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INTERAGENCY
316(a) TECHNICAL GUIDANCE MANUAL
AND
GUIDE FOR THERMAL EFFECTS SECTIONS OF NUCLEAR FACILITIES ENVIRONMENTAL IMPACT STATEMENTS

U. S. Environmental Protection Agency
Office of Water Enforcement
Permits Division
Industrial Permits Branch
Washington, D. C.

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1.0 Acknowledgements

This manual represents the efforts of many who unselfishly contributed their time and expertise. Originally, specific assignments were delegated to working groups but, as time went by, individuals in these working groups were asked to provide assistance in other areas. Therefore, to simplify the acknowledgements, the following is a list of those who at one time or another contributed to the development of this manual:

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2.0 INTRODUCTION DRAFT

2.1 Background Information

2.1.1 Brief History of the Evolution of this Document

Prior to the enactment of Public Law 92-500 [the Federal Water Pollution Control Act Amendments of 1972 (FWPCA)], the Atomic Energy Commission (AEC) had regulatory authority pursuant to the National Environmental Policy Act of 1969 (NEPA) to impose effluent limitations on facilities requiring an AEC license or permit.

The FWPCA now requires the Environmental Protection Agency (EPA) to establish (for use in permits for the discharge of pollutants to waters of the United States from point sources as defined in the FWPCA such as nuclear power plants, etc.) effluent limitations for all pollutants. The FWPCA provides that nothing under NEPA shall be deemed to authorize any Federal agency to review any effluent limitation or other requirement established pursuant to the FWPCA, or to impose, as a condition of any license or permit, an effluent limitation other than any such limitation established pursuant to FWPCA.

Pursuant to the authority of the FWPCA, EPA required applicants for discharge permits to submit information required by EPA in order to establish effluent limitations in permits. Pursuant to the authority of NEPA, the Nuclear Regulatory Commission (NRC) may require applicants for licenses or permits to submit information required by NRC in order to evaluate and consider the environmental impacts of any actions it may take. Consequently, the informational needs imposed by the two agencies may be similar in the area of impacts on water quality or biota.

NEPA requires that all Federal agencies prepare detailed environmental statements on proposed major Federal actions which can significantly affect the quality of the human environment. A principal objective of NEPA is to require the agency to consider, in its decision-making process, the environmental impacts of each proposed major action and the available alternative actions. Both EPA and NRC have responsibilities pursuant to NEPA regarding the issuance of licenses or permits for nuclear power plants and certain other facilities.

In late 1973, the Chairman of the Council on Environmental Quality (CEQ) wrote to the Chairman of the then AEC and the Administrator of EPA Suggesting steps that might be taken "to make the analysis of the water quality impact of nuclear power plants more effective and more meaningful and, at the same time, reduce demands for data being placed upon applicants for licenses."

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In summary, CEQ suggested that AEC and EPA:

(1) explore mechanisms available to assure that applicants' environmental reports to AEC contain sufficient data to satisfy EPA requirements on water quality matters;

(2) consider the possibility of preparing a single impact statement to meet AEC's requirements under NEPA and EPA's requirements under FWPCA; and

(3) consider the possibility of unified hearings.

In response to CEQ's suggestions, AEC (subsequently NRC) and EPA developed the Proposed Second Memorandum of Understanding regarding their perspective responsibilities under NEPA FWPCA, which was published in the Federal Register for public comment on November 7, 1974 (39 FR 39490), and in final on December 17, 1975 (40 FR 60115).

In summary, the Memorandum:

1. specified the statutory authority of both agencies for entering into the Memorandum.

2. Defined those licensing and regulatory activities to which the Memorandum shall be applicable.

3. specified that NRC and EPA will work together to identify needed environmental information for early evaluations related to impact from the identified activities on water quality and biota.

4. Provided for EPA to exercise its best efforts to evaluate impacts on water quality and biota as far as possible in advance of the issuance of NRC's final environmental impact statement for any covered activity, and specified that EPA and NRC will maintain close working relationships during the entire environmental review process.

5. Specified that EPA will issue to the applicant, where appropriate, in light of substantive requirements, a complete section 402 permit as far as possible in advance of authorization by the NRC of any commencement of construction or issuance by NRC of a license or early site approval, whichever is applicable.*

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* See 10 CRF Part 2, Appendix A, Paragraph I(c).

6. Specified that EPA and NRC will consider the feasibility of holding combined or concurrent hearings on EPA's proposed section 402 permits and NRC's proposed issuance of construction permits or other activities where appropriate.

7. Rescinded the Memorandum of Understanding Regarding Implementation of Certain Complementary Responsibilities under the FWPCA and dated January 15, 19, and 22, 1973 (38 FR 2713).

As a first step towards implementing the objectives of the Memorandum, a series of meetings between EPA and NRC took place in late November 1974. At these meetings it was decided that one of the most difficult tasks to be done, and one which should be started first, was to standardize aquatic biological data requirements to satisfy FWPCA requirements for EPA and NEPA requirements for NRC. Technical experts representing the two agencies in the field of aquatic biology held a series of meetings in December 1974, formulated many tentative agreements, and appointed a series of eight working groups. Each working group was co-chaired by one representative from each agency.

On January 28-30, 1975, the eight working groups met in Falls Church, Virginia, to complete specific writing assignments contributing to the development of a new guidance manual. Each working group submitted draft summaries of their work on the last day of the meeting and final summaries by early March 1975.

The long process of piecing the products of the eight working groups together into one cohesive technical manual was slowed by key personnel changes within the agencies and heavy schedules of other individuals on the working groups. In spite of the numerous setbacks, a December 11, 1975, draft was completed and reviewed by key working group members during January 1976 in Athens, Georgia. At this meeting it was indicated that several sections still needed revision and others should be deleted altogether. Areas of responsibility were assigned to willing working group members and this edition of the manual is the result of these efforts.

2.1.2 A Shift of Emphasis

In the course of the development of this draft, it became apparent to many working group members that early screening procedures by industry or their consultants could sometimes reveal those types of information which would not be necessary to gather in great detail at some sites. If initial pilot field surveys and literature surveys revealed that the site was one of low potential impact for phytoplankton for example, it would be unnecessary to conduct detailed studies to give the taxonomic identification of every species of phytoplankton in the vicinity.

2.1.3 Public Availability of 316(a) Demonstrations

It is the intention of EPA to make the technical information submitted by industries in accordance with 316(a) available for use by other industries, scientists, and members of the public. This will be done initially by placing copies of the demonstration and supporting documents into the collection of the responsible EPA Regional Office Library. A similar approach is also suggested for State agencies. In cases where demand for the demonstration materials exceeds the capability of an EPA or State agency library, the EPA Regional Administrator may also submit the materials to the National Technical Information Service (NTIS) so that the reports are available to the public in microfiche or hard copy form at the price of duplication. The EPA Regional Librarian will be able to provide detailed information regarding input and access to the NTIS system.

It is also noted that the Atomic Industrial Forum, Environmental Studies Project, has developed INFORUM, a data system which will extract information from reports submitted by utilities in accordance with sections 316(a) and (b). Questions should be referred to the Project at 1747 Pennsylvania Avenue, Washington, D.C. 20006, telephone 202-833-9234.

The September 30, 1974, draft of the EPA 316(a) Technical Guidance Manual suggests two possibilities for predictive demonstrations: Type II demonstrations (with specific data requirements for Representative Important Species (RIS) and biotic communities) and Type III demonstrations (an alternative plan following written concurrences from EPA). The NRC Regulatory Guide 4.2*, on the other hand, gives general guidance and includes mention of studying a wide spectrum of trophic levels which might be adversely affected by the power plant's operations. The net result of this combination of situations is that power companies have often embarked, without the benefit of appropriate screening or pilot studies, on large-scale, expensive, inappropriate studies which supply massive amounts of raw data but are not necessarily helpful to regulatory agencies in decision-making.

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* NRC Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations. July 1976, Revision #2: 102 p.

The decision train suggested by this manual encourages the utility to conduct preliminary pilot or screening procedures to determine how detailed the baseline biotic community studies should be and to initiate the appropriate selection of Type II, Type III, or low potential impact Type III demonstrations.

This procedure, plus an increased focus on comparing rationales developed by the applicant with decision criteria given in this draft, represents a shift of emphasis which will hopefully result in studies, demonstrations, and environmental reports which make more sense and are easier to interpret.

In developing this version of the manual, an emphasis has been placed upon identifying those types of information most relevant for decision making and for deleting data requirements which have been found to be of little use in past 316(a) decisions. By identifying such information needs by water body type (river, estuary, lake, ocean) and by defining which areas need less detailed studies, this version of the manual attempts to discourage the collection of masses of costly, unnecessary data which may actually confuse the issue by diverting attention from more important information.

In this regard, it is interesting to note the balance of general ecosystem (baseline, field work) data versus the RIS (laboratory and literature search) data proposed by this version of the manual. Past experience suggests that neither baseline field surveys nor RIS laboratory studies alone were sufficient for predictive demonstrations; some mixture of the two is desirable. General ecosystem field work is necessary to characterize the environment impacted, to have a basis of comparison for post operational studies, and to counter possible arguments that the entire ecosystem has not been examined. Laboratory studies on RIS are helpful because they offer increased predictive capabilities, such as how much of the thermal plume area will preclude reproduction or migration.

2.2 Suggested Uses of this Technical Manual by:

2.2.1 The U.S. Environmental Protection Agency

This version of the guidance manual, after in-house review within EPA, will replace the September 30, 1974, draft of the EPA 316(a) Technical Guidance Manual. The manual describes the information which should be developed and evaluated in connection with making technical determinations under section 316(a) of the Federal Water Pollution Control Act, as amended, 33 U.S.C. 1251, 1326(a), and 40 CFR Part 122.

Most of the "first round" of NPDES (National Pollutant Discharge Elimination System) permits for thermal discharges will have already been issued (or at least study plans will have been agreed upon by the applicant and the Regional Administrator), by the time this edition of the technical manual is issued. The determinations or study plans finalized to date have been made on the basis of case-by-case technical decisions made by the Regional Administrator. These earlier technical decisions and study plans which were finalized with the approval of the Regional Administrator or State Director will not be negated or otherwise adversely affected by the issuance of this newer version of the 316(a) technical manual.

The primary use seen for this version of the technical manual will be for new sources and for the "second round" of 316(a) determinations which will come when the first round of permits expire.

The manual is intended to be used as general guidance and as a starting point for discussions between industry and the Regional Administrators. For individual situations the Regional Administrator may request that the applicant follow the suggestions in the technical manual closely, or may specify an alternative plan.

The applicant should be aware that in general one or more Regional EPA permit program staff have been designated as 316 coordinators. It is suggested that applicants considering 316(a) demonstrations contact these individuals at an early date to discuss potential problems and available data.

2.2.2 States

Those States which have been delegated the administration of the NPDES permit program by EPA have the lead role for making 316(a) decisions within the State. The EPA retains what amounts to a veto capability through the requirement that they continue to review all permits before they are issued.

Since those States which have the permit program have essentially the same responsibilities as EPA, it follows that these States may find this technical manual useful in the same manner that the Regional Administrators of EPA find it useful. On the other hand, just as the Regional Administrators are not rigidly bound by the contents of this document, neither are the State Directors. It is suggested that those States which desire to administer their 316(a) program in a way different from that which is proposed here, first discuss these differences with the Regional Administrators so that common agreements can be reached and applicants can be assured that their 316(a) study designs will be acceptable to both the State and EPA.

The applicant should also be aware that in general one or more State permit program staff have been designated as 316 coordinators. It is suggested that applicants considering 316(a) demonstrations contact these individuals at an early date to discuss potential problems and available data.

2.2.3 The Nuclear Regulatory Commission

The Nuclear Regulatory Commission (NRC) tentatively plans to incorporate this 316(a) manual and the separate 316(b) manual with future drafts of NRC Regulatory Guide 4.2. The contents of these manuals would form the basis for aquatic ecology data requirements. Just how the manuals will be incorporated has not yet been decided, but one possibility discussed would be to include the 316(a) and 316(b) manuals in their entirety as appendices to future editions of NRC Regulatory Guide 4.2. There has also been some discussion of using parts of these manuals in future editions of NRC Regulatory Guide 4.7* and documents to be generated by the NRC coordinated State/Federal Siting Working Group.

2.2.4 The U.S. Fish and Wildlife Service, Department of Interior

The Fish and Wildlife Service (FWS) is mandated by the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661, et seq.), the Endangered Species Act of 1973, and other associated Acts, to coordinate review with the appropriate Federal regulatory agencies on projects that will have impact on fish and wildlife communities. These guidelines will provide a basis for coordination among FWS, EPA, NRC, and other agencies involved in

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* NRC Regulatory Guide 4.7, General Site Suitability Criteria for Nuclear Power Stations. November 1975, Revision #2: 32 p.

the 316(a) review process by representing a common understanding of the decision criteria agreed upon which the 316(a) variance will be based and, therefore, upon which the appropriate regulatory agency should be advised.

2.2.5 Other Federal Agencies

Although in no way bound by this document, other Federal agencies may find it useful as a source of information. For example, the National Marine Fisheries Service (NMFS) of the Department of Commerce has similar concerns and responsibilities as the FWS in the Federal regulatory review process. The NMFS was originally the Bureau of Commercial Fisheries which, together with the Bureau of Sport Fisheries and Wildlife (now FWS), constituted the old Fish and Wildlife Service in the Department of Interior (as referred to in the Fish and Wildlife Coordination Act). Reorganization Plan No. 4, which transferred the Bureau of Commericial Fisheries to the Department of Commerce, also transferred all associated responsibilities. Principle concerns of NMFS are marine and anadromous fish, as well as inland commercial fish. The FWS, by contrast, has a parallel responsibility in the fisheries aspect, but has an additional responsibility for aquatic waterfowl (both fresh water and marine) in the 316(a) review process.

2.2.6 The Electric Power Industry and Consulting Organizations

For each individual site, applicants for 316(a) or 316(b) determinations should discuss the contents of this manual with the lead NPDES Permit Program Agency (either the EPA Regional Administrator or the State Director) to determine the applicability of the manual's recommendations to that site. This document will serve as a starting point for discussions leading to a written concurrence between the applicant and the Regional Administrator/Director on individual study plans which will satisfy the requirements of both PL 92-500 and the aquatic ecology sections of NEPA.

3.0 PREDICTIVE DEMONSTRATIONS

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3.1 Introduction

Predictive studies and associated demonstrations representing the best estimate of "what will happen" are appropriate for 316(a) demonstrations for:

1. New sources not yet discharging;

2. Facilities discharging into waters which, during effluent for a sufficient period of time to allow evaluation of the effects of the effluent;

3. Facilities discharging into waters which, during the period of the applicant's prior thermal discharge, were so despoiled as to preclude evaluation of the effects of the thermal discharge on species of shellfish, fish and wildlife; and

4. Major changes in the facilities operational mode.

The two most detailed baseline aquatic ecology studies done for NRC under NEPA are done two years before a nuclear plant becomes operational. All studies done for 316(a) demonstrations during this time frame are therefore predictive in nature. The regulations (see 40 CFR Part 122) published by EPA provided for two possible types of predictive 216(a) demonstrations: Protection of Representative Important Species (Type II) and Alternative Demonstrations, with the written concurrence of the Regional Administrator or State Director (Type III). This section provides explanations of these demonstration types, details the decision train and decision flow chart, and recommends early screening procedures helpful in choosing the most appropriate demonstration type.

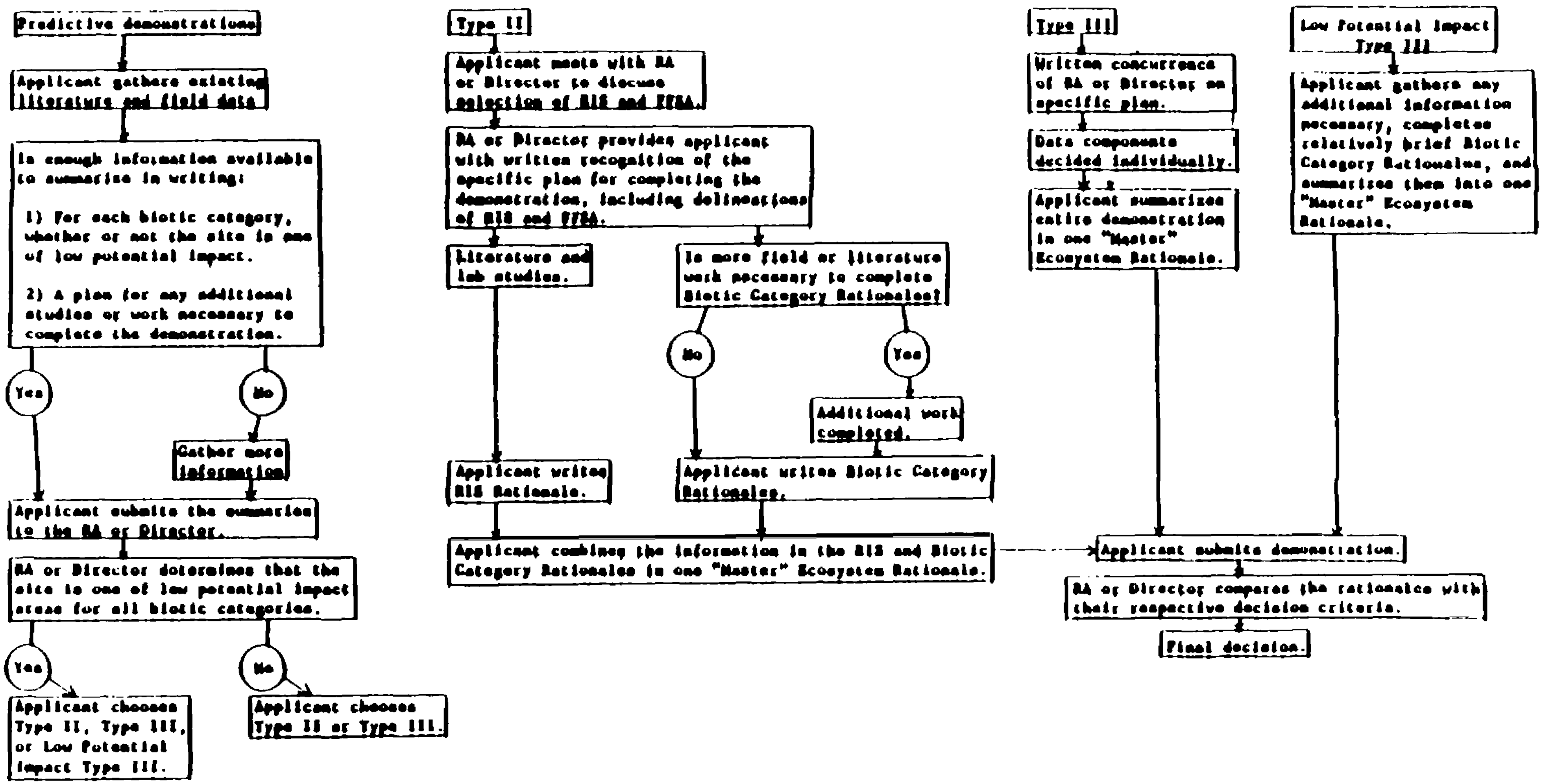
3.2 Decision Train

This section provides a flow chart and narrative summary of the recommended decision train.

3.2.1 Flow Chart

The flow chart identified as Figure 1. is a summary of the recommended sequence of events leading to the decision. The following is an explanation of abbreviations and terms used in the flow chart:

FIGURE 1. DECISION TRAIN FLOW CHART



Applicant	Industrial Representative Applying for EPA and NRC Permits and Licenses
Director	Director of the State NPDES Permit Program
FFSA	Far Field Study Area
RA	Regional Administrator, EPA
RIS	Representative Important Species

3.2.2 Decision Train Narrative

The decision train (sequence of events leading to a decision) listed here is designed as general guidance for both the applicant and the regulatory agencies:

1. Before designing aquatic ecology studies, the applicant consults with the Regional Administrator/Director* to verify the applicability of this technical manual for satisfying thermal plume effects (316(a) and effluent guidelines) requirements under PL 92-500. If the Regional Administrator/Director specifies an alternative or modified version of this manual, the applicant should utilize it. If the Regional Administrator/Director specifies using this technical manual as a guide, the applicant goes to the next step.

2. The applicant reads section 3.3 of this manual to determine what biological data requirements are necessary for early screening determinations such as defining low potential impact areas.

* NOTE: The Regional Administrator makes 316(a) determinations for EPA issued permits, while the State Director makes such determinations for permits issued by States with EPA approved permit programs. Such State permits, however, are subject to EPA review. It is therefore suggested that in the case of 316(a) determinations made by a State Director, either the Director or the applicant keeps the Regional Administrator informed at critical steps in the process to avoid the possibility of ultimate disapproval by EPA of a State permit or determination which could have been avoided by better communication throughout the process.

3. The applicant contacts the appropriate Regional Director of the U.S. Fish and Wildlife Service, representatives of the National Marine Fisheries Service, and of the States, to determine if there are any threatened or endangered species that may be affected by the proposed facility's discharge.

4. The applicant gathers existing literature and field data from previous studies by the company, resource agencies, academic institutions, and other researchers.

5. The applicant determines whether or not enough information is available to summarize in writing:

   a. For each biotic category, whether or not the site is one of low potential impact.

   b. A plan for any additional studies or work necessary to complete the demonstration.

   If more information is necessary, the information should be gathered through relatively brief "pilot" field surveys.

6. Applicant submits the summaries to the Regional Administrator/Director.

7. If the Regional Administrator/Director determines that the site is one of low potential impact for all biotic categories, the applicant may choose the new "short form" demonstration type, the Low Potential Impact Type III demonstration detailed in section 3.6; if not, the applicant chooses between Type II and Type III demonstrations.

8. Those applicants eligible for the low potential impact demonstrations gather any additional information necessary, complete relatively brief biotic category rationales, and summarize them into one "master" ecosystem rationale.

   If the proposed discharge will meet State water quality standards, the additional field studies necessary will not be extensive. The primary information that needs to be generated is simply that which is enough to satisfy the biotic category, resource zone, and master rationale criteria in section 3.8. One year's qualitative "pilot" field studies should be enough to generate enough information to complete the biotic category, resource zone, and master rationale. The applicant can then complete physical studies comparable to those in section 3.5.3 and proceed directly to step 19 below.

10. Applicants whose sites do not qualify for the above considerations will ordinarily select the Type II demonstration or a Type III demonstration of similar comprehensiveness. Applicants selecting a Type III demonstration should carefully read section 3.7 in order to gain a general understanding of the detail necessary for studies to be considered acceptable.

11. Those applicants selecting a Type II demonstration first meet with the Regional Administrator/Director to discuss selection of RIS and define the far field study area. If the regulatory agency has reached any tentative decisions regarding an allowable mixing zone (see section 3.8.3), these decisions should be discussed and understood by both parties. These decisions may be reviewed following completion of the demonstration.

    If the regulatory agency and the applicant reach an early agreement about the selection of RIS and the designation of the far field study area, the applicant may move on to the next step. If not, the regulatory agency may request that the applicant assist in the selection of RIS by doing studies and giving written justification for the proposed far field study area.

12. The Regional Administrator/Director checks with the Regional Director of the FWS and representatives of the NMFS and States to make sure the study plan includes appropriate consideration of threatened or endangered species as well as other fish and wildlife resources.

13. The Regional Administrator/Director provides the applicant with written recognition of the specific plan for completing the demonstration, including delineations of the RIS far field study area, and threatened or endangered species.

14. Applicant completes field and literature work required to finish biotic category rationales and writes the rationales in accordance with section 3.5.1.

15. Applicant completes literature and laboratory studies necessary to generate information for the RIS rationale, and develops the rationale as suggested in section 3.5.2.

16. Applicant develops engineering and hydrological data outlined in section 3.5.3.

17. Applicant combines the information on engineering and hydrological data with the RIS and biotic category rationales into one "Master" Ecosystem Rationale, as described in section 3.5.4.

18. Applicant arranges the rationales and other information in the format suggested in section 3.5.5.

19. Applicant submits demonstration to the Regional Administrator/Director.

20. The Regional Administrator/Director:

    Reviews the demonstration to see that key evidence is properly summarized in the "rationale" sections, that all of the required data has been submitted, and that the format in general follows that given in section 3.5.5 or an alternative format previously approved of by the Regional Administrator/Director.

    a. If the report is unacceptable due to improper format or omissions, the Regional Administrator/Director will return the demonstration to the applicant with an explanation of why it was deemed unacceptable.

    b. If the report is in an acceptable format and is complete, the Regional Administrator/Director will proceed to the next step.

21. The Regional Administrator/Director studies the data presented in the submittal to see if it justifies the conclusions reached in the biotic category rationales. If so, and if there is no conflicting evidence from other sources, the Regional Administrator/Director will proceed to the next step.

22. The Regional Administrator/Director studies each of the biotic category rationales to see if they support the 316(a) test of protection and propagation of the balanced indigenous population. If any of the five rationales fail to meet the tests (as detailed in the decision criteria sections), the demonstration is not successful. If all five meet the tests and there is not strong contrary evidence from other sources, the Regional Administrator/Director will proceed to the next step.

23. The Regional Administrator/Director studies the RIS information to see if it supports the conclusions in the Representative Important Species Rationale. If it does, the rationale is studied in relationship to the decision criteria given in section 3.8.2. If the decision criteria are met, the Regional Administrator/Director will proceed to the next step.

24. The Regional Administrator/Director studies as a composite the biotic category rationales, the Representative Important Species Rationale, the resource zones impacted, and the engineering and hydrological data to see if they provide justification for the conclusions reached in the master rationale. If they do and there is not strong contrary evidence from other sources, the Regional Administrator/Director will proceed to the next step.

25. The Regional Administrator/Director studies the master rationale in relationship to all other available data, considers the overall decision criteria in section 3.8.3, and determines if the 316(a) demonstration has been successfully made. Following discussions with technical experts on his staff as well as those from the Fish and Wildlife Service and other agencies required by law to be consulted, the Regional Administrator/Director makes the final decision.

If the Regional Administrator/Director concludes that the summary rationale is convincing, it is supported sufficiently by the other sections of the demonstration, and is not convincingly negated by outside evidence, the applicant's 316(a) demonstration is successful. The applicant has demonstrated that the proposed thermal discharge to navigable waters will be acceptable under PL 92-500 (for section 316(a) and effluent guidelines).

3.3 Biotic Category Determinations and Recommended Early Screening Procedures by Industry

It is recommended that applicants conduct pilot field surveys and literature searches before embarking upon massive, comprehensive, baseline, field sampling. These initial studies will often be sufficient to determine whether or not the site is one of low potential impact for individual biotic categories and to determine what additional studies will be required to develop biotic category rationales responsive to the decision criteria listed in this section.

The applicant should first read this section, then execute the initial pilot field surveys and literature searches in such a manner that they identify those biotic categories for which the site may be considered a low potential impact area.

It should be noted here that section 3.5.6.1 provides a discussion of why the data requirements proposed in this section are useful to regulatory agencies in the 316(a) decision-making process.

Identification of taxa in the various biotia categories should be to the species level for the RIS organisms and no less than family level for all others that are listed.

3.3.1 Phytoplankton

3.3.1.1 Decision Criteria.

The phytoplankton section of the 316(a) demonstration will be judged successful if the applicant can show that the site is a low potential impact area for phytoplankton. For other sites, the phytoplankton section of the 316(a) demonstration will be judged successful only if the applicant can demonstrate that:

1. A shift towards nuisance species of phytoplankton is not likely to occur;

2. There is little likelihood that the discharge will alter the indigenous community from a detrital to a phytoplankton based system; and

3. Appreciable harm to the balanced indigenous population is not likely to occur as a result of phytoplankton community changes caused by the heated discharge.

3.3.1.2 Low Potential Impact Areas for Phytoplankton (Open Ocean and Most Riverine Ecosystems).

Areas of low potential impact for phytoplankton are defined as open ocean areas or systems in which phytoplankton is not the food chain base. Ecosystems in which the food web is based on detrital material, e.g., embayments bordered by mangrove swamps, salt marshes, fresh water swamps, and most rivers and streams, are in this category.

The area will not be considered one of low potential impact if preliminary literature review and/or abbreviated "pilot" field studies reveal that:

1. The phytoplankton contribute a substantial amount of the primary photosynthetic activity supporting the community;

2. A shift towards nuisance species may be encouraged; or

3. Operation of the discharge may alter the community from a detrital to a phytoplankton based system.

3.3.1.3 Study Requirements for Areas Not Classified as Low Potential Impact (Some Lacustrine, Estuarine, and Possibly Other Water Body Types).

The applicant is not requested specifically to conduct detailed taxonomic studies of the phytoplankton, but information provided in the demonstration should be adequate to characterize the presence and abundance of pollution tolerant and nuisance forms as well as to provide baseline information about the phytoplankton community as a whole. The particular power plant site and aquatic system plus historical information will dictate the extent of taxonomic work required. In some situations only a few species or major taxonomic groups (e.g., species comprising >5% of total) will have to be identified and counted, whereas in other situations the identification and counting of several species or major groups may be required.

The experimental design should be appropriate to determine the general characteristics of the phytoplankton community within the entire primary study area. Sampling outside the primary study area should be done at locations most appropriate to generate data typical of the far field study area. Sample replication should be adequate to determine precision of the data collected and to conduct appropriate statistical tests.

Samples should be taken with appropriate gear as described in the EPA Biological Methods Manual.* Plankton nets are of limited value since many organisms pass through them. In certain cases where

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* Biological Field and Laboratory Methods (EPA-670/4-73-001).

extensive sampling is deemed necessary, it may be possible to use an indirect chemical method to assess seasonal or spatial phytoplankton fluctuations.

In most cases the study should determine the standing crop of phytoplankton at periods ranging from seasonal to bi-monthly depending on the available information. At a minimum, the data collected should include:

1. The standing crops of organisms per volume of water;

2. Identification of numerically dominant taxa (i.e., 5% or more by number) and nuisance organisms; and

3. Delineation of the euphotic zone, preferably with a submersible photometer.

3.3.2 Zooplankton and Meroplankton

3.3.2.1 Decision Criteria.

The zooplankton and meroplankton section of the 316(a) demonstration will be judged successful if the applicant can show that the site is a low potential impact area for these organisms, or that:

1. Changes in the zooplankton and meroplankton community in the primary study area that may be caused by the heated discharge will not result in appreciable harm to the balanced indigenous fish and shellfish population.

2. The heated discharge is not likely to alter the standing crop, relative abundance, with respect to natural population fluctuations in the far field study area from those values typical of the receiving water body segment prior to plant operation.

3. The thermal plume does not constitute a lethal barrier to the free movement (drift) of zooplankton and meroplankton.

3.3.2.2 Low Potential Impact Areas for Zooplankton and Meroplankton.

Areas of low potential impact for zooplankton and meroplankton are defined as those characterized by low concentrations of commercially important species, rare and endangered species, and/or those forms that are important components of the food web or where the thermal discharge will affect a relatively small proportion of the receiving water body.

Most estuarine areas will not be considered areas of low potential impact for zooplankton and meroplankton. However, where a logarithmic gradient of zooplankton and meroplankton abundance exists, those areas at the lowest level of abundance may be recognized as low potential impact areas at the discretion of the Regional Administrator.

If preliminary 316(a) studies indicate that the area is one of low potential impact, no further 316(a) studies are necessary. In this case the applicant need provide only a narrative discussion justifying the conclusion that the area is one of low potential impact.

3.3.2.3 Study Requirements for Other Areas.

For those facilities not sited in low potential impact areas, the applicant should describe the qualitative and quantitative characteristics of the zooplankton and meroplankton populations. The data should include:

1. Standing crop estimates;
2. Relative abundances of the taxa present;
3. Seasonal variations in the abundance and distributions of the various taxa encountered; and
4. The diel and tidal changes in the depth distribution.

The experimental design should be appropriate to determine the general characteristics of zooplankton and meroplankton within the entire primary study area. Sampling in the far field study area should be done in locations most appropriate to generate data typical of the remainder of the far field study area. The AIF Sourcebook* provides information related to the choice of sampling methods. Sample replication should be adequate to determine precision of the data collected and to conduct appropriate statistical tests.

If the applicant believes on the basis of the data collected that the zooplankton and meroplankton criteria can be met, the conceptual framework upon which the conclusion is based and corresponding data analysis must be included in the zooplankton and meroplankton rationale of the 316(a) demonstration. For a further discussion of information requirements for meroplankton, see section 3.3.4.3.

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* Atomic Industrial Forum, Sourcebook: "Environmental Impact Monitoring of Nuclear Power Plants," August 1974.

3.3.3 Habitat Formers

3.3.3.1 Decision Criteria.

The habitat formers section of a 316(a) demonstration will be judged successful if the applicant can show that the site is a low potential impact area for habitat formers. For other sites, the section will be judged successful if the applicant can demonstrate that:

1. The heated discharge will not result in any deterioration of the habitat formers community or that no appreciable harm to the balanced indigenous population will result from such deteriorations.

2. The heated discharge will not have an adverse impact on threatened or endangered species as a result of impact upon habitat formers.

Any probable thermal elimination of habitat formers from the estuarine or marine environments or their contiguous wetlands constitutes a basis for denial. Similarly, a basis for denial exists if important fish, shellfish, or wildlife are thermally excluded from the use of the habitat.

3.3.3.2 Low Potential Impact Areas.

In some situations, the aquatic environment at the proposed site will be devoid of habitat formers. This condition may be caused by low levels of nutrients, inadequate light penetration, sedimentation, scouring stream velocities, substrate character, or toxic materials. Under such conditions the site may be considered a low potential impact area. However, if there is some possibility the limiting factors (especially man-caused limiting factors) may be relieved and habitat formers may be established within the area, the applicant will be required to demonstrate that the heated discharge would not restrict re-establishment. Those sites where there is a possibility that the power plant will impact a threatened or endangered species through adverse impacts on habitat formers will not be considered low potential impact areas.

3.3.3.3 Study Requirements for Other Areas Not Classified as Low Potential Impact.

For areas that do not qualify as low potential impact areas, the applicant should provide the following information:

1. Regional site location map and a scaled aerial map showing the distribution of habitat formers in the region near the proposed site. The

aerial map should include the primary and far field study areas. When available, aerial maps showing historical changes in the distribution of habitat formers should be provided.

2. List of dominant species of habitat forming macrophytes, macroalgae, shellfish, corals, and sponges.

3. Standing crop estimates of the dominant species in terms of dry weight of organic matter per unit area. These estimates should be made at a minimum frequency of quarterly for one year.

4. Identification of those species of fish which are dominant species or threatened or endangered species and are dependent upon the existence of the habitat formers for protection or for use as feeding areas. For such species (which are not considered elsewhere in the 316(a) demonstration), the applicant should provide quantitative abundance estimates.

The experimental design should be appropriate to determine the general characteristics of the habitat former community within the entire primary study area. Sampling outside the primary study area should be done in locations most appropriate to generate data typical of the remainder of the far field study area. Sample replication should be adequate to determine the precision of the data generated and to conduct appropriate statistical tests.

3.3.4 Shellfish/Macroinvertebrates

3.3.4.1 Decision Criteria.

The shellfish/macroinvertebrates section of a 316(a) demonstration will be judged successful if the applicant can demonstrate that no appreciable harm to the balanced indigenous population will occur as a result of macroinvertebrate community changes caused by the heated discharge. For areas classified as ones of low potential impact for shellfish/macroinvertebrates, relatively little new field work may be required. Decision criteria related to individual parameters are discussed as follows:

1. Standing Crop. Reductions in the standing crop of shellfish and macroinvertebrates may be cause for denial of a 316(a) waiver unless the applicant can show that such reductions caused no appreciable harm to balanced indigenous populations within the water body segment.

2. Community Structure. Reductions in the components of diversity may be cause for the denial of a 316(a) waiver unless the applicant can show that the critical functions (defined in section 3.8.3.) of the macroinvertebrate fauna are being maintained in the water body segment as they existed prior to the introduction of heat.

   Generally, with the present state of knowledge it is impossible to state what effect a certain percentage of change in the components of diversity will have on functional integrity of the system, specifically the maintenance of a balanced indigenous population. From a generic standpoint, a major difficulty relates to the fact that the species richness of the macroinvertebrate fauna varies considerably in different systems and that the effects of a given level or percentage of change might be a function of the level of diversity extant prior to the introduction of heat stress.

   From a decision standpoint, actual or predicted reductions in diversity could serve primarily as an indication that the system is or will be stressed. Because of the difficulty in predicting changes with any degree of accuracy, this parameter could serve as a decision tool only in cases where the actual changes resulting from plant operation can be enumerated and reasonably applied to the proposed site.

3. Drift. The discharge of cooling water equal to 30% or more of the 7-day, 10-year low flow of a river or stream would be cause for concern and possible rejection of a 316(a) waiver unless the applicant can show that:

   1) Invertebrates do not serve as a major forage for the fisheries,

   2) Food is not a factor limiting fish production in the water body segment, or

   3) Drifting invertebrate fauna is not harmed by passage through the thermal plume.

4. Critical Functions (Estuaries). Areas which serve as spawning and nursery sites for important shellfish and/or macroinvertebrate fauna are considered as zero allowable impact areas and will be excluded from

consideration for the discharge of waste heat. Plants sited in locations which would impact these critical functions will not be eligible for a 316(a) waiver. Most estuarine sites will fall into this category.

3.3.4.2 Low Potential Impact Areas for Shellfish/Macroinvertebrates.

A low potential impact area for shellfish/macroinvertebrate fauna is defined as an area which, within the primary and far field study areas, can meet the following requirements:

1. Shellfish/macroinvertebrate species of existing or potential commercial value do not occur at the site. This requirement can be met if the applicant can show that the occurrence of such species is marginal.

2. Shellfish/macroinvertebrates do not serve as important components of the aquatic community at the site.

3. Threatened or endangered species of shellfish/macro-invertebrates do not occur at the site.

4. The standing crop of shellfish/macroinvertebrates at the time of maximum abundance is less than one gram ash-free dry weight per square meter.

5. The site does not serve as a spawning or nursery area for the species in 1, 2, or 3 above.

3.3.4.3 Study Requirements for Other Areas.

1. Sampling Design. The experimental design should be appropriate to determine the general characteristics of the shellfish/macroinvertebrate community within the entire primary study area. Sampling outside the primary study area should be done in locations most appropriate to generate data typical of the remainder of the far field study area. Sample replication and collection frequency should be adequate to determine the precision of the data generated and to conduct appropriate statistical tests.

   At a minimum, samples should be taken quarterly for one year. However, the actual periods selected should be keyed to known information on the seasonal occurrence of important forage species, rare and endangered species, and species of commercial importance. Sampling for these species must occur when vulnerable life stages are in the area. If, because of the transitory nature of such species and their various life stages, it is not possible to include them in a quarterly program or, if there is a complex of species whose timing in the area is unknown, then the frequency of sampling will have to be increased. For the benthic component of the shellfish/macroinvertebrates, community sampling stations should be selected for each major substrate type within the primary study area. Similar stations should be selected in the far field study area so that the relative importance of the two regions may be compared. Where appropriate, these stations should also be used for sampling the motile portion of the shellfish/macroinvertebrate community.

2. Sampling Methods. The applicant should use trawls, trapping, or netting techniques which are standard for the types and life stages of shellfish/macroinvertebrates found in the study area.

3. Information Requirements. The applicant should qualitatively enumerate as thoroughly as possible the species of shellfish/macroinvertebrates inhabiting the impact area and adjacent environments. For commercial species, important forage species, and threatened or endangered species information should be provided on their status in the area (permanent or transient), seasonal timing of presence (if applicable), and the life stages present including meroplankton. In addition, the applicant should describe the importance of the area for the critical functions of reproduction and early development. In cases where the discharge will potentially impact a highly productive shellfish/macroinvertebrate fauna, the applicant should provide quantitative estimates of the shellfish/macroinvertebrate standing crop. Such sites include estuaries, shallow nonfluctuating reservoirs, salmonid rivers, and open coastal sites which have characteristics similar to estuarine sites. However, the applicant should recognize that the level of effort is based on the area impacted and that sampling of the benthic component of the shellfish/macroinvertebrate

fauna would be minimal in the case of a site having sufficient depth that the plume does not reach the bottom. Many deep fluctuating reservoirs, as typified by some in the TVA system, have depauperate benthic fauna and will require a minimum amount of description information to document those characteristics. In the case of shallow non-fluctuating reservoirs typified by Lakes Marion and Moultrie in South Carolina, which have an abundant and diverse benthic fauna, the applicant should conduct detailed studies.

Other parameters which should be evaluated in the study include:

A. Standing crop. The standing crop of the various species should be estimated in terms of numbers and biomass per square meter for both the primary and far field study areas. The biomass estimate should be expressed as grams ash-free dry weight per square meter.

B. Community structure. The community structure should be evaluated in terms of:

   1) the number of species per sample,

   2) the number of individuals for each species in each sample,

   3) the total number of species in the study areas, and, when appropriate,

   4) the age structure of the species in each sample.

   Although it may be impossible to collect all species in the study areas, the applicant should make a conscious effort to augment the quantitative sample data with qualitative sampling adequate to obtain a reasonably complete list of taxa.

C. Drift. If a riverine site is being examined, the applicant must estimate the quantity and composition of the shellfish/macroinvertebrate biota which drift past and will be entrained into the thermal plume. The applicant should estimate the number and biomass of drift organisms per linear meter of river cross section. Sample replication and collection frequency should be adequate to determine the precision of the data generated and to conduct appropriate statistical tests. In addition, the applicant should enumerate those species which represent five percent or more of the total number or biomass of organisms comprising the drift. Where appropriate, the applicant may conduct in situ drift studies at an existing facility to determine whether the common indigenous macroinvertebrates can survive passage through the plume. These data may be useful for projecting the effects of the plume at the proposed site.

4. Data Presentation. The applicant should provide a scaled substate map which includes the primary and far field study areas. At least one map should be provided which shows the anticipated outer limits of the thermal plume to the 2°C isotherm. In addition, the applicant should provide maps showing the isotherms as they will exist along the bottom for the conditions of maximum and minimum ambient water temperatures.

   In the case of estuaries, the applicant should provide maps showing the relationship of the predicted plume to spawning areas, nursery areas, and migration routes for the various life stages of commercial species, threatened or endangered species, forage species, and species that are otherwise important to the functioning of the system.

   The applicant should thoroughly summarize the data using summary tables and graphics and report the raw data in a separate bound appendix. The applicant should then provide a narrative evaluation and interpretation of the data which explains why, in the judgment of the applicant, the impacts are sufficiently inconsequential that "the protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife in and on the body of water will be assured."

3.3.5 Fish

3.3.5.1 Decision Criteria.

The fish section of a 316(a) demonstration will be judged successful if the applicant can demonstrate that the site qualifies as a low potential impact area for fish. For other sites, the fish section of a 316(a) demonstration will be judged successful if the applicant can prove that fish communities will not suffer appreciable harm from:

1. Direct or indirect mortality from cold shocks;

2. Direct or indirect mortality from excess heat;

3. Reduced reproductive success or growth as a result of plant discharges;

4. Exclusion from unacceptably large areas; or

5. Blockage of migration.

3.3.5.2 Low Potential Impact Area.

A discharge may be determined to be in a low potential impact area for fishes within the primary and far field study areas if the following conditions are satisfied:

1. The occurrence of sport and commercial species of fish is marginal;

2. The discharge site is not a spawning or nursery area;

3. The thermal plume (bounded by the 2°C isotherm) will not occupy a large portion of the zone of passage which would block or hinder fish migration under the most conservative environmental conditions (based on 7-day, 10-year low flow or water level and maximum water temperature);

4. The plume configuration will not cause fish to become vulnerable to cold shock or have an adverse impact on threatened or endangered species.

3.3.5.3 Study Requirements for Areas Not Classified as Low Potential Impact.

1. Methodology and Frequency. Appropriate sampling methods and gear will be used to provide a basis for identifying the Representative Important Species (RIS) of fish and their respective life stages in various habitats and strata within the study area. Methods of fish sampling such as trawling, gill netting, seining, horizontal and vertical ichthyoplankton tows, etc., are acceptable. However, sampling methods will vary from one type of water body to another; therefore, a rationale for the choice of gear must be developed for each sampling program. Unless stringent requirements for specialized gear is apparent, the adoption of standardized gear is recommended to permit comparisons with other studies. At

no time during the study should new gear or sampling methods be introduced unless it can be demonstrated that the comparative efficiencies of the old and new gear and methods are similar. A change in sampling procedures can only be implemented after written approval by the Regional Administrator/Director.

For field studies, experimental design should be appropriate to determine the general characteristics of all life stages of fishes inhabiting the primary and far field study areas. The data collected should allow for a comparison of the relative importance of these two areas with respect to species composition, numbers of each type, growth, and reproduction.

Samples shall be taken at monthly intervals to provide data representing seasonal and life stage habits except during and immediately following periods of spawning when a more intensive sampling effort should be provided.

In northern latitudes, the monthly sampling requirement is subject to weather conditions and it may be necessary to provide the described data requirements from the literature and relate such information to expected discharge areas in a defendable rationale. Also, rationales could be developed from combinations of field data and literature sources.

It should be recognized that distribution of the various life stages of fish is dependent upon many factors including season, water movement, light intensity, density gradients, and food sources. As an example, during the appropriate season, night sampling will yield a more accurate estimation of the ichthyoplankton population because of their migration pattern during the diel cycle.

In most cases, sample replication and frequency must be determined for individual sites and be based on field studies to provide valid population estimates using appropriate statistical treatments.

2. Information Requirements. The studies conducted should provide the required information which will be used for purposes described above. Some of the fish information may be required separately for 316(b) studies. The applicant should meet with the Regional Administrator to determine which of the following information requirements should be developed to satisfy 316(a) requirements at the site:

Species Level: For the RIS, the following information may be required:

A. Reproduction. A discussion on spawning habits and fecundity characteristics of the principal species.

B. Life stage habitat utilization. A discussion on habitat utilized at the various life stages and seasonal timing of presence in the habitat types. Migration activity, if applicable to the designated species, should be addressed.

C. Condition factors. Comparative condition information for the principal species occurring in the primary and far field study areas.

D. Disease and parasitism. Occurrence of disease and parasitism in the indigenous populations and species susceptibility within the framework of expected thermal regimes should be discussed.

E. Age and growth. Trends in age and growth normally expected in the species should be discussed.

Community Level:

A. RIS and their general abundance. Spatial and temporal distribution information on the RIS in the primary and far field study areas will provide information on which species will be most vulnerable to intake and/or discharge effects.

B. Relative abundance of various species. This information can be calculated from the sampling data. The relative abundance of a species is the value determined by dividing total number of all fishes collected into the number of that species caught. It is often reported as percentage of the total catch. Relative abundance can fluctuate seasonally and diurnally; however, it should not be significantly different from year to year. Significant shifts in relative abundance over a period of time are indicative of changes within the fish community.

C. Principal association. By appropriate data analyses it is possible to identify principal associations. The principal associations are the groups of species which are represented in samples in a consistent manner. Presence or absence of a species directly or indirectly depends on the presence or absence of other species in the sample. Significant impact on one species, therefore, can result in changes in principal associations.

D. Map requirement. The applicant should provide maps depicting portions of the receiving water body used by the indigenous fish communities for such activities as spawning, nursery, feeding, migration, resting, etc. The applicant should discuss and show on the map the proportion of the total area used that will be influenced by the thermal discharge to the 2°C isotherm.

3.3.6 Other Vertebrate Wildlife

3.3.6.1 Decision Criteria.

The section of the demonstration dealing with other vertebrates will be judged successful if the applicant can show the site is one of low potential impact for other vertebrates. For other sites, the section of the demonstration dealing with other wildlife will be judged successful if the applicant can demonstrate that other wildlife community components will not suffer appreciable harm or will actually benefit from the heated discharge. The term "other vertebrate wildlife" includes wildlife which are vertebrates (i.e., ducks, geese, manatees, etc.) but not fish.

3.3.6.2 Low Potential Impact Areas for Other Vertebrate Wildlife.

Most sites in the United States will be considered ones of low potential impact for other vertebrate wildlife simply because the projected thermal plume will not impact large or unique populations of wildlife. The main exceptions will be sites in cold areas (such as North Central United States) which would be predicted to attract geese and ducks, and encourage them to stay through the winter. These would not be considered low potential impact areas unless they could demonstrate that the wildlife would be protected through a wildlife management plan or other methods from the potential sources of harm mentioned in the next section.

Other exceptions to sites classified as low potential impact would be those few sites where the discharge might affect important (or threatened and endangered) wildlife such as manatees.

For most other sites, brief site inspections and literature reviews would supply enough information to enable the applicant to write a brief rationale about why the site could be considered one of low potential impact for other vertebrates.

3.3.6.3 Study Requirements for Other Areas.

The applicant should undertake whatever investigation and planning steps are necessary to be able to write a rationale explaining what factors (or wildlife management plans) will ensure that other wildlife will not suffer appreciable harm from:

1. Excess heat or cold shock;

2. Increased disease and parasitism;

3. Reduced growth or reproductive success;

4. Exclusion from unique or large habitat areas; or

5. Interference with migratory patterns.

In the rationale, the applicant should discuss the relation of the effluent to the habits and habitats of any threatened or endangered species or organisms of commercial or recreational importance.

3.4 How to Select the Most Appropriate Demonstration Type

The basic recommended steps for the applicant's use in choosing the most appropriate demonstration type are summarized in section 3.2.2, the decision train narrative.

After completing the initial screening procedures and making a preliminary assessment of the amount of additional work needed in each biotic category, the applicant selects the demonstration type most appropriate for the site. If the site is one of low potential impact for all biotic categories, the applicant may choose the relatively streamlined low potential impact Type III demonstration outlined in section 3.6. If not, the applicant should propose study plans based on the Type II guidance in section 3.5 or the Type III guidance in section 3.7.

It is recommended that the Type II demonstration be used as a guide for the amount of detail required in most 316(a) demonstrations. The actual amount of detail required for an individual location will vary from site to site, but section 3.5 should serve as a useful starting point for discussions between the applicant and Regional Administrator/Director on what study plans are most appropriate for a particular site.

Applicants not eligible for a low potential impact Type III demonstration and not desiring to do a Type II demonstration may elect to do an alternate (Type III) demonstration.

If the site is one of low potential impact for most biotic categories but not all, studies less detailed than those recommended in section 3.5 may be appropriate. For example, if the site is one of low potential impact for all biotic categories except shellfish, the Regional Administrator/Director might conclude that few additional field studies (except for shellfish) would be required and that the only RIS that should be selected should be shellfish. This demonstration would be less detailed than other Type II demonstrations and could be referred to as a Type III demonstration.

3.5 Type II Demonstrations (Representative Important Species)

The Type II demonstration should be designed in such a manner to fully develop the three key biological components: completion of the Biotic Category Rationales (begun during early screening procedures), development of RIS rationales, and synthesis of all information into a master rationale. This section provides a discussion of the recommended components of the demonstration, a proposed format, and a discussion of why the data requirements are necessary for making 316(a) decisions.

3.5.1 Development of Biotic Category Rationales

During early screening procedures of literature surveys and pilot field investigations the applicant will develop some of the information needed to develop the Biotic Category Rationales. If the decision is made to do a Type II demonstration following these early screening procedures, the applicant should review sections 3.3 and 3.8.1, this section, and the data available, to determine what additional field studies, if any, will be necessary to complete the Biotic Category Rationales. In some cases, relatively little additional work will be necessary. In cases where additional work is required, the applicant should complete the studies as suggested in section 3.3 and then write the summary Biotic Category Rationales.

Each Biotic Category Rationale should provide a complete discussion as to why, in the judgment of the applicant, the impacts are sufficiently inconsequential that the protection and propagation of the balanced indigenous population of shellfish, fish, and wildlife in and on the body of water will be assured. In the rationale, the applicant should address each decision criteria for the biotic category in question. The discussion should include an evaluation of the impacts of the discharges into the receiving water body.

The conclusions drawn should be supported with an analysis of the data collected during the 316(a) studies and/or by the inclusion of supportive reports, documents and citations to the scientific literature. The conclusions should represent a logical extension of the information available and be scientifically defendable. Where citations are used that are not readily available in scientific journals (i.e., interim reports, various types of agency documents, annual reports, theses, etc.), the documents themselves should be provided.

If the impact of the discharge is projected using a mathematical model, the applicant should provide a complete documentation of the model that is used. The documentation should include a discussion of the merits and disadvantages of the model. The applicant should also provide sensitivity analyses of the model and a verification study. In addition, the statistical reliability of the model's predictions should be included along with a justification of the methods used in the statistical evaluation.

3.5.2 Development of Representative Important Species Rationale

The RIS Rationale should summarize why the results of the laboratory and literature studies specified in section 3.5.2.2 suggest that the RIS will not suffer appreciable harm as a result of the heated discharge.

The assumptions in the concept of RIS are:

1. It is not possible to study in great detail every species at a site; there is not enough time, money or expertise.

2. Since all species cannot be studied in detail, some smaller number will have to be chosen.

3. The species of concern are those casually related to power plant impacts.

4. Some species will be economically important in their own right, e.g., commercial and sports fishes or nuisance species, and thus "important."

5. Some species, termed "representative," will be particularly vulnerable or sensitive to power plant impacts or have sensitivities of most other species and, if protected, will reasonably assure protection of other species at the site.

6. Wide-ranging species at the extremes of their ranges would generally not be considered acceptable as "particularly vulnerable" or "sensitive" representative species but they could be considered as "important."

7. Often, all organisms that might be considered "important" or "representative" cannot be studied in detail, and a smaller list (e.g., greater than 1 but less than 15) may have to be selected as the "representative and important" list.

8. Often, but not always, the most useful list would include mostly sensitive fish, shellfish, or other species of direct use to man or for structure or functioning of the ecosystem.

9. Officially listed "threatened or endangered species" are automatically "important."

<u>3.5.2.1</u> <u>Selection of the Representative Important Species and Far Field Study Area</u>.

As previously discussed in the decision train (section 3.2.2, Step 11), applicants first meet with the Regional Administrator/Director to discuss selection of the RIS and define the far field study area.

The number of RIS selected for a particular site may be high (5-15) if the plans for biotic category field studies are not comprehensive, or low (2-5) if plans for additional field studies are extensive.

Some of the criteria for selection of RIS are found in the definition of the term (see section 4.0, Definitions and Concepts). Keeping in mind these criteria and the assumptions given above, the Regional Administrator/Director selects RIS from any combination of the following biotic categories: fish, shellfish, or habitat formers.

1. <u>Species Selection Where Information is Adequate</u>. Where information pertinent to species selection is adequate, the Regional Administrator/Director should promptly select RIS. The applicant may suggest species for his consideration and may, as a part of its demonstration, challenge any selection. Other considerations are as follows:

A. Applicable State Water Quality Standards. If the State's approved water quality standards designate particular species as requiring protection, these species should be designated, but alone may not be sufficient for purposes of a Type II demonstration.

B. Consultation with Director and with Secretaries of Commerce and Interior. In the cases of species selection by the Regional Administrator, he must seek the advice and recommendation of the Director as to which species should be selected. The Regional Administrator must consider any timely advice and recommendations supplied by the Director and should include such recommendations unless he believes that substantial reasons exist for departure.

The Secretary of Commerce (National Marine Fisheries Service) and the Secretary of the Interior (Fish and Wildlife Service), or their designees, and other appropriate persons (e.g., university biologists with relevant expertise), should also be consulted and their timely recommendations should be considered. The Director should also consult with the agency exercising administration of the wildlife resources of the State (see section 3.2.2, Decision Train, Step 12).

C. Threatened or Endangered Species. Species selection should specifically consider any present threatened or endangered species, at whatever biotic category or trophic level, except that no information should be requested that would require field sampling prohibited by the Endangered Species Act, 16 U.S.C. 1531 et seq. (see section 3.2.2, Decision Train, Step 12).

D. Thermally Sensitive Species. The most thermally sensitive species (and species group) in the local area should be identified and their importance should be given special consideration, since such species (or species groups) might be most readily eliminated from the community if effluent limitations allowed existing water temperatures to be altered. Consideration of the most sensitive species will best involve a total aquatic community viewpoint.

Reduced tolerance to elevated temperature may also be predicted, for example in species which experience natural population reduction during the summer. Species having the greatest northern range and least southward distribution may also possess reduced thermal tolerance.

E. Commercially or Recreationally Valuable Species. Selection of commercially or recreationally valuable species should be based on a consideration of the benefits of assuring their protection.

F. Far-Field and Indirect Effects. Consideration should include the entire water body segment. For example, an upstream cold water source should not be warmed to an extent that would adversely affect downstream biota. The impact of additive or synergistic effects of heat combined with other existing thermal or other pollutants in the receiving waters should also be considered.

G. Species Necessary (e.g., in the Food Chain or Habitat Formers) for the Well-Being of Species Determined Above. In addition to the above considerations, it is suggested that the Regional Administrator/Director ask himself the following questions before selecting the RIS:

1) Is the potential problem with this species credible (documented, a problem elsewhere, a good prediction)?

2) Is the problem likely to be significant?

3) Which species occur at the location?

4) Which species is likely to be closely involved with the source or damage?

5) Does the problem species rank as "important"?

6) Does the list of problem species fall in the range 5-15 or 2-5 (see text above)?

7) Are the identified problem species "representative"?

8) Should other species not clearly a problem be included as representative or important?

2. Species Selection Where Information is Inadequate. Where the available information is not adequate to enable the Regional Administrator/Director to select appropriate RIS, he may request the applicant attempting to make a Type II demonstration to conduct such studies and furnish such evidence as may be necessary to enable such selection. Where species selection is based on information supplied by the applicant, the appropriateness of the species as representative and important is an aspect of the applicant's burden of proof.

3.5.2.2 Laboratory and Literature Studies.

The laboratory and literature studies to be done for each RIS should be restricted to those which are necessary to fill out summary Tables A and B and to develop (on the basis of the data summaries in those tables) the RIS Rationale. Not all of the data listed in Tables A and B may be appropriate for a particular site or taxa. If the applicant feels that some are inappropriate and should be deleted, it should be discussed with the Regional Administrator/ Director at the same time other discussions about the RIS are taking place.

Assumptions for Tables A and B

1. The tables are merely aids to organizing biological data believed to be useful and important for making decisions regarding thermal discharge effects.

2. The species table should be workable for any important or representative species selected, whether it is selected as a species for protection or avoidance (e.g., nuisance species).

3. All thermal characteristics do not apply in a similar context to all taxonomic groups (taxa), requiring some special definitions or omission of a characteristic for a particular taxon.

4. There will be nonthermal influences (e.g., chemicals, scouring), often occurring simultaneously with thermal influences, that are not included in this table but which should be considered in their own right.

5. There may not be differences between adults and juveniles of all taxa, or there may be more than two distinct sensitivity categories. Distinctly different life stage requirements should be listed.

6. Data can be collected by the applicant for those thermal characteristics of the RIS that have not yet been determined but for which standardized methods are readily available.

7. For certain parameters that are still in the research or development stage, as opposed to standardized testing (e.g., gametogenesis requirements or predation on thermally stressed meroplankton), all available published data would be useful but it would not be necessary to develop new data for this category.

8. If more than one set of data are available for any category, the several sets should be presented (and referenced) and the rationale presented to aid in selecting one set for decision-making at the site in question.

9. Dates for gametogenesis and spawning imply appropriate seasonal times which will vary from area to area and year to year even without the influence of the power plant. The important point is whether these events would be seasonally precluded.

10. In fishes, optimum temperatures for growth and some performance factors (e.g., maximum swimming speed, greatest metabolic scope, final temperature preferendum, etc.) have been shown to be coincident for enough fishes that this coincidence is acceptable as a generalization. Exceptions could be important, however, and should be identified.

SAMPLE TABLE TO SUMMARIZE DATA FOR EACH
REPRESENTATIVE IMPORTANT SPECIES (RIS)

SCIENTIFIC NAME ______________________ COMMON NAME ______________________

THERMAL EFFECTS PARAMETER	TEMPERATURE LIMIT OR RANGE (°C)	SOURCE REFERENCE (IF APPROPRIATE)	MEAN AND MAXIMUM AREA UNAVAILABLE FOR FUNCTION (m^2)[a]	MEAN AND MAXIMUM TIME UNAVAILABLE FOR FUNCTION (DAYS)[a]	IS EFFECT, IF ANY, EXPECTED TO AFFECT THE POPULATION OF THE RIS? (YES OR NO)

[a] That area or time under average and worst case conditions that will not permit the specific biological function to occur satisfactorily.

SUMMARY CONCLUSION OF EFFECT OF HEAT ON THE REPRESENTATIVE IMPORTANT SPECIES (RIS): ______________________

____

TABLE B

THERMAL EFFECTS PARAMETERS APPLICABLE
TO AQUATIC ORGANISMS POTENTIALLY SELECTED AS RIS

THERMAL EFFECTS PARAMETERS	POSSIBLE METHODS FOR DETERMINATION	POTENTIAL TAXA F RIS
1. High Temperature Survival		
Aquatic Adult	TL_{50}, 24 hours	
Juvenile (Immature)	TL_{50}, 24 hours	
2. Thermal Shock Tolerance (Heat and Cold)	thermal gradient including worst case T	
Aquatic Adult	single shock to simulate plant shutdown	
Juvenile (Immature)	double shock (up and down) in traversing plume [3]	
Early Developmental Stages (incl. meroplankton)		
3. Optimum Temperature for Performance and Growth		
Non-breeding Adult	length, weight changes; productivity; DNA/RNA Ratio[2]	
Juvenile	length, weight changes; DNA/RNA Ratio[2]	
4. Maximum Temperature Regime Allowing Early Development Completion	long-term temperature exposure throughout development to juvenile[3]	
5. Normal Spawning Dates and Temperatures	months; range for spawning	
6. Special Temperature Requirements for Reproduction	1	

1 As available in the literature only.

2 Indicated by final preferendum for fish.

3 Only for species readily reared or held in the laboratory.

Narrative for Table B — Thermal Effects Parameters Applicable to Aquatic Organisms Selected As Representative Important Species

Thermal effects studies applicable to major taxa or broad biotic categories are summarized in Table B. Applicable thermal effects data should be obtained for each RIS selected. Remarks on study and notes of application of the results to make 316(a) and (b) decisions are indicated here.

1. High temperature survival for juveniles and adults:

Method: Determine TL_{50} (e.g., 48-hr. = ultimate incipient lethal temperature) for juveniles and non-breeding adults. Acclimation temperature should approximate the highest temperature at which the fish can be held. Expose animal to elevated temperatures in an acute (instantaneous) manner.

Application of Results: The TL_{50} value can be used for estimation of the upper non-lethal limit for the life-history stage in question (24-hr. TL_{50} minus 2°C). The TL_{50} value also can be used to estimate the upper temperature limit for appreciable growth (24-hr.-TL_{50} minus optimum growth time).

2. Thermal shock tolerance of selected life-history stages:

a) For juveniles and adults, simulate winter plant shutdown stress of plume entrained fishes and motile macro-crustacea.

Method: Expose organisms to acute temperature drops equal to the range of expected discharge t's, using maximum winter plume temperature as the acclimation temperature. Indicate temperature test regimes which produce equilibrium loss of 50% of the sample within 4 hours and mortality after 24 hours.

Application of Results: Identified winter plume vs. ambient temperature conditions which could result in thermal shock in the event of plant shutdown, and an ensuing high loss of organisms due to markedly increased susceptibility to predation.

b) For meroplankton, simulate temperature shock upon traversing a thermal plume.

Method: Expose eggs, embryos, and larvae to acute temperature elevations, followed by an acute drop in temperature at a series of exposure times and temperature gradients reflecting plume resident times and temperatures. Acclimation temperature should equal natural seasonal ambient conditions. Maximum test temperature should range up to the TL_{50} level for adults. Indicate time-temperature regime leading to death of 50% of the sample.

Application of Results: Lethal time-temperature stress regime minus 2°C can be used to estimate temperature limits of normal prey avoidance behavior. Increased temperature results in higher predation pressure.

3. Estimation of optimum temperature for growth:

   a) Fish and macroinvertebrates — determine rate of growth (length or weight increase) when maintained at a series of elevated temperatures and at otherwise near-optimum environmental conditions, with food provided *ad libitum*.

   b) Fish — determinations of final behavioral temperature preferendum will closely correspond to the temperature which is optimal for many physiological processes, including growth.

   c) Macrophytes — determine temperature producing maximum net photosynthesis for at least a 24-hour period, using an appropriate photoperiod.

   Application of Results: Optimum temperature for growth can be combined with ultimate incipient lethal temperature limit for acceptable growth (see #1 above).

4. Minimum optimum and maximum temperatures allowing completion of early development. Note: Studies to be conducted only for RIS which are capable of being readily reared in the laboratory.

   Method: Maintain fertilized eggs under a series of elevated temperature regimes to determine minimum, optimum and maximum conditions permitting greater than 80% survival to completion of development of juvenile (i.e., post-larval metamorphosis; in fish, to the point of successful initiation of feeding). Note that diurnally cyclic temperature regimes with a 5°C total range can be more adaptive for enhanced thermal tolerance than is a constant, non-cyclic temperature regime.

5. Normal spawning dates and temperatures:

Method: Cite range of dates (by month) and threshold temperatures reported to initiate and inhibit gametogenesis and spawning, as reported in the literature for areas closely related to the water body segment in question.

Application of Results: To provide background information to evaluate seasonally the relative impact of thermal discharge on timing of reproductive activities.

6. Special temperature requirement for reproduction:

Method: Information should be provided as available in previously published studies. Examples of relevant "special requirements" include:

a) Minimum of 10°C must be experienced before gametogenesis can be initiated in two boreal barnacles; and

b) Winter chill required for successful development in yellow perch.

3.5.3 Engineering and Hydrological Data for Type II Demonstration

This section describes the engineering and hydrologic information which should normally be included in 316(a) demonstrations. It also suggests formats for presentation of such information. The Regional Administrator/Director may request additional information or excuse the applicant from preparation of portions of this information as the situation warrants. The engineering and hydrologic information to be submitted should consist of all information reasonably necessary for the analysis. Where information listed in this chapter is not relevant to the particular case, it should be excused.

The engineering and hydrologic information and data supplied in support of a 316(a) demonstration should be accompanied by adequate descriptive material concerning its source. Data from scientific literature, field work, laboratory experiments, analytical modeling, infrared surveys and hydraulic modeling will all be acceptable, assuming adequate scientific justification for their use is presented.

In addition to the results obtained from analytical hydraulic models the applicant should present, under separate cover, the model which was used. The model should contain a rationale explaining why this particular model was used and explanations of all modifications to the original work.

3.5.3.1 Plant Operating Data.

1. Cooling water flow. Complete Table C (indicate units) and provide a descriptive flow diagram.

2. Submit a time-temperature profile graph indicating temperature on the vertical and horizontal scale. The graph should indicate status of water temperature from ambient conditions through the cooling system, and finally the discharge plume out to the loC isotherm. Worst case, anticipated average conditions, and ideal (e.g., minimum time/temperature impact) conditions should be illustrated (preferably on the same graph) consistent with representative plumes illustrated.

3. The amount of chlorine used daily, monthly and annually, the frequency and duration of chlorination and the maximum total chlorine residual at the point of discharge obtained during any clorination cycle. The chlorine demand of the receiving water body. For existing plants, a time-concentration graph of total chlorine residual at the point of discharge during a chlorination event.

4. A list of any other chemicals, additives or other discharges (with schematic diagrams) which discharge into the cooling water system including generic name, amount (including frequency and duration of application and the maximum concentration obtained prior to dilution), chemical composition and the reason for discharge.

5. A map of existing dissolved oxygen levels including vertical profiles in the plume and discharge vicinity in 0.5 mg/l increments for both average and worst case conditions. Where stratification or the presence of Biochemical Oxygen Demand (BOD) discharges will possibly lead to depression of oxygen levels as a result of the thermal discharge, the extent of the effect should be estimated.

6. A map of other contaminants within the plume caused by other discharges and natural sources for both average and worst case conditions.

3.5.3.2 <u>Hydrologic Information</u>

1. Flow: Provide information called for below as applicable to the location of the intake and discharge.

   A. Rivers: flow—monthly means and minima (rolling mean, 7-day, 10-year low flows) for each month.

   B. Estuaries: fresh water input, tidal flow volumes, net tidal flux—monthly means and minima for each—circulation patterns from typical tidal cycles.

   C. Reservoirs: flow through time, release schedules—monthly means and minima.

   D. Oceans: tidal heights and information on flushing characteristics.

2. Currents: Provide the information called for below, as applicable to the site:

   A. Rivers: maximum, minimum, and mean current speed giving daily, monthly or seasonal fluctuations and variations across cross-sections as appropriate to describe hydro-dynamics of the primary study area. Include speeds at mean annual flow to 7-day, 10-year low flow.

B. Estuaries: tidal and seasonal changes in current speed and direction. (Vertical profiles of current are needed where density currents occur.)

C. Large lakes and oceans: offshore prevailing currents, near shore currents/eddies; local tidal and seasonal changes in current speed and direction.

3. Tabulate or illustrate monthly and seasonal gradients for both thermal and salinity induced stratification at representative locations in the study area (consistent with the complexity of the study area conditions). If intake and discharge conditions are identical then so state and provide only one tabulation or illustration.

4. Tabulate or illustrate ambient temperature of the receiving waters, giving monthly means and monthly extremes for the preceding 10 years as data availability permits. If comparable site waters are used, indicate the basis and limits of comparablity. In addition, for biologically critical periods, weekly means and extremes, frequency distributions and daily variation should be provided. Temperature data upon which these values are based should, if possible, be obtained at least once hourly.

5. Indicate intake and receiving waters depth contours at 1 meter intervals and any changes which may occur due to sediment movements, construction, etc. Indicate bottom type. Provide other significant features (e.g., thermal bar) and characteristics needed to evaluate the hydrodynamics of the primary and far field study area. Information on water body size, surface area, volume, mean depth and maximum depth.

<u>3.5.3.3</u> <u>Meteorological Data</u>

If energy budget computations are included as part of the 316(a) demonstration, provide the following daily average meteorological data for the plant site, giving both monthly means and seasonal extremes. Indicate units:

1. Wet bulb air temperature.

2. Dry bulb air temperature (verified to site conditions).

3. Wind speed and direction.

4. Long wave (atmospheric) radiation (may be calculated).

5. Short wave (solar) radiation (may be calculated).

6. Cloud cover.

7. Evapotranspiration (may be calculated).

3.5.3.4 Outfall Configuration and Operation.

Provide the following information on outfall configuration and operation, indicating units:

1. Length of discharge pipe or canal

2. Area and dimensions of discharge port(s)

3. Number of discharge port(s)

4. Spacing (on centers) of discharge ports

5. Depth (mean and extremes)

6. Angle of discharge as a function of:

   A. horizontal axis

   B. vertical axis

   C. current directions

3.5.3.5 Plume Data Requirements.

The applicant will furnish estimates based upon model predictions and/or field data at existing plants of the following plume data:

1. Utilizing the load information in Table C, wind rose data and tidal/current data, a plume rose or locus of plumes shall be provided for each calendar month. The plumes shall be bounded by the 2°C above ambient isotherm. This shall be done for both surface isotherms and bottom isotherms when contact with benthic areas is made.

2. Representative plumes of the maximum size and most frequently occurring plumes shall be detailed showing instantaneous isotherms at the 2°C intervals to within 1°C of ambient for conditions of variations in tide, wind and current.

A. Rivers: Plumes for average and 7-day, 10-year low flows should be provided.

B. Lakes and Reservoirs: Plumes for summer conditions, winter conditions and after spring and fall overturns should also be provided. For flood control reservoirs, plumes for various water levels should be provided.

3. For isotherm plots required in number 2 above, vertical temperature profiles along the plume centerline extending to the bottom of the water body at 2°C intervals to within 1°C of ambient.

3.5.6.2 Engineering and Hydrological Data.

The information required in this section, for the most part, consists of parameters which are necessary input to analytical or physical predictive hydraulic or energy budget models. More information may be provided by the applicant for his particular demonstration, but this example represents the degree of detail which will be necessary in most cases.

The following corresponds directly with the respective paragraphs in section 3.6:

1. Plant Operating Data. Table C - The data required in Table C are necessary because they are required for predictive modeling. These numerical data also allow the reviewer to observe water usage.

   Time-Temperature Profile - The predicted time-temperature profile should be included because it illustrates what a typical non-motile particle would be subject to when entrapped and/or entrained in the cooling water system. Certain biological effects could be estimated with this type of input but the reviewer is cautioned not to assume this to be totally representative of stresses encountered on entrapped and/or entrained organisms. This path is an idealized streamline which, in all probability, would not occur due to turbulence of cooling water flow.

   Chlorine - Chlorine is a toxic element and if it is to be used by the discharger to control the growth of flora and fauna in the cooling water system, its usage should be projected. In most power plants chlorine is injected to the cooling water system for periods ranging from 15 minutes to two hours per application. The number of applications is site specific but usually totals less than two hours total per day. Ideally, only exact amounts of chlorine are introduced so that it reacts entirely, leaving no active residual at the discharge. In practice this is difficult to achieve, and some chlorine compounds are discharged. Chlorine reacts with dissolved organic matter in the cooling water to form various chlorinated organics which may be harmful to the balanced indigenous community. It is therefore necessary to project the usage of chlorine and consider the results of its interaction with the thermal component of the discharge.

Thermal Interaction - Section 316(a) specifies that the thermal component of the discharge must be evaluated "... taking into account the interaction of such thermal components with other pollutants...". While data on such synergistic effects are limited, certain information will assist the Regional Administrator/Director in assessing potential harmful interactions.

Other Chemicals - The addition of heat may increase the effect of other chemicals in the water body. Chemical information is needed to evaluate possible effects of this kind and to properly interpret biological data for thermal effects alone.

2. Hydrological Information. This entire section deals with conditions of the receiving water. This information should be required because it is basic siting information, modeling input data and necessary for proper interpretation of biological data.

3. Meteorological Data. This information should be included where energy budget computations are made as part of the 316(a) demonstration. It is not intended that all demonstrations include this data. When in doubt the applicant should discuss this with the Regional Administrator/Director.

4. Outfall Configuration and Operation. These numerical data describing the geometry and orientation of the outfall are necessary input for all predictive plume models.

5. Plume Data Requirements. This data is the result of the modeling effort. While the results may be presented in many formats, these suggested plume configurations yield a graphic portrayal of where the heat is going. These maps are necessary for making qualitative and quantitative assessments of biological changes.

3.5.4 Synthesis of All Information Into "Master" Ecosystem Rationale

The Master Rationales of the demonstration should summarize the key findings in a concise manner and should form a convincing argument that the balanced, indigenous community will be protected. The rationale should include a summary of an "overall picture" of the ecosystem as projected by the six Biotic Category Rationales, the resource zones impacted, and a summary of why the information in the rationales, along with the predictions in the RIS Rationale, the engineering and hydrological data, and other key facts, suggest that the balanced indigenous community will be protected.

3.5.5 Suggested Format for Type II Demonstration

(EXAMPLE) TABLE OF CONTENTS

I. Introduction (Brief)

II. Master Rationale for Demonstration (see Section 3.5.4 for Content)

III. Representative Important Species Rationale (Section 3.5.2)

IV. Biotic Category Rationales (Section 3.5.1)

A. Phytoplankton

1. Decision Criteria
2. Rationale

B. Zooplankton

1. Decision Criteria
2. Rationale

C. Habitat Formers

1. Decision Criteria
2. Rationale

COOLING WATER CHARACTERISTICS [1,2]

% Capacity	% Time at Fractional Load	Intake Velocity		Rate of Circulating Cooling Water Flow[3]	Condenser Rise Δ T	Discharge Δ T[4]	Rate of Discharge		Discharge Velocity[5]
		Channel Entrance	Screens				Cooling Water	Non-Cooling Water	
40% & Less									
40-50									
50-60									
60-70									
70-80									
80-90									
90-100									

1 A separate table should be prepared for each generating unit and for all units combined.

2 If seasonal variations occur, this should be indicated.

3 Variations of intake velocity with changes in ambient conditions (e.g., river flow, tidal height, water level) should be noted.

4 Discharge Δ T = Discharge temperature - Intake temperature (in many cases, condenser Δ T is equivalent to discharge Δ T; however, this is not the case for plants with supplemental cooling).

5 Discharge velocity should be provided at the point where cooling water leaves the discharge structure. Variations in discharge velocity, with changes in ambient conditions (e.g., river flow, tidal height, water level) should be noted.

D. Shellfish/Macroinvertebrates

1. Decision Criteria
2. Rationale

E. Fish

1. Decision Criteria
2. Rationale

F. Other Vertebrate Wildlife

1. Decision Criteria
2. Rationale

V. Brief Summary of Engineering and Hydrological Data and Why the Data are Supportive of the Predictions in the Above Rationales

VI. Demonstration Appendices

A. Information Supporting Master Rationale

B. Information Supporting Representative Important Species Rationale

C. Information Supporting Biotic Category Rationales

D. Engineering and Hydrological Information

1. Baseline Data (see Section 4.1)

2. Discussion of Relationship of the Physical Data to the Summary Rationales and Choice of Models or Other Predictive Methods

E. Supportive Reports, Documents, and Raw Data Not From the Open Scientific Literature

3.5.6 Discussion of Why the Required Data are Necessary for Making 316(a) Determinations

3.5.6.1 Biological Data.

1. Phytoplankton. The organisms of the phytoplankton community are a principal food source for most zooplankton and for some fish species. They may also become important in relation to industrial or recreational water use if blooms of certain species occur, which can have a variety of deleterious effects (e.g., clog filters and intake pipes, impart tastes and odors to water).

Many water bodies, such as the majority of rivers and streams, can be classified as "low potential impact areas" for phytoplankton, and relatively little information is necessary for a 316(a) demonstration. Nevertheless, more detailed data may be necessary in some instances if phytoplankton is a substantial component of food chains supporting the balanced indigenous population or if the thermal discharge is likely to cause a shift towards nuisance species. Even if firm predictions cannot be made on the basis of the increased data, these data may be necessary as a base for comparison with post-operational monitoring surveys to detect long-term community shifts.

A. Standing Crop Estimates. Estimates of standing crop are useful in determining the importance of phytoplankton in the productivity of the impacted body of water. Productivity is a principal factor in defining high and low impact areas.

B. Species Composition and Abundance. Taxonomic information will characterize the phytoplankton associated with the discharge area and will provide baseline data for detecting any shifts in species composition accompanying thermal discharge. A change in composition is often an indication that a nuisance condition may occur and that the food web of the system is being altered.

C. Delineation of Euphotic Zone. The euphotic zone of a water column is the upper layer into which sufficient light penetrates to permit photosynthesis. The comparison of this zone to the configuration of the discharge plume will indicate how much the thermal discharge will affect the productivity of the impacted body of water.

2. Zooplankton and Meroplankton. The zooplankton-meroplankton community is a key supportive component of the aquatic system. It is a primary food source for larval fish and shellfish and also makes up a portion of the diets of some adult species. Many important species of fish and wildlife have planktonic life stages (termed meroplankton, to differentiate them from organisms which are planktonic throughout their entire life cycle). If a heated discharge kills or prevents development of the meroplankton, fewer adult fish and shellfish will be produced each year. Estuarine environments are especially critical because of their high productivity and utilization as spawning and nursery areas for species with meroplanktonic larvae.

Specific types of data are essential for the following reasons:

A. Standing Crop Estimates. Information on standing crop helps in defining the importance of zooplankton and meroplankton in relation to the productivity of the affected system. Any significant change in standing crop becoming evident during post-operational monitoring may indicate an adverse impact resulting from the heated discharge.

B. Species Composition and Abundance. These data will identify dominant taxa in the system and provide baseline information for observing changes accompanying thermal discharge. Any appreciative alteration in the composition and relative abundance of the zooplankton and meroplankton constitutes an imbalance in the community and indicates possible adverse impact. Species data and related thermal tolerance information are also useful in developing thermal limits for the effluent.

C. Seasonal Variations. This information is essential for assessing impact because different species, with different thermal tolerances, become dominant at varying times of the year. It will also show when the important meroplankters are present in the discharge area.

D. Diel and Tidal Distribution. Sampling to show diel and tidal fluctuations in depth distribution are necessary because zooplankton and meroplankton organisms demonstrate distinct vertical movements which may be a function of both light intensity and tidal stage. The organisms are thus vulnerable to a discharge plume in varying degrees at different times of the day.

3. Habitat Formers. The role of habitat formers in an aquatic system remains unquestionably unique and essential to the propagation and well-being of fish, shellfish, and wildlife. Furthermore, habitat formers, particularly in the marine and estuarine environments, are a limited resource, slow to re-establish, and non-renewable in some cases. These organisms are subject to damage by a discharge plume in a number of ways. Rooted aquatic plants, including kelp, may be damaged or destroyed by excessive temperatures, velocities, turbidity, or siltation. Organisms may be damaged or destroyed by chlorine or other biocides contained in sinking plumes that flow along the bottom in winter. Thermal discharges may affect the natural balance of the bacteria and algae populations, favoring the bacteria. This situation, in turn, could reduce oxygen levels by increasing the amount of decomposing materials and could adversely affect habitat formers.

The proposed studies represent a minimal data base for the evaluation of the applicant's eligibility for modification of thermal treatment technology requirements. The data are necessary for the following reasons:

A. Mapping. Aerial mapping is required for a detailed depiction of the spatial distribution of habitat formers in relation to the projected and actual plume configuration.

B. Species Composition. Species composition information will identify the types of habitat formers associated with the discharge vicinity and provide a basis for determining thermal tolerance levels for selected species. Also, baseline information on diversity is essential to determine any compositional shifts in species with the addition of heat. Species replacements are often the first signs of an impending nuisance condition that ultimately leads to costly control and eradication programs.

C. Standing Crop Estimates. Studies to determine seasonal increases in standing crop biomass serve two purposes. First, a measured increase in biomass (dry weight) of primary producers over the growing season represents a conservative estimate of net production, which in turn represents a general measure of the functional well-being of the habitat formers and hence reflects the potential well-being of the organisms dependent on them for their success. Verification of this relationship requires concomitant sampling of the habitat for the presence or absence of the principal associated species. A secondary purpose for standing crop estimates is to identify any accelerated growth of macrophytes with increasing temperatures, which could lead to nuisance conditions.

D. Identification of Threatened or Endangered Species or Dominant Species of Fish Dependent Upon Habitat Formers. This information is useful in assessing impact in the case of adverse effects from heated discharge. Potential indirect adverse impact might otherwise be overlooked.

4. Shellfish/Macroinvertebrates. Functionally the macroinvertebrate fauna serves man in numerous ways. They are an important component of aquatic food webs and many invertebrates are directly important to man as a source of high-quality protein and as bait for sport and commercial fishermen. They modify and condition aquatic substrates and also aid in the

breakdown and decomposition of detritus, thus contributing to detrital food chains, detrital transport, and nutrient cycling. Estuarine systems are particularly important because of their high productivity and their role as nursery areas for benthic species.

A thermal discharge may have a variety of effects on macroinvertebrates. Aquatic insects having an emergent stage may enter the atmosphere early as a result of artificial heating of the water. The adults may emerge into cold air and die because of exposure, because food items are not in phase, or because normal egg laying conditions do not exist. Larval forms of marine invertebrates may develop at such high metabolic rates that the survival of individuals may be reduced during settling or maturation. Thermal discharges may stress ecosystems and cause shifts in community structure such that although the total biomass may not change significantly, desirable species may be replaced by less desirable species not involved directly in the food chain. The discharge of heat may cause stratification, which may diminish dissolved oxygen in the bottom layer and possibly eliminate benthic fauna.

Specific types of data are useful for the following reasons:

A. Standing Crop Estimates. These estimates are useful in determining the importance of macroinvertebrates to the productivity of the river or stream being impacted by the discharge. As previously discussed, the productivity of the affected portion of the system is a key factor in defining low and high impact areas.

B. Community Structure. The total number of species and the relative abundance of individual species (both components of diversity) in an aquatic system are a function of the physical, chemical, and biological characteristics of the system. Because diversity is sensitive to significant changes in the characteristics of the system (such as introduced heat), it can be an indicator of environmental stress. Additionally, a reduction in the diversity of a system frequently results in a diversion of production into non-useful forms.

C. Drift. In flowing waters, drift is an important survival mechanism for many species of macroinvertebrates. Since it is a passive function, the drifting organisms are subject to lethal temperatures occurring in a thermal plume. Drift is a stepwise downstream phenomenon, and many aquatic insects have a concomitant upstream movement of reproducing adults. The plume may thus affect populations both upstream and downstream from the area where mortality actually occurs.

D. Mapping. Mapping is necessary for a detailed representation of the distribution of substrates. This graphic information is important in the design of sampling studies, evaluating the suitability of the system for various benthic forms.

5. Fish. The discharge of waste heat can affect fish populations in many ways. The various data required are necessary in order to provide characterization of the indigenous fish community for the development of the RIS concept, to identify habitat utilization by the various populations, and to provide baseline information for comparison with post-operational studies.

Specific data parameters are related to possible adverse impacts from thermal discharge:

A. Species Level. Information on the spawning habits of individual species are necessary for assessing impact because spawning times may be shifted by thermal additions or habitats may be altered by scour or by changes in the habitat former community. Habitat use by any life stage may similarly be affected. Migration is an important factor to consider because thermal discharges can block upstream migration routes of spawning adults and downstream movements of small fish. Condition factors are useful in evaluation because heat additions may cause a loss of condition in certain species, especially in winter when their metabolic rate is still high but food supply is low.

The incidence of disease and parasitism may increase with a rise in water temperature. Age and growth data are helpful in comparing affected and non-affected areas, pre- and post-operational conditions.

B. Community Level. Data on species composition, relative abundance, and principal associations will define the dominant fish species at the site. Any appreciable change in these parameters signals an imbalance in the community and may indicate an adverse impact resulting from the thermal discharge. Species information is also necessary for developing thermal limits for the effluent.

C. Mapping. Maps are required in order to represent habitat areas (used for spawning, migration, etc.) in relation to the configuration of the discharge plume.

6. Other Vertebrate Wildlife. Data will be required in relatively few cases for this biotic category. In those cases where data is required, the type of data needed is decided by the applicant. The data selected should be the least amount of data necessary to complete this section of the demonstration.

7. Representative Important Species. Making predictions about "what will happen" are difficult without detailed information on the environmental requirements of communities or at least many populations and species. As mentioned in section 3.5.2, it is not economically feasible to study each species in great detail at each site. Therefore a few species are selected for detailed laboratory and literature survey. The data requirements of Tables A and B (section 3.5.2.2) are recommended as being helpful to those making 316(a) decisions for the following reasons:

A. They allow an estimation of the size of the areas which will be excluded for key biological functions and the duration of the exclusion.

B. They provide the basis for at least rough predictions of high temperature survival, heat and cold shock, and effects on reproduction and growth.

3.6 Type III Low Potential Impact Determinations

If the Regional Administrator/Director determines, after early screening studies, that the site is one of low potential impact for all biotic categories, the applicant may elect to do a "short form" demonstration, the "Low Potential Impact Type III Demonstration." The basic concept is that those applicants which have sites and proposed facilities which obviously pose little potential threat to the balanced indigenous population should be required to do less extensive (and expensive) aquatic studies than other (more poorly sited or otherwise having more potential for adverse impact) applicants.

Type III demonstrations in general are essentially any alternative demonstration type agreed upon by the applicant and the Regional Administrator/Director. The Low Potential Impact Type III demonstration proposed here is simply a recommended "short form" demonstration which considers information from each biotic category. This ensures that no major biotic category is ignored altogether and thus ensures that both the regulatory agencies and the applicant have examined and made judgments for each biotic category, but discourages collection of excess or unneeded data.

After the preliminary screening studies and determinations that all biotic categories are of low potential impact, the applicant summarizes this information (along with engineering and hydrological data and any other pertinent information) in one master rationale and submits the demonstration to the Regional Administrator/Director.

The format of the submittal should be similar to that suggested in section 3.5.5 except that the RIS sections should be deleted.

3.7 Other Type III Demonstrations (Biological, Engineering, and Other Data)

Those applicants not qualifying for a Low Potential Impact demonstration and not desiring to do a Type II demonstration, may (with the written concurrence of the Regional Administrator/Director) do a regular Type III demonstration. A Type III demonstration provides for the submittal of any information which the Regional Administrator/Director believes may be necessary or appropriate to facilitate evaluation of a particular discharge. This demonstration also provides for submittal of any additional information which the applicant may wish to have considered. Each Type III demonstration should consist of information and data appropriate to the case.

Detailed definition of a generally applicable Type III demonstration is not possible because of the range of potentially relevant information; the developing sophistication of information collection and evaluation techniques and knowledge, and the case-specific nature of the demonstration. Prior to undertaking any Type III demonstration, the applicant should consult with and obtain the advice of the Regional Administrator/Director regarding a proposed specific plan of study and demonstration. Decision guidance may also be suggested.

If the site is one of low potential impact for most biotic categories and/or there are other factors (small size or volume of water impacted, low percentage of cross section of receiving water affected, etc.) suggesting low potential for aquatic impact, the demonstration may not need to be completed in much more detail than the Low Potential Impact demonstration outlined in section 3.6. For most other sites, the demonstration should reflect a degree of detail and degree of proof comparable to the Type II demonstration (section 3.5). While Type III information may be different in thrust and focus, proofs should be generally as comprehensive as in Type II demonstrations and should result in similar levels of assurance of biotic protection.

Each item of information or data submitted as a part of a Type III demonstration should be accompanied by rationales comparable to those outlined in sections 3.5.1 and 3.5.4. The format of the demonstration should be similar to that outlined in section 3.5.5 except that the RIS sections should be deleted.

3.8 Decision Criteria

3.8.1 Biotic Categories

Decision criteria for each biotic category are given in section 3.3. The Regional Administrator/Director will compare the rationales (and other data) for each biotic category with the decision criteria in section 3.3 and determine if the decision criteria have been met.

3.8.2 Representative Important Species

The Regional Administrator/Director will find the Representative Important Species Rationale and other RIS information to be unacceptable if the information presented:

1. is too incomplete to allow a clear assessment; or

2. suggests (or does not provide a convincing argument to the contrary) that the balanced indigenous population may suffer appreciable harm because of:

   A. high temperature survival factors;

   B. heat or cold shock;

   C. improper temperature for growth, development, and reproduction; or

   D. the exclusion of areas and volumes of water from the above functions in critical combinations of time and space.

3.8.3 Resource Zones in Aquatic Systems

The strategies for reproduction, growth, and survival of the indigenous biota of freshwater, estuarine, and marine ecosystems are keyed to spatial and temporal variations in the structure (physical and chemical) of the environment. This structural variation in the environment, as it relates to the biota and to uses by man, has led to the concept of resource or "value zones" for use in evaluating or predicting the level of damage to aquatic systems from human activities. Since such zones vary in location, size, season of utilization, and criticality of function, their identification is also useful in planning purposes such as the siting of mixing zones for heated discharges. Application of this concept involves the identification and mapping of resource zones and critical functions* so that mixing zones can be sited in areas having minimum adverse impact on aquatic resources. Basic precepts necessary to application of the resource zoning concept include:

1. All discharges in the water body segment must be considered.

2. The acceptable area of damage is related to the resource value of the impacted area.

3. In cases where the effects of the discharged waste are transitory, the timing of mixing zone use is related to seasonal utilization of the impacted area.

4. The acceptable area of damage is related to the total amount of equivalent area available in the water body segment.

5. Areas supporting "critical functions" should be avoided (note item 3 above).

6. Acceptable damage is related to species generation time and/or fecundity.

7. For a given location, the smaller the damaged area the better.

3.8.3.1 Typical Resource Value Zones.

The following annotated list includes resource value zones which should be considered in the designation of mixing zones for heated discharges:

1. Spawning Sites. Reproduction is obviously a critical function in the survival of a species. Two factors of importance in designating mixing zones are the often limited area of habitat suitable for the spawning of a species and the limited time during which spawning occurs.

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* A zone having a "critical function" is one that provides a major contribution to primary productivity or is one that is limited in extent and necessary for the propagation and survival of a species.

If the availability of spawning sites for an important species is limited in extent, then such areas can generally be avoided and should not be designated for the disposal of waste heat. If it is totally impossible to avoid such sites, then the use for mixing should be timed to avoid the period of spawning. Seasonal avoidance is only feasible if the effects of the discharge are transitory.

2. <u>Food-Producing Areas</u>. The productivity of aquatic systems is directly related to the inputs of organic matter from green plants. The free-floating, relatively immotile microscopic plants (phytoplankton) are short-lived with rapid turnover rates and thus may not be critical in terms of mixing zones for heated discharges. The rooted vascular plants and macroalgae (macrophytes) which, with suitable substrate, grow from the shoreline to the depth of the photic zone (depth to which 1 percent of incident light penetrates) are relatively long-lived and perform a number of "critical functions" including:

   A. The production and export of vast quantities of organic fuel in the form of detritus—some are among the most productive plant communities known.

   B. As a result of an abundance of food and cover, they serve as nursery areas for the immature stages of many finfish and shellfish.

   C. The trapping and recycling of nutrients.

   D. The stabilization and building of substrate.

   Included in the category of food-producing areas are the wetlands—the interface between terrestrial and aquatic environments—which, in addition to the above enumerated functions, serve as freshwater recharge areas that meter freshwater inputs to lakes, rivers, and estuaries.

   Because of the many important and critical functions performed, the wetlands and other areas of macrophyte production in aquatic systems should be avoided when planning and designating mixing zones for heated discharges.

3. <u>Nursery Areas</u>. These are areas having an abundance of food and cover for the growth and development of the early life stages of many finfish and shellfish. Since the early life stages are the periods of maximum growth rates and maximum vulnerability to predation, the availability of suitable nursery areas may be the limiting factor determining the abundance of a species. Thus, the zones of freshwater, estuarine, and marine ecosystems identified as nursery areas have high resource value and should generally be avoided when designating mixing zones.

4. <u>Migratory Pathways</u>. Included in this category are routes utilized for movement to and from spawning grounds, feeding grounds, and nursery areas; thus, the life stage involved may be adult, egg, larval, or juvenile. In some cases, these pathways are very circumscribed; and total blockage could result in extermination of a population in the water body segment. Since these pathways serve a "critical function," they have high resource value and should be avoided when planning the discharge of waste heat. In situations where the usage of pathways is seasonal and the effects of the discharge are transitory, deleterious effects may be avoided by proper timing of disposal. In terms of power plants, this seasonal usage is important in evaluating the feasibility of seasonal mode operation of cooling devices.

A consideration of zones critical to endangered species, usage by waterfowl and wildlife, and shellfish beds are additional resource values that must be considered when selecting mixing zones for heated discharges.

<u>3.8.3.2</u> <u>Methodology</u>.

As discussed above, discharge sites should be selected which will have the least impact on important resource zones and "critical functions." The application of this concept to the selection of mixing zones is a stepwise procedure involving:

- A definition of the water body segment.

- Selection and listing of RIS in the water body segment and an enumeration of their strategies for propagation and survival.

- Preparation of a map of the water body segment showing zones of resource use, including areas supporting "critical functions."

- Assignment of a numerical value, per unit area, to each resource use.

- Superimpose predicted plumes on resource maps and select sites having least adverse impact on resource values.

1. Water Body Segment. In lakes and estuaries having discrete and easily definable physical boundaries, the designation of the water body segment will be a straightforward process. In large water bodies such as the Great Lakes, open coastal sites, and major river systems having no definable and reasonably sized physical boundaries, the selection of the water body segment may pose a difficult problem. Where they have been defined, the water body segments determined by the State Continuing Planning Process under section 303(e) of the Act will apply.

   The seasonal movements of important species of aquatic life must be considered when defining a water body segment. The spawning sites, nursery sites, and adult habitat sites of many freshwater and marine species (examples include salmonids, shrimps, crabs, spot, croaker, flounder, white bass, walleye, etc.) may be widely separated and include physically different water bodies. Seemingly slight impacts in the different areas used by such species may result in effects which, if considered cumulatively, would be intolerable. To avoid the potentially disastrous consequences of piecemeal consideration of adverse impacts, the water body definition should be sufficient to consider potential impacts throughout the contiguous range of populations of important species.

2. Representative Important Species. In general, this should include all species and communities of species that are critical to the functioning and the productivity of the aquatic system defined by the water body segment. Specifically included are species or communities which are:

   - Commercially and/or recreationally valuable.

   - Threatened or endangered.

- Primary producers—particularly those communities supporting relatively long-lived, fixed-location species that perform multiple services (form and stabilize habitat, produce organic matter, provide cover).

- Necessary (e.g., in the food chain) for the well-being of species determined in 1 and 2 above. Included here are the scavengers and decomposers critical to the breakdown and utilization of organic matter.

3. Map Preparation. Maps of the water body segment should, as a minimum, include depth contours, adjacent wetlands, tributaries and, in estuarine situations, the average salinity gradient and salinity stratification should be visually expressed in cross section. Resource zones and areas performing "critical functions" should be superimposed on the same or on a similarly scaled map. To avoid overlapping detail, it may sometimes be desirable to prepare separate maps for selected species.

4. Assignment of Values. Once the resource zones and zones supporting "critical functions" have been identified and mapped, then values per unit area can be assigned. If the effects of the discharge are transitory and the use of the resource zone is seasonal, the values may change throughout the year. If the zone supporting a "critical function" is limited in extent and is a function which limits the abundance and/or survival of a species, then that zone should be given a value of infinity and thus excluded from mixing zone use. Other zones may be assigned values according to their area and their importance in maintaining different species.

3.8.4 "Master" Rationale, Demonstration As a Whole

The Regional Administrator/Director will find the demonstration successful if:

1. It is found to be acceptable in all of the considerations outlined in steps 20-25 of the decision train (section 3.3.2).

2. There is no convincing evidence that there will be damage to the balanced, indigenous community, or community components, resulting in such phenomena as those identified in the definition of appreciable harm.

3. Receiving water temperatures outside any (State established) mixing zone will not be in excess of the upper temperature limits for survival, growth, and reproduction, as applicable, of any RIS occurring in the receiving water.

4. The receiving waters are not of such quality that in the absence of the proposed thermal discharge excessive growths of nuisance organisms would take place.

5. A zone of passage will not be impaired to the extent that it will not provide for the normal movement of populations of RIS, dominant species of fish, and economically (commercial or recreational) species of fish, shellfish, and wildlife.

6. There will be no adverse impact on threatened or endangered species.

7. There will be no destruction of unique or rare habitat without a detailed and convincing justification of why the destruction should not constitute a basis for denial.

8. The applicant's rationales present convincing summaries explaining why the planned use of biocides such as chlorine will not result in appreciable harm to the balanced indigenous population.

3.9 Non-Predictive Demonstrations (Type I, Absence of Prior Appreciable Harm)

All of the demonstrations done for NRC under the Memorandum of Understanding are predictive. Therefore, the predictive sections of this document were completed first. The EPA and other agencies may decide to mount a separate effort to revise this section at a later date. In the meantime, most of the requirements of section 3.2 (Decision Train), 3.3 (Early Screening Procedures), 3.5 (Type II), and 3.6-3.8, are applicable for determining lack of appreciable harm (Type I demonstrations). The primary language which is inappropriate and should be deleted is the language on predictive factors, predictive models, and Representative Important Species (sections 3.5.2, parts of other sections, and section 3.8.2).

4.0 Definitions and Concepts

The definitions and descriptions in this section pertain to a number of terms and concepts which are pivotal to the development and evaluation of 316(a) studies. These are developed for a general case to aid the Regional Administrator/Director in delineating a set of working definitions and concise endpoints requisite to a satisfactory demonstration for a given discharge.

Adverse Environmental Impact

Adverse aquatic environmental impacts occur whenever there will be damage as a result of thermal discharges. The critical question is the magnitude of any adverse impact.

The magnitude of an adverse impact should be estimated both in terms of short term and long term impact with reference to the following factors:

(1) Absolute damage (# of fish or percentage of larvae thermally impacted on a monthly or yearly basis);

(2) Percentage damage (% of fish or larvae in existing populations which will be thermally impacted, respectively);

(3) Absolute and percentage damage to any endangered species:

(4) Absolute and percentage damage to any critical aquatic organism

(5) Absolute and percentage damage to commercially valuable and/or sport fisheries yield; or

(6) Whether the impact would endanger (jeopardize) the protection and propagation of a balanced population of shellfish and fish in and on the body of water to which the cooling water is discharged (long term impact).

Aquatic Macroinvertabrates

Aquatic macroinvertabrates are those invertabrates that are large enough to be retained by a U.S. Standard No. 30 sieve (0.595-mm openings) and generally can be seen by the unaided eye.

Area of Potential Damage

The area of potential damage for RIS is defined as that area *of the thermal plume enclosed by the isotherm which coincides with the* appropriate (designated by the Regional Administrator/Director) water quality criteria for that particular RIS. This area can be determined from the plume rose data specified in section 3.5.3.

Balanced, Indigenous Community

The term "balanced, indigenous community" as defined here is consistent with the term "balanced, indigenous population" in section 316(a) of the Federal Water Pollution Control Act and 40 CFR section 122.9. A balanced, indigenous community consists of desirable species of fish, shellfish, and wildlife, including the biota at other trophic levels which are necessary as a part of the food chain or otherwise ecologically important to the maintenance of the community. In keeping with the objective of the Act, the community should be consistent with the restoration and maintenance of the biological integrity of the water. (See section 101(a).) However, it may also include species not historically native to the area which:

1. Result from major modifications to the water body (impoundments) or to the contiguous land area (deforestation attributable to urban or agricultural development) which cannot reasonably be prevented, removed, or altered.

2. Result from management intent, such as deliberate introduction in connection with a wildlife management program.

3. Are species or communities whose value is primarily scientific or aesthetic.

For purposes of a 316(a) demonstration, distribution and composition of the indigenous population should be defined in terms of the population which would be impacted by the thermal discharge caused by the alternative effluent limitation proposed under 316(a). A determination of the indigenous population should take into account all impacts on the population except the thermal discharge. then, the discrete impact of the thermal discharge on the indigenous population may be estimated in the course of a 316(a) demonstration. In order to determine the indigenous population which will be subject to a thermal discharge under an alternative 316(a) effluent limitation, it is necessary to account for all non-thermal impacts on the population such as industrial pollution, commercial fishing, and the entrapment and entrainment effects of any withdrawal of cooling water through intake structures under the alternative 316(a) effluent limitation. The above considerations will then make it possible to estimate the true impact of the thermal discharge on the population.

Balanced, Indigenous Population (BIP)

For the purposes of 316(a) demonstrations, the term "balanced, indigenous population" is synonymous with the term "balanced, indigenous community" as defined above.

Community

A community in general is any assemblage of populations living in a prescribed area or physical habitat; it is an organized unit to the extent that it has characteristics additional to its individual and population components, and functions as a unit through coupled metabolic transformations.

Critical Function Zone

A zone that provides a major contribution to primary productivity or is one that is limited in extent and necessary for the propagation and survival of a species.

Director

The Director of the State NPDES permit program in those States which have been delegated the program by EPA.

Discharge Vicinity

The "discharge vicinity" is that area described by a radius that is 1.5 times the maximum distance from point of discharge to within 1°C of ambient. The area of the discharge vicinity is based on a 30-50% variation in the predictive thermal plume modeling.

Dominant Species

Dominant species are defined as any species representing five percent of the total number of organisms in the sample collected according to recommended sampling procedures.

Estuary

An estuary is defined as a semi-enclosed coastal body of water which has a free connection with the open sea; it is thus strongly affected by tidal action, and within it sea water is mixed (and usually measurably diluted) with fresh water from land drainage. It may be difficult to precisely delineate the boundary of estuarine and river habitats in the upper reaches of a fresh water river discharging into marine waters. The interface is generally a dynamic entity varying daily and seasonally in geographical location. In such cases, determination of habitat boundaries should be established by mutual agreement on a case-by-case basis. Where boundary determination is not clearly established, both estuary and river habitat biological survey requirements should be satisfied in a combined determination for environmental effects and best available technology for minimizing adverse impact.

Far Field Effect

A far field effect is any perturbation of the aquatic ecosystem outside of the primary study area that is attributable to, or could be expected, from the thermal discharge (taking into account the interaction of the thermal component with other pollutants).

Far Field Study Area (FFSA)

The far field study area is that portion of the receiving water body, exclusive of the primary study area, in which impacts of the thermal discharge and its interaction with other pollutants are likely to occur. The area shall include:

1. The zones where the habitats are comparable to those existing in the primary study area, and

2. The zones inhabited by populations of organisms that may encounter the thermal effluent during their life history.

The actual boundary of the far field study area should be agreed upon by the Regional Administrator/Director.

Habitat Formers

Habitat formers are any assemblage of plants and/or animals characterized by a relatively sessile life stage with aggregated distribution and functioning as:

1. A living and/or formerly living substrate for the attachment of epibiota;

2. Either a direct or indirect food source for the production of shellfish, fish, and wildlife;

3. A biological mechanism for the stabilization and modification of sediments and contributing to the development of soil;

4. A nutrient cycling path or trap; or

5. Specific sites for spawning and providing nursery, feeding, and cover areas for fish and shellfish.

Macroinvertebrates

For this document, the term "macroinvertebrates" may be considered synonymous with "aquatic macroinvertebrates" as defined above.

Meroplankton

For the purposes of this document, meroplankton are defined as planktonic life stages (often eggs or larvae) of fish or invertebrates.

Migrants

Migrants are nonplanktonic organisms that are not permanent residents of the area but pass through the discharge zone and water contiguous to it. Examples include the upstream migration of spawning salmon and subsequent downstream migration of the juvenile forms, or organisms that inhabit an area only at certain times for feeding or reproduction purposes.

Nuisance Species

Any microbial, plant or animal species which indicates a hazard to ecological balance or human health and welfare that is not naturally a dominant feature of the indigenous community may be considered a nuisance species.

Nuisance species of phytoplankton include those algae taxa which in high concentration are known to produce toxic, foul tasting, or odoriferous compounds to a degree that the quality of water is impaired.

Other Vertebrate Wildlife

The term "other vertebrate wildlife" includes wildlife which are vertebrates (i.e., ducks, geese, manatees, etc.) but not fish.

Phytoplankton

Plant microorganisms such as certain algae, living unattached in the water.

Plankton

Organisms of relatively small size, mostly microscopic, that either have relatively small powers of locomotion or drift in the waters subject to the action of waves and currents.

Primary Study Area

The primary study area is the entire geographic area bounded annually by the locus of the 2°C above ambient surface isotherms (determined in section 3.5.3.5) as these isotherms are distributed throughout an annual period. The reference ambient temperature shall be recorded at a location agreed upon by the Regional Administrator/ Director.

Principal Macrobenthic Species

Principal macrobenthic species are those dominant macroinvertebrates and plants attached or resting on the bottom or living in bottom sediments. Examples include, but are not limited to, crustaceans, mollusks, polychaetes, certain macroalgae, rooted macrophytes, and coral.

Regional Administrator (Director)

This term refers to the Regional Administrator of the U.S. EPA except that in those States which have been delegated the NPDES permit program, the term refers to the Director of the State NPDES permit program.

Representative, Important Species (RIS)

Representative, important species are those species which are: representative, in terms of their biological requirements, of a balanced, indigenous community of shellfish, fish, and wildlife in the body of water into which the discharge is made. Specifically included are those species which are:

1. Commercially or recreationally valuable (i.e., within the top ten species landed—by dollar value);

2. Threatened or endangered;

3. Critical to the structure and function of the ecological system (e.g., habitat formers);

4. Potentially capable of becoming localized nuisance species;

5. Necessary in the food chain for the well-being of species determined in 1-4; or

6. Representative of the thermal requirements of important species but which themselves may not be important.

Shellfish

All mollusks and crustaceans (such as oysters, clams, shrimp, crayfish, and crabs) which, in the course of their life cycle, constitute important components of the benthic, planktonic, or nektonic fauna in fresh and salt water.

Threatened or Endangered Species

A threatened or endangered species is any plant or animal that has been determined by the Secretary of Commerce or the Secretary of the Interior to be a threatened or endangered species pursuant to the Endangered Species Act of 1973, as amended.

Water Body Segment

A water body segment is a portion of a basin the surface waters of which have common hydrologic characteristics (or flow regulation patterns); common natural physical, chemical, and biological processes, and which have common reactions to external stress, e.g., discharge of pollutants. Where they have been defined, the water body segments determined by the State Continuing Planning Process under section 303(e) of the Federal Water Pollution Control Act apply.

Zooplankton

Animal microorganisms living unattached in water. They include small crustacea such as daphnia and cyclops, and single-celled animals such as protozoa, etc.

GUIDANCE
FOR EVALUATING THE
ADVERSE IMPACT OF COOLING WATER
INTAKE STRUCTURES ON THE AQUATIC ENVIRONMENT:
SECTION 316(b) P.L. 92-500

U.S. Environmental Protection Agency
Office of Water Enforcement
Permits Division
Industrial Permits Branch
Washington, D.C.

May 1, *1977*

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I. STATEMENT OF WORK

The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) require cooling water intake structures to reflect the best technology available for minimizing adverse environmental impact.

Cooling water intakes can adversely impact aquatic organisms basically in two ways. The first is entrainment, which is the taking in of organisms with the cooling water. The organisms involved are generally of small size, dependent on the screen mesh size, and include phyto- and zooplankton, fish eggs and larvae, shellfish larvae, and many other forms of aquatic life. As these entrained organisms pass through the plant they are subjected to numerous sources of damage. These include mechanical damage due to physically contacting internal surfaces of pumps, pipes and condensers; pressure damage due to passage through pumps; shear damage due to complex water flows; thermal damage due to elevated temperatures in condenser passage, and toxicity damage caused by the addition of biocides to prevent condenser fouling and other corrosives. Those organisms which survive plant passage potentially could experience delayed mortality when returned to the receiving water.

The second way in which intakes adversely impact aquatic life is through entrapment-impingement. This is the blocking of larger entrained organisms that enter the cooling water intake by some type of physical barrier. Most electric generating plants have screening equipment (usually 3/8" mesh) installed in the cooling water flow to protect downstream equipment such as pumps and condensers from damage or clogging. Larger organisms, such as fish which enter the system and cannot pas through the screens, are trapped ahead of them. Eventually, if a fish cannot escape or is not removed, it will tire and become impinged on the screens. If impingement continues for a long time period the fish may suffocate because the water current prevents gill covers from opening. If the fish is impinged for a short period and removed, it may survive; however, it may lose its protective slime and/or scales through contact with screen surfaces or from the high pressure water jets designed to remove debris from the screens. Delayed mortality to many species of fish following impingement may approach 100 percent. For some species of fish, the intake represents a double jeopardy situation where the same population will be subject to increased mortality through entrainment of eggs and larvae and additional mortality to juveniles and adults through impingement.

The data presently available on the magnitude of entrainment losses at existing electric generating stations, although just beginning to accumulate, reveals very large numbers of fish passing through some facilities. Results of one of these studies, conducted at the Detroit Edison plant on Lake Erie near Monroe, Michigan, indicate that 400-800 million fish larvae may have passed through that plant during April-August 1974.[37] The fate of these larvae has not yet been determined but the data from previous years indicate that some may have disintegrated during passage through the plant.

Other studies have shown that mortality may be high among fish larvae that pass through plant cooling systems[4, 38] due mainly to mechanical damage or shearing forces.[2, 5] The circulating pump has been identified as the most likely site for mechanical damage.[4, 5] Coutant and Kedl[39] in a simulation study have demonstrated that the condenser tubes are an unlikely site for mechanical damage to occur.

A large amount of data are available on the magnitude of entrapment-impingement losses at cooling water intakes. The data available on fish losses at Great lakes cooling water intakes have been summarized by Edsall.[40] He reported the following losses:

> About 92,000 pounds of gizzard shad at the Ontario Hydro Lambton plant on the St. Clair River in 6 weeks during December 1971 - January 1972; 82,187 pounds (nearly 1.1 million individuals) at the Detroit Edison Company's plant on Lake Erie near Monroe, Michigan between April 1972 and march 1973, when the plant was operating at less than maximum capacity; 36,631 pounds (584,687 fish) at the Consumers Power Company's Palisades plant on Lake Michigan between July 1972 and June 1973, when the plant was operating at about 68 percent of its total capacity (the plant is now closed cycle); an estimated 1.2 million fish (no weight data given) at Commonwealth Edison's Waukegan (Illinois) plant on Lake Michigan between June 1972 and June 1973; 150,000 pounds of fish at the Ontario Hydro Pickering plant on Lake Ontario in April-June 1973; 659,000 fish (weight unavailable) at the Nine Mile Point plant generating unit number one on Lake Ontario during intermittent sampling from January-December 1973, representing an estimated total of about 5 million fish at unit one for that period; and about 67,950 pounds (929,000 fish) at Commonwealth Edison's Zion plant near Zion, Illinois, on Lake Michigan

during September-December 1973 and March-June 1974, when the monthly cooling water flow averaged only about 45 percent of the maximum capacity.

Approximately 14,000 fish of 44 species were impinged in 1974 at the Northern States Power Prairie Island Plant on the Mississippi River.[41] The Commonwealth Edison Company's Quad Cities Plant, also on the Mississippi River, impinged an estimated 1.8 million fish during 1974.[42]

The extent of fish losses of any given quantity needs to be considered on a plant-by-plant basis, in that the language of section 316(b) of P.L. 92-500 requires cooling water intakes to "minimize adverse environmental impact." Regulatory agencies should clearly recognize that some level of intake damage can be acceptable if that damage represents a minimization of environmental impact.

II. INTRODUCTION

This guidance manual describes the studies needed to evaluate the impact of Cooling water intake structures on the aquatic environment and allow for determination of the best technology available for minimizing adverse environmental impact. The 1972 amendments to the Federal Water Pollution Control Act (P.I,. 92-500) require in section 316(b) that:

> Any standard established pursuant to section 301 or sect ion 306 of this Act and applicable to a point source shall require that the location, design, construction and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.

Sections 301 and 306 of the Act refer to the development of effluent limitations and dates for achievement of various standards of performance for existing and new sources of waste discharges. The steam-electric generating point source category is the largest user of cooling water in the United States and this guidance manual is directed primarily at this category. Other categories of point source dischargers such as iron and steel and petrochemicals for which intakes withdraw a major portion for cooling water would also require such a determination. This document is intended for use by the U.S. Environmental Protection Agency (EPA), State water pollution control agencies, industry, and members of the public who may wish to participate in such determinations.

The overall goal of conducting intake studies should be to obtain sufficient information on environmental impact to aid in determining whether the technology selected by the company is the best available to minimize adverse environmental impact. In the case of existing plants, this goal will be accomplished by providing reliable quantitative estimates of the damage that is or may be occurring and projecting the long-range effect of such damage to the extent reasonably possible. In the case of proposed intakes, reliable estimates of any future damage are to be obtained through the use of historical data, pre-operational models, and the operating experience of other plants.

General guidance is provided for the development, conduct, and review of surveys designed to determine and evaluate that portion of aquatic biota potentially involved with and subject to adverse environmental impact from cooling water intake structures. Guidance is also supplied for the analytical methodology needed to determine the extent and importance of aquatic environmental impacts. The environment-intake interactions in question are highly site specific and the decision as to best technology available for intake design, location, construction, and capacity must be made on a case-by-case basis.

Information is not provided on available intake technology. Such information is contained in the "Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling-water Intake Structures for Minimizing Adverse Environmental Impact,"[47] which also contains additional references on intake impacts. Information is also not provided on non-aquatic impacts of cooling water intake structures.

This document will be most useful in situations where siting and intake design have not been finalized; however, procedures to determine and evaluate the environmental impact of existing cooling water intakes are included.

Readers are cautioned not to depend too heavily on this manual. More specific advice as regards procedures and individual site evaluations will be available from the agency staff responsible for decision making and the biologists who best understand the area in question.

III. INFORMATION FLOW CHART

The development of 316(b) programs is a new procedure for many regulatory agencies and user groups. To assist in an orderly processing of data requirements for both existing and new cooling water intakes, flow charts have been developed (Figures 1, 2, and 3).

The process for evaluating existing intakes (Figure 1) is intended to be flexible so that the data requirements can be revised based on an agency determination of the potential for adverse impact and the availability of data on the plant's intake. It is expected that for some existing plants, sufficient data may already exist to make further studies unnecessary for a decision regarding best technology available. The process for new intakes (Figures 2 and 3) is more extensive because of requirements for data acquisition and models prior to site review and approval by the appropriate regulatory agency. Proper intake siting, in many cases, is the only way of minimizing adverse environmental impact. To obtain the necessary pre-siting perspective, the utilization of valid historical data and local knowledge is essential. A one- to three-year biological survey is required to obtain, in a preliminary fashion, the necessary data for assessment of environmental impact. A one-year survey is generally of limited value. However, in circumstances where substantial valid historical data can be presented and the intake can be represented as having low potential impact, a one-year survey may be acceptable. A decision as to the appropriate number of years of preoperational data that are necessary will be made by the agency upon the submission of proposed study plans and their justification (see flow charts, Figures 2 and 3).

The type and extent of biological data appropriate in each case will be determined by the actual or anticipated severity or adverse environmental impact. Since the expected impact will vary, it is not expected that each case will require the same level of study.

A decision will be made at the outset by the agency as to whether the intake has high or low potential impact. Low potential impact intakes are generally those in which the volume of water withdrawn comprises a small percentage of the source water body segment and are located in biologically unproductive areas, or that have historical data shoving no effect, or which have other considerations indicating reduced impact. High potential impact intakes will generally require extensive field surveys or models to elucidate potential total water body effects. New intakes will provisionally be considered high impact until data is presented in support of an alternate finding.

Figure 1. 316(b) FLOW CHART
EXISTING INTAKES

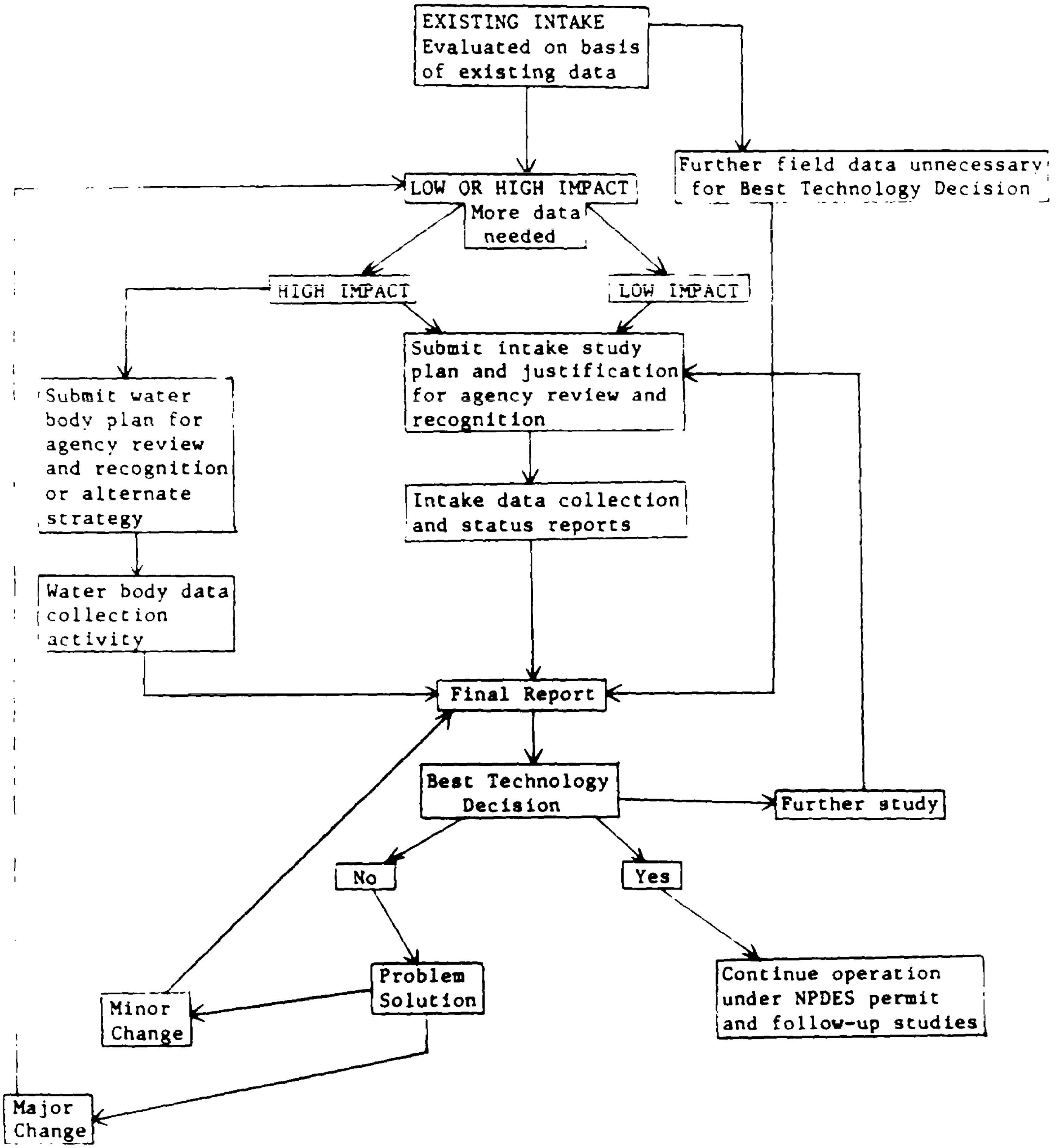


Figure 2. 316(b) FLOW CHART

NEW SOURCE INTAKES

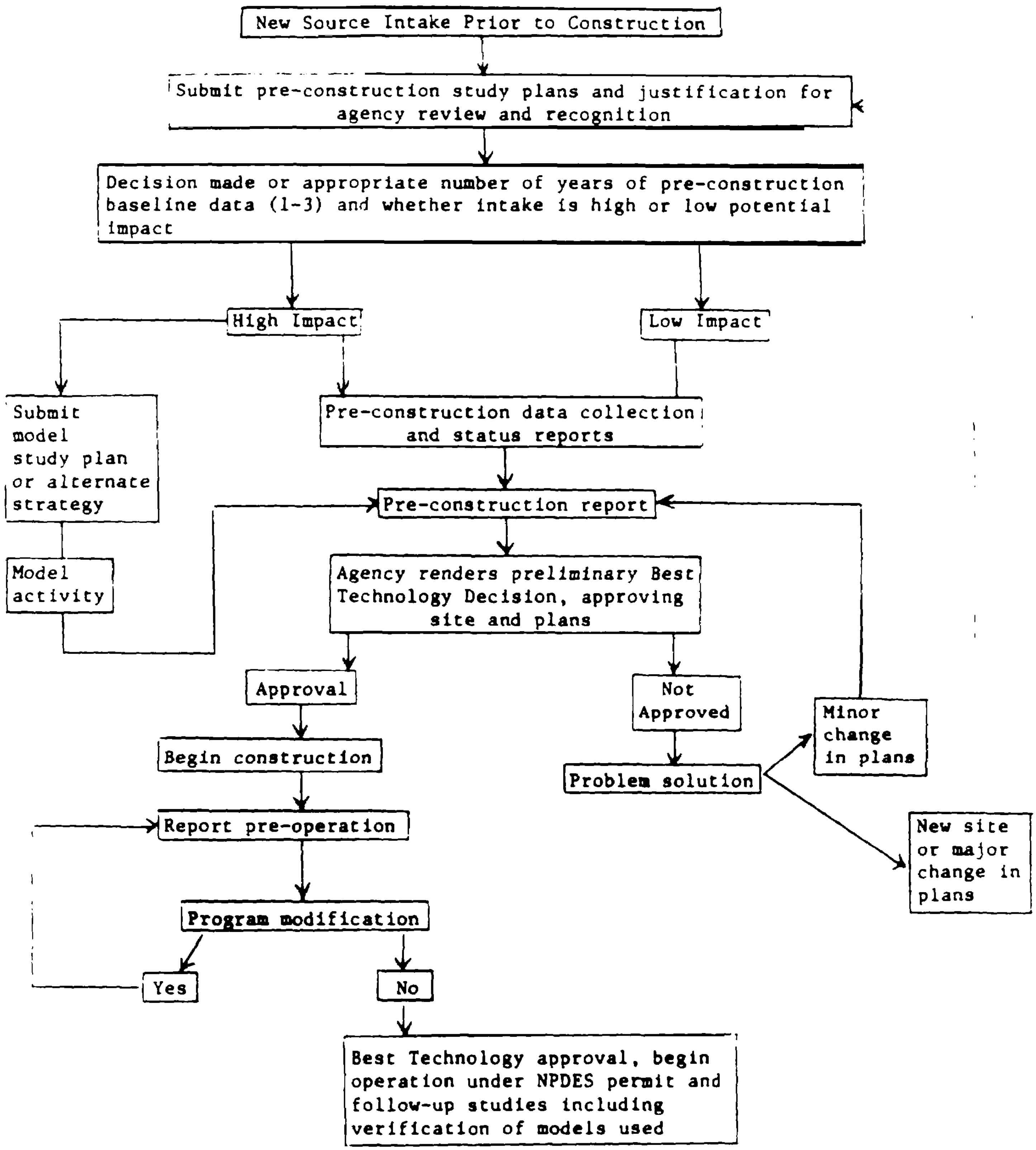
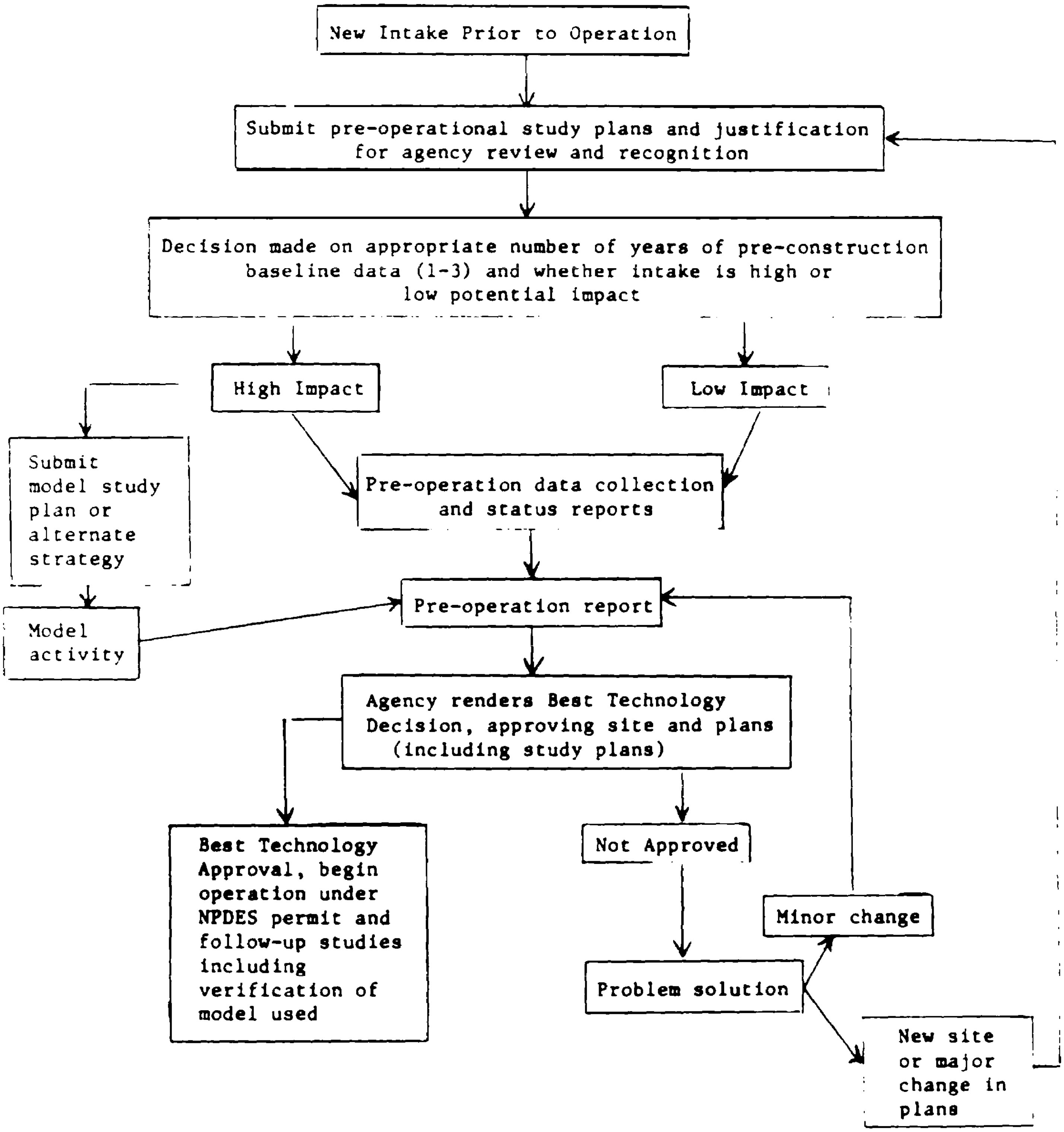


Figure 3. 316(b) FLOW CHART

NEW INTAKES (Not New Source)



The inclusion of several points in the flow chart for agency review and approval will ensure that all parties are in agreement as to the scope and specific details of work planned and will provide each party with a set of specific goals and schedules for completion. These review points should also ensure that studies address the important environmental and plant operational concerns of all parties, thereby resulting in timely and orderly completion. A further benefit from such review is that studies conducted throughout a water body segment can be coordinated so that methods utilized will result in a comparable data base. This uniform data base will allow for easier evaluation of any subsequent cumulative effect from all intakes operating on a water body.

IV. DECISION CRITERIA

Adverse aquatic environmental impacts occur whenever there will be entrainment or impingement damage as a result of the operation of a specific cooling water intake structure. The critical question is the magnitude of any adverse impact. The exact point at which adverse aquatic impact occurs at any given plant site or water body segment is highly speculative and can only be estimated on a case-by-case basis by considering the species involved, magnitude of the losses, years of intake operation remaining, ability to reduce losses, etc. The best guidance that can be provided to agencies in this regard would be to involve professional resource people in the decision-making process and to obtain the best possible quantitative data base and assessment tools for evaluation of such impacts. The Development document for 316(b) [47] is an essential reference for guidance in these evaluations.

Some general guidance concerning the extent of adverse impacts can be obtained by assessing the relative biological value of the source water body zone of influence for selected species and determining the potential for damage by the intake structure. For a given species, the value of an area is based on the following considerations:

1. principal spawning (breeding) ground;
2. migratory pathways;
3. nursery or feeding areas;
4. numbers of individuals present; and
5. other functions critical during the life history.

A once-through system for a power plant utilizes substantially more water from the source water body than a closed recirculating system for a similar plant and thus would tend to have a higher potential impact. A biological value-potential impact decision matrix for best intake technology available could be:

BIOLOGICAL VALUE	COOLING WATER FLOW (Relative to Source Water Body Segment)	
	HIGH	LOW
High	No	Questionable
Low	Questionable	Yes

(1) An open system large volume intake in an area of high biological value does not represent best technology available to minimize adverse environmental impact and will generally result in disapproval.

Exceptions to this may be demonstrated on a case-by-case basis where, despite high biological value and high cooling water flow, involvement of the biota is low or survival of those involved is high, and subsequent reduction of populations is minimal.

(2) Generally, the combination of low value and low flow most likely is a reflection of best technology available in location, design, and operation of the intake structure. Exceptions to this could involve significantly affected rare and endangered species.

(3) Other combinations of relative value-impact present the most difficult problems. In such circumstances, the biological survey and data analysis requires the greatest care and insight in accomplishing the impact evaluation upon which the judgment of best technology available is based. A case-by-case study is required and local knowledge and informed judgment are essential.

It is accepted that closed cycle cooling is not necessarily the best technology available, despite the dramatic reduction in races of water used. The appropriate technology is best determined after a careful evaluation of the specific aspects at each site. A detailed discussion of available intake technology is contained in the 316(b) Development Document.[47]

Biological survey requirements suggested in this manual should provide a sufficient data base to provide insight as to the best location, design, construction, and capacity characteristics appropriate for achieving minimal total impact.

A stepwise thought process[47] is recommended for cases where adverse environmental impact from entrapment/impingement is occurring and must be minimized by application of best technology available:

The first step should be to consider whether the adverse impact will be minimized by the modification of the existing screening systems.

The second step should be to consider whether the adverse impact will be minimized by increasing the size of the intake to decrease high approach velocities.

The third step should be to consider whether to abandon the existing intake and to replace it with a new intake at a different location and to incorporate an appropriate design in order to minimize adverse environmental impact.

Finally, if the above technologies would not minimize adverse environmental impact, consideration should be given to the reduction of intake capacity which may necessitate installation of a closed cycle cooling system with appropriate design modifications as necessary.

Where environmental impact from entrainment must be minimized, reliance must be placed primarily on flow reduction and intake relocation as remedial measures:

Reducing cooling water flow is generally an effective means for minimizing potential entrainment impact. In fact, this may be the only feasible means to reduce impact of entrainment where potentially involved organisms are in relatively large concentration and uniformly distributed in the water column. Entrapment and impingement may also be lessened with lower flow as proportionally fewer animals will be subject to contact with the intake structure; water velocities associated with the structure can be reduced, enhancing probability of survival if impinged or of escape if trapped. Reduction of flow is accomplished primarily by an increase in condenser temperature rise or through recirculating cooling systems. When cooling water flow is reduced, however, elevated temperature or the effects of an auxiliary cooling system can increase the mortality rate of the organisms that are entrained.

Site location measures may prove effective in areas of discontinuous, temporal or spatial occurrence (patchiness) of those species subject to entrainment (or entrapment/impingement).

Enhancing survival of organisms once entrained in the cooling water system generally appears to be the least effective means for avoiding adverse impact; however, operational regimes have been developed to decrease mortality of entrained species where heat, chlorine or both exert the predominant impact. Realistic laboratory studies can lead to optimal time-temperature regimes for survival. The effects of biocides can be reduced by intermittent and "split-stream" chlorination procedures. Mechanical methods for cleaning cooling system components where feasible can eliminate or reduce the need for biocides. The mechanical stress of entrainment is, in many cases, the critical factor in organism survival with the pump the site of major damage. At present, little can be done to minimize mechanical impact although potentially harmful effects may possibly be reduced by pump redesign which incorporates low RPM, low pressure and wide clearance characteristics. Reducing velocity changes, pressure, and turbulence in the piping system should prove helpful. Entrainment screening techniques such as leaky dams may have application in some circumstances. Regardless of beneficial measures taken, many fragile forms will not survive entrainment.

In summary, the location of a power plant, or other cooling water use, coupled with the associated intake structure design, construction, and capacity results in a unique situation. While generalities may be useful, the optimal combination of measures effectively minimizing adverse impact on the biota is site and plant specific. The best technology available should be established on a case-by-case basis making full use of the kinds of information suggested for acquisition in this manual.

V. DEFINITIONS AND CONCEPTS

Adverse Environmental Impact

Adverse aquatic environmental impacts occur whenever there will he entrainment or impingement damage as a result of the operation of a specific cooling water intake structure. The critical question is the magnitude of any adverse impact.

The magnitude of an adverse impact should be estimated both in terms of short term and long term impact with reference to the following factors:

(1) Absolute damage (# of fish impinged or percentage of larvae entrained on a monthly or yearly basis);

(2) Percentage damage (% of fish or larvae in existing populations which will be impinged or entrained, respectively);

(3) Absolute and percentage damage to any endangered species;

(4) Absolute and percentage damage to any critical aquatic organism;

(5) Absolute and percentage damage to commercially valuable and/or sport fisheries yield; or

(6) Whether the impact would endanger (jeopardize) the protectton and propagation of a balanced population of shellfish and fish in and on the body of water from which the cooling water is withdrawn (long term impact).

Agency

This term refers to the Regional Administrator of the U.S. Environmental Protection Agency or the Directors of those State agencies authorized to issue NPDES permits.

Community

A community in general is any aseemblage of populations living in a prescribed area or physical habitat; it is an organized unit to the extent that it has characteristics in addition to its individual and population components and functions as a unit through interacting metabolic transformations.

Critical Aquatic Organisms

Adverse environmental impact may be felt by many species in all trophic levels. A species need not be directly affected but nevertheless harmed due to loss of food organisms or other associated organisms in some way necessary for the well-being and continued survival of the population. It is not practicable to study all species that may be directly or indirectly harmed by Intake structure operations.

The critical aquatic organisms concept is defined in the 316(b) Development Document. Generally, 5 to 15 critical aquatic organisms will be selected for consideration on a case-by-case basis. Relative to environmental impact associated with intake structures, effects on meroplankton organisms, macroinvertebrates, and juvenile and adult fishes appear to be the first order problem. Accordingly. the selections of species should include a relatively large proportion of organisms in these categories that are directly impacted. Generally, because of short life span and population regeneration capacity, the adverse impact on phytoplankton and zooplankton species is less severe. It is suggested that, in addition to study of the selected species, the total phytoplankton and zooplankton communities be assessed to determine if the area under study is unique and important qualitatively or quantitatively. If preliminary sampling or prior data does not support special or unique value of these organisms at the site, phytoplankton and zooplankton species will generally not be selected.

The following guidelines are presented for selection of critical aquatic organisms for consideration in intake studies:

A. Critical aquatic organisms to be selected are those species which would be involved with the intake structure and are:

1. representative, in terms of their biological requirements, of a balanced, indigenous community of fish, shellfish, and wildlife;

2. commercially or recreationally valuable (e.g., among the top ten species landed -- by dollar value);

3. threatened or endangered;

4. critical to the structure and function of the ecological system (e.g., habitat formers);

5. potentially capable of becoming localized nuisance species;

6. necessary, in the food chain, for the well-being of species determined in 1-4;

7. one of 1-6 and have high potential susceptibility to entrapment-impingement and/or entrainment; and

8. critical aquatic organisms based on 1-7, are suggested by the applicant, and are approved by the appropriate regulatory agencies.

8. Assumptions in the selection of critical aquatic organisms:

    1. Since all species which are critical, representative, etc., cannot be stud led in detail, some smaller number (e.g., 5 to 15) may have to be selected.

    2. The species of concern are those most likely to be affected by intake structure, design, construction, and operation.

    3. Some species will be economically important in their own right, e.g., commercial and sports fishes.

    4. Some of the species selected will be particularly vulnerable or sensitive to intake structure impacts or have sensitivities of most other species and, if protected, will reasonably assure protection of other species at the site.

    5. Often, but not always, the most useful list would include mostly sensitive fish, shellfish, or other species of direct use to man, or to the structure or functioning of the ecosystem.

    6. Officially listed "threatened or endangered species" are automatically considered "critical."

    7. The species chosen may or may not be the same as those appropriate for a 316(a) determination dependent on the relative effects of the thermal discharge or the intake in question.

Cooling Water Intake Structure

The coaling water intake structure is the total structure used to direct water into the components of the cooling systems wherein the cooling function is designated to take place, provided that the intended use of the major portion of the water so directed is to absorb waste heat rejected from the process or processes employed or from auxiliary operations the premises, including air conditioning.

Entrainment

The incorporation of organisms into the cooling water flow is entrainment. There are two generally recognized types of entrainment: pumped entrainment -- referring to those organisms that enter the intake and are pumped through the condenser, and plume entrainment -- referring to organisms that are incorporated into the discharge plume by the dilution water. Plume entrainment is not covered by section 316(b) but is part of the thermal discharge effect to be considered in conjunction with thermal effects demonstrations under section 316(a).

Entrapment-Impingement

The physical blocking of larger organisms by a barrier, generally some type of screen system in the cooling water intake. Entrapment emphasizes the prevention of escape of organisms and impingement emphasizes the collision of an organism with a portion of the structure.

Estuary

An estuary is defined as a semi-enclosed coastal body of water which has a free connection with the open sea; it is thus strongly affected by tidal action and within it sea water is mixed (and usually measurably diluted) with fresh water from land drainage. It may be difficult to precisely delineate the boundary of estuarine and river habitats in the upper reaches of a fresh water river discharging into marine waters. The interface is generally a dynamic entity varying daily and seasonally in geographical location. In such cases, determination of habitat boundaries should be established by mutual agreement on a case-by-case basis. Where boundary determination is not clearly established, both estuary and river habitat biological survey requirements should be satisfied in a combined determination for environmental effects and best available technology for minimizing adverse impact.

Habitat Formers

Habitat formers are plants and/or animals characterized by a relatively sessile life state with aggregated distribution and functioning as:

1. a live and/or formerly living substrate for the attachment of epibiota;

2. either a direct or indirect food source for the production of shellfish, fish, and wildlife;

3. a biological mechanism for the stabilization and modification of sediments and contributing to processes of soil buildings;

4. a nutrient cycling path or trap; or

5. specific sites for spawning, and providing nursery, feeding, and cover areas for fish and shellfish.

High Potential Impact Intakes

High potential impact intakes are those located in biologically productive areas or where the volume of water withdrawn comprises a large proportion of the source water body segment or for which historical data or other considerations indicate a broad impact.

Impingement

See Entrapment-Impingement.

Lake

Any naturally occurring large volume of standing water occupying a distinct basin and, for purposes of this document, reservoirs and impoundments.

Low Potential Impact Intakes

Low potential impact intakes are those located in biologically unproductive areas and having low flow or having historical data showing no effect or for which other considerations indicate low impact. Plants with low capacity factors or with few remaining years of lifetime might be considered "low impact" despite their historical impact.

Macroinvertebrates

For the purposes of this document, the term macroinvertebrates may be considered synonymous with "aquatic macroinvertebrates" and are those invertebrates that are large enough to be seen by the unaided eye and can be retained by a U.S. Standard No. 30 sieve (0.595 mm. mesh opening).

Meroplankton

For the purposes of this document, meroplankton are defined as planktonic life stages (often eggs or larvae) of fish or invertebrates.

Oceans

The ocean habitat, for the purposes of this manual, is considered marine waters other than those water bodies classified as estuaries. This includes open coastal areas, embayments, fjords, and other semi-enclosed bodies of water open to the sea and not measurably diluted with fresh water from land drainage.

Two principal zones within the oceanic habitat potentially impacted are: (1) littoral zone -- from high tide level to low tide level, and (2) meritic zone (near shore) -- low tide level to the edge of the continental shelf.

Phytoplankton

Phytoplankton are the free-floating plants, usually microscopic algae, that photosynthetically fix inorganic carbon and are, therefore, primary producers in some aquatic environments.

Plankton

Plankton are essentially microscopic organisms, plant or animal, suspended in water which exhibit near neutral buoyancy. Because of their physical characteristics or size, most plankton organisms are incapable of sustained mobility in directions against water flow. Consequently, plankton drift more or less passively in prevailing currents.

Population

A population is generally considered to be comprised of individuals of the same species in a geographic area. Populations exhibit parameters such as mortality, natality, fecundity, intrinsic rate of increase, density, etc.

Primary Study Area

This includes the segment of the water body determined to be the area of potential damage. This concept is most pertinent to organisms subject to inner-plant passage, normally weakly motile or planktonic, and spatially subject to water body currents rather than possessing the ability to change location independent of water mass movements. Animals capable of large scale movements, i.e., migrant fishes, will move into this area periodically.

Rivers and Streams

A river or stream is a naturally occurring body of running (surface) water, with an unbroken, unidirectional flow, contained within a discrete channel. Reservoirs and/or impoundments, for the purposes of this document, will generally be viewed as lakes.

Secondary Study Area

The area within the water body segment outside the primary study area. Biota in this area directly affected by the intake structure may or may not be a significant component of the total population of indigenous species. For many species, particularly pelagic fishes, the total population may be spread over a wide geographical area. This area could be considered the secondary study area. However, other intake structures associated with cooling water uses, e.g., power plants, may also be impacting the population in these other areas. This may be considered in two ways:

1. consider the total population throughout the geographical range, estimate existing impacts, and determine to what extent the specific intake structure adversely impacts that portion of the population not already adversely stressed by sources outside the primary study area; or

2. consider only the population in the area of potential involvement and adjacent areas of occurrence not already impacted by an existing source of stress.

For example, when a number of intake structures are located within a water body such as the Hudson River, Ohio River, Long Island Sound, Western Basin of Lake Erie, Narragansett Bay, San Francisco Bay, etc., either of the two approaches may be taken to assess the impact of the structure under consideration. The total impact of all existing stresses may be weighed against the total population of biota studies and the adverse effects of the new stress added to existing stresses and assessed against impact to the total system. The alternative is to assign a section of the water body not already impacted by other intake structures and compare the segment of the community in the assigned area to the effect of the single structure concerned.

Threatened or Endangered Species

A threatened or endangered species is any plant or animal that has been determined by the Secretary of Commerce or the Secretary of the Interior to be a threatened or endangered species pursuant to the Endangered Species Act of 1973, as amended.

Water Body Segment

A water body segment is a portion of a basin, the surface waters of which have common hydraulic characteristics (or flow regulation patterns) common natural physical, chemical, and biological processes, and which have common reactions to external stress, e.g., discharge of pollutants. Where they have been defined, the water body segments determined by the State Continuing Planning Process under section 303(e) of P.L. 92-500 apply.

Zone of Potential Involvement

The zone of potential involvement is considered the water mass surrounding the intake structure and likely to be drawn into the structure itself or into the associated cooling water system. This varies with time and is dependent on ambient water movements in the affected body of source water as modified by the influx of cooling water at the intake structure. It will be difficult to precisely define the limits of this zone of influence because of temporal and spatial variables. The zone of potential involvement always includes the primary study area and may include the secondary study area.

Zooplankton

True zooplankton are free-floating animals which have little or no ability for horizontal movement. They are thus carried passively along with natural currents in the water body.

VI. STUDY FORMAT

The studies submitted as support for a finding that the cooling water intake represents best technology available for a minimization of adverse environmental impact should be in the following format to facilitate agency review. At least two copies should be submitted.

1. Title page (plant name, water body, company, permit information. rate).
2. Table of contents.
3. An executive summary of 2-3 paragraphs (essence of material and conclusions).
4. Detailed presentation of methods used in data collection, analysis and/or interpretation when different from standard references.
5. Supportive reports, documents, and raw data. Data from the open literature need not be included so long as it is readily available.
6. Bilbiographic citations to page number of cited text,
7. An interpretive, comprehensive narrative summary of the studies which will serve, in part, as the basis for the agency's decision. The summary should include a table of contents and may include table figures. Sources of data used in the summary should be cited to page number. The summary should include a clear discussion stating why the report shows (or does not show) that the water intake structure in question minimizes impact on the water resources and aquatic biota in the vicinity of the intake and throughout the water body segment.
8. An appendix listing the agencies and consultants conducting this or related work on the water body.
9. Reports generated in response to section 316(b) should be recorded and forwarded to the National Technical Information Service (NTIS) for recording and announcement. The folder, NTIS-PR-184, available from NTIS, U.S. Department of Commerce, Springfield, Virginia 22161, explains the procedure in detail.

It is the intention of the EPA to make the technical information submitted by industries in accordance with 315(b) available for use by other industries, scientists, and members of the public. This will be done initially by placing copies in the responsible EPA Regional Off Ice library. A similar approach is also suggested for State agencies. In cases where demand for the demonstration materials exceeds the capability of an EPA or State agency library, the EPA Regional Administrator may also submit the materials to the NTIS so that the reports are available co the public in microfiche or hard copy form at the price of duplication. In the meantime, EPA is developing lists of plants with completed 316(b) demonstrations and will submit the plant name and an abstract of each study to NTIS.

It is also noted chat the Atomic Industrial Forum has developed INFORUM, a data system which will extract and index information from reports submitted by utilities in accordance with sections 316(a) and (b). Questions should be referred to INFORUM at 1747 Pennsylvania Avenue, Washington, D.C. 20006, telephone 202-833-9234.

VII. DETAILED STUDY REFERENCES

This document, of necessity, is generalized to provide an overall framework of guidance and conceptual approach. Six references are recommended which treat various aspects of the study requirements in more specific detail:

1. U.S. Environmental Protection Agency, Office of Water & Hazardous Materials. Water Planning Division, September 30, 1974, Draft, 316(a) Technical Guidance on Thermal Discharges. (Revised draft to be published in 1976.)

2. U.S. Environmental Protection Agency, Office of Water 6 Hazardous Materials, Effluent Guidelines Division, April 1976, Development Document for Best Technology available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact.

3. Battelle Laboratories, Inc., Environmental Impact Monitoring of Nuclear Power Plants - Source Book. Atomic Industrial Forum, Inc. August 1974. 810 p.

4. Aquatic Ecological Surveys. American Nuclear Society, F.W. Hinsdale, Illinois, Draft, October 1974.

5. Entrainment: Guide to steam electric power plant cooling system siting, design and operation for controlling damage to aquatic organisms. Amer. Nuc. Std. Publ. N18. - 1974. Draft, July 1, 1974, 44 p. and appendices.

6. Entrapment/Impingement: Guide to steam electric power plant cooling system siting, design and operation for controlling damage to aquatic organisms at water intake structures. Amer. Nuc. Std. Publ. N18 - 1974. Draft, September, 1974, 24 p. and appendix.

VIII. SITE DESCRIPTION

The following information is generally needed to fully describe the potential experiences of organisms which may be entrapped within intake structures, impinged on parts of the structure and/or entrained in the water mass taken in and circulated through the associated cooling water system. It is necessary to describe the full range of resultant physical, chemical, and biological parameters of these experiences which could be encountered throughout the annual operation cycle. lnformation on daily and seasonal fluctuations is of special importance in those waters subject to wide variation in water quality at the specific site. Other data pertinent to the evaluation of environmental impact of the location or intake structure in question should be included even though not specifically listed.

The following data are required for adequate description of sites located on either fresh or marine water bodies:

1. Site location and layout

   A. Location of additional Intake structures - Smaller scale, map showing locations of intake structures, associated cooling water systems, and other pertinent discharges related to surrounding shore and water features in a 50-mile radius.

   8. Site Plan - Larger scale map with topographic and hydrographic data depicting specific location of structure in the water body. Data required includes:

      - Topographic details
      - Hydrological features (see U.S. Department of Commerce, National Ocean Survey Charts, where available), including depth contours
      - Water body boundaries
      - Affected water body segment
      - Location and description of other cooling water intakes in water body segment
      - Existing site with topographic and hydrological features as changed by proposed intake structure construction and operation (where applicable)

2. Meteorology (when hydrodynamic modeling is performed)

   - Air temperature, maximum, minimum, mean-monthly
   - Rainfall, monthly
   - Solar radiation kcal/m²/day (average/month for the annual cycle)
   - Wind speed and direction. prevailing winds identified as to seasonal patterns
   - Other relevant site specific data

3. Additional stresses on water body segment

   - Location of existing or planned point sources of potential adverse environmental impact
   - Summary of impacts associated with existing or future stresses (and citations to more extensive analyses, such as 316(a) demonstrations, impact statements, NPDES permits, etc.)

4. Cooling water intake structure

   A. Structure

   - Location with respect to cooling water system
   - Location in water body, horizontal and vertical (including skimmer walls)
   - Configuration, including canals and channels; detailed drawings
   - Capacity
   - Screening devices (behavioral and physical)
   - Fish by-pass and handling facilities
   - Average and maximum approach and thru-screen water velocities, by depth
   - Flow rates and frequency of occurrence correlated with load characteristics
   - Location, amount, and duration of recirculation water for deicing or tempering
   - Other relevant system-specific data

B. Pumps

- Design details (location in structure, configuration of blades, and housing)
- Revolutions per minute
- Number, capacities, and planned operating schedule
- Pressure regimes in water subjected to pumping
- Velocity shear stresses in pumping
- Sites of potential turbulence and physical impacts

C. Biocides

- Location of introduction in system
- Description and toxicity of biocide used
- Timing and duration of use
- Concentrations of biocide in various parts of cooling water system and receiving waters

D. Thermal experience

- Tabulation of annual ambient temperatures, thermal addition to cooling water of various operating capacities, and resultant time-temperature experience of organisms subjected to entrainment in cooling water system

E. Other relevant data on cooling water circulation system

- Dissolved gases
- Suspended solids and turbidity
- Other wastes and chemicals added
- Size of condenser tubes, heat exchanger components, water piping, siphon pits, etc.
- Maintenance procedures, use of heat treatment or deicing procedures

5. Plant Data

- Age and expected lifetime
- Capacity factor and percent of time at fractional loads
- History of intake model

IX. SOURCE WATER INVOLVEMENT

The physical interaction of the intake and the adjacent water body forms a base for assessment of biological impact by relating the behavior and motion of local organisms with the flow of water around the site and into the intake structure. To determine this involvement with the intake, it is desirable to identify the type or types of circulation which will be dominant in the water body, and to establish a program of monitoring currents and other relevant hydrological and physical parameters of the system. Predictive tools, such as computer models, are useful in assessment of impact, and for delineation of the area of potential damage. The approach outlined here is suggested for new plants having high potential impact when sufficient model accuracy is obtainable. The approach may be useful for other plants as well, as discussed in the impact assessment section below. The modeling program should be discussed with the agency in advance of application and should include sensitivity analyses.

1. Hydraulic Features

The dominant modes of circulation in the water body are frequently identified in the literature and include channel flow, tidal and wind-driven currents, estuary or gravitational circulation, littoral drift, and others. The local currents (or velocity structure) can be modified by bathymetry and transient atmospheric conditions, and contain local features such as eddies; their importance can he modified by their effect on biological processes. It is also useful to identify interface zones if several current regimes or physical processes are evident. Large water withdrawals and discharges can be sufficient to modify existing hydraulic patterns enough to create new biological habitats.

A program of monitoring the currents and other relevant physical parameters is desirable for the study of source water involvement, Whenever possible, historical data should be used to identify the expected circulations and guide in the selection of instrument stations, although as data comes in, a re-evaluation of the monitoring program is useful.

the relevant parameters are water current, speed and direction, wind speed and direction, tides or local water levels, temperature, and water density, Salinity data are important in an estuarine environment.

The spatial distribution of instrument stations is usually indicated by the circulation regime and local bathymetry, but is best organized to provide input to and verification data suitable for a predictive hydraulic model of the currents. Vertical spacing of instruments should be sufficient to identify any important depth variation in the circulation.

The use of a hydraulic model requires several other specific inputs to provide realistic prediction of currents in the area. typical parameters include:

1. boundary geometry;
2. bottom topography;
3. bottom friction coefficients;
4. latitude of the area;
5. tides or water levels at open boundaries;
6. river flows;
7. temperature and salinity;
8. wind stress;
9. power plant cooling water flow races; and
10. other point source flow rates.

A significant period of time (two weeks) night be chosen for a continuous (burst sampling) monitoring sequence to sense periodic variations in the circulation, and another program to sample changes on an annual (or longer) cycle. Careful recording of placement and start times is recommended.

The instruments chosen should be durable and resistant to fouling. The accuracy may be influenced by the scale of the parameters but for water level should generally be at least ± 0.01 ft. and, for current speed and direction, + .15 knots and ± 5.0° respectively. For temperature and salinity ± 0.1°C and ± 0.1°/₀₀ respectively can be expected. Special instrumentation for water current sensing may be necessary at threshold speeds.

An instrument calibration program is necessary to insure accuracy. Redundant marking of station locations and provision for recovery of unmarked instruments should be made.

Computer models as predictive tools represent the best available predictive tools and are useful in assessing water use and biological impact. Mathematical models solve the equations of water flow and are used to predict currents in the water body. Another model (of water quality) can he developed in tandem to solve the equation of mass flow and used co predict mass or concentrations of organisms under influence of the currents.

The selection of the appropriate model is guided by the circulation regime and the geomorphology of the water body. A number of mathematical models of tidal flow are available, and these can be extended to include channel flow. For example, the Leendertse 8, 9 type square-grid models for tidal currents and larvae transport have been used. Finite-element models[10] are being developed for tidal circulation, and may have advantages in certain areas. For river-bay situations, the channel-junction model[11] may have special advantages. Three-dimensional models such as those described in references 12,13, and 14 may be appropriate. A comprehensive summary of available models has been compiled by Gordon and Spaulding.[15] The rationale for selection of the particular set of models should be justified by either emphasizing their suitability or by demonstrating a lack of other sufficient models.

Verification of model output should be made for both current and organism concentrations. Data from the monitoring survey are useful for verifying the current model while the biological sampling program may be used to verify the motion of organisms. Dye studies may also be useful in model verification.

Means for delineating study area and source water involvement may vary from intuitive judgments to highly sophisticated predictive models. The most logical measures, consistent with the local conditions should be determined.

2. Probability of Entrainment

The zone of potential involvement of the cooling water intake varies with species of organisms and time but the core concept is the determination of probability of entrainment. The predictive models are useful for mapping probability isopleths. This could be done by the simulation of drifters with the hydraulic model, or the spread of mass from point sources into the intakes with the concentration model. Drogue or dye studies could be used for verification. Drifters, drogues, or dye may, however, be poor analogs for the organisms in question. As a consequence, any study of this nature must be accompanied by justification that adequate adjustment is being made for differences in behavior between the organisms and their mechanical analogs.

A map of probability of entrainment would be useful in delineating the outline of the area of potential involvement by a rational, analytical method. For example, the computer hydraulic model for currents could be used to simulate the flow of drogues in the region. A simulated release of drogues (several per hour) would be carried out until all drogues have either been entrained or have crossed the model boundaries and left the area. The ration of entrained drogues to the total gives the probability of entrainment. A repetition of this procedure for other release points gives a field distribution of probability.

An alternate method is to simulate mass transport from a field of points, wherein the ratio of mass entrained to the total released gives the probability. This method could be verified by the use of dye studies.

In environments likely to exhibit density stratification, or in which the organisms stratify, it may be necessary to use multi-level sampling for all parameters, and consider stratification in the models chosen. Wind effects are more likely to be important in shallow water. The spatial changes in parameters in stratified systems are likely to be larger, so this must also be incorporated in a sampling program.

Obviously, models are highly desirable and the probability isopleth concept is a powerful analytical tool. However, the time and costs involved will not be justifiable in many situations.

X. BIOLOGICAL SURVEY REQUIREMENTS (NEW INTAKES)

The purpose of the biological survey is to provide a sufficient and valid data base for rational assessment of environmental impact related to the location, design, construction, and capacity of a cooling water intake structure, prior to a final siting decision.

Due to the possibility of extreme fluctuations in overall abundance of the species from year to year and shifts within a study area of its centers of abundance, several years' study may be required. A term of three years is suggested as permitting an "exceptional" year to be detected and criticized on the grounds that events in so short a span cannot be understood in the context of long term trends. A period of 15 to 25 years is one in which many cyclic biological phenomena become evident, but a preliminary study of this length will be out of the question except as it can be gleaned from historical data. A one-year pre-operational study is generally of limited value but may be acceptable for preliminary agency determinations in situations where substantial historical data can be presented and the intake can be represented as having low potential impact.

Data collected must be sufficient to permit analysis and reduction to assessment criteria which will be useful in reaching a judgment on the existence and extent of an adverse impact. Suggested measures for data reduction and analysis, which are included in this manual, should be reviewed prior to development a survey program.

Designation of species of the critical aquatic organisms to be studied is the first step in a sequence of operations for the subsequent biological survey. The species selected may or may not be the same as the Representative Important Species designated in connection with demonstrations under section 316(a) of the Act. Differences would depend on the grater or lesser effect on such species of thermal discharges or intakes. Once species and source water involvement are known, the sampling methodology, survey study areas, and temporal characteristics of the survey can be determined to suit the organism selected, location, and characteristics of the intake structure. Each survey should be designed on a case-by-case basis recognizing the uniqueness of biota-site-structure interrelationships.

Biological surveys should be designed and implemented to determine the spatial and temporal variability of each of the important components of the biota that may be damaged by the intake. These surveys could include studies of meroplankton, benthic fish, pelagic fish, benthic macroinvertabrates, phytoplankton, zooplankton, benthic infauna and boring and fouling communities where appropriate. Generally, the majority of critical aquatic organisms will be fish or macroinvertabrates.

Once the occurrence and relative abundance of critical aquatic organisms at various life stages has been estimated, it is necessary to determine the potential for actual involvement with the intake structure. An organism may spend only a portion of its life in the pelagic phase and be susceptible to entrainment. Migratory species may be in the vicinity of the intake for a short segment of the annual cycle. Some species are subjected to intake structure effects during life history stages. For example, winter flounder larvae are found in the ichthyoplankton during their pelagic larval phase, and are susceptible to being entrained. During later life stages, as juveniles and adults, they are vulnerable to impingement. Both entrainment and impingement must be considered in subsequent impact assessment. Knowledge of the organism's life cycle and determination of local water circulation patterns related to the structure are essential to estimating an individual specie's potential for involvement.

Once involvement is determined, actual effects on those organisms must be estimated. As a first order approximation, 100 percent loss of individuals impinged, entrapped, or entrained could be assumed unless valid field or laboratory data are available to support a lower loss estimate.

The final step is to relate loss of individuals to effects on the local population as impacted by intake structure location, design, construction, and capacity. It is important to consider the means for data reduction and analysis in the early stages of survey design. Data must be amenable to biostatistical analyses, as utilized in arriving at the judgment for best available technology to minimize adverse environmental impact.

1. <u>Sampling Design</u>

It is necessary at the outset to clearly define the objectives of the sampling program and the area to be sampled. Quantitative sampling studies are designed to estimate numbers per unit and/or volume. The major considerations in these studies are:

- The dimension of the sampling unit. In general the smallest practical sampling unit should be used.

- The number of sampling units in each sample. The size of samples for a specified degree of precision can often be calculated if there is some preliminary sampling information. If not, preliminary sampling should be executed before extensive programs are developed.

- The location of sampling units in the sampling areas. Stratified random sampling is often preferable to simple random sampling. Strata can be unequal in area or volume, with sampling units allocated in proportion to the area or volume.

The survey effort should be intensive for at least the first year after which, based on first year results and historical data, lower effort progams could be justified. Survey data are usually of a time-series nature and, therefore, averages over time intervals within the series cannot be assumed independent. This situation limits the application of routine statistical procedures, Bartlett [17] and Quenoville. [18] Reference 19 is a recent example of the difficulties encountered when attempting to determine differences in portions of a time-series. The development of more powerful statistical methods for application to this type of data is necessary. It appears that only catastrophic impacts will be revealed to temporal comparisons of monitoring program data. Plant impact may be better revealed by spatial comparisons.

The discriminating power of surveys should be estimated prior to implementation.

This can be done by design based on previously collected data at the site, or by assuming the variability of the system based on previous studies at similar sites. The expected discriminating power of the survey should be adequate for the purposes for which the data are intended.

2. Sampling Methodology

Recommendations on specific sampling protocol and methodology are beyond the scope of this document. The optimal methodology is highly dependent on the individual species studied coupled with site and structure characteristics. Some general guidelines are provided here. More specific details are provided in reference 20.

Ichthyoplankton-Meroplankton Sampling

Sampling gear used should have known performance characteristics under the conditions in which it is to be used, or it will be tested in comparison with a standard gear (such as the 60 cm. "bongo" net developed for purposes of ichthyoplankton sampling by the National Marine Fisheries Service MARMAP program).

When a new gear is introduced, data should be included on its efficiency relative to a standard gear. Gear should not be changed in the course of long-term investigations unless the comparative efficiencies of the old gear and the new can be satisfactorily demonstrated.

It is recognized that no sampling gear is, in practice, strictly quantitative and equally efficient in retaining different sizes of organisms.

A rationale for the choice of gear, mesh size, etc., should be developed for each sampling program. In most cases, lacking strong reasons to the contrary, adoption of a standard gear to permit comparisons with other investigations is recommended.

In general, replicate tows indicate that horizontal distribution of fish eggs and larvae and other planktonic organisms is uneven or patchy in character, and that vertical distribution not only of actively swimming forms but of eggs commonly shows some stratification. This typically varies over 24 hours due to the influence of water movement and changes in light intensity. Depth distribution of individual species of fish eggs may change during the course of development, and buoyancy may differ at different periods of the spawning season.

Night tows frequently produce larger catches and may show less variability than day tows for fish larvae in the same area. Both phenomena are related in part to differences in net avoidance under conditions of light and darkness. However, certain larvae may be altogether unavailable to the usual plankton sampling gear at some time of a diel cycle; for example, they may lie on or near the bottom by day, and migrate upwards at night.

Night sampling must be considered in survey design as essential for an accurate picture of the numbers of ichthyoplankton actually present at a station, especially with regard to post-larvae and young juveniles. Sampling over the entire diel cycle should be conducted.

Characterization of the ichthyoplankton in a study area made exclusively from single tows at a series of stations is inadequate. Replication sufficient to show the typical variation between tows will be necessary, and it must be borne in mind that this may differ widely for different species, and may change over the course of a season. In reasonably homogeneous study areas, replicates can be taken at a subset of stations and the results applied to the rest. In certain circumstances, close to shore, or in the vicinity of the proposed intake, more rigorous error analysis is advisable, and this may require replication at each station. Determination of a suitable number of replicates will depend on characteristics at each site, and must be based on field studies. The most variable (patchy) of the critical species of ichthyoplankton under study at a given season will determine the number of replicates that are desirable.

Confidence limits for estimates of abundance must be based not only upon variation between tows at a given station, but must incorporate other sources of error, which include subsampling error (when aliquots of large samples are taken for lab analysis) and counting errors.

The ichthyoplankton-meroplankton sampling will generally be related to the impact of passing the organisms through the intake structure and associated cooling water system, i.e., entrainment.

Fishes and Macroinvertebrates

Sampling of fish and macroinvertebrates will be generally conducted in relation to the potential impact of entrapment and impingement. An exception would be juvenile and small fish of a size that would pass through intake screening rather than be caught upon such screens.

As previously noted, specific sampling methodology is detailed elsewhere.[20]

Some specimens taken from the screens may appear healthy; however, species-specific experiments with controls to assess the delayed mortality to these fish are required if less than 100 percent mortality is to be assumed.

Potential effects at proposed intake structures should make maximum use of existing data at operating structures to extrapolate involvement and mortality estimates to a new intake. Attention should be given to experiments which have statistically evaluated the effect of intake modifications on impingement-entrapment losses.

In cases where preliminary surveys indicate that the entrainment and entrapment-impingement losses may be high, it will be necessary to estimate the impact of these losses on the populations that will be involved. For each life stage susceptible to entrainment and/or entrapment-impingement, parameters necessary to adequately predict losses caused by power plant withdrawal include life stage duration, fecundity, growth and mortality rates, distribution, dispersal patterns, and intake vulnerability. These parameters can be either measured in the field or obtained from available literature. Estimates of equivalent adult stock loss on the basis of entrainment losses of immature forms requires a measure of natural mortality from immature to adult. For many if not most critical species, the natural mortality may be impossible to determine and the impact may have to be based on a reasonable judgment. Other data are required to project the long-term impact of the intake on the population and to include the population size, its age structure, and fecundity and mortality rates. These data can best be synthesized using mathematical models as discussed in section XII of this manual.

Zooplankton

Zooplankton sampling will generally be directed towards determination of entrainment impact. Zooplankton are essentially microscopic animals suspended in water with near neutral buoyancy. Because of their physical characteristics, most are incapable of sustained mobility in directions against water flow and drift passively in the currents.

In most cases, intake effects are of relatively short duration and confined to a relatively small portion of the water body segment because of short life span and regenerative capacity. Zooplankton, however, should not be dismissed from consideration without a preliminary assessment of the importance or uniqueness of the species' assemblage at the site.

Phytoplankton

Phytoplankton are free-floating green plants, usually microscopic in size, and are generally the main primary producers in the aquatic food web. Again, the potential cooling water intake structure impact on phytoplankton would be through entrainment. The short life-cycle and high reproductive capability of phytoplankters generally provides a high degree of regenerative capacity. In most cases, intake structure effects are of short duration and confined to a relatively small portion of the water body segment. Phytoplankton, however, should not be dismissed from consideration without a preliminary assessment of uniqueness or special importance of the species' assemblage at any particular site.

3. Follow-up Studies

Post-operational studies at new intakes will also be necessary in order to determine if the design, location, and operation, in fact, minimize adverse environmental impact and whether the model predictions utilized were realistic. Some suggestions for follow-up studies are available in section XI. However, the appropriate program at a new plant site should be determined in large part by the need for consistency with pre-operational study results.

XI. MONITORING PROGRAM (EXISTING INTAKES)

The study requirements necessary to evaluate losses of aquatic life at existing cooling water intakes can be considered in two separate steps. The first is assessment of the magnitude of the problem at each site through direct determination of the diel and seasonal variation in numbers, sizes and weights of organisms involved with operation of the intake. When losses appear to be serious, as a second step it may be necessary to conduct studies in the source water body if there is a need to evaluate such losses on a water-body-wide or local population basis. However, before requiring such studies it should be realized that the natural variability of biological systems, the difficulty of separating other stresses on population size, and difficulties in obtaining accurate and precise samples of the biota may mask the environmental impact from cooling water system operation. The magnitude of sampling variation is high and may range from 20 to 300 percent of the probable numbers.[36] Thus, effects of the Intake structure often cannot be identified above this "background noise" unless they are considerably greater, For many species, adverse environmental impact may be occurring at levels below that which can be "seen" with the standard survey and analytical techniques. Such field studies therefore will be extensive and difficult to conduct, and will generally require several years of data collection, all without certainty of results. Such studies should not be required unless absolutely necessary for the best technology available decision and then only to address specific questions. Because of the above difficulties, it may be necessary to base a determination of adverse impact on professional judgment by experienced aquatic scientists.

In evaluating data from the following studies, it is often desirable to assume "worst case" conditions where all organisms which pass through the intake suffer 100 percent mortality. If the magnitude of the numbers precludes such an analysis, specific mortality estimates may be necessary.

The following study requirements are based in part on the recommendations contained in the reports of the Lake Michigan Cooling Water Studies Panel[44] and Lake Michigan Cooling Water Intake Committee:[45]

1. Entrapment-Impingement

The objective of this sampling program is to document the magnitude of losses of fish life at operating cooling water intakes. Since it is possible to obtain a complete daily count of fish which are impinged by collecting the intake screen backwash material, this intensity of collection should be considered for application through one calendar year. The data which result will most accurately reflect the total annual loss by species. This approach does ignore possible delayed mortality to organisms involved with the intake structure but not impinged on the screens long enough to be killed. If total entrapment-impingement mortality is estimated by sampling from the screens, the sampling scheme must consider day-night and seasonal differences.

If a less than complete dally count over a year is utilized, dally sampling once every four days for one year is suggested as the lowest effort which will be acceptable from the standpoint of allowing for reliable loss project tons reflective of the plant's operation. Both more and less intensive sampling approaches may also be justifiable based on apparent impact, intake data, spawning periods, and other site specific and seasonal considerations. The 4-day interval for sampling is based on observed variability in daily impingement losses.

For example, in a study of the Central Illinois Light Company's E.D. Edwards Plant on the Illinois River, numbers of fish impinged varied from 7,000 on July 18 to 500 on July 19. On August 23, 1,500 fish were impinged versus 30,000 fish on August 26.[43] Not all plants exhibit such wide variations in numbers of fish impinged; however, until intensive sampling is completed at a site, total loss figures will be subject to question.

Collection of the samples can usually be accomplished by inserting collection baskets in the screen backwash sluiceway. These baskets should have a mesh size equal to or smaller than the intake screen mesh.

The following data should be collected during the sampling period:

A. Plant operating data required:

1. Flow rate;

2. Temperature (Intake and discharge);

3. Time started, duration, and amount of warm water recirculated for intake deicing and thermal defouling;

4. Total residual chlorine contained in recirculated water during condenser chlorination;

5. Current velocity at intake(s) over the range of water volumes used in plant operation (representative measurements or calculated values may suffice);

6. Number of times screens are operated between sampling intervals;

7. Tidal stage (where appropriate) and flow;

8. Salinity (where appropriate); and

9. Dissolved oxygen if intake withdraws water from an area (or strata) of potentially low oxygen content;

B. Data required from biological collections:

1. Species, number, length, weight, and age group (young of the year, yearlings, or adults) collected from the screens or representative subsamples when numbers of individual species collected are very large. Subsampling approaches should be approved in advance by the Agency;

2. Representative samples of each species for determination of sex and breeding condition;

3. Numbers of naturally occurring dead fish in the area ahead of the intake screening system should be estimated; and

4. Periodically conduct a test to determine the recovery rate of fish impinged on the screen. This can be done by spiking the screen with tagged dead fish and determining the proportion that are recovered in the screen backwash sluiceway.

2. <u>Sampling Program</u> - <u>Entrainment</u>

The following section describes investigations necessary to determine effects of entrainment of phytoplankton, zooplankton, benthos, fish , and shellfish at existing cooling water intakes. Such studies should generally concentrate on fish and shellfish unless the phytoplankton, zooplankton, or benthos are uniquely important at the site in question.

Fish and Meroplankton

The potential for damage to fish or shellfish populations by entrainment depends on the number of organisms that pass through the condenser system and on conditions experienced during passage.

Overall objectives of the study are to determine the species and numbers of fish and shellfish eggs and larvae drawn into and discharged from the cooling systems and, if necessary, determine the immediate and delayed effects of cooling system passage on these organisms.

A pump system is acceptable as the primary sampling method, provided it does not damage fragile organisms, and pumps are easier to automate and quantify than systems in which sampling is done with nets suspended in the cooling water flow.

Diel sampling is recommended because the numbers of organisms, even in areas known to be good spawning and nursery areas, typically have low concentrations, and their distribution in time and space is usually either changing rapidly or patchy as a result of natural conditions. Therefore, adequate representation of these organisms can usually only be obtained with continuous sampling throughout a diel cycle.

The actual volume of water to be pumped to provide an adequate sample is dependent on the densities of fish eggs and larvae in the water surrounding the cooling system intake structure. The sample volume should therefore be determined based on the least dense species of concern. If no a priori source water density data exists, then as large a sample volume as can be handled will be necessary. Once information is developed on the least detectible density for species of concern, sample volumes may be adjusted accordingly. This point is extremely critical to acceptance of the resulting data. If the sample volume is too small the study will be biased and show fewer organisms involved with the structure than actually exist.

Sample locations in the intake system should be located immediately ahead of the intake screens and, when less than 100 percent mortality is assumed, at a suitable point in the discharge system. When less than 100 percent is assumed, samples at intake and discharge should be from the same water mass. At each location one sampling point should be located near the surface, one near the bottom, and one at mid-depth. If uniform organism distribution can be demonstrated, one sampling depth may suffice.

Sampling should normally be conducted continuously at a frequency (e.g., every fourth day of plant operation) allowing the estimation of annual numbers of organisms with a 95 percent confidence interval which is ± 50%. More frequent sampling may be desirable during peak spawning seasons. Sampling should continue over at least one year. Sampling in subsequent years may be deemed necessary based on the results of the first year of study.

Macroinvertebrates

The primary concern regarding the effects of entrainment on macro-invertebrates is-does entrainment affect the rates of mortality, growth or reproduction? Specific objectives are to determine the kinds and numbers of organisms entrained, to assess the effect of entrainment on their survival and reproduction, and to describe the seasonal and diurnal patterns of entrainment. Pumped samples are acceptable provided the pump does not damage fragile organisms. A pump which will transfer small fish without harm is often satisfactory for zooplankton and benthos. Non-toxic material should be used throughout the sampling system.

Nets used to concentrate zooplankton and benthos from the pumped sample should be metered, or the pumping rate should be timed to provide an accurate determination of the volume filtered. Samples should be taken in duplicate. If no vertical stratification of organisms is documented, duplicate mid-depth or duplicate integrated samples may be taken.

Sampling sites should be established in the forebay, immediately ahead of the traveling screens, and as close as possible to the point of discharge.

Samples should be carefully concentrated in non-toxic containers and inspected microscopically for mortality and damage as soon as possible after collection.

Samples should be collected in the forebay and at the discharge during a 24-hour period at least monthly. Duplicate samples should be taken every 3 to 4 hours during the 24 hour survey.

Phytoplankton

Phytoplankton are susceptible to entrainment and possible damage in cooling water systems such that rates of mortality, growth, reproduction, and primary production are affected. Studies to determine those effects should involve microscopic examination, measurement of chlorophyll concentrations, measurement of rates of primary production, and observations of cell growth and division. In most cases, effects are of short duration and confined to a relatively small portion of the water body segment. Phytoplankton, however, should not be dismissed from consideration without a preliminary assessment of uniqueness or special importance of the species' assemblage at any particular site. Special sampling methodology can be found in reference 20.

Zooplankton

Zooplankton sampling will generally be directed towards determination of entrainment impact by an intake structure. Zooplankton are essentially microscopic animals suspended in water with near-neutral buoyancy. Because of their physical characteristics, most are incapable of sustained mobility in directions against water flow and drift passively in the currents.

In most cases, intake effects are of relatively short duration and confined to a relatively small portion of the water body segment because of short life span and regenerative capacity. Zooplankton, however, should not be dismissed from consideration without a preliminary assessment of the importance or uniqueness of the species' assemblage at the site.

3. Follow-up Studies

A follow-up monitoring program is also necessary at existing plants to determine whether the approved intake in fact minimizes environmental impact. In cases where an existing intake has been approved, it would be expected that the monitoring program could be on a reduced level from that noted above. However, where significant changes in intake location, design, construction, capacity, or operation have taken place, a program comparable to the pre-operational one should be followed.

XII. IMPACT ASSESSMENT

The goal of impact assessment is to analyze and reduce biological survey data to a form easily conceptualized and understood in the context of best available technology to minimize adverse environmental impact of intake structure location, design, construction, and capacity. The following approaches are suggested for use, although their application will not be appropriate in each case:

1. Biostatistical Analyses

In general, the minimum reduced raw sample data should include the arithmetic mean, the standard error (or the standard deviation), and the sample size from which these calculations were made.

If a large number of measurements or counts of a variable (e.g., species) are made, the data may be summarized as a frequency distribution. The form or pattern of a frequency distribution is given by the distribution in numerical form (as in a frequency table). However, the data is more clearly evident in a diagram such as a histogram (i.e., a graph in which the frequency in each class is represented by a vertical bar). The shape of a histogram describes the underlying sampling distribution. Known mathematical frequency distributions may be used as models for the populations sampled in the study, and the frequency distributions from samples may be compared with expected frequencies from known models.

The spatial distribution of individuals in a population can be described in quantitative terms. In general, three basic types of spatial distribution have been described. They are: a random distribution, a regular or uniform distribution, and a contiguous or aggregated distribution. The spatial dispersion of a population may be determined by the relationship between the variance and the mean, as well as by other methods. In a random distribution, the variance is equal to the mean. The variance is less than the mean in a uniform distribution, and it is greater than the mean in a contiguous distribution. In general, a Poisson distribution is a suitable model for a random distribution, a positive binomial is an approximate model for a uniform distribution, and a negative binomial is probably the most often used, among possible models, for a contiguous distribution.

Temporal and spatial changes in density can be compared statistically. Significance tests for comparisons of groups of data may be parametric when the distributions of the parent populations are known to be normal, or nearly normal, from previous experience or by deduction from the samples. Often, non-normal data may be transformed into data suitable for such testing. Otherwise, non-parametric tests for significance should be applied.

2. Predictive Biological Models

Models used to simulate currents (circulation models) and the dispersion of constituents (concentration models) are becoming more available for use in assessing impact. These models, when soundly-based conceptually, can usually be verified against hydrographic data and, therefore, represent an important tool for considering the influence of a power plant on its surroundings.

Diverse population and community models can be developed, but the assumptions on which they are based are difficult to test and the parameters difficult to estimate. Some important parameters depend on long time series of data (tens of years) and no level of effort can offset the requirement of time. These problems with biological models can sometimes be overcome by making "worse case" assumptions and estimates, but this course may tend to produce a plethora of models indicating potential disaster. Nevertheless, models are a means of integrating the available information and the subjective underlying assumptions about a problem in order to produce the most rational answer based on the inputs. In this regard, some models way serve an important rule in assessing impact.

As previously noted, hydrodynamic models in theory can he used to predict the source of water drawn through a power plant intake structure. This is done by simulating the movement of drifters or the dispersion of a constituent originating at a particular point in the area modeled. The simulation is carried nut for sufficient time for most of the material to be transported to the point of the assumed intake structure where it is considered entrained, or for the material to be transported sufficiently far away from the intake structure so that it has little chance of future entrainment. This procedure must be repeated (or performed simultaneously) for numerous constituent origins and for numerous initial flow or tidal conditions. These results will provide isopleths of entrainment probabilities surrounding a proposed intake structure. The isopleths can be compared with the biological value zone to assure that the plant will not draw a high percentage of entrainable organisms from highly productive areas. Various intake locations may be considered to minimize impact. In practice, it might be very expensive to calculate the probability of entrainment isopleths (source area) of an intake structure because a large area may have to be modeled and considerable computer time expended.

For a given critical aquatic organism, it may be possible to use hydrodynamic models to estimate the percent reduction in annual recruitment resulting from entrainment of pelagic early life stages. When the source of pelagic eggs and/or larvae is known, the dispersion of this biological material around the study area and the consumption by a plant intake may be simulated, indicating the reduction in recruitment that will result. In this procedure, entrainment mortality is separated from natural mortality. If natural mortality is density dependent, the impact of power plant entrainment will be overestimated or underestimated when entrainment mortality is estimated separately from natural mortality.

The method described above for estimating the reduction in recruitment resulting from entrainment can only be applied, as stated, for closed systems. For the more common situation where some larvae are dispersed out of the modeled study area (area for which circulation and dispersion is simulated) additional assumptions are required. If it is reasonable to assume that once organisms have been transported out of the modeled study area they have a low probability of contributing to support of the adult population of the study area. Then the dispersion of organisms around the study area for a period of time equal to the length of the species' vulnerable pelagic phase can be simulated with and without the entrainment impact of a simulated power plant. By comparing the number of organisms remaining in the area, the reduction in recruitment to later stages of the life cycle may be estimated. This approach was used in reference 24. The approach ignores the possible impact of a reduction in the number of organisms dispersed outside the modeled study area and other supporting populations.

For open systems where pelagic entrainable organisms are dispersed out of a modeled study area, it is often necessary to consider the effect of a plant on biological material transported across the model boundaries and into the system. If sufficient information is available, the concentration of organisms at the boundaries may be input to the model as boundary conditions. Again, the situation with and without a plant intake could be simulated and the number or organisms remaining in the modeled study area could be compared in order to derive an estimate of the reduction in recruitment. The reduction in recruitment will change as the population of the modeled study area is reduced and becomes more dependent on the input of biological material across the boundaries.

Hydrodynamic models are of little value for predicting the entrapment-impingement mortality rate suffered by populations. In the case of separate but similar intakes, this rate can be estimated after one is operational. Results may then be extrapolated to estimate the impact of additional intakes. Predictive models for entrapment-impingement are under development but have not yet been validated.

When the reduction in recruitment because of entrainment and the impingement mortality rates have been estimated for a critical aquatic organism, it is useful to assess the long-term impact on the local population. The dynamics of the population can be simulated by a compartment model with organisms distributed into compartments according to age. Each compartment is assumed to suffer non-power plant related mortality. Aging is simulated by advancing organisms to the next older compartment. Age-specific fecundity rates are used to determine the total biotic potential of the population. The recruitment to the youngest compartment is a function of total egg production. The effect of entrainment, entrapment, and impingement are incorporated by reducing the predicted recruitment by the appropriate proportion and adding age-(or size-) specific entrapment-impingement mortality to the age compartments. Computer simulations of the future dynamics of the population based on the compartment model with and without the plant can be compared.

Such simulations require knowledge of the life table for the species being considered. Life table information for some species may be based on the literature. It may be possible to supplement this information with knowledge gained from field studies. The age-(or length-) fecundity function and the egg production-recruitment relationship must also be known. The latter may be of three forms: (1) recruitment as a linear function of egg production, (2) recruitment as a density dependent function of egg production,[3, 25] or (3) recruitment independent of egg production. The choice of the appropriate egg production-recruitment relationship and estimation of parameters must be based on the available historical information on the species. At least twenty years of data is probably required to make such a decision. In the absence of enough data, the assumption of a linear egg production-recruitment relationship is appropriate. Note that for a linear egg production-recruitment model, there is only a single equilibrium condition, and any plant related mortality is likely to disturb this equilibrium.

If the population is not isolated, exchange with other populations may be modeled. The results of mark and recapture experiments may be useful for estimating exchange rates.

The methods for assessing impact described in this section are useful but of unknown validity. Most assessments based on biological models have yet to be field verified. Development of predictive models for assessing impact should be encouraged but only after full consideration of the difficulties involved, the expense compared to the reliability of results, and the dangers of a "worst case" analysis.

3. Community Response Parameters

The populations of all species in a given area or volume are defined as a community. Although the term "community" is considered a useful concept in delineating the group of interacting species in an area, it is believed to be a subjective entity. Thus, for specific studies and tests of hypothesis, the composition of the community must be strictly defined.

Community response parameters, such as changes in structure, have sometimes been studied and estimated by certain multivariate classification techniques. Various measures of species diversity or association coefficients have also been employed to measure community response to perturbations.

In estimating community diversity, the most widely used indices are those based on information theory. When the sample of species' abundances may be considered randomly taken from an ecological community or subcommunity, the Shannon index (also referred to as the Shannon-Wiener or Shannon Weaver Index) may be used. If the sample may not be considered a random set of species' abundances taken from a larger species' aggregation of interest, then the Brillouin Index should be used. Either index may be computed with computational ease [26] and, in either case, the logarithmic base used must be stated.

The shortcomings of all existing indices of species' diversity and the biological phenomena which may influence these values should be recognized. References 28, 29, and 30 should be consulted for further explanation of diversity indices and their utility.

For the purposes at hand, the phrase "classification of communities" is utilized for processes that sort species into groups, and it includes both discrimination and clustering. In general, discrimination techniques begin with a priori conceptual distinctions or with data divided into *a priori* groups. Then one should proceed to develop rules which separate data into these *a priori* categories. Clustering techniques, on the other hand, use *a priori* selection of a measure of similarity, a criterion, and a class description to find inherent empirical structure in data, i.e., clusters. Clustering does not use an externally supplied label and involves finding derived data groups which are internally similar. A good review and summary of various discrimination and clustering procedures is provided in reference 31.

The aquatic environment can often be stratified in some way, such as by depth, substrate composition, etc. It is suggested that such stratification be done and that tables showing the frequency, or density, of each species at each environmental stratum be compiled. These tables are analagous to the distribution curves made in a gradient analysis,[32] and are considered a natural and useful description for species association data. It is suggested that these tables be the basis for certain multivariate methods of data analysis for spatial and temporal variability, such as cononical variate analysis described in reference 33. In addition, for these data which now contain *a priori* groupings, the linear discriminant function may also be successfully utilized for testing the differences among environmental strata using multiple measurement or counting data.

4. Biological Value Concept

The concept of establishing relative biological value zones in the water body segment impacted by a cooling water intake structure could be a useful approach in determining best technology available for intake design, location, and operation to minimize adverse environmental impact. The principal use of this concept is in delineating the optimal location within the water body for minimum impact on the biota potentially involved with the specific intake structure.

The essence of this concept is in establishing biological value of various zones for the water body segment (or other defined area) within which the intake structure is to be located. A judgment of value is made for the representative important species considering type of involvement with the intake (entrapment, impingement, entrainment) and the numbers of each which are adversely impacted. Results are summed up by species, seasonally or annually, and represented by graphical means to depict areas of the water body highly important to the species and, conversely, areas of low relative value, thus potentially favorable intake structures.

Methodology. The following methodology for using the biological value concept is based on methods developed and utilized in community planning studies as described in reference 34.

Use of the biological value concept would require acceptance of the reasonableness of several basic premises:

1. There are areas of different concentrations of representative important species within the water body segment comprising potential sites for an intake structure.

2. Areas of biological concentrations can be expressed in terms of relative value to perpetuation of representative important species populations in the water body segment.

3. The area of zone of least biological value, expressed in relative terms of population densities, would be the optimal location for an intake structure in order to reduce adverse environmental impact.

This is not a precise method because of inexactness of differentiating relative value between species and difficulties in comparing importance of loss between eggs, larvae, and adults. Also, it is assumed that the adverse impact on the populations of critical aquatic organisms is significant to some degree and therefore, it is desirable to minimize this impact, thus giving importance, to best available intake locations.

If one can determine that one species is more important than another, one can weigh it in some way. If not, least concentrations of critical aquatic organisms in any one location indicate its intrinsic suitability for intake structure location.[34]

A step-by-step procedure could include:

1. Select critical aquatic organisms; and

2. Divide water body segment into spatial compartments (use hydrological model).

For each species and spatial compartment:

1. Determine life stages potentially involved with intake and type of involvement (entrapment, impingement, entrainment);

2. Estimate numbers of organisms involved at representative times during the annual operation cycle;

3. Estimate numbers of those involved that are lost (determine percent survival or mortality of those entrained or impinged) on an annual basis;

4. Estimate conversion ratios to express eggs and larvae lost in terms of number of adults (this is a value judgment and assumes the loss of one egg is not as important to survival of the species as the loss of an adult).;

5. Develop the data matrix for construction of the biological value level overlay charts (Table 1);

6. Construct transparent overlays for each species on chart of water body segment. Areas of different impact in terms of organisms lost due to involvement with the intake structure could be color-coded; e.g., areas of most value could be dark gray; areas of least value, clear. Generally, three levels of value will suffice;

7. Superimpose overlays for all representative important species on chart to obtain compositive value, indicated by relative color, for all spatial compartments in the water body segment; and

8. Analyze graphic display of relative value and identify light-toned areas as most favorable intake sites, heavy areas as least favorable.

The methodology is intended to be flexible. Various shades of different colors could indicate comparative value between selected species or variations in density with depth. The value grades could be expressed in terms of their relation to populations of critical aquatic organisms in the overall water body to provide insight on importance of the specific segment studies to the whole system.

The biological value concept for analyzing survey data in the determination of best technology available to minimize adverse environmental impact appears to have the principal application in selection of the minimal imact zones for locating the intake structure. The usability of the concept is, of course, data-dependent. As noted, it is not precise, but at least integrates multiple factors and presents a defined indication of suitability for location of an intake structure in the affected water body segment.

Three-dimensional computer graphic techniques can also be applied to portray spatial and temporal distribution of biological data.[10,35]

Time-series graphs can be useful in depicting the dynamic nature of occurrence and abundance of a designated species during the annual operating cycle of the intake structure. The principal application would appear to be in the determination of the optimal location of the intake structure. Also, graphic representations of the biologically predicted mathematical model output could assist in more clearly depicting intake structure impact on populations of Representative Important Species (RIS).

TABLE 1

EXAMPLE DATA MATRIX

DATA SHEET (SPECIES I)
(SPATIAL COMPARTMENT [A])

TYPE OF INVOLVEMENT	Organism Involved			% Lost (If assumed other than 100 %)			Numbers Lost			Calculated Equivalent Adult Loss				Value Grade
	Eggs	Larvae	Adult	Eggs	Larvae	Adult	E.	L.	A	E.	L.	A.	Total	I, II, III
Entrapment														
Impingement														
Entrainment														
Total Effect														

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