project or for others existing or yet in planning. By providing such assessment, ex post environmental monitoring serves to integrate the separate processes of environmental planning and environmental management.

Two good examples of ex post monitoring of water resources projects are given by Martin, Prosser, and Radonski (1983) and by Nelson, et. al. (1977). Under contract to the Corps of Engineers, Martin, Prosser, and Radonski (1983) closely examined 20 projects to compare and evaluate pre-project prediction for fish and wildlife with post-project occurrences. Nelson, et. al. (1977) studied 90 Federal projects in the western and central U.S. to identify what FWS (U.S. Fish and Wildlife Service) recommended measures for improving habitat and population had actually been implemented and to evaluate measure effectiveness.

Strategy and Implementation Considerations

Despite differences in terms and definitions, there are commonalities in the implementation and elements of the strategies applied. As a link between environmental planning and environmental management, environmental monitoring strategies generally provide for mechanisms that allow the assessment to continue along with the project evolution and mechanisms that allow the project to adapt in response the ecological considerations. Although the implementation of a monitoring or audit program appears, superficially, to be a conceptually simple exercise, there are difficulties, some of which relate to relative inexperience, at least on a long-term basis. In fact, as Bisset (1980) points out, the problems involved have led some to argue that audits cannot be carried out in a scientifically acceptable manner.

In scoping out an environmental monitoring strategy there are several basic and rather generic considerations to address as summarized below from Beanlands and Duinker, 1984; Holling, 1978; and Bisset, 1980. In addition, Appendix B details the more specific considerations for designing a long-term monitoring program (Dickson and Dindal, 198( ). The basic considerations are as follows:

1. Will the valued ecosystem components be affected in any way by the project?

2. How can direct effects on the valued ecosystem components be studied? If the effect is direct, and the component is amenable to study, then the assessment task is simplified.

3. How can indirect effects be studied? Investigators may resort to studying individual-level effects, the food chain, early life stages, or habitat interactions when the effects on important species are indirect.

4. Should indicator components be studied? In the event that interactions between a project and valued ecosystem components are not amenable to either direct or indirect means of investigation, then it may be advisable to study indicators of impact.

For example, in pollutant monitoring studies, if only one organism is used as an indicator, will it be so much more tolerant to the particular toxicant in question that the chemical will pass undetected and harm other members of the aquatic community? This is an important question in aquatic pollution monitoring; Cairns (1980) raises others.

5. Are there times in the development plan when changes can be made and new directions followed?

6. Will the analysis be able to respond at the right time with the information needed to influence the project development?

In addition to these questions, there are certain basic considerations to address (Holling, 1978; Bisset, 1980):

1. The predictions of environmental impact, as statements of future conditions, must have some basis in ecological principles related to natural processes (Walker and Norton, 1982). It is impossible to make a firm prediction without reference to time-associated ecological relationships.

2. The capacity of ecological methodology to supply data relevant to assessment goals.

3. The contemporary approaches to information processing and analysis.

4. The agency's capability to convert information into meaningful impact assessments.

5. The administrator's expectations and concerns for use of the assessment.

6. The level of reliability that the projections and measurements must have. According to Bisset (1980):

> "A problem exists in obtaining knowledge on project impacts and on the accuracy of predictions. For example, the location of stressed stations depends on predictions of impacts, area likely to be affected, and target organisms. Results from these stations are the only way of testing predictive accuracy. However, there is a "catch-22" situation: if the predictions were inaccurate, the monitoring data would provide a false impression of actual impacts and predictive accuracy. The situation can be altered if the characteristics of an impact an be identified readily, for example, visually. Subsequently, stressed stations could be changed an accurate information obtained, but this would require a further commitment of capital and manpower. In cases when impacts are not detectable except by statistical analyses of monitoring data, impacts may be missed entirely and a false impression gained about the accuracy of predictions. This would undoubtedly be the case where an impact was only apparent after a considerable time lapse in a location geographically distant from the source.
>
> If these problems could be overcome, or if it could be determined that their effected would be minimal in a particular case, there would still be problems in testing the accuracy of impact predictions. It could be ascertained that there has been a change similar to that predicted, but whether a predictive technique is accurate or not depends on an interpretation of the significance of the difference between the actual and the predicted impact."

7. How much of the budget should go to monitoring. Is it possible to monitor the parameters desired while achieving the same results at lower cost and greater efficiency?

8. Who is to collect and interpret the data. Bisset (1980) recommends that:

> "personnel establishing a monitoring program remain to carry it out, thereby maintaining consistency. To capitalize on feedback, people with expertise in experimental design and statistical inference should be cooperative in monitoring programs. However, it is difficult to ensure consistency of long-term monitoring because of staff turnover, which can result in the invalidation of monitoring data unless adequate supervision is exercised. Otherwise, there may be critical changes in what target parameters are monitored or what sampling techniques are applied. Supervision is not easy to maintain over the time periods required for monitoring because of the career structures and employment characteristics of organization responsible for monitoring."

9. The behavior of those responsible for constructing and operating a project. Again, Bisset (1980) elaborates:

> "Impact predictions are often made on the basis of facts about the characteristics of a project. Often, such facts are obtained from discussion with those only distantly responsible for the day-to-day management of construction and operation. Information on projects obtained prior to construction and operation can become easily outdated due to rapid technological change. projects with long lead times, such as power stations, or with multiphase construction periods can be subject to technical changes that may not have been considered in an EIS. These alterations may invalidate predictions as the causal factors assessed may have changed after the assessment was completed. Unless there is an attempt to keep track of technological changes, assessment of predictions may be misleading.
>
> Not only do technical changes have to be monitored to assess their influence on audits, but also on-site construction and operation has to be checked. Often, predictions of impacts and consequent identification of mitigating measures depend on assumptions that work will be carried out in a certain way. For example, there may be an agreement that constructions work on one part of a site will not occur during the nesting season of a nearby bird colony, but there can be difficulties in ensuring that such an agreement is carried out. Channels of communication can break down and result in actions being carried out which cause impacts not incorporated in an EIA. However, unless the existence of these events is known, testing the accuracy of impact prediction becomes impossible.

In summary, the technical design for a monitoring program must be done within the constraints of specific objectives, major assumptions, the resources at hand, and statistical concerns. The types of concerns and questions lie in these broad areas:

- What information is necessary -- when is (are) the impact(s) likely to occur, where is (are) they likely to occur, what resources are likely to be affected, what level is the impact likely to reach. A monitoring program which focuses solely on either habitat or species is incomplete in the long run and will fail to detect underlying cause and effect relationships (Salwasser et al., 1983).

- What analysis techniques are available to provide the necessary information; data analysis is necessary because it is often impossible to collect the specific data needed or it is not as accurate as desired.

- What time frames, spatial scales, and political jurisdictions are involved.

- What about the accuracy of impact prediction. As Canter (1984) points out; this is difficult to determine due to the lack of baseline and project operational data. Also, project design features may change between the EIS stage and the construction and operation stages. Further, assumptions used in impact calculations may not prove to be accurate with the result that calculated impacts are not accurate. perhaps more significant than these difficulties is the reality that prediction is an attempt to foresee change in a system that is complex, where many of the variables are imperfectly understood and where the system itself is constantly changing.

Components

The major components of the environmental monitoring process include: monitoring design, quality assurance, data management, data analysis, research and development in support of data collection and interpretation, coordination of agency activities, and the review, dissemination, and use of the resulting information (Buffington, 1980). Some put particular emphasis on the need for techniques for analyzing data and making decisions. Several authors, including Salwasser (1983), Beanlands and Duinker (1984), and Gianotti (1983) have indicated the key elements to contain in a monitoring program. To summarize their listings, these are:

1. Terms should be defined and definitions should be consistently used.

2. Specific objectives and management goals should be defined since these enable the system and its methodology to be most effective. The logical steps for applications then follow:

   - Define study area
   - State project objectives (e.g., water supply)
   - Identify actions and impacts to be evaluated

- Develop management strategy (e.g., mitigation, enhancements, etc.)

- Collect data and analyze.

- Evaluate results considering project effects and management goals.

3. A mechanism for early detection of problems, remedial actions, cost estimates, and prompt reporting of any adverse environmental conditions should be included.

4. Measures:

   - Measures of existing conditions to allow comparison with the effects of management.

   - Measures of effects; these should include the key variables that are identified as resource objectives, environmental standards, or indicators of land health and productivity.

   - Measures of impacts predicted. "...these should be testable, and free of ambiguities and should be stated as hypotheses which can be tested with an appropriate study plan. In this respect, a predictive analysis should strive to include quantified details on impact magnitude, duration, and spatial distribution" (Beanlands and Duinker, 1984).

5. Data:

   - Consistent data.

     "In implementing audits, it is vital to have monitoring data that have been obtained consistently through time. For example, data on phytoplankton biomass collected preoperationally should be comparable with data collected during operation.

     "It would be useless if other aspects of phytoplankton were monitored halfway through a program. Similarly, data have to be collected in a standardized manner. Sampling locations and techniques must not be changed, otherwise statistical analysis is rendered speculative" (Bisset, 1980).

   - Quantitative elements. A quantitative approach should prevail in baseline and monitoring studies and other field investigations (Beanlands and Duinker, 1984). Factors and parameters to include in the evaluation methodology are: (a) engineering data on type of project and physical effects; (b) descriptive physical data on various habitats within the project area; (c) primary producers; and (d) support populations.

o Baseline data.

"For most projects with a long operational life, monitoring is a lengthy, expensive, and time-consuming business. Operational monitoring is required for at least two years, and in most cases longer, before trends can be identified. To compare operational monitoring data with preoperational data, monitoring must carried out for a considerable time prior to operation. Most commentators consider that baseline data should cover more than one year to determine seasonal variations and natural longer-term fluctuations. Achieving this is difficult as there is often no time available to obtain the requisite preoperational data" (Bisset, 1980).

o Data suitable for statistical analysis.

"Data suitability can be an unknown factor; data can be subject to a variety of contingent factors, which might render conclusions at worst irrelevant or at best only indicative of a particular result. To audit properly, it is necessary to determine in advance the likely impacts, their geographic coverage, and the types of changes in environmental parameters or processes expected. It helps also if certain degrees or sizes of change are established as "benchmarks" to be identified by monitoring schemes. With this knowledge, monitoring must be devised to enable statistically valid analyses of both pre- and postoperational data (however, experience shows that monitoring schemes have rarely been devised in this manner). Haphazard monitoring schemes or schemes set up to detect "every occurrence" will result in much data which is not suitable for application of statistical techniques to interpret their meaning" (Bisset, 1980).

6. Components arrangement.

"There are two important implications in the content and arrangement of the components. The immediate implication is that the assessment information can be synthesized in an incremental fashion. This incremental approach is useful because the success of the assessment does not depend entirely on answering the question of what level the impact is likely to reach. Although this is the implied and desired goal of every impact assessment project, it is seldom attained, leading to assessments that leave the manager at a loss for management guidance. But, if impact information is developed in the proposed incremental fashion, each compartment can provide information that is useful to the administrator even without completion of the entire sequence. Since useable information is already assembled for the first rather than the latter compartments, at least a degree of rational assessment is highly probable for most assessment projects" (Holling, 1978).

Utility and Capability

In a general sense, a monitoring program has application to at least three resource management tasks: (a) testing the adequacy of impact predictions and mitigation recommendations, (b) revising management strategies, (c) and generally making better resource management decisions (Salwasser, 1983). The simplicity of this listing conceals two important points: first, that these applications benefit different purposes; and second, that their support would require different institutional arrangements. For these tasks, answers to questions such as who would benefit, who would be responsible for what, and who would fund, etc. would vary and so would have to be clearly determined if the program is to have utility. Given the objectives of environmental monitoring, it is certain that all institutional elements affected by or involved in a particular program will not be equally interested in it; the institutional mechanisms and responsibilities therefore have to have to be carefully set up.

Even the environmental audit concept, which has so far been used by industry and government nearly exclusively for pollution compliance with regulatory standards, may have application to other environmental regulations. Golten (1984) poses this question: "perhaps EA can be used to ensure that facilities (e.g., highways and dams) that get Federal funds operate responsibly and in compliance with applicable environmental regulations or risk losing their Federal fund." Golten believes that thus far, the environmental audit has proven itself useful in harmonizing and reconciling interests rather than fighting them out on the environmental battleground.

The benefits of environmental auditing programs can include overall improvement of environmental management, hazard identification, risk reduction, and enhanced assurance that management systems are working correctly. The limitations include: the diversity of methodologies used prevents strict comparisons, the complexities of environmental risk are not well known, and it may be difficult to judge which problems are important and which are not (Funkhouser, 1984). Auditing can be done in different ways to suit individual needs and constraints; there is no right or wrong way to audit. Therefore, the institutional arrangements within which conflicts and uncertain data and positions are negotiated will be crucial to successful environmental monitoring and or auditing.

As factors indicative of the utility of a monitoring program, Holling (1978) identified the following criteria for judging the application potential of a wildlife impact information system that was developed by the U.S. Fish and Wildlife Service:

1. The system should have the capability to discern impact over areas of several hundred to several thousand miles.

2. The system should be uniformly applicable to a reasonable representation of animal species in the geographic area of interest.

3. The system should allow for the analysis of influence of vegetation and habitat types in the geographic area of interest.

4. The system should be able to distinguish between ecological changes caused by project disturbance and ecological changes caused by specific physical disturbances (i.e., land, air and water).

Based on experience, the following criteria should be added to Holling's list:

5. The system should provide for input from and dialogue among all parties involved with the monitoring process and its results: those doing the monitoring, those doing the construction, and those impacted by the results of the monitoring.

6. The system should provide a means to facilitate dialogue and mediate conflicts over data, issues, and positions. This means must be perceived as legitimate and acceptable by all parties involved and affected by the monitoring process and its results. In cases of auditing, the items to be audited and the standards for comparison should be carefully reviewed to insure that they are specific and that they can be legally complied with.

QC and QA: Pertinent Concept and Analogy

The definitions of Quality Construction (QC) and Quality Assurance (QA), given in Appendix A, are interesting because conceptually the goal of QC and QA actions is the same as for monitoring and auditing. The Corps has a QC/QA program that it has built its reputation on, manages successfully, and is currently improving. Basically, it is a system that provides for the management of quality in the design and construction of facilities. Contract documents establish the level of quality required for construction and include detailed technical and special provisions to produce the end product. In addition to these provisions, there are systems for: (1) managing, controlling, and reporting daily operations; and (2) assurance testing and operations monitoring to make sure that the completed work in fact complies with contract requirements. One of the Special Provisions that can be included in a contract, as appropriate, is "Environmental Protection." Not only is the QC/QA concept relevant, it offers a model for developing an environmental monitoring program, and may, in addition already have elements that could also be employed in such a program. There is documentation (U.S. Army Corps of Engineers, 1983, Work Paper) of lessons learned about effectiveness of techniques to assure contract compliance though reward and/or sanction in the QC/QA area. This documentation could be vital to designing effective audit/monitoring systems.

Literature Cited

A.D. Little Inc. No date. Environmental auditing workbook. Prepared in cooperation with Edison Electric Institute.

American National Standards Institute. 1973. Quality assurance terms and definitions. N45.2.10. American Society of Mechanical Engineers.

Beanlands, G.E. and P.N. Duinker. 1984. An ecological framework for environmental impact assessment. J. Env. Mgmt. 18:267-277.

Bisset, R. 1980. Problems and issues in the implementation of EIA audits. EIA Review 1(4):379-396.

Buffington, J.D. 1980. A review of environmental data and monitoring. Chapter 2 In Biological monitoring for environmental effects, ed. by D.L. Worf. Lexington Books, D.C. Heath and Co., Lexington, Mass.

Cairns, J., Jr. 1980. Scenarios on alternative futures for biological monitoring, 1978-1985. Chapter 3 In Biological monitoring for environmental effects, ed. by D.L. Worf. Lexington Books, D.C. Heath and Co., Lexington, Mass.

Canter, L.W. 1984. Science and predictive methods in environmental impact assessment. Paper presented to the joint U.S.-Netherlands Seminar on Environmental Management. Washington, D.C. April 10-13, 1984.

Chemicals Manufacturers Association. No date. Work group on environmental auditing (EA) attended by representatives from the chemicals industry.

Cutler, R. 1984. The role of environmental auditing in the future. Paper presented at Environmental Auditing (EA) for Federal Facilities in Western States, a Conference Co-sponsored by the U.S. EPA and EPA Region VIII. Denver, Colorado, February 16-17, 1984.

Dickson, K. and D.L. Dindal. 1980. Issues in long-term biological monitoring. Chapter 22 In Biological monitoring for environmental effects, ed. by D.L. Worf. Lexington Books, D.C. Heath and Co., Lexington, Mass.

Funkhouser, J.T. 1984. Overview of environmental auditing. Paper presented at Environmental Auditing (EA) for Federal Facilities in Western States, a conference co-sponsored by the U.S. EPA and EPA Region VIII. Denver, Colorado, February 16-17, 1984.

Gianotti, D.A. 1983. Organizing corporate compliance efforts. American Bar Association.

Golten, R. 1984. Environmental auditing from the environmentalist's perspective. Paper presented at Environmental Auditing (EA) for Federal Facilities in Western States, a Conference Co-sponsored by the U.S. EPA and EPA Region VIII. Denver, Colorado, February 16-17, 1984.

Hoekstra, W.T., et al. 1983. Monitoring regional wildlife and fish habitats and populations for national assessments and appraisals. Trans. NA Wildl. Conf. 48:308-314.

Holdgate, M.W. and G.F. White. 1977. Environmental issues. (SCOPE Rep. No. 10). John Wiley and Sons, N.Y.

Holling, C.S. 1978. Adaptive environmental assessment and management. John Wiley and Sons, N.Y.

Horak, G.C. and J.E. Olson. 1980. Fish and wildlife mitigation: the need for standards and criteria to determine effectiveness and recommendations for reporting requirements. Fisheries 5(3):2-6.

Institute of Internal Auditors. 1978. Standards for the professional practice of internal auditing. Altamonte Springs, Florida.

Johnson, W.C. and S.P. Bratton. 1978. Biological monitoring in UNESCO biosphere reserves with special reference to the Great Smokey Mountains National Park. Biological Conservation 13(2):105-115.

Martin, R.G., Prosser, N.S., and Radonski, G. C. 1983. Adequacy and predictive value of fish and wildlife planning recommendations at Corps of Engineers reservoir projects. Sport Fishing Institute, Washington, D.C.

Nelson, W., et al. 1977. Habitat and population improvement measures accompanying water resource development projects. Prepared by Enviro Control, Inc., for U.S. Fish and Wildlife Service. Report No. FWS/OBS-77/30.

Palmisano, J. 1983. The evolution of environmental auditing: implications for firms and for regulators. Paper presented at 76th Annual Meeting of Air Pollution Control Association. Atlanta, Georgia. June 20, 1983.

Rosener, J. B., 1983. The Sanibel evaluation: what was learned?, pp. 409-423 In Public Involvement Techniques: A Reader of Ten Years Experience at the Institute for Water Resources, prepared by J. Creighton et al., IWR Research Report 82-R1, U.S. Army Engineer, Institute for Water Resources, Fort Belvoir, Virginia.

Salwasser, H., et al. 1983. Monitoring wildlife and fish: mandates and their implications. Trans. NA Wildl. Conf. 48:297-307.

Sanders, D. 1984. Planning, staffing, and preparing for environmental audits. Paper presented at Environmental Auditing (EA) for Federal Facilities in Western States, a Conference Co-sponsored by the U.S. EPA and EPA Region VIII. Denver, Colorado, February 16-17, 1984.

U.S. Army Corps of Engineers. 1983. Report of Blue Ribbon Panel on Management of Construction Quality in the U.S. Army Corps of Engineers.

Weiss, C. 1973. Politics and evaluation research. Evaluation 1(3): 37.

Wengert, N. and M. S. Hamiton. 1983. Citizen participation in state and local government control of power plant siting. Pp. 129-142, In Public Involvement and Social Impact Assessment, ed. by G. A. Daneke, et al. Westview Press, Social Impact Assessment Series, No. 9. Boulder, Colorado.

APPENDIX A

DEFINITIONS

AUDITING, ENVIRONMENTAL AUDITING, ETC

AUDITING (in general): A methodological examination involving analysis, tests, and confirmations — of local procedures and practices whose goal is to verify whether they comply with legal requirements, internal policies, and accepted practices. Auditing differs from assessment in that it requires collection and documentation of competent and sufficient evidence rather than an opinion based primarily on professional judgement. (A.D. Little, no date).

AUDITING: An independent appraisal function established within an organization to examine and evaluate its activities as a service to the organization. (Institute of Internal Auditors, 1978)

AUDIT FINDING: Any observed nonconformance with the environmental statutes, regulations, or TVA policy.

A Class A Finding is a nonconformance requiring immediate implementation of corrective action. This class includes nonconformances endangering public health or the environment and nonconformances possessing substantial risk of civil or financial penalties. EQS will monitor the corrective actions routinely until their completion. The audited organization is to respond in writing upon correction of the nonconformance. Should corrective actions extend beyond 30 days, written monthly status reports of the corrective actions should be submitted to EQS.

A Class B Finding is a nonconformance requiring eventual corrective action. This class would include all nonconformances not designated as Class A. A written response describing plans or actions to correct the nonconformance, including a schedule for completion, is due to EQS within 30 days of the audit report. (TVA)

AUDIT, Types of: Possible audit types include facility profile (detailing a baseline of the situation), compliance (assessing compliance with respect to applicable regulations), hazard management (assessing the cost-effectiveness of some aspect of the environmental management program), and special purpose (assessing special high priority problems). Most audit programs include some combination of these types. (Sanders, 1984)

ENVIRONMENTAL AUDIT: A structured program to assess and verify compliance with environmental laws and regulations and with corporate environmental policies. (A program is defined as being independent of normal operations and is endorsed by corporate management). (Chemicals Manufacturers Association, no date)

ENVIRONMENTAL AUDIT: A systematic assessment, analysis, and evaluation by a regulated entity of its compliance with environmental laws and regulations administered by the board and the division, applicable to its operation. (Environmental Compliance Act of 1983, sec. 3)

ENVIRONMENTAL AUDITING: Refers to internal management systems for reviewing facility operations and practices to assess and verify compliance with environmental regulations and corporate policies. (EPA)

ENVIRONMENTAL AUDITING: The process of determining whether all or selected levels of an organization are in compliance with regulatory requirements and internal policies and standards. (A.D. Little, no date)

ENVIRONMENTAL AUDITING: The process of determining whether all or selected levels of an organization are in compliance with regulatory requirements and internal policies and standards. It has proven to be a powerful component of environmental management. One key difference between environmental audits and other types of audits is the existence or absence of standards: few standards exist for environmental auditing. (A.D. Little, no date)

ENVIRONMENTAL AUDITING: The evaluation of a firms' compliance assurance activities. The evaluating may be a "snapshot" of the compliance system for one day in one plant or it might be a real-time-continuous-feedback-cybernetically-controlled self-generating-decision-support-system. Regardless of its form, it provides a systematic method of verifying that the firm's compliance assurance system is working as intended. (Palmisano, 1983)

ENVIRONMENTAL COMPLIANCE AUDIT: A detailed examination to determine the extent to which all aspects of TVA activities are in compliance with environmental regulatory requirements and TVA environmental policy. (TVA)

INTERNAL AUDIT: An examination and evaluation by the operating level (either Federal or contractor) of those portions of its internal ES&H program, program plan implementation, and operations retained under its direct control. (Dept of Energy)

MONITORING, ENVIRONMENTAL MONITORING, ETC

MONITORING: The orderly collection and analysis of resource data to evaluate progress in meeting resource management objectives. (BLM)

MONITORING: The successive inventory of resource production and use to evaluate how accurate projections of resource availability and use have been and how successful resource management plans have been in meeting quantified objectives. (Hoesktra, et al., 1983)

MONITORING: An activity (measuring) and a process (evaluation and refinement).

As an activity, it is the collection of data subject to assumptions, management objectives, sampling efficiency, and budgets.

As a process, it is the evaluation and use of the data as feedback to improve decisionmaking. In this sense, monitoring transcends inventory to become a vital link in the cycle of adaptive resource management. (Salwasser, 1983)

MONITORING: The systematic collection of data needed for environmental problem solving. (Holdgate and White, 1977).

BIOLOGICAL MONITORING: (Feedback of information about the biological portion of the system). The regular application of biological assessment techniques and methods to determine information about the quality and condition of a biological system. (Buffington, 1980).

ENVIRONMENTAL MONITORING: The systematic and repetitive collection and analysis of data which can be used: (1) to help determine the quality of the environment or condition of natural resources as they are or will be, and, (2) to help relate environmental quality or natural resources to factors which cause them to change or to effects produced by such changes. (Buffington, 1980)

IMPACT MONITORING: The process of repetitive observation of one or more elements or indicators of the environment according to pre-arranged schedules in space and time, in order to test postulates about man's impact on the environment. (Johnson and Bratton, 1978).

WILDLIFE AND FISH MONITORING: The collection and interpretation of population or habitat data, or both, to evaluate progress toward meeting objectives (attainment) and indicate needed adjustments in the course of management (feedback). The control aspects of monitoring, that is, feedback to indicate attainment or needed adjustments, form the major distinction between monitoring and inventory. Monitoring should be specific to plan objectives and major assumptions used in planning. (Salwasser, 1983)

INVENTORY AND MONITORING RELATIONSHIPS: Inventory and monitoring are vital components of fish and wildlife habitat management programs. The primary purpose of the Bureau's wildlife inventory program is to gather information on the location, condition, and use of fish and wildlife species and habitats which is needed by land managers to make sound management decisions. Inventory data also provide a baseline for monitoring. Inventories must be planned in advance, with well-defined objectives. Once baseline data have been collected, monitoring is established to determine the effects of various land-use decisions on fish and wildlife resources in keeping with wildlife management objectives. (BLM)

APPRAISAL OR ASSESSMENT

APPRAISAL: The process to estimate the significance of changes to EQ (environmental quality) resources based on consideration of technical, public, and institutional recognition. (BuRec)

ASSESSMENT: A process that measures or otherwise identifies changes to EQ resources anticipated to occur as a direct or indirect result of implementing a plan when compared to the future without the plan condition. (BuRec)

ASSESSMENT: An examination and evaluation by a program Secretarial Officer of those portions of its internal ES&H program, program plan implementation, and operations retained under its control. (Dept of Energy)

ENVIRONMENTAL ASSESSMENT: Means a concise public document for which a Federal agency is responsible that serves to:
(1) Briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact.
(2) Aid an agency's compliance with the Act when no environmental impact statement is necessary.
(3) Facilitate preparation of a statement when one is necessary.

An Environmental Assessment shall include brief discussions of the need for the proposal of alternatives as required by sec 102(2)(E), of the proposed action and alternatives, and a listing of agencies and persons consulted. (CEQ Regs, 40 CFR 1508).

FUNCTIONAL APPRAISAL: A documented review of an ES&H specialty discipline performed in accordance with written guidance and criteria to verify, by examination and evaluation of objective evidence (including visits to sites of activity), that applicable elements of the ES&H program have been developed, documented, and effectively implemented in accordance with specific ES&H requirements and needs. (Dept of Energy)

MANAGEMENT APPRAISAL: A determination of managerial effectiveness in establishing and implementing Environmental, Safety, and Health (ES&H) program plans which conform to DOE policy requirements.

It is based on an analysis of functional appraisals, internal audits, and other information, and on the application of appropriate criteria. This is a review and evaluation of management performance covering all ES&H disciplines and management responsibilities to assure proper ES&H program balance. (Dept of Energy).

TECHNICAL ENVIRONMENTAL ASSESSMENT: Based primarily on the principle of testing for environmental impact at increasing levels of detail until a judgement can be made. (HUD).

INVENTORY

INVENTORY: The periodic and systematic collection and analysis of data about the location, dimension, condition, and use of lands and resources. (BLM)

RESOURCE INVENTORY: The compiling of information on the kinds, amounts, and characteristics of physical and biological elements needed to plan and manage an area or resource. Inventory information and methods can be used in monitoring; but, the purposes of inventory -- a listing of things -- and monitoring -- an evaluation for feedback on objectives -- are different. Whereas monitoring indicates management attainment and supports resource plan adjustments, inventory will often encompass measurement of many things. Monitoring should be specific to plan objectives and major assumptions used in planning. (Salwasser, 1983).

INVENTORY AND MONITORING RELATIONSHIPS: Inventory and monitoring are vital components of fish and wildlife habitat management programs. The primary purpose of the Bureau's wildlife inventory program is to gather information on the location, condition, and use of fish and wildlife species is and habitats which is needed by land managers to make sound management decisions. Inventory data also provide a baseline for monitoring. Inventories must be planned in advance, with well-defined objectives. Once baseline data have been collected, monitoring is established to determine the effects of various land-use decisions on fish and wildlife resources in keeping with wildlife management objectives. (BLM)

COMPLIANCE

COMPLIANCE ASSURANCE: A systematic way of determining, attaining, and maintaining compliance with applicable environmental rules and regulations. (Palmisano, 1983)

COMPLIANCE PROGRAMS OBJECTIVES: (1) Establishing a new organizational structure to oversee and foster improvements in compliance efforts; (2) Setting out a strategic framework for compliance program refinements; and (3) Providing additional resources for increased monitoring and enforcement activities. (EPA; objectives)

COMPLIANCE, Policy: To foster high levels of compliance through a comprehensive effort to: promote voluntary compliance by the regulated community as a whole; conduct compliance monitoring activities to detect violations and identify priority compliance problems; and take firm but fair enforcement action when needed to bring individual violators into compliance quickly and to maintain a strong enforcement presence.

Where states have primary responsibility for compliance and enforcement, EPA will assure the adequacy of their efforts through review and evaluation of state compliance programs and provision of technical and legal support where needed. EPA will take direct enforcement action on violations for which a state's failure to take timely and appropriate enforcement action through lack of will, authority, or resources could threaten the achievement of national compliance goals. (EPA)

ENVIRONMENTAL COMPLIANCE AUDIT: A detailed examination to determine the extent to which all aspects of TVA activities are in compliance with environmental regulatory requirements and TVA environmental policy. (TVA)

MISCELLANEOUS

DEFINITIONS: Regions should reach agreement with states as to how certain state enforcement actions will be reported to and interpreted by EPA. This should be based upon the essential characteristics and impact of state enforcement actions and not merely upon what the actions are called. Where penalties are required, for example, state actions for equivalent sanctions also are acceptable. National program guidance setting forth consistent criteria for this purpose should be followed. (EPA)

CRITERIA: Rules or tests against which the quality of the performance can be measured. They are most effective when expressed quantitatively. Fundamental criteria are contained in policies and objectives, as well as codes, standards, regulations, and recognized professional practices that DOE and DOE contractor are required to observe. (Dept. of Energy)

EVALUATION RESEARCH: Assess the extent to which delineated goals are realized. It is characterized by the use of a systematic approach to the articulation of goals and objectives, and the development of criteria by which achievement of goals and objectives can be measured. It is concerned with analyzing factors associated with successful or unsuccessful outcomes. (Rosener, 1983).

FINDING: A statement of fact concerning a condition in the ES&H program that was investigated during an appraisal or internal audit. It may be a simple statement of proficiency, or a description of a deficiency -- a variance from procedures or criteria. Both severity and potential consequences should be addressed in describing a deficient condition. (Dept of Energy)

ECOSYSTEM MANAGEMENT: The integration of different land management goals to ensure that the integrity of the ecosystem will be maintained. Ecosystem management is directed toward habitat management rather than species management, the concept being that species will be maintained naturally if a proper mosaic of habitats exists. Ecosystem management encompasses featured species and species diversity to ensure compliance with existing laws; prevent species from becoming threatened or endangered; and provide values and uses for the public. The overall goal of ecosystem management for wildlife is retention or management of all natural habitats in sufficient quantities to support viable and self-sustaining populations of all native wildlife; e.g. riparian areas, cliffs, wetlands, and old-growth forests. (BLM)

ENVIRONMENTAL MANAGEMENT SYSTEM: The framework for a method of guiding an organization to achieve and sustain performance in accordance with established goals and in response to constantly changing regulation, social, financial, economic, and competitive pressures, and environmental risks. The system includes several interrelated functions: planning, organizing, guiding and directing, communicating, and reviewing. Environmental Auditing is one part of the review function. (A.D. Little, no date)

MITIGATION: Includes:
(a) Avoiding the impact altogether by not taking a certain action or parts of an action.
(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
(e) Compensating for the impact by replacing or providing substitute resources or environments. (CEQ Regs, 40 CFR 1508)

QUALITY ASSURANCE: All those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily when in service. (American Standards Institute)

QUALITY CONTROL: Those quality assurance actions which provide a means to control and measure the characteristics of a material, structure, component, or system to established requirements. Quality control is one aspect of quality assurance. (American Standards Institute)

DICTIONARY DEFINITIONS

APPRAISE: To set a value on, as goods; to estimate the amount of (a loss); hence, to judge as to quality. To evaluate, especially in an official capacity. To estimate the quality, amount, size, and other features of; to judge.

ASSESS: To evaluate; appraise. To set a value on; to appraise; specifically to make a valuation or official estimate of (property) for the purpose of taxation.

AUDIT: A formal or official examination and verification of accounts. An account as adjusted by auditors. An examination of records or accounts to check their accuracy.

COMPLIANCE: A yielding to a wish, request, or demand; acquiescence. Act or practice of complying; yielding, as to a desire, demand, or proposal.

EVALUATE: To ascertain or fix the value or worth of. To examine and judge; appraise, estimate. To calculate or set down the numerical value of; express numerically.

INSPECTION/INSPECT: Official examination or review. To look upon; to view closely and critically; scrutinize. To view and examine officially.

INVENTORY: A detailed list of things in one's view or possession; especially, a periodic survey of all goods and materials in stock. The process of making such a survey. The quality of goods and materials so determined.

MONITOR: To keep track of by means of an electronic devise. To check by means of a receiver for significant content. To scrutinize or check systematically with a view to collecting certain specified categories of data. To keep watch over, supervise.

SURVEILLANCE: The act of observing or the condition of being observed. Oversight; close supervision; close watch.

SURVEY: To examine or look at in a comprehensive way. To inspect carefully; scrutinize. A critical inspection, often official, to provide exact information; often a study of an area with respect to a comprehensive view.

TRACK: To pursue successfully; seek and overtake. To observe or monitor the course of, as by radar. To be in alignment. To follow the tracks or traces of.

APPENDIX B

CONSIDERATIONS FOR DESIGNING A LOG-TERM MONITORING PROGRAM

(From Dickson and Dindal, 1980, pp. 214-216)

II. Major Areas of Consideration Necessary in Implementing and Solving the Objective Goals
   A. Identification of study area
      1. Obtain specific site for continuous study
         a. Delimit site
         b. Determine how many sites needed to monitor given environmental parameters
      2. Institute permanence of site
         a. Establish stability of ownership
         b. Determine how the permanent monitoring site will be changed by monitoring activities
      3. Collect and record site characteristics
         a. Consider site as a system; describe the total ecosystem
         b. Collect and evaluate background (control) data; establish "background noise"
            (1) Variability within and between background samples
            (2) Temporal and spatial heterogeneity
            (3) Physical-chemical variables; correlation with biological factors
            (4) Flux rates
            (5) Background site processes; cause-and-effect pathways
         c. Delineate calibration sites
            (1) Representative of general control sites
            (2) Maintenance of uniformity
         d. Determine assimilative capacity of control site
   B. Personnel-institutional relationships
      1. Establish curricula to teach principles and methods of biomonitoring
         a. Train technicians and professionals for a career in biomonitoring
         b. Provide educators and scientists with necessary background for research and teaching
      2. Nurture interdisciplinary character of biomonitoring
         a. Develop integrated acquaintance with field and laboratory skills;
         b. Stimulate learning of updated knowledge of ecology
         c. Orient environmental thinking into an analysis of systems
      3. Convince universities and government agencies that biomonitoring is or can be a valid research area
         a. Promote national and international value of biomonitoring to all
         b. Remove stigma surrounding biomonitoring versus research
         c. Establish ways in which monitor-related research can count in tenure evaluations

        d. Develop the long-term hypotheses approach
        e. Modify survey, inventory work to include functional data (base-line information on processes) as well as structural data (species lists, standing crop) about biotic communities
    4. Develop cost-effective programs
        a. Educate administrations on the expenses to be expected in long-term programs
        b. Study and develop efficient time-person involvement scheme
C. Necessary development of methods and standards; an attempt to attain a minimal level of competence for all biomonitoring workers
    1. Develop a glossary to standardize all terms and definitions
        a. Prepare for both technical and nontechnical terms
        b. Include ecological terms
            (1) Community structural definitions
            (2) Functional definitions
            (3) Classification of ecosystem components
                (a) Organism
                (b) Population
                (c) Community
    2. Develop and standardize methods for biomonitoring
        a. Structural components
        b. Functional components
            (1) Nutrient cycling
            (2) Productivity, respiration, and utility of P/R ratio
            (3) Secondary produtivity
            (4) Microbial-enzymatic assays
        c. Perturbation
        d. Microcosm assays
        e. Synthetic concepts relating structure and function aspects
        f. Appropriate instrumentation
            (1) Field evaluations; chemical, physical, and biological sampling methods
            (2) Microcosm, microbial, and enzymatic assay technology
            (3) Remote sensing
            (4) Computer techniques
            (5) Environmental data base management
        g. Field calibration sites

III. Recommendations for Institutional Policymakers and Program Directors
A. Policymakers of governmental, educational, and private institutions should recogniz the value of long-term biomonitoring to the national intere t since biomonitoring provides information on the effects of environmental stress and serves as a basis to evaluate future environmental perturbations.
B. Educational institutions must recognize the interdisciplinary nature to the solution of environmental problem and thus develop the necessary curricula to meet this end.
C. Several types of reduced-scale workshops on biological monitoring should be organized and convened in the future; these should be in regional workshops and field of specialization workshops.

D. Sufficient funding should be provided to encourage specifically the fulfillment of the above objectives, the implementation of properly trained personnel, and the development and standardization of appropriate methods and procedures required by an effective, national, long-term biomonitoring program.