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WATER STRATEGY PAPER

Second Edition

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STATEMENT OF POLICY
FOR IMPLEMENTING THE REQUIREMENTS
OF THE
1972 FEDERAL WATER POLLUTION CONTROL ACT
AMENDMENTS

AND CERTAIN REQUIREMENTS
OF THE
1972 MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT

U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

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PREFACE

This February 15, 1974 edition of the Water Strategy has been prepared for use and review by Federal, State, and local government officials and for the information of the public. Major changes to the previous 1973 edition have been made. This edition has also been expanded to include many areas of program activities that were not previously covered. This edition of the Strategy reflects the final decisions on the Federal Government's FY 1975 budget.

Persons using the Strategy are reminded that the Strategy, while based on the law, is not the law, nor is it a regulation mandated by the law. It is guidance prepared for use by government agencies in implementing the Acts.

The Strategy Paper is written under the aegis of the Water Planning Division in EPA Headquarters. While much of the work undertaken in its development has been performed by people within this Division, it more fully reflects the work of individuals within all EPA Headquarters program areas, and the participation of EPA's Regional Offices and the States.

Comments on the Strategy are welcomed. They should be addressed to:

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A limited number of additional copies of the Strategy Paper are available, and can be had upon request by writing to the above address. For those seeking a more general discussion of this area, EPA's Office of Public Affairs has prepared several pamphlets describing the provisions of the Act, and will have available a summary primer covering the contents of this Strategy Paper.

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PURPOSE

The Water Strategy Paper is designed to play an important part in implementing the Federal Water Pollution Control Act Amendments of 1972 and the Marine Protection, Research, and Sanctuaries Act of 1972. As a part of the management system for their implementation, the Paper will ensure that program activities, by conforming to a single strategy, are consistent among each other. It will further serve as a means of promoting awareness and encouraging public participation.

The principal emphasis of the Strategy is on the implementation of the Federal Water Pollution Control Act, for which EPA has the major Federal responsibility. EPA's role under the Marine Protection, Research, and Sanctuaries Act in regulating ocean dumping is also included. However, specific programs governing the protection of public water supplies are not included in this Paper.

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II. INDIVIDUAL PROGRAM STRATEGIES

The basic elements of the Strategy for controlling water pollution are set by the scope and emphasis of the Act itself. Of all receiving waters, the Act focusses (Federal) attention on navigable waters first. Of all dischargers into these navigable waters, the Act assigns highest priority to point sources for control.

Accordingly, the initial sections of this part of the Water Strategy concern programs for the control of stationary point sources, discharging inland to streams, lakes, and rivers. Later sections deal with sources which are diffuse or intermittent, and with the pollution of oceans and groundwater.

The Act's primary mechanism for controlling point source discharges into inland and coastal waters is the National Pollutant Discharge Elimination System. Under NPDES, permits are issued stating the limits of allowable discharge in 1977 and 1983 (the general target dates of the Act) and a schedule of interim dates and allowable discharges. Section A explains the basis for the final effluent limitations contained in these NPDES permits.

A. The Basis for Effluent Limitations

Subject to certain cutoffs for ease in administering the program, under the Act every point source is subject to an effluent standard and a water quality standard. The effluent, or technology, standard states what is economically achievable in pollutant reduction for that class and type of discharger, nationally. The water quality standard can be used to determine what is environmentally necessary to achieve in pollutant reduction, if the particular stretch of water on which a discharger is located is to be used for its designated purpose (agriculture, swimming, etc.).

The effluent limitation which is contained in a discharger's permit is calculated by comparing the technology standard for the source category with the water quality standard for the receiving waters, and adopting whichever implied level of control is more stringent. In practice, the technology standard is used as the base level for limitations. Its provisions are tightened where necessary to meet water quality standards.

The concept of base-level limitations unrelated to local water quality is one of the major innovations of the Act. It represents a departure from water pollution control practice prior to the 1972 Amendments, when water quality standards alone were the basis for effluent limitations.

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New source review may initially be limited to large sources, to assure cost-effective review procedures. However, it may also be necessary to provide procedures to review the aggregate impact of multiple smaller sources. In stringent areas, the policy may dictate that no major new source be allowed unless it is balanced by the closure or increased control of certain existing facilities. In any case, every review of potential new source impacts must consider downstream as well as local effects.

Policies to prevent significant degradation of water quality will necessarily impact on land use planning. Water quality control policies must be developed and reviewed in a larger context to assure that water quality will be protected in a manner consistent with the overall projections and goals of the State.

A.3. Toxic Effluent Standards.

Strategic Guidance

By section 307(a) EPA is required to set effluent standards which will end the discharge into waters of toxic pollutants in toxic amounts. This has been intepreted as essentially an environmental and not an economic mandate, and the effluent standards which will result are so oriented. Toxic effluent standards are based on receiving water quality rather than available control technology. They typically consider the physical, chemical, and biological parameters which are to be protected, the assimilative capacity of the receiving water in terms of these parameters, and the ambient improvements to be derived.

The list of toxic pollutants for which effluent standards are promulgated is dynamic. To the initial list of nine pollutants others will be added, as the following criteria are satisfied: 1) data from laboratory or field studies indicate that a pollutant could constitute a serious environmental threat if discharged into water (these would include data on bioaccumulation, teratogenicity, mutagenicity, carcinogenicity, and high acute toxicity), 2) the pollutant is discharged, or has the potential of being discharged, from point sources, 3) data are available to establish effluent standards meeting the requirements of the Act, and 4) standards-setting under section 307(a) is appropriate because the prospective timing and effectiveness of abatement actions under other provisions of the Act are not commensurate with the seriousness of the problems identified by the above criteria.

For a toxic pollutant, the standards-setting methodology will begin with the determination of a concentration safe from undesirable effects (equivalent to the water quality criterion for that pollutant). If such a level cannot be established the effluent standard will be set or no discharge. If such a level can be established, than a model ecosystem will be constructed to find the particular limiting concentration for the most sensitive species that is considered important and which can be adversely affected. In some cases this may be an aquatic organism; in others, through bioaccumulation or

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exposure, it may be man. Each toxic standard will be expressed as a maximum allowable concentration, based on acute effects, and as a maximum allowable daily amount, based on chronic effects and the dilution characteristics of the water body on which a discharger is located.

Toxic effluent standards will apply to the significant classes of toxic pollutant dischargers-sources which are also covered by municipal and industrial guidelines. Toxic standards will bear no necessary relation to the removal levels of the other standards, because they are conceived on a different methodological basis (environmental damage vs. economic feasibility). Toxic standards will have uniformly stricter timetables, however: Congress provides that they be met within a year of final promulgation, as opposed to 1977 for other standards.

Toxic effluent standards, in effect, provide a short-cut to the control of the most dangerous individual pollutants presently being discharged into navigable waters. The legislative history is a record of Congress' concern on this subject, which is borne out by the requirement for a year's compliance with promulgated standards. Toxic effluent standards serve the same function, however, as water quality standards could theoretically serve: both are meant to achieve criteria levels in ambient waters. Water quality standards as an instrument of toxic control still face a variety of problems, including use designations not compatible with the Act's 1983 goals, the absence of toxic criteria from most standards, and technical difficulties in toxic modelling and load allocation. The final relationship for 1983 between toxic effluent standards and water quality standards has not been worked out yet. EPA's strategy will depend in part on the resolution of these issues.

Approach

Step 1 - EPA promulgated the following initial list of toxic pollutants on September 7, 1973:

Aldrin-Dieldrin
Benzidine
Cadmium
Cyanide
DDT (DDD, DDE)
Endrin
Mercury
Polychlorinated Biphenlys
Toxaphene

Step 2 - EPA published proposed effluent standards for materials on the toxic pollutants list on 27 December 1973.

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Step 3 - EPA will promulgate final toxic effluent standards for initial list by June 1974.

Step 4 - EPA will add materials to the list of toxic pollutants to be controlled by effluent standards as information on effects to substantiate a standard becomes available.

A.4. Thermal Limitations.

The Act treats discharges of heat differently from other pollutants. Control technology-related effluent standards do not necessarily provide the base level of limitations. Moreover, because long lead times are needed for the planning and construction of facilities having major thermal discharge components (principally power plants), longer immunity from other requirements may be provided.

Thermal Effluent Standards.

Guidelines for one of the major sources of thermal effluents--the steam electric power industry--will establish definitions of BPT, BAT, and new source performance standards. These will be consistent with the Administrator's statutory responsibility to identify the degree of effluent reduction attainable by various industries, independent of water quality considerations.

Thermal Water Quality Standards.

Few States currently have water quality standards for temperature that are adequate to assure the 1983 goal of aquatic life protection. Deficiencies exist in some areas because the waters are not classified for aquatic life uses; in others, although the waters are so classified, the established criteria do not provide the necessary level of protection.

Water quality criteria which the Administrator has published pursuant to section 304(a) of the Act address temperature. These are interim criteria: when final, they will supersede EPA's former recommendations contained in the 1968 NTAC Report. Water quality standards which are revised according to the new recommendations will provide more site-specific protection of indigenous populations by determining, for each waterway, the species of fish which should be protected as an indicator of the balanced population. For each species the new criteria list weekly average and maximum temperatures allowable in the summer and reproductive season, and weekly average temperatures for the winter months. Zones of passage beyond any thermal plume or mixing zone must also be determined pursuant to EPA recommendations.

The new thermal criteria recommendations should be integrated into each State's standards at the first review. Standards will be revised according to applicable statutory requirements, including public participation.

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STATEMENT OF BASIS AND PURPOSE

TOXIC POLLUTANT EFFLUENT STANDARDS

I. Legislative Basis

Part 104, Title 40, Code of Federal Regulations, establishes rules of practice applicable to public hearings in connection with the establishment of effluent standards for toxic pollutants. Section 104.4 states that "whenever the Administrator publishes a proposed effluent standard, he shall make available to any interested person a statement of the basis and purpose of such standard. Such statement ... shall include:

(a) an explanation of how the proposed standard was derived, including any assumptions or calculations necessary for its derivation;

(b) scientific and technical data and studies supporting the proposed standard; and

(c) such other information as is necessary to fully set forth the basis and purpose of the standard."

II. Summary

The following is a summary of the basis and purpose of the proposed effluent standards: The four basic factors considered in setting the standards were (1) toxicological data, (2) hydrodynamic data, (3) ample margins of safety and (4) calculations of the acute and chronic limitations for the standards. The primary basis

for toxicological considerations came from the Water Quality Criteria which were proposed in October (38 F.R. 29646 et seq., Friday, October 26, 1973). These criteria were based in part on a report by the National Academy of Sciences and the National Academy of Engineering entitled Water Quality Criteria, 1972 which is currently being published by the Environmental Protection Agency. The toxicity of the pollutants on the list, their persistence, degradability, the usual or potential presence of the affected organisms in any waters, the importance of the affected organisms, and the nature and extent of the effect of the toxic pollutant on such organisms, were considered in the establishment of the Water Quality Criteria upon which these standards are based.

Water Quality Criteria published pursuant to Section 304(a) of the Act are those concentrations which are acceptable in the receiving water body. The criteria were developed to protect a variety of water uses including industrial, agricultural, recreational, propagation of fish and wildlife, aesthetics and potable water supplies. The protection of fish and wildlife and potable water supplies was the most sensitive of the fresh water usages. In estuarine and marine waters, the protection of fish and wildlife generally yielded the more restrictive recommended limitations. The criteria, as proposed, were designed for both acute and chronic toxicological protection. Since protection against chronic effects requires more stringent criteria, the proposed Water Quality Criteria were derived from data or calculations designed to afford chronic protection.

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Because proposed Water Quality Criteria utilize both acute and chronic toxicity data to derive a single acceptable ambient water concentration, it was necessary to utilize the data upon which the criteria were based to calculate proposed standards which provide for protection against both acute and chronic toxicological effects.

To avoid the effects of acute toxicity it was determined that organisms need not necessarily be protected at all times from concentrations exceeding the proposed Water Quality Criteria, since brief exposures to higher concentrations may be tolerated. It may be assumed that most mobile organisms will not remain in the immediate vicinity of the outfall for as long as the usual 96-hour test period. Thus, for protection in the immediate vicinity of the outfall, a concentration of one tenth the 96-hour LC_{50} was determined to provide an ample margin of safety. (The 96-hour LC_{50} is that concentration derived from laboratory tests in which 50% of a group of test organisms survive after 96 hours of continuous exposure to a pollutant). In order to achieve a concentration in the vicinity of the outfall which does not exceed the acute threshold, the discharger may either discharge the acute toxicity concentration and provide immediate diffusion through appropriate flow devices or reduce the concentration below the acute threshold.

To avoid the effects of chronic toxicity, an effluent standard is provided which is designed to ensure that, in most cases, the proposed Water Quality Criteria, which are intended to

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provide protection from chronic effects, are not exceeded over the long term in the receiving waters. This is achieved by limitation of the total weight of the pollutant which can be discharged into receiving waters of given size. To provide an additional margin of safety, the allowable weight discharged per unit of flow was reduced by safety factors designed to compensate, in part, for non-point sources of the pollutant, multiple discharges in a small area, industrial growth, and the difference in water storage times among lakes, estuaries, streams, and coastal waters. The standard for each type of receiving water is expressed as a number which, when multiplied by the rate of receiving water flow, yields the allowable weight of discharge of the pollutant per day from any facility.

These standards are not intended, however, to assure that Water Quality Criteria would be achieved in all receiving waters, since standards sufficiently restrictive to attain water quality criteria in (for example) small streams with extraordinarily large clusters of dischargers, would be overly restrictive for the usual case. These special "worst-case" situations are to be handled by the application of water quality standards through waste load allocations under Section 303 of the Act. The resulting allocations may then be used to establish effluent limitations, if necessary, more stringent than the effluent standards set forth herein. These limitations would then be incorporated into permits issued under Section 402 of the Act.

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Since there are no proposed Water Quality Criteria for benzidine, a different methodology was required for the derivation of an effluent standard. The methodology employed was designed to determine a level of discharge which would result in an acceptable level of risk exposure to man, the primary affected organism. Effluent standards for benzidine were derived by the extrapolation of laboratory test animal data using conservative statistical methods, and are based upon a calculated level of risk of less than one case of tumor induction per million people exposed over an entire generation to drinking water from supplies derived from waters contaminated with the maximum permitted concentration of benzidine. It is recognized that certain inadequacies exist in the available data on which the benzidine standard is based. Therefore, it is reasonable to assume that these standards could be revised in the future. The Environmental Protection Agency is initiating research to gather appropriate oral dose-response data, improve analytical sensitivity, and establish monitoring procedures.

Pursuant to paragraph 3 of Section 307(a), any effluent standard promulgated under this section will be reviewed and, if appropriate, revised at least every three (3) years.

The standards for protection from chronic effects are applicable to the total of all discharges from any given facility. Thus, multiple outfalls from a single facility will not affect the total weight of any pollutant permitted to be discharged.

III. USE OF WATER QUALITY CRITERIA IN SETTING TOXIC POLLUTANT STANDARDS

A. GENERAL

Water Quality Criteria (WQC) are defined as the acceptable limits of constituents in receiving waters based upon an evaluation of the latest scientific information by the Environmental Protection Agency. Almost all of the criteria are taken from the recommendations of the National Academy of Science's report on Water Quality Criteria (In Press October 1973).

The criteria are based upon toxicity studies and other field and laboratory tests which assess the effects of pollutants on agricultural crops, domestic livestock, aquatic life, wildlife and man.

In most cases, propagation of aquatic life was the most sensitive of the water uses and those recommended water quality criteria concentrations were the most restrictive. The acceptable limits specified by the criteria for substances which exhibit toxic effects were derived by the application of scientific judgment to lethal dose or lethal concentration data in a manner that provides a margin of safety to test organisms. When acceptable levels of a toxicant are not specified in the criteria, safe levels are predicted by the use of an application factor. The application factor is usually an estimated factor used to predict chronic safe levels on the basis of acute toxicity data. The recommendations state that the given application factor should be used with the 96-hour LC_{50} derived for the most sensitive important species in the locality of the discharge.

The LC_{50} is the concentration of the material in the water which causes death to 50% of a test population within a specified time period.

Therefore, "Water Quality Criteria" give either an acceptable receiving water concentration of the pollutant or a recommended application factor.

B. RECEIVING WATER BODY CONSIDERATIONS

To derive an effluent standard from a recommended Water Quality Criteria concentration or application factor in conjunction with acute toxicity data, it is necessary to take into account the nature of the receiving waters.

Developing a hydrodynamic model of any type is accompanied by many frustrating problems. When examined from a National Effluent Standards point of view, this is especially true. Many engineers and ecologists have

doubted the utility of water body models. These engineers and ecologists are aware of the many complex and variable interactions that exist in aquatic ecosystems and feel that models tend to oversimplify these relationships.

Models that have been developed for a specific body of water in which measured parameters are "plugged" into the model in its developmental stages have in many cases been successful. Although somewhat less accurate, the generalized models into which a few specific measurable parameters of a water body can be inserted have been useful. The derivation of a water body model that is general to the extent that every stream, lake, or estuary can be described without the use of measured parameters immediately loses all usefulness since the number of assumptions and generalizations required leaves only a definition of the type of water body. Application of national effluent standards requires some descriptions of each water body in terms of parameters that are either readily available or easily measured.

The following definitions of water bodies and the method of quantitating them on the basis of available information are offered as a solution to the water modeling problem.

Streams:

Streams are defined as all water bodies having a flow gradient from an upper elevation to a lower elevation. Streams would include all rivers. All discharges into streams will be governed by stream toxic effluent standards except in those cases in which the receiving stream flows directly into an impoundment: in such cases the impoundment effluent standard will govern. Streams will be quantitated by their flow rate in cubic feet per second (cfs) as expressed in terms of probable low rate of stream flow occurring during a 7 consecutive day period once in 10 years at the effluent or the nearest upstream monitoring station.

Lakes and Impoundments:

Lakes and impoundments are defined as all bodies of water in which the flow velocity is impeded by a natural or man-made barrier in such a way that water is stored for more than 60 days. Those water bodies with less than 60 days retention time are considered streams. Quantitation of lakes and impoundments will be based on the addition of probable low rate of flow of the tributary water bodies occurring during a 7 consecutive day period once in 10 years. Impoundments, sumps, retention ponds or similar structures constructed for the storage, retention, or disposal of toxic effluents are exempt from this definition.

Estuaries:

Estuaries are defined as those water bodies from the coastal water baseline extending inland as far as the ebb and flow of the tide. For the calculation of maximum daily discharge which will not exceed the chronic critical limit, the size of the estuary will be determined using the additive probable low rate of stream flow occurring during a 7 consecutive day period once in 10 years of the tributaries entering the estuary above the point of discharge.

Coastal Waters:

Coastal waters are those waters of the open sea lying seward of the baseline from which the territorial sea is measured, as provided for in the Convention on the Territorial Sea and the Contiguous Zone (15 UST 1606; TIAS 5639). For the calculation of maximum daily discharge which will not exceed the chronic critical limit, the rate of flow of the coastal waters will be determined by the volume of water in the vicinity of the outfall which is influenced by the tidal range developed during the normal tidal cycle. The following calculation illustrates the above:

Assumptions - See Figure 1

1. Tidal action extends 1 nautical mile (6080 ft.)
2. Tidal range = 4 feet
3. Tidal cycle = 12 hours
4. Plant owned shoreline in vicinity of outfall = 1 mile (5280 ft.)

$$\frac{6080' \times 4' \times 5280'}{12\ hr} = \frac{4.08 \times 10^3 \times 5.28 \times 10^3\ ft^3}{1.2 \times 10\ hr} \times \frac{1\ hr}{3600\ sec} = 2970\ cfs/5280\ ft\ shoreline$$

Therefore there will be the equivalent of .5625 cfs/ft. shoreline

Those situations in which a facility has a coastal outfall but no shoreline footage will be handled on a case-by-case basis. It is also realized that the above hypothetical calculation of flow in the vicinity of a coastal outfall could be more scientifically accomplished by using dye studies.

The stream definition and quantitation should be adequate for the calculation of maximum daily discharge. Streams and rivers undergo rapid vertical mixing with longitudinal mixing proportional to flow velocity. Lateral mixing is generally achieved within a few miles, thus achieving nearly complete mixing.

The simplified descriptions of impoundments and estuaries are inadequate when one considers the possibility of discharge pooling, resulting in incomplete mixing. An additional safety factor can be applied to calculate maximum daily discharge.

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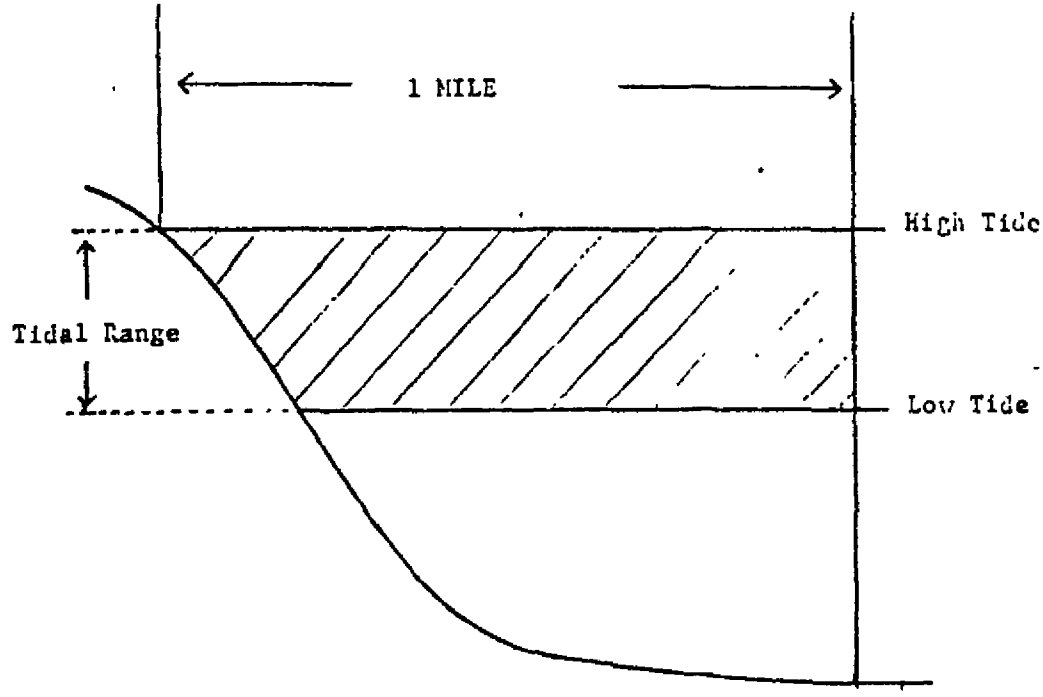
FIGURE 1



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Having defined water bodies and the method of quantitation, approaches to establishing effluent standards for protection against chronic affects are available.

1. Breakdown and grouping of receiving water body size.

   In this approach, receiving waters are grouped according to their size as measured by the flow rate of the streams themselves or the cumulative total of streams which serve as tributaries to impoundments and estuaries. The following table depicts the total length of water channels in various low flow rate categories.

cfs	Total Mileage of Streams	
10-100	100,000	
100-1000	80,000	
1000-10,000	22,000	
10,000	7,000	(1500 in lower Mississippi)

   The daily discharge maximum can be calculated on the basis of a percentile within each group. For example, in a 10-100 cfs grouping, the chronic critical limit can be used in conjunction with the 10 cfs flow value to calculate a daily maximum that will protect 100% of the streams within that group. Calculations based on 20 and 30 cfs would protect 90% and 80% of the group respectively. The use of any such grouping creates inequities because the discharger into a stream with a flow at the upper end of the group is forced to meet standards based on a stream at the lower end of the group. Conversely, if such a calculation were based on the 70th percentile, 30% of the water bodies in that group would be in danger of receiving damaging quantities of the pollutant.

2. Daily discharge maximum based on each receiving water flow rate. This method would be the most equitable and would insure protection of all receiving waters since the actual flow of each receiving water body would be used to calculate the maximum permissible daily loading in units of weight per day (lbs/day or kg/day). Once the safe chronic concentration is established on the basis of Water Quality Criteria, the discharger can calculate the daily maximum by determining from records the probable low rate of stream flow occurring during a 7 consecutive day period once in 10 years of the receiving stream, lake, or estuary. This approach offers the advantages of being simple to apply and enforce, as well as equitable and protective.

C. EFFLUENT STANDARD SETTING FOR ACUTE AND CHRONIC TOXICOLOGICAL PROTECTION

The setting of the effluent standards using this alternative employs the use of 1) critical limit determination for both acute and chronic toxicity 2) establishment of ample margins of safety and 3) consideration of the water bodies which receive the discharge.

1. Standard Setting for Chronic Toxicological Protection

As was noted in the water body discussion, there are several options available for this step of the analysis. The attached calculations are illustrative of detailed calculations for the rivers, lakes, estuaries and coastal waters which were used to determine the total weight per day which could be allowed from a discharge. It was determined that the step increment approach using percentile of flow was limited by the fact that any steps were arbitrary. Because of the conviction that dilution is not the solution to pollution, a careful evaluation of these increments was made which involved an examination of the maximum and minimum discharge amounts which coastal diffusion coefficients indicated.

It was determined that there should be defined a minimum size water body into which discharges of toxic pollutants would not be allowed. This was set at 10 cfs for streams and 500 acres for lakes. It was further determined that if the major needs for the incremented water body size were to assure reasonableness, then a continuous relationship defined as the slope of these incremental steps would be most reasonable. However, there must be an upper limit. Therefore, the chronic toxicological protective part of the effluent standards was determined as illustrated below.

In order to illustrate HATS usage of the WQC to set effluent standards for chronic protection, a detailed analysis is shown using Dieldrin discharges into fresh water streams.

The proposed "Criteria for Water Quality" (p. 125) October, 1973), show a value of 0.005 ug/l for the maximum permissible concentration of Dieldrin in whole (unfiltered) water sampled at any time and place. The above concentration was determined by multiplying the acute toxicity values for the more sensitive species by an application factor of 0.01 which results in an estimated safe chronic exposure level. To protect against chronic toxicity effects, a limit must be set on the total pounds of Dieldrin which can be discharged each day. This maximum value for a stream is obtained in the following manner:

$$5.4 \times \begin{matrix}\text{stream flow} \\ \text{in cfs}\end{matrix} \times \begin{matrix}\text{chronic critical} \\ \text{limit in PPM}\end{matrix} = \text{lbs/day}$$

$$5.4 \times 10{,}000 \text{ cfs} \times 0.003 \text{ ug.l} \times 10^{-3} \text{ mg/ug}$$

$$5.4 \times 10^{4} \times 3 \times 10^{-3} \times 10^{-3} = 16.2 \times 10^{-2} = 0.162 \text{ lbs/day}$$

which is the maximum quantity of Dieldrin which can be discharged into a 10,000 cfs fresh water stream. To convert this value from lbs/day to kg/day, divide 1.62×10^{-1} by 2.205 to obtain $.73 \times 10^{-1}$ or 0.073 kg/day.

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Explanation of terms in lbs/day effluent formula.

(1) "5.4" this conversion factor converts the flow in ft/sec. and the acceptable toxic pollutant concentration in mg/liter to lbs/day of pollutant discharge. Therefore:

$$\frac{ft^3}{sec} \times \frac{mg}{l} \times \frac{2.205 \times 10^{-6} \#}{mg} \times \frac{8.64 \times 10^4 \text{ sec}}{day} \times \frac{7.832 \times 10 \; l}{ft^3} = 5.4 \text{ lbs/day}$$

(2) "Chronic critical' limit is the Water Quality Criteria estimated acceptable chronic exposure concentration multiplied by a safety factor of 0.6 which takes into account non-toxicological factors such as background levels of the toxic pollutant from non-point sources, multiple discharges and clustering of industrial or point source discharges into a relatively small geographical area and an allowance for the expected industrial growth potential and the resulting increased propensity for discharging the toxic pollutant.

(3) "Stream flow in cfs" is the probable low rate of stream flow occurring during a 7 consecutive day period once in 10 years.

A question that should be addressed is why must there be a maximum cutoff and why is it at the 10,000 cfs flow? The answer to this question is part philosphy and intent of law interpretation and in part knowledge gained from experience. The use of diffusion is only desirable under carefully controlled and monitored conditions and at levels where a high degree of assurance can be given to the public that no harm can result. There has been a nondegradation philosphy relative to upgrading the quality of our waters which must not be violated. By placing no maximum on the total weight discharged, there is an open invitation to industry to abandon their facilities for new facilities to be located on large major inland waters and coastlines. Treatment technology does exist to provide significant removal of toxic pollutants and it is being used now. An incentive should be given to continue and expand its use. The river miles above 10,000 cfs have been estimated to be 7,000 and include some 20 rivers most of which have industrial development. The most severe need for a maximum cutoff is the lack of confidence in the simplistic models used to describe these water bodies. Also, it is not desirable to induce clustering of industries on extremely large water bodies because of more liberal effluent limitations.

Therefore, the chronic toxicological protection part of the effluent standard will be expressed as:

a. Into streams or estuaries with a low flow of less than or equal to 0.283 cubic meters per second (10 cfs) or into lakes with an area of less than or equal to 202 hectares (500 acres), there shall be no discharge of the listed pollutants.

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b. Into streams or estuaries with a low flow greater than 0.283 cubic meters per second (10 cfs) or into lakes with an area of greater than 202 hectares (500 acres), the total daily weight of the pollutant discharged from any facility shall not exceed a factor derived by the above calculations and given for each respective pollutant multiplied by the low flow of the receiving water body. 283 cubic meters per second (10,000 cfs) shall be the maximum value for the low flow of the receiving water body used in this calculation.

2. Standard Setting for Acute Toxicological Protection

To protect the affected important organisms from acute toxicity, three considerations must be noted: time of exposure, concentration of toxicant during exposure and sensitivity of the receptor. In establishing effluent standards the sensitivity of the receptor is given and fixed. It is difficult to control the time of exposure of the receptor except by controlling the rate of diffusion of the toxicant into the receiving water body which is related to controlling the concentration in the discharge pipe. It is important to realize that TLm or LC_{50} concentrations (e.g., 96-hour TLm) will kill 50 percent of the animal population when they are exposed to the toxicant for 96 hours. If significant fish kills in the area of the outfall are to be prevented when discharging the toxicant at the 96-hour TLm level, it is imperative that the discharge be rapidly diffused into the receiving water body. This action is required to drastically minimize the time of exposure and concentration of exposure to the fish in the area. In order to provide this rapid diffusion it is important that the ratio of the discharge of the effluent to the receiving water flow rate be sufficiently low (e.g., 1:10). The only other alternative to provide this protection is to use an application factor on the TLm level so that the resulting concentration in the effluent pipe is reduced to a safe acute level.

Again using Dieldrin to illustrate the use of proposed Water Quality Criteria in the derivation of acute toxicity limitations and standards, it is recalled that the dieldrin criteria for fresh water is 0.005 ug/l which is 0.01 times the 96-hour LC_{50} of an important species.

$$0.01 \times LC_{50} = 0.005 \text{ ug/l}$$

or,

$$LC_{50} = 0.5 \text{ ug/l}$$

It now follows that .5 ug/l is the acute toxicity level of Dieldrin that, if discharged without appropriate controls, would cause damage to the aquatic environment. Therefore, EPA's proposed standard must provide for acute toxicological protection by requiring a minimum of ten-fold diffusion when Dieldrin is discharged into water bodies. Therefore, the effluent concentration must be 0.5 ug/l or less with appropriate diffusion. The

effluent standards to protect against acute toxicological damage are as follows:

a. Into streams or estuaries with a low flow of less than or equal to 0.283 cubic meters per second (10 cfs) or into lakes with an area of less than or equal to 202 hectares (500 acres), there shall be no discharge of the listed pollutants.

b. Into streams or estuaries with a low flow greater than 0.283 cubic meters per second (10 cfs) or into lakes with an area of greater than 202 hectares (500 acres)

(1) the daily average pollutant concentration shall not exceed

(aa) 0.5 ug/l in waste streams which are diffused in water bodies which have a low flow greater than or equal to 10 times the water stream flow or

(bb) 0.05 ug/l in waste streams which flow into water bodies which have a low flow less than 10 times the waste stream flow.

D. APPARENT DIFFERENCE

There may be some differences between the Water Quality Criteria numbers and the effluent standard concentration numbers proposed here. It should be remembered that these effluent standards are designed to cover both the acute and chronic toxicity situations. In regard to the above possible differences it is fairly certain, when using 96-hour LC_{50} values, that the fish will not remain in the vicinity of the outfall for 96 hours and therefore, even though these effluent concentration numbers may be less strict than Water Quality Criteria, when the chronic toxicity (lbs/day) portion of the effluent standard is considered, the total effluent standard is designed to meet and be directly related to the receiving water quality criteria.

E. SPECIFIC CALCULATIONS AND DERIVATIONS OF 307(a) TOXIC POLLUTANT EFFLUENT STANDARDS

The following discussion is designed to illustrate a) the toxicological data and their source, b) their relationship to Water Quality Criteria, c) any adjustments necessary to use these data for effluent standard setting, d) the actual calculations following the steps previously defined and e) the numbers that are proposed to be used in the Federal Register document as standards.

MONS 205394

This discussion is broken down into the nine toxic pollutants. The discussion for Aldrin-Dieldrin is more detailed so that, having it in mind, one can follow annotated versions for the rest of the toxic pollutants.

1. Aldrin-Dieldrin

a. Fresh water

The proposed "Criteria for Water Quality" October 1973 (p. 125) list the following fresh water values for aldrin and dieldrin in whole (unfiltered) water sampled at any time and place.

	Permissible Maximum Concentration* (ug/l)
Aldrin	0.01
Dieldrin	0.005

*These concentrations were determined by multiplying the acute toxicity values for the more sensitive species by an application factor of 0.01. The reference for these values is "Water Quality Criteria of 1972" National Academy of Science Report, in press. Since aldrin is rapidly oxidized in the aquatic environment to dieldrin, it was decided to use the Water Quality Criteria values for dieldrin throughout the following calculations.

(a) Effluent Concentration: (Critical Acute Limit)

Since the dieldrin Water Quality Criteria value of 0.005 ug/l was obtained using a 0.01 application factor times the 96-hour LC_{50} for the more sensitive species, a freshwater maximum allowable effluent concentration of 100 times the Water Quality Criteria value or 0.5 ug/l at the outfall is suggested. It should be noted that the standard for aldrin-dieldrin requires that the outfall be diffused at least ten-fold in the receiving water and it is highly unlikely that the affected species will remain in the outfall area for 96 hours.

(b) Daily Load:

Since aldrin-dieldrin not only have an acute toxicity but also exhibit a chronic toxicity which may manifest itself in the form of bioconcentration in various organisms, a daily limit on the weight of aldrin-dieldrin

is proposed to be placed on outfalls. This daily limit is established using the Water Quality Criteria value of 0.005 ug/1 and performing the calculations which are shown on the following pages and thereby derive the effluent standards.

b. Salt Water

The proposed values listed in "Criteria for Water Quality" (October 1973 p. 297-8) are:

- Aldrin LC_{50} = 5.5 ug/1 (acute)

  0.01 x LC_{50} = 0.055 ug/1 (chronic)

- Dieldrin LC_{50} = 5.5 ug/1 (acute)

  0.01 x LC_{50} = 0.055 ug/1 (chronic)

In a similar manner as described under fresh water the above numbers were used, as the following illustrates, to calculate the acute and chronic limitations for the various water bodies.

(a) Effluent Concentration: (Critical Acute Limit)

Water Body	Max. Allow. Effluent Conc.
F.W. Stream	0.5 ug/1
F.W. Lake	0.5 ug/1
Estuary	5.5 ug/1
Coastal	5.5 ug/1

(b) Daily Load:

Water Body	WQC Chronic Limit	Safety Factor (%)	Correction for Safety	Critical Chronic Limit (ppb) (WQC Chronic Limit x Correction for Safety
F.W. Stream	0.005 ug/l	40	0.6	0.003 ug/l
F.W. Lake	0.005 ug/l	50	0.5	0.0025 ug/l
Estuary	0.055 ug/l	50	0.5	0.028 ug/l
Coastal	0.055 ug/l	40	0.6	0.033 ug/l

5.4 x cfs x Crit. Chronic Lim. in ppm = lbs/day ÷ 2.205 = kg/day

F.W. Stream: 5.4 x 10,000 x .000003 = 0.162 lbs/day ÷ 2.205 = 0.0735 kg/da

F.W. Lake: 5.4 x 10,000 x .0000025 = 0.135 lbs/day ÷ 2.205 = 0.0612 kg/day

Estuary: 5.4 x 10,000 x .000028 = 1.512 lbs/day ÷ 2.205 = 0.6857 kg/day

Coastal: 5.4 x 10,000 x .000033 = 1.782 lbs/day ÷ 2.205 = 0.808 kg/day

Effluent Standard Factors Aldrin-Dieldrin

The values to be used in determining Effluent Standards are tabulated below:

	Metric Unit Factors		English Unit Factors	
	Column 1 Maximum Effluent Concentration Critical Acute Limit (ug/l)	Column 2 Maximum Effluent Concentration Loading kg/day/m^3/sec	Column 3 Maximum Effluent Concentration Critical Acute Limit (ppb)	Column 4 Maximum Effluent Loading lbs/day/ft^3/
Stream	0.5	0.000259	0.5	0.0000162
Lakes	0.5	0.000216	0.5	0.0000135
Estuaries	5.5	0.00242	5.5	0.000151
Coastal Waters	5.5	0.00286	5.5	0.000178

To determine allowable loading for a specific water body multiply column 2 figure by flow in m^3/sec or column 4 by flow in cfs providing flow is within the range 0.283 to 283 in m^3/sec or 10 to 10,000 cfs.

MONS 205397

2. Benzidine

There are no Water Quality Criteria for this material and the derivation of its effluent standards is given as follows:

The data presented in the paper of Spitz, Maguigan, and Dobriner (Cancer 3, 789, 1950) on the carcinogenicity of injected benzidine in Sherman rats were used. In this experiment, rats were injected subcutaneously in the back once per week with 15 miligrams of benzidine throughout life or until illness or weight loss were evident. Among a total of 387 rats so injected, 107 had tumors at death, a tumor incidence of 0.276. We can therefore, state with 99% assurance that the "true" tumor incidence at the dose employed is no greater than 0.34.

The dose administered to the rats was 15 mg benzidine per week, and the rats achieved a weight averaging approximately 265 grams. To calculate the equivalent dose in humans, the experimental dose was multiplied by the two-thirds power of the ratio of human weight (taken as 60 kg) to the average rat weight on the assumption that the effects of a toxic compound are roughly proportional to the surface area of the animal species which, in turn, is roughly proportional to the two-thirds power of the weight. Thus, if the human dose equivalent to the experimental dose is H, then:

$$H = 15 \text{ mg/week} \times \left(\frac{60 \text{ kg}}{0.265 \text{ kg}}\right)^{2/3} = 557 \text{ mg/week} = 79.6 \text{ mg/day}$$

Thus, equating average human and rat responses to equivalent doses, we conclude with 99% assurance that a human dose of 79.6 mg/day will result in a tumor incidence in humans no greater that 34%.

We now want to calculate the dose which would correspond to a tumor incidence no greater than one per million (10^{-6}). The probit method of Mantel and Bryan is based on the assumption that susceptibility to the carcinogenic effects of a chemical is distributed normally among the human population, and that the incidence of cancer will decrease with decreasing dose at a rate of no less than one normal deviate (probit) per 10-fold decrease in dose. An incidence of 10^{-6} corresponds to a normal deviate of -4.753. The "observed" incidence of 0.34 corresponds to a normal deviate of -0.412. Thus, moving from a risk of 0.34 to a risk of 10^{-6} corresponds to a movement of -4.753 - (-0.412) = -4.341 normal deviates. On the assumption that a ten-fold reduction in dose will result in a decrease in risk corresponding to one normal deviate, the dose corresponding to a risk of 10^{-6} is calculated to be:

Maximum permissible human dose =

$$79.6 \text{ mg/day} \times 10^{-4.341} = 3.63 \text{ ug/day}$$

Toxic Substance Benzidine

(a) Water Body	Max. Allow. Effluent Conc.
F.W. Stream	1.8 ug/l
F.W. Lake	1.8 ug/l
Estuary	1.8 ug/l
Coastal	1.8 ug/l

(b) Daily Load

Water Body	Critical Chronic Limit	Safety Factor	Correction For Safety	(Chronic Critical Limit Times Correction For Safety) Adjusted Critical Chronic Limit (PPB)
F.W. Stream	1.8 ug/l	99	0.01	0.018 ug/l
F.W. Lake	1.8 ug/l	99	0.01	0.018 ug/l
Estuary	1.8 ug/l	99	0.01	0.018 ug/l
Coastal	1.8 ug/l	99	0.01	0.018 ug/l

Calculation: 5.4 x cfs x Adj. critical chronic limit in ppm = Maximum lbs/day ÷ 2.205 = maximum kg/day

F.W. Stream: 5.4 x 10,000 x 0.000018 = 0.97 lbs/day ÷ 2.205 = 0.44 kg

F.W. Lake: 5.4 x 10,000 x 0.000018 = 0.97 lbs/day ÷ 2.205 = 0.44 kg

Estuary: 5.4 x 10,000 x 0.000018 = 0.97 lbs/day ÷ 2.205 = 0.44 kg

Coastal: 5.4 x 10,000 x 0.000018 = 0.97 lbs/day ÷ 2.205 = 0.44 kg

Effluent Standard

In no case shall the levels of benzidine in discharges from facilities identified in 129.20 exceed the values tabulated below. Because of the inadequacies of the analytical methodology currently available, measurement of this material early in the process waste stream is regarded as sufficient for the determination of compliance when evaluated along with actual waste stream flows to calculate the effluent levels.

	Metric Unit Factors		English Unit Factors	
	Column 1 Maximum Effluent Concentration Critical Acute Limit (ug/l)	Column 2 Maximum Effluent Loading kg/day/m^3/sec	Column 3 Maximum Effluent Concentration Critical Acute Limit (ppb)	Column 4 Maximum Effluent Loading lbs/day/ft^3/sec
Streams	1.8	0.0016	1.8	0.0001
Lakes	1.8	0.0016	1.8	0.0001
Estuaries	1.8	0.0016	1.8	0.0001
Coastal Waters	1.8	0.0016	1.8	0.0001

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3. Cadmium

a. Fresh water

The fresh water WQC recommended levels were noted as follows:

*30 ug/l (Hard > 100 ug/l as $CaCO_3$)

* 4 ug/l (Soft ≤ 100 mg/l as $CaCO_3$)

*Note: Where crustacea and eggs and larvae of salmonids develop limits are:

3 ug/l (Hard water)

0.4 ug/l (Soft water)

Ref: WQC Page 104-105 Show following:

Safe levels Cd for fathead minnows and bluegill in Hard water = 30-60 ug/l

Safe levels coho salmon fry are 1-4 ug/l in soft water.

0.5 ug/l reduce reproduction of daphnia magna in one generation three week exposure.

Therefore, the 0.4 ug/l was used as though it represented a 1/100 acute level and the acute and chronic protection limitations were so derived as shown on the calculation sheet.

b. Salt water

Ref: WQC p. 265 Max Cd. Conc of 10 ug/l

The salt water WQC recommended level above was noted. Therefore 1000 ug/l and 10 ug/l should be the acute and chronic toxicity values respectively.

However, additional data gathered and reviewed by OAWP indicated the following:

Sand Shrimp: 96 hr. LC_{50} = 320 ug/l

Grass Shrimp: 96 hr. LC_{50} = 420 ug/l

Hermit Crab: 96 hr. LC_{50} = 320 ug/l

Therefore the acute limit was set at 320 ug/l and the chronic level at 3.2 ug/l

Calculations

Toxic Substance Cadmium

(a) Effluent Concentration: (Critical Acute Limit)

Water Body	Max. Allow. Effluent Conc.
F.W. Stream	40 ug/l
F.W. Lake	40 ug/l
Estuary	320 ug/l
Coastal	320 ug/l

(b) Daily Load

Water Body	WQC Chronic Limit	Safety Factor	Correction For Safety	(WQC Chronic Limit Times Correction For Safety) Critical Chronic Limit (PPB)
F.W. Stream	0.4 ug/l	40	0.6	0.24 ug/l
F.W. Lake	0.4 ug/l	50	0.5	0.2 ug/l
Estuary	3.2 ug/l	50	0.5	1.6 ug/l
Coastal	3.2 ug/l	40	0.6	1.9 ug/l

Calculation:

5.4 x cfs x critical chronic limit in ppm = lbs/day ÷ 2.205 = kg/day

F.W. Stream: 5.4 x 10,000 x .00024 = 12.96 lbs/day ÷ 2.205 = 5.88 kg/day

F.W. Lake: 5.4 x 10,000 x .00020 = 10.80 lbs/day ÷ 2.205 = 4.90 kg/day

Estuary: 5.4 x 10,000 x .00016 = 86.40 lbs/day ÷ 2.205 = 39.2 kg/day

Coastal: 5.4 x 10,000 x .00190 = 102.6 lbs/day ÷ 2.205 46.5 kg/day

MONS 205402

Effluent Standard Factors Cadmium

The values to be used in determining Effluent Standards are tabulated below:

	Metric Unit Factors		English Unit Factors	
	Column 1 Maximum Effluent Concentration Critical Acute Limit (ug/l)	Column 2 Maximum Effluent Loading kg/day/m^3/sec	Column 3 Maximum Effluent Concentration Critical Acute Limit (ppb)	Column 4 Maximum Effluent Loading lbs/day/ft^3/sec
Streams	40	0.0206	40	0.00130
Lakes	40	0.0173	40	0.001080
Estuaries	320	0.139	320	0.008640
Coastal Waters	320	0.164	320	0.01026

To determine allowable loading for a specific water body multiply Column 2 figure by flow in m^3/sec or Column 4 by flow in cfs providing flow is within the range 0.283 to 283 in m^3/sec or 10 to 10,000 cfs.

4. Cyanide

a. Fresh water

The WQC for cyanide was noted as 1/20 of 96 hr LC_{50} not exceeding 5 ug/l Acute = 100 (20 x 5 ug/l)

Ref: WQC p. 113

Therefore the acute limit was set at 100 ug/l and the chronic limit at 5 ug/l.

b. Salt water

The WQC for cyanide was noted as 1/10 96-hr LC_{50}

Ref: WQC p.289 max. of 10 ug/l of cyanides in marine or estuarine waters.

However, based upon additional data gathered by OAWP the following was noted:

MONS 205403

Pin Perch: LC_{50} = 70 ug/l

Pink Shrimp: LC_{50} = 100 ug/l

CN^- = 10 ug/l (Chronic WQC)

Therefore, the acute limit was set at 100 ug/l and the chronic was set at 10 ug/l.

It was determined, however, that chronic protection was not required for cyanide, since it is primarily an acute toxic pollutant. Therefore, only a concentration limitation was established.

Calculations

Toxic Substance Cyanide

(a) Effluent Concentration: (Critical Acute Limit)

Water Body	Max. Allow. Effluent Conc.
F.W. Stream	100 ug/l
F.W. Lake	100 ug/l
Estuary	100 ug/l
Coastal	100 ug/l

(b) Daily Load: Not applicable

5. DDT

a. Fresh water

From the WQC the recommended levels were noted as:

DDT = 0.002 ug/l (0.01 x LC_{50}) Chronic

Acute = 0.2 ug/l

Ref: Same as Aldrin WQC p. 125 Table 1

b. Salt water

From the WQC the recommended levels were noted as:

DDT = .006 ug/l (0.01 LC_{50}) Chronic

Ref: WQC p.297 Sand Shrimp 96-hr. LC_{50} = 0.6 ug/l Acute

Calculations

Toxic Substance DDT

(a) Effluent Concentration: (Critical Acute Limit)

Water Body	Max. Allow. Effluent Conc.
F.W. Stream	0.2 ug/l
F.W. Lake	0.2 ug/l
Estuary	0.6 ug/l
Coastal	0.6 ug/l

(b) Daily Load

Water Body	WQC Chronic Limit	Safety Factor	Correction For Safety	(WQC Chronic Limit Times Correction For Safety) Critical Chronic Limit (ppb)
F.W. Stream	.002 ug/l	40	0.6	0.0012 ug/l
F.W. Lake	.002 ug/l	50	0.5	0.001 ug/l
Estuary	.006 ug/l	50	0.5	0.003 ug/l
Coastal	.006 ug/l	40	0.6	0.0036 ug/l

Calculation:

5.4 cfs x critical chronic limit in ppm = lbs/day ÷ 2.205 = kg/day

F.W. Stream: 5.4 x 10,000 x .0000012 = 0.0648 lbs/day ÷ 2.205 = 0.0294 kg/day

F.W. Lake: 5.4 x 10,000 x .000001 = 0.054 lbs/day ÷ 2.205 = 0.02[illegible] kg/day

Estuary: 5.4 x 10,000 x .000003 = 0.16[illegible] lbs/day ÷ 2.205 = 0.0734 kg/day

Coastal: 5.4 x 10,000 x .0000036 = 0.194 lbs/day ÷ 2.205 = 0.088 kg/day

Effluent Standard Factors DDT, DDD, DDE

The values to be used in determining Effluent Standards are tabulated below:

	Metric Unit Factors		English Unit Factors	
	Column 1 Maximum Effluent Concentration Critical Acute Limit (ug/l)	Column 2 Maximum Effluent Loading kg/day/m^3/sec	Column 3 Maximum Effluent Concentration Critical Acute Limit (ppb)	Column 4 Maximum Effluen Loading lbs/day/ft^3/sec
Streams	0.2	0.000102	0.2	0.00000648
Lakes	0.2	0.0000866	0.2	0.0000054
Estuaries	0.6	0.000260	0.6	0.0000162
Coastal Waters	0.6	0.000311	0.6	0.0000194

To determine allowable loading for a specific water body multiply column 2 figure by flow in m^3/sec or column 4 by flow in cfs providing flow is within th range 0.283 to 283 in m^3/sec or 10 to 10,000 cfs.

6. Endrin

a. Fresh water

From the WQC the following recommended levels were noted:

Endrin LC_{50} = 0.2 ug/l (Acute)

.01 x LC_{50} = .002 ug/l (Chronic)

Ref: Same as Aldrin WQC p. 125 Table 1

b. Salt water

From the WQC the following recommended levels were noted:

Endrin LC_{50} = 0.6 ug/l (Acute)

.01 x LC_{50} = 0.006 ug/l (Chronic)

Ref: WQC p. 298

Calculations

Toxic Substance Endrin

(a) Effluent Concentration: (Critical Acute Limit)

Water Body	Max. Allow. Effluent Conc.
F.W. Stream	0.2 ug/l
F.W. Lake	0.2 ug/l
Estuary	0.6 ug/l
Coastal	0.6 ug/l

(b) Daily Limit

Water Body	WQC Chronic Limit	Safety Factor	Correction For Safety	(WQC Chronic Limit Times Correction for Safety) Critical Chronic Limit (ppb)
F.W. Stream	0.002 ug/l	40	0.6	0.0012 ug/l
F.W. Lake	0.002 ug/l	50	0.5	0.001 ug/l
Estuary	0.006 ug/l	50	0.5	0.003 ug/l
Coastal	0.006 ug/l	40	0.6	0.0036 ug/l

Calculation:

5.4 x cfs x Adj. C.C.L. in ppm = lbs/day ÷ 2.205 = kg/day

F.W. Stream: 5.4 x 10,000 x .0000012 = 0.0648 lbs/day ÷ 2.205 = 0.0294 kg/day

F.W. Lake: 5.4 x 10,000 x .000001 = 0.054 lbs/day ÷ 2.205 = 0.0245 kg/day

Estuary: 5.4 x 10,000 x .000003 = 0.162 lbs/day ÷ 2.205 = 0.0734 kg/day

Coastal: 5.4 x 10,000 x .0000036 = 0.194 lbs/day ÷ 2.205 = 0.088 kg/day

Effluent Standard Factors Endrin

The values to be used in determining Effluent Standards are tabulated below:

	Metric Unit Factors		English Unit Factors	
	Column 1 Maximum Effluent Concentration Critical Acute Limit (ug/l)	Column 2 Maximum Effluent Loading kg/day/m^3/sec	Column 3 Maximum Effluent Concentration Critical Acute Limit (ppb)	Column 4 Maximum Effluent Loading lbs/day/ft^3/sec
Streams	0.2	0.000102	0.2	0.00000648
Lakes	0.2	0.0000866	0.2	0.0000054
Esturaries	0.6	0.000260	0.6	0.0000162
Coastal Waters	0.6	0.000311	0.6	0.0000194

To determine allowable loading for a specific water body multiply column 2 figure by flow in m^3/sec or column 4 by flow in cfs providing flow is within the range 0.283 in m^3/sec or 10 to 10,000 cfs.

7. Mercury

a. Fresh water

From the WQC the following recommended levels and comments were noted:

Mercury = 0.05 ug/l chronic

This chronic level is required because of bioaccumulation of mercury in fish flesh in excess of FDA levels

Acute = 20 ug/l is based on acute toxicity of Hg to aquatic life.

Ref: WQC p. 119-120 Exposure of fish for 3 months to conc. of 0.05 ug/l of Hg in water resulted in conc. of 0.5 ug/g in fish (maximum FDA guidelin edible portions) Maximum acceptable total Hg conc. in water = 0.2 ug/l. Maximum average total Hg conc. in water = 0.05 ug/l.

b. Salt Water

From the WQC the following recommended levels were noted:

Mercury (0.01 x LC50)

Ref: WQC p. 275 maximum of 1.0 ug/l (Chronic)
Acute = 100 ug/l

It should be noted that the accumulation factors of mercury are reported to vary, but it is essential that some account be taken of this phenomenon and therefore any difference which may be noted between acute and chronic limitations are so justified.

Toxic Substance Mercury

(a) Effluent Concentration: (Acute Critical Limit)

Water Body	Max. Allow. Effluent Conc.
F.W. Stream	20 ug/l
F.W. Lake	20 ug/l
Estuary	100 ug/l
Coastal	100 ug/l

(b) Daily Load:

Water Body	WQC Chronic Limit	Safety Factor	Correction for Safety	(WQC Chronic Limit Times Correction for Safety) Critical Chronic Limit (ppb)
F.W. Stream	.05 ug/l	40	0.6	0.03 ug/l
F.W. Lake	.05 ug/l	50	0.5	0.025 ug/l
Estuary	1.0 ug/l	50	0.5	0.5 ug/l
Coastal	1.0 ug/l	40	0.6	0.6 ug/l

Calculation: 5.4 x cfs x critical chronic limit in ppm = lbs/day ÷ 2.205 = kg/day

F.W. Stream: 5.4 x 10,000 x 0.00003 = 1.620 lbs/day ÷ 2.205 = 0.735 kg/day

F.W. Lake: 5.4 x 10,000 x 0.000025 = 1.350 lbs/day ÷ 2.205 = 0.612 kg/day

Estuary: 5.4 x 10,000 x 0.0005 = 27.0 lbs/day ÷ 2.205 = 12.24 kg/day

Coastal: 5.4 x 10,000 x 0.0006 =32.4 lbs/day ÷ 2.205 = 14.7 kg/day

Effluent Standard Factors Mercury

The values to be used in determining Effluent Standards are tabulated below

	Metric Unit Factors		English Unit Factors	
	Column 1 Maximum Effluent Concentration Critical Acute Limit (ug/l)	Column 2 Maximum Effluent Loading kg/day/m^3/sec	Column 3 Maximum Effluent Concentration Critical Acute Limit (ppb)	Column 4 Maximum Effluc Loading lbs/day/ft^3/s
Streams	20	0.00260	20	0.000162
Lakes	20	0.00216	20	0.000135
Estuaries	100	.0431	100	0.0027
Coastal Waters	100	.0519	100	0.00324

To determine allowable loading for a specific water body multiply column 2 figure by flow in m^3/sec or column 4 by flow in cfs providing flow is within the range 0.283 to 283 m^3/sec or 10 to 10,000 cfs

8. Polychlorinated biphenyls (PCB's)

a. Fresh water

From the WQC the following data were noted:

Chronic = 0.002 ug/l due to bioaccumulation

Acute = 280 ug/l (based on acute Tox to F.W. Fish)

Ref: WQC p. 121

PCB residue levels of 500 ug/l in whole salmon eggs have been suggested as threshold for egg mortality. Such levels in eggs are associated with levels in body tissue of 2.5-5.0 ug/g. PCB's accumulation factors up to 200,000 long term-low level exposure in water have been reported.

b. Salt water

Page 320 of WQC states "The maximum acceptable concentration of PCB's in any sample consisting of a homogenate of 25 or more whole fish of any species that is consumed by fish-eating birds and mammals, within the size range consumed is 0.5 mg/kg (ppm) on a wet weight basis."

Using data gathered by HATS, the upper concentration factor for marine fish is 30,000. Dividing the recommended maximum acceptable residue level by the concentration factor results in:

$$\frac{0.5 \text{ ppm}}{3 \times 10^4} = 0.167 \times 10^{-4} \text{ ppm}$$

or 0.0167 ug/l

which meets "Water Quality Criteria" guidelines for chronic exposure in the marine environment.

For acute protection of important species the following data are presented:

Pink Shrimp, 48 HR LC_{100} = 100 ug/l

" " 48 " LC_0 = 10 ug/l

Oysters 96 HR TL_{100} = 100 ug/l

96 HR TL_{41} = 10 ug/l

Although no fatalities occur to pink shrimp at 10 ug/l in 48 hours, this concentration adversely affected oysters by reducing shell growth by 41% in 96 hours. Therefore, the acute critical limit is:

10.0 ug/l

Calculations

Toxic Substance PCB's

(a) Effluent Concentration: (Critical Acute Limit)

Water Body	Max. Allow. Effluent Conc.
F.W. Stream	280 ug/l
F.W. Lake	280 ug/l
Estuary	10 ug/l
Coastal	10 ug/l

(b) Daily Load:

Water Body	WQC Chronic Limit	Safety Factor	Correction For Safety	(WQC Chronic Limit Times Correction For Safety) - Critical Chronic Limit (ppb)
F.W. Stream	.002 ug/l	40	0.6	0.0012 ug/l
F.W. Lake	.002 ug/l	50	0.5	0.001 ug/l
Estuary	.017 ug/l	50	0.5	0.0085 ug/l
Coastal	.017 ug/l	40	0.6	0.0102 ug/l

Calculation:

5.4 x cfs x Adj. C.C.L. in ppm = lbs/day ÷ 2.205 = kg/day

F.W. Stream: 5.4 x 10,000 x .0000012 = .0648 lbs/day ÷ 2.205 = 0.0294 kg/day

F.W. Lake: 5.4 x 10,000 x .000001 = .054 lbs/day ÷ 2.205 = 0.0245 kg/day

Estuary: 5.4 x 10,000 x .0000085 = 0.459 lbs/day ÷ 2.205 = 0.208 kg/day

Coastal: 5.4 x 10,000 x .0000102 = 0.551 lbs/day ÷ 2.205 = .250 kg/day

MONS 205412

Effluent Standard Factors PCB's

The values to be used in determining Effluent Standards are tabulated below:

	Metric Unit Factors		English Unit Factor	
	Column 1 Maximum Effluent Concentration Critical Acute Limit (ug/l)	Column 2 Maximum Effluent Loading kg/day/m^3/sec	Column 3 Maximum Effluent Concentration Critical Acute Limit (ppb)	Column 4 Maximum Effluer Loading lbs/day/ft^3/sec
Streams	280	0.000104	280	0.00000648
Lakes	280	0.0000865	280	0.00000540
Estuaries	10	0.000735	10	0.0000459
Coastal Waters	10	0.000883	10	0.0000551

To determine allowable loading for a specific water body multiply column 2 figure by flow in m^3/sec or Column 4 by flow in cfs providing flow is within the range 0.283 to 283 in m^3/sec or 10 to 10,000 cfs.

9. Toxaphene

a. Fresh Water

From WQC the following recommended levels were noted:

Toxaphene LC_{50} = 1 ug/l (acute)

.01 x LC_{50} = 0.01 ug/l (chronic)

Ref: WQC p. 125 Table 1

Same as Aldrin

b. Salt Water

From WQC the following recommended levels were noted:

Toxaphene LC_{50} = 1.0 ug/l (acute)

.01 x LC_{50} = .01 ug/l (chronic)

Ref: WQC p. 302

CALCULATIONS

Toxic Substance Toxaphene

(a) Effluent Concentration: (Critical Acute Limit)

Water Body	Max. Allow. Effluent Conc.
F. W. Stream	1.0 ug/l
F. W. Lake	1.0 ug/l
Estuary	1.0 ug/l
Coastal	1.0 ug/l

(b) Daily Load:

Water Body	WQC Chronic Limit	Safety Factor (%)	Correc. for Safety	Crit. Chron Lim. (ppb) Chron. Lim. Correc. for
F. W. Stream	0.01 ug/l	40	0.6	0.006 ug/l
F. W. Lake	0.01 ug/l	50	0.5	0.005 ug/l
Estuary	0.01 ug/l	50	0.5	0.005 ug/l
Coastal	0.01 ug/l	40	0.6	0.006 ug/l

Calculation:

5.4 x cfs x Crit. Chron. Lim. in ppm = lbs/day ÷ 2.205 = kg/day

F.W. Stream: 5.4 x 10,000 x .000006 = 0.324 lbs/day ÷ 2.205 = 0.147 kg/day

F.W. Lake: 5.4 x 10,000 x .000005 = 0.270 lbs/day ÷ 2.205 = 0.122 kg/day

Estuary: 5.4 x 10,000 x .000005 = 0.270 lbs/day ÷ 2.205 = 0.122 kg/day

Coastal: 5.4 x 10,000 x .000006 = 0.324 lbs/day ÷ 2.205 = 0.147 kg/day

MONS 205415

Effluent Standard Factors Toxaphene

The values to be used in determining Effluent Standards are tabulated below:

	Metric Unit Factors		English Unit Factors	
	Column 1 Maximum Effluent Concentration (ug/l)	Column 2 Maximum Effluent Loading $kg/day/m^3/sec$	Column 3 Maximum Effluent Concentration (ppb)	Column Maximum Eff Loading $lbs/day/ft^3$
Streams	1.0	0.000519	1.0	0.0000324
Lakes	1.0	0.000431	1.0	0.0000270
Estuaries	1.0	0.000431	1.0	0.0000270
Coastal Waters	1.0	0.000519	1.0	0.0000324

To determine allowable loading for a specific water body multiply Column 2 figure by flow in m^3/sec or Column 4 by flow in cfs providing flow is within the range 0.283 to 283 in m^3/sec or 10 to 10,000 cfs.

MONS 205416

IV. EPA Proposed Water Quality Criteria for PCB's

Sections of the proposed Water Quality Criteria applicable to materials on the List of Toxic Pollutants and used as basic data in the formulation of the effluent standards are included as scientific and technical support for the proposed standards.

Note: For the purpose of this document only those references from the proposed Water Quality Criteria which are applicable to the toxic pollutants have been included.

MONS 205417

V. Freshwater Constituents

A. Aquatic Life

4. Organic Compounds

f. Polychlorinated Biphenyls (PCB's)

Maximum acceptable concentrations of PCB's in water are 0.002 ug/l, and maximum acceptable levels of residues in general body tissues of any aquatic organism are 0.5 ug/g.

Rationale (Polychlorinated Biphenyls):

PCB residue levels of 0.5 mg/l in whole salmon eggs have been suggested as the threshold for egg mortality (63). Such levels in eggs are associated with levels in the body tissue of 2.5 to 5.0 ug/g (1). PCB's are highly cumulative with accumulation factors of up to 200,000 indicated by long term exposure of fish to low PCB concentrations in water (1). Consequently, in order to provide adequate protection for egg development, and to provide an adequate safety factor to protect against excessive accumulations in tissue, the 0.002 ug/l maximum concentration limit in waters shall be observed.

B. Wildlife

4. Specific Harmful Substances

b. Acting After Food Chain Magnification

(3). Polychlorinat ! biphenyls (PCB's)

The body burdens of PCB's in birds and mammals should not be increased over present levels in order to maintain acceptable levels.

Rationale (Polychlorinated Biphenyls):

Although PCB's are widespread environmental containments, their biological effects at present environmental concentrations are not known (1). Because of the persistence of PCB's and their susceptibility to biological magnification, the body burdens of PCB's in birds and mammals should not be permitted to increase and monitoring programs should be instituted.

C. Public Water Supply Intake

5. Organic Compounds

h. Polychlorinated Biphenyls (PCB's)

No limit of acceptability is prescribed for acceptable concentrations of polychlorinated biphenyls in raw water used for drinking water supplies.

Rationale (PCB's):

Too little is known about the levels in water, the retention and the accumulation in humans and the effects of very low rates of ingestion to permit the establishment of acceptable PCB limits.

MONS 205420

VI. Marine Water Constituents

B. Wildlife

2. Specific Harmful Substances

d. Polychlorinated Biphenyls (PCB's)

The maximum acceptable concentrations of PCB in any sample consisting of a homogenate of 25 or more whole fish of any species that is consumed by fish-eating birds and mammals, within the size range consumed is 0.5 mg/kg on a wet weight basis.

Rationale (PCB):

Evidence is accumulating that PCB does not contribute to the shell thinning that has been a major symptom of the reproductive failures and population declines of raptorial and fish-eating birds (3). A PCB effect could not be associated with the thinning of Brown Pelican (Pelecanus occidentalis) eggshells (165) nor did dietary PCB produce any effect on the eggs of Mallard Ducks (Anas platyrhynchos) (166) or Ring Doves (Streptopelia risoria) (167). PCB may increase susceptibility to infectious agents such as virus diseases (168) and like other chlorinated hydrocarbons PCB increases the activity of liver enzymes that degrade steroids, including sex hormones (156, 169). Laboratory studies have indicated that PCB, with its derivatives or metabolites, causes embryonic death of birds (170, 171, 172,

173). Because exceptionally high concentrations are occasionally found in fish-eating and raptorial species (156, 174), it is highly probable that PCB has had an adverse effect on the reproductive capacity of some species of birds that have shown population declines (3). Median PCB concentrations in whole fish of eight species from Long Island Sound, obtained in 1970, were in the order of one mg/kg (158), and comparable concentrations have been reported from southern California (175). On the basis of the high probability that PCB in the environment has contributed to the reproductive failures of fish-eating birds, it is desirable to decrease these levels by at least a factor of two (3).

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MONS 205423

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MONS 205424

V. National Academy of Sciences Water Quality Criteria of 1972 for PCB's

Sections of the report of the National Academy of Sciences upon which the proposed Water Quality Criteria were largely based are included as scientific and technical support for the proposed effluent standards.

Note: For the purposes of this document only those references from the National Academy of Sciences Report which apply to the toxic pollutants have been included.

PCB's

MONS 205426

POLYCHLORINATED BIPHENYLS (PCB)

Polychlorinated biphenyls (PCB) consist of a mixture of compounds only slightly soluble in water; highly soluble in fats, oils, and nonpolar liquids; and highly resistant to both heat and biological degradation. PCB have a wide variety of industrial uses, primarily as insulating fluid in electrical and heat transfer equipment (Interdepartmental Task Force 1972).[311]

Exposure to PCB is known to cause skin lesions (Schwartz and Peck (1943)[320] and to increase liver enzyme activity that may have a secondary effect on reproductive processes (Risebrough et al. 1968,[317] Street et al. 1969,[321] Wassermann et al. 1970[323]). It is not clear at this time whether the effects are due to PCB or its contaminants, the chlorinated dibenzofurans that are highly toxic (Bauer et al. 1961,[307] Schulz 1968,[318] Verrett 1970[324]). It is also not known whether the chlorinated dibenzofurans are produced by degradation of PCB as well as during its manufacture.

The occurrence of PCB in our waters has been documented separately (New Scientist 1966,[314] Holmes et al. 1967,[310] Risebrough et al. 1968,[317] Jensen et al. 1969,[312] Koeman et al. 1969,[313] Schmidt et al. 1971,[315] Veith and Lee 1971[323]). They have been associated with sewage effluents (Holden 1970,[309] Schmidt et al. 1971[315]) and rainwater (Tarrant and Tatton 1968),[322] as well as releases and leakage. Failures of closed systems using PCB have caused some of the more well known releases (Kuratsune et al. 1969,[314] Duke et al. 1970[308]). It has been reported that the defined treatment process does little or nothing to remove PCB (Ahling and Jensen 1970).[306]

An epidemiological study on severe poisoning by rice oil contaminated with polychlorinated biphenyls in 1968 indicated that about 0.5 grams ingested over a period of approximately one month was sufficient to cause the *Yusho* disease. Many of those affected showed no signs of relief after about three years (Kuratsune et al. 1969).[314] Price and Welch (1971)[316] have estimated on the basis of 194 samples that 41 to 45 per cent of the general population of the U.S. may have PCB levels of 1.0 mg/kg or higher (wet weight) in adipose tissue. Therefore, it appears that PCB may accumulate in the body. On this basis it can be calculated that a daily intake of 0.02 mg would require about 70 years to be toxic. Applying a factor of safety of 10 would permit a daily intake of 0.002 mg, and assuming a two liter per day intake, suggests a permissible concentration in water to be 0.001 mg/l.

However, evaluation of the retention and accumulation of PCB from water instead of oil in humans is highly desirable. A study on rats with a single oral dose of 170 mg/kg showed urinary excretion (of PCB) to be limited, while 70 per cent of the dose was found in the feces during an eight week period (Yoshimura et al. 1971).[320] Information on PCB in the diet would also be helpful.

Conclusion

Because too little is known about the levels in waters, the retention and accumulation in humans, and the effects of very low rates of ingestion, no defensible recommendation can be made at this time.

MONS 205427

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MONS 205428

Polychlorinated Biphenyls (PCB) Polychlorinated biphenyls are chlorinated hydrocarbons which are highly resistant to chemical or biological degradation. They have been widespread environmental contaminants (Jensen et al. 1969,[180] Risebrough et al. 1968[180]). Their biological effects at present environmental concentrations are not known. PCB's can elevate microsomal enzyme activity (Risebrough et al. 1968,[180] Street et al. 1968[184]), but the environmental significance of that finding is not clear. The toxicity of PCB is influenced by the presence of small amounts of contaminated chlorinated dibenzofurans (Vos and Koeman 1970,[196] Vos et al. 1970[197]) which are highly toxic to developing embryos.

Recommendation

Because of the persistence of PCB and their susceptibility to biological magnification, it is recommended that the body burdens of PCB in birds and mammals not be permitted to increase and that monitoring programs be instituted (see Section IV).

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MONS 205429

TABLE III-14—*Acute Toxicity of Di-n-butyl Phthalate to Four Species of Fish and* Daphnia Magna.

Species	Temperature	LC50 in µg/l		
		24 hr	48 hr	96 hr
Fathead minnow (*Pimephales promelas*)			1400	1300 (Static-system
Bluegill (*Lepomis macrochirus*)		1230	730	730 (Static-system
Channel catfish (*Ictalurus punctatus*)		3720	2810	2110 (Static-system
Rainbow trout (*Salmo gairdneri*)				6470 (Static-system
Daphnia magna				>5000 (Static-system

POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls (PCB) have been found in fish and wildlife in many parts of the world and at levels that may adversely affect aquatic organisms (Jensen et al. 1969;[378] Holmes et al. 1967;[375] Koeman et al. 1969;[376] Risebrough et al. 1968).[384] The environmental occurrence, uses, and present toxicological aspects of PCB were recently reviewed by Peakall and Lincer (1970),[383] Gustafson (1970),[372] Risebrough (1970),[387] and Reynolds (1971).[388]

Diphenyls may have 1 to 10 attached chlorine atoms, making possible over 200 compounds (Gustafson 1970).[372] PCB occur as residues in fish, and presumably also in water, as mixtures of chlorinated biphenyl isomers as shown in Table III-15 (Stalling and Johnson, *unpublished data* 1970,[371] Stalling *in press*[393]).

Analysis of PCB has been accomplished by gas chromatography after separation of PCB from pesticides. A separation method has been described by Armour and Burke (1970)[24] and modified by Stalling and Huckins (1971).[391] A method using [illegible] on a charcoal column has shown good reproducibility (Frank and Rees, *personal communication*).[33] No standardized gas-liquid chromatography method has been proposed for the analysis of mixtures of PCB in environmental samples. The solubility of these formulations in water has not been precisely determined, but it is in the range of 100 to 1,000 µg/l (Papageorge 1970).[382] Since PCB have gas chromatographic characteristics similar to many organochlorine pesticides, they can cause serious interference in the gas chromatographic determination of chlorinated insecticides (Risebrough et al. 1968).[385]

The Monsanto Company, the sole manufacturer of PC

TABLE III-15—*Composition of PCB Residues in Selected Fish Samples from the 1970 National Pesticide Residue Monitoring Program*

River	Location	Species	PCB Residue of Aroclor ® type (µg/g whole body)				
			1232	1248	1254	1260	Total
Ohio	Cincinnati, O.	Carp (*Cyprinus carpio*)	16	75	46	6.6	127
Ohio	Cincinnati, O.	White crappie (*Pomoxis annularis*)	16	37	37	5.5	91
Ohio	Marietta, O.	Channel catfish (*Ictalurus punctatus*)	35	28	11	4.5	77
Ohio	Marietta, O.	Channel catfish	14	5.2	15	4.9	39
Yazoo	Belzoni, Miss.	Smallmouth buffalo (*Ictiobus bubalus*)	22	[illegible]	1.4	[illegible]	73
Holland	Zoutkamperlaag, N.H.	Golden Carpmouth (*Cyprinus carpio*)	0	133	38	[illegible]	215
Susquehanna	Harrisburg, Pa.	White sucker (*Catostomus commersoni*)	[illegible]	5.2	25	4.8	35
Delaware	Camden, N.J.	White perch (*Morone americana*)	[illegible]	5.4	6.1	3.6	15
Saint John	Lepreau Town, N.B.	Striped bass (*Morone saxatilis*)	10	[illegible]	2.6	1.1	23
Lake Ontario	7½ Island, N.Y.	White perch	10	[illegible]	6.6	1.1	18
Mississippi	Memphis, Tenn.	Drum (*Aplodinotus grunniens*)	11	[illegible]	6.3	1.4	19
Merrimack	Lowell, Mass.	Bream	31	75	6.1	3.2	98

MONS 205430

[illegible] United States (Gustafson [illegible]) markets eight [illegible] The last two digits of each [illegible] the [illegible] chlorine. Aroclor® 1248 [illegible] produced in [illegible] quantities. They are [illegible] fluids in [illegible] and in closed-system [illegible] (Papageorge 1970).[283] Aroclor® 1242 is [illegible] fluid, and Aroclor® 1260 as a plasticizer. Chlorinated terphenyls are [illegible] under the trademark [illegible] 5450, and a mixture of bi- and terphenyls [illegible] designated Aroclor® 4465. The Lomer composition and chromatographic characteristics of each formulation have been described by Stalling and Huckins (1971)[371] and Bagley et al. (1970).[370] A contaminant of some PCB, especially those manufactured in Europe, are chlorinated dibenzofurans (Brungs *personal communication* 1972).[393] Although these byproducts would appear to be extremely toxic, no data are available on their toxicity to aquatic life.

Direct Lethal Toxicity

Studies of toxicity of PCB to aquatic organisms are limited. They show considerable variation of toxicity to different species, as well as variation with the chlorine content of the PCB. Nevertheless, some trends in the toxic characteristics have become apparent, principally from the work of Mayer as described below:

- The higher the per cent chlorine, the lower the apparent toxicity of PCB to fish (Mayer, *in press*).[379] This was found in 15-day intermittent-flow bioassays using bluegills (*Lepomis macrochirus*) and channel catfish (*Ictalurus punctatus*) with Aroclor® 1242, 1248, 1254. All LC50 values were in the range 10 to 300 μg/l.
- The bluegill/channel catfish experiments also illustrated that all LC50 values decreased significantly when exposures continued from 15 to 20 days. The 96-hour LC50 of a PCB to fish cannot adequately measure its lethal toxicity.
- The same tests showed that the toxicity of Aroclor® 1248 doubled when the temperature was raised from 20 C to 27 C.

To invertebrates, Aroclor® 1242 has about the same acute toxicity that it has to fish. In 4- and 7-day tests (Saunders, *in press*),[389] it killed *Gammarus* at 42 μg/l and crayfish (*Cambarus*) at 30 μg/l, with values that were similar to the 15-day LC50 reported for bluegills. However, there [illegible] an extreme range in the reported short-term lethal levels [illegible] Aroclor® 1254 for invertebrates. Saunders (*in press*)[389] [illegible]ported a 96-hour LC50 as 80 μg/l for crayfish and only [illegible] μg/l for glass shrimp (*Paleomonetes*) in 7-day tests; and [illegible] al. (1970)[371] reported that as little as 0.94 μg/l [illegible] [illegible]ture pink shrimp (*Panaeus duorarum*). Part of this [illegible] related to exposure periods in the tests; part is no doubt the variation in species response. Again this [illegible] that short-term [illegible] PCB have serious limitations.

Marine animals may be more easily killed by PCB than freshwater ones (see Section IV). When two estuarine fishes (*Leiopaon rhomboides* and *Leiostomus xanthurus*) were exposed for 14 to 45 days to Aroclor® 1254, mortalities were observed at 5 μg/l (Hansen, et al. 1971).[372] This indicated a toxicity about five times greater than summarized above for freshwater fish but about the same as the toxicity for the marine crustaceans mentioned above.

Feeding Studies

Dietary exposure to PCB seems to be less of a direct hazard to fish than exposure in water. Coho salmon (*Oncorhynchus kisutch*) fed Aroclor® 1254 in varying amounts up to 14,500 μg/kg body weight per day accumulated whole body residues which were only 0.9 to 0.5 of the level in the food after 240 days of dietary exposure. Growth rates were not affected. However, all fish exposed to the highest treatment died after 240 days exposure; and thyroid activity was stimulated in all except the group treated at the lowest concentration (Mehrle and Grant *unpublished data* 1971).[394]

At present, evaluation of data from laboratory experiments indicates that exposures to PCB in water represents a greater hazard to fish than dietary exposures. However, in the environment, residue accumulation from dietary sources could be more important, because PCB have a high affinity for sediments, and therefore, they readily enter food chains (Duke et al. 1970;[371] Nimmo, et al. 1971).[383]

Residues in Tissue

It is clear that widespread pollution of major waterways has occurred, and that appreciable PCB residues exist in fish. When analyses of 40 fish from the 1970 National Pesticide Monitoring Program were made, only one of the fish was found to contain less than 1 μg/g PCB (Stalling and Mayer 1972).[390] The 10 highest residue levels in the 40 selected fish ranged from 19 μg/g to 213 μg/g whole body weight.

By contrast, residues measured in ocean fish have been generally below 1 μg/g (Risebrough 1970;[387] Jensen, et al. 1969).[376] Between the ranges in freshwater fish and those in marine fish are the levels of PCB found in seals (Jensen et al. 1969;[378] Holden 1970),[374] and in the eggs of fish-eating birds in North America (Anderson et al. 1969;[388] Mulhern et al. 1971,[390] Reynolds 1971).[385]

In laboratory experiments, crustacea exposed to varying levels of Aroclor® 1254 in the water concentrated the PCB within their bodies more than 20,000 times. The tissue residues may sometimes reach an equilibrium, and in *Gammarus fasciatus* PCB did not concentrate beyond 27,000 times despite an additional 3-week exposure to 1.6 μg/l Aroclor® (Saunders 1972).[388] In contrast, PCB residues in crayfish did not reach equilibrium after a 28-day exposure.

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[illegible] concentration factors by two estuarine fishes, *Lagodon* [illegible], and *Lepomis xanthurus*, were similar to that [illegible] above for crustaceans, i.e., about 10,000 to 50,000 times the exposure levels in water (Hansen et al. 1971).[373] It is important to note that these accumulations occurred at water concentrations of PCB that killed the fish in 15 to 45 days.

Also similar were the accumulation ratios of 26,000 to 56,000 for bluegills (*Lepomis macrochirus*) chronically exposed to 2 to 15 μg/l of Aroclor® 1248 and 1254. Fathead minnows (*Pimephales promelas*) chronically exposed to Aroclor® 1242 and 1254 for 8 weeks concentrated PCB 100,000 and 200,000 times the exposure levels, respectively. Residues of 50 μg/l (whole body) resulted from exposure for 8 weeks to 0.3 μg/l Aroclor® 1254 (Nebeker et al. 1972).[381] These experiments with bluegills also indicated that the maximum levels of PCB were generally related to the concentration of PCB in the water (50,000–200,000 times higher) to which they were exposed (Stalling and Huckins *unpublished data* 1971).[397]

Effects on Reproduction

PCB residues in salmon eggs are apparently related to mortality of eggs. In preliminary investigations in Sweden, Jensen and his associates (1970)[377] reported that when residues in groups of eggs ranged from 0.4 to 1.9 μg/g on a whole-weight basis (7.7 to 34 μg/g on a fat basis), related mortalities ranged from 16 per cent up to 100 per cent.

PCB concentrations in the range of 0.5 to 10 μg/l in water interfered with reproduction of several aquatic animals according to recent work of Nebeker et al. (1971).[381] About 5 μg/l of Aroclor® 1248 was the highest concentration that did not affect reproduction of *Daphnia magna* and *Gammarus pseudolimnaeus*. In tests of reproduction by fathead minnows (*Pimephales promelas*) all died when exposed chronically to greater than 8.3 μg/l of either Aroclor® 1242 or Aroclor® 1254. Reproduction occurred at and below 5.4 μg/l Aroclor® 1242, and at and below 1.8 μg/l of Aroclor® 1254.

The association between residue levels and biological effects in aquatic animals is scarcely known, but the work of Jensen et al. (1970)[377] suggested that about 0.5 μg/g of PCB in whole salmon eggs might be the threshold for egg mortality. Such a level in eggs would be associated with levels in general body tissue (e.g., muscle) of 2.5 to 5.0 μg/g. The residue in muscle corresponded to the present Food and Drug Administration level for allowable levels of PCB in fish used as human food. Residues measured in the survey by the 1970 National Pesticide Monitoring Program were generally above 5 μg/g.

Applying a minimal safety factor of 10 for protection of the affected population, and for protection of other species higher in the food chain, would yield a maximum permissible tissue concentration of 0.5 μg/g in any aquatic organism in any habitat affected by PCB.

General Considerations and Further Needs

Another means of control would be justified in view of the toxicity of PCB, the lack of knowledge about how it first enters natural ecosystems as a pollutant, and its apparent distribution in high concentrations in freshwater fish in the United States. This method would be to regulate the manufacture of PCB and maintain close control of its uses to avoid situations where PCB is lost to the environment. The Monsanto Company recently restricted the sale of PCB for uses in which disposal of the end products could not be controlled, as with plasticizers (Gustafson 1970).[372]

Basis for Recommendations

For PCB levels in water, the most sensitive reaction shown by aquatic organisms is to the lethal effects of low concentrations continually present in water for long periods (weeks or months). Concentrations in the range of 1 to 8 μg/l have been shown to be lethal to several animals.

The work of Hansen, et al. (1971)[373] and Stallings and Huckins (*unpublished data* 1971)[395] indicates that concentrations of 0.01 μg/l of PCB in water over periods of up to 36 weeks could lead to dangerous levels of PCB in the tissues of aquatic organisms. Accumulation by factors of 75,000 to 200,000 times is indicated by their work. If the higher ratio is taken, 0.01 μg/l in water might result in 2.0 μg/g in flesh on whole fish basis. This is comparable to the residue level in salmon eggs associated with complete mortality of embryos. Therefore, a concentration is recommended that is reduced by a factor of 5, or 0.002 μg/l. In addition, a control based on residue levels is required, as well as one based on PCB in the water.

Recommendations

Aquatic life should be protected where the maximum concentration of total PCB in unfiltered water does not exceed 0.002 μg/l at any time or place, and the residues in the general body tissues of any aquatic organism do not exceed 0.5 μg/g.

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TOXIC ORGANICS

The toxic organics constitute a considerable variety of chlorinated compounds, almost all of which are synthetic. The total production of synthetic organic chemicals in the U.S. in 1968 was 120,000 million pounds, a 15 per cent increase over 1967; 135,000 million pounds were produced in 1969, a 12 per cent increase over 1968 (United States Tariff Commission 1970).[377] This figure, in the order of 5×10^{13} grams, may be compared with the total productivity of the sea, which is in the order of 2×10^{16} grams of carbon incorporated into phytoplankton per year (Ryther 1969).[378] When considered in a global and future context, the production of synthetic chemicals by man cannot be considered an insignificant fraction of nature's productivity.

The majority of the synthetic organic chemicals, including those considered toxic, are readily degradable to elementary materials which reenter the chemical cycles in the biosphere. These pose no long-term hazard if applied or released into the environment in quantities sufficiently small to meet the recommendations for mixing zones (see p. 51).

The chemicals of most concern are the more stable compounds that enter the environment, whether they are introduced incidentally as waste materials or deliberately through their use. The toxicity, chemical stability, and resistance to biological degradation of such chemicals are factors that must be considered in assessing their potential effects on ecosystems. Moreover, because of the partitioning of nonpolar compounds among the components of marine ecosystems, relatively high concentrations of these, including halogenated hydrocarbons, are frequently found in organisms.

Only recently it was discovered that polychlorinated biphenyls (PCB), a class of chlorinated hydrocarbons used in a variety of industrial applications, were widespread contaminants in marine ecosystems (Duke et al.).[344a] Concentrations up to or higher than 1000 ppm in the body fat of estuarine birds have been recorded in both Europe and North America (Risebrough et al. 1968,[371] Jensen et al. 1969[344]). Moreover, both DDT and PCB have been found in organisms from depths of 3200 meters in the open North Atlantic Ocean (Harvey et al. 1972).[359]

The discovery of a man-made contaminant such as PCB, unknown in the environment a few years ago, in such unexpectedly high concentrations in marine organisms raises several questions. Are the concentrations of these compounds still increasing in the marine environment and at what rate, and what are the long-term effects upon the marine communities? Is it possible that other pollutants, undetected by the methodologies that measure the chlorinated hydrocarbons, are present in comparable amounts?

Criteria employed in the past to protect freshwater ecosystems were based on data now seen to be inadequate and on an approach that looked at pollutant concentrations in waste water effluents rather than in the receiving system. Evidently it is necessary to attempt to relate the amounts of input into the ecosystem to the levels in the various components of the ecosystem, including indicator organisms. The concentrations of a persistent pollutant in an indicator organism are considered the best way of following accumulation trends in an aqueous ecosystem that serves as a sink for the pollutant, once the capacity of the ecosystem to absorb the pollutant has been determined. If the concentrations in the indicator organisms exceed those considered safe for the ecosystem, input should then be reduced, restricted, or eliminated until environmental levels are acceptable on the basis of established criteria. Inputs of persistent pollutants into the marine environment, however, are in many cases indirect and not immediately controllable, e.g. river runoffs, atmospheric fallout, and dumping by foreign and domestic ships. The sources of the chemicals in atmospheric fallout may be located anywhere in the world. Different recommendations must therefore be developed to protect the marine environment from increasing amounts and varieties of organic pollutants that might be anticipated over the next century. The same recommendations may be applied to petroleum, but these must also be separated from a variety of chemicals that are less persistent and pose no long-term hazard, but that may, because of toxic effects upon organisms, cause unacceptable amounts of damage. These include many of the pesticides, components of sewage, biological wastes from slaughter houses, and other organic wastes from industry.

Acute toxicity values and subacute effects of pesticides on marine life are listed in Appendix III–Table 6, and in Table IV–7, p. 163. Table IV–6 is a summary of the "most sensitive" organisms taken from Appendix III–Table 6 and includes a list of chemicals that are considered to have potential environmental importance in estuarine or marine ecosystems. The list includes many of the pesticides that are readily degradable in the environment but because of their high toxicity are potentially dangerous to estuarine ecosystems. The list, which should be revised as new data become available, proposes a minimum number of such chemicals. Appendix III–Table 6 includes the following information relative to the potential importance of each material as coastal and marine contaminants. (a) Production figures, which are taken from the 1969 Tariff Commission reports, are listed in the second column. The production figures provide a useful clue to the compounds that are of potential importance as marine pollutants. The order of the chemicals generally follows that of the Tariff Commission reports and is not intended to be a ranking in order of importance. (b) The third column of the table indicates

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whether or not the compound has been detected in sea water or in marine organisms. Compounds which have been detected are of greater immediate concern than those which have not. Frequently, because of their low solubility in water, some of the non-polar compounds which are biologically accumulated can be detected in an organism but not in the water itself. (c) The fourth column, trophic accumulation, indicates whether the compound has been shown to pass through the food web from prey species to predator. Compounds that are so accumulated are of greater concern than compounds of comparable toxicity which are not. Finally, the species thought to be most sensitive to the compound are indicated in the final columns with reference to original studies in the scientific literature. These data are useful as a guide only and are not sufficient in themselves for definitive evaluation of the environmental significance of each compound.

The report, "The Effects of Chemicals on Aquatic Life, vol. 3, Environmental Protection Agency, Water Quality Office, 1971," has been useful as a guide to the available toxicity data of industrial chemicals on marine organisms. Appendix III–Table 6 is a compendium of data on toxicity of pesticides to marine organisms. These sources are incomplete and should be continually revised.

Bases for Recommendations

1. In order to provide an adequate level of protection for commercially important marine species and for species considered important in the maintenance of stability of the ecosystem, an application factor of one one-hundredth (0.01) is used when pesticides or organic wastes that are not trophically accumulated in food webs are applied or released in estuarine or marine environments. This factor is arbitrary and was derived from data available on marine and freshwater organisms. (See Section III, p. 40.) It assumes that a concentration of one one-hundredth (0.01) of that causing harm to the most sensitive species to be protected will not damage this species or the ecosystem. Future studies may show that the application factor must be decreased or increased in magnitude.

2. The application factor may also be used for the compounds that are trophically accumulated in food webs In order to protect fish and invertebrates to which these compounds are toxic. It cannot be used, however, to protect fish-eating birds and mammals which may trophically accumulate these compounds from their prey species, in part because sublethal effects such as eggshell thinning and hormone imbalance may adversely affect reproductive capacity and therefore the long term survival of populations. Levels that would protect fish-eating birds and mammals against the effects of compounds that are trophically accumulated from prey species are given in the discussion of Marine Wildlife (see pp. 31–43).

The recommendations below apply to all organics of both proved and potential toxicity.

Recommendations

In general, marine life with the exception of fish-eating birds and mammals should be protected where the maximum concentration of the chemical in the water does not exceed one one-hundredth (0.01) of the LC50 values listed in Column 7, Table IV–7, p. 163. If new data indicate that an ecosystem can adequately degrade a particular pollutant, a higher application factor for this pollutant may be used.

In order to maintain the integrity of the ecosystem to the fullest possible extent, it is essential to consider effects on all non-target organisms when applying pesticides to estuarine habitats in order to control one or more of the noxious species. For those occasions when chemicals must be used, the following guidelines are offered:

- a compound which is the most specific for the intended purpose should be preferred over a compound that has broad spectrum effects;
- a compound of low persistence should be used in preference to a compound of greater persistence;
- a compound of lower toxicity to non-target organisms should be used in preference to one of higher toxicity;
- water samples to be analyzed should include all suspended particulate and solid material residues associated with these should therefore be considered as present in the water;
- when a derivative such as p,p'-DDE or 1-napthol is measured with or instead of the parent compound, the toxicity of the derivative should be considered separately: i the toxicity of a derivative such as an ionic species of a pesticide is considered equivalent to that of the original parent compound concentrations should be expressed as equivalents of the parent compound.

It is recommended that the chemicals listed in Table IV–7 and all chemicals subsequently added to this list be considered as toxic organic compounds potentially harmful to the marine environment. It is emphasized that the data in Table IV–7 are not sufficient in themselves for final evaluation of the environmental significance of each compound.

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TABLE IV-7—Persistence and Toxicity of Organic Chemicals in the Marine System—Continued

Chemical (1)	U.S. production (2)	Persistence in water column (3)	Persistence in sediments (4)	Major commercial application (5)	Species tested (6)	Concentration (mg/l unless noted) (7)	Effect (8)	Test procedure (9)	Reference (10)
DDT compounds, cont.				Mosquito control (Marine shoreline)	Fish	0	LC-50	96 hr static bioassay	Eisler (1970)[a]
Fluorine-containing pesticide (4-chloro-2-(trifluoromethyl)phenyl 4-nitrophenyl ether)	Not available	Stable	Unlikely	Broad spectrum herbicide	Fish	11	LC-50	96 hr static bioassay	Eisler (1970)[a]
Herbicide (3-(1,2-dihydro-1-oxopyridyl)-6,8-dinitrobenzothiophene)	Not available	Unlikely	Unlikely	Postemergence herbicide	Mummichog	27	LC-50	96 hr static bioassay	Eisler (1970)[a]
Phenylmercuric 2-(2-hydroxyethoxy)-ethylammonium lactate (Phenmedipham)	Not available	Unlikely	Unlikely	Insufficient data					
Propanil (3,4-Dichloropropionanilide)	Not available	Unlikely	Unlikely	Cytochrome reduction	.....	0	Acetylcholinesterase activity[a] in nerve tissue, mean. Control: 1.39; Treated: 0.33	72 hr static exposure	Coppage (1972)[a]
DDT[a] (1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane)	Not available	Unlikely	Unlikely	Estuarine crustacean	.....	0	LC-50	96 hr static bioassay	Eisler (1970)[a]
Trichlorfon (O,O-Dimethyl-(1-hydroxy-2,2,2-trichloroethyl)phosphonate) (Dylox)	Not available	Unlikely	Unlikely	Crustacean	Artemia salina	4,000	TLM	48 hr static bioassay	Sparks and Mihursky (1969)[a]
TCPP (Trichloropropyl phosphate)	Not available	Unlikely	Unlikely	Crustacean	Virginia	>10,000[a]	TLM	144 hr static bioassay	Sparks and Mihursky (1969)[a]
Refuse products									
DDT (1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane)[b]	0 lb	Unknown	Unknown	Marine crustacean	.....	100	TLM	72 day static bioassay	Sparks and Mihursky (1969)[a]
Methyl bromide	2.0 x 10[a] lb	Unknown	Unknown	Fumigant gas	—	—	—	—	—
Oil and tar fractions									
Benzene	1.0 x 10[a] gal	Unknown	Unknown	Insufficient data					
Toluene	7.0 x 10[a] gal	Unknown	Unknown	Insufficient data					
Xylene	3.0 x 10[a] gal	Unknown	Unknown	Insufficient data					
Naphthalene	5.0 x 10[a] gal	Unknown	Unknown	Insufficient data					
Plastics									
Polyolefin polymers, total	4.0 x 10[a] lb	Expected	Unknown	Insufficient data					
Polyvinyl resins, total	6.0 x 10[a]	Unknown	Unknown	Insufficient data					
Surface-active agents									
Dodecylbenzenesulfonate, total	1.7 x 10[a] lb (1968)	Unknown	Unlikely	Insufficient data					
Lignosulfonates, total	4.0 x 10[a] lb	Unknown	Unknown	Insufficient data					
Trichloroethylene, solid	Not available	Unknown	Unlikely	Cytolytic agent	Mussel/oyster/soft-shell clam	0 x 10[a]	50% growth as compared to controls	72 hr static bioassay	Erkomaa et al. (1969)[a]
				Metabolic poisoning; Anesthesia blocker	Mussel/oyster/soft-shell clam	1 x 10[a]	100% mortality	7 day static bioassay	Galtsoff et al. (1935)[a]
Miscellaneous hydrocarbons									
Carbon tetrachloride	1.0 x 10[a] lb (1968)	Unknown	Unlikely	Insufficient data					
Dichlorodifluoromethane	3.0 x 10[a] (1968)	Unknown	Unlikely	Insufficient data					
Ethylene dichloride	4.0 x 10[a] (1968)	Expected	Unlikely	Insufficient data					
Polyvinyl chloride/vinyl hydrocarbon version of vinyl chloride production	2 x 10[a] lb (estimated as 10% of vinyl chloride production)	Surface waters and marine organisms of North Atlantic Ocean and North Sea (Jensen et al. 1969)[a]	Unknown	Carbon monoxide	97% 1,1,1-trichloroethane, 20% 1,2-dichloroethane	10,000	LC-50	96 hr static bioassay	Jensen et al. (1969)[a]
Polychlorinated biphenyl	Not available	Jensen et al. (1969)[a], Risebrough et al. (1968)[a]	.....	Process treatment fluid	Amphipod (Gammarus)	0.01	50% mortality	10 day intermittent exposure in flowing seawater	Nimmo et al. (1970)[a]
Polychlorinated terphenyl	Not available	Expected	Expected	Insufficient data					
Brominated biphenyls	Not available	Unknown	Expected	Insufficient data					
Metallic inorganics									
Mercuric chloride	0.5 x 10[a] lb	Expected	Unlikely	Insufficient data					
Phenyl	1.3 x 10[a] lb	Expected	Unlikely	Marine crustacean's food chain	.....	0.5 x 10[a]	TLM	48 hr static bioassay	Sparks and Mihursky (1969)[a]
Miscellaneous chemicals									
Tetrachloroethylene	0.1 x 10[a]	Unlikely	Unlikely	Insufficient data					

[a] Data not available for this chemical.

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Polychlorinated Biphenyls (PCB)

Evidence is accumulating that PCB does not contribute to the shell thinning that has been a major symptom of the reproductive failures and population declines of raptorial and fish-eating birds. Dietary PCB produced no shell thinning of eggs of Mallard Ducks (*Anas platyrhynchos*) (Heath et al. *in press* 1972),[49] nor did PCB have any effects on eggs of Ring Doves (*Streptopelia risoria*) (Peakall 1971).[50] A PCB effect could not be associated with the thinning of Brown Pelican (*Pelecanus occidentalis*) eggshells (Risebrough *in press* 1972).[51] PCB may increase susceptibility to infectious agents such as virus diseases (Friend and Trainer 1970).[44] Like other chlorinated hydrocarbons, PCB increases the activity of liver enzymes that degrade steroids, including the sex hormones (Risebrough et al. 1968;[64] Street et al. 1969).[47] The ecological significance of this phenomenon is not clear.

Because laboratory studies have indicated that PCB, with its derivatives or metabolites, causes embryonic death of birds (Vos et al. 1970;[73] Vos and Koeman 1970;[74] Vos *in press* 1972;[71] Peakal et al. *in press* 1972[39]) and because exceptionally high concentrations are occasionally found in fish-eating and raptorial species (Risebrough et al. 1968;[64] Jensen et al. 1969[48]), it is highly probable that PCB has had an adverse effect on the reproductive capacity of some species of birds that have shown population declines.

Median PCB concentrations in whole fish of eight species from Long Island Sound, obtained in 1970, were in the order of one milligram per kilogram (mg/kg) (Hays and Risebrough 1972),[47] and comparable concentrations have been reported from southern California (Risebrough 1969).[51] On the basis of the high probability that PCB in the environment has contributed to the reproductive failures of fish-eating birds, it is desirable to decrease these levels by at least a factor of two (see Section III on Freshwater Aquatic Life and Wildlife pp. 203–213).

Recommendation

It is recommended that PCB concentrations in any sample consisting of a homogenate of 25 or more whole fish of any species that is consumed by fish-eating birds and mammals, within the same size range as the fish consumed by any bird or mammal, be no greater than 0.5 mg/kg of the wet weight.

In the absence of a standardized methodology for the determination of PCB in environmental samples, it is recommended that estimates of PCB concentrations be based on the commercial Aroclor® preparation which is most closely resembles in chlorine composition. If the PCB composition should resemble a mixture of more than one Aroclor®, it should be considered a mixture for the basis of quantitation, and the PCB concentration reported should be the sum of the component Aroclor® equivalents.

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Appendix II F

Pesticides Recommended for Monitoring in the Environment

Common or trade name	Chemical name
Aldrin	not less than 95 percent of 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo-exo-5,8-dimethanonaphthalene
Amitraz	3-methyl-4-tolyl
Aromatic carbamates (fungicides and organic)	
Atrazine	2-chloro-4-ethylamino-6-(isopropylamino)-s-triazine
Azinphos-methyl (Guthion®)	O,O-dimethyl S-(4-oxo-1,2,3-benzotriazin-3(4H)-ylmethyl) phosphorodithioate
Bacillus thuringiensis (BTK)	a naturally occurring crystalline protein toxin produced by several bacteria and commonly available as technical powders, flowables and granules
Captan	N-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide
Carbaryl	not less than 95 percent of 1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene and not over 40 percent of related compounds
Carbofuran (furadan and other derivatives)	(2,4-dichlorophenoxy) acetic acid
DDT (including its isomers and dehydrochlorination products)	1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane; technical DDT consists of a mixture of the p,p'-isomer and the o,p'-isomer (in ratio of at least 3 to 1)
Dicamba	3,6-dichloro-o-anisic acid
Dieldrin	not less than 85 percent of 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5,8-dimethanonaphthalene
Dithiocarbamate pesticides	
Maneb	polymeric coordination complex of manganese
Nabam	disodium ethylenebisdithiocarbamate salt
Zineb	[polymeric] zinc ethylenebisdithiocarbamate
Endrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5,8-dimethanonaphthalene
Heptachlor	1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene
Heptachlor epoxide	1,4,5,6,7,8,8-heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindene
Lindane	1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer of not less than 99 percent purity
Malathion	diethyl mercaptosuccinate S-ester with O,O-dimethyl phosphorodithioate, 1a
Nitrogen-containing pesticides (inorganic and organic)	
Nitrapyrin	1,1,1-trichloro-2,2-bis(p-methylphenyl)ethane; technical methoxychlor contains at least 80 percent of the p,p'-isomer
Methyl parathion	O,O-dimethyl O-(p-nitrophenyl) phosphorothioate
Mirex	dodecachlorooctahydro-1,3,4-metheno-1H-cyclobuta[cd]pentalene
Nitrofen (Tok E-25®)	4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline
Parathion	O,O-diethyl O-(p-nitrophenyl) phosphorothioate
PCNB	pentachloronitrobenzene
Picloram	4-amino-3,5,6-trichloropicolinic acid
Simazine (including salts, esters, and other derivatives)	2-chloro-4,6-bis(ethylamino)-s-triazine
Strobane®	terpene polychlorinates containing 68 percent chlorine
2,4,5-T (including salts, esters, and other derivatives)	(2,4,5-trichlorophenoxy) acetic acid
TDE (DDD) (including its isomers and dehydrochlorination products)	1,1-dichloro-2,2-bis(p-chlorophenyl)ethane; technical TDE consists mainly of the o,p'-isomer and the p,p'-isomer
Toxaphene	chlorinated camphene containing 67-69 percent chlorine
2,4,5-TP	2-(2,4,5-trichlorophenoxy) propionic acid

Common or trade name	Chemical name
Secondary List of Chemicals for Monitoring	
DCPA (Dacthal®)	2,3,5,6-tetrachloro-4-(dimethyl ester)
Diazinon	O,O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate
Dichlofluanid (Euparen®)	N-(dichlorofluoromethylthio)-N',N'-dimethyl-N-phenylsulfamide
Dicofol	4-chloro-alpha-(4-chlorophenyl)-alpha-(trichloromethyl)benzenemethanol
Dimethoate (Cygon®)	O,O-dimethyl S-(N-methylcarbamoylmethyl) phosphorodithioate
Diuron	N-(3,4-dichlorophenyl)-N',N'-dimethylurea
Endosulfan (Thiodan®)	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide
Fenson	4-chlorophenyl phenyl sulfone
Fluvalinate	N-(2-chloro-4-trifluoromethylphenyl)-DL-valine (2-propynyl) ester
Isopropyl bromide (from fumigation-containing products)	
Lead-containing particles (such as lead arsenate)	
Linuron	N'-(3,4-dichlorophenyl)-N-methoxy-N-methylurea
PCP	pentachlorophenol
Propanil	3',4'-dichloropropionanilide
Triazine type herbicides:	
Simazine	2-chloro-4,6-bis(ethylamino)-s-triazine
Prometon	2-chloro-4,6-bis(isopropylamino)-s-triazine
Prometryne	2,4-bis(isopropylamino)-6-(methylthio)-s-triazine
TBA	2,3,6-trichlorobenzoic acid, usually available as sodium salt

Polychlorinated phenols (PCPs)	Mixtures of chlorinated phenols (some compounds among various percentages of chlorination.
Polychlorodibenzo-p-dioxins	Dibenzo-p-dioxins having a number of chlorine atoms such as the tetra-, hepta-, or octachloro congeners, present as impurities in various formulations containing phenols and early samples of 2,4,5-T.

a Chemical names are in accordance with Chemical Abstracts.

b Report individual isomers where possible.

c Since compounds of this group usually occur as mixtures of isomers in certain regions rather than randomly-mixed, for example, the herbicides 2,4-D and propanil are used mainly as single ester and salt, respectively.

d Note that aldrin has been removed to the Priority List.

e This list contains chemicals which, although not recognized to be pesticides themselves, are of special interest in monitoring studies.

f Schneider, 1971.[49]

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APPENDIX II-F

[18] Schechter, M. S. (1971), Revised chemicals monitoring guide for the National Pesticide Monitoring Program Journal. Vol. 5, No. 1, p. 60–71.

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