Environmental assessment : philosophy and method

Robert A. Fronk
The University of Montana

ENVIRONMENTAL ASSESSMENT:

PHILOSOPHY AND METHOD

By

Robert A. Fronk, Jr.

B.S., Oregon State University, 1958

Master of Engineering, Oregon State University, 1969

Presented in partial fulfillment of the requirements

for the degree of

Master of Resource Administration

UNIVERSITY OF MONTANA

1975

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

Date June 23, 1975

TABLE OF CONTENTS

APPENDICES

ILLUSTRATIONS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

A growing national concern for environmental quality in the United States prompts many citizens to characterize the Seventies as the "decade of the environment." Americans are aware that industrial, agricultural, and technological achievements are the basis of our wealth and power, but they also recognize that man is a part of his environment and must use his resources intelligently. A deterioration in his natural surroundings will eventually be reflected as a decline in man's quality of life.

The National Environmental Policy Act (NEPA) of 1969 recognized the effect of man's activities on his environment and established national policies and goals for maintaining environmental quality. Of particular concern are the impacts of population growth, urbanization, industrial expansion, resource use, and expanding technological advances.

Fittingly, NEPA was signed into law on New Year's Day of 1970, the first law of the new decade. This act is something of a landmark, but like all such landmarks, it is also something of an indictment. It is an indictment of our inability to change our ways of thinking and acting in a world confronted with drastic change in every other respect. We have been, and to a disheartening degree continue to be, as economist John Galbraith put it:

> "...guided in part by ideas that are relevant to another world, as a result we do many things that are unnecessary, some that are unwise, and a few that are insane." (1, p. 3)

We have been guided, for example, by the Judeo-Christian concept of man as a very special act of creation; as a creature outside of and superior to nature; as the master and subdoer of the earth. So the emphasis has and continues to be on mastery, not upon harmony.

We have been guided by the economic dogma that the common good emerges from the competitive struggle of private interests. The public interest has been neither expressed nor clarified and agreed upon. Consequently, the nation's wealth, which is to say, its human and natural resources, has been converted into money at a time when environmental conditions may become so degraded as to render wealth meaningless and which no amount of money can cure.

We have been guided by the belief that our democracy is the best form of government ever devised, a belief that is true, but also self-defeating when citizens become so satisfied in a faith that they ignore the practice. Democracy presupposes a citizenry which is informed and involved. This is starting to happen, although not always in that order.

We have been guided by a time perspective so narrow and so present-oriented that nearly every individual and agency is on a go now, pay later basis. Our environmental debt is enormous and payments are falling due. And if the population experts have taught us anything, they have taught us to think future, and practice a little self-restraint in the present.

We have been guided by unreserved faith that all questions are answerable; all problems soluble; and all tasks completable if we can only break them down into their most minute parts. But our analysis has not been accompanied by synthesis; the parts are not made whole again, and in fact the whole has become both greater than and different from the sum of its parts.

The National Environmental Policy Act, in its way, challenges these ideas which have guided us for the last few centuries. It asks that we relate harmoniously to our natural environment; it asks how human and natural resources will be influenced by our acts; it asks that the public be more effectively informed and involved in the affairs of government; it asks for thinking well into the future; it asks that our specialized knowledge be brought together into a meaningful whole.

We are not very well prepared for all this. For environmental impact assessment is an inexact process based on ecology, to date an inexact science. Cybernetics, systems analysis, telemetry, photogrametry, electronic and satellite surveillance, remote sensing and other promising tools all may aid, but still not assure environmental quality. It will only give us better data to aid in decisions. We still have to decide what it is we want, and what we are willing to give up or tolerate, to have it.

Since NEPA, the policy of the federal government requires the use of financial and technical assistance to maintain productive harmony between man and his natural surroundings. Government agencies are directed to use a systematic, inter-disciplinary approach that integrates social and natural sciences into resource planning and develop procedures for measuring environmental indicators in order to provide unbiased and reliable data to decision-makers. The advantages and disadvantages of alternative courses of action are to be displayed to show fully the potential conflicts in natural resource use. Procedures of agencies also must provide for timely public involvement in evaluating and planning federal programs that have potential environmental impacts (2).

The environmental impact assessment is a new concept of planning analysis. In this view the impact assessment is not merely a task to meet a new legal requirement for documentation, though it must achieve this result among others. Nor is it merely an inventory of birds, bees, phytoplankton, and benthic organisms whose habitat may be destroyed by a proposed action, though such inventories may be an important element of the analysis. Rather, it is a new thought process for predicting the consequences of alternative actions.

The purpose of this process is to permit a more informed choice, by private citizens and interest groups as well as public officials from among a range of alternatives.

Congress, through NEPA, has established the framework to consider and implement procedures to enhance and preserve the quality of the environment. Government agencies are beginning to consider these in their decisions and actions. The judgments of the courts are strengthening the implementation of the policy as established by congress. Some people would still like to ignore or downplay environmental factors, particularly when costs are involved. But this simply cannot be done if we expect to preserve and enhance the quality of life for our and future generations.

The easiest way to fulfill the spirit of NEPA is to place the cards out on the table and make explicit value judgments in the most objective manner possible. The problems, trade-offs, and impacts must be delineated and then decisions made. If these decisions are made in a straight forward manner, then there should be no qualms about defending them. We can expect controversy since these decisions involve trade-offs, great financial costs, and value judgments.

It is the intent of this paper to lay out a method for assessing environmental impacts within the spirit outlined above. An effort was made to develop a method which would permit a simple and rapid analysis. However, due to the complexity of many management actions, a sincere assessment does not lend itself to a "cookbook" approach. Therefore, caution and judgment must be exercised to avoid oversimplification in using this method.

The presentation of the methodology is done in two parts; the first part develops a general method for environmental assessment, and the second outlines the specific assessment criteria and data collection guidelines to be used in the analysis. The general format of the assessment procedure was adapted from the outline in the U.S. Army Corps of Engineer's, Columbia River and Tributaries—Environmental Assessment Manual. Other major sources of ideas were Cornell, Howland, Hayes and Marryfield, Preparation of Environmental Impact Statements and Soil Conservation Service, Environmental Assessment Procedure.

In each of the chapters, 5 through 11, is listed sources of information related to the subject matter of the respective chapters. These data sources were complied specifically for the State of Oregon.

PART ONE

ENVIRONMENTAL ASSESSMENT: PHILOSOPHY AND METHOD

CHAPTER 2

PHILOSOPHY AND METHOD

DEVELOPMENT OF ENVIRONMENTAL ASSESSMENTS

Since the enactment of the National Environmental Policy Act of 1969 with its mandate for the assessment of environmental impacts, assessment procedures have gone and are still going through a process of constant change, a change that is influenced by both experience and judicial direction.

At first, some federal agencies viewed environmental assessments as a new process, separate from the normal realm of planning and decision making. They saw this assessment as directed solely towards the preparation of a new document, the environmental impact statement; a document designed to provide public information and to meet the documentation requirements of the law, but not to provide a basis for decision making.

This concept of environmental assessments emerged in impact statements of projects that were substantially planned or designed at the time of NEPA's enactment. It continues to appear in other impact statements, statements that contain extremely detailed data on a principle proposal, but only generalities about alternatives. A narrow reading of NEPA suggests this view. Unfortunately, there have been judicial decisions that seem to reward it by dissolving environmental injunctions in response to voluminous appendices of raw data (3). The apparent strategy of this approach to environmental assessments was the accumulation of large amounts of data to support or at least to prevent judicial impedence of a previously favored course of action.

A second and more current view toward environmental impact assessments has evolved. In this new approach, which appears to be the current norm for most federal agencies, the assessment process is a data input device. Its purpose is to inject new information into the planning process about the range of possible consequences of alternative management actions. This information generally includes the direct impacts on physical entities, such as acres of land or numbers of wildlife, and the more general impacts on "the ecology." Also included by many agencies are impacts on various cultural values, such as disturbance of archeological or historic sites. However, in most agencies, this information tends to be limited to rough measures, such as acres of land affected, or to stress impacts on discrete items, like the impacts on flora and fauna.

It is not clear in this approach how this new information fits in the planning process. The weight given this environmental information does not seem to be on an equal plane with engineering, economic and other types of data on which decisions are made.

A broader approach, the underlying view of this presentation, is that the environmental assessment is a new concept of planning analysis. In this view, environmental values and studies are given the same consideration throughout the entire planning and decision making process as economic, engineering and social values. The environmental assessment becomes an integral part of planning, kept on an equal plane as the economic and engineering assessments. This perspective must be kept throughout the planning process, beginning with the establishment of the basic objectives and guidelines for the operation and modification of a system to the implementation of plans designed to achieve those objectives.

ENVIRONMENTAL ASSESSMENT PHILOSOPHY

The purposes of NEPA's environmental assessment requirements is to compel implementation of the law's intent not to produce documentation for its own sake. These purposes are concerned primarily with striking a better balance among the environmental, social, economic, technical and other considerations affected by federal actions. The environmental assessment must be treated as a form of planning analysis, aimed at developing information to clarify tradeoffs among alternatives, rather than simply at documenting the possible effects of a chosen course of action. The tradeoffs are what are important to planning and decision making, not the comprehensive description.

An environmental assessment should forecast the consequences of alternative actions and not just estimate their costs and benefits. If a proposed dam will destroy a spawning ground for steelhead, that is a consequence of the dam. Whether it is a benefit or cost, or neither, depends on the perspective from which one evaluates it; as a fisherman, as a water skier, or perhaps as an indifferent observer.

The environmental assessors have two principal tasks. They must identify the affected environmental components and then predict the directions and magnitudes of the modifications likely to result from each alternative. These are professional tasks. Professional understanding of the physical, biological and social systems is an appropriate basis for identifying the impacts on the environmental components. It is an appropriate basis for predicting the magnitudes of these impacts. It is not, however, an appropriate basis for evaluating the relative desirability of the alternatives once their consequences have been predicted. Such an evaluation is a political judgment based on the relative importance of the affected social values. This judgment should be based on participation by all persons whose values may be affected by the choice and not on professional opinion.

An environmental assessment does not mean concentrating only on the adverse effects of a proposed action. Nor should it mean emphasizing an alternative's benefits. Any major action will cause changes in the existing ecological patterns and resource uses. The urge to tag impacts, as good or bad, should be avoided.

An environmental assessment must be concerned with the resource uses affected by proposed actions and not only with the physical impacts for their own sake. Such functions include direct uses of the affected resources by human beings, as in traditional planning analyses, and those functions that have value in physical and biological systems affecting other human activities and life supporting systems. They should include functions that are significant in social value systems whether or not direct use is involved.

Many impact analyses tend to present detailed inventory data on lists of discrete environmental components that may be affected by the proposed actions. The evaluators or reviewers of the alternative actions, however, are not required to choose between gross national product and benthic organisms, but between alternative patterns of fulfillment for human desires and needs. If an environmental assessment is to serve the needs of decision makers, it must gather information selectively to illuminate impacts on valued resource uses rather than accumulate vast bodies of empirical data.

Matrices and tables are useful starting points for identifying affected variables. And they are useful display formats for showing tradeoffs among alternatives, but their static comparisons fail to show those interrelationships between environmental components that could influence the accuracy of any forecasts of impacts.

Most project-type actions taken by agencies and even some on going actions, such as operations and maintenance, are not single actions. A major new highway is a package of connected links. A river basin plan may involve a system of dams, channels, and floodplain regulations. In the past five years, many arguments have arisen as to the appropriate time to prepare an environmental impact statement. From the point of view of the environmental impact assessment, however, these arguments miss the point.

Even a single dam is a package or system of actions from which subsets of environmental impacts may result. One subset of impacts will arise from the use of materials, labor, and transportation as project inputs. A second subset will arise from the methods and procedures used in project construction. A third subset will result from the physical existence of the project itself, and so on. The point is that the environmental assessment must identify impacts at each of these levels in time for the information to be used when decisions are made at that level. The assessment team must look at the overall impacts of each action taken as a whole. They must also breakdown each action into its components to be sure they have not missed any important implications. A component, in this context, is any element of a proposed action to which sub-alternatives with significantly different consequences could be proposed. Environmental assessment must be recognized as an ongoing activity that takes place at increasing levels of detail throughout the planning process.

A typical flow diagram of a planning process shows neat sequences of activities proceeding from problem definition to formulation of alternatives, then on to impact assessment and finally evaluation, with feedback loops to show the iteration of the process. It can be argued that these four activities take place simultaneously and constantly throughout the course of planning, with only the level of detail and the emphasis changing as planning progresses.

In terms of an environmental assessment, this means that impacts are already being thought about during problem definition. It also means that impact assumptions, if not analysis of them, enter into the formulation of alternatives. The point is that if judgments about impacts do enter into the problem definition and the formulation of alternatives, then any practice of treating impacts assessment as a tack-on study late in the process should be replaced by the integration of impact assessment into planning from the start.

More than anything else, an environmental assessment should clarify the consequences of public decisions. It should communicate clearly and fairly the implications of choosing one action over another. It must consider all competing users of the resource systems affected. It must be an ongoing process, from the initial definition of a planning or engineering problem through the entire course of generating, analyzing, screening, and deciding among alternatives.

ENVIRONMENTAL ASSESSMENT OBJECTIVES

In developing the assessment methodology presented in this paper, certain objectives were used as guides. The overall objective was to formulate an assessment method which would determine in detail the environmental impacts of a specific action and its viable alternatives.

An assessment should include all significant environmental impacts. Each significant impact should be sufficiently investigated to identify its magnitude and nature. Failure to include or adequately analyze a significant impact could damage the credibility of the entire analysis.

Any and all unnecessary material should be identified as early as possible and then be excluded from further consideration.

The assessment report should be written for the layman and the general public. Technical names and jargon should only be used where their usage is common. The purpose of the assessment is to determine that action which is in the best interest of the general public. Gaining acceptance of or support for an action is difficult if the reader cannot understand the action or the reasons for its selection.

The assessment methodology should be usable for evaluation of actions of any size. Therefore, the assessment procedures must be capable of considering environmental impacts in a way that those that are not applicable for a specific assessment do not have to be used. This emphasizes the important impacts and lessens the distraction of the unimportant ones.

The results of any assessment method should be consistent with the normal accuracy of the technical data. Those analyses of impacts that yield only order of magnitude estimates because satisfactory correlations between environmental conditions and natural processes are lacking should be so described. Any degree of uncertainty in either the data or the conclusions should be identified.

Data of the required accuracy should be used where it is available and a reasonable effort should be made to improve the accuracy where needed. Efforts should not be made, however, to improve accuracy of data if the results will not significantly affect the conclusions.

Although a comprehensive assessment is desirable for all potential actions, the time and effort devoted to the preparation must be in keeping with the size of the action and its potential impacts. For example, an expensive comprehensive analysis should not always be required, without regard to the size of the action or the impact. On the other hand, a major effort may be necessary for a relatively small action which may have major impacts. The methodology should allow for adjustment of time and costs to the degree of effort needed for a particular action.

The cost of the assessment of an action may, by itself, be large enough to make the action uneconomical.

ENVIRONMENTAL ASSESSMENT PROCEDURE—SUMMARY

The environmental assessment is initiated in the earliest steps of the planning process. The general processes involved in the assessment procedure presented in this paper are shown in Figure 1. The product of this method is a detailed description of the environmental impacts of each of the alternatives that are selected for detailed consideration, plus a general description of the impacts of all other alternatives considered.

The first action in the assessment is a preliminary screening of the possible alternatives. This is to identify those alternatives expected to have the most desirable net environmental impacts.

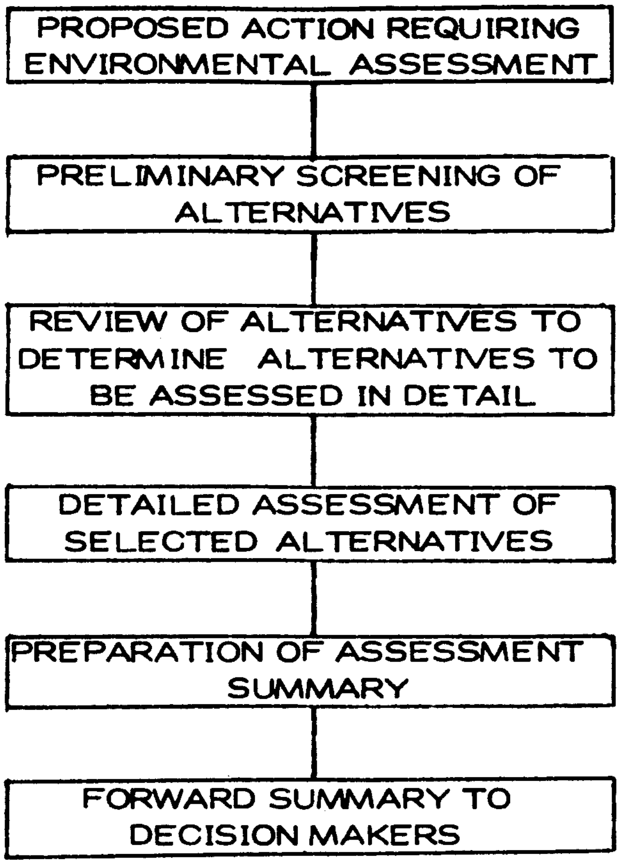


Figure 1. Major Steps in Environmental Assessment

The preliminary screening consists of developing a general description of each alternative, a general estimate of the magnitude of the environmental impacts for each alternative, and a general ranking of the alternatives in accordance with the magnitude of their environmental impacts.

The information developed in the preliminary screening is then reviewed by all interested parties to determine those alternatives that should have detailed assessments. In this review, all available engineering, economic, and environmental information for each alternative is analyzed. This will aid in determining which of the alternatives have the best potential balance of economic and environmental benefits and costs.

Alternatives selected during the review meeting for further consideration are then given a detailed environmental assessment. The main steps on this detailed assessment are: developing a detailed description of each alternative; identifying and describing the portions of the environment that would be significantly affected by each alternative; and estimating the magnitude of the environmental impacts that would occur. The end product is a comparative summary of the significant impacts of each alternative. This is forwarded to the decision-makers for use in determining the best course of action.

The assessment procedure provides only the environmental impact information needed for making planning decisions. Other information such as objectives, guidelines, engineering and economics needed for making such decisions, must be obtained from other sources.

The amount of energy expended on an environmental assessment depends on the size of the impacts and the significance of those impacts in relation to the total environment and the current social climate. When determining the magnitude of the environmental impacts, adequate consideration must be given to the concerns of the general public, with due caution that the expressed concerns are representative of both majority and minority opinions. Standard rules stating the amount of assessment required for an action of a specific size should be avoided. Instead, the amount of effort required for a particular action should be determined by studying that action.

The preparation of an environmental assessment requires an inter-disciplinary approach in which the areas of investigation are determined by the nature of the action being evaluated. The amount of effort required of each discipline depends upon the impacts and their magnitude. This also indicates the size of the team needed to make an assessment.

CHAPTER 3

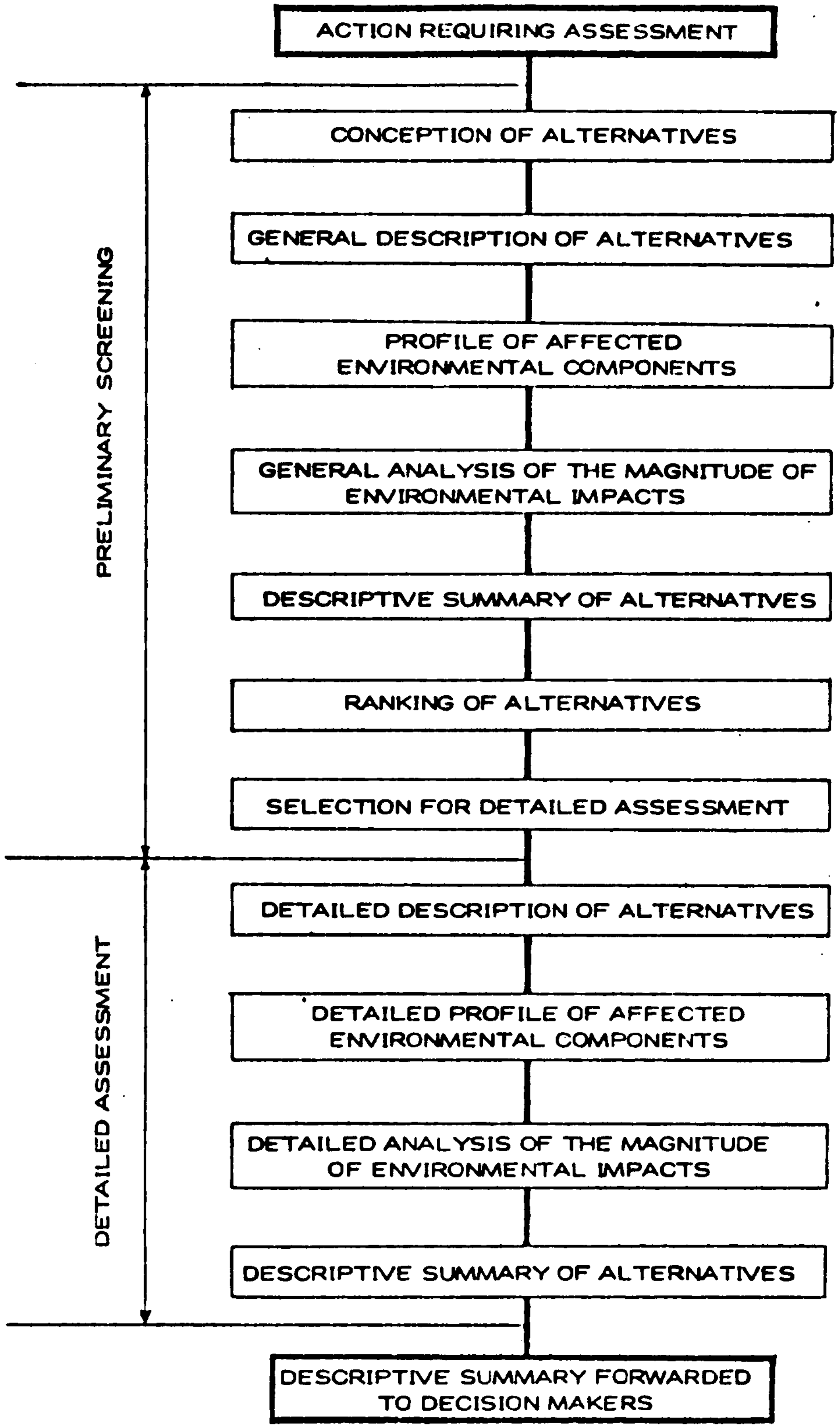
ENVIRONMENTAL ASSESSMENT PROCEDURE

As new federal actions are initiated, the environmental values and the studies of probable impacts are to be given the same consideration throughout the planning and decision making process as economics, engineering and social values. In line with this mandate, the environmental assessment procedure presented herein, is designed to determine in detail, the environmental impacts of a specific action and its viable alternatives. The product of the assessment is a detailed description of the environmental impacts of all the alternatives selected for detailed study, plus a general description of the impacts of all other alternatives considered.

The assessment procedure is divided into two segments, the preliminary screening and the detailed assessment (4). The steps in each segment are shown in Figure 2.

The object of the preliminary screening is to reduce the number of alternatives to only those that justify a detailed assessment. The detailed assessment then develops a detailed description of each selected alternative. Identifying and describing those portions of the environment that would be significantly affected and

Figure 2. Environmental Assessment Steps



estimating the magnitude of the environment impacts that would occur.

The purpose of the following discussion is to outline each step in the assessment procedure, illustrating what it should accomplish. Details for specific methods of achieving these results are outlined in Part II, "Specific Assessment Criteria and Data Collection Guidelines."

PRELIMINARY SCREENING OF ALTERNATIVES

An assessment of the environment should start whenever new actions are to be evaluated for adoption and implementation. Environmental assessments are only one part of the overall planning process. The assessment procedure discussed here has been developed to provide only the information on environmental impacts needed for making planning decisions. Other information also an integral part of the decision making process, such as objectives guidelines, engineering and economics, must be attained concurrently from other sources.

CONCEPTION OF ALTERNATIVES

The first step in the preliminary screening is the identification of methods or actions of accomplishing the project's objectives. It is a creative process and requires an unbiased approach. It is also an ideal time to initiate public involvement.

All reasonable actions suggested should be identified, regardless of their relative merit. No actions suggested should be eliminated unless it is very obvious that it is not possible.

The conception of alternatives begins with the identification of all major objectives of the proposed project. All actions thought of should be listed along with the objectives they accomplish. If there are obvious reasons why a particular action would not be feasible they should be noted and the particular action not given any further study. A possible way of documenting the alternatives conceived is shown in the following table.

TABLE 1

POSSIBLE ALTERNATIVES

Project__________________________

Project Objectives	Possible Action	Reasons Actions Not Feasible
1.	a.	
	b.	
	c.	
	etc.	
2.	a.	
	b.	
	c.	
3.		

Possible alternatives may be any one of the single actions or various combinations of actions depending on the complexity of the project. The objectives may be completely independent and be considered individually, each with its own alternatives. However, many times objectives are interdependent and can be accomplished by the same action or combination of actions and should be considered as a unit. For example, the objectives of flood control, irrigation and recreation could be accomplished by any of the following alternatives: (1) Multi-purpose reservoir, (irrigation, recreation and flood control), (2) multi-purpose reservoir, (irrigation and recreation), and channel enlargement, (3) multi-purpose reservoir (irrigation, recreation) and no action on flood control, etc. All the reasonable alternatives will be described in the next step.

The concept of new alternatives should be a reoccurring process throughout the assessment procedure. As the assessment proceeds, the participants become more familiar with the proposed actions and their impacts. Periodically, the alternatives being studied should be reviewed to see if additional alternatives or modifications to existing alternatives should be considered.

GENERAL DESCRIPTION OF ALTERNATIVE

The next step is to describe each alternative and its relationship to the physical environment. This relationship then becomes the basis for determining both the components of the environment affected and the probable amount of change to each. Only a general description is needed, and at this point no attempt should be made to develop design details.

The general description that should be followed for developing a description for each alternative is as follows:

1. Select the objective or objectives (from Table 1) for the alternative and express in terms of accomplishment. An example would be: provide flood prevention along the North Powder River, supplementing irrigation water to presently irrigated land and increased water-based recreational opportunities.
2. Determine a general design for any physical structures required for the alternative. If the alternative was a multi-purpose reservoir, it would mean determining the total storage and the capacities to be allocated to each use.
3. Select a site or sites if the action involves any major structures. The site selection, at this point, should be based on available maps and, if possible, a reconnaissance of the area.
4. Develop a general description of the facility (the structure and site from steps 2 & 3) and describe the nature of the environment physically affected, including the present use, both during and after completion of construction.

5. Prepare a short (one page) general description of each alternative. The description should be developed from available maps, a visual reconaissance of the site, and available literature.

The product for this step of the analysis is this general description of each alternative and its relation to the land and water resources. The purpose is to assure each member of the assessment team understands the general nature of the alternatives, including the physical structures, their locations, and the general nature of the environment likely to be affected.

PROFILE OF AFFECTED ENVIRONMENTAL COMPONENTS

A profile of the affected components of the environment is needed as a basis for determining the magnitude of the impacts each alternative will have on those components. This profile describes the existing physical, biological, and socio-economic characteristics of land and water supply, use, and control of the area likely to be affected by the proposed actions. As one of the viable alternatives, these existing conditions should be projected to portray what future conditions would be without any action. This is also a basis for comparison of the magnitude of the various impacts of the alternative actions.

Affected environmental components are often different for each alternative action. It is important that all the environmental impacts be identified initially for each alternative. There have been many useful aids developed to assist in identifying the affected environmental components. Table 2 illustrates a modification of one such aid, developed by Battelle, Pacific Northwest Laboratories for the U.S. Army Corps of Engineers. This matrix consists of lists of environmental changes across the top and the affected components in the left column. One matrix table should be used for each alternative, including the alternative of no action.

The first step in using the table is to read the list of environmental changes in the left column and place an X in the first row of squares for each change that will occur for the alternative being evaluated. Then for each environmental change, the affected components list across the top are identified by placing a check in the corresponding square.

Although the matrix of Table 2 is comprehensive, some alternatives may have impacts not identified on the matrix. It is desirable to have more than one person, preferably several persons expert in different disciplines, analyze the alternatives to determine the impacts. Each of these persons should be alert for affected areas not covered by the matrix.

For example, if the impoundment of water for supplemental irrigation, recreation and flood control uses were being considered,

the environmental components to be quantified for comparison purposes would be those that were significantly affected. In this example, the affected components would include:

--Agricultural land use changes due to increase in irrigation water supply, including changes in cropping patterns, management practices, productions, erosion, sedimentation, and wildlife habitat.

--Changes in flow regime of the particular river and impact on fish and other aquatic life.

--Reservoir land use, including impact of inundation on present forest cover and recreational homesites, and effect of drawdown on future recreation site developments.

--Water-based recreation pursuits including effects of reservoir drawdown.

For preliminary screening purposes, identification of the environmental impacts in terms of water and land resources would require the quantification of existing uses that would probably be significantly affected by the objectives or function of the alternative being studied. For the example used above, the required quantification would be an inventory of the affected resources including such things as: present cropping patterns and management practices, existing erosion and sediment amounts, present recreational facilities and activities, actual streamflows, and so forth.

There are two approaches to preparing this inventory of affected environmental components. The first is to prepare it at the same time the alternatives are studied for their impacts. In which case each time an alternate is noted to affect an environmental component, the existing condition of that component is inventoried. In the second method, the most commonly affected components of the land and water resources are quantifiably inventoried prior to the assessment. This second method is more practical and consumes less time of the assessment team since only those components not listed on the general resource inventory will have to be quantified by the team.

As each component of the environment that is expected to be affected by an alternative is identified, a general description of that portion should be prepared. This is a continuation of step two which requires a visualization of the physical location of the project and any structures, the operating and maintaining procedures for associated facilities and the general impacts of each alternative on the life forms in the area. Although treated as a separate step in the assessment procedure, this step and the following one of determining the magnitude of the impacts can usually be performed simultaneously. Often the general nature of an environmental impact will be evident before the affected environmental component is described. However, the study of the affected environmental components is necessary to assure that all significant impacts are identified.

A very important part of the description of the environment is the predicting of conditions both during installation and throughout the expected life of the action. This is particularly important if significant changes in conditions are expected.

GENERAL ANALYSIS OF THE MAGNITUDE OF ENVIRONMENTAL IMPACTS

A general description of the significant impacts of each alternative is required as a basis for comparing alternatives and then selecting the best ones. Environmental impacts which result from an action can be organized as shown in Figure 3 (4, p. 29). The procedures for determining impacts should move progressively from Level 1 to Level 4.

Level 1 includes the basic physical impacts which result from changes in air, water, and land; while Level 2 represents the direct ecological impacts of those alterations. Level 3 impacts are changes in human uses that result from Level 1 and 2 impacts. Level 4 impacts are socio-economic changes that result from Level 1 and 2 impacts. Level 4 impacts are socio-economic changes

Figure 3. Levels of Environmental Impacts

<u>LEVEL 1</u>	WATER	AIR	LAND
PHYSICAL IMPACTS	HYDROLOGY WATER QUALITY FLOOD CONTROL	CLIMATOLOGY METEOROLOGY AIR QUALITY	GEOLOGY SOILS EROSION
<u>LEVEL 2</u>			
ECOLOGICAL IMPACTS	AQUATIC BIOLOGY	TERRESTRIAL BIOLOGY	
<u>LEVEL 3</u>	WATER SUPPLY	AGRICULTURE	DEDICATED USE AREAS
CHANGES IN HUMAN USES	MUNICIPAL INDUSTRIAL IRRIGATION	RECREATION	
<u>LEVEL 4</u>			
HUMAN IMPACTS	SOCIO-ECONOMIC	CULTURAL	ESTHETICS

that result from Level 3 impacts. This is the level to which the general public can most readily relate; the changes identified at this level create the greatest concern.

The product of this portion of the assessment should be estimates of the incremental difference between conditions as they will be without the action and as they are estimated to be if the alternative is implemented. Those differences can be either positive or negative--that is, either beneficial or detrimental.

Using the impact of impoundment of water on the agricultural resource for illustrative purposes, incremental impacts might include:

--a change in cropping patterns and management systems,

--an accompanying increase in agricultural production and an increase or decrease in erosion and sedimentation,

--an accompanying dollar value attributed to the net increase or decrease in production,

--an accompanying increase or decrease in land values,

--estimated increases or decreases in full or part time jobs in the area accompanying change in cropping patterns and management systems,

--improved erosion and sediment control in some areas and decrease in other areas with an accompanying effect on land use and related economic values.

The impact on environmental components of the land and water resources affected by each alternative would be similarly determined. As this procedure is carried out, it will become apparent if each component is sufficiently detailed to permit the determination of the impacts of the particular alternative. This is particularly true in cases where the impacts are significant. It may be necessary to expand the description of the environment to include components not initially included or recognized. Should two or more alternatives have similar incremental impacts on the same environmental component, it may be necessary to increase the detail of one or more descriptions to allow a better comparison with the other alternative. This is particularly true where the other impacts of the alternatives do not clearly indicate the value of one alternative over the other.

Where only one alternative affects a given environmental component, the determination of the incremental impact can be more gross because it will be compared with a zero impact for the others.

Through the course of this procedure those impacts that are minor or insignificant will be identified. These need not be carried any further. This identification of neglibible, insignificant impacts is important documentation in the assessment process. This adds to the validity of the alternative recommended for adoption because rather than being overlooked, those water and land resources indicators were actually accessed and the incremental impact of the recommended alternative was found to be negligible or insignificant.

The magnitude of the impacts can be described in broad terms. This is adequate for the preliminary screening. This can be done by referring to the matrix of Table 2 and answering the question, "How does the environmental change effect each environmental component?" To assure completeness, all known impacts should be listed in a form similar to Table 3. Since only the significant impacts have to be identified in the final analysis, the significance of each impact described should be shown by filling in the last two columns of the table. This avoids placing undue emphasis on negligible impacts which complicate decisions by forcing consideration of these insignificant factors. It is important, however, that the reasons for those impacts felt insignificant be well documented.

As a guide to the significance of various environmental impacts the following classification is suggested (4, p. 34).

1. If an impact involves a rare or endangered environmental characteristic, the impact is significant if it results in a measurable or noticeable change in that characteristic. Note that this can be either favorable or detrimental.

2. If the impact can be measured in monetary terms and the affected component is commonplace, it usually is insignificant if the monetary value is less than one percent of the total of all economic benefits or costs. An exception is the case where there are numerous small monetary impacts that add up to a total equal to at least five percent of the total of all economic benefits and costs. In that case, all of these small impacts should be included in the final analysis as a single item.
3. A non-monetary impact is insignificant if it results in a change of a very small fraction (less than 0.1 percent) of a common environmental asset that is not expected to become rare.
4. A non-monetary impact is significant if it results in a change of more than 0.1 percent in occurrence of an environmental asset within the region under consideration.
5. A temporary impact usually is insignificant if the former conditions will be restored within a short time period after the action ceases, and the impact is not of major proportions while it exists.
6. An impact usually is insignificant if the effect is less than the accuracy of available methods of measurement.
7. The above criteria not withstanding, an impact should

be treated as if it is significant if it is of obvious public concern.

TABLE 3

SUMMARY OF ENVIRONMENTAL IMPACTS

Project ______________________________

Alternative ______________________________

Environmental Impact	Magnitude of Impact	Significance	Reason if Insignificant
1.			
2.			
3.			

DESCRIPTIVE SUMMARY OF ALTERNATIVES

As an aid in comparing the alternatives, a summary of the environmental impacts of the alternatives should be made. The use of a tabular format such as Table 4 may facilitate this comparison. This table is a composite of the information on Table 3. The first column in the table lists the environmental parameters affected by the alternatives. The other columns contain brief descriptions of the magnitude of the impact of each alternative on those parameters. In each case the basis for comparison is the existing conditions. The general procedure for filling in the table is:

1. List titles of each alternative across top of sheet.

The first alternative should be the alternative without any action.

2. List all the environmental impacts of concern to the assessment in the left column. This should include: all identified types of impacts for the alternatives, and all impacts for which there may be public concern.

3. Enter a brief description of the magnitude of each impact in the appropriate location for each alternative.

4. If an impact is classified as insignificant in Table 3, the word insignificant should be entered along with the description of the impact.

5. If there is no impact, the word "none" should be entered.

It is particularly important that the descriptions used in filling out the summary can be understood by the general public. Where possible, these descriptions should represent the actual impact on humans. Some of the physical impacts identified in an assessment do not directly affect humans and, therefore, cannot be expressed in terms that describe the human as well as the physical impact. Where ever possible, the human impact should also be included in the summary. As an example, operation of a water storage dam may result in a change in velocity and surface area in a stretch of a river. The average individual would not relate to a description in terms of the number of acre-feet or acres of water.

TABLE 4. DESCRIPTIVE SUMMARY OF ALTERNATIVES

Environmental Impacts*	Alternative No. 1	Alternative No. 2	Etc.
Land Use			
Impact on Aquatic Life			
Impact on Animal Life			
Impact on Bird Life			
Recreational Impact	(Enter brief description of impacts in comparison		
Impact on Air Quality	to the base case of not adopting any of the alternatives.)		
Impact on Water Quality			
Aesthetic Affects			
Fogging			
Icing			
Scenic			
Noise			
Odor			
Impact on Archeological Values			
Impact on Historical Values			
Human Displacement			
Etc.*			

*Parameters used as appropriate for the alternatives being considered.

The public would, however, be able to relate to that physical impact if it is expressed in terms of its resultant impact on humans, such as the change in visitor days for fishing, the change in fish population, or the change in visitor days for swimming.

Indefinite wording such as minor, major, etc., should not be used. If they are, they should be accompanied by a statement describing the actual impact. It should be stressed again that physical impacts generally should not be used as the primary measurement. They should however, be kept visible. Their primary use would be to substantiate the values selected to measure human impacts. An exception is the case where a rare or endangered resource is involved. Table 5 (4, p. 40) has been included to illustrate examples of general relationships between physical and human impacts.

RANKING OF ALTERNATIVES

The next step in the procedure is to rank impacts of all the alternatives. This is to aid in the selection of those alternatives to be given a detailed analysis. The ranking of the alternatives at this point is based solely on environmental impacts.

To rank the alternative it is best first, to classify them into categories so that all the alternatives in a category affect the same environmental components. For example, if construction

TABLE 5

EXAMPLE ENVIRONMENTAL IMPACT PARAMETERS

General Category	Sub-Topic	Associated Physical Effects	Human Effects
	Depth	- - -	Navigation Effects
	Temperature	Heated Area & Volume Swimming Conditions No. Fish	Visitor Days, Sport and Commercial Fishing and Value
	Bottom Conditions	No. Fish	Visitor Days, Sport and Commercial Fishing and Value
	Width	- - -	Navigation Effects
	Radioisotopes	Radiation Dose	Somatic and Genetic Damage
Land	Area	- - -	Dollar Value
	Erosion	Water Quality, Fish	Esthetic Value, Sport & Commercial Fishing
	Dehydration	Change in Plants, Animals, and Fish	Esthetic Value Agricultural Production
	Access	Change in Access	Recreation Use
	Salinity	Salinity Change	Agricultural Production
	Form	Structural Change	Agricultural Production Esthetic Values
Forestry	Production	Change in Product	Product Value
Agriculture	Production	Change in Quantity, Change in Type	Crop Value
Industrial Development	Quantity	- - -	No. Jobs, Gross State Product, Taxes
Business and Commercial	Quantity	Change in Quantity	No. Jobs, Gross State Product, Taxes
Air	Visibility	Fog, Smog	No. Persons Affected and Nature of Effect
	Composition	Cdor	No. Persons Affected and Nature of Effect
		Chemicals	No. Persons Affected and Nature of Effect

TABLE 5 (Continued)

General Category	Sub-Topic	Associated Physical Effects	Human Effects
Recreation	Hunting	Change in Habitat or No. Animals or Birds	Hunter Success
	Fishing	Change in Habitat or No. of Fish	Angler Success
	Picknicking	Change in Facilities or Attractiveness of Area	Carrying Capacity in Visitor Days
	Camping	Change in Facilities or Attractiveness of Area	Carrying Capacity in Visitor Days
Archeological	- - -	Loss or Gain of Site	Change in Know-ledge
Historical	- - -	Loss or Gain of Feature	Change in Cultural Cpportunity
Aesthetics	- - -	Change in View	Gain or Loss of Enjoyment
Education	- - -	Increased Information	Change of Knowledge
Tourism	- - -	Change in Facilities and Attractiveness of Area	Visitor Days Increase or Decrease
Demography	- - -	Change in Habitable Region	Population Change, Human Displacement
Water	Quality	Composition Change, Aquatic Habitat Conditions	Sport and Commercial Fishing, Taste, Odor
	Quantity	Quantity Change	Recreation Days Commercial Activities
	Velocity	Velocity Change	Visitor Days Navigation Effects
	Elevation	- - -	Power Generation

of an irrigation dam is being assessed, the categories might be:

1. dam sites,
2. dam heights,
3. wells,
4. direct river diversion.

The second step is to subjectively compare the impacts of the alternatives in each category. Any two of the alternatives are compared by studying the environmental effects of each and then selecting the one with the most favorable total impact. This process is repeated by comparing pairs of alternatives in a category until the relative ranks of all are known.

Using the information in Table 4 of the previous section, the alternatives can be rapidly compared by comparing only the differences between the alternatives. If an impact on an environmental component is the same for all alternatives, no information is included in the differential comparison for that component.

Table 6 illustrates this differential comparison method. Those environmental components that are significantly affected are listed in the first column. The impacts of a reference case is the differential comparison of the impacts of any alternative to the impacts of the base case of no action. This information can be taken directly from Table 4. Frequently the reference case alternative will be the alternative that was the basis for starting the

TABLE 6. DIFFERENTIAL COMPARISON OF ALTERNATIVES

Environmental Components*	Reference Case Impacts Alternative 1	Differential Impacts of Alternatives: Alternative 2	Alternative 3
Land Use			
Recreational			
Commercial			
Historical & Archeological			
Water Use	(Enter reference Case impacts in comparison to base case of no action.)	(Enter differences in impacts between each alternative and the reference case.)	
Commercial			
Recreational			
Aesthetics			
Social			
Etc.			

*Parameters used as appropriate for the alternatives being considered. A parameter is used only if there is a significant difference in impact between an alternative and the reference case.

assessment. Preferably it would be one of the alternatives that will finally be selected for detailed assessment.

The differential impacts in comparison to the reference case are presented in the table for the other alternatives. Again, these are for only the significant effects, and only significant differences in impacts are shown.

If the categories for classifying the alternatives have been selected so that all applicable alternatives affect the same environmental components, comparison of any two alternatives simply requires selection of the one with the more favorable differential. However, if two alternatives have different types of impacts, or if an increase in one impact has to be compared to a decrease in another impact, judgment must be used in the comparison. There is no generally accepted rule for equating two non-monetary impacts to monetary values. Also, it must be remembered that non-monetary values may vary widely in accordance with the general economic conditions in a region and the characteristics of the citizens of that region.

Therefore comparison of alternatives requires an awareness of the environmental climate as expressed by regional attitudes, customs, laws, legal decisions, etc. While the opinion of minority groups should not be ignored, a vocal minority should not be allowed to have excessive influence on the decisions. If a decision cannot be made as to which of two alternatives is preferable, they should be considered to have equal impact.

Comparison of all alternatives in a category should identify the relative ranking within that category. An overall ranking of the individual alternative can be determined by comparing relative rankings category by category. This could result in two or more alternatives appearing to be of equal merit. If this occurs there are two approaches. First, one of the alternatives can be selected as the representative one for detailed analysis and the others held for possible later consideration in the final analysis; or second, all of them may be carried forward. The first approach would be appropriate if the alternatives are not expected to be prime candidates for the final analysis, and the second approach, if they are.

SELECTION FOR DETAILED ASSESSMENT

Making a detailed environmental assessment can be both time consuming and costly. It could require extensive investigation by several technical specialists. Because some actions may have many alternatives, the cost for making a detailed assessment of all the alternatives could be prohibitively high. This is especially true if alternatives which have little chance of being selected for adoption are included. In addition, the selection of the final action also is based on engineering and economic factors so that the best alternative is not apparent solely on the basis of information from an environmental assessment. Consequently, after the general description and ranking of the alternatives is completed, a review meeting should be held with all interested parties to select those alternatives to be assessed in detail.

A summary document describing the results of the preliminary screening should be prepared for discussion at the review meeting. The contents of the document should include:

--general description of each alternative assessed (Step 2),

--general description of the affected environmental components for each alternative (Table 3),

--general description of the magnitude of each environmental impact (Table 3),

--descriptive summary (Table 4),

--differential comparison sheet (Table 6),

--summary of the ranking process and results.

DETAILED ENVIRONMENTAL ASSESSMENT

The review meeting and the subsequent decision should identify those alternatives to be assessed in detail. It is important that status of related engineering design and economic studies be made known to the assessment team for these disciplines now take on a role equally important to the environmental considerations. The actual conducting of the detailed environmental assessment involves repeating, in greater detail, several of the steps followed in the preliminary screening, on the selected alternatives.

DETAILED DESCRIPTION OF ALTERNATIVES

Each of the alternatives selected for detailed assessment, including the base case of no action, is now described in sufficient detail so that all environmental impacts can be determined with reasonable accuracy. Projections of conditions for the base case should cover the same time period and the same range of probable future conditions covered by predictions for each alternative. Should an alternative involve physical structures, the selection of a site and development of general design for the facility is now required. The design details need be developed only so far as required to determine the environmental impacts.

The procedure of the preliminary screening is repeated, only now with greater detail. Whereas previously only a general site for the facility would have been described, a specific site now would be selected on the basis of a general site reconnaissance by an appropriate specialist. Each design feature would be described in the detail needed for making a detailed assessment. As an example, the high water line for a reservoir would be drawn on a contour map and the terrain adjacent to that contour would be described.

DETAILED PROFILE OF AFFECTED ENVIRONMENTAL COMPONENTS

Those components of the water and land resources that would receive major alteration, should a given alternative be implemented, should have been identified in the preliminary screening. This provided a sufficient basis for determination of alternatives that should be eliminated from further consideration because of major detrimental impacts. A more precise evaluation is needed now to identify the more subtle differences among the remaining alternatives, so a selection of the final course of action can be made. While the components of the affected environment will be basically the same for each alternative as identified during preliminary screening, a more detailed assessment will probably be needed to evaluate more precisely the differences among the alternatives' incremental impacts on each environmental component.

Using the fishery resource for illustrative purposes and the example of an irrigation dam, a detailed description of affected environmental components relative to water and land resources would include:

--location of fish spawning beds by species and required streamflow, depth, velocity, and quality for optimum spawning conditions;

--stream locations and conditions presenting fish passage problems and the seasonal requirements for successful fish passage;

--areas important for fish rearing and for resident fish, by species, and seasonal requirements in streamflow, depth, velocity and quality for optimum fish production;

--existing levels of sport fishing by stream sections, seasons, and species, as well as associated annual value sport catches;

--existing recreation fishing access to streams and streamflows and water levels required for existing access to be usable.

Similarly, other affected environmental components should be described in comparable detail so that determination of the incremental impacts of each alternative on those environments can be made in a manner that will permit direct comparison. Each alternative is likely to affect different portions of the environment or to affect the same portion in a different manner. Thus an adequate description for evaluation of one alternative may require additional or different details to assess another alternative.

DETAILED ANALYSIS OF THE MAGNITUDE OF ENVIRONMENTAL IMPACTS

The detailed impacts on the environment are the basis for the final determination of the best course of action.

Detailed impacts on the water and land resources should be measured by a determination of incremental changes in the applicable factors quantified for affected environmental components. This requires quantification of the same factors for each alternative. Each of the affected portions of the environment is studied in detail to determine the changes that are expected to occur. The objective is to obtain as accurate an estimation of the expected change in the environment as is possible within the time and funds available.

DESCRIPTIVE SUMMARY OF ALTERNATIVES

A final report of the detailed assessment is now prepared. The purpose is to relate to the decision-maker the results of the assessment. A descriptive summary and document similar to that prepared for the preliminary screening will serve the purpose.

PART TWO

SPECIFIC ASSESSMENT CRITERIA AND DATA COLLECTION GUIDELINES

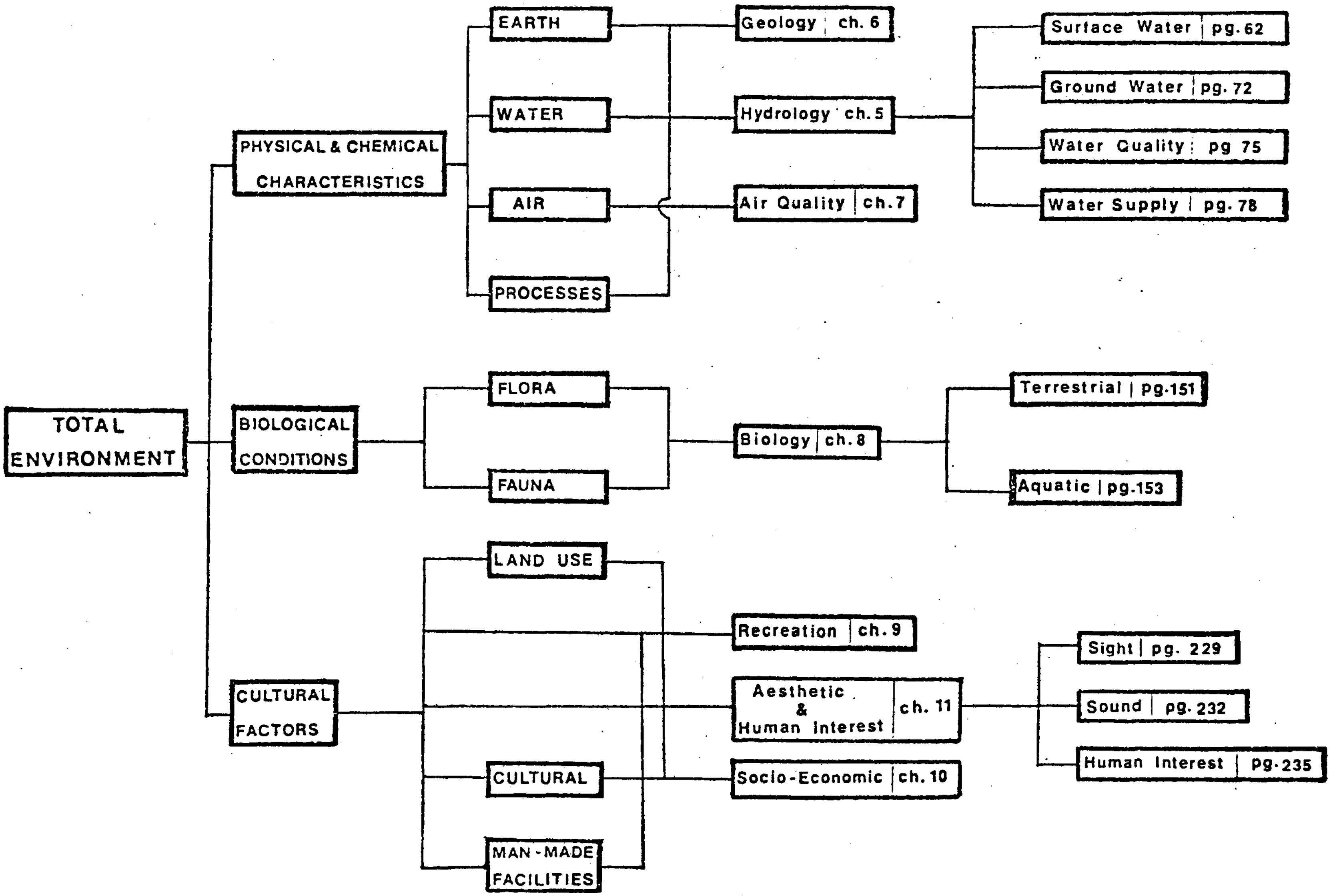
CHAPTER 4

INTRODUCTION TO PART TWO

Detailed in this part of the paper are the specific methods for evaluating the affected environmental components. An index to the specific assessment criteria and data collection guidelines is outlined in figure 4. In figure 4, the environmental components of Table 2 are grouped into broader categories and their relationship shown to a particular resource or function for which there are specific evaluating methods.

Where the categories represent such environmental components as terrestrial or aquatic biology, recreation, dedicated use lands, etc., the assessment revolves around the question, "What impact would each alternative have on those components?" Where the categories are project functions such as irrigation, flood control, etc., the question becomes "What impact would providing for those functions have on other environmental components?" Using irrigation as an example of the latter case, the environmental concern is not so much the impact that a proposed action would have on an irrigation development, but rather, what impact would the irrigation development have on other environmental components.

Figure 4. Index to Assessment Criteria and Data Collection.



CHAPTER 5

HYDROLOGY

Hydrology is fundamental to many environmental components. For this reason, the environmental impact cannot be described only by the changes in hydrology that would be caused by proposed actions. It requires knowledge of the impact that such changes would have on important environmental components that are dependent upon the maintenance of specific parameters within the hydrologic regime. Because of this hydrology appears first in the discussion of assessment criteria. Water quality and water supply, because of their close interdependence with hydrologic parameters, are included in this section.

Table 7 (4, p. 53) illustrates the extent to which types of management actions are affected by hydrology. A number system is used to show the significance of each parameter listed at the left to the management actions listed across the top.

The table represents a guide to the levels of data collection that would be needed for principal types of actions. The guide must be supplemented with judgment and knowledge of the magnitude of the action, the parameters that apply and their interrelationships.

TABLE 7

DATA COLLECTION GUIDE

Parameter	Management Action						
	Impoundment	Irrigation	Construction	Flood Control	Flow Management	Recreation & Parks	Municipal & Industrial
SURFACE WATER							
Discharge	2	2	2	2	2	1	1
Diversions & Returns	2	2	1	2	1	0	1
Stage	2	1	1	2	2	1	1
Velocity	2	1	2	2	2	1	1
Ice Formation	2	1	2	2	2	1	1
Channel Modification	1	1	2	2	2	2	1
Temperature	2	2	1	2	2	1	1
Coliform--Total + Fecal	2	2	1	1	1	2	2
Fecal Streptococcus	2	2	1	1	0	2	2
pH	1	2	2	1	1	2	2
Dissolved O_2	2	2	2	2	2	2	1
Dissolved N_2	2	0	0	2	2	0	0
Dissolved Solids	2	2	2	1	1	2	1
Suspended Sediment	2	2	2	2	2	2	1
Total Organic Carbon	2	2	1	2	2	2	1
Orthophosphate	2	2	1	1	1	2	0
Total Phosphate	2	2	1	1	1	2	1
Nitrogen (Organic)	2	2	1	1	1	2	1
Nitrogen (Ammonia)	2	2	1	1	1	2	1
Nitrogen (NO_2)	2	2	1	1	1	2	1
Nitrogen (NO_3)	2	2	1	1	1	2	1
Phytoplankton	2	2	1	2	2	2	1
Zooplankton	2	2	1	2	2	1	1
Benthos	1	1	1	1	1	0	1
Potassium	2	2	0	0	1	0	1
Heavy Metals	1	1	1	0	0	1	1
Hazardous Chemicals	1	2	1	1	2	1	2
Turbidity	2	2	2	1	1	2	1
GROUND WATER							
Well Locations	2	2	2	2	2	2	2
Affected Aquifers	2	2	2	2	2	2	2
Rate of Water Production	2	2	2	2	2	2	2
Well Water Levels	2	2	1	2	1	1	2
Well Capacities	2	2	2	2	1	1	2
Chemical and Physical Properties	2	2	2	1	1	1	2

Code: 0 = Insignificant or not applicable
1 = Requires only general or limited data
2 = Very significant, requiring extensive data and forecast information

Any action which changes the hydrologic regime of a stream, lake, or reservoir will have a primary impact on both the surface water and the ground water in the area. These, in turn, may significantly affect aquatic life, water quality, water supply, recreation opportunities and other environmental components.

The determination of the relevant environmental impacts requires identification of the environmental changes that would result from those changes in the environmentally dependent hydrologic parameters. This requires, first, quantification of the significant hydrologic parameters in terms that describe conditions both before and after the proposed action. The discussions to follow deal with hydrologic parameters that are most likely to require consideration.

Quantification of expected changes in the hydrologic parameters provides the basis for the second step; the translating of those changes into a measurement of the environmental impacts. This step is discussed in the subsequent section to follow that deals with the specific environmental components.

CLIMATE

A number of climatic elements influence or can be considered part of the hydrological cycle. They are, in particular, a measure of the available water supply. Therefore, understanding the characteristics of those elements is essential to prediction of the impact that a proposed resource management action will have on the environment. Climatic elements requiring consideration are detailed below.

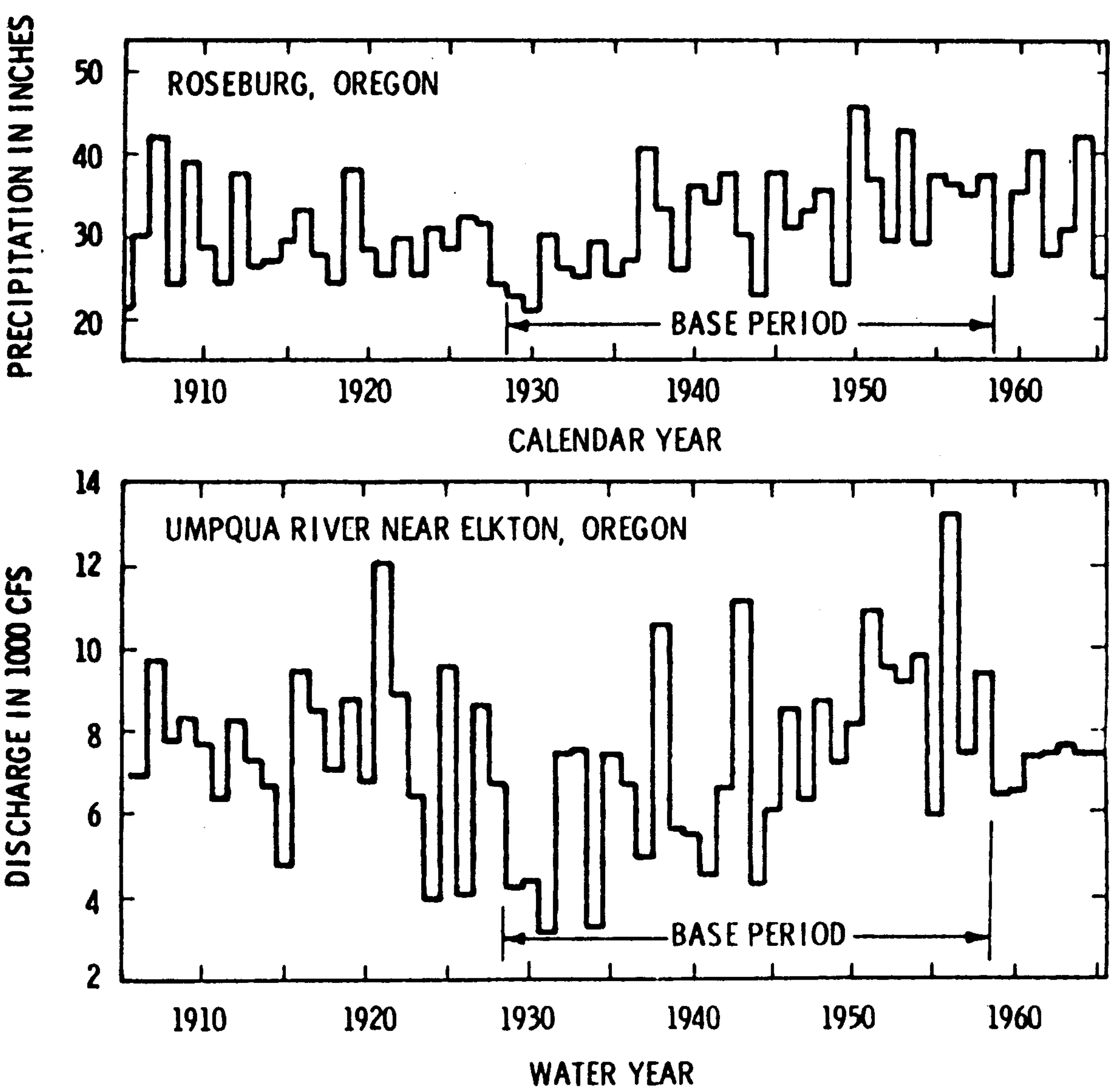
PRECIPITATION

Normally, precipitation in the form of rain and snow is unaffected by resource management actions. There are expections to this. One would be actions that might modify regional climate such as an extensive irrigation development in a formally arid area. Another would be an action directed toward the modification of the runoff pattern as in the case of watershed management to increase the snowpack and delay runoff. In such cases, the relationship between precipitation and streamflow should be established so that the extent of the induced changes can be estimated.

Most areas with a strong dependence upon snow will have an extensive data base for the estimation of snowpack water quantity. Data of this nature is published on a monthly basis to identify the water supply outlook by the Soil Conservation Service. Mathematical models are available for the prediction of rainfall distribution. It is important in the environmental evaluation to separate variables in a manner that will permit identification of the action related impacts or contributions.

Figure 5 is an example of a graphic method of illustrating the relationship between precipitation and the streamflow at a given location. It was adapted from "Appendix V, Water Resources," <u>Columbia-North Pacific Comprehensive Framework Study</u>.

Figure 5. Long-term Variation, Precipitation and Streamflow.



EVAPOTRANSPIRATION

Water supply can be modified by significant changes in the evaporation and transpiration characteristics. This is due to vegetation management, either planned or by accident, such as irrigation development and changes in agricultural technology, changes in watershed vegetation through logging and clearing, other land use changes such as extensive urban and industrial developments, and the creation of large reservoirs that increase evaporation losses.

If the proposed action contains elements that might significantly alter the existing evapotranspiration characteristics in an area then this aspect should be evaluated. Potential evapotranspiration of an area under existing conditions can be computed by approaches detailed in various hydrology hand or textbooks.

AIR TEMPERATURE, HUMIDITY, WIND, STORMS

Extremes in air temperature, humidity, wind and storms have a bearing on the use and feasibility of an area for such things as outdoor recreation and agriculture. These should not only be considered when determining the suitability of an area for a particular use, but also must be taken into account when estimating the intensity of that use.

The location of a climatological station and the applicable data can be obtained from Weather Service publications listed in the references in Table 9. Methods for using climatological data are detailed in the Climatological Handbook-Columbia Basin States, published by the Pacific Northwest River Basin Commission, various governmental agency's handbooks and hydrology textbooks.

SURFACE WATER

It is common practice to treat surface water and groundwater separately, even though they are not separable items in a hydrological sense. The common practice will be followed in this paper.

QUANTITY

Surface water quantity consideration includes those parameters that identify the various aspects of streamflow, stream management, and water utilization.

Streamflow

Streamflow data on major streams are generally available in Geological Survey Water Supply Papers. Methods for transposing and utilizing this information to ungaged streams are detailed in various hydrology textbooks and government agencies' handbooks.

While average streamflows are commonly used for project planning purposes, high and low flows and associated stream velocity and stage are of much greater significance from an environmental viewpoint.

Hydrographs are useful tools for describing streamflow characteristics that are important to the environmental components of concern. Examples of needed data that can be displayed in the hydrograph format are:

--mean annual flows,

--maximum, minimum, and mean daily or monthly flows,

--low and high flow frequencies and durations with emphasis on critical low flow years in which fully satisfying demands for both withdrawals and instream purposes may not be possible,

--base flow characteristics.

Such hydrographs would subsequently be used to determine the adequacy of water supply for specific purposes by superimposing on the applicable streamflow hydrograph requirements such as:

--optimum flows for water-based recreation,

--seasonal minimum and optimum flow requirements for fishlife,

--seasonal withdrawal requirements for irrigation, municipal, and industrial purposes.

Other important hydrologic characteristics that are also best described in graphic form include:

--stage discharge curves at key locations (important to water-based recreation, adjacent land use, fish spawning and migration, flood control),

--stage-velocity curves at key locations (affects the same environmental components as stage discharge relationship),

--discharge-travel time curves

--water temperature patterns (affects fish, recreation, water supply),

--water quality parameters (affects most water uses).

Examples of hydrographs and other graphic representations are illustrated in Figures 6 to 12. These were adapted from "Appendix V, Water Resources," Columbia-North Pacific Comprehensive Framework Study.

Flood Control

Environmental considerations stemming from alternatives involving flood control measures require the determination of:

--modification of streamflow characteristics in terms of high and low flows,

--reduction in flood stages and resultant damage reduction,

--magnitude of induced erosion resulting from keeping streams near bankfull stage during evacuation of flood storage from reservoirs,

--impact of modified streamflow characteristics on the other environmental components (aquatic resources, water-based recreation).

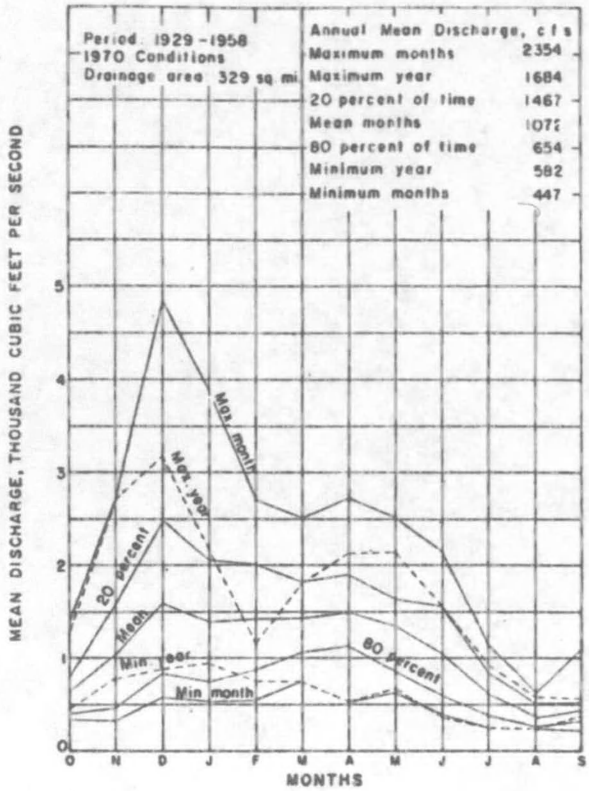


Figure 6. Monthly Discharge, Hood River near Hood River, Oregon.

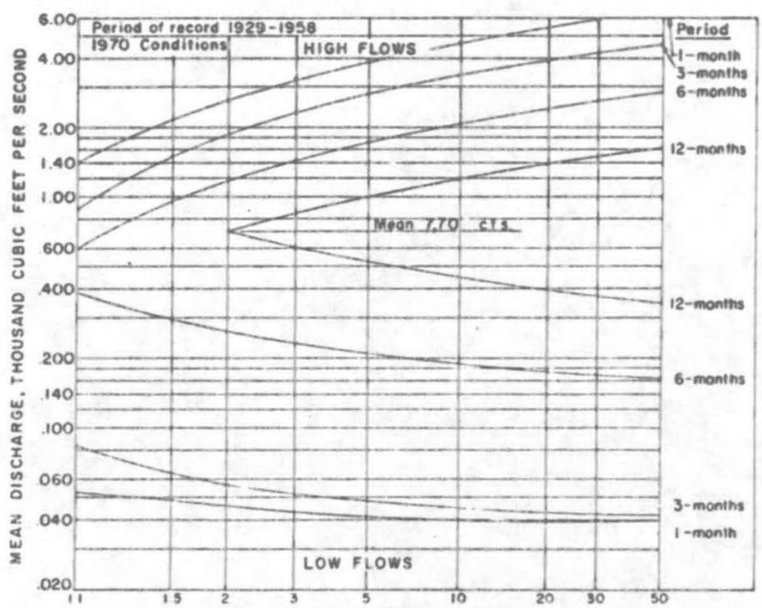


Figure 7. Frequency curves, Calapooia River at Holley, Oregon.

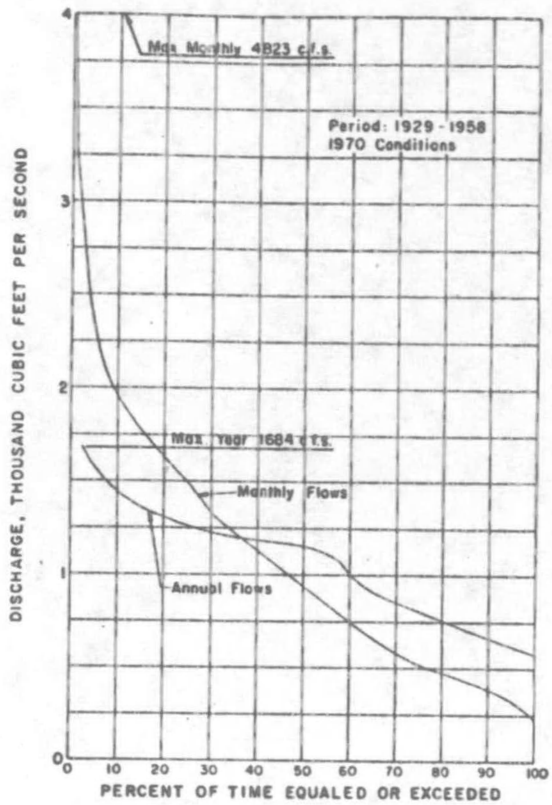


Figure 8. Duration curves, Hood River, near Hood River, Oregon.

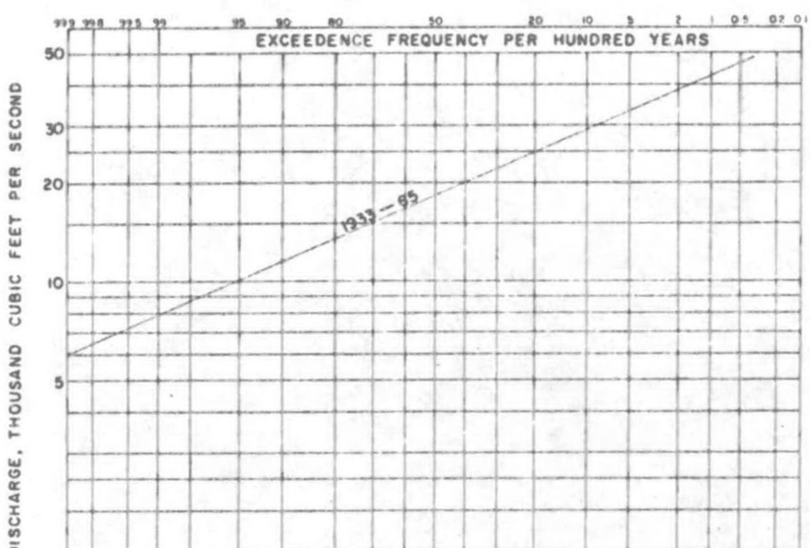


Figure 9. Frequency curves of annual peak flows, Alsea River near Tidewater.

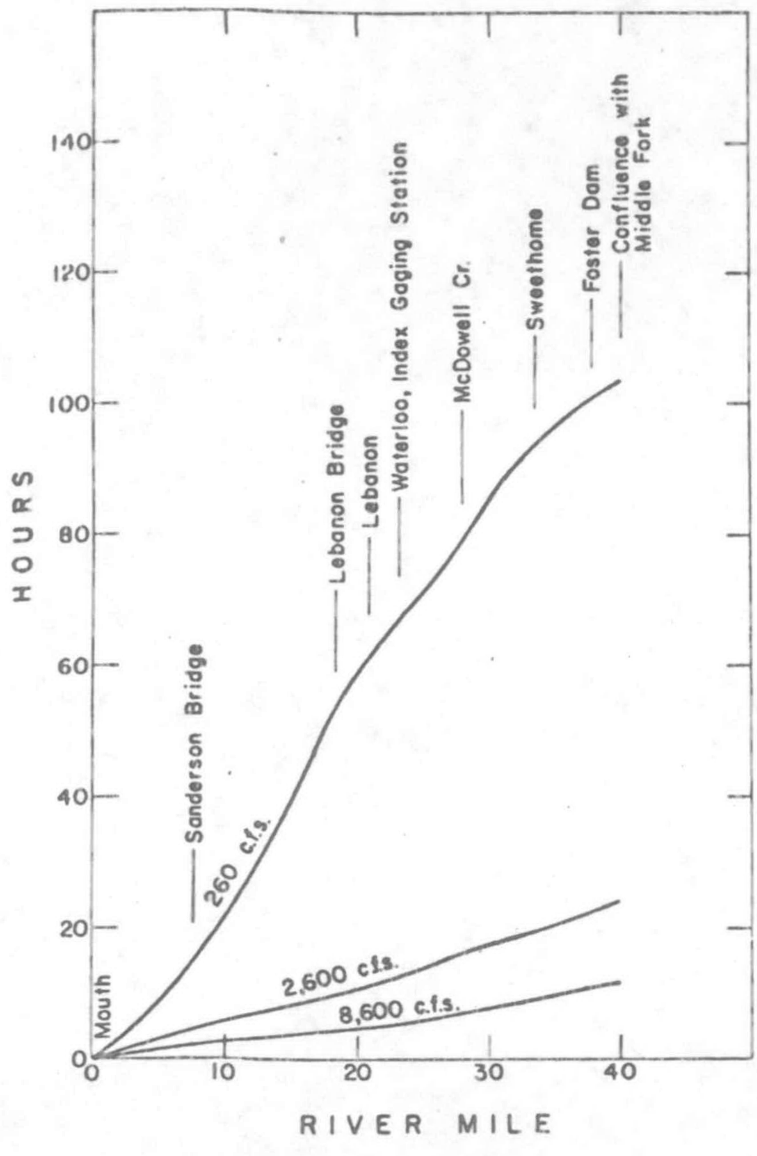


Figure 10. Time of Travel, South Santiam River, Oregon. For selected Discharges at Index Gaging Station.

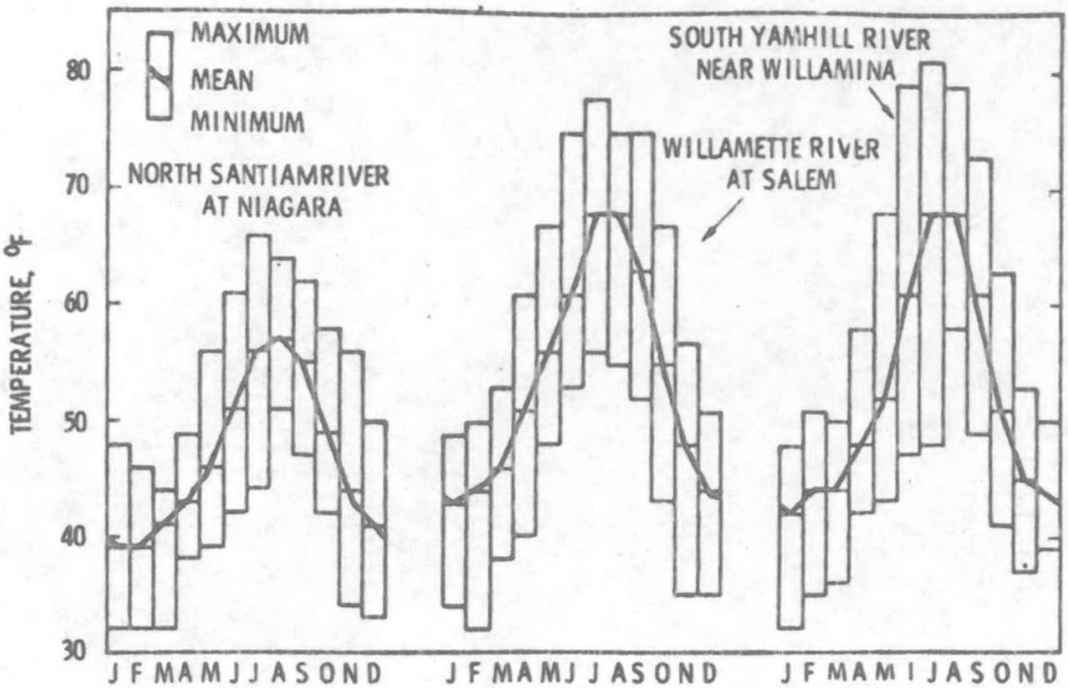


Figure 11. Monthly Water Temperatures at Selected Stations.

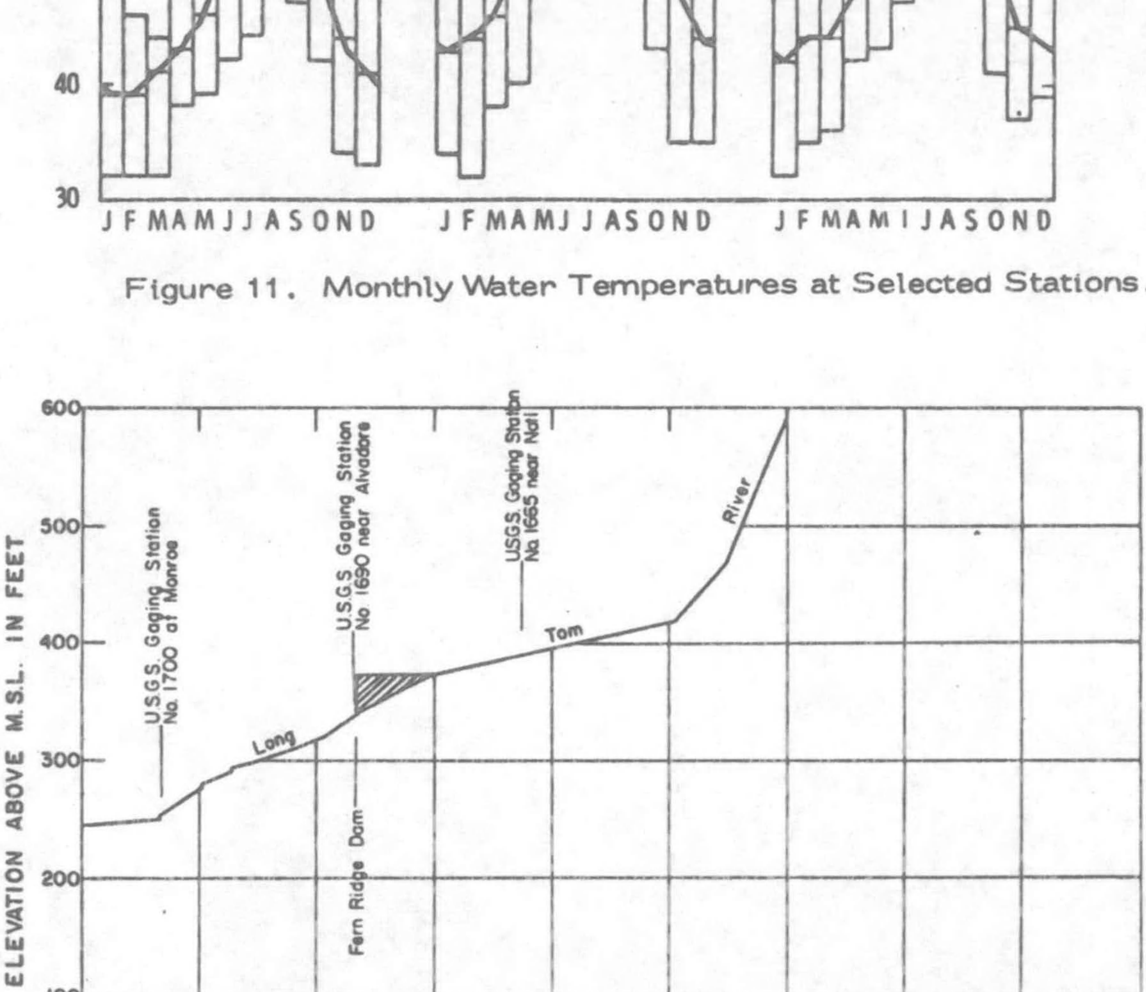


Figure 12. Stream Profile, Long Tom River, Oregon.

Standard methods are available for evaluating floods at various frequencies and magnitudes. It is assumed that the area of concern will have a floodplain study to provide the bases for evaluating floodplain management actions.

Stream Management

Knowledge of stream management guidelines and the rules of the regulating agencies and organizations is an important part of the identifying of the existing limits or constraints on any alternative action. Those stream management practices that have environmental impacts include:

--storage of water and storage releases,

--regulation of water diversions,

--streamflow regulation for irrigation, flood control and other purposes,

--water conservation measures.

In Oregon there are numerous compacts or agreements at the federal, state, municipal and utilities levels involving rights to use water, water supply regulations, land use, flow rates, energy allocation, storage regulations for flood control and irrigation, and others. These stream management regulations applicable to the alternatives being considered must be recognized in the environmental assessment process. This is especially true if the development and operation of storage and diversion facilities or the maintenance and modification of channels are involved.

Water Utilization

The impact that a proposed action will have on existing and future use of water, including the socio-economic impact, is a major environmental consideration. The assessment of the water requirements for specific purposes is discussed in those sections related to the particular environmental component. It is important, however, to recognize that the legal basis for the use of surface water is also a measure of the suitability and impact of an alternative. For this reason the following summary of the surface water law for Oregon is included as a part of this paper.

Oregon All waters within the State of Oregon from all sources (except a spring which does not flow into a well-defined channel and off the property of origin, under natural conditions) are declared by statute to belong to the public.

Subject to existing rights, all public waters within the state except those which may have been withdrawn by legislative action or by order of the State Engineer or by the Water Resources Board may be appropriated for use by complying with the requirements of the Surface Water Code or the Ground Water Act, and not otherwise.

Oregon is essentially an appropriation-doctrine state, and the terminology "riparian rights" has become little more than legal fiction. In cases brought before the Oregon Supreme Court it has held that the 1909 Water Code validly abrogated the common-law riparian rule except where the water had actually been applied to beneficial use prior to its enactment, which, in effect, makes it appropriative right.

The appropriation of the surface waters of the State of Oregon, which include the waters of rivers, lakes, streams, springs, waste waters, and waters stored in reservoirs and other surface sources, is governed by provisions of the Surface Water Code, which was adopted on February 24, 1909, and subsequent acts. Nothing in the Code, however, is so construed as to take away or impair the vested right of any person, firm, corporation, or association to any right for surface waters which was initiated prior to February 24, 1909.

A legal right for any surface water appropriation initiated after February 24, 1909, can be established only through application of water to beneficial use under the terms of a water right permit issued by the State Engineer. A claim to a vested right by virtue of use prior to February 24, 1909, and continued use thereafter, can be determined and made a matter of record only through a legal proceedings, known as an adjudication. This proceeding involves several administrative steps by the State Engineer and is concluded by a decree of a Court.

Adjudication proceedings have been completed for most of the major stream system in eastern and southern Oregon, but only for a few of the streams systems in the remainder of the state.

New water rights are obtained through the State Engineer and the water right remains valid and in force so long as it is not lost through intentional abandonment or through non-use for a period of five successive years or more. Under this system as of July 15, 1969, there had been issued 5,404 reservoir permits and 34,009 surface water permits.

With the establishment of the State Water Resources Board in 1955, a single agency was created to hold hearings and issue state water policy statements on unappropriated water for each of the river systems in Oregon. These water policy statements, among other things, may set minimum flow requirements and limit partially or entirely uses to which water may be put.

While subsequent applications for water rights are subject to the provisions of the water policy statement, nothing in the statement is construed to take away or impair any right to any water or to the use of any vested and inchoate right acquired prior to the adoption of the State Water

Resources Board policy.

Some restraints to the appropriation of water may be contained in the State Water Resources Board water policy statements. Other withdrawals are statutory in nature under Chapter 538 of the Oregon Revised Statutes. Also the State Engineer has withdrawn certain streams from further appropriation. Detailed limits such as duty, season of use, and total unused quantities are stated in the permits and court decrees.

The State Engineer has authority to declare critical ground water areas and may limit well drilling or impose other rules in these areas to prevent mining of the ground water.

While requirements of the State Sanitary Authority do not directly affect diversions of water, they can have a very real and practical affect in limiting the condition of the waters returning to the streams. Construction of diversion structures and pump stations are subject to rules and regulations of the State Fish and Game Commissions.

The State Engineer administers distribution of water in the state through a system of 15 watermaster districts. Records of gaging stations (not available in the USGS water supply papers) established for water administration are published and available upon request. (5, pp. 27-28)

GROUND WATER

The environmental importance of ground water is emphasized by the many water uses that are supported by wells and springs, and because of its large contribution to the surface water supply. Care must be taken, however, not to fall to the common misconception that the total water supply of an area is the sum of the streamflow and the volume of water in aquifers. When actually, a portion of the streamflow is groundwater leaving the area.

GEOLOGIC SIGNIFICANCE

Geology has a greater impact upon the quantity and quality of ground water at a particular location than any other factor. The assessing of the nature and extent of the ground water aquifers in an area normally requires field investigations by qualified ground water hydrologists. Table 8 summarizes the characteristics of the aquifer units found in Oregon. Table 10 lists sources of groundwater data. The quality of ground water is discussed in a later section under water quality.

INFILTRATION AND GEOPHYSICAL STABILITY

The rate of infiltration of surface waters into the ground from natural channels is usually in a state of dynamic equilibrium. However, construction of unlined reservoirs, large irrigated areas, and significant ground water withdrawals can greatly change the water table characteristics and ground water movement. Percolation is important as a pathway for dissolved chemicals and as a lubricant in the movement of unconsolidated soils which could create landslides.

Detailed knowledge requires measurement of the water tables of the affected aquifer. By obtaining data from key locations, simulation models can be used to estimate water tables, water movement, potential gradients, and times of travel. In many basins, because of the rapid state of development and the advanced state of water

TABLE 8

SUMMARY OF AQUIFER UNITS IN OREGON

No.	Aquifer Unit Group	Hydrologic Characteristics	Water Quality
1	Alluvial and glacial deposits; mostly Pleistocene in age; may include some Pliocene deposits.	Includes very porous and permeable deposits at many places; small to very large yields.	Generally good to excellent; dissolved solids, generally less than 300 mg/l; iron excessive at places.
2	Younger volcanic rocks; Pliocene-Pleistocene in age.	Moderately porous and very permeable deposits at many places. Generally large to very large yields.	Generally good to excellent; low dissolved solids.
3	Younger sedimentary rocks; chiefly Pliocene in age.	Moderately porous; coarser grained strata moderately permeable. Small to moderately large yields.	Good to fair; dissolved solids usually less than 700 mg/l.
4	Silicic volcanic rocks; Miocene-Pliocene in age.	Low porosity; permeability highly variable; small to large yields.	Generally good to fair; sodium, boron, fluoride excessive at places.
5	Basaltic and andesitic volcanic rocks; middle Tertiary in age.	Low porosity; moderately high permeability in some interflow zones. Small to large yields.	Generally good; dissolved solids generally less than 500 mg/l.
6	Volcanic and sedimentary rocks, undifferentiated.	Characteristics of 2 to 5, above.	Characteristics of 2 to 5, above.
7	Older volcanic rocks; chiefly Eocene-Oligocene in age.	Low porosity; generally low permeability; usually small yields.	Good to fair; excessive arsenic in some wells south of Eugene.
8	Older sedimentary rocks; chiefly Eocene-Oligocene in age.	Generally low porosity and permeability; small yields.	Shallow water good, deeper water may be moderately to highly saline.
9	Older volcanic and sedimentary rocks.	Low porosity, generally low permeability; small yields.	Generally good to fair; deeper water may be moderately mineralized.
10	Pre-Tertiary rocks, undifferentiated.	Little porosity and permeability except in weathered zone. Small yields.	Generally good; low dissolved solids; some mineralized water.

depletion, the ground water conditions are not in equilibrium and a predictive type of analyses will be necessary to establish baseline conditions.

In the cases where large changes in the ground water regime are anticipated, the probability of it affecting the stability of adjacent fluvatile deposits should be investigated in detail. Suspected areas may require a field drilling program to establish stratigraphy and then the existing ground water surfaces analysed. Where relief wells or other engineering expedients are required during a proposed project development, the related hydrologic impacts must be assessed.

WATER QUALITY

Water quality is of environmental concern in terms of its impact on organisms in the aquatic environment or on the beneficial uses of water. Water quality affects organisms in ways which vary widely in scope and complexity. For example, heavy metals and pathogens represent a threat to the life of the highest organism (man). Dissolved gases may affect recreation values in a region by reducing the numbers of fish in a particular reach of river. Refactory materials may be ingested into the food chain over a period of the lowest (phytoplankton) level. Movement through the food chain over a period of years may result in hazardous concentrations of these materials in fish and other predatory species. Some changes in water quality may be physically harmless to man but affect esthetic values as measured by the senses of smell, sight, and taste.

Most of the important water quality parameters are regulated by state and federal law. There is variation in the parameter limits because of the lack of clear understanding of each parameter's impact on the ecosystem. As a result, water quality standards will continue to change as more knowledge is gained.

A description of the change in water quality is part of the information needed to determine whether an alternative will cause significant environmental impacts on biological and human use of water. Figure 13 (4, p. 78) illustrates a water quality analysis procedure to follow in identifying the environmental impacts. As shown in the figure, representative questions requiring answers include:

--Will the water temperature change?

--Will the water solids content change because of increased suspension of solids, increased settling of solids, or a change in dissolved solids?

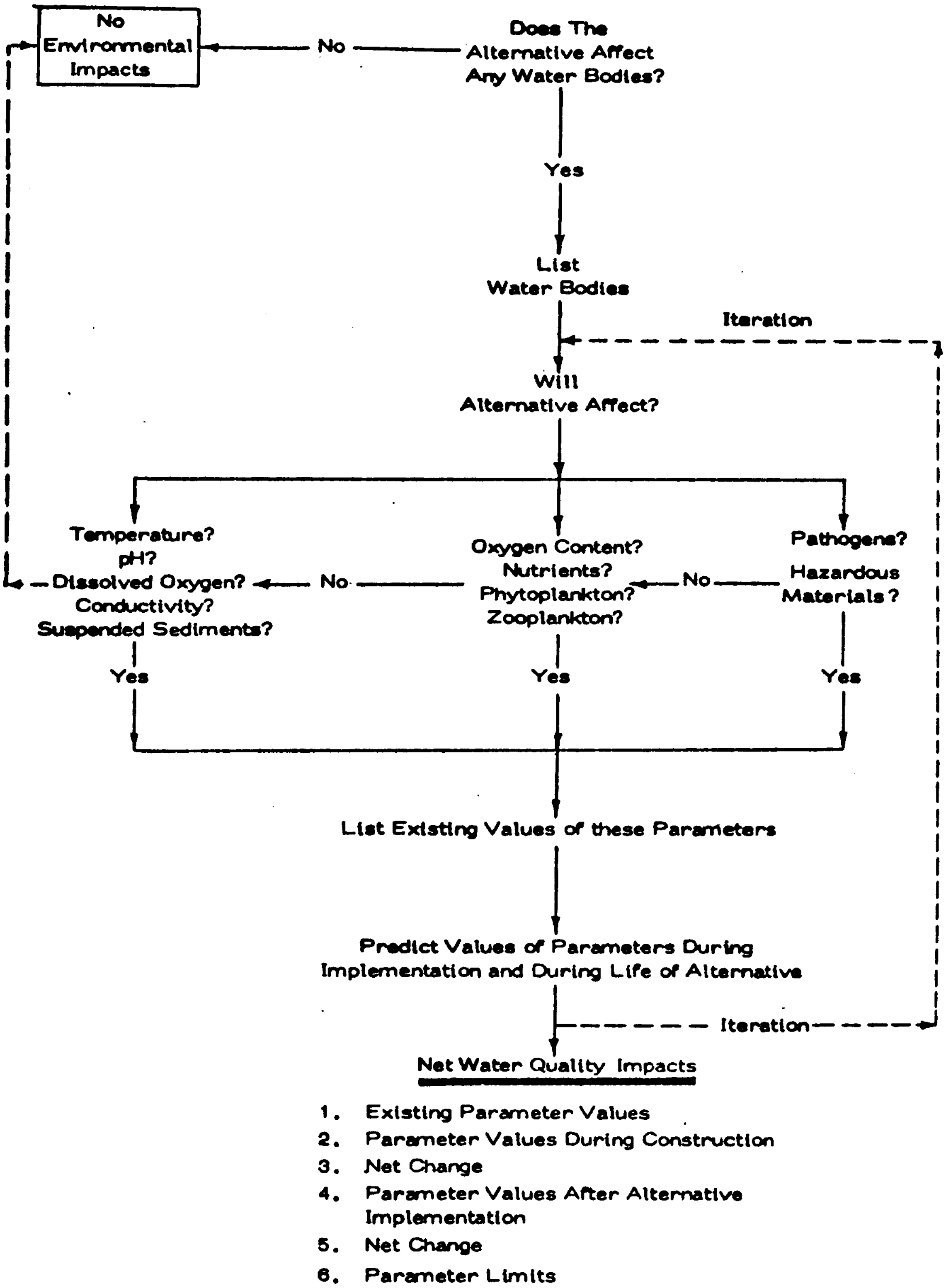
--Will there be a change in pathogens?

--Will impoundments or changes in water temperature change the eutrophication?

--Will the tast or odor change?

--Do any of the changes in water quality create conditions which are outside the permissible or

Figure 13. Water Quality Analysis Procedure.



desirable conditions expressed by water quality standards or the general social opinion?

--What will be the magnitude, location, and time distribution of these changes?

After answering these questions for each alternative, the detailed analysis can proceed along the following lines:

--Prepare a map showing the water bodies affected by the action.

--Prepare detailed maps of larger scale as needed to show the width, depth, and flow velocities of the water bodies. Also show expected use points and types of uses.

--Indicate on the maps the locations and nature of all water analyses available for the affected waters.

--Study the maps to determine whether ample water quality data are available for all water use points to permit the estimating of the impacts of the changes in water quality on those uses.

--Obtain water analyses for all use points for which adequate analyses currently are not available.

WATER SUPPLY

There are several significant reasons why the management of water supply and water use is of environmental concern.

--The impact that the withdrawal of a quantity of water from a stream or ground water aquifer might have on other uses. Or, the impact that a new allocation for a given quantity for a proposed in stream use might have on existing uses.

--The impact of the quality of the effluent returned to the stream system or to the ground water.

--The impact resulting from the physical structures required for each use (intakes, storage facilities, supply lines, discharge structures, etc.).

WATER ALLOCATION

The inhabitants of Oregon rely upon a combination of Appropriation and Riparian Doctrines in the allocating and administering of water use rights. The present water withdrawal demand can be measured in the terms of water rights and other water allocations. These data are available from the State Engineer, the State Water Resources Board or other state agencies which administer water rights. A complete listing appears under "Data Sources."

Consideration should be given to the factors listed below.

Description of Water Rights

- priority date
- location of diversion or withdrawal point

- permitted rate of withdrawal and total allowable annual withdrawal
- seasonal restrictions of use
- name of owner
- other applicable information

Description of Water Use

- type of diversion and transmission facilities
- magnitude of consumptive use, both seasonally and annually
- rate and location of return flow
- quality of return flow

Instream Uses

- magnitude and location of flows or quantities of water legally set aside for the public interest (legislative withdrawals and minimum flows for fish)
- bodies of water reserved for recreational use
- streams designated as "wild and scenic"
- allocations for other stream purposes
- others as applicable to the stream being considered.

WATER REQUIREMENTS

The requirements of each existing and potential use of water, whether withdrawn or used instream, must be understood in order to assess the environmental impacts of providing or not providing for the use. Significant factors include:

Existing and Expected Uses

- municipal and industrial water supply
- irrigation
- water-based recreation
- fish and wildlife
- water quality control
- esthetics
- others as applicable

Quantity and Quality Requirements

- by location in the system
- seasonal characteristics of the requirements

Existing or Anticipated Conflicts

- competition for available water quantities
- degrading of water quality by one use, thus affecting other uses
- incompatible timing requirements
- hydrological interaction between surface water and ground water use
- interference among ground water users due to insufficient recharge, excessive drawdown, ground

water contamination, etc.

- others as applicable.

ADEQUACY OF SUPPLY

The comparison of the hydrologic characteristics of the area with the present and projected water allocation demands will indicate the adequacy of the supply and identify environmental problems to be expected.

The hydrologic characteristics to be considered include the following, which were detailed earlier in this chapter:

Streamflow Characteristics

- annual average flows
- maximum and minimum flows
- low flow frequencies with emphasis on critical years in which fully satisfying water rights for both withdrawals and instream purposes may not be possible
- base flow characteristics
- water temperature patterns
- water quality parameters

Ground Water Characteristics

- location and extent of aquifers
- recharge rates and sustained yield capacities of the aquifers
- ground water areas designated as critical

- optimum well depth, spacing, and pumping rate for each aquifer
- ground water quality conditions
- impact on ground water of surface water withdrawals or additions
- impact of ground water withdrawal on streamflow
- others as applicable

Hydrographs for Key Locations

- stream flow under critical conditions
- seasonal minimum and optimum streamflow requirements for fish
- optimum flow for water-based recreation
- others as needed to determine adequacy of water supply.

EFFLUENT QUALITY

One important measure of the environmental impact of a given water use is the quality of the resulting effluent or return flow. Accordingly, data is required to permit the measurement of that factor for each use. The necessary data, described early in this chapter, includes:

Chemical and Biological

- biochemical oxygen demand
- nutrients

- toxic materials

- suspended sediments

- others as applicable

Temperature

- effluent temperatures

- temperatures of the receiving body of water

- rate of mixing at various distances from outfall

- impact at outfall and after mixing

- others as applicable.

Physical

- quantity

- location

- dispersion characteristics

- rate of percolation into ground water

These data provide the basis for determining the impact on other uses, such as aquatic and recreation, in terms of the relation between the effluent properties and the quality requirements of the affected uses.

IRRIGATION USE

Irrigation is a major consumptive user of water and because of this, special attention is given to the associated environmental impacts. The following list of the environmental considerations relative to irrigation is provided although some of the items are implied in the previous lists.

- soil stability
- wind and water erosion potential and associated stream sedimentation
- impact on wildlife, which can be detrimental by eliminating habitat for some species, especially big game, or beneficial by improving the habitat for other species, especially upland game and water fowl
- agricultural wastes and quality of runoff
- irrigation water requirements
- nature and extent of return flows from irrigation both overland into streams or through percolation into ground water aquifers
- impact on ground water quality
- impact on water table
- impact of fertilizers, herbicides, pesticides, and and insecticides on wildlife and water quality.

WATER SUPPLY STRUCTURES

The construction, operation, and maintenance of the physical structures for water supply can have a significant environmental impact. The assessment of the impacts require considering such items as those listed below. In many cases the required information would be provided in other sections of the assessment.

Location and Nature of Area Involved

- existing use of the area
- use of the adjacent areas
- terrestrial and aquatic resources
- other potential uses of the proposed area
- existing access to the area
- existing utility services, such as power, water, sewerage, etc.

Proposed Development Plan

- sizes, location, and design features of the proposed structures
- provisions for access
- sources and natures of proposed water and power supplies
- location and right-of-way requirements for pipelines
- waste treatment and disposal plants
- special provisions for other uses of the area (recreational development at a storage reservoir, etc.)

Environmental Impacts of the Proposed Action

- removal of vegetation
- interference with wildlife habitat or movement
- impact on fish interms of water withdrawal,

temperature or other quality affects, sedimentation or inundation of spawning gravels, barriers to migration, etc.

- esthetic impact, including view, noise, and odor
- compatibility with the use of adjacent area
- impact on local outdoor recreation opportunities
- others as applicable

DATA COLLECTION GUIDELINES

SURFACE WATER

Detailed data on flow, temperature, and other parameters have been collected for years by the United States Geological Survey and other agencies. Current data are stored in several computer sources, including STORET, HYDROMET, and USGS. Similarly, meteorological data have been collected by the U.S. Forest Service, USGS, Soil Conservation Service, and National Weather Service. Current information is now fed into the HYDROMET. The earlier data sources are available on tape or in publications. The more general surface hydrological references are listed in Table 9.

GROUND WATER

A number of major sources of ground water data are listed in Table 10. Almost all the data on ground water back through 1965 are filed in STORET. Most of the earlier data are found in U. S.

Geological Survey (USGS) reports and on USGS tapes. A list of various ground water studies for specific areas in Oregon are listed in Table 16. More data are also available in the Office of the State Engineer.

Areas for which the existing data are inadequate to the potential environmental impacts will require exploratory field programs.

WATER QUALITY

The USGS has operated water quality stations for over a decade. However, the data were collected for only a limited number of parameters and at a very few stations. The bulk of the present water quality data have been taken since 1965 and that information can be obtained from STORET. It must be realized that the controls on the reliability and accuracy of much of this data were almost non-existent. Data collected by USGS are subject to a system of quality control, but some of the data that comes from state and private sources lack uniform control and calibration. Many of the smaller areas are not included in the sampling network. In the case of some of the proposed actions data collection networks may have to be set up.

Sources of existing general water quality data are given in Table 11.

Some of the water quality parameters are better considered individually than in the general water quality framework. These are icing, hazardous materials and sediments.

Icing

Ice can modify water quality principally in two ways. First, ice eliminates the normal surface runoff processes, thus altering many biological and chemical interactions in a body of water. It also reduces the flow rates and amounts, resulting in higher concentrations of contaminants. These changes and others are complex and not adequately understood.

Sediments

Streams draining the more arid parts of the State, as a general rule transport higher concentrations of fluvial sediment than those draining the humid, forested parts. However, on an annual basis, more sediment may be transported out of the forested areas because of the more frequent storms and larger volumes of water.

Agriculture has a very significant impact on certain water quality factors and particularly sediment content. Areas of intensive agriculture may require data collection because little data exists due to the diverse nature of individual operations. Table 12 lists data sources for agricultural run off materials. Care must be taken in selecting data collection methods, so that each parameter that may have a potential environmental impact is monitored. Different methods are suitable for different circumstances. For example, a stretch of turbulent water may be so thoroughly mixed that a grab sample will be representative of all the dissolved materials in the entire stream. Also, the USGS has developed techniques by which an entire body of water can be characterized by the applying of one factor to a single sample. In some cases, a representative sample of the sediments may require integrated samples at various depths and at many cross sections along with an evaluation of the characteristics of the river bottom. In general, eliminating unimportant parameters early in the data collection process will save time and effort.

Since flow and temperature have significant impacts on water quality, high, low, average, and seasonal flows and temperatures should be obtained along with the water quality data.

Parameters that are sensitive to agricultural influence can be expected to have seasonal affects. Turbidity data is exceptionally seasonal. It is also influenced by such things as run off rates and such local factors as forest fires and construction activities.

Table 14 lists Oregon's standard for hazardous materials. Table 13 lists parameters, units, methods, and sample preservation data for more common water quality parameters.

The general principles of water data collection have been well studied. Much of the work was done by USGS and almost all of the parameters are covered in their publication, Recommended Methods for Water-Data Acquisition (6). It also lists some good reference sources. Other reference works are listed in Appendix A.

The best sources for the analytical methods are Standard Methods (7) and EPA's Methods (8).

Hazardous Material

In general, there are no areas in Oregon where hazardous materials reach serious levels.

Water Quality Models

Considerable research and development is currently being carried out on the development of predictive models for water quality. Good progress has been made in the prediction of physical parameters, especially temperature. The simulation of aquatic ecology is less developed because of the diversity of species composition and lack of fundamental data on the cell biology of the food chain web. A number of sound beginnings in ecological modeling exist which use indicator species as the primary means of judging the overall impact (4, p. 83).

QNET-1 Water Quality Prediction Within An Interbasin Transfer. This model (Texas Water Development Board, Austin) predicts the spatial and temporal levels of conservation water quality constituents and handles basic quantity management within an interconnected network of small basins. In addition to quantity, dissolved solids, sulfates and chlorides can be estimated. The model requires input quantities from a basin simulation model. Discharge concentration relationships are developed for each source of water in the system, including wastewater discharges. Reservoirs in the system are assumed to be completely mixed, implying that this model is most suitable for small systems. A mass balance analysis is performed for each day for each month during the simulation period.

The output from the water quality-quantity simulation is a table of flow and concentrations. The desired water quality at the demand location is used to determine the economic utility of transporting and mixing water from various sources.

EXPLORE-I: A River Basin Water Quality Model. The Environmental Protection Agency sponsored the development of a comprehensive mathematical water quality model by Battelle-Northwest for use in river basin planning and water resource studies. The generalized model can predict the hydrodynamics and water quality dynamic for rivers, well mixed estuaries and thermally stratified reservoirs. The model was set up, calibrated and verified, using historical hydraulic and water quality data, on a portion of the Williamette River Basin.

Agricultural Water. The impacts of diversions within a basin can be computed by standard hydrologic procedures. However, the problem of agricultural depletion and return is difficult to treat. These factors are related to the standard methods of computing evapotranspiration and percolation, but in addition are highly influenced by variation in agricultural practices, crops and general husbandry.

There are a number of models for estimating agricultural depletions and returns but none have received general acceptance.

Suspended Sediment Yield. Annual suspended sediment yields can be estimated by a computerized empirical model developed by C. E. Abrahan (9, pp. 144-146). The model computes the annual load which corresponds to the observed daily water discharge measurements. A relationship for the suspended sediment load is derived from a regression analysis of the observed daily discharge and the suspended sediment load. The model has options which compute weighted size distribution of the particles, related instantaneous sediment loads and flows, and determines frequency statistics for the annual loads. The computer program is available from the Hydrologic Engineering Center, Corps of Engineers, U.S. Army, Davis, California and is written in FORTRAN II.

Turbidity Structure. A mathematical model of the turbidity structure within an impoundment was developed by D. G. Fontane, et. al. (10), at the Waterways Experiment Station in Vicksburg, Mississippi. The model is an adaption of the reservoir model developed by Clay and Fruh at the University of Texas at Austin.

Turbidity is treated as a conservative substance and is related to the flow rate by a simple non-linear regression relationship. The model was verified with observed data from Hills Creek Reservoir and was used to analyse the Lost Creek Reservoir in Oregon.

DATA SOURCES

Data sources for surface water hydrology, ground water, and water quality appear in the following Tables 9 through 16. Also see Appendix B for selected water quality criteria.

TABLE 9

DATA SOURCES: SURFACE HYDROLOGY

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Climate Hydrology Surface water Ground water Water use Water quality Agricultural water needs	General data charts and graphs by major geo-graphical regions, both U.S. and world-wide	Todd, D. K. The Water Encyclopedia. Water Information Center, Inc., 550 pp., 1970	Book. Contains a very large and borad collection of data for almost any aspect of water use including navigation, husbandry, industrial, municipal, natural and climatic water data.	Water Information Center Water Research Bldg. Manhasset Isle, Port Washington, NY
Minimum stream flow requirements	3 methods of determination	Transcript of Proceeding of the In-stream Flow Requirement Workshop March 15-16, 1972, by Pacific Northwest River Basins Commission	Book. Presents several methods and criteria for establishing minimum stream flows for fish passage, spawning, and rearing.	Mr. Bill Catlin Director of Information Pacific Northwest River Basins Commission, 1 Columbia River Vancouver, WA 98660
Annual precipitation Annual runoff Groundwater Location of data Collection stations for streams, wells, snow, storage	Maps	Water Resource Investigations in Cregon, 1968, U.S. Geological Survey	Folder Maps of suspended sediment transport by streams. Maps of dissolved solids content of surface and groundwater. Maps of hardness of surface and groundwater. Maps of areas of published groundwater reports. Maps of groundwater availability, average precipitation, and average runoff	District Chief, Water Resources Division, U.S. Geological Survey, P. O. Box 3202 Portland, CR 97208

TABLE 9 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Dissolved solids, Hardness, Groundwater reports		Water Resource Investigations in Oregon, 1968 U.S. Geological Survey	Listing of water supply papers, circulars, hydrologic atlases, water data records, open file reports, professional papers, water supply bulletins, etc., relating to water resource investigations in each state	District Chief, Water Resources Div. U.S. Geological Survey P. O. Box 3202 Portland, OR 97208
Precipitation Temperature (air) Discharge Run off Water Quality	Subregion Stations and Maps Selected Sites Map--Annual mean General subregion, characteristics and problems	Water Resources, Appendix V, Columbia-North Pacific Region Comprehensive Framework Study by Pacific Northwest River Basins Commission, April, 1970	Book. Average monthly and annual precipitation. Temperature average and extremes. Reservoir capacities, stream discharges, annual average runoff. Monthly 20 and 30 percent discharges. Historical duration curves and frequency curves. Dependable yield low flow tables. Long-term precipitation and stream flow graphs for selected stations. Stream profiles.	Mr. Bill Catlin Director of Information Columbia River Basins Commission 1 Columbia River Vancouver, WA 98660
All water-related data	All available federal and state agency data and some private data	STORET-Federal computer-operated storage and retrieval system	Computer tape. Stored by river mile index, also by latitude and longitude and political boundaries. Programmed to supply statistical summations if desired	Environmental Protection Agency 1200 Sixth Avenue Seattle, WA Mr. Dan Tangerone

TABLE 9 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Sedimentation Temperature Aquifers	General General General Characteristics and locations		Map of solids content and hardness of region. Map of generalized sediment yield. Some selected river profile temperatures. Map of aquifer units. Map of general groundwater availability. Descriptions of major aquifer availability. Descriptions of major aquifer units and their hydrologic and water quality characteristics. Table of storage discharge and recharge of aquifer units. Hydrographs of selected wells. Estimated ground-water withdrawal and consumptive use.	Mr. Bill Catlin Director of Information Columbia River Basins Commission 1 Columbia River Vancouver, WA 98660
Temp. (air) Precipitation Runoff Atmospheric data Flow	Monthly, mean high, low, other Mean daily, monthly, historical, annual average, etc. River mile, historical averages, peaks, etc.	Williamette Basin Comprehensive Study. Water and Related Land Resources. Appendix B Hydrology, by Williamette Basin Task Force, Pacific Northwest River Basins Commission, 1969	Book. Reservoir Storage over 300 acre-feet. Principal diversions, climatological temp. data, precipitation data, climatic station locations. Evaporation, wind, humidity, etc. Hydrologic soil data. Stream gauging data, runoff data. Concordant flows	Mr. Bill Catlin
Hydrologic soil Dissolved solids Mineral content	Map, etc. Average annually			

TABLE 9 (Continued)

PARAMETERS	DETAILS	DATA SOURCES	COMMENTS	CONTACTS
Discharge	daily, recorded	Columbia-North Pacific Region (17) Appendix 2A, "List of Surface Water Stage and Discharge Stations", January 1973, CWDC U.S. Geological Survey	Manual. List of stations by name, latitude, longitude, state and county. Period of record, type of data sotrage, agency reporting, type of field measurement, type of data reported, e.g. daily discharge, peak, low flow, flood frequency, flow duration, coefficient of roughness, QW recurring measurement, QW non-recurring measurement, time of travel, precipitation, sedimentation studies, surface inflow-outflow, etc.	Mr. G. L. Bodhaine Regional Representative CWDC U.S. Geological Survey 345 Midelefield Road Menlo Park, CA 94025
River Mile, Index		"River Mile Index--River", Pacific Northwest River Basins Commission	A series of 21 reports for sections of the Columbia River system. Maps plus points of interest, elevations, drainage areas, etc.	Mr. Bill Catlin Director of Information Pacific Northwest River Basins Commission 1 Columbia River Vancouver, WA 98660
Streamflow	Data since early 1900's	"Pacific Northwest Daily Streamflow Records", by Hydrology Sub-committee Columbia Basin Inter-Agency Committee, January 1967	Report of data available on punch card or magnetic tape. Listing of all streamflow data for Pacific Northwest which is available on punchcard or magnetic tape. Effective date of computer data is Sept. 30, 1966. List includes 594 stations, years of record, and agency where tapes or cards are stored.	Mr. Bill Catlin

TABLE 9 (Continued)

PARAMETERS	DETAILS	DATA SOURCES	COMMENTS	CONTACTS
Discharge Peak discharge Low flow Cross section Flow duration Flood freq. Coefficient of roughness QW recurring measure QW non-recurring measure	All reported data from State, Federal Canadian, Municipal and private sources. Detail depends on station	Catalog of Information on Water Data, U.S. Geological Survey OWDC, A Appendix 2A, Columbia-North Pacific Region (17) List of Surface Water State and Discharge Stations, January 1973	Book. Listing of station, type of data, frequency of collection, agency, period of record, type of data storage. The station location is given by map number, agency station number, latitude and longitude, and state and county. Also whether station is existing, funded, or needed state of implementation.	Mr. G. L. Bodhaine Regional Representative OWDC U.S. Geological Survey 345 Middlefield Road Menlo Park, CA 94025
Time of travel Flood plain maps Precipitation Tides Datum Sedimentation studies Contents Surface-inflow Surface-outflow Change contents Change level	Listing back through 1965		This listing outlines data available from each station. The actual data can be obtained from STCRET or by writing the OWDC Office above. It is possible to get some computer listings and printouts of specific data.	

TABLE 9 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Sediment transport	Map--annual yield/ sq. mile selected sites		Sediment media particle size and critical discharge rate. Mean annual discharge, yield etc. Time distribution of sediment discharge	
Temperature Water level profiles	Selected stations, Stream profiles of main streams and tributaries		Mean-max-min monthly temperature. Water level profiles	
Time of travel Peak travel time	Main stem and tributaries		Time of travel for various flow rates	
Percent Land Area snow covered Temp. (H_2C) Temp. (Air) Wind volocity Precipitation (H_2C) Stream Flow Water equivalent Snow data Discharge Elevation Gauge Height	Selected stations	HYDROMET--Federal Interagency data collection network	Present collection system information is collected via teletype, telephone, and postcard. A modernized remote collection network is being established. Completion expected by June, 1975	U.S. Corps of Engineers Division Office 210 Custom House Portland, OR 97209 Mr. Ray Garza

TABLE 9 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Temperature (H_2O)	All data since 1930's	"Pacific Northwest Water Temperature Inventory", Hydrology Subcommittee Pacific Northwest River Basins Commission, August 1967	Report of data available. A listing of all temperature data records since the 1930's is published here on a state-by-state basis in downstream order. The following details are listed: Agency supplying data Station location and name River mile Period of record Frequency of data collection Location of station on river bank	Mr. Bill Catlin Director of Information Pacific Northwest River Basins Commission 1 Columbia River Vancouver, WA 98660

TABLE 9 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
List of State publications regarding water		Giefer, G. J., and D. K. Todd. Water Publications at State Agencies. Water Information Center, 1972	Book. Lists bulletins, pamphlets circulars, books, reports, Theses by state agency and also gives agency address. Agency listings include the following: Bureau of Mines and Geology Dept. of Water Administration Department of Health Fish and Game Department Water Resources Research Institute State Board of Health Commission on Conservation Conservation Council Dept. of Agriculture and Publicity State Engineer Irrigation Commission Dept. of Planning and Economic Development State Soil Conservation Committee Water Pollution Control Council Water Resources Board Dept. of Environmental Quality Department of Ecology Division of Power Resources Oceanographic Commission Water Research Center Other Publications Note: Titles may vary slightly from state-to-state	Water Information Center Water Research Building Manhasset Isle, Port Washington, NY 11050

TABLE 10

DATA SOURCES: GROUNDWATER

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Aquifer descriptions and maps. Ground-water availability maps. Chemical quality, natural recharge and discharge hydrographs. Consumptive use and withdrawals	By subregion	"Appendix V—Water Resourced Columbia-North Pacific Region Comprehensive Framework Study of Water and Related Lands", Pacific Northwest River Basins Commission, April 1970	Book. General description of hydrology and quality of region and regional problems	Mr. Bill C. Catlin Director of Information Pacific Northwest River Basins Commission 1 Columbia River Vancouver, WA 98660
Well characteristics, data, state groundwater reports	List of all state reports	State Engineer's Office	Reports, permits, logs, on file in regulating state agency office	Office of the Oregon State Engineer, Salem, Oregon
Maps and lists of groundwater reports	State map	Appendix V. Columbia North Pacific Comprehensive Framework Study; also, Water Resource Investigations in Oregon, USGS circular.	Circular, book. Map of state is printed showing areas covered by ground water reports. USGS Reports are listed.	Mr. Bill C. Catlin Director of Information Pacific Northwest River Basins Commission
Groundwater availability	Maps & Charts	Willamette Basin Comprehensive Study. Water and Related Land Resources Appendix B. Hydrology, by	Book. General groundwater discussion, problems and quality. Availability in maps and charts.	Mr. Bill C. Catlin
Groundwater quality	Maps	Willamette Basin Task Force, Pacific Northwest River Basins Commission, 1969.	Maps of dissolved solids, hardness, iron and arsenic in groundwater. Also general quality discussion.	

TABLE 10 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Temp., S_p conductance, turbidity, color, odor, pH, EH, susp. solids, chlorine, dissolved solids, notrogen, phosphorus, hardness, common ions, D.O., radiochemical, pesticides, other gases, detergents, BOD, total dis. carbon, coliform, susp. sediment, particle size--suspended, particle size--bed, water level	Varies with station. Complete listing of all Federal, State, Municipal, and private stations submitting data. Listing back through 1965 only	Catalog of Information on Water Data, U.S. Geol. Survey, OWDC, Appendix 2c, Columbia-North Pacific Region (17), List of Groundwater Quality Stations (wells only). OWDC, January, 1973	Manual with Listing. Includes agency, station name number, state, county, period of record, type of data storage and specific data and analyses recorded. Map of stations may be obtained by writing OWDC above. This listing outlines the data available. Actual data are obtained through STORET, the individual agency, or by writing OWDC above.	Mr. G. L. Bodhaine Regional Representative CWDC U.S. Geol. Survey 345 Middlefield Road Menlo Park, CA 94025
All	Selected areas	See "Groundwater" listings in bibliography	Selected USGA and other reports, circulars, maps, etc., are listed in bibliography	

TABLE 11

DATA SOURCES: WATER QUALITY

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Water quality, problems, potential development	General data by river basin and subbasin	Mineral and water Resources of Oregon. Report of the Committee on Interior and Insular Affairs of the United States Senate, prepared by the U.S. Geological Survey, 1969	Report. Discusses general water characteristics by river basin including water quantity, quality and problems. Discusses current and potential water development for flood, irrigation, navigation and recreational uses by subbasin.	District Chief, Water Resources Division U.S. Geological Survey P. O. Box 3202 Portland, OR 97208
Waste discharges	By subregion; municipal, industrial, and rural wates produced for each region and for each major point source are given in P.E. as well as volume of pollutants discharged	Columbia-North Pacific Region Comprehensive Framework Study, Appendix XII, Water Quality and Pollution Control. Pacific Northwest River Basins Commission, December, 1971	Book. General to semi-specific discussion of water quality problems including major pollution sources and amounts, locations and effects. Water Quality parameters plotted by river mile. Details total waste productions, locations, and sources from municipal, agriculture, industrial, and rural sources. Also estimates waste productions through the year 2020 and populations. Minimum flows to maintain water quality for various treatment levels are plotted. Projections are given for land use, irrigation water use, and agricultural animal production in P.E. Average monthly discharges, 1 in 10 yr. flows, and mean, min. and max. water quality data also given for some subregions.	Mr. Bill Catlin Director of Information Pacific Northwest River Basins Commission 1 Columbia River Vancouver, WA 98660
Agricultural animal waste production	Total P.E. Produced and amount reaching waterways.			
Irrigation effects	Consumptive use; Mode and amount of irrigated land; General water quality effects.			

TABLE 11 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Temperature Sp. Conduct. Turbidity, color Odor, pH, EH Susp. Solids Diss. Solids Cl_2, hardness Common ions Nitrogen-nutrient Phosphorous Radiochemical D.O., BOD Other gases Minor elements Pesticides Detergents Diss. Carbon Total Carbon Coliform Other micro-organisms Sediment conc. Sediment particle size Sediment bed particle size Water Discharge Time of Travel Other	All data reported from Federal, State, Municipal and private Detail depends on station Listing back through 1965	Catalog of Information on Water Data, as above, except Appendix 2B, Columbia-North Pacific Region (17) List of Surface-Water Quality Stations, OWDC, January, 1973	Book. Listing of Station, type of data, frequency of collection, agency, period of record, type of data storage. The station location is given by map number, agency station number, latitude and longitude, and state and county. Also whether station is existing, funded, or needed state of implementation. This listing outlines data available from each station. The actual data can be obtained from STORET or by writing the OWDC Office above. It is possible to get some computer listings and print-outs of specific data.	Mr. G. L. Bodhaine Regional Representative OWDC U.S. Geological Survey 345 Middlefield Road Menlo Park, CA

TABLE 11 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Temp., D.O. pH, BOD, Coliform, Sulfite Waste, Sediment Reservoir storage capacities Waste generation Minimum stream flows	Some data by river mile for critical periods others typical or critical values Major reservoirs Specific to a given company plant, municipality, etc. Total animal waste Legislated flows	Willamette Basin Comprehensive Study. Water and Related Land Resources. Appendix L, 1969, Willamette Basin Task Force, Pacific Northwest River Basins Commission	Book. Annual, maximum and other detailed data about specific pollutants such as tons of nitrate, phosphate, and sediment released. Tons of waste from specific industrial sources. PE of industrial and municipal waste. Irrigation water use and runoff. Detailed discussion of problems, practices, trends. Predictions of future waste productions, irrigated water used, etc. Predicted water model is used to predict future flows needed to meet D.O. requirements in Willamette River and tributaries.	Mr. Bill Catlin Director of Information Pacific Northwest River Basins Commission 1 Columbia River Vancouver, WA 98660
(Not yet published)	(Unpublished to date)	Water Quality Management Plan for Department of Environmental Quality, State of Oregon	Report. A series of 20 reports are soon to be published on individual basins.	Mr. Ken Spies Department of Environmental Quality State of Oregon Portland, OR

TABLE 11 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Flow BOD Susp. solids Coliform pH	Average flows and concentrations expected. Expected pH range	Environmental Protection Agency Enforcement Division files of discharge permit applications	Environmental Protection Agency Discharge Permit: Average flows, BOD, Susp. Solids, Fecal coliform, pH range — Required on all discharge permits from municipal and industrial sources	Mr. James Sweeny Cregon Cperations Cffice Environmental Protection Agency 1234 S.W. Morrison St. Portland, OR 97205
Design of a Water Quality Monitoring System	Quantitative methods	Beckers, C. V., S. G. Chamberlain, and G.P. Grimsud, "Quantitative Methods for preliminary Design of Water Quality Surveillance Systems", EPA Socio-economic Environmental Studies Series, EPA-R5-72-001, 1972		
Regularly collected Federal Water Quality Data Sources		The Federal Environmental Monitoring Directory, Council on Environmental Quality, May 1973	This publication lists Federal agencies and the data which they regularly collect. Water quality sources and contacts are listed.	

TABLE 12

DATA SOURCES: AGRICULTURE

PARAMETERS	DETAILS	DATA SOURCES	COMMENTS	CONTACTS
Irrigated acreage, sprinkler acreage and acreage by other methods. Acreage by crop. Trends in irrigation practices.	Subregion	Extension Irrigation and Water Use Specialists	Personal Communication. These people are probably the most knowledgeable around for a given subregion.	Extension Agricultural Engineers and Water Use Specialists at Agriculture Research and Extension Centers
Irrigated acreage and sprinkler irrigated.	By state	Irrigation Journal, November–December, 1972.	Journal. Data by state for at least the past ten years.	
Current research projects on agriculture and forestry and environmental impacts.	Outlines scope of research, current status and lists associate publications.	University of Idaho Water Resources Research Institute Annual Report, August, 1973.	Report. Most of the research here deals with the most acute current problems in the region This is a valuable source of information for current projects.	Director, Water Resources Research Institute
Pesticides and general agriculture		Director of Water Resources Research Institute for each state.	Specific research projects on pesticides, agriculture, and other water quality aspects are being carried out.	Mr. Bob Alexander Director WRR Institute, Oregon State University, Corvallis, OR

TABLE 12 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
NO_3, PO_4, K, Na, Color, Temp., pH, Conductivity, Sediment	One field at Twin Falls	Bondurant, James A., Quality of Surface Irrigation Runoff Water, Preprint of ASAE Annual Meeting, WSU, Pullman, Washington, June 27-30, 1971. Paper No. 71-247.	Paper. Quality analyses of applied water and run-off water were compared on a small field.	
Irrigation water diversion and depletions	Regional and subregional and subarea.	Columbia-North Pacific Region Comprehensive Framework Study, Appendix IX, Irrigation. Pacific Northwest River Basins Commission	Book. Irrigation diversions, percent delivery losses, percent farm losses, percent return flow, percent non-beneficial consumptive use and ground-water build up. Irrigation water quality. Acres under irrigation and projected future needs, projected non-irrigated crop land through 2020. Projected water deliveries and depletions. Potentially irrigable land, land classification, available water supply, acres and methods of irrigation. Sources and adequancy of water supply. Acreages of individual crops.	Mr. Bill C. Catlin Director of Information Pacific Northwest River Basins Commission 1 Columbia River Vancouver, Wa. 98666
General irrigation practices and effects.	General textbook	Israelson, O. W. and V. E. Hansen, Irrigation Principles & Practices, John Wiley and Sons, Inc. 1962.	Textbook. General discussion, tables, charts, mathematical relationships, etc.	John Wiley and Sons, Inc., New York, NY

TABLE 12 (Continued)

PARAMETERS	DETAILS	DATA SOURCE	COMMENTS	CONTACTS
Agricultural animal waste production	Total PE produced and amount reaching waterways	Columbia-North Pacific Region Comprehensive Framework Study, Appendix XII, Water Quality and Pollution Control. Pacific Northwest River Basins Commission, December 1971	Details total waste productions, locations, and sources from municipal, agriculture, industrial, and rural sources. Also estimates waste productions through the year 2020 and populations. Minimum flows to maintain water quality for various treatment levels are plotted. Projections are given for land use, irrigation water use, and agricultural animal production in P.E. Average monthly discharges, 1 in 10 yr. low flows, and mean, min. and max. water quality data also given for some subregions.	Mr. Bill Catlin Director of Information Pacific Northwest River Basins Commission 1 Columbia River Vancouver, WA 98660

TABLE 13

METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES

		References to be Used						
PARAMETER	REPORTED AS	STD Methods (1)	ASTM Std. (2)	EPA Method (3)	METHOD	PRESERVATIVE	MAXIMUM HOLDING PERIOD	AMOUNT REQUIRED FOR ANALYSIS
Acidity, total	mg/1 $CaCO_3$			5	Electrometric titration pH 8.3	refrigeration at 4°C	24 hours	250 ml
Alkalinity	mg/1 $CaCO_3$		155		Electrometric titration pH4.5	refrigeration at 4°C	24 hours	250 ml
Arsenic	g/1	62-64			Silver diethyldi-thiocarbamate	---	6 months	250 ml
Biochemical Oxygen Demand	mg/1 BOD	489-493	727-732	NCASI Report	Winkler azide or DO analyzer	refrigeration at 4°C	ASAP (4)	1 liter
Chemical Oxygen Demand	mg/1 COD	495-499	244	16-28	Dichromate reflux	1 ml:H_2SO_4 per liter	7 days	250 ml
Chloride	mg/1 C1	97			Mercuric nitrate	none required		250 ml
Color	Color units	160		38-40	Platinum-cobalt	refrigeration at 4°C	24 hours	250 ml
Cyanide	mg/1			41-52	Silver nitrate titration or probe	NaOH to pH 10	ASAP (4)	250 ml
Dissolved Oxygen	mg/1			53-63	Winkler azide or DO analyzer	determine on site		
Fluoride	mg/1	171-176		64-65 72-75	SPADNS specific ion probe	none required		250 ml

TABLE 13 (Continued)

PARAMETER	REPORTED AS	References to be Used: STD Methods (1)	ASTM Std. (2)	EPA Method (3)	METHOD	PRESERVATIVE	MAXIMUM HOLDING PERIOD	AMOUNT REQUIRED FOR ANALYSIS
Hardness	mg/1 $CaCO_3$	179-184			EDTA titration or Ca+Mg by A.A.	none required		250 ml
Methylene Blue active substance	mg/1 MBAS	339-342			Methylene Blue	none required		500 ml
Nitrogen, Ammonia	NH_3-N-mg/1			134-140	Distillation-Nesslerization	40 mg $HgC1_2$ per liter 4°C	7 days	1 liter
Nitrogen, Nitrate	NO_3-N-mg/1			170-174	Brucine sulfate	40 mg $HgC1_2$ per liter 4°C	7 days	250 ml
Nitrogen, Nitrite	NO_2-N-mg/1			195-197	Diazotization	40 mg $HgC1_2$ per liter 4°C	7 days	250 ml
Nitrogen, Kjeldahl total	TKN, gm/1			149-157	Digestion	40 mg $HgC1_2$ per liter 4°C	ASAP (4)	1 liter
Oil and Grease	mg/1	245-256		217-220	Solvent extraction	use glass oversize bottles 5 ml 1:1 H_2SO_4/1	24 hours	500 ml each
pH	pH units	276-281	284		Electrometric	none available	ASAP (4)	250 ml
Phenolics	mg/1	501-516	517		4-aminoantipyrine chloroform extraction method	1 g. $CuSO_4$+H_3PO_4 to pH 4.0-4°C	ASAP (4)	500 ml

TABLE 13 (Continued)

PARAMETER	REPORTED AS	References to be Used: STD Methods (1)	ASTM Std. (2)	EPA Method (3)	METHOD	PRESERVATIVE	MAXIMUM HOLDING PERIOD	AMOUNT REQUIRED FOR ANALYSIS
Phosphorus	P, mg/1			239-245		40 mg $HgC1_2$ per liter 4°C	7 days	250 ml
Solids total	mg/1			280-281	Gravemetric	none available	----	250 ml
Solids filterable	mg/1			275-283	Filtration through glass fibre	none available	----	250 ml
Specific conductivity	mho/cm at 25°C	323-326	183		Wheatstone bridge (25°C)	none required	----	250 ml
Sulfate	mg/1		56-58	288-291	Colorimetric	refrigeration at 4°C	7 days	250 ml
Sulfide	mg/1	336-337			Iodometric or methylene blue	2 ml/zinc acetate per liter	7 days	250 ml
Temperature	°C	348-349		296	Mercury, dial or thermister	determine on site	----	----
Turbidity	JTU			308-312	Hach 2100 or 2100A	none available	ASAP (4)	250 ml
Metals	mg/1 Al, Cd, Ca, Cr, Cu, Fe, Pb, Mg, Mn, K, Ag, Na and Zn			Refer to appropriate metal	Atomic adsorption	5 ml HNO_3 per liter except Ca, Mg, K and Na	6 months	1 liter

TABLE 13 (Continued)

PARAMETER	REPORTED AS	References to be Used: STD Method (1)	ASTM Std. (2)	EPA Method (3)	METHOD	PRESERVATIVE	MAXIMUM HOLDING PERIOD	AMOUNT REQUIRED FOR ANALYSIS
Whatman 40	mg/1	(as reported in "Procedures for Analysis of Pulp and Paper Mill Effluents," September 27, 1968)						2 liters
PBI	mg/1	(as reported in "Tappi 46, June 1963, using the Standard SSL Calibration method)						250 ml
Bacteriological	colonies/ 100 ml	635-711			Membrane filter		30 hours	250 ml

(1) Standard Methods for the Analysis of Water and Wastewater, Thirteenth Edition (1971).
(2) ASTM Standards, Part 23 (1968).
(3) Methods for Chemical Analysis of Water and Waste, EPA, July 1971.
(4) As Soon As Possible (ASAP). Check with laboratory personnel.

TABLE 14

OREGON HAZARDOUS MATERIALS STANDARDS

	mg/1
Arsenic (As)	0.01
Barium (Ba)	1.00
Boron (B)	0.50
*Cadmium (Cd)	0.01-.003
*Chloride (Cl)	25.00-50.00
*Chromium (Cr)	0.02-0.05
Copper (Cu)	0.005
*Cyanide (CN)	0.005-0.01
Fluoride (F)	1.0
Iron (Fe)	0.1
Lead (Pb)	0.05
Manganese (Mn)	0.05
Phenols (totals)	0.001
*Total dissolved solids	100.-200.-750.
*Zinc (Zn)	0.01-0.10
Heavy metals (totals including Cu, Pb, Zn)	0.5

*Varies with location. See State Standard for details.

TABLE 15

DATA SOURCES: HAZARDOUS MATERIALS

PARAMETERS	DETAILS	DATA SOURCES	COMMENTS	CONTACTS
Aldrin Chlordane DDD DDE DDT Dieldrin Endrin Heptachlor Heptachlor-epoxide Lindane 2,4,-D 2,4,5,-T Silvex	Monthly	Water Resources Data for Oregon, Part 1, Surface Water Records, (year), U.S. Dept. of the Interior Geological Survey	Book. Only a few data at a very few locations are available for these pesticide parameters.	
As, Cd, Cr, Co, Pb, Hg, Zn	Sampling at various sites in each state	Duram, W. H., J. D. Hem, S. G. Heidel, "Reconnaissance of Selected Minor Elements in Surface Waters of the United States" USGS Circular 643, October, 1970	Circular. Samples in the survey were taken at 13 stations in Oregon. Analyses were made for 7 heavy metals.	Supt. of Documents U. S. GPO Washington, DC 20402
Heavy metals, hazardous chemicals		See General Water Quality References also		
Pesticides Heavy metals	Some rivers	Annual Reports—Environmental Health Sciences Center, Oregon State Univ. Corvallis, Oregon	Report. General Reconnaissance Level Data	Dr. Virgil Freed Director, Environmental Health Sciences Center Oregon State University Corvallis, OR

TABLE 16

GROUNDWATER STUDIES, OREGON

Brown, S. G. Occurrence of Ground Water in the Columbia River Basalt near Pilot Rock, Oregon. U.S. Geological Survey Open File Report, 1955.

Brown, S. G. Occurrence of Ground Water near Ana Springs, Lake County, Oregon. U. S. Geological Survey Open File Report, 1957.

Brown, S. G. Problems of Utilizing Ground Water in the West Side Business District of Portland, Oregon. U.S. Geological Survey Water Supply Paper 1619-0, 1963.

Brown, S. G. and R. C. Newcomb. Ground Water Resources of Cow Valley, Malheur County, Oregon. U.S. Geological Survey Water Supply Paper 1619-M, 1962.

Brown, S. G. and R. C. Newcomb. Ground Water Resources of the Coastal Sand Dune Area North of Coos Bay, Oregon. U.S. Geological Survey Water Supply Paper 1619-D, 1963.

Ducret, G. L., Jr. and D. B. Anderson. Records of Wells, Water Levels, and Chemical Quality of Water in Baker Valley, Baker County, Oregon. U. S. Geological Survey Open File Report, 1965.

Dyer, K. L. and H. W. Young. A Reconnaissance of the Quality of Water from Irrigation Wells and Springs in the Snake Plain Aquifer, Southeastern Idaho. U. S. Geological Survey Open File Report, July 1971.

Foxworthy, B. L. and C. T. Bryant. Artificial Recharge Through a Well Tapping Basalt Aquifer at The Dalles, Oregon. U.S. Geological Survey Water Supply Paper 1594-E, 1967.

Foxworthy, B. L., G. M. Hogenson and E. R. Hampton. Records of Wells and Springs, Water Levels, and Chemical Quality of Ground Water in the East Portland Area, Oregon. U.S. Geological Survey Open File Report, 1964.

Hampton, E. R. Ground Water in the Coastal Dune Area Near Florence, Oregon. U.S. Geological Survey Water Supply Paper 1539-K, 1963.

TABLE 16 (Continued)

Hampton, E. R. Records of Wells, Water Levels, and Chemical Quality of Ground Water in the Molalla-Salem Slope Area, Northern Willamette Valley, Oregon. Oregon Ground Water Report No. 2, 1963.

Hampton, E. R. Geologic Factors that Control the Occurrence and Availability of Ground Water in the Fort Rock Basin, Lake County, Oregon. U.S. Geological Survey Professional Paper 383-B, 1964.

Hampton, E. R. Evaluation of Potential Sources of Water in Crater Lake National Park, Oregon. U.S. Geological Survey Open File Report, 1967.

Hampton, E. R. and S. G. Brown. Geology and Ground Water Resources of the Upper Grande Ronde River Basin, Union County, Oregon. U. S. Geological Survey Water Supply Paper 1597, 1964.

Hart, D. H. Artificial Recharge to Ground Water in Oregon and Washington. U. S. Geological Survey Open File Report, 1958.

Hart, D. H. and R. C. Newcomb. Geology and Ground Water of the Tualatin Valley, Oregon. U. S. Geological Survey Water Supply Paper 1697, 1965.

Hart, D. H. List of Ground Water Sources in Oregon Known to Yield Mineralized Water (Over 1,000 ppm Dissolved Solids or 60 Percent Sodium). U.S. Geological Survey Open File Report, 1954.

Helm, D. C. Records of Wells, Water Levels, and Chemical Quality of Water in the Lower Santiam River Basin, Middle Willamette Valley, Oregon. U. S. Geological Survey Open File Report, 1968.

Hogenson, G. M. Geology and Ground Water of the Umatilla River Basin, Oregon. U. S. Geological Survey Water Supply Paper 1620, 1964.

Hogenson, G. M. and B. L. Foxworthy. Ground Water in the East Portland Area, Oregon. U.S. Geological Survey Water Supply Paper 1793, 1965.

Lystrom, D. J., W. L. Nees and E. R. Hampton. Ground Water of Baker Valley, Baker County, Oregon. U.S. Geological Survey Hydrologic Investigations Atlas HA-242, 1967.

TABLE 16 (Continued)

Meyers, J. D. and R. C. Newcomb. Geology and Ground Water Resources of the Swan Lake-Yonna Valleys Area, Klamath County, Oregon. U. S. Geological Survey Open File Report, 1952.

Newcomb, R. C. Ground Water Available for Irrigation in the Fort Rock Basin, Northern Lake County, Oregon. U. S. Geological Survey Open File Report, 1953.

Newcomb, R. C. Snake River Basin in Oregon South of the Wallowa Mountains. U. S. Geological Survey Open File Report, 1960.

Newcomb, R. C. and D. H. Hart. Preliminary Report on the Ground Water Resources of the Klamath River Basin, Oregon. U.S. Geological Survey Open File Report, 1958.

Newcomb, R. C. Ground Water in the Western Part of the Cow Creek and Soldier Creek Grazing Units, Malheur County, Oregon. U.S. Geological Survey Water Supply Paper 1475-E, pp. 159-172, 1961.

Newcomb, R. C. and G. M. Hogenson. Availability of Ground Water in the Schoolie Flat Area, Wasco County, Oregon. U. S. Geological Survey Open File Report, 1956.

Oregon Agricultural Experiment Station. The Ground Water Problems in Oregon. Oregon State College Agricultural Experiment Station Circular 124, 1937.

Price, D., D. H. Hart and B. L. Foxworthy. Artificial Recharge in Oregon and Washington. U.S. Geological Survey Water Supply Paper 1594-C, 1965.

Price, D. Records of Wells, Water Levels, and Chemical Quality of Ground Water in the French Prairie-Mission Bottom Area, Northern Willamette Valley, Oregon. U. S. Geological Survey Open File Report, 1961.

Price, D. Geology and Water Resources in the French Prairie Area, Northern Willamette Valley, Oregon. U.S. Geological Survey Water Supply Paper 1833, 1967.

Price, D. Ground Water Reconnaissance in the Burnt River Valley Area, Oregon. U.S. Geological Survey Water Supply Paper 1839-I, 1967.

TABLE 16 (Continued)

Price, D. Ground Water in the Ecola-Amity Hills Area, Northern Willamette Valley, Oregon. U.S. Geological Survey Water Supply Paper 1847, 1967.

Piper, A. M. Geology and Ground Water Resources of The Dalles Region, Oregon. U.S. Geological Survey Water Supply Paper 659-B, pp. 107-189, 1932.

Piper, A. M., T. W. Robinson and C. F. Park, Jr. Geology and Ground Water Resources of the Harney Basin, Oregon (With a Statement of Precipitation and Tree Growth by L. T. Jessup). U.S. Geological Survey Water Supply Paper 841, 1939.

Piper, A. M. Ground Water Resources of the Willamette Valley, Oregon. U.S. Geological Survey Water Supply Paper 890, 1942.

Robison, J. H. Availability and Quality of Ground Water in the Ashland Quadrangle, Jackson County, Oregon. U.S. Geological Survey Hydrologic Investigations Atlas HA-421, 1972.

Robinson, J. R. Estimated Existing and Potential Ground Water Storage in Major Drainage Basins in Oregon. U.S. Geological Survey Open File Report, April 1968.

Robinson, J. W. and D. Price. Ground Water in the Prineville Area, Crook County, Oregon. U.S. Geological Survey Water Supply Paper 1619-P, 1963.

Sceva, J. E. and R. DeBow. Ground Water Levels, 1965. Oregon State Engineer Ground Water Report 9, 1966.

Sceva, J. E. A Reconnaissance of the Ground Water Resources of the Hood River and the Cascade Locks Area, Hood River County, Oregon. Oregon State Engineer Ground Water Report No. 11, 1966.

Trauger, F. D. Basic Ground Water Data in Lake County, Oregon. U.S. Geological Survey Open File Report, 1950.

Trauger, F. D. Ground Water Resources of Baker Valley, Baker County, Oregon. U.S. Geological Survey Open File Report, 1950.

Wagner, N. S. Ground Water Studies in Umatilla and Morrow Counties, Oregon. Oregon Department of Mines and Geology, 1949.

TABLE 16 (Continued)

Wolfe, J. W. Effect of Controlled River Level on Field of Irrigation Wells Near Jefferson, Oregon. Oregon State College Agricultural Experiment Station (Corvallis) Miscellaneous Paper 84, 1959.

CHAPTER 6

GEOLOGY

The environmental concerns that are related to geology are twofold.

1. The recognition of geologic hazards in order to prevent problems that will result when land is used for purposes for which it is not suited. Hazards of this nature would include:

    - landslide prone areas,
    - floodplains,
    - erosion prone areas,
    - groundwater problems such as high water tables or non-potable water,
    - geological faults,
    - areas of highly compressible soils.

2. The identification of important geological values to prevent actions that will excessively reduce the economic or the environmental features of geologic areas.

GEOLOGIC HAZARDS

The geologic impacts of many actions are not immediately apparent. Many of the effects are subtle and very slow to develop. Specific factors that may require study and evaluation depend on the nature of the proposed action. These factors are discussed below.

LANDSLIDES AND ACCELERATED EROSION

Landslides can develop when slopes are made unstable by steepening, either naturally or artifically. Slope instability can also result from internal conditions caused by such actions as an increase in the quantity of water entering the ground formations.

The impacts of landslides and other types of accelerated erosion are undesirable particularly in the case of streams and rivers. The resulting sediment can be especially damaging to such things as fish spawning and rearing areas.

To assess the landslide and accelerated erosion potential of an area the following data are required:

- Determine the nature, attitude and origin of all geologic materials within one mile of the area expected to be influenced. The exploration should extend at least to the ground water table or bedrock, whichever is the deeper.
- Identify precise location of excavations. Determine the degree of erodability by wind and water of the exposed areas. Also

determine the areas where subaerial and subaqueous deposition will occur.

- Identify sites within ten miles of the proposed project where landsliding has occurred both in the historic and geologic past.
- Identify the probable causes of sliding and the potential for sliding within the proposed action area.
- Estimate the net impact of the project on the ground water table. If the water table is to be raised, or perched water is to be created, identify the sites and the potential for landslides.
- Determine the impact that the removal of vegetation will have on wind erosion.
- Determine the impact that changes in drainage patterns will have on surface erosion resulting from runoff.
- Determine the impact of erosion on water quality.

PUBLIC SAFETY HAZARDS

Detailed knowledge of foundation conditions is required of all alternatives that include major structures. This is to assure structural safety. Information of this nature is usually obtained as a part of the engineering assessment of any major project.

Other types of land use or development, however, often take place without adequate investigation of the geologic suitability of the area, or the geologic hazards. Examples of this are recreation or residential developments. Therefore in addition to the landslide and erosion potential discussed above, identification should be made of any hazards such as:

- fault zones that make a site questionable for permanent structures,
- flood plains,
- steep slopes, bluffs, etc., that will require some controls to provide for public safety,
- areas unsuitable for structures because of highly compressible soils.

GEOLOGIC VALUES

Commercially important mineral resources and the recreation, educational, and scientific values offered by unique geologic areas are examples of environmental considerations that should not be overlooked. Specific factors to assess are discussed below.

MINERAL RESOURCES

If the proposed alternative involves land use, an inventory of the mineral resources (sand and gravel, crushed rock, metallic ores, etc.), should be made to identify areas containing commercially important minerals. If mining is to be an aspect of the alternative, the associated reclamation practices (such as land restoration) should be assessed to determine the impact on the future use of the land for other beneficial purposes.

RECREATION, EDUCATION AND SCIENTIFIC VALUES

Unique geologic areas provide an outdoor laboratory for illustrating the general principles of geology to students. These areas are also scientifically important for obtaining knowledge about the natural forces that created and control certain aspects of the environment. In addition, many geologic features have definite recreational values or opportunities.

It is, therefore, important to locate and identify any geologic features that merit recognition and preservation because of a distinctive character or scientific, educational, or historic value. Once identified, the impact of the proposed action on these values should be assessed.

Figure 14 is an illustration of how to graphically show geologic values. This figure shows areas and features of importance to rockhounds and others interested in outdoor recreation in central Oregon. The information was adapted from the map, Central Oregon Rockhound and Recreation Sites, distributed by the Oregon State Highway Commission.

DATA COLLECTION GUIDELINES

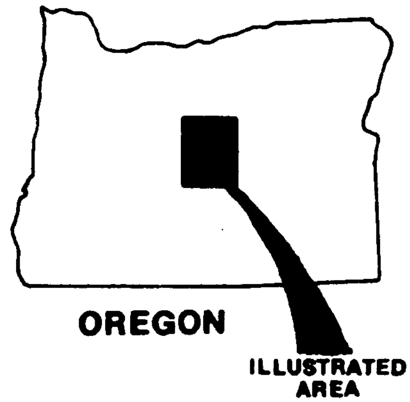
The traditional methods of evaluating the geologic features

Figure 14.

CENTRAL OREGON ROCKHOUND AND RECREATION SITES

● PUBLIC RECREATION SITES

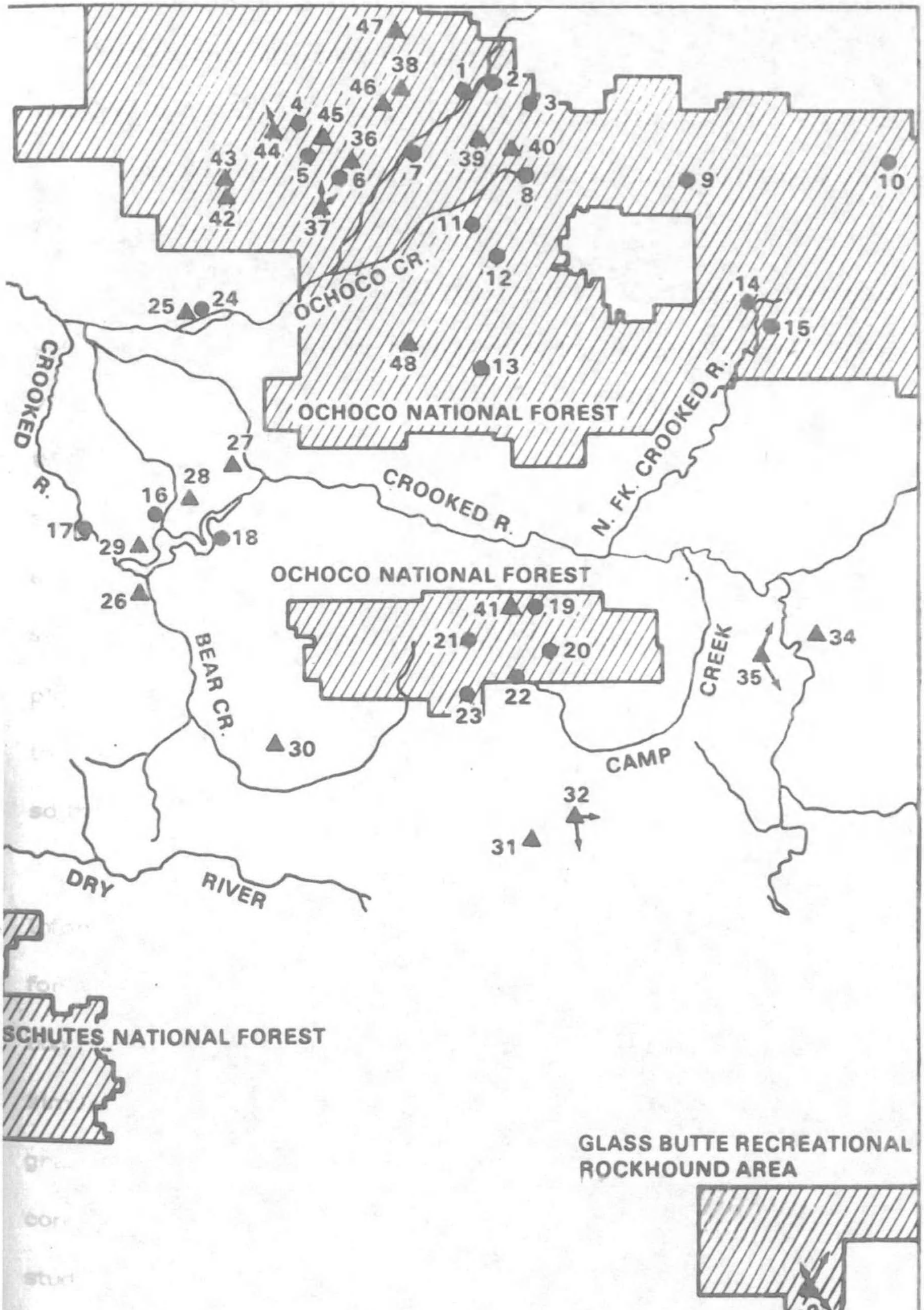
1. BANDIT STATE REST AREA
2. OCHOCO DIVIDE
3. WILDWOOD
4. CAYUSE
5. WILDCAT
6. WHITE ROCK
7. COUGAR
8. WALTON LAKE
9. SCOTTS
10. DERR
11. OCHOCO
12. CANYON CREEK
13. ARVID NELSON
14. DEEP CREEK
15. TWIN SPRING
16. PRINEVILLE RESERVOIR STATE PARK
17. CHIMNEY ROCK
18. JASPER POINT COUNTY PARK
19. DRAKE CREEK
20. WILEY FLAT
21. PINE CREEK
22. DOUBLE CABIN
23. ANTELOPE
24. OCHOCO LAKE STATE PARK



▲ DIGGING LOCATIONS

	NAME	MAJOR FEATURE
25.	OCHOCO RESERVOIR	OCHOCO JASPER
26.	MOUTH OF BEAR CREEK	AGATE
27.	EAGLE ROCK	AGATE
28.	CAREY AGATE BEDS	CAREY AGATE
29.	RESERVOIR HEIGHTS	BLACK MOSS AGATE
30.	FISCHER CANYON	PETRIFIED WOOD
31.	SMOKEY MOUNTAIN	LIMB CAST
32.	OWENS WATER-SOUTH POLE CREEK	GREEN PETRIFIED WOOD
33.	GLASS BUTTE-BLACK BUTTE	OBSIDIAN VARIETIES
34.	CONGLETON HOLLOW	LIMB CAST
35.	SOUTH FORK	LIMB CAST
36.	WHITE ROCK	THUNDEREGGS
37.	WHITE FIR SPRING	THUNDEREGGS
38.	WHISTLER SPRING	THUNDEREGGS
39.	COYLE SPRING	GREEN JASPER
40.	AHALT CREEK	VISTAITE
41.	SHOTGUN CREEK	VARIED MOSS AGATE
42.	DRY CREEK	JASPER
43.	DRY CREEK	THUNDEREGGS
44.	HARVEY GAP	THUNDEREGGS
45.	FORKED HORN BUTTE	THUNDEREGGS
46.	DESOLATION CANYON	THUNDEREGGS
47.	ROAD 1223	GREEN MOSS AGATE
48.	SHEEP CREEK	GREEN MOSS AGATE

Figure 14. (Continued)



are adequate for predicting the effect of the construction, operation and maintenance of water resources projects. This data normally obtained by geologists and engineers is also useful for the environmental assessment. However, additional attention to those processes of environmental concern is usually required.

The assessment should begin with a review of the published geologic maps and reports to determine the regional setting. Site visits and reconnaissance studies should then be made to determine the scope and extent of additional work needed to fully document the site. The site, commonly, should be mapped geologically on large-scale topographic maps (1:24,000, or still larger scales) and/or on similarly scaled aerial photographs. The geologic information is plotted directly on the maps or photos. It is a good idea to use the same scale on the maps or photos for all field studies on the site so that the multidisciplinary data can be more easily integrated.

Normally, for an adequate assessment of a site, more information is needed than generally obtained for design purposes for a water resources action. The additional information is often complementary to the required design data and can be obtained simultaneously. Identification of the geologic structures and stratigraphy are routine and necessary for determining the foundation conditions. Faults are also identified as a part of the engineering study, but additional data are needed for the total environmental assessment. Any faults that are identified should be traced and their offset and age of latest movement should be determined.

Ground waters should be assessed for potential changes resulting from the proposed action. Special emphasis should be given to possible long term impacts and those which may not immediately develop but appear at some later date during the project life. Faults can be either water conduits or barriers, depending upon the types of rocks they intersect. They can divert ground water in unanticipated directions. An impact is particularly likely when heads are increased due to the possibility of developing new aquifer recharging paths. Studies should be made to identify the geologic controls to the ground water flow and the area of ground water recharge and discharge. This information can be used to better predict the water level and gradients in the intervening areas.

Changing water levels can have a considerable impact. The lowering of ground water levels can result from the irrigation from wells or from drainage projects. Raised water levels, both ground and surface, result from dams, reservoirs, irrigation projects that use imported waters, and the diversion and disposal of waters at new sites. The fluctuation of water surfaces commonly result from the periodic storage and release of water. The impact of changing water levels can be either detrimental or beneficial. A particularly detrimental impact can result when ground water is diverted into a different geologic formation.

GEOLOGIC VALUES

During the initial site study, mineral resources usually can be identified. Mineral resources include such things as materials usable in projected construction as well as those that are valuable from a recreational, educational, or scientific standpoint. Construction material would include sands, gravels, rock suitable for crushing, rip-rap, pozzolan, pumice, pumicite, clays and other similar material. Petrified wood, agates, geodes, fossils, zeolites, garnets, artifacts and archeological materials may be of considerable value to rockhounds or professional geologists.

Determination should be made of the nature, location, occurrence, and recreational and educational value of the geologic materials within the affected area. Natural landmarks are often of historic value as are features of scientific and educational interest.

DATA SOURCES

Geologic hazards, published geologic maps, reports and seismologic data and general seismologic evaluations are available for all parts of Oregon.

U.S. Geological Survey topographic maps are available either commercially or from the offices of the Geological Survey. These maps are most appropriate at the scales of 1:24,000. Aerial photographs at comparable or larger scales are very valuable in identifying potential problem areas.

U. S. Geological Survey geologic maps and reports, including the Water Supply Papers of the Water Resources Division, are also sources of data. Data can often be obtained from various state, federal and private agencies, some of which are listed below.

- The U. S. Bureau of Mines
- U. S. Geological Survey
- U. S. Army Corps of Engineers, North Pacific Division, Portland, Oregon 97209
- Oregon Department of Geology and Mineral Industries, Portland, Oregon 97201
- Soil Conservation Service
- Oregon State Engineer
- Oregon State University, Department of Geology, Corvallis, Oregon 97331
- Portland State University, Department of Geology, Portland, Oregon 97207
- University of Oregon, Department of Geology, Eugene, Oregon 97403
- State Historical Society
- Local Rock and Mineral Societies.

The assessing of the potential impacts of an alternative can be greatly assisted by requesting an identification of the expected impacts from the applicable agencies or groups. The request should be accompanied by a brief description of the proposed action along with maps outlining the areas that will be affected by each alternative.

CHAPTER 7

AIR QUALITY

The proposed alternative could change the quality of the atmosphere both during and after its implementation. Activities which have potential atmospheric impacts include flood control, irrigation and recreation. The impact from the construction phase of a project results primarily from the increased usage of automobiles, trucks and other vehicles. The importance of the impact on the atmosphere depends upon the scope, size and magnitude of the specific alternative. The climatic and meteorological elements that influence the air pollution potential are included in this chapter.

PRELIMINARY ASSESSMENT

To determine if the alternative will have an impact on the air quality of sufficient magnitude to require a detailed assessment, the following factors should be considered.

--The types of contaminants, particularly those that are toxic or a nuisance such as carbon monoxide, nitrogen dioxide, sulfur oxides, particulate matter, odors, etc.

--The proximity to human habitations, especially if the alternative is within one mile of airports, schools, residential areas, etc., because of the possible impacts on health, vegetation, animal life, visibility, and esthetics.

--Location near hill or mountains and especially if located within a confined basin or valley.

--Relation to the ventilation factor, described below.

--Ventilation factor as measured by the volume of air available for dispersal of pollutants (which is dependent upon the character and height of the temperature inversion layer and the amount of wind flow).

--Air pollution history of the area surrounding the site of the alternative, especially if the local air quality standards are presently being exceeded.

--The existing industrial concentration and the present air contaminants.

--The average annual precipitation as a measure of the areas ability to clean up air pollutants.

--The potential for changes in the microclimate of the area.

The preliminary assessment of the air quality should identify any existing facilities which would have similar pollution impacts to the proposed alternative. Information from actual experiences from similar action would provide a suitable base for making a general estimate of the impact of the proposed actions.

DETAILED ASSESSMENT

Assuming that the alternative being considered requires a detailed assessment of its impact on air quality, Figure 15 suggests the steps that should be followed in the analysis procedure. These include:

--Describe the sources of airborne emissions due to the action.

--Determine the nature of the sources, i.e., height of emissions, temperature of the emissions, exit velocity of emissions, emission rates, types (point, line, area, volume), release rates (continuous, instantaneous, intermittent), and the types of air contaminants (heat, gas, particulate). Obtain engineering or meteorologic estimates of the emission rates for the potential sources of pollution.

--Determine whether the emissions of the airborne contaminants resulting from the proposed action meet local emission pollution standards.

--Evaluate any unavoidable adverse impacts on the regional microclimate.

--Evaluate the possible short and long term impacts of the pollutants.

--After the change in air quality has been estimated, determine the population which will be affected and the health and safety impacts of the pollutants.

DATA COLLECTION GUIDELINES

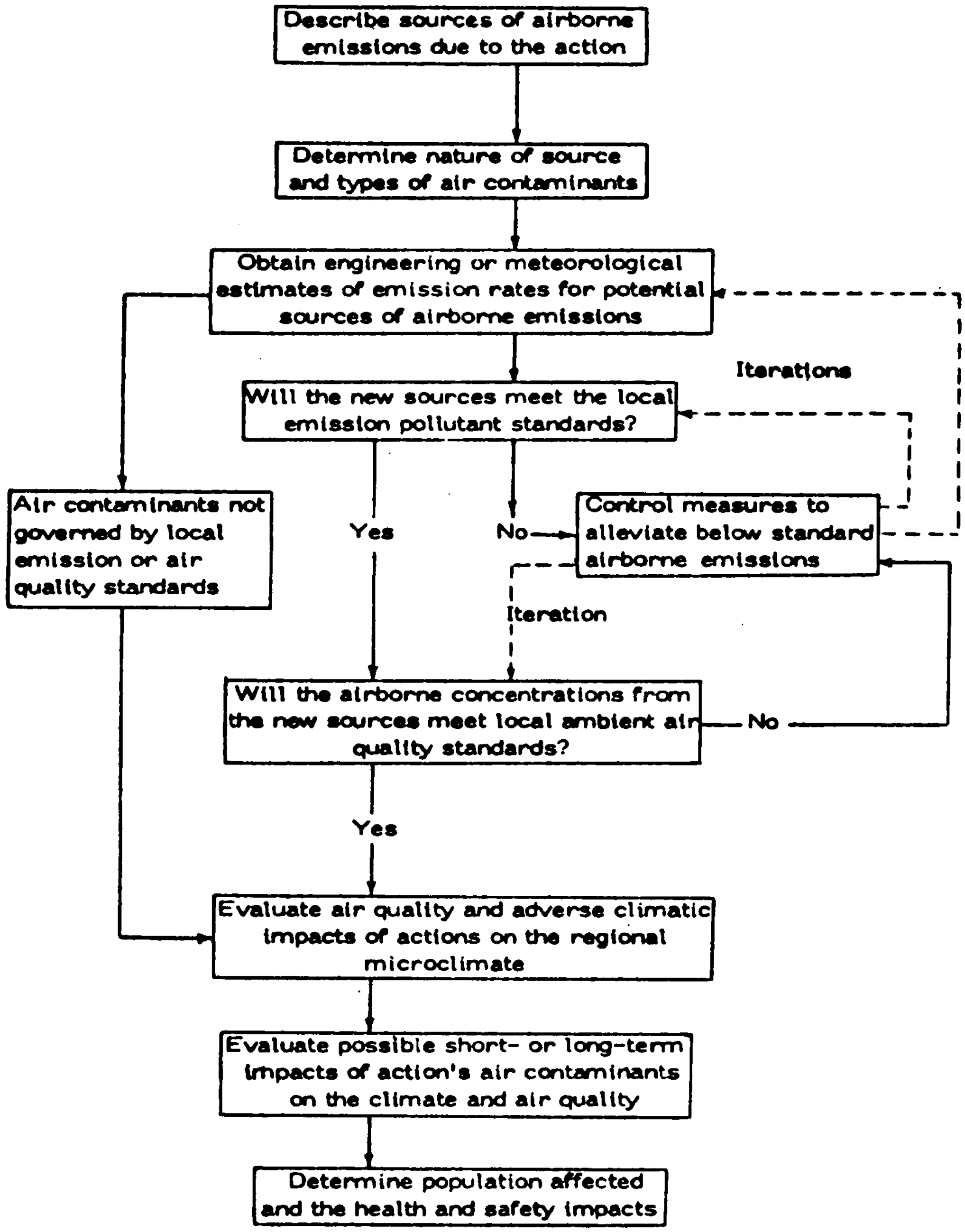
CLIMATIC FACTORS

Describe the general climate of the area in which the alternative is located. The Meteorologic elements that should be considered in the description are listed below.

Evaporation - the physical process by which a liquid or solid is transformed to the gaseous state. Relevant data: amount of water evaporated.

Humidity - (relative humidity, dewpoint, mixing ratio)

Figure 15. Air Quality Analysis Procedure.



measure of the water–vapor content of air. Relevant data: means, maximums, minimums.

Hydrometeors - (rain, snow, cloudiness, hail, fog, blowing snow, frost, etc.) any product of condensation or sublimation of the atmospheric water vapor. Relevant data: means, maximums, minimums, range maximum in 24 hours (precipitation), mean number of days and frequency of occurrence.

Lithometeors - (dust, haze, smoke, sand) dry atmospheric suspensoids. Relevant data: frequency of occurrence.

Temperature - degree of hotness or coolness as measured by thermometers. Relevant data: means, maximums, minimums, range.

Wind - air in motion relative to the surface of the earth. Relevant data: mean and prevailing wind directions, mean and maximum wind speeds, gustiness, turbulence.

Visibility - the greatest distance in a given direction at which it is just possible to see and identify a prominent object with the unaided eye. Relevant data: frequency of occurrence of different visibility classes and visual obstructions.

Storm Statistics - frequency of occurrence of cyclonic storms, thunderstorms, tornadoes and dust storms. Relevant data: daily and monthly weather summaries. Data for climatic description should be chosen in relation to the specific alternatives under study.

Some of the meteorologic elements may be unnecessary for description or impact assessment.

METEOROLOGIC FACTORS

Analyze the air pollution potential of the region where the alternative is located. The meterologic factors which should be determined in the pollution potential description are discussed below.

Mixing depth - the vertical distance between the ground and an elevated temperature inversion where turbulent mixing of pollutants may occur. Relevant data: mean, maximum and minimum heights of temperature inversions.

Wind speed - Relevant data: mean wind speed for different categories of mixing depths.

Atmospheric stability - a measure of the degree to which the atmosphere resists or enhances vertical motion. Atmospheric stability can be determined from the measuring of the temperature change with respect to height (vertical temperature gradient). When upper air soundings are not available for stability measurements a system developed by Dr. F. Pasquill and others is often used for classifying the atmospheric stability. This information can be obtained for first order (24 hour) weather stations by the National Climatic Center's "Star" Computer Code. Relevant data: actual measurements or the Pasquill stability categories.

AIR QUALITY DATA

Obtain information concerning the existing air pollutant emission and the ambient air quality for the general area around the location of the proposed alternative. Compare the existing ambient air quality for the area with the state or local air quality standards.

The air pollutants that are usually included in the ambient air quality standards are listed below.

Suspended Particulate Matter - Liquid or solid particles from industrial and natural sources such as dust, mist, ash, smoke, fumes, pollens and metallic dusts or oxides. Particulate matter reduces visibility and when it is highly concentrated, and is in the presence of sulfur dioxide, may be a hazard to health. Relevant measurements: concentration micrograms per cubic meter.

Sulfur Dioxide - a colorless gas with a pungent odor, released during the heating and burning of "fossil fuels" such as oil or coal. Sulfur dioxide will often further oxidize to form sulfur trioxide, which, when combined with the moisture in the air forms a sulfuric acid mist. Both sulfur dioxide and trioxide can damage vegetation and affect the health of both humans and animals. Relevant measurements: milligrams per cubic meter or parts per million.

Carbon Monoxide - a colorless, odorless, and very toxic gas. It is one of the products of the incomplete combustion of carbonaceous fuels, such as those used in most internal combustion engines. Relevant measurements: concentration micrograms per meter or parts per million.

Photochemical Oxidants - result from a chemical reaction between nitrogen dioxide and organic compounds in the presence of sunshine. The major impacts of photochemical oxidants are reduction in visibility, damage to vegetation, and irritation to the eyes. The largest segment of photochemical smog is ozone. Other ingredients of this smog include nitrogen dioxide and peroxyacetylnitrate. Relevant measurement: micrograms per cubic meter or parts per million.

Hydrocarbons - result from incomplete combustion and range from methane, a simple organic gas, to complex molecules containing carbon, hydrogen and oxygen in varying proportions. In the atmosphere these pollutants react with other gases (oxides of nitrogen) under the influence of ultra-violet radiation to produce photochemical smog. Relevant measurements: concentration micrograms per cubic meter.

Nitrogen Dioxide - is a gas seen as a brown haze. Most nitrogen dioxide is produced by automobile exhausts. Relevant measurements: concentration micrograms per cubic meter or parts per million.

Calcium Oxide - lime dust. Sources are commercial production plants such as cement plants. Relevant measurements: micrograms per cubic meter or grams per square inch per month.

Fluoride - a compound of fluorine which can occur either in the gaseous form or as a particulate. Sources are steel mills, phosphate, fertilizer plants, aluminum reduction plant, ceramic and brick kilns, metal processing and oil refineries. Fluorides can cause damage to plants and indirectly affect human and animal health when quantities of fluoride-impregnated plants are eaten. Relevant measurements: concentration parts per billion or parts per million.

Lead - well known metal that can be poisonous. It is emitted from industrial sources and is present in automobile exhaust as a particulate. Relevant measurements: concentration micrograms per cubic meter.

Air quality standards are divided into two categories: primary and secondary standards. The primary standards are designed to protect human health, and the less stringent secondary standards are to protect property and aesthetics. Whenever there is a variation between the state or local and the federal air quality standards, the strictest one applies.

The Oregon air quality standards are listed at the end of this chapter.

DATA SOURCES

Climate and Meteorology

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Environmental Data Service
National Climatic Center
Federal Building
Asheville, North Carolina 28801

Salt Lake City Regional Office
National Oceanic & Atmospheric Administration
Federal Building
Salt Lake City, Utah

Oregon State University
Corvallis, Oregon 97331

Oregon University
Eugene, Oregon 97403

Libraries

Departments of Meteorology, Atmospheric Science, Atmospheric Resources and Engineering

Air Quality

Department of Environmental Quality
1234 S. W. Morrison
Portland, Oregon 97205

Mid-Willamette Air Pollution Authority
2585 State Street
Salem, Oregon 97301

AMBIENT AIR QUALITY STANDARDS

31-005 DEFINITIONS. As used in this regulation, unless otherwise required by content:

(1) "Ambient Air" means the air that surrounds the earth excluding the general volume of gases contained within any building or structure.

(2) "Equivalent Method" means any method of sampling and analyzing for an air contaminant deemed by the Department of Environmental Quality to be equivalent in sensitivity, accuracy, reproducibility and selectivity to a method approved by and on file with the Department of Environmental Quality. Such method shall be equivalent to the method or methods approved by the federal Environmental Protection Agency.

(3) "Primary Air Mass Station" means a station designed to measure contamination in an air mass and represent a relatively broad area. The sampling site shall be representative of the general area concerned. The sampler shall be a minimum of 15 feet and a maximum of 150 feet above ground level. Actual elevations should vary to prevent adverse exposure conditions caused by surrounding buildings and terrain. The probe inlet for sampling gaseous contaminants shall be placed approximately twenty feet above the roof top, or not less than two feet from any wall. Suspended particulate filters shall be mounted on the sampler and placed not less than three feet, and particulate fallout jar openings not less than five feet, above the roof top.

(4) "Primary Ground Level Monitoring Station" means a station designed to provide information on contaminant concentrations near the ground. The sampling site shall be representative of the immediate area. The sample shall be taken from a minimum of 10 feet and a maximum of 15 feet above ground level, with a desired optimum height of 12 feet. The probe inlet for sampling gaseous contaminants shall be placed not less than two feet from any building or wall. Suspended particulate filters shall be mounted on the sampler and placed not less than 3 feet, or particle fallout jar openings not less than 5 feet, above the supporting roof top.

(5) "Special Station" means any station other than a Primary Air Mass Station or Primary Ground Level Monitoring Station.

31-010 PURPOSE AND SCOPE OF AMBIENT AIR QUALITY STANDARDS

(1) Ambient air quality standard is an established concentration, exposure time and frequency of occurrence of an air

contaminant or multiple contaminants in the ambient air which shall not be exceeded. The ambient air quality standards set forth in this subdivision are designed to protect both public health and public welfare.

(2) Ambient air quality standards are not generally intended as a means of determining the acceptability or unacceptability of emissions from specific sources of air contamination. More commonly, measured ambient air quality in comparison with ambient air quality standards is used as a criteria for determining the adequacy or effectiveness of emission standards for the aggregate of sources which are deemed to be singularly responsible for ambient air quality standards being exceeded in the particular locality, the violation of said standards shall be due cause for imposing emission standards more stringent than those generally applied to the class of sources involved. Similarly, proposed construction of new sources or expansions of existing sources, which may prevent or interfere with the attainment and maintenance of ambient air quality standards, shall be due cause for issuance of an order prohibiting such proposed construction, pursuant to ORS 499.712 and OAR Chapter 340, Section 20-030.

(3) In adopting the ambient air quality standards in this subdivision, the Environmental Quality Commission recognizes that one or more of the standards are currently being exceeded in certain parts of the State. It is hereby declared to be the policy of the Environmental Quality Commission to achieve, by application of a timely but orderly program of pollution abatement, full compliance with ambient air quality standards throughout the State at the earliest possible date, but in no case later than July 1, 1975.

31-015 SUSPENDED PARTICULATE MATTER
Concentrations of suspended particulate matter at a primary air mass station, as measured by a method approved by and on file with the Department of Environmental Quality, or by an equivalent method, shall not exceed:

(1) 60 micrograms per cubic meter of air, as an annual geometric mean for any calendar year.

(2) 100 micrograms per cubic meter of air, 24 hour concentration for more than 15 percent of the samples collected

in any calendar month.

(3) 150 micrograms per cubic meter of air, 24 hour concentration, more than once per year.

31-020 SULFUR DIOXIDE
Concentrations of sulfur dioxide at a primary air mass station, primary ground level station, or special station, as measured by a method approved by and on file with the Department of Environmental Quality, or by an equivalent method, shall not exceed:

(1) 60 micrograms per cubic meter of air (0.02 ppm), annual arithmetic mean.

(2) 260 micrograms per cubic meter of air (0.10 ppm), maximum 3 hour average, more than once per year.

31-025 CARBON MONOXIDE
Concentrations of carbon monoxide at a primary air mass station or primary ground level station, as measured by a method approved by and on file with the Department of Environmental Quality or by an equivalent method, shall not exceed:

(1) 10 milligrams per cubic meter of air (8.7 ppm), maximum 8 hour average, more than once per year.

(2) 40 milligrams per cubic meter of air (35 ppm), maximum 1 hour average, more than once per year.

31-030 PHOTOCHEMICAL OXIDANTS
Concentrations of photochemical oxidants at a primary air mass station, as measured by a method approved by and on file with the Department of Environmental Quality, or by an equivalent method, shall not exceed 160 micrograms per cubic meter (0.08 ppm), maximum 1 hour average, more than once per year.

31-035 HYDROCARBONS
Concentrations of hydrocarbons at a primary air mass station, as measured and corrected for methane by a method approved by and on file with the Department of Environmental Quality, or by an equivalent method, shall not exceed 160 micrograms

per cubic meter of air (0.24 ppm), maximum 3 hour concentration measured from 0600 to 0900, not to be exceeded more than once per year.

31-040 NITROGEN DIOXIDE
Concentrations of nitrogen dioxide at a primary air mass station, as measured by a method approved and on file with the Department of Environmental Quality, or by an equivalent method, shall not exceed 100 micrograms per cubic meter of air (0.05 ppm), annual arithmetic mean.

31-045 PARTICLE FALLOUT
The particle fallout rate at a primary air mass station, primary ground level station, or special station, as measured by a method approved by and on file with the Department of Environmental Quality or by an equivalent method, shall not exceed:

(1) 10 grams per square meter per month in an industrial area, or

(2) 5.0 grams per square meter per month in an industrial area if visual observations show a presence of wood waste or soot and the volatile fraction of the sample exceeds seventy percent (70%).

(3) 5.0 grams per square meter per month in residential and commercial area, or

(4) 3.5 grams per square meter per month in residential and commercial area if visual observation show the presence of wood waste or soot and the volatile fraction of the sample exceeds seventy percent (70%).

31-050 CALCIUM OXIDE (Lime Dust)

(1) Concentrations of calcium oxide present as suspended particulate at a primary air mass station, as measured by a method approved by and on file with the Department of Environmental Quality, or by an equivalent method, shall not exceed 20 micrograms per cubic meter in residential and commercial areas at any time.

(2) Concentrations of calcium oxide present as particle fallout at a primary air mass station, primary ground level

station, or special station, as measured by a method approved by and on file with the Department of Environmental Quality or by an equivalent method, shall not exceed 0.35 grams per square meter per month in residential and commercial areas. (22, pp. 86–88).

CHAPTER 8

BIOLOGY

The general description of the biological environment is the basis for determining the impacts of an alternative on the biological system. This requires the identification of the biological units as well as the development of a taxonomic description of the important species present. A description of the required habitat of those species is also important.

TERRESTRIAL BIOLOGY

AFFECTED ENVIRONMENTAL COMPONENTS

Before estimating any changes in the environment due to the proposed action, the status of the present biological community should be inventoried. A native community is usually in a near equilibrium condition evolving towards this direction. Whenever the natural flora and fauna are well established, nutrient cycling, food chains, and interdependence are usually in harmony.

Examples of questions that require answers in the identifying of the affected environmental components are:

- What land area will be changed? In what manner will it be altered?

- What are the current populations of the primary species of direct interest to humans?
- Does the affected area have any rare or endangered species native to them?
- Are there important or rare habitats within the area?

All vegetation types within the area should be mapped and described. Population estimates should be made for all animals, birds, and reptiles. These estimates should include total numbers per area, biomass and frequency. A special emphasis should be placed on any species that is rare or endangered. The interrelationships should be described, including any species requirements or dependence upon particular plants, for such things as food, cover, or nesting and breeding areas. The transfer of the food from one feeding level to the next may be important not only to the animals but also to man. Any seasonal variation in the populations should also be described.

The biologic community may be further described by classifying the vegetation. This classification would include such things as soil relationships, cover types, land use patterns, distribution and abundance of plants and animals, and topography. Quantitative information, such as number or weights of individual animal or plants per unit area, the composition and dominating species are all basic descriptions of an environment.

BIOLOGICAL IMPACTS

The estimation of the major impacts of an alternative on the terrestrial environment is generally based upon the comparison of the species population and habitat conditions before and after the action. Examples of questions that should be answered are:

- What will be the primary populations?
- What special habitats will be changed, and what will be the impacts of the changes?
- Can the displaced species be accommodated elsewhere without a loss in population?
- What species are most likely to become predominant?
- Will the action change any present migration patterns?
- Will the vegetation over a large area of land be changed?
- Are there any important commercial or sports species in the area?
- Are there any endangered species of plants or animals?

Some of these questions may be answered by documenting the impacts observed in an area where similar actions have been implemented.

AQUATIC BIOLOGY

AFFECTED ENVIRONMENTAL COMPONENTS

Examples of the types of questions that should be answered in identifying the affected aquatic components of the environment for all water resources related alternatives are:

- What are the bodies of water that will be affected and what changes will take place?
- What is the existing population of the primary aquatic species of direct interest to humans in the affected areas?
- Are there any rare or endangered aquatic species native to the area?
- Are important or rare habitats within the affected water systems?

If there have been no recent major changes in the aquatic environment, the biological community is probably in equilibrium and the existing conditions can be considered to be representative of the future. If, however, there have been recent major changes in that environment, the biological conditions may be in the process of change, and a prediction of the future conditions must be made. The forecast should span the present conditions through until a new equilibrium is reached.

BIOLOGICAL IMPACTS

Past changes in the physical environment of a biological community have frequently resulted in major changes in that community. Once a community has been altered, the biological and non-biological factors assume different dimensions. For better or worse, the plants and animals are placed in a new environment, and there is a dynamic response. The community is in a changing state and not at all in equilibrium. The main objective of the assessment is to estimate what the equilibrium condition will be for the biological community during and after the implementation of the proposed action.

It is well known that Oregon, particularly western Oregon, is an important anadromous fish region. A number of studies have been made of the relationship of the salmon and steelhead resource to water development projects.

Some of the biological questions which should be considered in an assessment are:

- What will be the primary aquatic populations?
- What will be the impact on the aquatic eco-systems, at the site and downstream from the action?
- Will anadromous or catadromous fish be encountered?
- Will siltation problems be encountered?
- Will spawning areas be altered? If so, how much and in what manner?
- Will there be a change in eutrophication?
- Are there any endangered species?

Aquatic populations that might be affected when the aquatic environment is changed include:

For streams,

- Phytoplankton--may be significant in large streams,
- Periphyton--this community, and the allochthonous organic matter, constitute the basic portion of the food-web in most stream ecosystems,
- Invertebrates and bottom fauna--these organisms and small fish are the connecting link between the above two, and the larger fish; both the bottom drifting and the bottom dwelling organisms should be sampled,
- Forage fish--these are the smaller species and the juvenile stages of the larger fish,
- Large fish--these include both the herbivorous and carnivorous species and will probably include the important species as far as significant impact is concerned,
- Bacteria--these organisms are crucial to the breakdown and the recycling of the organic matter.

For impoundments,

- Phytoplankton--this population will be the dominant primary producer in most large lakes,
- Periphyton--this community, except in the relatively shallow lakes, is usually of less importance as a

source of food for herbivorous fishes and invertibrates,

- Macrophytes--this community will be of importance in lakes with a large proportion of shallow water,
- Invertebrates and bottom fauna--important links in the food-web,
- Zooplankton--this community will represent the greatest portion of the secondary production in most lakes and will be of great importance,
- Forage fish--in streams the important link for carnivorous fish,
- Large fish--both the herbivorous and carnivorous species are most likely to be considered the most important species present,
- Bacteria--important decomposers in all parts of the aquatic ecosystems.

DATA COLLECTION GUIDELINES

The first step in the investigation of any ecosystem should be a thorough search through the literature. This can save many hours in the field and laboratory. Once the literature has been reviewed a data collection program can be designed to fill in the missing information.

The data collection methods outlined below are intended to familiarize the layman with the most common techniques, but not to qualify him to do the actual sampling. Any data collection should be supervised by a professional biologist. Without this close supervision, the inexperienced person will make gross errors. The data interpretation will also require professional input for each biological field of study.

TERRESTRIAL BIOLOGY

The actual field sampling or data collection should be done in the area to be affected by the project actions. Studies done, however, in similar areas can provide useful information for assessing the impacts in the project area.

The following parameters represent those that should be included in the field measurements or the measurements done in similar areas. Not all of the parameters are likely to be important in a single area.

Plants	Animals
Species composition	Species composition
Biomass	Biomass
Grazing impact	Density
Nutrients	Fecundity
Spatial distribution	Natality
Physiological status	Population density in relation to available breeding sites
Geographic distribution	Geographic distribution
Plant cover (%)	Food and cover availability
Frequency (%)	Animal diets, composition and nutritional requirements
Disease	Home range size

Migrational tendencies
Social interactions
Expected life span
Interaction with other plants and animals
Disease

The natural environment is the result of the controlling factors of climate, geological materials, and available plants and animals interacting through time. An environmental change due to the activities of man is considered as induced succession and may result in a regression of the plants and animals currently present within the natural environment. Some of the basic characteristics resulting from natural succession and induced succession are outlined in Table 17 (4, p. 196).

Aerial Photography

Aerial photography is one of the most direct methods of mapping vegetation. Aerial reconnaissance mapping is a convenient way of classifying vegetation-soil relationships, cover types and distribution, land use patterns, and topography. These aerial photographs will also provide a valuable permanent record of the assessed area (11). Cover maps derived from aerial photographs are helpful for the assessment of the general vegetation types. Cover types can be divided into three groups: (1) overstory, (2) understory, and (3) ground cover. Aerial photographs of an area may be taken at different seasons of the year to help identify

TABLE 17

CHARACTERISTICS OF NATURAL AND INDUCED SUCCESSION

Natural Habitats (relatively unmodified by man)

1. Species diversity of plants and animals
2. Assortment of food, cover and space
3. No crops
4. Few pest species of plants or animals
5. Rare and endangered species
6. Winter and/or range for big game animals
7. Livestock grazing

Wildlife Refuges (moderately modified by man)

1. Increase of selected waterfowl and aquatic mammals
2. Special crops for wildlife food and cover
3. Increase of aquatic plants
4. Decrease of plants and animals that require a specific habitat before new management practices are established
5. Potential increase in riparian habitat by reservoir construction
6. Parks may be managed for the native species such as the Elk range in Jackson Hole, Wyoming

Agricultural Use (greatly modified by man)

1. Native hay meadows: native grasses and sedges. Small mammals, furbearers, ground nesting birds, deer and elk, ruffed grouse.
2. Dry land farming: cereal grains. Small mammals, ground nesting birds, house mouse, starlings, forage water fowl in season, mourning doves.
3. Irrigator farming: row crops, cereals grains, orchards, vine-yards, and hopyards. Small mammals, pheasants, quail, morning doves, waterfowl forage in season, deer, tree nesting birds, house mouse, and starlings.
4. Extermination of native plants and some mammals.
5. Increase in pest species, weeds and animals.

Urban Use (extreme modification by man)

1. Residential and Industrial development.
2. Reduced space for native plants and animals.
3. Increase of pest species and such as house sparrows, starlings.
4. Low biological productivity.

TABLE 17

CHARACTERISTICS OF NATURAL AND INDUCED SUCCESSION

Natural Habitats (relatively unmodified by man)

1. Species diversity of plants and animals
2. Assortment of food, cover and space
3. No crops
4. Few pest species of plants or animals
5. Rare and endangered species
6. Winter and/or range for big game animals
7. Livestock grazing

Wildlife Refuges (moderately modified by man)

1. Increase of selected waterfowl and aquatic mammals
2. Special crops for wildlife food and cover
3. Increase of aquatic plants
4. Decrease of plants and animals that require a specific habitat before new management practices are established
5. Potential increase in riparian habitat by reservoir construction
6. Parks may be managed for the native species such as the Elk range in Jackson Hole, Wyoming

Agricultural Use (greatly modified by man)

1. Native hay meadows: native grasses and sedges. Small mammals, furbearers, ground nesting bi rds, deer and elk, ruffed grouse.
2. Dry land farming: cereal grains. Small mammals, ground nesting birds, house mouse, starlings, forage water fowl in season, mourning doves.
3. Irrigator farming: row crops, cereals grains, orchards, vine-yards, and hopyards. Small mammals, pheasants, quail, morning doves, waterfowl forage in season, deer, tree nesting birds, house mouse, and starlings.
4. Extermination of native plants and some mammals.
5. Increase in pest species, weeds and animals.

Urban Use (extreme modification by man)

1. Residential and Industrial development.
2. Reduced space for native plants and animals.
3. Increase of pest species and such as house sparrows, starlings.
4. Low biological productivity.

different vegetative types. Mosaics made from the aerial photographs serve as excellent bases for classifying and mapping the different categories of plants and animals.

Vegetation Analysis

After the aerial reconnaissance has been analyzed, the key areas should be field surveyed. The vegetation analyses of the critical areas on the ground would include the gathering of data on one or more of the following characteristics (12, 13).

Basal area refers to the area of ground surface covered by the root crown of the plant or the surface area that is penetrated by the stems.

Cover is defined as the vertical projection of the above ground parts of the plant onto the ground.

Density is the number of individual plants per unit area.

Dominance indicates the impact of the environmental factors on the position occupied by a species in a stand.

Frequency is the percentage of sample plots in which the species occurs.

Height measurements are taken from the ground level to the apex of the plant.

Weight is used to express the amounts of herbage and is one of the best single measurements of growth.

Species composition is the aggregate of the different species within an area.

Importance is the value of a given plant for a given purpose and may be determined from frequency, density and occurrence.

There are a great many sampling methods of vegetation within a given area. These methods are discussed in detail in the literature (12, 13, 14).

Sample units are square or circular, either simple or are divided into subplots. The sampling units may vary in size, shape, number and arrangement, depending upon the nature of the vegetation and the objectives of the study. The following units are used as sampling methods:

- List unit--Lists of organisms or species by name and allows an assignment of frequency index.
- Count unit--Number and name of each species found are recorded.
- Cover unit--The actual or relative coverage is recorded as a percentage of the area of the ground surface that is covered.

These sampling methods may be used individually or collectively, depending on the type of study.

Transects

A transect is a cross section of a sampling unit used for studying vegetation. The width and length depend upon the study and the experimental design. A transect is the basis of a method for determining changes from one association to another. It is also used for studying zonations which occur along the banks of rivers or ponds and on mountain slopes. Density, frequency and distribution may be calculated from these transects.

A Belt Transect is a transect of uniform width and considerable length. The vegetation in this area is measured for some feature, depending upon the problem being studied.

The Line Intercept Method involves taking measurements along lines which are laid out either randomly or systematically. This method yields the following data:

- Frequency of an individual species.
- Percentage of occurrence for each species.
- Spacing of each species linearly along the belt.
- The total distance of interintercept by all species per line.

The type or types of transects used in a study will depend upon the information required.

If a more detailed analysis were required it would include a periodic sampling scheme for the vegetation and an analysis showing the interrelationships of all parameters measured.

Wildlife Food and Cover

The vegetation which develops in any given location indicates climatic, soil, moisture condition, wildlife use, past disturbances and agricultural potentials. Plants which dominate the habitat can serve as an indicator species within the habitat (15).

Indicator plants for wildlife uses are those that provide food and cover. Examples of such plants are:

Service berry	Cattail
Poplar	Ceanothus snowbush
Willow	Sedge
Birch	Pine
Bullrush	Western snowberry
Red alder	Bitterbrush
Oregon ash	Mountain mahogany
Douglas fir	Sagebrush
Black cottonwood	Oregon grape

Animal Populations

There are many methods for estimating population numbers (14). Some of the common procedures for estimating mammal populations are listed below.

Roadside Counts. The number of individuals of a particular species counted are related to the number of miles traveled.

Tract Counts. Track counts for a particular species in an area give indices of population densities. The relationships among animal number, spatial distribution, and the abundance of tracts must be known to utilize this technique.

Age, Sex and Kill Ratios. These ratios can provide an estimate of population trends in an area.

Pellet Counts. Fecal droppings or pellets are counted for a number of species, including deer, rabbit, and other mammals within an area. Pellet counts are used extensively to estimate deer population on rangelands.

Peterson or Lincoln Index. This is a ratio estimator which involves mark and recapture methods.

Some of the common methods for estimating bird populations are listed below (16).

Nest Counts. These are roughly equivalent to the number of resident pairs.

Roadside Counts. Number of individuals of a particular species being counted are related to the number of miles traveled.

Flushing. All birds are tallied as they are encountered and their distances from the observer are recorded. The width of the census strip is defined as twice the mean distance from the observer.

Strip Censusing. A complete count of all birds within a narrow strip is attempted.

Age, Sex and Kill Ratios. These ratios can provide an estimate of population trends in an area.

Auditory Index. This method involves the counts of singing males and indicates the numbers of resident birds.

Mark and Retally Fraction. This method involves capturing, marking and releasing species of birds in an area, then comparing these to the unmarked population in subsequent sampling.

Some of the above yield quite reliable data at low cost. However, if greater detail on species information is required, other methods are required.

Indicator Species of Wildlife

Species of wildlife which are important indicators of changes that occur within a habitat are listed below (17).

Golden Eagle Bald Eagle Osprey	When present, these species indicate a high quality environment with a low chemical contamination.
Starling Domestic Pigeon Norway Rat	These species feed from the refuse of man's activities, so are most often found only in areas of high population density.
Mallard Canada Goose	The presence of these species indicate good wildlife management practices, such as provisions for food, resting areas and nesting sites.
Beaver	Beaver require a highly natural ecological system for survival. They are quite sensitive to human activities that would affect tree and shrub supply or the change in water levels.

Other species of animals may be equally or more important within a local area and may serve as excellent indicators of changes within a habitat.

The endangered species of the area may be found in the publication, "Threatened Wildlife of the United States" (17). These species should have high priority in any assessment.

AQUATIC BIOLOGY

There are a great number of methods for collection of aquatic data. The key element in the formulation of an aquatic sampling program is the choosing of an accepted method which can be applied either directly or can be modified to fit a particular site. The basic trophic levels of primary producers, herbivores, carnivores, detritivores, and decomposers are essentially present in all aquatic ecosystems. The selection of an appropriate method for sampling these organisms will depend on: (1) the physical characteristics of the particular site, (2) the uniqueness of the site, (3) the accessibility of the site, and (4) the amount of data needed for the environmental assessment.

The developing of a sampling method that is consistent and has a valid statistical design is essential to the credibility of the data. There is no one method that can be recommended for collecting and estimating the population of any one component of an aquatic habitat. The following discussion will cover some of the basic techniques and outline some literature sources to consult for the designing of either a qualitative or quantitative sampling program. To aid in maintaining consistency in the collection data a listing of units is given for each type of life.

Primary Producers

Phytoplankton--Some of the most widely accepted methods for collecting and evaluating phytoplankton are summarized in Table 18 (4, p. 176). The quantitative methods described essentially require that a unit volume of water is collected and processed so that no organisms are lost through the nets.

The results can be expressed in the following units:

--Number of organisms/liter. Probably best all around, but very time consuming.

--Weight (mg)/liter. Faster, best expressed as dry or ash free weight of the organic matter.

--Cubic microns/liter. Factors in volume of individual species with numbers; good, but requires a lot of time and effort.'

--Carbon content (mg)/liter. Mainly used for productivity and bioenergetic studies.

Periphyton--Qualitative sample of periphyton can be collected by scraping the communities from various substrates present in the water. These can be preserved for later examination and species identification in the laboratory.

Quantitative sampling of the periphyton community involves collection and analysis of organisms from a known area. In situ methods have been developed utilizing artificial substrates, but true quantitative sampling from natural substrates is difficult. The most popular method for estimating the size of the periphyton community

TABLE 18

METHODS FOR COLLECTING AND EVALUATING PHYTOPLANKTON

Name of Method	Apparatus Required	Critical Appraisal
Capture with a net	Plankton net	Exclusively useful for qualitative work on the meso and micro-plankton; nonnoplankton and ultraplankton are not captured.
Quantitative Methods		
Chambers	Flat chambers of precise volumes (0-5, 1, 2 ml)	Only advisable for nannoplankton and ultraplankton with higher plankton densities.
Sedimentation methods	No special apparatus needed	Degree of the plankton density can be adjusted to the conditions at the time; rather cumbersome to operate.
Tubular chamber method	Inverted microscope; special tubular chambers	Advantages of the chambers and sedimentation methods are combines; the best limnological method.
Centrifuge method	Electric centrifuge (a hand centrifuge is not suitable)	Possible to investigate the whole plankton in a living state.
Membrane filtration	Membrane filtration apparatus	The whole plankton is captured but delicate organisms are deformed; convenient to operate by hand.

TABLE 18 (Continued)

Name of Method	Apparatus Required	Critical Appraisal
Chlorophyll estimation	Membrane filtration apparatus and photometer	Saves considerable time; only the total plankton is captured; no individual values; suitable only for problems of production biology.
Estimation of the photosynthesis with C_{14}	Geiger-Muller counter	Suitable only for determining the primary production. Regarded as troublesome by some investigators.

employs artificial substrates of a known size. Various types and sizes of substrates are used for the colonization but the most common are glass slides. A good coverage of this topic can be found in "Limnological Investigation Methods for the Periphyton ("Aufwuchs") Community," by Sladeckova (18).

The recommended units for expressing results are the same as for phytoplankton except that an areal rather than a volumetric basis should be used, for example the number of organisms/cm^2.

Macrophytes--Macrophytes can be qualitatively sampled by any means by which the plants needed are gathered. Quantitative sampling usually involves harvesting the plants from a given area. The analysis are similar to those for periphyton in that the samples can be counted, biomass determinations made, or chlorophyll extracts measured . Some of the equipment used in sampling is summarized in Table 19 (19).

The following units are recommended for listing results:

--Weight (g)/m^2 - Wet, dry, and ash free or organic matter weights are generally used after excess moisture is removed.

--Other expressions under phytoplankton are also useful, but the relatively larger size of samples must be given consideration.

TABLE 19

MACROPHYTE SAMPLING EQUIPMENT

EQUIPMENT	APPLICATION
Diver operated scoop	important root systems
Ekman dredge	mud and small root systems
Peterson dredge	hard bottom and poor sampling conditions
Modified Peterson dredge	hard bottom and better sampling conditions
Cylindrical sampler	soft bottom with tall plants with small root systems
Pronged grab	large vegetation and roots and only from soft bottom

Primary Productivity

There are a number of ways to measure the primary productivity, the most common of which is the ^{14}C technique. In this method a known amount of $NaHC^{14}O_3$ is added to a sample containing the community in question. The amount of uptake of ^{14}C is then measured, from which the rate of uptake is computed. The reference, "A Manual of Methods for Measuring Primary Production in Aquatic Environments," by Vollenweider (19) gives details on this and other methods of measuring primary productivity.

Invertebrates

Zooplankton. In nearly all quantitative sampling of zooplankton, the organisms are filtrated through nets at some stage of the processing. The reference, "A Manual on Methods for the Assessment of Secondary Productivity in Fresh Water" (20, p. 14), covers this topic. Quoted from this reference is the following summary of recommended samplers and the bodies of water in which they can be used.

> (1) For large, deep waters, the Clarke-Bumpus sampler is the best for most purposes.
>
> Ordinarily, it will be used as described to minimize variation, but by taking short halls in thin depth ranges, it can be used to some extent to study small scale variations.
>
> When collection of protozoa and other small organisms is required, water sampling and gravitational concentration of samples of general litre size is recommended.
>
> When this sampler is not available, comparable results may be obtained by vertical hauls with a net provided with anterior cone.
>
> (2) For shallow ponds or small lakes, water samplers may be the most practicable. The tube method can be used whenever it is appropriate.
>
> (3) Whenever the emphasis is on the relation between the condition of animal populations and their food supply or other environmental conditions, point samples or linear samples over short distances are required unless it is known that distribution is homogeneous on a scale commensurate with the sampling. In particular, horizontal variations in zooplankton abundance may be related to irregularity in phytoplankton distribution, and the relation between the two will not be discoverable in samples taken over long distances.
>
> (4) The pump method can be used for any water accessible to it. It is recommended that each investigator assure himself that he is not obtaining samples biased by the size

selection by comparing day and night samples and observing the behavior of animals at the inlet of the hose.

The analyses of the samples are usually done in the laboratory. The results may be expressed as follows:

--Number of organisms/liter. Probably the best, but very time consuming.

--Weight (mg)/liter. Faster, and is the same units as for phytoplankton.

--Cubic microns/liter. Same as for phytoplankton.

Benthic Organisms. The apparatus used in sampling benthic organisms is generally of the type that can retrieve the sample of the substrate in which the organisms are located.

The methods for sampling various standing water habitats are discussed in detail in the reference, "A Manual on Methods for the Assessment of Secondary Productivity in Fresh Water" (20). A summary of the more common methods is given below.

Shallow Habitats

- Soft bottom. Core samplers, Ekman dredges. Jaw type dredges must be fully closed to prevent loss of the sample.
- Hard bottom. Ekman dredge on a pole, Kaczmarek sampler, O'Conner sampler. The simple grab samplers will not penetrate. For stoney bottoms,

trays with small stones can be put out or a suitable area enclosed within a box or cylinder. Large rocks are usually retrieved and organisms scraped or hand picked.

Deep Habitats

- Soft bottom. Core samplers, jaw type dredges.
- Very soft bottom. Drzycimski, Elgmork, or Jenkin samplers. Much care must be exercised so that light sediments are not washed away.
- Hard bottom. Core samplers and suitable jaw types with additional weight for penetration. Use of SCUBA to hand manipulate samplers is useful. Artificial substrates are often used.

Special care must be taken when sampling the benthos in flowing water. The current many times can be a hinderance to the manipulation of equipment. Details for various types of sampling are given in the reference, "A Manual on Methods for the Assessment of Secondary Productivity in Fresh Water" (20, p. 73). The following methods are recommended in this reference.

(1) For sand and silt the Ekman grab operated by hand in shallow water and with a pole or by scuba diving in deep water.

(2) For stony substrate, a cylindrical box sampler. Possibly this instrument could be improved by adding to it a replaceable skirt of

foam plastic or rubber on the outside about 4 cm above the teeth which should help to improve the seal. It must be replaced as soon as it wears enough to interfere with use.

(3) For rooted plants, the bag sampler.

(4) For moss and other plants attached to rock either an area scraped into a net or random hand-collection of a definite volume. All meshes used should have at least 30 threads/cm.

The results from these samples may be expressed in the same units as zooplankton except an areal basis should be used instead of a volumetric one.

Secondary Production

The subject of secondary production and its sampling is too large a subject to adequately discuss here. For details and techniques for the estimating of the rate of secondary production, the cited references (20, 21) are good sources.

Fish

Qualitative and quantitative sampling for fish involves a wide variety of equipment. Qualitative sampling can use various types of nets, seines, electrofishing equipment, toxicants, SCUBA, and explosives. Quantitative sampling is extremely difficult and depends upon the habitats of the different species and how these are affected by a host of chemical, physical, and biological parameters. Essentially the same equipment is used for quantitative sampling as for qualitative sampling.

Selection of suitable equipment for the collection of fish is best approached by the consideration of the habitat (4, p. 182).

- Shallow (less than 4 feet) water--hand seines, electrofishing equipment, toxicants.
- Deep (over 4 feet) standing water--gill nets, trammel nets, trap nets, SCUBA, explosives, trawl nets, purse seines.
- Shallow (less than 2 feet) running water--hand seines, electrofishing equipment, toxicants, wiers and traps.
- Deep (over 2 feet) running water--explosives, anchored trap nets, SCUBA, trawl nets.

Creel census are also useful in assessing fish populations.

The following units are recommended for fish:

Lakes and Reservoirs

- Number or weight/net set. Less meaningful but a faster index to obtain.
- Number of weight/siene haul. Fast, but only applicable where it can be used.
- Number/hectare. Gives meaningful numbers but requires extensive sampling and statistical treatments to be valid.
- Weight/hectare. Same as above.

Streams

- Number of fish/unit length. Good if entire stream can be blocked off and adequate sample can be taken.
- Weight/unit length. Same as above.
- Weight or number/net set. Gives an index which is applicable in streams where gill or trap nets can be used.
- Weight or number/seine haul. Applicable where it can be done.

In general, streams are more difficult to quantify because of the widely varying sizes and differences in the various sections of the streams.

Two groups of references are given below from which one can evaluate general collection methods and from which some insight can be derived into the various problems associated with fish population model and estimates.

General Techniques:

Langler, Karl F. 1952. Freshwater Fishery Biology. Wm. C. Brown Co., Iowa, 360 pp.

Calhoun, Alex (ed.). 1966. Inland Fisheries Management. The Resources Agency, Dept. of Fish and Game, California, 546 pp.

Population Models and Estimates:

Ricker, W. E. (ed.). 1968. Methods for Assessment of Fish Production in Freshwaters, IBP Handbook No. 3, Blackwell Scientific Publications, Oxford, 313 pp.

Beverton, R. J. H. and S. H. Holt. 1957. On the Dynamics of Exploited Fish Populations. Her Majesty's Stationery Office, London.

Chapman, D. G. and W. S. Overton. 1966. Estimating and Testing Differences Between Population Levels by the Schnabel Estimation Method. J. Wildl Mgt. 30:173-180.

Eberhardt, L. L. 1969. Population Analysis. In-Wildlife Management Techniques, R. H. Giles (ed.), the Wildlife Society, Washington, D.C., pp. 403-456.

Paulik, G. J. and D. S. Robson. 1969. Statistical Calculations for Change-in-Ratio Estimators of Population Parameters. J. Wildlife Mgt. 33:1-27.

Regier, H. A. and D. S. Robson. 1967. Estimating Population Number and Mortality Rates. In-The Biological Basis of Freshwater Fish Production, So. O. Gerking (ed.) Blackwell, Oxford, pp. 31-66.

Ricker, W. E. 1958. Handbook of Computations for Biological Statistics of Fish Populations. Bull. No. 19, Fisheries Research Board of Canada, Queen's Printer, Ottawa.

Robson, D. S. and H. A. Regier. 1964. Sample Size in Peterson Mark Recapture Experiments. Trans. Amer. Fish. Soc. 93:215-226.

Paulik, G. J. and J. W. Greenough, Jr. 1966. Management Analysis for a Salmon Resource. Chapter 9, pp. 215-252, In-Systems Analysis in Ecology, Vol. 1, B. Patten (ed.), Academic Press, N. Y.

Carlander, K. D. 1958. Some Simple Mathematical Models as Aids in Interpreting the Effect of Fishing. Iowa St. J. Sci. 32:395-418.

Larkin, P. A. and A. S. Hourston. 1964. A Model for Simulation of the Population Biology of Pacific Salmon. J. Fish. Res. Bd. Canada 21: 1245-1265.

DATA SOURCES

A thorough review of the literature is an essential beginning of any data collection project. The literature survey may provide either a basis for rejecting or selecting variables for study. Many man-hours and expense in the field and laboratory can be saved by a conscientious literature search.

Listed below are the journals, in Table 20, books, in Table 21, agencies, and universities which are likely to have biological information for Oregon.

State and Federal Agencies

Pacific Northwest Forest and Range Experiment Stations
809 NE 6th Avenue
P. O. Box 3141
Portland, Oregon 97208

Regional Office
Bureau of Sports Fisheries and Wildlife
1500 NE Irving Street
Portland, Oregon 97208

Bureau of Land Management
729 NE Oregon Street
Portland, Oregon 97208

National Wildlife Refuges
Regional Director
730 NE Pacific Street
Portland, Oregon 97208

Oregon Wildlife Commission
Office of the Director
P. O. Box 3503
1634 SW Alder Street
Portland, Oregon 97205

Fish and Wildlife Service
Region 1
Box 3737
Portland, Oregon 97208

National Marine Fisheries Service
Northwest Region
1700 Westlake Avenue, North
Seattle, Washington

Bureau of Reclamation
550 W. Fort Street
P. O. Box 043
Boise, Idaho 83702

Bureau of Land Management
P. O. Box 3861
Portland, Oregon 97208

Universities

Eastern Oregon College
LaGrande, Oregon

George Fox College
Newberg, Oregon

Lewis and Clark College
Portland, Oregon

Linfield College
McMinnville, Oregon

Oregon State University
Corvallis, Oregon

Oregon Technical Institute
Klamath Falls, Oregon

Portland State University
Portland, Oregon

Oregon College of Education
Monmouth, Oregon

Southern Oregon College
Ashland, Oregon

University of Oregon
Eugene, Oregon

National Wildlife Refuges

National Wildlife Refuges may provide sources of information on waterfowl, migration, habitat requirements, nesting, etc., in addition to information on other animals and plants. Information obtained from these refuges may save hours in the field.

McKay Creek	Pendleton, Oregon
Cold Springs	Hermistion, Oregon
Malheur	Burns, Oregon
Klamath Forest	Klamath Falls, Oregon
Upper Klamath	Klamath Falls, Oregon
Lower Klamath	Klamath Falls, Oregon
Hart Mountain	Plush, Oregon
Wilham L. Finley	Corvallis, Oregon
Ankey	Jefferson, Oregon
Bashetslew	Dallas, Oregon

TABLE 20

DATA SOURCES: JOURNALS

American J. of Botany

American Midland Naturalist

American Naturalist

Animal Behavior

Animal Kingdom

Ann. Review of Botany

Audubon Field Notes

Audubon Magazine

Auk

Australian Journal of Botany

Austrailian Journal of Agric.

Avian Diseases

Bird-Banking

Botanical Review

Botanical Gazette

British Birds

CSIRO Wildlife Research

California Dept. of Fish and Game Bulletin

California Fish and Game

Canadian Audubon

Canadian Field Naturalist

Cadanian Journal of Botany

Canadian Wildlife Service Occas. Papers

Condor

Conservationist (New York)

Danish Review of Game Biology

East African Wildlife Journal

Ecological Monographs

Ecology

IUCN Bulletin

Ibis

Idaho Wildlife Review

Illinois Natural History Survey Biological Notes, Bull., Circulars

International Assoc. of Game, Fish & Conserv. Comm. Proc.

Journal of American Ecology

Journal of Mammalogy

Journal of Range Management

Journal of the Bombay Natural History Society

TABLE 20 (Continued)

Journal of the East African Nat. Hist. Soc. and Coryndon Museum

Journal of Wildlife Management

Koedoe

Meddelelser Fra Statens Viltundersokelser (Paper of Norwegian State Game Research Institute)

Michigan Conservation

Missouri Conservationist

Murrelet

Natural History

Nevada Wildlife

New York Fish & Game Journ.

New Zealand Ecological Soc.

North American Wildlife & Nat. Res. Conf. Trans.

Northeast Section of Wildlife Society (W.S.) Proc.

Northwest Science

Oryx

Pennsylvania Game News

Plant and Soil

Puku

Riistatieteelisia Julkaisuja (Finnish Game Research)

Southeast Assoc. of Game & Fish

Southwestern Naturalist

Suoment Riista

Terre et la vie

Texas Parks and Wildlife

U.S. Fish & Wildlife Service Circular

U.S. Fish & Wildlife Service Special Sci. Report—Wildlife

U.S. Natural Museum Bulletin

U. S. Nat. Museum Proceedings

University of Kansas Museum Nat. History Misc. Publications

Utah Academy of Science

Viltrevy

Virginia Wildlife

Wildlife Disease Association Bul.

Wildlife Diseases

Wildlife in North Carolina

Wildlife Monographs

Wilson Bulletin

Zeit. fur Jagdwissenschaft

Zeit. fur Saugetierkunde

Theses at Universities

TABLE 21

DATA SOURCES: REFERENCE LITERATURE

<u>Birds</u>

O. S. Pettingill, Jr. 1955. A Laboratory and Field Manual of Ornithology (2nd ed.). Burgess Publishing Co. 381 pp.

J. Van Tyne, and A. J. Burger. 1966. Fundamentals of Ornithology, John Wiley and Sons, Inc., N. Y. 624 pp.

C. W. Robbins, B. Bruun, and H. S. Zim. A Guide to Field Identification Birds of North America. Golden Press, N. Y. 340 pp.

<u>Mammals</u>

E. R. Hall, and K. R. Kelson. 1959. The Mammals of North America. Ronald Press, N. Y. Vol. I-II.

W. W. Dalquest. 1948. Mammals of Washington. Univ. of Kansas Pub. Museum of Natural History. 444 pp.

W. H. Burt and R. P. Grossenheider. 1964. A Field Guide to the Mammals. 2nd ed. Houghton Mifflin Co., Boston. 284 pp.

<u>Plants</u>

C. L. Hitchcock, A. Cronquist, M. Ownbey, and J. W. Thompson. 1971. Vascular Plants of the Pacific Northwest. 3rd printing. Univ. of Washington Press. Vol. 5.

C. L. Hitchcock, and A. Cronquist. 1973. Flora of the Pacific Northwest. Univ. of Washington Press, Seattle and London. 730 pp.

C. Milner, and R. E. Hughes. 1968. Methods for the Measurement of the Primary Production of Grassland. Burgess and Son (Abingdon) Ltd. Abingdon, Berkshire. IBP Handbook 6. 70 pp.

TABLE 21 (Continued)

General

M.J. Morris. 1967. An Abstract Bibliography of Statistical Methods In Grassland Research. U. S. Department of Agriculture. Forest Service. Misc. Pub. 1030. 222 pp.

J. S. Horton. 1972. An Abstract Bibliography of Evapotranspiration and Water Research Related to Riparian and Phreatophyte Management. U.S. Department of Agriculture. Forest Service. Misc. Pub. 1234. 192 pp.

Primary Producers (phytoplankton, periphyton, macrophytes)

Sharma, Rajendra K. (comp.), 1973, Fish Protection at Water Diversions and Intakes: A Bibliography of Published and Unpublished References, ANL/ESP-1, 33 pp.

Water Resources Scientific Information Center, 1973, A Selected Annotated Bibliography on Columbia and Snake Rivers, Wash. Dept. of Ecology WRIS Info. Bull. No. 6, 357 pp.

Invertebrates

Same as Primary Producers above

Fish, Resident and Migratory

Fish Commission of Oregon Research Reports

Federal Publications (Government Printing Office, in general)

Fish Passage Reports
Corps of Engineers
North Pacific Division
Portland and Walla Walla District

Fishery Bulletins
Dept. of Commerce
National Marine Fisheries Service
Seattle, WA

TABLE 21 (Continued)

Special Scientific Reports--Fisheries
Department of Commerce
National Marine Fisheries Service
Seattle, Washington

Sport Fishery Abstracts
U. S. Department of Interior
Fish & Wildlife Service
Bureau of Sport Fisheries and Wildlife
Narragansett, Rhode Island

Co-operative Fishery Unit Annual Reports
U. S. Department of Interior
Fish & Wildlife Service
Washington, D. C.
(Units are located at the Oregon State University)

Bell, Milo C. 1973. Fisheries Handbook of Engineering Requirements and Biological Criteria. Corps of Engineers, Contract Number DACW57-68-C-0086.

<u>Endangered or Rare Species</u>

Honegger, Rene E. (comp.) Red Data Book, Vol. 3, Amphibia & Reptilia. International Union for Conservation of Nature and Natural Resources, Switzerland, 1968.

Miller, Robert R. (comp.) Red Data Book, Vol. 4, Pisces. International Union for Conservation of Nature and Natural Resources Switzerland, 1968.

Bureau of Sport Fish and Wildlife. Rare and Endangered Fish and Wildlife of the United States. Resource Publication No. 34, Revised edition, 1968.

<u>Taxonomic References</u>

Bond, Carl E. 1961. Keys to Oregon freshwater fishes. OSU Ag. Exp. Sta. Tech. Bull. 58, 42 pp.

Edmondson, R. T. (ed.). Fresh-water Biology (Second Ed.), John Wiley & Sons, Inc., N. Y., 1249 pp., 1959.

TABLE 21 (Continued)

Muenscher, W. C., Aquatic Plants of the United States, Comstock Publ. Co., Inc., Cornell University, 374 pp., 1944.

Patrick, R. and C. W. Reimers, The Diatoms of the United States, Exclusive of Alaska and Hawaii, Phila. Acad. Nat. Sci. Monog. No. 13, 688 pp.

Pennak, Robert W., Fresh-water Invertebrates of the United States, The Ronald Press Col., N. Y. 769 pp., 1953.

Prescott, G. W., Algae of the Western Great Lakes Area, Cranbook Institute of Science Bull. No. 31, Revised Ed., Wm. C. Brown Publ., Iowa, 977 pp., 1966.

Reece, Maynard. 1963. Fish and Fishing. Meredith Press. 224 pp.

Schultz, Leonard P. Keys to the Fishes of Washington, Oregon and Closely Adjoining Regions. U. of Washington Publ. in Biol. Vol. 2, pp. 103-228, 1936.

Steward, A. N., L. J. Dennis, and H. M. Gilkey, Aquatic Plants of the Pacific Northwest, Oregon State U. Press, 2nd Ed., 261 pp., 1963.

Warren, Charles E., 1971. Biology and Water Pollution Control. W. B. Saunders Co. 434 pp.

CHAPTER 9

RECREATION

Many times management actions affect the recreation use of an area through the change in water and land bodies. Because of these changes some types of recreation are no longer possible and other types become possible. In particular, the improvement of access or the including of recreation facilities in an action can substantially increase the recreation use of an area.

ASSESSMENT METHODS

PRELIMINARY ASSESSMENT

An assessment should begin with an inventory of the recreation resources and facilities that are existing within the area influenced by the proposed action. A general inventory can be made by reviewing United States Geological Survey maps; by reviewing special studies such as the Western U.S. Water Plan (Westwide) Study being compiled by the U.S. Bureau of Reclamation in co-ordination with the Pacific Northwest River Basins Commission which inventories many areas of outstanding natural beauty and scenic quality as well as areas of major historical, cultural, geological and archeological significance; by reviewing Oregon

Areas of Environmental Concern; by reviewing the National Register of Historic Places and the National Registry of Natural Landmarks; and, by contacting the owner or manager of the included lands.

The inventory should encompass:

--Beaches

--City and County Parks

--Estuaries

--Hiking Trails

--Historic Sites

--Lakes and Rivers

--National Forests

--National Parks

--National Wilderness Areas

--Public and Private Recreational Facilities

Campgrounds

Boat launching and rental areas

Picnic grounds

Swimming areas

--State Parks

--Streams

--Unique Geological Features

--Unique Vegetation Species

--View Points

--Water Falls

--Wetlands

--Wild, Scenic and Recreational Rivers.

DETAILED ASSESSMENT

A detailed assessment of the impact that an alternative might have on the recreational use of an area requires estimates of the recreation use that would be made of that area under the following two conditions (4, p. 252).

1. That the proposed action will be implemented, that the action will continue for a definite period of time, that the expected recreational use of the area is based on recreation facilities and resources, access to the area, competition from other nearby recreation areas, and the propensity of the area's residents to engage in the outdoor recreation that will exist after the adoption of the alternative.

2. That the action will not be implemented, that recreational use of the same area during the same time period used in 1 above be related to the area's recreational facilities and resources, access to the area, competition from other nearby recreational areas, and the propensity of the area's residents to engage in outdoor recreation that will exist if the alternative is not enacted.

The estimates of recreational use of an area with or without the proposed alternative must be consistent. They must both cover the same time period and the same geographical area. Each estimate must recognize the influence that access and competing areas have on the recreational use of the action area. Estimates of area population, with and without the action should be used to estimate the recreational use. In either case, the estimates of future recreational use should not exceed the capacity of the area for such use.

A detailed assessment requires an evaluation of the resources that will support the recreational use. This may mean field investigation to develop the information needed. Supplemental information can be gathered through a review of the literature and the contact of recreation specialists.

Recreation Use Estimate

The types of alternatives and the areas over which the recreational resources may be impacted vary from a minor action that will affect only the recreation use of a few acres to major projects like a large reservoir which may inundate a great many acres. One of the procedures used for estimating recreational use of an area after an action takes place is described as the "most similar" concept. Existing actions that are comparable in size, operation, and anticipated recreation use are selected as a basis for the estimating technique. Information is developed to correlate the recreation use information from the existing actions to the proposed action under study. This technique has been successfully tested by the U.S. Army Engineers in the evaluation of reservoir recreation. The technique is described in Technical Report No. 2, Estimating Initial Reservoir Recreation Use, issued October 1969 by the Office, Chief of Engineers, Department of the Army. Briefly stated, this method is composed of the following eleven steps:

1. Evaluate the proposed action characteristics.
2. Select a similar action by comparing characteristics.
3. Evaluate the day use market area of the similar action.
4. Determine the day use market area of the proposed action.
5. Select a per capita use curve for the similar action.
6. Modify the per capita use curve to reflect the dissimilarities between the similar and proposed actions.
7. Determine the county populations within the day use area for the anticipated year that operation will begin and derive per capita use rates for each county population by measuring road mile distance from the action to the center of the most populated city within the county.
8. Calculate annual day use from each county (per capita rate x county population).
9. Sum the contribution from each county to find initial

annual day use for the action.

10. Determine the percent of the total day use that the foregoing estimate represents: if 100 percent, it is used "as is"; if less, adjust accordingly.

11. Determine the percentage of camping use for the similar action and apply this to the day use to get total use.

The recreation use, estimated from this procedure will give the initial year total recreation use in recreation days (standard unit of use consisting of a visit by one individual to a development or area for recreation purposes during any reasonable portion or all of a 24 hour period). Estimates of the recreational use for successive years would be based on the increases in area population, per capita participation rates and the effect of competing recreational resources.

This same procedure can be adapted to estimate recreation use of non-reservoir actions. However, the non-reservoir actions, in many cases, will affect recreation use over a much smaller area, and may only add a small incremental capacity to the inventory of the recreation resources in the action area. Under these conditions estimates of recreation use can be made by evaluating the use currently being made of similar facilities within the general area. The evaluation can be made in terms of the number of recreation days per picnic table, trail or campsite, etc.

Recreation Use Impacts

The impact of a proposed action on the recreation use of an area is the difference between the recreation use of the resources with the proposed action as compared to the use without the action. The differential recreation use should be identified in terms of visitor days for most activities. However, angler days may be used for sport fishing and hunter days for hunting activities.

Just as important is the impact that the recreation use of an area will have on the natural values and the other environmental characteristics of the area. The feasibility and compatibility of environmental-recreational aspects of the area should be based in part on:

--feasibility of recreation activities at the area being assessed

--spacing of the participants in an activity

--tolerance of the environment to intensity levels of the activity

--compatibility of activities

--management practices that are necessary to minimize crowding, environmental impact, and intra-activity conflict.

DATA COLLECTION GUIDELINES

There are a number of federal and state agencies that are responsible for managing resources for recreation use. In many cases, these agencies possess the best available information on the recreation use presently being made of an area. Information on the problems of resource management of the area should also be available from these agencies.

The U. S. Forest Service has developed and is using a computer information system, Recreation Information Management (RIM), to assist them in managing their recreation resources. Information on the visitor days for a number of activities on National Forests is available from this system. The Forest Service defines a visitor day as the recreational use of National Forest land or water for a total of 12 hours. A visitor day may entail use by 1 person for 12 hours, 12 persons for 1 hour, or any equivalent combination of individual or group use, either continuous or intermittent.

The Oregon Wildlife Commission has divided the State into a number of habitat units. Estimates of recreation use and historical trends are available by units. This information is maintained in the STORET system. Another system program is available that will allow summarization of unit data within geographic boundaries (such as counties or watersheds).

Oregon State Park attendance information is available on a monthly basis from the State Parks Division of the Department of Transportation. The visitor attendance is listed both by day and overnight use. Eleven additional parks are managed by the Oregon

State Department of Forestry. Daily attendance counts are made on 10 of these parks.

In those areas where recreation use information is not available, a "ballpark" estimate can be made by obtaining the total recreational activity days for the county in which the alternative is located, then appropriate a fair share of those activity days to the action area. All Pacific Northwest states have programs for statewide outdoor recreation planning in compliance with Public Law 88-578, (The Land and Water Conservation Fund Act).

Part of this statewide program for outdoor recreation is estimating the activity day demand at the county level. In general, the methods used to estimate recreation demand are the standard techniques used by the Outdoor Recreation Resources Review Commission. Demand is based on the estimated population level times the annual activity participation rate. The activity participation rate, in this case, is expressed in terms of activity days. Resident participation rates are usually determined by telephone survey. Nonresident demand, which is generally determined from origin and destination studies, is then divided by the resident population and the results added to the resident participation rate.

The Bureau of Outdoor Recreation has established a uniform methodology and common bank of data for estimating recreation demand for Oregon. The initial one year program which ended

November, 1974 was sponsored by the Pacific Northwest River Basins Commission. Participants in this program include state and federal agency personnel who are involved in recreation programs. The systems model approach to be developed focuses on origin and destination information and is to provide demand estimates on a county basis. As the program matures, elements such as leisure time, income and mobility will be fed into the demand estimates.

Estimates of future recreation use expected in the action area may be available from the land owner or managing agency. If estimates of present use are available, projections can be made to estimate future use by increasing the usage by an amount proportional to regional population growth and correcting for forecast increases in the per capita participation rate in the appropriate activities.

For those areas where current use was derived from estimates of county-wide estimates of activity days, estimates of future levels of recreation use can be derived by using the same approach as discussed for estimating current use levels.

DATA SOURCES

Federal Recreation Use Information

U.S. Forest Service
Division of Recreation
P. O. Box 3623
Portland, Oregon 97208

Bureau of Outdoor Recreation
Regional Director
1000 Second Avenue
Seattle, Washington 98104

National Park Service
Regional Director
523 4th Pike Building
Seattle, Washington 98101

Bureau of Land Management
729 N.E. Oregon Street
Portland, Oregon 97232

Bureau of Sports Fisheries and Wildlife
Regional Director
1500 N. E. Irving
P. O. Box 3737
Portland, Oregon 97208

State Recreation Use Information

Department of Transportation
Recreation Planner
307 Highway Building
Salem, Oregon 97310

Oregon Wildlife Commission
1634 S. W. Alder
P. O. Box 3530
Portland, Oregon 97208

Oregon Department of Forestry
Recreation Specialist
Star Route, Box 70
Forest Grove, Oregon 97116

CHAPTER 10

SOCIO-ECONOMICS

The impacts of any action are environmental, social and economic. The combined monetary and nonmonetary impacts must be weighed for each alternative in order to assess its effects toward satisfying the objectives for the planning area. The combined impacts of each alternative must be compared and trade-offs made to select the alternative that will best meet the objectives.

Economic considerations are important in selection of alternatives. Any alternative of significance will have a major impact on the general economic conditions in the immediate vicinity and could have impacts on larger areas. These impacts are illustrated by changes in those activities related to economic conditions, such as employment, business activity, industrial activity and population.

Changes in these conditions are often considered part of the economic costs and benefits for a particular alternative; they are also indicators of changes in the social environment.

ASSESSMENT METHODS

PRELIMINARY ASSESSMENT

As a basis for estimating the impacts of an alternative, the general description of the socio-economic conditions that exist before adoption of action is needed. Information required to describe these conditions include:

--physical area affected from a social-economic standpoint

--employment

--population

--number of households

--general description of industrial and agricultural activities

--total retail sales

--total personal income

--total industrial and agricultural income

--tax payments.

Site Description

A survey of the area that would be impacted by the action should be made to determine the specific and general nature of the resulting changes. All other data should be obtained from general reference works supplemented by a reconnaissance of the affected area. The data in the reference works should be updated to account for normal growth since the date of the last published data. If there are major changes expected in the socio-economic climate resulting from factors other than normal growth, they should be considered in the analysis.

The first step for this type of determination should be a field investigation accompanied by a review of certain basic documents, such as the Census of Population, Census of Trade and Business Services, Census of Agriculture, Census of Minerals, and other reports. Along these official reports, there should also be a review of the state's Directory of Industries, and various state revenue reports.

For some areas in the state, the Bonneville Power Administration has prepared special economic evaluations and analyses. Also the Bureau of Economic Analysis has developed comprehensive estimates and projections of many of the economic measurements for River Basins and other designated Economic Areas in the State. Aerial photographs also help in identifying activity within the planning areas, particularly for determining the location of households, industrial plants, agricultural areas, etc.

Existing Land Use

A major feature of the preliminary assessment is the quantification of existing land use patterns that are typical of the area. The following are some typical land use types found in Oregon.

--agricultural

cropland
pastureland
rangeland

--commercial

--extractive

surface mined

--industrial

--forest

private
public

--recreational

--residential

--wetland

--dedicated

--non-use

Demography

The demography of a region describes the general nature of the population. This includes such social factors as age, race, education, marital status and disability and such economic factors as employment status, total and median earnings, and types of workers. Change in the demography in an area as a result of an action may mean a change in the quality of life. Almost all the information needed for a demographic description can be extracted from the Census of Population reports. Unless there are planned actions which will change the demography, the current demography should be assumed to be representative of the future.

Estimated Impact of Actions

The impact of each alternative on the socio-economic characteristics is determined by calculating the incremental changes in those characteristics that result from the proposed actions. Calculation of the incremental changes can be accomplished by using the factors outlined below (4, pp. 272-273).

Physical Area. The smallest area for which socio-economic data generally is available in the county. Unless there is reason to expect influence on a greater area, the area affected by an action usually includes all counties which contain or border on the area physically altered by the action. The area affected should also include all counties which have a significant population change as a result of either construction or operation.

Employment. The total employment change from an action is equal to the change in direct employment due to the action times a factor of two for construction jobs and a factor of three for other types of jobs. These factors of two and three take into account the change in secondary workers for each job class.

Population. The total change in population due to the action is equal to the change in direct employment due to the action times a factor of 3.8 for construction jobs and a factor of 5.7 for other types of jobs.

Households. The number of households necessary to house the change in population is equal to the change in direct employment multiplied by 1.4 for construction workers and 2.1 for other types of jobs.

Retail Sales. The change in retail sales is equal to the change in population times the average per capita retail sales in the previous year for the entire region or state.

Total Personal Income. The change in total personal income is equal to the change in population times the average personal income in the previous year for the entire region or state.

Industrial or Agricultural Income. Changes in these types of income are determined by multiplying known changes in production by the most recent published sales price for each community.

Tax Payments. Changes in taxes paid by individuals can be determined by multiplying the change in population by the average per capita tax payments for the region or state.

Demographic Impacts. By use of the description of the existing demography and the employment information developed above, an estimate can be made of the numbers and types of inhabitants likely to be affected by an alternative and the impact on those persons. The total demographic situation can then be estimated by calculating the change in current demography. The demography after the adoption of the action is compared to the demography that would have existed without the action to see if there will be a significant change and the nature of that change.

DETAILED ASSESSMENT

The information collected for the preliminary assessment should be updated and confirmed for each alternative by a detailed census of the effected area. Detailed maps should be made for all areas where human activities will be directly affected by the action. In the case where census or economic data is not available or if the most recent data may not be representative, special censuses or samplings may have to be made.

Socio-Economic Impacts

The objective of a detailed socio-economic assessment is to determine the change in jobs, population, households, wages, revenue, personal income and gross area product resulting from the action being considered.

Assessment Steps

The assessment steps discussed below were adapted from an economic assessment procedure presented in the U.S. Army Corps of Engineers, Columbia River and Tributaries--Environmental Assessment Manual. The data sources and descriptions of procedures are identified within each step. For the smaller actions, it may not be necessary to perform such a complete assessment and the evaluation can be reduced accordingly.

1. If the action involves construction such as a dam, flood control structure, or irrigation system, the peak

construction force and probable period of construction activity can be estimated by a knowledgeable engineer. Although construction can require several years time, and have a work force of considerable range resulting in a one-time peak, it is usually more realistic and practical to measure the total workers in terms of an annual average. This one average becomes very handy later in the assessment for estimating payrolls and their general impact on the area's personal income, trade levels, and revenue generation. However, calculations should also be made for the peak construction force in order to define the problems that may exist at that time in providing adequate housing and municipal services.

As a rule of thumb measure, most economists accept the premise that basic jobs (such as construction workers) generate 1½ to 3 secondary jobs in an economy, depending upon the maturity of that economy. However, for construction work which is likely to develop in many areas in Oregon, where the workers are recruited from outside the action area, it may be more realistic to use a lower basic to secondary job ratio. A ratio of one basic worker to one secondary worker may be more realistic. This assumption implies that for every construction job there will be one secondary job operative somewhere throughout the affected area. A complication in this particular case may be that the secondary job generated by the construction worker may come in an establishment located outside the assumed area affected.

For operating jobs created by the action, a ratio of two secondary workers for each operating job is more representative and should be used.

2. In any action, there is always the possibility that populations and households will be physically affected and, therefore, actually be moved out of the area affected. The number of these can be estimated by a field investigation of the area affected and the use of specialized maps which identify structures in the area.

Steps 3 through 7 relate to the direct physical impact of the action on any of the area's commercial production, and extraction activities. In all these economic categories of activity, the impact can be in terms of both jobs and dollar value. Ultimately, the employment generated here for all kinds of activities can be fed into Step 8, which is the net result of combining the plus and minus counts of jobs generated from the five activities (commercial, industrial, mineral, agricultural, and timber).

The dollar values related to these activities are to be totaled in Step 15. These dollars may not have a direct beneficial impact upon the personal income of the area but could be an influence in regard to tax revenues.

The following procedures are based on the assumption that data on changes in employment and dollar volumes cannot be obtained directly from the affected business and agricultural establishments. If such data can be obtained, it should be used in preference to estimated data.

3. If the area affected is less than county-size, it will be necessary to estimate the number of establishments likely to be eliminated. This can be done by a field investigation or rough approximation. The number of establishments multiplied by the average number of workers per establishment (as obtained from the *1970 Census of Business* for that county) will provide an estimate of the number of employees affected by the action. If the area affected is a county or group of counties, the number of establishments and their employment can be obtained from the *1970 Census of Business*. Supporting measurements of commercial employment can also be obtained from the reports of covered employment by county, published by the State Department of Employment Security.

The same procedures and sources utilized in estimating the number of commercial employees can be applied to the estimate of dollars of commercial activity, with the exception that dollars of revenue are presented in the census report but not in the state report of covered employment.

4. Step 4 pertains to the industrial activities (manufacturing and basic processing) which were moved out of the project area. If the area affected is county-size, this information can be obtained from the 1970 Census of Manufacturing. In cases where the area affected is less-than-county-size, the number of establishments needs to be surveyed and the firms contacted for estimates of employment. State Department of Employment Security reports of covered employment can also be used in making these estimates. Dollars of industrial production can be obtained from the Census of Manufacturers at the county level only. With less-than-county-size areas, only estimates are possible. However, the establishments themselves can usually be identified from the State's Directory of Manufacturers. State revenue reports do not usually cover these industrial activities.

5. Step 5 relates to the extractive activities of the area.

In a less-than-county-size area, employment must be estimated on the basis of extracts from the latest mineral census plus discussions with representatives of the State Department of Mines and Geology. Offices of the U.S. Bureau of Mines can help in this analysis and are usually prepared to do so. Whenever the area affected is county size, complete data for mineral-related activities can also be obtained from the same state department, as well as the Census of Minerals. In the case of workers, reports of covered employment, published by the State Department of Employment Security office will provide counts of establishments and workers under the classification of mining.

The dollars of revenue from extractive operations can be obtained in the same way as the numbers of employment, discussed above, except that covered employment reports will not be helpful. Since the number of extractive establishments is likely to be small, it will not be much of a job to contact them directly to learn their extractive dollar volumes. Such revenue data are usually confidential, but most companies will normally offer some estimates of revenue which will be lost if they were to cease or curtail operation in the area.

6. In the case of agricultural employment, the procedure is complicated since much of agricultural employment is that of the proprietor and his unpaid family members. Counts of self-employment are sometimes difficult to obtain. Numbers of paid farm workers are covered in the Census of Agriculture. Contacts with local offices of the State's Employment Security Department will generally produce considerably more detailed information on employment. In areas smaller than county size, numbers of farm workers can only be a best judgment estimate. Estimates of agricultural production are also difficult to develop. If the affected area is county size, considerable information on its farm production value can be obtained from the latest Census of Agriculture. If it is smaller than county size, it will be necessary to estimate the number of acres affected by the action and the average crop production for the acreage multiplied by the current price of the commodity.

The estimation of the impact of an action on agriculture and related industries in a large region requires a two step procedure; (1) Estimate the change in agricultural cropland. This estimate is made by studying the design of the alternatives and the nature of the land use where the action will be located to determine the amount of cropland removed from production because of occupancy by components of the action or alteration of irrigation water supplies and the amount of additional cropland resulting from increased availability of land or water. (2) Estimate the change in crop value and the general economy. Assume that the crop value and population density equals the average value for similar cropland in that county or region. If the action results in a large increase in irrigated land, the following method should be used for estimating the changes.

An irrigation project increases the gross value of commodities by 10.5 times over those produced by dryland farming. As estimated 3.3 times as many farm families could be supported by this increased production. Many of the agricultural products would be processed in the area. This processing activity would increase the gross value of the resultant products to 21.2 times the value of the commodities presently produced and processed in the area. The number of families that the area would support as a result of this processing activity would be 10.7 times the number of families supported without the irrigation project. With the increase in the level of economic activity, there would be an increase in the services industry. This would result in a 12.3 fold increase in the number of families supported directly and indirectly as a result of the project (4, pp. 279-280).

If there is no current agriculture on land that is converted to irrigation, the average crop values and population for similar land that is being irrigated should be used.

7. This step relates to timber harvesting and processing. Like mineral extraction, timber harvesting and processing are easily identifiable and can be accounted for with a minimum number of field investigations and conversations with regulatory agencies. Counts of timber volumes harvested by county are usually prepared by the State Department of Natural Resources. This department, as well as the U.S. Forest Service, are knowledgeable as to how much cutting is being done in an area. Timber harvests multiplied by the average stumpage price will provide an estimate of the basic production values. The Census of Manufacturers will provide the data on timber processing employment and the dollars of value added by the processing at the county level.

8. All of the job related data developed in Steps 3 through 7 go into step 8, where they are totaled. Some of the impacts will be on the negative side, and some on the positive side. Therefore, the final total will represent the net number of jobs to be accounted for.

9. This step is the preparation of a composite employment estimate including construction, operation, secondary

job employment, and the changes in affected employment levels as reflected by Step 8. Inputs from Step 1 (construction and secondary jobs) combined with the inputs from Step 8 provides an overall composite estimate of employment attributable to the action.

10. Approximately 10 percent of the total work force is composed of single persons living alone. The remainder will be workers with families averaging about 3.2 persons per family. On the basis of more recent trends, this family size is probably lowering and the population estimate probably should be based on about 3.0 persons per family. Because each family unit contains about 1.5 workers, the total number of households for the workers, the total number of households for the workers directly related to the action is obtained by multiplying the number of workers by 0.7. For example:

$$\frac{\text{(Number of families)}}{\text{(1.5 workers/family)}} + \text{No. of single workers} = \text{No. of households}$$

For one worker, this equation becomes:

$$\frac{0.9}{1.5} + 0.1 = 0.7$$

The total population associated with the workers is obtained by multiplying the number of workers by 1.9. Where – (0.6 household for married worker) x (3.0

persons/household) + 0.1 single workers.

The populations and households associated with the secondary workers are obtained in the same manner as above. The number of households and populations for secondary workers associated with construction workers is equal to the numbers calculated above for the construction workers. The population and household numbers for secondary workers associated with operating workers is equal to twice the numbers calculated in the above paragraph for the operating workers.

11. To estimate the change in household population which could be attributed to the physical impact of the action, the assumption is made that there are two secondary workers associated with each primary worker. The change in population and households is then calculated as in Steps 1 and 10.

12. In this step, the population changes attributed to construction and secondary employment, as well as the population changes which can be attributed to the basic production and extractive activities plus those attributable to the elimination of some residences, are merged into a composite estimate of the total population change.

13. Through the composite or net total production change,

estimates of retail trade and service sales can be calculated by application of a per capita sales average to this population total. This per capita average can be obtained by dividing the Census reported state yearly sales totals by the state total population estimated for the same year.

14. Estimates of personal income can be obtained by multiplying the total number of job changes by some representative salary average. This total will represent the additional dollars of personal income generated by the action. Although greater precision might be achieved by utilizing a separate (and probably different) average such as the total reported covered wages for the entire state for a recent year divided by the total average covered employment for the same year.

15. This study phase is the aggregate of the direct physical impacts of the action on the income generating sections of the action area's economy. It will include the dollars of value which had been generated in the study in Steps 3 through 7. These cover such activities as industrial production, mineral extraction, agricultural production, and timber harvesting. There may be other income generating sectors identified as the full scale study

proceeds.

16. Under some conditions, state and local tax revenues are likely to be impacted by the action, either in its various stages of construction or in full time operation. For example, in the case of state personal income tax, the value of the revenue generated can be obtained by multiplying total wages paid (Step 14) by some personal income tax rate average for the area or state. In practice, this rate will not be the same as the published tax rate, since there are always allowances for personal deductions and covered expenses for such items as medical and mortgage interest.

Demographic Impacts

In the situation where data is not available for those parameters expected to be altered by the action, an appropriate census or economic survey should be made. Any survey made should follow standard census procedures.

The demography should be analyzed to determine if demographic areas exist that are unique to the affected area. Examples of these would be:

agricultural areas	industrial areas
residential areas	urban areas
ethnic colonies	recreation areas.

Separate demographic data should be developed for any such area if the alternate is expected to have an impact on it.

DATA COLLECTION GUIDELINES

Such economic information as population, employment, labor sources, industrial output and retail sales are regularly assembled by the State and by various federal offices. At times, special estimates and forecasts are made for population and employment by various planning and development agencies.

DATA SOURCES

All the data sources listed below give data at the county level, unless otherwise noted. In the case of the Bureau of Census population reports, counties can be broken down into "census division" and "tracts." The sources and data are described and identified in Table 22 (4, pp. 284-287). Table 23 (4, p. 288) gives the categories for which employment data are available.

Secondary Impacts

The secondary economic impacts may be an important variable in the management decisions at the local level. Input/output tables and descriptive reports are useful sources of data for measuring these impacts. These tables are available for Grant, Klamath, Clatsop, and Douglas Counties in Oregon. Information of these tables is available from:

Department of Economics
University of Oregon
Eugene, Oregon 97401

Department of Economics
Oregon State University
Corvallis, Oregon 97331

Social Impacts

A report titled "Assessing the Social Effects of Public Works Projects" has been prepared for the Corps of Engineers, Board of Engineers for Rivers and Harbors by E. Jackson Baur, Resident Scholar, 1972-1973. This report deals with two related subjects. The first is the development of an inventory of social phenomena, and the second is a discussion of problems in assessing the impacts of public works on human society. It considers both the substantive and methodological aspects. Included are such items as general parameters of society, persons, activities, interaction, adaptation, and cohesion. The report points out that the assessment of social impacts for the purpose of making decisions on engineering projects is an extremely complex problem that cannot be reduced to a simple formula. The report may be purchased from:

The National Technical Information Service
Department of Commerce
Springfield, Virginia 22151

TABLE 22

ECONOMIC DATA SOURCES

ECONOMIC STATISTICS	SOURCE	RELEASE	FREQUENCY	LEVEL OF DETAIL	COMMENTS
Vehicle Highway Counts	State Highway Departments	Annual Report on Highway Traffic	Annually	Counts of vehicles passing through scheduled county stations and average daily traffic at these points computed.	Some of these county stations are fixed and permanent while others are meters installed for short periods of time for some specific purpose. Typically, the highway department computes average daily traffic flows for special studies.
State Visitor Estimates	State Tourist and Promotion Offices	Special Analysis and Reports	Infrequent	Stated estimates of non-resident visitor parties.	Some of these estimates attempt to breakdown non-resident visitor parties by region of state visited.
GROSS STATE PRODUCTION					
Value of Production	Bank of California	Pacific Coast Market and Business	Monthly	Dollars of Gross product expressed in 1- and 2-digit SIC classifications.	
INDUSTRIAL PRODUCTION					
Dollars of value added by manufacturing	Bureau of Census	Census of Manufacturers	Every 5 years	Total value of selected products are shown.	These statistics cannot be totaled since the final output of one manufacturer could be raw material of another.

TABLE 22 (Continued)

ECONOMIC STATISTICS	SOURCE	RELEASE	FREQUENCY	LEVEL OF DETAIL	COMMENTS
EMPLOYMENT					
Total Employment	U.S. Census Bureau	1970 & previous Census of Population	Every 10 years	2-digit SIC classifications only. Pertains to all types of employment, including self-employment. Census tapes are available for smaller than county areas.	Industry classifications from Census reports can differ from those of other official agencies.
Total Estimated Employment	State Depts. of Employment	Monthly report	Monthly	Usually 2-digit class.	Estimated for major counties for local employment offices.
Total Estimated Employment	Bonneville Power Admin.	Special studies and regional analysis	Infrequent	2-, 3-, and 4-digit SIC class. with estimates for current years and fore-casts to Year 2000.	Develop as part of the agency's forecasting program.
Total Estimated Employment	Office of Bus-iness Economics, U.S. Dept. of Commerce	OBE Economic Areas	1-time study	2-digit SIC class. em-ployment estimates and forecasts to 2020.	These estimates may be larger than county units, but county data are extractable.
Covered Employment	State Depart-ment of Employ-ment Security	Quarterly Report	Average monthly em-ployment issued quarterly	Employment reported by 2-, 3-, & 4-digit SIC classification.	Employer reporting em-ployment covered by the state's unemployed com-pensation act. Note that some industries will not be included.

TABLE 22 (Continued)

ECONOMIC STATISTICS	SOURCE	RELEASE	FREQUENCY	LEVEL OF DETAIL	COMMENTS
Social Security Covered Employment	Old Age and Survivor's Insurance	Counties Business Patterns	Yearly but limited to second quarter report for each year.	2-, 3-, and 4-digit SIC class.	Employer reporting employment covered by Social Security.
Manufacturing Employment	Bureau of the Census	Census of Manufacturers	Every 5 years	2, 3, & 4-digit SIC class. Group 19-29. Data pertains to the payroll period nearest to the 15th of April.	Includes complete information on employment, production, wages, etc.
Trade Employment	Bureau of the Census	Census of Business	Every 5 years	2-digit wholesale and retail trade SIC class.	Includes complete retail-wholesale data.
Business Services	Census Bureau	Census of Business	Every 5 years	SIC sectors pertaining to all types of business and personal services.	All types of services are covered in detail.
Governmental	Census Bureau	Census of Government	Every 5 years	SIC sectors pertaining to governmental activities.	Includes government employment by type.
POPULATION					
Number of Inhabitants	Bureau of Census	Census of Population, Volume A.	Every 10 years	Population counts for counties, census districts, and incorporated areas.	Counts of population detail for characteristics are contained in Volumes B, C, & D.

TABLE 22 (Continued)

ECONOMIC STATISTICS	SOURCE	RELEASE	FREQUENCY	LEVEL OF DETAIL	COMMENTS
Number of Inhabitants	State Census Board	Special reports	Usually annually but coordinated to supply between census period information.	Counties and incorporated communities	State maintains such a census board to provide yearly estimates of counties population as well as ten year forecasts.
Number of Inhabitants	Bonneville Power Administration	Special Reports	Infrequent but usually between census periods.	Estimates and forecasts for county and municipal populations.	Develop as part of that agency's forecasting program.
Number of Inhabitants	Pacific North-West Bell Research Department	Population Reports	Infrequent	County Population Estimates	Emphasis on area served by system.
Population Forecasts	Office of Business Economics, U.S. Dept. of Commerce	OBE Economic Areas	1-Time study	County detail in some instances including forecasts.	Part of a broad forecasting program.
Estimates of the Population	Bureau of Census	P-25 Series	Infrequent but generally yearly level of detail.	Between census period estimates of county populations.	Usually developed in coordination with state census boards.

TABLE 22 (Continued)

ECONOMIC STATISTICS	SOURCE	RELEASE	FREQUENCY	LEVEL OF DETAIL	COMMENTS
HOUSEHOLDS					
Number of Households	Bureau of the Census	Census of Housing	Every 10 years	Household counts for counties and some census districts.	The statistic "number of families" reported in the census of populations is somewhat similar to this count of households.
Number of Households	Bonneville Power Admin.	Special BPA Reports	Infrequent but usually between census periods.	Estimates of households by county.	These estimates are usually coordinated with those from the census bureau.
Number of Households	Pacific Northwest Bell	Population Reports	Infrequent	Estimates of households by county.	
RETAIL SALES					
Dollars of Retail Sales	Census Bureau	Census of Business	Every 5 years	Major retail sectors at 2-digit SIC code for total annual sales by county.	Various aspects of retail trade are presented including number of establishments and self-employed proprietors.
Dollars of Retail Sales	Sales Management Magazine	Survey of Buying Power	Annually	Data are presented by count for retail trade activity.	While no official release, this source provides excellent reference points between the 5-year census releases.

TABLE 22 (Continued)

ECONOMIC STATISTICS	SOURCE	RELEASE	FREQUENCY	LEVEL OF DETAIL	COMMENTS
WHOLESALE TRADE					
Wholesale Sales	Census Bureau	Census of Business	Every 5 years	2-digit SIC classifications for wholesale trade in annual totals only.	In addition to wholesale information on the number of establishments other data are presented.

TABLE 23

CATEGORIES FOR WHICH EMPLOYMENT DATA

ARE AVAILABLE FOR LOCAL AREAS

CIVILIAN LABOR FORCE

WORKERS IN LABOR-MANAGEMENT DISPUTES

UNEMPLOYMENT

  Percent of Labor Force

EMPLOYMENT

  Agricultural

  Nonagricultural

    Employer, Own Account, Unpaid, and Domestics

WAGE AND SALARY WORKERS, NONAGRICULTURAL*

TOTAL MANUFACTURING

  Food and Kindred Products

  Printing, Publishing, and Allied Products

  Chemicals and Allied Products

  Stone, Clay, and Glass Products

  Fabricated Metal Products and Machinery (excluding electrical)

CONTRACT CONSTRUCTIONS

TRANSPORTATION, COMMUNICATIONS, AND UTILITIES

WHOLESALE AND RETAIL TRADE

FINANCE, INSURANCE, AND REAL ESTATE

TABLE 23 (Continued)

BUSINESS SERVICES

OTHER SERVICES AND MISCELLANEOUS

GOVERNMENT

Educational Services

All Other Government

CHAPTER 11

AESTHETICS AND HUMAN INTERESTS

This chapter will consider the assessment of the impacts of an action on aesthetics and important heritage resources that are found throughout Oregon. The aesthetic affects will be analyzed from two aspects—sight and sound. The analysis of the impacts on human interests will concentrate on those archeological, historical or cultural areas affected by the action.

ASSESSMENT METHODS--SIGHT

PRELIMINARY ASSESSMENT

A general description should be made of the landscape of the area. This should include any unique visual resources which would be threatened or destroyed by the proposed action. The purpose of this is to identify any obviously valuable visual resources which might be lost inadvertently. General estimates should be made of the number of people who would have visual contact with the proposed action during a year.

The change in views resulting from the proposed action should be made. This is done by making a subjective estimate of the change in quality of the views. This information will be used later in evaluation of the general social impact of the alternatives.

An estimate also should be made of the scarcity of the view before the proposed action.

DETAILED ASSESSMENT

The detailed analysis of visual impact focuses on the evaluation of the change in the visual quality of a landscape as they may appear before and after the proposed action is implemented. The change in the visual quality of the view as impacted by the alternatives is one index of its visual affect. This change, multiplied by the number of times the view is observed is the full measure of the visual impacts for that viewpoint.

Viewpoint selection depends upon viewing populations, viewpoint distances from the site, vertical observer position, direction of view relative to the site's setting and visual condition. Of all these variables, the most important is viewing population, since visual impact must depend upon the presence of a viewer.

In order to carry out the visual analysis, the following data should be prepared.

- Location, topographic maps and aerial photography suitable for stereo vision.
- A description of the visual characteristics of the action.

- Site plan locating the major structures and showing the base and top elevations of the major structures.
- Population distribution data for the area, including both resident and transient demographic features.

Site Survey

The first step of any analysis should be a survey of the potential site for unique visual resources which might be disturbed or lost by the proposed action. Particular attention should be given to areas which will be physically changed by the action.

This visual survey should investigate the degree to which the site occupies a crucial position in the larger landscape. It should determine the degree to which the site is visually typical of other areas nearby, and the level of uniqueness of its features.

Evaluation of Changes in Visual Quality

Evaluation of the visual quality of each "before and after" landscape should be made by several evaluators. The evaluator should record his immediate visual response to the landscape, rating its visual quality from 1 (very high visual quality) to 100 (very low visual quality). Consideration should be given to the degree the landscape is scenic, distinctive, stimulating and visually harmonious. A scale of comparison is implied, suggesting that view such as Grand Canyon or Grand Tetons might be scored close to 1, while views of unrestored strip mines or polluted waterlands might be given scores near 100.

In order to determine the severity of change relative to the original visual quality, it is not adequate only to express the difference in visual quality before and after the action. It is also necessary to assess the level of visual quality of the site in its original condition. Visual impact is partially a function of the number of people who will view the altered landscape and partially a measure of the loss of important visual resources at the site itself.

Since visual assessments often will be required in the absence of after conditions, a certain amount of perceptual projection will be needed. The use of sketches or modified photographs can be of assistance in the evaluation of the final impact.

ASSESSMENT METHODS--SOUND

PRELIMINARY ASSESSMENT

The following factors should be considered when making an assessment of noise to determine the affected environment.

Human Habitations--All actions that are to be located near schools, residential areas, recreational and business areas, will have a higher probability for possible impacts of noise. All areas that could be affected should be described.

Terrain--Actions located near hills or mountains and especially within confined basins or valleys should be given a special analysis.

Distance-- Noise reduces rapidly with distance.

The preliminary estimate of the noise impacts can be made by determining the noise impacts of other similar actions. At this point in the assessment, only a general evaluation of the impacts from noise can be made. The previous identification of the affected components should have developed a general description of all sources of noise and the noise levels at the sources. By a general analysis of this information with use of observations for similar sources, it should be possible to form a general opinion of the probable noise level at the nearest location of impact. This opinion should be expressed as no impact or an insignificant, minor, or major impact and an example of the impact should be stated.

Included in the analysis should be an estimate of the number of persons experiencing increased noise levels and the expected impact on them.

DETAILED ASSESSMENT

The following factors should be considered when making a detailed assessment.

--characteristics of noise from the action

--ambient noise level in the areas affected by the action

--sensitivity of area to noise

Noise levels in the area surrounding the proposed action may be estimated by forecasting the noise levels due to the action and adding those to the ambient noise level. Next, the suitability of the new noise levels, for the existing land use may be estimated by comparing the resultant noise level with local or national noise control standards and previous levels. A useful guideline is the standard listed by the Office of Housing and Urban Development in its publication, "Noise Assessment Guidelines."

Figure 16 (4, p. 308) shows the steps in conducting a detailed assessment on noise. The specific procedure is outlined below.

--Determine and plot on a map the ambient noise levels, natural and man-made, at the proposed site, as well as noise levels adjacent to the site.

--Describe or define on a map sources of noise emissions from the proposed action and the resultant noise levels. Typical sources of noise are:

construction equipment,

drilling and blasting,

vehicular traffic,

aircraft,

agriculture,

industrial plants,

running or cascading water.

--Determine or estimate the resultant noise levels by projecting the new action's noise levels onto the ambient noise levels. Do the resultant noise levels meet local and national standards?

--Evaluate impacts of noise pollution on the surrounding areas. The criteria for evaluating the impact of the noise from the action should be based on the following:

total population affected by the noise,

physiological impacts on humans,

psychological impacts on humans,

physical impacts on humans,

impacts on wildlife, and

social-economic impact.

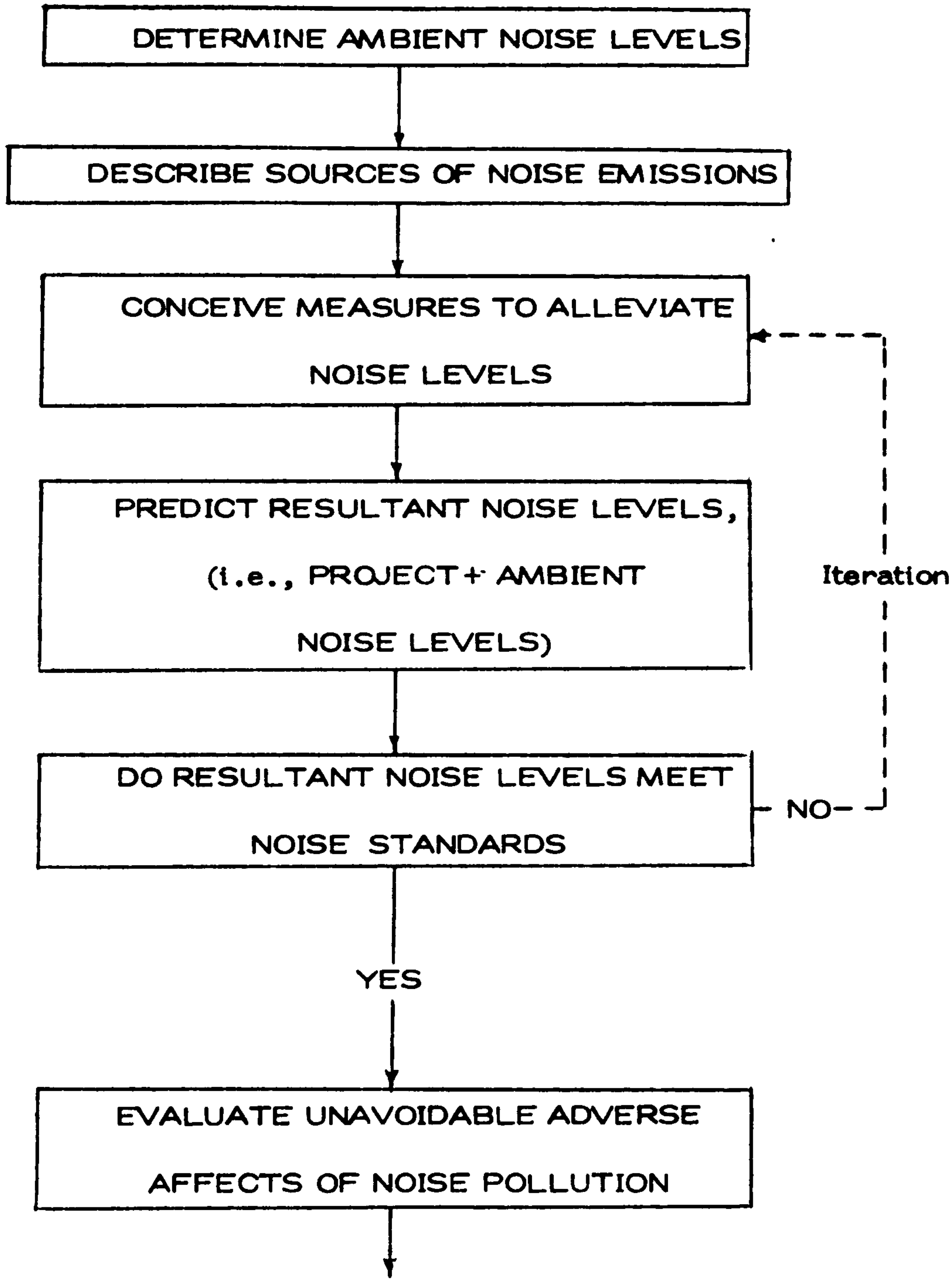
ASSESSMENT METHODS--HUMAN INTERESTS

PRELIMINARY ASSESSMENT

Since the exact location of a proposed action and its alternatives may not be known at this point in the assessment, a regional map should be developed which locates known historic, cultural, archeological and architectural resources and pioneer cemeteries.

The maps showing the locations of these sites and the regions altered by the actions should be studied to determine the impact in terms of the potential for:

Figure 16. Steps in Detailed Assessment of Noise.



- inundation,
- physical destruction or alteration,
- increased human use, and
- increased vandalism.

DETAILED ASSESSMENT

Once the specific sites for the proposed actions are known, a detailed statement should be written which identifies and describes the heritage of the local area around and within the proposed actions. Identify where heritage sites are located, what impact the action may have on the sites, and what can be done to preserve the inherent value afforded by the site.

Authorities and specialists in the areas of history, culture, archeology, architecture and pioneer cemeteries should be contracted to conduct literature research and field investigations to identify and discover heritage sites that may be lost or altered through action implementation.

DATA SOURCES

SIGHTS

An overview evaluation of the aesthetic values for Oregon is contained in the following report.

National Park Service, An Evaluation of the Aesthetic Values as Related to the Water Resources of the Columbia-North Pacific Region, 1973.

A number of articles and reports have been published on detailing visual evaluation. Among them are:

Battelle-Pacific Northwest Laboratories, A Technique for Environmental Decision-Making Using Quantified Social and Aesthetic Values, February 1974.

Leopold, L., Quantitative Comparison of Some Aesthetic Factors Among Rivers, U.S. Geological Survey Circular 620, (Washington, D.C.), 1969.

Litton, B., et al., An Aesthetic Overview of the Role of Water in the Landscape, Department of Landscape Architecture, University of California, 1971.

Zube, E. H., "Scenery as a Natural Resource: Implications of Public Policy and Problems of Definition, Description, and Evaluation," Landscape Architecture, Vol. 63, no. 2., (January, 1973).

SOUND

Federal Agencies

U.S. Department of Housing and Urban Development
Washington, D.C. 20410

Office of Noise Abatement and Control
U.S. Environmental Protection Agency
Washington, D. C. 20460

U.S. Environmental Protection Agency
Region X
Office of Radiation, Pesticides and Noise Programs
1200 6th Avenue
Seattle, Washington

HUMAN INTERESTS

The National Register of Historic Places

The complete National Register appears annually in the Federal Register on the last day of February. Additions and deletions appear in the Federal Register on the first Tuesday of every month.

State Agencies

In Oregon, archeology is handled in a separate office from the historical information, therefore, a copy of the request should be sent to both of the addresses below.

State Historic Preservation Officer
Oregon State Highway Building
Salem, Oregon 97310
Attn: Ms. Elizabeth Walton

Museum of Natural History
University of Oregon
Eugene, Oregon 97403
Attn: Assistant Curator for Anthropology

Archeology or Anthropology Departments of Universities

University of Oregon
Eugene, Oregon

Oregon State University
Corvallis, Oregon

Portland State University
Portland, Oregon

Cemeteries

Historical Societies have a great deal of information on pioneer cemeteries which will be made available upon request. The Society will also identify individuals at the local level who could help in identifying cemeteries within the area of influence of the proposed action.

Genealogist
Oregon Historical Society
1230 S.W. Park Avenue
Portland, Oregon 97205

Federal Agencies

Regional Archeologist
National Park Service
Pacific Northwest Region
523 4th Pike Building
Seattle, Washington 98101

Information may also be available from the Smithsonian Institution, Washington, D.C.

APPENDIX A

BIBLIOGRAPHY FOR HYDROLOGY

AND WATER QUALITY

WATER QUALITY

GENERAL

Blakey, J. F., Temperature of Surface Waters in the Conterminous United States. U.S. Geological Survey HA-235, 1966.

California Water Pollution Control Board. Water Quality Criteria, Publication 3-A, 1963.

Chen, C. W., and Orlob, G. T., Predicting Quality Effect of Pumped Storage. Water Resources Engineers, Inc., Walnut Creek, California. Paper, International Conference on Pumped Storage Development and Environmental Effects, Milwaukee, Wisconsin, September, 1971.

Clark, B. D. Basic Waste Characteristics at Winter Recreation Areas. Pacific Northwest Laboratory, FWPCA, NTIS - PB 208 437, Corvallis, Oregon.

Feth, J. H., et al., Preliminary Map of the Conerminous United States Showing Depth to and Quality of Shallowest Ground Water Containing More than 1,000 ppm Dissolved Solids, U.S. Geological Survey HA-199, 1965.

Moore, A. M., Water Temperatures in the Lower Columbia River, U.S. Geological Survey Circular, 1968.

Pacific Northwest River Basins Commission. "Appendix L," Water Pollution Control, Willamette Basin Task Force, 1969.

Santos, J. F., Quality of Surface Waters in the Lower Columbia River Basin. U.S. Geological Survey Water Supply Paper 1784, 1965.

U.S. Geological Survey, "Parts 9-14," Quality of Surface Waters of the United States, Published annually before 1966.

U.S. Geological Survey, Quality of Surface Waters for Irrigation, Western States, Published annually before 1966.

Van Denburgh, A. S., and Feth, J. H., Solute Erosion and Chloride Balance in Selected River Basins of the Western Conterminous United States, Water Resources Research, Vol. 1, No. 4, pp. 537-541, 1965.

National Water Commission, New Directions in U.S. Water Policy--Summary, Conclusions and Recommendations, 1973.

Goldblatt, E. L., Van Denburgh, A. S., and Marsland, R. A., "The Unusual and Widespread Occurrence of Arsenic in Well Waters of Lane County, Oregon." Prepared in cooperation with Lane County Health Department and U.S. Geological Survey, 1963.

Madison, R. J., "U.S. Geological Survey Water Quality Data in the Willamette Basin, Oregon, 1910-1964," U.S. Geological Survey Basic Data Report, 1966.

McHugh, R. A., An Interim Study of Some Physical, Chemical and Biological Properties of Selected Oregon Lakes, Oregon State Department of Environmental Quality, Portland, Oregon, January, 1972.

Moore, A. M. "Correlation and Analysis of Water - Temperature Data for Oregon Streams," U.S. Geological Survey Water Supply Paper 1819-K, 1967.

Stoevener, H. H., Stevens, J. B., Horton, H. F., Sololoski, A., Parrish, L. P., and Castle, E. N., "Multi-Disciplinary Study of Water Quality Relationships: A Case Study of Yaquina Bay, Oregon," Oregon State University Agriculture Experiment Station Special Report 348, 1972.

Sceva, J. E., Liquid Waste Disposal in the Lava Terrain of Central Oregon. FWPCA, April 1968.

U.S. Geological Survey, Geologic and Water Supply Reports, and Maps, Oregon. (List of State Publications).

Van Winkle, W., "Quality of Surface Waters of Oregon," U.S. Geological Survey Water Supply Paper 363, 1914.

Water Resources Research Institute, "The Quality of Oregon's Water Resources," National Technical Information Service PB-206, 952. Oregon State University, Corvallis, Oregon, 1971.

GROUNDWATER

Bartholemew, W. S. and Debow, R., Ground Water Levels, 1966, U. S. Geological Survey, 1967.

Hickey, J. J., "Important Considerations in the Process of Designing a Groundwater Data Collection Program," U. S. Geological Survey, Water Resources Research, 8(1):178-181, February, 1972.

Krieger, R. A., Hatchett, J. L., and Poole, J. L., "Preliminary Survey of the Saline Water Resources of the United States," U. S. Geological Survey Water Supply Paper 1374, 1957.

McGuinness, C. L., "Generalized Map Showing Annual Runoff and Productive Aquifers in the Conterminous United States," U. S. Geological Survey HA-194, 1964.

Mack, L. E., "Groundwater Management in Development of a National Policy on Water," National Water Commission PB 201 536, January 1971.

Newcomb, R. C., "Storage of Ground Water Behind Subsurface Dams in the Columbia River Basalt, Washington, Oregon, and Idaho," U. S. Geological Survey Professional Paper 383-A, 1961.

Price, D., Hart, D. H., and Foxworthy, B. L., "Artificial Recharge in Oregon and Washington, 1962" U. S. Geological Survey Water Supply Paper 1594-C, 1965.

Theis, C. V., and Conover, C. S., "Chart for Determination of the Percentage of Pumped Water Being Diverted from a Stream or Drain, in Shortcuts and Special Problems in Aquifer Tests," U. S. Geological Survey Water Supply Paper 1545-C, 1963.

Winter, T. C., "An Approach to the Design of Statewide or Regional Groundwater Information Systems," U. S. Geological Survey, Water Resources Research 8(1):222-230, February 1972.

HYDROLOGY

GENERAL

Harris, D. D., "Evaporation Study at Warm Springs Reservoir, Oregon," U. S. Geological Survey Open File Report, 1967.

Pacific Northwest River Basins Commission, "Water Resources, Appendix V," Columbia-North Pacific Framework Study, 1970.

Rainwater, F. H., "Stream Composition of the Conterminous United States," U. S. Geological Survey Hydrologic Investigation Atlas HA-61, 1962.

Blue, C. D., "Principal Lakes in the United States," U. S. Geological Survey Circular 476, 1963.

Hulsing, H. and Kallio, N. A., "Magnitude and Frequency of Floods in the United States--Part 14, Pacific Slope Basins in Oregon and Lower Columbia River Basin," U. S. Geological Survey Water Supply Paper 1689, 1964.

Eisenhuth, H. P., "Index of Surface Water Records to September 30, 1967, Part 14, Pacific Slope Basins in Oregon and Lower Columbia River Basin," U. S. Geological Circular 584, 1968.

Jones and Helland, "Index to River Surveys Made by the United States Geological Survey and Other Agencies," U. S. Geological Survey Water Supply Paper 995, 1948.

Rainwater, F. H., "Stream Composition of the Conterminous United States," U. S. Geological Survey HA-61, 1962.

Randolph, J. R., and Deike, R. G., "Bibliography of Hydrology of the United States," U. S. Geological Survey Water Supply Paper 1863, 1966.

Surface Water Supply of the United States, 1961-1965, Part 12, Vol. 2, Also Part 13 and Part 14. U. S. Geological Survey Publication 776 pp., 1971.

Thomas, N. O., and Harbeck, G. E. Jr., "Reservoirs in the United States," U. S. Geological Survey Water Supply Paper 1360-A.

U. S. Geological Survey, "Compilation of Records of Surface Waters of the United States, October 1950 to September 1960," U.S. Geological Survey Water Supply Paper 1738, 1963.

U. S. Geological Survey, "Surface Water Supply of the United States, 1961-1965. Part 14: Pacific Slope Basins in Oregon and Lower Columbia River Basin," U. S. Geological Survey Water Supply Paper 1935, 1971.

U. S. Geological Survey, "Index of Surface Water Records to September 30, 1970," Part 14: Pacific Basins in Oregon and Lower Columbia River Basin, U. S. Geological Survey, Washington, D. C.

WATER RESOURCES

Griffin, W. C., Watkins, F. A. Jr., and Swenson, H. A., "Water Resources of the Portland, Oregon, and Vancouver, Washington Area," U. S. Geological Survey Circular 372, 1956.

Harris, D. D., and Williams, R. C., "Streamflow, Sediment-Transport, and Water Temperature Characteristics of Three Small Watersheds in the Alsea River Basin, Oregon," U. S. Geological Survey Circular 642, Washington, D. C., 1971.

Larson, D. W., and Donaldson, J. R., "A Compilation of the Lakes in Oregon, with Bibliography," Corvallis Department of Fisheries and Wildlife, Oregon State University Water Resources Research Institute Research Report WRR1-8, August, 1971.

Price, D., "Geology and Water Resources of the Franch Prairie Area, Northern Willamette Valley, Oregon," U. S. Geological Survey Water Supply Paper 637-D, 1930.

Stearns, H. T., "Geology and Water Resources of the Middle Deschutes River Basin, Oregon," U. S. Geological Survey Water Supply Paper 637-D, 1930.

Stearns, H. T., "Geology and Water Resources of the Upper McKenzie Valley, Oregon," U. S. Geological Survey Water Supply Paper 597-D, 1929.

RUNOFF

Busby, M. W., "Annual Runoff in the Conterminous United States," U. S. Geological Survey Hydrologic Investigation Atlas 212, 1968.

Oster, E. A., "Patterns of Runoff in the Willamette Basin Oregon," U. S. Geological Survey Hydrologic Investigation Atlas 247, 1968.

STREAMFLOW, DISCHARGE, TRAVEL RATES

Harris, D. D., "Travel Rates of Water for Selected Streams in the Willamette River Basin, Oregon," U. S. Geological Survey Hydrologic Investigation Atlas HA-273, 1968.

Orem, H. M., "Discharge in the Lower Columbia River Basin, 1928-1965," U. S. Geological Survey Circular 550, 1968.

Searcy, J. K., "Flow Duration Curves, (Manual of Hydrology: Part 2, Low Flow Techniques)," U. S. Geological Survey Water Supply Paper 1542-A, 1959.

WATER QUALITY

Beckers, C. V., Chanberlain, S. G., Grimsrud, G. P., "Quantitative Methods for Preliminary Design of Water Quality Surveillance Systems," EPA Socioeconomic Environmental Studies Series EPA-R5-72-001, November, 1972.

Goerlitz, D. F., and Brown, E.,"Methods for Analysis of Organic Substances in Water," U. S. Geological Survey TWRI Book 5, 1972.

Hem, J. D., "Reference for Water Quality Investigations," WSP 1473: Study and Interpretation of the Chemical Characteristics of Natural Water (Second Edition). 1970.

Rainwater, F., H., and Thatcher, L. L., "Methods for Collection and Analysis of Water Samples," U. S. Geological Survey Water Supply Paper 1454, 1960.

Vanderholm, D. H., and Ward, R. C., "Data Acquisition for Water Quality Management--An Analysis of Traditional Grab Sampling Methods," Iowa State University, Ames, Iowa, In: Watersheds in Transition, Proceedings of Symposium held at Fort Collins, Colorado, June 19-22, 1972; Urbana, Illinois American Water Resources Association Proceedings Series No. 14, pp. 107-112, 1972.

Petri, L. R., "Need for Water Quality Data in Planning Water Resource Developments." Proceedings National Symposium on Data and Instrumentation for Water Quality Management Conference of State Sanitary Engineers, Wisconsin University, July 21,23, 1970.

Thomann, R. V., "Lessons to be Learned When Collecting Valid Data." Proceedings National Symposium on Data and Instrumentation for Water Quality Management Conference of State Sanitary Engineers, Wisconsin University, July 21-23, 1970.

U. S. Geological Survey, "Techniques of Water Resource Investigation," Book 5.

Rainwater, F. H., and Thatcher, L. L., "Methods for the Collection and Analysis of Water Samples," U. S. Geological Survey Water Supply Paper No. 1454.

Kiltrell, F. W., "A Practical Guide to Water Quality Studies of Streams," USDI, FWPCA, 1969.

Hern, J. D., "Study and Interpretation of the Chemical Characteristics of Natural Water," U. S. Geological Survey Water Supply Paper No. 1473, 1970.

SUSPENDED SEDIMENT AND SEDIMENT LOAD

Porterfield, G., "Computation of Fluvial-Sediment Discharge," U. S. Geological Survey, TWRI Book 3.

Colby, B. R. and Hubbell, D. W., "Simplified Methods for Computing Total Sediment Discharge with the Modified Einstein Procedure," U. S. Geological Survey Water Supply Paper 1593, 1961.

Guy, H. P., "Fluvial Sediment Concepts," U. S. Geological Survey TWR I Book 3, 1970.

Guy, H. P., "Laboratory Theory and Methods for Sediment Analysis," U. S. Geological Survey TWRI Book 5, 1969.

Guy, H. P., and Norman, V. W., "Field Methods for Fluvial Sediment Measurements," U. S. Geological Survey TWRI Book 3, 1970.

Colby, B. R. and Hubbell, D. W., "Simplified Methods for Computing Total Sediment Discharge with the Modified Einstein Procedure" U. S. Geological Survey Water Supply Paper No. 1593.

Guy, J. P., "Fluvial Sediment Concepts," U. S. Geological Survey Techniques of Water Resources Inv., Book 3, Chapter C1, 55 pp., 1970.

"Laboratory Theory and Methods for Sediment Analysis," U.S. Geological Survey Techniques of Water Resources Inv., Book 5, 1969.

Guy, H. P., and Norman, V. W., "Field Methods for Measurement of Fluvial Sediment," U. S. Geological Survey Techniques of Water Resources Inv., Book 3, 1970.

Ritter, J. R. and Helley, E. J., "Optical Method for Determining Particle Sizes of Coarse Sediment," U. S. Geological Survey Techniques of Water Resources Inv., Book 5, 1969.

U. S. Inter-Agency Committee on Water Resources, Subcommittee on Sedimentation, A Study of Methods Used in Measurement and Analysis of Sediment Loads in Streams, published by the St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minnesota.

Sheppard, J. R., "Methods and Their Suitability for Determining Total Sediment Quantities," Proc. of the Federal Inter-Agency Sedimentation Conference, 1963, AR S Special Publication No. 970, pp. 273-287, 1965.

Zernial, G. A. and Laursen, E. M.: "Sediment-Transporting Characteristics of Streams," ASCE HY 1:117, 1963.

HYDROLOGY

Buchanan, T. J., and Somer, W. P., "State Measurements at Gaging Stations," U.S. Geological Survey, TWRI Book 3, 1968.

Buchanan, T. J., and Somers, W. P., "Discharge Measurements at Gaging Stations," U.S. Geological Survey, TWRI Book 3, 1969.

Carter, R. W. and Davidian, J., "General Procedure for Gaging Streams," U.S. Geological Survey, TWRI Book 3, 1968.

Corbet, D. M., et al., "Stream Gauging Procedure, A Manual Describing Methods and Practice of the Geological Survey," U. S. Geological Survey Water Supply Paper 888, 1943.

Dalrymple, T., and Benson, M. A., "Measurement of Peak Discharge by the Slope Area Method," U. S. Geological Survey, TWRI Book 3, 1967.

Friday, J., "Crest State Gaging Stations in Oregon," U. S. Geological Survey Open File Report, 1966.

Garber, M. S., and Koopman, F. C., "Methods of Measuring Water Levels in Deep Wells," U. S. Geological Survey, TWRI Book 8, 1968.

Harris, D. D., Sanderson, R. B., "Use of Dye Tracers to Collect Hydrolic Data in Oregon," American Water Resources Association, Water Resources Bulletin, 4(2): 51-68, 1968.

Hulsing, H., "Measurement of Peak Discharge at Dams by Indirect Methods," U. S. Geological Survey TWRI Book 3, 1967.

Jenkins, C. T., "Computation of Rate and Volume of Stream Depletion by Wells," U. S. Geological Survey, TWRI Book 4, 1968.

Pinder, G. F., " A Digital Model for Aquifer Evaluation," U. S. Geological Survey, TWRI Book 7, 1970.

Riggs, H. C., "Frequency Curves," U. S. Geological Survey, TWRI Book 4, 1968.

Riggs, H. C., "Low-Flow Investigations," U. S. Geological Survey TWRI Book 4, 1972.

Riggs, H. C., "Some Statistical Tools in Hydrology," U.S. Geological Survey, TWRI Book 4, 1968.

Riggs, H. C. and Haridosn, C. H., "Storage Analyses for Water Supply," U. S. Geological Survey, TWRI Book 4, 1973.

Smoot, G. C. and Novak, C. E., "Measurement of Discharge by Moving-Boat Method," U. S. Geological Survey, TWRI Book 3, 1969.

Soil Conservation Service, "Section 4, Hydrology," SCS National Engineering Handbook, U.S.D.A., 1971.

MODELS

Baca, R. G., Brandstetter, A., and Dakan, R. B., "A Computer Similation Model for Prediction of Sediment Transport in Rivers and Reservoirs," Battelle Pacific Northwest Laboratories, June 1973.

Bowers, C. E., Pabst, A. F., and Larson, S. P., "Computer Programs in Hydrology," Water Resources Research Catalog Bulletin 44, University of Minnesota Graduate School, 1972.

Chen, C. W., and Orlob, G. T., "Ecologic Simulation for Aquatic Environments," Water Resources Engineers, Inc., OWRRC-2044, 1972.

Fountaine, D. G., Bohan, J. P., and Grace, J. L., Jr. "Mathematical Simulati of the Turbidity Structure Within an Impoundment," Research Report H-73-2, U. S. Army Engineers Waterways Experiment Station Hydraulics Laboratory, Vicksburg, Mississippi.

SEDIMENTATION

Columbia Basin Inter-Agency Committee, "Inventory of Published and Unpublished Sediment-Load Data in the Pacific Northwest," 1961, Water Supply and Water Pollution Control Subcommittee, BCIAC, Portland, Oregon, 1962.

Flaxman, E. M., and High, R. D., "Sedimentation in Drainage Basins of the Pacific Coast States," U. S. Department of Agriculture, Soil Conservation Service, Portland, Oregon 1955.

Fredricksen, R. L., "Sedimentation after Logging Road Construction in a Small Western Oregon Watershed," Federal Inter-Agency Sedimentation Conference, Jackson, Mississippi, Proceedings, pp. 56-69, 1963.

U.S. Corps of Engineers, Report on Sedimentation Survey of Cottage Grove Reservoir, Coast Fork Willamette River, Oregon. Portland, Oregon, 1949.

U.S. Corps of Engineers, Report on Sedimentation Survey of Fern Ridge Reservoir, Long Tom River, Oregon. Portland, Oregon, 1949.

U. S. Corps of Engineers, Report on Sedimentation, Willamette River Basin, Oregon. Portland, Oregon, 1954.

U. S. Corps of Engineers, Report on Silting in Dorena Reservoir, Row River, Oregon. Portland, Oregon, 1958.

Williams, R. C., "Sedimentation in Three Small Forested Drainage Basins in the Alsea River Basin, Oregon," U. S. Geological Survey Circular 490.

GENERAL

Brohl, R. E., "Design Considerations for Agricultural Drains on the Columbia Basin Project," U. S. Bureau of Reclamation Paper No. 71-242, American Society Agriculture Engineers 1971 Annual Meeting, Pullman, Washington, June, 1971.

Heady, E. O., Madsen, H. C., Nicol, K. J., and Hargrive, S. H., Agricultural Water Demands, Future Water and Land Use: Effects of Selected Public Agricultural and Irrigation Policies on Water Demand and Land Use., Center for Agricultural and Rural Development, Iowa State University, November 1971.

Pacific Northwest River Basins Commission, "Irrigation, Appendix IX," Columbia-North Pacific Framework Study, February, 1971.

Wadleigh, D. H., "1968 Wastes in Relation to Agriculture and Forestry," Miscellaneous Publication No. 1064, U.S. Department of Agriculture, U.S. Government Printing Office, Washington, D. C.

IRRIGATION AND RUNOFF

Skogerboe, G. V., Sahni, V. T., and Walker, W. R., Selected Irrigation Return Flow Quality Abstracts 1968-1969. Colorado State University, Fort Collins, Colorado.

Skogerboe, G. V., and Law, J. P., Research Needs for Irrigation Return Flow Quality Control. Colorado State University, Fort Collins, Colorado, and Robert S. Kerr, Water Research Center, Environmental Protection Agency, Ada, Oklahoma.

Soil Conservation Service, "Section 4, Hydrology," Soil Conservation Service National Engineering Handbook, U. S. Soil Conservation Service Manual.

Wischmeier, W. H., and Smith, D. D., "Predicting Rainfall Erosion Losses from Cropland, Etc.," U. S. Department of Agriculture Handbook 282, 1965.

FORESTRY

Groman, W. A., Forest Fertilization—A State of the Art Review and Description of Environmental Effects, NERC, Environmental Protection Agency, Corvallis, Oregon.

Northwest Region, FWPCA, "Industrial Waste Guide on Logging Practices," NTIS - PB 207 644, Portland, Oregon.

Oregon State University, Studies on Effects of Watershed Practices on Streams, Corvallis, Oregon.

Brown, G. W., "Logging and Water Quality in the Pacific Northwest," National Symposium on Watersheds in Transition.

ANIMAL WASTES

School of Agricultural and Life Sciences, Role of Animal Wastes in Agricultural Land Runoff. North Carolina State University, Raleigh, North Carolina, NTIS-PB 209 213.

Texas Technical University. Characteristics of Wastes from Southwestern Cattle Feedlots, Texas Technical University, Lubbock, Texas.

APPENDIX B

SELECTED WATER QUALITY CRITERIA

TABLE B-1

SURFACE WATER CRITERIA FOR PUBLIC WATER SUPPLIES*

Constituent or characteristic	Permissible criteria	Desirable criteria	Paragraph
Physical:			
Color (color units)	75	<10	1
Odor	Narrative	Virtually absent	2
Temperature •	do	Narrative	3
Turbidity	do	Virtually absent	4
Microbiological:			
Coliform organisms	10,000/100 ml [1]	<100/100 ml [1]	5
Fecal coliforms	2,000/100 ml [1]	<20/100 ml [1]	5
Inorganic chemicals:	(mg/l)	(mg/l)	
Alkalinity	Narrative	Narrative	6
Ammonia	0.5 (as N)	<0.01	7
Arsenic •	0.05	Absent	8
Barium •	1.0	do	8
Boron •	1.0	do	9
Cadmium •	0.01	do	8
Chloride •	250	<25	8
Chromium,• hexavalent	0.05	Absent	8
Copper •	1.0	Virtually absent	8
Dissolved oxygen	≥4 (monthly mean) ≥3 (individual sample)	Near saturation	10
Fluoride •	Narrative	Narrative	11
Hardness •	do	do	12
Iron (filterable)	0.3	Virtually absent	8
Lead •	0.05	Absent	8
Manganese • (filterable)	0.05	do	8
Nitrates plus nitrites •	10 (as N)	Virtually absent	13
pH (range)	6.0–8.5	Narrative	14
Phosphorus •	Narrative	do	15
Selenium •	0.01	Absent	8
Silver •	0.05	do	8
Sulfate •	250	<50	8
Total dissolved solids • (filterable residue).	500	<200	16
Uranyl ion •	5	Absent	17
Zinc •	5	Virtually absent	8
Organic chemicals:			
Carbon chloroform extract • (CCE)	0.15	<0.04	18
Cyanide •	0.20	Absent	8
Methylene blue active substances •	0.5	Virtually absent	19
Oil and grease •	Virtually absent	Absent	20
Pesticides:			
Aldrin •	0.017	do	21
Chlordane •	0.003	do	21
DDT •	0.042	do	21
Dieldrin •	0.017	do	21
Endrin •	0.001	do	21
Heptachlor •	0.018	do	21
Heptachlor epoxide •	0.018	do	21
Lindane •	0.056	do	21
Methoxychlor •	0.035	do	21
Organic phosphates plus carbamates.•	0.1 [2]	do	21
Toxaphene •	0.005	do	8
Herbicides:			
2,4-D plus 2,4,5-T, plus 2,4,5-TP •	0.1	do	21
Phenols •	0.001	do	8
Radioactivity:	(pc/l)	(pc/l)	
Gross beta •	1,000	<100	8
Radium-226 •	3	<1	8
Strontium-90 •	10	<2	8

• The defined treatment process has little effect on this constituent.

[1] Microbiological limits are monthly arithmetic averages based upon an adequate number of samples. Total coliform limit may be relaxed if fecal coliform concentration does not exceed the specified limit.

[2] As parathion in cholinesterase inhibition. It may be necessary to resort to even lower concentrations for some compounds or mixtures. See par. 21.

*Committee on Water Quality Criteria, op. cit.

TABLE B-2

MAJOR CHEMICAL CONSTITUENTS IN WATER--THEIR SOURCES, CONCENTRATIONS, AND EFFECTS UPON USABILITY

Constituent	Major sources	Concentration in natural water	Effect upon usability of water
Silica (SiO_2)	Feldspars, ferromagnesium and clay minerals, amorphous silicachert, opal.	Ranges generally from 1.0 to 30 ppm, although as much as 100 ppm is fairly common, as much as 4,000 ppm is found in brines.	In the presence of calcium and magnesium, silica forms a scale in boilers and on steam turbines that retards heat; the scale is difficult to remove. Silica may be added to soft water to inhibit corrosion of iron pipes.
Iron (Fe)	1. *Natural sources:* Igneous rocks: Amphiboles, ferromagnesian micas, ferrous sulfide (FeS), ferric sulfide or iron pyrite (FeS_2), magnetite (Fe_3O_4). Sandstone rocks: Oxides, carbonates, and sulfides or iron clay minerals. 2. *Manmade sources:* Well casing, piping, pump parts, storage tanks, and other objects of cast iron and steel which may be in contact with the water. Industrial wastes.	Generally less than 0.50 ppm in fully aerated water. Ground water having a pH less than 8.0 may contain 10 ppm; rarely as much as 50 ppm may occur. Acid water from thermal springs, mine wastes, and industrial wastes may contain more than 6,000 ppm.	More than 0.1 ppm precipitates after exposure to air; causes turbidity, stains plumbing fixtures, laundry and cooking utensils, and imparts objectionable tastes and colors to foods and drinks. More than 0.2 ppm is objectionable for most industrial uses.
Manganese (Mn)	Manganese in natural water probably comes most often from soils and sediments. Metamorphic and sedimentary rocks and mica biotite and amphibole hornblende minerals contain large amounts of manganese.	Generally 0.20 ppm or less. Ground water and acid mine water may contain more than 10 ppm. Reservoir water that has "turned over" may contain more than 150 ppm.	More than 0.2 ppm precipitates upon oxidation; causes undesirable tastes, deposits on foods during cooking, stains plumbing fixtures and laundry, and fosters growths in reservoirs, filters, and distribution systems. Most industrial users object to water containing more than 0.2 ppm.
Calcium (Ca)	Amphiboles, feldspars, gypsum, pyroxenes, aragonite, calcite, dolomite, clay minerals.	As much as 600 ppm in some western streams; brines may contain as much as 75,000 ppm.	Calcium and magnesium combine with bicarbonate, carbonate, sulfate and silica to form heat-retarding, pipe-clogging scale in boilers and in other heat exchange equipment. Calcium and magnesium combine with ions of fatty acid in soaps to form soap suds; the more calcium and magnesium, the more soap required to form suds. A high concentration of magnesium has a laxative effect, especially on new users of the supply.
Magnesium (Mg)	Amphiboles, olivine, pyroxenes, dolomite, magnesite, clay minerals.	As much as several hundred parts per million in some western streams; ocean water contains more than 1,000 ppm, and brines may contain as much as 57,000 ppm.	
Sodium (Na)	Feldspars (albite); clay minerals; evaporites, such as halite (NaCl) and mirabilite ($Na_2SO_4 \cdot 10H_2O$); industrial wastes.	As much as 1,000 ppm in some western streams; about 10,000 ppm in sea water; about 25,000 ppm in brines.	More than 50 ppm sodium and potassium in the presence of suspended matter causes foaming, which accelerates scale formation and corrosion in boilers. Sodium and potassium carbonate in recirculating cooling water can cause deterioration of wood in cooling towers. More than 65
Potassium (K)	Feldspars (orthoclase and microcline), feldspathoids, some micas, clay minerals.	Generally less than about 10 ppm; as much as 100 ppm in hot springs; as much as 25,000 ppm in brines.	

TABLE B-2 (Continued)

Constituent	Major sources	Concentration in natural water	Effect upon usability of water
			ppm of sodium can cause problems in ice manufacture.
Carbonate (CO_3)	Limestone, dolomite.	Commonly 0 ppm in surface water; commonly less than 10 ppm in ground water. Water high in sodium may contain as much as 50 ppm of carbonate.	Upon heating, bicarbonate is changed into steam, carbon dioxide, and carbonate. The carbonate combines with alkaline earths—principally calcium and magnesium—to form a crustlike scale of calcium carbonate that retards flow of heat through pipe walls and restricts flow of fluids in pipes. Water containing large amounts of bicarbonate and alkalinity are undesirable in many industries.
Bicarbonate (HCO_3)		Commonly less than 500 ppm; may exceed 1,000 ppm in water highly charged with carbon dioxide.	
Sulfate (SO_4)	Oxidation of sulfide ores; gypsum; anhydrite; industrial wastes.	Commonly less than 1,000 ppm except in streams and wells influenced by acid mine drainage. As much as 200,000 ppm in some brines.	Sulfate combines with calcium to form an adherent, heat retarding scale. More than 250 ppm is objectionable in water in some industries. Water containing about 500 ppm of sulfate tastes bitter; water containing about 1,000 ppm may be cathartic.
Chloride (Cl)	Chief source is sedimentary rock (evaporites); minor sources are igneous rocks. Ocean tides force salty water upstream in tidal estuaries.	Commonly less than 10 ppm in humid regions; tidal streams contain increasing amounts of chloride (as much as 19,000 ppm) as the bay or ocean is approached. About 19,300 ppm in sea water; and as much as 200,000 ppm in brines.	Chloride in excess of 100 ppm imparts a salty taste. Concentrations greatly in excess of 100 ppm may cause physiological damage. Food processing industries usually require less than 250 ppm. Some industries—textile processing, paper manufacturing, and synthetic rubber manufacturing—desire less than 100 ppm.
Fluoride (F)	Amphiboles (hornblende), apatite, fluorite, mica.	Concentrations generally do not exceed 10 ppm in ground water or 1.0 ppm in surface water. Concentrations may be as much as 1,600 ppm in brines.	Fluoride concentration between 0.6 and 1.7 ppm in drinking water has a beneficial effect on the structure and resistance to decay of children's teeth. Fluoride in excess of 1.5 ppm in some areas causes "mottled enamel" in children's teeth. Fluoride in excess of 6.0 ppm causes pronounced mottling and disfiguration of teeth.
Nitrate (NO_3)	Atmosphere; legumes, plant debris, animal excrement, nitrogenous fertilizer in soil and sewage.	In surface water not subjected to pollution, concentration of nitrate may be as much as 5.0 ppm but is commonly less than 1.0 ppm. In ground water the concentration of nitrate may be as much as 1,000 ppm.	Water containing large amounts of nitrate (more than 100 ppm) is bitter tasting and may cause physiological distress. Water from shallow wells containing more than 45 ppm has been reported to cause methemoglobinemia in infants. Small amounts of nitrate help reduce cracking of high-pressure boiler steel.
Dissolved solids	The mineral constituents dissolved in water constitute the dissolved solids.	Surface water commonly contains less than 3,000 ppm; streams draining salt beds in arid regions may contain in excess of 15,000 ppm. Ground water commonly contains less than 5,000 ppm; some brines contain as much as 300,000 ppm.	More than 500 ppm is undesirable for drinking and many industrial uses. Less than 300 ppm is desirable for dyeing of textiles and the manufacture of plastics, pulp paper, rayon. Dissolved solids cause foaming in steam boilers; the maximum permissible content decreases with increases in operating pressure.

TABLE B-3 PESTICIDES

(48-hour TL_m values from static bioassay, in micrograms per liter.** Exceptions are noted.)

Pesticide	Stream invertebrate[1] Species	TL_m	Cladocerans[2] Species	TL_m	Fish[3] Species	TL_m	Gammarus lacustris,[4] TL_m
Abate	Pteronarcys californica.	100			Brook trout	1,500	640
Aldrin[5]	P. californica	8	Daphnia pulex.	28	Rainbow trout.	3	12,000
Allethrin	P. californica	28	D. pulex	21	do	19	20
Azodrin					do	7,000	
Aramite			D. magna	345	Bluegill	35	100
Baygon[5]	P. californica	110			Fathead	25	50
Baytex[5]	P. californica	130	Simocephalus serrulatus.	3.1	Brown t.	80	70
Benzene hexachloride (lindane).	P. californica	8	D. pulex	460	Rainbow t.	18	88
Bidrin	P. californica	1,900	D. pulex	600	do	8,000	790
Carbaryl (sevin)	P. californica	1.3	D. pulex	6.4	Brown t.	1,500	22
Carbophenothion (trithion).			D. magna	0.009	Bluegill	225	28
Chlordane[5]	P. californica	55	S. serrulatus	20	Rainbow t.	10	80
Chlorobenzilate			S. serrulatus	550	do	710	
Chlorthion			D. magna	4.5			
Coumaphos			D. magna	1			0.14
Cryolite			D. pulex	5,000	Rainbow t.	47,000	
Cyclethrin			D. magna	55			
DDD (TDE)[5]	P. californica	1,100	D. pulex	3.2	Rainbow t.	9	1.8
DDT[5]	P. californica	19	D. pulex	0.36	Bass	2.1	2.1
Delnav (dioxathion)					Bluegill	14	690
Delmeton (systex)				14	do	81	
Diazinon[5]	P. californica	60	D. pulex	0.9	do	30	500
Dibrom (naled)	P. californica	16	D. pulex	3.5	Brook t.	78	160
Dieldrin[5]	P. californica	1.3	D. pulex	240	Bluegill	3.4	1,000
Dilan			D. magna	21	do	16	600
Dimethoate (cygon).	P. californica	140	D. magna	2,500	do	9,600	400
Dimethrin					Rainbow t.	700	
Dichlorvos[5] (DDVP)	P. californica	10	D. pulex	0.07	Bluegill	700	1
Disulfoten (di-syston)	P. californica	18			do	40	70
Dursban	Peteronareella badia	1.8			Rainbow t.	20	0.4
Endosulfan (thiodan)	P. californica	5.6	D. magna	240	do	1.2	64
Endrin[5]	P. californica	0.8	D. pulex	20	Bluegill	0.2	4.7
EPH			D. magna	0.1	do	17	36
Ethion	P. californica	14	D. magna	0.01	do	230	3.2
Ethyl guthion[5]			D. pulex		Rainbow t.		
Fenthion	P. californica	39	D. pulex	4			
Guthion[5]	P. californica	8	D. magna	0.2	Rainbow t.	10	0.3
Heptachlor[5]	P. badia	4	D. pulex	42	do	9	100
Kelthane (dicofel)	P. californica	3,000	D. magna	390	do	100	
Kepone					do	37.5	
Malathion[5]	P. badia	6	D. pulex	1.8	Brook t.	19.5	1.8
Methoxychlor[5]	P. californica	8	D. pulex	0.8	Rainbow t.	7.2	1.3
Methyl parathion[5]			D. magna	4.8	Bluegill	8,000	
Morestan	P. californica	40			do	96	
Ovex	P. californica	1,500			do	700	
Paradichlorobenzene					Rainbow t.	880	
Parathion[5]	P. californica	11	D. pulex	0.4	Bluegill	47	6
Perthane			D. magna	9.4	Rainbow t.	7	
Phosdrin[5]	P. californica	9	D. pulex	0.16	do	17	310
Phosphamidon	P. californica	460	D. magna	4	do	8,000	3.8
Pyrethrins	P. californica	64	D. pulex	25	do	54	18
Rotenone	P. californica	900	D. pulex	10	Bluegill	22	350
Strobane[5]	P. californica	7			Rainbow t.	2.5	
Tetradifon (tedion)					Bluegill	1,100	140
TEPP[5]					Fathead	390	52
Thanite			D. magna	450			
Thimet					Bluegill	5.5	70
Toxaphene[5]	P. californica	7	D. pulex	15	Rainbow t.	2.8	70
Trichlorofon (dipterex).[5]	P. badia	22	D. magna	8.1	do	160	60
Zectran	P. californica	16	D. pulex	10	do	8,000	76

*"Water Quality Criteria." Nat. Tech. Advisory Comm., FWPCA, April 1968.

**TL_m is concentration at which 50% of test species died within 48 hours.

TABLE B-3 (Continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS, ALGICIDES

Pesticide	Stream Invertebrate [1] Species	TLm	Cladocerans [2] Species	TLm	Fish [3] Species	TLm	Gammarus lacustris,[4] TLm
Ametryne					Rainbow t.	3,400	
Aminotriazole							
Aquathol					Bluegill	257	
Atrazine			Daphnia magna.	3,600	Rainbow t.	12,600	
Azide, potassium					Bluegill	1,400	10,000
Azide, sodium					do	980	9,000
Copper chloride					do	1,100	
Copper sulfate					do	150	
Dichlobenil	Pteronarcys californica.	44,000	Daphnia pulex.	3,700	do	20,000	1,500
2,4-D, PGBEE			D. pulex	3,200	Rainbow t.	960	1,800
2,4-D, BEE	P. californica	1,800			Bluegill	2,100	760
2,4-D, isopropyl					do	800	
2,4-D, butyl ester					do	1,300	
2,4-D, butyl + isopropyl ester.					do	1,500	
2,4,5-T isooctyl ester					do	16,700	
2,4,5-T isopropyl ester					do	1,700	
2,4,5-T PGBE					do	560	
2(2,4-DP) BEE					do	1,100	
Dalapon	P. californica Very low toxicity		D. magna	6,000	Very Low toxicity.		
Dead-X	P. californica	5,000	D. pulex	3,700	Rainbow t.	9,400	5,600
DEF	P. californica	2,300			Bluegill	36	230
Dexon	P. californica	42,000			Bluegill	23,000	6,000
Dicamba					non-tox.		5,800
Dichlone			D. magna	26	Rainbow t.	48	11,500
Difolitan	P. californica	150			Channel Cat.	31	6,500
Dinitrocresol	P. californica	560			Rainbow t.	210	
Diquat					do	12,300	
Diuron	P. californica	2,800	D. pulex	1,400	do	4,300	380
Du-ter					Bluegill	33	
Dyrene			D. magna	490		15	
Endothal, copper					Rainbow t.	290	
Endothal, dimethylamine.					do	1,150	
Fenac, acid	P. californica	70,000			do	16,500	
Fenac, sodium	P. californica	80,000	D. pulex	4,500	do	7,500	18,000
Hydram (molinate)	P. californica	3,500			do	290	
Hydrothol 191					do	690	1,000
Lanstan (korax)					do	100	5,500
LFN					do	79	
Paraquat	P. californica Very low toxicity		D. pulex	3,700	Very low toxicity.		18,000
Propazine					Rainbow t.	7,800	
Silvex, PGBEE			D. pulex	2,000	do	650	
Silvex, isoctyl					Bluegill	1,400	
Silvex, BEE					do	1,200	
Simazine	P. californica	50,000			Rainbow t.	5,000	21,000
Sodium arsenite	P. californica Very low toxicity		Simocephalus serrulatus.	1,400	do	36,500	
Tordon (picloram)					do	2,500	48,000
Trifuralin	P. californica	4,200	D. pulex	240	do	11	5,600
Vernam [5] (vernolate)					do	5,900	25,000

[1] Stonefly bioassay was done at Denver, Colo., and at Salt Lake City, Utah. Denver tests were in soft water (35 mg/l TDS), non-aerated, 60 F. Salt Lake City tests were in hard water (150 mg/l TDS), aerated, 48-50 F. Response was death.

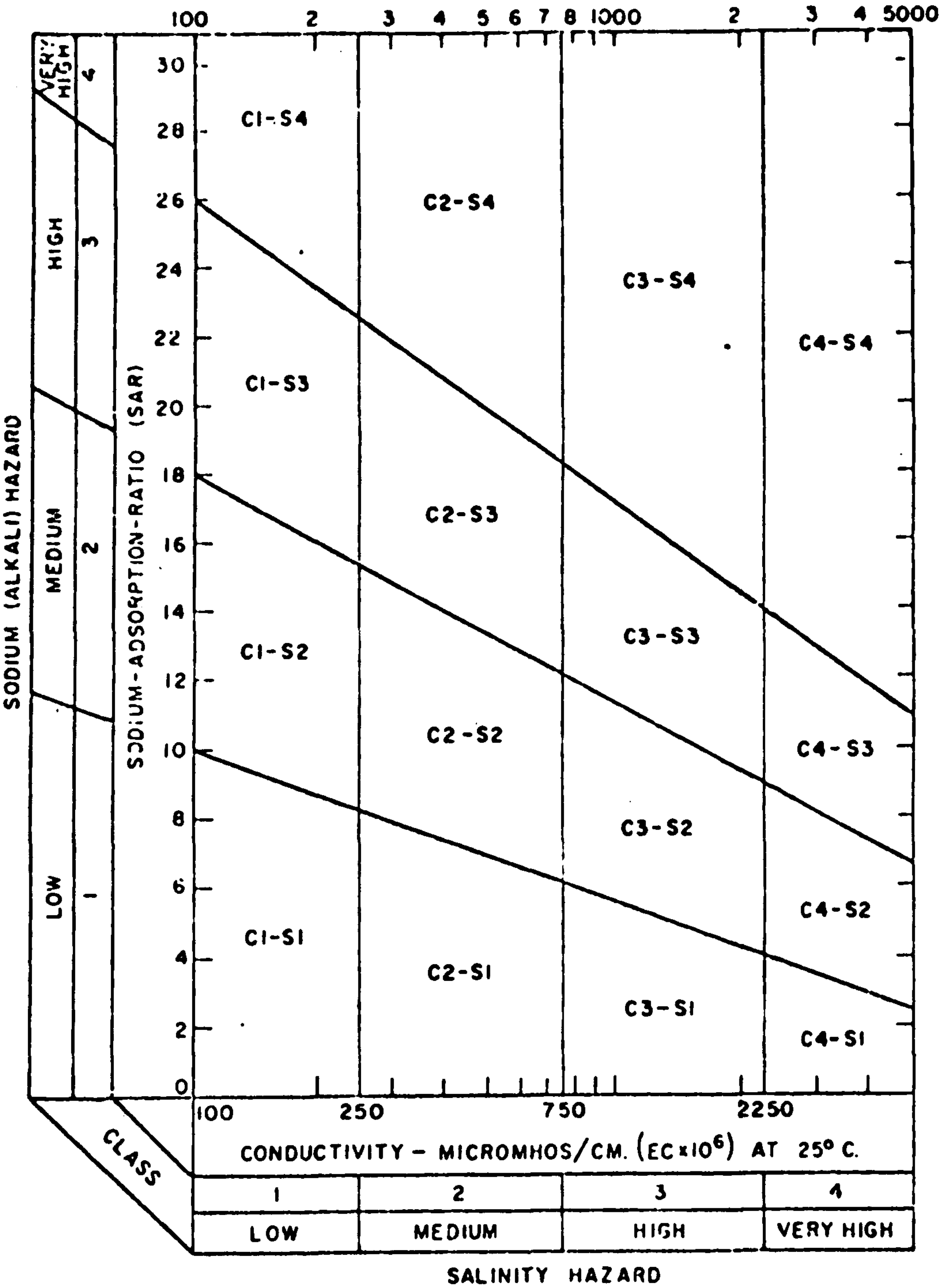
[2] Daphnia pulex and Simocephalus serrulatus bioassay was done at Denver, Colo., in soft water (35 mg/l TDS), non-aerated, 60 F. Daphnia magna bioassay was done at Pennsylvania State University in hard water (146 mg/l TDS), non-aerated, 68 F. Response was immobilization.

[3] Fish bioassay was done at Denver, Colo., and at Rome, N.Y. Denver tests were with 2-inch fish in soft water (35 mg/l TDS), non-aerated; trout at 55 F; other species at 65 F. Rome tests were with 2-2½ inch fish in soft water (6 mg/l TA; pH 5.85-6.4), 60 F. Response was death.

[4] Gammarus bioassay was done at Denver, Colo., in soft water (35 mg/l TDS), non-aerated, 60 F. Response was death.

[5] Becomes bound to soil when used according to directions, but highly toxic (reflected in numbers) when added directly to water.

FIGURE B-1. DIAGRAM FOR THE CLASSIFICATION OF IRRIGATION WATERS*



*McKee & Wolfe, "Water Quality Criteria."

TABLE B-4

LIMITS OF BORON IN IRRIGATION WATER

A. Permissible Limits
(Boron in parts per million)

Class of water	Crop Group		
	Sensitive	Semitolerant	Tolerant
Excellent	< 0.33	< 0.67	< 1.00
Good	0.33 to 0.67	0.67 to 1.33	1.00 to 2.00
Permissible	0.67 to 1.00	1.33 to 2.00	2.00 to 3.00
Doubtful	1.00 to 1.25	2.00 to 2.50	3.00 to 3.75
Unsuitable	> 1.25	> 2.50	> 3.75

B. Crop Groups of Boron Tolerance
(In each group, the plants first named are considered as being more tolerant; the last named, more sensitive.)

Sensitive	Semitolerant	Tolerant
Pecan	Sunflower (native)	Athel *(Tamarix aphylla)*
Walnut (Black; and Persian, or English)	Potato	Asparagus
Jerusalem-artichoke	Cotton (Acala and Pima)	Palm *(Phoenix canariensis)*
Navy bean	Tomato	Date palm *(P. dactylifera)*
American elm	Sweetpea	Sugar beet
Plum	Radish	Mangel
Pear	Field pea	Garden beet
Apple	Ragged Robin rose	Alfalfa
Grape (Sultanina and Malaga)	Olive	Gladiolus
Kadota fig	Barley	Broadbean
Persimmon	Wheat	Onion
Cherry	Corn	Turnip
Peach	Milo	Cabbage
Apricot	Oat	Lettuce
Thornless blackberry	Zinnia	Carrot
Orange	Pumpkin	
Avocado	Bell pepper	
Grapefruit	Sweet potato	
Lemon	Lima bean	

TABLE B-5

MAXIMUM CONCENTRATIONS OF COPPER SULFATE SAFE FOR FISH

Fish	Safe Copper Sulfate Concentration	
	ppm.	*lb./mil. gal.*
Trout	0.14	1.2
Carp	0.30	2.5
Suckers	0.30	2.5
Catfish	0.40	3.5
Pickerel	0.40	3.5
Goldfish	0.50	4.0
Perch	0.75	6.0
Sunfish	1.20	10.0
Black Bass	2.10	17.0

he Water Encyclopedia." D.K. Todd, 1970.

TABLE B-6

GUIDES FOR EVALUATING THE QUALITY OF WATER FOR AQUATIC LIFE

Determination *	Threshold Concentration** Freshwater	Saltwater
Total dissolved solids (TDS), mg/liter	2000†	
Electrical conductivity, μmhos/cm at 25°C	3000†	
Temperature, maximum °C	34	34
Maximum for salmonoid fish	23	23
Range of pH	6.5-8.5	6.5-9.0
Dissolved oxygen (D.O.), minimum mg/liter	5.0††	5.0††
Flotable oil and grease, mg/liter	0	0†
Emulsified oil and grease, mg/liter	10†	10†
Detergent, ABS, mg/liter	2.0	2.0
Ammonia (free), mg/liter	0.5†	
Arsenic, mg/liter	1.0†	1.0†
Barium, mg/liter	5.0†	
Cadmium, mg/liter	0.01†	
Carbon dioxide (free), mg/liter	1.0	
Chlorine (free), mg/liter	0.02	
Chromium, hexavalent, mg/liter	0.05†	0.05†
Copper, mg/liter	0.02†	0.02†
Cyanide, mg/liter	0.02†	0.02†
Fluoride, mg/liter	1.5†	1.5†
Lead, mg/liter	0.1†	0.1†
Mercury, mg/liter	0.01	0.01
Nickel, mg/liter	0.05†	
Phenolic compounds, as phenol, mg/liter	1.0	
Silver, mg/liter	0.01	0.01
Sulfide, dissolved, mg/liter	0.5†	0.5†
Zinc, mg/liter	0.1	

**Threshold concentration is value that normally might not be deleterious to fish life. Waters that do not exceed these values should be suitable habitats for mixed fauna and flora.

† Values not to be exceeded more than 20 percent of any 20 consecutive samples, nor in any 3 consecutive samples. Other values should never be exceeded. Frequency of sampling should be specified.

†† Dissolved oxygen concentrations should not fall below 5.0 mg/liter more than 20% of the time and never below 2.0 mg/liter. (NOTE: Recent data indicate also that rate of change of oxygen tension is an important factor, and that diurnal changes in D.O. may, in sewage-polluted water, render the value of 5.0 of questionable merit.)

* "The Water Encyclopedia," D. K. Todd, 1970.

TABLE B-7

EFFECT OF ALKYL-ARYL SULFONATE, INCLUDING ABS, ON AQUATIC ORGANISMS

Organisms	Concentration (mg/l)	Time	Effect	References
Trout	5.0	26 to 30 hours	Death	Wurtz-Arlet, 1960.
	3.7	24 hours	TL_m	
	5.0		Gill pathology	Schmid and Mann, 1961.
Bluegills	4.2	24 hours	TL_m	Turnbull, et al., 1954.
	3.7	48 hours	TL_m	
	0.86		Safe	
	16.0	30 days	TL_m	Lemke and Mount, 1963.
	5.6	90 days	Gill damage	Cairns and Scheier, 1963.
	17.0	96 hours	TL_m	
Fathead minnows	2.3		Reduced spawning	Pickering, 1966.
	13.0	96 hours	TL_m	Henderson, et al., 1959.
	11.3	96 hours	TL_m	Thatcher, 1966.
Fathead minnow fry	3.1	7 days	TL_m	Pickering, 1966.
Pumpkinseed sunfish	9.8	3 months	Gill damage	Cairns and Scheier, 1964.
Salmon	5.6	3 days	Mortality	Holland, et al., 1960.
Yellow bullheads	1.0	10 days	Histopathology	Bardach, et al., 1965.
Emerald shiner	7.4	96 hours	TL_m	Thatcher, 1966.
Bluntnose minnow	7.7	96 hours	TL_m	Thatcher, 1966.
Stoneroller	8.9	96 hours	TL_m	Thatcher, 1966.
Silver jaw	9.2	96 hours	TL_m	Thatcher, 1966.
Rosefin	9.5	96 hours	TL_m	Thatcher, 1966.
Common shiner	17.0	96 hours	TL_m	Thatcher, 1966.
Carp	18.0	96 hours	TL_m	Thatcher, 1966.
Black bullhead	22.0	96 hours	TL_m	Thatcher, 1966.
"Fish"	6.5		Min. lethality	Leclerc and Devlaminck, 1952.
Trout sperm	10.0		Damage	Mann and Schmid, 1961.
Daphnia	5.0	96 hours	TL_m	Sierp and Thiele, 1954.
	20.0	24 hours	TL_m	Godzch, 1961.
	7.5	96 hours	TL_m	Godzch, 1961.
Lirceus fontinalis	10.0	14 days	6.7 percent survival (hard water).	Surber and Thatcher, 1963.
Crangonyx setodactylus [1]	10.0	14 days	0 percent survival (hard water).	Surber and Thatcher, 1963.
Stenonema ares	8.0	10 days	20–33 percent survival.	Surber and Thatcher, 1963.
	16.0	10 days	0 percent survival	Surber and Thatcher, 1963.
Stenonema heterotarsale	8.0	10 days	40 percent survival	Surber and Thatcher, 1963.
	16.0	10 days	0 percent survival	Surber and Thatcher, 1963.
Isonychia bicolor	8.0	9 days	0 percent survival	Surber and Thatcher, 1963.
Hydropsychidae (mostly cheumatopsyche).	16.0	12 days	37–43 percent survival.	Surber and Thatcher, 1963.
	32.0	12 days	20 percent survival	Surber and Thatcher, 1963.
Orconectes rusticus	16.0	9 days	100 percent survival	Surber and Thatcher, 1963.
	32.0	9 days	0 percent survival	Surber and Thatcher, 1963.
Goniobasis livescens	16.0	12 days	40–80 percent survival.	Surber and Thatcher, 1963.
	32.0	12 days	0 percent survival	Surber and Thatcher, 1963.
Snail	18.0	96 hours	TL_m	Cairns and Scheier, 1964.
	24.0	96 hours	TL_m	Cairns and Scheier, 1964.
Chlorella	3.6		Slight growth reduction.	Maloney, 1966.
Nitzchia linearis	5.8		50 percent reduction in growth in soft water.	Cairns, et al., 1964.
Navicula seminulum	23.0		50 percent reduction in growth in soft water.	Cairns, et al., 1964.

[1] Misidentified originally as Synurella.

*Committee on Water Quality Criteria. *op. cit.*

TABLE B-8

THERMAL DEATH POINTS OF FISH ACCLIMIZED AT THE INDICATED TEMPERATURES

(F=Freshwater, A=Marine-Atlantic, P=Pacific)

Fish	Acclimation Temperature, C	Thermal Death-Point, C	Occurrence
Atlantic salmon	–	29.5-30.5	A-F
Atlantic salmon (grilse)	–	32.5-33.8	F
Atlantic salmon (parr)	–	29.8	F
Blacknose dace	10	28.8	F
Blacknose dace	20	29.3	F
Bluegill	15	30.7	F
Bluegill	20	31.5	F
Bluegill	30	33.8	F
Bluntnose minnow	25	33.3	F
Brook stickleback	25-26	30.6	F
Brook trout	5	23.7	A-F
Brook trout	10	24.4	A-F
Brook trout	15	25	A-F
Brook trout	20	25.3	A-F
Brook trout	25	25.3	A-F
Brown bullhead	15	31.8	F
Brown bullhead	20	33.4	F
Brown bullhead	30	36.5	F
Brown trout	26	26	A-F
Brown trout (fry)	5-6	22.5	F
Brown trout (fry)	20	23	F
Brown trout (yearling)	–	25.9	A-F
Brown trout (parr)	–	29	A-F
Carp	20	31-34	F
Chinook salmon (fry)	15	25	F
Chinook salmon (fry)	20	25.1	F
Chum salmon (fry)	15	23.1	F
Chum salmon (fry)	20	23.7	F
Coho salmon (fry)	15	24.3	F
Coho salmon (fry)	20	25	F
Common shiner	15	30.3	F
Common shiner	30	31.0	F
Creek chub	10	27.3	F
Creek chub	15	29.3	F
Creek chub	25	30.3	F
Emerald shiner	10	26.7	F
Emerald shiner	15	28.9	F
Emerald shiner	25	30.7	F
Fathead minnow	10	28.2	F
Fathead minnow	20	31.7	F
Fathead minnow	30	33.2	F
Gizzard shad	25	34.3	A-F
Gizzard shad	30	35.9	A-F

*"Water Quality Criteria Data Book, Volume III," Environmental Protection Agency, May 1971

TABLE B-8 (Continued)

Fish	Acclimation Temperature, C	Thermal Death-Point, C	Occurrence
Golden shiner	15	30.5	F
Golden shiner	25	33.2	F
Golden shiner	30	34.7	F
Goldfish	10	30.8	F
Goldfish	20	34.8	F
Goldfish	30	38.6	F
Guppy	30	34	F
Largemouth bass	20	32.5	F
Largemouth bass	25	34.5	F
Largemouth bass	30	36.4	F
Mosquito fish	15	35.4	A-F
Mosquito fish	20	37.3	A-F
Mosquito fish	30	37.3	A-F
Opaleye	20	31.4	P
Opaleye	30	31.4	P
Perch	–	23-25	F
Perch	10	25.0	F
Perch	15	27.7	F
Perch	25	29.7	F
Pink salmon (fry)	5	21.3	F
Pink salmon (fry)	10	22.5	F
Pink salmon (fry)	20	23.9	F
Pumpkinseed	25-26	34.5	F
Rainbow trout	–	28	A-F-P
Rainbow trout (Kamloops var)	11	24	P-F
Roach	20	29.5	F
Roach	25	30.5	F
Roach	30	31.5	F
Sockeye salmon (fry)	5	22.9	F
Sockeye salmon (fry)	10	23.4	F
Sockeye salmon (fry)	20	24.8	F
Tench	–	29-30	F
White sucker	25	29.3	F
Yellow Perch	15	27.7	F

TABLE B-9

MINIMUM OXYGEN VALUES AT VARIOUS TEMPERATURES AT WHICH FISH CAN EXIST UNDER LABORATORY CONDITIONS

Fish	Oxygen, ppm	Temperature, C
Bleak	0.68-1.44	16
Blunt-nosed minnow	2.25	20-26
Brook trout	2.0	10
Brook trout	2.2	15
Brook trout	2.5	20
Brook trout	1.52	3.5
Brook trout	2.4	23
Brook trout	2.5	19-20
Brook trout	1.35-2.35	15.6
Brown bullhead	0.3	30
Brown trout	1.13	6.4
Brown trout	1.16	9.5-10
Brown trout	2.13	18
Brown trout	2.8	24
Brown trout	1.28-1.6	9.4
Brown trout	1.64-2.48	17.2
Brown trout	2.9	–
Carp	1.1	30
Carp (mirror)	0.59-2.5	16
Coho salmon	1.3	16
Coho salmon	1.4	20
Coho salmon	2.0	24
Dace	0.57-1.1	16
Eel	1.0	17
Goldfish	0.5	10
Goldfish	0.6	20
Goldfish	0.7	30
Perch	1.1-1.3	16
Rainbow trout	2.4-3.7	16
Rainbow trout	2.5	19-20
Rainbow trout	0.83-1.42	11.1
Rainbow trout	1.05-2.06	18.5
Roach	0.67-0.69	16
Salmon parr	2.0-2.2	8
Smallmouth bass	0.63-0.98	15-16
Steel-colored shiner	2.25	20-26
3-spined stickleback	0.25-0.50	–
Tench	0.35-0.52	16
Yellow perch	2.25	20-26
Yellow perch	0.37-0.88	15.5

* Water Quality Criteria Data Book Volume III op. cit.

APPENDIX C

GLOSSARY

This glossary is reprinted from a pamphlet issued by the Office of the Chief of Engineers, U. S. Army Corps of Engineers.

EP 1105-2-2
30 Nov 73

AN ECOLOGICAL GLOSSARY

FOR

ENGINEERS AND RESOURCE MANAGERS

Prepared By The Institute of
Ecology (TIE) For The U. S.
Army Corps of Engineers

AFFORESTATION - The process of allowing or encouraging the development of forests; in N. America, syn. with reforestation.

ALGAE - Any of a group of chiefly marine or freshwater chlorophyll-bearing aquatic plants with no true leaves, stems or roots. Ranging from microscopic single-cell organisms or colonies (ponduceds) to large macroscopic seaweeds, etc.

ALKALI - A soluble mineral layer present in quantities detrimental to agriculture in some soils of basic pH in arid regions; a soluble mineral (salt) obtained from the ashes of plants and consisting largely of potassium or sodium carbonate.

ALKALINITY - The quality of being alkaline or basic in pH i.e. greater than pH 7. (Opposite to acid).

ALKALIPHOBIC - Avoiding alkaline conditions.

ALLOCHTHONOUS - Of/ material derived from outside habitat or environment under consideration; e.g. allochthonous detritus of a lake is that derived from surrounding terrestrial environment or from influent streams.

ALGAL BLOOM - Rapid and flourishing growth of algae.

ALLOPATRY - Two or more, usually closely related species, not occurring in the same region, i.e., with different geographic distributions or ranges; see sympatry.

ALLUVIAL - Of/ alluvium (q.v.)

ALLUVIUM - Sediments,us.mineral or inorganic, desposited by running water.

ALPINE - at region which is above the montane timberline; charac erized by the presence of herbs and grass-like plants and low, slow-growing shrubs.

AMBIENT - Surrounding on all sides.

AMMONIFICATION - Production of ammonia in decomposition of nitrogen-containing compounds such as proteins.

AMPHIBIAN - Any of a class of vertebrate (q.v.) animals most of which pass through an aquatic larval stage with gills and then through a terrestrial stage with lungs (e.g. salamanders, frogs and toads.)

ANADROMOUS - Of/ fish (such as salmon) which ascend fresh water streams from saltwater to spawn.

ANAEROBIC - Capable of living or active in the absence of air or free oxygen.

ANNUAL - Pertaining to yearly occurrence.

ANNUAL INCREMENT - That which is added or gained in one year.

ANNUAL PLANT - A plant which grows from seed and reproduces in one year.

ANOXIC - Pertaining to conditions of oxygen deficiency.

APHOTIC - Lightless, as below the photic zone (q.v.) in oceans or lakes.

APHOTIC ZONE - The lower portion of bodies of water not reached by light.

AQUACULTURE - Production of food from managed aquatic systems.

AQUATIC - Growing, living in, frequenting or pertaining to marine or fresh water.

AQUATIC HABITAT - A habitat (q.v.) located in water.

AQUIFER - A water bearing stratum of permeable rock, sand or gravel.

ARABLE LAND - Land fit for cultivation.

ARCTIC - of, or characteristic of, the region around the north pole to approximately 65° north latitude; all regions north of the boreal timber line.

ASPECTION - Periodic, i.e. seasonal, changes in the appearance of a group of species, associated with periods of foliation or flowering, which are reflected in the appearnace of the community as a whole or its members (cf. periodicity).

ASSIMILATION - Transformation of absorbed nutrients into body substances.

ASSOCIATION - A definite or characteristic assemblage of plants living together in an area essentially uniform in environmental conditions; any ecological unit of more than one species.

ASSOCIES - An association (q.v.) constituting a temporary stage of plant-succession; a non-climax community to be replaced by another in the process of succession (q.v.).

AUTOCHTHON - A native species; indigenous.

AUTOTROPHIC - The nutrition of these plants that are able to construct organic matter from inorganic.

AUTOTROPHS - Organisms capable of autotrophic (q.v.)growth. See also producers.

AVIFAUNA - The total bird world (all species(q.v.) of birds) of a region.

AZOIC - Without animals (life); of a lifeless region; of/ the part of geologic time before life appeared.

BACTERIA - Any of a class of free-living, parasitic or pathogenic micro-scopic organisms having single-celled or non-cellular bodies; devoid of conventional nuclei; often living in colonies; colloq. microbes.

BASAL AREA - The area of cross section of a tree usually referring to the section at breast height (4 1/2 feet above the ground); or, the summed basal area per acre or larger unit occupied by stems of one species or forest type.

BASELINE PROFILE - Used for a complete survey of the environmental conditions and organisms existing in a region prior to unnatural disturbances.

BASELINE STUDY - See, Baseline profile.

BATHYAL - Of/ lake or ocean bottoms of very deep water, e.g. below 300 meters in a lake or below 5000 m. in the sea.

BATTUE - The beating of woods and bushes to flush game; a hunt.

BEACH - Depositional area at the shore of an ocean or lake covered by mud, sand, gravel or larger rock fragments and extending into the water for some distance.

BEDROCK - The solid rock at the surface or underlying other surface materials.

BENTHIC - Of/ the bottom of lakes or oceans. Of/ organisms which live on the bottom of water bodies.

BENTHOS - Those organisms which live on the bottom of a body of water.

BIG GAME - Large animals especially mammals pursued or taken in hunting.

BIOASSAY - Determination of the physiological effect of a substance (such as a drug) by comparing its effects on a test organ or living organism with that of some standard substance; in contrast to chemical assay or analysis.

BIOCOENOSIS - An ecological unit comprising both the plant and animal populations of a habitat; a biological or biotic community.

BIOCIDE - Any chemi .l or agent that kills organisms.

BIODEGRADABLE - Can be broken down to simple inorganic substances by t action of decay organisms (bacteria or fungi).

BIOLOGICAL DIVERSITY - The number of kinds of organisms pe unit area or volume; the richness of species in a given area.

BIOCHEMICAL OXYGEN DEMAND - The amount of oxygen required to decompose (oxidize) a given amount of organic compounds to simple, stable substances.

BIOLOGICAL CONCENTRATION - The active concentration of a substa :e (molecule or compound) by an organism as a result of normal activities, e.g. abserption or ingestion.

BIOLOGICAL MAGNIFICATION - The step by step concentration of substances in successive levels of food chains (q.v.); commonly reported only for harmful substances.

BIOLOGICAL PROCESSES - Processes characteristic of, or resulting from, the activities of living organisms.

BIOLOGICAL PRODUCTIVITY - see, productivity.

BIOLOGICAL STABILITY - see, stability.

BIOGEOCHEMICAL CYCLING - The movement of chemical elements from the physical environment to organisms in an ecosystem and back to the environment.

BIOMASS - The total weight of matter incorporated into (living and dead) organisms.

BIOME - Any of the major terrestial ecosystems of the world such as tundra, deciduous forest, desert, taiga, etc.

IOSPHERE - That portion of the solid and liquid earth and its atmosphere where living organisms can be and are sustained; "organic nature" in general.

IOTA - All of th named or namable organisms of an area; fauna and flora (= biota) of a region.

IOTIC - Of/ life.

IOTIC SUCCESSION - see, succession.

IOTIC POTENTIAL - The inherent ability of members of a population to grow in numbers within a given time and under stated environmental conditions.

IOTIC COMMUNITY - see community; biotic implies plants and animals.

IOTIC PYRAMID - The set of all food chains (q.v.) or hierarchic arrangments of organisms as eaters and eaten in a prescribed area when tabulated by numbers or by biomasses, usually takes a pyramidal form.

IOTOPE - A segment, us. a small segment, of a habitat (q.v.).

IOTYPE - A genetically homogeneous population composed only of closely similar individuals; a genotypic race or group of organisms.

UFFER - An intermediate region or ecotone (q.v.) between two systems whose presence reduces the effects of one system on the other; a chemical substance which tends to maintain constant pH.

IVALVE - A gastropod having a shell composed of two valves, e.g. a clam.

LOOM - To flower; of algae, to appear or occur suddenly or in large quantity or degree; see, algal bloom.

OG - A quagmire or wet, spongy ground; often a filled-in lake; composed primarily of dead plant tissues (peat); principally mosses.

RACKISH WATER - Water, salty between the concentrations of fresh water and sea water; usually 5-10 parts per thousand.

BROWSE - Shoots, twigs and leaves of trees and shrubs eaten by cattle or other large herbivores, e.g. deer.

CALORIE - (Abbrev. cal.) The heat required (at one atmosphere pressure) to raise the temperature of one gram of water one degree (specifically from 4 to 5 degrees) centigrade. A Calorie (abbrev. K Cal or Cal.) in nutrition, is 1000 calories.

CANOPY - The leafy cover of vegetation, e.g. the uppermost leafy layer in forests.

CARNIVORE - An organism that eats living animals.

CARCINOGEN - A substance or agent producing or inciting cancer.

CARRYING CAPACITY - The maximum population size of a given species in an area beyond which no significant increase can occur without damage occurring to the area.

CATADRAMOUS - Living in fresh water and going to salt water to spawn.

CATHAROBES - The organisms of "pure" water, poor in organic matter.

CHAPARRAL - The climax (q.v.) vegetation generally found in temperate (mediterranean climate) regions which have at least moderate winter rainfall and dry summers; small trees and shrubs characterized by hard, thick evergreen leaves.

CHEMICAL OXYGEN DEMAND - See, Biochemical Oxygen Demand.

CHEMOSYNTHESIS - The process by which some organisms (bacteria) obtain their energy for CO_2 assimilation by the chemical oxidation of simple inorganic compounds (in contrast to photosynthesis).

CHLORINATION - Treatment or combination with chlorine or a chlorine compound.

CHLOROPHYLL - The green, photosynthetic pigments of plants.

CIRCADIAN RHYTHM-The regular repetition of activities (cellular or organismic) at intervals of about 24 hours, even in the absence of regular diurnal cues such as light.

CLIMATE - The average conditions of the weather over a number of years; macroclimate is the climate representative of relatively large area; microclimate is the climate of a small area, particularly that of the living space of a certain species, group or community.

CLIMATIC CLIMAX - A climax (q.v.) in which the regional climate is the controlling factor.

CLIMAX - The final, stable community in an ecological succession (q.v.) which is able to reproduce itself indefinitely under existing conditions.

CLIMAX COMMUNITY - see climax.

CLINE - A continuous series of differences (structural or functional) exhibited by a group of related organisms, usually along a line of geographic or environmental gradient.

CLOSED SYSTEM - An organized assemblage of system objects, in which there is not exchange of material with objects outside of the system.

CLONE - The vegetatively produced,genetically identical, offspring of a single individual.

COACTION - The interaction of organisms with each other.

CODOMINANT - Any of equally dominant forms; one of several species which dominate a community, no one to the exclusion of the others.

COEN (rare) - An organized system which functions to produce a common product or effect.

COLIFORM - Structurally and functionally resembling certain bacteria of the vertebrate intestine called "Bacillus" or Escherichia" coli.

COLIFORM LEVELS - Numbers referring to the density of coliform bacteria in water bodies.

COLLOID - A dispersion of particles larger than small molecules and which do not pass through semi-permeable membranes and do not settle out.

COLLUVIUM - Rock and soil accumulated at the foot of a slope from gravitational forces.

COLONIZING - Of/organisms which occupy areas previously barren; or at least areas presently unoccupied by that species.

COMMUNITY - All of the plants and animals in an area or volume; a complex association usually containing both animals and plants.

COMMUNITY METABOLISM - The combined metabolism (metabolic activity) of all organisms in a given area or community.

COMMUNITY RESPIRATION - The combined respiration of all organisms in a community.

COMPENSATION LEVEL - Depth in a body of water at which the light available is just sufficient to allow enough photosynthesis to balance respiration over an appreciable time.

COMPETITION - Of/ interaction of organisms which utilize common resources in short supply.

CONIFER - Pines, cedars, hemlocks, etc; any of a type of (mostly) evergreen trees and shrubs with (botanically) true cones.

CONJUGATION - The fusion of two similar (i.e. not obviously differentiated) gametes; us. in contrast to fertilization (q.v.)

CONSERVATION - Supervision, management and maintenance of natural resources.

CONSOCIAL (rare)- Of/ plant species found together in a given community.

CONSUMER - An organism that consumes another.

CONSUMER (PRIMARY) - An organism which consumes green plants.

CONSUMER (SECONDARY) - An organism which consumes a primary consumer.(q.v.)

CONTROLLED BURN - Of/ fires used in forest or range management to secure growth and/or reproduction of desired species or to eliminate potentially disastrous fire hazards such as dry, shrubby undergrowth.

COPEPODS - A large subclass of usually minute (0.1 to 5 mm.), mostly pelagic or free-swimming fresh- or salt-water crustaceans (q.v.).

COVER (GROUND COVER) - Vegetation used to reduce wind and water erosion of bare soil.

CRUSTACEAN - A large class of (arthropodan) animals, usually aquatic, bearing a horny shell, such as lobsters, barnacles, shrimps, water fleas, etc.

CRYPTOGAM - A plant which does not produce flowers or true seeds: ferns, mosses, liverworts, and algae.

CYBERNETICS - The study and design of feedback control systems.

CYST - A pouch or sac without an opening, such as a resting spore in certain algae, or bacteria or a parasite walled-off within the body of the host.

DECIDUOUS - Falling off or actively shed at maturity or at certain seasons.

DECOMPOSERS - Those organisms, usually bacteria (q.v.) or fungi, which participate in the breakdown of large molecules associated with organisms. Hence, those organisms which recycle dead organisms.

DELTA - The alluvial deposit at the mouth of a river.

DEMERSAL - Applied to eggs which are heavy and sink to the bottom of a stream or other body of water.

DENITRIFICATION - Chemical conversion of nitrates to molecular (gaseous) nitrogen (N_2) or to nitrous oxide or to ammonia by bacteria or by lightning.

DESICCATION - Drying out; a method by which organisms and their disseminules (q.v.) survive unfavorable periods.

DETRITUS - A non-dissolved product of disintegration or wearing away. Pertains to organic or inorganic matter.

DEVONIAN - Of/ that period of geologic time (or the rocks of that period) marked especially by the major evolution of aquatic vertebrates (q.v.); the "age of fishes".

DIATOM - Any of a class of minute, planktonic or attached unicellular or colonial algae with cases of silica (opal).

DIEL - Referring to the 24 hour daily period; to avoid ambiguity of diurnal (q.v.).

DISSEMINULE - General term for seeds, spores, resting eggs, pelagic eggs or larvae, etc.

DISSOLVED OXYGEN - An amount of gaseous oxygen dissolved in volume of water.

DISCLIMAX - A climax (q.v.) which is the consequence of repeated or continuous disturbance by man, domesticated animals or natural events.

DISTRIBUTION - The geographic range of a species.

DIURNAL - Pertaining to phenomena of daily occurence; of/ that portion of the day in which light occurs.

DIVERSITY - see, biological diversity.

DOMINANCE - The degree of influence (usually inferred from the amount of area covered) that a species exerts over a community.

DOMINANT - An organism that controls the habitat at any stage of development; in practice the organism that is most conspicuous and covers the most area.

DRUMLIN - An elongate or oval hill of glacial drift, molded by moving ice above and at its sides.

DUNE - A hill of drifting sand usually formed on existing or former shores or coasts, but often carried far inland by prevailing winds.

DYNAMIC EQUILIBRIUM - A state of relative balance between forces or processes having opposite effects.

DYSTROPHIC - A type of lake in which the water usually has an acid reaction and brown peaty color; lack of nutrients; often associated with bogs (q.v.).

EBULLITION - The act, process or state of boiling or bubbling up.

ECOCLINE - Gradual changes in the morphological or physiological features in organisms along an environmental gradient.

ECOLOGY - The study of the interrelationships of organisms with and within their environment.

ECOLOGICAL AMPLITUDE - Pertains to the breadth of a species' tolerance (q.v.) to an environmental factor.

ECOLOGICAL BALANCE - Range of response normally expressed by an unperturbed ecosystem.

ECOLOGICAL CONSCIENCE - As defined by Aldo Leopold, a philosophical and political concern for conservation of all natural resources, but especially for scenic and other nonobvious values of undisturbed ecosystems.

ECOLOGICAL DOMINANCE - Pertains to a species' control, competitiveness and alteration of conditions for the remainder of the community. (q.v. species dominant)

ECOLOGICAL EQUIVALENT - Analogous species in similar environmental contexts; that is, distantly related species displaying closely similar adaptive mechanisms, like loons and cormorants, flying squirrels and flying phalangers, etc.

ECOLOGICAL INDICATOR - Use of certain species' tolerances (q.v.) to reflect or infer more general environmental characteristics; see, indicator.

ECOLOGICAL NICHE - The functions of the organism in its ecological setting; see niche.

ECOLOGICAL RESILIENCE - A system's ability to return to a prior state following environmental perturbation (stress).

ECOLOGICAL SUCCESSION - see, succession

ECOLOGICAL SYSTEM - see, ecosystem

ECOSYSTEM - A community and its (living and nonliving) environment considered collectively; the fundamental unit in ecology. May be quite small, as the ecosystem of one-celled plants, in a drop of water, or indefinitely large, as in the grassland ecosystem.

ECOSYSTEM ANALYSIS - Examination of structure, function and control mechanisms present and operating in an ecosystem.

ECOSYSTEM DYNAMICS - Characteristic and measurable processes within an ecosystem such as (1) succession (q.v.); (2) energy flow and nutrient cycling (q.v.); (3) community metabolism.

ECOSYSTEM FUNCTION - Energy flow and material production cycling within an ecosystem.

ECOSYSTEM INTEGRITY - Implications of ecosystem properties as a whole, especially of resilience (q.v.) or its lack.

ECOSYSTEM STRUCTURE - The who, what, and where of an ecosystem; its functionally important and weighable components mostly organisms; the pattern of organism's interrelations and spatial arrangements.

ECOSPHERE - Envelope of the earth's surface where biological and ecological activities occur. See, biosphere.

ECOTONE - A transition zone between two recognized communities (q.v.).

ECOTYPE - Race or subdivision of species adapted to local habitat and climate. These genetic groups are broader than a biotype (q.v.) and narrower than a species. Ecocline (q.v.).

EDAPHIC - Of/ the influence of the soil especially on the plants growing upon it.

EDAPHIC CLIMAX - Self perpetuating community where soil is limiting further succession at a stage believed to be short of climatic potential.

EDGE EFFECT - Phenomena such as changed diversity and/or density of organisms that occur in the vicinity of community boundaries (ecotones, q.v.).

EFFICIENCY (ECOLOGICAL) - Defined exchange of energy and /or nutrients between trophic (q.v.) levels; us. the ratio between production (q.v.) of one level and that of a lower level in the same food chain (q.v.).

ELECTRODIALYSIS - Separation of charged particles in solution in an electric field through a semipermeable membrance.

EMBRYO - An early stage of development of animals or plants. Usually passed through by an egg after fertilization and before "hatching".

EMERGENT - Aquatic plants, usually rooted, which during part of their life cycle have portions above water.

ENDANGERED SPECIES - Species that are in danger of becoming extinct.

ENDEMIC - Indigenous or native in a restricted locality; confined naturally to a certain limited area or region.

ENDOTHERMS - "Warm blooded" animals. Animals which have the facility to regulate their body temperatures over a wide range of external temperatures. (see homeotherms)

ENERGY (ECOLOGICAL) - Most commonly, that portion of the visible solar radiation (light) captured by plants and ultimately used for food by the animals in an ecosystem.

ENERGY BUDGET - A quantitative account sheet of inputs, transformations, and outputs of energy in an ecosystem. May apply to the long-wave radiation (heat) of an organism or a lake, or to the food taken in and subsequently reduced to heat by an individual or a population.

ENERGY CYCLING - (Although this term is sometimes used to imply that the ecological energy in an ecosystem is reused, the term is incorrect.) Use instead, energy flow. (see below)

ENERGY FLOW - The one-way passage of energy (largely chemical) through the system, entering via photosynthesis, being exchanged through feeding interactions, and at each stage, being reduced to heat.

ENERGY SUBSIDY - The man-induced addition of energy designed to increase the production by ecological energy. Example: The use of fossil-fuel energy in tractors to increase the amount of solar energy available from agricultural crops.

ENERGY SYSTEM (IN ECOSYSTEM) - The ecosystem carries out a number of functions including energy flow and the cycling of numerous elements and materials. This energy flow including the energetic equivalent of the materials, is the energy system of the ecosystem.

ENERGY TRANSFER PROCESS - Any process which transfers energy from one component in an ecosystem to another. Photosynthesis, feeding, bacterial break-down are examples.

ENTERIC - Pertaining to the gut or digestive tract.

ENTIRE - (Morphol.) individual or linear in outline, as an entire (non-toothed) leaf margin.

ENTROPY - The state of thermal disorganization of a system. In a system, entropy is proportional to the nonuseable heat produced.

ENVIRONMENT - The sum total or the resultant of all the external conditions which act upon an organism.

ENVIRONMENTAL AMENITIES - Attractive or esthetically pleasing environments or portions of environments.

ENVIRONMENTAL CRITERIA - Standards of physical, chemical and biological (but sometimes including social, aesthetic, etc.) components that define a given quality of an environment

ENVIRONMENTAL EFFECT - Resultant of natural or man-made perturbations of the physical, chemical or biological components making up the environment.

ENVIRONMENTAL INVENTORY - A listing of the components making up an environment - or a listing of types of environments.

ENVIRONMENTAL MONITORING - The systematic (simultaneous or sequential) measuring of various components constituting the environment.

ENVIRONMENTAL PARAMETERS - Physical, chemical or biological components and their interactions which can be stated in quantitative terms; a parameter is what is measured by a statistic.

ENVIRONMENTAL QUALITY - Human (individual or social) considerations of desirable ecological situations.

ENVIRONMENTAL RESISTANCE - The restrictions imposed upon the numerical increase of a species by the physical and biological factors of the environment.

ENVIRONMENTAL SCIENCE - All sciences contributing to understanding of the total environment.

ENVIRONMENTAL SETTING - Environmental context.

ENVIRONMENTAL STRESS - Perturbations likely to cause observable changes in ecosystems; usually departures from normal or optimum. See , stress.

ENVIRONMENTALIST - One concerned about the environment.

ENVIRONS - The neighborhood; surroundings.

ENZYME - An organic catalyst of protein nature.

EPIBENTHOS - Life forms attached to and growing upon rather than within the bottoms of standing and flowing waters.

EPILIMNION - The turbulent superficial layer of a lake between the surface and a horizontal plane marked by the maximum gradient of temperature and density change. Above the hypolimnion, (q.v.)

EPIPHYTES - Plants which grow on other plants but which are not parasitic.

EPIZOOTIC - Any organism causing disease in many animals of one kind at the same time; an animal epidemic, but epidemic means "upon the people."

EQUILIBRIUM - In environmental science, a steady state in a dynamic system, with outflow balancing inflow about which the system ordinarily fluctuates to some small degree. (Often applied to an animal population at zero growth, to the steady interaction of two species (predator-prey), to the energy flow through an ecosystem, and to the nutrient cycling pattern of an ecosystem).

EROSION - The removal of soil or rock by wearing away of land surface.

ESTUARINE - Of/ the mouth region of a river that is affected by tides.

ETHNOLOGICAL - Of that branch of anthropology that deals with extant races and cultures ("peoples"), rather than with language or with extinct cultures.

ETHOLOGY - Study of behavior of organisms usually or preferably in their natural environment.

EUPHOTIC - Of the upper layers of water in which sufficient light penetrates to permit growth of green plants.

EURYHALINE - Of/ species peculiar to or living in brackish waters of marine or non-marine origin, and which are resistant to great changes in salinity.

EURYTHERMAL - Of/ organisms having the ability of living through a wide range of temperature conditions.

EURYTOPIC - Adaptation of species to widely varied conditions (places).

EUTROPHIC - (lit., "well-fed") Of/ lakes characterized by the paucity or absence of oxygen in the bottom waters; as a consequence of high primary production and high nutrient content.

EXOTHERMS - Organisms like fish, reptiles and insects which cannot regulate their own body temperature independent of the temperature of their surroundings.

EXOTIC - Of/ any non-native or rare species; usually introduced.

EXCRETION - Elimination of waste material from the body of an organism.

FACIATION - (rare) A portion of an association (q.v.) in which one or more of the dominants have dropped out and been replaced by other forms; the general community aspect remaining unchanged.

FAUNA - The animals of a given region taken collectively; as in the taxonomic sense, the species, or kinds, of animals in a region.

FECUNDITY - Capacity to produce offspring; in insect ecology, the number of eggs per female that hatch or become larvae.

FEEDBACK - Principle of information returning to sender or to input channel, thus affecting output.

FERTILIZATION - Sexual union at the cellular level; fusion of the nuclei of a male and a female gamete.

FETCH - The expanse of open water which can be affected by the wind.

FIDELITY - The degree to which species are confined to certain communities.

FISH KILL - Pertaining to sudden death of fish population.

FISHERY - Of/ fish populations as the basis of an industry, recreational or commercial.

FLOOD PLAIN - That portion of a river valley which is covered in periods of high (flood) water; ordinarily populated by organisms not greatly harmed by short immersions.

FLORA - Plants; organisms of the plant kingdom; specifically, the plants growing in a geographic area, as the Flora of Illinois.

FLORA (MICRO) - Usually bacteria or fungi.

FLUCTUATION - Change in level.

FLUVIAL - Applied to plants growing on streams.

FLYWAY - Of/ the routes taken by migratory birds usually waterfowl during migration.

FOOD CHAIN - Animals linked together by food and all dependent, in the long run, on plants.

FOOD WEB - see, food chain. Implies many cross connections rather than straight line connections.

FORAGE - Search for, pursue, capture and ingest food.

FORAGE FISH - Fish eaten by other fish.

FORB - An herbaceous plant, not a grass.

FOREST - An association (q.v.) dominated by trees;usually defined as woody plants over 10 m. tall.

FOREST COVER TYPE - All trees and other woody plants (underbrush) covering the ground in a forest. Includes trees, herbs and shrubs, litter and the rich humus of partly decayed vegetable matter at the surface of the soil. See, forest type.

FOREST GAME - Any forest animal usually a mammal or bird, upon which hunting is regulated by law.

FOREST TYPE - A forest stand community, or association, essentially similar throughout its extent as regards composition and development under essentially similar conditions.

FRAGILE - Easily broken or disrupted; us. refers to communities or ecosystem particularly susceptible to disruption by man.

FRESHET - An overflowing of a stream swollen by heavy rain or melted snow, usually occuring in the spring.

GALLERIA - Refers to a fringe of forest along a river especially in tropical grassland or savannah areas.

GAME - Wild animals usually mammals or birds hunted for sport or food and subject to legal regulations.

GENETICS - The study of heredity or inherited features in individuals or populations.

GENUS - A unit of biological classification (taxonomy, q.v.) including one or several species sharing certain fundamental characteristics, supposedly by common descent.

GLADE - An open space in a woods or forest.

GREENBELT - A plot of vegetated land separating or surrounding areas of intensive residential or industrial use and devoted to recreation or park uses.

GRADIENT - A more or less continuous change of some property in space. Gradients of environmental properties are ordinarily reflected in gradients of biota.

GREENHOUSE EFFECT - Warming of the earth's surface resulting from the capacity of the atmosphere to transmit short-wave energy (visible and ultra-violet light) to the earth's surface, and to absorb and retain heat radiating from the surface; carbon dioxide and water vapor in the atmosphere both contribute to the effect.

GROUND WATER - Water found underground in porous rock or soil strata.

GYRE - A circular or spiral pattern of oceanic or atmospheric circulation.

GRASSLAND - An area in which grasses are the major plants; trees and shrubs are largely absent.

HABITAT - The environment ,us. the natural environment in which a population of plants or animals occurs.

HABITAT STRUCTURE - The physical structure of a habitat; e.g., the layering of vegetation in a forest, or the grain of a coral reef.

HALOPHYTE - A plant which grows in salty soil or water.

HALOPHYTIC - See halophyte.

HEAT BUDGET - The quantitative listing of all heat inputs, transformations and outputs of an ecosystem or organism.

HERBACEOUS - Of/ any plant lacking woody tissue in which the leaves and stem fall to ground level during freezing or drying weather.

HERBICIDE - A chemical substance used to kill plants or inhibit plant growth.

HERBIVORE - An organism which eats living plants or plant parts (e.g., seeds).

HERPETOFAUNA - The amphibian and reptile species characteristic of an area.

HETEROTROPHS - Organisms which must obtain their food from living or dead organic matter.

HIGHER PLANTS - "Flowering" plants which reproduce by seeds; phanerogams, not cryptogams (q.v.)

HOLOCOENOTIC - Of/ a system which is organized so that the total system has properties not present in its individual parts; as this is true of all systems, the term is superfluous but often used for emphasis. See, ecosystem.

HOLOMICTIC - A lake in which surface and bottom waters are completely mixed by vertical circulation, occasionally at least.

HOME RANGE - The area or space of normal activity of an individual animal; sometimes, but not necessarily defended against intrusion by other individuals. See territory.

HOMEOSTASIS - The inherent stability or self-regulation of a biological system; the ability of such a system to resist external changes.

HOMEOTHERMS - Animals (mammals and birds) which maintain a more or less constant body temperature despite variations in external temperature; warm-blooded animals or endotherms (q.v.).

HUMIC - Of/ the soil or water borne substance resulting from the partial decay of leaves and other plant material.

HYDRARCH - Of/ successions which originate in aquatic habitats such as lakes and ponds and progress toward more terrestial conditions, as in bogs and swamps.

HYDRIC - Characterized or pertaining to conditions of abundant moisture supply.

HYDRODYNAMICS - The branch of physics which studies the movements of water and other liquids.

HYDROPHYTE - A plant which grows in water or very wet earth.

HYPOLIMNION - In certain lakes, the portion (below the zone of warmer water) which receives no heat directly from sunlight and no aeration by vertical circulation.

INDICATOR - An organism or collection of organisms having relatively narrow requirements and thus indicating the presence of certain environmental conditions.

INDICATOR ORGANISM - See indicator.

INDIGENOUS - Of/ native species; not introduced.

INFLUENT - Anything flowing into something, as a stream to a lake. (rare or obsolete) An organism such as a parasite which has important but nonobvious relations in the biotic balance and interaction.

INHIBITOR - A substance which slows or prevents growth or reproduction of an organism.

INORGANIC - Of/ matter that is neither living nor immediately derived from living matter; typically does not contain carbon, but carbon dioxide is inorganic.

INSECTICIDE - Any substance used to kill insects.

INTERACTION - A relationship in which each component influences the other.

INTERFACE - A surface that lies between two areas or volumes and forms their common boundary.

INTERTIDAL - Of/ the region of marine shoreline between high-tide mark and low-tide mark; where neap, spring and storm tides are important; usage is flexible.

INVERSION - In meteorology, a condition in which cooler surface air is trapped under an upper layer of warmer air, preventing vertical circulation.

INVERTEBRATE - Any animal lacking a backbone (i.e., insects, spiders, crustaceans, segmented worms, round and flatworms, molluscs, etc.)

IRRIGATION - To supply agricultural land with water by artificial means.

ISOHALINE - In an organism, the property of being in balance with the salt concentration of its surroundings.

ISOTHERM - A line on a map connecting points having the same temperature at the same time.

KEYSTONE SPECIES - A species whose removal causes marked changes to the community.

LACUSTRINE - Of/ originating in, or inhabiting a lake.

LAGOON - A shallow area of water generally separated from a larger body of water by a partial barrier.

LAG TIME - The delay between aome event and its effect.

LAKE - A large body of water contained in a depression of the earth's surface and supplied from drainage of a larger area. Locally may be called a pond.

LAKE TURNOVER - The complete top-to-bottom circulation of water in a lake which occurs when the density of the surface water is the same or slightly greater than that at the lake bottom; most temperate zone lakes circulate in Spring and again in Fall.

LARVA - An early developmental stage of an animal which changes structurally when it becomes an adult (e.g., a tadpole or caterpillar).

LEACHATE - The soluble material which is washed or dissolved during leaching.

LEACHING - The removal of various soluble materials from surface soil layers by the passage of water through (around) the layers.

LENTIC - Of/ still or slowly flowing water situations (e.g., lakes, ponds, swamps).

LIFE CYCLE or LIFE HISTORY - The series of changes or stages undergone by an organism from fertilization, birth or hatching to reproduction of the next generation.

LIFE SYSTEM - (rare) A population and the environment which influences it; see ecosystem.

LIFE ZONE - (rare) An altitudinal or latitudinal zone defined by climatic characteristics and having certain plants and animals (especially birds and mammals).

LIMITING FACTOR - An environmental factor (or factors) which limits the distribution and/or abundance of an organism or its population, i.e., the factor which is closest to the physiological limits of tolerance of that organism.

LIMNETIC ZONE - The open water zone of a lake or pond from the surface to the depth of effective light penetration; Offshore, from areas shallow enough to support rooted aquatic plants.

LIMNOLOGY - The study of the biological, chemical, and physical features of inland waters.

LITTORAL - Of/ the shoreward region of a body of water in which light penetrates to the bottom; in lakes or ponds, from shoreline to the lakeward limit of rooted aquatic plants; in oceans, from shoreline to a depth of 200 meters.

LOTIC - Of/ rapid water situations, living in waves or currents.

MACROFAUNA - The large (i.e., visible to the naked eye) animals of an area.

MACROPHYTES - Large bodied aquatic plants; non-microscopic.

MARINE - Of/ the sea or ocean.

MARSH - A tract of low-lying soft, wet land, commonly covered (sometimes seasonally) entirely or partially with water; a swamp dominated by grasses or grass-like vegetation.

MERISTIC VARIATION - Variation among segments in a segmented animal.

MEROMICTIC - Lakes which undergo only a partial circulation.

MESIC - Characterized or pertaining to conditions of medium moisture supply.

METALIMNION - The zone over which temperature drops relatively rapidly with depth. See, <u>thermocline</u>.

MICROBIOTA - The microscopic organisms present in an area or volume.

MICROCLIMATE - Conditions of moisture, temperature, etc., as influenced by the topography, vegetation, and the like. See , <u>climate</u>.

MICROENVIRONMENT (HABITAT) - A small or restricted set of distinctive environmental conditions, such as a dead animal or a fallen log.

MICROFLORA - The microscopic plants present in an area or volume.

MICROPHYTE - The smaller algae, e.g., diatoms.

MIGRATION - A regular movement from one region to another.

MINIMAL AREA - The smallest area upon which a community reaches its mature or developed stage, including all of its characteristic components.

MIXOTROPHIC - Fed by several alternative modes of nutrition; usual for some one-celled animals and plants.

MOLLUSC - Any of a phylum of invertebrate animals including oysters, clams, mussels, snails, slugs, squids, octupi, whelks, and other shellfish.

MONOCULTURE - Cultivation of land in a single crop.

MONOMICTIC - A polar or tropical lake in which the water never exceeds or falls below (respectively) 4° C., and thus has only one period of turnover or circulation per year.

MONOSPECIFIC - Of/ a single species of organism.

MORBIDITY - In medical ecology, the incidence (measured frequency) of disease in a population; the illness rate.

MORIBUND - In a dying state.

MORPHOLOGY - The study of the form and structure (but not the functions) of an organism.

MORTALITY - Of/ death in a population; the death rate.

MOSAIC - A patchwork pattern of distribution of habitats or communities.

MUSKEG - Moss-covered countryside, or continuous boggy ground; e. g. moss bogs of the Canadian forest.

MUTUALISM - A form of interrelationship between two organisms in which both involved organisms benefit. See, symbiosis.

NANOPLANKTON - Extremely small, free-floating aquatic organisms. See plankton.

NATALITY - An expression of the birthrate of a population.

NATURAL AREA - An area in which natural processes predominate, fluctuations in numbers of organisms are allowed free play and human intervention is minimal.

NATURAL ENVIRONMENT - The complex of atmospheric, geological and biological characteristics found in an area in the absence of artifacts or influences of a well developed technological, human culture; an environment in which human impact is not controlling, or significantly greater than that of other animals. See natural area.

NATURAL POLLUTION - The production and emission by geological or non-human biological processes of substances commonly associated with human activities (e. g. natural oil seeps, hydrocarbons or toxins released by plants or animals).

NATURAL SELECTION - A biological process resulting in differential survival of different gene combinations selected in a particular environment.

NATURAL SETTING - The complex of atmospheric, geological and biological characteristics of an area as they determine its appearance. (See natural environment).

NEKTON - Free-swimming organisms of open water, large and strong enough to be independent of turbulent water movement (fish).

NET PRODUCTION - See Productivity, net primary.

NERTIC ZONE - The zone of shallow water adjoining a coast line.

NEUSTON - Microorganisms in contact with or in the surface film of water.

NICHE - The range of sets of environmental conditions which an organism's behavioral morphological and physiological adaptations enable it to occupy; the role an organism plays in the functioning of a natural system, in contrast to habitat.

NITROGEN FIXATION - A step in the nitrogen cycle involving hydrogenation (reduction) of molecular nitrogen (N_2) to amino or ammonia nitrogen (NH_2 or NH_3) performed by certain nitrogen-fixing (soil) bacteria and blue-green algae.

NITROGEN GAS SUPERSATURATION - An excess of dissolved nitrogen which may be toxic to animals, and which causes the "bends" in divers.

NITRIFICATION - A step in the nitrogen cycle technically involving oxidation of nitrogen, e. g. NH_3 from ammonia to nitrates (NO_3). Soil dwelling (chemosynthetic) bacteria nitrify ammonia in two steps, to nitrite (NO_2) and to nitrate (NO_3) in which form it is most available to plants. Chemical reduction of nitrogen, as to N_2, is denitrification.

NOCTURNAL - Occurring or active during the period between sunset and sunrise (night).

NON-RENEWABLE RESOURCE - A natural, normally nonliving, resource such as a mineral which is present in finite supply and is not revewed by natural system.

NON-VASCULAR PLANTS - Plants without specialized conductive tissues (xylem or phloem). e.g. algae, mosses, liverworts.

NURSERY AREA - An area where animals congregate for giving birth or where the early life history stages develop. e.g. (estuaries for shrimp, Scammon's lagoon; Baja California, for gray whale).

NUTRIENTS - Chemical elements essential to life. Macronutrients are those of major importance required in relatively large quantities (C, H. O, N, S, and P); micronutrients are also important but required in smaller quantities (Fe, Mo).

NUTRIENT CYCLING - The movement of nutrients from the nonliving (abiotic) through the living (biotic) parts of the environment and back to the abiotic parts.

NYMPHS - Immature stage of Arthopods (primarily insects) with incomplete metamorphosis; not larva because not sufficiently different from adults.

OLGOAEROBE - Organism which thrives at low oxygen concentrations.

OLIGOAEROBIC - Conditions of low oxygen "tension" (pressure or concentration).

OLIGOTHERMAL - Low temperatures.

OLIGOTROPHIC (lit., "poorly fed") - Of lakes characterized by abundant oxygen in deep water as a consequence of small nutrient supply and low productivity of organic material: see, eutrophic

OMNIVOROUS - Eating a wide variety of food both plant and animal.

ONTOGENY - Development of an individual organism.

ORGANIC - Compounds containing carbon (and hydrogen); living or derived from living matter.

ORGANIC DETRITUS - Particles or fragments of a larger living or recently dead body produced by its disintegration. In aquatic systems finely divided, settleable particles whose continued destruction consumes oxygen.

ORGANISM - Any living or recently dead thing.

OVERTURN - The complete circulation or mixing of the upper and lower waters of a lake when the temperatures (and densities) are similar.

OXYGEN DEPLETION - Removal or exhaustion of oxygen by chemical or biological use.

OXYGEN SAG - A drop in oxygen concentration usually at night, due to respiration.

PARAMETER - A measurable, variable quantity as distinct from a statistic or estimate.

PARASITE - An organism living on or in a living organism, without killing it immediately, and deriving its nutrition from it with a detrimental effect on the host.

PASSERINE - Perching birds (e.g. sparrow) including all songbirds.

PELAGIC ZONE - Free open water of the ocean or lake with no association with the bottom.

PERIODICITY - A regular cyclic behavior of an organ, cell or organism in time (see photoperiodism).

PERIPHYTON - Community of organisms usually small but densely set, closely attached to stems and leaves of rooted aquatic plants or other surfaces projecting above the bottom.

PERMAFROST - Permanently frozen subsoil thawing at the surface in summer characteristic of Arctic tundra.

PESTICIDE - Toxic chemical used for killing organisms. Usually widely toxic to living things (see herbicide, insecticide).

pH - ("power hydrogen") negative logarithm of hydrogen-ion concentration, a numerical expression of acidity (see acid, alkaline).

PHANEROGAM - A general name for seed-bearing or higher plants. See cryptogam.

OXIDATION - A reaction between molecules involving transfer of an electron from a reduced to oxidized molecule (see reduction); ordinarily involves gain of oxygen and/or loss of hydrogen, i.e. dehydrogenation.

PHENOLOGY - The study of the periodic phenomena of nature, especially animal and plant life in their relations to weather and climate (e.g. bird migration, flowering, bud opening, freezing and thawing).

PHOTOPERIODISM - Response of plants and animals to relative duration of light and darkness.

PHOTOTROPISM - A growth curvature of a plant in response to a unilateral light source; (obsolete), behavioral response of an animal or microbe to light stimulus.

PHOTIC ZONE - The region of aquatic environments in which the intensity of light is sufficient for photosynthesis.

PHREATOPHYTE - A plant which derives its water supply from ground water and is more or less independent of rainfall.

PHOTOSYNTHESIS - Synthesis of carbohydrates from carbon dioxide and water with chlorophyll as a mediator using light as energy with oxygen as a by-product.

PHRAGHITES - A genus of reeds: tall (2-12 ft.) grasses growing in marshes.

PHYLOGENY - The evolutionary history of a group of organisms.

PHYSIOGNOMY - The general outward appearance of a community, determined by the life form of the dominant species (e.g. forest or grassland).

PHYTOPLANKTON - Small, mostly microscopic, plants floating in the water column. (See benthos, neuston)

PHYTOTOXICITY - A toxic effect produced by or on a plant.

PIONEER - Any early occupant of an open or disturbed area of ground.

PLANKTON - Small organisms (animals, plants or microbes) passively floating in water; macroplankton are relatively large (1.0 mm to 1.0 cm); mesoplankton of intermediate size; microplankton are small.

PLANKTON - MERO - Organisms with temporary planktonic phases in their life cycle, e.g., oyster and crab larvae.

PLANT NUTRIENTS - See nutrients.

PLATTING - The legal division of land, by public record, usually preliminary to sale for development.

PLEUSTON - The community of organisms floating on a lake's surface.

POIKILOTHERMIC - A "cold-blooded" organism whose body termperature varies approximately with the environment. Generally other than birds and mammals.

POLLUTANT - A residue (usually of human activity) which has an undesirable effect upon the environment [Particularly of concern when in excess of the natural capacity of the environment to render it innocuous].

POLLUTION - An undesirable change in atmospheric, land or water conditions harmfully affecting the material or aesthetic attributes of the environment.

POLYCLIMAX - Two or more simultaneously existing, stable, self-maintaining communitites controlled by local environmental conditions in a larger area (see climax).

POND - A small lake.

POPULATION - A group of organisms of the same species.

POPULATION DENSITY - The number of individuals of a population per unit area, or volume.

POPULATION INDEX - An estimate of size or other characteristic of a population, obtained by indirect means (e.g., by songs, droppings).

POPULATION IRRUPTION - A sudden, large increase in population density, resulting in emigration or immigration.

POPULATION PRESSURE - A metaphor implying the magnitude of demand of a population on space or other resources.

POTAMOLOGY - The study of streams, especially large rivers.

POLYTHERMAL - Confined to high temperatures (rare); in contrast to oligothermal, (q.v.).

PREDATOR - An organism, usually an animal, which kills and consumes another organism in whole or part.

PREDATOR CHAIN - See food chain; also trophic and biotic pyramid

PREY - An organism killed and at least partially consumed by a predator.

PREDOMINANT = DOMINANT - An organism of outstanding abundance or obvious importance in a community (q.v.).

PRISTINE STATE - A state of nature without human effect or with negligible human effect.

PRODUCER = PRODUCER ORGANISM - An organism which can synthesize organic material using inorganic materials and an external energy source (light or chemical). See autotroph; also, biotic pyramid.

PRODUCTION - The amount of organic material produced by biological activity in an area or volume.

PRODUCTIVITY - The rate of production of organic matter produced by biological activity in an area or volume. (e.g.: grams per square meter per day, or other units of weight or energy per area or volume and time).

PRODUCTIVITY, GROSS PRIMARY - The rate of synthesis of organic material produced by photosynthesis (or chomosythesis), including that which is used up in respiration by the producer organism.

PRODUCTIVITY, NET PRIMARY - The rate of accumulation of organic material in plant tissues. Gross primary productivity less respiratory utilization by the producer organism.

PRODUCTIVITY, SECONDARY - The rate of production of organic materials by consumer organisms (animals) which eat plants (which are the primary producers). See, hetrotrophs

PROFUNDAL ZONE - The bottom of a body of water below the metalimnion, (q.v.) or below the limit of macrophytic vegetation (e.g.: rooted plants or seaweeds, large algae such as Chara; or mosses.

PROLIFIC - Producing numerous young or fruit; marked by abundant productivity.

PROVENANCE - The geographical source or place of origin of something, e.g., a genetic stock or a lot of seed.

RANGE - The geographic area of occurrence of a species; the region over which a given form occurs, naturally or after introduction.

RAPTORS - Any of several birds of prey (hawks, falcons, eagles, owls).

RECENT - Informal, (geological) usually referring to the period of time from the last glaciation to the present. U.S.G.S. uses it formally, as Recent, but has not defined it; most geologists prefer "Holocene".

RECYCLING - The repeated use of a finite body of resources such as minerals.

RED TIDE - A reddish color of near-shore marine waters due to the presence of extremely large numbers of red-pigmented micro-organisms, which liberate toxins lethal to fish.

REDUCERS - See reducer organisms.

REDUCER ORGANISMS - Those organisms which have the capability of promoting chemical reductions (see below), as green plants reduce CO_2 and sulfate-reducing bacteria reduce sulfate ($SO_4^{=}$).

REDUCTION - A reaction between molecules in which the transfer of an electron is involved (the reduced molecule acquires an electron). Ordinarily involves loss of oxygen and/or addition of hydrogen.

RELICT - A species properly belonging to an earlier community type than that in which it is found. A community (or fragment of one) that has survived some important change, and now seems to be or is "left behind."

RELIEF - Variations in elevation of the earth's surface.

REMOTE SENSING - A method for determining the characteristics of an object, organism or community from afar.

REPTILES - One of the major groups of vertebrate animals, including crocodilians, turtles, lizards, and snakes, having scales or horny plates, true lungs and a 3- or 4-chambered heart.

RESERVOIR - An artificially impounded body of water; also, the supply of any commodity, as a reservoir of infection, etc.

RESIDENT - Normally to be found when looked for; of birds, nonmigratory

RESILIENCE - The ability of any system, e.g., an ecosystem, to resist or to recover from stress.

RESISTANT - Said of organisms not overly susceptible to environmental stresses; most pests are pestiferous because resistant.

RESPIRATION - (Commonly) breathing; (in biology) the oxidative breakdown of food molecules by cells with the release of energy.

RESOURCES, UNIQUE - Supplies of a commodity not (or not usually) found elsewhere; for other organisms, most resources are material substances, but for man, many nonmaterial qualities of environment and of society, are unique resources.

RETROGRESSING - Changing in a reverse order to a simpler or earlier state.

REVERSE OSMOSIS - The movement of water through a semi-permeable membrane in the direction of a concentration gradient; with suitable membranes and energy supplies, the process can be used to purify contaminated water.

RHEOTROPISM - The behavioral response of an organism, cell, or organ to a current of water.

RIVERBANK OVERSTORY - Those plants growing along streams whose canopies occupy the greatest heights.

RIVERINE - Of/ rivers.

ROOKERY - The breeding or nesting place of colonies of birds, seals, etc.

ROTTEN ICE - Ice, the mechanical strength of which has been reduced by warming and percolation of water.

ROUGH FISH - A non-sport fish, usually omnivorous in food habits, but not prized owing to poor flavor, excessively bony flesh or inadequate cooperation with anglers.

RUDERAL - A weed; an introduced plant species growing under disturbed conditions, in waste places or among rubbish.

SALINITY - The concentration of any salt; concentration of sodium chloride is, technically, halinity or sodium chlorinity.

SALINITY WEDGE - The movement of subsurface saline water into an aquifer, or, in an estuary. Of a body of saline (sea) water under the fresh water.

SALMONID - Of/ salmon, trout, char and allied freshwater and anadromous fishes.

SALT MARSH - Similar to a fresh (grass-dominated) marsh, but adjacent to marine areas covered periodically (tidally or seasonally) with saline water.

SANCTUARY - An area, usually set aside by legislation or deed restrictions, for the preservation and protection of organisms.

SAPROPEL - Ooze; slimy black or brown sediment of marine, estuarine or (rarely) lacustrine deposition consisting largely of organic debris. Finely divided, rich in iron and sulfide; and chemically strongly reducing.

SAPROBIC - Of/ forms living in foul, badly polluted, or septic waters.

SAPROPHYTE - A plant deriving all its nourishment from the bodies of decaying organisms.

SAVANNA - (Also spelled savannah, sabana, etc.) Grasslands (q.v.) containing numerous but isolated trees.

SCIENTIFIC CLASSIFICATION - (flora & fauna) - See Taxonomy.

SEASONALITY - Phenomena which show cyclic or repeated behavior according to the season.

SEDGE MEADOW - A vegetation (usually in wet situations) consisting of low grass-like plants belonging to the family Cyperaceae, distinguished from grasses by having stems triangular in cross-section.

SEDIMENT - Any usually finely divided organic and/or mineral matter deposited by air or water in non-turbulent areas.

SEEPAGE - The relatively slow trickling of water, or other liquid from a source; a seepage lake has no visible surface inflow.

SEICHE - An internal wave that oscillates in lakes, gulfs or bays over periods of a few minutes or hours - resulting from wind, tidal forces, or (rarely) from seismic activity. Oscillation is most dramatic and most likely to cause damage after the wind has dropped.

SEPTIC - Referring to the presence of disease-producing bacteria or other micro-organisms.

SERAL (STAGES) - Developmental temporary communities in a sere; not fixed.

SERE - A developmental series of communities which can be verified during succession (q.v.); one of a chain of seral stages containing the initial (pioneer), one or more transitional stages and a single (often hypothetical) climax stage, (q.v.)

SESSILE - Stationary; attached; non-moving; in botany, non-stalked.

SESTON - Particulate material including plankton, living and dead, and detritus or tripton,(q.v.)retained by fine-meshed nets; a collective term designating everything that floats or is suspended in the water.

SHELL FISH - Aquatic animals, usually molluscs (q.v.), having an external shell or exoskeleton.

SHOAL - A shallow place in a body of water; also (from "school") a mass of plankton or fish.

SHRUB - A woody perennial of smaller height than a tree.

SILTATION - Referring to the deposition of silt-sized (smaller than sand-sized) particles.

SILURIAN - The period of the Paleozoic era characterized by the appearance of land plants; also, the rocks of that period.

SILVICULTURE - The care and cultivation of forest trees.

SLOUGH - A wet place of deep mud or mire, or temporary or permanent lake; ordinarily found on or at the edge of the flood plain of a river.

SLUDGE - (Biological) The organic or mixed organic and inorganic deposit accumulating on the bottom of a stream; particle size is that of silt or clay (not sand).

SLUSH - Partially melted snow or ice.

SOIL AGGREGATION - The lumping together of soil particles into a coherent mass.

SOIL ORGANISM - An organism ordinarily found living and reproducing in the soil.

SOIL PROFILE - The physical and chemical features of the soil imagined or seen in vertical section from its surface to the point at which the characteristics of the parent rock are not modified by surface weathering or soil processes.

SOLUM - Upper weathered part of the soil (A and B horizons).

SPAWNING BEDS - Those places in which the eggs of aquatic animals lodge or are placed during or after fertilization.

SPECIES - The smallest natural population regarded as sufficiently different from all other populations to deserve a name, and assumed or proved to remain different despite interbreeding with related species.

SPECIES - DOMINANT - See, dominant.

SPECIES COMPOSITION - Referring to the kinds and numbers of species occupying an area.

SPECIES DIVERSITY - Refers to the number of species or other kinds in an area, and, for purposes of quantification, to their relative abundance as well.

SPECIES DIVERSITY INDEX - Any of several mathematical indices which express in one term the number of kinds of species and the relative numbers of each in an area.

SPECIES, RARE - Unusual species in an area.

SPECIES, RELICT - See, relict.

SPORE - A non-sexual reproductive cell in plants.

STABILITY (ecological) - The tendency of systems, especially ecosystems, to persist, relatively unchanged, through time; also persistence of a component of a system; the inverse of its turnover time.

STAND - An aggregation of plants, ordinarily trees, standing in a definite limited area.

STANDING CROP - The biological mass (biomass) of certain or all living organisms of an area or volume at some specific time, i.e., what could be harvested.

STENOTOPIC - With narrow limits of tolerance to varied conditions.

STENOHALINE - Of/ organisms which can endure only a narrow range of salt in solution. Stenohaline marine organisms cannot withstand significant departures from full marine salinity, 30-35 parts per thousand.

STENOTHERMAL - Of/ species restricted to a narrow range of temperatures.

STRATIFICATION - The natural division of plant community into superposed strata or layers; also, division of a water body into two or more depth zones, as in "thermal" or "density stratification".

STRATUM, STRATA - Layers, as of sedimentary or otherwise bedded rocks.

STRATIFICATION, THERMAL - The division of water or air into layers (depth zones) of different temperatures and/or densities.

STRESS - The result or consequent state of a physical or chemical, or social stimulus on an organism or system; properly, a state of strain, resulting from stress; a stimulus but medical ecology uses "stressor".

STERILIZATION - The killing of all organisms in an area or volume; also, the removal of the ability to reproduce.

SUBCLIMAX - A stage in a community's development, i.e., succession (q.v.) before its final (climax) stage; a community simulating climax because of its further development being inhibited by some disturbing factor (e.g., fire, poor soil).

SUBLITTORAL - Below the lake or seashore; of/ the area between the low tide mark and (say) 20 fathoms.

SUBSTRATE - The layer on which organisms grow, often used synonymously with surface of ground; also, the substance, usually a protein, attached by an enzyme; often but improperly used as a variant of substratum.

SUCCESSION - The replacement of one community by another; the definition includes the (controversial or hypothetical) possibility of "retrograde" succession.

SUCCESSION, PLANT - The replacement of one kind of plant assemblage by another through time.

SUCCESSION, PRIMARY - Refers to succession which begins on bare, unmodified substrata.

SUCCESSION, SECONDARY - Refers to succession which occurs on formerly vegetated areas (i.e., having an already developed soil) after disturbance or clearing.

SUSPENDED SOLIDS - Refers to solid (particulate) materials held in suspension; i.e., in more or less turbulent air or water, and capable of settling out when turbulence ceases.

SWAMP - A flat, wet area usually or periodically covered by standing water and supporting a growth of trees, shrubs and grasses; in contrast to a bog (q.v.), the organic soil is thin and readily permeated by roots and nutrients.

SYMBIOSIS - The living together of dissimilar organisms, by definition when the relationship is both mutually beneficial and essential.

SYMPATRY - Two or more species living in the same area; usually closely related .

SYNUSIA - Layers or strata, composed of plants of similar form and size, like dogwoods in a maple beach forest.

SYSTEMS ECOLOGY - That branch of ecology which incorporates the viewpoints and techniques of systems analysis and engineering especially those having to do with the simulation of systems using computers and mathematical models.

SYSTEM STABILITY - The degree to which a system continues to function relatively unchanged when stressed (perturbed).

SYNERGISM - The nonadditive effect of two or more substances or organisms acting together. Examples include synthesis of lachrymotors from other hydrocarbons in sunlit smog and dependence of termites on intestinal protozoans for digestion of cellulose (wood).

TAIGA - Flat, marshy subarctic forests; usually of spruce, firs or pine trees; the area between the tundra and the steppe (in Russia), and between tundra and deciduous forest or grassland in North America.

TAXON - Any taxonomic unit, from biotype or ecotype to phylum or kingdom.

TAXONOMY - The study of principles and practice for the orderly classification of organisms.

TELEOST - Of/ pertaining to ordinary ("bony") fishes, exclusive of sharks, lampreys, gar, sturgeons and a few others.

TERRAIN - A tract of land; also (terrane), its physical features with special emphasis on bedrock geology.

TERRESTRIAL - Of/ land, the continents, and/or dry ground; contrasted to aquatic.

TERRITORIALITY - Any active behavioral mechanism that spaces organisms or groups apart from one another (usually shown by vertebrate (q.v.) animals).

TERRITORY - That area which an animal actively defends. Home range (q.v.) is not necessarily territory.

THERMOCLINE - A narrow [horizontal] zone of water in lakes and oceans with a steep temperature gradient, separating a warmer surface layer (epilimnion, epithalassa) from a cooler bottom layer (hypolimnion, hypothalassa); as a thermocline is a plane, but a zone is observed, the preference or usual term is metalimnion (q.v.)

THERMAL POLLUTION - The excessive raising or lowering of water temperatures above or below normal seasonal ranges in streams, lakes, or estuaries or oceans as the result of discharge of hot or cold effluents into such waters.

THERMAL STRATIFICATION - The seasonal formation of horizontal layers of water in lakes and oceans (warm surface, cool bottom) of markedly varying temperatures, separated by a zone with a steep temperature gradient.

THERMOCOUPLE - A device used to measure temperature differences.

THERMOTAXIS - Directional movement induced by heat; moving toward or away from a heat source.

THIGMOTROPIC - A response of an organism to touch, i.e. to mechanical stimulation.

TIDAL MARSH - Marsh land periodically inundated by tidal oceanic or estuarine water (i.e., salt marsh).

TOLERANCE - An organism's capacity to endure or adapt to (usually temporary) unfavorable environmental factors. See ecological amplitude.

TOLERANT ORGANISM - An organism exhibiting a capacity to survive relatively large environmental changes.

TOPOGRAPHY - Description or representation of natural or artificial features of the landscape; the description of any surface, but usually the earth's.

TOXIC - Of/ poison.

TRACE ELEMENTS - Chemical elements appearing in minute quantities in natural systems or media; may occasionally be concentrated by specific organisms. Nutrients such as P, though in minute quantities, are not usually called trace elements.

TRANSECT - A line (or belt) through a community on which are indicated the important characterisitics of the individuals of the species observed; sampling along a transect may be plotless or refer to specific plots.

TRANSPIRATION - The loss of water from plants normally as vapor.

TRIPTON - The nonliving component of the seston (q.v.); suspended non-living matter in a body of water.

TROPHIC - Of/ nourishment or feeding. See eutrophic, biotic pyramid (to be carefully distinguished from - TROPIC, responding or inclining and TOPIC, referring to place.)

TROPHIC LEVEL - All organisms which secure their food at a common step away from the first level e.g., 1. plants; 2. herbivores; 3. carnivores.

TUNDRA - Arctic, subarctic or high alpine land, devoid of trees, with mosses and sedges dominant and (in the Arctic) underlain by permafrost (q.v.), the upper layer of which thaws in summer.

TURBIDITY - Condition of water resulting from suspended matter; water is turbid when its load of suspended material is conspicuous.

TURNOVER (overturn) - (limnology) Mixing of a water body from top to bottom ordinarily in Fall and Spring, resulting from wind action on uniformly heated or at least uniformly dense water; separates periods of stratification and may result in upwelling of nutrient-rich bottom waters. Also (systems ecology), the reciprocal of residence time, an aspect of the stability or persistence of a component (such as a species population).

UBIQUITOUS - Being found in many widely divergent places; able to thrive under different conditions.

UNDERSTORY - Vegetation zone lying between the forest canopy (overstory) layer and the vegetation covering the ground (ground cover).

UPLAND - All types of land forms other than depressions (occupied by lakes, swamps) or those areas in close proximity to rivers, streams or seas (flood plains, beaches, mud- or tide-flats, salt marshes).

UPLAND GAME - Term describing huntable animals living in upland (q.v.) areas.

VAPOR - A substance in a gaseous state, i.e. neither "liquid" nor "solid".

VASCULAR - Of/ vessels or channels for conveying fluids (as blood or sap); also, tissues supplied with such channels.

VECTOR - An organism that carries a disease, parasite, or infection; also (physics), a force that has both magnitude and directionality.

VECTOR CONTROL - Process of controlling a disease, parasite, or infection by control of the carrier.

VEGETATION - Plants in general, or the total assemblage of plants, and their gross appearance as determined by the largest and most common. Flora (q.v.) is used for the list of kinds of plants.

VEGETATION TYPE - A plant community of any size, rank or state of development.

VERNAL - Of/ spring.

VERTEBRATE - Those animals possessing a spinal column or backbone, i.e., fishes, birds, amphibians, mammals, and reptiles .

VOLATILES - Material that pass into a gaseous state at ordinary temperatures and pressures; in geochemistry, substances that readily move or have moved through the earth's atmosphere.

WARMWATER FISHERIES - The organized, sustained exploitation of populations of fishes inhabitating warm (or tropical) waters; us. implies bass, pike, etc., in contrast to salmonid fisheries.

WASTEWATER - Water derived from a municipal or industrial waste treatment plant.

WASTE - Refuse from places of human or animal habitation; a solid, liquid, or gaseous by-product derived from human activities.

WATERFOWL - Birds frequenting water; ordinarily referring to game birds such as ducks and geese.

WATER POLLUTION - See pollution.

WATER TABLE - The upper limit of that part of the ground which is saturated with water.

WATERSHED - An entire drainage basin including all living and non-living components of the system.

WETLANDS - Land containing high quantities of soil moisture, i.e. where the water table (q.v.) is at or near the surface for most of the year.

WILDERNESS - A tract or region of land uncultivated and uninhabited by human beings, or unoccupied by human settlements.

WILDLIFE - Undomesticated animals; often hunted or at least noticed by man, and therefore consisting mainly of mammals, birds, and a few lower vertebrates and insects.

WILDLIFE ENCHANCEMENT - Manipulation of wildlife regions to promote increases in the amount or quality of living animals.

WILDLIFE HABITAT - Suitable upland or wetland areas promoting survival of wildlife.

WINTERKILL - Wildlife or vegetation dying from exposure to cold winter weather, or fishes dying from suffocation under snow-covered ice.

WOODLAND - Areas dominated by small scattered trees with little overlap of canopy branches, or loosely,a small tract of closed forest.

XERIC - Characterized by or pertaining to conditions of scanty moisture supply.

XEROPHYTE - A plant which can subsist with a small amount of moisture, as a desert plant.

ZONATION - Of/ distinct, conspicuous layers or belts, e.g., in soils, vegetation, bodies of water, and on mountains.

ZOOPLANKTON - Small aquatic animals, see plankton.

CITED REFERENCES

1. Galbraith, John Kenneth, The Affluent Society, New York: Houghton Mifflin Company, 1957.

2. National Environmental Policy Act of 1969, (Public Law 91-190, of January 1, 1970).

3. Conservation Council of North Carolina, et al., vs. Froelke (M.D. North Carolina, February 14, 1972; affirmed, 4th Circuit May 2, 1972).

4. U.S. Army Corps of Engineers, North Pacific Division, Columbia River and Tributaries: Environmental Assessment Manual, Washington D.C.: Government Printing Office, 1974.

5. Pacific Northwest River Basin Commission, "Appendix V, Water Resources," Columbia-North Pacific Comprehensive Framework Study, Vancouver, April 1970.

6. U.S. Geological Survey, Recommended Methods for Water Data Acquisition, Preliminary Report, Office of Water Data Coordination, 1972.

7. American Public Health Association, Standard Methods for the Examination of Water and Wastewater, New York, 1971.

8. Environmental Protection Agency, Methods for Chemical Analysis of Water and Wastes, Cincinnati, Ohio, 1971.

9. Bowers, C. E., Pabst, A. F., and Larson, S. P., Computer Programs in Hydrology, Water Resources Center, University of Minnesota, St. Anthony Falls, Hydraulic Laboratory, January, 1972.

10. Fontane, D. G., Boha, J. P., and Grace, J. L., Jr., "Mathematical Simulation of the Turbidity Structure Within an Impoundment," Research Report H-72-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg: 1973.

11. Giles, Robert H., Wildlife Management Techniques, The Wildlife Society, Washington, D. C.: 1969.

12. National Academy of Science, Range Research: Basic Problems and Techniques, National Research Council Publication No. 980, 1962.

13. Greig-Smith, Peter, Quantitative Plant Ecology (2nd Ed.), Washington, D. C.: Butterworth, 1964.

14. Cochran, William Gemmell, Sampling Techniques (nd. Ed.) New York: John Wiley & Sons, Inc., 1963.

15. Martin, A. C., Zim, H. S., and Nelson, A. L., American Wildlife and Plants: A Guide to Wildlife Food Habits,

16. Emlen, J. T., "Population Densities of Birds, Derived from Transect Counts," The Auk, 88(2): 323-342, 1973.

17. U.S. Department of Interior, Threatened Wildlife of the United States, Bureau of Sport Fisheries and Wildlife Publication No. 114, Washington, D. C.: 1973.

18. Sladeckova, A., "Limnological Investigation Methods for the Periphyton ("Aufwucks") Community," Botanical Review 28:286-350, 1962.

19. Vollenwelder, Richard Albert, A Manual on Methods for Measuring Production in Aquatic Environments, IBP Handbook No. 12, Philadelphia: F. A. Davis Col., 1969.

20. Edmondson, W. T., and Winberg, G. G, (Eds.) A Manual on Methods for Assessment of Secondary Productivity in Fresh Water, IBP Handbook No. 17, Oxford: Blackwell Scientific Publications, 1971.

21. Schwoerbel, Jurgen, Methods of Hydrobiology: Freshwater Biology, Toronto: Pergamon Press, 1970.

22. Oregon, "Oregon Air Pollution Control Regulations", Oregon Administrative Rules, Chapter 340, Department of Environmental Quality, Air Pollution Control (as amended through January 11, 1974).