INTRODUCTION

The Federal Water Pollution Control Act Amendments of 1972, commonly referred to as Public Law 92-500, established definite goals regarding the restoration and maintenance of the physical, chemical, and biological integrity of the Nation's waters. The Act requires that water quality management planning, carried out under Section 208 of the Act, include a process that identifies non-point sources of water pollution and that establishes methods to control those sources to the extent feasible. Non-point sources associated with silviculture and related runoff are among several sources specifically mentioned in the Act as areas to be addressed during 208 planning and implementation.

The purpose of this technical handbook is to provide a systematic, procedural, and analytical methodology for identifying and assessing alternative technical solutions to existing or potential non-point source problems associated with site-specific silvicultural activities. While the specific analytical methods presented are not the only methods available, they were carefully chosen according to the capabilities of the science and the present state-of-the art.

Non-point sources of pollution result from natural causes, human actions, and the interactions between natural events and conditions associated with human use of the land and its resources. To control these sources, the United States Environmental Protection Agency (EPA) has adopted, through Federal Regulation, the concept of Best Management Practices. As defined by EPA,

> Best Management Practices (BMP) means a practice or combination of practices that are determined by a state (or designated area-wide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

This handbook deals specifically with the concern and requirement for control of non-point sources of water pollution related to silvicultural activities as expressed in the Federal Water Pollution Control Act Amendments of 1972 and the Clean Water Act of 1977. The handbook covers only the technical aspects of non-point source water pollution control; it does not address the economic, social, and institutional aspects that are also an important part of the Best Management Practices identification process. The economic considerations are described in "Silvicultural Activities and Non-Point Pollution Abatement: A Cost-Effectiveness Analysis Procedure" (USDA FS 1978). The social and institutional considerations are manifested through public involvement during environmental assessment review processes.

DEFINITION OF EXISTING WATER QUALITY AND WATER QUALITY OBJECTIVES

A prerequisite for use of this technical evaluation procedure is the identification of existing water quality and water quality objectives as quantifiable numerical expressions. This type of objective provides a base against which the impacts of the proposed silvicultural activities can be compared so the degree of additional control measures necessary can be identified.

In defining water quality objectives against which analysis results will be compared, it must be noted that the present state-of-the-art is, at best, a rational estimation procedure. Comparative analysis will often fall short of predicting absolute values.

APPLICATION OF THE PROCEDURE

Silvicultural activities to which the described procedures apply include timber harvesting, transportation systems, and various cultural practices such as site preparation and timber stand improvement. These silvicultural activities are discussed in relationship to the principal potential water pollutants that may be generated and transported from the site. Such pollutants include inorganic sediment, nutrients (primarily nitrogen and phosphorus), heat, organic debris and introduced chemicals such as pesticides and fertilizers.

Technical procedures and methods suggested in this handbook fit within the overall process for non-point source control as identified in EPA's "Non-Point Source Control Guidance Silviculture" document (Singer and Maloney 1977). The subjects covered in this handbook are those within the shaded area shown in the process outline, figure 1. Included are the specific analysis methods required to meet steps 1 through 7 of the non-point control process. The methodology also provides a simulation technique that can be used to estimate the past and present condition of receiving waters (step 3) when such information is not available.

The procedure gives proper recognition to space and time variations occurring in natural environments, to the pollution generation processes involved, and to defined water quality objectives. Thus, it permits evaluation of water quality management options at a level compatible with other resource evaluations. It also permits comparison of the effects of proposed management alternatives on water quality in different watersheds and on different areas within a specific watershed, given the same data base.

Application of the technical methodology generally requires a basic knowledge of hydrology plus a working knowledge of forestry, soil science, and engineering principles as they are applied in a natural environment. For all practical purposes, analysis and prediction of non-point sources of water pollution is a rational estimation procedure that is useful in comparative analysis of alternatives. Therefore, it is necessary for informed professionals to use local experience in applying the analysis techniques.

Although primarily a guide for the technical specialist, the handbook is also designed for water quality management planners and other land managers. The flow charts in the "Introduction," "Procedural Summary," and "Control Opportunities" chapters guide these managers in defining technical assessments needed. The analytical procedures and references in the technical chapters guide technical specialists or consultants in making those assessments. The step-by-step illustrations in the "Control Opportunities" chapter guide project designers and managers in identifying appropriate practices for the particular activity and site conditions.

CHARACTERIZATION OF THE SITE

Because the character of a site largely determines the non-point sources that might be encountered and the effectiveness of specific control measures, good site characterization data is essential.

Soil survey reports, stream survey reports, and geologic, climatic, topographic, and vegetation maps with accompanying descriptive materials all provide input for development of water quality plans and other environmental assessments. The level of detail in these documents should be compatible with the degree of reliability expected from the analysis (recognizing the sensitivity as well as the strengths and weaknesses of the analytical procedure in terms of data input.)

In order to evaluate non-point sources on specific sites or projects, the level of information must be compatible with the map resolution used to identify the first-, second-, or third-order drainage basins as described by Strahler (1957). The handbook analysis procedure is applicable only to these headwater areas (third-order basins or smaller).

A larger basin may be characterized from selected third-order drainages within that basin through data analysis and extrapolation based upon the similarities in site and management activities. These evaluations may be useful in identifying general types of practices which may represent BMP and in analyzing responses for specific silvicultural activities basin-wide. However, the site-specific analysis is the only option that considers site and activity variability and the identification of a site-specific BMP.

An environmental setting is a continuum which includes the hydrologic cycle, the nutrient cycle, and the erosion/sediment processes. The nature of the non-point process is such that the potential pollutant must be traced as thoroughly as possible

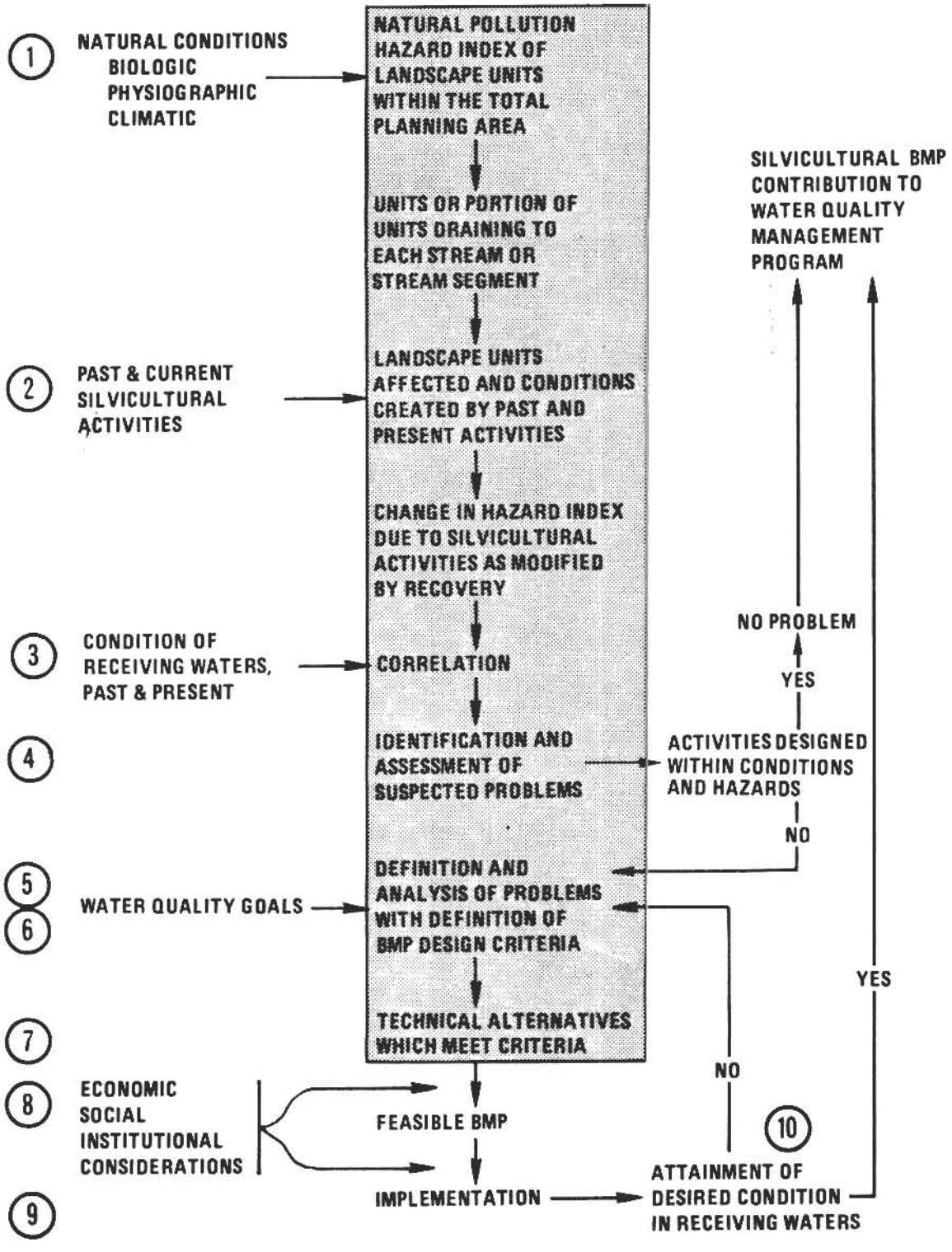

Figure 1.—Non-point pollution control process for silviculture (Singer and Maloney 1977).

through the entire system; therefore, all major environmental factors significantly affecting its generation and transport (into the receiving waters) must be recognized. Then these factors must be related to the physical and biological processes that govern the pollutant's ultimate disposition. This process is critical in determining controls for non-point sources caused by silvicultural activities because most water quality constituents identified as pollutants also occur naturally within the system. The analysis methodology is structured to differentiate natural pollution sources from those which may have resulted from human activities.

This document does not discuss all potential pollutants. It does describe, in a procedural manner, those potential pollutants that have been identified as being most important on a national basis.

General Procedural Description

The handbook procedure addresses the examination of the factors associated with generation and transport of pollutants; it discusses identification, in comparative, numerical, or qualitative terms, of the changes in pollutant output expected to follow particular silvicultural activities on a specific site.

The techniques suggested for comparing existing water quality with the water quality changes expected from proposed silvicultural activity provide a rational approach for dealing with the following facts: (1) day-to-day variations in water quality in undisturbed forest watersheds are substantial, particularly during the periods of changing flows; and (2) fluctuations in undisturbed systems may be as great as those in apparently similar, but disturbed, systems.

The procedure evaluates proposed silvicultural plans to identify expected changes in water quality and to determine the type and degree of control needed, if any, to meet water quality objectives. The evaluation process continues until: (1) a combination of preventive and mitigative controls that meets the objectives has been identified, or (2) an acceptable land use alternative, which meets the objectives, has been determined. Mitigative controls may be necessary to correct existing non-point sources before any new activities can be made technically acceptable.

The following requirements must be met before applying the analysis procedure presented in this handbook:

1. Water quality objectives should be identified and described with current information suitable for comparative analyses.

2. The pollutants should be identified in terms of units, time, and space; and those terms should be compatible with the terms of the analysis procedure.

3. Specific information as required for the analysis should be available to evaluate the silvicultural impacts onsite on a third-order basin or smaller.

4. The causes of non-point sources should be recognizable.

5. Water quality existing prior to initiation of silvicultural activities should be measured or estimated with a reasonable degree of reliability through analysis of other appropriate types of information.

6. Water quality after silvicultural activities should be estimated using the same approach applied to define existing conditions.

This document includes an introduction; a procedural summary; a control opportunities section; five technical chapters with quantitative discussions of hydrology, surface erosion, soil mass movement, total potential sediment, and temperature; an example demonstrating the quantitative procedures; three technical chapters with qualitative discussions of nutrients, dissolved oxygen and organic matter, and introduced chemicals; and a glossary of terms. The procedural summary provides a general overview and a simplified analysis methodology for each subsequent chapter showing the general processes and their relationships. The control opportunities and technical chapters present a detailed discussion of the procedures involved and the interrelationships between processes.

The general procedure and interrelationships between the control opportunities and the technical chapters, both quantitative and qualitative, are presented in the flow diagram, figure 2. The diagram depicts the iterative process that may be required if the proposed silvicultural activity does not meet water resource goals. During this process, the control opportunities are evaluated and the silvicultural activity revised as needed.

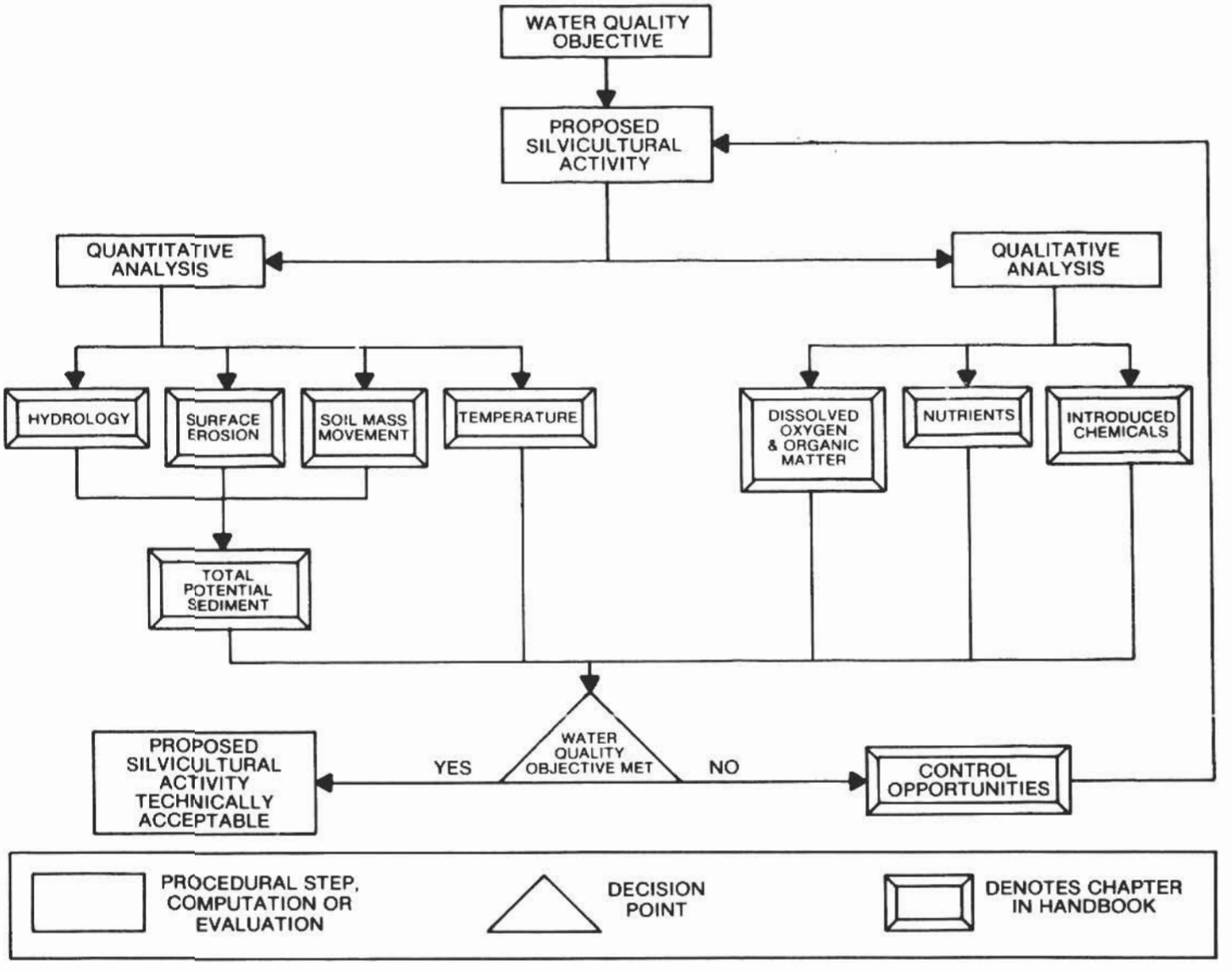

Figure 2.—Interrelationships between the quantitative, qualitative, and control chapters and their application to a proposed silvicultural activity.

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