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CERCLA SITE DISCHARGES TO POTWS

TREATABILITY MANUAL

Prepared by

THE INDUSTRIAL TECHNOLOGY DIVISION

OFFICE OF WATER REGULATIONS AND STANDARDS

OFFICE OF WATER

Prepared for

OFFICE OF EMERGENCY AND REMEDIAL RESPONSE

U.S. ENVIRONMENTAL PROTECTION AGENCY

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EXECUTIVE SUMMARY

The "CERCLA Site Discharges to POTWs Treatability Manual" was prepared for the U.S. Environmental Protection Agency under Contract No. 68-03-3412. The manual is a compilation of mostly technical information and treatability data obtained in a study conducted by the Office of Water Regulations and Standards Industrial Technology Division (OWRS-ITD) on Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) wastewater discharges to POTWs. The information is provided to aid in the evaluation of the feasibility of discharging wastes from CERCLA sites to publicly owned treatment works (POTWs). This executive summary provides a brief overview of the contents of each section of the manual.

SECTION 1 - SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES. This section lists the October 1986 analytical data from proposed and final National Priorities List (NPL) sites, providing an overview of the types of contaminants that may be present in the CERCLA wastestream.

SECTION 2 - SUBSTANCES FOUND IN CERCLA SITE WASTEWATERS. As part of the ITD CERCLA site discharges to POTWs study, samples from seventeen sites with contaminated groundwater and from three sites with leachate were collected and analyzed for the full ITD list of 443 compounds. Tables were generated to give the user an indication of the contaminants, the frequency of occurrence, and the concentrations at which they occurred at the groundwater and leachate CERCLA sites sampled.

SECTION 3 - CERCLA SITE SAMPLING DATA REPORT. Section 3 presents an evaluation of the sampling data from 20 sampling visits regarding the following:

1. Frequency of occurrence of compounds,

2. Variations (daily and annually) in the treatability of CERCLA site wastewater,

3. Contaminant treatability,

4. Comparison of CERCLA site treatability data to data in the USEPA Office of Research and Development (ORD) Treatability Data Base, and

5. Comparison of indicator parameter treatability to organic contaminant treatability.

SECTION 4 - SUMMARY SITE VISIT REPORT. Site visits were conducted with personnel associated with 27 CERCLA sites which had existing, potential, or denied discharges to a POTW. The site visits consisted of meetings with members of USEPA, state, POTW, or potentially responsible parties (PRPs) in order to discuss experiences with implementing the discharge of wastewater from a specific CERCLA site.

Section 4 presents a summary of individual site visits conducted with representatives from EPA, state, POTW, or responsible parties to discuss the discharge of a specific CERCLA site wastewater to a POTW. The information presents the major political, technical, and economic issues concerning the discharge of CERCLA site wastewaters to POTWs that were found to arise in the negotiations and approval process, and is provided to aid the user in foreseeing potential issues that may require consideration.

SECTION 5 - STATE NPDES PROGRAM STATUS. Section 5 presents the status of State National Pollutant Discharge Elimination System (NPDES) programs. The table indicates whether the state is authorized to administer the NPDES permit program, regulate federal facilities, and whether the state has an approved state pretreatment program. The NPDES authority can assist in the identification of POTWs that may accept a CERCLA site discharge and provide specific information about the POTW that will be helpful for screening the POTWs during the RI/FS process. Section 5 identifies the appropriate agency to contact (either the USEPA regional office or a state agency) for NPDES issues.

SECTION 6 - PERCENT REMOVAL OF COMPOUNDS IN POTWS. To evaluate the feasibility of discharging wastes from CERCLA sites to POTWs, the user of the treatability manual may need to estimate the treatability of compounds in the CERCLA waste and their potential to impact removal processes in the treatment system. The removal mechanisms in a POTW include air stripping, partitioning (sorption) to the solids and biomass, and biodegradation. Section 6 presents summary tables of published treatability data for individual compounds that can be used to estimate a mass balance for each compound detected in a CERCLA wastestream if site specific treatability data is unavailable.

SECTION 7 - COMPUTER SOFTWARE PACKAGES. Section 7 presents a list of computer software packages that can assist the POTW authorities and regulatory agencies in developing local limits. Local limits can be used to determine the level of pretreatment required at a CERCLA site.

SECTION 8 - PHYSICAL/CHEMICAL CONSTANTS OF COMPOUNDS. Section 8 presents the compound name, the molecular weight, Henry's Law Constant, Log octanol/water coefficient (Kow), and solubility of compounds where information was available for compounds on the ITD list of analytes (Section 9). The physical and chemical constants of compounds detected in CERCLA wastestreams can be used to evaluate a compound's fate in a POTW where no other data are available. The compound's fate can be estimated by using its physical and chemical constants (as well as its compound class) to locate similar compounds for which fate (percent removal) data are available.

SECTION 9 - USEPA CONTAMINANT LISTS. Section 9 presents several commonly referenced lists of compounds: a) the ITD List of Analytes, taken from "The 1987 Industrial Technology Division List of Analytes"; USEPA Industrial Technology Division; Office of Water Regulations and Standards; Washington, D.C.; March 1987, b) the Target Compound List (TCL), a list developed by the Superfund program, which contains compounds commonly found at CERCLA sites, c) the Priority Pollutant List, developed by the USEPA Office of Water and lists organic toxic pollutants, d) the "Appendix VIII List", a list of the RCRA

hazardous constituents as defined in the Federal Register, Volume 51, Number 151 Appendix VIII, and e) the "Section 110 SARA List", a list of 100 hazardous substances as defined by Section 110 of SARA in the Federal Register, Volume 52, Number 74.

SECTION 10 - DESCRIPTION OF AEROBIC BIOLOGICAL SYSTEMS. Various studies have documented the fate of contaminants in the most common conventional biological treatment processes. Those processes include aerated lagoons, activated sludge, trickling filters, rotating biological contactors (RBCs), and powdered activated carbon treatment (PACT) facilities. Section 10 presents a description of each of the above listed treatment processes.

SECTION 11 - INFORMATION FOR EVALUATING PRETREATMENT TECHNOLOGIES.

Prior to discharge of a CERCLA wastestream to a POTW, the stream may require pretreatment. Pretreatment systems are commonly composed of a number of unit operations, depending on the types of contaminants and concentrations in a wastestream. Section 11 provides information on 12 separate unit operations that may be used to construct a pretreatment system. A description of each unit operation (how the process works, equipment types available, advantages and limitations, design criteria, etc.) and a detailed evaluation of the process (effectiveness, implementability, costs, etc.) are included. The section is structured to contain information in the same format as a CERCLA Feasibility Study.

The user of the technology manual may use Section 11 in two ways:

- To help make screening decisions while assembling the pretreatment train.
- To provide information that can be used in the detailed evaluation of the "discharge to POTW" alternative.

SECTION 12 - ORD TREATABILITY PROJECTS. The USEPA Office of Research and Development Water Engineering Research Laboratory (ORD-WERL) conducted research to support the evaluation for the potential to use POTWs to treat CERCLA and Resource Conservation and Recovery Act (RCRA) wastes. ORD, in conjunction with the Engineering Department at the University of Cincinnati, performed pilot-scale treatability studies at the EPA Testing and Evaluation Facility to generate treatability data for toxic organic compounds. Eight technical papers were produced as a result of the studies. Section 12 presents a list of the papers with a brief description of each study.

SECTION 13 - WERL TREATABILITY DATA BASE. The USEPA Office of Research and Development Water Engineering Research Laboratory (ORD-WERL) developed and is continuing to expand a data base containing information on the treatability of compounds in various types of waters and wastewaters. The data base consists of selected published data taken from government reports and data bases, peer reviewed journals, and various other publications. Each source has been reviewed by a quality review committee before inclusion in the data base. In addition to treatability data, the data base contains chemical and physical

properties, environmental data, and adsorption data for specific compounds, where available. Section 13 includes installation instructions.

SECTION 14 - FATE MODEL. As part of the CERCLA Site Discharges to POTWs study, a user friendly, computerized model has been developed to evaluate the fate of inorganic and organic pollutants discharged to POTWs. POTW managers and feasibility study writers can use the model to evaluate the fate and treatability of toxic pollutants discharged to POTWs by predicting the overall percent removal of the compounds and percent removals of organic compounds due to volatilization, sorption, and biodegradation.

The FATE User's Manual, provided in Section 14, introduces the user of the model to the concepts and assumptions used in its development and presents simple instructions for the model's operation.

SECTION 1

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES

OCTOBER 1986

SECTION 1 - SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES. This section lists the October 1986 analytical data obtained from 888 proposed and final National Priorities List (NPL) sites, providing an overview of the types of contaminants that may be present in the CERCLA wastestream.

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES
OCTOBER 1986

CHEMICAL NAME	FREQUENCY
TRICHLOROETHYLENE (TCE)	311
LEAD (PB)	286
TOLUENE	243
CHROMIUM AND COMPOUNDS, NOS (CR)	220
BENZENE	208
CHLOROFORM	179
POLYCHLORINATED BIPHENYLS, NOS	159
1,1,1-TRICHLOROETHANE	151
1,1,2,2-TETRACHLOROETHENE	149
ZINC AND COMPOUNDS, NOS (ZN)	142
CADMIUM (CD)	141
ARSENIC	141
PHENOL	121
XYLENE	113
ETHYLBENZENE	111
COPPER AND COMPOUNDS, NOS (CU)	106
1,2-TRANS-DICHLOROETHYLENE	104
METHYLENE CHLORIDE	91
1,1-DICHLOROETHANE	85
1,1-DICHLOROETHENE	79
MERCURY	78
CYANIDES (SOLUBLE SALTS), NOS	73
VINYLCHLORIDE	70
NICKEL AND COMPOUNDS, NOS (NI)	65
1,2-DICHLOROETHANE	64
CHLOROBENZENE	64
CARBON TETRACHLORIDE	61
HEAVY METALS, NOS	56
PENTACHLOROPHENOL (PCP)	53
NAPHTHALENE	48
METHYL ETHYL KETONE	42
TRICHLOROETHANE, NOS	38
IRON AND COMPOUNDS, NOS (FE)	33
BARIUM	32
VOLATILE ORGANICS, NOS	31
MANGANESE AND COMPOUNDS, NOS (MN)	31
ACETONE	30
PHENANTHRENE	28
BENZO A PYRENE	27
CHROMIUM, HEXAVALENT	27
1,1,2-TRICHLOROETHANE	25
ARSENIC AND COMPOUNDS, NOS (AS)	25
DICHLOROETHYLENE, NOS	24
DDT	22
STYRENE	22

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES
OCTOBER 1986

CHEMICAL NAME	FREQUENCY
ANTHRACENE	22
LINDANE	21
BIS (2-ETHYLHEXYL) PHTHALATE	21
TETRACHLOROETHANE, NOS	21
SELENIUM	20
1,1,2,2-TETRACHLOROETHANE	19
CREOSOTE	19
PYRENE	19
WASTE OILS/SLUDGES	18
SULFURIC ACID	18
ALUMINUM AND COMPOUNDS, NOS (AL)	18
ACID, NOS	17
BENZO (J,K) FLUORENE	17
FLUORENE, NOS	17
RADIUM AND COMPOUNDS, NOS (RA)	16
TRICHLOROFLUOROMETHANE	15
ASBESTOS	15
DICHLOROETHANE, NOS	15
ACENAPTHENE	14
CIS-1,2-DICHLOROETHYLENE	14
ETHYL CHLORIDE	14
CHLORDANE	13
TRINITROTOLUENE (TNT)	13
URANIUM AND COMPOUNDS, NOS (U)	13
ANTIMONY AND COMPOUNDS, NOS (SB)	13
HEXACHLOROBENZENE	12
DI-N-BUTYL-PHTHALATE	12
RADON AND COMPOUNDS, NOS (RN)	12
AMMONIA	12
DICHLOROBENZENE, NOS	12
TETRAHYDROFURAN (I)	11
CHLOROMETHANE	11
METHYL ISOBUTYL KETONE	10
CHRYSENE	10
TETRACHLOROETHENE, NOS	10
DIOXIN	10
DDE	10
PESTICIDES, NOS	9
WASTE SOLVENTS	9
HEXACHLOROCYCLOPENTADIENE (C56)	9
2,4-DINITROTOLUENE	9
1,4-DICHLOROBENZENE	9
DIELDRIN	9
NITRATES, NOS	9
DIBROMOCHLOROMETHANE	9

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES
OCTOBER 1986

CHEMICAL NAME	FREQUENCY
THORIUM AND COMPOUNDS, NOS (TH)	9
HYDROCARBONS, NOS	9
TRIBROMOMETHANE	8
ETHYL ETHER	8
2,6-DINITROTOLUENE	8
DIETHYL PHTHALATE	8
1,2-DICHLOROBENZENE	8
CRESOLS	8
BROMOMETHANE	8
RDX	8
FLUORIDE, NOS	8
CHLORINATED HYDROCARBONS, NOS	8
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	8
BERYLLIUM AND COMPOUNDS, NOS (BE)	8
WASTE LACQUER/PAINT	7
GREASE AND OIL	7
HEXACHLOROBUTADIENE (C46)	7
1,2-DICHLOROPROPANE	7
HEPTACHLOR	7
ENDRIN	7
ALDRIN	7
BORON AND COMPOUNDS, NOS (B)	7
DDD	6
SILVER	6
TRICHLOROPHENOLS, NOS	6
CHROMIUM, TRIVALENT	6
PHTHLATES, NOS	6
DIBENZOFURAN	6
CHLORIDE (ION)	6
COAL TARS	6
1,2,3-TRICHLOROPROPANE	6
METHANOL	5
2,4-DIMETHYLPHENOL	5
DICHLORODIFLUOROMETHANE	5
1,3-DICHLOROBENZENE	5
CYCLOHEXANE	5
BIS (2-CHLOROETHYL) ETHER	5
BENZ A ANTHRACENE	5
ACROLEIN	5
M-XYLENE	5
TRIMETHYL BENZENE	5
PHOSPHORIC ACID	5
ACENAPTHYLENE	5
HALOGENATED SOLVENTS, NOS	5
CHROMIC ACID	5

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES
OCTOBER 1986

CHEMICAL NAME	FREQUENCY
METHANE	5
SULFATE (ION)	5
COBALT AND COMPOUNDS, NOS (CO)	5
1,2,4-TRICHLOROBENZENE	5
1,3,5-TRINITROBENZENE	4
NITROBENZENE	4
HYDROGEN SULFIDE	4
1,2-DIBROMO-3-CHLOROPROPANE	4
CUMENE	4
2-CHLOROPHENOL	4
CALCIUM CHROMATE	4
TOXAPHENE	4
SODIUM CYANIDE	4
METHYLNAPHTHALENE	4
TRICHLOROBENZENE	4
HALOGENATED ORGANICS, NOS	4
HEXACHLOROCYCLOHEXANE, NOS	4
NITRIC ACID	4
SODIUM HYDROXIDE	4
HYDROCHLORIC ACID	4
N-PENTANE	4
HEXANE	4
N-HEPTANE	4
N-NITROSODIPHENYLAMINE	4
BROMODICHLOROMETHANE	4
POLYNUCLEAR AROMATIC HYDROCARBONS	3
2,4,5-TP (SILVEX)	3
2,4,5-T	3
RESORCINOL	3
4-NITROPHENOL	3
FORMALDEHYDE	3
1,2-DIPHENYLHYDRAZINE	3
DI-N-OCTYL PHTHALATE	3
2,4-DICHLOROPHENOL	3
P-CHLORO-M-CRESOL	3
BENZIDINE	3
ANILINE	3
FLUORINE (F)	3
ENDOSULFAN	3
BERYLLIUM DUST, NOS	3
ARSENIC TRIOXIDE	3
1,2-DICHLOROETHENE	3
DINITROTOLUENE, NOS	3
SULFATES, NOS	3
ALIPHATIC HYDROCARBONS, NOS	3

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES
OCTOBER 1986

CHEMICAL NAME	FREQUENCY
MIREX	3
OCTANE	3
VANADIUM AND COMPOUNDS, NOS (V)	3
TIN AND COMPOUNDS, NOS (SN)	3
MAGNESIUM AND COMPOUNDS, NOS (MG)	3
TITANIUM AND COMPOUNDS, NOS (TI)	3
NITROPHENOL, NOS	3
ISOPROPANOL	3
ISOPHORONE	3
ETHYLENE GLYCOL	3
ETHANOL	3
BUTADIENE	3
ADIPIC ACID	3
SELENIUM AND COMPOUNDS, NOS (SE)	3
PHTHALIC ESTERS, NOS	3
HALOMETHANE, NOS	3
BENZO (B) FLUORANTHENE	3
BARIUM AND COMPOUNDS, NOS (BA)	3
MINERAL SPIRITS	2
PLATING SLUDGES	2
NON-VOLATILE ORGANICS, NOS	2
ALCOHOL, NOS	2
METHOXYCHLOR	2
2,4,5-TRICHLOROPHENOL	2
TOLUENE DIISOCYANATE	2
PENTACHLOROBENZENE	2
METHYL METHACRYLATE	2
4,4'-METHYLENE-BIS-(2-CHLOROANILINE)	2
HYDROFLUORIC ACID	2
HEXACHLOROETHANE	2
ETHYL ACETATE	2
1,4-DIOXANE	2
DIMETHYL PHTHALATE	2
3,3'-DICHLOROBENZIDINE	2
CYCLOHEXANONE	2
1-BUTANOL	2
BIS (2-CHLOROETHOXY) METHANE	2
ACRYLONITRILE	2
PHOSGENE	2
PARATHION	2
2,4-DINITROPHENOL	2
BENZYL CHLORIDE, NOS	2
CARBON DISULFIDE	2
2,4-DICHLOROPHENOXYACETIC ACID	2
DITHIANE, NOS	2

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES
OCTOBER 1986

CHEMICAL NAME	FREQUENCY
2,4,6-TRINITROTOLUENE	2
DIETHYLHEXYL PHTHALATE	2
THIOCYANATES, NOS	2
TRINITROPHENYLMETHYLNITRAMINE	2
1,3,5-TRIMETHYLBENZENE	2
N-BUTYLBENZENE	2
TRIS, NOS	2
PHENOL, DICHLORO, NOS	2
3,4-BENZOFLUORANTHENE	2
METHYLENE CHLOROFORM	2
NICKEL CHLORIDE	2
PLUTONIUM 239	2
TRITIUM	2
1,2,4-TRIMETHYLBENZENE	2
DIACETONE-ALCOHOL	2
ATRAZINE	2
PROPENYLBENZENE	2
KETONES, NOS	2
OLEFINIC HYDROCARBONS, NOS	2
DIMETHYLANILINE	2
PENTACHLOROBUTADIENE	2
POLYBROMINATED BIPHENYL (PBB), NOS	2
(P) ETHYL TOLUENE	2
(P) METHYL STRYRENE	2
HYPOCHLORIC ACID	2
BROMOCHLOROMETHANE	2
METHYLCYCLOHEXANE	2
DIMETHYL FORMAMIDE (DMF)	2
ZIRCONIUM AND COMPOUNDS, NOS (ZR)	2
SULFUR (ELEMENTAL - S)	2
STRONTIUM AND COMPOUNDS, NOS (SR)	2
SODIUM AND COMPOUNDS, NOS (NA)	2
PHOSPHOROUS AND COMPOUNDS, NOS (P)	2
PHENOLIC COMPOUNDS, NOS	2
MOLYBDENUM AND COMPOUNDS, NOS (MO)	2
BIPHENYL	2
SULFUR DIOXIDE	2
4-NITROTOLUENE	2
NITROCELLULOSE	2
NAPHTHA	2
ISOPROPYL ETHER	2
DICYCLOPENTADIENE	2
CHLORODIFLUOROMETHANE	2
4-CHLOROPHENOL	2
THALLIUM AND COMPOUNDS, NOS (TL)	2

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES
OCTOBER 1986

CHEMICAL NAME	FREQUENCY
MUSTARD GAS	2
ARAMITE	2
CAUSTICS, NOS	1
BRAKE FLUID (OFF. SPEC.)	1
GLYCOLS, MIXED	1
FUNGICIDES	1
PYRETHRUM	1
BEARING PACKING	1
PLASTICIZERS	1
#2 FUEL OIL	1
PETROLEUM AND PETROLEUM DISTILLATES	1
GASOLINE	1
TRIS (2,3-DIBROMOPROPYL) PHOSPHATE	1
1,2,4,5-TETRACHLOROBENZENE	1
PYRIDINE	1
2-METHYLPYRIDINE	1
PHTHALIC ANHYDRIDE	1
PENTACHLOROETHANE	1
N-NITROSO-N-METHYLURETHANE	1
KEPONE	1
HYDRAZINE	1
FURFURAL	1
3,3'-DIMETHOXYBENZIDINE	1
1,2-DIBROMOETHANE	1
DIBENZ (A,H) ANTHRACENE	1
4-CHLORO-2-METHYLBENZENAMINE	1
2-(CHLOROMETHYL) OXIRANE	1
CHLOROBENZILATE	1
CHLORAL	1
(TRICHLOROMETHYL) BENZENE	1
ACETOPHENONE	1
ACETONITRILE	1
ACETALDEHYDE	1
ZINC CYANIDE	1
SODIUM AZIDE OR SMITE	1
POTASSIUM CYANIDE	1
PHORATE	1
N-NITROSODIMETHYLAMINE	1
NITROGLYCERINE	1
2-METHYLAZIRIDINE	1
HYDROCYANIC ACID	1
AZIRIDINE	1
DISULFOTON	1
CYANOGEN	1
COPPER CYANIDE	1

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES
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CHEMICAL NAME	FREQUENCY
DIMETHYLPHENOL, NOS	1
TETRACHLOROPHENOL, NOS	1
STODDARD SOLVENT	1
BENZYL BUTYL PHTHLATE	1
PHENOL SULFONATE	1
TETRACHLOROBUTADIENE	1
C-66	1
TETRAMETHYLPENTANONE	1
TRIMETHYLCYCLOHEXANOL	1
METHYLPHENANTHRENE, NOS	1
BROMOCHLOROBENZENE, NOS	1
1-ETHYL-2-METHYL BENZENE	1
TRIMETHYLOXABICYCLOOCTANE	1
2-METHYL 1,3,-DINITROBENZENE	1
AMMONIUM, NOS	1
BENZOPYRENE, NOS	1
BENZOPHENANTHRENE, NOS	1
PERYLENE	1
TERPENES, NOS	1
BROMOBENZENE	1
OCTACHLORODINITRODICYCLOPENTADIENE	1
4,4-DIAMINO-3,3-DICHLORODIPENYLMETHAN	1
2,4-DIMETHYL-1,3 DIOXANE	1
PHORONE	1
PLUTONIUM 238	1
TETRAMETHYL BENZENE, NOS	1
CHROMIUM ALUMEN	1
PALLADIUM, NOS	1
KELTHANE	1
POTASSIUM CHROMATE	1
BORAX	1
CARBON	1
MALATHION	1
ETHION	1
ORATREN	1
CAPTAN	1
TRICARBOXYLIC ACID, BETA-ACETOXYTRBUT	1
LORSBAN	1
PHOSPHORODITHIOIC ACID, 0-ETHYL S,S-D	1
PHENOL, 4,4-ISOPROPYLIDENEDI-(BISPHEN)	1
INDENE	1
BENZOTHIOPHENE, NOS	1
ESTERS, NOS	1
LEAD-MOLYBDENUM CHROMATE	1
LEAD CHROMATE	1

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES
OCTOBER 1986

CHEMICAL NAME	FREQUENCY
HEXAMETHYLENEDIAMINE	1
ETHYLAMINE	1
CAMPHOR	1
BUTANE	1
BENZOIC ACID	1
AMYL ALCOHOL	1
HEXACHLOROCYCLOHEXANE, BETA ISOMER	1
HEXACHLOROCYCLOHEXANE, ALPHA ISOMER	1
1,3-DINITROBENZENE	1
DICHLOROFLUOROMETHANE	1
TRICHLOROPROPANE, NOS	1
SILVER AND COMPOUNDS, NOS (AG)	1
N-NITROSONORNICOTINE	1
HEPTACHLOR EPOXIDE (ALPHA, BETA, GAMMA)	1
CHLORINATED ETHANE, NOS	1
BUTYLBENZYL PHTHALATE	1

Number of Recorded Substances - 466
Number of Sites with Chemical Data - 888

SECTION 2

SUBSTANCES FOUND IN CERCLA SITE WASTEWATERS

SECTION 2 - SUBSTANCES FOUND IN CERCLA SITE WASTEWATERS. As part of the ITD CERCLA Site Discharge to POTWs study, samples from 17 sites with contaminated groundwater and from 3 sites with leachate were collected and analyzed for the full ITD list of compounds (See Section 9). The resulting data was used to generate Tables 2-1 through 2-6. The tables present the frequency at which the compounds occurred above the detection limits at the sites and the minimum and maximum concentrations at which they occurred. Tables 2-1, 2-3, and 2-5 present the data for organic, inorganic, and conventional and non-conventional pollutants at the groundwater sites, respectively, and 2-2, 2-4, and 2-6 present the data from the leachate sites.

The tables were generated to give the user an indication of the contaminants, the frequency of occurrence, and the concentrations at which they occurred at the groundwater and leachate CERCLA sites sampled. The tables, as in Section 1, show the wide variety of contaminants among sites and the wide range of concentrations detected.

TABLE 2-1
COMMON ORGANIC CONTAMINANTS IN CERCLA SITE WASTEWATER
GROUNDWATER SAMPLED AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
TRICHLOROETHENE	13	19.9	8369.7	UG/L
TRANS-1,2-DICHLOROETHENE	11	11.4	1516.5	UG/L
TETRACHLOROETHENE	9	34.6	58017.0	UG/L
1,2-DICHLOROBENZENE	8	14.2	4742.0	UG/L
ACETONE	8	56.0	19420.0	UG/L
TOLUENE	8	19.2	9178.3	UG/L
BENZENE	7	12.2	314.5	UG/L
METHYLENE CHLORIDE	7	18.6	3571.0	UG/L
PHENOL	7	10.9	1441.8	UG/L
BENZOIC ACID	6	55.3	1825.0	UG/L
CHLOROBENZENE	6	34.8	3646.0	UG/L
P-DIOXANE	6	13.2	955.0	UG/L
1,4-DICHLOROBENZENE	5	13.4	1451.2	UG/L
2-BUTANONE (MEK)	5	396.2	2817.1	UG/L
4-METHYL-2-PENTANONE	5	68.3	2767.0	UG/L
BIS(2-ETHYLHEXYL)PHTHALATE	5	59.4	2261.7	UG/L
CHLOROFORM	5	406.3	1000.0	UG/L
ISOPHORONE	5	13.2	1910.0	UG/L
OCDD	5	0.0	0.5	PPT
1,1-DICHLOROETHANE	4	15.0	269.3	UG/L
1,2-DICHLOROETHANE	4	15.2	38.8	UG/L
1,3-DICHLOROBENZENE	4	123.0	403.0	UG/L
2,3,7,8-TCDF	4	0.0	10.8	PPT
2,4-DIMETHYLPHENOL	4	28.4	131.2	UG/L
ETHYLBENZENE	4	33.5	287.0	UG/L
HEXANOIC ACID	4	35.0	347.0	UG/L
N,N-DIMETHYLFORMAMIDE	4	68.0	422.0	UG/L
NAPHTHALENE	4	24.7	326.5	UG/L
O-+P-XYLENE	4	12.0	55.6	UG/L
1,1,1-TRICHLOROETHANE	3	363.6	935.5	UG/L
1,1,2,2-TETRACHLOROETHANE	3	31.2	3481.0	UG/L
1,2,3,4,6,7,8-HpCDD	3	0.0	0.1	PPT
1,2,4-TRICHLOROBENZENE	3	70.6	167.0	UG/L
ANILINE	3	20.1	1223.0	UG/L
BENZYL ALCOHOL	3	19.5	89.6	UG/L
BIPHENYL	3	11.7	5541.5	UG/L
M-XYLENE	3	18.0	50.5	UG/L

TABLE 2-1
COMMON ORGANIC CONTAMINANTS IN CERCLA SITE WASTEWATER
GROUNDWATER SAMPLED AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
N-DODECANE (N-C12)	3	10.5	969.7	UG/L
O-CRESOL	3	11.3	165.8	UG/L
P-CRESOL	3	29.2	70.7	UG/L
TOTAL HpCDD	3	0.0	0.1	PPT
VINYL CHLORIDE	3	22.4	230.0	UG/L
1,1,2-TRICHLOROETHANE	2	17.0	244.3	UG/L
1,1-DICHLOROETHENE	2	43.7	49.7	UG/L
2,4,5-T	2	136.0	1100.0	PPT
2,4-D	2	150.0	430000.0	PPT
2-NITROPHENOL	2	159.8	174.3	UG/L
4-NITROPHENOL	2	230.7	446.9	UG/L
N-DECANE (N-C10)	2	14.5	278.1	UG/L
O-TOLUIDINE	2	15.0	37.0	UG/L
STYRENE	2	12.0	240.0	UG/L
1,1,1,2-TETRACHLOROETHANE	1	70.3	70.3	UG/L
1,2,3-TRICHLOROBENZENE	1	20.4	20.4	UG/L
1,2,3-TRICHLOROPROPANE	1	5667.9	5667.9	UG/L
1,3-DICHLORO-2-PROPANOL	1	23.0	23.0	UG/L
2,4,5-TP (SILVEX)	1	1550.0	1550.0	PPT
2,4-DIAMINOTOLUENE	1	112.0	112.0	UG/L
2,4-DICHLOROPHENOL	1	66.7	66.7	UG/L
2,4-DINITROPHENOL	1	435.7	435.7	UG/L
2-CHLOROPHENOL	1	87.6	87.6	UG/L
2-HEXANONE	1	151.4	151.4	UG/L
2-METHYL-4,6-DINITROPHENOL	1	174.3	174.3	UG/L
2-METHYLNAPHTHALENE	1	15.0	15.0	UG/L
3-CHLOROPROPENE	1	13.8	13.8	UG/L
ACETOPHENONE	1	87.1	87.1	UG/L
ACROLEIN	1	63.0	63.0	UG/L
ALPHA-PICOLINE	1	52.8	52.8	UG/L
ALPHA-TERPINEOL	1	11.5	11.5	UG/L
BIS(2-CHLOROETHYL)ETHER	1	19.0	19.0	UG/L
BUTYL BENZYL PHTHALATE	1	1708.1	1708.1	UG/L
CHRYSENE	1	24.0	24.0	UG/L
DIBENZOFURAN	1	30.0	30.0	UG/L
DIETHYL ETHER	1	64.0	64.0	UG/L
DIMETHYL PHTHALATE	1	105.9	105.9	UG/L

TABLE 2-1
COMMON ORGANIC CONTAMINANTS IN CERCLA SITE WASTEWATER
GROUNDWATER SAMPLED AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
FLUORENE	1	246.5	246.5	UG/L
HEXACHLOROETHANE	1	10.6	10.6	UG/L
ISOBUTYL ALCOHOL	1	11.4	11.4	UG/L
N-OCTACOSANE (N-C28)	1	10.8	10.8	UG/L
NITROBENZENE	1	18378.0	18378.0	UG/L
OCDF	1	0.1	0.1	PPT
P-CYMENE	1	20.8	20.8	UG/L
PCB-1232	1	10445.0	10445.0	UG/L
PHENANTHRENE	1	130.0	130.0	UG/L
PHOSPHAMIDON	1	8500.0	8500.0	PPT
TEPP	1	79000.0	79000.0	PPT
TOTAL HpCDF	1	0.0	0.0	PPT
TRICHLOROFLUOROMETHANE	1	200.8	200.8	UG/L
VINYL ACETATE	1	50.0	50.0	UG/L

TABLE 2-2
COMMON ORGANIC CONTAMINANTS IN CERCLA SITE WASTEWATER
LEACHATE SAMPLED AT 3 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
PHENOL	3	35.0	1548330.0	UG/L
BENZOIC ACID	3	53.5	2316700.0	UG/L
1,1,2,2-TETRACHLOROETHANE	2	1305.0	2942.0	UG/L
CHLOROFORM	2	518.0	8958.0	UG/L
AZINPHOS METHYL	2	50.0	51.7	UG/L
TRICHLOROETHENE	2	601.0	3525.5	UG/L
TRANS-1,2-DICHLOROETHENE	2	170.0	1359.5	UG/L
TOLUENE	2	13483.0	18166.0	UG/L
TETRACHLOROETHENE	2	1299.0	3615.5	UG/L
P-CRESOL	2	72.5	161.0	UG/L
2,3,7,8-TCDD	2	5.9	31.6	PPT
ACETONE	2	3245.5	52518.0	UG/L
BENZENE	2	1740.0	2934.5	UG/L
BENZYL ALCOHOL	2	709.0	13308.0	UG/L
HEXANOIC ACID	2	24.5	131.0	UG/L
CHLOROBENZENE	2	2670.5	3773.0	UG/L
ACETOPHENONE	1	20.5	20.5	UG/L
1,2,3-TRICHLOROBENZENE	1	596.0	596.0	UG/L
CARBON TETRACHLORIDE	1	141.0	141.0	UG/L
BIS(2-CHLOROETHYL)ETHER	1	52.0	52.0	UG/L
2,4-DIMETHYLPHENOL	1	101.0	101.0	UG/L
1,2,4-TRICHLOROBENZENE	1	4662.0	4662.0	UG/L
ETHYLBENZENE	1	2639.0	2639.0	UG/L
2,4-DICHLOROPHENOL	1	833.0	833.0	UG/L
ISOPHORONE	1	58.5	58.5	UG/L
METHYLENE CHLORIDE	1	3544.5	3544.5	UG/L
N-DOCOSANE (N-C22)	1	10.5	10.5	UG/L
N-EICOSANE (N-C20)	1	15.0	15.0	UG/L
N-HEXADECANE (N-C16)	1	23.0	23.0	UG/L
N-OCTADECANE (N-C18)	1	24.5	24.5	UG/L
2,4,5-TRICHLOROPHENOL	1	1167.0	1167.0	UG/L
1,4-DICHLOROBENZENE	1	964.0	964.0	UG/L
PENTACHLOROBENZENE	1	548.0	548.0	UG/L
2,3,7,8-TCDF	1	0.4	0.4	PPT
1,2-DICHLOROETHANE	1	1835.5	1835.5	UG/L
1,2-DICHLOROBENZENE	1	719.0	719.0	UG/L

TABLE 2-2
COMMON ORGANIC CONTAMINANTS IN CERCLA SITE WASTEWATER
LEACHATE SAMPLED AT 3 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
CHLOROMETHANE	1	10566.0	10566.0	UG/L
DI-N-BUTYL PHTHALATE	1	26.5	26.5	UG/L
AZINPHOS ETHYL	1	1.2	1.2	UG/L
N-TETRADECANE (N-C14)	1	17.5	17.5	UG/L
FENSULFOTHION	1	1.9	1.9	UG/L
CHLORFEVINPHOS	1	7.2	7.2	UG/L
FENTHION	1	4.2	4.2	UG/L
CROTOXYPHOS	1	14.4	14.4	UG/L
LEPTOPHOS	1	13.1	13.1	UG/L
DIAZINON	1	10.1	10.1	UG/L
MALATHION	1	7.7	7.7	UG/L
DICROTOPHOS	1	29.1	29.1	UG/L
MEVINPHOS	1	1.6	1.6	UG/L
DIOXATHION	1	27.0	27.0	UG/L
PARATHION	1	4.5	4.5	UG/L
CHLORPYRIFOS	1	5.0	5.0	UG/L
DICHLORVOS	1	27.6	27.6	UG/L
DIMETHOATE	1	28.4	28.4	UG/L
DISULFOTON	1	0.5	0.5	UG/L
DELTA-BHC	1	1.6	1.6	UG/L
PCB-1254	1	6.0	6.0	UG/L
PHORATE	1	21.0	21.0	UG/L
SULFOTEPP	1	1.0	1.0	UG/L
TERBUFOS	1	5.0	5.0	UG/L
TETRACHLORVINPHOS	1	0.8	0.8	UG/L

TABLE 2-3
COMMON INORGANIC CONTAMINANTS IN CERCLA SITE WASTEWATER
GROUNDWATER SAMPLED AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
SODIUM	17	5560.0	1075000.0	UG/L
CALCIUM	17	21620.0	487600.0	UG/L
MAGNESIUM	17	2960.0	1242857.1	UG/L
BARIUM	17	5.6	870.5	UG/L
SILICON	17	3.0	34500.0	UG/L
MANGANESE	17	25.4	341000.0	UG/L
SULFUR	17	2.4	6337143.0	UG/L
IRON	17	16.0	387400.0	UG/L
BORON	16	20.8	168000.0	UG/L
ZINC	16	6.7	56042.9	UG/L
STRONTIUM	14	0.7	12420.0	UG/L
TITANIUM	13	3.0	722.0	UG/L
ALUMINUM	12	110.0	1994285.7	UG/L
POTASSIUM	11	2.0	30700.0	UG/L
CHROMIUM	10	10.2	121428.6	UG/L
COPPER	10	8.0	9370.0	UG/L
NICKEL	10	25.0	19520.0	UG/L
COBALT	9	9.6	3380.0	UG/L
YTTRIUM	9	2.0	4594.0	UG/L
CADMIUM	8	5.2	2826.0	UG/L
ARSENIC	8	2.4	6000.0	UG/L
MOLYBDENUM	8	12.0	541.0	UG/L
VANADIUM	8	3.0	1620.0	UG/L
PHOSPHORUS	7	1500.0	12000.0	UG/L
BERYLLIUM	7	1.8	120.0	UG/L
LITHIUM	5	0.1	2200.0	UG/L
SILVER	5	7.5	44.0	UG/L
TIN	5	30.0	50.2	UG/L
LANTHANUM	5	100.0	2100.0	UG/L
GADOLINIUM	4	540.0	857.0	UG/L
CERIUM	4	6300.0	19000.0	UG/L
LEAD	4	69.0	1550.0	UG/L
NEODYMIUM	4	400.0	3300.0	UG/L
SELENIUM	4	3.5	21.0	UG/L
IODINE	3	533.0	6000.0	UG/L
IRIDIUM	3	240.0	3229.0	UG/L
GOLD	3	2900.0	3371.0	UG/L

TABLE 2-3
COMMON INORGANIC CONTAMINANTS IN CERCLA SITE WASTEWATER
GROUNDWATER SAMPLED AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
YTTERBIUM	3	100.0	400.0	UG/L
OSMIUM	3	0.2	1100.0	UG/L
GALLIUM	2	600.0	700.0	UG/L
ANTIMONY	2	4.0	34.0	UG/L
DYSPROSIUM	2	400.0	960.0	UG/L
SCANDIUM	2	250.0	300.0	UG/L
URANIUM	2	640.0	1300.0	UG/L
SAMARIUM	2	620.0	780.0	UG/L
TANTALUM	2	700.0	2740.0	UG/L
PRASEODYMIUM	1	1600.0	1600.0	UG/L
RUTHENIUM	1	4300.0	4300.0	UG/L
LUTETIUM	1	200.0	200.0	UG/L
NIOBIUM	1	1543.0	1543.0	UG/L
GERMANIUM	1	320.0	320.0	UG/L
ERBIUM	1	410.0	410.0	UG/L
TUNGSTEN	1	1000.0	1000.0	UG/L
INDIUM	1	1100.0	1100.0	UG/L
MERCURY	1	6.0	6.0	UG/L
ZIRCONIUM	1	100.0	100.0	UG/L

TABLE 2-4
COMMON INORGANIC CONTAMINANTS IN CERCLA SITE WASTEWATER
LEACHATE SAMPLED AT 3 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
NICKEL	3	18.5	1567.0	UG/L
SODIUM	3	51750.0	3495000.0	UG/L
ALUMINUM	3	140.0	3515.0	UG/L
SULFUR	3	7050.0	471500.0	UG/L
IRON	3	6700.0	763000.0	UG/L
SILICON	3	2040.0	6400.0	UG/L
POTASSIUM	3	1010.0	621000.0	UG/L
ZINC	3	70.0	555.0	UG/L
CALCIUM	3	4145.0	821500.0	UG/L
TITANIUM	3	8.0	36.5	UG/L
MAGNESIUM	3	2885.0	254000.0	UG/L
MANGANESE	3	708.0	12800.0	UG/L
BORON	3	247.0	14950.0	UG/L
COPPER	2	26.0	28.9	UG/L
MOLYBDENUM	2	31.0	293.0	UG/L
BARIUM	2	15.0	77.0	UG/L
LITHIUM	2	600.0	9400.0	UG/L
STRONTIUM	2	1500.0	3150.0	UG/L
OSMIUM	2	100.0	100.0	UG/L
PHOSPHORUS	2	1285.0	118000.0	UG/L
VANADIUM	1	32.5	32.5	UG/L
LEAD	1	108.0	108.0	UG/L
IODINE	1	2000.0	2000.0	UG/L
CADMIUM	1	23.5	23.5	UG/L
COBALT	1	16.0	16.0	UG/L
CHROMIUM	1	53.5	53.5	UG/L
TIN	1	33.0	33.0	UG/L
ARSENIC	1	28.5	28.5	UG/L
TANTALUM	1	500.0	500.0	UG/L
URANIUM	1	1000.0	1000.0	UG/L

TABLE 2-5
COMMON CONVENTIONAL AND NON-CONVENTIONAL CONTAMINANTS IN
CERCLA SITE WASTEWATER
GROUNDWATER SAMPLED AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
SPECIFIC CONDUCTANCE	17	264.0	17571.4	UMH/C
CHLORIDE	17	10833.0	2900000.0	UG/L
SULFATE	16	14500.0	19428571.0	UG/L
TOC	16	2180.0	1300000.0	UG/L
NITRATE + NITRITE, AS N	15	51.0	250042.0	UG/L
FLASH POINT	14	0.0	57000.0	25 DE
AMMONIA, AS N	13	158.0	21667.0	UG/L
COD	13	30800.0	4340000.0	UG/L
PHOSPHORUS, TOTAL AS P	12	103.0	12000.0	UG/L
NITROGEN, TOTAL KJELDAHL	11	104.0	24857.0	UG/L
BOD	11	6850.0	1446000.0	UG/L
TSS	10	15857.0	2500000.0	UG/L
TDS	10	231429.0	33000000.0	UG/L
FLUORIDE	9	207.0	250000.0	UG/L
OIL & GREASE, TOTAL RECOVERABLE	8	5000.0	54000.0	UG/L
RESIDUE, FILTERABLE	6	180000.0	30000000.0	UG/L
CORROSIVITY	6	1.7	92.0	MPY
SULFIDE, TOTAL (IODOMETRIC)	6	1000.0	28000.0	UG/L
NITROGEN, TOTAL KJELDEHL	5	156.0	24667.0	UG/L
CYANIDE, TOTAL	4	24.3	100.0	UG/L
RESIDUE, NON-FILTERABLE	4	12117.0	266667.0	UG/L
FLOURIDE	3	308.0	16500.0	UG/L
TOTAL ORGANIC CARBON	1	2467.0	2467.0	UG/L

TABLE 2-6
COMMON CONVENTIONAL AND NON-CONVENTIONAL CONTAMINANTS IN
CERCLA SITE WASTEWATER
LEACHATE SAMPLED AT 3 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
TDS	3	128.5	1300.0	MG/L
OIL & GREASE, TOTAL RECOVERABLE	3	21.0	545.0	MG/L
TSS	3	16.5	18500.0	MG/L
TOC	3	89.0	3350.0	MG/L
COD	3	260.0	10400.0	MG/L
SULFIDE, TOTAL (IODOMETRIC)	3	2.0	76.0	MG/L
BOD	3	52.0	6500.0	MG/L
PHOSPHORUS, TOTAL AS P	3	0.4	310.0	MG/L
NITROGEN, TOTAL KJELDAHL	3	2.1	44.0	MG/L
AMMONIA, AS N	2	1.6	7.9	MG/L
FLUORIDE	2	0.7	12.0	MG/L
SPECIFIC CONDUCTANCE	1	275.0	275.0	UMH/C
SULFATE	1	52.0	52.0	MG/L
NITRATE + NITRITE, AS N	1	5.5	5.5	MG/L
FLASH POINT	1	44.0	44.0	DEG C
CHLORIDE	1	58.0	58.0	MG/L

SECTION 3

CERCLA SITE SAMPLING DATA

SECTION 3 - CERCLA SITE SAMPLING DATA REPORT. The CERCLA site sampling data described previously (Section 2) was evaluated and presented in the CERCLA Site Sampling Data Summary Report in Section 3. Specific tasks presented in the report include:

1. Evaluation of the frequency of occurrence of compounds.

2. Evaluation of the daily variation in treatability of CERCLA site wastewater.

3. Evaluation of the variability between sampling events at the Stringfellow Site.

4. Evaluation of contaminant treatability.

5. Comparison of CERCLA site treatability data to data in the USEPA Office of Research and Development (ORD) Treatability Data Base.

6. Evaluation of air sampling data from the Chemdyne site.

7. Comparison of indicator parameter treatability to organic contaminant treatability.

Section 3 was generated to provide the user with a summary of the variety of ITD as well as non-ITD compounds and concentration ranges present at CERCLA sites, the treatability of CERCLA compounds, and the efficiency of on-site treatment systems.

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3-1.0 INTRODUCTION

As part of the CERCLA Site Discharge to POTWs study, the U.S. Environmental Protection Agency (USEPA) Industrial Technology Division (ITD) directed various sampling visits in order to collect samples from several CERCLA sites. This report evaluates and summarizes the results of the CERCLA site sampling data. Specific tasks presented in this report include:

1. Evaluation of the frequency of occurrence of contaminants,
2. Evaluation of the daily variation in treatability of CERCLA site wastewater,
3. Evaluation of the variability between sampling events at the Stringfellow site,
4. Evaluation of contaminant treatability,
5. Comparison of CERCLA Site Treatability Data to data in the USEPA Office of Research and Development (ORD) Treatability Data Base,
6. Evaluation of the air sampling data from the Chemdyne site, and
7. Comparison of indicator parameter treatability to organic contaminant treatability.

3-1.1 Background

The objectives of sampling the CERCLA sites were to:

- Identify the variety of compounds and concentration ranges present at the CERCLA sites;
- Collect data on the treatability of compounds achieved by various on-site pretreatment systems; and
- Evaluate the impact of CERCLA discharges to a receiving Publicly Owned Treatment Works (POTW).

Based on these objectives, the original criteria for site selection was sites with current discharges to POTWs. An extensive research of Records of Decision (RODs) led to the identification of approximately 100 sites that listed the discharge to a POTW as part of the selected remedial action. However, only twelve sites were verified to have actually implemented the discharge to a POTW. Of these twelve sites, only seven were sampled. Access was restricted at the remaining sites which were currently involved in sensitive negotiations. In order to achieve the first two sampling objectives with a larger representative data base, the scope of sampling was expanded to include sites using remedial alternatives other than discharging to a POTW. In all, eighteen different sites were sampled. Of the sites sampled:

- seven sites discharge to a POTW,
- five sites discharge directly to surface water,
- one site reinjects to groundwater, and

- six sites' monitoring wells were sampled.

3-1.2 Site Summaries

Attachment A presents detailed descriptions for each site sampled and Table 3-1 presents a summary of each of the CERCLA sites sampled. The summary table provides information with regard to the average flow, wastewater type, treatment, where the treated water is discharged, and the total mass loading to the site.

The CERCLA sites sampled spanned most of the USEPA Regions across the United States. Exceptions to this included Region VII and Region VIII. In general few CERCLA sites are located in either region. One site was contacted in Region VII but not chosen for sampling due to the low contaminant concentrations in its' wastestream. Region VIII has the fewest sites of any region. In addition, many of those located in Region VIII are mining sites with wastestreams consisting primarily of only one or two contaminants.

The majority of the sites sampled were operating 24 hours per day, 7 days per week at the time of sampling. Exceptions to this included Stringfellow and United Chrome, both of which operated 8 hours per day, 5 days per week, and Love Canal, which only operated 8 hours per day, 2 days per week.

A wide range of wastewater flow rates was observed at the CERCLA sites sampled. The average flow rates ranged from 0.006 MGD at Hyde Park to 5.0 MGD at Well 12A. Sites discharging to POTWs typically had flow rates lower than those discharging to surface water. Flow rates ranged from 0.006 MGD (Hyde Park) to 1.4 MGD (Reilly Tar) for sites discharging to POTWs and from 0.1 MGD (Tyson's Dump) to 5.0 MGD (Well 12A) at sites discharging to surface water. The average flow rate of all sites discharging to a POTW was 0.25 MGD compared to 1.9 MGD for sites discharging to surface water.

The average capacity of the POTWs which received the CERCLA sites discharges ranged from 8.8 MGD to 220 MGD. The flow from the sites was therefore diluted by factors ranging from approximately 100 (Tyson's Dump) to 8,000 (Hyde Park). In addition, the sites provided high levels of pretreatment prior to discharging to the POTW. As a result, once the CERCLA wastestream is discharged to the POTW, wastes are typically not detectable in the POTW influent. This was evident in the fact that an original objective of the program was to sample POTWs currently accepting CERCLA discharges. No POTWs could be identified where a CERCLA waste would be detectable.

In order to reduce sampling errors and account for system anomalies, sites that were currently operating a treatment system, with the exception of Bridgeport Rental, were sampled each day over a 4 to 5 day period. In addition, the Stringfellow site was sampled at three different times during the program (November 1987, March 1988, and August 1989) in order to assess the variability of contaminants and the treatment process over an extended period of time.

Site	Episode	Region	City, State	Date of Visit	Avg. Flow	Operating Hours	Wastewater Type	Treatment [1]	Discharge [2]	Influent [3] Mass Loading (LBS/Yr)
Bridgeport Rental	1222	II	Logan Township, NJ	Dec. 17, 1987	300 GPM	24 Hours/7Days	Leachate	OS-DAF-MF-HT-GAC	Surface Water	111,490
Charles George	1309	I	Tyngsborough, MA	Apr. 28, 1988	--	--	Groundwater	Future Treatment	--	--
Chemdyne	1807	V	Hamilton, OH	Oct. 9-13, 1989	750 GPM	24 Hours/7 Days	Groundwater	AS	60% Surface Water 40% Reinjection	675,720
Geneva	1224	VI	Houston, TX	Feb. 16, 1988	--	--	Groundwater	Future Treatment	--	--
Gold Coast Oil	1242	IV	Miami, FL	Mar. 24, 1988	--	--	Groundwater	Future Treatment	--	--
Hyde Park	1220	II	Niagra Falls, NY	Sep. 30, 1987	< 6,000 GPD	--	Leachate	Lagoon	48 MGD POTW	1,286,620
Love Canal	1219	II	Niagra Falls, NY	Sep. 29, 1987	40,000 GPD	2 Days/Wk	Leachate	GAC	48 MGD POTW	48,020
Nyanza	1310	I	Ashland, MA	Apr. 27, 1988	--	--	Groundwater	Future Treatment	--	--
Reilly Tar	1239	V	St. Louis Park, MN	Feb, 22-26, 1988	1,000 GPM	24 Hours/7 Days	Groundwater	SF-GAC	5% to POTW, 95% to Drinking Water Supply	630,650
Stringfellow	1221 1240 1805	IX	Glen Avon Heights, CA	Nov. 3, 1987 Mar. 7-11, 1988 Aug. 21-25, 1989	0.04 MGD	8 Hours/ 5 Days	Groundwater	CP-SF-GAC	220 MGD POTW	542,740 1,029,030 968,190
Sylvester	1325	II	Nashua, NH	May 16-21, 1988	300 GPM	24 Hours/7 Days	Groundwater	CP-SF-AS-BT	Reinjection	247,300
Time Oil	1804	X	Tacoma, WA	Aug. 14-19, 1989	150 GPM	24 Hours/ 7 Days	Groundwater	GAC	--	46,850
Tyson's Dump	1568	III	King of Prussia, PA	Jun. 25-29, 1988	100,000 GPD	24 Hours/2 Days/Wk	Groundwater	AS	Surface Water 8-10 MGD POTW	7,190
United Chrome	1738	X	Corvallis, OR	Apr. 24-27, 1988	50,000 GPD	8 Hours/5 Days	Groundwater	CP-HT	8.8 MGD POTW	229,420
Verona	1223	V	Battle Creek, MI	Jan. 25-30-1988	2,000 GPM - 2,100 GPM	24 Hours/7 Days	Groundwater	GAC-AS	Surface Water	1,742,570
Well 12A	1808	X	Tacoma, WA	Aug. 14-18, 1989	3,500 GPM	24 Hours/7 Days	Groundwater	AS	Surface Water	1,247,300
Western Proc.	1739	X	Kent, WA	May 1-6, 1989	100 GPM	24 Hours/7 Days	Groundwater	AS-CP-GAC	42 MGD POTW	416,660
Whitehouse Oil	1241	IV	Whitehouse, FL	Mar. 22,1988	--	--	Groundwater	Future Treatment	--	--

Notes:

1. AS = Air Stripping
   BT = Biological Treatment
   CP = Chemical Precipitation
   DAF = Dissolved Air Flotation
   GAC = Granular Activated Carbon
   HT = Holding Tank
   MF = Multi-Media Filter
   OS = Oil/Water Separator
   SF = Sand Filter

2. POTW flows are yearly averages

3. Includes organic and inorganic Industrial Technology Division Analytes

TABLE 3-1
CERCLA SITES CHARACTERIZATION

6098-01

At each CERCLA site sampled, samples were collected across each unit process, where possible, and analyzed for the full ITD List of Analytes. The ITD list is composed of 443 pollutants including organic and inorganic compounds and miscellaneous conventional and non-conventional parameters (e.g., total organic carbon, chemical oxygen demand, reactivity, etc.). The list, along with the CAS number for each contaminant, is presented in Section 9 of this Treatability Manual.

The sampling data collected from the eighteen CERCLA sites have been incorporated into a site sampling data base. The data base is a dBASE file consisting of the following:

1. Compound name
2. Class of the compound (organic, inorganic, semi-quantitative screen metal, conventional, non-conventional, pesticide/PCB)
3. Amount detected
4. Detection limit if amount detected was a non-detect
5. Laboratory qualifier, where applicable
6. Concentration units
7. Episode number
8. Sample number

3-2.0 REDUCTION OF CERCLA SITE SAMPLING DATA BASE

Prior to evaluating the CERCLA site data, it was necessary to reduce the data. The data base originally consisted of samples taken at various points in the treatment process and the corresponding contaminant concentration that was detected for each day that samples were collected. In order to compare treatability of contaminants across different sites and to determine the frequency with which contaminants occurred at the eighteen sites, an average concentration of each sample point was calculated for sites where sampling occurred for more than one day. Duplicate samples taken during each sampling event were also averaged with its respective sample location. In addition, raw wastewater samples collected at two different sample locations were averaged for Hyde Park (These samples were averaged since the leachate collected at the sample locations is pumped from the wells and combined in a holding lagoon where separation of the aqueous and non-aqueous phase occurs). For samples reported as non-detect, the detection limit was used in calculating the average.

To determine the frequency of occurrence of contaminants at the sites, the averaged data were used as described above; however, if non-detect data were observed for a contaminant in more than fifty percent of the samples across the unit processes that composed the treatment system, the contaminant concentration was considered to be non-detectable and thus, not detected in all samples collected at the site. This criterion was followed to account for system or analytical anomalies that may have occurred. The criterion was not followed if the influent concentration was above the detection limit and all other samples collected over the system were non-detect. The criterion was also not followed for some of the organics data collected at Tyson's Dump. Many of the concen-

trations detected for duplicate samples collected at the site were higher than concentrations detected for other samples at the site. Therefore, if other samples collected at the site for a contaminant were non-detect, except for the concentration of the duplicate, the contaminant was considered non-detect in the wastestream when calculating the frequency of occurrence.

A more detailed description of the reduction of the CERCLA site data and the actual data and the percent removals across each unit process at each site are presented in the "CERCLA SITE DISCHARGES TO POTWs CERCLA SITE SAMPLING PROGRAM: DETAILED DATA REPORT" (EPA/542/90/008).

3-3.0 EVALUATION OF CERCLA SITE SAMPLING DATA BASE

The seven data evaluation tasks are discussed below.

3-3.1 Task 1: Frequency of Occurrence of Contaminants

The frequency of occurrence of contaminants detected at the sites was evaluated for sites treating groundwater and for sites treating leachate. Site wastewater defined as groundwater was subsurface water that was either extracted and treated or extracted, placed in a holding lagoon for storage, and subsequently treated. Wastewater defined as leachate was wastewater collected at a landfill site that was collected in a leachate collection system for treatment. The lagooned waste at Bridgeport Rental was evaluated as a leachate since it consisted of an oily waste not representative of groundwater.

In 1987, a list was compiled from analytical data collected from proposed and final National Priorities List (NPL) sites. The frequency of occurrence was compiled for contaminants detected in soil, water, and other media and is presented in Section 1 of this Treatability Manual.

3-3.1.1 Contaminants Detected and Frequency of Occurrence.

Tables 3-2 through 3-7 present the frequency of occurrence of contaminants at the sites sampled, the maximum concentrations, and the regulatory lists (Resource Conservation and Recovery Act [RCRA]-Appendix VIII, Target Compound List (TCL), Superfund Amendments and Reauthorization Act [SARA]-110, and/or Priority Pollutant) for each contaminant. The TCL, formerly the Hazardous Substance List (HSL), was established under CERCLA and SARA and the Priority Pollutant List was developed by the USEPA Office of Water under the Clean Water Act. The TCL, Priority Pollutant, RCRA-Appendix VIII, and SARA-110 lists are presented in Section 9, Tables 9-5 through 9-8 respectively. Tables 3-2, 3-4, and 3-6 present organic, inorganic, and conventional and non-conventional contaminants, respectively, for sites treating groundwater. Tables 3-3, 3-5, and 3-7 present the data for the leachate streams. Table 3-8 presents a summary of the total number of contaminants detected above the detection limit at each of the specific sites sampled for each class of compound.

The organic contaminants most frequently detected at the sites varied somewhat between the groundwater and leachate sites (Table 3-2 and 3-3). Phenol was

TABLE 3-2
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
ORGANIC CONTAMINATES IN CERCLA GROUNDWATER AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
TRICHLOROETHENE	13	19.9	8369.7	UG/L	X	X	X	X
TRANS-1,2-DICHLOROETHENE	11	11.4	1516.5	UG/L	X	X	X	X
TETRACHLOROETHENE	9	34.6	58017.0	UG/L	X	X	X	X
1,2-DICHLOROBENZENE	8	14.2	4742.0	UG/L	X	X	X	X
ACETONE	8	56.0	19420.0	UG/L		X		
TOLUENE	8	19.2	9178.3	UG/L	X	X	X	X
BENZENE	7	12.2	314.5	UG/L	X	X	X	X
METHYLENE CHLORIDE	7	18.6	3571.0	UG/L	X	X	X	X
PHENOL	7	10.9	1441.8	UG/L	X	X	X	X
BENZOIC ACID	6	55.3	1825.0	UG/L		X	X	
CHLOROBENZENE	6	34.8	3646.0	UG/L	X	X	X	X
P-DIOXANE	6	13.2	955.0	UG/L	X		X	
1,4-DICHLOROBENZENE	5	13.4	1451.2	UG/L	X	X	X	X
2-BUTANONE (MEK)	5	396.2	2817.1	UG/L	X	X	X	
4-METHYL-2-PENTANONE	5	68.3	2767.0	UG/L		X	X	
BIS(2-ETHYLHEXYL)PHTHALATE	5	59.4	2261.7	UG/L	X	X	X	X
CHLOROFORM	5	406.3	1000.0	UG/L	X	X	X	X
ISOPHORONE	5	13.2	1910.0	UG/L		X	X	X
OCDD	5	0.0	0.5	PPT				
1,1-DICHLOROETHANE	4	15.0	269.3	UG/L	X	X	X	X
1,2-DICHLOROETHANE	4	15.2	38.8	UG/L	X	X	X	X
1,3-DICHLOROBENZENE	4	123.0	403.0	UG/L	X	X	X	X
2,3,7,8-TCDF	4	0.0	10.8	PPT	X			
2,4-DIMETHYLPHENOL	4	28.4	131.2	UG/L	X	X	X	X
ETHYLBENZENE	4	33.5	287.0	UG/L		X	X	X
HEXANOIC ACID	4	35.0	347.0	UG/L				
N,N-DIMETHYLFORMAMIDE	4	68.0	422.0	UG/L				
NAPHTHALENE	4	24.7	326.5	UG/L	X	X		X
O-+P-XYLENE	4	12.0	55.6	UG/L		X	X	
1,1,1-TRICHLOROETHANE	3	363.6	935.5	UG/L	X	X	X	X
1,1,2,2-TETRACHLOROETHANE	3	31.2	3481.0	UG/L	X	X	X	X
1,2,3,4,6,7,8-HpCDD	3	0.0	0.1	PPT				
1,2,4-TRICHLOROBENZENE	3	70.6	167.0	UG/L	X	X	X	X
ANILINE	3	20.1	1223.0	UG/L	X		X	
BENZYL ALCOHOL	3	19.5	89.6	UG/L		X		
BIPHENYL	3	11.7	5541.5	UG/L				
M-XYLENE	3	18.0	50.5	UG/L		X	X	
N-DODECANE (N-C12)	3	10.5	969.7	UG/L				
O-CRESOL	3	11.3	165.8	UG/L	X	X		
P-CRESOL	3	29.2	70.7	UG/L	X	X		
TOTAL HpCDD	3	0.0	0.1	PPT				

TABLE 3-2 (CONTINUED)
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
ORGANIC CONTAMINATES IN CERCLA GROUNDWATER AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
VINYL CHLORIDE	3	22.4	230.0	UG/L	X	X	X	X
1,1,2-TRICHLOROETHANE	2	17.0	244.3	UG/L	X	X	X	X
1,1-DICHLOROETHENE	2	43.7	49.7	UG/L	X	X	X	X
2,4,5-T	2	136.0	1100.0	PPT	X			
2,4-D	2	150.0	430000.0	PPT				
2-NITROPHENOL	2	159.8	174.3	UG/L		X		X
4-NITROPHENOL	2	230.7	446.9	UG/L	X	X		X
N-DECANE (N-C10)	2	14.5	278.1	UG/L				
O-TOLUIDINE	2	15.0	37.0	UG/L				
STYRENE	2	12.0	240.0	UG/L		X		
1,1,1,2-TETRACHLOROETHANE	1	70.3	70.3	UG/L	X			
1,2,3-TRICHLOROBENZENE	1	20.4	20.4	UG/L				
1,2,3-TRICHLOROPROPANE	1	5667.9	5667.9	UG/L	X			
1,3-DICHLORO-2-PROPANOL	1	23.0	23.0	UG/L	X	X		
2,4,5-TP (SILVEX)	1	1550.0	1550.0	PPT	X			
2,4-DIAMINOTOLUENE	1	112.0	112.0	UG/L	X			
2,4-DICHLOROPHENOL	1	66.7	66.7	UG/L	X	X	X	X
2,4-DINITROPHENOL	1	435.7	435.7	UG/L	X	X	X	X
2-CHLOROPHENOL	1	87.6	87.6	UG/L	X	X		X
2-HEXANONE	1	151.4	151.4	UG/L		X		
2-METHYL-4,6-DINITROPHENOL	1	174.3	174.3	UG/L		X	X	
2-METHYLNAPHTHALENE	1	15.0	15.0	UG/L		X		
3-CHLOROPROPENE	1	13.8	13.8	UG/L				
ACETOPHENONE	1	87.1	87.1	UG/L	X			
ACROLEIN	1	63.0	63.0	UG/L	X		X	
ALPHA-PICOLINE	1	52.8	52.8	UG/L				
ALPHA-TERPINEOL	1	11.5	11.5	UG/L				
BIS(2-CHLOROETHYL)ETHER	1	19.0	19.0	UG/L	X	X	X	X
BUTYL BENZYL PHTHALATE	1	1708.1	1708.1	UG/L	X	X		X
CHRYSENE	1	24.0	24.0	UG/L	X	X	X	X
DIBENZOFURAN	1	30.0	30.0	UG/L		X		
DIETHYL ETHER	1	64.0	64.0	UG/L	X		X	
DIMETHYL PHTHALATE	1	105.9	105.9	UG/L	X	X	X	X
FLUORENE	1	246.5	246.5	UG/L		X		X
HEXACHLOROETHANE	1	10.6	10.6	UG/L	X	X	X	X
ISOBUTYL ALCOHOL	1	11.4	11.4	UG/L	X			
N-OCTACOSANE (N-C28)	1	10.8	10.8	UG/L				
NITROBENZENE	1	18378.0	18378.0	UG/L	X	X	X	X
OCDF	1	0.1	0.1	PPT				
P-CYMENE	1	20.8	20.8	UG/L				
PCB-1232	1	10445.0	10445.0	UG/L	X	X	X	X

TABLE 3-2 (CONTINUED)
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
ORGANIC CONTAMINATES IN CERCLA GROUNDWATER AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
PHENANTHRENE	1	130.0	130.0	UG/L		X	X	X
PHOSPHAMIDON	1	8500.0	8500.0	PPT				
TEPP	1	79000.0	79000.0	PPT	X			
TOTAL HpCDF	1	0.0	0.0	PPT				
TRICHLOROFLUOROMETHANE	1	200.8	200.8	UG/L	X		X	
VINYL ACETATE	1	50.0	50.0	UG/L		X		

TABLE 3-3
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
ORGANIC CONTAMINATES IN CERCLA LEACHATE AT 3 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
PHENOL	3	35.0	1548330.0	UG/L	X	X	X	X
BENZOIC ACID	3	53.5	2316700.0	UG/L		X	X	
1,1,2,2-TETRACHLOROETHANE	2	1305.0	2942.0	UG/L	X	X	X	X
CHLOROFORM	2	518.0	8958.0	UG/L	X	X	X	X
AZINPHOS METHYL	2	50.0	51.7	UG/L				
TRICHLOROETHENE	2	601.0	3525.5	UG/L	X	X	X	X
TRANS-1,2-DICHLOROETHENE	2	170.0	1359.5	UG/L	X	X	X	X
TOLUENE	2	13483.0	18166.0	UG/L	X	X	X	X
TETRACHLOROETHENE	2	1299.0	3615.5	UG/L	X	X	X	X
P-CRESOL	2	72.5	161.0	UG/L	X	X		
2,3,7,8-TCDD	2	5.9	31.6	PPT	X		X	X
ACETONE	2	3245.5	52518.0	UG/L		X		
BENZENE	2	1740.0	2934.5	UG/L	X	X	X	X
BENZYL ALCOHOL	2	709.0	13308.0	UG/L		X		
HEXANOIC ACID	2	24.5	131.0	UG/L				
CHLOROBENZENE	2	2670.5	3773.0	UG/L	X	X	X	X
ACETOPHENONE	1	20.5	20.5	UG/L	X			
1,2,3-TRICHLOROBENZENE	1	596.0	596.0	UG/L				
CARBON TETRACHLORIDE	1	141.0	141.0	UG/L	X	X	X	X
BIS(2-CHLOROETHYL)ETHER	1	52.0	52.0	UG/L	X	X	X	X
2,4-DIMETHYLPHENOL	1	101.0	101.0	UG/L	X	X	X	X
1,2,4-TRICHLOROBENZENE	1	4662.0	4662.0	UG/L	X	X	X	X
ETHYLBENZENE	1	2639.0	2639.0	UG/L		X	X	X
2,4-DICHLOROPHENOL	1	833.0	833.0	UG/L	X	X	X	X
ISOPHORONE	1	58.5	58.5	UG/L		X	X	X
METHYLENE CHLORIDE	1	3544.5	3544.5	UG/L	X	X	X	X
N-DOCOSANE (N-C22)	1	10.5	10.5	UG/L				
N-EICOSANE (N-C20)	1	15.0	15.0	UG/L				
N-HEXADECANE (N-C16)	1	23.0	23.0	UG/L				
N-OCTADECANE (N-C18)	1	24.5	24.5	UG/L				
2,4,5-TRICHLOROPHENOL	1	1167.0	1167.0	UG/L	X	X		
1,4-DICHLOROBENZENE	1	964.0	964.0	UG/L	X	X	X	X
PENTACHLOROBENZENE	1	548.0	548.0	UG/L				
2,3,7,8-TCDF	1	0.4	0.4	PPT	X			
1,2-DICHLOROETHANE	1	1835.5	1835.5	UG/L	X	X	X	X
1,2-DICHLOROBENZENE	1	719.0	719.0	UG/L	X	X	X	X
CHLOROMETHANE	1	10566.0	10566.0	UG/L	X	X	X	X
DI-N-BUTYL PHTHALATE	1	26.5	26.5	UG/L	X	X	X	
AZINPHOS ETHYL	1	1.2	1.2	UG/L				
N-TETRADECANE (N-C14)	1	17.5	17.5	UG/L				
FENSULFOTHION	1	1.9	1.9	UG/L				

TABLE 3-3 (CONTINUED)
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
ORGANIC CONTAMINATES IN CERCLA LEACHATE AT 3 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
CHLORFEVINPHOS	1	7.2	7.2	UG/L				
FENTHION	1	4.2	4.2	UG/L				
CROTOXYPHOS	1	14.4	14.4	UG/L				
LEPTOPHOS	1	13.1	13.1	UG/L				
DIAZINON	1	10.1	10.1	UG/L				
MALATHION	1	7.7	7.7	UG/L				
DICROTOPHOS	1	29.1	29.1	UG/L				
MEVINPHOS	1	1.6	1.6	UG/L				
DIOXATHION	1	27.0	27.0	UG/L				
PARATHION	1	4.5	4.5	UG/L	X			
CHLORPYRIFOS	1	5.0	5.0	UG/L				
DICHLORVOS	1	27.6	27.6	UG/L				
DIMETHOATE	1	28.4	28.4	UG/L	X			
DISULFOTON	1	0.5	0.5	UG/L	X			
DELTA-BHC	1	1.6	1.6	UG/L		X	X	X
PCB-1254	1	6.0	6.0	UG/L	X	X	X	X
PHORATE	1	21.0	21.0	UG/L	X			
SULFOTEPP	1	1.0	1.0	UG/L	X			
TERBUFOS	1	5.0	5.0	UG/L				
TETRACHLORVINPHOS	1	0.8	0.8	UG/L				

TABLE 3-4
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
INORGANIC CONTAMINATES IN CERCLA GROUNDWATER AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
SODIUM	17	5560.0	1075000.0	UG/L		X		
CALCIUM	17	21620.0	487600.0	UG/L		X		
MAGNESIUM	17	2960.0	1242857.1	UG/L		X		
BARIUM	17	5.6	870.5	UG/L	X	X		
SILICON	17	3.0	34500.0	UG/L				
MANGANESE	17	25.4	341000.0	UG/L		X		
SULFUR	17	2.4	6337143.0	UG/L				
IRON	17	16.0	387400.0	UG/L		X		
BORON	16	20.8	168000.0	UG/L				
ZINC	16	6.7	56042.9	UG/L		X	X	X
STRONTIUM	14	0.7	12420.0	UG/L				
TITANIUM	13	3.0	722.0	UG/L				
ALUMINUM	12	110.0	1994285.7	UG/L		X		
POTASSIUM	11	2.0	30700.0	UG/L		X		
CHROMIUM	10	10.2	121428.6	UG/L	X	X	X	X
COPPER	10	8.0	9370.0	UG/L		X		X
NICKEL	1	25.0	19520.0	UG/L	X	X	X	X
COBALT	9	9.6	3380.0	UG/L		X		
YTTRIUM	9	2.0	4594.0	UG/L				
CADMIUM	8	5.2	2826.0	UG/L	X	X	X	X
ARSENIC	8	2.4	6000.0	UG/L	X	X	X	X
MOLYBDENUM	8	12.0	541.0	UG/L				
VANADIUM	8	3.0	1620.0	UG/L		X		
PHOSPHORUS	7	1500.0	12000.0	UG/L				
BERYLLIUM	7	1.8	120.0	UG/L	X	X	X	X
LITHIUM	5	0.1	2200.0	UG/L				
SILVER	5	7.5	44.0	UG/L	X	X	X	X
TIN	5	30.0	50.2	UG/L				
LANTHANUM	5	100.0	2100.0	UG/L				
GADOLINIUM	4	540.0	857.0	UG/L				
CERIUM	4	6300.0	19000.0	UG/L				
LEAD	4	69.0	1550.0	UG/L	X	X	X	X
NEODYMIUM	4	400.0	3300.0	UG/L				
SELENIUM	4	3.5	21.0	UG/L	X	X	X	X
IODINE	3	533.0	6000.0	UG/L				
IRIDIUM	3	240.0	3229.0	UG/L				
GOLD	3	2900.0	3371.0	UG/L				
YTTERBIUM	3	100.0	400.0	UG/L				
OSMIUM	3	0.2	1100.0	UG/L				
GALLIUM	2	600.0	700.0	UG/L				
ANTIMONY	2	4.0	34.0	UG/L	X	X		X

TABLE 3-4 (CONTINUED)
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
INORGANIC CONTAMINATES IN CERCLA GROUNDWATER AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
DYSPROSIUM	2	400.0	960.0	UG/L				
SCANDIUM	2	250.0	300.0	UG/L				
URANIUM	2	640.0	1300.0	UG/L				
SAMARIUM	2	620.0	780.0	UG/L				
TANTALUM	2	700.0	2740.0	UG/L				
PRASEODYMIUM	1	1600.0	1600.0	UG/L				
RUTHENIUM	1	4300.0	4300.0	UG/L				
LUTETIUM	1	200.0	200.0	UG/L				
NIOBIUM	1	1543.0	1543.0	UG/L				
GERMANIUM	1	320.0	320.0	UG/L				
ERBIUM	1	410.0	410.0	UG/L				
TUNGSTEN	1	1000.0	1000.0	UG/L				
INDIUM	1	1100.0	1100.0	UG/L				
MERCURY	1	6.0	6.0	UG/L	X	X	X	X
ZIRCONIUM	1	100.0	100.0	UG/L				

TABLE 3-5
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
INORGANIC CONTAMINATES IN CERCLA LEACHATE AT 3 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
NICKEL	3	18.5	1567.0	UG/L	X	X	X	X
SODIUM	3	51750.0	3495000.0	UG/L		X		
ALUMINUM	3	140.0	3515.0	UG/L		X		
SULFUR	3	7050.0	471500.0	UG/L				
IRON	3	6700.0	763000.0	UG/L		X		
SILICON	3	2040.0	6400.0	UG/L				
POTASSIUM	3	1010.0	621000.0	UG/L		X		
ZINC	3	70.0	555.0	UG/L		X	X	X
CALCIUM	3	4145.0	821500.0	UG/L		X		
TITANIUM	3	8.0	36.5	UG/L				
MAGNESIUM	3	2885.0	254000.0	UG/L		X		
MANGANESE	3	708.0	12800.0	UG/L		X		
BORON	3	247.0	14950.0	UG/L				
COPPER	2	26.0	28.9	UG/L		X		X
MOLYBDENUM	2	31.0	293.0	UG/L				
BARIUM	2	15.0	77.0	UG/L	X	X		
LITHIUM	2	600.0	9400.0	UG/L				
STRONTIUM	2	1500.0	3150.0	UG/L				
OSMIUM	2	100.0	100.0	UG/L				
PHOSPHORUS	2	1285.0	118000.0	UG/L				
VANADIUM	1	32.5	32.5	UG/L		X		
LEAD	1	108.0	108.0	UG/L	X	X	X	X
IODINE	1	2000.0	2000.0	UG/L				
CADMIUM	1	23.5	23.5	UG/L	X	X	X	X
COBALT	1	16.0	16.0	UG/L		X		
CHROMIUM	1	53.5	53.5	UG/L	X	X	X	X
TIN	1	33.0	33.0	UG/L				
ARSENIC	1	28.5	28.5	UG/L	X	X	X	X
TANTALUM	1	500.0	500.0	UG/L				
URANIUM	1	1000.0	1000.0	UG/L				

TABLE 3-6
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
CONVENTIONALS/NON-CONVENTIONALS IN GROUNDWATER AT 17 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
SPECIFIC CONDUCTANCE	17	264.0	17571.4	UMH/C				
CHLORIDE	17	10833.0	2900000.0	UG/L				
SULFATE	16	14500.0	19428571.0	UG/L				
TOC	16	2180.0	1300000.0	UG/L				
NITRATE + NITRITE, AS N	15	51.0	250042.0	UG/L				
FLASH POINT	14	0.0	57000.0	25 DE				
AMMONIA, AS N	13	158.0	21667.0	UG/L			X	
COD	13	30800.0	4340000.0	UG/L				
PHOSPHORUS, TOTAL AS P	12	103.0	12000.0	UG/L				
NITROGEN, TOTAL KJELDAHL	11	104.0	24857.0	UG/L				
BOD	11	6850.0	1446000.0	UG/L				
TSS	10	15857.0	2500000.0	UG/L				
TDS	10	231429.0	33000000.0	UG/L				
FLUORIDE	9	207.0	250000.0	UG/L				
OIL & GREASE, TOTAL RECOVERABLE	8	5000.0	54000.0	UG/L				
RESIDUE, FILTERABLE	6	180000.0	30000000.0	UG/L				
CORROSIVITY	6	1.7	92.0	MPY				
SULFIDE, TOTAL (IODOMETRIC)	6	1000.0	28000.0	UG/L				
NITROGEN, TOTAL KJELDEHL	5	156.0	24667.0	UG/L				
CYANIDE, TOTAL	4	24.3	100.0	UG/L	X	X	X	X
RESIDUE, NON-FILTERABLE	4	12117.0	266667.0	UG/L				
FLOURIDE	3	308.0	16500.0	UG/L				
TOTAL ORGANIC CARBON	1	2467.0	2467.0	UG/L				

TABLE 3-7
RCRA-APP. VIII, TCL, SARA 110, AND PRIORITY POLLUTANT
CONVENTIONALS/NON-CONVENTIONALS IN LEACHATE AT 3 SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS	RCRA CONTAMINANT	TCL CONTAMINANT	SARA 110 CONTAMINANT	PRIORITY POLLUTANT CONTAMINANT
TDS	3	128.5	1300.0	MG/L				
OIL & GREASE, TOTAL RECOVERABLE	3	21.0	545.0	MG/L				
TSS	3	16.5	18500.0	MG/L				
TOC	3	89.0	3350.0	MG/L				
COD	3	260.0	10400.0	MG/L				
SULFIDE, TOTAL (IODOMETRIC)	3	2.0	76.0	MG/L				
BOD	3	52.0	6500.0	MG/L				
PHOSPHORUS, TOTAL AS P	3	0.4	310.0	MG/L				
NITROGEN, TOTAL KJELDAHL	3	2.1	44.0	MG/L				
AMMONIA, AS N	2	1.6	7.9	MG/L			X	
FLUORIDE	2	0.7	12.0	MG/L				
SPECIFIC CONDUCTANCE	1	275.0	275.0	UMH/C				
SULFATE	1	52.0	52.0	MG/L				
NITRATE + NITRITE, AS N	1	5.5	5.5	MG/L				
FLASH POINT	1	44.0	44.0	DEG C				
CHLORIDE	1	58.0	58.0	MG/L				

TABLE 3-8
NUMBER OF CONTAMINANTS DETECTED AT CERCLA SITES

Site	Discharge	Organics	Dioxins	Pesticides PCBs	Inorganics	Semi Quan. Screen Metals
Bridgeport	Leachate	14	0	2	15	4
Hyde Park	Leachate	16	2	22	15	9
Love Canal	Leachate	21	1	0	13	6
Chemdyne	Groundwater	16	5	0	12	4
Charles George	Groundwater	10	0	0	14	5
Geneva	Groundwater	14	1	1	19	4
Gold Coast Oil	Groundwater	6	0	0	12	3
Nyanza	Groundwater	10	0	0	19	11
Reilly Tar	Groundwater	4	1	0	9	4
Stringfellow (1221)	Groundwater	12	1	0	22	21
Stringfellow (1240)	Groundwater	32	0	0	22	20
Stringfellow (1805)	Groundwater	24	3	0	20	10
Sylvester	Groundwater	28	0	0	14	4
Time Oil	Groundwater	8	0	0	9	3
Tyson's Dump	Groundwater	12	0	0	12	3
United Chrome	Groundwater	5	1	2	20	13
Verona	Groundwater	16	1	0	15	3
Well 12A	Groundwater	4	3	0	7	3
Western Processing	Groundwater	28	1	5	20	5
Whitehouse Oil	Groundwater	11	0	0	21	8

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detected at seven and benzoic acid at six of the seventeen groundwater sites but were detected at all three of the leachate sites. In addition, pesticides and/or PCBs were detected at two of the three leachate sites (Hyde Park and Bridgeport) whereas few pesticides and only one PCB was detected (PCB-1232, detected at Geneva) at the groundwater sites.

- Detectable concentrations for organic contaminants (including PCBs, pesticides, and dioxins) at groundwater sites ranged from 0.001 parts per trillion (ppt) and 58,017 $\mu g/\ell$ (2, 3, 7, 8-TCDF, detected at Reilly Tar and tetrachloroethene, detected at Gold Coast Oil). Concentrations for the organic contaminants detected at the leachate sites ranged from 3.85×10^{-4} $\mu g/\ell$ (2,3,7,8-TCDF, detected at Hyde Park) and 2,316,700 $\mu g/\ell$ (benzoic acid, also detected at Hyde Park). The total number of organic pollutants detected ranged from 5 to 32 at the groundwater sites and from 16 to 40 at the leachate sites.

The inorganic contaminants most frequently detected at the sites treating groundwater were similar to the most frequently detected contaminants at the sites treating leachate. Silicon, sodium, sulfur, manganese, magnesium, iron, and calcium were detected at all of the sites (Tables 3-4 and 3-5). The maximum concentrations detected of the above listed inorganic contaminants were generally higher at the groundwater sites than at the leachate sites (except for sodium, iron, and calcium). The concentrations for inorganic contaminants at the groundwater sites ranged from 0.05 $\mu g/\ell$ (lithium, detected at Geneva) and 6,337,143 $\mu g/\ell$ (sulphur, detected at Stringfellow). The minimum inorganic concentration detected at the leachate sites was 8.0 $\mu g/\ell$ (titanium, detected at Bridgeport) and the maximum concentration detected was 3,495,000 $\mu g/\ell$ (sodium, detected at Hyde Park). The total number of inorganic contaminants detected at the sites varied between sites. The total number of inorganics detected at groundwater sites ranged from 10 to 43 inorganic contaminants and from 19 to 24 at the leachate sites (see Table 3-8).

3-3.1.2 Frequency of Occurrence of Contaminants on Regulatory Lists.

Of the 345 organic contaminants (volatiles, semi-volatiles, pesticides, PCBs, and dioxins) on the ITD list of analytes, only 88 (approximately 26%) were detected at one or more sites where groundwater is being treated (see Table 3-2). Of those 88 contaminants, approximately 63% are on the TCL, 44% are on the Priority Pollutant list, 59% are RCRA-listed, and 50% are SARA 110-listed. Many of the analytes on the ITD list and not on the TCL, RCRA, Priority Pollutant, and/or SARA lists were detected at only one site. Organic contaminants on the ITD list but not on the TCL that were detected at groundwater sites are presented in Table 3-9. Only two of the most frequently occurring organic contaminants (detected at five or more sites of the seventeen sites sampled) are currently on the ITD list and not on the TCL list (OCDD and p-dioxane). All of the non-TCL organic contaminants detected at any site were detected at concentrations below 1000 $\mu g/\ell$, with the exception of three contaminants; biphenyl (5,541 $\mu g/\ell$), aniline (1,223 $\mu g/\ell$), and 1,2,3-trichloropropane (5,668 $\mu g/\ell$).

TABLE 3-9
NON-TCL ORGANIC CONTAMINANTS
DETECTED AT 17 CERCLA GROUNDWATER SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
P-DIOXANE	6	13.200	955.000	UG/L
OCDD	5	0.030	0.520	PPT
O-+P-XYLENE	4	12.000	55.570	UG/L
2,3,7,8-TCDF	4	0.000	10.850	PPT
N,N-DIMETHYLFORMAMIDE	4	68.000	422.000	UG/L
HEXANOIC ACID	4	35.000	347.000	UG/L
TOTAL HpCDD	3	0.030	0.120	PPT
ANILINE	3	20.140	1223.000	UG/L
N-DODECANE (N-C12)	3	10.500	969.710	UG/L
M-XYLENE	3	18.000	50.500	UG/L
BIPHENYL	3	11.670	5541.500	UG/L
1,2,3,4,6,7,8-HpCDD	2	0.030	0.080	PPT
2,4,5-T	2	136.000	1100.000	PPT
O-TOLUIDINE	2	15.000	37.000	UG/L
2,4-D	2	150.000	430000.000	PPT
N-DECANE (N-C10)	2	14.500	278.140	UG/L
ACROLEIN	1	63.000	63.000	UG/L
ALPHA-PICOLINE	1	52.830	52.830	UG/L
ALPHA-TERPINEOL	1	11.500	11.500	UG/L
ACETOPHENONE	1	87.140	87.140	UG/L
3-CHLOROPROPENE	1	13.800	13.800	UG/L
2,4-DIAMINOTOLUENE	1	112.000	112.000	UG/L
1,2,3-TRICHLOROBENZENE	1	20.430	20.430	UG/L
1,3-DICHLORO-2-PROPANOL	1	23.000	23.000	UG/L
TOTAL HpCDF	1	0.040	0.040	PPT
2-METHYL-4,6-DINITROPHENOL	1	174.290	174.290	UG/L
1,2,3-TRICHLOROPROPANE	1	5667.860	5667.860	UG/L
N-OCTACOSANE (N-C28)	1	10.830	10.830	UG/L
OCDF	1	0.060	0.060	PPT
DIETHYL ETHER	1	64.000	64.000	UG/L
P-CYMENE	1	20.830	20.830	UG/L
1234678-HpCDD	1	0.030	0.030	PPT
TRICHLOROFLUOROMETHANE	1	200.830	200.830	UG/L
1,1,1,2-TETRACHLOROETHANE	1	70.330	70.330	UG/L
2,4,5-TP (SILVEX)	1	1550.000	1550.000	PPT
ISOBUTYL ALCOHOL	1	11.400	11.400	UG/L
PHOSPHAMIDON	1	8500.000	8500.000	PPT
TEPP	1	79000.000	79000.000	PPT

Organic contaminants detected at the sites treating leachate (see Table 3-3) were similar to those found at groundwater sites. Sixty-one (approximately 18%) organic contaminants that are ITD listed were found at detectable concentrations. Of the 61 organic contaminants, 48% are on the TCL, 39% are on the Priority Pollutant list, 51% RCRA-listed, and 43% SARA 110-listed. Most of the contaminants that are not listed on the RCRA, TCL, Priority Pollutant, or SARA 110 lists were detected at only one of the three sites, many of which were pesticides detected at Hyde Park. The organic contaminants on the ITD list but not on the TCL that were detected at leachate sites are presented in Table 3-10. Azinphos methyl, hexanoic acid, and 2,3,7,8-TCDD were the only compounds detected at two or more of the three sites sampled that are ITD-listed but not on the TCL. All of the organic contaminants detected at the leachate sites that are not on the TCL were detected at concentrations below 500 $\mu g/\ell$ with the exception of pentachlorobenzene (548 $\mu g/\ell$) and 1,2,3-trichlorobenzene (596 $\mu g/\ell$).

Of the 69 inorganic analytes of the ITD list, 56 (approximately 81%) were detected at one or more sites treating groundwater (see Table 3-4). Of the 56 contaminants detected, 39% are on the TCL, 21% are on the Priority Pollutant list, 20% are RCRA-listed, and 18% are SARA 110-listed. Most of the inorganic parameters that are on the ITD list and not on the other three regulatory lists were detected at more than one site. Sulfur and silicon are not on the TCL but were detected at all of the groundwater sites sampled.

Thirty of the 69 ITD-listed inorganic parameters (approximately 43%) were detected at sites treating leachate (see Table 3-5). Fifty-seven percent of the 30 are on the TCL, 23% are on the Priority Pollutant list, and 20% are RCRA and SARA 110 listed. Again, many of the inorganic parameters detected that are on the ITD list but not on one or more of the three other regulatory lists were detected at two or more of the three sites. Sulfur, silicon, titanium, and boron were detected at all three of the sites and are not on the TCL.

The only conventional and non-conventional contaminants detected in groundwater that are on the RCRA, TCL, Priority Pollutant, and/or SARA 110 lists were cyanide, which is listed on all four regulatory lists, and ammonia, which is found on SARA 110 (see Table 3-6). Cyanide was detected at four of the seventeen sites treating groundwater and ammonia was detected at thirteen of the seventeen sites sampled.

Of the conventional and non-conventional contaminants detected at the sites treating leachate (see Table 3-7), ammonia was the only contaminant detected that is listed on one of the four regulatory list (SARA 110). The remaining contaminants are not listed on RCRA, TCL, Priority Pollutant, or SARA 110.

Table 3-11 presents a summary of the total number of contaminants detected (by class) at each specific CERCLA site sampled and the number of contaminants detected that are on the ITD, TCL and Priority Pollutant lists. Many of the organic and inorganic contaminants detected that are ITD-listed are also on the TCL. On the average, 79% of the organics detected (not including pesticides and PCBs) and 81% of the TCL metals are on both the TCL and ITD list. Twelve percent of the semi-quantitative screened metals detected are on the TCL.

TABLE 3-10
NON-TCL ORGANIC CONTAMINANTS
DETECTED AT 3 CERCLA LEACHATE SITES

CONTAMINANT	FREQUENCY	MINIMUM CONCENTRATION DETECTED	MAXIMUM CONCENTRATION DETECTED	UNITS
2,3,7,8-TCDD	2	5.950	31.620	PPT
AZINPHOS METHYL	2	50.000	51.700	UG/L
HEXANOIC ACID	2	24.500	131.000	UG/L
1,2,3-TRICHLOROBENZENE	1	596.000	596.000	UG/L
2,3,7,8-TCDF	1	0.390	0.390	PPT
ACETOPHENONE	1	20.500	20.500	UG/L
AZINPHOS ETHYL	1	1.200	1.200	UG/L
CHLORFEVINPHOS	1	7.250	7.250	UG/L
CHLORPYRIFOS	1	5.000	5.000	UG/L
CROTOXYPHOS	1	14.400	14.400	UG/L
DIAZINON	1	10.100	10.100	UG/L
DICHLORVOS	1	27.600	27.600	UG/L
DICROTOPHOS	1	29.100	29.100	UG/L
DIMETHOATE	1	28.450	28.450	UG/L
DIOXATHION	1	27.000	27.000	UG/L
DISULFOTON	1	0.500	0.500	UG/L
FENSULFOTHION	1	1.950	1.950	UG/L
FENTHION	1	4.250	4.250	UG/L
LEPTOPHOS	1	13.050	13.050	UG/L
MALATHION	1	7.650	7.650	UG/L
MEVINPHOS	1	1.600	1.600	UG/L
N-DOCOSANE (N-C22)	1	10.500	10.500	UG/L
N-EICOSANE (N-C20)	1	15.000	15.000	UG/L
N-HEXADECANE (N-C16)	1	23.000	23.000	UG/L
N-OCTADECANE (N-C18)	1	24.500	24.500	UG/L
N-TETRADECANE (N-C14)	1	17.500	17.500	UG/L
PARATHION	1	4.450	4.450	UG/L
PENTACHLOROBENZENE	1	548.000	548.000	UG/L
PHORATE	1	21.000	21.000	UG/L
SULFOTEPP	1	1.000	1.000	UG/L
TERBUFOS	1	4.950	4.950	UG/L
TETRACHLORVINPHOS	1	0.850	0.850	UG/L

TABLE 3-11
NUMBER OF ITD, TCL, AND PRIORITY POLLUTANTS DETECTED

Site	Discharge	Organic			Dioxins			Pesticides/PCBs			Inorganics			Semi-Quan. Metals		
		ITD	TCL	PP	ITD	TCL	PP	ITD	TCL	PP	ITD	TCL	PP	ITD	TCL	PP
Bridgeport	Leachate	14	8	4	0	0	0	2	1	1	15	13	5	4	1	0
Hyde Park	Leachate	16	16	13	2	0	0	22	1	1	15	12	5	9	1	0
Love Canal	Leachate	21	18	14	1	0	1	0	0	0	13	9	2	6	1	0
Chemdyne	Groundwater	16	12	12	5	0	0	0	0	0	12	10	4	4	1	0
Charles George	Groundwater	10	7	3	0	0	0	0	0	0	14	11	4	5	1	0
Geneva	Groundwater	14	11	9	1	0	0	1	1	1	19	14	5	4	0	0
Gold Coast Oil	Groundwater	6	5	4	0	0	0	0	0	0	12	10	3	3	0	0
Nyanza	Groundwater	10	9	9	0	0	0	0	0	0	19	16	7	11	1	0
Reilly Tar	Groundwater	4	3	2	1	0	0	0	0	0	9	7	1	4	0	0
Stringfellow (1221)	Groundwater	12	11	9	1	0	0	0	0	0	22	18	9	21	1	0
Stringfellow (1240)	Groundwater	32	25	20	0	0	0	0	0	0	22	17	8	20	1	0
Stringfellow (1805)	Groundwater	24	20	15	3	0	0	0	0	0	20	16	7	10	1	0
Sylvester	Groundwater	28	23	17	0	0	0	0	0	0	14	13	6	4	0	0
Time Oil	Groundwater	8	8	8	0	0	0	0	0	0	9	7	1	3	1	0
Tyson's Dump	Groundwater	12	8	7	0	0	0	0	0	0	12	10	3	3	0	0
United Chrome	Groundwater	5	3	1	1	0	0	2	0	0	20	15	6	13	1	0
Verona	Groundwater	16	14	10	1	0	0	0	0	0	15	11	3	3	0	0
Well 12A	Groundwater	4	4	4	3	0	0	0	0	0	7	7	1	3	1	0
Western Processing	Groundwater	28	17	19	1	0	0	5	0	0	20	16	8	5	1	0
Whitehouse Oil	Groundwater	11	6	2	0	0	0	0	0	0	21	18	9	8	1	0

NOTES: ITD - Industrial Technology Division Analyte
TCL - Target Compound List

Sixty-three percent of the organics detected and 32% of the TCL metals detected are on the Priority Pollutant list. No semi-quantitative screened metals are on the Priority Pollutant list.

3-3.2 Task 2: Daily Variation in Treatability of CERCLA Site Wastewater

For each CERCLA site where sampling occurred for more than one day, the percent removal and the total removal for the system was calculated for each compound across each unit process each day that samples were collected. Sites included Verona, Reilly Tar, Stringfellow, Sylvester, Time Oil, Tyson's Dump, United Chrome, Chemdyne (including both the wastewater and air data), Well 12A, and Western Processing.

The daily variability in wastestream and air characteristics and the treatment efficiencies on a daily basis were assessed for the sites. Although some variability existed, the variability of the organic contaminants concentration and removal efficiency was low for all sites. Contaminants were consistently detected at similar concentrations and the removal efficiency remained fairly consistent across each unit process for all days. For example, the concentration of trichloroethene, detected at the Verona Well Fields, ranged from 506 $\mu g/\ell$ to 812 $\mu g/\ell$ for the days of sampling; the total removal remained consistent, ranging from 98% to 99%.

The variability of inorganic parameters in the CERCLA site wastestreams was also low at most sites. Some of the inorganic contaminants received little or no treatment, but the treatability remained constant. This is an indication that the system was not specifically designed to treat the particular contaminant (i.e., sodium at the Sylvester site) and probably is not a concern. The inorganic data for the Tyson's Dump site appears to be questionable. The influent concentrations for many of the inorganic contaminants are less than the final effluent concentrations, resulting in negative percent removals. As a result, the data were considered questionable and not used for evaluating the treatability of inorganic contaminants. The treatment system at Tyson's Dump has also been updated and improved since this sampling event. As a result, any anomalies due to the actual treatment system may have been corrected.

The variability of the conventional and non-conventional contaminants is consistently high for many of the parameters at all of the sites sampled. As was discussed previously, this is probably due to variation in the wastestreams and the low influent concentrations detected for the conventional and non-conventional contaminants.

3-3.3 Task 3: Variability at the Stringfellow Site

The Stringfellow site was sampled three different times during the program; a one-day sampling event on November 3, 1987 (Episode 1221), a five-day sampling event from March 7 through 11, 1988 (Episode 1240), and a four-day sampling event from August 22 through 25, 1989 (Episode 1805). The site was sampled three times in order to assess the variability of contaminants and the treatment process over an extended period of time.

In general, the number of contaminants detected at the site changed over time for the organic compounds and stayed fairly consistent for the inorganics. Thirteen organic compounds were detected above the detection limit during Episode 1221, 32 organic compounds were detected during Episode 1240, and 27 organic compounds were detected during Episode 1807. The influent concentrations and treatability of organic contaminants detected during the three events remained fairly consistent and are summarized in Table 3-12. Contaminants showing the most variability included 1,3-dichlorobenzene and acetone. The treatability of all organic contaminants detected during all events remained high and consistent between events (i.e., greater than 90% for most compounds).

A number of organic contaminants detected above the detection limit during the four- and five-day events were not detected during the one-day event and are summarized in Table 3-13. Many of these contaminant's influent concentrations were at levels below 1,000 ug/ℓ. Exceptions to this included 2-butanone (1,500 μg/ℓ and 2,817 ug/ℓ) and 4-methyl-2-pentanone (1,404 μg/ℓ and 2,767 ug/ℓ) during the four- and five-day events, respectively, and butylbenzyl phthalate, which was detected only during the five-day event (1,708 ug/ℓ). Treatability of some of the contaminants detected during the four- and five-day events were also somewhat lower (less than 70% removal). Lower removals are, however, probably due to the lower influent concentrations detected.

Arsenic was the only TCL inorganic detected above the detection limit during the one-day sampling event that was not detected during the four- and five-day events. Although the semi-quantitative screened metals varied somewhat between events, the actual number was the same.

The influent concentrations of most of the inorganics remained fairly consistent (i.e., within 30%). Exceptions to this included compounds such as boron, magnesium, and molybdenum. Influent concentrations decreased over time for boron (16,900 ug/ℓ, 4,215 ug/ℓ, and 3,034 μg/ℓ) and molybdenum (512 ug/ℓ, 12 ug/ℓ, and 100 μg/ℓ) and increased for magnesium (355,000 ug/ℓ, 1,242,857 ug/ℓ, and 1,156,000 μg/ℓ). Treatability remained fairly consistent between sampling events.

3-3.4 Task 4: Evaluation of Contaminant Treatability

The treatability of CERCLA pollutants was evaluated by calculating the percent removal across each unit process at each individual site. Tables for each site summarizing the number of contaminants, the minimum and maximum influent and effluent concentrations for organics and inorganics, the total mass discharged to and from the treatment system, the percent removal over each unit process, and the total removal for the system are presented in Attachment B. The data presented in the tables are the average concentrations that were calculated, as described previously. Total removal for the system was not calculated for the Stringfellow site since two different streams were combined mid-way through the system and flow information was not available.

TABLE 3-12

ORGANIC CONTAMINANTS DETECTED AT ALL THREE STRINGFELLOW SAMPLING EVENTS

Compound	Influent Conc. (μg/ℓ)/GAC% Removal*		
	1221	1240	1807
1,2-Dichlorobenzene	3,985/99	3,624/99	4,742/99
1,3-Dichlorobenzene	123/90	155/89	403/60
1,4-Dichlorobenzene	1,077/96	1,432/97	1,451/96
Acetone	14,116/96	19,420/97	5,006/97
Chlorobenzene	1,264/97	1,469/97	1,515/97
Chloroform	1,000/96	945/97	970/97
Isophorone	1,910/99	1,782/99	1,027/99
Methylene Chloride	3,571/99	1,860/99	2,415/98
Trichloroethene	8,020/99	8,369/>99	6,847/99

*GAC - Granular Activated Carbon

TABLE 3-13

ORGANIC CONTAMINANTS NOT DETECTED
DURING SAMPLING EPISODE 1221

Compound	Influent Conc. (μg/ℓ)/GAC % Removal* 1240	1807
1,2,4-Trichlorobenzene	91/17	
1,2-Dichloroethane		15/<1
1,2,3,4,6,7,8-HpCDD		$3x10^{-5}$/24
2,4-Dinitrophenol	436/22	
2-Butanone	2,817/93	1,500/92
2-Chlorophenol	88/25	
2-Hexanone		151/<1
2-Methyl-4, 6-Dinitrophenol	174/26	
2-Nitrophenol	174/59	
4-Methyl-2-Pentanone	2,767/92	1,404/48
4-Nitrophenol	447/61	
Acetophenone	87/29	
Benzene		12/<1
Benzyl Alcohol	90/65	
Benzene	12/<1	
Bis(2-Ethylhexyl)phthalate	105/23	
Butyl Benzyl Phthalate	1,708/<1	
Dimethyl Phthalate	106/59	
Ethylbenzene		83/30
Isobutyl Alcohol		11.4/<1
M-Xylene		49/9
Napthalene	118/73	106/25
N,N-Dimethylformamide	165/77	
N-Decane	278/23	
N-Dodecane	970/53	
O- + P-Xylene		29/<1
OCDD		$3x10^{-5}$/<1
P-Dioxane	357/<1	215/1
Tetrachloroethene	386/90	200/66
Toluene	632/92	443/86
Total HpCDD		$3x10^{-5}$/<1
Trans-1,2-Dichloroethene		30/9
Vinyl Acetate		50/<1

*GAC - Granular Activated Carbon

Tables sumarizing the treatment efficiency of the various unit processes at the sites sampled are presented in Attachment C. The tables present the pollutant, treatment technology, matrix (groundwater or leachate), effluent concentration, and the site episode number. The data is divided according to the influent concentration range (i.e., 0-100 $\mu g/\ell$, 100-1,000 $\mu g/\ell$, 1,000-10,000 $\mu g/\ell$, 10,000-100,000, and >100,000 $\mu g/\ell$). The organic compounds evaluated include those pollutants in the top 25% of those most frequently detected at the sites sampled and are presented in Table C-1.

The top 25% most frequently occurring inorganics plus six additional compounds are presented in Table C-2. The additional inorganic compounds were added to include more priority pollutants in the evaluation. Since air stripping and granular activated carbon are not typically used to treat inorganic contaminants in wastewater, these technologies were not evaluated for the inorganic pollutants.

3-3.4.1 Treatability of Inorganic Contaminants. The inorganic contaminants that were analyzed for are presented in Section 9, Table 9-4, to show the two groups the inorganic contaminants were divided into for analysis; the inorganics that are included on the CERCLA Target Compound List (TCL) and the semi-quantitative screened inorganics.

In general, treatment of inorganic contaminants was effective for sites where chemical precipitation was a component of the treatment system (Stringfellow, Sylvester, United Chrome, and Western Processing). These systems were designed to treat metals since the concentrations were generally higher at those sites compared to sites that did not use precipitation. Chemical precipitation achieved treatment levels, on the average, greater than 75% for many of the TCL and priority pollutant inorganics detected at these sites. Removal was often higher (greater than 90%) at concentrations greater than 100 $\mu g/\ell$. The metals listed on the semi-quantitative list (see Section 9, Table 9-4) showed slightly lower treatment levels (averaged less than 55%). In addition, calcium, sodium, and tin showed low levels of treatment at all of the sites sampled.

3-3.4.2 Treatability of Organic Contaminants. Treatment systems at the CERCLA sites varied from site to site, depending on the type of contaminants present. Activated carbon and air stripping were the primary treatment technologies used at the sites to treat organic contaminants. Activated carbon was used at five of the sites (Stringfellow, Reilly Tar, Love Canal, Time Oil, and Bridgeport). Air stripping was used at Sylvester, Tyson's Dump, Chemdyne, and Well 12A. Carbon adsorption followed by air stripping was used at the Verona Well Fields, and air stripping followed by carbon adsorption was used at Western Processing. The treatment of organic contaminants using these systems was generally effective at the sites that were sampled since most of the concentrations of organic contaminants detected in the influent were reduced to the detection limits.

In order to evaluate the effectiveness of the organic treatment systems, the removal efficiency of compounds treated with air stripping and the removal

efficiency of compounds treated using carbon adsorption were compared for contaminants detected at more than one site. In general, activated carbon was slightly more effective for treating volatile organic compounds at the CERCLA sites sampled, although both carbon and air stripping showed removal efficiencies greater than 90%. The influent concentrations discharged to the carbon adsorption units were, however, often higher than the influent concentrations discharged to the air stripper; higher influent concentrations often result in relatively higher removal efficiencies.

Activated carbon was typically the technology used to treat semi-volatile contaminants and was again effective for reducing contaminant concentrations to their detection limits.

Carbon adsorption followed by air stripping was used at the Verona Well Fields. For most organic contaminants, carbon adsorption alone effectively treated the site wastewater (total removal did not increase substantially after the stream was treated using air stripping). However, for a few volatile organics (1,1,1-trichloroethane, acetone, and trans-1,2-dichloroethene) treatment with air stripping did increase the level of treatment.

Air stripping followed by chemical precipitation and carbon adsorption was used at Western Processing. Of the organic contaminants detected above the detection limit at the site, removal due to carbon adsorption increased for approximately 50% of the compounds. The percent removal due to carbon ranged from 1% (benzene) and 83% (trichloroethene). In general, removal due to carbon adsorption was observed for both volatile and semi-volatile compounds. However, most compounds that were not treated by carbon adsorption were semi-volatiles that were already effectively removed using only air stripping (i.e., 2-nitrophenol, 4-nitrophenol, and phenol) or were removed by air stripping as well as by chemical precipitation (e.g., benzoic acid, o-cresol, isophorone, etc.).

3-3.5 Task 5: Comparison of CERCLA Site Treatability Data to Data in the ORD Treatability Data Base

Table 3-14 presents a summary comparison of the treatability of selected frequently occurring compounds detected at the CERCLA sites to data in the ORD Treatability Data Base. The contaminant, treatment technology, ORD influent concentration range in which the CERCLA influent falls, the CERCLA site percent removal, and the ORD percent removal are presented in the table. The type of wastestream treated is defined in the ORD data base by the "Source Matrix" (i.e., groundwater, industrial, domestic, etc.). The wastestreams at the CERCLA sites sampled were either groundwater or leachate. Therefore, since data in the ORD data base were limited for some compounds that were treated in either a groundwater or leachate wastestream, percent removal data from the ORD data base was evaluated for industrial flow, hazardous leachate, superfund waste, and/or groundwater (rather than evaluating only data for groundwater or hazardous leachate), depending on the data that were available. Section 13 of this Treatability Manual presents the ORD data base.

TABLE 3-14
COMPARISON OF CERCLA SITE TREATABILITY DATA TO DATA IN ORD TREATABILITY DATA BASE

CONTAMINANT	*TECHNOLOGY	CERCLA INFL. CONC. RANGE (μg/ℓ)	CERCLA PERCENT REMOVAL	ORD PERCENT REMOVAL
Trichloroethene	Air Str.	0-100	50-83	87-99.68
	Air Str.	100-1000	94-96	87-99.9
	Carbon	0-100	83	98.6->98.8
	Carbon	100-1000	95-98	>95.8->99.36
	Carbon	1000-10,000	98->99.9	>99.46
	Carbon + Air Str.	100-1000	99	No data
	Air Str. + Carbon	1000-10,000	99	No data
Trans-1,2-Dichloroethene	Air Str.	0-100	12	No data
	Air Str.	100-1000	94-97	No data
	Air Str.	1000-10,000	95	>99.9
	Air Str.	0-100	84	No data
	Carbon	0-100	9-32	No data
	Carbon	100-1000	94-98	>92.5
	Carbon + Air Str.	100-1000	88	No data
Methylene Chloride	Act Sl.	0-100	60	>77-92
	Air Str.	0-100	29-74	No data
	Air Str.	100-1000	91	99
	Carbon	0-100	25-64	No data
	Carbon	100-1000	99	>94.4->99
	Carbon + Air Str.	0-100	46	No data
	Air Str. + Carbon	0-100	88	No data
Benzene	Act Sl.	0-100	46	>89.6
	Air Str.	100-1000	93	99.09->99.74
	Carbon	0-100	60	No data
	Carbon	1000-10,000	>99	>99.28
	Carbon + Air Str.	0-100	60	No data
	Air Str. + Carbon	0-100	60	>90.9
1,1,2,2-Tetra-chloroethene	Air Str.	0-100	54-68	No data
	Carbon	1000-10,000	98->99	>99.11
Zinc	Precip.	0-100	1.0	No data
	Precip.	100-1000	87	96.7
	Precip.	10,000-100,000	>99.9	99.932
Nickel	Precip.	100-1000	78	No data
		1000-10,000	93-99	58-93.4
		10,000-100,000	>99	84-99.52

TABLE 3-14
(continued)
COMPARISON OF CERCLA SITE TREATABILITY DATA TO DATA IN ORD TREATABILITY DATA BASE

CONTAMINANT	*TECHNOLOGY	CERCLA INFL. CONC. RANGE (μg/ℓ)	CERCLA PERCENT REMOVAL	ORD PERCENT REMOVAL
Boron	Act. Sl.	100-1000	12	No data
	Precip.	100-1000	24-86	No data
	Precip.	1000-10,000	2-71	69
	Precip.	>100,000	76	No data
	Precip.	100-1000	0-45	No data
	Carbon	>10,000	9	No data
Cadmium	Precip.	100-1000	99	No data
	Precip.	1000-10,000	99->99.9	99.31
	Carbon	0-100	11-23	No data

*Technology Key: Air Str. - Air Stripping
Act. Sl. - Activated Sludge
Carbon - Granular Activated Carbon
Precip. - Chemical Precipitation

In most instances, treatability at the CERCLA sites compares closely to the data found in the ORD data base for the technologies and concentration ranges where data were available. Many of the CERCLA percent removals are in the range or close to the range of data in the ORD data base which indicates that the removal efficiencies of treatment technologies at CERCLA sites are similar to those of industrial waste treatment facilities.

Data at various concentration ranges for specific technologies were unavailable or limited for some compounds (trans-1,2-dichloroethene, methylene chloride, benzene, zinc, boron, and cadmium). In addition, data for the treatability of phenol, acetone, and benzoic acid for the concentration ranges and technologies observed at the CERCLA sites were unavailable in the ORD data base.

3-3.6 Task 6: Evaluation of Chemdyne Air Sampling Data

Air sampling at the Chemdyne site was performed in order to evaluate air emission concentrations relative to wastewater concentrations and to evaluate process efficiency ratings. A description of the sample locations, data reduction, the treatment efficiency of the vapor phase activated carbon unit, and the results of the mass balance of the air stripper are presented in subsequent sections.

3-3.6.1 Sample Point Description. The treatment process at the Chemdyne facility consists of one air stripper. Air emitted from the stripping tower is treated using vapor phase activated carbon since the wastewater at the site is primarily contaminated with volatile organic compounds. The average wastewater flow through the system is 750 gpm and flows into an airstream flowing at approximately 7,212 cubic feet per minute (ft^3/min).

Air samples from the system were collected over a three day period. Samples were taken at the carbon scrubber inlet and outlet simultaneously to determine the carbon scrubber efficiency. In addition, one sample was collected at the intake of the stripper, one blank (ambient air) sample was collected, and a duplicate was collected at the carbon scrubber inlet and outlet. Each sample was analyzed for the list of 41 priority pollutants (based on previous wastewater sampling results) presented in Table 3-15. The air samples were analyzed using Method T014 in EPA's Compendium of Methods for the Determination of Toxic Compounds in Ambient Air, modified to detect all of the compounds presented in Table 3-15.

3-3.6.2 Data Reduction. To evaluate the analytical data, it was assumed that the air stripping process was leak tight (i.e., air enters through one duct and exits through one duct). Secondly, air entering the air stripping process was considered clean for mass balance purposes.

To evaluate the air sampling data, the concentrations detected at each sample point over the three day sampling event were averaged. The duplicate samples taken at the carbon scrubber inlet and outlet were included in the average. The averaged data was then reduced so that the emission concentrations relative to the wastewater concentrations could be compared.

TABLE 3-15

VOLATILE ORGANIC COMPOUND LIST FOR
AIR SAMPLE ANALYSIS USING GC-MS METHOD OF TO-14

Dichlorodifluoromethane
Methyl Chloride
1,2-Dichloro-1,1,2,2-tetrafluoroethane
Vinyl Chloride
Methyl bromide
Ethyl chloride
Trichlorofluoromethane
Methylene Chloride
1,1-Dichloroethene
1,1,2-Trichloro-1,2,2-Trifluoroethane
1,1-Dichloroethane
cis-1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
1,1,1-Trichloroethane
Benzene
Carbon Tetrachloride
1,2-Dichloropropane
Trichloroethene
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
1,1,2-Trichloroethane
Toluene
1,2-Dibromoethane
Tetrachloroethene
Chlorobenzene
Ethylbenzene
m-Xylene
p-Xylene
Styrene
1,1,2,2-Tetrachloroethane
o-Xylene
1,3,5-Trimethylbenzene
1,2,4-Trimethylbenzene
m-Dichlorobenzene
Benzyl chloride
o-Dichlorobenzene
p-Dichlorobenzene
1,2,4-Trichlorobenzene
Hexachlorobutadiene
1,2-trans-Dichloroethene

The mass balance on the air stripper was performed using a wastewater flow rate of 750 gpm and an air flow rate of 7,212 ft^3/min. The wastewater flow is an approximate rate for the period during which sampling occurred. The air flow rate was calculated using the measured air velocity through the stripper and the area of the stripper. Although a three day average was calculated and used in the mass balance, system anamolies can effect the velocity and cause it to fluctuate within plus or minus 10%.

Prior to evaluating the air data, the field blank (ambient air), laboratory canister blanks, and air intake data were analyzed to determine that field or laboratory contamination were not contributing to the analytical sample data. All concentrations detected in both the field blank and canister blanks were below the detection limit.

Some compounds were detected in the sample collected at the intake of the stripper. The concentrations detected were, however, low (i.e., less than 1 $\mu g/\ell$ after reducing, as described previously) and were therefore considered negligible.

3-3.6.3 Treatment Efficiency and Mass Balance. The treatment efficiency of the vapor phase activated carbon system was evaluated and is summarized in Table 3-16. The compound, carbon scrubber inlet and outlet concentrations, and percent removal are presented. Although the percent removal for many of the compounds was low (less than 60%) many of the contaminants were treated to their detection limits. In many cases, the low percent removals are therefore probably due to low influent concentrations rather than low efficiency. In addition to low influent concentrations, low removal efficiencies could also be attributed to system anamolies, or the fact that a particular compound is not effectively treated using carbon (i.e., vinyl chloride).

The results of the mass balance of the air stripper for those contaminants detected in the wastewater are summarized in Table 3-17. The raw wastewater concentration entering the stripper, the wastewater air stripper effluent, the concentration emitted from the air stripper, and the total mass recovered (air stripper effluent plus air stripper emission) are presented. A mass balance within 20% was achieved for many of the compounds (1,1-dichloroethane, trichloroethene, 1,1,2-trichloroethane, chlorobenzene, and 1,1,2,2-tetrachloroethane). However, the mass recovered of the remaining compounds was significantly different than the mass discharged to the air stripping system. Factors possibly contributing to the discrepencies include both the air and wastewater flow rates (which can fluctuate plus or minus ten percent), a high relative humidity, fluctuations in air temperature and pressure throughout the day, and analytical variations.

3-3.7 Task 7: Comparison of Indicator Parameter Treatability to Organic Contaminant Treatability

An attempt was made to evaluate the removal efficiency for various organic contaminants by comparing the removal efficiency of specific organic contaminants at a site to the various indicator parameters for the site (i.e., biological oxygen demand and chemical oxygen demand). It was, however, not

TABLE 3-16

VAPOR PHASE ACTIVATED CARBON
TREATMENT EFFICIENCY

Compound	Scrubber[1] Inlet (ug/ℓ)	Scrubber[1,2] Outlet (ug/ℓ)	Percent Removal
Vinyl Chloride	4.8	6.2	<1
1,1-Dichloroethene	1.40	1.5	<1
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.06	0.08U	<1
1,1-Dichloroethane	0.30	0.30	0
Cis-1,2-Dichloroethene	6.39	6.30	1
Chloroform	0.16	0.15	6
1,2-Dichloroethane	0.39	0.35	10
1,1,1-Trichloroethane	0.09	0.07	22
Benzene	0.95	0.42	56
Trichloroethane	2.44	1.50	39
1,1,2-Trichloroethane	3.13	0.30	90
Toluene	0.15	0.07U	>53
Tetrachloroethene	2.23	0.07U	>97
Chlorobenzene	0.40	0.07U	>83
Ethylbenzene	1.53	0.07U	>95
P-Xylene	2.10	0.07U	>97
1,1,2,2-Tetrachloroethane	0.78	0.07U	>91
O-Xylene	0.10	0.07U	>30
1,3,5-Trimethylbenzene	0.09	0.07U	>22
1,2,4-Trimethylbenzene	0.21	0.07U	>67
1,2-trans-Dichloroethene	0.54	0.56	<1

[1]Represents concentrations detected in air samples that have been reduced for comparison to wastewater samples.

[2]U indicates the compound was analyzed for but not detected. The minimum detection limit for the sample is reported (e.g., 0.07U).

TABLE 3-17

AIR STRIPPER MASS BALANCE

Compound	Raw Water (lbs/day)	Air Stripper Effluent (lbs/day)	Air Stripper[1] Emission (lbs/day)	Total Mass Recovered (lbs/day)
Vinyl Chloride	0.53	0.09	3.11	3.20
1,1-Dichloroethene	0.45	0.09	0.91	1.00
1,1-Dichloroethane	0.63	0.16	0.19	0.35
1,2-Dichloroethane	0.34	0.09	0.25	0.34
Benzene	0.41	0.09	0.62	0.71
Trichloroethene	2.03	0.09	1.58	1.67
1,1,2-Trichloroethane	2.20	0.29	2.03	2.32
Tetrachloroethene	4.00	0.09	1.45	1.54
Chlorobenzene	0.31	0.09	0.26	0.35
Ethylbenzene	0.30	0.09	0.99	1.08
0- + P-Xylene	0.35	0.08	1.43	1.52
1,1,2,2-Tetrachloroethane	0.77	0.35	0.51	0.86
Trans-1,2-Dichloroethene	2.06	0.09	0.35	0.44

[1]Also the Vapor Phase Activated Carbon Scrubber Inlet.

possible to compare the indicator parameters to organic contaminants due to the low and inconsistent influent and effluent concentrations of the indicator parameters. The concentrations of both the influent and effluent at all of the sites were typically low and the effluent concentration was often slightly greater than the influent. As a result, overall percent removal of many of the indicator parameters was either low or negative and inconsistent between sites, which made it impossible to compare to organic compound removal efficiencies.

3-4.0 CONCLUSIONS

In general, the CERCLA sites sampled are providing high levels of treatment to most inorganic and organic contaminants detected at the sites. Chemical precipitation effectively treats most inorganic contaminants and both air stripping and carbon adsorption individually provide effective removals of organic contaminants. Many of the contaminants are being treated to their detection limits prior to discharge. In addition, in those cases where the discharge is to a POTW, the CERCLA wastewater discharge volumes and contaminant concentrations are typically low relative to the total POTW treatment volume and contaminant loading. It is therefore possible, that in those cases where the discharge is to a POTW, the predicted treatment potential of the POTW is not fully used. This is emphasized by the treatability data in the ORD treatability data base which indicated that biological treatment, the technology used at a majority of POTWs, is effective for organics at concentrations between 0 and 100 $\mu g/\ell$ (for those compounds evaluated).

The day-to-day contaminant levels and treatment effectiveness in the wastestreams at sites sampled for more than one day was generally consistent for organics as well as inorganic contaminants. The inorganic data from Tyson's dump is, however, an exception since the influent concentration for many of the inorganic parameters was consistently lower than the effluent concentration. The data is therefore questionable and should not be used as an indication of the removal efficiency of inorganic contaminants.

The wastestreams at the CERCLA sites sampled varied in contamination type, the ranges of concentrations, and the actual number of contaminants detected at each site. The most frequently occurring contaminants detected at all of the sites (both groundwater and leachate) were conventional and non-conventional pollutants, which is to be expected. The most frequently occurring inorganic parameters detected at the sites treating groundwater and at the sites treating leachate were similar (zinc, sodium, manganese, boron, iron, and calcium). The organic parameters, however, varied somewhat between sites. Inorganic contaminant concentrations ranged from 8 $\mu g/\ell$ to 3,495,000 $\mu g/\ell$ at leachate sites and from 0.05 $\mu g/\ell$ to 6,337,143 $\mu g/\ell$ at groundwater sites. Organic pollutants ranged from 3.85×10^{-4} to 2,316,700 $\mu g/\ell$ at leachate sites and 10^{-6} $\mu g/\ell$ to 58,017 $\mu g/\ell$ at groundwater sites. The actual number of organic and inorganic contaminants detected above the detection limit at individual sites ranged from 35 to 65 at leachate sites and 17 to 74 at groundwater sites.

All of the samples collected from each of the CERCLA sites were analyzed for the full ITD list of 443 organic and inorganic analytes. A summary of the percent of ITD analytes detected at the sites and, of those compounds detected, the percent on the RCRA Appendix VIII, TCL, SARA 110, and Priority Pollutant contaminant lists is presented in Table 3-18.

Many of the organic contaminants detected at the leachate sites that are not on the TCL were pesticides. This explains the low percentage of organics detected at the leachate sites that are not on the TCL. In addition, most organic contaminants that are not on the TCL and were detected at the leachate and groundwater sites were detected at low concentrations (less than 500 $\mu g/\ell$ and 1,000 $\mu g/\ell$, respectively).

Of the inorganic parameters detected that are not on the TCL, most were the semi-quantitative screened metals. Approximately 81% of the ITD list metals detected are on the TCL whereas only 12% of the semi-quantitative screened metals were on the TCL. Overall, the number of both organic and inorganic contaminants detected at the CERCLA sites was much lower than the compounds analyzed for from the ITD List (345 organics and 69 inorganics).

In general, concentrations of organic and inorganic contaminants at the Stringfellow site stayed fairly consistent. The concentrations for most contaminants in both classes of compounds did not fluctuate substantially and the treatability of many contaminants remained high (i.e., greater than 90%) during all events.

The treatment efficiency of the vapor phase activated carbon system at the Chemdyne site was low (less than 60%) for many of the contaminants. Many contaminants were, however, treated to their detection limits which indicates that low percent removals were probably due to low influent concentrations rather than low efficiencies.

The mass balance of the Chemdyne air stripper was within 20% for many compounds. Differences in mass recovered from the mass discharged to the system was probably due to various factors including discrepencies in the air and wastewater flow rates, a high relative relative humidity, fluctuations in air temperature and pressure, and analytical variations.

It was not possible to compare the removal efficiencies of organic contaminants to the removal efficiency of indicator parameters due to the low influent and effluent concentrations detected for the indicator parameters.

TABLE 3-18
PERCENTAGE OF CONTAMINANTS DETECTED
FROM VARIOUS REGULATORY LISTS

		Percent of ITD Listed Contaminants Detected	Percent of Contaminants Detected on Various Regulatory Lists			
			RCRA	TCL	SARA	Priority Pollutant
Groundwater	organic	26%	59%	63%	50%	44%
	inorganic	81%	20%	39%	18%	21%
Leachate	organic	18%	51%	48%	43%	39%
	inorganic	43%	20%	57%	20%	23%

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ATTACHMENT A
SITE DESCRIPTIONS

BRIDGEPORT RENTAL - EPISODE 1222
SITE DESCRIPTION

The Bridgeport Rental and Oil Services (BROS) site is located on Cedar Swamp Road at the divergence of Route 130 and I-295 in Logan Township, Gloucester County, NJ, approximately one mile east of the Town of Bridgeport, NJ and about 2 miles south of the Delaware River. The total area of the site is about 30 acres. The site includes a tank farm and a 12.7 acre lagoon that contains waste oil and wastewater. The area surrounding the BROS facility is predominately rural and agricultural.

The BROS lagoon began to form in the 1940's when dumping of waste oil into a sand and gravel excavation was initiated. From the 1940's to present, the lagoon increased in size from 0.54 acres to 12.7 acres as various liquids and oil accumulated. Presently the lagoon is 21 feet deep in some locations and the bottom 13 feet of lagoon contents are in contact with the groundwater. The lagoon contents consist of a layer of surface oil and scum 1 to 2 feet thick, a middle aqueous layer approximately 10 feet thick, and a bottom layer of oily sludge. Review of analytical data from the middle of the aqueous layer indicated only low levels of contamination with 10-15 pollutants.

Remedial efforts at the BROS site have been divided into three separate contract phases. Phase I consists of removal of all tanks and waste associated with the tank farm and removal and on-site treatment of the aqueous phase liquid from the lagoon. Phase I began in the summer of 1987 and is projected to be completed by the end of 1987. Operation of the wastewater treatment system began only a few weeks prior to this site visit.

The second contract, projected to cover approximately three years, includes removal and disposal of nonaqueous waste from the lagoon by either on-site or off-site incineration and the final lagoon closure (backfill and revegetate). A third contract will include an RI/FS for the purpose of determining the most cost effective groundwater cleanup approach.

The present on-site treatment system for aqueous waste was designed by TAMS and constructed by the U.S. Army Corps. of Engineers (COE). The system includes oil/water separation, flocculation and sedimentation with chemical addition, dissolved air flotation, multi-media filtration, and granular activated carbon filtration. The treated wastewater is discharged to Little Timber Creek. Separated oil will be disposed of in the same manner as the oil removed from the lagoon. The system is projected to be used for treatment of aqueous phase liquids encountered during cleanup of buried drums, incidental maintenance pumping, and future groundwater cleanup.

Two previous removal actions to lower the liquid level of the lagoons before COE involvement, included pumping of the aqueous phase liquid through a mobile activated carbon treatment system.

CHARLES GEORGE - EPISODE 1309
SITE DESCRIPTION

The Charles George Land Reclamation Trust (CGLRT) site is an inactive municipal and industrial waste landfill, located on approximately 63 acres in the southwestern corner of Tyngsborough, Massachusetts, and on seven adjoining acres in the neighboring town of Dunstable. The site is in Middlesex County, about 60 miles northwest of Boston, Massachusetts, and 4 miles south of Nashua, New Hampshire.

The landfill is bordered on the north and northwest of Blodgett-Cummings Road and the Tyngsborough-Dunstable town boundary, on the east by the U.S. Route 3, on the south by the Cannongate II condominium complex, and on the west by Dunstable Road.

In the mid- to late 1950s, on-site waste disposal activities began near the intersection of Dunstable and Blodgett-Cummings roads. The site served as the Tyngsborough municipal dump, operated by a private contractor until 1973. The site was acquired by Charles George, Sr., in 1967, and by CGLRT in 1971. In 1973, the Massachusetts DWPC issued CGLRT a permit to accept hazardous waste (USEPA, 1985).

In 1976, the Town of Tyngsborough authorized the CGLRT to extend the landfill to the east, expanding its area from 38 to 63 acres (NUS, 1986). In 1977, CDM designed a clay liner for the landfill to prevent downward migration of leachate in the site's eastern and central portions. Previous investigations found no record of actual construction of a liner (NUS-RAMP, November 1983).

Hazardous wastes, including drummed and bulk VOCs and toxic metal sludges, were known to have been disposed on-site from January 1973 to June 1976. The quantity and burial locations of discarded wastes are not known. According to the preliminary RI report, CGLRT violated DEQE regulations from 1978 to 1982 (NUS, 1986). VOCs were found in 1982 at water supply wells serving the Cannongate condominium complex, located approximately 800 feet southeast of the landfill. The DEQE closed these wells in July 1982. A temporary, aboveground pipeline was installed to supply water to the complex. This water line froze during December 1982. In 1983, the Massachusetts Attorney General, acting for the DEQE, suspended use of the site as a landfill (USEPA, 1985).

Two RODs concerning the CGLRT have been issued by USEPA, one in December 1983 and the other in July 1985. To address Operable Unit I, the USEPA installed a temporary insulated pipeline under the ROD issued on December 29, 1983. A permanent waterline connecting the complex to the Lowell municipal water supply was required in the 1983 ROD. Under this ROD, the waterline may also serve as a water supply to a limited number of private residences in the Cannongate-Dunstable Road area, if necessary.

In 1983 and 1984, USEPA contracted for the installation of a security fence around portions of the landfill, regraded part of the landfill, placed a soil cover over exposed refuse, and installed 12 gas vents. Explorations during the

1984 preliminary RI disclosed the need for on-site source control measures. The objectives of Operable Unit II were addressed and a source control recommendation was presented in a subsequent source-oriented FS (NUS, 1985). As a result, USEPA issued their second ROD on July 11, 1985, to install a flexible membrane cap over the landfill surface, a leachate collection system, and additional gas vents as primary contaminant source-control measures. Operable Units III and IV are being addressed through a USEPA contract to Ebasco initiated in June 1986.

CHEMDYNE-EPISODE 1807
SITE DESCRIPTION

The Chem-Dyne site is located in a northern section within the limits of the City of Hamilton, Ohio. The site is bounded by a residential district, a municipal park, the Ford Hydraulic Canal which flows to the Great Miami River, and a railroad right-of-way adjacent to a sheet metal fabrication plant.

The Chem-Dyne site is believed to have begun receiving hazardous substances as early as 1974. Additionally, Spray-Dyne, an affiliated company, produced antifreeze solution on-site by recycling chemical wastes and using virgin chemicals. By 1976, Chem-Dyne was a rapidly growing corporation specializing in storage, recycling, and disposing a wide variety of industrial chemical waste. Chem-Dyne sold chemical fuels produced by mixing chemical wastes in bulk storage tanks, open containers, and gravel-lined loading docks. Other wastes were stored in drums and tanks (including at least one old leaking railroad tank car) in buildings and outdoors.

In five years of operation, the facility accepted waste from approximately 200 generators. Materials handled included pesticides and pesticide residues, chlorinated hydrocarbons, solvents, waste oils, plastics and resins, polybrominated biphenyls, polychlorinated biphenyls, flame retardants, acids and caustics, heavy metal and cyanide sludges, and package laboratory chemicals. More than 300,000 drums and 300,000 gallons of bulk materials were on-site when Chem-Dyne ceased operations.

Chem-Dyne operations resulted in uncontrolled releases of hazardous materials. Mixing of liquid wastes was often done in open gravel-lined pits, releasing noxious vapors into the atmosphere, and contaminating soil and groundwater. Reportedly, 55-gallon drums were punctured and were allowed to leak, or were dumped on the ground and into troughs and sewers. Wastes were frequently spilled, and at one time, a large pool of waste reportedly covered one portion of the site surface.

A number of environmental incidents were reported at the Chem-Dyne facility during its operation, including at least five fish kills, a series of fires, many odor complaints, and a fuming railroad tank car incident caused by improper mixing of chemical wastes. Legal actions resulting from Chem-Dyne's handling of wastes resulted in settlements with which Chem-Dyne did not comply. Eventually, court action forced Chem-Dyne to stop operations, remove wastes from the site, and clean up suspected soil and groundwater contamination.

The Chem-Dyne facility ceased operation in January 1980 when the state of Ohio named a receiver to assume operations and respond to the problems at Chem-Dyne. In 1981, the receivership ran short of funds to continue waste removal from the site and stopped operation. USEPA began removal actions and initiated a site remedial investigation (RI) and feasibility study (FS) in March 1982. Potentially responsible parties (PRPs), generators of wastes left on-site, were also identified and contacted to remove wastes and negotiate cleanup contributions.

As a result of the initial cleanup operations, all containerized surface waste has not been removed from the site, and an RI and FS have been completed. The RI indicated extensive soil contamination by priority pollutant acids and volatile organic compounds (VOCs), several of which are considered carcinogens. Inorganic chemicals, semivolatile organic compounds, and pesticides were found in the upper three feet of soils at the site while VOCs were found mainly in the upper six feet of soil.

A hydrogeological investigation and chemical analyses of groundwater samples conducted as part of the RI indicated that a contaminant consisting primarily of VOCs is present in groundwater near the site and has the potential to affect receptors in the near future. Aquifer characteristics suggest that plume contaminants could be taken in by a number of industrial production wells located within a one-mile radius, resulting in near-term exposures due to volatilization of contaminants within these industrial facilities from the use of contaminated water. The city of Hamilton's contamination of drinking water would result in long-term exposures due to contamination of the drinking water supply.

RI sampling and observation also indicated extensive contamination of some of the utilities and buildings on-site which present a future source of soil and groundwater contamination and pose a current threat from direct contact or air exposure.

The FS developed and evaluated remedial action alternatives to address environmental problems as identified in the site RI. USEPA issued a Record-of-Decision (ROD) on July 5, 1985, documenting the selection of a remedial action alternative which has since been implemented. Remediation includes source control measures and groundwater extraction, treatment by air stripping, clarification, and vapor-phase carbon adsorption for air stripping offgas discharge in part to the aquifer to increase the efficiency of the extraction system and also to the Ford Canal.

GENEVA - EPISODE 1224
SITE DESCRIPTION

The Geneva Industries site is a 13.5 acre tract located at 9334 Caniff Road in Houston, Texas immediately adjacent to the limits of the city of South Houston. The site is within one mile of Interstate Highway 45 and within two miles of William P. Hobby Airport. The property is bound on the north by Caniff Road, on the southwest by Easthaven Boulevard, and on the east by a Harris County Flood Control Channel.

The site is an abandoned refinery which manufactured a variety of organic compounds including biphenyl, polychlorinated biphenyls (PCBs), phenyl phenol, naptha, and Nos. 2 and 6 fuel oils from 1967 through 1978.

Prior to 1967, the property was used for petroleum exploration and production. Geneva Industries began manufacturing biphenyl by distillation of toluene dealkylation bottoms in June 1967, began producing PCBs in June 1972, and declared bankruptcy in November 1973. Since that time, four other corporations owned and operated the Geneva facility, including:

Pilot Industries, February 1974 - December 1976
Intercoastal Refining, December 1976 - December 1980
Lonestar Fuel Co., December 1980 - May 1982
Fuhrmann Energy, May 1982 - Present

Operation of the facility ceased in September 1978 and was never resumed. The current owner, Fuhrmann Energy, has salvaged much of the equipment onsite for resale.

Records from the Texas Water Quality Board and the Harris County Pollution Control district indicate that several citations were issued to the various owners for unauthorized discharges of wastewater into the adjacent flood control channel. These records also indicate that plant operation was marked by numerous spills and process leaks and that housekeeping and disposal practices deteriorated with time. As of 1981, the site contained processing tanks, piping, and equipment, three open and one closed wastewater lagoon, a diked tank area, several drum storage areas, a landfill, and possibly a landfarm.

A Planned Removal was performed by EPA during the period from October 1983 to February 1984 to close out three onsite lagoons, remove all drummed waste on the surface, remove all offsite soils containing greater than 50 ppm PCBs, install a cap over all onsite soils containing greater than 50 ppm PCBs, and improve site drainage. Approximately 3,400 cubic yards of contaminated soils and sludges, 550 drums, and 30 tons of asbestos were removed and transported to an approved disposal facility in Emmelle, Alabama. Other removal actions to plug abandoned wells onsite and remove storage tank materials were performed in May and September 1984, respectively.

A Cooperative Agreement for a Remedial Investigation and Feasibility Study (RI/FS) for $630,000 was awarded by EPA to the State of Texas in December 1983.

D'Appolonia, Inc., not IT Corporation, in association with Environmental Research and Technology, Inc., and Rollins Environmental Services (TX) Inc., was contracted by the State to conduct the RI/FS. The initial site work was completed in September 1984, at which time it was determined that additional field work would be required. An amendment to the grant for $300,000 was awarded in March 1985 to investigate possible a seismic faulting at the site. All field work was completed in October 1985.

The Remedial Investigation was completed in December 1985. The Feasibility Study began in December 1984 and completed in April 1986. The long feasibility study period was due to the need for the extensive fault investigation conducted in September 1985. The detailed development and evaluation of remedial alternatives could not be done until the effects of possible faulting across the site could be determined.

Due to the temporary protective cap placed on the site during the 1984 Planned Removal, on-site surface expressions of faulting were not discovered during the site investigation. However, faulting in the vicinity of Geneva Industries has been documented by the United States Geologic Survey. To further define the potential for faulting at the site, an area survey was conducted to locate surficial expressions of faulting within 1/2 mile of the site.

Wells M-5 and M-9 tap the shallow water and deep water aquifers, respectively. Remediation efforts include plans to convert monitoring wells M-5 and M-9 to extraction wells for a future pump and treat system. These two wells were the recommended sample points for an EPA-ITD sampling effort.

GOLD COAST OIL - EPISODE 1242
SITE DESCRIPTION

The Gold Coast Oil Corporation (GCO) site is a 2-acre parcel of flat, sandy land located at 2835 SW 71st Avenue, Miami, Florida. The site has no distinguishable surface drainage and is enclosed by a fence with a locking gate. It is bordered on the north and west by railroad tracks, on the south by a group of small businesses and on the east by SW 71st Avenue. The site operations are currently inactive. The Coral Gables Canal is approximately 850 feet south of the site on the other side of the small businesses. The canal drains to the Biscayne bay and on to the Atlantic Ocean.

The site property is owned by Seabord Systems Railroad Company, which is now known as CSX Transportation, who leased the property to Gold Coast Oil Corporation in the early 1970s. Gold Coast Oil, along with Solvent Extraction, Incorporated were in the business of distilling mineral spirits and lacquer thinner and reclaiming solvents. All waste generated by the solvent recovery operations were disposed or stored on site; no waste was shipped off-site during the 11 years of operation. Blowdown from the operations sprayed directly onto the ground, and 53 drums of sludge-contaminated soil were stored in the southwest area of the site near the distillation unit. Still-bottomwaste from the distilling operation was pumped into a tank truck for storage. There were also 2500 corroded and leaking drums containing sludge from the distilling operation, contaminated soils, and paint sludges located on site, along with large storage tanks of hazardous waste.

Representatives of the Dade County Department of Environmental Resources Management (DERM) took samples of illegally dumped and stored sludge, and from on-site wells at the Gold Coast Oil site on April 22, 1980. DERM issued a complaint for temporary, permanent, mandatory and prohibitory injunctive relief, civil damages, and civil penalties against Gold Coast Oil, on January 14, 1981. On March 16, 1981, the complaint was amended to include CSX Transportation, the owner of the property.

The DERM reported the site to the EPA in early May 1981. The EPA Surveillance and Analyses Division (SAD) conducted a sampling investigation of the site in June 1981. The SAD sampled groundwater from existing wells, soil, and waste material. In August 1981, the EPA filed a complaint against Gold Coast Oil along with a Consent Agreement and Final Order. In the fall of 1981, the Gold Coast Oil site was submitted to the EPA for inclusion on the Interim National Priority List. Two hazard ranking scores by Ecology and Environment's (E&E) Field Investigation Team (FIT) was 46:51.

Also, in October 1981, the FDER conducted a RCRA interim status inspection and reported the results to EPA. On December 1, 1981, EPA filed a Default Order against Gold Coast Oil for failing to file a timely answer to the complaint issued previously and for non-payment of the civil penalty imposed. In December 1981, an earth resistivity survey by FIT IV was conducted. In early 1982, Dade County, with the assistance of FDER, began to prepare an enforcement case against the property owner, the CSX Transportation Company, as well as the

Gold Coast Oil Corporation. CSX Transportation was also advised that the EPA was going to undertake immediate removal of the hazardous waste on-site under the authority of CERCLA. Neither of these actions were undertaken because in June of 1982, CSX Transportation evicted Gold Coast Oil from the property and agreed to voluntarily clean up the site. In July 1982, CSX Transportation submitted for approval a cleanup and disposal plan to clean up the site's surface.

The cleanup action of the surface contaminants at the GCO site was undertaken the following month. The clean-up, conducted by Chemical Waste Management under contract to the Railroad, involved removing the drums, emptying the storage tanks and excavating and removing contaminated soils to a depth of approximately six inches.

In March 1983, the Florida Department of Environmental Regulation requested that EPA take the lead at this site, and in September 1983 the GCO site was added to the National Priority List with a 46.5 hazardous ranking score.

In June 1983, a Remedial Action Master Plan (RAMP) was developed by NUS Corporation under an EPA contract. In March 1984, BCM Eastern Incorporated, consultants for the PRP Steering Committee, produced an "Environmental Investigation of the Gold Coast Site". In June 1984 a "Draft Remedial Alternatives Evaluation Report for the Gold Coast Oil Corporation Site" was produced by Engineering and Science under an EPA contract. In May 1985 BCM Eastern submitted a "Selection of Remedial Approach" report, again a report for the PRP Steering Committee.

The Biscayne Aquifer Study area-wide groundwater Record of Decision was signed by the Assistant Administrator, Office of Solid Waste and Emergency Response in September 1985. The cleanup levels established as a result of that study and that Record of Decision have been revised and approved by the Florida Department of Environmental Regulation for the Gold Coast Oil site.

The groundwater data associated with the site indicate an area of significant contamination in the northeast corner of the site. The levels of contaminants have generally decreased across the site except for the levels of trichloroethylene and tetrachloroethylene which have increased in this northeast corner. The levels of metals in the groundwater are considered to be at normal environmental levels since they are relatively constant throughout the entire area of the site. Wells M-8 and M-13 are considered representative of the area of highest levels of contamination and are recommended sample points for an EPA-ITD sampling effort.

HYDE PARK - EPISODE 1220
SITE DESCRIPTION

The Hyde Park landfill is approximately 15 acres in area and is located northwest of the City of Niagara Falls in the northwest corner of the Town of Niagara. It is immediately surrounded by several industrial facilities and property owned by the Power Authority for the State of New York. There is a residential neighborhood to the northwest and south of the landfill. The Niagara River is located 2,000 feet to the northwest.

From 1954 until 1975, Occidental Chemical Corporation (OCC), then known as Hooker Chemical and Plastics Corporation, disposed of approximately 80,000 tons of chemical wastes in the Hyde Park Landfill. These wastes included chlorobenzenes, hexachlorocyclopentadiene (C-56) and trichlorophenols. Previous chemical analyses have identified 2,3,7,8-tetrachlorodibenzo-p-dioxin in the Hyde Park wastes.

In 1979, EPA and, in 1980, the State of New York Department of Environmental Conservation (NYSDEC) sued OCC to clean up the on-site and off-site contamination resulting from leakage of chemical wastes from the landfill. Negotiations were held among all the parties and on April 30, 1982, a Stipulation and Judgement approving the Hyde Park Settlement Agreement was approved by the United States District Court.

The Settlement Agreement provided that OCC (1) conduct surveys and tests (Aquifer Survey Program) to determine how far and how deep groundwater had carried chemicals away from the Hyde Park Landfill and (2) assess ways to contain and/or clean up this contamination through the use of Requisite Remedial Technology (RRT). OCC completed this survey program in December 1983 and presented its findings to the federal and state governments. The findings stated that a two-phase "plume" of chemicals is migrating away from the landfill: a non-aqueous phase liquid (NAPL) and an aqueous phase liquid (APL). NAPL is composed of many chemicals that do not dissolve readily in water. It moves more slowly than APL through soil and rock, and is more dense than water. APL also is composed of many chemicals; however, the chemicals are dissolved in groundwater and tend to be carried along with it. The APL plume has spread further away from the landfill than the NAPL plume.

As required by the Settlement Agreement, OCC began a RRT Study in October 1983 to determine which remedies were most appropriate to clean up and/or contain the chemicals that had escaped and were continuing to escape from the Hyde Park Landfill. OCC submitted its RRT report to the EPA and NYSDEC in May 1984 and the agencies responded to the report in September 1984. Since that time, the EPA, NYSDEC, and OCC have had many meetings to resolve outstanding issues and concerns raised by OCC's report and the agencies' review of that report. The RRT ultimately agreed to by the parties is described in a document entitled Stipulation on Requisite Remedial Technology Program submitted to the United States District Court for approval on November 26, 1985.

To date, OCC has installed a barrier collection system around the perimeter of the landfill and capped the site. Leachate intercepted by the barrier drain

system collects in two wet-wells located at the two western corners of the landfill. The leachate is pumped from the wet-wells to a holding lagoon where separation of APL and NAPL occurs. The APL is transferred from the lagoon to a tank truck several times each day. The truck hauls the waste to OCC's off-site pretreatment facility. The NAPL removed to an on-site storage area consisting of four 10,000 gallon railroad tank cars surrounded by a clay dike. Presently, OCC is requesting authorization to incinerate the NAPL at an incineration facility located at its plant on Buffalo Avenue in Niagara Falls.

LOVE CANAL - EPISODE 1219
SITE DESCRIPTION

Love Canal is an abandoned landfill once owned by Hooker Chemicals (now Occidental Chemical Corporation) where 21,800 tons of both drummed and undrummed liquid and solid chemical wastes were disposed from 1942 to 1953. Love Canal is now a contained area controlled by the New York State Department of Environmental Conservation (NYSDEC) since August 1978.

NYSDEC installed a French drain around the dump boundary and capped the site in 1979. Leachate and groundwater intercepted by the drain collects in four collection chambers located along the collection system. In the northern and central sectors of the canal, vertical centrifugal pumps transfer leachate from the collection chambers to six underground storage cells (30,000-gallon total capacity) located behind the leachate treatment plant. Horizontal centrifugal pumps transfer leachate collected in the southern sector to a 25,000-gallon in-ground holding tank at a rate of 300 gpm.

Raw leachate from the holding tank and the storage cells is pumped to a 2,000-gallon fiberglass storage tank located inside the treatment building. A double-diaphragm pump transfers the water from the fiberglass tank to the 15,600-gallon rectangular clarifier that contains redwood flights and weirs. Equipment is available for the addition of coagulants and flocculants, however, it is not used. Every other month, sludge is removed from the clarifier to a fiberglass holding tank. The effluent from the clarifier flows by gravity to a 2,000-gallon fiberglass filter feed tank. Two double-diaphragm pumps transfer the water at a rate of 160 gpm from the filter feed tank through two separate feed lines to 50 μm polypropylene filter bags (a series of two in each line). Filtrate from the filters combines before going to two Calgon carbon adsorbers operated in series. Treated wastewater is discharged from the treatment system to the City's sewer at an average rate of 40,000 gallons per operating day.

Sludge removed from the clarifier is transferred to a 1,500-gallon sludge holding tank. Supernatant from the sludge holding tank is recycled back to the filter feed tank, and the settled sludge is pumped to one of the four on-site outdoor storage tanks, each with a 10,000-gallon capacity. Three of the four outdoor sludge storage tanks are unlined: one is epoxy-lined. The Love Canal pretreatment system produces approximately 150 gallons per month of sludge, which is being stored on-site until NYSDEC officials can find a suitable means for its disposal.

All of the treatment system piping at Love Canal was teflon-lined, and the system itself was designed by Conestoga-Rovers & Associates, Waterloo, Ontario, Canada.

The entire pretreatment system at Love Canal is closed to the atmosphere, and 55-gallon carbon canisters scrub the vented gases from the treatment plant unit operations, including the raw leachate holding tank, the clarifier, the filter feed tank, and the sludge holding tank.

The current average wastewater discharge from Love Canal is 40,000 gallons per operating day. During the summer, discharge occurs approximately once every two weeks; during the spring, discharge is as often as twice per week. The volume of discharge has decreased from 4.5 to 2.5 million gallons per year since capping of the site was completed.

The pollutants identified in previous studies at Love Canal are Lindane (33 percent), and chlorinated hydrocarbons (67 percent) such as toluene, benzene, heptachlor, di-octyl phthalates, chloroform, methylene chloride, tetrachloroethylene, trichloroethylene, total phenols, and chlorobenzene.

NYANZA CHEMICAL - EPISODE 1310
SITE DESCRIPTION

The 35-acre Nyanza site is located on Megunko Road in the Town of Ashland, Middlesex County, Massachusetts, approximately 35 miles west of Boston. The site was the location of chemical dye manufacturing facilities for 61 years and is currently occupied by several small industrial enterprises. The current owners are MCL Development Corporation (MCL) and Edward Camille.

From 1917 to 1977, the site was occupied by several companies involved in the manufacture of textile dyes and dye intermediates. During that period, several types of chemical wastes were disposed in various on-site locations. These wastes included partially treated process wastewater; chemical sludge from the wastewater treatment process; solid process wastes (e.g., chemical precipitate and filter cakes) in drums; solvent recovery distillation residue in drums; and off-specification products. Process chemicals that could not be recycled or reused (e.g., phenol, nitrobenzene, and mercuric sulfate) were also disposed on-site. The most recent dye manufacturing company to occupy the site, Nyanza, Inc., acquired the property in 1965.

The first type of contamination linked to Nyanza was mercury, discovered in the Sudbury River in 1972 (CDM, 1982). From 1972 through 1977, the Massachusetts Departments of Public Health and Water Pollution Control (DPH and DWPC) cited Nyanza, Inc., for several contamination problems associated with dumping activities. In 1974, Camp, Dresser, and McKee (CDM), working for Nyanza, Inc., devised plans to control groundwater contamination on the Nyanza property; however, implementation did not occur. Nyanza, Inc., ceased business in 1978 due to financial difficulties.

Edward Camille, a private citizen, acquired the property from Nyanza, Inc., in 1978. In 1979, the Department of Environmental Quality Engineering (DEQE) stayed plans, on behalf of Mr. Camille, to complete the groundwater pollution control activities, pending further investigation by the newly established DEQE Division of Hazardous Waste.

Since 1972, several investigations have been prompted by contamination present at or originating from Nyanza. JBF Scientific Corporation conducted a 1972 Sudbury River investigation that revealed mercury contamination caused by uncontrolled sludge disposal at the Nyanza, Inc., property. The CDM groundwater pollution control program designed in 1974 for Nyanza, Inc., included a site investigation aimed at source identification. In 1979, Mr. Camille hired Connorstone Engineering, Inc., to complete the CDM pollution control program. In 1980, the DEQE released a Preliminary Site Assessment Report summarizing the site history and findings of previous investigations at the site (DEQE, October 1980).

In 1981, MCL acquired a portion of the property. MCL hired Connorstone Engineering, Inc., and Carr Research Laboratory, Inc., to characterize soil composition and locate sludge deposits.

The Nyanza site was included on the original National Priority List (NPL) of Superfund sites in 1982. A preliminary Remedial Action Master Plan (RAMP) was prepared for EPA by CDM in 1982. To expedite remediation, the RI/FS for Nyanza was divided into two phases, or "operable units." At that time, some sampling and analysis had been performed, and it became evident that site remediation would ultimately address two distinct problems: surficial deposits of sludges and sediments contaminated primarily by heavy metals, and groundwater contaminated primarily by organic chemicals. The surficial sludge and sediment problem was designated Phase I, or Operable Unit I, and primarily encompassed source identification and control. In 1984, EPA authorized NUS Corporation (NUS) to complete an RI/FS for Operable Unit I (NUS, March 1985).

A Record of Decision (ROD) for Operable Unit I was signed in September 1985. The ROD calls for excavation of nine localized areas of contamination; solidification of the excavated sludges, sediments, and soils; and placement of those materials on the "Hill" area in the southern part of the site. A diversion trench will also be constructed around the southern end of the capped area to divert surface water flow and lower the groundwater table within the capped area.

In 1986, EPA authorized CDM to conduct additional field investigations to define source locations and design the remedial action stipulated in the ROD. The design is currently underway, and remediation of some contaminated areas is in progress.

After further investigation, EPA elected to divide the remaining problems at Nyanza into two additional operable units. Operable Unit II addresses groundwater contamination and migration. This study is the focus of Nyanza II.

REILLY TAR - EPISODE 1239
SITE DESCRIPTION

The Reilly Tar and Chemical Company site occupies 80 acres of land located in St. Louis Park, Minnesota. The plant site, called the Republic Creosote Works, is located west of Gorham, Republic, and Louisiana Avenues, south of 32nd Street, east of Pennsylvania Avenue, and north of Walker Street. The City of St. Louis Park purchased the land from Reilly in 1972. The St. Louis Park Housing and Redevelopment Authority currently controls the site. The City is contiguous to the City of Minneapolis and exhibits a similar population density. Currently, the site is a park with a portion of it developed with condominiums. It is located in the midst of a residential area with some small industry.

From 1918 to 1972 the company operated a coal tar distillation facility and wood preserving plant. Its primary production was creosote. The chemical compounds associated with this process are polynuclear aromatic hydrocarbons (PAH) and phenolics. The release to the environment of these compounds occurred during the coal distillation process and from materials stored on the site. The materials were apparently dumped into a well, referred to as W-23, which penetrated to the Mt. Simon/Hinckley Aquifer, a depth of about 900 feet. The well was cleaned out by the Minnesota Pollution Control Agency (MPCA) to a depth of 866 feet. Coal tar was removed down to a depth of 740 feet. Wastes containing coal tar and its distillation by-products were discharged, as a matter of disposal practice, overland into ditches that emptied into a peat bog south of the site. This practice, according to Reilly, occurred from 1917 to 1939. In 1940 and 1941 Reilly installed a wastewater treatment plant and discharged the effluent into the bog south of the site. The values of both phenolics and oil and grease in the discharge water varied typically from 100 to 1,000 milligrams per liter. This discharge continued for the duration of Reilly's operation. The peat bog has retained contamination that was discharged over the years and, as is explained below, is now a major source of groundwater contamination.

In 1972, the plant was dismantled and the land sold to the City of St. Louis Park. In 1973, a storm water runoff collection system was built which fed into a lined pond on the site. The pond discharges into a drain which is routed to another pond off-site before it eventually discharges into Minnehaha Creek. The City of St. Louis Park (SLP) monitors the discharge into the creek. Construction of a block of condominiums on the northern part of the site began in 1976. At this time, no further construction is underway, although plans for new development of the site are pending by the Housing and Redevelopment Authority. All excavation of material has been inspected by the State and if contaminated, the soils were disposed of.

There are three conceptual operable units involved with the Reilly Tar Remedial response. These include: (1) restoration of drinking water supply to St. Louis Park, (2) containment or treatment of groundwater in contaminated aquifers, and (3) source control of the bog and contaminated soil at the site.

In August 1981, the MPCA was awarded a cooperative agreement to investigate Well W23, and to perform a feasibility study for restoration of drinking water.

During that study, the State removed coal tar deposits from Well W23 that were a source of groundwater contamination. The well itself is now clean although some residual contamination probably remains in the aquifers penetrated by the well.

Presently, there are two extraction wells that alternately pump contaminated groundwater to an on-site pretreatment facility. The wastestream is pumped to a sand filter (iron removal) prior to discharge to a granular activated carbon unit. Treated effluent from the carbon unit flows to a 1.5 million gallon holding tank where approximately 95 percent of the water is discharged to the drinking water supply for the City. The remaining 5 percent is discharged to the City's sewer system.

STRINGFELLOW ACID PITS - EPISODE 1221
SITE DESCRIPTION

Stringfellow Acid Pit was operated by Stringfellow Quarry Co. from 1956 to 1972 as a hazardous waste disposal facility. The landfill disposal site was permitted by the Santa Ana Regional Water Quality Control Board (RWQCB). About 34 million gallons of wastes, mostly from metal finishing, electroplating, and DDT production, were deposited on approximately 17 acres of the site. In 1969 and 1978, excessive rainfall caused the ponds used for solar evaporation to overflow, spreading contamination into the nearby town of Glen Avon. In July 1980, the RWQCB advocated total removal of all solids and liquids but the funds were not available. In December 1980, RWQCB selected an interim plan that included installation of channels to divert surface water, a gravel drain and a network of wells for monitoring and extraction, and a clay core barrier dam downgradient to stop subsurface leachate migration.

California placed Stringfellow at the top of the California priority list. The State conducted a study in compliance with the National Oil and Hazardous Substances Pollution Contingency Plan (the National Contingency Plan or NCP) to obtain CERCLA funds. The results of the study indicated that on-site management was more cost effective than total removal.

On July 22, 1983, Lee Thomas, Assistant Administrator of the Office of Solid Waste and Emergency Response (OSWER), signed a Record of Decision (ROD) which endorsed the State's request for funds for both existing activities and proposed actions. The interim actions authorized in the ROD were:

- removal of DDT contaminated material
- operation of extraction wells upgradient of the clay barrier to protect the barrier
- fencing the entire site to prevent entry
- erosion control to prevent destruction of a clay cap

The state also requested EPA to lead a fast track Remedial Investigation/Feasibility Study (RI/FS) while the Department of Health Services completed the long-term RI/FS.

As a result of the fast track RI/FS, a pretreatment system was installed to treat the groundwater before its discharge to the Santa Ana Watershed Project Authority. The series of extraction wells transfer two groundwater streams from the contaminated canyon area to the field storage tanks. On-site groundwater (Stream A), known to contain metal compounds and organics, is transferred from the field storage tanks to one of four equalization tanks (each with a 12,000-gallon capacity) at the on-site treatment plant. Once equalization of Stream A occurs, Stream A proceeds to a 400-gallon capacity rapid mix tank where lime and caustic soda are added to aid precipitation and to control acidity/alkalinity, and polymer is added to aid floc formation. The chemically treated and mixed stream flows to two parallel-operating clarifiers.

The thickened sludge is pumped from the clarifiers to the sludge holding tanks, and the clarified effluent flows to two gravity sand filters operating in parallel. Each filter has a 7.6 square foot area, and the sand is about three feet deep. Wastewater from the sand filters is transferred to the 500-gallon Stream A filter effluent tank.

Groundwater from mid-canyon (Stream B), which contains mostly organic compounds, is transferred from the field storage tanks to one of three equalization tanks (12,000-gallon capacity each) located at the on-site treatment plant. Stream A effluent from the 500-gallon filter effluent tank is blended with Stream B before discharging to activated carbon adsorption vessels. The two carbon adsorption vessels each have a 10-ton capacity for granular activated carbon and are operated in series with a third vessel functioning as a transfer tank.

Effluent from the carbon adsorption vessels is transferred to one of four final effluent storage tanks (80,000-gallon total capacity), before it is discharged to the sewer at an average rate of 870,000 gallons per month. As necessary, effluent from these storage tanks is used as backwash and other plant utility water.

Sludge is pumped from the clarifiers to two 11,000-gallon sludge holding tanks. The sludge from the two sludge holding tanks is fed to two plate-and-frame filter presses. Depending on the pollutant content, the filtrate from the filter press operation can be recycled to either the Stream A influent equalization tanks, the Stream B influent equalization tanks, or the Stream A filter effluent tank. Usually, the filtrate is pumped to the Stream A equalization tanks. The sludge cake is discharged into containers and is hauled off-site by a contractor for disposal at a RCRA approved Class I disposal site as hazardous waste.

As part of the Stringfellow discharge permit, the effluent must be tested prior to any discharge. Currently, the facility is allowed to fill two storage tanks simultaneously, but is only required to test one tank.

The pretreatment system located at Stringfellow operates five days per week during the daylight hours.

STRINGFELLOW ACID PITS - EPISODE 1240
SITE DESCRIPTION

Stringfellow Acid Pit was operated by Stringfellow Quarry Co. from 1956 to 1972 as a hazardous waste disposal facility. The landfill disposal site was permitted by the Santa Ana Regional Water Quality Control Board (RWQCB). About 34 million gallons of wastes, mostly from metal finishing, electroplating, and DDT production, were deposited on approximately 17 acres of the site. In 1969 and 1978, excessive rainfall caused the ponds used for solar evaporation to overflow, spreading contamination into the nearby town of Glen Avon. In July 1980, the RWQCB advocated total removal of all solids and liquids but funds were not available. In December 1980, RWQCB selected an interim plan that included installation of channels to divert surface water, a gravel drain, and a network of wells for monitoring and extraction, and a clay core barrier dam downgradient to stop subsurface leachate migration.

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- removal of DDT contaminated material
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The State also requested EPA to lead a fast track Remedial Investigation/Feasibility Study (RI/FS) while the Department of Health Services completed the long-term RI/FS.

As a result of the fast track RI/FS, a pretreatment system was installed to treat the groundwater before its discharge to the Santa Ana Watershed Project Authority. The series of extraction wells transfer two groundwater streams from the contaminated canyon area to the field storage tanks. On-site groundwater (Stream A), known to contain metal compounds and organics, is transferred from the field storage tanks to one of four equalization tanks (each with a 12,000-gallon capacity) at the on-site treatment plant. Once equalization of Stream A occurs, Stream A proceeds to a 400-gallon capacity rapid mix tank where lime and caustic soda are added to aid precipitation and to control

acidity/alkalinity, and polymer is added to aid floc formation. The chemically treated and mixed stream flows to two parallel-operating clarifiers.

The thickened sludge is pumped from the clarifiers to the sludge holding tanks, and the clarified effluent flows to two gravity sand filters operating in parallel. Each filter has a 7.6 square foot area, and the sand is about three feet deep. Wastewater from the sand filters is transferred to the 500-gallon Stream A filter effluent tank.

Groundwater from mid-canyon (Stream B), which contains mostly organic compounds, is transferred from the field storage tanks to one of three equalization tanks (12,000-gallon capacity each) located at the on-site treatment plant. Stream A effluent from the 500-gallon filter effluent tank is blended with Stream B before discharging to activated carbon adsorption vessels. The two carbon adsorption vessels each have a 10-ton capacity for granular activated carbon and are operated in series with a third vessel functioning as a transfer tank.

Effluent from the carbon adsorption vessels is transferred to one of four final effluent storage tanks (80,000-gallon total capacity), before it is discharged to the sewer at an average rate of 870,000 gallons per month. As necessary, effluent from these storage tanks is used as backwash and other plant utility water.

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As part of the Stringfellow discharge permit, the effluent must be tested prior to any discharge. Currently, the facility is allowed to fill two storage tanks simultaneously, but is only required to test one tank.

The pretreatment system located at Stringfellow operates five days per week during the daylight hours.

A one-day sampling episode was conducted by E.C. Jordan Co. at the Stringfellow site on November 3, 1987. The decision was made at that time to return for a supplemental five-day sampling episode if permission could be obtained. Upon receipt of permission, Jordan personnel conducted the sampling as outlined in this report.

SYLVESTER - EPISODE 1325
SITE DESCRIPTION

The Gilson Road hazardous waste dump site is located in the City of Nashua, New Hampshire, off Route 111, in the south easterly corner of that community. The 6-acre site had been used as a sand borrow pit for an undetermined number of years. During the late 1960s, the operator of the pit began an unapproved and illegal waste disposal operation, apparently intending to fill the excavation. Household refuse, demolition materials, chemical sludges, and hazardous liquid chemicals all were dumped at the site at various times. The household refuse and demolition material were usually buried, while the sludges and hazardous liquids were either mixed with the trash or were allowed to percolate into the ground adjacent to the old sand pit. Some hazardous liquids were also stored in steel drums which were either buried or placed on the ground surface.

The illegal dumping at the site was first discovered in late 1970. After several court appearances, and court actions, an injunction was issued in 1976 which ordered the removal of all materials from the site. This injunction was ignored by the operator.

The first indication that the illegal dumping had included hazardous wastes came in November 1978 when State personnel observed drums being stored at the site. A court order was issued in October 1979 prohibiting all further disposal of hazardous wastes on the site.

It is impossible to estimate the total quantities of waste materials discarded at the site. However, it has been documented that over 800,000 gallons of hazardous waste were discarded there during a ten month period in 1979.

In 1981, initial investigations showed that there were high concentrations of heavy metals and volatile and extractable organics in the groundwater under the site. The contamination formed a plume in the groundwater which was moving from the site toward Lyle Reed Brook at the rate of 0.8 to 1.6 feet per day.

The Gilson Road hazardous waste site has received remedial action under the Comprehensive Emergency Response, Compensation, and Liability Act (CERCLA) since November, 1981. EPA used CERCLA emergency funds to install a ground water interception and recirculation system. This system was operated until October, 1982 when a slurry wall was completed. The State of New Hampshire developed a remedial investigation and feasibility study in January, 1982 and a supplemental study providing costs associated with various groundwater treatment rates in July, 1982. A Record of Decision was signed in July, 1982 which approved the installation of the slurry wall and pilot studies.

Upon completion of the slurry wall, a pilot treatment plant was constructed and operated for several months. The data from this pilot study resulted in a recommendation to construct a treatment plant capable of removing 90 percent of the hazardous constituents within the slurry wall. This design was based on evaluating the present and potential hazards to human health and environmental targets previously identified in the risk assessment portion of the feasibility

study and supplement. A subsequent design modified to reduce operation and maintenance costs, but still capable of 90 percent removal is presently operating at the site.

The treatment system includes chemical precipitation, filtration, and air stripping before the waste stream splits. Approximately 250 gpm is reinjected through recharge trenches inside the slurry wall and the remaining flow (~ 50 gpm) receives biological treatment before reinjection to the groundwater through trenches outside the slurry wall.

TIME OIL - EPISODE 1804
SITE DESCRIPTION

The Time Oil Site's history includes waste oil recycling processes and paint and lacquer thinner manufacturing. The City of Tacoma maintains a treatment system for a production well (Well 12A) near the Time Oil Site. Studies associated with Well 12A resulted in the development of the present treatment system at the Time Oil Site. Operation of the Well 12A treatment system by the City of Tacoma continues on a seasonal basis to protect the wellfield.

Because the remedial investigation completed in late 1982 identified a general source area only and not a specific site, EPA authorized in December 1982 a study of historical solvent use and disposal practices in the suspect area. Records of past investigations by the Tacoma/Pierce County Health Department, Tacoma Water Division and the State Department of Ecology were reviewed and interviews were conducted with owners of numerous businesses in the area. A follow-up study focused on the historical uses and disposal of 1,1,2,2-tetrachloroethane in the vicinity of Well 12A. These studies reduced both the number and location of potential sources of the contamination.

In mid-May 1983, EPA authorized a supplemental remedial investigation to define further the extent of groundwater contamination and to attempt to locate the source. Four monitoring wells were installed and these, as well as the previously installed monitoring wells, were sampled several times between July and November. One of the new wells (near the Time Oil, Fleetline and Burlington Northern property) showed levels of trichloroethylene, 1,1,2,2-tetrachloroethane and 1,2-trans-dichloroethylene in the low parts per million (ppm) range; substantially higher than detected in other wells.

With the apparent source area narrowed down substantially, EPA obtained air and near surface soil samples along the Burlington Northern railroad spur adjacent to the Time Oil plant. Air sampling results showed very low levels of contaminants, but soil samples were very high in trichloroethylene and 1,1,2,2,-tetrachloroethane.

Research into the past ownership and activities on these properties indicated that waste oil and solvent reclamation processes were used and that some of the spent filter cake was used to build the railroad spur. The use of the Time Oil site for oil recycling and related operations dates back to 1927 when William Palin began operations under the name of Palin and Son. In 1933, the business name was changed to National Oil and Paint. The two main activities of the businesses were waste oil recycling and paint and lacquer thinner manufacturing.

The waste oil recycling process consisted of collecting waste oil in a large tank, adding chemicals such as sulfuric acid, and pressurizing and heating the contents of the vessel. This process resulted in the formation for a tar-like sludge on the bottom of the tank which was removed and disposed of. Absorbents and clay materials were also added to the oil. The sludge was filtered from the oil, and the resulting filter cake was disposed of or stored in various piles on the site. Some of this sludge was also used for fill around the site.

The paint and lacquer thinner manufacturing involved the use of many solvents that were stored on the site in barrels which may have leaked their contents into the soil.

Prior to purchase of the property by Time Oil, Inc., in 1964, the remaining barrels and drums of solvent were removed from the site. After Time Oil purchased the property, operations continued under the name National Oil and Paint until 1972. During this period, National Oil was involved only in waste oil recycling. Waste sludges and filter cakes were not known to be stored on the site during this period.

In 1972, Time Oil leased the facilities to Golden Penn, Inc. Golden Penn operated on the site until 1976, before going out of business as a result of a destructive fire. In 1975 and 1976, Golden Penn was ordered by the State of Washington to clean up the site by removing some of the filter cake and spilled oil from the ground.

In 1976, Time Oil resumed operation at the site. Since then their operation has been limited to canning oil brought to the site in bulk containers. In 1982, the Burlington Northern Railroad spur was extended by Time Oil to its present length so that oil could be delivered by tanker car. During the construction of the spur, some of the filter cake or sludge material stored on the site was used in the roadbed.

During the remedial investigation, the extent of soil and groundwater contamination near the Time Oil plant was explored by means of surface soil samples, shallow and deep soil borings and monitoring wells.

Chemical data for 1,1,2,2-tetrachloroethane and tetrachloroethylene taken from soil borings along the spur and along a North-South line and data for trichloroethylene shows these compounds are the ones of primary interest because they are the contaminants at Well 12A. Many others, not found at Well 12A, were also detected at much lower concentrations.

Along the east-west line of borings, high values of soil contamination are located along the spur adjacent to the western Time Oil building and continuing for a distance of at least 150 feet west of that building. Measured concentrations of the contaminants is greater than 3,000 parts per billion (ppb) of soil to depths of about 25 feet. Highest concentrations were found near the surface at levels up to 1000 parts per million (ppm) of soil.

Along the north-south soil boring line, soil contamination concentrations to about 3,000 ppb of soil were measured to a depth of about 20 feet on the north end of the Fleetline property.

Continuity between this near surface soil contamination and that in the aquifer was established. The total quantity of solvents contained in the soil from the ground surface to the groundwater level was grossly estimated at about 1500 lbs.

Groundwater contamination was found along the east-west line of borings in the same boreholes as the major soil contamination, Levels ranged up to about

11,000 ppb of water. Along the north-south line of borings, levels up to 863,000 ppb were measured under the Fleetline property. This southward displacement of the highest aquifer contamination is likely to have resulted from the previous pumping action of the wellfield.

Prior to startup of the Well 12A treatment system in July 1983, Well 12A had been shutdown since mid 1981, except for brief periods of operation for water sampling. However, other wells in the wellfield had been being operated on demand.

The approximate contours of 1,1,2,2-tetrachloroethane that existed at the time of startup of the treatment system shows the highest concentrations existed near the Time Oil site with decreasing concentrations toward the wellfield. The translation of the plume is toward operating wells (9A & 2B). After pumping began at Well 12A, the contamination levels increased at Well 12A and decreased at the other production wells as the plume was preferentially drawn to Well 12A. At the end of the pumping season in early November, the 1,1,2,2-tetrachloroethane concentration at Well 12A was about 45 ppb, a decrease from the mid August level of about 60 ppb. Following shutdown of the 12A treatment system in November, the plume contours returned more nearly to their original locations, and the concentration at Well 12A was reduced to about 5 ppb.

A liquid phase carbon adsorption system is used at the Time Oil facility to pump and treat contaminated groundwater. Treated groundwater is discharged to a stormwater sewer system. Sampling was conducted during the same week as sampling at the Well 12A site.

TYSON'S DUMP - EPISODE 1568
SITE DESCRIPTION

Tyson's Dump Site is an abandoned septic waste and chemical waste disposal site reported to have operated from 1960 to 1970 within a sandstone quarry. The site is located in Upper Merion Township, Montgomery County, Pennsylvania. Several formerly unlined lagoons were used to store various industrial municipal, and chemical wastes. Spills and overflows reportedly occurred during the period of operation, thus allowing for the dispersal of wastes throughout the site. Surface water run-off and seeps contributed to off-site migration of the wastes toward the Schuylkill River. The approximately 4-acre plot, which constitutes a series of formerly unlined lagoons, is bordered on the east and west by unnamed tributaries to the Schuylkill River, a steep quarry high-wall to the south, and a Conrail railroad switching yard to the north. North of the Conrail tracks is the Schuylkill River floodplain. The area of the former lagoon lies above the 100-year floodplain.

The Tyson's Site was owned and operated by companies owned by Franklin P. Tyson and Fast Pollution Treatment, Inc. (FPTI). The stock of FPTI was owned by the current owner of the land, General Devices, Inc. (GDI) and by Franklin P. Tyson. The site was used by Tyson and FPTI for disposal of liquid septic tank waste and sludges and chemical wastes which were hauled to the site in bulk tank trucks.

The Pennsylvania Department of Environmental Resources (PADER) ordered GDI to close the facility in 1973. Although some ponded water was removed in 1973, GDI did not arrange for removal and off-site disposal of contaminated soils.

In January 1983, EPA investigated an anonymous citizen complaint about conditions at Tyson's and subsequently determined that immediate removal measures were required. These measures included the construction of a leachate collection and treatment system, drainage controls and cover over the site, and the erection of a fence around the lagoon area.

Between January 1983 and August of 1984, EPA and its contractors conducted a series of investigations primarily in what is now referred to as the On-Site Area. The On-Site Area is defined here as that area south of the railroad tracks and within or immediately adjacent to the security fence erected during the emergency response measures. In December 1984, EPA issued its Record of Decision (ROD) for the On-Site Area which recommended the following remedial actions:

- Excavation and off-site disposal of contaminated soils and wastes to a permitted Resource Conservation and Recovery Act (RCRA) landfill.

- Upgrading the existing air-stripping facility to treat leachate, shallow groundwater and surface run-on encountered during excavation.

- Excavation and off-site disposal of contaminated sediments within the tributary which receives effluent from the existing air stripper.

Following issuance of the ROD, EPA began remedial design for the selected alternative in January 1985. this design included additional borings throughout the lagoon area to define the volume of material to be excavated. From August 1985 through November 1985, EPA performed additional borings and magnetometer surveys throughout the lagoon area to better delineate the areas to be excavated.

In the fall of 1985, CIBA-GEIGY Corporation agreed to conduct a further investigation of the Off-Site Area, the need for which was described in the December 1984 EPA ROD. The Off-Site Area is defined here as that area outside of the security fence including the deep aquifer (bedrock aquifer). EPA subdivided the Off-Site Area into five sub-areas or "operable units." The Off-Site Operable Units included the following:

- Deep Aquifer (Operable Unit 1)
- Hillside Area (Operable Unit 2)
- Railroad Area (Operable Unit 3)
- Floodplain/Wetlands (Operable Unit 4)
- Seep Area (Operable Unit 5)

On May 27, 1986, an Administrative Consent Order (ACO) was signed between EPA and Ciba-Geigy Corporation for the Off-Site Operable Unit Remedial Investigation/Feasibility Study (RI/FS).

In November 1986, Ciba-Geigy Corporation initiated an on-site pilot study using an innovative vacuum extraction technology process. Due to zoning restrictions, the pilot study operated for only a short duration (less than 10 days). However, in May 1987, the pilot study was recommended and operated for more than three weeks.

In December 1986, Ciba-Geigy submitted a draft Off-Site Operable Unit RI Report to EPA. This report indicated that much of the site-related contamination had migrated off-site into the deep aquifer toward the Schuylkill River.

On March 24, 1987, a second addendum to the Off-site RI/FS Work Plan was submitted to EPA by Ciba-Geigy Corporation. This addendum included a detailed investigation of the Schuylkill River and the installation of wells on the north side of the river.

In June and July 1987, four responsible parties, Ciba-Geigy Corporation, Smith-Kline Beckman, Wyeth Laboratories, and Essex Group submitted a proposal to EPA for clean-up of the on-site lagoon areas, upgrading of the leachate collection system and clean-up of the tributary sediments. Additionally, the parties proposed to initiate groundwater remediation measures since the information contained in the draft Off-Site Operable Units RI report indicated that much of the contamination formerly in the lagoon areas was now in the aquifer system, downgradient of the site, and was discharging to the Schuylkill River.

The parties' proposal was based on a Comprehensive Feasibility Study (CFS) submitted to the Agency on June 15, 1987. The CFS was developed independently

by Ciba-Geigy Corporation and was not formally commented on by EPA. The CFS incorporated the results of the innovative vacuum extraction process for clean-up of the lagoon soils, preliminary results of the Off-Site RI and additional studies for the installation of groundwater recovery wells. Some of the results of the CFS indicated that the contaminants in the bedrock underlying the lagoons would be a source of continuing contamination of the backfilled soil. The study raised the possibility that the remedy selected in the ROD would be of limited effectiveness without the installation of a barrier, which would limit upward movement of contamination from the underlying bedrock.

On July 29, 1987, Ciba-Geigy Corporation submitted the final draft Operable Units RI report to EPA. This report concluded that much of the site contamination, specifically the dense non-aqueous phase liquids (DNAPLS), were in the underlying bedrock and aquifer. The report also found that a dissolved portion of the DNAPLs was discharging into the Schuylkill River.

The leachate collection and treatment system constructed in 1983 is scheduled to operate through 1988, and will then be dismantled. The air-stripping treatment system was installed to remove volatile organic compounds from the collected leachate. The plant is effective in removing many volatile organic compounds, however, its efficiency for reducing some organic compounds, particularly xylenes and 1,2,3 trichloropropane, is lower.

UNITED CHROME - EPISODE 1738
SITE DESCRIPTION

The United Chrome Products (UCP) site is a former industrial hard chrome plating facility located at 2000 Airport Road in the Airport Research Industrial Park complex, approximately 3.5 miles south of the city of Corvallis, Oregon. The UCP site consists of a single building on approximately 1.5 acres of level ground and is bounded by the Corvallis Airport. The city of Corvallis owns the UCP site and all surrounding property.

UCP began electroplating operations in 1956. A dry well disposal pit was created in the same year and was reportedly used until 1975 to dispose of floor drippings, washings, and product rinsate from a sump within the building. Liquids were reportedly neutralized with sodium hydroxide and/or soda ash prior to disposal in the dry well. The specific composition of water discharged is unknown; however, the nature of the facility indicates that spent plating bath solutions, spent stripping and cleaning bath solutions, and sludges from plating baths may have been disposed in the dry well. Quantities of waste discharges are unknown, but have been estimated at 1,000 gallons per year. Use of the dry well reportedly ceased in 1975. The amount and disposition of wastes produced since then is unknown.

In November 1984, UCP announced that it would shut down and cease all operations, and in May 1985, the equipment and contents of the building were sold. The building is currently vacant, and the city of Corvallis has indicated that it presently has no plans for alternative use of the site area and building, or for demolition of the facility.

Environmental investigations at UCP conducted by the Oregon Department of Environmental Quality (ODEQ) and EPA took place between November 1982 and December 1984. In July 1983, the site was scored using the Hazard Ranking System and subsequently included on the National Priorities List. Investigations indicated considerable chromium contamination in the soil beneath and near the building and in both the upper and lower aquifers as a result of leaching from the drywell and plating tanks. Investigations also indicated contamination of approximately 2.4 million gallons of groundwater in the upper unconfined and lower confined aquifers. Total chromium concentrations in the upper aquifer are as high as 1.5 percent near the former plating tanks, but range from 142 to 689 milligrams per liter (mg/l) in the surrounding monitoring wells. Total chromium concentrations in the lower aquifer are generally an order of magnitude lower; however, the primary drinking water standard of 0.05 mg/ has been exceeded in numerous deep well samples.

An immediate removal action initiated in July 1985 and completed in October 1985 stabilized the site after the company vacated the building. Perimeter fencing was installed, and spent plating solution, drums, and containers were removed from the site. All hazardous substance source materials are believed to have been removed from the site with the exception of residual sludges in plating tanks.

EPA completed a Feasibility Study (FS) addressing site cleanup alternatives in August 1985. A Record-of-Decision (ROD) was issued by EPA Region X in September 1986 recommending limited excavation of contaminated soil from the dry well and plating tank areas, and unconfined and confined aquifer groundwater extraction, treatment, and surface discharge. Installation of two percolation barriers in the excavated area was recommended to flush contaminated soil in the unsaturated zone above the shallow groundwater table. The ROD recommended that the drainage ditch within the contaminated area be culverted to protect the local surface drainage ditch system from contamination. The objective of the selected alternative is to remove contamination in the confined aquifer and control the migration of further contamination from the upper unconfined zone. The cleanup criteria in the confined aquifer is the drinking water standard of 0.05 mg/ for chromium, because this aquifer is considered a drinking water source in direct hydraulic connection with the local drinking water supply wells. The cleanup criteria for the unconfined aquifer is also 0.05 mg/. The site boundary is considered the point of compliance at which these criteria must be met.

UCP site remediation is currently in progress. Extracted groundwater is being treated on-site. Groundwater is pumped to an influent holding tank and then transferred to a sectioned tank. Metals are reduced chemically in the first section. Groundwater then flows to a section where the pH is raised to between 9 and 10 to cause the formation of metal hydroxides and a polymer flocculant solution is added. Groundwater then flows to the final section for settling and clarification. After settling and clarification, the groundwater flows from the sectioned tank through polishing filters (not operating during sample episode) to one of the two holding tanks where total chromium and pH are monitored to determine whether the water meets discharge standards. If treated water does not meet discharge standards, it is recirculated through the treatment system. Adequately treated water is discharged as a batch from the holding tank to an on-site sewer which connects to the Corvallis wastewater treatment plant.

VERONA - EPISODE 1223
SITE DESCRIPTION

The Verona Well Field is located approximately 1/2 mile northeast of Battle Creek, Michigan. The well field incorporates property on both sides of the Battle Creek River, consisting of three wells west of the river (in Bailey Park), and 27 wells, with a major pumping/water treatment station, east of the river. The area north and east of the well field is essentially rural. Land use to the south and west is light to heavy industrial, with a residential area directly south, and the Grand Trunk Western Railroad (Grand Trunk) marshaling yard adjoining the well field on the east.

The Verona Well Field provides potable water to 35,000 residents of Battle Creek, and part or all of the water supply requirements for two major food processing industries and a variety of other commercial and industrial establishments. A review of the monthly pumping data indicates that the City requires an average supply of water equal to approximately 10 million gallons/day (MGD) with additional supplies needed to meet a peak demand equalling 19 MGD.

During August 1981, while conducting routine testing of private water supplies, the Calhoun County Health Department discovered that the water supply from the Verona Well Field was slightly contaminated with volatile organic compounds (VOCs). Follow-up testing by the Calhoun County Health Department and the Michigan Department of Public Health (MDPH) revealed that ten of the City's 30 wells contained detectable levels of volatile compounds. The MDPH then began weekly sampling of the well field.

During that same period, the MDPH began sampling private residential wells in the area to the south of the well field. To date, approximately 80 private wells have been found to contain varying concentrations of contaminants. Several of the private wells have total VOC contamination levels on the order of 1,000 parts per billion (ppb); the private well with the highest reported level had a dichloroethylene concentration of 3,900 ppb.

The Verona Well Field was listed as a National Priorities List site in July 1982. Since then several studies, investigations, and activities have been conducted in the area.

The Michigan Department of Natural Resources (MDNR) investigated potential sources of the contamination, and identified the Thomas Solvent Company facilities, the Grand Trunk marshaling yard, and the Raymond Road Landfill as possible sources of the volatile hydrocarbons. The EPA Technical Assistance Team (TAT) conducted a groundwater survey during the spring of 1982, and further concluded that the source of contamination was most likely in the vicinity of the Thomas Solvent facilities. The U.S. Geological Survey (USGS) initiated a hydrological investigation under contract with the City of Battle Creek in 1982. The study examined the geology and groundwater flow patterns in the vicinity of the Verona Well Field. The USGS has prepared a groundwater flow model (1985) to evaluate the effects of pumping Verona wells on groundwater flow. EPA began Phase I of a remedial investigation (RI) in November 1983.

The purpose of the RI was to identify the sources of contamination to the well field.

By January 1984, all but six of the City's 30 water supply wells in the Verona Well Field were contaminated with VOCs from the advancing groundwater plume. Under these conditions, it was apparent that there would not be a sufficient supply of uncontaminated water to meet the City's peak demand in the summer of 1984. In response, EPA initiated a focused feasibility study (FFS) in February 1984 to address the water supply problem, while the remedial investigation on the sources of contamination proceeded.

The FFS resulted in a Record-of-Decision by Region V, EPA in May 1984 that recommended the installation of three new water supply production wells, and the use of selected existing Verona wells to form a blocking well system to halt the spread of contamination to the northernmost Verona wells. The purge water from the blocking wells would be treated by an air stripper to be constructed at the well field.

Blocking well operations were initiated in May 1984, with temporary carbon adsorption beds providing treatment until the air stripper could be constructed. Construction of the air stripper was completed in August 1984. Since operation of the barrier wells began, the advance of the contaminant plume has been halted. In its Record-of-Decision, EPA determined that the barrier system should be maintained for a period of five years to insure adequate supplies of uncontaminated water until final remedial measures are implemented.

The results of the Phase I remedial investigation were published in technical memorandum in November 1984. The results confirmed that the Thomas Solvent facilities are major sources of groundwater contamination, and also identified an unknown source of perchloroethylene (PCE) from a location east of the well field.

Phase II of EPA's remedial investigation was initiated in July 1984 to characterize in greater detail the extent of VOC contamination at the Thomas Solvent facilities, and to investigate the source of the eastern plume of PCE.

The Thomas Solvent Company operations at the Raymond Road facility consisted of the packaging and distribution of liquid solvent commercial products, with the exception of minor amounts of reclaimed acetone. The generators of the reclaimed acetone hauled by Thomas are unknown, and since this activity represented a minor portion of Thomas Solvent business (less than 5 percent), enforcement efforts have been directed at Thomas as owner/operator.

In February 1985, EPA determined that source control measures at the Verona Well Field site should be carried out in separate operable units. Source control at the Thomas Raymond Road facility was identified as the first operable unit that should be conducted at the Verona Well Field site because of the relative magnitude of contamination at the facility. The groundwater beneath and surrounding the facility is contaminated at levels exceeding 100,000 ppb VOCs. This is approximately 100 times more concentrated than levels in the majority of the plume.

Presently, contaminated groundwater from the Thomas Raymond Road facility is pumped from several on-site extraction wells to the pretreatment facility at the Verona Well Field site. This wastestream is discharged to two of three activated carbon adsorption vessels before blending with groundwater from the blocking well system. The blended streams collect in a wet well prior to being pumped through an air stripping unit. Final discharge is to the Battle Creek River.

Personnel from MDNR have noted that desorption of several compounds from the granular activated carbon units occurs periodically. These compounds are not air-stripped efficiently and have on occasion been found by MDNR in the final effluent.

WELL 12A - EPISODE 1808
SITE DESCRIPTION

The Well 12A site in Tacoma, Washington is a production well with treatment consisting of an air stripping system discharging treated water to either Commencement Bay or to the City's water system. During the remedial investigation, 11 monitoring wells were installed. By measuring groundwater elevation in the wells, it was determined that the natural (undisturbed by well field pumping) groundwater flow direction was from west to east with a relatively flat gradient and therefore, a low flow velocity. The study also determined that the major source of contamination was generally northeast of Well 12A. A specific source was not identified. Under these conditions, with the wellfield shut down most of the year, the contaminant plume moves slowly away from the production wells. However, under the influence of production well pumping action, the natural gradient is reversed and the contamination is drawn towards the operating wells.

One conclusion of the Remedial Investigation was that operation of Well 12A would intercept the contamination drawn from the source area even if other production wells were pumping. In effect, Well 12A would provide a barrier to the spread of contamination and protect the rest of the wellfield. If Well 12A were not operated to provide a barrier, other operating wells would draw the contaminant plume and would be lost for use.

To avoid the potential loss of the wellfield during the approaching summer peak water demand period, U.S. Environmental Protection Agency (EPA), in January 1983, authorized a focused feasibility study to determine a cost-effective treatment system for the output of Well 12A. Treatment of the wellwater was necessary to achieve a quality that would permit discharge to Commencement Bay, or would permit its use in the City water system.

The initial remedial measure for Well 12A treatment was determined to be an air stripping system consisting of five packed towers operating in parallel at a total flow rate of 3,500 gallons per minute (gpm) and discharging treated water to either Commencement Bay or the the City's water system depending on measured quality and the City's needs. The decision level used to determine whether the treated well water would be used in the City water system or discharged to the bay was the 10^{-6} level of hazard at the tap (after dilution in the system).

Construction of this treatment system was authorized in late March 1983, and it was started up in mid-July and operated by the City until early November. Treatment performance was better than anticipated and effluent solvent concentrations did not reach the design levels. Treated water was therefore suitable for use in the City's water system during the full pumping season.

Operation of the Well 12A treatment system by the City of Tacoma will continue on a seasonal basis to protect the wellfield.

Research into the past ownership and activities on these properties indicated that waste oil and solvent reclamation processes were used and that some of the

spent filter cake was used to build the railroad spur. The use of the Time Oil site for oil recycling and related operations dates back to 1927 when William Palin began operations under the name of Palin and Son. In 1933, the business name was changed to National Oil and Paint. The two main activities of the businesses were waste oil recycling and paint and lacquer thinner manufacturing.

The waste oil recycling process consisted of collecting waste oil in a large tank, adding chemicals such as sulfuric acid, and pressurizing and heating the contents of the vessel. This process resulted in the formation of a tar-like sludge on the bottom of the tank which was removed and disposed of. Absorbents and clay materials were also added to the oil. The sludge was filtered from the oil, and the resulting filter cake was disposed of or stored in various piles on the site. Some of this sludge was also used for fill around the site.

The paint and lacquer thinner manufacturing involved the use of many solvents that were stored on the site in barrels which may have leaked their contents into the soil.

Prior to purchase of the property by Time Oil, Inc., in 1964, the remaining barrels and drums of solvent were removed from the site. After Time Oil purchased the property, operations continued under the name National Oil and Paint until 1972. During this period, National Oil was involved only in waste oil recycling. Waste sludges and filter cakes were not known to be stored on the site during this period.

In 1972, Time Oil leased the facilities to Golden Penn, Inc. Golden Penn operated on the site until 1976, before going out of business as a result of a destructive fire. In 1975 and 1976, Golden Penn was ordered by the State of Washington to clean up the site by removing some of the filter cake and spilled oil from the ground.

In 1976, Time Oil resumed operation at the site. Since then their operation has been limited to canning oil brought to the site in bulk containers. In 1982, the Burlington Northern Railroad spur was extended by Time Oil to its present length so that oil could be delivered by tanker car. During the construction of the spur, some of the filter cake or sludge material stored on the site was used in the roadbed.

During the remedial investigation, the extent of soil and groundwater contamination near the Time Oil plant was explored by means of surface soil samples, shallow and deep soil borings and monitoring wells.

Chemical data for 1,1,2,2-tetrachloroethane and tetrachloroethylene taken from soil borings along the spur and along a north-south line and data for trichloroethylene shows these compounds are the ones of primary interest because they are the contaminants at Well 12A. Many others, not found at Well 12A, were also detected at much lower concentrations.

Along the east-west line of borings, high values of soil contamination are located along the spur adjacent to the western Time Oil building and continuing

for a distance of at least 150 feet west of that building. Measured concentrations of the contaminants is greater than 3,000 parts per billion (ppb) of soil to depths of about 25 feet. Highest concentrations were found near the surface at levels up to about 1,000 parts per million (ppm).

Along the north-south soil boring line, soil contamination concentrations to about 3,000 ppb of soil were measured to a depth of about 20 feet on the north end of the Fleetline property.

Continuity between this near surface soil contamination and that in the aquifer was established. The total quantity of solvents contained in the soil from the ground surface to the groundwater level was grossly estimated at about 1,500 pounds.

Groundwater contamination was found along the east-west line of borings in the same boreholes as the major soil contamination. Levels ranged up to about 11,000 ppb of water. Along the north-south line of borings, levels up to 863,000 ppb were measured under the Fleetline property. This southward displacement of the highest aquifer contamination is likely to have resulted from the previous pumping action of the wellfield.

WESTERN PROCESSING - EPISODE 1739
SITE DESCRIPTION

The Western Processing site is located at 7215 South 196th Street in Kent, King County, Washington. From 1953 to 1961, the site was leased and used as a U.S. Army Nike Anti-Aircraft Artillery facility. In 1961, the property was sold to Western Processing Company, Inc. (Western Processing). Originally, Western Processing was a reprocessor of animal by-products and brewer's yeast. In the 1960s, the business expanded to recycling, reclaiming, treating, and disposing of many industrial wastes, including waste oils, electroplating wastes, waste pickle liquor, battery acids, steel mill flue dust, pesticides, spent solvents, and zinc dross.

Discharges from Western Processing were monitored and regulated by the Washington Department of Ecology (WDOE) until 1981. U.S. Environmental Protection Agency (EPA) inspected the site in March 1981 to determine compliance with the new RCRA regulations and in September 1982, EPA initiated an investigation. Western Processing had violated many EPA hazardous waste management regulations. Approximately 100 of the 129 priority pollutants were detected in the soil or groundwater on and off the Western Processing Site, or in the adjacent Mill Creek.

After soil and groundwater sample analyses were completed in April 1983, confirming widespread site contamination, EPA ordered cessation of site operations. Western Processing could not comply with EPA's specifications to clean up the site, so EPA conducted emergency cleanup operations funded by Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The emergency response activities included removal of wastes (drums, liquids, and solids) for off-site disposal, reorganization of the remaining on-site drums, and excavation of contaminated soil from the reaction pond area.

A Record-of-Decision was signed in 1984. In July 1984, further site cleanup activities were initiated as a result of the agreement reached between EPA, WDOE, and the potentially responsible parties (PRPs) for the Phase I remedial action program. These surface cleanup activities were completed in November 1984 under the direction of Chemical Waste Management, Inc. (consultant for the PRPs).

The selected alternative for the Phase II remedial action program included installation of a slurry wall around the site to a depth of 42 to 46 feet below ground and pumping and treating the groundwater from the shallow aquifer directly below the site and contaminated groundwater from deeper in the aquifer that has migrated off-site. More than 200 well points, laid out in a grid across the site, will be used to extract groundwater from below the site. Extraction wells located off-site will be used to pump contaminated groundwater from deeper in the aquifer. The on-site well points and off-site pumping wells are divided into six different cells so that the pumping zones and the pumping rate from each cell can be controlled. Interspersed amongst the on-site well points are infiltration drains that will be used to recycle clean water through the unsaturated zone and flush contamination from the shallow soils. The

groundwater was pumped initially at a rate of 100 gallons per minute (gpm) and routed through an on-site pretreatment plant designed by Chemical Waste Management, Inc. (and subcontractors HDR and Canoni). The pumping system and pretreatment plant are designed to pump and treat the groundwater at a rate of up to 200 gpm. Pretreated groundwater is discharged directly into the city sewer system for additional treatment by activated sludge at the Renton wastewater treatment plant.

Negotiations were initiated in 1986 between EPA, WDOE and the POTW authority of Metropolitan Seattle (Metro) to discuss the feasibility of discharging contaminated water from the Western Processing site. Initially, Metro was reluctant to accept the wastewater because of concerns about liability. In April 1987, EPA entered a Consent Decree to expedite the Phase II clean-up effort. Chemical Waste Management, Inc., submitted a contract to Metro for discharge from the site in the summer of 1987. After Metro received written indemnification assurance from EPA and WDOE regarding environmental consequences associated with accepting the contaminated wastewater, Metro developed initial local limits for acceptable loading from the site.

The Western Processing pretreatment plant operates 24 hours per day, and will operate for a minimum of seven years. The pretreatment plant process includes sequentially: air stripping with carbon adsorption and hot gas regeneration systems to control volatile emissions; phenol oxidation; metals reduction; pH adjustment; flocculation; inclined-plate clarification; and sludge thickening. A stand-by granulated carbon adsorption system to treat the groundwater is also in place. The sludge generated from the pretreatment plant is disposed at the Arlington, Oregon, hazardous waste landfill.

WHITEHOUSE OIL - EPISODE 1241
SITE DESCRIPTION

The community of Whitehouse, Florida is located within 0.25 miles east and southeast of the site. Two major east-west highways, U.S. Highway 90 and Interstate 10, are approximately 0.5 miles south of the site. A low-density residential area is located west and northwest of the site, and several miles northwest of the site is the Cecil Field U.S. Naval Air Station. The area north and northeast of the site is largely undeveloped land comprised of pine forests and cypress swamp.

The Whitehouse Waste Oil Pits occupy approximately seven acres on an upland area. The northern and western sides of the site border a swamp system through which the Northeast Tributary runs. The stream originates from a 220-acre cypress swamp located approximately 0.5 miles upstream from the site. The southern side of the site is bordered by open grassland, with the exception of the southwestern corner, which is a private residence.

The site consists of seven unlined pits where waste oil sludge, acid, and contaminated waste oil from an oil reclaiming process were disposed. Allied Petroleum constructed the pits to dispose of waste oil sludge and acid from its oil reclaiming process. The first pits were constructed in 1958, and by 1968 the company had constructed and filled seven pits. Allied Petroleum then went bankrupt, and most of the property transferred to the City of Jacksonville for nonpayment of taxes. After they were abandoned by Allied Petroleum, the pits remained an "open dump" for several years. It is reasonable to assume that indiscriminate dumping occurred during that time.

The waste oil recovery process used by Allied Petro Products was the Acid-Clay Process. This process forms, as by-products, a waste-acid tar and spent acidic clays which are corrosive. The seven unlined pits contained an estimated 127,000 cubic yards of waste. Stabilization activities have increased the volume of contaminated material to an estimated 240,000 cubic yards.

Major contaminants at the site include hexavalent chromium, arsenic, lead, phenols, benzene, and polynuclear aromatic hydrocarbons (PAH) (fluoranthene, phenanthrene, pyrene).

Improvements made to the site by the City of Jacksonville in 1980 and the initial remedial measures (IRM) done under cooperative agreement with the State have significantly reduced the hazards at the site and ensured that no large-scale spills would occur again. Erosion continues to be a problem at the site. Testing by the State indicated that heavy rains and eroding dike walls have allowed pollutants to slowly seep into surface water. As expected, soil samples from beneath the clay cap of the pits show gross contamination by heavy metals and low levels of a few organic compounds. The only soils beyond the pits which are badly contaminated are the soils in the swamp or floodplain north of the pits, between the pits and the northeast tributary.

The quality of surface water was tested at five sampling stations in the drainage basin. These samples show that the surface water quality in McGirt's Creek significantly improved since 1977. This improvement is directly related to the work done by the local, state, and federal agencies which prevented further large scale contamination. However, the effect of the pits is still evident since the surface water contains heavy metals and a lowered pH. The water quality of the creek is also threatened by the seepage which has polluted the soil in the flood plain north of the pits.

Areas of potential groundwater contamination were located by conductivity tests. Thirty-six wells at a variety of depths were installed to sample groundwater. The shallow groundwater (7 to 15 feet) between the pits and the northeast tributary is grossly contaminated by heavy metals and organic compounds. Only low levels of organic compounds were detected across the northeast tributary and beyond the south drainage ditch. Thus, shallow groundwater contamination seems to be localized close to the site.

Vertical migration has reached into the aquitard (35 - 60 feet). The deeper wells (100 to 125 feet) close to the site show low levels of heavy metals and organic compounds. This is of special concern since these wells are in the same aquifer used by many residents. All the residential wells near the site that were downgradient of the pits were tested during the remedial investigation. No contamination from the pits was detected in any of the wells. The State will continue to monitor quality of the residential wells.

The eventual receptor for surface runoff is McGirt's creek which empties into the St. John's River approximately ten miles downstream. Neither of these bodies of water supply drinking water, but are areas of environmental concern.

As late as 1983 (prior to completion of the IRM), seepage of contaminated leachate through the dike walls was observed. State bioassays using a weak concentration of the leachate showed it to be very toxic. Direct contact with leachate and leachate contaminated surface water is a concern.

The domestic water supply aquifer beneath the site is protected by a fairly consistent aquitard. Sampling has shown contamination in the shallow aquifer and evidence of contamination moving down into the aquitard (permeability about 10^{-5} centimeters/second). Groundwater degradation is an immediate concern and a reason for taking preventative action.

Although the IRM was constructed as an attempt to reinforce the dike walls and prevent further spread of contamination, this measure is not adequate for long-term containment of the waste. To compound site problems, erosion caused by motorcycles, dirt buggies, heavy rainfall, and hurricanes pose additional risks to all population groups surrounding the site.

Monitoring Wells MW-5 and MW-9, and RW-1 (4-inch pump test well) are being considered in future remediation efforts as representative wells to be used as extraction wells for a pump and treat system. These wells would be recommended sample points for an EPA-ITD sampling effort.

STRINGFELLOW ACID PITS - EPISODE 1805
SITE DESCRIPTION

Stringfellow Acid Pit was operated by Stringfellow Quarry Co. from 1956 to 1972 as a hazardous waste disposal facility. The landfill disposal site was permitted by the Santa Ana Regional Water Quality Control Board (RWQCB). About 34 million gallons of wastes, mostly from metal finishing, electroplating, and DDT production, were deposited on approximately 17 acres of the site. In 1969 and 1978, excessive rainfall caused the ponds used for solar evaporation to overflow, spreading contamination into the nearby town of Glen Avon. In July 1980, the RWQCB advocated total removal of all solids and liquids but the funds were not available. In December 1980, RWQCB selected an interim plan that included installation of channels to divert surface water, a gravel drain and a network of wells for monitoring and extraction, and a clay core barrier dam downgradient to stop subsurface leachate migration.

California placed Stringfellow at the top of the California priority list. The State conducted a study in compliance with the National Oil and Hazardous Substances Pollution Contingency Plan (the National Contingency Plan or NCP) to obtain CERCLA funds. The results of the study indicated that on-site management was more cost effective than total removal.

On July 22, 1983, Lee Thomas, Assistant Administrator of the Office of Solid Waste and Emergency Response (OSWER), signed a Record of Decision (ROD) which endorsed the State's request for funds for both existing activities and proposed actions. The interim actions authorized in the ROD were:

- removal of DDT contaminated material
- operation of extraction wells upgradient of the clay barrier to protect the barrier
- fencing the entire site to prevent entry
- erosion control to prevent destruction of a clay cap

The state also requested EPA to lead a fast track Remedial Investigation/Feasibility Study (RI/FS) while the Department of Health Services completed the long-term RI/FS.

As a result of the fast track RI/FS, a pretreatment system was installed to treat the groundwater before its discharge to the Santa Ana Watershed Project Authority. The series of extraction wells transfer two groundwater streams from the contaminated canyon area to the field storage tanks. On-site groundwater (Stream A), known to contain metal compounds and organics, is transferred from the field storage tanks to one of four equalization tanks (each with a 12,000-gallon capacity) at the on-site treatment plant. Once equalization of Stream A occurs, Stream A proceeds to a 400-gallon capacity rapid mix tank where lime and caustic soda are added to aid precipitation and to control acidity/alkalinity, and polymer is added to aid floc formation. The chemically treated and mixed stream flows to two parallel-operating clarifiers.

The thickened sludge is pumped from the clarifiers to the sludge holding tanks, and the clarified effluent flows to two gravity sand filters operating in parallel. Each filter has a 7.6 square foot area, and the sand is about three feet deep. Wastewater from the sand filters is transferred to the 500-gallon Stream A filter effluent tank.

Groundwater from mid-canyon (Stream B), which contains mostly organic compounds, is transferred from the field storage tanks to one of three equalization tanks (12,000-gallon capacity each) located at the on-site treatment plant. Stream A effluent from the 500-gallon filter effluent tank is blended with Stream B before discharging to activated carbon adsorption vessels. The two carbon adsorption vessels each have a 10-ton capacity for granular activated carbon and are operated in series with a third vessel functioning as a transfer tank.

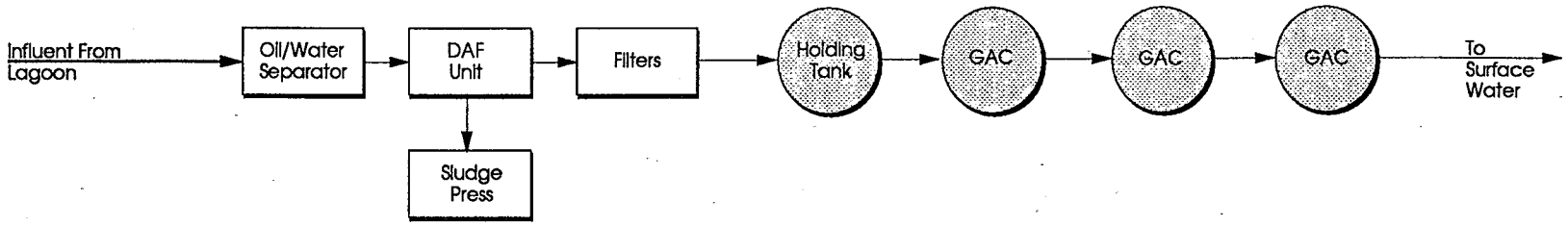
Effluent from the carbon adsorption vessels is transferred to one of four final effluent storage tanks (80,000-gallon total capacity), before it is discharged to the sewer at an average rate of 870,000 gallons per month. As necessary, effluent from these storage tanks is used as backwash and other plant utility water.

Sludge is pumped from the clarifiers to two 11,000-gallon sludge holding tanks. The sludge from the two sludge holding tanks is fed to two plate-and-frame filter presses. Depending on the pollutant content, the filtrate from the filter press operation can be recycled to either the Stream A influent equalization tanks, the Stream B influent equalization tanks, or the Stream A filter effluent tank. Usually, the filtrate is pumped to the Stream A equalization tanks. The sludge cake is discharged into containers and is hauled off-site by a contractor for disposal at a RCRA approved Class I disposal site as hazardous waste.

As part of the Stringfellow discharge permit, the effluent must be tested prior to any discharge. Currently, the facility is allowed to fill two storage tanks simultaneously, but is only required to test one tank.

The pretreatment system located at Stringfellow operates five days per week during the daylight hours.

ATTACHMENT B
SITE SUMMARY TABLES



Treatment: OS - DAF - MF - HT - GAC
Wastewater Type: Leachate
Average Flow: 300 GPM (24 Hours/7Days)
Surface Water Discharge

	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge[3]	% Mass Removed OS[4]	% Mass Removed DAF[4]	% Mass Removed MF[4]	% Mass Removed GAC[4]	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	5 : 8 : 16	6-3246 ug/L	6-101 ug/L	330 : 5,000	117 : 3,690	< 1 : 9	19 : 17	15 : 6	50 : < 1	65 : 26
Metals	5 : 14 : 19	8-51750 ug/l	19-313 ug/L	680 : 106,490	112 : 188,090	4 : 1	72 : < 1	37 : 5	< 1 : < 1	84 : < 1

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte

2. From samples collected from a one day sampling event

3. OS = Oil/Water Separator
   DAF = Dissolved Air Flotation
   HT = Holding Tank
   MF = Multi-Media Filter
   GAC - Granular Activated Carbon

FIGURE B-1
BRIDGEPORT RENTAL - 1222
ONE DAY SAMPLING EVENT
REGION II LOGAN TOWNSHIP, NJ

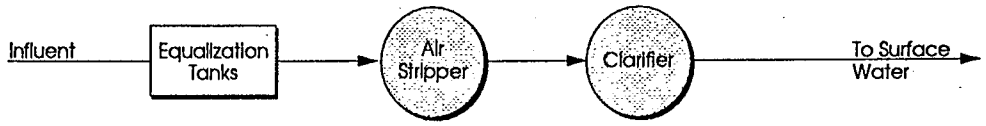
Treatment: Future
Wastewater Type: Groundwater

Pollutant	# Compounds Detected[1] PP : TCL : ITD	Conc ITD[2] Min-Max	Conc PP[2] Min-Max
Total Organics	3 : 7 : 10	15-643 ug/L	15-93 ug/L
Metals	4 : 12 : 19	0.200-15900 ug/L	10-213 ug/L

NOTES:
1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte

2. From samples collected from a one day sampling event

FIGURE B-2
CHARLES GEORGE - 1309
ONE DAY SAMPLING EVENT
REGION I TYNGSBOROUGH, MA



Treatment: Air Stripping
Wastewater Type: Groundwater
Average Flow: 750 GPM (24 Hours/7Days)
60% to Surface Water/ 40% Reinjected

	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge[3]	% Mass Removed AS[4]	% Mass Removed CL[4]	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	12 : 12 : 16	0.027ppt - 444 ug/L	34 - 444 ug/L	5,110 : 6,300	344 : 490	89 : 88	41 : 34	93 : 92
Metals	4 : 11 : 16	2 - 137,167 ug/L	6 - 34 ug/L	225 : 669,420	97 : 375,900	13 : 3	78 : 42	57 : 43

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. Taken from concentration averages over a four day sampling event
3. Based on pollutant concentration averages
4. AS = Air Stripping
   CL = Clarifier

FIGURE B-3
CHEMDYNE - 1807
FIVE DAY SAMPLING EVENT
REGION V HAMILTON, OH

6098-01

Treatment: Future
Wastewater Type: Groundwater

Pollutant	# Compounds Detected[1] PP : TCL : ITD	Conc ITD[2] Min-Max	Conc PP[2] Min-Max
Total Organics	20 : 25 : 32	11 ppt-10445 ug/L	16-10,445 ug/L
Metals	5 : 14 : 23	3-1,075,000 ug/L	5-25 ug/L

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte

2. From samples collected from a one day sampling event

FIGURE B-4
GENEVA INDUSTRIES - 1224
ONE DAY SAMPLING EVENT
REGION VI HOUSTON, TX

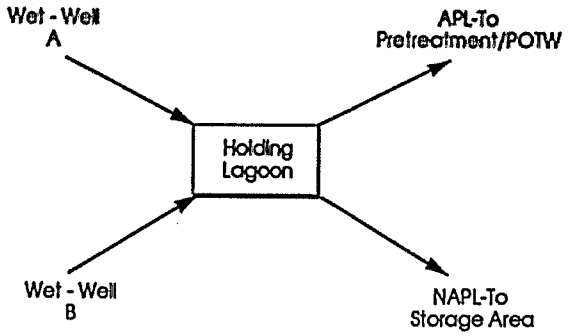
Treatment: Future
Wastewater Type: Groundwater

Pollutant	# Compounds Detected[1] PP : TCL : ITD	Conc ITD[2] Min-Max	Conc PP[2] Min-Max
Total Organics	4 : 5 : 6	12-58,017 ug/L	30-58,017 ug/L
Metals	3 : 10 : 15	4-205,000 ug/L	4-1,130 ug/L

NOTES:
1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte

2. From samples collected from a one day sampling event

FIGURE B-5
GOLD COAST OIL - 1242
ONE DAY SAMPLING EVENT
REGION IV MIAMI, FL



Treatment: Lagoon
Wastewater Type: Leachate
Average Flow: <6,000 GPD
To 48 MGD POTW

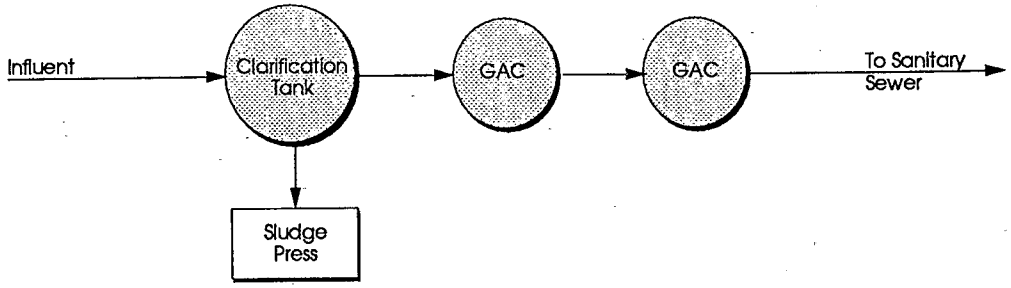
	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP : ITD	(LBS/YR) PP : ITD	PP : ITD
Total Organics	15 : 17 : 40	0.38 ppt-2,316,700 ug/L	32ppt-1,548,330 ug/L	195,180 : 484,690	118,500 : 517,250	39 : < 1
Metals	5 : 13 : 24	16-349,500 ug/L	24-1567 ug/L	270 : 801,930	91 : 521,260	66 : 35

NOTES:

1. APL = Aqueous Phase Liquid
   NAPL = Non-Aqueous Phase Liquid
2. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
3. From samples collected from a one day sampling event
4. Based on average of raw leachate collected from two wet-wells

FIGURE B-6
HYDE PARK - 1220
ONE DAY SAMPLING EVENT
REGION II NIAGRA FALLS, NY

6098-01



Treatment: Granular Activated Carbon
Wastewater Type: Leachate
Average Flow: 40,000 GPD (2Days/Wk)
To 48 MGD POTW

	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading	Discharge	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD
Total Organics	15 : 18 : 22	6ppt-51496 ug/L	6ppt-18,166 ug/L	3050 : 7,800	12 : 23	> 99 : > 99
Metals	2 : 10 : 19	27-225000 ug/L	70-144 ug/L	19 : 40,220	7 : 37,130	63 : 8

NOTES:
1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte

2. From samples collected from a one day sampling event

FIGURE B-7
LOVE CANAL - 1219
ONE DAY SAMPLING EVENT
REGION II NIAGRA FALLS, NY

6098-01

Treatment: Future
Wastewater Type: Groundwater

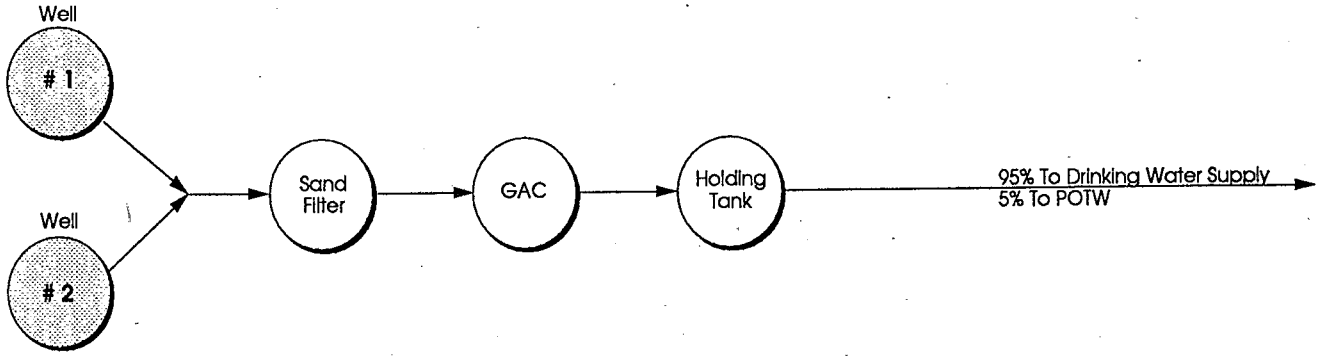
Pollutant	# Compounds Detected[1] PP : TCL : ITD	Conc ITD[2] Min-Max	Conc PP[2] Min-Max
Total Organics	9 : 9 : 10	164-18,378 ug/L	164-18,378 ug/L
Metals	7 : 17 : 30	12-821,000 ug/L	12-6000 ug/L

NOTES:
1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte

2. From samples collected from a one day sampling event

FIGURE B-8
NYANZA CHEMICAL - 1310
ONE DAY SAMPLING EVENT
REGION I ASHLAND, MA

6098-01



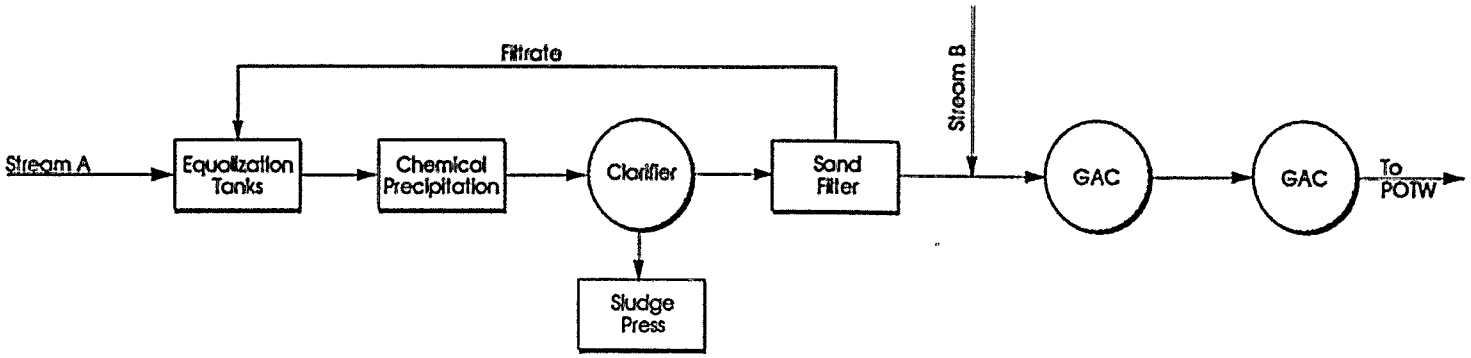
Treatment: SF-GAC
Wastewater Type: Groundwater
Average Flow: 500 GPM (24 Hours/7Days)
95% To Drinking Water Supply
5% To POTW

	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge	% Mass Removed SF[4]	% Mass Removed GAC[4]	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	2 : 2 :4	0.001 ppt-2262 ug/L	18-2262 ug/L	9,970 :10,070	900 : 990	82 :81	50 :49	91 : 90
Metals	1 : 7 : 13	7-89617 ug/L	7 ug/L	29 : 620,580	245 : 616,060	< 1 : < 1	< 1 : < 1	< 1 : < 1

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. Taken from concentration average over a five day sampling event
3. Based on pollutant concentration averages
4. SF = Sand Filter
   GAC = Granular Activated Carbon

FIGURE B-9
REILLY TAR - 1239
FIVE DAY SAMPLING EVENT
REGION V ST. LOUIS PARK, MN



Treatment: CP-SF-GAC
Wastewater Type: Groundwater
Average Flow: 0.04 MGD (8 Hours/5 Days/Wk)
To 220 MGD POTW

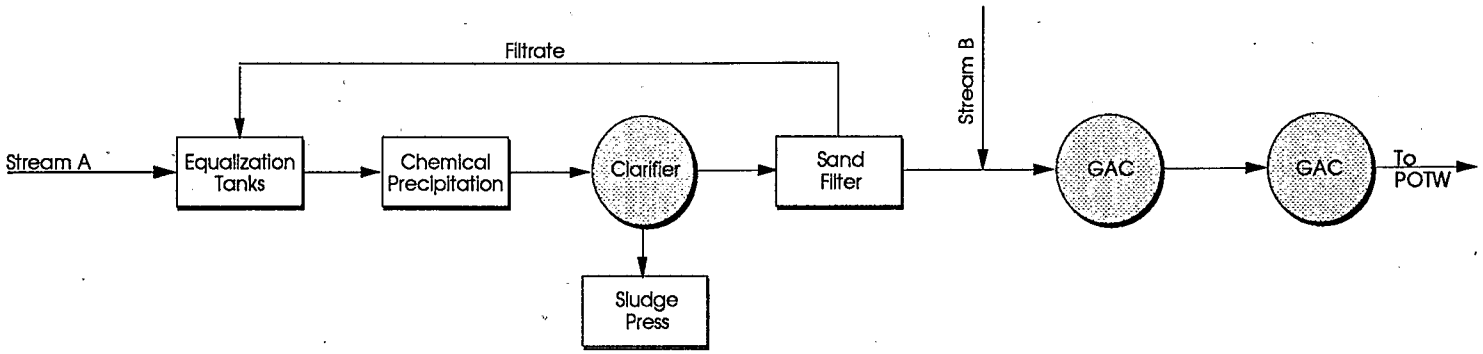
	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading	Discharge[4]	% Mass Removed CP[5]	% Mass Removed SF[5]	% Mass Removed GAC[5]
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	9 : 11 : 13	0.131ppt-14,116 ug/L	100-123 ug/L	1,830 : 3,240	8 : 17	39 : 57	< 1 : < 1	98 : 97
Metals	9 : 19 : 43	9-2,130,000 ug/L	44-103,000 ug/L	15,930 : 539,500	11 : 196,420	> 99 : 48	< 1 : < 1	33 : 9

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. From samples collected from a one day sampling event
3. Based on pollutant concentration averages
4. The flows for streams A and B are unavailable - overall removal can not be calculated
5. CP = Chemical Precipitation
   SF = Sand Filter
   GAC = Granular Activated Carbon

FIGURE B-10
STRINGFELLOW - 1221
ONE DAY SAMPLING EVENT
REGION IX GLEN AVON HEIGHTS, CA

6098-01



Treatment: CP-SF-GAC
Wastewater Type: Groundwater
Average Flow: 0.04 MGD (8 Hours/5 Days/Wk)
To 220 MGD POTW

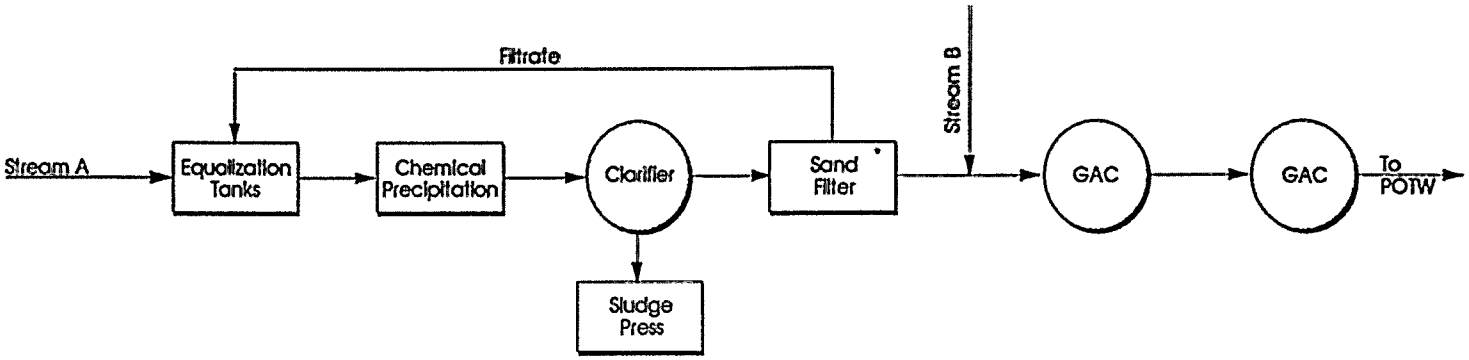
	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading	Discharge[4]	% Mass Removed CP[5]	% Mass Removed SF[5]	% Mass Removed GAC[5]
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	20 : 25 : 32	87-19,420 ug/L	88-8,370 ug/L	2,090 : 4,540	108 : 195	50 : 63	7 : < 1	83 : 82
Metals	8 : 18 : 42	12-6,337,143 ug/L	13-121,429 ug/L	18,010 : 1,024,440	11 : 218,960	> 99 : 68	3 : < 1	56 : 14

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. Taken from concentration averages over a five day event
3. Based on pollutant concentration averages
4. The flows for streams A and B are unavailable - overall removal can not be calculated
5. CP = Chemical Precipitation
   SF = Sand Filter
   GAC = Granular activated Carbon

FIGURE B-11
STRINGFELLOW - 1240
FIVE DAY SAMPLING EVENT
REGION IX GLEN AVON HEIGHTS, CA

6098-01



Treatment: CP-SF-GAC
Wastewater Type: Groundwater
Average Flow: 0.04 MGD (8 Hours/5 Days/Wk)
To 220 MGD POTW

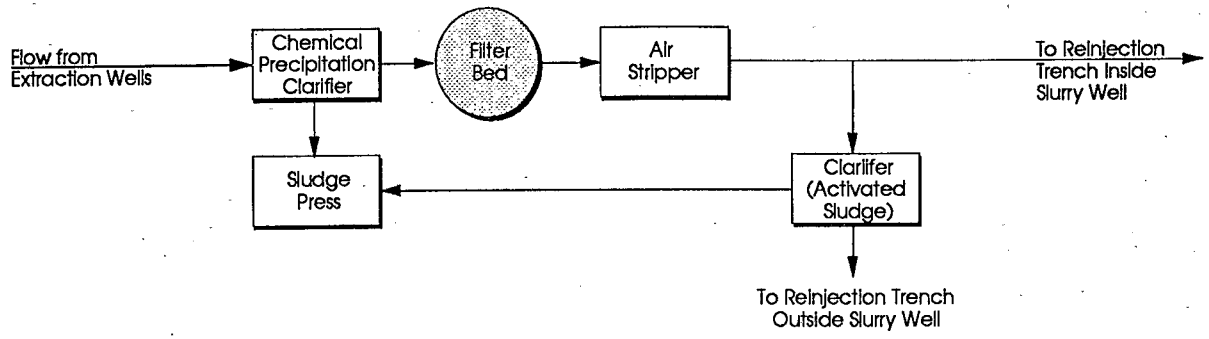
	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading	Discharge	% Mass Removed CP[5]	% Mass Removed SF[5]	% Mass Removed GAC[5]
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	15 : 20 : 27	0.028ppt -6,848 ug/L	12 - 6,848 ug/L	1,760 : 2,490	13 : 45	24 : 29	14 : 17	97 : 94
Metals	7 : 17 : 30	30 - 5,792,000 ug/L	114 - 112,600 ug/L	16,780 : 965,700	8 : 212,460	> 99 : 57	33 : < 1	58 : 5

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. Taken from concentration averages over a four day sampling event
3. Based on pollutant concentration averages
4. The flows for streams A and B are unavailable - overall removal can not be calculated
5. CP = Chemical Precipitation
   SF = Sand Filter
   GAC = Granular Activated Carbon

FIGURE B-12
STRINGFELLOW - 1805
FOUR DAY SAMPLING EVENT
REGION IX GLEN AVON HEIGHTS, CA

6098-01



Treatment: CP - SF - AS - BT
Wastewater Type: Groundwater
Average Flow: 400,000 GPD (7Days/Wk, 24 Hrs/Day)
Reinjected Treated Water
Sludge Temporarily Disposed at On-Site Landfill

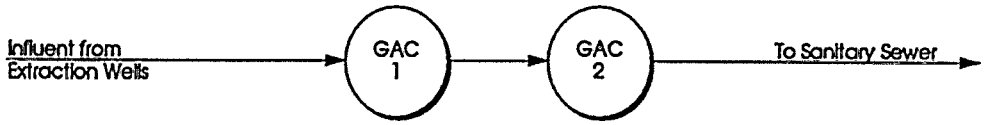
	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge	% Mass Removed CP[4]	% Mass Removed SF[4]	% Mass Removed AS[4]	% Mass Removed BT[4]	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	17 : 23 : 28	11-9,178 ug/L	13-9,178 ug/L	19,580: 23,050	37 : 175	21 : 19	6 : 7	94 : 88	96 : 92	> 99 : 99
Metals	6 : 14 : 18	8-78,716 ug/L	8-5,224 ug/L	7,766: 224,246	45 : 34,450	96 : 22	15 : < 1	< 1 : < 1	86 : 81	99 : 85

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. Taken from concentration averages over a five day sampling event
3. Based on pollutant concentration averages
4. CP = Chemical Precipitation
   SF = Sand Filtration
   AS = Air Stripping
   BT = Biological Treatment

FIGURE B-13
SYLVESTER - 1325
REGION II NASHUA, NH

6098-01



Treatment: Granular Activated Carbon
Wastewater Type: Groundwater
Average Flow: 150 GPM
Stormwater Sewer System

	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge	% Mass Removed GAC[1]	% Mass Removed GAC[4]	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	8 : 8 : 8	17 - 1,243 ug/L	17 - 1,243 ug/L	3,720 : 3,720	250 : 250	96 : 96	< 1 : < 1	93 : 93
Metals	1 : 8 : 12	3 - 21,620 ug/L	18 ug/L	12 : 43,130	9 : 47,380	30 : < 1	< 1 : < 1	25 : < 1

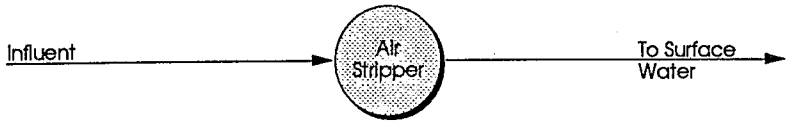
NOTES:
1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte

2. Taken from concentration averages over a five day sampling event

3. Based on pollutant concentration averages

FIGURE B-14
TIME OIL - 1804
FIVE DAY SAMPLING EVENT
REGION X TACOMA, WA

6098-01



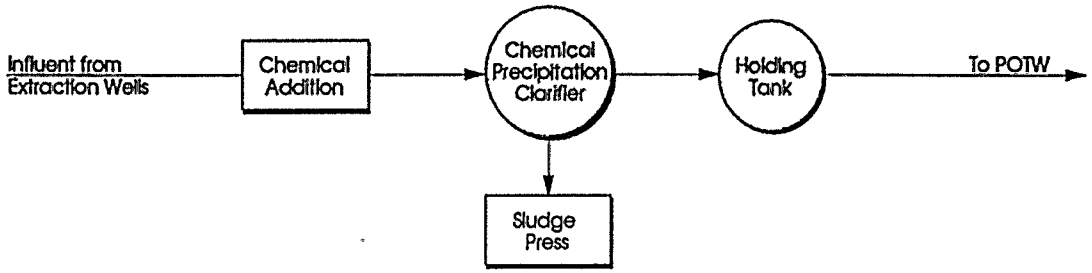
Treatment: Air Stripping
Wastewater Type: Groundwater
Average Flow: 43,000 GPD (24 Hours/2 Days/WK)
Surface Water Discharge

	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP : ITD	(LBS/YR) PP : ITD	PP : ITD
Total Organics	7 : 8 : 12	11-5,668 ug/L	11-70,571 ug/L	22 : 520	7 : 164	68 : 68
Metals	3 : 10 : 15	2-22,357 ug/L	2-289 ug/L	27 : 6,670	45 : 6,920	< 1 : < 1

NOTES:
1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. From samples collected from a one day sampling event
3. Based on pollutant concentration averages

FIGURE B-15
TYSON'S DUMP - 1568
FIVE DAY SAMPLING EVENT
REGION III KING OF PRUSSIA, PA

6098-01



Treatment: CP - HT
Wastewater Type: Groundwater
Average Flow: 50,000 GPD (8 Hours/5 Days)
To 8.8 MGD POTW

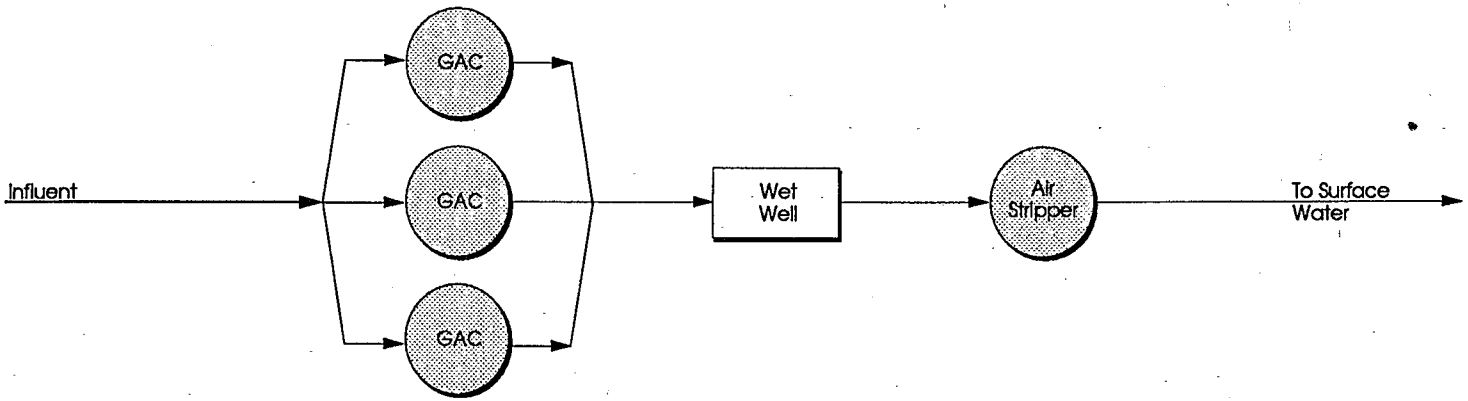
	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge	% Mass Removed CP[4]	% Mass Removed HT[4]	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	1 : 3 : 8	0.37ppt - 542 ug/L	82 ug/L	9 : 77	6 : 89	< 1 : < 1	43 : 3	33 : < 1
Metals	6 : 16 : 33	12 - 487,600 ug/L	12 - 1,226 ug/L	133,130 : 229,340	640 : 621,690	> 99	3 : < 1	> 99 : < 1

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. Taken from concentration averages over a five day sampling event
3. Based on pollutant concentration averages
4. CP = Chemical Precipitation
   HT = Holding Tnak

FIGURE B-16
UNITED CHROME - 1738
FIVE DAY SAMPLING EVENT
REGION X CORVALLIS, OR

6098-01



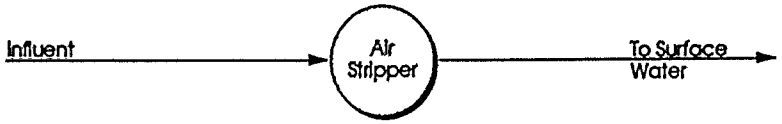
Treatment: GAC - AS
Wastewater Type: Groundwater
Average Flow: 2,000 GPM (24 Hours/7 Days)
Surface Water Discharge

Pollutant	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge	% Mass Removed GAC[4]	% Mass Removed WW[4]	% Mass Removed AS[4]	% Mass Removed Overall
	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	10 : 13 : 17	0.004ppt-1,884 ug/L	11-532 ug/L	21,715 : 44,700	2,130 : 4,800	74 : 64	62 : 69	3 : 4	89 : 90
Metals	3 : 11 : 18	6-103,200 ug/L	6-10 ug/L	238 : 1,697,865	206 : 1,490,590	10 : 11	1 : < 1	3 : 2	13 : 12

NOTES:
1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. Taken from concentration averages over a five day sampling event
3. Based on pollutant concentration averages
4. GAC = Granular Activated Carbon
   WW = Wet Well
   AS = Air Stripping

FIGURE B-17
VERONA WELL FIELDS - 1223
FIVE DAY SAMPLING EVENT
REGION V BATTLE CREEK, MI

6098-01



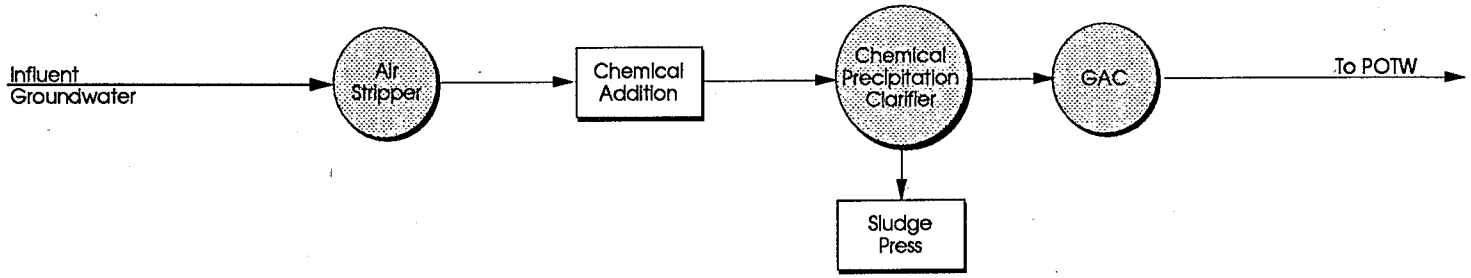
Treatment: Air Stripping
Wastewater Type: Groundwater
Average Flow: 3,500 GPM (24 Hours/7 Days)
Surface Water Discharge

Pollutant	# Compounds Detected[1] PP : TCL : ITD	Conc ITD[2] Min-Max	Conc PP[2] Min-Max	Influent Loading[3] (LBS/YR) PP : ITD	Discharge (LBS/YR) PP : ITD	% Mass Removed Overall PP : ITD
Total Organics	4 : 4 : 7	0.084 - 142 ug/L	11 - 142 ug/L	3,740 : 3,740	4,120 : 4,120	< 1 : < 1
Metals	1 : 8 : 10	6 - 24,360 ug/L	52 ug/L	790 : 1,243,560	122 : 1,246,260	85 : < 1

NOTES:
1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. Taken from concentration averages over a five day sampling event
3. Based on pollutant concentration averages

FIGURE B-18
WELL 12A - 1808
FIVE DAY SAMPLING EVENT
REGION X TACOMA, WA

6098-01



Treatment: AS - CP - GAC
Wastewater Type: Groundwater
Average Flow: 100 GPM (24 Hours/7 Days)
To 42 MGD POTW

	# Compounds Detected[1]	Conc ITD[2]	Conc PP[2]	Influent Loading[3]	Discharge	% Mass Removed AS[4]	% Mass Removed CP[4]	% Mass Removed GAC[4]	% Mass Removed Overall
Pollutant	PP : TCL : ITD	Min-Max	Min-Max	(LBS/YR) PP:ITD	(LBS/YR) PP:ITD	PP : ITD	PP : ITD	PP : ITD	PP : ITD
Total Organics	19 : 17 : 34	0.12ppt - 1,804 ug/L	14 - 1,804 ug/L	2,740 : 3,270	100 : 240	90 : 79	35 : 46	40 : 44	46 : 93
Metals	8 : 17 : 25	2 - 341,667 ug/L	2 - 35,533 ug/L	17,200 : 413,390	70 : 327,220	< 1 : 5	99 : 5	69 : 12	> 99 : 21

NOTES:

1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte
2. Taken from concentration averages over a five day sampling event
3. Based on pollutant concentration averages
4. AS = Air Stripper
   CP = Chemical Precipitation
   GAC = Granular Activated Carbon

FIGURE B-19
WESTERN PROCESSING - 1739
FIVE DAY SAMPLING EVENT
REGION X KENT, WA

Treatment: Future
Wastewater Type: Groundwater

Pollutant	# Compounds Detected[1] PP : TCL : ITD	Conc ITD[2] Min-Max	Conc PP[2] Min-Max
Total Organics	2 : 6 : 11	20-4,850,000 ug/L	64-364 ug/L
Metals	9 : 19 : 29	4-852,500 ug/L	4-6,375 ug/L

NOTES:
1. PP = Priority Pollutant
   TCL = Compound from Target Compound List
   ITD = Industrial Technology Division Analyte

2. From samples collected from a one day sampling event

FIGURE B-20
WHITEHOUSE OIL PITS - 1241
ONE DAY SAMPLING EVENT
REGION IV WHITEHOUSE, FL

ATTACHMENT C
UNIT PROCESS TREATMENT EFFICIENCY TABLES

KEY TO EPISODE NUMBERS

SITE	EPISODE NUMBER
Bridgeport Rental	1222
Charles George	1309
Chemdyne	1807
Geneva Industries	1224
Gold Coast Oil	1242
Hydepark Landfill	1220
Love Canal	1219
Nyanza	1310
Reilly Tar	1239
Stringfellow	1221
Stringfellow	1240
Stringfellow	1805
Sylvester	1325
Time Oil	1804
Tyson's Dump	1568
United Chrome	1738
Verona Well Fields	1223
Well 12A	1808
Western Processing	1739
White House Oil	1241

KEY TO TECHNOLOGIES

AirS	Air Stripping
Bio	Activated Sludge
ChPt	Chemical Precipitation
DAF	Dissolved Air Flotation
GAC	Granular Activated Carbon
OWS	Oil-Water Separator
SF	Sand Filter

TABLE C-1

UNIT PROCESS TREATMENT EFFICIENCY
ITD ORGANIC POLLUTANTS FREQUENTLY DETECTED AT 18 CERCLA SITES

TABLE C-1
UNIT PROCESS TREATMENT EFFICIENCY
ITD ORGANIC POLLUTANTS FREQUENTLY DETECTED AT 18 CERCLA SITES

1,1,2,2-TETRACHLOROETHANE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	68	1808
AirS	GW	39.17	54	1807

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	10.00	99	1219
LAGOON	LE	2435.00	17	1220
GAC	GW	84.67	98	1804

1,2,4-TRICHLOROBENZENE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	11.00	2	1240
GAC	GW	10.00	17	1240
AirS	GW	10.00	86	1568
ChPt	GW	11.20	88	1240

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	10.00	> 99	1219

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

1,2-DICHLOROETHANE (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	11.20	-12	1739
GAC	GW	10.00	0	1805
SF	GW	10.00	2	1805
GAC	GW	10.00	11	1739
ChPt	GW	10.25	33	1805
AirS	GW	10.00	38	1739
AirS+ChPt+GAC	GW	10.00	38	1739
AirS	GW	10.00	73	1807
GAC	GW	64.20	-65	1223
GAC+AirS	GW	10.00	74	1223
AirS	GW	10.00	84	1223

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	1211.00	34	1220

1,3-DICHLOROBENZENE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	60	1805

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

1,3-DICHLOROBENZENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	48.20	23	1805
SF	GW	69.20	17	1240
GAC	GW	10.00	89	1240
GAC	GW	10.00	90	1221
SF	GW	100.00	0	1221

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	100.00	19	1221
ChPt	GW	83.40	46	1240
ChPt	GW	62.25	85	1805

1,4-DICHLOROBENZENE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	26	1568

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	96	1221
GAC	GW	10.00	96	1805
GAC	GW	10.00	97	1240

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

1,4-DICHLOROBENZENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	476.00	2	1221
SF	GW	605.80	8	1805
SF	GW	605.40	14	1240
GAC	LE	10.00	99	1219

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	485.00	55	1221
ChPt	GW	704.60	51	1240
ChPt	GW	656.00	55	1805

2,4-DIMETHYLPHENOL

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	15.00	6	1222
AirS	GW	17.57	38	1568
BIO	GW	10.00	69	1325
SF	GW	39.40	-17	1325
ChPt	GW	33.60	2	1325
ChPt+SF+AirS+BIO	GW	10.00	71	1325
AirS	GW	32.40	18	1325
GAC	GW	10.00	78	1739

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

2,4-DIMETHYLPHENOL (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	44.60	35	1739
SF	LE	24.00	68	1222

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
OWS	LE	110.00	-9	1222
OWS+DAF+SF+GAC	LE	15.00	85	1222
DAF	LE	74.00	33	1222
AirS	GW	69.00	47	1739
AirS+ChPt+GAC	GW	10.00	92	1739

2,4-DINITROPHENOL

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	74.80	-23	1240
GAC	GW	50.00	22	1240

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	60.80	86	1240

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

2-BUTANONE (MEK) (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	50.00	8	1223

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	54.20	86	1223
GAC+AirS	GW	50.00	87	1223
ChPt	GW	691.00	-27	1738
GAC	GW	50.00	92	1805
GAC	GW	50.00	93	1240

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	1105.00	6	1240
SF	GW	1076.40	13	1805
ChPt	GW	1242.25	17	1805
ChPt	GW	1179.00	58	1240

4-METHYL-2-PENTANONE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	71.00	-42	1739

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

4-METHYL-2-PENTANONE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	50.00	27	1739
AirS+ChPt+GAC	GW	50.00	27	1739
GAC	GW	50.00	30	1739
BIO	GW	50.00	38	1325
GAC	GW	50.00	48	1805

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	80.20	87	1325
GAC	GW	50.00	92	1240
SF	GW	613.00	17	1805
SF	GW	599.20	35	1325

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	1009.20	6	1240
ChPt	GW	915.80	17	1325
ChPt+SF+AirS+BIO	GW	50.00	95	1325
ChPt	GW	738.00	47	1805
ChPt	GW	1070.00	61	1240

ACETONE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	53.00	5	1738

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

ACETONE (CONTINUED)

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
BIO	GW	50.00	66	1325
ChPt	GW	582.20	-10	1325
ChPt+SF+AirS+BIO	GW	50.00	91	1325
SF	GW	590.20	-1	1325
AirS	GW	145.20	75	1325
AirS	GW	55.33	94	1223

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	50.00	96	1221
GAC	GW	50.00	97	1805
GAC	GW	50.00	97	1240
GAC	GW	912.80	52	1223
GAC+AirS	GW	55.33	97	1223
GAC	LE	2565.00	-8	1222
SF	LE	2350.00	3	1222
DAF	LE	2426.00	17	1222
SF	GW	4964.00	-60	1240
OWS	LE	2925.00	10	1222
OWS+DAF+SF+GAC	LE	2565.00	21	1222
ChPt	GW	5343.50	-7	1805

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

ACETONE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	4085.00	24	1805

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	2256.00	84	1221
ChPt	GW	3110.20	84	1240
LAGOON	LE	63472.00	-21	1220

BENZENE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	0	1223
GAC	GW	10.00	0	1805
SF	GW	10.00	0	1805
GAC	GW	10.67	1	1739
ChPt	GW	10.00	18	1805
ChPt	GW	10.80	38	1739
BIO	GW	10.00	46	1325
GAC	GW	10.00	60	1223
GAC+AirS	GW	10.00	60	1223
AirS	GW	17.40	34	1739
AirS+ChPt+GAC	GW	10.67	60	1739

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

BENZENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	78	1807

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	245.60	-2	1325
AirS	GW	18.40	93	1325
ChPt	GW	241.20	23	1325
ChPt+SF+AirS+BIO	GW	10.00	97	1325

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	10.00	99	1219
LAGOON	LE	2363.00	19	1220

BENZOIC ACID

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	50.00	0	1739
GAC	LE	50.00	0	1222
OWS	LE	67.00	-25	1222
OWS+DAF+SF+GAC	LE	50.00	7	1222
ChPt	GW	72.60	-31	1325

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

BENZOIC ACID (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt+SF+AirS+BIO	GW	50.00	10	1325
ChPt	GW	50.00	12	1739
BIO	GW	50.00	16	1325
DAF	LE	124.00	-85	1222
SF	GW	80.00	-10	1325
AirS	GW	56.80	23	1739
AirS+ChPt+GAC	GW	50.00	32	1739
AirS	GW	59.80	25	1325

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	LE	60.00	52	1222
GAC	GW	50.00	90	1221
GAC	GW	45.00	91	1240
SF	GW	1023.20	-51	1240
SF	GW	736.00	10	1221
ChPt	GW	677.40	25	1240

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	819.00	55	1221

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	50.00	> 99	1219

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

BENZOIC ACID (CONTINUED)

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	3210030.00	-39	1220

BENZYL ALCOHOL

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	21.00	-18	1223
SF	GW	24.60	5	1240
GAC	GW	10.00	65	1240
GAC	GW	17.80	49	1223
GAC+AirS	GW	21.00	40	1223
ChPt	GW	26.00	71	1240

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	10.00	99	1219

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	8220.00	38	1220

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

BIS(2-ETHYLHEXYL)PHTHALATE (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	37.80	23	1240
SF	GW	59.20	-17	1240
GAC	GW	46.40	22	1223

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	50.80	52	1240
GAC	GW	206.17	-77	1804
AirS	GW	239.33	-69	1808
GAC	GW	192.17	51	1239

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	394.60	83	1239
SF+GAC	GW	192.17	92	1239

CHLOROBENZENE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
BIO	GW	10.00	28	1325

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

CHLOROBENZENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	71	1807

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	13.80	93	1325
SF	GW	186.00	2	1325
ChPt	GW	189.60	15	1325
ChPt+SF+AirS+BIO	GW	10.00	96	1325
GAC	GW	10.00	97	1221
GAC	GW	10.00	97	1805
GAC	GW	10.00	97	1240
SF	GW	1000.00	-67	1221
SF	GW	620.00	6	1240
SF	GW	737.20	16	1805

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	600.00	53	1221
ChPt	GW	657.20	55	1240
ChPt	GW	878.00	42	1805
LAGOON	LE	2267.00	15	1220
GAC	LE	10.00	> 99	1219

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

CHLOROFORM (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	47	1739
BIO	GW	10.00	57	1325
ChPt	GW	19.00	66	1739

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	96	1221
GAC	GW	10.00	97	1240
GAC	GW	10.00	97	1805
SF	GW	368.40	-2	1325
AirS	GW	23.00	94	1325
AirS	GW	56.00	86	1739
AirS+ChPt+GAC	GW	10.00	98	1739
ChPt	GW	359.40	18	1325
ChPt+SF+AirS+BIO	GW	10.00	98	1325
GAC	LE	10.00	98	1219
SF	GW	491.60	6	1240
SF	GW	1000.00	-84	1221
SF	GW	603.60	16	1805
ChPt	GW	523.80	45	1240

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

CHLOROFORM (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	718.50	26	1805
ChPT	GW	544.00	46	1221

CHLOROMETHANE

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	7049.00	33	1220

ETHYLBENZENE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
BIO	GW	10.00	0	1325
GAC	GW	10.00	30	1805
AirS	GW	10.00	70	1807
SF	GW	30.20	18	1805
ChPt	GW	37.00	55	1805

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	419.00	-46	1325
ChPt+SF+AirS+BIO	GW	10.00	97	1325

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

ETHYLBENZENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	97	1325
SF	GW	345.00	18	1325

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	2156.00	18	1220

HEXANOIC ACID

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
DAF	LE	10.00	0	1222
GAC	LE	10.00	0	1222
SF	LE	10.00	0	1222
OWS	LE	10.00	59	1222
OWS+DAF+SF+GAC	LE	10.00	59	1222
GAC	GW	9.00	78	1240
GAC	GW	10.00	90	1221
SF	GW	100.00	0	1221

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	10.00	92	1219

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

HEXANOIC ACID (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	154.00	-7	1240
SF	GW	97.00	37	1240
ChPT	GW	100.00	71	1221

ISOPHORONE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	0	1739
BIO	GW	10.00	9	1325
ChPt	GW	10.00	18	1739
SF	GW	13.20	-5	1325
ChPt	GW	12.60	4	1325
ChPt+SF+AirS+BIO	GW	10.00	24	1325
AirS	GW	11.00	17	1325
AirS	GW	12.20	21	1739
AirS+ChPt+GAC	GW	10.00	35	1739
GAC	LE	23.00	57	1222
SF	LE	60.00	-3	1222
OWS	LE	60.00	-3	1222
OWS+DAF+SF+GAC	LE	23.00	61	1222
DAF	LE	58.00	3	1222

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

ISOPHORONE (CONTINUED)

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	99	1221
GAC	GW	10.00	99	1805
GAC	GW	10.00	99	1240

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	1749.25	-70	1805
SF	GW	1130.00	-3	1221
SF	GW	1495.60	5	1240
SF	GW	1269.20	27	1805
ChPt	GW	1577.40	12	1240
ChPT	GW	1102.00	42	1221

METHYLENE CHLORIDE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	29	1223
GAC	GW	14.00	25	1223
GAC+AirS	GW	10.00	46	1223

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

METHYLENE CHLORIDE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	27.40	-26	1739
BIO	GW	10.00	60	1325
GAC	GW	10.00	64	1739
ChPt	GW	52.33	36	1738
AirS	GW	21.80	74	1739
AirS+ChPt+GAC	GW	10.00	88	1739

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	271.60	-9	1325
AirS	GW	25.20	91	1325
ChPt	GW	249.60	24	1325
ChPt+SF+AirS+BIO	GW	10.00	97	1325
GAC	GW	10.00	99	1805
GAC	GW	10.50	99	1240
GAC	GW	10.00	99	1221

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	1226.40	0	1240
SF	GW	1382.00	-12	1805
ChPt	GW	1227.80	34	1240
ChPt	GW	1230.25	49	1805
SF	GW	2706.00	1	1221

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

METHYLENE CHLORIDE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	2279.00	36	1220
ChPT	GW	2729.00	24	1221

N,N-DIMETHYLFORMAMIDE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	18.83	51	1739
ChPt	GW	78.40	-15	1325
ChPt+SF+AirS+BIO	GW	10.00	85	1325
GAC	GW	15.50	77	1240
AirS	GW	78.40	-2	1325
ChPt	GW	38.80	50	1739
BIO	GW	10.00	87	1325
SF	GW	76.80	2	1325
AirS	GW	77.80	15	1739
AirS+ChPt+GAC	GW	18.83	79	1739

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	109.40	26	1240
ChPt	GW	147.00	11	1240

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

P-CRESOL (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	0	1739
GAC	LE	10.00	63	1222
ChPt	GW	48.20	-65	1325
ChPt+SF+AirS+BIO	GW	10.00	66	1325
SF	LE	44.00	-22	1222
BIO	GW	10.00	76	1325
ChPt	GW	10.00	78	1739
SF	GW	52.40	-9	1325
AirS	GW	42.20	19	1325
DAF	LE	36.00	45	1222
AirS	GW	44.80	37	1739
AirS+ChPt+GAC	GW	10.00	86	1739
OWS	LE	66.00	9	1222
OWS+DAF+SF+GAC	LE	10.00	86	1222

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	10.00	94	1219

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

P-DIOXANE (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	11.00	17	1738
GAC	GW	83.00	1	1805
GAC	GW	119.83	-20	1240

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	150.60	-47	1739
SF	GW	107.00	4	1240
AirS	GW	102.60	27	1739
AirS+ChPt+GAC	GW	131.83	6	1739
GAC	GW	131.83	12	1739
SF	GW	152.00	2	1805
ChPt	GW	155.25	28	1805
ChPt	GW	111.60	69	1240
AirS	GW	471.60	-3	1325
SF	GW	457.40	0	1325
BIO	GW	367.50	22	1325
ChPt	GW	459.40	12	1325
ChPt+SF+AirS+BIO	GW	367.50	30	1325

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

PHENOL (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	0	1739
AirS	GW	10.00	8	1568
ChPt	GW	10.00	44	1739
SF	LE	45.00	-67	1222
GAC	LE	27.00	16	1222
OWS	LE	36.00	-3	1222
OWS+DAF+SF+GAC	LE	27.00	23	1222
DAF	LE	27.00	25	1222
BIO	GW	10.00	77	1325
AirS	GW	42.60	14	1325
GAC	GW	10.00	83	1240

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	49.60	61	1325
GAC	GW	10.00	93	1221
ChPt	GW	162.00	-2	1240
SF	GW	134.20	17	1240
GAC	LE	10.00	95	1219
ChPt	GW	125.80	39	1325

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

PHENOL (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt+SF+AirS+BIO	GW	10.00	95	1325
SF	GW	215.00	19	1221

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	17.80	99	1739
AirS+ChPt+GAC	GW	10.00	99	1739

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	932050.00	40	1220

TETRACHLOROETHENE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	0	1223
ChPt	GW	11.00	-10	1739
GAC	GW	10.00	9	1739
BIO	GW	10.00	41	1325
GAC	GW	10.00	66	1805
AirS	GW	10.00	71	1568
SF	GW	65.00	22	1805

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

TETRACHLOROETHENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	93.00	1	1240
GAC	GW	10.00	90	1240

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	17.00	88	1325
AirS	GW	10.00	93	1739
AirS+ChPt+GAC	GW	10.00	93	1739
SF	GW	145.60	3	1325
GAC	GW	15.00	91	1804
ChPt	GW	83.00	58	1805
ChPt	GW	150.20	35	1325
ChPt+SF+AirS+BIO	GW	10.00	96	1325
ChPt	GW	94.00	76	1240
AirS	GW	10.00	98	1807
GAC	GW	10.00	98	1223
GAC+AirS	GW	10.00	98	1223

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	10.00	99	1219
LAGOON	LE	3037.00	16	1220

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

TOLUENE (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	0	1223
GAC	GW	10.00	15	1739
GAC	GW	10.00	48	1804
ChPt	GW	11.80	56	1739
AirS	GW	26.80	53	1739
AirS+ChPt+GAC	GW	10.00	82	1739
GAC	GW	10.00	86	1805

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	92	1240
SF	GW	155.20	19	1805
SF	GW	207.80	8	1240
BIO	GW	10.00	96	1325
ChPt	GW	192.25	57	1805
GAC	GW	10.00	98	1223
GAC+AirS	GW	10.00	98	1223
ChPt	GW	224.80	64	1240

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	270.60	96	1325

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

TOLUENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	6397.00	9	1325
ChPt	GW	7006.40	24	1325
ChPt+SF+AirS+BIO	GW	10.00	> 99	1325

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	9757.00	28	1220
GAC	LE	10.00	> 99	1219

TRANS-1,2-DICHLOROETHENE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	9	1805
AirS	GW	10.00	12	1808
GAC	GW	10.00	34	1739
SF	GW	14.80	6	1805
SF	GW	19.40	-9	1239
SF+GAC	GW	13.17	26	1239
GAC	GW	13.17	32	1239
ChPt	GW	15.20	33	1739
ChPt	GW	15.75	48	1805
BIO	GW	10.00	84	1325

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

TRANS-1,2-DICHLOROETHENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	LE	10.00	94	1219
GAC	GW	334.60	-87	1223
GAC+AirS	GW	21.00	88	1223
AirS	GW	10.00	96	1807
AirS	GW	21.00	94	1223
GAC	GW	10.00	98	1804
AirS	GW	22.80	97	1739
AirS+ChPt+GAC	GW	10.00	99	1739

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	1320.20	-2	1325
AirS	GW	60.60	95	1325
LAGOON	LE	1000.00	26	1220
ChPt	GW	1299.60	14	1325
ChPt+SF+AirS+BIO	GW	10.00	99	1325

TRICHLOROETHENE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	50	1568

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

TRICHLOROETHENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
BIO	GW	10.00	60	1325
AirS	GW	10.00	68	1223
ChPt	GW	60.00	-11	1739
AirS	GW	10.00	83	1808
GAC	GW	10.00	83	1739

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS	GW	10.00	96	1807
AirS	GW	25.20	94	1325
SF	GW	388.60	1	1325
ChPt	GW	393.00	22	1325
ChPt+SF+AirS+BIO	GW	10.00	98	1325
GAC	LE	10.00	98	1219
GAC	GW	31.60	95	1223
GAC+AirS	GW	10.00	99	1223

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	30.67	98	1804
GAC	GW	10.00	99	1805
AirS	GW	54.00	97	1739
AirS+ChPt+GAC	GW	10.00	99	1739
GAC	GW	10.00	99	1221

TABLE C-1 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

TRICHLOROETHENE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
GAC	GW	10.00	> 99	1240
LAGOON	LE	2661.00	25	1220
SF	GW	2977.20	19	1805
SF	GW	3366.40	9	1240
SF	GW	5247.00	3	1221
ChPt	GW	3654.00	47	1805
ChPT	GW	5429.00	32	1221
ChPt	GW	3679.40	56	1240

TABLE C-2

UNIT PROCESS TREATMENT EFFICIENCY
ITD INORGANIC POLLUTANTS FREQUENTLY DETECTED AT 18 CERCLA SITES

TABLE C-2
UNIT PROCESS TREATMENT EFFICIENCY
ITD INORGANIC POLLUTANTS FREQUENTLY DETECTED AT 18 CERCLA SITES

ALUMINUM

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	LE	9.00	86	1222
SF	GW	92.80	1	1325

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt+SF+AirS+BIO	GW	119.33	-8	1325
ChPt	GW	94.00	15	1325
BIO	GW	119.33	-7	1325
OWS+DAF+SF+GAC	LE	37.00	91	1222
OWS	LE	422.00	-5	1222
DAF	LE	66.00	84	1222

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	2230.00	9	1221
LAGOON	LE	2760.00	21	1220
SF	GW	5262.00	3	1240
ChPt	GW	35.00	> 99	1738
SF	GW	5580.00	38	1805

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	229.00	99	1739
AirS+ChPt+GAC	GW	136.67	> 99	1739

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

ALUMINUM (CONTINUED)

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	2460.00	> 99	1221
ChPt	GW	8987.50	> 99	1805
ChPt	GW	5440.00	> 99	1240

ARSENIC

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS+ChPt+GAC	GW	3.15	71	1739
ChPt	GW	2.00	84	1739
ChPt	GW	20.00	-56	1738
SF	GW	40.00	-82	1221
LAGOON	LE	6.00	79	1220

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	123.00	-8	1325
BIO	GW	104.50	21	1325
ChPt+SF+AirS+BIO	GW	104.50	81	1325
ChPt	GW	114.20	80	1325
ChPT	GW	22.00	97	1221

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

BARIUM (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	LE	9.30	0	1222
SF	GW	13.20	1	1325
OWS+DAF+SF+GAC	LE	13.00	13	1222
OWS	LE	16.00	-7	1222
DAF	LE	9.30	42	1222
BIO	GW	17.83	-10	1325
SF	GW	27.80	-8	1805
SF	GW	31.00	-19	1221
ChPt	GW	25.75	14	1805
ChPt+SF+AirS+BIO	GW	17.83	59	1325
ChPt	GW	13.40	69	1325
ChPt	GW	9.00	81	1738
AirS+ChPt+GAC	GW	11.67	76	1739
ChPt	GW	9.80	86	1739

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	98.20	3	1240
SF+GAC	GW	171.33	2	1239
SF	GW	170.20	3	1239

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

BORON (CONTINUED)

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	124.40	-4	1325
BIO	GW	135.83	12	1325
ChPt	GW	119.20	24	1325
ChPt+SF+AirS+BIO	GW	135.83	13	1325
SF	LE	177.00	17	1222
SF	GW	225.20	-1	1239
SF+GAC	GW	225.00	0	1239
DAF	LE	214.00	11	1222
OWS+DAF+SF+GAC	LE	135.00	45	1222
OWS	LE	241.00	2	1222
ChPt	GW	52.67	86	1738
SF	GW	950.20	-2	1805

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	1204.00	1	1240
AirS+ChPt+GAC	GW	1820.00	18	1739
ChPt	GW	2246.00	2	1739
ChPt	GW	931.00	69	1805
ChPt	GW	1212.00	71	1240

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	0.01	> 99	1220

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

BORON (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	40400.00	-2	1221

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	39800.00	76	1221

CADMIUM

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	4.20	12	1805
SF	GW	7.20	-16	1240
SF	GW	13.00	0	1221
LAGOON	LE	21.00	11	1220

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS+ChPt+GAC	GW	4.00	99	1739
ChPt	GW	4.60	99	1739

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	6.20	> 99	1240
ChPT	GW	13.00	> 99	1221
ChPt	GW	4.75	> 99	1805

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

CALCIUM (CONTINUED)

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	LE	3850.00	-1	1222
DAF	LE	3830.00	7	1222
OWS	LE	4110.00	1	1222
OWS+DAF+SF+GAC	LE	4030.00	3	1222

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	59380.00	0	1325
BIO	GW	72816.67	-18	1325
ChPt+SF+AirS+BIO	GW	72816.67	8	1325
ChPt	GW	59360.00	25	1325
SF	GW	89920.00	0	1239
SF+GAC	GW	89633.33	0	1239
AirS+ChPt+GAC	GW	61800.00	34	1739
ChPt	GW	82920.00	17	1739

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	545000.00	-40	1221
ChPt	GW	684250.00	-52	1805
ChPt	GW	190333.33	61	1738
SF	GW	578000.00	-6	1221
SF	GW	763000.00	-12	1805

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

CALCIUM (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	665000.00	19	1220
SF	GW	891800.00	-1	1240

CHROMIUM

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
BIO	GW	10.17	11	1325
SF	GW	10.40	10	1325
SF	LE	6.00	54	1222
ChPt+SF+AirS+BIO	GW	10.17	28	1325
ChPt	GW	11.60	18	1325
SF	GW	28.00	18	1221
SF	GW	45.00	1	1240
SF	GW	29.40	41	1805
OWS	LE	55.00	-3	1222
OWS+DAF+SF+GAC	LE	4.00	93	1222
DAF	LE	13.00	76	1222

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS+ChPt+GAC	GW	13.00	99	1739
ChPt	GW	12.60	99	1739

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	34.00	> 99	1221

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

CHROMIUM (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	50.00	> 99	1805
ChPt	GW	45.60	> 99	1240

COBALT

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	9.00	0	1805
SF	GW	10.00	0	1221
LAGOON	LE	10.00	38	1220
SF	GW	25.00	0	1240
ChPt	GW	20.00	67	1738
AirS+ChPt+GAC	GW	20.00	77	1739

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	20.00	85	1739

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	10.00	> 99	1221
ChPt	GW	25.00	99	1240
ChPt	GW	9.00	> 99	1805

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

COPPER (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
DAF	LE	37.00	-54	1222
OWS	LE	24.00	8	1222
OWS+DAF+SF+GAC	LE	17.00	35	1222
SF	LE	18.00	51	1222
SF	GW	17.60	75	1325
ChPt+SF+AirS+BIO	GW	24.17	72	1325
ChPt	GW	71.20	17	1325
BIO	GW	24.17	74	1325

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	140.00	7	1221
SF	GW	250.00	9	1240
SF	GW	198.80	37	1805
AirS+ChPt+GAC	GW	9.00	98	1739
ChPt	GW	44.40	90	1739
ChPt	GW	6.00	99	1738

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	315.00	96	1805
ChPt	GW	274.80	97	1240

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

COPPER (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	150.00	98	1221

IRON

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	25.00	55	1738
SF	GW	60.00	15	1221

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	102.20	10	1240
SF	GW	70.40	52	1805
SF	GW	233.60	8	1325
SF+GAC	GW	149.33	75	1239
SF	GW	49.00	92	1239
BIO	GW	148.00	84	1325

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	LE	635.00	92	1222
OWS+DAF+SF+GAC	LE	308.00	97	1222
OWS	LE	9070.00	0	1222
DAF	LE	8260.00	9	1222

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt+SF+AirS+BIO	GW	148.00	99	1325

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

IRON (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	253.40	99	1325

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS+ChPt+GAC	GW	614.50	99	1739
ChPt	GW	371.20	> 99	1739
ChPt	GW	113.40	> 99	1240
ChPT	GW	71.00	> 99	1221
ChPt	GW	147.25	> 99	1805
LAGOON	LE	0.01	> 99	1220

LEAD

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	LE	24.00	0	1222
SF	GW	41.00	0	1805
SF	GW	50.00	0	1221
SF	GW	50.00	1	1240
DAF	LE	24.00	73	1222

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
OWS	LE	88.00	19	1222
OWS+DAF+SF+GAC	LE	24.00	78	1222

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

LEAD (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	50.40	77	1240
ChPt	GW	41.00	92	1805

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	50.00	97	1221

MAGNESIUM

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	LE	2690.00	0	1222
DAF	LE	2680.00	6	1222
OWS	LE	2860.00	1	1222
OWS+DAF+SF+GAC	LE	2460.00	15	1222
SF	GW	2964.00	2	1325
BIO	GW	3355.00	0	1325
ChPt	GW	3014.00	55	1325
ChPt+SF+AirS+BIO	GW	3355.00	50	1325

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	31560.00	-1	1239
SF+GAC	GW	31466.67	-1	1239
SF	GW	45700.00	-20	1805

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

MAGNESIUM (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS+ChPt+GAC	GW	34216.67	17	1739
ChPt	GW	39480.00	11	1739

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	107020.00	2	1240
SF	GW	136000.00	1	1221
ChPt	GW	7723.33	95	1738
LAGOON	LE	201000.00	21	1220
ChPT	GW	137000.00	61	1221
ChPt	GW	38000.00	97	1805
ChPt	GW	109500.00	91	1240

MANGANESE

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	42.40	6	1325
SF	GW	84.20	0	1239
SF+GAC	GW	83.00	2	1239

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
BIO	GW	29.83	86	1325
DAF	LE	847.00	-20	1222

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

MANGANESE (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
OWS	LE	705.00	0	1222
OWS+DAF+SF+GAC	LE	668.00	6	1222
SF	LE	814.00	4	1222

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	1117.80	-6	1805
ChPt	GW	4.00	> 99	1738
SF	GW	2334.00	2	1240
SF	GW	4740.00	2	1221
ChPt	GW	45.00	99	1325
ChPt+SF+AirS+BIO	GW	29.83	99	1325
AirS+ChPt+GAC	GW	1471.67	83	1739

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	0.01	> 99	1220
ChPt	GW	2278.00	83	1739

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	4820.00	98	1221
ChPt	GW	1058.75	> 99	1805
ChPt	GW	2388.00	99	1240

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

NICKEL (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	10.20	7	1805
OWS	LE	21.00	-14	1222
OWS+DAF+SF+GAC	LE	15.00	19	1222
SF	LE	19.00	10	1222
DAF	LE	21.00	0	1222
SF	GW	22.00	0	1240
SF	GW	29.00	-7	1221
SF	GW	31.20	-8	1325
BIO	GW	38.00	-9	1325

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	30.00	78	1738

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	0.01	> 99	1220
AirS+ChPt+GAC	GW	60.33	97	1739
ChPt	GW	217.40	93	1739
ChPt+SF+AirS+BIO	GW	38.00	99	1325
ChPt	GW	28.80	99	1325

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	22.00	> 99	1240

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

NICKEL (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	27.00	> 99	1221
ChPt	GW	11.00	> 99	1805

POTASSIUM

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
OWS	LE	1000.00	1	1222
SF	GW	1560.00	1	1240
ChPt	GW	1580.00	0	1240
SF	LE	3420.00	13	1222

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	15700.00	-8	1738
SF	GW	20500.00	1	1221
ChPT	GW	20700.00	14	1221
ChPt	GW	24900.00	-3	1805
SF	GW	24920.00	0	1805
AirS+ChPt+GAC	GW	26167.00	15	1739
ChPt	GW	30400.00	4	1739

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
LAGOON	LE	438000.00	29	1220

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

SILICON (CONTINUED)

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	0.01	> 99	1240

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	129.00	28	1221

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	1240.00	2	1239
SF+GAC	GW	1267.00	0	1239
SF	LE	1620.00	4	1222
OWS	LE	2090.00	-2	1222
OWS+DAF+SF+GAC	LE	1550.00	24	1222
DAF	LE	1690.00	19	1222
SF	GW	4140.00	1	1325
BIO	GW	4050.00	5	1325
LAGOON	LE	5200.00	19	1220
ChPt	GW	0.01	> 99	1240
ChPt+SF+AirS+BIO	GW	4050.00	45	1325
ChPt	GW	4180.00	43	1325
ChPt	GW	3067.00	66	1738

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	179.00	99	1221

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

SILICON (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS+ChPt+GAC	GW	5133.00	66	1739
ChPt	GW	2340.00	88	1739
ChPt	GW	225.00	99	1805

SODIUM

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	8332.00	-1	1239
SF+GAC	GW	8351.67	-1	1239

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	31080.00	-23	1325
ChPt+SF+AirS+BIO	GW	38400.00	-52	1325
SF	GW	31160.00	0	1325
BIO	GW	38400.00	-20	1325
OWS	LE	51900.00	0	1222

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	LE	124000.00	-1	1222
ChPt	GW	484600.00	-66	1739
AirS+ChPt+GAC	GW	466333.33	-36	1739
ChPt	GW	996000.00	-15	1240

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

SODIUM (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPT	GW	943000.00	0	1221
SF	GW	943000.00	0	1221
SF	GW	1290000.00	-30	1240
SF	GW	1656000.00	0	1805
LAGOON	LE	2500000.00	28	1220

STRONTIUM

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	200.00	0	1325
SF	GW	200.00	0	1239
SF+GAC	GW	200.00	0	1239
BIO	GW	200.00	0	1325
ChPt	GW	200.00	50	1325
ChPt+SF+AirS+BIO	GW	200.00	50	1325
AirS+ChPt+GAC	GW	400.00	37	1739
ChPt	GW	520.00	28	1739
SF	GW	1120.00	-36	1805

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	1100.00	-2	1221
ChPT	GW	1080.00	2	1221
SF	GW	1440.00	0	1240

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

STRONTIUM (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	1440.00	7	1240
ChPt	GW	825.00	59	1805
LAGOON	LE	2300.00	27	1220

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	6967.00	44	1738

SULFUR

INFLUENT CONCENTRATION 1,000 - 10,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	LE	4180.00	1	1222
DAF	LE	4230.00	32	1222
OWS+DAF+SF+GAC	LE	3090.00	56	1222
OWS	LE	6210.00	12	1222
SF	GW	8800.00	8	1239
SF+GAC	GW	9167.00	4	1239

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt+SF+AirS+BIO	GW	37200.00	-92	1325
ChPt	GW	34780.00	-79	1325
BIO	GW	37200.00	-9	1325
SF	GW	34620.00	0	1325

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

SULFUR (CONTINUED)

INFLUENT CONCENTRATION > 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	203000.00	-17	1739
AirS+ChPt+GAC	GW	147167.00	28	1739
LAGOON	LE	379000.00	20	1220
SF	GW	1600000.00	-7	1221
SF	GW	1712000.00	-3	1805
SF	GW	1760000.00	-1	1240
ChPT	GW	1490000.00	30	1221
ChPt	GW	1655000.00	71	1805
ChPt	GW	1746000.00	72	1240

TITANIUM

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	4.20	1	1805
SF	LE	5.00	0	1222
SF	GW	9.00	-29	1221
OWS+DAF+SF+GAC	LE	5.00	38	1222
OWS	LE	9.00	-12	1222
DAF	LE	5.00	44	1222
SF	GW	13.00	-20	1240

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

TITANIUM (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS+ChPt+GAC	GW	13.17	-7	1739
ChPt	GW	3.60	83	1739
LAGOON	LE	40.00	-10	1220

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	4.25	96	1805
ChPt	GW	10.80	91	1240
ChPt	GW	6.67	98	1738
ChPT	GW	7.00	98	1221

ZINC

INFLUENT CONCENTRATION 0 - 100 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
SF	GW	8.00	32	1805
SF	GW	20.20	-46	1240
SF	GW	18.00	18	1221
BIO	GW	24.33	-10	1325
SF	GW	30.00	-23	1325
ChPt+SF+AirS+BIO	GW	24.33	1	1325
ChPt	GW	24.40	1	1325
SF	LE	17.00	60	1222

INFLUENT CONCENTRATION 100 - 1,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
ChPt	GW	18.00	87	1738

TABLE C-2 (CONTINUED)
UNIT PROCESS TREATMENT EFFICIENCY

ZINC (CONTINUED)

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
DAF	LE	42.00	86	1222
OWS+DAF+SF+GAC	LE	25.00	92	1222
OWS	LE	309.00	1	1222
LAGOON	LE	593.00	-7	1220

INFLUENT CONCENTRATION 10,000 - 100,000 UG/L

TECHNOLOGY	MATRIX	EFFL. CONC.	PERCENT REMOVAL	EPISODE
AirS+ChPt+GAC	GW	59.67	> 99	1739
ChPT	GW	22.00	> 99	1221
ChPt	GW	11.75	> 99	1805
ChPt	GW	220.40	> 99	1739
ChPt	GW	13.80	> 99	1240

SECTION 4

SITE VISIT SUMMARY REPORT

SECTION 4 - SUMMARY SITE VISIT REPORT. Site visits were conducted with personnel associated with 27 CERCLA sites which had existing, potential, or denied discharges to a POTW. The site visits consisted of meetings with members of USEPA, state, POTW, or potentially responsible parties (PRPs) in order to discuss experiences with implementing the discharge of wastewater from a specific CERCLA site.

Section 4 presents a summary of individual site visits conducted with representatives from EPA, state, POTW, or responsible parties to discuss the discharge of a specific CERCLA site wastewater to a POTW. The information presents the major political, technical, and economic issues concerning the discharge of CERCLA site wastewaters to POTWs that were found to arise in the negotiations and approval process, and is provided to aid the user in foreseeing potential issues that may require consideration.

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1.0 INTRODUCTION

USEPA initiated a two-year program to collect information regarding technical, economic, regulatory, and administrative issues associated with Superfund site wastewater discharges to POTWs. The purpose of the study was to conduct site visits in each USEPA region with USEPA and state regulatory personnel, responsible parties, and POTW representatives to evaluate current experience with the discharge to POTW remedial alternative. During 1988 and 1989, sites with existing or prospective discharges to POTWs were identified. Where site access was provided, 47 site visits were conducted associated with 27 Superfund sites with existing, potential, or denied discharges of wastewater to a POTW.

Each site visit consisted of an informational meeting with a regional USEPA, state, POTW, or responsible party representative to discuss discharge of a specific Superfund site wastewater to a POTW. The site visit program targeted all ten USEPA regions to address potential regional variations in implementation of discharges and other issues and concerns associated with the POTW discharge alternative. Table 1 provides a regional overview of the sites visited and their discharge status at the time of the visit.

The site visits were used to collect a broad range of information. Information obtained from POTW operators ranged from basic technical data concerning POTW treatability characteristics and flow capacity to specific information concerning economic and liability issues associated with accepting a Superfund wastewater discharge. Information derived from discussions with USEPA and state regulatory personnel was geared toward developing an understanding of the negotiation process and administrative, regulatory, and technical issues involved in evaluating and implementing a discharge of Superfund wastewater to a POTW. The remainder of this report summarizes the variety of Superfund wastestreams considered for POTW discharges and the characteristics of the POTWs that have been evaluated as potential receptors. The significant issues that affect the implementability of the POTW discharge alternative are also presented.

2.0 SUPERFUND SITE WASTEWATER CHARACTERISTICS

Contaminated groundwater is the most common wastestream either currently being discharged or considered for discharge to a POTW; leachate is the second most common. Surface water, storm water, decontamination water, and wastewater generated by on-site soil treatment methods have also been discharged or considered for discharge to a POTW. Most wastewaters are pretreated or planned for pretreatment either on- of off-site before discharge to a POTW. Both the untreated and pretreated wastestreams generally contained only low levels of contaminants. For the Superfund sites studied, wastewater discharge volumes generally comprised less than four percent of the POTW influent volume.

TABLE 4-1
REGIONAL OVERVIEW OF SITES VISITED AND DISCHARGE STATUS

USEPA REGION	SITES VISITED	NUMBER OF POTW DISCHARGES			ALTERNATE DISCHARGES
		EXISTING	NEGOTIATING	DENIED	
I	1			1	
II	8	4	4		
III	1	1			
IV	1		1		
V	5	2	3		
VI	2	1			1
VII	1	1			
VIII	1			1	
IX	3	2	1		
X	4	2			2

Most Superfund wastewaters are transported to the receiving POTW via an existing sewer. In several cases, sewer lines are planned or were constructed specifically to receive Superfund site wastewaters. Sewer transport was preferred for its safety and convenience. When sewer transport was not available or feasible, truck transport was typically the next most common transport method. One of the planned future discharges will use dedicated pipe to transport the wastestream from the site to the POTW.

Under the Domestic Sewage Exclusion at Title 40 Code of Federal Regulations Part 261.4, when the Superfund wastewater is considered a hazardous waste under the Resource Conservation and Recovery Act (RCRA), but is mixed with domestic waste as it flows through the sewer system to the POTW, the POTW is not required to meet the additional regulatory requirements for a RCRA permit-by-rule facility. None of the POTWs visited were RCRA permit-by-rule facilities, nor were any interested in adopting additional RCRA requirements.

3.0 POTW CHARACTERISTICS

Each of the 16 POTWs receiving existing or potential discharges of Superfund wastewaters use secondary treatment processes. The most prevalent form is activated sludge, followed by rotating biological contactors and other aerated biological treatment processes including brush aeration, oxidation ponds, and trickling filters. One POTW employs physical-chemical treatment. At least five POTWs use additional tertiary treatment.

Seven POTWs have design flows less than 10 million gallons per day (MGD), six have flows between 10 and 100 MGD, and three have flows greater than 100 MGD. Nine POTWs land-apply, two landfill, and three incinerate their sludge. One POTW is storing incinerator ash for an undetermined reuse, one landfills its ash, and another sends ash off-site for metals reclamation.

The majority of the POTWs which have previously received or are currently receiving Superfund wastewaters have approved pretreatment programs and most have good compliance records. In some cases, a poor POTW compliance record led USEPA to eliminate discharge to the POTW from consideration as a remedial alternative.

4.0 SIGNIFICANT ISSUES

Several significant issues which affected the evaluation and implementation of Superfund site wastewater discharges to POTWs were identified during the site visit study. These issues are discussed in the following paragraphs.

4.1 Negotiations

Discharge negotiations proceeded most smoothly when POTW representatives were involved in discharge planning either during the remedial investigation or early in the feasibility study process. POTW representatives indicated that they were more likely to accept a Superfund wastewater when they were technically confident that POTW operations would not be adversely impacted. Early involvement in discharge planning and technical evaluation fostered this confidence.

4.2 POTW Concerns

POTW representatives expressed various concerns which impacted their decisions to accept or reject Superfund site wastewater discharges. Limited availability of specific regulatory guidance addressing Superfund wastewater discharges discouraged some POTW representatives from accepting discharges. Other POTWs were willing to accept Superfund site discharges as a service to the community. Occasionally, POTW representatives accepted discharges in exchange for discharger-provided community benefits, such as sewer construction subsidies or site-related construction contract bidding preference.

Most POTW representatives were primarily concerned about the potential impact of Superfund wastewater on the POTW's biological treatment systems, effluent quality, and sludge management practices. Several POTW representatives expressed concern that accepting a Superfund discharge for many years would reserve POTW capacity that might better serve community growth. In some instances, negative public responses impacted the POTW's decision to accept the discharge.

4.3 Discharge Limits

Contaminant concentration limits for discharges of Superfund site wastewaters to POTWs are set in various ways. Discharges of Superfund wastewaters must comply with identified applicable or relevant and appropriate requirements. If a POTW had previously developed pretreatment limits for compounds in its existing influent, those limits often became part of the site discharge limits. Some sites used national categorical standards when the Superfund site previously operated as an industry for which standards are promulgated. In most cases, discharge limits were based on concentrations believed or proven to be treatable at the POTW, or based on alternative regulatory criteria such as ambient water quality criteria or toxicity characteristic leaching procedure concentrations.

Though some Superfund site wastewater contaminants are often not regulated by local limits or any published standard, many contaminants are the same as those found in industrial discharges. POTW representatives familiar with industrial discharges are therefore somewhat more prepared to evaluate effects of Superfund wastewater discharges on POTW operations than representatives of POTWs which more exclusively treat domestic sewage. Many POTWs needed guidance or lacked the financial resources to perform detailed treatability studies to evaluate the potential impacts of unfamiliar Superfund site wastewater contaminants on POTW treatment operations, permit compliance, and sludge management. POTW representatives commonly instituted highly conservative site discharge limits that did not fully utilize predictable treatment potential at the POTW. These highly conservative limits were set to protect the POTW from violating its own discharge permit or other environmental or safety standards. The POTW was rarely considered a primary treatment source for Superfund site wastewaters. Rather, discharging to a POTW was considered a cost-effective form of secondary treatment for highly pretreated wastewaters. Discharge limits often reflected the highest level of contaminant removal attainable by on-site pretreatment systems.

In a few cases, USEPA or state regulatory personnel requested more conservative limits than the limits agreed upon by the POTW and responsible party. USEPA and state regulatory personnel explained that conservative discharge limits are often set to (1) reduce the possibility of environmental degradation once wastewaters leave the Superfund site; (2) address POTW representatives' concerns about the potential impacts of the wastewater on the POTW's operations; and (3) address citizens' concerns.

4.4 Liability

When POTW representatives, regulatory personnel, and responsible parties failed to come to a discharge agreement, irreconcilable liability issues were often cited. Factors influencing the amount of liability protection a POTW required before authorizing a discharge include community concern, wastewater contaminants, and POTW toxic pollutant treatment experience. A POTW's discharge authorization and control mechanisms usually reflected the level of liability protection POTW representatives required.

Some POTW representatives requested indemnification agreements releasing the POTW of any and all liability for adverse impact to POTW treatment processes, effluent, or sludge. However, under Section 119(c)(5)(D) of the Superfund Amendments and Reauthorization Act (SARA) and subsequent USEPA decisions, USEPA cannot provide indemnification to any POTWs under Section 119 authority (USEPA, 1987).

POTW representatives authorized discharges of Superfund site wastewaters either by contract, permit, or letter agreement with the discharger. The majority of discharges were authorized by permits renewable annually or every two years. These permits generally specified acceptable site discharge limits and/or conditions and contained enforcement provisions for violations. Permits provided POTW representatives a convenient regulation and liability protection method. Under Section 107(J) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), "federally permitted releases" are exempt from clean up cost liabilities. A POTW with an approved pretreatment program can protect itself from CERCLA liabilities by regulating the contaminants of concern in its local limits or in a permit issued to the Superfund wastewater discharger.

Because most Superfund site wastewater discharges are anticipated to extend beyond one permit term, the permit system does not guarantee the wastewater's access to the POTW throughout site remediation. Contracts were favored by some dischargers because they offered more reliable long-term access to the POTW. Contracts generally described conditions under which the POTW could terminate the discharge. In several cases, a less formal letter agreement was used when the negotiating parties readily came to agreement upon the duration of and contaminant concentrations in the wastewater discharge.

4.5 Costs

POTW representatives did not want to accept a Superfund site wastewater discharge if acceptance would cost more than collected revenue either in labor costs, monitoring costs, or fines resulting from enforcement actions. POTWs accepting Superfund site wastewater discharges have incurred unanticipated

costs for increased recordkeeping requirements, sample analyses which must be contracted outside the POTW laboratory, and increased liability insurance premiums.

Many state and regional USEPA regulatory personnel and responsible parties considered POTW discharge a relatively inexpensive Superfund remedial alternative component. POTWs usually charge for treatment services on a per-gallon or contaminant concentration-based rate. The rate applied to Superfund site discharges was often the same rate applied to local industrial discharges. In some cases, however, the Superfund discharge's rate increased to reflect increased POTW liability insurance and monitoring costs. Discharge to POTW costs increased if no sewer existed to transport the waste from the site to the POTW. Where sewer lines were not readily available, more costly truck transport was used, or new sewer lines were planned and constructed. For the sites studied, disposal of Superfund wastewaters at an off-site RCRA treatment facility was predictably more costly than discharging to a POTW. Lengthy negotiations, POTW treatability studies, and wastewater monitoring requirements can also affect the cost of Superfund wastewater discharges to POTWs.

Costs of discharging a Superfund wastewater to a POTW are often comparable to or lower than the costs of discharging directly to surface waters. Implementing a direct discharge could require costly permit negotiations, and meeting potentially more stringent direct discharge standards could increase on-site pretreatment costs. Discharge pipe construction or trucking costs could also increase direct discharge costs.

5.0 CONCLUSION

The information collected as part of the site visit study indicated that the POTW discharge alternative can be a successful, effective, and safe means of disposing wastestreams from Superfund sites. Like any other remedial alternative, there are important issues that affect and complicate the evaluation and implementation process. The wastewater characteristics, POTW characteristics, and the level and type of wastewater pretreatment provided or required created a unique set of circumstances at each site.

The information that was gathered from discussions with USEPA, state, PRP, and POTW representatives familiar with the evaluation and implementation process served to highlight the major issues and obstacles that must be overcome to successfully implement the POTW discharge alternative. In summary, the major issues are as follows:

- Comprehensive regulatory and technical guidance was not previously available to assist POTW representatives, PRPs, and RPMs with evaluating and implementing CERCLA site discharges to POTWs; agreement on acceptable discharge limits often represents several iterations of negotiation;

- Superfund wastewater discharge volumes and contaminant concentrations are typically low relative to total POTW treatment volume and contaminant loading;

- USEPA cannot provide indemnification to any POTWs accepting Superfund wastestreams. This lack of indemnification has lead to concern over liability and, therefore, can impact a POTW's decision to accept a Superfund wastewater discharge;

- Including a POTW early in the negotiation process is a key step to developing open communication and can facilitate the evaluation of the POTW discharge alternative;

- Currently, there are few incentives offered to POTWs to encourage acceptance of Superfund wastestreams. POTWs that have accepted Superfund wastestreams have incurred additional costs related to increased recordkeeping and reporting requirements, sample analyses, and increased liability insurance premiums;

- Most POTWs considered for CERCLA site wastewater discharges lack the resources to conduct treatability studies for unfamiliar wastewater contaminants. As a result, the Superfund wastestreams are often highly pretreated and the treatment capability of the POTW is not fully employed;

- Community perception and acceptance is an important variable in a POTW's willingness to accept CERCLA site wastewaters.

6.0 REFERENCES

USEPA Memorandum, 1987. "USEPA Interim Guidance on Indemnification of Superfund Response Action Contractors Under Section 119 of SARA"; J.W. Porter, Office of Solid Waste and Emergency Response; C.M. Kinghorn, Office of Administration and Resources Management; Directive No. 9835.5, October 6, 1987.

USEPA 1990 "CERCLA Site Discharges to POTWs," Office of Water, Industrial Technology Division, Draft, April 1990.

SECTION 5

STATE NPDES PROGRAM STATUS
JULY 1987

SECTION 5 - STATE NPDES PROGRAM STATUS. Section 5 presents the status of State National Pollutant Discharge Elimination System (NPDES) programs. The table indicates whether the state is authorized to administer the NPDES permit program, regulate federal facilities, and whether the state has an approved state pretreatment program. The NPDES authority can assist in the identification of POTWs that may accept a CERCLA site discharge and provide specific information about the POTW that will be helpful for screening the POTWs during the RI/FS process. Section 5 identifies the appropriate agency to contact (either the USEPA regional office or a state agency) for NPDES issues.

STATE NPDES PROGRAM STATUS

	Approved State NPDES Permit Program	Approved to Regulate Federal Facilities	Approved State Pretreatment Program
*Arkansas	11/01/86	11/01/86	11/01/86
Alabama	10/19/79	10/19/79	10/19/79
California	05/14/73	05/05/78	--
*Colorado	03/27/75	--	--
Connecticut	09/26/73	--	06/03/81
Delaware	04/01/74	--	--
Georgia	06/28/74	12/08/80	03/12/81
Hawaii	11/28/74	06/01/79	08/12/83
*Illinois	10/23/77	09/20/79	--
Indiana	01/01/75	12/09/78	--
Iowa	08/10/78	08/10/78	06/03/81
Kansas	06/28/74	08/28/85	--
*Kentucky	09/30/83	09/30/83	09/30/83
Maryland	09/05/74	--	09/30/85
Michigan	10/17/73	12/09/78	06/07/83
Minnesota	06/30/74	12/09/78	07/16/79
Mississippi	05/01/74	01/28/83	05/13/82
*Missouri	10/30/74	06/26/79	06/03/81
*Montana	06/10/74	06/23/81	--
Nebraska	06/12/74	11/02/79	09/07/84
Nevada	09/19/75	08/31/78	--
*New Jersey	04/13/82	04/13/82	04/13/82
New York	10/28/75	06/13/80	--
North Carolina	10/19/75	09/28/84	06/14/82
North Dakota	06/13/75	--	--
Ohio	03/11/74	01/28/83	07/27/83
*Oregon	09/26/73	03/02/79	03/12/81
Pennsylvania	06/30/78	06/30/78	--
*Rhode Island	09/17/84	09/17/84	09/17/84
South Carolina	06/10/75	09/26/80	04/09/82
Tennessee	12/28/77	--	08/10/83
*Utah	07/07/87	07/07/87	07/07/87
Vermont	03/11/74	--	03/16/82
Virgin Islands	06/30/76	--	--
Virginia	03/31/75	02/09/82	--
Washington	11/14/73	--	09/30/86
*West Virginia	05/10/82	05/10/82	05/10/82
*Wisconsin	02/04/74	11/26/79	12/24/80
Wyoming	01/30/75	05/18/81	--
TOTALS	39	30	25

COMPLETE State Programs (NPDES, Federal Facilities & Pretreatment) 20

* - indicates State approved to issue General Permits

SECTION 6

PERCENT REMOVAL OF COMPOUNDS IN POTWS

SECTION 6 - PERCENT REMOVAL OF COMPOUNDS IN POTWS. To evaluate the feasibility of discharging wastes from CERCLA sites to POTWs, the user of the treatability manual may need to estimate the treatability of compounds in the CERCLA waste and their potential to impact removal processes in the treatment system. The removal mechanisms in a POTW include air stripping, partitioning (sorption) to the solids and biomass, and biodegradation. Section 6 presents summary tables of published treatability data for individual compounds that can be used to estimate a mass balance for each compound detected in a CERCLA wastestream if site specific treatability data is unavailable.

The data presented in Table 6-1 was generated from a number of different published studies on the total percent removal of specific pollutants in biological treatment systems. Biological treatment systems presented in the tables include aerated lagoon (AL), activated sludge (AS), and trickling filter (TF). The data was separated into six concentration ranges, and distinguished between effluent samples that were chlorinated and those that were not. The number of observations (OBSV) is the number of publications from which data was taken and averaged to obtain a mean percent removal. The minimum and maximum percent removal, standard error (SE), and 90% confidence interval are also presented.

The following key is to be used with Table 6-1:

AL	- Aerated Lagoon	MEAN	- Mean Percent Removal
AS	- Activated Sludge	MIN	- Minimum Percent Removal
TF	- Trickling Filter	MAX	- Maximum Percent Removal
N	- Number of Data Points	SE	- Standard Error
OBSV	- Number of Publications Used	90% CI	- 90% Confidence Interval

Table 6-2 presents an estimated average percent of the influent that may be partitioned to sludge and/or volatilized in activated sludge treatment systems for many compounds. Published partitioning and volatilization data in biological treatment systems were limited for most compounds and non-existent for almost all compounds with regard to biodegradation. The tables can, however, be used to obtain an estimated overall percent removal.

TABLE 6-1
TOTAL PERCENT REMOVAL IN BIOLOGICAL TREATMENT PLANTS
CERCLA SITE DISCHARGES TO POTWS GUIDANCE MANUAL

PARAMETER: 1,1,1-TRICHLOROETHANE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	6	1	88.76	88.76	88.76	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	140	16	50.51	0.00	95.35	10.45	(32,69)
51-100	29	4	83.47	58.94	98.65	8.68	(63,99)
101-500	24	4	87.82	68.66	99.56	6.76	(72,99)
501-1000	-	-	-	-	-	-	-
1001-5000	0	1	98.28	98.28	98.28	0.00	(0,0)
> 5000	6	1	87.04	87.04	87.04	0.00	(0,0)

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	30	5	55.08	0.00	98.00	22.57	(7,100)
51-100	12	1	97.00	97.00	97.00	0.00	(0,0)
101-500	6	1	92.94	92.94	92.94	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	90.91	90.91	90.91	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	103	18	69.67	0.00	100.00	7.06	(57,82)
51-100	6	2	77.64	69.57	85.71	8.07	(19,100)
101-500	24	4	95.33	90.40	99.77	1.93	(91,100)
501-1000	-	-	-	-	-	-	-
1001-5000	7	2	98.93	97.98	99.88	0.95	(93,100)
> 5000	6	2	99.25	98.64	99.24	0.60	(95,100)

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	41.18	41.18	41.18	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	6	1	98.40	98.40	98.40	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: 1,1,2,2-TETRACHLOROETHANE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	53	4	22.22	0.00	88.89	22.22	(0,75)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	7	2	85.29	70.59	100.00	14.71	(0,100)
51-100	-	-	-	-	-	-	-
101-500	0	1	90.00	90.00	90.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	6	2	95.31	94.53	96.15	0.81	(90,100)

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: 1,1,2-TRICHLOROETHANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	81	5	47.67	0.00	95.65	19.83	(5,90)	5	3	52.78	0.00	100.00	29.00	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	20	2	79.47	78.95	80.00	0.53	(76,83)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: 1,1-DICHLOROETHANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	62.96	62.96	62.96	0.00	(0,0)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	1	68.75	68.75	68.75	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	12	3	45.83	0.00	87.50	25.35	(0,100)	47	11	49.97	0.00	100.00	9.59	(33,55)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	2	92.22	90.00	94.44	2.22	(78,100)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	0.00	0.00	0.00	0.00	(0,0)	6	1	75.00	75.00	75.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	1	34.72	34.72	34.72	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: 1,1-DICHLOROETHENE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	100	8	50.92	0.00	98.61	15.43	(22,80)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	75.00	75.00	75.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	14	1	60.85	60.85	60.85	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	12	4	53.47	0.00	97.22	20.33	(6,100)
51-100	20	1	99.74	99.74	99.74	0.00	(0,0)
101-500	14	2	94.20	93.40	95.00	0.80	(89,100)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	50.00	50.00	50.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	14	1	59.91	59.91	59.91	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: 1,2,4-TRICHLOROBENZENE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	2	57.35	50.00	64.71	7.35	(11,100)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	0	1	83.33	83.33	83.33	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	16	4	89.51	83.33	100.00	3.75	(81,98)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: 1,2-DICHLOROBENZENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	76	11	53.22	0.00	95.65	12.27	(31,75)	36	8	39.96	0.00	100.00	14.72	(12,68)
51-100	6	1	98.00	98.00	98.00	0.00	(0,0)	-	-	-	-	-	-	-
101-500	6	1	94.29	94.29	94.29	0.00	(0,0)	5	3	91.79	90.00	93.82	1.11	(89,95)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	6	2	99.72	99.50	99.94	0.22	(98,100)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	12	2	25.00	0.00	50.00	25.00	(0,100)	6	1	28.57	28.57	28.57	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: 1,2-DICHLOROETHANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	1	70.59	70.59	70.59	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	4	21.72	0.00	86.91	21.72	(0,73)	4	4	60.30	0.00	90.00	20.71	(12,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	2	87.81	85.62	90.00	2.19	(74,100)
501-1000	-	-	-	-	-	-	-	5	1	98.28	98.28	98.28	0.00	(0,0)
1001-5000	6	1	99.75	99.75	99.75	0.00	(0,0)	-	-	-	-	-	-	-
> 5000	6	2	60.94	32.85	89.03	28.09	(0,100)	6	2	98.41	98.25	98.57	0.16	(97,99)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	50.00	50.00	50.00	0.00	(0,0)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	1	39.22	39.22	39.22	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: 1,2-DICHLOROPROPANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	8	2	75.00	50.00	100.00	25.00	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	6	1	99.54	99.54	99.54	0.00	(0,0)	25	3	94.33	90.00	98.06	2.35	(88,100)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	6	2	99.33	99.01	99.65	0.32	(97,100)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	33.33	33.33	33.33	0.00	(0,0)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: 1,3-DICHLOROBENZENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	2	45.70	33.33	58.07	12.37	(0,100)	0	1	87.10	87.10	87.10	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	90.00	90.00	90.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	6	3	99.80	99.48	99.99	0.16	(99,100)
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: 1,4-DICHLOROBENZENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	11	2	83.33	67.67	100.00	16.67	(0,100)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	1	83.33	83.33	83.33	0.00	(0,0)	36	5	86.52	70.59	100.00	5.02	(76,97)
51-100	-	-	-	-	-	-	-	11	1	94.62	94.62	94.62	0.00	(0,0)
101-500	-	-	-	-	-	-	-	0	1	90.00	90.00	90.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	11	1	37.63	37.63	37.63	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: 2,4-DICHLOROPHENOL

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	11	1	32.02	32.02	32.02	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	1	50.00	50.00	50.00	0.00	(0,0)	2	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	16	3	95.88	93.08	99.54	1.92	(90,100)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	6	2	86.19	77.18	95.20	9.01	(29,100)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	11	1	12.28	12.28	12.28	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: 2,4-DIMETHYLPHENOL

CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	3	1	100.00	100.00	100.00	0.00	(0,0)
51-100	8	1	99.06	99.06	99.06	0.00	(0,0)
101-500	5	2	96.57	95.00	98.15	1.57	(87,100)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: 2,4-DINITROPHENOL

CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	0	1	90.00	90.00	90.00	0.00	(0,0)
501-1000	5	1	91.23	91.23	91.23	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-
> 5000	6	1	99.31	99.31	99.31	0.00	(0,0)

INFL CONC.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: 2-CHLORONAPHTHALENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	50.00	50.00	50.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	95.00	95.00	95.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: 2-CHLOROPHENOL

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	1	0.00	0.00	0.00	0.00	(0,0)	2	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	5	1	33.96	33.96	33.96	0.00	(0,0)
101-500	-	-	-	-	-	-	-	0	1	95.00	95.00	95.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: ACENAPHTHENE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	2	89.18	88.89	89.47	0.29	(87,91)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	1	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	18	3	99.00	96.99	100.00	1.01	(96,100)
51-100	5	1	94.05	94.05	94.05	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: ACENAPHTHYLENE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	0	1	50.00	50.00	50.00	0.00	(0,0)
51-100	5	1	92.31	92.31	92.31	0.00	(0,0)
101-500	0	1	95.00	95.00	95.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: ANTHRACENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	6	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	116	14	8.10	0.00	80.00	6.02	(0,19)	62	11	17.95	0.00	100.00	12.04	(0,49)
51-100	6	1	78.85	78.85	78.85	0.00	(0,0)	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	95.00	95.00	95.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	42	6	6.76	0.00	40.54	6.76	(0,20)	6	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: ANTIMONY

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	3	41.23	0.00	73.68	21.72	(0,100)	0	2	17.11	0.00	34.21	17.11	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	0.00	0.00	0.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: ARSENIC

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	149	19	39.40	0.00	90.63	7.53	(26,53)	45	3	33.85	18.93	63.33	14.74	(0,77)
51-100	0	1	50.00	50.00	50.00	0.00	(0,0)	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	50.00	50.00	50.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	25.00	25.00	25.00	0.00	(0,0)	6	1	10.00	10.00	10.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: BARIUM

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	6	1	56.60	56.60	56.60	0.00	(0,0)
101-500	6	1	75.90	75.90	75.90	0.00	(0,0)	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	72.09	72.09	72.09	0.00	(0,0)	-	-	-	-	-	-	-
51-100	37	5	70.43	64.15	75.64	2.24	(66,75)	12	2	75.82	72.62	79.01	3.20	(56,96)
101-500	170	18	72.75	43.72	99.17	3.79	(66,79)	52	10	76.14	62.31	94.21	4.04	(69,84)
501-1000	4	1	65.68	65.68	65.68	0.00	(0,0)	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	18	3	58.56	38.89	87.37	14.72	(16,100)	-	-	-	-	-	-	-
101-500	30	4	50.21	21.28	70.23	11.91	(22,78)	12	2	55.65	53.55	57.75	2.10	(42,69)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: BENZENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	2	2	100.00	100.00	100.00	0.00	(100,100)
51-100	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
101-500	6	1	98.91	98.91	98.91	0.00	(0,0)	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	124	13	53.68	0.00	85.71	9.02	(38,70)	56	12	74.04	48.53	98.25	5.58	(64,84)
51-100	-	-	-	-	-	-	-	20	1	99.73	99.73	99.73	0.00	(0,0)
101-500	18	3	96.72	91.09	99.55	2.81	(89,100)	13	4	98.41	95.00	99.83	1.14	(96,100)
501-1000	-	-	-	-	-	-	-	5	1	98.97	98.97	98.97	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	15	3	99.95	99.87	100.00	0.04	(99,100)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	30	4	56.74	0.00	96.97	21.26	(7,100)	6	1	91.67	91.67	91.67	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: BIS(2-CHLOROETHOXY) METHANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	1	66.67	66.67	66.67	0.00	(0,0)	0	1	66.67	66.67	66.67	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	10.00	10.00	10.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: BIS(2-CHLOROETHYL) ETHER

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	0	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
-	-	-	-	-	-	-
-	-	-	-	-	-	-
11	1	28.67	28.67	28.67	0.00	(0,0)
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

TREATMENT: AS

N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0	3	66.67	0.00	100.00	33.33	(0,100)
-	-	-	-	-	-	-
11	2	84.51	79.02	90.00	5.49	(50,100)
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

TREATMENT: TF

N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
-	-	-	-	-	-	-
-	-	-	-	-	-	-
11	1	7.69	7.69	7.69	0.00	(0,0)
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

PARAMETER: BIS(2-ETHYLHEXYL) PHTHALATE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	6	1	40.65	40.65	40.65	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	157	17	39.80	0.00	87.50	7.91	(26,54)
51-100	36	6	61.57	0.00	89.54	14.37	(33,91)
101-500	18	4	76.24	55.63	98.76	9.93	(53,100)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	36	5	32.94	14.29	64.52	8.50	(15,51)
51-100	6	2	6.06	0.00	12.12	6.06	(0,44)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
5	1	100.00	100.00	100.00	0.00	(0,0)
6	1	23.47	23.47	23.47	0.00	(0,0)
11	1	79.76	79.76	79.76	0.00	(0,0)
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

TREATMENT: AS

N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
41	10	43.93	0.00	78.00	9.40	(27,61)
26	4	48.41	10.11	78.14	16.56	(9,87)
61	6	82.25	58.53	100.00	6.19	(70,95)
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

TREATMENT: TF

N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
12	3	65.66	33.33	100.00	19.27	(10,100)
-	-	-	-	-	-	-
11	1	76.79	76.79	76.79	0.00	(0,0)
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

PARAMETER: BROMODICHLOROMETHANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	18	4	30.83	0.00	50.00	10.83	(5,56)	5	2	87.50	75.00	100.00	12.50	(9,100)
51-100	-	-	-	-	-	-	-	20	1	99.78	99.78	99.78	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: BUTYL BENZYL PHTHALATE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	0.00	0.00	0.00	0.00	(0,0)	6	2	96.43	92.86	100.00	3.57	(74,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	146	20	24.60	0.00	92.00	7.16	(12,37)	74	15	47.90	0.00	100.00	10.72	(29,67)
51-100	6	1	96.67	96.67	96.67	0.00	(0,0)	5	1	93.02	93.02	93.02	0.00	(0,0)
101-500	6	2	99.56	99.43	99.68	0.13	(99,100)	0	1	95.00	95.00	95.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	48	7	32.06	0.00	97.30	15.76	(1,63)	12	2	31.25	0.00	62.50	31.25	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: CADMIUM

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	6	1	44.00	44.00	44.00	0.00	(0,0)
51-100	6	1	0.00	0.00	0.00	0.00	(0,0)	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	265	35	39.47	0.00	99.47	6.24	(29,50)	119	15	30.60	0.00	97.06	9.47	(14,47)
51-100	12	2	43.14	0.00	86.28	43.14	(0,100)	6	1	97.02	97.02	97.02	0.00	(0,0)
101-500	6	1	91.38	91.38	91.38	0.00	(0,0)	0	1	27.00	27.00	27.00	0.00	(0,0)
501-1000	6	1	90.06	90.06	90.06	0.00	(0,0)	-	-	-	-	-	-	-
1001-5000	6	1	93.96	93.96	93.96	0.00	(0,0)	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	48	7	6.35	0.00	33.33	4.76	(0,16)	20	2	14.00	0.00	28.00	14.00	(0,100)
51-100	-	-	-	-	-	-	-	6	1	76.12	76.12	76.12	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: CHLOROBENZENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	100.00	100.00	100.00	0.00	(0,0)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	41	2	40.00	0.00	80.00	40.00	(0,100)	17	3	62.22	20.00	100.00	23.20	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	6	2	99.32	98.91	99.72	0.40	(97,100)	20	4	97.10	90.00	99.89	2.37	(92,100)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	2	37.50	0.00	75.00	37.50	(0,100)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: CHLOROETHANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	5	1	58.33	58.33	58.33	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	95.00	95.00	95.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: CHLOROFORM

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	6	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	1	60.74	60.74	60.74	0.00	(0,0)
501-1000	6	1	97.79	97.79	97.79	0.00	(0,0)	3	1	100.00	100.00	100.00	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	152	23	40.27	0.00	96.49	6.78	(29,52)	166	28	59.22	0.00	100.00	5.56	(50,69)
51-100	41	2	60.44	52.06	68.83	8.39	(7,100)	-	-	-	-	-	-	-
101-500	6	1	50.00	50.00	50.00	0.00	(0,0)	39	4	92.58	86.67	97.37	2.55	(87,99)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	0	1	99.25	99.25	99.25	0.00	(0,0)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	42	6	37.64	0.00	87.50	15.59	(6,69)	12	3	87.83	77.78	100.00	6.50	(69,100)
51-100	6	1	85.92	85.92	85.92	0.00	(0,0)	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	1	24.44	24.44	24.44	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: CHLOROMETHANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	58.33	58.33	58.33	0.00	(0,0)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	0	1	100.00	100.00	10.00	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	47	2	0.00	0.00	0.00	0.00	(0,0)	6	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	18	3	81.65	67.29	97.98	8.92	(56,100)	0	1	95.00	95.00	95.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	0.00	0.00	0.00	0.00	(0,0)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	6	1	60.32	60.32	60.32	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: CHROMIUM

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	6	1	48.78	48.78	48.78	0.00	(0,0)
101-500	-	-	-	-	-	-	-	14	1	70.59	70.59	70.59	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	6	1	89.78	89.78	89.78	0.00	(0,0)	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	58	8	45.67	0.00	83.72	13.66	(20,72)	12	2	85.39	73.33	97.44	12.05	(9,100)
51-100	53	9	68.55	18.99	94.55	7.61	(54,83)	18	4	78.29	68.75	94.55	5.79	(65,92)
101-500	160	19	75.05	21.43	93.44	4.20	(68,82)	50	10	81.29	70.00	89.49	1.90	(78,85)
501-1000	6	1	93.36	93.36	93.36	0.00	(0,0)	45	1	46.03	46.03	46.03	0.00	(0,0)
1001-5000	18	3	94.24	89.73	97.46	2.32	(87,100)	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	36	5	36.41	0.00	58.33	10.12	(15,58)	6	1	67.39	67.39	67.39	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	12	2	46.49	22.59	70.40	23.90	(0,100)	20	2	54.20	51.58	56.18	2.62	(38,71)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: COPPER

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	6	1	20.97	20.97	20.97	0.00	(0,0)
101-500	6	1	96.38	96.38	96.38	0.00	(0,0)	14	1	74.20	74.20	74.20	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	39	7	63.77	0.00	90.00	11.82	(41,87)	6	2	45.24	0.00	90.48	45.24	(0,100)
51-100	89	10	80.18	41.27	99.00	6.26	(69,92)	12	3	79.93	56.10	99.00	12.61	(43,100)
101-500	137	18	81.85	50.00	95.51	2.95	(77,87)	62	10	80.07	0.00	96.97	9.18	(63,97)
501-1000	18	3	91.47	89.91	93.82	1.20	(88,95)	45	1	80.00	80.00	80.00	0.00	(0,0)
1001-5000	6	1	92.43	92.43	92.43	0.00	(0,0)	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	0.00	0.00	0.00	0.00	(0,0)	-	-	-	-	-	-	-
51-100	12	2	53.89	49.15	58.62	4.73	(24,84)	-	-	-	-	-	-	-
101-500	24	4	58.41	38.18	74.79	9.56	(36,81)	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: CYANIDE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	6	1	7.35	7.35	7.35	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	6	1	89.78	89.78	89.78	0.00	(0,0)	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	50	6	55.68	0.00	85.71	11.87	(32,80)	12	4	47.57	0.00	75.00	17.45	(7,89)
51-100	83	8	18.99	0.00	67.07	9.65	(1,37)	-	-	-	-	-	-	-
101-500	42	8	59.78	28.76	91.87	7.99	(45,75)	30	7	58.29	33.14	90.00	7.97	(43,74)
501-1000	12	2	69.04	57.91	80.17	11.13	(0,100)	6	1	65.41	65.41	65.41	0.00	(0,0)
1001-5000	18	3	86.72	71.13	97.58	7.99	(63,100)	18	3	85.49	79.92	89.49	2.87	(77,94)
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	6	1	36.15	36.15	36.15	0.00	(0,0)	-	-	-	-	-	-	-
101-500	36	5	39.29	0.00	73.14	16.19	(5,74)	12	2	42.16	26.64	57.68	15.52	(0,100)
501-1000	6	1	56.80	56.80	56.80	0.00	(0,0)	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: DI-N-OCTYL PHTHALATE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	1	0.00	0.00	0.00	0.00	(0,0)	13	2	82.56	82.14	82.98	0.42	(80,85)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: DIBROMOCHLOROMETANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	5	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	20	1	87.93	87.93	87.93	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: DIETHYL PHTHALATE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	6	2	50.00	0.00	100.00	50.00	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	187	23	54.03	0.00	100.00	8.05	(40,68)	85	14	28.68	0.00	100.00	11.57	(8,49)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	5	2	91.64	90.00	93.28	1.64	(81,100)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	30	4	33.75	0.00	60.00	13.44	(2,65)	12	2	30.77	0.00	61.54	30.77	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: ETHYLBENZENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	61.54	61.54	61.54	0.00	(0,0)	9	2	91.67	83.33	100.00	8.33	(39,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	1	75.68	75.68	75.68	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	199	24	41.53	0.00	97.73	8.98	(26,57)	95	17	62.10	0.00	99.22	9.57	(45,79)
51-100	-	-	-	-	-	-	-	26	3	96.66	90.72	99.76	2.97	(88,100)
101-500	12	3	98.73	97.45	98.73	0.64	(97,100)	19	4	96.91	94.60	99.80	1.26	(94,100)
501-1000	-	-	-	-	-	-	-	24	1	100.00	100.00	100.00	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	0	1	99.95	99.95	99.95	0.00	(0,0)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	48	7	33.03	0.00	90.00	13.06	(8,58)	12	6	25.00	0.00	50.00	25.00	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	14	1	72.07	72.07	72.07	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: FLUORANTHENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	11	1	65.39	65.39	65.39	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	2	41.67	0.00	83.33	41.67	(0,100)	13	4	85.46	64.71	100.00	7.73	(67,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	11	1	95.19	95.19	95.19	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	11	1	52.89	52.89	52.89	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: FLUORENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	1	0.00	0.00	0.00	0.00	(0,0)	10	3	97.42	94.12	100.00	1.74	(92,100)
51-100	-	-	-	-	-	-	-	5	1	91.07	91.07	91.07	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: HEPTACHLOR

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	3	1	66.67	66.67	66.67	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	11	2	79.71	6.67	92.74	13.04	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	3	1	53.85	53.85	53.85	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

POTW - Percent Removal

PARAMETER: IRON

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	6	1	25.98	25.98	25.98	0.00	(0,0)
> 5000	6	1	85.46	85.46	85.46	0.00	(0,0)	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	6	1	81.18	81.18	81.18	0.00	(0,0)	-	-	-	-	-	-	-
1001-5000	120	15	80.66	42.58	98.00	3.37	(75,87)	111	12	85.41	67.00	96.65	3.27	(80,91)
> 5000	85	9	88.41	66.78	99.20	4.11	(81,96)	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	24	3	74.52	55.23	90.71	10.36	(44,100)	-	-	-	-	-	-	-
1001-5000	18	3	32.65	3.74	69.97	19.58	(0,90)	12	6	72.30	68.87	75.72	3.42	(65,79)
> 5000	6	1	50.61	50.61	50.61	0.00	(0,0)	-	-	-	-	-	-	-

PARAMETER: ISOPHORONE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	11	1	23.60	23.60	23.60	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	2	1	100.00	100.00	100.00	0.00	(0,0)
51-100	11	1	97.75	97.75	97.75	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	5	1	100.00	100.00	100.00	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	11	1	19.10	19.10	19.10	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: LEAD

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	6	1	7.83	7.83	7.83	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	148	15	45.95	0.00	97.96	10.88	(27,65)
51-100	56	9	77.21	1.96	98.68	10.59	(58,97)
101-500	65	12	73.91	51.22	98.18	4.86	(65,83)
501-1000	6	1	79.93	79.93	79.93	0.00	(0,0)
1001-5000	6	1	97.22	97.22	97.22	0.00	(0,0)
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	42	6	9.03	0.00	54.17	9.03	(0,27)
51-100	-	-	-	-	-	-	-
101-500	6	1	19.62	19.62	19.62	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	6	1	0.00	0.00	0.00	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	14	1	57.58	57.58	57.58	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	18	0	0.00	0.00	0.00	0.00	(0,0)
51-100	24	5	48.17	9.09	86.46	13.20	(20,76)
101-500	38	7	56.59	25.20	83.09	8.56	(40,73)
501-1000	45	1	87.50	87.50	87.50	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	0.00	0.00	0.00	0.00	(0,0)
51-100	6	1	45.06	45.06	45.06	0.00	(0,0)
101-500	14	1	47.88	47.88	47.88	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: LINDANE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	0	2	37.50	0.00	75.00	37.50	(0,100)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	3	1	43.59	43.59	43.59	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	11	2	31.91	20.51	43.30	11.39	(0,100)
51-100	0	1	7.58	7.58	7.58	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	3	1	12.82	12.82	12.82	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: MANGANESE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	21	3	33.33	0.00	50.00	16.67	(0,82)
51-100	7	1	33.33	33.33	33.33	0.00	(0,0)
101-500	91	9	32.69	11.77	86.67	7.96	(18,47)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	45	1	38.46	38.46	38.46	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: MERCURY

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	66.67	66.67	66.67	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	205	27	42.06	0.00	93.75	7.08	(30,54)
51-100	6	1	40.01	40.01	40.01	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	48	7	42.82	0.00	75.00	12.15	(19,66)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	111	16	53.18	0.00	100.00	10.17	(35,71)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	12	2	60.71	50.00	71.43	10.71	(90,100)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: METHYLENE CHLORIDE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	81.62	81.62	81.62	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	116	16	29.71	0.00	60.00	5.78	(20,40)
51-100	47	3	40.98	27.69	60.67	10.05	(12,70)
101-500	6	2	27.31	0.00	54.61	27.31	(0,100)
501-1000	12	3	36.33	0.00	78.21	22.75	(0,100)
1001-5000	24	3	66.66	3.04	99.19	31.82	(0,100)
> 5000	6	1	11.36	11.36	11.36	0.00	(0,0)

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	30	4	74.65	66.67	83.33	3.69	(66,83)
51-100	12	2	76.31	75.95	76.67	0.36	(74,79)
101-500	6	1	54.84	54.84	54.84	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	6	1	96.15	96.15	96.15	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	3	1	100.00	100.00	100.00	0.00	(0,0)
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	75	14	37.11	0.00	93.29	8.50	(22,52)
51-100	18	3	61.43	34.41	77.33	13.58	(22,100)
101-500	45	7	79.91	0.00	100.00	13.93	(53,100)
501-1000	0	1	71.87	71.87	71.87	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-
> 5000	6	2	99.81	99.72	99.91	0.10	(99,100)

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	6	1	66.04	66.04	66.04	0.00	(0,0)
101-500	6	1	89.33	89.33	89.33	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: NAPHTHALENE

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	157	17	41.12	0.00	96.33	10.33	(23,59)
51-100	12	2	89.79	85.46	94.12	4.33	(62,100)
101-500	6	1	94.65	94.65	94.65	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	18	3	16.67	0.00	50.00	16.67	(0,65)
51-100	6	1	60.00	60.00	60.00	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	8	2	50.00	0.00	100.00	50.00	(0,100)
51-100	-	-	-	-	-	-	-
101-500	11	1	66.67	66.67	66.67	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	80	13	31.94	0.00	100.00	11.88	(11,53)
51-100	8	1	99.09	99.09	99.09	0.00	(0,0)
101-500	11	2	95.65	95.00	96.30	0.65	(92,100)
501-1000	5	1	99.25	99.25	99.25	0.00	(0,0)
1001-5000	0	1	97.83	97.83	97.83	0.00	(0,0)
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	96.30	96.30	96.30	0.00	(0,0)
51-100	0	1	100.00	100.00	100.00	0.00	(0,0)
101-500	11	1	31.48	31.48	31.48	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: NICKEL

CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	6	1	75.69	75.69	75.69	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	104	16	39.86	0.00	94.44	8.49	(25,55)
51-100	99	7	22.45	0.00	56.99	8.24	(6,38)
101-500	80	13	50.26	15.00	99.71	7.92	(36,64)
501-1000	6	3	44.87	0.00	76.56	23.06	(0,100)
1001-5000	6	1	81.22	81.22	81.22	0.00	(0,0)
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	24	4	15.92	0.00	56.00	13.48	(0,48)
51-100	18	2	54.43	23.44	85.42	30.99	(0,100)
101-500	6	1	4.27	4.27	4.27	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

TREATMENT: AL

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	13.64	13.64	13.64	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	14	1	35.46	35.46	35.46	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: AS

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	30	5	8.33	0.00	41.67	8.33	(0,26)
51-100	18	3	39.37	16.67	66.67	14.62	(0,82)
101-500	77	7	35.19	5.80	60.00	6.64	(22,48)
501-1000	0	2	27.34	0.00	54.69	27.34	(0,100)
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

TREATMENT: TF

INFL CONC.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	6	1	35.48	35.48	35.48	0.00	(0,0)
101-500	20	2	32.84	30.50	35.19	2.34	(18,48)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER: NITROBENZENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	2	93.89	90.00	97.79	3.90	(69,100)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	5	1	96.97	96.97	96.97	0.00	(0,0)
> 5000	-	-	-	-	-	-	-	6	2	65.83	33.87	97.80	31.97	(0,100)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: PCB-1254

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	8	1	91.34	91.34	91.34	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	92.00	92.00	92.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: PENTACHLOROPHENOL

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	104	9	38.52	0.00	86.67	10.04	(20,57)	6	1	50.00	50.00	50.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	11	1	32.14	32.14	32.14	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	36	5	30.87	0.00	68.89	13.50	(2,60)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	11	1	2.38	2.38	2.38	0.00	(0,0)
101-500	-	-	-	-	-	-	-	6	1	35.86	35.86	35.86	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: PHENANTHRENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	11	1	57.90	57.90	57.90	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	40	4	35.16	0.00	90.63	21.93	(0.87)	8	2	93.95	90.63	97.28	93.95	(73,100)
51-100	6	1	78.85	78.85	78.85	0.00	(0,0)	11	1	95.79	95.79	95.79	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	0	1	98.24	98.24	98.24	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	11	1	46.32	46.32	46.32	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER: PHENOL

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	0.00	0.00	0.00	0.00	(0,0)	9	2	75.00	50.00	100.00	25.00	(0,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	11	1	33.33	33.33	33.33	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	116	14	31.28	0.00	94.44	11.67	(11,52)	54	9	19.07	0.00	80.00	10.11	(0,37)
51-100	18	3	54.82	11.11	95.71	24.46	(0,100)	-	-	-	-	-	-	-
101-500	53	4	93.12	80.10	99.59	4.48	(83,100)	61	7	94.14	80.77	100.00	2.69	(89,99)
501-1000	12	2	99.57	99.25	99.89	0.32	(98,100)	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	6	1	99.99	99.99	99.99	0.00	(0,0)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	96.08	96.08	96.08	0.00	(0,0)	6	2	90.00	80.00	100.00	10.00	(37,100)
51-100	-	-	-	-	-	-	-	6	1	98.18	98.18	98.18	0.00	(0,0)
101-500	-	-	-	-	-	-	-	11	2	74.60	49.21	100.00	25.40	(0,100)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

POTW - Percent Removal

PARAMETER:PYRENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	11	1	65.39	65.39	65.39	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	18	3	86.04	64.71	100.00	10.84	(54,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	11	1	95.19	95.19	95.19	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	11	1	53.85	53.85	53.85	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER:SILVER

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	35	4	72.38	26.04	94.22	15.72	(35,100)	45	4	58.80	26.04	94.22	16.15	(21,97)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	90.00	90.00	90.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER:TETRACHLOROETHENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	1	6	80.00	80.00	80.00	0.00	(0,0)	6	2	95.65	91.30	100.00	4.53	(68,100)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	95	17	47.11	0.00	100.00	9.07	(31,63)	120	21	62.69	0.00	100.00	7.02	(51,75)
51-100	9	6	78.63	32.69	97.53	9.93	(59,99)	-	-	-	-	-	-	-
101-500	18	3	74.02	65.20	79.49	4.46	(61,87)	47	4	93.50	90.00	96.68	1.37	(90,97)
501-1000	0	1	99.21	99.21	99.21	0.00	(0,0)	6	2	98.24	97.42	99.05	0.82	(93,100)
1001-5000	6	1	84.63	84.63	84.63	0.00	(0,0)	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	30	4	48.50	0.00	81.82	17.29	(8,89)	12	2	90.00	86.67	93.33	3.33	(69,100)
51-100	12	2	90.59	87.27	93.90	3.32	(70,100)	-	-	-	-	-	-	-
101-500	6	1	97.80	97.80	97.80	0.00	(0,0)	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER:TETRACHLOROMETHANE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	14	1	78.26	78.26	78.26	0.00	(0,0)
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	12	1	50.00	50.00	50.00	0.00	(0,0)	0	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	26	3	93.61	81.16	100.00	6.23	(75,100)
101-500	6	1	87.79	87.79	87.79	0.00	(0,0)	2	2	95.00	90.00	100.00	5.00	(63,100)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	0	1	99.90	99.90	99.90	0.00	(0,0)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER:TOLUENE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	6	1	88.89	88.89	88.89	(0,0)	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	6	1	97.23	97.23	97.23	0.00	(0,0)	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	124	17	53.74	0.00	97.73	9.51	(37,70)	112	19	85.21	0.00	100.00	5.65	(75,95)
51-100	12	2	98.24	97.86	98.63	0.39	(96,100)	19	4	98.01	96.67	99.00	0.49	(97,99)
101-500	57	6	78.88	0.00	99.11	15.87	(47,100)	58	6	98.85	95.00	100.00	0.78	(97,100)
501-1000	12	2	96.16	92.84	99.48	3.32	(75,100)	6	1	95.39	95.39	95.39	0.00	(0,0)
1001-5000	6	1	99.81	99.81	99.81	0.00	(0,0)	5	1	99.84	99.84	99.84	0.00	(0,0)
> 5000	-	-	-	-	-	-	-	0	1	99.94	99.94	99.94	0.00	(0,0)
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	42	6	61.90	0.00	96.00	14.50	(33,91)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	6	1	97.29	97.29	97.29	0.00	(0,0)	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER:TRANS-1,2-DICHLOROETHANE

CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	0.00	0.00	0.00	0.00	(0,0)	146	20	42.09	0.00	100.00	8.88	(27,57)	48	7	47.07	0.00	97.67	17.99	(12,82)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

NON-CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	87.50	87.50	87.50	0.00	(0,0)	59	11	49.22	0.00	93.75	12.45	(27,72)	6	1	50.00	50.00	50.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	90.00	90.00	90.00	0.00	(0,0)	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER:TRIBROMOMETHANE

CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

NON-CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)	-	-	-	-	-	-	-
51-100	14	1	83.33	83.33	83.33	0.00	(0,0)	14	1	67.78	67.78	67.78	0.00	(0,0)	14	1	54.44	54.44	54.44	0.00	(0,0)
101-500	-	-	-	-	-	-	-	0	1	65.00	65.00	65.00	0.00	(0,0)	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	0	1	100.00	100.00	100.00	0.00	(0,0)	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER:TRICHLOROETHENE

CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	75.00	75.00	75.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	157	17	48.24	0.00	97.73	10.22	(30,66)
51-100	36	5	78.46	51.72	98.21	7.87	(62,95)
101-500	12	2	89.71	86.86	92.56	2.85	(72,100)
501-1000	6	1	86.80	86.80	86.80	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	24	3	94.19	88.84	98.04	2.85	(86,100)
51-100	18	3	94.19	88.84	98.04	2.85	(86,100)
101-500	6	1	99.19	99.19	99.19	0.00	(0,0)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	97.30	97.30	97.30	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	106	18	53.77	0.00	100.00	8.26	(39,68)
51-100	6	1	97.65	97.65	97.65	0.00	(0,0)
101-500	26	3	97.74	95.00	99.61	1.40	(94,100)
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	2	91.67	83.33	100.00	8.33	(39,100)
51-100	6	1	88.24	88.24	88.24	0.00	(0,0)
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER:TRICHLOROFLUOROMETHANE

CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	41	2	48.65	0.00	97.30	48.65	(0,100)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	6	1	0.00	0.00	0.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

NON-CHLORINATED

INFL CONC.	TREATMENT: AL N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: AS N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-
101-500	0	1	95.00	95.00	95.00	0.00	(0,0)
501-1000	5	1	100.00	100.00	100.00	0.00	(0,0)
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

INFL CONC.	TREATMENT: TF N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	0	1	100.00	100.00	100.00	0.00	(0,0)
51-100	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-

PARAMETER:VINYL CHLORIDE

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	41	2	0.00	0.00	0.00	0.00	(0,0)	5	1	100.00	100.00	100.00	0.00	(0,0)
51-100	6	1	71.43	71.43	71.43	0.00	(0,0)	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	0	1	95.00	95.00	95.00	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	6	1	94.05	94.05	94.05	0.00	(0,0)	-	-	-	-	-	-	-
> 5000	6	1	92.93	92.93	92.93	0.00	(0,0)	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PARAMETER:ZINC

INFL CONC.	CHLORINATED							NON-CHLORINATED						
	TREATMENT: AL							TREATMENT: AL						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	-	-	-	-	-	-	-	6	1	51.10	51.10	51.10	0.00	(0,0)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	6	1	89.98	89.98	89.98	0.00	(0,0)	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TREATMENT: AS							TREATMENT: AS						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	7	1	97.50	97.50	97.50	0.00	(0,0)	-	-	-	-	-	-	-
51-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
101-500	183	21	68.59	29.73	68.59	3.41	(63,74)	48	9	79.90	60.00	90.27	3.42	(74,86)
501-1000	24	3	82.13	74.15	88.74	4.27	(70,95)	18	3	77.24	82.55	80.45	1.63	(72,82)
1001-5000	69	13	83.32	49.05	99.25	4.66	(75,92)	45	3	74.10	62.90	90.63	8.26	(51,99)
> 5000	12	2	71.27	63.64	78.90	7.63	(23,100)	-	-	-	-	-	-	-
	TREATMENT: TF							TREATMENT: TF						
	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.	N	OBSV	MEAN	MIN	MAX	SE	90% C.I.
0-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-100	6	1	17.20	17.20	17.20	0.00	(0,0)	-	-	-	-	-	-	-
101-500	42	6	47.20	30.77	75.17	6.27	(34,60)	12	2	69.25	65.49	73.01	3.76	(46,93)
501-1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1001-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 6-2
PERCENT OF INFLUENT PARTITIONED TO SLUDGE AND VOLATILIZED
IN ACTIVATED SLUDGE TREATMENT PLANTS

COMPOUND	PERCENT OF INFLUENT VOLATILIZED	PERCENT OF INFLUENT PARTIONED TO SLUDGE
** METALS (ANION)		
ARSENIC	0	50
SELENIUM	0	50
** METALS (CATION)		
ANTIMONY	0	0
BARIUM	0	90
CADMIUM	0	27
CHROMIUM	0	70
LEAD	0	30
MERCURY	0	50
NICKEL	0	35
SILVER	0	90
** MISCELLANEOUS		
CYANIDE	1	90
** PCBs		
PCB-1016	9	34
PCB-1221	9	34
PCB-1232	9	34
PCB-1242	9	34
PCB-1248	9	8
PCB-1254	9	8
PCB-1260	9	8
** PESTICIDES (HERBICIDE)		
DNBP	0	7
** PESTICIDES (ORGANOHALIDE)		
2,4,5-TRICHLOROPHENOXYACETIC ACID	0	7
2,4-DICHLOROPHENOXYACETIC ACID	0	7
ALDRIN	0	33
CAPTAN	0	7
CHLORODANE	9	33
ENDRIN	0	35
METHOXYCHLOR	54	8
TOXAPHENE	57	4
TRIFLURALIN	0	33
** PESTICIDES (ORGANOPHOSPHOROUS)		
DIAZINON	0	7
DICHLORVOS	0	9
DISULFOTON	0	7
FENTHION	0	6
MEVINPHOS	0	9
NALED	0	8
PARATHION	0	0
PHORATE	0	7
** SEMI-VOLATILES (ACID)		
2,4,6-TRICHLOROPHENOL	0	8
2,4-DICHLOROPHENOL	0	8
2,4-DIMETHYLPHENOL	0	8
2,4-DINITROPHENOL	0	9
2-CHLOROPHENOL	0	8
CRESOLS	0	8
PENTACHLOROPHENOL	0	17
PHENOL	0	14
RESORCINOL	0	10
** SEMI-VOLATILES (BASE)		
BENZENAMINE	0	10
DIPHENYLAMINE	0	7
N-NITROSODIMETHYLAMINE	0	9
P-NITROANILINE	0	0
PYRIDINE	0	2
** SEMI-VOLATILES (NEUTRAL)		
1,2,4-TRICHLOROBENZENE	42	8
1,2-DICHLOROBENZENE	45	32
1,3-DICHLOROBENZENE	45	3
1,4-DICHLOROBENZENE	45	22
2-CHLORONAPHTHALENE	1	35

TABLE 6-2 (CONTINUED)
PERCENT OF INFLUENT PARTITIONED TO SLUDGE AND VOLATILIZED
IN ACTIVATED SLUDGE TREATMENT PLANTS

COMPOUND	PERCENT OF INFLUENT VOLATILIZED	PERCENT OF INFLUENT PARTIONED TO SLUDGE
ACENAPHTHYLENE	19	9
ANTHRACENE	0	52
BIS(2-CHLOROETHOXY)METHANE	0	1
BIS(2-CHLOROETHYL) ETHER	1	9
BIS(2-ETHYLHEXYL) PHTHALATE	0	66
BUTYL BENZYL PHTHALATE	0	43
DIETHYL PHTHALATE	0	1
ETHYLENETHIOUREA	0	8
HEXACHLOROBUTADIENE	1	9
HEXACHLOROETHANE	1	9
NAPHTHALENE	1	27
NITROBENZENE	0	9
** VOLATILES		
1,1,1,2-TETRACHLOROETHANE	48	4
1,1,1-TRICHLOROETHANE	76	9
1,1,2,2-TETRACHLOROETHANE	36	4
1,1,2-TRICHLOROETHANE	40	0
1,1-DICHLOROETHANE	63	0
1,1-DICHLOROETHENE	76	0
1,2,3-TRICHLOROPROPANE	30	6
1,2-DICHLOROETHANE	45	4
1,2-DICHLOROPROPANE	45	0
1,4-DIOXANE	0	9
2-BUTANONE	1	10
2-PICOLINE	1	8
2-PROPANONE	1	10
2-PROPENAL	1	10
2-PROPENENITRILE	0	0
BENZENE	24	2
BROMOMETHANE	86	0
CARBON DISULFIDE	76	1
CHLOROBENZENE	27	14
CHLOROETHANE	76	1
CHLOROFORM	63	2
CHLOROMETHANE	86	1
DIBROMOMETHANE	42	13
ETHYLBENZENE	24	0
METHYLENE CHLORIDE	38	13
STYRENE	22	14
TETRACHLOROETHENE	45	3
TETRACHLOROMETHANE	72	12
TOLUENE	24	27
TRANS-1,2-DICHLOROETHENE	63	49
TRIBROMOMETHANE	36	5
TRICHLOROETHENE	66	6
TRICHLOROFLUOROMETHANE	76	0
VINYL CHLORIDE	86	2
XYLENES	24	14

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SECTION 7

COMPUTER SOFTWARE PACKAGES

SECTION 7 - COMPUTER SOFTWARE PACKAGES. Section 7 presents a list of computer software packages that may aid POTW authorities and regulatory agencies in developing local limits. Local limits can be used to determine the level of pretreatment required at a CERCLA site.

COMPUTER SOFTWARE PACKAGES

- Wastewater Data Management System. This software package was reviewed in the April issue of Pollution Engineering magazine. It is IBM PC/XT-, AT-compatible, costs about $2,000, and rated very highly except for ease of use, initially. For more information, contact WDMS Computer Services, P.O. Box 27561, Tulsa, Oklahoma 74149, (918) 241-5755.

- Pretreatment. This software package was written by a USEPA pretreatment coordinator. It is IBM PC-, PC/XT-, or PC/AT-compatible and costs about $2,500. For more information, contact Spica Systems, 4921 Seminary Road, Suite 1502, Alexandria, Virginia 22311, (703) 671-5874.

- PCME Software. This is a package developed by USEPA to go along with the PCME guidance and training. It is IBM PC-, PC/XT-, or PC/AT-compatible and will be essentially free. For more information, contact Richard Kinch at (203) 475-8319.

- PRELIM. This is a USEPA product for use in developing local limits. It is IBM PC-, PC/XT-, or PC/AT-compatible. For more information, call (202) 475-9539.

- PRETRE. This is a comprehensive package that is IBM PC-, PC/XT-, and PC/AT-compatible and costs about $2,500. For more information, contact Jay Fink, Cochran Associates, Inc., 236 Huntington Avenue, Boston, Massachusetts 02115, (617) 247-0444.

- Operator Ten. This is a package that requires minimal development, is IBM PC-, PC/XT-, and PC/AT-compatible, and costs about $2,500. For more information, contact Don G. Knaur, Macola Inc., 196 S. Main Street, P.O. Box 485, Marion, Ohio 43302, (800) 468-0834.

- Integrated Model For Predicting The Fate Of Organics In Wastewater Treatment Plants. This software package is currently being developed by the USEPA Office of Research and Development. For more information contact Richard Dobbs at (513) 569-7649.

- FATE. The Fate and Treatability Estimator (FATE) model predicts the fate of pollutants in activated sludge POTWs and is contained in Section 14. This IBM PC-compatible software was developed by C-E Environmental, Inc. for the USEPA Industrial Technology Division (ITD). For more information, contact ITD at (202) 382-7149.

SECTION 8

PHYSICAL/CHEMICAL CONSTANTS OF COMPOUNDS

SECTION 8 - PHYSICAL/CHEMICAL CONSTANTS OF COMPOUNDS. Section 8 presents the compound name, the molecular weight, Henry's Law Constant, Log octanol/water coefficient (Kow), and solubility of compounds where information was available for compounds on the ITD list of analytes (Section 9). Values of Henry's Law constant and Log Kow were extracted from various EPA publications (i.e., Treatability Manual; Vols. 1-5; USEPA 600/2 82-001A through 600/2 82-042; September-October 1986 and "Superfund Public Emergency and Remedial Response; USEPA/540/1-86/060; 1986) and in most cases, were measured values.

The physical and chemical constants of compounds detected in CERCLA wastestreams can be used to evaluate a compound's fate in a POTW where no other data are available. The compound's fate can be estimated by using its physical and chemical constants (as well as its compound class) to locate similar compounds for which fate (percent removal) data are available.

TABLE 8-1
CHEMICAL AND PHYSICAL PROPERTIES

REGULATORY NAME	MOLECULAR WEIGHT (g/mole)	HENRY'S LAW COEF. (atm m3/mole)	LOG KOW	SOLUBILITY (ppm)	SOLUBILITY TEMP (CELCIUS)
** DIOXINS					
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin					
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin					
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin					
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin					
1,2,3,7,8-Pentachlorodibenzo-p-dioxin					
Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-	322	3.60x10E-03	6.72	0.0002	
Hexachlorodibenzo-p-dioxins					
Hexachlorodibenzofurans					
Pentachlorodibenzo-p-dioxins					
Pentachlorodibenzofurans					
Tetrachlorodibenzo-p-dioxins					
Tetrachlorodibenzofurans					
** METALS (ANIONS)					
Arsenic	75				
Boron	10.81				
Chlorine	35.45				
Iodine	126.9				
Phosphorus (black, white, red, yellow, or violet)	30.97				
Selenium	79				
Silicon	28.09				
Sulfur	32.06				
** METALS (CATIONS)					
Aluminum	26.98				
Antimony	122				
Barium	137				
Beryllium	9				
Bismuth	208.98				
Cadmium	112				
Calcium	40.08				
Cerium	140.12				
Chromium	52				
Cobalt	58.93				
Copper	64				
Dysprosium	162.5				
Erbium	167.26				
Europium	151.96				
Gallium	69.72				
Germanium	72.59				
Gold	196.97				
Hafnium	178.49				
Holmium	164.93				
Hydrogen ion					
Indium	114.82				
Iridium	192.2				
Iron	56				
Lanthanum	138.91				
Lead	207				
Lithium	6.94				
Lutetium	174.97				
Magnesium	24.31				
Manganese	55				
Mercury	201				
Molybdenum	95.94				

TABLE 8-1 (CONTINUED)
CHEMICAL AND PHYSICAL PROPERTIES

REGULATORY NAME	MOLECULAR WEIGHT (g/mole)	HENRY'S LAW COEF. (atm m3/mole)	LOG KOW	SOLUBILITY (ppm)	SOLUBILITY TEMP (CELCIUS)
Neodymium	144.24				
Nickel	59				
Niobium	92.91				
Osmium	190.2				
Palladium	106.4				
Platinum	195.09				
Potassium	39.1				
Praseodymium	140.91				
Rhenium	186.2				
Rhodium	102.91				
Ruthenium	101.07				
Samarium	150.35				
Scandium	44.96				
Silver	108				
Sodium	22.99				
Strontium	87.62				
Tantalum	180.95				
Tellurium	127.6				
Terbium	158.92				
Thallium	204				
Thorium	232.04				
Thulium	168.93				
Tin	118.69				
Titanium	47.9				
Tungsten	183.85				
Uranium	238				
Vanadium	51				
Ytterbium	173.04				
Yttrium	88.91				
Zinc	65				
Zirconium	91.22				
** MISCELLANEOUS					
Ammonia	17.03				
Asbestos					
Biochemical Oxygen Demand					
Chemical Oxygen Demand					
Chloramine					
Chloride					
Chlorine dioxide	67.45				
Chlorite					
Copper cyanide (CuCN)	115.58				
Corrosivity					
Cryptosporidium					
Cyanides (soluble salts and complexes) NOS					
Cyanogen chloride					
Disodium cyanodithioimidocarbonate					
Fluoride					
Hypochlorite ion					
Ignitability					
Nitrate/nitrite					
Nitrites					
Oil and grease					
Oil and grease					
Reactivity					
Residue, filterable					

TABLE 8-1 (CONTINUED)
CHEMICAL AND PHYSICAL PROPERTIES

REGULATORY NAME	MOLECULAR WEIGHT (g/mole)	HENRY'S LAW COEF. (atm m3/mole)	LOG KOW	SOLUBILITY (ppm)	SOLUBILITY TEMP (CELCIUS)
Residue, non-filterable					
Residue, total					
Specific conductivity					
Sulfide					
Total organic carbon					
Total volatile organic carbon					
** PCB					
PCB-1016	257.9	1.8x10E-04	4.38	0.049	24C
PCB-1221	200.7	3.24x10E-04	4.08	0.59	24C
PCB-1232	232.2	8.64x10E-04	4.54	1.45	25C
PCB-1242	266.5	5.7x10E-04	4.11	0.10	24C
PCB-1248	299.5	3.5x10E-03	5.60	0.054	25C
PCB-1254	328.4	2.8x10E-03	6.04	0.057	24C
PCB-1260	375.7	7.1x10E-03	7.15	0.08	24C
** PESTICIDES (CARBAMATES)					
Ethylenebisdithiocarbamic acid, salts and esters					
Diallate \ Avadex	274	1.65x10E-04	0.73	14	
Nabam	256.34				
Maneb \ Vancide	265.3				
Zineb \ Dithane Z	275.73				
Busan 85					
Carbamic acid, methyldithio-, monopotassium salt					
Carbamic acid, dimethyldithio-, sodium salt					
Thiram \ Thiuram \ Arasan	240.41	Low	Low		
Ziram \ Cymate	273.59				
** PESTICIDES (HERBICIDES)					
2,4-D \ Acetic acid, (2,4-dichlorophenoxy)-	221	1.88x10E-04	2.81	620	
Pronamide \ Kerb	256.14				
DNBP \ Dinoseb \ 2-sec-butyl-4,6-dinitrophenol	240	1.20x10E-03		50	
Dinex \ DN-111 \ 2-Cyclohexyl-4,6-dinitrophenol	266.25				
2,4,5-TP \ Silvex	269.51			140	25C
** PESTICIDES (ORGANOHALIDES)					
Isodrin (Stereoisomer of Aldrin)					
Mirex \ Dechlorane					
Kepone	490.6		2.00	0.010	
Dichlone \ Phygon	227			Insoluble	
Endrin	380.9	0.5x10E-06	5.6	0.26	25C
Aldrin	365	1.6x10E-05	5.30	0.017-0.18	25C
2,4,5-T \ Weedone \ Acetic acid, 2,4,5-trichlorophenoxy-	255.48			278	25C
Heptachlor epoxide	389.3	4.39x10E-04	2.70	0.35	25C
Dieldrin	381	4.58x10E-07	3.50	0.20	25C
Alachlor \ Metachlor \ Lasso					
4,4'-DDD/Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-	320	7.96x10E-06	6.20	0.02-0.09	25C
4,4'-DDE/Benzene, 1,1'-(dichloroethenlyidine)bis[4-chloro	318	6.8x10E-05	7.00	0.040	20C
4,4'-DDT/Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro	354.5	5.13x10E-04	6.19	0.0031	25C
Chlordane	409.8	9.63x10E-06	3.32	0.056-1.85	25C
Heptachlor	373.3	8.19x10E-04	4.40	0.18	25C
Captafol \ Difolatan					
Captan	300.6	4.7x10E-05	2.35	0.5	25C

TABLE 8-1 (CONTINUED)
CHEMICAL AND PHYSICAL PROPERTIES

REGULATORY NAME	MOLECULAR WEIGHT (g/mole)	HENRY'S LAW COEF. (atm m3/mole)	LOG KOW	SOLUBILITY (ppm)	SOLUBILITY TEMP (CELCIUS)
Methoxychlor					
Chlorobenzilate \ Ethyl-4,4'-dichlorobenzilate	325.2				
Lindane \ gamma-BHC \ Hexachlorocyclohexane (gamma)	290.8	7.85x10E-06	3.90	17.0	24C
alpha-BHC	290.8	5.87x10E-06	3.90	1.63	25C
delta-BHC	290.8	2.07x10E-07	4.10	21.3	25C
beta-BHC	290.8	4.47x10E-07	3.90	0.70	25C
6,9-Methano-2,3,4-benzodioxathiepin, 6,7	423		3.66	0.117	
Thiodan I					
Thiodan II					
Endrin aldehyde					
Endrine ketone					
Nitrofen \ TOK					
Camphechlor	414	4.89x10E-03	3.3	0.5	25C
o,p'-DDT					
Trifluralin \ Treflan					
** PESTICIDES (ORGANOPHOSPHOROUS)					
Coumaphos \ Co-Ral	362.8	3.2x10E-08		1.5	25C
Crotoxyphos \ Ciodrin					
Mevinphos \ Phosdrin	224.2			Miscible	25C
Phosphorodithioic acid, O,O,S-triethyl ester					
Phosphorodithioic acid, O,O-diethyl S-methyl ester					
Zinophos \ Thionazin					
PCNB \ Terraclor \ Quintozene	295	6.18x10E-04	5.45	0.071	
Phosacetin					
Trichlorofon \ Dylox	257	1.71x10E-11	2.29	154,000	25C
Naled \ Dibrom	380.8			Almost Ins	
Dichlorvos \ DDVP	221	3.4x10E-07		10,000	20C
Tetrachlorvinphos \ Gardona					
Chlorfenvinphos \ Supona					
Dicrotophos \ Bidrin					
Monocrotophos \ Azodrin					
Phosphamidon \ Dimecron					
Tricresylphosphate \ TCP \ TOCP					
Trimethylphosphate					
Hexamethylphosphoramide \ HMPA					
Demeton \ Systox					
Diazinon \ Spectracide	304.4	1.4x10E-06		40	20C
Chlorpyrifos \ Dursban	350.6	4.1x10E-06		2	35C
Fensulfothion \ Desanit					
Phorate \ Thimet	260.4			50	
Disulfoton	274.4	2.5x10E-06		25	23C
Azinphos-ethyl \ Ethyl Guthion					
Terbufos \ Counter					
Azinphos-methyl \ Guthion	317.3	3.8x10E-06		33	25
Phosmet \ Imidan					
Cygon \ Dimethoate	229		2.71	25,000	
Fenthion \ Baytex					
Ethion \ Bladan	384.5			Slightly	
Dioxathion					
Carbophenothion \ Trithion					
Parathion \ Parathion, ethyl	291.3	6.1x10E-07		24	25C
Methyl parathion \ Parathion-methyl \ Metaphos	263.2	5.59x10E-08	1.91	60	25C
Famphur \ Famophos					
Leptophos \ Phosvel					
EPN \ Santox					

TABLE 8-1 (CONTINUED)
CHEMICAL AND PHYSICAL PROPERTIES

REGULATORY NAME	MOLECULAR WEIGHT (g/mole)	HENRY'S LAW COEF. (atm m3/mole)	LOG KOW	SOLUBILITY (ppm)	SOLUBILITY TEMP (CELCIUS)
Malathion \ Sumitox	330.36		2.89	145	25C
TEPP \ Phosphoric acid, tetraethyl ester	290.2			Miscible	
Sulfotepp \ Bladafum \ Tetraethyldithiopyrophosphate	322.31			25-66	20C
** SEMI-VOLATILES (ACIDS)					
2,3,4,6-Tetrachlorophenol	231.89		4.1	1,000	
2,3,6-Trichlorophenol	197.46				
2,4,5-Trichlorophenol	197.45	2.18x10E-04	3.72	1190	25C
2,4,6-Trichlorophenol	197.45	4.0x10E-06	3.87	800	25C
2,4-Dichlorophenol	163.0	2.75x10E-06	2.90	4,500	25C
2,4-Dimethylphenol	122.17	2.52x10E-06	2.50	1,000	20C
2,4-Dinitrophenol	184.11	6.45x10E-10	1.53	5,600	18C
2,6-Dichlorophenol	163.0				
2-Chlorophenol	128.56	4.7x10E-06	2.17	28,500	20C
4-Chloro-3-methylphenol	142.59	2.5x10E-06	3.13	3,850	20C
4-Nitrophenol	139.11		1.91	16,000	25C
Benzoic acid	122.1	1.82x10E-08		2,900	20C
Benzonitrile, 3,5-dibromo-4-hydroxy-	276.92				
Hexanoic acid	116.16				
Pentachlorophenol	266.34	2.8x10E-06	5.04	14	20C
Phenol	94.11	4.54x10E-07	1.48	80,000	25C
Phenol, 2-methyl-4,6-dinitro-	198.13	4.49x10E-05	2.70	250	
Resorcinol	110.11	1.0x10E-13	0.80	2,290,000	30C
Sulfurous acid, 2-chloroethyl-, 2-[4-(1,1-dimethylethyl) phenoxy]-1-methylethyl ester	334.87				
m-Cresol	108.15				
o-Cresol	108.14			31,000	40C
p-Cresol	108.14			24,000	40C
** SEMI-VOLATILES (BASES)					
1,1'-Biphenyl-4,4'-diamine, 3,3'-dimethoxy	244	1x10E-11	1.46		
1,2,4,5-Tetrachlorobenzene	215.89		4.67	0.3	22C
1,2-Diphenylhydrazine	184.24	3.42x10E-09	2.90	1840	
1,2-Ethanediamine, N,N-dimethyl-N'-2pyridinyl-N'-(2-thienylmethyl)-	261.39				
1,3-Benzenediamine, 4-methyl-	122	1.28x10E-10	0.35	47,700	
1,3-Benzodioxole, 5-(1-propenyl)-	168	3.25x10E-12	2.66	1090	
1,4-Dichlorobenzene	147.0	3.1x10E-03	3.60	79	25C
1,5-Naphthalenediamine	158.21				
1-Naphthylamine	143	5.21x10E-09	2.07	2350	
2,3-Dichloroaniline	162.02				
2,6-Dinitrotoluene	182.1	3.27x10E-06	2.05	270	22C
2,6-dichloro-4-nitroaniline	207.02				
2-(Methylthio)benzothiazole					
2-Chloronaphthalene	162.5	3.15x10E-04	4.12	6.74	25C
2-Nitroaniline	138.13				
3,3'-Dichlorobenzidine	253.13	8.33x10E-07	3.50	4.0	22C
3-Nitroaniline	267				
4,4'-Methylenebis(2-chloroaniline)					
4-Chloro-2-nitroaniline					
5-Nitro-o-toluidine	152				
7,12-Dimethylbenz(a)anthracene	256		6.94	0.0004	
Acetamide, N-(4-ethoxyphenyl)-	179.21			760	
Ammonium, (4-(p-(dimethylamino)-alpha-phenylbenzylidine)-2,5-cylcohexadien-1-ylidene)-dimethyl chloride					
Aniline, 2,4,5-trimethyl-					

TABLE 8-1 (CONTINUED)
CHEMICAL AND PHYSICAL PROPERTIES

REGULATORY NAME	MOLECULAR WEIGHT (g/mole)	HENRY'S LAW COEF. (atm m3/mole)	LOG KOW	SOLUBILITY (ppm)	SOLUBILITY TEMP (CELCIUS)
Benzenamine	93.1	1.1x10-E06	0.98	35,000	25C
Benzenamine, 4-chloro-	127.57		1.83		
Benzenamine, N,N-dimethyl-4-(pehnylazo)-	225	7.19x10E-09	3.72	13.6	
Benzenethiol	110.17		2.52	470	15C
Benzidine	184.23	3.03x10E-07	1.30	400	12C
Carbazole	167.21				
Di-n-propylnitrosamine	130.19	6.92x10E-06	1.50	9,900	25C
Diphenylamine	169	1.47x10E-07	3.60	57.6	
N-Nitrosodi-n-butylamine					
N-Nitrosodiethylamine	102	Low	0.48		
N-Nitrosodimethylamine	74.08	7.9x10E-07	0.68	Miscible	25C
N-Nitrosodiphenylamine	198.23		2.57		
N-Nitrosomethylethylamine					
N-Nitrosomethylphenylamine					
N-Nitrosomorpholine					
N-Nitrosopiperidine	114	1.11x10E-08	-0.49	1,900,000	
Nitrobenzene	123.1	1.3x10E-05	1.85	1,900	20C
Phenothiazine	199.28				
Propane, 1,2-dibromo-3-chloro-	236	3.11x10E-04	2.29	1,000	
Pyridine	79.10	7.0x10E-09	0.66	Miscible	
Thioxanthe-9-one					
[1,1'-Biphenyl]-4-amine	169.0	1.59x10E-08	2.78	842	
beta-Naphthylamine	143.0	8.23x10E-08	2.07	586	
o-Anisidine	123.16				
o-Toluidine	107.16				
o-Toluidine, 5-chloro-	141.61				
p-Nitroaniline	138.13	1x10E-06	1.39		
** SEMI-VOLATILES (NEUTRAL)					
1,2,3-Trichlorobenzene	181.45				
1,2,3-Trimethoxybenzene	168.2				
1,2,4-Trichlorobenzene	181.4	2.3x10E-03	4.28	12	22C
1,2-Benzenedicarboxylic acid, dibutyl ester	278.35	2.8x10E-07	5.6	13	25C
1,2-Benzenedicarboxylic acid, dimethyl ester	194.2	2.10x10E-07	2.12	5,000	20C
1,2-Dichlorobenzene	147.0	1.93x10E-03	3.60	145	25C
1,2:3,4-Diepoxybutane	86.09				
1,3,5-Trithiane	138.27				
1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	272.8	1.37x10E-03	5.04	1.8	25C
1,3-Dichloro-2-propanol	128.99				
1,3-Dichlorobenzene	147.0	3.59x10E-03	3.56	123	25C
1,3-Dinitrobenzene	168		1.62	470	
1,4-Naphthoquinone	158.16				
1-Chloro-3-nitrobenzene	157.56				
1-Methylfluorene	180.25				
1-Methylphenanthrene	192.26				
1-Phenylnaphthalene	204.28				
17-alpha-19-Norpregna-1,3,5(10)-trien-20-yn-17-ol, 3-methoxy-					
2,3-Benzofluorene	216.29				
2,3-Dichloronitrobenzene	192				
2,4-Dinitrotoluene	182.1	5.09x10E-06	2.01	270	22C
2,6-di-tert-Butyl-p-benzoquinone	222.23				
2,7-Dimethylphenanthrene	206.28				
2-Isopropylnaphthalene	170.25				
2-Methylbenzothioazole					
2-Methylnaphthalene	142.20				

TABLE 8-1 (CONTINUED)
CHEMICAL AND PHYSICAL PROPERTIES

REGULATORY NAME	MOLECULAR WEIGHT (g/mole)	HENRY'S LAW COEF. (atm m3/mole)	LOG KOW	SOLUBILITY (ppm)	SOLUBILITY TEMP (CELCIUS)
2-Nitrophenol	139.11	1.44x10E-05	1.76	2,100	20C
2-Phenylnaphthalene	204.28				
3,3'-Dichloro-4,4'-diaminodiphenyl ether					
3,6-Dimethylphenanthrene	206.28				
4,5-dimethyl phenanthrene	206.28				
4-Bromophenyl phenyl ether	249.1		4.28		
4-Chlorophenylphenyl ether	204.66		4.08	3.3	25C
Acenaphthene	154.2	9.2x10E-05	4.33	3.42	25C
Acenaphthylene	152.2	1.45x10E-03	4.07	3.93	25C
Anthracene	178.2	1.02x10E-03	4.48	1.29	25C
Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-					
Benzanthrone					
Benzo(a)anthracene	228.3	1.38x10E-09	5.61	0.014	25C
Benzo(a)pyrene	252.3	1.38x10E-09	6.04	0.0038	25C
Benzo(b)fluoranthene	252.3	2.01x10E-05	6.06	0.0012	25C
Benzo(ghi)perylene	276.0	5.34x10E-08	6.51	0.00026	25C
Benzo(k)fluoranthene	252.3	3.94x10E-05	6.06	0.00055	25C
Benzyl alcohol	108.15	6.10x10E-07		35,000	
Biphenyl	154.2	1.01x10E-01		2.0	
Biphenyl, 4-nitro	199.21				
Butyl benzyl phthalate	312.4	1.0x10E-06	4.80	2.9	25C
Chloropicrin	164.38				
Chrysene	228.3	1.05x10E-06	5.61	0.006	25C
Di-n-octyl phthalate	391.0	3.0x10E-07	9.2	3	25C
Dibenzo(a,h)anthracene	278.4	7.33x10E-08	6.80	0.0005	25C
Dibenzofuran	168.21				
Dibenzothiophene	184.27				
Diethyl phthalate	222.24	1.14x10E-06	2.50	896	25C
Dimethyl sulfone	218.28				
Diphenyl ether	170.21	2.24x10E-03		2.0	
Diphenyldisulfide	218.34				
Ethane, pentachloro-	202.3	2.17x10E-03	3.67		
Ethanethioamide	75.13		-0.46	140,000	25C
Ethanone, 1-phenyl	120.14	3.3x10E-07	1.58	Insoluble	
Ethylenethiourea	102		-0.66	2,000	
Fluoranthene	202.3	6.46x10E-06	4.90	0.26	25C
Fluorene	166.23	1.78x10E-06	4.18	1.98	25C
Hexachlorobenzene	284.8	6.81x10E-04	5.23	0.11	24C
Hexachlorobutadiene	260.8	2.56x10E-02	4.57	2	20C
Hexachloroethane	236.7	2.49x10E-03	4.62	50	22C
Hexachloropropene	249.76				
Indeno(1,2,3-cd)pyrene	276.3	6.86x10E-08	6.50	0.62	25C
Isophorone	138.2	5.8x10E-06	1.7	12,000	
Longifolene	204.36				
Methanesulfonic acid, ethyl ester	124	9.12x10E-08	0.21	369,000	
Methyl methanesulfonate					
N,N-Dimethylformamide	73.09				
Naphthalene	128.2	4.8x90E-04	3.34	30.0	25C
Pentachlorobenzene	250	7.30x10E-03	5.19	0.135	
Pentamethylbenzene	148.25				
Perylene	252.32				
Phenanthrene	178.2	1.59x10E-04	4.46	0.816	21C
Pyrene	202.26	5.04x10E-06	4.88	0.16	26C
Safrole	162.19	1.29x10E-07	2.53	1,500	
Squalene	410.74				
Thianaphthene					

TABLE 8-1 (CONTINUED)
CHEMICAL AND PHYSICAL PROPERTIES

REGULATORY NAME	MOLECULAR WEIGHT (g/mole)	HENRY'S LAW COEF. (atm m3/mole)	LOG KOW	SOLUBILITY (ppm)	SOLUBILITY TEMP (CELCIUS)
Triphenylene	228.29				
Tripropyleneglycol methyl ether					
alpha-Terpineol	154.26				
bis(2-Chloroethoxy)methane	173.1	2.7x10E-07	1.26	81,000	25C
bis(2-Chloroethyl) ether	143.01	1.3x10E-05	1.46	10,200	25C
bis(2-Chloroisopropyl) ether	171.07	1.13x10E-04	2.10	1,700	
bis(2-Ethylhexyl) phthalate	390.54	3.0x10E-07	8.70	0.285	24C
n-Decane	142.29				
n-Docosane	310.61				
n-Dodecane	170.34				
n-Eicosane	282.56				
n-Hexacosane	366.72				
n-Hexadecane	226.45				
n-Octacosane	394.78				
n-Octadecane	254.51				
n-Tetracosane	338.67				
n-Tetradecane	198.4				
n-Triacontane	422.83				
p-Cymene	134.22				
** VOLATILES					
1,1,1,2-Tetrachloroethane	167.85	3.81x10E-04	3.04	200	20C
1,1,1-Trichloroethane	133.4	1.44x10E-02	2.49	4,400	20C
1,1,2,2-Tetrachloroethane	167.8	3.8x10E-04	2.39	2,900	20C
1,1,2-Trichloroethane	133.4	1.17x10E-03	2.47	4,500	20C
1,1-Dichloroethane	98.96	4.26x10E-03	1.80	5,500	20C
1,1-Dichloroethene	96.94	3.4x10-02	1.84	210	25C
1,2,3-Trichloropropane	147.43		2.01		
1,2-Dibromoethane	187.9	6.73x10E-04	1.76	4,310	30C
1,2-Dichloroethane	98.98	9.78x10E-04	1.53	8,690	20C
1,2-Dichloropropane	113.0	2.31x10E-03	2.00	2,700	20C
1,3-Dichloropropane	112.99				
1,4-Dioxane	88	1.07x10E-05	0.001		
1-Bromo-2-chlorobenzene	191.46				
1-Bromo-3-chlorobenzene	191.46				
1-Propene, 3-chloro-	76.53	0.4		3,600	
2-Butanone	72	2.74x10E-05	0.26	268,000	
2-Butenal	70.1	1.4x10E-05		180,000	20C
2-Butene, 1,4-dichloro (mixture of cis and trans)	125				
2-Chloro-1,3-butadiene	88.5				
2-Chloroethylvinyl ether	106.55	2.16x10E-05	1.28	6,000	
2-Hexanone	100.16				
2-Picoline	93.13	2.4x10E-05	1.20		
2-Propanone	58.08	2.06x10E-05	0.57	Miscible	
2-Propen-1-ol	58.08	3.69x10E-06	-0.22	5.10x10E5	
2-Propenal	56.1	6.79x10E-05	-0.097	208,000	20C
2-Propenenitrile	53.1	8.84x10E-05	0.25	73,500	20C
2-Propenenitrile, 2-methyl-	67.09				
4-Methyl-2-pentanone	100.16				
Benzene	78.11	5.55x10E-03	2.13	1,780,1800	25C
Bromodichloromethane	163.8	2.12x10E-03	1.88		
Bromomethane	94.94	1.06X10E-01	1.10	900	20C
Carbon disulfide	76.14	1.2x10E-02	2.00	2,940	20C
Chloroacetonitrile	75.5				
Chlorobenzene	112.56	3.72x10E-03	2.84	488	25C
Chloroethane	64.52	1.48x10E-02	1.54	5,740	20C

TABLE 8-1 (CONTINUED)
CHEMICAL AND PHYSICAL PROPERTIES

REGULATORY NAME	MOLECULAR WEIGHT (g/mole)	HENRY'S LAW COEF. (atm m3/mole)	LOG KOW	SOLUBILITY (ppm)	SOLUBILITY TEMP (CELCIUS)
Chloroform	119.4	3.39x10E-03	1.97	9,300	25C
Chloromethane	50.49	4.4x10E-02	0.95	6,450	20C
Dibromochloromethane	208.3	2.08x10E-03	2.09	0.2	
Dibromomethane	173.85	9.98x10E-04		11,000	
Dichloroiodomethane	210.83				
Diethyl ether	74.12				
Ethyl cyanide	55.08				
Ethyl methacrylate	114.15				
Ethylbenzene	106.2	6.44x10E-03	3.15	152	20C
Iodomethane	142	5.34x10E-03	1.69	14,000	
Isobutyl alcohol	74				
Methyl methacrylate	100.13	2.43x10E-01	0.79		20C
Methylene chloride	84.94	2.03x10E-03	1.30	16,700	25C
Styrene	104.1	9.7x10E-03	2.95	300	20C
Tetrachloroethene	165.8	2.59x10E-02	2.6	150	20C
Tetrachloromethane	153.8	23x10E-02	2.64	785	20C
Toluene	92.13	6.7x10E-03	2.73	515	20C
Total xylenes	106.2	5.1x10E-03	2.8-3.2	Insoluble	
Tribromomethane	252.8	5.52x10E-04	2.4	3,200	30C
Trichloroethene	131.4	9.10x10E-03	2.38	1,100	25C
Trichlorofluoromethane	137.4	5.8x10E-02	2.53	1,100	25C
Vinyl acetate	86.10	6.20x10E-04		20,000	20C
Vinyl chloride	62.5	8.19x10E-02	1.38	1.1	25C
cis-1,3-Dichloropropene	111.0	3.55x10E-03	1.98	2,700	25C
o + p xylene	106.2				
trans-1,2-Dichloroethene	96.94	6.6x10E-03	0.48	600	20C
trans-1,3-Dichloropropene	111.0	3.55x10E-03	1.98	2,800	25C
trans-1,4-Dichloro-2-butene					

SECTION 9

USEPA CONTAMINANT LISTS

SECTION 9 - USEPA CONTAMINANT LISTS. Section 9 presents several commonly referenced lists of compounds: a) the ITD List of Analytes, taken from "The 1987 Industrial Technology Division List of Analytes"; USEPA Industrial Technology Division; Office of Water Regulations and Standards; Washington, D.C.; March 1987, b) the Target Compound List (TCL), is a list generally used by the CERCLA program, which contains compounds commonly found at CERCLA sites, c) the Priority Pollutant List, was developed by the USEPA Office of Water and lists organic toxic pollutants, d) the "Appendix VIII List", a list of the RCRA hazardous constituents as defined in the Federal Register, Volume 51, Number 151 Appendix VIII, and e) the "Section 110 SARA List", a list of 100 hazardous substances as defined by Section 110 of SARA in the Federal Register, Volume 52, Number 74.

Tables 9-1 through 9-4 present the ITD list analytes in various formats. Table 9-1 lists the compounds according to their compound classification (volatiles, semi-volatiles, elements, etc). Within each compound classification, the compounds are listed alphabetically according to each compound's Regulatory Name. The CAS Number and Common Name are also listed to help locate the specific compound of interest. To further aid the user in locating the compound of interest, Tables 9-2 through 9-4 are also presented. Table 9-2 lists the compounds according to the CAS Number. The Regulatory Name, Common Name, and Compound Class are also included. Table 9-3 lists the compounds alphabetically according to the Common Name and also includes the Regulatory Name, Compound Class, and CAS Number. Table 9-4 lists the ITD inorganic contaminants.

Tables 9-5 through 9-8 present the remaining lists mentioned above.

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
** DIOXINS		
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	37871004	1,2,3,4,6,7,8-HpDD
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1-030	1,2,3,4,7,8-HxDD
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653857	1,2,3,6,7,8-HxDD
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408743	1,2,3,7,8,9-HxDD
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321764	1,2,3,7,8-PeDD
Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-	1746016	Dioxin \ TCDD \ 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Hexachlorodibenzo-p-dioxins	1-200	Hexachlorodibenzo-p-dioxins
Hexachlorodibenzofurans	1-201	Hexachlorodibenzofurans
Pentachlorodibenzo-p-dioxins	1-289	Pentachlorodibenzo-p-dioxins
Pentachlorodibenzofurans	1-290	Pentachlorodibenzofurans
Tetrachlorodibenzo-p-dioxins	1-331	Tetrachlorodibenzo-p-dioxins
Tetrachlorodibenzofurans	1-332	Tetrachlorodibenzofurans
** METALS (ANIONS)		
Arsenic	7440382	As
Boron	7440428	B
Chlorine	7782505	Chlorine
Iodine	7553562	I
Phosphorus (black, white, red, yellow, or violet)	7723140	P
Selenium	7782492	Se
Silicon	7440213	Si
Sulfur	7704349	S
** METALS (CATIONS)		
Aluminum	7429905	Al
Antimony	7440360	Sb
Barium	7440393	Ba
Beryllium	7440417	Be
Bismuth	7440699	Bi
Cadmium	7440439	Cd
Calcium	7440702	Ca
Cerium	7440451	Ce
Chromium	7440473	Cr
Cobalt	7440484	Co
Copper	7440508	Cu
Dysprosium	7429916	Dy
Erbium	7440520	Er
Europium	7440531	Eu
Gallium	7440553	Ga
Germanium	7440564	Ge
Gold	7440575	Au
Hafnium	7440586	Hf
Holmium	7440600	Ho
Hydrogen ion	1-006	pH
Indium	7440746	In
Iridium	7439885	Ir

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
Iron	7439896	Fe
Lanthanum	7439910	La
Lead	7439921	Pb
Lithium	7439932	Li
Lutetium	7439943	Lu
Magnesium	7439954	Mg
Manganese	7439965	Mn
Mercury	7439976	Hg
Molybdenum	7439987	Mo
Neodymium	7440008	Nd
Nickel	7440020	Ni
Niobium	7440031	Nb
Osmium	7440042	Os
Palladium	7440053	Pd
Platinum	7440064	Pt
Potassium	7440097	K
Praseodymium	7440100	Pr
Rhenium	7440155	Re
Rhodium	7440166	Rh
Ruthenium	7440188	Ru
Samarium	7440199	Sm
Scandium	7440202	Sc
Silver	7440224	Ag
Sodium	7440235	Na
Strontium	7440246	Sr
Tantalum	7440257	Ta
Tellurium	13494809	Te
Terbium	7440279	Tb
Thallium	7440280	Tl
Thorium	7440291	Th
Thulium	7440304	Tm
Tin	7440315	Sn
Titanium	7440326	Ti
Tungsten	7440337	W
Uranium	7440611	U
Vanadium	7440622	V
Ytterbium	7440644	Yb
Yttrium	7440655	Y
Zinc	7440666	Zn
Zirconium	7440677	Zr
** MISCELLANEOUS		
Ammonia	7664417	Ammonia
Asbestos	1332214	Asbestos
Biochemical Oxygen Demand	1-002	BOD
Chemical Oxygen Demand	1-004	COD
Chloramine	0-012	Chloramine

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
Chloride	1-003	Chloride
Chlorine dioxide	10049044	Chlorine oxide
Chlorite	0-011	Chlorite
Copper cyanide (CuCN)	544923	Copper cyanide
Corrosivity	1-014	Corrosivity
Cryptosporidium	0-039	Cryptosporidium
Cyanides (soluble salts and complexes) NOS	57125	Cyanides (soluble salts and complexes)
Cyanogen chloride	506774	Chlorine cyanide
Disodium cyanodithioimidocarbonate	138932	Disodium cyanodithioimidocarbonate
Fluoride	16984488	Fluoride
Hypochlorite ion	0-009	Hypochlorite ion
Ignitability	1-013	Ignitability
Nitrate/nitrite	1-005	Nitrate/nitrite
Nitrites	14797650	Nitrites
Oil and grease	1-007	O&G
Oil and grease	1-016	Retort
Reactivity	1-015	Reactivity
Residue, filterable	1-010	Total dissolved solids \ TDS
Residue, non-filterable	1-009	Total suspended solids \ TSS
Residue, total	1-008	Total solids
Specific conductivity	1-011	Conductivity, specific
Sulfide	18496258	Sulfide
Total organic carbon	1-012	TOC \ Organic carbon, total
Total volatile organic carbon	1-001	TVOA \ VOC \ Organic carbon, volatile
** PCB		
PCB-1016	12674112	Aroclor 1016
PCB-1221	11104282	Aroclor 1221
PCB-1232	11141165	Aroclor 1232
PCB-1242	53469219	Aroclor 1242
PCB-1248	12672296	Aroclor 1248
PCB-1254	11097691	Aroclor 1254
PCB-1260	11096825	Aroclor 1260
** PESTICIDES (CARBAMATES)		
Carbamodithioic acid, 1,2-ethanediylbis-, salts and esters	111546	Ethylenebisdithiocarbamic acid, salts and esters
Carbamothioic acid, bis(1-methylethyl)-S-(2,3-dichloro -2-propenyl) ester	2303164	Diallate \ Avadex
Ethylenebisdithiocarbamic acid, -sodium salt	142596	Nabam
Ethylenebisdithiocarbamic acid,-manganese salt	12427382	Maneb \ Vancide
Ethylenebisdithiocarbamic acid,-zinc salt	12122677	Zineb \ Dithane Z
Potassium dimethyldithiocarbamate	128030	Busan 85
Potassium-N-methyldithiocarbamate	137417	Carbamic acid, methyldithio-, monopotassium salt
Sodium dimethyldithiocarbamate	128041	Carbamic acid, dimethyldithio-, sodium salt
Thioperoxydicarbonic diamide, tetramethyl	137268	Thiram \ Thiuram \ Arasan
Zinc bis(dimethyldithiocarbamato)-	137304	Ziram \ Cymate

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
** PESTICIDES (HERBICIDES)		
2,4-Dichlorophenoxyacetic acid, salts and esters	94757	2,4-D \ Acetic acid, (2,4-dichlorophenoxy)-
Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-	23950585	Pronamide \ Kerb
Phenol, 2-(1-methylpropyl)-4,6-dinitro-	88857	DNBP \ Dinoseb \ 2-sec-butyl-4,6-dinitrophenol
Phenol, 2-cyclohexyl-4,6-dinitro-	131895	Dinex \ DN-111 \ 2-Cyclohexyl-4,6-dinitrophenol
Propanoic acid, 2-(2,4,5-trichlorophenoxy)-	93721	2,4,5-TP \ Silvex
** PESTICIDES (ORGANOHALIDES)		
1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5, 8-endo,endo-dimethanonaphthalene	465736	Isodrin (Stereoisomer of Aldrin)
1,3,4-Metheno-1H-cyclobuta[cd]pentalene, 1,1a,2,2,3,3a, 4,5,5,5a,5b,6,-dodecachlorooctahydro	2385855	Mirex \ Dechlorane
1,4-Naphthoquinone, 2,3-dichloro-	117806	Dichlone \ Phygon
1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro- 1a,2,2a,3,6,6a,7,8,8a-octahydro-endo,endo-	72208	Endrin
1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro- 1,4,4a,5,8,8a-hexahydro-endo,exo-	309002	Aldrin
2,4,5-Trichlorophenoxyacetic acid	93765	2,4,5-T \ Weedone \ Acetic acid, 2,4,5-trichlorophenoxy-
2,5-Methano-2H-indeno[1,2b]oxirene, 2,3,4,5,6,7,7-hepta chloro-1a,1b,5,5a,6,6a-hexahydro- (alpha, beta, and gamma isomers)	1024573	Heptachlor epoxide
2,7:3,6-Dimethanonaphth(2,3-b)oxirene, 3,4,5,6,9,9-hexa chloro-1a,2,2a,3,6,6a,7,7a-oxtahydro-, (1a-alpha, 2-beta 2a-alpha, 3-beta, 6-beta, 6a-alpha, 7-beta, 7a-alpha)-	60571	Dieldrin
2-Chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl) acetamide	15972608	Alachlor \ Metachlor \ Lasso
4,4'-DDD	72548	4,4'-DDD/Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-
4,4'-DDE	72559	4,4'-DDE/Benzene, 1,1'-(dichloroethenlyidine)bis[4-chloro
4,4'-DDT	50293	4,4'-DDT/Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro
4,7-Methano-1H-indene 1,2,4,5,6,7,8,8-octachloro-2,3,3a, 4,7,7a-hexahydro-	57749	Chlordane
4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-da,4,7, 7a-tetrahydro-	76448	Heptachlor
4-Cyclohexene-1,2-dicarboximide N-((1,1,2,2-tetrachloro ethyl)thio)-	2425061	Captafol \ Difolatan
4-Cyclohexene-1,2-dicarboximide N-(trichloromethyl)thio-	133062	Captan
4-Metheno-2H-cyclobuta(cd)pentalen-2-one, 1,1a,3,3a, 4,5,5,5a,5b,6-decachlorooctahydro-	143500	Kepone
Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4- methoxy-	72435	Methoxychlor
Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)- alpha-hydroxy, ethyl ester	510156	Chlorobenzilate \ Ethyl-4,4'-dichlorobenzilate

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-alpha, 3-beta, 4-alpha, 5-alpha, 6-beta)	58899	Lindane \ gamma-BHC \ Hexachlorocyclohexane (gamma)
Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-alpha, 3-beta, 4-alpha, 5-beta, 6-beta)-	319846	alpha-BHC
Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-alpha, 3-alpha, 4-beta, 5-alpha, 6-beta)-	319868	delta-BHC
Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-beta, 3-alpha, 4-beta, 5-alpha, 6-beta)-	319857	beta-BHC
Endosulfan sulfate	1031078	6,9-Methano-2,3,4-benzodioxathiepin, 6,7
Endosulfan-I	959988	Thiodan I
Endosulfan-II	33213659	Thiodan II
Endrin aldehyde	7421934	Endrin aldehyde
Endrin ketone	53494705	Endrine ketone
Ether, 2,4-dichlorophenyl p-nitrophenyl-	1836755	Nitrofen \ TOK
Toxaphene	8001352	Camphechlor
o,p'-DDT	789026	o,p'-DDT
p-Toluidine, alpha, alpha, alpha-trifluoro-2,6-dinitro-N,N-dipropyl-	1582098	Trifluralin \ Treflan
** PESTICIDES (ORGANOPHOSPHOROUS)		
Coumarin, 3-chloro-7-hydroxy-4-methyl-, O-ester with O, O-diethylpyrophosphorothioate	56724	Coumaphos \ Co-Ral
Crotonic acid, 3-hydroxy, alpha-methylbenzyl ester, di methylphosphate (E)	7700176	Crotoxyphos \ Ciodrin
Crotonic acid, 3-hydroxy-, methyl ester, dimethyl phos phate (E)-	7786347	Mevinphos \ Phosdrin
O,O,O-Triethylphosphorothioate	126681	Phosphorodithioic acid, O,O,S-triethyl ester
O,O-Diethyl S-methyl ester of phosphorodithioic acid	3288582	Phosphorodithioic acid, O,O-diethyl S-methyl ester
O,O-Diethyl-O-(2-pyrazinyl)phosphorothioate	297972	Zinophos \ Thionazin
Pentachloronitrobenzene	82688	PCNB \ Terraclor \ Quintozene
Phosphoramidothioic acid, acetamidoyl, O,O-bis(p-chlorophenyl) ether	4104147	Phosacetin
Phosphoric acid, (2,2,2-trichloro-1-hydroxyethyl)-, dimethyl ester	52686	Trichlorofon \ Dylox
Phosphoric acid, 1,2-dibromo-2,2-dichloroethyl di methyl ester	300765	Naled \ Dibrom
Phosphoric acid, 2,2-dichlorovinyl dimethyl ester	62737	Dichlorvos \ DDVP
Phosphoric acid, 2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl ester	961115	Tetrachlorvinphos \ Gardona
Phosphoric acid, 2-chloro-1-(2,4-dichlorophenyl)vinyl di methyl ester	470906	Chlorfenvinphos \ Supona
Phosphoric acid, dimethyl ester, ester with (E)-3-hydrox-N,N-dimethylcrotonamide	141662	Dicrotophos \ Bidrin
Phosphoric acid, dimethyl ester, ester with (E)-3-hydroxy-N-methylcrotonamide	6923224	Monocrotophos \ Azodrin
Phosphoric acid, dimethyl ester, ester with 2-chloro-N-N-diethyl-3-hydroxycrotonamide	13171216	Phosphamidon \ Dimecron

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
Phosphoric acid, tri-o-tolyl ester	78308	Tricresylphosphate \ TCP \ TOCP
Phosphoric acid, trimethyl ester	512561	Trimethylphosphate
Phosphoric triamide, hexamethyl-	680319	Hexamethylphosphoramide \ HMPA
Phosphorodithioic acid, O,O-diethyl O-(2-(ethylthio) ethyl) ester mixed with O,O-diethyl S-(2-(ethylthio) ethyl) ester (7:3)	8065483	Demeton \ Systox
Phosphorodithioic acid, O,O-diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl) ester	333415	Diazinon \ Spectracide
Phosphorodithioic acid, O,O-diethyl O-(3,5,6-trichloro-2-pryidyl) ester	2921882	Chlorpyrifos \ Dursban
Phosphorodithioic acid, O,O-diethyl O-(p-(methylsul finyl)phenyl ester	115902	Fensulfothion \ Desanit
Phosphorodithioic acid, O,O-diethyl S-[(ethylthio) methyl] ester	298022	Phorate \ Thimet
Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio) ethyl] ester	298044	Disulfoton
Phosphorodithioic acid, O,O-diethyl ester, S-ester with 3-(mercaptomethyl)-1,2,3-benzotriazin-4(3H)-one	2642719	Azinphos-ethyl \ Ethyl Guthion
Phosphorodithioic acid, O,O-diethyl-S-(((1,1-dimethyl ethyl)thio)methyl ester	13071799	Terbufos \ Counter
Phosphorodithioic acid, O,O-dimethyl ester, S-ester with 3-(mercaptomethyl)-1,2,3-benzotriazin-4(3H)-one	86500	Azinphos-methyl \ Guthion
Phosphorodithioic acid, O,O-dimethyl ester, S-ester with N-(mercaptomethyl)phthalimide	732116	Phosmet \ Imidan
Phosphorodithioic acid, O,O-dimethyl s-[2-(methylamino)-2-oxoethyl] ester	60515	Cygon \ Dimethoate
Phosphorodithioic acid, O,O-dimethyl-, O-(4-methylthio)-m-tolyl)ester	55389	Fenthion \ Baytex
Phosphorodithioic acid, S,S'-methylene O,O,O',O'-tetra ethyl ester	563122	Ethion \ Bladan
Phosphorodithioic acid, S,S'-p-dioxane-2,3-dryl O,O,O', O'-tetraethyl ester	78342	Dioxathion
Phosphorodithioic acid, s(((p-chlorophenyl)thio) methyl) O,O-diethyl ester	786196	Carbophenothion \ Trithion
Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester	56382	Parathion \ Parathion, ethyl
Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester	298000	Methyl parathion \ Parathion-methyl \ Metaphos
Phosphorothioic acid, O,O-dimethyl O-[p-[(dimethylamino) sulfonyl)phenyl] ester	52857	Famphur \ Famophos
Phosphorothioic acid, phenyl, O-(4-bromo-2,5-dichloro phenyl) O-methyl ester	21609905	Leptophos \ Phosvel
Phosphorothioic acid, phenyl-, O-ethyl O-(p-nitro phenyl) ester	2104645	EPN \ Santox
Succinic acid, mercapto-, diethyl ester, S-ester with O, O-dimethyl phosphorodithioate	121755	Malathion \ Sumitox
Tetraethylpyrophosphate	107493	TEPP \ Phosphoric acid, tetraethyl ester

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
Thiopyrophosphoric acid ([(HO)2P(S)]2O), tetraethyl ester	3689245	Sulfotepp \ Bladafum \ Tetraethyldithiopyrophosphate
** SEMI-VOLATILES (ACIDS)		
2,3,4,6-Tetrachlorophenol	58902	Phenol, 2,3,4,6-tetrachloro-
2,3,6-Trichlorophenol	933755	2,3,6-Trichlorophenol
2,4,5-Trichlorophenol	95954	Phenol, 2,4,5-trichloro-
2,4,6-Trichlorophenol	88062	Phenol, 2,4,6-trichloro-
2,4-Dichlorophenol	120832	Phenol, 2,4-dichloro-
2,4-Dimethylphenol	105679	Phenol, 2,4-dimethyl-
2,4-Dinitrophenol	51285	Phenol, 2,4-dinitro
2,6-Dichlorophenol	87650	Phenol, 2,6-dichloro-
2-Chlorophenol	95578	Phenol, 2-chloro
4-Chloro-3-methylphenol	59507	p-Chloro-m-cresol \ Phenol, 4-chloro-3-methyl-
4-Nitrophenol	100027	p-Nitrophenol \ Phenol, 4-nitro-
Benzoic acid	65850	Benzoic acid
Benzonitrile, 3,5-dibromo-4-hydroxy-	1689845	Bromoxynil \ 3,5-Dibromo-4-hydroxybenzonitrile
Hexanoic acid	142621	Caproic acid
Pentachlorophenol	87865	PCP \ Phenol, pentachloro-
Phenol	108952	Carbolic acid
Phenol, 2-methyl-4,6-dinitro-	534521	2-Methyl-4,6-dinitrophenol \ DNOC \ 4,6-Dinitro-o-cresol
Resorcinol	108463	1,3-Benzenediol
Sulfurous acid, 2-chloroethyl-, 2-[4-(1,1-dimethylethyl) phenoxy]-1-methylethyl ester	140578	Aramite
m-Cresol	108394	3-Methylphenol \ Phenol, 3-methyl-
o-Cresol	95487	2-Methylphenol \ o-Cresylic acid \ Phenol, 2-methyl-
p-Cresol	106445	4-Methylphenol \ Phenol, 4-methyl-
** SEMI-VOLATILES (BASES)		
1,1'-Biphenyl-4,4'-diamine, 3,3'-dimethoxy	119904	3,3'-Dimethoxybenzidine
1,2,4,5-Tetrachlorobenzene	95943	Benzene, 1,2,4,5-tetrachloro-
1,2-Diphenylhydrazine	122667	Hydrazine, 1,2-diphenyl
1,2-Ethanediamine, N,N-dimethyl-N'-2pyridinyl-N'-(2-thienylmethyl)-	91805	Methapyrilene
1,3-Benzenediamine, 4-methyl-	95807	2,4-Diaminotoluene \ Toluene, 2,4-diamino-
1,3-Benzodioxole, 5-(1-propenyl)-	120581	Isosafrole
1,4-Dichlorobenzene	106467	Benzene, 1,4-dichloro- \ p-Dichlorobenzene
1,5-Naphthalenediamine	2243621	1,5-Naphalenediamine
1-Naphthylamine	134327	alpha-Naphthylamine
2,3-Dichloroaniline	608275	2,3-Dichloroaniline
2,6-Dinitrotoluene	606202	Benzene, 2-methyl-1,3-dinitro-
2,6-dichloro-4-nitroaniline	99309	Dichloran \ Botran
2-(Methylthio)benzothiazole	615225	2-(Methylthio)benzothiazole
2-Chloronaphthalene	91587	Naphthalene, 2-chloro-
2-Nitroaniline	88744	Benzenamine, 2-nitro
3,3'-Dichlorobenzidine	91941	1,1'-Biphenyl-4,4'-diamine, 3,3'-dichloro
3-Nitroaniline	99092	Benzenamine, 3-nitro

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
4,4'-Methylenebis(2-chloroaniline)	101144	Benzenamine, 4,4'-methylenebis[2chloro \ MOCA
4-Chloro-2-nitroaniline	89634	4-Chloro-2-nitroaniline
5-Nitro-o-toluidine	99558	Benzenamine, 2-methyl-5-nitro
7,12-Dimethylbenz(a)anthracene	57976	9,10-Dimethyl-1,2-Benzanthracene
Acetamide, N-(4-ethoxyphenyl)-	62442	Phenacetin \ Phorazetim
Ammonium, (4-(p-(dimethylamino)-alpha-phenylbenzylidine)-2,5-cylcohexadien-1-ylidene)-dimethyl chloride	569642	Malachite green \ C.I. Basic Acid Green 4
Aniline, 2,4,5-trimethyl-	137177	2,4,5-Trimethylaniline
Benzenamine	62533	Aniline
Benzenamine, 4-chloro-	106478	p-Chloroaniline
Benzenamine, N,N-dimethyl-4-(pehnylazo)-	60117	p-Dimethylaminoazobenzene
Benzenethiol	108985	Thiophenol \ Mercaptobenzene
Benzidine	92875	(1,1'-Biphenyl)-4,4'-diamine
Carbazole	86748	Carbazole
Di-n-propylnitrosamine	621647	N-Nitrosodi-n-propylamine
Diphenylamine	122394	Benzenamine, N-phenyl
N-Nitrosodi-n-butylamine	924163	1-Butenamine, N-butyl-N-nitroso
N-Nitrosodiethylamine	55185	Ethanamine, N-ethyl-N-nitroso-
N-Nitrosodimethylamine	62759	Dimethylnitrosamine \ Methamine, N-methyl-N-nitroso-
N-Nitrosodiphenylamine	86306	Benzenamine, N-nitroso-N-phenyl
N-Nitrosomethylethylamine	10595956	Ethanamine, N-methyl-N-nitroso
N-Nitrosomethylphenylamine	614006	N-Nitrosomethylphenylamine
N-Nitrosomorpholine	59892	Morpholine, 4-nitroso-
N-Nitrosopiperidine	100754	Piperidine, 1-Nitroso-
Nitrobenzene	98953	Benzene, nitro-
Phenothiazine	92842	Nemazine \ 10H-Phenothiazine
Propane, 1,2-dibromo-3-chloro-	96128	Dibromochloropropane \ DBCP
Pyridine	110861	Pyridine
Thioxanthe-9-one	492228	Thioxanthone \ Thiaxanthone
[1,1'-Biphenyl]-4-amine	92671	4-Aminobiphenyl
beta-Naphthylamine	91598	2-Naphthylamine
o-Anisidine	90040	o-Anisidine
o-Toluidine	95534	o-Toluidine
o-Toluidine, 5-chloro-	95794	5-Chloro-o-toluidine
p-Nitroaniline	100016	Benzenamine, 4-nitro-
** SEMI-VOLATILES (NEUTRAL)		
1,2,3-Trichlorobenzene	87616	1,2,3-Trichlorobenzene
1,2,3-Trimethoxybenzene	634366	1,2,3-Trimethoxybenzene
1,2,4-Trichlorobenzene	120821	Benzene, 1,2,4-trichloro-
1,2-Benzenedicarboxylic acid, dibutyl ester	84742	Di-n-butyl phthalate \ Dibutyl phthalate
1,2-Benzenedicarboxylic acid, dimethyl ester	131113	Dimethyl phthalate
1,2-Dichlorobenzene	95501	Benzene, 1,2-dichloro- \ o-Dichlorobenzene
1,2:3,4-Diepoxybutane	1464535	Erythritol anhydride \ 2,2'-Bioxirane
1,3,5-Trithiane	291214	1,3,5-Trithiane
1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	77474	Hexachlorocyclopentadiene \ HCP
1,3-Dichloro-2-propanol	96231	1,3-Dichloro-2-propanol

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
1,3-Dichlorobenzene	541731	Benzene, 1,3-dichloro- \ m-Dichlorobenzene
1,3-Dinitrobenzene	99650	Benzene, 1,3-dinitro- \ m-Dinitrobenzene
1,4-Naphthoquinone	130154	1,4-Naphthalenedione
1-Chloro-3-nitrobenzene	121733	3-chloronitrobenzene
1-Methylfluorene	1730376	1-Methylfluorene
1-Methylphenanthrene	832699	1-Methylphenanthrene
1-Phenylnaphthalene	605027	1-Phenylnaphthalene
17-alpha-19-Norpregna-1,3,5(10)-trien-20-yn-17-ol, 3-methoxy-	72333	Mestranol \ 17-alpha-Ethynylestradiol 3-methyl ether
2,3-Benzofluorene	243174	2,3-benzofluorene
2,3-Dichloronitrobenzene	3209221	2,3-Dichloronitrobenzene
2,4-Dinitrotoluene	121142	Benzene, 1-methyl-2,4-dinitro
2,6-di-tert-Butyl-p-benzoquinone	719222	2,6-di-tert-Butyl-p-benzoquinone
2,7-Dimethylphenanthrene	1576698	2,7-Dimethylphenanthrene
2-Isopropylnaphthalene	2027170	2-Isopropylnaphthalene
2-Methylbenzothioazole	120752	2-Methylbenzothioazole
2-Methylnaphthalene	91576	Naphthalene, 2-methyl
2-Nitrophenol	88755	Phenol, 2-nitro-
2-Phenylnaphthalene	612942	2-Phenylnaphthalene
3,3'-Dichloro-4,4'-diaminodiphenyl ether	28434868	3,3'-Dichloro-4,4'-diaminodiphenyl ether
3,6-Dimethylphenanthrene	1576676	3,6-Dimethylphenanthrene
4,5-dimethyl phenanthrene	203645	4,5-dimethyl phenanthrene
4-Bromophenyl phenyl ether	101553	1-Bromo-4-phenoxybenzene \ Benzene, 1-bromo-4-phenoxy-
4-Chlorophenylphenyl ether	7005723	Benzene, 1-chloro-4-phenoxy
Acenaphthene	83329	Acenaphthylene, 1,2-dihydro-
Acenaphthylene	208968	Acenaphthylene
Anthracene	120127	Anthracene
Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	56495	3-Methylcholanthrene
Benzanthrone	82053	Benzanthrone
Benzo(a)anthracene	56553	Benz[a]anthracene \ 1,2-Benzanthracene
Benzo(a)pyrene	50328	Benzo(a)pyrene
Benzo(b)fluoranthene	205992	Benz[e]acephenanthrylene
Benzo(ghi)perylene	191242	Benzo(ghi)perylene
Benzo(k)fluoranthene	207089	Benzo(k)fluoranthene
Benzyl alcohol	100516	Benzenemethanol
Biphenyl	92524	Diphenyl
Biphenyl, 4-nitro	92933	4-Nitrobiphenyl
Butyl benzyl phthalate	85687	1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester
Chloropicrin	76062	Methane, trichloronitro-
Chrysene	218019	Chrysene
Di-n-octyl phthalate	117840	1,2-Benzenedicarboxylic acid, dioctyl ester \ Dioctyl ph
Dibenzo(a,h)anthracene	53703	Dibenz[a,h]anthracene
Dibenzofuran	132649	Dibenzofuran
Dibenzothiophene	132650	Dibenzothiophene
Diethyl phthalate	84662	1,2-Benzenedicarboxylic acid, diethyl ester
Dimethyl sulfone	67710	Dimethyl sulfone
Diphenyl ether	101848	Diphenyl ether

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
Diphenyldisulfide	882337	Diphenyl sulfide
Ethane, pentachloro-	76017	Pentachloroethane
Ethanethioamide	62555	Thioacetamide
Ethanone, 1-phenyl	98862	Acetophenone
Ethylenethiourea	96457	Ethylenethiourea
Fluoranthene	206440	Fluoranthene
Fluorene	86737	Fluorene
Hexachlorobenzene	118741	HCB \ Benzene, hexachloro-
Hexachlorobutadiene	87683	1,3-Butadiene, 1,1,2,3,4,4-hexachloro-
Hexachloroethane	67721	Ethane, hexachloro
Hexachloropropene	1888717	1-Propene, 1,1,2,3,3,3-hexachloro-
Indeno(1,2,3-cd)pyrene	193395	Indeno(1,2,3-cd)pyrene
Isophorone	78591	3,5,5-Trimethyl-2-cyclohexenone
Longifolene	475207	Longifolene
Methanesulfonic acid, ethyl ester	62500	Ethyl methanesulfonate
Methyl methanesulfonate	66273	Methylsulfonic acid, methyl ester
N,N-Dimethylformamide	68122	N,N-Dimethylformamide
Naphthalene	91203	Naphthalene
Pentachlorobenzene	608935	Benzene, pentachloro-
Pentamethylbenzene	700129	Pentamethylbenzene
Perylene	198550	Perylene
Phenanthrene	85018	Phenanthrene
Pyrene	129000	Benzo[def]phenanthrene
Safrole	94597	1,3-Benzodioxole, 5-(2-propenyl)-
Squalene	7683649	Squalene
Thianaphthene	95158	2,3-Benzothiophene \ Benzo(b)thiophene
Triphenylene	217594	Triphenylene
Tripropyleneglycol methyl ether	20324338	Tripropyleneglycol methyl ether
alpha-Terpineol	98555	alpha-Terpineol
bis(2-Chloroethoxy)methane	111911	Ethane, 1,1'-[methylenebis(oxy)]bis[2-chloro-
bis(2-Chloroethyl) ether	111444	Dichloroethyl ether
bis(2-Chloroisopropyl) ether	108601	Propane, 2,2'-oxybis[1-chloro-
bis(2-Ethylhexyl) phthalate	117817	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl)ester
n-Decane	124185	n-C10
n-Docosane	629970	n-C22
n-Dodecane	112403	n-C12
n-Eicosane	112958	n-C20
n-Hexacosane	630013	n-C26
n-Hexadecane	544763	n-C16
n-Octacosane	630024	n-C28
n-Octadecane	593453	n-C18
n-Tetracosane	646311	n-C24
n-Tetradecane	629594	n-C14
n-Triacontane	638686	n-C30
p-Cymene	99876	p-Isopropyltoluene

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
** VOLATILES		
1,1,1,2-Tetrachloroethane	630206	Ethane, 1,1,1,2-tetrachloro-
1,1,1-Trichloroethane	71556	Methyl chloroform \ Ethane, 1,1,1-trichloro-
1,1,2,2-Tetrachloroethane	79345	Ethane, 1,1,2,2-tetrachloro
1,1,2-Trichloroethane	79005	Ethane, 1,1,2-trichloro
1,1-Dichloroethane	75343	Ethylidene chloride \ Ethane, 1,1-dichloro-
1,1-Dichloroethene	75354	1,1-Dichloroethylene \ Vinylidine chloride
1,2,3-Trichloropropane	96184	Propane, 1,2,3-trichloro-
1,2-Dibromoethane	106934	Ethylene dibromide \ EDB \ Ethane, 1,2-dibromo-
1,2-Dichloroethane	107062	Ethylene dichloride \ EDC \ Ethane, 1,2-dichloro-
1,2-Dichloropropane	78875	Propylene dichloride \ Propane, 1,2-dichloro-
1,3-Dichloropropane	142289	1,3-Dichloropropane
1,4-Dioxane	123911	p-Dioxane \ 1,4-Diethyleneoxide
1-Bromo-2-chlorobenzene	694804	2-Bromochlorobenzene
1-Bromo-3-chlorobenzene	108372	3-Bromochlorobenzene
1-Propene, 3-chloro-	107051	Allyl chloride \ 3-Chloropropene
2-Butanone	78933	Methyl ethyl ketone \ MEK
2-Butenal	4170303	Crotonaldehyde \ Crotylaldehyde
2-Butene, 1,4-dichloro (mixture of cis and trans)	764410	1,4-Dichloro-2-butene
2-Chloro-1,3-butadiene	126998	Chloroprene \ 1,3-Butadiene, 2-chloro
2-Chloroethylvinyl ether	110758	Ethene, (2-chloroethoxy)
2-Hexanone	591786	2-Hexanone
2-Picoline	109068	alpha-Picoline \ 2-Methylpyridine
2-Propanone	67641	Acetone
2-Propen-1-o1	107186	Allyl alcohol
2-Propenal	107028	Acrolein
2-Propenenitrile	107131	Acrylonitrile
2-Propenenitrile, 2-methyl-	126987	Methacrylonitrile
4-Methyl-2-pentanone	108101	MIBK \ Methylisobutylketone \ 2-Pentanone, 4-methyl
Benzene	71432	Benzene
Bromodichloromethane	75274	Methane, bromodichloro
Bromomethane	74839	Methyl bromide \ Methane, bromo
Carbon disulfide	75150	Carbon disulfide
Chloroacetonitrile	107142	Chloroethanenitrile
Chlorobenzene	108907	Benzene, chloro-
Chloroethane	75003	Ethane, chloro \ Ethyl chloride
Chloroform	67663	Methane, trichloro- \ Trichloromethane
Chloromethane	74873	Methyl chloride \ Methane, chloro
Dibromochloromethane	124481	Chlorodibromomethane \ Methane, dibromochloro-
Dibromomethane	74953	Methylene bromide \ Methane, dibromo
Dichloroiodomethane	0-015	Dichloroiodomethane
Diethyl ether	60297	Diethyl ether
Ethyl cyanide	107120	Propionitrile \ Propanenitrile
Ethyl methacrylate	97632	2-Propenoic acid, 2-methyl-, ethyl ester
Ethylbenzene	100414	Benzene, ethyl
Iodomethane	74884	Methyl iodide \ Methane, iodo
Isobutyl alcohol	78831	1-Propanol, 2-methyl-

TABLE 9-1
CLASSES OF COMPOUNDS
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

REGULATORY NAME	CAS NUMBER	COMMON NAME
Methyl methacrylate	80626	2-Propenoic acid, 2-methyl, methyl ester
Methylene chloride	75092	Dichloromethane \ Methane, dichloro-
Styrene	100425	Benzene, ethenyl-
Tetrachloroethene	127184	Perchloroethylene \ Ethene, tetrachloro
Tetrachloromethane	56235	Carbon tetrachloride \ Methane, tetrachloro-
Toluene	108883	Benzene, methyl
Total xylenes	1330207	Benzene, dimethyl- \ Xylenes \ Xylene, (total)
Tribromomethane	75252	Bromoform \ Methane, tribromo-
Trichloroethene	79016	Ethene, trichloro \ Trichloroethylene
Trichlorofluoromethane	75694	Fluorotrichloromethane \ Methane, trichlorofluoro-
Vinyl acetate	108054	Acetic acid, ethenyl ester
Vinyl chloride	75014	Ethene, chloro
cis-1,3-Dichloropropene	10061015	1-Propene, 1,3-dichloro-, (Z)-
o + p xylene	1-952	o + p xylene
trans-1,2-Dichloroethene	156605	Ethene, 1,2-dichloro-, (E)-
trans-1,3-Dichloropropene	10061026	1-Propene, 1,3-dichloro-, (E)-
trans-1,4-Dichloro-2-butene	110576	2-Butene, 1,4-dichloro-, (E)-

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
0-009	Hypochlorite ion	Hypochlorite ion	MISC
0-011	Chlorite	Chlorite	MISC
0-012	Chloramine	Chloramine	MISC
0-015	Dichloroiodomethane	Dichloroiodomethane	VOL
0-039	Cryptosporidium	Cryptosporidium	MISC
1-001	Total volatile organic carbon	TVOA \ VOC \ Organic carbon, volatile	MISC
1-002	Biochemical Oxygen Demand	BOD	MISC
1-003	Chloride	Chloride	MISC
1-004	Chemical Oxygen Demand	COD	MISC
1-005	Nitrate/nitrite	Nitrate/nitrite	MISC
1-006	Hydrogen ion	pH	MISC
1-007	Oil and grease	O&G	MISC
1-008	Residue, total	Total solids	MISC
1-009	Residue, non-filterable	Total suspended solids \ TSS	MISC
1-010	Residue, filterable	Total dissolved solids \ TDS	MISC
1-011	Specific conductivity	Conductivity, specific	MISC
1-012	Total organic carbon	TOC \ Organic carbon, total	MISC
1-013	Ignitability	Ignitability	MISC
1-014	Corrosivity	Corrosivity	MISC
1-015	Reactivity	Reactivity	MISC
1-016	Oil and grease	Retort	MISC
1-030	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1,2,3,4,7,8-HxDD	DIOXINS
1-200	Hexachlorodibenzo-p-dioxins	Hexachlorodibenzo-p-dioxins	DIOXINS
1-201	Hexachlorodibenzofurans	Hexachlorodibenzofurans	DIOXINS
1-289	Pentachlorodibenzo-p-dioxins	Pentachlorodibenzo-p-dioxins	DIOXINS
1-290	Pentachlorodibenzofurans	Pentachlorodibenzofurans	DIOXINS
1-331	Tetrachlorodibenzo-p-dioxins	Tetrachlorodibenzo-p-dioxins	DIOXINS
1-332	Tetrachlorodibenzofurans	Tetrachlorodibenzofurans	DIOXINS
1-952	o + p xylene	o + p xylene	VOL
50293	4,4'-DDT	4,4'-DDT/Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro	P(OH)
50328	Benzo(a)pyrene	Benzo(a)pyrene	SV(N)
51285	2,4-Dinitrophenol	Phenol, 2,4-dinitro	SV(A)
52686	Phosphoric acid, (2,2,2-trichloro-1-hydroxyethyl)-, dimethyl ester	Trichlorofon \ Dylox	P(OP)
52857	Phosphorothioic acid, O,O-dimethyl O-[p-[(dimethylamino)sulfonyl)phenyl] ester	Famphur \ Famophos	P(OP)
53703	Dibenzo(a,h)anthracene	Dibenz[a,h]anthracene	SV(N)
55185	N-Nitrosodiethylamine	Ethanamine, N-ethyl-N-nitroso-	SV(B)
55389	Phosphorodithioic acid, O,O-dimethyl-, O-(4-methylthio)-m-tolyl)ester	Fenthion \ Baytex	P(OP)
56235	Tetrachloromethane	Carbon tetrachloride \ Methane, tetrachloro-	VOL
56382	Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester	Parathion \ Parathion, ethyl	P(OP)
56495	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	3-Methylcholanthrene	SV(N)
56553	Benzo(a)anthracene	Benz[a]anthracene \ 1,2-Benzanthracene	SV(N)
56724	Coumarin, 3-chloro-7-hydroxy-4-methyl-, O-ester with O, O-diethylpyrophosphorothioate	Coumaphos \ Co-Ral	P(OP)
57125	Cyanides (soluble salts and complexes) NOS	Cyanides (soluble salts and complexes)	MISC
57749	4,7-Methano-1H-indene 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-	Chlordane	P(OH)
57976	7,12-Dimethylbenz(a)anthracene	9,10-Dimethyl-1,2-Benzanthracene	SV(B)
58899	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-alpha,3-beta, 4-alpha, 5-alpha, 6-beta)	Lindane \ gamma-BHC \ Hexachlorocyclohexane (gamma)	P(OH)

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
58902	2,3,4,6-Tetrachlorophenol	Phenol, 2,3,4,6-tetrachloro-	SV(A)
59507	4-Chloro-3-methylphenol	p-Chloro-m-cresol \ Phenol, 4-chloro-3-methyl-	SV(A)
59892	N-Nitrosomorpholine	Morpholine, 4-nitroso-	SV(B)
60117	Benzenamine, N,N-dimethyl-4-(pehnylazo)-	p-Dimethylaminoazobenzene	SV(B)
60297	Diethyl ether	Diethyl ether	VOL
60515	Phosphorodithioic acid, O,O-dimethyl s-[2-(methylamino)-2-oxoethyl] ester	Cygon \ Dimethoate	P(OP)
60571	2,7:3,6-Dimethanonaphth(2,3-b)oxirene, 3,4,5,6,9,9-hexa chloro-1a,2,2a,3,6,6a,7,7a-oxtahydro-, (1a-alpha, 2-beta2a-alpha, 3-beta, 6-beta, 6a-alpha, 7-beta, 7a-alpha)-	Dieldrin	P(OH)
62442	Acetamide, N-(4-ethoxyphenyl)-	Phenacetin \ Phorazetim	SV(B)
62500	Methanesulfonic acid, ethyl ester	Ethyl methanesulfonate	SV(N)
62533	Benzenamine	Aniline	SV(B)
62555	Ethanethioamide	Thioacetamide	SV(N)
62737	Phosphoric acid, 2,2-dichlorovinyl dimethyl ester	Dichlorvos \ DDVP	P(OP)
62759	N-Nitrosodimethylamine	Dimethylnitrosamine \ Methamine, N-methyl-N-nitroso-	SV(B)
65850	Benzoic acid	Benzoic acid	SV(A)
66273	Methyl methanesulfonate	Methylsulfonic acid, methyl ester	SV(N)
67641	2-Propanone	Acetone	VOL
67663	Chloroform	Methane, trichloro- \ Trichloromethane	VOL
67710	Dimethyl sulfone	Dimethyl sulfone	SV(N)
67721	Hexachloroethane	Ethane, hexachloro	SV(N)
68122	N,N-Dimethylformamide	N,N-Dimethylformamide	SV(N)
71432	Benzene	Benzene	VOL
71556	1,1,1-Trichloroethane	Methyl chloroform \ Ethane, 1,1,1-trichloro-	VOL
72208	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro- 1a,2,2a,3,6,6a,7,8,8a-octahydro-endo,endo-	Endrin	P(OH)
72333	17-alpha-19-Norpregna-1,3,5(10)-trien-20-yn-17-ol, 3- methoxy-	Mestranol \ 17-alpha-Ethynylestradiol 3-methyl ether	SV(N)
72435	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4- methoxy-	Methoxychlor	P(OH)
72548	4,4'-DDD	4,4'-DDD/Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-	P(OH)
72559	4,4'-DDE	4,4'-DDE/Benzene, 1,1'-(dichloroethenlyidine)bis[4-chloro	P(OH)
74839	Bromomethane	Methyl bromide \ Methane, bromo	VOL
74873	Chloromethane	Methyl chloride \ Methane, chloro	VOL
74884	Iodomethane	Methyl iodide \ Methane, iodo	VOL
74953	Dibromomethane	Methylene bromide \ Methane, dibromo	VOL
75003	Chloroethane	Ethane, chloro \ Ethyl chloride	VOL
75014	Vinyl chloride	Ethene, chloro	VOL
75092	Methylene chloride	Dichloromethane \ Methane, dichloro-	VOL
75150	Carbon disulfide	Carbon disulfide	VOL
75252	Tribromomethane	Bromoform \ Methane, tribromo-	VOL
75274	Bromodichloromethane	Methane, bromodichloro	VOL
75343	1,1-Dichloroethane	Ethylidene chloride \ Ethane, 1,1-dichloro-	VOL
75354	1,1-Dichloroethene	1,1-Dichloroethylene \ Vinylidine chloride	VOL
75694	Trichlorofluoromethane	Fluorotrichloromethane \ Methane, trichlorofluoro-	VOL
76017	Ethane, pentachloro-	Pentachloroethane	SV(N)
76062	Chloropicrin	Methane, trichloronitro-	SV(N)
76448	4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-da,4,7,7a-tetrahydro-	Heptachlor	P(OH)
77474	1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	Hexachlorocyclopentadiene \ HCP	SV(N)
78308	Phosphoric acid, tri-o-tolyl ester	Tricresylphosphate \ TCP \ TOCP	P(OP)

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
78342	Phosphorodithioic acid, S,S'-p-dioxane-2,3-dryl O,O,O', O'-tetraethyl ester	Dioxathion	P(OP)
78591	Isophorone	3,5,5-Trimethyl-2-cyclohexenone	SV(N)
78831	Isobutyl alcohol	1-Propanol, 2-methyl-	VOL
78875	1,2-Dichloropropane	Propylene dichloride \ Propane, 1,2-dichloro-	VOL
78933	2-Butanone	Methyl ethyl ketone \ MEK	VOL
79005	1,1,2-Trichloroethane	Ethane, 1,1,2-trichloro	VOL
79016	Trichloroethene	Ethene, trichloro \ Trichloroethylene	VOL
79345	1,1,2,2-Tetrachloroethane	Ethane, 1,1,2,2-tetrachloro	VOL
80626	Methyl methacrylate	2-Propenoic acid, 2-methyl, methyl ester	VOL
82053	Benzanthrone	Benzanthrone	SV(N)
82688	Pentachloronitrobenzene	PCNB \ Terraclor \ Quintozene	P(OP)
83329	Acenaphthene	Acenaphthylene, 1,2-dihydro-	SV(N)
84662	Diethyl phthalate	1,2-Benzenedicarboxylic acid, diethyl ester	SV(N)
84742	1,2-Benzenedicarboxylic acid, dibutyl ester	Di-n-butyl phthalate \ Dibutyl phthalate	SV(N)
85018	Phenanthrene	Phenanthrene	SV(N)
85687	Butyl benzyl phthalate	1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester	SV(N)
86306	N-Nitrosodiphenylamine	Benzenamine, N-nitroso-N-phenyl	SV(B)
86500	Phosphorodithioic acid, O,O-dimethyl ester, S-ester with3-(mercaptomethyl)-1,2,3-benzotriazin-4(3H)-one	Azinphos-methyl \ Guthion	P(OP)
86737	Fluorene	Fluorene	SV(N)
86748	Carbazole	Carbazole	SV(B)
87616	1,2,3-Trichlorobenzene	1,2,3-Trichlorobenzene	SV(N)
87650	2,6-Dichlorophenol	Phenol, 2,6-dichloro-	SV(A)
87683	Hexachlorobutadiene	1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	SV(N)
87865	Pentachlorophenol	PCP \ Phenol, pentachloro-	SV(A)
88062	2,4,6-Trichlorophenol	Phenol, 2,4,6-trichloro-	SV(A)
88744	2-Nitroaniline	Benzenamine, 2-nitro	SV(B)
88755	2-Nitrophenol	Phenol, 2-nitro-	SV(N)
88857	Phenol, 2-(1-methylpropyl)-4,6-dinitro-	DNBP \ Dinoseb \ 2-sec-butyl-4,6-dinitrophenol	P(H)
89634	4-Chloro-2-nitroaniline	4-Chloro-2-nitroaniline	SV(B)
90040	o-Anisidine	o-Anisidine	SV(B)
91203	Naphthalene	Naphthalene	SV(N)
91576	2-Methylnaphthalene	Naphthalene, 2-methyl	SV(N)
91587	2-Chloronaphthalene	Naphthalene, 2-chloro-	SV(B)
91598	beta-Naphthylamine	2-Naphthylamine	SV(B)
91805	1,2-Ethanediamine, N,N-dimethyl-N'-2pyridinyl-N'-(2- thienylmethyl)-	Methapyrilene	SV(B)
91941	3,3'-Dichlorobenzidine	1,1'-Biphenyl-4,4'-diamine, 3,3'-dichloro	SV(B)
92524	Biphenyl	Diphenyl	SV(N)
92671	[1,1'-Biphenyl]-4-amine	4-Aminobiphenyl	SV(B)
92842	Phenothiazine	Nemazine \ 10H-Phenothiazine	SV(B)
92875	Benzidine	(1,1'-Biphenyl)-4,4'-diamine	SV(B)
92933	Biphenyl, 4-nitro	4-Nitrobiphenyl	SV(N)
93721	Propanoic acid, 2-(2,4,5-trichlorophenoxy)-	2,4,5-TP \ Silvex	P(H)
93765	2,4,5-Trichlorophenoxyacetic acid	2,4,5-T \ Weedone \ Acetic acid, 2,4,5-trichlorophenoxy-	P(OH)
94597	Safrole	1,3-Benzodioxole, 5-(2-propenyl)-	SV(N)
94757	2,4-Dichlorophenoxyacetic acid, salts and esters	2,4-D \ Acetic acid, (2,4-dichlorophenoxy)-	P(H)
95158	Thianaphthene	2,3-Benzothiophene \ Benzo(b)thiophene	SV(N)
95487	o-Cresol	2-Methylphenol \ o-Cresylic acid \ Phenol, 2-methyl-	SV(A)

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
95501	1,2-Dichlorobenzene	Benzene, 1,2-dichloro- \ o-Dichlorobenzene	SV(N)
95534	o-Toluidine	o-Toluidine	SV(B)
95578	2-Chlorophenol	Phenol, 2-chloro	SV(A)
95794	o-Toluidine, 5-chloro-	5-Chloro-o-toluidine	SV(B)
95807	1,3-Benzenediamine, 4-methyl-	2,4-Diaminotoluene \ Toluene, 2,4-diamino-	SV(B)
95943	1,2,4,5-Tetrachlorobenzene	Benzene, 1,2,4,5-tetrachloro-	SV(B)
95954	2,4,5-Trichlorophenol	Phenol, 2,4,5-trichloro-	SV(A)
96128	Propane, 1,2-dibromo-3-chloro-	Dibromochloropropane \ DBCP	SV(B)
96184	1,2,3-Trichloropropane	Propane, 1,2,3-trichloro-	VOL
96231	1,3-Dichloro-2-propanol	1,3-Dichloro-2-propanol	SV(N)
96457	Ethylenethiourea	Ethylenethiourea	SV(N)
97632	Ethyl methacrylate	2-Propenoic acid, 2-methyl-, ethyl ester	VOL
98555	alpha-Terpineol	alpha-Terpineol	SV(N)
98862	Ethanone, 1-phenyl	Acetophenone	SV(N)
98953	Nitrobenzene	Benzene, nitro-	SV(B)
99092	3-Nitroaniline	Benzenamine, 3-nitro	SV(B)
99309	2,6-dichloro-4-nitroaniline	Dichloran \ Botran	SV(B)
99558	5-Nitro-o-toluidine	Benzenamine, 2-methyl-5-nitro	SV(B)
99650	1,3-Dinitrobenzene	Benzene, 1,3-dinitro- \ m-Dinitrobenzene	SV(N)
99876	p-Cymene	p-Isopropyltoluene	SV(N)
100016	p-Nitroaniline	Benzenamine, 4-nitro-	SV(B)
100027	4-Nitrophenol	p-Nitrophenol \ Phenol, 4-nitro-	SV(A)
100414	Ethylbenzene	Benzene, ethyl	VOL
100425	Styrene	Benzene, ethenyl-	VOL
100516	Benzyl alcohol	Benzenemethanol	SV(N)
100754	N-Nitrosopiperidine	Piperidine, 1-Nitroso-	SV(B)
101144	4,4'-Methylenebis(2-chloroaniline)	Benzenamine, 4,4'-methylenebis[2chloro \ MOCA	SV(B)
101553	4-Bromophenyl phenyl ether	1-Bromo-4-phenoxybenzene \ Benzene, 1-bromo-4-phenoxy-	SV(N)
101848	Diphenyl ether	Diphenyl ether	SV(N)
105679	2,4-Dimethylphenol	Phenol, 2,4-dimethyl-	SV(A)
106445	p-Cresol	4-Methylphenol \ Phenol, 4-methyl-	SV(A)
106467	1,4-Dichlorobenzene	Benzene, 1,4-dichloro- \ p-Dichlorobenzene	SV(B)
106478	Benzenamine, 4-chloro-	p-Chloroaniline	SV(B)
106934	1,2-Dibromoethane	Ethylene dibromide \ EDB \ Ethane, 1,2-dibromo-	VOL
107028	2-Propenal	Acrolein	VOL
107051	1-Propene, 3-chloro-	Allyl chloride \ 3-Chloropropene	VOL
107062	1,2-Dichloroethane	Ethylene dichloride \ EDC \ Ethane, 1,2-dichloro-	VOL
107120	Ethyl cyanide	Propionitrile \ Propanenitrile	VOL
107131	2-Propenenitrile	Acrylonitrile	VOL
107142	Chloroacetonitrile	Chloroethanenitrile	VOL
107186	2-Propen-1-o1	Allyl alcohol	VOL
107493	Tetraethylpyrophosphate	TEPP \ Phosphoric acid, tetraethyl ester	P(OP)
108054	Vinyl acetate	Acetic acid, ethenyl ester	VOL
108101	4-Methyl-2-pentanone	MIBK \ Methylisobutylketone \ 2-Pentanone, 4-methyl	VOL
108372	1-Bromo-3-chlorobenzene	3-Bromochlorobenzene	VOL
108394	m-Cresol	3-Methylphenol \ Phenol, 3-methyl-	SV(A)
108463	Resorcinol	1,3-Benzenediol	SV(A)
108601	bis(2-Chloroisopropyl) ether	Propane, 2,2'-oxybis[1-chloro-	SV(N)

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
108883	Toluene	Benzene, methyl	VOL
108907	Chlorobenzene	Benzene, chloro-	VOL
108952	Phenol	Carbolic acid	SV(A)
108985	Benzenethiol	Thiophenol \ Mercaptobenzene	SV(B)
109068	2-Picoline	alpha-Picoline \ 2-Methylpyridine	VOL
110576	trans-1,4-Dichloro-2-butene	2-Butene, 1,4-dichloro-, (E)-	VOL
110758	2-Chloroethylvinyl ether	Ethene, (2-chloroethoxy)	VOL
110861	Pyridine	Pyridine	SV(B)
111444	bis(2-Chloroethyl) ether	Dichloroethyl ether	SV(N)
111546	Carbamodithioic acid, 1,2-ethanediylbis-, salts and esters	Ethylenebisdithiocarbamic acid, salts and esters	P(C)
111911	bis(2-Chloroethoxy)methane	Ethane, 1,1'-[methylenebis(oxy)]bis[2-chloro-	SV(N)
112403	n-Dodecane	n-C12	SV(N)
112958	n-Eicosane	n-C20	SV(N)
115902	Phosphorodithioic acid, O,O-diethyl O-(p-(methylsulfinyl)phenyl ester	Fensulfothion \ Desanit	P(OP)
117806	1,4-Naphthoquinone, 2,3-dichloro-	Dichlone \ Phygon	P(OH)
117817	bis(2-Ethylhexyl) phthalate	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl)ester	SV(N)
117840	Di-n-octyl phthalate	1,2-Benzenedicarboxylic acid, dioctyl ester \ Dioctyl ph	SV(N)
118741	Hexachlorobenzene	HCB \ Benzene, hexachloro-	SV(N)
119904	1,1'-Biphenyl-4,4'-diamine, 3,3'-dimethoxy	3,3'-Dimethoxybenzidine	SV(B)
120127	Anthracene	Anthracene	SV(N)
120581	1,3-Benzodioxole, 5-(1-propenyl)-	Isosafrole	SV(B)
120752	2-Methylbenzothioazole	2-Methylbenzothioazole	SV(N)
120821	1,2,4-Trichlorobenzene	Benzene, 1,2,4-trichloro-	SV(N)
120832	2,4-Dichlorophenol	Phenol, 2,4-dichloro-	SV(A)
121142	2,4-Dinitrotoluene	Benzene, 1-methyl-2,4-dinitro	SV(N)
121733	1-Chloro-3-nitrobenzene	3-chloronitrobenzene	SV(N)
121755	Succinic acid, mercapto-, diethyl ester, S-ester with O,O-dimethyl phosphorodithioate	Malathion \ Sumitox	P(OP)
122394	Diphenylamine	Benzenamine, N-phenyl	SV(B)
122667	1,2-Diphenylhydrazine	Hydrazine, 1,2-diphenyl	SV(B)
123911	1,4-Dioxane	p-Dioxane \ 1,4-Diethyleneoxide	VOL
124185	n-Decane	n-C10	SV(N)
124481	Dibromochloromethane	Chlorodibromomethane \ Methane, dibromochloro-	VOL
126681	O,O,O-Triethylphosphorothioate	Phosphorodithioic acid, O,O,S-triethyl ester	P(OP)
126987	2-Propenenitrile, 2-methyl-	Methacrylonitrile	VOL
126998	2-Chloro-1,3-butadiene	Chloroprene \ 1,3-Butadiene, 2-chloro	VOL
127184	Tetrachloroethene	Perchloroethylene \ Ethene, tetrachloro	VOL
128030	Potassium dimethyldithiocarbamate	Busan 85	P(C)
128041	Sodium dimethyldithiocarbamate	Carbamic acid, dimethyldithio-, sodium salt	P(C)
129000	Pyrene	Benzo[def]phenanthrene	SV(N)
130154	1,4-Naphthoquinone	1,4-Naphthalenedione	SV(N)
131113	1,2-Benzenedicarboxylic acid, dimethyl ester	Dimethyl phthalate	SV(N)
131895	Phenol, 2-cyclohexyl-4,6-dinitro-	Dinex \ DN-111 \ 2-Cyclohexyl-4,6-dinitrophenol	P(H)
132649	Dibenzofuran	Dibenzofuran	SV(N)
132650	Dibenzothiophene	Dibenzothiophene	SV(N)
133062	4-Cyclohexene-1,2-dicarboximide N-(trichloromethyl)thio-	Captan	P(OH)
134327	1-Naphthylamine	alpha-Naphthylamine	SV(B)
137177	Aniline, 2,4,5-trimethyl-	2,4,5-Trimethylaniline	SV(B)

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
137268	Thioperoxydicarbonic diamide, tetramethyl	Thiram \ Thiuram \ Arasan	P(C)
137304	Zinc bis(dimethyldithiocarbamato)-	Ziram \ Cymate	P(C)
137417	Potassium-N-methyldithiocarbamate	Carbamic acid, methyldithio-, monopotassium salt	P(C)
138932	Disodium cyanodithioimidocarbonate	Disodium cyanodithioimidocarbonate	MISC
140578	Sulfurous acid, 2-chloroethyl-, 2-[4-(1,1-dimethylethyl)phenoxy]-1-methylethyl ester	Aramite	SV(A)
141662	Phosphoric acid, dimethyl ester, ester with (E)-3-hydrox-N,N-dimethylcrotonamide	Dicrotophos \ Bidrin	P(OP)
142289	1,3-Dichloropropane	1,3-Dichloropropane	VOL
142596	Ethylenebisdithiocarbamic acid, -sodium salt	Nabam	P(C)
142621	Hexanoic acid	Caproic acid	SV(A)
143500	4-Metheno-2H-cyclobuta(cd)pentalen-2-one, 1,1a,3,3a, 4,5,5,5a,5b,6-decachlorooctahydro-	Kepone	P(OH)
156605	trans-1,2-Dichloroethene	Ethene, 1,2-dichloro-, (E)-	VOL
191242	Benzo(ghi)perylene	Benzo(ghi)perylene	SV(N)
193395	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	SV(N)
198550	Perylene	Perylene	SV(N)
203645	4,5-dimethyl phenanthrene	4,5-dimethyl phenanthrene	SV(N)
205992	Benzo(b)fluoranthene	Benz[e]acephenanthrylene	SV(N)
206440	Fluoranthene	Fluoranthene	SV(N)
207089	Benzo(k)fluoranthene	Benzo(k)fluoranthene	SV(N)
208968	Acenaphthylene	Acenaphthylene	SV(N)
217594	Triphenylene	Triphenylene	SV(N)
218019	Chrysene	Chrysene	SV(N)
243174	2,3-Benzofluorene	2,3-benzofluorene	SV(N)
291214	1,3,5-Trithiane	1,3,5-Trithiane	SV(N)
297972	O,O-Diethyl-O-(2-pyrazinyl)phosphorothioate	Zinophos \ Thionazin	P(OP)
298000	Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester	Methyl parathion \ Parathion-methyl \ Metaphos	P(OP)
298022	Phosphorodithioic acid, O,O-diethyl S-[(ethylthio) methyl] ester	Phorate \ Thimet	P(OP)
298044	Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio) ethyl] ester	Disulfoton	P(OP)
300765	Phosphoric acid, 1,2-dibromo-2,2-dichloroethyl di methyl ester	Naled \ Dibrom	P(OP)
309002	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-endo,exo-	Aldrin	P(OH)
319846	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-alpha,3-beta, 4-alpha, 5-beta, 6-beta)-	alpha-BHC	P(OH)
319857	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-beta, 3-alpha, 4-beta, 5-alpha, 6-beta)-	beta-BHC	P(OH)
319868	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-alpha,3-alpha, 4-beta, 5-alpha, 6-beta)-	delta-BHC	P(OH)
333415	Phosphorodithioic acid, O,O-diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl) ester	Diazinon \ Spectracide	P(OP)
465736	1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-endo,endo-dimethanonaphthalene	Isodrin (Stereoisomer of Aldrin)	P(OH)
470906	Phosphoric acid, 2-chloro-1-(2,4-dichlorophenyl)vinyl dimethyl ester	Chlorfenvinphos \ Supona	P(OP)
475207	Longifolene	Longifolene	SV(N)
492228	Thioxanthe-9-one	Thioxanthone \ Thiaxanthone	SV(B)
506774	Cyanogen chloride	Chlorine cyanide	MISC
510156	Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)-alpha-hydroxy, ethyl ester	Chlorobenzilate \ Ethyl-4,4'-dichlorobenzilate	P(OH)

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
512561	Phosphoric acid, trimethyl ester	Trimethylphosphate	P(OP)
534521	Phenol, 2-methyl-4,6-dinitro-	2-Methyl-4,6-dinitrophenol \ DNOC \ 4,6-Dinitro-o-cresol	SV(A)
541731	1,3-Dichlorobenzene	Benzene, 1,3-dichloro- \ m-Dichlorobenzene	SV(N)
544763	n-Hexadecane	n-C16	SV(N)
544923	Copper cyanide (CuCN)	Copper cyanide	MISC
563122	Phosphorodithioic acid, S,S'-methylene O,O,O',O'-tetra ethyl ester	Ethion \ Bladan	P(OP)
569642	Ammonium, (4-(p-(dimethylamino)-alpha-phenylbenzylidine)-2,5-cylcohexadien-1-ylidene)-dimethyl chloride	Malachite green \ C.I. Basic Acid Green 4	SV(B)
591786	2-Hexanone	2-Hexanone	VOL
593453	n-Octadecane	n-C18	SV(N)
605027	1-Phenylnaphthalene	1-Phenylnaphthalene	SV(N)
606202	2,6-Dinitrotoluene	Benzene, 2-methyl-1,3-dinitro-	SV(B)
608275	2,3-Dichloroaniline	2,3-Dichloroaniline	SV(B)
608935	Pentachlorobenzene	Benzene, pentachloro-	SV(N)
612942	2-Phenylnaphthalene	2-Phenylnaphthalene	SV(N)
614006	N-Nitrosomethylphenylamine	N-Nitrosomethylphenylamine	SV(B)
615225	2-(Methylthio)benzothiazole	2-(Methylthio)benzothiazole	SV(B)
621647	Di-n-propylnitrosamine	N-Nitrosodi-n-propylamine	SV(B)
629594	n-Tetradecane	n-C14	SV(N)
629970	n-Docosane	n-C22	SV(N)
630013	n-Hexacosane	n-C26	SV(N)
630024	n-Octacosane	n-C28	SV(N)
630206	1,1,1,2-Tetrachloroethane	Ethane, 1,1,1,2-tetrachloro-	VOL
634366	1,2,3-Trimethoxybenzene	1,2,3-Trimethoxybenzene	SV(N)
638686	n-Triacontane	n-C30	SV(N)
646311	n-Tetracosane	n-C24	SV(N)
680319	Phosphoric triamide, hexamethyl-	Hexamethylphosphoramide \ HMPA	P(OP)
694804	1-Bromo-2-chlorobenzene	2-Bromochlorobenzene	VOL
700129	Pentamethylbenzene	Pentamethylbenzene	SV(N)
719222	2,6-di-tert-Butyl-p-benzoquinone	2,6-di-tert-Butyl-p-benzoquinone	SV(N)
732116	Phosphorodithioic acid, O,O-dimethyl ester, S-ester withN-(mercaptomethyl)phthalimide	Phosmet \ Imidan	P(OP)
764410	2-Butene, 1,4-dichloro (mixture of cis and trans)	1,4-Dichloro-2-butene	VOL
786196	Phosphorodithioic acid, s(((p-chlorophenyl)thio) methyl) O,O-diethyl ester	Carbophenothion \ Trithion	P(OP)
789026	o,p'-DDT	o,p'-DDT	P(OH)
832699	1-Methylphenanthrene	1-Methylphenanthrene	SV(N)
882337	Diphenyldisulfide	Diphenyl sulfide	SV(N)
924163	N-Nitrosodi-n-butylamine	1-Butenamine, N-butyl-N-nitroso	SV(B)
933755	2,3,6-Trichlorophenol	2,3,6-Trichlorophenol	SV(A)
959988	Endosulfan-I	Thiodan I	P(OH)
961115	Phosphoric acid, 2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl ester	Tetrachlorvinphos \ Gardona	P(OP)
1024573	2,5-Methano-2H-indeno[1,2b]oxirene, 2,3,4,5,6,7,7-heptachloro-1a,1b,5,5a,6,6a-hexahydro- (alpha, beta, and gamma isomers)	Heptachlor epoxide	P(OH)
1031078	Endosulfan sulfate	6,9-Methano-2,3,4-benzodioxathiepin, 6,7	P(OH)
1330207	Total xylenes	Benzene, dimethyl- \ Xylenes \ Xylene, (total)	VOL
1332214	Asbestos	Asbestos	MISC
1464535	1,2:3,4-Diepoxybutane	Erythritol anhydride \ 2,2'-Bioxirane	SV(N)

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
1576676	3,6-Dimethylphenanthrene	3,6-Dimethylphenanthrene	SV(N)
1576698	2,7-Dimethylphenanthrene	2,7-Dimethylphenanthrene	SV(N)
1582098	p-Toluidine, alpha, alpha, alpha-trifluoro-2,6-dinitro- N,N-dipropyl-	Trifluralin \ Treflan	P(OH)
1689845	Benzonitrile, 3,5-dibromo-4-hydroxy-	Bromoxynil \ 3,5-Dibromo-4-hydroxybenzonitrile	SV(A)
1730376	1-Methylfluorene	1-Methylfluorene	SV(N)
1746016	Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-	Dioxin \ TCDD \ 2,3,7,8-Tetrachlorodibenzo-p-dioxin	DIOXINS
1836755	Ether, 2,4-dichlorophenyl p-nitrophenyl-	Nitrofen \ TOK	P(OH)
1888717	Hexachloropropene	1-Propene, 1,1,2,3,3,3-hexachloro-	SV(N)
2027170	2-Isopropylnaphthalene	2-Isopropylnaphthalene	SV(N)
2104645	Phosphorothioic acid, phenyl-, O-ethyl O-(p-nitro phenyl) ester	EPN \ Santox	P(OP)
2243621	1,5-Naphthalenediamine	1,5-Naphalenediamine	SV(B)
2303164	Carbamothioic acid, bis(1-methylethyl)-S-(2,3-dichloro -2-propenyl) ester	Diallate \ Avadex	P(C)
2385855	1,3,4-Metheno-1H-cyclobuta[cd]pentalene, 1,1a,2,2,3,3a, 4,5,5,5a,5b,6,-dodecachlorooctahydro	Mirex \ Dechlorane	P(OH)
2425061	4-Cyclohexene-1,2-dicarboximide N-((1,1,2,2-tetrachloro ethyl)thio)-	Captafol \ Difolatan	P(OH)
2642719	Phosphorodithioic acid, O,O-diethyl ester, S-ester with 3-(mercaptomethyl)-1,2,3-benzotriazin-4(3H)-one	Azinphos-ethyl \ Ethyl Guthion	P(OP)
2921882	Phosphorodithioic acid, O,O-diethyl O-(3,5,6-trichloro- 2-pryidyl) ester	Chlorpyrifos \ Dursban	P(OP)
3209221	2,3-Dichloronitrobenzene	2,3-Dichloronitrobenzene	SV(N)
3288582	O,O-Diethyl S-methyl ester of phosphorodithioic acid	Phosphorodithioic acid, O,O-diethyl S-methyl ester	P(OP)
3689245	Thiopyrophosphoric acid ([(HO)2P(S)]2O), tetraethyl ester	Sulfotepp \ Bladafum \ Tetraethyldithiopyrophosphate	P(OP)
4104147	Phosphoramidothioic acid, acetamidoyl, O,O-bis(p- chlorophenyl) ether	Phosacetin	P(OP)
4170303	2-Butenal	Crotonaldehyde \ Crotylaldehyde	VOL
6923224	Phosphoric acid, dimethyl ester, ester with (E)-3-hydroxy-N-methylcrotonamide	Monocrotophos \ Azodrin	P(OP)
7005723	4-Chlorophenylphenyl ether	Benzene, 1-chloro-4-phenoxy	SV(N)
7421934	Endrin aldehyde	Endrin aldehyde	P(OH)
7429905	Aluminum	Al	M(C)
7429916	Dysprosium	Dy	M(C)
7439885	Iridium	Ir	M(C)
7439896	Iron	Fe	M(C)
7439910	Lanthanum	La	M(C)
7439921	Lead	Pb	M(C)
7439932	Lithium	Li	M(C)
7439943	Lutetium	Lu	M(C)
7439954	Magnesium	Mg	M(C)
7439965	Manganese	Mn	M(C)
7439976	Mercury	Hg	M(C)
7439987	Molybdenum	Mo	M(C)
7440008	Neodymium	Nd	M(C)
7440020	Nickel	Ni	M(C)
7440031	Niobium	Nb	M(C)
7440042	Osmium	Os	M(C)
7440053	Palladium	Pd	M(C)
7440064	Platinum	Pt	M(C)
7440097	Potassium	K	M(C)
7440100	Praseodymium	Pr	M(C)
7440155	Rhenium	Re	M(C)

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
7440166	Rhodium	Rh	M(C)
7440188	Ruthenium	Ru	M(C)
7440199	Samarium	Sm	M(C)
7440202	Scandium	Sc	M(C)
7440213	Silicon	Si	M(A)
7440224	Silver	Ag	M(C)
7440235	Sodium	Na	M(C)
7440246	Strontium	Sr	M(C)
7440257	Tantalum	Ta	M(C)
7440279	Terbium	Tb	M(C)
7440280	Thallium	Tl	M(C)
7440291	Thorium	Th	M(C)
7440304	Thulium	Tm	M(C)
7440315	Tin	Sn	M(C)
7440326	Titanium	Ti	M(C)
7440337	Tungsten	W	M(C)
7440360	Antimony	Sb	M(C)
7440382	Arsenic	As	M(A)
7440393	Barium	Ba	M(C)
7440417	Beryllium	Be	M(C)
7440428	Boron	B	M(A)
7440439	Cadmium	Cd	M(C)
7440451	Cerium	Ce	M(C)
7440473	Chromium	Cr	M(C)
7440484	Cobalt	Co	M(C)
7440508	Copper	Cu	M(C)
7440520	Erbium	Er	M(C)
7440531	Europium	Eu	M(C)
7440553	Gallium	Ga	M(C)
7440564	Germanium	Ge	M(C)
7440575	Gold	Au	M(C)
7440586	Hafnium	Hf	M(C)
7440600	Holmium	Ho	M(C)
7440611	Uranium	U	M(C)
7440622	Vanadium	V	M(C)
7440644	Ytterbium	Yb	M(C)
7440655	Yttrium	Y	M(C)
7440666	Zinc	Zn	M(C)
7440677	Zirconium	Zr	M(C)
7440699	Bismuth	Bi	M(C)
7440702	Calcium	Ca	M(C)
7440746	Indium	In	M(C)
7553562	Iodine	I	M(A)
7664417	Ammonia	Ammonia	MISC
7683649	Squalene	Squalene	SV(N)
7700176	Crotonic acid, 3-hydroxy, alpha-methylbenzyl ester, di methylphosphate (E)	Crotoxyphos \ Ciodrin	P(OP)
7704349	Sulfur	S	M(A)
7723140	Phosphorus (black, white, red, yellow, or violet)	P	M(A)

TABLE 9-2
ANALYTES SORTED BY CAS NUMBER
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

CAS NUMBER	REGULATORY NAME	COMMON NAME	CLASS
7782492	Selenium	Se	M(A)
7782505	Chlorine	Chlorine	M(A)
7786347	Crotonic acid, 3-hydroxy-, methyl ester, dimethyl phosphate (E)-	Mevinphos \ Phosdrin	P(OP)
8001352	Toxaphene	Camphechlor	P(OH)
8065483	Phosphorodithioic acid, O,O-diethyl O-(2-(ethylthio) ethyl) ester mixed with O,O-diethyl S-(2-(ethylthio) ethyl) ester (7:3)	Demeton \ Systox	P(OP)
10049044	Chlorine dioxide	Chlorine oxide	MISC
10061015	cis-1,3-Dichloropropene	1-Propene, 1,3-dichloro-, (Z)-	VOL
10061026	trans-1,3-Dichloropropene	1-Propene, 1,3-dichloro-, (E)-	VOL
10595956	N-Nitrosomethylethylamine	Ethanamine, N-methyl-N-nitroso	SV(B)
11096825	PCB-1260	Aroclor 1260	PCB
11097691	PCB-1254	Aroclor 1254	PCB
11104282	PCB-1221	Aroclor 1221	PCB
11141165	PCB-1232	Aroclor 1232	PCB
12122677	Ethylenebisdithiocarbamic acid,-zinc salt	Zineb \ Dithane Z	P(C)
12427382	Ethylenebisdithiocarbamic acid,-manganese salt	Maneb \ Vancide	P(C)
12672296	PCB-1248	Aroclor 1248	PCB
12674112	PCB-1016	Aroclor 1016	PCB
13071799	Phosphorodithioic acid, O,O-diethyl-S-(((1,1-dimethyl ethyl)thio)methyl ester	Terbufos \ Counter	P(OP)
13171216	Phosphoric acid, dimethyl ester, ester with 2-chloro-N-N-diethyl-3-hydroxycrotonamide	Phosphamidon \ Dimecron	P(OP)
13494809	Tellurium	Te	M(C)
14797650	Nitrites	Nitrites	MISC
15972608	2-Chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl) acetamide	Alachlor \ Metachlor \ Lasso	P(OH)
16984488	Fluoride	Fluoride	MISC
18496258	Sulfide	Sulfide	MISC
19408743	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1,2,3,7,8,9-HxDD	DIOXINS
20324338	Tripropyleneglycol methyl ether	Tripropyleneglycol methyl ether	SV(N)
21609905	Phosphorothioic acid, phenyl, O-(4-bromo-2,5-dichloro phenyl) O-methyl ester	Leptophos \ Phosvel	P(OP)
23950585	Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-	Pronamide \ Kerb	P(H)
28434868	3,3'-Dichloro-4,4'-diaminodiphenyl ether	3,3'-Dichloro-4,4'-diaminodiphenyl ether	SV(N)
33213659	Endosulfan-II	Thiodan II	P(OH)
37871004	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1,2,3,4,6,7,8-HpDD	DIOXINS
40321764	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1,2,3,7,8-PeDD	DIOXINS
53469219	PCB-1242	Aroclor 1242	PCB
53494705	Endrin ketone	Endrine ketone	P(OH)
57653857	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1,2,3,6,7,8-HxDD	DIOXINS

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
(1,1'-Biphenyl)-4,4'-diamine	Benzidine	SV(B)	92875
1,1'-Biphenyl-4,4'-diamine, 3,3'-dichloro	3,3'-Dichlorobenzidine	SV(B)	91941
1,1-Dichloroethylene \ Vinylidine chloride	1,1-Dichloroethene	VOL	75354
1,2,3,4,6,7,8-HpDD	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	DIOXINS	37871004
1,2,3,4,7,8-HxDD	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	DIOXINS	1-030
1,2,3,6,7,8-HxDD	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	DIOXINS	57653857
1,2,3,7,8,9-HxDD	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	DIOXINS	19408743
1,2,3,7,8-PeDD	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	DIOXINS	40321764
1,2,3-Trichlorobenzene	1,2,3-Trichlorobenzene	SV(N)	87616
1,2,3-Trimethoxybenzene	1,2,3-Trimethoxybenzene	SV(N)	634366
1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl)ester	bis(2-Ethylhexyl) phthalate	SV(N)	117817
1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester	Butyl benzyl phthalate	SV(N)	85687
1,2-Benzenedicarboxylic acid, diethyl ester	Diethyl phthalate	SV(N)	84662
1,2-Benzenedicarboxylic acid, dioctyl ester \ Dioctyl ph	Di-n-octyl phthalate	SV(N)	117840
1,3,5-Trithiane	1,3,5-Trithiane	SV(N)	291214
1,3-Benzenediol	Resorcinol	SV(A)	108463
1,3-Benzodioxole, 5-(2-propenyl)-	Safrole	SV(N)	94597
1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	Hexachlorobutadiene	SV(N)	87683
1,3-Dichloro-2-propanol	1,3-Dichloro-2-propanol	SV(N)	96231
1,3-Dichloropropane	1,3-Dichloropropane	VOL	142289
1,4-Dichloro-2-butene	2-Butene, 1,4-dichloro (mixture of cis and trans)	VOL	764410
1,4-Naphthalenedione	1,4-Naphthoquinone	SV(N)	130154
1,5-Naphalenediamine	1,5-Naphthalenediamine	SV(B)	2243621
1-Bromo-4-phenoxybenzene \ Benzene, 1-bromo-4-phenoxy-	4-Bromophenyl phenyl ether	SV(N)	101553
1-Butenamine, N-butyl-N-nitroso	N-Nitrosodi-n-butylamine	SV(B)	924163
1-Methylfluorene	1-Methylfluorene	SV(N)	1730376
1-Methylphenanthrene	1-Methylphenanthrene	SV(N)	832699
1-Phenylnaphthalene	1-Phenylnaphthalene	SV(N)	605027
1-Propanol, 2-methyl-	Isobutyl alcohol	VOL	78831
1-Propene, 1,1,2,3,3,3-hexachloro-	Hexachloropropene	SV(N)	1888717
1-Propene, 1,3-dichloro-, (E)-	trans-1,3-Dichloropropene	VOL	10061026
1-Propene, 1,3-dichloro-, (Z)-	cis-1,3-Dichloropropene	VOL	10061015
2,3,6-Trichlorophenol	2,3,6-Trichlorophenol	SV(A)	933755
2,3-Benzothiophene \ Benzo(b)thiophene	Thianaphthene	SV(N)	95158
2,3-Dichloroaniline	2,3-Dichloroaniline	SV(B)	608275
2,3-Dichloronitrobenzene	2,3-Dichloronitrobenzene	SV(N)	3209221
2,3-benzofluorene	2,3-Benzofluorene	SV(N)	243174
2,4,5-T \ Weedone \ Acetic acid, 2,4,5-trichlorophenoxy-	2,4,5-Trichlorophenoxyacetic acid	P(OH)	93765
2,4,5-TP \ Silvex	Propanoic acid, 2-(2,4,5-trichlorophenoxy)-	P(H)	93721
2,4,5-Trimethylaniline	Aniline, 2,4,5-trimethyl-	SV(B)	137177
2,4-D \ Acetic acid, (2,4-dichlorophenoxy)-	2,4-Dichlorophenoxyacetic acid, salts and esters	P(H)	94757
2,4-Diaminotoluene \ Toluene, 2,4-diamino-	1,3-Benzenediamine, 4-methyl-	SV(B)	95807
2,6-di-tert-Butyl-p-benzoquinone	2,6-di-tert-Butyl-p-benzoquinone	SV(N)	719222
2,7-Dimethylphenanthrene	2,7-Dimethylphenanthrene	SV(N)	1576698
2-(Methylthio)benzothiazole	2-(Methylthio)benzothiazole	SV(B)	615225
2-Bromochlorobenzene	1-Bromo-2-chlorobenzene	VOL	694804
2-Butene, 1,4-dichloro-, (E)-	trans-1,4-Dichloro-2-butene	VOL	110576
2-Hexanone	2-Hexanone	VOL	591786

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
2-Isopropylnaphthalene	2-Isopropylnaphthalene	SV(N)	2027170
2-Methyl-4,6-dinitrophenol \ DNOC \ 4,6-Dinitro-o-cresol	Phenol, 2-methyl-4,6-dinitro-	SV(A)	534521
2-Methylbenzothioazole	2-Methylbenzothioazole	SV(N)	120752
2-Methylphenol \ o-Cresylic acid \ Phenol, 2-methyl-	o-Cresol	SV(A)	95487
2-Naphthylamine	beta-Naphthylamine	SV(B)	91598
2-Phenylnaphthalene	2-Phenylnaphthalene	SV(N)	612942
2-Propenoic acid, 2-methyl, methyl ester	Methyl methacrylate	VOL	80626
2-Propenoic acid, 2-methyl-, ethyl ester	Ethyl methacrylate	VOL	97632
3,3'-Dichloro-4,4'-diaminodiphenyl ether	3,3'-Dichloro-4,4'-diaminodiphenyl ether	SV(N)	28434868
3,3'-Dimethoxybenzidine	1,1'-Biphenyl-4,4'-diamine, 3,3'-dimethoxy	SV(B)	119904
3,5,5-Trimethyl-2-cyclohexenone	Isophorone	SV(N)	78591
3,6-Dimethylphenanthrene	3,6-Dimethylphenanthrene	SV(N)	1576676
3-Bromochlorobenzene	1-Bromo-3-chlorobenzene	VOL	108372
3-Methylcholanthrene	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	SV(N)	56495
3-Methylphenol \ Phenol, 3-methyl-	m-Cresol	SV(A)	108394
3-chloronitrobenzene	1-Chloro-3-nitrobenzene	SV(N)	121733
4,4'-DDD/Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-	4,4'-DDD	P(OH)	72548
4,4'-DDE/Benzene, 1,1'-(dichloroethenlyidine)bis[4-chloro	4,4'-DDE	P(OH)	72559
4,4'-DDT/Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro	4,4'-DDT	P(OH)	50293
4,5-dimethyl phenanthrene	4,5-dimethyl phenanthrene	SV(N)	203645
4-Aminobiphenyl	[1,1'-Biphenyl]-4-amine	SV(B)	92671
4-Chloro-2-nitroaniline	4-Chloro-2-nitroaniline	SV(B)	89634
4-Methylphenol \ Phenol, 4-methyl-	p-Cresol	SV(A)	106445
4-Nitrobiphenyl	Biphenyl, 4-nitro	SV(N)	92933
5-Chloro-o-toluidine	o-Toluidine, 5-chloro-	SV(B)	95794
6,9-Methano-2,3,4-benzodioxathiepin, 6,7	Endosulfan sulfate	P(OH)	1031078
9,10-Dimethyl-1,2-Benzanthracene	7,12-Dimethylbenz(a)anthracene	SV(B)	57976
Acenaphthylene	Acenaphthylene	SV(N)	208968
Acenaphthylene, 1,2-dihydro-	Acenaphthene	SV(N)	83329
Acetic acid, ethenyl ester	Vinyl acetate	VOL	108054
Acetone	2-Propanone	VOL	67641
Acetophenone	Ethanone, 1-phenyl	SV(N)	98862
Acrolein	2-Propenal	VOL	107028
Acrylonitrile	2-Propenenitrile	VOL	107131
Ag	Silver	M(C)	7440224
Al	Aluminum	M(C)	7429905
Alachlor \ Metachlor \ Lasso	2-Chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl)	P(OH)	15972608
Aldrin	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-	P(OH)	309002
Allyl alcohol	2-Propen-1-o1	VOL	107186
Allyl chloride \ 3-Chloropropene	1-Propene, 3-chloro-	VOL	107051
Ammonia	Ammonia	MISC	7664417
Aniline	Benzenamine	SV(B)	62533
Anthracene	Anthracene	SV(N)	120127
Aramite	Sulfurous acid, 2-chloroethyl-, 2-[4-(1,1-dimethylethyl)	SV(A)	140578
Aroclor 1016	PCB-1016	PCB	12674112
Aroclor 1221	PCB-1221	PCB	11104282
Aroclor 1232	PCB-1232	PCB	11141165
Aroclor 1242	PCB-1242	PCB	53469219

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
Aroclor 1248	PCB-1248	PCB	12672296
Aroclor 1254	PCB-1254	PCB	11097691
Aroclor 1260	PCB-1260	PCB	11096825
As	Arsenic	M(A)	7440382
Asbestos	Asbestos	MISC	1332214
Au	Gold	M(C)	7440575
Azinphos-ethyl \ Ethyl Guthion	Phosphorodithioic acid, O,O-diethyl ester, S-ester with	P(OP)	2642719
Azinphos-methyl \ Guthion	Phosphorodithioic acid, O,O-dimethyl ester, S-ester with	P(OP)	86500
B	Boron	M(A)	7440428
BOD	Biochemical Oxygen Demand	MISC	1-002
Ba	Barium	M(C)	7440393
Be	Beryllium	M(C)	7440417
Benz[a]anthracene \ 1,2-Benzanthracene	Benzo(a)anthracene	SV(N)	56553
Benz[e]acephenanthrylene	Benzo(b)fluoranthene	SV(N)	205992
Benzanthrone	Benzanthrone	SV(N)	82053
Benzenamine, 2-methyl-5-nitro	5-Nitro-o-toluidine	SV(B)	99558
Benzenamine, 2-nitro	2-Nitroaniline	SV(B)	88744
Benzenamine, 3-nitro	3-Nitroaniline	SV(B)	99092
Benzenamine, 4,4'-methylenebis[2chloro \ MOCA	4,4'-Methylenebis(2-chloroaniline)	SV(B)	101144
Benzenamine, 4-nitro-	p-Nitroaniline	SV(B)	100016
Benzenamine, N-nitroso-N-phenyl	N-Nitrosodiphenylamine	SV(B)	86306
Benzenamine, N-phenyl	Diphenylamine	SV(B)	122394
Benzene	Benzene	VOL	71432
Benzene, 1,2,4,5-tetrachloro-	1,2,4,5-Tetrachlorobenzene	SV(B)	95943
Benzene, 1,2,4-trichloro-	1,2,4-Trichlorobenzene	SV(N)	120821
Benzene, 1,2-dichloro- \ o-Dichlorobenzene	1,2-Dichlorobenzene	SV(N)	95501
Benzene, 1,3-dichloro- \ m-Dichlorobenzene	1,3-Dichlorobenzene	SV(N)	541731
Benzene, 1,3-dinitro- \ m-Dinitrobenzene	1,3-Dinitrobenzene	SV(N)	99650
Benzene, 1,4-dichloro- \ p-Dichlorobenzene	1,4-Dichlorobenzene	SV(B)	106467
Benzene, 1-chloro-4-phenoxy	4-Chlorophenylphenyl ether	SV(N)	7005723
Benzene, 1-methyl-2,4-dinitro	2,4-Dinitrotoluene	SV(N)	121142
Benzene, 2-methyl-1,3-dinitro-	2,6-Dinitrotoluene	SV(B)	606202
Benzene, chloro-	Chlorobenzene	VOL	108907
Benzene, dimethyl- \ Xylenes \ Xylene, (total)	Total xylenes	VOL	1330207
Benzene, ethenyl-	Styrene	VOL	100425
Benzene, ethyl	Ethylbenzene	VOL	100414
Benzene, methyl	Toluene	VOL	108883
Benzene, nitro-	Nitrobenzene	SV(B)	98953
Benzene, pentachloro-	Pentachlorobenzene	SV(N)	608935
Benzenemethanol	Benzyl alcohol	SV(N)	100516
Benzo(a)pyrene	Benzo(a)pyrene	SV(N)	50328
Benzo(ghi)perylene	Benzo(ghi)perylene	SV(N)	191242
Benzo(k)fluoranthene	Benzo(k)fluoranthene	SV(N)	207089
Benzo[def]phenanthrene	Pyrene	SV(N)	129000
Benzoic acid	Benzoic acid	SV(A)	65850
Bi	Bismuth	M(C)	7440699
Bromoform \ Methane, tribromo-	Tribromomethane	VOL	75252
Bromoxynil \ 3,5-Dibromo-4-hydroxybenzonitrile	Benzonitrile, 3,5-dibromo-4-hydroxy-	SV(A)	1689845

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
Busan 85	Potassium dimethyldithiocarbamate	P(C)	128030
COD	Chemical Oxygen Demand	MISC	1-004
Ca	Calcium	M(C)	7440702
Camphechlor	Toxaphene	P(OH)	8001352
Caproic acid	Hexanoic acid	SV(A)	142621
Captafol \ Difolatan	4-Cyclohexene-1,2-dicarboximide N-((1,1,2,2-tetrachloro	P(OH)	2425061
Captan	4-Cyclohexene-1,2-dicarboximide N-(trichloromethyl)thio-	P(OH)	133062
Carbamic acid, dimethyldithio-, sodium salt	Sodium dimethyldithiocarbamate	P(C)	128041
Carbamic acid, methyldithio-, monopotassium salt	Potassium-N-methyldithiocarbamate	P(C)	137417
Carbazole	Carbazole	SV(B)	86748
Carbolic acid	Phenol	SV(A)	108952
Carbon disulfide	Carbon disulfide	VOL	75150
Carbon tetrachloride \ Methane, tetrachloro-	Tetrachloromethane	VOL	56235
Carbophenothion \ Trithion	Phosphorodithioic acid, s(((p-chlorophenyl)thio)	P(OP)	786196
Cd	Cadmium	M(C)	7440439
Ce	Cerium	M(C)	7440451
Chloramine	Chloramine	MISC	0-012
Chlordane	4,7-Methano-1H-indene 1,2,4,5,6,7,8,8-octachloro-2,3,3a,	P(OH)	57749
Chlorfenvinphos \ Supona	Phosphoric acid, 2-chloro-1-(2,4-dichlorophenyl)vinyl di	P(OP)	470906
Chloride	Chloride	MISC	1-003
Chlorine	Chlorine	M(A)	7782505
Chlorine cyanide	Cyanogen chloride	MISC	506774
Chlorine oxide	Chlorine dioxide	MISC	10049044
Chlorite	Chlorite	MISC	0-011
Chlorobenzilate \ Ethyl-4,4'-dichlorobenzilate	Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)-	P(OH)	510156
Chlorodibromomethane \ Methane, dibromochloro-	Dibromochloromethane	VOL	124481
Chloroethanenitrile	Chloroacetonitrile	VOL	107142
Chloroprene \ 1,3-Butadiene, 2-chloro	2-Chloro-1,3-butadiene	VOL	126998
Chlorpyrifos \ Dursban	Phosphorodithioic acid, O,O-diethyl O-(3,5,6-trichloro-	P(OP)	2921882
Chrysene	Chrysene	SV(N)	218019
Co	Cobalt	M(C)	7440484
Conductivity, specific	Specific conductivity	MISC	1-011
Copper cyanide	Copper cyanide (CuCN)	MISC	544923
Corrosivity	Corrosivity	MISC	1-014
Coumaphos \ Co-Ral	Coumarin, 3-chloro-7-hydroxy-4-methyl-, O-ester with O,	P(OP)	56724
Cr	Chromium	M(C)	7440473
Crotonaldehyde \ Crotylaldehyde	2-Butenal	VOL	4170303
Crotoxyphos \ Ciodrin	Crotonic acid, 3-hydroxy, alpha-methylbenzyl ester, di	P(OP)	7700176
Cryptosporidium	Cryptosporidium	MISC	0-039
Cu	Copper	M(C)	7440508
Cyanides (soluble salts and complexes)	Cyanides (soluble salts and complexes) NOS	MISC	57125
Cygon \ Dimethoate	Phosphorodithioic acid, O,O-dimethyl s-[2-(methylamino)-	P(OP)	60515
DNBP \ Dinoseb \ 2-sec-butyl-4,6-dinitrophenol	Phenol, 2-(1-methylpropyl)-4,6-dinitro-	P(H)	88857
Demeton \ Systox	Phosphorodithioic acid, O,O-diethyl O-(2-(ethylthio)	P(OP)	8065483
Di-n-butyl phthalate \ Dibutyl phthalate	1,2-Benzenedicarboxylic acid, dibutyl ester	SV(N)	84742
Diallate \ Avadex	Carbamothioic acid, bis(1-methylethyl)-S-(2,3-dichloro	P(C)	2303164
Diazinon \ Spectracide	Phosphorodithioic acid, O,O-diethyl O-(2-isopropyl-6-	P(OP)	333415
Dibenz[a,h]anthracene	Dibenzo(a,h)anthracene	SV(N)	53703

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
Dibenzofuran	Dibenzofuran	SV(N)	132649
Dibenzothiophene	Dibenzothiophene	SV(N)	132650
Dibromochloropropane \ DBCP	Propane, 1,2-dibromo-3-chloro-	SV(B)	96128
Dichlone \ Phygon	1,4-Naphthoquinone, 2,3-dichloro-	P(OH)	117806
Dichloran \ Botran	2,6-dichloro-4-nitroaniline	SV(B)	99309
Dichloroethyl ether	bis(2-Chloroethyl) ether	SV(N)	111444
Dichloroiodomethane	Dichloroiodomethane	VOL	0-015
Dichloromethane \ Methane, dichloro-	Methylene chloride	VOL	75092
Dichlorvos \ DDVP	Phosphoric acid, 2,2-dichlorovinyl dimethyl ester	P(OP)	62737
Dicrotophos \ Bidrin	Phosphoric acid, dimethyl ester, ester with (E)-3-	P(OP)	141662
Dieldrin	2,7:3,6-Dimethanonaphth(2,3-b)oxirene, 3,4,5,6,9,9-hexa	P(OH)	60571
Diethyl ether	Diethyl ether	VOL	60297
Dimethyl phthalate	1,2-Benzenedicarboxylic acid, dimethyl ester	SV(N)	131113
Dimethyl sulfone	Dimethyl sulfone	SV(N)	67710
Dimethylnitrosamine \ Methamine, N-methyl-N-nitroso-	N-Nitrosodimethylamine	SV(B)	62759
Dinex \ DN-111 \ 2-Cyclohexyl-4,6-dinitrophenol	Phenol, 2-cyclohexyl-4,6-dinitro-	P(H)	131895
Dioxathion	Phosphorodithioic acid, S,S'-p-dioxane-2,3-dryl O,O,O',	P(OP)	78342
Dioxin \ TCDD \ 2,3,7,8-Tetrachlorodibenzo-p-dioxin	Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-	DIOXINS	1746016
Diphenyl	Biphenyl	SV(N)	92524
Diphenyl ether	Diphenyl ether	SV(N)	101848
Diphenyl sulfide	Diphenyldisulfide	SV(N)	882337
Disodium cyanodithioimidocarbonate	Disodium cyanodithioimidocarbonate	MISC	138932
Disulfoton	Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)	P(OP)	298044
Dy	Dysprosium	M(C)	7429916
EPN \ Santox	Phosphorothioic acid, phenyl-, O-ethyl O-(p-nitro	P(OP)	2104645
Endrin	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-	P(OH)	72208
Endrin aldehyde	Endrin aldehyde	P(OH)	7421934
Endrine ketone	Endrin ketone	P(OH)	53494705
Er	Erbium	M(C)	7440520
Erythritol anhydride \ 2,2'-Bioxirane	1,2:3,4-Diepoxybutane	SV(N)	1464535
Ethanamine, N-ethyl-N-nitroso-	N-Nitrosodiethylamine	SV(B)	55185
Ethanamine, N-methyl-N-nitroso	N-Nitrosomethylethylamine	SV(B)	10595956
Ethane, 1,1'-[methylenebis(oxy)]bis[2-chloro-	bis(2-Chloroethoxy)methane	SV(N)	111911
Ethane, 1,1,1,2-tetrachloro-	1,1,1,2-Tetrachloroethane	VOL	630206
Ethane, 1,1,2,2-tetrachloro	1,1,2,2-Tetrachloroethane	VOL	79345
Ethane, 1,1,2-trichloro	1,1,2-Trichloroethane	VOL	79005
Ethane, chloro \ Ethyl chloride	Chloroethane	VOL	75003
Ethane, hexachloro	Hexachloroethane	SV(N)	67721
Ethene, (2-chloroethoxy)	2-Chloroethylvinyl ether	VOL	110758
Ethene, 1,2-dichloro-, (E)-	trans-1,2-Dichloroethene	VOL	156605
Ethene, chloro	Vinyl chloride	VOL	75014
Ethene, trichloro \ Trichloroethylene	Trichloroethene	VOL	79016
Ethion \ Bladan	Phosphorodithioic acid, S,S'-methylene O,O,O',O'-tetra	P(OP)	563122
Ethyl methanesulfonate	Methanesulfonic acid, ethyl ester	SV(N)	62500
Ethylene dibromide \ EDB \ Ethane, 1,2-dibromo-	1,2-Dibromoethane	VOL	106934
Ethylene dichloride \ EDC \ Ethane, 1,2-dichloro-	1,2-Dichloroethane	VOL	107062
Ethylenebisdithiocarbamic acid, salts and esters	Carbamodithioic acid, 1,2-ethanediylbis-, salts and	P(C)	111546
Ethylenethiourea	Ethylenethiourea	SV(N)	96457

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
Ethylidene chloride \ Ethane, 1,1-dichloro-	1,1-Dichloroethane	VOL	75343
Eu	Europium	M(C)	7440531
Famphur \ Famophos	Phosphorothioic acid, O,O-dimethyl O-[p-[(dimethylamino)	P(OP)	52857
Fe	Iron	M(C)	7439896
Fensulfothion \ Desanit	Phosphorodithioic acid, O,O-diethyl O-(p-(methylsul	P(OP)	115902
Fenthion \ Baytex	Phosphorodithioic acid, O,O-dimethyl-, O-(4-methylthio)-	P(OP)	55389
Fluoranthene	Fluoranthene	SV(N)	206440
Fluorene	Fluorene	SV(N)	86737
Fluoride	Fluoride	MISC	16984488
Fluorotrichloromethane \ Methane, trichlorofluoro-	Trichlorofluoromethane	VOL	75694
Ga	Gallium	M(C)	7440553
Ge	Germanium	M(C)	7440564
HCB \ Benzene, hexachloro-	Hexachlorobenzene	SV(N)	118741
Heptachlor	4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-da,4,7,	P(OH)	76448
Heptachlor epoxide	2,5-Methano-2H-indeno[1,2b]oxirene, 2,3,4,5,6,7,7-hepta	P(OH)	1024573
Hexachlorocyclopentadiene \ HCP	1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	SV(N)	77474
Hexachlorodibenzo-p-dioxins	Hexachlorodibenzo-p-dioxins	DIOXINS	1-200
Hexachlorodibenzofurans	Hexachlorodibenzofurans	DIOXINS	1-201
Hexamethylphosphoramide \ HMPA	Phosphoric triamide, hexamethyl-	P(OP)	680319
Hf	Hafnium	M(C)	7440586
Hg	Mercury	M(C)	7439976
Ho	Holmium	M(C)	7440600
Hydrazine, 1,2-diphenyl	1,2-Diphenylhydrazine	SV(B)	122667
Hypochlorite ion	Hypochlorite ion	MISC	0-009
I	Iodine	M(A)	7553562
Ignitability	Ignitability	MISC	1-013
In	Indium	M(C)	7440746
Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	SV(N)	193395
Ir	Iridium	M(C)	7439885
Isodrin (Stereoisomer of Aldrin)	1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,	P(OH)	465736
Isosafrole	1,3-Benzodioxole, 5-(1-propenyl)-	SV(B)	120581
K	Potassium	M(C)	7440097
Kepone	4-Metheno-2H-cyclobuta(cd)pentalen-2-one, 1,1a,3,3a,	P(OH)	143500
La	Lanthanum	M(C)	7439910
Leptophos \ Phosvel	Phosphorothioic acid, phenyl, O-(4-bromo-2,5-dichloro	P(OP)	21609905
Li	Lithium	M(C)	7439932
Lindane \ gamma-BHC \ Hexachlorocyclohexane (gamma)	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-alpha,	P(OH)	58899
Longifolene	Longifolene	SV(N)	475207
Lu	Lutetium	M(C)	7439943
MIBK \ Methylisobutylketone \ 2-Pentanone, 4-methyl	4-Methyl-2-pentanone	VOL	108101
Malachite green \ C.I. Basic Acid Green 4	Ammonium, (4-(p-(dimethylamino)-alpha-phenylbenzyli	SV(B)	569642
Malathion \ Sumitox	Succinic acid, mercapto-, diethyl ester, S-ester with O,	P(OP)	121755
Maneb \ Vancide	Ethylenebisdithiocarbamic acid,-manganese salt	P(C)	12427382
Mestranol \ 17-alpha-Ethynylestradiol 3-methyl ether	17-alpha-19-Norpregna-1,3,5(10)-trien-20-yn-17-ol, 3-	SV(N)	72333
Methacrylonitrile	2-Propenenitrile, 2-methyl-	VOL	126987
Methane, bromodichloro	Bromodichloromethane	VOL	75274
Methane, trichloro- \ Trichloromethane	Chloroform	VOL	67663
Methane, trichloronitro-	Chloropicrin	SV(N)	76062

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
Methapyrilene	1,2-Ethanediamine, N,N-dimethyl-N'-2pyridinyl-N'-(2-	SV(B)	91805
Methoxychlor	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-	P(OH)	72435
Methyl bromide \ Methane, bromo	Bromomethane	VOL	74839
Methyl chloride \ Methane, chloro	Chloromethane	VOL	74873
Methyl chloroform \ Ethane, 1,1,1-trichloro-	1,1,1-Trichloroethane	VOL	71556
Methyl ethyl ketone \ MEK	2-Butanone	VOL	78933
Methyl iodide \ Methane, iodo	Iodomethane	VOL	74884
Methyl parathion \ Parathion-methyl \ Metaphos	Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl)	P(OP)	298000
Methylene bromide \ Methane, dibromo	Dibromomethane	VOL	74953
Methylsulfonic acid, methyl ester	Methyl methanesulfonate	SV(N)	66273
Mevinphos \ Phosdrin	Crotonic acid, 3-hydroxy-, methyl ester, dimethyl phos	P(OP)	7786347
Mg	Magnesium	M(C)	7439954
Mirex \ Dechlorane	1,3,4-Metheno-1H-cyclobuta[cd]pentalene, 1,1a,2,2,3,3a,	P(OH)	2385855
Mn	Manganese	M(C)	7439965
Mo	Molybdenum	M(C)	7439987
Monocrotophos \ Azodrin	Phosphoric acid, dimethyl ester, ester with (E)-3-	P(OP)	6923224
Morpholine, 4-nitroso-	N-Nitrosomorpholine	SV(B)	59892
N,N-Dimethylformamide	N,N-Dimethylformamide	SV(N)	68122
N-Nitrosodi-n-propylamine	Di-n-propylnitrosamine	SV(B)	621647
N-Nitrosomethylphenylamine	N-Nitrosomethylphenylamine	SV(B)	614006
Na	Sodium	M(C)	7440235
Nabam	Ethylenebisdithiocarbamic acid, -sodium salt	P(C)	142596
Naled \ Dibrom	Phosphoric acid, 1,2-dibromo-2,2-dichloroethyl di	P(OP)	300765
Naphthalene	Naphthalene	SV(N)	91203
Naphthalene, 2-chloro-	2-Chloronaphthalene	SV(B)	91587
Naphthalene, 2-methyl	2-Methylnaphthalene	SV(N)	91576
Nb	Niobium	M(C)	7440031
Nd	Neodymium	M(C)	7440008
Nemazine \ 10H-Phenothiazine	Phenothiazine	SV(B)	92842
Ni	Nickel	M(C)	7440020
Nitrate/nitrite	Nitrate/nitrite	MISC	1-005
Nitrites	Nitrites	MISC	14797650
Nitrofen \ TOK	Ether, 2,4-dichlorophenyl p-nitrophenyl-	P(OH)	1836755
O&G	Oil and grease	MISC	1-007
Os	Osmium	M(C)	7440042
P	Phosphorus (black, white, red, yellow, or violet)	M(A)	7723140
PCNB \ Terraclor \ Quintozene	Pentachloronitrobenzene	P(OP)	82688
PCP \ Phenol, pentachloro-	Pentachlorophenol	SV(A)	87865
Parathion \ Parathion, ethyl	Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl)	P(OP)	56382
Pb	Lead	M(C)	7439921
Pd	Palladium	M(C)	7440053
Pentachlorodibenzo-p-dioxins	Pentachlorodibenzo-p-dioxins	DIOXINS	1-289
Pentachlorodibenzofurans	Pentachlorodibenzofurans	DIOXINS	1-290
Pentachloroethane	Ethane, pentachloro-	SV(N)	76017
Pentamethylbenzene	Pentamethylbenzene	SV(N)	700129
Perchloroethylene \ Ethene, tetrachloro	Tetrachloroethene	VOL	127184
Perylene	Perylene	SV(N)	198550
Phenacetin \ Phorazetim	Acetamide, N-(4-ethoxyphenyl)-	SV(B)	62442

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
Phenanthrene	Phenanthrene	SV(N)	85018
Phenol, 2,3,4,6-tetrachloro-	2,3,4,6-Tetrachlorophenol	SV(A)	58902
Phenol, 2,4,5-trichloro-	2,4,5-Trichlorophenol	SV(A)	95954
Phenol, 2,4,6-trichloro-	2,4,6-Trichlorophenol	SV(A)	88062
Phenol, 2,4-dichloro-	2,4-Dichlorophenol	SV(A)	120832
Phenol, 2,4-dimethyl-	2,4-Dimethylphenol	SV(A)	105679
Phenol, 2,4-dinitro	2,4-Dinitrophenol	SV(A)	51285
Phenol, 2,6-dichloro-	2,6-Dichlorophenol	SV(A)	87650
Phenol, 2-chloro	2-Chlorophenol	SV(A)	95578
Phenol, 2-nitro-	2-Nitrophenol	SV(N)	88755
Phorate \ Thimet	Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)	P(OP)	298022
Phosacetin	Phosphoramidothioic acid, acetamidoyl, O,O-bis(p-	P(OP)	4104147
Phosmet \ Imidan	Phosphorodithioic acid, O,O-dimethyl ester, S-ester with	P(OP)	732116
Phosphamidon \ Dimecron	Phosphoric acid, dimethyl ester, ester with 2-chloro-N-	P(OP)	13171216
Phosphorodithioic acid, O,O,S-triethyl ester	O,O,O-Triethylphosphorothioate	P(OP)	126681
Phosphorodithioic acid, O,O-diethyl S-methyl ester	O,O-Diethyl S-methyl ester of phosphorodithioic acid	P(OP)	3288582
Piperidine, 1-Nitroso-	N-Nitrosopiperidine	SV(B)	100754
Pr	Praseodymium	M(C)	7440100
Pronamide \ Kerb	Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-	P(H)	23950585
Propane, 1,2,3-trichloro-	1,2,3-Trichloropropane	VOL	96184
Propane, 2,2'-oxybis[1-chloro-	bis(2-Chloroisopropyl) ether	SV(N)	108601
Propionitrile \ Propanenitrile	Ethyl cyanide	VOL	107120
Propylene dichloride \ Propane, 1,2-dichloro-	1,2-Dichloropropane	VOL	78875
Pt	Platinum	M(C)	7440064
Pyridine	Pyridine	SV(B)	110861
Re	Rhenium	M(C)	7440155
Reactivity	Reactivity	MISC	1-015
Retort	Oil and grease	MISC	1-016
Rh	Rhodium	M(C)	7440166
Ru	Ruthenium	M(C)	7440188
S	Sulfur	M(A)	7704349
Sb	Antimony	M(C)	7440360
Sc	Scandium	M(C)	7440202
Se	Selenium	M(A)	7782492
Si	Silicon	M(A)	7440213
Sm	Samarium	M(C)	7440199
Sn	Tin	M(C)	7440315
Squalene	Squalene	SV(N)	7683649
Sr	Strontium	M(C)	7440246
Sulfide	Sulfide	MISC	18496258
Sulfotepp \ Bladafum \ Tetraethyldithiopyrophosphate	Thiopyrophosphoric acid ([(HO)2P(S)]2O), tetraethyl	P(OP)	3689245
TEPP \ Phosphoric acid, tetraethyl ester	Tetraethylpyrophosphate	P(OP)	107493
TOC \ Organic carbon, total	Total organic carbon	MISC	1-012
TVOA \ VOC \ Organic carbon, volatile	Total volatile organic carbon	MISC	1-001
Ta	Tantalum	M(C)	7440257
Tb	Terbium	M(C)	7440279
Te	Tellurium	M(C)	13494809
Terbufos \ Counter	Phosphorodithioic acid, O,O-diethyl-S-(((1,1-dimethyl	P(OP)	13071799

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
Tetrachlorodibenzo-p-dioxins	Tetrachlorodibenzo-p-dioxins	DIOXINS	1-331
Tetrachlorodibenzofurans	Tetrachlorodibenzofurans	DIOXINS	1-332
Tetrachlorvinphos \ Gardona	Phosphoric acid, 2-chloro-1-(2,4,5-trichlorophenyl)	P(OP)	961115
Th	Thorium	M(C)	7440291
Thioacetamide	Ethanethioamide	SV(N)	62555
Thiodan I	Endosulfan-I	P(OH)	959988
Thiodan II	Endosulfan-II	P(OH)	33213659
Thiophenol \ Mercaptobenzene	Benzenethiol	SV(B)	108985
Thioxanthone \ Thiaxanthone	Thioxanthe-9-one	SV(B)	492228
Thiram \ Thiuram \ Arasan	Thioperoxydicarbonic diamide, tetramethyl	P(C)	137268
Ti	Titanium	M(C)	7440326
Tl	Thallium	M(C)	7440280
Tm	Thulium	M(C)	7440304
Total dissolved solids \ TDS	Residue, filterable	MISC	1-010
Total solids	Residue, total	MISC	1-008
Total suspended solids \ TSS	Residue, non-filterable	MISC	1-009
Trichlorofon \ Dylox	Phosphoric acid, (2,2,2-trichloro-1-hydroxyethyl)-,	P(OP)	52686
Tricresylphosphate \ TCP \ TOCP	Phosphoric acid, tri-o-tolyl ester	P(OP)	78308
Trifluralin \ Treflan	p-Toluidine, alpha, alpha, alpha-trifluoro-2,6-dinitro-	P(OH)	1582098
Trimethylphosphate	Phosphoric acid, trimethyl ester	P(OP)	512561
Triphenylene	Triphenylene	SV(N)	217594
Tripropyleneglycol methyl ether	Tripropyleneglycol methyl ether	SV(N)	20324338
U	Uranium	M(C)	7440611
V	Vanadium	M(C)	7440622
W	Tungsten	M(C)	7440337
Y	Yttrium	M(C)	7440655
Yb	Ytterbium	M(C)	7440644
Zineb \ Dithane Z	Ethylenebisdithiocarbamic acid,-zinc salt	P(C)	12122677
Zinophos \ Thionazin	O,O-Diethyl-O-(2-pyrazinyl)phosphorothioate	P(OP)	297972
Ziram \ Cymate	Zinc bis(dimethyldithiocarbamato)-	P(C)	137304
Zn	Zinc	M(C)	7440666
Zr	Zirconium	M(C)	7440677
alpha-BHC	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-alpha,	P(OH)	319846
alpha-Naphthylamine	1-Naphthylamine	SV(B)	134327
alpha-Picoline \ 2-Methylpyridine	2-Picoline	VOL	109068
alpha-Terpineol	alpha-Terpineol	SV(N)	98555
beta-BHC	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-beta,	P(OH)	319857
delta-BHC	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1-alpha, 2-alpha,	P(OH)	319868
n-C10	n-Decane	SV(N)	124185
n-C12	n-Dodecane	SV(N)	112403
n-C14	n-Tetradecane	SV(N)	629594
n-C16	n-Hexadecane	SV(N)	544763
n-C18	n-Octadecane	SV(N)	593453
n-C20	n-Eicosane	SV(N)	112958
n-C22	n-Docosane	SV(N)	629970
n-C24	n-Tetracosane	SV(N)	646311
n-C26	n-Hexacosane	SV(N)	630013
n-C28	n-Octacosane	SV(N)	630024

TABLE 9-3
ANALYTES SORTED BY COMMON NAME
USEPA INDUSTRIAL TECHNOLOGY DIVISION LIST OF ANALYTES

COMMON NAME	REGULATORY NAME	CLASS	CAS NUMBER
n-C30	n-Triacontane	SV(N)	638686
o + p xylene	o + p xylene	VOL	1-952
o,p'-DDT	o,p'-DDT	P(OH)	789026
o-Anisidine	o-Anisidine	SV(B)	90040
o-Toluidine	o-Toluidine	SV(B)	95534
p-Chloro-m-cresol \ Phenol, 4-chloro-3-methyl-	4-Chloro-3-methylphenol	SV(A)	59507
p-Chloroaniline	Benzenamine, 4-chloro-	SV(B)	106478
p-Dimethylaminoazobenzene	Benzenamine, N,N-dimethyl-4-(pehnylazo)-	SV(B)	60117
p-Dioxane \ 1,4-Diethyleneoxide	1,4-Dioxane	VOL	123911
p-Isopropyltoluene	p-Cymene	SV(N)	99876
p-Nitrophenol \ Phenol, 4-nitro-	4-Nitrophenol	SV(A)	100027
pH	Hydrogen ion	M(C)	1-006

TABLE 9-4
ITD LIST OF INORGANIC CONTAMINANTS

TCL-LISTED INORGANICS	SEMI-QUANTITATIVE SCREEN METALS	
Antimony	Bismuth	Phosphorus
Arsenic	Cerium	Platinum
Aluminum	Dysprosium	Potassium
Barium	Erbium	Praseodymium
Beryllium	Europium	Rhenium
Boron	Gadolinium	Rhodium
Cadmium	Gallium	Ruthenium
Calcium	Germanium	Samarium
Chromium	Gold	Scandium
Cobalt	Hafnium	Silicon
Copper	Holminum	Strontium
Iron	Indium	Sulfur
Lead	Iodine	Tantalum
Magnesium	Iridium	Tellurium
Manganese	Lanthanum	Terbium
Mercury	Lithium	Thorium
Molybdenum	Lutetium	Thulium
Nickel	Neodymium	Tungston
Selenium	Niobium	Uranium
Silver	Osmium	Ytterbium
Sodium	Palladium	Zirconium
Thallium		
Tin		
Titanium		
Vanadium		
Yttrium		
Zinc		

TABLE 9-5
USEPA TARGET COMPOUND LIST

1,1,1-TRICHLOROETHANE
1,1,2,2-TETRACHLOROETHANE
1,1,2-TRICHLOROETHANE
1,1-DICHLOROETHANE
1,1-DICHLOROETHENE
1,2,4-TRICHLOROBENZENE
1,2-DICHLOROBENZENE
1,2-DICHLOROETHANE
1,2-DICHLOROPROPANE
1,3-DICHLOROBENZENE
1,4-DICHLOROBENZENE
2,4,5-TRICHLOROPHENOL
2,4,6-TRICHLOROPHENOL
2,4-DICHLOROPHENOL
2,4-DIMETHYLPHENOL
2,4-DINITROPHENOL
2,4-DINITROTOLUENE
2,6-DINITROTOLUENE
2-BUTANONE (MEK)
2-CHLOROETHYLVINYLETHER
2-CHLORONAPHTHALENE
2-CHLOROPHENOL
2-HEXANONE
2-METHYLNAPHTHALENE
2-NITROANILINE
2-NITROPHENOL
3,3'-DICHLOROBENZIDINE
3-NITROANILINE
4,4-DDD
4,4-DDE
4,4-DDT
4,6-DINITRO-2-METHYLPHENOL
4-BROMOPHENYL-PHENYLETHER
4-CHLORO-3-METHYLPHENOL
4-CHLOROANILINE
4-CHLOROPHENYL-PHENYLETHER
4-METHYL-2-PENTANONE
4-NITROANILINE
4-NITROPHENOL
ACENAPHTHENE
ACENAPHTHYLENE
ACETONE
ALDRIN
ALPHA-BHC
ALPHA-CHLORDANE
ALUMINUM
ANTHRACENE
ANTIMONY
ARSENIC
BARIUM
BENZENE
BENZO(A)ANTHRACENE
BENZO(A)PYRENE
BENZO(B)FLUORANTHENE
BENZO(G,H,I)PERYLENE
BENZO(K)FLUORANTHENE
BENZOIC ACID
BENZYL ALCOHOL
BERYLLIUM
BETA-BHC
BIS(2-CHLOROETHOXY)METHANE
BIS(2-CHLOROETHYL)ETHER
BIS(2-CHLOROISOPROPYL)ETHER
BIS(2-ETHYLHEXYL)PHTHALATE
BROMODICHLOROMETHANE
BROMOFORM
BROMOMETHANE
BUTYL BENZYL PHTHALATE
CADMIUM
CALCIUM
CARBON DISULFIDE
CARBON TETRACHLORIDE
CHLOROBENZENE
CHLOROETHANE
CHLOROFORM
CHLOROMETHANE
CHROMIUM
CHRYSENE
CIS-1,3-DICHLOROPROPENE
COBALT
COPPER
CYANIDE
DELTA-BHC
DI-N-BUTYLPHTHALATE
DI-N-OCTYL PHTHALATE
DIBENZ(A,H)ANTHRACENE
DIBENZOFURAN
DIBROMOCHLOROMETHANE
DIELDRIN
DIETHYLPHTHALATE
DIMETHYL PHTHALATE
ENDOSULFAN I
ENDOSULFAN II
ENDOSULFAN SULFATE
ENDRIN
ENDRIN ALDEHYDE
ENDRIN KETONE
ETHYLBENZENE
FLUORANTHENE
FLUORENE
GAMMA-BHC
GAMMA-CHLORDANE
HEPTACHLOR
HEPTACHLOR EPOXIDE
HEXACHLOROBENZENE
HEXACHLOROBUTADIENE
HEXACHLOROCYCLOPENTADIENE
HEXACHLOROETHANE
INDENO(1,2,3-CD)PYRENE
IRON
ISOPHORONE
LEAD
MAGNESIUM
MANGANESE
MERCURY
METHOXYCHLOR
METHYLENE CHLORIDE
N-NITROSO-DI-N-PROPYLAMINE
N-NITROSODIPHENYLAMINE (1)
NAPHTHALENE
NICKEL
NITROBENZENE
O-CRESOL
P-CRESOL
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260
PENTACHLOROPHENOL
PHENANTHRENE
PHENOL
POTASSIUM
PYRENE
SELENIUM
SILVER
SODIUM
STYRENE
TETRACHLOROETHENE
THALLIUM
TOLUENE
TOTAL XYLENES
TOXAPHENE
TRANS-1,2-DICHLOROETHENE
TRANS-1,3-DICHLOROPROPENE
TRICHLOROETHENE
VANADIUM
VINYL ACETATE
VINYL CHLORIDE
ZINC

TABLE 9-6
THE USEPA PRIORITY POLLUTANTS

1,1,1-TRICHLOROETHANE
1,1,2,2-TETRACHLOROETHANE
1,1,2-TRICHLOROETHANE
1,1-DICHLOROETHANE
1,1-DICHLOROETHENE
1,2,4-TRICHLOROBENZENE
1,2-DICHLOROBENZENE
1,2-DICHLOROETHANE
1,2-DICHLOROPROPANE
1,2-DIPHENYLHYDRAZINE
1,3-DICHLOROBENZENE
1,4-DICHLOROBENZENE
2,3,7,8-TCDD
2,4,6-TRICHLOROPHENOL
2,4-DICHLOROPHENOL
2,4-DIMETHYLPHENOL
2,4-DINITROPHENOL
2,4-DINITROTOLUENE
2,6-DINITROTOLUENE
2-CHLOROETHYLVINYLETHER
2-CHLORONAPHTHALENE
2-CHLOROPHENOL
2-NITROPHENOL
2-PROPENAL
2-PROPENENITRILE
3,3'-DICHLOROBENZIDINE
4,4-DDD
4,4-DDE
4,4-DDT
4,6-DINITRO-2-METHYLPHENOL
4-BROMOPHENYL-PHENYLETHER
4-CHLOROPHENYL-PHENYLETHER
4-NITROPHENOL
ACENAPHTHENE
ACENAPHTHYLENE
ALDRIN
ALPHA-BHC
ANTHRACENE
ANTIMONY
ARSENIC
ASBESTOS
BENZENE
BENZIDINE
BENZO(A)ANTHRACENE
BENZO(A)PYRENE
BENZO(B)FLUORANTHENE
BENZO(G,H,I)PERYLENE
BENZO(K)FLUORANTHENE
BERYLLIUM
BETA-BHC
BIS(2-CHLOROETHOXY)METHANE
BIS(2-CHLOROETHYL)ETHER
BIS(2-CHLOROISOPROPYL)ETHER
BIS(2-ETHYLHEXYL)PHTHALATE
BROMOCHLOROMETHANE
BROMOFORM
BROMOMETHANE
BUTYL BENZYL PHTHALATE
CADMIUM
CARBON TETRACHLORIDE
CHLORDANE
CHLOROBENZENE
CHLOROETHANE
CHLOROFORM
CHLOROMETHANE
CHROMIUM
CHRYSENE
COPPER
CYANIDE
DELTA-BHC
DI-N-BUTYLPHTHALATE
DI-N-OCTYL PHTHALATE
DIBENZ(A,H)ANTHRACENE
DIBROMODICHLOROMETHANE
DIELDRIN
DIETHYLPHTHALATE
DIMETHYL PHTHALATE
ENDOSULFAN I
ENDOSULFAN II
ENDOSULFAN SULFATE
ENDRIN
ENDRIN ALDEHYDE
ETHYLBENZENE
FLUORANTHENE
FLUORENE
GAMMA-BHC
HEPTACHLOR
HEPTACHLOR EPOXIDE
HEXACHLOROBENZENE
HEXACHLOROBUTADIENE
HEXACHLOROCYCLOPENTADIENE
HEXACHLOROETHANE
INDENO(1,2,3-CD)PYRENE
ISOPHORONE
LEAD
MERCURY
METHYLENE CHLORIDE
N-NITROSODI-N-PROPYLAMINE
N-NITROSODIMETHYLAMINE
N-NITROSODIPHENYLAMINE (1)
NAPHTHALENE
NICKEL
NITROBENZENE
P-CHLORO-M-CRESOL
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260
PENTACHLOROPHENOL
PHENANTHRENE
PHENOL
PYRENE
SELENIUM
SILVER
TCDD
TETRACHLOROETHENE
THALLIUM
TOLUENE
TOXAPHENE
TRANS-1,2-DICHLOROETHENE
TRANS-1,3-DICHLOROPROPENE
TRICHLOROETHENE
VINYL CHLORIDE
ZINC

TABLE 9-7
RCRA LISTED COMPOUNDS

COMPOUND	CAS NUMBER
(1,1'-Biphenyl)-4,4'-diamine	92875
1,1 Dimethylhydrazine	57147
1,1'-Biphenyl-4,4'-diamine, 3,3'-dichloro	91941
1,1-Dichloroethylene \ Vinylidine chloride	75354
1,2 Dimethylhydrazine	540738
1,2 Propylenimene	75558
1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl)ester	117817
1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester	85687
1,2-Benzenedicarboxylic acid, diethyl ester	84662
1,2-Benzenedicarboxylic acid, dioctyl ester \ Dioctyl ph	117840
1,3 Dichloropropene	542756
1,3 Propane sultone	1120714
1,3-Benzenediol	108463
1,3-Benzodioxole, 5-(2-propenyl)-	94597
1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	87683
1,3-Dichloro-2-propanol	96231
1,3-Dichloropropane	142289
1,4-Dichloro-2-butene	764410
1,4-Naphthalenedione	130154
1-(o-Chlorophenyl) thoiurea	5344821
1-Acetyl-2-thiourea	591082
1-Bromo-4-phenoxybenzene \ Benzene, 1-bromo-4-phenoxy-	101553
1-Butenamine, N-butyl-N-nitroso	924163
1-Chloro 2,3-epoxpropane	106898
1-Propanol, 2-methyl-	78831
1-Propene, 1,1,2,3,3,3-hexachloro-	1888717
1-Propene, 1,3-dichloro-, (E)-	10061026
1-Propene, 1,3-dichloro-, (Z)-	10061015
2,4,5-T \ Weedone \ Acetic acid, 2,4,5-trichlorophenoxy-	93765
2,4,5-TP \ Silvex	93721
2,4-D \ Acetic acid, (2,4-dichlorophenoxy)-	94757
2,4-Diaminotoluene \ Toluene, 2,4-diamino-	95807
2,6-Toluenediamine	823405
2-Acetylaminofluorene	53963
2-Butene, 1,4-dichloro-, (E)-	110576
2-Cyclohexyl-4,6-dinitrophenol	131895
2-Methyl-4,6-dinitrophenol \ DNOC \ 4,6-Dinitro-o-cresol	534521
2-Methylphenol \ o-Cresylic acid \ Phenol, 2-methyl-	95487
2-Naphthylamine	91598
2-Nitropropane	79469
2-Propenoic acid, 2-methyl, methyl ester	80626
2-Propenoic acid, 2-methyl-, ethyl ester	97632
2-methyllactonitrile	75865
3,3'-Dimethoxybenzidine	119904
3,3-Dimethylbenzdine	119937
3,4 Dihydroxy-alpha-(methylamino)methyl benzyl alcohol	329657
3,4-Toluenediamine	496720
3-Chloropropionitrile	542767
3-Methylcholanthrene	56495
3-Methylphenol \ Phenol, 3-methyl-	108394
4,4'-DDD/Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-	72548
4,4'-DDE/Benzene, 1,1'-(dichloroethenlyidine)bis[4-chloro	72559
4,4'-DDT/Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro	50293
4-Aminobiphenyl	92671

TABLE 9-7 (CONTINUED)
RCRA LISTED COMPOUNDS

COMPOUND	CAS NUMBER
4-Aminopyridine	504245
4-Methylphenol \ Phenol, 4-methyl-	106445
4-Nitroquinoline-1-oxide	56575
5-(Aminomethyl)-3-isoxazolol	2763964
7H-Dibenzo(c,g)carbazole	194592
9,10-Dimethyl-1,2-Benzanthracene	57976
Acetonitrile	75058
Acetophenone	98862
Acetyl chloride	75365
Acrolein	107028
Acrylamide	79061
Acrylonitrile	107131
Aflatoxins	1402682
Aldicarb	116063
Aldrin	309002
Allyl alcohol	107186
Allyl chloride \ 3-Chloropropene	107051
Alpha-Naphthylthiourea	86884
Aluminum phosphide	20859738
Amitrole	61825
Ammonium vanadate	7803556
Aniline	62533
Antimony	7440360
Antimony and compounds, N.O.S.	7440360
Aramite	140578
Aroclor 1016	12674112
Aroclor 1221	11104282
Aroclor 1232	11141165
Aroclor 1242	53469219
Aroclor 1248	12672296
Aroclor 1254	11097691
Aroclor 1260	11096825
Arsenic	7440382
Arsenic Acid	7778394
Arsenic pentoxide	1303282
Arsenic trioxide	1327533
Auramine	492808
Barium	7440393
Barium cyanide	542621
Benz(c)acridine	225514
Benz[a]anthracene \ 1,2-Benzanthracene	56553
Benz[e]acephenanthrylene	205992
Benzal chloride	98873
Benzenamine, 2-methyl-5-nitro	99558
Benzenamine, 4,4'-methylenebis[2chloro \ MOCA	101144
Benzenamine, 4-nitro-	100016
Benzenamine, N-phenyl	122394
Benzene	71432
Benzene, 1,2,4,5-tetrachloro-	95943
Benzene, 1,2,4-trichloro-	120821
Benzene, 1,2-dichloro- \ o-Dichlorobenzene	95501
Benzene, 1,3-dichloro- \ m-Dichlorobenzene	541731
Benzene, 1,4-dichloro- \ p-Dichlorobenzene	106467
Benzene, 1-methyl-2,4-dinitro	121142

TABLE 9-7 (CONTINUED)
RCRA LISTED COMPOUNDS

COMPOUND	CAS NUMBER
Benzene, 2-methyl-1,3-dinitro-	606202
Benzene, chloro-	108907
Benzene, methyl	108883
Benzene, nitro-	98953
Benzene, pentachloro-	608935
Benzo(a)pyrene	50328
Benzo(j)fluoranthene	205823
Benzonearsonic acid	98055
Benzotrichloride	98077
Benzyl chloride	100447
Beryllium	7440417
Bis(2-chloroisopropyl) ether	39638329
Bis(chloromethyl)ether	542881
Bromoacetone	598312
Bromoform \ Methane, tribromo-	75252
Brucine	357573
Cacodylic acid	75605
Cadmium	7440439
Calcium chromate	13765190
Calcium cyanide	592018
Camphechlor	8001352
Carbolic acid	108952
Carbon disulfide	75150
Carbon oxyfluoride	353504
Carbon tetrachloride \ Methane, tetrachloro-	56235
Chlomaphazine	494031
Chloral	75876
Chlorambucil	305033
Chlordane	57749
Chlorinated benzenes (N.O.S.)	
Chlorinated ethane N.O.S.	
Chlorinated fluorocarbons N.O.S.	
Chlorinated naphthalene N.O.S.	
Chlorinated phenol N.O.S.	
Chlorine cyanide	506774
Chloroacetaldehyde	107200
Chloroalkyl ethers, N.O.S.	
Chlorobenzilate \ Ethyl-4,4'-dichlorobenzilate	510156
Chloromethyl methyl ether	107302
Chloroprene \ 1,3-Butadiene, 2-chloro	126998
Chromium	7440473
Chrysene	218019
Citrus red No. 2	6358538
Coal tars	8005452
Copper cyanide	544923
Creosote	8001589
Cresols (Cresylic acid)	1319773
Crotonaldehyde \ Crotylaldehyde	4170303
Cyanides (soluble salts and complexes)	57125
Cyanogen	460195
Cyanogen bromide	506683
Cycasin	14901087
Cygon \ Dimethoate	60515
DNBP \ Dinoseb \ 2-sec-butyl-4,6-dinitrophenol	88857

TABLE 9-7 (CONTINUED)
RCRA LISTED COMPOUNDS

COMPOUND	CAS NUMBER
Daunomycin	20830813
Di-n-butyl phthalate \ Dibutyl phthalate	84742
Diallate \ Avadex	2303164
Dibenz(a,h)acridine	226368
Dibenz[a,h]anthracene	53703
Dibenzo(a,e)pyrene	192654
Dibenzo(a,h)pyrene	189640
Dibenzo(a,i)pyrene	189559
Dibromochloropropane \ DBCP	96128
Dichlorobenzene, N.O.S.	25321226
Dichlorodiffuoromethane	75718
Dichloroethyl ether	111444
Dichloroethylene N.O.S.	25323302
Dichloromethane \ Methane, dichloro-	75092
Dichlorophenylarsine	696286
Dichloropropane,N.O.S.	26638197
Dichloropropanol,N.O.S.	26545733
Dichloropropene N.O.S.	26952238
Dieldrin	60571
Diethyl-p-nitro phenyl phosphate	311455
Diethylarsine	692422
Diethylstilbesterol	56531
Dihydrosafrole	94586
Diisopropylfluorophosphate (DFP)	55914
Dimethyl phthalate	131113
Dimethyl sulfate	77781
Dimethylcarbamoyl chloride	79447
Dimethylnitrosamine \ Methamine, N-methyl-N-nitroso-	62759
Dinex \ DN-111 \ 2-Cyclohexyl-4,6-dinitrophenol	131895
Dinitrobenzene N.O.S.	25154545
Dioxin \ TCDD \ 2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746016
Disulfoton	298044
Dithiobiuret	541537
Dubenz(a)acridine	224420
Endosulfan	115297
Endothal	145733
Endrin	72208
Endrine ketone	53494705
Erythritol anhydride \ 2,2'-Bioxirane	1464535
Ethanamine, N-ethyl-N-nitroso-	55185
Ethanamine, N-methyl-N-nitroso	10595956
Ethane, 1,1'-[methylenebis(oxy)]bis[2-chloro-	111911
Ethane, 1,1,1,2-tetrachloro-	630206
Ethane, 1,1,2,2-tetrachloro	79345
Ethane, 1,1,2-trichloro	79005
Ethane, hexachloro	67721
Ethene, (2-chloroethoxy)	110758
Ethene, 1,2-dichloro-, (E)-	156605
Ethene, chloro	75014
Ethene, trichloro \ Trichloroethylene	79016
Ethyl methanesulfonate	62500
Ethylene dibromide \ EDB \ Ethane, 1,2-dibromo-	106934
Ethylene dichloride \ EDC \ Ethane, 1,2-dichloro-	107062
Ethylene glycol monoethyl ether	110805

TABLE 9-7 (CONTINUED)
RCRA LISTED COMPOUNDS

COMPOUND	CAS NUMBER
Ethylene oxide	75218
Ethylenebisdithiocarbamic acid, salts and esters	111546
Ethyleneimine	151564
Ethylenethiourea	96457
Ethylidene chloride \ Ethane, 1,1-dichloro-	75343
Famphur \ Famophos	52857
Fluoranthene	206440
Fluorine	7782414
Fluoroacetamide	640197
Fluoroacetic acid, sodium salt	62748
Fluorotrichloromethane \ Methane, trichlorofluoro-	75694
Formaldehyde	50000
Glycidylaldehyde	765344
HCB \ Benzene, hexachloro-	118741
Halomethane N.O.S.	
Heptachlor	76448
Heptachlor epoxide	1024573
Heptachlor epoxide	1024573
Hexachlorocyclopentadiene \ HCP	77474
Hexachlorodibenzo-p-dioxins	
Hexachlorodibenzofurans	
Hexachlorophene	70304
Hexaethyltetraphosphate	757584
Hydrazine	302012
Hydrazine, 1,2-diphenyl	122667
Hydrogen cyanide	74908
Hydrogen fluoride	7664393
Hydrogen sulfide	7783064
Indeno(1,2,3-cd)pyrene	193395
Iron dextran	9004664
Isodrin (Stereoisomer of Aldrin)	465736
Isosafrole	120581
Kepone	143500
Lasiocarpine	303344
Lead	7439921
Lead acetate	301042
Lead phosphate	7446277
Lead subacetate	1335326
Lindane	58899
Lindane \ gamma-BHC \ Hexachlorocyclohexane (gamma)	58899
MNNG	70257
Malec hydrazide	123331
Maleic anhydride	108316
Malononitrile	109773
Melphalan	148823
Mercury	7439976
Mercury fulminate	628864
Methacrylonitrile	126987
Methane, trichloro- \ Trichloromethane	67663
Methapyrilene	91805
Methomyl	16752775
Methoxychlor	72435
Methyl bromide \ Methane, bromo	74839
Methyl chloride \ Methane, chloro	74873

TABLE 9-7 (CONTINUED)
RCRA LISTED COMPOUNDS

COMPOUND	CAS NUMBER
Methyl chloroform \ Ethane, 1,1,1-trichloro-	71556
Methyl ethyl ketone \ MEK	78933
Methyl ethyl ketone peroxide	1338234
Methyl hydrazine	60334
Methyl iodide \ Methane, iodo	74884
Methyl isocyanate	624839
Methyl parathion	298000
Methyl parathion \ Parathion-methyl \ Metaphos	298000
Methylchlorocarbonate	79221
Methylene bromide \ Methane, dibromo	74953
Methylsulfonic acid, methyl ester	66273
Methylthiouracil	56042
Mitomycin C	50077
Morpholine, 4-nitroso-	59892
Mustard Gas	505602
N,N-Diethylhydrazine	1615801
N-Nitroso-N-ethyl urea	759739
N-Nitroso-N-methylurea	684935
N-Nitroso-N-methylurethane	615532
N-Nitrosodi-n-propylamine	621647
N-Nitrosodiethanolamine	1116547
N-Nitrosomethylvinylamine	4549400
N-Nitrosonornicotine	16543558
N-Nitrososarcosine	13256229
Nabam	142596
Naphthalene	91203
Naphthalene, 2-chloro-	91587
Nickel	7440020
Nickel carbonyl	13463393
Nickel cyanide	557197
Nicotine and salts	54115
Nitric oxide	10102439
Nitrogen dioxide	10102440
Nitrogen mustard N-oxide and hydrochloride salt	126852
Nitrogen mustard and hydrochloride salt	51752
Nitroglycerin	55630
Nitrosamine, N.O.S.	35576911
Nitrosopyrrolidine	930552
Octamethylpyrophosphoramide	152169
Osmium tetroxide	20816120
PCNB \ Terraclor \ Quintozene	82688
PCP \ Phenol, pentachloro-	87865
Paraldehyde	123637
Parathion \ Parathion, ethyl	56382
Parathon	56362
Pentachlorethane	76017
Pentachlorodibenzo-p-dioxins	
Pentachlorodibenzofurans	
Pentachloroethane	76017
Perchloroethylene \ Ethene, tetrachloro	127184
Phenacetin \ Phorazetim	62442
Phenol, 2,3,4,6-tetrachloro-	58902
Phenol, 2,4,5-trichloro-	95954
Phenol, 2,4,6-trichloro-	88062

TABLE 9-7 (CONTINUED)
RCRA LISTED COMPOUNDS

COMPOUND	CAS NUMBER
Phenol, 2,4-dichloro-	120832
Phenol, 2,4-dimethyl-	105679
Phenol, 2,4-dinitro	51285
Phenol, 2,6-dichloro-	87650
Phenol, 2-chloro	95578
Phenylenediamine	25265763
Phenylmercury acetate	62384
Phenylthiourea	103855
Phorate \ Thimet	298022
Phosgene	75445
Phosphine	7803512
Phosphorodithioic acid, O,O,S-triethyl ester	126681
Phosphorodithioic acid, O,O-diethyl S-methyl ester	3288582
Phthalic acid esters, N.O.S.	
Phthalic anhydride	85449
Piperidine, 1-Nitroso-	100754
Potassium cyanide	151508
Potassium silver cyanide	506616
Pronamide \ Kerb	23950585
Propane, 1,2,3-trichloro-	96184
Propane, 2,2'-oxybis[1-chloro-	108601
Propargyl alcohol	107197
Propionitrile \ Propanenitrile	107120
Propylene dichloride \ Propane, 1,2-dichloro-	78875
Propylthiouracil	51525
Pyridine	110861
Pyridine	110861
Reserpinen	50555
Saccharin and salts	81072
Selenium	7782492
Selenium dioxide	7783008
Selenium sulfide	7446346
Selenourea	630104
Silver	7440224
Silver cyanide	506649
Sodium cyanide	143339
Streptozotocin	18883664
Strontium sulfide	1314961
Strychnine and salts	57249
Sulfotepp \ Bladafum \ Tetraethyldithiopyrophosphate	3689245
TEPP \ Phosphoric acid, tetraethyl ester	107493
Tetrachlorodibenzo-p-dioxins	
Tetrachlorodibenzofurans	
Tetrachloroethane N.O.S.	25322207
Tetraethyl lead	78002
Tetranitromethane	509148
Thallium	7440280
Thallium (1) sulfate	10031591
Thallium and compounds N.O.S.	7440280
Thallium selenite	12039520
Thallium(1) nitrate	10102451
Thallium(1)acetate	563688
Thallium(1)carbonate	6533739
Thallium(1)chloride	7791120

TABLE 9-7 (CONTINUED)
RCRA LISTED COMPOUNDS

COMPOUND	CAS NUMBER
Thioacetamide	62555
Thiodan I	959988
Thiodan II	33213659
Thiofanox	39196184
Thiophenol	108985
Thiophenol \ Mercaptobenzene	108985
Thiosemicarbazide	79196
Thiourea	62566
Thiram \ Thiuram \ Arasan	137268
Thoimethanol	74931
Toluene diisocyanate	584849
Toluenediamine	25376458
Trichloromethanethiol	75707
Trichloropropane, N.O.S.	
Tris(1-aziridinyl)phosphine sulfide	52244
Tris(2,3-dibromopropyl)phosphate	126727
Trypan blue	72571
Undecamethlyenediamine,N,N-bis(2-chlorobenzyl)-dihydrochloride	2056259
Uracil mustard	66751
Vanadium pentoxide	1314621
Vinyl Chloride	75014
Warfarin	81812
Zinc cyanide	557211
Zinc phosphide	1314847
Zinophos \ Thionazin	297972
alpha,alpha-Dimethylphenethylamine	122098
alpha-Naphthylamine	134327
alpha-Picoline \ 2-Methylpyridine	109068
n-Propylamine	107108
p-Benzoquinone	106514
p-Chloro-m-cresol \ Phenol, 4-chloro-3-methyl-	59507
p-Chloroaniline	106478
p-Dimethylaminoazobenzene	60117
p-Dioxane \ 1,4-Diethyleneoxide	123911
p-Nitrophenol \ Phenol, 4-nitro-	100027
p-Toluidine	106490
q-Toluidine hydrochloride	636215
sym-Trinitrobenzene	99354

TABLE 9-8
SARA LISTED COMPOUNDS

COMPOUND	CAS NUMBER
** PRIORITY GROUP 1	
BENZO(A)PYRENE	50328
DIBENZO(A),(H)ANTHRACENE	53703
BENZO(A)ANTHRACENE	56553
CYANIDE	57125
DIELDRIN/ALDRIN	60571
CHLOROFORM	67663
BENZENE	71432
VINYL CHLORIDE	75014
METHYLENE CHLORIDE	75092
HEPTACHLOR/HEPTACHLOR EPOXIDE	76448
TRICHLOROETHENE	79016
N-NITROSODIPHENYLAMINE	86306
1,4-DICHLOROBENZENE	106467
BIS(2-ETHYLHEXYL)PHTHALATE	117817
TETRACHLOROETHENE	127184
BENZO(B)FLUORANTHENE	205992
CHRYSENE	218019
P-DIOXIN	1745016
LEAD	7439921
NICKEL	7440020
ARSENIC	7440382
BERYLLIUM	7440417
CADMIUM	7440439
CHROMIUM	7440473
PCB-1260,54,48,42,32,21,1016	11196825
** PRIORITY GROUP 2	
CARBON TETRACHLORIDE	56235
CHLORDANE	57749
N-NITROSODIMETHYLAMINE	62759
4,4-DDE,DDT,DDD	72559
CHLOROETHANE	75003
BROMODICHLOROMETHANE	75274
1,1-DICHLOROETHENE	75354
ISOPHORONE	78591
1,2-DICHLOROPROPANE	78875
1,1,2-TRICHLOROETHANE	79005
1,1,2,2-TETRACHLOROETHANE	79435
PENTACHLOROPHENOL	87865
3,3'DICHLOROBENZIDINE	91941
BENZIDINE	92875
1,2-DICHLOROETHANE	107062
TOLUENE	108883
PHENOL	108952
BIS(2-CHLOROETHYL)ETHER	111444
2,4-DINITROTOLUENE	121142
BHC-ALPHA,GAMMA,BETA,DELTA	319846
BIS(CHLOROMETHYL)ETHER	542881
N-NITROSODI-N-PROPYLAMINE	621647
MERCURY	7439976
ZINC	7440666
SELENIUM	7782492

COMPOUND	CAS NUMBER
** PRIORITY GROUP 3	
1,1,1-TRICHLOROETHANE	71556
CHLOROMETHANE	74873
OXIRANE	75218
BROMOFORM	75252
1,1-DICHLOROTHANE	75343
DI-N-BUTYL PHTHALATE	84742
2,4,6-TRICHLOROPHENOL	88062
NAPTHALENE	91203
NITROBENZENE	98953
ETHYLBENZENE	100414
ACROLEIN	107028
ACRYLONITRILE	107131
CHLOROBENZENE	108907
HEXACHLOROBENZENE	118741
1,2-DIPHENYLHYDRAZINE	122667
CHLORODIBROMOMETHANE	124481
1,2 TRANS-DICHLOROETHENE	156606
INDENO(1,2,3-CD)PYRENE	193395
2,6 DINITROTOLUENE	606202
TOTAL XYLENES	1330207
ENDRIN ALDEHYDE/ENDRIN	7221934
SILVER	7440224
COPPER	7440508
AMMONIA	7664417
TOXAPHENE	8001352
** PRIORITY GROUP 4	
2,4-DINTROPHENOL	51285
P-CHLORO-M-CRESOL	59507
ANITINE	62533
BENZOIC ACID	65850
HEXACHLOROETHANE	67721
BROMOMETHANE	74839
CARBONDISULFIDE	75150
FLUOROTRICHLOROMETHANE	75694
DICHLORODIFLUOROMETHANE	75718
2-BUTANONE	78933
DIETHYL PHTHALATE	84662
PHENANTHRENE	85018
HEXACHLOROBUTADIENE	87683
PHENOL,2-METHYL	95487
1,2-DICHLOROBENZENE	95501
2,4-DIMETHYLPHENOL	105679
2-PENTANONE, 4-METHYL	108101
1,2,4-TRICHLOROBENZENE	120821
2,4-DICHLOROPHENOL	120832
1,4-DIOXANE	123911
DIMETHYL PHTHALATE	131113
FLUORANTHENE	206440
4,6-DINITRO-2-METHYLPHENOL	534521
1,3-DICHLOROBENZENE	541731
THALLIUM	7440280

SECTION 10

DESCRIPTION OF AEROBIC BIOLOGICAL SYSTEMS

SECTION 10 - DESCRIPTION OF AEROBIC BIOLOGICAL SYSTEMS. Various studies have documented the fate of contaminants in the most common conventional biological treatment processes. Those processes include aerated lagoons, activated sludge, trickling filters, rotating biological contactors (RBCs), and powdered activated carbon treatment (PACT) facilities. Section 10 presents a description of each of the above listed treatment processes.

BIOLOGICAL TREATMENT PROCESSES

The fate of contaminants has been studied in the most common conventional biological treatment processes, including aerated lagoons, activated sludge trickling filters, rotating biological contactors (RBCs), and powdered activated carbon treatment (PACT) facilities. Each treatment process and its use and performance characteristics is discussed in the following sections.

AERATED LAGOON

Aerated lagoons are completely mixed biological reactors without biomass recycle. They can be large multicellular basins or individual basins that are mixed and aerated using surface aerators (either fixed or floating). Good removal of soluble organic matter can be achieved with the proper mix of retention time and aeration. A biomass removal step must follow the aerated lagoon process before discharge to the receiving water. This is often accomplished in a large quiescent pond or in a section of the aerated lagoon isolated by baffles or dikes. If the lagoon is used as a pretreatment device, the biomass is carried with the liquid to subsequent unit processes. The primary purpose of the operation is to remove soluble organic matter by conversion to biological mass. The main differences between it and the activated sludge system is that the microorganisms in the lagoon are grown in the dispersed state rather than as a flocculant mass, and biomass is not recycled from the sedimentation step to the aeration step.

The performance of aerated lagoons in removing biodegradable organic compounds depends on several parameters, including detention time, temperature, and the nature of waste. Aerated lagoons generally provide a high degree of BOD reduction. In general, problems with aerated lagoons are excessive algae growth, offensive odors if sulfates are present and dissolved oxygen is depressed, and seasonal variations in effluent quality. Aerated lagoons can handle considerable variations in organic and hydraulic loading if sized properly, and are less vulnerable to process upsets than most biological wastewater treatment methods.

ACTIVATED SLUDGE

The activated sludge system is a biological treatment process including a mixed suspension of aerobic and facultative microorganisms, a settling basin for separation of the biomass, and a biomass recirculation system.

The microorganisms oxidize soluble organics and agglomerate colloidal and particulate solids in the presence of dissolved molecular oxygen. The mixture of microorganisms, agglomerated particles, and wastewater (referred to as mixed liquor) is aerated in a basin. The aeration step is followed by sedimentation to separate biological solids from the treated wastewater. A major portion of these biological solids are removed by sedimentation and recycled to the aeration basins to be recombined with the incoming wastewater. The excess biological solids (i.e., waste sludge) must be disposed of by thickening,

pretreatment, dewatering, or direct disposal (e.g., land-spreading, landfilling, and incineration.)

Activated sludge is the most widely used biological wastewater treatment process. The effectiveness of this process is dependent on several design and operation variables such as organic loading, sludge retention time, mixed liquor suspended solids concentration, hydraulic detention time, and oxygen supply. In addition to the removal of dissolved organics by biosorption, the biomass can also remove suspended and colloidal matter. The suspended matter is removed by enmeshment in the biological floc, and the colloidal matter is removed by physiochemical adsorption to the biological floc. VOCs may be air-stripped to a certain extent during the aeration process, and metals are partially removed and accumulate in the sludge.

TRICKLING FILTER

A trickling filter is a biological waste treatment process in which a microbial population adheres to a fixed medium and is used to biodegrade the organic components of a wastewater. The physical unit consists of a suitable structure packed with an inert medium (e.g., rock, wood, or plastic) on which a biological mass is grown. The wastewater is distributed over the upper surface of the medium. As it flows through the medium, which is covered with biological slime, both dissolved and suspended organic matter are removed by adsorption. The adsorbed matter is oxidized by the organisms in the slime during their metabolic processes. Air flows through the filter by convection or through the use of blowers, thereby providing the oxygen necessary to maintain aerobic conditions. Recycling a large portion of the flow is necessary to attain high BOD removals. A wide range of effluent quality can be expected, depending on the design and operating conditions. Many modifications of the traditional trickling filter system are available, but all rely on a fixed media with an attached biological growth to perform the treatment.

ROTATING BIOLOGICAL CONTACTOR

RBCs provide a fixed-film biological treatment method for the removal of BOD from wastewaters. The most common types consist of corrugated plastic discs mounted on horizontal shafts to which a biological mass attaches. The medium slowly rotates in the wastewater with 40 to 50 percent of its surface immersed. During rotation, the medium picks up a thin layer of wastewater (when submerged), which then absorbs oxygen when exposed to the atmosphere. The biological mass growing on the medium surface adsorbs, coagulates, and biodegrades the organic pollutants from the wastewater. The excess microorganisms continuously slough from the disc because of the shearing forces created by the rotation of the discs in the wastewater. This rotation also mixes the wastewater, keeping the sloughed solids in suspension until they are removed in a final clarifier.

POWDERED ACTIVATED CARBON TREATMENT

PACT is the addition of powdered activated carbon to a biological process (usually activated sludge). The powdered activated carbon is added to the aeration tank of the activated sludge system. Depending on waste characteristics, mixed liquor carbon levels in the tank will range from approximately 1,000 mg/ℓ to as high as 10,000 mg/ℓ. After aeration, the solids are separated in the final clarifier and a portion of the solids are recycled to meet the requirements of the activated sludge system (Meidl and Wilhelmi, 1986).

Performance of the PACT process generally depends on the amount of carbon carried in the aeration tank and the solids retention time in the system. The PACT process is able to effect greater removals of conventional and nonconventional organics than the activated sludge process (Grieves, et al., 1978; Hutton and Temple, 1979).

REFERENCES

Greives, L. et al. "Powdered Carbon Enhancement Versus Granular Carbon Adsorption for Oil Refinery Wastewater Treatment"; 51st Annual Conference; WPCF; Anaheim, California; October 1978.

Hutton, D. and S. Temple. "Priority Pollutant Removal: Comparison of DuPont PACT Process and Activated Sludge"; 52nd Annual Conference, WPCF; Houston, Texas; October 1979.

SECTION 11

INFORMATION FOR EVALUATING PRETREATMENT TECHNOLOGIES

SECTION 11 - INFORMATION FOR EVALUATING PRETREATMENT TECHNOLOGIES.

Prior to discharge of a CERCLA wastestream to a POTW, the stream may require pretreatment. Pretreatment systems are commonly composed of a number of unit operations, depending on the types of contaminants and concentrations in a wastestream. Section 11 provides information on 12 separate unit operations that may be used to construct a pretreatment system. A description of each unit operation (how the process works, equipment types available, advantages and limitations, design criteria, etc.) and a detailed evaluation of the process (effectiveness, implementability, costs, etc.) are included. The section is structured to contain information in the same format as a CERCLA Feasibility Study.

The user of the technology manual may use Section 11 in two ways:

- To help make screening decisions while assembling the pretreatment train.
- To provide information that can be used in detailed evaluation of the "discharge to POTW" alternative.

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

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SECTION 11

INFORMATION FOR EVALUATING PRETREATMENT TECHNOLOGIES

This section provides information for evaluating pretreatment technologies. It should be used to construct and evaluate a pretreatment train as a part of the overall POTW discharge alternative. The FS writer may use this section in two ways.

- This section may be used to help make screening decisions while assembling the pretreatment train. This section contains detailed information and references that discuss applicability, performance, and feasibility of technologies for specific contaminants and wastestreams.

- Once the pretreatment train is assembled, this section provides information that can be used in the detailed evaluation of the "discharge to POTW" alternative.

Section 11 is organized into 12 subsections, each discussing a separate unit operation. These unit operations are not intended to be used individually, but should be combined into an appropriate pretreatment train. The information on each technology has been tailored to address the "discharge to POTW" alternative.

Each subsection is organized into two major parts:

Description. The description contains information on how the process works, major types of equipment available, advantages and limitations of the technology, chemicals required to implement the process, residuals generated or released, design criteria, and a discussion of expected performance. The description also contains the technical data and references necessary to select and size an appropriate unit operation.

Evaluation. The evaluation is designed specifically for use by the FS writer. Once the process has been selected, the evaluation provides the information necessary to perform a detailed evaluation of the process. Included are discussions of effectiveness, implementability, and cost. Costs are presented only to provide a general sense of relative costs of different technologies. The costing figures included in this section were generated from information gathered from several sources. The references listed at the end of this section provide an initial source for costing information. However, any FS should rely on site-specific estimates, derived from discussions with process vendors and other sources.

11-1 OIL AND GREASE SEPARATION

This subsection discusses the use of oil/water separators to remove free oils and greases from wastestreams prior to discharge to the POTW. Information is

provided to aid in the evaluation of this technology as a part of a total waste treatment alternative.

11-1.1 Description

Oil/water separators are used to separate nonaqueous phase organic liquids (oils and grease) from a CERCLA waste discharge. Separators find use in removing oil and grease from leachate streams and in separating the organic phase from joint groundwater/floating product extraction systems.

The oil in these streams can exist as either free or emulsified oil, depending on the wastestream characteristics and the recovery technique. Free oils can be separated by gravity separators, which operate on the principal that under quiescent conditions, the lighter phase will rise to the surface and may be collected. Emulsified oils exist as small droplets of oil interspersed throughout the aqueous stream. These emulsions are treated to cause the small droplets to combine and separate by gravity similar to free oils. The emulsion breaking step can be achieved using thermal treatment, chemical additives, or coalescing devices.

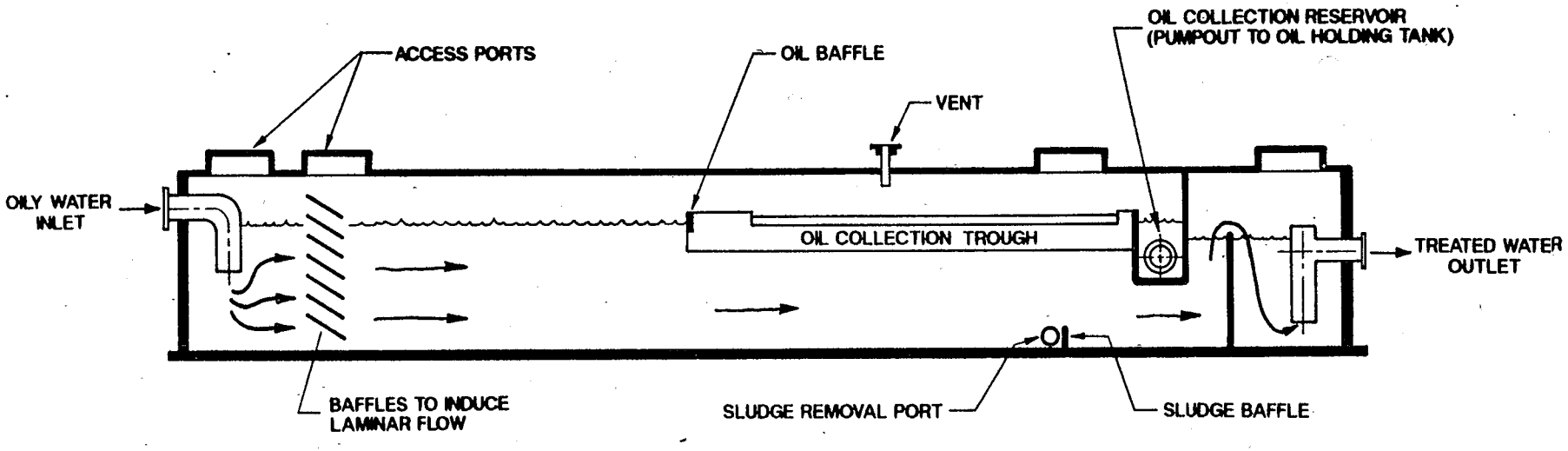
Oil/water separation is typically one of the first unit processes in a treatment train. The separators are usually large tanks that provide several minutes (i.e., 10 to 30) of holding time for the wastewater stream.

The oil/water separator generates three effluent streams: the treated wastewater, the nonaqueous phase organic layer, and any sludge resulting from the settling of solids. The treated wastewater may be suitable for discharge to a POTW or further pretreatment. If the oil phase is hazardous, it should be disposed of as a RCRA waste or reclaimed. Likewise, if the sludge is hazardous, it can be dewatered and disposed of as a RCRA waste.

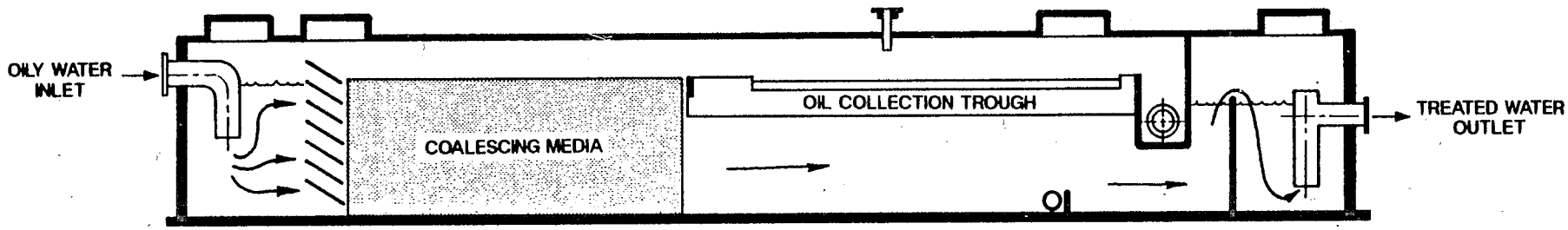
11-1.1.1 Equipment Types Available. Most oil/water separators are based on the design developed by the American Petroleum Institute (API) for treatment of wastewater containing oil. This basic design has been modified by numerous vendors to optimize flow patterns and oil collection efficiency. These units are available as self-contained package units, or can be designed and installed with relative ease.

The two major types of treatment units are presented in Figure 11-1. The raw discharge enters the treatment unit into an equalization basin area. Treatment chemicals may be added here, if necessary. Heavy solids settle to the bottom of the equalization basin. The flow then proceeds through a series of baffles designed to produce laminar flow conditions, which promote separation of oil and the remaining solids. Flow through the central part of the separator is characterized by the settling of solid particles to the bottom of the chamber and rising of oil particles to the surface of the water.

Sludge collecting on the bottom is trapped by a sludge baffle and drawn off periodically. Any nonaqueous phase organics that are heavier than water would also be removed at this point. Lighter oils are trapped by an upper baffle and diverted into an oil collection reservoir. Alternate methods for removing the light oils include rope skimmers or rotating drums. These skimmer systems pass



GRAVITY OIL/WATER SEPARATOR



COALESCING OIL/WATER SEPARATOR

FIGURE II-1
OIL/WATER SEPARATION

5307-83

through the oil phase collecting oil on the surface of the rope or drum. The oil is then scraped into a collection reservoir. Oils are periodically pumped out of the collection reservoir. Wastewater passing through the baffles exits the oil/water separator ready for further pretreatment or discharge.

Coalescing separators are similar to gravity-type separators. In the center portion of the separator, a series of baffles, tubes, or plates are installed to act as a coalescing medium (see Figure 11-1). These plates are composed of oleophilic (i.e., oil-loving) materials that attract small oil droplets. These droplets collect on the surface of the media and form larger globules that detach and float to the surface. Oil removal and sludge removal are conducted similarly to gravity separators. Alternative arrangements are available from vendors for specialized applications.

11-1.1.2 Advantages and Limitations. Gravity oil/water separators are simple processes that are easy to design and construct. The units are extremely reliable within design operating ranges and require little maintenance. Dispersed or emulsified oils require the use of chemical additives or coalescing-type separators. High removal efficiencies can be achieved through the use of emulsion-breaking chemicals; however, these chemicals may increase the volume of sludge, making treatment of the sludge more difficult. Limitations of chemical treatment include increased cost and the need for skilled operators.

11-1.1.3 Chemicals Required. Chemicals are only required if it is necessary to break chemically stable emulsions to separate oils. Chemicals used include polymers, ferric chloride ($FeC\ell_3$), alum, and sulfuric acid.

11-1.1.4 Residuals Generated. Oil skimmings are generally disposed of by recycling, incineration, or other commercial disposal. Sludges may be disposed by dewatering and landfilling or incinerating. Chemicals used to break emulsions may increase the metals content of the sludges, but these metals are of low toxicity (Fe, Al).

11-1.1.5 Design Criteria. Effective oil removal requires careful consideration of the physical properties and mechanical relationships of oil and wastewater. Properties such as types of oily wastes, specific gravity, and viscosity, plus mechanical relationships such as rate of rise, short-circuiting factor, turbulence factor, horizontal velocity, and overflow rate, are important in sizing oil separation units. Treatment of emulsified oils requires consideration of chemical type, dosage and sequence of addition, pH, mechanical shear and agitation, heat, and retention time.

Design of the API separator is based on the following three basic design relationships:

1. Minimum Total Horizontal Area

$$A_H = F \frac{Q_m}{V_t}$$

where:

A_H = minimum total horizontal area (ft^2)

F = design factor

Q_m = flow rate of wastewater (ft^3/min)

V_t = rate of rise of the minimum-size oil droplet to be removed; typically 150 microns (ft/min)

The design factor F is the product of a short-circuiting factor recommended as 1.2 and a turbulence factor (varying from 1.07 to 1.45 for V_H/V_t ratios from 3 to 20; where V_H = mean horizontal velocity of waste through separator and V_t = rate of rise of the minimum-size oil droplet to be removed).

The velocity of the rising droplet, V_t, is found using a modified version of Stokes Law.

$$V_t = 0.0241 \frac{S_w - S_o}{\mu}$$

where: S_w = specific gravity of wastestream
S_o = specific gravity of oil
μ = absolute viscosity of wastestream (poises)

All values are based on design temperature.

2. Minimum Vertical Cross-sectional Area

$$A_c = \frac{Q_m}{V_H}$$

where:

A_c = vertical cross-sectional area (ft^2)

Q_m = flow rate of wastewater (ft^3/min)

V_H = horizontal flow velocity (ft/min)

The value of V_H should not exceed 15 times the value of V_t and should not exceed 3 feet/minute.

3. Minimum Ratio of Depth to Width of 0.3

These specifications are designed for a stream containing oil droplets of 150-micron diameter or larger. For smaller droplets, a coalescing-type separator is recommended. In practice, most package units are designed to

meet these specifications. For large flow systems, units may be operated in series or parallel to optimize oil removal and operating efficiencies.

11-1.1.6 Performance. The removal efficiency of oil by gravity separation is partly a function of the retention time of the water in the tank and the waste stream composition. The performance level of emulsion-breaking is dependent primarily on the raw waste characteristics and proper maintenance and functioning of the system components. The systems discussed in the previous sections are designed to remove free oil and grease to below 15 mg/liter (ppm). Gravity separators will achieve this level of performance for droplets larger than 150 microns. Coalescing separators will achieve this level of performance for emulsions containing droplets as small as 20 microns.

11-1.2 Evaluation of Oil and Grease Separation

This section provides information for evaluation of oil/water separators as a part of an alternative in the FS. The information is organized under three general headings: effectiveness, implementability, and cost.

11-1.2.1 Effectiveness. Oil/water separators provide a highly reliable method for removing free organic phase oils from a wastestream. Typical effluent concentrations of 15 mg/ℓ total oil and grease can be achieved. The technology provides a significant reduction of free oils in the wastestream. The oils may be disposed of using permanent disposal technologies, such as incineration.

Oil/water separation is one of the first steps in an overall treatment train. Separators available as package units are typically constructed as enclosed containers, reducing the possibility for VOC emissions. In combination with other pretreatment technologies and/or discharge to a POTW, oil/water separators will successfully achieve and maintain a high level of protection of public health and the environment.

11-1.2.2 Implementability. Oil/water separators are well-proven technologies that are available in a variety of packaged units for specific applications. The technology has been well-demonstrated for removal of free oils and grease from aqueous streams. With relatively few moving parts and low maintenance requirements, separators achieve a high level of reliability.

Separators generally are placed at the beginning of a treatment train and may also act as flow equalization tanks and sedimentation basins for large solids. Trash should be removed from a stream prior to the oil/water separator. Post-treatment may include treatment for additional removal of organics or inorganics, depending on the specific discharge requirements.

Prepackaged oil/water separators can be installed with relatively little site work. O&M requirements are minimal. The separator must be emptied of sludge and oil on a regular schedule. Appropriate disposal options must be identified for these materials.

11-1.2.3 Cost. Cost information was compiled for flow rates ranging from 30 to 1,000 gpm. These costs are based on the following assumptions.

Capital Costs

- Oil/water separator of API gravity separator design with and without coalescing media.
- Separator with coalescing media designed to remove droplets as small as 20 microns with an effluent quality of less than 15 mg/ℓ total oil and grease.
- Separator without coalescing media designed to remove droplets down to 150 microns with an effluent quality of less than 15 mg/ℓ total oil and grease.
- Oil pumped from separator to storage tank capable of holding 2 percent of daily volumetric flow.
- Pumps and piping designed with 100-percent backup capability.
- Oil/water separator installed on concrete pad.

O&M Costs

- Electricity to operate pumps is included.
- Labor required to operate and maintain system is 8 hours/week for system flows less than 100 gpm, and 16 hours/week for system flows greater than 100 gpm.
- No disposal costs for residual streams are included.
- No chemical costs are included.

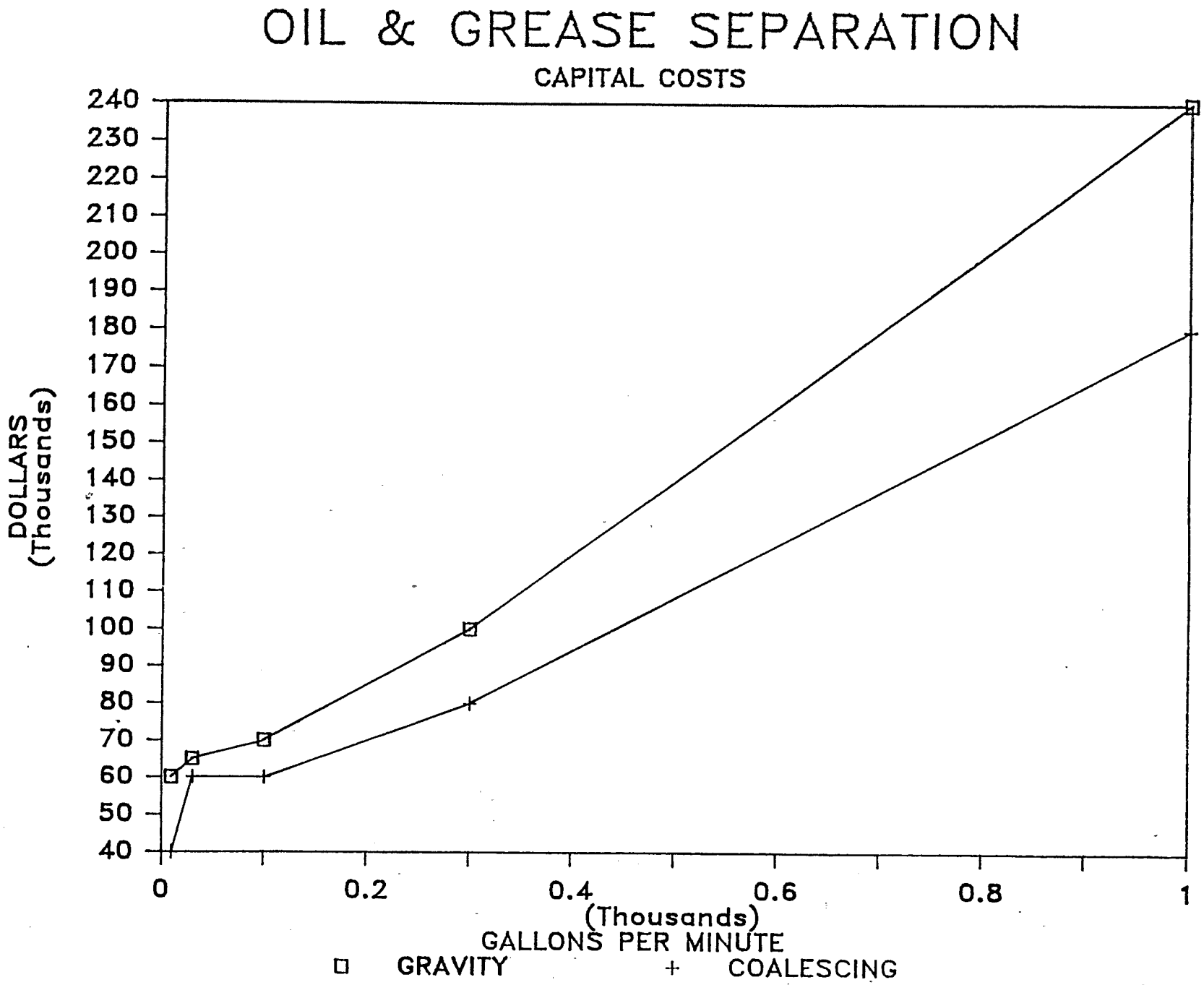
Cost information is presented in Figures 11-2 and 11-3. Cost curves were prepared for two cases: Case I, a standard API gravity separator for use with nonemulsified oils; and Case II, a coalescing separator for use with emulsified oils.

11-2 OXIDATION

11-2.1 Description

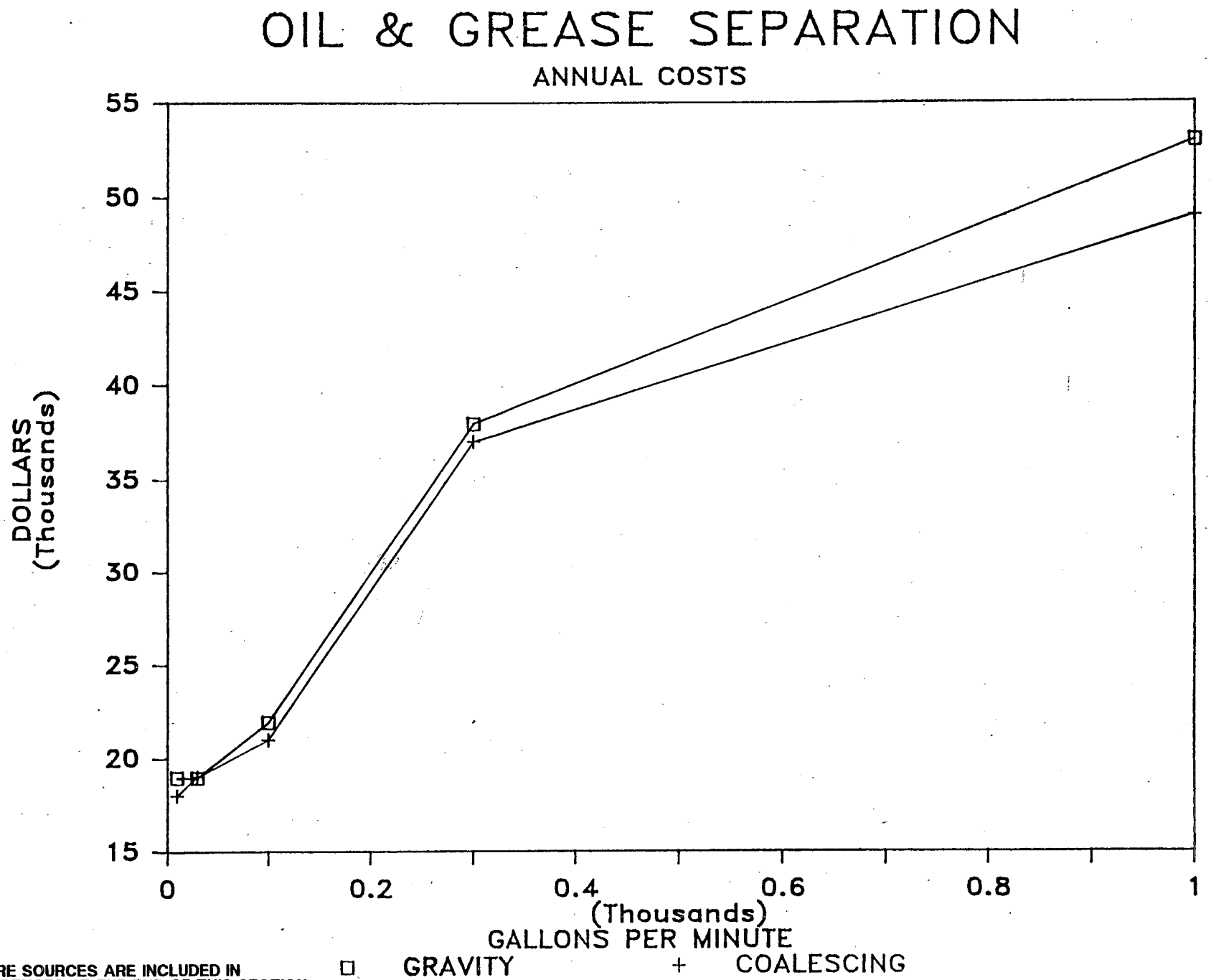
Oxidation is a chemical reaction in which one or more electrons are transferred from the chemical being oxidized to an oxidizing agent. The process can be controlled to oxidize undesirable compounds through control of pH and choice of oxidizing agent. Metals and inorganic compounds can be oxidized to less toxic forms. Organics can either be completely oxidized to carbon dioxide and water, or partially oxidized to a form more desirable for subsequent treatment.

Industrial wastewater treatment applications of chemical oxidation include destruction of cyanide, transformation of selected organics to biodegradable



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-2
OIL AND GREASE SEPARATION - CAPITAL COSTS



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-3
OIL AND GREASE SEPARATION - OPERATION AND MAINTENANCE COSTS

forms, or detoxification of organics and inorganics. Frequently, oxidation is used as a preliminary step to precipitation of metals.

11-2.1.1 Equipment Types Available. A variety of oxidizing agents are available for use. The contaminant requiring oxidation controls the choice of oxidizing agent; therefore, it also determines the equipment that will be required. Table 11-1 lists some commonly used oxidizing agents and their corresponding applications.

All oxidizing agents in Table 11-1 can be applied as batch or continuous processes. Generally, smaller quantities of wastewater are treated more economically in batch, while larger quantities are treated continuously. Reaction times for oxidation are typically less than one hour. Therefore, batch operations may require a significant amount of operator attention. The choice between batch and continuous oxidation is generally reduced to a comparison of the tank sizes and operational requirements.

Two process flow diagrams are shown in Figures 11-4 and 11-5. The first represents a general diagram for continuous oxidation using chemical additions such as ozone, chlorine, permanganate, or hydrogen peroxide. The second represents continuous oxidation using ultraviolet (UV) photolysis in combination with a hydrogen peroxide. UV photolysis is also applied in combination with ozonation.

Both flow diagrams contain conventional process equipment: influent feed pumps, reaction tanks, chemical addition metering pumps, mixers, oxidation reduction potential (ORP) meters (with controls), and pH monitors (with controls). The differences are the types of reactors or contact tanks. The reaction tanks and chemical feed points should be designed to allow complete mixing and reaction of waste and chemicals.

The UV photolysis contact tank, shown in Figure 11-5, is baffled to ensure the UV radiation sufficiently contacts the wastewater. UV light is easily absorbed by suspended solids and by the water itself. If the wastestream is inconsistent in flow or concentration, a flow equalization chamber may be required at the beginning of the treatment train. Depending on the oxidizing agent employed, various wastewater characteristics may affect the equipment requirements. Parameters affecting the process configurations are included in the discussion of required chemicals (see Section 11-2.1.3).

11-2.1.2 Advantages and Limitations. Advantages of using oxidation as a metals treatment include its reliability and proven effectiveness on industrial wastewaters. Oxidation can destroy cyanide and oxidize selected metals to a more precipitable form. If reduction must also be applied to the wastestream (i.e., chromium reduction), the oxidized contaminant must be removed from solution prior to reduction, and vice versa. The equipment and chemicals required to oxidize most wastestreams are readily available.

Oxidation of organics is a growing application. However, the primary disadvantage of the technology is its inability to selectively oxidize an individual contaminant in a wastestream. Excessive doses of oxidizing agent may be required to oxidize the target pollutant. For instance, if a wastestream

TABLE 11-1
APPLICATIONS OF COMMONLY USED OXIDIZING AGENTS

OXIDIZING AGENT	TARGET COMPOUND	REFERENCE
Ozone	Manganese, Cyanide, Phenol	Patterson, 1985
	Organics (general)	Kawamura, 1987
	Iron	Clifford et al., 1986
Chlorine or Chlorine Dioxide	Cyanide	Weber, 1972
	Iron, Manganese	Clifford et al., 1986
	Cyanide, Selenium, Phenol	Patterson, 1985
Potassium Permanganate	Iron	Clifford et al., 1986
	Manganese, Selenium, Phenol	Patterson, 1985
Hydrogen Peroxide	Phenol, Selenium	Patterson, 1985
Ultraviolet/Ozone or Hydrogen Peroxide	Methylene Chloride, Pentachlorophenol	Fletcher, 1987
	Phenols	McShea et al., 1986 Fletcher, 1987
	Polychlorinated Biphenyls	Arisman et al., 1980 Fletcher, 1987
	Organics (general)	Hager, 1988 Bourbigot et al., 1985 Fletcher, 1987

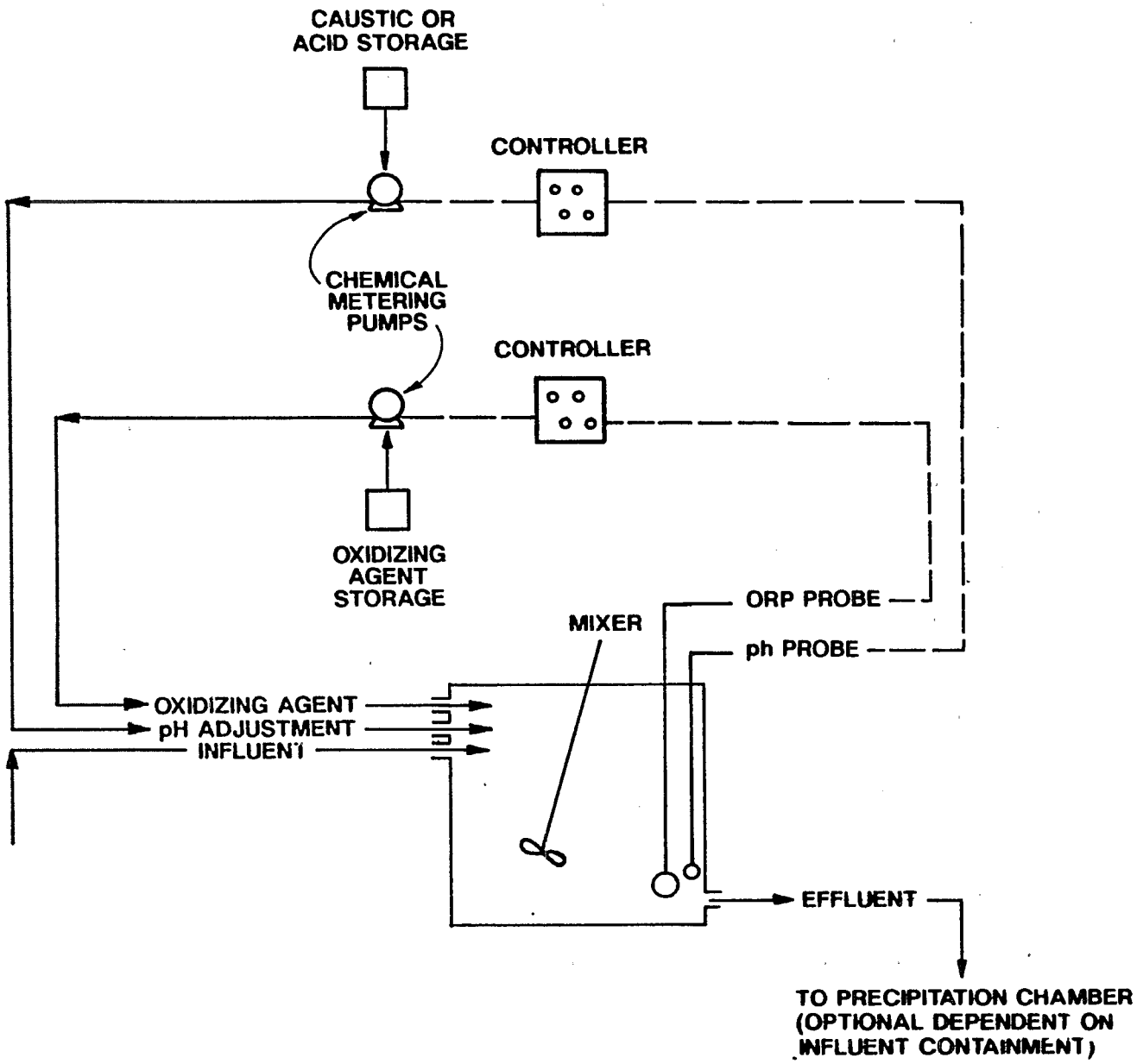
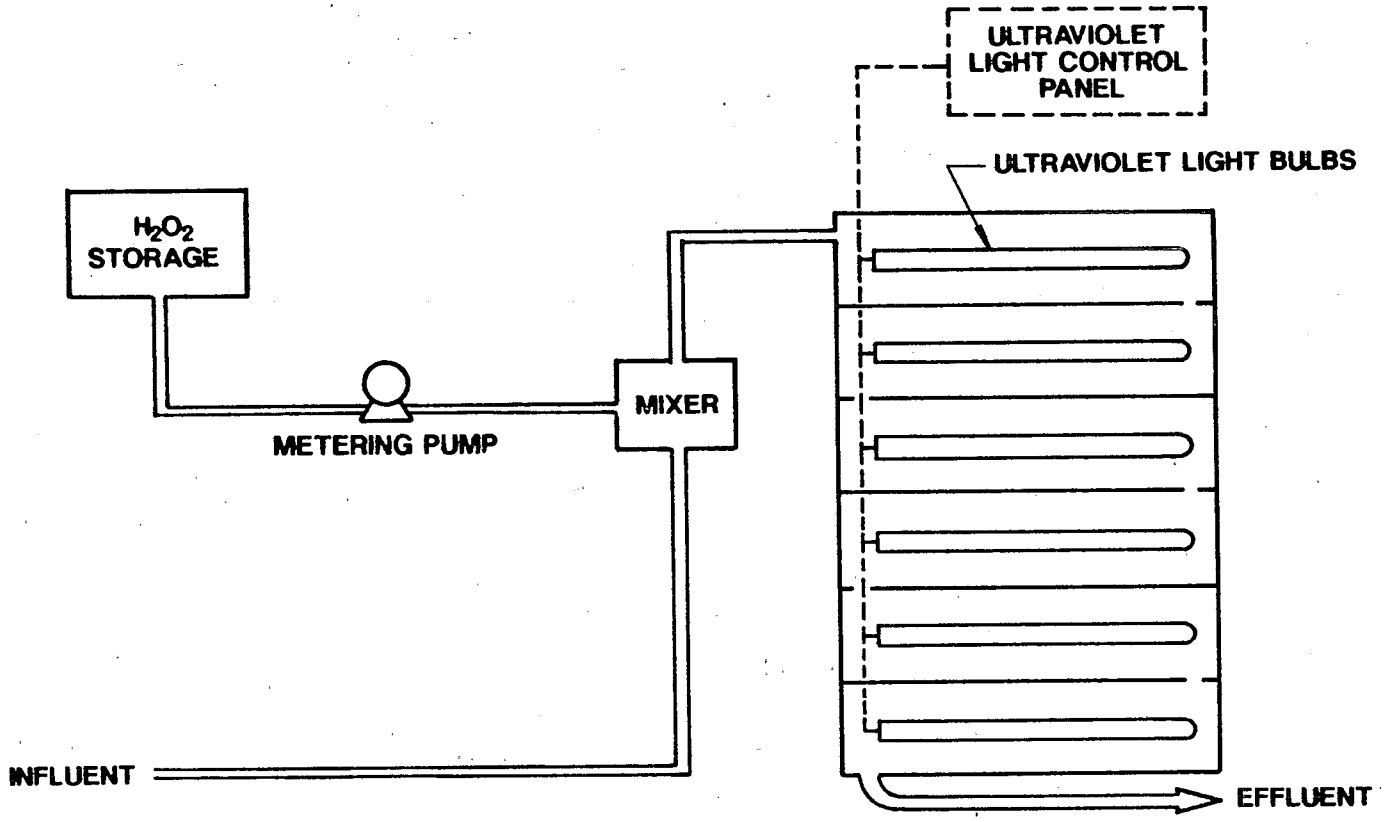


FIGURE II-4
CHEMICAL OXIDATION



REF.: HAGER 1988

FIGURE II-5
ULTRAVIOLET/HYDROGEN PEROXIDE OXIDATION

contains high concentrations of iron, and the pollutant requiring oxidation is phenol, most of the iron will be oxidized before the oxidizing agent reacts with the phenol. A similar disadvantage occurs when the wastewater contains various contaminants. Chemical interactions may take place and interfere with oxidation of the target pollutant, thus requiring high oxidant dosing.

The individual oxidizing agents have specific advantages and limitations. These advantages and limitations are discussed with the description of the oxidizing agents in the following subsection.

11-2.1.3 Chemicals Required. In addition to the oxidizing agent, oxidation usually requires pH adjustment. Ozone is the only oxidant in Table 11-1 that is not pH-sensitive. The remainder of the oxidizing agents listed require pH adjustment or buffering agents to provide the hydroxide or hydrogen ions required of the reaction. Weber (1972) and Snoeyink and Jenkins (1980) provide complete discussions on the calculation of buffer requirements and appropriate buffering agents. The following paragraphs discuss individual oxidizing agents.

Ozone. Ozone is a highly reactive and unstable form of oxygen and it must be generated on-site. Ozone is generated by passing air or oxygen through an electronic arc. Because ozone is used as a gas, high organic materials concentrations can create frothing in the reaction tank, requiring skimmers and ultimate disposal of the froth. Air quality standards will require additional equipment to recycle or treat ozone escaping from the reaction tank. Most reaction tanks are covered to minimize off-gas losses. A catalytic destruction system is often employed to convert ozone back to oxygen. The additional equipment requirements associated with the use of ozone make it much more expensive than other chemical oxidants; however, it is the most powerful oxidant. The oxidizing potential of ozone is only slightly sensitive to pH; however, ozone is more stable in acidic solutions. Manufacturers offer complete ozone generation and monitoring equipment.

Chlorine/Chlorine Dioxide. Chlorine (Cl_2) has been used as a disinfectant and oxidant in wastewater treatment for over a century. The oxidation potential of chlorine generally increases with increasing pH. Chlorine is a gas at atmospheric pressure; therefore, it requires special handling considerations. Sodium hydroxide can be used as a method for increasing the pH during chlorination. Chlorine is used extensively in the destruction of cyanide.

Chlorine oxidation of wastewaters with high organic content can produce chlorophenols or trihalomethanes (THMs) as by-products; however, oxidation with chlorine dioxide reduces the production of toxic chlorophenols and THMs. Chlorine dioxide is similar to ozone in that they both require on-site generation (due to chemical instability), making chlorine dioxide more expensive than chlorine. Chlorine dioxide is produced from sodium chlorite ($NaClO_2$) and chlorine gas (Cl_2).

Permanganate. Permanganate oxidation potential increases with increasing pH. Most organics will not completely oxidize even under severe alkaline conditions. Rates of oxidation of metals and inorganics can be increased through the use of catalysts and pH adjustments. Potassium permanganate ($KMnO_4$) is the

most easily manageable form for oxidation purposes, as it will keep indefinitely as a solid when stored in a cool dry place. Potassium permanganate is generally added to the process stream as a liquid of known concentration.

Hydrogen Peroxide. Use of hydrogen peroxide for organics decomposition is growing; however, at present it does not provide economic oxidation of inorganics. At increased pH, hydrogen peroxide provides more oxidizing power than ozone for organics. The oxidation potential can be further increased when it is used in conjunction with UV radiation. Hydrogen peroxide may cause foaming similar to ozone, resulting in floc flotation problems during precipitation.

UV/Ozone or UV/Hydrogen Peroxide. Use of UV radiation with hydrogen peroxide or ozone is recognized as economical and efficient for the destruction of toxic organics. UV photolysis treatment processes require specially designed reaction tanks to ensure adequate UV-wastewater contact. Suspended solids may interfere with UV contact by absorbing UV radiation.

11-2.1.4 Residuals Generated. Whether a residual is generated depends on the oxidation process employed. For example, oxidation of organics using ozone creates a froth, which ultimately must be landfilled or incinerated. In addition, oxidation with ozone will require either recycling or treatment of gases escaping from the reaction tank. For iron and manganese, oxidation is a preparatory step for precipitation. Oxidation of iron or manganese will produce sludges using any oxidant. The sludge generated during the precipitation process will require disposal or incineration. The documents referenced in the performance section indicate whether residuals are generated during individual applications.

11-2.1.5 Design Criteria. Design of an oxidation process for a wastestream is straightforward. Weber (1972) and Snoeyink and Jenkins (1980) provide information on appropriate oxidizing agents and pH for given undesirable contaminants. Several oxidizing agents may be appropriate for the wastewater. Determination of the most effective reagent, where several may be appropriate, is a function of the following:

- reagent consumption (grams of oxidizing agent/gallon of wastewater)
- required reaction or contact time

These factors vary with the composition and concentration of the wastewater requiring treatment. Estimates of reagent consumption and the required reaction times are possible through literature comparisons with similar applications. Table 11-1 lists references for information on full-scale and pilot-scale applications of a variety of oxidants and contaminants.

Although oxidation has been widely used as a treatment method for industrial wastestreams, bench-testing is almost always required to determine the necessary reaction times and oxidant concentration requirements. To determine the reagent consumption and reaction time in a bench test, batch reactors are generally used. By performing a series of batch tests at different oxidant concentrations, the optimum dosage requirement can be determined. Sampling of the supernatant at various times throughout the reaction will reveal the optimum reaction time.

Bench-testing establishes the relationship between the ORP of the wastewater and completeness of the reaction. The relationship between ORP and concentration of an unoxidized contaminant is important because in full-scale designs, ORP electrodes can provide continuous adjustment of chemical addition to meet the demand of the wastewater, resulting in a consistent effluent quality. While analytical data on concentrations can take months to acquire, ORP electrodes are attached to instrumentation that can immediately adjust feed rate of oxidizing agents. Knowing the relationship between the ORP of the reaction and a specific contaminant concentration can ensure that the process will effectively meet discharge limits.

The optimum doses and reaction times, with the flow rates and flow fluctuations, provide sufficient information to determine type and size of the necessary equipment.

11-2.1.6 Performance. As discussed in previous sections, oxidation is not selective, and the order in which an oxidizing agent reacts with the compounds in the wastestream is dependent on the wastewater characteristics. Most metals can be oxidized and subsequently precipitated. The potential for oxidation of VOCs and SVOCs varies within the compound class. Table 11-1 provides references for the treatability of several commonly oxidized compounds.

11-2.2 Evaluation of Oxidation

11-2.2.1 Effectiveness. The oxidation process can transform a variety of compounds into more stable, less toxic forms. When used in conjunction with precipitation, inorganics are transformed into more stable solid forms. Although this significantly reduces the volume of the contaminant, the solids settle to produce a sludge that must be disposed of. Oxidation alone (i.e., UV/hydrogen peroxide), or followed by biological degradation, can permanently transform organics to less toxic forms. Because oxidation of metals generally requires pH adjustment to conditions not normally encountered in nature, there is little potential for the contaminants to revert to their more toxic forms.

Because of their strong oxidizing power, many of the common oxidants can be toxic to microorganisms and therefore may require residuals monitoring prior to discharge to a POTW. For example, chlorine is used as a disinfectant for drinking water because of its known toxicity to many microorganisms. Residuals should be carefully controlled to prevent substituting one undesirable pollutant for another.

11-2.2.2 Implementability. Oxidation is well-demonstrated for concentrated industrial wastestreams (see Section 11-2.1.6). Application at hazardous waste sites is well-demonstrated in pilot- and full-scale. The equipment required for this technology is conventional and readily available. The operational requirements are minimal when metering pumps are used in conjunction with pH and ORP monitoring devices and controls.

As discussed in Section 11-2.1.5, oxidation is not a selective process, and bench-testing is normally required prior to design of a full-scale operation system to identify optimum operating parameters.

Residuals created during oxidation may require equipment for monitoring, removal, or treatment. One example is oxidation used prior to precipitation, where sludge is generated. Another example is oxidation by ozonation, which frequently requires recycling or treatment of the ozone off-gas and disposal of froth.

11-2.2.3 Cost. Capital cost estimates for treatment by oxidation are presented in Figure 11-6. The figure shows two different chemical doses, representative of hydrogen peroxide treatment of phenol. The doses used in the cost estimate represent those found in the literature (5 and 20 milligrams of hydrogen peroxide per milligram of phenol in the influent, with influent concentrations of phenol ranging from 5 to 500 ppm) (Patterson, 1985). Additional assumptions used to develop the capital cost estimates include the following:

- all storage tanks for hydrogen peroxide are a maximum 3,000 gallons and separated by concrete dikes for safety;
- pH is adjusted to 2 to 3 using sulfuric acid in quantities of approximately half the oxidizing agent;
- all pumps are duplicated for easy repair and maintenance;
- all pumps and piping are directly attached to pH and ORP probes for automatic addition adjustments;
- reaction times are assumed to be on the order of 5 minutes; and
- storage tanks provide at least one-month storage.

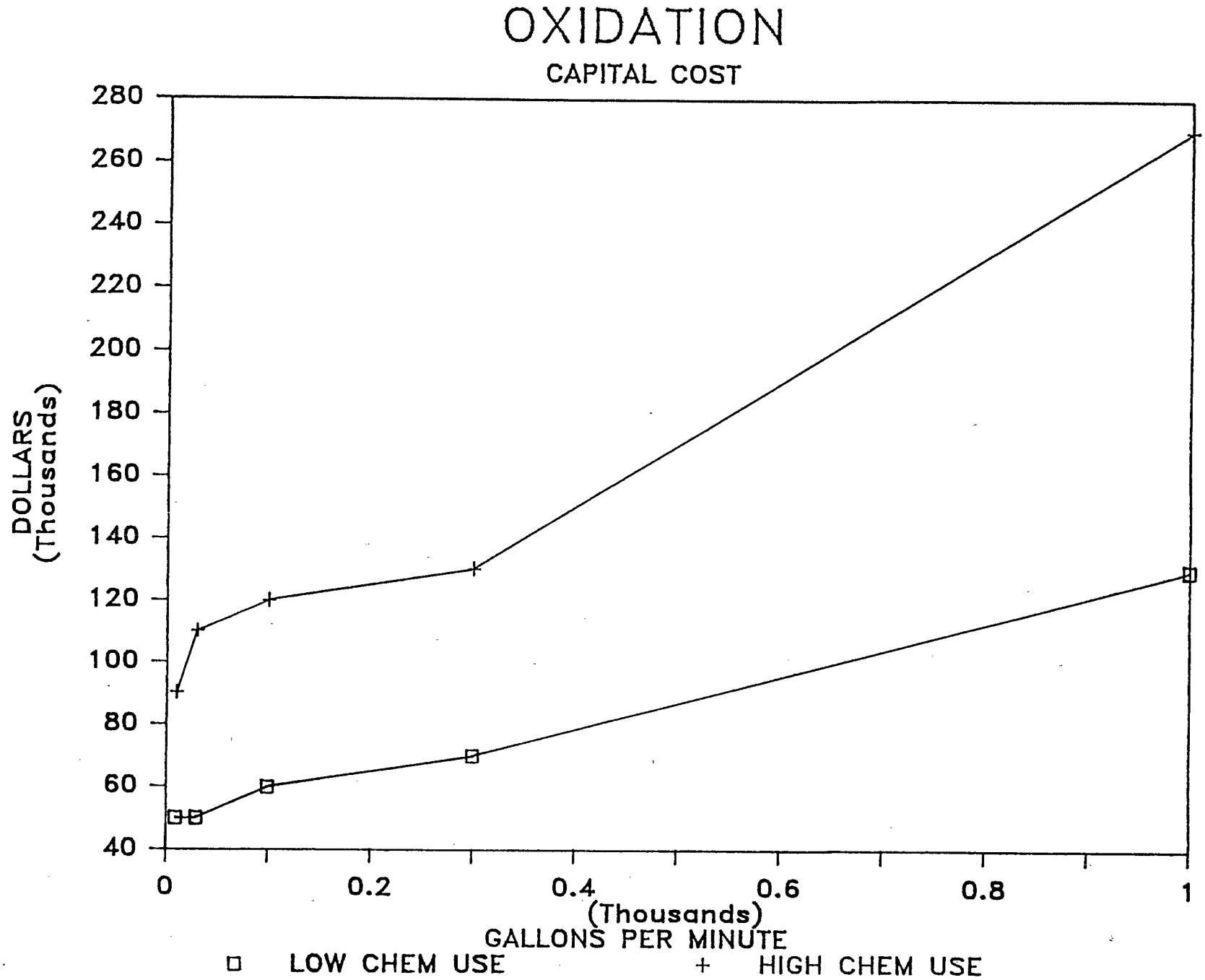
Operation and maintenance costs are presented in Figure 11-7. These costs include chemical requirements, operator labor, and electricity. The costs for the two different chemical usage rates bracket the range of O&M costs for hydrogen peroxide oxidation of phenols. Because of its explosive nature, hydrogen peroxide is one of the more expensive oxidants. Ozone is more expensive because it requires on-site generation and off-gas treatment.

Both capital and O&M costs are dependent on the contaminant type and concentration.

11-3 REDUCTION

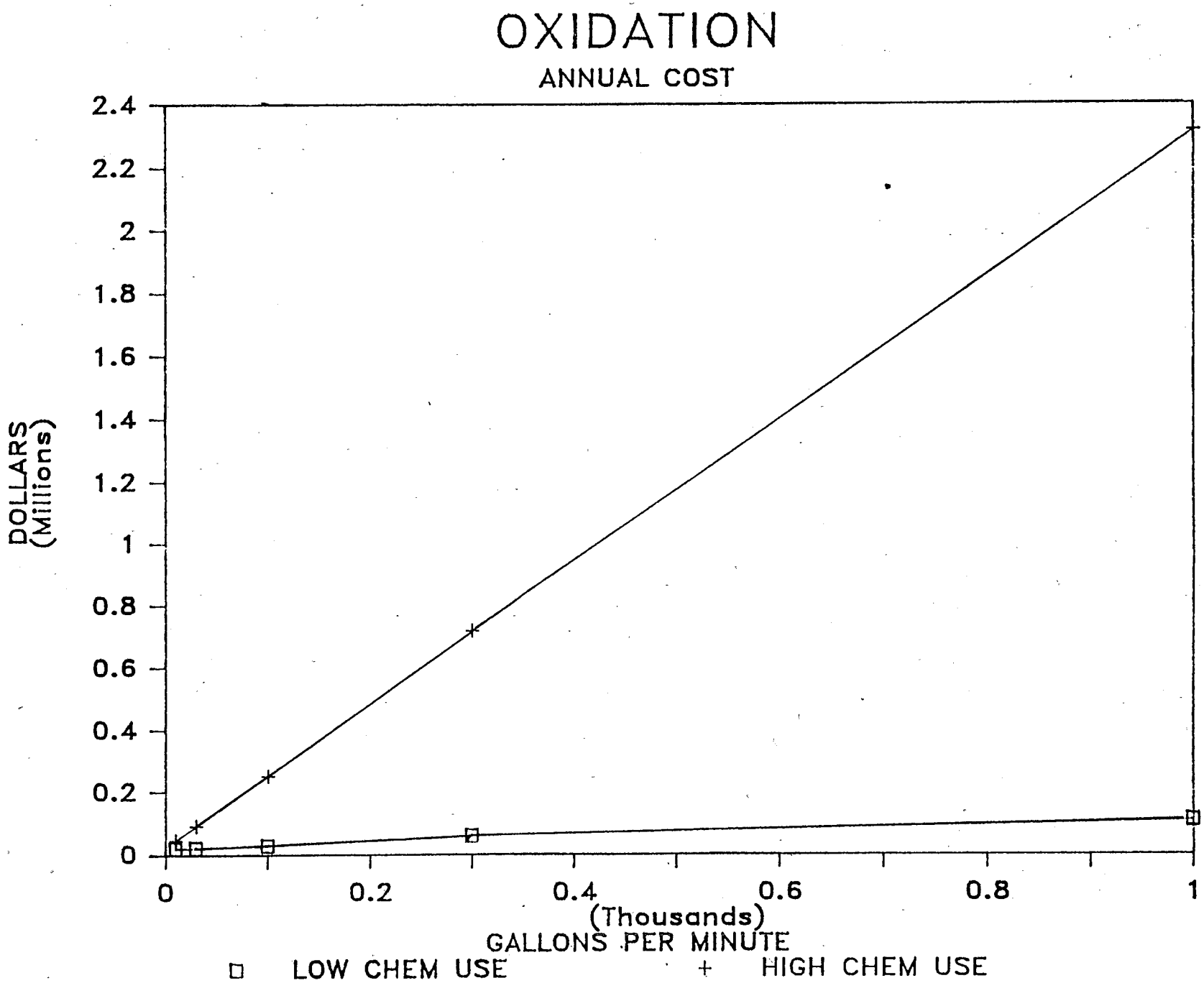
11-3.1 Description

Chemical reduction and oxidation occur simultaneously when electrons are transferred during a chemical reaction from one chemical (the reducing agent) to another. Reduction is defined as the gain of electrons; oxidation as the loss of electrons. Chemical reduction is commonly used to detoxify chromium in metal-plating wastewaters. Other applications not practiced as widely are mercury and lead reduction. Generally, chemical reduction must be accompanied by precipitation, ion exchange, or some other form of pretreatment for adequate wastewater treatment. There are currently no common applications involving



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-6
OXIDATION - CAPITAL COSTS



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-7
OXIDATION - OPERATION AND MAINTENANCE COSTS

reduction of organic compounds. The process of reducing chemicals in a wastewater normally consists of an initial pH adjustment followed by addition of the reducing agent. Although the pH adjustment can direct the reduction process to be more reactive with certain metals to a limited extent, reduction is generally not a selective process.

11-3.1.1 Equipment Types Available. Reduction process equipment is similar to oxidation process equipment. Batch and continuous process configurations are available for both technologies. Generally, batch processes are limited to low flow rates, less than 10 gallons per minute (gpm). Reaction times for reduction processes are typically short; therefore, batch reactions may require more operator time than continuous reactions.

A continuous flow diagram is shown in Figure 11-8, which represents the most commonly used configuration. ORP and pH probes measure the effluent parameters for process control. Chemicals are added near the influent to ensure adequate mixing, and reaction time prior to pH and ORP measurement. The pH and ORP probes are connected to control devices, which continuously feed the appropriate amounts of reducing agent and caustic or acid to maintain the desired pH and ORP. If the flow rate of the influent is highly variable, flow meters can be used in conjunction with the pH and ORP probes to more accurately apply the chemicals. Several different control schematics are available from manufacturers.

Although complete package systems are not available for the continuous flow configuration, the individual pieces of equipment shown in the process flow diagram are easily obtained from several manufacturers.

11-3.1.2 Advantages and Limitations. Advantages of chemical reduction include simple and readily available equipment. It is a well-studied and understood reaction. The continuous process configuration is easily automated, reducing operator requirements.

Disadvantages relate to its nonselective nature. The potential for reducing nontarget compounds in a complex wastewater can create increased reducing agent requirements. Also, because many reduced forms of organics and metals are more toxic than the oxidized form, nonselective reduction may render a wastewater more toxic than before the reduction. Chemical reduction appears to be limited to a few selected metals as a water treatment method. Reduction has not been demonstrated as a treatment method for organic compounds.

11-3.1.3 Chemicals Required. The major chemicals required during chemical reduction are the caustic or acid for pH adjustment and the reducing agent. Full-scale industrial wastewater treatment operations show sulfur dioxide to be the most commonly used reducing agent for chromium when waste sulfur dioxide is available (Patterson, 1985). When sulfur dioxide is not available, chemical reducing agents such as sodium bisulfite, sodium metabisulfite, or ferrous sulfate can be used. Commonly used reducing agents for mercury include aluminum, zinc, hydrazine, stannous chloride, or sodium borohydride.

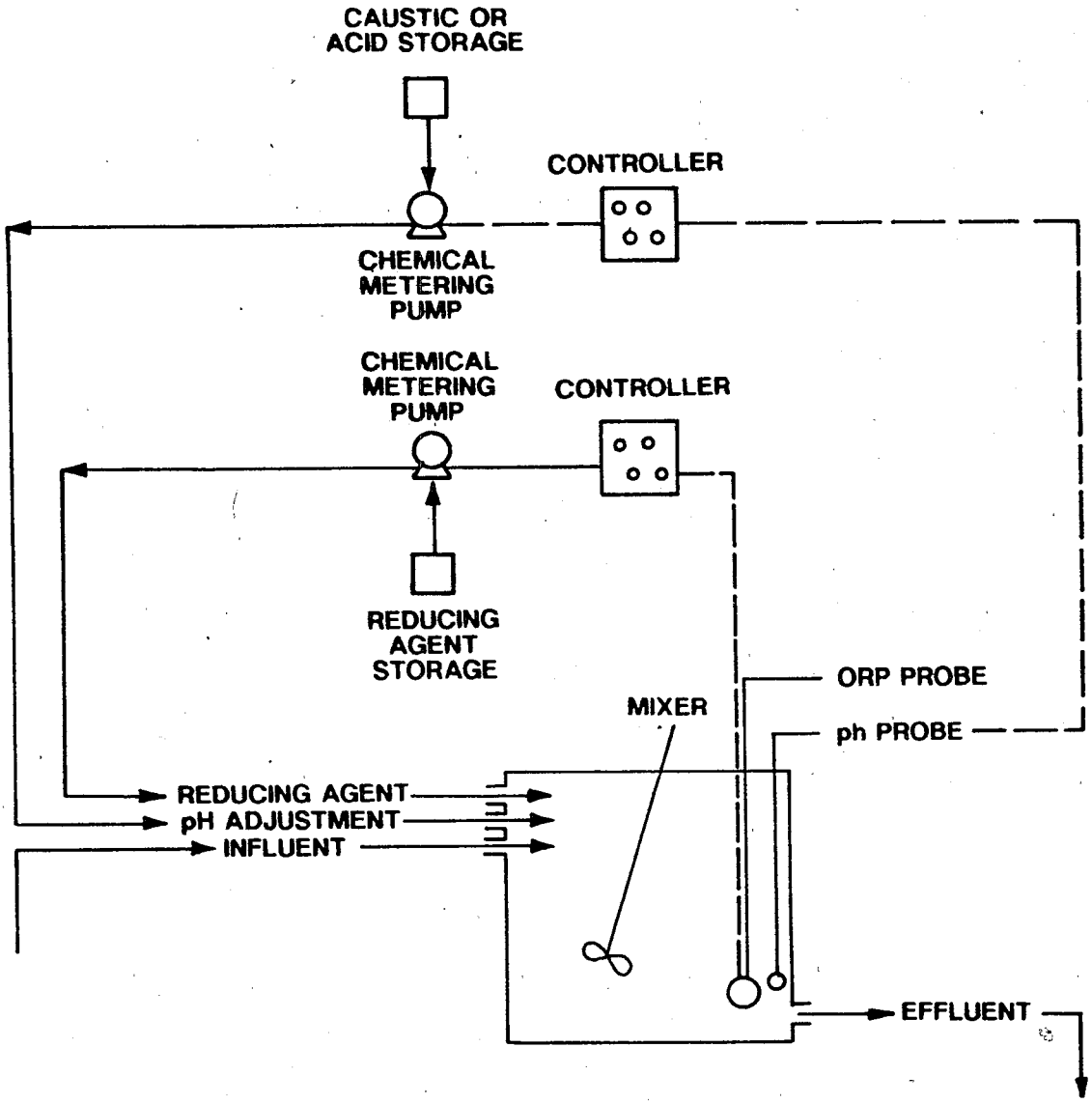


FIGURE II-8
CHEMICAL REDUCTION

Typically, the pH for chromium reduction is adjusted with the addition of hydrochloric or sulfuric acid. Mercury reduction occurs at varying pH for different reducing agents. These reagents are readily available.

11-3.1.4 Residuals Generated. As with any chemical reaction, potential exists for the residual reducing agent to exit the reaction chamber in the effluent stream. Proper control systems regulating the reducing agent feed pump reduce the chance for this to occur. Also, if reduction is followed by precipitation (as in the case of chromium), sludge that requires disposal is produced.

11-3.1.5 Design Criteria. Information necessary to design a system capable of reducing one or several metals should be acquired through bench-testing prior to the design. The design information consists of the following:

- reducing agent type and dosage
- reaction time
- optimal pH
- ORP-contaminant concentration ratio

These criteria vary with the characteristics of the wastewater due to the nonselective nature of the process. A variety of compounds may compete for the reducing agent, which can increase the reducing agent dosage and potentially the reaction time required. The pH is affected by the concentration of the reducing agent applied. Knowing the relationship between the target contaminant concentration and the ORP of the wastewater will reduce the possibility of either discharging an excess of the reducing agent or allowing excessive pass-through of the nonreduced contaminant.

The size of the reaction chamber can be determined from the known flow rate and the required reaction time (determined during bench-testing). Weber (1972) discusses in detail the process of calculating tank sizes.

11-3.1.6 Performance. Chemical reduction of chromium (Cr) and mercury (Hg) has been widely practiced in full-scale operations. The reduction of Cr^{+6} to Cr^{+3} decreases the metal's toxicity to organisms and allows subsequent removal by precipitation. Reduction of ionic mercury allows recovery in the metal form. Treatability information on the reduction of mercury and chromium is presented in the literature. Applications of reduction to organics do not appear to be practical.

11-3.2 Evaluation of Chemical Reduction

The following sections evaluate some of the characteristics of chemical reduction as they might be discussed in an FS. The evaluation focuses mainly on reduction of chromium and mercury because these are the two compounds that have been chemically reduced in full-scale operations successfully.

11-3.2.1 Effectiveness. Reduction of chromium from Cr^{+6} to Cr^{+3} results in a decrease in the toxicity of the chemical form. Chromium can be permanently removed from the wastewater through reduction and precipitation processes. When ionic mercury is reduced to its metallic form, it can be permanently removed from the wastewater by subsequent precipitation. In summary, reduction

of chromium or mercury followed by precipitation decreases the toxicity of the wastewater.

11-3.2.2 Implementability. A complex wastewater may contain chemicals in their oxidized form, exerting a demand on the reducing agent. Increased demand on the reducing agent may decrease the overall efficiency of the reaction. Another potential problem associated with reducing a complex wastewater is that oxidized chemicals may be reduced to more toxic forms. These potentially adverse effects can be investigated through bench-testing.

In general, the process of chemical reduction of a wastewater can be quickly and easily implemented. The equipment is readily available and many manufacturers offer controls for automation.

11-3.2.3 Cost. Cost estimates for the capital requirements of reduction of a chromium waste using sodium metabisulfite are presented in Figures 11-9 and 11-10. The two curves are representative of low and high published chemical doses (Patterson, 1985). Sodium metabisulfite, the most commonly used reducing agent for industries, is a medium-priced reducing agent. The capital costs are based on the following:

- a reaction time of 20 minutes
- premixing the dry reducing agent for influent flow rates less than 300 gpm
- dry feed addition of the reducing agent for influent flow rates above 300 gpm
- chemical storage for a minimum of one month
- all reaction tanks are surrounded by dikes for leak protection
- all pumps and piping are in parallel to facilitate maintenance

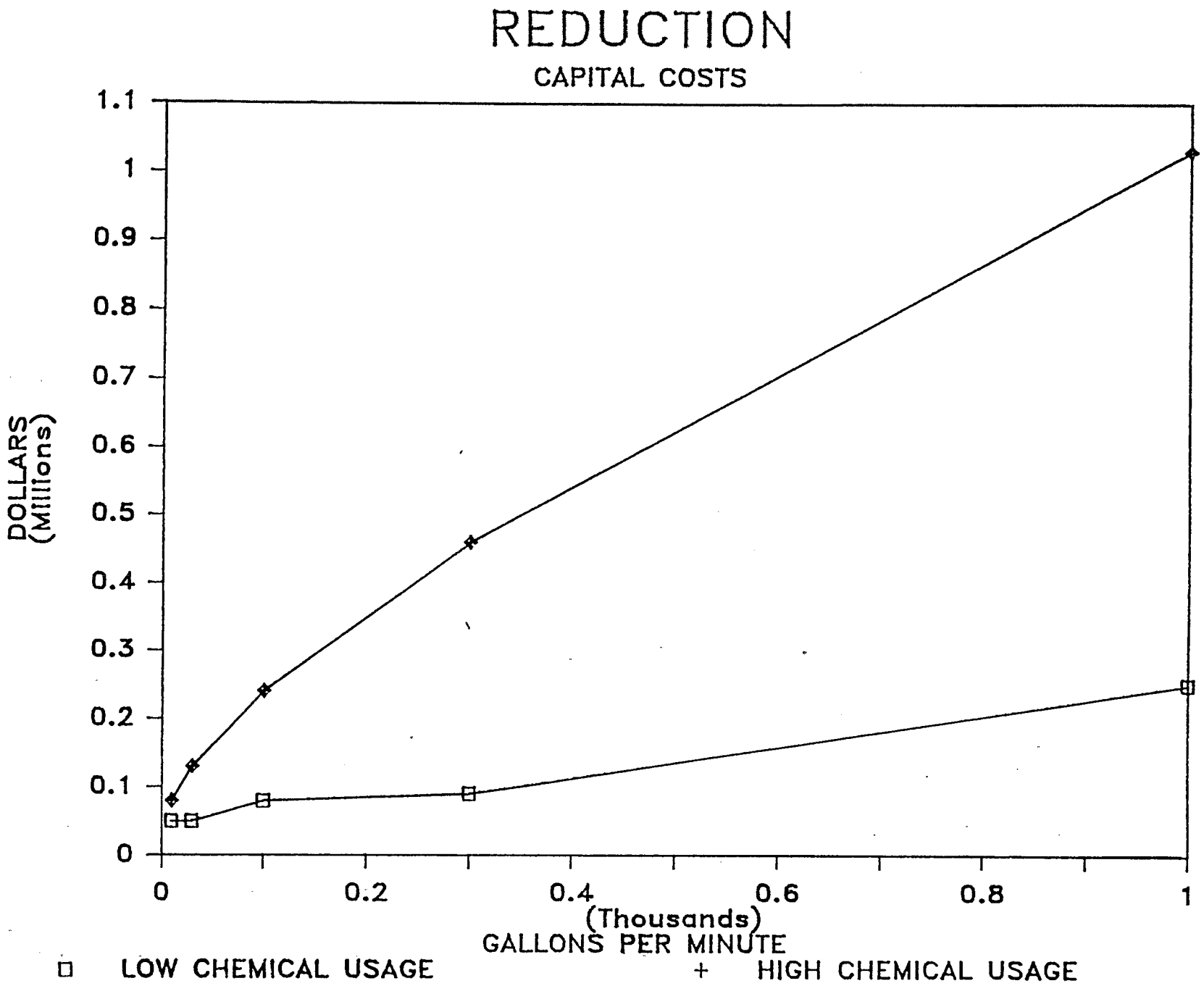
Because sodium metabisulfite is readily soluble in water, its premix requirements may be less than those of other reducing agents (e.g., sulfur dioxide).

O&M cost estimates, presented in Figure 11-10, include operator's labor, low and high published chemical doses, and electricity. O&M costs are primarily affected by the labor requirements involved in the chemical addition. Reducing agents that are difficult to handle, or that may produce undesirable off-gases or sludges, will increase the O&M costs.

11-4 PRECIPITATION

11-4.1 Description

Precipitation is a chemical unit process in which soluble metallic ions are removed from solution by conversion to an insoluble form. It is a commonly used treatment technique for removal of heavy metals, phosphorus, and hardness.



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-9
REDUCTION - CAPITAL COSTS

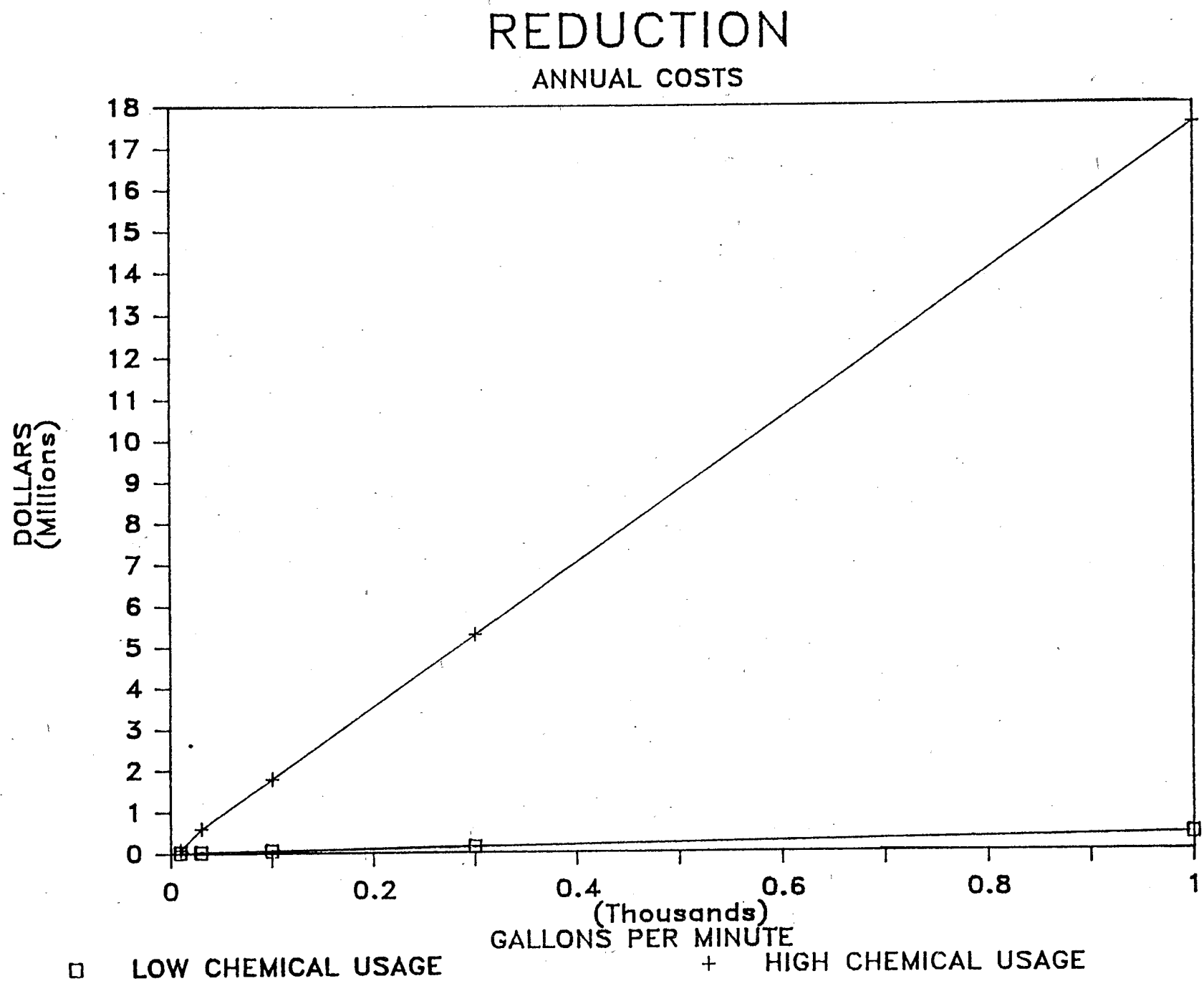


FIGURE II-10
REDUCTION - OPERATION AND MAINTENANCE COSTS

NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

Chemical precipitation is always followed by a solids-separation operation, which may include clarification/sedimentation or filtration to remove the precipitates (see Sections 11-6 and 11-7, respectively). The process can be preceded by chemical oxidation or reduction to change the valence of certain metal ions to a form that can be precipitated (see Sections 11-2 and 11-3).

The most common precipitation treatment processes use either hydroxide, carbonate, or sulfide compounds to produce insoluble metal salts. Each process is pH-dependent and governed by the optimal pH for removal of the metals desired. A brief description of each process follows.

Hydroxide Precipitation. Hydroxide precipitation, the most common technique, uses alkaline agents as a source of hydroxide to raise the pH of the wastewater to the optimum pH for precipitation. The metal ions subsequently precipitate as insoluble metal hydroxides. A general form of the hydroxide precipitation reaction may be written as:

$$M^{+X} + X\,(OH^{-}) = M\,(OH)_X$$

metal ion + hydroxide compound = insoluble metal hydroxide

where X equals the metal cation charge

Principal sources of hydroxide are lime (CaO), hydrated lime ($Ca(OH)_2$), and caustic soda (NaOH). Lime hydrolizes in water to form the hydroxide ion.

Carbonate Precipitation. Carbonate precipitation may be used to remove metals either by direct precipitation or by converting hydroxides into carbonates using carbon dioxide. A general form of the direct carbonate precipitation reaction may be written as:

$$M^{+2} + CO_3^{-2} = MCO_3$$

or

$$2M^{+3} + 3CO_3^{-2} = M_2(CO_3)_3$$

metal ion + carbonate compound = insoluble metal carbonate

The principal sources of carbonate are sodium carbonate ($NaCO_3$) and calcium carbonate ($CaCO_3$). However, calcium carbonate is ineffective in highly alkaline water.

Sulfide Precipitation. Sulfide precipitation occurs when a metal and sulfide ion react to produce an insoluble metal sulfide. A simple form of direct sulfide precipitation may be written as:

$$M^{+2} + S^{-2} \quad 2MS$$

or

$$2M^{+3} + 3S^{-2} \quad M_2S_3$$

metal ion + sulfide compound insoluble metal sulfide

Two processes used to precipitate metal sulfides are (1) insoluble sulfide precipitation (ISP) (i.e., sulfide is added as a slightly soluble iron sulfide [FeS] slurry); and (2) soluble sulfide precipitation (SSP) (i.e., sulfide is added as sodium sulfide [Na_2S] or sodium hydrosulfide [NaHS]). With the SSP process, overdosing of sulfide compounds can produce toxic hydrogen sulfide gas (H_2S); therefore, reaction tanks should be covered and vented. The advantages and limitations of each process are discussed in Section 11-4.1.2.

11-4.1.1 Equipment Types Available. Chemical precipitation typically requires using a reaction tank with a mixer, a pH monitoring system, and pumps for influent flow and chemical addition. Chemicals utilized in precipitation are discussed in Sections 11-4.1.2 and 11-4.1.3; this subsection addresses basic process equipment types (Figures 11-11 and 11-12).

Chemical precipitation requires a tank in batch (see Figure 11-11) or continuous operation for reaction (see Figure 11-12). For small or intermittent flow rates or where waste characteristics may vary substantially with time, batch systems are more feasible. Continuous treatment is applicable to uniform and high flow rate wastewater streams (Peters et al., 1985). A continuous system may use an equalization tank in which retention times range from several hours to a few days, to even out fluctuations in contaminant levels and flows before treatment begins (Clifford et al., 1986).

The batch treatment tanks serve the multiple functions of equalizing the flow, acting as a reactor, a flocculation chamber, and a settler. In Figure 11-11, a cone bottom tank is used to allow solids to be removed.

Pump selection will depend on characteristics of the wastestream. Corrosive environments may necessitate special materials of construction. The metering pumps, for precipitant and pH adjustment chemicals, are sized after assessing the concentration of metal ions to be removed and their associated chemical demand. Chemical demand is determined through bench-scale testing.

Several vendors offer package precipitation treatment systems. Alternatively, individual components are readily available to fit other designs.

11-4.1.2 Advantages and Limitations. The benefits of precipitation include low treatment cost, and reliable and easily operated equipment. However, precipitation is primarily a metal ion removal process, potentially interfered with by other organic, chelating, or oil and grease contaminants (Federal Register, 1987). The advantages and limitations of each hydroxide, carbonate, and sulfide precipitation process are listed in the following paragraphs (Peters et al., 1985).

Hydroxide Precipitation. The advantages of the hydroxide precipitation process are as follows:

- Certain chemicals for precipitation are available at low cost.
- Systems can be automated, minimizing operator time.
- Heavy metal ion concentrations can be effectively reduced.

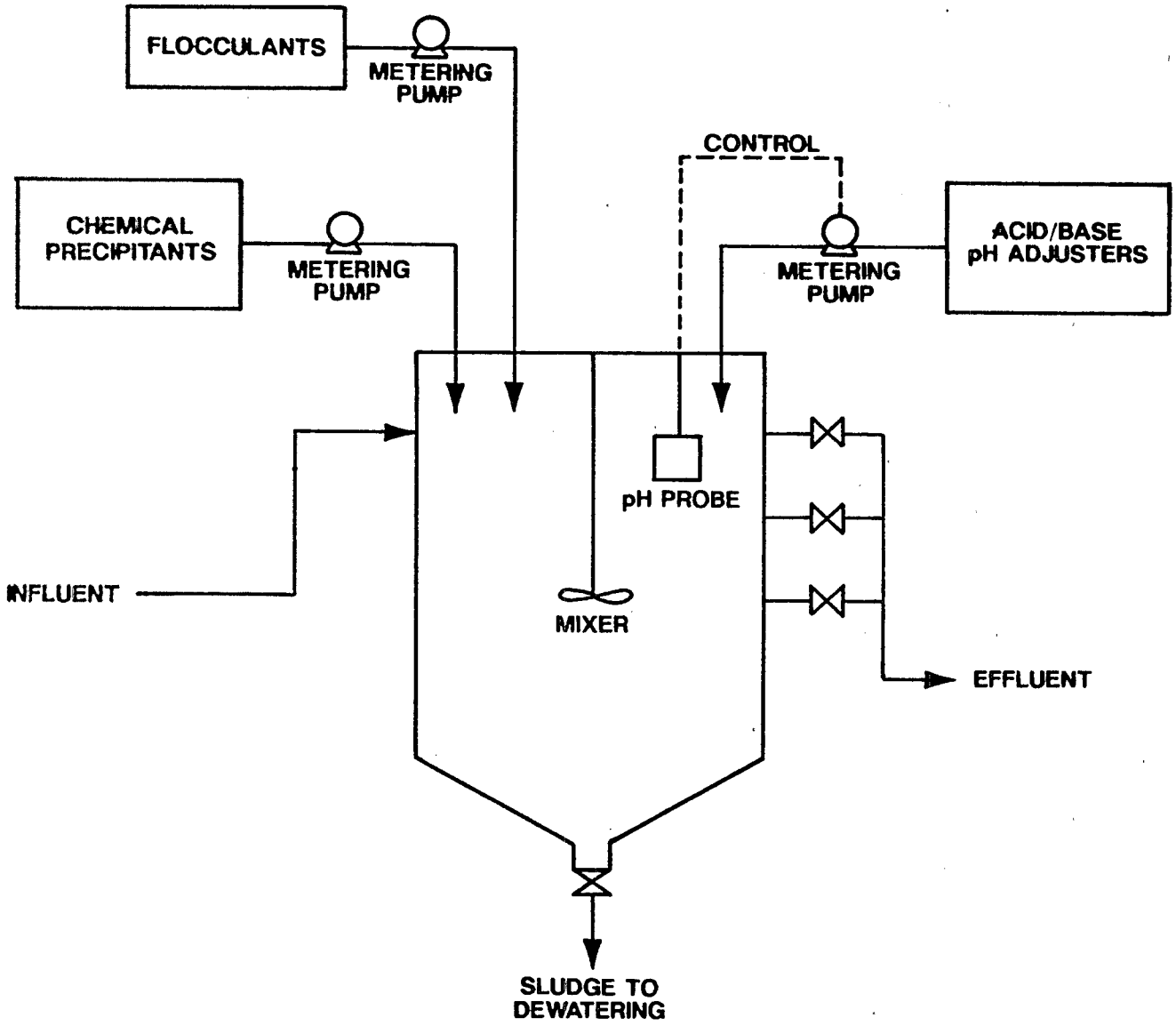


FIGURE II-11
CHEMICAL PRECIPITATION - BATCH FLOW

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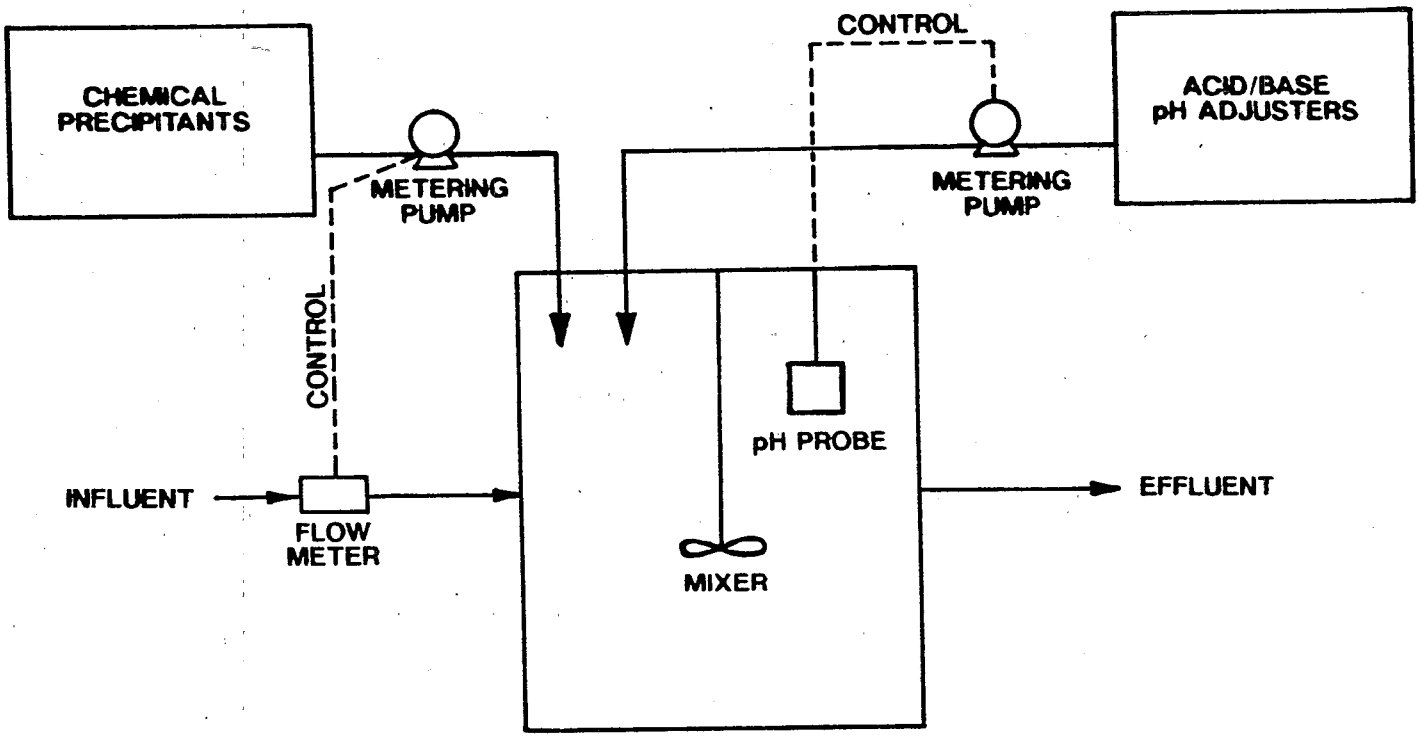


FIGURE II-12
CHEMICAL PRECIPITATION - CONTINUOUS FLOW

5307-83

The limitations of the hydroxide precipitation process are as follows:

- The pH must be strictly controlled near the optimal pH to ensure effective removal.
- Systems must be designed to allow adequate reaction times.
- Certain metals (e.g., chromium, iron, and manganese) must be reduced or oxidized prior to precipitation.
- If two or more metals are present, the optimal pH for removal may be different for each, thus affecting removal efficiency.
- Precipitated metals can resolubilize if pH changes.
- Complexing agents (e.g., cyanide, ethylene-diamine-tetraacetic acid [EDTA], and other chelating agents) may adversely affect removal if the wastestream is not pretreated to overcome these effects.
- Sludges may require further treatment prior to dewatering.

Carbonate Precipitation. The advantages of the carbonate precipitation process are as follows:

- Certain metals require lower pH values to initiate precipitation.
- Certain metals can be removed more effectively than by hydroxide precipitation.
- Generally, a denser sludge is produced that is easier to settle and dewater.

Carbonate precipitation limitations are similar to hydroxide precipitation. Metals can resolubilize, complexing agents can interfere with the chemical reactions, and the sludge may require further treatment.

Sulfide Precipitation. The advantages of the sulfide precipitation process are as follows:

- The process removes metal ions at pHs as low as 2 to 3.
- Sulfides reduce hexavalent chromium to trivalent state under the same conditions as required for precipitation.
- Sulfides are highly reactive, thus requiring less detention time.
- Thicker sludges are easier to dewater and dispose.

The limitations of the sulfide precipitation process are as follows:

- The process is more expensive.
- Toxic hydrogen sulfide gas is generated in the SSP process if strict control of chemical addition is not maintained.
- High sulfide concentrations in the effluent can inhibit POTW biological treatment processes.

However, the hydrogen sulfide gas and sulfide can be reduced by controlling the sulfide reagent dose or aerating after reaction time. Housing and venting the process equipment controls hydrogen sulfide fumes.

Coprecipitation. In coprecipitation, contaminants that cannot be removed effectively by direct precipitation are removed by incorporating them into particles of another precipitate. It is a phenomenon that can be induced by adding calcium, iron, or other ions to the wastewater prior to precipitation. Examples of coprecipitation have been documented in Peters et al. (1985).

11-4.1.3 Chemicals Required. The following chemicals are described in Section 11-4.1. The advantages and disadvantages of each type of precipitation are listed in Section 11-4.1.2.

Hydroxide Precipitation: Quicklime (CaO), hydrated lime ($Ca(OH)_2$), and liquid caustic soda (NaOH). These compounds are most commonly used; others are available at a higher cost.

Sulfide Precipitation: Sodium sulfide (Na_2S) and ferrous sulfide (FeS).

Carbonate Precipitation: Calcium carbonate ($CaCO_3$), carbon dioxide (CO_2), and sodium carbonate ($NaCO_3$).

11-4.1.4 Residuals Generated. Chemical precipitation generates solids that must be removed in a subsequent treatment step (e.g., clarification or filtration). Ultimately, the treatment train produces a sludge that must be dewatered and disposed of. The sludge should be sampled and tested for contaminant concentrations that would classify it as a hazardous waste.

11-4.1.5 Design Criteria. In all design considerations, bench- and pilot-scale studies should be conducted to match waste characteristics with a treatment process. The reaction tank is sized based on wastewater flow and chemical contact time required. Pilot- and bench-scale testing can provide other design criteria that depend on contaminant concentration, as follows:

- performance of different chemical precipitant types
- chemical dosage requirements to drive the precipitation reaction to completion
- minimum contact time to produce the desired quality of effluent

- rate of mixing to allow the chemicals and waste to react
- equipment sizes
- optimal pH for the reaction to occur
- sludge handling requirements

The precipitating reagent choice is important because the chemicals affect the solubility and settling characteristics of precipitated metal compounds. The chemical choice can be complicated by metal complexing agents that reduce the number of free metal ions available to precipitate. Polyelectrolyte (i.e., flocculant) addition is required to induce particle flocculation when precipitated particles are too small to readily settle easily.

The most important operating parameter of the precipitation process is pH. Since each metal ion has its lowest solubility at a different pH, operating pH for a mixture of metal ions is either a compromise value, or must be based on the pH optimum for the metal constituent requiring the most stringent effluent limitation. Alternatively, a staged precipitation process can be used that has different pH settings for specific metals to be removed during each stage (Cliffqrd et al., 1986).

During operation, it is easier to control pH for a batch system than a continuous system. A continuous system requires controls to keep the pH in optimal range. Air treatment and controls are sometimes needed (as with sulfide precipitation) to vent hydrogen sulfide fumes.

11-4.1.6 Performance. The precipitation process is effective in removing metal ions from wastewater. Equipment is relatively simple and easy to operate. The process is most sensitive to the chemistry involved. Chemical choice, dose, and the optimum operating pH are best determined from bench- or pilot-scale studies. However, Table 11-2 and Figure 11-13 will provide a starting point for chemical and pH considerations. Table 11-2 lists priority metal pollutants and the precipitating compounds most effective in removing that contaminant. The graph in Figure 11-13 shows the solubility of some of the same metal ions as a hydroxide or sulfide metal salt. Figure 11-13 may be helpful in choosing an optimum pH for a target metal ion, provided other ions do not interfere with the chemical reaction. Bench- or pilot-scale data are not available for confirmation. However, the metal salts solubility indicates that precipitation may occur.

11-4.2 Evaluation of Precipitation

11-4.2.1 Effectiveness. Chemical precipitation can be an effective, permanent means of reducing the metal ion concentration in wastewater. Pre- and/or post-treatment is necessary to remove other contaminants such as organics, suspended solids, oil and grease, or residual metals.

The level of metal removal partially depends on how well the waste characteristics were evaluated with bench- and pilot-scale tests. The pH must be strictly

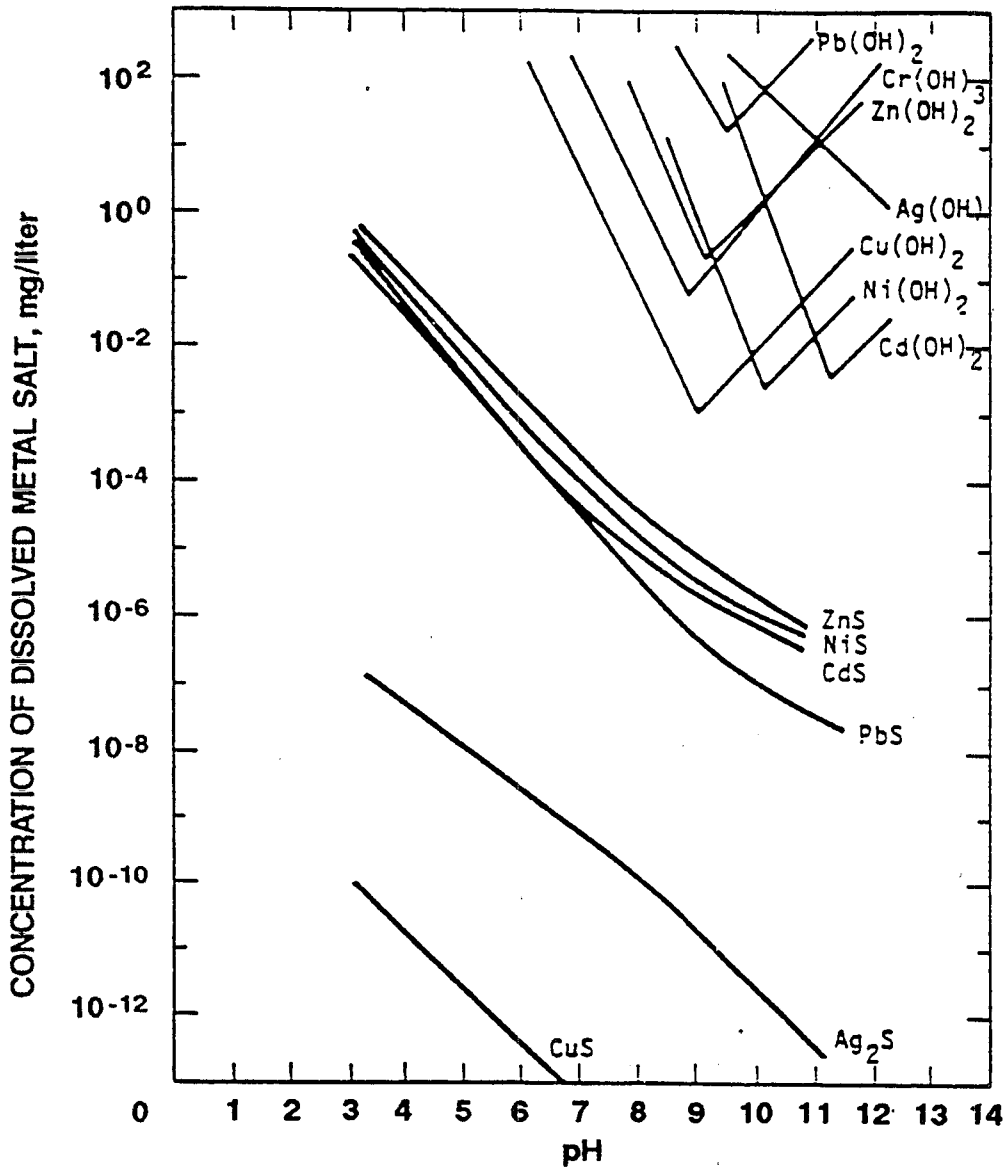
TABLE 11-2
EFFECTIVE TYPES OF PRECIPITATION FOR SELECTED METAL IONS

METAL ION	TYPE OF PRECIPITATION		
	HYDROXIDE	SULFIDE	CARBONATE
Antimony			
Arsenic	X	X	
Beryllium		X	T
Cadmium	X		X
Chromium	X	X	
Copper	X	X	
Lead	X	X	X
Mercury		X	
Nickel	X	X	X
Selenium			
Silver	X	T	
Thallium		T	
Zinc	X	X	T
Iron	X	X	
Manganese	X	T	

NOTES:

"X" indicates process is applicable for removal of the metal ion. Bench- or pilot-scale data are available to affirm precipitation occurrence.

"T" indicates process may be applicable for removal of the metal ion. Bench- or pilot-scale data are not available for confirmation. However, the metal salt's solubility indicates precipitation may occur.



SOURCE: A HANDBOOK ON TREATMENT OF HAZARDOUS WASTE LEACHATE (USEPA, 1986)

FIGURE II-13
SOLUBILITY OF METAL HYDROXIDES AND SULFIDES

controlled to assure optimal precipitating conditions. Metal complexing agents that bind metal ions in solution need to be identified.

11-4.2.2 Implementability. Precipitation is a widely used and well-demonstrated method of metal removal. The equipment is basic and easily designed. Many manufacturers also provide compact single treatment units that are deliverable to a site. Precipitating chemicals are readily available and, as in the case of lime, relatively inexpensive.

Sludge production can be voluminous, difficult to dewater, and may require further treatment prior to disposal. Landfill or incineration should be considered as disposal methods. Contaminated sludges may need RCRA approval for transport and disposal.

11-4.2.3 Cost. A continuous flow sodium hydroxide (NaOH) precipitation process has been costed based on the following assumptions.

Capital Costs

- Chemically resistant reaction tanks are closed and vented. They are sized for a 20-minute detention time.
- Chemical storage tanks for liquid NaOH and a polymer are sized for 30 days' storage. The NaOH storage tank is insulated and heat-traced to prevent crystallization.
- A NaOH premix tank with paddle mixer and metering pump controls is included to dilute the NaOH in case it is too concentrated for the wastestream.
- Variable speed mixers are in reaction tanks.
- Metering pumps and a pH probe control NaOH and polymer addition.
- Pumps and piping are designed with 100-percent backup capability.
- The process equipment is installed on a concrete pad.

O&M Costs

- Electricity to operate pumps and mixers is included.
- A 50-percent NaOH solution is costed for a range of 200 mg/ℓ (0.262 gal/1,000 gal) to 1,000 mg/ℓ (1.31 gal/1,000 gal).
- The polymer dose ranges from 1 to 100 mg/ℓ.
- Labor is 8 hours/week for system flows less than or equal to 100 gpm, and 16 hours/week for flows greater than 100 gpm.
- Solids disposal is not costed (solids will be removed later in the treatment train).

Capital and O&M costs are presented as a range of costs in Figures 11-14 and 11-15.

11-5 NEUTRALIZATION

One of the common types of chemical treatment used by industrial wastewater treatment facilities is pH adjustment. Waters that are acidic or alkaline could be disruptive to collection systems, treatment plants, and receiving waters. The adjustment of alkalinity or acidity to yield a final pH of approximately 7.0 is called neutralization.

One reason for pH adjustment is that the General Pretreatment Regulations prohibit any discharge to a POTW with a pH less than 5.0. Further, wastes entering biological treatment processes should have a pH between 6.5 and 8.0 for optimum growth of the microorganisms (Sundstrom and Klei, 1979; Water Pollution Control Federation, 1977).

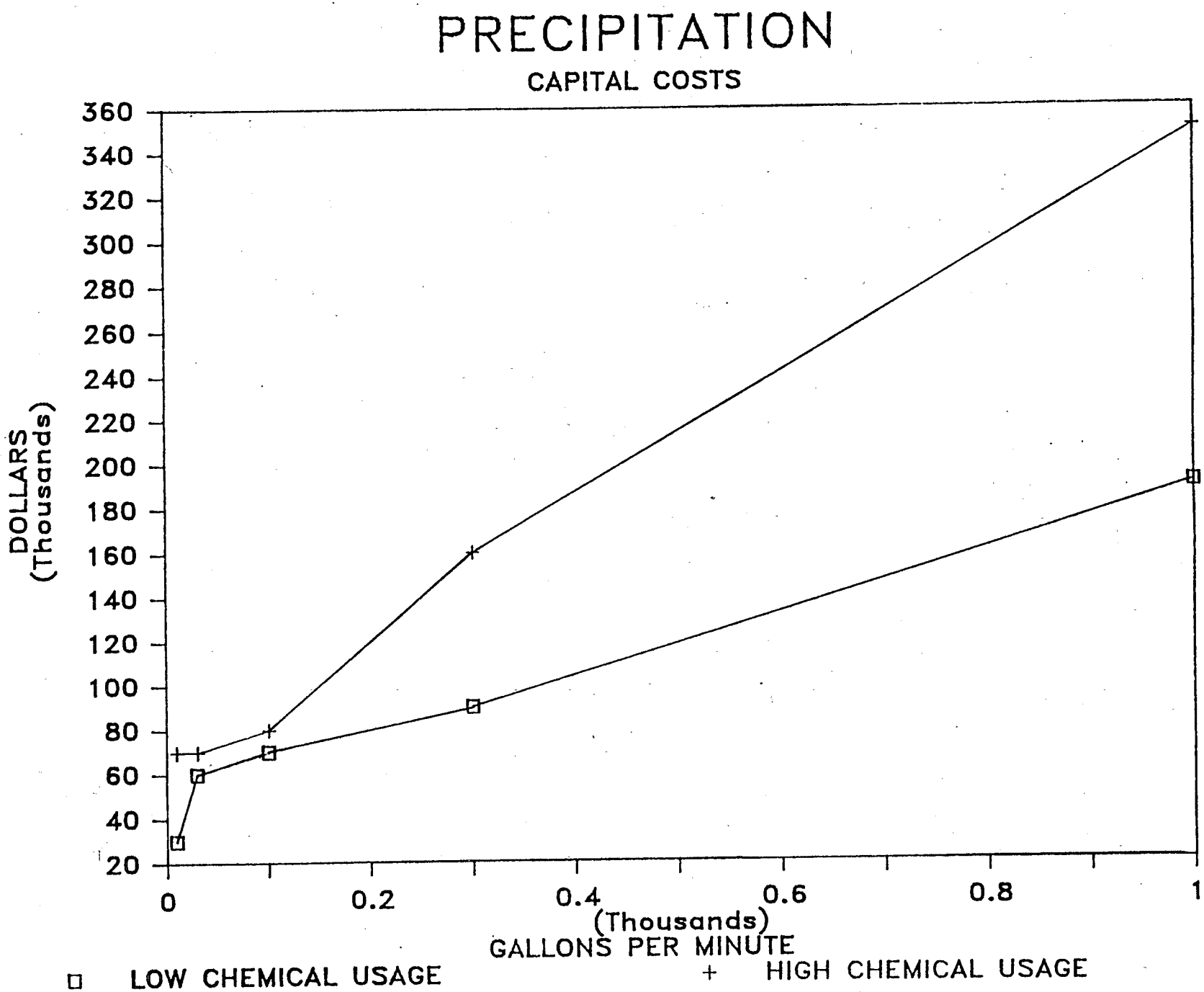
11-5.1 Description

The process of neutralization is the interaction of an acid with a base or vice versa. The typical properties exhibited by acids in solution are a result of the hydrogen ion (H^+) concentration in solution. Similarly, alkaline (or basic) properties are a result of the hydroxyl ion (OH^-) concentration. In aqueous solutions, pH is a measure of acidity and basicity where pH = - log [H^+], or pH = 14.0 + log [OH^-] at room temperature, respectively. Streams with a higher concentration of OH^- ion that H^+ ion have pH levels greater than 7.0 and are said to be basic or alkaline. Streams with a higher concentration of hydrogen ions [H^+] have pH levels less than 7.0, and are said to be acidic. A typical neutralization system is shown in Figure 11-16.

Many industries produce effluents that are acidic or alkaline in nature. Neutralization of an acidic or basic wastestream is necessary in a variety of situations, for example:

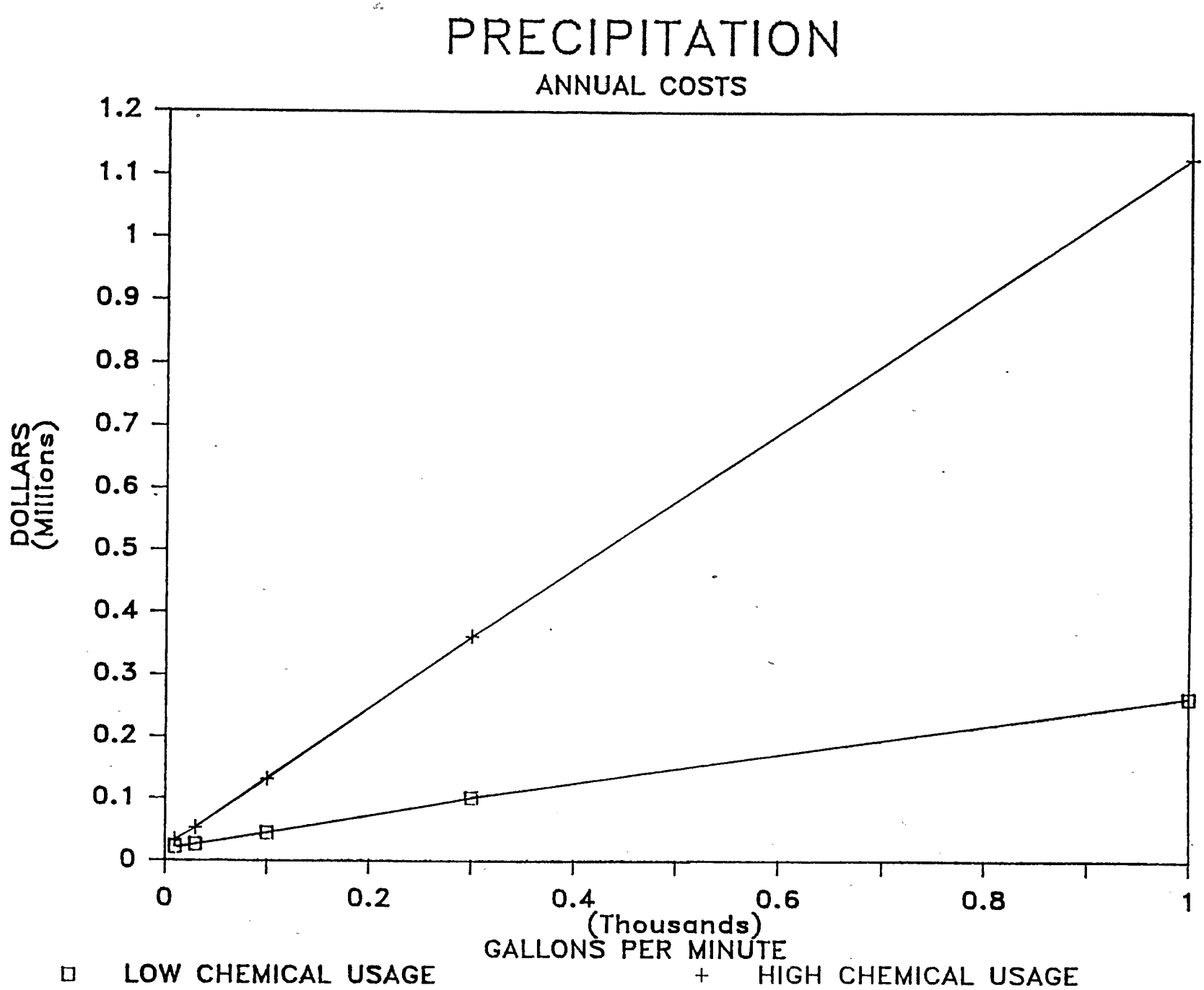
- pH adjustment for precipitation
- preventing metal corrosion and/or damage to other materials
- preliminary treatment, allowing effective operation of biological treatment processes
- providing neutral pH water for recycling uses and reducing detrimental effects in the receiving water
- oil-emulsion breaking (see Section 11-1.1)
- controlling of chemical reaction rates (e.g., chlorination)

11-5.1.1 Equipment Types Available. Many acceptable methods of neutralizing acidic or basic wastewaters are available, including the following:



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-14
PRECIPITATION - CAPITAL COSTS



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-15
PRECIPITATION - OPERATION AND MAINTENANCE COSTS

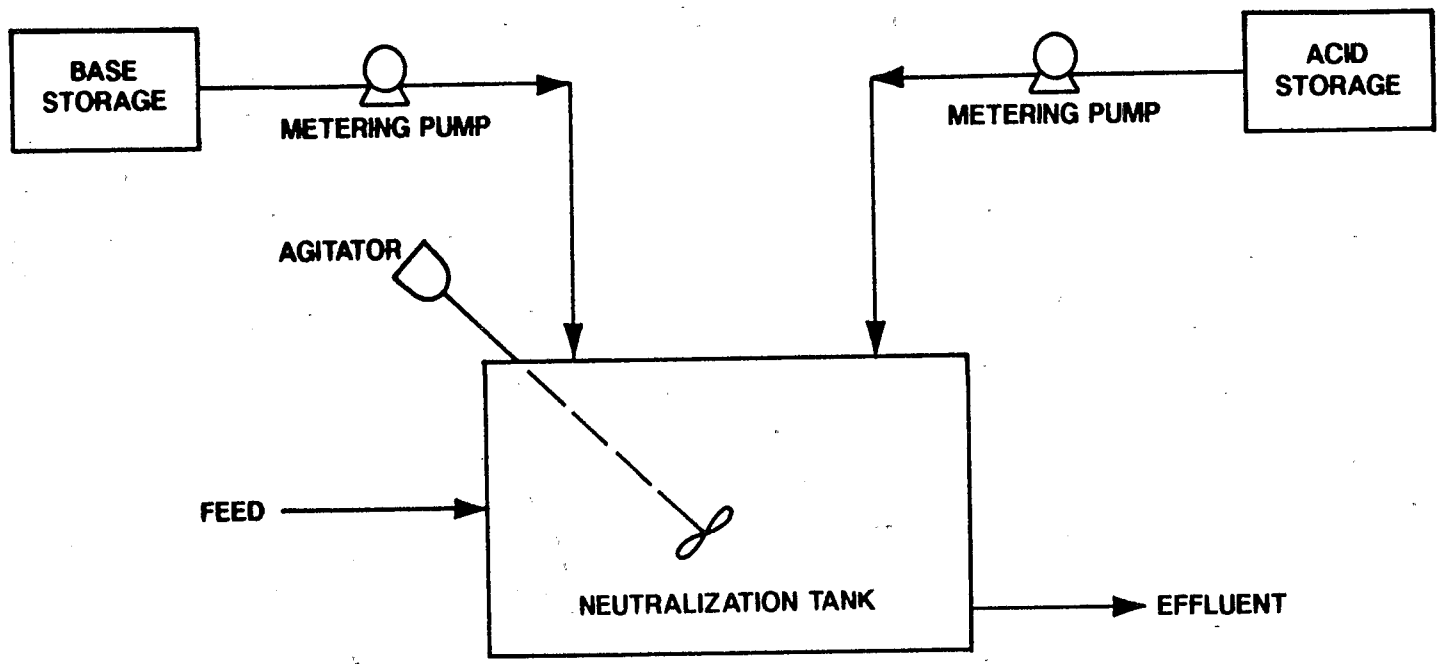


FIGURE II-16
NEUTRALIZATION

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- mixing acidic and alkaline wastes so that the net effect is a near-neutral pH
- passing acid wastes through beds of limestone
- mixing acid wastes with lime slurries or dolomitic lime slurries
- adding basic solutions (e.g., caustic soda [NaOH] and soda ash [Na_2CO_3]) to acid wastes
- blowing waste boiler-flue gas through alkaline wastes
- adding carbon dioxide (CO_2) to alkaline wastes
- adding acid (e.g., sulfuric and hydrochloric) to alkaline wastes (Nemerow, 1971)

The method chosen depends on the wastewater characteristics and subsequent handling or use. For example, mixing of various streams is often insufficient as a preliminary step to biological treatment or sanitary sewer discharge. In this case, supplemental chemical addition is generally required to obtain the proper pH.

Equipment for acid or base addition include dry feeders, metering pumps, slurry pumps, and eductors. Lime compounds (i.e., CaO, CaC_3O, and $Ca(OH)_2$) are added to a mixing tank with a dry feeder, water is added, and the solution is mixed to form a slurry. Slurry pumps or eductors (water-induced flow) are used to feed the slurry into the wastestream for neutralization. Metering pumps are used for feeding solutions such as sodium hydroxide, potassium hydroxide, or acids to the wastestream.

Addition of neutralization chemicals is controlled by pH monitoring equipment, placed near the discharge of the neutralization tank. Mixers are required to ensure adequate mixing of reagents. Where large variations in wastewater flow can occur, flow monitoring equipment is commonly used in conjunction with pH controls to control the speed and frequency of metering or slurry pumps.

Mixing of wastestreams can be performed in a collection tank, rapid mix tank, neutralization tank, or equalization tank. Final pH adjustment in preparation for discharge can be done in a small neutralization tank at the end of the treatment process.

<u>11-5.1.2 Advantages and Limitations</u>. The major limitation of neutralization is that it is subject to the influence of temperature and the resulting heat effects common to most chemical reactions. In neutralization, the reaction between acid and base normally is exothermic (i.e., creates heat), and may raise the temperature of the wastewater stream or create hydrogen gas (an explosion hazard). An average value for heat released during neutralization of dilute solutions by strong acids or bases is 13,400 cal/g mole (24,100 BTU/lb. mole) of water formed. By controlling the rate of addition of the neutralizing reagent(s), the heat produced may be dissipated and the temperature increase minimized. Heat can also be recovered by heat exchangers and used in other

processes (e.g., building heating). For each reaction, the final temperature depends on initial wastestream temperature, chemical species participating in the reaction (e.g., strong acids or strong bases), and pH of the wastestream. In general, concentrated solutions with extreme pH values (i.e., less than 3 or greater than 12) can produce large temperature increases. This can result in boiling and splashing of the solution, and accelerated chemical attack on materials, or hydrogen generation. In most cases, proper planning of the neutralization system with respect to required dosages of neutralizing agent, rate of addition, reaction time, and equipment design can alleviate the heating problem.

Neutralization will usually cause increased TDS content due to addition of chemical agents. Anions and cations (e.g., sulfate, chloride, and calcium) resulting from neutralization may not be considered hazardous; however, local limits may exist for discharge to a POTW.

Acidification of streams containing sulfide tends to produce toxic gases. If there is no satisfactory alternative, the gas must be removed through scrubbing or some other treatment. Salt-containing wastestreams should be bench-scale-tested to determine if such a problem would occur.

11-5.1.3 Chemicals Required. Chemicals used in neutralization are specific to the wastewater being treated. Chemicals used frequently are lime (CaO), hydrated lime ($Ca(OH)_2$), limestone ($CaCO_3$), sodium hydroxide (NaOH), sodium carbonate (Na_2CO_3), carbon dioxide (CO_2), sulfuric acid (H_2SO_4), potassium hydroxide (KOH), and hydrochloric acid (HCl).

The selection of a neutralization chemical depends on factors such as price, availability, and process compatibility. Sulfuric acid is the most common acid used for the neutralization of alkaline waste. It is less costly than hydrochloric acid, but tends to form precipitates with calcium-containing alkaline wastewater. When hydrochloric acid is used for neutralization, the compounds formed are soluble. An important consideration in the use of alkaline reagents for neutralization of acidic wastewaters is the "basicity factor" (see Section 11-5.1.5), which is the number of grams of calcium oxide equivalent available for reaction in a particular alkali. Caustic soda has a high basicity factor and high solubility; however, it is expensive. Lime compounds are less costly, but have low-to-moderate solubility and form precipitates with acidic wastewaters containing sulfuric acid, potentially causing disposal and scaling problems. Soda ash has a low-to-moderate basicity and higher solubility than lime.

11-5.1.4 Residuals Generated. Neutralization may be accompanied by metals precipitation if the treatment proceeds to an alkaline pH. This may result in the generation of residuals that can be removed in subsequent operations, such as clarification or filtration.

11-5.1.5 Design Criteria. There is no direct correlation between acidity or basicity and pH. Therefore, to determine the chemical feed requirements for design purposes, a laboratory titration curve using a pH meter and a titrant of standardized normality should be prepared using a representative sample of the wastewater to be treated (Water Pollution Control Federation, 1977).

Depending on the volumes of wastewater, either batch treatment or continuous treatment can be utilized. With continuous treatment, a minimum detention time of 10 minutes is recommended.

Continuous systems can be designed as a single or multiple stage. As a general rule, one stage can be used if the pH of the raw wastewater is between 4 and 10. Two or more stages are often required if the pH is as low as 2 or higher than 10. Two-stage pH adjustment is often used in metal hydroxide precipitation. The first stage provides rough pH control, followed by a second pH "trimming" step.

Design of an acid feed system is influenced by many factors, including type and quantity of acid to be fed, purchase and installation costs, labor, and method of control. The size of the neutralizing vessel depends on the wastewater volume or flow, reaction time, solubility of the reagent, and the insoluble precipitates formed during the reaction.

11-5.2 Evaluation of Neutralization

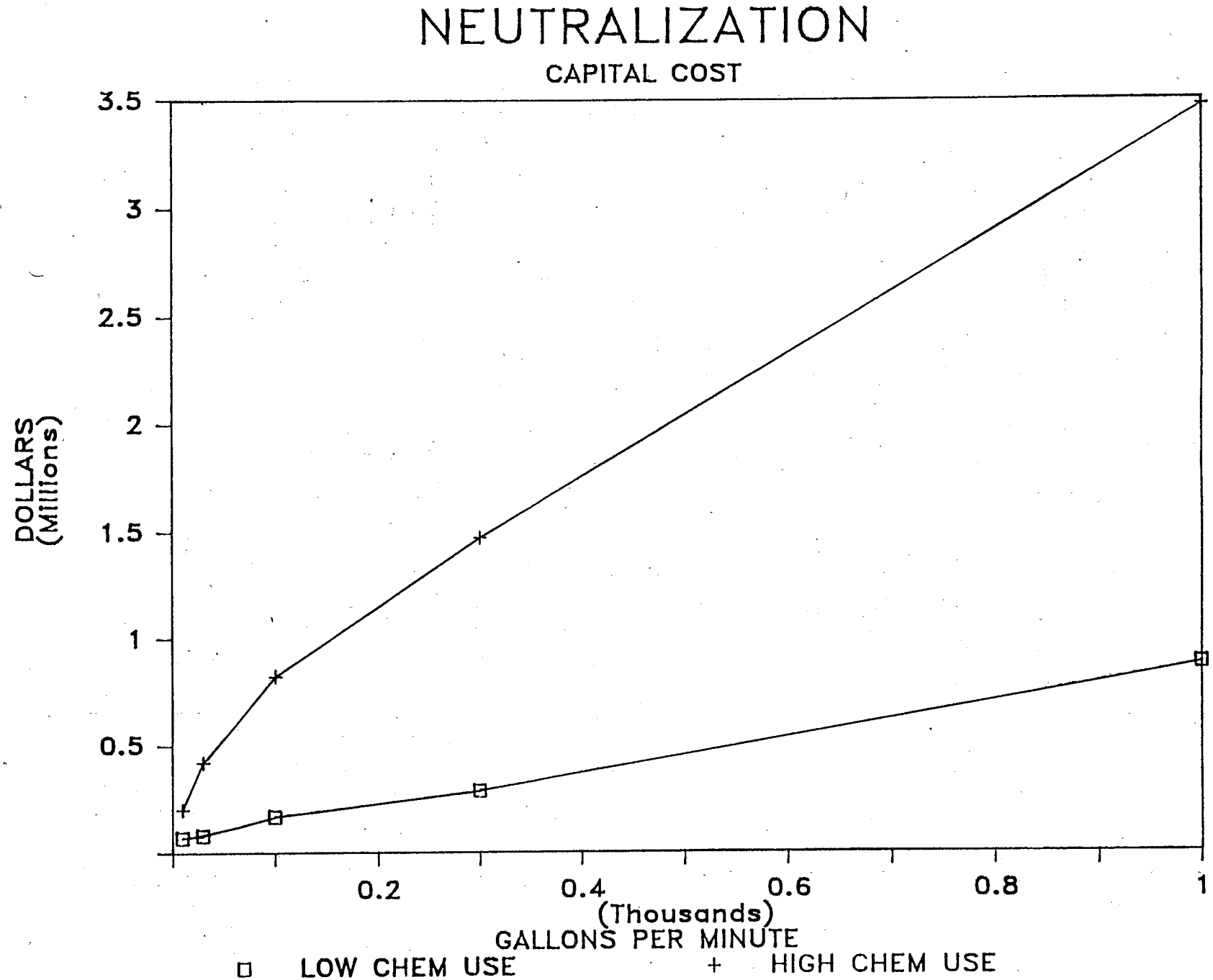
11-5.2.1 Effectiveness. Neutralization efficiency varies with the pH of the influent stream and the reaction time. Off-gas treatment units may be required when treating wastewaters that could produce hydrogen sulfide or other undesirable gases. Effluent streams from a neutralization unit include the neutralized wastewater and sometimes solids or gases. The treated water may require additional treatment to meet discharge limits. Pretreatment may be required for wastewater streams containing large amounts of suspended solids, and oils and greases. Neutralization substantially reduces the toxicity due to pH of the influent water.

11-5.2.2 Implementability. Neutralization systems are feasible for on-site pretreatment when large volumes of contaminated water/groundwater require pH adjustment. Neutralization is suitable for the treatment of water with high or low pH levels (outside the range of 6 to 9).

Neutralization is used to process contaminated water at hazardous waste sites, manufacturing facilities, and municipal water treatment plants. On-site facilities have proven successful for a broad range of pH values and flow rates. Due to the nature of the neutralization process, a consistent quality effluent can be obtained, provided there are no large changes in pH that the system has not been designed to handle.

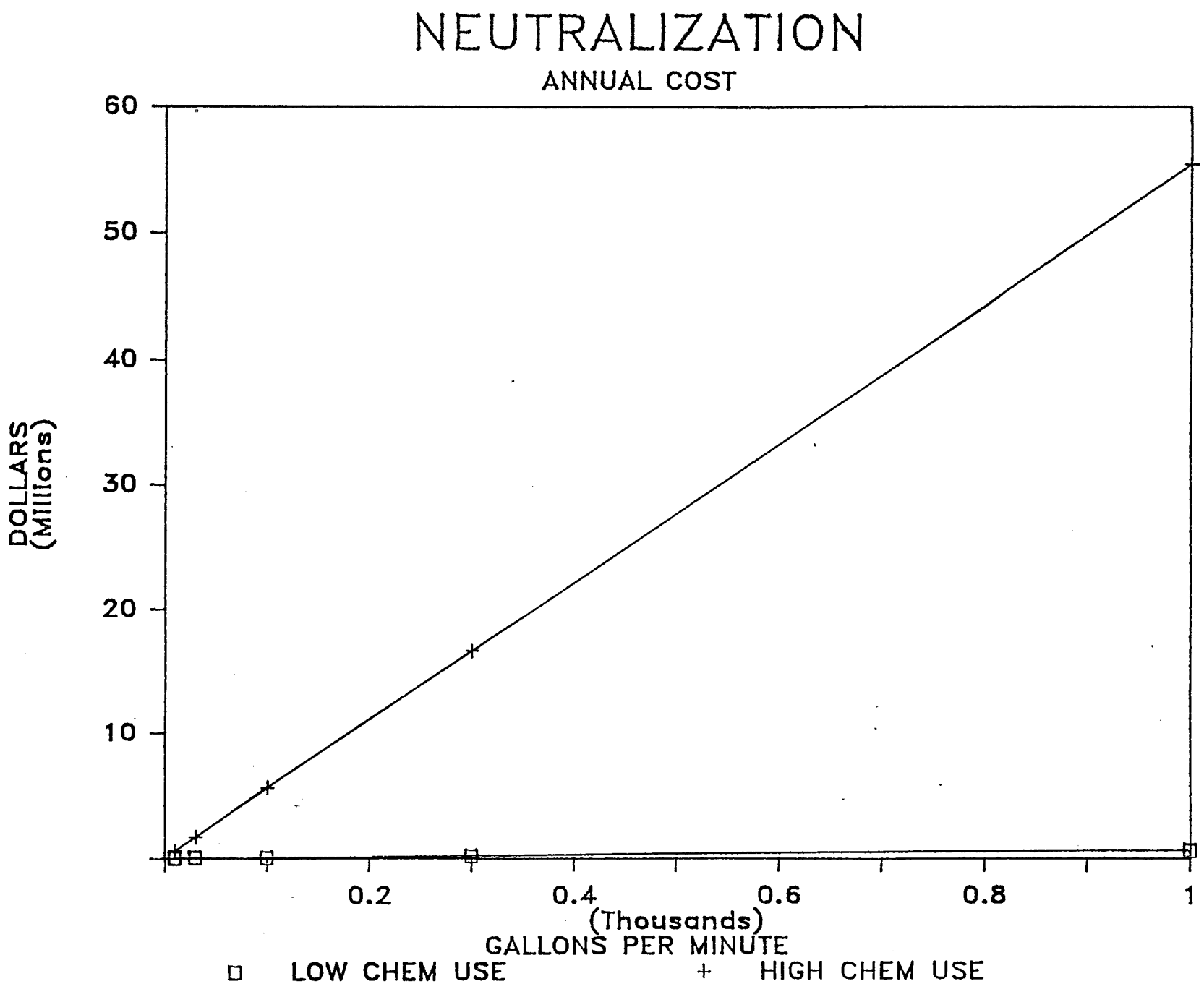
11-5.2.3 Cost. The material and methods used should be selected on the basis of overall cost, because material costs vary widely and equipment for utilizing various agents will differ with the method selected. The flow, type, and pH of acid or alkali waste to be neutralized are also factors in deciding which neutralizing agent to use (Nemerow, 1971).

For illustration, cost information was compiled for flow rates ranging from 10 to 1,000 gpm. These costs, as presented in Figures 11-17 and 11-18, are based on the following assumptions.



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-17
NEUTRALIZATION - CAPITAL COSTS



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-18
NEUTRALIZATION - OPERATION AND MAINTENANCE COSTS

Capital Costs

- neutralization tank equipped with both acid and caustic feed systems
- influent acidity concentrations ranging from 10 to 1,000 mg/ℓ

O&M Costs

- Electricity to operate pumps is included.
- Labor required to operate and maintain system is 8 hours/week for system flows less than or equal to 100 gpm, and 16 hours/week for system flows greater than 100 gpm.
- Chemical costs are included.

Systems that require neutralization greater than 1,000 mg/ℓ will require heat exchangers or special tank construction at additional costs, depending on the duration of the acid flow, tank volume, and acid concentration.

11-6 SEDIMENTATION

11-6.1 Description

Sedimentation is a physical process that removes suspended solids from a liquid matrix by gravitational settling. The following are fundamental elements of most sedimentation processes:

- a basin or container of sufficient size to maintain the liquid in a relatively quiescent state for a specified period of time;
- a means of directing the liquid to be treated into the basin or container in a manner that is conducive to settling;
- a means of removing the settled particles from the liquid or vice versa, as may be required; and
- a means of removing the clarified liquid from the tank without disturbing the separation of solids and liquid.

Sedimentation is often preceded by precipitation or coagulation/flocculation. Precipitation converts dissolved material to suspended form and coagulation/flocculation combines colloidal particles into larger, faster settling particles. Whether or not it is preceded with chemical pretreatment, plain sedimentation involves feeding the wastewater into a tank or lagoon, where it loses velocity and the suspended solids settle.

Sedimentation is used to separate suspended solids, chemically precipitated solids, and other settleable solids from wastewater. It is also used in conjunction with other unit processes to separate solids generated in other waste treatment. The settling basins can also be used for other purposes, such as oil and grease separation (see Section 11-1) and flow equalization.

11-6.1.1 Equipment Types Available. Sedimentation tanks are square, rectangular, or circular in plan view, and may operate with a horizontal or vertical flow path. They may have flat, pitched, conical, or hopper bottoms; and may be of single-story, two-story, or multiple-tray design. Sludge collection equipment is a part of most units, although it is sometimes not included in small installations.

Sedimentation tanks can be operated on a batch or a continuous-flow basis. Continuous-flow is more common except in small installations or in tanks serving the dual purposes of chemical treatment and sedimentation. Dual-purpose tanks are usually limited to small flow rates because of their lower operating efficiency. Batch treatment, however, provides more reliable control of effluent quality, especially with widely varying waste compositions or flow rates; therefore, it is used when critical control of effluent is necessary (Gurnham, 1955).

Although there are many variations of the sedimentation process, the components of the settling process are the same. The settling chamber has four zones: the inlet zone, the clarification zone, the outlet zone, and the sludge zone. The inlet zone allows a smooth transition from the high velocities of the inlet pipe to the low uniform velocity needed in the settling zone. Careful control of the velocity change is necessary to avoid turbulence, short-circuiting, and carry over. The clarification zone must be large enough to reduce the net upward water velocity to below the settling rate of the solids. The outlet zone provides a transition from the low velocity settling zone to the relatively high overflow velocities. The sludge zone must effectively settle, compact, and collect the solids and allow removal of the sludge without disturbing the settling zone above. The major representative types are discussed in the following paragraphs and are shown in Figures 11-19 and 11-20.

Settling Ponds. Settling ponds can vary from less than 1 acre to several hundred acres in size. The wastewater is merely decanted as the particles accumulate on the bottom of the pond and eventually fill it. The accumulated sludge is periodically emptied by mechanical shovels, draglines, or siphons.

Sedimentation Tanks. The tanks in which sedimentation is carried out may be circular or rectangular in design and generally employ sludge collection equipment. The sedimentation basins are also classified as horizontal-flow or vertical-flow, according to the predominant direction of the flow. Applications of vertical-flow units are generally settling compartments in flocculation-clarifiers and solids contact units.

Flow-through rectangular basins or tanks enters at one end, pass a baffle arrangement, and traverse the length of the tank to effluent weirs. Rectangular tanks are generally used for removal of truly settleable particles from a liquid. The settled solids are mechanically transported along the bottom of the tank by a scraper mechanism and removed as a sludge underflow. The sludge-removal equipment usually consists of crosspieces or flights attached to endless conveyor chains, or suspended by a bridge-type mechanism that travels up and down the tank on rails supported on the sidewalls.

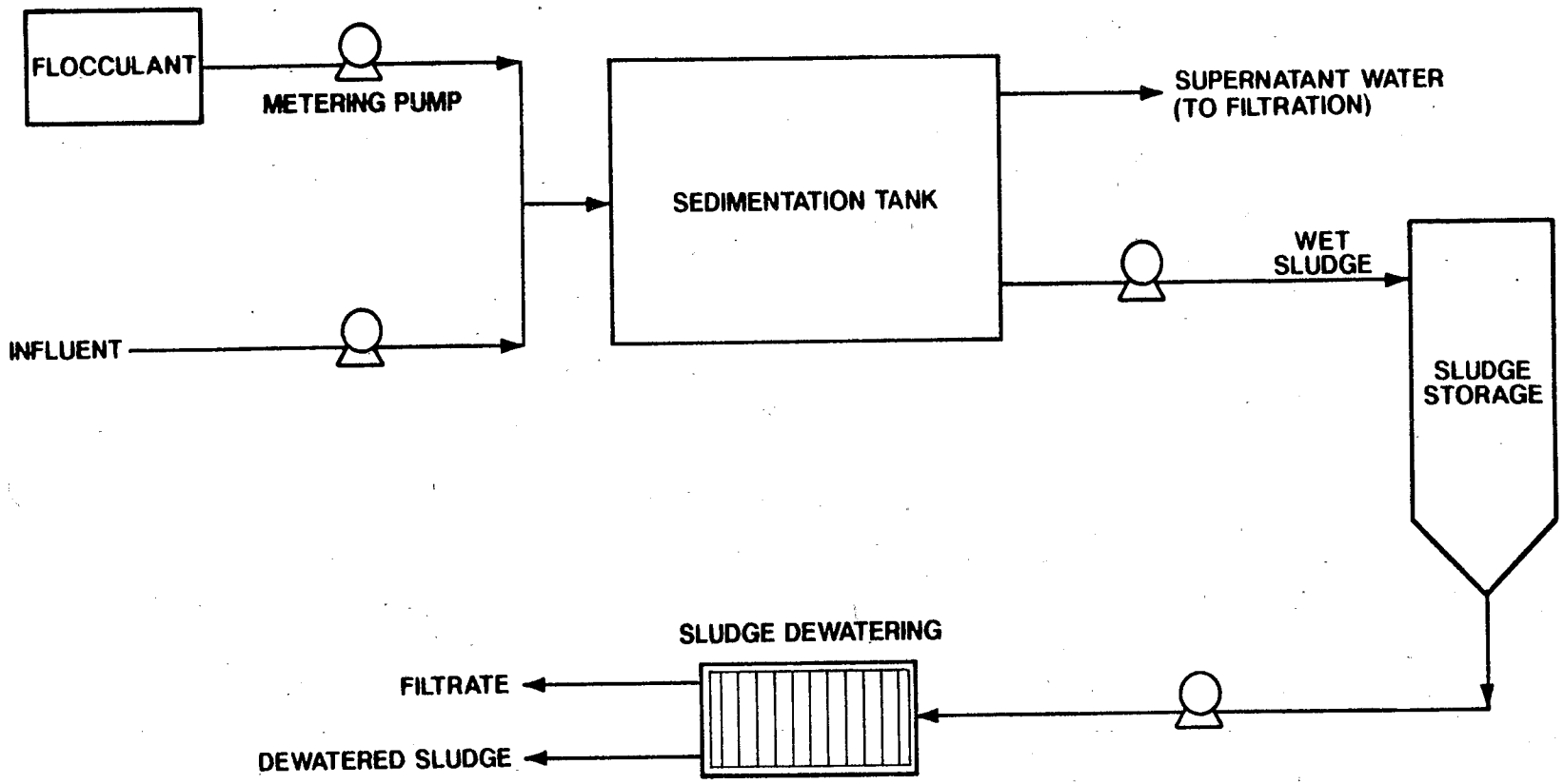
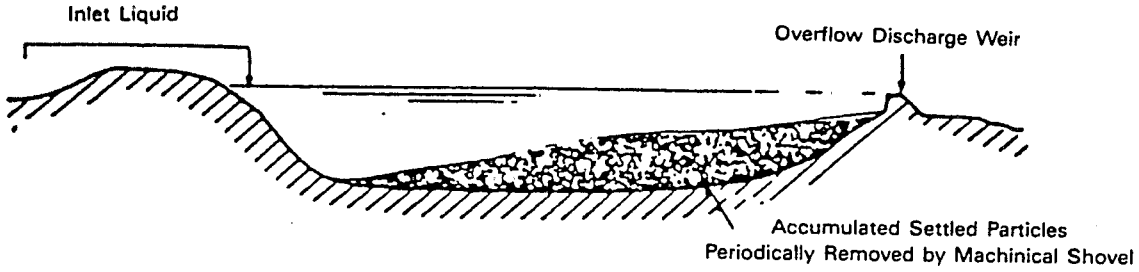


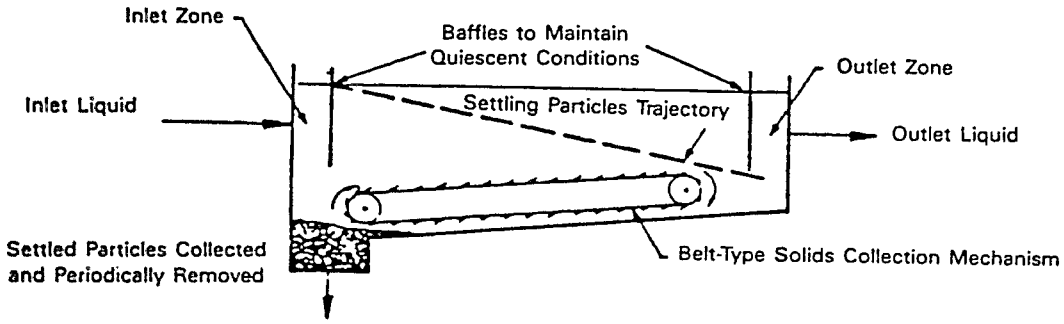
FIGURE II-19
SEDIMENTATION

5307-83

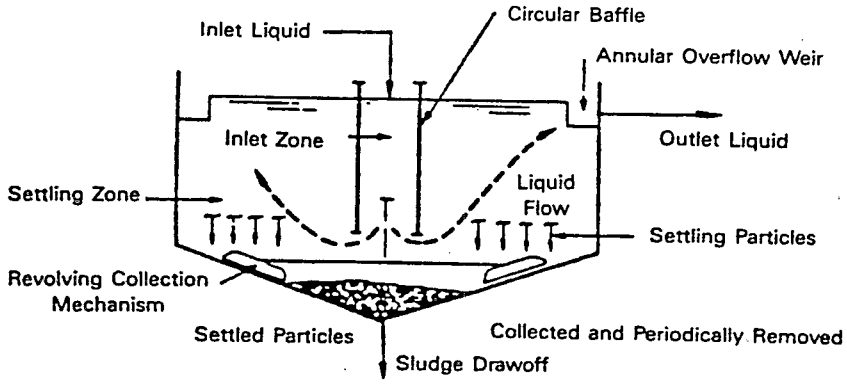
SETTLING POND



SEDIMENTATION BASIN



CIRCULAR CLARIFIER



Source: De Renzo, 1978

FIGURE II-20
REPRESENTATIVE TYPES OF SEDIMENTATION

5307-87

The most common type of circular basin or clarifier is the center-feed, in which the wastewater to be treated enters the clarifier through the feedwell located at or near the liquid surface in the center. The bottom of the clarifier is usually sloped 5 to 8 degrees to the center of the unit where sludge is collected in a hopper for removal. Mechanically driven sludge rakes rotate continuously and scrape the sludge down the sloped bottom to the sludge hopper. The clarifier effluent or overflow leaves the clarifier over a weir mounted on the rim of the tank. Equipment associated with the clarifier tank and sludge-rake drive assembly may include surface skimmers and scum pits to collect foam and/or oil that may collect on the surface of the clarifier, scum pumps, and sludge pumps. Vacuum sludge-removal equipment is also available for the rapid removal of biological sludges.

Circular clarifiers are usually used in applications that involve precipitation, flocculation, sedimentation, and biological sludge removal. Very often all three processes occur within the same piece of equipment, because many clarifiers are equipped with separate zones for chemical mixing, flocculation, and settling. Clarifiers that use settling aids are equipped with a low lift turbine, which mixes a portion of the previously settled solids with the incoming feed to improve the settling efficiency.

The peripheral-feed or rim-feed circular clarifiers are designed to utilize the entire volume of the clarifier basin for sedimentation. Wastewater is introduced into the clarifier around the periphery of the tank causing a radial flow pattern. The clarified liquid flows over weirs located in the center of the tank.

Clarifiers or settling basins can be designed to include inclined plates, slanted tubes, and lamella settlers placed in the clarifier tank or basin to decrease the vertical settling distance and reduce turbulence, and to increase the capacity of the clarifier or basin.

11-6.1.2 Advantages and Limitations. The major advantage of solids removal by settling is the simplicity of the process itself. The major limitation of simple settling (without chemical addition) is the long retention time necessary to achieve complete settling, especially if the specific gravity of the suspended matter is close to that of water. In addition, some materials are not removed by simple sedimentation alone (i.e., dissolved solids), and chemicals must be added to achieve removal.

The major advantage of clarifiers and basins is that they require less space than settling ponds. In addition, with clarifiers and basins, closer control of operating parameters (e.g., retention time and sludge removal) can be maintained, while problems such as runoff from precipitation and short-circuiting can be avoided. However, the cost of installing and maintaining a clarifier or basin is substantially greater than the cost associated with a settling pond.

11-6.1.3 Chemicals Required. No chemicals are required in this process, although settling aids such as polymers, lime, or alum may be used.

11-6.1.4 Residuals Generated. Inorganic and/or organic sludge is generated. The quantity of sludge per unit volume of wastewater treated depends on the characteristics of the wastewater treated, the type of equipment, and chemical conditioning agents added during pretreatment.

11-6.1.5 Design Criteria. Because the individual particle settling theories are of little practical use to the designer, design data must be obtained by study of existing plants and by laboratory or pilot plant investigations of the waste in question. Batch sedimentation tanks, operating on the fill-and-draw principle, are used for small flow rates; however, continuous-flow units with continuous or intermittent removal of sludge are commonly preferred for larger flow rates. For continuous-flow sedimentation tanks, the elemental design factors to be specified include surface area, depth, ratio of length to width, and sludge-collecting facilities. Detention time, overflow rate, and liquid velocity are governed by these factors (Gurnham, 1955).

Sedimentation tank performance is related to the surface hydraulic loading, which is the inflow divided by the surface area of the basin, commonly expressed in units of flow per day per unit area (i.e., L/day/sq.m. or gpd/sq.ft.).

Therefore, a practical and economical tank depth is selected for use with the permissible overflow rate, in settling tank design. The depth should usually be at least 5 feet (8 to 10 feet is more common), and depths of 12 to 14 feet are often used. Common geometrical ratios for rectangular units are length:width of 3:1 or greater; and width:depth of 1:1 to 2.25:1. Typical depths when used as a primary settling tank are 2.4 to 3.0 m (8 to 10 feet); and when used as a secondary tank, 3.0 to 4.2 m (10 to 15 feet).

The diameters of circular units range from 3 to greater than 60 m (10 to 200 feet). Tank side water depths, when used for primary settling, range from 2 to 3 m (8 to 10 feet); and when used for secondary settling and thickening, from 3 to 4 m (10 to 14 feet) and greater (Water Pollution Control Federation, 1977). Design of sedimentation tanks as outlined herein will usually result in detention times of 1 to 4 hours. For most wastes, 1 to 2 hours are sufficient; however, if sedimentation is the sole form of treatment provided, more thorough removals may be necessary (Gurnham, 1955).

11-6.1.6 Performance. A properly operating sedimentation system can efficiently remove suspended solids and precipitated materials from wastewater. The performance of the process depends on a variety of factors, including the density and particle size of the solids, the effective charge on the suspended particles, and the types of chemicals used in pretreatment. The performance of simple settling is a function of the surface loading, upflow rate or retention time, and settleable solids. The sedimentation process preceded by chemical precipitation and/or coagulation and flocculation will remove colloidal and dissolved solids, some of which could be toxic pollutants. Performance data for such removal are included in the appropriate technology descriptions.

11-6.2 Evaluation of Sedimentation

11-6.2.1 Effectiveness. The efficiency of sedimentation tanks depends, in general, on the following factors:

- detention period
- wastewater characteristics
- tank depth
- floor surface area and overflow rate
- operation (cleanliness)
- temperature
- particle size
- inlet and outlet design
- weir loading rate
- velocity of particles
- density of particles
- container-wall effect
- number of tanks (baffles)
- sludge removal
- pretreatment (grit removal)
- flow fluctuations
- wind velocity

For removal from aqueous sources, efficiencies can be as high as 90-percent removal of suspended solids based on design and residence times. Dewatering of sludge is normally required.

Effluent streams from a sedimentation tank include the effluent water, scum, and settled solids. The treated water may require additional treatment to further reduce concentrations to discharge limits. The solids may need to be treated or dewatered prior to disposal. Influent restrictions to a sedimentation system may dictate pretreatment prior to settling. Pretreatment may be required for wastewater streams containing large amounts of suspended solids and oils and greases.

Sedimentation substantially reduces the toxicity of the influent water caused by the solids. The volume of contaminated media is reduced by transferring to the solid phase. Sedimentation processes transfer the potential for mobility of the contaminant from the water to the solids.

11-6.2.2 Implementability. Sedimentation is feasible for on-site pretreatment when large volumes of contaminated water/groundwater require treatment. Sedimentation is suitable for the treatment of water with high concentrations of solids. However, solids settled from groundwater treatment must be disposed of.

Sedimentation tanks currently process contaminated water at hazardous waste sites, manufacturing facilities, and municipal water treatment plants. On-site facilities have proven successful for a broad range of contaminants and flow rates. Due to the nature of the sedimentation process, a consistent quality

effluent can be obtained, provided there are no large fluctuations in influent concentrations.

11-6.2.3 Cost. Consideration of the rate of waste flow through the settling tank (in gallons per day) and overflow rate (in gallons per day per square foot) provides design data for the area of settling tank needed. If flow is variable over a 24-hour period, the area must be increased to correspond with maximum flow rate, except perhaps for purely momentary high rates. If the area is greater than 2,500 or 3,500 square feet, a circular settling tank is probably cheaper than a rectangular tank. Rectangular tanks are usually less expensive for smaller installations; however, these generalizations must be used with discretion, because factors of land value, compactness of plant, topography, and price quotations on specific equipment may reverse the trend (Gurnham, 1955). Cost information was compiled for flow rates ranging from 10 to 1,000 gpm, and two polymer addition rates: 0.5 and 10 mg/ℓ.

Capital Costs

- carbon-steel sedimentation tank
- polymer feed system

O&M Costs

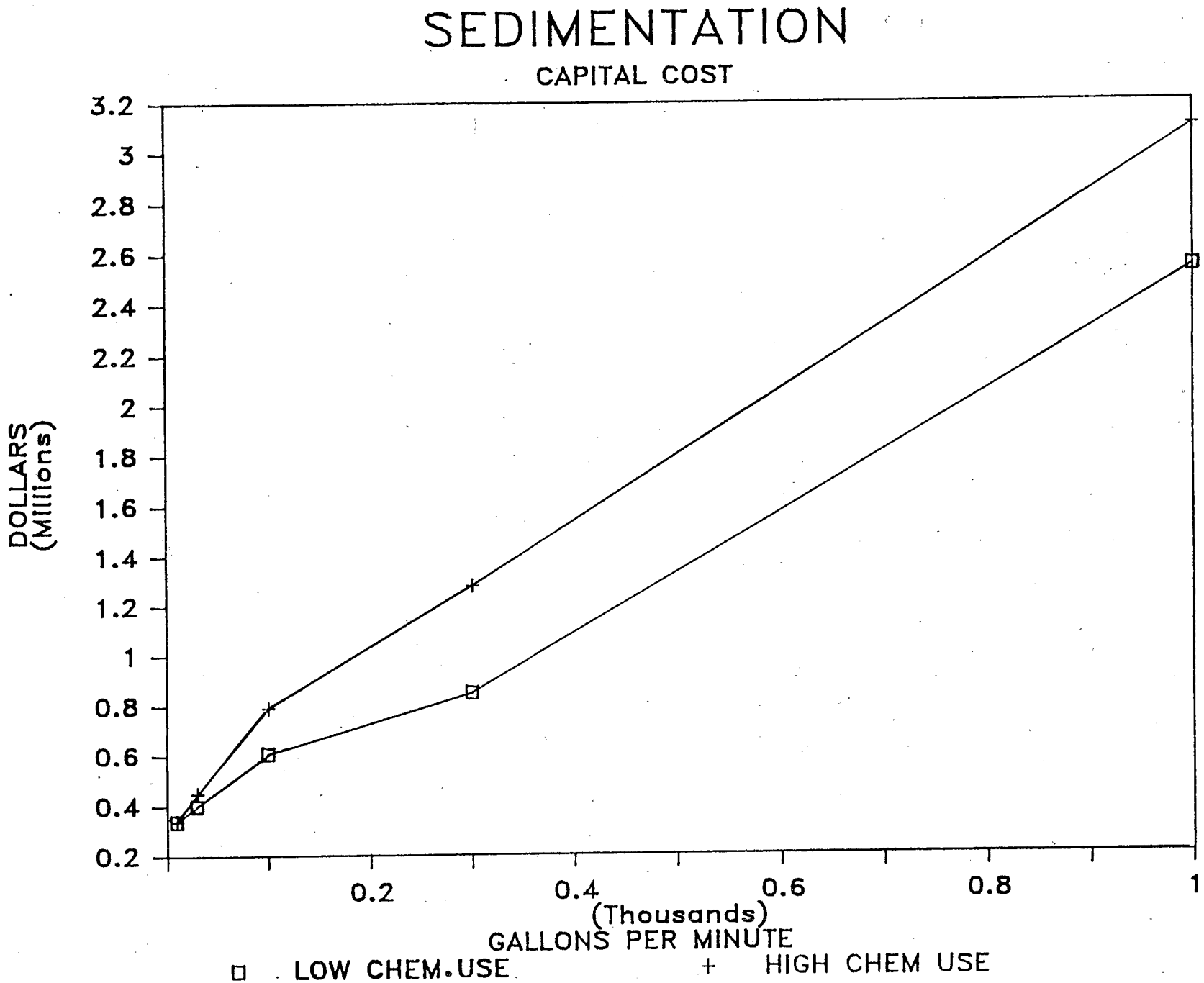
- Electricity to operate pumps is included.
- Labor required to operate and maintain system is 8 hours/week for system flows less than or equal to 100 gpm, and 16 hours/week for system flows greater than 100 gpm.
- Disposal costs for sludge.
- Chemicals required at specified addition rates of 0.5 and 10 mg/ℓ.

Capital and O&M costs are presented in Figures 11-21 and 11-22.

11-7 FILTRATION

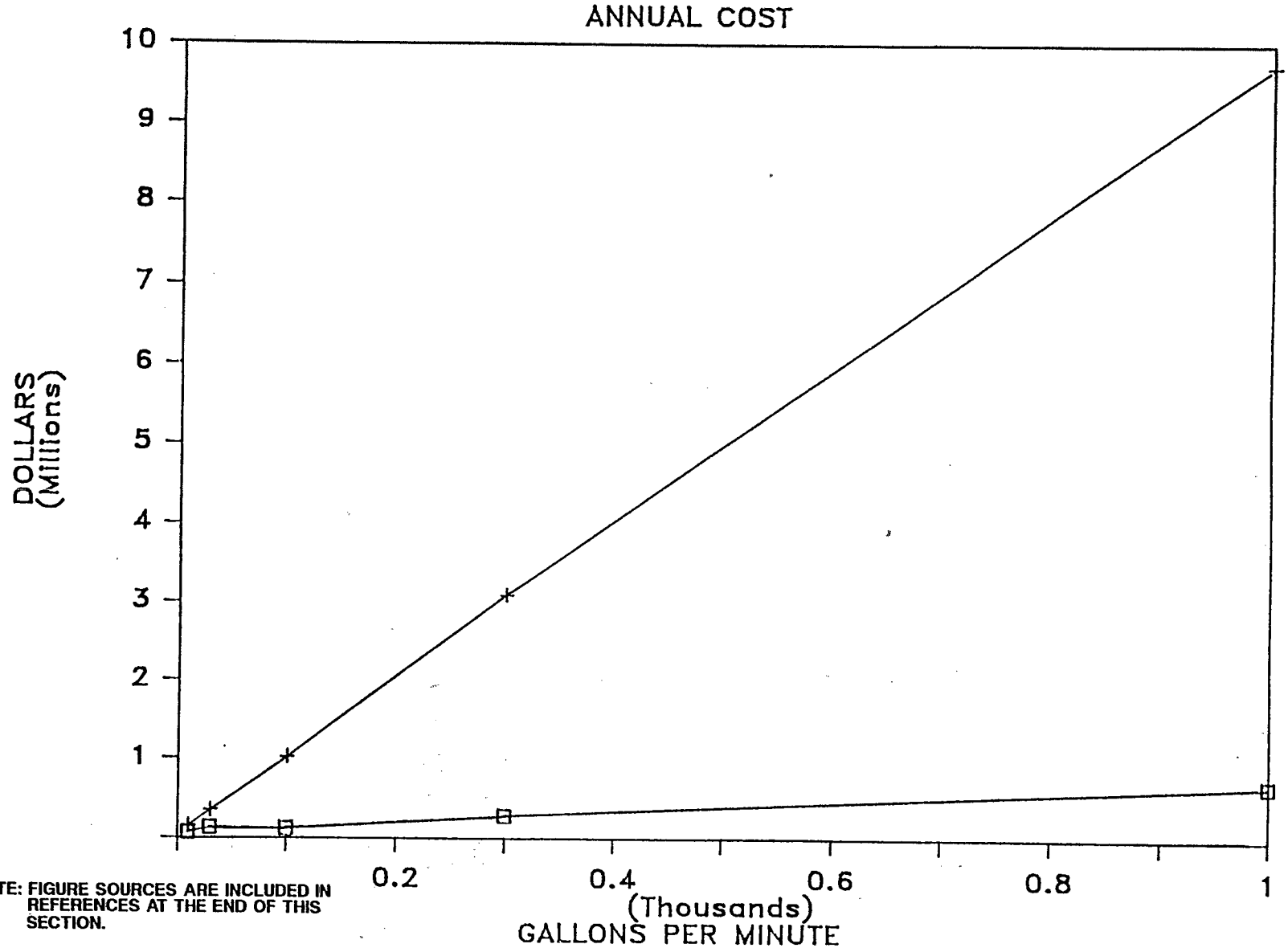
11-7.1 Description

Filtration is a physical process used to remove suspended solids from wastewater. The separation is accomplished by passing water through a physically restrictive medium, resulting in the entrapment of suspended particulate matter. The flow pattern is usually top-to-bottom, but other patterns are sometimes used (e.g., upflow, horizontal flow, and biflow). The media used for filtration include sand, coal, garnet, and diatomaceous earth (USEPA, 1986c). Within the treatment train, the filtration process is generally preceded by chemical precipitation and neutralization (see Sections 11-4 and 11-5, respectively). To further polish the effluent, filtration can be followed by carbon adsorption or ion exchange (see Sections 11-11 and 11-12, respectively).



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-21
SEDIMENTATION - CAPITAL COSTS



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-22
SEDIMENTATION - OPERATION AND MAINTENANCE COSTS

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11-7.1.1 Equipment Types Available. Filtration equipment types range from traditional, built-in-place, gravity granular-media design to new, compact, pressure-filtration units. Filter beds vary in filter media, backwash methods, underdrain design, and rate and direction of flow. A typical filtration bed is shown in Figure 11-23. A discussion of different filter bed types follows.

Gravity granular-media bed typically contains one to three layers of filter media. The top layer is coarse (e.g., anthracite), the middle layer is sand, and the bottom layer is fine garnet. This grading allows particles to collect in-depth; that is, particles are filtered throughout the media depth, not just at the media surface. The media is supported by an underdrain system that collects the filtrate. During filter operation, particles removed from the applied wastewater clog media pores. The filters are cleaned by backwashing in the reverse direction of original flow. During this scouring process, solids are dislodged from the media, collected in a backwash trough, and discharged in the spent wash cycle. Water or an air/water combination is used to scour the filter media during the backwash cycle.

Diatomaceous-earth filters, employing a diatomite earth material as a medium, operate on three steps. A support material is precoated with diatomite, wastewater is filtered through, and finally, the dirty filter cake is disposed.

Pressure filters have the granular media and underdrains contained in a steel tank. Water is pumped through the filter under pressure. For relatively low flows, cartridge filtration can be used. Wastewater is pumped through a sealed vessel until flow drops, indicating plugged media. The plugged matted cloth cartridge is disposed of and replaced with a new one.

Self-backwashing filters are sold by some filter manufacturers. The units divide influent equally among several filter cells. Backwashing is automatic, using the effluent of the remaining on-line filters. The units often run unattended (Kawamura, 1987).

There are many design alternatives among these types of filters. For example, each filter described, except diatomaceous-earth filters, can employ carbon as a medium to adsorb contaminants. Reference text, wastewater engineers, and manufacturers can help match the wastewater with a proper filtration unit.

11-7.1.2 Advantages and Limitations. Filtration is a conventional, proven method of removing suspended solids from wastewater. Biological flocs are also filtered, although the flocs generally plug filter media at a faster rate. Filters normally require little space and can be installed easily.

Filtration's limitation is that contaminants other than suspended solids will not be removed. Filter media will not catch colloidal-size particles and dissolved solids (coagulants can be added before filtration to remove these fine particles). Oil and grease coat filter media and prevent effective backwash; therefore, pretreatment to remove oil and grease is required. Pretreatment is also necessary if the total suspended solids concentration is high enough (30 to 50 mg/ℓ for gravity granular-media filters) to clog the media too quickly.

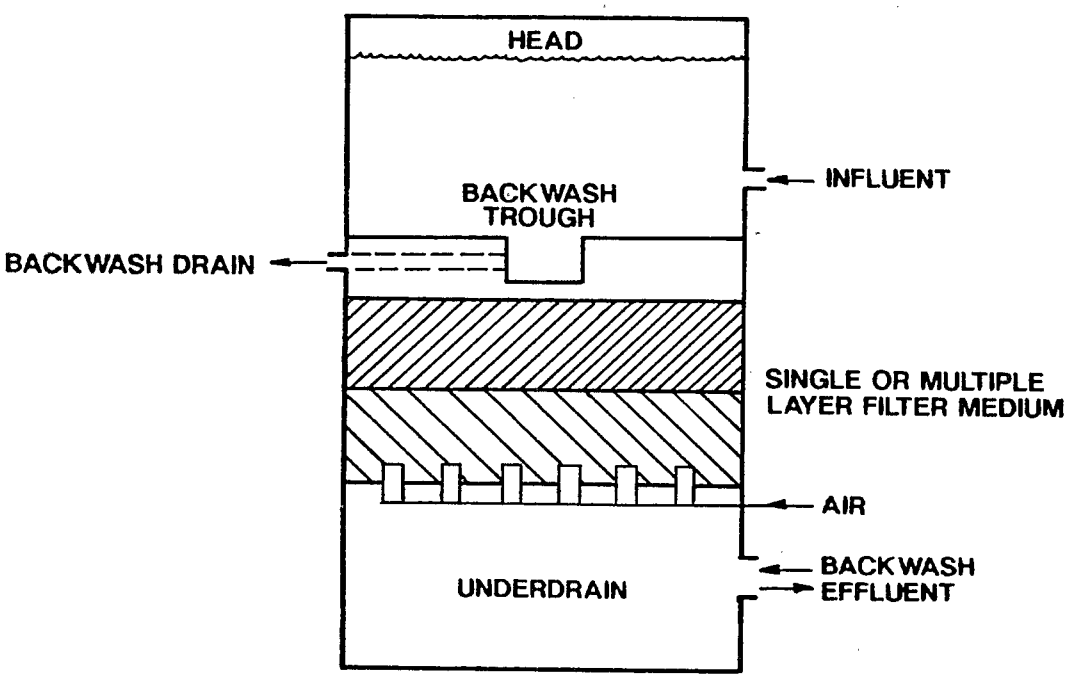

FIGURE II-23
GRANULAR MEDIA FILTRATION BED

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11-7.1.3 Chemicals Required. The filtration process does not require chemical use for the removal of suspended solids. Alum salts, iron salts, and polymers can be added as coagulants or coagulant aids directly ahead of filtration units for colloidal and dissolved solids removal. This will generally improve solids captured by the filter, but at the expense of reduced run lengths.

11-7.1.4 Residuals Generated. The residue cleaned from surface filters requires disposal. Backwash water (generally 2 to 10 percent of the throughput) from the cleaning of granular media filters requires further treatment and disposal; spent backwash often is returned to the head of the plant for treatment by sedimentation (USEPA, 1986c).

11-7.1.5 Design Criteria. Final quality of the filtered wastestream will depend on how well the design criteria and operating parameters are chosen, based on wastewater characteristics. The wastestream should be evaluated for the concentration of TSS, the size of these particles, and the presence of grease and oil that may coat the media. These characteristics and the wastestream flow will affect filtration performance.

Design criteria to be considered include the following:

- bed sizing as a function of wastewater flow and design loading rate
- a bed deep enough to allow relatively long filter runs
- filter media possessing qualities coarse enough to retain large quantities of floc, sufficiently fine to prevent passage of suspended solids, and graded to permit backwash cleaning (Viessman and Hammer, 1985)
- an underdrain to support the bed, prevent loss of media with water, and evenly distribute flow during backwash

Whenever possible, designs should be based on pilot filtration studies of the actual wastewater to be treated. Pilot tests should help determine operating parameters (i.e., hydraulic loading rate, run time, terminal head loss, and backwash or air scour rate) that best remove the concentration of suspended solids to acceptable levels.

Pilot studies can also help evaluate the following:

- cost comparisons between different filter designs capable of equivalent performance
- effluent quality for a given medium
- adequate run times between backwashing cycles
- determination of the effects of pretreatment variations (USEPA, 1987e)

As general guidance, typical operating parameters for granular, gravity flow filters are as follows:

- o hydraulic loading rate 2 to 10 gpm/ft^2
- o backwash rate 10 to 30 gpm/ft^2
- o air scour rate 3 to 5 standard cubic feet/min

11-7.1.6 Performance. Filtration is an established, reliable method for suspended solids and biological floc removal. However, the filtration process can be inhibited by too great a concentration of suspended solids that clog filter media, and excessive oil and grease that coat filter media to prevent effective backwashing. In addition, collodial-size particles and dissolved solids will not be filtered, but will pass through into the effluent. In each case, a pretreatment process to remove suspended solids, separate oil and grease, or coagulate colloidal and dissolved solids should be considered.

The performance of any filtration system should be determined from pilot studies on the actual wastewater or from information provided by filter manufacturer services.

11-7.2 Evaluation of Filtration

11-7.2.1 Effectiveness. Filtration is an effective treatment for suspended solids and biological floc removal. The process will, at some point in the treatment cycle, produce a residual sludge for which disposal must be considered. Surface filters produce sludge on the medium surface. In-depth filters, backwashed for regeneration, generally send residual back to the treatment headworks. At some point, perhaps during clarification, the residuals will be collected. Landfill and incineration are disposal alternatives; waste from a CERCLA site will generally require RCRA-permitted disposal.

11-7.2.2 Implementability. Filtration is a conventional, proven treatment technology. It is rarely used as the sole method of treatment, but rather in conjunction with other technologies, such as precipitation and clarification.

Filtration equipment is relatively simple to install and no chemicals are required. Design should be based on pilot studies performed on actual wastewater. Filter manufacturers supply integrated field units. Where filter units are not automated, skilled operators may be needed to monitor parameters such as backwash.

11-7.2.3 Cost. The filtration process costing is based on a vendor package unit. Assumptions are listed as follows.

Capital Costs

- o Gravity flow with a loading rate of 5 gpm/ft^2
- o A 30-inch bed depth of multigrade sand media

- At least two units are installed in parallel to cover unit downtime during backwash cycles, thus providing continuous filtering capability
- Influent pump and piping designed with 100-percent backup capability
- Concrete pad to support each unit

O&M Costs

- Electricity for influent pump and unit is included.
- Backwash water is recycled treated effluent.
- Labor is 8 hours/week for system flows less than or equal to 100 gpm, and 16 hours/week for flows greater than 100 gpm.
- No disposal cost for the backwash stream is included. Assume stream is returned to the treatment headworks.

The cost curves are presented in Figures 11-24 and 11-25.

11-8 AIR- AND STEAM-STRIPPING

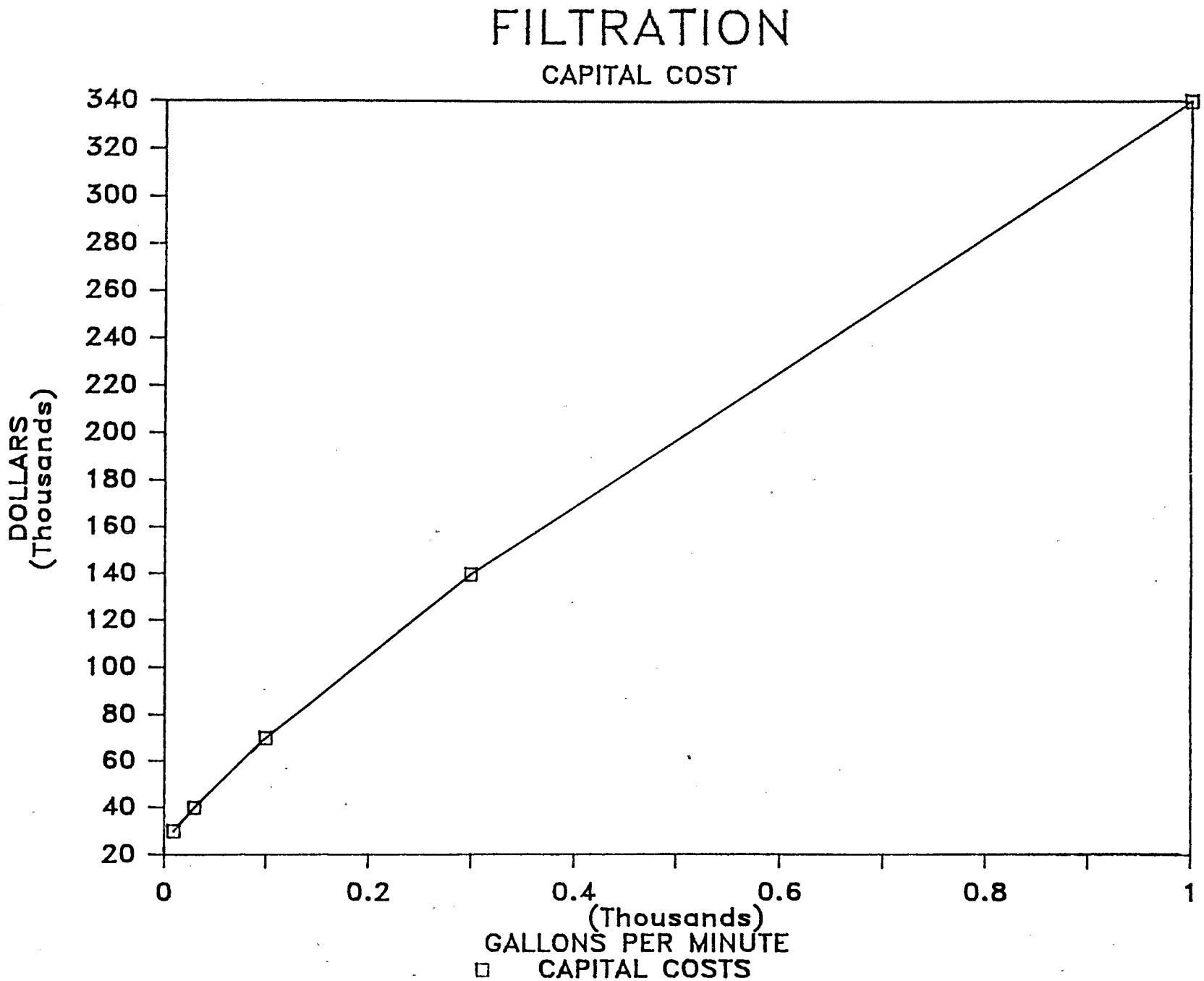
Stripping, in general, refers to the removal of relatively volatile components from wastewater by the passage of air, steam, or other gas through the contaminated liquid. Contaminants are transferred to the gas phase; therefore, off-gas treatment is often employed.

To improve removal efficiencies (or rates) by stripping, the temperature and/or pH of the wastewater may be adjusted. Efficiency is not only a function of temperature and pH, but also of size, shape, arrangement, and surface characteristics of the column; its packing material; the rates of liquid and vapor flowing; and various physical properties and distribution of the vapor and liquid (Brown, 1950).

In most cases, air-stripping will achieve effective removals of ammonia, chlorinated solvents, monoaromatics, and other VOCs. Steam is used as the stripping medium for increased efficiency, removal of less volatile compounds, or applications in cold weather. Steam-stripping may also be used to remove phenols and trace organics from wastewater. However, removal rates of some compounds decrease with increasing temperature.

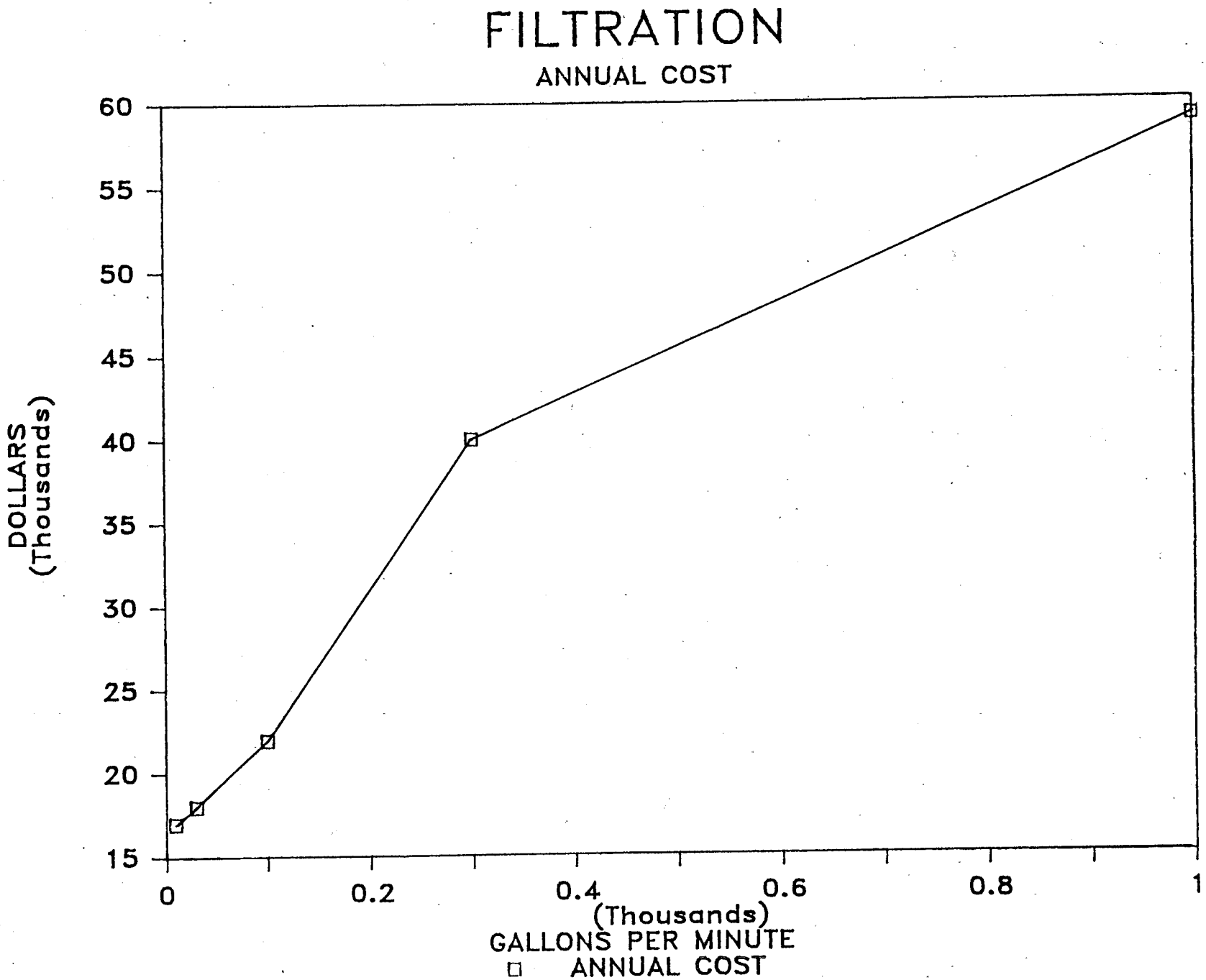
11-8.1 Description

Typical stripping processes involve surface aeration, spray aeration, diffused aeration, packed-tower aeration, bubble-cap trays, valve trays, or sieve trays. This discussion will be limited to packed-tower processes involving the application of steam or air. The function of the packing material is to increase the area of contact between the air or steam and the liquid waste.



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-24
FILTRATION - CAPITAL COSTS



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-25

FILTRATION - OPERATION AND MAINTENANCE COSTS

The tower consists of a cylindrical column containing a liquid inlet, a distributing device, and a gas outlet at the top; a gas inlet, a distributing space, and a liquid outlet at the bottom; and a packing material in the tower. The air or steam enters the distributing space below the packed section, rises upward through the packing, and contacts the descending liquid flowing through the same openings. The packing disperses the influent water, providing a large area of intimate contact between the liquid and gas phase. Figure 11-26 is a schematic of the packed tower flow and characteristics.

Many different types of tower packing have been developed and several are used commonly. Packings, which usually are dumped at random in the tower, are available in sizes of 3 to 75 mm, and are made of inert materials such as clay, porcelain, graphite, or plastic. These packings are dumped into the tower with redistribution plates to prevent channeling of the liquid.

Stacked packing with sizes of 75 mm and larger is also used. The packing is stacked vertically, with open channels running uninterrupted throughout the bed. Typical stacked packings are wood grids, drip-point grids, spiral partition rings, and PVC films (Geankoplis, 1983).

11-8.1.1 Equipment Types Available. Stripping processes differ according to the stripping medium and packing material chosen for the treatment system. Air and steam are the most common media; inert gases are also used. Air- and steam-stripping using packed towers are described in the following paragraphs.

Air-stripping. The stripping tower consists of a cylindrical vertical shell filled with packing material, and blowers to induce air flow. The towers are of two basic types: countercurrent and cross-flow. In countercurrent towers, the entire air flow enters at the bottom of the tower, while the water enters the top of the tower and falls through the packing material to the bottom. In crossflow towers, the air is pulled through the sides of the tower along its entire height, while water flow proceeds down the tower through the packing. In either type flow, treated effluent is collected in a sump at the bottom of the tower.

Reflux (i.e., condensing a portion of the vapors from the top of the column and returning it to the column) may be practiced if it is desired to increase the concentration of the stripped material derived from the stripping column. Introducing the feed at a point below the top of the column (while still using the same height of packing in the stripper) will yield a vapor stream richer in VOCs. The combination of using reflux and introducing the feed at a lower level will further increase the concentration of the VOC component in the overhead.

Steam-stripping. Steam-stripping is fundamentally comparable to air-stripping. The process is used to volatilize contaminants from a wastewater stream. Steam is used in cases where the volatility of the organic constituents makes removal at ambient air temperatures difficult. This unit operation has been applied to the removal of water-immiscible compounds (i.e., chlorinated hydrocarbons), which must be reduced to trace levels because of their toxicity.

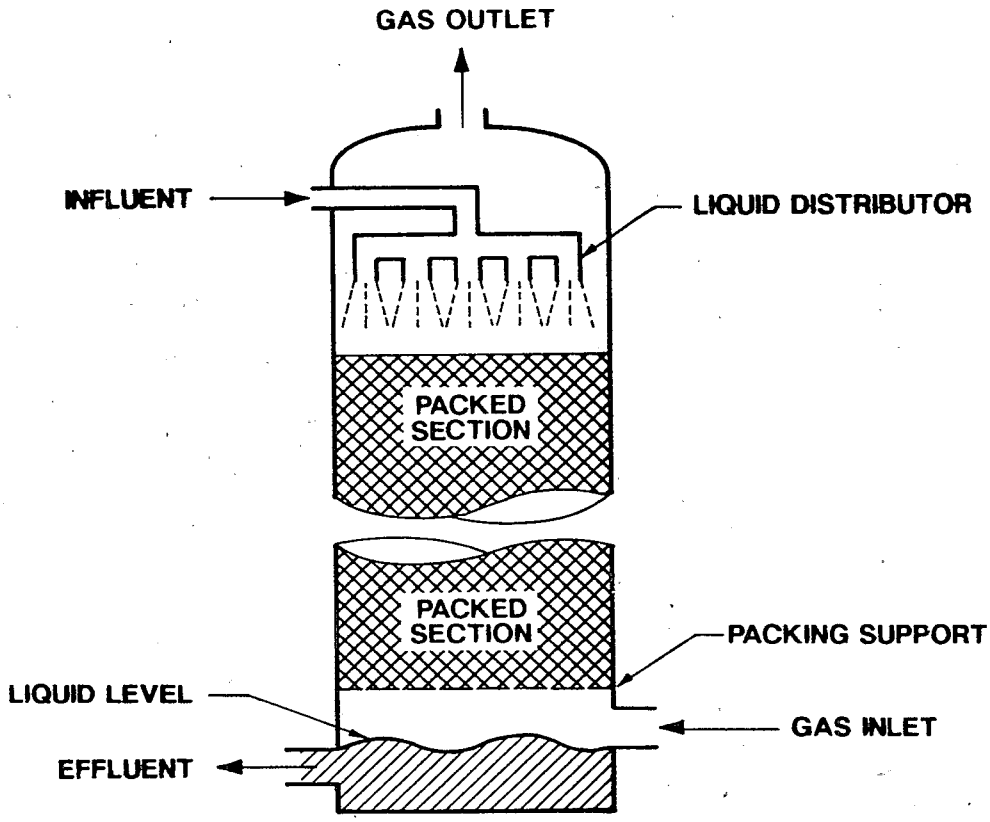


FIGURE II-26
AIR STRIPPING

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Steam-stripping is usually conducted as a continuous operation in a packed tower. Figure 11-27 shows a schematic of a typical steam-stripping system. Wastewater, preheated by a heat exchanger, enters at the top of the column and flows by gravity down through the packing. Steam rises up from the bottom of the column and volatilizes contaminants. As the wastewater passes down through the column, it contacts the vapors and steam rising from the lower portion of the column. Due to the countercurrent flow pattern, this contact progressively lessens the concentrations of VOCs or gases in the wastewater as it approaches the bottom of the column. At the bottom of the column, the wastewater is heated by the incoming steam to further reduce the concentration of VOC component(s) to their final concentration. Much of the heat in the wastewater discharged from the bottom of the column is recovered by the heat exchanger preheating the feed to the column.

The contaminated steam passes out through the top of the column. Depending on the contaminant, the steam may be condensed to a liquid and separated from the contaminant or refluxed to the tower. If concentrations are at permissible levels, the steam may be emitted directly into the atmosphere. Otherwise, the condensed stream must be treated to remove the organics or disposed of at an appropriate facility.

11-8.1.2 Advantages and Limitations. Advantages of both stripping processes are that acids and other corrosive materials can be handled because appropriate construction materials are available. Packings can be fabricated from ceramic, stainless steel, Teflon, or chemical-resistant plastics. Towers can be constructed of polyethylene, stainless steel, or chemical-resistant plastics. Also, liquids that tend to foam may be handled more readily in packed columns because of the relatively low degree of liquid agitation by the gas (Perry, 1973).

Disadvantages are associated with the packing material of the column. Some packing materials break easily during insertion into the column or from thermal expansion and contraction. Low liquid flow rates (air-to-water ratios up to 5:1) decrease the contact efficiency due to incomplete wetting of the column packing. Packed columns are limited to operating ranges narrower than other stripping processes using film packings.

A drawback of air-stripping is its low efficiency in cold weather. Also, when lime is used to raise the pH, fouling problems may occur in towers and the efficiency of the process is affected. The pH also affects the volatility of compounds. Iron and manganese can be oxidized and magnesium and calcium can be precipitated by the process, creating scale that can cause channeling of flow in the column. High suspended solids, as well as oils and greases, can also accumulate in the stripper and cause fouling.

Steam-stripping is more efficient than air-stripping in certain applications, but has much higher operating costs. Also, if VOCs react with each other, as in refinery sour water containing hydrogen sulfide (H_2S) and ammonia, the vapor pressure exerted by each component must be experimentally developed because vapor/liquid equilibrium data do not exist for many specific combinations of water soluble components.

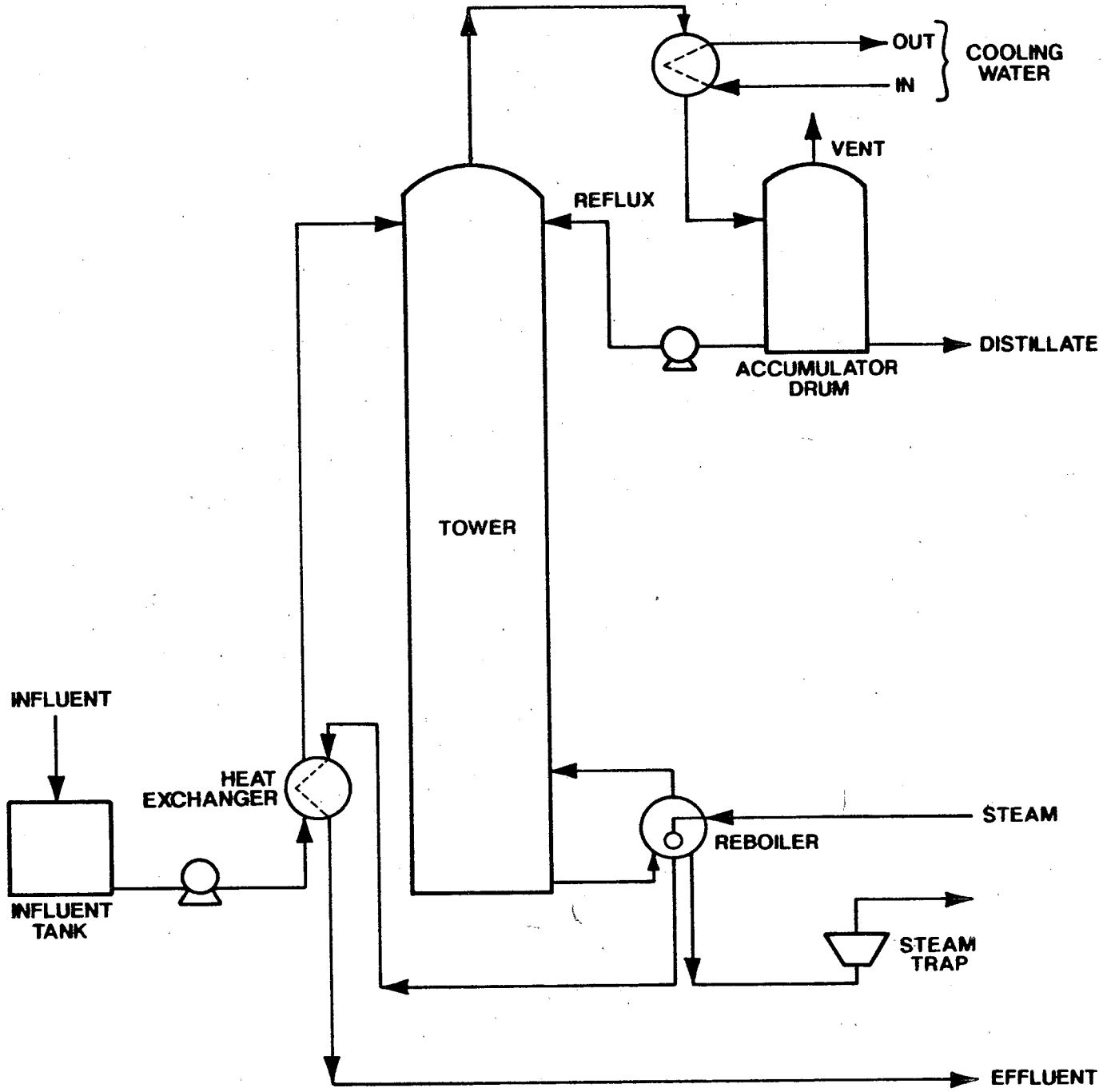

FIGURE II-27
STEAM STRIPPING

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11-8.1.3 Chemicals Required. For wastewater containing high concentrations of calcium, an inhibiting polymer may be added to ease the fouling problem. Acid wash systems can be used to solubilize the scale in a continuous or batch-flow tower.

11-8.1.4 Residuals Generated. Stripped VOCs in the off-gas can be processed further for recovery or incineration. For sites that are in areas attaining the National Ambient Air Quality Standards for ozone, VOC air emissions may need control to meet state ARARs, risk management guidelines or other requirements of CERCLA Section 121. In ozone nonattainment areas VOC controls are more likely to be required to meet state ozone attainment strategies. The USEPA policy memorandum "Control of Air Emissions from Superfund Air Strippers at Superfund Groundwater Sites" (OSWER Directive 9355.0-28, June 15, 1989) provides more guidance on VOC air emission control.

Scale from packed towers may need to be recycled or landfilled. Spent acid wash chemicals are saved for recovery. Post-treatment of the effluent stream may be necessary if the effluent concentration(s) are above discharge limits.

11-8.1.5 Design Criteria. Design considerations and factors important in the removal of organics from wastewater by stripping include temperature, pressure, air-to-water ratio, and surface area available for mass transfer.

The first design variables to specify for a stripping system include the water flow rate and composition, and the desired effluent concentration of one or more of the solutes. Next, the packing material for the column should be selected, and should offer the following characteristics: (1) large interstitial surface between liquid and gas; (2) desirable fluid-flow characteristics; (3) chemical inertness to fluids being processed; (4) structural strength to permit easy handling and installation; and (5) low cost (Treybal, 1955).

Given the packing type and the water flow rate, the designer must then determine an optimum gas flow rate through the packed column to yield the desired contaminant removal. The practice is to design for gas velocities at 40 to 70 percent of the flooding velocity (Treybal, 1955), with the optimum operating velocity about 50 percent of flooding (Stenzel and Gupta, 1985; and Perry, 1973).

Vendor recommendations can then be used to determine the tower height and diameter, provided that the tower will be operated for the specified removal rate. The removal rate dictates the depth of packing, which in turn determines the air flow rate at a given liquid flow. Operating pressure, the pressure drop across the tower, and the blower or reboiler specifications can then be determined (Stenzel and Gupta, 1985; and USEPA, 1984).

Practical tower diameters range from 1 to 12 feet, with packing heights as high as 50 feet; air-to-water volumetric ratios may range from 10 to 1, up to 300 to 1.

11-8.1.6 Performance. One indicator of a compound's volatility relative to water is the Henry's Law constant. Other factors that affect both the magni-

tude of the Henry's Law constant and the compound strippability include molecular weight, solubility, vapor pressure, and polarity (Michael, 1988).

Stripping has been shown to achieve removals of 90 to 99 percent for certain VOCs (Lenzo, 1988; Stenzel and Gupta, 1985; and USEPA, 1986a).

Several researchers have published analytical techniques to predict removal efficiencies based on mass-transfer theory and packed tower design. However, if a definitive prediction is required, pilot tests should be conducted rather than relying on a theoretical method.

11-8.2 Evaluation of Air- and Steam-stripping

11-8.2.1 Effectiveness. Removal efficiencies vary with the volatility and concentration of the compound. For removal from aqueous sources, efficiencies can be as high as 99.99-percent removal. Off-gas treatment with granular activated carbon (GAC) or condensation units may be required to meet federal and state air emission standards.

Effluent streams from a stripping tower include the off-gas, effluent water, and tower scale. The off-gases may contain VOCs requiring treatment. The treated water may require additional treatment to further reduce VOC and SVOC concentrations to discharge limits. The scale from the tower may need to be treated prior to disposal.

Influent restrictions to a stripping system may dictate pretreatment prior to stripping. High influent concentrations of metals such as iron, manganese, calcium, or magnesium that would oxidize and cause scaling or fouling of the tower may need to be reduced before stripping. Pretreatment may be required for wastewater streams containing large amounts of suspended solids and oils and greases.

Stripping substantially reduces the toxicity of the influent water caused by the contaminants. The contaminant(s) is transferred to the gas phase. Stripping processes significantly decrease the potential for mobility of the contaminant in groundwater, but increase mobility in the atmosphere. The remedy is permanent if stripping is used in conjunction with vapor-phase treatment.

11-8.2.2 Implementability. Stripping systems are feasible for on-site pretreatment when large volumes of VOC-contaminated water/groundwater require treatment. Stripping is suitable for the treatment of water with high concentrations of VOCs (greater than 100 ppm). However, concentrated organics extracted from groundwater treatment must be disposed of, and tower off-gases may require treatment (i.e., scrubbing, carbon absorption or incineration) to meet local and federal air quality standards.

Stripping towers currently process VOCs, THMs, and ammonia-contaminated water at hazardous waste sites, manufacturing facilities, and municipal water treatment plants. On-site facilities have proven successful for a broad range of contaminants and flow rates. Due to the nature of the air-stripping process, a

consistent quality effluent can be obtained, provided there are no large increases in influent concentrations or irreversible tower fouling.

11-8.2.3 Cost. Only after the tower has been designed can the capital and operating costs be estimated for treatment of the wastestream. Information on process equipment costs has been published in various engineering books, journals, and several USEPA reports. The cost methods presented in this section have been derived from these sources, and not from vendor quotes or case histories.

Capital costs are the costs of the equipment used, and are expressed in terms of purchased cost, delivered cost, and installed cost. An installation factor, usually different for each type of equipment, can be used to determine the installed capital cost. Installation factors are usually based on the purchased equipment cost.

The capital cost of air-/steam-stripping systems can be grouped into costs for the following major components:

- mass transfer equipment (tray and packed towers)
- heat transfer equipment (heat exchangers, condensers, and reboilers)
- fluid transfer and handling equipment (pumps, compressors, and tanks)
- installation materials including foundation, structural, instrumentation and controls, paint, insulation, and electrical and piping, as well as labor

The purchased cost for tray and packed towers can be divided into the following components:

- shell cost, including heads, skirts, manholes, and nozzles
- cost for internals, including trays and accessories, packing, supports, and plates
- cost for auxiliaries, such as platforms, ladders, handrails, and insulation

The basic engineering design parameters that have primary impact on the cost of stripping VOCs are effluent concentrations, required system size, and air-to-water ratio.

Cost information was compiled for flow rates ranging from 10 to 1,000 gpm, and is based on the following assumptions.

Capital Cost

- o air-stripping tower of packed-tower design
- o tower capable of removing up to 99.5 percent of the influent trichlorethene (TCE)
- o air-stripping tower installed on concrete pad

O&M Costs

- o Electricity to operate pumps is included.
- o Labor required to operate and maintain system is 8 hours/week for system flows less than or equal to 100 gpm, and 16 hours/week for system flows greater than 100 gpm.
- o No disposal costs for residual streams are included.
- o No pretreatment chemicals are included.

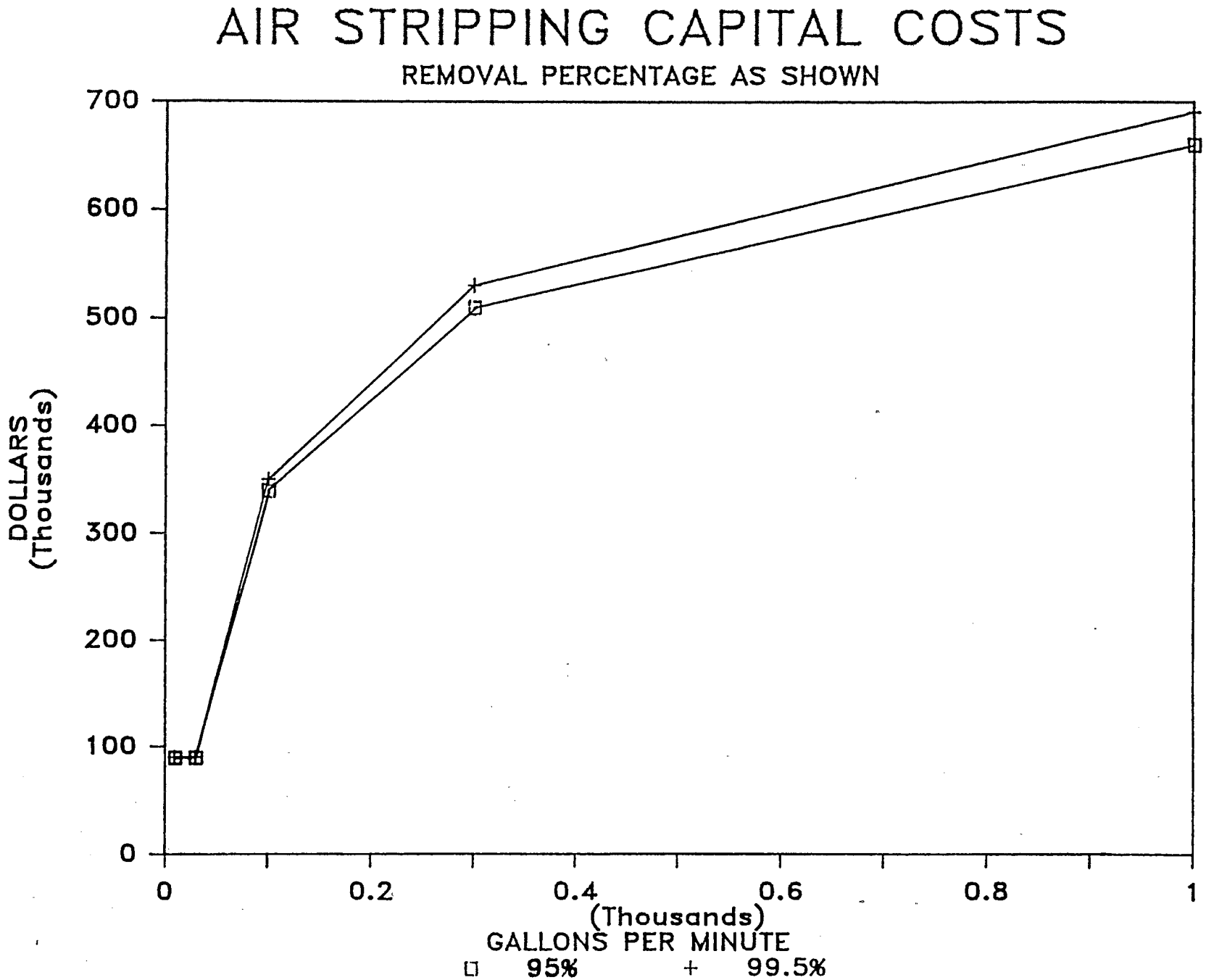
Cost information is presented in Figures 11-28 and 11-29. Cost curves were prepared for two cases: (1) a packed air-stripping tower to treat 100 ppb of influent TCE; and (2) a packed air-stripping tower to treat influent TCE at 1,000 ppb.

11-9 ANAEROBIC BIOLOGICAL TREATMENT

11-9.1 Description

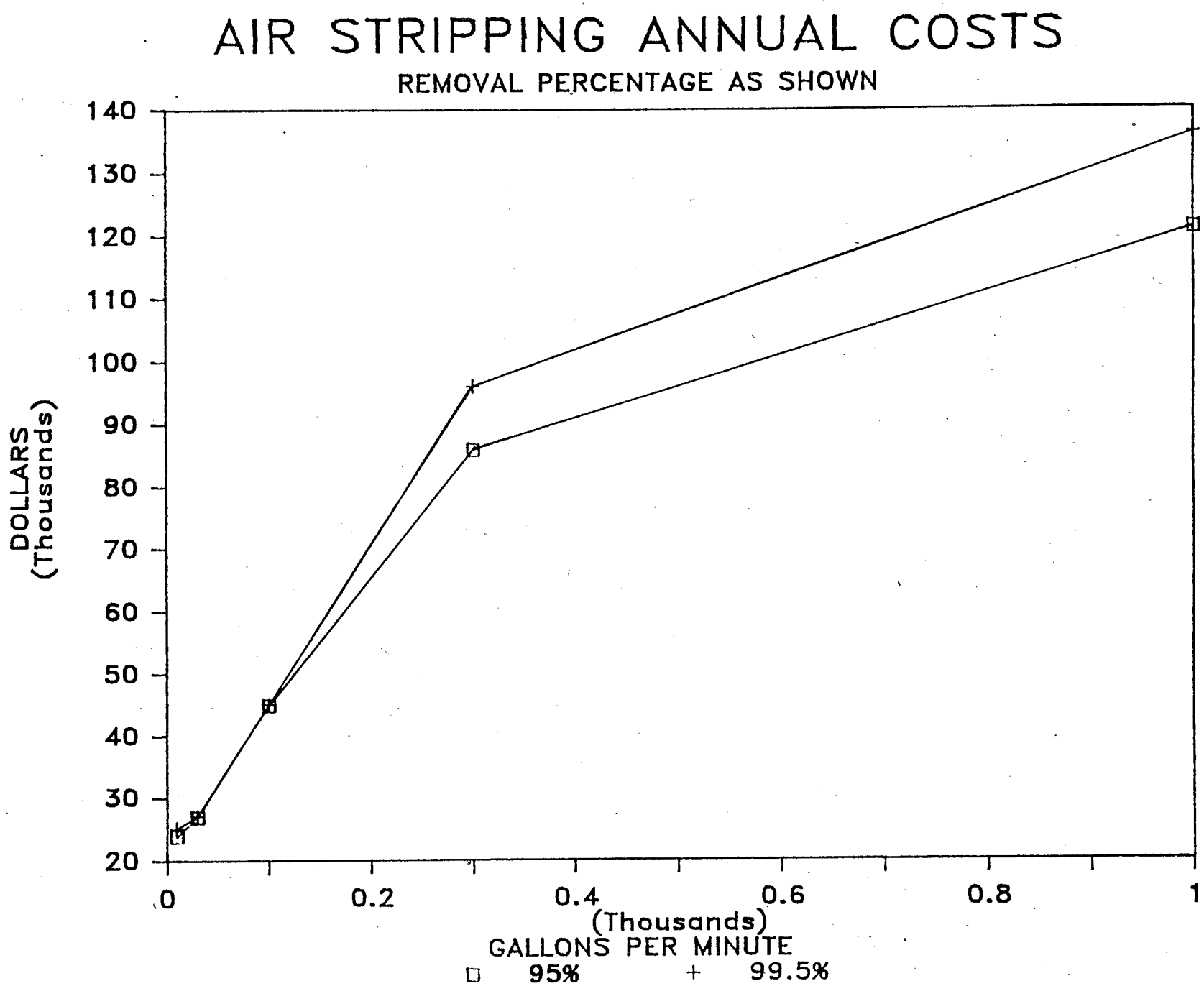
The anaerobic biological treatment process involves bacterial reduction of organic matter in an oxygen-free environment. The complex microbiological process involved in anaerobic treatment utilizes many types of bacteria working in an assembly-line fashion under favorable conditions for growth. In general, certain key factors encompass a favorable environment for anaerobic treatment to occur efficiently, including optimum bacterial retention time, adequate bacterial-substrate contact, proper pH, proper temperature control, adequate concentrations of proper nutrients, the absence or assimilation of toxic materials, and proper feed characteristics (Parkin and Owen, 1986). Anaerobic treatment is best utilized specifically to reduce high strength organic wastes and wastewaters to concentrations that can be degraded aerobically (VandenBerg, 1984).

The anaerobic treatment process has traditionally been used to stabilize and reduce municipal treatment plant sludges and to treat easily biodegradable wastes and food industry effluents. The process suffers from a reputation of unreliability, fostered in part by various unknowns associated with physical, biological, and chemical operational factors, and has had difficulty in being applied to a variety of wastestreams as an alternative to aerobic treatment. However, a wide variety of applications have been seen, generally on concentrated wastestreams with or without suspended solids (Olthof and Oleszkiewicz, 1982).



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-28
AIR STRIPPING - CAPITAL COSTS



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-29
AIR STRIPPING - OPERATION AND MAINTENANCE COSTS

11-9.1.1 Equipment Types Available. Essentially, there are two anaerobic system and reactor process types available for use. The first is a straight-through, completely mixed, suspended-growth reactor system similar to the sludge-digester system, in which microorganisms are not attached to fixed or suspended media and the hydraulic retention time (HRT) equals the biological solids retention time (SRT). In this type of system, the minimum SRT is approximately 12 days, therefore leading to the design of large reactors and a system generally not chosen for industrial application (Anderson et al., 1982). Examples of reactors within this process type include septic tanks, anaerobic lagoons, and sludge bed reactors.

The second process type is the contact reactor (Figure 11-30), in which the biomass is retained by attachment on fixed or suspended media to maintain a high SRT; at the same time, a low HRT is allowable, resulting in a smaller reactor volume. The attached growth systems offer advantages of a high biomass concentration retained in the reactor, increased resistance to adverse conditions due to the longer period of time the microorganism has to adapt to a variety of conditions, and the likelihood that natural stratification of the various microorganisms will occur and allow the optimum species to prevail (Anderson et al., 1982). Examples of these reactors include stationary medium reactors (which include upflow or downflow randomly dumped or fixed orientation filter systems, and rotating biological disc systems) and fluidized bed reactors in which bacteria form films around small-diameter solids held in fluid suspension by recycling a percentage of the substrate flowthrough.

In general, if easy-to-degrade organics, high-suspended organic solids, low concentrations of toxic compounds, and higher temperatures are present in the wastewater, suspended-growth reactors have been selected over fixed growth; opposite characteristics result in a fixed growth selection (Olthof et al., 1984). Selection of the appropriate process configuration and reactor type is critical and warrants detailed consideration; each offers varying SRTs and HRTs and has different optimal operating parameters and effluent treatment efficiencies (Switzenbaum and Grady, 1986). Literature searches, treatability studies, and vendor contacts should be conducted to determine the optimum system for a particular wastestream.

11-9.1.2 Advantages and Limitations. Anaerobic biological treatment has certain advantages over aerobic treatment, including (1) reduced energy requirements, due to the lack of need for aeration or oxygen-providing equipment and the possibility of using the resulting methane as a fuel; (2) reduced sludge production (10 percent of aerobic); (3) freedom from the constraints that food to microorganism (F/M) operational controls place on aerobic systems, allowing the anaerobic systems to treat the high strength wastes above 1,000 mg/ℓ COD, which are difficult to treat aerobically, as well as more dilute wastes; (4) less sensitivity to heavy metal poisoning; and (5) reduced nutrient requirements (Witt et al., 1979).

Anaerobic systems can break down some halogenated organic compounds and can treat the high strength organic wastes that cannot be treated efficiently by aerobic systems (USEPA, 1986f).

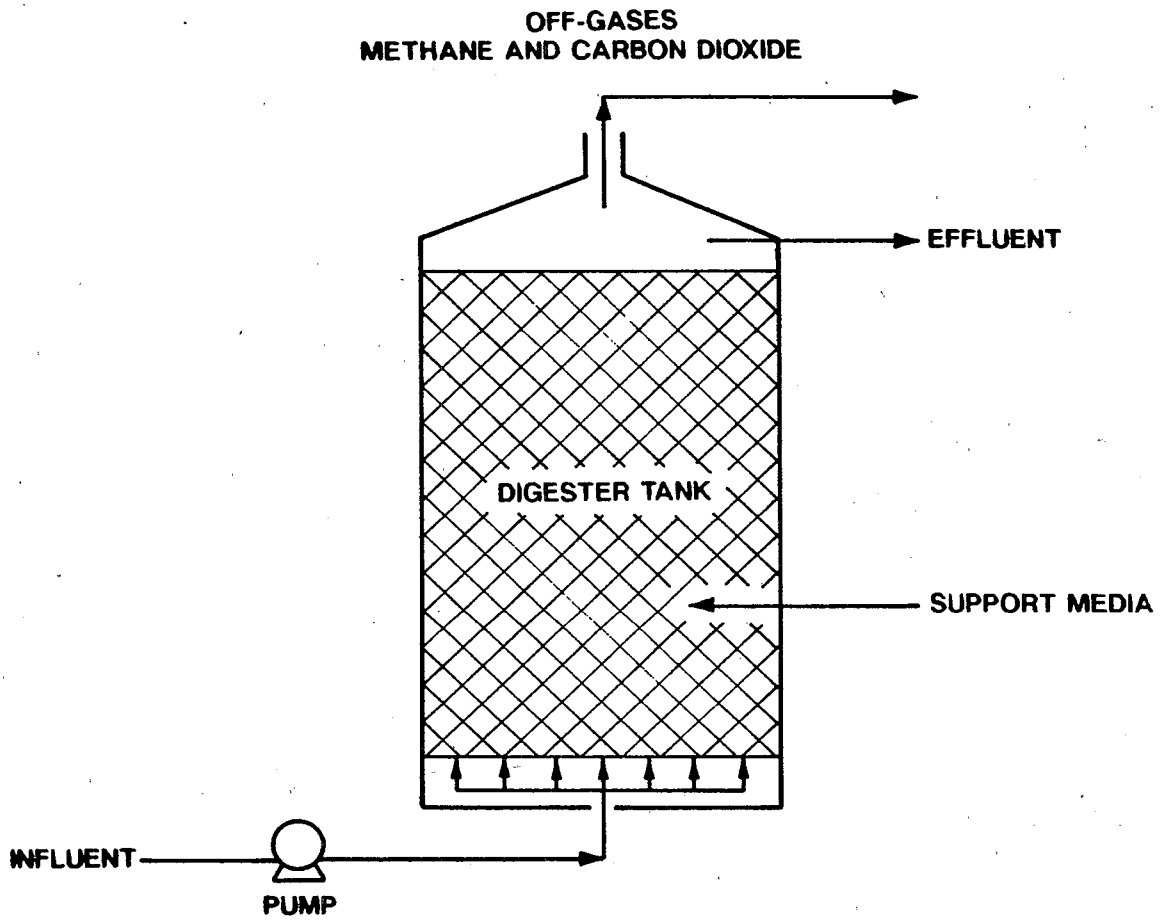


FIGURE II-30
ANAEROBIC UPFLOW FILTER

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The disadvantages of anaerobic systems include (1) the relative lack of practical experience in full-scale operations, and general lack of acceptance as a treatment method; (2) the relatively long and variable start-up period required to allow for microorganism development (i.e., nine months for filter, 10 weeks for sludge blanket); (3) the need for process optimization data for various types of wastewater; and (4) the general understanding that, to meet water quality standards, anaerobic processes are limited to pretreatment applications prior to aerobic or other organics-removal options (for treatment of low-strength COD concentrations, only 50- to 60-percent conversion is expected) (Obayaski et al., 1981). Also, for lower-strength wastes, larger digester volumes are frequently required. Because this is a biological process, it is subject to toxicity failure if certain toxic levels are reached. Relative toxicity limits must be determined for the wastewater to be treated, as well as whether the toxicity is reversible or irreversible. Methane bacteria are reportedly killed easily by low concentrations of toxic substances (Yang and Speece, 1985), and often recover much more slowly after toxic shocks.

Anaerobic treatment has had unfavorable past experiences, and is a poorly understood process, resulting in a generally negative feeling toward its use as a wastewater treatment system. Significant odors may be given off if the gas is not collected and treated and, if the methane is to be stored or utilized, the sulfur must be removed.

11-9.1.3 Chemicals Required. As in aerobic systems, certain chemicals and/or nutrients may be required to ensure that (1) toxic conditions that could inhibit growth and anaerobic degradation do not develop within the biological reactors; (2) the required nutrients are present in sufficient quantities to ensure that efficient microbial growth and biological degradation are occurring; and (3) certain other inhibitory conditions, correctable with chemical addition, do not persist (Olthof and Oleszkiewicz, 1982). Extensive laboratory bench- and pilot-scale testing is sometimes necessary to pinpoint the problem areas and determine the chemical additions required to efficiently operate the systems.

11-9.1.4 Residuals Generated. The primary residuals of the anaerobic process include methane, carbon dioxide, and sludge. Of the amount of COD entering the system, it has been shown that 11 to 15 percent is converted into biomass (sludge) requiring treatment/disposal, versus 50 to 60 percent conversion in aerobic systems; therefore, the anaerobic system is a more efficient organic degradation system (Suidan et al., 1981). It has been shown that 90 percent of the biodegradable fraction of organics is converted into methane, which comprises approximately 75 to 80 percent of the total gas produced, and is yielded at a rate of approximately 0.350 m^3/kg COD (Olthof and Oleszkiewicz, 1982). Depending on SRT, HRT, strength of incoming wastes, and operation efficiency, the methane production rate will vary. The methane generated can be utilized as a fuel supply and/or to heat the influent prior to treatment (which allows for more efficient removal of organics). However, if hydrogen sulfide gas is present in the gas stream, it must be scrubbed before it can be stored or used as a fuel. An iron sponge scrubber system has been utilized to perform this task and to precipitate the H_2S as ferrous sulfide.

11-9.1.5 Design Criteria. There are basically two approaches to designing wastewater reactors: (1) use of years of process-type information involving volumetric organic loadings and expected effluent quality; or (2) use of conceptual simulation models of processes and conditions to predict the optimum design. Numerous models are described in the literature of fixed film reactors; however, to date, none have been sufficiently refined to be used to design full-scale systems. Due to the lack of many full-scale systems treating high-strength wastes, and the relative lack of published design criteria and research and development, treatability and pilot studies are normally required. These studies will be useful to pinpoint problem areas and modify system design and operation constraints, in order to determine (1) if additive, antagonistic synergistic toxicities will result among the various chemicals in the wastewater, and (2) the rate-limiting step. The preferred sequential approach for design parameter selection should include (1) toxicity testing and wastewater analyses studies combined with a detailed literature search of available anaerobic treatment technologies; (2) bench-scale tests in fixed film and flowthrough reactors installed in parallel; and (3) pilot-scale tests on the selected process to determine scale-up factors and specific reactor requirements (Olthof and Oleszkiewicz, 1982).

In an effort to provide an understanding of anaerobic toxicity, Table 11-3 lists a few of the reported wastewater concentrations that generally are toxic to anaerobic wastewater treatment. Several contaminants of concern are listed more than once to illustrate the differences among the concentration generalizations made or reported by different authors.

There are many published general design recommendations of which to be aware when considering anaerobic systems. The desirable design will maximize the SRT and minimize the HRT. Sludge and flow recycling is usually required, as well as efficient solids recapture of the recycle. Recycle pumps and piping that have no high shear zones, which would disperse biomass flocs, are preferred. Reactor configurations ensuring low turbulence, efficient sedimentation, and prevention of plugging are also recommended. Processes resulting in a higher biomass concentration in the reactor are generally preferred, and induced thickening of the return sludge often will improve efficiency. Optimal design is also dependent on adequate bacterial and food source contact, often achieved by active or passive mixing. If fluctuations in flow or waste strength are anticipated, consideration should be given to adding an equalization tank to the process; stable, consistent operating conditions are necessary for efficient results.

Whether primary sedimentation is required depends on the reactor hydrolysis rates and HRT. Methods to remove gaseous products from early stages of bacterial conversion improves efficiency in the later stages of treatment and increases process stability.

11-9.1.6 Treatability of Waste/Performance. As previously noted, anaerobic processes are more efficient than aerobic processes in treating high-strength biodegradable organics. Anaerobic treatment processes have been consistently recommended for treating wastewater stronger than 1,000 mg/ℓ COD. Anaerobic systems typically handle wastewaters greater than 3,000 to 5,000 mg/ℓ COD, while aerobic systems are limited to concentrations below 5,000 mg/ℓ COD due to

TABLE 11-3
VARIOUS CHEMICAL/LOADING-SPECIFIC TOXICITY OR INHIBITION RESPONSES
IN ANAEROBIC WASTEWATER TREATMENT

CHEMICAL/PARAMETER	INHIBITION/ TOXICITY RESPONSE	SOURCE
Inorganic		
Total Dissolved Inorganics	>30,000 mg/ℓ	Olthof and Oleszkiewicz, 1982
Nickel, Copper, Cyanide	>1 mg/ℓ	Obayaski et al., 1981
Nickel	>2 mg/ℓ	Parkin and Owen, 1986
	2-200 mg/ℓ	USEPA, 1987b
Copper	<0.5 mg/ℓ	Parkin and Owen, 1986
	0.5-100 mg/ℓ	USEPA, 1987b
Sulfide	>300 mg/ℓ	Anderson et al., 1986
Sulfide	>200 mg/ℓ	McCarty, 1964
	50-100 mg/ℓ	USEPA, 1987b
Potassium	>12,000 mg/ℓ	McCarty, 1964
Magnesium	>3,000 mg/ℓ	McCarty, 1964
	1,000 mg/ℓ	USEPA, 1987b
Sodium	>8 g/ℓ	Obayaski et al., 1981; and McCarty, 1964
	3,500 mg/ℓ	USEPA, 1987b
Ammonia-N	>3,000 mg/ℓ	McCarty, 1964a; and Obayaski et al., 1981
	1,500-3,000 mg/ℓ	USEPA, 1987b
Alkalinity	<1,000-5,000 mg/ℓ	Metcalf & Eddy, 1979
Bicarbonate Alkalinity	<1,000 mg/ℓ	McCarty, 1964
Calcium	>8,000 mg/ℓ	Parkin and Owen, 1986
$Chromium^{+6}$	>3 mg/ℓ	Parkin and Owen, 1986
Zinc	>1 mg/ℓ	Parkin and Owen, 1986
	1-10 mg/ℓ	USEPA, 1987b
pH	6.8 <pH <7.5	Obayaski et al., 1981
pH	6.6 <pH <7.6	McCarty and Smith, 1986
Arsenic	0.1-1 mg/ℓ	USEPA, 1987b
Boron	2 mg/ℓ	USEPA, 1987b
Cadmium	.02-1 mg/ℓ	USEPA, 1987b
Chloride	20,000 mg/ℓ	USEPA, 1987b
Chromium (total)	1.5-50 mg/ℓ	USEPA, 1987b
Cyanide	0.1-4 mg/ℓ	USEPA, 1987b
Iron	5 mg/ℓ	USEPA, 1987b
Lead	50-250 mg/ℓ	USEPA, 1987b
Mercury	1,400 mg/ℓ	USEPA, 1987b
Tin	9 mg/ℓ	USEPA, 1987b
Organic		
Ethyl benzene	>200-1,000 mg/ℓ	Parkin and Owen, 1986
Kerosene	>500 mg/ℓ	Parkin and Owen, 1986
Volatile acids	>250 mg/ℓ	Metcalf & Eddy, 1979

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TABLE 11-3
(continued)
VARIOUS CHEMICAL/LOADING-SPECIFIC TOXICITY OR INHIBITION RESPONSES
IN ANAEROBIC WASTEWATER TREATMENT

CHEMICAL/PARAMETER	INHIBITION/ TOXICITY RESPONSE	SOURCE
Organic (continued)		
Volatile acids	>6,000 mg/ℓ	Parkin and Owen, 1986
Vinyl acetate	>200-400 mg/ℓ	Stuckey et al., 1980
Vinyl chloride	>5-10 mg/ℓ	Stuckey et al., 1980
Methylene chloride	≥3 mg/ℓ	Stuckey et al., 1980
Chloroform	>0.5 mg/ℓ	Parkin and Owen, 1986
Formaldehyde	>2.4-200 mg/ℓ	Parkin and Owen, 1986
Formaldehyde	>400 mg/ℓ	Speece, 1983
Phenol	>2,000 mg/ℓ	Speece, 1983
	>28 mg/ℓ	Parkin and Owen, 1986
	100-200 mg/ℓ	USEPA, 1987b
Ethylene dichloride	>5-7 mg/ℓ	Stuckey et al., 1980
Halogenated aliphatics	>1 mg/ℓ	Jewell, 1987
	0.1-100 mg/ℓ	USEPA, 1987b
Nitro/chlorogenic semivolatiles	variable, in 100-mg/ℓ range	Johnson and Young, 1983
COD	<1,500 mg/ℓ	USEPA, 1986b
COD	<2,000-3,000 mg/ℓ	Olthof and Oleszkiewicz, 1982
COD	<10,000 mg/ℓ	Sachs et al., 1982
BOD	1,000 <BOD<15,000 mg/ℓ	USEPA, 1986b
BOD	<500 mg/ℓ	Switzenbaum and Jewell, 1980
Aromatics	100-870 mg/ℓ	USEPA, 1987b
Chlorinated benzenes	0.1-1 mg/ℓ	USEPA, 1987b
Nitrogen compounds	5-500 mg/ℓ	USEPA, 1987b
Oxygenated compounds	20-1,000 mg/ℓ	USEPA, 1987b
Organic acids	10 mg/ℓ	USEPA, 1987b
Chlorophenols	0.2-100 mg/ℓ	USEPA, 1987b
Nitrophenols	100 mg/ℓ	USEPA, 1987b

limitations in oxygen mass-transfer. Because no oxygen is required in anaerobic treatment, this limitation does not exist. As noted previously, proper reactor and system configuration and careful operational control result in increased organics removal efficiency. Metals removal at rates of 50 to 60 percent have been noted in anaerobic systems. If metals removals are a concern, treatability studies should determine if sufficient removals are possible in the anaerobic system.

Chemicals normally considered inhibitory or toxic to anaerobic bacteria can often be degraded or removed efficiently if the system provides high SRTs. Examples of chemicals that have been treated anaerobically are listed in Table 11-4. As discussed previously, attempts to extrapolate these data to determine treatability in a particular wastestream are generally not recommended; bench- and pilot-scale testing will likely provide the degree to which particular contaminants will be removed.

11-9.2 Evaluation of Anaerobic Biological Treatment

11-9.2.1 Effectiveness. Anaerobic treatment of wastewater for organics removal is a permanent remedy that reduces a significant portion of biologically degradable organics into methane and innocuous end-products. Under optimum conditions, anaerobic treatment has removed over 98 percent of influent organic contaminants in wastestreams. With proper design, no significant public health risks would result. However, as discussed in Section 11-9.1.6, with varying influent concentrations, certain contaminants are more readily removed than others, and the system design and operating parameters should be tailored to optimize treatment. In addition, to operate with efficiency, the minimum COD in the substrate surrounding anaerobic bacteria should be in the 600 to 900 mg/ℓ range; concentration levels lower than these result in reduced treatment effectiveness, with expected COD degradation of 50 to 60 percent (URS Company, Inc., 1987). Therefore, to decrease effluent BOD to acceptable concentrations for discharge to receiving waters, it is sometimes necessary to use aerobic treatment systems after anaerobic systems. Also, depending on the discharge criteria, additional processes to remove residual VOCs and suspended solids may be required.

The methane generated is usually treated and/or used as a fuel, or flared on-site; these are permanent remedies for this by-product. The sludge generated in the anaerobic process will usually contain a certain amount of the influent metals and organics. Therefore, the sludge may require dewatering followed by incineration or further treatment prior to consideration for landfilling.

11-9.2.2 Implementability. Most of the existing full-scale wastewater applications are for treatment of warm, concentrated organic wastestreams, such as grain milling, sugar refining, food processing, fermentation, pharmaceutical, organic chemical, textile, tanning, petrochemical, pulp and paper, coal processing, and synfuels wastewater. Perhaps the most suitable application is as an organics treatment step for landfill leachate, during which storage, mixing, and flow regulation can be accomplished. However, before widespread use of anaerobic systems occurs, process design information must be developed.

TABLE 11-4
EXAMPLES OF ORGANICS DEGRADED ANAEROBICALLY

ORGANIC COMPOUND	REFERENCE
Acetaldehyde	(1)
Acetic acid	(5)
Acetic anhydride	(1)
Acetone	(1)
Acrylic acid	(1)
Adipic acid	(1)
Aniline	(1)
1-Amino butyric acid	(1)
Benzoic acid	(1)
Butanoic acid	(5)
Butanol	(1)
Butyraldehyde	(1)
Butyl Benzyl Phthalate Esters	(2)
Butylene glycerol	(1)
Butyric acid	(3)
Catechol	(1)
Chloroform	(4)
Cresol	(1)
Crotonaldehyde	(1)
Crotonic acid	(1)
DDT	(2)
Diacetone gulusonic acid	(1)
Dieldrin	(2)
Dimethoxy benzoic acid	(1)
Dimethylnitrosamine	(2)
1,1-Dichloroethane	(7)
1,1-Dichloroethene	(10)
dichloromethane	(7)
Ethanol	(1)
Ethyl acetate	(1)
Ethyl acrylate	(1)
Ethylphenol	(9)
Ferulic acid	(1)
Formaldehyde	(1)
Formic acid	(1)
Fumaric acid	(1)
Glutamic acid	(1)
Glutaric acid	(1)
Glycerol	(1)
Hexachloro 1,3-Butadiene	(8)
Hexachlorocyclopentadiene	(8)
Hexachloroethene	(8)
Hexanoic acid	(1)
Hydroquinone	(1)
Indole	(5)
Introhenzene	(2)
Isobutyric acid	(1)

TABLE 11-4
(continued)
EXAMPLES OF ORGANICS DEGRADED ANAEROBICALLY

ORGANIC COMPOUND	REFERENCE
Isopropanol	(1)
Isopropyl alcohol	(1)
Lactic acid	(1)
Lindane	(2)
Maleic acid	(1)
Methanol	(1)
Methyl acetate	(1)
Methyl acrylate	(1)
Methyl ethyl ketone	(1)
Methyl formate	(1)
Nitrobenzene	(1)
Pentachlorophenol	(2)
Pentanoic acid	(5)
P-Cresol	(5)
P-Nitrophenol	(2)
Pentaerythritol	(1)
Pentanol	(1)
Phenol	(1)
Phloroglucinol	(2)
Phthalic acid	(1)
Propanal	(1)
Propanol	(1)
Propionate	(1)
Propionic Acid	(3)
Propylene glycol	(1)
Protocatechuic acid	(1)
Pyridine	(9)
Quinoline	(5)
Resorcinol	(1)
Sec-butanol	(1)
Sec-butylamine	(1)
Sorbic acid	(1)
Syringaldehyde	(1)
Syringic acid	(1)
Succinic acid	(1)
Tert-butanol	(1)
1,1,1-Trichloroethane	(7)
Toluene	(2)
Trichloroethane	(2, 4)
Trichloroethylene	(4, 10)
Trichloromethane	(2)
Trihalomethane	(6)
Valeric acid	(3)
Vanillic acid	(1)
Vinyl acetate	(1)
Vinyl chloride	(10)
Vinylidine chloride	(10)
3,4-Xylenol	(9)

TABLE 11-4 (continued)
EXAMPLES OF ORGANICS DEGRADED ANAEROBICALLY

REFERENCES

(1) Speece, 1983
(2) Olthof et al., 1984
(3) Parkin and Owen, 1986
(4) Switzenbaum and Grady, 1986
(5) Fox et al., 1988
(6) Bouwer et al., 1981
(7) Vargas and Ahlert, 1987
(8) Johnson and Young, 1983
(9) Blum et al., 1986
(10) Fogel et al., 1986

Various vendors exist and can provide selected microbes, nutrients, and system designs. In addition, most of the companies that offer mobile aerobic systems also offer anaerobic systems. However, vendors are generally reluctant to recommend the anaerobic systems (USEPA, 1986d). As discussed previously, to assess the implementability of anaerobic treatment on a particular wastestream, laboratory and pilot-scale treatability studies should be conducted to determine (1) to what extent the wastewater is degraded; (2) what type of reactor should be used; (3) what nutrients are required; (4) maximum loading and gas composition; (5) the necessity of supplemental alkalinity; and (6) whether there is any inhibition or toxicity. These treatability studies can take more than six months to conduct, with additional time required for system design and construction.

The residuals produced during treatment must be disposed of. Sludge dewatering technology, gas treatment systems, and landfilling are widely used and available. Once the system is operating, frequent monitoring is required to ensure efficient treatment. Downtime occurs during repairs to process tanks or piping, for removal of excess solids (which may plug the reactor), and/or for reseeding with microorganisms, if necessary. Sufficient surface area should be made available for the system, process downtime wastewater storage, emergency wastewater removal, and/or additional pretreatment units, if determined necessary during design.

11-9.2.3 Cost. Capital costs for anaerobic reactors have been shown to be similar to those for aerobic reactors. For example, capital costs for anaerobic reactors can be approximately 10 percent greater than those for aerobic reactors (Witt et al., 1979; and Olthof and Oleszkiewicz, 1982). However, depending on design, anaerobic reactors can have a capital cost 25 percent below that of aerobic reactors. Increased costs result in systems that require a refined flow distribution system and added pumps, as required in the fluidized bed systems. These requirements also apply frequently to aerobic systems. Increased costs for filter media have added to a reluctance to use anaerobic systems, with packing materials costs found to be comparable to tank costs. For example, for a large system (assuming 10-percent annual interest, 1988 dollars), reactors and media each have been indicated to cost $560/m^3$ (Speece, 1983).

When considering anaerobic versus aerobic wastewater treatment systems, the cost savings most often indicated for anaerobic systems are those due to decreased O&M (i.e., lower sludge production, energy conservation, and methane production/use), with savings of $.20 to $.50/1,000 gallons treated (Jewell, 1987). Although available literature often praises the O&M costs savings of anaerobic systems over aerobic systems ($160/metric ton COD treated, assuming $.06/kWh, $4.50/$10^6$ BTU for methane [1988 dollars], and $100/ton dewatered sludge disposal [Speece, 1983]), it has been noted that, when COD loading is below 15,000 pounds per day, there is little difference between anaerobic and aerobic operating costs. It has also been noted that anaerobic treatment may become cost-effective when the process generates enough methane to heat the system.

To accurately estimate costs, bench-scale tests should be used to determine if biological treatment alone is sufficient to meet treatment requirements.

Typical costs and cost curves have not been developed for anaerobic treatment systems because costs are highly site-specific and therefore should be developed on a site-by-site basis.

11-10 AEROBIC BIOLOGICAL TREATMENT

11-10.1 Description

Aerobic biological treatment is used to remove biodegradable organic matter from wastestreams through microbial degradation in the presence of dissolved oxygen. Oxygen acts as an electron acceptor for microorganisms, and should be present in sufficient quantity to promote and sustain their growth. As a treatment technology, biological treatment is often technically more effective and less costly than physical-chemical treatment for control of organic pollutants in wastewaters, especially those with complex mixtures of waste. In some cases, a combination of biological and physical-chemical treatment will be the optimum treatment option (Bishop and Jaworski, 1986).

Aerobic processes can be used to significantly reduce a wide range of organic and hazardous compounds; however, in general, only dilute wastes (i.e., less than 1 percent) are normally treatable. Relatively low levels (i.e., BOD less than 10,000 mg/ℓ) of nonhalogenated and/or certain halogenated organic wastestreams are recommended for aerobic biological treatment, with consistent, stable operating conditions required.

One feature that makes biological treatment practical is the retention of biological cells in a large biomass, which fosters rapid and complete oxidation of organic matter within a relatively short liquid detention time. The goal of biological treatment of wastewater is mineralization of the organic constituents. However, this process is never 100-percent complete, and degradation products are usually released. These degradation products may be toxic, depending on the influent characteristics.

11-10.1.1 Equipment Types Available. Two general types of biological reactors are in use: (1) suspended, mobilized growth reactors, and (2) fixed film, immobilized cell reactors. Suspended growth reactors are generally stirred-tank reactors in which the microorganisms (biomass) and substrate (biodegradable organics) in the wastestream are totally or partially mixed. In immobilized cell reactors, the biomass is attached, or fixed, to media, and the substrate contacts immobilized biomass by flowing over the media (URS Company, Inc., 1987). Section 10 provides a brief description of five common aerobic systems.

The two most common and longest standing methods of aerobic treatment are the activated sludge, suspended growth reactor and the trickling filter, fixed film reactor. In the activated sludge process (Figure 11-31), microorganisms must accumulate into relatively large aggregates known as flocs. These large masses of cells can settle after they exit the aeration tank in a secondary clarifier, and are returned to the reactor tank to allow buildup of biomass. In trickling filter systems, the cell mass is retained directly in the filter media, and is attached to fixed, solid surfaces. Organic contaminant and ammonia removal,

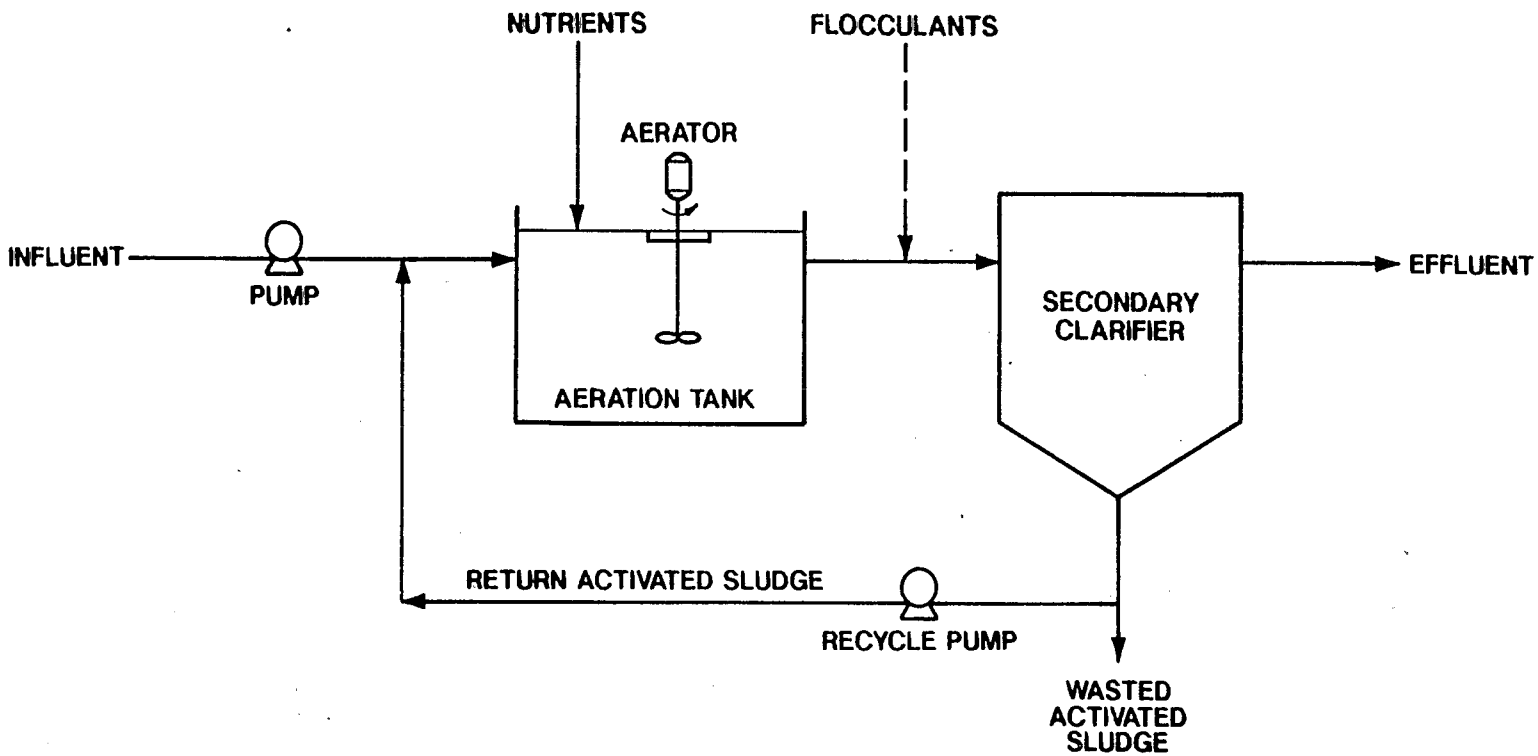

FIGURE II-31
AEROBIC BIOLOGICAL TREATMENT - ACTIVATED SLUDGE

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oxygen use, new cell mass growth, and biofilm retention all occur on and around the media. The wastewater moves from the trickling filter to a settler to improve effluent quality, but settled cell mass is not usually returned to the filter reactor (Rittman, 1987). Detailed descriptions of these two, as well as other aerobic treatment types, are provided in Section 10.

11-10.1.2 Advantages and Limitations. There are various advantages when choosing aerobic biological treatment over other wastewater treatment systems. Depending on the system type, these advantages include the following:

- technology often offers the lowest cost method of treatment per pound of organic removed, destroying organic compounds at a much lower cost than carbon absorption
- biomass acclimates to degrade many compounds that are initially refractory
- handles fluctuating organic loading
- good resistance to shock loads if designed properly, and adapts to many types of wastewater treatment problems
- operates within a limited space environment and provides a high quality effluent

However, certain disadvantages are often noted when selecting aerobic biological treatment systems. Depending on the specific system type, these disadvantages include the following:

- requires relatively consistent, stable operating conditions and can treat wastes with generally low levels (i.e., BOD less than 10,000 mg/ℓ) of non-halogenated organic and/or certain halogenated organics
- not suitable for removal of many aliphatics, amines, aromatic compounds, and certain heavy metals and other organics
- relative high complexity of system operation and equipment; high amount of sludge production; and high energy requirements
- relative sensitivity of the systems, possibly requiring precipitation/flocculation/sedimentation to remove metals and suspended solids, neutralization to bring the pH to near neutral, nutrient addition, post-treatment carbon adsorption to remove nonbiodegradable organics, and filtration to remove suspended solids; chemical additions may be required to achieve the desired result
- start-up time may be slow if the organism needs to be acclimated to the wastes
- hydraulic detention times can be long for complex wastes

- loss of VOCs from unit processes can pose localized air pollution and a health hazard to field personnel

- the sludge produced may be considered a hazardous waste, which would require RCRA-approved disposal

11-10.1.3 Chemicals Required. As discussed previously, certain chemical additions may be required to bring the wastestream to optimum conditions before introducing the wastestream to the biologically active reactor. Oxygen or air must usually be provided and distributed in the amount and manner necessary to ensure efficient oxygen mass transfer within the reactor. Regarding sludge settling, inert solids or coagulants are sometimes added in the secondary clarifier to cause sludge to clump together, and small concentrations of chlorine, heavy metals and/or lime may be added to reduce the number of filamentous bacteria present. Bench- and pilot-scale treatability studies are especially useful to pinpoint problem areas and determine the chemical additions required to efficiently operate the system.

11-10.1.4 Residuals Generated. Sludge production is a function of the type of aerobic system selected and the type of wastewater entering the system. For example, a high colloid concentration in the influent results in increased sludge production, and use of an extended aeration system results in low net sludge production. Conversion of at least 40 to 60 percent of the organic material, as COD, into excess sludge is a rule of thumb. The sludge will often require further treatment prior to disposal, usually through (1) direct discharge into aerobic or anaerobic digesters for volume reduction; and/or (2) dewatering, through use of belt or filter presses, or sludge drying beds. After dewatering, sampling and analyses are usually conducted to determine whether the sludge is disposed of as a hazardous waste.

VOC releases may occur in the various treatment processes, possibly resulting in localized air pollution and health hazards. In addition, if anaerobic conditions exist within the system, either through inadequate operation or intentional design, methane and hydrogen sulfide gases may be released. These released gases may possibly require collection and treatment.

11-10.1.5 Design Criteria. Several steps should be taken before deciding on a biological treatment system for the cleanup of a particular groundwater: (1) search literature for biodegradability of the compound; (2) run generic organic concentration tests (i.e., BOD, COD, TOC); (3) run treatability studies; and (4) select and design process to be applied.

Specific design criteria vary among the different types of biological treatment systems. For example, activated sludge process design considerations include loading criteria, selection of the reactor type, sludge production and process control, oxygen requirements and transfer, nutrient requirements, environmental requirements, solids separation, effluent characteristics, settling basin sidewater depth, overflow rate, and weir loading. Aerated lagoon design criteria considerations include BOD removal, effluent characteristics, oxygen requirements, temperature effects, energy requirements for mixing, and solids separation. Trickling filter design criteria considerations include the type and dosing characteristics of the distribution system, type and physical

characteristics of filter medium to be used, configuration of the underdrain system, provision for adequate ventilation (either natural or forced air), and design of the required settling tanks (Metcalf & Eddy, 1979).

Most of these criteria can be designed through use of reported design calculations, characteristics of the influent, and desired effluent, rather than empirical derivations from treatability studies for each specific wastewater. A partial listing of design criteria available in the literature for a specific system (e.g., activated sludge, conventional and mechanical aeration) is provided in Table 11-5.

11-10.1.6 Performance. Table 11-6 a summarizes the response to biodegradation of 10 classes of chemical species found in hazardous wastestreams.

Aerobic bacteria are usually used to treat organic concentrations between 50 and 4,000 mg/ℓ BOD with capabilities for treatment of 10,000 or even 15,000 mg/ℓ for small waste flows (Nyer, 1985). Table 11-7 provides a list of treatment efficiencies for various systems. As noted previously, specific treatment efficiency will be more accurately defined after treatability results are received for a particular wastestream.

11-10.2 Evaluation of Aerobic Biological Treatment

11-10.2.1 Effectiveness. Aerobic biological treatment of wastewater for organics removal is a permanent remedy that reduces a significant portion of biologically degradable organics into carbon dioxide and water end-products. As indicated previously, under optimum conditions, aerobic treatment has removed over 95 percent of influent organics. However, to achieve effluent quality capable of discharge to receiving waters, additional treatment (often in the form of carbon adsorption, filtration, and/or chlorination) may be required. Also, it is often necessary to pretreat the wastestreams before using the biological systems that use physical/chemical treatment processes.

The VOCs that may be released during treatment might require treatment. The sludge generated will usually contain metals and organics. The sludge can usually be treated anaerobically, which will reduce the volume and increase its stability. It may then require dewatering followed by incineration or further treatment prior to consideration for landfilling.

11-10.2.2 Implementability. Biological treatment has not been used as widely for hazardous site remediation as activated carbon, filtration, and precipitation/flocculation. As previously indicated, the process is well established for treating a wide variety of organic contaminants. It is a broadly used technology in industry for organics treatment.

As a general rule, biological systems will work best under stable, consistent operating conditions with little variation in wastewater characteristics. Pretreatment units and careful monitoring may be needed to achieve this requirement. Several clean-up contractors have used biological treatment as part of their mobile treatment systems. In addition, several companies have

TABLE 11-5
PARTIAL LISTING OF DESIGN CRITERIA:
ACTIVATED SLUDGE, CONVENTION/MECHANICAL AERATION

CRITERIA	VALUE
Volumetric loading, lb BOD_5/day/1,000 ft^3	25-50
Aeration detention time, hours (based on average daily flow)	4-8
Mixed liquor suspended solids, mg/ℓ	1,500-3,000
F/M, lb BOD_5/day/mixed liquor volatile suspended solids	0.25-0.5
Air required, standard ft^3/lb BOD_5 removed	800-1,500 (agitator - sparger system only)
Sludge retention time, days	5-10

SOURCE: USEPA, 1980a

TABLE 11-6
PRIORITY POLLUTANT COMPOUND CLASS RESPONSES TO BIODEGRADATION

COMPOUND CLASS	DEGREE OF BIODEGRADATION
Alcohols	General removals of 75-100%
Aliphatics	Wide range of removal efficiency
Amines	Some readily degradable with acclimated cultures; others showing inhibition to system
Aromatics	Generally high removal, although removals may be due to air-stripping or adsorption onto biomass
Halocarbons	Generally biorefractory; removals may be due to air-stripping
Metals	Removals at levels below toxicity threshold; toxicity and inhibition at levels above threshold
Pesticides	No significant degradation
Phenols	Greater than 70% removals generally reported; toxic effects have been reported
Phthalate	High removals reported; may be attributed to air-stripping or adsorption onto biomass
Polynuclear Aromatics	Generally inhibitory or refractory

SOURCE: Venkataramani et al., 1983

TABLE 11-7
PERFORMANCE OF AEROBIC BIOLOGICAL SYSTEM

PROCESS TYPE	Performance BOD_5 REMOVALS	Performance NH_4-N REMOVALS
Activated Sludge: Conventional; Diffused or Mechanical Aeration	85-90%	10-20%
Activated Sludge: High Rate, Diffused Aeration		
(A) Modified Aeration	50-70%	5-10%
(B) High Rate Aeration	85-95%	5-10%
Activated Sludge: Pure Oxygen, Covered	89-95%	20-98%
Activated Sludge: Pure Oxygen, Uncovered	75-95%	20-98%
Activated Sludge: Extended Aeration, Diffused and Mechanical	85-95%	50-90%
Contact Stabilization, Diffused Aeration	80-95%	10-20%
Aerated Lagoons	60-90%	--
Oxidation Ditch	92-94%	40-80%
Rotating Biological Contactors	80-90%	up to 90%
Trickling Filter, Plastic Media	80-90%	20-30%
Trickling Filter, High Rate, Rock Media	60-80%	20-30%
Trickling Filter, Low Rate, Rock Media	75-90%	20-40%

SOURCE: USEPA, 1980a

developed mobile biological reactors that are well-suited to treatment of aqueous wastestreams contaminated with low levels of organics.

The main restrictions associated with aerobic biological treatment have limited the application of biological technology to wastestreams that can meet those factors. These restrictions include the need for continuous sources of food (organics), nutrients, and oxygen; project start-up time of two to eight weeks; and lower and upper BOD limits of 75 and 4,000 mg/ℓ, respectively (Nyer, 1985).

Laboratory and pilot studies should be conducted to determine the proper system design, nutrients and toxicity limits, and treatment efficiency. The residuals produced must be disposed of. Sludge dewatering technology, gas treatment systems (if necessary), and landfilling are widely used and available. Once the system is operating, frequent monitoring is required to ensure efficient treatment. Downtime occurs during repairs to process tanks or piping, and for reseeding with microorganisms, if necessary. Sufficient surface area should be made available for the system, emergency process downtime wastewater storage, emergency wastewater removals, and/or additional pretreatment units, if determined necessary during design.

11-10.2.3 Cost. The characteristics of treatment vary from case to case, and because factors specific to various treatment processes available from vendors result in different effluent qualities, cost comparisons between processes are generally not valid. However, there have been attempts to compare costs between systems for magnitude estimation only (Venkataramani, 1983).

Cost information was compiled for a package-activated sludge system incorporating powdered activated carbon (PAC). Two different wastestream characteristics were assumed to aid the costing. A lower level concentration wastestream contains the following:

COD = 500 mg/ℓ
BOD = 200 mg/ℓ
TSS = 200 mg/ℓ

A relatively concentrated wastestream contains the following:

COD = 10,000 mg/ℓ
BOD = 4,000 mg/ℓ
TSS = 3,000 mg/ℓ

Design assumptions and the package unit description are listed as follows.

Capital Costs

- The vendor package unit is equipped with an aeration-contact tank, final clarifier, aerobic digestion tank, recycle pump, mixers, blowers, and polyelectrolyte and carbon feed systems.

- A filter press, conveyor equipment, conditioning tanks, sludge storage tanks, and pressure pump system is costed to dewater the waste sludge to 40-percent solids. A graph from the "Innovative and Alternative Technology Assessment Manual" (USEPA, 1980a), adjusted for 1988 dollars, provided the cost data.

- Pumps and piping are designed with 100-percent backup capability.

- Concrete pads support the units.

- No off-gas treatment is costed.

- No carbon regeneration systems are costed.

O&M Costs

- Electricity to operate all equipment is included.

- Analytical testing depends on wastestream characteristics and the POTW local limits. This example includes three BOD_5 analyses per week and one VOC analysis per month.

- Carbon dose must be determined in bench- or pilot-scale studies. To cost, the easy-to-treat wastestream assumed less than 50 mg/ℓ of carbon use; the difficult-to-treat wastestream assumed greater than 500 mg/ℓ.

- The unit provides polymer storage and feed systems for 0.25 to 5.0 mg/ℓ of polymer addition. The 0.25 mg/ℓ was assumed to apply to the easy-to-treat wastestream; 5.0 mg/ℓ applies to the difficult-to-treat wastestream.

- No nutrients are costed.

- Labor required was 8 hours/week for system flows less than 100 gpm, and 16 hours/week for flows greater than 100 gpm.

- Sludge wasting during operation is derived from graphs provided by the vendor. The graphs are based on BOD loading and solids retention time.

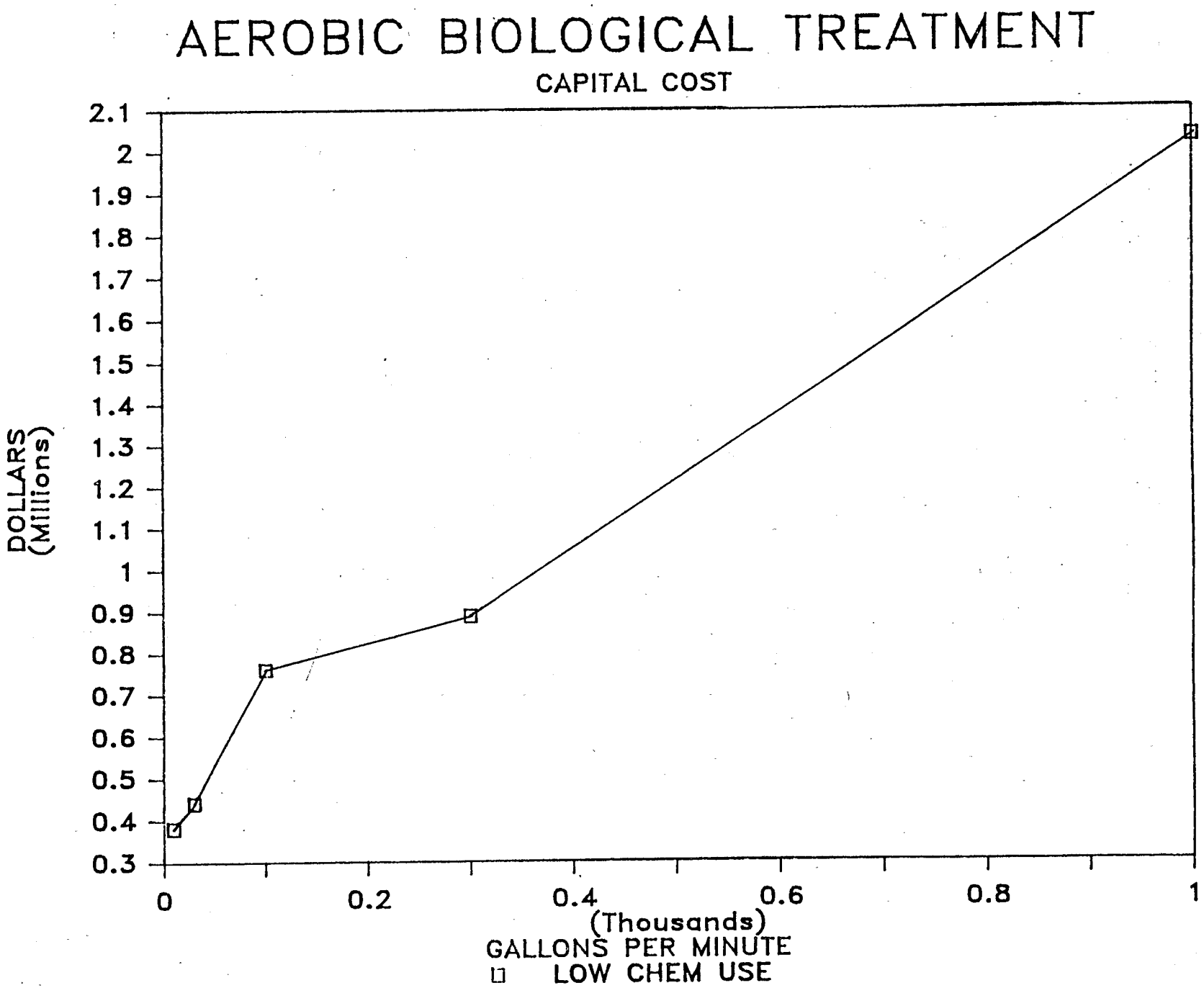
- The dewatered sludge is trucked 500 miles to a RCRA landfill.

Capital and O&M costs are presented in Figures 11-32 and 11-33, respectively.

11-11 CARBON ADSORPTION

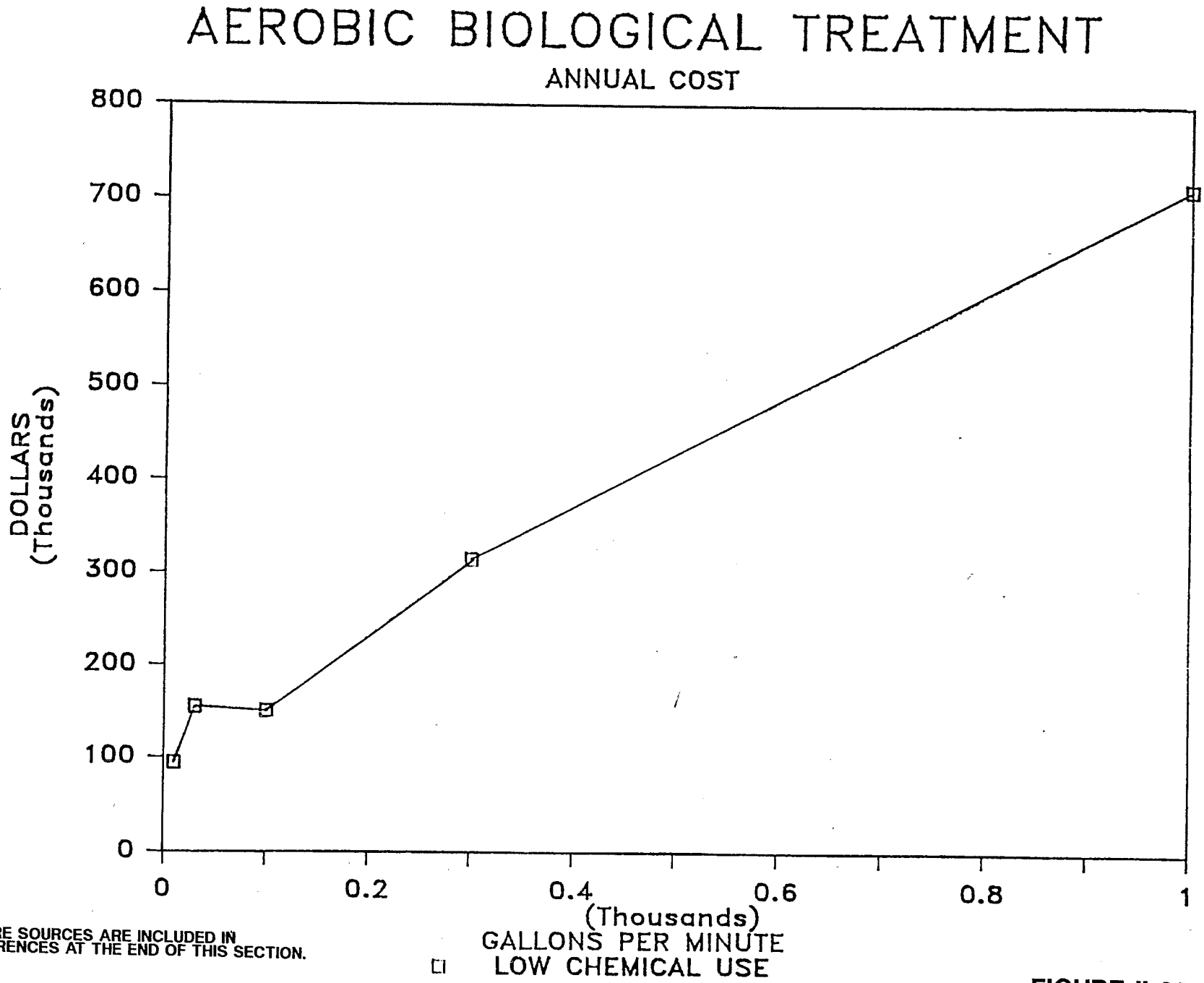
11-11.1 Description

Activated carbon adsorption is a physical separation process in which organic and inorganic materials are removed from wastewater by sorption or the



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-32
AEROBIC BIOLOGICAL TREATMENT - CAPITAL COSTS



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-33
AEROBIC BIOLOGICAL TREATMENT - OPERATION AND MAINTENANCE COSTS

attraction and accumulation of one substance on the surface of another. Traditionally, activated carbon has been used to remove undesirable odors and colors in drinking water, or to aid in treatment of wastewater. An important aspect of carbon adsorption is its capability of removing organics that are not completely removed by conventional biological treatment. Activated carbon can be used to (1) reduce COD, BOD, and other related parameters; (2) remove toxic and refractory organics; (3) remove and recover certain organics; and (4) remove selected inorganic chemicals including some heavy metals from wastewaters. Most dissolved organics can be adsorbed by carbon.

Much of the surface area available for adsorption by carbon is found in the pores within the carbon particles created during the activation process. A carefully controlled process of dehydration, carbonization, and oxidation of raw materials (e.g., coal, wood, coconut shells, and petroleum-based residues) yields the activated carbon. As activated carbon adsorbs molecules or ions from wastewater, the carbon pores eventually become saturated and the exhausted carbon must be regenerated for reuse or replaced with fresh carbon. The adsorptive capacity of the carbon can be partially restored by chemical or thermal regeneration.

11-11.1.1 Equipment Types Available. There are two forms of activated carbon in common use: granular (GAC) and powdered (PAC). Granular carbon is effective on dilute aqueous solutions with low suspended solids. GAC is primarily used in two forms: (1) columns, where wastewater passes vertically through the column; and (2) beds, where the wastewater passes horizontally through the bed. Carbon columns are convenient for flow rates below 1 mgd. Beds are more practical in the range of 1 mgd and greater. The column or bed is sized to allow enough contact time for the carbon to reduce the contaminant levels to a predetermined concentration.

PAC is generally mixed with a more concentrated wastewater in an aerated settling chamber. The wastewater detention time is predetermined to allow sufficient contact time for contaminant removal. PAC is removed as a sludge during clarification or sedimentation, and is not usually regenerated. When used in combination with biological processes, PAC can greatly increase removal of nonbiodegradable toxic organics. Details of the process configurations for both forms of carbon are presented in the following paragraphs.

Granular Activated Carbon. GAC is about 0.1 to 1 mm in diameter and contacts wastewater in columns or beds. Generally, carbon beds are used in large-scale applications; that is, 1 mgd or greater. The bed provides the advantage of easy access to the activated carbon for replacement. Columns become cost-effective at lower flow rates. They require less design and maintenance effort than beds. Therefore, the remainder of this section discusses process configurations related to activated carbon columns.

The water to be treated either flows down (downflow) or up (upflow) through the carbon column. Upflow configurations include countercurrent operations, in which exhausted carbon is continuously removed from the bottom of the column; fluidized bed, in which forced flows expand the column's carbon bed volume by 10 percent; and fixed bed, in which wastewater flow is interrupted periodically to replace portions of exhausted carbon.

Downflow configurations use fixed beds, with complete replacement of the column when breakthrough has occurred. (Breakthrough occurs when the concentrations of the target pollutant in the effluent are higher than the desired level.) Multistage operations for fixed bed configurations (upflow or downflow) provide more efficient use of activated carbon than single-stage configurations.

In a typical downflow fixed bed operation, two columns are operated in series with a spare column. Figure 11-34 shows a series operation of two downflow columns, including the sampling port between the columns used to monitor the exit concentration of the lead column. When breakthrough occurs for the lead column, it is removed from service for carbon disposal or regeneration. The partially exhausted second column becomes the lead column, and the first spare column is added as a second column in the series. When breakthrough is again reached, the cycle is repeated. Influent to the carbon column is normally filtered prior to passing into the column, to minimize clogging. Although downflow configurations are more sensitive to suspended solids, downflow fixed-bed columns are the most widely used form of GAC.

In an upflow configuration, the exhausted carbon is periodically removed from the bottom of the column, and virgin or regenerated carbon is added at the top. Continuous addition of carbon is not widely practiced because of difficulties in moving solids through the active column without affecting the liquid flow.

Powdered Activated Carbon. PAC is about 50 to 70 microns in diameter and is usually mixed with the wastewater to be treated. This "slurry" of carbon and wastewater is then agitated to allow proper contact. Finally, the spent carbon carrying the adsorbed impurities is coagulated, settled, or filtered. In practice, a multistage countercurrent process is commonly used to make the most efficient use of the carbon's capacity. Often, PAC is used in conjunction with aerobic biological treatment.

Because PAC is generally used to enhance removal of high concentrations of contaminants through settling, this application generates large volumes of sludge. Normally, it is not economical to regenerate this form of carbon. Spent PAC must be landfilled (RCRA-landfilled when hazardous) or incinerated.

11-11.1.2 Advantages and Limitations. The major benefits of carbon treatment include applicability to a wide variety of organics and inorganics, with high removal efficiencies. The system is compact, and recovery of adsorbed materials is sometimes practical. Compared to biological systems for removal of organic pollutants, activated carbon offers the following advantages:

- insensitivity to toxics (the system will remove most toxic organics and some heavy metals)
- reduced sensitivity to temperature
- less time required for installation and start-up
- increased tolerance of concentration and flow rate variations
- reduction of organics to drinking water standards (GAC)

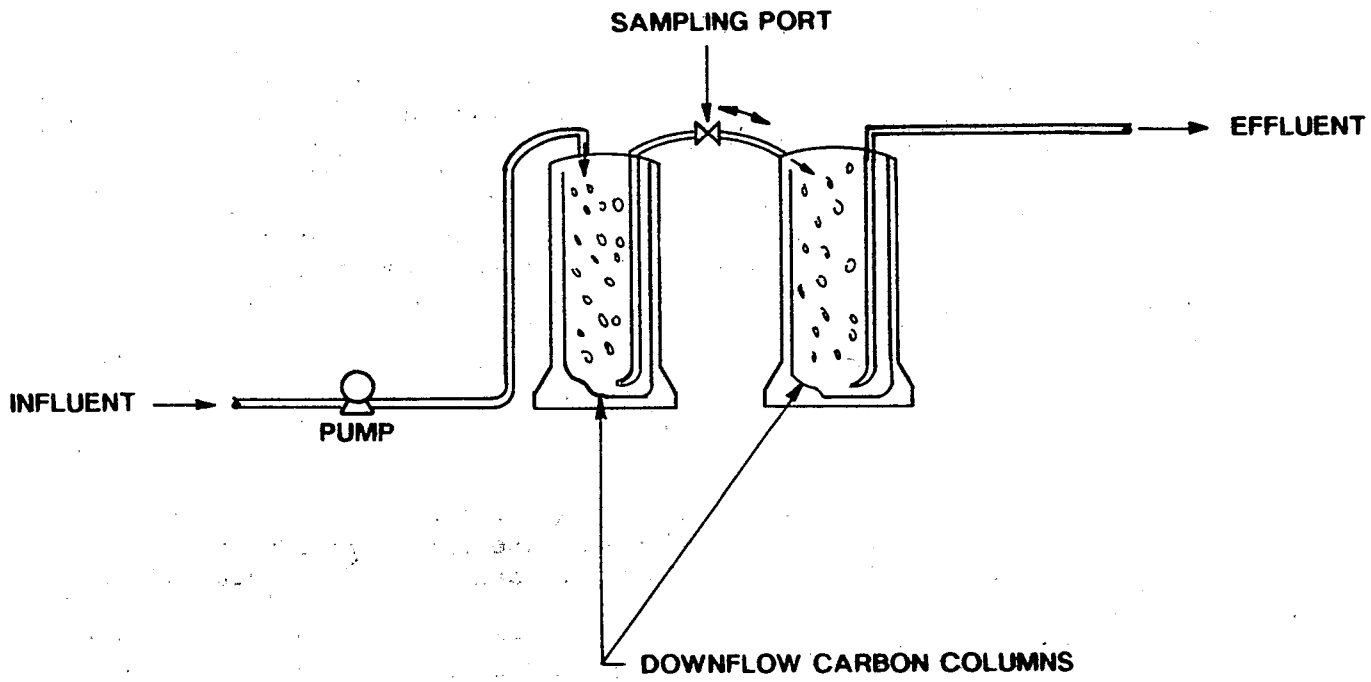


FIGURE II-34
CARBON ADSORPTION

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- higher removal of BOD, COD, and total organic carbon (TOC) for many wastes (PAC)

- effectiveness in streams with high dissolved solids

Limitations of the process include ineffective removal of low molecular weight, highly soluble or highly polar organics; low tolerance for suspended solids in the wastewater; and relatively high capital and operating costs. Iron concentrations of 10 ppm or greater may host slime-producing bacteria which can clog the carbon. In addition, concentrated aqueous solutions can result in rapid exhaustion of the carbon, increasing the O&M costs.

In general, carbon adsorption is a well-proven treatment for dilute solutions of organics and inorganics. Prefabricated packages are readily available, and manufacturers can provide expeditious treatability information for specific wastestreams.

11-11.1.3 Chemicals Required. Acid may be required to wash the exhausted or regenerated carbon to remove metals, as well as other inorganic materials, adsorbed on the carbon. GAC columns usually require periodic replacement and/or regeneration. PAC will have to be continuously or periodically supplied to the system.

11-11.1.4 Residuals Generated. PAC will generate sludge requiring disposal. GAC can be landfilled, incinerated, or regenerated even when it contains hazardous constituents. Only one RCRA-permitted facility is currently operable for commercial regeneration of hazardous GAC. On-site regeneration may be practical if large volumes of carbon are used. The cost-effectiveness of regeneration versus disposal must be evaluated on a site-by-site basis.

11-11.1.5 Design Criteria. Design of an activated carbon treatment system is difficult without bench- or pilot-scale information on the treatability of the particular wastewater. The size of the carbon columns (GAC) or the contacting and settling basins (PAC) are both flow- and contaminant-concentration-dependent. Pilot-scale tests and laboratory bench-scale testing (see Section 11-11.1.6) can provide the following design criteria:

- performance of different carbon types under the same dynamic flow conditions

- minimum contact time required to produce the desired quality of effluent

- pretreatment requirements to (1) reduce suspended solids; (2) remove oil and grease; (3) adjust pH to the optimum level; and (4) equalize flow and organic concentrations

- activated carbon dosages in terms of kilograms (kg) of carbon per million liters of wastewater treated, kg of organic material removed per kg of carbon, or pounds of carbon per 1,000 gallons treated

- breakthrough characteristics of the system

- hydraulic loadings, head loss characteristics, and backwash needs
- biological growth effects

Carbon system sizing is based on consideration of the required carbon contact time and the breakthrough characteristics of the system. Hydraulic loadings and head loss (GAC only) characteristics will determine the size and type of pumps and piping. The other design criteria provide information on potential complications in the full-scale system.

11-11.1.6 Performance. Activated carbon is effective in removing various organic and inorganic materials. Compound-specific isotherms are useful in assessing the adsorption ability of a wastewater with a single contaminant. "Carbon Adsorption Isotherms for Toxic Organics" contains a compilation of compound-specific adsorption information (USEPA, 1980b). However, wastewater is commonly a mixture of many compounds. The compounds may mutually enhance adsorption, act relatively independently, or interfere with one another.

The following generalizations regarding the relative adsorption of compounds help to determine whether carbon adsorption can provide the appropriate level of removal. In general, molecules are more readily adsorbed than ionized compounds. The aromatic compounds tend to be more readily adsorbed than the aliphatics, and large molecules more readily adsorb than smaller ones. However, extremely high molecular weight materials can be too large to penetrate the pores in the carbon. Less soluble organics are more readily adsorbed than soluble organics. Organics adsorption increases with decreasing pH; inorganic adsorption varies with pH among compounds. Because activated carbon is slightly polar, slightly polar compounds are readily adsorbed; whereas, extremely polar compounds are not.

The generalizations and the information contained in the literature can be extrapolated to use on any particular wastestream. However, accurate quantitative information can only be determined on a site-by-site basis through pilot-testing or carbon manufacturer services. Manufacturers provide services to assess the treatability of individual wastestreams. One approach uses computer simulation; another provides reduced-scale laboratory column-testing. Both methods correlate well to full-scale treatment, and can often significantly reduce treatability testing costs.

Pilot studies can be more time-consuming and expensive than the services provided by manufacturers. However, pilot tests provide the most complete and accurate information on treatability of specific wastewaters.

11-11.2 Evaluation of Carbon Adsorption

11-11.2.1 Effectiveness. Treatment with activated carbon is a permanent remedy. However, carbon adsorption is a separation process that generates either contaminated GAC or a sludge of PAC as a residual. GAC may be landfilled or incinerated; however, it is sometimes feasible to reactivate it. Thermal reactivation is considered permanent.

PAC from a CERCLA waste generally will require disposal in a RCRA-permitted landfill or incineration. Landfilling is not permanent and, therefore, poses uncertainties in the long-term scope regarding effectiveness. Incineration in a RCRA-permitted facility is a permanent remedy.

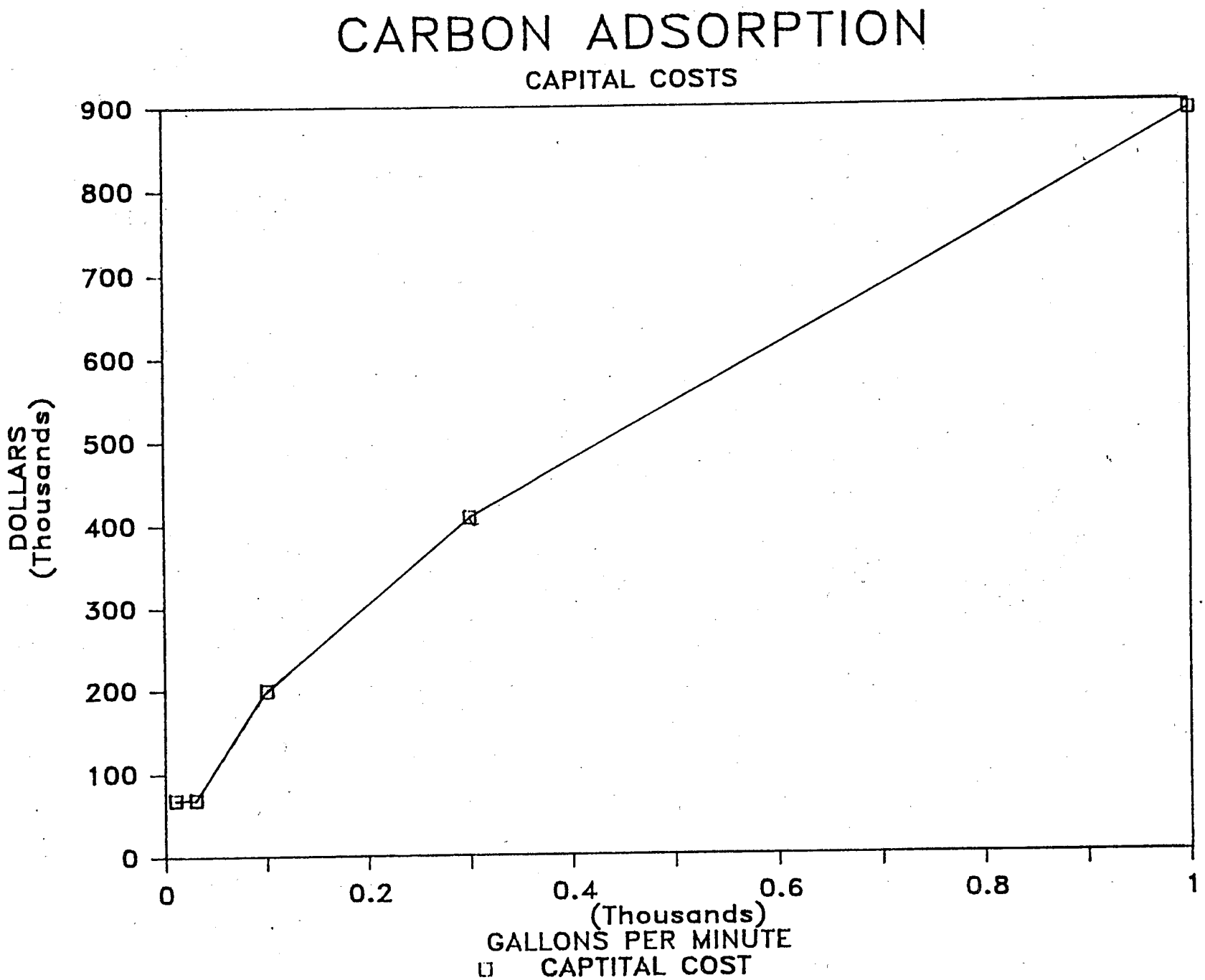
11-11.2.2 Implementability. Activated carbon adsorption is well-demonstrated full-scale as a polisher (GAC), and as an additive to primary treatment (PAC). Both forms of activated carbon are applicable to a variety of toxic organics and inorganics. GAC columns are readily available from manufacturers and can be installed quickly. PAC is readily available for use in settling chambers. GAC columns may require filters or silt traps on the influent. Full-scale designs of carbon columns require frequent monitoring to determine when breakthrough occurs. Regeneration and incineration are well-documented residual management technologies. However, the availability of incineration may be limited by the type of waste removed. The availability of off-site regeneration facilities is currently limited to a single RCRA-permitted facility. Landfilling of exhausted activated carbon is widely used and available, and can be quickly implemented.

11-11.2.3 Cost. Capital cost of treatment with activated carbon is dependent on contaminant concentrations in the wastestream. Capital costs are also increased in cold weather climates where buried piping, heating, and housing units are required. O&M costs increase proportionally with concentration. The three major contributors to O&M costs are (1) replacement of exhausted carbon, (2) management of residuals generated, and (3) monitoring effluent concentrations. The first two contributors depend on waste concentration.

Cost information on capital requirements is presented in Figure 11-35. The figure shows estimates for flow rates varying from 10 to 1,000 gpm for a downflow carbon column system. The capital costs were developed for five flow rates using the following assumptions:

- pumps and piping installed with 100-percent backup
- carbon columns are sized to handle maximum flow rate possible
- two carbon columns are used in a series with one spare on-site
- all equipment is installed on a concrete pad
- valves are available for monitoring the effluent concentrations

Capital costs are dependent on contaminant types and concentration. As discussed in Section 11-11.1.6, the contaminants present in a wastewater can mutually enhance or interfere with the absorption process. The carbon columns chosen for costing purposes were sized for the maximum flow rate the columns could support hydraulically (taken from the manufacturer's specifications). Therefore, the capital cost is representative of a low carbon usage rate, similar to what could be required of a mutually enhancing or noninterfering mixture of contaminants. Contaminant mixtures that increase the overall carbon usage rate, associated with interfering contaminants, would require larger carbon columns, increasing the overall capital cost.



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-35
CARBON ADSORPTION - CAPITAL COSTS

O&M costs are presented in Figure 11-36 for the same range of flow rates. O&M costs were estimated for two different carbon usage rates: 0.1 and 10.0 pounds of carbon per thousand gallons influent. These carbon use rates fall at the low and high ends of the scale provided in the literature. O&M costs include operator labor, electricity, carbon purchase, and disposal. The O&M costs will increase proportionally with the amount of monitoring required; disposal costs can vary with type of contaminant and transport distance.

11-12 ION EXCHANGE

11-12.1 Description

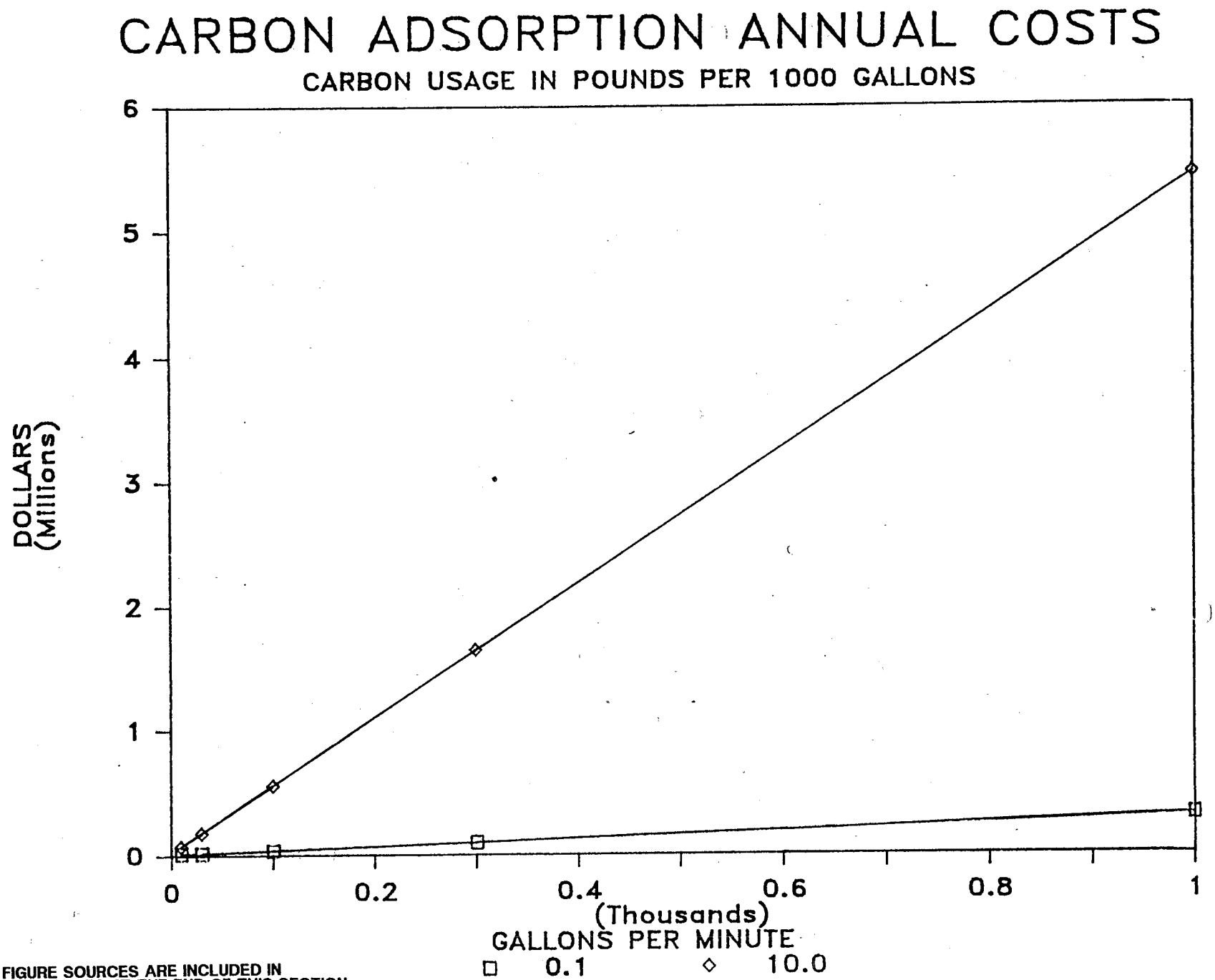
Ion exchange is the process of exchanging selected dissolved ionic contaminants in a wastewater with a set of substitute ions. The exchange occurs on a synthetic or natural resin containing the substitute ions (functional ionic groups) and is reversible. Undesirable ions are removed from a wastewater by contacting the wastewater with the resin. Because the process is reversible, backwashing with regeneration solutions can remove the ions from the resin. Backwashing the resin transfers the ions to a concentrated liquid, and leaves the resin ready to treat a new volume of wastewater. The regeneration solutions are strong or weak acids or bases, depending on the application.

Traditional uses of ion exchange include removal of selected dissolved metals as polishing or recovery steps, nitrate removal for drinking water purification, and decreasing TDS of influents. Ion exchange is frequently used in water treatment to soften the water by removing ions (e.g., calcium and manganese).

Industrial applications of ion exchange are primarily recovery operations for dilute solutions of metals, where the value of the recovered metals makes the process economical. Metals can be removed as ions in solution or as complexes. Organic compounds are generally not removed with ion exchange.

11-12.1.1 Equipment Types Available. Various resin types are available. These differences provide systems that are selective to discrete ionic mixes. The generic categories of resins are strong acid, weak acid, strong base, and weak base. The acid exchangers replace cations in the wastewater with hydrogen ions, and the base exchangers replace anions with hydroxide ions. Ions other than hydrogen or hydroxide can be exchanged, depending on the resin types and functional groups to which they are attached. Other exchangeable ions include sodium, chlorine, lithium, carbonate, and ammonium.

The weak acid and base exchangers are selective for only the more easily removed ions. The strong acid and base exchangers are less selective, and will remove most ions in the wastewater. A typical cation removal sequence is as follows:



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-36
CARBON ADSORPTION - OPERATION AND MAINTENANCE COSTS

$$Ra^{+2} > Ba^{2+} > Pb^{2+} > Sr^{2+} > Ca^{2+} >$$
$$Ni^{2+} > Cu^{2+} > Co^{2+} > Zn^{2+} > Mn^{2+} >$$
$$UO_2^{2+} > Ag^{+} > Cs^{+} > K^{+} > NH^{4+} >$$
$$Na^{+} > Li^{+}$$

where radium is the most preferred ion, and lithium is the least preferred (Clifford et al., 1986). Similarly, a typical anion sequence is as follows:

$$HCrO_4 > CrO_4^{2-} > ClO_4^{-} > SeO_4^{2-}$$
$$> SO_4^{2-} > NO_3^{-} > Br^{-} > HPO_4^{2-},$$
$$HAsO_4^{2-}, SeO_3^{2-}, CO_3^{2-} > CN^{-} > NO_2^{-}$$
$$> Cl^{-} > H_2PO_4^{-}, H_2AsO_4^{-}, CHO_3^{-} > OH^{-}$$
$$> CH_3COO^{-} > F^{-}$$

Weak acid and base resins will remove the more preferred ions present in the wastewater, while a strong acid or base resin would sequentially remove all ions present in the wastewater, including those more difficult to adsorb. Advances in the development of synthetic resins have resulted in numerous resins with unique selectivity sequences. Resin manufacturers can provide specific information on the applicability of the various resins.

Several process configurations are available to contact the wastewater with the ion exchange resin. Batch, fixed-bed column, and continuous column contact schematics are the most widely used. Column contact occurs most commonly in fixed-bed downflow operation. In the fixed-bed downflow system, wastewater is passed through the column from top to bottom and periodically backwashed (bottom to top) to regenerate the resin. This form of column contact requires minimal suspended solids, to avoid clogging the void spaces within the resin.

Batch operations consist of adding resin to the wastewater, and mixing well for a specified time. This method of contact can be inefficient because ion exchange ceases when chemical equilibrium is reached. Column operation is generally preferred over batch unless:

- the resin has unusually high selectivity for the target compound at equilibrium; or
- the ion released from the resin precipitates or reacts with another chemical so that it is removed from solution.

Continuous column contact consists of regenerating the resin while treating the wastewater. This method of ion exchange eliminates the need to interrupt the treatment process for backwashing. It also allows a more complete and efficient use of the resin. Continuous column contact can be better than fixed-bed column contact for high flows or high ionic concentrations. However, continuous column contact is not commonly used because of the complexity of the mechanics involved in removing the solids for regeneration.

Figure 11-37 shows a typical fixed-bed column operation with anion and cation columns in series. Ion exchange column manufacturers have developed many different column arrangements for treatment of specific combinations of contaminants. Weber (1972) describes several available package systems; continuous contact column diagrams are discussed in Seamster and Wheaton (1966).

The actual contact apparatus is available through a number of manufacturers. The ancillary equipment that the process requires (i.e., pumps, flow meters, valves, and storage tanks) is conventional chemical processing equipment. Figure 11-39 shows a millivolt controller measuring the conductivity of the effluent. This controller is generally connected to a control device to activate the backwash cycle when the conductivity of the effluent reaches a certain point (see Section 11-12.1.5 for design details).

11-12.1.2 Advantages and Limitations. Generally, ion exchange is used as a polishing step. Dissolved solids concentrations in the range of 1,000 mg/ℓ may require an evaluation of the relative cost-effectiveness of other alternatives (Weber, 1972). Suspended solids concentration must be kept to a minimum to prevent clogging of the resin void spaces. Iron, manganese, calcium, and high organics concentrations may permanently foul the resins. The resins are generally highly sensitive to oxidants; contact with oxidants should be avoided to prevent degradation of the resin. Large organic molecules can clog the void spaces of the resin. If a single exchange column is used, the effluent may be basic or acidic, requiring neutralization (see Section 11-5).

Advantages of ion exchange include its versatile selectivity for specific contaminants. High removal efficiencies are possible for dilute wastestreams. The systems are insensitive to variations in flow rates; and are available for a wide range of flows.

11-12.1.3 Chemicals Required. Ion exchange requires regeneration of the exchange resin. In general, regenerates are commonly used chemicals. Examples are sodium hydroxide, sodium chloride, sulfuric acid, calcium oxide, and ammonia (Kunin, 1969). The regenerate is dependent on the resin type and the functional group required to remove the undesirable ionic contaminants in the wastewater.

11-12.1.4 Residuals Generated. Residuals generated during ion exchange include waste solutions from the regeneration process and spent resins. The waste solution will be concentrated in the ionic contaminants removed from the wastewater. This liquid must be disposed of potentially as a RCRA waste or further treated on-site. Possible solutions are on-site precipitation, oxidation, reduction, and off-site incineration. Spent resins can be landfilled or incinerated (also potentially as a RCRA waste).

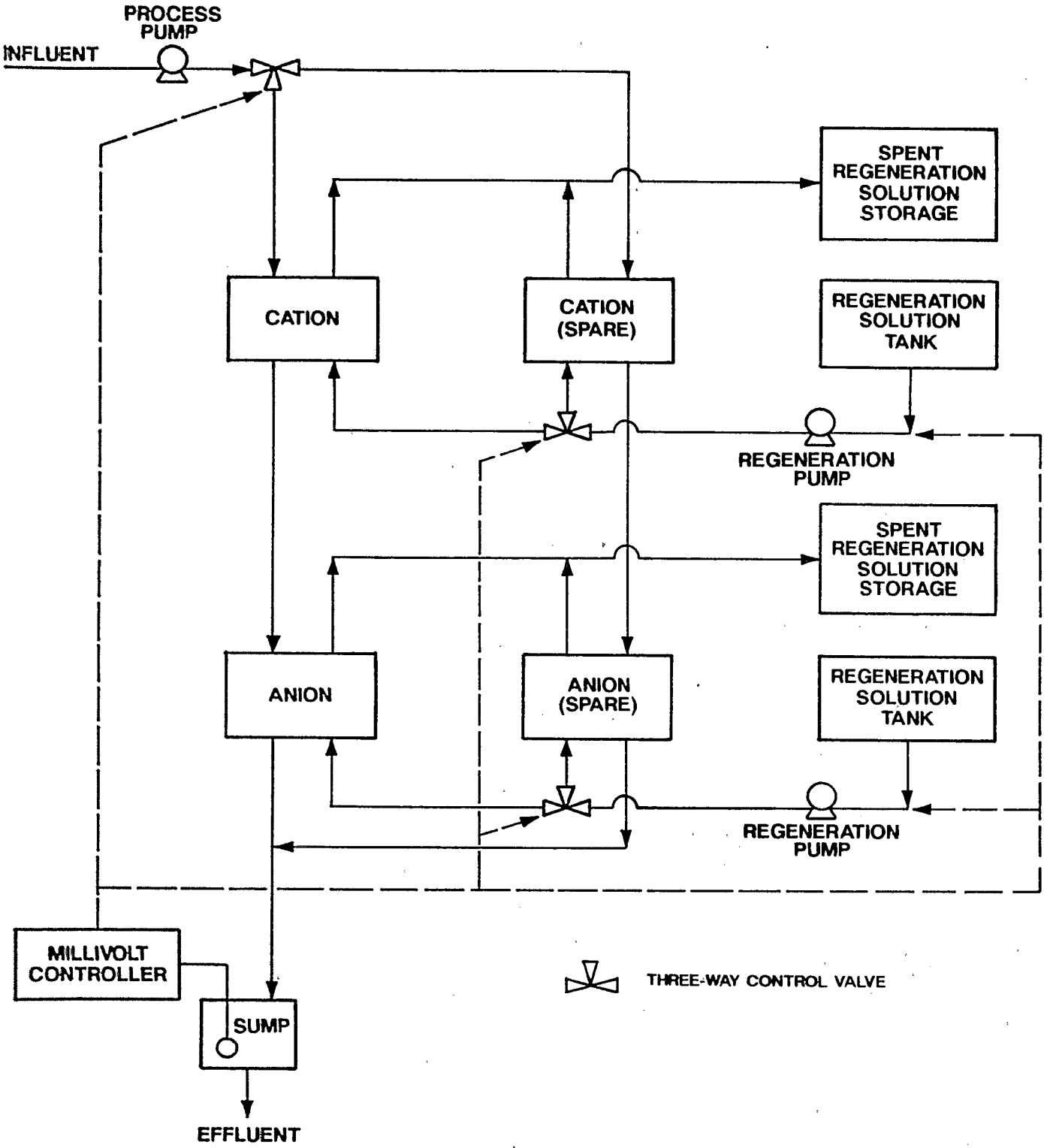


FIGURE II-37
ION EXCHANGE

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11-12.1.5 Design Criteria. A wide variety of resins is available for use in designing ion exchange systems. Manufacturers provide charts that characterize the resins they produce, including recommendations for typical applications. Generally, the manufacturer can suggest an appropriate resin based on the wastewater characteristics. Final decisions on which resin is best-suited for a particular application can be made through laboratory testing of the wastewater.

Column configurations and the number of columns are a function of the wastewater characteristics. As discussed in Section 11-12.1.1, resin manufacturers have developed several configurations that decrease the need to neutralize the wastestream, while maximizing the efficiency of the column. Resins release ionic constituents (i.e., hydroxide and hydrogen ions) during ion exchange, which alter the pH. Frequently, a single column in use will require effluent neutralization prior to discharge. Where both anions and cations require removal, using acid and base columns in series can eliminate the need for neutralizing the effluent. Manufacturers can provide guidance on potential column configurations.

The resins possess theoretical exchange capacities, defined as the number of ionic groups per unit weight or volume of the resin. The theoretical capacity is expressed in equivalents per volume (e.g., eq/ft^3) of resin. (NOTE: an equivalent per mole is defined as the molecular weight of a chemical species divided by its charge: grams/mole/charge. Equivalents are expressed in municipal wastewater treatment as grams of calcium carbonate, as a normalization technique for a wastestream with several contaminants. One equivalent is equal to 50 grams of calcium carbonate. The molecular weight of calcium carbonate is 100 g/mole and the change is 2; therefore, one equivalent is 100/2 or 50.) Theoretical capacity is not achievable during operations due to equilibrium, time, influent concentration, and economic considerations. The efficiency of a column of resin is defined as the operating capacity divided by the theoretical capacity. Determination of the operating capacity is accomplished during bench tests. Manufacturers provide samples of resins for bench-testing purposes.

The bench tests can be conducted using small-diameter glass columns packed with resin. By passing known quantities of wastewater through the column, measuring the conductivity (in millivolts), and sampling the effluent for analysis every few bed volumes, a relationship can be determined between the conductivity of the wastewater and the concentration of the contaminants. The result of this relationship is an operating capacity per unit volume of influent (i.e., the volume of resin required to treat a unit volume of wastewater).

The dimensions of the column are guided by several factors. The total volume is dependent on the desired time between backwashes (usually on the order of hours to days):

Total Column Volume = volume resin required per unit volume influent

X influent flow rate

X period of time between backwashes

A vertical cross section should allow a maximum 5 to 10 gpm/ft^2 (Weber, 1972), and most ion exchange columns are 2 to 6 feet high.

11-12.1.6 Performance. Ion exchange, when used on wastestreams with low suspended solids (i.e., less than 50 mg/ℓ [USEPA, 1987a]) and low TDS (i.e., 5,000 mg/ℓ [Patterson, 1985]), can exhibit high removal efficiencies for metals and other ionic inorganic species. Applications to organics are infrequent because many organics can permanently foul and degrade the resins.

Weak acid and base resins remove only strongly ionized cations and anions, but require less regeneration solution. Strong acid and base resins remove both weakly and strongly ionized species and require more regeneration solution than the weak resins. Table 11-8 presents work on ion exchange in industrial waste treatment (Patterson, 1985).

11-12.2 Evaluation of Ion Exchange

11-12.2.1 Effectiveness. Treatment using ion exchange is a permanent remedy, in that the selected ionic contaminants are permanently removed from the wastewater. Removal can be accomplished to the ppb level. However, ion exchange transfers the ions to a more concentrated solution. The residual is a waste solution highly concentrated with the exchanged ions. This wastewater must be further treated using precipitation, oxidation, or some other treatment method, or it must be disposed of as a hazardous waste. The resin, when used properly, has a long lifetime but may require replacement if permanent fouling occurs. Spent resins can be incinerated or landfilled at RCRA facilities.

11-12.2.2 Implementability. Ion exchange is in use in full-scale industrial wastewater treatment applications where the wastewater contains valuable recoverable metals. Municipal water treatment plants use ion exchange full-scale as a water softener (i.e., removal of dissolved calcium and manganese).

Full-scale exchange equipment is widely available from several resin manufacturers. The manufacturers provide consulting services and brochures to aid in selecting the appropriate resins and regenerates. Also, laboratory quantities of the resins are available for use in bench-testing. The regeneration solutions are generally common commercial-grade chemicals; therefore, they are also readily available. Periodically, the resin must be checked for degradation. The effluent must be sampled and analyzed to ensure that no pass-through will occur.

Several wastewater characteristics may preclude the use of ion exchange as an effective treatment. The wastewater must:

- have low suspended solids less than 50 mg/ℓ (USEPA, 1987a)
- have low total dissolved solids less than 5,000 mg/ℓ (Patterson, 1985)
- not contain cyanide (except ferrocyanides), ferrous iron, strong oxidants, oil and grease, or cadmium-cyanide compounds, because these may permanently foul or degrade the resin

TABLE 11-8
ION EXCHANGE APPLICATION SUMMARY

ION	WASTEWATER SOURCE	SCALE OF APPLICATION	MOST COMMON TREATMENT METHOD
Al^{3+}	--	Pilot	Precipitation
As^{5+}	Acid mine drainage	Full	Precipitation
Ba^{2+}	Groundwater	Full	Precipitation
Cd^{2+}	--	Full	Precipitation
Cr^{6+}	Chromium plating rinse water	Full	Reduction
Cr^{3+}	Dilute chromium plating rinse water	Full	Precipitation
Cu^{2+}	(dilute)	Full	Lime precipitation
CN^{-}	Not applicable - cyanide deteriorates resins		
F^{-}	Sodium fluoride solutions	Pilot	Activated alumina
Fe^{2+}	Acid mine drainage	Pilot	Precipitation
Fe^{2+}	Water treatment	Full	Ion exchange, coagulation
Pb^{2+}	Ammunition	Pilot	Precipitation, coagulation
Mn^{2+}	Water treatment	Full	Ion exchange, coagulation
Hg^{2+}	Chlor-alkali plants	Full	Ion exchange (polisher)
Ni^{2+}	Nickel sulfate plating bathwater	Full	Precipitation, ion exchange
Nitrate/Nitrite	Drinking water	Full	Biological, ion exchange
Se^{2-}	Sewage treatment	Pilot	Ion exchange, precipitation
Ag^{+}	Plating rinse water	Full	Precipitation, ion exchange
Zn^{2+}	Plating rinse water	Pilot	Precipitation

NOTE:

-- = Not available from text

SOURCE: Patterson, 1985

Additionally, large organic molecules can foul ion exchangers. Chemical cleaning can reduce the problem. Finally, other treatment equipment may be required to treat the residual backwash (e.g., oxidation, precipitation, or reduction equipment).

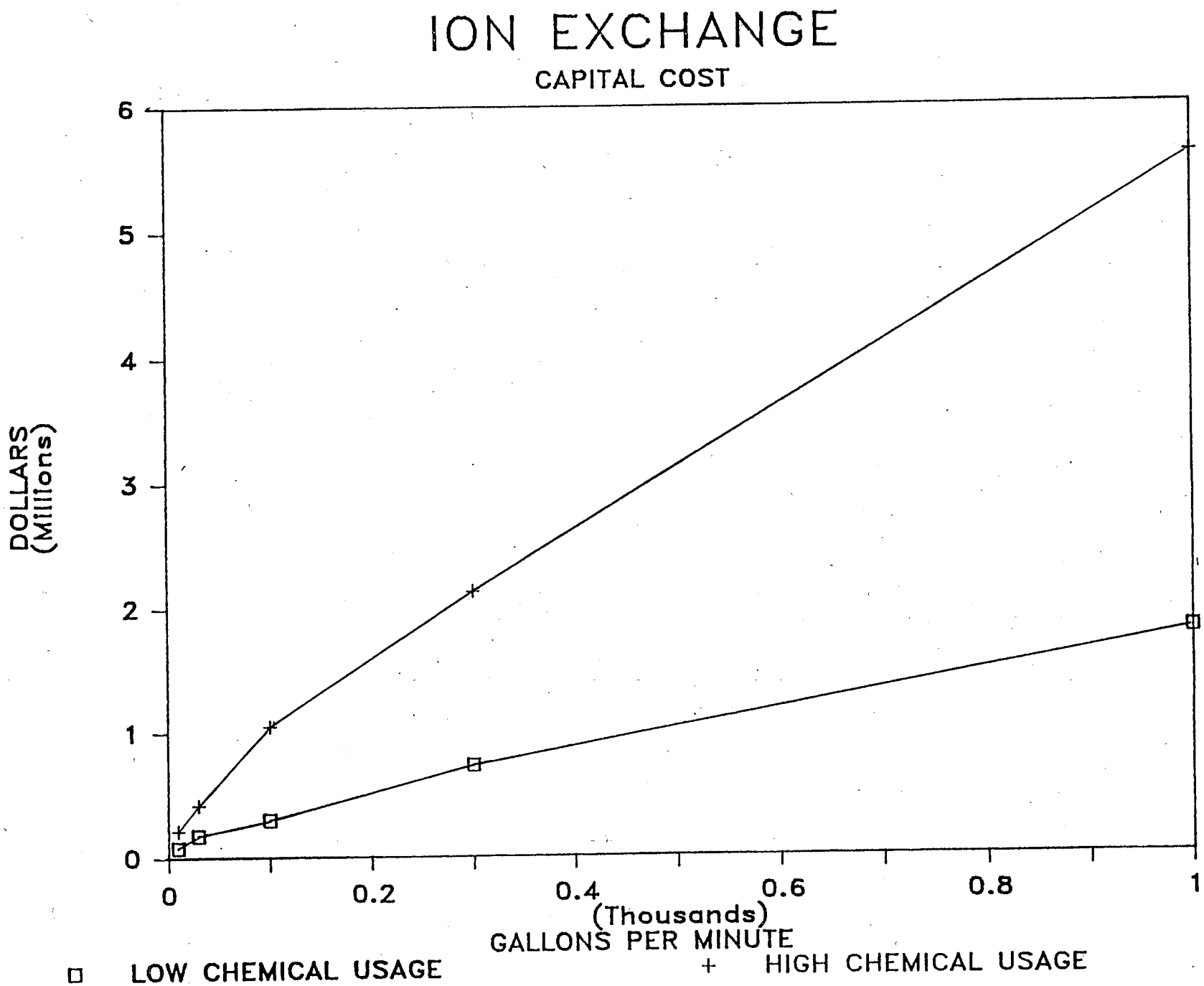
11-12.2.3 Cost. Capital cost estimates for treatment by ion exchange are presented in Figure 11-38. The figure shows two cost estimates that reflect the extremes of the treatability of wastewaters using ion exchange. The low chemical dose line on the figure represents a system using weak acid and base columns, with low chemical regenerant requirements. The high chemical dose line represents a system using strong acid and base columns, with high chemical regenerant requirements. The following list compares the design parameters used in creating the capital costs.

Design Assumptions	High Dose	Low Dose
Column cross-sectional area	5 gpm/ft^2	10 gpm/ft^2
Column depth	6 feet	3 feet
Regenerant (anion and cation)	20 lb/ft^3 resin	1 lb/ft^3 resin
Resin type	macroporous	gel

Both capital costs reflect dual columns in series with spare columns in parallel for continuous operation during regeneration. Also, both estimates include millivolt controllers to activate regeneration, with the appropriate valving, pumps, and storage tanks contained on a concrete pad with a retaining wall to contain any leaking substances.

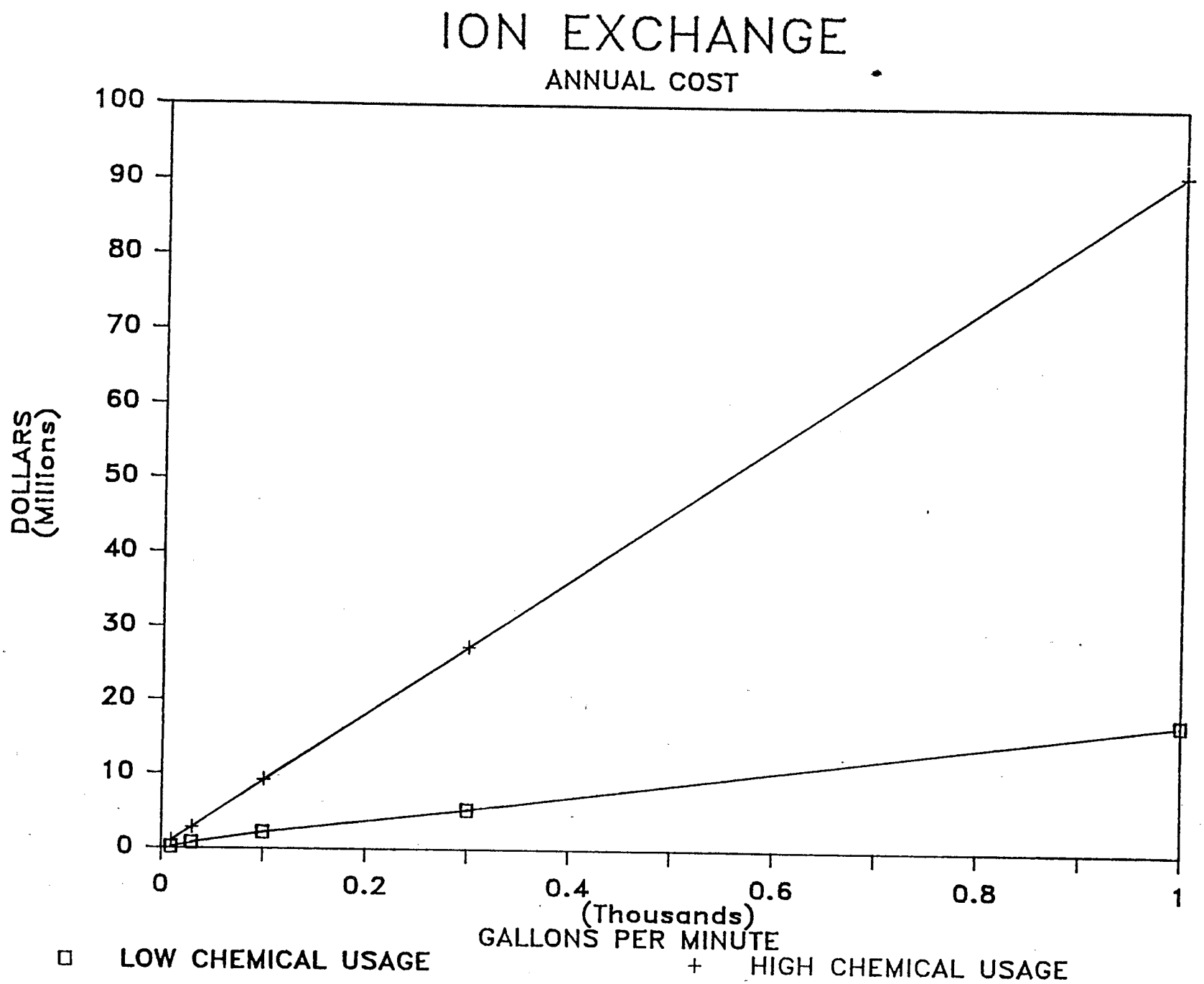
O&M cost estimates for the two systems are shown in Figure 11-39. The costs include operator labor, chemical regenerant requirements, spent regeneration solution disposal, resin replacement, and electricity.

The costs for the two chemical regenerant requirements correspond to low and high published doses (Weber, 1972). The low regeneration requirements parallel the capital cost for the weak acid and base resins, while the high regeneration requirements parallel the capital cost for the strong acid and base resins.



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-38
ION EXCHANGE - CAPITAL COSTS



NOTE: FIGURE SOURCES ARE INCLUDED IN REFERENCES AT THE END OF THIS SECTION.

FIGURE II-39
ION EXCHANGE - OPERATION AND MAINTENANCE COSTS

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

API	American Petroleum Institute
ARARs	Applicable or Relevant and Appropriate Requirements
BOD	biochemical oxygen demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COD	chemical oxygen demand
EDTA	ethylene-diamine-tetraacetic acid
F/M	food to microorganism
FS	Feasibility Study
GAC	granular activated carbon
gpm	gallons per minute
HRT	hydraulic retention time
ISP	insoluble sulfide precipitation
kg	kilogram
m	meter
mm	millimeter
mgd	million gallons per day
mg/ℓ	milligrams per liter
O&M	operation and maintenance
ORP	oxidation reduction potential
PAC	powdered activated carbon
POTW	publicly owned treatment works
ppb	parts per billion
ppm	parts per million
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
SRT	solids retention time
SSP	soluble sulfide precipitation
SVOC	semivolatile organic compound
TCE	trichloroethene
TDS	total dissolved solids
THM	trihalomethane
TOC	total organic carbon
TSS	total suspended solids

USEPA	U.S. Environmental Protection Agency
UV	ultraviolet
VOC	volatile organic compound

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SECTION 12

ORD TREATABILITY PROJECTS

SECTION 12 - ORD TREATABILITY PROJECTS. The USEPA Office of Research and Development (ORD) in Cincinnati, Ohio conducted research to support the evaluation for the potential to use POTWs to treat CERCLA and Resource Conservation and Recovery Act (RCRA) wastes. ORD, in conjunction with the Engineering Department at the University of Cincinnati, performed pilot-scale treatability studies at the EPA Testing and Evaluation Facility to generate treatability data for toxic organic compounds. Eight technical papers were produced as a result of the studies. Section 12 presents a list of the papers with a brief description of each study.

ORD TREATABILITY RESEARCH

The USEPA Office of Research and Development (ORD) in Cincinnati, Ohio, was contracted to conduct research supporting the evaluation for POTWs' potential to treat CERCLA and RCRA wastes. ORD, in conjunction with the Engineering Department at the University of Cincinnati, performed bench and pilot-scale treatability studies at the USEPA Test and Evaluation Facility to generate treatability data for RCRA and CERCLA organic compounds. Eight technical papers were produced as a result of the studies. Below is a list of the papers with a brief description of the purpose of each study:

1. "The Determination of Biodegradability and Biodegradation Kinetics of Organic Pollutant Compounds with the Use of Electrolytic Respirometry," Tabak et al., April 1989.

This report explains in detail the methodology of electrolytic respirometry which was used to determine acclimation periods and Monod and first-order degradation rate constants for approximately 50 RCRA and CERCLA compounds. This study supports the development of the treatability fate model by experimentally determining rate constants. The biodegradation data will also be used to validate a University of Cincinnati modeling routine which is being developed to estimate biological rate constants from an organic compound's physical structure.

2. "Biodegradation Studies With Selected Leachate Compounds Using Electrolytic Respirometry, Part I (September 1988), Part II (October 1988)," Tabak et al.

The purpose of this study was to experimentally determine biokinetic rate constants (i.e., maximum specific growth rate, half saturation constant, and yield coefficient) for six CERCLA compounds. Studies were initially performed at a concentration of 100 mg/l for each compound and consisted of measuring the oxygen uptake of microorganisms characteristic of an activated sludge plant.

3. "Prediction and Modeling of Biodegradation Kinetics of Hazardous Waste Constituents," Govind et al., April 1989.

The fate model being generated by ORD will have three methods to input a biodegradation rate constant. A user will be able to input his own value, select a value from an existing database, or use a submodel to estimate the rate constant from the organic compound's chemical structure. The biodegradation rate constant estimation methodology compared nine predicted values with experimentally derived values. The average error in prediction of the first-order degradation rate constant ranged from 13 to 85 percent for the compounds evaluated.

4. "Fate and Effects of RCRA and CERCLA Toxics in Anaerobic Digestion of Primary and Secondary Sludge," Dobbs et al.

Data on the fate of selected RCRA and CERCLA compounds in pilot-scale anaerobic digesters was presented in this paper. Both volatile and semi-volatile compounds did not appear to inhibit digester operation at the low digester input concentrations. In the RCRA study, methane and total gas production were 13 and 6 percent less, respectively, between test and control digesters. In the CERCLA study, methane production was not affected and total gas production was 12 percent less in the test digesters when compared to the control. Data indicated that volatile compounds were removed by volatilization and degradation while semi-volatile compounds were degraded or sorbed onto solids.

5. "Status Report: Development of a Fate Model for Organics in a Wastewater Treatment Plant," Govind et al., April 1989.

This report provided a brief description of individual models to describe volatilization, sorption, and biodegradation of organic pollutants discharged to a POTW. Flow charts were presented to describe the model process for each mechanism.

6. "The Effect of Carbon Tetrachloride on Anaerobic Digestion of Primary and Waste Activated Sludge," B.M. Wysock, March 1989.

This work studied: (1) the effect of carbon tetrachloride on anaerobic digestion of sludge; (2) the effect of carbon tetrachloride on various phases of anaerobic digestion of sludge; and (3) the effect of gas recirculation on the digester performance if carbon tetrachloride was present. Serum bottles and a pilot-scale digester were used in this study. The study concluded: (1) in serum bottle studies, up to 14 mg/l of carbon tetrachloride had no effect on gas production while up to 5 mg/l had no significant effect on digester performance in pilot-scale studies; (2) carbon tetrachloride affected mostly the methanogenic phase of digester operation; (3) acclimation and increased solids concentration within the digester could be utilized to treat carbon tetrachloride and avoid inhibition; and (4) recirculation of the gas did not impact volatile solids or volatile acid reduction.

7. "Treatability of RCRA Compounds in a BOD/Nitrification Wastewater Treatment System with Dual Media Filtration," Safferman et al.

This study utilized a pilot-scale extended aeration system to: (1) investigate the treatability and fate of selected RCRA pollutants in a nitrification process under both acclimated and unacclimated conditions; and (2) determine the effectiveness of effluent dual media filtration on the removal of RCRA pollutants. Pollutants were composited before addition to the system's influent stream. This report provided an extensive literature review on the nitrification process and modeling the fate of organic pollutants discharged to a POTW. The results can be summarized as follows:

- no inhibition effects of organic pollutants at mg/l levels on chemical oxygen demand removal (supported by discussions with ORD personnel);

- no inhibition effects of organic pollutants at mg/l levels on suspended solids removal;

- no inhibition effects of organic pollutants at mg/l levels on phosphorous removal;

- significant inhibition of ammonia removal at a composite organic spike concentration of 19.2 mg/l. Nitrification may have been inhibited at low concentrations, though ammonia reduction by secondary treatment was not inhibited until an influent concentration of 4.8 to 19.2 mg/l was reached. This result was supported by discussions with ORD personnel who provided a reference on pollutant concentrations and the associated percent nitrification inhibition;

- sorption not a significant removal mechanism for volatile compounds;

- little observed experimental difference between acclimated and unacclimated systems; and

- dual media effluent filters were only effective on removal of the strongly sorbed compounds.

8. "Treatability of RCRA and CERCLA Wastes in POTWs," Bhattacharya et al.

This report reviews the findings of the five pilot-scale research projects completed by the USEPA Office of Research and Development. The projects generated data regarding:

- pollutant concentrations that caused inhibition of POTW biological treatment process;

- biodegradation of organic pollutants.

In addition to these technical papers, ORD is currently developing a software package entitled, "Integrated Model for Predicting the Fate of Organics in Wastewater Treatment Plants." The model will attempt to simulate the fate of organic compounds in a wastewater treatment plant.

SECTION 13

WERL TREATABILITY DATA BASE

SECTION 13 - WERL TREATABILITY DATA BASE. The USEPA Water Engineering Research Laboratory (WERL) developed and is continuing to expand a data base containing information on the treatability of compounds in various types of waters and wastewaters. The data base consists of selected published data taken from government reports and data bases, peer reviewed journals, and various other publications. Each source was reviewed by a quality review committee before including it in the data base. In addition to treatability data, the data base contains chemical and physical properties, environmental data, and adsorption data for specific compounds, where available. Section 13 contains instructions for loading the data base onto a computer.

For any additional information concerning the WERL data base contact:

Mr. Kenneth A. Dostal
Risk Reduction Engineering Laboratory
Environmental Protection Agency
26 W. Martin Luther King Drive, Rm 191
Cincinnati, Ohio 45268

(513) 569-7503

TO LOAD WERL TREATABILITY DATABASE PROGRAM

COPY DISK 1 TO THE COMPUTER HARD DRIVE, IN A SUBDIRECTORY. TO DO THIS, AT THE SUBDIRECTORY PROMPT (SUCH AS C:\DBASE\EPA\) TYPE

```
COPY A:*.*   [ENTER]
```

COPY DISKS 2, 3, AND 4 TO THE SAME SUBDIRECTORY BY TYPING AT THE PROMPT:

```
COPY A:*.*   [ENTER]
```

THE FILES ON THE DISKS HAVE BEEN "ARCHIVED", ALLOWING US TO USE THE DISKS MORE EFFICIENTLY AND MINIMIZE THE NUMBER REQUIRED. TO RUN THE PROGRAM THE FILES MUST BE UNARCHIVED. TO UNARCHIVE THE PROGRAMS TYPE THE FOLLOWING, AT THE SUBDIRECTORY PROMPT, TYPE:

```
EPALOAD      [ENTER]
```

THE FOLLOWING MESSAGES WILL APPEAR ON SCREEN:

```
PKARC FAST! . . . . . . . . . .
UNARCING . . . .
UNSQUASHING . . . .
UNCHRUNCHING . . . .
        ETC . . . .
```

WHEN UNARCHIVING OF THE FILES IS FINISHED THE COMPUTER AUTOMATICALLY RETURNS TO THE SUBDIRECTORY PROMPT. TO RUN THE PROGRAM AT THE PROMPT TYPE:

```
MAIN   [ENTER]
```

THE UNARCHIVING NEED ONLY BE DONE THIS ONE TIME. FROM THEN ON TO RUN THE PROGRAM ENTER THE SUBDIRECTORY AND TYPE:

```
MAIN    [ENTER]
```

SECTION 14

FATE MODEL

SECTION 14 - FATE MODEL - As part of the CERCLA Site Discharges to POTWs study, a user friendly, computerized model has been developed to evaluate the fate of inorganic and organic pollutants discharged to POTWs. POTW managers and feasibility study writers can use the model to evaluate the fate and treatability of toxic pollutants discharged to POTWs by predicting the overall percent removal of the compounds and percent removals of organic compounds due to volatilization, sorption, and biodegradation.

The FATE User's Manual, provided in Section 14, introduces the user of the model to the concepts and assumptions used in its development and presents simple instructions for the model's operation.

FATE

FATE AND TREATABILITY ESTIMATOR FOR CONVENTIONAL ACTIVATED SLUDGE TREATMENT PLANTS

USERS' MANUAL

OFFICE OF WATER REGULATIONS AND STANDARDS
OFFICE OF WATER
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC

◆JUNE 1990◆

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1. INTRODUCTION

This manual describes the uses and components of the EPA Fate and Treatability Estimator (FATE) Model. This model was developed to help users understand the fate and treatability of pollutants in wastewaters discharged to conventional activated sludge Publicly Owned Treatment Works (POTWs). It aids the user in evaluating whether pollutants in an influent to a POTW are sorbed onto sludge, are volatilized off into the atmosphere, or are biodegraded. The software also will estimate the amount of the pollutant in each process end point of the model, as well as percent total removal from the wastewater influent stream.

The FATE model has the capability to evaluate the treatability of both inorganic and organic pollutants discharged to a POTW. Since inorganic and organic compounds are removed by different physical and chemical processes in a POTW, FATE consists of separate models for organic fate analysis and inorganic fate analysis.

The calibration and validation of the FATE model is based on actual plant data from a recent nation-wide survey of domestic POTWs. Plant performance data used in the calibration and validation was obtained from actual measurements of the influents and effluents of the surveyed POTWs.

The major assumptions used in developing the FATE model are:

1) The model is for conventional diffused aeration activated sludge sewage treatment plants only.

2) No significant volatilization or biodegradation occurs in the primary clarifier.

3) All reactors are completely mixed.

4) Steady state is assumed to exist in all reactors (e.g., aeration basin and clarifiers) so that pollutant concentrations in a reactor do not change over time. (Thus, the model may not be as accurate for plants with pulse inputs of pollutants).

5) Liquid inflow equals liquid outflow.

6) For volatilization, the concentration of the organic compound of interest is assumed to be negligible in the inlet gas used for aeration.

7) For volatilization, the partial pressure of an individual compound in the gas exiting the aeration basin is in equilibrium with the individual compound concentration in the aeration basin liquid.

8) Sorption partitioning follows a linear relationship between concentrations in the liquid and solid phases.

9) Biodegradation follows Monod kinetics and the organic compound influent concentration is assumed to be much less than the Monod half-saturation coefficient (i.e., influent concentrations are at relatively low levels).

10) For the biodegradation model step, it is assumed that a compound is removed by secondary utilization.

11) The fate of a compound is not affected by the presence of other compounds except as may be inherent in the data used for model calibration.

12) The POTW is operating effectively and no inhibition of the biological process is occurring.

13) For model calibration, measured effluent concentrations reported as not detected were assumed to equal half the reported detection limit.

14) The organic model was calibrated with all compounds grouped together rather than by individual compound.

15) Removal mechanisms (volatilization, biodegradation, and sorption in the primary and secondary clarifiers) were estimated using final effluent concentration data and best engineering judgement.

16) Data for bis(2-ethylhexyl)phthalate, di-n-octyl phthalate, aldrin, and alpha-BHC were not used for final calibration due to inconsistencies in the analytical data compared to other compounds within similar classes.

17) Total removal of compounds primarily removed by sorption may be slightly overpredicted, while compounds primarily removed by volatilization and biodegradation may be slightly underpredicted.

A printout listing these assumptions may be obtained using the **Print** option, which is explained in Section 5.6.

Section 2.0 - Installation describes the system package contents, the program's hardware and software requirements, and steps for installing the program for use on an IBM compatible personal computer (PC).

Section 3.0 - Tutorial guides the user through an example session.

Section 4.0 - Operation Modes describes the different modes of operation and the functions they perform in using the model.

Section 5.0 - Reports discusses printed report options and reports of the databases, including single compound and multiple compound reports.

A glossary, index, appendices with warning errors and messages, a technical description of the model, a list of organic and inorganic compounds FATE is capable of modeling, a description of the four databases which FATE uses, and a FATE model map of cursor key movements follow at the end .

2. INSTALLATION

When you receive the FATE diskette, the following files should be available:

FILE NAME	EXTENSION
FC	DBF
CO	DBF
CI	DBF
CV	DBF
HELP	DBF
HELP	DBT
HELP	NTX
FCFCL	NTX
FCSEL	NTX
COCMP	NTX
CICMP	NTX
CISEL	NTX
COSEL	NTX
CVPRM	NTX
FATE	EXE
INSTALL	BAT

If any of these files are missing or are damaged, the program will not run.

FATE may be run on any IBM compatible or near compatible computers with a minimum of 384K of available memory. Installing FATE is a simple process using the INSTALL program and the following directions:

1. Insert FATE diskette No. 1 into the selected disk drive.

2. Type the following commands after the prompt:

A: <ENTER>

INSTALL A: C:<ENTER>

If FATE is located in a drive other than A, type the letter of that drive instead of A in the commands above.

The install program creates a subdirectory entitled EPA FATE and copies the files to this subdirectory. After FATE has been installed, the user is automatically in the C:\EPA FATE subdirectory.

NOTE

It is very important to backup the five database files (files with the DBF extention) in case the files get damaged. You should also maintain a backup copy of the entire FATE diskette. Backup the files prior to attempting to run the model.

3. TUTORIAL

In this section you will be shown how to run the FATE model. FATE has many options, only a few of which will be displayed in this tutorial. Other functions are described in succeeding chapters of this manual.

3.1. Using FATE

In order to run FATE, you must be in the appropriate subdirectory containing the FATE programs. Once you are in this directory, at the prompt, simply type:

FATE

After two header screens, FATE's main data screen will appear as below:

```
                                                                                SLCT
SELECT  FACILITY:   3/3   TYPE          SELECT ORGANIC:   1/345      TYPE mg/l
        LARGE                 *          1,1'-Biphenyl-4,4'-diamine *   0.1000
        MEDIUM                *          1,1,1,2-Tetrachloroethane  *   0.1000
        SMALL                 *          1,1,1-Trichloroethane      *   0.1000
                                         1,1,2,2-Tetrachloroethane  *   0.1000
Plant flow (Q)            140.0  MGD     1,1,2-Trichloroethane      *   0.1000
Pri sludge flow (Qp)   400000    gpd     1,1-Dichloroethane         *   0.1000
Pri sludge conc (Xp)        4.00  %
Acr basins vol (V)   39207700    gal     CAS NUMBER        119904
MLSS (Xi)                3000   mg/l     Henry's Law constant       1.00E-11 M
Gas flow rate (G)   245514000   cf/d     Log of octanol/water       1.46     M
Waste sludge flo(Qw)  1232000    gpd     Log of bio rate           -3.000    E
Waste sludge conc (Xv)      0.75  %

<F2>-EDIT   <F3>-COPY   <F4>-ADD   <F5>-DELETE   <F10>-MORE KEYS
```

Figure 3-1

NOTE

No matter what function is performed, FATE will always return you to this screen.

This screen is divided into two halves: facility information on the left and pollutant information on the right. The left section displays facilities and their corresponding operating parameters. Note that the operating parameters displayed in the lower left section correspond to the specific facility highlighted in the upper left section. The user has the option of creating his/her own facility with specific operating parameters. The right half of the screen displays information concerning the pollutants contained in the compound data bases. The upper right section lists compounds and the lower right section displays the chemical constants for the compound highlighted in the upper right. At the bottom of the screen, the function keys are defined. For more information on the function keys, refer to Section 4.1.3.

In order to move between screens, you must use the right and left arrow keys on your keyboard. The arrow keys do not allow access to the lower half of the display for any facility or compound that is marked with an '*' in the column titled **TYPE**. These facilities and compounds cannot be altered in any way since they are the default parameters. Access to the lower half of the display will be discussed in Section 4.2.

NOTE

If your keyboard does not have dedicated keys for arrows, then use the number pad to the right of the main key board with the numbers lock disabled so that the arrow keys may be used.

3.2. Selecting a Facility

In this section you will learn how to run FATE using a default facility ('**SMALL**,' '**MEDIUM**,' or '**LARGE**'), and how to run FATE for a facility that you have created.

3.2.1. Selecting an Existing Facility

A facility is selected by moving the cursor with the up or down arrow keys to the desired facility and pressing the **<SPACE>** bar. A yellow '#' will appear to the left of the chosen facility. FATE informs you that you are in the selection mode when "SLCT" appears in the uppermost right hand corner of the screen. For more information on modes of operation, refer to Section 4.0 of this manual.

> **NOTE**
>
> Only one facility at a time may be chosen. A facility must be chosen in order for FATE to run.

Example: Choose the 'MEDIUM' facility:

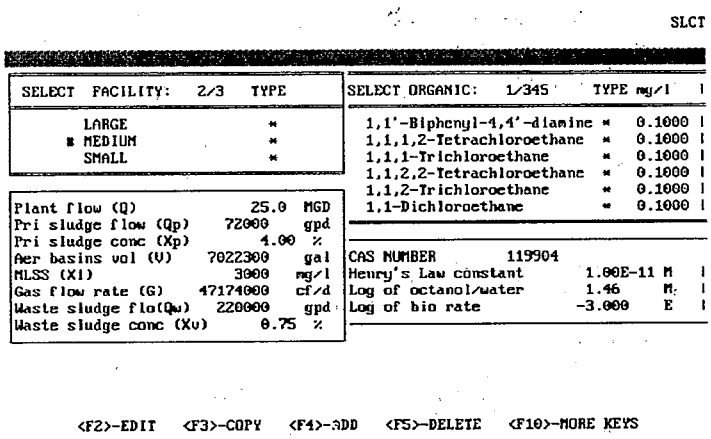

Figure 3-2

The 'MEDIUM' facility has now been chosen for a FATE run. If you press the **<SPACE>** bar again, the '#' will disappear, and the facility is no longer chosen for a FATE run. You now have the option of selecting a new facility.

3.2.2. Selecting and Creating A New Facility

You may want to run FATE for a facility not included as a default. To add a new facility press the **<F4>** function key (which is called '**ADD**,' at the bottom of the screen). Figure 3-3 shows what the screen should look like. Use of the function keys are described in more detail in Section 4.1.3.

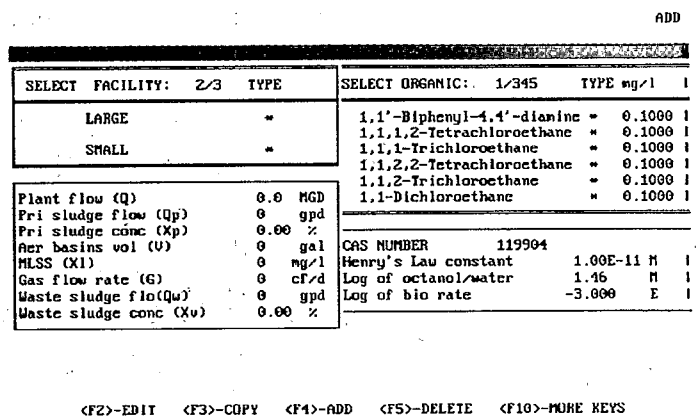

Figure 3-3

Now you are able to input data from any POTW you wish. First, type the name of the POTW you wish FATE to model. For example, type 'PORTLAND MAINE' in the facility name box, and press **<ENTER>**. Note that you are now in the **TYPE** column. Enter a letter or symbol for your own records, or simply leave it blank, then press **<ENTER>**. The cursor should now be blink-

ing at the first entry for the facility parameter section, which is Plant Flow Rate. FATE now asks for PORTLAND MAINE's plant operating parameters. For the first entry, **Plant rate (Q)**, assume PORTLAND MAINE's plant flow rate is 50 MGD. Type in this number, and press **<ENTER>**. Follow the same procedure for the remaining plant parameters:

Plant Parameter:	Enter this value:	Unit:
Qp (Primary Sludge Flow Rate)	75000	GPD
Xp (Primary Sludge Concentration)	4	%
V (Volume of the Aeration Basins)	10000000	GAL
Xl (Mixed Liquor Suspended Solids)	4000	MG/L
G (Gas Volumetric Flow Rate)	100000000	cf/d
Qw (Wasted Sludge Flow Rate)	250000	GPD
Xv (Wasted Sludge Concentration)	2	%

You should now be viewing a screen which looks like Figure 3-4.

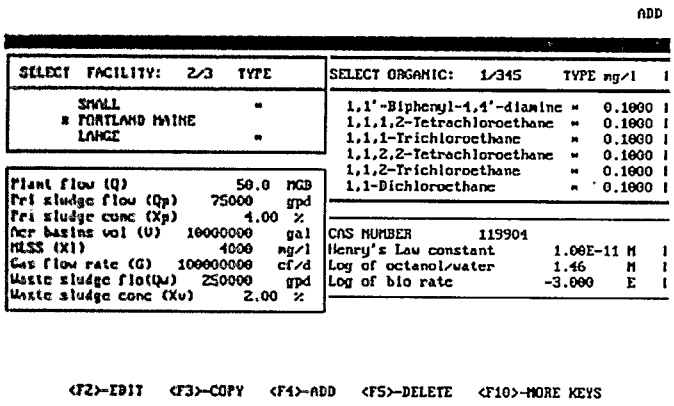

Figure 3-4

NOTE

You do not have to use the units provided. For further instruction on unit conversion, read on.

After pressing the **<ENTER>** key for Xv (Wasted Sludge Concentration), FATE asks you if you want to accept the data shown on the screen or continue to edit the facility parameters. As you have all the data you need typed in the appropriate boxes, press **'Y'** and FATE will store PORTLAND MAINE's facility parameters in the database.

For more information on the aspects of creating your own facility, please refer to Section 4.1.3 of this manual.

FATE will allow input of these plant parameters in units of measure other than those that appear on the screen. For example, while the cursor still appears in front of the PORTLAND MAINE facility, press **<F2>** to invoke the **Edit** command. This key allows you to change information already typed in the facility fields. Now, arrow down to Xp (Primary Sludge Concentration). While holding the **<SHIFT>** key, press **<F2>** again. Your screen should now be similar to Figure 3-5.

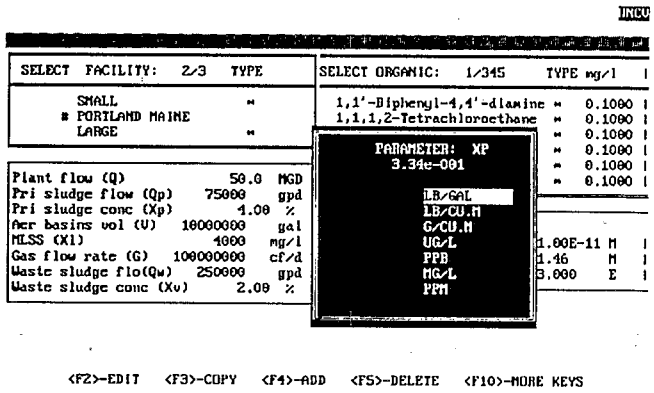

Figure 3-5

Example: Your POTW keeps track of the primary sludge concentration in units of mg/l and the value is 35,000 mg/l. Arrow down to the 'mg/l' option, and press **<ENTER>**. Type in '35000', and your screen should look like Figure 3-6. Now, when you press **<ENTER>**, the pop-up screen should disappear, and in place of the '4%' you typed in previously, Xp will be '3.5 %'. (Figure 3-7)

```
                                                                    INCU
SELECT  FACILITY:   2/3   TYPE        SELECT ORGANIC:   1/345     TYPE mg/l   |
                                      1,1'-Biphenyl-4,4'-diamine *   0.1000 |
      LARGE                 *         1,1,1,2-Tetrachloroethane  *   0.1000 |
    # PORTLAND MAINE                                             *   0.1000 |
      SMALL                 *                                    *   0.1000 |
                                                                 *   0.1000 |
                                                                 *   0.1000 |
Plant flow (Q)              50.0  MGD
Pri sludge flow (Qp)      75000   gpd
Pri sludge conc (Xp)       4.00   %
Aer basins vol (V)    10000000    gal
MLSS (X1)                 4000    mg/l
Gas flow rate (G)    100000000    cf/d
Waste sludge flo(Qw)    250000    gpd
Waste sludge conc (Xw)     2.00   %

                                                                 1.00E-11 M   |
                                                                 1.46     M   |
                                                                 3.000    E   |

<F6>-UNMARK   <F7>-GROUP MARKS   <F8>-CAS SEARCH   <F10>-MORE KEYS
```

PARAMETER: XP
4.00e+004

LB/GAL
LB/CU.M
G/CU.M
UG/L
PPB
35000 MG/L
PPM

Figure 3-6

```
                                                                    SLCT
SELECT  FACILITY:   4/4   TYPE        SELECT ORGANIC:   1/345     TYPE mg/l   |
                                      1,1'-Biphenyl-4,4'-diamine *   0.1000 |
      LARGE                 *         1,1,1,2-Tetrachloroethane  *   0.1000 |
    # PORTLAND MAINE                   1,1,1-Trichloroethane      *   0.1000 |
      MEDIUM                *         1,1,2,2-Tetrachloroethane  *   0.1000 |
                                      1,1,2-Trichloroethane      *   0.1000 |
                                      1,1-Dichloroethane         *   0.1000 |
Plant flow (Q)              50.0  MGD
Pri sludge flow (Qp)      75000   gpd
Pri sludge conc (Xp)       3.50   %
Aer basins vol (V)    10000000    gal
MLSS (X1)                 4000    mg/l
Gas flow rate (G)    100000000    cf/d
Waste sludge flo(Qw)    250000    gpd
Waste sludge conc (Xw)     2.00   %

                                      CAS NUMBER        119904
                                      Henry's Law constant       1.00E-11 M   |
                                      Log of octanol/water       1.46     M   |
                                      Log of bio rate           -3.000    E   |

</>-MENU   <F1>-HELP   <F10>-MORE KEYS
```

Figure 3-7

For more information on this feature of FATE refer to Section 4 of this manual. In order to continue with the model run press the **<ESC>** key and, as before, press '**Y**', and FATE will return you to the upper half display of the facility database.

Select the PORTLAND MAINE facility as described previously. If FATE tells you that a facility has already been selected, simply arrow up or down to the facility which has a '#' in front of its facility name, and press the **<SPACE>** bar. Be sure that a '#' appears in front of the PORTLAND MAINE facility before continuing.

3.3. Selecting a Compound

In this section you will learn how to choose a compound for a FATE run. FATE allows you to choose an organic or an inorganic compound. The upper right section of the screen displays the organic compound list. If you use the right arrow key, the inorganic compound listing will appear in the upper right corner of the screen.

Using the right arrow key, move the cursor from the PORTLAND MAINE facility over to the organic compound list. For further information on the separate databases please refer to Appendix D. Selecting a compound is accomplished in the same manner as selecting a facility; move the cursor to the desired compound using the up or down arrow key, press the **<SPACE>** bar and a '#' will appear to the left of the compound name. FATE now asks you to enter the influent concentration of the compound you have chosen. You may either choose the default concentration (0.100 mg/l) or input some other concentration. Press **<ENTER>** and FATE asks you to accept what is on the screen; press '**Y**'.

NOTE

If physical/chemical constants are not available for a compound, FATE will not allow you to select it for a model run.

If you do not wish to run a compound you have already selected, press the <SPACE> bar again, and the '#' will disappear. There is no limit to the number of compounds FATE can run at one time.

FATE has a few special features which will make selecting a compound easier. If the compound you wish to choose is not shown on the immediate screen, you may press the first letter or number of the compound you wish to choose, and FATE will take you to the area in its database where that compound is listed. The compounds are listed in the database in numerical and then alphabetical order.

Example 1: Suppose you wish to choose 'Benzene'. Simply press the letter **'B'**, and FATE will take you to the first compound beginning with the letter 'B' - 'Benzanthrone' (Figure 3-8). FATE tells you which compound is highlighted in the bottom center of the screen, just above the Function Key Menu. In our case, 'Benzathrone' is written. Now, arrow down to 'Benzene', and press the **<SPACE>** bar. FATE now asks you to enter the influent concentration of the compound you have chosen. You may either choose the default concentration (0.100 mg/l) or input some concentration of benzene. Press **<ENTER>** and FATE once again asks you to accept what is on the screen; press **'Y'**. 'Benzene,' at the selected influent concentration, is now chosen for a FATE run.

Another way to choose a compound is by performing a CAS number search. FATE allows you to do this by pressing the **<F8>** key,

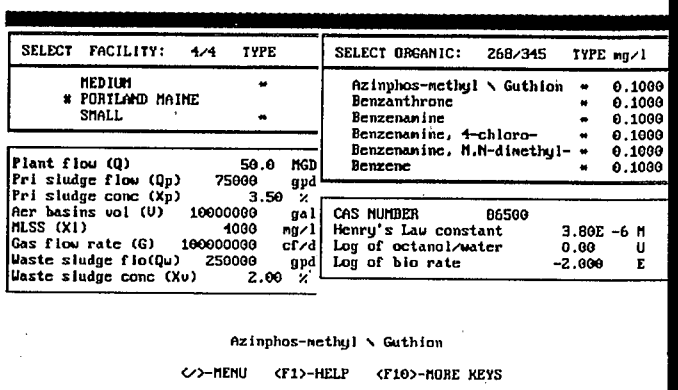

Figure 3-8

as indicated at the bottom of the screen in the Function Key Menu. FATE asks you for the CAS number of the compound you wish to choose.

Example 2: Choose bis(2-ethylhexyl) phthalate which has a CAS number of '117817'. Press **<F8>**, type **<117817>**, press **<ENTER>**, and FATE will bring you to the section of its database where bis(2-ethylhexyl) phthalate is listed. Once again, press the **<SPACE>** bar and input the concentration of bis(2-ethylhexyl) phthalate, say 0.100 mg/l; press **<ENTER>** again to accept the screen.

Example 3: Use the right arrow key to obtain the inorganic compound list. To choose 'nickel' you may arrow down until this compound is highlighted on the screen, or you may simply press **'N'** and FATE will take you to the portion of the database where the inorganic compounds beginning with **'N'** are listed. Press the space bar and a '#' will appear to the left of the compound name.

As with the facility database, compounds can be added or copied for editing of the default

parameters. For more information see Section 4.1.3, Function Keys, of this manual.

A facility (PORTLAND MAINE) and three compounds (benzene, bis(2-ethylhexyl) phthalate, and nickel have been selected). FATE is now ready to run.

3.4. Running/Printing

In this section you will learn how to run the FATE model and how to print the results.

In order to run the FATE model, you must access the **Menu Mode** by pressing the </> (forward slash) key. The menu will appear at the top of the screen (Figure 3-9). Use the left or right arrow key to work your way across the menu options, and highlight the '**Run**' option. Press **<ENTER>** and FATE runs for the first selected organic compound.

```
                                                                                SLCT
SELECT  FACILITY:   4/4   TYPE                SELECT ORGANIC:   129/345   TYPE mg/l
      MEDIUM                  *                 Azinphos-methyl \ Guthion  *   0.1000
    # PORTLAND MAINE                            Benzanthrone               *   0.1000
      SMALL                   *                 Benzenamine                *   0.1000
                                                Benzenamine, 4-chloro-     *   0.1000
                                                Benzenamine, N,N-dimethyl- *   0.1000
                                              # Benzene                    *   0.1000

Plant flow (Q)              50.0  MGD
Pri sludge flow (Qp)     75000    gpd
Pri sludge conc (Xp)        3.50  %
Aer basins vol (V)   10000000    gal
MLSS (Xl)                 4000   mg/l
Gas flow rate (G)   100000000   cf/d
Waste sludge flo(Qw)   250000    gpd
Waste sludge conc (Xv)      2.00  %

                                                CAS NUMBER        71432
                                                Henry's Law constant      5.55E -3 M
                                                Log of octanol/water      2.13     M
                                                Log of bio rate          -2.000    E

                                                Benzene

<F2>-EDIT   <F3>-COPY   <F4>-ADD   <F5>-DELETE   <F10>-MORE KEYS
```

Figure 3-9

Figure 3-10 is an example of the screen displaying the results for the PORTLAND MAINE facility and benzene. Note the total percent removal and the effluent concentration (labeled overall removal and sec. eff. conc, respectively) are reported in the lower right hand corner of this pop-up screen. Also note that the mechanism removals [primary sorption (pri. sorbed), secondary sorption (sec. sorbed), volatilization (volatized) and biodegradation (biodegraded)] are rounded off to the nearest integer, and therefore do not exactly total to the reported overall percent removal. (For further information on screen Reports, refer to Section 5.1 of this manual.) To run FATE for the second and third compounds, successively press **<ENTER>** or any other key, and the results for bis(2 ethylhexyl) phthalate and then nickel will appear, respectively. When FATE has finished running all the compounds selected, press **<ENTER>** and the cursor will return to the menu.

```
Ru  COMPOUND: Benzene
    FACILITY: PORTLAND MAINE                          Press any key to continue...

    pri. influent conc.          0.1000 mg/l    pri. sorbed        1      %
    pri. sorpt. rem. rate        0.49   lb/dy   sec. sorbed       10      %
    pri. clar. eff. conc.        0.0988 mg/l    volatilized       43      %
    vol. rem. rate              17.95   lb/dy   biodegraded       13      %
    bio. rem. rate               5.32   lb/dy   overall removal   67      %
    sec. sorpt. rem. rate        4.25   lb/dy   sec. eff. conc.   0.0328 mg/l

Plant flow (Q)              50.0  MGD
Pri sludge flow (Qp)     75000    gpd
Pri sludge conc (Xp)        3.50  %
Aer basins vol (V)   10000000    gal
MLSS (Xl)                 4000   mg/l
Gas flow rate (G)   100000000   cf/d
Waste sludge flo(Qw)   250000    gpd
Waste sludge conc (Xv)      2.00  %

                                                CAS NUMBER        71432
                                                Henry's Law constant      5.55E -3 M
                                                Log of octanol/water      2.13     M
                                                Log of bio rate          -2.000    E

                                                Benzene

<F6>-UNMARK   <F7>-GROUP MARKS   <F8>-CAS SEARCH   <F10>-MORE KEYS
```

Figure 3-10

In order to obtain a printout of the FATE results, press the </> key to return to the menu, arrow over to the '**Print**' option of the menu, and press **<ENTER>**. You are now allowed to select a single compound report or a summary report for multiple compounds. A single report prints an extensive FATE analysis, the compound information and the facility parameters for one compound only. If more than one compound is selected, a single report

will be generated for the last compound selected. A multiple report prints facility parameters, effluent concentrations and percent removals for all compounds chosen. Arrow over to **'Single'**, and press **<ENTER>**. Your printer will give you a report which will be similar to Figure 3-11. Once FATE returns you to the menu, arrow over to **'Multiple'**, and press **<ENTER>**. Now, your printer will give you a report which will be similar to Figure 3-12.

These are the report options you have for obtaining printouts of FATE results. For further information and discussion of the results obtained, see Section 5 of this manual.

You have now seen what FATE can accomplish. This tutorial was meant to be only an introduction to the FATE model. The model has many options which are not discussed in this tutorial, but are discussed in detail in other sections of this manual. In addition, Appendix E contains a FATE model map of cursor key movements for quick and easy reference.

```
                    Fate And Treatability Estimator
                  for Conventional Activated Sludge
                    Publicly Owned Treatment Works

                          Version 1.05
                            05/22/90

                    ABB Environmental Services, Inc.
                          Portland, Maine

                  U. S. Environmental Protection Agency
              Industrial Technology Division, Washington, DC

COMPOUND: Nickel
    Primary coefficient................ RW   =      130.00  mg/l
    secondary coefficient............... ML   =     1000.00  mg/l
    plant influent concentration....... Si   =       0.1000  mg/l

FACILITY: Portland maine
    plant flow......................... Q  =          50  MGD
    primary sludge flow rate........... Qp =       75000  gpd
    primary sludge concentration........ Xp =         3.5  %
    total volume of aeration tanks...... V  =    10000000  gal
    temperature of aeration basins...... T  =          20  C
    mixed liquor suspended solids....... Xl =        4000  mg/l
    total gas volumetric flow rate...... G  =   100000000  ft3/d
    secondary wasted sludge flow rate... Qw =      250000  gpd
    concentration of wasted sec. sludge. Xv =         2.0  %

MODEL RESULTS:
    Removal in Primary Clarifier(s):
    primary removal rate................   =        9.23  lbs/day
    primary clarifier effluent conc..... So =        0.08  mg/l

    Removal in Aeration Tank(s) and Secondary Clarifier(s):
    secondary removal rate..............   =        1.31  lbs/day

    Overall removal rate................   =       10.55  lbs/day

    Final effluent concentration........   =      0.0752  mg/l

    Overall percent removal.............   =        25.3  %
```

Figure 3-11

```
                    Fate And Treatability Estimator
                  for Conventional Activated Sludge
                    Publicly Owned Treatment Works

                          Version 1.05
                            05/22/90

                    ABB Environmental Services, Inc.
                          Portland, Maine

                  U. S. Environmental Protection Agency
              Industrial Technology Division, Washington, DC

FACILITY: PORTLAND MAINE
    plant flow......................... Q  =          50  MGD
    primary sludge flow rate........... Qp =       75000  gpd
    primary sludge concentration........ Xp =         3.5  %
    total volume of aeration tanks...... V  =    10000000  gal
    temperature of aeration basins...... T  =          20  C
    mixed liquor suspended solids....... Xl =        4000  mg/l
    total gas volumetric flow rate...... G  =   100000000  ft3/d
    secondary wasted sludge flow rate... Qw =      250000  gpd
    concentration of wasted sec. sludge. Xv =           2  %

Influent      Effluent      ----------------Percent Removals----------------
Conc. mg/l    Conc. mg/l    Total    Sorption   Volatilization  Biodegradatio
==========================================================================
Benzene
     0.1000       0.0328    67.1    1.2 / 10.2       43.0          12.8
bis(2-Ethylhexyl) phthalate
     0.1000       0.0000   100.0   70.5 / 29.5        0.0           0.0
Nickel
       0.10         0.08    25.3
```

Figure 3-12

4. OPERATION MODES

The FATE model is composed of two modes of operation: the **Selection Mode** and the **Menu Mode**. This section describes the two modes of operation in detail.

4.1. SELECTION MODE

When the user starts the FATE model program, the **Selection Mode** is automatically displayed. The **Selection Mode** is indicated by the letters **"SLCT"** in the upper right hand corner of the display screen. From the **Selection Mode** the user can view the default parameters of the facility database, the organic compound database, and the inorganic compound database. Two of the three databases will be displayed on the screen at the same time: either the facility and organic compound database or the facility and inorganic compound database.

NOTE

If your keyboard does not have dedicated keys for arrows, then use the number pad to the right of the main keyboard with the numbers lock disabled so that the arrow keys may be used.

4.1.1. SELECTING A FACILITY

This section provides instructions for selecting a facility to perform a FATE run.

The upper left of the facility screen displays the names of all facilities contained in the facility database. Those facilities marked with an asterisk (*) in the **TYPE** column are defaults and cannot be altered in any way. The asterisk facilities are named **'SMALL'**, **'MEDIUM'**, and **'LARGE'** and contain operating plant parameters which are representative of a range of plant flow rates.

The user may view plant parameters for any facility; these are listed in the lower left section of the screen:

Plant flow (Q)	Plant Flow Rate
Pri sludge flow (Q_p)	Primary Sludge Flow Rate
Pri sludge conc (X_p)	Primary Sludge Concentration
Aer basins vol (V)	Total Volume of Aeration Basins
MLSS (X_l)	Mixed Liquor Suspended Solids
Gas flow rate (G)	Gas Volumetric Flow Rate to Aeration Basins
Waste sludge flo (Q_w)	Secondary Wasted Sludge Flow Rate
Waste sludge conc (X_v)	Secondary Wasted Sludge Concentration

A facility is selected by moving the cursor with the up or down arrow key to the desired facility and pressing the **<SPACE>** bar. A yellow **'#'** will appear to the left of the chosen facility.

NOTE

Only one facility at a time may be chosen. A facility must be chosen to run FATE.

If you press the **<SPACE>** bar again, the '#' sign will disappear; the facility is no longer chosen for a FATE run, and you have the option of selecting a new facility. For further information on adding/editing a user added facility refer to Section 4.1.3, Function Keys.

4.1.2. SELECTING A COMPOUND

FATE allows the user to select either organic or inorganic compounds. The upper right section of the screen displays the organic compound list. Using the right arrow key while the organic compound list is displayed will move the user to the inorganic compound list.

In the lower right hand corner of the screen, FATE displays chemical information on the pollutant that is highlighted.

Chemical information for a highlighted organic compound includes the Chemical Abstract System (CAS) Number, the Henry's Law Constant, the log octanol/water partition coefficient constant and the biodegradation rate constant. The values of these constants are either measured, estimated, or unavailable and FATE indicates this with 'M', 'E', or 'U' written after the constant's values.

When an inorganic compound is highlighted, the lower right hand corner of the screen displays the inorganic CAS number and the primary and secondary removal coefficients. For a description of these coefficients and their relation to the inorganic FATE model, refer to the technical report included as Appendix B of this manual.

Appendix C lists all organic and inorganic compounds with their respective CAS numbers, constants and coefficients, and Appendix D explains in more detail the contents of the organic and inorganic databases.

Selecting a compound is accomplished in the same manner as selecting a facility: move the cursor to the desired compound using the up or down arrow key, press the **<SPACE>** bar and a yellow '#' will appear to the left of the compound name. FATE will then ask you to enter the influent concentration of the compound you have chosen. You may choose the default concentration (0.100 mg/l) or input some other concentration. Press **<ENTER>** and FATE asks you to accept what is on the screen. To unmark a compound already selected, press the **<SPACE>** bar (after accepting a compound concentration) and the '#' will disappear. There is no limit to the number of compounds FATE can run.

FATE has a special feature which will make selecting a compound easier. If the compound you wish to choose is not shown on the immediate screen, you may press the first letter or number of the compound you wish to choose, and FATE will take you to the area in its database where that compound is listed. The compounds are listed in the database in numerical and then alphabetical order.

EXAMPLE: You wish to select Toluene. Go to the organic compound database and type in the letter "T". Then, use the down arrow key to select toluene. Once the cursor is next to toluene you will be able to view the information in the database on toluene. To use toluene in either a single or multiple compound analysis press the space bar. A pound sign (#) will appear to indicate that toluene was selected for the model run. Enter the desired compound concentration, press **<ENTER>**, and press **'Y'** to accept the concentration. Press the **<SPACE>** bar again and toluene will no longer be selected.

4.1.3. FUNCTION KEYS

When you are in the **Selection Mode**, you may define your own facility or change the chemical parameters of any compound from the default parameters provided in the model. This option gives you the flexibility to use the model in specific real-life situations. The mechanics of defining your own facility and changing the parameters for a compound are discussed in the following descriptions of the various function keys.

4.1.3.1. HELP <F1>

The **Help** function is activated by pressing the **<F1>** key. While using the **Help** function, a message referring to the specific mode or variable currently being used is displayed. The Help Mode provides immediate on-line guidance to the user and **can be activated in every mode of the FATE program**. Use the up or down arrow keys to scroll through the help message. Press **<ESC>** to return to the program.

4.1.3.2. EDIT <F2> AND UNIT CONVERSION <SHIFT><F2>

The **Edit** command allows you to change the facility operating parameters (e.g., plant flow rate, primary sludge concentration, etc.) and/or the chemical constants for a specific compound (e.g., Henry's Law Constant.)

By editing different parameters and then running the model, the user may evaluate the fate of compounds under different plant conditions. In addition, if the user has obtained chemical properties for a compound that differ from the default values, or has measured values from studies performed at his/her plant (e.g., plant specific biodegradation rate constants from treatability studies), then these may be entered in the **EDIT Mode**.

NOTE

You may not edit the operational parameters of a facility or chemical constants of a compound if the facility or compound is followed by an asterisk. If this is the case, see the directions for the **Copy Mode <F3>**.

To actually edit a facility or compound, select the facility or compound to be edited and press the **<F2>** key. The items which you will be able to edit will be highlighted; select the parameter to be changed, type in the new entry, press **<RETURN>**, and move on to the next entry. To obtain an explanation of the specific parameter you wish to edit, press **<F1>** for help.

UNIT CONVERSION

FATE will allow input of plant parameters in units other than those that appear on the screen. For example, highlight a facility, press **<F2>** to invoke the **EDIT** command, and arrow down to a facility parameter of your choice. While holding the **<SHIFT>** key, press **<F2>**, and a pop-up screen will appear to the right. This pop-up screen contains a list of units for which that parameter may be recorded in a POTW. You may enter a value for that parameter in any of the units displayed. By pressing **<ENTER>** over the unit you wish to select, inputing your value and pressing **<ENTER>** again, FATE converts your entered value to standard FATE units. After you have altered all of the parameters you wish, press the **<ESC>** key. The following message will appear:

```
Press <Y> to accept, <N> to continue edit, or <ESC> to abort changes

<F2>-EDIT   <F3>-COPY   <F4>-ADD   <F5>-DELETE   <F10>-MORE KEYS
```

Figure 4-1

Press the appropriate key for your situation.

Remember that pressing the escape key again while this message still appears on the screen will mark this record for deletion. See the instructions on Delete for further guidance. For record removal, see Section 4.2.3.

4.1.3.3. COPY <F3>

The **Copy** command is used when the user wishes to edit a default facility or compound (shown by an asterisk). Once you have identified the facility or compound you wish to edit (copy), move the cursor to that facility or compound and press the **<F3>** key. The following message will appear when the copy has been successfully accomplished:

```
Record has been copied:  ready for editing

Press any key to continue...
```

Figure 4-2

Press any key to remove this message from the screen. When the message is removed, the copied data is highlighted. This data is now available to be edited; use the up or down arrow key to go from data field to data field, and the right or left arrow key to move the cursor within a data field. For more information on the contents of the facility or compound databases, refer to Appendix D.

NOTE

It is a good idea to edit the name field of the facility or compound (e.g., change Toluene to Toluene1) to identify any records that you have created.

4.1.3.4. ADD <F4>

The **Add** command allows the user to add a new facility or compound record to a selected database by pressing the **<F4>** key. The data fields that need to be filled to complete the new record will be highlighted. The database is now ready for you to add data to it. The up or down arrow key will move the cursor from one data field to the next, and the right or left arrow key will move the cursor within the data field. Once you are in a data field, pressing the **<F1>** key (Help key) will display a description of the data requirements for that field. Refer to Section 4.1.3.2. for a description of the unit conversion option which allows you to enter facility parameters in units other than what appear in the lower left of the screen. Also, refer to Appendix D for a description of the facility and compound database contents.

4.1.3.5. DELETE <F5>

The deletion of a facility or compound record is a two step process. Use of the **Deletion** command is the first step. It may more accurately be called the "Mark-for-Deletion" command. Use the arrow keys to move to the desired record and press the **<F5>** key once. A **"D"** in the **"SLCT"** column indicates a record marked for deletion. To actually delete the record the **Utilities-Maintenance** function in the **Menu Mode** is used and is described in the **Menu Mode**, Section 4.2.3. To remove the mark-for-deletion press the **<F5>** key once again. The record is not actually deleted, however, until you perform the **Utilities-Maintenance** function in the **Menu Mode**.

NOTE

Facilities or compounds followed by an asterisk (*) cannot be deleted. Because these records are defaults, they have been protected against any changes.

You may overwrite the mark-for-selection (a # sign) with a mark-for-deletion (a 'D'), however, you may not overwrite a mark-for-deletion with a mark-for selection.

4.1.3.6. UNMARK <F6>

The purpose of the **Unmark** command is to clear selection markings in the organic and inorganic compound databases between runs of the model. Using the **Unmark <F6>** function prevents compounds that were selected for a previous model run from being inadvertently included in subsequent model runs.

4.1.3.7. GROUP <F7>

The **Group** command option searches for all compounds that have been selected for a model run and groups them at the bottom of the database. By pressing **<F7>** you activate the search and can view the resulting list of compounds that have been selected together as a group.

4.1.3.8. CAS SEARCH <F8>

The **CAS SEARCH** command allows you to search for a particular compound by its Chemical Abstract System (CAS) number. The option is especially useful for a compound with several names that you cannot seem to find in the database.

NOTE

When you type in the CAS number, **do not use hyphens**. For example, the CAS number for acetic acid, 10-80-54, would be entered as "108054".

4.2. MENU MODE </>

In the **Menu Mode** a user may access several primary commands. Pressing the forward slash </> key (as indicated in the lower left-hand corner of the screen) activates the **Menu Mode**. The top line of the screen should read as follows:

```
  Run   Print   Utilities   System   Continue   Quit
Run the model for the current parameters
```

Figure 4-3

To return to the **Select Mode**, press the **<ESC>** key.

Options are selected and activated in the **Menu Mode** by moving the arrow keys to highlight the desired menu choice and pressing **<ENTER>**. You may also type the first character of the option to make a selection (e.g. type **<R>** for **RUN**).

The following sections describe the different options available while in the **Menu Mode**. These are:

RUN

PRINT

UTILITIES

SYSTEM ACCESS

CONTINUE

QUIT

4.2.1. RUN

After you have marked the desired compounds (in both the organic and inorganic database) activate the **Menu Mode**, while in the **Selection Mode**, by typing </>. In the Menu Mode, the **Run** menu option will run the FATE model for each selected compound.

The system runs the program for the organic compounds first and then for the inorganic compounds.

The **Run** command can be used to recalculate removal rates of pollutants in the plant influent after you have copied the records and changed various operating parameters.

4.2.2. PRINT

To use the **Print** option, make sure you are in the **Menu Mode.** The **Print** option **<P>** displays the **Print Menu**; the top line of the screen should read as follows:

```
Single   Multiple   Facility   Compound   Assumpt   Page   Line   Quit
Print run results for a single compound
```

Figure 4-4

The print option consists of six sub options: Single, Multiple, Facility, Compound, Page and Line.

Single - Prints a report of the results for a FATE run for one compound.

Multiple - Prints a report for a FATE run for any number of compounds selected.

Facility - Generates a report of all facilities in the facility database.

Compound - Generates a report listing all organic and inorganic compounds in their respective databases.

Assumptions - Generates a report listing the major model assumptions.

Page - Sends a form feed command to the printer.

Line - Sends a line feed command to the printer.

For more information concerning content of the various reports, refer to Section 5.

NOTE

All reports in this version of the FATE model are set up for 80 column output.

4.2.3. UTILITIES

The **Utility** option is used for maintenance of the databases. It is composed of three sub-options: Maintenance, Rebuild, and Backup.

Maintenance

Selecting **Maintenance** deletes blank records (where no facility or compound name has been given) and those records which are "marked for deletion." (Refer to Section 4.1.3.5 for instructions on deletion of records.) The **Maintenance** option also updates index files that are used to sort records according to compound name, selection, or some other attribute.

Rebuild

The **Rebuild** option is used to rebuild index files that have become damaged, possibly during a power outage.

NOTE

It is very important to backup the five database files on a regular basis in case the files get damaged. You should also maintain a backup copy of the original FATE model program and databases.

Backup

The **Backup** option copies the database files to a diskette.

4.2.4. SYSTEM ACCESS

The **System** option allows you to exit to DOS while still running the FATE model program. You can perform other tasks in DOS, such as checking disk space, formatting diskettes, or locating a file program, and then return to the FATE model program by typing **'EXIT'** and pressing **<RETURN>**.

4.2.5. CONTINUE

The **Continue** option allows the user to continue using the FATE model program after the model results are obtained for all selected compounds.

4.2.6. QUIT

The **Quit** option ends the modeling session and exits from the FATE model program.

NOTE

Each time you exit to DOS using this option and then reenter the FATE model program, additional computer memory is used. You should not use this option on a regular basis since the computer may run out of memory. If this occurs, it will not be possible to access DOS.

5. REPORTS

The FATE model program allows you to print reports for single or multiple compound formats and to print the facility or compound (organic and inorganic) databases .

Step-by-step instructions for generating reports are as follows:

- Begin in the **Selection Mode.**

1. Select the desired facility using the space bar (e.g., small, medium, large, or user-created facility.)

2. Use the right arrow key to move to the organic or inorganic compound database.

3. Use the space bar to select the desired compound(s).

- Press the forward slash key (/) to obtain the **Menu Mode.** Make sure the printer is on-line and the paper is aligned.

1. If you wish to view the results on the screen before you print them, select **Run** from the **Menu Mode.** The run results for the selected compound(s) will appear at the top of the screen (this report is discussed in Section 6.1). When you are finished viewing the results, *press any key to continue.*

2. If you don't wish to view the results before printing them, select **Print** from the **Menu Mode** and select a report option: Single, Multiple, Facility, or Compound. These reports are described in the following sections.

When the report has finished printing the program will return you back to the main level of the **Menu Mode.** From there, you may **Quit** the program, **Continue** to use the program, **Run** the current model again, or print another report.

NOTE

Printing may be terminated by pressing the **<ESC>** key.

5.1. SCREEN REPORT

When you choose the **Run** option from the **Menu Mode**, FATE provides an on-screen report as shown in Figure 3-10. The values shown on this report are defined below:

Organic Compounds:

pri. influent conc. is the influent concentration (mg/l) that you entered in the compound database at the upper right hand side of the screen.

pri. sorpt. rem. rate is the sorption removal rate (lb/dy) from the primary clarifier.

pri. clar. eff. conc. is the effluent concentration (mg/l) from the primary clarifier.

vol. rem. rate is the volatilization removal rate (lb/dy) from the aeration basins. .

bio. rem. rate is the biodegradation removal rate (lb/dy) from the treatment system.

sec. sorpt. rem. rate is the sorption removal rate (lb/dy) from the secondary clarifier.

pri. sorbed is the percent sorbed to the sludge in the primary clarifier.

sec. sorbed is the percent sorbed to the sludge in the secondary clarifier.

volatilized is the percent of the compound which will volatilize in the treatment system.

biodegraded is the percent of the compound which will biodegrade in the treatment system.

overall removal is the total percent removal of the compound through the POTW.

sec. eff. conc. is the effluent concentration (mg/l) from the secondary clarifier.

Inorganic Compounds:

primary inf. conc. is the influent concentration (mg/l) that you entered in the compound database at the upper right hand side of the screen.

primary rem. rate is the removal rate (lb/dy) from the primary clarifier.

secondary rem. rate is the removal rate (lb/dy) from the secondary clarifier.

overall rem. rate is the overall removal rate (lb/dy) from the treatment system.

primary eff. conc. is the effluent concentration (mg/l) from the primary clarifier.

primary rem. is the percent removal from the primary clarifier.

secondary rem. is the percent removal in the secondary clarifier.

overall rem. is the overall percent removal from the treatment system.

final eff. conc. is the effluent concentration (mg/l) from the secondary clarifier.

After viewing the results press **<ENTER>** to view other selected compounds, or *press any key to continue.*

5.2. SINGLE COMPOUND REPORTS

A **'Single'** report not only generates a detailed FATE analysis of the selected compound, but also reports the selected facility's parameters and compound chemical information. Figure 3-11 is an example of a single report. The report format is as follows:

Compound information - This section presents chemical information on the selected compound - Henry's Law Constant, log octanol/water partition coefficient, biodegradation rate constant, and the plant influent concentration. For more information on specific chemical data refer to Appendix D.

Facility information - This section prints all the plant parameters of the selected facility. For more information on facility parameters, refer to section 4.1.1.

FATE analysis - The removal rates, concentrations and percent removals are reported in this section. Refer to Section 5.1 for definitions.

Notes: These notes are the assumptions of the model as explained in Section 1 of this manual.

NOTE

If more than one compound was selected, only the last compound run may be printed by selecting **Print** and then **Single**.

When the report has finished printing the program will return to the main level of the **Menu Mode.**

5.3. MULTIPLE COMPOUND REPORTS

Multiple compound reports present the facility operating parameters and the percent removals of each compound selected. Figure 3-12 is an example of a Multiple Compound Report. The format is described as follows:

Facility - As for the single compound report, the selected facility's plant parameters are reported here. For a more detailed description of these parameters refer to Section 4.1.1.

Results - The results of the FATE analysis for every compound selected are reported here. Unlike the single report option, only the effluent concentration and percent removals are reported. For more detailed FATE analysis, you have the option of generating single reports for all compounds of interest or choosing the **Run** option from the **Main Menu**, and viewing detailed analysis for each selected compound.

When printing is complete, the program will return you to the **Main Menu.**

5.4. PRINTING THE FACILITY DATABASE

To generate a complete printout of all the parameters in the facility database, you need to perform the following steps:

Press the forward slash key </> to get to the **Menu Mode.**

Select **Print** from the **Menu Mode.**

Make sure the printer is on-line and the paper is aligned. Select **Facility** from the **Print Menu** and the complete facility database will begin printing.

When the printout is complete, the program returns you back to the main level of the **Menu Mode.** You may then **Quit** the program, **Continue** using the program, or **Run** the current model again.

5.5. PRINTING THE COMPOUND DATABASES

The procedure for printing the organic compound database and the inorganic compound database is exactly the same as the procedure for printing the facility database.

After you have selected **Print** and verified the printer is on-line and the paper is aligned, select **Compound** from the **Print Menu**, rather than **Facility**.

A complete list of both the organic and the inorganic compounds will begin printing. The compound database is attached as Appendix C.

When the report is finished printing you will be at the main level of the **Menu Mode.** As before, you may **Quit**, **Continue**, or **Run** the model again.

5.6. PRINTING THE MODEL ASSUMPTIONS

The procedure for printing the list of model assumptions used during the development of FATE is the same as the procedure for printing the facility and compound databases.

After you have selected **Print** and verified the printer is on-line and the paper is aligned, select **Assumptions** from the **Print Menu**.

A complete list of the model assumptions will begin printing. The list of assumptions is presented in Section 1.0.

When the report is finished printing, you will be at the main level of the **Menu Mode.** As before, you may **Quit**, **Continue**, or **Run** the model again.

ACRONYMS AND ABBREVIATIONS

Aer basins vol	total volume of the aeration basins
bio. rem. rate	biodegradation removal rate
CAS number	Chemical Abstract System Number
cf/d	cubic feet per day
cfm	cubic feet per minute
conc.	concentration
CU.FT	cubic feet
CU.FT/D	cubic feet per day
CU.FT/HR	cubic feet per hour
CU.M	cubic meters
CU.M/D	cubic meters per day
CU.M/HR	cubic meters per hour
D	when present to the left of a compound or facility, this record is marked for deletion
DOS	Disk Operating System
E	indicates a value has been estimated using an accepted method
effluent conc.	effluent concentration
EPA	Environmental Protection Agency
ESC	The escape key
FATE	Fate And Treatability Estimator
final eff. conc.	effluent concentration reported after the secondary clarifier

G	gas volumetric flow rate to the aeration basins
G/CU.M	grams per cubic meters
gal.	gallons
Gas flow rate	gas volumetric flow rate to the aertion basins
gpd	gallons per day
gpm	gallons per minute
H	Henry's law constant (atm - m^3/mole)
influent conc.	influent concentration
L	liters
L/D	liters per day
LB/CU.M	pounds per cubic meters
LB/DY	pounds per day
LB/GAL	pounds per gallon
LK1	log (base 10) of the biodegration rate constant
LKOW	log (base 10) of the octanol/water partition coefficient
Log of bio rate	log (base 10) of the biodegration rate constant
Log of octanol/water	log (base 10) of the octanol/water partition coefficient
M	a measured value taken from the literature
MCU.FT/D	millions of cubic feet per day
mg/l	milligrams per liter
MGAL	million gallons
MGD	millions of gallons per day
ML	coefficient that predicts removal of an inorganic compound in the secondary clarifier

MLSS	mixed liquor suspended solids
overall rem	overall removal of the compound
overall rem. rate	overall removal rate of the compound
plant flow	plant flow rate of wastewater into POTW
POTW	publicly owned treatment works
ppb	parts per billion
ppm	parts per million
pri. clar. eff. conc.	primary clarifier effluent concentration
pri. influent conc.	primary clarifier influent concentration
pri. sludge conc.	primary clarifier sludge concentration
pri. sludge flow	sludge flow rate from the primary clarifier
pri. sorbed	amount of the compound sorbed in the primary clarifier
pri. sorpt. rem. rate	the sorption removal rate in the primary clarifier
primary coefficient	coefficient (RW) that predicts removal of an inorganic compound in the primary clarifier
primary eff. conc.	primary clarifier effluent concentration
primary rem.	percent removal of compound from the primary clarifier
primary rem. rate	removal rate of compound from the primary clarifier
Q	plant flow rate
Qp	primary sludge flow rate
Qw	wasted secondary sludge flow rate
RW	coefficient that predicts removal of an inorganic compound in the primary clarifier
sec. eff. conc.	secondary clarifier effluent concentration of compound

sec. sorbed	percent of the compound sorbed in the secondary clarifier
sec. sorpt. rem. rate	removal rate of the compound in the secondary clarifier
secondary coeff.	coefficient (ML) that predicts the removal of an inorganic compound in the secondary clarifier
secondary rem.	percent removal of compound in the secondary clarifier
secondary rem rate	removal rate of compound from the secondary clarifier
Si	concentration of contaminant in the raw wastewater (influent to primary clarifier)
SLCT	indicates the SELECT MODE
So	concentration of contaminant in the primary clarifier (also equal to primary clarifier effluent concentration)
T	temperature of the aeration basins (assumed to be 20° C)
U	the value is unavailable and must be supplied by the user
ug/l	micrograms per liter
V	volume of the aeration basins
vol. rem.	volatilization removal rate
waste sludge conc.	sludge concentration from the secondary clarifier
waste sludge flo	sludge flow rate from the secondary clarifier
Xl	mixed liquor suspended solids
Xp	primary sludge concentration
Xv	secondary sludge concentration
#	if present to the left of a facility or compound, it is selected for a FATE run
*	indicates a default facility or compound

APPENDIX A

Warning Errors and Messages

The following list of error and warning messages may appear in a window if an operation attempted by a user does not meet certain conditions. The messages typically appear in a pop-up window at the bottom-center of the screen and require the user to respond with a keystroke to clear the message.

Warning #1: "The printer is not ready."

The printer is not attached to the computer, is not on-line, or some other printer error has occurred.

Error #100: "Cannot edit deleted or marked (*) record"

A field marked with an asterisk (*) has been provided by EPA and the values are protected from alterations. You may copy a record <F3> which automatically removes the asterisk and allows parameters to be edited.

Error #101: "Cannot delete a marked (*) entry."

See Error #100

Error #102: "More than one facility selected."

The user interface allows only one facility to be run at a time.

Error #103: "No compounds selected."

The user has attempted to run the model before selecting any compounds.

Error #104: "No facility selected."

The user has attempted to run the model before selecting a facility.

Error #105: "User cannot use an asterisk for this entry."

The asterisk (*) character is reserved for the default database records.

Error #106: "Type must be Measured, Estimated, or Unavailable."

Each organic compound chemical parameter is qualified based on the source of the information. The data represented is a measured value when the type field contains the capital letter 'M'. Similarly 'E' and 'U' are used to qualify data is estimated or unavailable. When adding or editing records the user should follow this convention.

Error #107: "Select is other than inorganic or organic."

Error #108: "Select is other than facility, inorganic or organic."

Error #109: "Scientific notation demands this field to be 1 or greater."

Error #111: "Cannot select deleted record."

A record which has been marked for deletion may not be selected for a model run. To select a record marked for deletion the user must first undelete the record (using <F5>) and then select it (using the space bar).

Error #112: "This entry cannot begin with blank."

Name fields may not begin with a blank since they are used as Key fields in the index which controls the order of the database.

Warning #113: "This entry should be between -13 & 2."

Warning #114: "This entry should be between -3 & 10."

Warning #115: "This entry should be between -5 & -1 (or 0 if U)."

This biodegradation rate constant is entered as the log(K).

Warning #116: "This entry should be between 0 & 100."

Warning #117: "This entry should be between 0 & 1000."

Warning #118: "This entry should be between 1000 * Q & 9000 * Q."

Q is the plant flow rate in units of MGD.

Warning #119: "This entry should be between 3 & 8%."

Warning #120: "This entry should be between 74,000 * Q & 372,000 * Q."

Q is the plant flow rate in units of MGD.

Warning #121: "This entry should be between 1500 & 7000."

Warning #122: "This entry should be between 2,000,000 * Q & 40,000,000 * Q."

Q is the plant flow rate in units of MGD.

Warning #123: "This entry should be between 500 * Q & 20,000 * Q."

Q is the plant flow rate in units of MGD.

Warning #124: "This entry should be between 0.5 & 2%."

Warning #125: "This entry should be between 0 & 35."

Warning #126: "This entry should be between 'N'."

Warning #127: "Cannot run this compound, Henry's or log type is U."

An organic compound must have an 'E' or an 'M' qualifier for the Henry's Law Constant and Log K_{ow} in order to be run. The 'U' qualifier indicates that the data is currently unavailable.

Error #200: "Select inorganic or organic database for CAS number search."

Error #201: "CAS number not found."

Error #202: "No results to print. Run model first."

For single run printouts the model must be run first using '/R'.

Error #203: "Printer is not ready."

Error #204: "Not enough memory to run a DOS shell."

The fate model requires that 60K of memory be available before it will attempt to run a DOS shell.

Error #207: "Cannot change K for an asterisked (*) entry with U or M."

Error #208: "No more records marked for run."

The following errors indicate that an internal error has taken place and is probably beyond the users control:

Internal Error #900: "Unknown error number."

Internal Error #901: "Unknown mode."

Internal Error #902: "Database empty."

If this error occurs reinstall the database and index files from the distribution diskette or backup copies by using DOS to copy all .DBF, .DBT and .NTX files to the appropriate disk or directory.

Internal Error #903: "dspfk mode other than 1, 2, 3."

Internal Error #904: "Missing record or corrupt CV.DBF, CVPARM.NTX files."

The user should rebuild the indices using the rebuild utility in the Menu Mode.

APPENDIX B

FATE Model Technical Report

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FATE MODEL TECHNICAL REPORT

1.0 INTRODUCTION

The U. S. Environmental Protection Agency (USEPA), Industrial Technology Division (ITD) has supported the development of a user friendly, computerized model, "Fate and Treatability Estimator" (FATE), to evaluate the fate of various inorganic and organic pollutants discharged to conventional activated sludge Publicly Owned Treatment Works (POTWs). FATE was designed to assist POTW operators and feasibility study writers in evaluating the fate and treatability of pollutants discharged to POTWs. FATE users will be able to estimate the overall percent removal of a pollutant discharged to a plant, and percent removal attributed to the three principal mechanisms for removal included in the model (i.e., volatilization, sorption, and biodegradation). USEPA's guidelines for use of mathematical models for regulatory assessment and decision making (USEPA, 1989) were followed wherever applicable during the development of FATE.

The purpose of this report is to present technical considerations and methodologies used in the development of FATE. Topics addressed in this report are: 1) review of various fate models available in the literature, 2) development of the inorganic and organic mathematical submodels which compose FATE, 3) selection of default plant parameter values and ranges used to check a user's input values, 4) methodology to obtain Henry's Law constants, octanol/water partition coefficients, and biodegradation rate constants, 5) sensivity analysis conducted on FATE's organic compound removal algorithms, and 6) calibration and validation of FATE.

2.0 LITERATURE REVIEW OF FATE IN POTW MODELS

The literature reviewed in the development of the organic and inorganic FATE models is described in subsequent sections.

2.1 ORGANIC MODELS

Several models were available in the literature for estimation of overall fate of organic pollutants discharged to a treatment facility. Blackburn et al. (1985) developed an overall fate model which included parameters such as hydraulic residence time, biomass concentration, air flow volumes, and chemical and physical properties of the pollutant to estimate fate of organics discharged to an activated sludge treatment process. Blackburn et al. (1985) and Blackburn (1987) presented a fate model which predicts overall removal of organic pollutants. This model has been validated against laboratory and bench-scale studies for seven organic compounds. Namkung and Rittmann (1987) and Rittmann et al. (1988) have presented overall fate models developed from performing a mass balance across an aeration basin and secondary clarifier. Namkung and Rittmann (1987) used this model to estimate volatile organic compound (VOC) emissions of eleven VOCs from two POTWs, and found that a comparison of the total VOC removal rate estimated from the model to actual data from two plants resulted in estimated overall removals within 10 percent of the actual removal rate. Barton (1987) developed a model which included similar biodegradation and sorption removal equations as in the models of Blackburn, and Namkung and Rittmann; however, removal due to volatilization included both stripping due to surface or subsurface aeration and volatilization. All of these models had the ability to model the aeration basin and secondary clarifier. Clark (1986) developed a model which included the primary clarifier, aeration basin, and secondary clarifier to estimate overall removal and removal due to a specific removal mechanism. This model has been computerized, unlike the other models reviewed.

Due to the lack of sufficient data for model calibration and validation and the variability associated with actual plant performance as indicated in USEPA's evaluation of toxic treatability by POTWs (USEPA, 1982), a complicated model was not believed to provide more reliable estimates of plant performance. As a result, most of the models reviewed were eliminated as a basis for the FATE organic model. The advantages in user understanding, computational simplicity, and minimal amount of easily obtained plant- and chemical-specific input parameters, however, made the model of Namkung and Rittmann a solid basis for development of the FATE organic model.

2.2 INORGANIC MODELS

After an extensive literature search and personal communication with researchers in this area, only three models predicting the fate of inorganic compounds in POTWs were identified. Neufeld (1975) used batch studies to develop an expression to describe the accumulation of metals on biological sludge. The

resulting expression was used to generate isotherm equations that could represent kinetic and equilibrium relationships for six metals (lead, cadmium, mercury, chromium, zinc, and nickel). Neufeld predicted that there was a maximum attainable value of metal that could be associated with sludge. Nelson et al. (1981) also performed batch experiments to generate adsorption isotherms that could represent equilibrium of metals between bacterial solids and solution phases. Three metals were modeled (zinc, copper, and cadmium). Nelson emphasized that the adsorption constants generated were valid only at the pH and chemical composition of the water used in the experimental system. Patterson and Kodukula (1984) used data from extended pilot studies to develop models to predict the distribution of metals in activated sludge processes. A correlation was found between percent removal of metals and percent suspended solids removal; the total concentration of metals in the effluent increased as the effluent suspended solids increased. Using this correlation, Patterson and Kodukula proposed models for eight metals (aluminum, cadmium, chromium, copper, iron, lead, nickel, and zinc).

Based on the inorganic literature review, the Patterson and Kodukula approach was chosen as the basis for the FATE inorganic model. The approach was selected for a number of reasons:

1) Patterson and Kodukula modelled the most metals;

2) pilot plant studies as opposed to adsorption isotherm studies were used as the basis for the model;

3) constants developed to estimate removal in the primary and in the secondary clarifiers were given for the eight metals; and

4) the model is based on the relationship between the volatile suspended solids and metal concentrations of the process streams rather than only the metal concentrations.

3.0 FATE MODEL DEVELOPMENT

FATE has the capability to estimate the treatability of both inorganic and organic compounds discharged to a POTW. The following two subsections describe development of the separate models which estimate removal of organics and inorganics.

3.1 ORGANICS MODEL

The organics portion of the fate model uses a mass balance approach to describe removal of an organic compound in a conventional activated sludge treatment facility. Significant removal of organic compounds is assumed to occur in only the primary clarifier(s) and aeration basin(s)/secondary clarifier(s). Removal mechanisms are assumed to be only sorption in the primary system and volatilization (by stripping), sorption, and biodegradation in the secondary systems. The model of Namkung and Rittmann (1987) served as the basis for the aeration basin(s) and the secondary clarifier(s), except for a change to the organic partitioning to solids relationship.

3.1.1 Mass Balance About the Primary Clarifier

Figure 3-1 presents a schematic of the primary clarifier. The mass balance equation for removal in the primary clarifier(s) can be written as:

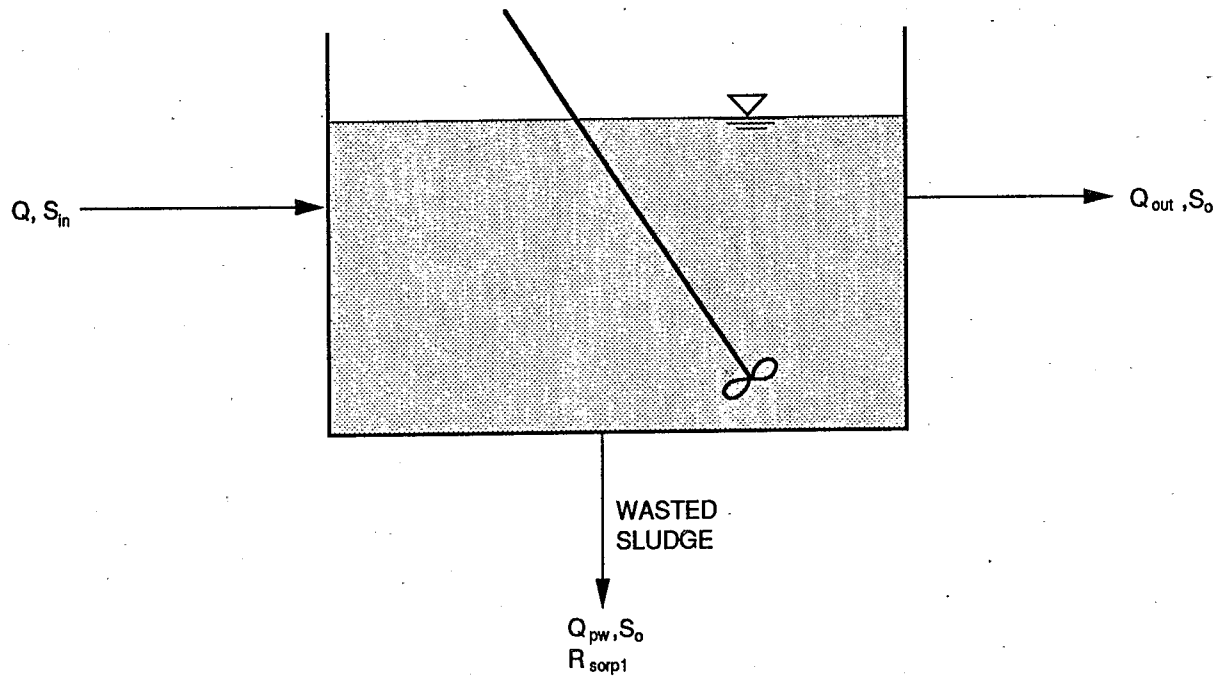
$$V_{pr}\ dS_o/dt = QS_{in} - Q_{out}So - Q_{pw}S_o - R_{sorp1} \qquad (1)$$

where: V_{pr} = the total plant primary clarifier(s) volume, m^3;
S_{in} = the individual compound concentration in the influent to the primary clarifier(s), gm/m^3 or mg/l;
t = the time, days;
Q = the influent flowrate, m^3/day;
Q_{out} = the primary clarifier(s) effluent flowrate, m^3/day;
Q_{pw} = the primary clarifier(s) sludge removal rate, m^3/day;
S_o = the individual compound concentration in the primary clarifier(s), which also exits to the aeration basis(s), gm/m^3 or mg/l; and
R_{sorp1} = the rate of compound removal in the primary clarifier(s) due to sorption onto organic solids, gm/day.

By assuming steady state conditions (dS/dt = 0) and liquid outflow equal to liquid inflow ($Q_{out} + Q_{pw} = Q$), Equation (1) reduces to:

$$0 = Q\ (S_{in} - S_o) - R_{sorp1} \qquad (2)$$

The sorption removal rate assumes that the compound partitions according to a linear relationship between the liquid and solid phase, and this can be described by an empirical relationship relating partitioning to a compound's octanol/water partition coefficient, Kow. The empirical relationship relating



KEY

- Q - Total Flow
- Q_{out} - Primary Effluent Flow Rate
- Q_{pw} - Primary Wasted Sludge Flow Rate
- S_{in} - Influent Compound Concentration
- S_o - Steady State Compound Concentration
- R_{sorp1} - Compound Removal Rate due to Primary Adsorption

FIGURE 3-1
FATE ORGANIC MODEL
PRIMARY CLARIFIER

6098-81

partitioning of an organic compound onto the organic fraction of primary sludge to Kow was obtained from an experimental study which examined the sorption of organic compounds onto wastewater solids (Dobbs et al., 1989). Data for sorption of six organics (methylene chloride, chloroform, 1,1-dichloroethylene, carbon tetrachloride, chlorobenzene, and tetrachlorethylene) onto primary sludge was used to obtain a relationship between the partition coefficient, Kp (units of m^3/g VSS) and Kow. This relationship is written as:

$$K_p = 5.9 \times 10^{-5} (Kow^{0.35}) \quad (3)$$

The statistical measure, R^2, for this relationship was determined to be 0.72. The rate of compound removal due to sorption can then be written as:

$$R_{sorp1} = Q_{pw} X_{pw} (0.000059*Kow^{0.35}) S_o \quad (4)$$

where X_{pw} is the concentration of organic solids present in the primary clarifier sludge (gm VSS/m^3) and is assumed to be 70 percent of the total solids concentration, X_p (Viessman and Hammer, 1985).

The individual compound concentration within and exiting the primary clarifier can then be calculated by substituting Equation (4) into Equation (2), and including the assumption of 70 percent VSS in the primary sludge, to give:

$$S_o = (Q\ S_{in}) / (Q + Q_{pw} X_p (4.1x10^{-5}*Kow^{0.35})) \quad (5)$$

where S_o is the concentration of an organic pollutant entering the aeration basin(s) in gm/m^3 or mg/l.

3.1.2 Secondary System

Figure 3-2 presents a schematic of the aeration basin and secondary clarifier. The mass balance for the aeration basin(s)/secondary clarifier(s) can be written as:

$$V\ dS/dt = QS_o - Q_eS - Q_wS - R_{bio} - R_{sorp} - R_{vol} \quad (6)$$

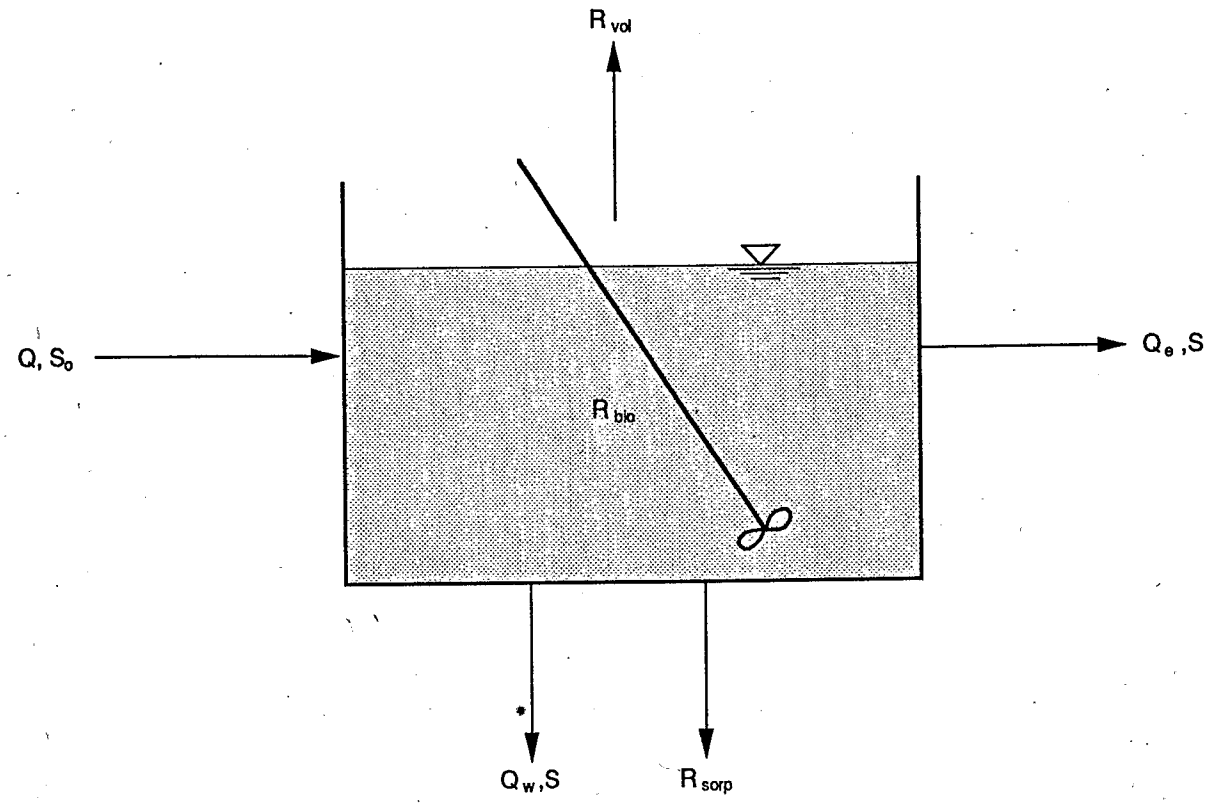
where: V = the aeration basin(s) volume, m^3;
S = the individual compound concentration in the aeration basin(s)/secondary clarifier(s) system, which also is the plant effluent concentration, gm/m^3 (mg/l);

Q_e = the effluent flow rate, m^3/day;

Q_w = the wasted sludge flow rate, m^3/day; and

R_{bio}, R_{sorp}, and R_{vol} = the rates of compound removal due to biodegradation, sorption, and volatilization, respectively, gm/day.

By assuming steady state conditions (dS/dt = 0) and the liquid outflow equal to the liquid inflow ($Q_e + Q_w = Q$), Equation (6) reduces to:



KEY

- Q - Total Flow
- Q_e - Effluent Flow Rate
- Q_w - Wasted Sludge Flow Rate
- S_o - Influent Compound Concentration
- S - Steady State Compound Concentration
- R_{bio}, R_{sorp}, R_{vol} - Compound Removal Rates due to Biodegration, Sorption, and Volatilization

FIGURE 3-2
FATE ORGANIC MODEL
AERATION BASIN AND SECONDARY CLARIFIER

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$$0 = Q\ (S_o - S) - R_{bio} - R_{sorp} - R_{vol} \quad (7)$$

The biodegradation removal rate is assumed to follow Monod kinetics and the compound influent concentration is assumed to be much less than the Monod half saturation coefficient. The organic compound is assumed to be removed by secondary utilization; therefore, the active cell concentration, X_a, of the system can be assumed to equal some fraction of the total biomass in the system. The biodegradation removal rate can be written as:

$$R_{bio} = k_1\ X_a\ SV \quad (8)$$

where k_1 is the apparent first-order biodegradation rate constant, m^3/gm VSS-day, and X_a is assumed to be 0.64 of the mixed liquor suspended solids concentration (MLSS) (Namkung and Rittmann, 1987).

Secondary utilization is the process whereby an organic substrate at low concentrations is utilized by a microorganism, but does not supply the growth and energy requirements of the microorganism. The microorganism uses another individual substrate or combination of substrates for its energy and maintenance requirements and, in the process, mineralizes the compound at low concentration. In this situation, it is assumed that the primary substrate is the large volume of varied organic carbon entering the plant which is measured as the plant's influent biological oxygen demand. Namkung and Rittman provide a more detailed description of secondary utilization.

The sorption removal rate assumes that the compound partitions according to a linear relationship between the liquid and solid phase and this partitioning can be described by an empirical relationship obtained experimentally by Matter-Muller (1980). This empirical relationship relating partitioning to Kow was developed for the sorption of several chlorinated organics onto activated sludge solids. The sorption removal rate in the secondary clarifier(s) can then be written as:

$$R_{sorp2} = 3.06 \times 10^{-6}\ Q_w\ X_v\ (Kow)^{0.67}\ S \quad (9)$$

where X_v is the wasted secondary sludge concentration in mg/l.

The volatilization removal rate assumes that the individual compound is negligible in the inlet gas and the partial pressure of the gas exiting the aeration tank liquid is in equilibrium with the compound concentration.

$$R_{vol} = GHS/RT \quad (10)$$

where: G = the total gas volumetric flow rate, m^3/day;

H = the compound's Henry's Law constant, atm-m^3/mole;

R = the universal gas constant, 8.206×10^{-5} m^3atm/°K-mole; and

T = the temperature of the aeration basin in °K.

The steady state concentration exiting the secondary clarifier(s) can be calculated from substituting Equations (8), (9), and (10) into Equation (7) and solving for S:

$$S = (Q\ S_o)/(Q + GH/RT + Q_w X_v (3.06 \times 10^{-6})(Kow)^{0.67} + k_1 X_a V) \qquad (11)$$

For organic compounds, FATE first calculates a steady state concentration in the primary clarifier(s). This concentration is used as the influent concentration to the aeration basin(s)/secondary clarifier(s) system where a second steady state concentration is calculated. The mass removal rates of sorption in the primary and secondary clarifier(s), and volatilization and biodegradation in the aeration basin(s) are then calculated, as is the percent removal due to each of these particular removal mechanisms. Finally, FATE calculates an overall plant percent removal.

3.2 INORGANICS MODEL

The data available for inorganics removal, primarily metals, was extremely limited during initial formulation of the FATE model. The only approach that appeared to be reasonable based on that data was to attempt to relate total removal as a function of the entire treatment system and the initial concentration. The resultant model was calibrated to the available data through linear regression based on the simple model:

$$\ell n(S_{out}) = a * \ell n(S_{in}) + b \qquad (12)$$

where: S_{out} = the plant effluent concentration, mg/l;
S_{in} = the plant influent concentration, mg/l; and
a,b = the linear regression coefficients.

The correlation coefficients resulting from this analysis were extremely poor. Also evaluated, but with no more reliable results, was a model that considered that the removal was dependent on influent concentration, with a and b assumed to have different values for two specified concentration ranges.

In view of the inadequacy of both this model and the data base for calibration, the literature was searched for a more reliable model with the anticipation of a larger data base for inorganics removal by POTWs. Based on a review of the literature as described in Section 2.2, the model of Patterson and Kodukula (1984) was selected as appropriate for purposes of the FATE model.

Patterson and Kodukula proposed models that related total metals removal in a wastestream to the organic volatile suspended solids removal in that unit. While it was recognized that other parameters such as pH might affect sorption-solubility relationships, these parameters were not well defined for typical plant operation, and if the plant was operating within normal ranges, the effects of these other parameters would not be significant when compared to the mechanism of sorption to organic volatile suspended solids (VSS), and the

removal of these solids in the clarifier(s). They obtained fair to mostly good and excellent correlation of the model predictions with actual EPA pilot plant survey data for eight metals.

The form of Patterson's and Kodukula's (PK) model as used in this version of FATE is referred to in their article as Model I. They modified their model to calculate removals across treatment trains as follows:

$$M_t/\text{Delta}(M_s) = 1 + B/\text{Delta}(VSS) \quad (13)$$

Where: M_t = the total metals influent concentration;
Delta (M_s) = the change in the solids-bound metal across the clarifier;
Delta (VSS) = the change in the VSS concentration across the clarifier; and
B = the correlation coefficient for the settleable portion of the influent VSS to the clarifier.

This model may be applied about the primary and secondary systems to yield estimates of metals removed in each unit. This is accomplished by formulating a mass balance about the each of the primary and secondary units (as described in the following sections) in order to express the PK model in terms of data input to the FATE model.

3.2.1 Mass Balance About the Primary Clarifier

Figure 3-3 presents a schematic of the primary clarifier. In applying the PK model about the primary clarifier, the streams are identified as RW for raw waste, PE for primary effluent, and P for primary system. The model may then be manipulated as follows to arrive at an expression for removal rate in the primary clarifier as a function of the FATE model required input parameters.

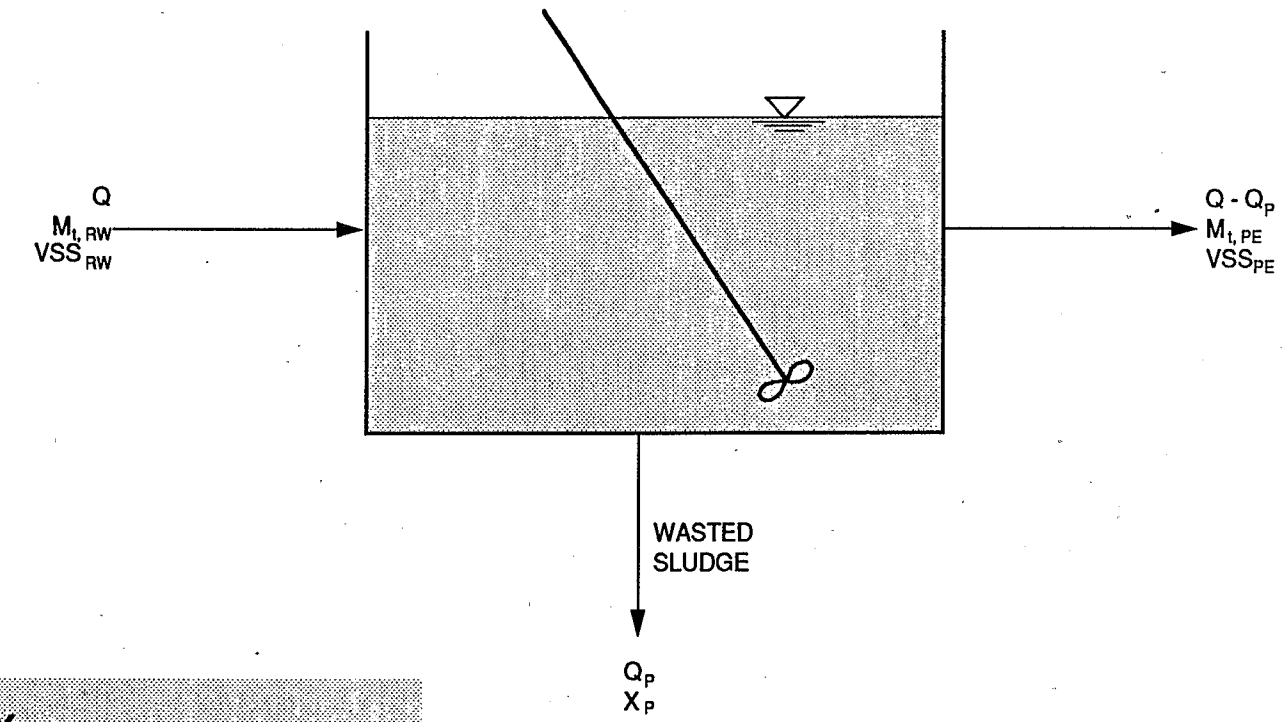
Patterson and Kodukula define the changes in concentration across the clarifier as

$$M_{t,PE} = M_{t,RW} - \text{Delta}(M_{s,P}) \quad (14)$$

into which the model (Equation 13) solved for Delta($M_{s,P}$) can be substituted and rearranged to get

$$M_{t,PE} = M_{t,RW}\ (Bp/(\text{Delta}(VSS_p) + Bp)) \quad (15)$$

Some removal efficiency for VSS is assumed in the primary clarifer to satisfy the model and is referred to as E_1. This efficiency value is currently defaulted to 0.5 in the model. If the sludge removal volume rate is small compared to the total flow, which is usually the case, and the efficiency does not vary much from the default value, then the removal rate is relatively insensitive to the actual efficiency, as will be seen in the following development.



KEY

Q - Total Flow
Q_P - Wasted Primary Sludge Flow Rate
VSS - Volatile Suspended Solids
X_P - Wasted Sludge VSS Concentration
RW - Raw Waste
PE - Primary Effluent
M_t - Total Metals Concentration

FIGURE 3-3
FATE INORGANIC MODEL
PRIMARY CLARIFIER

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As with the organics model, and based on EPA studies, the organic portion of the volatile suspended solids in the primary system is taken as 70% of the total suspended solids. Thus the mass balance for VSS is:

$$Q(VSS_{RW}) = (Q - Q_p)(VSS_{PE}) + .7Q_pX_p \quad (16)$$

where: Q = the influent flowrate;
VSS_{RW} = the VSS raw waste VSS concentration;
Q_p = the sludge withdrawal rate;
VSS_{PE} = the VSS primary effluent concentration; and
X_p = the total volatile solids concentration in the sludge waste stream.

Patterson and Kodukula take the change in concentration across the clarifier to be:

$$Delta(VSS_P) = VSS_{RW} - VSS_{PE} \quad (17)$$

Equation (16) can be solved for VSS_{PE} and substituted into Equation (17):

$$Delta(VSS_P) = VSS_{RW} - (Q(VSS_{RW}) - .7Q_PX_P)/(Q - Q_P) \quad (18)$$

Since

$$E_1 = .7Q_PX_P/(Q(VSS_{RW})) \quad (19)$$

rearrangement gives,

$$Delta(VSS_P) = .7Q_PX_P(1 - Q_P/Q(E_1)/(Q - Q_p) \quad (20)$$

which, as noted previously, is relatively insensitive to values of E_1 close to the default when $Q >> Q_P$.

The rate of removal in the primary clarifier ($rate_1$) is given by:

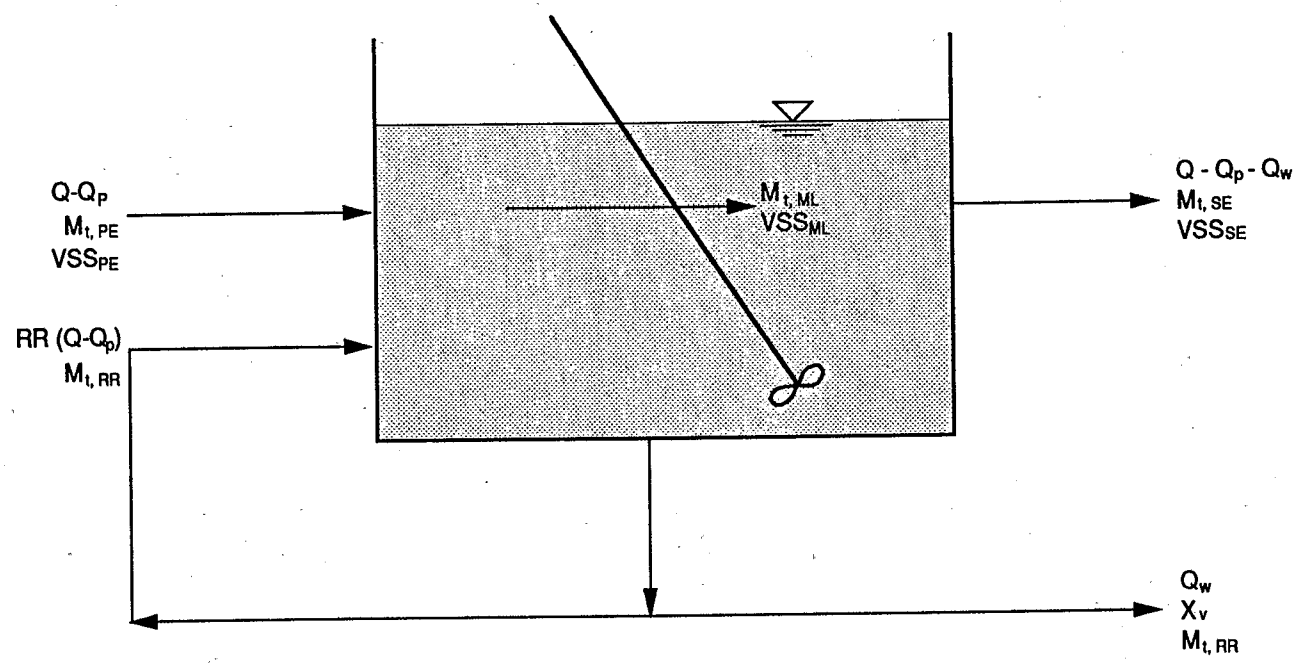
$$rate_1 = M_{t,RW}(Q - Qp)(Bp/(Delta(VSS_P) + B_P) \quad (21)$$

and the percent removal (% $removal_1$) is the removal rate divided by the influent rate:

$$\% \ removal_1 = 100(rate_1/Q(M_{t,RW})) \quad 22)$$

3.2.2 Secondary System

Figure 3-4 shows a schematic of the aeration basin and secondary clarifier. The derivation of equations for the secondary removal parallels that for the primary clarifier.



KEY

Q - Total Flow
ML - Influent Mixed Liquor Stream
SE - Secondary Clarifier Effluent
Q_w - Wasted Secondary Sludge Rate
X_v - Total Suspended Solids Concentration
M_t - Total Metals Concentration
PE - Primary Effluent
VSS - Volatile Suspended Solids
RR - Recycle Flow Rate

FIGURE 3-4
FATE INORGANIC MODEL
AERATION BASIN AND SECONDARY CLARIFIER

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For these expressions, we use ML to indicate the influent mixed liquor stream, SE as the secondary clarifier effluent, and S to indicate the secondary system. An equation similar to Equation (15) can be written as:

$$M_{t,SE} = M_{t,ML}(B_s/(Delta(VSS_s) + B_s) \quad (23)$$

A balance around the secondary clarifier can be written and an expression, E_2, for the efficiency of the secondary clarifier incorporated:

$$1 - E_2 = VSS_s(Q - Q_p - Q_w)/((Q_p)\ (1 + RR)VSS_{ML}) \quad (24)$$

Where: RR = the recycle rate; and
QW = the wasted secondary sludge rate.

The recycle ratio (RR) represents the ratio of the recycle stream to the influent stream. It is defaulted in this version of the model to 0.5. For the secondary system, the fraction of organic settleable solids is taken as 0.64 of the total mixed liquor suspended solids (Namkung and Rittman, 1987). Also, the efficiency can be expressed as:

$$E_2 = Q_wX_v/(Q - Qp)(1 + RR)(X_1) \quad (25)$$

Where: X_v = the concentration of the total suspended solids; and
X_1 = concentration of mixed liquor suspended solids.

Again paralleling the development of the equations for the primary, Equation (23) can be written upon substitution and rearrangement:

$$Delta(VSS_s) = VSS_{ML}(1 - (1 - E_2)(Q - Q_p)(1 + RR)/(Q - Q_p - Q_w)) \quad (26)$$

Next, calculation of $M_{t,ML}$ is required. This cannot be passed along from the calculations about the primary since there are large amounts of solids generated in the secondary system. Due to the recycle stream, it is necessary to write an extra mass balance equation around a component of the system in order to be able to solve for the removal in terms of the input parameters.

First, the balance about the aeration basin is written as:

$$(Q - Q_p)(1 + RR)M_{t,ML} = (Q - Q_p)M_{t,PE} + RR(Q-Q_p)Mt_{t,RR} \quad (27)$$

and, by cancelling the common term $(Q-Q_p)$,

$$(1 + RR)M_{t,ML} = M_{t,PE} + RRM_{t,RR} \quad (28)$$

Taking the mass balance about the entire system yields:

$$(Q - Q_p)M_{t,PE} = (Q - Q_p - Q_w)M_{t,SE} + Q_w M_{t,RR} \tag{29}$$

or solving for $M_{t,RR}$:

$$M_{t,RR} = ((Q - Q_p)M_{t,PE} - (Q - Q_p - Q_w)M_{t,SE})/Q_w \tag{30}$$

Substituting Equation (30) into Equation (28):

$$(1 + RR)M_{t,ML} = M_{t,PE} + RR((Q - Q_p)M_{t,PE} - (Q - Q_p - Q_w)M_{t,SE})/Q_w \tag{31}$$

Next Equation (23) can be substituted into Equation (31), rearranged, and solved for $M_{t,ML}$:

$$M_{t,ML} = M_{t,PE}(1 + RR(Q - Q_p)/Q_w)/((1 + RR) + (RR\ (Q - Q_p - Q_w)\ (B_s/(Delta(VSS_s) + B_s)))/Q_w) \tag{32}$$

Equation (32) can be substituted back into Equation (23) to give:

$$M_{t,SE} = M_{t,PE}(1 + RR(Q - Q_p)/Q_w)(B_s/(Delta(VSS_s) + B_s))/((1 + RR) + (RR(Q - Q_p - Q_w)(B_s/(Delta(VSS_s) + B_s)))/Q_w) \tag{33}$$

The secondary removal rate is then:

$$rate_2 = (Q - Q_p)M_{t,PE} - (Q - Q_p - Q_w)M_{t,SE} \tag{34}$$

and the percent removal is:

$$\%\ removal_2 = 100(rate_2/QM_{t,RW}) \tag{35}$$

Since both individual removal rates are based on the total influent (raw waste stream) contaminant mass, the total removal rate and total percent removals are simply sums of those of the individual units.

Note that the final removal in the secondary system does not appear to depend directly on the secondary clarifier efficiency, E_2, since the efficiency is completely determined in Equation (25) by the input variables (RR is defaulted to 0.5). The user should check, using Equation (25), that the variables input for concentrations (i.e., X_v and X_1) are appropriate for the system simulation. Note that while Equation (26) would appear to indicate that the removal in the secondary is more sensitive to changes in the clarifer efficiency than is the primary, the probable ranges in efficiency are much smaller for the secondary clarifier than for the primary.

3.3 MODEL ASSUMPTIONS

A number of assumptions were used in developing the FATE model. It is important that the user be aware of these assumptions in order to understand the

limitations and basis of the model results. The major assumptions are as follows:

1) The model is for conventional diffused aeration activated sludge sewage treatment plants.

2) No significant volatilization or biodegradation occurs in the primary clarifier.

3) All reactors are completely mixed.

4) Steady state exists in all reactors (i.e., aeration basin and clarifiers) which implies that pollutant concentrations in a reactor do not change over time. (The model may therefore not be accurate for plants with pulse inputs of pollutants).

5) Liquid inflow equals liquid outflow.

6) For volatilization, the concentration of the organic compound of interest is assumed to be negligible in the inlet gas used for aeration.

7) For volatilization, the partial pressure of an individual compound in the gas exiting the aeration basin is in equilibrium with the individual compound concentration in the aeration basin liquid.

8) Sorption partitioning follows a linear relationship between concentrations in the liquid and solid phases.

9) Biodegradation follows Monod Kinetics and the organic compound influent concentration is assumed to be much less than the Monod half-saturation coefficient (i.e., influent concentrations are at relatively low levels).

10) For the biodegradation model step, it is assumed that a compound is removed by secondary utilization.

11) The fate of a compound is not affected by the presence of other compounds except as may be inherent in the data used for model calibration.

12) The POTW is operating effectively and no inhibition of the biological process is occurring (i.e., the POTW is acclimated to the compounds and concentrations present in the influent).

13) For model calibration, measured effluent concentrations reported as not detected were assumed to equal half the reported detection limit.

14) The organic model was calibrated with all compounds grouped together rather than by individual compound.

15) Removal mechanisms (volatilization, biodegradation, and sorption in the primary and secondary clarifiers) were estimated using final effluent concentration data and best engineering judgement.

16) Data for bis(2-ethylhexyl)phthalate, di-n-octyl phthalate, aldrin, and alpha-BHC were not used for final calibration due to inconsistencies in the analytical data compared to other compounds within similar classes.

17) Total removal of compounds primarily removed by sorption may be slightly over predicted while compounds primarily removed by volatilization and biodegradation may be slightly underpredicted.

4.0 DEFAULT VALUES AND INPUT VALUE RANGES

FATE users can either input their own plant-specific parameters or select default values for three POTWs spanning a range of size. Default influent flow values of 3.3, 25, and 140 million gallons per day are available to FATE users. MLSS concentration was obtained from standard reported practice (WPCF and ASCE, 1977) and temperature (20°C) was obtained from plant operating experience (Lovejoy, 1989). The remainder of the plant default values were obtained from a USEPA report which evaluated the cost of POTW construction (USEPA, 1984). Default values for all plant-specific operating parameters required for FATE are presented in Table 4-1.

If the default values are not used, FATE was designed so that a warning message will appear if the user inputs a plant or compound parameter that is either outside of a standard acceptable range or is inconsistent with previous plant inputs. Ranges for log Kow and Henry's Law constants were obtained from Lyman et al. (1982) and expanded to include known log Kow and Henry's Law constant values in FATE's organic data base. Ranges and relationships for plant conditions were obtained from Viessman and Hammer (1985) and WPCF and ASCE (1977). Sludge flow rates, aeration basin(s) volumes, and air flow rates were related to the plant influent flow. Concentration levels of various organic and inorganic pollutants that result in biological inhibition were obtained from a number of references (Anthony and Breimhurst, 1981, Russell et al., 1983, Tabak et al., 1981, USEPA, 1987a, USEPA, 1987b, and Volskay and Grady, 1988). The user will be warned if an influent concentration exceeding the inhibition level is entered. For organic compounds where inhibition data is unavailable, an influent concentration of 10,000 ug/l was used. This level was set so that inhibition effects would not affect the biodegradation removal rate and the secondary utilization, and so that first-order kinetics assumptions would be followed. Table 4-2 lists parameters, ranges, and associated references for all FATE plant input values.

TABLE 4-1
DEFAULT PLANT PARAMETERS

Parameter		Large	Medium	Small
Q	(Plant Flow Rate, MGD)	140.0	25.0	3.3
Qp	(Primary Sludge Flow Rate, gpd)	400,000	72,000	9,500
Xp	(Primary Sludge Concentration, %)	4.00	4.00	4.00
V	(Total Volume of Aeration Basins, gal)	39,287,700	7,022,300	931,900
Xl	(Mixed Liquor Suspended Solids, mg/l)	3,000	3,000	3,000
G	(Gas Volumetric Flow Rate, ft^3/d)	245,514,000	47,174,000	6,359,000
Qw	(Secondary Wasted Sludge Flow Rate, gpd)	1,232,000	220,000	29,000
Xv	(Secondary Wasted Sludge Concentration, %)	0.75	0.75	0.75

TABLE 4-2
PLANT PARAMETER RANGES

Parameter	Range	Reference
Q (Plant Flow Rate, MGD)	0 < Q < 1,000	Lovejoy, 1989
Qp (Primary Sludge Flow Rate, gpd)	1,000*Q < Qp < 9,000*Q	WPCF, ASCE, 1982
Xp (Primary Sludge Concentration, %)	3.0 < Xp < 8.0	Viessman, et al., 1985
V (Total Volume of Aeration Basins, gal.)	74,000*Q < V < 372,000*Q	Viessman, et al., 1985
Xl (Mixed Liquor Suspended Solids, mg/l)	1,500 < Xl < 7,000	Viessman, et al., 1985
G (Gas Volumetric Flow Rate, ft^3/d)	2,000,000*Q < G < 40,000,000*Q	WPCF, ASCE, 1982
Qw (Secondary Wasted Sludge Flow Rate, gpd)	500*Q < Qw < 20,000*Q	WPCF, ASCE, 1982
Xv (Secondary Wasted Sludge Concentration, %)	0.5 < Xv < 2.0	Viessman, et al., 1985

5.0 MODEL COEFFICIENTS AND CONSTANTS

Measured values of octanol/water partition coefficients and Henry's Law constants for compounds in FATE's organic compound data base were obtained from a number of sources. Sources included data from chemical manufacturers (e.g., material safety data sheets), USEPA resources (USEPA manuals and data bases), and journal publications.

Experimentally-determined values of octanol/water partition coefficients and Henry's Law constants were not available for many compounds. In addition, biodegradation rate constants for all compounds in the data base in an activated sludge treatment plant are not available. Thus, some octanol/water partition coefficients and Henry's Law constants and all data base-stored biodegradation rate constants had to be estimated. Estimation of octanol/water partition coefficients and Henry's Law constants was conducted from knowledge of a compound's molecular structure and other physical/chemical properties of the organic compound. Estimation of biodegradation constants was generally performed by relating rate of degradation to degree of degradation associated with biological processes.

5.1 OCTANOL/WATER PARTITION COEFFICIENTS

Unknown octanol/water partition coefficients were estimated from knowledge of a compound's molecular structure. The Universal Quasi-Chemical Functional Group Activity Coefficient (UNIFAC) approach was used to estimate a compound's activity coefficients in water and in octanol. The UNIFAC approach computes activity coefficients from knowledge of the compound's molecular structure, heat of fusion, and melting temperature. Compound heats of fusion and melting point temperatures were obtained from Verschueren (1977).

The computer program, AROSOL (Fu et al., 1986), was used to estimate activity coefficients of a compound in octanol and water. This program was developed through the support from EPA's Robert S. Kerr Environmental Research Laboratory to estimate organic solute solubility in a mixed solvent system. Kow can be estimated from the approach of Arbuckle (1983) as:

$$Kow = 0.151\ \sigma^{w}/\sigma^{o} \qquad (36)$$

where σ^{w} is the compound's activity in the water phase and σ^{o} is the compound's activity in the octanol phase. During estimation of a compound's activity coefficients in water and octanol, AROSOL was programmed to allow for the solubility of water in octanol (2.6 M) and octanol in water (0.0178M).

5.2 HENRY'S LAW CONSTANTS

Henry's Law constants (atm-m^3/mole) were estimated from knowledge of the compound's activity in pure water and the compound's vapor pressure as follows (Arbuckle, 1983):

$$H = (18 \times 10^{-6})\ \text{sigma}^{w}\ P_{vp} \qquad (37)$$

where sigma^{w} is the activity of the compound in pure water (provided by AROSOL) and P_{vp} (atm) is the compound's vapor pressure as estimated from knowledge of its boiling point (Lyman et al., 1982).

5.3 BIODEGRADATION RATE CONSTANTS

No large data base of biodegradation rate constants for secondary utilization of an organic compound in an environment similar to an activated sludge system was available. In addition, actual biodegration rate constants for individual compounds are facility specific. Therefore, a methodology was developed to assign compound-specific biodegradation rate constants based on the compound's relative biodegradability for input into FATE's data base.

A sensitivity analysis conducted on FATE's organic compound removal algorithms indicated that a biodegradation rate constant of 0.1 m^3/gm VSS-day resulted in overall removals in the low 90-percent range which were typical of removals observed in the field for highly biodegradable compounds (USEPA, 1982). The sensitivity analysis also indicated that a biodegradation rate constant of 0.0001 resulted in insignificant compound biodegradation removal for compounds which were removed mostly by volatilization or biodegradation. This conclusion is also supported by sensitivity analyses performed by Namkung and Rittmann (1987). From the sensitivity analysis performed on the biodegradation rate constant, a highly biodegradable compound would have a rate constant of about 0.1 m^3/gm-day while a compound resistant to biodegradation would have a rate constant of 0.0001 or lower.

The biodegradability of compounds was first estimated based on three different sources of information. The first source was obtained from a study in Lyman et al. (1982) where it was reported that a highly biodegradable compound would have a BOD/COD ratio of 1 while a resistant compound would have a value of 0. Reported ratios spanned three orders of magnitude and were assigned rate constants according to the compound's BOD/COD ratio. The BOD/COD ratios and corresponding rate constants assigned were as follows:

Reported BOD_5/COD ratio	Assigned Biodegradation Rate Constant
0 - 0.01	1×10^{-4}
0.01 - 0.05	1×10^{-3}
0.05 - 0.10	5×10^{-3}
0.10 - 0.25	1×10^{-2}
0.25 - 0.60	5×10^{-2}
>0.60	1×10^{-1}

Another study reported in Lyman et al. (1982) listed average rates of biodegradation in mg COD/gm-hr. These data were also used to estimate the biodegradability and subsequently, the rate constant. The average rate and corresponding rate constant assigned were as follows:

Average Rate of Removal (mgCOD/g-hr)	Assigned Biodegradation Rate Constant
0	1×10^{-4}
1-9	1×10^{-3}
10-25	1×10^{-2}
> 25	1×10^{-1}

Finally, the relative biodegradability of compounds in aerobic treatment systems was obtained from a USEPA guidance manual (USEPA, 1987b) that based the biodegradability on USEPA's Best Professional Judgement. The rate of biodegradation was judged to be "Rapid, Moderate, Slow, or Resistant". A rate constant of 1×10^{-1}, 1×10^{-2}, 1×10^{-3}, and 1×10^{-4} was respectively assigned to compounds where a rate was predicted.

All three of the previously described sources of information were considered in assessing the biodegradability of a compound. If a compound was listed in more than one reference, an average was used.

If a compound was not listed in any of the sources above, a number of "Rules of Thumb of Biodegradability" (Lyman et al, 1982) were used to aid in estimating values and are presented in Table 5-1. Next, rate constants were assigned by attempting to interpret particular biodegradability patterns based on a compounds functional groups by using all of the information described above. For example chlorinated compounds were assumed to have a rate constant of 1×10^{-3} since these compounds are more resistant to degradation; acids, alcohols, and esters were given values of 1×10^{-2} while ethers and ketones (mostly chlorinated) were assigned values from 1×10^{-4} to 1×10^{-3}; dioxans and furans (mostly chlorinated) were assigned values of 1×10^{-4}; functional groups (i.e. benzo-, fluoro-, chloro-, nitro-, etc.) were grouped with similar compounds, and if a pattern could be established from estimates or assumptions already made, the pattern was followed (i.e., chlorobenzene with benzene, ethylbenzene, toluene, etc.).

Finally, compounds that could not be assigned a value using any of the previously described methods were given values based on compounds within the same class (e.g., dioxins, pesticides, semi-volatile organics, volatile organics, etc.). Values assigned based on such a ranking were conservatively estimated since little is known about the compound's characteristics and its susceptibility to biodegradation.

The ITD list of 345 organic compounds, their estimated biodegradation rate constants, and the method of estimation is presented in Attachment A. The full

TABLE 5-1

RULES OF THUMB FOR BIODEGRADABILITY

- Sulfate-reducing bacteria more rapidly degrade long length carbon chains than short-length carbon chains.
- Alcohols, aldehydes, acids, esters, amides, and amino acids are more susceptible to biodegradation than the corresponding alkanes, olefins, ketones, dicarboxylic acids, nitriles, amines, and chloroalkanes.
- Functional groups on aromatic rings: benzoic acid is quickly degraded; monochloro - and monofluoro - benzoates are more resistant to biodegradation but can be degraded; di-, tri-, and tetra-functional groups are quite resistant. The more chlorines, the more resistant the compound.
- For naphthalene compounds, nuclei bearing simple small alkyl groups (methyl, ethyl, or vinyl) oxidize at a more rapid rate than those with a phenyl substitute.
- ether functions are sometimes particularly resistant to biodegradation.

Source: Lyman, W.J. and D.H. Rosenblatt, Handbook of Chemical Property Estimation Methods, McGraw Hill Book Co., New York, New York, 1982.

ITD list of organic and inorganic compounds is presented in Section 9 of this Treatability Manual.

6.0 MODEL CALIBRATION AND VALIDATION

Model calibration/validation is the process that adjusts the overall theoretically based FATE model to more accurately predict effluent concentrations and percent removals that are observed in actual plant processes. The process of calibration/validation, including a sensitivity analysis, is described in subsequent sections.

6.1 SENSITIVITY ANALYSIS

Prior to actual calibration/validation, Jordan performed a sensitivity analysis on the FATE model. The detailed report summarizing the methodology, results, and conclusions was submitted to EPA in February 1990. A brief summary is presented here. The sensitivity analysis was performed to evaluate how sensitive output parameters (i.e., percent removals for volatilization, biodegradation, and sorption) are to changes in input parameters (e.g., plant flow, temperature, primary sludge concentration, etc.).

A number of compounds and all of the FATE model input parameters were chosen for the analysis. The compounds were divided into four different categories according to their primary mechanisms for removal (i.e., compounds that primarily sorb to sludge, volatilize, biodegrade, or both volatilize and biodegrade). An overall summary of the results of the FATE Model Sensitivity analysis is presented in Table 6-1. The four compound categories and the list of parameters analyzed are presented with a mark in the appropriate box to indicate if the compound in a particular category showed some level of sensitivity to a specific plant or compound parameter.

After performing the sensitivity analysis on the FATE model, the following conclusions were made:

1. Parameters the model was not sensitive to included compound input concentration (relative to percent removals) and temperature in the aeration basin.

2. FATE predicts that the following removal mechanisms may contribute significantly to removal of a compound in a POTW:

   Primary Adsorption
   Secondary Adsorption
   Volatilization/Stripping
   Biodegradation

   In all cases, except for changes in compound concentration and temperature, one or more of these mechanisms contributed to compound removal when a parameter was changed. However, of the mechanisms, primary adsorption was the least sensitive to changes in input parameters. This is partly due to the non-linear dependence on the

TABLE 6-1
SENSITIVITY ANALYSIS

COMPOUND CLASSES SENSITIVE TO INPUT PARAMETERS

INPUT PARAMETER	COMPOUND CLASSIFICATION			
	SORB	BIODEGRADE	VOLATILIZE	BIODEGRADE/ VOLATILIZE
COMPOUND CONCENTRATION				
PLANT FLOW	✦	✦	✦	✦
PRIMARY SLUDGE CONCENTRATION	✦			
PRIMARY SLUDGE FLOW RATE	✦			
AERATION BASIN VOLUME		✦		✦
MIXED LIQUOR SUSPENDED SOLIDS CONCENTRATION		✦		✦
TEMPERATURE OF AERATION BASIN				
TOTAL GAS VOLUMETRIC FLOW RATE			✦	✦
WASTE SLUDGE FLOW RATE	✦			
WASTED SECONDARY SLUDGE CONCENTRATION	✦			
HENRY'S LAW CONSTANT			✦	✦
Kow CONSTANT	✦			
BIO RATE CONSTANT	✦	✦	✦	✦

✦ Compound classes sensitive to changes in input parameters

rate of removal with Kow while being directly proportional to sludge concentration and sludge flow rate.

Input parameters that affected primary adsorption included plant flow, primary sludge concentration, primary sludge flow rate, and Kow.

3. Based on the results of the sensitivity analysis, data collection efforts for calibration/validation were not prioritized except that emphasis was not placed on collection of data for temperature of the aeration basin since the model indicated that predicted removal is not sensitive to this parameter. Further, temperature was defaulted in the model to 20°C and no input for temperature is required of the user.

6.2 DATA COLLECTION/SELECTION

Analytical data and plant operating parameters for calibration and validation were obtained from the following sources:

- USEPA, 1982. "Fate of Priority Pollutants in Publicly Owned Treatment Works," USEPA/440/1-82/303, Washington, D.C.
- Contacts with additional conventional activated sludge POTWs to obtain plant operational data and chemical concentration for the plant influent and effluent.

The USEPA study involved sampling the influent, effluent, and sludge for various organic and inorganic pollutants at a number of POTWs. Only data from conventional activated sludge treatment plants that use diffused aeration were used. In addition, each of the POTWs used was contacted and the plant parameters under which the plant operated during the sampling period were obtained and used for calibration. Additional data were obtained from a number of operating conventional activated sludge treatment plants. Jordan requested analytical data (i.e., priority pollutant scans and monthly monitoring data) as well as corresponding plant operating parameters for the sampling days.

Data to calibrate and validate FATE's organic and inorganic compound algorithms were limited to the following selection criteria. First, a data pair (an influent and a corresponding effluent concentration value) was used only if the reported influent concentration was greater than the detection limit. Second, if the effluent concentration was reported as zero or nondetect, the detection limit (typically a value of 5 or 10 ug/l) was used. This selection criteria should result in a consistent set of acceptable data for calibration and validation of the algorithms of FATE. It should also provide an accurate account of what a POTW would encounter if required to follow strict laboratory analytical procedures and reporting requirements.

6.3 ORGANIC MODEL CALIBRATION

The procedure used to calibrate the FATE Organic Model is described in subsequent sections.

6.3.1 FATE Model Predictions

FATE's organic model is specifically intended for activated sludge wastewater treatment systems that employ primary and secondary clarifiers. The development of the organic model was detailed in Section 3.1.

The organic model requires thirteen input parameters; nine are facility-specific, three are compound-specific, and one is both compound and facility-specific (influent concentration). These input parameters are listed in Table 6-2.

The organic model predicts six output parameters; steady-state concentrations in the primary and secondary clarifiers, and removal rates of the selected compound through sorption in the primary clarifier and sorption, volatilization, and biodegradation in the secondary clarifier. In addition, removal efficiencies are also computed. These output parameters are also presented in Table 6-2. Four of the eleven model outputs require calibration for the model to be considered valid; specifically, the four predicted removal rates. Calibration of the removal rates will result in calibration of all other parameters since the remaining output parameter values are dependent on the removal rates.

6.3.2 Actual Observations

The data required for model calibration was collected from a variety of sources, as described in Section 6.2. The collected data provided inputs to FATE in order to predict removal rates and effluent concentration for each set of input data. These model predictions were compared to actual observations of removal rates and effluent concentrations provided by the collected data. All data sources used to calibrate FATE provided observations of all the FATE input parameters. None of the data sources provided observations of the four removal mechanisms that require calibration. However, all the data sources did provide observations of POTW effluent concentrations.

Because observations of the four removal mechanisms were not provided, FATE could not be directly calibrated by removal mechanism. Nevertheless, the availability of effluent concentration data allowed FATE to be calibrated for total removal. Subsequently, calibration of each removal mechanism was conducted by using best engineering judgement.

6.3.3 Calibration

The purpose of model calibration is to adjust the theory-based model equations with a calibration factor to minimize the differences between actual observations and model predictions. The process of calibration is facilitated by a copious amount of actual observations. A greater number of actual observations increases the likelihood that the model will accurately predict the

TABLE 6-2
FATE Organic Model Inputs and Outputs

Model Inputs

Q	Influent flow rate to primary clarifier
Q_o	Flow rate between primary and secondary clarifiers
Q_p	Primary clarifier wasted sludge flow rate
Q_w	Secondary clarifier wasted sludge flow rate
V	Volume of aeration basin(s)
G	Gas flow rate through aeration basin(s)
$X\ell$	concentration of mixed liquor suspended solids
X_p	Concentration of cells in wasted primary sludge
X_v	Concentration of cells in wasted secondary sludge
S_i	Influent concentration of pollutant to primary clarifier
K_{ow}	Octanol-water partition coefficient of pollutant
H	Henry's Law constant of pollutant
K_1	First-order biodegradation rate constant of pollutant

Model Outputs

S_o	Steady-state concentration of pollutant in primary clarifier
S	Steady-state concentration of pollutant in secondary clarifier (effluent conc.)
$R_{sorp,1}$	Mass removal rate of pollutant by sorption in primary clarifier
$R_{sorp,2}$	Mass removal rate of pollutant by sorption in secondary clarifier
R_{vol}	Mass removal rate of pollutant by volatilization/stripping in aeration basin
R_{bio}	Mass removal rate of pollutant by biodegradation in secondary system
$f_{sorp,1}$	Percent of pollutant removed by sorption in primary clarifier
$f_{sorp,2}$	Percent of pollutant removed by sorption in secondary clarifier
f_{vol}	Percent of pollutant removed by volatilization/stripping in aeration basin
f_{bio}	Percent of pollutant removed by biodegradation in secondary system
f_{total}	Percent of pollutant removed by all mechanisms in POTW

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removal of a pollutant from the influent waste stream. Without actual observations, the model can not be calibrated.

The calibration of the model is a potentially complex process. Four different removal mechanisms are predicted by the model, each requiring calibration. Actual observations do not exist for these mechanisms; thus, calibration factors for each removal mechanism were estimated from actual observations of total removal. Compounds used in the calibration process are listed in Table 6-3 by compound class.

Calibration factors were incorporated into the formula of each removal mechanism as follows:

$$R_{sorp1} = (Q_{pw}X_{pw}\ (0.000059 * K_{ow}^{0.35})\ S_o)\ calb_{s1} \quad (38)$$

$$R_{bio} = (k_1X_aSV)\ calb_b \quad (39)$$

$$R_{vol} = (GHS/RT)\ calb_v \quad (40)$$

$$R_{sorp2} = (3.06 \times 10^{-6}\ Q_wX_vK_{ow}^{0.67}\ S)\ calb_{s2} \quad (41)$$

Hence, the computation of steady-state concentrations in the primary and secondary clarifiers can be rewritten as

$$S_o = (QS_{in})/(Q + Q_{pw}X_p\ (4.1 \times 10^{-5} * K_{ow}^{0.35})\ calb_{s1}) \quad (42)$$

$$S = (QS_o)/(Q + (GH/RT)calb_v + Q_wX_v(3.06 \times 10^{-6}\ K_{ow}^{0.67})calb_{s2} + k_1X_aVcalb_b) \quad (43)$$

The calibration process began by entering actual observations of model input data into FATE, which then predicted four removal rates and an effluent concentration for each set of input data. Statistical distributions of the model predictions and corresponding actual observations were subsequently evaluated and residuals (a measure of error between actual observations and model predictions) computed. The residuals were evaluated for statistical distributions and dependencies on input parameters. Finally, the calibration factors were estimated from statistical evaluations of the residuals and best engineering judgement.

6.3.4 Calibration Model Runs

Actual observations of facility parameters were entered into a facility data base that included the facility name, the pollutant observed, all facility input parameters (see Table 6-2), influent concentration, and effluent concentration. Compound input parameters from the FATE organic data base were used. The model was then run with calibration factors set at iteratively determined values.

The model output was formatted such that the model predictions were listed alongside the facility name, pollutant observed, the facility and compound input parameters, and the actual observations of influent and effluent concentrations. The output was subsequently imported into SYSTAT (Systat, Inc., 1989) for statistical evaluation.

TABLE 6-3

Compounds used in FATE Calibration

Compound Class	Compound CAS No.	Compound Name
Aromatic Volatile Organic Compounds (ARO)		
	100414	Ethylbenzene
	108883	Toluene
	71432	Benzene
Halogenated Volatile Organic Compounds (HVO)		
	107062	1,2-Dichloroethane
	127184	Tetrachloroethene
	156605	trans-1,2-Dichloroethene
	56235	Tetrachloromethane
	67663	Chloroform
	71556	1,1,1-Trichloroethane
	75003	Chloroethane
	75092	Methylene Chloride
	75343	1,1-Dichloroethane
	75354	1,1-Dichloroethene
	75694	Trichlorofluoromethane
	79005	1,1,2-Trichloroethane
	79016	Trichloroethene
	79345	1,1,2,2-Tetrachloroethane
Miscellaneous Volatile Organic Compounds (MVO)		
	107131	2-Propenenitrile
	67641	2-Propanone
Polycyclic Aromatic Hydrocarbons (PAH)		
	120127	Anthracene
	129000	Pyrene
	191242	Benzo(ghi)perylene
	205992	Benzo(b)fluoranthene
	206440	Fluoranthene
	207089	Benzo(k)fluoranthene
	218019	Chrysene
	50328	Benzo(a)pyrene
	56553	Benzo(a)anthracene
	85018	Phenanthrene
	86737	Fluorene
	91203	Naphthalene

TABLE 6-3

Compounds Used in FATE Calibration
(continued)

Compound Class	Compound CAS No.	Compound Name
Polychlorinated Biphenyls (PCB)		
	11097691	PCB-1254
	53469219	PCB-1242
Pesticides (POH)		
	309002	Aldrin
	319846	alpha-BHC
	50293	4,4'-DDT
	58899	Lindane
	60571	Dieldrin
	76448	Heptachlor
Phthalates (PTH)		
	117817	bis(2-Ethylhexyl) phthalate
	117840	Di-n-octyl phthalate
	121142	2,4-Dinitrotoluene
	131113	1,2-Benzenedicarboxylic acid, dimethyl ester
	78591	Isophorone
	84662	Diethyl phthalate
	84742	1,2-Benzenedicarboxylic acid, dibutyl ester
	85687	Butyl benzyl phthalate
	95501	1,2-Dichlorobenzene
Acid Extractable Semivolatile Compounds (SVA)		
	105679	2,4-Dimethylphenol
	108952	Phenol
	120832	2,4-Dichlorophenol
	51285	2,4-Dinitrophenol
	65850	Benzoic acid
	87865	Pentachlorophenol
	95578	2-Chlorophenol
Base Extractable Semivolatile Compounds (SVB)		
	106467	1,4-Dichlorobenzene
	122667	1,2-Diphenylhydrazine
	606202	2,6-Dinitrotoluene
	91587	2-Chloronaphthalene

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6.3.5 Statistical Evaluation

6.3.5.1 Method. The objectives of the statistical evaluation were to demonstrate calibration of the FATE predicted effluent concentration with measured effluent concentration and demonstrate that removal rates for each mechanism agreed with best engineering judgement.

The demonstration of calibration was conducted with an analysis of FATE residuals. The residual, which is a measure of error between predicted and measured effluent concentration, can be defined in several ways depending on the distribution of the predicted and measured data. For example, if the predicted and measured concentrations are normally distributed, the residual can be simply defined as

$$E = S_{meas} - S_{pred} \tag{44}$$

Where E = residual,
S_{meas} = measured effluent concentration (mg/ℓ), and
S_{pred} = FATE predicted effluent concentration (mg/ℓ).

If the predicted and measured concentrations are lognormally distributed, the residual can be defined as

$$E = \log_{10}S_{meas} - \log_{10}S_{pred} \tag{45}$$

Thus, the first step in the calibration demonstration was the evaluation of the distribution of the predicted and measured effluent concentrations. After the evaluation was completed, the residual was defined and computed for each case. The residual was evaluated for normality and the mean and variance subsequently computed. Calibration was demonstrated when the mean of the residuals equaled zero. The variance was computed to represent the precision of the model.

In some cases, measured effluent concentrations were reported as not detected. For the purpose of calibration, these concentrations were assumed to equal half the reported detection limit. A few cases reported measured effluent concentrations greater than measured influent concentrations. These cases were rejected on the basis that they violated mass balances.

The agreement of removal rates with best engineering judgement was demonstrated by analyzing the contribution of each removal mechanism to the total removal rate. The contributions were defined as

$$f_{sorp1} = R_{sorp1}/R_{total} \tag{46}$$
$$f_{bio} = R_{bio}/R_{total} \tag{47}$$
$$f_{vol} = R_{vol}/R_{total} \tag{48}$$
$$f_{sorp2} = R_{sorp2}/R_{total} \tag{49}$$

where f = fraction of total removal, and
$R_{total} = R_{sorp1} + R_{bio} + R_{vol} + R_{sorp2}$ = total removal.

Compounds with known properties were selected for evaluation. For example, phenol is known to biodegrade readily and is expected to have an f_{bio} of approximately 0.95. Chloroethane and trans-1,2-dichloroethene are known to volatilize readily and are expected to have an f_{vol} of approximately 0.95. Polycyclic Aromatic Hydrocarbons (PAHs) are known to sorb readily and are expected to have a sum of f_{sorp1} and f_{sorp2} greater than 0.95.

Thus, the selection of calibration factors was conducted through an iterative process that produced a model calibrated for total removal with individual removal mechanisms adjusted to agree with best engineering judgement.

6.3.5.2 Results - Uncalibrated Model. The calibration factors for the organics model were set equal to unity to evaluate the model in its uncalibrated state. Measured and predicted effluent concentration distributions were evaluated. The distributions included all cases, regardless of the compound, and in both the measured and predicted cases, a lognormal distribution adequately characterized the data. Probability plots of the measured and predicted effluent concentration data are presented in Attachment B.

The residual for each case was computed in accordance with Equation (45). The normal distribution adequately characterized the distribution of the residuals and a mean of 1.13 was computed with a standard deviation of 1.28. The mean indicates that on average, the uncalibrated model predicts effluent concentrations below measured effluent concentrations by a factor of 13.5. This can be seen by rewriting Equation (45) as

$$S_{meas}/S_{pred} = 10^{E} \qquad (50)$$

Since predicted effluent concentrations were much lower than measured, the total removal rate predicted by the uncalibrated model was too high.

Boxplots of the residuals by compound class are presented in Figure 6-1, while boxplots of the residuals by compound are presented in Attachment B. A bar chart of the removal mechanism contributions for each compound class is presented in Figure 6-2, while bar charts for each compound are presented in Attachment B. These charts facilitate the selection of calibration factors by highlighting the differences between compounds and compound classes.

Analysis of the bar charts indicates that sorption removal was overpredicted relative to biodegradation and volatilization, and that biodegradation was overpredicted relative to volatilization. Examples include phenol where biodegradation accounted for only 88% of the mass removed when 95% was expected, and chloroethane where volatilization accounted for only 72% of the mass removed when 95% was expected.

6.3.5.3 Results-Calibrated Model. Calibration factors were adjusted iteratively until the mean of the residuals equaled zero and the removal mechanism contributions agreed with best engineering judgement. The statistical evaluation of each iteration was identical to that of the uncalibrated model. The statistical evaluation of the final iteration is presented here.

Figure 6-1
Boxplots of FATE Residuals by Compound Class

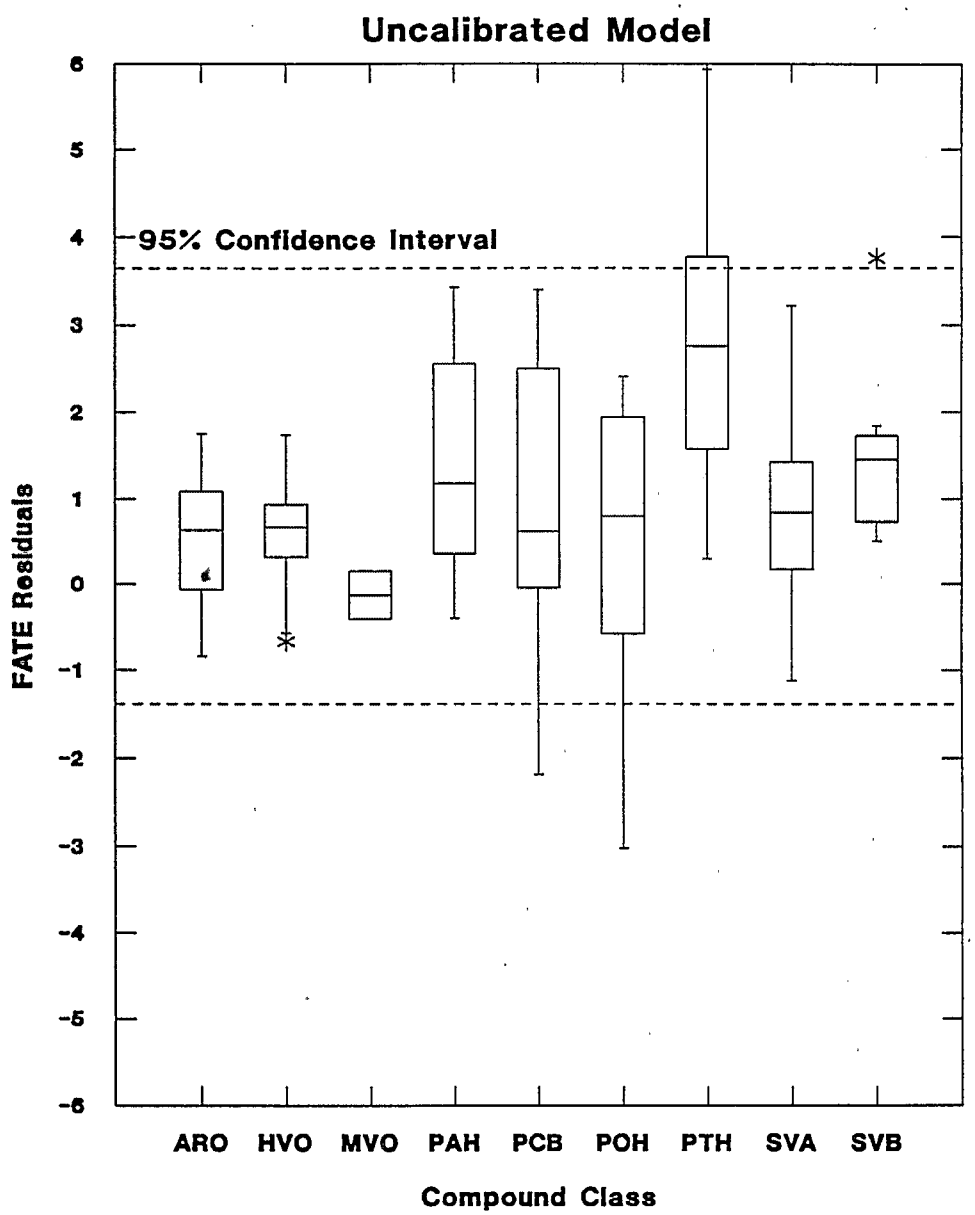
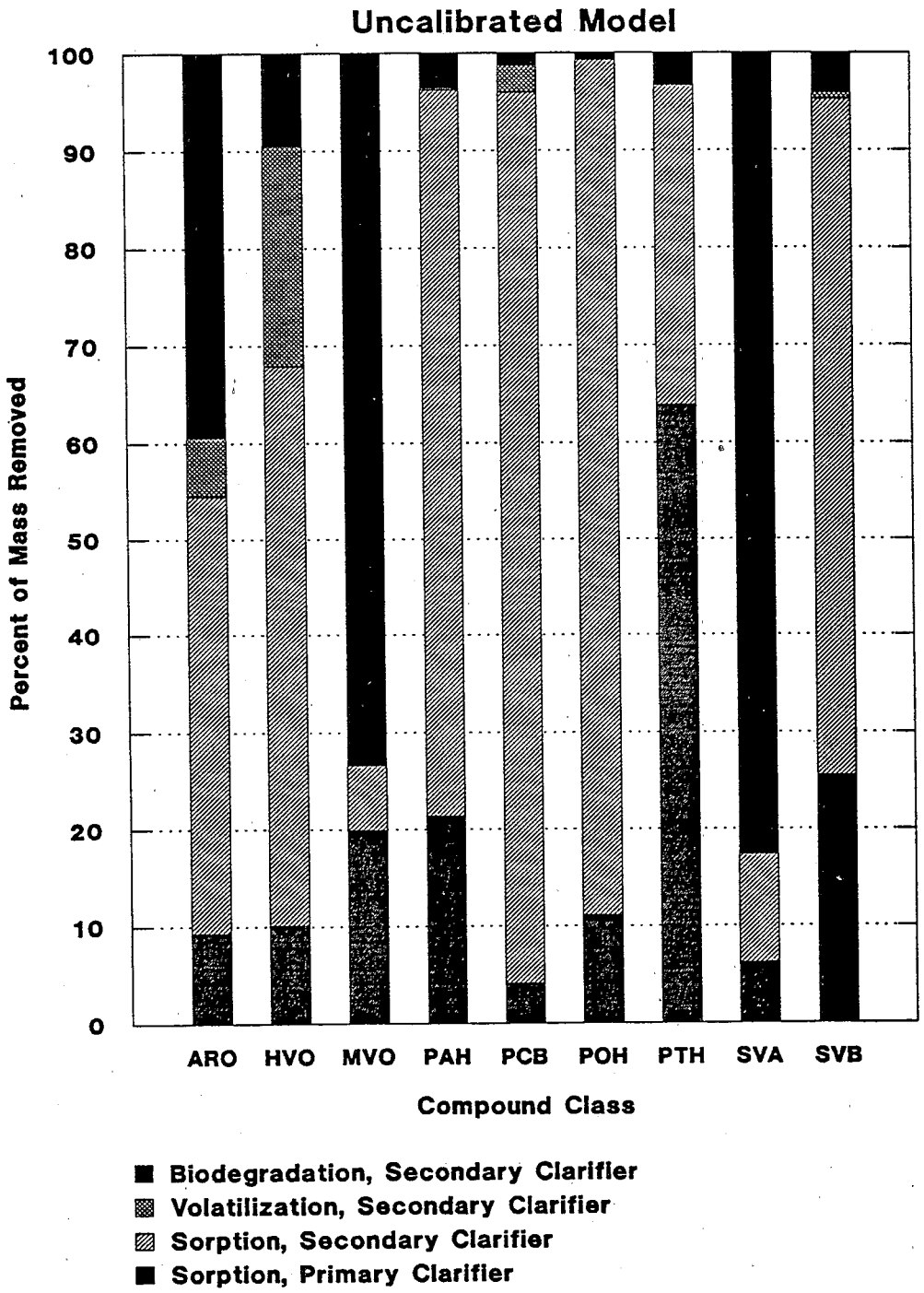


Figure 6-2
Percent of Mass Removed by Each Mechanism



The lognormal distribution adequately characterized the predicted effluent concentration data. Thus, the residuals were computed identically to the uncalibrated model. The normal distribution adequately characterized the distribution of the residuals with a mean of -0.00543 and a standard deviation of 0.774. The mean is sufficiently close to zero given the standard deviation of the residuals (coefficient of variation = -142). The probability plot of the residuals is presented in Figure 6-3.

Boxplots of the residuals by compound class are presented in Figure 6-4 while boxplots of the residuals by compound are presented in Attachment B. A bar chart of the removal mechanism contributions for each compound class is presented in Figure 6-5, while bar charts for each compound are presented in Attachment B.

Analysis of the bar charts indicates that the contributions of each removal mechanism to total removal are consistent with best engineering judgement. Examples include phenol where biodegradation accounted for 93% of the mass removed, chloroethane where volatilization accounted for 92% of the mass removed, and a variety of PAHs where sorption accounted for nearly 100% of the mass removed.

Analysis of the boxplots indicates that some bias in the model exists on a compound specific basis. Generally, compounds with higher sorption removal tend to be slightly overpredicted while compounds predominantly removed by volatilization and biodegradation tend to be slightly underpredicted. As a result, residual dependence on input parameters was evaluated. The residuals did not correlate strongly with any of the input parameters, although some correlation was exhibited between the residuals and $\log_{10} K_{ow}$.

The correlation between the residuals and $\log_{10} K_{ow}$ is most likely a result of the equations used to represent the partition coefficients to the respective clarifier solids, K_p. The relationships between K_p and K_{ow}, shown in Equations (3) and (9), were established empirically from data obtained for volatile organic compounds (VOCs). These relationships are limited to ranges of $\log_{10} K_{ow}$ from 0 to 3; however, the readily sorbed compounds, such as PAHs, PCBs, pesticides, and phthalates, have a $\log_{10} K_{ow}$ range from 3 to 10. The extrapolation of the empirical relationships established for VOCs into the higher range of $\log_{10} K_{ow}$ probably provided the slight bias exhibited in the boxplots.

The calibrated model does not account for the dependence of the residuals on $\log_{10} K_{ow}$. Revising the relationship between K_p and K_{ow} could not be justified in the absence of published research evaluating the relationship between K_p and K_{ow} for compounds with high K_{ow}. Additionally, since the random error in the model is greater than the error induced by the K_{ow} bias, accounting for the K_{ow} bias would not significantly reduce the random error of the model.

Finally, four compounds were eliminated from the final calibration iteration: bis(2-ethylhexyl)phthalate, di-n-octylphthalate, aldrin, and alpha-BHC. These compounds contained a substantial proportion of extreme residual values. The two phthalates are common contaminants during sampling and laboratory analysis

Figure 6-3
Probability Plot of FATE Residuals

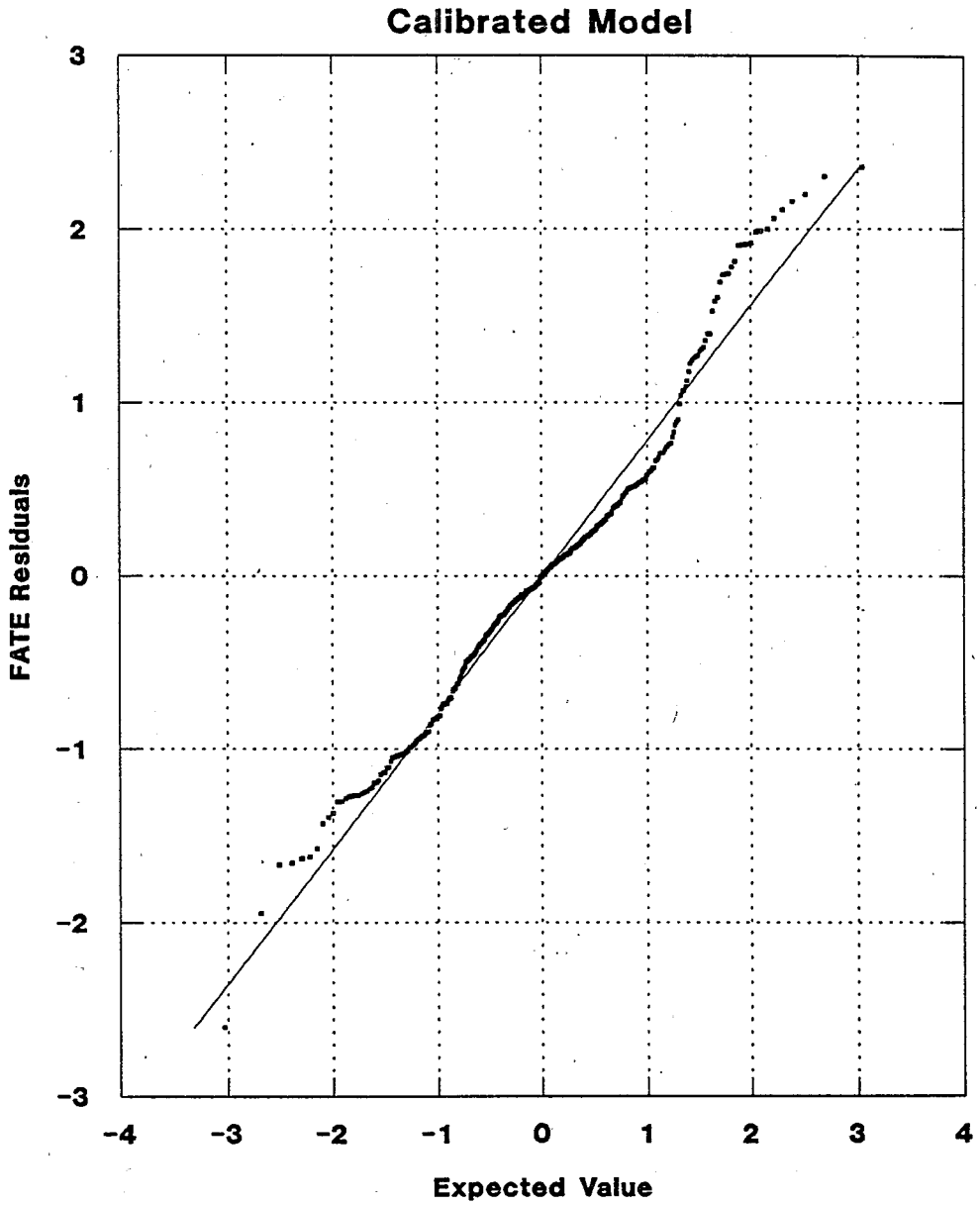


Figure 6-4
Boxplots of FATE Residuals by Compound Class

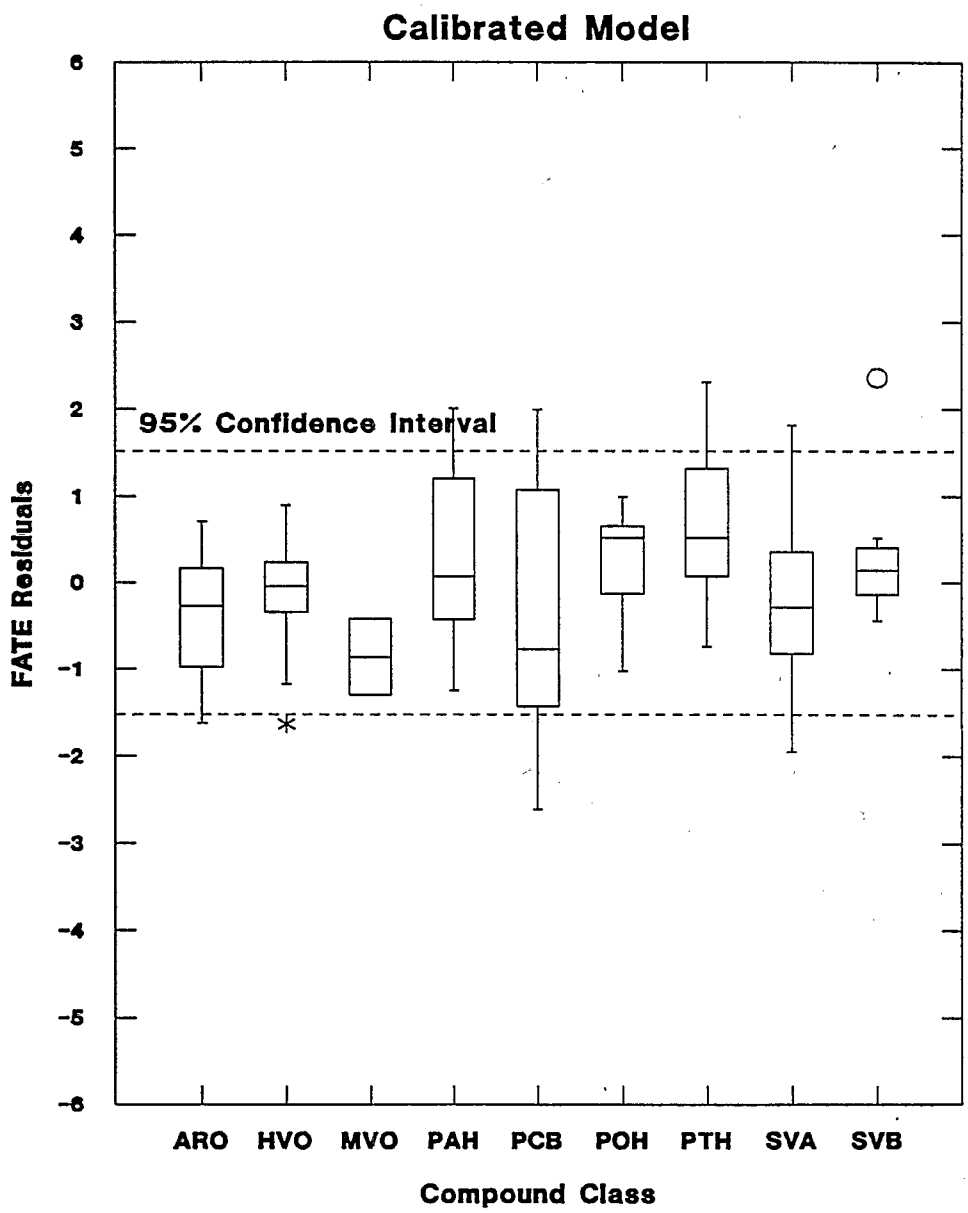
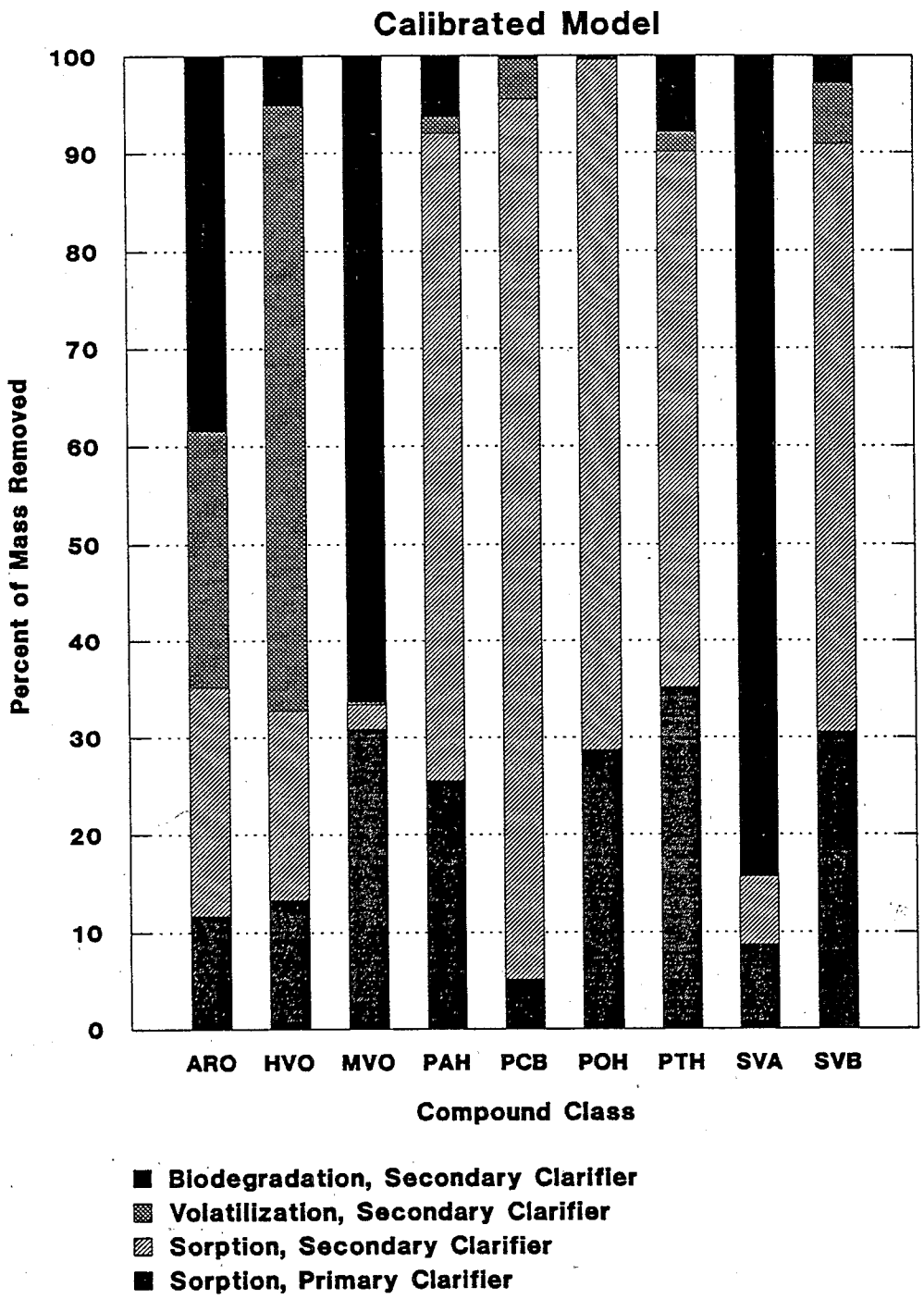


Figure 6-5
Percent of Mass Removed by Each Mechanism



which can potentially bias the measured removal efficiency to values lower than expected. The consistent overprediction of removal efficiency by the model indicates that this bias may be present. Additionally, the results highlight the necessity of evaluating the empirical relationship between K_p and K_{ow} for these and similar compounds, and possibly a laboratory confirmation of the reported K_{ow} values.

The final calibration factors were established as follows

$calb_{s1} = 1.0$
$calb_v = 0.38$
$calb_b = 0.076$
$calb_{s2} = 0.038$

These calibration factors were subsequently entered into the model computer code.

6.4 INORGANIC MODEL CALIBRATION

The procedure used to calibrate the FATE Model for inorganic compounds is described in subsequent sections.

6.4.1 Fate Model Predictions

Fate's inorganic model is specifically intended for activated sludge wastewater treatment systems that employ primary and secondary clarifiers. The development of the inorganic model was detailed in Section 3.2.

The inorganic model requires ten input parameters; seven are facility-specific, two are compound-specific, and one is both compound and facility-specific. These input parameters are listed in Table 6-4.

The inorganic model predicts six output parameters; effluent concentrations from the primary and secondary clarifiers, and removal rates of the selected compound in each clarifier. In addition, removal efficiencies are also computed. These output parameters are also presented in Table 6-4. Two of the six model outputs require calibration for the model to be considered valid; specifically the two predicted removal rates. Calibration of the removal rates will result in calibration of all other output parameters since the remaining output parameter values are dependent on the removal rates.

6.4.2 Actual Observations

The data required for model calibration was collected from a variety of sources, as described in Section 6.2. The collected data provided inputs to FATE in order to predict removal rates and effluent concentration for each set of input data. These model predictions were compared to actual observations of removal rates and effluent concentrations provided by the collected data. All data sources used to calibrate FATE provided observations of all the FATE input parameters. None of the data sources provided observations of the FATE removal

TABLE 6-4
FATE Inorganic Model Inputs and Outputs

Model Inputs

Q	Influent flow rate to primary clarifier
Q_o	Flow rate between primary and secondary clarifiers
Q_p	Primary clarifier wasted sludge flow rate
Q_w	Secondary clarifier wasted sludge flow rate
$X\ell$	Concentration of mixed liquor suspended solids
X_p	Concentration of cells in wasted primary sludge
X_v	Concentration of cells in wasted secondary sludge
$M_{t,Rw}$	Influent concentration of pollutant to primary clarifier
B_p	Primary clarifier calibration factor of pollutant
B_s	Secondary clarifier calibration factor of pollutant

Model Outputs

$M_{t,PE}$	Primary clarifier effluent concentration
$M_{t,SE}$	Secondary clarifier effluent concentration
$rate_1$	Mass removal rate of pollutant in primary clarifier
$rate_2$	Mass removal rate of pollutant in secondary clarifier
% $removal_1$	Percent of pollutant removed in primary clarifier
% $removal_2$	Percent of pollutant removed in secondary clarifier
% removal	Percent of pollutant removed in POTW

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rates that require calibration. However, all the data sources did provide observations of POTW effluent concentrations. Because observations of the two removal rates were not provided, FATE could not be calibrated by each removal rate. Nevertheless, the availability of effluent concentration data allowed FATE to be calibrated for total removal. Calibration of each removal rate was conducted by best engineering judgement.

6.4.3 Calibration

The calibration of the inoganics model is a relatively simple process. Since the model is based on an empirical relationship between removal of a metal and removal of volatile suspended solids (VSS), calibration factors are already included. However, because actual observations of primary clarifier effluent concentrations did not exist, linear regression analysis could not be used to determine the compound-specific calibration factors, B_p and B_s. Instead, the factors were determined iteratively to accomplish calibration of the total removal rate and estimate primary and secondary removal rates to agree with best engineering judgement.

The calibration process began by entering actual observations of model input data into FATE, which then predicted two removal rates and an effluent concentration for each set of input data. Statistical distributions of the model predictions and corresponding actual observations were subsequently evaluated and residuals computed. The residuals were evaluated for statistical distributions and dependencies on input parameters. Finally, the calibration factors were estimated from statistical evaluations of the residuals and best engineering judgemeent.

6.4.4 Calibration Model Runs

Actual observations of facility parameters were entered into a facility data base that included the facility name, the pollutant observed, all facility input parameters (see Table 6-4), influent concentration, and effluent concentration. Compound input parameters, B_p and B_s, were stored in the FATE inorganic data base. The model was then run with B_p and B_s set at iteratively determined values.

The model output was formatted such that the model predictions were listed alongside the facility name, pollutant observed, the facility input parameters, and the actual observations of influent and effluent concentrations. The output was subsequently imported into SYSTAT (Systat, Inc., 1989) for statistical evaluation.

6.4.5 Statistical Evaluation

6.4.5.1 Method. The objectives of the statistical evaluation were to demonstrate calibration of the FATE predicted effluent concentration with measured effluent concentration and demonstrate that removal rates for each clarifier agreed with best engineering judgement.

The first step in the calibration demonstration was the evaluation of the distribution of the predicted and measured effluent concentrations. After the evaluation was completed, the residual was defined and computed for each case. The residual was evaluated for normality and the mean and variance subsequently computed. Calibration was demonstrated when the mean of the residuals equaled zero.

In some cases, measured effluent concentrations were reported as not detected. For the purpose of calibration, these concentrations were assumed to equal half the reported detection limit. A few cases reported measured effluent concentrations greater than measured influent concentrations. These cases were rejected on the basis that they violated mass balances.

The agreement of removal rates with best engineering judgement was demonstrated by analyzing the contribution of each removal mechanism to the total removal rate. The contributions were defined as

$$f_1 = rate_1/rate_{total} \quad (51)$$
$$f_2 = rate_2/rate_{total} \quad (52)$$

Where f = fraction of total removal, and
$rate_1$ = removal in the primary clarifier
$rate_2$ = removal in the secondary clarifier
$rate_{total} = rate_1 + rate_2$

The B_p and B_s factors for eight of the fourteen metals were initially set equal to those determined by Patterson and Kodukula. Residuals and contributions were computed for the first iteration. For the eight metals, the contributions computed in the first iteration were assumed valid. Thus, the calibration of a metal was considered complete when the mean of the residuals equaled zero and the contributions equaled those of the first iteration. Based on the results of the first eight metals, the remaining six metals were considered calibrated when the residuals equaled zero, the primary removal contribution was 70%, and the secondary removal contribution was 30%.

6.4.5.2 Results-Calibrated Model. The lognormal distribution adequately characterized the measured and predicted effluent concentration data. Probability plots of the measured and predicted effluent concentration data are presented in Figures 6-6 and 6-7, respectively. The residuals were computed in accordance with Equation (45). The normal distribution adquately characterized the distribution of the residuals with a mean of -1.9×10^{-4} and a standard deviation of 0.48. The mean was sufficiently close to zero given the standard deviation of the residuals (coefficient of variation = 2,500). The probability plot of the residuals is presented in Figure 6-8.

Boxplots of the residuals by compound are presented in Figure 6-9, while bar charts of the removal contributions by compound are presented in Figure 6-10. The boxplots indicate that each of the fourteen metals is calibrated. The bar chart indicates that primary clarifier removal is dominant, with contributions ranging from 55 percent to 87 percent.

Figure 6-6
Probability Plot of Measured Effluent Concentration

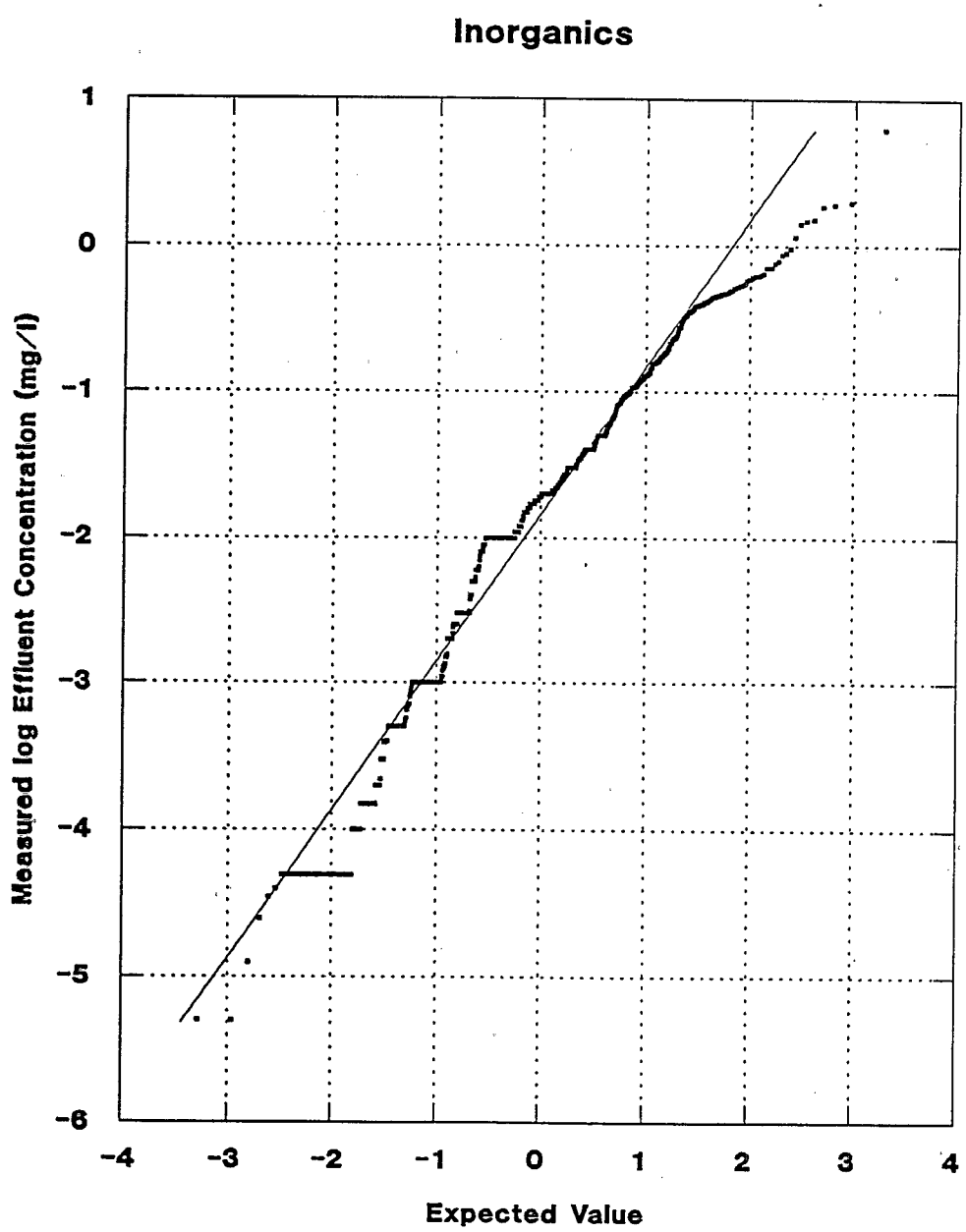


Figure 6-7
Probability Plot of Predicted Effluent Concentration

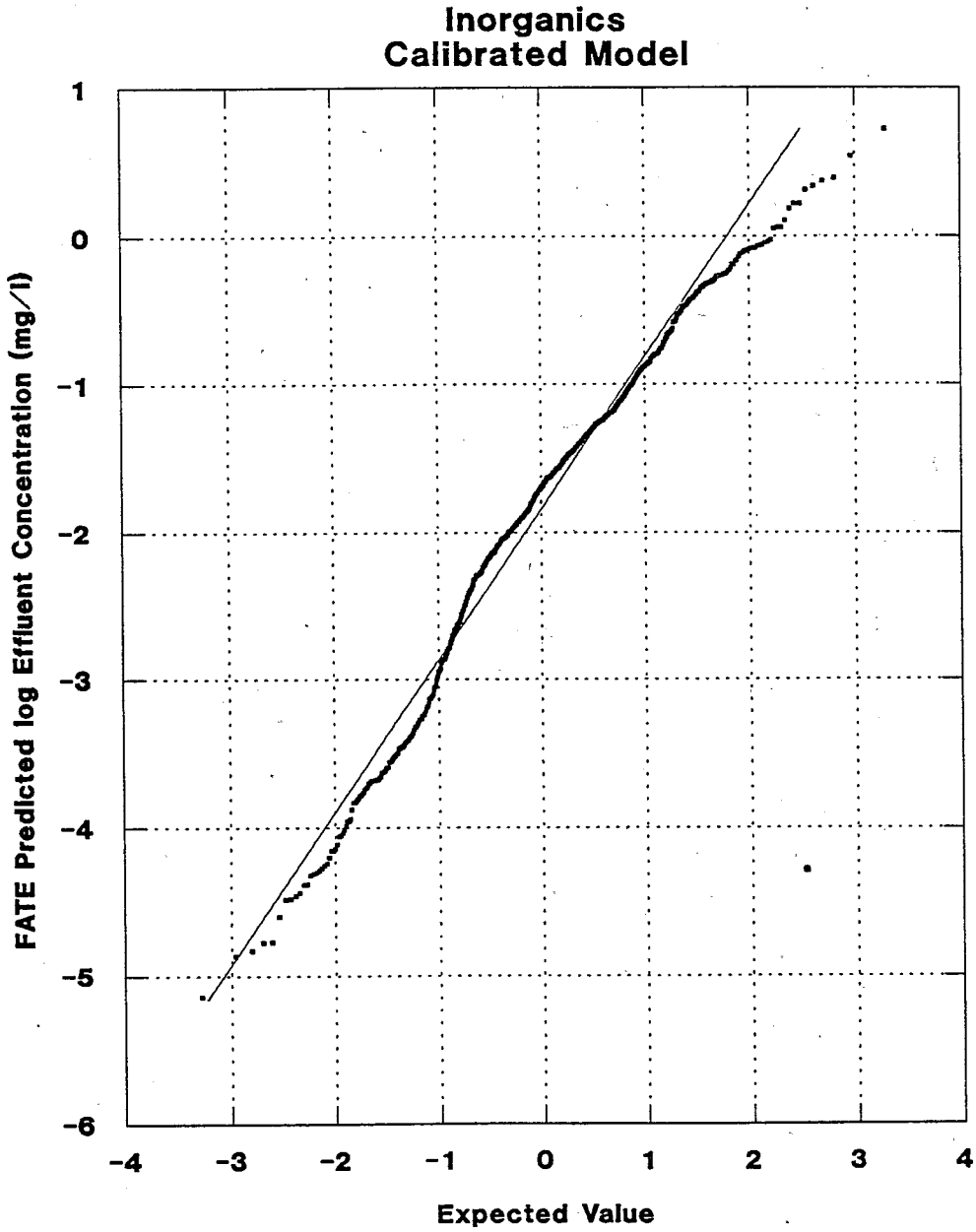


Figure 6-8
Probability Plot of FATE Residuals

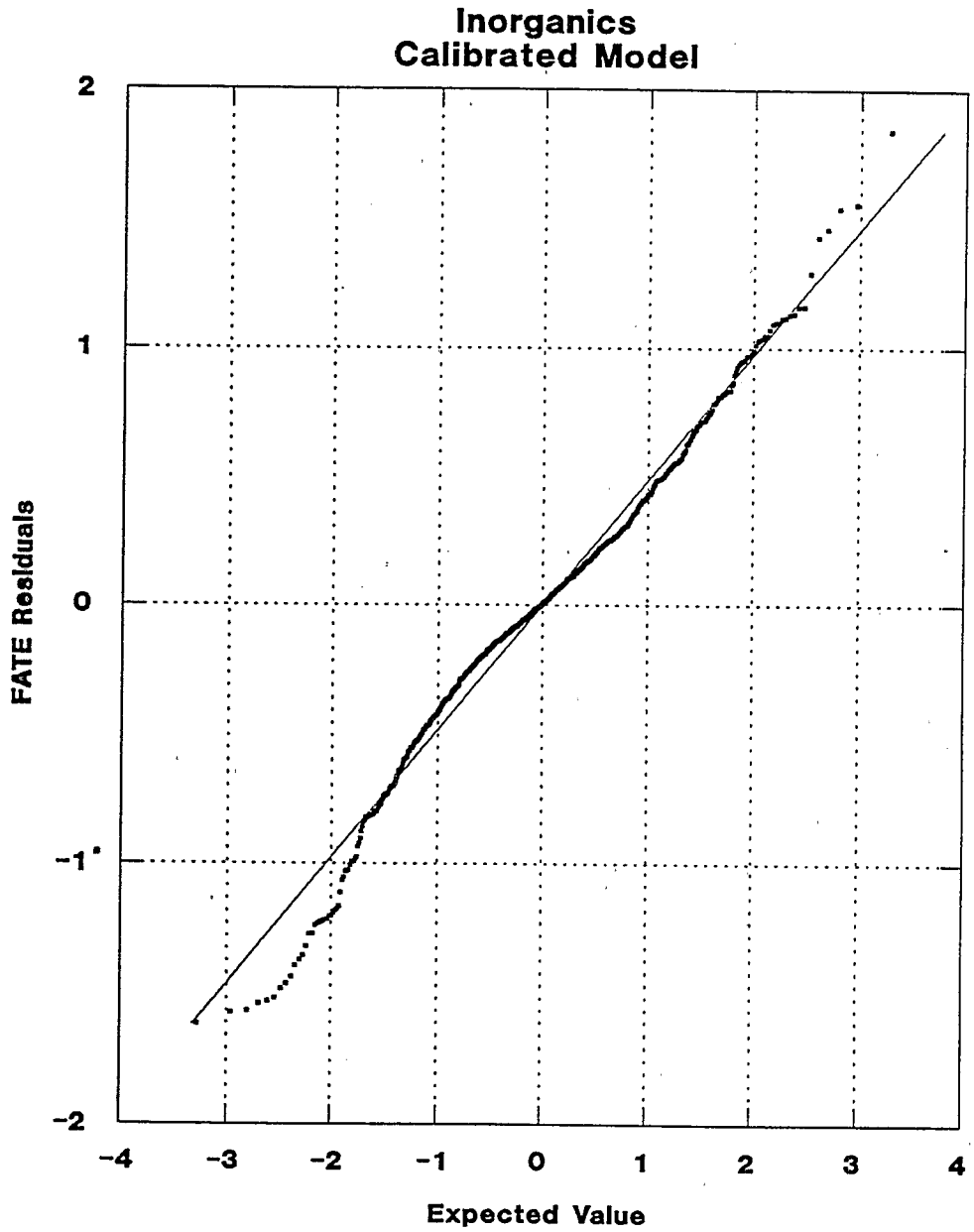


Figure 6-9
Boxplots of FATE Residuals by Compound

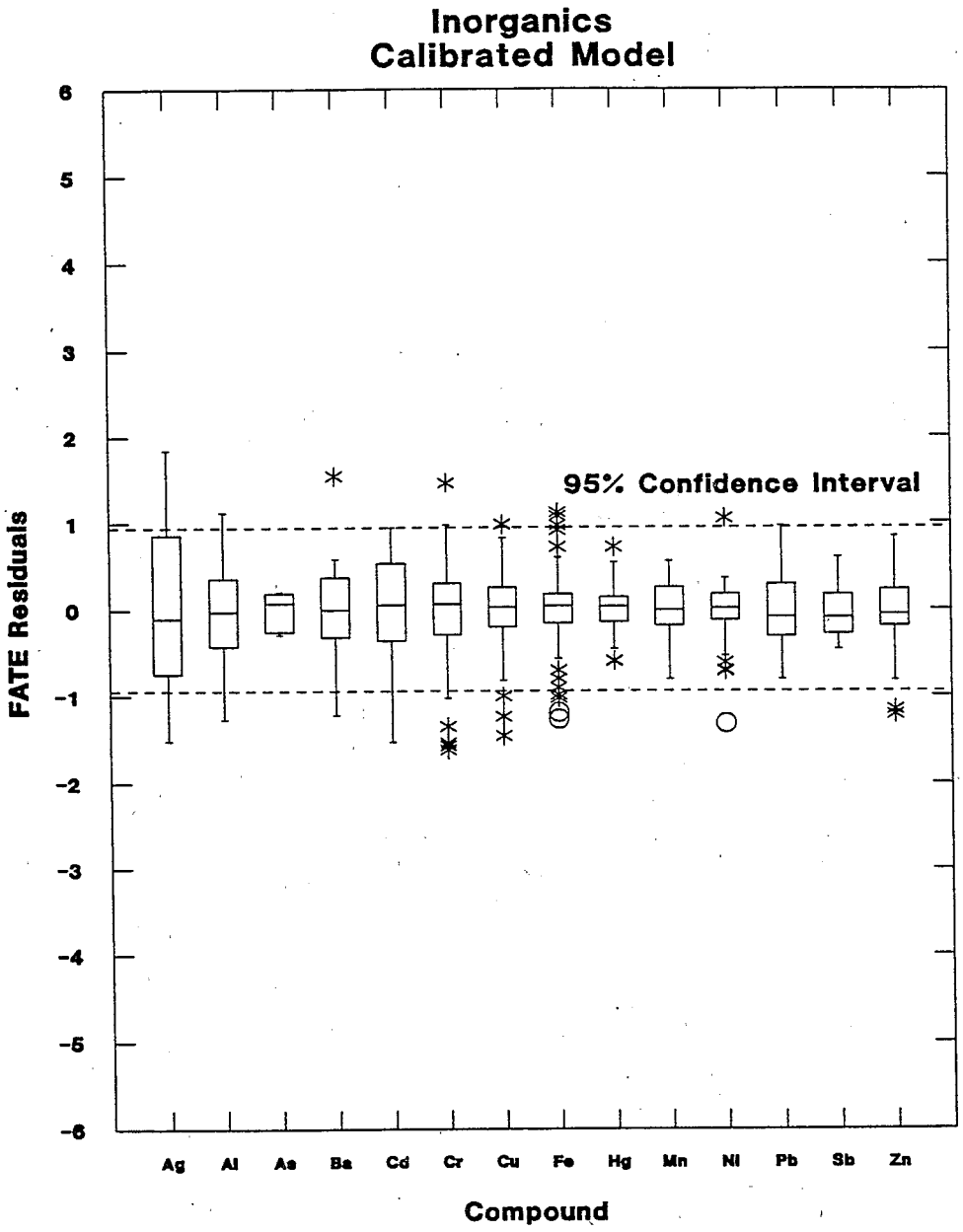
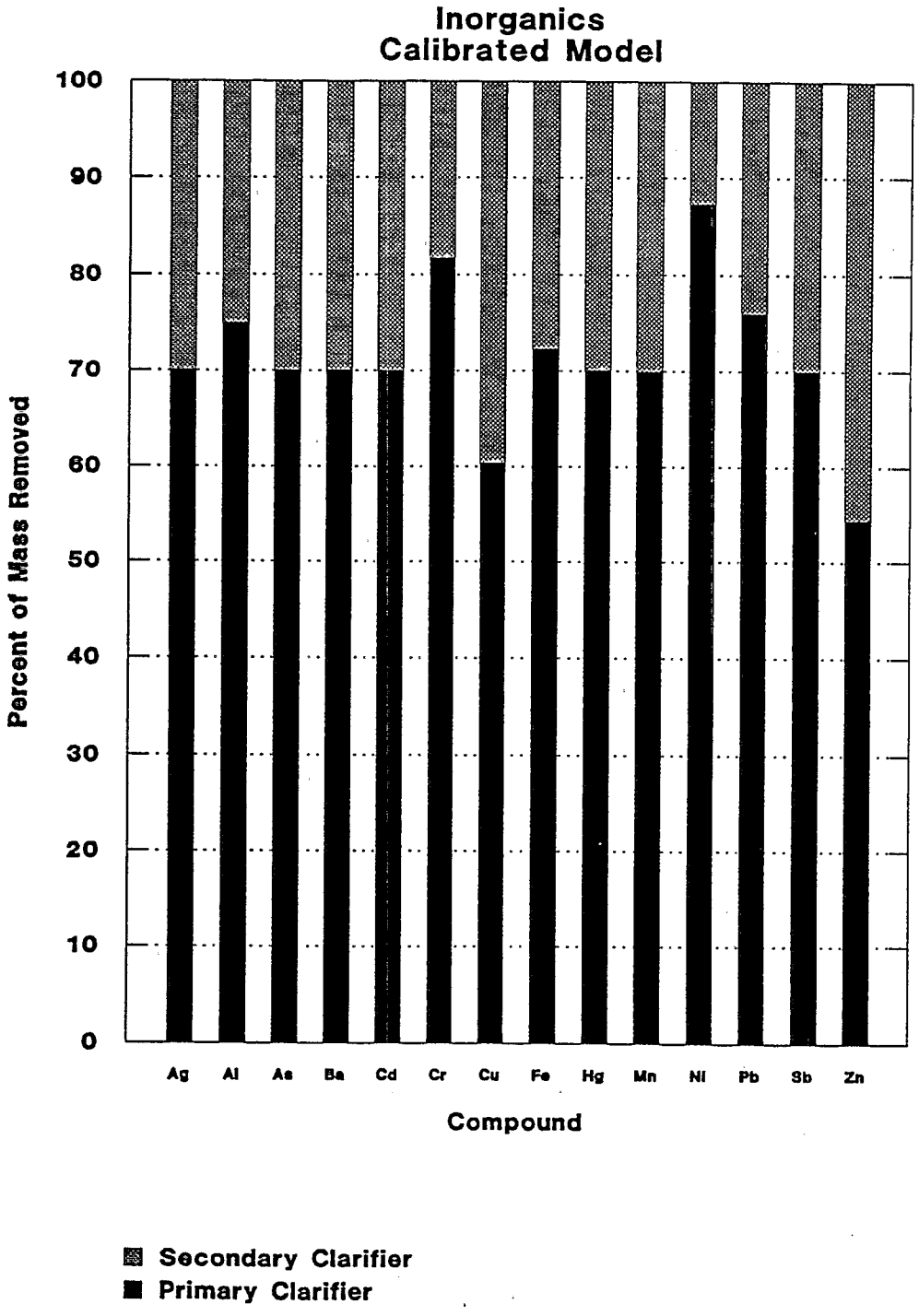


Figure 6-10
Percent of Mass Removed by Each Clarifier



The final calibration coefficients for each metal are listed in Table 6-5. These factors were subsequently entered into the inorganics database.

Evaluation of the inorganic residual indicated a dependency existed between the residual and each facility. The residual was evaluated against each of the facility input parameters for correlation. Strong dependencies were not demonstrated with the input parameters, although the residual was somewhat dependent on solids concentrations. Unfortunately, parameters such as pH and pE were not available for evaluation.

The calibrated model does not account for the dependence of the residuals on facility parameters. Revising the model equations could not be justified in the absence of pH and other facility parameters. Additionally, the random error of the inorganics model is smaller in magnitude than that of the organics model, indicating the inorganics model is more precise.

6.5 VALIDATION

The purpose of model validation is to demonstrate that the calibrated model is statistically valid for facilities not included in the calibration process. The validation process evaluates the mean of the measured and predicted effluent concentration for significanct differences. If significant differences are not indicated, the model is considered valid for the additional facilities.

Data from three facilities not included in the calibration database were used for model validation. Input parameters were stored in appropriate databases and entered into FATE with the calibration factors established in Sections 6.3 and 6.4. The data distributions were evaluated to determine whether parametric comparisons could be conducted.

6.5.1 Results - Organic Model

The lognormal distribution adequately characterized both measured and predicted concentrations. The data was transformed to logarithmic concentrations and a z-test was used to compare the means.

The z-test compares a computed z-statistic with critical z-values based on a selected error rate. Assuming the error rate equals 0.10, the lower and upper critical z-values are -1.645 and 1.645, respectively. The z-statistic is computed from

$$z = (\bar{S}_{meas} - \bar{S}_{pred})/[(V_{meas}/N_{meas}) + (V_{pred}/N_{pred})]^{1/2} \quad (53)$$

Where $\bar{S}_{meas}$ = average of log-transformed measured values,

$\bar{S}_{pred}$ = average of log-transformed predicted values,

V_{meas} = variance of log-transformed measured values,

TABLE 6-5

Inorganics Model Calibration Factors

Compound	Bp	Bs
Aluminum (Al)	46.4	30.4
Antimony (Sb)	127	80
Arsenic (As)	150	130
Barium (Ba)	90	64
Cadmium (Cd)	60	83
Chromium (Cr)	50	124
Copper (Cu)	110	50
Iron (Fe)	59	37
Lead (Pb)	59	88
Manganese (Mn)	217	193
Mercury (Hg)	150	115
Nickel (Ni)	130	1,000
Silver (Ag)	36	20
Zinc (Zn)	135	62

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V_{pred} = variance of log-transformed predicted values,

N_{meas} = number of measured values, and

N_{pred} = number of predicted values.

The computed z-statistic was -0.144, which lies between the critical z-values. Thus, the z-test indicates the means are not significantly different. The result demonstrates that FATE's organic model is valid for the additional facilities.

6.5.2 Results - Inorganic Model

The lognormal distribution adequately characterized both measured and predicted concentrations. The data was transformed to logarithmic concentrations and a z-test was used to compare the means.

The computed z-statistic was 1.006, which lies between the critical z-values. Thus, the z-test indicates the means are not significantly different. The result demonstrates that FATE's inorganic model is valid for the additional facilities.

6.6 MODEL PRECISION

The calibration process minimized the differences between measured and predicted effluent concentrations. Validation verified that the differences were acceptable given the precision of the model. Because model validation is sensitive to model precision, discussion of model precision is essential to understanding the ability of the model to produce accurate results.

6.6.1 Precision Evaluation Procedure

The standard deviation of the residuals is a measure of model precision because it allows the user to estimate the probability that the model will predict an effluent concentration within a certain range about the measured value. A small deviation indicates a precise model since it indicates the model has a high probability of producing a result close to the measured value. Conversely, a large deviation indicates an imprecise model since it indicates the model has a low probability of producing a result close to the measured value.

The probability that a predicted value will fall within a specified interval about the measured value is estimated by first computing a quantile of the standard normal distribution, Z_p.

$$Z_p = (E_p - \overline{E})/\sigma \quad (54)$$

where Z_p = p^{th} quantile of the standard normal distribution,
E_p = specified residual interval,

$\overline{E}$ = mean of residuals, and
σ = standard deviation of residuals.

The value for p is estimated from tables that list p values versus Z_p. Since the interval above and below $\overline{E}$ is desired, the probability that the predicted effluent value falls within a specified interval about the measured value is determined from p by the following:

$$P = 1-2(1-p) \quad (55)$$

where P = probability that the predicted value falls within the p and -p quantiles of the standard normal distribution.

For example, assume the mean and standard deviation of a set of residuals obtained from lognormally distributed data are 0.0 and 0.10, respectively. Also assume that the model is desired to predict a value within a factor of 2 of the measured value. Because the residuals were obtained from lognormally distributed data, E_p is set equal to $\log_{10}2$, or 0.301. Equation (54) is used to compute Z_p and is equal to 3.01. The value of p is obtained from a table (0.9987), and Equation (55) is used to compute P. In this case, P = 99.74 percent, which means that the probability that a predicted value will fall within a factor of 2 of the measured value is 99.74 percent. Thus, the model meets the desired precision.

The precision of the organic and inorganic models was evaluated with this procedure. The results are presented in the following sections.

6.6.2 Precision Evaluation Results - Organic Model

Calibration of the organic model produced residuals with a mean of -0.00543 and a standard deviation of 0.774. Values of E_p and P are presented in Table 6-6.

The results indicate that the organic model lacks precision; the model is only expected to predict a value within an order of magnitude ($10^{E_p} = 10$) of the measured result with a probability of 80 percent. The 99 percent probability interval is achieved with a factor of 80.

Such a broad range can have a marked effect on the percent removal computation. For example, if the measured percent removal was 99 percent ($S_{meas} = 0.01S_i$) and the predicted effluent concentration was a factor of 10 greater than the measured effluent concentration ($S_{pred} = 0.1\ S_i$), then the predicted percent removal is only 90 percent. Conversely, if the predicted effluent concentration

TABLE 6-6

ORGANIC MODEL PRECISION

Probability (P) that Predicted Effluent Value Falls Within Interval	Interval of Predicted Values	10^{Ep}
30%	$S_{pred} \div 2$ to $S_{pred} \times 2$	2
46%	$S_{pred} \div 3$ to $S_{pred} \times 3$	3
56%	$S_{pred} \div 4$ to $S_{pred} \times 4$	4
63%	$S_{pred} \div 5$ to $S_{pred} \times 5$	5
72%	$S_{pred} \div 7$ to $S_{pred} \times 7$	7
80%	$S_{pred} \div 10$ to $S_{pred} \times 10$	10
91%	$S_{pred} \div 20$ to $S_{pred} \times 20$	20
96%	$S_{pred} \div 40$ to $S_{pred} \times 40$	40
99%	$S_{pred} \div 80$ to $S_{pred} \times 80$	80

was a factor of 10 less than the measured effluent concentration (S_{pred} = 0.001 S_i), then the predicted percent removal is 99.9 percent.

6.6.3 Precision Evaluation Results - Inorganic Model

Calibration of the inorganic model produced residuals with a mean of -0.0001911 and a standard deviation of 0.482. Values of E_p and P are presented in Table 6-7.

The results show the inorganic model is more precise than the organics model; the model is expected to predict a value within an order of magnitude of the measured result with a probability of 96 percent. The 99 percent probability interval is achieved with a factor of 20.

The greater precision of the inorganic model is substantially attributable to the calibration of each metal individually. Since the organic model was not calibrated by compound, more random error is inherently incorporated in the model. Nevertheless, the inorganic model also lacks precision which affects the percent removal computations. Assuming a measured percent removal of 99 percent and the predicted effluent concentration was a factor of 4 greater than the measured effluent concentration (S_{pred} = 0.04 S_i), then the predicted removal is only 96 percent. Conversely, if the predicted effluent concentration was a factor of 4 less than the measured effluent concentration (S_{pred} = 0.0025 S_i) then the predicted percent removal is 99.8 percent.

TABLE 6-7
INORGANIC MODEL PRECISION

Probability (P) that Predicted Effluent Value Falls Within Interval	Interval of Predicted Values	10^{Ep}
47%	$S_{pred} \div 2$ to $S_{pred} \times 2$	2
68%	$S_{pred} \div 3$ to $S_{pred} \times 3$	3
79%	$S_{pred} \div 4$ to $S_{pred} \times 4$	4
86%	$S_{pred} \div 5$ to $S_{pred} \times 5$	5
92%	$S_{pred} \div 7$ to $S_{pred} \times 7$	7
96%	$S_{pred} \div 10$ to $S_{pred} \times 10$	10
99%	$S_{pred} \div 20$ to $S_{pred} \times 20$	20

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7.0 SUMMARY AND CONCLUSIONS

The FATE model evaluates the fate of various organic and inorganic pollutants discharged to conventional activated sludge POTWs. The model was designed to assist POTW operators and feasibility study writers in evaluating the fate and treatability of pollutants discharged to POTWs. Since organic and inorganic compounds are removed by different physical and chemical processes in a POTW, FATE consists of separate models for organic fate analysis and inorganic fate analysis. The FATE organic and inorganic models were developed based on models developed by Namkung and Rittman (1987) and Patterson and Kodukula (1984), respectively. The organic model approach assumes significant removal of organic compounds in only the primary clarifier(s) and aeration basin(s)/secondary clarifier(s). Removal mechanisms are assumed to be only sorption in the primary system and volatilization (by stripping), sorption, and biodegradation in the secondary systems. The inorganics model relates total metals removal in a wastestream to the organic volatile suspended solids removal in the primary and secondary clarifiers.

Both the FATE organic and inorganic models were calibrated and validated using analytical data collected from a USEPA study (USEPA, 1982) and a number of operating conventional activated sludge treatment plants. All of the sources provided observations of POTW influent and effluent concentrations which allowed FATE to be calibrated for total removal. However, because observations of the four organic removal mechanisms and inorganic removal rates in the primary and secondary clarifiers were not available, calibration of the removal mechanisms and rates was conducted using best engineering judgement.

Calibration of the organics model was demonstrated when, after adjusting calibration factors, the mean of the computed residuals (measure of error between predicted and measured effluent concentration) equaled zero and the removal mechanism contributions agreed with best engineering judgement. Analysis of the results indicated that the contributions of each removal mechanism are generally consistent with best engineering judgement. The organics model does, however, tend to slightly overpredict total removal for compounds primarily removed by sorption and slightly underpredicts removal for compounds primarily removed by volatilization and biodegradation. Validation of the organics model was conducted using the z-test. The results demonstrated that FATE's organic model is valid for the facilities used in the process.

Calibration of FATE's inorganic model was based on an empirical relationship between removal of a specific metal and removal of VSS. The mean of the residuals computed was found to be sufficiently close to zero and thus demonstrated calibration. The results indicate that primary clarifier removal is dominant. The results of validation of the inorganics model using the z-test also demonstrated that FATE's inorganic model is valid for the facilities used in the process.

Finally, the precision of each model was evaluated. The results indicated that the organic model lacks precision; the model is only expected to predict an effluent concentration within an order of magnitude of the measured result with a probability of 80 percent. The inorganic model was found to be more precise;

the model is expected to predict an effluent concentration within an order of magnitude of the measured result with a probability of 96 percent.

The lower precision of the organic model is primarily due to the lack of calibration on a compound-specific basis. Calibration by compound would have reduced the error of the organic model by eliminating bias attributed to K_{ow} and reducing the bias associated with the large proportion of undetected effluent concentrations. The inorganic model was more precise because it was calibrated by compound.

In summary, FATE adequately predicts the fate of various organic and inorganic compounds in conventional activated sludge POTWs. Although the models lack precision, they can be used to predict a reasonable preliminary estimate of the overall fate of the compounds in a POTW and to indicate the dominant removal processes during treatment.

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ATTACHMENT A

BIODEGRADATION RATE CONSTANT
ESTIMATION TECHNIQUES

CODE	SOURCE
A	BOD_5/COD ratios reported in Lyman, W.G., and D.H. Rosenblatt, 1982. Handbook of Chemical Property Estimation Methods, McGraw Hill Book Co., New York, New York.
B	COD rate of removal reported in Lyman, 1982.
C	USEPA, 1987b. "Guidance Manual on the Development and Implementation of Local Discharge Limits Under the Pretreatment Program," Office of Water Enforcement and Permits, USEPA Contract No. 68-01-7043, Vols. I and II, Washington, D.C.
D	Table 5-1, Rules of Thumb for Biodegradability. Lyman, 1982.
E	Estimated based on compound functional group(s).
F	Estimated based on compound class.

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
1,1'-Biphenyl-4,4'-diamine, 3,3'-dimethoxy	-3.000	F
1,1,1,2-Tetrachloroethane	-3.000	C
1,1,1-Trichloroethane	-3.000	A,C
1,1,2,2-Tetrachloroethane	-4.000	C
1,1,2-Trichloroethane	-3.000	C
1,1-Dichloroethane	-4.000	A,C
1,1-Dichloroethene	-2.300	E
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	-4.000	E
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	-4.000	E
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	-4.000	E
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	-4.000	E
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	-4.000	E
1,2,3-Trichlorobenzene	-3.000	E
1,2,3-Trichloropropane	-3.000	E
1,2,3-Trimethoxybenzene	-3.000	E
1,2,4,5-Tetrachlorobenzene	-3.000	E
1,2,4-Trichlorobenzene	-3.000	C
1,2-Benzenedicarboxylic acid, dibutyl ester	-2.000	A,C
1,2-Benzenedicarboxylic acid, dimethyl ester	-2.000	E
1,2-Dibromoethane	-2.300	E
1,2-Dichlorobenzene	-3.000	C
1,2-Dichloroethane	-3.000	A,C
1,2-Dichloropropane	-3.000	C
1,2-Diphenylhydrazine	-2.000	E
1,2-Ethanediamine, N,N-dimethyl-N'-2pyridinyl-N'-(2-	-3.000	F
1,2:3,4-Diepoxybutane	-2.300	E
1,3,5-Trithiane	-2.300	F
1,3-Benzenediamine, 4-methyl-	-2.000	E
1,3-Benzodioxole, 5-(1-propenyl)-	-3.000	E
1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	-2.000	E
1,3-Dichloro-2-propanol	-3.000	E
1,3-Dichlorobenzene	-3.000	C
1,3-Dichloropropane	-3.000	E

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
1,3-Dinitrobenzene	-4.000	B
1,4-Dichlorobenzene	-3.000	C
1,4-Dioxane	-4.000	A
1,4-Naphthoquinone	-2.300	E
1,5-Naphthalenediamine	-2.000	E
1-Bromo-2-chlorobenzene	-2.300	E
1-Bromo-3-chlorobenzene	-2.300	E
1-Chloro-3-nitrobenzene	-3.000	E
1-Methylfluorene	-3.000	E
1-Methylphenanthrene	-3.000	E
1-Naphthylamine	-4.000	B
1-Phenylnaphthalene	-3.000	E
1-Propene, 3-chloro-	-3.000	E
17-alpha-19-Norpregna-1,3,5(10)-trien-20-yn-17-ol, 3-	-3.300	F
2,3,4,6-Tetrachlorophenol	-2.300	E
2,3,6-Trichlorophenol	-2.000	E
2,3-Benzofluorene	-2.300	E
2,3-Dichloroaniline	-3.000	E
2,3-Dichloronitrobenzene	-3.000	E
2,4,5-T \ Weedone \ Acetic acid, 2,4,5-trichlorophenoxy-	-2.000	D
2,4,5-TP \ Silvex	-2.000	D
2,4,5-Trichlorophenol	-2.000	E
2,4,6-Trichlorophenol	-2.000	C
2,4-D \ Acetic acid, (2,4-dichlorophenoxy)-	-1.000	A,C
2,4-Dichlorophenol	-2.000	C
2,4-Dimethylphenol	-1.000	C
2,4-Dinitrophenol	-3.000	E
2,4-Dinitrotoluene	-2.000	E
2,6-Dichlorophenol	-3.000	E
2,6-Dinitrotoluene	-2.000	E
2,6-di-tert-Butyl-p-benzoquinone	-2.300	E
2,6-dichloro-4-nitroaniline	-4.000	E
2,7-Dimethylphenanthrene	-2.300	E

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
2-(Methylthio)benzothiazole	-2.000	E
2-Butanone	-1.000	A,C
2-Butenal	-2.300	D
2-Butene, 1,4-dichloro (mixture of cis and trans)	-3.000	E
2-Chloro-1,3-butadiene	-3.000	E
2-Chloroethylvinyl ether	-4.000	D
2-Chloronaphthalene	-2.300	E
2-Chlorophenol	-1.000	C
2-Hexanone	-2.000	F
2-Isopropylnaphthalene	-2.300	E
2-Methylbenzothioazole	-2.300	E
2-Methylnaphthalene	-2.300	E
2-Nitroaniline	-4.000	E
2-Nitrophenol	-2.000	E
2-Phenylnaphthalene	-3.000	E
2-Picoline	-2.300	F
2-Propanone	-1.300	A
2-Propen-1-o1	-2.300	A
2-Propenal	-2.300	F
2-Propenenitrile	-2.300	A,C
2-Propenenitrile, 2-methyl-	-3.000	E
3,3'-Dichloro-4,4'-diaminodiphenyl ether	-4.000	D
3,3'-Dichlorobenzidine	-3.000	E
3,6-Dimethylphenanthrene	-2.300	E
3-Nitroaniline	-4.000	E
4,4'-DDD/Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-	-2.300	E
4,4'-DDE/Benzene, 1,1'-(dichloroethenlyidine)bis[4-chloro	-2.300	E
4,4'-DDT/Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro	-2.300	E
4,4'-Methylenebis(2-chloroaniline)	-4.000	E
4,5-dimethyl phenanthrene	-2.300	F
4-Bromophenyl phenyl ether	-4.000	D
4-Chloro-2-nitroaniline	-4.000	E

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
4-Chloro-3-methylphenol	-1.000	C
4-Chlorophenylphenyl ether	-4.000	D
4-Methyl-2-pentanone	-3.000	A
4-Nitrophenol	-2.000	E
5-Nitro-o-toluidine	-4.000	E
6,9-Methano-2,3,4-benzodioxathiepin, 6,7	-4.000	F
7,12-Dimethylbenz(a)anthracene	-3.000	E
Acenaphthene	-2.000	E
Acenaphthylene	-2.000	C
Acetamide, N-(4-ethoxyphenyl)-	-3.000	F
Alachlor \ Metachlor \ Lasso	-3.300	F
Aldrin	-2.000	E
Ammonium, (4-(p-(dimethylamino)-alpha-phenylbenzyli	-3.000	E
Aniline, 2,4,5-trimethyl-	-2.000	E
Anthracene	-3.000	E
Azinphos-ethyl \ Ethyl Guthion	-2.000	D
Azinphos-methyl \ Guthion	-2.000	D
Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	-2.300	E
Benzanthrone	-2.300	E
Benzenamine	-1.300	A,B
Benzenamine, 4-chloro-	-3.000	B
Benzenamine, N,N-dimethyl-4-(pehnylazo)-	-4.000	E
Benzene	-2.000	A,C
Benzenethiol	-3.000	F
Benzidine	-3.000	F
Benzo(a)anthracene	-3.000	E
Benzo(a)pyrene	-2.300	E
Benzo(b)fluoranthene	-2.300	E
Benzo(ghi)perylene	-2.300	E
Benzo(k)fluoranthene	-2.300	E
Benzoic acid	-1.000	A
Benzonitrile, 3,5-dibromo-4-hydroxy-	-3.000	F
Benzyl alcohol	-2.000	D

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
Biphenyl	-2.300	E
Biphenyl, 4-nitro	-3.000	E
Bromodichloromethane	-3.300	E
Bromomethane	-3.000	A,C
Busan 85	-2.000	F
Butyl benzyl phthalate	-1.000	C
Camphechlor	-3.300	F
Captafol \ Difolatan	-2.000	E
Captan	-2.000	E
Carbamic acid, dimethyldithio-, sodium salt	-2.000	D
Carbamic acid, methyldithio-, monopotassium salt	-2.000	D
Carbazole	-3.000	F
Carbon disulfide	-2.000	C
Carbophenothion \ Trithion	-2.000	D
Chlordane	-4.000	C
Chlorfenvinphos \ Supona	-2.000	D
Chloroacetonitrile	-3.000	E
Chlorobenzene	-2.000	A,C
Chlorobenzilate \ Ethyl-4,4'-dichlorobenzilate	-2.000	D
Chloroethane	-3.000	C
Chloroform	-3.000	A,B,C
Chloromethane	-3.000	A,C
Chloropicrin	-3.000	E
Chlorpyrifos \ Dursban	-2.000	D
Chrysene	-2.300	F
Coumaphos \ Co-Ral	-2.300	E
Crotoxyphos \ Ciodrin	-2.000	D
Cygon \ Dimethoate	-2.000	D
DNBP \ Dinoseb \ 2-sec-butyl-4,6-dinitrophenol	-3.000	E
Demeton \ Systox	-2.000	D
Di-n-octyl phthalate	-2.000	C
Di-n-propylnitrosamine	-4.000	E
Diallate \ Avadex	-2.000	D

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
Diazinon \ Spectracide	-2.000	D
Dibenzo(a,h)anthracene	-3.000	E
Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-	-4.000	E
Dibenzofuran	-2.300	E
Dibenzothiophene	-2.300	E
Dibromochloromethane	-3.000	E
Dibromomethane	-3.000	A,C
Dichlone \ Phygon	-3.000	E
Dichloroiodomethane	-3.300	E
Dichlorvos \ DDVP	-2.000	D
Dicrotophos \ Bidrin	-2.000	D
Dieldrin	-2.300	E
Diethyl ether	-4.000	D
Diethyl phthalate	-1.000	C
Dimethyl sulfone	-3.000	E
Dinex \ DN-111 \ 2-Cyclohexyl-4,6-dinitrophenol	-3.000	E
Dioxathion	-2.000	D
Diphenyl ether	-4.000	D
Diphenylamine	-3.300	E
Diphenyldisulfide	-3.000	E
Disulfoton	-2.000	D
EPN \ Santox	-2.000	D
Endrin	-2.000	C
Endrin aldehyde	-2.000	D
Endrine ketone	-3.000	D
Ethane, pentachloro-	-3.000	E
Ethanethioamide	-3.000	E
Ethanone, 1-phenyl	-2.300	E
Ethion \ Bladan	-2.000	D
Ethyl cyanide	-2.300	E
Ethyl methacrylate	-2.300	D
Ethylbenzene	-1.300	A,C
Ethylenebisdithiocarbamic acid, salts and esters	-2.000	D

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
Ethylenethiourea	-3.000	E
Famphur \ Famophos	-2.000	D
Fensulfothion \ Desanit	-2.000	D
Fenthion \ Baytex	-2.000	D
Fluoranthene	-2.300	E
Fluorene	-2.000	E
Heptachlor	-4.000	E
Heptachlor epoxide	-4.000	E
Hexachlorobenzene	-3.000	E
Hexachlorobutadiene	-3.000	C
Hexachlorodibenzo-p-dioxins	-4.000	E
Hexachlorodibenzofurans	-4.000	E
Hexachloroethane	-3.000	C
Hexachloropropene	-3.000	E
Hexamethylphosphoramide \ HMPA	-2.300	F
Hexanoic acid	-2.000	D
Indeno(1,2,3-cd)pyrene	-2.300	F
Iodomethane	-3.000	D
Isobutyl alcohol	-1.000	A,C
Isodrin (Stereoisomer of Aldrin)	-2.000	E
Isophorone	-2.000	E
Kepone	-4.000	E
Leptophos \ Phosvel	-2.000	D
Lindane \ gamma-BHC \ Hexachlorocyclohexane (gamma)	-2.000	E
Longifolene	-3.000	F
Malathion \ Sumitox	-2.000	D
Maneb \ Vancide	-2.000	D
Methanesulfonic acid, ethyl ester	-2.000	D
Methoxychlor	-2.300	C
Methyl methacrylate	-2.000	A
Methyl methanesulfonate	-2.000	D
Methyl parathion \ Parathion-methyl \ Metaphos	-2.000	D
Methylene chloride	-2.000	A,C

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
Mevinphos \ Phosdrin	-2.000	D
Mirex \ Dechlorane	-4.000	E
Monocrotophos \ Azodrin	-2.000	D
N,N-Dimethylformamide	-1.300	A
N-Nitrosodi-n-butylamine	-4.000	E
N-Nitrosodiethylamine	-4.000	E
N-Nitrosodimethylamine	-4.000	E
N-Nitrosodiphenylamine	-4.000	E
N-Nitrosomethylethylamine	-4.000	E
N-Nitrosomethylphenylamine	-4.000	E
N-Nitrosomorpholine	-3.000	E
N-Nitrosopiperidine	-3.000	E
Nabam	-2.000	D
Naled \ Dibrom	-2.000	D
Naphthalene	-2.000	A,C
Nitrobenzene	-2.000	A,C
Nitrofen \ TOK	-4.000	D
PCB-1016	-3.300	C
PCB-1221	-3.300	C
PCB-1232	-3.300	C
PCB-1242	-3.300	C
PCB-1248	-3.300	C
PCB-1254	-3.300	C
PCB-1260	-3.300	C
PCNB \ Terraclor \ Quintozene	-3.300	F
Parathion \ Parathion, ethyl	-2.000	D
Pentachlorobenzene	-3.000	E
Pentachlorodibenzo-p-dioxins	-4.000	E
Pentachlorodibenzofurans	-4.000	E
Pentachlorophenol	-2.000	C
Pentamethylbenzene	-4.000	E
Perylene	-2.300	F
Phenanthrene	-2.300	E

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
Phenol	-1.000	A,B,C
Phenol, 2-methyl-4,6-dinitro-	-2.000	E
Phenothiazine	-2.300	F
Phorate \ Thimet	-2.000	D
Phosacetin	-2.300	D
Phosmet \ Imidan	-2.000	D
Phosphamidon \ Dimecron	-2.000	D
Phosphorodithioic acid, O,O,S-triethyl ester	-2.000	D
Phosphorodithioic acid, O,O-diethyl S-methyl ester	-2.000	D
Pronamide \ Kerb	-2.000	D
Propane, 1,2-dibromo-3-chloro-	-3.000	E
Pyrene	-2.300	E
Pyridine	-2.000	A,C
Resorcinol	-1.000	B
Safrole	-2.300	F
Squalene	-3.000	F
Styrene	-2.300	A
Sulfotepp \ Bladafum \ Tetraethyldithiopyrophosphate	-2.000	D
Sulfurous acid, 2-chloroethyl-, 2-[4-(1,1-dimethylethyl)	-3.000	D,E
TEPP \ Phosphoric acid, tetraethyl ester	-2.000	F
Terbufos \ Counter	-2.000	D
Tetrachlorodibenzo-p-dioxins	-4.000	E
Tetrachlorodibenzofurans	-4.000	E
Tetrachloroethene	-3.000	C,D
Tetrachloromethane	-3.000	A,C
Tetrachlorvinphos \ Gardona	-2.000	D
Thianaphthene	-2.300	E
Thiodan I	-3.300	F
Thiodan II	-3.300	F
Thioxanthe-9-one	-3.000	F
Thiram \ Thiuram \ Arasan	-2.000	F
Toluene	-1.300	A,C
Total xylenes	-2.300	E

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
Tribromomethane	-3.000	C
Trichloroethene	-3.000	C,D
Trichlorofluoromethane	-3.000	A,C
Trichlorofon \ Dylox	-2.000	D
Tricresylphosphate \ TCP \ TOCP	-2.000	D
Trifluralin \ Treflan	-3.000	E
Trimethylphosphate	-2.000	D
Triphenylene	-2.300	F
Tripropyleneglycol methyl ether	-3.000	D
Vinyl acetate	-2.000	A,B
Vinyl chloride	-3.000	A,B
Zineb \ Dithane Z	-2.000	D
Zinophos \ Thionazin	-2.300	F
Ziram \ Cymate	-2.000	F
[1,1'-Biphenyl]-4-amine	-2.000	D
alpha-BHC	-2.000	E
alpha-Terpineol	-2.300	F
beta-BHC	-2.000	E
beta-Naphthylamine	-4.000	D
bis(2-Chloroethoxy)methane	-4.000	C
bis(2-Chloroethyl) ether	-4.000	D
bis(2-Chloroisopropyl) ether	-4.000	D
bis(2-Ethylhexyl) phthalate	-2.000	C
cis-1,3-Dichloropropene	-3.000	E
delta-BHC	-2.000	E
m-Cresol	-1.000	A
n-Decane	-2.300	D
n-Docosane	-2.300	D
n-Dodecane	-2.300	D
n-Eicosane	-2.300	D
n-Hexacosane	-2.000	D
n-Hexadecane	-2.300	D
n-Octacosane	-2.000	D

USEPA FATE MODEL
BIODEGRADATION RATE CONSTANT
ESTIMATION SOURCES

COMPOUND	ESTIMATED BIODEGRADATION RATE CONSTANT	SOURCE CODE
n-Octadecane	-2.300	D
n-Tetracosane	-2.000	D
n-Tetradecane	-2.300	D
n-Triacontane	-2.000	D
o + p xylene	-2.300	A
o,p'-DDT	-2.300	F
o-Anisidine	-2.300	F
o-Cresol	-1.000	A
o-Toluidine	-3.000	E
o-Toluidine, 5-chloro-	-3.000	E
p-Cresol	-1.000	A
p-Cymene	-2.000	E
p-Nitroaniline	-4.000	B
trans-1,2-Dichloroethene	-3.000	C,D
trans-1,3-Dichloropropene	-3.000	E
trans-1,4-Dichloro-2-butene	-3.000	E

ATTACHMENT B

MODEL CALIBRATION PLOTS

Figure B-1
Probability Plot of Measured Effluent Concentration

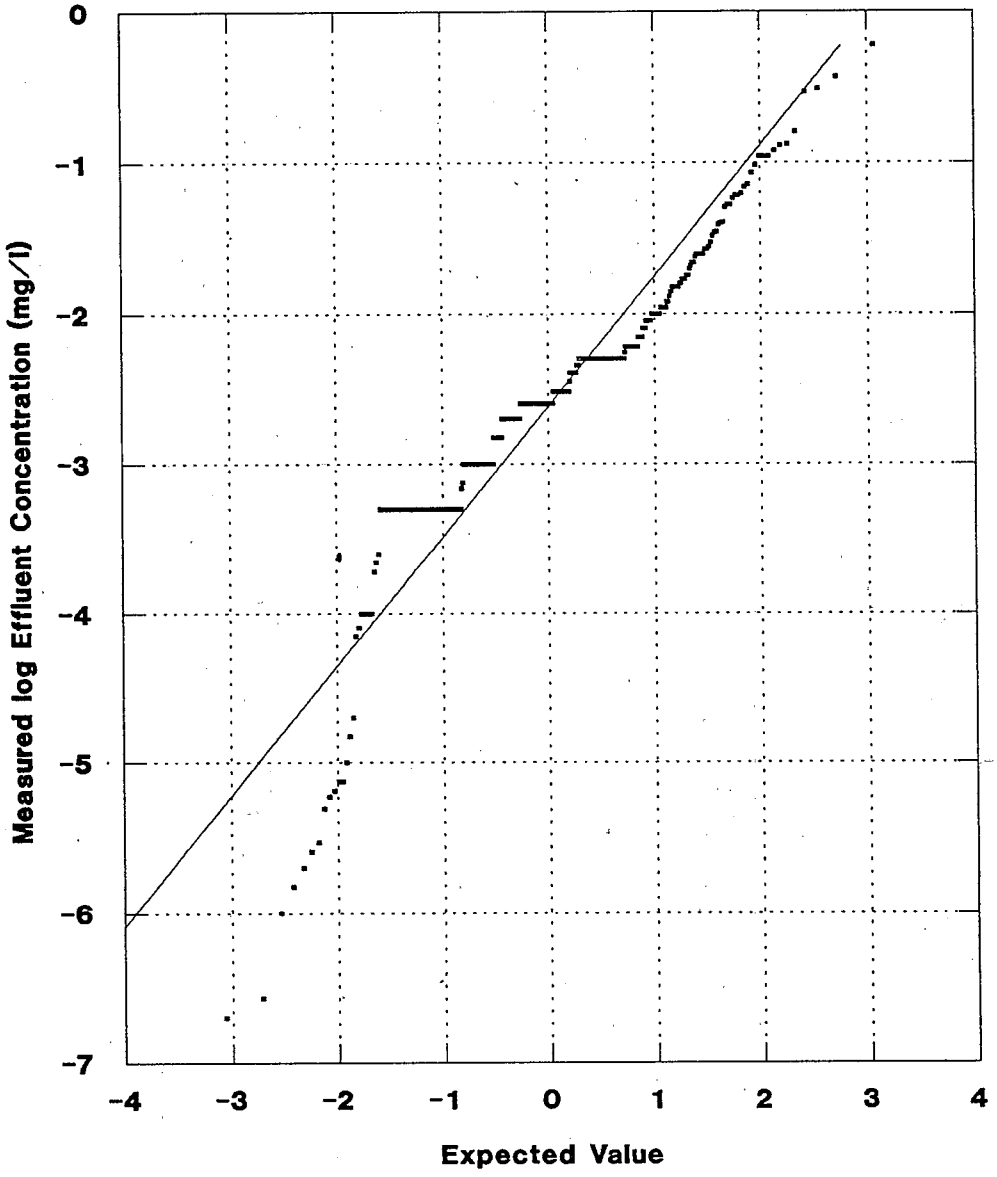


Figure B-2
Probability Plot of Predicted Effluent Concentration

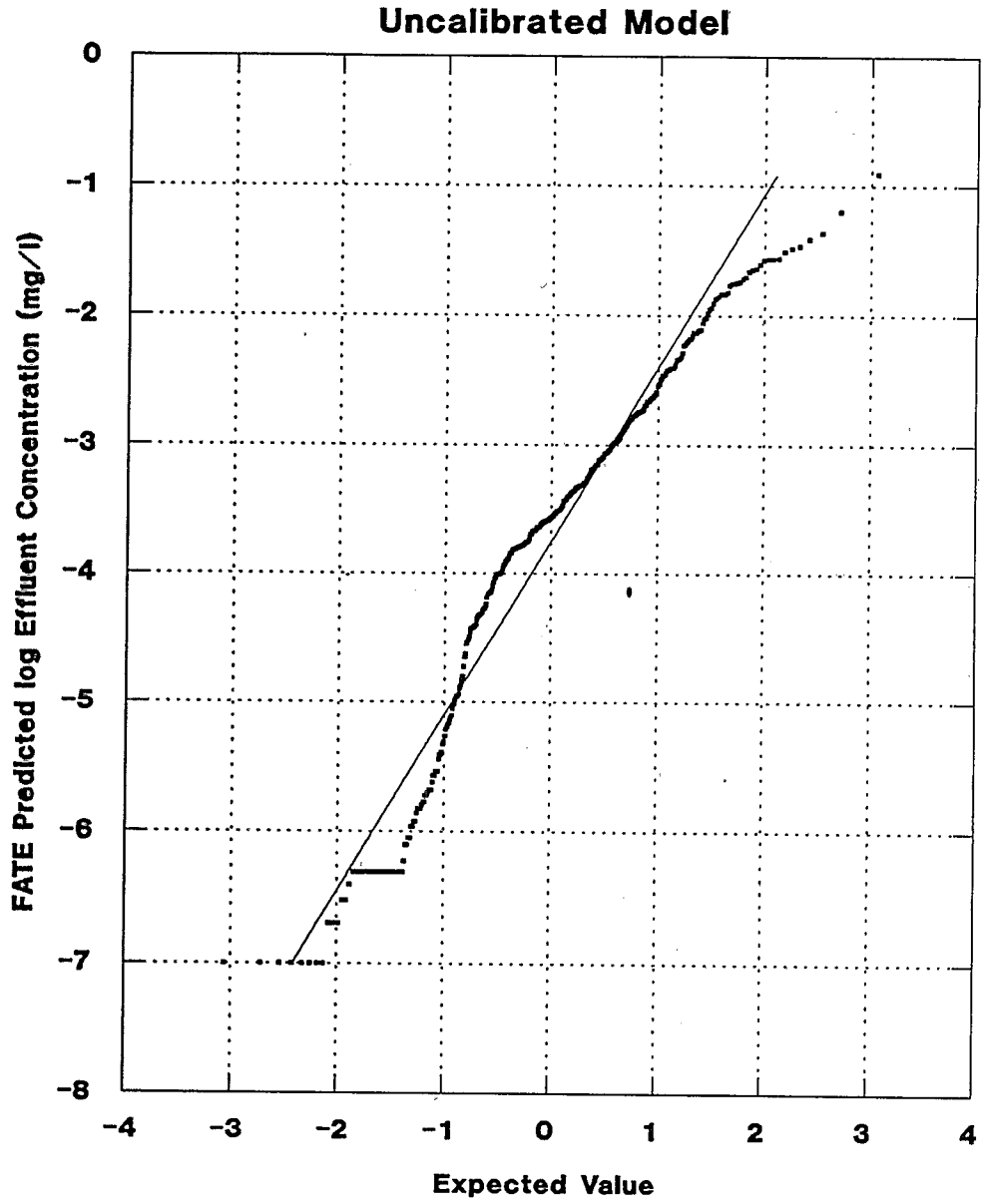


Figure B-3
Probability Plot of Predicted Effluent Concentration

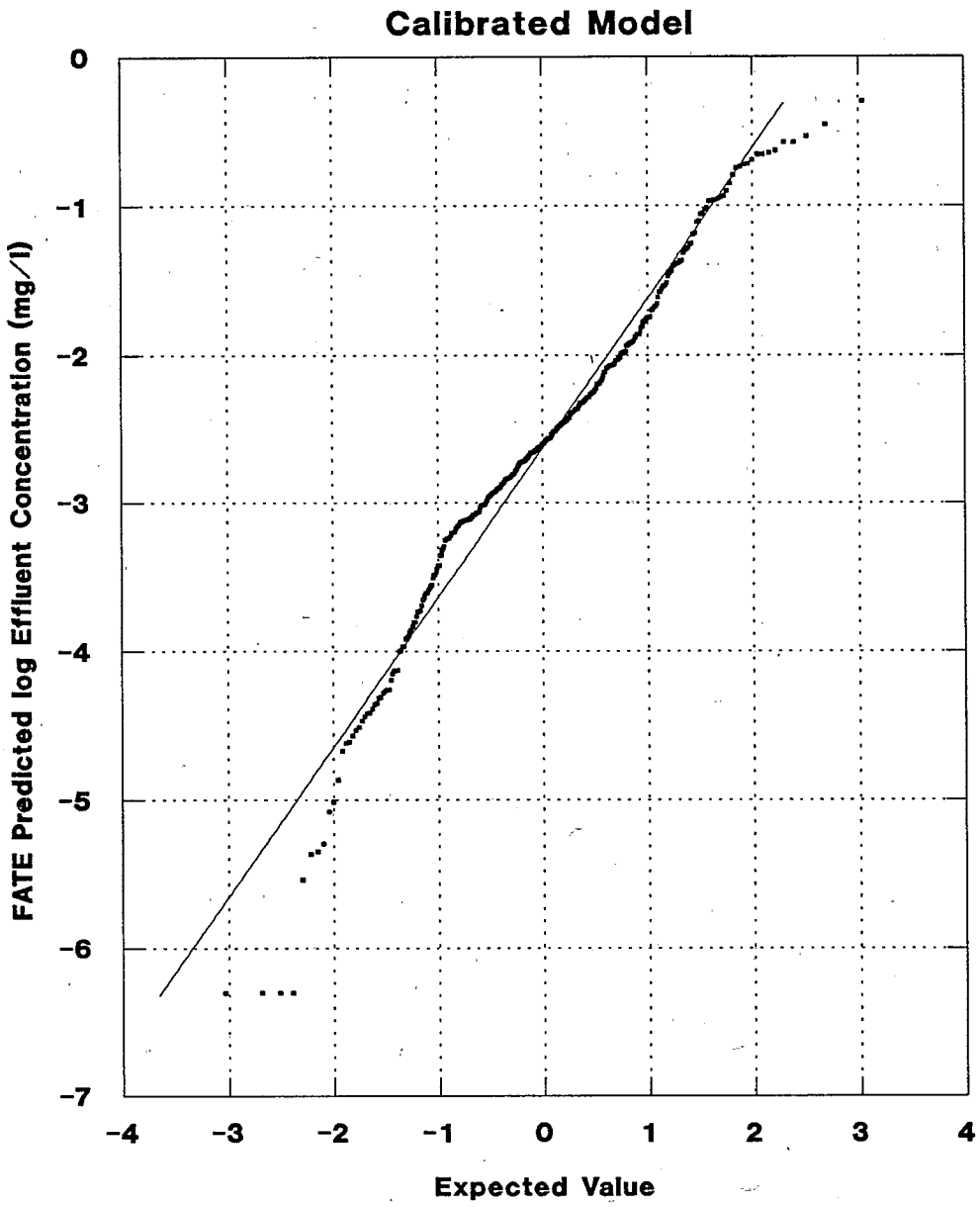


Figure B-4
Probability Plot of FATE Residuals

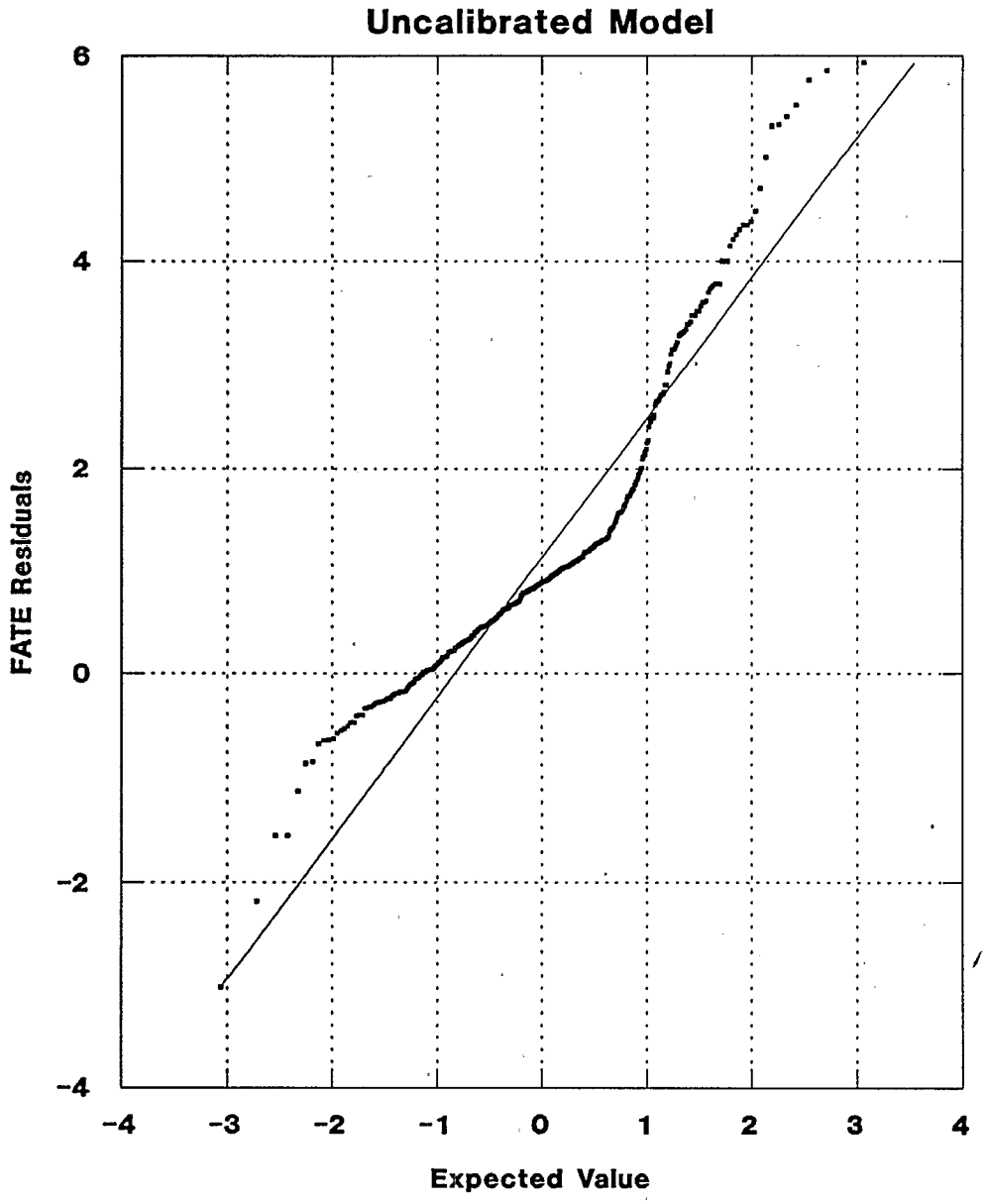


Figure B-5
Boxplots of FATE Residuals by Compound

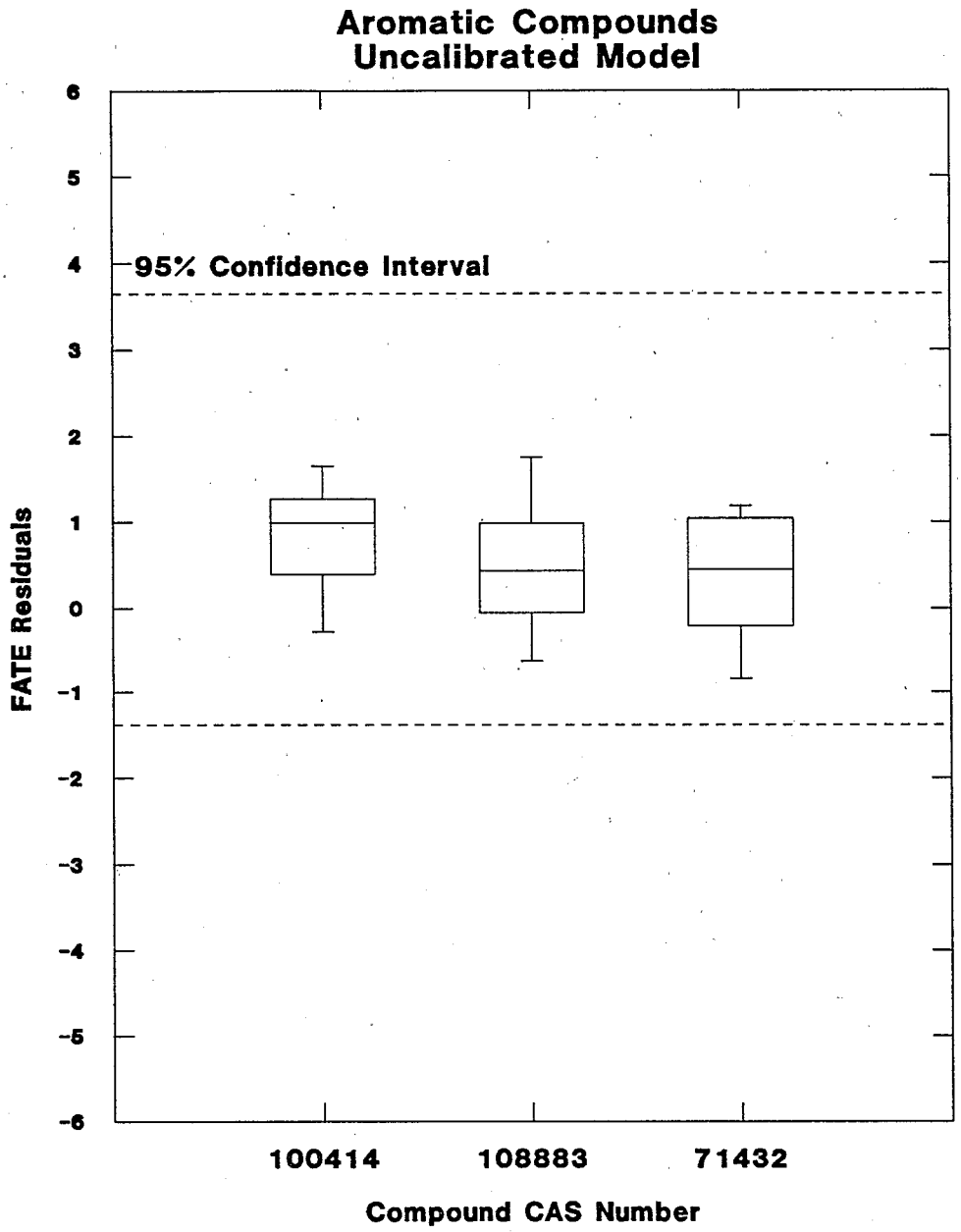


Figure B-6
Boxplots of FATE Residuals by Compound

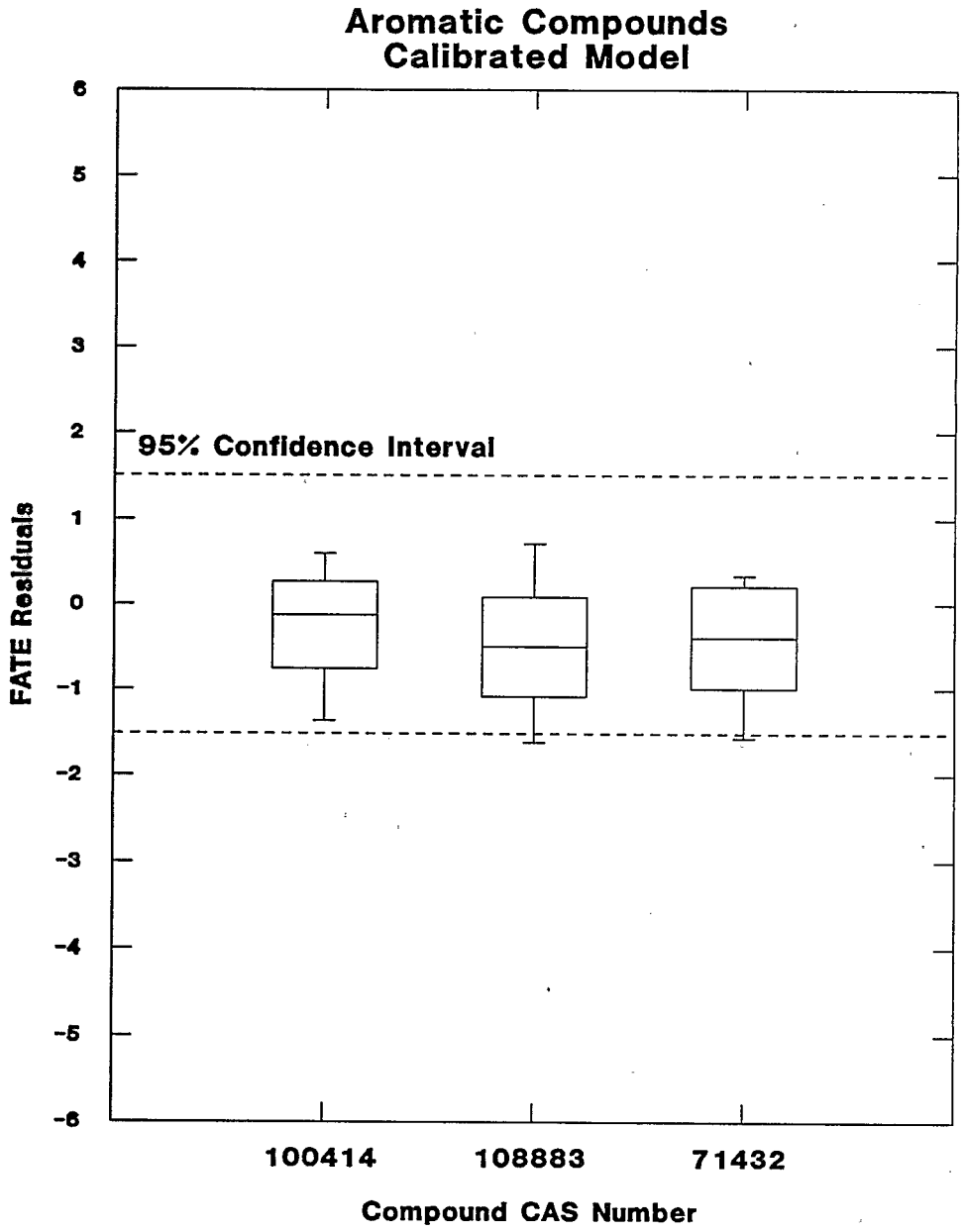


Figure B-7
Percent of Mass Removed by Each Mechanism

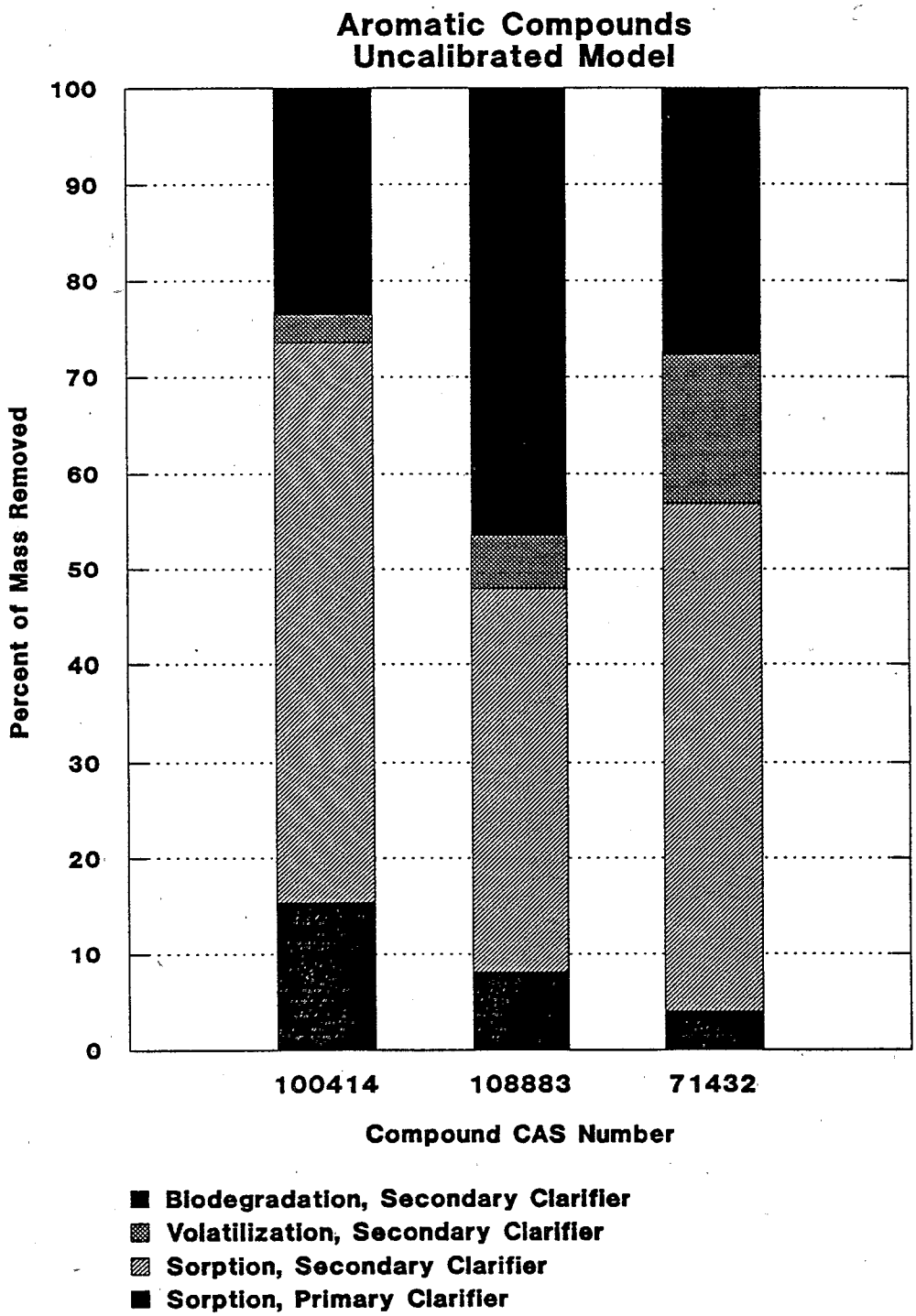


Figure B-8
Percent of Mass Removed by Each Mechanism

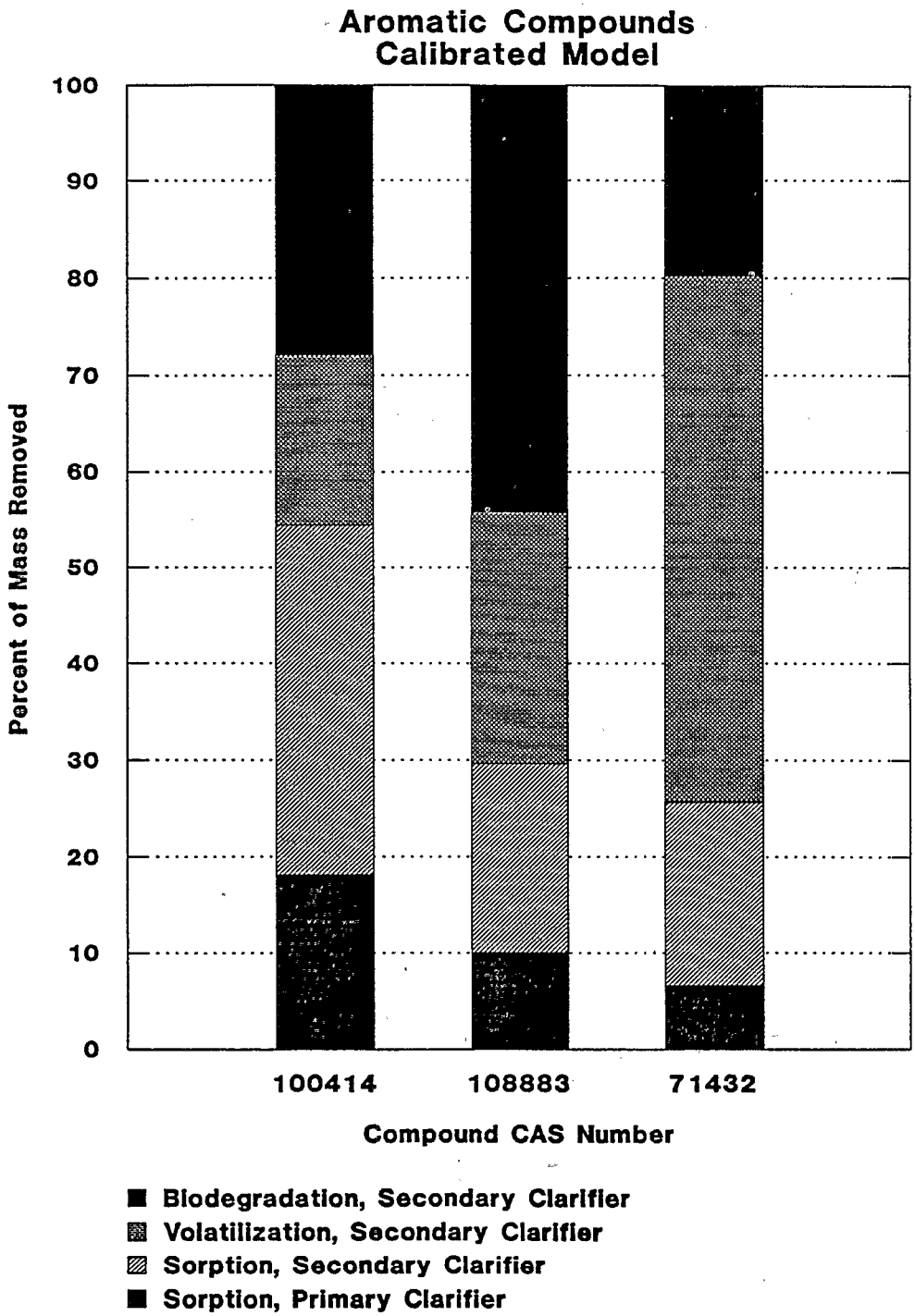


Figure B-9
Boxplots of FATE Residuals by Compound

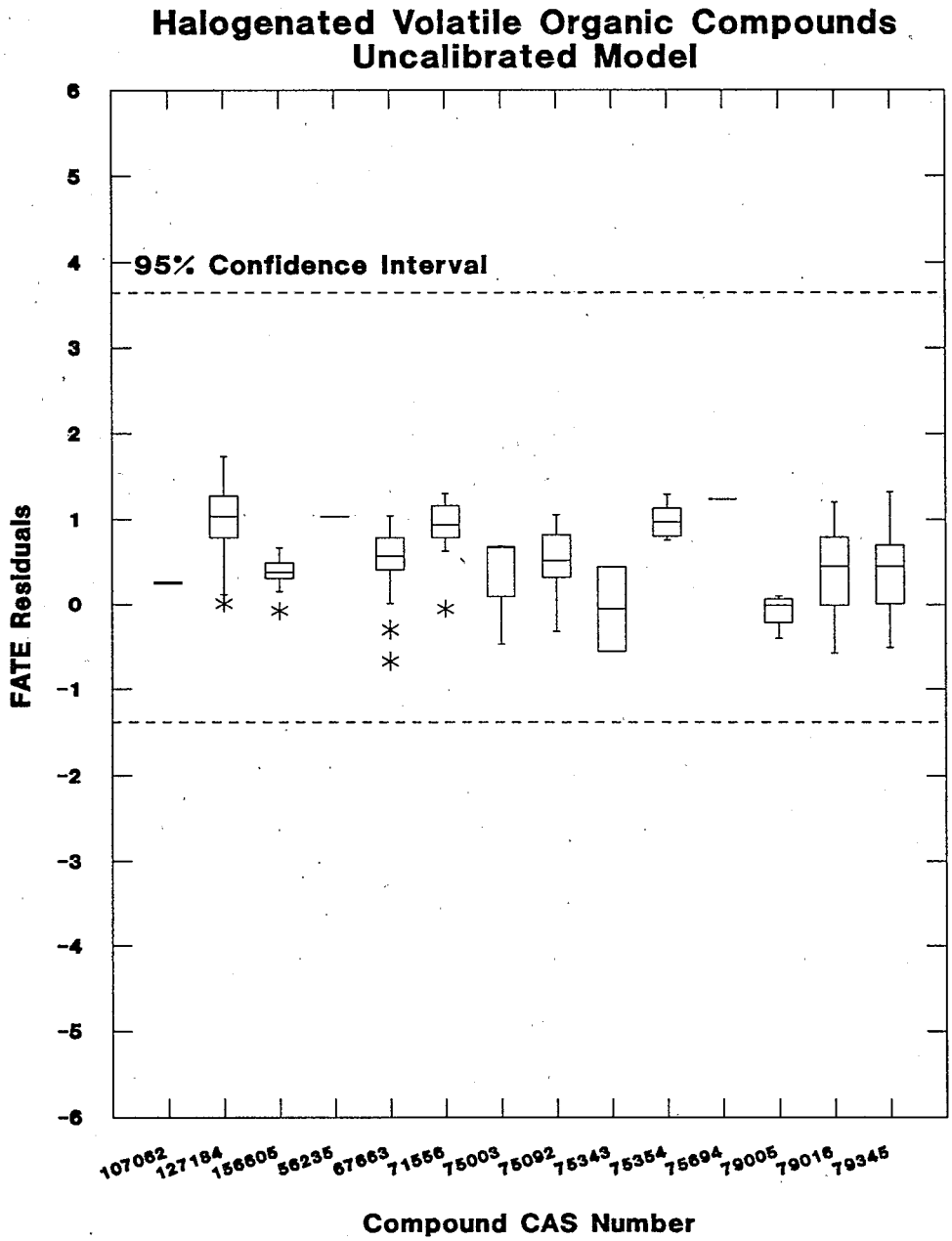


Figure B-10
Boxplots of FATE Residuals by Compound

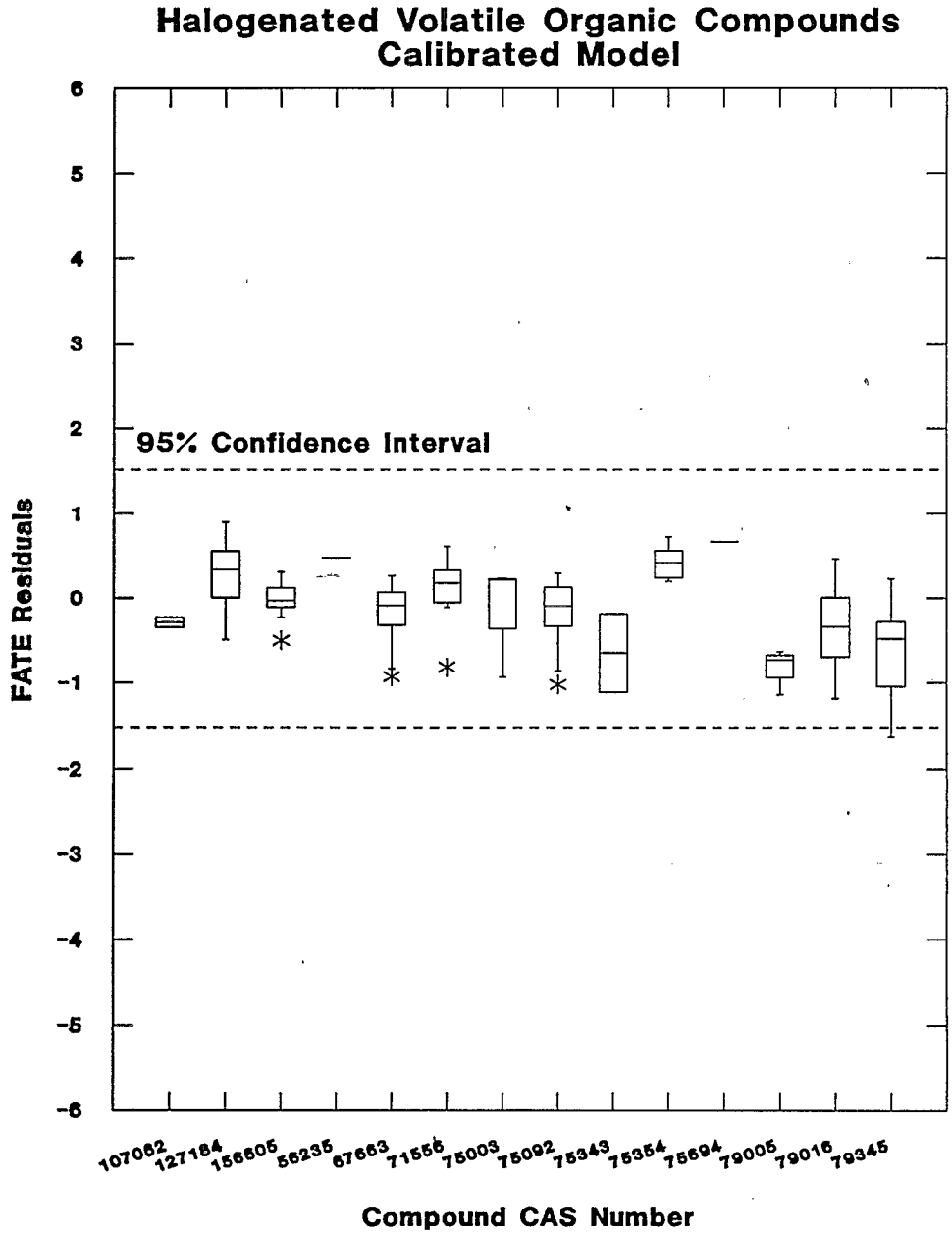


Figure B-11
Percent of Mass Removed by Each Mechanism

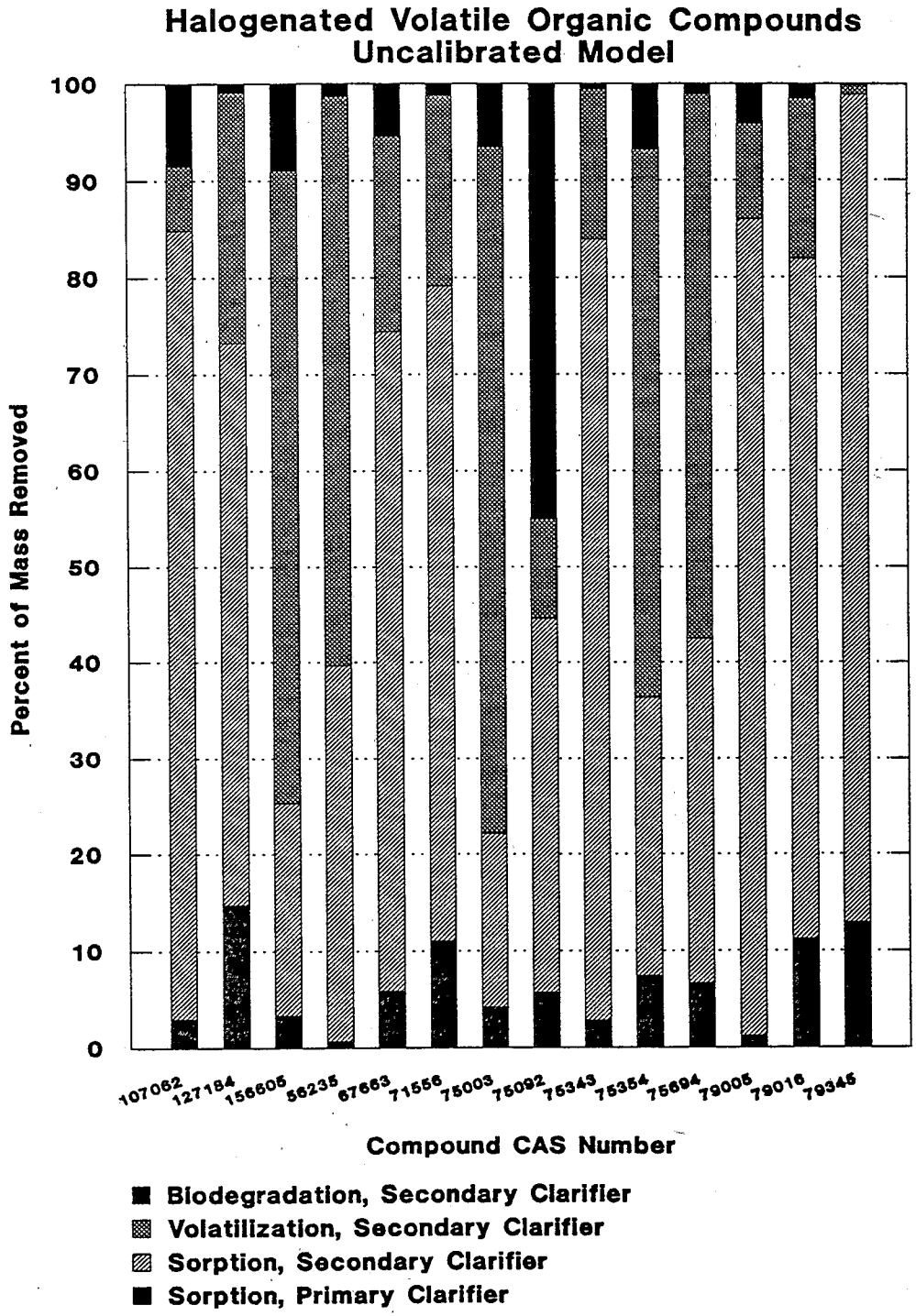


Figure B-12
Percent of Mass Removed by Each Mechanism

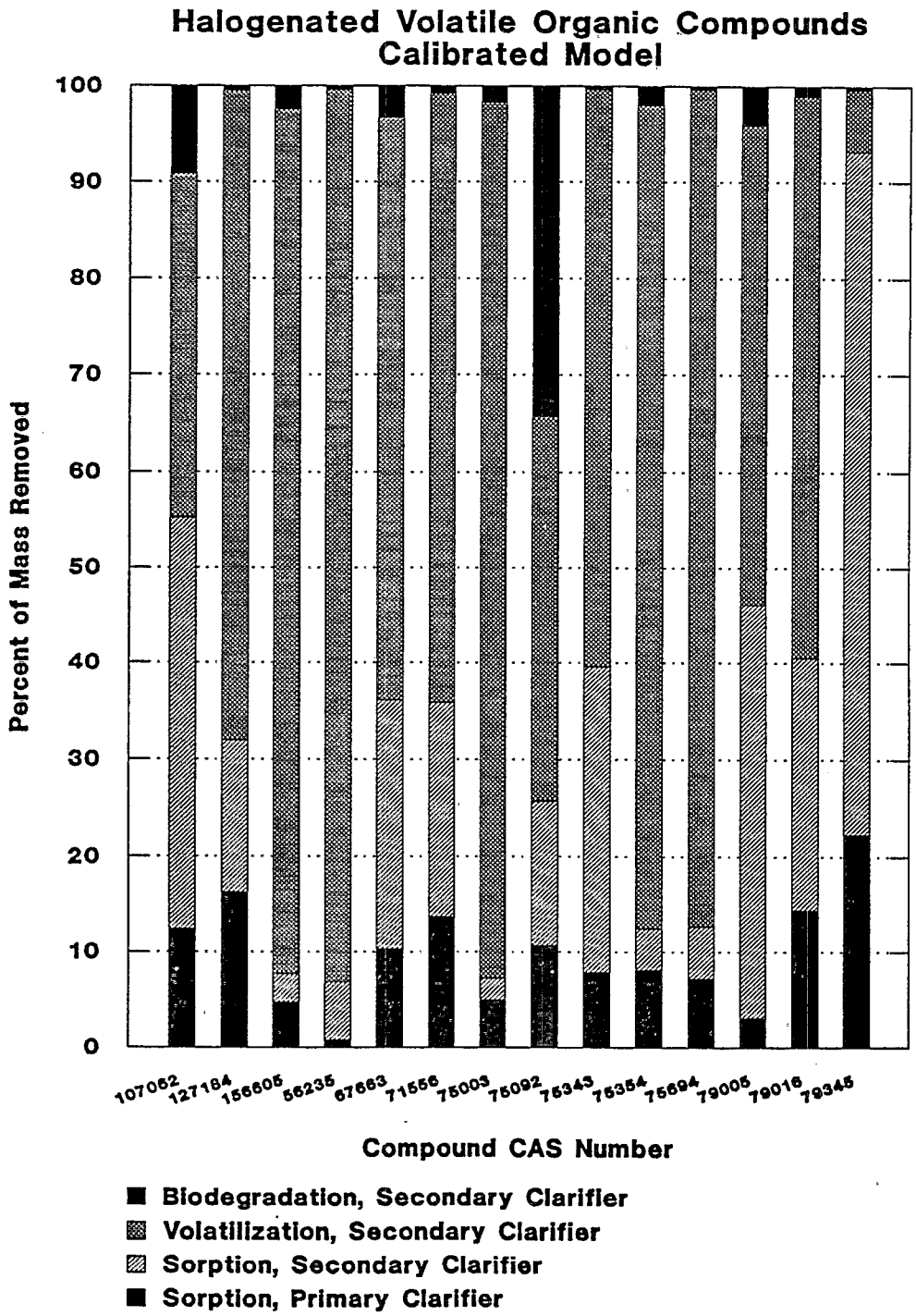


Figure B-13
Boxplots of FATE Residuals by Compound

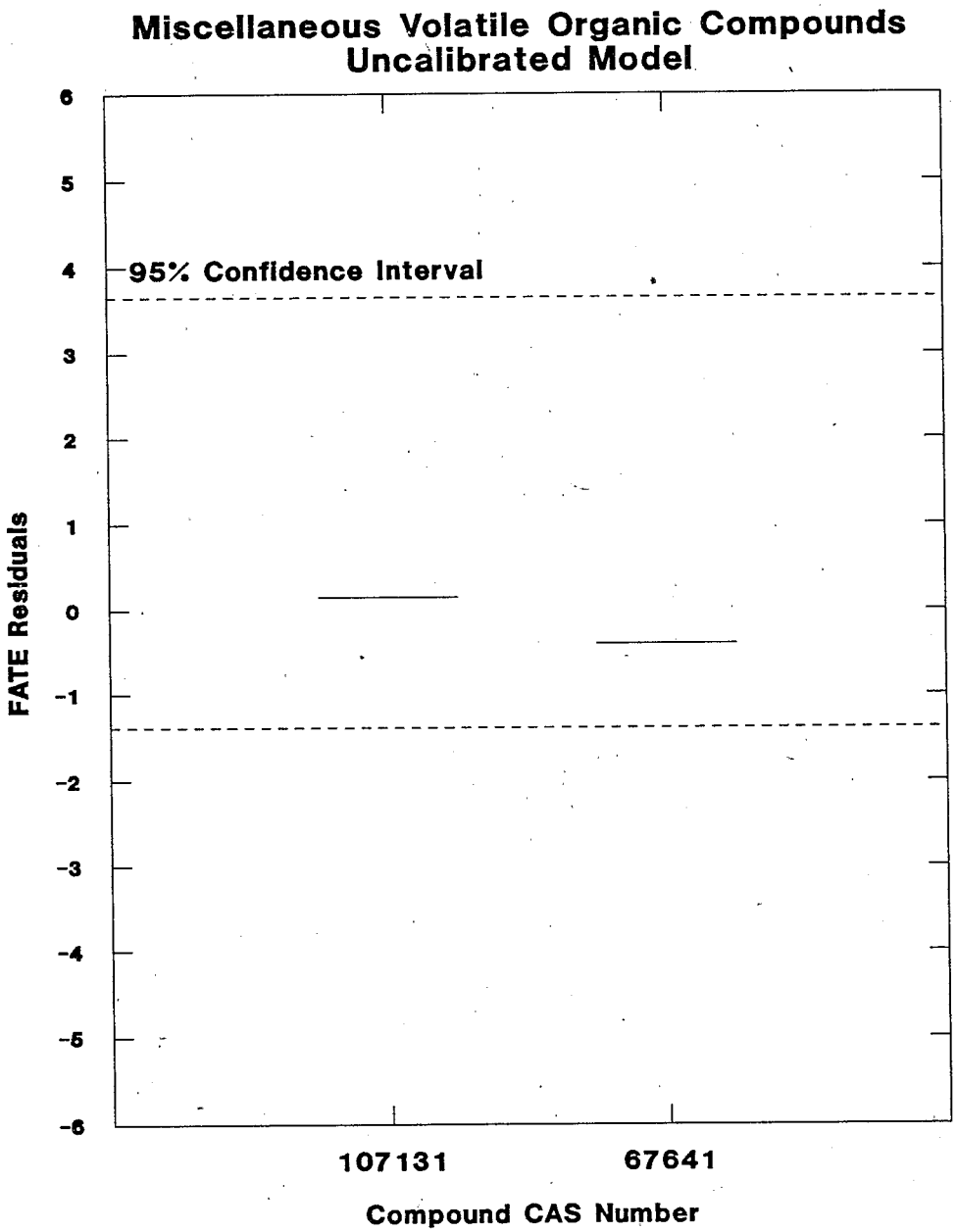


Figure B-14
Boxplots of FATE Residuals by Compound

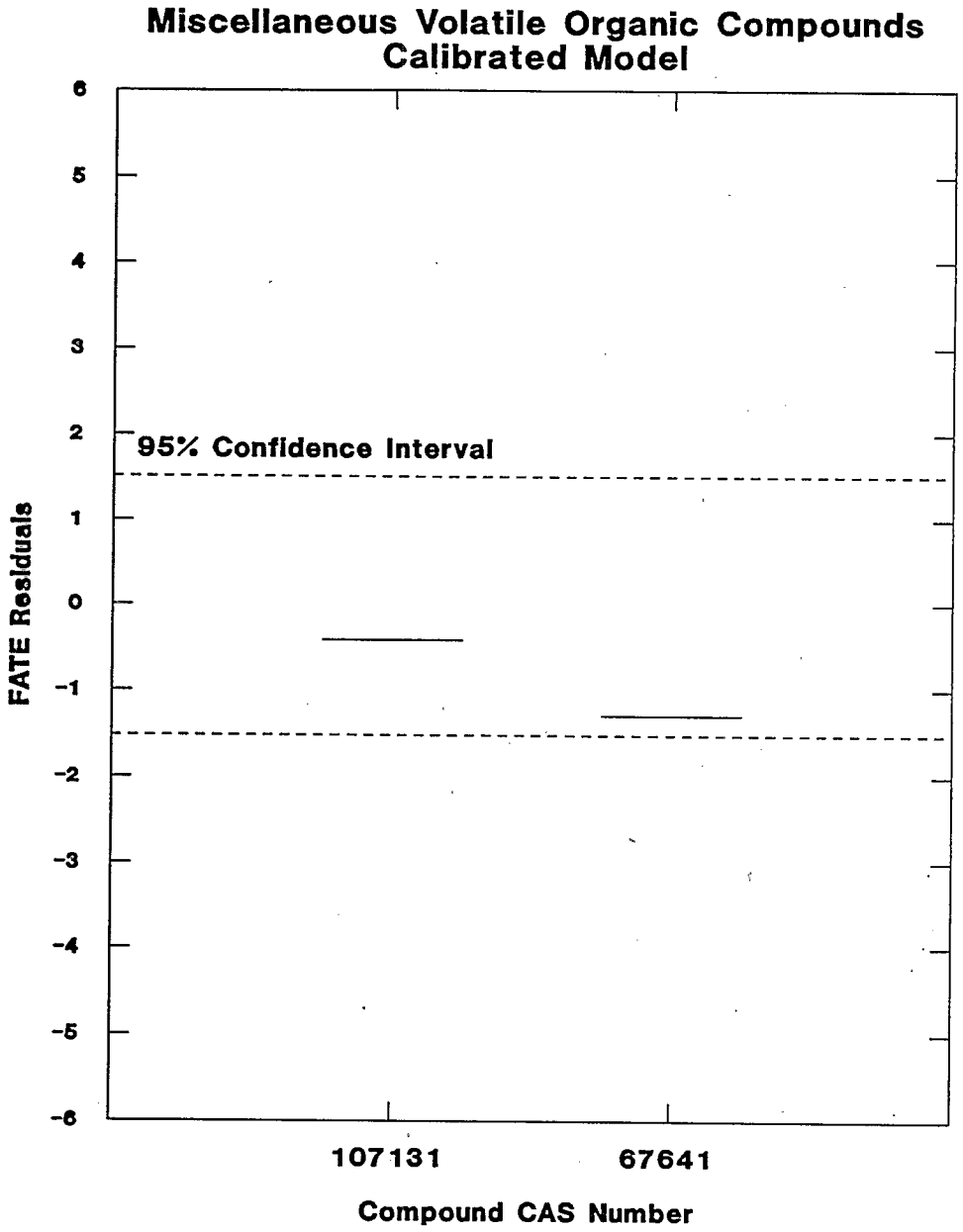


Figure B-15
Percent of Mass Removed by Each Mechanism

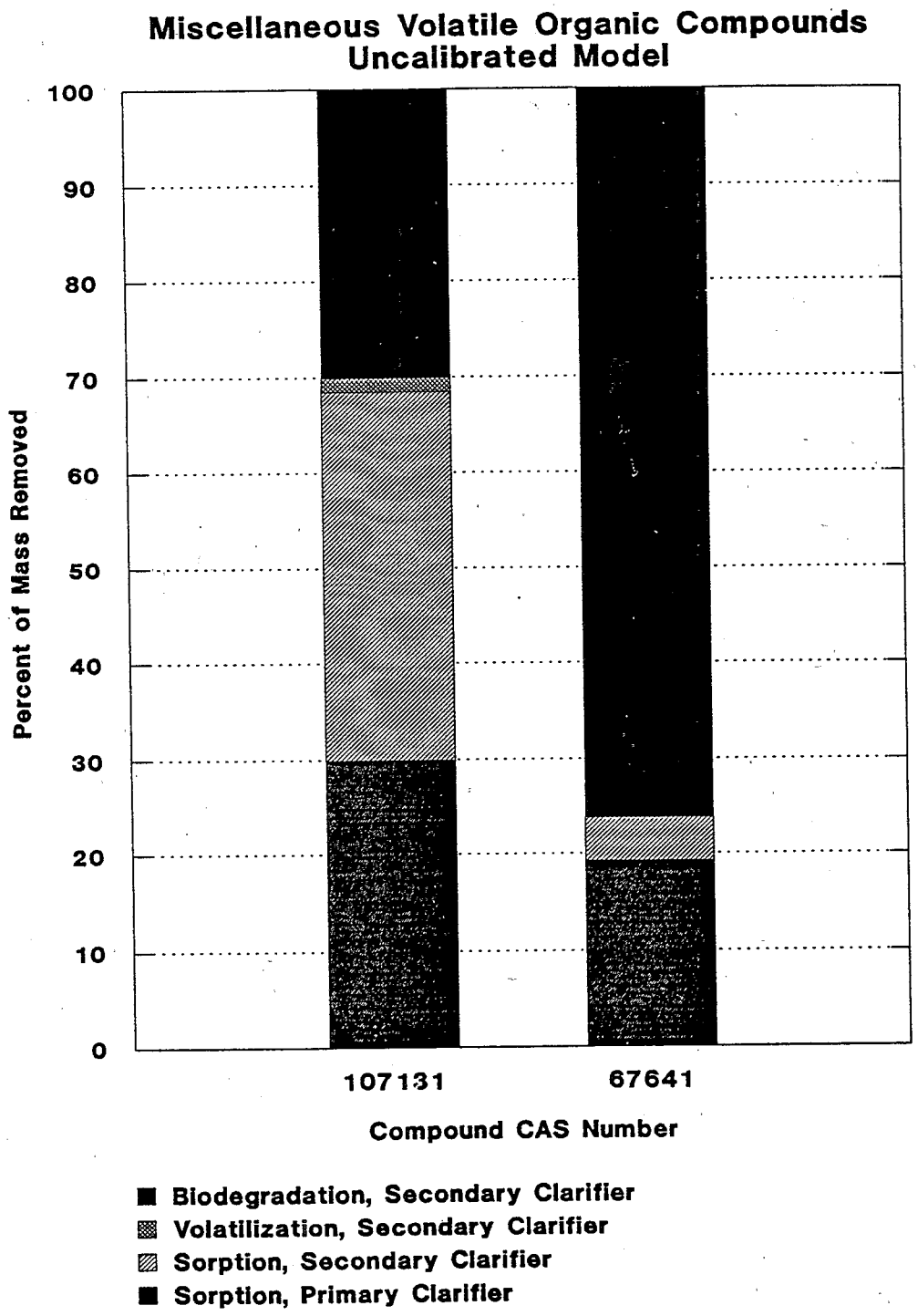


Figure B-16
Percent of Mass Removed by Each Mechanism

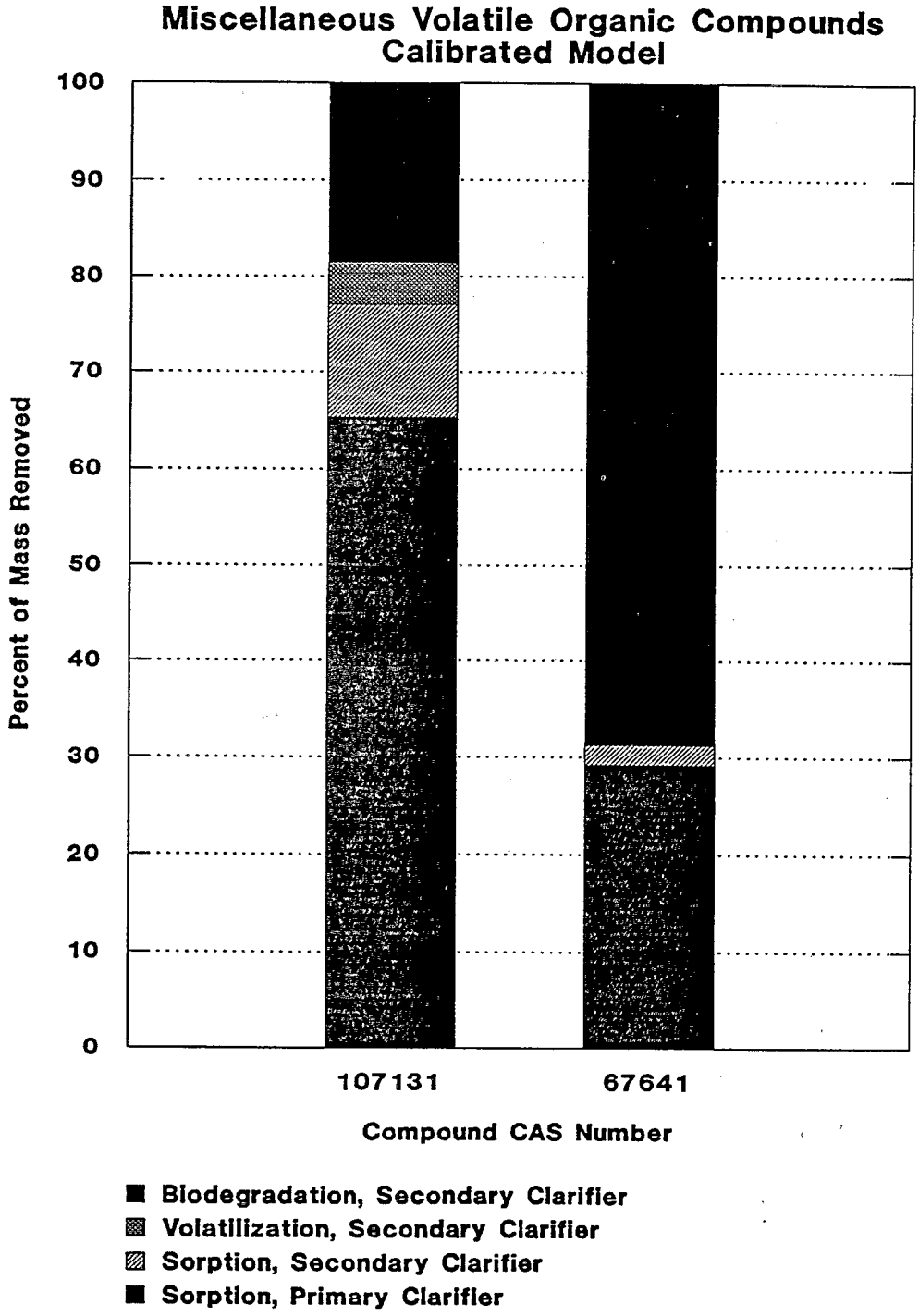


Figure B-17
Boxplots of FATE Residuals by Compound

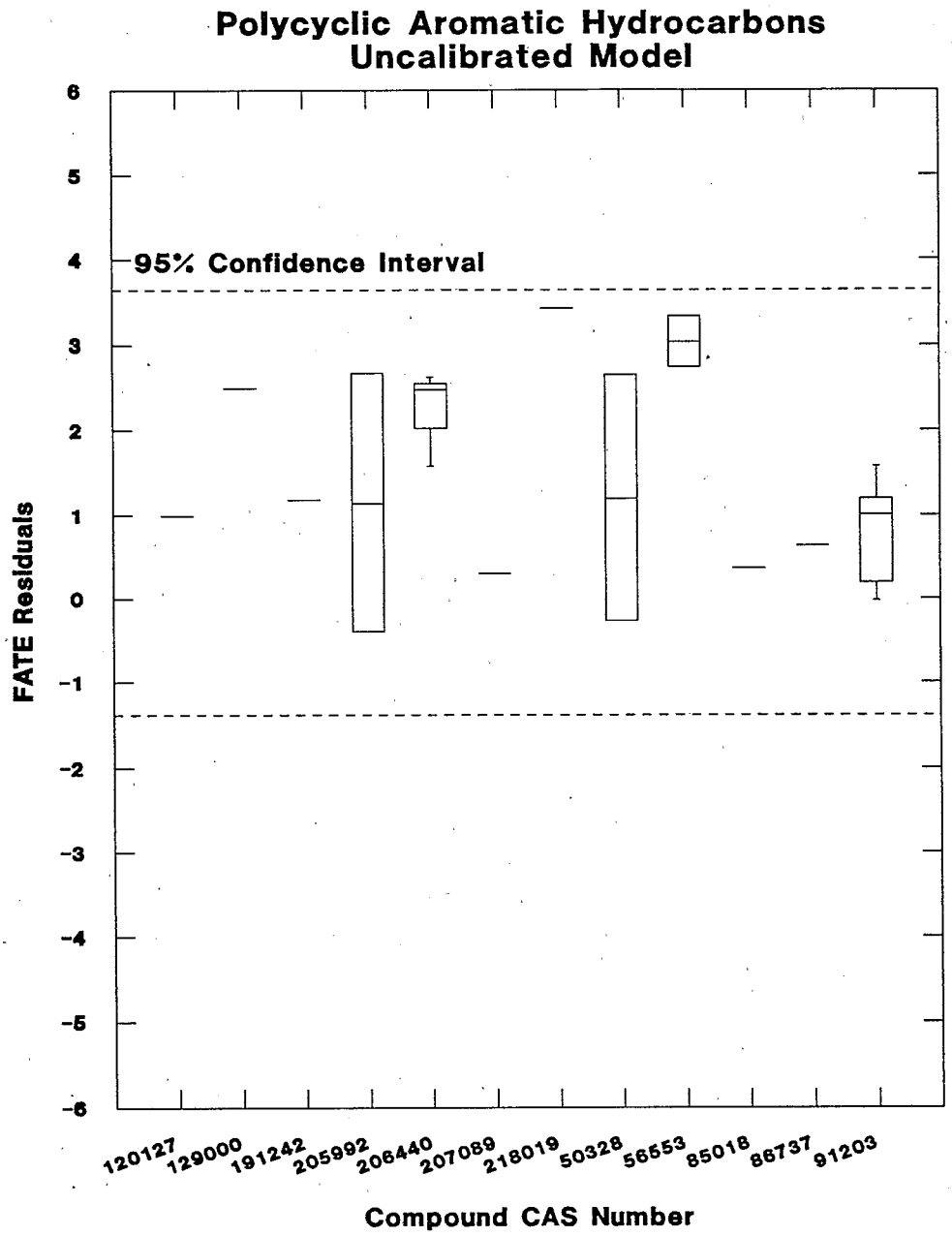


Figure B-18
Boxplots of FATE Residuals by Compound

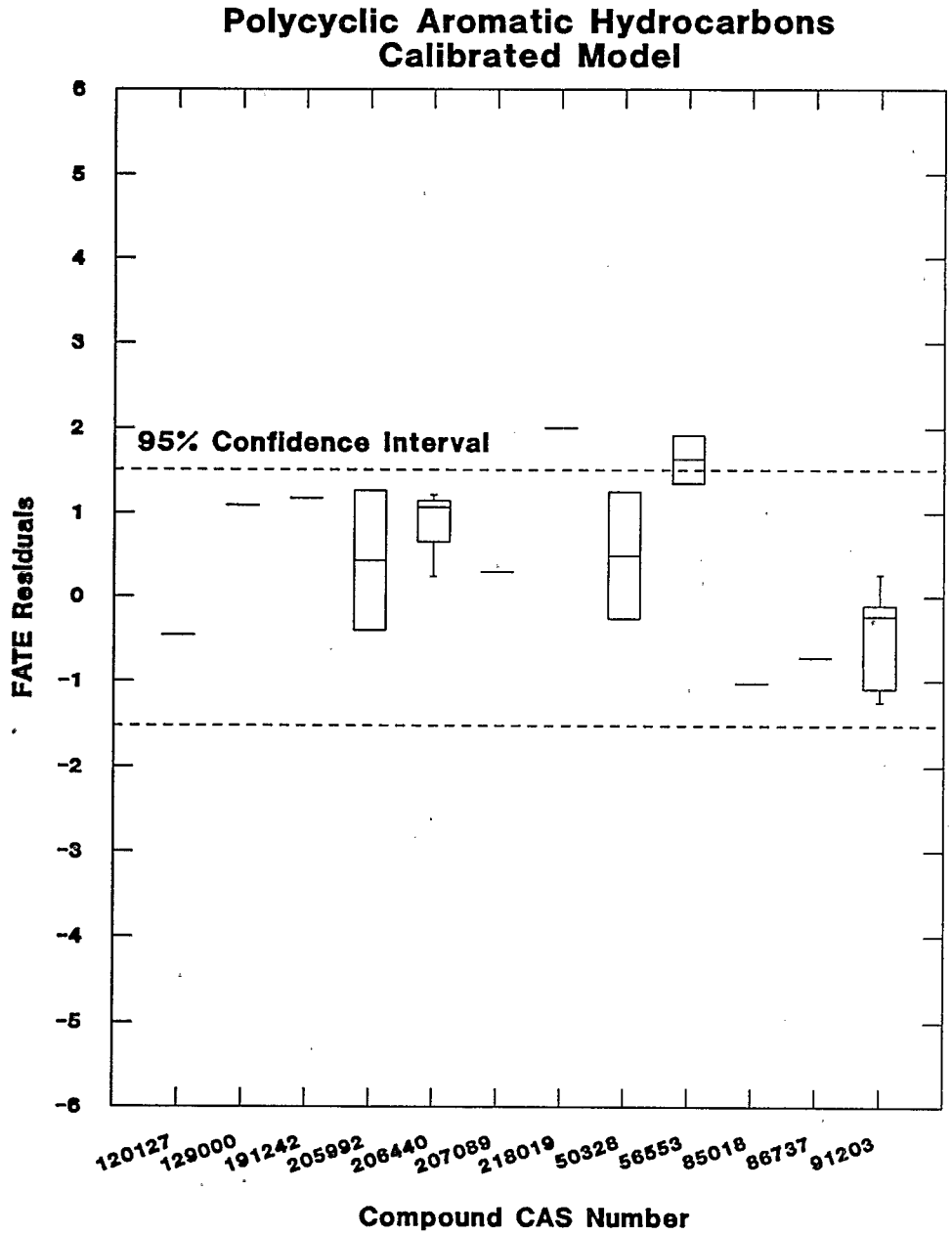


Figure B-19
Percent of Mass Removed by Each Mechanism

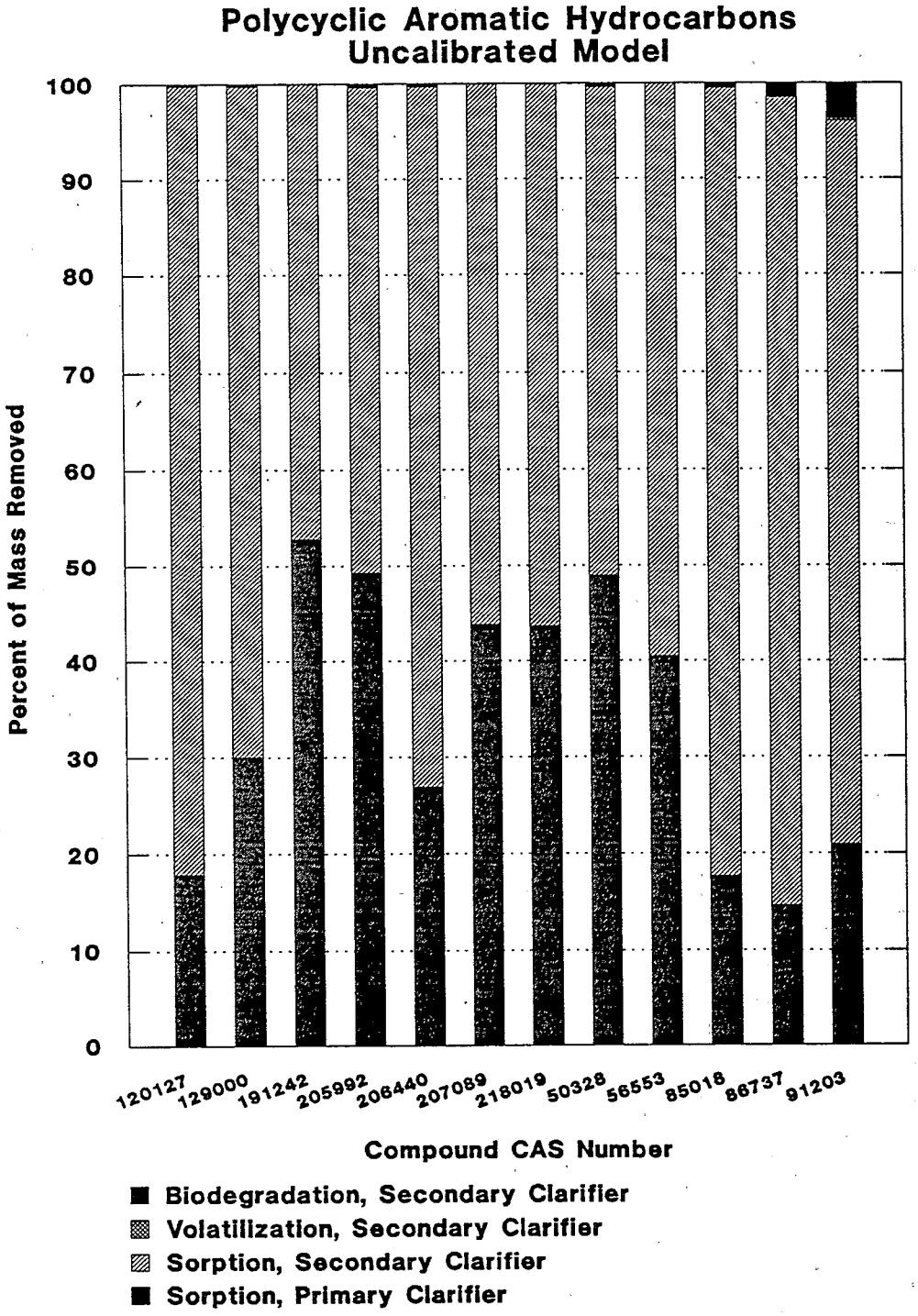


Figure B-20
Percent of Mass Removed by Each Mechanism

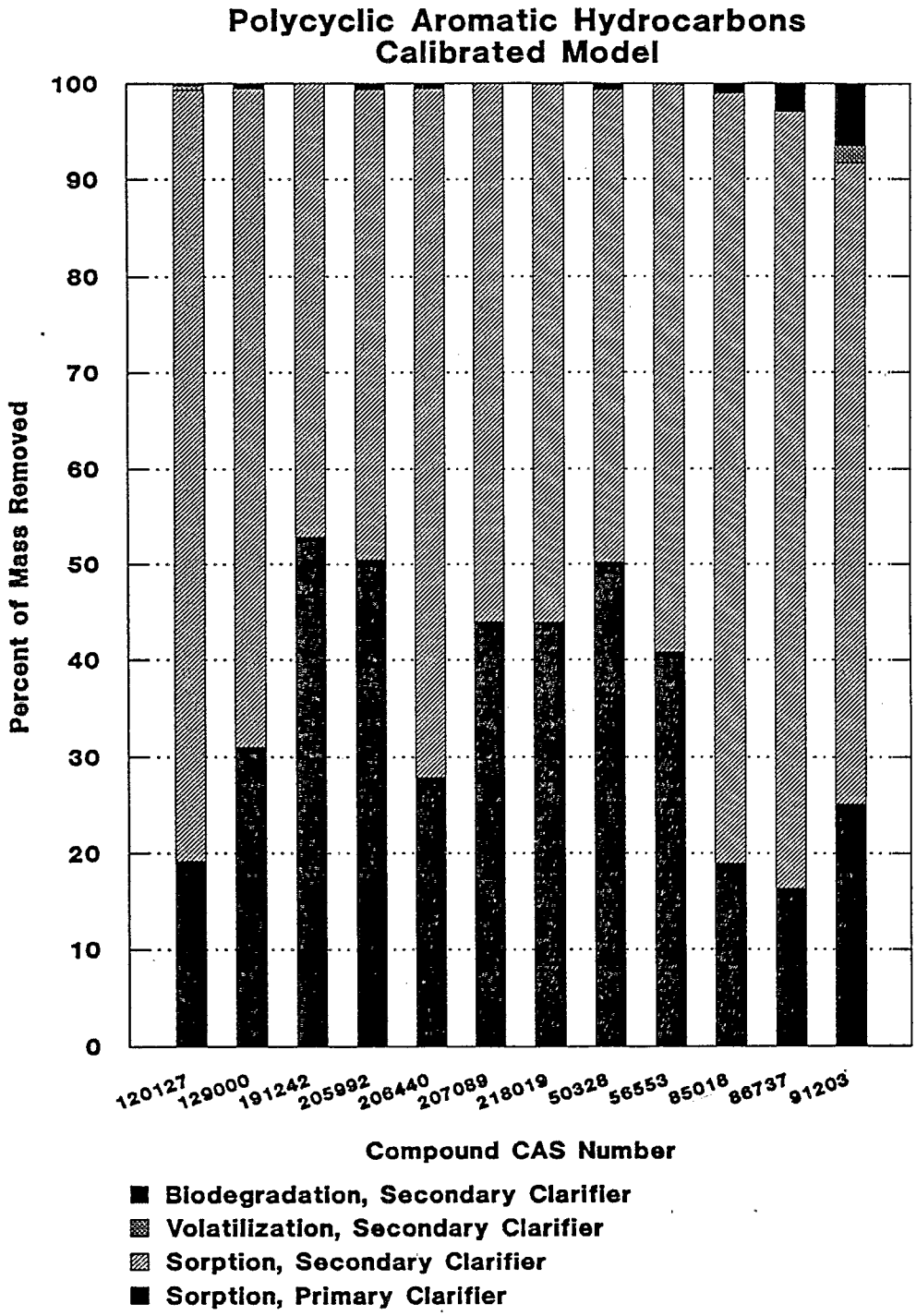


Figure B-21
Boxplots of FATE Residuals by Compound

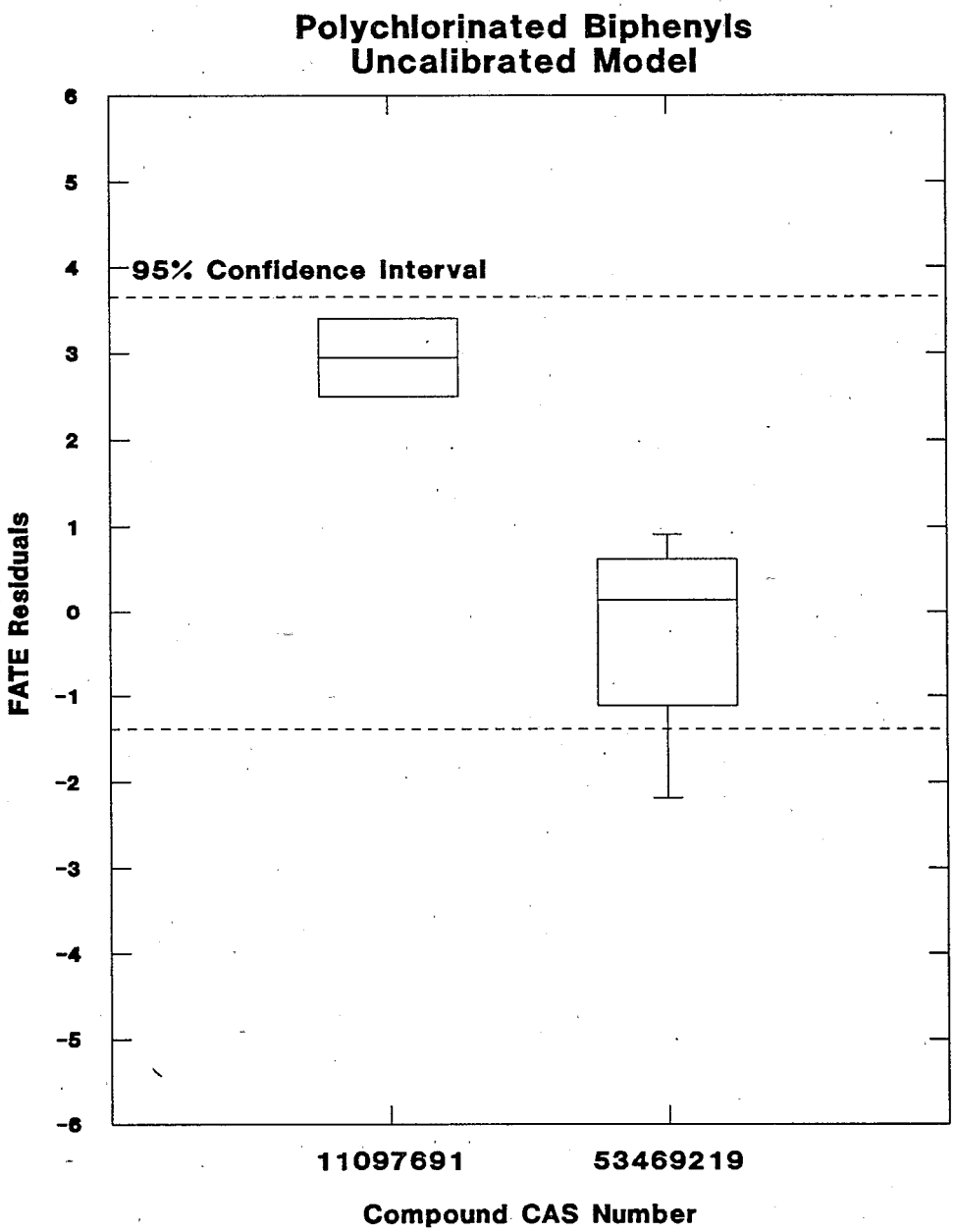


Figure B-22
Boxplots of FATE Residuals by Compound

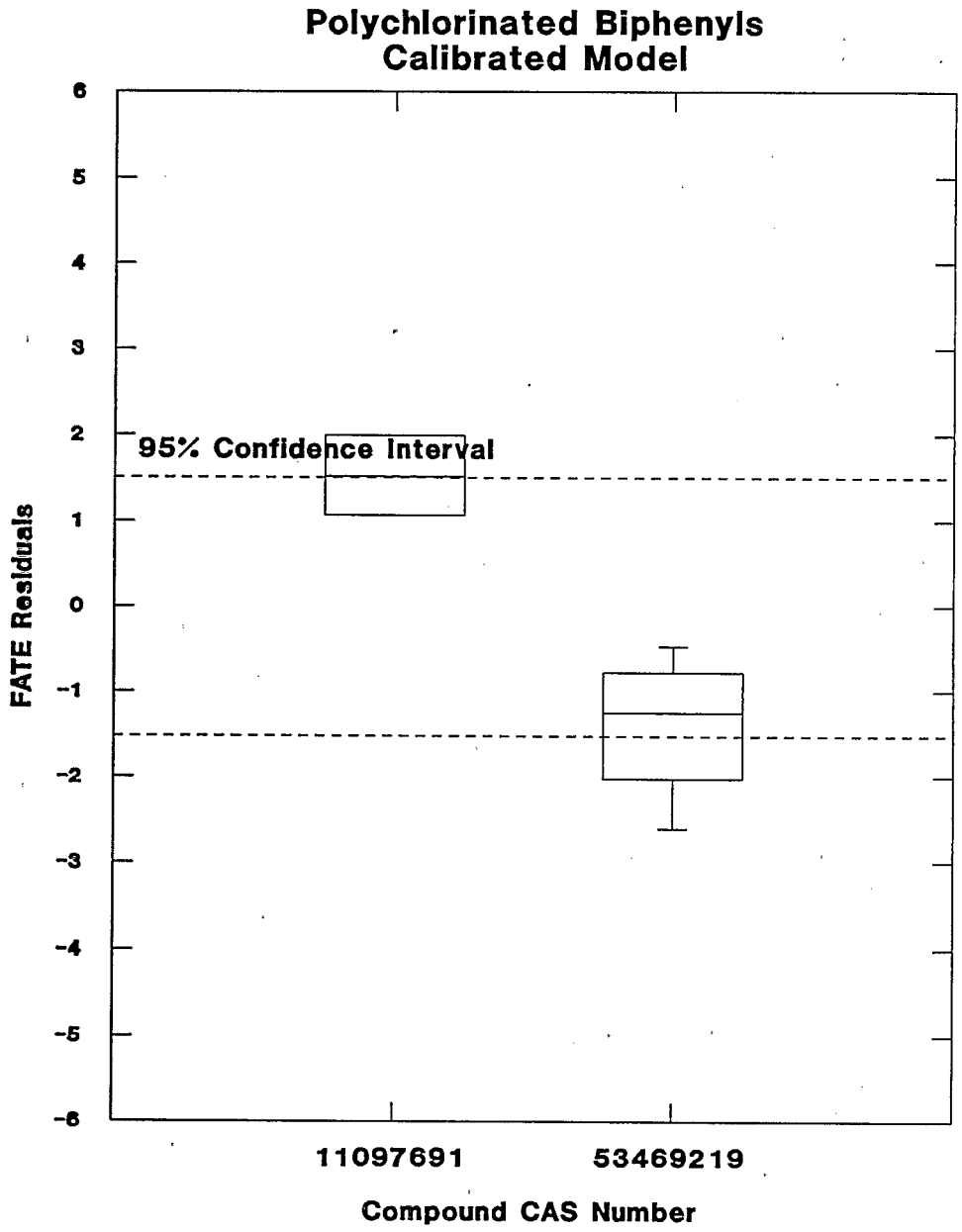


Figure B-23
Percent of Mass Removed by Each Mechanism

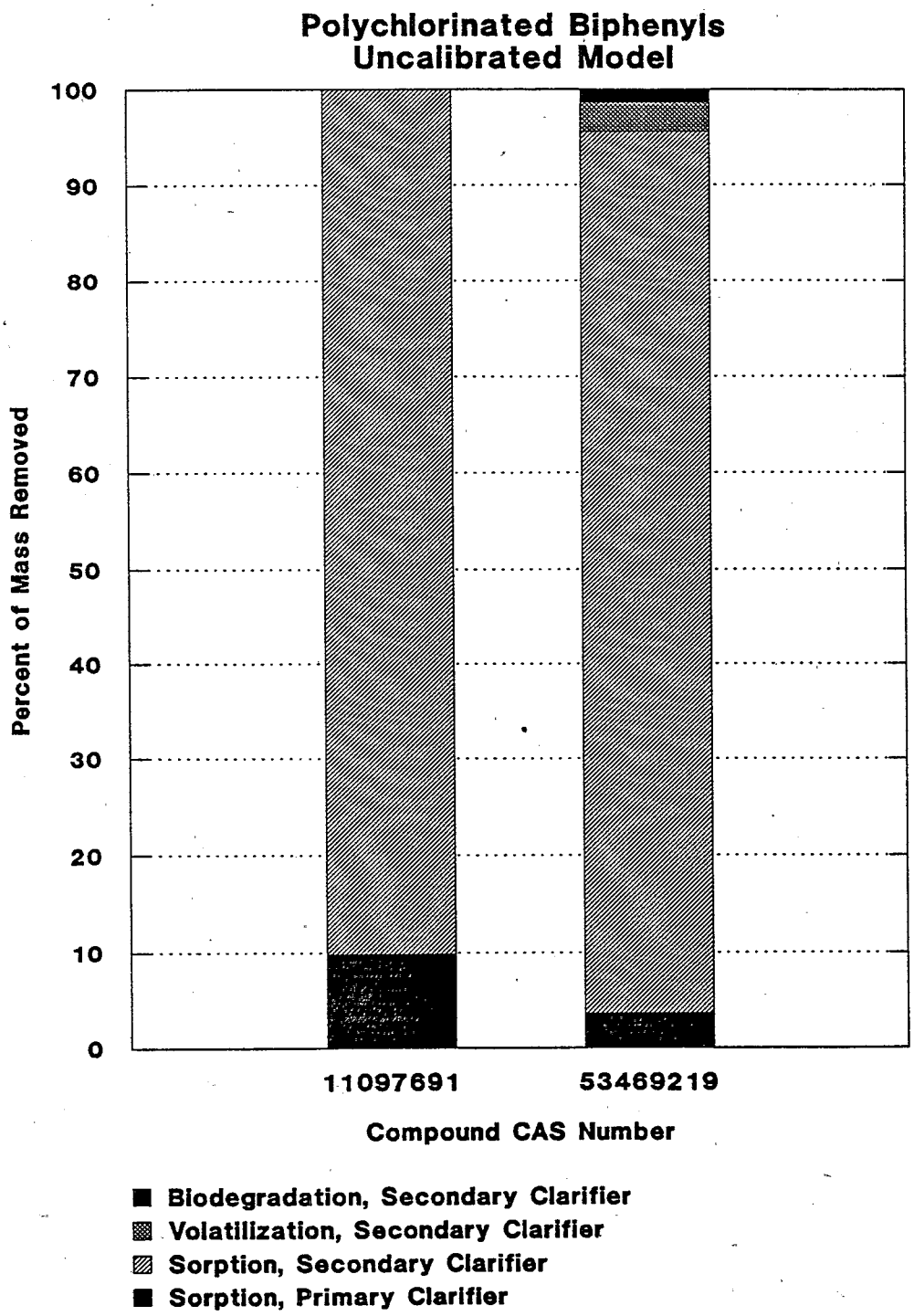


Figure B-24
Percent of Mass Removed by Each Mechanism

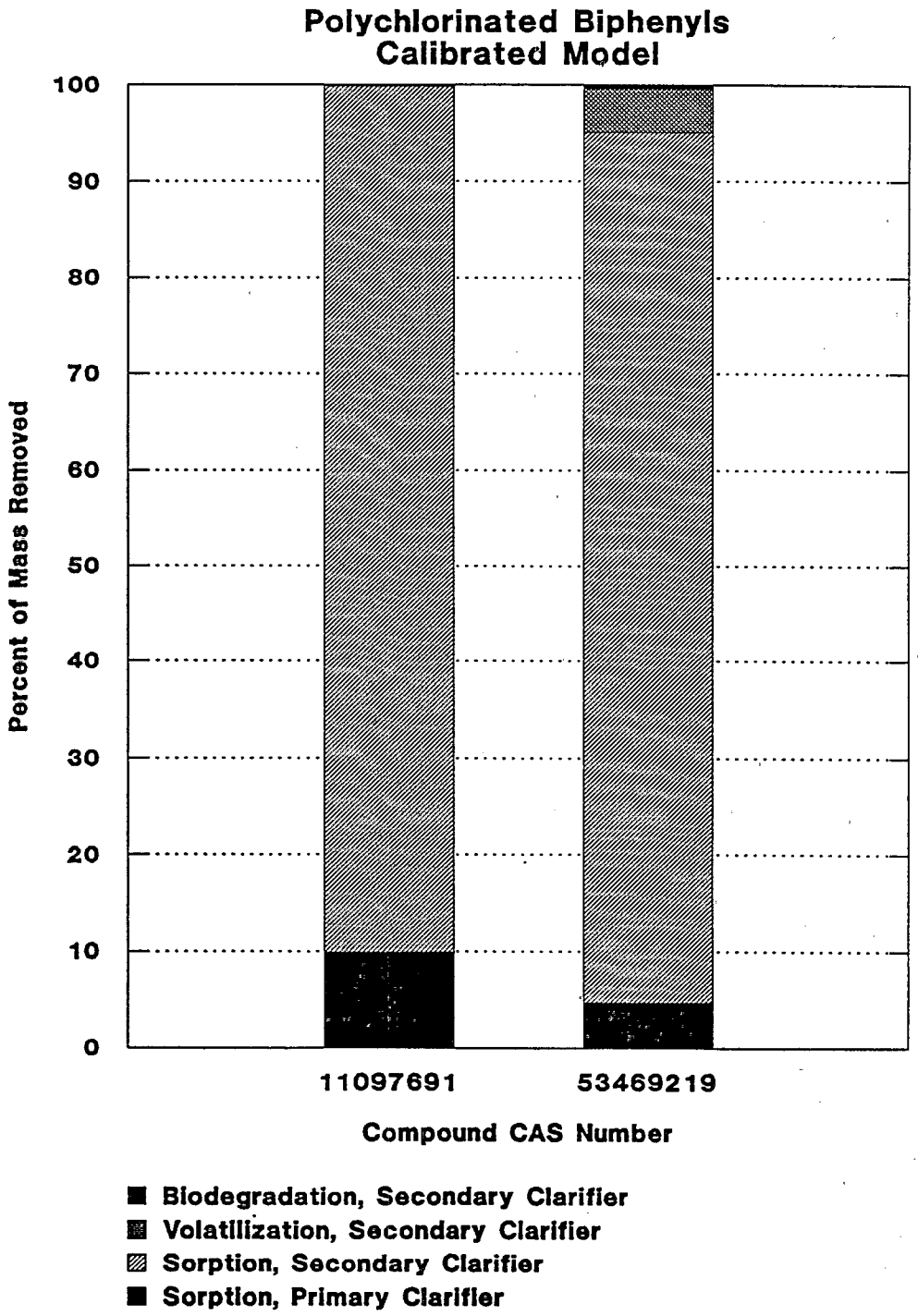


Figure B-25
Boxplots of FATE Residuals by Compound

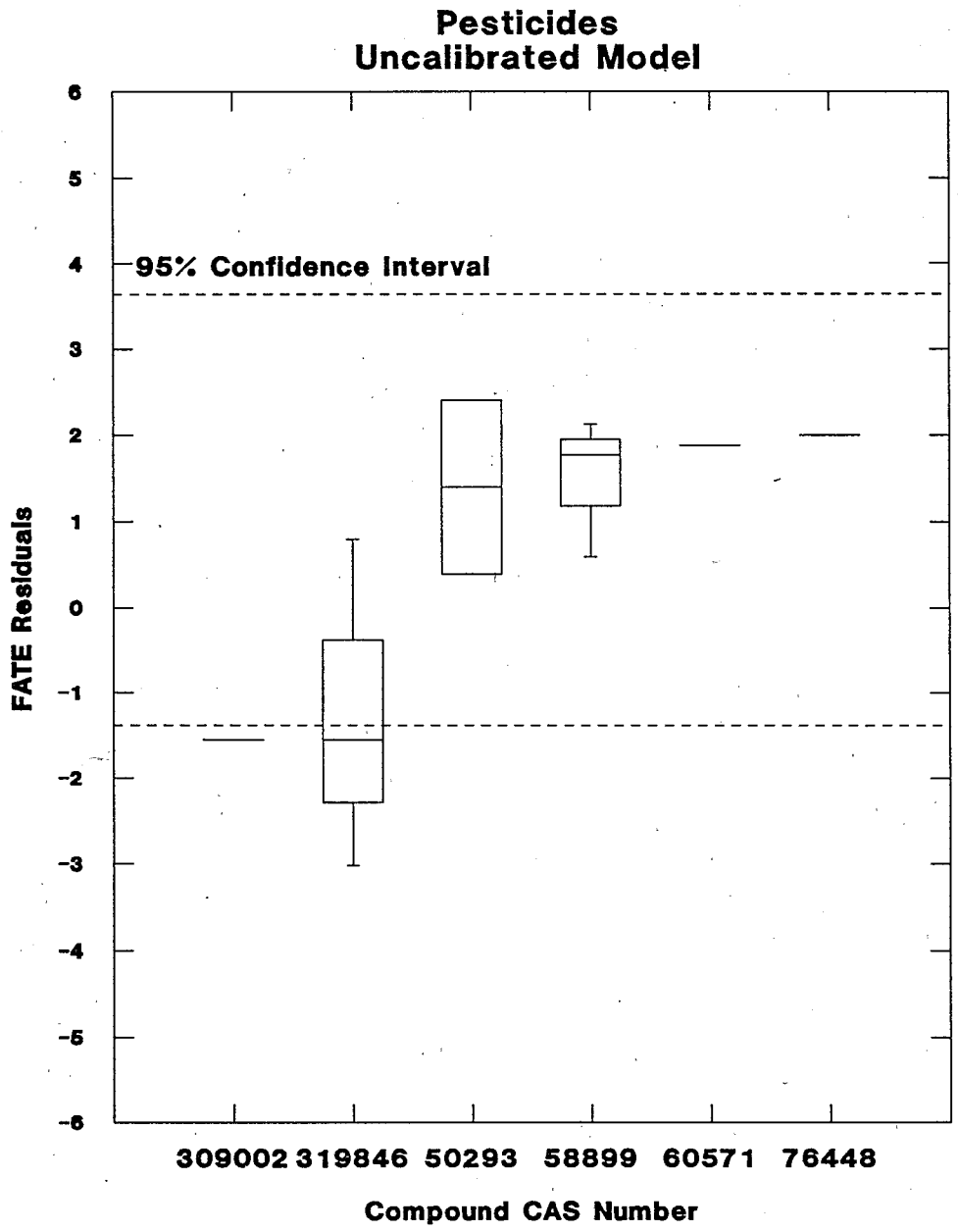


Figure B-26
Boxplots of FATE Residuals by Compound

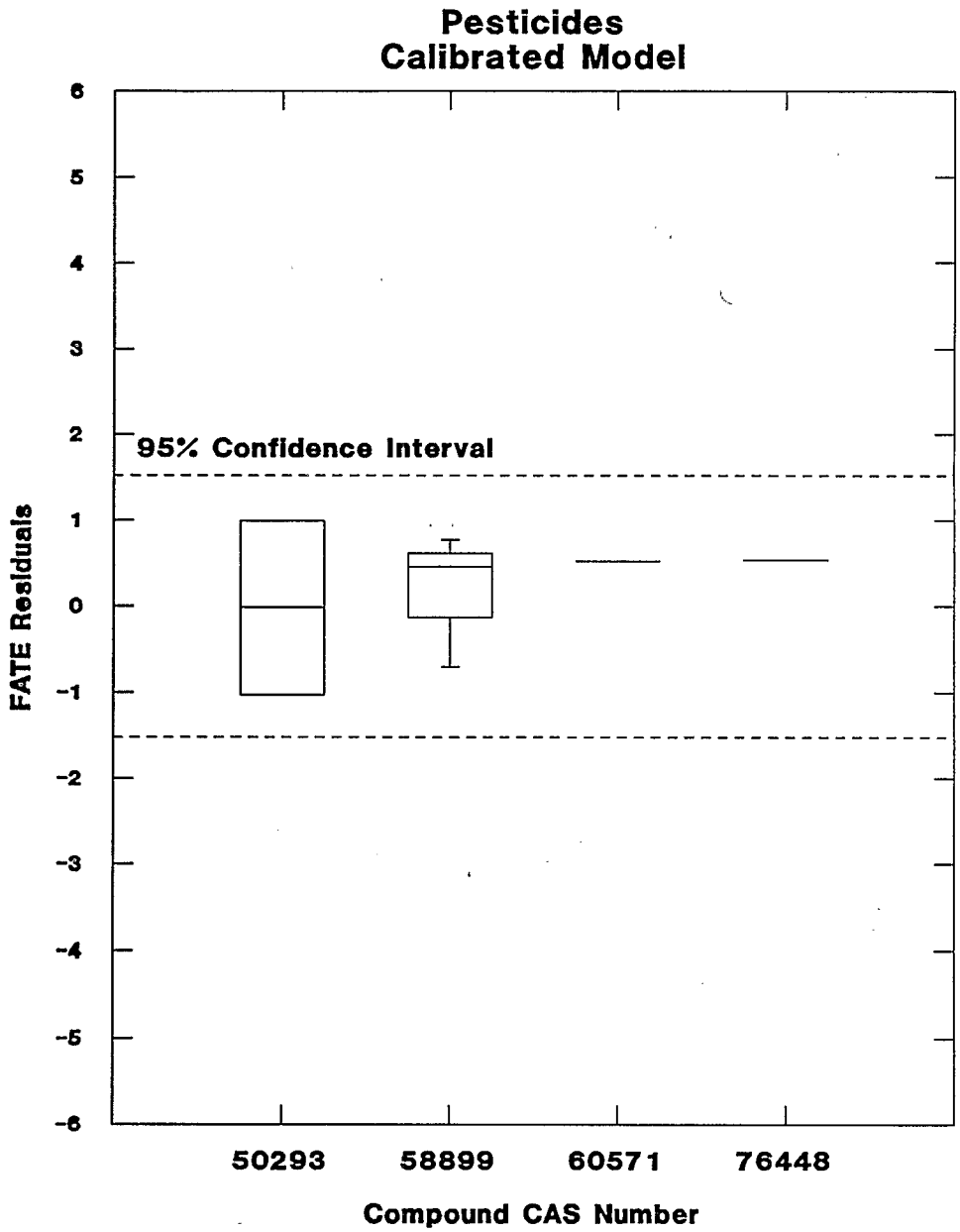


Figure B-27
Percent of Mass Removed by Each Mechanism

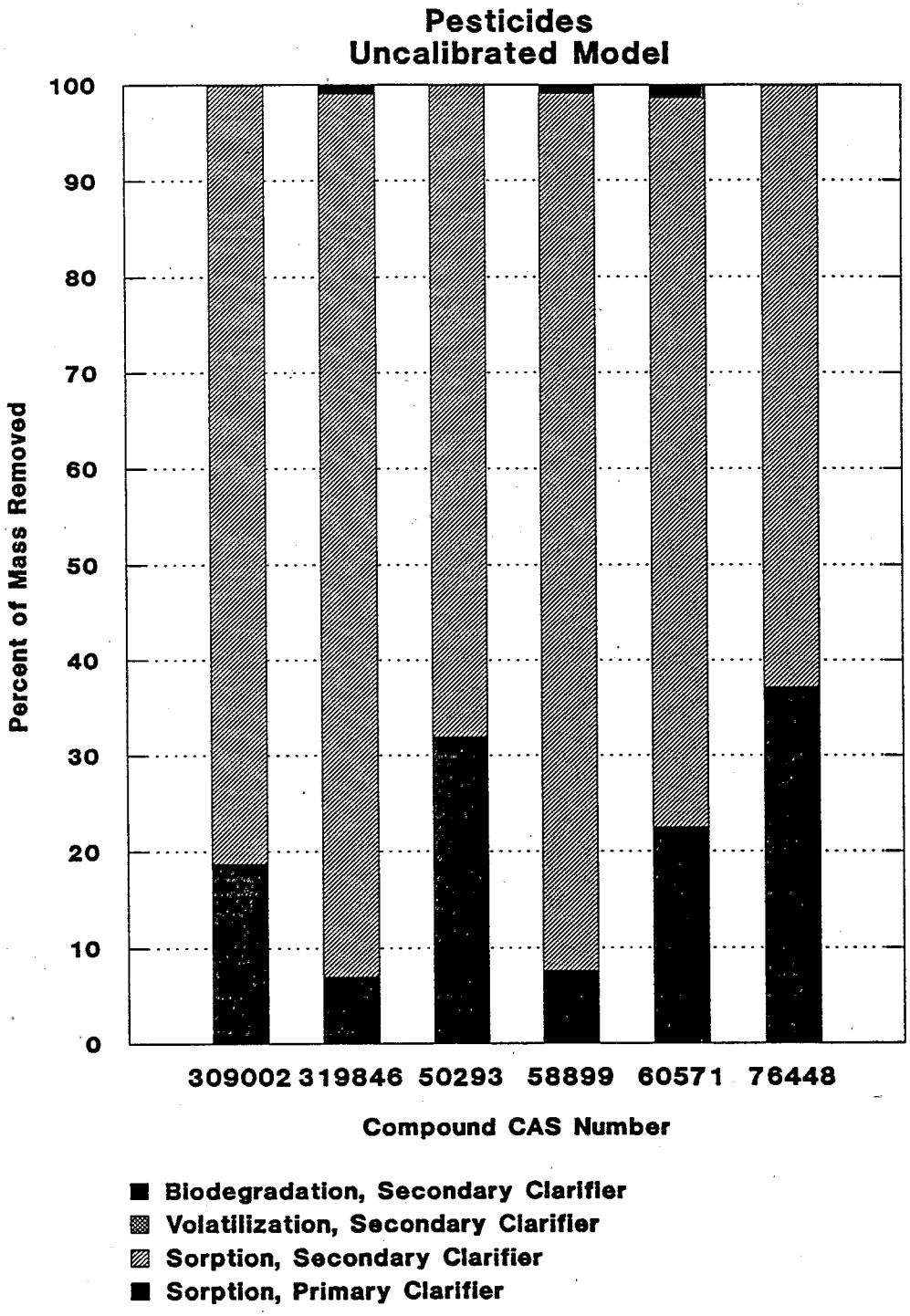


Figure B-28
Percent of Mass Removed by Each Mechanism

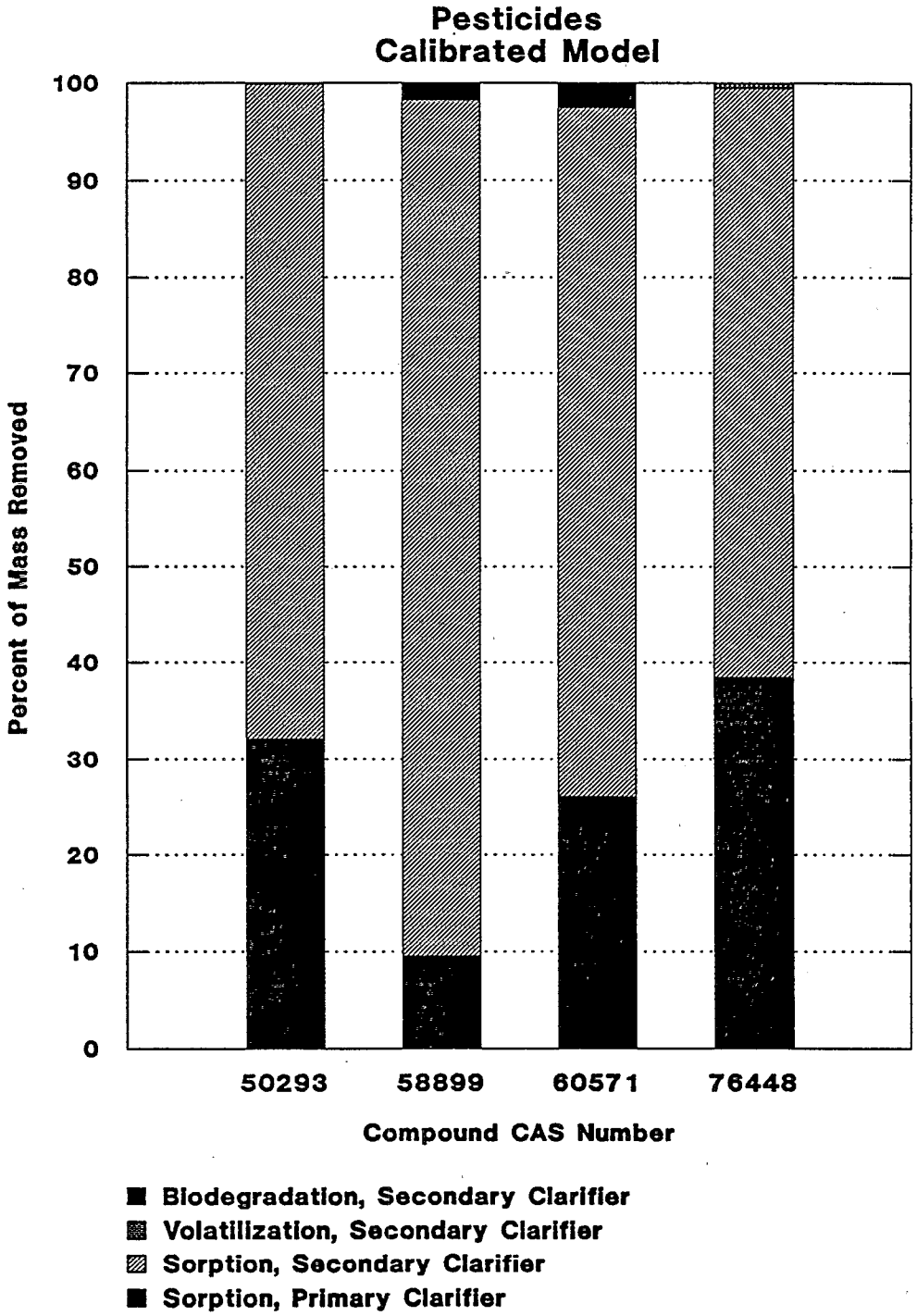


Figure B-29
Boxplots of FATE Residuals by Compound

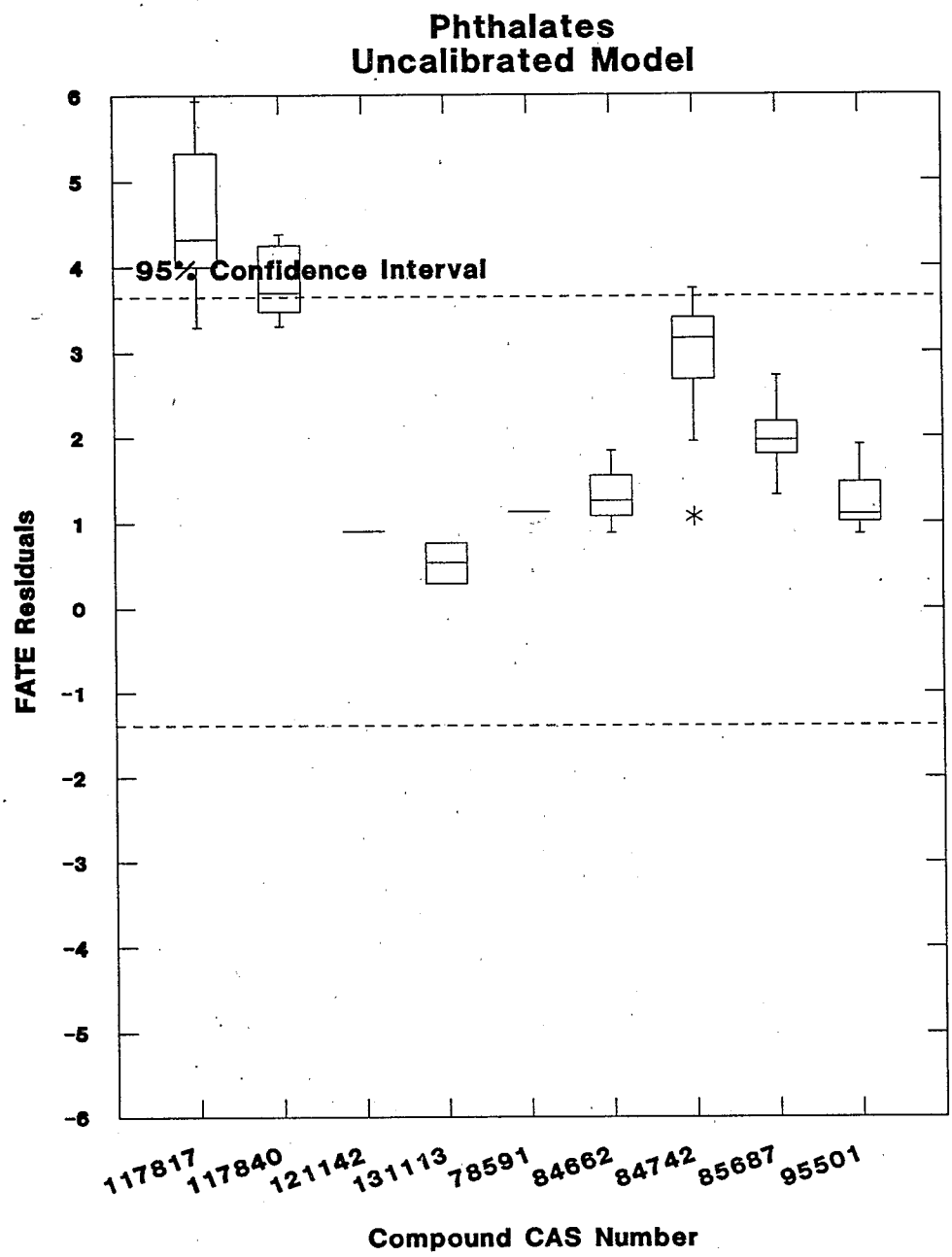


Figure B-30
Boxplots of FATE Residuals by Compound

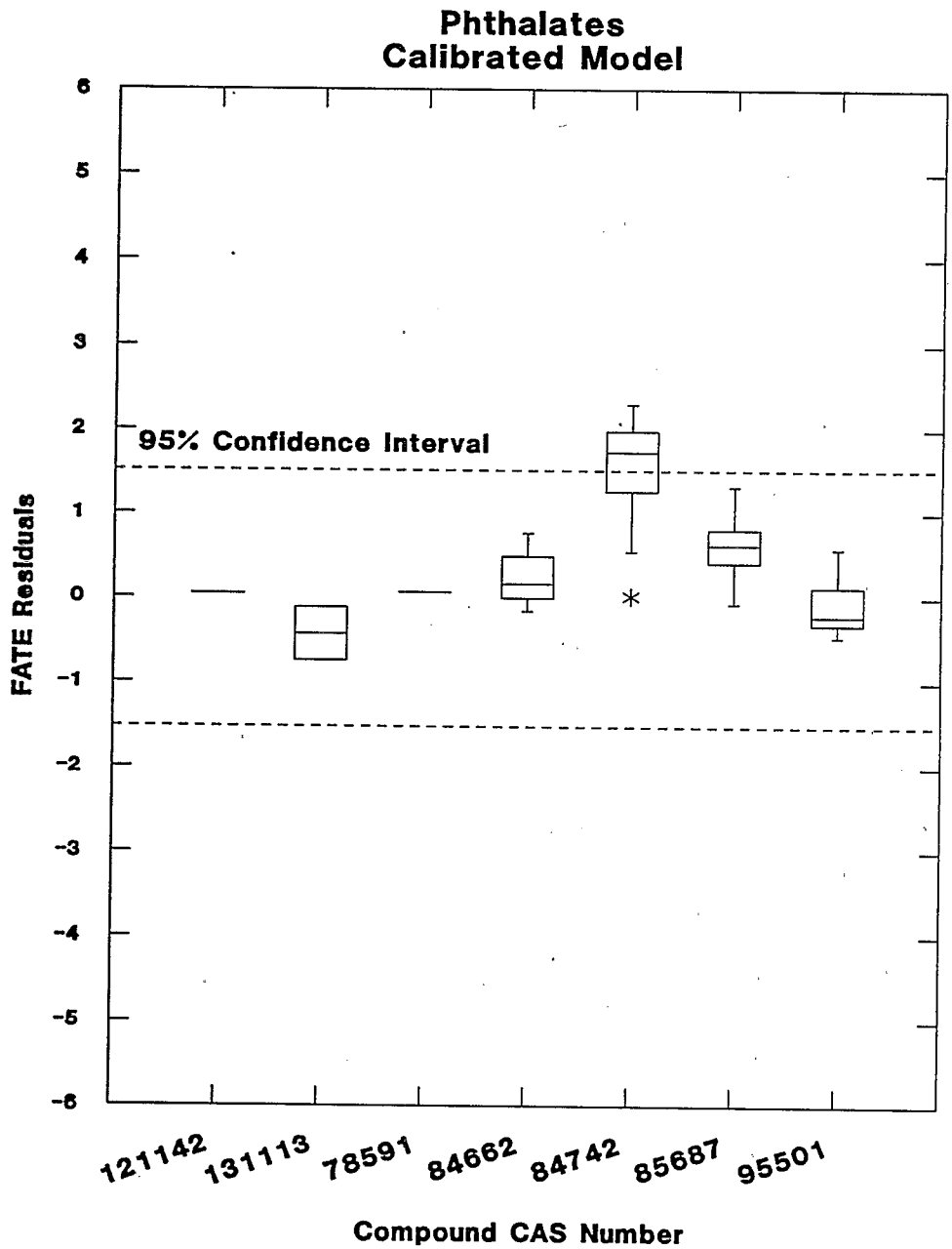


Figure B-31
Percent of Mass Removed by Each Mechanism

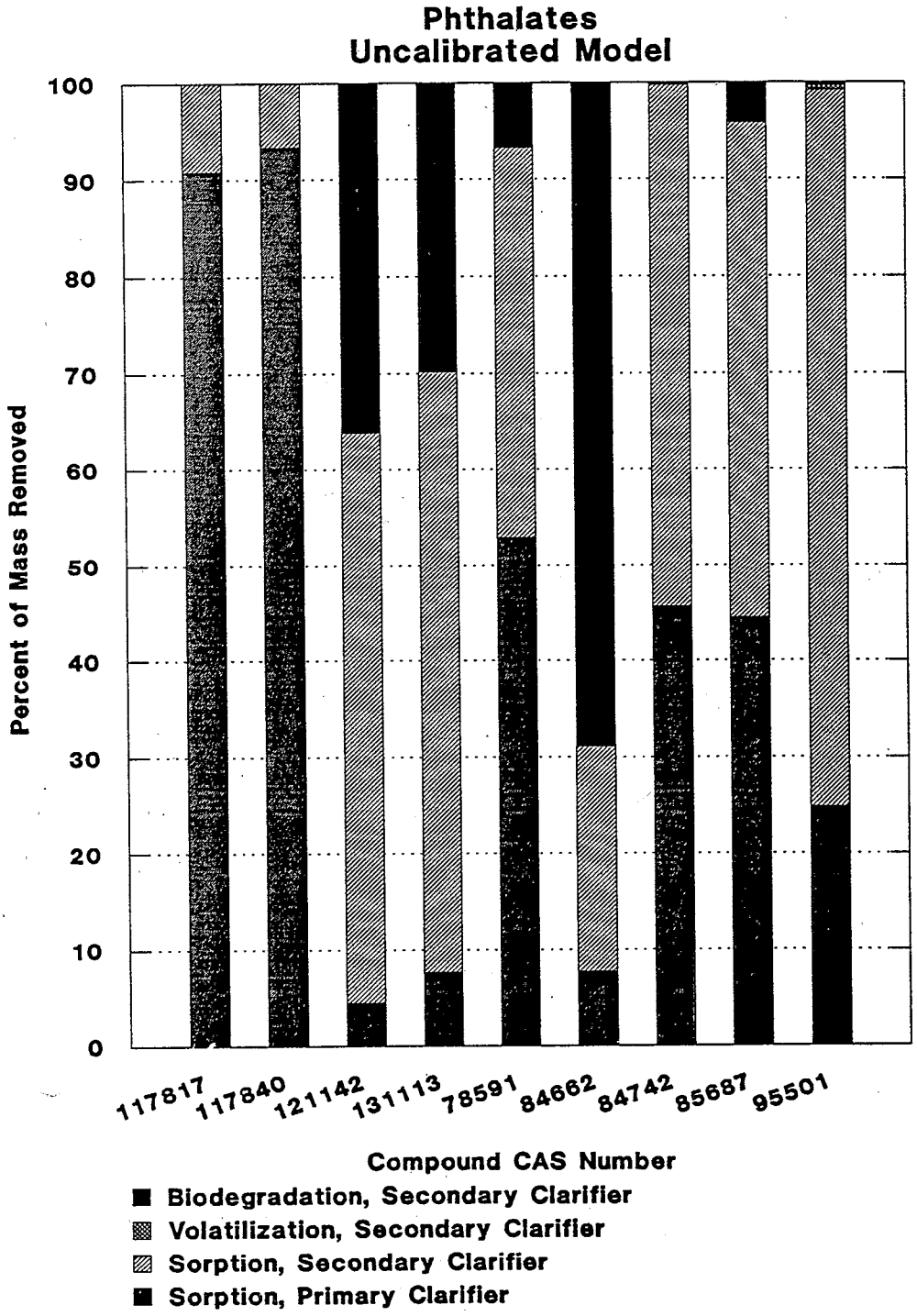


Figure B-32
Percent of Mass Removed by Each Mechanism

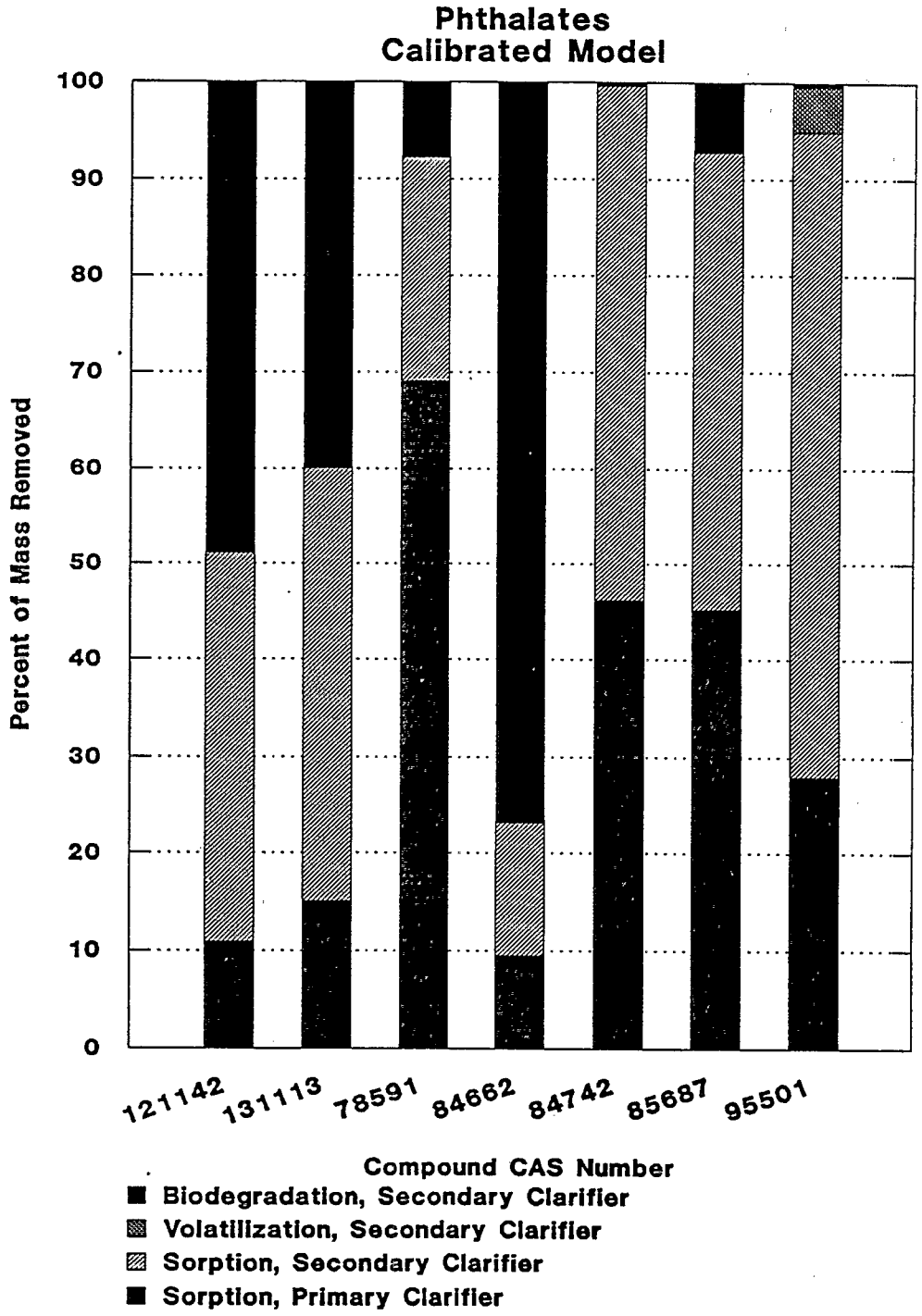


Figure B-33
Boxplots of FATE Residuals by Compound

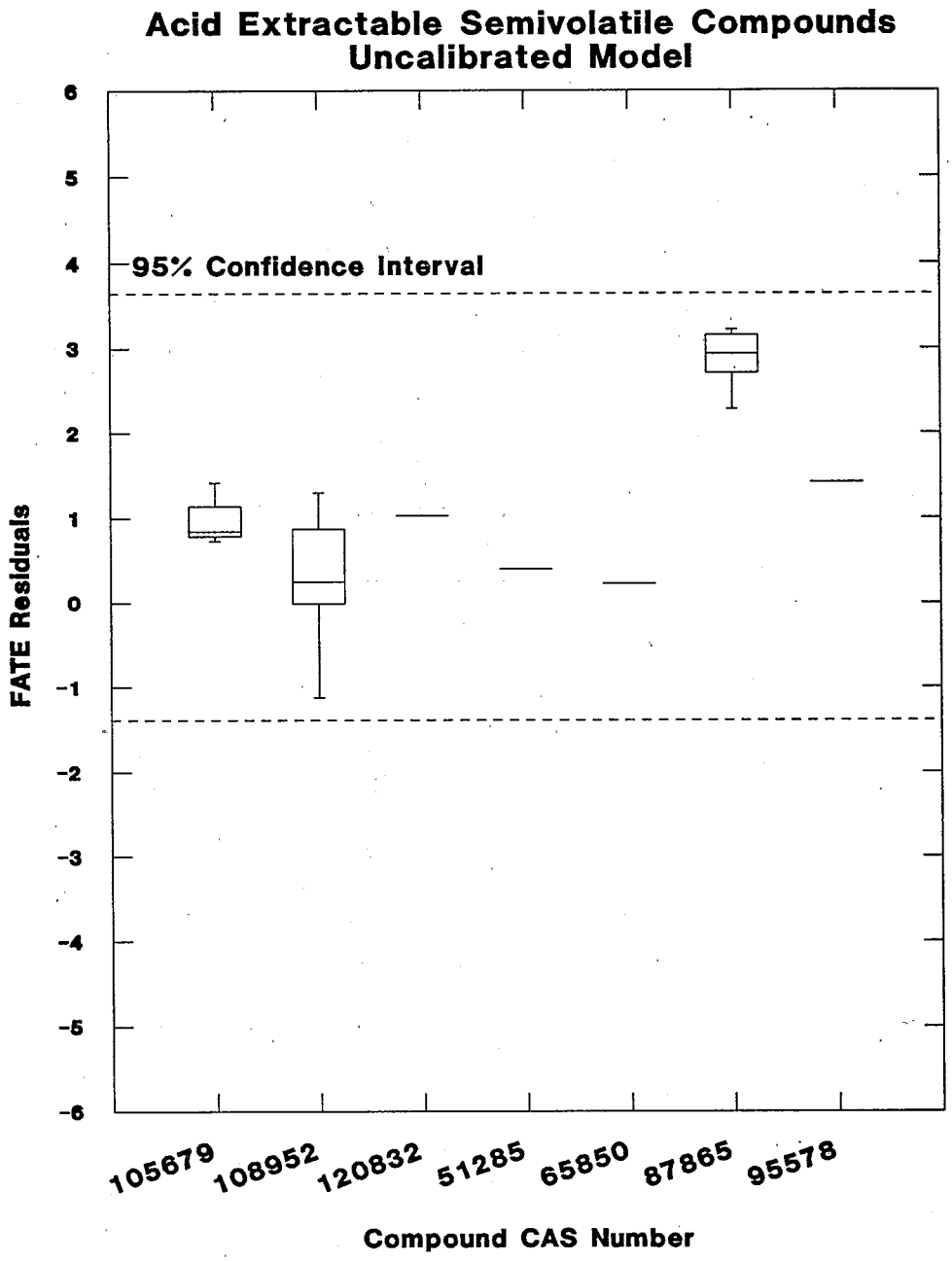


Figure B-34
Boxplots of FATE Residuals by Compound

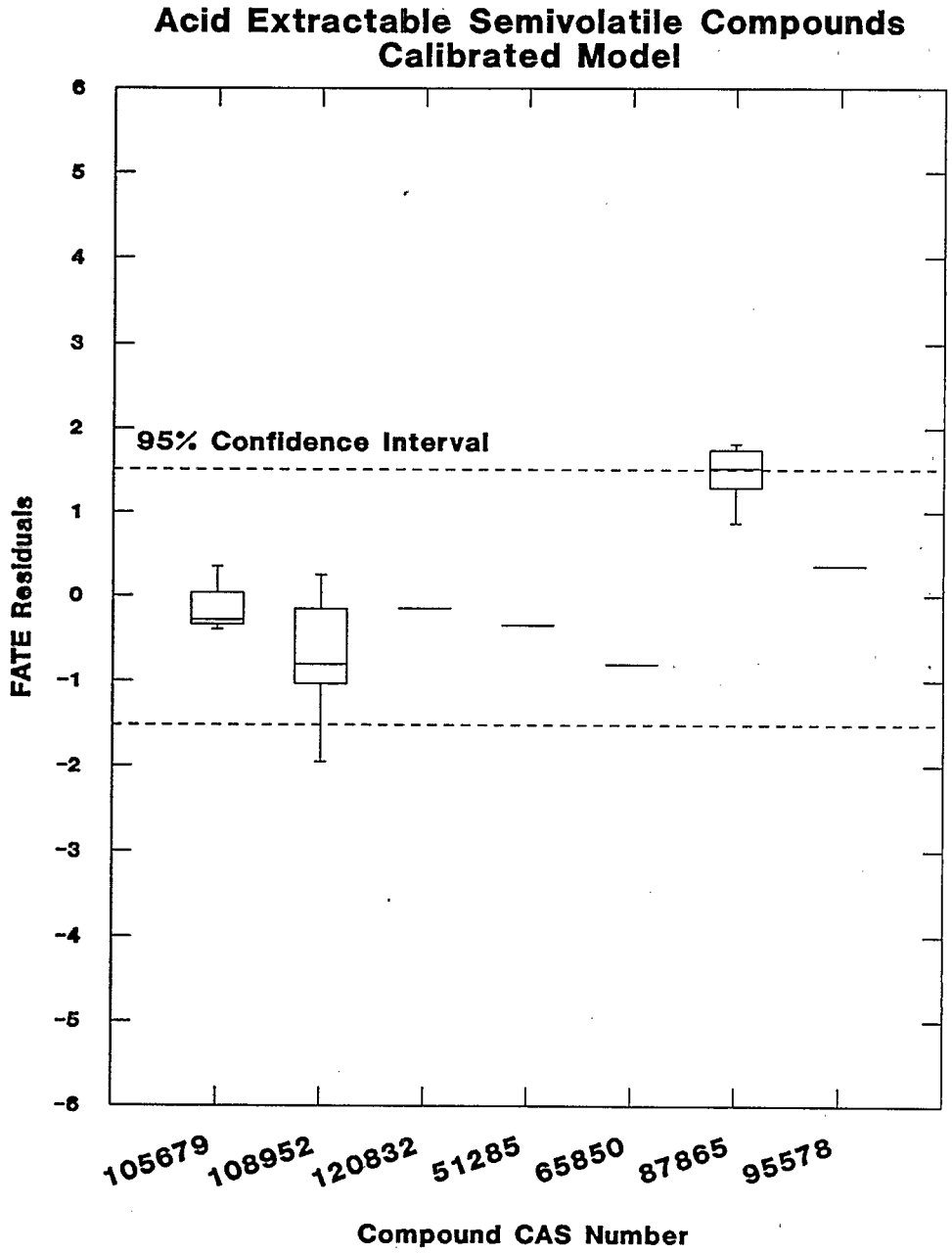


Figure B-35
Percent of Mass Removed by Each Mechanism

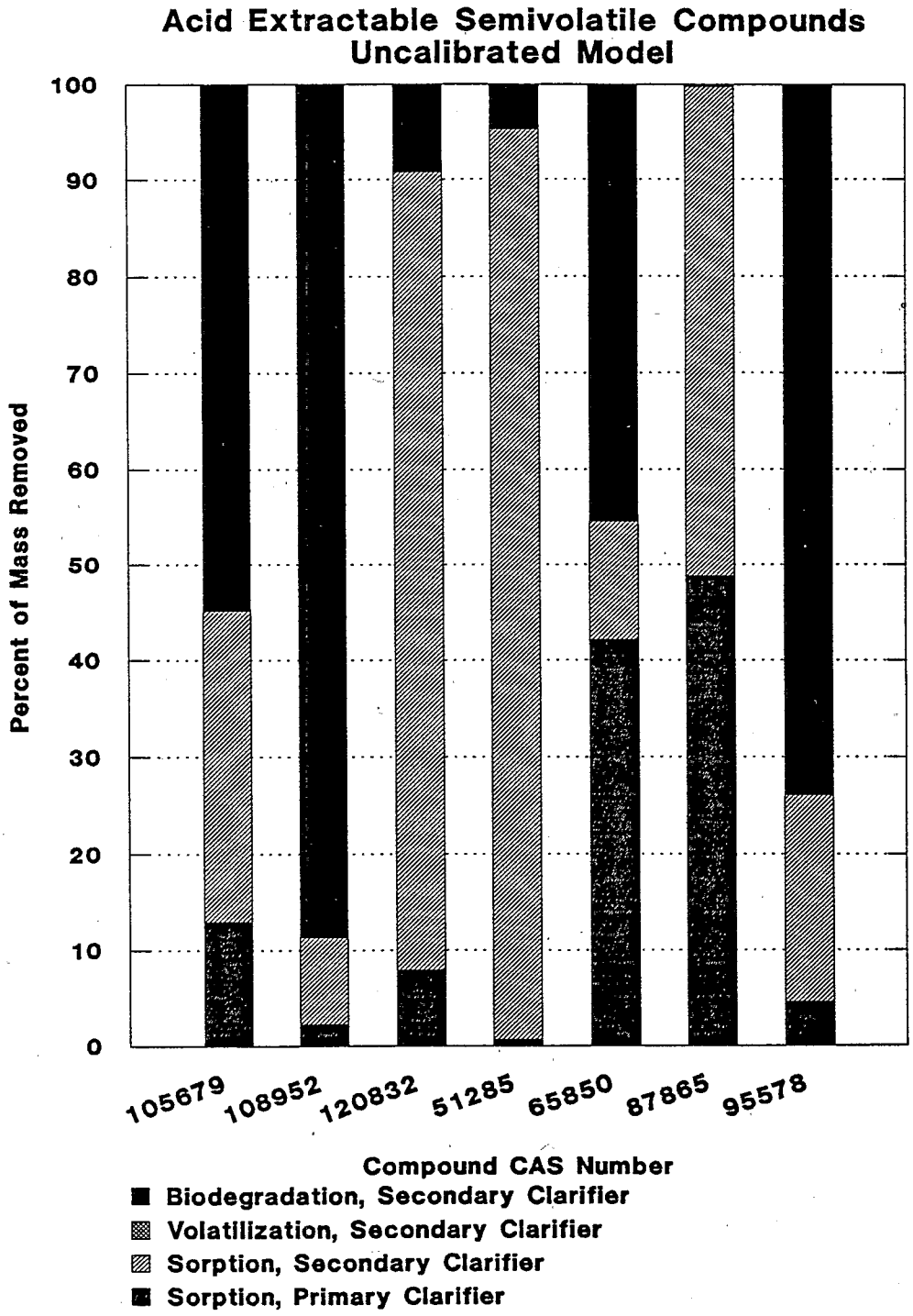


Figure B-36
Percent of Mass Removed by Each Mechanism

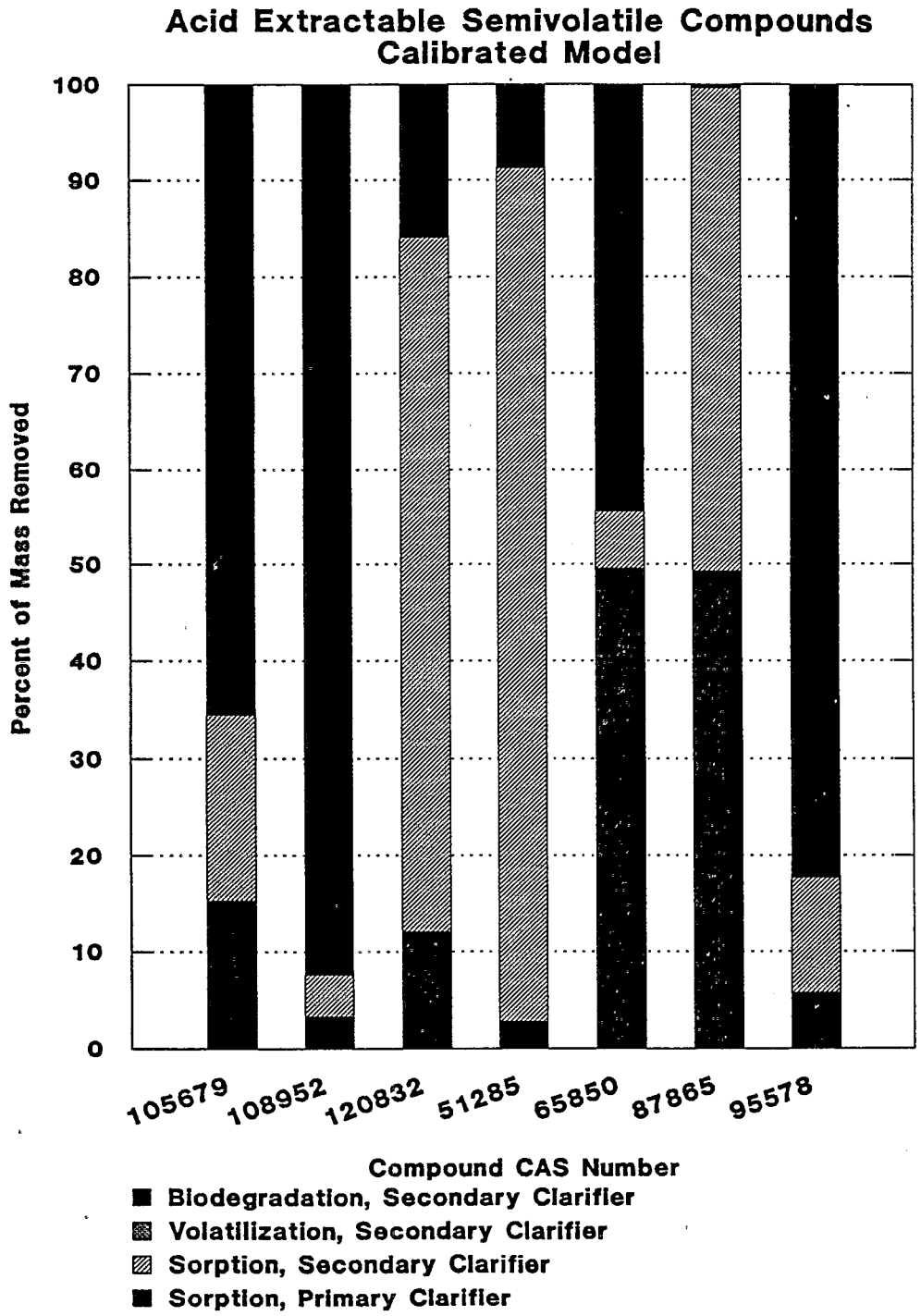


Figure B-37
Boxplots of FATE Residuals by Compound

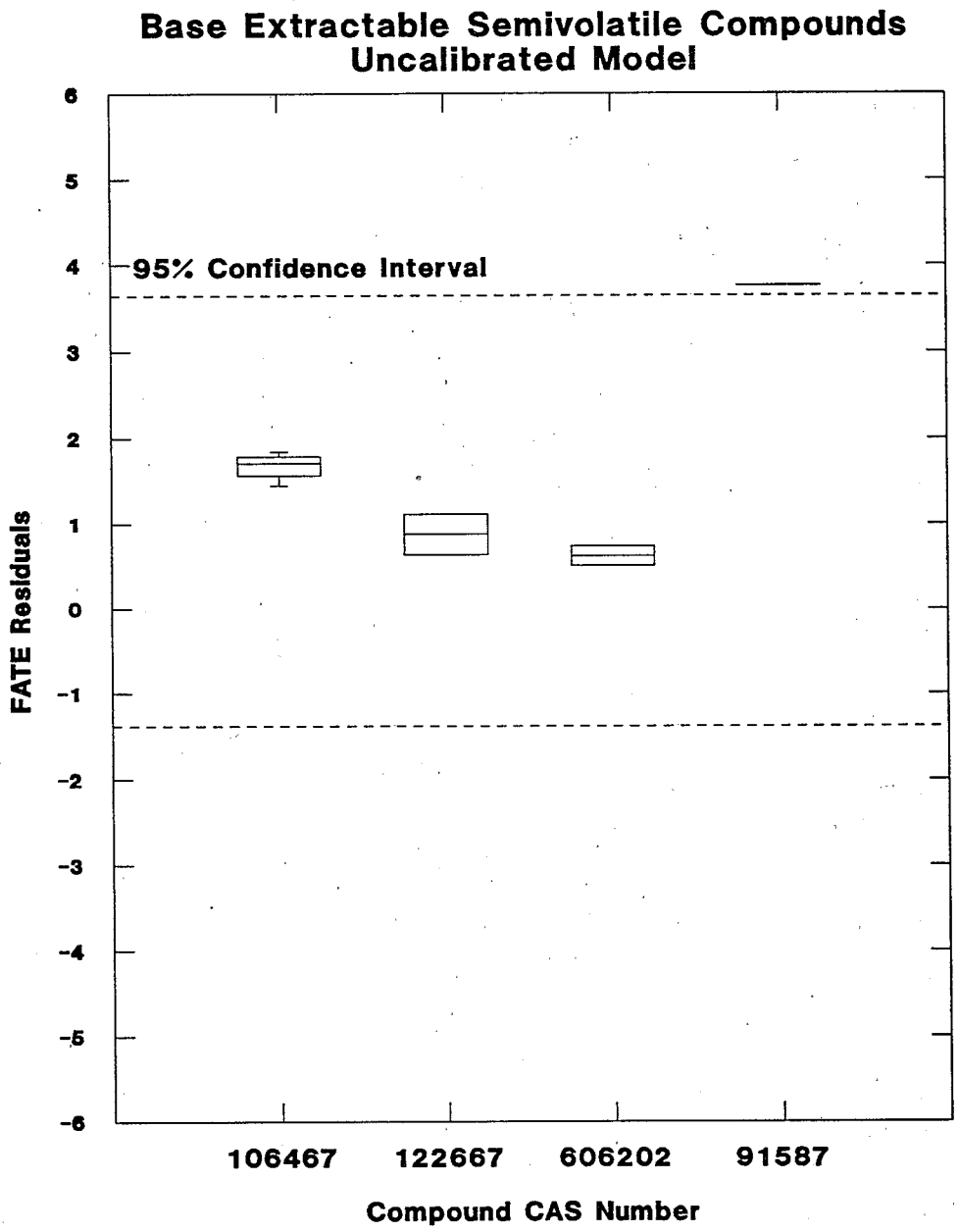


Figure B-38
Boxplots of FATE Residuals by Compound

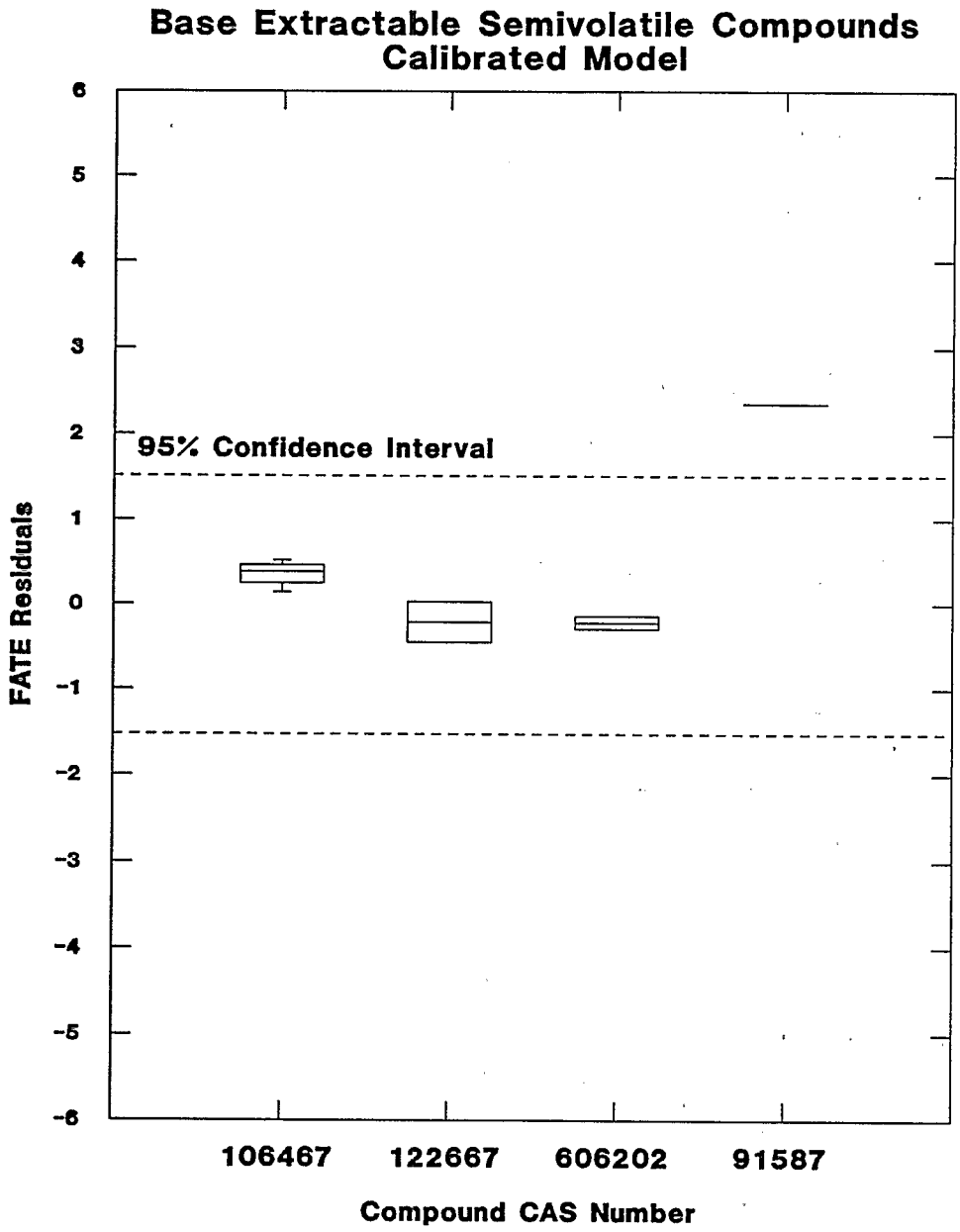


Figure B-39
Percent of Mass Removed by Each Mechanism

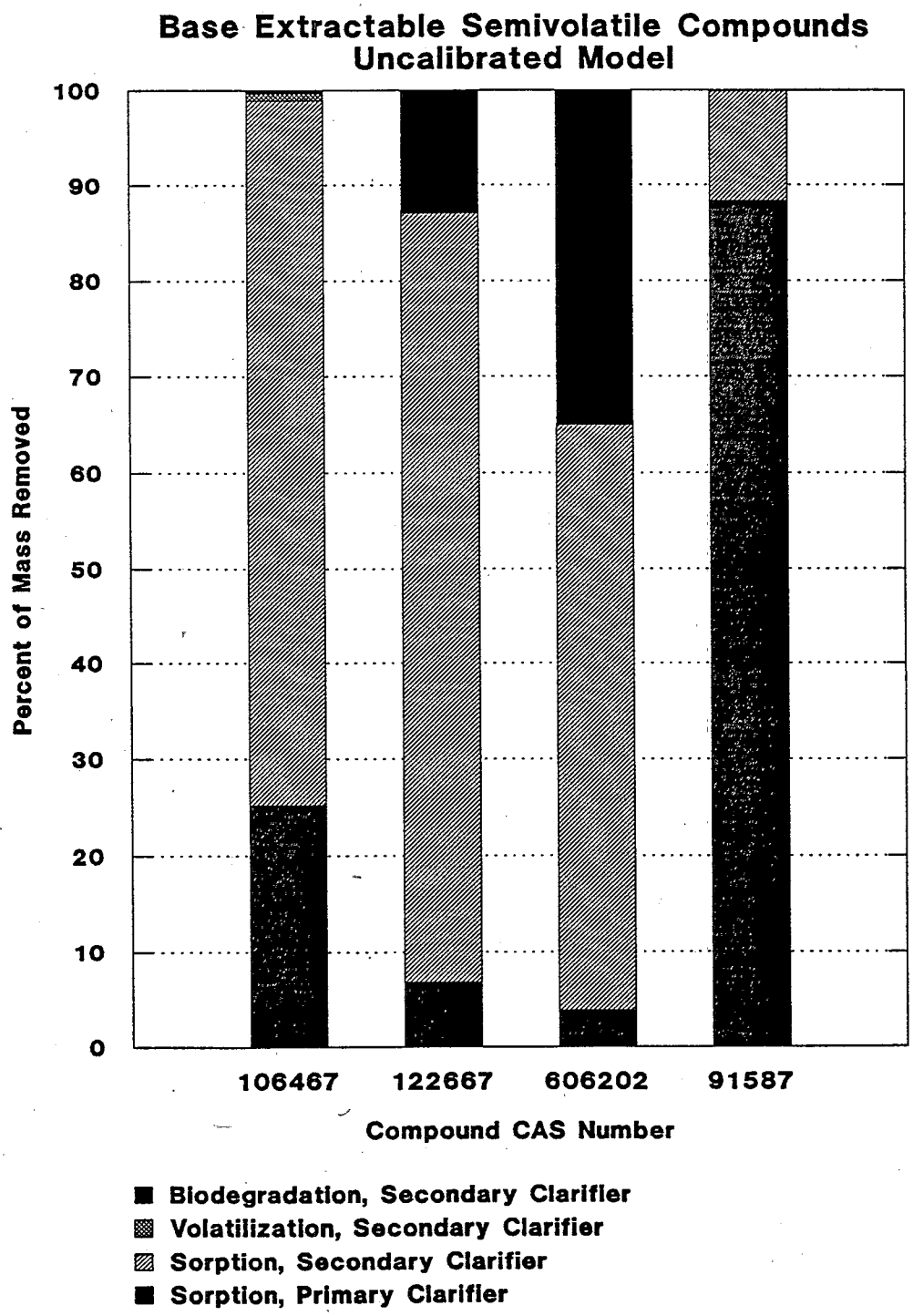
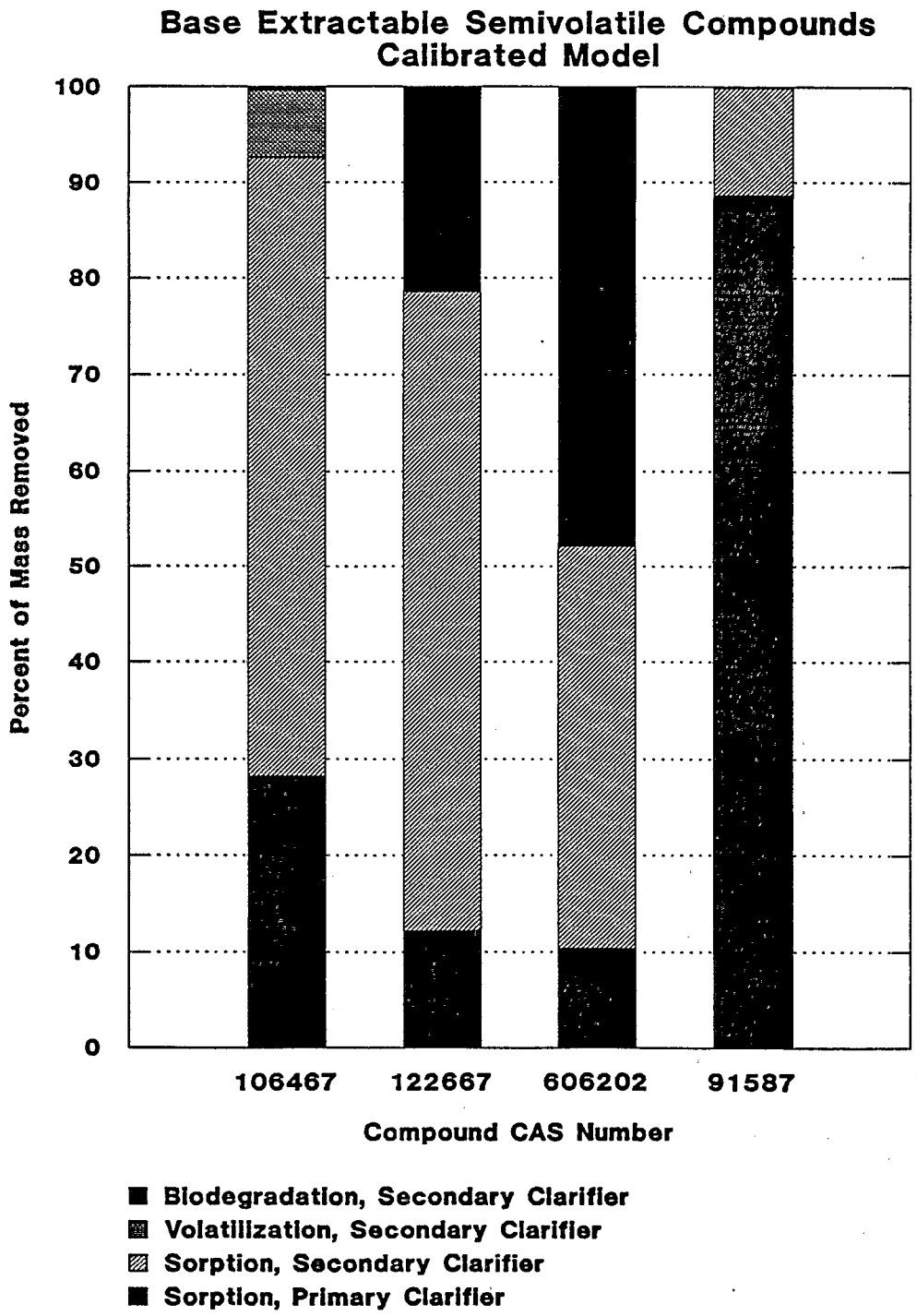


Figure B-40
Percent of Mass Removed by Each Mechanism



APPENDIX C

Inorganic/Organic Compound List

Fate And Treatability Estimator
for Conventional Activated Sludge
Publicly Owned Treatment Works

Version 2.00
06/18/90

ABB Environmental Services, Inc.
Portland, Maine

U. S. Environmental Protection Agency
Industrial Technology Division, Washington, DC

ORGANIC DATABASE LISTING

	Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
1,1,1,2-Tetrachloroethane	3.81E-4 (M)	3.04 (M)	-3.00 (E)	630206
1,1,1-Trichloroethane	1.44E-2 (M)	2.49 (M)	-3.00 (E)	71556
1,1,2,2-Tetrachloroethane	3.80E-4 (M)	2.39 (M)	-4.00 (E)	79345
1,1,2-Trichloroethane	1.17E-3 (M)	2.47 (M)	-3.00 (E)	79005
1,1-Dichloroethane	4.26E-3 (M)	1.79 (M)	-4.00 (E)	75343
1,1-Dichloroethene	3.40E-2 (M)	1.84 (M)	-2.30 (E)	75354
Isodrin (Stereoisomer of Aldrin)	0.00E0 (U)	0.00 (U)	-2.00 (E)	465736
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.00E0 (U)	0.00 (U)	-4.00 (E)	37871004
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.00E0 (U)	0.00 (U)	-4.00 (E)	1030
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.00E0 (U)	0.00 (U)	-4.00 (E)	57653857
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.00E0 (U)	0.00 (U)	-4.00 (E)	19408743
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.00E0 (U)	0.00 (U)	-4.00 (E)	40321764
1,2,3-Trichlorobenzene	4.77E-3 (E)	4.42 (E)	-3.00 (E)	87616
1,2,3-Trichloropropane	4.06E-4 (E)	2.01 (M)	-3.00 (E)	96184
1,2,3-Trimethoxybenzene	3.39E-7 (E)	2.62 (E)	-3.00 (E)	634366

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
1,2,4,5-Tetrachlorobenzene			95943
9.87E-3 (E)	4.67 (M)	-3.00 (E)	
1,2,4-Trichlorobenzene			120821
2.30E-3 (M)	4.28 (M)	-3.00 (E)	
1,2-Benzenedicarboxylic acid, dibutyl ester			84742
2.80E-7 (M)	5.60 (M)	-2.00 (E)	
1,2-Benzenedicarboxylic acid, dimethyl ester			131113
2.10E-7 (M)	2.12 (M)	-2.00 (E)	
1,2-Dibromoethane			106934
6.73E-4 (M)	1.76 (M)	-2.30 (E)	
1,2-Dichlorobenzene			95501
1.93E-3 (M)	3.60 (M)	-3.00 (E)	
1,2-Dichloroethane			107062
9.78E-4 (M)	1.53 (M)	-3.00 (E)	
1,2-Dichloropropane			78875
2.31E-3 (M)	2.00 (M)	-3.00 (E)	
1,2-Diphenylhydrazine			122667
3.42E-9 (M)	2.90 (M)	-2.00 (E)	
1,2-Ethanediamine, N,N-dimethyl-N'-2pyridinyl-N'-(2-			91805
0.00E0 (U)	0.00 (U)	-3.00 (E)	
1,2:3,4-Diepoxybutane			1464535
3.54E-8 (E)	-1.80 (U)	-2.30 (E)	
Mirex \ Dechlorane			2385855
0.00E0 (U)	0.00 (U)	-4.00 (E)	
Kepone			143500
0.00E0 (U)	2.00 (M)	-4.00 (E)	
1,3,5-Trithiane			291214
0.00E0 (U)	0.00 (U)	-2.30 (E)	
1,3-Benzenediamine, 4-methyl-			95807
1.28E-10 (M)	0.35 (M)	-2.00 (E)	
1,3-Benzodioxole, 5-(1-propenyl)-			120581
3.25E-12 (M)	2.66 (M)	-3.00 (E)	
1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-			77474
1.37E-2 (M)	5.04 (M)	-2.00 (E)	
1,3-Dichloro-2-propanol			96231
7.84E-7 (E)	1.04 (E)	-3.00 (E)	
1,3-Dichlorobenzene			541731
3.59E-3 (M)	3.56 (M)	-3.00 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
1,3-Dichloropropane 9.80E-4 (M)	1.97 (E)	-3.00 (E)	142289
1,3-Dinitrobenzene 1.95E-7 (E)	1.62 (M)	-4.00 (E)	99650
1,4-Dichlorobenzene 2.89E-3 (M)	3.60 (M)	-3.00 (E)	106467
1,4-Dioxane 1.07E-5 (M)	0.01 (M)	-4.00 (E)	123911
1,4-Naphthoquinone 2.31E-5 (U)	1.78 (M)	-2.30 (E)	130154
Dichlone \ Phygon 0.00E0 (U)	0.00 (U)	-3.00 (E)	117806
Endrin 5.00E-7 (M)	5.60 (M)	-2.00 (E)	72208
Aldrin 1.60E-5 (M)	5.30 (M)	-2.00 (E)	309002
1,5-Naphthalenediamine 0.00E0 (U)	0.00 (U)	-2.00 (E)	2243621
1-Bromo-2-chlorobenzene 0.00E0 (U)	0.00 (U)	-2.30 (E)	694804
1-Bromo-3-chlorobenzene 0.00E0 (U)	0.00 (U)	-2.30 (E)	108372
1-Chloro-3-nitrobenzene 0.00E0 (U)	2.44 (U)	-3.00 (E)	121733
1-Methylfluorene 0.00E0 (U)	0.00 (U)	-3.00 (E)	1730376
1-Methylphenanthrene 0.00E0 (U)	0.00 (U)	-3.00 (E)	832699
1-Naphthylamine 5.21E-9 (M)	2.07 (M)	-4.00 (E)	134327
1-Phenylnaphthalene 0.00E0 (U)	0.00 (U)	-3.00 (E)	605027
1-Propene, 3-chloro- 9.15E-3 (M)	1.71 (E)	-3.00 (E)	107051
17-alpha-19-Norpregna-1,3,5(10)-trien-20-yn-17-ol, 3- 0.00E0 (U)	0.00 (U)	-3.30 (E)	72333
2,3,4,6-Tetrachlorophenol 4.53E-6 (U)	4.10 (M)	-2.30 (E)	58902

	Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
2,3,6-Trichlorophenol	0.00E0 (U)	0.00 (U)	-2.00 (E)	933755
2,3-Benzofluorene	0.00E0 (U)	0.00 (U)	-2.30 (E)	243174
2,3-Dichloroaniline	0.00E0 (U)	0.00 (U)	-3.00 (E)	608275
2,3-Dichloronitrobenzene	0.00E0 (U)	0.00 (U)	-3.00 (E)	3209221
2,4,5-Trichlorophenol	2.18E-4 (M)	3.72 (M)	-2.00 (E)	95954
2,4,5-T \ Weedone \ Acetic acid, 2,4,5-trichlorophenoxy-	7.80E-9 (U)	2.34 (U)	-2.00 (E)	93765
2,4,6-Trichlorophenol	4.00E-6 (M)	3.87 (M)	-2.00 (E)	88062
2,4-Dichlorophenol	2.75E-6 (M)	2.90 (M)	-2.00 (E)	120832
2,4-D \ Acetic acid, (2,4-dichlorophenoxy)-	1.88E-4 (M)	2.81 (M)	-1.00 (E)	94757
2,4-Dimethylphenol	2.52E-6 (M)	2.50 (M)	-1.00 (E)	105679
2,4-Dinitrophenol	6.45E-10 (M)	1.53 (M)	-3.00 (E)	51285
2,4-Dinitrotoluene	5.09E-6 (M)	2.01 (M)	-2.00 (E)	121142
Heptachlor epoxide	4.39E-4 (M)	2.70 (M)	-4.00 (E)	1024573
2,6-Dichlorophenol	4.80E-6 (U)	0.00 (U)	-3.00 (E)	87650
2,6-Dinitrotoluene	3.27E-6 (M)	2.05 (M)	-2.00 (E)	606202
2,6-di-tert-Butyl-p-benzoquinone	0.00E0 (U)	0.00 (U)	-2.30 (E)	719222
2,6-dichloro-4-nitroaniline	6.54E-3 (U)	0.00 (U)	-4.00 (E)	99309
2,7-Dimethylphenanthrene	0.00E0 (U)	0.00 (U)	-2.30 (E)	1576698
Dieldrin	4.58E-7 (M)	3.50 (M)	-2.30 (E)	60571

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
2-(Methylthio)benzothiazole			615225
0.00E0 (U)	0.00 (U)	-2.00 (E)	
2-Butanone			78933
2.74E-5 (M)	0.26 (M)	-1.00 (E)	
2-Butenal			4170303
1.40E-5 (M)	1.08 (E)	-2.30 (E)	
2-Butene, 1,4-dichloro (mixture of cis and trans)			764410
1.15E-4 (E)	2.04 (E)	-3.00 (E)	
2-Chloro-1,3-butadiene			126998
1.19E-2 (E)	2.06 (E)	-3.00 (E)	
Alachlor \ Metachlor \ Lasso			15972608
3.40E-7 (U)	2.32 (U)	-3.30 (E)	
2-Chloroethylvinyl ether			110758
2.16E-5 (M)	1.28 (M)	-4.00 (E)	
2-Chloronaphthalene			91587
3.15E-4 (M)	4.12 (M)	-2.30 (E)	
2-Chlorophenol			95578
4.70E-6 (M)	2.17 (M)	-1.00 (E)	
2-Hexanone			591786
1.24E-5 (M)	1.38 (M)	-2.00 (E)	
2-Isopropylnaphthalene			2027170
0.00E0 (U)	0.00 (U)	-2.30 (E)	
2-Methylbenzothioazole			120752
0.00E0 (U)	0.00 (U)	-2.30 (E)	
2-Methylnaphthalene			91576
4.14E-4 (E)	3.86 (M)	-2.30 (E)	
2-Nitroaniline			88744
6.28E-9 (E)	1.83 (E)	-4.00 (E)	
2-Nitrophenol			88755
1.44E-5 (M)	1.76 (M)	-2.00 (E)	
2-Phenylnaphthalene			612942
0.00E0 (U)	0.00 (U)	-3.00 (E)	
2-Picoline			109068
2.40E-5 (M)	1.20 (M)	-2.30 (E)	
2-Propanone			67641
6.80E-6 (M)	-0.24 (M)	-1.30 (E)	
2-Propen-1-ol			107186
3.69E-6 (M)	-0.22 (M)	-2.30 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
2-Propenal			107028
6.79E-5 (M)	-0.10 (M)	-2.30 (E)	
2-Propenenitrile			107131
8.84E-5 (M)	0.25 (M)	-2.30 (E)	
2-Propenenitrile, 2-methyl-			126987
3.92E-1 (U)	0.00 (U)	-3.00 (E)	
3,3'-Dichloro-4,4'-diaminodiphenyl ether			2843486
0.00E0 (U)	0.00 (U)	-4.00 (E)	
3,3'-Dichlorobenzidine			91941
8.33E-7 (M)	3.50 (M)	-3.00 (E)	
3,6-Dimethylphenanthrene			1576676
0.00E0 (U)	0.00 (U)	-2.30 (E)	
3-Nitroaniline			99092
1.54E-9 (E)	1.83 (M)	-4.00 (E)	
4,4'-DDD/Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-			72548
7.96E-6 (M)	6.20 (M)	-2.30 (E)	
4,4'-DDE/Benzene, 1,1'-(dichloroethenlyidine)bis[4-chloro			72559
6.80E-5 (M)	7.00 (M)	-2.30 (E)	
4,4'-DDT/Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro			50293
5.13E-4 (M)	6.19 (M)	-2.30 (E)	
4,4'-Methylenebis(2-chloroaniline)			101144
4.06E-11 (E)	3.94 (E)	-4.00 (E)	
4,5-dimethyl phenanthrene			203645
0.00E0 (U)	0.00 (U)	-2.30 (E)	
Chlordane			57749
9.63E-6 (M)	3.32 (M)	-4.00 (E)	
Heptachlor			76448
8.19E-4 (M)	4.40 (M)	-4.00 (E)	
4-Bromophenyl phenyl ether			101553
0.00E0 (U)	4.28 (M)	-4.00 (E)	
4-Chloro-2-nitroaniline			89634
0.00E0 (U)	0.00 (U)	-4.00 (E)	
4-Chloro-3-methylphenol			59507
2.50E-6 (M)	3.13 (M)	-1.00 (E)	
4-Chlorophenylphenyl ether			7005723
1.02E-2 (U)	4.08 (M)	-4.00 (E)	
Captafol \ Difolatan			2425061
0.00E0 (U)	0.00 (U)	-2.00 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Captan			133062
4.70E-5 (M)	2.35 (M)	-2.00 (E)	
4-Methyl-2-pentanone			108101
1.17E-4 (M)	1.62 (E)	-3.00 (E)	
4-Nitrophenol			100027
3.31E-8 (M)	1.91 (M)	-2.00 (E)	
5-Nitro-o-toluidine			99558
7.61E-3 (U)	0.00 (U)	-4.00 (E)	
7,12-Dimethylbenz(a)anthracene			57976
2.73E-10 (U)	6.94 (M)	-3.00 (E)	
Acenaphthene			83329
9.20E-5 (M)	4.33 (M)	-2.00 (E)	
Acenaphthylene			208968
1.48E-3 (M)	3.70 (M)	-2.00 (E)	
Acetamide, N-(4-ethoxyphenyl)-			62442
2.23E-7 (U)	0.00 (U)	-3.00 (E)	
Ammonium, (4-(p-(dimethylamino)-alpha-phenylbenzyli			569642
0.00E0 (U)	0.00 (U)	-3.00 (E)	
Aniline, 2,4,5-trimethyl-			137177
4.06E-6 (E)	3.39 (E)	-2.00 (E)	
Anthracene			120127
1.02E-3 (M)	4.45 (M)	-3.00 (E)	
Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-			56495
1.34E-4 (U)	7.11 (U)	-2.30 (E)	
Pronamide \ Kerb			23950585
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Benzanthrone			82053
0.00E0 (U)	0.00 (U)	-2.30 (E)	
Benzenamine			62533
1.10E-6 (M)	0.98 (M)	-1.30 (E)	
Benzenamine, 4-chloro-			106478
6.55E-7 (E)	1.83 (M)	-3.00 (E)	
Benzenamine, N,N-dimethyl-4-(pehnylazo)-			60117
7.19E-9 (M)	3.72 (M)	-4.00 (E)	
Benzene			71432
5.50E-3 (M)	2.13 (M)	-2.00 (E)	
Methoxychlor			72435
1.58E-5 (E)	4.83 (M)	-2.30 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Chlorobenzilate \ Ethyl-4,4'-dichlorobenzilate			510156
7.24E-8 (E)	4.36 (E)	-2.00 (E)	
Benzenethiol			108985
0.00E0 (U)	2.52 (M)	-3.00 (E)	
Benzidine			92875
3.03E-7 (M)	1.30 (M)	-3.00 (E)	
Benzo(a)anthracene			56553
1.16E-6 (M)	5.61 (M)	-3.00 (E)	
Benzo(a)pyrene			50328
1.55E-6 (M)	6.04 (M)	-2.30 (E)	
Benzo(b)fluoranthene			205992
1.19E-5 (M)	6.06 (M)	-2.30 (E)	
Benzo(ghi)perylene			191242
5.34E-8 (M)	6.51 (M)	-2.30 (E)	
Benzo(k)fluoranthene			207089
3.94E-5 (M)	6.06 (M)	-2.30 (E)	
Benzoic acid			65850
1.82E-8 (M)	1.19 (E)	-1.00 (E)	
Benzonitrile, 3,5-dibromo-4-hydroxy-			1689845
0.00E0 (U)	0.00 (U)	-3.00 (E)	
Benzyl alcohol			100516
6.10E-7 (M)	1.10 (M)	-2.00 (E)	
Biphenyl			92524
1.01E-1 (M)	4.04 (M)	-2.30 (E)	
Biphenyl, 4-nitro			92933
3.54E-6 (E)	3.77 (E)	-3.00 (E)	
Bromodichloromethane			75274
2.12E-3 (M)	1.88 (M)	-3.30 (E)	
Bromomethane			74839
1.06E-1 (M)	1.10 (M)	-3.00 (E)	
Butyl benzyl phthalate			85687
1.00E-6 (M)	4.80 (M)	-1.00 (E)	
Ethylenebisdithiocarbamic acid, salts and esters			111546
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Diallate \ Avadex			2303164
1.65E-4 (M)	0.73 (M)	-2.00 (E)	
Carbazole			86748
4.40E-4 (U)	3.29 (M)	-3.00 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Carbon disulfide			75150
1.20E-2 (M)	2.00 (M)	-2.00 (E)	
Chloroacetonitrile			107142
0.00E0 (U)	0.00 (U)	-3.00 (E)	
Chlorobenzene			108907
3.72E-3 (M)	2.84 (M)	-2.00 (E)	
Chloroethane			75003
1.48E-2 (M)	1.54 (M)	-3.00 (E)	
Chloroform			67663
3.39E-3 (M)	1.97 (M)	-3.00 (E)	
Chloromethane			74873
4.40E-2 (M)	0.95 (M)	-3.00 (E)	
Chloropicrin			76062
0.00E0 (U)	2.44 (U)	-3.00 (E)	
Chrysene			218019
1.05E-6 (M)	5.61 (M)	-2.30 (E)	
Coumaphos \ Co-Ral			56724
3.20E-8 (M)	0.00 (U)	-2.30 (E)	
Crotoxyphos \ Ciodrin			7700176
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Mevinphos \ Phosdrin			7786347
0.00E0 (U)	0.54 (U)	-2.00 (E)	
Lindane \ gamma-BHC \ Hexachlorocyclohexane (gamma)			58899
7.85E-6 (M)	3.90 (M)	-2.00 (E)	
alpha-BHC			319846
5.87E-6 (M)	3.90 (M)	-2.00 (E)	
delta-BHC			319868
2.07E-7 (M)	4.10 (M)	-2.00 (E)	
beta-BHC			319857
4.47E-7 (M)	3.90 (M)	-2.00 (E)	
Di-n-octyl phthalate			117840
3.00E-7 (M)	9.20 (M)	-2.00 (E)	
Di-n-propylnitrosamine			621647
6.92E-6 (M)	1.50 (M)	-4.00 (E)	
Dibenzo(a,h)anthracene			53703
7.33E-8 (M)	6.80 (M)	-3.00 (E)	
Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-			1746016
3.60E-3 (M)	6.72 (M)	-4.00 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Dibenzofuran			132649
1.26E-5 (E)	4.31 (M)	-2.30 (E)	
Dibenzothiophene			132650
0.00E0 (U)	0.00 (U)	-2.30 (E)	
Dibromochloromethane			124481
0.78E-3 (M)	2.09 (M)	-3.00 (E)	
Dibromomethane			74953
9.98E-4 (M)	1.53 (E)	-3.00 (E)	
Dichloroiodomethane			0015
0.00E0 (U)	0.00 (U)	-3.30 (E)	
Diethyl ether			60297
1.72E-3 (E)	0.89 (M)	-4.00 (E)	
Diethyl phthalate			84662
1.14E-6 (M)	2.50 (M)	-1.00 (E)	
Dimethyl sulfone			67710
0.00E0 (U)	0.00 (U)	-3.00 (E)	
Diphenyl ether			101848
2.24E-3 (M)	4.20 (M)	-4.00 (E)	
Diphenylamine			122394
1.47E-7 (M)	3.60 (M)	-3.30 (E)	
Diphenyldisulfide			882337
0.00E0 (U)	0.00 (U)	-3.00 (E)	
6,9-Methano-2,3,4-benzodioxathiepin, 6,7			1031078
0.00E0 (U)	3.66 (M)	-4.00 (E)	
Thiodan I			959988
0.00E0 (U)	3.55 (M)	-3.30 (E)	
Thiodan II			33213659
0.00E0 (U)	3.62 (E)	-3.30 (E)	
Endrin aldehyde			7421934
0.00E0 (U)	5.60 (E)	-2.00 (E)	
Endrine ketone			53494705
0.00E0 (U)	0.00 (U)	-3.00 (E)	
Ethane, pentachloro-			76017
2.17E-3 (M)	3.67 (M)	-3.00 (E)	
Ethanethioamide			62555
0.00E0 (U)	-0.46 (M)	-3.00 (E)	
Ethanone, 1-phenyl			98862
3.30E-7 (M)	1.58 (M)	-2.30 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Nitrofen \ TOK 0.00E0 (U)	0.00 (U)	-4.00 (E)	1836755
Ethyl cyanide 3.12E-5 (E)	0.87 (E)	-2.30 (E)	107120
Ethyl methacrylate 0.00E0 (U)	0.00 (U)	-2.30 (E)	97632
Ethylbenzene 6.44E-3 (M)	3.15 (M)	-1.30 (E)	100414
Nabam 0.00E0 (U)	1.92 (M)	-2.00 (E)	142596
Maneb \ Vancide 0.00E0 (U)	0.00 (U)	-2.00 (E)	12427382
Zineb \ Dithane Z 0.00E0 (U)	0.00 (U)	-2.00 (E)	12122677
Ethylenethiourea 3.08E-10 (E)	-0.66 (M)	-3.00 (E)	96457
Fluoranthene 6.46E-6 (M)	4.90 (M)	-2.30 (E)	206440
Fluorene 6.42E-5 (M)	4.18 (M)	-2.00 (E)	86737
Hexachlorobenzene 6.81E-4 (M)	5.23 (M)	-3.00 (E)	118741
Hexachlorobutadiene 1.03E-2 (M)	4.78 (M)	-3.00 (E)	87683
Hexachlorodibenzo-p-dioxins 0.00E0 (U)	0.00 (U)	-4.00 (E)	1200
Hexachlorodibenzofurans 0.00E0 (U)	0.00 (U)	-4.00 (E)	1201
Hexachloroethane 2.49E-3 (M)	4.62 (M)	-3.00 (E)	67721
Hexachloropropene 0.00E0 (U)	0.00 (U)	-3.00 (E)	1888717
Hexanoic acid 1.04E-6 (E)	1.90 (M)	-2.00 (E)	142621
Indeno(1,2,3-cd)pyrene 6.86E-8 (M)	6.50 (M)	-2.30 (E)	193395
Iodomethane 5.34E-3 (M)	1.69 (M)	-3.00 (E)	74884

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Isobutyl alcohol			78831
1.03E-5 (M)	0.61 (M)	-1.00 (E)	
Isophorone			78591
5.80E-6 (M)	1.70 (M)	-2.00 (E)	
Longifolene			475207
0.00E0 (U)	0.00 (U)	-3.00 (E)	
Methanesulfonic acid, ethyl ester			62500
9.12E-8 (M)	0.21 (M)	-2.00 (E)	
Methyl methacrylate			80626
2.43E-1 (M)	0.79 (M)	-2.00 (E)	
Methyl methanesulfonate			66273
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Methylene chloride			75092
2.03E-3 (M)	1.30 (M)	-2.00 (E)	
N,N-Dimethylformamide			68122
3.55E-7 (E)	-1.01 (M)	-1.30 (E)	
N-Nitrosodi-n-butylamine			924163
5.21E-6 (E)	1.92 (M)	-4.00 (E)	
N-Nitrosodiethylamine			55185
1.20E-6 (E)	0.48 (M)	-4.00 (E)	
N-Nitrosodimethylamine			62759
7.90E-7 (M)	0.68 (M)	-4.00 (E)	
N-Nitrosodiphenylamine			86306
5.00E-6 (E)	2.57 (M)	-4.00 (E)	
N-Nitrosomethylethylamine			10595956
0.00E0 (U)	0.00 (U)	-4.00 (E)	
N-Nitrosomethylphenylamine			614006
0.00E0 (U)	0.00 (U)	-4.00 (E)	
N-Nitrosomorpholine			59892
4.18E-8 (E)	-4.40 (M)	-3.00 (E)	
N-Nitrosopiperidine			100754
1.11E-8 (M)	-0.49 (M)	-3.00 (E)	
Naphthalene			91203
4.80E-4 (M)	3.34 (M)	-2.00 (E)	
Nitrobenzene			98953
1.30E-5 (M)	1.85 (M)	-2.00 (E)	
Phosphorodithioic acid, O,O,S-triethyl ester			126681
0.00E0 (U)	0.00 (U)	-2.00 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Phosphorodithioic acid, O,O-diethyl S-methyl ester			3288582
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Zinophos \ Thionazin			297972
0.00E0 (U)	0.00 (U)	-2.30 (E)	
PCB-1016			12674112
1.80E-4 (M)	4.38 (M)	-3.30 (E)	
PCB-1221			11104282
3.24E-4 (M)	4.08 (M)	-3.30 (E)	
PCB-1232			11141165
8.64E-4 (M)	4.54 (M)	-3.30 (E)	
PCB-1242			53469219
5.70E-4 (M)	4.11 (M)	-3.30 (E)	
PCB-1248			12672296
3.50E-3 (M)	5.60 (M)	-3.30 (E)	
PCB-1254			11097691
2.80E-3 (M)	6.04 (M)	-3.30 (E)	
PCB-1260			11096825
7.10E-3 (M)	7.15 (M)	-3.30 (E)	
Pentachlorobenzene			608935
7.30E-3 (M)	5.19 (M)	-3.00 (E)	
Pentachlorodibenzo-p-dioxins			1289
0.00E0 (U)	0.00 (U)	-4.00 (E)	
Pentachlorodibenzofurans			1290
0.00E0 (U)	0.00 (U)	-4.00 (E)	
PCNB \ Terraclor \ Quintozene			82688
6.18E-4 (M)	5.45 (M)	-3.30 (E)	
Pentachlorophenol			87865
2.80E-6 (M)	5.04 (M)	-2.00 (E)	
Pentamethylbenzene			700129
0.00E0 (U)	0.00 (U)	-4.00 (E)	
Perylene			198550
0.00E0 (U)	6.50 (M)	-2.30 (E)	
Phenanthrene			85018
1.59E-4 (M)	4.46 (M)	-2.30 (E)	
Phenol			108952
4.54E-7 (M)	1.48 (M)	-1.00 (E)	
DNBP \ Dinoseb \ 2-sec-butyl-4,6-dinitrophenol			88857
1.20E-3 (M)	2.09 (M)	-3.00 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Dinex \ DN-111 \ 2-Cyclohexyl-4,6-dinitrophenol			131895
0.00E0 (U)	0.00 (U)	-3.00 (E)	
Phenol, 2-methyl-4,6-dinitro-			534521
4.49E-5 (M)	2.70 (M)	-2.00 (E)	
Phenothiazine			92842
1.99E-2 (U)	0.00 (U)	-2.30 (E)	
Phosacetin			4104147
0.00E0 (U)	0.00 (U)	-2.30 (E)	
Trichlorofon \ Dylox			52686
1.71E-11 (M)	2.29 (M)	-2.00 (E)	
Naled \ Dibrom			300765
0.00E0 (U)	1.38 (U)	-2.00 (E)	
Dichlorvos \ DDVP			62737
3.50E-7 (M)	1.47 (M)	-2.00 (E)	
Tetrachlorvinphos \ Gardona			961115
1.84E-9 (E)	3.53 (M)	-2.00 (E)	
Chlorfenvinphos \ Supona			470906
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Dicrotophos \ Bidrin			141662
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Monocrotophos \ Azodrin			6923224
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Phosphamidon \ Dimecron			13171216
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Tricresylphosphate \ TCP \ TOCP			78308
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Trimethylphosphate			512561
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Hexamethylphosphoramide \ HMPA			680319
1.51E-8 (E)	0.03 (M)	-2.30 (E)	
Demeton \ Systox			8065483
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Diazinon \ Spectracide			333415
1.40E-6 (M)	2.76 (U)	-2.00 (E)	
Chlorpyrifos \ Dursban			2921882
4.10E-6 (M)	5.11 (M)	-2.00 (E)	
Fensulfothion \ Desanit			115902
0.00E0 (U)	0.00 (U)	-2.00 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Phorate \ Thimet			298022
4.37E-7 (U)	-2.49 (U)	-2.00 (E)	
Disulfoton			298044
2.50E-6 (M)	3.26 (U)	-2.00 (E)	
Azinphos-ethyl \ Ethyl Guthion			2642719
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Terbufos \ Counter			13071799
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Azinphos-methyl \ Guthion			86500
3.80E-6 (M)	0.00 (U)	-2.00 (E)	
Phosmet \ Imidan			732116
0.00E0 (U)	2.83 (M)	-2.00 (E)	
Cygon \ Dimethoate			60515
9.17E-7 (U)	2.71 (M)	-2.00 (E)	
Fenthion \ Baytex			55389
2.00E-7 (U)	2.68 (U)	-2.00 (E)	
Ethion \ Bladan			563122
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Dioxathion			78342
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Carbophenothion \ Trithion			786196
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Parathion \ Parathion, ethyl			56382
6.10E-7 (M)	3.81 (M)	-2.00 (E)	
Methyl parathion \ Parathion-methyl \ Metaphos			298000
5.59E-8 (M)	1.91 (M)	-2.00 (E)	
Famphur \ Famophos			52857
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Leptophos \ Phosvel			21609905
2.66E-6 (U)	6.31 (M)	-2.00 (E)	
EPN \ Santox			2104645
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Busan 85			128030
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Carbamic acid, methyldithio-, monopotassium salt			137417
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Propane, 1,2-dibromo-3-chloro-			96128
3.11E-4 (M)	2.29 (M)	-3.00 (E)	

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
2,4,5-TP \ Silvex			93721
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Pyrene			129000
5.04E-6 (M)	4.88 (M)	-2.30 (E)	
Pyridine			110861
7.00E-9 (M)	0.66 (M)	-2.00 (E)	
Resorcinol			108463
1.00E-13 (M)	0.80 (M)	-1.00 (E)	
Safrole			94597
1.29E-7 (M)	2.53 (M)	-2.30 (E)	
Carbamic acid, dimethyldithio-, sodium salt			128041
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Squalene			7683649
0.00E0 (U)	0.00 (U)	-3.00 (E)	
Styrene			100425
9.70E-3 (M)	2.95 (M)	-2.30 (E)	
Malathion \ Sumitox			121755
3.75E-7 (E)	2.89 (M)	-2.00 (E)	
Sulfurous acid, 2-chloroethyl-, 2-[4-(1,1-dimethylethyl)			140578
0.00E0 (U)	0.00 (U)	-3.00 (E)	
Tetrachlorodibenzo-p-dioxins			1331
0.00E0 (U)	6.20 (M)	-4.00 (E)	
Tetrachlorodibenzofurans			1332
0.00E0 (U)	0.00 (U)	-4.00 (E)	
Tetrachloroethene			127184
2.59E-2 (M)	2.60 (M)	-3.00 (E)	
Tetrachloromethane			56235
2.41E-2 (M)	2.64 (M)	-3.00 (E)	
TEPP \ Phosphoric acid, tetraethyl ester			107493
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Thianaphthene			95158
0.00E0 (U)	3.10 (U)	-2.30 (E)	
Thiram \ Thiuram \ Arasan			137268
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Sulfotepp \ Bladafum \ Tetraethyldithiopyrophosphate			3689245
0.00E0 (U)	0.00 (U)	-2.00 (E)	
Thioxanthe-9-one			492228
0.00E0 (U)	0.00 (U)	-3.00 (E)	

	Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
Toluene	6.70E-3 (M)	2.73 (M)	-1.30 (E)	108883
Total xylenes	5.10E-3 (M)	3.55 (M)	-2.30 (E)	1330207
Camphechlor	4.89E-3 (M)	3.30 (M)	-3.30 (E)	8001352
Tribromomethane	5.52E-4 (M)	2.40 (M)	-3.00 (E)	75252
Trichloroethene	9.10E-3 (M)	2.38 (M)	-3.00 (E)	79016
Trichlorofluoromethane	5.80E-2 (M)	2.53 (M)	-3.00 (E)	75694
Triphenylene	0.00E0 (U)	0.00 (U)	-2.30 (E)	217594
Tripropyleneglycol methyl ether	0.00E0 (U)	0.00 (U)	-3.00 (E)	20324338
Vinyl acetate	6.20E-4 (M)	0.73 (M)	-2.00 (E)	108054
Vinyl chloride	8.19E-2 (M)	1.38 (M)	-3.00 (E)	75014
Ziram \ Cymate	0.00E0 (U)	0.00 (U)	-2.00 (E)	137304
[1,1'-Biphenyl]-4-amine	1.59E-8 (M)	2.78 (M)	-2.00 (E)	92671
alpha-Terpineol	1.35E-5 (E)	2.90 (E)	-2.30 (E)	98555
beta-Naphthylamine	8.23E-8 (M)	2.07 (M)	-4.00 (E)	91598
bis(2-Chloroethoxy)methane	2.70E-7 (M)	1.26 (M)	-4.00 (E)	111911
bis(2-Chloroethyl) ether	1.30E-5 (M)	1.46 (M)	-4.00 (E)	111444
bis(2-Chloroisopropyl) ether	1.13E-4 (M)	2.10 (M)	-4.00 (E)	108601
bis(2-Ethylhexyl) phthalate	3.00E-7 (M)	8.70 (M)	-2.00 (E)	117817
cis-1,3-Dichloropropene	3.55E-3 (M)	1.98 (M)	-3.00 (E)	10061015

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
m-Cresol 1.09E-7 (E)	1.96 (M)	-1.00 (E)	108394
n-Decane 7.68E-2 (E)	4.46 (E)	-2.30 (E)	124185
n-Docosane 0.00E0 (U)	9.68 (E)	-2.30 (E)	629970
n-Dodecane 8.27E-2 (E)	5.33 (E)	-2.30 (E)	112403
n-Eicosane 0.00E0 (U)	8.81 (E)	-2.30 (E)	112958
n-Hexacosane 0.00E0 (U)	0.00 (U)	-2.00 (E)	630013
n-Hexadecane 9.90E-2 (E)	7.07 (E)	-2.30 (E)	544763
n-Octacosane 0.00E0 (U)	12.29 (E)	-2.00 (E)	630024
n-Octadecane 1.38E-1 (E)	7.94 (E)	-2.30 (E)	593453
n-Tetracosane 0.00E0 (U)	10.55 (E)	-2.00 (E)	646311
n-Tetradecane 7.12E-2 (E)	6.20 (E)	-2.30 (E)	629594
n-Triacontane 0.00E0 (U)	0.00 (U)	-2.00 (E)	638686
o + p xylene 5.26E-3 (M)	3.13 (U)	-2.30 (E)	1952
o,p'-DDT 0.00E0 (U)	6.19 (M)	-2.30 (E)	789026
o-Anisidine 1.38E-6 (E)	0.95 (M)	-2.30 (E)	90040
o-Cresol 1.20E-6 (M)	1.95 (M)	-1.00 (E)	95487
o-Toluidine 2.72E-6 (E)	1.32 (M)	-3.00 (E)	95534
o-Toluidine, 5-chloro- 0.00E0 (U)	0.00 (U)	-3.00 (E)	95794
p-Cresol 7.78E-7 (M)	1.94 (M)	-1.00 (E)	106445

Henry's Law Constant atm-m3/mole	log octanol/water partition coefficient m3h20/m3octanol	biodegradation rate constant m3/gVSS.d	CASNO
p-Cymene			
0.00E0 (U)	4.10 (M)	-2.00 (E)	99876
p-Nitroaniline			
1.00E-6 (M)	1.39 (M)	-4.00 (E)	100016
Trifluralin \ Treflan			
2.64E-5 (E)	5.38 (M)	-3.00 (E)	1582098
trans-1,2-Dichloroethene			
6.60E-3 (M)	0.48 (M)	-3.00 (E)	156605
trans-1,3-Dichloropropene			
3.55E-3 (M)	1.98 (M)	-3.00 (E)	10061026
trans-1,4-Dichloro-2-butene			
2.65E-4 (E)	2.38 (E)	-3.00 (E)	110576
1,1'-Biphenyl-4,4'-diamine, 3,3'-dimethoxy			
1.00E-11 (M)	1.46 (M)	-3.00 (E)	119904

NOTES:

1. Compound parameters are categorized by their source. Qualifiers are:
   M - a measured value taken from the literature
   E - a value estimated using an accepted method
   U - The value is unavailable an must be supplied by the user.
   S - Biodegradation rate constant has been simulated.
2. Choose <PRINT> <ASSUMPTIONS> from Main Menu for list of model assumption

Fate And Treatability Estimator
for Conventional Activated Sludge
Publicly Owned Treatment Works

Version 2.00
06/18/90

ABB Environmental Services, Inc.
Portland, Maine

U. S. Environmental Protection Agency
Industrial Technology Division, Washington, DC

INORGANICS DATABASE LISTING

	Primary Coeff.	Secondary Coeff.	CASNO
Antimony	127.00	80.00	7440360
Barium	90.00	64.00	7440393
Aluminum	46.40	30.40	7429905
Chromium	50.00	124.00	7440473
Copper	110.00	50.00	7440508
Iron	59.00	37.00	7439896
Lead	59.00	88.00	7439921
Manganese	217.00	193.00	7439965
Mercury	150.00	115.00	7439976
Nickel	130.00	1000.00	7440020
Silver	36.00	20.00	7440224
Zinc	135.00	62.00	7440666
Arsenic	130.00	130.00	7440382
Cadmium	60.00	83.00	7440439

APPENDIX D

SYSTEM DATABASE DESCRIPTION

The FATE model is composed of four databases: the Facility, Organic, Inorganic, and Unit Conversion databases. This appendix describes the components of each database, and how the FATE model uses each database for its functions.

The Facility Database is used to store specific operating plant parameters for the three default POTWs - 'SMALL,' 'MEDIUM,' and 'LARGE.' It also has capacity to store operating data for any POTW the user wishes FATE to estimate. Table 1 lists and describes each parameter contained in the Facility Database.

The Organics Database lists all organic compounds used by FATE, their CAS numbers and class, and their respective chemical constants (e.g., Henry's Law Constant, octanol/water partition coefficient, and Biodegradation rate constant.) The influent concentration of the organic compound of concern is also stored in the Organics Database, as is concentration values where, at that particular concentration, inhibition effects are present. Table 2 lists all parameters contained in the Organics Database.

The Inorganics Database lists the inorganic compounds for which FATE will run, their corresponding CAS numbers, and coefficients used to predict the fate of the inorganic compound. The influent concentration of the compound of concern is also stored in the Inorganics Database. Table 3 describes each parameter contained in the Inorganics Database.

For the Unit Conversion Database, standard units for FATE facility parameters were established from a poll of actual POTWs which determined the most common units POTWs use in their record keeping. FATE therefore has the capacity to convert facility parameters, which appear in the lower left of the FATE screen, from one unit to another. If a facility does not record its operating parameters in the standard units which appear on the screen, FATE will allow input of the values in alternate units and subsequently convert them to standard FATE units. Table 4 lists and describes the standard units used in FATE, alternate units FATE is capable of converting for each specific parameter, and the numerical conversion factor.

Table 1 - Facility Database

Variable Name	Description	Unit
FCSEL	If FCSEL equals '#,' the facility has been selected for a FATE model run	NA
FCFCL	Name of Facility	NA
FCSTD	Record Type ('*' indicates default facility)	NA
FCQ	Plant Flow Rate	MGD
FCQP	Primary Sludge Flow Rate	gpd
FCXP	Primary Sludge Concentration	%
FCV	Total Volume of Aeration Basins	gal
FCXL	Mixed Liquor Suspended Solids	mg/l
FCG	Gas Volumetric Flow Rate to Aeration Basin	cu.ft/d
FCQW	Wasted Sludge Flow Rate	gpd
FCXV	Wasted Sludge Concentration	%

Table 2 - Organics Database

Variable Name	Description	Unit
COSEL	If COSEL equals '#,' then the organic compound has been selected for the FATE model	NA
COCMP	Regulatory organic compound name	NA
COCASNO	CAS number of the organic compound	NA
COSTD	If COSTD equals '*', then the compound CAS number and chemical constants are default values	NA
COHC	Henry's Law Constant of the organic compound	atm - m^3/mole
COHCE	Henry's Law Constant Exponent	NA
COHTYPE	Henry's Law Constant type (COHTYPE may equal 'M' - Measured, 'E' - Estimated, or 'U' - Unavailable)	NA
COLKOW	Log octanol/water partition coefficient of the organic compound	m^3H_2O/m^3 octanol
COLTYPE	Log octanol/water partition coefficient type (COLTYPE may equal 'M,' 'E,' or 'U' as described previously)	
COK	Biodegradation rate constant of the organic compound	
COKTYPE	Biodegradation rate constant type (COKTYPE equals 'E;' all rate constants were estimated)	
COSI	Influent concentration of organic compound	mg/l
COCLASS	Class of the compound: DIO - Dioxin PC - Pesticide (Carbamate) PH - Pesticide (Herbicide) POH - Pesticide (Organo halide) POP - Pesticide (Organo phosphorous) SVA - Semi-volatile (Acid) SVB - Semi-volatile (Base) SVN - Semi-volatile (Neutral) VOL - Volatile	NA
COI	Inhibition concentration	mg/l
COINTYPE	Scale at which inhibition concentration was measured (U-Unknown, B-Benchtop, P-Pilot plant, F-Full scale, NA-Not available)	NA

Table 3 - Inorganics Database

Variable Name	Description	Unit
CISEL	If CISEL equals '#,' then the inorganic compound has been selected for the FATE model	NA
CICMP	Regulatory inorganic compound name	NA
CICASNO	Inorganic compound CAS number	NA
CISTD	If CISTD equals '*,' then the compound name and CAS number are EPA standards	NA
CIRW	Constant for the inorganic in the primary system	mg/l
CIML	Constant for inorganic in the secondary system	mg/l
CISI	Influent concentration of the inorganic compound	mg/l

Table 4 - Unit Conversion Database

Facility Parameter	FATE Default Unit	Other Units
Plant flow (Q)	MGD	CU.M/D L/D GPD
Primary sludge flow (Q_p)	gpd	GPM MGD L/D
Primary sludge conc. (X_p)	%	LB/GAL LB/CU.M G/CU.M UG/L PPB MG/L PPM
Aeration basins volume (V)	gal	L CU.FT CU.M MGAL
MLSS (X_l)	mg/l	LB/GAL LB/CU.M PPM UG/L PPB % G/CU.M
Gas flow rate (G)	cf/d	L/D CU.FT/HR CU.M/HR CU.M/D CFM
Waste sludge flow rate (Q_w)	gpd	GPM MGD L/D
Waste sludge conc. (Xv)	%	UG/L MG/L PPB LB/CU.M LB/GAL G/CU.M PPM

APPENDIX E

FATE MODEL MAP OF CURSOR KEY MOVEMENTS

FATE MODEL KEY MOVEMENTS

FUNCTION	KEY(S)	COMMENTS
CURSOR MOVEMENT		
UP	↑	
DOWN	↓	
LEFT	←	
RIGHT	→	
SELECT		
FACILITY	< SPACE BAR >	" # " APPEARS TO LEFT OF NAME
COMPOUND	< SPACE BAR >	" # " APPEARS TO LEFT OF NAME
RUN		
RUN	/ R	
PRINT		
SINGLE COMPOUND REPORT	/ PS	
MULTIPLE COMPOUND REPORT	/ PM	
FACILITY DATABASE	/ PF	
COMPOUND DATABASE	/ PC	ORGANIC AND INORGANIC DATABASES OBTAINED
GENERAL		
HELP	< F1 >	
UNMARK SELECTEDRECORDS	< F6 >	
GROUP MARKS	< F7 >	MAY VIEW ALL SELECTED RECORDS AT ONCE
GO TO (LETTER OR NUMBER)	(LETTER OR NUMBER)	FOR ORGANIC/INORGANIC DATABASES ONLY
CAS # SEARCH	< F8 >	
SYSTEM UTILITIES		
GO TO DOS	/ S	TYPE " EXIT " TO RETURN TO FATE
REMOVE BLANK OR MARK-FOR-DELETION RECORDS	/ UM	
REBUILD INDEXES OF DATABASES	/ UR	
EDITING		
EDIT	< F2 >	NOT VALID FOR " * " RECORDS
COPY	< F3 >	
ADD	< F4 >	
DELETE	< F5 >	TO DELETE FROM DATABASE FOLLOW WITH / UM

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#	5, 7 - 8, 11 - 12, 14
Add <F4>	5, 8, 11, 14
Backup	3, 16, 17
CAS # <F8>	8, 12, 15
Continue	6, 15, 17
Copy<F3>	8, 13, 14
Delete <F5>	13 - 14, 16
Edit <F2>	6, 11, 13, 14
Facility	5
Group <F7>	15
Help <F1>	13 - 14
Maintenance	14, 16
Menu Mode	9, 11, 14 - 15, 18, 20
Print	9, 15 - 16, 18, 19, 20
Quit	15, 17
Rebuild	16
Run	4 - 5, 9, 11, 15 - 16, 18
Selection Mode	11 - 12, 15, 18
System	15 - 17
Unit	13 - 14
Unit Conversion	6, 13
Unmark <F6>	12, 15
Utilities	14 - 16