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AMENDED SECTION 301(h) TECHNICAL SUPPORT DOCUMENT

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PREPARED FOR:

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PREFACE

The following is a draft amended technical support guidance document for the Clean Water Act Section 301(h) program. When finalized, this guidance document will completely supercede the earlier *Revised Section 301(h) Technical Support Document*.

This guidance document, when finalized, will provide municipal dischargers and the U.S. Environmental Protection Agency personnel with technical guidance on preparing and evaluating applications for Section 301(h) modified permits. One of the primary purposes for revising this guidance document is to add guidance concerning proposed revisions to EPA's Section 301(h) regulations (Part 125, Subpart G) that the Agency intends to promulgate in the near future. EPA is revising the Section 301(h) regulations primarily to implement new Section 301(h) requirements imposed by the Water Quality Act of 1987.

This guidance document, when finalized, will be a general statement of policy. It will not establish or affect legal rights or obligations. It will not establish a binding norm and will not be finally determinative of the issues addressed. Agency decisions in any particular case will be made by applying the law and regulations on the basis of specific facts and actual actions.

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EXECUTIVE SUMMARY

Section 301(h) of the 1977 Clean Water Act (CWA) allows the U.S. Environmental Protection Agency (U.S. EPA) to issue National Pollutant Discharge Elimination System (NPDES) permits to publicly owned treatment works (POTWs) for the discharge of less-than-secondary treated effluent. One of the primary purposes of this document is to identify changes to the Section 301(h) regulations promulgated by EPA to implement new Section 301(h) conditions imposed by the Water Quality Act (WQA) of 1987 and to provide technical guidance for implementing those changes. Guidance is also provided on assessments and data analyses that applicants must perform to satisfy regulatory requirements, and on methods that regulatory personnel may use to evaluate compliance with those regulatory requirements. This guidance is provided in three forms:

- Explanations of WQA Sections 303(a) through 303(g), and resulting changes in the Section 301(h) regulations (i.e., all citations to Part 125)

- Technical guidance for implementing the new regulations, and updated technical guidance for implementing regulations that have not changed

- Guidance on the preparation of applications for reissuance of Section 301(h) modified NPDES permits, on the evaluation of those applications to determine compliance with the regulations, and on the issuance and reissuance of Section 301(h) modified permits.

The WQA of 1987 amended CWA Section 301(h) in eight respects, as summarized below. References to key affected subsections of the amended CWA 301(h) regulations, as renumbered, are shown in brackets.

1) Section 301(h) modified discharges are prohibited from interfering, *alone or in combination with pollutants from other sources*, with the attainment or maintenance of water quality which assures the protection and uses listed in Section 301(h)(2). (emphasis added) [125.62(f)]

2) The scope of monitoring investigations is limited to only those investigations necessary to study the effects of the modified discharge. [125.63(a)]

3) With respect to any toxic pollutant introduced by an industrial source and for which there is no applicable pretreatment requirement in effect, POTWs serving populations of 50,000 or more are required to demonstrate that sources introducing waste into the POTW are in compliance with all applicable pretreatment requirements, that the POTW will enforce those requirements, and that the POTW has in effect a pretreatment program which, in combination with the POTW's own treatment processes, removes the same amount of toxic pollutant as would be removed if the POTW were to apply secondary treatment and had no pretreatment program for that pollutant. [125.65, 125.58(g), 125.58(j), 125.58(q), 125.58(w), 125.58(b)]

4) At the time the Section 301(h) modified permit becomes effective, the POTW must be discharging effluent that has received at least primary or equivalent treatment [as defined in Subsection 125.58(r)], and that meets the water quality criteria established under 304(a)(1) of the WQA after initial mixing in the receiving waters. [125.60, 125.58(r), 125.62(a)]

5) Section 301(h) modified permits may not be issued for discharges into waters that contain significant amounts of

previously discharged effluent from the POTW. [Regulations not amended.]

6) Section 301(h) modified permits may not be issued for discharges into saline estuarine waters that exhibit stressed conditions, regardless of the applicant's contribution to those stressed conditions. Section 301(h) modified permits may not be issued for discharges into the New York Bight Apex under any conditions. [125.59(b)(4), 125.62(f)]

7) Any POTW that had an agreement before 31 December 1982 to use an outfall operated by another POTW which had applied for or received a Section 301(h) modified permit could have applied for its own Section 301(h) modified permit within 30 days of enactment of the WQA. [Regulations not amended.]

8) Some provisions of the WQA do not apply to applications that received tentative or final approval before enactment of the WQA, but apply to all applications for renewal of Section 301(h) modified permits. [125.59(e)]

Among the eight major changes listed above, numbers 1, 3, 4, 5, and 8 are most important to applicants and permittees that are not prohibited from applying for a Section 301(h) modified permit under other provisions of the amended regulations. The first major change requires POTWs to consider the impacts of their discharge on the receiving environment and biota in combination with pollutants from other sources. Previously, POTWs were required only to consider whether their discharge contributed to such impacts.

Change number 3 requires applicants to implement an urban pretreatment program. This new statutory requirement complements the toxics control program requirements in Part 125.66, and applies in addition to any applicable pretreatment requirements contained in 40 CFR Part 403. Dischargers may demonstrate compliance with Part 125.65 by demonstrating

that an applicable pretreatment requirement is in effect, or by demonstrating "secondary removal equivalency."

Applicable pretreatment requirements may be in the form of categorical pretreatment standards promulgated by the U.S. EPA under CWA Section 307, local limits developed in accordance with 40 CFR Part 403, or a combination of both. It is anticipated that most dischargers will be required to use a combination of both approaches to satisfy Part 125.65 with respect to all toxic substances introduced into the treatment works by industrial sources.

Alternatively, a discharger may demonstrate that its own treatment processes, in combination with pretreatment by industrial dischargers, achieves secondary removal equivalency. Dischargers are required to make this demonstration whenever they cannot show that a toxic pollutant introduced by an industrial discharger is subject to an "applicable pretreatment requirement." Although secondary treatment is intended to control conventional, nontoxic pollutants, a certain amount of each toxic pollutant in the influent is removed during the process. The intent of this part of WQA Section 303(c) is to ensure that a Section 301(h) discharger removes that same amount of a toxic substance through industrial pretreatment plus the applicant's own treatment at less-than-secondary levels, as would be removed if the applicant were to apply secondary treatment and no pretreatment requirements existed for that pollutant. This demonstration requires the use of a secondary treatment pilot plant to determine empirically the amount of a toxic pollutant the would be removed from the influent if the applicant were to apply secondary treatment. For each pollutant introduced by an industrial source, that applicant would then demonstrate that industrial pretreatment plus the POTW's own treatment processes removed the same amount of pollutant as was removed by the secondary treatment pilot plant.

Change number 4 requires all Section 301(h) dischargers to achieve a minimum of primary or equivalent treatment, thereby establishing a primary treatment floor for all marine and estuarine POTWs. It also requires all Section 301(h) dischargers to meet the water quality criteria established

under WQA Section 304(a)(1) after initial mixing in the receiving waters. Section 301(h) dischargers have always been required to meet state water quality standards that are appropriate to local conditions, and that have been approved by the U.S. EPA. For this reason, Section 301(h) dischargers are required first to demonstrate compliance with water quality standards, and then to demonstrate compliance with water quality criteria only for those pollutants for which no directly corresponding numerical water quality standard exists. For example, if a water quality standard exists only for a group of toxic substances, such as metals, applicants would also be required to demonstrate compliance with the water quality criteria for individual metals (e.g., cadmium, lead, zinc) to demonstrate compliance with Part 125.60.

The Section 301(h) regulations were not amended with respect to change number 5--recirculation and reentrainment of previously discharged effluent from the POTW. However, POTWs that discharge into receiving environments where reentrainment is likely must consider the possible effects of such entrainment when demonstrating compliance with applicable water quality standards, water quality criteria, and other Section 301(h) criteria. Reentrainment is most often of concern in bays and estuaries where tidal currents predominate, and where previously discharged effluent is likely to be advected into the ZID after the tidal currents reverse.

Change number 8 in the regulations "grandfathers" applicants that had received tentative or final approval of their Section 301(h) modified permits before passage of the WQA. Such applicants are "grandfathered" for changes 1, 3, 4, and 5 above, but only for the term of the existing Section 301(h) modified permit. Applicants for reissuance of Section 301(h) modified permits must demonstrate compliance with all applicable Section 301(h) criteria to qualify for renewal of the Section 301(h) modified permit. Moreover, under Subpart 125.59(e) applicants for new or reissued Section 301(h) modifications (including grandfathered applicants) must, within 90 days of the effective date of the amended Section 301(h) regulations, submit to the Administrator additional information regarding their intent to demonstrate compliance with Part 125.60 (i.e., primary treatment

floor, compliance with water quality criteria) and Section 125.65 (i.e., urban area pretreatment requirements). Such applicants will then have 2 yr to demonstrate compliance with Parts 125.60 and 125.65, or in the case of some grandfathered applicants, until the time of application for permit renewal if that time is more than 2 yr away.

In addition, definitions of primary or equivalent treatment, pretreatment, categorical pretreatment standard, secondary removal equivalency, water quality criteria, permittee, and New York Bight Apex have been added to the amended Section 301(h) regulations, and definitions of industrial source, ocean waters, applications, and application questionnaire have been changed.

New technical guidance given in this document primarily addresses major changes numbers 1, 3, 4, and 5 above. Hence, it includes the following:

- Guidance for assessing impacts of the applicant's modified discharge "alone or in combination with pollutants from other sources"

- Guidance on methods for demonstrating compliance with urban area pretreatment requirements

- Guidance on methods for demonstrating compliance with applicable water quality standards and criteria

- Guidance for demonstrating that dilution water does not contain significant amounts of previously discharged effluent.

Updated guidance that reflects technical advances made since publication of the earlier version of this guidance document, the *Revised Section 301(h) Technical Support Document*, is also provided for demonstrating compliance with existing Section 301(h) regulations. Technical areas that have been updated most extensively include the physical and water quality assessments and the discussion of navigational requirements.

General guidance, new guidance, and updated guidance are provided in the format of the Application Questionnaire, with supporting appendices as warranted. General guidance includes discussions of the types of demonstrations that should be included by applicants when responding to each question. Detailed technical explanations of analytical methods that may be used to demonstrate compliance with specific regulatory criteria are provided in six supporting appendices. Methods for calculating initial dilution of the wastefield are provided in Appendix A (Physical Assessment). Detailed descriptions of analytical methods used to demonstrate compliance with water quality regulations are presented in Appendix B (Water Quality Assessment). These methods address suspended solids deposition, dissolved oxygen concentrations, sediment oxygen demand, suspended solids concentrations, effluent pH, light transmittance, and other water quality variables. Guidance for biological assessments, as represented by benthic community evaluations, is presented in Appendix C. Navigational considerations for sampling in estuarine and coastal areas are discussed in Appendix D. The new urban area pretreatment requirements and methods for demonstrating compliance with them are described in Appendix E. Finally, additional information on water quality-based toxics control is presented in Appendix F.

Because of the extensive redundancy that existed between the Small and Large Applicant Questionnaires in the 1982 regulations, a single Application Questionnaire is included in the amended Section 301(h) Regulations. It combines relevant questions from the two earlier questionnaires and includes new questions that address the changes in the Section 301(h) regulations. In addition to providing technical guidance for responding to questions in the Application Questionnaire, this document identifies who must respond to each question (i.e., large dischargers, small dischargers, or both). It also discusses the levels of detail that are appropriate for responses by dischargers of different sizes and into different receiving environments.

Each application for a Section 301(h) modified NPDES permit is submitted to, and reviewed by, the appropriate U.S. EPA Region. Having reached a decision regarding an application for reissuance of a Section 301(h)

modified permit, the Region may reissue the Section 301(h) modified permit with the same or different permit conditions, or deny the Section 301(h) modification. In the case of denial, the NPDES permit would then be reissued by the U.S. EPA (or, in NPDES-delegated states, by the state) with secondary treatment requirements. This document defines the conditions under which each of these actions is appropriate, and provides the Region with guidance on procedures for reissuing and terminating Section 301(h) modified permits. It does not provide guidance on the preparation of NPDES permits, which has been published elsewhere (U.S. EPA 1986b).

INTRODUCTION

Section 301(h) of the 1977 Clean Water Act (CWA) allows the U.S. Environmental Protection Agency (U.S. EPA) Administrator, upon application by publicly owned treatment works (POTWs) and with concurrence of the state, to issue National Pollutant Discharge Elimination System (NPDES) permits for the discharge of less-than-secondary treated effluent. POTWs were eligible to apply for such modified permits if they discharged to marine or estuarine waters, and if they could demonstrate compliance with Section 301(h) criteria and all other NPDES permit requirements.

Section 301(h) was amended in 1981 by the Municipal Wastewater Treatment Construction Grants Amendments, and the deadline for submittal of Section 301(h) applications was extended to 29 December 1982. In 1982, the *Revised Section 301(h) Technical Support Document* (Tetra Tech 1982b) was issued. It identified the new regulatory requirements of Section 301(h) and provided technical guidance on the preparation of Section 301(h) applications. A companion document, *Design of 301(h) Monitoring Programs for Municipal Wastewater Discharges to Marine Waters* (Tetra Tech 1982a), was also issued in 1982. It provided guidance on the development and implementation of monitoring programs that would meet Section 301(h) requirements.

Section 301(h) was amended again by the Water Quality Act (WQA) of 1987. That act did not extend the 1982 application deadline or reopen the application process to POTWs that had not applied by the 1982 deadline. However, it did amend Section 301(h) for POTWs already in the program. One of the primary purposes of this document is to identify changes to the Section 301(h) regulations promulgated by EPA to implement new Section 301(h) conditions imposed by the Water Quality Act of 1987 and to provide technical guidance for implementing those changes. This document also provides guidance on assessments and data analyses that applicants must perform to satisfy all applicable regulatory requirements, and on methods

that regulatory personnel may use to evaluate compliance with those regulatory requirements.

This document supercedes the *Revised Section 301(h) Technical Support Document*. It incorporates relevant guidance from that earlier document and from more recent guidance documents produced under the 301(h) program since 1982. *Design of 301(h) Monitoring Programs for Municipal Wastewater Discharges to Marine Waters* remains relevant to the 301(h) program, although much additional technical guidance is now available (see Question III.F.1 under the section entitled "Appropriate Analyses and Presentations of Results" below). The more recent guidance documents provide state-of-the-art guidance on the collection, analysis, and interpretation of monitoring data, including references for the most up-to-date laboratory and analytical techniques. This more recent guidance and the general guidance provided in the 1982 document provide a solid technical basis for the design and execution of Section 301(h) monitoring programs.

This *Amended Section 301(h) Technical Support Document* is divided into two major sections: a main body of text and appendices. The main body of text reviews the regulations implementing Section 301(h) (i.e., Part 125 Subpart G) and highlights proposed changes to those regulations made by EPA to reflect the references to Section 301(h) made by the 1987 WQA. It also provides general technical guidance to dischargers on the preparation of Section 301(h) applications for permit reissuance, including general discussions of the types of demonstrations that should be included by applicants when responding to each question in the application questionnaire. For example, it specifies whether large or small dischargers should respond to a given question, and discusses the level of detail that is appropriate to each. Methods that EPA personnel may use to evaluate compliance with regulatory criteria are also discussed. The appendices contain detailed technical explanations of the analytical methods that may be used to demonstrate compliance with specific regulatory criteria (e.g., formulas to determine dissolved oxygen concentration following initial dilution, detailed discussions of methods to demonstrate compliance with urban area pretreatment requirements).

The Section 301(h) regulations distinguish between large and small dischargers, and that distinction is maintained throughout this document. Dischargers are considered to be large or small based on their effluent flow and service population. Large dischargers are defined as POTWs that "have contributing populations equal to or more than 50,000 people or average dry weather flows of 5.0 MGD (million gallons per day) or more." Small dischargers "have contributing populations of less than 50,000 people and average dry weather flows of less than 5.0 MGD." The definition in Subpart 125.58(c) further stipulates that estimates of "the contributing population and flows shall be based on projections for the end of the five year permit term. Average dry weather flows shall be the average daily total discharge flows for the maximum month of the dry weather season."

BACKGROUND

Section 301(h) was amended by WQA Section 303, entitled "Discharges into Marine Waters." Section 303 includes Sections 303(a) through 303(g). The Section 301(h) regulations have been changed in response to these statutory amendments, and guidance is now needed to implement the new regulations. As background to providing such guidance, each of the statutory amendments is summarized below, followed by a brief description of the corresponding changes in the Section 301(h) regulations. Citations to the Part 125, Subpart G regulations that appear in the discussion below refer to the section numbers of the regulations *as renumbered*.

Section 303(a) amends Subsection 301(h)(2) to state that the modified discharge "will not interfere *alone or in combination with pollutants from other sources*, with the attainment or maintenance of water quality which assures protection of public water supplies and the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife, and allows recreational activities, in and on the water" (emphasis added). This amendment strengthens the existing regulations to prohibit Section 301(h) discharges into receiving waters where pollutants from the discharge would, in combination with pollutants from other sources, result in adverse impacts to water quality, recreational activities, or the resident biota.

In response to WQA Section 303(a), language was added to Subpart 125.62(f) to clarify this issue. The new language makes clear that it is not sufficient to demonstrate that the applicant's own discharge will not interfere with the attainment or maintenance of water quality as specified in the remainder of Part 125.62. Applicants must now demonstrate compliance with Part 125.62 based on the combined effects of the applicant's modified discharge and pollutants from other sources.

Under WQA Section 303(b), the scope of a Section 301(h) discharger's monitoring program is limited to "those scientific investigations that are necessary to study the effects of the proposed discharge." This limitation is applicable only to modifications and renewals of modifications that are tentatively or finally approved after the date of enactment of the WQA. Although the existing Section 301(h) requirements for monitoring programs were already generally focused on the effects of the applicant's discharge, this limitation was added to Part 125.63 of the regulations. This limitation does not affect the precedent for developing monitoring programs on a case-by-case basis.

WQA Section 303(c) is applicable only to large dischargers that discharge toxic pollutants introduced by industrial sources. It mandates that for any toxic pollutant introduced by an industrial source for which there are no applicable pretreatment requirements in effect, the applicant will demonstrate that sources introducing waste into the POTW are in compliance with all applicable pretreatment requirements, the applicant will enforce those requirements, and the applicant will demonstrate that the POTW has in effect a pretreatment program which, in combination with the POTW's own treatment processes, removes the same amount of toxic pollutant as would be removed if the POTW were to apply secondary treatment and had no pretreatment program for the pollutant. This "secondary equivalency" requirement places a technology-based standard on the discharge of toxic pollutants by applicable Section 301(h) dischargers. Under this provision, each such applicant must demonstrate, for each toxic pollutant introduced by an industrial discharger, either that it has an "applicable pretreatment requirement in effect" or that it has implemented a program that achieves

"secondary removal equivalency." Section 303(c) also requires POTWs to demonstrate that industrial sources of toxic substances are in compliance with all of their pretreatment requirements, including numerical standards set by local limits, and that those standards will be enforced.

To implement WQA Section 303(c), Part 125.65 was added to the regulations, definitions were added to Part 125.58, and existing definitions in Part 125.58 were revised. Part 125.65 requires that an urban area pretreatment program be implemented by applicable POTWs to demonstrate that toxic pollutants are being controlled. It also provides options for implementing that program. Definitions that are relevant to the urban area pretreatment program and that have been revised or added to the regulations include "categorical pretreatment standard," "industrial discharger" or "industrial source," "pretreatment," "secondary removal equivalency," and "water quality criteria."

WQA Section 303(d), establishes a minimum of primary treatment (or its equivalent). "Primary or equivalent treatment" is defined in Subsection 303(d)(2) as "treatment by screening, sedimentation, and skimming adequate to remove at least 30 percent of the biological oxygen demanding material and of the suspended solids in the treatment works influent, and disinfection, where appropriate." This subsection also mandates compliance with federal water quality criteria (U.S. EPA 1980, 1985b, 1986a) for Section 301(h) dischargers.

To implement WQA Section 303(d), Part 125.60 requiring a minimum of primary or equivalent treatment was added to the regulations, and the definition of "primary or equivalent treatment" stated in the WQA was incorporated into the Section 301(h) regulations without change [see Subpart 125.58(r)]. Subpart 125.62(a) of the regulations was also amended to state that at and beyond the boundary of the zone of initial dilution (ZID), applicants must meet all applicable water quality standards, and all water quality criteria established under Subsection 304(a)(1) of the WQA where no directly corresponding numerical water quality standards exist. Hence, after demonstrating compliance with water quality standards [as was

required under the 1982 Section 301(h) regulations], applicants need only demonstrate compliance with those water quality criteria (if any) for which no directly corresponding water quality standards exist.

Under WQA Section 303(e), Section 301(h) modified permits may not be issued for discharges into marine waters where the dilution water contains "significant amounts of previously discharged effluent from such treatment works." Re-entrainment of previously discharged effluent is often a potential problem in receiving waters that exhibit poor flushing characteristics, such as semi-enclosed bays or long, narrow estuaries. This section also prohibits issuance of Section 301(h) modified permits for discharges into the New York Bight Apex, and for discharges into saline estuarine waters unless those waters meet all of the following conditions:

- Support a balanced indigenous population (BIP) of shellfish, fish, and wildlife

- Allow for recreational activities

- Exhibit ambient water quality characteristics that are adequate to protect public water supplies; protect shellfish, fish, and wildlife; allow for recreational activities; and comply with standards that assure the protection of such uses.

A Section 301(h) permit may not be issued if any one of the foregoing conditions does not exist, regardless of whether the applicant's discharge contributes to departures from or retards recovery of such conditions. Hence, WQA Section 303(e) prohibits Section 301(h) modified NPDES permits for discharges into stressed saline estuarine waters.

Subpart 125.62(a)(1) of the 1982 regulations required the applicant's diffuser to be located and designed to provide initial dilution, dispersion, and transport sufficient to ensure compliance with water quality standards at and beyond the ZID boundary under critical environmental and treatment plant conditions. Because Subpart 125.62(a) was viewed to be a sufficient

criterion for ensuring that "significant amounts" of previously discharged effluent are not entrained, this subpart was not modified in response to WQA Section 303(e). [However, guidance is provided herein on how to position monitoring stations to determine compliance with this provision of the WQA.] Subpart 125.59(b)(4) was modified to include the prohibition of Section 301(h) modified discharges into stressed saline estuarine waters, and Subpart 125.62(f) was modified to apply only to stressed ocean waters.

WQA Section 303(f) applies only to POTWs that had existing agreements (i.e., prior to 31 December 1982) to use outfalls of Section 301(h) POTWs. This provision allows those POTWs to apply for their own Section 301(h) modified permit within 30 days of enactment of the WQA. Because no POTW applied under this provision, the Section 301(h) regulations were not amended to reflect Section 303(f).

As stated in WQA Section 303(g), Sections 303(a), (c), (d), and (e) do not apply to Section 301(h) modified permits that were tentatively or finally approved prior to enactment of the WQA. However, Section 303(g) further states that those sections will apply to all renewals of Section 301(h) modified permits that postdate enactment of the WQA. In response, Subpart 125.59(e)(1)(iii)(D) was added to the regulations, allowing certain applicants to defer compliance with the specified section of the WQA until permit renewal. [Applicants that had been issued tentative denials, or that had withdrawn their Section 301(h) applications prior to enactment of the WQA may not take advantage of this "grandfathering" provision.] A requirement was also added to Subpart 125.59(e) stating that "grandfathered" applicants and permittees must, within 90 days of the effective date of the regulatory revisions, submit additional information regarding their intent to demonstrate compliance with the new requirements under Parts 125.60 (primary or equivalent treatment requirements) and 125.65 (urban area pretreatment requirements) upon permit renewal.

The statutory deadline for Section 301(h) applications was 29 December 1982. Neither the WQA nor the amended Section 301(h) regulations extend that deadline. Hence, the aforementioned statute and changes to the

regulations only apply to POTWs presently in the 301(h) program. POTWs presently in the program include those that presently hold Section 301(h) modified permits, and those awaiting a final decision from U.S. EPA.

PURPOSE AND SCOPE

The primary purpose of this document is to provide technical support for implementing the Section 301(h) regulations that were amended in response to WQA Section 303. It does so in the following ways:

- Explaining WQA Sections 303(a) through 303(g), and resulting changes in the Section 301(h) regulations (provided above, in the section entitled "Background," and below, in the section entitled "Statutory Criteria and Regulatory Requirements")

- Providing technical guidance for implementing the new regulations, and updating that guidance for existing regulations (provided below, in the chapter entitled "Demonstrations of Compliance by Permittees")

- Providing guidance on the preparation of applications for reissuance of Section 301(h) modified NPDES permits (provided below, in the chapter entitled "Demonstrations of Compliance by Permittees"), on the evaluation of those applications to determine compliance with the regulations, and on the issuance and reissuance of Section 301(h) modified permits (provided below, in the chapters entitled "Evaluations of Compliance by U.S. EPA" and "Reissuance or Termination of Section 301(h) Modified Permits," respectively).

This document provides the following new technical guidance on how the results of studies and monitoring can be used to demonstrate compliance with the new regulations:

- Guidance for assessing impacts of the applicant's modified discharge "alone or in combination with pollutants from other sources"

- Guidance on methods for demonstrating compliance with urban area pretreatment requirements

- Guidance on demonstrating compliance with applicable water quality standards and criteria

- Guidance for demonstrating that dilution water does not contain significant amounts of previously discharged effluent.

This guidance appears in the section entitled "Appropriate Analyses and Presentation of Results" below, and in some cases, the appendices. Updated guidance is also provided on the calculation of initial dilution, navigation and station positioning methods, analysis of water quality data, assessments of the long-term effects of 301(h) discharges, sedimentation and dispersion models, calculations of initial mixing relative to conditions at the ZID boundary, and the degree of recirculation in the presence of contaminated receiving waters.

Monitoring data collected during the term of the modified NPDES permit are submitted to the regional jurisdiction of the U.S. EPA (hereinafter referred to as Regions) in accordance with permit procedures. The Regions use these data to determine continuing compliance with the terms and conditions of the permit, and with Section 301(h) regulations. Although this document was not written to help the Regions evaluate monitoring data during the terms of the modified permits, much of the guidance provided below is applicable to such evaluations.

NPDES permits are issued for 5-yr periods. At least 180 days prior to expiration, POTWs holding Section 301(h) modified permits must apply for reissuance of their NPDES permits. At the same time, they may apply for reissuance of their Section 301(h) modification, as stipulated in Parts

125.59, 122.21(d), and 124.3. Because the deadline for original applications for Section 301(h) modified permits has expired, only applications upon which there has not yet been a decision and applications for reissuance will be considered by the U.S. EPA in the future.

According to Subpart 125.59(c), "applicants for permit renewal shall support continuation of the modification by supplying to EPA, upon request, the results of studies and monitoring performed during the life of the permit." However, neither this subpart nor other subparts of Part 125, Subpart G [Criteria for Modifying the Secondary Treatment Requirements under Section 301(h) of the Clean Water Act] provide specific guidance on how the results of studies and monitoring should be used to support the application for permit reissuance.

In the 1982 Section 301(h) regulations, U.S. EPA recognized the limited financial resources of most small applicants and the lower potential for environmental impacts typically associated with small discharges. Those regulations provided separate questionnaires for large and small applicants, with fewer requirements placed on small applicants. To avoid the excessive duplication that existed with the separate questionnaires, the amended Section 301(h) regulations, and hence this document, present a single questionnaire. In this document, each question in the combined questionnaire is followed by a statement as to who must respond (i.e., large dischargers, small dischargers, or both), and guidance on how to respond.

As was true under the 1982 regulations, the level of detail expected of small applicants in their responses is considerably less than that required of large applicants for the same question. Because the amended Section 301(h) regulations do not provide specific guidance on the required level of detail, the Regions have considerable discretion regarding the level of detail necessary for applicants to demonstrate continued compliance with the 301(h) regulations. This document addresses the levels of detail that the Regions may require of small and large applicants during the permit reissuance process.

This document provides the Regions with procedures for evaluating compliance with Section 301(h) regulations. Appropriate uses of monitoring data to evaluate compliance with regulatory criteria are discussed, including the use of monitoring data to evaluate predictions of conditions that were expected to occur during the term of the Section 301(h) modified permit. Guidance is also provided to the Regions on how to evaluate the presence or absence of environmental impacts, and whether those impacts comply with 301(h) criteria.

Having reached a decision regarding an application for reissuance of a Section 301(h) modified permit, the Region may reissue the Section 301(h) modified permit with the same or different permit conditions, or deny the Section 301(h) modification. In the case of denial, the NPDES permit would then be reissued by the U.S. EPA (or, in NPDES-delegated states, by the state) with secondary treatment requirements. This document defines the conditions under which each of these actions is appropriate, and provides the Region with guidance on procedures for reissuing and terminating Section 301(h) modified permits. It does not provide guidance on the preparation of NPDES permits, which has been published elsewhere (U.S. EPA 1986b).

STATUTORY CRITERIA AND REGULATORY REQUIREMENTS

The WQA of 1987 amended CWA Section 301(h) in eight respects. Each of these is summarized below, followed by references to key subsections of the 301(h) regulations that respond to the statutory criteria of the CWA.

1) Section 301(h) modified discharges are prohibited from interfering, *alone or in combination with pollutants from other sources*, with the attainment or maintenance of water quality which assures the protection and uses listed in Subsection 301(h)(2). (emphasis added) [125.62(f)]

2) The scope of monitoring investigations is limited to only those investigations necessary to study the effects of the modified discharge. [125.63(a)]

3) With respect to any toxic pollutant introduced by an industrial source and for which there is no applicable pretreatment requirement in effect, POTWs serving populations of 50,000 or more are required to demonstrate that sources introducing waste into the POTW are in compliance with all applicable pretreatment requirements, that the POTW will enforce those requirements, and that the POTW has in effect a pretreatment program which, in combination with the POTW's own treatment processes, removes the same amount of toxic pollutant as would be removed if the POTW were to apply secondary treatment and had no pretreatment program for that pollutant. [125.65, 125.58(g), 125.58(j), 125.58(q), 125.58(w), 125.58(b)]

4) At the time the Section 301(h) modified permit becomes effective, the POTW must be discharging effluent that has received at least primary or equivalent treatment [as defined in Subpart 125.58(r)], and that meets the water quality criteria established under 304(a)(1) of the WQA after initial mixing in the receiving waters. [125.60, 125.58(r), 125.62(a)]

5) Section 301(h) modified permits may not be issued for discharges into waters that contain significant amounts of previously discharged effluent from the POTW. [Regulations not amended.]

6) Section 301(h) modified permits may not be issued for discharges into saline estuarine waters that exhibit stressed conditions, regardless of the applicant's contribution to those stressed conditions. Section 301(h) modified permits may not be issued for discharges into the New York Bight Apex under any conditions. [125.59(b)(4), 125.62(f)]

7) Any POTW that had an agreement before 31 December 1982 to use an outfall operated by another POTW that had applied for or received a Section 301(h) modified permit could have applied for its own Section 301(h) modified permit within 30 days of enactment of the WQA. [Regulations not amended.]

8) Some provisions of the WQA do not apply to applications that received tentative or final approval before enactment of the WQA, but apply to all applications for renewal of Section 301(h) modified permits. [125.59(e)]

Among the eight major changes listed above, numbers 1, 3, 4, 5, and 8 are most important to applicants and permittees that are not prohibited from applying for a Section 301(h) modified permit under other provisions of the amended regulations. The first major change requires POTWs to consider the impacts of their discharge on the receiving environment and biota in combination with pollutants from other sources. Previously, POTWs were required only to consider whether their discharge contributed to such impacts.

Change number 3 requires applicants to implement an urban pretreatment program (discussed in detail below under "Demonstrations of Compliance by Permittees" and in Appendix E). This new statutory requirement complements the toxics control program requirements in Part 125.66, and applies in addition to any applicable pretreatment requirements contained in Subpart 403. Dischargers may demonstrate compliance with Part 125.65 by demonstrating that an applicable pretreatment requirement is in effect, or by demonstrating secondary equivalency.

Applicable pretreatment requirements may be in the form of categorical pretreatment standards promulgated by the U.S. EPA under CWA Section 307, local limits developed in accordance with Subsection 403, or a combination of both. It is anticipated that most dischargers will be required to use a combination of both approaches to satisfy Part 125.65 with respect to all toxic substances introduced into the treatment works by industrial sources.

Alternatively, dischargers may demonstrate that its own treatment processes, in combination with pretreatment by industrial dischargers, achieves "secondary removal equivalency." Dischargers are required to make this demonstration whenever they cannot show that a toxic pollutant introduced by an industrial discharger is subject to an "applicable pretreatment requirement." Although secondary treatment is intended to control conventional, nontoxic pollutants, a certain amount of each toxic pollutant in the influent is removed during the process. The intent of this part of WQA Section 303(c) is to ensure that a Section 301(h) discharger removes that same amount of a toxic substance through industrial pretreatment plus the applicant's own treatment at less-than-secondary levels, as would be removed if the applicant were to apply secondary treatment and no pretreatment requirements existed for that pollutant. This demonstration requires the use of a secondary treatment pilot plant to determine empirically the amount of a toxic pollutant the would be removed from the influent if the applicant were to apply secondary treatment. For each pollutant introduced by an industrial source, that applicant would then demonstrate that industrial pretreatment plus the POTW's own treatment processes removed the same amount of pollutant as was removed by the secondary treatment pilot plant.

Change number 4 requires all Section 301(h) dischargers to achieve a minimum of primary or equivalent treatment, thereby establishing a primary treatment floor for all marine and estuarine POTWs. It also requires all Section 301(h) dischargers to meet the water quality criteria established under WQA Subsection 304(a)(1) after initial mixing in the receiving waters. Section 301(h) dischargers have always been required to meet state water quality standards that are appropriate to local conditions, and that have been approved by the U.S. EPA. For this reason, Section 301(h) dischargers are required first to demonstrate compliance with water quality standards, and then to demonstrate compliance with water quality criteria only for those pollutants for which no directly corresponding numerical water quality standard exists. For example, if a water quality standard exists only for a group of toxic substances, such as metals, applicants would also be required to demonstrate compliance with the water quality criteria for individual

metals (e.g., cadmium, lead, zinc) to demonstrate compliance with Part 125.60.

The Section 301(h) regulations were not amended with respect to the change number 5, recirculation and re-entrainment of previously discharged effluent from the POTW. However, POTWs that discharge into receiving environments where re-entrainment is likely must consider the possible effects of such entrainment when demonstrating compliance with applicable water quality standards, water quality criteria, and other Section 301(h) criteria. Re-entrainment is most often of concern in bays and estuaries where tidal currents predominate, and previously discharged effluent is likely to be advected into the ZID after the tidal currents reverse. Technical guidance is provided herein to assist applicants with demonstrating compliance with this new requirement.

Finally, the change number 8 in the regulations "grandfathers" applicants that had received tentative or final approval of their Section 301(h) modified permits before passage of the WQA. Such applicants are "grandfathered" for changes 1, 3, 4, and 5 above, but only for the term of the existing Section 301(h) modified permit. Applicants for reissuance of Section 301(h) modified permits must demonstrate compliance with all applicable Section 301(h) criteria to qualify for renewal of the Section 301(h) modified permit. Moreover, under Subpart 125.59(e), applicants for new or reissued Section 301(h) modifications (including grandfathered applicants) must, within 90 days of the effective date of the amended Section 301(h) regulations, submit to the Administrator additional information regarding their intent to demonstrate compliance with Part 125.60 (i.e., primary treatment floor, compliance with water quality criteria) and Part 125.65 (i.e., urban area pretreatment requirements). Such applicants will then have 2 yr to demonstrate compliance with Parts 125.60 and 125.65, or in the case of some grandfathered applicants, until the time of application for permit renewal if that time is more than 2 yr away.

Each of these eight major statutory changes has been integrated into the amended Section 301(h) regulations, and must be satisfied by applicants

for reissuance of Section 301(h) permits. Regulations applicable to such applications include NPDES permit regulations (Part 122) and the amended Section 301(h) regulations (Part 125, Subpart G). These regulations, including the changes that resulted from the WQA are discussed below in detail.

Part 122. U.S. EPA Administered Programs: The National Pollutant Discharge Elimination System

Subpart 122.21(d). Duty to Apply--

Under the subpart, POTWs with an exiting NPDES permit must submit an application for a new NPDES permit a minimum of 180 days before the existing permit expires. The applicant may ask to submit the new application after this due date, and the Region may grant such a request. The Region may extend the due date up to the expiration date of the existing permit. Upon review of an application, the Region may determine that additional information is needed to determine compliance with 301(h) regulations and permit conditions. Such information may be requested at anytime (including after the application deadline has passed) in accordance with Subpart 122.41(h).

It is strongly recommended that POTWs submit their applications for reissuance of Section 301(h) modified permits as early as possible, and no later than 180 days prior to expiration of the existing permit. This early submittal is particularly important because of the need to establish compliance with the recent statutory amendments to Section 301(h). As discussed below, early submittal gives the Regions time to review applications for completeness, and to request any information needed to complete applications before existing permits expire. An applicant must submit a completed application containing all required information prior to expiration of the existing permit, or at the time the application is due, whichever is first. Timely submittal of a completed application is required to qualify for the continuation described below.

Part 122.6 Continuation of Expiring Permits--

A permittee may have submitted a complete, timely application to the Region, but through no fault of the permittee, the Region may not have issued a new permit with an effective date on or before the expiration of the previous permit. This section provides that in those cases, the previous permit will remain fully effective and enforceable, pursuant to the Administrative Procedures Act.

Part 125, Subpart G

Part 125.56. Scope and Purpose--

Part 125, Subpart G establishes the criteria by which the U.S. EPA evaluates requests for Section 301(h) modified permits. It also establishes special permit conditions that must be included in Section 301(h) modified permits.

Part 125.57. Law Governing Issuance of Section 301(h) Modified Permit--

All applicants for Section 301(h) modified permits must demonstrate satisfactorily to the U.S. EPA that nine requirements will be met by the modified discharge:

1. An applicant must demonstrate that an applicable water quality standard exists for each pollutant for which the modification is requested. Details of this requirement are given in Part 125.61. Demonstrations that applicable water quality standards exist will be superfluous for reissuance of Section 301(h) modified permits because the original Section 301(h) modified permit was based, in part, on successful demonstrations that such standards exist. However, as specified in Part 125.61, an applicant must demonstrate that the modified discharge will comply with applicable water quality standards. An applicant must also provide a determination signed by an

authorized state or interstate agency, stating that the modified discharge will comply with state law. Both the demonstration of compliance with applicable water quality standards and the state's determination are required of applicants for reissuance of Section 301(h) modified permits.

2. An applicant must demonstrate that the modified discharge, alone or in combination with pollutants from other sources, will not interfere with the attainment or maintenance of water quality that assures the protection of public water supplies; assures the protection and propagation of a balanced indigenous population of fish, shellfish, and wildlife; and allows for recreational activities. Specific demonstrations that must be performed by an applicant are stated in Part 125.62. All are required of applicants for reissuance of Section 301(h) modified permits.

3. An applicant must demonstrate that a monitoring program has been established, and that this monitoring program is capable of documenting the impact of the modified discharge on a representative sample of aquatic biota. The scope of that monitoring program should only include those investigations necessary to study the effects of the modified discharge. General requirements of monitoring program design and specific requirements of the biological, water quality, and effluent monitoring components are specified in Part 125.63. Demonstrating that an effective monitoring program has been established will be simple for most POTWs that apply for reissuance of Section 301(h) modified permits because monitoring data will have been collected over the life of the existing permit. However, the U.S. EPA may require an applicant to demonstrate the effectiveness of an established monitoring program when the quality of the data is suspect, or when incomplete data have been submitted to the U.S. EPA.

4. An applicant must demonstrate that the modified discharge will not result in additional requirements on other point or nonpoint sources of pollutants. Part 125.64 requires an applicant to provide a determination signed by an authorized state or interstate agency indicating whether the modified discharge will result in any such additional requirements. The foregoing demonstration and determination of compliance are required of applicants for reissuance of Section 301(h) modified permits.

5. An applicant must demonstrate that pretreatment requirements for sources that introduce wastes into the treatment works will be enforced. This demonstration includes chemical analyses of the discharge for all toxic pollutants and pesticides; identification of sources of toxic pollutants and pesticides; and development of, implementation of, and compliance with an approved industrial pretreatment program, as specified in Part 125.65. However, these requirements are waived for small applicants that certify that there are no known or suspected sources of toxic pollutants and pesticides, and who document the certification with an industrial user survey as described by Subsection 403.8(f). Because they receive influent only from municipal sources, most small applicants for reissuance of Section 301(h) modified permits will be required to provide only an updated certification that there are no known or suspected sources of toxic pollutants or pesticides. Because industrial sources of pollutants may have changed over the term of the original Section 301(h) modified permit, both large and small applicants should review updated information on industrial sources of pollutants before performing the required demonstration or certifying that there are no known industrial sources of toxic pollutants or pesticides.

6. An applicant with treatment works serving a population of 50,000 or more must demonstrate that at the time of final permit approval, applicable pretreatment requirements will be in effect for each toxic pollutant introduced into the treatment works from industrial users. Applicable pretreatment requirements are defined in detail in Subpart 125.65. In Part 125.65, it is further stated that applicants may alternatively meet the requirements of this section with respect to a particular toxic pollutant pretreatment program in effect [125.65(c)], or by having in effect a program that achieves secondary removal equivalency for that pollutant [125.65(d)].

7. An applicant must demonstrate that a schedule of activities has been established to eliminate the introduction of toxic substances from nonindustrial sources into the treatment works. Just as was required in the original Section 301(h) application, applicants must comply with the specific requirements of Part 125.65(d). These requirements are that a public education program be developed, submitted with the application, and implemented; that nonindustrial source control programs be developed and implemented in accordance with schedules submitted with the application; and that the foregoing program may be revised by the U.S. EPA before issuance or reissuance of a Section 301(h) modified permit, or during the term of that permit. However, for small applicants certifying that there are no known or suspected problems related to toxic pollutants or pesticides in the discharge, only a public education program is required. As was true for original Section 301(h) applications, most small applicants should be able to provide the foregoing certification. However, updated information on water quality, sediment quality, and biological conditions should be reviewed by the small applicant before certifying that there are no known or suspected water quality, sediment

accumulation, or biological problems that are related to the discharge of toxic pollutants or pesticides.

8. An applicant must demonstrate that the modified discharge will not result in new or substantially increased discharges of the pollutant for which a Section 301(h) modification is being requested above the discharge specified in the Section 301(h) modified permit. Details of this requirement are given in Part 125.67, which states that where pollutant discharges are attributable, in part, to combined sewer overflows, an applicant must minimize such overflows and prevent increased discharges of pollutants. An applicant must also project effluent volumes and mass emission rates for pollutants to which the modification applies. These projections must be provided in 5-yr increments for the design life of the facility. This demonstration applies to applicants for reissuance of Section 301(h) modified permits.

9. An applicant must demonstrate that the modified discharge will have received at least primary or equivalent treatment, as required under Part 125.60. An applicant must also meet the criteria established under CWA Subsection 304(a)(1) in accordance with Subpart 125.62(a). Section 301(h) defines primary or equivalent treatment. It also prohibits Section 301(h) modified discharges into waters that contain "significant amounts of previously discharged effluent from such treatment works," and into saline estuarine waters that at the time of application do not support a balanced indigenous population of shellfish, fish and wildlife, or allow recreation in or on the waters, or which exhibit ambient water quality that does not meet specified standards. EPA has determined that a "significant amount of previously discharge effluent" is that amount which would cause the discharge plume to violate water quality beyond the zone of initial dilution.

Part 125.58. Definitions--

This section defines terms applicable to Subpart G regulations. Definitions of primary or equivalent treatment, pretreatment, categorical pretreatment standard, secondary removal equivalency, water quality criteria, permittee, and New York Bight Apex have been added to the amended Section 301(h) regulations, and definitions of industrial source, ocean waters, applications, and application questionnaire have been changed.

Part 125.59. General--

This section establishes general criteria and requirements that must be met by applicants for Section 301(h) modified permits. Also specified are several regulatory options that may be exercised by U.S. EPA during the application process. As indicated below, some of the general regulations are not relevant to applications for reissuance of Section 301(h) modified permits.

According to Subpart 125.59(a), an application may be based on a current, improved, or altered discharge into ocean waters or saline estuarine waters. This requirement remains relevant to applications for reissuance of Section 301(h) modified permits.

No Section 301(h) modified permits may be issued for the following discharges [see Part 125.59(b)]:

- Discharges that would not assure compliance with Part 122 and Part 125, Subpart G
- Discharges of sewage sludge
- Discharges that would not be in compliance with state, local, or other federal laws and Executive Orders [Subpart 125.59(b)]

- Applicants that have not met at least primary or equivalent treatment requirements (Part 125.60)

- Discharges entering saline estuarine waters that are stressed in the manner set forth in Subpart 125.59(b)(4)

- Discharges that enter the New York Bight.

This requirement is relevant to applications for reissuance of Section 301(h) modified permits.

Subpart 125.59(c) specifies that all applications for Section 301(h) modified permits must contain a signed, completed NPDES application; a completed Application Questionnaire; and a certification of veracity. This provision remains valid for applications for reissuance of Section 301(h) modified permits. Applicants for permit renewal should support continuation of their modification with results of studies and monitoring performed during the life of the permit. As was the case for original Section 301(h) applications, the level of detail required of applicants responding to questions in the Application Questionnaire will vary according to the volume, composition, and characteristics of the discharge, and to the characteristics of the receiving environment and biota. Applicants should consult with the EPA Region for permit reissuance well in advance of the application deadline. Timely consultation will ensure that each applicant is informed of the appropriate level of detail required to complete the Application Questionnaire, and will ensure that all data necessary for completing the questionnaire have been collected and are adequate to demonstrate compliance with 301(h) criteria and regulations.

Revisions to original Section 301(h) applications that were submitted under the 1979 and 1982 application deadlines are discussed in Subpart 125.59(d). Such revisions are not relevant to applications for reissuance of Section 301(h) modified permits. As noted above, a discharger holding an existing Section 301(h) modified permit must submit an application for a new

Section 301(h) modified permit at least 180 days before the existing permit expires.

Deadlines for submittal of applications for reissuance of Section 301(h) modified permits are specified in Subpart 122.21(d) and are discussed above. The distribution of such applications is not specified in Part 124 or Part 125, Subpart G. However, applicants should adhere to the distribution schedule required for original Section 301(h) applications, as indicated in Subpart 125.59(f)(1): one original and one copy to the appropriate U.S. EPA Regional Administrator, and one copy to state and interstate agencies authorized to provide certification or concurrence in accordance with Parts 124.53-124.55. Deadlines for applicants desiring to submit revised applications following the issuance of a tentative decision are stated in Subpart 125.59(f)(2).

Under Subpart 125.59(e), applicants or permittees are required to submit additional information regarding their intent to demonstrate compliance with Part 125.60 (Primary or Equivalent Treatment) and Part 125.65 (Urban Area Pretreatment Program) within 90 days of the effective date of the regulations. Subpart 125.59(e) specifies the additional information required, and the conditions under which the submittal of this information may be delayed until the time of permit renewal. Deadlines for providing additional information to demonstrate compliance with Parts 125.60 and 125.65 are specified in Subpart 125.59(f)(3).

A favorable state determination is required before the Region reviews an application. Under Subpart 125.59(f)(4), state determinations are due to the regions no more than 90 days after an application is submitted to the U.S. EPA. The Regions may extend this 90-day deadline upon request by the state. However, extensions are not recommended because they decrease the amount of time remaining until expiration of the existing modified permit, and the amount of time available for an applicant to respond to concerns of the state. It is strongly recommended that the applicant ensure that it obtains a timely determination from the state to submit to the Region, so as

not to diminish an applicant's likelihood of being reissued a Section 301(h) modified permit.

Under Subpart 125.59(g), the Regions may authorize or request an applicant or permittee to submit additional data after the application deadline. Such information must be submitted within 1 yr of the date of the authorization or request.

Options that the Regions and states may exercise in granting or denying a Section 301(h) modified permit are specified in Subpart 125.59(i). All remain relevant to applications for reissuance of Section 301(h) modified permits. For the Administrator to grant a Section 301(h) modified permit, an applicant must have demonstrated compliance with Parts 125.59-125.68. State certification (concurrence) is also required, with the state director cosigning the Section 301(h) modified permit if an intent to do so was indicated in the written concurrence. Section 301(h) modified permits must be issued in accordance with procedures in Part 124, and must contain all applicable terms and conditions specified in Parts 122 and 125.69. Appeals of Section 301(h) determinations may be made in accordance with procedures in Part 124. Under Subpart 125.59(h), the Administrator may grant a tentative decision on a Section 301(h) modified permit if the applicant can demonstrate that the modified discharge will comply with the provisions of Subpart 125 based on a schedule submitted by the applicant.

Part 125.68. Special Conditions for Section 301(h) Modified Permits--

Part 125.68 sets forth special conditions that must be included in Section 301(h) modified permits, in addition to those specified in Part 122. All remain valid for reissued Section 301(h) modified permits. The special conditions are as follows:

- That effluent limitations and mass loadings assure compliance with 301(h) regulations

- That schedules of compliance be included for the required industrial pretreatment program [Subpart 125.66(c)], the nonindustrial toxics control program [Subpart 125.66(d)], and control of combined sewer overflows [Part 125.67]

- That the proposed monitoring program include provisions for monitoring biota [Subpart 125.63(b)], water quality [Subpart 125.63(c)], and effluent [Subparts 125.60(b) and 125.63(d)]

- That the monitoring data be reported at the frequency prescribed in the approved monitoring program.

DEMONSTRATIONS OF COMPLIANCE BY PERMITTEES

The recently promulgated amendments to Part 125, Subpart G have been integrated into the Section 301(h) application questionnaire, which must be completed and included with all applications for renewal of Section 301(h) modified permits. Explanations of the demonstrations to be made by applicants are given below following each question, and in the appendices to this document, as appropriate.

All applicants for new or reissued Section 301(h) modified permits are required to demonstrate compliance with the new regulatory criteria. However, Part 125.59 establishes special procedures and deadlines for demonstrating compliance with Part 125.60 (i.e., primary treatment floor) and 126.65 (i.e., urban area pretreatment requirements). Compliance with Subpart 125.62(a)(1) (i.e., water quality criteria) is not included in the special procedures and deadlines established under Part 125.59.

Under Subpart 125.59(e), applicants for new or reissued Section 301(h) modified permits must submit a letter of intent to demonstrate compliance with Parts 125.60 and 125.65. For compliance with Part 125.60, the letter of intent must include a description of the proposed treatment system and a project plan for achieving compliance (including a schedule for data collection; dates for design and construction of necessary facilities; submittal of influent, effluent, and receiving water quality data; and any other information necessary for determining compliance with Part 125.60). For compliance with Part 126.65, the letter of intent must include a description of the approach that will be used to achieve compliance and a project plan for achieving compliance (including necessary data collection activities, submittal of additional information, and the development of any appropriate pretreatment limits). Applicants that submit additional information must modify their NPDES form and Application Questionnaire as needed to ensure that the information in their application is complete and

correct, must obtain new state determinations as specified in Subparts 125.61(b)(2) and 125.64(b), and must provide the certification required under Subpart 122.22(d).

Subpart 125.59(f) requires permittees and applicants with tentative or final approval of Section 301(h) modifications to submit a letter of intent that contains the information required under Subpart 125.59(e)(1). This letter must be submitted within 90 days of the promulgation of the amended Section 301(h) regulations. Applicants that have not yet received tentative approval of a Section 301(h) modification must submit a letter of intent within 90 days of receipt of that tentative approval. Applicants that are not "grandfathered" under Subpart 125.59(e)(1)(iii)(D) must demonstrate compliance with Parts 125.60 and 125.65 within 2 years of the promulgation of the amended Section 301(h) regulations. Applicants grandfathered under the aforementioned subsection must demonstrate compliance with these subsections at the time of permit renewal or within 2 years of the promulgation of the amended Section 301(h) regulations, whichever is later.

APPLICATION FORMAT

As specified in Subpart 125.59(c), a full, completed application for a Section 301(h) modified permit contains a certification of veracity; a signed, completed NPDES application [Short Form A or Standard Form A in accordance with Subparts 122.21(d) and 124.3]; and a completed Application Questionnaire. The order in which these parts are assembled is not specified in the 301(h) regulations, but many applicants for original Section 301(h) modified permits used the following sequence:

- Cover letter to U.S. EPA with the certification of the application's veracity either included in, or attached to, the letter [many large applicants included the cover letter and certification of veracity in the introduction to the Application Questionnaire (i.e., Part I)]

- The signed, completed NPDES application, establishing the requested permit conditions (e.g., effluent limitations)

- The completed Application Questionnaire.

Although the foregoing sequence of application parts is not mandatory, it is recommended because it facilitates review by the Region and appropriate state agencies. Accessory documents that would be useful to the Region during review of the application (e.g., data reports) should be appended to the application.

The Application Questionnaire given as Appendix A of Part 125, Subpart G is designed to provide the U.S. EPA with all information necessary to determine whether an applicant meets the statutory criteria and regulations of Subpart G. Guidance provided in this document and in *Design of 301(h) Monitoring Programs for Municipal Wastewater Discharges to Marine Waters* (Tetra Tech 1982a) complements the questionnaire. Although applicants are required to respond to applicable questions, the Regions may determine the appropriate level of response to each question for each applicant. The Region may also allow an applicant to incorporate data by reference to previous submittals.

The appropriate levels of response to questions should be communicated by the Regions to each applicant through timely consultation, which will help permittees submit the appropriate information on time. Because of the substantial differences among permittees and their respective receiving environments, applicants' responses to a given question are expected to range from a single sentence to a very detailed analysis. Close working relationships, particularly during the end of the existing permit term, will ensure that all data necessary for completion of the Application Questionnaire are available well in advance of the application deadline, and that each applicant understands the level of detail appropriate for each response. Such discussions should result in more concise responses to the questions, and should help avoid unnecessary effort and expense by the applicant during the application process.

REQUIRED DATA

Applicants "shall support continuation of the modification by supplying to EPA, upon request, the results of studies and monitoring performed during the life of the permit" [Subpart 125.59(c)]. For many dischargers, data collected during these studies and monitoring programs will be relevant to many, or all, of the questions in the Application Questionnaires. Additional relevant data may be found in publications and technical reports produced by other agencies, institutions, and companies working in nearby areas of the receiving environment. Data from such surveys could be used to better define environmental factors, such as the critical density profile for initial dilution calculations or biological conditions in a reference area. However, for some applicants, no new data [i.e., data collected after issuance of the original Section 301(h) modified permit] will be available to respond to some of the questions in the Application Questionnaire.

Although it is the permittee's responsibility to submit the appropriate information, it is critical that the Regions work with permittees, and communicate to them any perceived information deficiencies well in advance of the application deadline. Once informed of information deficiencies, permittees must collect, analyze, and interpret the necessary information for incorporation into the application for permit reissuance. Failure to supply necessary information could result in permit denial, based on the grounds that a complete application was not submitted. After an application has been received, however, the Region may determine that additional information is needed to determine compliance with 301(h) regulations and permit conditions. Such information may be requested at any time (including after the application deadline has passed) in accordance with Subparts 125.59(f) and 122.41(h).

APPROPRIATE ANALYSES AND PRESENTATION OF RESULTS

Guidance is provided below for the preparation of complete applications for Section 301(h) modified permits. Special instructions and exceptions for

small applicants are also provided. The sequence below corresponds to that recommended in the preceding discussion of application format. Accessory documents (e.g., data reports) should be appended to the application.

Just as original Section 301(h) applications were based on the most recent, appropriate, and technically correct data available at the time the application was prepared, applications for renewed Section 301(h) modified permits should consider monitoring data collected over the term of the existing modified permit, as required under Subpart 125.59(c)(4). When monitoring data and other information collected over the term of the existing permit confirm that all values of the variables used in a given calculation or demonstration have not changed and are not expected to change over the term of the new modified permit, the applicant may simply reproduce the calculation or demonstration that was given in the original application. However, in cases where the values of one or more variables have changed, or where new monitoring data are useful for supporting a given demonstration, those data should be included in the required response. All demonstrations of compliance with applicable statutes and regulations must consider the effects of the discharge singly and in combination with pollutants from other sources, if any other sources exist [301(h)(2) and Subparts 125.57(a)(2) and 125.62(f)].

I. INTRODUCTION

For clarity and consistency, it is recommended that the application be assembled in the following sequence:

- A cover letter signed by the responsible official for the POTW
- The statement of veracity mandated in Subpart 125.59(c)(3), also signed by the responsible official for the POTW
- A table of contents for the application, including any appendices
- A list of figures for the application
- A list of tables for the application
- A signed, completed NPDES Application Short Form A or Standard Form A
- A completed Application Questionnaire
- Any accessory documents (e.g., technical reports) considered necessary for an independent review of the application.

Guidance for preparing a complete application for reissuance of a Section 301(h) modified permit is provided below. The sequence in which the application parts are discussed corresponds to that recommended above.

Just as original Section 301(h) applications were based on the most recent, appropriate, and technically correct data available at the time the application was prepared, applications for reissuance of Section 301(h) modified permits should consider monitoring data collected over the term of the existing modified permit as required under Subpart 125.59(c)(4). When monitoring data and other information collected over the term of the

existing permit confirm that all values of the variables used in a given calculation or demonstration have not changed and are not expected to change over the term of the new modified permit, the applicant may simply reproduce the calculation or demonstration that was given in the original application. However, in cases where the values of one or more variables have changed, or where new monitoring data are useful for supporting a given demonstration, those data should be included in the required response.

Under 301(h)(2) and Subparts 125.57(a)(2) and 125.62(f), all demonstrations of compliance with applicable statutes and regulations must consider the effects of the discharge singly and in combination with pollutants from other sources, if any other sources exist. When demonstrating such compliance, the level of detail required of small applicants is considerably less than that required of large applicants for the same demonstration. Applicants should consult with U.S. EPA personnel before submitting an application to determine the level of detail that is appropriate for their discharge. POTWs that have been classified as small dischargers, but that no longer meet the conditions of the definition of small discharger [Subpart 125.58(c)] or that are not expected to meet those conditions during the next permit term, must apply for reissuance of this Section 301(h) modified permit as a large discharger.

II. GENERAL INFORMATION AND BASIC DATA REQUIREMENTS

II.A. Treatment System Description

II.A.1. Are you applying for a modification based on a current discharge, improved discharge, or altered discharge as defined in Part 125.58? [Subpart 125.59(a)]

**** Large and small dischargers must respond.*

Applicants should consider "current discharge" to mean the actual volume, composition, and location of a 301(h) permittee's discharge at the time of permit reapplication. Use of the latest 12 mo of data would be most appropriate in the application.

An "improved discharge" may result from any of the following changes:

- Improvements to the collection system, treatment plant, or outfall (including outfall relocations)
- Improvements to treatment levels or discharge characteristics
- Improvements in the operation or maintenance of the treatment system
- Measures to control the introduction of pollutants into the treatment works.

For improved discharges, applicants should briefly describe the changes to the treatment system or its operation upon which the application is based.

Discharge alterations include all changes that result in a treatment level less than that currently achieved, including changes in effluent volume or composition. All changes that result in the downgrading of effluent

characteristics, regardless of whether the outfall was previously improved or relocated to compensate for lower effluent quality, are considered altered discharges. Applications for altered discharges are permissible only for downgrading of effluent characteristics that are attributable entirely to population growth and/or industrial growth within the service area. Applicants who propose altered discharges based on population growth and/or industrial growth, and who propose improvements in treatments levels, should briefly describe the changes to the treatment system or its operation upon which the application is based.

II.A.2. Description of the Treatment/Outfall System [Subparts 125.62(a) and 125.62(e)]

a. *Provide detailed descriptions and diagrams of the treatment system and outfall configuration which you propose to satisfy the requirements of Section 301(h) and Part 125 Subpart G. What is the total discharge design flow upon which this application is based?*

b. *Provide a map showing the geographic location of the proposed outfall(s) (i.e., discharge). What is the latitude and longitude of the proposed outfall(s)?*

c. *For a modification based on an improved or altered discharge, provide a description and diagram of your current treatment system and outfall configuration. Include the current outfall's latitude and longitude, if different from the proposed outfall.*

**** Large and small dischargers must respond.*

Most of the above information can be found in Sections 1-13 of the NPDES Standard Form A. Past experience in the 301(h) program has shown that applicants often neglect to describe the treatment and outfall system in sufficient detail to allow evaluation of the technical merit of the appli-

cation. Applicants should provide a detailed description of this system such that the reader will have a complete picture of the physical aspects of the treatment and outfall system and will be able to understand the treatment processes that occur therein. Information on diffuser dimensions that are used to determine the port flow distribution achieved by the outfall are especially important (see Question II.A.7 below), and should be specified as accurately as possible. Figures and drawings with dimensions should be included if possible. In those descriptions, applicants should emphasize any changes in the service area, treatment system, or outfall system that were implemented during the term of the existing permit. Water depths and navigational coordinates of the outfalls as they exist should be correctly specified. Water depth of the outfall should be specified as the water depth at the midpoint of the diffuser, referenced to mean sea level or mean lower low water. Water depths and navigational coordinates found in engineering design documents are often not correct because of changes in the lengths and routes of the outfalls made during construction. Hence, drawings of as-built conditions should be used.

II.A.3. Primary or equivalent treatment requirements [Part 125.60]

a. *Provide data to demonstrate that your effluent meets at least primary or equivalent treatment requirements as defined in Subpart 125.58 (r)? [Part 125.60]*

b. *If your effluent does not meet primary or equivalent treatment requirements, when do you plan to meet them? Provide a detailed schedule, including design, construction, start up, and full operation, with your application. This requirement must be met by the effective date of the new section 301(h) modified permit.*

*** Large and small dischargers must respond.

Applicants must demonstrate that the treatment works will discharge, at a minimum, primary treated effluent (or its equivalent) at the time their modification becomes effective, as mandated by Parts 125.57 and 125.60. Applicants are advised that "primary or equivalent treatment" is defined in Subpart 125.58(r) as "treatment by screening, sedimentation, and skimming adequate to remove at least 30 percent of the biological oxygen demanding material and of the suspended solids in the treatment works influent, and disinfection, where appropriate." To support this demonstration, the applicant should supply monthly averaged data (typically monthly averages) for influent BOD, effluent BOD_5, suspended solids, pH, and flow for the last 1-yr period. The form of such data (e.g., weekly averages, monthly averages) should be specified precisely for each variable. Applicants should also submit data on the predicted maximum 2- to 3-h flow for the new end-of-permit year, and on measured effluent coliform bacteria concentrations in a form that satisfies state water quality regulations. Where average values are given (e.g., average dry-weather flow), applicants should specify how they were calculated.

II.A.4. Effluent Limitations and Characteristics [Subparts 125.61(b) and 125.62(e)(2)]

a. *Identify the final effluent limitations for 5-day biochemical oxygen demand (BOD_5), suspended solids, and pH upon which your application for a modification is based:*

- *BOD_5 _____ mg/L*
- *Suspended solids _____ mg/L*
- *pH _____ (range)*

b. Provide data on the following effluent characteristics for your current discharge as well as for the modified discharge if different from the current discharge:

Flow (m^3/sec):

- *minimum*
- *average dry weather*
- *average wet weather*
- *maximum*
- *annual average*

BOD_5 (mg/L) for the following plant flows:

- *minimum*
- *average dry weather*
- *average wet weather*
- *maximum*
- *annual average*

Suspended solids (mg/L) for the following plant flows:

- *minimum*
- *average dry weather*
- *average wet weather*
- *maximum*
- *annual average*

Toxic pollutants and pesticides (ug/L):

- *list each identified toxic pollutant and pesticide*

pH:

- *minimum*
- *maximum*

Dissolved oxygen (mg/L, prior to chlorination) for the following plant flows:

- *minimum*
- *average dry weather*
- *average wet weather*
- *maximum*
- *annual average*

Immediate dissolved oxygen demand (mg/L)

**** Large and small dischargers must respond.*

Applicants should specify the effluent limitations requested for their Section 301(h) modified permits, and the basis (e.g., monthly average values) for those limits. Applicants must request specific limitations. Except for pH, ranges of values or a list of alternatives are not acceptable. The remaining information on effluent characteristics can usually be found by analyzing plant operating records.

II.A.5. Effluent Volume and Mass Emissions [Subpart 125.62(e)(2) and Part 125.67]

a. *Provide detailed analyses showing projections of effluent volume (annual average, m^3/sec) and mass loadings (mt/yr) of BOD_5 and suspended solids for the design life of your treatment facility in 5 year increments. If the application is based upon an improved or altered discharge, the projections must be provided with and without the proposed improvements or alterations.*

b. *Provide projections for the end of your 5 year permit term for 1) the treatment facility contributing population and 2) the average daily total discharge flow for the maximum month of the dry weather season.*

**** Large and small dischargers must respond.*

Applicants should project effluent flows and mass emissions for the term of the modified permit being requested, and for subsequent years at 5-yr intervals. Projections should be based on annual average flows and annual average effluent characteristics. Projections should reflect expected changes in the service area and population over the term of the modified permit being requested, and over the subsequent periods of time being considered. Projections for the new end-of-permit year must be given, including the average daily flow for the maximum month of the dry-weather season, and average effluent characteristics for that month.

II.A.6. Average Daily Industrial Flow (m^3/sec). Provide or estimate the average daily industrial inflow to your treatment facility for the same time increments as in Question II.A.5 above. [Part 125.66]

**** Large and small dischargers must respond.*

Annual average flow data will generally be sufficient for nonseasonal (i.e., continuous operation) industries. For seasonal industries, average daily flows for the periods of operation should be provided. Supporting information (e.g., lists of industries and products manufactured) may be required.

II.A.7. Combined Sewer Overflows [Subpart 125.67(b)]

a. *Does (will) your collection and treatment system include combined sewer overflows?*

b. *If yes, provide a description of your plan for minimizing combined sewer overflows to the receiving water.*

**** Large and small dischargers must respond.*

Locations, flow quantities, and frequency of overflows should be specified. Data on total effluent flow and on effluent suspended solids and BOD_5 concentrations should be provided for times when overflows occur. The effect of increased infiltration during the rainy season should be discussed. Applicants should also provide a narrative description and schedule of a plan for minimizing the discharge of combined sewer overflows to the receiving water.

II.A.8. Outfall/Diffuser Design. Provide the following data for your current discharge as well as for the modified discharge, if different from the current discharge: [Subpart 125.62(a)(1)]

- *Diameter and length of the outfall(s) (meters)*
- *Diameter and length of the diffuser(s) (meters)*
- *Angle(s) of port orientation(s) from horizontal (degrees)*
- *Port diameter(s) (meters)*
- *Orifice contraction coefficient(s), if known*
- *Vertical distance from mean lower low water (or mean low water) surface and outfall port(s) centerline (meters)*
- *Number of ports*
- *Port spacing (meters)*
- *Design flow rate for each port, if multiple ports are used (m^3/sec)*

*** *Large and small dischargers must respond.*

The information requested above should be available from the engineering drawings for the treatment plant outfall and diffuser system. If risers are used, information sufficient to compute the riser discharge coefficient using the method of Koh (1973) should also be provided. For example, if the riser consists of a vertical pipe the following details should be specified: length and inside diameter of the pipe, material from which it is made, and diameter of the port orifice. Missing information should be so indicated in the responses to the foregoing questions. Because outfalls and diffusers are often built somewhat differently than specified in the engineering design drawings, applicants are advised to provide as-built information.

In addition to the foregoing information, applicants should provide information on the slope of the diffuser and the slope of the port centerlines if they differ from that of the diffuser. If the diffuser ports discharge to opposite sides of the diffuser, that information should be noted. The depths of the ports below mean lower low water (or mean low water as applicable) should be provided, as should any variations in port depths along the length of the diffuser.

The information provided in this section is routinely used in the review process to determine whether the diffuser is well-designed hydraulically for the range of flow (daily minimum to daily maximum) expected during the requested permit term. Among the characteristics of a well-designed diffuser are uniform port flows and individual port densimetric Froude numbers that are always greater than 1. Methods for computing the port flow distribution from a multiport diffuser are described by Grace (1978) and Fischer et al. (1979). Discharge coefficients for risers can be computed using methods provided by Koh (1973). [The explanation of these methods provided by Fischer et al. (1979) should not be used because it is incomplete and contains errors.] The effect of the bottom slope must be included in the diffuser hydraulics computations because some diffusers behave properly on a horizontal seafloor, but poorly on a sloping bottom, especially at low flow rates.

II.B. Receiving Water Description

II.B.1. Are you applying for a modification based on a discharge to the ocean [Subpart 125.58(n)] or to a saline estuary [Subpart 125.58(v)]? [Subpart 125.59(a)]

**** Large and small dischargers must respond.*

"Ocean waters" are defined in Subpart 125.58(n) as coastal waters landward of the baseline of the territorial seas, the deep waters of the territorial seas, or the waters of the contiguous zone. Territorial seas extend 3 mi outward from the baseline and the contiguous zone extends an additional 9 mi. This term does not include saline estuarine waters.

"Saline estuarine waters" are defined in Subpart 125.58(v) as semi-enclosed coastal waters that have a free connection to the territorial sea, undergo net seaward exchange with ocean waters, and have salinities comparable to those of the ocean. Generally, these waters are near the mouth of estuaries and have cross-sectional, annual mean salinities greater than 25 ppt. It should be noted, however, that 25 ppt is used as a general test in Subpart 125.58(v). The failure of the receiving water to meet this salinity concentration does not absolutely preclude eligibility for consideration under Section 301(h). However, where salinities fall substantially below this concentration, applicants should be careful to document that the waters into which they discharge meet the other requirements of Subpart 125.58(v) (i.e., free connection to the territorial sea and net seaward exchange with ocean waters).

Estuarine dischargers are advised that according to Subparts 125.57(a)(9) and 125.59(b)(4), Section 301(h) modified permits may not be issued for discharges into saline estuarine waters unless those waters meet all of the following conditions:

- Support a balanced indigenous population of shellfish, fish, and wildlife

- Allow for recreational activities in and on the waters

- Exhibit ambient water quality below applicable water quality standards adopted for the protection of public water supplies, shellfish, fish and wildlife or recreational activities or such other standards necessary to assure support and protection of such uses.

These conditions must be met, regardless of whether the applicant's discharge contributes to departures from such conditions. According to Section 301(h)(3) and Subpart 125.57(e), the foregoing prohibition does not apply to discharges with Section 301(h) modified permits that were tentatively or finally approved prior to the enactment of the Water Quality Act of 1987. However, it is further stated that the foregoing prohibitions are in force for all renewals of Section 301(h) modified permits that postdate enactment of the Water Quality Act of 1987. Thus, all estuarine dischargers must demonstrate that the receiving waters exhibit the above characteristics (i.e., that they are not stressed) at the time of permit reissuance, regardless of whether such conditions existed at the time the existing Section 301(h) modified permit was issued.

> *II.B.2. Is your current discharge or modified discharge to stressed waters as defined in Subpart 125.58(z)? If yes, what are the pollution sources contributing to the stress? [Subparts 125.59(b)(4) and 125.62(f)]*

**** Large and small dischargers must respond.*

"Stressed waters" are defined in Subpart 125.58(z) as those ocean waters in which the absence of a balanced indigenous population of shellfish, fish, and wildlife is caused solely by human perturbations other than the applicant's modified discharge. If the discharge is to stressed waters,

Subpart 125.57(a) prohibits permit reissuance if the discharge *alone or in combination with pollutants from other sources* adversely impacts the balanced indigenous population, water quality, or recreational activities. In addition, estuarine dischargers are advised that under Section 301(h)(9) and Subparts 125.57(a)(2) and 125.59(b)(4), permits may not be reissued for discharges to stressed saline estuarine waters.

Applicants that respond "no" to this question should state the basis for their conclusion.

II.B.3. Provide a description and data on the seasonal circulation patterns in the vicinity of your current and modified discharge(s). [Subpart 125.62(a)]

**** Large and small dischargers must respond.*

The applicant should provide sufficient information on current speed and direction in the vicinity of the discharge to predict the dispersion and transport of diluted effluent. This information should include a description of current patterns and general density structure on a seasonal basis, as well as the variation over a tidal cycle. Estimates of near-surface and near-bottom lowest 10 percentile current speeds should be provided, as well as the locations of the current meters and the time span over which data were collected. Hydraulic residence times and flushing characteristics should be described for discharges into estuaries and semi-enclosed bodies of water. Any periods of net drift stagnation and natural upwelling should be described, including changes in the current patterns and stratification.

The applicant should also discuss the occurrence of onshore surface currents. Because onshore winds induce onshore currents, wind speed and direction statistics that are appropriate for the diffuser location should also be provided. Useful sources of information include data collected during execution of the monitoring program for the existing modified permit, data collected in the vicinity of the discharge by other researchers, and

U.S. Department of Commerce tidal current tables (e.g., Tidal Current Tables 1988, Atlantic Coast of North America; Tidal Current Tables 1988, Pacific Coast of North America and Asia).

Subpart 125.57(a)(9) prohibits Section 301(h) modified permits for discharges where the dilution water contains "significant amounts of previously discharged effluent from such treatment works." In responding to Question II.B.3, applicants should discuss the potential for re-entrainment of previously discharged effluent. Re-entrainment is a potential problem primarily in receiving waters that exhibit poor flushing characteristics. Such conditions can also occur, however, in open coastal areas during periods of tidal or wind-driven current reversals, or temporary stagnation of longshore coastal currents.

II.B.4. Oceanographic conditions in the vicinity of the current and proposed modified discharge(s). Provide data on the following: [Subpart 125.62(a)]

- *Lowest ten percentile current speed (m/sec)*
- *Predominant current speed (m/sec) and direction (true) during the four seasons*
- *Period(s) of maximum stratification (months)*
- *Period(s) of natural upwelling events (duration and frequency, months)*
- *Density profiles during period(s) of maximum stratification*

**** Only large dischargers must respond.*

The vertical and areal distribution of currents and water density in both the near field and far field are needed to evaluate plume dilution, wastefield transport, and potential re-entrainment of previously discharged effluent. Data collected from previous studies or nearby similar areas will often be appropriate.

The number and location of sampling stations needed to provide sufficient data will depend on the bathymetric and hydrographic environment. For open coastal sites with uniform bathymetry and minimal freshwater inflows, as few as five stations may be adequate. However, for an estuary with significant freshwater inflow and highly variable bathymetry, as many as 50 stations may be necessary.

For existing discharges, the measurements should be made in the vicinity of the outfall but outside the region directly influenced by the discharge. For relocated outfalls, measurements should be made in the vicinity of the proposed discharge location. Current data should be obtained near the surface, at the approximate depth of the wastefield, and in the bottom 2 m (6.6 ft) of the water column. Water depths at the stations should be similar to the water depth at the site of the existing and relocated outfalls (if present).

The duration of time within which these measurements should be obtained is dependent on the current regime and the variability of the density structure. If the currents are predominantly tidal (which could be the case for both open coastal and estuary sites), the current measurements should be at approximately 30-min intervals for not less than 29 days. If seasonal changes in oceanographic conditions (e.g., low or variable longshore current speeds or directions, upwelling, shoreward transport, high and low runoff) are significant, then information should be obtained for each season. The question is based on the presumption that periods of maximum stratification will be important for calculating critical initial dilutions. Field data on other potentially critical periods (e.g., periods of longshore current stagnation) may be necessary for determining whether this presumption is true.

Reduction and presentation of data should be of sufficient detail to support the interpretation and analyses performed in the application. The following forms of data reduction and presentation are recommended:

- Current persistence tables - Summary of the frequency and duration of specific current speed and direction events. For example, currents with speeds between 10 and 15 cm/sec (0.33 and 0.49 ft/sec), directions between 260 and 280 degrees (T), and durations of at least 1 h occurred for 18 percent of the data record.

- Current speed and direction frequency tables - Frequency of specific current speed and direction intervals. For example, currents with speeds between 5 and 10 cm/sec (0.16 to 0.33 ft/sec) occurred for 20 percent of the data record, and currents with directions between 80 and 90 degrees (T) occurred for 23 percent of the data record.

- Net coastal orthogonal component analysis - By determining the predominant directions of current flow, a primary axis for orthogonal component decomposition of each current vector can be selected. The net component relative to each axis can then be determined. If the currents do not exhibit predominant flow directions, an axis parallel to the local bathymetry or in the direction of an area of significance can be selected.

- Current mean and variance - For the predominant directions of current flow or the selected primary axis, the mean and variance of the current speed can be determined.

Guidance on instrumentation and methods for oceanographic data collection is provided in *Design of 301(h) Monitoring Programs for Municipal Wastewater Discharges to Marine Waters* (Tetra Tech 1982a).

II.B.5. Do the receiving waters for your discharge contain significant amounts of effluent previously discharged from the treatment works for which you are applying for a section 301(h) modified permit? [Subpart 125.57(a)(9)]

*** *Large and small dischargers must respond.*

Applicants should explain the basis for their response to this question. Explanations should reflect the hydrographic characteristics of the receiving environment and the behavior of the effluent plume through time. Applicants that respond negatively to this question should demonstrate that little or no previously discharged effluent will be advected into the ZID (after having been transported out of the ZID) to become entrained in the effluent plume. This demonstration will be relatively simple for applicants that discharge to open coastal areas where currents are unidirectional most of the time. Those applicants should be able to plot effluent transport through time, and thereby demonstrate that little or no effluent re-enters the ZID. The demonstration will be much more complicated for dischargers into estuarine environments where tidal currents oscillate. In estuaries, effluent transported away from the ZID during the first half of a tidal cycle may be transported back into the ZID on the second half of that cycle. If effluent is likely to be transported back into the ZID, the applicant should estimate the quantities of effluent that would be entrained.

In responding to this question, applicants should demonstrate that all applicable water quality standards and water quality criteria are met at and beyond the ZID boundary. If the dilution water contained significant quantities of previously discharged effluent, it is unlikely that an applicant would be able to meet all applicable water quality standards and criteria. Responses given for Questions II.D.1, II.D.2, and II.D.3 of the Application Questionnaire may be cited to support this demonstration.

II.B.6. Ambient water quality conditions during the period(s) of maximum stratification: at the zone of initial dilution (ZID) boundary, at other areas of potential impact, and at control stations. [Subpart 125.62(a)]

a. Provide profiles (with depth) on the following for the current discharge location and for the modified

discharge location, if different from the current discharge:

- *BOD_5 (mg/L)*
- *Dissolved oxygen (mg/L)*
- *Suspended solids (mg/L)*
- *pH*
- *Temperature (^oC)*
- *Salinity (ppt)*
- *Transparency (turbidity, percent light transmittance)*
- *Other significant variables (e.g., nutrients, toxic pollutants and pesticides, fecal coliform bacteria)*

b. *Provide available data on the following in the vicinity of the current discharge location and for the modified discharge location, if different from the current discharge:*

- *Dissolved oxygen (mg/L)*
- *Suspended solids (mg/L)*
- *pH*
- *Temperature (^oC)*
- *Salinity (ppt)*
- *Transparency (turbidity, percent light transmittance)*
- *Other significant variables (e.g., nutrients, toxic pollutants and pesticides, fecal coliform bacteria)*

c. *Are there other periods when receiving water quality conditions may be more critical than the period(s) of maximum stratification? If so, describe these other critical periods and the data requested in 5.a. for the other critical period(s). [Subpart 125.62(a)(1)]*

**** Large dischargers must respond to Parts a and c. Small dischargers must respond to Parts b and c.*

To document the periods of maximum stratification, temperature and salinity profiles that are sufficient to determine the most stratified and the typical conditions should be provided for each oceanographic season. The "most stratified" temperature and salinity profile with depth is the profile that will produce the lowest initial dilution (see Question III.A.1 for definition). In some locations, such a profile has the steepest gradients of temperature or salinity near mid-depth. Both temperature (expressed in degrees C) and salinity (expressed in ppt) should be measured accurately to two decimal places so that density (expressed in gm/cm^3) can be computed accurately to five decimal places. Also, only measured profiles should be provided. Averages of measured profiles or "representative" profiles should never be substituted. Density profiles should exhibit a stable water column over the plume height-of-rise (i.e., no higher density water should overlie lower density water). The minimum period of time over which oceanographic data must be collected to establish typical and most stratified conditions is 1 yr. Because oceanographic conditions vary among years, it is recommended that data collected over 5 yr be provided.

Sampling for nutrients, coliform bacteria, and other major variables may be conducted at selected depths. Secchi disc depth data should be provided if transparency data are not available. However, because the Secchi disc measures transparency from the surface down into the water column, use of the Secchi disc is not appropriate when the effluent plume does not surface. In addition, because sunlight greatly increases die-off rates of enteric bacteria (Elliot and Colwell 1985; Crane and Moore 1986), bacteriological sampling should be conducted during early morning or at night. Ambient water quality data collection procedures and requirements are different for existing and for proposed or relocated discharge locations, as discussed in *Design of 301(h) Monitoring Program for Municipal Wastewater Discharges to Marine Waters* (Tetra Tech 1982a) and summarized below.

For existing discharges, station locations should include sampling at the ZID boundaries (both upcurrent and downcurrent), at control (i.e., background ambient) stations, along the primary axis of the longshore component of the current (both upcurrent and downcurrent), at intermediate upcurrent stations located between the ZID boundary and the upcurrent control station, and in potential impact areas (e.g., in the nearshore zone and close to areas with distinctive habitats). The applicant should use information on local currents and wastefield dispersion patterns to select sampling station locations in potentially impacted areas. Sampling stations located at the ZID boundary, at control stations along the primary axis of current, and at intermediate upcurrent stations should be in waters of approximately the same depth. Control (i.e., background ambient) stations should be located in areas not influenced by the applicant's discharge. The intermediate upcurrent stations are intended to represent the approximate residual wastefield concentrations (i.e., affected ambient) upcurrent of the discharge location to account for potential recirculation of previously discharged effluent (by reversing tidal currents, upwelling, or stagnant net circulation). Data should be collected at the intermediate and ZID stations at least twice during the day (e.g., high and low tide slack), to allow evaluation of short-term conditions. The duration of the longshore current in relation to the time of sampling is an important factor in determining whether the intermediate upcurrent stations are representative of persistent conditions or of only a temporary plume reversal. For discharges involving outfall relocation, monitoring stations must be located at the existing discharge site until cessation of that discharge, and at the relocation site.

For each survey, the following information should be submitted along with the data: a chart showing exact locations of the stations, the depth at which the measurements were taken, and the sampling dates and times. For existing discharges, the applicant should state whether effluent was discharging from the outfall at the time of the survey and should provide the flow rate, BOD_5 concentration, pH, and suspended solids concentration of the effluent, if available. Any unusual meteorological or oceanographic conditions (e.g., storms, onshore transport, low or stagnant longshore

currents) should be discussed. Current data or other oceanographic information (e.g., drogues) should be deployed at the time of the survey to determine the direction of movement of the wastefield.

Other periods when water quality conditions may be more critical include periods of maximum hydraulic loading from the POTW, exceptional biological activity, poor background water quality, minimum stratification, low net circulation, and low effective net flushing or low intertidal mixing. The latter three cases represent the potential for recirculation of previously discharged effluent. The degree of recirculation would become significant if it caused the discharge to violate water quality criteria at the ZID boundary, when under normal circulation conditions it would meet the criteria at the ZID boundary.

II.B.7. Provide data on steady state sediment dissolved oxygen demand and dissolved oxygen demand due to resuspension of sediments in the vicinity of your current and modified discharge(s) (mg/L/day).

**** Only large dischargers must respond.*

Dissolved oxygen depletion due to steady sediment demand and sediment resuspension depends on sediment composition (e.g., grain size distribution and organic content), sediment accumulation rates, current speeds, and circulation patterns. Field or laboratory measurements can sometimes be used to determine oxygen consumption rates. If such measurements are made, the results and procedures used should be described.

II.C. Biological Conditions

In the Section 301(h) process, the determination of adverse biological effects involves assessing whether or not a BIP of shellfish, fish, and wildlife exists in the vicinity of the discharge and in other areas potentially affected by the discharge. Since the BIP concept forms an

integral part of the applicant's biological assessment, it is important to establish the meaning and interpretation of the term in the context of a Section 301(h) biological demonstration.

The term "population" does not mean a reproductive unit of a single species but rather all biological communities existing in the receiving water body. Similarly, the terms "shellfish," "fish," and "wildlife" should be interpreted to include any and all biological communities that may be affected adversely by a marine POTW discharge [Subpart 125.58(y)].

A BIP is defined in the Section 301(h) regulations [Subpart 125.58(f)] as "an ecological community which: 1) exhibits characteristics similar to those of nearby, healthy communities existing under comparable but unpolluted environmental conditions; or 2) may reasonably be expected to become re-established in the polluted water body segment from adjacent waters if sources of pollution were removed." Balanced indigenous populations occur in unpolluted waters. The second part of the definition concerning the re-establishment of communities is included because of its relevance to proposed, improved discharges and to discharges into waters that are stressed by sources of pollution other than the applicant's modified discharge.

The biological community characteristics that might be examined in an evaluation of a BIP include (but are not limited to) species composition, abundance, biomass, dominance, and diversity; spatial and temporal distributions; growth and reproduction of populations; disease frequency; trophic structure and productivity patterns; presence or absence of certain indicator species; bioaccumulation of toxic materials; and the occurrence of mass mortalities of fish and invertebrates.

The first step in an applicant's BIP demonstration is to define the "indigenous population" and establish the natural variability of the "balanced population." Because U.S. EPA has determined that these are observable characteristics of natural that communities that exist in the absence of human disturbance, a comparative strategy is found throughout the Section 301(h) regulations. Biological variables of concern within and

beyond the ZID should be compared to the range of natural variability found in comparable but unpolluted habitats.

The extent of documentation provided by the applicant in the marine biological assessment should reflect the quality and quantity of the effluent and the sensitivity of the receiving environment. Data requirements will probably be least for applicants without substantial industrial waste sources whose discharges into ocean waters do not potentially affect distinctive habitats of limited distribution or important fishery resources.

> *II.C.1. Provide a detailed description of representative biological communities (e.g., plankton, macrobenthos, demersal fish, etc.) in the vicinity of your current and modified discharge(s): within the ZID, at the ZID boundary, at other areas of potential discharge-related impact, and at reference (control) sites. Community characteristics to be described shall include (but not be limited to) species composition; abundance; dominance and diversity; spatial/temporal distribution; growth and reproduction; disease frequency; trophic structure and productivity patterns; presence of opportunistic species; bioaccumulation of toxic materials; and the occurrence of mass mortalities.*

**** Only large dischargers must respond.*

Of the marine communities that may be affected by POTW discharges, benthic communities or other communities that depend upon the benthos as a food source (i.e., bottom-dwelling or bottom-feeding organisms) are usually the most sensitive to pollutants. The rate of accumulation of discharged solids and associated toxic substances near a POTW outfall affects the magnitude and extent of impacts to benthic communities. Based on the review of biological conditions near both large and small discharges in a variety of marine and estuarine environments, it is apparent that the effects of POTW discharges on the benthos are determined primarily by the influence of the local hydrographic regimes on solids deposition and accumulation. Observed biological effects in areas of solids accumulation are generally

associated with decreased abundances of suspension-feeding animals and increased abundances of deposit-feeding animals. Such effects would be expected to occur in sediments enriched with organic matter (e.g., from POTWs).

The biological information must be used to describe existing conditions near the discharge and to determine whether or not a BIP exists (or will exist) near the existing and modified discharges. This descriptive information must be used as the basis for the applicant's response to Question III.D.1.

Applicants must submit descriptions of representative biological communities (typically benthic infauna and demersal fishes) in the receiving water body. These descriptions will form the basis for the comparative BIP demonstrations. It is important that the applicant assess biological community characteristics at a minimum of four sites: within the ZID, at or immediately beyond the ZID boundary, within the expected discharge impact area outside the ZID, and at appropriate reference sites.

Benthic data should be adequate to perform valid statistical and community analyses for the purposes of determining whether or not the following conditions exist:

- Benthic community structure in the discharge area differs from that in the control area

- Benthic biomass in the discharge area differs from that in the control area

- Opportunistic or pollution-tolerant species dominate benthic communities in the discharge area

- Anoxic sediment conditions occur in the discharge area

- Distinctive habitats of limited distribution (when present) are adversely affected by the applicant's discharge

- The discharge contributes to or perpetrates ambient stresses in the receiving environment (stressed water discharges only).

When the applicant's discharge is located in an area of soft substrates, sediment data must also be collected simultaneously with the benthic community at each sampling station. These data should include grain size composition and a measure of organic content. Data on Kjeldahl nitrogen, sediment BOD_5, and other sediment variables may also be collected. Sediment data will be used to identify correlations between benthic community structure and attributes of the sedimentary environment in the receiving waters. Detailed guidance for evaluating benthic community conditions in the vicinity of outfall is given in Appendix C.

II.C.2. a. Are distinctive habitats of limited distribution (such as kelp beds or coral reefs) located in areas potentially affected by the modified discharge? [Subpart 125.62(c)]

b. If yes, provide information on type, extent, and location of habitats.

**** Large and small dischargers must respond.*

"Distinctive habitats of limited distribution" include marine environments whose protection is of special concern because of their ecological significance or value to humans. These habitats include, but are not limited to, coral reefs, kelp beds, seagrass meadows, salt marshes, spawning or nursery areas for commercial species, sites of aesthetic appeal, and rocky intertidal habitats (where they are uncommon). Distinctive habitats of limited distribution may be highly susceptible to the potential effects of discharged suspended solids and nutrients on the unique floral (e.g., kelp, seagrass) or faunal (e.g., coral) components of the communities. The potential for adverse effects of bioaccumulation of toxic substances is

also relatively high because sessile floral and faunal organisms may constitute important trophic pathways within these communities. These attached communities are also susceptible because of the potential for continuous exposure to the effluent plume.

The applicant must describe distinctive habitats of limited distribution within the receiving water environment, as follows:

- Kinds of distinctive habitats that occur in the general vicinity of the discharge
- Areal extent and location of the habitats in the region (shown on a map)
- Approximate distance from the discharge to sensitive habitats
- Physical characteristics of each distinctive habitat (water column and substrate)
- Species composition of the flora and fauna
- Abundance or percent cover (as applicable) of resident species
- Spatial and temporal variations in the biotic and abiotic components of each distinctive habitat present.

The basic information supplied by the applicant is expected to be descriptive in nature, and should not require field surveys. Possible sources for information on distinctive habitats include contacts with local offices of state conservation agencies, and literature and resource maps, which are available for many areas.

II.C.3. a. Are commercial or recreational fisheries located in areas potentially affected by the discharge? [Subparts 125.62(c) and (d)]

b. If yes, provide information on types, location, and value of fisheries.

**** Large and small dischargers must respond.*

Assessment of impacts on fisheries is important because of their economic significance, their recreational potential, and the potential for human consumption of contaminated organisms. The applicant should provide information on all fishery resources, both harvested and unharvested, near the outfall and in other areas potentially influenced by the discharge. Emphasis should be placed upon regulatory or health-related factors that prevent utilization of the resource, especially if such factors are related to contamination. Sources of information include natural resource agencies, public health agencies, local anglers, and academic institutions. For this assessment, the applicant should specify where species of recreational or commercial importance occur (i.e., in the immediate vicinity of the discharge, in the general region of the discharge, as migrants through the region).

The immediate vicinity of a discharge includes the outfall structure and the area associated with the discharge plume or clearly impacted by the deposition of discharged sediment. The spatial extent of the fisheries data will depend on the size and potential effects of the discharge, and on the characteristics of the data. Many state fish and game agencies have established statistical areas for recording fisheries data. In these cases, an applicant can consider regional fisheries as those occurring in the statistical block that includes the outfall. If the outfall is located within an embayment or estuary where fisheries occur, the applicant should address commercial and recreational fisheries throughout the embayment or estuary.

Distances of the various fishery resources from the discharge should be provided. The following information should be provided:

- Magnitude of the fisheries
  - Effort levels (e.g., number of vessels or number of fishermen)
  - Economic value of commercial landings or sport fishery
- Temporal pattern of the fisheries.

II.D. *State and Federal Laws [Subparts 125.61 and 125.62(a)(1)]*

II.D.1. Are there water quality standards applicable to the following pollutants for which a modification is requested:

- *Biochemical oxygen demand or dissolved oxygen?*
- *Suspended solids, turbidity, light transmission, light scattering, or maintenance of the euphotic zone?*
- *pH of the receiving water?*

**** Large and small dischargers must respond.*

Applicants should contact the state water quality agency for an answer to this question.

II.D.2. If yes, what is the water use classification for your discharge area? What are the applicable standards for your discharge area for each of the parameters for which a modification is requested? Provide a copy of all applicable water quality standards or a citation to where they can be found.

*** *Large and small dischargers must respond.*

Applicants should contact the state water quality agency for an answer to this question.

> *II.D.3. If there are no directly corresponding numerical applicable water quality standards approved by EPA, provide data to demonstrate that water quality criteria established under Subsection 304(a)(1) of the Water Quality Act are met at or beyond the boundary of the ZID under critical environmental and treatment plant conditions in the waters surrounding or adjacent to the point at which your effluent is discharged. [Subpart 125.62-(a)(1)]*

At the time the 301(h) modification becomes effective, the applicant's outfall and diffuser must be located and designed to provide adequate dilution, dispersion, and transport of wastewater to meet, at or beyond the ZID, all applicable water quality standards and all applicable water quality criteria for which there are no corresponding approved water quality standards.

To demonstrate compliance with water quality criteria, applicants must demonstrate the applicable numerical criteria are not exceeded after critical initial dilution. Guidance for performing such demonstrations is given under Questions III.B.1-III.B.6 for conventional water quality variables, under Questions III.E.2 and III.F.1 for conventional and pathogen variables, and under Questions III.H.1-III.H.4 for toxic substances. Applicants are reminded that demonstrations of compliance must be made for the applicant's discharge in combination with pollutants from other sources. Hence, data on pollutant loadings in the ambient receiving waters may be required to calculate values of water quality variables after initial dilution.

Another approach that the U.S. EPA has used to assess the potential impacts of wastewater discharges on water quality and the biota in the

receiving environment is the water quality-based toxics control approach. Although this approach is not directly applicable to the demonstrations required to answer this question, information derived from its use may be used to further support the applicant's response. Guidance for implementing the water quality-based toxics control approach is given in Appendix F.

II.D.4. Will the modified discharge: [Subpart 125.59(b)(3)]

- *Be consistent with applicable State coastal zone management program(s) approved under the Coastal Zone Management Act as amended, 16 U.S.C. 1451 et seq.? [See 16 U.S.C. 1456(c)(3)(A)]*
- *Be located in a marine sanctuary designated under Title III of the Marine Protection, Research, and Sanctuaries Act (MPRSA) as amended, 16 U.S.C. 1431 et seq., or in an estuarine sanctuary designated under the Coastal Zone Management Act as amended, 16 U.S.C. 1461? If located in a marine sanctuary designated under Title III of the MPRSA, attach a copy of any certification or permit required under regulations governing such marine sanctuary. [See 16 U.S.C. 1432(f)(2)]*
- *Be consistent with the Endangered Species Act as amended, 16 U.S.C. 1531 et seq.? Provide the names of any threatened or endangered species that inhabit or obtain nutrients from waters that may be affected by the modified discharge. Identify any critical habitat that may be affected by the modified discharge and evaluate whether the modified discharge will affect threatened or endangered species or modify a critical habitat. [See 16 U.S.C. 1536(a)(2)]*

*** *Large and small dischargers must respond.*

Applicants should contact the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and applicable state coastal zone management agency for answers to this question.

> *II.D.5. Are you aware of any State or Federal laws or regulations (other than the Clean Water Act or the three statutes identified in item 4 above) or an Executive Order which is applicable to your discharge? If yes, provide sufficient information to demonstrate that your modified discharge will comply with such law(s), regulation(s), or order(s). [Subpart 125.59 (b)(3)]*

*** *Large and small dischargers must respond.*

Because each application for permit reissuance is considered to be an application for a new NPDES permit, applicants are required to provide new determinations of compliance with all applicable local, state, and federal laws and regulations, as indicated above. Moreover, in response to Question II.D.5, applicants should demonstrate compliance with federal water quality criteria established by the U.S. EPA (1986a) [Subpart 125.60(b)].

Individual states often have water quality standards that must be met independently from federal water quality criteria. State standards that are applicable to the discharge must be provided in this section, and determinations of compliance with those standards must be provided in Section III.B.6. Occasionally, state water quality standards are dependent on the location of the outfall diffuser. If the effluent wastefield is transported to a location having different standards than the diffuser location, then both sets of standards apply.

III. TECHNICAL EVALUATION

III.A. Physical Characteristics of Discharge [Subpart 125.62(a)]

III.A.1. What is the critical initial dilution for your current and modified discharge(s) during 1) the period(s) of maximum stratification? and 2) any other critical period(s) of discharge volume/composition, water quality, biological seasons, or oceanographic conditions?

**** Large and small dischargers must respond.*

POTW effluents are normally discharged into marine waters through outfalls that range from open-ended pipes to extensive diffusers. The characteristics of the effluent and the receiving water, the diffuser design, and the depth of discharge will determine the amount of effluent dilution achieved. As shown in Figure 1, the lower-density (nonsaline) discharged effluent creates a buoyant plume that rises rapidly toward the water surface, entraining significant amounts of ambient saline water. The momentum and buoyancy of the discharged effluent are primarily responsible for the entrainment of dilution water (i.e., mixing of ambient saline water with effluent). As the plume rises and entrains ambient saline water, its density increases and its momentum and buoyancy decrease accordingly. If a sufficient ambient vertical density gradient or zone of stratification (like a pycnocline or thermocline) is present, the plume will spread horizontally at the level of neutral buoyancy (i.e., where the plume density equals ambient water density). If a sufficient density gradient is not present, the diluted effluent will reach the water surface and flow horizontally. The vertical distance from the discharge points to the centerline of the plume when it reaches the level of neutral buoyancy or the water surface is called the "height-of-rise" (sometimes referred to as the height to "trapping" or "equilibrium" level).

The dilution achieved at the completion of this process is called the "initial dilution." Dilution is the ratio of the total volume of a sample

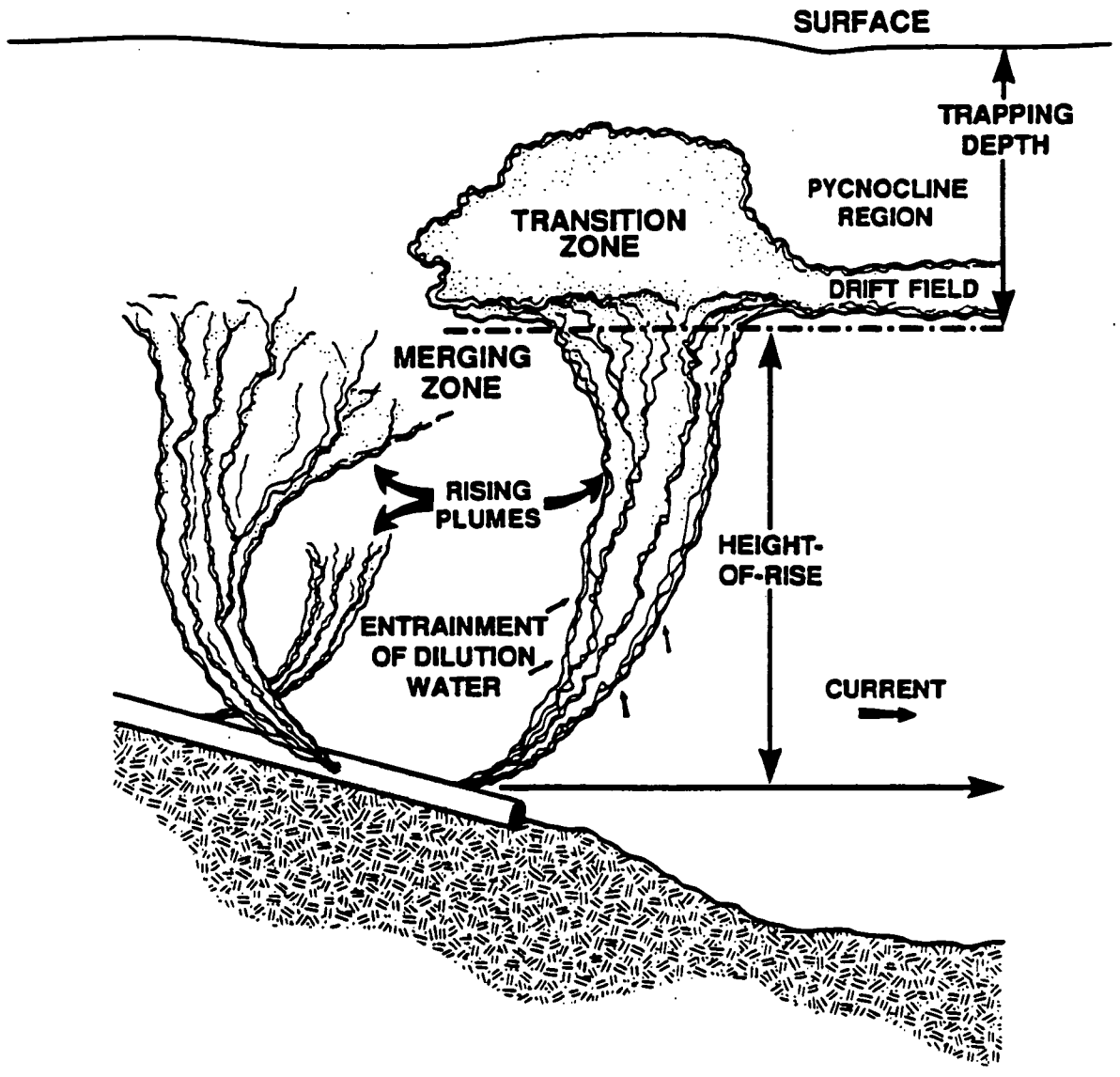


Figure 1. Wastefield generated by a simple ocean outfall.

(ambient water plus effluent) to the volume of effluent in the sample. A dilution of 100 is, therefore, a mixture composed of 99 parts of ambient water to 1 part of effluent. The initial dilution is a critical parameter relative to compliance with water quality standards and is thus discussed in some detail in the evaluation of both large and small applications. The magnitude of initial dilution achieved is dependent on ambient density gradients and diffuser design.

The lowest (i.e., critical) initial dilution must be computed for each of the critical environmental seasons. The predicted peak 2- to 3-h effluent flow for the new end-of-permit year and the current speed no higher than the lowest 10 percentile current speed must be used. A simplified procedure for computing initial dilution is described in Appendix A. Five U.S. EPA-approved computer models (i.e., UPLUME, UOUTPLM, UMERGE, UDKHDEN, ULINE) and several analytical formulas for computing initial dilution are described by Muellenhoff et al. (1985a,b). ASCII files containing FORTRAN code for these models are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 [(703) 487-4650]. These files are on either nine-track tape or on floppy diskettes that can be read by an IBM-compatible personal computer. Muellenhoff et al. (1985a) discuss guidelines for use of the models. During computation of initial dilution by one of these methods, the flow from each of the ports modeled should be approximately constant within a section of the diffuser. The initial dilution and trapping depth for each section should be a flow-rate averaged to obtain the initial dilution and trapping depth, respectively, for the entire diffuser. The depth of the discharge is determined as the depth of section below mean lower low water or mean low water, or as the average for the diffuser. If the adjacent ports discharge on opposite sides of the diffuser, the port spacing should be equal to the distance between ports discharging on the same side of the diffuser. (This stipulation is applicable to UMERGE and UDKHDEN, but not ULINE.) Sufficient documentation of the methods and parameters used by the applicant to calculate initial dilution must be provided so that the results obtained can be duplicated independently.

For many applicants, conditions specified in the original application will not have changed, and it will be necessary only to reproduce the calculations given in the original application. Other applicants will find, however, that monitoring data or other information collected during the term of the original modified permit requires that new calculations be performed. For example, new calculations will be required where the water column density profile is better defined, effluent flows have changed or are expected to change, or the number of open ports has changed.

III.A.2. What are the dimensions of the zone of initial dilution for your modified discharge(s)?

**** Large and small dischargers must respond.*

The ZID is the region of initial mixing surrounding or adjacent to the end of the outfall pipe or diffuser ports and includes the underlying seabed. The ZID describes an area in which inhabitants, including the benthos, may be chronically exposed to concentrations of pollutants in violation of water quality standards and criteria or at least to concentrations more severe than those predicted for critical conditions. The ZID is not intended to describe the area bounding the entire mixing process for all conditions, or the total area impacted by the sedimentation of settleable material.

In general, the ZID can be considered to include that bottom area and the water column above that area circumscribed by D distance from any point of the diffuser, where D is equal to the water depth. Several different diffuser configurations and corresponding ZID dimensions are shown in Figure 2. The water depth used should be the maximum water depth along the diffuser axes with respect to mean lower low water or mean low water, as applicable.

Unless changes to the outfall system have been made or are anticipated, or unless incorrect water depths or outfall characteristics were used in the original Section 301(h) application, the calculation presented here should

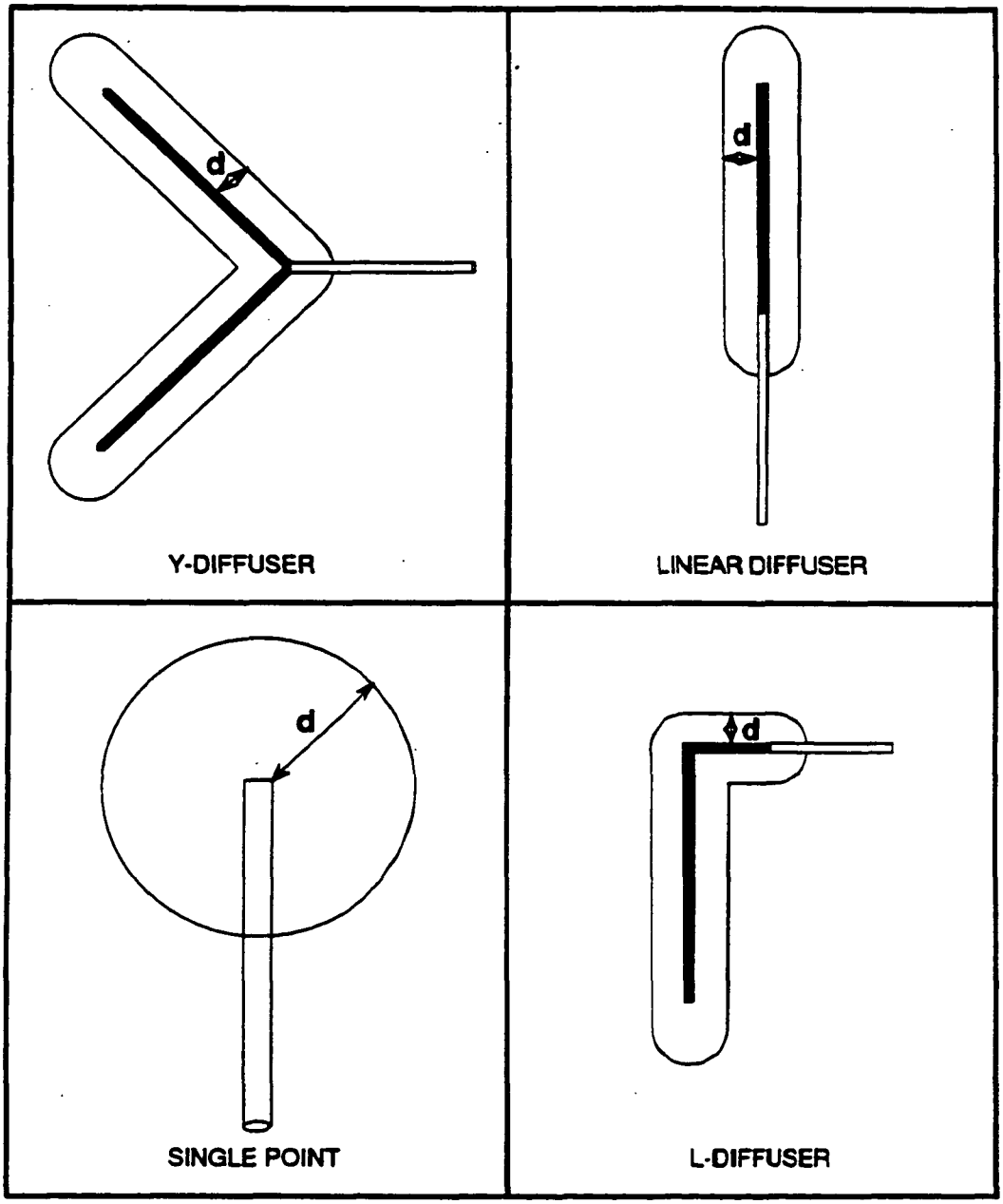


Figure 2. Diffuser types and corresponding ZID configurations.

be identical to that presented in the original application. Repetition of the calculation in the application for reissuance of the Section 301(h) modified permit is necessary to confirm that all values used in the original application were correct, and that the outfall system has not, and will not, change over the term of the new permit.

III.A.3. What are the effects of ambient currents and stratification on dispersion and transport of the discharge plume/wastefield?

**** Only large dischargers must respond.*

A general description of the ambient currents expected within the influence of the diffuser site is required by U.S. EPA. Since this description is primarily of use in determining where the effluent wastefield is likely to be transported during several days' time, the response to this subsection should be of sufficient detail for this purpose. Knowledge of the subsequent movement of the wastefield is also needed to address the potential for re-entrainment of previously discharged effluent, which could effectively increase wastefield concentrations at the boundary of the ZID. The applicant should take into account that dilution water is entrained into the effluent plume throughout the depth over which the plume rises. The diluted wastefield may be transported by either surface currents or subpycnocline currents at different times during a tidal cycle. In a region where currents are predominantly tidal, current persistence and the mean current speed and its variance with respect to the primary directions of water flow should be given. If the currents have large components unrelated to tidal influences (e.g., wind-induced currents), then a more detailed analysis should be performed. The mean, variance, and direction of the tidal component should be determined, and a synopsis of the nontidal current speed, direction, and persistence should be provided. Vertical variations in currents are important at depths where the effluent wastefield is trapped.

The basis for the current estimates should be provided. Acceptable sources of information are site-specific measurements and published measurements or predictions. The Tidal Current Tables published annually by the U.S. Department of Commerce (see National Ocean Survey 1988a,b) provide tidal current information for a large number of locations. Information from other published documents is usable if the documents are available to U.S. EPA on request.

Expected or measured effluent dilutions at important shoreline stations should be included. Chapters B-I, B-III, and B-IV in Appendix B of this document provide further guidance on computing farfield dilutions for water quality variables.

Under certain circumstances, such as low nontidal currents or reversing tidal currents, the affected "ambient" water quality concentrations of the ocean water with which the plume is diluted may be temporarily higher than the normal background concentration (i.e., when the ocean water is unaffected by the discharge). This issue is of primary concern for discharges located in estuaries or semi-enclosed water bodies but may also be of concern for open costal sites. To ensure that the discharge meets all applicable water quality criteria during these other critical conditions, the applicant should evaluate the recirculation potential of the existing or proposed discharge through an analysis of currents, dye or field mixing studies (for existing discharges only), numerical modeling analyses (for relocated or proposed new discharges), or evaluation of water quality data collected during the existing discharge monitoring program. A monitoring strategy is described below in guidance for Question III.F (Establishment of a Monitoring Program).

Dye studies are particularly useful to evaluate the recirculation potential under short-term tidal cycle influences for existing discharges. Current-meter data should be made available to evaluate both the high frequency (tidal) and low frequency (nontidal) current regimes that exist at the time of the dye study.

For relocated or proposed new discharges, numerical circulation and transport models are the most useful methods for assessing the effects of ambient currents and stratification on dispersion and transport of the wastefield and for estimating the potential for recirculation of previously discharged effluent. There are two general approaches. The first is to simulate a conservative substance (i.e., no decay) as a tracer for the wastefield to estimate numerical dilution factors surrounding the discharge. These dilution factors can be used to estimate the affected ambient concentration of any water quality variable as input to the initial and subsequent dilution techniques presented elsewhere in this document. The second approach, which is more complex, is to directly simulate the water quality variables and kinetic processes that govern their fate (e.g., BOD decay, suspected solids settling).

Several specific guidelines can be offered to applicants in the use of numerical models. Typically, the most critical conditions for recirculation and build-up of previously discharged effluent would occur when the water column is density-stratified in the presence of tidally reversing currents and low nontidal currents, and the wastefield remains submerged below the pycnocline following initial dilution. If such conditions occur at the applicant's outfall site, the numerical model should be layered vertically, with a minimum of two layers. The plume should be discharged into the bottom layer to simulate the submerged discharge. The applicant should set up the grid system for the numerical model such that the smallest segments are located in the vicinity of the difruser and gradually increase in size with distance from the diffuser. The applicant might choose to experiment with grid configuration by starting with a coarse grid and then decreasing the grid size until the model results do not change greatly.

A variety of numerical circulation and transport models exist with various levels of detail, user documentation, and applicability. Examples of potentially applicable models include CAFE/DISPER (Wang and Connor 1975; Christodoulou et al. 1976a,b; Pagenkopf et al. 1976); TEA/ELA (Baptista et al. 1984; Westerink et al. 1985); Ariathuria (1982); Spaulding and Pavish (1984); and Sheng and Butler (1984). The applicant must use a model that is

supported by a fully documented computer program so that U.S. EPA and other interested parties may conduct analyses (i.e., run simulations) on generally available computer systems.

III.A.4. Will there be significant sedimentation of suspended solids in the vicinity of the modified discharge?

**** Only small dischargers must respond.*

The accumulation of suspended solids from municipal wastewater discharges may lower dissolved oxygen concentrations in near-bottom waters and cause changes in benthic communities. Accumulation of suspended solids in the vicinity of a discharge is influenced by the amount of solids discharged, the settling velocity distribution of the particles in the discharge, the plume height-of-rise, and current velocities. Hence, sedimentation of suspended solids is generally of little concern for small discharges into well-flushed receiving environments.

In response to this question, the applicant must predict the seabed accumulation that results from the discharge of suspended solids into the receiving water. The applicant may use any applicable well-documented sedimentation model. A simplified approach for small dischargers is provided in Chapter B-I of Appendix B. A simplified sedimentation model for large discharges, or small dischargers for whom the simplified approach is not appropriate, is also described in Chapter B-I of Appendix B. The sedimentation model DECAL (a simplified Deposition Calculation) is available as an Ocean Data Evaluation System (ODES) tool.

III.A.5. Sedimentation of suspended solids.

a. What fraction of the modified discharge's suspended solids will accumulate within the vicinity of the modified discharge?

b. What are the calculated area(s) and rate(s) of sediment accumulation within the vicinity of the modified discharge(s) ($g/m^2/yr$)?

c. What is the fate of settleable solids transported beyond the calculated sediment accumulation area?

**** Only large dischargers must respond.*

Information on the fate of suspended solids is needed to calculate oxygen consumption rates and interpret biological data. Settling velocity distributions of the effluent should be provided, if available. Graphs that show the settling velocity (cm/sec) and percent of solids that settle at that velocity or less are preferred. The suspended solids concentration (mg/L), test conditions, and laboratory procedures that are used should be described.

The applicant should calculate whether substantial sedimentation of suspended solids occurs. These calculations should be made for the annual period and for the critical 90-day period (i.e., the 90-day period during which the highest sedimentation rate occurs). The average plume height-of-rise with respect to the seafloor should be used in these calculations. A simplified procedure for calculating the effect of sedimentation is described in Chapter B-I of Appendix B.

III.B. Compliance with Applicable Water Quality Standards [Subparts 125.61(b) and 125.62(a)]

III.B.1. What is the concentration of dissolved oxygen immediately following initial dilution for the period(s) of maximum stratification and any other critical period(s) of discharge volume/composition, water quality, biological seasons, or oceanographic conditions?

*** *Large and small dischargers must respond.*

Dissolved oxygen in the receiving water is diminished by the low oxygen content and immediate dissolved oxygen demand (IDOD) of the effluent within the ZID and by the oxidation of organic material in the diluted effluent beyond the ZID. A simplified procedure for calculating the dissolved oxygen concentration immediately following initial dilution is explained in Chapter B-II of Appendix B. Note that some states limit the maximum allowable depression in dissolved oxygen concentration, and that the maximum dissolved oxygen depression may not occur during the season that has the lowest initial dilution.

III.B.2. What is the farfield dissolved oxygen depression and resulting concentration due to BOD exertion of the wastefield during the period(s) of maximum stratification and any other critical period(s)?

*** *Large and small dischargers must respond.*

A simplified procedure for computing the farfield dissolved oxygen depression is given in Chapter B-III of Appendix B.

III.B.3. What are the dissolved oxygen depressions and resulting concentrations near the bottom due to steady sediment demand and resuspension of sediments?

*** *Only large dischargers must respond.*

Suspended solids that accumulate on the seabed may exert a dissolved oxygen demand due to continuous oxidation of organic material at the sediment surface and occasional rapid oxidation of resuspended sediments. Estimates of dissolved oxygen depressions that result from steady sediment demand and resuspension of solids should be made using the methods described in Chapter B-IV of Appendix B. If field or laboratory measurements are available, the results can be used in these analyses.

III.B.4. What is the increase in receiving water suspended solids concentration immediately following initial dilution of the modified discharge(s)?

**** Large and small dischargers must respond.*

Suspended solids in the water column may reduce light transmittance and thus water clarity. Reduction of the depth to which sunlight penetrates may also affect biological communities within the water column. The suspended solids concentration following initial dilution can be estimated by a simple mass balance calculation.

The formula provided in Chapter B-V of Appendix B should be used to calculate the receiving water suspended solids concentration following critical initial dilution. In cases where the initial dilution or the concentration of suspended solids in the effluent have not changed since the original application was submitted, and are not expected to change over the term of the new permit, it will be necessary only to reproduce the calculation provided in the original application. However, changes in either variable will necessitate recalculating the receiving water suspended solids concentration.

III.B.5. What is the change in receiving water pH immediately following initial dilution of the modified discharge(s)?

**** Only large dischargers must respond.*

The pH of the receiving water can be affected by the discharge of highly acidic or highly alkaline wastes. Final pH values after initial dilution can be estimated from field measurements or calculated from carbonate system alkalinity relationships.

In most settings, the influence of a municipal waste discharge on the receiving water pH is small. This section provides a method to calculate

the pH change of receiving waters due to a waste discharge and to determine whether standards are violated.

The pH at completion of initial dilution can be estimated from Table 1. The values shown in this table were generated by a pH-alkalinity model (based on the carbonate system) that simulates the mixing of effluent and seawater. The methods used to calculate the values in this table are explained in Chapter B-VI of Appendix B. Because waste plumes are usually submerged during initial dilution, no exchange with the atmosphere is included. The results are based on a seawater alkalinity of 2.3 meq/L (Stumm and Morgan 1981), and dissociation constants from Stumm and Morgan (1981) and Dickson and Riley (1979).

Effluent alkalinity depends on the alkalinity of the source water and any infiltrating water, the type of treatment process, and the volume and type of industrial waste that enters the treatment plant. Effluent alkalinity can range from 0 to 6.0 meq/L. A typical value for effluent alkalinity is 2 meq/L or higher (Metcalf and Eddy 1979). Because alkalinity data are scarce, final pH values calculated for a range of alkalinities are provided in Table 1. If significant industrial waste is present in an effluent, or if pure oxygen or nitrification-denitrification treatment processes are used, effluent pH and alkalinity should be measured. For cases of weak primary effluents with no industrial waste components, an alkalinity value of 0.1 meq/L with an effluent pH of 6.0 can be used to estimate the final pH. If the lowest effluent pH is 6.5 or higher, an alkalinity value of 0.5 meq/L with an effluent pH of 6.5 can be used to estimate the final pH.

The applicant should first estimate the pH at completion of initial dilution for the case when the effluent pH is 6.0 and the ambient pH is equal to the minimum ambient pH in the vicinity of the discharge. The estimated value should be compared with the appropriate state standard to determine whether the standard is met.

TABLE 1. ESTIMATED pH VALUES AFTER INITIAL DILUTION

Seawater Temp. °C	5°C					15°C					25°C				
Seawater pH	10	25	50	75	100	10	25	50	75	100	10	25	50	75	100
						Effluent pH = 6.0 Alk = 0.1									
7.00	6.97	6.98	6.99	6.99	6.99	6.97	6.99	6.99	6.99	6.99	6.97	6.99	6.99	6.99	6.99
7.50	7.40	7.46	7.48	7.48	7.49	7.42	7.47	7.48	7.49	7.49	7.43	7.47	7.48	7.49	7.49
7.70	7.58	7.65	7.67	7.68	7.68	7.61	7.66	7.68	7.69	7.69	7.63	7.67	7.68	7.69	7.69
8.00	7.89	7.96	7.98	7.98	7.99	7.93	7.97	7.99	7.99	7.99	7.96	7.98	7.99	7.99	7.99
8.30	8.23	8.27	8.28	8.29	8.29	8.27	8.29	8.29	8.29	8.29	8.28	8.29	8.29	8.29	8.29
8.50	8.46	8.48	8.49	8.49	8.49	8.48	8.49	8.49	8.49	8.49	8.49	8.49	8.49	8.49	8.49
						Effluent pH = 6.0 Alk = 0.6									
7.00	6.80	6.91	6.95	6.96	6.97	6.80	6.91	6.95	6.96	6.97	6.80	6.91	6.95	6.97	6.97
7.50	7.05	7.28	7.38	7.42	7.43	7.07	7.30	7.39	7.42	7.44	7.09	7.32	7.40	7.43	7.45
7.70	7.13	7.42	7.55	7.60	7.62	7.18	7.46	7.58	7.62	7.64	7.22	7.50	7.60	7.63	7.65
8.00	7.29	7.69	7.85	7.90	7.92	7.40	7.78	7.90	7.93	7.95	7.53	7.84	7.92	7.95	7.96
8.30	7.57	8.06	8.19	8.23	8.24	7.82	8.15	8.23	8.25	8.26	7.98	8.19	8.25	8.26	8.27
8.50	7.90	8.32	8.41	8.44	8.46	8.15	8.38	8.44	8.46	8.47	8.25	8.41	8.46	8.47	8.48
						Effluent pH = 6.0 Alk = 1.0									
7.00	6.70	6.85	6.92	6.94	6.96	6.70	6.86	6.92	6.94	6.96	6.71	6.86	6.92	6.95	6.96
7.50	6.89	7.17	7.31	7.37	7.40	6.90	7.19	7.33	7.38	7.41	6.92	7.21	7.34	7.39	7.42
7.70	6.94	7.28	7.46	7.54	7.57	6.97	7.33	7.50	7.56	7.60	7.01	7.38	7.53	7.59	7.62
8.00	7.04	7.50	7.74	7.83	7.87	7.12	7.62	7.82	7.88	7.91	7.22	7.71	7.87	7.91	7.93
8.30	7.20	7.86	8.11	8.18	8.21	7.40	8.02	8.17	8.22	8.24	7.65	8.10	8.21	8.24	8.25
8.50	7.39	8.17	8.35	8.40	8.43	7.77	8.29	8.40	8.43	8.45	8.01	8.34	8.42	8.45	8.46
						Effluent pH = 6.0 Alk = 2.0									
7.00	6.53	6.75	6.85	6.90	6.92	6.53	6.75	6.86	6.90	6.92	6.54	6.75	6.86	6.90	6.92
7.50	6.64	6.97	7.17	7.26	7.31	6.65	6.99	7.19	7.28	7.33	6.67	7.01	7.21	7.30	7.34
7.70	6.67	7.04	7.28	7.40	7.46	6.69	7.08	7.33	7.44	7.50	6.71	7.12	7.38	7.48	7.53
8.00	6.72	7.17	7.50	7.66	7.74	6.76	7.27	7.62	7.75	7.82	6.81	7.39	7.71	7.82	7.86
8.30	6.79	7.39	7.87	8.03	8.11	6.88	7.64	8.02	8.12	8.17	6.99	7.84	8.10	8.17	8.20
8.50	6.86	7.67	8.17	8.29	8.35	7.01	8.00	8.28	8.36	8.40	7.23	8.15	8.34	8.39	8.42
						Effluent pH = 6.5 Alk = 0.5									
7.00	6.95	6.98	6.99	6.99	6.99	6.95	6.98	6.99	6.99	6.99	6.95	6.98	6.99	6.99	6.99
7.50	7.35	7.44	7.47	7.48	7.48	7.37	7.45	7.47	7.48	7.48	7.39	7.45	7.47	7.48	7.48
7.70	7.52	7.62	7.66	7.67	7.68	7.55	7.64	7.67	7.68	7.68	7.58	7.65	7.67	7.68	7.69
8.00	7.81	7.93	7.96	7.97	7.98	7.87	7.95	7.97	7.98	7.98	7.91	7.97	7.98	7.99	7.99
8.30	8.16	8.25	8.27	8.28	8.28	8.22	8.27	8.28	8.29	8.29	8.24	8.28	8.29	8.29	8.29
8.50	8.40	8.46	8.48	8.48	8.49	8.44	8.47	8.49	8.49	8.49	8.46	8.48	8.49	8.49	8.49
						Effluent pH = 6.5 Alk = 1.0									
7.00	6.90	6.95	6.97	6.98	6.98	6.90	6.96	6.98	6.98	6.98	6.90	6.96	6.98	6.98	6.99
7.50	7.23	7.38	7.43	7.45	7.46	7.25	7.39	7.44	7.46	7.47	7.27	7.40	7.45	7.46	7.47
7.70	7.35	7.55	7.62	7.65	7.66	7.40	7.58	7.64	7.66	7.67	7.44	7.60	7.65	7.66	7.67
8.00	7.59	7.84	7.92	7.95	7.96	7.70	7.89	7.95	7.96	7.97	7.78	7.92	7.96	7.97	7.98
8.30	7.96	8.18	8.24	8.26	8.27	8.09	8.22	8.26	8.27	8.28	8.15	8.24	8.27	8.28	8.28
8.50	8.24	8.41	8.45	8.47	8.48	8.33	8.44	8.47	8.48	8.48	8.38	8.45	8.47	8.48	8.48

TABLE 1. (Continued)

Seawater Temp. °C	5°C					15°C					25°C				
Seawater pH	10	25	50	75	100	10	25	50	75	100	10	25	50	75	100
						Effluent pH = 6.5 Alk = 2.0									
7.00	6.82	6.91	6.95	6.97	6.97	6.82	6.91	6.95	6.97	6.97	6.82	6.92	6.95	6.97	6.97
7.50	7.06	7.28	7.38	7.41	7.43	7.08	7.29	7.39	7.42	7.44	7.10	7.31	7.40	7.43	7.45
7.70	7.14	7.42	7.55	7.59	7.62	7.18	7.46	7.57	7.61	7.63	7.22	7.49	7.60	7.63	7.65
8.00	7.28	7.68	7.84	7.89	7.92	7.39	7.76	7.89	7.92	7.94	7.50	7.82	7.91	7.94	7.96
8.30	7.54	8.04	8.18	8.22	8.24	7.78	8.13	8.22	8.24	8.26	7.93	8.17	8.24	8.26	8.27
8.50	7.85	8.30	8.40	8.44	8.45	8.10	8.36	8.43	8.45	8.46	8.21	8.39	8.45	8.46	8.47
						Effluent pH = 9.0 Alk = 2.0									
7.00	7.06	7.02	7.01	7.00	7.00	7.06	7.02	7.01	7.00	7.00	7.07	7.02	7.01	7.00	7.00
7.50	7.56	7.52	7.51	7.50	7.50	7.56	7.52	7.51	7.50	7.50	7.56	7.52	7.51	7.50	7.50
7.70	7.75	7.72	7.70	7.70	7.70	7.75	7.72	7.71	7.70	7.70	7.75	7.72	7.71	7.70	7.70
8.00	8.03	8.01	8.00	8.00	8.00	8.03	8.01	8.00	8.00	8.00	8.03	8.01	8.00	8.00	8.00
8.30	8.31	8.30	8.30	8.30	8.30	8.31	8.30	8.30	8.30	8.30	8.31	8.30	8.30	8.30	8.30
8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.49	8.49
						Effluent pH = 9.0 Alk = 4.0									
7.00	7.10	7.04	7.02	7.01	7.00	7.10	7.04	7.02	7.01	7.01	7.11	7.04	7.02	7.01	7.01
7.50	7.59	7.53	7.51	7.51	7.50	7.59	7.53	7.51	7.51	7.50	7.59	7.53	7.51	7.51	7.50
7.70	7.76	7.72	7.71	7.70	7.70	7.76	7.72	7.71	7.70	7.70	7.76	7.72	7.71	7.70	7.70
8.00	8.02	8.01	8.00	8.00	8.00	8.02	8.00	8.00	8.00	8.00	8.02	8.00	8.00	8.00	8.00
8.30	8.29	8.29	8.29	8.29	8.29	8.28	8.29	8.29	8.29	8.29	8.28	8.29	8.29	8.29	8.29
8.50	8.47	8.48	8.49	8.49	8.49	8.46	8.48	8.49	8.49	8.49	8.46	8.48	8.49	8.49	8.49
						Effluent pH = 9.0 Alk = 6.0									
7.00	7.14	7.05	7.02	7.01	7.01	7.14	7.05	7.02	7.01	7.01	7.15	7.06	7.03	7.02	7.01
7.50	7.61	7.54	7.52	7.51	7.51	7.61	7.54	7.52	7.51	7.51	7.61	7.54	7.52	7.51	7.51
7.70	7.78	7.73	7.71	7.71	7.70	7.77	7.73	7.71	7.71	7.70	7.77	7.73	7.71	7.71	7.70
8.00	8.02	8.00	8.00	8.00	8.00	8.01	8.00	8.00	8.00	8.00	8.01	8.00	8.00	8.00	8.00
8.30	8.27	8.28	8.29	8.29	8.29	8.26	8.28	8.29	8.29	8.29	8.26	8.28	8.29	8.29	8.29
8.50	8.44	8.47	8.48	8.49	8.49	8.43	8.47	8.48	8.49	8.49	8.43	8.47	8.48	8.48	8.49

The applicant may also perform laboratory tests when the predicted pH values in Table 1 indicate that contraventions of pH standards are possible. Some of the buffering constituents in municipal effluents are not readily quantified (e.g., organic acid ligands), and have not been included in the calculations used to produce the table. The laboratory test would include measuring pH of effluent-receiving water mixtures as discussed below.

If the effluent pH drops below 6.0, the applicant should indicate the number of times per year effluent pH values fell below 6.0 and the suspected cause(s) of those low values. If effluent pH values below 6.0 occur frequently, a laboratory test of pH after mixing the effluent and receiving water should be performed for the critical conditions. The sample mixture should not be allowed to equilibrate with the atmosphere. The pH should be measured at close intervals until no further change in pH is observed. The applicant should describe conditions of the test, including temperature, pH, and alkalinity of the effluent and receiving water; initial dilution; and the measured values after mixing. The measured values should then be compared with the applicable standard to determine whether a violation is likely. The frequency of violations should be estimated.

III.B.6. Does (will) the modified discharge comply with applicable water quality standards for:

- *Dissolved oxygen?*
- *Suspended solids or surrogate standards?*
- *pH?*

**** Large and small dischargers must respond.*

The applicant must demonstrate compliance with applicable receiving water quality standards. Typically, standards exist for dissolved oxygen, suspended solids, and pH, in which case the results of previous sections may be used. If a quantitative state standard exists for turbidity expressed in a given turbidity unit, then turbidity of the effluent and the receiving water (expressed in turbidity units as a function of concentration) should be measured to demonstrate that the standard will be met. Other state

standards may also exist, such as for coliform bacteria concentrations at the edge of a mixing zone. Monitoring data collected during the term of the original Section 301(h) permit may also be useful for demonstrating compliance with applicable receiving water standards and criteria, and for verifying predictions made in the original application.

According to Subpart 125.57(a)(9), permits may not be issued if the dilution water for the discharge contains substantial amounts of previously discharged effluent. In general, this criterion will be met if all water quality standards are met.

Detailed guidance for assessing compliance with specific water quality standards is provided in Chapters B-VII and B-VIII of Appendix B.

III.B.7. Provide the determination required by Subpart 125.61(b)-(2) or, if the determination has not yet been received, a copy of a letter to the appropriate agency(s) requesting the required determination.

**** Large and small dischargers must respond.*

Because all applications for reissuance of Section 301(h) modified permits are considered applications for new NPDES permits, all applicants are required to provide new determinations of compliance, as required by Subpart 125.61(b)(2). A copy of the letter that requests the required determination may be provided if the determination by the appropriate state agency has not yet been received.

III.C. Impact on Public Water Supplies [Subpart 125.62(b)]

III.C.1. Is there a planned or existing public water supply (desalinization facility) intake in the vicinity of the current or modified discharge?

**** Large and small dischargers must respond.*

It is possible that a public water supply (desalinization plant) intake could be contaminated by marine POTW discharges. Although such a possibility may be remote, the applicant should verify that no public water supply intakes are located within 16 km (10 mi) of the discharge. If none exist within 16 km (10 mi) of the discharge, no analyses are required. The name of the agencies contacted and the person involved should be listed in the application.

III.C.2. If the answer to Question III.C.1. is yes,

a. What is the location of the intake(s) (latitude and longitude)?

b. Will the modified discharge(s) prevent the use of intake(s) for public water supply?

c. Will the modified discharge(s) cause increased treatment requirements for public water supply(s) to meet local, state, and U.S. EPA drinking water standards?

**** Large and small dischargers must respond.*

If the answer to Question III.C.1 is affirmative, the location of the desalinization plant should be shown on a map with the discharge site marked. The travel time to the intake should be estimated using the average current speed. Using the methods discussed in this document, the applicant should show that all water quality standards are met at the intake.

III.D. Biological Impact of Discharge [Subpart 125.62(c)]

POTW discharges can affect biological communities in the following ways:

- Modifications to structure of benthic communities (bottom dwelling/feeding fishes and invertebrates) caused by accumulation of discharged solids on the seabed

- Increases in phytoplankton or macroalgal growth due to nutrient inputs

- Reductions in phytoplankton or macroalgal growth due to turbidity increases

- Reductions in dissolved oxygen due to phytoplankton blooms and subsequent die-offs, leading to mass mortalities of fishes or invertebrates

- Bioaccumulation of toxic substances in marine organisms due to direct contact with sediment, ingestion of sediment, direct uptake from effluent, or ingestion of contaminated organisms

- Induction of diseases in marine organisms caused by contact with contaminated sediments, ingestion of contaminated organisms, or exposure to effluent.

Most of these potential impacts are associated with discharged particulate matter. The potential effects of discharged solids may be compounded by the toxic substances adsorbed to these solids. Hence, the primary potential effects of sediment enrichment by organic particles and sediment contamination by toxic substances are closely linked, and are generally manifested in the same biotic groups. Discharged effluent solids tend to accumulate near the sewage outfalls, and bottom-dwelling marine organisms (e.g., benthic macroinvertebrates and bottom-feeding fishes) are potentially affected by these accumulations because they live in or on the sediments.

Additional environmental effects are associated with the discharge of plant nutrients, which may result in eutrophication, especially in estuaries or coastal embayments. Related impacts can include stimulation of toxic or nuisance algal blooms. Such phytoplankton blooms may adversely affect commercial and recreational fisheries because the decomposition of phyto-

plankton after massive blooms can cause dissolved oxygen deficiencies and associated fish or invertebrate kills.

Biological assessments for improved discharges, altered discharges, or discharges into stressed waters involve predictive demonstrations of future biological conditions near the outfall and elsewhere in the receiving water body. These analyses may involve establishing relationships between water quality conditions and biological conditions and predicting future conditions based on these relationships. Thus, biological assessments for improved or altered discharges involve not only describing existing biological communities but also determining whether a BIP will exist beyond the ZID after improvements or alterations to the discharge.

To support a Section 301(h) modification, the applicant does not have to show that conditions of each biological community at all points beyond the ZID fall within the natural range of variation observed at the reference sites. Rather, the applicant's assessment should concentrate on determining the conditions of the following types of biological assemblages at control sites and at the areas of potential impact:

- Communities that are most susceptible to impacts from POTW discharges

- Communities with aesthetic, recreational, or commercial importance

- Communities with distributional patterns that enable quantitative assessment with reasonable sampling effort and resources.

Using this approach, applicants should be able to study the important communities that are expected to demonstrate discharge-related effects while not wasting effort on studies with a limited potential for providing meaningful results. Based on the review of existing Section 301(h) applications, the major potential effects of POTW discharges are associated

with benthic macroinvertebrates and demersal fishes. Because of their distribution characteristics, both of these communities can be assessed quantitatively with a reasonable level of sampling effort. Benthic macroinvertebrates are also the primary food items for demersal fishes and early-life stages of certain other fishes. Consequently, these two communities are linked by a food web relationship, and severe impacts on benthic macroinvertebrates may result in secondary impacts to demersal or other fishes.

Benthic macroinvertebrates and demersal fishes are two important groups that typically warrant BIP demonstrations. However, it should not be assumed that these are the only biological communities that should be studied in all cases. The concept of a BIP includes any and all biological communities potentially affected by the discharge.

III.D.1. Does (will) a balanced indigenous population of shellfish, fish, and wildlife exist:

a. Immediately beyond the ZID of the current and modified discharge(s)?

b. In all other areas beyond the ZID where marine life is actually or potentially affected by the current and modified discharge(s)?

**** Large and small dischargers must respond.*

The purpose of the question is to determine whether unacceptable biological impacts occur or will occur beyond the ZID. Effective demonstrations that the modified discharge, either singly or in combination with other discharges, does not contribute to adverse biological impacts include comparisons of biological conditions and habitat characteristics among stations or groups of stations. The applicant should demonstrate that biological conditions and habitat characteristics do not differ substantially among stations (or groups of stations) in ZID-boundary, nearfield, farfield, and reference areas.

The applicant should compare the ranges of biological characteristics among the four specified areas where communities are to be assessed. If differences that are attributable to the discharge are detected between study areas (e.g., ZID boundary vs. reference), the applicant should assess the spatial extent of those differences. In addition, the magnitude of the effect should be characterized with regard to the relative deviation from reference conditions (e.g., percent reduction in species richness), the potential for intertrophic effects (e.g., reductions in fish food organisms), and the potential for involvement of recreationally or commercially important species.

Numerous variables may be used to describe and compare biological communities (e.g., numbers of species; total abundances of organisms; abundances of selected pollution-sensitive, pollution-tolerant, and opportunistic species). [See Tetra Tech (1987f) for further guidance on the selection of biological indices.] Physical characteristics of the receiving environment that are often measured include water column characteristics, (e.g., depth, water temperature, salinity, nutrient concentrations, chlorophyll *a* concentrations) and substrate characteristics (e.g., bottom type and composition). Information on the physical characteristics of the environment may be used to interpret the biological data and to determine whether the discharge is altering the physical or chemical characteristics of the receiving environment.

Species vary in their sensitivities to pollutants, including organic enrichment. Changes in species composition and abundance begin to occur when the mass emission rates of materials in a sewage discharge are sufficiently high to affect the most sensitive species. As the abundances of pollution-sensitive species decrease or are driven to zero, abundances of opportunistic and pollution-tolerant species are typically enhanced. For this reason, changes in the values of community variables (e.g., numbers of species, total abundances, dominance) are often accompanied by changes in the abundances of opportunistic and pollution-tolerant species. Additional

guidance on the evaluation of biological communities is provided in Appendix C.

Special Considerations for Small Dischargers

During the preparation of applications for original Section 301(h) modified permits, many small applicants were able to respond to this question without conducting field studies of biological communities in the vicinity of the discharge. Those small applicants used existing information to demonstrate that the characteristics of the discharge and receiving environment indicated a very low potential for adverse impacts. If an applicant was not required to collect biological information during the term of the existing permit, that applicant may continue to use other available information to demonstrate that the characteristics of the discharge and receiving environment indicate a very low potential for adverse impacts. Applicants are reminded, however, that such demonstrations must consider the potential for adverse impacts of the discharge singly and in combination with other discharges (if any exist) [Subpart 125.57(a)(2)]. The following characteristics indicate a low potential for impact:

- Location of the discharge in water depths greater than 10 m (33 ft)

- Hydrographic conditions that result in low predicted solids accumulation rates

- The absence of distinctive habitats of limited distribution and the absence of fisheries in the vicinity of the outfall, when such absences are not due to anthropogenic stresses

- The absence of known or suspected sources of toxic pollutants and pesticides or low concentrations of these substances in the effluent.

Most small dischargers that previously demonstrated a low potential for impact should be able to do so again. They only need demonstrate that characteristics of the discharge and receiving environment did not change greatly during the term of the existing permit. Monitoring data collected during the term of the original Section 301(h) modified permit should also be useful for such demonstrations.

Some small dischargers may not be able to demonstrate a low potential for impacts because characteristics of the discharge or receiving environment differ from those listed above. In some cases, the discharge or receiving environment may not have exhibited the aforementioned characteristics at the time the original application for a Section 301(h) modified permit was prepared. In others, characteristics of the discharge or receiving environment may have changed, or additional information may now be available that documents a greater potential for impact than was previously supposed. For example, the composition of the discharge may have changed to include toxic pollutants or pesticides from a new industrial source. Alternatively, a fishery for a previously underutilized species may have developed in the vicinity of the discharge, or research by local scientists may have discovered that the habitat in the vicinity of the outfall is an important nursery ground for a commercially harvested species of fish or shellfish.

When it is apparent for one or more reasons that the discharge or receiving environment does not exhibit characteristics that would indicate a low potential for impacts, the Regions have the discretion to require that an applicant perform a detailed assessment of biological conditions in the vicinity of the outfall. The level of detail that would be expected in such a demonstration would be comparable to that required by large dischargers.

In some cases, the applicant may have been required to monitor one or more biological communities under the conditions of the existing Section 301(h) modified permit. The Region may require the applicant to analyze and discuss those biological monitoring data in response to this question. When biological monitoring data were not collected, but concern exists that the modified discharge might cause adverse impacts to the biota, the Region may

require the applicant to collect biological data in support of the application for permit reissuance. If the Region requires the collection of additional data, the Region should consult with the applicant well in advance of the application deadline, thereby giving the applicant adequate time to design and execute appropriate studies. Applicants required to perform these field surveys should consult Tetra Tech (1982a, 1987a,c,f) for guidance on the design and execution of those surveys. To ensure the collection of adequate, high quality data, the Region should work closely with the applicant during all phases of the necessary studies.

III.D.2. Have distinctive habitats of limited distribution been impacted adversely by the current discharge and will such habitats be impacted adversely by the modified discharge?

**** Large and small dischargers must respond.*

If distinctive habitats are present in areas potentially influenced by the discharge, the applicant should provide information that documents the extent and condition of those habitats. The applicant should also provide a detailed evaluation of available historical information on the spatial distribution of any distinctive habitats near the outfall and in nearby control areas. Trends in spatial occurrence should be evaluated relative to historical discharges by the applicant and relative to other water quality or biological factors that may influence the habitat.

If available, the applicant should include documentation of any long-term changes in the spatial extent or general health of the distinctive habitat. Examples of such information include areal extent of kelp beds or condition of algal cover on coral reefs. If historical changes in the habitat have occurred, the applicant should attempt to relate those changes to natural or pollution-related events. For example, severe storms may damage coral reefs, and heavy pedestrian traffic can degrade rocky intertidal communities.

- Health-related factors [including paralytic shellfish poisoning (PSP), bacteriological contamination, and bioaccumulation of toxic substances]

- Economic or marketing considerations

- Resource protection closures

- Other regulatory closures.

If reasons for closures are due to tissue contamination, the applicant should specify the contributing pollutant sources.

Many sources of information are available to address the fish and fishery concerns outlined above:

- Local anglers

- Public, institutional, and agency libraries

- Academic institutions (e.g., marine science, biology, zoology departments; Sea Grant offices; cooperative fishery research units)

- Local (e.g., conservation boards), state (e.g., fish and game departments), and federal natural resource agencies and affiliated laboratories (e.g., National Marine Fisheries Service, U.S. Fish and Wildlife Service)

- Regional fishery management councils (contact information available from National Marine Fisheries Service)

- County, state, and federal environmental protection and public health agencies.

Environmental protection and public health agencies should be contacted to obtain information on the health of fishes in the vicinity of an outfall. These agencies monitor water quality and coliform bacteria concentrations in shellfish as part of a national public health program. They will also provide information on PSP if it is known to occur in the geographic area. Depending on the distribution of fishery resources and pollutant levels in receiving waters, these agencies may also conduct laboratory studies on toxic bioaccumulation in fish species harvested for human consumption. An applicant should request all available information concerning the region and immediate vicinity of the discharge, and, with the assistance of agency personnel, attempt to determine the discharge's contribution to any observed fish health problems. A conclusion by agency personnel that the discharge is not contributing to public health problems should be documented by the applicant.

State departments of environmental protection or ecology are generally responsible for recording occurrences of fish kills within state waters. Typically, a report is filed by the departmental agent who investigated the kill, recording such information as the severity of the incident and its probable causes. An applicant should request and review reports of relevant fish kills and document whether the discharge has been implicated in any of these incidents.

Most environmental protection and public health agencies do not routinely assess the health status of fish unless a serious problem with toxics bioaccumulation is suspected in species sought by commercial or recreational fishermen. Sources of information on fish disease or abnormalities include academic institutions or fisheries agencies, which may have conducted fish surveys in the vicinity of an outfall.

A careful review of available information should enable a small applicant to characterize the local fish communities and fisheries without an actual field survey, unless there is sufficient evidence to indicate that the discharge has, or is likely to, adversely impact important fish resources.

The applicant should evaluate any effects of the discharge with emphasis on the physical, chemical, and biological conditions that occurred within the distinctive habitats in the vicinity of the outfall during the term of the existing 301(h) permit. The applicant's discussion should be oriented towards an assessment of the potential for contact of the effluent plume with any nearby distinctive habitats. In cases where a distinctive habitat occurs near an outfall, the applicant can evaluate impacts by considering the following:

- Degree of initial dilution
- Degree of farfield dispersion
- Frequency and direction of waste transport
- Lack of prior appreciable harm.

The most effective demonstrations of impacts (or the lack of impacts) include comparisons of potentially impacted areas with reference areas beyond the influence of the discharge. Experience with applications for Section 301(h) modified permits has shown, however, that suitable reference areas for distinctive habitats of limited distribution are often difficult to find. The biota that characterize distinctive habitats often require specific environmental conditions that occur discontinuously within the biogeographic zone, and often only in small areas. When a suitable reference area for a distinctive habitat of limited distribution does not occur in the vicinity of the applicant's outfall, the applicant should present (to the extent possible) detailed information on the typical physical, chemical, and biological characteristics of that distinctive habitat within the biogeographic zone. When suitable data are available, applicant should assess potential impacts to distinctive habitats of limited distribution by using the graphical and mathematical tools discussed in Appendix C.

Special Considerations for Small Dischargers

When it appears that a small discharger is causing (or has the potential to cause) impacts to distinctive habitats of limited distribution, the Region may require the applicant to perform a detailed assessment of distinctive habitats in the vicinity of the discharge. Such a detailed assessment would be comparable to that required of large dischargers, as described above. Therefore, guidance provided above and under Questions II.C.2 and III.D.1 of this questionnaire is relevant to the performance of such detailed demonstrations. The Region should notify the applicant well in advance of the application deadline of the need for additional data on distinctive habitats, so as to give the applicant adequate time to design and execute appropriate studies. Moreover, the Region should work closely with the applicant during all phases of the studies to ensure that adequate, high quality data are collected.

III.D.3. Have commercial or recreational fisheries been impacted adversely by the current discharge (e.g., warnings, restrictions, closures, or mass mortalities) or will they be impacted adversely by the modified discharge?

**** Large and small dischargers must respond.*

If fisheries resources are present in areas potentially influenced by the discharge, the applicant should assess the effects of the discharge on these resources by analyzing catch records, market acceptability, contamination of tissues by toxic substances, prevalence of disease, and harvest warnings/closures.

The applicant should also determine whether any potential fishery resources remain unharvested in the area because of warnings or closures. If unharvested resources are identified, the applicant should indicate the reasons why these resources are not utilized, such as the following:

III.D.4. Does the current or modified discharge cause the following within or beyond the ZID: [Subpart 125.62(c)(3)]

a. Mass mortality of fishes or invertebrates due to oxygen depletion, high concentrations of toxics, or other conditions?

b. An increased incidence of disease in marine organisms?

c. An abnormal body burden of any toxic material in marine organisms?

d. Any other extreme, adverse biological impacts?

**** Only large dischargers must respond.*

This question requires the assessment of several specific potential impacts of POTW discharges. The applicant should review and summarize available information on occurrences of mass mortalities of marine organisms in the receiving water environment. The suspected causes of mass mortalities should be evaluated to determine whether any of these events could have resulted from the discharge. Evaluation of actual or potential mass mortalities is especially important for applicants with discharges into estuaries or enclosed embayments. Dissolved oxygen deficiencies in environments with limited flushing characteristics may result from BOD inputs or algal decomposition following bloom conditions. Evaluation of disease incidence or tissue contamination in marine organisms should be conducted by spatial comparisons of communities near the discharge (ZID and ZID boundary) with those in control areas (see Tetra Tech 1985a-d; 1987d).

Many studies have suggested that a relationship exists between the incidence of disease in marine organisms and contact with POTW effluents. These diseases include exophthalmia in spotfin croakers *(Roncador stearnsil)* and white seabass *(Cynoscion nobilis)*, lip papilloma in white croakers *(Genyonemus lineatus)*, and discoloration in halibut *(Macrostomus pacificus)* (Mearns and Sherwood 1974; McDermott-Ehrlich et al. 1977). Bioaccumulation of chlorinated hydrocarbons and trace metals has been reported in marine organisms collected near sewage outfalls off southern California. Affected

species included the Dover sole *(Microstomus pacificus)*, rock crab *(Cancer anthonyi)*, mussel *(Mytilus californianus)*, and rock scallop *(Hinnites multirugosus)* (McDermott et al. 1976; Young et al. 1976a; McDermott-Ehrlich et al. 1978; and Young et al. 1978;).

The discharge of sewage effluents containing toxic substances can result in bioaccumulation, especially in areas of organic sediment accumulation. Toxic heavy metals and persistent synthetic organic compounds generally have the highest potential for bioaccumulation in marine organisms. The identification of substantial concentrations of such substances in the plant effluent in combination with either of the following receiving water characteristics indicates the need for evaluation of bioaccumulation:

- Evidence of effluent transport toward areas used for shellfish harvesting

- Significant occurrence of important recreational or commercial species and evidence of potential sediment accumulation near the outfall.

The potential for bioaccumulation may be evaluated by the applicant by comparing the concentrations of toxic substances after initial dilution with U.S. EPA saltwater criteria. Two types of information are required for this comparison:

1. Concentration of the pollutant in the discharged effluent

2. Critical initial dilution.

The value of (1) divided by (2) should then be compared with the available criterion.

Most of the toxic substances with a high bioaccumulation potential will be associated with organic particulates in the discharged effluent. Thus, in determining bioaccumulation potential, it is important not only to

evaluate concentrations of these substances in the effluent and in the receiving water following initial dilution, but also to examine sediment accumulation patterns. Substantial bioaccumulation is possible even when water quality criteria are met because of localized accumulation of contaminated sediments. Alternatively, the applicant may be able to demonstrate that bioaccumulation is not a serious problem even though toxic substances are present in the effluent, by providing information that demonstrates the following:

- Adequate initial dilution
- Sufficient circulation to prevent localized accumulation of solids or trapping of effluent plumes.

The degree to which the applicant may be required to assess bioaccumulation using field surveys is also dependent upon the kinds of organisms present. Several investigators have demonstrated the ability of bivalve molluscs and crustaceans to accumulate metals and organic substances near sewage discharges (Young et al. 1976b, 1978). Studies at some of the same sites and at other contaminated areas have indicated that demersal marine fishes do not generally accumulate metals in muscle tissue (with the exception of organic mercury) but accumulate organic substances such as high molecular weight chlorinated hydrocarbons (McDermott-Ehrlich et al. 1978; McDermott et al. 1976). Thus, in the case where an effluent contains substantial quantities of heavy metals, the potential data requirements would be greater if shellfish resources occurred in potentially impacted areas than if fishes constituted the only locally important resources. Furthermore, the potential for bioaccumulation would be less if fishes with only transitory plume exposure were present (e.g., pelagic or migratory species) than if demersal species dominated in areas of sediment deposition.

Sessile filter-feeding molluscs that are highly susceptible to bioaccumulation, and that may also be important commercial or recreational resources, are generally found in nearshore habitats, especially in embayments or estuaries. If an applicant can demonstrate that shellfish

resources do not occur in the outfall vicinity or in other areas potentially impacted by the discharge, or that effluent dispersion is adequate, tissue analyses of indigenous biota may not be required to demonstrate the absence of adverse bioaccumulation. Discharges located in areas with limited dispersion, such as estuaries or embayments, may cause contamination of local shellfish resources. In such cases, the applicant should conduct analyses of tissue concentrations of toxic substances identified in the plant effluent. Examples of species that may be appropriate for tissue analyses include oysters, clams, mussels, crabs, or lobsters.

An additional situation which will influence the requirement for direct assessment of bioaccumulation is where other pollutant sources cause observed contamination of fish or shellfish resources. This would especially pertain to cases of nearby fishery closures or harvesting restrictions due to pollutant inputs. In such cases, it is important for the applicant to demonstrate that its discharge is not contributing to the existing contamination. This demonstration can be accomplished by the previously described analyses of effluent pollutant concentrations and initial dilutions, or by evaluation of existing information on the spatial patterns of pollutant concentrations in organisms or sediments. It may be necessary for the applicant to conduct tissue or sediment analyses if effluent and dilution analyses indicate the potential for bioaccumulation and if sufficient data are not available to determine pollutant sources in areas of existing contamination of fishery resources.

III.D.5. For discharges into saline estuarine waters: [Subpart 125.62(c)(4)]

a. *Does or will the current or modified discharge cause substantial differences in the benthic population within the ZID and beyond the ZID?*
b. *Does or will the current or modified discharge interfere with migratory pathways within the ZID?*
c. *Does or will the current or modified discharge result in bioaccumulation of toxic pollutants or pesticides at*

levels which exert adverse effects on the biota within the ZID?

No section 301(h) modified permit shall be used where the discharge enters into stressed saline estuarine waters as stated in Subpart 125.59(b)(4).

**** Large and small dischargers must respond.*

The Water Quality Act of 1987 prohibits the issuance of Section 301(h) modified permits for discharges into saline estuaries with the following characteristics:

- The estuary does not support a balanced indigenous population of shellfish, fish, and wildlife

- The estuary does not allow for recreational activities

- The estuary exhibits ambient water quality characteristics that are not adequate to protect public water supplies; protect shellfish, fish, and wildlife; allow for recreational activities; and comply with standards that assure and protect such uses.

A Section 301(h) modified permit may not be issued if the receiving waters exhibit any of the foregoing conditions, regardless of the causes of any of those conditions.

Estuaries are generally more productive than coastal areas, and are often more sensitive to pollutants. They also serve as spawning and nursery grounds for many invertebrates and fishes. Moreover, the flushing characteristics of estuaries may be considerably less than those of open coastal areas, especially during periods of reduced freshwater input. Thus, for a given discharge size, there is generally a higher potential impact in estuaries than in open coastal environments.

Additional information is required for saline estuarine discharges. U.S. EPA regulations [Subpart 125.62(c)(4)] require applicants to demonstrate that no substantial differences exist between benthic communities within the ZID and beyond the ZID. Hence, applicants discharging into saline estuaries must compare benthic communities within the ZID and beyond the ZID boundary with benthic communities at reference sites.

The applicant should also assess the degree to which the discharge could interfere with migratory pathways within the ZID. In conducting this assessment, the applicant may calculate the proportion of the cross sectional area of the estuary that is influenced by the ZID. The potential for migratory interference may then be evaluated by considering the relative size and characteristics of the discharge-affected area and its location in the estuary with respect to known migratory pathways.

Applicants with saline estuarine discharges must also assess the bioaccumulation of toxic substances within the ZID. If elevated or increasing concentrations of toxic substances are found in fish or shellfish, the applicant should assess the potential for adverse impacts such as restrictions on human use (e.g., FDA Action Levels), induction of disease, or interference with fish and shellfish growth or reproduction (see Tetra Tech 1985a-d; 1987d).

Special Considerations for Small Dischargers

When there is reasonable concern that one or more of the foregoing conditions has come into existence during the term of the existing Section 301(h) modified permit, the Regions should require small applicants with discharges into saline estuaries to demonstrate successfully that none of the foregoing conditions exist. To do so, small applicants may be required to perform a detailed biological survey similar to that required of large dischargers. Small applicants are advised to consult the information provided under Questions II.C.1 and III.D.1 (above) and in Section III.F for guidance on the design and execution of detailed biological surveys. The

Regions should notify applicants well in advance of the application deadline if a demonstration is required to document the absence of stressed conditions in the receiving environment.

III.D.6. For improved discharges, will the proposed improved discharge(s) comply with the requirements of Subparts 125.62(a) through 125.62(d)? [Subpart 125.62(e)]

**** Large and small dischargers must respond.*

U.S. EPA regulations require applicants who propose discharge improvements to demonstrate that the improvements will result in compliance with Subparts 125.62(a) through 125.62(d). This demonstration might be accomplished by comparing conditions at the outfall location with conditions near discharges that are similar to the proposed improved discharge. Assuming that there is a basic similarity in indigenous biota of the receiving environment, such a comparison may be sufficient to predict protection of a BIP. Applicants may also conduct predictive analyses of effluent dispersion and seabed accumulation of solids following discharge improvements.

Applicants whose discharge improvement plans include outfall relocation should describe existing biological conditions at both the proposed and existing outfall sites. Those applicants are also to predict future biological conditions at the proposed site following relocation of the outfall. Such predictions might be conducted by comparisons with other discharges that are similar to the relocated discharge. Discharges used for such comparisons should be located in receiving environments similar to the applicant's.

III.D.7. For altered discharge(s), will the altered discharge(s) comply with the requirements of Subparts 125.62(a) through 125.62(d)? [Subpart 125.62(e)]

*** *Large and small dischargers must respond.*

Applicants that request modifications for altered discharges may use predictive methods similar to those described for improved discharges. However, such applicants must demonstrate that the increased pollutant loading that will result from population growth or industrial growth within the service area will still enable compliance with Subpart 126.62(a)-(d). These predictions of compliance with 301(h) criteria during the 5-yr permit term may be technically difficult, and may require extensive analyses.

III.D.8. If your current discharge is to stressed ocean waters, does or will your current or modified discharge: [Subpart 125.62(f)]

a. Contribute to, increase, or perpetuate such stressed condition?

b. Contribute to further degradation of the biota or water quality if the level of human perturbation from other sources increases?

c. Retard the recovery of the biota or water quality if human perturbation from other sources decreases?

*** Large and small dischargers must respond.

When it appears that an applicant's receiving waters are or may be stressed, the Region may require the applicant to demonstrate the presence or absence of stressed conditions. If stressed conditions exit, the areal extent and magnitude of those stresses should be documented. Because stressed water determinations are largely based on biological conditions in the receiving environment, applicants may be required by the Regions to perform detailed biological surveys. Applicants required to perform detailed biological surveys for the purpose of determining whether stressed waters exist in the receiving environment should consult Section III.F of this document and guidance documents cited therein for information on the design and execution of those surveys. The Regions should notify applicants

well in advance of the application deadline if surveys of the biota are required to determine whether stressed conditions exist in the receiving environment. Moreover, the Regions should work closely with applicants during all phases of the required studies to ensure the collection of adequate, high quality data.

III.E. Impacts of Discharge on Recreational Activities [Subpart 125.62(d)]

It is necessary to ensure that a 301(h) modified discharge will 1) meet water quality standards relevant to recreational activities beyond the ZID, and 2) will not cause legal restrictions on activities that would be lifted or modified by upgrading the applicant's POTW to secondary treatment.

III.E.1. Describe the existing or potential recreational activities likely to be affected by the modified discharge(s) beyond the zone of initial dilution.

**** Large and small dischargers must respond.*

The impact of POTW discharges on recreational activities must be assessed. Recreational fisheries are considered in the biological evaluation section. Other activities involving contact with water may be affected by microbial contamination. For recreational impact assessment, dispersion and transport of the effluent needs to be considered in conjunction with the applicant's disinfection procedures.

All recreational activities currently occurring within the bay, estuary, or an 8-km radius of the outfall should be identified (e.g., swimming, boating, fishing, shellfishing, underwater diving, picnicking, other beach activities). Any additional potential future recreational activities should also be identified (e.g., new ports, boat harbors). A map should be provided that indicates the location of existing activities, along with the location of the existing or proposed outfall. Qualitative or, whenever possible, quantitative information should be provided that indicates the

extent of the existing activities. This could include the number of boats or boat slips in the area, species of fish and shellfish recreationally harvested, size of catch, and number of beach user days.

III.E.2. What are the existing and potential impacts of the modified discharge(s) on recreational activities? Your answer should include, but not be limited to, a discussion of fecal coliform bacteria.

**** Large and small dischargers must respond.*

Water quality standards for protecting recreational uses, particularly coliform bacteria or enterococci standards, should be provided. Water classifications within 8 km of the discharge should be indicated. The schedule and frequency of chlorination should be established. To confirm compliance with standards relevant to recreational activities, any required coliform or enterococci bacteria monitoring data for the effluent, at the ZID boundary, and on the adjacent shoreline should be submitted. As noted in Section III.F.2, bacteriological sampling should be limited to the night or early morning hours. If shoreline areas are not normally monitored, sampling should occur on the shore near popular water-activity areas. If noncompliance with coliform bacteria standards is noted, an explanation and corrective measures should be provided. Other sources of coliform bacteria present in the area that could be contributing to the problem should be identified.

III.E.3. Are there any Federal, State, or local restrictions on recreational activities in the vicinity of the modified discharge(s)? If yes, describe the restrictions and provide citations to available references.

**** Large and small dischargers must respond.*

Any federal, state, or local restrictions or closures relating to the discharge and recreational activities should be identified. The nature of

restrictions, the date implemented, and the agency responsible (e.g., state department of health) should be indicated.

III.E.4. If recreational restrictions exist, would such restrictions be lifted or modified if you were discharging a secondary treatment effluent?

**** Large and small dischargers must respond.*

If restrictions are in place, the relation of the restriction to the current or modified discharge quantity and quality should be established. If an improvement in the discharge quality would modify or eliminate the restriction on recreational activities, this should be indicated. In all such events, it should be determined whether secondary treatment would improve the discharge sufficiently to allow the restriction to be modified.

III.F. Establishment of a Monitoring Program [Subpart 125.63]

Establishment of a monitoring program for applicants granted Section 301(h) modified discharge permits is important to evaluate the impact of the modified discharge on selected marine biological communities, to demonstrate continued compliance with applicable water quality standards, and to monitor effectiveness of the urban pretreatment and toxics control programs. Only those scientific investigations that are necessary to study the effects of the proposed discharge should be included in the scope of the monitoring program [Subpart 125.63(a)(1)(i)(B)]. Unless special circumstances exist (e.g., the presence of distinctive habitats, high mass emission rates of toxic substances), monitoring programs for small dischargers are typically much less comprehensive than those for large discharges.

The monitoring program consists of three parts: biological, water quality, and effluent. Although each of these parts involves sampling at different locations and for different variables, they should not be considered as independent activities, but as an integrated study. In this manner, the applicant will be able to meet specific objectives of each part

of the study while also conducting a meaningful assessment of impacts of the discharge. Moreover, as predictable relationships are established among the biological, water quality, and effluent monitoring variables, it should be possible to delete certain elements of the field monitoring studies.

The continued assessment of marine biota as part of the monitoring program involves the same type of comparative strategy as is required for a BIP demonstration in the application. The characteristics of selected marine communities in the discharge vicinity are compared with biological characteristics at reference areas. Hence, a primary objective of the biological monitoring program is to evaluate continued compliance with the BIP requirements. This demonstration can be accomplished by conducting periodic (e.g., quarterly) seasonal surveys of biological communities.

Biological communities selected for study in the monitoring program should include those communities that are most likely affected by the discharge. As is the case for BIP demonstrations in the original application, the monitoring program should address any biological effects in terms of spatial extent, magnitude, potential for secondary impacts, and potential for involvement of commercial or recreational species. All of these factors will be important in determining whether or not detectable differences in biological characteristics are adverse.

Bioaccumulation determinations and sediment sampling are used to evaluate biological effects of toxic substances in the effluent. The results of these studies can indicate the potential for adverse effects on human health, especially if recreationally or commercially important fishery resources occurred in the outfall vicinity. These results may also be used to determine the need for additional (or fewer) analyses of toxic substances in sediments or in organisms exposed to the diluted effluent.

The water quality monitoring program is intended to evaluate compliance with applicable water quality standards and criteria, and to measure the presence of toxic substances. An additional objective of the water quality monitoring program is to provide information that will supplement the

biological monitoring program, in particular to assist in the interpretation of observed biological differences.

Monitoring POTW effluent is important for providing supplementary information for both the water quality and biological programs. Effluent monitoring data are also used for demonstrating continued compliance with the modified permit effluent limitations and as a data source for permit renewal applications.

> *III.F.1. Describe the biological, water quality, and effluent monitoring programs which you propose to meet the criteria of Part 125.63. Only those scientific investigations that are necessary to study the effects of the proposed discharge should be included in the scope of the monitoring program [Subpart 125.63(a)(1)(i)(B)].*

**** Large and small dischargers must respond.*

The extent of the monitoring program required as part of a Section 301(h) variance will depend upon the characteristics of the discharge and the receiving environment. Monitoring of the effluent and receiving water may also be required as part of the applicant's existing NPDES permit or to meet state regulations. The applicant's proposed monitoring program must be submitted with the Section 301(h) application.

Detailed guidance on the design of Section 301(h) monitoring programs is provided in *Design of 301(h) Monitoring Programs for Municipal Wastewater Discharges to Marine Water* (Tetra Tech 1982a) and *Framework for 301(h) Monitoring Program* (Tetra Tech 1987e). Although some technical information (primarily literature citations, analytical protocols, and legal citations and requirements) provided in Tetra Tech (1982a) has been superceded, most of the information is still valid and applicable to the design of 301(h) monitoring programs. More recent documents (e.g., Tetra Tech 1985e, 1986, 1987c, 1987e) include the addition of recent literature citations, updated analytical protocols, and updated legal citations and requirements. The

updated information in these more recent documents, together with the earlier guidance provided by Tetra Tech (1982a, 1987e), is sufficient to design and implement an effective monitoring program. Applicants are referred to the following documents for additional or updated guidance on specific topics relevant to the design and execution of 301(h) monitoring programs:

- Tetra Tech (1987a, 1988) for information on positioning methods in nearshore marine and estuarine waters
- Tetra Tech (1985c,d,e, 1986) for information on analytical methods
- Tetra Tech (1987c) for information on quality assurance/ quality control procedures for field and laboratory methods
- Tetra Tech (1985a,b,c,d, 1987d) for information on bio-accumulation monitoring studies
- Tetra Tech (1987b) for information on fish liver pathology monitoring studies.

Biological Monitoring

The applicant's biological monitoring program must include the following elements to the extent practicable:

1. Periodic surveys of control sites and biological communities most likely to be affected by the discharge
2. Periodic bioaccumulation studies and examination of possible adverse effects of effluent-related toxic substances

3. Periodic sampling of sediments

4. Periodic assessment of commercial or recreational fisheries (if present).

Small applicants are not subject to items 2 through 4 immediately above if they discharge at depths greater than 10 m, and if they demonstrate through a suspended solids deposition analysis that there will be negligible seabed accumulation in the vicinity of the modified discharge.

The objectives of the biological monitoring program are to evaluate the impact of the modified discharge and to demonstrate compliance with Section 301(h) biological requirements. Thus, the biological monitoring program must enable the same spatial comparisons (i.e., ZID, ZID boundary, discharge impact area, and control) as are required for demonstration of a BIP.

The applicant's monitoring program should include only those study elements that are practicable and appropriate in the receiving water environment. When the applicant considers that one or more of the aforementioned study elements is not practicable, a justification for the proposed deletion from the monitoring program should be provided. Examples of situations in which reductions in the frequency or extent of biological surveys would be reasonable might include conditions of high current speeds or adverse climatic periods (sampling not practical) and periods of low biological variability or extremely low productivity (sampling not appropriate).

Monitoring program specifications supplied by the applicant must include the following information:

- Biological groups to be sampled
- Sampling methods
- Station locations

- Sampling schedules
- Preservation techniques
- Analytical techniques
- Quality assurance/quality control procedures
- Statistical analyses
- Taxonomic sources.

The three types of sampling stations that should generally be included in the periodic biological surveys to the extent practicable are located as follows:

- In the vicinity of the ZID
- In other areas of potential discharge impact
- In control (i.e., reference) areas.

Monitoring at sites intermediate between control and outfall locations may be necessary, especially for large discharges where definition of the spatial extent of biological effects is an important consideration. Additional station requirements would also be associated with discharges into estuaries (within-ZID station), into stressed waters, or in situations where other pollutant sources potentially affect biological communities near the discharge. For modified discharges involving outfall relocation, monitoring must be conducted at the existing discharge site until cessation of that discharge, and at the relocation site.

Selection of control stations is one of the more important aspects of monitoring program design, as BIP comparisons will rely on data from these

sites. Control station(s) should be located in areas not influenced by the applicant's previous or existing discharge or other pollutant sources. Sediment characteristics at the control station(s) should be similar to those expected to occur naturally in the vicinity of the discharge. Discharge and control stations should be located at similar water depths.

Bioaccumulation studies are to be included in the monitoring program to evaluate the potential adverse effects of toxic substances. *In situ* bioassays may be needed on a case-by-case basis. Caged specimens of bivalve molluscs (e.g., *Mytilus edulis* or *M. californianus*) are recommended as test organisms for *in situ* bioassays. Exposures should be conducted in the discharge vicinity and at an appropriate reference site. Additional exposure sites may be necessary for large dischargers, especially in situations where other pollutant sources contribute toxic substances to the receiving water body. Only those toxic pollutants and pesticides identified in the applicant's discharge need to be measured in the exposed organisms.

The monitoring program must also include sediment sampling for toxic substances in the vicinity of the discharge, in other areas of expected solids accumulation, and at appropriate reference sites. Within-ZID sampling should be undertaken where practicable. The sediment sampling is intended to provide an indication of the toxics accumulation within sediments near the discharge and the associated contamination potential. If elevated or increasing concentrations of toxic substances are detected, the applicant must also analyze tissue concentrations of toxic substances in indigenous organisms to determine whether adverse bioaccumulation is occurring. Recommended organisms for such analyses include demersal fishes (e.g., flounder or sole), epibenthic megainvertebrates (e.g., crabs or lobster) or sessile filter-feeding organisms (e.g., clams, mussels, or oysters).

Sediment samples should also be analyzed for characteristics that would support the water quality and biological surveys. These variables should include particle size distribution and total volatile solids. Other variables such as BOD_5, sulfides, and total organic carbon, are also useful and may be required by some states.

If recreational or commercial fisheries are present in areas potentially affected by the discharge, the applicant must also periodically assess those fisheries. The kinds of evaluations conducted will depend on the nature of the local fisheries and on the level of detail in available fisheries data. These evaluations must reflect an understanding of the potential impacts of the discharge on the fisheries. Sources of information used to determine the productivity and status of fisheries include state resource agencies, voluntary logbooks, interviews, and field observations. The periodic and level of effort of fishery surveys will depend upon the size and location of the discharge, concentrations of toxic substances in the effluent, species harvested, and the importance of the commercial or recreational fishery.

Water Quality Monitoring

The objectives of the water quality monitoring program are to provide data for determining compliance with applicable water quality standards and criteria, to measure the presence of toxics identified or expected in the effluent, and to assist in the evaluation of biological data.

The water quality measurements usually required include dissolved oxygen, BOD_5, suspended solids, pH, temperature, salinity, and light transmittance. Light transmittance standards may be specified in terms of turbidity, Secchi disc depth, extinction coefficient, or percent light transmittance. With the exception of Secchi disc depth, water column profiles should be determined for these variables. However, because the Secchi disc provides cumulative data on water transparency measured from the surface down to the depth at which it disappears from sight, the Secchi disc should not be used to detect the effect of a submerged plume on light transmittance.

Other variables that may be required include nitrogen (nitrate, nitrite, total Kjeldahl nitrogen, and ammonia), total and reactive phosphorus, toxic substances identified in the effluent, chlorophyll *a*, floating particulates, color, settleable solids, surface oil and grease, total and fecal coliform

bacteria, and enterococci bacteria. Samples for these variables should be collected 1.0 m (3.3 ft) below the water surface, at mid-depth, and 1.0 m (3.3 ft) above the bottom. In deep water, sampling at additional water column depths may be required. The applicant's monitoring program should specify the variables for which profiles are to be taken along with the sampling interval.

For existing discharges, stations should be located in the following areas:

- ZID boundaries (both upcurrent and downcurrent)
- Control (i.e., background) stations along the primary axis of the longshore component of the current (both upcurrent and downcurrent)
- Intermediate upcurrent stations located between the ZID boundary and the upcurrent control station
- Potential impact areas (e.g., in the nearshore zone and close to areas with distinctive habitats).

The applicant should use information on local currents and wastefield dispersion patterns when selecting sampling station locations in potentially impacted areas. Sampling stations located at the ZID boundary, control stations, and intermediate upcurrent stations should be in approximately the same depth of water. Control stations should be located in areas not influenced by the discharge. Intermediate upcurrent stations should be selected to represent the approximate residual wastefield concentrations upcurrent of the location, thereby accounting for potential recirculation of previously discharged effluent (by reversing tidal currents, upwelling, or stagnant net circulation). Data should be collected at the intermediate and ZID stations at least twice daily (e.g., high and low slack tides), to evaluate short-term conditions. The duration of the longshore current in relation to the time of sampling is an important factor in determining

whether the intermediate upcurrent stations are representative of persistent conditions or of only a temporary plume reversal. For discharges involving outfall relocation, monitoring stations must be located at the current discharge site until cessation of the discharge, and at the relocation site.

For all cases, the applicant should include a chart showing the location of the outfall, the shoreline, any distinctive habitats, and all sampling stations. The latitude, longitude, and depths of the stations should be specified.

Sampling frequencies should be selected to comply with state requirements and to provide data for critical periods. In most cases, quarterly surveys that include the critical periods (e.g., time of maximum stratification) should meet state requirements. More frequent sampling (e.g., for coliform bacteria) in swimming or shellfish harvesting areas may be required by some states. The analytical methods and quality control/quality assurance procedures should be described (see Section III.F.2 for additional guidance).

Effluent Monitoring

The major objectives of treatment plant monitoring are to provide data for determining compliance with permit effluent limitations and state requirements, to measure the effectiveness of the toxic substance control program, and to relate discharge characteristics to the receiving water biological and water quality conditions. In addition, influent and effluent monitoring provide data for assessment of treatment plant performance, which may be required to meet modified discharge permit conditions.

Variables that should be measured in the effluent are flow, BOD_5, suspended solids, pH, dissolved oxygen, and the toxic pollutants and pesticides present or likely to be present in the discharge. The toxic pollutants and pesticides that should be measured are specified in Subparts 125.58(z) and (o) of the Section 301(h) regulations. Additional variables, which may be required by other permit conditions, include grease and oil,

settleable solids, nutrients, total and fecal coliform bacteria, and temperature.

Influent samples for conventional pollutant and nutrient analyses, if required, should be collected just downstream of any coarse screens or grit chambers. Effluent samples should be collected downstream of any chlorination or disinfection units. Effluent samples to be analyzed for toxic substances should be collected just upstream of the outfall. In general, grab samples should be collected for pH and total and fecal coliform bacteria. For the other conventional pollutants (e.g., suspended solids), 24-h flow composite samples are recommended.

III.F.2. Describe the sampling techniques, schedules, and locations, analytical techniques, quality control, and verification procedures to be used.

**** Large and small dischargers must respond.*

The following information must be provided for all portions of the proposed monitoring program:

- Variables to be measured
- Sampling methods
- Sampling schedule
- Sampling locations
- Analytical techniques
- Quality control and verification procedures.

Guidance on the above subjects is provided in the documents listed in Section III.F.1. Current U.S. EPA-approved methods should be used for all

variables. Additional guidance on navigational requirements is provided in Appendix D.

III.F.3. Describe the personnel and financial resources available to implement the monitoring programs upon issuance of a modified permit and to carry it out for the life of the modified permit.

**** Large and small dischargers must respond.*

The applicant must provide information on available personnel, facilities, and financial resources to show that the proposed monitoring program can be implemented and continued for the term of the modified discharge permit if a Section 301(h) variance is granted. The applicant should review state monitoring requirements to ensure that the proposed program meets those requirements.

III.G. Effect of Discharge on Other Point and Nonpoint Sources [Part 125.64]

III.G.1. Does (will) your modified discharge(s) cause additional treatment or control requirements for any other point or nonpoint pollution source(s)?

**** Large and small dischargers must respond.*

The Section 301(h) regulations require an analysis of whether a decreased treatment level at the applicant's discharge would require other pollution sources in the vicinity to increase their treatment levels or apply other additional controls. For open coastal waters, a list of discharges within the anticipated impact area of the applicant's modified discharge should be provided. The subsequent dilution at each outfall can be estimated using Table B-5 in Chapter B-IV of Appendix B of this document. The total dilution is the product of the initial dilution and the subsequent dilution. If the effect of the applicant's discharge is small at other sources, further analysis may not be needed. Otherwise, an analysis of

compliance with water quality standards at the other discharger sites is appropriate for determining the effects of the applicant's discharge at these sites. For most small POTW discharges, the effects on other sources should be negligible.

In estuaries where outfalls are close together, effects on other sources are possible. The approach outlined above can be used to estimate total dilution at the other outfalls.

> *III.G.2. Provide the determination required by Subpart 125.64(b) or, if the determination has not yet been received, a copy of a letter to the appropriate agency(s) requesting the required determination.*

**** Large and small dischargers must respond.*

The applicant must provide a copy of a determination from the state or interstate agencies that are authorized to establish wasteload allocations indicating whether the proposed discharge will result in the imposition of additional pollution control requirements on any other point or nonpoint sources. This determination must also explain the basis of the conclusions.

If the required determination has not been received when the application is submitted to U.S. EPA, the applicant should include copies of the request letters to the appropriate agencies. When the determination is made, a copy of the determination letter should be forwarded to U.S. EPA.

III.H. Toxics Control Program [Part 125.66]

The toxics control program is designed to identify and assure control of toxic pollutants and pesticides discharged to the POTW. The Section 301(h) toxic control regulations require both industrial and nonindustrial source control programs. However, the control of industrial sources is addressed separately by pretreatment program regulations [Subpart 403.8(d)] that require all industrial pretreatment programs to have been approved by 1

July 1983. Applicants must nonetheless adhere to the Section 403 program requirements and compliance schedules.

U.S. EPA's Section 301(h) toxics control program regulations apply to all applicants. However, small applicants who certify that there are no known or suspected sources of toxic pollutants and pesticides to the POTW are relieved of most of the cost burden for toxics control program development.

> *III.H.1. a. Do you have any known or suspected industrial sources of toxic pollutants or pesticides?*
>
> *b. If no, provide the certification required by Subpart 125.66(a)(2).*
>
> *c. If yes, provide the results of wet- and dry-weather effluent analyses for toxic pollutants and pesticides.*
>
> *d. Provide an analysis of known or suspected industrial sources of toxic pollutants and pesticides identified in III.H.1.c above.*

**** Large dischargers must respond to parts a through d.*

**** Small dischargers must respond to parts a and b in full, and to parts c and d to the extent practicable.*

Toxic pollutants and pesticides are defined in Subparts 125.58(aa) and 125.58(p), respectively, and include those substances listed in Table 2. Marine water quality criteria are summarized in Table 3. Guidance on sampling and analytical methods is found in Tetra Tech (1982a, 1987c,e) and 40 CFR Part 136.

If there are no known or suspected industrial sources of toxic pollutants or pesticides, the applicant must certify this fact, based on the results of an industrial user survey. This survey must be conducted as described in 40 CFR 403.8(f)(2).

TABLE 2. TOXIC POLLUTANTS AND PESTICIDES
AS DEFINED IN SECTION 125.58 (aa) and (p)

Pesticides

Demeton	Methoxychlor
Guthion	Mirex
Malathion	Parathion

Toxic Pollutants

1. Acenaphthene
2. Acrolein
3. Acrylonitrile
4. Aldrin/dieldrin
5. Antimony and compounds[a]
6. Arsenic and compounds
7. Asbestos
8. Benzene
9. Benzidine
10. Beryllium and compounds
11. Cadmium and compounds
12. Carbon tetrachloride
13. Chlordane (technical mixture and metabolites)
14. Chlorinated benzenes (other than dichlorobenzenes)
15. Chlorinated ethanes (including 1,2-dichloroethane, 1,1,1-trichloroethane, and hexachloroethane)
16. Chloroalkyl ethers (chloroethyl and mixed ethers)
17. Chlorinated naphthalene
18. Chlorinated phenols (other than those listed elsewhere; includes trichlorophenols and chlorinated cresols)
19. Chloroform
20. 2-Chlorophenol
21. Chromium and compounds
22. Copper and compounds
23. Cyanides
24. DDT and metabolites
25. Dichlorobenzenes (1,2-, 1,3-, and 1,4-dichlorobenzenes)
26. Dichorobenzidine
27. Dichloroethylenes (1,1-and 1,2-dichloroethylene)
28. 2,4-Dichlorophenol
29. Dichlorophropane and dichloropropene
30. 2,4-Dimethylphenol
31. Dinitrotoluene
32. Diphenylhydrazine

TABLE 2. (Continued)

33. Endosulfan and metabolites
34. Endrin and metabolites
35. Ethylbenzene
36. Fluoranthene
37. Haloethers (other than those listed elsewhere; includes chlorophenylphenyl ethers, bromophenylphenylether, bis(dichloroisopropyl) ether, bis-(chloroethoxy) methane, and polychlorinated diphenyl ethers)
38. Halomethanes (other than those listed elsewhere; includes methylene chloride, methyl-chloride, methylbromide, bromoform, and dichlorobromo-methane)
39. Heptachlor and metabolites
40. Hexachlorobutadiene
41. Hexachlorocyclohexane
42. Hexachlorocyclopentadiene
43. Isophorone
44. Lead and compounds
45. Mercury and compounds
46. Naphthalene
47. Nickel and compounds
48. Nitrobenzene
49. Nitrophenols (including 2,4-dinitrophenol, dinitrocresol)
50. Nitrosamines
51. Pentachlorophenol
52. Phenol
53. Phthalate esters
54. Polychlorinated biphenyls (PCBs)
55. Polynuclear aromatic hydro-carbons (including benzanthra-cenes, benzopyrenes, benzofluor-anthene, chrysenes, dibenzanth-racenes, and indenopyrenes)
56. Selenium and compounds
57. Silver and compounds
58. 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)
59. Tetrachloroethylene
60. Thallium and compounds
61. Toluene
62. Toxaphene
63. Trichloroethylene
64. Vinyl chloride
65. Zinc and compounds

[a] The term "compounds" includes both organic and inorganic compounds.

TABLE 3. SUMMARY OF U.S. EPA MARINE WATER QUALITY CRITERIA

Pollutant	Concentrations (ug/L) Acute	Chronic	References (see below)
Acenaphthene	970[a]	710[a]	Goldbook
Acrolein	55[a]	[b]	Goldbook
Acrylonitrile	[b]	[b]	Goldbook
Aldrin	1.3[c]	[b]	Goldbook
Antimony	[b]	[b]	Goldbook
Arsenic			
Pentavalent	2,319[a]	13[a]	Goldbook
Trivalent	69[d]	36[e]	Goldbook
Asbestos	[b]	[b]	Goldbook
Benzene	5,100[a]	700[a]	Goldbook
Benzidine	[b]	[b]	Goldbook
Beryllium	[b]	[b]	Goldbook
Cadmium	43[d]	9.3[e]	Goldbook
Carbon tetrachloride	50,000[a]	[b]	Goldbook
Chlordane	0.09[c]	0.004[f]	Goldbook
Chlorinated benzenes	160[a]	129[a]	Goldbook
Chlorinated ethanes			
Dichloroethane 1,2	113,000[a]	[b]	Goldbook
Hexachloroethane	940[a]	[b]	Goldbook
Pentachloroethane	390[a]	281[a]	Goldbook
Tetrachloroethane 1,1,2,2	9,020[a]	[b]	Goldbook
Trichloroethane 1,1,1	31,200[a]	[b]	Goldbook
Chlorinated ethylenes			
Dichloroethylenes	224,000[a]	224,000[a]	Goldbook
Tetrachloroethylene	10,200[d]	450[a]	Goldbook
Trichloroethylene	2,000[a]	[b]	Goldbook

TABLE 3. (Continued)

Pollutant	Concentrations (ug/L) Acute	Chronic	References (see below)
Chlorinated naphthalene	7.5[a]	[b]	Goldbook
Chlorinated phenols			
Chlorophenol 2	[b]	[b]	Goldbook
Chlorophenol 4	29,700[a]	[b]	Goldbook
Pentachlorophenol (penta)	13[d]	7.9[e]	Update No. 2
Tetrachlorophenol 2,3,5,6	440[a]	[b]	Goldbook
Chlorine	13[d]	7.5[e]	
Chloroalkyl ethers	[b]	[b]	Goldbook
Chloroethyl ether	[b]	[b]	Goldbook
Chloroform	[b]	[b]	Goldbook
Chlorpyrifos	0.011[d]	0.0056[e]	Update No. 2
Chromium			
Hexavalent	1,100[d]	50[e]	Goldbook
Trivalent	10,300[a]	[b]	Goldbook
Copper	2.9[d]	2.9[e]	Goldbook
Cyanide	1.0[d]	1.0[e]	Goldbook
DDT	0.13[c]	0.001[f]	Goldbook
DDT Metalbolites			
DDD (TDE)	3.6[a]	[b]	Goldbook
DDE	14[a]	[b]	Goldbook
Demeton	[b]	0.1	Goldbook
Dichlorobenzenes	1,970[a]	[b]	Goldbook
Dichlorobenzidines	[b]	[b]	Goldbook
Dichlorophenol 2,4	[b]	[b]	Goldbook
Dichloropropanes	10,300[a]	3,040[a]	Goldbook
Dichloropropenes	790[a]	[b]	Goldbook

TABLE 3. (Continued)

Pollutant	Concentrations (ug/L) Acute	Chronic	References (see below)
Dieldrin	0.71[c]	0.0019[f]	Goldbook
Dimethylphenol 2,4	[b]	[b]	Goldbook
Dinitrotoluene	590[a]	370[a]	Goldbook
Dioxin (2,3,7,8-TCDD)	[b]	[b]	Goldbook
Diphenylhydrazine 1,2	[b]	[b]	Goldbook
Endosulfan	0.034[c]	0.0087[f]	Goldbook
Endrin	0.037[c]	0.0023[f]	Goldbook
Ethylbenzene	430[a]	[a]	Goldbook
Fluoranthene	40[a]	16[a]	Goldbook
Guthion	[b]	0.01	Goldbook
Haloethers	[b]	[b]	Goldbook
Halomethanes	12,000[a]	6,400[a]	Goldbook
Heptachlor	0.053[c]	0.0036[f]	Goldbook
Hexachlorobutadiene	32[a]	[b]	Goldbook
Hexachlorocyclohexane (HCH)			
Lindane (gamma-HCH)	0.16[c]	[b]	Goldbook
HCH (mixture of isomers)	0.34[a]	[b]	Goldbook
Hexachlorocyclopentadiene	7.0[a]	[b]	Goldbook
Isophorone	12,900[a]	[b]	Goldbook
Lead	140[d]	5.6[e]	Goldbook
Malathion	[b]	0.1	Goldbook
Mercury	2.1[d]	0.025[e]	Goldbook

TABLE 3. (Continued)

Pollutant	Concentrations (ug/L) Acute	Chronic	References (see below)
Methoxychlor	b	0.03	Goldbook
Mirex	b	0.001	Goldbook
Naphthalene	2,350[a]	b	Goldbook
Nickel	75[c]	8.3[f]	Update No. 2
Nitrobenzene	6,680[a]	b	Goldbook
Nitrophenols	4,850[a]	b	Goldbook
Nitrosamines	3,300,000[a]	b	Goldbook
Parathion	b	b	Update No. 2
Phenol	5,800[a]	b	Goldbook
Phosphorous (elemental)	b	0.1	
Phthalate esters	2,944[a]	3.4[a]	Goldbook
Polychlorinated biphenyls	10[a]	0.03[f]	Goldbook
Polynuclear aromatic hydrocarbons	300[a]	b	Goldbook
Selenium (inorganic selenite)	410[c]	54[f]	Goldbook
Silver	2.3[c]	b	Goldbook
Sulfur (hydrogen sulfide, H_2S)	b	2[f]	Goldbook
Thallium	2,130[a]	b	Goldbook
Toluene	6,300[a]	5,000[a]	Goldbook
Toxaphene	0.21[d]	0.0002[e]	Update No. 2
Vinyl chloride	b	b	Goldbook
Zinc	95[d]	86[e]	Update No. 2

TABLE 3. (Continued)

[a] Data insufficient to derive criteria. Value presented is the lowest observed effect level (LOEL). These concentrations represent apparent threshold levels for acute and/or chronic toxic effects, and are intended to convey information about the degree of toxicity of a pollutant in the absence of established criteria.

[b] Criterion has not been established for marine water quality.

[c] Not to be exceeded at any time.

[d] Maximum 1-h average. Not to be exceeded more than once every 3 yr on the average.

[e] Maximum 96-h (4-day) average. Not to be exceeded more than once every 3 yr.

[f] Maximum 24-h average. Not to be exceeded more than once every 3 yr.

References: Goldbook=U.S. EPA 1986a; Update No. 2=U.S. EPA 1987.

If known or suspected industrial sources of toxic pollutants or pesticides exist, applicants must submit results of wet- and dry-weather analyses of the treatment plant effluent. If available, influent data would also be helpful. If historic data are available, they should be presented as well. Results of the analyses should be tabulated in a summary form that allows the toxic quality of the discharge to be evaluated. The applicant should describe the sampling effort by describing the procedures for collecting, compositing, and preserving the samples. The number of grab samples taken for volatile organics analysis should be included in the discussion.

Rainfall data submitted for at least 5 days preceding the sampling will confirm wet or dry conditions at the time of sampling. In past analyses (Feiler 1980), toxics concentrations have been substantially higher during Monday through Friday than on Saturday and Sunday. It is therefore recommended that composite effluent samples not be collected on weekends unless it can be shown that this sampling period is more representative.

Analytical methods should be discussed, with appropriate references to published analytical procedures. The identity of the analytical laboratory should be given. Quality assurance procedures for the analysis should be summarized, and results presented for review. Differences between the wet- and dry-weather analysis should be explained, if possible. Also, a comparison with past results could be made.

Sources of detected toxic pollutants must be identified and, to the extent practicable, categorized according to industrial and nonindustrial origins. The purpose of this identification and categorization is to provide a useful reference for toxics monitoring and source controls. If the applicant recognizes that the source list requires improvement, procedures to accomplish this improvement should be described. In-system sampling and analysis, industrial discharge analysis, permit data, and site inspections could yield quantitative information as to sources of identified priority pollutants.

Special Considerations for Small Dischargers

In the original Section 301(h) application, many small applicants were exempted from providing an analysis of toxic substances and pesticides in their effluent because they were able to certify that there are no known or suspected sources of those substances in their service area. However, those exemptions were not permanent (U.S. EPA 1982, p. 53673). Subpart 125.62(d) requires all Section 301(h) permittees to analyze their effluent for toxic substances and pesticides, to the extent practicable, as part of their monitoring programs. Hence, to the extent practicable, all Section 301(h) permittees shall have performed at least one effluent analysis for toxic substances at a representative time during the 5-yr term of the original Section 301(h) permit. To the extent practicable, they shall also perform another effluent analysis for toxic substances at a representative time during the 5-yr term of the reissued permit. Results of those analyses should be used to demonstrate compliance with federal water quality criteria.

> *III.H.2. a. Are there any known or suspected water quality, sediment accumulation, or biological problems related to toxic pollutants or pesticides from nonindustrial sources to your modified discharge(s).*
>
> *b. If no, provide the certification required by Subpart 125.66(d)-(2) together with available supporting data.*
>
> *c. If yes, provide a schedule for development and implementation of nonindustrial toxics control programs to meet the requirements of Subpart 126.66(d)(3).*

**** Only small dischargers must respond.*

The purpose of nonindustrial source control programs is to identify the specific nonindustrial sources of priority pollutants and pesticides and then to develop specific means for their control. To properly address these

requirements, the applicant should describe existing programs or present a schedule and description of proposed programs to identify and control non-industrial sources of toxic pollutants and pesticides. At a minimum, all applicants must develop a public education program to limit nonindustrial sources (see Question III.H.7 below).

Nonindustrial source control programs must be developed and implemented on the earliest possible schedule. Implementation is required within 18 months of the issuance of a 301(h)-modified permit. The schedule must include the following two elements:

- A schedule of activities for identification of nonindustrial sources of toxic pollutants and pesticides

- A schedule for the development and implementation of practicable control programs for nonindustrial sources of toxic pollutants and pesticides.

Activities to identify nonindustrial sources could include literature searches, in-system sampling and analysis, research on nonindustrial products commonly released to the sewer, and pooling of information with other POTW operators having a similar mix of users.

There are no clearly defined rules to determine the level of effort that an applicant should apply to identify nonindustrial sources. However, this level of effort is expected to be directly related to the size of the discharger. For example, dischargers with diverse land uses within the service area may find it necessary to perform in-system sampling and analysis to explain the occurrence of toxic pollutants and pesticides.

Concentrations of pollutants within the system that are not accounted for by industrial sources are generally attributable to nonindustrial sources. Applicants should therefore be careful not to duplicate any in-system sampling efforts performed for compliance with industrial pretreatment regulations.

Extensive control measures may be necessary where nonindustrial sources produce concentrations of toxic pollutants and pesticides within 50 percent or more of the receiving water criteria after initial dilution. These measures could include control of the sale, use, handling, and disposal stages of substances that contain priority pollutants and pesticides.

U.S. EPA recognizes the serious potential for adverse effects on marine organisms and humans that can result from bioaccumulation of discharged toxic pollutants and pesticides. U.S. EPA also recognizes the potential complexity of nonindustrial source control programs. Therefore, applicants are encouraged to consult with U.S. EPA during development of nonindustrial source control programs. Proposed nonindustrial source control programs are subject to review and revision by U.S. EPA prior to issuing a Section 301(h) modified permit, and during the term of any such permit.

III.H.3 Provide the results of wet- and dry-weather effluent analyses for toxic pollutants and pesticides as required by Subpart 125.66(a)(1).

**** Large dischargers must respond in full. Small dischargers must respond to the extent practicable.*

III.H.4 Provide an analysis of known or suspected industrial sources of toxic pollutants and pesticides identified in 2. above.

**** Large dischargers must respond in full. Small dischargers must respond to the extent practicable.*

III.H.5. Do you have an approved industrial pretreatment program?

a. If yes, provide the date of U.S. EPA approval.

b. If no, and if required by 40 CFR Part 403 to have an industrial pretreatment program, provide a proposed schedule for development

and implementation of your industrial pretreatment program to meet the requirements of 40 CFR Part 403.

**** Large and small dischargers must respond.*

An applicant with known or suspected industrial sources of toxic pollutants or pesticides must have an approved pretreatment program and demonstrate compliance with its requirements. Applicants that certify to the Administrator that they have no known or suspected industrial sources of toxic pollutants or pesticides are not required to have an industrial pretreatment program.

In this section, applicants required to have an industrial pretreatment program should clearly present the history of compliance with the Part 403 industrial pretreatment program. If such a program has already been approved by U.S. EPA it is only necessary to indicate the date of approval. If the program has not been approved, a schedule of activities, including the expected date of submittal to U.S. EPA, that will lead to compliance with Part 403 must be provided.

III.H.6. Urban area pretreatment requirement [Subpart 125.65]

a. Provide data on all toxic pollutants introduced into the treatment works from industrial sources (categorical and non-categorical).

b. Note whether applicable pretreatment requirements are in effect for every industrial source of each toxic pollutant. Are the industrial sources introducing such toxic pollutants in compliance with all of their pretreatment requirements? Are these pretreatment requirements being enforced? [Subpart 125.65(b)(2)]

c. If applicable pretreatment requirements do not exist for each toxic pollutant in the POTW effluent introduced by industrial sources,

- *Provide a description and a schedule for your development and implementation of applicable pretreatment requirements [Subpart 125.65(c)], or*

- *Describe how you propose to demonstrate secondary removal equivalency for each of those toxic pollutants, including a schedule for compliance, by using a secondary treatment pilot plant. [Subpart 125.65(d)]*

*** *Dischargers serving populations of 50,000 or more must respond.*

At the time of final permit approval, applicants must have in effect applicable pretreatment requirements for each toxic pollutant from industrial users that is found in the proposed discharge. Applicable pretreatment requirements may take the form of categorical standards, local limits, or a combination of both. When an industrial discharger is subject to both a categorical standard and a local limit, the more stringent of the two limits applies.

Categorical standards (see 40 CFR 403.6) are nationally uniform, technology-based limits developed for specific industries. They are applied when categorical industrial users are the only sources of particular toxic pollutants in the POTW waste stream. Local limits for specific toxic pollutants found in the discharge are applied when the toxic pollutants cannot be entirely attributed to categorical industrial users.

Local limits (see 40 CFR 403.5) are determined from general and specific prohibitions. General prohibitions include requirements that industrial users may not introduce pollutants into a POTW that will cause pass-through or interference with the treatment works. Pass-through is the discharge of concentrations of toxic pollutants or pesticides that alone or in combination with discharges from other sources will cause violation of the applicant's NPDES permit. Interference is the disruption of treatment processes or operations that alone or in combination with discharges from

other sources causes a violation of the applicant's NPDES permit. Specific prohibitions include requirements that pollutants with the following characteristics shall not be discharged to a POTW by industrial users:

- Pollutants that create a fire or explosion hazard
- Pollutants that will cause corrosion to a POTW or have a pH below 5.0
- Pollutants that are solid or viscous and are discharged in amounts that will obstruct flow in the POTW, resulting in interference
- Pollutants (including oxygen-demanding pollutants) that are released at a rate that will cause interference
- Heat in amounts that inhibit biological activity in the POTW and result in interference, or cause the temperature at the POTW to exceed 40^{0} C (104^{0} F) without approval.

For every toxic pollutant in the discharge that is not from a categorical industrial user and for which there is no local limit, the applicant must develop local limits, or demonstrate secondary removal equivalency to the U.S. EPA, or use a combination of these alternatives. To demonstrate secondary equivalency, an applicant must demonstrate that the combination of its own treatment plus pretreatment by industrial dischargers achieves "secondary removal equivalency." A successful demonstration of secondary removal equivalency will show, for each toxic substance in the effluent, that the applicant's own less-than-secondary treatment plus pretreatment by industrial dischargers removes that same amount of each toxic substance as would be removed if the applicant were to apply secondary treatment and there were no pretreatment requirements for those pollutants. Applicants must make this demonstration whenever they cannot show that a toxic pollutant introduced by an industrial discharger is subject to an "applicable pretreatment requirement" in effect.

To demonstrate secondary removal equivalency, an applicant would need to use a secondary treatment pilot plant. By diverting part of its influent to the pilot plant, the applicant would empirically determine the incremental amount of each toxic pollutant that would be removed from the influent if secondary treatment were applied. Having determined the amount of each toxic pollutant removed, the applicant would then demonstrate that its existing less-than-secondary treatment plus industrial pretreatment removes the same amount of each toxic substance as did the secondary treatment pilot plant without any industrial pretreatment.

In cases where an applicant already has an ongoing industrial pretreatment program, it may be simpler to perform this empirical demonstration using influent that has been subject to that industrial pretreatment. Such a demonstration would be conservative because it would overstate the amount of toxic pollutant that would be removed by applying only secondary treatment. Because it would be conservative, applicants are permitted (but not required) to make the secondary equivalency demonstration using effluent that has undergone industrial pretreatment.

III.H.7. Describe the public education program you propose to minimize the entrance of nonindustrial toxic pollutants and pesticides into your treatment system [Subpart 125.66(d)(1)].

**** Large and small dischargers must respond.*

The applicant must propose a public education program to minimize the amounts of nonindustrial toxic pollutants and pesticides that enter the waste stream. The plan must be implemented within 18 months of the issuance of a 301(h) modified permit. The public education program may include preparation of newspaper articles, posters, or radio and television announcements to increase public awareness of the need for proper disposal of waste oils, solvents, herbicides, pesticides, and other substances that contain toxic pollutants.

III.H.8 Provide a schedule for development and implementation of a nonindustrial toxics control program to meet the requirements of Subpart 125.66(d)(3).

**** Only large dischargers must respond.*

EVALUATIONS OF COMPLIANCE BY U.S. EPA

DETERMINATIONS OF COMPLIANCE WITH SECTION 301(h) MODIFIED PERMIT CONDITIONS

POTWs that hold Section 301(h) modified permits must comply with Section 301(h) criteria and regulations, applicable state water quality standards and regulations, and federal water quality criteria (U.S. EPA 1986a). General guidance is presented below for assessing whether a permittee's demonstration of compliance with the conditions specified in the Section 301(h) modified permit is reasonable. As discussed under Questions II.D.1-II.D.4 of the Application Questionnaire (above), the newly mandated federal water quality criteria [Subpart 125.63(c)(1)] place additional requirements on all Section 301(h) dischargers. These federal water quality criteria have the potential to expand the scope of the water quality demonstrations that must be made by each Section 301(h) discharger to include more variables, but do not create a fundamentally different, or new, class of criteria or requirements that must be met. Therefore, the general guidance provided below is also relevant to determinations of compliance with the newly mandated federal water quality criteria that will be performed by the Regions.

The first step in evaluating a permittee's demonstration of compliance with applicable criteria and regulations, or in determining compliance with criteria and regulations when monitoring data are examined by the Regions, is to compare the data that were submitted by the permittee with the data collection requirements specified in the existing Section 301(h) modified permit. The following two key questions should be addressed:

- Were all physical, chemical, and biological variables required by the Section 301(h) modified permit measured?

- Was each required variable measured at the specified locations and at the specified frequency?

If either question cannot be answered affirmatively, the applicant should be considered not to have complied with the terms of the existing Section 301(h) modified permit.

In cases of apparent noncompliance, the Regions have the option of denying the application for reissuance of the modified permit without further examination of the monitoring data. However, the Regions are strongly advised to ask the applicant (if no explanation of the apparent deficiencies was previously made by the applicant) the reasons for the apparent noncompliance. Unforeseen events or conditions beyond the control of the applicant may have been responsible for failures to execute the conditions of the modified permit.

Having received all the appropriate data from the applicant, the Region's second step is to evaluate the technical merit and (as warranted) the applicant's interpretation of those data. Three major issues should be addressed during that evaluation:

- Data quality
- Execution of the analyses
- Interpretation of the analytical results.

Successful demonstrations of compliance should provide sufficient information for the Region to document that data quality is high, analyses were properly executed, and data interpretation is reasonable.

To determine whether the applicant's data were collected properly, the Regions are referred to guidance given by Tetra Tech (1982a,b, 1987c) and to guidance given under the appropriate questions in the Application Questionnaire (especially Questions III.F.1-III.F.2). Of critical importance to the

collection of data for any variable is whether appropriate field and laboratory methods were used to collect the data, and whether appropriate quality assurance/quality control procedures were followed. Data are of little value if they were collected using inappropriate methods, or if the collection process was so poorly executed that their accuracy is in doubt.

As is true for data collection methods, data analysis methods vary greatly among the various types of physical, chemical, and biological variables. Again, the Regions are referred to the aforementioned documents. The following general questions should be addressed during the evaluation of the data analyses:

- Are values for each variable reported in appropriate units?
- Are the analytical methods appropriate for the type of data being analyzed?
- Do the mathematical or graphical analyses illustrate what is being discussed in the text of the application?
- Are calculations correct, and have data points been plotted correctly?

Provided that the foregoing questions (and other questions related to data analysis that may be relevant in specific instances) are answered in the affirmative, the Region should determine whether the applicant's data and the results of analyses of those data support the applicant's conclusions. If the Region determines otherwise, alternative conclusions must be developed by the Region for use in determining whether the applicant's existing or proposed discharge contributes to adverse impacts on the receiving environment or biota.

DETERMINATIONS OF COMPLIANCE WITH 301(h) CRITERIA

When the permittee's monitoring data indicate that impacts to water quality, sediment quality, or biota are occurring, it will be necessary for the Regions to determine whether such impacts are adverse. Determinations of adverse impacts are reasonably straightforward for many physical and chemical criteria (e.g., dissolved oxygen concentrations, concentrations of toxic substances in the water column after initial dilution) because such criteria are quantitative, and because determinations of compliance rely primarily on the results of well-documented mathematical calculations. Providing that the physical and chemical data were properly collected and analyzed, the resultant values for each physical and chemical variable need only be compared with applicable Section 301(h) criteria, state standards, and federal water quality criteria. Results of those comparisons can be used to determine the presence of an adverse impact that causes noncompliance with Section 301(h) criteria.

When the values of one or more physical or chemical variables consistently fall outside the ranges specified by the foregoing criteria, the discharge can be inferred (by definition) to be causing adverse impacts to the physical or chemical characteristics of the receiving environment, thereby resulting in noncompliance with Section 301(h) criteria. In those cases, the Regions have the option of denying the request for reissuance of the Section 301(h) modified permit, or requesting that the applicant make improvements to the outfall or treatment system such that compliance with applicable criteria is assured. In most cases, applicants proposing improvements will be required to predict the values of previously noncompliant variables following implementation of the proposed improvements.

Determinations of the presence or absence of adverse environmental impacts that result in noncompliance with Section 301(h) criteria are more difficult for biological criteria because adverse impacts are not defined quantitatively. Some extreme adverse impacts may be assessed more easily because they are defined specifically in the 301(h) regulations, and because they are endpoints in a spectrum of possible biological conditions that may

result from the discharge of sewage effluent. For example, the 301(h) regulations state that conditions within the ZID must not contribute to extremely adverse biological impacts, including the following conditions:

- Destruction of distinctive habitats of limited distribution
- Presence of disease epicenters
- Stimulation of phytoplankton blooms that have adverse impacts beyond the ZID
- Conditions that result in mass mortalities of fish and invertebrates.

The regions should deny applications for reissuance of Section 301(h) modified permits where such impacts have been demonstrated to occur over the life of the existing permit, or are expected to occur over the life of the reissued permit. The Regions may consider applications that propose improvements to eliminate any of the foregoing adverse impacts. But because all of these impacts are considered extremely adverse, it would be difficult to demonstrate that a balanced indigenous population will become reestablished following improvements to the treatment plant or outfall.

Many biological impact assessments that are required under 301(h) regulations necessitate determinations of degrees of impact relative to unstressed conditions, and subsequent judgments as to whether documented changes are in compliance with 301(h) criteria. These assessments rely largely on comparisons of biological conditions between reference areas and potentially impacted areas to determine the locations of changes along theoretically or empirically derived gradients of impacts. Quantitative comparisons between reference and potentially impacted areas may be made using various types of biological data [e.g., numbers of individuals per unit area, values of the Infaunal Trophic Index (Word 1978, 1980)] and various analytical tools (e.g., normal classification analysis) as discussed under Question III.D.1 (above). However, no quantitative biological criteria

have been established by which the results of these analyses may be judged. Therefore, determinations of whether changes in, or differences among, biological communities constitute noncompliance with Section 301(h) criteria require careful consideration of the types of responses that are manifested by the pollutant stress, as well as their spatial extents and magnitudes.

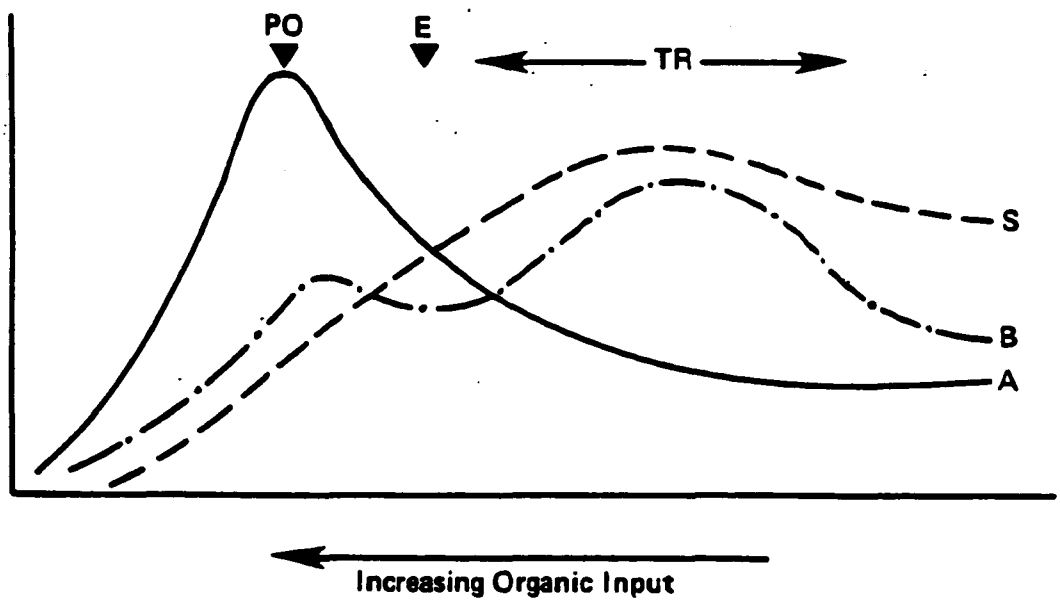
Three approaches have been used in the 301(h) program to determine whether a specified degree of change in the biota (and associated receiving environment) should be considered to be in compliance with 301(h) criteria. The first is to determine whether the observed change represents a reduction in the areal extent or health of a community or ecosystem. This approach has most often been used in cases where the major taxa that characterize the community greatly modify the environment, thereby creating habitat for other species. Primary examples include distinctive habitats of limited distribution such as kelp communities, coral reefs, and seagrass beds. Because most of the taxa in these communities are highly dependent on the major taxa that characterize the community (and create habitat niches), the loss of those major taxa due to pollutant impacts results in destruction of the community. Unlike some other communities (such as benthic infauna), one assemblage of organisms is not replaced by another in which the species belong to the same, or similar, major taxonomic groups, and in which the new taxa are able to tolerate, and in many cases thrive, in the modified environment. Clearly, in cases where a community or ecosystem is highly dependent on a limited number of major taxa to provide habitat for a wide variety of dependent species, any loss or decline in the health of those major taxa is an adverse impact, and is therefore not in compliance with 301(h) criteria.

In communities where pollutant impacts result in changes in species composition and abundance, but not in the destruction of the habitat, it is more difficult to determine whether such changes constitute noncompliance with Section 301(h) criteria. However, two approaches to the problem have been used in the 301(h) program. The first is based on the assumption that a major change in the function (i.e., trophic relationships) of a community (e.g., benthic infauna, demersal fishes) constitutes noncompliance with

Section 301(h) criteria because it affects, or has the potential to affect, all of the major elements of the ecosystem. The second approach is a corollary of the first. It assumes that a major change in the structure (i.e., species composition and abundance) of a community constitutes noncompliance with Section 301(h) criteria because a change in the function of that community has occurred, regardless of whether a change in function can be demonstrated. Because a change in the structure of a community is usually much easier to document than is a change in the function of a community, the second approach has been used most commonly in the 301(h) program.

Benthic infauna are used in the following example to demonstrate how the functional and structural approaches may be implemented. The generalized model developed by Pearson and Rosenberg (1978) for changes in benthic communities along a gradient of organic enrichment (Figure 3) has been used extensively in the 301(h) program, and has been successfully applied to a variety of soft-bottom benthic communities in temperate and tropical latitudes. At low to moderate levels of organic enrichment (i.e., the "transition zone" in Figure 3), biomass increases moderately and numbers of species increase slightly. Abundances do not increase greatly until the "ecotone point" is approached. In the "transition zone," there is simply an enhancement of the community that is typical of the biogeographic region, with the addition of a few new species. There are no major functional or structural changes. Providing that there are no major problems with other aspects of the benthic infauna (e.g., bioaccumulation of toxic substances), the impact to benthic infauna may not be considered to be out of compliance with Section 301(h) criteria.

At and beyond the "peak of opportunists" as shown in Figure 3, Pearson and Rosenberg (1978) document that species composition and abundance of the benthic infauna change substantially. The fauna becomes dominated by a few opportunistic or pollution-tolerant species whose abundances increase dramatically in response to increased organic loading. Most of these species are surface or subsurface deposit feeders. Suspension feeders and surface detrital feeders typically decrease in abundance, or are eliminated.



S = Species numbers
A = Total abundance
B = Total biomass
PO = Peak of opportunists
E = Ecotone point
TR = Transition zone

Reference: Figure 2 of Pearson and Rosenberg (1978).

Figure 3. Generalized depiction of changes in species numbers, total abundances, and total biomass along a gradient of organic enrichment.

Hence, the structure (i.e., species composition and abundance) and function (i.e., trophic relationships) of the benthic infauna are altered substantially.

In most cases, information is not available to demonstrate that major changes in the structure and function of a particular benthic community affect other biological communities (e.g., demersal fishes). However, many cases of prey specificity by demersal fishes and large epibenthic invertebrates that prey on benthic infauna have been recorded in the scientific literature. Hence, there is a sound scientific basis for assuming that major changes in the structure and function of benthic communities as a result of organic enrichment can induce changes in the species composition and abundance of predators on infauna, most of which are demersal fishes and large epibenthic invertebrates. Therefore, major changes in the structure and function of the benthic infaunal community have often been considered to constitute noncompliance with Section 301(h) criteria.

Decisions regarding adverse impacts should be based on the results of the biological demonstrations required of the applicant in the various parts of the Application Questionnaire. Those biological demonstrations should include monitoring data collected over the term of the existing modified permit. The Regions are referred to discussions under relevant questions in the questionnaire (above) for guidance on data analysis and interpretation.

If a Region decides that an existing discharge may be causing an adverse impact to the biota, or that the proposed discharge will likely cause an adverse impact to the biota, the Region should require that applicant to perform detailed biological demonstrations to support the application. Such demonstrations would most likely be required in cases where possible adverse impacts would result in noncompliance with Section 301(h) criteria, such as adverse impacts to distinctive habitats of limited distribution, discharges into estuarine waters, and discharges into stressed waters. It is important that the Region work closely with the applicant over the term of the existing permit, so that possible adverse impacts or conditions that would result in noncompliance with Section 301(h) criteria

are identified well in advance of the application deadline. Early notification of potential adverse impacts will ensure that the applicant has sufficient time to design and execute appropriate studies. The Region should also work closely with the applicant during all phases of survey design and execution to ensure the collection of adequate, high quality data.

EVALUATIONS OF PREDICTED CONDITIONS AND PREDICTED CONTINUED COMPLIANCE

POTWs were allowed to apply for first-time Section 301(h) modified permits based on current, improved, or altered discharges. A current discharge is defined in Part 125 Subpart G as the volume, composition, and location of an applicant's discharge at the time of permit application. An improved discharge may include planned improvements in the outfall, the level of treatment, discharge characteristics, operation and maintenance, or controls on the introduction of pollutants into the treatment system. An altered discharge is defined as any discharge other than a current discharge or an improved discharge as defined in Part 125.58.

For improved and altered discharges, applicants were required to predict conditions that would occur in the receiving environment following implementation of the proposed improvements or alterations. Section 301(h) modified permits were issued upon a satisfactory demonstration that the predicted conditions were reasonable and would satisfy Section 301(h) criteria and regulations. For dischargers whose original Section 301(h) modified permit was issued based in part on predictions of conditions that would occur after proposed improvements or alterations were implemented, it is necessary to evaluate whether the predicted conditions have been realized. Because the Regions should receive monitoring data collected during the term of the existing permit in support of the application for permit reissuance, evaluations of the applicant's original predictions of compliance are not unlike other determinations of compliance. Therefore, the Regions should conduct those evaluations as discussed above in the two previous sections of this chapter, entitled "Determinations of Compliance with Section 301(h) Modified Permit Conditions" and "Determinations of Compliance with 301(h) Criteria."

As was permitted for original Section 301(h) applications, applications for reissuance of Section 301(h) modified permits may propose improved levels of sewage treatment, either in response to comments by the U.S. EPA, or at the permittee's initiative. Applications for permit reissuance that are based on altered discharges are also permitted when downgrading of effluent quality is attributable entirely to population growth and/or industrial growth within the service area. Proposals for improved and altered discharges mandate that the permittee predict the physical, chemical, and biological conditions that will occur in the receiving environment. In such cases [as in the original Section 301(h) applications], it will be necessary for the Regions to evaluate whether the permittee's predictions are reasonable, and whether the predicted conditions would satisfy Section 301(h) criteria and regulations.

Evaluations of applicant's predictions should include the following assessments:

- Appropriateness of the models used to generate the predictions
- Data quality
- Execution of the analyses
- Interprctation of the analytical results.

It is essential that the applicant conduct each of these steps in the predictive process properly. Otherwise, the validity of the results and compliance with applicable regulations and criteria will be suspect.

To predict conditions that will occur as a result of a proposed discharge, applicants may compare attributes of the proposed discharge (e.g., volume and composition) and receiving environment with conditions near other outfalls that discharge effluent of similar volume and composition and in similar receiving environments. The validity of such comparisons rests on

the similarity of the discharges and the similarity of the receiving environments. Substantial differences in the volumes of the two discharges or the mass emission rates of pollutants from the two discharges would render such comparisons questionable, especially for biological variables. For physical and chemical variables, it might be possible to compensate mathematically for such differences. However, biological responses to pollutants cannot be assumed to be linear. Therefore, the validity of predictions involving comparisons between substantially different discharges is very tenuous unless the response patterns of the biota within the biogeographic region are well known.

Similarity of the receiving environments is also critical to such comparisons. It is important that both discharges be located within the same biogeographic zone because responses to pollutants vary among species. Species in one biogeographic zone may respond somewhat differently to a given pollutant than do species in another biogeographic zone. For that reason, it may be possible to predict the general types of changes that may occur as a result of the proposed discharge, but it will not generally be possible to predict the areal extent or magnitude of such changes. It is also important that the physical and chemical characteristics of both receiving environments be similar. For example, discharges into open coastal areas should not be compared with discharges in embayments. The more similar the two receiving environments are to each other, the more reliable the applicant's predictions may be assumed to be.

Applicants may also use models that describe cause-and-effect relationships to predict impacts of the proposed discharge. Such models would be especially helpful for physical and chemical variables (e.g., deposition of suspended solids in the receiving environment, concentrations of toxic substances at the ZID boundary). The appropriateness of such models should be judged on their prior use in the 301(h) program, their acceptance or recommendation by the U.S. EPA, and their acceptance by the scientific community. Models that have not been evaluated previously or that have not been received favorably should be avoided.

Having determined that the applicant used appropriate models to predict conditions in the receiving environment and biota, the Region should address the issues of data quality, execution of analyses, and interpretation of analytical results. These issues should be addressed in a manner similar to that described above for determining compliance with Section 301(h) modified permit conditions.

REISSUANCE OR TERMINATION OF SECTION 301(h) MODIFIED PERMITS

As stated in Subpart 125.59(c)(4), Section 301(h) modified permits "may be renewed under the applicable procedures of 40 CFR Part 124." Relevant subparts are Parts 124 Subparts A (General Program Requirements) and D (Specific Procedures Applicable to NPDES Permits). These subparts provide an outline of the mechanics of the permit decision-making process, including review of applications for completeness, conditions for permit reissuance and termination, and special procedures applicable to Section 301(h) modified permits. Important sections of these subparts are discussed briefly below.

In addition, Part 124 provides procedures for public notification, public hearings, issuance of draft permits, and keeping of the administrative record (Subparts A and D); procedures governing evidentiary hearings for U.S. EPA-issued NPDES permits (Subpart E); and procedures governing non-adversary panel hearings (Subpart F). These procedures are not discussed below as they are beyond the scope of this document.

PROCEDURES FOR REGULATORY ACTION

Part 124 contains U.S. EPA procedures for issuing, modifying, revoking and reissuing, and terminating all NPDES permits. Other types of permits are also included. Regulatory terms used in Part 124 are defined in Part 124.2. All definitions in this subsection remain applicable to applicants for reissuance of Section 301(h) modified permits.

Subpart D of Part 124 establishes decision-making procedures that are specific to NPDES permits. All tentative decision documents for 301(h) permit renewals must be signed by the appropriate Administrator. A tentative decision document may go to the checklist procedure recommended for

original 301(h) decisions, or may simply be represented by a cover sheet referencing the fact sheet and draft permit.

Special procedures relevant to applications for Section 301(h) modified permits are set forth in Part 124.68. These procedures were also applicable to original Section 301(h) applications, and remain applicable to applications for reissuance of Section 301(h) modified permits. When an applicant fails to meet Section 301(h) requirements, the Region must deny the request. Information collected during monitoring studies and other studies conducted during the term of the existing Section 301(h) modified permit will be critical to this determination. According to Subpart 125.59(e)(iii)(B), 125.61(b)(2), and 125.64(b), the U.S. EPA may not issue a Section 301(h) modified permit unless the state has concurred or waived concurrence. It also specifies actions that may be taken by the State Director in states with approved NPDES permit programs (discussed earlier).

REGULATORY OPTIONS

Depending on the Region's decision regarding reissuance of a Section 301(h) modified permit, the applicant's permit may be reissued with changes, reissued without changes, or terminated. Administrative procedures that should be followed by the Regions when permits are reissued or terminated are set forth in Part 124.5, and are not discussed herein. However, the conditions under which each of these two regulatory options apply are relevant to the decision-making process. These conditions, set forth in Part 122.62-122.64, are discussed below.

Section 301(h) modified permits may be terminated during the term of the permit, or may be denied during the permit reissuance process for the following reasons, which are set forth in Part 122.64:

- Noncompliance with the conditions of the modified permit
- Failure to provide all relevant information or misrepresentation of relevant information

- A determination that the modified discharge endangers human health or the environment, and that such adverse impacts can be reduced to acceptable levels through permit modification or termination

- Any condition that results in a temporary or permanent cessation of the discharge, such as the consolidation of two POTWs that results in elimination of the permittee's discharge.

All terminations of permits must be made in accordance with procedures specified in Part 124.

When it is evident for reasons specified in Part 122.64 that termination of a Section 301(h) modified permit is warranted, the Regions may terminate the permit under applicable procedures of Part 124. Section 301(h) modified permits may be reissued under the provisions of Subpart 122.62(b). Because no specific guidance is given as to which of these two regulatory options is appropriate under different conditions, the Regions have considerable discretionary authority over the reissuance or termination of a Section 301(h) modified permit that has not been in compliance with all of the 301(h) regulations. In cases where it does not appear that the applicant will be able to satisfy the conditions of the 301(h) regulations while holding a Section 301(h) modified permit, the modified permit should be terminated or allowed to expire without reissuance. However, in cases where conditions of the permit may be adjusted to achieve compliance with the 301(h) regulations, the Region may modify the permit with different permit specifications, as necessary. Effective adjustments of the permit conditions will require careful examination of all available data and accurate predictions of the conditions that will result as a consequence of those adjustments.

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APPENDIX A
PHYSICAL ASSESSMENT

APPENDIX A
PHYSICAL ASSESSMENT

The primary focus of this appendix is to provide guidance on the calculation of initial dilution and trapping depth. For the purpose of Section 301(h) evaluations, "dilution" is defined as the ratio of the total volume of a sample (ambient water plus wastewater) to the volume of wastewater in that sample. A dilution of 100 to 1, therefore, is a mixture composed of 99 parts of ambient water and 1 part of wastewater. The calculation of initial dilution and trapping depth consists of two set of procedures:

- Calculate the port flow distribution along the outfall diffuser(s) for the total effluent flow rates of importance

- Compute initial dilution and trapping depth based on a characterization of the computed port flow distribution, the physical characteristics of the outfall diffuser, and receiving water density and current velocity profiles.

An important variable in both sets of procedures is the total effluent flow rate. Historical data should be used to determine the minimum, average, highest 2- to 3-h average, and maximum flow rates for dry-weather, wet-weather, and annual average conditions. The adequacy of the diffuser's hydraulic design is dependent on the port flow distribution of the diffuser during minimum and maximum flow. Characteristics of a hydraulically well-designed diffuser are described by Grace (1978). According to the Section 301(h) regulations, the critical (i.e., minimum) initial dilutions must be calculated on the basis of the highest 2- to 3-h average flow rates. Average flow rates, together with average receiving water current speeds, are commonly used to compute the trapping depth used in effluent suspended solids accumulation predictions.

Port flow distribution along an outfall diffuser is commonly calculated using computer programs based on well-known hydraulic methods (Grace 1978; Fischer et al. 1979). This distribution depends on the total effluent flow rate, the effluent density, the density of seawater at the average diffuser port depth, and the physical specifications of the diffuser. The physical specifications include diffuser pipe diameter, depth, and port diameter and type (i.e., bell-mouth or sharp-edged) for each port in the diffuser. In the event that the risers are used instead of ports, then specifications sufficient to compute the discharge coefficient of the risers must be known. These specifications include the diameter, length, shape, type of transition between the riser pipe and the diffuser pipe, number of ports, and shape and diameter of the ports for each riser. The report of Koh (1973) contains a useful method for computing riser discharge coefficients. (The summary of this method in Fischer et al. (1979) contains errors.) Head loss determinations for contractions, expansions, and bends can be found in standard engineering and hydraulics texts (Brater and King 1976; Daugherty and Franzini 1977).

The port flow distribution should be computed for the minimum and maximum flows to ensure that the diffuser is hydraulically well-designed (Grace 1978). For any diffuser, there is a minimum flow below which the diffuser is inoperable. For lower flows than the minimum, not all of the ports flow full and the port flows from the diffuser can behave erratically (Grace 1978). On a sloping bottom, the minimum operational flow usually increases with increasing bottom slope. Port flows along the diffuser may be very uneven on a sloping bottom, even for flows above the minimum operational flow. The hydraulic behavior of the diffuser should also be checked to investigate whether or not the port flows vary greatly at maximum flows.

Initial dilution computations are usually not performed for each port individually, but rather on groups of ports within which the port flows are relatively uniform. The initial dilution and trapping depth for each group of ports are then computed based on the average port flow and port depth

within the group. The group initial dilutions and trapping depths can then be group flow-rate averaged to obtain estimates of the average initial dilution and trapping depth for the diffuser for a specific total effluent flow rate and set of receiving water conditions. A common choice for a group is a diffuser pipe section, within which the diffuser pipe diameter and the diffuser port (riser) specifications are constant.

Initial dilution is the flux-averaged dilution achieved during the period when dilution is primarily a result of plume entrainment. It is averaged over the cross-sectional area of the plume, and characterized by a time scale on the order of minutes. With proper location and design, marine outfalls can achieve initial dilution values of about 100 to 1 or better before the plume begins a transition from essentially vertical flow to an essentially horizontal flow dominated by ambient oceanographic conditions.

Adequate initial dilution is necessary to assure compliance with water quality standards. The following factors influence the degree of initial dilution that will be achieved:

- Discharge depth
- Flow rates
- Density of effluent
- Density gradients in the receiving water
- Ambient current speed and direction
- Diffuser characteristics
  - Port sizes
  - Port spacing

- Port orientation

- Port depth.

Because initial dilution calculations can be strongly dependent on the vertical gradient of ambient density, larger applicants should evaluate a substantial amount of data from both the discharge site and nearby areas that have similar environmental conditions before selecting a worst-case density profile (i.e., the profile producing the lowest initial dilution). Often the worst-case profiles are not the most stratified, but rather are those having sufficiently steep density gradients some distance [on the order of 5 m (16 ft)] above a diffuser port. These profiles can usually be identified only by computing initial dilutions for several or all of the available density profiles. Because ambient currents may affect the initial dilution achieved, a modest amount of current (the lowest 10 percentile) can be used when predicting initial dilution for use in determining compliance with applicable water quality standards and criteria.

Five numerical mathematical models to calculate initial dilution (Muellenhoff et al. 1985a, 1985b) are available from U.S. EPA. Characteristics of these models are summarized below and in Table A-1:

- UPLUME - Analyzes a single, positively buoyant plume in an arbitrarily stratified stagnant environment.

- UOUTPLM - Analyzes a single, positively buoyant plume in an arbitrarily stratified flowing environment.

- UDKHDEN - Analyzes a multiport, positively buoyant plume in a linearly stratified flowing receiving water.

TABLE A-1. SUMMARY OF PLUME MODEL CHARACTERISTICS[a]

Model Name	Current Speed	Current Direction θ[b]	Port Type	Density Profile Type
UPLUME	No		Single	Arbitrary
UOUTPLM	Yes	90^0	Single	Arbitrary
UDKHPLM	Yes	$45^0 < \theta < 135^0$	Multiple	Arbitrary
UMERGE	Yes	90^0	Multiple	Arbitrary
ULINE	Yes	$0 \leq \theta \leq 180^0$	Line	Arbitrary

[a] From Table 1 of Muellenhoff et al. (1985a).

[b] A current flowing perpendicular to the diffuser axis has current direction $\theta = 90^0$. The widest range of possible angles is 0 to 180^0.

- UMERGE - Analyzes either positively or negatively buoyant discharges. Analyzes a plume element through the history of its trajectory and dilution, accounting for the effects of adjacent plume interference in a receiving water with arbitrary vertical density and current variation.

- ULINE - Treats discharges as a line source accounting for adjacent plume interference. Can analyze positively buoyant discharges in an arbitrarily stratified receiving water with a current flowing parallel or perpendicular to the diffuser.

In situ observation may also be used to determine initial dilution. However, if *in situ* observations are used, the applicant should demonstrate that they represent the lowest dilutions in center sections of the effluent wastefield, not merely a typical dilution.

Other mathematical methods available in the published literature can be adapted for estimating initial dilution. The following references describe several of these methods: Abraham (1963, 1971); Baumgartner and Trent (1970); Baumgartner et al. (1971); Briggs (1969); Brocard (1985); Brooks (1973); Cederwall (1971); Davis (1975); Davis and Shirazi (1978); Fan (1967); Hinwood and Wallis (1985); Hirst (1971a,b); Isaacson et al. (1983); Kannberg and Davis (1976); Koh and Fan (1970); Lee and Cheung (1986); Morton (1959); Morton et al. (1956); Priestley and Ball (1955); Roberts (1979); Roberts et al. (1989a,b,c); Rouse et al. (1952); Sotil (1971); Teeter and Baumgartner (1979); Wallace and Sheff (1987); Winiarski and Frick (1976); and Wright (1982). Only flux-averaged initial dilutions should be used in water quality computations. Other types of initial dilutions, such as centerline and minimum surface, must be converted to flux-averaged. Many of the above investigations provide ways to estimate flux-averaged initial dilutions (see Fischer et al. 1979 for additional guidance).

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APPENDIX B

WATER QUALITY ASSESSMENT

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INTRODUCTION

This appendix provides detailed guidance for responding to water quality-related questions in the Application Questionnaire. Methods for predicting values of the following water quality variables are presented:

- Suspended solids deposition
- Dissolved oxygen concentration following initial dilution
- Farfield dissolved oxygen depression
- Sediment oxygen demand
- Suspended solids concentration following initial dilution
- Effluent pH after initial dilution
- Light transmittance
- Other water quality variables.

B-I. SUSPENDED SOLIDS DEPOSITION

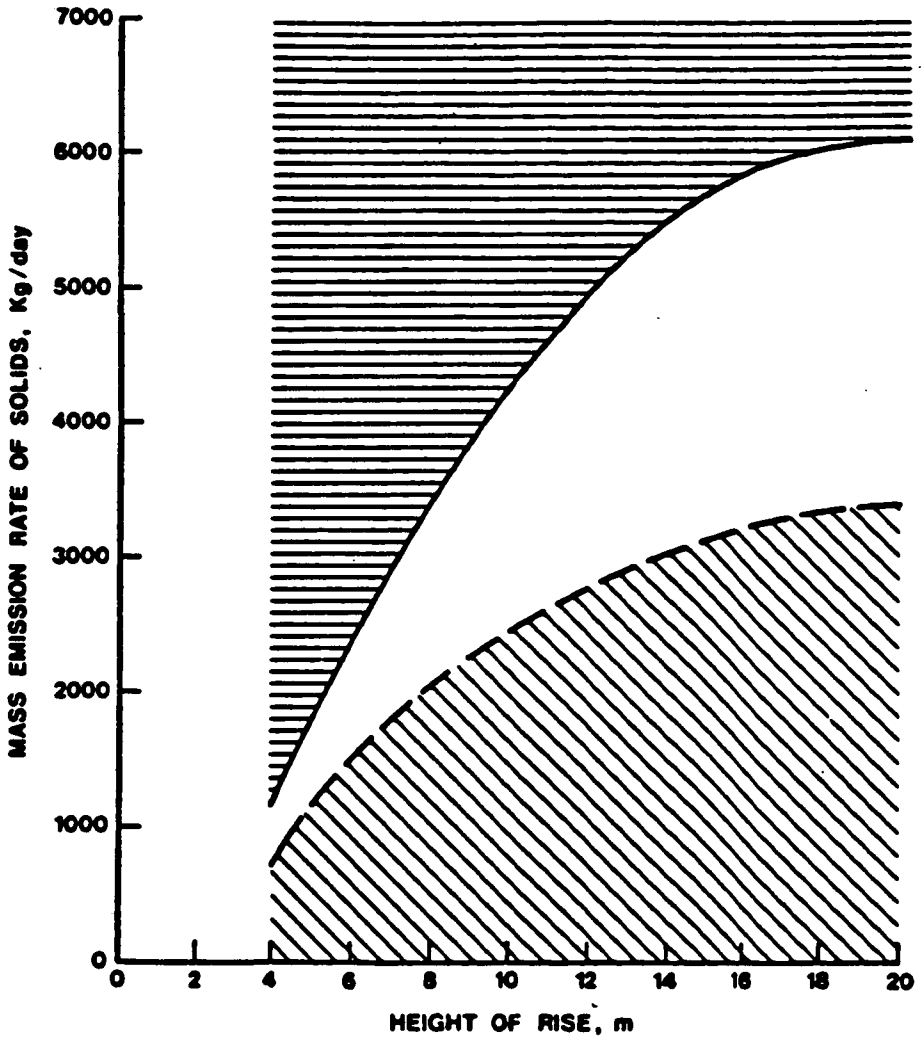
The applicant must predict the seabed accumulation due to the discharge of suspended solids into the receiving water. Two prediction methods are described in this appendix. The first is a simplified approach for small dischargers only. If this method is applicable, then a small discharger need not perform dissolved oxygen calculations dependent on settled effluent suspended solids accumulations. The second prediction method is applicable for both small and large dischargers.

SMALL DISCHARGER APPROACH

Two types of problems (dissolved oxygen depletion and biological effects) and two types of receiving water environments (open coastal and semi-enclosed bays or estuaries) are considered in the following approach.

Figure B-1 is to be used for open coastal areas that are generally considered well flushed. The dashed line represents combinations of solids mass emission rates and plume heights-of-rise that would result in a steady-state sediment accumulation of 50 g/m^2. Review of data from several open coast discharges has indicated that biological effects are minimal when accumulation rates were estimated to be below this level. Consequently, if the applicant's mass emission rate and height-of-rise fall below this dashed line no further sediment accumulation analyses are needed. Applicants whose charge characteristics fall above the line should conduct a more detailed analysis of sediment accumulation discussed in the following section.

The solid line in Figure B-1 represents a combination of mass emission rates and plume heights-of-rise that were projected to result in sufficient sediment accumulation to cause a 0.2 mg/L oxygen depression. Applicants whose discharge falls below this solid line need not provide any further analysis of sediment accumulation as it relates to dissolved oxygen.



Reference: Tetra Tech (1982).

Figure B-1. Projected relationships between suspended solid mass emission, plume height-of-rise, sediment accumulation, and dissolved oxygen depression for open coastal areas.

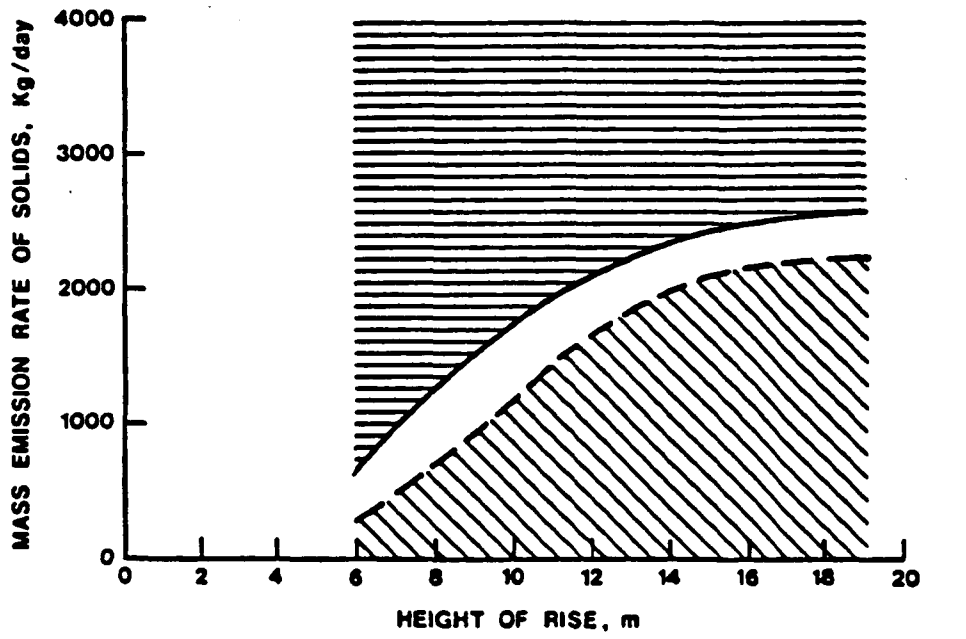
Figure B-2 should be used in a similar manner for discharges to semi-enclosed embayments or estuaries. Because estuaries and semi-enclosed embayments are potentially more sensitive than open coastal areas, the critical sediment accumulation was set at 25 g/m^2.

Methods described in Tetra Tech (1982) were used to determine the mass emission rates and heights-of-rise resulting in the sediment accumulation rates specified above. In order to use these methods, several assumptions were made. A current velocity of 5 cm/sec was assumed for the open coastal sites and a velocity of 2.5 cm/sec was assumed for the semi-enclosed embayments. These velocities are conservative estimates of average current velocities over a 1-yr period. The settling velocity (V_S) distribution used is considered typical of primary or advanced primary effluents and is shown below:

5 percent have $V_S \geq 0.1$ cm/sec
20 percent have $V_S \geq 0.01$ cm/sec
30 percent have $V_S \geq 0.006$ cm/sec
50 percent have $V_S \geq 0.001$ cm/sec

The remaining solids settle so slowly that they are assumed to remain suspended in the water column indefinitely. The effluent is considered to be 80 percent organic and 20 percent inorganic. The above distribution is based on the review of data in Section 301(h) applications and other published data (Myers 1974; Herring and Abati 1978).

The annual suspended solids mass emission rate should be calculated using the average flow rate and an average suspended solids concentration. The plume height-of-rise, determined previously in the initial dilution calculation, or 0.6 times the water depth, whichever is larger, should be used to enter the appropriate figure (Figure B-1 or B-2).



STEADY STATE SEDIMENT ACCUMULATION LESS THAN 25g/m^2

DO DEPRESSION DUE TO STEADY-STATE SEDIMENT DEMAND > 0.2 mg/l

Reference: Tetra Tech (1982).

Figure B-2. Projected relationships between solid mass emission, plume height-of-rise, sediment accumulation, and dissolved oxygen depression for semi-enclosed embayments and estuaries.

LARGE DISCHARGER APPROACH

The approach described here considers the processes of sediment deposition, decay of organic materials, and resuspension. However, the strictly quantitative prediction of seabed accumulation is based only on the processes of deposition and decay. Because resuspension is not evaluated easily using simplified approaches, the analyses described in this chapter consider resuspension separately and in a more qualitative manner that is based on measured near-bottom current speeds in the vicinity of the diffuser.

Data Requirements

To predict seabed deposition rates of suspended solids, the following information is required:

- Suspended solids mass emission rate
- Current speed and direction
- Height-of-rise of the plume
- Suspended solids settling velocity distribution.

The mass emission rate, M (kg/day), is:

$$M = 86.4(S)(Q) \qquad \text{B-1}$$

where:

S = Suspended solids concentration, mg/L

Q = Volumetric flow rate, m^3/sec.

It is suggested that the applicant develop estimates of the suspended solids mass emission rate for the season (90-day period) critical for seabed

deposition and for a yearly period. If the applicant anticipates the mass emission rate will increase during the permit term, the mass emission rate at the end of the permit term should be used.

Current-speed data are needed to determine the distance from the outfall that the sediments will travel before accumulating on the bottom. Consequently, depth-averaged values are best, if available. Otherwise, current speeds near mid-depth may be sufficient. The following current data are needed for the assessment:

- Average value upcoast, when the current is upcoast
- Average value downcoast, when the current is downcoast
- Average value onshore, when the current is onshore
- Average value offshore, when the current is offshore.

If no current data are available, values of 5 cm/sec for longshore transport and 3 cm/sec for onshore-offshore transport have been found to be reasonable values.

Plume trapping levels representative of the critical 90-day period and of the annual cycle are needed. The applicant should use density profiles, effluent volumetric flow rates, and ambient currents characteristic of these time periods. Extreme values should not be used. Usually the annual average and critical 90-day average flow rates and current speeds (in the predominant current direction) should be used. The expected average plume heights-of-rise above the seafloor should be determined using available receiving water density profiles. If large numbers of profiles exist for each month (or oceanographic season), then the applicant could compute the plume height-of-rise above the seafloor for each of the available profiles, and then average the heights. If relatively few profiles are available for each month, then the applicant could compute the plume height of risk for each profile and use the lowest height-of-rise as the average. The monthly

average heights of rise can then be used to compute the average height-of-rise for annual and critical 90-day periods. If so few profiles exist that it is not possible to determine whether differences exist between months (or oceanographic seasons), then the applicant should use the lowest plume height-of-rise (based on calculations using the average effluent flow and current speed) as the average height-of-rise for both the annual and critical 90-day periods.

If the applicant has not determined a suspended solids settling velocity distribution, the following can be used based on data from other Section 301(h) applications:

Primary or Advanced Primary Effluent	Raw Sewage
5 percent have $V_s \geq 0.1$ cm/sec	5 percent have $V_s \geq 1.0$ cm/sec
20 percent have $V_s \geq 0.01$ cm/sec	20 percent have $V_s \geq 0.5$ cm/sec
30 percent have $V_s \geq 0.006$ cm/sec	40 percent have $V_s \geq 0.1$ cm/sec
50 percent have $V_s \geq 0.001$ cm/sec	60 percent have $V_s \geq 0.01$ cm/sec
	85 percent have $V_s \geq 0.001$ cm/sec.

The remaining solids settle so slowly that they are assumed to remain suspended in the water column indefinitely (i.e., they act as colloids). Consequently, 50 percent of the suspended solids in a treated effluent and 85 percent of those in a raw sewage discharge are assumed to be settleable in the ambient environment.

Prediction of Deposition

Although a portion of the settled solids is inert, primary concern is with the organic fraction of the settled solids. For purposes of this evaluation, composition of the waste discharge can be assumed to be as follows:

- 80 percent organic and 20 percent inorganic, for primary or advanced primary effluent

- 50 percent organic and 50 percent inorganic, for raw sewage.

Accumulation should be predicted for the critical 90-day period when seabed deposition is likely to be highest and for steady-state conditions where average annual values are used. The results should be presented in graphical form, as shown in Figure B-3. Supporting tables should be submitted with the application. The applicant must exercise judgment when developing the contours, especially when accounting for rapid depth changes offshore. Sediment contours should be expressed in units of g/m^2, not as an accumulation depth.

An applicant may use a proprietary or publicly available sedimentation model. Two widely known models are those of Hendricks (1987), which has been used extensively offshore of Palos Verdes Peninsula in the Southern California Bight, and Farley (Tetra Tech 1987), which describes the Ocean Data Evaluation System (ODES) model DECAL. The model DECAL is publicly available through the U.S. EPA. A simple model is described herein. It can be used to obtain acceptable estimates of sediment accumulation in a variety of environments. If its use results in sediment accumulations that lead to violations of state standards or federal criteria for receiving water quality, an applicant may use a more sophisticated effluent sediment accumulation model that better simulates the marine environment.

The method described below assumes that effluent sediment particles having a specific particle fall velocity settle uniformly within an elliptical area. This area depends on the plume height-of-rise relative to the seafloor (not the port depth), the particle fall velocity, and the average currents speeds in four directions (upcoast, downcoast, onshore, and offshore) appropriate for an effluent wastefield at the plume height-of-rise. For the following sample calculations, the diffuser was assumed to be a point source. Use of this assumption may not produce reasonable estimates of sediment accumulation if the diffuser is long. If the diffuser is long,

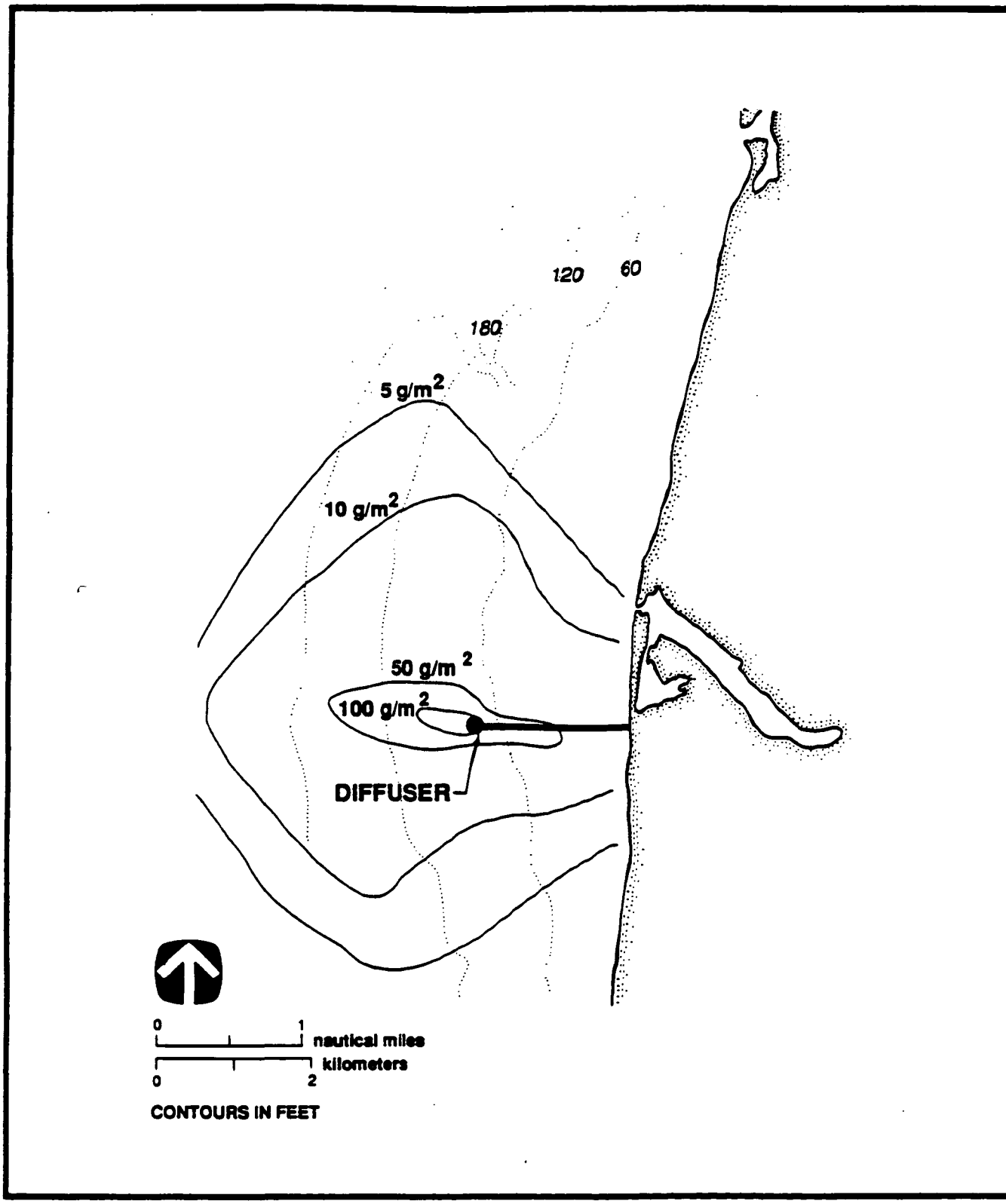


Figure B-3. Examples of predicted steady-state sediment accumulation around a marine outfall.

then estimates of the sediment accumulation from each diffuser port can be summed to obtain an estimate for the entire diffuser. This sum is approximately the same as that obtained from assuming that the sediment accumulation area is a ZID-like area (with ends the same as the similar elliptical halves computed for a single point discharge) and that the effluent suspended solids having the specific particle fall velocity uniformly settle in this area. The sediment accumulation due to the entire discharge is the sum of the accumulations for each particle fall velocity modeled.

To begin computations for a discharge at a point location, the applicant can create a table similar to Table B-1, showing the amount of organic solids that settle within each settling velocity group, and the maximum distance from the outfall at which each group settles. If the applicant has current data for more than four quadrants, those data can be used. The maximum settling distances for each group in each direction are calculated using the formula shown in the footnote of Table B-1.

With a sufficiently detailed map (e.g., a NOAA bathymetric chart), each point D_1 through D_{16}, or R_1 through R_{20}, can be plotted with the center of the diffuser as the reference point. Depositional contours are formed by the four points that define the perimeter of a depositional field (e.g., $D_1D_2D_3D_4$). The applicant should join these points by smooth lines, so that the contours are elliptically shaped. If the applicant has current data at 60^0 or 30^0 intervals, instead of the 90^0 intervals used here, then the contours could be created more accurately.

The deposition rates corresponding to each contour are determined as follows. First, predict the deposition rate within each contour due to each individual settling velocity group, as shown in Table B-2. This quantity is M_i/A_i, or the group deposition rate divided by the area within the contour. The area within any contour is a function of the four points (e.g., D_1, D_2, D_3, and D_4), and is denoted in the table by $f(D_1D_2D_3D_4)$. A planimeter is probably the most accurate method of finding the area. Once the deposition rates by group have been found, then the total deposition rate can be calculated by summing all contributing deposition rates. For

TABLE B-1. EXAMPLE TABULATIONS OF SETTLEABLE ORGANIC COMPONENT BY GROUP, AND MAXIMUM SETTLING DISTANCE BY GROUP

Mass Emission Rate = M_T

Organic Component = Mo = { 0.8 M_T, for primary effluent; 0.5 M_T, for raw effluent

Percent by Settling Velocity Group	Organic Component by Group	Maximum Settling Distance from Outfall[a]			
		Upcoast	Downcoast	Onshore	Offshore
Primary Effluent					
5 (V_s = 0.1 cm/sec)	0.04 M_T	D_1	D_2	D_3	D_4
15 (V_s = 0.01 cm/sec)	0.12 M_T	D_5	D_6	D_7	D_8
10 (V_s = 0.006 cm/sec)	0.08 M_T	D_9	D_{10}	D_{11}	D_{12}
20 (V_s = 0.001 cm/sec)	0.16 M_T	D_{13}	D_{14}	D_{15}	D_{16}
	Sum = 0.40 M_T				
Raw Sewage					
10 (V_s = 1.0 cm/sec)	0.05 M_T	R_1	R_2	R_3	R_4
10 (V_s = 0.5 cm/sec)	0.05 M_T	R_5	R_6	R_7	R_8
20 (V_s = 0.1 cm/sec)	0.10 M_T	R_9	R_{10}	R_{11}	R_{12}
20 (V_s = 0.01 cm/sec)	0.10 M_T	R_{13}	R_{14}	R_{15}	R_{16}
25 (V_s = 0.001 cm/sec)	0.125 M_T	R_{17}	R_{18}	R_{19}	R_{20}
	Sum = 0.425 M_T				

[a] The distance D (or R) is calculated as: $D \text{ (or } R) = \frac{V_a H_T}{V_s}$

where:

V_a = Ambient velocity = 5 cm/sec upcoast and downcoast (default) and 3 cm/sec onshore and offshore (default)

H_T = Average trapping level of plume, measured above bottom

V_s = Appropriate settling velocity by group for primary or raw discharges

If the bottom slope is 5 percent or greater, D should be calculated as follows:

$$D = \frac{H_T}{S + \frac{V_s}{V_a}}$$

where:

S = Slope, m/m, positive if onshore, negative if offshore.

TABLE B-2. EXAMPLE TABULATIONS OF DEPOSITION RATES AND ACCUMULATION RATES BY CONTOUR

Organic Mass Component by Group	Bottom Area	Mass Deposition Rate, by Group	Total Organic Deposition Rate within Area ($g/m^2/yr$)	Accumulation (g/m^2) Steady-State	Accumulation (g/m^2) 90 Day
Primary Effluent					
$0.04\ M_T = M_1$	$A_1 = f(D_1D_2D_3D_4)$	M_1/A_1	$M_1/A_1+M_2/A_2+M_3/A_3+M_4/A_4 = f_1$		
$0.12\ M_T = M_2$	$A_2 = f(D_5D_6D_7D_8)$	M_2/A_2	$M_2/A_2+M_3/A_3+M_4/A_4 = f_2$	$\frac{f_i}{k_d}$	$\frac{f_i}{k_d}\ [1-\exp(-90k_d)]$
$0.08\ M_T = M_3$	$A_3 = f(D_9D_{10}D_{11}D_{12})$	M_3/A_3	$M_3/A_3+M_4/A_4 = f_3$		
$0.16\ M_T = M_4$	$A_4 = f(D_{13}D_{14}D_{15}D_{16})$	M_4/A_4	$M_4/A_4 = f_4$		
Raw Sewage					
$0.05\ M_T = M_1$	$A_1 = f(R_1R_2R_3R_4)$	M_1/A_1	$M_1/A_1+M_2/A_2+M_3/A_3+M_4/A_4+M_5/A_5 = f_1$		
$0.05\ M_T = M_2$	$A_2 = f(R_5R_6R_7R_8)$	M_2/A_2	$M_2/A_2+M_3/A_3+M_4/A_4+M_5/A_5 = f_2$	$\frac{f_i}{k_d}$	$\frac{f_i}{k_d}\ [1-\exp(-90k_d)]$
$0.10\ M_T = M_3$	$A_3 = f(R_9R_{10}R_{11}R_{12})$	M_3/A_3	$M_3/A_3+M_4/A_4+M_5/A_5 = f_3$		
$0.10\ M_T = M_4$	$A_4 = f(R_{13}R_{14}R_{15}R_{16})$	M_4/A_4	$M_4/A_4+M_5/A_5 = f_4$		
$0.125\ M_T = M_5$	$A_5 = f(R_{17}R_{18}R_{19}R_{20})$	M_5/A_5	$M_5/A_5 = f_5$		

Note: Units of f_i are $g/m^2/day$.

example, the innermost contour receives contributions from all groups, while the outermost contour receives a contribution only from one group.

So far, only the rates of organic deposition (in units of $g/m^2/yr$) have been predicted. The accumulation of the organic material (S_i) can be predicted by including decay as follows:

$$S_i \ (g/m^2) = \frac{f_i}{k_d}, \text{ at steady state}$$

$$S_i \ (g/m^2) = \frac{f_i}{k_d} \ [1 - \exp(-90\ k_d)], \text{ for 90 days.} \qquad \text{B-2}$$

The f_i are the deposition rates in units of $g/m^2/day$, as contrasted to the units of $g/m^2/yr$ in Table B-2. The decay rate constant, k_d, has a typical value of 0.01/day. For example, if the organic deposition rate for annual conditions is 100 $g/m^2/yr$, the steady-state accumulation is:

$$100\ g/m^2/yr \times \frac{1\ yr}{365\ days} \times \frac{1}{0.01/day} = 27\ g/m^2. \qquad \text{B-3}$$

If the organic deposition rate for the critical 90-day period is 300 $g/m^2/yr$, the 90-day accumulation is:

$$300\ g/m^2/yr \times \frac{1\ yr}{365\ days} \times \frac{1}{0.01/day} \times [1-\exp(-90 \times 0.01)] = 49\ g/m^2. \qquad \text{B-4}$$

This example shows that input data for the 90-day and steady-state accumulations are different. Consequently, Tables B-1 and B-2 should each be completed twice. Also the accumulation over a critical 90-day period can exceed the steady-state accumulation. This is caused by short-term deposition rates that are considerably higher than the long-term average. In the example, the maximum 90-day deposition rate of 300 $g/m^2/yr$ would eventually decrease to values below 100 $g/m^2/yr$, so that on a yearly basis the deposition rate is 100 $g/m^2/yr$.

B-II. DISSOLVED OXYGEN CONCENTRATION FOLLOWING INITIAL DILUTION

When wastewater is discharged through a single port or a diffuser, the effluent forms a buoyant plume that entrains ambient water as it rises. Because the initial dilution process occurs rapidly (i.e., on the order of minutes), BOD exertion (a relatively slow process) is negligible during this period. However, an immediate dissolved oxygen demand (IDOD), which represents the oxygen demand of reduced substances that are rapidly oxidized (e.g., sulfides to sulfates), might not be negligible. The dissolved oxygen concentration following initial dilution can be predicted using the following expression:

$$DO_f = DO_a + (DO_e - IDOD - DO_a)/S_a \qquad \text{B-5}$$

where:

DO_f = Final dissolved oxygen concentration of receiving water at the plume trapping level, mg/L

DO_a = Affected ambient dissolved oxygen concentration immediately upcurrent of the diffuser averaged over the tidal period (12.5 h) and from the diffuser port depth to the trapping level, mg/L

DO_e = Dissolved oxygen of effluent, mg/L

IDOD = Immediate dissolved oxygen demand, mg/L

S_a = Initial dilution (flux-averaged).

The applicant should use the least favorable combination of values for effluent dissolved oxygen, IDOD, affected ambient dissolved oxygen, and initial dilution. The effluent dissolved oxygen concentration at the point

of discharge from the treatment plant is often 0.0 mg/L. Because the critical case is desired, a concentration of 0.0 mg/L is a reasonable value. However, if data show that dissolved oxygen concentrations in the effluent are greater than 0.0 mg/L during the critical periods, then these data may be used.

The IDOD values typically vary from 0 to 10 mg/L, but can be higher depending on the level of treatment and presence of industrial flows. Table B-3 can be used to select reasonable IDOD values. Alternatively, the IDOD can be measured as discussed below. The influence of the effluent IDOD on ambient dissolved oxygen can be estimated from the following table (calculated as $-IDOD/S_a$):

Contribution of IDOD to Lowering of DO_f (mg/L)

IDOD (mg/L)	Initial Dilution			
	10	30	50	100
1	-0.1	-0.03	-0.02	-0.01
2	-0.2	-0.07	-0.04	-0.02
5	-0.5	-0.17	-0.1	-0.05
10	-1.0	-0.33	-0.2	-0.10
20	-2.0	-0.67	-0.4	-0.20

At high initial dilutions, the IDOD contribution is small. Thus, the expense of laboratory tests may be unwarranted. If IDOD is to be determined experimentally, the procedures in *Standard Methods* (American Public Health Association 1985, p. 530) should be generally followed except that the dilution water should be seawater from the discharge site instead of distilled water, and the effluent sample should be incubated anaerobically for a length of time equal to the travel times from the plant through the diffuser for minimum, average, and maximum flow conditions. The effluent sample should be mixed with the dilution water after incubation. The dissolved oxygen concentration of the effluent and dilution water should be measured separately after incubation and before mixing the samples. The dissolved oxygen of the mixture should be measured 15 min after preparation.

TABLE B-3. TYPICAL IDOD VALUES

Treatment Level	Effluent BOD_5, mg/L	Travel Time, min[a]	IDOD, mg/L
Untreated or less than primary		<60	5
		60-200	10
		200-300	15
		>300	20
Primary	50-100	0-100	2
	50-100	100-300	3
	50-100	>300	4
	100-150	0-100	3
	100-150	100-300	4
	100-150	>300	5
	150-200	0-100	5
	150-200	100-300	7
	150-200	>300	8
Advanced primary	<50	0-60	0
	<50	>60	1

[a] Travel time should include the total travel time from the treatment plant through the diffuser, including any land portion of the outfall.

Note: Information compiled from 301(h) applications.

The IDOD is calculated using the following equation:

$$IDOD = \frac{(DO_D)(P_D) + (S)(P_S) - DO_M}{P_S} \qquad B\text{-}6$$

where:

IDOD = Immediate dissolved oxygen demand, mg/L

DO_D = Dissolved oxygen of dilution water (seawater), mg/L

P_D = Decimal fraction of dilution water used

S = Dissolved oxygen of effluent after incubation, mg/L

P_S = Decimal fraction of effluent used

DO_M = Dissolved oxygen of mixture after 15 min, mg/L.

Several dilutions should be used, preferably close to the actual initial dilution, unless the difference between the initial and mixed concentrations is less than 0.1 mg/L. All data used in the above calculations, the incubation times, and the computed results for each test should be included in the application.

The lowest initial dilution (flux-averaged) should be used for the final dissolved oxygen calculation. Usually, this dilution will correspond to the maximum flow rate at the end of the permit term. Low initial dilutions can also occur at smaller effluent flow rates if stratification is sufficiently severe. Typically, dilutions during periods of maximum stratification should be used for the final dissolved oxygen calculation.

The affected ambient dissolved oxygen concentrations should also represent critical conditions. Usually, critical conditions will occur

during the maximum stratification period in the late summer or in the spring when upwelling of deep ocean water occurs. For existing discharges, the affected ambient data should be collected at locations directly upcurrent of the diffuser, thereby incorporating the potential effects of recirculation. For proposed new or relocated discharges, affected ambient dissolved oxygen levels upcurrent of the diffuser should be estimated from mathematical models of the discharge or by extrapolation from similar situations. Dissolved oxygen data, as well as any ambient water quality constituent, may be averaged between the depth of the discharge ports and the plume trapping level, which corresponds to the lowest initial dilution that was used to predict the final dissolved oxygen concentrations. If applicants use a mathematical model that allows multiple vertical levels of input for ambient water quality instead of an average value, this should be noted.

The time period over which ambient data may be averaged may depend on specifications of intensity and duration factors in applicable water quality standards. For example, if certain numerical values shall not be compromised over a period of 4 h, a 4-h average of input data may be reasonable. Absent any more stringent specification in locally applicable standards, an average over a half tidal cycle (approximately 12.5 h) would provide a generally conservative estimate.

The affected ambient dissolved oxygen concentration can change substantially as a function of depth, depending on environmental characteristics and seasonal influences (e.g., upwelling). As the plume rises during initial dilution, water from deeper parts of the water column is entrained into the plume and advected to the plume trapping level. If the dissolved oxygen concentration is lower in the bottom of the water column than at the trapping level, the low dissolved oxygen water is advected to a region formerly occupied by water containing higher concentrations of dissolved oxygen. The result is an oxygen depression caused by entrainment.

This oxygen depression caused by the waste discharge and associated entrainment (ΔDO_1) should be computed as the difference between DO_f as

defined in Equation B-5 and the affected ambient dissolved oxygen concentration at the trapping depth (DO_t).

$$\Delta DO_1 = DO_f - DO_t = DO_a - DO_t + (DO_{e-} - IDOD - DO_a)/S_a \qquad B\text{-}7$$

The oxygen depression of the wastefield relative to the trapping depth expressed in percent is $(-\Delta DO_1/DO_t)100$.

For cases when the effect of entraining low dissolved oxygen water can be neglected, the oxygen depletion (ΔDO_2) should be computed as the difference between the average affected ambient dissolved oxygen concentration (DO_a) in the entrained water and DO_f as shown below.

$$\Delta DO_2 = DO_f - DO_a = (DO_e - IDOD - DO_a)/S_a \qquad B\text{-}8$$

The oxygen depletion of the wastefield relative to the average affected ambient dissolved oxygen concentration is $(-\Delta DO_2/DO_a)100$.

The equation of Baumgartner (1981) for the percentage depression is:

$$\frac{(DO_t - DO_e + IDOD)}{DO_t \times S_a} \times 100 \qquad B\text{-}9$$

This equation can be derived by assuming that $DO_a = DO_t$ in Equation B-7. Use of Equation B-9 has been allowed in the State of California.

These differences can be described as a percentage of the ambient concentration or as a numerical difference, depending on the requirements of the state. In some states, the final dissolved oxygen concentration must be above a specified limit or must be converted to percent saturation to determine whether the final concentration is above a prescribed limit. Dissolved oxygen saturation can be determined as a function of temperature and salinity using the method of Green and Carritt (1967) and Hyer et al. (1971) as tabulated in Table B-4. The applicant may want to consult with

TABLE B-4. DISSOLVED OXYGEN SATURATION VALUES

Temperature (° C)	Dissolved Oxygen Saturation, mg/L Salinity (ppt)								
	20	22	24	26	28	30	32	34	36
0	12.8	12.6	12.5	12.3	12.1	12.0	11.8	11.7	11.5
1	12.5	12.3	12.2	12.0	11.8	11.7	11.5	11.4	11.2
2	12.1	12.0	11.9	11.7	11.5	11.4	11.2	11.1	10.9
3	11.8	11.7	11.5	11.4	11.2	11.1	10.9	10.8	10.7
4	11.5	11.4	11.3	11.1	11.0	10.8	10.7	10.5	10.4
5	11.3	11.1	11.0	10.8	10.7	10.6	10.4	10.3	10.1
6	11.0	10.9	10.7	10.6	10.4	10.3	10.2	10.0	9.9
7	10.7	10.6	10.5	10.4	10.2	10.1	9.9	9.8	9.7
8	10.5	10.3	10.2	10.1	9.9	9.8	9.7	9.6	9.4
9	10.2	10.1	10.0	9.8	9.7	9.6	9.5	9.3	9.2
10	10.0	9.9	9.7	9.6	9.5	9.4	9.2	9.1	9.0
11	9.6	9.6	9.5	9.4	9.3	9.2	9.0	8.9	8.8
12	9.5	9.4	9.3	9.2	9.1	9.0	8.8	8.7	8.6
13	9.3	9.2	9.1	9.0	8.9	8.8	8.7	8.5	8.4
14	9.1	9.0	8.9	8.8	8.7	8.6	8.5	8.4	8.3
15	8.9	8.8	8.7	8.6	8.5	8.4	8.3	8.2	8.1
16	8.7	8.6	8.5	8.4	8.3	8.2	8.1	8.0	8.0
17	8.6	8.5	8.4	8.3	8.2	8.1	8.0	7.9	7.8
18	8.4	8.3	8.2	8.1	8.0	7.9	7.8	7.7	7.6
19	8.2	8.1	8.0	8.0	7.9	7.8	7.6	7.6	7.5
20	8.1	8.0	7.9	7.7	7.7	7.6	7.6	7.5	7.4
21	7.9	7.9	7.7	7.7	7.6	7.5	7.5	7.4	7.3
22	7.8	7.7	7.6	7.6	7.5	7.4	7.4	7.3	7.2
23	7.7	7.6	7.5	7.5	7.4	7.3	7.3	7.2	7.1
24	7.6	7.5	7.4	7.4	7.3	7.2	7.2	7.1	7.1
25	7.5	7.4	7.3	7.3	7.2	7.1	7.1	7.0	7.0
26	7.4	7.3	7.2	7.2	7.1	7.1	7.0	7.0	7.0
27	7.2	7.2	7.2	7.1	7.0	7.0	6.9	6.9	6.9
28	7.2	7.1	7.1	7.0	7.0	6.9	6.9	6.9	6.8
29	7.1	7.1	7.0	7.0	6.9	6.9	6.8	6.8	6.8
30	7.1	7.1	7.0	6.9	6.9	6.8	6.8	6.8	6.7

the state water quality agency to determine whether any other methods are used to determine compliance with the dissolved oxygen standards.

B-III. FARFIELD DISSOLVED OXYGEN DEPRESSION

Subsequent to initial dilution, dissolved oxygen in the water column is consumed by the BOD in the wastefield. The effluent BOD_5 after initial dilution is needed to estimate farfield dissolved oxygen depletion. The final BOD_5 concentration can be estimated using the following expression:

$$BOD_f = BOD_a + (BOD_e - BOD_a)/S_a \qquad \text{B-10}$$

where:

BOD_f = Final BOD_5 concentration, mg/L

BOD_a = Affected ambient BOD_5 concentration immediately updrift of the diffuser averaged over one-half the tidal period (12.5 h) and from the diffuser port depth to the trapping depth, mg/L

BOD_e = Effluent BOD_5 concentration, mg/L

S_a = Initial dilution (flux-averaged).

This equation provides an estimate of the total BOD_5 concentration in the receiving water. The maximum contribution due to the effluent alone can be determined by dividing the effluent BOD_5 concentration by the initial dilution. This value is used later to estimate farfield effects of the effluent. As a critical case, the maximum monthly average effluent BOD_5 concentration should be used with the (monthly) critical initial dilution. For existing plants, the previous 12 mo of effluent BOD_5 data is used to support the selection of a BOD_5 concentration. For proposed or modified treatment plants where effluent data are not available, monthly average influent BOD_5 data should be provided along with the range of daily values.

The average removal efficiency for the new or modified plant is also needed to compute estimated effluent BOD_5 concentrations.

Three approaches to assessing farfield dissolved oxygen demand are described below:

- Simplified mathematical models predicting dissolved oxygen depletions, using calculation techniques that do not require computer support

- Numerical models predicting dissolved oxygen depletions, using a computer

- Evaluation of field data, using a data-intensive approach where dissolved oxygen concentrations are measured in the water column and compared to ambient concentrations.

Before undertaking any analysis to determine whether farfield BOD exertion causes a violation of the dissolved oxygen standard, the applicant should first check to see whether:

$$DO_{STD} \leq DO_f - BOD_{fu}, \text{ for critical conditions} \qquad \text{B-11}$$

where:

DO_{STD} = Dissolved oxygen standard

DO_f = Dissolved oxygen concentration at the completion of initial dilution

BOD_{fu} = Ultimate BOD at the completion of initial dilution (= BOD_f x 1.46).

If the above inequality is true, then the discharge will not violate the dissolved oxygen standard due to BOD exertion and no further analysis of

farfield BOD exertion is required. If the inequality is not true, then further analysis is required.

SIMPLIFIED MATHEMATICAL MODELS

Oxygen depletion due to coastal or estuarine wastewater discharges is primarily caused by exertion of BOD, although increased nutrient levels can affect oxygen concentrations indirectly by altering algal photosynthesis and respiration rates. BOD consists of a carbonaceous component (CBOD) and nitrogenous component (NBOD). Both components can contribute to oxygen depletion. CBOD is often reported as BOD_5, the 5-day BOD. Before using BOD to predict oxygen depletion, the applicant should convert it to BOD_L, the ultimate BOD, by the following relationship:

$$BOD_L = 1.46\ BOD_5 \qquad \text{B-12}$$

A typical decay rate for CBOD is 0.23/day (base e) at 20^{o} C. A temperature correction should be made as follows:

$$k_T = 0.23 \times 1.047^{T-20}/\text{day} \qquad \text{B-13}$$

where:

k_T = BOD decay rate at temperature T (^{o} C).

NBOD might not always contribute to oxygen depletion. If the applicant discharges into open coastal waters where there are no other major discharges in the vicinity, the background population of nitrifying bacteria might be negligible. Under these circumstances, the NBOD will not be exerted immediately. In more enclosed estuarine waters, nitrification in the water column has been documented from numerous water quality studies. Applicants should analyze the potential impact of NBOD, if they discharge into estuarine waters.

NBOD can be estimated based on data for total Kjeldahl nitrogen concentration (the sum of organic nitrogen and ammonia nitrogen) in the waste discharge using the following relationships:

$$NBOD_L = 4.57\ (TKN) \qquad \text{B-14}$$

$$NBOD_5 = NBOD_L/2.54$$

where:

TKN = Total Kjeldahl nitrogen

$NBOD_L$ = Ultimate NBOD

$NBOD_5$ = 5-day NBOD.

The decay rate of NBOD can be taken as:

$$k_T = 0.10 \times 1.047^{T-20}/day \qquad \text{B-15}$$

where:

k_T = The decay rate at temperature T (^{o} C)

0.10 = The decay rate at 20^o C (base e).

Simplified mathematical models are an acceptable alternative to the more complex numerical models. In the simplest model of oxygen depletion, the following are generally assumed:

- The wastewater plume is submerged at the completion of initial dilution for critical conditions (so that direct reaeration of atmospheric oxygen into the wastefield does not occur).

- Oxygen depletion is a function of distance from the discharge and is caused by carbonaceous oxygen demand and nitrogenous oxygen demand.

- The wastefield entrains ambient water as a function of travel time. Lateral dilution is the predominant mechanism of entrainment.

If the applicant demonstrates that the plume will always surface, then the effects of atmospheric reaeration can be included; otherwise they should not be included.

When applying a model that predicts farfield oxygen depletion, it is suggested that the applicant plot dissolved oxygen depletion as a function of travel time so that the behavior of dissolved oxygen concentrations in the wastefield can be examined to locate minimum values.

Example oxygen depletion curves as a function of travel time are shown in Figure B-4. The depletion indicated at time, t=0, denotes the depletion immediately following initial dilution. The dissolved oxygen deficits plotted in the figure are relative to the ambient concentration, and tend to approach zero at travel times longer than those shown in the figure.

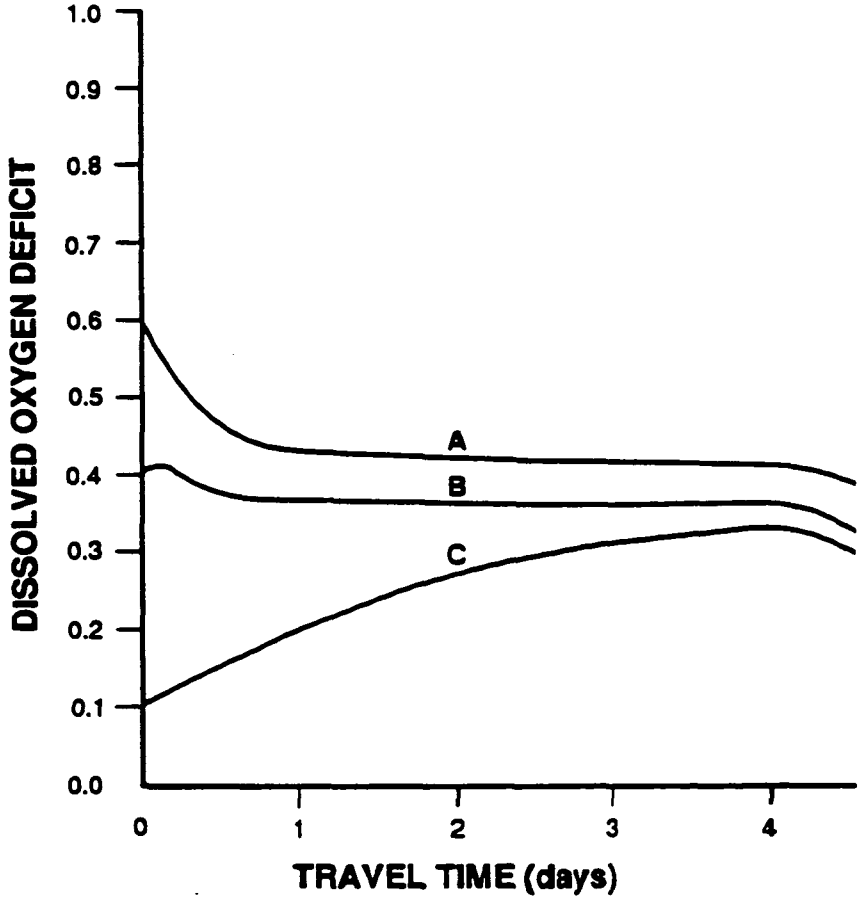
For the three cases, the maximum deficits occur at the following travel times:

- 0.0 days for Curve A

- Approximately 0.2 days for Curve B

- Approximately 4.0 days for Curve C.

The primary reason for the difference in magnitude and time of occurrence of the maximum deficits is the IDOD, which varies from a high of 66 mg/L for Curve A to 0.0 mg/L for Curve C. When the IDOD is 66 mg/L (a high value,



CURVE	BOD_f (ultimate) (mg/L)	INITIAL DO DEMAND (mg/L)
A	3.5	66.
B	3.5	44.
C	3.5	0.

Figure B-4. Dissolved oxygen deficit vs. travel time for a submerged wastefield.

but one that could be associated with an unusual discharge), the maximum depletion is caused by initial mixing processes, and not by farfield BOD exertion. Conversely, when IDOD is 0.0 mg/L, the maximum depletion is caused by BOD exertion, and occurs at some distance from the discharge.

The simplified farfield oxygen depletion model for coastal waters suggested herein is based on an approach developed by Brooks (1960) for predicting wastefield dilution subsequent to initial dilution. The dissolved oxygen concentration in the receiving waters can be expressed as a function of travel time as follows:

$$DO(t) = DO_a + \frac{DO_f - DO_a}{D_s} - \frac{L_{fc}}{D_s}\ 1-\exp(-k_c t) - \frac{L_{fn}}{D_s}\ 1-\exp(k_n t) \qquad \text{B-16}$$

where:

$DO(t)$ = Dissolved oxygen concentration in a submerged wastefield as a function of travel time t, mg/L

DO_a = Affected ambient dissolved oxygen concentration immediately updrift of the diffuser, mg/L

DO_f = Dissolved oxygen concentration at the completion of initial dilution calculated using Equation B-5, mg/L

k_c = CBOD decay rate constant

k_n = NBOD decay rate constant

L_{fc} = Ultimate CBOD concentration above ambient at completion of initial dilution, mg/L

L_{fn} = Ultimate NBOD concentration above ambient at completion of initial dilution, mg/L

D_s = Dilution attained subsequent to initial dilution as a function of travel time.

The above equation expresses the dissolved oxygen deficit that arises because of an initial deficit at the completion of initial dilution (DO_a-DO_f) plus that caused by exertion of BOD in the water column. The last term in the above equation estimates the exertion due to NBOD. The dissolved oxygen deficit tends to decrease at longer travel times as a result of subsequent dilution and to increase as a result of BOD exertion. Depending on the particular case being analyzed, one influence can dominate the other over a range of travel times so that a minimum dissolved oxygen level can occur either immediately following initial dilution or at a subsequent travel time, as previously shown in Figure B-4.

To predict farfield oxygen distribution, one must determine the dilution attained within the wastefield as a function of time following discharge. For open coastal areas, dilution is often predicted using the 4/3 law (Brooks 1960), which states that the lateral diffusion coefficient increases as the 4/3 power of the wastefield width. In mathematical form:

$$\epsilon = \epsilon_o \left(\frac{L}{b}\right)^{4/3} \qquad \text{B-17}$$

where:

ϵ = Lateral diffusion coefficient, ft^2/sec

ϵ_o = Diffusion coefficient when L = b

L = Width of sewage field at any distance from the ZID, ft

b = Initial width of sewage field (approximately as the longest dimension of the ZID), ft.

The initial diffusion coefficient can be predicted from:

$$\epsilon_o = 0.001\ b^{4/3}\ ft^2/sec \qquad \text{B-18}$$

Based on the 4/3 law, the centerline dilution, D_S, is given by:

$$D_s = 1/erf\left(\left[\frac{1.5}{\left(1 + \frac{8\ \epsilon_o\ t}{b^2}\right)^3 - 1}\right]^{1/2}\right) \qquad \text{B-19}$$

where:

t = Travel time, sec

erf = The error function.

The 4/3 law is not always applicable, especially in coastal areas or estuaries. In coastal areas, Grace (1978) suggests that the diffusion coefficient vary linearly with L. The subsequent dilution can be expressed as:

$$D = 1/erf\left(\left[\frac{1.5}{\left(1 + \frac{12\epsilon_o t}{B^2}\right)^2 - 1}\right]^{1/2}\right) \qquad \text{B-20}$$

A more conservative choice is to assume the diffusion coefficient is a constant. The subsequent dilution can then be expressed as:

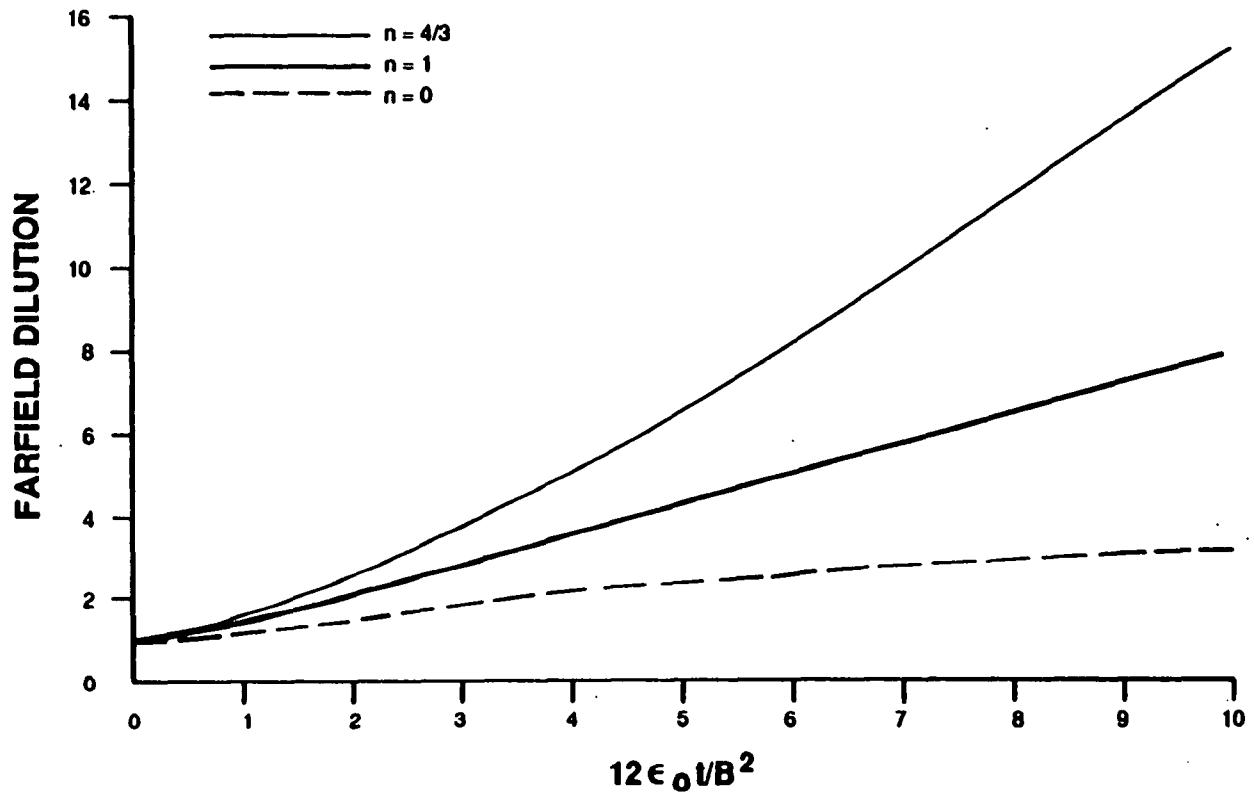
$$D_s = 1/erf\left[\left(\frac{b^2}{16\ \epsilon_o\ t}\right)^{1/2}\right] \qquad \text{B-21}$$

These three equations are cumbersome to use, especially if repeated applications are needed. To facilitate predicting subsequent dilutions, values of D_s as a function of $12\epsilon_0 t/b^2$ are shown in Figure B-5 for values of Brooks' n equal to 0, 1, and 4/3. For example, if b = 100 ft, and t = 9,000 sec (2.5 h), then $\epsilon_0 = 0.464$ ft^2/sec and $12\epsilon_0 t/b^2 = 5.0$. Assuming that Brooks' n = 1, then use of Figure B-5 shows that $D_s = 4.3$ approximately.

The figure also reveals that the predicted dilutions are substantially different, depending on the relationship obeyed by the lateral diffusion coefficient. In some instances, the Brooks' n = 1 law might overestimate subsequent dilution, even if the outfall is in coastal waters. To attain the subsequent dilutions predicted at large travel times, a large amount of dilution water must be available. Because many outfalls, particularly small ones, are not far from shore, the entrainment rate of dilution water can be restricted by the presence of the shoreline and the depth of the water. As the wastefield widens substantially, the rate of entrainment could decrease, and neither the Brooks' n = 4/3 nor the Brooks' n = 1 law may be obeyed. It is suggested that applicants be conservative and base subsequent dilution on a constant lateral diffusion coefficient (i.e., Brooks' n = 0), rather than the Brooks' n = 1 or Brooks' n = 4/3 laws. However, if the applicant can show that the 4/3 law (or some other relationship) is applicable to the discharge site, then that relationship should be used.

If the applicant's discharge is near the mouth of a wide estuary, the approach just discussed can be used directly to predict oxygen depletion. If, however, the applicant discharges into a long narrow estuary, then it is likely that the sides of the estuary will limit the lateral dilution that is attainable. Under these conditions, the maximum dissolved oxygen deficit with respect to saturation can be predicted as:

$$D = \frac{kW}{A(k_2-k)}\left[\frac{1}{\sqrt{4kE_L}} - \frac{1}{\sqrt{4k_2E_L}}\right] \qquad \text{B-22}$$



Reference: Brooks (1960).

Figure B-5. Farfield dilution as a function of $12\epsilon_o t/B^2$.

where:

D = Dissolved oxygen deficit

A = Cross-sectional area of the estuary near the discharge site

k = CBOD decay rate constant

k_2 = Reaeration rate constant

E_L = Longitudinal dispersion coefficient

W = Mass loading rate of CBOD.

The applicant can predict the deficits due to NBOD by using the appropriate k and W values and adding the two deficits to get the total. With reasonable values for the constants, the total dissolved oxygen deficit for discharge to narrow estuaries becomes:

$$D = (3.14\ W_c + 2.55\ W_n)\ 10^{-4}/A \qquad \text{B-23}$$

where:

A = Cross-sectional area in m^2

W_c = Mass emission rate of CBOD, g/day

W_n = Mass emission rate of NBOD, g/day

D = Dissolved oxygen deficit, mg/L.

The NBOD term can be added when data are available.

NUMERICAL MODELS

Numerical models are an acceptable method of predicting oxygen depletion caused by a discharge. Numerical models may consider the combined effect of farfield demand in the water column, as discussed above, and the oxygen demand associated with organic sediments. If not, the applicant may have to augment the numerical modeling analysis to address unanswered questions associated with sediment oxygen demand.

The applicant should try to isolate the impact of the outfall on dissolved oxygen concentrations by considering that the applicant's discharge is the sole source of oxygen depletion in the system being modeled. The applicant can then predict the dissolved oxygen depletion caused by the discharge by subtracting the background dissolved oxygen level from those predicted by the model. This approach also simplifies the applicant's analysis because data from other wastewater sources are not required.

Specific guidelines can be offered to applicants who choose to use numerical models. Typically, the most severe dissolved oxygen depletion due to BOD exertion occurs when the water column is density stratified in the presence of tidally reversing currents and low nontidal currents, and the wastefield remains submerged following initial dilution. If such conditions occur at the applicant's outfall site, then the numerical model should be layered vertically, with a minimum of two layers. The plume should be discharged into the bottom layer to simulate the submerged discharge with the consequence that direct atmospheric reaeration is not present in this layer.

The applicant should set up the grid system for the numerical model such that the smallest segments are located in the vicinity of the diffuser and gradually increase in size with distance from the diffuser. The volume of the segments in the immediate vicinity of the diffuser should approximate the volume of the ZID in order to prevent an initial dilution that is artificially high and that would cause the model to underestimate dissolved oxygen depletion. The applicant might choose to experiment with grid

configuration by starting with a coarse grid and then decreasing grid size until the model results do not significantly change.

A steady-state numerical model will be acceptable for the dissolved oxygen analysis because dynamic or unsteady analyses are generally more costly, more difficult to implement, and require more data. The applicant should consider, however, whether intratidal variations can cause more severe depletions than are predicted by a steady-state model that calculates average oxygen depletions over a tidal cycle. Slack tide, for example, might be critical because oxygen-demanding materials can accumulate in the vicinity of the discharge. For existing discharges, the applicant might want to augment the steady-state modeling analysis by an abbreviated sampling program to determine dissolved oxygen depletions during slack-tide periods within a tidal cycle. Intratidal variations are likely to be more important in enclosed estuaries than along open coastal areas.

EVALUATION OF FIELD DATA

Extensive field data collection and analysis are required to fully implement this third approach. Limited samples of water column dissolved oxygen may be inadequate to demonstrate compliance with standards under critical conditions. Limited information should be supplemented with analyses based on numerical or simplified mathematical modeling.

These statements should not discourage applicants from collecting and submitting dissolved oxygen data from the vicinity of an existing discharge. To the contrary, such data, if available, should be submitted, particularly if the Section 301(h) application is for a current discharge or for an improved or altered discharge at the same location. However, the data might reveal only a portion of the impact of the wastefield, for the following reasons:

- The location of the maximum oxygen depletion might not be sampled.

- The sampling program could have been conducted during a period that was not critical with respect to the discharge or receiving water conditions. Critical discharge conditions are generally associated with high effluent BOD and high volumetric flow rates. Critical receiving water conditions are usually associated with minimum initial dilutions (maximum density stratification), maximum water temperatures, and possibly slack-tide or low nontidal current conditions.

- Ambient dissolved oxygen concentrations can vary spatially and temporally for conditions unrelated to the discharge (e.g., upwelling effects). Consequently, dissolved oxygen depletions associated with the discharge can be masked by background variability.

Some applicants might have access to dissolved oxygen demand data collected adjacent to another outfall at a nearby coastal area and attempt to use those data to show that their own discharge will not violate dissolved oxygen standards. This approach can be, but is not always, reliable. The applicants should include in the application sufficient information such that the data collection program for the nearby area can be reviewed, and then show that the predicted dissolved oxygen depletions are the maximum likely to be produced at the nearby discharge site. The applicant should also demonstrate that the results of the nearby discharge can be extrapolated to the applicant's discharge. Essentially, the dissolved oxygen depletion at the adjacent discharge (due to both BOD utilization and sediment oxygen demand) will need to be at least as severe as that at the applicant's discharge.

B-IV. SEDIMENT OXYGEN DEMAND

The oxygen depletion due to a steady sediment oxygen demand can be predicted by:

$$\Delta DO = \frac{\bar{S}_B \; X_M}{86{,}400 \; UHD} = \frac{a \; \bar{S} \; k_d \; X_M}{86{,}400 \; UHD} \qquad \text{B-24}$$

where:

ΔDO = Oxygen depletion, mg/L

$\bar{S}_B$ = Average benthic oxygen demand over the deposition area, g $O_2/m^2/day$

X_M = Length of deposition area (generally measured in longshore direction), m

H = Average depth of water column influenced by sediment oxygen demand, measured above bottom, m

U = Minimum sustained current speed over deposition area, m/sec

k_d = Sediment decay rate constant, 0.01/day

a = Oxygen:sediment stoichiometric ratio, 1.07 mg O_2/mg sediment

$\bar{S}$ = Average concentration of deposited organic sediments over the deposition area, g/m^2

D = Dilution caused by horizontal entrainment of ambient water as it passes over the deposition area (always ≥ 1).

Both $\bar{S}$ and X_M can be determined from the analysis performed in the Chapter B-I on "Suspended Solids Deposition." Figure B-4 in that chapter shows an example plot of seabed deposition. For that example, an appropriate estimate of $\bar{S}$ is the average of the maximum and minimum values, or

$$\frac{100 + 5}{2} = 52 \text{ g/m}^2 \qquad \text{B-25}$$

The distance X_M, measured parallel to the coast and within the 5 g/m^2 contour, is 8,000 m.

The depth of water affected by the sediment oxygen demand is not really a constant value (as suggested by the previous formula) but varies as a function of the travel time across the zone of deposition. The affected depth H (in meters) is chosen to represent the average depth influenced by the sediment oxygen demand and can be estimated as:

$$H = 0.8 \left(\frac{\epsilon_z X_M}{U} \right)^{1/2} \qquad \text{B-26}$$

where:

ϵ_z = Vertical diffusion coefficient (cm^2/sec).

For the example case where U = 3 cm/sec, X_M = 8,000 m, and ϵ_z = 1 cm^2/sec,

$$H = 0.8 \times \left(\frac{1 \times 8{,}000 \times 100}{3} \right)^{1/2} \times \frac{1}{100} \text{ m} = 4.1 \text{ m} \qquad \text{B-27}$$

If the applicant desires to compute a value of vertical diffusivity, the following empirical expression can be used:

$$\epsilon_z = \frac{10^{-4}}{\frac{1}{\rho}\frac{d\rho}{dz}} \qquad \text{B-28}$$

where:

ϵ_z = Vertical diffusion coefficient, cm^2/sec

ρ = Ambient water density, kg/m^3 (1,024)

$\frac{d\rho}{dz}$ = Ambient density gradient, kg/m^4.

The density gradient used should reflect the most severe stratification condition that is likely to occur during the critical period.

The dilution D that is used in Equation B-24 can be found from Table B-5 where the field width is the width of the deposition area. For the appropriate travel time and field width, the smaller of the two estimates shown in the table should be used.

In Chapter B-I (Suspended Solids Deposition), the applicant is asked to compute the long-term accumulation and the critical 90-day accumulation. Because the critical 90-day accumulation might exceed the long-term average, the applicant should use the more critical case when predicting sediment oxygen demand.

Oxygen Demand Due to Resuspension of Sediments

It is more difficult to accurately predict oxygen demand due to resuspension than due to either farfield BOD decay or a steady sediment oxygen demand. To simplify the analysis, the approach here considers a worst-case situation. The amount of sediment to be resuspended is equal to the critical 90-day accumulation, which is found using the methods discussed in the above guidance on "Suspended Solids Deposition."

TABLE B-5. SUBSEQUENT DILUTIONS[a] FOR VARIOUS INITIAL FIELD WIDTHS AND TRAVEL TIMES

Travel Time (h)	Initial Field Width (ft)					
	10	50	100	500	1,000	5,000
0.5	2.3/5.5	1.5/2.0	1.3/1.6	1.0/1.1	1.0/1.0	1.0/1.0
1.0	3.1/13	2.0/3.9	1.6/2.6	1.2/1.3	1.1/1.1	1.0/1.0
2.0	4.3/32	2.7/8.5	2.2/5.1	1.4/1.9	1.2/1.5	1.0/1.0
4.0	6.1/85	3.7/21	3.0/11	1.9/3.5	1.5/2.3	1.1/1.2
8.0	8.5/>100	5.2/53	4.1/29	2.5/7.3	2.0/4.4	1.4/1.7
12	10/>100	6.3/95	5.1/50	3.0/12	2.4/6.8	1.6/2.3
24	15/>100	8.9/>100	7.1/100	4.2/30	3.4/16	2.1/4.4
48	21/>100	13/>100	10/>100	5.9/80	4.7/41	2.8/10
72	26/>100	15/>100	12/>100	7.3/>100	5.8/73	3.4/17
96	29/>100	18/>100	14/>100	8.4/>100	6.6/100	3.9/24

[a] The dilutions are entered in the table as N_1/N_2, where N_1 is the dilution assuming a constant diffusion coefficient, and N_2 is the dilution assuming the 4/3 law.

For the material to remain suspended, the ambient current speed has to be sufficiently great that the volume of water containing the resuspended material increases over time as ambient water is entrained. It is assumed that this process continues for up to 24 h.

The applicant should compute the oxygen depletion as a function of time during this period. This can be done using the following relationship:

$$\Delta DO = \frac{\bar{S}_r}{DH}\left[1-\exp\left(\frac{-k_r t}{24}\right)\right] \qquad \text{B-29}$$

where:

ΔDO = Oxygen depletion, mg/L

$\bar{S}_r$ = Average concentration (in g/m^2) of resuspended organic sediment (based on 90-day accumulation)

H = Depth of water volume containing resuspended materials, m

k_r = Decay rate of resuspended sediments, 0.1/day

t = Elapsed time following resuspension, h (t varies from 0 to 24 h)

D = Dilution as defined previously (generally set equal to 1).

The variable H is a function of travel time and can be predicted from:

$$H = \frac{1.6}{100}\left(3{,}600\ t\ \epsilon_z'\right)^{1/2} \qquad \text{B-30}$$

where:

ϵ_z' = Vertical diffusion coefficient when resuspension is occurring ($5\ cm^2/sec$)

t = Elapsed time following resuspension, h.

The applicant should check to be sure that H does not exceed the water depth. If it does, set H equal to the water depth.

The concentration of resuspended sediments $\bar{S}_r$ can be approximated as the average concentration over the width of the zone of deposition. This can be determined directly from the contour plots of sediment accumulation, developed in response to the guidance on "Suspended Solids Deposition" in Chapter B-I.

The applicant should calculate ΔDO for 3-h increments for a period of up to 24 h. The results can be tabulated as shown below. Data and calculations should be included in the application.

t (h)	DO (mg/L)
0	0
3	↓
6	
9	
12	
15	
18	
21	
24	predictions

Most often, a maximum depletion will occur somewhere in the 24-h period, with depletions decreasing for larger travel times.

B-V. SUSPENDED SOLIDS CONCENTRATION FOLLOWING INITIAL DILUTION

The concentration of suspended solids at the completion of initial dilution should be calculated using the following equation:

$$SS_f = SS_a + \frac{SS_e - SS_a}{S_a} \qquad \text{B-31}$$

where:

SS_f = Suspended solids concentration at completion of initial dilution, mg/L

SS_a = Affected ambient suspended solids concentration immediately upcurrent of the diffuser averaged over one-half the tidal period (12.5 h) and from the diffuser port depth to the trapping level, mg/L

SS_e = Effluent suspended solids concentration, mg/L

S_a = Initial dilution (flux-averaged).

The maximum change, ΔS, due to the effluent can be computed as follows:

$$\Delta S = SS_e/S_a \qquad \text{B-32}$$

where the terms are as defined above. Equation B-32 is appropriate as long as the effluent suspended solids concentration is much greater than the background concentration. During spring runoff in some estuaries, the background suspended solids concentration may exceed the effluent concentration. In these cases, the final suspended solids concentration will be below the background concentration.

U.S. EPA requires data for periods of maximum stratification and for other periods when discharge characteristics, oceanographic conditions, water quality, or biological seasons indicate more critical situations exist. The critical period generally occurs when water quality standards are most likely to be violated. If the standard is expressed as a maximum numerical limit, the critical period would be when the background concentrations are highest and the initial dilution is low. If the standard is expressed as a numerical difference from background, the critical period would be when effluent concentrations are high and initial dilution low. When the standard is expressed as a percent difference from background, the critical period could occur when background concentrations are low.

Because effluent suspended solids concentrations can vary with discharge flow rate, the concentration at the completion of initial dilution should be computed for the minimum, average dry- and wet-weather, and maximum flow rates, using the associated suspended solids concentration. The range and average effluent concentrations should be provided in the application by month, unless locally applicable standards require compliance over shorter durations. This information should be available from operating records.

The selection of an appropriate background suspended solids concentration may be difficult due to a general lack of data. A common problem for coastal sites is that measurements may be available only at the mouths of large rivers. Concentrations are often higher at such locations than farther offshore because of the solids contribution from runoff. Selected values of background suspended solids concentrations are shown in Table B-6. Suspended solids background data should be obtained at control stations, at the ZID boundary of the existing discharges, and at stations between the ZID-boundary and control stations. Data should be collected over the tidal cycle and at several depths so the average concentration over the height-of-rise of the plume over the tidal cycle can be calculated. This value should be used in Equation B-31.

TABLE B-6. SELECTED BACKGROUND SUSPENDED SOLIDS CONCENTRATIONS

Water Body	Suspended Solids Concentration, mg/L
Cook Inlet, AK	250-1,280
Southern California Bight	0.7-60
Pacific Ocean near San Francisco, CA	1-33
Broad Sound, MA	18.6-25.2
Massachusetts Bay near South Essex	1.2-30.5
New Bedford Harbor, MA	0.4-6.1
East River, NY	6.0-25.6
Ponce, PR (near shore)	13.5
Puget Sound, WA	0.5-2.0
Outer Commencement Bay, Tacoma, WA	33-51
Commencement Bay near Puyallup River, WA	23-136
Tacoma Narrows, WA	33-63

Note: Data are from 301(h) applications.

Compliance with the water quality standard can be determined directly if the standard is expressed in the form of suspended solids concentrations. If only a general standard exists, the maximum increase due to the effluent should be computed. If the increase is less than 10 percent, then no substantial effect in the water column is likely. However, seabed deposition could still be substantial depending on the mass emission rate of suspended solids and ambient currents at the discharge site, and thus should be evaluated.

The water quality standards may also specify limitations on the level of suspended solids removal. For example, California has a requirement that 75 percent of the solids entering POTWs must be removed. Compliance with this standard can be determined by estimating the average removal efficiency for each month based on the average monthly influent and effluent suspended solids concentrations. The removal efficiency should be equal to or greater than the required percentage in all months. The applicant should include the monthly average influent and effluent suspended solids concentrations along with the computed removal efficiencies.

B-VI. EFFLUENT pH AFTER INITIAL DILUTION

The calculation of effluent pH following initial dilution is chemically more sophisticated than other chemical calculations in this document. This appendix details the basis for Table 1 in the main text showing the ranges of probable effluent pH following initial dilution. The method for calculating effluent pH following initial dilution is described herein, assuming that all of the required variables are known. These variables include initial dilution and the temperature, salinity, pH, and alkalinity of the effluent and the receiving water. Effluent and receiving water temperature, salinity, and pH are normally measured. The (usually critical) initial dilution is routinely calculated as part of either the Section 301(h) waiver application process or the Section 301(h) permit renewal process. However, neither the alkalinity of the receiving water nor that of the effluent is usually measured. The alkalinity of seawater is relatively constant, however, at a value of 2.3 meq/L (Stumm and Morgan 1981). The alkalinity of effluent varies from 0.1 to 6.0 meq/L.

The method described herein predicts pH at the completion of initial dilution of an effluent-receiving water mixture. Because the initial dilution process occurs over a short time period, mixing is considered to occur in a closed system. Also, in stratified receiving waters, the wastewater plume is often trapped below the surface. Thus, the plume does not equilibrate with the atmosphere, and carbon dioxide exchange between the atmosphere and mixture is considered negligible. This method is useful for the calculation of pH, alkalinity, and total inorganic carbon concentration in the plume after initial dilution.

The pH of the effluent receiving water mixture is calculated using the equations for aqueous carbonate equilibrium in a closed system (Stumm and Morgan 1981). For this condition, the five equations that describe the relationships between pH, the carbonate species, and alkalinity are:

$$[H^+]\ [HCO_3^-]/[H_2CO_3^*] = K_1 \qquad \text{B-33}$$

$$[H^+]\ [CO_3^{2-}]/[HCO_3^-] = K_2 \qquad \text{B-34}$$

$$[H^+]\ [OH^-] = K_w \qquad \text{B-35}$$

$$C_T = [H_2CO_3^*] + [HCO_3^-] + [CO_3^{2-}] \qquad \text{B-36}$$

$$\text{Alkalinity} = [HCO_3^-] + 2[CO_3^{2-}] + [OH^-] - [H^+] \qquad \text{B-37}$$

where:

$[H_2CO_3^*]$ = The sum of aqueous CO_2 and true H_2CO_3 concentrations

C_T = Total carbonate concentration.

The carbonate species can also be expressed in terms of ionization fractions α_0, α_1, and α_2:

$$[H_2CO_3^*] = C_T\ \alpha_0 \qquad \text{B-38}$$

$$[HCO_3^-] = C_T\ \alpha_1 \qquad \text{B-39}$$

$$[CO_3^{2-}] = C_T\ \alpha_2 \qquad \text{B-40}$$

where:

$$\alpha_0 = \left[1 + \frac{K_1}{[H^+]} + \frac{K_1 K_2}{[H^+]^2} \right]^{-1} \qquad \text{B-41}$$

$$\alpha_1 = \left[\frac{[H^+]}{K_1} + 1 + \frac{K_2}{[H^+]} \right]^{-1} \qquad \text{B-42}$$

$$\alpha_2 = \left[\frac{[H^+]^2}{K_1 K_2} + \frac{[H^+]}{K_2} + 1 \right]^{-1} \qquad \text{B-43}$$

Substituting the hydroxide-hydrogen ion relationship and ionization fractions into the alkalinity equation yields:

$$\text{Alkalinity} = C_T \, (\alpha_1 + 2\alpha_2) + \frac{K_w}{[H^+]} - [H^+] \qquad \text{B-44}$$

Because total carbonate is conserved and α_1 and α_2 are functions solely of pH, the above equation has only one variable: hydrogen ion concentration. The model solves the equation to determine the pH of the effluent-receiving water mixture. The steps involved in the calculations are listed below:

- Determine input data
- Calculate ion product of water, K_w, and carbonate dissociation constants, K_1 and K_2, of the effluent and receiving water based on temperature and salinity data
- Check consistency between alkalinity and pH of both effluent and receiving water
- Calculate total carbonate in effluent and receiving water separately
- Calculate total carbonate, alkalinity, salinity, and temperature of the effluent-receiving water mixture following initial dilution (based on proportions of effluent and receiving water)
- Calculate K_w, K_1, and K_2 for the effluent-receiving water mixture following initial dilution

- Use a stepping procedure to find pH based on the computed values for total carbonate and alkalinity of the effluent-receiving water mixture

- Record results.

The ion product and dissociation constants are calculated for the appropriate temperature and salinity based on the equations given below. The equations for the receiving water have been revised so that salinity (in ppt) can be used.

For effluent:

$$pK_1 = \frac{3,407.7}{T} + 0.03279T - 14.8435 \text{ (Kelts and Hsu 1978, p. 300)} \quad \text{B-45}$$

$$pK_2 = \frac{2,902.4}{T} + 0.02379T - 6.498 \text{ (Kelts and Hsu 1978, p. 300)} \quad \text{B-46}$$

$$pK_w = \frac{4,471.0}{T} + 0.01706T - 6.0875 \text{ (Stumm and Morgan 1981, p. 127)} \quad \text{B-47}$$

For receiving water and the effluent-receiving water mixture:

$$pK_1 = \frac{3,404.7}{T} + 0.03279T - 14.712 - 9.1575S^{1/3} \quad \text{B-48}$$
(Stumm and Morgan 1981, p. 205)

$$pK_2 = \frac{2,902.4}{T} + 0.02379T - 6.471 - 0.3855S^{1/3} \quad \text{B-49}$$
(Stumm and Morgan 1981, p. 206)

$$pK_w = \frac{3,441.0}{T} + 2.241 - 0.0925S^{1/2} \quad \text{B-50}$$
(Dickson and Riley 1979, p. 97)

where:

T = Temperature in degrees Kelvin

S = Salinity in ppt.

The receiving water equations are valid for salinities down to about 10 ppt.

B-VII. LIGHT TRANSMITTANCE

Increased suspended solids concentrations associated with municipal discharges can cause a decrease in light penetration within the water column. Reductions in light penetration can result in a decrease in phytoplankton productivity as well as a reduction in the areal distribution of attached macroalgae such as kelp. Therefore, several states have enacted regulations governing the allowable levels of interference with light transmittance.

The evaluation of light transmittance may require the measurement of one or more water clarity variables and a comparison of values recorded in the vicinity of the outfall with those recorded in control areas. Variables that are widely measured to assess light transmittance include turbidity, Secchi disc depth, beam transmittance, and downward irradiance. While many of the state requirements are very specific in terms of the light transmittance measurements, others leave the selection of the sampling methods to the discretion of the applicant.

Turbidity is a measure of the optical clarity of water, and many standards are written in terms of Nephelometric Turbidity Units (NTU). Measurements are made with a nephelometer, which provides a comparison of the light-scattering characteristics of the sample with a standard reference. Differences in the optical design of nephelometers can cause differences in measured values even when calibrated against the same turbidity standard. For this reason, caution must be exercised when comparing measurements of turbidity made from different field sampling programs.

A Secchi disc is used to make visual observations of water clarity. Records of the depth at which the Secchi disc is just barely visible can be used to make comparisons of light transmittance among sampling sites. Measurements of Secchi disc depth are probably the most widely used means of estimating light penetration. The Secchi disc is easy to use, is accurate

over a wide range of conditions, and can be used to estimate the attenuation coefficients for collimated and diffuse light and, therefore, to estimate the depth of the euphotic zone. However, since a wastewater plume may be held below the upper regions of this zone during periods of stratification, Secchi disc measurements may not be appropriate under all conditions.

Beam transmittance is measured with a transmissometer and is a measure of the attenuation of a collimated beam of artificial light along a fixed path length (usually 1 m). The attenuation is caused by suspended and dissolved material as well as the water itself. These measurements, therefore, provide information about both the absorption and scattering properties of the water. The attenuation of a collimated beam of light in a water path is described by the Beer-Lambert law:

$$T_d = e^{-\alpha d} \qquad \text{B-51}$$

where:

T_d = The proportion of light transmitted along a path of length d, m

α = Light attenuation coefficient, m^{-1}.

Measurements of beam transmittance are made *in situ* at any depth.

The intensity and attenuation of daylight penetration are measured with an irradiance meter, which utilizes a photovoltaic cell to record incident light levels. Measurements are made just below the surface and at selected depth intervals throughout the water column so that light attenuation over specific depths can be determined. Unlike beam transmittance measurements, irradiance measurements are influenced by sunlight as well as surface conditions.

Empirical relationships can be derived among the light transmittance variables measured by these methods, which permits the estimation of one based on recorded values of another. These values can also be predicted

from suspended solids concentrations. The derivation of these relationships from existing data, in some instances, may be sufficient to allow for the demonstration of compliance with state standards. Existing data can also be used to predict the transparency characteristics in the vicinity of an improved discharge. Alternatively, a sampling program can be designed to assess compliance with light transmittance standards based on such empirical relationships.

Where standards are written in terms of maximum allowable turbidity or turbidity increase, predicted turbidity in the receiving water at the completion of initial dilution can be used to demonstrate compliance. By treating turbidity as a conservative variable, the turbidity in the receiving water at the completion of initial dilution can be predicted as:

$$T_f = T_a + \frac{T_e - T_a}{S_a} \qquad \text{B-52}$$

where:

T_f = Turbidity in receiving water at the completion of initial dilution, typically NTU or Jackson Turbidity Units (JTU)

T_a = Ambient or background turbidity

T_e = Effluent turbidity

S_a = Initial dilution.

Initial dilution can be predicted based on the methods presented in Appendix A. Equation B-52 can be used, then, to directly evaluate compliance with standards written in terms of maximum allowable turbidity or a turbidity increase.

Laboratory experimental work can also be used in lieu of field sampling to demonstrate compliance with standards written in terms of an allowable

turbidity increase. These analyses consist of determining the turbidity of a seawater-effluent mixture prepared in the same proportions corresponding to the predicted concentrations following initial dilution. Experiments should be conducted to simulate worst-case conditions. Simulations of expected receiving water turbidity should be made for periods of highest effluent turbidity (greatest suspended solids concentrations) as well as lowest initial dilutions. Values of the initial turbidity of the seawater, the effluent mixture, and the simulated dilution should accompany all test results.

By deriving a relationship between turbidity and Secchi depth and utilizing the method of prediction for turbidity in the receiving water following initial dilution (Equation B-52), compliance with state standards written in terms of Secchi depth can be evaluated. Secchi disc and turbidity can be related in the following manner. Assume that the extinction coefficient of visible light (α) is directly proportional to turbidity (T) and inversely proportional to Secchi disc (SD), or:

$$\alpha = k_1 T \qquad \text{B-53}$$

and

$$\alpha = \frac{k_2}{SD} \qquad \text{B-54}$$

where k_1 and k_2 are constants which need not be specified since they cancel out in further calculations. These two relationships have theoretical bases, as discussed in Austin (1974) and Graham (1966). Combining those two expressions, the relationship between Secchi disc and turbidity becomes:

$$T = \left(\frac{k_2}{k_1}\right)\left(\frac{1}{SD}\right) \qquad \text{B-55}$$

When state standards are written in terms of Secchi disc, it is convenient to combine Equations B-52 and B-55 to yield:

$$\frac{1}{SD_f} = \frac{1}{SD_a} + \frac{\frac{1}{SD_e} - \frac{1}{SD_a}}{S_a} \qquad \text{B-56}$$

or

$$SD_e = \left[\left(\frac{1}{SD_f} - \frac{1}{SD_a}\right) S_a + \frac{1}{SD_a}\right]^{-1} \qquad \text{B-57}$$

where:

SD_f = Minimum allowable Secchi disc reading in receiving water such that the water quality standard is not violated

SD_a = Ambient Secchi disc reading

S_a = Minimum initial dilution that occurs when the plume surfaces

SD_e = Critical Secchi disc depth of effluent.

In this manner, the critical effluent Secchi depth (SD_e) can be calculated. An effluent reading higher than this value indicates that standards will not be violated. This method of predicting the final Secchi depth in the receiving water can be utilized to provide an estimate of the effect of the wastewater discharge on the receiving water. This method should only be used where the standard is exclusively in terms of the acceptable decrease in the Secchi depth.

Values of the critical effluent Secchi depth (SD_e) calculated using Equation B-57 are presented in Table B-7. In this example, the water quality standard for the minimum Secchi visibility is 1 m (3.3 ft). Effluent having a Secchi depth greater than those presented for the selected ambient conditions and initial dilution will not violate the clarity standard of the example receiving water. Primary effluents typically have

TABLE B-7. CALCULATED VALUES FOR THE CRITICAL EFFLUENT SECCHI DEPTH (cm) FOR SELECTED AMBIENT SECCHI DEPTHS, INITIAL DILUTIONS, AND A WATER QUALITY STANDARD FOR MINIMUM SECCHI DISC VISIBILITY OF 1 m

Initial Dilution	Ambient Secchi Depth (m)				
	2	3	4	5	10
10	18	14	13	12	11
20	10	7	7	6	6
40	5	4	3	3	3
60	3	2	2	2	2
100	2	1	1	1	1

Secchi disc values of 5-30 cm (2-12 in). For this case, with an initial dilution greater than 40 and an ambient Secchi depth of 2 m (6.6 ft) or greater, these calculations indicate that the standard would not be violated.

Since Secchi disc measurements are made from the water surface downward, critical conditions (in terms of the Secchi disc standard) will occur when the initial dilution is just sufficient to allow the plume to surface. It is notable that maximum turbidity or light transmittance impacts of a wastewater plume will occur when the water column is stratified, the plume remains submerged, and initial dilution is a minimum. Under these same conditions, however, Secchi disc readings might not be altered at all, if the plume is trapped below the water's surface at a depth exceeding the ambient Secchi disc depth.

The ability to relate measurements of turbidity to the attenuation coefficient (α) for collimated light has been demonstrated by Austin (1974). The attenuation coefficient can be expressed in terms of turbidity as:

$$\alpha = k \times JTU \qquad \text{B-58}$$

where:

JTU = Turbidity, JTU

k = Coefficient of proportionality.

Combining Equations B-51 and B-58, turbidity can be expressed as:

$$JTU = \frac{-\ln T_d}{kd} \qquad \text{B-59}$$

where:

T_d = Fraction of beam transmittance over distance d.

The coefficient of proportionality (k) takes on values 0.5-1.0. Therefore, to utilize these relationships for demonstrating compliance with a turbidity standard based on existing light transmittance data, the value of k must be determined empirically. This requires simultaneous measurements of beam transmittance and determination of turbidity covering the complete range of existing light transmittance records. If data are not available, the "k" value can be set equal to 1 as a conservative estimate.

Where a relationship between suspended solids concentration and beam transmittance data at a particular site can be derived, the suspended solids concentration at the completion of initial dilution from Equation B-31 can be used to predict compliance with standards written in terms of light transmittance.

B-VIII. OTHER WATER QUALITY VARIABLES

Other variables for which water quality standards may exist include total dissolved gases, coliform bacteria, chlorine residual, temperature, salinity, radioactivity, and nutrients. Variables concerned with aesthetic effects that also may be included are color, floating material, taste and odor, and hydrocarbons (i.e., grease and oil). For most dischargers, temperature, salinity, and radioactivity standards are unlikely to be violated. Aesthetic effects are more likely to occur when the plume surfaces and the dilution is low. Compliance with aesthetic standards can best be checked by field observations at the discharge site and along the shore.

TOTAL DISSOLVED GASES

Several states have a limit for total dissolved gases of 110 percent of saturation. Supersaturation of dissolved gases is not considered to be a likely problem for municipal wastewater discharges to the marine environment and is not discussed further.

CHLORINE RESIDUAL

Chlorine residual standards may be expressed as a concentration limit in the effluent or as a maximum concentration in the receiving water at the completion of initial dilution. If the effluent is not chlorinated, no further information is required. If the standard is expressed as an effluent limit, chlorine residual data from treatment plant operating reports, or other sources, should be presented in the application. If no data are available, then the procedure for chlorination, including the compound used, quantity, and occurrence of any operational problems, should be described. If the standard is expressed as a maximum limit at the

completion of initial dilution, the concentration in the receiving water, assuming the ambient concentration is 0.0 mg/L, can be estimated as follows:

$$Cl_f = Cl_e/S_a \qquad \text{B-60}$$

where:

Cl_f = Chlorine residual at completion of initial dilution, mg/L

Cl_e = Chlorine residual in effluent, mg/L

S_a = Lowest flux-averaged initial dilution.

As a worst-case approach, the maximum observed chlorine residual in the effluent should be used with the lowest dilution. If violations are predicted, the applicable water quality standard may require information on the frequency of occurrence.

NUTRIENTS

Standards can be expressed as maximum receiving water concentrations of total nitrogen or total phosphorus or as a general prohibition on amounts that would cause objectionable aquatic life. In general, for small discharges when the initial dilution is large, nutrients are not likely to cause problems. Appropriate state agencies should be contacted to ascertain if algal blooms, red tides, or other unusual biological activity have occurred near the discharge site in the past.

Receiving water and effluent nutrient data can be used to estimate concentrations at the completion of initial dilution. For screening purposes, the nutrients can be treated as conservative variables. The concentration is estimated as follows in a similar manner to suspended solids:

$$C_f = C_a + \frac{C_e - C_a}{S_a} \qquad \text{B-61}$$

where:

C_a = Affected ambient concentration immediately upcurrent of diffuser, mg/L

C_e = Effluent concentration, mg/L

S_a = Initial dilution (flux-averaged)

C_f = Concentration at the completion of initial dilution, mg/L.

The predicted concentration can then be compared to the state standard.

Because water quality criteria are often prescribed as maximum values not to be exceeded following initial dilution, it is useful to rearrange the above equation to express the maximum allowable effluent concentration as follows:

$$(C_e)_{max} = C_a + (S_a)_{min} (C_c - C_a) \qquad \text{B-62}$$

where:

$(C_e)_{max}$ = Maximum allowable effluent concentration such that water quality criteria are not exceeded

C_c = Applicable water quality criterion

$(S_a)_{min}$ = Minimum expected initial dilution.

The maximum observed effluent concentration can then be compared to the predicted allowable concentration. This approach can be used for any conservative constituent. Thus, if other specific limits exist such as

for color, effects due to the discharge can be determined as shown in Equations B-61 and B-62.

COLIFORM BACTERIA

Standards may exist for total or fecal coliform bacteria or enterococci and are usually expressed as a mean or median bacterial count and a maximum limit that cannot be exceeded by more than 10 percent of the samples. If the effluent is continuously disinfected using chlorination or an equivalent process, analyses for coliform bacteria may be needed only to verify the effectiveness of disinfection. If disinfection is done part of the year, analyses should be representative of conditions when the effluent is not so treated. The chemicals used, quantities, and frequency of use should be provided along with a discussion of the reliability of the system.

The coliform bacteria count at the completion of initial dilution due to the discharge can be estimated as follows:

$$B_f = B_e/S_a \qquad \text{B-63}$$

where:

B_e = Effluent coliform bacteria count, MPN/100 mL

S_a = Initial dilution.

As a conservative approach, the maximum effluent count and the lowest initial dilution should be used. If onshore currents occur only during a particular season, the coliform count at the completion of initial dilution can be estimated using the lowest initial dilution appropriate for that season. Effluent coliform data should be submitted to support the applicant's values. The predicted value can be compared with the appropriate standard at the ZID boundary. This value can also be used to estimate the bacterial concentration at specific locations away from the ZID.

Because different limits may apply to specific areas (e.g., shellfish harvesting areas, beaches, diving areas), the maximum bacterial count at a specified distance from the discharge may be of concern. This bacterial count can be estimated in a manner analogous to the estimation of the BOD exerted as the wastefield spreads out from the ZID. The maximum bacterial count at the centerline of the wastefield can be estimated as a function of distance from the discharge as follows:

$$B_x = B_a + \frac{B_f - B_a}{D_s D_b} \qquad \text{B-64}$$

where:

B_x = Bacteria count at distance x from ZID, #/100 mL

B_a = Affected ambient bacteria count immediately upcurrent of diffuser, #/100 mL

B_f = Bacteria count at completion of initial dilution, #/100 mL

D_s = Dilution attained subsequent to initial dilution at distance x

D_b = "Dilution" due to dieoff of bacteria caused by the combined effects of exposure to seawater and sunlight.

when $x = 0$, $B_x = B_f$. In cases where the background bacterial count is negligible or the effect of the discharge alone is desired, the terms for the ambient bacterial count can be dropped, simplifying Equation B-64 to:

$$B_x = \frac{B_f}{D_s D_b} \qquad \text{B-65}$$

Values for subsequent dilution as a function of $12\epsilon_0 t/B^2$ in Figure B-5. Guidance is included in Chapter B-III ("Farfield Dissolved Oxygen Demand")

on methods for estimating subsequent dilution for sites located in narrow estuaries or bays.

The decay rate of bacteria in the ocean is influenced by water temperature, incident light, salinity, and other factors. As a conservative estimate, the minimum decay rate should be used. If no violations would occur, then further calculations are not needed. Flocculation and sedimentation can cause an apparent decrease in coliform count in the water column, but the bacteria are retained in the sediment. Thus, this process is not included in the above approach. If the applicant has information indicating that the decay rate at the discharge site should be a different value, the revised decay rate may be used. The evidence for the revised decay rate, including any data or results of laboratory tests, should be included in the application.

In this report, dieoff due to the combined effects of exposure to saltwater and exposure to sunlight only are considered. The dieoff due to exposure to saltwater, D_{SW}, and the dieoff due to exposure to sunlight, D_{Sl}, are (Gameson and Gould 1975):

$$D_{SW} = \exp(k_{SW}t) \qquad \text{B-66}$$

$$D_{Sl} = \exp[\alpha I(t)] \qquad \text{B-67}$$

where:

k_{SW} = Bacteria decay rate due to exposure to saltwater, 1/h

α = Constant, m^2/MJ

$I(t)$ = Total intensity of sunlight received by bacteria during the travel time, MJ/m^2

t = Travel time, h.

The bacteria dieoff due to the combined effects of saltwater and sunlight is $D_b = D_{sw}D_{sl}$. Gameson and Gould (1975) indicate that $\alpha = 1.24\ m^2/MJ$ *in situ* for Dorset, England seawater. The total intensity of sunlight received at the water surface can be measured, or estimated using site-specific data or general methods (Wallace and Hobbs 1977). If the wastefield is submerged, then the calculation of the total sunlight received should reflect the effect of turbidity on light transmission from the sea surface to the top of the wastefield.

The bacteria decay rate due to the exposure to saltwater is known for both coliform bacteria and enterococcus bacteria. For coliform bacteria,

$$k_{sw} = 2.303 \exp[(0.0295T - 2.292)2.303] / h \qquad \text{B-68}$$

where T = water temperature (^{o} C), based on field measurements at Bridport (Dorset, England) (Gameson and Gould 1975). The enterococcus bacteria dieoff rate due to exposure to saltwater is:

$$k_{sw} = 0.5262 / (24\ h) \qquad \text{B-69}$$

at a temperature of 20^o C (Hanes and Fragala 1967). [It should be noted that Hanes and Fragala (1967) determined that k_{sw} for coliform bacteria is 0.0424/h at 20^o C, a value slightly smaller than the value of 0.0457/h at 20^o C based on the formula from Gameson and Gould (1975).]

The estimated coliform count at the location of interest should be compared to the applicable standard. If a violation is predicted, the water quality standards may require that the approximate frequency should be discussed based on the percentage or likelihood of currents transporting the wastefield in the direction of interest.

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APPENDIX C

BIOLOGICAL ASSESSMENT

APPENDIX C
BIOLOGICAL ASSESSMENT

Because benthic infauna are sedentary and must adapt to pollutant stresses or perish, this assemblage is often used to define the spatial extent and magnitude of biological impacts in the vicinity of sewage discharges. The general changes in benthic community structure and function that occur under conditions of organic enrichment of the sediments (e.g., due to municipal sewage effluent) have been well documented (Pearson and Rosenberg 1978). Slight to moderate enrichment results in slight increases in numbers of species, abundances, and biomass of benthic communities (see Figure 3 in main text), while species composition remains unchanged. As enrichment increases, numbers of species decline because less tolerant species are eliminated. The total abundance of organisms increases as a few species adapted to disturbed environments or organically enriched sediments become very abundant. When enrichment levels are optimal for those few species, they become extremely abundant and overwhelmingly dominate the benthic community (corresponding to the "peak of opportunists" shown in Figure 3). Biomass generally decreases, however, because many of those opportunistic species are small. Further organic enrichment of the sediments drastically reduces the number of species and abundances of benthic organisms, as conditions become intolerable for most taxa.

Because the model developed by Pearson and Rosenberg (1978) has been shown to be valid in many benthic environments, it is often instructive to examine the abundances of species that the authors identify as opportunistic or pollution-tolerant. Those data, in conjunction with the applicant's data on numbers of species, total abundances, and biomass at stations in the vicinity of the outfall, are often sufficient to determine the relative degree of impact within and beyond the ZID.

Comparable models that describe changes in the structure and function of plankton and demersal fish communities in organically enriched receiving environments have not yet been developed. However, it may be instructive to examine the scientific literature that is available for the biogeographic region in which the outfall is located. That literature often contains information describing the responses of the local fauna and flora to organic materials and other pollutants, and identifying opportunistic and pollution-tolerant species. Such information is extremely useful for interpreting data collected in the vicinity of the outfall.

A variety of analytical tools may be used to conduct biological comparisons for Section 301(h) applications. Applicants may analyze the data graphically or statistically, or may use other mathematical tools such as multivariate analyses (e.g., classification and ordination procedures). Graphical analyses can be especially useful for presenting data in an easily understood format. In Figure C-1, data on numbers of species in each replicate sample at stations in the vicinity of an outfall have been plotted to show the range of reference values in comparison with values at within-ZID, ZID-boundary, nearfield, and farfield stations. These data may be tested statistically to determine those test stations at which mean values differ from mean values at either or both reference stations. But even without such tests, the data in Figure C-1 clearly indicate that a gradient of effects occurs near the outfall. Relative to reference conditions, numbers of species are depressed at the within-ZID and downcurrent ZID-boundary stations, and may be depressed at the nearfield and upcurrent ZID-boundary stations.

Graphical analyses are especially useful for presenting data on the physical characteristics of the habitat. For example, it is often instructive to plot water column or substrate characteristics in relation to distance from the outfall (see Figures C-2 and C-3). Gradients of effects (as in Figure C-3) are often revealed in such simple presentations. An especially useful method for presenting data on sediment grain size distributions that has proven useful in analyses of 301(h) data was developed by Shepard (1954). Sediments are classified by the proportions of

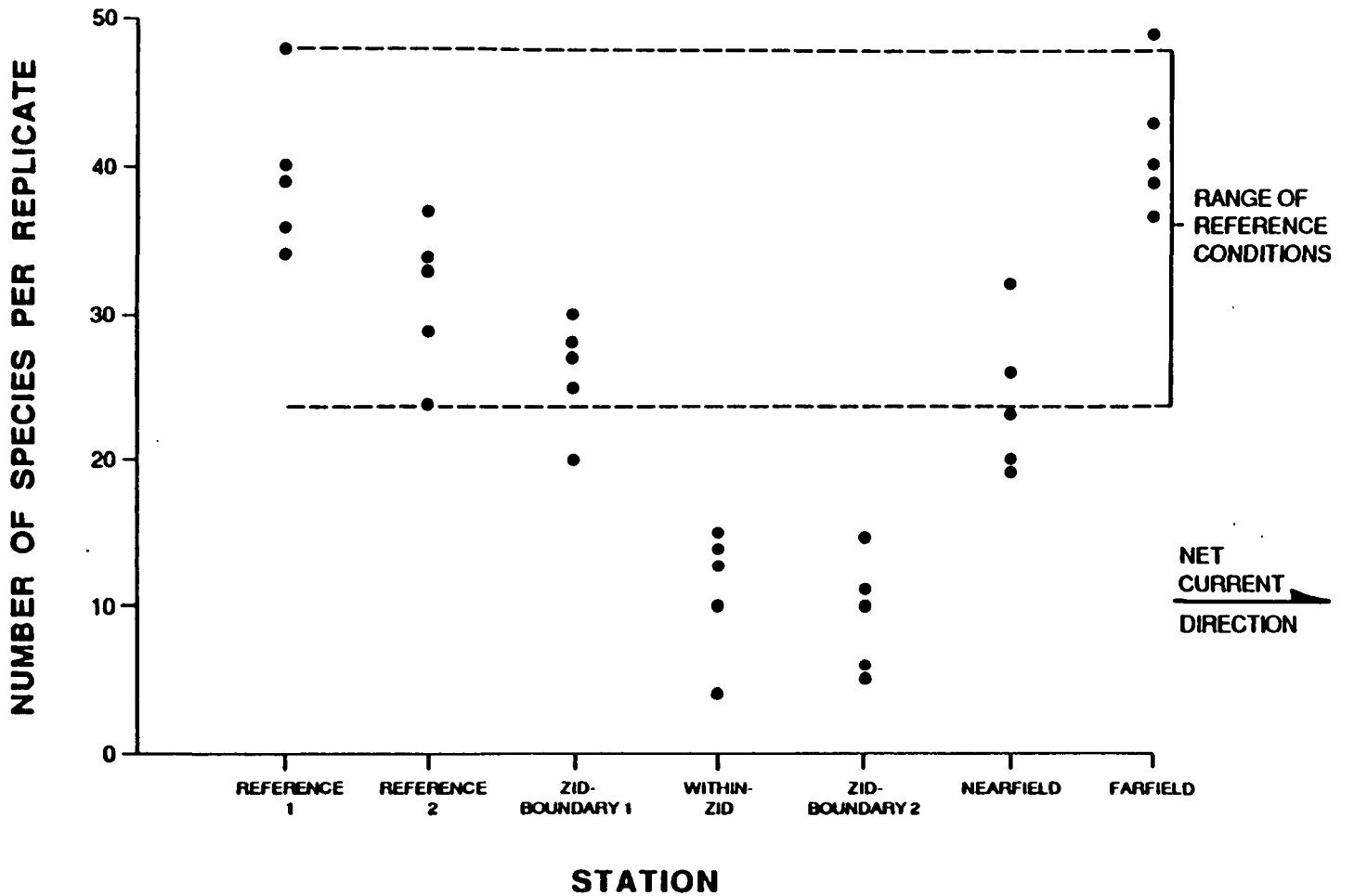

Figure C-1. Numbers of species collected in replicate benthic grab samples at stations in the vicinity of the outfall.

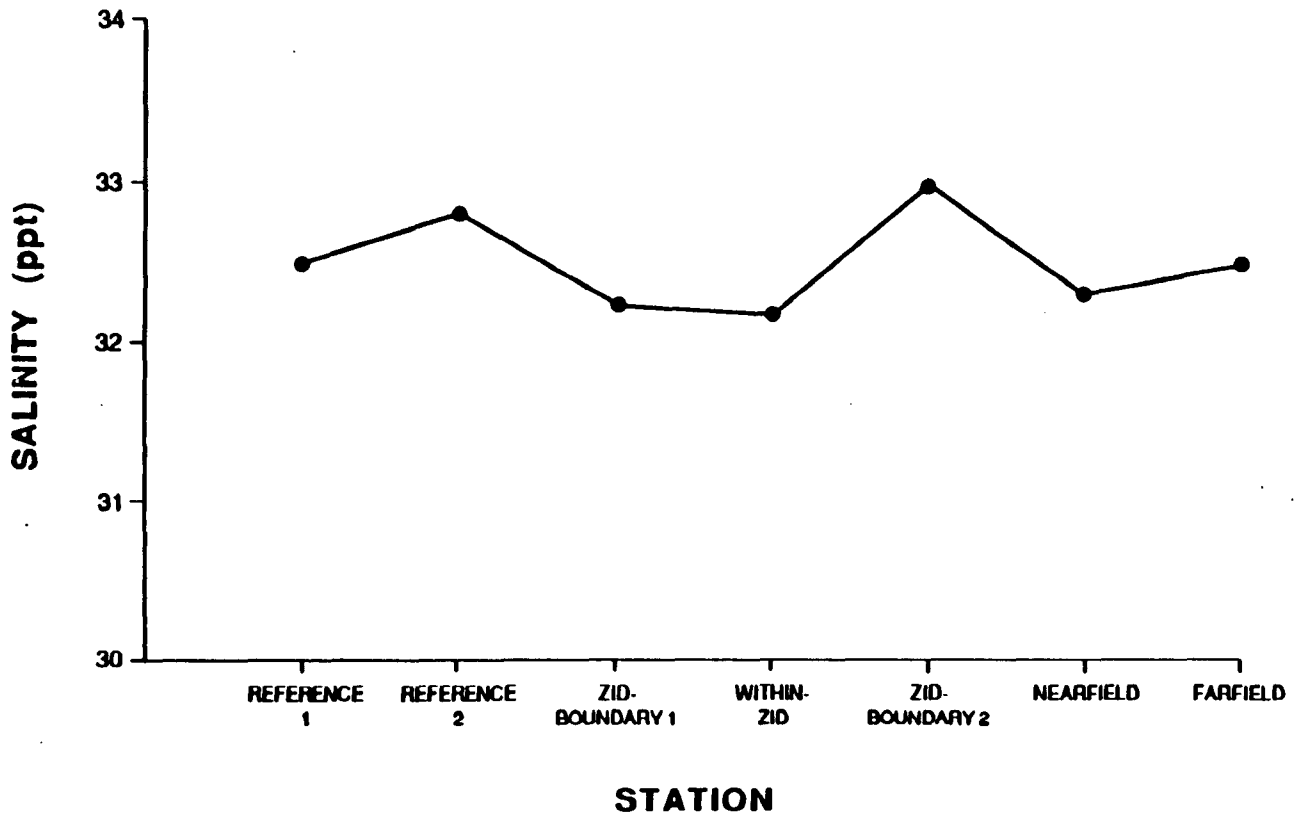

Figure C-2. Salinity at stations in the vicinity of the outfall.

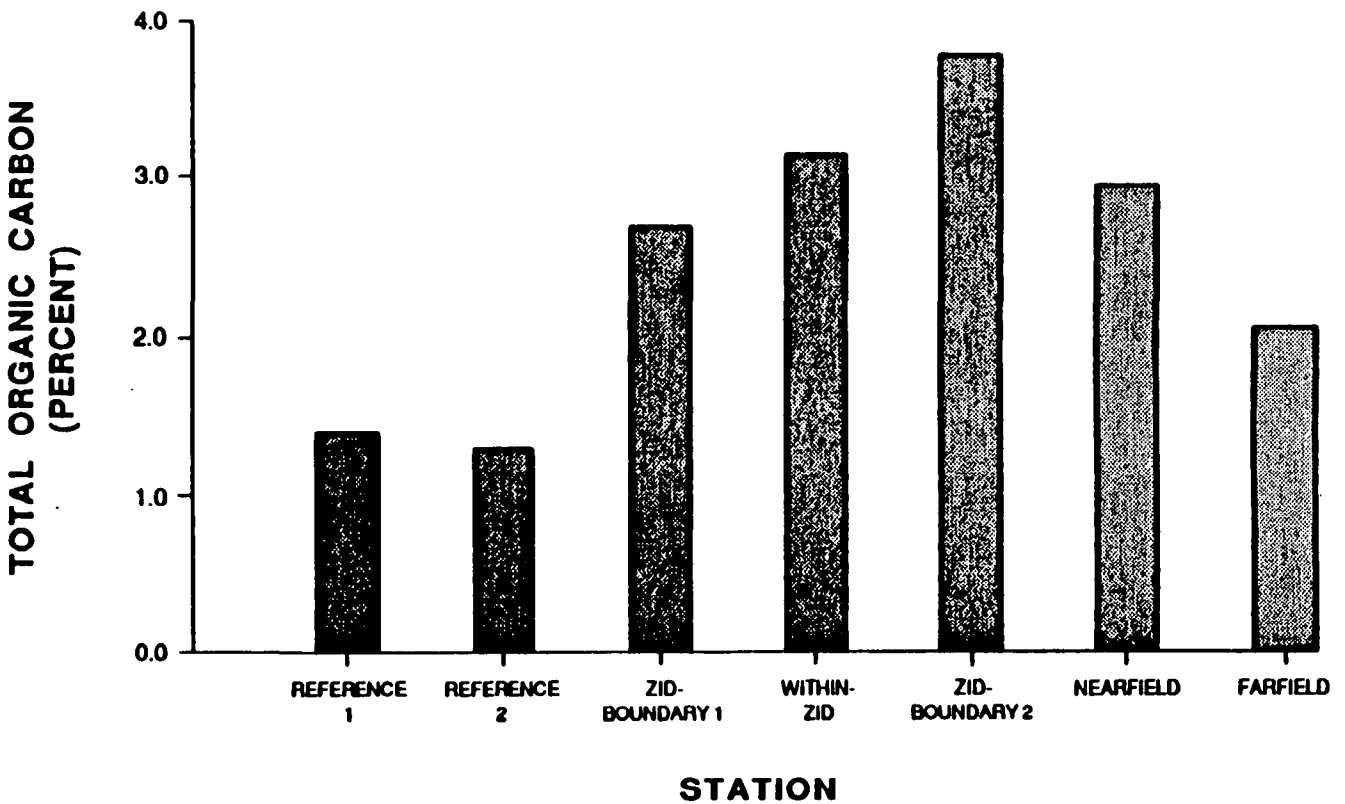

Figure C-3. Total organic carbon content of the sediments at stations in the vicinity of the outfall.

their three major grain-size categories (Figure C-4)
. Sand, silt, and clay are often the most useful categories. However, the gravel, sand, and mud (silt plus clay) categories are useful where sediments are relatively coarse. [See Shepard (1963) for information on sediment grain size scales.]

Statistical tests are among the most effective tools for comparing biological communities among stations. A variety of statistical tests are available, the most widely used of which is one way analysis of variance (ANOVA). ANOVA and other statistical tests have been used extensively for biological comparisons in the 301(h) program, but they have often been used improperly. For this reason, procedures for conducting statistical comparisons using biological data are discussed briefly below. Applicants are encouraged to consult references on biostatistics (e.g., Zar 1974; Sokal and Rohlf 1981) for more specific guidance on the application of these procedures.

The use of one way ANOVA for biological comparisons is preferred because ANOVA is an efficient and robust test. ANOVA compares the mean values of a given variable among stations (or groups of stations) for the purpose of detecting significant differences at a predetermined probability level. ANOVA requires a minimum of three replicate values at each station to estimate the mean value and associated variance.

ANOVA is a parametric test based on three assumptions: the error of an estimate is a random normal variate, the data are normally distributed, and the data exhibit homogeneous variances. Corrections for the first are not easily achieved, and an erroneous assumption can greatly affect the results of the test. Fortunately, error estimates in survey data are usually independent.

ANOVA is relatively robust with respect to the assumption that the data are normally distributed. Substantial departures from normality can occur before the value of the F-statistic is affected greatly (Green 1979). For

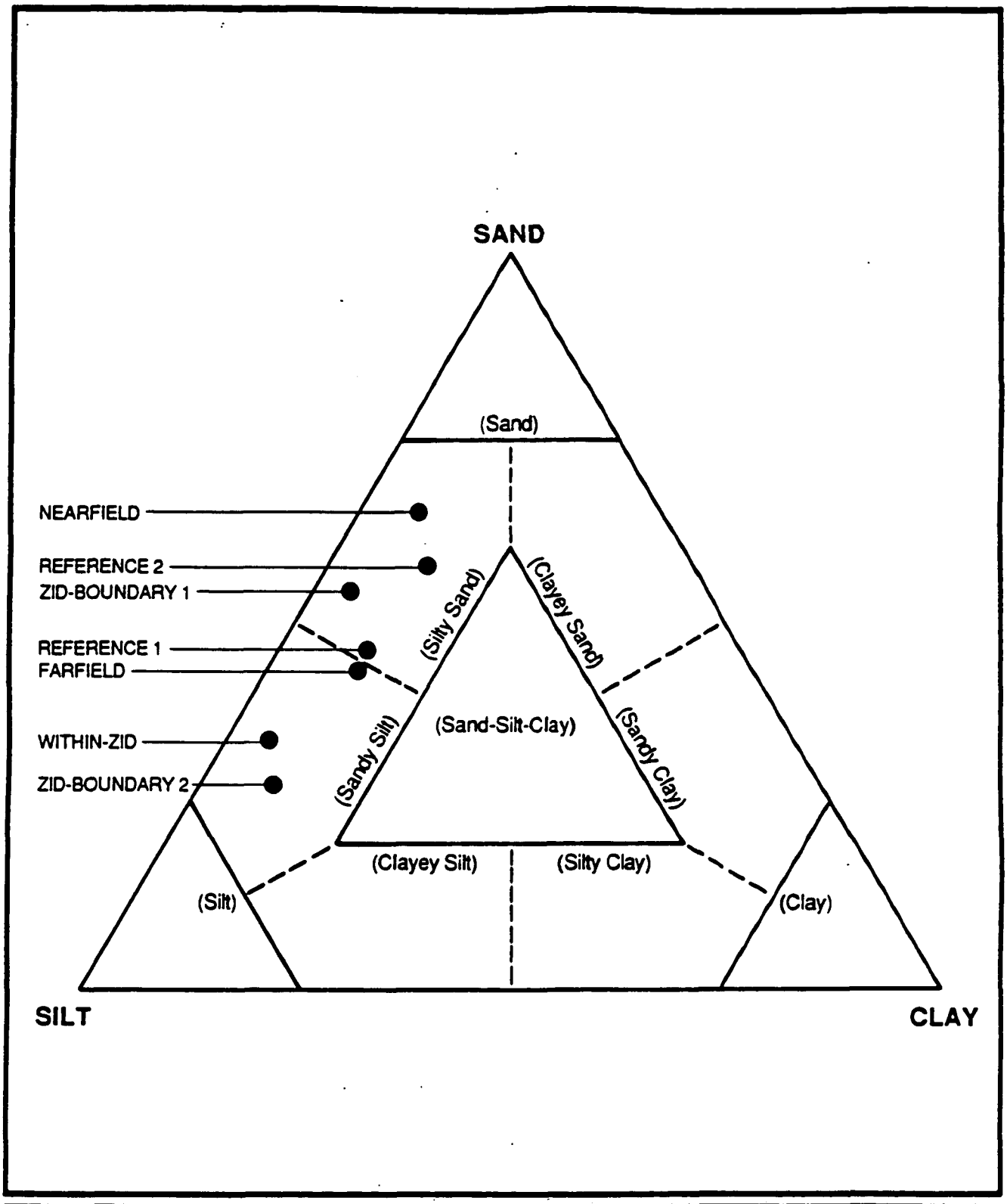

Figure C-4. Sediment grain size characteristics at stations in the vicinity of the outfall.

this reason, tests for normality are not usually conducted before data are analyzed using ANOVA.

The third assumption, that variances are homogeneous, is critical to execution of ANOVA. Heterogeneous variances can greatly affect the value of the F-statistic, especially in cases where the statistical design is unbalanced (i.e., where numbers of replicate values vary among the stations or station groups being tested).

Several tests are available to determine whether variances are homogeneous. The Fmax test (see Zar 1974; Sokal and Rohlf 1981) and Cochran's C test (Winer 1971) are both appropriate, although the latter is preferred because it uses more of the information in the data set. Bartlett's test is not recommended because it is overly sensitive to departures from normality (Sokal and Rohlf 1981).

When sample variances are found to differ significantly ($P<0.01$), a transformation should be applied to the data. [A more conservative probability level (e.g., $P<0.05$) should be used when the statistical design is unbalanced. ANOVA is sensitive to unbalanced statistical designs.] Sokal and Rohlf (1981) describe several transformations that may be used. Because ANOVA on transformed data is usually a more efficient test for detecting departures from the null hypothesis than is the Kruskal-Wallis test (the nonparametric analog of ANOVA), the Kruskal-Wallis test should only be used when the appropriate transformation fails to correct for heterogeneous variances (Sokal and Rohlf 1981). The Kruskal-Wallis test requires a minimum of five replicate values per station because it is a test of ranks.

When ANOVA or a Kruskal-Wallis tests are performed, significant differences ($P<0.05$) among individual stations or groups of stations may be determined using the appropriate *a posteriori* comparison. Of most importance in 301(h) demonstrations are differences among reference stations and stations within the ZID, at the ZID boundary, and beyond the ZID. It is primarily these comparisons upon which determination of the presence or absence of a balanced indigenous population is based.

Classification analyses (e.g., cluster analyses) have also been used extensively in the 301(h) program. In the normal classification mode, stations are grouped by the attributes of the assemblages that occur there (e.g., species composition and abundance). This type of analysis is very useful for identifying the stations that are the most similar and least similar to one another in fauna and/or flora. Because biological communities respond to organic materials and other pollutants, stations at which pollutant impacts are occurring typically cluster together in interpretable groups. Inverse classification analysis, in which taxa are grouped by the stations at which they co-occur, is also helpful because it defines assemblages that are characteristic of different levels and types of pollutant impacts.

Classification analysis involves two analytical steps: calculation of a matrix of similarity values for all possible station pairs, and grouping of stations based on those between-station similarity values. Many similarity indices and clustering strategies are available to perform these two tasks (see Boesch 1977; Green 1979; Gauch 1982; Pielou 1984; Romesburg 1984). However, only the Bray-Curtis similarity index and either the group average clustering strategy (i.e., the unweighted pair-group method using arithmetic averages) or the flexible sorting strategy have been used commonly in 301(h) demonstrations. Their continued use is recommended. The Bray-Curtis index is easily understood, and has been used widely in ecological studies. Moreover, two comparisons of similarity indices (i.e., Bloom 1981; Hruby 1987) have shown it to be superior to many of the other commonly used resemblance measures. Both the group average clustering strategy and the flexible sorting strategy are recommended because they produce little distortion of the original similarity matrix. [See Tetra Tech (1985) for additional rationale on the use of these three indices.]

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APPENDIX D

NAVIGATIONAL REQUIREMENTS AND METHODS

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APPENDIX D
NAVIGATIONAL REQUIREMENTS AND METHODS

Information presented below addresses navigational requirements and methods for Section 301(h) dischargers. It is summarizes more detailed discussions in Tetra Tech (1987, 1988).

MONITORING STATION LOCATIONS

Compliance with conditions of a secondary treatment variance requires monitoring at a site-specific array of sampling locations. The types of stations usually specified in 301(h) monitoring programs are depicted in Figure D-1. Positioning accuracy is most critical for the within-ZID and ZID-boundary stations (Stations Z_0, Z_1, Z_2 in Figure D-1). Applicants must be able to sample at a specific boundary location on any given occasion, and to return to nearly the same location on subsequent trips. At gradient (G_1, G_2, G_3, G_4) and control or reference (C_1) stations, initial accurate location is not as critical. However, it is important to relocate these stations accurately during subsequent surveys to enable quantification of temporal changes in the variables sampled (e.g., benthic community characteristics). This requirement for high repeatable accuracy also applies to stations in or near special habitats (H_1, H_2). The ability to conduct sampling at the appropriate depth contour is also very important. Sampling programs for 301(h) typically include requirements that a bottom sampling station can be relocated to within 10 m (32.8 ft).

ACCURACY LIMITATIONS

Both the procedures and equipment used to establish a navigational position contribute errors that affect the overall accuracy of a fix. Absolute or predictable accuracy is a measure of nearness to which a system can define a position by latitude and longitude (Bowditch 1984). Repeatable

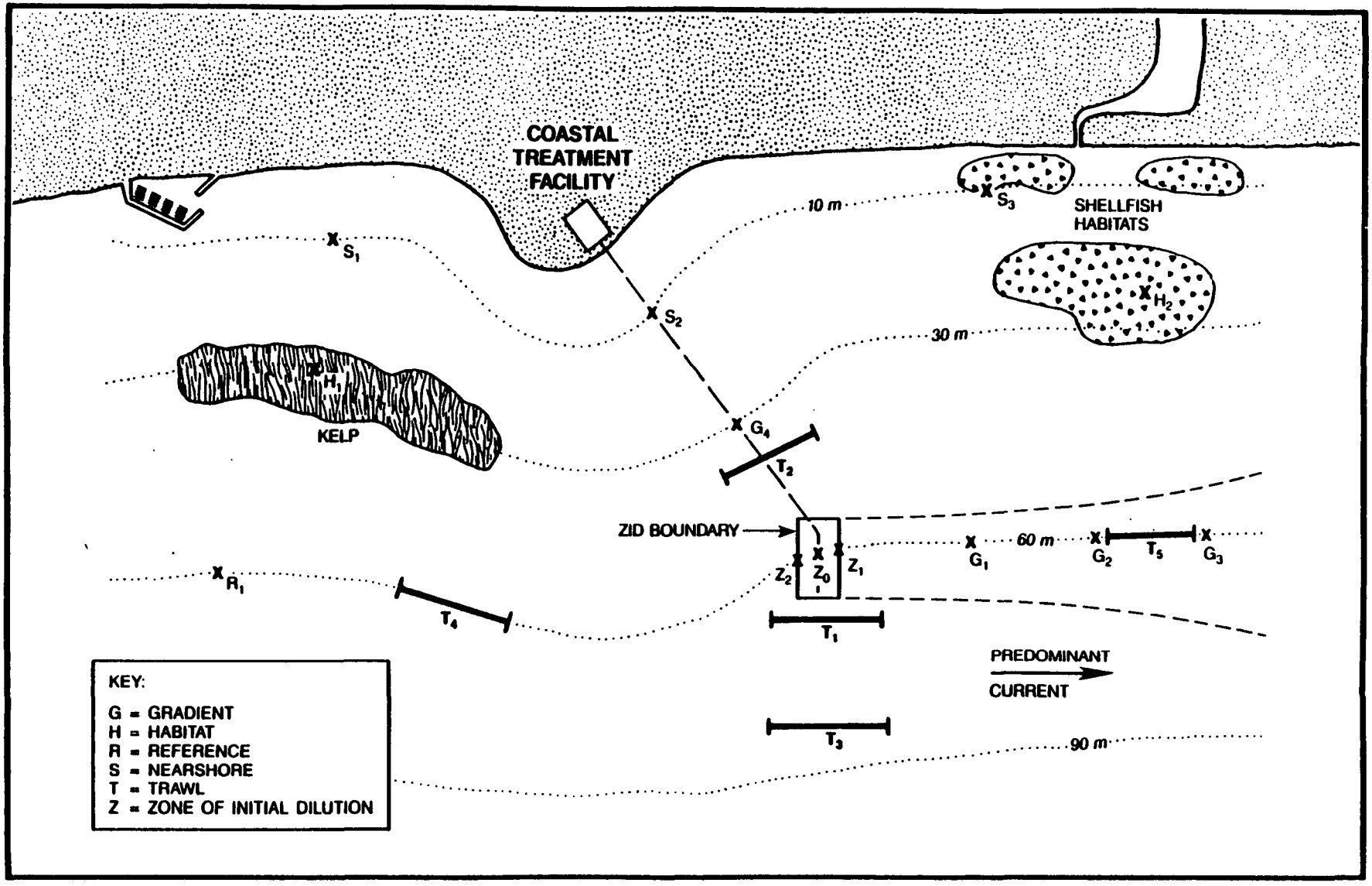

Figure D-1. Examples of some key 301(h) monitoring station locations for a medium-large marine municipal discharge.

or relative accuracy is a measure of a system's ability to return the user to a given position with coordinates that were previously measured with the same system. The difference between these two accuracies can be substantial. For example, depending on one's location in the coverage area, Loran-C has a repeatable accuracy in offshore areas of 15-90 m (49-295 ft), but an absolute accuracy of 185-463 m (607-1,519 ft) (Dungan 1979). In many instances, repeatable accuracy is more important than absolute accuracy (e.g., retrieval of crab pots, return to desirable fishing grounds, avoidance of underwater obstructions, and reoccupation of reference stations).

For coastal outfall monitoring, both repeatable and absolute accuracy can be important, depending on the type of sampling site. For within-ZID and ZID-boundary stations, both accuracies are important because sampling stations must be located within or very near the boundary and be repeatedly occupied during the program. For gradient, special habitat, and reference stations, repeatable accuracy is more important than absolute geographic location. Once such a station is established within a special habitat, it is often necessary to return to the same site to identify temporal variations in the previously sampled biological community. Thus, it is important to select navigational procedures and equipment with both the absolute and repeatable accuracies needed to meet the monitoring program objectives.

Because repeatable accuracy of navigational equipment is usually at least 1 order of magnitude better than absolute accuracy, the latter frequently limits the overall positioning accuracy of a sampling vessel during coastal monitoring programs. Therefore, the following discussion focuses on absolute accuracies that can be achieved by various procedures and associated equipment.

Practical considerations also limit the accuracy of an offshore positional fix. Resolution of a position to better than 1-2 m (3.3-6.6 ft) becomes meaningless when measuring the location of a moving vessel (e.g., during trawling) or a vessel that is on station but pitching and rolling.

Antenna movement alone usually precludes higher resolution in position coordinates. Exceptions to this rule can occur when conditions are unusually calm.

POSITIONING ERROR

Many factors contribute to the total error in position of the water column or benthic sampling point. These factors include movement or drift of the "on-station" vessel, offsets between the deployment point of sampling equipment and the navigational system antenna, and offsets between the deployment point and the subsurface location of the sampling or profiling equipment, and error in the ship's initial location. Most of these factors are site- or operationally specific, and can be estimated with varying degrees of confidence. Because the accuracy to which the actual sampling point is known is highly dependent on all these factors, they should be carefully considered in both the design and conduct of monitoring programs.

A ZID-boundary error proportional to some percentage of the ZID dimension has been selected as the controlling parameter for 301(h) navigational requirements. Because ZID size is proportional to water depth, the allowable error in position is thus also proportional to depth. For example, ZID-boundary stations can be located at a distance from the diffuser axis equal to one-half the ZID width plus 20 percent of the water depth at mean tide level. The allowable maximum error in the location of these stations can then be $\pm$20 percent of the water depth. As a result, the closest to the diffuser that sampling would occur is at the ZID boundary, and the farthest from the diffuser that sampling would occur is 40 percent of the water depth beyond this boundary. Nominally, however, sampling would be performed within a distance from the ZID boundary equal to 20 percent of the water depth. Example ZID-boundary station locations using this approach for a variety of ZID sizes are listed in Table D-1. The ZID-boundary and sampling station locations for discharges at the 100-, 60-, and 20-m (328-, 197-, and 66-ft) depths are shown in Figure D-2.

TABLE D-1. EXAMPLE ZID-BOUNDARY STATION LOCATIONS

Average Diffuser Depth (m)	Average Diffuser Diameter (m)	ZID Width (m)	Recommended Station Location[a] (m)	Recommended Allowable Error[b] (m)
100	4.0	204.0	122.0	±20
90	3.6	183.6	109.8	±18
80	3.4	163.4	87.7	±16
70	3.2	143.2	85.6	±14
60	3.0	123.0	73.5	±12
50	2.5	102.5	61.3	±10
40	2.2	82.2	49.1	±8
30	2.0	62.0	37.0	±6
20	1.8	41.8	24.9	±4
15	1.5	31.5	18.8	±3
10	1.5	21.5	13.8	±3
5	1.0	11.0	8.5	±3
3	0.5	6.5	6.3	±3

[a] Distance from the zone of initial dilution centerline to the station, based on 0.5 times the ZID width plus 20 percent of the average water depth of the diffuser when over 15 m (49 ft).

[b] Error magnitude is equal to ±20 percent of the average diffuser depth, when over 15 m (49 ft).

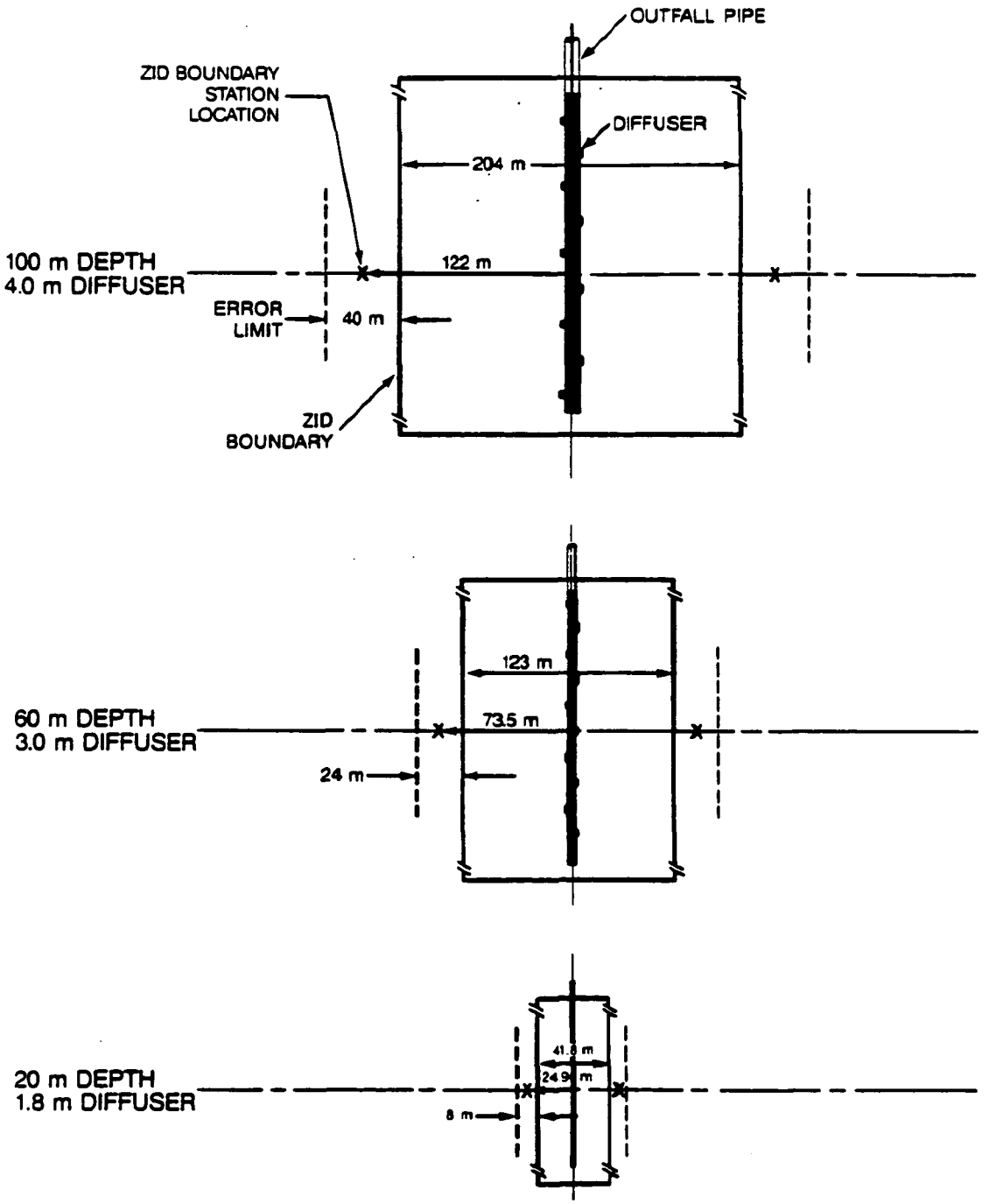

Figure D-2. Locations of ZID-boundary stations for selected ZID sizes.

When discharge depths are less than approximately 15 m (49 ft), the 20 percent error allowance results in an overly restrictive positional error [i.e., less than ±3 m (9.8 ft)]. Therefore, a positioning error of ±3 m (9.8 ft) is considered to be more appropriate when sampling station depths are less than 15 m (49 ft). Although the percent error as a function of water depth increases at shallower depths, this minimum error is considered reasonable given available navigating techniques for small sampling vessels in other than extremely calm waters. Stations beyond the ZID may be similarly located using the 20 percent of depth rule beyond the 15-m (49-ft) contour and the ±3-m (9.8 ft) error limitation for shallower locations. As indicated earlier, it is recognized that the ability to reoccupy a given site can be as important as knowing its exact geographical location. However, relocation beyond the ZID probably will not be a problem if the same navigational equipment used to locate ZID-boundary stations is also used elsewhere.

SUMMARY OF RECOMMENDED PROCEDURES AND EQUIPMENT

Based on Tetra Tech's evaluation of optional positioning methods, the systems recommended for coastal positioning include theodolites, sextants, electronic distance measuring instruments (EDMIs), total stations, and microwave and range-azimuth systems. Although satellite systems offer adequate accuracy (when used in a differential mode), their use may be limited because a sufficient number of satellites may not always be available.

CANDIDATE SYSTEM SELECTION

The details of positioning techniques and associated equipment are described in Tetra Tech (1987). No single system is best for all coastal monitoring purposes. Needs vary according to the size and complexity of the planned monitoring program, the nature of the immediate and surrounding areas, and other navigational or surveying requirements of a municipality.

Positioning techniques fall into three principal measurement categories:

- Multiple horizontal angles
  - Theodolite intersection
  - Sextant angle resection
- Multiple electronic ranges
  - Distance-measuring instruments
    - Range-range mode
    - Hyperbolic mode
    - Satellite ranging
- Range and angle
  - Theodolite and EDMI
  - Total station
  - Range-azimuth navigation systems

Systems within these categories that will meet or exceed the positional accuracy recommended herein are summarized in Table D-2. Additional information on the recommended categories is provided below.

Multiple Horizontal Angles

In the multiple horizontal angles category, theodolites were found to have the angular accuracies required for the maximum ranges anticipated. Their costs range from $1,000 to $4,000 (30-sec vs. 10-sec accuracy), and

TABLE D-2. SUMMARY OF RECOMMENDED SYSTEMS

Category	Representative[a] Equipment	Accuracy	Cost	Advantages	Disadvantages
Theodolite	Table B-1 Table B-2	10-30 sec ±1 m (3.3 ft)	$1,000-$4,000	Traditional method. Inexpensive. High accuracy. Successfully applied. Restricted areas.	Line-of-sight. Two manned shore stations. Simultaneous measurements. Limits on intersection angles. Area coverage; station movement.
Sextant	Table B-3	±10 sec ±2 m (6.6 ft)	$1,000-$2,000	Rapid. Easy to implement. Most widely used. Low cost. No shore party. High accuracy.	Simultaneous measurement of two angles. Target visibilities, location, maintenance. Line-of-sight. Best in calm conditions. Limits on acceptable angles.
EDMI	Table B-4	1.5-3.0 cm	$3,500-$15,000	Extremely accurate. Usable for other surveying projects. Cost. Compact, portable, rugged.	Motion and directionality of reflectors. Visibility, unless microwave. Two shore stations. Ground wave reflection.
Total stations	Table B-5	5-7 cm	$8,000-$30,000	Single onshore station. Other uses. Minimum logistics.	Reflector movement and directionality. Prism costs.
Microwave navigation systems	Table B-6	±1-3 m	$40,000-$90,000	No visibility restrictions. Multiple users. Highly accurate. Radio line-of-sight.	Cost. Multiple onshore stations. Logistics. Security.
Range-azimuth systems	Table B-10	0.01° and 0.5 m	$65,000-$100,000	High accuracy. Single station. Circular coverage.	Single user. Cost.
Satellite systems	Table B-9	1-10 m	$150,000-$300,000 (initial units)	High accuracy. Minimum logistics. Use in restricted/congested areas. Future cost. No shore stations.	Current coverage. Initial development cost.

[a] Table references refer to Tetra Tech (1987).

they are readily available because they are widely used as a surveying instrument. At least two theodolites, two operators, a vessel siting target, and a three-way communications link to coordinate fixes are required. Visibility can be a limiting factor.

By comparison, sextant angle resection can be performed using one instrument if the vessel is stationary, or using two instruments simultaneously if the vessel is moving. Achievable angular accuracy of ±10 sec is adequate, and relatively inexpensive sextants ($1,000-$2,000) are readily available. Again, visible range can be limiting. Shooting an accurate fix from a non-stationary platform in any significant sea or swell could be more difficult than shooting with theodolites from shore. A distinct advantage of sextant angle resection is location of the navigators on the survey vessel. The method generally requires highly visible shore targets and a three-arm protractor for plotting positions.

Multiple Electronic Ranges

Positioning using multiple ranges can be accomplished with two staffed EDMI stations. Accuracies were found to be more than adequate but ranges were found to be marginal [if needed beyond 3 km (1.9 mi)] unless multiple prisms are used. Because such prisms are directional, procurement of multiple clusters for more than one direction could result in substantial additional costs. The initial investment (i.e., without multiple prisms) is $3,500-$5,000 each for two shorter-range units, or $8,000-$15,000 each for two longer-range units. Several microwave navigation systems with more than adequate range and sufficient accuracy are available in the $40,000-$90,000 range. Limitations include geometry of shore stations; position of the vessel in the coverage area (i.e., crossing angle limitations); and possible interferences due to line-of-sight obstructions, sea-surface reflective nulls, and land-sea boundaries. The hyperbolic mode provides multiple user capability, but at the cost of an additional shore station.

Satellite ranging holds promise because required accuracies should be achievable in the near future. Transit satellite-based systems do not offer

sufficient accuracy, except with multiple passes, and multiple passes are impractical when a given sampling station is occupied only briefly. Accuracies needed will undoubtedly be achievable in the future using differential global positioning system (GPS) techniques ($10,000-$40,000 for first units; as low as $1,000 for subsequent production models). Commercial geosynchronous satellite networks, such as GEOSTAR, may become available at a proposed system interrogator cost of $450 plus a monthly fee. However, this system is in the very early stages of planning, having only recently received FCC approval of requested frequencies. Finally, the codeless GPS systems (SERIES or Aero Services Marine GPS System) currently under development could be used, but at a current cost of over $250,000.

Range and Angle

Systems in the range-azimuth category show great promise. Required angular and range accuracies are available, only one shore station is needed, and costs depend on system refinements. At the low end of the scale, an EDMI and theodolite could be paired with a communication link for approximately $10,000-$12,000. Total stations developed specifically for this requirement range in cost from $8,000 for a manual station to $15,000-$30,000 for a fully automatic station. Optical and infrared range limitations apply to these systems. The three range-azimuth navigational systems examined provide sufficient positional accuracy with a single station at costs ranging from $65,000 for manual tracking to $70,000-$100,000 for fully automatic tracking.

SHALLOW-WATER POSITIONING METHODS

When sampling stations are located in relatively shallow water, they can be identified by relatively inexpensive methods (in addition to those discussed earlier in this report). Provided the center of the ZID over the outfall can be located (e.g., by diver-positioned surface float), an optical range finder may be used to establish the required distances to nearby water quality or biological sampling stations. An optical range finder is used by simply focusing a split-image on the target float, enabling the slant

distances to the target to be read from the instrument scale. When combined with a careful compass reading, this distance reading allows positioning of the sampling vessel.

A survey of accuracies claimed for commercially available instruments suggests that the ±3 m (9.8 ft) recommended minimum accuracy can be achieved for ranges up to approximately 100 m (328 ft) from the surface target. The Lietz Model 1200, for example, provides an accuracy of ±1 m (3.3 ft) at 100 m (328 ft). Beyond this distance, instrumental errors increase rapidly. For the instrument cited, a ±9 m (29.5 ft) accuracy is quoted at 300 m (984 ft). The suggested U.S. list prices of optical range finders vary from $35 to $120 (Folk, L., 21 March 1985, personal communication).

An acceptable alternative method for collecting bottom samples from desired locations in shallow water is to use divers. Provided visibility is adequate, divers may measure radial distances to desired locations by holding a tape at the outfall and traversing the appropriate distance over the bottom in the proper direction.

Visual ranges have sometimes been used to establish a station position. This method requires that a minimum of two objects are in alignment, enabling the vessel to be placed on a common axis extending to the vessel's position. Simultaneous siting on a second set of at least two objects places the vessel at the intersection of the two common axes. The accuracy of each visual range is highly dependent on the quality of the visual range (e.g., alignment), the distance from the alignment objects to the vessel, and the angle between each range. Also, the number of visual ranges used affects the magnitude of the positional error. Although this technique is frequently used for positioning single sampling stations in bays, harbors, and other areas in which two or more conveniently alignable targets can be selected, the method is not considered acceptable for coastal monitoring at ZID-boundary stations. Also, it is not likely that a sufficient number of alignment target-pairs will be present for all desired locations. In addition, the unpredictability of repeatable position error detracts from the value of this method.

Permanent installation of a marker buoy at the outfall terminus or midpoint of the diffuser allows easy return to this point on subsequent sampling trips. Using the previously discussed range-finder technique or a line of desired length enables positioning at desired distances from the marker buoy. However, it is not uncommon to lose such a buoy due to vandalism, impact, or severe weather conditions. Therefore, it is necessary that the sampling party be prepared to relocate the outfall (e.g., by diver, sonar, or pinger mounted on the outfall itself), if location of stations is dependent on knowledge of the outfall location.

Because the techniques described here are inexpensive to implement (as are use of the sextant resection or theodolite intersection methods), they are attractive to small coastal municipalities. However, use of more sophisticated and less labor-dependent techniques may be achievable at moderate costs by renting or leasing, rather than buying such equipment.

USE OF LORAN-C

In their evaluation of positioning methods, Tetra Tech (1987) concluded that Loran-C did not provide the absolute and repeatable accuracies needed for the 301(h) program. However, because Loran-C is in such wide use and is relatively inexpensive, use of Loran-C in a special operating mode was re-examined in Tetra Tech (1988). The special operating mode is called differential Loran-C, which requires an additional Loran-C receiver onshore at a known geographic location. At this location, the Loran-C signals are received, and a correction is generated and transmitted to the survey vessel, allowing the correction to be applied to signals received by the ship's Loran-C unit.

Differential Loran-C was found to significantly improve the positional accuracies achievable compared to Loran-C in the normal mode. During a simulated monitoring program near Newport Beach, California, normal Loran-C positional errors of 40-50 m (131-164 ft) were reduced to 7-15 m (23-49 ft) using differential Loran-C in conjunction with special vessel operating

procedures, a video display, and data averaging techniques. Higher accuracies are expected in other coastal areas where improved lattice line crossing angles occur. Acceptability may depend on relative orientations of the diffuser and the error ellipse axes (Figure D-3, Table D-3). For those considering use of differential Loran-C, a procedure for determining the error in a ZID-boundary station location is provided in Tetra Tech (1988).

SYSTEM SELECTION PROCEDURE

A procedure for selecting an appropriate navigation system is described in detail in Tetra Tech (1987). The procedure involves definition of positioning requirements, establishment of screening criteria (e.g., range, accuracy, availability, and costs), review of candidate systems, and evaluation of purchase/lease options. As indicated in Figure D-4, a stepwise screening technique is recommended to identify an optimal system for a given monitoring program. At each step in the screening process, systems that cannot achieve the required criterion are removed from further consideration.

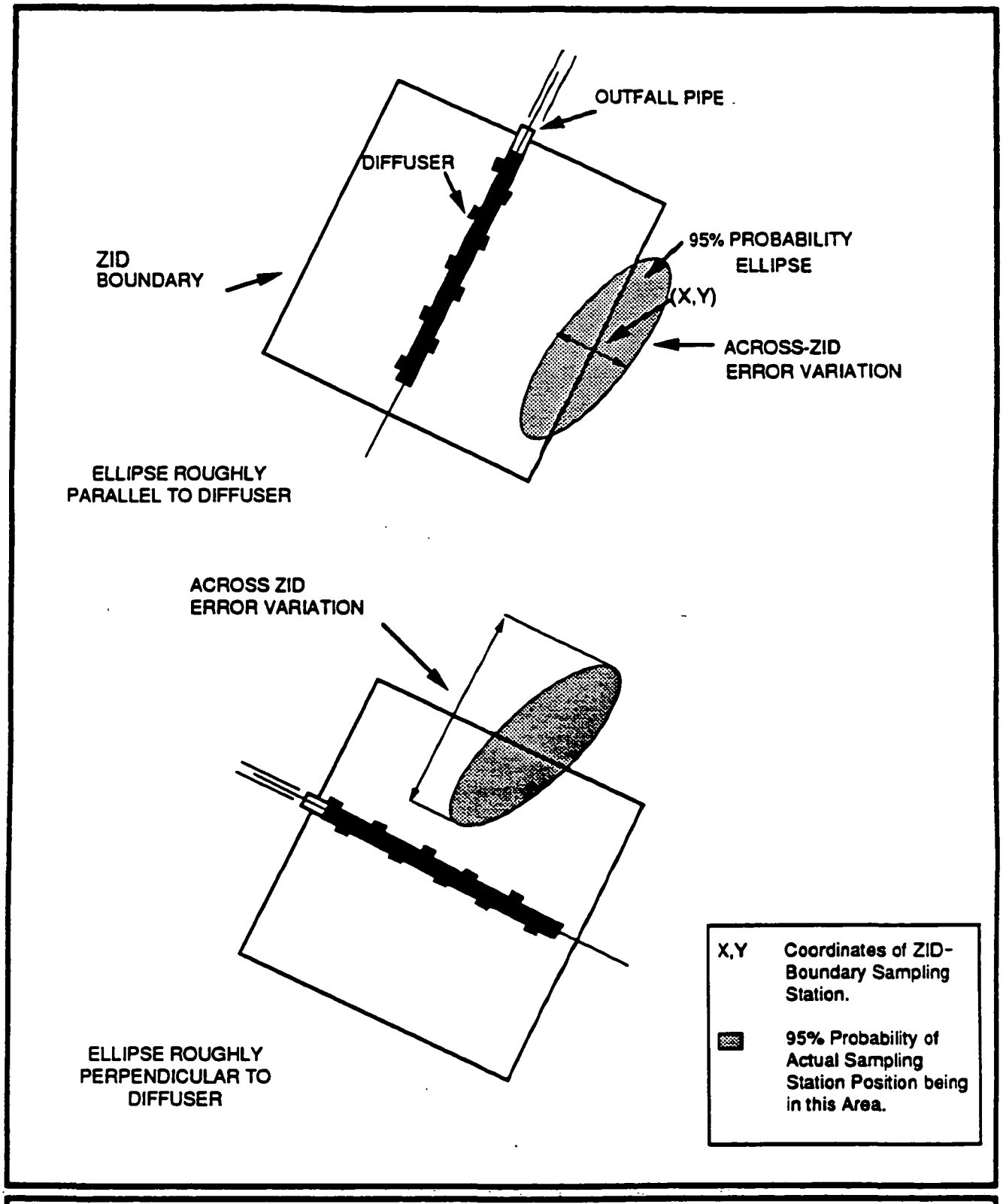

Figure D-3. Examples of differential Loran-C error ellipse orientation at a ZID-boundary sampling station.

TABLE D-3. THEORETICAL ERROR ELLIPSES OF DIFFERENTIAL LORAN-C FOR VARIOUS U.S. LOCATIONS

Location	Approximate Direction of Major Axis	Length of Major Axis[a]	Length of Minor Axis[a]
Anchorage, AK	NW/SE	70	20
Puget Sound, WA	NW/SE	180	40
San Francisco, CA	NE/SW	60	30
Los Angeles, CA	NE/SW	90	30
San Diego, CA	N/S	90	20
Mississippi Delta, LA	NW/SE	50	20
Panama City, FL	N/S	30	20
Chesapeake Bay, VA	W/E	40	20
Boston, MA	N/S	30	20

[a] Lengths are given to the nearest 10 m based on 95 percent confidence level error ellipses. Standard deviation of time differences is 25 nsecs (achievable with differential Loran-C).

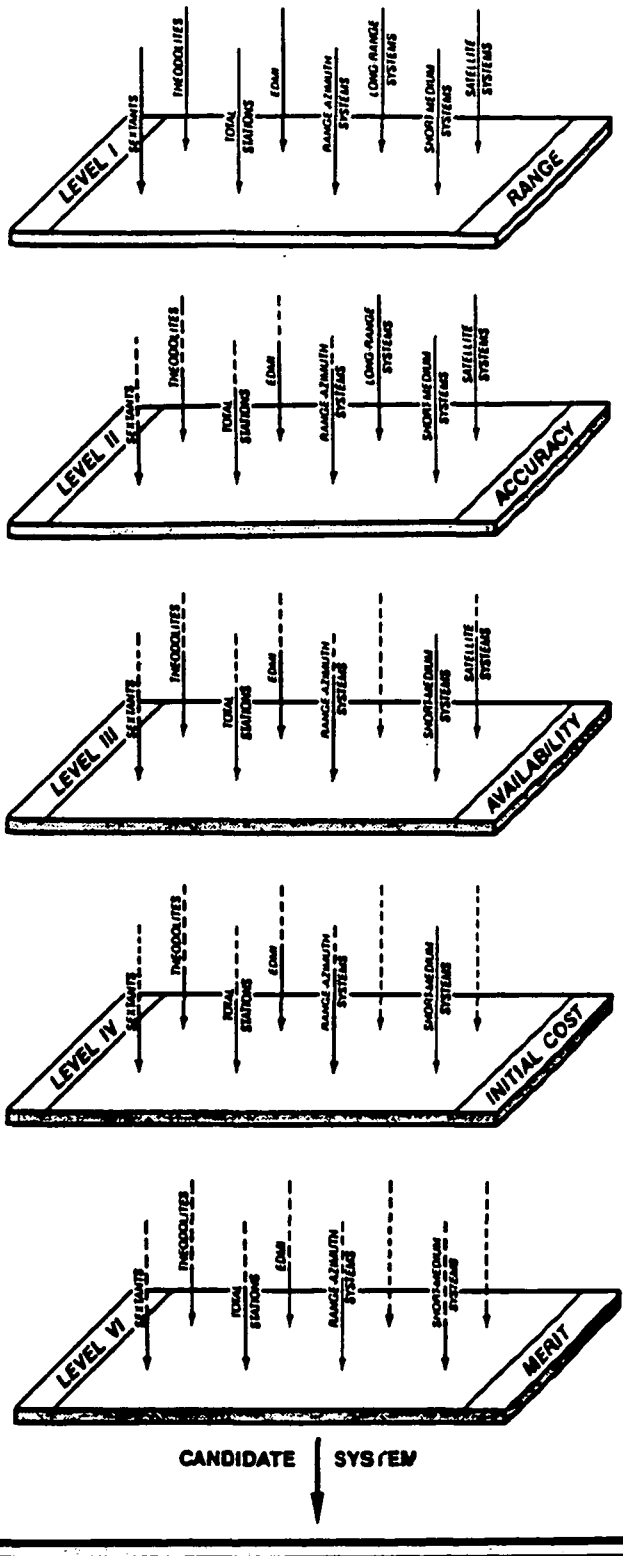

Figure D-4. Navigation system preliminary screening criteria.

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APPENDIX E

URBAN AREA PRETREATMENT REQUIREMENTS

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INTRODUCTION

Section 303(c) of the Water Quality Act of 1987 amended Section 301(h) of the 1977 Clean Water Act by adding the "urban area pretreatment requirement." This requirement applies only to POTWs serving a population of at least 50,000 and only to toxic pollutants introduced by industrial dischargers. For each toxic pollutant introduced by an industrial discharger in affected POTWs, the applicant must demonstrate that it meets one of the following two conditions:

- Has an "applicable pretreatment requirement in effect"
- Achieves "secondary removal equivalency."

This new statutory requirement complements the toxics control program requirements in the existing Section 301(h) regulations (40 CFR 125.66) and other pretreatment requirements in 40 CFR 403.

The intent of this appendix is to help POTWs interpret and comply with the new requirement. For site-specific reasons, concepts and procedures recommended herein may not necessarily apply to all 301(h) applicants. Issues that are not addressed by this appendix should be directed to U.S. EPA Regional offices. Applicants should also check with appropriate state and local agencies for any explicit requirements (e.g., water quality standards) that apply to them. The procedures to demonstrate compliance with this urban area requirement must be formulated and implemented by each POTW with concurrence from the appropriate U.S. EPA Regional office. Compliance with the urban area pretreatment requirement is required before a 301(h) permit may be issued by U.S. EPA, although tentative approval may be granted on demonstration of the applicant's good faith effort.

When a review of the 301(h) application indicates that noncompliance with pretreatment requirements is substantial and that the applicant is not taking effective steps to assure compliance, then U.S. EPA may deny the permit. Factors relevant to such a decision include the number of non-complying industrial sources, the nature of their toxic pollutant contribution to the POTW, and potential or actual POTW interference of pass-through.

APPLICABLE TREATMENT PROGRAM APPROACH

Applicable pretreatment requirements for each toxic pollutant may take one of two forms:

- Categorical standards
- Local limits.

Categorical standards are nationally uniform, technology-based pretreatment limitations developed for specific industrial categories under Section 307 of the Clean Water Act. All categorical industries must comply with categorical standards, even if they discharge to a POTW without a federally approved local pretreatment program. By contrast, local limits are developed by the POTW to prevent interference with the treatment works or pass-through of toxic pollutants, as required by 40 CFR 403.5(b).

A given industrial discharger may be subject to categorical standards for some pollutants and local limits for other pollutants, or to both types of limitations for the same pollutant. In the latter case, the stricter standard applies. The urban area pretreatment requirement for all toxic pollutants entering a POTW will probably require a combination of both forms of pretreatment standards.

U.S. EPA GUIDANCE

The U.S. EPA Office of Water Enforcement and Permits (OWEP) and the U.S. EPA Office of Water Regulations and Standards (OWRS) have issued the following guidance manuals to assist POTWs in implementing pretreatment regulations and developing technically based local limits:

- *Guidance Manual for POTW Pretreatment Program Development* (U.S. EPA 1983a)

- *Procedures Manual for Reviewing a POTW Pretreatment Program Submission* (U.S. EPA 1983b)

- *NPDES Compliance Inspection Manual* (U.S. EPA 1984)

- *Guidance Manual for Implementing Total Toxic Organics (TTO) Pretreatment Standards* (U.S. EPA 1985a)

- *Guidance Manual for the Use of Production-Based Pretreatment Standards and the Combined Wastestream Formula* (U.S. EPA 1985b)

- *Pretreatment Compliance Monitoring and Enforcement Guidance* (U.S. EPA 1986a)

- *Guidance Manual for Preventing Interference at POTWs* (U.S. EPA 1987a)

- *Guidance for Reporting and Evaluating POTW Noncompliance with Pretreatment Implementation Requirements* (U.S. EPA 1987b)

- *Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program* (U.S. EPA 1987c) (enclosed as Attachment 2 to this appendix).

The implementation and enforcement guidelines in these manuals require the POTW to undertake the following:

- In the POTW industrial waste survey (which must be updated on a regular basis), identify and locate all industries that discharge pollutants into the POTW

- Demonstrate that the sampling procedures and analysis program undertaken were adequate to characterize industrial and nonindustrial pollutant loading to the POTW, and pollutant concentrations in the POTW influent, effluent, and sludge

- Compare measured pollutant concentrations to applicable sludge criteria or guidelines, water quality criteria or standards, and POTW process inhibition thresholds

- Demonstrate that the existing pretreatment program is adequate to control industrial user discharges, and that it contains specific numerical limits for industrial pollutants

- Demonstrate that local limits are technically based, adequate to protect the POTW, and allow compliance with its NPDES permit

- Demonstrate that steps have been taken to identify the causes of past POTW operating problems (e.g., industrial discharges, equipment failures, plant upsets, NPDES permit violations, sludge contamination) and correct them

- Demonstrate that POTW inspection and compliance monitoring procedures exist and are being implemented

- Demonstrate that the needed resources (e.g., funds, staff, equipment) are available to carry out program requirements.

LOCAL LIMITS

The technical approach used by a POTW to develop local limits is primarily a local decision, provided that the local limits are enforceable and scientifically based. Most POTWs use the headworks loading method in the U.S. EPA (1987c) local limits guidance manual. OWEP-recommended procedures for developing local limits appear as Attachment 1 to this

appendix. Best professional judgment can be used to establish pretreatment requirements when data or criteria are insufficient to perform a pollutant loading analysis for a specific pollutant of concern. The applicant may implement the local limits via uniform maximum allowable concentrations or discharger-specific maximum allowable mass emissions.

Local limits should be reviewed and revised periodically in response to changes in federal or state regulations, environmental protection criteria, plant design and operational criteria, or the nature of industrial contributions to POTW influent. For example, the following specific changes could affect criteria used to derive local limits:

- Changes in NPDES permit limits to include additional or more restrictive toxic pollutant limits
- Changes in water quality limits including toxicity requirements
- Changes in sludge disposal standards or POTW disposal methods
- Availability of additional site-specific data pertaining to pollutant removal efficiencies and/or process inhibition.

OWEP is presently developing guidance to determine the technical adequacy of local limits and to ensure their enforcement. This guidance will also clarify the use of best professional judgment for establishing local discharge limits or technology-based limits when the data are insufficient.

SECONDARY REMOVAL EQUIVALENCY APPROACH

One approach that 301(h) applicants may use to satisfy the new urban area pretreatment requirement is to demonstrate secondary removal equivalency. As noted in 40 CFR 125.65(d):

> An applicant shall demonstrate that it achieves secondary removal equivalency through the use of a secondary treatment pilot plant at the applicant's facility which provides an empirical determination of the amount of a toxic pollutant removed by the application of secondary treatment to the applicant's discharge, where the applicant's influent has not been pretreated. Alternatively, an applicant may make this determination using influent that has been pretreated, notwithstanding section 125.58(w).

In effect, the applicant's existing treatment processes and industrial pretreatment program must remove at least as much of a toxic pollutant as would be removed if the applicant applied secondary treatment and did not have an industrial pretreatment requirement for that pollutant. This approach can be represented as follows:

POTW existing treatment	+	industrial pretreatment	=	POTW existing treatment upgraded to secondary treatment	+	no industrial pretreatment

U.S. EPA recognizes, however, that it would be simpler for applicants to perform this demonstration by using a secondary treatment pilot plant on the actual pretreated influent. This approach is shown below:

POTW existing treatment	+	industrial pretreatment	=	POTW existing treatment upgraded to secondary treatment	+	industrial pretreatment

Although U.S. EPA will consider them, demonstrations to account for the effects of industrial pretreatment will probably be difficult. The secondary treatment pilot plant approach is conservative (i.e., protective) where it uses influent that has received industrial pretreatment, because the calculated required removals will be greater than those resulting from a demonstration using influent that has not been pretreated.

Secondary treatment at POTWs typically involves biological processes that remove organic matter through biochemical oxidation, usually variations of the activated sludge process. Other physical-chemical secondary treatment processes (e.g., coagulation, filtration, carbon adsorption) may also be used, particularly for nonbiodegradable wastewaters. The specific secondary treatment process used by a POTW is dependent on numerous factors such as wastewater quantity, waste biodegradability, and available space at the POTW site. Each POTW must determine the best strategy and the most applicable treatment process for complying with the secondary removal equivalency requirements.

The level of effluent quality attainable through the application of secondary treatment is defined in 40 CFR 133 (Table E-1). Treatment processes that are considered equivalent to secondary treatment (e.g., trickling filter, waste stabilization pond) are discussed in 40 CFR 133.105. Minimum levels of effluent quality attainable from these equivalent treatment processes differ from those shown in Table E-1.

Because secondary treatment levels were defined only for BOD, suspended solids, and pH, POTWs were usually not required to institute technology specifically to control toxic pollutants. Under the 1977 Clean Water Act, toxic pollutants in the POTW effluents were controlled predominantly through pretreatment programs, categorical standards, and local POTW limits required by the issuance of NPDES permits.

TABLE E-1. EFFLUENT WATER QUALITY VALUES THAT SHALL NOT BE EXCEEDED UNDER SECONDARY TREATMENT

Variable[a]	30-Day Average	7-Day Average	30-Day Average (Percent Removal)
BOD_5	30 mg/L	45 mg/L	>85
$CBOD_5$[b]	25 mg/L	40 mg/L	>85
SS	30 mg/L	45 mg/L	>85
pH	6.0 to 9.0		

[a] BOD_5 = 5-day measure of biochemical oxygen demand; $CBOD_5$ = 5-day measure of carbonaceous biochemical oxygen demand; SS = suspended solids.

[b] At the option of the NPDES-permitting authority, $CBOD_5$ may be substituted for BOD_5.

SECONDARY TREATMENT PILOT PLANT DESIGN CRITERIA

A secondary treatment pilot plant should be designed for an average flow of approximately 150 GPD. The flow rate should remain constant over a 24-h period. The pilot plant should require minimum operation and maintenance time, and must be able to operate unattended for 16-24 h. The organic loading will vary with the diurnal and seasonal fluctuations in the BOD_5 concentration in the existing POTW effluent. Design criteria for the secondary treatment pilot plant are shown in Table E-2.

A conventional activated sludge system (Figure E-1) for a POTW includes the following related components:

- Single or multiple reactor basins (i.e., aeration tanks) where microorganisms consume the organic wastes. These basins are designed to allow for complete mixing of its contents, which are defined as mixed liquor suspended solids (MLSS). Each basin must provide typical hydraulic retention times of 2-24 h.

- Pressurized or atmospheric oxygen-containing gases that are dispersed into the reactor basin.

- Settling basin (i.e., final clarifier) to separate the MLSS from the treated wastewater.

- Equipment to collect the solids in the settling basin, and to recycle the active biological solids (i.e., activated sludge) to the reactor basin.

- Equipment to remove excess active biological solids from the system.

Typical design variables for the conventional activated sludge process are shown in Table E-3. Additional information on activated sludge systems is

TABLE E-2. SECONDARY TREATMENT PILOT PLANT DESIGN CRITERIA

Reactor Basin (Aeration Tank)	
Volume	50 gal (189 L)
Detention time	8 h
Organic loading	25-60 lb BOD/1,000 ft^3/day (0.4-1.0 kg/m^3/day)
Air requirement	0.20-0.44 ft^3/min (0.33-0.75 m^3/h)
Settling Basin (Final Clarifier)	
Volume	20 gal (76 L)
Surface Area	0.375 ft^2 (0.035 m^2)
Overflow Area	400 gal/ft^2/day (16.3 m^3/m^2/day)
Solids Loading	14 lb/ft^2/day (68.4 kg/m^2/day)
Weir Length	0.5 ft (0.152 m)
Detention Time	3 h
Influent Feed Pump	
Capacity	0-290 gal/day (0-12.7 L/sec)
Type	Peristaltic
Return Activated Sludge Pump	
Capacity	0-130 gal/day (0-5.7 L/sec)

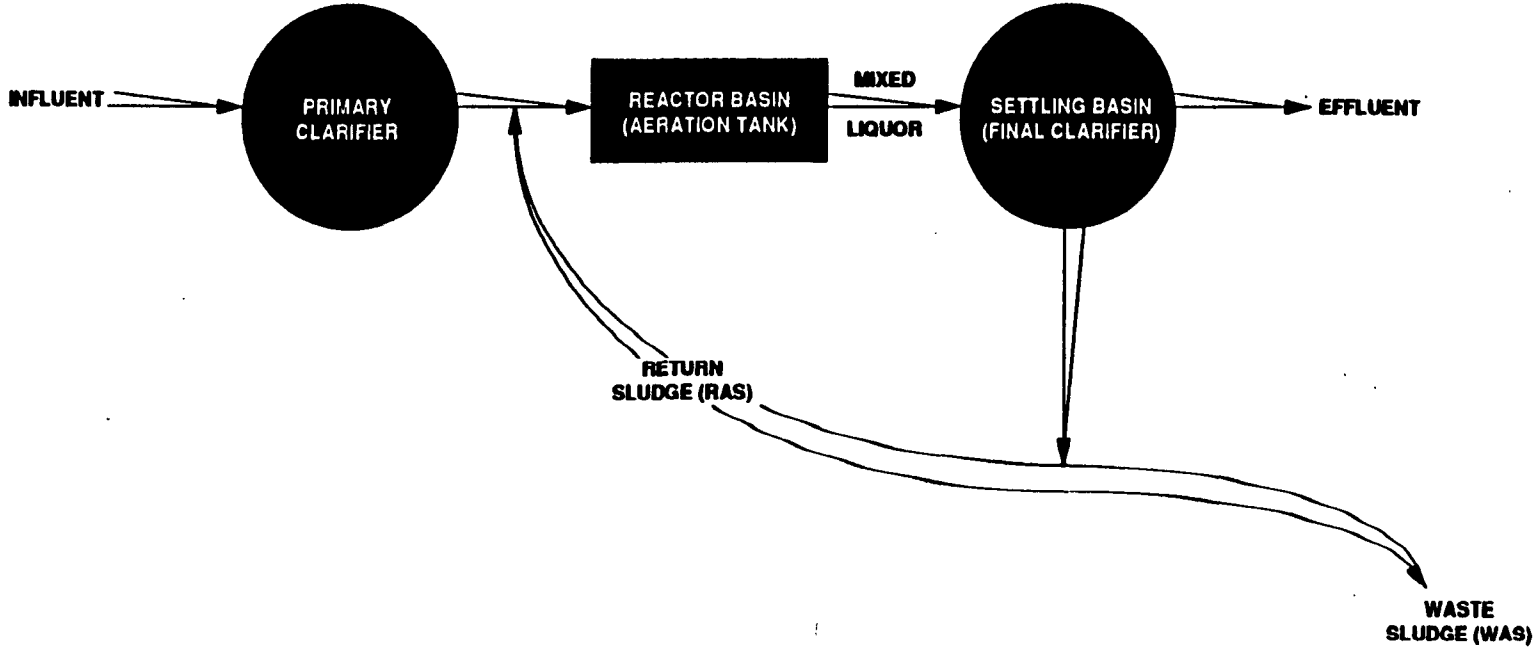

Figure E-1. Components of a conventional activated sludge system.

TABLE E-3. CONVENTIONAL ACTIVATED SLUDGE DESIGN PARAMETERS

Food to microorganism ratio	0.15-0.4 lb BOD_5/lb MLSS/day
Mean cell residence time	5-15 days
Aeration detention time	4-8 h
Oxygen requirements	0.8-1.1 lb (kg) O_2/lb (kg) BOD_5 removed
Return activated sludge flow rate	30-100 percent influent flow
Mixed liquor suspended solids (MLSS)	1,500-4,000 mg/L
Organic loading at 3,000 mg/L MLSS	20-60 lb BOD/1,000 ft^3 (0.3-1.0 kg BOD/m^3)
Respiration (oxygen uptake) rate at 3,000 mg/L MLSS	15-45 mg oxygen/L/h
Sludge volume index	90-150
Waste activated sludge	0.4-0.6 lb (kg)/lb (kg) BOD removed

provided by the Water Pollution Control Federation [(WPCF) 1976, 1987] and WPCF/American Society for Civil Engineers (1977).

SECONDARY TREATMENT PILOT PLANT STARTUP

In the activated sludge process, microorganisms metabolize nearly all soluble organic matter in the influent. The microorganisms (i.e., active biological solids) must be removed from the settling basin to produce an acceptable effluent, and the proper operation of the settling basin is critical. The following process control parameters should be monitored to ensure proper operation of the activated sludge system:

- MLSS
- Mixed liquor volatile suspended solids (MLVSS)
- Dissolved oxygen
- Sludge volume index (SVI)
- Sludge density index (SDI)
- Organic loading
- Return activated sludge (RAS) flow rate
- Waste activated sludge (WAS) flow rate
- Mean cell residence time (MCRT)/solids retention time (SRT)
- Food/microorganism ratio (F/M)
- Temperature

- Hydrogen ion concentration (pH)

- Respiration rate (RR).

In addition to these process control parameters, microscopic examination of the MLSS should be performed.

An initial F/M ratio of 0.2 should be achieved. Field operators should adjust the F/M ratio by changing the MLSS concentration in the reactor basin if the required 30-day average effluent quality (i.e., 30 mg/L BOD, 30 mg/L suspended solids) cannot be achieved. If temperature varies substantially between summer and winter, the F/M ratio will probably need to be lowered during winter to achieve the required effluent quality.

The pilot plant should be seeded with MLSS from a local domestic wastewater treatment facility. Acclimation of the pilot plant will require about 4-6 wk. If there is no local source of MLSS, the pilot plant may be started using the POTW's effluent. An additional 4-6 wk may be needed to ensure that the MLSS meets the desired design concentration.

The MLSS should be fed with domestic wastewater for the first 2-3 days. The volumetric proportion of the effluent should then be adjusted to 10 percent of the total feed for 4-5 days. After the initial week of operation, the volumetric proportion of the regular POTW effluent in the pilot plant feed can be increased approximately 5 percent per day until the system is receiving 100 percent POTW effluent.

Sampling for BOD_5 and suspended solids should be conducted daily during and after the acclimation period. Sampling for toxic pollutants should not be started until 2 wk after the pilot plant is receiving 100 percent POTW effluent.

SECONDARY TREATMENT PILOT PLANT OPERATING CRITERIA

The process control parameters identified in the preceding section should be monitored to provide information for process control and to determine treatment efficiency. A monitoring schedule is shown in Table E-4. The frequency of sample collection and analysis may vary for each POTW, however, depending on the size of the POTW, available laboratory facilities, available staff, and technical skills of personnel. Additional sampling and analysis may be required for abnormal conditions or during periods of process upsets. Implementation of the monitoring program, data interpretation, and pilot plant operation and maintenance is estimated to require about 5 labor hours per day. Each process control parameter is discussed below.

Mixed Liquor Suspended Solids

Samples of MLSS should be collected from the effluent end of the reactor basin twice daily and analyzed for suspended solids. This analysis will measure the total amount of solids in the aeration system. The concentration of the MLSS, which depends on the influent BOD_5 concentration, should be adjusted based on the daily average.

Mixed Liquor Volatile Suspended Solids (MLVSS)

Each MLSS sample should be analyzed for MLVSS. This analysis indirectly measures the living biological percentage of the MLSS. The concentration of MLVSS is normally 70 to 80 percent of the concentration of the MLSS.

Dissolved Oxygen

The concentration of dissolved oxygen in the reactor basins should be measured twice daily to ensure that a concentration of 1-3 mg/L is maintained. Samples should be collected about 2 ft below the surface of the reactor basin, near the effluent weir. The plant operator should adjust the air supply to provide more air if the dissolved oxygen concentration is less than 1 mg/L and less air if it is greater than 3 mg/L.

TABLE E-4. PILOT PLANT MONITORING SCHEDULE

Sampling Point	Parameters[a]	Frequency
Primary Effluent	Temperature	1 grab daily
	pH	1 grab daily
	SS	4 grabs weekly and 3 24-h composites weekly
	BOD_5	3 24-h composites weekly
	Overflow rate	1 grab daily
	$CBOD_5$	1 24-h composite weekly
MLSS	Temperature	1 grab daily
	pH	1 grab daily
	Dissolved oxygen	2 grabs daily
	Respiration rate	2 grabs daily
	Sludge volume index	2 grabs daily
	SS	1 grab daily
	VSS	1 grab daily
	Microscopic examination	1 grab daily
WAS/RAS	SS	1 grab daily
Secondary Clarifier	Sludge blanket depth	2 grabs daily
Final Effluent	Temperature	1 grab daily
	pH	1 grab daily
	Settleable solids	1 grab daily
	SS	4 grabs weekly and 3 24-h composites weekly
	BOD_5	3 24-h composites weekly
	$CBOD_5$	1 24-h composite weekly

[a] SS = Suspended solids; BOD_5 = 5-day biochemical oxygen demand; $CBOD_5$ = 5-day carbonaceous biochemical oxygen demand; VSS = volatile suspended solids.

Sludge Volume Index (SVI)

The rate at which the MLSS settles in the settling basin depends on the sludge characteristics. These characteristics are described by a simple settling test: 1,000 mL of the MLSS effluent is collected and allowed to settle for 30 min in a Mallory settleometer. At the end of 30 min, the volume of the settled sludge is measured. The SVI is calculated as follows:

$$SVI = \frac{\text{volume of settled sludge (mL)} \times 1{,}000}{\text{MLSS (mg/L)}}$$

The lower the SVI, the more dense the sludge. An SVI of 150 or less is usually considered good.

Sludge Density Index (SDI)

The SDI test is also used to indicate the settling characteristics of the sludge, and it is arithmetically related to the SVI:

$$SDI = \frac{100}{SVI}$$

SDI of a "good settling sludge" is about 1.0. A value of less than 1.0 indicates light sludge that settles slowly. An index greater than 1.5 indicates dense sludge that settles rapidly.

Organic Loading

From routine laboratory BOD_5 analysis, the plant operator can determine organic loading in the reactor basin.

$$\text{Organic loading} = (\text{lb BOD}/1{,}000\ \text{ft}^3/\text{day})$$

$$\text{POTW Effluent BOD (mg/L)} \times \frac{\text{POTW Effluent Flow (MGD)} \times 0.0624}{\text{Reactor Basin Volume (MG)}}$$

Return Activated Sludge (RAS) Flow Rate

To properly operate the activated sludge process, an MLSS that settles adequately must be achieved and maintained. The MLSS are settled in the settling basin and then returned to the reactor basin as RAS. The RAS allows the microorganisms to remain in the treatment system longer than the flowing wastewater. Changes in the activated sludge quality and settling characteristics will require different RAS flow rates.

Two basic approaches can be used to control the RAS flow rate. One approach establishes a constant RAS flow rate, independent of the influent flow. This approach is simple (i.e., maximum solids loading in the settling basin occurs at the start of the peak flow periods) and less operator attention is needed. A disadvantage of this approach is that the F/M ratio is constantly changing. However, because of short-term variation in the MLSS due to hydraulic loading, the range of fluctuation in the F/M ratio is generally small enough to ensure that no significant problems arise.

A second approach establishes the RAS flow rate as a constant percentage of the influent flow. This approach reduces variations in the MLSS concentration and the F/M ratio, and the MLSS remain in the settling basin for shorter time periods (which may reduce the possibility of denitrification in the basin). The most significant disadvantage of this approach is that the settling basin is subjected to maximum solids loading when the basin contains the maximum amount of sludge, which produces excessive solids in the effluent.

Two methods are commonly used to determine the RAS flow rate. The settleability method uses the settled sludge volume from the SVI test to calculate the RAS flow rate:

$$\text{RAS Flow Rate (MGD)} = \text{Volume of Settled Sludge (mL)} \times \frac{\text{[POTW Effluent Flow (MGD)]}}{1{,}000 \text{ mL}}$$

The second and more direct method is to monitor the depth of the sludge blanket in the settling basin. The depth of the sludge blanket should be less than one-fourth of the water depth of the settling basin sidewall. The operator must check the sludge blanket depth twice daily, adjusting the RAS flow to control the blanket depth. If the depth of the sludge blanket is increasing, increasing the RAS flow is only a short-term solution. Increases in sludge blanket depth may result from too much activated sludge in the treatment system, a poorly settling sludge, or both. If the sludge is settling poorly, increasing the RAS flow may cause even more problems by further increasing the flow through the settling basin. Long-term corrections noted below must be made to improve the settling characteristics of the sludge or remove the excess solids from the treatment system:

- If the sludge is settling poorly because of bulking, the environmental conditions for the microorganisms must be improved

- If there is too much activated sludge in the treatment system, the excess sludge must be wasted.

The best time to measure RAS flow is during the period of maximum daily flow, because the clarifier is operating under the highest solids loading rate. Adjustments in the RAS flow rate should be needed only occasionally if the activated sludge process is operating properly.

Waste Activated Sludge (WAS) Flow Rate

The increase of activated sludge is a cumulative process that eventually produces surplus WAS. This surplus has to be permanently removed from the treatment process and collected for ultimate disposal. The WAS flow rate should be determined and adjusted daily to maintain the desired mean cell

residence time (MCRT), based on the MLSS in the entire secondary system, and RAS suspended solids concentration:

$$\text{WAS Flow Rate (MGD)} = \text{MLSS (mg/L)} \times \frac{\text{[Aeration Tank Volume (MG) + Clarifier Volume (MG)]}}{\text{[desired MCRT(days)]} \times \text{[RAS Suspended Solids (mg/L)]}}$$

Mean Cell Residence Time (MCRT)/Solids Retention Time (SRT)

The MCRT, which is also called the SRT, is a measure of the age of sludge. Under normal conditions, the MCRT is 5-15 days. MCRT is defined as:

$$\frac{\text{Suspended solids in total secondary system (lb)}}{\text{Solids wasted (lb/day) + effluent solids (lb/day)}} =$$

$$\frac{\text{[MLSS (mg/L)]} \times \text{[Aeration Tank Volume(MG) + Secondary Clarifier Volume(MG)]}}{\text{[WAS Suspended solids (mg/L) x WAS Flow (MGD)] + [Effluent Suspended solids (mg/L) x Effluent Flow (MGD)]}}$$

MCRT is the best process control technique available to the plant operator. By using the MCRT, the operator can control the quantity of food available to the microorganisms and calculate the amount of activated sludge that should be wasted.

Food/Microorganism Ratio (F/M)

The F/M ratio is the ratio of BOD in the POTW effluent to the MLVSS. An F/M ratio of 0.15 to 0.4 is desirable. F/M is defined as:

$$\frac{\text{POTW Effluent BOD (mg/L)}}{\text{MLVSS (mg/L)}}$$

To control the F/M ratio, the operator must adjust the MLSS by wasting more or less sludge.

Temperature

In process control, accurate temperature measurements are required to predict and evaluate process performance, thereby enhancing microbial growth. Typically, the rate of microbial growth doubles for every 10^{o} C increase in temperature within the specific temperature range of the microbe.

Hydrogen Ion Concentration (pH)

The activity and health of microorganisms is affected by pH. Sudden changes or abnormal pH values may indicate an adverse industrial discharge. A pH drop will also result when nitrification is occurring in a biological process; alkalinity is destroyed and carbon dioxide is produced during the nitrification process.

Respiration Rate (RR)

The efficiency of the activated sludge process depends primarily on the activity of bacteria that use organic compounds in sewage for energy and reproduction. When in contact with an adequate food supply, viable bacteria will have a respiration rate (i.e., oxygen uptake rate) of 5-15 mg oxygen/h/g MLSS. Respiration rate data provide immediate information concerning viability, nitrification, organic loading, nutrient levels, and toxicity in the activated sludge.

The respiration rate, or oxygen uptake rate, is monitored with a dissolved oxygen meter over a time interval (t) (e.g., 6-10 min). The respiration rate is a measure of the decrease in dissolved oxygen concentration:

$$\text{RR (mg oxygen/h/g MLSS)} = \frac{[\text{DO change over t (mg/L)}] \times [60{,}000]}{[\text{MLSS (mg/L)}] \times [\text{t (min)}]}$$

Microscopic Examination

Microscopic examination of the MLSS can be used to evaluate the effectiveness of the activated sludge process. The most important microorganisms are the protozoa, heterotrophic bacteria, and autotrophic bacteria responsible for purifying the wastewater. Both protozoa (e.g., ciliates) and rotifers are indicators of treatment performance, and large numbers of these organisms in the MLSS indicate good quality sludge. Large numbers of filamentous organisms and certain ciliates indicate poor sludge quality, a condition commonly associated with a sludge that settles poorly (i.e, the sludge floc is usually light and fluffy because it has a low density). Many other organisms in the sludge (e.g., nematodes, waterborne insect larvae) may be found in the sludge. However, these organisms are not significant to the activated sludge process.

TOXIC POLLUTANT MONITORING PROGRAM, TESTING PROCEDURES, AND QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

A sampling strategy must be developed to estimate the difference between toxic pollutant concentrations in the existing discharge and those in the secondary treatment pilot plant discharge. Samples must be collected using proper techniques and analyzed using appropriate analytical methods. Both field and laboratory methods must be performed under defined QA/QC procedures.

Applicants are referred to the following documents for guidance on specific topics relevant to the design and execution of 301(h) monitoring programs:

- Sampling/Monitoring Program
  - *NPDES Compliance Sampling Manual* (U.S. EPA 1979a)
  - *Design of 301(h) Monitoring Programs for Municipal Wastewater Discharges to Marine Waters* (U.S. EPA 1982a)
  - *Handbook for Sampling and Sample Preservation of Water and Wastewater* (U.S. EPA 1982c)
- Chemical Analytical Methods
  - *Methods for Chemical Analysis of Water and Wastes* (U.S. EPA 1979b, revised 1983)
  - *Guidelines Establishing Test Procedures for the Analysis of Pollutants* [40 CFR Part 136 (1984)]

- *Standard Methods for the Examination of Water and Wastewater (16th ed.)* (American Public Health Association 1985)

- *Analytical Methods for EPA Priority Pollutants and 301(h) Pesticides in Estuarine and Marine Sediments* (Tetra Tech 1986a)

- *Analytical Methods for EPA Priority Pollutants and 301(h) Pesticides in Tissues from Estuarine and Marine Organisms* (Tetra Tech 1986b)

■ Quality Assurance/Quality Control (QA/QC)

- *Handbook for Analytical Quality Control in Water and Wastewater Laboratories* (U.S. EPA 1979c)

- *Quality Assurance/Quality Control (QA/QC) for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods* (Tetra Tech 1987).

Information from these documents is summarized below.

SAMPLING FREQUENCY

The frequency of sampling is dependent on the characteristics of the discharge (e.g., influent and effluent toxic pollutant variability, flow, size and location of the discharge). For example, large applicants with substantial quantities of toxic pollutants should conduct more frequent sampling than small dischargers with fewer toxic pollutants. Also, if existing toxic pollutant data are minimal, and estimates of periods of maximum pollutant loadings and peak concentrations are not known, then more frequent monitoring is needed.

The concentrations of toxic pollutants in the discharge may vary in response to periodic peak inflows. If a fixed periodic trend is observed (e.g., a sine curve) the sampling plan could be designed to collect samples during the peak period.

If a fixed sampling interval is chosen that is equal to or a multiple of the period, every sample would be taken at the same inflow condition and the estimate of the mean difference in toxic pollutant concentrations between samples would not take into effect all possible inflows. The most favorable sampling situation occurs when the fixed sampling interval is an odd multiple of the half-period (i.e., successive deviations above and below the mean inflow would mathematically cancel one another, and the mean difference in concentration between samples would take into effect the mean inflow). However, toxic pollutant effluent data from the applicant may not be sufficient to identify the odd multiple of the half-period. In this case, a fixed sampling interval would not be recommended.

Assuming that the toxic pollutant limits for the POTW will be based on the pollutant concentrations measured in the secondary treatment effluents, a flexible sampling scheme for secondary treatment pilot plant effluents may involve sample collection for 1 day/wk (over 24 h) on different days of the week over a 1-yr period of pilot plant operation. This flexible sampling frequency would generate a data set that represents an acclimated biological treatment system. It would also address the day/night, weekday/weekend, and seasonal variations in domestic, industrial/commercial, and wet- and dry-weather discharges.

SAMPLE COLLECTION AND ANALYSIS

Representative samples must be collected to ensure that data are reliable. Care must be taken to select appropriate sampling devices and procedures. Depending upon the toxic pollutant to be analyzed, three types of samples may be collected:

- Grab sample - a discrete sample volume is collected. (This type of sample will not always provide an accurate measure of wastewater characteristics, particularly when the flow or pollutants are heterogeneous or vary with time.)

- Simple composite sample - equal sample volumes are collected sequentially overtime and combined in a single reservoir. (This type of sample does not measure the mass of pollutants discharged, because pollutant loading is a flow-related value.)

- Flow-proportioned composite sample - incremental samples are collected over time and sample volumes are proportional to flow. Incremental samples are combined in a single reservoir. (This type of sample provides the most accurate measurement of wastewater quality and pollutant loading.)

The methods to be used for the analysis of toxic pollutants are summarized in Tables E-5, E-6, and E-7. Grab samples for volatile organic compounds, total recoverable phenolic compounds, and cyanide should be collected manually at least four times during the discharging period of the POTW during a 24-h period (e.g., at least every 6 h within a 24-h period, assuming continuous discharge). Samples for all other variables should be collected using an automatic sampler. The automatic sampler should collect a selected number of sample aliquots (minimum of 100 mL each) during the discharging period of the POTW. Recommended sample sizes, containers, preservation techniques, and holding times are shown in Table E-8. Sample analyses will generally be completed by the analytical laboratory within 4-6 wk; data analyses will generally require an additional week. Interpretation of all data collected at the pilot plant during 1 yr will require about 2 wk.

TABLE E-5. LIST OF TEST PROCEDURES APPROVED BY U.S. EPA FOR INORGANIC COMPOUNDS IN EFFLUENT

Note: This table is an exact reproduction of Table 1B in 40 CFR 136.3.

Parameter, units, and method	Reference (method No. or page)				
	EPA 1979	Standard methods 16th Ed.	ASTM	USGS [1]	Other
1 Acidity, as $CaCO_3$ mg/L: Electrometric end point or phenolphthalein end point.	305.1	402(4.a)	1067-82(E)		
2. Alkalinity, as $CaCO_3$ mg/L:					
Electrometric or colorimetric titration to pH 4.5, manual, or	310.1	403	D1067-82(B)	I-1030-84	33.014 [2]
Automated	310.2			I-2030-84	
3. Aluminum—Total [3] mg/L: Digestion [3] followed by:					
AA direct aspiration	202.1	303C		I-3051-84	
AA furnace	202.2	304			
Inductively coupled plasma, or					200.7 [4]
Colorimetric (Erichrome cyanine R)		306B			
4. Ammonia (as N), mg/L: Manual distillation (at pH 9.5) [5] followed by:	350.2	417A			33.057 [2]
Nesslerization	350.2	417B	D1426-79(A)	I-3520-84	33.057 [2]
Titration	350.2	417D			
Electrode	350.3	417 E or F	D1426-79(D)		
Automated phenate or	350.1	417G	D1426-79(C)	I-4523-84	
Automated electrode					Note 6.
5. Antimony—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration	204.1	303A			
AA furnace, or	204.2	304			
Inductively coupled plasma					200.7 [4]
6 Arsenic—Total [3], mg/L: Digestion [3] followed by	206.5				
AA gaseous hydride	206.3	303E	D2972-84(B)	I-3062-84	
AA furnace	206.2	304			
Inductively coupled plasma, or					200.7 [4]
Colorimetric (SDDC)	206.4	307B	D2972-84(A)	I-3060-84	
7 Barium—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration	208.1	303C		I-3084-84	
AA furnace, or	208.2	304			
Inductively coupled plasma					200.7 [4]
8. Beryllium—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration	210.1	303C	D3654-84(A)	I-3095-84	
AA furnace,	210.2	304			
Inductively coupled plasma, or					200.7 [4]
Colorimetric (aluminon)		309B			
9. Biochemical oxygen demand (BOD_5), mg/L:					
Dissolved Oxygen Depletion	405.1	507		I-1578-78 [7]	33.019 [2], p. 17 [8]
10. Boron—Total, mg/L:					
Colorimetric (curcumin)	212.3	404A		I-3112-84	
or Inductively Coupled plasma					200.7 [4]
11. Bromide, mg/L: Titrimetric	320.1		D1246-82(C)	I-1125-84	p. S44. [9]
12. Cadmium—Total [3], mg/L. Digestion [3] followed by:					
AA direct aspiration	213.1	303 A or B	D3557-84 (A or B).	I-3135-84 or I-3136-84.	33.089 [2], p. 37 [8]
AA furnace	213.2	304			
Inductively coupled plasma					200.7 [4]
Voltammetry [10], or			D3557-84(C)		
Colorimetric (Dithizone)		310B			
13 Calcium—Total [3], mg/L. Digestion [3] followed by					
AA direct aspiration	215.1	303A	D511-84(B)	I-3152-84	

TABLE E-5. (Continued)

Parameter, units, and method	Reference (method No. or page)				
	EPA 1979	Standard methods 16th Ed	ASTM	USGS [1]	Other
Inductively coupled plasma, or					200.7 [4]
Titrimetric (EDTA)	215.2	311C	D511-84(A)		
14. Carbonaceous biochemical oxygen demand (CBOD$_5$), mg/L [11] Dissolved Oxygen Depletion with nitrification inhibitor		507(5 e,6)			
15. Chemical oxygen demand (COD), mg/L.					
Titrimetric, or	410.1, 410.2, or 410.3	508A	D1252-83	I-3560-84 or I-3562-84.	33.034 [2], p. 17 [8]
Spectrophotometric, manual or automated.	410.4			I-3561-84	Notes 12 or 13
16. Chloride, mg/L.					
Titrimetric (silver nitrate)		407A	D512-81(B)	I-1183-84	
or (Mercuric nitrate), or	325.3	407B	D512-81(A)	I-1184-84	33.067 [2]
Colorimetric, manual or			D512-81(C)	I-1187-84	
Automated (Ferricyanide)	325.1, or 325.2	407D		I-2187-84	
17. Chlorine—Total residual, mg/L.					
Titrimetric:					
Amperometric direct	330.1	408C	D1253-76(A)		
Starch end point direct	330.3	408A	D1253-76(B) Part 18.3		
Back titration either end point [14], or	330.2	408B			
DPD-FAS	330.4	408D			
Spectrophotometric, DPD	330.5	408E			
Or Electrode					Note 15
18. Chromium VI dissolved, mg/L; 0.45 micron filtration followed by:					
AA chelation-extraction, or	218.4	303B		I-1232-84	
Colorimetric (Diphenylcarbazide)				I-1230-84	307B.[16]
19. Chromium—Total [3], mg/L. Digestion [4] followed by:					
AA direct aspiration	218.1	303A	D1687-84(D)	I-3236-84	33.089 [2]
AA chelation extraction	218.3	303B			
AA furnace	218.2	304			
Inductively coupled plasma or					200.7 [4]
Colorimetric (Diphenylcarbazide)		312B	D1687-84(A)		
20. Cobalt—Total [3], mg/L: Digestion [4] followed by:					
AA direct aspiration	219.1	303 A or B	D3558-84 (A or B).	I-3239-84 or I-3240-84	P 37.[8]
AA furnace, or	219.2	304			
Inductively coupled plasma					200.7 [4]
21. Color platinum cobalt units or dominant wavelength, hue, luminance purity:					
Colorimetric (ADMI), or	110.1	204D			Note 17
(Platinum cobalt), or	110.2	204A		I-1250-84	
Spectrophotometric	110.3	204B			
22. Copper—Total[3] mg/L: Digestion[4] followed by:					
AA direct aspiration	220.1	303 A or B	D1688-84 (D or E).	I-3270-84 or I-3271-84.	33.089[2], p. 37 [8]
AA furance	220.2	304			
Inductively coupled plasma,					200.7.[4]
Colorimetric (Neocuproine), or		313B	D1688-84(A)		
(Bicinchoninate)					Note 18.
23. Cyanide—Total, mg/L: Manual distillation with $MgCl_2$ followed by		412B			
Titrimetric, or		412C			p. 22.[8]
Spectrophotometric, manual or	335.2	412D	D2036-82(A)	I-3300-84	
Automated.[19]	335.3		D2036-82(A)		

TABLE E-5. (Continued)

Parameter, units, and method	Reference (method No. or page)				
	EPA 1979	Standard methods 16th Ed	ASTM	USGS [1]	Other
24 Cyanide amendable to chlorination, mg/L. Manual distillation with MgCl, followed by titrimetric or spectrophotometric.	335.1	412F	D2036-82(B)		
25 Fluoride—Total, mg/L. Manual distillation[2] followed by:		413A			
Electrode, manual or	340.2	413B	D1179-80(B)		
Automated				I-4327-84	
Colorimetric (SPADNS)	340.1	413C	D1179-80(A)		
Or Automated complexone	340.3	413E			
26. Gold—Total[3], mg/L. Digestion[3] followed by:					
AA direct aspiration, or	231.1	303A			
AA furnace	231.2	304			
27. Hardness—Total, as $CaCO_3$, mg/L.					
Automated colorimetric	130.1				
Titrimetric (EDTA), or Ca plus Mg as their carbonates, by inductively coupled plasma or AA direct aspiration. (See Parameters 13 and 33.)	130.2	314B	D1126-80	I-1338-84	33.082.[3]
28. Hydrogen ion (pH), pH units:					
Electrometric, measurement, or	150.1	423	D1293-84 (A or B).	I-1586-84	33.006.[3]
Automated electrode					Note 20.
29. Indium—Total[4], mg/L. Digestion[3] followed by:					
AA direct aspiration, or	235.1	303A			
AA furnace	235.2	304			
30. Iron—Total[4], mg/L. Digestion[3] followed by:					
AA direct aspiration	236.1	303 A or B	D1068-84 (C or D).	I-3381-84	33.089.[3]
AA furnace	236.2	304			
Inductively coupled plasma, or					200.7.[4]
Colorimetric (Phenanthroline)		315B	D1068-84(A)		Note 21.
31 Kjeldahl nitrogen—Total, (as N), mg/L. Digestion and distillation followed by:	351.3	420 A or B	D3590-84(A)		
Titration	351.3	417D	D3590-84(A)		33.051.[3]
Nesslerization	351.3	417B	D3590-84(A)		
Electrode	351.3	417 E or F			
Automated phenate	351.1			I-4551-78 [7]	
Semi-automated block digestor, or	351.2		D3590-84(A)		
Potentiometric	351.4		D3590-84(A)		
32 Lead—Total[4], mg/L. Digestion[3] followed by:					
AA direct aspiration	239.1	303 A or B	D3559-85 (A or B).	I-3399-84	33.089.[3]
AA furnace	239.2	304			
Inductively coupled plasma					200.7.[4]
Voltametry [10], or			D3559-85(C)		
Colorimetric (Dithizone)		316B			
33 Magnesium—Total[4], mg/L. Digestion [1] followed by:					
AA direct aspiration	242.1	303A	D511-84(B)	I-3447-84	33.089.[3]
Inductively coupled plasma, or					200.7.[4]
Gravimetric		318B	D511-77(A)		
34 Manganese—Total[4], mg/L. Digestion [1] followed by:					
AA direct aspiration	243.1	303 A or B	D858-84 (B or (C)	I-3454-84	33.089.[3]
AA furnace	243.2	304			
Inductively coupled plasma, or					200.7.[4]
Colorimetric (Persulfate), or (Periodate)		319B	D858-84(A)		33.126.[3] Note 22.

TABLE E-5. (Continued)

Parameter, units, and method	Reference (method No. or page)				
	EPA 1979	Standard methods 16th Ed.	ASTM	USGS [1]	Other
35. Mercury—Total [3], mg/L:					
Cold vapor, manual or	245.1	303F	D3223–80	I–3462–84	33.095. [2]
Automated	245.2				
36. Molybdenum—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration	246.1	303C		I–3490–84	
AA furnace, or	246.2	304			
Inductively coupled plasma					200.7. [4]
37. Nickel—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration	249.1	303 A or B	D1886–84 (C or D).	I–3499–84	
AA furnace	249.2	304			
Inductively coupled plasma, or					200.7. [4]
Colorimetric (Heptoxime)		321B			
38. Nitrate (as N), mg/L: Colorimetric (Brucine sulfate), or Nitrate-nitrite N minus Nitrite N (See parameters 39 and 40).	352.1		D992–71		33.063 [2], 419D [16], p. 28. [5]
39. Nitrate-nitrite (as N), mg/L: Cadmium reduction, Manual or	353.3	418C	D3867–85(B)		
Automated, or	353.2	418F	D3867–85(A)	I–4545–84	
Automated hydrazine	353.1				
40. Nitrite (as N), mg/L: Spectrophotometric:					
Manual or	354.1	419	D1254–67		Note 24.
Automated (Diazotization)				I–4540–84	
41. Oil and grease—Total recoverable, mg/L: Gravimetric (extraction).	413.1	503A			
42. Organic carbon—Total (TOC), mg/L: Combustion or oxidation.	415.1	505	D2579.85 (A or B).		33.044 [2], p. 4. [23]
43. Organic nitrogen (as N) mg/L: Total Kjeldahl N (Parameter 31) minus ammonia N (Parameter 4.).					
44. Orthophosphate (as P), mg/L: Ascorbic acid method:					
Automated or	365.1	424G		I–4601–84	33.116. [2]
Manual single reagent	365.2	424F	D515–82(A)		33.111. [2]
or Manual two reagent	365.3				
45. Osmium—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration, or	252.1	303C			
AA furnace	252.2	304			
46. Oxygen dissolved, mg/L: Winkler (Azide: modification), or	360.2	421B	D888–81(C)	I–1575–78 [7]	33.028. [8]
Electrode	360.1	421F		I–1576–78 [7]	
47. Palladium—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration, or	253.1				P. S27. [9]
AA furnace	253.2				P. S28. [9]
48. Phenols, mg/L:					
Manual distillation [10]	420.1		D1783–80 (A or B).		Note 26.
Followed by:					
Colorimetric (4AAP) manual, or	420.1				Note 26.
Automated [10]	420.2				
49. Phosphorus (elemental) mg/L: Gas-liquid chromatography.					Note 27.
50. Phosphorus—Total, mg/L: Persulfate digestion followed by	365.2	424C(III)			33.111. [2]
Manual or	365.2 or 365.3.	424F	D515–82(A)		
Automated ascorbic acid reduction, or.	365.1	424G		I–4600–84	33.116. [2]
Semi-automated block digestor	365.4				

TABLE E-5. (Continued)

Parameter, units, and method	Reference (method No. or page)				
	EPA 1979	Standard methods 16th Ed.	ASTM	USGS [1]	Other
51. Platinum—Total [2], mg/L: Digestion [3] followed by:					
AA direct aspiration, or	255.1	303A			
AA furnace	255.2	304			
52. Potassium—total [3], mg/L: Digestion followed by:					
AA direct aspiration	258.1	303A		I-3630-84	33.103.[3]
Inductively coupled plasma					200.7.[4]
Flame photometric, or		322B	D1428-82(A)		
Colorimetric (Cobaltinitrate)					317B.[16]
53. Residue—Total, mg/L: Gravimetric, 103-105°C.	160.3	209A		I-3750-84	
54. Residue—filterable, mg/L: Gravimetric, 180°C.	160.1	209B		I-1750-84	
55. Residue—nonfilterable, (TSS), mg/L: Gravimetric, 103-105°C post washing of residue.	160.2	209C		I-3765-84	
56. Residue—settleable, mg/L: Volumetric, (Imhoff cone) or gravimetric.	160.5	209E		1	
57. Residue—Volatile, mg/L: Gravimetric, 550°C.	160.4	209D		I-3753-84	
58. Rhodium—Total [2], mg/L: Digestion [3] followed by:.					
AA direct aspiration, or	265.1	303A			
AA furnace	265.2	304			
59. Ruthenium—Total [2], mg/L: Digestion [3] followed by:					
AA direct aspiration, or	267.1	303A			
AA furnace	267.2	304			
60. Selenium—Total [2], mg/L: Digestion [3] followed by:					
AA furnace	270.2	304			
Inductively coupled plasma, or					200.7[4]
AA gaseous hydride	270.3	303E	D3859-84(A)	I-3667-84	
61. Silica—Dissolved, mg/L: 0.45 micron filtration followed by:					
Colorimetric, Manual or	370.1	425C	D859-80(B)	I-1700-84	
Automated (Molybdosilicate), or				I-2700-84	
Inductively coupled plasma					200.7.[4]
62. Silver—Total [28], mg/L: Digestion [3] followed by:					
AA direct aspiration	272.1	303 A or B		I-3720-84	33.089 [3], p. 37.[6]
AA furnace.	272.2	304			
Colorimetric (Dithizone), or					319B.[16]
Inductively coupled plasma					200.7.[4]
63. Sodium—Total [2], mg/L: Digestion [3] followed by:					
AA direct aspiration	273.1	303A		I-3735-84	33.107.[3]
Inductively coupled plasma, or					200.7.[4]
Flame photometric		325B	D1428-82(A)		
64. Specific conductance, micromhos/cm at 25°C: Wheatstone bridge	120.1	205	D1125-82(A)	I-1780-84	33.002.[3]
65. Sulfate (as SO_4), mg/L:					
Automated colorimetric, (barium chloranilate).	375.1				
Gravimetric, or	375.3	426 A or B	D516-82(A)		33.124.[3]
Turbidimetric	375.4		D516-82(B)		426C.[29]
66. Sulfide (as S), mg/L:					
Titrimetric (iodine) or	376.1	427D		I-3840-84	228A.[30]
Colorimetric (methylene blue)	376.2	427C			
67. Sulfite (as SO_3), mg/L: Titrimetric (iodine-iodate)	377.1	428A	D1339-84(C)		
68. Surfactants, mg/L: Colorimetric (methylene blue).	425.1	512B	D2330-82(A)		
69. Temperature, °C., Thermometric	170.1	212			Note 31

TABLE E-5. (Continued)

Parameter, units, and method	Reference (method No. or page)				
	EPA 1979	Standard methods 16th Ed.	ASTM	USGS [1]	Other
70. Thallium—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration	279.1	303A			
AA furnace, or	279.2	304			
Inductively coupled plasma					200.7 [4]
71. Tin—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration, or	282.1	303A		I-3850-78 [7]	
AA furnace	282.2	304			
72. Titanium—Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration, or	283.1	303C			
AA furnace	283.2	304			
73. Turbidity, NTU: Nephelometric	180.1	214A	D1889-81	I-3860-84	
74. Vanadium, Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration	286.1	303C			
AA furnace	286.2	304			
Inductively coupled plasma, or					200.7 [4]
Colorimetric (Gallic acid)		327B	D3373-84(A)		
75. Zinc-Total [3], mg/L: Digestion [3] followed by:					
AA direct aspiration	289.1	303A or B	D1691-84 (C or D).	I-3900-84	33.089 [2], p. 37. [8]
AA furnace	289.2	304			
Inductively coupled plasma, or					200.7 [4]
Colorimetric (Dithizone) or		329C			
(Zincon)					Note 32.

[1] "Methods for Analysis of Inorganic Substances in Water and Fluvial Sediments," U.S. Department of the Interior, U.S. Geological Survey, Open-File Report 85-495, 1986, unless otherwise stated.

[2] "Official Methods of Analysis of the Association of Official Analytical Chemists," methods manual, 14th ed. (1985).

[3] For the determination of total metals the sample is not filtered before processing. A digestion procedure is required to solubilize suspended material and to destroy possible organic-metal complexes. Two digestion procedures are given in "Methods for Chemical Analysis of Water and Wastes, 1979." One (section 4.1.3), is a vigorous digestion using nitric acid. A less vigorous digestion using nitric and hydrochloric acids (Section 4.1.4) is preferred; however, the analyst should be cautioned that this mild digestion may not suffice for all sample types. Particularly, if a colorimetric procedure is to be employed, it is necessary to ensure that all organo-metallic bonds be broken so that the metal is in a reactive state. In those situations, the vigorous digestion is to be preferred making certain that at no time does the sample go to dryness. Samples containing large amounts of organic materials would also benefit by this vigorous digestion. Use of the graphite furnace technique, inductively coupled plasma, as well as determinations for certain elements such as arsenic, the noble metals, mercury, selenium, and titanium require a modified digestion and in all cases the method write-up should be consulted for specific instruction and/or cautions.

NOTE: If the digestion included in one of the other approved references is different than the above, the EPA procedure must be used.

Dissolved metals are defined as those constituents which will pass through a 0.45 micron membrane filter. Following filtration of the sample, the referenced procedure for total metals must be followed. Sample digestion for dissolved metals may be omitted for AA (direct aspiration or graphite furnace) and ICP analyses provided the sample solution to be analyzed meets the following criteria:

a. has a low COD (<20)
b. is visibly transparent with a turbidity measurement of 1 NTU or less.
c. is colorless with no perceptable odor, and
d. is of one liquid phase and free of particulate or suspended matter following acidification.

[4] The full text of Method 200.7, "Inductively Coupled Plasma Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes," is given at Appendix C of this Part 136.

[5] Manual distillation is not required if comparability data on representative effluent samples are on company file to show that this preliminary distillation step is not necessary; however, manual distillation will be required to resolve any controversies.

[6] Ammonia, Automated Electrode Method, Industrial Method Number 379-75 WE, dated February 19, 1976, Technicon AutoAnalyzer II, Technicon Industrial Systems, Tarrytown, NY. 10591.

[7] The approved method is that cited in "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments", USGS TWRI, Book 5, Chapter A1 (1979).

[8] American National Standard on Photographic Processing Effluents, Apr. 2, 1975. Available from ANSI, 1430 Broadway, New York, NY 10018.

[9] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1981).

[10] The use of normal and differential pulse voltage ramps to increase sensitivity and resolution is acceptable.

[11] Carbonaceous biochemical oxygen demand ($CBOD_5$) must not be confused with the traditional BOD_5 test which measures "total BOD." The addition of the nitrification inhibitor is not a procedural option, but must be included to report the $CBOD_5$ parameter. A discharger whose permit requires reporting the traditional BOD_5 may not use a nitrification inhibitor in the procedure for reporting the results. Only when a discharger's permit specifically states $CBOD_5$ is required, can the permittee report data using the nitrification inhibitor.

TABLE E-5. (Continued)

[12] OIC Chemical Oxygen Demand Method. Oceanography International Corporation. 512 West Loop. P.O. Box 2980. College Station. TX 77840

[13] Chemical Oxygen Demand. Method 8000. Hach Handbook of Water Analysis. 1979. Hach chemical Company. P.O. Box 389. Loveland. CO 80537

[14] The back titration method will be used to resolve controversy.

[15] Orion Research Instruction Manual. Residual Chlorine Electrode Model 97-70. 1977. Orion Research Incorporated. 840 Memorial Drive. Cambridge. MA 02138.

[16] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*. 14th Edition. 1976.

[17] National Council of the Paper Industry for Air and Stream Improvement. (Inc.) Technical Bulletin 253. December 1971.

[18] Copper. Biocinchoninate Method. Method 8506. Hach Handbook of Water Analysis. 1979. Hach Chemical Company. P.O. Box 389. Loveland. CO 80537.

[19] After the manual distillation is completed. the autoanalyzer manifolds in EPA Methods 335.3 (cyanide) or 420.2 (phenols) are simplified by connecting the re-sample line directly to the sampler. When using the manifold setup shown in Method 335.3. the buffer 6.2 should be replaced with the buffer 7.6 found in Method 335.2.

[20] Hydrogen Ion (pH) Automated Electrode Method. Industrial Method Number 378-75WA. October 1976. Technicon Auto-Analyzer II. Technicon Industrial Systems. Tarrytown. NY 10591.

[21] Iron. 1.10-Phenanthroline Method. Method 8008. 1980. Hach Chemical Company. P.O. Box 389. Loveland. CO 80537

[22] Manganese. Periodate Oxidation Method. Method 8034. Hach Handbook of Wastewater Analysis. 1979. pages 2-113 and 2-117. Hach Chemical Company. Loveland. CO 80537.

[23] Goerlitz. D., Brown. E., "Methods for Analysis of Organic Substances in Water," U.S. Geological Survey Techniques of Water-Resources Inv., book 5. ch. A3. page 4 (1972).

[24] Nitrogen. Nitrite. Method 8507. Hach Chemical Company. P.O. Box 389. Loveland. CO 80537.

[25] Just prior to distillation. adjust the sulfuric-acid-preserved sample to pH 4 with 1 + 9 NaOH.

[26] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*. 14th Edition. The colorimetric reaction is conducted at a pH of 10.0±0.2. The approved methods are given on pp. 576-81 of the 14th Edition: Method 510A for distillation. Method 510B for the manual colorimetric procedure. or Method 510C for the manual spectrophotometric procedure.

[27] R. F. Addison and R. G. Ackman. "Direct Determination of Elemental Phosphorus by Gas-Liquid Chromatography." *Journal of Chromatography*. vol. 47. No. 3. pp. 421-426. 1970.

[28] Approved methods for the analysis of silver in industrial wastewaters at concentrations of 1 mg/L and above are inadequate where silver exists as an inorganic halide. Silver halides such as the bromide and chloride are relatively insoluble in reagents such as nitric acid but are readily soluble in an aqueous buffer of sodium thiosulfate and sodium hydroxide to a pH of 12. Therefore. for levels of silver above 1 mg/L. 20 mL of sample should be diluted to 100 mL by adding 40 mL each of 2 M $Na_2S_2O_3$ and 2M NaOH. Standards should be prepared in the same manner. For levels of silver below 1 mg/L the approved method is satisfactory.

[29] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*. 15th Edition.

[30] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*. 13th Edition.

[31] Stevens. H. H.. Ficke. J. F.. and Smoot. G. F.. "Water Temperature—Influential Factors. Field Measurement and Data Presentation." U.S. Geological Survey. Techniques of Water Resources Investigations. Book 1. Chapter D1. 1975.

[32] Zinc. Zincon Method. Method 8009. Hach Handbook of Water Analysis. 1979. pages 2-231 and 2-333. Hach Chemical Company. Loveland. CO 80537.

TABLE E-6. LIST OF TEST PROCEDURES APPROVED BY U.S. EPA FOR NON-PESTICIDE ORGANIC COMPOUNDS

Note: This table is an exact reproduction of Table 1C in 40 CFR 136.3.

Parameter [1]	EPA Method Number [2]			Other
	GC	GC/MS	HPLC	
1 Acenaphthene	610	625, 1625	610	
2 Acenaphthylene	610	625, 1625	610	
3. Acrolein	603	[4]624, 1624		
4 Acrylonitrile	603	[4]624, 1624		
5 Anthracene	610	625, 1625	610	
6. Benzene	602	624, 1624		
7. Benzidine		[3]625, 1625	605	Note 3, p. 1:
8. Benzo(a)anthracene	610	625, 1625	610	
9 Benzo(a)pyrene	610	625, 1625	610	
10. Benzo(b)fluoranthene	610	625, 1625	610	
11 Benzo(g,h,i)perylene	610	625, 1625	610	
12. Benzo(k)fluoranthene	610	625, 1625	610	
13. Benzyl chloride				Note 3, p. 130: Note 6, p. S102.
14. Benzyl butyl phthalate	606	625, 1625		
15. Bis(2-chloroethoxy) methane	611	625, 1625		
16. Bis(2-chloroethyl) ether	611	625, 1625		
17 Bis(2-ethylhexyl) phthalate	606	625, 1625		
18. Bromodichloromethane	601	624, 1624		
19 Bromoform	601	624, 1624		
20 Bromomethane	601	624, 1624		
21 4-Bromophenylphenyl ether	611	625, 1625		
22 Carbon tetrachloride	601	624, 1624		Note 3, p 130
23 4-Chloro-3-methylphenol	604	625, 1625		
24 Chlorobenzene	601, 602	624, 1624		Note 3, p. 130.
25 Chloroethane	601	624, 1624		
26 2-Chloroethylvinyl ether	601	624, 1624		

TABLE E-6. (Continued)

Parameter	EPA Method Number - GC	GC/MS	HPLC	Other
27 Chloroform	601	624, 1624		Note 3, p 130
28 Chloromethane	601	624, 1624		
29 2-Chloronaphthalene	612	625, 1625		
30 2-Chlorophenol	604	625, 1625		
31 4-Chlorophenylphenyl ether	611	625, 1625		
32 Chrysene	610	625, 1625	610	
33 Dibenzo(a,h)anthracene	610	625, 1625	610	
34 Dibromochloromethane	601	624, 1624		
35 1,2-Dichlorobenzene	601, 602, 612	624, 625, 1625		
36 1,3-Dichlorobenzene	601, 602, 612	624, 625, 1625		
37 1,4-Dichlorobenzene	601, 602, 612	625, 1624, 1625		
38 3,3'-Dichlorobenzidine		625, 1625	605	
39 Dichlorodifluoromethane	601			
40 1,1-Dichloroethane	601	624, 1624		
41 1,2-Dichloroethane	601	624, 1624		
42 1,1-Dichloroethene	601	624, 1624		
43 trans-1,2-Dichloroethene	601	624, 1624		
44 2,4-Dichlorophenol	604	625, 1625		
45 1,2-Dichloropropane	601	624, 1624		
46 cis-1,3-Dichloropropene	601	624, 1624		
47 trans-1,3-Dichloropropene	601	624, 1624		
48 Diethyl phthalate	606	625, 1625		
49 2,4-Dimethylphenol	604	625, 1625		
50 Dimethyl phthalate	606	625, 1625		
51 Di-n-butyl phthalate	606	625, 1625		
52 Di-n-octyl phthalate	606	625, 1625		
53 2,4-Dinitrophenol	604	625, 1625		
54 2,4-Dinitrotoluene	609	625, 1625		
55 2,6-Dinitrotoluene	609	625, 1625		
56 Epichlorohydrin				Note 3, p. 130; Note 6, p. S102.
57 Ethylbenzene	602	624, 1624		
58 Fluoranthene	610	625, 1625	610	
59 Fluorene	610	625, 1625	610	
60 Hexachlorobenzene	612	625, 1625		
61 Hexachlorobutadiene	612	625, 1625		
62 Hexachlorocyclopentadiene	612	625, 1625		
63 Hexachloroethane	612	625, 1625		
64 Ideno(1,2,3-cd)pyrene	610	625, 1625	610	
65 Isophorone	609	625, 1625		
66 Methylene chloride	601	624, 1624		Note 3, p. 130;
67 2-Methyl-4,6-dinitrophenol	604	625, 1625		
68 Naphthalene	610	625, 1625	610	
69 Nitrobenezene	609	625, 1625		
70 2-Nitrophenol	604	625, 1625		
71 4-Nitrophenol	604	625, 1625		
72 N-Nitrosodimethylamine	607	625, 1625		
73 N-Nitrosodi-n-propylamine	607	625, 1625		
74 N-Nitrosodiphenylamine	607	625, 1625		
75 2,2'-Oxybis(1-chloropropane)	611	625, 1625		
76 PCB-1016	608	625		Note 3, p. 43;
77 PCB-1221	608	625		Note 3, p. 43;
78 PCB-1232	608	625		Note 3, p. 43;
79 PCB-1242	608	625		Note 3, p. 43;
80 PCB-1248	608	625		Note 3, p. 43;
81 PCB-1254	608	625		Note 3, p. 43;
82 PCB-1260	608	625		Note 3, p. 43;
83 Pentachlorophenol	604	625, 1625		Note 3, p. 140;
84 Phenanthrene	610	625, 1625	610	
85 Phenol	604	625, 1625		
86 Pyrene	610	625, 1625	610	
87 2,3,7,8-Tetrachlorodibenzo-p-dioxin		613		
88 1,1,2,2-Tetrachloroethane	601	624, 1624		Note 3, p. 130;
89 Tetrachloroethene	601	624, 1624		Note 3, p. 130;
90 Toluene	602	624, 1624		
91 1,2,4-Trichlorobenzene	612	625, 1625		Note 3, p. 130;

TABLE E-6. (Continued)

Parameter	EPA Method Number - GC	GC/MS	HPLC	Other
92 1,1,1-Trichloroethane	601	624, 1624		
93 1,1,2-Trichloroethane	601	624, 1624		Note 3 p 130
94 Trichloroethene	601	624, 1624		
95 Trichlorofluoromethane	601	624		
96 2,4,6-Trichlorophenol	604	625, 1625		
97 Vinyl chloride	601	624, 1624		

Table IC Notes

[1] All parameters are expressed in micrograms per liter (μg/L).

[2] The full text of Methods 601–613, 624, 625, 1624, and 1625, are given at Appendix A, "Test Procedures for Analysis of Organic Pollutants," of this Part 136. The standardized test procedure to be used to determine the method detection limit (MDL) for these test procedures is given at Appendix B, "Definition and Procedure for the Determination of the Method Detection Limit," of this Part 136.

[3] "Methods for Benzidine; Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater" U.S. Environmental Protection Agency, September, 1978.

[4] Method 624 may be extended to screen samples for Acrolein and Acrylonitrile. However, when they are known to be present, the preferred method for these two compounds is Method 603 or Method 1624.

[5] Method 625 may be extended to include benzidine, hexachlorocyclopentadiene, N-nitrosodumethyamine, and N-nitrosodiphenylamine. However, when they are known to be present, Methods 605, 607, and 612, or Method 1625, are preferred methods for these compounds.

[6] 625, Screening only.

[7] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," *Supplement to the Fifteenth Edition of Standard Methods for the Examination of Water and Wastewater* (1981).

[8] Each analyst must make an initial, one-time, demonstration of their ability to generate acceptable precision and accuracy with Methods 601–613, 624, 625, 1624, and 1625 (See Appendix A of this Part 136) in accordance with procedures each in section 8.2 of each of these Methods. Additionally, each laboratory, on an on-going bases must spike and analyze 10% (5% for Methods 624 and 625 and 100% for methods 1624, and 1625) of all samples to monitor and evaluate laboratory data quality in accordance with sections 8.3 and 8.4 of these Methods. When the recovery of any parameter falls outside the warning limits, the analytical results for that parameter in the unspiked sample are suspect and cannot be reported to demonstrate regulatory compliance.

NOTE: These warning limits are promulgated as an "interim final action with a request for comments."

TABLE E-7. LIST OF TEST PROCEDURES APPROVED BY U.S. EPA FOR PESTICIDES[1]

Note: This table is an exact reproduction of Table 1D in 40 CFR 136.3.

Parameter, µg/L	Method	EPA[2,7]	Standard Methods 15th Ed	ASTM	Other
1. Aldrin	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
2. Ametryn	GC				Note 3, p. 83; Note 6, p. S68.
3. Aminocarb	TLC				Note 3, p. 94; Note 6, p. S16.
4. Atraton	GC				Note 3, p. 83; Note 6, p. S68.
5. Atrazine	GC				Note 3, p. 83; Note 6, p. S68.
6. Azinphos methyl	GC				Note 3, p. 25; Note 6, p. S51.
7. Barban	TLC				Note 3, p. 104; Note 6, p. S64.
8. α-BHC	GC	608	509A	D3086	Note 3, p. 7.
	GC/MS	[5] 625			
9. β-BHC	GC	608		D3086	
	GC/MS	625			
10. δ-BHC	GC	608		D3086	
	GC/MS	[5] 625			
11. γ-BHC (Lindane)	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
12. Captan	GC		509A		Note 3, p. 7.
13. Carbaryl	TLC				Note 3, p. 94; Note 6, p. S60.
14. Carbophenothion	GC				Note 4, p. 30; Note 6, p. S73.
15. Chlordane	GC	608	509A	D3086	Note 3, p. 7.
	GC-MS	625			
16. Chloropropham	TLC				Note 3, p. 104; Note 6, p. S64.
17. 2,4-D	GC		509B		Note 3, p. 115; Note 4, p. 35.
18. 4,4'-DDD	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC-MS	625			
19. 4,4'-DDE	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
20. 4,4'-DDT	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			

TABLE E-7. (Continued)

Parameter µg/L[1]	Method	EPA[2]	Standard Methods 15th Ed	ASTM	Other
21. Demeton-O	GC				Note 3, p. 25; Note 6, p. S51
22. Dementon-S	GC				Note 3, p. 25; Note 6, p. S51
23. Diazinon					Note 3, p. 25; Note 4, p. 30; Note 6, p. S51
24. Dicamba	GC				Note 3, p. 115.
25. Dichlofenthion	GC				Note 4, p. 30; Note 6, p. S73.
26. Dichloran	GC		509A		Note 3, p. 7
27. Dicofol	GC			D3086	
28. Dieldrin	GC	608	509A		Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
29. Dioxathion	GC				Note 4, p. 30; Note 6, p. S73.
30. Disulfoton	GC				Note 3, p. , Note 6, p. S51.
31. Diuron	TLC				Note 3, p. 104 Note 6, p. S64.
32. Endosulfan I	GC	608	509A	D3086	Note 3, p. 7.
	GC/MS	[3] 625			
33. Endosulfan II	GC	608	509A	D3086	Note 3, p. 7.
	GC/MS	[3] 625			
34. Endosulfan sulfate	GC	608			
	GC/MS	625			
35. Endrin	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	[3] 625			
36. Endrin aldehyde	GC	608			
	GC/MS	625			
37. Ethion	GC				Note 4, p. 30; Note 6, p. S73.
38. Fenuron	TLC				Note 3, p. 104; Note 6, p. S64.
39. Fenuron-TCA	TLC				Note 3, p. 104; Note 6, p. S64.
40. Heptachlor	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30
	GC/MS	625			
41. Heptachlor epoxide	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30; Note 6, p. S73.
	GC/MS	625			
42. Isodrin	GC				Note 4, p. 30; Note 6, p. S73.
43. Linuron	TLC				Note 3, p. 104; Note 6, p. S64.
44. Malathion	GC		509A		Note 3, p. 25; Note 4, p. 30; Note 6, p. S51.
45. Methiocarb	TLC				Note 3, p. 94; Note 6, p. S60.
46. Methoxychlor	GC		509A	D3086	Note 3, p. 7; Note 4, p. 30.
47. Mexacarbate	TLC				Note 3, p. 94; Note 6, p. S60.
48. Mirex	GC		509A		Note 3, p. 7.
49. Monuron	TLC				Note 3, p. 104; Note 6, p. S64.
50. Monuron-TCA	TLC				Note 3, p. 104; Note 6, p. S64.
51. Neburon	TLC				Note 3, p. 104; Note 6, p. S64.
52. Parathion methyl	GC		509A		Note 3, p. 25; Note 4, p. 30.
53. Parathion ethyl	GC		509A		Note 3, p. 25.
54. PCNB	GC		509A		Note 3, p. 7.
55. Perthane	GC			D3086	
56. Prometron	GC				Note 3, p. 83; Note 6, p. S68.
57. Prometryn	GC				Note 3, p. 83; Note 6, p. S68.
58. Propazine	GC				Note 3, p. 83; Note 6, p. S68.
59. Propham	TLC				Note 3, p. 104; Note 6, p. S64.
60. Propoxur	TLC				Note 3, p. 94; Note 6, p. S60.
61. Secbumeton	TLC				Note 3, p. 83; Note 6, p. S68.
62. Siduron	TLC				Note 3, p. 104; Note 6, p. S64.
63. Simazine	GC				Note 3, p. 83; Note 6, p. S68.
64. Strobane	GC		509A		Note 3, p. 7.
65. Swep	TLC				Note 3, p. 104; Note 6, p. S64.
66. 2,4,5-T	GC		509B		Note 3, p. 115; Note 4, p. 35.
67. 2,4,5-TP (Silvex)	GC		509B		Note 3, p. 115.
68. Terbuthylazine	GC				Note 3, p. 83; Note 6, p. S68.
69. Toxaphene	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
70. Trifluralin	GC		509A		Note 3, p. 7

Table ID Notes

[1] Pesticides are listed in this table by common name for the convenience of the reader. Additional pesticides may be found under Table IC, where entries are listed by chemical name.

TABLE E-7. (Continued)

[2] The full text of methods 608 and 625 are given at Appendix A, "Test Procedures for Analysis of Organic Pollutants" of this Part 136. The standardized test procedure to be used to determine the method detection limit (MDL) for these test procedures is given at Appendix B, "Definition and Procedure for the Determination of the Method Detection Limit", of this Part 136.

[3] "Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater." U.S. Environmental Protection Agency, September, 1978. This EPA publication includes thin-layer chromatography (TLC) methods.

[4] Methods for Analysis of Organic Substances in Water." U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 5, Chapter A3 (1972).

[5] The method may be extended to include α-BHC, δ-BHC, endosulfan I, endosulfan II, and endrin. However, when they are known to exist, Method 608 is the preferred method.

[6] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1981).

[7] Each analyst must make an initial, one-time, demonstration of their ability to generate acceptable precision and accuracy with Methods 608 and 625 (See Appendix A of this Part 136) in accordance with procedures given in section 8.2 of each of these methods. Additionally, each laboratory, on an on-going basis, must spike and analyze 10% of all samples analyzed with Method 608 or 5% of all samples analyzed with Method 625 to monitor and evaluate laboratory data quality in accordance with Sections 8.3 and 8.4 of these methods. When the recovery of any parameter falls outside the warning limits, the analytical results for that parameter in the unspiked sample are suspect and cannot be reported to demonstrate regulatory compliance.

NOTE: These warning limits are promulgated as an "interim final action with a request for comments."

TABLE E-8. RECOMMENDED SAMPLE SIZES, CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR EFFLUENT SAMPLES[a]

Measurement	Minimum Sample Size[b] (mL)	Container[c]	Preservative[d]	Maximum Holding Time
pH	25	P, G	None	Analyze immediately[e]
Temperature	1,000	P, G	None	Measure immediately[e]
Turbidity	100	P, G	Cool, 4° C	48 h
Total suspended solids	1,000	P, G	Cool, 4° C	7 days
Settleable solids	1,000	P, G	Cool, 4° C	48 h
Floating particulates	5,000	P, G	None	Analyze immediately[e,f]
Dissolved oxygen				
Probe	300	G bottle and top	None	Analyze immediately[e]
Winkler	300	G bottle and top	Fix onsite; store in dark	8 h
Biochemical oxygen demand	1,000	P, G	Cool, 4° C	48 h
Total chlorine residual	200	P, G	None	Analyze immediately[e]
Oil and grease	1,000	G only	Cool, 4° C H_2SO_4 to pH<2	28 days
Nitrogen				
Ammonia-N	400	P, G	Cool, 4° C H_2SO_4 to pH<2	28 days
Total Kjeldahl-N	500	P, G	Cool, 4° C H_2SO_4 to pH<2	28 days
Nitrate+Nitrite-N	100	P, G	Cool, 4° C H_2SO_4 to pH<2	28 days
Phosphorus (total)	50	P, G	Cool, 4° C H_2SO_4 to pH<2	28 days
Priority pollutant metals				
Metals, except mercury	100	P, G	HNO_3 to pH<2	6 mo
Mercury	100	P, G	HNO_3 to pH<2	28 days
Priority pollutant organic compounds				
Extractable compounds (includes phthalates, nitrosamines, organochlorine pesticides, PCBs, nitroaromatics, isophorone, polycyclic aromatic hydrocarbons, haloether, chlorinated hydrocarbons, phenols, and TCDD)	4,000	G only, TFE-lined cap	Cool, 4° C 0.008% $Na_2S_2O_3$[g] Store in dark	7 days until extraction 40 days after extraction
Purgeable compounds	40	G only, TFE-lined septum	Cool, 4° C 0.008% $Na_2S_2O_3$[g]	7 days[h]

TABLE E-8. (Continued

Measurement	Minimum Sample Size[b] (mL)	Container[c]	Preservative[d]	Maximum Holding Time
Total and fecal coliform bacteria	250-500	P, G	Cool, 4° C 0.008% $Na_2S_2O_3$[g]	6 h
Enterococcus bacteria	250-500	P, G	Cool, 4° C 0.008% $Na_2S_2O_3$[g]	6 h

[a] Reference: Adapted from U.S. EPA (1979b), 40 CFR Part 136.

[b] Recommended field sample sizes for one laboratory analysis. If additional laboratory analyses are required (e.g., replicates), the field sample size should be adjusted accordingly.

[c] P = Polyethylene; G = Glass.

[d] Sample preservation should be performed immediately upon sample collection. For composite samples, each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, the samples should be maintained at 4° C until compositing.

[e] Immediately means as soon as possible after the sample is collected, generally within 15 min (U.S. EPA 1984).

[f] No recommended holding time is given by U.S. EPA for floating particulates. Analysis should therefore be made as soon as possible.

[g] Should only be used in the presence of chlorine residual.

[h] Holding time and preservation technique for purgeable compounds are based on the use of U.S. EPA Method 624 for screening all priority pollutant volatiles organic compounds, including acrolein and acrylonitrile. If analysis of acrolein and acrylonitrile is found to be of concern, a separate subsample should be preserved by adjusting the pH to 4-5 and the sample should then be analyzed by U.S. EPA Method 603.

QA/QC

QA/QC procedures should be detailed in the quality assurance project plan (QAPP) (U.S. EPA 1979c; Tetra Tech 1987). The following items should be discussed in the QAPP:

- Statement and prioritization of study objectives
- Responsibilities of personnel associated with sample collection and analysis
- Sampling locations, frequency, and procedures
- Variables to be measured, sample sizes, sample containers, preservatives, and sample holding times
- Equipment checklist
- Sample splits or performance samples to be submitted with the samples
- Sample handling, packaging, labeling, and shipping requirements
- Laboratories to which samples will be shipped.

Tetra Tech (1987) provides QA/QC guidance for the following activities:

- Preparation for sampling program
- Sample collection
- Sample processing
- Sample size

- Sample containers
- Sample preservation
- Sample holding times
- Sample shipping
- Recordkeeping
- Labeling
- Custody procedures
- Analytical methods
- Calibration and preventive maintenance
- Quality control checks
- Corrective action
- Data reporting requirements.

Field Sampling Procedures

For the field sampling effort, the following procedures are recommended:

- Establish and implement chain-of-custody protocols to track samples from the point of collection to final disposition
- Establish and implement protocols to prepare sample containers

- Prepare field "blank" samples to assess potential sample contamination by the sampling devices

- Prepare "trip blanks" to assess potential contamination by volatile organic analytes en route to the laboratory (1 trip blank per sample shipment)

- Collect replicate samples to assess sample precision and the homogeneity of samples collected

- Use appropriate sample collection procedures (see Table E-8).

Volatile organic samples and split composite samples should be collected carefully. Grab samples for volatile organic analyses should be collected in duplicate. Residual chlorine should be eliminated, and the volatile sample containers should be filled with a minimum of mixing and to capacity leaving no headspace. When splitting composite samples into discrete aliquots for analyses, the composite sample should be mixed to provide a homogeneous mixture. A representative portion of any solids in the container should be suspended in the composite sample. Composite samples may be homogenized by hand stirring with clean glass rods or by mechanical stirring with teflon-coated paddles. Metal mixing devices should not be used.

Laboratory Procedures

Laboratory analytical results must be accurate and reliable. Laboratory QA/QC procedures are generally specified for each different analytical method, and the level of QA/QC and associated deliverables vary among methods (Tables E-5 to E-7). The following documentation is required by the analytical laboratory for QA review of data on organic substances (see Tables E-6 and E-7):

- Initial multipoint calibration
- Demonstration of method proficiency
- Determination of method detection limit [usually 5-10 ppb for base, neutral, and acid organic compounds (U.S. EPA Method 625); 0.005-0.10 ppb for pesticide/PCB analysis (U.S. EPA Method 608); and 1-10 ppb for volatiles (U.S. EPA Method 624)]
- Daily checks of calibration and instrument tuning
- Daily analysis of method blanks (1 blank/20 samples)
- Analysis of duplicate samples (minimum of 5 percent of samples analyzed) and conduct of matrix spikes to determine organic recoveries.

The following documentation is required by the analytical laboratory for QA review of data on inorganic substances (see Table E-5):

- Multipoint calibration
- Analysis of reagent blanks
- Matrix spikes of 0.5-5 times the sample concentration
- Determination of method detection limits
- Analysis of full method blanks at a minimum frequency of every 20 samples, rather than reagent water blanks
- Verification of calibration by analysis of standards (daily or with every 10 sample batches)

- Performance of duplicate analyses for a minimum of 5 percent of the total number of samples analyzed

- Use of the method of standard additions for samples demonstrating interferences.

Data Evaluation

Data generated from the monitoring program should be evaluated using the step-wise approach discussed below.

1. Assemble the original raw data reports and the associated QA/QC data. The analytes and analytical methods used will determine the types of QA/QC data generated, and may include the following:

   - Sample results

   - Blank sample results

   - Instrument calibrations (initial and continuing)

   - Matrix spike/matrix spike duplicate results

   - Surrogate recovery data

   - Instrument tuning data

   - Chain-of-custody records

   - Analytical request forms

   - Gas chromatograms

   - Mass spectra

- Instrument detection limit determinations
- Serial dilution results
- Clean-water precision and accuracy studies
- Furnace atomic absorption quality control data
- Interference check data
- Laboratory control sample results
- Holding time documentation.

2. Because the resulting data will be used to determine regulatory compliance of the discharge, the following sequence is recommended to conduct a QA review of the data:

   - Confirm the sample identifier, container, and preservation with chain-of-custody records
   - Confirm the analytical (e.g., extraction or digestion) procedure used with the procedure requested
   - Confirm that an acceptable instrument detection limit was achieved
   - Confirm that the analysis proceeded in the manner specified
   - Confirm that all quality control data deliverables specified by the analytical protocol have been submitted
   - Confirm that the analysis was performed within the specified sample holding time

- Confirm that the instrumentation used was properly calibrated initially and that the method was validated

- Confirm detection limits, precision, and accuracy for each substance and review duplicate analysis results

- Confirm that blank samples were analyzed and that the field sampling and analytical procedures did not contaminate the data

- Evaluate the presence of matrix interferences through the use of surrogate recoveries and matrix spikes

- Annotate the data with appropriate qualifiers, and note deviations from prescribed methods

- Detail problems associated with the analyses.

UPGRADING TO A FULL-SCALE SECONDARY TREATMENT FACILITY

Data obtained from the monitoring program described above will be used to determine the mean and peak concentrations and site-specific toxic pollutant removal capabilities for secondary treatment. Performance of the secondary treatment pilot plant will be closely related to the attention and expertise of the operator controlling the plant. If the pilot plant is not properly operated, the data will not approximate the removals that could be achieved with a full-scale facility. Conventional pollutant data (e.g., suspended solids, BOD) can be used to determine when the pilot plant is operating within the expected design removal efficiencies. The most important factor in performing site-specific toxic pollutant removal investigations is to ensure that an acclimated biological seed exists prior to initiating sample collection for pollutant analyses.

Plant operators should be aware that activated sludge microorganisms are susceptible to biological and chemical effects that may kill the organisms or severely inhibit their effectiveness. Accumulations of toxic waste components (via gradual concentration from continuous discharges, or sudden slugs) could limit the ability of the activated sludge system to achieve design effluent quality (see Tables E-9 and E-10). Disruptions or changes could be found by reviewing operating records (e.g., settling characteristics of secondary sludge, species populations in the MLSS). If inhibition or upset conditions are found, the concentration and source of each pollutant of concern should be determined. Concentrations shown in Tables E-9 and E-10 are not absolute and should be used only for comparison purposes and preliminary investigations.

Toxic pollutant removal efficiencies at the secondary treatment pilot plant may be greater than those expected in a full-scale secondary treatment facility. The pilot plant will be operated at a constant flow rate and will not be subject to the diurnal and seasonal flow fluctuations normally

TABLE E-9. REPORTED VALUES FOR ACTIVATED SLUDGE BIOLOGICAL PROCESS TOLERANCE LIMITS OF ORGANIC PRIORITY POLLUTANTS

Pollutant	Threshold of Inhibitory Effect (mg/L)[a]
Acenaphthene	NI[b] at 10
Acrolein	NI at 62
Acrylonitrile	NI at 152
Benzene	125
Benzidine	5
Carbon tetrachloride	NI at 10
Chlorobenzene	NI at 1
1,2,4-Trichlorobenzene	NI at 6
Hexachlorobenzene	5
1,2-Dichloroethane	NI at 258
1,1,1-Trichloroethane	NI at 10
Hexachloroethane	NI at 10
1,1-Dichloroethane	NI at 10
1,1,2-Trichloroethane	NI at 5
1,1,2,2-Tetrachloroethane	NI at 201
bis-(2-Chloroethyl) ether	NI at 10
2-Chloroethyl vinyl ether	NI at 10
2-Chloronaphthalene	NI at 10
2,4,6-Trichlorophenol	50
para-Chloro-*meta*-cresol	NI at 10
Chloroform	NI at 10
2-Chlorophenol	NI at 10
1,2-Dichlorobenzene	5
1,3-Dichlorobenzene	5
1,4-Dichlorobenzene	5
1,1-Dichloroethylene	NI at 10
1,2-*trans*-Dichloroethylene	NI at 10
2,4-Dichlorophenol	NI at 75
1,2-Dichloropropane	NI at 182
1,3-Dichloropropylene	NI at 10
2,4-Dimethylphenol	NI at 10
2,4-Dinitrotoluene	5
2,6-Dinitrotoluene	5
1,2-Diphenylhydrazine	5
Ethylbenzene	NI at 10
Fluoranthene	NI at 5

TABLE E-9. (Continued)

Pollutant	Threshold of Inhibitory Effect (mg/L)[a]
bis-(2-Chloroisopropyl) ether	NI[b] at 10
Chloromethane	NI at 180
Bromoform	NI at 10
Dichlorobromomethane	NI at 10
Trichlorofluoromethane	NI at 10
Chlorodibromomethane	NI at 10
Hexachlorobutadiene	NI at 10
Hexachlorocyclopentadiene	NI at 10
Isophorone	NI at 15.4
Naphthalene	500
Nitrobenzene	500
2-Nitrophenol	NI at 10
4-Nitrophenol	NI at 10
2,4-Dinitrophenol	1
N-Nitrosodiphenylamine	NI at 10
N-Nitroso-di-N-propylamine	NI at 10
Pentachlorophenol	0.95
Phenol	200
bis-(2-Ethyl Hexyl) phthalate	NI at 10
Butyl Benzyl phthalate	NI at 10
Di-n-butyl phthalate	NI at 10
Di-n-octyl phthalate	NI at 16.3
Diethyl phthalate	NI at 10
Dimethyl phthalate	NI at 10
Chrysane	NI at 5
Acenaphthylene	NI at 10
Anthracene	500
Fluorene	NI at 10
Phenanthrene	500
Pyrene	NI at 5
Tetrachloroethylene	NI at 10
Toluene	NI at 35
Trichloroethylene	NI at 10
Aroclor-1242	NI at 1
Aroclor-1254	NI at 1
Aroclor-1221	NI at 1
Aroclor-1232	NI at 10
Aroclor-1016	NI at 1

[a] Unless otherwise indicated.

[b] NI = no inhibition at tested concentrations. No concentration is listed if reference lacked concentration data.

Reference: U.S. EPA (1986c).

TABLE E-10. REPORTED VALUES FOR ACTIVATED SLUDGE BIOLOGICAL PROCESS TOLERANCE LIMITS OF INORGANIC PRIORITY POLLUTANTS

Pollutant	Threshold of Inhibitory Effect (mg/L)
Arsenic	0.1
Cadmium	1
Chromium (VI)	1
Chromium (III)	10
Copper	1
Cyanide	0.1
Lead	0.1
Mercury	0.1
Nickel	1
Silver	5
Zinc	0.03

Reference: U.S. EPA (1986c).

experienced at treatment facilities, nor the slug loadings and batch discharges which POTWs can experience in daily operation. In addition, at the relatively higher aeration rates of the pilot plant system, higher degrees of volatile organics stripping may occur, thereby implying higher levels of removal of biodegradable material than might actually happen under full-scale situations.

DEMONSTRATING COMPLIANCE USING PILOT PLANT DATA

The purpose of operating a secondary treatment pilot plant is to determine the concentrations of toxic substances in the effluent that would be realized if the applicant were providing secondary treatment, rather than less-than-secondary treatment as requested in the 301(h) application. Effluent from the secondary treatment pilot plant is then analyzed to determine the concentration of each toxic substance in the effluent. These concentrations define the maximum allowable concentrations in the discharge of less-than-secondary treated effluent.

To demonstrate secondary equivalency, the applicant must demonstrate that the concentration of each toxic substance in the effluent of the Section 301(h) modified discharge is equal to, or less than, the concentration achieved using the secondary treatment pilot plant. For toxic substances whose concentration in the Section 301(h) modified discharge is greater than the concentration in the secondary treated effluent, the applicant must lower the concentration using either or both of two approaches. The first approach is to establish local limits for such substances, in accordance with the guidance given above. The second approach is to upgrade the treatment process within the POTW. Having implemented either or both of these approaches, the applicant must then provide results of additional effluent analyses to demonstrate that the maximum allowable concentrations of toxic substances are not being exceeded after the proposed controls have been implemented.

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ATTACHMENT 1 TO APPENDIX E

U.S. EPA OFFICE OF WATER ENFORCEMENT AND PERMITS PROCEDURES FOR DEVELOPING TECHNICALLY BASED LOCAL LIMITS

U.S. EPA OFFICE OF WATER ENFORCEMENT AND PERMITS PROCEDURES FOR DEVELOPING TECHNICALLY BASED LOCAL LIMITS

INTRODUCTION

Publicly owned treatment works (POTWs) which discharge wastewater into marine waters may be granted a waiver under Section 301(h) of the Clean Water Act (CWA) from the requirement for secondary treatment [Section 301(b)(1)(B)]. The Water Quality Act (WQA) of 1987 added a new requirement, the urban area pretreatment program, to Section 301(h) of the CWA for POTWs serving a population of 50,000 or more with respect to toxic pollutants introduced by industrial dischargers. This provision now requires each applicant to demonstrate that it has a pretreatment program in effect for each toxic pollutant which, in combination with the applicant's own treatment of discharges, removes the same amount of a given toxic pollutant as would be removed if the applicant were to apply secondary treatment (as defined in 40 CFR Part 133) and if it had no pretreatment program for the toxic pollutant. This new "secondary removal equivalency" requirement applies only with respect to a toxic pollutant introduced into a POTW by an industrial discharger for which there is no "applicable pretreatment in effect."

Under this new provision, for each toxic pollutant introduced by an industrial user, the applicant must demonstrate either that there is an applicable pretreatment requirement in effect or that it has a secondary removal equivalency program for any toxic pollutant from industrial sources for which there is no applicable pretreatment requirement. Applicable pretreatment requirements may take the form of Federal categorical pretreatment standards, local limits developed in accordance with 40 CFR Part 403, or a combination thereof.

POTWs must demonstrate that local limits developed are adequate and enforceable. This new CWA provision also requires POTWs to demonstrate that industrial sources are in compliance with all of their pretreatment requirements, including numerical standards set by local limits, and that those requirements will be enforced.

The following discussion provides a review of procedures for developing technically-based local limits. Further details on the various approaches are provided in U.S. EPA's Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program (December 1987). Questions about this guidance should be directed to the U.S. EPA Regional Pretreatment Coordinators or to The Office of Water Enforcement and Permits in Washington, DC.

OVERVIEW OF LOCAL LIMITS

Local discharge limitations are requirements developed by a POTW based on local conditions and unique requirements at the POTW. These limits are primarily intended to protect the treatment plant from industrial discharges which could interfere with POTW treatment processes or pass through the treatment plant to receiving waters and adversely impact water quality. Local limits are also designed to prevent sludge contamination and protect workers at the treatment plant.

Local limits are usually developed on a chemical specific basis and are implemented as requirements that individual industrial dischargers must meet. Once adopted, local limits are deemed to be Federal standards for the purposes of the Clean Water Act Section 307(d) prohibition against violating pretreatment standards [40 CFR 403.5(d) and 40 CFR 403.3(j)].

LOCAL LIMITS DEVELOPMENT APPROACHES

U.S. EPA's Guidance on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program (1987) provides various methods for calculating local limits. The predominant approach

used by POTWs and advocated in the Guidance is a chemical specific approach known as the maximum allowable headworks loading method. This method involves back calculating from environmental and plant protection criteria to a maximum allowable headworks loadings. This is accomplished pollutant by pollutant for each environmental criteria or plant requirement and the lowest or most limiting value for each pollutant serves as the basis for allocation to industry and ultimate local limits. The steps of the maximum allowable headworks loading local limits development process are shown in Figure 1, and discussed below.

Maximum Allowable Headworks Loading Method

Determine Applicable Environmental Criteria--

The first step in developing local limits by the maximum allowable headworks loading method is to determine applicable environmental criteria. Environmental criteria generally include NPDES permit limits, water quality standards or criteria, sludge disposal requirements, and unit process inhibition values. The POTW should use all applicable environmental criteria when developing local limits. Other appropriate requirements may include worker health and safety criteria, collection system effects, incinerator emission requirements or other applicable federal, state, or local environmental protection requirements. Further information on how to incorporate applicable environmental criteria into the local limits development process is contained in the guidance manual.

Another less frequently used environmental criterion is biological toxicity. POTWs that have conducted biological toxicity testing indicating toxicity should develop local limits to correct the toxicity. Although there is no method in the guidance manual to calculate maximum allowable headworks loadings based on the results of toxicity testing, the manual provides guidance and additional references on the Toxicity Reduction Evaluation (TRE) process.

Characterize Existing Loadings--

Industrial Users--During the local limits development process, the POTW must characterize existing loadings to the treatment plant. Local limits should be based on site-specific monitoring data. This can be accomplished by conducting monitoring of all industrial users. Either POTW monitoring or self-monitoring data are acceptable, and information from the POTW's industrial waste survey may also be of use.

Hauled Waste--If hauled wastes are accepted at the POTW, they may be a significant source of toxic pollutant loadings. In such a case the POTW should consider them as a significant nondomestic source in the determination of local limits.

Domestic Loadings--The POTW must also characterize domestic loadings. Site-specific monitoring of a representative portion of the POTW's collection system should form the basis for loadings from domestic/background sources. Use of literature values must be justified by the POTW.

Treatment Plant Monitoring--The POTW must conduct sufficient monitoring at the treatment plant to characterize influent, effluent, and sludge loadings. Monitoring of the treatment plant influent, effluent, and sludge should represent a minimum of 5 consecutive days. Preferably, monitoring should include data for at least 1 day per month over at least 1 yr for metals and other inorganic pollutants, and 1 day of sampling per year for toxic pollutants [priority pollutants and Resource Conservation and Recovery Act (RCRA) Appendix 9 constituents].

Determine Pollutants of Concern--

As one approach for achieving compliance with Section 301(h) regulations, POTWs serving a population of 50,000 or more must demonstrate that applicable pretreatment requirements are in effect for any and all toxic pollutants contributed by an industrial user. Therefore, data should be collected for any toxic pollutants of concern that could reasonably be

expected to be discharged to the POTW in quantities that could pass through or interfere with the POTW treatment process, contaminate the sludge, or jeopardize worker health and safety or the collection system.

The POTW should perform at least one priority pollutant scan and one RCRA Appendix 9 scan to identify potential pollutants of concern in the influent, effluent, and sludge. The POTW must then address all toxic pollutants (40 CFR 401.15) that are identified in any analysis above detection limits by developing a local limit for each pollutant.

Calculate Maximum Headworks Loadings--

The POTW must calculate the maximum amount (lb/day) of each toxic pollutant contributed by an industrial user or received at the headworks of the treatment plant that will allow the POTW to achieve all of the above applicable environmental criteria. If the POTW does not calculate the maximum allowable headworks loading to the POTW for each toxic pollutant, it must provide justification why it has not done so. The nonconservative pollutants (volatiles) require special consideration when conducting headworks analysis (e.g., alternative formulas and allocation methods). All calculations should be consistent with the approach outlined in the guidance manual.

During this step of the local limits development process, the POTW should demonstrate that an acceptable mass balance exists between the actual loadings of pollutants at the headworks and the estimated loadings of pollutants from specific source discharges. This mass balance can be accomplished by calculating the actual loading of each pollutant from influent monitoring data and comparing this value with the sum of the estimated loadings from all individual sources (e.g., domestic, industrial, hauled waste). The resulting calculated loadings from various sources should be within 80 to 120 percent of the actual total influent loading and flow.

Calculate Allowable Industrial Loadings--

Once the POTW has calculated the maximum allowable headworks loading, a safety factor must be applied and the value discounted for domestic/background loadings in order to determine the maximum allowable allocation available for industrial users. A safety factor is incorporated into the calculations to allow for future industrial growth and other discrepancies that may enter into the calculations because of the use of default data or variations in analytical procedures. The POTW should provide justification for the selected safety factor, which will usually range from 10 to 30 percent.

Allocate Allowable Industrial Loading--

After the POTW has calculated the allowable industrial loading, the method chosen to allocate this loading depends on the number and types of industrial users and the method of application (permits, contract, or sewer use ordinance) employed by the POTW. Where the current loading of a pollutant exceeds the maximum allowable headworks loading, the POTWs must establish a local limit to reduce loadings to within the range of the maximum allowable headworks loading. Where the current loading is far below or approaches the maximum allowable headworks loading, the POTW must set industrial discharge limits at current loadings to maintain the status quo.

The POTW should ensure that it has selected local limits that are reasonable. All local limits should be at or above detection limits and should not be so lenient as to provide industry additional opportunity to pollute or encourage discharge of hazardous waste to the POTW.

Revise Local Limits--

Many variables on which these local limits calculations are based may vary with time. Local limits must be revised on a periodic basis to reflect changes in conditions or assumptions. Conditions which might require that local limits be revised include but are not limited to changes in environ-

mental criteria, availability of additional monitoring data, changes in plant processes, and changes in POTW capacity or configuration.

Implement Local Limits--

Once local limits have been developed, they must be effectively implemented. Local limits should be incorporated into the sewer use ordinance or some form of individual control mechanisms.

OTHER LOCAL LIMITS APPROACHES

Other methods of local limits development have been used by POTWs. They include the collection system approach, industrial user management practice plans, and case-by-case discharge limits. These approaches are briefly described below. U.S. EPA has published extensive guidance on the development and implementation of local limits. Further information on each of these methods and the maximum allowable headworks loading method can be found in the *Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program* (U.S. EPA 1987).

Collection System Approach

To apply this method, the POTW identifies pollutants that may cause fire and explosion hazards or other worker health and safety concerns. Pollutants found to be present are evaluated for their propensity to volatilize and are simplistically modeled to evaluate their expected concentration in air. Comparisons are made with worker health exposure criteria and lower explosive limits. Where values are of concern, the POTW may set limits or require development of management practices to control undesirable discharges. The collection system approach may also consider the prohibition of pollutants with specific flashpoints to prevent discharge of ignitable wastes.

Industrial User Management Practice Plans

This approach consists of POTWs requiring industrial users to develop management practices as enforceable pretreatment requirements for the handling of chemicals and wastes. Examples of management practice plans include chemical management practices, best management practices, and spill prevention plans. Management practice plans are usually narrative local limits.

Case-by-Case Discharge Limits

In this approach a POTW sets numeric local limits based on best professional judgment and on available technologies that are known to be economically feasible. This approach is most often used when insufficient data are available to employ the other methods noted above.

ATTACHMENT 2 TO APPENDIX E

U.S. EPA GUIDANCE MANUAL ON THE DEVELOPMENT AND IMPLEMENTATION OF LOCAL DISCHARGE LIMITATIONS UNDER THE PRETREATMENT PROGRAM

APPENDIX F

WATER QUALITY-BASED TOXICS CONTROL

WATER QUALITY-BASED TOXICS CONTROL

Most applicants for Section 301(h) modified NPDES permits must demonstrate satisfactorily to the U.S. EPA that discharge from the POTWs to the marine or estuarine waters is in compliance with Section 301(h) of the Clean Water Act (CWA). POTWs must enforce all applicable industrial pretreatment requirements and demonstrate the effectiveness of both industrial and nonindustrial source control programs. (Small dischargers, with service area populations of less than 50,000 people and average dry weather flows of less than 5.0 MGD, are exempt from effluent analysis and industrial pretreatment requirements if they can certify that there are no known or suspected sources of toxic pollutants or pesticides to the POTW.) Section 301(h) industrial source control programs must be consistent with pretreatment regulations and NPDES permit requirements. Under Sections 308 and 402 of the CWA, NPDES permit applicants [including 301(h) POTWs] are required to collect effluent chemical (and possibly toxicity) data and receiving water biological data to assure compliance with state water quality standards. [If no state standards have been developed for specific pollutants at the time of permit issuance, small and large dischargers must then meet U.S. EPA's marine water quality criteria at the boundary of the zone of initial dilution (ZID).]

In 1984, U.S. EPA (1984) recommended that whole-effluent toxicity testing be used as a complement to chemical-specific analyses to assess effluent discharges and determine NPDES permit limitations. [U.S. EPA developed this approach because of certain disadvantages of the chemical-specific techniques (i.e., the difficulty in identifying all potentially toxic pollutants; the antagonistic, synergistic, or additive effects of toxic pollutants; and the possibility of complex chemical interactions).] The integrated approach is recommended to assure the attainment of water

quality standards, to protect designated water uses, and to provide a tool to control pollutants beyond the CWA technology-based requirements [e.g., Best Available Technology Economically Achievable (BAT)].

The Water Quality Act (WQA) of 1987 also emphasized the need for an integrated approach of whole-effluent and chemical-specific analyses. Congress required U.S. EPA to report on methods for establishing and measuring water quality criteria for toxic pollutants through the use of biological monitoring and assessment methods, and pollutant-specific analyses. The WQA also signalled a shift in emphasis from discharge requirements that were based primarily on technology-based pollution controls to requirements that combined both technology-based and water quality-based pollution controls.

In 1985, U.S. EPA's Office of Water Enforcement and Permits (OWEP) and the Office of Water Regulations and Standards (OWRS) prepared the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA 1985a). Guidance was provided on the implementation of a biomonitoring policy for the assessment and control of toxics using both the chemical-specific approach and the whole-effluent toxicity approach. The chemical-specific approach uses water quality criteria or state standards to limit specific pollutants directly. The whole-effluent toxicity approach, as described in the technical support document predominantly for non-marine waters, involves the use of test organisms [e.g., *Daphnia spp.* (water flea), *Pimephales Promelas* (fathead minnow)] that are exposed to serial dilutions of municipal or industrial effluent/receiving water to measure acute (rapid response) and/or chronic (long term response) toxicity. The document also provided guidance for each step in the water-quality based toxics control program, including the development of water quality standards and criteria, effluent characterization, health hazard assessment, wasteload allocation, permit requirements, and compliance monitoring.

In 1985, the U.S. EPA also issued a manual that established standardized methods for measuring the acute toxicity of effluents to freshwater and marine organisms (U.S. EPA 1985b) and the chronic toxicity of effluents to

freshwater organisms (U.S. EPA 1985c). In 1988, U.S. EPA released a document that established standardized methods for estimating the chronic toxicity of effluents to marine and estuarine organisms (U.S. EPA 1988). Chronic toxicity test methods were provided for five species: the sheepshead minnow *(Cyprinodon variegatus)*, the inland silverside *(Menidia beryllina)*, the mysid *(Mysidopsis bahia)*, the sea urchin *(Arbacia punctulata)* and the red macroalga *(Champia parvula)*. However, because these tests use non-indigenous species to estimate the chronic toxicity of effluents and receiving waters to marine and estuarine organisms, test results may not necessarily reflect actual field conditions within or near the ZID. Moreover, test results may not accurately represent impacts of pollutant discharges on balanced indigenous populations (BIPs).

U.S. EPA developed a permit writer's guide (U.S. EPA 1987) to assist state and Federal NPDES permit writers in establishing water quality-based permit limits for toxic pollutants. To meet these water quality-based limits, the U.S. EPA is continuing to develop criteria that will assist states in establishing their water quality standards and effluent permit limitations. The U.S. EPA criteria under development include recommended magnitudes, durations, and allowable frequencies of exceedance of pollutant concentrations for both acute and chronic biological effects. POTW permit limits on effluent toxicity could be imposed, and the NPDES permittee would be required to conduct a toxicity reduction evaluation (TRE) and implement, if necessary, a toxics control program (TCP) (U.S. EPA 1985a, 1987).

The TRE, a critical component of the TCP, must be conducted to identify effluent toxicity sources, to determine (if possible) specific pollutants responsible for the toxicity, and to identify source control options. The TRE includes a review of the magnitude and extent of the toxicity problem, the discharge characteristics, the receiving water characteristics, the need for additional monitoring to determine water quality/toxicity effects and the other potential point and nonpoint toxicity sources in the POTW service area.

Because all NPDES-permitted discharges are unique, no single effluent TRE procedure is applicable to every case. A TCP must be developed on an individual case-by-case basis, and must include an evaluation of the impact of 1) the existing POTW wastewater treatment process, 2) point and nonpoint contributors to the POTW influent, 3) types of industries in the POTW service area, 4) the variability, toxicity, and treatability of chemicals in the effluent; and 5) the variability in species sensitivity based on whole-effluent toxicity test results. Either technology-based or water quality-based) source control options also need to be evaluated to determine their effectiveness in reducing effluent toxicity and alleviating the water quality violations.

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