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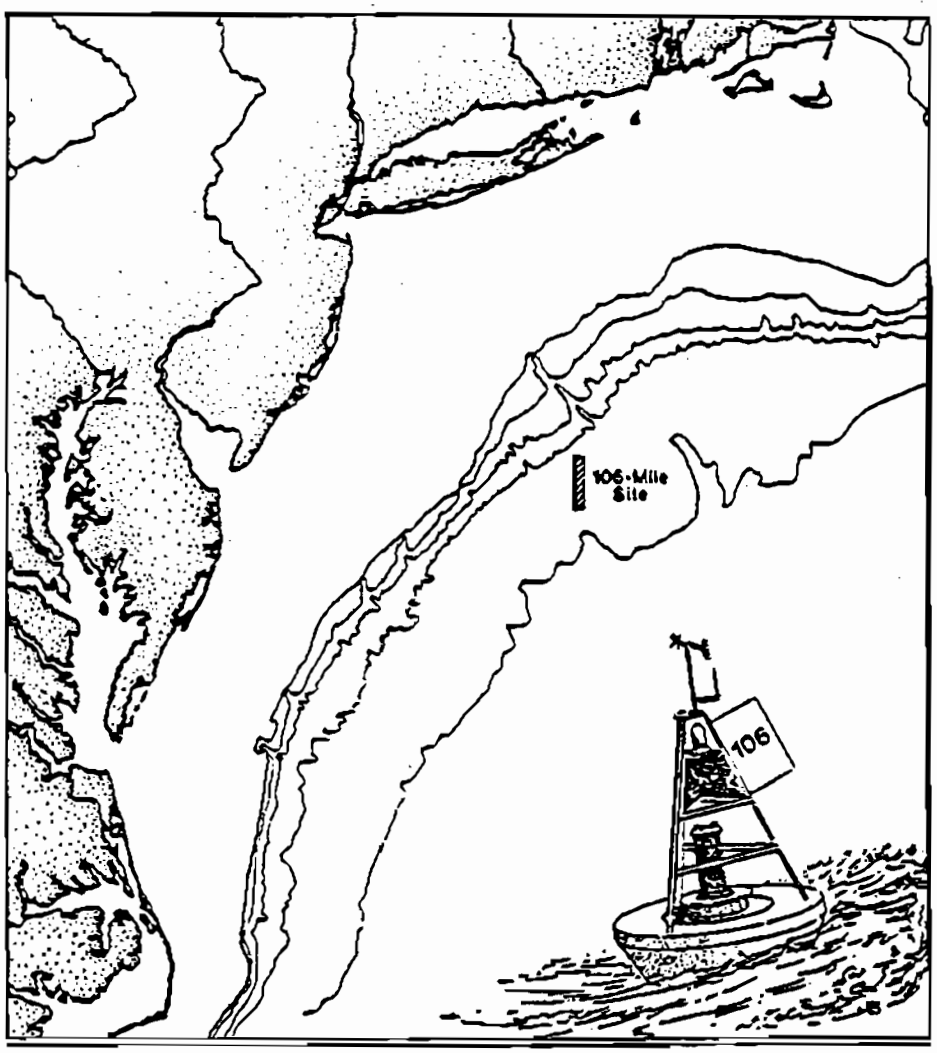

FINAL REPORT

CHARACTERISTICS OF SEWAGE SLUDGE FROM THE NORTHERN NEW JERSEY-NEW YORK CITY AREA, AUGUST 1988

October 19, 1988

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Marine and Estuarine Protection
Washington, DC

and

Region II
New York, New York

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1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA), under the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA, PL 92-532) is responsible for regulating disposal of sludge in ocean waters. Effective January 1, 1988, all sewerage authorities in the New York and New Jersey region, under court order, have shifted sewage sludge disposal operations from the 12-Mile Site in the New York Bight to the 106-Mile Deepwater Municipal Sludge Site (106-Mile Site). EPA recently received permit applications from nine sludge generators in the New York-New Jersey area for continued use of the 106-Mile Site. EPA is in the final process of determining whether to issue or deny permits for continued dumping of sludge.

Prior to these applications a site monitoring program was developed by EPA (EPA , 1992a, 1992b), to assist in assessing the fate and effects of the sludge at the 106-Mile Site. As part of this monitoring program, several plumes at the 106-Mile Site were studied in September 1987 (EPA , 1992c) specifically to determine the rate of sewage sludge dilution in the ocean and to evaluate whether toxic chemicals in the sludge were diluted below marine water quality criteria (WQC) 4 h after disposal or when it reached the site boundary, whichever occurred first. Data obtained on sewage sludge plume behavior during this survey were used to determine that the plume dispersion models used to set the court-ordered disposal rates were inappropriate (EPA , 1992d). Results from this survey also demonstrated that the current court-ordered dumping rate of 15,500 gal/min could result in exceedance of marine water quality criteria after the 4-h initial mixing period (EPA , 1992c) under some oceanic conditions. Therefore, a new formulation for calculating sludge dumping rates was developed using data from the September 1987 survey. This formulation was used to determine sludge dumping rates (EPA , 1992d) that would ensure marine WQC are met at the site.

One of the coefficients in this formulation is the amount of sludge dilution required to meet water quality criteria 4 h after disposal. In the formulation, the required dilution can be derived using either toxic chemical concentrations in the sludge or the toxicity-based limiting permissible concentrations (LPC). This required dilution is then used to calculate the

dumping rates specific to each permitted authority. Therefore, estimates of the amount of dilution required 4 h after disposal depend on accurate measures of toxic chemical concentrations and reliable toxicity (acute) data for the sludge.

Sludge characteristics data for estimating the amount of sludge dilution required after disposal are available from several sources. These sources include data published in the open literature, data from the quarterly sludge monitoring reports submitted to EPA by the dumpers, and data included in support of the permit applications for sludge disposal at the 106-Mile Site. Review of the published sludge characteristics for the sewage treatment plants using the 106-Mile Site (Santoro and Fikslin, 1987) reveals that the concentration of toxic compounds within the sludge generated at individual sewage treatment plants may vary by as much as 30 percent (reported as the coefficient of variation) through time. Between-plant variability of individual chemical concentrations in sludge is much greater and can range over a factor of 10 to 100. Significant variability among treatment plants has also been observed in the toxicity of these sludges to mysid shrimp and Atlantic silversides (Miller et al., in press). However, all of these data are several years old. Thus, although published data provide estimates of the expected variability in sludge characteristics, the concentration and toxicity results may not represent the present character of the sludges generated in the New York-New Jersey area. Therefore, these data are not the most appropriate for estimating the required sludge dilutions, and thus the disposal rates at the 106-Mile Site required for each sewerage authority.

Recent sludge characteristics data, submitted in support of applications for permits to dispose sewage sludge at the 106-Mile Site, and quarterly sludge characteristics monitoring reports historically required of the dumpers by EPA, are also available and have been evaluated for quality and representativeness (Battelle/SAIC, in preparation). This evaluation determined that analytical quality control and quality assurance procedures included with these data were inadequate to determine the reliability of the sludge characteristics data for several of the sewerage authorities. The data included in the permit applications were also insufficient to allow estimates of temporal variability in the characteristics of the sludge from

each plant. Even though a mean concentration could be derived from the data for most authorities, a statistically based characteristic concentration or toxicity of the sludge could not be derived with any degree of confidence. Data submitted to EPA in quarterly monitoring reports were also reviewed and found insufficient in completeness of the reported data and quality control and quality assurance issues. Thus, these data are also insufficient to establish statistically valid estimates of temporal variability and to determine the representativeness of the data included in the permit applications.

Finally, an evaluation of toxicity-based LPCs relative to water quality criteria and toxic chemical concentrations in the sludge suggests that using a toxicity-based LPC to determine the amount of sludge dilution necessary to meet regulatory requirements at the site may not always provide sufficient dilution to meet water quality criteria 4 h after disposal under all oceanographic conditions.

Because of uncertainties in the completeness, reliability, and representativeness of the available sludge characteristics data, EPA determined that sewage sludge generated by the nine New York-New Jersey sewerage authorities (Table 1) applying for permits to dump sewage sludge at the 106-Mile Site should be independently sampled and characterized. The data from this characterization will be used to evaluate the representativeness and accuracy of the sludge characteristics data submitted to EPA in the permit applications and to calculate the required sludge dilution that will be used to determine sludge disposal rates for each sewerage authority, using the newly developed formulation for determining sludge dumping rates (EPA , 1992d). The characterization data generated during this study are not intended to provide a statistical representation of the characteristics of the sludge through time.

Because of the narrow purpose of the study, the parameters measured in the characterization were limited to those that may directly influence the determination of sewage sludge disposal rates (EPA , 1992c) or that can be used to evaluate settling and transport behavior in the receiving waters. The sludge characteristics evaluated include concentrations of pesticides, total PCB, semivolatile organic priority pollutants, selected metals, sludge

TABLE 1. SEWAGE TREATMENT PLANTS SAMPLED FOR CHARACTRIZATION OF SEWAGE SLUDGE GENERATED BY THE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES APPLYING FOR PERMITS TO DUMP SEWAGE SLUDGE AT THE 106-MILE MUNICIPAL SEWAGE DISPOSAL SITE.

Sewerage Authority	Location	Plant Sampled
Linden-Roselle Sewerage Authority	Linden, NJ	a
Bergen County Utilities Authority	Little Ferry, NJ	a
Passaic Valley Sewerage Commissioners	Newark, NJ	a
Middlesex County Utilities Authority	Sayerville, NJ	a
Joint Meeting of Essex and Union Counties	Elizabeth, NJ	a
Rahway Valley Sewerage Authority	Rahway, NJ	a
New York City Department of Environmental Protection	Wards Island, NY	Wards Island Water Pollution Control Plant[b]
Nassau County Department of Public Works	Bay Park, East Rockaway, NY	Bay Park Water of Pollution Control Plant
Westchester County Department of Environmental Facilities	Yonkers, NY	Yonkers Joint Treatment Plant

[a]Plant name is the same as the sewerage authority.

[b]Sample from Wards Island is a composite of the sludge loaded onto a barge and represents a mixture of New York City sewage treatment plants.

priority pollutants, selected metals, sludge toxicity, and various measures of the physical characteristics of the sludge (Table 2).

The number of parameters determined in this study was reduced from that required of the permittees (EPA , 1988a), so that samples from all authorities applying for permits could be characterized. The specific parameters selected for evaluation were based on information from the September 1987 survey of the 106-Mile Site and the available characteristics (or lack thereof) of the sludge generated by the sewerage authorities. Sludge characteristics and field data available through July 1988 indicated copper and lead are the only metals that are sufficiently elevated in the sludge to affect the dumping rate requirements at the 106-Mile Site. Survey results for cadmium and mercury have shown that they are diluted below WQC shortly after disposal. However, because the London Dumping Convention (LDC) prohibits cadmium and mercury in the sludge, except in trace amounts, these metals were included in the characterization study.

Organic priority pollutant concentrations (pesticides, total PCB, and other organic priority pollutants such as PAH) were included in this characterization because concentrations reported in the permit applications were incomplete for most authorities and the reported detection limits were too high to allow assessment of the actual concentrations in the sludge.

Toxicity (96-h acute) tests using representative marine species (Acartia sp., Menidia beryllina, and Mysidopsis bahia) were also planned. These tests were necessary because of identified discrepancies in the quality control and quality assurance aspects of the toxicity data submitted to EPA as part of the permit applications. The ocean dumping regulations require toxicity tests to determine applicable LPC in the receiving waters in the absence of water quality criteria.

Finally, because the ocean dumping regulations contain specific requirements for testing materials containing settleable solids, the sludge samples were evaluated for the following physical characteristics: settleable solids, total suspended solids, total solids, specific gravity, and density of the sludge particles. These parameters were evaluated to assess the settling characteristics of the sludge tested.

The remainder of the report is organized as follows. Analytical methods are discussed in Section 2. Results and estimates of the required

TABLE 2. PARAMETERS MEASURED IN SEWAGE SLUDGES SAMPLES COLLECTED FROM THE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES APPLYING FOR PERMITS TO DISPOSE SEWAGE SLUDGE AT THE 106-MILE SITE.

A. Toxicity Tests (whole sludge only)

1. *Acartia* sp.
2. *Menidia beryllina*
3. *Mysidopsis bahia*

B. Chemical Characterization (whole sludge only)

1. Metals (Cu, Pb, Cd, Hg)
2. Pesticides
3. PCB
4. Organic priority pollutants (base neutral and acid fractions)
5. Phenols

C. Other Characterization

1. Settleable matter
2. Total suspended solids, (residue, filterable)
3. Total solids, (residue, total)
4. Wet to dry weight ratio (settling character of the sludge)
5. Sludge solids density (settling character of sludge)
6. Specific gravity

dilution are discussed in Section 3. Section 4 summarizes required dilutions. Section 5 discusses the results with recommendations for use of the data. Quality control information for the chemical characterizations can be found in Appendices A through E. Appendix F summarizes the toxicity tests.

2.0 METHODS

2.1 SAMPLE COLLECTION

Sludge samples were collected from the nine New York-New Jersey sewerage authorities (Table 1) during August 1988 as planned (EPA , 1988b). For two authorities (Nassau County Department of Public Works (NCDPW), and New York City Department of Environmental Protection (NYCDEP)), sludge is produced at more than one treatment plant, then transported to a single location for loading onto barges. For these authorities, sludge samples were collected from the treatment plant where the sludge is combined and loaded onto barges. The treatment plant sampled is listed in Table 1 for these authorities. Sludge from Rahway Valley Sewerage Authority (RVSA) is piped to the Linden-Roselle Sewerage Authority (LRSA) for storage and loading. The RVSA sludge is held in separate storage tanks from the LRSA sludge. However, sludge from both authorities can be and is combined during barge loading operations for transport to the 106-Mile Site.

Because of the manner in which the various authorities handle the sludge and scheduling of barge loading, some difficulty was encountered in coordinating sample collections with barge operations. As a result, a single grab sample was obtained from the Joint Meeting of Essex and Union Counties (JMEUC). This sample was collected during the final minutes of barge loading. Because the Passaic Valley Sewerage Commissioners (PVSC) facility holds sludge in continuously mixed tanks, a one-time grab sample was collected from one of their holding tanks. Sludge transfer operations for NYCDEP are such that a single fully loaded barge was sampled using a plastic core-type sampler ("sludge judge"). Each of the 10 compartments on the barge were sampled and these samples composited into a single sample for distribution and characterization. For all other authorities, samples were

collected during barge loading operations. Samples were collected from these plants such that a flow-weighted composite sample was obtained.

All sampling equipment was cleaned by the following sequence prior to sample collection: wash with Alconox, rinse with tap water, rinse with ultra-pure water (deionized), rinse with methanol. All sampling equipment was sealed in aluminum foil until used. Dippers, jars, and measuring cups were cleaned after the completion of sample collection from each authority.

Whenever possible, sample collection started shortly after barge loading was initiated (Table 3). Samples were obtained from a tap located on the discharge side of the sludge transfer pump. Samples were collected at predetermined time intervals (Table 3) using either a 750-mL, long-handled stainless steel dipper or a pyrex measuring cup. The sampler used depended on the accessibility of the tap for drawing samples from the sludge delivery line. The time interval between samples was established from expected duration of barge loading.

The samples collected at each interval were added to an 8-L I-CHEM brown glass container for compositing. If the 8-L container was filled prior to the completion of barge loading, the sludge in the container was thoroughly mixed and equal volumes (500 mL) measured into individual 1-L I-CHEM amber glass containers designated for chemical/physical characterization and toxicity testing. If the time interval for sample collections extended beyond the capacity of the 8-L jar used for sample homogenization, the procedures outlined above were repeated with a second 8-L I-CHEM bottle. Equal volumes of sludge from this container were then added to each container used to distribute the samples.

A total of 11 L of sludge from each treatment plant was distributed to various analytical laboratories (Table 3). Samples were stored on ice immediately after collection and shipped to the analytical laboratories on ice via overnight mail. All samples were stored at 4°C prior to analysis or toxicity testing. Large-volume grab samples were also collected from PVSC and NSPDW. These samples were sent to the EPA Environmental Research Laboratory, Narragansett, RI, for unspecified studies.

TABLE 3. SUMMARY OF SAMPLE COLLECTION DATES, TIMES, METHODS, AND DISTRIBUTION TO ANALYTICAL LABORATORIES.

Plant	Date	Sample Method	Sample Location	Time After Loading Started	Sample Collection Duration (h)	Interval Between Grab Samples	Distribution		
							Battelle	SAIC	ERLN
PVSC	8/04	Grab	Tank 6	NA	10 min	NA	6 L	5 L	12 L[a]
MCUA	8/19	Pooled	Pump Tap	NA	5.5 h	0.5 h	6 L	5 L	None
BCUA	8/12	Pooled	Pump Tap	0	5.5 h	0.5 h	6 L	5 L	None
LRSA	8/08	Pooled	Pump Tap	0	3.3 h	0.5 h	6 L	5 L	None
RVSA	8/08	Grab	Pump Tap	5 min[b]	10 min	NA	6 L	5 L	None
JMEUC	8/19	Grab	Outside Tap	2 h	10 min	NA	6 L	5 L	None
NYCDEP	8/02	SJ[c]	Barge	Completed	45 min	NA	6 L	5 L	None
NCDPW	8/02	Pooled	Outside Tap	5 min	1.75 h	0.25 h	6 L	5 L	12 L[a]
WCDEF	8/01	Pooled	Pump Tap	2.5 h	1.5	0.33 h	6 L	5 L	None

PVSC = Passaic Valley Sewerage Commissioners.

MCUA = Middlesex County Utilities Authority.

BCUA = Bergen County Utilities Authority.

LRSA = Linden-Roselle Sewerage Authority.

RVSA = Rahway Valley Sewerage Authority.

JMEUC = Joint Meeting of Essex and Union Counties.

NYCDEP = Composite of the New York City Department of Environmental Protection facilities.

NCDPW = Nassau County Department of Public Works.

WCDEF = Westchester County Department of Environmental Facilities.

NA = Not available.

[a]Grab sample only.

[b]Combined pumping with LRSA sludge prevented initiating sampling earlier.

[c]Pooled samples using a "Sludge Judge" (SJ); one SJ from each of 10 barge compartments.

2.2 QUALITY CONTROL REQUIREMENTS

Because the data generated in this study will be used to establish the sludge dumping rates that will be included in permits for disposal of sewage sludge at the 106-Mile Site, extensive quality control and quality assurance were required for the analysis. Data quality requirements for the chemical and physical characteristics analysis and toxicity testing are listed in Table 4. Quality control requirements included processing of sample equipment blanks, procedural blanks, matrix spike recoveries, and analysis of sample replicates for all chemical parameters. Quality control for the toxicity tests included processing of samples in duplicate at each level of sludge dilution for each test species, conducting control tests with each test species in the seawater used to dilute the sludge, and testing of each species with a reference toxicant.

The quality assurance documentation and the quality control results are included in Appendix A to F. In general, quality control objectives were met for all analyses. All data were audited at the originating laboratory to ensure traceability and completeness.

2.3 ANALYTICAL PROCEDURES

2.3.1 Organic Compounds

Each sludge sample was extracted and analyzed using the EPA approved methods (EPA, 1986) listed in Table 5. The target list of compounds is presented in Table 6. No analyses for volatile organic priority pollutants were conducted.

An aliquot of each whole sludge sample (10 mL) was Soxhlet-extracted for nonvolatile and semivolatile organic compounds using Method 3540 (EPA, 1986). Originally it was intended that 500-mL samples be extracted in a separatory funnel. However, the consistency of the sludge necessitated use of the Soxhlet extraction of Method 3540. After the extractions were completed, the sample extracts were put through gel-permeation cleanup (Method 3640) to remove lipids, polymers, and other potentially interfering materials. After cleanup the sample extracts were

TABLE 4. DATA QUALITY REQUIREMENTS FOR ANALYSIS OF NEW YORK-NEW JERSEY SEWAGE SLUDGE SAMPLES.

Parameter	Units	Detection Limit	Precision[a] ± %	Accuracy[b] % of actual	Volume (mL)
Cu	µg/L	20	15	90 - 110	100[c]
Pb	µg/L	1	15	90 - 110	100[c]
Hg	µg/L	0.2	15	90 - 110	100
Cd	µg/L	10	15	90 - 110	100[c]
Pesticides	µg/L	0.05	25	48 - 136	500[c]
PCB	µg/L	0.5	25	30 - 125	500[c]
Acid fraction	µg/L	10	25	33 - 128[d]	500[c]
Base neutrals	µg/L	10	25	33 - 128[d]	500[c]
Phenols	µg/L	10	25	15 - 103	500[c]
Residual					
Filterable	mg/L	10	10	90 - 100	100
Total	mg/L	10	10	90 - 110	100
Settleable matter	mL/L	10	10	90 - 100	1000
Specific gravity	Unitless	0.001	10	90 - 110	100
Wet/Dry weight	Unitless	NA	10	90 - 110	100
Solids density	g/mL	NA	10	90 - 110	100
Toxicity tests	% Whole Sludge	NA	25	90% survival[e] of control	4000

NA = Not appropriate.

[a]Precision as the percent relative deviation of duplicate sample analysis.

[b]Accuracy as the percent recovery of surrogate or matrix spike of samples.

[c]A single sample may be used for these analyses.

[d]Range may vary depending on the specific analyte.

[e]80% for Acartia sp. tests.

TABLE 5. ANALYTICAL METHODS USED TO DETERMINE THE CHEMICAL AND PHYSICAL CHARACTERISITICS OF SEWAGE SLUDGE FROM THE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES APPLYING FOR PERMITS TO DISPOSE SEWAGE SLUDGE AT THE 106-MILE SITE.

Parameter	Method	Source
Metal digestion	3010	A
Metal analysis		
Cu	6010	A
Pb	6010 and 7420	A
Cd	6010	A
Hg	7470	A
Organic extraction	3540	A
Cleanup	3640	A
Analysis		
Pesticides	8080	A
PCB	8080	A
Base neutrals	8270	A
Acid fraction	8270	A
Acid base partitioning	3650	A
Phenols	8040	A
Other characteristics		
Residual, Non-filterable[a]	160.2	B
Residue, Total	160.3	B
Settleable solids	209E	C
Wet to dry weight ratio	NA	D
Sludge solids density	Density bottle method	E
Specific gravity	213E	C

A EPA, 1986. Test Methods for Evaluating Solid Waste. SW-846, 3rd Edition.

B EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA600/4-79-020.

C APHA, 1985. Standard Methods For the examination of Water and Wastewater, 16th Edition, American Public Health Association, Washington DC.

D Results come from residual, total determination.

E Head. 1980. Manual of Soil Laboratory Testing. Vol. 1. "Soil Classification and Compaction Tests." Pentech Press. Plymouth, England. 125-127.

[a]This measure is equivalent to the total suspended solids content of the sludge.

TABLE 6. TARGET COMPOUNDS FOR PRIORITY POLLUTANT ANALYSIS. SEMIVOLATILE ORGANIC COMPOUNDS BY METHOD 8270, PCBS/PESTICIDES BY METHOD 8080, PHENOLS BY METHOD 8040.

SEMIVOLATILE ORGANIC COMPOUNDS
Phenol
Bis(2-Chloroethyl)ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl alcohol
1,2-Dichlorobenzene
2-Methylphenol
Bis(2-chloroisopropyl)ether
4-Methylphenol
N-Nitroso-Di-N-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic acid
Bis(2-chloroethoxy)methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethyl phthalate
Acenaphthylene
3-Nitroaniline
Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl phenyl ether
Fluorene
4-Nitroaniline

TABLE 6. (Continued)

4,6-Dinitro-2-methylphenol
N-Nitrosodiphenylamine
4-Bromophenyl phenyl ether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-n-butylphthalate
Fluoranthene
Pyrene
Butyl benzyl phthalate
3,3'-Dichlorobenzidine
Benzo(a)anthracene
Bis(2-ethylhexyl)phthalate
Chrysene
Di-n-octyl phthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenzi(a,h)anthracene
Benzo(g,h,i)perylene
PCB/PESTICIDES
Aldrin
alpha-BHC
beta-BHC
delta-BHC
gamma-BHC (Lindane)
Chlordane
4,4'-DDD
4,4'-DDE
4,4'-DDT
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan Sulfate
Endrin
Endrin aldehyde
Heptachlor
Heptachlor epoxide
Methoxychlor
Toxaphene
PCB-1016
PCB-1221
PCB-1231
PCB-1242
PCB-1248
PCB-1254
PCB-1260

TABLE 6. (Continued)

PHENOLS

Phenol
2-Chlorophenol
2-Nitrophenol
2,4-Dimethylphenol
2,4-Dichlorophenol
4-Chloro-3-methylphenol
2,4,6-Trichlorophenol
2,4-Dinitrophenol
4-Nitrophenol
2-Methyl-4,6-dinitrophenol
Pentachlorophenol

split: analyses for semivolatile compounds were conducted by gas chromatography/mass spectrography (GC/MS) (Method 8270); organochlorine pesticides and PCBs were determined by GC (Method 8080). Even though the Soxhlet extraction reduced the amount of sludge extracted from that originally planned, the resulting extracts still required additional dilution before they could be analyzed by GC or GC/MS methods.

Phenols were determined on separate sample aliquots. Samples were extracted by the Soxhlet method (Method 3540) and the extract cleaned according to the acid-base partitioning technique (Method 3650). Phenolic compounds were determined by gas chromatography (GC) (Method 8040) using flame ionization detection (FID).

Triplicate aliquots were extracted and analyzed for the PVSC and Bergen County Utilities Authority (BCUA). A matrix spike and matrix spike duplicate were extracted for the PVSC sample. Sludge from all other authorities, except for Westchester County Department of Environmental Facilities (WCDEF) and NCDPW, was extracted in duplicate for analysis of semivolatile compounds. Duplicate extractions for phenol analysis were conducted on samples from the latter two authorities.

All initial extractions were completed within required holding times except for samples from LRSA and RVSA. Completion of extraction for these samples exceeded the holding times for pesticides and PCB by 4 days due to an error in the surrogate spike added during the initial extractions. The error required extraction of new sample aliquots.

The lower limit of detection (LLD) achieved in the laboratory was approximately twice that listed in Table 4 for the semivolatile compounds and pesticides (See Tables A-1, B-1, in Appendices A, and B). The LLD for the phenols varied with each compound and ranged from 4 to 112 times higher than targeted LLD (Table C-1 Appendix C). The higher-than-required detection limits for sludge samples result from a combination of matrix effects and dilution of extracts by two- to fivefold prior to analysis. The practical quantification limit (PQLs) for the whole sludge matrix were ≈25 times higher than the LLD for all organic compounds (Tables A-1, B-1, and C-1). The reported PQL is at least 10 times lower than required in the work/quality assurance project plan (EPA , 1988b). Analysis of method blanks did not

detect any contribution of compounds of interest to the results from the analytical procedures or the sample collection equipment.

Generally, surrogate spike recoveries added prior to the GC/MS analysis were within the required recovery windows for the analytical methods. Appendix A discusses the quality control results for the surrogate spikes. Recoveries of the surrogate (dibutyl chlorendate) used for the PCB/pesticide analysis varied between samples (Table B-3, Appendix B) but were within acceptable limits of the analytical method. Surrogate recoveries for phenols (Method 8040) were within acceptable ranges (Table C-3, Appendix C).

Recoveries of compounds spiked into the sludge matrix (matrix spike and matrix spike duplicates) were generally within the limits specified in the work/quality assurance project plan for the semivolatile organic compounds, PCBs, pesticides, and phenols (Appendix Tables A-4, B-4, and C-4). High recoveries were found for acenaphthene in the matrix spike (MS) and pentachlorophenol in the matrix spike duplicate (MSD) for this sample, whereas low recoveries were obtained for phenol, 4-nitrophenol, and 2,4-dinitrotoluene. Pesticide/PCB determinations found good matrix spike recoveries that were well within the required recovery limits. Only aldrin exceeded the recommended acceptance criteria for matrix spike compounds. The matrix spike recoveries exhibited for phenols show erratic recoveries for 4-nitrophenol and pentachlorophenol. Recovery for the one of the surrogate compounds (2,4,6,-tribromophenol) added to the two matrix spike samples was also low, possibly contributing to the observed low and variable recoveries. The matrix spike recoveries of phenol compounds may also reflect the relatively low sample concentrations.

With few exceptions, precision for the semivolatile, PCB, and pesticide analyses was well within requirements specified for the analytical methods. For most compounds the relative percent difference (RPD) was less than 10 percent and frequently less than 5 percent. The precision of the phenol analysis was not as good, with RPDs ranging from 5 to 155 percent.

The quality control data for the organic analysis indicate that, with few exceptions, the results are within the acceptance limits for equipment and procedural blanks, matrix spike recoveries, and analytical precision. Thus, the organic data is considered to be reliable and

representative of the sludge characteristics at the time the samples were collected.

2.3.2 Metals

Methods used to determine the metal concentrations in the sludges are listed in Table 5. All digestions were initiated within the required holding times for analysis of metals. Sludge samples were digested using Method 3010 (EPA, 1986). This method deviated from that listed in the work/quality assurance project plan. Method 3010 was substituted for Method 3050 because Method 3050 is more appropriate for solid matrices. Analytical results were not affected by this change. Cadmium, copper, and lead concentrations in the digests were determined using inductively coupled plasma (ICP) analysis. Lead concentrations in the sludges were also determined by flame atomic absorption (Method 7420). Even though lead concentrations were sufficiently high for quantification by ICP, flame AAS analyses were performed because significant matrix interference problems can be experienced during lead analysis by ICP. Therefore, the digests were reanalyzed to determine if matrix interferences were present. Comparison of the results from the FAAS analysis and ICP analysis (Table D-4, Appendix D) show that agreement between the two methods was within 20 percent as the relative percent difference. This difference was applicable over a broad range of lead concentrations. Thus, the ICP results were determined to be acceptable and are reported for the sludges. Mercury was determined using cold vapor atomic absorption spectroscopy (CVAAS).

Quality control measures for the analysis of metals included procedural (method) blanks, triplicate digestion and analysis of samples from PVSC and BCUA, and analysis of matrix spike duplicates on samples from these two authorities. Quality control data are summarized in Appendix D.

Detection limits achieved for cadmium and mercury were lower than listed in Table 4, whereas those for lead and copper were higher (Table D-1, Appendix D). The higher-than-targeted LLD for lead and copper were caused by dilutions required to bring sample concentrations within the measurement limits of the instrumentation. These higher than required detection limits

did not affect the final results because metal concentrations in all sludges were several orders of magnitude greater than the required detection limit.

Four method blanks were run with the samples. With the exception of mercury in the fourth blank, concentrations of all metals in all blanks were below the LLD. Matrix spike recoveries for metals added to samples were consistent between the duplicate spiked samples. Metal recoveries were within the required limits for the BCUA sample (Appendix D, Table D-3) but were slightly outside of the required limits for the samples from PVSC. Sludge from PVSC is unique to this set of sewerage authorities in that it undergoes a high temperature and pressure process. Because of this uniqueness, recovery of metals spiked into this sludge may be affected. Further characterization of sludge from this authority may be necessary to determine the appropriate digestion methods for complete recovery of metals from this sludge. Finally, the precision of the metals analysis was well within the limits defined in the work/quality assurance project plan (Appendix D, Table D-3).

The quality control data for the analysis of metals indicate the metal concentrations reported for these sludges were reliable and representative of the nature of the sludge at the time of sampling.

2.3.3 Physical Properties

Physical property measurements (total residue, non-filterable residue, settleable matter, specific gravity, and sludge solids density) were conducted using the methods listed in Table 5. A method for determining the density of the sludge solids was not identified in the work plan. Review of available methods determined that the density bottle method (Head, 1980) was appropriate to determine this parameter and was applied to each of the sludges. The method specified in the work/quality assurance project plan (Imhof Cone procedure, Method 160.5) for determining settleable solids was replaced by Standard Method 209 E, 3b (ASTM, 1985) because the optical density of the sludges prevented observation of any settling in the Imhof cone. Also, the method specified in the work plan for determining the solids content of the sludge was changed from Method 160.1 to 160.2 after samples were received at the analytical laboratory because Method 160.2 was

determined to be the more appropriate test for determining the solids content of the sludge. Terminology used to describe these tests in the EPA methods manual (EPA, 1986) was found to be misleading and inconsistent with the manner in which sludges solids (total suspended solids) content is generally reported. The terminology contributed to difficulties in identifying the proper tests to measure the solids content of the sludges.

The only other modification of physical property determinations involved the reduction of sample volumes for non-filterable residue from 100 mL to, for certain samples, as low as 1 mL because of blockage of the filters. Finally, physical property characteristics were determined from triplicate measurement of each parameter on each sludge sample.

2.4 TOXICITY TESTS

2.4.1 Test Procedures

The toxicity of the sludges was determined with two representative marine species, Menidia beryllina (fish) and Mysidopsis bahia (mysid). Tests were conducted using 96-h acute toxicity tests. Tests using the marine zooplankton species Acartia sp. (copepod) were not successfully completed (see Section 2.4.2). The methods for testing the toxicity of the sludge to the fish and mysid were adapted from "Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms," (EPA, 1985). Each toxicity test was conducted on whole sludge. The upper limit for the sludge dilution was determined using a 24-h screening test for both the mysid and fish. Sludge dilutions used for the screening tests were based on data included in the permit applications submitted to EPA by each authority tested. Sludge dilutions for these tests were between 0.6 and 10 percent whole sludge and depended on the origin of the sludge being tested.

Toxicity test conditions and any changes in protocols from the work/quality assurance plan are summarized below. Complete details of each test series are included in Appendix F. Test organisms were purchased from commercial suppliers and received at the analytical laboratory within 1 to 2 days of testing, except for one test series (repeat tests for WCDEF and LRSA and original tests for MCUA and JMEUC) where mysids from a Battelle

Ocean Sciences culture were used. All organisms were acclimated to the prescribed test conditions for 24 h (mysid) or 48 h (fish) prior to testing. In some cases, extreme hot weather affected the shipping conditions and thus the requirements for acclimation of the test organisms. The sequence in which sludge samples arrived at the laboratory also caused delays in initiating testing of several sludges. As a result, prescribed holding times for initiating tests were slightly exceeded for some sludge samples (Table 7).

Each toxicity test consisted of exposure to five sludge dilutions, with the least dilute treatment (highest concentration of sludge) based on the results of the screening test. Each dilution series was conducted in duplicate. Sludge dilutions were performed using filtered (20 μm) natural seawater collected from Duxbury Harbor, Massachusetts prior to the tests. Sludge from two or three authorities was tested simultaneously depending on the sequence of arrival and number of retests required. A control treatment consisting of Duxbury Bay dilution water was included with each sludge sample and test organism. This test was used to verify the health of the test animals and determine the acceptability of the testing conditions. Control vessels were treated identically to all other test treatments. In addition, a reference toxicant was concurrently tested for each species in the test array. Initially it was planned to aerate the test series only if dissolved oxygen fell below 40 percent of saturation. However, loss of oxygen observed during the first test series indicated that aeration was necessary. Aeration was started 24 h after test start-up for the first test series. All subsequent tests were conducted using aeration throughout the test.

Each test was examined every 24 h for water quality parameters and to determine mortality. Water quality parameters (temperature, salinity, pH, and dissolved oxygen) in each test series were determined on representative treatments. Mortality checks were conducted on each test chamber as follows. If no viable animals were observed in a treatment, the test solution was decanted and checked for live animals. No live animals were found when this procedure was followed. Due to the amount and color of the sludge material, final counts of surviving animals could only be obtained at the termination of the test. This procedure did not affect the final determination of the LC50.

TABLE 7. SUMMARY OF DATES FOR TOXICITY TESTS CONDUCTED ON SEWAGE SLUDGES COLLECTED FROM THE NINE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES IN AUGUST 1988.

Authority[a]	Date Sampled	Test Type	Date Successful Test Started	Days from Collection	# of Retests
PVSC	8/04	Mysidopsis	8/05	1	0
		Menidia	8/05	1	0
MCUA	8/19	Mysidopsis	8/23	4	0
		Menidia	8/23	4	0
BCUA	8/12	Mysidopsis	8/18	6	0
		Menidia	8/18	6	0
LRSA	8/08	Mysidopsis	8/23	15	2
		Menidia	8/11	3	0
RVSA	8/08	Mysidopsis	8/18	10	1
		Menidia	8/11	3	0
JMEUC	9/19	Mysidopsis	8/23	4	0
		Menidia	8/23	4	0
NYCDEP	8/16	Mysidopsis	8/18	2	0
		Menidia	8/18	2	0
NCDPW	8/02	Mysidopsis	8/4	2	0
		Menidia	8/4	2	0
WCDEF	8/01	Mysidopsis	8/23	22	1
		Menidia	8/04	3	0

[a]Abbreviations are defined in Table 3.

The timing of sample receipt and the delays discussed above also affected the age of the fish used in two tests (MCUA and JMEUC). For these tests, animals between 28 and 36 days old were employed rather than animals whose age was between 14 and 28 days as required in the work/quality assurance project plan. Use of these older animals had no effect on the toxicity test results because the results for the controls with older animals and also the reference test LC50 were found to be the same as those found for younger animals.

For several tests, the criterion for acceptance of the test results (>90 percent survival of the control animals) was exceeded, requiring retesting of the sample. These samples were retested within a week of completion of the unsuccessful test. The retesting caused holding times of the sludge samples to be exceeded for completion of those tests. Examination of data from all samples that were retested for mysid toxicity (Linden-Roselle twice; Westchester County and Rahway 1 time each) indicate that the LC50 for the retested samples was within 15 to 40 percent of that LC50 obtained for the unaccepted tests. There also was a trend of increasing toxicity with each subsequent test.

The LC50 for each sludge and test species was determined using the trimmed Spearman-Karver method. When control mortalities were observed the Abbots correction was applied. The toxicity of the sludge is reported in terms of percent whole sludge.

2.4.2 Acartia sp. Tests

The method for the Acartia sp. (copepod) test was adapted from EPA (1987). Tests were conducted as follows. Acartia were received from a commercial supplier. Acclimation was completed under the conditions described in the method and within the prescribed 48-h acclimation period, however, increments used to adjust salinity were larger than specified. Thus, these animals may have experienced excessive stress prior to testing. After acclimation, a 15-mL sample of sludge from each dilution level was added to each of five 20-mL glass scintillation vials. Two animals were then added to each test vial and a cover loosely placed on the vial. The zooplankton tests were aerated using an orbital shaker rather than bubble

aeration to avoid damage to the animals (personal communication, Don Miller, U.S. EPA Environmental Research Laboratory, Narragansett, RI, July 28, 1988). Water quality measurements were conducted at the beginning and end of the test sequence.

Successful tests results were not obtained for the first series of sludge samples tested. Because 100 percent mortality was observed in all treatments, including the controls and reference toxicant, tests were suspended after the first set of samples.

After this test, several attempts were made to obtain a zooplankton culture with which to continue the toxicity testing. Additional animals were purchased from commercial suppliers and animals were also collected from Duxbury Bay. These animals were carefully cultured, but could not be maintained for longer than 2 weeks. Recommendations from scientists (Dr. Ann Durbin, University of Rhode Island, August 17, 1988; Dr. Al Barker, New England Aquarium, August 16, 1988; Mr. Tim Word, ENSCO, Marblehead, Ma., August 18, 1988) who have or are actively culturing Acartia sp. indicated that cultures should remain viable for 30 days prior to testing to ensure that the animals could survive in the toxicity tests. Because cultures could not be maintained for this time period, no zooplankton tests could be conducted. Additional options pursued for the zooplankton testing included using indigenous zooplankton species collected from the vicinity of the 106-Mile Site in mid-September 1988. However, these animals also did not survive sufficiently long for determining the toxicity of the sludges. In addition, the sludge holding times had been exceeded by at least 3 weeks by the time these animals became available.

There are currently no options that will allow completion of zooplankton toxicity tests within the time frame of the permitting process for the 106-Mile Site on the sludge samples collected in August 1988. The experience with the Acartia tests clearly indicates that toxicity testing with this organism is difficult and not in the realm of "routine" toxicity testing. Future "routine" testing with Acartia sp. and related species must carefully consider the requirements and objectives of the testing from several perspectives including regulatory requirements, practicality of the tests, use of the LC50 data, and time and costs involved in ensuring successful completion of the tests.

3.0 RESULTS

3.1 ANALYTICAL RESULTS

3.1.1 Organic Compounds

Organics compound results were characterized by the absence of detectable PCB and pesticides in the sludges (Table 8). Because quantitative results were not available, the amount of dilution required to meet WQC for specific compounds at the 106-Mile Site cannot be calculated. However, an upper limit can be determined based on the PQL listed in Appendix B, Table 1. Dilutions on the order of 6,000 to 25,000 would ensure WQC are met, if the pesticides or PCB were at the PQL in the sludge. Lower concentrations would require lower dilutions. The upper limit for the required dilution of these organic contaminants is within the range determined for the metals. Thus, dilution of the metals to acceptable WQC will ensure that these organic compounds are also diluted to acceptable levels.

Only 11 of the 63 target semivolatile organic compounds were identified in the sewage sludges (Table 9). For the majority of the authorities sampled, only one or two semivolatile compounds were found at concentrations that could be quantified using standard EPA methods. Sludge from MCUA, PVSC, LRSA, and RVSA contained six to seven identifiable semivolatile compounds. The concentrations of these compounds were highly variable between the authorities when a common organic contaminant was identified in each authority's sludge. Most of the compounds identified (the phthalates) are common contaminants and are of low concern in the environment.

A total of four phenols were identified in the sludges (Table 10). Two of these were found in the MCUA sample. One, pentachlorophenol, is highly toxic and may be of concern environmentally. The acute marine WQC for this compound is 13 $\mu g/L$, which requires a initial dilution of only 1,100 for the MCUA sludge to meet WQC upon disposal.

The absence of measurable amounts of environmentally significant organic priority pollutant compounds is consistent with information

TABLE 8. SUMMARY OF RESULTS FOR PCB/PESTICIDE CONCENTRATIONS (METHOD 8080) FOUND IN SEWAGE SLUDGE FROM THE NINE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES SAMPLED IN AUGUST 1988.

Authority[a]	Concentration (μg/L)	
	PCBs	Pesticides
WCDEF	ND	ND
NCDPW	ND	ND
MCUA	ND	ND
PVSC (Rep 1)	ND	ND
PVSC (Rep 2)	ND	ND
PVSC (Rep 3)	ND	ND
LRSA	ND	ND
RVSA	ND	ND
NYCDEP	ND	ND
JMEUC	ND	ND
BCUA (Rep 1)	ND	ND
BCUA (Rep 2)	ND	ND
BCUA (Rep 3)	ND	ND

ND = Not detected at the Reporting Limit listed in Table B-1 in Appendix B.

[a]Abbreviations are defined in Table 3.

TABLE 9. CONCENTRATIONS OF SEMI-VOLITILE ORGANIC PRIORITY POLLUTANT COMPOUNDS (µg/L) IDENTIFIED IN WHOLE SEWAGE SLUDGE FROM THE NINE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES SAMPLED IN AUGUST 1988.

Compound	Sewerage Authority[a]								
	WCDEF	NCDPW	MCUA[b]	PVSC[b]	LRSA[b]	RUSA[b]	NYCDEP[b]	JMEUC[b]	BUCA[b]
Phenol	520		502(5.2)	6,200(16)	1,830(2.5)	1,790(5.9)			
Benzyl alcohol			503(6.6)	3,000(53)					
1,2-Dichlorobenzene				1,900(86)	13,500(6.7)	11,200(4.5)			
4-Methylphenol			3,600(4.3)		47,600(20)	55,600(11)	1,470(10)		
2,4-Dimethylphenol					626(12)	641(11)			
1,2,4-Trichlorobenzene				660(8.0)					
2-Methylnaphthalene				560(8.6)					
Diethylphthalate		650							
Di-n-butylphthalate			529(77)	1,400(52)	6,260(48)				
Bis(2-ethylhexyl)phthalate	3,420	3,500	50,900(8.3)	2,700(18)	56,400(21)	44,200(60)	7,110(62)	10,500(2.9)	2,980(26)
Di-n-octylphthalate						14,100(80)			

[a]Abbreviations are defined in Table 3.

[b]Mean of duplicate analysis. Percent relative deviation in parentheses.

TABLE 10. RESULTS OF DUPLICATE ANALYSIS OF PHENOLS (µg/L) IN WHOLE SEWAGE SLUDGE SAMPLES FROM THE NINE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES SAMPLED IN AUGUST 1988.

Compound	Sewerage Authority[a]								
	WCDEF	NCDPW	MCUC	PVSC	LRSA	RVSA	NYCDEP	JMEUC	BCUA
Phenol	ND	ND	ND	6,700	ND	ND	ND	ND	ND
2-Chlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Nitrophenol	ND	ND	16,000	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Chloro-3-methylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,6-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dinitrophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Nitrophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyl-4,6-dinitrophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	15,000	ND	1,100	ND	ND	ND	ND

ND = Not detectable above the reporting limits shown in Appendix C, Table C-1.

[a]Abbreviations are defined in Table 3.

included in the permit applications. Generally, dilution of the sludge on disposal will decrease organic compound concentrations to levels that are below any marine water quality criteria, as observed to date on the surveys of the 106-Mile Site (EPA , 1992c). Determination of the concentrations of specific compounds in the sludges at lower detection limits will probably require application of more sophisticated extract cleanup steps than provided in the EPA methods (EPA, 1986) used for this characterization.

3.1.2 Metals

Of the four metals determined in the sludge, copper consistently (8 of the 9 authorities sampled) had the highest concentration (Table 11). Pb was highest in the ninth plant (PVSC). Hg and Cd concentrations were present in the lowest concentration in the sludges. Cd, Cu, Hg, and Pb concentrations in the sludges displayed large differences among the various plants sampled. Cu showed the least variability among the plants. The difference between the authority with the highest Cu concentration and the one having the lowest concentration is only a factor of 6.6. The concentration range for the other metals varied by at least a factor 20, with Cd showing the greatest differences among the authorities tested.

Hg concentrations were consistent among the authorities tested (concentration range less than a factor of 4) except for the sludge from BCUA, which had a Hg concentration of 2 mg/L. This concentration was higher than found for the other plants by at least a factor of 6. Repeated analysis of the sludge from the sample bottle used for the initial analysis and also from the other sample containers gave the same result. Thus, the high Hg level was not the result of laboratory contamination nor the sampling procedure. Because this Hg concentration was anomalous relative to concentrations in sludge from the other authorities and to concentrations reported previously by BCUA, repeated sampling of this plant is recommended to confirm that the high result is representative of this sludge.

With few exceptions, metal concentrations in August 1988 were lower than the mean concentration calculated from recent data (permit application process, monthly reports or quarterly reports) submitted to EPA since 1986 (Table 12). The deviation from the mean depends upon the metal

TABLE 11. WHOLE SLUDGE METAL CHARACTERIZATION RESULTS FROM THE NINE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES APPLYING FOR PERMITS TO DISCHARGE SEWAGE SLUDGE AT THE 106-MILE SITE. SAMPLES WERE COLLECTED IN AUGUST 1988.

Authority[a]	Metal (mg/L whole sludge)				Required Dilution[b]	Metal
	Cd	Cu	Pb	Hg		
PVSC[c]	1.20	42.0	53.0	0.29	14,500	Cu
MCUA	1.90	68.0	6.3	0.07	23,450	Cu
BCUA[c]	1.50	25.0	4.0	2.00[d]	80,000	Hg
LRSA	0.59	80.0	10.0	0.31	27,590	Cu
RVSA	0.08	16.0	2.6	0.23	5,520	Cu
JMEUC	0.67	36	9.1	0.17	12,410	Cu
NYCDEP	0.20	38.0	13.0	0.17	13,100	Cu
NCDPW	0.14	12.0	3.9	0.13	4,140	Cu
WCDEF	0.19	56.0	9.2	0.11	19,310	Cu

[a]Abbreviations are defined in Table 3.

[b]Dilution based on the metal requiring the greatest amount of dilution to meet water quality.

[c]Mean of triplicate analyses reported.

[d]Sample analyzed several times with the same result obtained.

TABLE 12. COMPARISON OF AUGUST 1988 WHOLE SLUDGE METAL CONCENTRATIONS (mg/L WHOLE SLUDGE) TO THE MEAN CONCENTRATIONS DERIVED FROM DATA SUBMITTED IN THE PERMIT APPLICATIONS, MONTHLY, AND QUARTERLY MONITORING REPORTS. THE COEFFICIENT OF VARIATION (%) IS INCLUDED IN PARENTHESIS.

	Cd		Cu		Pb		Hg	
Authority[a]	1988	MEAN	1988	MEAN	1988	MEAN	1988	MEAN
PVSC	1.20	4.40(b)	42.0	57(b)	53.0	187(b)	0.29	0.45(b)
MCUC	1.90	2.95(48)	68.0	92(45)	6.3	17.8(121)	0.07	0.18(394)
BCUA	1.50	2.18(100)	25.0	42(100)	4.0	4.1(85)	2.00	0.13(131)
LRSA	0.59	NA	80.0	NA	10.0	NA	0.31	NA
RVSA	0.08	NA	16.0	NA	2.6	NA	0.23	NA
JMEUC	0.67	2.12(42)	36.0	77(54)	9.1	26.3(90)	0.17[d]	0.17(35)
NYCDEP	0.20	0.16 to 8.5(c)	38.0	33 to 103(c)	13.0	2.3 to 113(c)	0.17	0.04 to 0.37(c)
NCDPW	0.14	0.30(b)	12.0	84(b)	3.9	8.6(b)	0.13	0.04(b)
WCDEF	0.19	0.61(89)	56.0	94(73)	9.2	17.4(165)	0.11	0.14(71)

NA = Not available.

[a] Abbreviations are defined in Table 3.

[b] Single analysis available.

[c] Range reported for 14 NYC treatment plants.

[d] Range reported for 13 NYC treatment plants, results from one plant not included due to extreme variability in results (219 % as the CV).

and the authority. For Cd, the August 1988 concentrations were from 1.5 to 3 times less than the mean of the available data, and Pb was 2 to 3 times lower. Hg closely matched the mean concentrations but Cu varied within a factor of 0.1 to 5 of the mean. Only Hg in the BCUA sludge was higher than the average concentration and was well outside of the 95th percentile (0.41 mg/L) for this authority. This result suggests that the Hg value in August 1988 may have been unique to this sample set.

A single mean concentration for all NYCDEP plants was not derived for comparison due to uncertainties in the amount of sludge contributed by each plant to the barge sampled in August 1988. For comparison, the range in mean metal concentrations for all NYCDEP plants is included in Table 12. Generally, the metal concentrations in the barge sampled August 1988 fell near the lower end of the range and were consistent with the concentrations found for most of the NYCDEP treatment plants.

Calculation of the amount of sludge dilution that will be required for each of the authorities (Table 11) indicated that the dilutions are driven by the copper content of the sludge, except for BCUA, which has its required dilution driven by the Hg content of the sludge. Generally, the August 1988 data indicate that the amount of sludge dilution required to meet WQC at the 106-Mile Site is lower than calculated in EPA (1992d), which used historical data from Santoro and Fikslin (1986). The amount of sludge dilution required at the 106-Mile Site is discussed further in Section 4.0.

3.1.3 Physical Characteristics

The physical characteristics of the nine sludges tested are compiled in Table 13. Only one plant (LRSA) had a fraction of the sludge that settled during the standard settleability test. The settleable fraction was ≈25 percent of the total solids content of the sludge. The concentration of non-filterable solids (equivalent to total suspended solids (TSS)) ranged from 13,100 mg to 83,900 mg/L. This is equivalent to a solids content of 1.3 to 8.4 percent and is within the expected range for these sludges. The solids content of the sludge from six of the nine authorities fell in the

TABLE 13. WHOLE SLUDGE PHYSICAL CHARACTERIZATION RESULTS FROM THE NINE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES APPLYING FOR PERMITS TO DISCHARGE SEWAGE SLUDGE AT THE 106-MILE SITE. SAMPLES WERE COLLECTED IN AUGUST 1988. THE AVERAGE CONCENTRATION AND COEFFICENT OF VARIATION (%) FOR THE TRIPLICATE ANALYSIS OF EACH SLUDGE ARE REPORTED.

Authority[b]	Non-Filterable Residual[a] (mg/L)	Total Residual (mg/L)	Settleable Solids (mg/L)	Specific Gravity (g/cm^3)	Solids Density (g/cm^3)
PVSC	76,500(5.0)	83,700(6.2)	<4(-)	1.030(0.22)	1.62
MCUA	27,800(17)	41,100(1.40	<4(-)	1.013(0.04)	1.59
BCUA	18,500(19)	25,700(1.7)	<4(-)	1.000(0.29)	1.63
LRSA[c]	83,900(13)	61,600(8.9)	21,700(36)	1.013(0.99)	1.61
RVSA	53,300(17)	63,900(7.9)	<4(-)	1.016(0.12)	1.64
JMEUC	19,400(21)	32,200(3.7)	<4(-)	1.003(0.22)	1.59
NYCDEP	20,700(2.0)	26,200(2.0)	<4(-)	1.006(0.08)	1.74
NCDPW	13,100(11)	18,000(3.3)	<4(-)	0.989(0.11)	1.63
WCDEF	22,100(4.4)	21,500(4.4)	<4(-)	1.020(0.22)	1.62

[a]Non-Filterable residue is equivalent to the total suspended solids.

[b]Abbreviations are defined in Table 3.

[c]Sample was heterogeneous and exhibited inconsistent behavior during processing.

range of 13,000 to 30,000 mg/L. The remaining plants had solids concentrations of >50,000 mg/L.

The total residual (solids plus dissolved constituents remaining when the sludge is dried) was 10 to 50 percent higher than the non-filterable residue. The percentage increase in the total residual varied between the plants. The specific gravity of the sludges ranged from 0.989 to 1.030 g/cm^3 with most sludges having a specific gravity of less than 1.016. Sludge from PVSC sewerage treatment facility, which uses the Zimpro method of sludge digestion, had the highest specific gravity, reflecting the high solids content of this sludge. The specific gravity of all sludges except that from PVSC was lower than that of seawater typically found at the 106-Mile Site ($\approx$ 1.024 g/cm^3 at a salinity of 32 o/oo and a temperature of 10°C). Generally, higher the solids content of the sludge corresponds with higher specific gravity. The sludge from WCDEF appears to have a high specific gravity relative to the solids content of the sludge, whereas that from LRSA is low relative to the very high solids content. Sludge from LRSA was also found difficult to work with and exhibited behavior that was not consistent with the other sludges.

The physical characterization data for the August 1988 samples were compared with mean results compiled from recent data (permit application process, monthly reports or quarterly reports) submitted to EPA. The specific gravity of the sludge in August 1988 was higher than the 95th percentile derived from recent data submitted by the sewerage authorities. On average most plants are reporting their sludge to have a specific gravity between 0.99 and 1.03 g/cm^3, with most reporting a specific gravity of 1.00 g/cm^3. Total solids content and non-filterable residual (TSS) were found to be similar to those reported by the authorities and were within 2 standard deviations of the mean of the available concentrations (Table 14).

3.2 TOXICITY

The results of the toxicity testing are summarized in Table 15. LC50 results for Menidia beryllina ranged from 0.49 to 5.95 percent of the whole sludge. For Mysidopsis bahia, the LC50 ranged between 0.06 and 2.25 percent of the whole sludge. Of the two species successfully tested,

TABLE 14. COMPARISON OF TOTAL SUSPENDED SOLIDS CONCENTRATIONS (mg/L) IN SLUDGE COLLECTED IN AUGUST 1988 TO SUSPENDED SOLIDS CONCENTRATIONS INCLUDED IN THE PERMIT APPLICATIONS FROM NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES APPLYING TO DISCHARGE SEWAGE SLUDGE AT THE 106-MILE SITE. THE MEAN CONCENTRATION AND COEFFICENT OF VARIATION (%) FOR THE DATA AVAILABLE FOR EACH AUTHORITY ARE SHOWN.

Authority[a]	August 1988 Non-Filterable Residual[b]	Total Suspended Solids in Recent Data From the Applicants
PVSC	76,500	35,300 to 113,000[c]
MCUA	27,800	32,900(11)
BCUA	18,500	19,000(69)
LRSA	83,900	19,100 to 24,900
RVSA	53,300	22,000 to 44,000
JMEUC	19,400	32,900(21)
NYCDEP	20,700	12,400 to 52,300[d]
NCDPW	13,100	13,150
WCDEF	22,100	24,000(101)

[a]Abbreviations are defined in Table 3.

[b]Non-Filterable residue is equivilent to the total suspended solids.

[c]From permittee applications only.

[d]Range of individual plant means.

TABLE 15. WHOLE SLUDGE TOXICITY RESULTS FROM THE NINE NEW YORK-NEW JERSEY SEWERAGE AUTHORITIES APPLYING FOR PERMITS TO DISCHARGE SEWAGE SLUDGE AT THE 106-MILE SITE. SAMPLES WERE COLLECTED IN AUGUST 1988. THE MAXIMUM TOXICITY BASED SLUDGE DILUTION REQUIRED FOR EACH MUNICIPALITY ARE LISTED.

Authority[a]	LC50 (% whole sludge)		Toxicity Based Required Dilution[b]
	Menidia beryllina	*Mysidopsis bahia*	
PVSC	0.49	0.17	58,800
MCUA	5.95	2.11	4,740
BCUA	1.55	2.10	6,450
LRSA	0.53	0.06	166,700
RVSA	1.49	0.88	11,360
JMEUC	1.92	1.68	5,950
NYCDEP	1.59	2.25	6,290
NCDPW	2.33	0.92	10,870
WCDEFW	0.91	1.17	10,990

[a]Abbreviations are defined in Table 3.

[b]The species with the lowest LC50 and an application factor of 0.01 were used to determine the required dilution.

Mysidopsis was the most sensitive to the sludge from six of the nine authorities characterized. The sludges from Westchester County, NYC, and Bergen County were more toxic to Menidia than to Mysidopsis. No correspondence was found between the ranking (highest to least toxic) of the toxicity of sludge to the two test species. Thus, the toxicity of the sludge to one species cannot be used to indicate the toxicity that will be experienced by other test species.

The LC50s for both Menidia and Mysidopsis were within a factor of 1 to 3 of the results reported in the permit applications (Table 16), except for Mysidopsis in the RVSA sludge. Mysidopsis in the August 1988 sample was 5 times less sensitive than reported in the permit application for this plant. The LC50 for Menidia in sludge from three authorities (MCUA, NYCDEP, JMEUC) was higher (less toxic) in the August 1988 characterization than reported in the permit applications. The other plants had lower Menidia LC50s (more toxic) than reported in the permit applications. These differences were generally within a factor of 1.5 of the value included in the permit application, except for MCUA and LRSA sludges.

The LC50 for Mysidopsis in the August 1988 sampling was higher (less toxic) than reported in the permit applications for four authorities, lower (more toxic) for three authorities, and within 10 percent of the reported results for two authorities. Authorities with higher LC50s were PVSC, RVSA, NYCDEP, BCUA; those with the same LC50s were JMEUC and WCDEF. Differences were generally within a factor of 2 of the permit applications except at LRSA (3 times more toxic) and RVSA (5 times less toxic).

Given that sludge quality (TSS, toxic compound concentration, ammonia, etc.) may vary by 30 to 50 percent due to operational factors in the treatment plants, differences in the toxicity reported in the permit applications and for the August 1988 sampling are not unexpected. Furthermore, small differences (2 to 3 times) in toxicity observed from those found in August 1988 should be expected in future tests. Therefore, until a more complete time series of sludge toxicity is available, no specific meaning should be attached to the observed differences.

TABLE 16. COMPARISON OF AUGUST 1988 WHOLE SLUDGE TOXICITIES TO THOSE REPORTED IN THE PERMIT APPLICATIONS. LC50 RESULTS ARE REPORTED AS THE PERCENTAGE OF THE WHOLE SLUDGE.

Authority[a]	*Menidia beryllina*		*Mysidopsis bahia*	
	August 1988	Permit Application	August 1988	Permit Application
PVSC	0.49	0.63	0.17	0.09
MCUA	5.95	1.95	2.11	2.80
BCUA	1.55	1.95	2.10	0.66
LRSA	0.53	0.96	0.06	0.20
RVSA	1.49	1.60	0.88	0.11
JMEUC	1.92	1.35	1.68	1.50
NYCDEP	1.59	1.30	2.25	1.41
NCDPW	2.33	2.87	0.92	1.40
WCDEFW	0.91	1.47	1.17	1.16

[a]Abbreviations are defined in Table 3.

4.0 REQUIRED SLUDGE DILUTIONS

For each sewerage authority, the maximum dilution required to meet WQC for metals (Table 11) or the toxicity based limiting permissible concentration of sludge (Table 15) was calculated. For each authority, the results of these two dilution calculations were compared to determine the maximum dilution that be will required in order to set sludge disposal rates. This maximum required dilution is listed in Table 17 along with the parameter dictating the dilution.

The required dilution that was determined in EPA , (1992d) is also listed in Table 17 for comparison. For six of the nine authorities, the maximum required dilution decreased from the required dilution determined from historical data (EPA , 1992d). For these authorities, the dumping rate can be expected to increase. However, for most of these authorities the increase will be no more than a factor 2 or 3. For two authorities (LRSA and BCUA), the required dilution increased as a result of the August 1988 characterization study thus dumping rates will decrease from those calculated in EPA (1992d). No change in the dilution required to meet water quality criteria was found for MCUA. The largest impact from the newly determined required dilutions will be realized by NYCDEP (8-fold decrease), WCDEF (4-fold decrease), and LRSA (4-fold increase).

5.0 DISCUSSION

One objective of this sludge characterization was to evaluate the representativeness and accuracy of the sludge characteristics data submitted to EPA by the New York and New Jersey municipal sewerage treatment authorities in their applications to dispose sludge at the 106-Mile Site. The second objective was to use the most recent sludge data to establish the amount of sludge dilution required to meet water quality criteria 4 h after disposal. This required dilution is one of the primary coefficients used to establish dumping rates (EPA , 1992d). These results are to be used to determine sludge dumping rates that will be included in any permits issued for sludge disposal at the 106-Mile Site.

TABLE 17. DILUTIONS REQUIRED TO MEET WATER QUALITY CRITERIA OR LIMITING PERMISSIBLE CONCENTRATIONS FOR WHOLE SLUDGE AT THE 106-MILE SITE. RESULTS ARE BASED ON THE SLUDGE CHARACTERIZATION RESULTS FROM SAMPLES COLLECTED IN AUGUST 1988 FROM THE NINE MUNICIPALITIES APPLYING FOR PERMITS TO DISCHARGE SEWAGE SLUDGE AT THE 106-MILE SITE.

Authority[a]	Required Dilution[b]	Test	Dilution in Battelle (1988d)
PVSC	58,500	Mysdopsis bahia	100,000
MCUA	23,450	Cu	21,100
BCUA	80,000	Hg[c]	58,800
LRSA	166,700	Mysdopsis bahia	50,000
RVSA	11,360	Mysdopsis bahia	91,000
JMEUC	12,410	Cu	20,000
NYCDEP	13,100	Cu	107,600
NCDPW	10,870	Mysdopsis bahia	28,830
WCDEF	19,310	Cu	69,700

aAbbreviations are defined in Table 3.

bDilution based on the test requiring the greatest amount of dilution to meet water quality criteria.

cHg concentration was not consistent with historical data.

The sludge characteristics determined in August 1988 are generally comparable to those submitted to EPA by the nine sewerage authorities in the form of permit applications and quarterly monitoring reports. The physical characteristics of the sludge from each authority were found to be similar to those reported by the authorities. In August 1988, organic compounds were found at notably low concentrations (relative to the method detection limits for the EPA methods used for the analysis). Metal concentrations in August 1988 were generally lower than mean concentrations calculated from the characteristics data available over the previous 2 years. Although not discussed in detail in this report, the metal concentration data available prior to August 1988 are highly variable (EPA. 1989). This longer term variability may represent changes in sludge characteristics that occur during normal plant operations, results from lower inputs to the treatment plants, or results from analytical imprecision and inaccuracies in the laboratory data. Regardless of the cause, the August 1988 characterization data will serve as a baseline against which sludge variability and changes in characteristics can be determined over the next several years.

As previously found, the amount of sludge dilution that is required for each authority to meet regulatory guidelines is different. The basis for setting the required dilution also varies from authority to authority. From the August 1988 data, metal concentrations establish the required dilution for sludge from MCUA, BCUA, JMEUC, NYCDEP, and WCDEF. Toxicity-based dilutions drive the disposal rates for the other treatment authorities.

6.0 REFERENCES

ASTM. 1985. Standard Methods for the Examination of Water and Wastewater. American Public Health Association. 16th edition, Washington, DC.

EPA. 1985. Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms, 3rd Edition, (EPA/600/4-85-013).

EPA. 1986. Test Methods for Evaluating Solid Waste. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Responses, SW 846, 3rd Edition, Washington, DC.

EPA. 1987. Bioassay Procedures for the Ocean Disposal Permit Program, March 1987. (EPA/600/9-78-010).

EPA. 1988a. Permittee Monitoring Requirements: 106-Mile Deepwater Municipal Sludge Site Monitoring Program. Environmental Protection Agency Oceans and Coastal Protection Division (formerly OMEP), Washington, DC.

EPA. 1988b. Operating Program for the 106-Mile Site, Sewage Sludge Characterization Study. Work/Quality Assurance Project Plan for WA 1-111, Amendment 1. Environmental Protection Agency Oceans and Coastal Protection Division (formerly OMEP), Washington, DC.

EPA. 1989. Summary of Characteristics of Municipal Sludges Dumped at the 106-Mile Site. Environmental Protection Agency Oceans and Coastal Protection Division (formerly OMEP), Washington, DC.

EPA. 1992a. Final Draft Monitoring Plan for the 106-Mile Deepwater Municipal Sludge Site. Environmental Protection Agency. EPA 842-S-92-009.

EPA. 1992b. Final Draft Implementation Plan for the 106-Mile Deepwater Municipal Sludge Site Monitoring Program. Environmental Protection Agency. EPA 842-S-92-010.

EPA. 1992c. Final Report for Nearfield Monitoring of Sludge Plumes at the 106-Mile Deepwater Municipal Sludge Site: Results of a Survey Conducted August 31 through September 5, 1987. Environmental Protection Agency. EPA 842-S-92-004.

EPA. 1992d. Determination of Sludge Dumping Rates for the 106-Mile Site. Environmental Protection Agency. EPA 842-S-92-006.

Head, K.H. 1980. Soil classification and compaction tests. In: Manual of Soil Laboratory Testing, Vol 1. Pentech Press, Plymouth, England.

Miller, D.C., M. Marcy, W. Berry, C. Deacutis, S. Lussier, A. Kuhn, M. Heber, S. Schimmel, and E. Jackim. In press. The acute toxicity of sewage sludge to marine fish, mysids, and copepods. In: D.A. Wolfe and T.P. O'Conner (eds.), Wastes in Coastal Marine Environments. Robert Krieger Pub. Co. Malabar, FL.

Santoro, E.D. and J.J. Fikslin. 1987. Chemical and Toxicological Characteristics of Sewage Sludge Ocean Dumped in New York Bight. Mar. Poll. Bull. 18(7):394-399.

APPENDIX A

QUALITY CONTROL RESULTS FOR SEMIVOLATILE ORGANIC COMPOUNDS

Quality control results for the semivolatile organic priority pollutants are listed in the following tables. Table A-1 lists lower limits of detection and practical limits of quantification for the target analytes. Table A-2 presents the method blanks, Table A-3 lists surrogate spike recoveries, and Table A-4 details the matrix spike recoveries.

Recoveries of semivolatile surrogate compounds were outside of the limits specified in EPA (1986) for 2,4,6 tribromophenol for several samples (MCUA, Replicates 1 and 2; JMEUC, Replicates 1 and 2). In addition, for the sample from NCDPW no semivolatile surrogate compounds were found, indicating that the spike solution was inadvertently left out during extract preparation.

Generally, precision of analysis was acceptable, as were the matrix spike recoveries. High recoveries were experienced for acenaphthene for one sample (PVSC, matrix spike) and pentachlorophenol (PVSC, matrix spike duplicate). Low recoveries were obtained for phenol, 4-nitrophenol and 2,4-dinitrotoluene in these samples.

EPA, 1986. Test Methods for Evaluating Solid Waste. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Responses, SW 846 3rd Edition, Washington, DC.

TABLE A-1. REPORTING LIMITS FOR SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS ANALYZED BY METHOD 8270.

Compound	Reporting Limit (µg/L)	Lower Limit of Detection (µg/L)
Phenol	500	20
Bis(2-Chloroethyl)ether	500	20
2-Chlorophenol	500	20
1,3-Dichlorobenzene	500	20
1,4-Dichlorobenzene	500	20
Benzyl alcohol	500	20
1,2-Dichlorobenzene	500	20
2-Methylphenol	500	20
Bis(2-Chloroisopropyl)ether	500	20
4-Methylphenol	500	20
N-Nitroso-Di-N-propylamine	500	20
Hexachloroethane	500	20
Nitrobenzene	500	20
Isophorone	500	20
2-Nitrophenol	500	20
2,4-Dimethylphenol	500	20
Benzoic acid	2,500	100
Bis(2-Chloroethoxy)methane	500	20
2,4-Dichlorophenol	500	20
1,2,4-Trichlorobenzene	500	20
Naphthalene	500	20
4-Chloroaniline	500	20
Hexachlorobutadiene	500	20
4-Chloro-3-methylphenol	500	20
2-Methylnaphthalene	500	20
Hexachlorocyclopentadiene	500	20
2,4,6-Trichlorophenol	500	20
2,4,5-Trichlorophenol	2,500	100
2-Chloronaphthalene	500	20
2-Nitroaniline	2,500	100
Dimethyl phthalate	500	20
Acenaphthylene	500	20
3-Nitroaniline	2,500	100
Acenaphthene	500	20
2,4-Dinitrophenol	2,500	100
4-Nitrophenol	2,500	100
Dibenzofuran	500	20
2,4-Dinitrotoluene	500	20
2,6-Dinitrotoluene	500	20
Diethylphthalate	500	20
4-Chlorophenyl phenyl ether	500	20
Fluorene	500	20
4-Nitroaniline	2,500	100

TABLE A-1. (Continued)

4,6-Dinitro-2-methylphenol	2,500	100
N-Nitrosodiphenylamine	500	20
4-Bromophenyl phenyl ether	500	20
Hexachlorobenzene	500	20
Pentachlorophenol	2,500	100
Phenanthrene	500	20
Anthracene	500	20
Di-n-butylphthalate	500	20
Fluoranthene	500	20
Pyrene	500	20
Butyl benzyl phthalate	500	20
3,3'-Dichlorobenzidine	1,000	40
Benzo(a)anthracene	500	20
Bis(2-ethylhexyl)phthalate	500	20
Chrysene	500	20
Di-n-octyl phthalate	500	20
Benzo(b)fluoranthene	500	20
Benzo(k)fluoranthene	500	20
Benzo(a)pyrene	500	20
Indeno(1,2,3-cd)pyrene	500	20
Dibenzi(a,h)anthracene	500	20
Benzo(g,h,i)perylene	500	20

TABLE A-2. SUMMARY OF RESULTS AND SURROGATE RECOVERIES FOR SEMI-VOLATILE (METHOD 8270) ORGANIC COMPOUNDS IN METHOD BLANKS.

Compound	Concentration	Surrogate Recoveries (%)		
		MB-1	MB-2	MB-3
All target analytes	ND[a]	-	-	-
d5-Nitrobenzene		37	81	63
2-Fluorobiphenyl		43	62	51
d14-p-terphenyl		62	174	167
d5-Phenol		41	67	53
2-Fluorophenol		34	64	46
2,4,6-Tribromophenol		27	230	245

[a]Not detected at levels provided in the Reporting Limit Table (Table A-1).

TABLE A-3. SUMMARY OF SURROGATE RECOVERIES (%) FOR SEMIVOLATILE ORGANIC COMPOUNDS IN SEWAGE SLUDGE USING METHOD 8270. RESULTS OF EACH ANALYTICAL REPLICATE ARE INCLUDED.

	Authority																		
			MCUA		PVSC			LRSA		RVSA		NYCDEP		JMEUC		BCUA			
Compound	WCDEF	NCDPW	1	2	1	2	3	1	2	1	2	1	2	1	2	1	2	3
d5-Nitrobenzene	33	0[a]	62	73	42	43	43	73	79	64	67	51	58	70	67	67	68	60
2-Fluorobiphenyl	42	0[a]	182	148	42	42	42	76	84	77	73	50	58	78	67	68	72	74
d14-p-Terphenyl	76	0[a]	-	-	30	25	23	71	108	79	53	97	156	158	148	139	177	176
d6-Phenol	37	0[a]	-	-	40	45	44	72	71	66	69	45	58	75	63	62	65	56
2-Fluorophenol	30	0[a]	-	-	26	28	28	62	65	49	52	38	46	55	53	54	58	52
2,4,6-Tribromophenol	47	0[a]	-	-	56	57	60	57	122	83	159	142	188	261	265	228	186	144

PVSC = Passaic Valley Sewerage Commissioners.

MCUA = Middlesex County Utilities Authority.

BCUA = Bergen County Utilities Authority.

LRSA = Linden-Roselle Sewerage Authority.

RVSA = Rahway Valley Sewerage Authority.

JMEUC = Joint Meeting of Essex and Union Counties.

NYCDEP= Composite of the New York City Department of Environmental Protection facilities.

NCDPW = Nassau County Department of Public Works.

WCDEF = Westchester County Department of Environmental Facilities.

[a]Surrogate spike not added to sample.

TABLE A-4. RECOVERIES AND ANALYTICAL PRECISION FOR MATRIX SPIKE (MS) AND MATRIX SPIKE DUPLICATES (MSD) FOR SEMIVOLATILE (METHOD 8270) ORGANIC COMPOUNDS AND ASSOCIATED ANALYTICAL SURROGATE RECOVERIES FROM PASSAIC VALLEY SEWAGE SLUDGE.

Compound	Matrix Spike Recoveries (%)		Precision of Duplicate Recovery (RPD)	Recoveries of Surrogate (%)	
	MS	MSD		MS	MSD
Phenol	84	ND	-	-	-
2-Chlorophenol	75	80	3.2	-	-
1,4-Dichlorobenzene	69	73	2.8	-	-
n-Nitroso-di-n-propylamine	91	93	1.1	-	-
1,2,4-Trichlorobenzene	81	84	1.7	-	-
4-Chloro-3-methylphenol	90	95	2.7	-	-
Acenaphthene	240	94	44	-	-
4-Nitrophenol	15	ND	-	-	-
2,4-Dinitrotoluene	ND	100	-	-	-
Pentachlorophenol	120	200	25	-	-
Pyrene	63	61	1.6	-	-
d5-Nitrobenzene	-	-	-	45	48
2-Fluorobiphenyl	-	-	-	41	45
d14-p-Terphenyl	-	-	-	29	28
d5-Phenol	-	-	-	46	15
2-Fluorophenol	-	-	-	30	33

RPD = Relative percent diference.

APPENDIX B

QUALITY CONTROL RESULTS FOR PCB AND PESTICIDES

Quality control results for the analysis of PCB and pesticides are reported in this appendix. Table B-1 reports the lower limits of detection and practical quantification limits; Table B-2 presents the method blanks; Table B-3 lists surrogate spike recoveries; and Table B-4 details the matrix spike recoveries.

TABLE B-1. REPORTING LIMITS FOR PCB/PESTICIDE PRIORITY POLLUTANTS ANALYZED BY METHOD 8080.

Compound	Reporting Limit (µg/L)	Lower limit of Detection (µg/L
PCB/PESTICIDES		
Aldrin	25	1
alpha-BHC	25	1
beta-BHC	25	1
delta-BHC	25	1
gamma-BHC (Lindane)	250	10
Chlordane	25	1
4,4'-DDD	25	1
4,4'-DDE	25	1
4,4'-DDT	25	1
Dieldrin	25	1
Endosulfan I	25	1
Endosulfan II	25	1
Endosulfan Sulfate	25	1
Endrin	25	1
Endrin aldehyde	25	1
Heptachlor	25	1
Heptachlor epoxide	25	1
Methoxychlor	25	1
Toxaphene	250	10
PCB-1016	250	10
PCB-1221	250	10
PCB-1231	250	10
PCB-1242	250	10
PCB-1248	250	10
PCB-1254	250	10
PCB-1260	250	10

TABLE B-2. SUMMARY OF RESULTS AND SURROGATE RECOVERIES FOR PCB/PESTICIDES (METHOD 8080) IN EQUIPMENT AND METHOD BLANKS.

Location	Sample Type	Concentration (µg/L)		Surrogate[a] Recovery (%)
		PCB	Pesticides	
Westchester	Equipment Blank	ND	ND	95
Nassau	Equipment Blank	ND	ND	96
SAIC	Method Blank	ND	ND	96
SAIC	Reagent Blank 1	ND	ND	87
SAIC	Reagent Blank 2	ND	ND	91

ND = Not Detected, see Reporting Limit Table (B-1) for detection limits.

[a]Dibutyl chlorendate

TABLE B-3. SUMMARY OF SURROGATE RECOVERIES OF DIBUTYL CHLORENDATE FOR PCB/PESTICIDES IN SEWAGE SLUDGE USING METHOD 8080.

Authority	Recovery (%)
WCDEF	64
NCDPW	82
MCUA	122
PVSC (Rep 1)	77
PVSC (Rep 2)	91
PVSC (Rep 3)	79
LRSA	233
RVSA	43
NYCDEP (Ward Is.)	68
JMEUC	111
BCUA (Rep 1)	86
BCUA (Rep 2)	86
BCUA (Rep 3)	87

See Table A-3 for defination of abbreviations.

TABLE B-4. SUMMARY OF RESULTS FOR MATRIX SPIKE (MS) AND MATRIX SPIKE DUPLICATE (MSD) FOR PCB/PESTICIDES USING METHOD 8080.

Compound	Recovery (%) MS	MSD	RPD (%)
gamma-BHC	113	115	2.1
Heptachlor	104	106	2.1
Aldrin	132	137	3.7
Dieldrin	91	95	3.9
Endrin	88	91	4.4
4,4'-DDT	71	73	2.5
Dibutyl chlorendate[a]	80	82	1.2

[a]Surrogate spike.

APPENDIX C

QUALITY CONTROL RESULTS FOR PHENOLS

Quality control results for the analysis of phenols are reported in this appendix. Table C-1 reports the lower limits of detection and practical quantification limits; Table C-2 presents the method blanks; Table C-3 lists surrogate spike recoveries; and Table C-4 details the matrix spike recoveries. With the exception of low recoveries on 2-fluorophenol for Replicate 1 of the WCDEF sample and 2,4,6-tribromophenol for Replicate 3 of PVSC, these appear acceptable.

WCDEF=Westchester County Department of Environmental Facilities.

TABLE C-1. REPORTING LIMITS FOR PHENOL ORGANIC PRIORITY POLLUTANTS ANALYZED BY METHOD 8040.

Compound	Reporting Limit (µg/L)	Lower Limit of Detection (µg/L)
Phenol	1000	40
2-Chlorophenol	3000	120
2-Nitrophenol	4000	160
2,4-Dimethylphenol	3000	120
2,4-Dichlorophenol	3000	120
4-Chloro-3-methylphenol	4000	160
2,4,6-Trichlorophenol	4000	240
2,4-Dinitrophenol	6000	520
4-Nitrophenol	28000	1120
2-Methyl-4,6-dinitrophenol	16000	640
Pentachlorophenol	7000	280

TABLE C-2. SUMMARY OF RESULTS FOR PHENOLS (METHOD 8040) IN EQUIPMENT/METHOD BLANKS.

Location	Sample	Phenol (µg/l)	Surrogate Recovery(%)	
			2-Fluorophenol	2,4,6-Tribromophenol
SAIC	Method Blank 1	ND	18	53
SAIC	Reagent Blank 1	ND	28	58
SAIC	Reagent Blank 3	ND	77	137
WCDEF	Equipment Blank	ND	38	47
NCDPW	Equipment Blank	ND	30	34

ND=None detected at levels provided in the Reporting Limit Table (Table C-1).

TABLE C-3. SURROGATE RECOVERIES FOR PHENOL IN SEWAGE SLUDGE USING METHOD 8040.

Authority[a]	Replicate	Surrogate Recovery (%)	
		2-Fluorophenol	2,4,6-Tribromophenol
WCDEF	1	14	27
WCDEF	2	27	49
NCDPW	1	23	47
NCDPD	2	23	45
MCUA	1	36	75
PVSC	1	42	19
PVSC	2	26	26
PVSC	3	23	10
LRSA	1	39	65
RVSA	1	35	87
NYCDEP (Ward Is.)	1	37	89
JMEUC	1	43	67
BCUA	1	34	75
BCUA	2	30	76
BCUA	3	37	82

[a]See Table A-3 for definition of abbreviations.

TABLE C-4. SUMMARY OF RESULTS FOR MATRIX SPIKE (MS) AND MATRIX SPIKE DUPLICATE (MSD) FOR PHENOLS USING METHOD 8040.

Compound	Recovery (%)		Precision of Duplicate Recovery (RPD)
	MS	MSD	
Phenol	46	77	51
2-Chlorophenol	70	98	33
4-Chloro-3-methyphenol	40	42	5
4-Nitrophenol	22	3	155
Pentachlorphenol	108	30	113
2-Fluorophenol	23	37	23
2,4,6 - Tribromophenol	10	18	29

RPD = Relative percent diference.

APPENDIX D

QUALITY CONTROL RESULTS FOR METALS

Quality control results for the analysis of metals are reported in this appendix. Table D-1 reports the lower limits of detection and the method reporting limit. Table D-2 presents the method blanks. Table D-3 lists the matrix spike recoveries and analytical precision. Table D-4 compares the Pb analysis using Inductively Coupled Plasma (ICP) and flame atomic absorption spectrometry (FAAS) analysis methods.

TABLE D-1. AVERAGE SAMPLE DETECTION AND REPORTING LIMITS FOR METALS MEASURED IN SEWAGE SLUDGES FROM THE NEW YORK-NEW JERSEY AREA, AUGUST 1988.

Element (Method)	Sample Detection Limit (µg/L)	Method Reporting Limit[a] (µg/L)
Cadmium	2.3	25
Copper	75	830
Lead (ICP)	50	550
Lead (flame)	200	NR
Mercury	0.056	28

NR = Not reported.

[a]The sample detection limit is based upon an initial sample volume of 0.1 liters and a final digestate volume of 0.1 liters. Actual sample reporting limits may increase due to further sample dilutions which must be made in order to place samples of high concentrations within the linear range of the instruments.

TABLE D-2. SUMMARY OF METHOD BLANKS FOR METAL DETERMINATIONS IN SLUDGES SAMPLED FROM THE NEW YORK-NEW JERSEY AREA IN AUGUST 1988.

Method Blank #	Metal (µg/L)			
	Cadmium	Copper	Lead	Mercury
1	ND	ND	ND	ND
2	ND	ND	ND	ND
3	ND	ND	ND	ND
4	ND	ND	ND	2.5

ND=Not detected at concentrations greater than reported in Table D-1.

TABLE D-3. RECOVERIES OF METALS FOR A MATRIX SPIKE (MS) AND MATRIX SPIKE DUPICATE (MSD) ADDED TO SEWAGE SLUDGE FROM PASSAIC VALLEY AND BERGEN COUNTY.

Metal	Recovery (%)		Precision of Duplicate Recovery (RPD)
	MS	MSD	
Passaic Valley			
Cadmium	80	78	2.2
Copper	78	78	0.0
Lead	77	77	0.0
Mercury	124	124	0.0
Bergen County			
Cadmium	95	95	0.0
Copper	98	112	9.0
Lead	80	90	8.0
Mercury	107	107	0.0

RPD = Relative percent diference.

TABLE D-4. COMPARISON OF LEAD RESULTS IN SEWAGE SLUDGE DIGESTATES USING INDUCTIVELY COUPLE PLASMA (ICP) AND FLAME ATOMIC ABSORPTION (FAAS) ANALYSIS TECHNIQUES.

Authority[a]	Sample Designation	ICP (µg/L)	FAAS (µg/L)	RPD (%)
WCDEF		9200	9500	3
NCDPW		3900	3700	5
PVSC	Rep 1	50000	39000	25
PVSC	Rep 2	55000	48000	14
PVSC	Rep 3	53000	52000	2
PVSC	MS	130000	130000	0
PVSC	MSD	130000	130000	0
LRSA		20000	9800	2
RVSA		2600	2200	17
BCUA	Rep 1	4000	4700	16
BCUA	Rep 2	3700	4200	13
BCUA	Rep 3	4200	5100	19
BCUA	MS	12000	14000	15
BCUA	MSD	13000	14000	7
NYCDEP (Ward Is.)		13000	12000	8
MCUA		6300	7400	16
JMEUC		9100	11000	19

RPD = Relative percent diference.

MS = Matrix spike.

MSD = Matrix spike duplicate.

[a]See Table A-3 for definition of abbreviations.

APPENDIX E

QUALITY CONTROL RESULTS FOR PHYSICAL CHARACTERIZATION

Table E-1 presents the equipment blanks for the determination of the sludge physical properties of the sludge.

TABLE E-1. SUMMARY OF EQUIPMENT BLANKS FOR PHYSICAL PROPERTIES.

Authority[a]	Total Residue (mg/L)	Non-filterable Residue (mg/L)	Settleable Matter (mg/L)	Specific Gravity
WCDEF	<10	<4	<4	1.000
NCDPW	<10	<4	<4	1.000
MCUA	<10	<4	<4	.999
LRUA	20	<4	<4	.997
RVUA	80	<4	<4	1.000

[a]See Table A-3 for definition of abbreviations.

APPENDIX F

SUMMARY RESULTS FOR TOXICOLOGY TESTS CONDUCTED ON THE WHOLE SLUDGE

These tables summarize the conditions of the toxicology tests conducted on the whole sludges. The test conditions, organism history and acclimation, water quality parameters, significant test deviations and observations, and final results are included within each summary. Test summaries for Mysidopsis bahia for each authority are included in Tables F-1 through F-9. Test summaries for Menidia beryllina are included for each authority in Tables F-10 through F-18.

TABLE F-1. WESTCHESTER COUNTY (001) MYSID TOXICITY TEST REPORT

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 001-1009/Yonkers (Westchester County)
Shipped by (Date, Time): SAIC-08-01-88/1430
Received by (Date, Time): Battelle Ocean Sciences 08-02-88/1000
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: dark brown/black "pudding-like" consistency
Sample Modifications: 1° stock=5% of sludge in seawater. Salinity adjusted to 30°/oo with seawater brine. pH adjusted to 7.9 with 10N NaOH

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 μm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 μg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Mysid shrimp
Test Organism (Taxon): *Mysidopsis bahia*
Test Organism Source: Battelle Ocean Sciences
Test Organism Age: approximately 24 h at time of test start
Test Organism Size: juvenile, lengths not measured
Acclimated to Test Lab Conditions (Yes, No): Yes, hatched at 30°/oo salinity
If Yes, Acclimation period: 24 h (hatching period)

TABLE F-1. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay, seawater, 30°/oo
Organism Food Type: *Artemia salina* nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's Organochlorine Pesticides
Concentration: ND (<1.0 ppm) ND (<1.0 ppb)
Fed During Test (Yes, No): Yes
If Yes, feeding rate: 2-4 drops *Artemia* suspension to each chamber at least once daily

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Russ Winchell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of mysids
Nominal Test Concentrations: 0 (control), 0.31%, 0.62%, 1.25%, 2.5%, 5.0% whole sludge
Test Initiation: 1145/08-23-88
Test Completion: 1030/08-27-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 90x50 mm glass crystallizing dish, covered
Test Container Size: 250 mL
Test Solution Volume: 200 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 13.7 mg/L, 95% confidence limits 12.8-14.6 mg/L

TABLE F-1. (Continued)

V. Deviations from Work/QA Plan

1. Sample storage time (at 4°C) was 21 days because initial test conducted with Sample 001 was invalid (control mortality >10%). The sample was received on 08-02-88 and retested on 08-23-88.

2. All test chambers were aerated from the time of test initiation because previous testing with this and other samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 h period.

3. The number of test organisms per chamber was not counted within two hours of test initiation because turbidity of the sample in the chambers prevented direct observation of test organisms.

4. Mysids were fed at least once daily.

TABLE F-1. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.0 - 21.2	19.9	0.68	20
Salinity (o/oo)	29.0 - 30.5	30.0	0.34	14
Dissolved oxygen (mg/L)	6.0 - 7.2	6.8	0.28	20
pH	7.81- 8.23	8.02	0.21	10

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.31	-	-	-	5
0.62	-	-	-	1
1.25	-	-	-	11
2.50	-	10	20	20
5.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 1.17% sludge.
95 Percent Confidence Limits: 0.88-1.56% sludge
Method: Trimmed Spearman-Karber

VII. Comments:

*Counts of organisms at 24 h, 48 h, and 72 h were impeded by presence of solids in test chambers. At these periods, only organisms visibly swimming were counted. When it was suspected that all organisms were dead (none observed swimming), solutions were decanted to confirm absence of living organisms. At 96 h all surviving organisms were accurately counted.

Approval: _____ Date: October 18, 1988

TABLE F-2. NASSAU COUNTY (002) MYSID TOXICITY TEST REPORT

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 002-2009/Nassau County
Shipped by (Date, Time): SAIC-08-02-88 (Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-03-88/1000
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: dark brown/black "pudding-like" consistency
Sample Modifications: 5% dilution as 1° stock. Salinity adjusted to 29°/oo, pH adjusted to 7.95 w/250 µL 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Mysid shrimp
Test Organism (Taxon): *Mysidopsis bahia*
Test Organism Source: MultiAqua Culture Systems, Amagensett, NY 08-03-88
Test Organism Age: approximately 72 h at time of test start
Test Organism Size: juvenile, not measured
Acclimated to Test Lab Conditions (Yes, No): Yes, received at 29.5°/oo salinity, tested at 30°/oo
If Yes, Acclimation period: 24 h

TABLE F-2. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay, seawater, 30°/oo
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's Organochlorine Pesticides
Concentration: ND (<1.0 ppm) ND (<1.0 ppb)
Fed During Test (Yes, No): Yes
If Yes, feeding rate: 2-4 drops Artemia suspension to each chamber at least once daily

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Russ Winchell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of mysids
Nominal Test Concentrations: 0 (control), 0.31%, 0.62%, 1.25%, 2.5%, 5.0% whole sludge
Test Initiation: 1700/08-04-88
Test Completion: 1425/08-08-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L):≥40% saturation
Test Salinity (°/oo):30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 90x50 mm glass crystallizing dish, covered
Test Container Size: 250 mL
Test Solution Volume: 200 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 20 mg/L, not calculable by Spearman-Karber method within dosing range tested.

TABLE F-2. (Continued)

V. Deviations from Work/QA Plan

1. Test chambers were aerated beginning approximately 10 hours after test initiation because dissolved oxygen was observed to be dropping to near 40% saturation. A decision was made not to wait until solutions dropped below 40% saturation as specified in the Work/QA Plan.

2. Mysids were fed at least once daily.

3. The number of test organisms per chamber was not counted within two hours of test initiation because turbidity of the sample in the chambers prevented direct observation of test organisms.

4. Adjustment rates for temperature during the acclimation period were exceeded because organisms were shipped during hot weather resulting in elevated temperature. The acclimation period was not extended in this case because of the specification for minimizing sample holding time.

TABLE F-2. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.2 - 21.7	20.1	0.81	20
Salinity (°/oo)	29.5 - 30.5	30.0	0.26	12
Dissolved oxygen (mg/L)	5.6 - 7.3	6.5	0.53	20
pH	7.93- 8.10	8.00	0.05	8

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	2	2	2
0.31	-	-	-	3
0.62	-	-	-	7
1.25	-	-	-	14
2.50	-	1	10	19
5.00	-	10	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 0.92% sludge.
95 Percent Confidence Limits: 0.72-1.16% sludge
Method: Trimmed Spearman-Karber with Abbott's Correction for control mortality.

VII. Comments:

*Counts of organisms at 24 h, 48 h, and 72 h were impeded by presence of solids in test chambers. At these periods, only organisms visibly swimming were counted. When it was suspected that all organisms were dead (none observed swimming), solutions were decanted to confirm absence of living organisms. At 96 h all surviving organisms were accurately counted.

Approval: _____ Date: October 18 1988

TABLE F-3. MIDDLESEX COUNTY (003) MYSID TOXICITY TEST REPORT

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. **Toxicity Test--Compound and Test Identification**

Description of Sample: 003-3009/Middlesex County
Shipped by (Date, Time): SAIC-08-18-88 (Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-19-88/1000
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: very liquid--grey/black
Sample Modifications: 10% dilution as 1° stock. Salinity adjusted to 30°/oo, pH adjusted to 7.96 using 50 µL in 10N NaOH

II. **Toxicity Test--Dilution Water Characterization**

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. **Toxicity Test--Test System**

Test Organisms (Common Name): Mysid shrimp
Test Organism (Taxon): *Mysidopsis bahia*
Test Organism Source: Battelle Ocean Sciences
Test Organism Age: approximately 24 h
Test Organism Size: juvenile, not measured
Acclimated to Test Lab Conditions (Yes, No): Yes, hatched at 30°/oo salinity
If Yes, Acclimation period: 24 h (hatching period)

TABLE F-3. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay, seawater, 30°/oo
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's Organochlorine Pesticides
Concentration: ND (<1.0 ppm) ND (<1.0 ppb)
Fed During Test (Yes, No): Yes
If Yes, feeding rate: 2-4 drops Artemia suspension to each chamber at least once daily

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Russ Winchell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of mysids
Nominal Test Concentrations: 0 (control), 0.62%, 1.25%, 2.5%, 5.0% 10.00% whole sludge
Test Initiation: 1105/08-23-88
Test Completion: 1000/08-27-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L):≥40% saturation
Test Salinity (°/oo):30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 90x50 mm glass crystallizing dish, covered
Test Container Size: 250 mL
Test Solution Volume: 200 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 13.7 mg/L, 95% confidence limits 12.8-14.6 mg/L

TABLE F-3. (Continued)

V. Deviations from Work/QA Plan

1. Sample storage time (at 4°C) was approximately 96 h at 4°C.

2. All test chambers were aerated from the time of test initiation because previous testing with other sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 h period.

3. Dissolved oxygen dropped below 40% of saturation in one test chamber (highest test concentration). Air flow had stopped to this single chamber. In the other replicate of this treatmean the dissolved oxygen concentration remained acceptable. Air flow was restarted (valve adjustment) when restricted flow was observed. 100% mortality was observed in both replicates of this treatment, thus it appears that this did not affect the test results.

4. The number of test organisms per chamber was not counted within two hours of test initiation because turbidity of the sample in the chambers prevented direct observation of test organisms.

5. Mysids were fed at least once daily.

TABLE F-3. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	18.9 - 21.5	19.8	0.80	23
Salinity (o/oo)	29.0 - 30.0	29.8	0.30	16
Dissolved oxygen (mg/L)	*2.2 - 7.2	6.4	1.16	23
pH	7.86- 8.12	7.92	0.15	12

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead** 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.62	-	-	-	1
1.25	-	-	-	6
2.50	-	-	-	12
5.00	-	-	-	16
10.00	-	10	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 5.95% sludge.
95 Percent Confidence Limits: 5.16-6.85% sludge
Method: Trimmed Spearman-Karber

VII. Comments:
*Aeration in one chamber (24 h observation) restricted. Readjusted flow.

**Counts of organisms at 24 h, 48 h, and 72 h were impeded by presence of solids in test chambers. At these periods, only organisms visibly swimming were counted. When it was suspected that all organisms were dead (none observed swimming), solutions were decanted to confirm absence of living organisms. At 96 h all surviving organisms were accurately counted.

Approval: _____ Date: October 13 1988

TABLE F-4. PASSAIC VALLEY (004) MYSID TOXICITY TEST REPORT

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 004-4009/Passaic Valley County)
Shipped by (Date, Time): SAIC-08-04-88 (Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-05-88/1024
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: dark black slurry
Sample Modifications: 2% dilution as 1° stock. Salinity adjusted to 29°/oo, pH adusted to 7.9 with 450 µL 10N NaOH

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Mysid shrimp
Test Organism (Taxon): Mysidopsis bahia
Test Organism Source: MultiAquaculture Systems, Amagansett, NY/08-03-88
Test Organism Age: approximately 96 h
Test Organism Size: juvenile, not measured
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 48 h

TABLE F-4. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay, seawater, 30°/oo
Organism Food Type: *Artemia salina* nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's — Organochlorine Pesticides
Concentration: ND (<1.0 ppm) — ND (<1.0 ppb)
Fed During Test (Yes, No): Yes
If Yes, feeding rate: 2-4 drops *Artemia* suspension to each chamber at least once daily

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): No, definitive test initiated on day of sample arrival.
Test Description: 96 h acute
Test Conducted By: Russ Winchell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of mysids
Nominal Test Concentrations: 0 (control), 0.03%, 0.06%, 0.12%, 0.25%, 0.50% whole sludge
Test Initiation: 1415/08-05-88
Test Completion: 1400/08-09-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 90x50 mm glass crystallizing dish, covered
Test Container Size: 250 mL
Test Solution Volume: 200 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 20 mg/L, not calculable by Spearman-Karber method within dosing range tested.

TABLE F-4. (Continued)

V. Deviations from Work/QA Plan

1. All test chambers were aerated from the time of test initiation because previous testing with other samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 h period.

2. Dissolved oxygen dropped below 40% of saturation in one test chamber (highest treatment). Air flow had diminished in a single chamber. In the other replicate of this treatment, the dissolved oxygen concentration remained >40% saturation. Air flow was restarted (valve adjustment) when flow was observed to be restricted. 100% mortality was observed in both replicates of this treatment, thus it appears that this did not affect the test results.

3. The number of test organisms per chamber was not counted within two hours of test initiation because turbidity of the sample in the chambers prevented direct observation of test organisms.

4. Mysids were fed at least once daily.

TABLE F-4. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	18.5 - 20.9	20.1	0.74	20
Salinity (o/oo)	29.5 - 31.0	30.5	0.55	16
Dissolved oxygen (mg/L)	*2.8 - 7.2	6.4	0.95	21
pH	7.87- 8.06	7.98	0.06	12

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead** 24 h	48 h	72 h	96 h
Seawater Control	1	1	1	1
0.03	1	1	1	1
0.06	-	-	-	1
0.12	-	-	-	4
0.25	-	-	-	18
0.50	-	-	-	20

Number of test organisms at time of test start = 20.

LC50 Value: 0.17% sludge.
95 Percent Confidence Limits: 0.14-0.19% sludge
Method: Trimmed Spearman-Karber with Abbott's Correction for control mortality.

VII. Comments:

*Aeration in one chamber (24h observation) restricted. Readjusted flow.

**Counts of organisms at 24 h, 48 h, and 72 h were impeded by presence of solids in test chambers. At these periods, only organisms visibly swimming were counted. When it was suspected that all organisms were dead (none observed swimming), solutions were decanted to confirm absence of living organisms. At 96 h all surviving organisms were accurately counted.

Approval: _____ Date: October 13 1988

TABLE F-5. LINDEN ROSELLE (005) MYSID TOXICITY TEST REPORT

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 005-5009/Linden Roselle
Shipped by (Date, Time): SAIC-08-08-88 (Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-09-88/0930
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: dark ooze/odorous
Sample Modifications: 3% dilution as 1° stock. Salinity adjusted to 30°/oo, pH adusted to 7.9 using 200 µL of 10N NaOH

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Mysid shrimp
Test Organism (Taxon): *Mysidopsis bahia*
Test Organism Source: Battelle Ocean Sciences
Test Organism Age: approximately 24 h
Test Organism Size: juvenile, not measured
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 24 h (hatching period)

TABLE F-5. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay, seawater, 30°/oo
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's Organochlorine Pesticides
Concentration: ND (<1.0 ppm) ND (<1.0 ppb)
Fed During Test (Yes, No): Yes
If Yes, feeding rate: 2-4 drops Artemia suspension to each chamber at least once daily

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test plus two definitive tests
Test Description: 96 h acute
Test Conducted By: Russ Winchell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of mysids
Nominal Test Concentrations: 0 (control), 0.02%, 0.03%, 0.06%, 0.12%, 0.25% whole sludge
Test Initiation: 1205/08-23-88
Test Completion: 1100/08-27-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 90x50 mm glass crystallizing dish, covered
Test Container Size: 250 mL
Test Solution Volume: 200 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 13.7 mg/L, 95% confidence limits 12.8-14.6 mg/L

TABLE F-5. (Continued)

V. Deviations from Work/QA Plan

1. All test chambers were aerated from the time of test initiation because previous testing with this sample demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 h period.

2. The number of test organisms per chamber was not counted within two hours of test initiation because turbidity of the sample in the chambers prevented direct observation of test organisms.

3. Mysids were fed at least once daily.

TABLE F-5. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.0 - 21.4	19.8	0.72	21
Salinity (°/oo)	29.5 - 30.5	30.0	0.24	14
Dissolved oxygen (mg/L)	6.8 - 7.2	7.0	0.14	21
pH	7.81- 8.01	7.95	0.07	11

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.02	-	-	-	0
0.03	-	-	-	0
0.06	-	-	-	11
0.12	-	-	20	20
0.25	-	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 0.06% sludge.
95 Percent Confidence Limits: 0.05-0.07% sludge
Method: Trimmed Spearman-Karber

VII. Comments:

*Counts of organisms at 24 h, 48 h, and 72 h were impeded by presence of solids in test chambers. At these periods, only organisms visibly swimming were counted. When it was suspected that all organisms were dead (none observed swimming), solutions were decanted to confirm absence of living organisms. At 96 h all surviving organisms were accurately counted.

Approval: _____ Date: October 13 1988

TABLE F-6. RAHWAY VALLEY (006) MYSID TOXICITY TEST REPORT

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 006-6009/Rahway
Shipped by (Date, Time): SAIC-08-08-88 (Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-09-88/0930
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: black liquid
Sample Modifications: 5% dilution as 1° stock. Salinity adjusted to 30°/oo, pH adjusted to 7.88 w/280 µL 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Mysid shrimp
Test Organism (Taxon): Mysidopsis bahia
Test Organism Source: MultiAqua Culture Systems, Amagensett, NY 08-17-88
Test Organism Age: approximately 72 h at time of test start
Test Organism Size: juvenile, not measured
Acclimated to Test Lab Conditions (Yes, No): Yes, received at 31°/oo
If Yes, Acclimation period: 24 h

TABLE F-6. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay, seawater, 30°/oo
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's Organochlorine Pesticides
Concentration: ND (<1.0 ppm) ND (<1.0 ppb)
Fed During Test (Yes, No): Yes
If Yes, feeding rate: 2-4 drops Artemia suspension to each chamber at least once daily

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Russ Winchell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of mysids
Nominal Test Concentrations: 0 (control), 0.16%, 0.31%, 0.62%, 1.25%, 2.50% whole sludge
Test Initiation: 1600/08-18-88
Test Completion: 1545/08-22-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L):≥40% saturation
Test Salinity (°/oo):30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 90x50 mm glass crystallizing dish, covered
Test Container Size: 250 mL
Test Solution Volume: 200 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 24.2 mg/L, 95% confidence limits 20.8-28.2 mg/L

TABLE F-6. (Continued)

V. Deviations from Work/QA Plan

1. Sample storage time (at 4°C) was 9 days because the initial test conducted on Sample 006 was invalid (control mortality >10%). The sample was received on 08-09-88 and retested on 08-18-88.

2. All test chambers were aerated from the time of test initiation because previous testing with other samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 h period.

3. The number of test organisms per chamber was not counted within two hours of test initiation because turbidity of the sample in the chambers prevented direct observation of test organisms.

4. Mysids were fed at least once daily.

TABLE F-6. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	20.0 - 21.3	20.4	0.32	20
Salinity (°/oo)	29.0 - 31.5	30.2	0.77	13
Dissolved oxygen (mg/L)	6.1 - 7.0	6.6	0.28	20
pH	7.91- 8.20	8.04	0.09	9

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	1	1	1
0.15	-	-	-	1
0.31	-	-	-	1
0.62	-	-	-	13
1.25	-	-	-	20
2.50	-	-	10	20

Number of test organisms at time of test start = 20.

LC50 Value: 0.56% sludge.
95 Percent Confidence Limits: 0.48-0.65% sludge
Method: Trimmed Spearman-Karber with Abbott's Correction for control mortality.

VII. Comments:

*Counts of organisms at 24 h, 48 h, and 72 h were impeded by presence of solids in test chambers. At these periods, only organisms visibly swimming were counted. When it was suspected that all organisms were dead (none observed swimming), solutions were decanted to confirm absence of living organisms. At 96 h all surviving organisms were accurately counted.

Approval: _____ Date: October 13, 1988

TABLE F-7. NEW YORK CITY (007) MYSID TOXICITY TEST REPORT

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 007-7009/NYC
Shipped by (Date, Time): SAIC-08-16-88 (Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-17-88/1050
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: black slurry
Sample Modifications: 5% dilution as 1° stock. Salinity adjusted to 30°/oo, pH adjusted to 7.91 using 200µL 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Mysid shrimp
Test Organism (Taxon): Mysidopsis bahia
Test Organism Source: MultiAqua Culture Systems, Amagensett, NY 08-17-88
Test Organism Age: approximately 72 h at time of test start
Test Organism Size: juvenile, not measured
Acclimated to Test Lab Conditions (Yes, No): Yes, received at 31°/oo
If Yes, Acclimation period: 24 h

TABLE F-7. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay, seawater, 30°/oo
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's Organochlorine Pesticides
Concentration: ND (<1.0 ppm) ND (<1.0 ppb)
Fed During Test (Yes, No): Yes
If Yes, feeding rate: 2-4 drops Artemia suspension to each chamber at least once daily

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Russ Winchell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of mysids
Nominal Test Concentrations: 0 (control), 0.31%, 0.62%, 1.25%, 2.5%, 5.0% whole sludge
Test Initiation: 1445/08-18-88
Test Completion: 1530/08-22-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 90x50 mm glass crystallizing dish, covered
Test Container Size: 250 mL
Test Solution Volume: 200 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 24.2 mg/L, 95% confidence limits 20.8-28.2 mg/L

TABLE F-7. (Continued)

V. Deviations from Work/QA Plan

1. All test chambers were aerated from the time of test initiation because previous testing with other sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 h period.

2. The number of test organisms per chamber was not counted within two hours of test initiation because turbidity associated with the sample prevented direct observation of test organisms.

3. Mysids were fed at least once daily.

TABLE F-7. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.8 - 20.9	20.2	0.33	21
Salinity (o/oo)	29.0 - 31.0	29.2	0.66	14
Dissolved oxygen (mg/L)	6.1 - 7.1	6.6	0.34	21
pH	7.93- 8.33	8.10	0.11	10

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	1	1
0.30	-	-	-	0
0.62	-	-	-	0
1.25	-	-	-	3
2.50	-	-	-	11
5.00	-	10	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 2.25% sludge.
95 Percent Confidence Limits: 1.88 - 2.70 sludge
Method: Trimmed Spearman-Karber with Abbott's Correction for control mortality.

VII. Comments:

*Counts of organisms at 24 h, 48 h, and 72 h were impeded by presence of solids in test chambers. At these periods, only organisms visibly swimming were counted. When it was suspected that all organisms were dead (none observed swimming), solutions were decanted to confirm absence of living organisms. At 96 h all surviving organisms were accurately counted.

Approval: D. W. Hill Date: October 13 1983

TABLE F-8. JOINT MEETING OF ESSEX AND UNIO COUNTY (008) MISID TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 008-8009/Joint meeting
Shipped by (Date, Time): SAIC-08-19-88 (Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-20-88/0943
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: liquid grey/black
Sample Modifications: 10% dilution as 1° stock. Salinity adjusted to 30°/oo, pH adjusted to 7.94 using 750µL 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Mysid shrimp
Test Organism (Taxon): Mysidopsis bahia
Test Organism Source: Battelle Ocean Sciences
Test Organism Age: approximately 24 h at time of test start
Test Organism Size: juvenile, not measured
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 24 h, during hatching period

TABLE F-8. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay, seawater, 30°/oo
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's Organochlorine Pesticides
Concentration: ND (<1.0 ppm) ND (<1.0 ppb)
Fed During Test (Yes, No): Yes
If Yes, feeding rate: 2-4 drops Artemia suspension to each chamber at least once daily

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Russ Winchell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of mysids
Nominal Test Concentrations: 0 (SW control), 0.62%, 1.25%, 2.5%, 5.0%, 10% whole sludge
Test Initiation: 1300/08-23-88
Test Completion: 1115/08-27-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 90x50 mm glass crystallizing dish, covered
Test Container Size: 250 mL
Test Solution Volume: 200 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 13.7 mg/L, 95% confidence limits 12.8-14.6 mg/L

TABLE F-8. (Continued)

V. Deviations from Work/QA Plan

1. Sample storage time was 75h from the time of delivery, exceeding the specification by 3 hours. The excess time was required for sample preparation.

2. All test chambers were aerated from the time of test initiation because previous testing with other samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 h period.

3. The number of test organisms per chamber was not counted within two hours of test initiation because turbidity associated with the sample prevented direct observation of test organisms.

4. Mysids were fed at least once daily.

TABLE F-8. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.0 - 21.6	20.0	0.83	20
Salinity (o/oo)	29.0 - 30.0	29.6	0.41	14
Dissolved oxygen (mg/L)	5.3 - 7.2	6.8	0.48	20
pH	7.88- 8.19	8.04	0.09	11

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.62	-	-	-	1
1.25	-	-	-	5
2.50	-	-	-	16
5.00	-	20	20	20
10.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 1.68% sludge.
95 Percent Confidence Limits: 1.37 - 2.05% sludge
Method: Trimmed Spearman-Karber

VII. Comments:

*Counts of organisms at 24 h, 48 h, and 72 h were impeded by presence of solids in test chambers. At these periods, only organisms visibly swimming were counted. When it was suspected that all organisms were dead (none observed swimming), solutions were decanted to confirm absence of living organisms. At 96 h all surviving organisms were accurately counted.

Approval: [signature] Date: October 13 1988

TABLE F-9. BERGEN COUNTY (009) MYSID TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 009-9009/Bergen County
Shipped by (Date, Time): SAIC (Date/time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-13-88/1030
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: grey/black fluid
Sample Modifications: 5% dilution as 1° stock. Salinity adjusted to 30°/oo, pH adjusted to 8.12 using 500µL 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Mysid shrimp
Test Organism (Taxon): Mysidopsis bahia
Test Organism Source: MultiAquaculture Systems, Inc., Amagansett, NY, received 08-17-88
Test Organism Age: approximately 72 h at time of test start
Test Organism Size: juvenile, not measured
Acclimated to Test Lab Conditions (Yes, No): Yes, received at 31°/oo, 25.6°C
If Yes, Acclimation period: 24 h

TABLE F-9. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay, seawater, 30°/oo
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's Organochlorine Pesticides
Concentration: ND (<1.0 ppm) ND (<1.0 ppb)
Fed During Test (Yes, No): Yes
If Yes, feeding rate: 2-4 drops Artemia suspension to each chamber at least once daily

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Russ Winchell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of mysids
Nominal Test Concentrations: 0 (SW control), 0.31%, 0.62%, 1.25%, 2.5%, 5.0% whole sludge
Test Initiation: 1210/08-18-88
Test Completion: 1420/08-22-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 90x50 mm glass crystallizing dish, covered
Test Container Size: 250 mL
Test Solution Volume: 200 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 24.2 mg/L, 95% confidence limits 20.8-28.2 mg/L

TABLE F-9. (Continued)

V. Deviations from Work/QA Plan

1. Sample storage time was 75h from the time of delivery, exceeding the specification by 3 hours. The excess time was required for sample preparation.

2. All test chambers were aerated from the time of test initiation because previous testing with other sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 h period.

3. The number of test organisms per chamber was not counted within two hours of test initiation because turbidity associated with the sample prevented direct observation of test organisms.

4. Mysids were fed at least once daily.

TABLE F-9. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.6 - 20.8	19.2	0.35	21
Salinity (o/oo)	29.5 - 31.0	30.0	0.41	14
Dissolved oxygen (mg/L)	6.2 - 7.0	6.6	0.28	21
pH	8.03- 8.18	8.10	0.04	10

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.30	-	-	-	0
0.62	-	-	-	1
1.25	-	-	-	2
2.50	-	-	-	12
5.00	-	-	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 2.10% sludge.
95 Percent Confidence Limits: 1.74 - 2.54% sludge
Method: Trimmed Spearman-Karber

VII. Comments:

*Counts of organisms at 24 h, 48 h, and 72 h were impeded by presence of solids in test chambers. At these periods, only organisms visibly swimming were counted. When it was suspected that all organisms were dead (none observed swimming), solutions were decanted to confirm absence of living organisms. At 96 h all surviving organisms were accurately counted.

Approval: [signature] Date: October 13, 1983

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TABLE F-10. WESTCHESTER COUNTY (001) MINNOW TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 001-1009/Yonkers (Westchester County)
Shipped by (Date, Time): SAIC 08-01-88/1430
Received by (Date, Time): Battelle Ocean Sciences 08-02-88/1000
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: dark brown/black "pudding-like" consistency
Sample Modifications: 1° stock = 5% of sludge in seawater. Salinity adjusted to 30% w/seawater brine. pH adjusted to 7.9 w/ 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 μm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 μg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Silverside minnow
Test Organism (Taxon): Menidia beryllina
Test Organism Source: Cultured Aquatics, Northport, NY
Test Organism Age: hatched 07-11-88/received 08/02/88; 24 days old
Loading Rate: 0.04 g/L
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 48 h

TABLE F-10. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay seawater
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's, Pesticides
Concentration: ND (<1.0 ppm), <1.0 ppb pesticides)
Fed During Test (Yes, No): No
If Yes, feeding rate: N/A

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Tom Angell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of minnows
Nominal Test Concentrations: 0 (control), 0.31%, 0.62%, 1.25%, 2.5%, 5.0%, whole sludge
Test Initiation: 1430/08-04-88
Test Completion: 1500/08-08-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 1 Liter glass jars
Test Container Size: 9 x 13 cm
Test Solution Volume: 800 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 6.60 mg/L, 95% confidence limits 6.01-7.24 mg/L

TABLE F-10. (Continued)

V. Deviations from Work/QA Plan

1. The number of test animals in test chambers was not checked immediately after distribution, nor were they checked for mortality after 2 hours of exposure. (Section 12.5.3, p. 30). The turbidity of the sludge sample prevented direct observation at these times.

2. Gentle aeration was provided to all test chambers because experience with sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 hour period, when not aerated.

3. Mortality in minnows received from a commercial supplier was greater than 10 percent during the acclimation period (Section 12.5.3, p. 30). Shipping stress and possibly accelerated salinity adjustment resulted in 12% mortality in the minnow culture during the acclimation period. In the judgement of the Task Leader, this deviation did not affect the results of the test, because minnows used for testing were apparently healthy and vigorous. Also control survival was acceptable ($\geq$90%) during the test and the reference toxicant LC50 was within the expected range. At the time, minimizing sample holding times was considered a priority and a replacement shipment of minnows was not available.

4. Adjustment rates for salinity were exceeded (Section 12.5.3, p. 30). The specification was for adjustment at $<$2 °/oo per 12h period. The minnows received for testing were received at 20 °/oo salinity despite requests from the Task Leader to receive them at a higher salinity. No other sources of minnows were available during the testing program. Minimizing sample storage time was considered a priority so acclimation periods were not extended. In the judgement of the Task Leader, this deviation did not affect the results of the test because mortality in the SW controls was acceptable($\geq$90%), and the reference toxicant LC50 was within the expected range.

TABLE F-10. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.4 - 22.0	20.4	0.89	18
Salinity (°/oo)	30.0	30.0	0.00	11
Dissolved oxygen (mg/L)	5.8 - 7.4	6.7	0.55	18
pH	7.92 - 8.09	8.04	0.08	8

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	2
0.31	-	1	1	2
0.62	-	1	1	3
1.25	-	1	7	18
2.50	1	20	20	20
5.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 0.91% sludge.
95 Percent Confidence Limits: 0.81 - 1.02 % sludge
Method: Trimmed Spearman-Karber with Abbott's Correction for control mortality.

VII. Comments:

*Counts of test organisms prior to 96 h were impeded by the turbidity of the sample. At 96h test solutions were decanted from the rest chambers and an accurate count of living/dead minnows was made.

Approval: _____ Date: January 18, 1988

TABLE F-11. NASSAU COUNTY (002) MINNOW TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 002-2009/(Nassau)
Shipped by (Date, Time): SAIC 08-02-88/(Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-03-88/1000
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: dark brown/black "pudding-like" consistency
Sample Modifications: 5% dilution as 1° stock. Salinity adjusted to 29.0% w/seawater brine. pH adjusted to 7.95 w/250µL 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Silverside minnow
Test Organism (Taxon): Menidia beryllina
Test Organism Source: Cultured Aquatics, Northport, NY
Test Organism Age: hatched 07-11-88/received 08/02/88; 24 days old
Loading Rate: 0.04 g/L
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 48 h

TABLE F-11. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay seawater
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's, Pesticides
Concentration: ND (<1.0 ppm), <1.0 ppb pesticides)
Fed During Test (Yes, No): No
If Yes, feeding rate: N/A

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Tom Angell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of minnows
Nominal Test Concentrations: 0 (control), 0.31%, 0.62%, 1.25%, 2.5%, 5.0%, whole sludge
Test Initiation: 1510/08-04-88
Test Completion: 1515/08-08-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 1 Liter glass jars
Test Container Size: 9 x 13 cm
Test Solution Volume: 800 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 6.60 mg/L, 95% confidence limits 6.01-7.24 mg/L

TABLE F-11. (Continued)

V. Deviations from Work/QA Plan

1. The number of test animals in test chambers was not checked immediately after distribution, nor were they checked for mortality after 2 hours of exposure. (Section 12.5.3, p. 30). The turbidity of the sludge sample prevented direct observation at these times.

2. Gentle aeration was provided to all test chambers because experience with sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 hour period, when not aerated.

3. Mortality in minnows received from a commercial supplier was greater than 10 percent during the acclimation period (Section 12.5.3, p. 30). Shipping stress and possibly accelerated salinity adjustment resulted in 12% mortality in the minnow culture during the acclimation period. In the judgement of the Task Leader, this deviation did not affect the results of the test, because minnows used for testing were apparently healthy and vigorous. Also control survival was acceptable (≥90%) during the test and the reference toxicant LC50 was within the expected range. At the time, minimizing sample holding times was considered a priority and an replacement shipment of minnows was not available.

4. Adjustment rates for salinity were exceeded (Section 12.5.3, p. 30). The specification was for adjustment at <2°/oo per 12h period. The minnows received for testing were received at 20°/oo salinity despite requests from the Task Leader to receive them at a higher salinity. No other sources of minnows were available during the testing program. Minimizing sample storage time was considered a priority so acclimation periods were not extended. In the judgement of the Task Leader, this deviation did not affect the results of the test because mortality in the SW controls was acceptable (≥90%), and the reference toxicant LC50 was within the expected range.

TABLE F-11. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.2 - 21.7	20.2	0.84	20
Salinity (o/oo)	30.0	30.0	0.00	11
Dissolved oxygen (mg/L)	5.7 - 7.4	6.7	0.56	19
pH	7.89 - 8.04	7.99	0.06	8

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.31	0	0	0	0
0.62	0	0	0	1
1.25	0	0	0	1
2.50	0	1	2	10
5.00	3	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 2.33% sludge.
95 Percent Confidence Limits: 1.94 - 2.80 % sludge
Method: Trimmed Spearman-Karber.

VII. Comments:

*Counts of test organisms prior to 96 h were impeded by the turbidity of the sample. At 96h test solutions were decanted from the rest chambers and an accurate count of living/dead minnows was made.

Approval: _____ Date: October 18 1988

TABLE F-12. MIDDLESEX COUNTY (003) MINNOW TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 003-3009/(Middlesex)
Shipped by (Date, Time): SAIC 08-18-88/(Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-19-88/1000
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: very liquid--grey/black
Sample Modifications: 10% dilution as 1° stock. Salinity adjusted to 30.0‰. pH adjusted to 7.96 using 50 µL 10N NaOH

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Silverside minnow
Test Organism (Taxon): Menidia beryllina
Test Organism Source: Cultured Aquatics, Northport, NY
Test Organism Age: hatched 7/18/88 and 7/26/88; 28-36 days old
Loading Rate: 0.22 g/L
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 48 h

TABLE F-12. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay seawater
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's, Pesticides
Concentration: ND (<1.0 ppm), <1.0 ppb pesticides)
Fed During Test (Yes, No): No
If Yes, feeding rate: N/A

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Tom Angell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of minnows
Nominal Test Concentrations: 0 (control), 0.62%, 1.25%, 2.5%, 5.0%, 10.0% whole sludge
Test Initiation: 1220/08-23-88
Test Completion: 1440/08-27-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L):≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 1 Liter glass jars
Test Container Size: 9 x 13 cm
Test Solution Volume: 800 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 6.37 mg/L, 95% confidence limits 5.71-7.12 mg/L

TABLE F-12. (Continued)

V. Deviations from Work/QA Plan

1. The number of test animals in test chambers was not checked immediately after distribution, nor were they checked for mortality after 2 hours of exposure. (Section 12.5.3, p. 30). The turbidity of the sludge sample prevented direct observation at these times.

2. Gentle aeration was provided to all test chambers because experience with sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 hour period, when not aerated.

3. Sample holding time exceeded 72 h (Section 7.3.1, p. 8). Sludge sample 003 was delivered on a Friday and stored until the following Tuesday (98 h) when testing could be initiated.

4. The age of minnows used for testing exceeded specification (Table 6, p.25). The age of minnows used for testing sludge sample 003 was 28-36 days. This deviation resulted from difficulties in coordinating sample deliveries with the availability of minnows 14-28 days old. In the judgement of the Task Leader, this did not affect the results of the test because control survival was acceptable ($\geq$ 90%), loading rates were not violated (<0.4 g wet weight per liter), and the reference toxicant test result (LC50) was nearly identical to the LC50 obtained for the specified age group.

TABLE F-12. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.0 - 20.9	19.9	0.65	20
Salinity (o/oo)	29.0 - 31.0	29.9	0.70	13
Dissolved oxygen (mg/L)	5.7 - 7.3	6.9	0.38	20
pH	7.90 - 8.05	7.97	0.05	9

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.62	0	0	0	0
1.25	0	0	0	0
2.50	0	0	0	1
5.00	0	1	1	4
10.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 5.95% sludge.
95 Percent Confidence Limits: 5.16 - 6.85 % sludge
Method: Trimmed Spearman-Karber.

VII. Comments:

*Counts of test organisms prior to 96 h were impeded by the turbidity of the sample. At 96h test solutions were decanted from the rest chambers and an accurate count of living/dead minnows was made.

Approval: [signature] Date: October 18, 1988

TABLE F-13. PASSAIC VALLEY (004) MINNOW TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 004-4009/(Passaic Valley)
Shipped by (Date, Time): SAIC 08-04-88/(Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-05-88/1024
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: dark brown slurry
Sample Modifications: 2% dilution as 1° stock. Salinity adjusted to 29.0%. pH adjusted to 7.90 using 450 µL 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Silverside minnow
Test Organism (Taxon): Menidia beryllina
Test Organism Source: Cultured Aquatics, Northport, NY
Test Organism Age: hatched 7/11/88; 24 days old
Loading Rate: 0.08 g/L
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 72 h

TABLE F-13. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay seawater
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's, Pesticides
Concentration: ND (<1.0 ppm), <1.0 ppb pesticides)
Fed During Test (Yes, No): No
If Yes, feeding rate: N/A

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): No
Test Description: 96 h acute
Test Conducted By: Tom Angell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of minnows
Nominal Test Concentrations: 0 (control), 0.12%, 0.25%, 0.50%, 1.00%, 2.00% whole sludge
Test Initiation: 1510/08-05-88
Test Completion: 1630/08-09-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L):≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 1 Liter glass jars
Test Container Size: 9 x 13 cm
Test Solution Volume: 800 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 6.60 mg/L, 95% confidence limits 6.01-7.24 mg/L

TABLE F-13. (Continued)

V. Deviations from Work/QA Plan

1. The number of test animals in test chambers was not checked immediately after distribution, nor were they checked for mortality after 2 hours of exposure. (Section 12.5.3, p. 30). The turbidity of the sludge sample prevented direct observation at these times.

2. Gentle aeration was provided to all test chambers because experience with sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 hour period, when not aerated.

3. Mortality in minnows received from a commercial supplier was greater than 10 percent during the acclimation period (Section 12.5.3, p. 30). Shipping stress and possibly accelerated salinity adjustment results in 12% mortality in the minnow culture during the acclimation period. In the judgement of the Task Leader, this deviation did not affect the results of the test, because minnows used for testing were apparently healthy and vigorous. Also control survival was acceptable ($\geq$90%) during the test and the reference toxicant LC50 was within the expected range. At the time, minimizing sample holding times was considered a priority and a replacement shipment of minnows was not available.

4. Adjustment rates for salinity were exceeded (Section 12.5.3, p.30). The specification was for adjustment at $<2^{o}/oo$ per 12 h period. The minnows received for testing were received at $20^{o}/oo$ salinity despite requests from the Task Leader to receive them at a higher salinity. No other sources of minnows were available during the testing program. Minimizing sample storage time was considered a priority so acclimation periods were not extended. In the judgement of the Task Leader, this deviation did not affect the results of the test because mortality in the SW controls was acceptable ($\geq$90%), and the reference toxicant LC50 was within the expected range.

TABLE F-13. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.2 - 21.7	20.3	0.74	18
Salinity (°/oo)	29.5 - 30.0	29.8	0.25	15
Dissolved oxygen (mg/L)	3.1 - 7.3	6.3	1.27	18
pH	7.86 - 8.06	7.85	0.26	12

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.12	0	0	0	1
0.25	0	0	2	2
0.50	2	7	9	9
1.00	20	20	20	20
2.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 0.49% sludge.
95 Percent Confidence Limits: 0.40 - 0.60 % sludge
Method: Trimmed Spearman-Karber.

VII. Comments:

*Counts of test organisms prior to 96 h were impeded by the turbidity of the sample. At 96h test solutions were decanted from the rest chambers and an accurate count of living/dead minnows was made.

Approval: [signature] Date: October 19, 1988

TABLE F-14. LINDEN ROSELLE (005) MINNOW TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 005-5009/(Linden Roselle)
Shipped by (Date, Time): SAIC 08-08-88/(Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-09-88/0930
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: black ooze/odorous
Sample Modifications: 3% dilution as 1° stock. Salinity adjusted to 30.0°/oo. pH adjusted to 7.90 using 200 µL 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Silverside minnow
Test Organism (Taxon): Menidia beryllina
Test Organism Source: Cultured Aquatics, Northport, NY
Test Organism Age: hatched 7/18/88; 24 days old
Loading Rate: 0.09 g/L
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 48 h

TABLE F-14. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay seawater
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's, Pesticides
Concentration: ND (<1.0 ppm), <1.0 ppb pesticides)
Fed During Test (Yes, No): No
If Yes, feeding rate: N/A

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Tom Angell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of minnows
Nominal Test Concentrations: 0 (control), 0.19%, 0.38%, 0.75%, 1.50%, 3.00% whole sludge
Test Initiation: 1110/08-11-88
Test Completion: 1145/08-15-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 1 Liter glass jars
Test Container Size: 9 x 13 cm
Test Solution Volume: 800 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 6.60 mg/L, 95% confidence limits 6.00-7.26 mg/L

TABLE F-14. (Continued)

V. Deviations from Work/QA Plan

1. The number of test animals in test chambers was not checked immediately after distribution, nor were they checked for mortality after 2 hours of exposure. (Section 12.5.3, p. 30). The turbidity of the sludge sample prevented direct observation at these times.

2. Gentle aeration was provided to all test chambers because experience with sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 hour period, when not aerated.

3. Adjustment rates for salinity were exceeded (Section 12.5.3, p.30). The specification was for adjustment at <2°/oo per 12 h period. The minnows received for testing were received at 20°/oo salinity despite requests from the Task Leader to receive them at a higher salinity. No other sources of minnows were available during the testing program. Minimizing sample storage time was considered a priority so acclimation periods were not extended. In the judgement of the Task Leader, this deviation did not affect the results of the test because mortality in the SW controls was acceptable (≥90%), and the reference toxicant LC50 was within the expected range.

TABLE F-14. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.5 - 21.4	20.0	0.64	18
Salinity (°/oo)	29.5 - 30.0	29.8	0.34	12
Dissolved oxygen (mg/L)	5.7 - 7.5	7.0	0.45	18
pH	7.83 - 8.09	8.00	0.08	8

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.19	0	0	1	2
0.38	0	0	0	1
0.75	0	3	10	19
1.50	2	20	20	20
3.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 0.53% sludge.
95 Percent Confidence Limits: 0.51 - 0.56 % sludge
Method: Trimmed Spearman-Karber.

VII. Comments:

*Counts of test organisms prior to 96 h were impeded by the turbidity of the sample. At 96h test solutions were decanted from the rest chambers and an accurate count of living/dead minnows was made.

Approval: _____ Date: October 18, 1988

TABLE F-15. RAHWAY VALLEY (006) MINNOW TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 006-6009/(Rahway Valley)
Shipped by (Date, Time): SAIC 08-08-88/(Time not documented)
Received by (Date, Time): Battelle Ocean Sciences
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: black liquid
Sample Modifications: 5% dilution as 1° stock. Salinity adjusted to 30°/oo. pH adjusted to 7.88 using 250 µL 10N NaOH.

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Silverside minnow
Test Organism (Taxon): *Menidia beryllina*
Test Organism Source: Cultured Aquatics, Northport, NY
Test Organism Age: hatched 7/18/88; 24 days old
Loading Rate: 0.06 g/L
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 48 h

TABLE F-15. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay seawater
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's, Pesticides
Concentration: ND (<1.0 ppm), <1.0 ppb pesticides)
Fed During Test (Yes, No): No
If Yes, feeding rate: N/A

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Tom Angell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of minnows
Nominal Test Concentrations: 0 (control), 0.31%, 0.62%, 1.25%, 2.50%, 5.00% whole sludge
Test Initiation: 1155/08-11-88
Test Completion: 1230/08-15-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 1 Liter glass jars
Test Container Size: 9 x 13 cm
Test Solution Volume: 800 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 6.60 mg/L, 95% confidence limits 6.00-7.26 mg/L

TABLE F-15. (Continued)

V. Deviations from Work/QA Plan

1. The number of test animals in test chambers was not checked immediately after distribution, nor were they checked for mortality after 2 hours of exposure. (Section 12.5.3, p. 30). The turbidity of the sludge sample prevented direct observation at these times.

2. Gentle aeration was provided to all test chambers because experience with sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 hour period, when not aerated.

3. Adjustment rates for salinity were exceeded (Section 12.5.3, p.30). The specification was for adjustment at $<2^{o}/oo$ per 12 h period. The minnows received for testing were received at $20^{o}/oo$ salinity despite requests from the Task Leader to receive them at a higher salinity. No other sources of minnows were available during the testing program. Minimizing sample storage time was considered a priority so acclimation periods were not extended. In the judgement of the Task Leader, this deviation did not affect the results of the test because mortality in the SW controls was acceptable ($\geq$90%), and the reference toxicant LC50 was within the expected range.

TABLE F-15. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.4 - 21.2	19.9	0.60	18
Salinity (o/oo)	28.5 - 30.0	29.5	0.54	12
Dissolved oxygen (mg/L)	5.2 - 7.5	7.0	0.49	18
pH	7.90 - 8.15	8.02	0.08	8

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	1
0.31	0	0	1	1
0.62	0	0	0	0
1.25	0	1	1	6
2.50	12	20	20	20
5.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 1.49% sludge.
95 Percent Confidence Limits: 1.30 - 1.70 % sludge
Method: Trimmed Spearman-Karber with Abbott's Correction for control mortality.

VII. Comments:

*Counts of test organisms prior to 96 h were impeded by the turbidity of the sample. At 96h test solutions were decanted from the rest chambers and an accurate count of living/dead minnows was made.

Approval: _____ Date: October 18, 1988

TABLE F-16. NEW YORK CITY (007) MINNOW TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. **Toxicity Test--Compound and Test Identification**

Description of Sample: 007-7009/(Middlesex)
Shipped by (Date, Time): SAIC 08-16-88/(Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-17-88/1050
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: black slurry
Sample Modifications: 5% dilution as 1° stock. Salinity adjusted to 30.0%. pH adjusted to 7.91 using 200 µL 10N NaOH

II. **Toxicity Test--Dilution Water Characterization**

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. **Toxicity Test--Test System**

Test Organisms (Common Name): Silverside minnow
Test Organism (Taxon): Menidia beryllina
Test Organism Source: Cultured Aquatics, Northport, NY
Test Organism Age: hatch dates 07/18/88 and 07/26/88; 24-31 days old
Loading Rate: 0.14 g/L
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: minimum of 48 h

TABLE F-16. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay seawater
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's, Pesticides
Concentration: ND (<1.0 ppm), <1.0 ppb pesticides)
Fed During Test (Yes, No): No
If Yes, feeding rate: N/A

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Tom Angell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of minnows
Nominal Test Concentrations: 0 (control), 0.31%, 0.62%, 1.25%, 2.50%, 5.00% whole sludge
Test Initiation: 1150/08-18-88
Test Completion: 1440/08-22-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 1 Liter glass jars
Test Container Size: 9 x 13 cm
Test Solution Volume: 800 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 6.37 mg/L, 95% confidence limits 5.71-7.12 mg/L

TABLE F-16. (Continued)

V. Deviations from Work/QA Plan

1. The number of test animals in test chambers was not checked immediately after distribution, nor were they checked for mortality after 2 hours of exposure. (Section 12.5.3, p. 30). The turbidity of the sludge sample prevented direct observation at these times.

2. Gentle aeration was provided to all test chambers because experience with sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 hour period, when not aerated.

3. The age of minnows used for testing exceeded specification (Table 6, p.25). The age of minnows used for testing sludge sample 007 was 24-31 days. This deviation resulted from difficulties in coordinating sample deliveries with the availability of minnows 14-28 days old. In the judgement of the Task Leader, this did not affect the results of the test because control survival was acceptable ($\geq$ 90%), loading rates were not violated ($<$0.4 g wet weight per liter), and the reference toxicant test result (LC50) was nearly identical to the LC50 obtained for the specified age group.

TABLE F-16. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.7 - 20.7	20.1	0.32	19
Salinity (°/oo)	30.0 - 31.0	30.2	0.33	12
Dissolved oxygen (mg/L)	6.3 - 7.2	6.8	0.30	19
pH	7.99 - 8.12	8.06	0.06	9

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.31	0	0	0	0
0.62	0	0	0	1
1.25	0	0	0	2
2.50	2	4	7	20
5.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 1.59% sludge.
95 Percent Confidence Limits: 1.42 - 1.79% sludge
Method: Trimmed Spearman-Karber.

VII. Comments:

*Counts of test organisms prior to 96 h were impeded by the turbidity of the sample. At 96h test solutions were decanted from the rest chambers and an accurate count of living/dead minnows was made.

Approval: [signature] Date: October 18, 1988

TABLE F-17. JOINT MEETING OF ESSEX AND UNION COUNTY (008) MINNOW TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. Toxicity Test--Compound and Test Identification

Description of Sample: 008-8009/(Joint Meeting)
Shipped by (Date, Time): SAIC 08-16-88/(Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-20-88/0943
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: liquid, grey/black
Sample Modifications: 10% dilution as 1° stock. Salinity adjusted to 30.0°/oo. pH adjusted to 7.94 using 750 µL 10N NaOH

II. Toxicity Test--Dilution Water Characterization

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. Toxicity Test--Test System

Test Organisms (Common Name): Silverside minnow
Test Organism (Taxon): Menidia beryllina
Test Organism Source: Cultured Aquatics, Northport, NY
Test Organism Age: hatch dates 07/18/88 and 07/26/88; 28-36 days old
Loading Rate: 0.25 g/L
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: 7-14 days

TABLE F-17. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay seawater
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's, Pesticides
Concentration: ND (<1.0 ppm), <1.0 ppb pesticides)
Fed During Test (Yes, No): No
If Yes, feeding rate: N/A

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Tom Angell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of minnows
Nominal Test Concentrations: 0 (control), 0.62%, 1.25%, 2.50%, 5.00%, 10.00% whole sludge
Test Initiation: 1205/08-23-88
Test Completion: 1255/08-27-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L):≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 1 Liter glass jars
Test Container Size: 9 x 13 cm
Test Solution Volume: 800 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 6.37 mg/L, 95% confidence limits 5.71-7.12 mg/L

TABLE F-17. (Continued)

V. Deviations from Work/QA Plan

1. The number of test animals in test chambers was not checked immediately after distribution, nor were they checked for mortality after 2 hours of exposure. (Section 12.5.3, p. 30). The turbidity of the sludge sample prevented direct observation at these times.

2. Gentle aeration was provided to all test chambers because experience with sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 hour period, when not aerated.

3. The age of minnows used for testing exceeded specification (Table 6, p.25). The age of minnows used for testing sludge sample 008 was 24-31 days. This deviation resulted from difficulties in coordinating sample deliveries with the availability of minnows 14-28 days old. In the judgement of the Task Leader, this did not affect the results of the test because control survival was acceptable ($\geq$ 90%), loading rates were not violated (<0.4 g wet weight per liter), and the reference toxicant test result (LC50) was nearly identical to the LC50 obtained for the specified age group.

TABLE F-17. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.0 - 20.8	19.8	0.66	18
Salinity (o/oo)	29.0 - 31.0	30.0	0.50	12
Dissolved oxygen (mg/L)	5.5 - 7.4	6.8	0.51	18
pH	7.93 - 8.04	8.01	0.06	10

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.62	0	0	1	1
1.25	0	0	0	0
2.50	1	5	15	17
5.00	20	20	20	20
10.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 1.92% sludge.
95 Percent Confidence Limits: 1.71 - 2.16% sludge
Method: Trimmed Spearman-Karber.

VII. Comments:

*Counts of test organisms prior to 96 h were impeded by the turbidity of the sample. At 96h test solutions were decanted from the rest chambers and an accurate count of living/dead minnows was made.

Approval: [signature] Date: October 19 1988

TABLE F-18. BERGEN COUNTY (009) MINNOW TOXICITY TEST REPORT.

Testing Laboratory: Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

Title of Study: Sewage Sludge Characterization

Client: U.S. Environmental Protection Agency

Task Leader: J. Williams

I. **Toxicity Test--Compound and Test Identification**

Description of Sample: 009-9009/(Bergen County)
Shipped by (Date, Time): SAIC 08-12-88/(Time not documented)
Received by (Date, Time): Battelle Ocean Sciences 08-13-88/1030
Duxbury, Massachusetts
Test Material Storage Location: Tox Lab Refrigerator
Storage Conditions: 4°C
Sample Characterization: grey/black fluid
Sample Modifications: 5% dilution as 1° stock. Salinity adjusted to 30.0°/oo. pH adjusted to 8.12 using 500 µL 10N NaOH

II. **Toxicity Test--Dilution Water Characterization**

Type of Dilution Water: Duxbury Bay seawater
Dilution Water Treatment: Filtered, Unfiltered, 20 µm filtered
If filtered, Size of filter
Dilution Water Chemical Analysis (Date): 08-26-88
Dilution Water Particulate Matter: ND (<1 mg/L)
Dilution Water Total Organic Carbon: 0.73 mg/L
Dilution Water Un-ionized Ammonia: 1.3 mg/L
Dilution Water Residual Chlorine: ND (<0.005 mg/L)
Dilution Water Total Pesticides: ND (<0.25 ng/L)
Dilution Water PCB: ND (<2.5 µg/L)

III. **Toxicity Test--Test System**

Test Organisms (Common Name): Silverside minnow
Test Organism (Taxon): Menidia beryllina
Test Organism Source: Cultured Aquatics, Northport, NY
Test Organism Age: hatch dates 07/18/88 and 07/26/88; 24-31 days old
Loading Rate: 0.19 g/L
Acclimated to Test Lab Conditions (Yes, No): Yes
If Yes, Acclimation period: minimum of 48 h

TABLE F-18. (Continued)

III. Toxicity Test--Test System (Continued)

Test Organism Culture Method: static
Test Organism Culture Medium: Duxbury Bay seawater
Organism Food Type: Artemia salina nauplii (<48 h)
Food Chemical Analysis (Yes, No): Yes
If Yes, Specification: PCB's, Pesticides
Concentration: ND (<1.0 ppm), <1.0 ppb pesticides)
Fed During Test (Yes, No): No
If Yes, feeding rate: N/A

IV. Toxicity Test--Specifications

Test Protocol Followed: EPA/600/4-85/013, Methods for Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms, March, 1985
Preliminary Testing (If Yes, Description): Screening test
Test Description: 96 h acute
Test Conducted By: Tom Angell/Battelle
Test End Point: Mortality
Test Dosing Method (Flow-through, Static, Renewal): Static
Sample Appearance: Within dosing range, settleable solids hampered direct observation of minnows
Nominal Test Concentrations: 0 (control), 0.31%, 0.62%, 1.25%, 2.50%, 5.00% whole sludge
Test Initiation: 1320/08-18-88
Test Completion: 1500/08-22-88
Test Duration: 96 h
Test Temperature (°C): 20 ± 2, Dissolved oxygen (mg/L): ≥40% saturation
Test Salinity (°/oo): 30 ± 2, pH: 8.0 ± 0.2
Photoperiod During Test: 14:10
Light Intensity: ambient laboratory level
Test Container Type: 1 Liter glass jars
Test Container Size: 9 x 13 cm
Test Solution Volume: 800 mL
Number of Concentrations (including control(s)): 6
Number of Replicates per Treatment: 2
Number of Organisms per Replicate: 10
Reference Test, Sodium dodecyl sulfate: LC50 6.37 mg/L, 95% confidence limits 5.71-7.12 mg/L

TABLE F-18. (Continued)

V. Deviations from Work/QA Plan

1. The number of test animals in test chambers was not checked immediately after distribution, nor were they checked for mortality after 2 hours of exposure. (Section 12.5.3, p. 30). The turbidity of the sludge sample prevented direct observation at these times.

2. Gentle aeration was provided to all test chambers because experience with sludge samples demonstrated that dissolved oxygen concentration dropped to near 40% of saturation within an 8-10 hour period, when not aerated.

3. The age of minnows used for testing exceeded specification (Table 6, p.25). The age of minnows used for testing sludge sample 009 was 24-31 days. This deviation resulted from difficulties in coordinating sample deliveries with the availability of minnows 14-28 days old. In the judgement of the Task Leader, this did not affect the results of the test because control survival was acceptable ($\geq$ 90%), loading rates were not violated ($<$0.4 g wet weight per liter), and the reference toxicant test result (LC50) was nearly identical to the LC50 obtained for the specified age group.

4. Sample holding time exceeded 72h (Section 7.3.1, p8). Sludge sample 009 was delivered on a Saturday and test organisms were not available until 5 days later.

5. Adjustment rates for salinity were exceeded (Section 12.5.3, p.30). The specification was for adjustment at $<$2°/oo per 12 h period. The minnows received for testing were received 20°/oo salinity despite requests from the Task Leader to receive them at a higher salinity. No other sources of minnows were available during the testing program. Minimizing sample storage time was considered a priority so acclimation periods were not extended. In the judgement of the Task Leader, this deviation did not affect the results of the test because mortality in the SW controls was acceptable ($\geq$90%), and the reference toxicant LC50 was within the expected range.

TABLE F-18. (Continued)

VI. Toxicity Test--Results (Raw data attached)

Water Quality Data Summary

Parameter	Range	Mean	s	n
Temperature (°C)	19.8 - 20.8	20.2	0.25	18
Salinity (°/oo)	29.5 - 30.5	30.1	0.29	12
Dissolved oxygen (mg/L)	6.3 - 7.1	6.8	0.27	18
pH	8.00 - 8.23	8.11	0.06	9

Mortality Data

Sludge Dilution (% Whole Sludge)	Number of Organisms Observed Dead* 24 h	48 h	72 h	96 h
Seawater Control	0	0	0	0
0.31	0	0	1	1
0.62	0	0	0	1
1.25	0	0	0	4
2.50	0	4	20	20
5.00	20	20	20	20

Number of test organisms at time of test start = 20.

LC50 Value: 1.55% sludge.
95 Percent Confidence Limits: 1.34 - 1.78% sludge
Method: Trimmed Spearman-Karber.

VII. Comments:

*Counts of test organisms prior to 96 h were impeded by the turbidity of the sample. At 96h test solutions were decanted from the rest chambers and an accurate count of living/dead minnows was made.

Approval: _____ Date: October 18, 1988