GUIDELINES FOR REVIEW OF ENVIRONMENTAL IMPACT STATEMENTS

VOLUME III

IMPOUNDMENT PROJECTS

U.S. ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF FEDERAL ACTIVITIES

PREFACE

This volume presents detailed guidance for the assessment of the primary impacts of impoundment projects.

In its current form, this volume is intended to serve as a supplement to the Environmental Protection Agency's 309 Review Manual and existing assessment techniques related to water resources projects. In toto, these documents provide the detailed framework for the Environmental Protection Agency's review of impoundment project environmental impact statements.

As additional or refined review techniques and assessment procedures become available, this document will be reissued or revised as necessary. Note, however, that only the numbered copies are on the distribution list for revised materials.

Comments and suggestions regarding this document should be directed to the attention of the Director, Office of Federal Activities (A-104), Environmental Protection Agency, Washington, D.C. 20460.

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I. INTRODUCTION

The development of water resources continues at a high level in response to the need for water supply, flood control, irrigation, power generation, navigation, and other purposes. Virtually all of the larger streams in the United States are either already impounded or have been studied and identified as potential impoundment sites. Concurrently, pressures for conservation and preservation have been increasing because of concerns for the ecological, historical, aesthetic, and recreational values of our natural resources. There is also a growing awareness that these resources are rapidly being lost to development of all kinds. The conflict between development and preservation is particularly evident in the case of impoundment projects, since the major commitments of a freely flowing stream and riparian lands to permanent or periodic inundation, and the associated water quality and ecological impacts, are essentially unavoidable as long as the project remains in place.* From an ecological standpoint the worst thing that can happen to a stream is impoundment, and the second worst thing is channelization.[1] Impoundment has totally changed the molluscan fauna of the Tennessee River, dammed to form the Kentucky Reservoir, and it is concluded that the rich preimpoundment fauna is doomed. Over one-half the known species of mussels of the Illinois River have disappeared, and many others are on the verge of extinction. In addition, the maintenance of impoundments can result in significant environmental impacts in areas totally removed from the impounded area. For example, to prolong the life of reservoirs and to maintain the depth of navigation channels about 450 million cubic yards of bottom materials are dredged each year, and much of the spoil is dumped on marshes, swamps, and flood plains. It is apparent, then, that a complete assessment of resource commitments in terms of land, natural stream, and alteration of riverine ecology is fundamental to the process of weighing the benefits of an impoundment against the project's impacts.

Often the basic question of whether a given stream should be impounded at all sparks the most controversy and cannot be adequately answered using traditional methods of analyzing benefits and costs. Intangible costs, relating to the maintenance of natural environmental values, take on greater significance as the supply of the affected resources declines. Monetary values

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*The term, "Impoundment projects" in this document includes most fresh water impoundments from the largest to the small watershed work type.

for land acquisition, recreation days lost, and other factors do not adequately reflect these costs. The weighing of impacts that involve long-term resource commitments needs to be examined very carefully in the context of environmental goals and objectives. Planning must also be conducted relative to the fate of the project after its useful economic or structural life ends. The dismantling, evaculation, or continued maintenance of an impoundment should be consistent with environmental safeguards used during facility operation. The seriousness of this problem is illustrated by the fact that reservoirs in the Great Plains and elsewhere are accumulating sediments at the rate of 1 million acre feet per year. The average life of such reservoirs is estimated to be less than 50 years.

EPA's involvement in the impoundment development process stems from the mandates of the Federal Water Pollution Control Act (FWPCA), as amended, the National Environmental Policy Act (NEPA) of 1969 and the Clean Air Act Amendments of 1970.*

Under the FWPCA, EPA has authority and responsibility for effecting national water quality goals specified by the law. In particular, impoundment projects may affect EPA authority under Sections 102(b), 208, 303, 313, 402, and 404 of the FWPCA. The relationship of impoundments to these sections of the FWPCA are addressed in more detail below.

In view of the legal jurisdiction of, and special expertise within EPA, Section 102(2)(C) of the NEPA obligates Federal agencies to obtain comments from EPA wherever an action related to air or water quality, noise abatement, solid waste management, generally applicable environmental radiation criteria and standards, or other provisions of the authority of EPA are involved. Section 309 of the Clean Air Act Amendments of 1970 gives EPA the explicit legal mandate to comment in writing on the environmental impact of any matter relating to EPA's duties and responsibilities. To implement these responsibilities, the EPA manual Review of Federal Actions Affecting the Environment[2] (hereafter referred to as the "309 Review Manual" has established detailed policies, responsibilities, and administrative procedures for the Agency's review of Federal actions impacting the environment. This manual provides that, where an environmental impact statement (EIS) has been sent to EPA for comment, EPA's comments on

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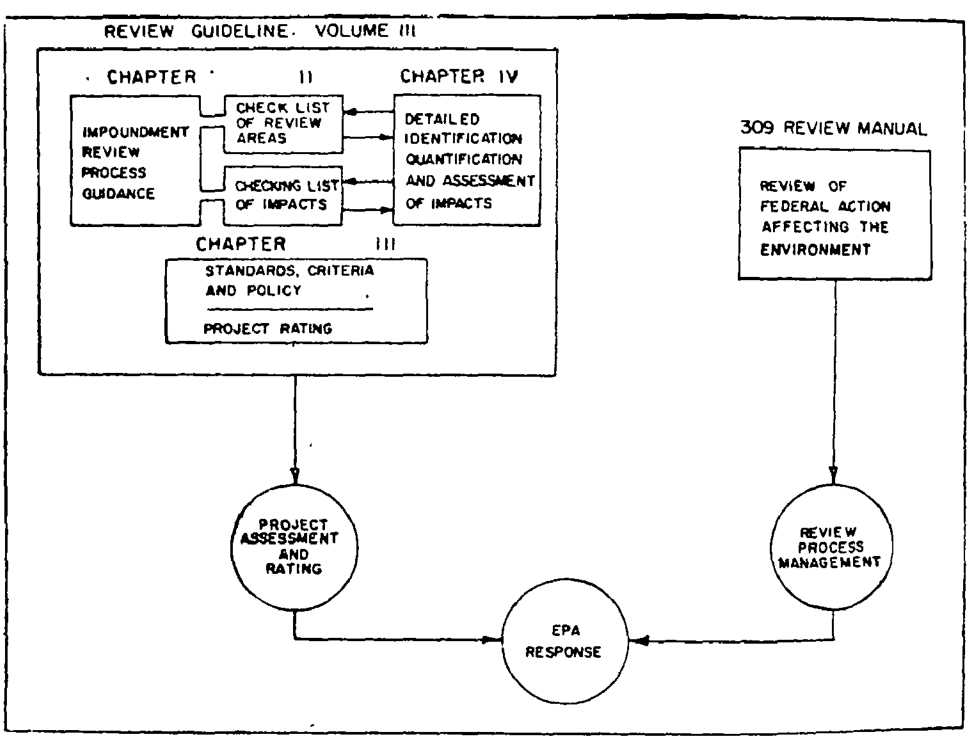
*A listing of other relevant legislation, Executive Orders, and Office of Management and Budget circulars and bulletins may be found in Basic Documents Concerning Federal Programs to Control Environmental Pollution From Federal Government Activities, U.S. EPA, Office of Federal Activities, February 1975.

the EIS shall also constitute its comments for purposes of the Section 309 review. Furthermore, it is EPA policy to use the Section 309 process in conjunction with EPA's other authorities to: (a) provide technical assistance to Federal, State, regional, and local governmental entities; (b) assist the environmentally-related activities of EPA and other Federal, State, regional, and local entities; and (c) assist Federal agencies in meeting the objectives of the National Environmental Policy Act.

Because the 309 Review Manual does not provide guidance for applying the Section 309 review process to specific types of projects, the Office of Federal Activities, in conjunction with the EPA program and regional offices, has prepared a series of detailed review guidelines for several major project categories. As one of the documents in that series, this guideline provides detailed information for applying the EPA EIS review process to impoundment projects. Figure I-1 illustrates the EIS review process. Chapters II and III of this guideline expand the manual's guidance for implementing the EPA policy described above. Chapter IV supplements the manual by providing a synthesis of the possible land use, water quality, ecological, solid waste, air, and noise impacts associated with impoundment projects. Information on the analysis and assessment of such impacts is also presented. Finally, a detailed bibliography is provided to permit the reviewer to explore specific problem areas in greater depth.

Figure I-1: Impoundment Project Review Elements



II. IMPOUNDMENT PROJECT REVIEW

As described in the 309 Review Manual, the EPA EIS review process consists of pre-EIS activities, review of Draft EIS's, pre-final EIS Liaison, review of Final EIS's, and post EIS follow-up. Guidance for the review of impoundment projects is given in the following subsections in terms of these five review phases. While it is recognized that unique situations within each region may dictate emphasis on one phase over another, all phases of the review process should be conducted to the fullest extent of the region's resources. In any case, it should be kept in mind that the goal of the review process is to maximize the effectiveness of the EPA involvement in impoundment projects. Generally, this is accomplished when the EPA involvement: (1) reflects the total environmental responsibilities of EPA, especially in those cases where the basic nature of the EIS indicates a need for a coordinated multi-program response; (2) is part of a continued working relationship with the originating agency to improve their project planning and design processes; (3) focuses sharply on environmentally unsatisfactory actions; (4) lends EPA support to projects having beneficial impacts on the environment; and (5) produces review responses which are expressed in constructive language, pointing out specific environmental problems that a proposed action might cause.

Note on Cooling Lakes

Impoundments constructed for the purpose of serving as cooling lakes for stream electric power plants will be treated in a separate technical manual yet to be developed. Revisions to the effluent guidelines for the Steam Electric Power Generating Point Source Category were proposed on 26 March 1976 (41 Federal Register 12694) to allow for the construction and use of on-stream cooling lakes, if the lakes meet criteria involving (1) the environmental acceptability of the lake in terms of municipal water supplies, shellfish beds and fishery areas, wildlife and recreation; (2) thermal efficiency; (3) recirculation requirements. Since procedures and information on review of cooling lakes proposals will be the subject of a separate manual, they are not discussed herein.

II.A. Pre-EIS Activity

"Pre-EIS activity" is a generic term which includes pre-EIS coordination within EPA as well as coordination and information exchanges with Federal, State, and local agencies responsible for project planning or licensing. Pre-EIS activity within EPA involves the coordination of EIS review with other EPA actions which may affect the impoundment project, such as discharge permits (NPDES), review of 404 permits, non-point source management under Sections 208 and 303, Federal facilities pollution control under Section 313, flow augmentation determinations under Section 102(b)(3), and sole-source aquifer determinations under Section 1424(e) of the Safe Drinking Water Act of 1974. Additionally, EPA positions expressed previously on the project or project site, as might be contained in reviews of earlier EIS's, Congressional correspondence, or other agency statements, must be considered in developing a consistent EPA position.

External pre-EIS activity includes a wide-range of activities outlined in the 309 Review Manual: (1) review of an applicant's environmental report or agency pre-draft EIS; (2) review of negative declarations; (3) participation at agency meetings describing the project; (4) substantive discussions with agency officials responsible for a proposed action, with emphasis on alternative mitigation measures; (5) provision of background materials for use in developing the EIS; (6) review of basin plans (Level B studies); (7) site visits. In order to fully realize such opportunities for pre-EIS liaison it is important that EIS Coordinators maintain frequent and regular contact with appropriate field agencies. EIS Coordinators should understand planning processes and associated outputs that might be useful in determining an early environmental assessment of developing projects. As a reference, the Appendix contains brief descriptions of the planning processes of the Corps of Engineers, the Soil Conservation Service, the Water Resources Council, the River Basin Commissions, and the Fish and Wildlife Service.

Pre-EIS liaison with Federal agencies may also be formalized through (1) a memorandum of understanding or (2) through protocols developed by the Federal agency. A memorandum of understanding, such as that developed with the Nuclear Regulatory Commission (NRC) contains provisions for joint preparation of an EIS for projects requiring an NRC license and a new source NPDES permit from EPA. (The NRC-EPA memorandum of understanding is contained in the Appendix). Under such an MOU, EPA bears responsibilities both as an EIS preparer (as issuer of the new source permit) and EIS reviewer (of the EIS on NRC's licensing action). In order to ensure an even-handed and consistent EPA approach in discharging these duties, the MOU establishes procedures requiring close coordination between the agencies at the EIS preparation stage. This specialized form of pre-EIS liaison is necessary in those circumstances in which EPA is involved in granting a permit to a facility that is being licensed by another Federal agency. MOU's analogous to that between EPA and NRC will probably be developed with the Rural Electrification Administration and the Federal Power Commission.

A more general type of arrangement is the pre-EIS protocol established by the Soil Conservation Service. In the early stages of planning, the SCS writes to EPA's regional offices to seek consultation on matters within EPA's area of responsibility and special expertise (See section 650.10(a)(6) of the SCS NEPA regulations). It is the responsibility of the EIS coordinator to ensure that the region is responsive to the SCS request for technical assistance as the planning process is initiated.

Pre-EIS activity is extremely important in preventing potential environmental problems from being realized. It is at the very early pre-EIS stages of project development that environmental problems are most susceptible to EPA-recommended mitigation measures. Similarly, the consideration of project alternatives is most practical when done before any single alternative becomes entrenched in the minds of project planners. The EIS review function is one of the few Agency programs by which EPA practices prevention, rather than abatement, of environmental problems. To secure the greatest benefit from this program, effective pre-EIS liaison is essential.

II.B. Review of Draft EIS

While the purpose of the review is to assess the environmental impact of the proposed project, it is also obviously necessary to assess the completeness (i.e., adequacy) of the material presented in the EIS. It is emphasized that the main objective of the EPA review is to assess the impacts related to air, water, noise, solid waste management, and other environmental areas within EPA's jurisdiction and expertise, and not primarily to critique the way in which the EIS is organized or written.

In determining the adequacy of the EIS, the reviewers should consider both the material presented in the EIS and the material presented in reference documents. According to the Council on Environmental Quality (CEQ) guidelines for preparation of impact statements,[3] "Highly technical and specialized analyses and data should be avoided in the body of the draft impact statement. Such materials should be attached as appendices or footnoted with adequate bibliographic references." In what follows, then, the term "EIS" is used in the generic sense of "EIS and referenced technical documents," provided that, first, the EIS contains adequate summaries of the methodologies and results of the various technical analyses, and, second, the detailed reports describing these methodologies and results are available.

The reviewer should note that the foregoing does not preclude the requirement that the EIS itself should contain sufficient "information, summary technical data, and maps and diagrams, where relevant, adequate to permit an assessment of potential environmental impact by commenting agencies and the public."[3]

A systematic review procedure is necessary to insure that all significant primary impacts have been considered and that the assessment of the various types of impacts can be combined into a single assessment of the project. The CEQ Guidelines (1500.8) have defined the major analysis categories to be included in an EIS:

(1) Project description;

(2) Relationship to land use plans, policies, and controls for the affected area;

(3) Probable impact of the project;

(4) Alternatives to the project;

(5) Probable adverse impacts which cannot be avoided;

(6) Relationship between local short-term use of man's environment and the maintenance and enhancement of long-term productivity;

(7) Irreversible or irretrievable commitments of resources;

(8) Other interests and consideration of Federal policy affecting the project decision.

The following review guidance is structured along these lines.

II.B.1. Project Description

Project description includes a statement of project purposes as well as a description of environmental effects. According to the CEQ guidelines, "the amount of detail provided (in the description of the proposed action) should be commensurate with the extent and expected impact of the action, and with the amount of information required at the particular level of decision making...." The reviewer should place the project in context with respect to the purpose of the project, the area in which the project will be constructed, and the relationship between the proposed project and other projects. This effort should aid the reviewer in defining the general level of review that will be required. To gain insight into a project, the reviewer may need to develop information from outside sources. Investigation of the history of project development and discussions with local groups who may have personal knowledge of the project characteristics can provide useful additional information and understanding of the project.

As an aid in checking the completeness of the EIS, a review checklist for impoundment projects is given in Table II-1. Since no single checklist can be applied to all situations, the reviewer is cautioned to utilize the technical review information in Chapter IV to determine which, and to what extent, each of the checklist items apply to the specific project under review.

II.B.2. Relationships of Project to Land Use Plans, Policies and Controls for the Affected Area

EPA's particular interest in reviewing an impoundment project under this criteria centers on the consistency of the project with the requirements of the Federal Water Pollution

Control Act, in particular sections 208 and 303. Under guidelines recently issued as 40 CFR Parts 130 and 131, States are to assume overall responsibility for development and implementation of water quality management plans mandated by section 208 and 303 to meet the goals of the FWPCA: (1) the determination of effluent limitations needed to meet applicable water quality standards, including the requirement to at least meet existing water quality; and (2) development of State and areawide management programs to implement abatement measures for all pollutant sources.

All States have developed a river basin planning process consistent with Section 303(e) of the Act. The basin planning program has resulted in the development of plans setting out effluent limitations needed by point sources to meet existing State water quality standards (Phase I Water Quality Management Plans). Under 40 CFR Parts 130 and 131, States must consider revisions to water quality standards to meet the "fishable, swimmable" goals of Section 101(a)(2) of the Act. The revised plans (Phase II Water Quality Management Plans) should consider all available means to meet water quality standards including effluent limitations for point sources and management of non-point sources.

Impoundment projects play a double role in the overall water quality management plan. On the one hand, impoundments are hydrologic modifications classified as possible indirect sources of pollution requiring the application of "best management practices."* On the other hand, an impoundment may provide storage leading to water quality improvements by retaining and settling polluted flood waters until their eventual release during periods of low flow. Section 102(b) of PL 92-500 makes specific provision for the consideration of water quality storage in impoundments constructed by Federal agencies or licensed by the Federal Power Commission. In addition, Section 102(b)(3) gives EPA the responsibility for determining the need for, value of, and impact of the inclusion of such storage for water quality control. Section 102(b)(1), however, specifically prohibits use of streamflow regulation as a substitute for adequate treatment or source management.

*The term Best Management Practices (BMP) means a practice, or combination of practices, that is determined by a State (or designated areawide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

The development of State water quality management plans must factor in the water quality effects of existing impoundments, both as indirect sources of pollution and as possible means of retaining indirect source pollution from extreme hydrologic events, or of reducing through flow augmentation the adverse effects of point source pollution. Determinations by EPA under 102(b)(3) should be tied to the water quality management plan for the river basin area that will be affected by proposed federally-sponsored or licensed impoundments. Section 102(b)(3) is discussed in more detail below.

Present and Projected Waste Discharges Within Reservoir Area. The water quality management (WQM) plan will contain information on the location and characteristics of wastewater discharges. If a proposed impoundment is to be used for public water supply, water contact recreation, or other purposes which require water of uniformly high quality, more stringent effluents limitations or even relocation of wastewater outfalls may be necessary. Nutrients, potentially toxic chemicals, organic matter, or other substances contained in treated wastewater discharges may be readily trapped and perhaps reach undesirable concentrations in the impounded water body, reducing its value for intended uses.

Alteration of Hydrographic Regime. A WQM plan is to contain, for each water quality segment, an analysis of the total maximum daily loads of those pollutants that violate applicable water quality standards, including a provision for seasonal variation. The plan should establish discharge load allocations or effluent limitations among significant discharges with an allowance for anticipated economic and demographic growth over twenty years. These determinations will generally be made through application of mathematical modeling techniques for specific flow conditions.

Many impoundments will be located on streams where water pollution is not a problem. Their operation may cause major changes in the flow regime at downstream points where serious water quality problems do exist. Low flows may be augmented, even if no storage has been allocated specifically for water quality control, and high flows during normally wet seasons may be severely curtailed as water is held for later release. Such changes may affect previously determined waste load allocations for downstream water quality segments or priorities for treatment plant construction.

EPA regulations[4] require that WQM plans be revised every five years, or more frequently where significant changes occur within the basin as brought about, perhaps, by impoundment construction. The affected State should be consulted regarding the possible impacts of regulated flow patterns on its areawide water quality management program. As a matter of policy concerning flow regulation by an impoundment project, EPA considers any flow regulation practices that result in lower than natural low flows to be in violation of the antidegradation clause of the water quality standards. On the other hand, any dependable upward revision of low flows which is expected from the operation of a proposed reservoir may affect interpretation of water quality standards and planning for individual treatment works. Both water quality standards and design of treatment plants are based on a specific, often statistically derived low flow value that may not be representative of the Post-impoundment flow conditions. Ideally, these issues should be resolved by the state water pollution control agency, with the assistance of EPA, during the planning phase of the impoundment.

Alteration of Preimpoundment Water Quality. An impoundment may have both beneficial and adverse effects on water quality in the impoundment and in downstream reaches. Changes in water quality parameters may directly affect the attainment of water quality standards and associated uses. For example, anaerobic conditions existing in the impoundment hypolimnion may result in high manganese and iron content, thus resulting in increased costs of treatment for water supply facilities. A more direct effect of the impoundment would be the elimination of a stream cold-water fishery, a high use supportable in a free-flowing stream but not in an impoundment. Improvement of water quality may be directly related to increased streamflow and waste assimilative capacity or to the settling and retention characteristics of the reservoir pool. Because basin planning, area-wide waste treatment management planning, and the discharge permit program are strongly oriented to the analysis and regulation of specific pollutants, predicted changes caused by impoundment may need to be considered. For example, an impoundment may substantially reduce suspended solids, turbidity, or coliform bacteria. If any of these parameters violate water quality standards or cause water quality problems in and downstream from a proposed reservoir area, then there may be cause for revising effluent limitations or other restrictions on these pollutants to allow for the "treatment" capacity of the impoundment. Any degradation of preimpoundment water quality, such as reduction of dissolved oxygen in the discharge, is detrimental.

Remedial measures should be evaluated during project planning and EIS review just as would be done for any other discharge which adversely affects water quality (see section IV.B.3 for descriptions of several alternatives).

Alteration of Water and Related Land Use. The direct and indirect changes in land use induced by a reservoir may have far reaching effects on water quality. In some cases, implications for future land use may be readily apparent. For instance, the location and amount of land to be brought into or taken out of agricultural production by use of impoundment-supplied irrigation water should be fairly well defined.

Likewise, storage allocated for municipal or industrial water supply may aid in supporting future development within or near those municipalities receiving the additional supply. Other growth may occur in the vicinity of the reservoir itself due to enhanced recreational attractiveness, or in downstream flood plains if control storage is included.

Although development of particular areas would often be expected regardless of whether an impoundment was constructed, the project may nevertheless stimulate such growth earlier than would otherwise have occurred. Coordination of impoundment planning (by BLM, COE, SCS, TVA, and BuRec) and areawide water quality planning is necessary so that potentially accelerated development, especially in water limited regions, is properly evaluated. A revision of growth projections in basin, land use, and other plans may be required as allowances for wastewater volume increases may no longer be representative of expected conditions. The EPA, in overseeing state water quality management programs, should ensure that any such changes in relevant planning factors are properly considered and incorporated as necessary into the basin plan.

Evaluation of Water Quality Control Storage. As discussed earlier, Section 102(b) of the Federal Water Pollution Control Act (FWPCA), as amended, gives EPA full responsibility for determining the need for, the value of, and the impact of storage for water quality control at federally planned impoundments and impoundments licensed by the Federal Power Commission. EPA has issued a policy statement and guidelines to regional offices for implementing the requirements of Section 102(b). Pertinent EPA memoranda that are important for review of impoundment EIS's and for pre-EIS studies of water quality control storage are:

- "Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies," 16 January 1973, (being revised).

- "Implementation of Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies" (7 February 1973).

- "Policy on Storage and Releases for Water Quality Control in Reservoirs," amendment to the first memorandum listed above (31 October 1973).

The policies and guidance contained in these documents apply to both requests for water quality storage studies and to the review of reports and EIS's involving Federal proposals for reservoir storage allocated for water quality purposes. All the environmental consequences of such studies should be considered so that the reviewer will be in a position to comment on the water quality storage aspect of the draft EIS when it is circulated. This procedure obviates the need for an additional, detailed review of proposed storage for water quality control at the draft EIS stage.

It should be noted that releases from multiple-purpose projects for navigation, recreation, fish and wildlife conservation, or other nonwithdrawal uses may provide incidental water quality improvement benefits. EPA should evaluate flow regulation specifically for these purposes in terms of its effect on water quality. The impoundment planning agency is responsible for actual determination of needs and values of storage allocated to purposes other than water quality control.

II.B.3. Probable Impact of the Proposed Project

Review of the probable impact of the proposed project should include the determination that all potentially significant impacts have been identified, the potential impacts have been properly quantified (within the limits of the state-of-the-art and commensurate with the severity of the impact expected), and that the impacts have been assessed with respect to applicable standards, criteria, and regulations.

In reviewing the EIS it is important to recognize the complexity of the changes that can occur in water quality due to impoundment and artificial management of a river. These changes can be broadly classed as:

- Changes that might occur in the water due to the presence of the project. This includes water quality changes due to impoundment such as DO depletion in bottom layers, seasonal temperature stratifications, the effect on sediment transport, warming trends, and potential eutrophication.

- Changes which might occur in water quality due to project operation. For instance, the operation of a reservoir for flood control can prolong the release of turbid water later in the year than normal and can appreciably alter temperature regime of the stream for a distance below the dam. The elimination of high velocity flood flows can disrupt the flushing action of the river and can lead to increased sediment accumulation with resultant effects on aquatic life. Levels of outlets will be important in the regulation of water quality and temperature of released waters. This may affect downstream uses as well as downstream ecology.

Table II-2 presents a comprehensive list of environmental impacts that could be associated with impoundment projects and gives the location in Chapter IV for detailed discussions of their identification, quantification, and assessment. Since this is a general list, the reviewer must determine the applicability of each item to the specific project at hand through the use of Chapter IV and other sources. By proceeding in this way, Table II-2 may be used as a checklist to help insure a complete review. As a further aid in the use of this table as an "overview," a synthesis of the major considerations for physical impacts is given below.

In addition to the cumulative impacts of impoundment in terms of the loss of land and a reach of freely-flowing stream, important changes in impounded water may affect water quality constituents in both the impounded stream section and downstream reaches. Initial impacts from organic decomposition resulting from permanent inundation of the impoundment site will generally lead to adverse water quality conditions, lasting from two to several years. The impounded stream segment also experiences a permanent reduction in its reaeration capacity, thus altering the capacity of the stream to assimilate oxygen-demanding wastes; however, the long retention times in other than run-of-the-river impoundments may mitigate the loss of reaeration capacity. The modified hydrological regime also results in important alterations in aquatic biota, particularly under stratified conditions. Oxygen depletion below the thermocline may prevent important sport fish (e.g. trout, salmon) from inhabiting the lower reaches of the impoundment (hypolimnion). On the other hand, the oxygen-rich waters above the thermocline (epilimnion) may reach summer-time temperatures which are unsuitable for the support of these cold-water game fish. Impoundments almost invariably reduce the diversity of the aquatic ecosystem in the impounded reach, leading to situations under which rough fish will out-compete and predominate over more desirable game fish.

The high probability that the quality of impounded water will be poorer than that of streams flowing into the impoundment has important implications for specific quality-sensitive water uses for downstream reaches as well as the impounded reach. Alterations of water quality that take place in the reservoir will similarly be transferred to downstream reaches. Sports fisheries downstream may be affected by the generally poorer quality water released from the impoundment. For municipal water supply, lowering of water quality in the reservoir may necessitate increased treatment costs for removal of iron, manganese, tastes and odors, algae, or other undesirable substances. These costs should be fully evaluated as a component of total costs of the project.

Water quality changes in downstream reaches result from the water quality of impoundment releases and by alteration of natural flows, water temperatures, and waste assimilative capacities. Stream conditions are not likely to remain static over the life of an impoundment, however, and impacts which may appear to be minor may become highly significant when viewed in conjunction with other incremental effects. An impoundment may alter the thermal regime through discharges of treated wastewater and cooling water, increased urban runoff from paved areas, and removal of streamside vegetation. Although each of these effects may be small, when combined they may jeopardize the maintenance of the natural stream ecosystem. The same analysis may apply to changes in flow regime, which arise not only from impoundments but also from downstream withdrawal uses of river water, diversion, and other losses.

Changes in water quantity and water quality downstream from a dam are certain to affect river ecology. Elimination or reduction of either cold or warm-water species of fish, invertebrates, and other fauna can be anticipated at impoundments that significantly change the thermal regime of the river. Flow regulation, alone or along with temperature and other changes, may interrupt fish migrations and spawning.

Stabilization of flows may provide conditions more favorable to some fish species, although the reduction of bank overflows will detrimentally affect the seasonal wetland vegetation characteristic of undeveloped river bottom lands and valley storage areas. Traditionally, modification of fish and wildlife resources, vegetation, and the ecology of areas affected by impoundments has been equated with losses or gains of hunting, fishing, or other recreational opportunities. However, this sort of analysis ignores many of the intangible values associated with the preservation of the remaining rivers in their natural states. (For example, areas of unique ecological or geological value would not be adequately evaluated using this technique alone).

Many indirect ecological impacts are related to changes in land use and increased development pressures resulting from impoundment construction. Intensive recreational use of shoreline areas around a reservoir will adversely affect wildlife and wildlife habitat as will the relocation of roads, railroads, and other facilities above the maximum reservoir elevation. Residential or second home development along the shorefront and on adjacent hillsides can also have detrimental impacts on terrestrial ecology and aesthetics. In the longer term, increased traffic and home development will exert additional pressures on wildlife in areas surrounding an impoundment. Such impacts can be traced to land use changes in downstream flood plains which are offered greater protection by an impoundment project and in areas of water use for water supply or irrigation.

Most impoundment projects incorporate major concerns for primary and secondary impacts on water quality, land use, and ecology. It should be realized that adequate assessment techniques do not exist for all impacts, even those which can be accurately identified and predicted. Downstream ecology can be altered substantially by fairly small changes in flow regime, temperature, characteristics of the stream bed, and other factors while all the parameters addressed in applicable water quality standards and criteria are being met. Such subtle shifts in ecology can rarely be evaluated in economic terms. These problems cannot be resolved readily within the existing framework of environmental criteria. Such impacts should be evaluated as fully as possible to indicate a need for a more comprehensive environmental quality standard or further study of the impact area significance.

The environmental effects, and feasibility of project alternatives should be described fully in the EIS . In the case of multiple-purpose projects, a combination of nonimpoundment alternatives would probably be required to meet various water

- Alternative methods of accomplishing each proposed project function. For instance, in the case of flood control, show that adequate consideration has been given to nonstructural alternatives such as flood plain management or zoning, flood-proofing, etc.

- Alternative structural components of the impoundment and/or alternative structural methods of achieving project purposes

- Alternative methods outside of agency responsibility

- Rescheduling of action

- Compensatory or mitigating measures

The effort required for assessment of each alternative will be a function of the type of alternative under consideration. The alternative must be reviewed in sufficient detail to identify all impact changes, whether they increase or decrease.

The review should recognize that the EIS's consideration of alternatives will be one of demonstrating why the alternative was unacceptable. In most cases, socioeconomic considerations will be a major factor. It is the reviewer's task to:

- Determine that all viable alternatives have been considered

- Determine that their environmental effects have been set forth adequately

- Review the alternatives from the standpoint of their mitigation of environmental impact possibilities over the proposed project's lifetime

II.B.5. Probable Adverse Impacts that Cannot be Avoided

The probable adverse impacts that cannot be avoided will be the basis for the overall assessment and rating of the project.

For each alternative considered, the reviewer should summarize the probable adverse impacts and relate the adverse impacts to the proposed project and other alternatives. After all alternatives have been considered the reviewer should be able to determine whether the proposed project both minimizes the environmental impact over all other alternatives and is within acceptable environmental impact limits.

Although these guidelines are concerned mainly with the primary pollutant impacts, to the extent possible the project assessment rating also should include consideration of secondary pollutant impacts. The crux of the review assessment is to insure that the EIS contains sufficient information to "explore alternative action that will avoid or minimize adverse impacts and to evaluate both the long and short-range implications of proposed actions to man, his physical and social surrounding, and to nature."[3]

II.B.6. Relationship of Short-Term Uses vs Long-Term Productivity

From the Council on Environmental Quality guidelines,[3] "This section should contain a brief discussion of the extent to which the proposed action involves tradeoffs between the short term environmental gains at the expense of long term losses, or vice versa, and a discussion of the extent to which the proposed action forecloses future options." Assessment of impacts within this category requires that the reviewer determine the extent of the limitations, if any, placed on future benefits of the project area, such as:

- The effects the project will have on the natural value of free-flowing rivers which must be considered diminishing resources themselves

- The potential long-term decreases in environmental productivity due to the artificial control of basin hydrology for short-term economic gain

- An evaluation of flood hazard in locating federally owned or financed buildings, roads, and other facilities and in disposing of federal lands and properties (i.e., review of EO11296)

II.B.7. Irreversible and Irretrievable Commitments to the Proposed Project

The intent here is to determine that the environmental impact statement has identified properly "the extent to which the action irreversibly curtails the range of potential areas of the environment."[3] Especially noteworthy are the effects associated with connecting a free-flowing river to an artificially managed water body and the potential commitment of a river's flood plain for surface water use and general development. Assessment in these areas, if well posed, can provide significant inputs to the EPA review response.

II.B.8. Other Interests and Considerations of Federal Policy

The CEQ Guidelines refer to such Federal policies that are "thought to offset the adverse environmental effects of the proposed action." EPA reviewers should, however, consider the project from the standpoint of all Federal policies for which EPA has primary responsibility. Most of these policies are, of course, contained in EPA's legislative authority and implementing regulations. Other sources of EPA policy are contained in the Administrator's Decision Statements, the 309 Review Manual, and the notebook containing Policy and Guidance documents compiled by OFA. The OFA Policy and Guidance notebook provides guidance on a number of policy areas which are under the cognizance of other Federal agencies, but which nevertheless impact EPA programs. Laws relating to such policy areas include the Coastal Zone Management Act, the Endangered Species Act of 1973, the National Historic Preservation Act of 1966, E.O. 11296, and the Fish and Wildlife Coordination Act. All but the last two areas are specifically discussed in the OFA Policy and Guidance notebook.

II.C. Pre-Final Impact Statement Consultation

Efforts should be maintained to follow up and work with agencies which have submitted draft EIS's that are rated with categories ER, EU, or 3, so that they are improved at the final stage. At the request of the principal reviewer, appropriate EPA personnel should meet with officials of the initiating agency to discuss EPA's comments, provide additional information, and to recommend means to improve the proposed action and supporting EIS. Meetings conducted at the Headquarters level shall be coordinated by OFA. If an agency requests an EPA position on a proposed final EIS, the principal reviewer may acknowledge tentative concurrence or nonconcurrence with the agency's response to EPA's comments on the draft EIS. Care should be taken to avoid written statements that can be taken as an EPA endorsement of an action or objection to an action on nonenvironmental grounds.

SCS has requested that EPA be available to provide an evaluation of its response to the EPA comments on draft EIS's not rated "LO." Complying with SCS's request for an EPA position on proposed final EIS's (for drafts rated ER, EU, or 3), responses to their comments should be made within 30 days of receipt, provided that the EPA concerns have been adequately resolved in pre-final consultation. The reviewer should acknowledge EPA's tentative concurrence with SCS's response to the comments on the draft through a letter subsequent to the pre-final EIS consultation. If the EPA concerns cannot be resolved with SCS during pre-final consultation, the normal final EIS review procedure should be followed.

A follow-up on EPA's comments on draft EIS's relating to permits under consideration (for issuance pursuant to Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the FWPCA) is especially important because of the Administrator's responsibility under Section 404(c). Principal reviewers should determine whether the final EIS contains sufficient information to provide a basis for the exercise of the Section 404(c) responsibility.

II.D. Review of Final EIS

For each draft EIS which was rated category 2, 3, ER, or EU, the final EIS will be reviewed to determine whether the statement substantially resolves the problems surfaced by the draft EIS. The principal reviewer will consult and coordinate, as necessary, with those EPA offices included in the review of the draft EIS. In reviewing the final EIS, primary attention should be directed to substantive issues related to assessing the environmental impact of the proposed action.

The principal reviewer must also review the final EIS where the Agency's draft EIS comments were rated 2 or 3 to ensure that the originating agency provides sufficient information for a comprehensive review of the final EIS. It is necessary that the review of the final EIS be effected in an expeditious manner. The comments generated by EPA must be issued within the 30-day deadline. Thirty days is the period the initiating agency must wait before taking action on the proposed project.

II.E. Project Follow-Up

After completion of the reviews of an EIS, the principal reviewer should conduct a post-EIS follow-up where the EPA determines that the proposed action, as reflected in the final EIS, contains environmental reservations, or is environmentally unsatisfactory, or that the final EIS is unresponsive. The principal reviewer should effect post-EIS liaison by preparing a plan of action and submitting this plan to OFA for Headquarters comment and coordination. (See Transmittal 2 for procedural requirements). In carrying out his post-EIS follow-up responsibilities the principal reviewer shall ensure that he coordinates his activities with the responsible initiating agency official, appropriate state and local environmental protection officials, and other EPA officials. These officials will include, among others, regional or state enforcement officials for NPDES permitting, regional enforcement officials for Section 404 enforcement, and regional air program officials for transportation control strategy compliance and state implementation plan requirements.

In the long term, a project follow-up will consist of the review of Operation and Maintenance EIS's. These EIS's are written for large in-place impoundments and should include a description of the releases from the dam as well as the management of the recreational developments, fisheries, and land use plans of both Federal, non-Federal, and other responsible agencies.

Table II-1. Impoundment Review Checklist

I. Review the Project Environmental Setting

Issue: What is there now? What are the baseline conditions?

Physical

° Topography

° Soils and geology

°° stability (slides and slumps)

°° earthquake potential, geological evolution

° Basin geomorphology

Cultural

° Land use

°° commercial, industrial, residential

°° forestry

°° mining

°° agricultural

°° recreational

°° aesthetic: wilderness, scenic, open space, parks, unique physical features, historical and archaeological sites

Biological (flora and fauna)

° Aquatic

°° endangered species

°° unique ecosystems

°° fish and shellfish, including migration routes and spawning areas

- °° benthic organisms
- °° insects
- °° microfauna, microflora
- °° aquatic plants

° Terrestrial

- °° endangered species
- °° unique ecosystems
- °° range and habitat, migratory patterns, barriers, and corridors
- °° vegetation: trees, grasses, shrubs, crops

° Wetlands

- °° relation to aquatic, terrestial habitat
- °° type and value

<u>Hydrological</u>

° Climate

° Flows, floods (highest and lowest, recurrence intervals)

° Erosion and sediment production, deposition

° Geohydrological

- °° aquifer location and extent
- °° recharge characteristics

° Water quality

- °° existing uses
- °° existing levels of water quality parameters

° Rainfall-runoff/snow - snow melt characteristics

° Estuaries

- Floodplains and wetlands

II. Review the Project Characteristics

Issue: What is this project for? What will it do? What does it look like?

Physical

- Impoundment morphometry
- Size: height, acre-feet, conservation levels, flood control pools
- Construction techniques
- Auxiliary systems: roads, transmission lines, boat ramps, power houses

Functions

- Single purpose
  - flood control
  - navigation
  - water quality
  - recreation
  - water supply
  - irrigation
- Multi-purpose

Economics

- Demand studies: bases for project need
- Supply studies: ways to meet identified needs
  - alternative projects
    - structural
    - non-structural

° Project life

° Benefit/cost analysis

° Application of Water Resource Council Principles and Standards

Operating Characteristics

° Schedule of releases for each project function

° Design

°° outlet levels

°° reaeration procedures

III. Review Environmental Impacts of Project

Issue: How will completion of this impoundment project (described in II above) affect the environment (described in I above)?

° Review the predicted effects of the proposed impoundment on the environmental characteristics of the river basin: Physical, cultural, biological, hydrological (I above).

° In particular, review:

°° Projected changes in water quality parameters resulting from impoundment construction and operation

- in the impoundment itself

- in downstream reaches

°° Projected changes in uses (e.g. aquatic biota, water supply, recreation) resulting from charges in water quality parameters.

- in the impoundment

- in downstream reaches

°° Projected charges in land use, such as a shift from low intensity (agriculture) to high intensity (industry) uses on the flood plain.

- effect on wetlands, aquatic and terrestial habitat

- effect on water quality management planning

- effect on air quality maintenance planning

° Review predictive modeling techniques for:

°° reasonableness of assumptions

°° technical validity

°° predictive reliability

°° sensitivity analysis under differing assumptions

° Review alternatives

°° design

- impoundment size

- operating policy

- operating design (e.g. multi-level outlets)

°° non-structural

- no project

° Review mitigation measures

°° design modifications

- aeration of releases

- destratification; hypolimnetic aeration

- multi-level outlets

IV. Review Project Impacts for Consistency with Federal Environmental Policy

Issue: Does the severity of the environmental impacts (described in III above) of the project render it inconsistent with the objectives, standards, or implementing procedures of Federal environmental policy?

- Review EPA legislative authority
  - Is project consistent with legislated environmental objectives and policies?
  - Is project consistent with regulations implementing environmental objectives and policies?
  - Will the project lead to standards violations?
- Review consistency of project with environmental planning efforts
  - Is project consistent with State Water Quality Management Plans?
  - Is project consistent with Air Quality Maintenance Plans?
- In particular, review consistency of project with environmental requirements most likely to be affected by impoundment projects.
  - Water quality standards
    - flow requirements
    - water quality criteria
    - designated water quality uses
    - anti-degradation policy
  - Section 313 (Federal facilities) pollution control
  - Section 404 (Dredge and Fill). If disposal of dredged or fill material is involved, review for compliance with 404 Guidelines (40 CFR 230)
    - wetlands
    - municipal water supplies
    - fisheries and shellfish beds
    - wildlife
    - recreational areas

- ◦◦ Administrator's Decision Statement on Wetlands

◦ Review project under related Federal environmental requirements

- ◦◦ Conformance with NEPA requirements and CEQ Guidelines
- ◦◦ Conformance with Water Resources Council's Principles and Standards (if applicable)
- ◦◦ Conformance with:
  - Coastal Zone Management Act
  - Endangered Species Act
  - Fish and Wildlife Coordination Act
  - National Historic Preservation Act

◦ Review project in terms of mitigation measures (including alternative projects and delayed construction) which could reduce the adverse environmental effects of the project

- ◦◦ Mitigation measures available to reduce adverse effects should be fully utilized.

Table II-2. Impoundment Impact Checklist

Topic	Page Reference in Chapter IV
Construction Phase Impacts	
Sediment pollution and stream siltation	14
Pesticides, petrochemicals, and other potential pollutants	14,15
Quantification of erosion and sediment generation	25
Relevant criteria for sediment pollution	47
Protection of water quality during construction - general	47,48
Erosion and sediment control techniques	48,49
Treatment of polluted water from construction site	51
Activity scheduling	56
Components of solid waste from construction operations	66
Disposal of chemicals and containers	68
Summary of solid waste impacts	72
Air pollution sources at construction sites	73
Noise generators at impoundment construction site	78
Typical construction noise levels	80
Rough estimation of noise impacts	81,82
Damaging effects of noise	85
Impacts in Impoundment	
Probable land use impacts	1,2
General methodology for evaluating land use changes and impacts	3,4
Loss of stream and bottom land	4,5
Relocation impacts	5
Recreational development - general	5,6
Secondary air pollution impacts (parking facilities)	77
Solid waste generation at recreational areas	69,70
Impact of land inundation on impoundment water quality	16
Organic decomposition and dissolved oxygen deficiency	16,17
Solution of iron and manganese	17
Loss of wildlife habitat	17,35,36
Assimilative capacity changes - general	
Primary determinants	17
Critical water quality conditions	18,19
Effects of stratification and density currents	18,19
Eutrophication and associated impacts	19
Consideration of evaporation	20,35
Shift from river to lake environment and reduction of species diversity	20,36
Sedimentation in impoundment	21
Modelling of impoundment water quality	25,26
Estimating significance of site conditions with respect to impoundment water quality	27,28
Potential for erosion in reservoir	28,29

Table II-2. Impoundment Impact Checklist
(Cont'd)

Topic	Page Reference in Chapter IV
Impacts in Impoundment (Cont'd)	
Relationship of morphometry to potential eutrophication and weed problems	30-33
Nutrient sources and loadings	30-33
Quantification of influent water quality	32
EPA responsibilities for point and nonpoint pollution sources	32,33
Probability of water quality problems in stratified reservoirs	33,34
Evaluation of reservoir fisheries	51-55
Summary of water quality parameters that may be affected by impoundment and relevant criteria	52,53
Thermal criteria for fisheries	54
Downstream and in areas of water use	
Influence of land acquisition policy on reservoir development	5-7
Induced development in region	7
Land use impacts due to increased flood protection	7,8
Land use impacts of irrigation impoundments	8,9
Evaluation of water pollution from irrigation	8,9
Policy concerning use of flood plains	10
Prevention of water quality degradation from irrigation projects	9-12
Impact of water quality changes on downstream biota	23,24
Impact of dam as barrier	24
Flow regime changes - general	37
Quantification of hydrographic modification	38
Seasonal and diurnal flow variations	39
Minimum release requirements	39,40
Low-flow augmentation analysis	40
Effects on riparian vegetation	40
Flow requirements for salmon and other species	41,42
Temperature changes - general	42
Important categories of fish species	42,43
Effects of outlet location and impoundment operation	43,44
Possible thermal effects on downstream species composition	44,45
Thermal criteria for fisheries	54
Effects on downstream uses	60-62
Alternatives for mitigating impoundment and downstream water quality impacts	
Reservoir clearing	55,56
Removal of soil and organic matter	56
Selective withdrawal	57
Turbine aeration	62,63
Howell-Bunger valves	63,64
Destratification and hypolimnetic aeration	64,65

III. PROJECT RATING

The basis for the EPA comments on the environmental impact of impoundment projects is quite broad. As stated in the Clean Air Act, Section 309(a), EPA comments on "...any matter relating to duties and responsibilities granted pursuant to this Act or other provisions of the authority of the Administrator...." The NEPA, section 102(2)(C) states "...the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to the environmental impact involved."

The above mandates have been interpreted to mean that the EPA comments should be related to the impact of projects on water quality, air quality, solid waste management, noise, radiation control, and pesticide and other toxic substances use and control. Water quality concerns include protection of beneficial water uses, wetlands, aquatic life and habitat, and water-related wildlife. Comments related to land use, terrestrial wildlife, aesthetics, recreation, and other areas must be related to areas of expertise. It is proper to discuss residential or industrial development that an impoundment project may induce if it will aggravate an already serious air or water pollution problem. It is also proper to evaluate the potential for downstream development in floodprone areas as a result of flood control impoundments as well as the extent to which projects benefits assigned to flood control include such projected development.

If an EPA reviewer has special insight on a project, such as that resulting from an on-site inspection or discussion with community leaders, it is appropriate to make comments on matters falling outside of EPA's specific areas of jurisdiction. The EPA policy is that such comments are for information only and are not used to justify the assigned EPA rating. Furthermore, such comments must include a statement to the effect that final determination on the matter is deferred to the Federal agency with the appropriate jurisdiction.

The specific bases for the EPA assessment of environmental impacts consists of the standards, criteria, EPA policy decisions, and consistency requirements with other EPA program responsibilities as shown in Table III-1.

As detailed in the 309 Review Manual, the EPA rating scheme is different for draft EIS's, final EIS's, and pre-Clean Air Act Amendments EIS's. At the draft stage comments shall be designated by an environmental impact rating of LO (Lack of Objections), ER (Environmental Reservations), or EU (Adequate), Category 2 (Insufficient Information), or Category 3 (Inadequate). If a draft EIS is assigned a Category 3, normally no rating will be made on the environmental impact of the proposed project or action since a basis does not generally exist on which to make such a determination. When there is a basis for assessing the environmental impact of a proposed action, such as independent documents or on-site surveys, such a rating may be established at the discretion of the principal reviewer after consultation with OFA.

At the final stage, no alpha-numeric designations are made since only the project impact is considered and not the completeness of the EIS. The project impact rating assignments for the final EIS consist of Lack of Objection, Environmental Reservations and Environmentally Unsatisfactory. A rating assignment of Unresponsive Final Impact Statement can be made if the final EIS has not responded adequately to comments made by EPA on the draft EIS. Such comments may also be offered if new environmental concerns have been brought to the EPA's attention since the review of the draft EIS and the originating agency does not adequately evaluate these factors in the final EIS. In the case of projects which were authorized prior to passage of the Clean Air Act Amendments (December 31, 1970), the determination of Environmentally Unsatisfactory shall not be used. Instead, the final EIS comment should present EPA's substantive comments on the project, omitting both reference to Section 309 and use of the term, Environmentally Unsatisfactory.

The general criteria for assigning the Environmental Reservations, Environmentally Unsatisfactory, or Category 3 ratings are given in Table III-2. The reviewer should note that these criteria are intended to be used as guidelines rather than strict rules. The decision regarding the impact of each project must incorporate all the mitigating factors for that particular project. The sensitivity of the impoundment environment to the changes imposed by the project, as well as the effectiveness of mitigating measures, must be taken into account.

Table III-1. Standards, Criteria and Regulations Related to Impoundment Projects

Standards

- Latest version of primary drinking water standards prepared by EPA pursuant to the Safe Drinking Water Act (PL 93-523)
- Water Quality: State adopted water quality standards consisting of designated use and water quality criteria and plans for the enforcement and implementation as referenced in 40 CFR Part 120 and 130.17
- Air Quality: National primary and secondary ambient air quality standards as specified in 40 CFR Part 50

Criteria, Regulations and Policy

- Criteria for Water Quality, Volume 1 (Proposed) U.S. EPA, October 1973
- Water Quality Information, Volume II (Proposed), U.S. EPA, October 1973
- Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, U.S. EPA, March 1974
- Regulation for the Disposal and Storage of Pesticides and Pesticide Containers, 40 CFR Part 165
- EPA Policy to Protect the Nation's Wetlands, Administrator's Decision No. 4
- Navigable Water, Procedures and Guidelines for Disposal of Dredged or Fill Material, 40 CFR Part 230
- Latest regulations prepared by EPA pursuant to Section 1424(e) of the Safe Drinking Water Act regarding Federal projects in a recharge area of an aquifer designated as a sole source aquifer
- Amended FIFRA Act. The Federal Environment Pesticide Control Act of 1972 (FEPCA)
- Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies, 16 January 1973 (two enclosures) and amendment, 31 October 1973
- Implementation of Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies, 7 February 1973
- Thermal Processing and Land Disposal of Solid Waste Guidelines, 40 CFR, Parts 240, 241

Consistency with Other EPA Programs

- Areawide Waste Treatment Management Planning Areas ("208" Plans), 40 CFR Part 126
- State and Areawide Water Quality Management Plans, 40 CFR Parts 130 and 131
- National Pollutant Discharge Elimination System, 40 CFR Part 125
- State Air Implementation Plans, 40 CFR, Parts 50 and 51

Table III-2. Rating Impoundment Projects

General Criteria (from 309 Review Manual)	Specific Criteria for Impoundments
Category EU	Category EU
a. Where it is highly probable that a violation of standards will occur. 1. Federal, State, and local standards are included; includes EPA regulations and guidelines.	° Violations of water quality standards, including noncompliance by Federal facilities with requirements for pollution abatement and control (section 313); °° violations of water quality criteria defining uses designated in standards; °° violations of flow requirements required by water quality standards; °° violation of State anti-degradation provision or EPA's anti-degradation policy; °° violation of State mixing zone policy. ° Violation of informational guidelines, such as those for non-point source control (304(e)). ° Unacceptability under FWPCA Section 404, i.e. impoundment projects for which EPA has denied a permit under 404(c) for reasons relating to water supply, shellfish beds and fishery areas, wildlife, or recreational areas.

2. Projects which as "an initial step do not violate standards, but inherently create significant pollution problems in related areas."	° Projects which, with high probability, will lead to undesirable growth rates adversely affecting the attainment of air quality goals in critical Air Quality maintenance areas or water quality goals established through State Water Quality Management Plans (Section 208, 303). ° Projects which will not "stand along," i.e. those for which full realization of benefits <u>strongly</u> implies further system development which, taken as a whole, would lead to standards violations or "undesirable growth rates" described above.
b. Where a Federal agency violates its own substantive environmental requirements.	° As applicable.
c. Where there is a violation of an EPA policy declaration.	° Violation of EPA's Statement of Policy on Protection of Nation's Wetlands (38 FR 10834). ° Violation of EPA policy regarding 102(b) of the FWPCA.
d. Where there are no applicable standards or where applicable standards will not be violated but there is potential for significant and severe environmental degradation: (1) which could be mitigated by other feasible alternatives; <u>or</u>	° Where adverse environmental effects are beyond EPA's jurisdiction and expertise (e.g. historic site, wild and scenic rivers), but there exists a feasible alternative (i.e. one that would substantially accomplish project purposes) which would significantly reduce adverse environmental effects.

(2) which relates to EPA's area of jurisdiction or expertise.

- Where severe adverse environmental effects are within EPA jurisdiction and expertise but no standards violations are expected, e.g. either no standard exists for a particular water quality parameter, or considerable uncertainty regarding project environmental effects exist.
- Where aquatic biota, water supply, or recreational areas are threatened, but no 404 permit is involved.

Category 3	Category 3
a. Insufficient information to permit a reasonable review of project features, thus precluding evaluation of project effects on EPA standards, regulations, or policies.	° Inadequate description of water quality parameters and their effects on uses (e.g. aquatic biota, water supply), either for the impoundments or downstream reach. ° Inadequate description of project operation, purposes, benefits and costs, construction techniques, resulting growth patterns, and other features necessary to allow comparison of project effects with area Water Quality Management Plans (and, perhaps, Air Quality Maintenance Plans).
b. EIS's which, whether intended or not, are overview EIS's covering a broad class of actions for which the initiating agency either does not intend to prepare detailed project-by-project EIS's, or where the Inadquate rating, coupled with specific comments, would substantially aid the initiating agency in its useful project-by-project EIS's.	° Projects which may provide comparisons with Water Quality Management Plans, but are inadequate for determining local effects on water quality, aquatic biota, or other areas of EPA jurisdiction and expertise.

IV. IDENTIFICATION AND ASSESSMENT OF PROJECT IMPACTS

IV.A. Review of Land Use Impacts

Land use impacts related to construction and operation of an impoundment may not be limited to the immediate project area and may vary depending upon the purposes of the impoundment. It is critical that the scope of the EIS is broad enough to cover significant secondary land use effects which may be experienced downstream or in other locations. The primary focus of the review should be on the expected environmental impacts of land use changes following impoundment construction and on the significance of the affected natural resources.

IV.A.1. Sources of Impacts

The impacts of an impoundment on land use may be associated with three different zones within the project's area of influence, namely, the reservoir area itself, the immediate vicinity of the impoundment, including surrounding communities, and the region that benefits from the project's functions and purposes. Identification and quantification of impacts become increasingly difficult in areas directly affected by, but geographically removed from, the project site. Guidance for impact assessment becomes less definitive and precise when dealing with impoundment-induced impacts on land use. Some land use impacts within an impoundment's area of influence are included in the following sections.

IV.A.1.a. In Impoundment

Impoundment construction necessitates acquisition and removal, from existing uses, of a certain amount of land area and natural stream. A number of environmental and socioeconomic impacts, both primary and secondary, may be associated with land conversion for a reservoir:

- Loss of freely flowing stream and associated recreational opportunities
- Alteration of aesthetic values
- Displacement of families
- Loss of flora and fauna
- Change in aquatic biota characteristics

- Increase in employment during construction
- Loss of agricultural land and farm revenues
- Loss of forest land and timber production
- Loss of wetlands
- Increase in lake-related recreational opportunities
- Loss of archaeological resources
- Loss of historic sites
- Loss of wildlife habitat (possible effect on rare and endangered species)
- Effects on water quality and possible effects on applicability of existing water quality standards

IV.A.1.b. In Vicinity of Impoundment

Land use changes and related impacts in the area surrounding an impoundment depend largely on the characteristics and purposes of the project. The following are examples of impacts that may occur:

- Relocation of transportation networks and utilities
- Change in economic base
- Development of concessions and recreational service facilities
- Development of second homes
- Change in recreational use below dam
- Increase in traffic, noise, and air pollution
- Increase in waste management problems
- Impacts on aquifer
- Environmental and health effects including psychological, physiological changes and changes in life styles.

IV.A.1.c. In Impoundment Area of Influence

Possibly the greatest long-term land use impacts of an impoundment will be felt in those areas that receive project outputs such as flood control, water supply, irrigation, or recreation benefits. Impacts on land use may occur in less well defined areas in the region but it is difficult if not impossible, to isolate the contributing influence of an impoundment from general economic and social stimuli for development. With concentration on areas principally affected by an impoundment, important land use changes and impacts include:

- Further development of downstream flood plains
- Concentration or growth, and consequently pollution sources, in urban or other areas receiving water supply
- Loss of natural vegetative cover on newly irrigated lands
- Impacts on existing agricultural producers and markets
- Increase in wastewater discharges
- Pollution problems from irrigation drainage and runoff

More detailed outlines of socioeconomic, land use, and related ecological considerations can be found in publications by Hagan and Roberts[5] and Warner et al.[6]

IV.A.2. Review of Impact Quantification

In the long-term commitment of land for an impoundment, existing and potential future uses and values of the inundated area must be put into perspective so that the magnitude and significance of the action can be estimated. Many natural resources and ecological values cannot be described fully in economic terms. For these values, a reasonably accurate determination of regional significance or uniqueness is especially important. With respect to each category of land or stream use in a proposed impoundment area an adequate description of impacts should address, and quantify as appropriate, at least the following:

° What is the magnitude of the resources involved (e.g. miles of stream, acres of agricultural bottom land, etc.)?

° What is the supply of similar resources in the vicinity of the project, the watershed, and the region?

° What is the quality of the resource relative to similar resources in the region (e.g. fertile bottom land versus marginal agriculture nearby, good stream fishery, highly utilized waterfowl breeding area, etc.)?

° Does the resource have special significance because of uniqueness (e.g. historic or archaeological values, candidate for wild and scenic river status, spectacular scenic beauty, rare or endangered flora and fauna, etc.)?

° Can the resource commitment be mitigated or avoided by utilizing a different site, a change in proposed pool elevation, or a non-impoundment alternative?

Since land commitment for an impoundment is essentially permanent, the aspects of regional supply and quality of the particular resource should be projected into the future, to a certain extent, to complete the analysis. Pertinent considerations to quantification of various land use impacts are discussed below.

Loss of Stream. On both the national and regional scale, natural, unimpounded rivers are diminishing resources. There are only a few areas where the supply meets the demand, either because of damming or because of water quality degradation, or other factors that detract from the usefulness of streams for recreation and other purposes. A continuing decrease in the supply of natural streams also enhances the values of the remaining streams.

The loss of "x" miles of freely flowing stream must be related to the availability both of other such streams in the region and of attendant values such as stream fishing for trout or other species, white water canoeing, or unique natural beauty. Because of the long-term commitment of a stream resource, it is not sufficient to quantify the environmental impact in terms of a loss of so many visitor-days per year. Numerous intangible impacts and costs should also be expressed, at least through comparison with similar resources in the region. Important points to look for in the EIS to aid this assessment are:

° Description of stream biota and analysis of how they will be affected by impoundment.

° Description of other existing, authorized, or proposed impoundments in the basin or region. If the impoundment constitutes only one of several projects in a comprehensive water resources development program, cumulative losses of natural streams may be critically important.

- Discussion of alternatives. The alternatives of "no-build," construction of a smaller project, a dry-bed reservoir, lower pool elevation, or location at a different site might avoid or reduce stream losses.

Loss of Agricultural and Forest Land. The best agricultural land in an area is often preempted for an impoundment site. It is probable that the need for this land will steadily increase while at the same time marginal lands are being brought into production and more fertile areas lost to various types of development. There is no way to mitigate the loss of highly productive river bottom land that is committed to reservoir use. The local impact of reduced agricultural productivity can be measured and assessed by relating the amount of farm land and the value of crops affected by an impoundment to similar parameters of the agricultural economy in surrounding areas. Regionally, the impact of changes in agricultural land use due to impoundment construction may be minor and is usually difficult to quantify. However, these impacts may be cumulative.

The same comparisons for forest and timber land, pasture, natural wetlands, and other land resources within the impoundment area can be used as an aid in determining their importance near the project site.

Relocation Impacts. Relocation of residences, commercial establishments, transportation facilities, and even small communities are evaluated in terms of economic costs. Land use impacts may extend into areas adjacent to a proposed impoundment, both directly as a result of the need for certain relocations and indirectly from the alteration of local resources. Construction or reconstruction of access roads, highways, railroads, transmission lines and other corridor-type utilities is commonly required at impoundment sites. The topography along the perimeter of a reservoir often presents more difficult conditions for construction than that of the lower valley. Adverse aesthetic and environmental impacts may accompany relocation of such facilities and are best addressed in rigid construction specifications for the project.

Recreational Development Impacts. Development of extensive recreational facilities at an impoundment project can be expected to result in secondary environmental impacts. It is important that the number, type, and location of proposed facilities, as well as projected initial and future recreational use, be specified in the EIS. Intensively used recreation areas such as campgrounds, picnic areas, and swimming beaches experience greater environmental degradation than do hiking trails, nature study areas, and other sites receiving less heavy use. Localized traffic congestion, degradation of air quality near parking lots, soil compaction, loss of vegetation, increased waste generation, and potential water quality problems may occur and should be addressed in the EIS. Anticipated visitation on peak summer weekends should also be quantified.

Provision for recreational facilities in the project plan may stimulate development of supporting enterprises such as sporting goods stores, boat rentals, concessions, and other businesses. Such development may occur near the lake shore or in peripheral areas made accessible by existing or relocated roads. Construction of cottages or summer homes overlooking or along the shoreline of the reservoir may take place, particularly if the impoundment offers significant recreational opportunities.

The same factors of supply and quality previously discussed pertain to water-based and shoreline recreational development at an impoundment. Some of the comments on the draft EIS for TVA's proposed Tellico Project brought up the point that 19 other major impoundments with a total surface area of over 80,000 ha (200,000 acres) were located within an 80-kilometer (50-mile) radius of the Tellico site.[7] It was indicated that these impoundments could meet the demand for water-oriented recreation and that the reservoir fisheries were underutilized. These and similar issues should be appropriately discussed, and quantitative data presented, in the EIS so that impacts can be assessed fully.

Land use changes in the vicinity of an impoundment may be influenced substantially by the amount of public land acquired at the periphery of the project. Federal acquisition, in fee or easement, allows close control over shorefront development and access to the reservoir. Land to be purchased by the government should be delineated on a reservoir map along with the limits of the normal water surface. It is a fairly common practice among federal impoundment construction agencies to purchase lands within a taking line at a certain elevation, perhaps several feet above the spillway crest elevation, and to obtain flowage easements for areas that will be only occasionally inundated. Fee ownership of the reservoir perimeter may preclude development of private shore front homes and easements may specify compatible land uses such as agriculture or pasturage.

Hillside overlooks and privately owned shoreline areas may be desirable locations for second homes or recreational enterprises. Subsurface sewage disposal systems that are used to serve this type of development constitute a potential source of nutrients and other pollutants to the impoundment. The normal increase in human activity around an impoundment due to recreational use, relocation of roads, new access points, and second home development will also have an adverse impact on wildlife habitat that, for the most part, cannot be avoided. Some of these impacts may be avoided or mitigated by changes to the project design.

Regional Land Use. Provision of storage for flood control or irrigation may induce alteration of land use patterns in downstream flood plains and in areas of water use. These usually can be clearly identified but the actual magnitude and importance of induced effects may be difficult to estimate.

Because of EPA's broad responsibilities for water and air quality management programs, it is important that impoundment related changes in land use be identified and assessed as to their impacts on these programs and on overall environmental quality. Projections of economic or demographic growth with and without an impoundment are very difficult to make, particularly since water availability is usually a necessary but not sufficient condition for growth.

Given time and resource constraints for review of an impoundment EIS, the data, projections, and descriptive information contained in the statement may furnish a base from which to assess the effects of induced land use changes. Stimulation of further development in areas with existing water or air quality problems may aggravate environmental degradation or complicate attainment of applicable environmental standards.

Effects of Flood Control. A variety of information is necessary for quantifying land use impacts for flood control including:

- Location and description of downstream damage centers, both agricultural and urban
- The degree of flood protection afforded by the project
- Local or state flood plain regulations in effect
- An indication of whether damage centers have qualified for federal flood insurance and the extent to which landowners are utilizing the program
- General economic, demographic, and land use trends in flood-prone areas

- Amount of undeveloped but readily developed land within the flood-prone area and flood hazard zone

- Degree to which projected downstream development in flood-prone areas is part of the flood control benefits

Development of areas subject to flooding is often encouraged by construction of an upstream storage reservoir, even when substantial flood risks still exist. Industries are especially apt to locate near the river because of the availability of process water. Growth in the downstream flood plain can be evaluated in general teams for its effect on water and air quality plans, and in its specific effect on the flood plain. Specific effects include hydrological and ecological changes resulting from the conversion of flood plains from agricultural, or less intensive uses, to more intensive uses, such as industrialization. The flood plain belongs, in a physical sense, to the stream, i.e. it is part of the stream's hydrological and ecological regime. The conversion of flood plain to industrial use affects that regime by destroying vegetation cover and reducing riparian aquatic habitat. In addition, the flood plain loses some of its natural capacity for storing flood waters and for filtering water-borne pollutants. The impoundment may, to some extent, mitigate the need for these flood plain functions, but the loss of habitat is generally irreplaceable.

Floodplain development may also affect EPA's authority under Section 404, FWPCA (dredge and fill). While the Corps of Engineers has primary responsibility for issuing these permits, EPA may overrule such approvals if the permit will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas, wildlife, or recreational areas. Thus, where 404 permits are involved, EPA's regulatory authority and expertise includes several areas in which EPA has exercised little previous jurisdiction.

Effects of Irrigation. The impacts of developing agricultural land must be analyzed for impoundments supplying irrigation water. The following factors are important for quantification of environmental impacts in the area of irrigation water use:

- Amount, location, composition and drainage characteristics of land to be brought into production, level of water table

- Existing vegetative cover and uses of land to be brought into production

- Types of crops expected

- Irrigation methods to be employed

- Amount of return flow, discharge locations, and general water quality of receiving stream

- Probable salinity and other pollutant increases and method of treatment, if any

- Secondary economic and environmental effects on agricultural areas outside the area to which the irrigation water is delivered (e.g., due to competitive advantage which may be given to farmers in impoundment irrigated lands because of cheap water)

The existing character of land to be irrigated must be described in relation to its ecological values and physical features. Ecological impacts will probably be less in the conversion of an already cultivated land or pasture to a more intensively irrigated agriculture than in altering natural grasslands or flood plain areas. Physical features of the area including soil type and salinity, location of the water table, and topography will affect long-term agricultural use and potential water quality in nearby streams. Irrigation may increase the antecedent moisture conditions in irrigated areas and this condition can yield increased runoff.

Water pollution from irrigated lands is generally associated with overland runoff and drainage water. Pollutants accompanying runoff include sediments, nutrients, pesticides, and decaying vegetation. Irrigation return flows, in the form of drainage water, may also contain high concentrations of dissolved solids composed primarily of ions of sodium, calcium, magnesium, potassium, boron, chloride, bicarbonate, sulfate, and nitrate.[8] Present technology may in some cases be inadequate for predicting the quality of irrigation return flow. The problems resulting from irrigation development are usually confronted after-the-fact.[9] Because such estimates are more likely to be qualitative than quantitative in the EIS, only general observations on water quality changes may be possible. In any case, dissolved solids, nutrients, and perhaps pesticides and suspended solids concentrations would normally increase.

It is important that present water quality and water uses in the stream reaches that are affected by proposed increases in irrigated agricultural land, are clearly identified and quantified. It should be noted also that continuous irrigation over long periods of time may result in elevated groundwater levels and salt buildup to the point where crops can no longer be grown. Most irrigation return flows are not now treated and may not be treated (for economic reasons) in the near future. Therefore, increases in salinity, nutrients, sediments, and other pollutants may be expected. Good irrigation practices can minimize the adverse impacts on the water quality of the return flow. The type of irrigation system to be used should be evaluated. The EIS should discuss the model used to predict water quality, the data base used, the accuracy of the results, the sensitivity of the model to variations in input data and should also relate the results obtained from the modeling to downstream water uses and standards.

IV-A.3. Assessment of Impacts

The key to assessing changes in land use and impacts is the ability to judge the suitability of lands for supporting the type and intensity of growth which might be induced by the project. This means evaluating the benefits as well as the environmental impacts of such growth. The quantities of water made available for water supply and irrigation may be directly converted to population or land area equivalents. Not only the magnitude but also the probable phasing of such development will influence how well environmental quality is maintained during the induced growth period. If the supply of water to a city removes a major growth constraint, development may proceed more rapidly than in an area not hampered by water availability limit. Local and regional water and air quality conditions and goals may serve as important indicators to assess the desirability of further growth in particular areas. The existence of pollution problems should be interpreted as a signal that natural resources are being overutilized and overstressed.

Extensive shoreline development may threaten water quality and increase the potential for eutrophication in an impoundment. In assessing the adequacy of an EIS discussion of land uses and impacts around a proposed reservoir, consideration must be given to ensuring maximum protection of water and environmental quality. Because nutrients from septic tank leaching field systems can be readily transported through the soil to a reservoir, public sewering of developable shoreline areas should be evaluated. Requirements for a minimum setback distance might also be recommended. If proposed Federal land acquisition for the project leaves large sections of shoreline open to private development, extension of public ownership to further protect water quality and maintain open space may be necessary.

In many cases development will occur downstream from an impoundment partially due to the increased flood protection afforded by the presence of the dam. Under Executive Order 11296 Federal agencies are responsible "to provide leadership in encouraging a broad and unified effort to prevent uneconomic uses and development in the nation's flood plains...." EPA feels that it is appropriate to advise agencies on preventative as well as recovery tactics. The EIS should provide information on requirements for local cooperation in zoning and planning in flood plains as well as information on health, building and subdivision regulations. If the EIS claims flood control benefits for structures which are expected to be located in the flood plain below the dam at some time in the future, the project may be inconsistent with the policies stated in Executive Order 11296. Conversion of agricultural lands, wildlife habitat or recreation areas in flood-prone areas (for example, in the 100-year flood plain) to urban development is environmentally undesirable and should not be promoted by any Federal actions.

In the case of irrigation where definite modifications of land use are more easily identified, the assessment of impacts can be more specific. Water used in irrigation may reenter a stream either as a point source discharge (drainage return flow) or nonpoint discharge (surface or subsurface runoff). The latter may be controlled best by proper land management and good irrigation methods which includes mulching, contour planting, terracing, careful regulation of the amount of water applied, and suitable fertilizer and pesticide application techniques. The salinity of the soils in areas to be irrigated has an important influence on the water quality of return flows. It might be feasible to avoid irrigating those areas where soils are formed from shales or are high in natural salts if other land is available. Any method which reduces evaporation and transpiration losses aids also in limiting salinity increases. Drip or "trickle" irrigation and subsurface irrigation systems, offer a number of advantages over furrow or sprinkler systems among which are a reduction of evaporation and resultant salt concentrations and a high degree of water and nutrient control.[10] Presently, treatment of drainage water for removal of minerals and salts is considered infeasible except in special situations. Special situations are deemed to be where high-value crops are grown in a water-short area and where brine disposal would be relatively inexpensive or where the treatment would be carried out in combination with the production of power or some other process generating large amounts of water heat.[8]

The development of irrigated agriculture may degrade water quality in streams receiving drainage water such that water quality requirements of certain water users would no longer be met. Raw water sources for public supplies should not contain more than 250 mg/l of either chloride or sulfate unless no other source containing less than that concentration is available.[11] Maximum acceptable concentrations for nitrate and various pesticides are described in EPA Proposed Interim Primary Drinking Water Standards. Certain industrial users may have fairly rigid water quality requirements that may not be met after the addition of irrigation drainage water without extensive additional investment in water treatment facilities. The reviewer should consult Section V of "Water Quality Criteria"[12] for further information on water quality characteristics and requirements for various industrial classifications.

Any practices that result in more efficient use of irrigation water may reduce water quality degradation due to return flows. Subsurface irrigation may produce comparable crop yields with as much as 40-50 percent less water than is required with furrow irrigation.[13] Installations of lined canals or closed conduit conveyance systems will reduce seepage losses, salt pickup, and evapotranspiration losses due to phreatophtes. Conduits also have the added advantage of reducing direct evaporation losses. Tile drains designed to intercept less saline groundwaters will minimize deep percolation losses and reduce water quality problems due to salts. A pumpback system for tailwater control increases the efficiency of water use and minimizes pesticides, phosphorus, and heavy metals in the return flows. The EIS should contain descriptions of how the irrigation system will be operated, what provisions will be made for monitoring water use and quality at individual farms, and how pollution from return flows will be minimized. Plans to implement land treatment programs, and other water quality protection measures, should be fully described in the EIS along with the agencies responsible for implementation. The publication "Evaluation of Salinity Created by Irrigation Return Flow,"[13] discusses irrigation water quality problems and control methods in greater detail and should be consulted if further assessment information is needed.

IV.B. REVIEW OF WATER QUALITY AND ECOLOGICAL IMPACTS

Potential water quality and ecological impacts are basically related to the direct and indirect environmental changes caused by the project. Three general , but interrelated, areas of influence are the impounded water body, the river downstream from the dam, and the areas of impoundment-related land use change. The latter area is discussed in greater detail in section IV.A, Land Use Impacts.

The effects on temperature, dissolved oxygen, dissolved and suspended solids, flow, and bacteria are usually the most important with respect to water uses and ecology. Certain impacts can be expected, and described, in relation to particular site characteristics, upstream conditions, and proposed reservoir operations. Quantification of impact magnitudes and significance may be difficult, other than to say that an effect may or may not occur. Water quality and related ecological impacts are obviously major issues for impoundments requiring careful review and coordination with agencies having specific interest and expertise in these areas. The guidance presented herein may be supplemented by reference to the cited technical publications or through appropriate program offices within EPA.

IV.B.1. Sources of Impacts

Impacts on water quality and ecology can be associated with impoundment construction inundation of land areas, creation of an artificial lake, operational procedures, and any water uses which influence both the impoundment itself and downstream waters. Impacts to water quality in the impounded water body and the river downstream from the dam should be related to applicable state and federal water quality standards and criteria, as discussed further in section IV.B.3.

The impact statement must recognize the existing situation with regard to dischargers upstream. In some cases, particularly with sewage treatment discharges, a higher level of treatment may be necessary due to the dam. The cost of installing this higher level of treatment should be included in the project cost and calculated into the benefit/cost ratio.

IV.B.1.a. Impoundment Construction

Sediment, pesticides, petroleum products, and other materials are potentially significant water pollutants at an impoundment construction site. These are described briefly below with further information available in section 6.0 of "Methods of Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollution."[14]

Sediment. A major source of water pollution at an impoundment site is construction generated sediment transported primarily by water and, to a lesser extent, by wind. Erosion of land areas disturbed by construction activities is dependent on many factors including the characteristics of the soil, climatolotical conditions, and topography of the site, particularly in areas where clearing and excavation are to take place.

During the construction of an impoundment any of the following activities may be potential sources of sediment pollution:

- Site preparation - clearing, grubbing
- Earthmoving (cutting, filling and stockpiling)
- Construction and removal of cofferdams or other diversion structures or stream relocation
- Relocation of existing facilities
- Dredging
- Access and haul road construction and use
- Removal of material from borrow areas
- Rock blasting, drilling, tunnelling, or channelling
- Dam foundation preparation and placement of materials
- Landscaping and general site clean-up operations
- Sediment control pond discharges

Wash waters from processing stone aggregate and concrete batching, placement, curing, and clean-up operations are also common sources of sediment.

Pesticides. Depending on the type of dam and ultimate use of the impoundment, a number of chemical compounds may be used at the impoundment construction site. They are used to control the growth of aquatic vegetation, kill or retard growth of vegetation around the impoundment (dam faces), or suppress insect populations (primarily mosquitoes which breed in standing water).

Petrochemicals. Gasoline, diesel fuel, and lubricants are the major petroleum products used at construction sites.

Potential pollution problems may occur from any of the following:

- Storage depots (accidental spills)
- Leaky vehicles (crankcase oil, gas lines, seals, and hydraulic lines)
- Road oiling (reduces dust)
- Disposal of waste oils onto the ground (crankcase)
- Spillage when filling vehicles

Petrochemicals are significant because they will form a film on the water surface, are odorous, and may adversely affect wildlife which contact the water surface.

Sanitary Wastes. The four basic methods for handling sanitary wastewater at the impoundment construction site are the pit privy, chemical toilet, holding tank, and septic tank with leaching field. None of these systems should present a pollution hazard under normal conditions provided that the facilities are properly located and maintained. Areas with steep slopes, high water table, poorly draining soils, and sites subject to flooding or heavy runoff should be avoided.

Other Construction Activities. Other materials used at a construction site may be potentially harmful if introduced into waterways through spillage, improper disposal, or careless application. Some of the materials and operations which may create adverse environmental effects are the following:

Activity	Materials Used	Potential Effect on Waterbody
• Cleaning masonry surfaces	Usually acids	Lower pH
• Landscaping	Lime, fertilizers	Raise pH, Eutrophication
• Other cleaning agents, solvents	Kerosene, toluene, Turpentine, etc.	May be toxic to fish and other biota
• Solid waste management	Solid waste	Water pollution Floating refuse

The EIS should identify potentially toxic or hazardous chemicals to be used and their application rate, particularly when used adjacent to or in waterways.

IV.B.1.b. Inundation of Land and Creation of Artificial Lakes

Replacement of a freely flowing stream with a lake environment, inundation of land, and altered hydraulic characteristics represent the principal sources of water quality and ecological impacts in an impoundment. Thermal stratification, sedimentation, expected land use around the reservoir, and inflowing water quality all affect the physical, chemical, and biological properties of the impounded water. The impacts described below are likely to occur at many impoundment projects. The EIS should be reviewed with adequate consideration given to these effects.

Impacts Due to Land Inundation. The nature and composition of vegetative cover and soils within a proposed reservoir area can influence the overlying water quality subsequent to impoundment. Water quality changes resulting from initial inundation of the reservoir and continuing for varying periods up to several years may affect both withdrawal (consumptive) and downstream uses of the water. At most impoundments, even large and deep ones, changes are likely to be evident for a few years. Substantial depletion of dissolved oxygen, organic enrichment, increases in iron, manganese, nutrients, dissolved substances, and increased algae growth are just a few such changes.

These changes in water quality result from the following processes:[15]

- Ion exchange through the clay and humic colloids in the soil under water-saturated conditions
- Microbiologic degradation of organic materials, which releases dissolved materials and carbon dioxide
- Leaching of organic and mineral substances from the soil or vegetation
- Microbiologic activity at the soil-water interface, which depletes dissolved oxygen possibly causing anaerobic conditions and a change in the products of decomposition

Submergence of vegetative matter and other organic debris such as might exist in an area used for disposal of sanitary or solid wastes causes an oxygen demand. Microbiologic activity which, in the initial years of filling and operation, may be sufficient to deplete dissolved oxygen or even produce anaerobic conditions in parts of a reservoir. In many impoundments the reduction of dissolved oxygen due to organic decomposition and leaching alone will be significant for only one or two years. However, the effect is the same as the addition of an external waste source. Downstream waste assimilative capacity or intended water uses may be temporarily impaired.

Associated with an oxygen-deficient environment at the bottom of a newly created reservoir may be other biochemical reactions which also adversely affect overlying water quality. Under normal, oxygenated conditions, iron and manganese are only slightly soluble and form precipitated complexes with phosphate and other substances. In anaerobic waters, the complexes are reduced to free iron, manganese, and phosphate in solution.[15]

Land flooded by an impoundment is lost as habitat for terrestrial wildlife. Areas exposed by seasonal drawdown or subject to recurring inundation from flood control operations may have significantly reduced ecological value. Inundation may destroy wildlife or plants of special significance because of their rarity or uniqueness. Decomposition of organic matter and solution of nutrients are likely to create an initially high rate of productivity in the reservoir that may decline after several years.

Alteration of Assimilative Capacity. The creation of an impoundment on a previously free-flowing stream can substantially alter the capacity to assimilate oxygen-demanding waste introduced either into upstream reaches above the dam or to downstream sections. With respect to basin-wide water quality management and planning, changes in reaeration rates, travel times, and flow and temperature regimes within the impoundment's zone of influence may have far-reaching effects on optimal waste loading and allocation.

The assimilative capacity of a water body is defined in terms of the waste load that can be introduced without degrading the water below a minimum acceptable quality for a certain water use. A variety of factors combine to determine the assimilative capacity of a stream and as any of the factors change, so does assimilative capacity. Among the primary determinants are:

- Flow, which affects the amount of dilution a waste will receive
- Stream gradient and depth, which affect vertical mixing and turbulence
- Surface area of water exposed to atmospheric reaeration
- Temperature, which affects the saturation concentration of dissolved oxygen and BOD reaction rate
- "Background" BOD or concentration of organic wastes and chemical oxygen demand (COD)

- Dissolved oxygen concentrations present, which affect gas transfer at the air-water interface

- Biological and chemical characteristics

The items listed above are interrelated in terms of their effects on waste assimilative capacity, and all can be drastically altered by impounding and regulating a freely flowing stream. Altered conditions in an impoundment can substantially affect the application and basis for interpretation of stream standards, water quality criteria, waste load allocations, and other regulatory and planning devices for water pollution control. Existing EPA-approved state water quality standards recognize the variability of assimilative capacity with the above-listed factors. Interpretation of the standards is generally based on the average minimum consecutive 7-day flow to be expected once in 10 years. Such low flow generally coincides with the warmest season of the year when water temperatures approach their highest annual levels and defines the critical water quality period with respect to assimilation of wastes. In general, the reviewer should recognize that upstream sources of pollution, including both nonpoint sources and treated wastewater effluents, will often create poorer water quality conditions in an impounded stream segment than in an unimpounded reach.

An inflowing stream will seek its own density level in thermally stratified reservoirs and may move as an interflow or underflow rather than staying in the epilimnion where waste assimilative capacity is decidedly greater.[16] Such density currents are primarily the result of temperature differences although dissolved solids and suspended solids may also cause density differences. If the impoundment is used for flood control, highly turbid waters from heavy runoff may move through the reservoir as a distinct layer at a level determined by density. With respect to waste assimilative capacity, any inflowing water which sinks and spreads horizontally below the epilimnion is effectively removed from the two major sources of oxygen replenishment, namely, reaeration by contact with the atmosphere and photosynthesis. Oxygen depletion may also occur in the absence of stratification.

Under stratified conditions water quality in an impoundment may be altered significantly with important effects on aquatic biota. Parts of the total volume of the reservoir below the thermocline may be uninhabitable by fish if oxygen deficiencies develop. The magnitude of hypolimnetic oxygen depletion may be largely dependent on productive or eutrophic conditions in the epilimnion, since this is the level from which dead algae and other organic matter sink adding to the oxygen demand. Nutrients may be released from bottom sediments when dissolved oxygen concentrations are low and then recyled to the euphotic zone by mixing in the autumn, winter, and spring.

Eutrophication. Eutrophication is the process whereby water bodies become enriched with nutrients, resulting in generally undesirable changes in water quality. Excessive growths of algae and sometimes higher aquatic plants characterize a eutrophic lake or impoundment. Although numerous elements are essential for the growth of algae, phosphorus and nitrogen are most likely to be in limited supply in natural waters.

The change in flow regime from a free-flowing stream to an impounded lake results in the reduction of the assimilative capacity of the water body. This fact, combined with the inundation of land rich in nutrients and/or favorable nutrient influx conditions, may result in eutrophication of the impoundment. In addition, hard waters are more likely to be eutrophic than soft waters. Portions of the reservoir may exhibit the characteristics of eutrophic waters while other portions may not.

Eutrophication is essentially irreversible. Although numerous methods for restoring and enhancing water quality of eutrophic lakes are being used and researched, most are remedial and have generally limited long-term effectiveness. The potential for eutrophication as well as possible preventive measures must be thoroughly analyzed in the EIS, since impacts associated with eutrophication are likely to detract from the usefulness of an impoundment. Impacts caused by eutrophication of an impoundment include the following:

- Reduced water clarity
- Possible increase in water temperatures in the surface layers, due to increased turbidity
- Tastes and odors
- Increased water treatment costs for disinfection, filtration, and coagulation in impoundments used for water supply
- Production of organic matter which contributes to dissolved oxygen deficiencies in the hypolimnion,
- Nuisance weed growths that interfere with boating and water contact sports

Other Impacts. Other possible impacts in an impoundment are reduction of coliform bacteria and other potentially harmful microorganisms, reduction of sediment load, reduction of color, increases in salinity due to evaporation, loss of sport fish, and alteration of species composition and diversity. If widely fluctuating water levels are anticipated, erosion in the drawdown zone and impacts on fish spawning should also be considered.

Impoundment of a reservoir may have the effect of creating habitat for pool types of mosquitoes depending on construction design, operation of water levels, and aquatic weed control. In addition, operation of the water level of the impoundment may be favorable to production of flood-water types of mosquitoes, particularly if reservoir levels are allowed to fluctuate above normal pool level for a week or more during mosquito breeding season. On the other hand, establishment of an impoundment may have the overall effect of reducing mosquito and other anthropoid problems by flooding breeding areas. This is particularly true where rocky fast-flowing streams (the habitat for blood-sucking black flies) are inundated, or where flood-water mosquito habitats created by periodic flooding of local streams are permanently inundated and changed to a permanent or semi-permanent pool situation. Often low lying, shallow, swampy areas and small ponds which are particularly productive can be permanently eliminated by impoundment with deep waters.

The die-off of bacteria and reduction of color in an impoundment are usually regarded as beneficial effects. Although coliform bacteria may be carried into watercourses from soils and vegetation in the watershed, microorganisms in sewage effluent will generally be the greatest source of bacterial pollution.

Increases in salinity in an impoundment will require consideration only for projects located in arid or semi-arid regions where high rates of evaporation are anticipated, or where dissolved solids concentrations in inflowing streams are high. Salinity problems presently are of greatest concern in the seventeen western states and often result from irrigation drainage and water loss. High salinity may make a water source unpalatable or unacceptable, from a health standpoint, for public supply. Water with high dissolved solids concentrations contributes to salt build-up in irrigated soils, may damage plants, and must be applied in greater quantities to maintain a salt balance.

Impoundment of a stream almost invariably reduces the diversity of the aquatic ecosystem. The total number of organisms present is likely to be greater than in the stream because of expanded aquatic habitat in a reservoir. It is probable that, with time, the species composition will change. Stocking in a newly created impoundment may allow for substantial populations of the stocked fish but after the initial stocking of fry mature, the rough fish may be able to outcompete, and therefore predominate the desired species. Impoundments may become overpopulated with rough fish making management for more desirable game species difficult. This adjustment, although adversely affecting recreational fishing, serves to maintain an ecological balance. For the most part this situation is unavoidable.

Increased depth and decreased water velocities in an impoundment cause sedimentation of suspended material on the reservoir bottom. These changes may eliminate or severly reduce populations of benthic organisms and insects that are adapted to a stream environment. Improved water clarity due to sedimentation of suspended matter allows greater light penetration, possibly enhancing productivity of an impoundment and stimulating growth of aquatic weeds in shallow areas. The possibility of earthquakes may be an important matter for discussion in some impoundments, especially those located in areas of recent seismic activity or fault zones.

IV.B.1.c. Downstream Impacts from Impoundment Operation

Primary and secondary ecological impacts downstream from an impoundment can be traced, essentially, to changes in physical chemical, and biological quality and to changes in water quantity and flow regime. Alterations of nutrient supply, dissolved oxygen, temperature, sediment load, and flow changes are usually the most important factors to be considered in regard to downstream impacts. Changes in chemical and biological water quality that take place in an impoundment will influence downstream conditions, although factors of flow, outlet location, season, size, and morphometry of an impoundment will also affect stream quality. The impacts described in this section are encountered at many impoundments and they should be addressed in the EIS.

Impacts on Water Quality and Assimilative Capacity. To a large extent the uses of a reservoir determine the operation of the project and, thus, the changes in the river's flow regime. Artificial variations in flow, the quality of released waters, hydraulic characteristics of the river, and other factors influence downstream water quality and quantity. Much of the technical literature concerning the impacts of impoundments on downstream waste assimilative capacity and water quality focuses on thermally stratified impoundments which are used for, among other purposes, the generation of electrical energy. Many problems similar to those associated with hydroelectric power generation may also occur at other types of impoundment projects.

Because hypolimnetic waters in deep, stratified reservoirs are often depleted of dissolved oxygen, their release through deep outlets or power penstocks may degrade water quality downstream. Hypolimnetic water quality may deteriorate progressively from the onset of stratification. By the critical water quality period (later summer or early autumn) low concentrations of dissolved oxygen and possibly high BOD, iron manganese, and dissolved solids usually accompany reservoir discharge.

The same factors causing changes in reaeration in the upstream backwaters of an impoundment affect the replenishment of dissolved oxygen in downstream reaches. A zone of high turbulence is usually created in the tailrace below a dam by deflectors, hydraulic jump stilling basins, or other energy dissipation devices. The short time of turbulent contact may not be sufficient to induce significant reaeration. Below the tailrace section, velocity decreases and depth increases, both of which work against increases in reaeration. Kittrell[17] observed that high discharge rates with deep flow and short times of travel allowed a minimum of reaeration. Although it is possible that a greater total quantity of dissolved oxygen would be transferred during periods of high discharge below a dam, the concentration of DO is of interest for protecting downstream aquatic life and assuring good water quality for other uses.[18] Churchill[19] found that dissolved oxygen concentrations in the Holston River below Cherokee Dam were consistently and significantly lower at higher discharge rates associated with hydroelectric power generation. Such conditions should be anticipated in impoundment projects which create large, deep reservoirs with low-level intakes. Methods for predicting, as well as techniques to minimize or avoid adverse effects of impoundment on downstream water quality, are discussed in greater detail in sections IV.B.2 and IV.B.3.

Besides the possibility of low dissolved oxygen and reduced waste assimilative capacity, other probable water quality effects may include:

- Raising or lowering of downstream water temperatures
- Changes in nutrient and dissolved solids concentrations
- Nitrogen supersaturation (if large spillway discharges are expected)
- Decrease in sediment load
- Decrease of coliform bacteria

The magnitude and significance of these effects depend on associated flow regimen variations and on downstream consumptive and nonconsumptive uses of water. Increased water treatment costs may be necessitated by increases in iron, algae, or other undesirable constituents altering a stream's aesthetic value. Major factors influencing downstream water quality changes are the existence and extent of thermal stratification in a reservoir, outlet location, upstream water quality, and the extent and timing of artificial flow regulation.

Impacts on Stream Ecology. Many organisms have very definite habitat requirements for survival, growth, and reproduction that may be affected either adversely or beneficially by construction and operation of an impoundment. When analyzing the ecological impacts the reviewer should keep in mind that the effects of one factor on biota may be either negated or magnified by another. Cool water releases to enhance salmon or trout spawning may be ineffective unless the concomitant discharge magnitude and timing are sufficient to provide proper stimuli and maintain suitable spawning beds. Evaluation of probable ecological impacts is largely contingent on the kind and amount of information presented in the EIS about the existing ecosystem, important species, proposed operating criteria and procedures, and future water uses above and below the impoundment site. Ecological impacts of various impoundment-induced changes are identified below.

- Temperature. Decrease in temperature from low-level releases at a stratified impoundment may reduce the numbers and diversity of fish, insects, and other organisms whose life cycles do not conform with colder water temperatures during the summer. Overall productivity in the stream may decline due to the temperature dependence of many chemical and biochemical reactions. On the other hand, cold water releases may enhance a trout fishery and other life forms that require or can adapt to cooler water temperatures. High-level releases may warm the stream excessively and have detrimental effects on some species. In particular, increases in temperature from the release of warmer epilimnetic waters during the summer may adversely affect coldwater species.

- Dissolved Oxygen (DO). Reduction of DO concentrations normally accompanies deep releases from stratified reservoirs. The tolerance of different organisms to low DO levels varies substantially. If channel gradient and stream depth are such that a DO deficit persists for some distance downstream then a shift to more pollution-tolerant species may occur. Low dissolved oxygen concentrations would have a greater adverse impact on trout, migrating salmon, and other generally valuable species than on some warmwater biota.

- Nutrients. An impoundment usually reduces the total nutrient input to downstream reaches due to utilization by algae and entrapment in bottom sediments. The downstream nutrient load may deviate considerably from concentrations observed in inflowing waters. In particular, discharge of nutrients may be high during stratification if concentrations build up in the hypolimnion under reducing conditions and discharge water is drawn from deep parts of the impoundment. Variations in nutrient concentrations affect autotrophic organisms such as algae that form the basis of the food chain.

- Sediments. Reduction of sediments in water passing through an impoundment improves water quality downstream. This change may enhance productivity by increasing light penetration, especially if the stream is highly turbid in its preimpoundment state. In stratified reservoirs turbid water may move in distinct layers which, if they coincide with the discharge level, may cause downstream turbidity problems over a longer time period. Depending on flow regime, scouring of the stream channel and bank erosion may increase as a new equilibrium sediment load is attained. The stream reach below the dam may, in a short time, be degraded for a considerable distance. The stream may also be turbid for longer periods of time, and more frequently, below an impoundment. If high flows are significantly reduced or eliminated, sediment may deposit on the stream bottom causing impacts on bottom-dwelling organisms and fish spawning.

- Flow. All of the above factors may be affected by flow. Ecological impacts depend on the timing, duration, and magnitude of flow regime changes and coincident water quality conditions. Within the general area of flow regime modification, the functioning of a dam as a physical barrier to upstream movement of migratory or anadromous species should be viewed as a potential source of ecological impacts.

IV.B.2. Review of Impact Quantification

It should be noted at the outset that quantification of water quality and ecological impacts following impoundment is a highly complex task, particularly in the case of reservoirs that are expected to exhibit strong thermal stratification. Numerous mathematical modelling techniques may be used for prediction of postimpoundment water quality, both in the reservoir and downstream. All such models have inherent limitations due to the need for various simplifying assumptions and the inability to verify results until data from the operating reservoir are available. Any quantitative method used to describe flow or water quality variations for a proposed impoundment should be identified either in the EIS or in appropriately referenced planning or study reports made available to the reviewer. In addition, and perhaps more importantly, the degree of reliability or confidence associated with any such estimates should be stated to avoid misinterpretation. The time frame of analysis may also have particular importance. If, for example, estimates of downstream releases or water temperature are presented as monthly averages, the possibility of significant daily, weekly or erratic deviations from mean values because of reservoir operations should not be overlooked.

The following three sections describe the kinds of analyses and impact quantification techniques that should be looked for in EIS's on impoundment projects. Guidance is also given for relating project scope, physical features, and environmental characteristics to the magnitude and importance of various impacts.

IV.B.2.a. Impoundment Construction Impacts

For the most part, the potential for water pollution at an impoundment construction site is directly related to the scale of construction operations. Relevant considerations include the amount of land area to be cleared and/or grubbed; the location and size of excavation, borrow, and fill areas; the extent of highway and railroad relocations; and the scheduling of various work items.

Numerous quantitative methodologies for determining erosion and sediment generation can be found in the literature, several of which are summarized in "Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollution."[14] Application of these techniques requires considerable data and assumptions that would not generally be obtainable from an impoundment EIS. In reviewing potential water pollution impacts from impoundment construction the focus should include pollution control as well as quantification of effects. Enforcement of definitive environmental protection specifications and appropriate federal, state, and local regulations should minimize water pollution hazards.

There are no generally available techniques for quantifying water pollution caused by impoundment construction other than for soil erosion. The potential for water pollution from chemicals used at the site is a function of the scope of the construction project and size of the stream, for example, spillage of oil is likely to have a greater adverse impact on water quality and stream biota in a small brook than in a large river. Also, the larger an impoundment, the greater will be the area of soil disturbance and quantity of various chemicals used at the construction site.

Except in the event of direct spills to the watercourse, chemical pollutants will often be transported along with sediments by erosion. Sedimentation due to construction may not be evaluated quantitatively in the EIS, but should be addressed in construction specifications limiting turbidity increases in the stream. Estimates of process water and runoff volumes used in the design of treatment systems for removal of turbidity or other pollutants should be stated in the EIS and compared to low-flow stream conditions. If projected wastewater volumes are large relative to streamflow then pollutants contained in process waters and runoff from exposed areas may have a significant impact on stream quality.

Quantification of construction impacts is difficult. Knowledge of the magnitude of construction operations, stream characteristics, and stream uses will help the reviewer to estimate whether significant pollution potential exists and whether proposed measures for protecting water quality are adequate.

IV.B.2.b. Impacts of Land Inundation and Creation of Artificial Lakes

Generally, a number of quantitative methodologies for predicting water quality or project facility design (such as selective withdrawal outlets for control of downstream water temperature and/or quality) are used to support conclusions reached in the EIS. Predictions of reservoir temperatures and the discharge thermal regime, dissolved oxygen, chemical parameters, and, for multilevel outlets, hydraulic and withdrawal zone characteristics are often made. All of the federal impoundment and water-related agencies have conducted considerable research on the effects of impoundments on water quality. Data requirements, assumptions, applicable conditions, and the validity of results for selected reservoir water quality models are summarized in section III of "An Assessment Methodology for the Environmental Impact of Water Resource Projects."[20] This reference discusses models for prediction of reservoir and downstream water temperatures, dissolved oxygen in reservoirs and streams, and nitrogen, phosphorus, and toxic compounds. Other authors[21-24] have described models of reservoir hydraulics and selective withdrawal outlets as well as their relationship to downstream water quality.

In the absence of water quality modelling studies, it is still possible to get a reasonable indication of the postimpoundment water quality characteristics and possible impacts by studying: (1) site characteristics, including vegetative cover types, soils, topography and morphometry; (2) existing stream quality data; (3) design and operational characteristics such as anticipated modification of natural flows, reservoir fluctuations, depth of outlets; and, (4) project purposes and stream and water uses. The following paragraphs discuss use of information in these various categories in quantifying or estimating potential water quality impacts at proposed impoundments.

Impacts Due to Land Inundation. For a period of from one to several years after an impoundment is initially filled, overall water quality in the reservoir will be affected more strongly by the characteristics of the newly inundated bottom land area than by inflowing water. The designated uses of the impounded water and the stream below the dam, along with applicable water quality criteria supporting such uses, will define acceptable limits for those water quality constituents which would be subject to change as a result of impoundment. If a portion of the reservoir storage is allocated to public water supply or low-flow augmentation, the impounded water quality will be critically important to the values derived from these water uses. Pursuant to Section 102 of the FWPCA, it is the responsibility of EPA to determine the value of flow augmentation for water quality control for projects authorized after the Act was passed.

In order to estimate the impact of impoundment area conditions on future water quality, information concerning the location and extent of various types of soil and plant cover is basic. Knowledge of land uses, such as presently cultivated and abandoned agricultural fields and pasture, gives some indication of potential nutrient supplies to the overlying water following inundation. Forest and brush land can contribute to an overall deterioration of water quality, particularly with respect to dissolved oxygen (DO), color and dissolved materials. This occurs even though such lands are generally a smaller source of nutrients for algae growth in the initial years of impoundment than fertilized farm land. It is important that land uses within an impoundment are fully described and quantified in the EIS, using reservoir maps to depict areas and tabulations to indicate percentages of the total floodable area. Agricultural land, marshes, swamps, and other areas rich in organic matter or nutrients can be expected to degrade water quality more than less fertile sites such as coniferous forest areas.

Iron and manganese problems are most likely encountered impoundment sites exhibiting a large proportion of organic soils, such as muck, peat, and vegetative matter, in the areas to be flooded. Such site characteristics will also influence the initial, and perhaps the longer-term, productivity of the impoundment since phosphates, nitrogen compounds, and other inorganic nutrients could be released from the underlying soils. Initially high rates of biological productivity in newly created impoundments are characteristic of organically enriched sites which have settling and decay of algal cells. This condition could compound the oxygen deficiency in the lower strata. The maintenance of reservoir fertility, after the nutrient supply originating from inundated soils and plants is stabilized, depends primarily on inputs from upstream sources, recycling from accumulated bottom sediments, and the amounts of nutrients discharged from the reservoir. Algal blooms, which depend in part upon nutrients released from bottom material, are capable of changing water quality more than any other single factor.

The potential for water quality deterioration due to soils and vegetation that will be flooded should be investigated carefully. The reservoir soils should be classified according to their organic content and general areal extent. An arbitrary classification scheme could be: trace to 20 percent, mineral soil; 20-50 percent, organic soil (muck); and 50-100 percent, organic soil (peat).[25] Additional tests should include subjection of reservoir soils to water-soil contact under laboratory conditions to predetermine their effect per unit area on overlying water. Recommended analyses include DO, color, nitrate, ammonia, algal counts, and pH measurements for at least one month.[15] Soils within proposed drawdown areas will be subject to alternate exposure and inundation and their erodibility will influence turbidity in the impoundment. Wave action and changes in soil pore pressures are likely to cause sloughing or landslides, particularly on steeper, unvegetated slopes. Such field studies and soil analyses are essential for estimating possible water quality problems and for evaluating the necessity of special site preparation measures beyond the usual clearing.

The general topography and morphometry of an impoundment may have considerable influence on its subsequent water quality characteristics. The effect of morphometry on stratification is most important although several other factors that bear on water quality and related problems can be identified.

<u>Erosion in Drawdown Zone.</u> As a general rule, the steeper an area subject to recurring inundation or drawdown, the greater the threat of substantial erosion problems. From a detailed topographic map of the proposed impoundment, an estimate of the amount of land within the inundation-drawdown area that could pose special stability problems can be made. The contour map would also allow correlation of erosion-prone areas with different flood heights and frequencies. Information on the

magnitude and frequency of water level fluctuations contained in the EIS should be translatable into pool elevations and inundated areas. The design flood, which would fill the reservoir to or above the spillway crest elevation, may have a recurrence interval of several hundred years. Pool stages expected on an average of once in two to five years would clearly define the reservoir area that might be subject to severe erosion problems on a regular basis. The season in which flood control operations are expected should also be noted. Winter floods sometimes occur due to unseasonably warm temperatures and, with subsequent refreezing before the flood pool is drawn down, ice may be an additional erosive agent.

If much of a project's flood storage capacity is derived from shallow inundation of flat bottomland, and steeper hillside areas are only rarely subject to flooding, erosion may be less severe than at a reservoir confined largely to a narrow valley where slopes are submerged every year during flood control operations. If the reservoir valley is oriented so as to coincide with the prevailing wind direction at the site, the potential for shoreline erosion by wave action is greater than if crosswinds predominated.

Other features of the flooding/drawdown zone, especially vegetation and soil types, may also affect the potential for erosion. Borrow areas and agricultural land within the flood pool limits may be susceptible to erosion and should be identified on the reservoir map. Loose, unconsolidated soils also erode easily, particularly if vegetation is sparse. At some New England flood control impoundments, erosion of sandy soils in pine-forested areas is troublesome and is compounded by undermining of the roots, loss of trees, and further exposure to erosive forces. Clay content may promote flow or slippage of the soil when wetted by a rising flood pool. For the same parcel of land, heavy grass cover may offer better protection against erosion than forest cover. The factors of slope and flooding frequency should also be considered when viewing erosion potential at different locations in the reservoir.

As land in a flood control reservoir is inundated, the saturation of soils with water adds weight and may reduce cohesion. If the water freezes, expansive forces are exerted. These phenomena, in addition to the direct action of wind, ice, and waves may enhance erosion by producing conditions favorable for localized slope failures, slumping, or sloughing. In many instances, impoundment EIS's treat this subject in general terms, if at all. Information on reservoir operation, topography, soils, and vegetative cover should be available in the section describing the project and its environmental setting. With this data, a reasonable, site-specific estimate of at least the location and frequency of potential erosion problems due to water level fluctuations is possible. In addition to these factors, artificial cuts and fills associated with roads, highways, and railroads that will be abandoned in the reservoir, and subject to inundation, may pose special erosion and stability problems.

Eutrophication and Aquatic Vegetation. The morphometry of a reservoir will also indicate where, and to what extent, aquatic weeds and algal blooms will occur and create problems for water supply or recreation. Because sedimentation in the reservoir will increase water clarity, unless algal bloom conditions occur, areas of the proposed normal pool where water depths will be less than about 5 meters (15 feet) may be subject to aquatic weed infestations. An impoundment that covers a broad valley bottom may have far greater shallowly inundated area than a reservoir of the same capacity located in a deep narrow canyon. This comparison is illustrated by the area-capacity curves for two reservoirs, Figures IV-1 and IV-2, taken from EIS's.

Both the Crooked Creek Project and the Tellico Project would have volumes of 400,000 acre-feet (483,000,000 cu m) at respective surface elevations of 790 feet msl and 812.5 feet msl. Yet, for the given surface elevations, water depths of 15 feet (5 meters) or less cover only 2,750 acres (1,110 hectares) of reservoir bottom at the former, as compared with 5,400 acres (2,180 ha) at the Tellico Project. This information can be used in a number of different ways. Besides giving an indication of the extent of shallow areas, an area-capacity curve can be useful in interpreting and estimating water quality impacts associated with thermal stratification and hypolimnetic releases. Areas identified in this way as being susceptible to weed growth should be located on a reservoir map, where their proximity to proposed recreational developments such as swimming beaches, cottages, and marines, can be ascertained and potential nuisance conditions identified.

Shallow areas, particularly in the upstream reaches of a reservoir, may also be subject to heavy sedimentation and build-up of undesirable bottom deposits creating aesthetic and possible water quality problems.

In addition to impoundment morphometry, other key factors which must be considered in evaluating the potential for eutrophication include nutrient loading, presence or absence of temperature stratification, length of stratification period, latitude, retention time, land to be inundated, light, and turbidity.

The major contributors to the nutrient load in an impoundment include nutrient-laden influent streams, the entrance of

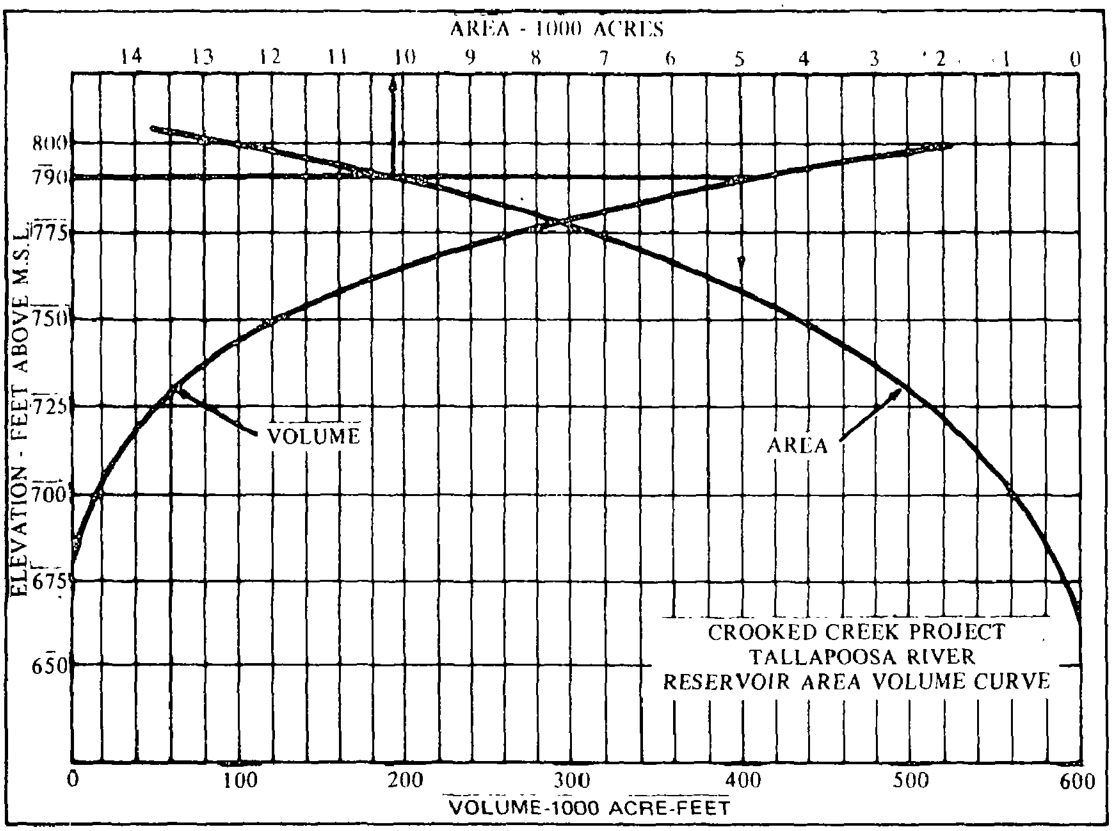


Figure IV-1. Crooked Creek Project Area-Volume Curve

SOURCE FEDERAL POWER COMMISSION, DRAFT ENVIRONMENTAL STATEMENT CROOKED CREEK PROJECT NO 2628 EXHIBIT H 2 MARCH 1972 (NTIS PB 207 260 D)

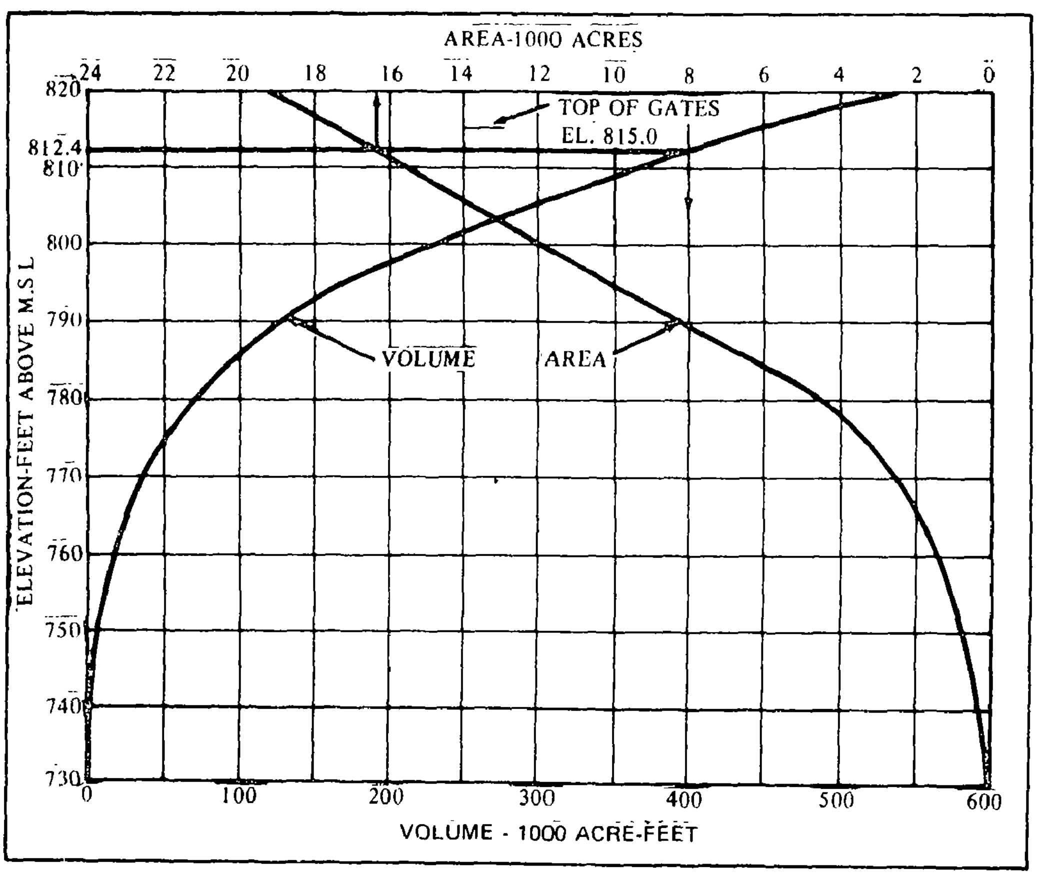


Figure IV-2. Tellico Project Area-Volume Curve

SOURCE TENNESSEE VALLEY AUTHORITY FINAL ENVIRONMENTAL STATEMENT TELLICO PROJECT VOL 2 10 FEBRUARY 1972 PG II 1 40 (NTIS PB 200 025 F2) runoff or seepage containing nutrients from areas surrounding the impoundment, and the land to be inundated. Modes of transport of nutrients into the lake include surface water, ground water, precipitation, nitrogen fixation, dry fallout, and wildlife. The most significant sources of nutrients entering most impoundments by various modes of transmission will usually be domestic wastes and/or agricultural runoff.

Information on the nutrient load as well as the morphometry, and mean depth of the reservoir will help the reviewer assess the potential for eutrophication.[26] Depending on the conditions at the particular impoundment, the nutrient load may be minimized through regulation of pollutant sources. Reduction in the nutrient load should result in lowering the potential for eutrophication of the impoundment. It must be remembered that there are a wide variety of factors which may be limiting in an impoundment.

In order to determine the potential for eutrophication, the EIS should provide data on the quality of the incoming water with regard to nitrogen, phosphorus, silica, carbonate, and organics. Upstream point and nonpoint sources of nutrients should be identified. If water quality data indicates a potential for eutrophication of the impoundment under the existing influent conditions, then methods of controlling nutrient input from upstream sources and the status of current EPA control measures should be described. If nutrient input is mostly from nonpoint sources, the EPA has jurisdiction under section 402 of the FWPCA. The sponsoring agency should not place the onus on the EPA to resolve issues surrounding sections 208 and 402 but should recognize the existing situation and present state of the program in these areas as limitations in their project planning. The major issues involved here include the following:

- Nonpoint source nutrient input may originate from septic tanks, privies, or cesspools located near the incoming stream and seeping into it. The state's priorities in sewage treatment plant grants in the basin should be investigated to determine whether a reduction in the sanitary waste input may be forthcoming by construction of a sewage treatment plant which would take the place of the existing inadequate treatment. Other possible nonpoint sources of nutrient pollution are agricultural and silvicultural runoff. This type of pollution is difficult to control. The EPA must determine whether the nonpoint source contribution of nutrients is controllable in a reasonable period of time. This will involve investigation of current planning priorities in the basin. Leaching of nutrients from surrounding land may also contribute nutrients by seepage.

- Point sources which may contribute to the nutrient load of the stream should be identified in the EIS. There should be sufficient data on their effluents to determine the feasibility of EPA's altering the plant's effluent discharge limitations to require a greater degree of treatment. Where a need exists, it may be possible to change the permit's treatment requirements from best practicable treatment (BPT) to best available treatment (BAT). Such an alteration of permit conditions would decrease the base load of nutrients in the influent stream, thereby decreasing eutrophication potential.

The EIS should provide data on development around the lake. Specific data on the types of sewage treatment facilities and the volume to be treated per day should be provided. All point source discharges to the lake should be identified and allowances should be made for evaporation and concentration of nutrients in the impoundment.

The reviewer should combine the data on nutrient input sources and their location with the map of the impoundment to assess the potential for eutrophication and the impoundment as a whole. The reviewer should also attempt to assess the potential for problems of algal blooms or aquatic weeds in various areas of the impoundment. Among the factors which should be considered are morphometry of the impoundment, drawdown practices, thermal stratification, and flow in the section of the impoundment being evaluated. For example, a long narrow reservoir may exhibit the characteristics of eutrophy in the upper sections and not in the lower sections if incoming water is rich in nutrients.

Groundwater could also account for a significant portion of the nitrogen loading in some lakes. Phosphorus input from groundwater usually accounts for a smaller portion of the phosphorus loading but may be significant.

Alteration of Assimilative Capacity. The area, depth, and volume relationships describing an impoundment project can aid in determining whether potential water quality and ecological impacts have been adequately addressed in an EIS. Several parameters such as depth, period of storage, and climate can help determine whether thermal stratification should be expected.[27]

The presence of oxygen-demanding wastes in influent streams is not necessary for oxygen deficiency in the hypolimnion of a reservoir. There are many examples of significant dissolved oxygen depletion in reservoirs receiving water with negligible pollution.[17] Changes in water quality that take place in the hypolimnia of most stratified impoundments are detrimental to uses for public water supply and recreation. These changes may degrade downstream water quality if discharges are made through outlets below the thermocline. Although their prediction is most difficult, problems with dissolved oxygen deficiency, tastes, odors, and high concentrations of iron, manganese, and possibly hydrogen sulfide generation are quite likely to occur in any reservoir that is expected to stratify thermally and should be accounted for in the EIS.

It is not possible to specify exact numerical criteria or guidelines for levels of influent water quality parameters that either will or will not cause deterioration of impoundment water quality. However, all upstream sources of both point and nonpoint pollution should be identified and resultant stream quality should be compared with applicable water quality standards. Treated effluents may be as important as other pollution sources since conventional secondary treatment of sewage, for instance, has relatively little effect on inorganic nutrient concentrations. The existence of upstream wastewater discharges, extensive agricultural land use, or large scale forest harvesting should be a signal of possible water quality problems in stratified or large impoundments.

The assimilative capacity of an impoundment may differ significantly from that of a freely flowing stream because of increased depth and surface area and decreased velocity. The rate of atmospheric reaeration in a water body, as measured by the reaeration coefficient, is a direct function of average velocity and an inverse function of average depth.[28] An oxygen-demanding waste discharge entering the backwater area of an impoundment may cause a greater depletion of dissolved oxygen than would have occurred in the unimpounded stream. Assimilation of the waste may take place over a much shorter distance.[29] Reaeration by the action of wind and waves, as well as photosynthesis, may counter the loss of reaeration capacity due to turbulence and mixing. Additionally, the deposition of organic matter as velocity decreases may cause an additional BOD exertion. In a stratified impoundment, productivity of the epilimnion also has a strong influence on water quality conditions in the hypolimnion. If nutrient loadings and other factors are conducive to eutrophication, the cycling of dead algae, weeds, and other organic matter to hypolimnetic waters may aggravate dissolved oxygen deficiencies and water quality deterioration.

The possibility of density flows in a stratified impoundment should be assessed in considering assimilative capacity changes. If existing summer water temperatures in inflowing streams are likely to be considerably lower than expected epilimnion temperatures, the water may move through an impoundment in a layer below the epilimnion where reaeration is minimal. These temperature differences might be due to cold water releases from an upstream impoundment, or a particular watershed characteristic. High-gradient, well-shaded streams may be significantly cooler than others with flat gradients flowing through unforested areas. Any oxygen-demanding waste entering the hypolimnion with inflowing water will probably contribute to lowering hypolimnetic water quality.

Evaporation. Another consideration relevant to water quality prediction or estimation is evaporation, which may be significant in certain geographical areas. Fairly accurate estimates of water losses by evaporation can be made through studies of pan evaporation and the reservoir heat budget. The problem may reach major proportions in arid or semi-arid regions in the West and Middle West. As an example of the magnitude of water that can be involved, evaporation and seepage losses from Cheney Reservoir in Kansas represent about 42 percent of river inflow and local precipitation.[30-31] Such losses will result in increased concentrations of dissolved solids both in the reservoir and downstream, as well as proportional decreases in streamflow. Several Weather Bureau atlases are useful in providing such evaporation data.

Impacts on Fisheries and Other Biota. Ecological impacts in the area of impoundment result from both the loss of terrestrial habitat due to the initial filling and from the continued existence of the artificial lake. In quantifying the short- and long-term implications of flooding an area of land, general concepts of magnitude, quality, relative supply, and uniqueness of the resource (as described in section IV.A.2) should be used. The relationship of different land uses and habitat types to the regional resource base must be logically described if an accurate estimate of impact is to be made. The values of an impoundment's ecological and recreational resources should not be quantified in an isolated analysis. Instead, a comparison with resource availability in the region should be the basis for the analysis.

The biological characteristics of an impoundment will be determined largely by conditions discussed previously in other sections. These characteristics include impoundment water quality as affected by morphometry, inflowing water quality, site characteristics, project operational features, and the ecological character of an unimpounded stream including species composition and diversity. In addition, introduced or stocked species of fish will alter impoundment ecology.

The productivity of an artificial impoundment with respect to fisheries will be affected by many factors, but in general will closely parallel changes in trophic status beginning when the reservoir is filled. Almost all impoundments undergo an initial surge in productivity for a few years after dam closure and the growth of game fish populations may be rapid. It is important that proposed management of the impoundment fishery be delineated in the EIS. In the absence of conscious management and/or insufficient harvest by anglers, the full value of the fishery as a recreational resource may not be realized. In many parts of the country, there is an overabundant supply of lake-type warmwater fishing opportunities and an undersupply of coldwater fishing. This situation may prohibit an impoundment from receiving the high degree of fishing pressure normally required to maintain and improve reservoir warmwater fisheries.

In order to establish and keep a coldwater fishery in an impoundment, there must be adequate temperature and adequate dissolved oxygen. Generally, trout need water temperatures throughout the summer of less than 65°F to 70°F, at the most, and dissolved oxygen concentrations about 5 to 6 mg/l to survive and grow adequately. These conditions will probably not be met in portions of the hypolimnia of many thermally stratified impoundments, especially if nutrient levels either from upstream sources or reservoir bottom land are expected to be high. The feasibility of establishing a trout fishery in a stratified reservoir is best evaluated after impoundment when detailed water quality surveys can be taken in the lake. Any benefits assigned to trout fishing in an impoundment should be analyzed carefully with regard to suitable temperature and oxygen requirements.

Area-volume curves for an impoundment, comparable to those shown in Figures IV-1 and IV-2, may be of some use in estimating impoundment characteristics in relation to possible impacts on aquatic biota. The approximate depth of the thermocline at a proposed impoundment may be predicted or estimated in an EIS. If not, examination of thermal stratification data for nearby lakes or reservoirs of similar size may give a rough approximation of conditions to expect. The area-volume curve can then be used to estimate the volume of water stored in the hypolimnion of the proposed impoundment. This may define, in effect, the portion of the impoundment that will be unusable by fish and other organisms if conditions of hypolimnetic oxygen deficiency are expected. Continuous releases of cold water from an impoundment with a relatively small hypolimnetic volume may exhaust the cold water supply at some time in the summer. As warmer waters sink from above, outlet water temperatures may rise significantly. This occurrence would obviously jeopardize maintenance of a coldwater fishery in downstream sections.

The shift from a stream ecosystem to a lake environment will be accompanied by important changes in the relative abundance of aquatic organisms. Eutrophication; water level fluctuations; and alteration of temperature, velocity, depth, bottom characteristics, and water quality all influence the resulting composition and diversity of species in an impoundment. Many biota have narrow or well defined tolerances with respect to these conditions. Based on an inventory of species and populations in the stream segment, the reviewer should expect the EIS to state which species will be favored, decreased in abundance, or eliminated following impoundment. Experience at other reservoirs in the region may prove valuable for assessing the probable decline or increase of various species. The importance of certain fish and other biota for recreation and other uses should be quantified in relation to the supply of the resource in the region.

IV.B.2.c. Downstream Impacts from Impoundment Operation

Downstream impacts are closely related to impoundment water quality, method of discharge, and changes in flow regime caused by a project. Impacts on water quality caused by land use changes are discussed separately in section IV.A. Downstream water quality will normally compare closely with the quality of impounded water at the level of the outlet. Discharges from near the surface would probably be well oxygenated, clear, and somewhat warmer than inflowing water, whereas hypolimnetic releases would reflect the possibly poorer quality water stored there.

The magnitude and importance of ecological changes vary according to the purposes, site characteristics, size, and regional environmental setting of an impoundment thus necessitating a case-by-case evaluation. Flood control impoundments that do not include extended storage for other purposes have the least effect on downstream flows, with little or no regulation except during potential flood situations. Aquatic ecological impacts in downstream reaches will probably be minor unless water temperatures are changed markedly. For large multipurpose projects, operational patterns are more complex and discharges may deviate substantially from natural conditions. Changes in physical and chemical water quality may complicate analysis of ecological impacts. The likelihood of significant impacts on resident and anadromous species (if present), productivity, and aquatic habitats increases as temperature, flow rates, sediment load, and water quality depart further from natural unimpounded conditions.

Changes in Hydrographic Regime

Impacts on Water Quality Management. The general pattern of flow regulation by an impoundment will be largely determined by the hydrology of the basin, project uses, and allocation of storage to these uses. Artificial manipulation of streamflow may follow daily cycles, as at peaking power dams, temporary or seasonal shifts caused by flood control and flow augmentation, and a general decrease in discharge due to withdrawal uses of water and evaporation. Any of these may be superimposed at multipurpose projects. The reservoir operating policy and resulting flow modification will have a strong influence on the nature of other physical, water quality, and biological impacts which occur downstream from the dam.[32] Quantitative estimates of the degree and timing of flow regulation at an impoundment are therefore important for comparing expected discharge patterns with preimpoundment flows and an assessment of possible impacts.

Since withdrawal uses of water at an impoundment project, as well as evaporation, will decrease streamflow below the dam, the following aspects of these uses should be quanitifed in the EIS:

- The volume of impoundment storage allocated to withdrawal uses and corresponding reservoir elevations
- The maximum annual yield from the allocated storage for different annual inflows (set, normal and dry years)
- Minimum project release requirements during withdrawal
- Restrictions on rate of pool drawdown
- Seasonal requirements of withdrawal uses
- Projected water demands and use of stored water in impoundment

The first two items above define the decrease in annual streamflow, neglecting evaporation and other losses, that could be expected from maximum water supply withdrawals under various hydrologic conditions.

Minimum release requirements and regulation of the rate of pool drawdown may often be spelled out in a contract between the government and the water supply user. This will have an influence on the amount of water that can be withdrawn from an impoundment. If the impoundment is a flood control/water supply project, discharge to the downstream channel may be strongly influenced by regulation which takes place during withdrawal. At some impoundments the intake or diversion works may be completely separate from the outlet structures that control flow downstream from the dam, while different water uses may govern other reservoir releases.

In water supply contracts between the Corps of Engineers and water users the government may reserve "the right to maintain at all times a minimum downstream release of ___ cubic feet per second..."[33]

Any special seasonal flow requirements should be fully described in the EIS. The minimum flow may be set at a level exceeding the design flow for downstream waste treatment plants, but the sustained occurrence, during periods when natural flow is substantially higher, may interfere with water quality management. Maximum daily pollutant loads for Water Quality segments are to include provision for seasonal variation,[34] and might have to be adjusted accordingly if water withdrawals frequently and regularly interrupt normal downstream flows. Thermal load allocations established under the state's Section 303(e) basin planning program, as well as individual NPDES permits, might have to be revised in light of significantly altered discharge and temperature conditions.

Hydroelectric plants used to generate peak power usually cause very large fluctuations in downstream flow, both diurnally and between weekdays and weekends. Cyclic discharges related to peaking operation may reach several thousand cubic feet per second during the daytime period of high power demand, while flows at night or other off-peak periods may be restricted essentially to leakage and local inflow. It has been shown that aeration capacity lost at high discharge is greater than that gained at low flow.[28] The release of poorly aerated hypolimnetic water may cause a significant reduction in downstream assimilative capacity even with high flows. The abrupt changes in flow over a 24-hour period caused by power generation may have other effects on water quality. Suspended organic matter entering the stream at the waste discharge points may settle, at a water velocity of less than 0.183 m/sec (0.6 ft/sec), to the stream bottom during off-peak hours and be resuspended when the velocity reaches 0.305 to 0.458 m/sec (1.0 to 1.5 ft/sec).[19] The suspension of sludge deposits in the vicinity of a sewage outfall due to flow increases may result in a further decrease in DO. Extreme variations in flow may cause severe scouring and bank erosion in downstream sections.

Federal law relating to low-flow augmentation has undergone a number of revisions, the most recent and important of which is contained in section 102(b) of the FWPCA Amendments of 1972. The new law, and attendant implementing policy, requires that the EPA determine the value of flow augmentation for water quality control. The policy states that flow augmentation for water quality control cannot be used as a substitute for adequate treatment at the source. This may take place at the preauthorization phase, postauthorization study stage and during review. EPA policy and guidelines regarding low-flow augmentation, and any earlier EPA recommendations made during project planning, are relevant inputs to the EIS review process. Projects for which funds to initiate construction were appropriated prior to 18 October 1972 are not subject to EPA's determinations regarding water quality control storage. Predicted impoundment water quality and the timing and methods of discharge are especially important in assessing low-flow augmentation. The quality of reservoir outflow will be a major determinant of the volume of storage needed for a certain incremental improvement of stream quality.

The issuance of NPDES permits that specify maximum daily pollutant loadings in terms of weight, and in some cases concentration or discharge as well, have given the states control over variable and increased waste discharges. This control, if used effectively, could be an alternative to low-flow augmentation. Regulation of downstream uses of the extra dilution water may depend on applicable water rights such as the riparian or prior appropriation doctrines. Further information on state water policies and special situations relating to flow augmentation may be obtained from the report, "Legal Aspects of Water Storage for Flow Augmentation,"[33] although it is not reflective of new requirements under the FWPCA Amendments of 1972. It should be noted that storage required to offset mineral water quality deterioration primarily attributable to irrigation must be allocated to that purpose rather than water quality control.[35]

The EIS should present sufficient information on anticipated hydrographic modification at an impoundment project so that probable effects on water quality management can be identified. If the magnitude and frequency of low flows are altered by the impoundment, or if greater variability of discharge results, water quality may suffer. Since treatment plants are typically designed for waste flows that may occur 15 to 20 years in the future the reviewer must also be able to determine what impoundment-induced alterations in water quality and quantity may occur within this longer time frame. A few possibilities might be the siting of a thermal-electric power plant near the reservoir to obtain cooling water, phased increases in water supply withdrawals, or utilization of irrigation storage over a number of years.

Impacts on Stream Ecology. Many of the ecological impacts associated with alteration of a stream's flow pattern are subtle and not easily quantified. Because of the interrelationships of discharge with physical and chemical water quality, ecological changes below a dam may often occur due to a combination of these factors. Effects on fish spawning, benthic organisms, riparian and stream vegetation, and other biota have been related directly or indirectly to flow regime modifications. The difficulties in predicting the magnitude of such impacts become evident upon examining relevant published materials. The guidelines presented herein are oriented primarily to identification of probable impacts downstream from a proposed impoundment, supplemented by quantitative information and techniques as available.

Generally, greater downstream ecological changes should be expected with increased deviations from the preimpoundment flow regime since the aquatic ecosystem is adjusted to natural seasonal variations. Ideally, the determination of discharge recommendations should be based on quantification of the water flow needs of the species inhabiting reaches below a dam. In practice, these needs may conflict with the attainment of maximum economic benefits from a project so that a compromise must be reached. An assessment of downstream ecological impacts should begin by noting the major features of the proposed flow regulation schedule, including the effect of the project on natural high and low flows and on total annual discharge. In certain instances (such as at hydroelectric peaking power plants) diurnal and weekly variations may be substantial. An inventory of downstream fish species and a brief description of other water resource projects contributing to flow regime changes in downstream sections are also important for evaluation of ecological changes.

Ecological impacts caused by reduction of flood peaks below an impoundment project may relate to the flood plain areas, the stream itself, and, in certain cases, to the estuary. Except in the event of an unusually large flood, most flood control projects are designed to keep flows below a safe channel capacity. In some parts of the country allowable discharges may be higher in the non-growing season when agricultural crops are not threatened by flooding. An impoundment may provide protection to industries, residences, commercial establishments, roads, farmland, and other developments in the flood plain. Undeveloped natural flood plains may exhibit unique associations of vegetation that are tolerant of recurrent inundation during periods of high runoff. These semi-wetland areas often drain slowly after recession of flood peaks with large amounts of water remaining in standing pools and infiltrating into the ground.

In most cases, reduction of streamflow due to impoundment will adversely affect downstream ecology while flow augmentation may have certain benefits. Frequently, decreases in discharge result in increased stream temperatures. This may be critical at certain times of the year. The flow and thermal requirements of salmon and other anadromous species have received the most intensive study, but the general observations may apply also to resident or migratory freshwater fish as well. For salmon, low water levels during migration may cause significant delay in reaching spawning grounds because of either low water velocities, exposure of obstructions, or barriers in the stream channel.[36] Streamflows during the incubation period following spawning must be sufficient to prevent deposition of sediment on the eggs, wash away waste products, and prevent dehydration. Fraser[37] describes situations where curtailing flows may result in riparian vegetation encroachment on spawing areas for salmon. Many fish, most notably trout, occupy and defend certain territories, the size of which decreases with increasing velocity. It is probable that sustained streamflow reductions may in fact reduce the carrying capacity of a regulated river.

The EIS should provide data on both preimpoundment and post-impoundment low flow events on a monthly, weekly, and daily basis. Comparisons of these date will help reveal the extent of the hydrologic modification and its effect on the downstream communities. If the impoundment is in an arid area fed by one or more streams, whether ephemeral or intermittent, water quality conditions at low flow must be estimated. Evaporation may be an important consideration in these cases.

Changes in Thermal Regime

The major focus of state water quality standards and certain EPA programs is on thermal pollution and prevention of unacceptable water temperature increases. An impoundment has the potential to significantly raise or lower downstream water temperatures. The direction, magnitude, and timing of such thermal regime changes determine, in part, the biological impacts that occur below a dam. Quantification or estimation of these impacts is dependent on (1) baseline data describing the existing temperature regime and aquatic biota, (species and composition), (2) the expected temperature patterns under impounded conditions, and (3) definition of downstream priorities for fisheries and stream use related temperature requirements. The following paragraphs explain the importance and use of this information in evaluating temperature related ecological impacts. Temperature patterns downstream from the reservoir can be computed via energy budget techniques involving meterological and hydrological information.[38-39]

The existing temperature pattern in and below the stream reach to be impounded may be relatively free from human influence. It may be modified by upstream thermal effluent discharges, cold-water releases from an upstream reservoir, or land use practices, such as clearing of trees along the banks that contribute to warming of the stream. Fish, insects, and other biota inhabiting the stream are reflective of the particular thermal regime because reproduction, growth, and survival of different species often depend on water temperature.

As a minimum, the EIS should present data on general seasonal variations of preimpoundment stream temperatures, such as monthly average values, along with approximate summer maxima. This information is valuable for purposes of comparison with predicted temperature patterns, estimation of fish spawning periods, and possible temporal shifts. An inventory of fish species in the vicinity of the project site is valuable for characterizing the stream habitat. Important categories are: (1) cold water and warm water game fish, whether native, stocked, or native and supplemented by stocking; (2) nongame fish both rough and forage species; (3) anadromous and catadromous species; and (4) rare and endangered species. The state fish and game agency or the U.S. Fish and Wildlife Service can furnish a complete, or nearly complete, species list if the EIS contains insufficient information (for example, only species sought by anglers might be mentioned). The EIS should also include information on the thermal requirements of these organisms (see Table IV-3, page IV-54).

Prediction of discharge water temperatures for various inflow, storage, and discharge conditions at a proposed impoundment is a prerequisite to identification of downstream ecological impacts. The process may be relatively straightforward for single purpose projects or it might be complicated by such factors as variable discharge elevation, thermally induced density currents, depth of thermocline, thickness of the withdrawal layer, and thermal discharges to the impoundment or river upstream from the reservoir.

If discharges are to be made from the surface layer, using either an overflow weir or selective withdrawal gates at different elevations according to the pool level, downstream temperature will correspond closely to that of the reservoir surface. Both the pool surface area exposed to solar heating and flow-through time in the upper layer will affect discharge temperatures, which, during the summer and early autumn, may be significantly higher than inflow temperature. If the normal summer pool is not expected to stratify, the location of reservoir outlets near the surface or near the bottom is likely to be unimportant with respect to discharge water temperature since such a pool would be nearly isothermal. Major changes in the downstream thermal regime will accompany continuous or intermittent hypolimnetic discharges from deep, thermally stratified impoundments. Temperature predictions under these conditions are most difficult, especially if water is withdrawn from two different layers simultaneously as might be done to improve water quality of the releases. For purposes of estimating ecological impacts, the temperature variations in the period from late spring through early or mid-autumn are usually most critical. The effects of temperature variations on the ecological community at other times of the year should not be overlooked, however.

Knowledge of thermal constraints for various stream uses is essential for impoundment projects whose operation may substantially alter or provide a high degree of control over downstream water temperatures. Possibly conflicting thermal requirements should be addressed and thermal priorities should be established in the EIS. Most of the questions concerning the effects of downstream temperature changes would involve the desirability of releasing cold hypolimnetic water during the stratified period. Specific issues that may arise include the preservation of an existing, or creation of a new, coldwater fishery, maintenance of existing warmwater species composition, and releases of cold water to benefit downstream withdrawal uses for water supply or cooling.

Low-level releases from an impoundment may cause a significant reduction in downstream water temperatures from spring through early summer or later. In the winter, a warming effect may be evident when the deepest water will have a temperature near 4°C (39°F) as opposed to inflow temperatures just above freezing. In reservoirs with hypolimnetic outlets, altered thermal regime has been implicated in the elimination or reduction of benthic fauna as well as certain fish species for varying distances downstream. Many insect species, which are important food organisms for fish and other animals, have life cycles dependent on strict temperature requirements. Lehmkuhl[40] observed a marked decrease in the number of species and abundance of macroinvertebrates for a distance of 70 miles downstream from a reservoir on the South Saskatchewan River. He attributed the decline to hypolimnetic discharges from the dam since the warm water requirement for hatching and growth of the species involved was not met. Most aquatic invertebrates have temperature-dependent seasonal life cycles and may not be able to tolerate major modifications of a river's thermal regime.

Because macroinvertebrates form an important link between primary producers such as phytoplankton and fish in the food chain, their reduction may adversely affect productivity of the stream fishery. Prediction of this relationship is complicated by the influence of temperature on gross productivity and chemical reactions and the fact that nutrient inputs to the downstream ecosystem may change due to impoundment. Hynes' book "The Ecology of Running Waters"[41] offers some information on temperature requirements and seasonal life cycles of various aquatic insects and may be used to develop a general estimation of changes in species composition.

The predicted thermal regime below an impoundment will directly affect the type, and perhaps the quality, of the stream fishery that can be maintained. If hypolimnetic discharges are planned, estimates should be made of both the discharge temperature variation during the stratified period and the temperature "recovery" as a function of distance below the dam. Temperatures could be expected to rise less rapidly in deep and/or well shaded streams. The cooler water temperatures in the affected zone may delay or prevent spawning of warmwater fish species and enhance conditions for trout or other coldwater species. Changes in fish species composition due to impoundment can be quite dramatic. In a preimpoundment survey of Beaver Reservoir on the White River, Arkansas, 72 species and 5 hybrid combinations were reported. Subsequent to impoundment only 29 species were collected in the tailwater area below the dam.[42] Cold tailwater temperatures may also inhibit reproduction of warmwater species without causing their complete disappearance. Certain tradeoffs may have to be made with respect to a postimpoundment downstream fishery. In a survey of 32 projects in southern states, 43 percent of the total tailwater miles were reported to be marginal waters which provided little or no fishing.[43] The views of the Fish and Wildlife Service, which should be summarized in the EIS, should aid in evaluating the effects of impoundment on the downstream fishery. Replacement of a productive, heavily fished stream, whether warmwater or coldwater, with a marginal, or a "put-and-take," trout fishery that must be maintained by stocking should be considered an adverse ecological impact even though recreational use may be increased considerably.

In the absence of significant inputs of thermal effuents downstream from an impoundment, the release of warmer epilimnetic water is unlikely to have a measurable adverse effect on an existing warmwater fishery below a dam. This mode of operation would undoubtedly create temperature conditions unsuitable for the survival and reproduction of trout and other coldwater species if they were present prior to dam construction.

The major changes in flow regime, water temperature, and dissolved oxygen that may occur downstream from stratified impoundments often overshadow the effects of other water quality parameters. Two effects which may be extremely harmful to downstream biota, but which occur only in special cases, are supersaturation of dissolved gases and accumulation and release of hydrogen sulfide. Nitrogen supersaturation is a major problem at high dams in the Northwest and West where heavy spillway discharges are encountered. The phenomenon causes gas bubble disease and often mortality in affected fish. Further biological information is contained in "Proposed Criteria for Water Quality," Volume I. Quantitative data and general discussions of the problem can be found in articles by Beininger and Ebel[44] and Boyer.[45]

Hydrogen sulfide is toxic to fish at low concentrations (see Table IV-2., page IV-52). In some instances fish kills have occurred downstream from dams releasing anaerobic water containing hydrogen sulfide. It is not likely that the problem would persist for a long distance downstream if it were to occur because mixing and aeration would disperse the gas to the atmosphere.

Reduction of sediment load combined with release of possibly nutrient-rich water from the hypolimnion may stimulate eutrophication downstream. Wright observed that cities withdrawing water from rivers downstream of large impoundments experienced taste and odor problems due to algae growth. This necessitated additional water treatment in some cases.[46] Whether nutrient increases have resulted in better productivity of downstream fisheries is uncertain. Since temperature, oxygen, and flow may all vary considerably, it is difficult to separate out the effects of any one factor.

Ecological impacts due to combinations of the changes discussed above may be evident long distances downstream from an impoundment. These far-reaching impacts often occur cumulatively in basins whose water resources are highly developed for power, flood control, irrigation, and water supply. Effects on estuarine ecosystems and agricultural productivity in deltas, generally linked to major flow regime and sediment-load changes, are discussed in the report "Analyzing the Environmental Impacts of Water Projects"[32] and in the publications referenced therein.

IV.B.3. Assessment of Impacts

EPA's basic policy[47] regarding the water related impacts of impoundments is as follows:

> Flow regulation practices that result in lower than natural low flows (i.e., those which would occur in the absence of the impoundment) or release water of less than preimpoundment quality (e.g., zero dissolved oxygen) are considered to be in violation of the antidegradation clause of the water quality standards. During the periods when natural flows are equal to or less than the flow values used to design waste treatment facilities located downstream from the site of a proposed impoundment, the rate of discharge past the dam should be at least equal to the rate of inflow above the dam, whether or not water quality storage is provided.

An assessment of impacts should therefore relate identified and quantified impacts to appropriate environmental standards and criteria and determine the need, applicability, and effectiveness of alternative mitigative techniques. Alternatives to the proposed project such as scope, location, or alternative means of meeting water resource objectives, which may or may not be addressed in the EIS, should also be included.

IV.B.3.a. Impacts During Construction

Water pollution from construction activities, although usually of short duration, may be an important source of environmental impacts. Deposition of sediments on the stream bed may severely reduce populations of bottom-dwelling organisms and eliminate habitat for species that require clean gravel or rubble for spawning. Aesthetic and recreational values of a stream may also be adversely affected by turbidity during construction. Pesticide residuals resulting from application in proper dosages probably will not directly affect aquatic biota. However, some such chemicals are highly toxic, nonbiodegradable, readily concentrated by plants and animals, and may have cumulative impacts. Accidental spills of pesticides, as well as oil and other chemicals, pose the possibility of fish kills and other environmental damage at impoundment construction sites. Careful handling and use of hazardous materials are necessary to minimize water quality and ecological impacts. The discussion of pesticides should cite standards for fish flesh as well as for water. Food and Drug Administration standards for the marketing of commercial fish should be applied to assessing the viability of a future commercial or sport fishery.

Construction related impacts on water quality cannot be quantified easily even though it is known that some pollution will occur during the construction period. The purpose of assessing water pollution from construction should be to assure the use of all feasible methods for reducing or avoiding pollution and maintaining water quality standards. EPA's proposed water quality criteria specify that for freshwater aquatic life the maximum acceptable total concentration of suspended solids is 80 mg/l, depending on the level of protection desired. The basic rationale for this criterion is that waters containing suspended solids concentrations in excess of 80 mg/l are unlikely to support good freshwater fisheries. Water quality standards of some states specify numerical criteria for turbidity as well as general guidelines relating to the effects of suspended matter in watercourses. Vermont's water quality standards require turbidity levels not to exceed 10 Jackson Turbidity Units (JTU) for coldwater streams and oligotrophic lakes supporting trout, or 25 JTU in warm waters "as a result of any discharge or activity, except as may result from natural conditions or as may be permitted in accord with the conditions of a temporary pollution permit or order of the Secretary."[48] The rules further state that Class B waters be free of pollutants that affect the composition of bottom fauna, affect the physical or chemical nature of the bottom, and interfere with the propagation of fish.

It is important that the review be coordinated with appropriate state agencies that may have specific recommendations or requirements for environmental protection during construction. During construction of Martis Creek Dam, California's Regional Water Quality Control Board established requirements which limited the increase in turbidity in the creek (which is an important trout stream) to not more than 10 JTU during any one-hour period, nor more than 100 JTU at any one time.[49] The requirements were incorporated into construction specifications for the project.

Downstream uses may contribute largely to a determination of acceptable turbidities and concentrations of other pollutants originating at a construction site. The EPA's, "Proposed Criteria for Water Quality", suggests that clarity for bathing and swimming waters be such that a Secchi disc is visible at a minimum depth of 4 feet. This corresponds to a turbidity of about 10 JTU.[50] In some instances, the protection of recreational and aesthetic values may necessitate even stricter controls than are required for preserving fish and wildlife. Water supplies withdrawn from the river below an impoundment construction site may also be affected adversely by higher than normal turbidity, perhaps to the extent that addtional expenditures or process modifications for treatment are required.

In the construction of a dam, some excavation and earthmoving, (and other activities) will occur in the stream or immediately adjacent to it. A special set of criteria may be desirable for application during constuction. The criteria should be designed for reasonable protection of the most water quality sensitive stream use, with perhaps some degree of flexibility (for example, as in the turbidity limits for construction of Martis Creek Dam mentioned above). For protection of water quality in the construction period, activity scheduling and proper location of access and haul roads, as well as land treatment and process water treatment systems should be considered. Depending on the particular topographic conditions, any of the following methods of erosion control might apply: (1) minimize soil exposure, (2) control runoff, (3) shield soil, and (4) bind soil. These are discussed briefly below with supplemental information available in "Processes, Procedures, and Methods to Control Pollution Resulting from All Construction Activity."[51]

Soil Exposure. Minimizing the exposure of disturbed soils, particularly during seasons of the year when high intensity rains may be expected, can be best accomplished by careful timing. Excavation and earthmoving activities should be scheduled to minimize total exposure at any given time.

Control Runoff. Minimizing the quanity of water before it can run over an exposed slope is accomplished by using terraces, ditches, and dikes on upper slope areas. Rain falling directly onto the surface may be handled by scarifying slopes to reduce the flow velocity and inducing infiltration, thereby reducing erosion. This is accomplished with shallow grooves following contours of the slope.

Shield Soil. Numerous types of ground cover, both vegetative and nonvegetative, may be used to protect exposed slopes. Nonvegetative mulches include straw, hay, wood chips, stone, and gravel. The erosion control effectiveness of these mulches has been evaluated under closely controlled experimental conditions. Some of these results are summarized in Table IV-1. In these experiments, stone, gravel, and wood chips were tested because of their general availability at construction sites. The table may be used to determine whether specifications relating to slope protection are stringent enough to avoid severe erosion. Due to increased restrictions on open burning, small trees, brush, and limbs from the clearing of impoundment areas may provide a large source of wood chips for use as mulch material. The greatest shortcoming of nonvegetative mulches is the possibility of rilling. Mulching loses much of its effectiveness if drainage becomes established in small rills rather than through the mulch material.

Fine mesh netting, stone riprap, and impermeable materials such as tarpaulins and plastic mats may also be used for temporary stabilization of relatively small areas. The faces of earth dams are commonly riprapped with stone since maintenance is reduced considerably in comparison with sodded embankments.

Bind Soil. Vegetation such as grasses, shrubs, and other ground cover is often used to bind the soil and minimize water erosion. It is important that the vegetation be tolerant of the adverse conditions expected at the site such as drought, sun, shade, and soil nutrients. During construction periods, fastgrowing annual grasses, either alone, or in a mixture, with longer-lived grasses and/or mulches may be used to provide more permanent control. Chemical binders, usually in liquid form, may be sprayed over exposed slopes or mixed with mulches to aid in reducing soil loss. Due caution should be exercised when using potentially toxic or otherwise polluting chemicals to avoid contamination of surface and/or groundwater in the impoundment area.

Sediment control techniques may be necessary at an impoundment site in addition to the erosion control procedures described above. Vegetative controls may be used to detain or filter overland runoff before sediment enters waterways. Provision for natural or planted vegetative buffer strips between the watercourses and borrow areas, haul roads, or other areas where soil is exposed may aid in minimizing turbidity increases.

Table IV-1. Soil Losses from 5 Inches of Simulated Rain on Denuded Slopes for Various Types and Rates of Mulch

Mulch	Application Rate (tons/acre)	Soil Loss (tons/acre)	Percent Reduction in Soil Loss
None	-	39.6	-
Portland cement	-	32.7	17
Wood chips*	2	27.1	32
Crushed stone*	15	25.6	35
Gravel	70	14.7	63
Straw	2.3	12.1	69
Crushed stone	60	11.4	71
Wood chips	4	8.5	79
Wood chips*	7	5.5	86
Crushed stone*	135	3.5	91
Crushed stone*	240 & 375	2	95
Wood chips*	14 & 25	2	95

Rain intensity, 2.5 inches per hour; slope length, 35 feet; slope steepness, 20 percent; soil, calcareous till beneath Wingate silt loam.
*Based on one replication; others are averages for two replications.

Source: Meyer, L.D., C.B. Johnson, and G.R. Foster, "Stone and Wood-chip Mulches for Erosion Control on Construction Sites," Journal of Soil and Water Conservation, Vol. 27, No. 6, November-December 1972 p. 267.

In many cases more elaborate controls are necessary, particularly where waste streams may be amenable to clarification by physical and chemical treatment. Temporary holding basins that allow larger particles to settle out from highly turbid waters may be constructed at low points in the impoundment area. Turbidity control plants have been used at impoundment sites to treat aggregate wash water, water that collects around diversion tunnels and other structures, and other water containing high concentrations of suspended solids. Chemical flocculants are often used to aid in removing fine particles. These chemicals should not be toxic to fish, wildlife, or vegetation. Adequate inspection should be required to insure application in proper and safe dosages. If not specified in the EIS, these or other techniques should be recommended for all polluted water that can be readily collected and treated.

IV.B.3.b. Impacts Due to Creation of Artificial Lakes and Impoundment Operation

Based on EPA and state antidegradation policies, and the guidelines in previous sections, it should be possible to assess water quality and ecological impacts at impoundments of differing sizes, site characteristics, purposes, and operational features. Table IV-2 summarizes water quality criteria for various constituents that may be affected by an impoundment. Individual states may have EPA approved water quality standards prescribing different levels for these parameters, in which case state regulations would take precedence.

These standards are designed to protect and enhance both aquatic life and stream water uses and should be the primary basis for assessing aquatic ecological impacts as well.

Table IV-3 lists the thermal criteria for protection of a number of important freshwater and anadromous fish during their spawning seasons. The fish listed are considered important because of their value for sport and commercial fishing. Although only a few of the listed species may be found in a given stream, their requirements are likely to govern the desirabliity and acceptability of thermal regime modifications caused by an impoundment project.

By comparing the thermal criteria for fish currently existing at an impoundment site with the expected temperature patterns, the reviewer can determine which species will be adversely or beneficially affected in downstream reaches. Special circumstances, such as the existence of rare or endangered species, or other locally important species, may intorduce different temperature requirements.

Table IV-2. Water Quality Criteria for Selected Constituents and Probable Effect of Impoundment*

Constituent	Water Use**	Criterion	Probable Effect of Impoundment
Iron	WS I	0.5 mg/l 5.0 mg/l for continuous irrigation	Increase in anaerobic or oxygen-deficient hypolimnion
Manganese	WS	0.3 mg/l	Increase in anaerobic or oxygen-deficient hypolimnion
Dissolved Oxygen	A WS	Variable[a] None prescribed, preferable near saturation	Depletion or deficiency, hypolimnion, with low-level outlets, may persist downstream
Sulfides (Hydrogen sulfide)	A	0.002 mg/l	May be present in anoxic hypolimnion
Dissolved Solids	I WS	500-1000 mg/l for sensitive crops None prescribed[b]	May increase due to evaporation, water diversion irrigation, or leaching
Sulfate	WS	250 mg/l	May increase due to evaporation, water diversion irrigation, or leaching
Chloride	WS	250 mg/l	May increase due to evaporation, water diversion irrigation, or leaching
Ammonia	WS	0.5 mg/l	May increase in anaerobic or oxygen-deficient hypolimnion, from bottom sediments
Odor	WS R	Essentially none Essentially none	May be problem in hypolimnion due to reduction products or in epilimnion due to algae
Clarity	R	4 feet Secchi disc visibility	May improve upon impoundment; however, excessive algae growth may reduce clarity

Table IV-2. Water Quality Criteria for Selected Constituents and Probable Effect of Impoundment* (Cont'd)

Constituent	Water Use**	Criterion	Probable Effect of Impoundment
Microorganism Fecal coliform	I WS R	1000/100 ml 2000/100 ml (raw water) 200/100 ml (waters used for swimming or water contact sports)	Normally significant reduction in impoundment; however, increases have been observed following drawdown after flood control operations
Mercury	WS	.002 mg/l	May increase due to evaporation. High concentrations are hazardous to human health
Lead	WS	.50 mg/l	May increase due to evaporation High concentrations are hazardous to human health
Zinc	WS	5.0 mg/l	May increase due to evaporation High concentrations are hazardous to human health

*Table source should be consulted for further background information

** I = Irrigation
A = Aquatic Life
WS = Public Water Supply Intake
R = Recreational Waters

[a]Varies with temperature and species
[b]Sulfate and chloride are most troublesome components

Source: U.S. Environmental Protection Agency, "Proposed Criteria for Water Quality," Volume I, Washington, D.C., October 1973.

Table IV-3. Maximum Weekly Average Temperature for Spawning and Short-Term Maxima for Survival During the Spawning Season (Centrigrade and Fahrenheit)*

Species	Optimum Spawning	Maximum	Spawning Season
Atlantic Salmon	5 (41)	18 (64)	Oct. - Dec.
Bigmouth Buffalo	17 (63)	-	Late Apr. into June
Black Crappie	16 (61)	-	Mar. - July
Bluegill	25 (77)	31 (88)	Apr., June - late Aug.
Brook Trout	9 (48)	22 (72)	Sept. - Nov.
Carp	20 (68)	31 (88)	Mar. - Aug.
Channel Catfish	27 (80)	34 (93)	Mid Apr. - late July
Coho Salmon	10 (50)	22 (72)	Fall
Emerald Shiner	23 (73)	29 (84)	May - Aug.
Freshwater Drum	21 (70)	-	Early May - late June
Lake Hering (Cisco)	4 (39)	18 (64)	Mid. Nov. - mid Dec.
Largemouth Bass	21 (70)	30 (86)	Apr. - June (North) Nov. - May (Florida)
Northern Pike	12 (54)	-	Feb. - June
Rainbow Trout	9 (48)	26.5 (78)	Nov. - Feb. Feb. - June
Sauger	10 (50)	-	Apr. - May
Smallmouth Bass	17 (63)	-	May - July (Ontario)
Smallmouth Buffalo	17 (63)	-	Late Mar. thru June
Sockeye Salmon	10 (50)	22 (72)	Fall
Striped Bass	18 (64)	-	Apr. - July
Threadfin Shad	18 (64)	-	Apr. - Aug.
White Bass	19 (66)	-	Apr. - July (North) Mar. - May (Tennessee)
White Crappie	18 (64)	-	Mar. - July
White Sucker	10 (50)	24 (75)	Mar. - June
Yellow Perch	12 (54)	22 (72)	Mar. - June

*Based on 24-hour median lethal limit minus 2°C (3.6°F) and acclimation at the maximum weekly average temperature for optimum spawning for that month.

Source: U.S. EPA, "Proposed Criteria for Water Quality, Volume I," Washington, D.C., 1973, p. 165 and Appendix A.

The criteria of quality and uniqueness should be applied to ecological resources impacted by an impoundment project, whether they are rare or endangered species, anadromous fish, or of special scenic, historic, aesthetic, or geologic value. Mitigation measures cannot replace committed resources. Such alternatives as acquisition of wildlife ranges, wetlands and other lands; construction of fish by-pass facilities; or minimization of water quality impacts should receive full consideration and evaluation in an EIS.

The EIS must be responsive to water quality and ecological impacts that will result from impoundment. There should be a full evaluation of alternative measures for maintaining water quality that will be as good as, or better than, that existing prior to impoundment. Several techniques have been employed including site preparation measures, selective withdrawal outlets, turbine aeration, discharge aeration using Howell-Bunger valves, and artificial destratification and hypolimnetic aeration. These are described in the following sections with enough detail to determine their applicability at certain types of impoundments, the water quality problems that can be ameliorated, and any drawbacks and limitations.

Site Preparation Measures.

In the past, reservoir site preparation has varied from the removal of marketable timber only, to complete clearing and stripping of all organic soil, vegetation, and debris. Neither extreme is usually optimal with respect to both future water quality protection and cost. The EIS should describe and justify the degree of anticipated site preparation work in terms of balancing water quality gains, recreational, and aesthetic considerations against cost. The evaluation may be supported by field investigations or may be a result of general reconnaissance, consideration of proposed uses of the impoundment, and professional judgement.

Removal of trees from an impoundment area is widely practiced. Its purposes include aesthetics; elimination of boating, fishing, and debris accumulation hazards; and protection of impounded water quality. Cases often arise where total clearing is not justifiable, feasible, or even desirable. Standing timber, stumps, and other vegetation can increase fishery productivity and result in a greater sport fish harvest. Few reservoirs are cleared up to the gross pool (spillway) elevation, particularly if a portion of the total storage is allocated to flood control and is used only infrequently or for relatively short periods during high runoff. Many Corps of Engineers' reservoirs (existing or being planned) in the Northeast have no provision for extended storage and are operated so as to evacuate stored flood waters and recover flood control capacity as rapidly as possible following recession of a flood peak downstream. Clearing elevation for such projects is often chosen on the basis of the storage required to regulate a flood of a certain frequency or recurrence interval. This interval is sometimes taken to be five years.

Removal of stumps (grubbing), brush, herbaceous vegetation, and topsoil may be included as part of reservoir site preparation activities, particularly if impoundment storage is to be used for public water supply. Such operations may involve considerable expense. As a result, grubbing, if done at all, is restricted to higher elevations in the reservoir where drawdown is frequent. Removal of all stumps, roots, and topsoil for a marginal 20 feet has been recommended.[52] Taste, odor, and other objectionable characteristics in water supplies may be avoided or lessened by the removal of organic materials.

The methods and scheduling of reservoir clearing, grubbing, and other site preparation techniques should be assessed for resultant impacts on water and general environmental quality. Access roads through the basin should be planned to follow reservoir contours. This will minimize soil erosion and allow piling and burning of brush in place rather than dragging it toward the valley bottom.[53] Large depressions in the reservoir drawdown area should be self-draining to avoid ponding and stagnation of reservoir water. This means that channels or ditches may have to be cut. Reservoir clearing should be scheduled for the dry season to minimize erosion of the unprotected reservoir during heavy rains. Reservoir clearing should be scheduled closely with work progress on the dam structure and ideally should be completed just prior to reservoir filling so that time of exposure is kept as short as possible. In addition to the increased threat of erosion, the regrowth of herbaceous cover in a long lag period between clearing and filling of the reservoir can contribute a significant additional oxygen demand in the first years of impoundment.[54]

Soil conditions in some parts of the reservoir may pose exceptional hazards to future water quality. Swamps, bogs, or peaty soils with high organic contents are likely to impart characteristics unacceptable from the public water supply standpoint. Organic rich soils may be stripped and removed from the reservoir, plowed under, or covered with a layer of mineral soil to prevent leaching of excessive iron, manganese, color, and other undesirable constituents. The decision whether to do any of these things will be influenced by the amount of area exhibiting unfavorable soil conditions, the anticipated impairment of water quality for proposed water uses, the cost of the treatment, and the arrangements for water supply withdrawal and reservoir discharge.

Selective Withdrawal Outlets

Dissolved oxygen and temperature are two principal water quality criteria used to gauge the need for multilevel releases at an impoundment project.[55] Downstream requirements, uses of impounded water, and physical features of the project are also of concern in evaluating the applicability of selective withdrawal to a particular reservoir. Multilevel intake structures have been constructed at all types of single and multiple-purpose projects. A 1970 survey of 90 dams equipped with selective withdrawal devices is summarized in Table IV-4 to indicate the prevailing uses.

Table IV-4. Types of Impoundments Equipped With Selective Withdrawal

Primary Purpose(s)	Number of Projects
Single-purpose flood control	20
Single-purpose water supply	21
Single-purpose power	2
Water supply and flood control	21
Water supply and low-flood augmentation	6
Flood control and power	4
Other (includes navigation, irrigation and fish propagation in various combinations with the above)	16

Source: "Register of Selective Withdrawal Works in the United States," Task Committee on Outlet Works, Committee on Hydraulic Structures, R.E. Nece, Chairman, Journal of the Hydraulics Division, ASCE, Vol. 96, No. HY9, Proc. Paper 7533, September 1970, pp. 1841-1872.

Water supply is a primary impoundment purpose in 63 percent of the projects surveyed. Assuring provision of high quality water for municipal and industrial uses was an important factor in the decision to utilize selective withdrawal facilities.

If the EIS has satisfactorily demonstrated the probability of strong thermal stratification, eutrophication, and associated water quality problems at a proposed impoundment, then adverse downstream impacts from low-level discharges may occur. Multilevel outlets should be considered as one mitigation alternative worthy of investigation. Uses, advantages, and limitations of selective withdrawal are discussed below.

Withdrawal from Impoundment for Water Supply. The most common use of selective withdrawal facilities is for controlling the temperature or chemical quality of water which is withdrawn from an impoundment for municipal and industrial water supply. Withdrawal points may vary from two intakes (one near the surface and one deeper in the reservoir) to numerous intakes which are evenly or unevenly spaced and are capable of blending water from two or more elevations. Multilevel intakes can provide some flexibility and control over the quality of water introduced to a supply system. It should be noted, however, that their inclusion in a project may simply be a safety precaution in the event that quality problems are encountered after construction. In any case, the design should be based on thermal and hydraulic modelling studies and detailed water quality studies. The most frequently noted water quality problems that can sometimes be ameliorated by selectively withdrawing water from an impoundment consist of:

- Tastes and Odors. Highly objectionable tastes and odors may be imparted to hypolimnetic waters under anaerobic or low dissolved oxygen conditions due to decaying organic matter and high sulfide concentrations. In eutrophic reservoirs, water from the euphotic zone may also have some taste and odor from algae, thus restricting the range of depths from which water of suitable quality can be drawn during the stratified period.[56]

- Iron and Manganese. Metallic salts of iron and manganese are released from bottom sediments in a reducing environment. They may reach concentrations at which objectionable tastes and odors are detectable and the staining of clothes occurs. Although they are primarily "aesthetic" pollutants, criteria for acceptable maximum levels of iron and manganese are included in federal drinking water standards. Oxidation of excessive iron and manganese during prechlorination of such hypolimnetic water produces undesirable color, which once in a water system may persist for several weeks.[56] Since a buildup of these compounds is normally confined to the deeper, unoxygenated parts of a reservoir, withdrawal from the epilimnion or thermocline may avoid high concentrations of these ions.

- Turbidity. Sediment laden density currents are fairly common in larger reservoirs. Their course through a reservoir is influenced by sediment concentrations, inflowing current velocities, and temperature differentials.[57] High turbidity may contribute to chlorine demand or interfere with water treatment processes such as coagulation and ion exchange. By using outlets at different depths, water may be withdrawn from above or below the undesirable layer.

- Salinity. Because of the extensive development of irrigation projects and reuses of water, salinity has become a major problem in the West. Variations of dissolved solids with depth in a reservoir may be pronounced which suggests that multilevel intakes could be used to select water with acceptable dissolved solids concentraitons, if available. These substances are not removed by conventional treatment and may cause tastes at levels higher than the recommended limits.

- Radioactivity and Toxic Substances. It has been suggested that knowledge of seasonal stratification, flow patterns, density currents, and other characteristics may be useful in special circumstances for protecting the quality of water released from a dam or withdrawn for public use.[58] Accidental spills of toxic or radioactive substances upstream from a stratified reservoir are likely to be confined to a narrow depth band as the inflow seeks its density level. In the summer stratification period the pollutant may enter as an overflow or interflow and remain confined to a well defined layer. Use of multilevel withdrawal in this instance could perhaps prevent or minimize interruption of water supply service by safely drawing water from another level. The situation could be complicated by suspended matter absorbing harmful material and settling to the bottom or deeper parts of the reservoir.

- Temperature. Although no specific temperature limits exist for municipal water supplies in the United States, there is a definite aesthetic benefit associated with cool waters.[59] Economic advantages may also be evident if the impounded water supply is used for industrial cooling. Because of overriding water quality considerations mentioned previously, it is sometimes not feasible to operate multilevel outlet works solely for maintaining cold water in the supply and distribution system. Withdrawal depth limitations imposed by taste and odor, iron and manganese, or other constituents may necessitate use of water with a higher than desirable temperature. However, the flexibility of temperature control may be critical in maintaining downstream conditions favorable for other water uses.

Impoundment Releases for Downstream Quality Control. Water quality problems caused by the development of thermal stratification and consequent dissolved oxygen changes should be considered in the planning of any impoundment. Because an impoundment may have a useful operating life of one hundred years or more, probable future stream uses must be analyzed in conjunction with impoundment-induced water quality changes. Justification for selective withdrawal or other mitigating project features may not be evident on the basis of current conditions alone. Some uses of selective withdrawal for controlling or influencing downstream water quality are:

- Regulation of Temperature. Distinct thermal gradients in a stratified impoundment may permit fairly close control of discharge temperatures. Downstream water uses may in some cases present mutually exclusive temperature requirements. It is important that the various needs be identified in the EIS. Use of the stream as a source of cooling water for an electric power generating station or industry would favor release of cold water, as would the creation of a new, or maintenance of an existing coldwater fishery. On the other hand, temperatures comparable to those occurring without impoundment might be desirable for irrigation water supplies, recreation, and preservation of natural fish life. Since the thermal structure of a stratified impoundment is very much interrelated with water quality, temperature regulations for particular uses cannot be separated from accompanying quality characteristics. A deficiency of dissolved oxygen in water selectively discharged from the hypolimnion may negate the benefits of reduced temperatures for downstream fisheries. The water may also be corrosive or contain concentrations of iron or other substances detrimental to use for public water supply.

- Maintenance of Assimilative Capacity. Release of water containing adequate dissolved oxygen to meet stream standards and waste load requirements may be accomplished by selectively withdrawing from the epilimnion in the summer months. Downstream temperatures are likely to be increased by this mode of operation.

- Regulation of Physical and Chemical Quality. Any physical or chemical constituents exhibiting vertical gradients, or affected by inflow density currents, may be controlled to some extent by use of multilevel outlets (several examples were discussed previously in relation to water supply withdrawals).

Design and Operational Considerations. If selective withdrawal works are proposed as part of an impoundment project plan the EIS should contain supporting information on their proposed operation relative to water quality or temperature selection.

Predictions of water quality changes, stream uses, and hydrographic modifications are necessary to judge whether mitigating measures for water quality control not considered in the EIS warrant attention and study.

An assessment of the need for selective withdrawal facilities should include several considerations. Initially the determination of existing and future needs and objectives for water quality management should form the basis for design of selective withdrawal facilities. Secondly, in order to meet specific physical, chemical, and biological requirements of the releases, there should be an evaluation of the effects of the size, shape, spacing, and number of outlets.[60] Finally, criteria indicating when and how the facilities will be used and formulae for predicting withdrawal layer characteristics are essential for effective operation of multilevel outlet works.[61]

The Tennessee Valley Authority, the Bureau of Reclamation, and the Corps of Engineers have all constructed project incorporating selective withdrawal facilities. Some hydroelectric dams licensed by the Federal Power Commission also have multilevel outlets. Knowledge of the hydraulic and water quality behavior of reservoirs under various conditions has been gained both from research and from observations and studies of existing impoundments. Experience has shown that professional judgement or extrapolation of results at one impoundment to another cannot substitute for detailed, site-specific investigations and modeling. Prior to construction of Folsom Dam in California it was concluded, based on experience at the existing Shasta and Friant Dams, that multilevel power outlets would not be required for maintaining suitable fall spawning temperatures for salmon in the American River.[56] The conclusion proved to be incorrect as cold hypolimnetic water was frequently depleted before the fall spawning period. If multilevel discharge facilities are included in a project plan, or if potential water quality problems suggest their inclusion, the reviewer should ascertain that accepted prediction techniques are used (See Section IV.B.2) to provide reasonable assurance that proposed objectives for water quality control will be met.

Use of selective withdrawal may not completely solve the anticipated water quality problems discussed earlier and may have some detrimental effect on water quality. If nutrient loadings in streams draining the area upstream from a proposed reservoir site are relatively high then the situation typified by undesirable algae growth in the epilimnion and oxygen deficiency in the hypolimnion is likely to occur. At the Casitas Reservoir in California, nine selectively level intakes with a vertical spacing of 7.3 m (24 ft) have not afforded sufficent flexibility to eliminate withdrawal of poor quality water for municipal supply. Treatment with copper sulfate for algae control and destratification by air injection have both been used to supplement selective withdrawal.[56]

The Corps of Engineers has sponsored a number of studies on the effects of selective withdrawal on water quality and fisheries, the results of which may aid in identifying and assessing potential impacts of different discharge regimes. Analysis of data from more than 100 stratified impoundments indicate that continuous discharges from the hypolimnion may increase dissolved oxygen levels in the deeper parts of a reservoir[62]. The data were reflective of late summer and fall conditions. This is a period of intense stratification and usually results in the lowest dissolved oxygen levels. These results suggest that the fishery potential of a stratified impoundment may be enhanced if releases of relatively poorer quality hypolimnetic water are made.

The above observations neglect possible downstream thermal requirements and the impact of relatively poorer quality hypolimnetic discharges on waste assimilative capacity and other water uses. Discharges from the hypolimnion or thermocline region may induce water quality patterns in an impoundment that are different from those resulting from release of surface waters. The differences may be important in determining how to operate selective withdrawal works for specific management purposes.

Turbine Aeration

In impoundment projects which provide hydroelectric power generation facilities, turbine aeration offers a means to increase dissolved oxygen concentrations of water drawn through low-level power intakes. The simplest system introduces air through draft tube vents that are built into many projects to control vibration.[63] Air flow is induced by negative static pressures developed in the draft tube. The location of modern turbines at or below the tailrace elevation may eliminate negative pressures or produce positive pressures in the draft tubes necessitating an external power source to force air into the water stream. This difficulty can be overcome by using wedge-shaped deflector plates to create negative pressures and draw air into the draft tube.[64] Once air is introduced, turbulence and increasing pressure enhance absorption of oxygen.

Capital costs for turbine aeration systems are relatively small and operating costs consist mainly of reduction of generating efficiency. Turbine efficiency losses averaging less than .1 percent to about 5 percent have been reported. Power generating efficiency losses during turbine aeration decrease with increasing head and with increasing flow through the turbine. Most studies conducted at existing projects have shown that transfer efficiency falls off rapidly as the oxygen concentration in water passing through the turbines increases. The technique of turbine aeration should not be relied on to increase dissolved oxygen concentrations of anaerobic or poorly aerated water more than about 2-3 mg/l with higher initial oxygen levels. Oxygen transfer may also be less efficient at higher flows than at low flows.

The degree of aeration attainable by simple turbine venting may be insufficient to meet minimum stream standards for dissolved oxygen during summer and fall; the time period when oxygen depletion in the hypolimnion is typically greatest.

A highly valued stream fishery might be adversely affected by dissolved oxygen concentrations below 4 mg/l. The concentration of 4 mg/l is a floor value to protect sizeable populations of resistant species and successful passage of most migrants. Higher concentrations may be needed in many cases because production of sensitive species may be reduced at the lower DO concentration. Location of a hydroelectric impoundment on a freely flowing tributary stream may present conditions that are conducive to rapid natural reaeration downstream with no significant water uses intervening in the affected reach. In this case, the need for high concentrations of dissolved oxygen immediately downstream from the dam may not be as critical. In assessing mitigating features for water quality improvement, downstream water uses and water quality requirements should be examined and compared with expected water quality of impoundment discharges.

Discharge Aeration Using Howell-Bunger Valves

The Tennessee Valley Authority has conducted extensive research regarding the aeration efficiency of the Howell-Bunger valve, which is a fixed dispersion cone valve. The valve has been used at several TVA impoundments and has been shown to be an effective aeration device. Aeration efficiencies, defined as the ratio of the difference between the initial and final oxygen deficits to the initial deficit, were found to be consistently greater than 0.8 when outflow velocities exceeded 9 m/sec (30 ft/sec).[65] Initial dissolved oxygen concentrations were not found to affect appreciably aeration efficiency.

It appears that Howell-Bunger valves could be used successfully for aeration at a wide variety of impoundment projects where hypolimnetic discharges are expected to cause downstream water quality problems. The valves may be situated to discharge water horizontally into a containment structure or tunnel as well as directly into the stream channel below a dam. Such facilities could be provided at hydroelectric projects to aerate the relatively small, off-peak discharges occurring at night and on weekends.

Several possible advantages of utilizing Howell-Bunger type valves for reservoir discharge aeration should be considered. In contrast to turbine aeration discussed above, a properly designed cone valve aeration system is effective in increasing dissolved oxygen to near-saturation values regardless of initial concentrations. The valve could not be used during a peak power generating cycle because of the magnitude of discharges involved. It appears that the Howell-Bunger valve would permit maintenance of both cooler temperatures and better oxygenated conditions downstream from a stratified impoundment in the summer and autumn. Whether the altered thermal regime is beneficial would depend in large part on downstream water supply, cooling, fisheries, recreation, and other uses and needs.

Destratification and Hypolimnetic Aeration

Various systems for mixing and aerating stratified reservoirs have been devised although actual operating experience has been restricted almost exclusively to impoundments with volumes of less than 5 x 10^6 m^3 (40,500 acre ft). The basic purpose of either destratification or hypolimnetic aeration is to eliminate or avoid exygen depletion and associated water quality changes in the deeper parts of an impoundment. Maintenance of aerobic conditions inhibits the leaching of color, solutions of iron, manganese, and nutrients from bottom sediments and the production of hydrogen sulfide. All of these could be detrimental to various water uses.

Prediction or estimation of the concentrations of objectionable substances that will occur in a new impoundment, as a result of anaerobic conditions, cannot be done with any degree of certainty using present modelling or quantitative techniques. However, it is reasonable to assume that concentration levels will probably exceed prescribed limits for raw water sources if stable stratification and oxygen depletion are expected. Under these conditions, artificial destratification can be used to maintain dissolved oxygen throughout the reservoir and suppress the solution or leaching of iron, manganese, color, and other constituents. Other possible effects of destratification should also be anticipated and assessed in view of overall water resource needs. Destratification tends to increase the heat budget of an impoundment considerably. The entire water body will become isothermal and exhibit a temperature that may approach that of the epilimnion under stratified conditions. The cold water reserve of the hypolimnion may be needed for cooling purposes or for regulation of stream temperatures below the dam during certain periods. This situation might arise during migration and spawning of anadromous species that have definite thermal requirements. Attempts to lower water temperatures and eliminate oxygen deficits by artificial destratification, thereby creating suitable summer trout habitat, have been unsuccessful. Desirable dissolved oxygen levels can be maintained but minimum temperatures are increased to intolerable levels.[66]

Table IV-3 and pertinent state water quality criteria should be consulted for thermal requirements applicable to important fish species which may be present in or downstream from a proposed impoundment area. Protection of indigenous aquatic biota or migratory species will define, in some cases, allowable thermal alterations due to impoundment. Artificial destratification reduces flexibility in downstream temperature control and may lead to unacceptably high temperatures during critical spawning or migration in the autumn. The evaluation of thermal requirements should be coordinated with the U.S. Fish and Wildlife Service or the state fish and game agency if specific constraints due to fisheries exist or if the EIS is deficient or unclear as to possible effects.

Some of the advantages and disadvantages of artificial destratification and hypolimnetic aeration are summarized in "Measures for the Restoration and Enhancement of Quality of Freshwater Lakes."[66] Several case studies and cost estimates are also presented. Although some detrimental effects have been observed, these methods may improve the quality of raw water in an impoundment, reduce treatment costs, and perhaps benefit the reservoir fishery. Not enough is known about the ecological impacts on reservoir productivity, algae, zooplankton, and fish to permit a thorough assessment of their beneficial and detrimental effects. The need for reservoir aeration or mixing can best be determined after a project becomes operational. Toetz _et al_.[67] have reviewed and analyzed a large portion of the literature concerning biological impacts of artificial destratification and aeration. This publication should be consulted for additional information on ecological effects.

IV.C. Review of Solid Waste Management Impacts

Activities during both the construction and operational phases of an impoundment project may generate solid wastes that require handling and disposal. The reviewer should insure that short-term and long-term solid waste management requirements have been identified and appropriately quantified in the EIS. Acceptable disposal methods should be employed to minimize potential adverse impacts.

IV.C.1. Sources of Impacts

Solid waste impacts may occur both in the short term during construction of an impoundment and in the long term from recreation-generated refuse and other waste sources. Among the common components of solid waste that must be dealt with during the construction phase are demolition materials such as concrete, brick, wallboard, plaster, and used lumber; packaging materials including paper, cardboard, plastic, excelsior and metal retaining bands; wood including trees and scrap products; rubber; plastic; glass; pesticides; and pesticide containers. During operational phases, flood debris and refuse from public use areas represent the major sources of solid waste. A full review of potential impacts includes consideration of the storage, collection, transport, resource recovery, waste reduction, and ultimate disposal of waste materials.

Storage. Storage of solid waste at the construction site is generally temporary. Provisions must be made for proper handling to minimize impacts. Operations such as clearing and grubbing, stripping of topsoil for future use, and excavation can generate a significant amount of material. Of particular interest is stockpiled soil which could be transported to nearby streams by erosion processes. Stumps, timber, and slash usually present no significant pollution problems, although disposal may pose difficulties because of the massive quantities involved.

Contractors often utilize temporary scrap depots for used or leftover materials such as lumber, various pieces of fabricated metals, large empty containers and other material. Except for empty containers which may have toxic residues, most of this material is nonpolluting.

The impact of refuse generated from food, and food containers, merits special consideration when the construction activities occur near inhabited areas. The major problem is the potential attraction of rats, dogs, and cats to the site. Covered waste containers strategically placed around the construction site and emptied periodically tend to eliminate these problems.

The long-term solutions for adverse storage impacts are oriented toward reduction of litter, prevention of entry by animals, and reduction of odors. Provisions for temporary storage of recreation-generated refuse obviously must be made. Although open top barrels are often used, it is preferable to use enclosed containers with easy to open lids or doors. A sufficient number of containers should be provided to accommodate peak loads and thus reduce littering. The Corps of Engineers requires a minimum of one trash receptacle for each three to five picnic tables at the recreation areas.[68]

Collection. The EIS should identify waste collection methods and the frequency of collection, where applicable, both during construction and after the impoundment has been completed. The latter would apply to recreational areas, visitor centers, and routine collection of floating debris at outlet structures and log booms. For garbage and other solid waste generated at recreational sites, collection at least twice a week is desirable to minimize problems with flies and odors.

Transport. Transport of solid waste from the construction site to the ultimate disposal area may cause dust and noise problems and contribute to the damage to local roads. Narrow roads with gravel shoulders are most susceptible to pavement edge-breaking, especially during periods of alternate freezing and thawing. Covering all loaded materials before traveling off-site may be required by State or local regulations. Mud and dust problems from construction vehicles traveling on public ways may be particularly important if the site is near an urbanized area.

Resource Recovery and Waste Reduction. Waste recovery is especially important where materials are proposed to be disposed of in a local disposal facility. Reduction of waste volume at the construction site will be beneficial, and may be necessary, if available local landfills would be severely impacted by the added load of construction debris. This reduction in volume would also reduce the vehicle hours travelled on municipal roads. The reuse of "waste" materials, such as wood mulch from timber and slash, should be encouraged. The mulch, for example, could be used as a substitute for netting in stabilizing slopes and for prevention of erosion. Removal of all marketable timber from areas to be cleared would reduce disposal problems. Since the quantities of spoil material may be significant, its use as fill in borrow areas should also be considered.

The EIS should address the issue of clearing, which may affect the amount of waste produced and the overall impact of solid waste operations. A balance between clearing to facilitate construction operations and preservation of vegetation should be reached, especially if there are species unique to the area. Plans should delineate the types and extent of various species before construction and should also show what would be removed and/or replaced after construction. Other effective steps to reduce the amount of waste generated should also be considered, particularly during construction.

Ultimate Disposal. Ultimate disposal of construction-generated refuse is the key element in the review of solid waste management operations. For the most part local and State regulations will apply to disposal of such waste. In the absence of either local or State regulations, or if disposal sites are on Federal land, the "Thermal Processing and Land Disposal of Solid Waste"[69] guidelines should be followed.

Disposal of stumps, timber and slash from clearing and grubbing operations generally represents the largest source of solid waste at an important construction site. Proposed disposal areas and methods should be clearly delineated in the EIS, particularly if a disposal site outside of the impoundment area is required. Unsalvageable demolition debris generated by removing or relocating structures from the flood pool area may in some instances add significantly to waste volumes requiring disposal.

On-site disposal practices typically consist of some form of land disposal method such as burying the material in an abandoned borrow area, which is then inundated, or by open burning. On-site disposal methods should be questioned if they involve disposal of empty chemical containers from paints, solvents, pesticides and herbicides; acids for cleaning masonry and asphalt; or other potentially hazardous materials. Many of these containers leave residues which are nonbiodegradable and can remain chemically active for many years. The disposal of unused pesticides and pesticide containers should be done in accordance with EPA's proposed rules, "Pesticides and Containers; Acceptance, Disposal, and Storage."[70] The environmental impact statement should include a provision that garbage and other non-inert materials will not be disposed of in "inert" waste disposal areas.

A long-term consideration is the disposal of debris which accumulates in and around the impoundment area. This problem may be particularly acute at flood storage reservoirs following pool drawdown. The material brought down by floodwaters consists mostly of fallen timber and brush which remains in the drawdown zone or is conveyed to the dam or trashracks protecting the outlet works. Left to rot, the dried timber may present a serious fire hazard. The EIS for a flood control impoundment should address this problem and indicate how disposal of the debris is to be accomplished, particularly if larger quantities are involved.

IV.C.2 Review of Impact Quantification

It is quite difficult, if not impossible, to determine accurately the quantities of construction refuse since site characteristics and the extent of reuse of materials vary considerably, particularly such things as forming materials, timber, slash and other spoil material. However, a general schedule of expected waste generation, including recovered materials, could serve an important function if local community disposal sites are to be used. If peak waste generation periods such as produced from clearing, grubbing, and final clean-up operations coincided with peak tourist inflow in a particular community, transporting the solid waste to the local disposal facility might increase traffic congestion or result in temporary economic decline from a reduced number of tourists. For on-site disposal this schedule becomes less important.

Reasonable estimates of waste quantities generated from recreational areas or visitor centers can be made based on projected visitation figures and the number of various types of facilities. It is important that potential recreational development by private interests as well as the federal government be described in the EIS. Table IV-5 may be used to estimate waste quantities if projections of initial and future recreational development are available.

It is not uncommon for recreational facilities at even fairly small impoundments, with water surface areas of less than 1000 acres or so, to attract several hundred thousand visitors in a season. At larger projects, annual visitation may run in the millions. Using a waste generation rate from Table IV-5 of 0.93 lb/picnicker day (0.423 kg/picnicker day)and hypothetical annual total of 400,000 picnickers, 186 tons (173 metric tons) of waste would require disposal. Also, most of the refuse would be generated in the 3 or 4 warmer months. This waste load increment would not significantly affect a large sanitary landfill operation. However, a rural landfill serving 2000 people may process 4 or 5 tons per day of refuse. In this case, the addition of an average 1.5 to 2 tons per day during the recreation season may put a substantial burden on the operation and available landfill space.

The quantities of the debris resulting from flood control operations are difficult to estimate. Although no specific

Table IV-5. Waste Generation Rates for Recreation Sites

Recreation Site	Average rate of waste generation (90 percent confidence interval)
Campground	1.2 ± 0.08 lb/camper day
Family picnicground	0.93 ± 0.16 lb/picnicker
Group picnicground	1.16 ± 0.26 lb/picnicker
Organization camp	1.81 ± 0.39 lb/occupant day
Resort area	
Rented cabin	1.46 ± 0.31 lb/occupant day
Lodge room (wo/kitchen)	0.59 ± 0.59 lb/occupant day
Restaurant	0.71 ± 0.40 lb/meal served
Residence	2.13 ± 0.54 lb/occupant day
Observation site	0.05 ± 0.03 lb/incoming axle
Visitor center	0.02 ± 0.008 lb/visitor
Swimming beach	0.04 ± 0.01 lb/swimmer
Concession stand	0.14 lb/patron

Source: Little, H.R., "Design Criteria for Solid Waste Management in Recreational Areas," U.S. Environmental Protection Agency, Solid Waste Management Series Report (SW-91ts), 1972, p. 7.

techniques exist to assess the magnitude of this debris problem, experience at other impoundment projects in the region may give some insight into the quantities of floating material to expect.

IV.C.3. Assessment of Impacts

The major element in assessing the impact of recreational and other solid waste is the relationship between anticipated waste quantities and the capacity of the selected disposal areas. Initial estimates can be made to determine the significance of solid waste from recreational areas as described in the preceding section. The development of a landfill to serve recreational areas at an impoundment would not, in most cases, require a significant amount of land. However, site characteristics would need to be suitable for avoiding or minimizing potential pollution problems. Generally, the guidance on design and operational criteria for recreational landfills contained in "Design Criteria for Solid Waste Management in Recreational Areas,"[71] should be followed. To aid in this assessment a summary of impoundment-related solid waste impacts is given in Table IV-6.

Disposal of construction waste should not pose any pollution hazards if acceptable sites and methods are set forth adequately in construction specifications for the project. Much of the construction debris may normally be buried in excavation or borrow areas or in the lower reservoir that will be flooded. This will create few solid waste problems for nearby disposal sites. Where the proposed conservation pool is small and shallow, debris disposal at the bottom of the reservoir may not be feasible or desirable. An off-site landfill may be required to receive construction waste, particularly stumps, cleared trees, and brush. If no discussion of construction waste disposal appears in the EIS, and the amount of clearing or other operations suggest the generation of potentially large quantities of solid waste, then clarification of these points should be requested.

Estimation and assessment of the effects of open burning of solid waste are discussed in the section on air impacts. Open burning should be discouraged unless it has been demonstrated that no feasible disposal alternatives exist. Due caution must be taken to avoid burning smoke-producing materials such as rubber and plastics or containers with potentially toxic residues. Favorable meteorological conditions should also prevail.

Table IV-6. Summary of Solid Waste Impacts

Material	Source	Characteristics	Significance	Mitigative Measures
Stumps, timber and slash	Clearing and grubbing	Basically nonpolluting	Economic impact on local community if its disposal site is used. Generally largest source of solid waste. Clearing might result in a potential source of erosion and sediment transport to streams. If burned on-site, refer to air impact.	Cut and clear selectively; sell marketable timber, reuse on-site as mulch.
Rock	Blasting, excavation of dam foundation, spillway channel, etc.	Basically nonpolluting	If a borrow area is used, might result in permanent scar on landscape unless provisions are made for restoration. Volume may be significant.	Use as rip-rap in core of dams or road foundations
Masonry waste	Concrete dam or appurtenant structures	Nonpolluting when hardened	Must avoid disposal of wet concrete near bodies of water to prevent siltation.	Use as fill in borrow areas.
Excess building & scrap materials	Forming activities & supplies	Mostly nonpolluting	Litter problem at construction site; partially full containers with toxic materials (solvents, pesticides, acids) might be discarded and cause potential pollution problem due to high -ocalized concentrations. Might be burned at construction site.	Reuse in future projects, estimate material quantities accurately, dispose of empty containers properly, use partially full containers at other jobs.
Food products & containers	Recreational & visitor centers & construction workers	Polluting potential, malodorous	Might create litter and odor problems, and attract animals. Might be burned at construction site.	Provide sufficient number of containers, collect frequently, and dispose of in a landfill or other acceptable manner.
--	Construction vehicles on public roads transporting solid waste to local disposal facility	--	Creates broken pavement, noise, mud on street, dust, and adds to traffic congestion.	Select alternative routes, reduce loads, keep vehicles clean and in good repair. Schedule deliveries to alleviate any potential traffic problems.
--	Excavation of impoundment area	Potentially polluting	Stockpiled soil materials might be a source of sediment to streams.	Place waste material in borrow and fill areas as soon as practicable; grade and seed or apply mulch.
Other spoil material	Debris at log booms, outlet structures; debris from flood waters	Generally nonpolluting	Volume may be significant, especially at flood control reservoirs. Potential killing of trees and other vegetation by submergence; unsightly and harmful mud deposits.	Practice good upstream forestry management; maintain disposal area for this material, adjacent to site (such as borrow area), to reduce impact on local community.

IV.D. Review of Air Impacts

In most cases the effects of impoundments on air quality will be less important in comparison with impacts on water quality, water resources, ecology, and land use. Except under special circumstances of proximity to densely populated areas, generation of significant traffic volumes, or probable secondary development, an analysis of air quality impacts will probably not be carried out in any detail in an impoundment EIS, nor would it be required. To ensure that potential air pollution problems are not overlooked, however, guidance is presented for the identification of situations where primary and secondary air impacts may be significant and a determination of the adequacy of air quality analysis in the EIS should be made.

IV.D.1. Sources of Impacts

The primary air quality impacts associated with impoundment development occur as a result of construction stage activities. Construction related air pollution sources are best illustrated by association with the pollutants they produce. These pollutants include:

Dust. One of the noticeable types of air pollution at a construction site is particulate matter such as dust and smoke. The types of construction activities which might produce noticeable amounts of particulate include clearing and grubbing, excavation, blasting, drilling, sand blasting and grinding, gunite operations, concrete production, aggregate production and spreading, stockpiling of materials, application of lime and fertilizers, pesticides and herbicides, and dust generated by movement of equipment over the construction site.

Combustion By-Products. Another source of particulate matter, as well as other air contaminants, is open or incinerator burning of wood and other combustible wastes from clearing and grubbing operations. Such burning should be permitted only when no justifiable alternative is available. The relatively low burning temperatures associated with open burning usually result in the emission of particulates, carbon monoxide, and hydrocarbons although the low temperature tends to suppress the emission of oxides of nitrogen. Since the sulfur content of the debris from clearing and grubbing operations is negligible, the resultant emission of sulfur oxides is also negligible. Available emission factors for the burning of wood may be found in "Compilation of Air Pollutant Emission Factors."[72]

Vehicular Emissions. Heavy-duty, diesel-powered vehicles are the primary contributors of construction stage vehicular emissions. Diesel vehicles emit pollutants from the same sources as gasoline-powered vehicles and have the same general characteristics as auto exhausts. Concentrations of some of the pollutants, however, may vary considerably.

- Sulfur Dioxide. Emissions of sulfur dioxide are a direct function of the fuel composition. Because of the higher average sulfur content of diesel fuel (0.20 percent S) as compared with gasoline (0.035 percent S), Sulfur dioxide emissions are relatively higher from diesel exhausts.

- Carbon Monoxide and Hydrocarbons. Because diesel engines allow more complete combustion and use less volatile fuels than spark-ignited engines, their hydrocarbon and carbon monoxide emissions are relatively low. The hydrocarbons in diesel exhaust are largely unburned diesel fuel.

- Nitrogen Dioxide. Both the high temperatures and the large excesses of oxygen involved in diesel combustion result in relatively high nitrogen oxide emission.

- Particulates. Particulates from diesel exhaust are in two major forms, black smoke and white smoke. White smoke is emitted when the fuel droplets are kept cool in an environment abundant in oxygen as in cold starts. Black smoke is emitted when the fuel droplets are subjected to high temperatures in an environment lacking in oxygen as in road conditions. A hot diesel engine properly adjusted and operated under design loads should emit no visible smoke.[72]

Emission factors for heavy-duty, diesel-powered vehicles typical of those used at large construction sites are also presented in the publication "Compilation of Air Pollutant Emission Factors."[72]

Secondary air pollution sources associated with impoundment development include, when applicable, highway development or modification, parking facility development, and recreational area development such as camping facilities where open fires might be permitted. Induced development of flood plains below an impoundment due to increased flood protection is another possible source of air pollution.

IV.D.2. Review of Impact Quantification

Unless any of the secondary air pollution sources listed are present and apparently significant, only construction stage impacts will warrant evaluation. Even then, unless the reviewer can pinpoint that a major possible impact is evident, no detailed critical evaluation is required.

Should a possible impact be identified, the impact potential should be quantified in terms of the percentage of generated pollutants which would reach the sensitive receptor under the most adverse possible meteorological conditions. The probability of the occurrence of worst case meteorlogical conditions, construction timing, and geographical influences must be carefully considered along with background ambient air quality levels. Meteorological data should contain a one-year historical record if modeling is to be employed. These inputs combined with an approximation of the magnitude of the project emissions should provide sufficient background for the evaluation of sensitive receptor impact and the need for abatement. For comparative purposes the pertinent National Primary and Secondary Air Quality Standards are listed in Table IV-7. Air quality standards and applicable state implementation plan strategies are specific requirements that must be addressed in any EIS on impoundment projects.

IV.D.3. Assessment of Impacts

The air quality assessment must first identify the primary and secondary air pollution generators associated with the impoundment project. The time span and magnitude of these pollutant generators must also be addressed.

Air pollution sensitive receptors should be identified. Existing ambient air quality and the air quality influence of area meteorological and geographical conditions should be addressed to the extent applicable.

In many cases no significant air pollution problems will arise. Reasonable care should be taken to see that any possible significant impact is identified, its magnitude estimated and related to existing standards, and that abatement plans, if necessary, are formulated.

For the limited secondary impact of existing highway modification which does not increase capacity, no air quality analysis, either microscale or mesoscale, will be required for rural areas.[73]

In the case of the associated secondary impact of parking facility development, outside of standard metropolitan statistical areas, as defined by the U.S. Office of Management and Budget, no new parking facility nor other new indirect source with an associated parking capacity of less than 2000 cars, nor any modified parking facility, nor any modification of an associated parking area which increases parking capacity by less than 1000 cars requires an "indirect source" environmental analysis of air quality impact.[74] The EPA's "Interim Guidelines for Review of the Impact of Indirect Sources on Ambient Air Quality," published July 1974, may prove useful for evaluating parking facilities, amusement parks, and recreational areas.

The referenced publications may be of assistance should any question exist as to the significance or impact of any other identified secondary source.

IV.E. Review of Noise Impacts

In the context of the overall environmental impact of an impoundment project, noise pollution is not ordinarily considered a major impact category. Depending on the location, size, and uses of an impoundment, noise impacts may be significant enough to warrant analysis in the EIS, at least in qualitative terms. The guidelines of this section are intended to assist in identifying probable noise impacts, estimating their significance, and determining the adequacy of noise impact assessment in an impoundment EIS.

IV.E.1. Sources of Impacts

As an environmental pollutant, noise may be defined as any sound, independent of loudness, that may produce an undesired physiological or psychological effect in an individual to the degree that it may interfere with the social ends of the individual or group. It is important to note that, unlike other forms of pollution, noise has a rapid decay time. That is, when the source of the noise is turned off, the noise dissipates within a matter of seconds and further degradation of the environment ceases immediately.

The impact of noise is primarily dependent upon the characteristics of the sound such as the sound pressure level or loudness, its frequency, pattern and duration, the proximity of the receiver, and the existing ambient level of background noise.

The primary and secondary noise generators for an impoundment project will consist of some combination of the following:

- The primary construction noise generated on-site and during on-road hauling operations.
- Facilities constructed as part of the impoundment development (i.e., power generating stations)
- Recreational facilities created as part of the impoundment development (i.e., lakes for power boating, trails for motorcycling and snowmobiling, and parking lots adjacent to sensitive facilities).
- Highways and rail lines developed, relocated or expanded as part of the impoundment/development

IV.E.2. Review of Impact Quantification

Few EIS's on projects involving impoundments will be encountered which contain detailed analyses of noise impacts.

There are several reasons for this, including: (1) construction noise impacts are of relatively short-term consequence, lasting, at most, over a construction period of up to several years, (2) impoundments located in remote areas have no sensitive receptors nearby, and (3) noise sources associated with impoundment operation and use such as power generating facilities, off-road vehicles, motorboats, and others are generally overlooked or dismissed as insignificant. Since these noise impacts can be important, they should either be evaluated in the EIS or supporting information should be given to justify a conclusion that the impacts are not significant.

The reviewer should be familiar with the following EPA publications for further background material on the description and evaluation of noise:

- "Noise Facts Digest," prepared by Informatics, Inc., June 1972
- "Fundamentals of Noise Measurement, Rating Schemes and Standards," NTID300.15
- "Effects of Noise on People," NTID300.7
- "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," March 1974 (550/9-74-004)

If special expertise is needed, the Office of Noise Abatement and Control should be contacted.

In most cases the greatest impoundment-associated noise impacts will occur during the construction phase. As a first estimate, Tables IV-8 and IV-9 may be used to determine the noise levels generated during various types of construction.

Since the actual noise levels decrease as distance from the site increases, the noise levels established in Tables IV-8 and IV-9 must be adjusted for each receptor under consideration. Table IV-10 may be used to obtain the specific reduction value required.

In addition to the distance reduction, a natural barrier such as a dense growth of trees extending at least 15 feet above any line of sight between the source of noise and extending 100 feet (30.5m) deep can provide an attentuation of approximately 5 dBA. An additional woods depth of 100 feet (30.5m) may provide an additional 5 dBA attenuation, but the total attenuation from vegetation should not exceed 10 dBA.

Table IV-8. Typical Ranges of Noise Levels at Construction Sites with a 50 dBA Ambient Typical of Suburban Residential Areas*

	I	II	Units
Ground Clearing	84	84	Energy Average dBA
Excavation	88	78	Energy Average dBA
Foundations	88	88	Energy Average dBA
Erection	79	78	Energy Average dBA
Finishing	84	84	Energy Average dBA

*Noisiest piece of equipment at 50 feet, other equipment at 200 feet from observer.
I - All pertinent equipment present at site
II - Minimum required equipment present at site

Source: Bolt, Beranek and Newman, Inc., "Noise from Construction Equipment and Operations, Building Equipment and Home Appliances," U.S. Environmental Protection Agency, December 31, 1971, p. 19.

Table IV-9. Typical Ranges of Noise Levels at Construction Sites with a 70 dBA Ambient Typical of Urban Areas*

	I	II	Units
Ground Clearing	84	84	Energy Average dBA
Excavation	89	79	Energy Average dBA
Foundations	88	88	Energy Average dBA
Erection	79	79	Energy Average dBA
Finishing	84	84	Energy Average dBA

*Noisiest piece of equipment, at 50 feet, other equipment at 200 feet from observer.
I - All pertinent equipment present at site
II - Minimum required equipment present at site

Source: Bolt, Beranek and Newman, Inc., "Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances," U.S. Environmental Protection Agency, December 31, 1971, p. 20.

Table IV-10. Reduction of a-Scale Sound Level at Various Distances from a Vehicular Point Source, Relative to 50-ft. Distance

Distance		Reduction
(ft)	(m)	(dBA)
50	15.3	0
100	30.5	6
150	45.8	9.5
200	61	12
500	153	20
750	230	23.5
1000	305	26
2010	613	33.5
3140	957	40

Source: Anderson, G.S., L.N. Miller, and J.R. Shadley, Fundamentals and Abatement of Highway Traffic Noise, prepared for the Federal Highway Administration, June, 1973, p. 1-32.

Any receptor noise levels estimated from the preceding tables must be considered in terms of a specified noise level which is either on or off as a function of time. If this noise level is projected over a period of time, and the normal background sound level at the receptor is available, the expected receptor noise impact may be converted to impact levels for comparison with those in Table IV-11 (page IV-85) through the following operations:

Let L_b = the background noise. This level may be considered as the equivalent sound level (L_{eq}) existing before the introduction of the new noise, provided that its fluctuation with time is small relative to the maximum value of the new noise level.

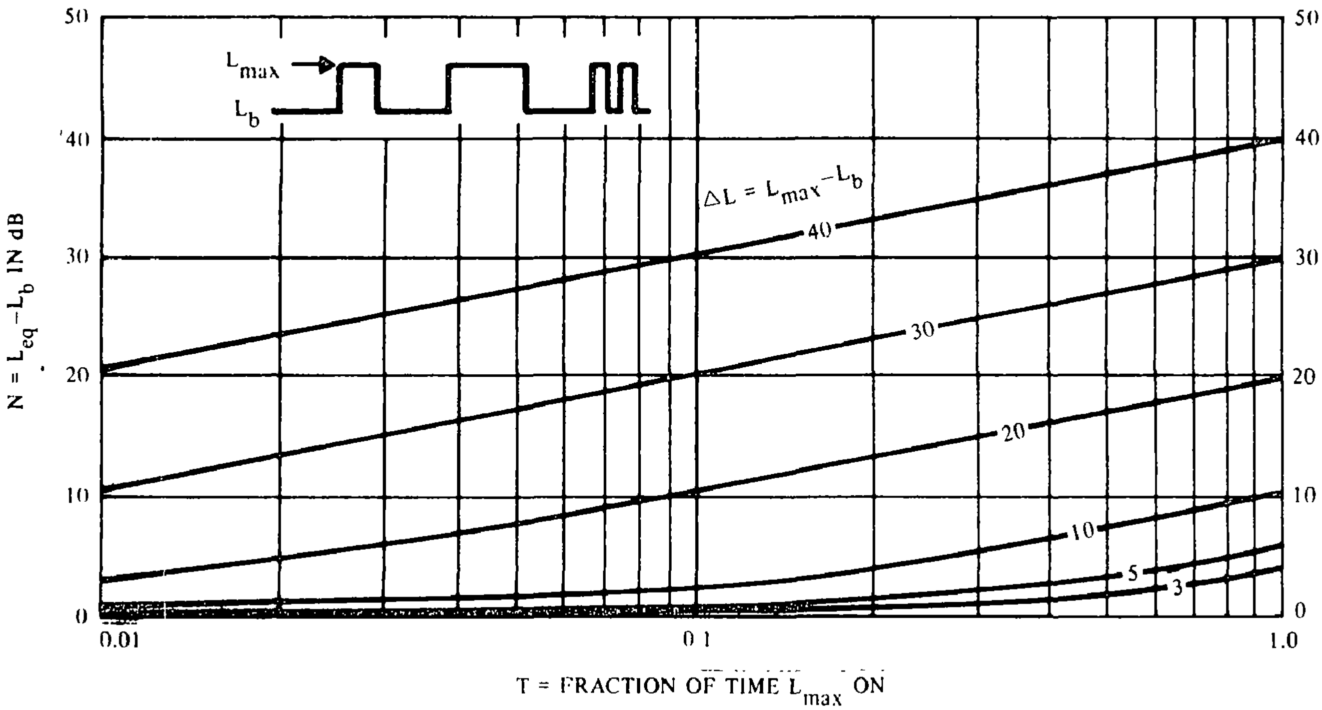


Figure IV-3. L_{eq} for Intermittent L_{max} to L_b

SOURCE U S EPA, OFFICE OF NOISE ABATEMENT AND CONTROL, "INFORMATION ON LEVELS OF ENVIRONMENTAL NOISE REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY" WASHINGTON D C, MARCH 1974 P A 8

Let L_{MAX} = the established level of continuous construction noise reaching the receptor.

Let Y = the fraction of the total time for L_b during which L_{MAX} is present.

Let L = $L_{MAX} - L_b$.

Then the value N, which is the decibel difference between the new L_{eq} and the previously existing noise level (L_b), may be established by reference to Figure IV-3. This gives a rough "worst case" estimate.

It is most important that the significance of the predicted Leq noise impacts be weighted by the <u>total</u> time span, the length of the construction stage, over which they will be experienced as well as by the sensitivity of the receptor at the time of day during which impacts will actually occur.

IV.E.3. Assessment of Impacts

Although noise can be a subjective experience in that the same sound might be objectionable to one observer but not to another, the following direct and indirect effects on humans have been well documented.

<u>Hearing Damage Risk</u>. Potential hearing impairment, which is a direct effect of noise, is of prime importance. Hearing impairment may be classified as temporary or permanent. Temporary hearing impairment may result from exposure to high impulse noise such as from blasting or impact equipment. Repeated exposure to such noise or continuous high level noise above 90 dBA can produce permanent hearing damage. Except under unusual conditions, hearing damage risk to persons off the the impoundment construction site is almost nonexistent.

<u>Communication</u>. Another direct effect of noise is its potential interference with normal speech conversation and teaching, telephone communication, listening to television and radio broadcasts, and listening to music.

<u>Relaxation and Sleep Interference</u>. Noise affects sleeping habits in two ways. It may lengthen the time taken to fall asleep and it may interrupt sleep stages leading to awakening.

<u>Other Effects</u>. Physiological and psychological stress, annoyance, and task interference are for the most part dependent on the particular individual and it is therefore difficult to establish criteria. Physiological stress may include increase in blood pressure and heart beat rate, such as from a sudden, high level sound like blasting. Noise may also be a contributing factor to headaches, indigestion, ulcers, heartburn, and gastro-intestinal complications. Noise generated from impact equipment such as from pile drivers, jack hammers, and rock drills is a likely source for most physiological stress. This equipment might also be responsible for so-called psychological effects including increased irritiability and nervous tensions. The type of noise is particularly important in determining the effect on individuals in this category of effects. High frequency sound also tend to be more disturbing than low frequency at the same level.

The masking effect of noise may also present a serious hazard if auditory caution signals are masked such as railroad crossings and back-up alarms on construction vehicles.

The effects of noise on wildlife are varied and the reviewer should consult the publication "Effects of Noise on Wildlife and Other Animals."[75] This may be particularly important if endangered species are involved.

Further information on the determination of the effects of noise may be obtained from "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety."[76] This document presents information on noise levels based on current analyses, extrapolations, and evaluations of the present state of scientific knowledge. The informational levels provided in this report are listed in Table IV-11. These noise level values are given in L_{eq} (24) and L_{dn}. L_{eq} (24) is an equivalent A-weighted sound level over 24 hours. L_{dn} is an L_{eq} (24) sound level with a 10 decibel penalty applied to nighttime levels. The levels provided should not be construed as standards, nor should they be thought of as discrete numbers, since they are described as energy equivalents prepresenting noise levels based upon cumulative exposure over a period of time. It must be kept in mind that the data upon which the information statistics in Table IV-11 are based is not "short run" or single event noises.

In summary, each of the following areas must be assessed to a degree sufficient to fully explore all short-term and long-term probable noise impacts associated with the project under review.

- Sufficient background and technical information in the introduction to the topic of noise

- Adequate identification of existing noise levels, probable sources of impacts, and probable impacts, both direct and indirect

- A discussion of applicable noise control regulations including:

  (1) Existing noise ordinances

  (2) Construction contract specifications concerning noise

  (3) Responsibility for contract specification enforcement

  (4) Possible noise abatement strategies, if necessary. See "Noise Source Abatement Technology and Cost Analysis Including Retrofitting."[77]

Table IV-11. Yearly Average* Equivalent Sound Levels Identified as Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety

	Measure	Indoor: Activity Interference	Indoor: Hearing Loss Consideration	Indoor: To Protect Against Both Effects (b)	Outdoor: Activity Interference	Outdoor: Hearing Loss Consideration	To Protect Against Both Effects (b)
Residential with Outside Space and Farm Residences	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Residential with No Outside Space	L_{dn}	45		45			
	$L_{eq(24)}$		70				
Commercial	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Inside Transportation	$L_{eq(24)}$	(a)	70	(a)			
Industrial	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Hospitals	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Educational	$L_{eq(24)}$	45		45	55		55
	$L_{eq(24)}$(d)		70			70	
Recreational Areas	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Farm Land and General Unpopulated Land	$L_{eq(24)}$				(a)	70	70(c)

Code:

a. Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those circumstances where speech communication is a critical activity. See Figure D-2 for noise levels as a function of distance which allow satisfactory communication.

b. Based on lowest level.

c. Based only on hearing loss

d. An $L_{eq(8)}$ of 75 dB may be identified in these situations so long as the exposure over the remaining 16 hours per day is low enough to result in a negligible contribution to the 24-hour average, i.e., no greater than an L_{eq} of 60 dB.

Note: Explanation of identified level for hearing loss: The exposure period which results in hearing loss at the identified level is a period of 40 years.

*Refers to energy rather than arithmetic averages.

Source: U.S. EPA, "Information on Levels of Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," Washington, D.C., March 1974, p. 29 (EPA 550/9-74-004).

APPENDIX

FEDERAL AGENCY PROCEDURES RELATED TO

ENVIRONMENTAL ASSESSMENT OF IMPOUNDMENT PROJECTS

U.S. ARMY CORPS OF ENGINEERS[78-80]

The U.S. Army Corps of Engineers acts as an engineer consultant to Congress and develops most of its water resources projects by specific Congressional authorization. When local interests feel the need for a flood control project they petition their representatives in Congress. The Senator or Representative then requests the appropriate Congressional committee to direct the Corps to make a survey and furnish necessary recommendations. The authority for a study is either a resolution adopted by appropriate Senate or House Committees or a Congressional Act. Some studies may be confined to a small area and have a comparatively simple solution. Other studies may cover an entire river basin and require consideration of, among other things, navigation, flood control, erosion control, hurricane protection, water supply, water quality control, hydroelectric power, drainage, irrigation, and recreation.

When Congress makes funds available for construction, the Corps prepares plans and specifications, awards contracts, and supervises construction. The completed projects may be operated and maintained by the Corps, or they may be transferred to another agency or to local interests to operate and maintain. For projects with limited scope, Congress has authorized the Secretary of the Army and the Chief of Engineers to approve these projects. Projects of limited scope include small river and harbor improvements for navigation, small flood control projects, shore and beach restoration, emergency bank protection, channelization, flood repair, removal of wrecked vessels, and dissemination of information to states and local communities. Generally, for projects in which federal financing is more than $1,000,000, Congressional approval for investigation and installation is required; whereas, projects in which federal financing is less than $1,000,000 may receive Corps approval.

The projects receiving Congressional approval are different in nature and scope from projects receiving Corps approval. As such, the Corps has elected to employ two separate planning processes.

A. Congressionally Approved Projects

The planning process for congressionally approved projects consists of the following six steps:

(1) Project Investigation. During this step an inventory of environmental resources is made, and the District Engineer (DE) prepares a summary of environmental considerations. A determination is made on whether further investigation and expenditure of funds for a more comprehensive and detailed survey are

warranted. Public participation in the form of public meetings is initiated and is used to develop a dialogue to assist in the formulation of the project and the identification of environmental concerns. Also at this time, coordination with federal, state, and local agencies is begun. Where necessary, assistance from these agencies may be requested.

(2) Public Hearings. This activity provides a means for the DE to make recommendations for improvements. Through a series of public meetings, in which alternatives for improvements are discussed, the DE is able to refine his determination of the proper scale and scope of improvements, the economic justification, and the equitable sharing of costs and responsibilities by federal and nonfederal interests. These findings make up the Survey Report which is completed at this time. Also completed at this time is the Preliminary Draft EIS. The DE circulates the Survey Report and the Preliminary Draft EIS to concerned federal, state, and local agencies, citizen groups and individuals on the project mailing list for review and comment. Utilizing the comments received, the DE revises the above reports which then serve as a basis for the DE to make recommendations for improvement.

(3) Corps Recommendations. The Survey Report and the Draft EIS are reviewed by the Division Engineer, the Office of the Chief of Engineers (OCE), and the Board of Engineers for Rivers and Harbors (BERH). Based upon this review, OCE and BERH make proposed recommendations.

(4) Formal Review and Comment. OCE completes the Draft EIS. The Survey Report and the Draft EIS are then circulated for review and comment to local, state, and federal agencies at the Washington level in accordance with established procedures. The Draft EIS and other reports are furnished to the Council on Environmental Quality (CEQ) at this time.

Based on the comments received, BERH may revise its recommendations, the DE prepares the Final EIS, and OCE prepares its final report on the proposed project.

(5) Transmittal of EIS. The Final Report and the Final EIS are transmitted by OCE to the Office of the Secretary of the Army (OSA) for review. Following the review, OSA transmits these documents to the Office of Management and Budget (OMB). OMB reviews the documents and furnishes OSA with comments which are then incorporated into the Final Report. OSA then transmits the report to Congress with its recommendations for improvements. A copy of this report is sent to CEQ, EPA, the DE, the Division Engineer, state and local agencies, citizen groups, and individuals on the project mailing list. OCE also informs the public that the Final EIS is available for review.

(6) Approval. The Senate and House Committee on Public Works holds open hearings on the Final Report submitted to Congress for the purpose of deciding whether or not to include the project in an omnibus River and Harbor and Flood Control Bill. If included, the passage of the act will authorize the construction of the project.

After the hearings, the Committee prepares a report on the bill under consideration and the proposed bill is brought to the floor of Congress for consideration. Enactment by Congress and approval by the President are the final steps in authorization for construction of the project. Authorization, however, does not provide funds for planning and construction of the project. These funds must be secured independently through the normal procedures of budget presentation and annual appropriation proceedings.

B. Corps Approved Projects

The planning process for Corps-approved projects consists of the following four steps:

(1) Project Investigation and Findings. The DE undertakes a reconnaissance study to determine if a detailed study is warranted. If detailed studies are warranted, the DE undertakes studies to determine the scope and nature of the project. At the same time public meetings are held to assist the DE in project formulation as well as identification of environmental concerns. The DE concludes the detailed studies by preparing a Detailed Project Report (DPR) and a Draft Environmental Impact Statement (DEIS).

(2) Review and Comment. The DE circulates the DEIS and the DPR to concerned federal, state, and local agencies for review and comment. At the same time, the DE will circulate the DEIS for review and comment to other agencies, groups, and individuals on the project mailing list. In addition, copies of the DEIS will be furnished directly to CEQ and higher authorities. A news release informing the public of the availability of the DEIS is issued by the CEQ.

After receipt and evaluation of agency review comments, comments of the interested public, and information obtained at the public meeting (optional), the DE prepares the Final Environmental Impact Statement (FEIS) and completes the Detailed Project Draft.

The Division Engineer then approves the project formulation, the technical aspects of the project report, and the adequacy of the FEIS and transmits these documents to OCE.

(3) Transmittal. After OCE reviews the DPR and the FEIS for policy and procedure, OCE or OSA will transmit the FEIS to CEQ. The DE also furnishes copies of the FEIS to agencies, groups, and individuals on the project mailing list and to the appropriate state, regional, and metropolitan clearinghouses. In addition, CEQ issues a news releas informing the public of the availability of the FEIS.

(4) Approval. At the appropriate time OCE approves the DPR and authorizes the project. OCE notifies the Division Engineer who then notifies the governor and interested congressmen of the project approval.

SOIL CONSERVATION SERVICE[81-84]

The Watershed Protection and Flood Prevention Act of 1954 (PL 566), as amended, provides for technical, financial, and credit assistance for watershed planning and program development for the conservation of soil and water resources. Local organizations are responsible for the initiation and development of projects. Close cooperation and assistance of local, state, and federal agencies are generally encouraged.

To be eligible for federal assistance a watershed project must not exceed 101,000 hectares (250,000 acres) in size, nor include any single structure which provides more than 1.54×10^6 m^3 (12,500 acre-feet) of floodwater detention capacity, nor more than 3.08×10^6 m^3 (25,000 acre-feet) of total capacity. The planning process for watershed projects is initiated when a sponsor applies for planning assistance to deal with authorized project purposes. Authorized purposes which may involve impoundments include watershed protection, flood prevention, agricultural water management, public recreation, public fish and wildlife, municipal and industrial water supply, and water quality management. The sponsor may be a state, or political subdivision thereof, soil or water conservation district, flood control district, or any other agency having authority to carry out, operate, and maintain works of improvement. Nonprofit irrigation or reservoir companies, water users' associations, or similar organizations having such authority are also eligible if approved by the Secretary of Agriculture.

Despite the differences in authorization, all watershed projects employ a similar planning process for the development and review of the EIS. This planning process is described in the following six step procedure:

(1) Application Development. Application for planning assistance is initiated and completed by local organizations such as

water conservation districts. Public meetings to define and evaluate watershed problems are conducted in concert with the application development. Comments from state and areawide A-95 clearinghouses are received and included in the application. The application is prepared by the sponsoring organization and submitted to a designated state agency for approval. If an application is disapproved, no further action is taken by the SCS. The designated state agency may also defer action until a field examination under the direction of the SCS is conducted to acquire sufficient information. If the application is approved, the state conservationist performs a thorough review and transmits it to the SCS Administrator. The Administrator acknowledges receipt of the application by notifying the sponsors, state conservationist, and appropriate clearinghouses.

(2) Preliminary Investigation. Once a request for planning assistance has been approved, the state conservationist, with the assistance of the SCS and participating agencies, conducts a preliminary investigation of the project. Sufficient information is assembled to determine if national and regional standards are met. Public meetings are held to obtain and disseminate information, discuss alternatives, and reach a tentative consensus on the impacts of available alternatives. Based on the preliminary investigation, the state conservationist may request authorization to begin planning and preparation of the EIS.

(3) Detailed Planning. Once the Administrator (SCS) grants planning authority, appropriate agencies, organizations, and heads of government are notified. Those notified include the designated state agency, state conservationist, heads of concerned federal agencies, the sponsoring local organizations, and appropriate clearinghouses.

With the initiation of planning, a preliminary draft EIS is prepared by the SCS under the direction of the state conservationist. Assisting agencies are determined by the state conservationist and CEQ guidelines. The guidelines for watershed projects do not include the EPA as an agency having legal jurisdiction to assist. The Preliminary Draft EIS is then reviewed and commented on by the public, appropriate clearinghouses, and other interested local, state, and federal agencies. Following the informal field review, the state conservationist prepares the Draft EIS which is reviewed by the Technical Service Center.

(4) Formal Review and Comment. The state conservationist distributes the Draft EIS for a formal interagency review. Those included in the review are CEQ, sponsors, heads of governments, designated state agencies, appropriate state and federal agencies, clearinghouses, and the general public. Review and comment are requested within 60 days. Comments received are used by the state conservationist in the preparation of the Final

EIS, which is then reviewed by the Technical Service Center.

(5) Transmittal of EIS. The state conservationist signs and approves the Final EIS. If the project requires congressional approval, the Administrator also signs and approves the Final EIS. Following approval, the Final EIS is transmitted to the CEQ, to all who commented on the Draft EIS, and to others upon request.

(6) Authorization. Final approval to proceed with the project is given. For congressionally approved projects, the appropriate congressional committees approve the project, with the Administrator authorizing installation. For administratively approved projects, the state conservationist approves the project and authorizes installation. In both cases, the state conservationist notifies appropriate offices of federal and state agencies, clearinghouses, and others who have indicated an interest. For congressional plans, the Administrator notifies the Secretaries of HEW, Interior, Labor, Commerce, the FPC, and the Corps of Engineers.

BUREAU OF RECLAMATION [85,86]

The Reclamation Act of 1902 (43 U.S.C. 391 et seq.) authorized the Secretary of the Interior to locate, construct, operate, and maintain works for the storage, diversion, and development of waters for the reclamation of arid and semiarid lands in the western states. A Reclamation Service was established in the Geological Survey (later separated from the Survey and renamed the Bureau of Reclamation) in 1923. In promoting optimum development of water and related land resources in the seventeen contiguous western states, the Bureau's program has expanded to include impoundments that may serve some or all of the following concurrent purposes: irrigation water service, municipal and industrial water supply, hydroelectric power generation, flood control, and navigation related uses.

The development of a reclamation project may be initiated by the Bureau itself or at the request of a local agency or group. In the latter case, the local sponsors must bear one-half of the cost of the investigation. The study process entails two major steps. The first step is a preliminary reconnaissance investigation which is generally defined as recognition of potential development, the collection of all readily available information in the particular area, and having as its chief purpose the determination of whether further investigation is justified. The second step is a feasibility investigation, based on the reconnaissance report, which is conducted to determine the engineering, economic, and financial feasibility of a project.

When a project is proposed, the Commissioner of Reclamation, upon receiving clearance from the Office of the Secretary of the Interior, directs the appropriate Regional Office of the Bureau to undertake a reconnaissance investigation. This first phase study is normally funded from an annual appropriation for investigation. The Area Development Office in the vicinity of the proposed project conducts the field investigations. The Regional Director then uses this information to prepare a reconnaissance report which is coordinated with interested agencies and groups.

If the reconnaissance report indicates that further study of a project is justified, the Bureau then seeks authorization and funding for a feasibility investigation. The Area Development Office where the project is located carries out the feasibility investigation and prepares a draft report that describes the findings and serves as the basis for receiving construction authorization. Each of the feasibility components must be analyzed thoroughly. Engineering feasibility relates to the adequacy of site conditions, hydrology, and other physical factors influencing design, construction, or operation of the project. The economic feasibility criterion specifies that the project benefits must exceed costs, including the evaluation of both primary and secondary gains and losses. In addition, a description of intangible values affected by the proposed project must be included. The study of financial feasibility concentrates on the equitable distribution of costs among various project purposes and whether reimbursable costs can be returned by project beneficiaries.

Several federal agencies, including the EPA, may assist the Bureau in these feasibility evaluations. The Bureau itself generally assesses irrigation benefits derived from a proposed project. Hydroelectric power benefits are evaluated with the assistance of the Federal Power Commission. The Corps of Engineers supplies information concerning flood control and navigation, both of which are generally nonreimbursable project benefits. The EPA may be called on to furnish data concerning water supply and treatment, water quality benefits associated with the proposed project, or the value of storage allocated specifically to flow augmentation for quality control. The Fish and Wildlife Service and the Bureau of Outdoor Recreation may be consulted for an evaluation of project benefits and costs in their respective areas of expertise.

After completion of the feasibility studies, the Area Development Office in charge of the investigation prepares a draft of a proposed planning report and a draft environmental statement. These are forwarded to the Bureau's Regional Office for review. The drafts are then circulated for review and comment to interested local and state agencies and to regional offices of interested federal agencies. After further review by national levels of the Bureau, a final draft of the report is prepared and submitted to the Secretary of the Interior for approval and adoption. Comments on the Final Draft are solicited from affected or interested state and federal agencies and the Secretary's final feasibility report is transmitted to the Office of Management and Budget, the President, and Congress for authorization and funding.

Because of federal emphasis on comprehensive planning for water and related land resources, the Bureau's program has begun to shift from isolated, project-oriented reconnaissance investigations and reports to more broadly based planning activities. As a result, project planning currently falls into one of three general areas: (1) comprehensive framework (Type I) studies begun under the Water Resources Planning Act of 1965; (2) Western United States Water plan which provides reconnaissance coverage of 11 of the 17 states in the Bureau's jurisdiction; and (3) reconnaissance type state-wide plans for Kansas, Colorado, Montana, Nebraska, Oklahoma, and New Mexico which are not included in the Western United States Water Plan above. With the exception of some projects for which reconnaissance studies have been completed, new impoundments will generally be studied as part of one of the above planning processes. However, the feasibility phase for individual projects will be based on information in the more comprehensive reconnaissance study.

TENNESSEE VALLEY AUTHORITY[87]

The Tennessee Valley Authority (TVA), a corporation wholly owned by the federal government, was created by an act of Congress on 18 May 1933. Its basic purpose is to conduct a unified program of conservation, development, and use of the resources of the Tennessee Valley. The TVA presently operates a system of dams and reservoirs on the Tennessee River and its tributaries and investigates the need for, and feasibility of, additional river control projects in the region. Impoundment purposes are varied and may include development of navigation, flood control, hydroelectric power, water supply, recreation, irrigation, and other beneficial uses of water.

Consideration of the environmental aspects of a proposed TVA action is to begin at the earliest possible point in the planning process. The TVA's policies and procedures relating to implementation of NEPA and EIS's require the preparation of an Environmental Evaluation Record (EER) when project planning is initiated. The EER contains three major sections:

- A description of the need or opportunity which has arisen and a preliminary identification of alternatives.

- A proposal and discussion of one or more solutions that are to be favored in the planning process

- An outline of environmental compliance procedure

These steps are fully coordinated internally within TVA to uncover alternatives, special environmental problems, and otherwise assist the initiating office, which in the case of impoundments is normally the Division of Water Management. The Division of Environmental Planning works closely with the initiating office throughout the planning and EIS development stages of a proposed project.

The outline of environmental compliance procedures lists both the important steps in the planning process and the studies and investigations required to assess a proposed action. The initiating office also recommends an appropriate time in the planning process for issuing a draft EIS. The timing is based on the schedules for studies and the gathering of pertinent environmental information. The EPA and other Federal or state agencies may be requested to investigate specific aspects of the proposed project during the planning phase. Consultation and coordination with non-TVA groups may also take place through the normal working relationships that have been established.

After consultation with the Division of Environmental Planning on the need for additional investigations, relevant information from the EER (and other studies) is synthesized into a preliminary draft EIS. This preliminary draft is reviewed by offices and divisions within TVA, revised as necessary, and transmitted to the General Manager who may approve or reject the document. If rejected, the draft is returned with instructions for revisions. When the General Manager approves the preliminary draft, it becomes the Draft Environmental Impact Statement and is submitted to CEQ and to interested agencies and groups for external review. The DEIS is subject to CEQ guidelines and procedures established pursuant to the Office of Management and Budget Circular A-95.

Special environmental studies conducted with the TVA and by other agencies during planning for a proposed impoundment project will normally be summarized and referenced in the Draft EIS. The reviewer should be able to contact the agency responsible for investigating a certain environmental aspect of a project, or obtain the original report, if he has questions on information included in the EIS.

FEDERAL POWER COMMISSION[88]

The use of hydroelectric power is regulated at the federal level by the Federal Power Commission (FPC). The FPC is an independent agency of the federal government originally established in 1920 under the Federal Water Power Act. This Act extended federal control over water power development on navigable streams. The Commission's authority covers the licensing and regulation of both conventional and pumped-storage hydroelectric projects.

An applicant for an FPC license may be a utility company, a private business or association, an individual, a municipality, or a state. The FPC's guidelines concerning implementation of the NEPA require that all applications for major prospects (those in excess of 2,000 horsepower) or for reservoirs which only provide regulatory flows to downstream major hydroelectric projects shall be accompanied by the applicant's detailed statement on environmental considerations (Exhibit W). The same requirement also applies to applications for license amendments which propose changes in construction or operation of a project. This report is one of several exhibits which the applicant must prepare and submit to the FPC along with the license application. If, after an initial review of the materials submitted, it is determined that the proposal will be a major federal action significantly affecting the quality of the human environment, the Commission staff will proceed to prepare an environmental impact statement. Often the applicant's Exhibit W is used to supply much of the information eventually included in an EIS.

Other exhibits of particular interest to the EIS reviewer are Exhibit H, the operation of the project with respect to water use and quality; Exhibit R, the recreation plan; and Exhibit S, the impact on fish and wildlife. Applicant's are expected to have consulted with appropriate federal, regional, state, and local entities during the preliminary planning stages for the purpose of identifying relevant environmental factors. As these exhibits may contain a considerable amount of background information which is not always put into the EIS, the reviewer should make sure he has copies of them to assist in the impact evaluation.

The question of low-flow augmentation at FPC projects is specifically addressed in Section 102 of the Federal Water Pollution Control Act Amendments of 1972. The law states that:

> No license granted by the Federal Power Commission for a hydroelectric power project shall include storage for regulation of streamflow for the purpose of water quality control unless the Administrator (of EPA) shall recommend its inclusion....

Evaluation of a water quality storage proposal should be conducted in accordance with the EPA's policy on low-flow augmentation. Although the reviewer of a project EIS would not normally be responsible for this evaluation, he should be acquainted with any water quality concerns raised in those cases where flow regulation for water quality control has been studied by EPA.

WATER RESOURCES COUNCIL AND RIVER BASIN COMMISSIONS - WATER RESOURCES PLANNING ACT[89]

The Water Resources Planning Act of 1965 has as its stated purpose:

> ...to provide for the optimum development of the Nation's natural resources through the coordinated planning of water and related land resources, through the establishment of a water resources council and river basin commissions, and by providing financial assistance to the states in order to increase state participation in such planning.

The Water Resources Council is composed of the Secretaries of Interior; Agriculture; Army; Health, Education and Welfare; Transportation; and the Chairman of the Federal Power Commission.

The Council has primary responsibility for continuing studies and periodic assessments of the adequacy of water supplies in the United States. The Council also reviews water and related land resource plans prepared by river basin commissions, or by interagency coordinating committees, and formulates recommendations on these plans prior to transmittal to the President and Congress.

The Water Resources Planning Act directed the Council to establish guidelines for water resource planning as well. The "Principles and Standards for Planning Water and Related Land Resources"[89] provides guidance for developing comprehensive plans through the coordinated efforts of federal, state, and local governments, private businesses and organizations, and individuals. The standards apply to the impoundment planning and evaluation studies normally carried out by federal agencies as well as to river basin commissions, federal-state interagency or coordinating committees, and other entities engaged in comprehensive water resource planning with coordinated federal technical or financial assistance.

River basin commissions created under the 1965 Act serve to coordinate federal, state, interstate, local, and nongovernmental water and related land resources development plans in their areas. The commissions may undertake and encourage studies of problems that relate to the preparation or updating of a comprehensive and coordinated plan for water resource development. The commissions may make recommendations concerning individual water projects included in a comprehensive plan.

The Water Resources Council defines three levels of planning: Level A, framework studies and assessments; Level B, regional or river basin plans; and Level C, implementation studies. The framework studies are comprehensive evaluations of regions with complex water resource problems that require interagency and interdisciplinary coordination. The framework study may lead directly to recommendations for undertaking implementation studies without further study or to "Level B" planning at the river basin, sub-basin or regional level.

This second level of planning addresses the complex, long-range problems identified in the framework studies through reconnaissance-type studies. A federal agency, such as a river basin commission, the Bureau of Reclamation, or the Corps of Engineers may take the lead for coordinating interagency involvement in the development of a regional or river basin plan. Section 209 (a) of the Federal Water Pollution Control Act Amendments of 1972 provides that Level B plans must be completed by the Water Resources Council for all river basins in the United States by 1980.

Implementation studies are program or project feasibility, studies and are usually undertaken by a single federal, state, or local agency. Their purpose is to carry out the recommendations contained in higher level plans. In the case of federal impoundments, the planning process would be comparable to that used by the various agencies involved. Such plans are oriented to near-term needs; those that require action within 10 to 15 years.

The reviewer of an impoundment EIS is specifically concerned with Level C, the implementation study phase of a proposed project. It should be noted, however, that if more comprehensive Level A, Level B, or similar studies, have preceded planning for an individual project they may contain considerably more information on regional characteristics, interrelationships with other existing or planned water resource developments, alternatives, and other factors than is found in the EIS. The Water Resources Council planning standards call for a full evaluation of "without project" and "with project" conditions and an accounting of beneficial and/or adverse effects in the four categories: national economic development, environmental quality, regional development, and social well-being. The standards also discuss quantification of these effects, either in monetary terms or otherwise. Since the EIS for an impoundment is apt to be the product of numerous earlier planning and environmental studies, the reviewer should refer, if necessary, to these documents for background information and data on the project. Planning studies done under the auspices of the Water Resources Council may be particularly useful for tracing the development of a project and understanding its basin-wide implications.

FISH AND WILDLIFE SERVICE - FISH AND WILDLIFE COORDINATION ACT

The major activities of the United States Fish and Wildlife Service occur under the authorization of the Fish and Wildlife Coordination Act of 1934, as amended. The Bureau of Sport Fisheries and Wildlife was established in the Department of the Interior by the Fish and Wildlife Act of 1956, as amended. This Bureau is directly involved with environmental coordination of federal water resource development efforts. Enabling legislation provides that fish and wildlife conservation, protection, and enhancement receive equal consideration along with other water resources project purposes. Furthermore, any federal agency or licensee proposing to modify or control any stream of water body must first consult with the Fish and Wildlife Service and with the fish and wildlife agencies in the state(s) in which a project is to be located.

One of the six regional offices of the Bureau of Sport Fisheries and Wildlife, Division of River Basin Studies, will be responsible for carrying out the duties of the Fish and Wildlife Service under the Fish and Wildlife Coordination Act. The Bureau staff normally conducts surveys and investigations concurrently with ongoing planning, feasibility, or other studies by the lead agency. Their report contains an inventory of fish and wildlife species; habitat types in the proposed project area, including any rare, endangered, or other unique biota; the probable beneficial and/or adverse effects of the project on these resources; means to mitigate damages; and ways to develop and improve fish and wildlife values. The report and recommendations of concerned state fish and wildlife agencies accompany any report submitted by the originating agency to Congress. The views expressed in the report are also usually integrated into the Draft Environmental Impact Statement for a proposed project.

The Bureau of Sport Fisheries and Wildlife generally becomes involved early in the planning process in the case of the Corps of Engineers projects, the Bureau of Reclamation projects, and in the EIS review phase.

The Fish and Wildlife Service may or may not conduct studies of proposed small watershed projects of the Soil Conservation Service. State fish and wildlife agencies will normally investigate such proposed projects whether or not the Service participates directly.

For hydroelectric projects under the jurisdiction of the Federal Power Commission, a report on fish and wildlife resources (Exhibit S) must be submitted with applications for licensing or relicensing. The exhibit should describe the effects of the project on fish and wildlife resources in the project area, or in other areas affected by the project, and potential mitigation or enhancement measures. The applicant for a license prepares the report "on the basis of studies made after consultation and in cooperation with the U.S. Fish and Wildlife Service, Department of the Interior, and appropriate state fish and wildlife agencies...". The Fish and Wildlife Service reviews Exhibit S and the applicant's Draft Environmental Impact Statement (Exhibit W) and recommends license stipulations and other requirements relating to conservation and development of fish and wildlife resources affected by the project.

The reviewer should regard the Fish and Wildlife Service as a source of technical assistance in all areas of fish and wildlife conservation and management, particularly with respect to ecological impacts of flow regime, thermal regime, water quality, and habitat changes resulting from impoundment.

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