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# Issues in Establishing Contaminated Sediment Clean-Up Objectives[1]

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Regulatory agencies in many areas are in the process of developing contaminated sediment management plans in order to prevent the pollution of waterbodies by chemical constituents present in the waterbody's sediments. In the US a pollutant is a constituent that impairs the aquatic life resources of a waterbody of concern to the public. One of the most significant problems with developing a sediment quality management plan is an assessment of the water quality impacts of chemical constituents in the sediments. It has been known for over 30 years that aquatic sediments have a significant ability to detoxify and immobilize a wide variety of chemical constituents, rendering the constituents "inert" - non-reactive in the sediment environment. This means that the total concentrations of chemical constituents in sediments is not a reliable indicator of pollutants and potential water quality problems that could arise from the chemical constituents in the sediments. There are sediments with very high concentrations of constituents that are normally considered highly hazardous - detrimental to water quality in which the constituent is bound to the solid phase in the sediments to such an extent as to cause no impairment of water quality - aquatic life or other beneficial uses of the water of concern to society in which the contaminated sediments are located. There are other situations where the binding of potentially hazardous or deleterious chemicals in sediments is only a partial binding (detoxification - immobilization) with the result that there is still sufficient toxicity - mobility to impair the numbers, types and characteristics of desirable organisms in the waterbody in which the sediments are located, i.e. to cause pollution.

## Goals of Contaminated Sediment Management Programs

The key issue in developing a technically valid, cost-effective approach for managing sediments that are considered to be contaminated, i.e. have elevated concentrations of chemical constituents and therefore are thought by some to be able to potentially cause an impairment of the uses of a waterbody, is a reliable assessment of the toxic - available forms of chemical constituents in the sediments and the establishment of sediment quality clean-up objectives that will address pollutants without wasting funds managing inert chemical constituents. Associated with addressing this issue is the reliable assessment of the benefits in the waterbody water quality that will result from remediating the contaminated sediments to certain degrees. This paper presents a discussion of some of the problems with approaches that are being used today in assessing the water quality impacts of chemical constituents in aquatic sediments and provides guidance on approaches that should be used to develop the remediation approach and extent of

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remediation of contaminated sediments in a particular area.

## Approaches for Establishing Sediment Clean-up Objectives

There are basically two approaches that are used today to try to assess water quality significance of chemical constituents in sediments: chemically-based and biological effects-based approaches.

Chemically-Based Approaches. Chemically-based approaches typically involve attempts to relate (co-occurrence) total concentrations of chemical constituents in sediments with biological effects that have been measured at some location in which the total concentration of the chemical of concern was also measured. Examples of these types of values are the Long and Morgan ER-M and MacDonald PEL values as well as the Apparent Effects Threshold values (AET's). While it may be possible for a specific sediment through extensive site-specific study to empirically correlate total concentrations of certain chemical constituents with adverse impacts, it is highly unreliable to use total concentrations or co-occurrence-based concentrations of constituents such ER-M, PEL or AET values to even screen sediments for potential water quality problems, much less to use these literature values as clean-up objectives for a particular sediment. Such approaches can lead to over-regulation and therefore waste of funds in clean-up, or under-regulation where expenditure of funds does not result in an improvement in the beneficial uses of a waterbody.

A version of the chemical-based approach is the equilibrium partitioning approach that is being developed in which an attempt is made to simplify the aquatic chemistry of constituents in sediments into a simple two-box model (solid phase and interstitial water dissolved phase) in which a single type of chemical reaction is used to describe the partitioning between these two phases. For metals, the partitioning is assumed to be governed by precipitation as a sulfide. For organics, it is assumed that the partitioning is controlled by sorption reactions between the dissolved phase and the interstitial waters and the particulate organic carbon in the sediments. While sulfides and organic carbon are important detoxification mechanisms for heavy metals and some organics, it is inappropriate to assume that they are the only important mechanisms controlling the toxic available forms in a sediment. Establishing clean-up objectives based on equilibrium partitioning approaches will tend to significantly over-regulate, i.e. lead to excessive clean-up of the sediments for the regulated chemicals of concern.

Another of the major problems with chemically-based approaches for establishing contaminated sediment clean-up objectives is that only a very small number of the total potentially hazardous - deleterious chemicals present in aquatic sediments in many locations are regulated today, i.e. have water quality and/or sediment quality criteria - standards. There are 60,000 chemicals in commerce in North America today; only about 100 to 200 of these are regulated. There can readily be unregulated chemical constituents in sediments that cause the sediments to require remediation which are not regulated by chemically-based approaches. It is because of the lack of reliability of chemical approaches, either based on co-occurrence or equilibrium partitioning, that biological effects-based approaches have been used for many years to regulate the management of contaminated sediments in the US Corps of Engineers and US EPA navigation channel maintenance dredging program.

Biological Effects-Based Approaches. There are three types of biological effects that are of primary concern associated with chemically-contaminated sediments. These are the toxicity of the chemical constituents to aquatic life associated with the sediments, the bioaccumulation of chemical constituents present in the sediments within aquatic organisms that cause the organisms to be adversely affected through the development of tumors or other non-systemic toxicity, as well as the accumulation in edible tissue of the organism to cause this tissue to be considered hazardous for use as a food due to a health advisory. Typically, health advisories are based on the potential to cause cancer or neurological damage in humans. An area of increasing attention is the bioaccumulation of sediment-associated contaminants within aquatic organisms which serve as food for wildlife such as fish- or other aquatic life-eating birds and animals as well as birds like swallows that eat insects that have larval forms that live in aquatic sediments. There is now well-established evidence that aquatic sediments can serve as reservoirs for chemical constituents that cause impaired reproduction in bird populations through thin eggshells and possibly other mechanisms. In order to enable these bird populations to develop to their full potential in a region it will be necessary to remediate contaminated sediments to control those chemical constituents that are transferred through the food web to the wildlife and are adverse to the wildlife.

**Sediment Toxicity**

At this time the focus of sediment remediation programs is primarily on identifying those sediments which are significant sources of chemical constituents to be toxic to benthic - epibenthic organisms that are of significance to society in terms of the beneficial uses of the waterbody. While many sediments show toxicity to some forms of aquatic life, in laboratory tests at this time it is impossible to relate the meaning of a laboratory test-based toxicity result to an impairment of the numbers, types and characteristics of desirable aquatic life (fish, shellfish, etc.) in a waterbody. It is certainly inappropriate that contaminated sediment clean-up objectives be based on eliminating all toxicity from the sediments to all forms of aquatic life.

Natural Sediment Toxicity. The most common causes of toxicity in sediments are the low dissolved oxygen, and the concomitant elevated ammonia and hydrogen sulfide that naturally occur in most aquatic sediments. This naturally caused toxicity is typically related to the aquatic plant nutrient load to the waterbody which stimulates algal growth that ultimately leads to the deoxygenation of the sediments. It is very important that an understanding be developed between sediment toxicity as measured in laboratory tests and impacts of such toxicity on the quality of aquatic life resources in a waterbody in order to develop contaminated sediment management plans that do, in fact, cost-effectively address real water quality problems in a technically valid manner. Failure to do so will almost certainly lead to massive waste of public and private funds in implementing inadequately developed sediment remediation plans where large amounts of funds will be spent remediating sediments but there will be little in the way of change in the character of the water resource in which the sediment is located.

**Bioaccumulation**

The second primary area of focus of contaminated sediment remediation is the control of chemical constituents in the sediments that lead to excessive bioaccumulation in desirable aquatic organisms. There are some waterbodies that have fish or other aquatic life health advisories based on excessive accumulation of certain chemical constituents, usually chlorinated hydrocarbon pesticides, PCB's, dioxins and/or mercury, where the constituent that has accumulated to excessive levels in the aquatic life was ultimately derived from aquatic sediments. It is important that those responsible for developing contaminated sediment management plans do not make the mistake of assuming that the so-called hot spots for that chemical constituent (areas in which there are elevated concentrations of it in the sediments) are necessarily the source of the chemical constituent that accumulates in aquatic organism tissue above health advisory levels.

Bioaccumulation (transfer of chemical constituents from sediments to organisms) is also based on available forms of chemical constituents in the sediments. As with toxicity, there are a wide variety of chemical reactions that occur within sediments which immobilize chemical constituents, making them unavailable or available only to a limited extent, for accumulation in organism tissue. Whether a pesticide, PCB or dioxin residue in sediments is bioavailable depends on the amount of immobilizing agent, such as particulate organic carbon, sulfides and polysulfides, carbonates, clays, etc., which can bind with a constituent, making it unavailable. Hot spots for many constituents away from the original source such as an effluent or area of spill are areas in which the constituent is more highly bound to the sediments. These are areas that typically have higher concentrations of effective binding agents. It could be that the highest concentrations in the hot spot represent constituents that are highly bound and are not available. It would, therefore, be the mid to lower constituent concentrations in the sediments that are the source of the chemical constituents that lead to a health advisory. Whether a particular hot spot is a source of chemical constituents that ultimately lead to a health advisory in edible tissue or, for that matter, thin eggshells in fish-eating bird populations must be determined through site-specific evaluations of the actual transfer that takes place from that area.

**Anthropogenic *vs.* Natural Sediment Toxicity**

While some regulatory agencies focus regulatory emphasis on a few anthropogenically-derived heavy metals and organics, such a focus could readily result in spending large amounts of money to clean-up contaminated sediments containing these constituents but have little or no impact on the overall aquatic life resource of the region that is adversely impacted by the natural or anthropogenically-derived toxicity associated with the load of aquatic plant nutrients (N and P) to the waterbody. It is situations such as this that should mandate that before any sediment clean-up program is initiated in a region that a fairly clear understanding be established between the amount of clean-up that will occur and the improvement that will result in the beneficial uses of the waterbody of concern to society who must ultimately pay for this clean-up. In times of limited financial resources, such as now, the public should be entitled to know what they will gain in the way of improved resources for the money spent and jobs lost, etc. as a result of the proposed sediment remediation program. This is an area that has received essentially no attention thus far in the development of sediment remediation programs. It is one in which there is an urgent need for attention if technically valid, cost-effective contaminated sediment remediation programs are to be developed.

**Importance of Controlling Sources of Chemical Pollutants in Sediments**

In many contaminated sediment remediation programs rather arbitrary decisions are being made about the areal extent and depth of needed sediment clean-up. Typically, the areal extent and depth are governed by the clean-up objectives adopted. Often these objectives are applied only to a limited reach/area of a waterbody, such as part of a river channel. Examination of many of these situations shows that while large amounts of money can be spent dredging part of a river channel to remove sediments to meet some clean-up objective, the areas upstream and to the sides of the channel that are dredged will after completion of dredging serve as a source of chemical constituents that move into the dredged area which will result in the remediation program being ineffective in restoring the waterbody to its desired designated use, such as fish and aquatic life. An area of particular concern today is the management of contaminated sediments associated with combined sewer overflows where the combined sewer overflow problem is not corrected before sediment remediation is undertaken. Obviously, any technically valid sediment management program must include the implementation of an appropriate chemical contaminant control program for the sources of contaminants that could lead to future sediment quality problems after completion of the management program.

**Sediment Pollution Prevention Programs**

One of the components of many contaminated sediment management programs is the development of a pollution prevention program which reduces or eliminates the input of chemical constituents to the waterbody that are possibly responsible for sediment contamination. Some of the approaches being developed today involve requiring point-source dischargers, such as of municipal and industrial wastewaters, and stormwater dischargers from urban and rural sources to control through initiation of treatment or additional treatment of the discharge the chemical constituent load to the waterbody. Such approaches can be very expensive to the public and therefore before such an approach is adopted, it is important that a good understanding exist between the concentration - load of chemical constituents in the discharge - runoff and the concentrations of toxic - available forms that occur in the receiving water sediments that lead to the impairment of the aquatic resources of the area. At this time, except under unusual conditions, such an understanding does not exist. It is certainly inappropriate to assume as it is sometimes done that there is a direct relationship between the concentration of a chemical constituent in a discharge - runoff and the presence of a chemical constituent in sediments that is significantly adverse to aquatic life resources in an area. In most situations highly sophisticated site-specific studies must be conducted to develop technically valid, cost-effective pollution prevention programs that will protect aquatic resources of a significance to the public without significant unnecessary expenditures for chemical constituent control.

## Clean-up Objectives *vs.* Enhancement of Aquatic Resources

It is the authors' experience that frequently contaminated sediment management plans and the remediation programs involve inadequate attention to reliably develop sediment clean-up objectives. Further, it is rare, if ever, that an understanding of the relationship between achieving the clean-up objective and the changes in the quality of the aquatic resource that the objective is supposed to protect - enhance is achieved. Because of the very large amounts of money that are involved in many sediment remediation programs and the limited financial resources, both public and private, available today, before initiating a sediment clean-up program, adequate resources should be devoted to developing reliable clean-up objectives that will protect the desirable aquatic resources in an area impacted by the contaminants in the sediments. Further, and of great importance, is the development of an understanding of the improvements in the quality of the aquatic resources in the region that will accrue as a result of implementation of the clean-up program.

## Suggested Approach

The first step in developing a contaminated sediment management program is the finding of a real, significant water quality problem in a waterbody that is attributable to the presence of one or more chemical constituents in aquatic sediments. It is very important not to assume that just because chemical constituents at some location from some sources cause water quality problems in some waterbodies that all chemical constituents of that type present in aquatic sediments cause significant water quality problems in any waterbody in which elevated concentrations are found in the water column or sediments.

Contaminated sediment management plans should be based on achieving biological effects-based sediment quality objectives where significant toxicity, excessive bioaccumulation and foodweb transport to higher trophic-level organisms of concern is managed to the degree necessary to restore the aquatic resource to the desired levels without unnecessary expenditures for sediment clean-up and/or implementation of pollution prevention programs. Chemically-based sediment quality evaluation approaches, such as co-occurrence and equilibrium partitioning, should not be used to establish sediment clean-up objectives. Equilibrium partitioning approaches can, however, be used after real water quality problems have been identified using biological effects-based approaches to help determine the chemical constituents in the sediments responsible for the aquatic resource impairment in the area.

**Summary Biographical Information**

**G. Fred Lee, PhD, PE, DEE and Anne Jones-Lee, Ph.D.**

Dr. G. Fred Lee is president and Dr. Anne Jones-Lee is vice president of G. Fred Lee & Associates, an environmental consulting firm located in El Macero, California.

For 30 years Dr. G. F. Lee held university graduate-level teaching and research positions at the Universities of Wisconsin-Madison and Texas-Dallas, and at Colorado State University. He retired from university teaching and research as a Distinguished Professor of Civil and Environmental Engineering, in 1989. Dr. Anne Jones-Lee held university teaching and research positions for 11 years, including an Associate Professorship in Civil and Environmental Engineering at the New Jersey Institute of Technology.

Dr. G. F. Lee holds a PhD degree from Harvard University in environmental engineering and environmental sciences and a Master of Science in Public Health degree from the University of North Carolina. He obtained a bachelor's degree from San Jose State University. Dr. Anne Jones-Lee obtained a bachelor's degree in biology from Southern Methodist University and masters and Ph.D. degrees in environmental sciences from the University of Texas at Dallas.

Dr. G. F. Lee has conducted over $6 million in research on various aspects of water and sediment quality and solid and hazardous waste impact evaluation and management. He has published more than 650 papers and reports on his work. Since the mid-1970's Dr. Anne Jones-Lee has worked with Dr. G. F. Lee in this research and in developing publications. They have served as advisors to numerous governmental agencies and industries in the US and other countries on chemically contaminated aquatic sediment management issues.

Dr. G. F. Lee is a registered Professional Engineer in Texas and a Diplomate in the American Academy of Environmental Engineers.

Dr. G. F. Lee has over 35 years experience in evaluating and developing management approaches for contaminated aquatic sediments. In the 1960's and 1970's he pioneered in the development of water quality assessment approaches for potential public health and environmental impacts of chemical contaminants in aquatic sediments. He has conducted over two million dollars in research devoted to development of contaminated dredged sediment disposal criteria and evaluating the impact of chemical constitutes in sediments on the designated beneficial uses of waterbodies. He has been involved in numerous site- specific studies designed to evaluate the impact of a chemical(s) and the development of site-specific approaches for managing the significant impacts. Dr. G. F. Lee has extensive experience in developing sediment quality criteria and is active in working with various agencies and industries in evaluating the approaches being used to develop chemically-based sediment quality criteria at the federal and state levels. He is involved in the development and utilization of biological effects-based sediment quality assessment approaches.

## Selected Recent Publications in Contaminated Sediment Evaluation and Management


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# Issues in Establishing Clean-Up Objectives for Contaminated Sediments

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## Goals of CSMP
## Contaminated Sediment Management Program

- Clean Up Contaminated Sediments That Are Causing Significant Adverse Impacts on Beneficial Uses of a Waterbody
  - Domestic Water Supply
  - Fish and Aquatic Life
    - Numbers, Types & Characteristics of Desirable Forms of Aquatic Life
  - Terrestrial Wildlife and Birds
    - Thin Eggshells - Reproductive Success
- *Prevent Recontamination* and New Contamination That Will Impair Uses

Management Programs for Contaminated Sediment Should Be Carried Out in a Technically Valid, Cost-Effective Manner

Management Programs for Contaminated Sediment Should Not Become Another Superfund - "Aquafund"

## "Typical" Sediment Remediation Approach

1. Sediment Clean-Up Objectives Arbitrarily Selected
2. Remediation Approaches Selected
3. "Remediation" Undertaken

## Prudent Protective Approach

. Identify Beneficial Use-Impairment
. Demonstrate Sediment as Significant Cause of Problem
. Cost of Most Remediation Programs Sufficient to Make Development of Reliable Sediment Clean-Up Objectives Prudent
. Before Remediation Plan Undertaken, Should Be Able to Reliably Predict the Nature and Degree of Improvement in Water Quality - Beneficial Uses That Will Result
  Do Not Spend Public Money to See What Will Happen!!
. Monitor to Determine Results of Remediation

## Frequently Heard Beliefs about Sediment Remediation Programs

"Contaminated Sediments Are Too Complex to Understand."

"Do Not Confuse Me with Aquatic Chemistry and Toxicology. I Know That the Sediment Is Bad and Must Be Remediated."

"It Is Common Sense That Higher Concentrations Are Bad.

"Something Must Be Done."

"Just Pick Some Chemical Concentration Clean-Up Objective and Let's Get on with 'Remediation'."

"If What We Do in Remediation Now Is Not Enough, We Can Do More 'Remediation' Later."

"Any Remediation Will Be Beneficial."

"It Is Only the Companies' or Cities' Money - They Can Afford It."

## Approaches for Sediment Clean-Up Objectives: Issue Is Reliability

Developing Sediment Clean-up Objectives - First Step in Developing *Contaminated Sediment Management Plan*

Many Approaches Used for Sediment Clean-Up Objectives Not Reliable
- Over-Estimate Impact of Regulated Chemicals
- Under-Estimate Impact of Unregulated Chemicals
  - 60,000 Chemicals in Use in North America; about 200 Regulated
- No General Relationship between Total Concentration of a Chemical Constituent in Sediments and Impact

Examples of Unreliable Approaches for Screening & Objectives
- Total Chemical Concentrations
- Co-Occurrence-Based Values
  - Long & Morgan ER-M • MacDonald PEL • AET *(Apparent Effect Threshold)*
- Numeric Triad
  - Total Chemical Concentration • "Toxic" Response • Organism Assemblage
- California Sediment Quality Objectives (Proposed in 1991)
  - Geometric Mean: AET • Spiked Bioassay • Equilibrium Partitioning
    - Geometric Mean of 3 Unreliable Values Does Not Produce a Reliable Value

## Equilibrium Partitioning-Based Sediment Clean-Up Objectives

Approach

- Chemical Concentration Data Normalized by Parameters Such as
  - TOC for Some Organics
  - $S^{=}$ for Some Heavy Metals
- In a Simple Partitioning Model - (Dissolved Interstitial Water vs. Particulate)
- Not Reliable for Establishing Sediment Clean-Up Objectives

Sediments More Complex Than Can Be Reliably Represented a Simple Two-Box Model

- Many Causes of Potential Pollutant Detoxification Besides TOC & $S^{=}$

While Equilibrium Partitioning Not Reliable for Predicting Toxicity and Bioaccumulation, Can Be Used as Part of Sediment TIE to Help Identify Cause of Toxicity

## Use of Biomarkers in Establishing Sediment Clean-Up Objectives

Biomarkers - Less Than Whole-Organism Response to Chemical Exposure

- Biochemical, Physiological, Histological Responses, etc.
  - Enzyme Responses
  - Impact on DNA

Biomarkers Are Interesting Curiosities - Not Reliable for Establishing Sediment Clean-Up Objectives

- Need Research on Basic Biochemistry of Organisms to Be Able to Interpret Biomarker Results

Biomarkers Should Not Be Used to Establish Need for Sediment Remediation, or Clean-Up Objectives

## Aquatic Chemistry Key to Developing Sediment Remediation Programs

Aquatic Chemistry $\neq$ Chemical Analysis

Chemicals Exist in Aquatic Systems (Water and Sediments) in a Variety of Chemical Forms, Only Some of Which Are Toxic/Available

Many Chemical Reactions That Occur in Sediments Detoxify Potential Pollutants

No General Relationship between Total Concentrations of Potential Pollutants and Impacts

Impact Cannot Be Assessed by Chemical Concentration. Impact Determined by

- Toxicity/Availability of Forms of Chemicals Present • Binding Agents in Sediments • Nature & Duration of Organism Exposure
  - TOC, $S^{=}$, $CO_3^{=}$, Type of Organics, Oxygen Content, Clay, Particle Size, pH, etc. Influence Sediment Toxicity/Availability

## Chemical Constituent vs. Pollutant

US Water Pollution Control Program Intended to Control Water *Pollution*

*Pollution* Defined as ***Impairment of Designated Beneficial Uses***

Do Not Assume Because Some Chemical Constituent (e.g., Copper) from Some Sources (e.g., Inadequately Treated Plating Wastes) Cause a Use-Impairment in Some Waterbody That All Copper from All Sources Causes Water Quality/Use Impairments in All Waterbodies

- Assumption Leads to Massive Waste of Money in Sediment "Clean-Up" Programs for Non-Problems

Must Clearly Distinguish between Chemical Constituents and Pollutants in Sediment Remediation Programs

Do Not Remediate Inert Chemical Constituents - Focus Remediation Programs on Constituents That Significantly Impair Designated Beneficial Uses of Waterbodies (i.e., on Pollutants)

## Principal Areas of Concern in Sediment Contamination

ediment Toxicity That Significantly Impairs Beneficial Uses of a 'aterbody

ediments That Serve as a Source of Bioaccumulatable Chemicals 1at Cause Human Health Advisories, Cause Cancer in Fish or ther Aquatic Life, and/or Impair Wildlife

ediment Toxicity and Bioaccumulation Cannot Be Reliably stimated by Chemical Analytical Approaches - Must Use ological Effects-Based Approaches

- Measure Toxicity Using a Suite of Sensitive Organisms
- Measure Bioaccumulation in Aquatic Organism Tissue

United States Environmental Protection Agency | Department Of The Army U.S. Army Corps Of Engineers | EPA 503/8-91/001 February 1991

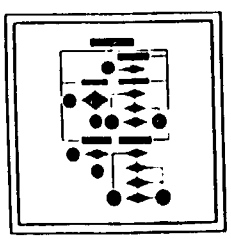
Office of Water (WH-556F)

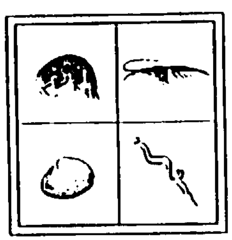
EPA

U.S. Army Corps Of Engineers

**Evaluation Of Dredged Material Proposed For Ocean Disposal**

Testing Manual





Biological Effects-Based Testing Procedures

## Sediment Toxicity

Does All Sediment Toxicity Need to Be Remediated?

- Natural vs. Anthropogenic Toxicity

Many Aquatic Sediments Toxic Due to Naturally Low Dissolved Oxygen, $H_2S$, and/or Ammonia

Many Waterbodies That Have Toxic Sediments Also Have Excellent Aquatic Life Resources

## Natural vs. Anthropogenic Toxicity

Does It Make Sense to "Remediate" Sediments to Eliminate Toxicity Due to Heavy Metals or Organics, While Ignoring the Toxicity Due to Natural Causes, Such as Ammonia, $H_2S$, and Low Dissolved Oxygen?

## Nitrogen and Phosphorus as Causes of Sediment Toxicity

$N + P + CO_2 \xrightarrow{[h\nu]}$ Algae and Other Plants

Algae $+ O_2 \rightarrow CO_2 + H_2O +$ Organic N + P

Algae + [No $O_2$] $\rightarrow CH_4 + CO_2 +$ Organic N $+ NH_3 + P$

Organic N $\rightarrow NH_3$ - Toxic - Accumulate in Sediments

$SO_4^{=}$ [no $O_2$] $\rightarrow H_2S$ - Toxic

1 P + 16 N - in Algae - Uses 243 Oxygen Atoms

## Estimating Bioaccumulation Potential

Bioaccumulation Potential in Fish and Other Higher Trophic-Level Organisms Cannot Be Estimated by Chemical Procedures Such as Equilibrium Partitioning, and Laboratory Exposures

Chemical Approaches and Laboratory Exposures Can Be Used to Rule Out Excessive Bioaccumulation - Lack of Availability

Cannot Predict Excessive Bioaccumulation

Must Use Field Evaluation of Residues in Important Organisms

## Determination of "Excessive" Bioaccumulation

For Human Health Concerns:
Food and Drug Administration Action Levels
US EPA Risk-Based Levels

Unjustified to Presume That Elevated Concentration of a Chemical in an Organism's Tissue Is Adverse to Organism or Higher Trophic-Level Organisms

## Utility of "Reference" Sediment

Approach:

Compare Results of Sediment Toxicity Test and/or Bioaccumulation from Contaminated Sediment to a "Reference Sediment"

If "Excessive" Compared with Reference Sediment ⇒ Need Remediation

Not Technically Valid

Absolute - Not Relative - Impacts of Concern

Do Not Use Reference Sediment Approach to Evaluate Impacts or Determine Need for Remediation

## Approaches That Should Be Used to Designate and Rank Sediments in Need of Remediation and/or Contaminat-Input Control

Conduct Site-Specific Evaluation Using Best Professional Judgement (True Weight-of-Evidence) of Panel of "Experts" in a Public, Peer-Reviewed Discussion of Non-Numeric Triad

- Sediment Toxicity and Bioaccumulation
- Sediment Chemical Characteristics
- Organism Assemblages

## Establishing Priorities

Are All Organisms in Sediments of Equal Value to the Public?

What Is the Relationship Between Sediment Toxicity as Measured in Laboratory Toxicity Tests and the Impact of That Toxicity on the Designated Beneficial Uses of Waterbody?

Should Not Assume that All Statistically Significant Toxicity as Measured in Laboratory Tests Results in Significant Water Quality Use-Impairments
Area of Urgent Need for Research and Policy Development

In Time of Limited Financial Resources, Must Focus Funds Available on Solving Real, Significant Use-Impairments

## Remediation of Sediment "Hot Spots"

Hot Spots Are Areas of Elevated Concentrations of ***Potential*** Pollutants

Reminder: No General Relationship Between Elevated Concentrations and Impacts

Hot Spots Are Areas of High Binding - Detoxification

Hot Spots Are a Source of Pollutants Only If Binding Capacity of Sediment Matrix Exceeded

Do Not Assume a Hot Spot Is a Source of Bioaccumulatable Chemicals

Conduct Site-Specific Studies to Determine If Sediment Binding Capacity Exceeded

Does Sediment "Remediation" Make Sense If Cause of Sediment Contamination Not Controlled?

Will Polluted Sediments Move into Area That Has Been Remediated?

## Natural Remediation

Contaminated Sediments Naturally Detoxify Due to Burial, Dispersion-Dilution, and Chemical Reaction

"Remediation" Can Increase Availability of Chemical Constituents That Are Not Now Available Because of Natural Remediation

## Pollution Prevention

Control Causes of Pollution at Source to Prevent Recontamination and New Pollution

Must Focus Prevention Programs on Controlling Pollutants, Not Chemical Constituents

# Short-Course on Water and Sediment Quality Evaluation and Management - Sediment Quality Criteria -

Duration: 2 to 4 days

Instructor: Dr. G. Fred Lee

Last Offered: April 1995 - San Francisco, CA

Next Offering: To Be Arranged

For Further Information Contact Dr. G. Fred Lee

Short-Course on

# WATER AND SEDIMENT QUALITY EVALUATION AND MANAGEMENT — SEDIMENT QUALITY CRITERIA

Approaches used in evaluating the water quality significance of water column and sediment-associated chemical contaminants are presented in this short-course. Chemically-based and biological effects-based evaluation procedures are discussed. Co-occurrence and equilibrium partitioning-based sediment quality criteria development approaches are discussed with respect to theoretical and empirical foundations and reliability. Consideration is given to sediment-association contaminants that are toxic to aquatic life such as heavy metals, pesticides, PAH's and ammonia, and those that serve as a source of contaminants that result in excessive bioaccumulation of potentially hazardous chemicals in aquatic organism tissue such as Hg, chlorinated hydrocarbon pesticides, PCB's and dioxins.

**Objective:** To provide an overview of the various approaches that are being used to evaluate the water quality significance of chemical contaminants in water and aquatic sediments as they may impact aquatic life-related beneficial uses of waterbodies. Particular attention is given to discussion of the significant technical problems associated with current regulatory approaches. Information is provided on alternative approaches that will lead to more technically valid, cost-effective management of water quality and sediment quality problems than is typically occurring today.

**Selected Topics Covered:**

- Water Quality Criteria (WQC)/standards development and implementation
- Relationship between Sediment Quality Criteria (SQC) and WQC
- Factors affecting the transfer of contaminants between water and sediments
- Co-occurrence-based sediment quality evaluation procedures, AET, ER-M and PEL
- Equilibrium partitioning-based SQC utility
  - TOC non-polar organic SQC
  - AVS heavy metal SQC
- Sediment toxicity tests and interpretation
- Sediment as source of nutrients (N & P)
- Sediment quality evaluation and regulation
- Water quality impacts of dredged sediment disposal
  - Dredged sediment disposal criteria
- US EPA National Sediment Inventory
- US EPA Contaminated Sediment Management Strategy
- Sediment quality management
- California Toxic Hot Spot regulations
- Stormwater runoff and sediment quality
- Examples of sediment regulatory issues
  - San Francisco Bay, Santa Monica Bay, San Diego Bay, Grand Calumet River
- Discussion of participants' specific water quality and sediment quality problems

A detailed outline of the course is available upon request.

**Instructor:** Dr. G. Fred Lee, PE, DEE is President of G. Fred Lee & Associates of El Macero, California. He has a Ph.D. in Environmental Engineering from Harvard University. For 30 years he held university graduate-level environmental engineering and science teaching and research positions during which time he pioneered in development of aquatic sediment quality evaluation and management approaches. He has conducted several million dollars in research on water and sediment quality issues and has published over 400 papers and reports on these studies. Since 1989 he has been a full-time consultant to governmental agencies, industry and others on water quality and solid and hazardous chemical/waste issues. A considerable part of his activities is devoted to contaminated sediments and water. He has frequently presented invited lectures, professional papers and short-courses on water and sediment quality issues in the US and in other countries. A list of Dr. G. Fred Lee's publications pertinent to this course are available upon request. Copies of key publications will be mailed to participants prior to the initiation of the short-course for participant review.

**Prerequisite:** None. Highly desirable to have at least an introductory knowledge of aquatic chemistry and aquatic toxicology as they apply to water quality and sediment quality evaluation and management.

**Preparation:** Should review US EPA publications on water quality and sediment quality evaluation and management approaches.

**Level of Knowledge:** Overview. Participants with limited knowledge of aquatic chemistry and aquatic toxicology are encouraged to participate in a one-day introductory discussion of these topic areas that will be held the day before the short-course.

**Duration:** The duration of the short-course is 2.5 days excluding the aquatic chemistry and aquatic toxicology review.

**Cost:** To Be Arranged

**Date/Location:** To Be Arranged

For further information on this course, contact: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# References
# Contaminated Sediment Evaluation & Management


Lee, G. F., and Jones, R. A., "Water Quality Aspects of Dredging and Dredged Sediment Disposal," In: Handbook of Dredging Engineering, McGraw Hill pp. 9-23 to 9-59, (1992).

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Jones-Lee, A., and Lee, G.F., "Potential Significance of Ammonia as a Toxicant in Aquatic Sediments," Proceedings of First International Specialized Conference on Contaminated Aquatic Sediments: Historical Records, Environmental Impact, and Remediation, International Assoc. Water Quality, Milwaukee, WI, pp. 223-232, June (1993).

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Lee, G. F., and Jones-Lee, A., "Summary of Key Issues: Sediment Quality Evaluation and Sediment Quality Criteria," Prepared for the Southern California Toxicity Assessment Group's Sediment Quality Criteria Workshop, Fountain Valley, CA, March (1994).

Lee, G. F., and Jones-Lee, A., "Comments on US EPA's Proposed Sediment Quality Criteria," Report of G. Fred Lee and Associates, El Macero, CA, 13pp, May (1994).

Lee, G. F., "Comments on US EPA Contaminated Sediment Management Strategy dated August 1994," Submitted to US EPA, Washington, D.C., 16pp, November (1994).

Lee, G. F., "Contaminated Dredged Sediment Disposal Criteria," Proceedings of ASCE "Dredged 94" Second International Conference on Dredging and Dredged Materials Placement, Orlando, FL, pp. 121-130 (1994).

Lee, G. F., and Jones-Lee, A., "Comments on US EPA Proposed Sediment Quality Criteria Based on Acid Volatile Sulfide Normalization Heavy Metal Data," Submitted to the Science Advisory Board Sediment Criteria Subcommittee, Washington, D.C., 7pp, December (1994).

Lee, G. F., "US EPA Sediment Quality Inventory Development Approach Technically Flawed," Submitted to US EPA, Washington, D.C., 10pp., November (1994); Submitted for publication, February (1995).


Copies Available Upon Request

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