Appendices

Appendix A
Local Limits Development Process Checklist

PRELIMINARY DATA		
TASK		**DONE**
POTW highest Monthly Avg Flow (MGD)		
The total of these flows should = total flow	Domestic Flow (mgd)	
	Non-domestic flow (mgd)	
	Hauled Waste (mgd)	
	SIU Flow (mgd)	
% Solids to Disposal		
Biosolids Flow to Disposal (mgd)		
Biosolids Disposal Site Area and Site Life		
Density of Biosolids to Disposal		
Influent Data		
Effluent Data		
Biosolids Data		
Commercial Data		
Domestic Data		
Get the Following Information from NPDES Permit and the Fact Sheet/Rationale		
Aquatic Life Uses		
Designated Uses		
Hardness of Upstream Receiving Water		
Aquatic Life – acute protection low-flow (1 Q 30)		
Aquatic Life – chronic protection low-flow (7 Q 10)		
NPDES Permit Limits		
Acute limits (metals and organics) for Stream Segment		
Chronic Limits (metals and organics) for Stream Segment		
Human Health Standards Applicable to the Stream Segment		
Final MCL Criteria if Stream Segment or downstream stream segment is a drinking water supply		
Process inhibition criteria (if needed for your POTW)		
Biosolids Limits based upon disposal options		

Influent Scan	
TASK	**DONE**
Has at least one influent scan been performed in the last 12 months that meet the criteria listed in Step 1 of this strategy?	
Perform priority pollutant scan according to criteria in Step 1 of this strategy	
Identify any pollutant from the influent priority pollutant scan that meet the criteria listed in Step 1 of this strategy.	
Prior to eliminating a compound identified as a pollutant of concern seek approval from the Approval Authority	
Generate a complete list of pollutants of concern	
Is there enough data available for the determined POCs that no additional sampling is needed?	
Development of Sampling Plan	
TASK	**DONE**
Identification of needed sampling locations (e.g. influent, effluent, sludge, hauled waste, SIUs, receiving water, commercial, domestic only) see Step 3 for details	
Do your sampling locations meet all the criteria listed in Step 2 of this strategy	
Parameters to be sampled at each location	
Type of sample needed for each parameter (grab, composite, flow or time proportioned, etc)	
Identification of containers, preservatives, holding times, and shipping/storage procedures for each parameter	
ID of analytical methods and required MDL for analysis of each parameter	
Date and number of samples to be collected at each location	
POTW process hydraulic detention time between sampling at each location (for calculation of removal efficiencies)	
Chain of Custody form for identification of data to be recorded for each sample	
Sampling Program	
TASK	**DONE**
All wastewater sampling and analysis must be done in accordance with the methods specified by 40 CFR Part 136	
Sludge analyses must be in accordance with 40 CFR 503.8, or if not addressed in 503.8, with the latest edition of "Biosolids Management Handbook…"	
Collect at least six samples from each sampling location	
Good sampling techniques used for all sampling (list of techniques in Step 3 of this strategy).	
POTWs with a lagoon treatment system, see Step 3 of this strategy for special instructions	

Compiling Needed Information	
TASK	**DONE**
Choose a method to handle BLD Data listed in Step 4 of this Strategy	
Receiving Water Data: If data shows BDL, assume zero until data is generated showing presence	
Biosolids Data: BDL Biosolids data should be reported as ½ the MDL	
Choose a removal efficiency calculation method for each pollutant of concern(see methods in Step 4)	
Calculate removal efficiency for each pollutant of concern (see Appendix F)	
Local Limits Calculation	
Each pollutant of concern evaluated for applicable critera listed in Step 5 of this Strategy	
Evaluation of Local Limits for Organics (see Step 5 of this strategy).	
Evaluation of BTEX Local Limits (see Step 5 of this strategy).	
Determination of Safety & Expansion factor (see guidance in Step 5 of this strategy).	
Calculate local limits with Region 8 Local Limits Spreadsheet (see Step 5 of Strategy)	
Develop a Local Limits for each POC	
Arsenic, cadmium, chromium (total or III), chromium VI, copper, lead, mercury, molybdenum, nickel, selenium, silver, and zinc local limits developed?	
Any POC, based on current loadings, that meet the criteria in Section IV of the Strategy	
Allocation of Pollutant Loadings	
Determine allocation method to be used for each pollutant (see Step 5 and Step 7 of strategy for guidance)	
Describe allocation method used for each pollutant (to be submitted with approval package)	
List of each SIU and the mass of each POC that will be allocated to each user (for mass limits)	
A description of the tracking/methodology to be used to show that MAILs are not exceeded	
Review ordinance/rules and regulations language for MAILs in Step 7 of this strategy.	
Review options for permit language concerning pollutant limits in Step 7 of this strategy.	

Local Limits Approval Package	
Information requested in Appendix B	
A simple schematic of POTW including treatment units, designation of treatment processes, sample locations for influent, effluent, and biosolids	
Initial influent scan and other data used to identify POC	
A complete list of Pollutants of Concern	
A statement that the POW has all chain of custody info on file and that the records will remain on file as long as the current limits are in effect	
Explanations for not developing a limit for a pollutant of concern	
The Local Limits Spreadsheet (including any notes on data entered into spreadsheet)	
Explanation of decisions that deviated from the Strategy	
Explanation of abbreviations used on data sheets and in calculations	
Draft Legal Authority language showing what will be changed	
Calculated Local Limits	
An attorney statement	
Submission made by the authorized signatory official for the POTW	
Any other data requested by the Approval Authority	
MODIFICATION OF ORDINANCE/RULES	
Local limits submittal approved	
A modified ordinance that includes local limits	
Description of process to be used to update any orders/permits	
A timeline for implementation	
Public Notice and comment period	
Approval Authority approval or denial	

APPENDIX B

BIOCONCENTRATION FACTORS

POLLUTANT	BIOCONCENTRATION FACTOR
acrolein	215
acenaphthene	242
4-bromophenyl phenyl ether	1640
butylbenzyl phthalate	414
2-chloronaphthalene	202
4-chlorophenyl phenyl ether	1200
3,3'-dichlorobenzidine	312
fluroranthene	1150
hexachlorobenzene	8690
aldrin	4670
chlordane	14100
4,4'-DDT	53600
4,4'-DDE	53600
4,4'-DDD	53600
dieldrin	4670
alpha-endosulfan	270
beta-endosulfan	270
endosulfan sulfate	270
endrin	3970
endrin aldehyde	3970
heptachlor	11200
heptachlor epoxide	11200
PCB-1242	31200
PCB-1254	31200
PCB-1221	31200
PCB-1232	31200
PCB-1248	31200
PCB-1260	31200
PCB-1016	31200
toxaphene	13100
Mercury, Total	5500, 3760, 9000
2,3,7,8-TCDD - Dioxin	5000

APPENDIX C
Formula's Used in Local Limits Calculations

NPDES PERMIT CRITERIA

$$L_{IN} = \frac{(8.34)(C_{CRIT})(Q_{POTW})}{(1-R_{POTW})}$$

where: L_{IN} = Allowable headworks loading lbs/day
C_{CRIT} = NPDES permit limit, mg/L
Q_{POTW} = Highest monthly average POTW flow for past 12 months, MGD
R_{POTW} = Removal efficiency across POTW (USE DECIMAL)

WATER QUALITY CRITERIA

Water quality criteria represent in-stream concentrations that may not be exceeded in the receiving stream. For metals, hardness correction is often needed (Table 1). The following formulas are used for calculating maximum headworks loadings based on water quality criteria:

For chronic limits:

$$L_{IN/C} = \frac{(8.34)[C_{CWQ}(Q_{STR} + Q_{POTW}) - (C_{STR}Q_{STR})]}{(1-R_{POTW})}$$

where: $L_{IN/C}$ = Allowable headworks loading based on chronic toxicity standard, lbs/day
C_{CWQ} = Chronic water quality standard, mg/L
Q_{STR} = Receiving steam flow, MGD (USE STREAM FLOW THAT IS CONSISTENT WITH WHAT YOUR STATE WOULD USE FOR CHRONIC CRITERIA) For example, some states specify a 30E3 for chronic.
Q_{POTW} = Highest monthly average POTW flow for past 12 months, MGD
C_{STR} = Background (upstream) pollutant concentration in receiving stream, mg/L
R_{POTW} = Removal efficiency across POTW (USE DECIMAL)

For acute limits:

$$L_{IN/A} = \frac{(8.34)[C_{AWQ}(Q_{STR} + Q_{POTW}) - (C_{STR}Q_{STR})]}{(1-R_{POTW})}$$

where: $L_{IN/A}$ = Allowable headworks loading based on acute toxicity standard, lbs/day
C_{AWQ} = Acute water quality standard, mg/L
Q_{STR} = Receiving steam flow, MGD (USE STREAM FLOW THAT IS CONSISTENT WITH WHAT YOUR STATE WOULD USE FOR ACUTE CRITERIA) For example, some states specify a 1E3 for acute.
Q_{POTW} = Monthly average POTW flow for past 12 months, MGD
C_{STR} = Background (upstream) pollutant concentration in receiving stream, mg/L
R_{POTW} = Removal efficiency across POTW (USE DECIMAL)

SAFETY AND EXPANSION FACTORS

Maximum allowable industrial loadings are calculated by applying a safety/growth factor to the maximum allowable headworks loading and subtracting the domestic/commercial contributions to the headworks. The formula is as follows:

$$L_{ALL} = (1-SF)L_{MAHL} - L_{DOM}$$

where: L_{ALL} = Maximum allowable industrial loading, lbs/day
SF = Safety/growth factor, decimal
L_{MAHL} = Maximum allowable headworks loading
L_{DOM} = Domestic/commercial wastewater pollutant loading, lbs/day

APPENDIX D

Table - MDLs (ug/l) for Wastewater Analytical Methods

Metal	Flame	Furnace	ICP	1631	1632	1637	1638	1639	1640
As [1]	2	1	53		0.003				
Cd	5	0.1	4			0.0075	0.025	0.023	0.0024
Cr (T)	50	1	7						
Cr (III)									
Cr(IV)									
Cu	20	1	6				0.087		0.024
Pb	100	1	42				0.015		0.0081
Hg	0.2 [2]			0.00005					
Mo	100	1	8						
Ni	40	1	15				0.33	0.65	0.029
Se	2	2	75				0.45	0.83	
Ag	10	0.2	7				0.029		
Zn	5	0.05	2				0.14	0.14	

1. Gaseous hydride method
2. Cold vapor technique

EPA may periodically update these values. It is recommended that the reader check for the latest MDLs.

APPENDIX E

PRETREATMENT PROGRAM MODIFICATIONS

REGION VIII GUIDANCE ON DEFINING AND PROCESSING APPROVED PROGRAM MODIFICATIONS

USEPA - Region 8
Industrial Pretreatment Program
June 15, 1999

EPA promulgated modifications to pretreatment program modification procedures (40 CFR Section 403.18) on July 17, 1997 (62 FR 38406). This regulation also modified other Sections of 40 CFR Part 403 that relate to approved POTW pretreatment program modifications. The proposed regulations were public noticed on July 30, 1996 (61 FR 39804). This Guidance summarizes those changes and provides guidance to Approval Authorities and Control Authorities on implementation of the modified rules.

In general, the modified regulation revised what types of program changes are considered to be substantial, how public notices are to be performed, and a new procedure for non-substantial modifications.

SUBSTANTIAL MODIFICATIONS

The following program changes are considered substantial modifications:

- Modifications that relax POTW legal authorities unless the modifications directly reflect revisions to Part 403;

- Modifications that relax local limits, except modifications of pH to the pH 5 minimum or reallocations of MAILs;

- Changes to the type or form of control mechanism used by the POTW for SIUs (e.g. order vs permit);

- A decrease in the frequency of self-monitoring or reporting for industrial users (general policy or approved program);

- A decrease in the frequency of industrial user inspections or sampling by the POTW (general policy or approved program);

- Changes to the POTWs confidentiality procedures;

- Any other modification that the Approval Authority deems substantial.

All substantial modifications shall be submitted to the Approval Authority. The submittal should include all of the following:

1. A statement of basis for the proposed modification;

2. An attorney's statement confirming that the modified legal authority will comply with the requirements of local law, including complying with state and local law, regarding review and adoption by the Control Authority of the new/modified legal authority. The attorney's statement shall also confirm that the changes will not result in the POTW being in violation of its NPDES permit;

3. A copy of the draft legal authority that shows additions (by means of **CAPITALIZATION AND BOLDING** and deletions by means of ~~**STRIKETHROUGHS AND BOLDING**~~ at a minimum;

4. A copy of the draft legal authority showing all changes as they will look in final format;

5. A copy of the new forms/procedures affected by this modification;

6. Any other documentation required by the Approval Authority.

Substantial modifications shall be public noticed for comment in a paper of general circulation. No further public notice is required if the original public notice provides for only one public notice **AND** no comments are received **AND** the requested modification can be approved without change. The public notice may be performed by the POTW if the Approval Authority agrees **AND** the public notice language is approved by the Approval Authority. The decision on what party will perform the actual public notice is decided by the Approval Authority. The Approval Authority is responsible for all public notices in any case.

All substantial and non-substantial modifications approved in accordance with 40 CFR Section 403.18 become enforceable conditions of the POTWs NPDES permit (40 CFR Section 122.63(g)).

Appendix F

National Recommended Water Quality Criteria: 2002
USEPA – OW
EPA-822-R-02-047

National Recommended Water Quality Criteria: 2002
Human Health Criteria Calculation Matrix
USEPA-OW
EPA -822-R-02-012

Documents from the Office of Water can be accessed at: http://yosemite.epa.gov/water/owrccatalog.nsf/

Appendix G - Federal Sewage Sludge Standards

Biosolids Land Application Limitations

Pollutant	Ceiling Concentration* (Table 1, 40 CFR 503.13)		Monthly Average Pollutant Concentration* (Table 3, 40 CFR 503.13)		Cumulative Pollutant Loading Rates* (Table 2, 40 CFR 503.13)		Annual Pollutant Loading Rate* (Table 4, 40 CFR 503.13)	
	mg/kg	lbs/1000 lbs	mg/kg	lbs/1000 lbs	kg/hectare	lbs/acre**	kg/hectare/ 365-day period	lbs/acre/ 365-day period**
Arsenic	75	75	41	41	41	37	2	1.8
Cadmium	85	85	39	39	39	35	1.9	1.7
Copper	4,300	4,300	1,500	1,500	1,500	1,338	75	67
Lead	840	840	300	300	300	268	15	13
Mercury	57	57	17	17	17	15	0.85	0.76
Molybdenum	75	75	-	-	-	-	-	-
Nickel	420	420	420	420	420	375	21	19
Selenium	100	100	100	100	100	89	5	4.5
Zinc	7,500	7,500	2,800	2,800	2,800	2,498	140	125

* Dry weight.

** Calculated using metric standards specified in 40 CFR 503.13 multiplied by the conversion factor of 0.8922.

Source: 40 CFR §503.13, Tables 1-4, October 25, 1995

Surface Disposal

Distance from the Boundary of Active Biosolids Unit to Surface Disposal Site Property Line (meters)	**Pollutant Concentration***		
	Arsenic (mg/kg)	Chromium (mg/kg)	Nickel (mg/kg)
0 to less than 25	30	200	210
25 to less than 50	34	220	240
50 to less than 75	39	260	270
75 to less than 100	46	300	320
100 to less than 125	53	360	390
125 to less than 150	62	450	420
Equal to or greater than 150	73	600	420

* Dry-weight.

Source: 40 CFR Part 503

Conversion Factors

pounds per acre (lbs/ac) x 1.121 = kilograms per hectare (kg/ha)
kilograms per hectare (kg/ha) x 0.8922 = pounds per acre (lbs/ac)
pound (lb) = 0.4536 kilogram (kg)
kilogram (kg) = 2.205 pounds (lbs)
English ton = 0.9072 metric tonne
metric tonne = 1.102 English ton

APPENDIX H - TOXICITY CHARACTERISTIC LEACHATE PROCEDURE (TCLP) LIMITATIONS

EPA Hazardous Waste No.	Contaminant	CAS No.[1]	Regulatory Level (mg/L)
D004	Arsenic	7440-38-2	5.0
D005	Barium	7440-39-3	100.0
D018	Benzene	71-43-2	0.5
D006	Cadmium	7440-43-9	1.0
D019	Carbon tetrachloride	56-23-5	0.5
D020	Chlordane	57-74-9	0.03
D021	Chlorobenzene	108-90-7	100.0
D022	Chloroform	67-66-3	6.0
D007	Chromium	7440-47-3	5.0
D024	o-Cresol	95-48-7	[2]200.0
D024	m-Cresol	108-39-4	[2]200.0
D025	p-Cresol	106-44-5	[2]200.0
D026	Cresols		[2]200.0
D016	2,4-D	94-75-7	10.0
D027	1,4-Dichlorobenzene	106-46-7	7.5
D028	1,2-Dichloroethane	107-06-2	0.5
D029	1,1-Dichloroethylene	75-35-4	0.7
D030	2,4-Dinitrotoluene	121-14-2	[3]0.13
D012	Endrin	72-20-8	0.02
D031	Heptachlor (and its epoxide)	76-44-8	0.008
D032	Hexachlorobenzene	118-74-1	[3]0.13
D033	Hexachlorobutadiene	87-68-3	0.5
D034	Hexachloroethane	67-72-1	3.0
D008	Lead	7439-92-1	5.0
D013	Lindane	58-89-9	0.4
D009	Mercury	7439-97-6	0.2
D014	Methoxychlor	72-43-5	10.0
D035	Methyl ethyl ketone	78-93-3	200.0

EPA Hazardous Waste No.	Contaminant	CAS No.[1]	Regulatory Level (mg/L)
EPA Hazardous Waste No.	Contaminant	CAS No.[1]	Regulatory Level (mg/L)
D036	Nitrobenzene	98-95-3	2.0
D037	Pentachlorophenol	87-86-5	100.0
D038	Pyridine	110-86-1	[3]5.0
D010	Selenium	7782-49-2	1.0
D011	Silver	7440-22-4	5.0
D039	Tetrachloroethylene	127-18-4	0.7
D015	Toxaphene	8001-35-2	0.5
D040	Trichloroethylene	79-01-6	0.5
D041	2,4,5-Trichlorophenol	95-95-4	400.0
D042	2,4,6-Trichlorophenol	88-06-2	2.0
D017	2,4,5-TP (Silvex)	93-72-1	1.0
D043	Vinyl chloride	75-01-4	0.2

1 Chemical abstracts service number.
2 If o-, m-, and p-Cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level of total cresol is 200 mg/l.
3 Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level.

Source: 40 CFR 261.24, August 31, 1993.

APPENDIX I - DRINKING WATER STANDARDS

National Primary Drinking Water Regulations

Contaminants	Maximum Contaminant Level Goal (MGLC) in mg/L	Maximum Contaminant Level (MCL) in mg/L
INORGANICS		
Antimony	0.006	0.006
Arsenic	none	0.05
Asbestos	7 MFL*	7 MFL
Barium	2	2
Beryllium	0.004	0.004
Cadmium	0.005	0.005
Chromium (total)	0.1	0.1
Copper	1.3	Action Level=1.3
Cyanide (as free cyanide)	0.2	0.2
Fluoride	4.0	4.0
Lead	zero	Action Level=0.015
Inorganic Mercury	0.002	0.002
Nitrate (as Nitrogen)	10	10
Nitrite (as Nitrogen)	1	1
Selenium	0.05	0.05
Thallium	0.0005	0.002
Acrylamide	zero	**
Alachlor	zero	0.002
Atrazine	0.003	0.003
Benzene	zero	0.005
Benzo(a)pyrene	zero	0.0002
Carbofuran	0.04	0.04
Carbon tetrachloride	zero	0.005
Chlordane	zero	0.002
Chlorobenzene	0.1	0.1
2,4-D	0.07	0.07
Dalapon	0.2	0.2
1,2-Dibromo-3-chloropropane (DBCP)	zero	0.0002
o-Dichlorobenzene	0.6	0.6

Contaminants	Maximum Contaminant Level Goal (MGLC) in mg/L	Maximum Contaminant Level (MCL) in mg/L
p-Dichlorobenzene	0.075	0.075
1,2-Dichloroethane	zero	0.005
1-1-Dichloroethylene	0.007	0.007
cis-1, 2-Dichloroethylene	0.07	0.07
trans-1,2-Dichloroethylene	0.1	0.1
Dichloromethane	zero	0.005
1-2-Dichloropropane	zero	0.005
Di(2-ethylhexyl)adipate	0.4	0.4
Di(2-ethylhexyl)phthalate	zero	0.006
Dinoseb	0.007	0.007
Dioxin (2,3,7,8-TCDD)	zero	0.00000003
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Epichlorohydrin	zero	***
Ethylbenzene	0.7	0.7
Ethylene dibromide	zero	0.00005
Glyphosate	0.7	0.7
Heptachlor	zero	0.0004
Heptachlor epoxide	zero	0.0002
Hexachlorobenzene	zero	0.001
Hexachlorocyclopentadiene	0.05	0.05
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Oxamyl (Vydate)	0.2	0.2
Polychlorinated biphenyls (PCBs)	zero	0.0005
Pentachlorophenol	zero	0.001
Picloram	0.5	0.5
Simazine	0.004	0.004
Styrene	0.1	0.1
Tetrachloroethylene	zero	0.005
Toluene	1	1
Total Trihalomethanes (TTHMs)	none	0.10
Toxaphene	zero	0.003
2,4,5-TP (Silvex)	0.05	0.05

Contaminants	Maximum Contaminant Level Goal (MGLC) in mg/L	Maximum Contaminant Level (MCL) in mg/L
1,2,4-Trichlorobenzene	0.07	0.07
1,1,1-Trichloroethane	0.20	0.2
1,1,2-Trichloroethane	0.003	0.005
Trichloroethylene	zero	0.005
Vinyl chloride	zero	0.002
Xylenes (total)	10	10

*** Million fibers per liter, longer than 10 micrometers (Fm) in length.**
**** Not to exceed 0.05% dosed at 1 ppm (or equivalent).**
***** Not to exceed 0.01% dosed at 20 ppm (or equivalent).**

Source: 40 CFR Part 141, National Primary Drinking Water Regulations and http://www.epa.gov/safewater/mcl.html

National Primary Drinking Water Regulations

Disinfection Byproduct	Maximum Contaminant Level Goal (MGLC) in mg/L	Maximum Contaminant Level (MCL) in mg/L
Total Trihalomethanes*	-	0.080
Bromodichloromethane	zero	-
Dibromochloromethane	0.06	-
Tribromomethane (Bromoform)	zero	-
Trichloromethane (Chloroform)	zero	-
Haloacetic Acids (HAA5)**	-	0.060
Dichloroacetic Acid	zero	-
Trichloroacetic Acid	0.3	-
Bromate	zero	0.010
Chlorite	0.8	1.0

* Sum of the concentrations of Bromodichloromethane, Dibromochloromethane, Tribromomethane, and Trichloromethane.

** Sum of the concentrations of Dichloroacetic acid, Trichloroacetic acid, Monochloroacetic acid, Monobromoacetic acid, and Dibromoacetic acid.

Disinfectant Residual	Maximum Residual Disinfection Level Goal (MRDLG) in mg/L	Maximum Residual Disinfection Level (MRDL) in mg/L
Chlorine (as Cl_2)	4	4
Chloramines (as Cl_2)	4	4
Chlorine dioxide (as ClO_2)	0.8	0.8

Source: National Primary Drinking Water Regulations: Disinfectants and Disinfection Byproducts (also known as the Stage 1 Disinfection Byproducts Rule - DBPR); 63 FR, December 16, 1998, p 69389.

National Secondary Drinking Water Regulations

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

Source: 40 CFR Part 143, National Secondary Drinking Water Regulations; http://www.epa.gov/safewater/mcl.html.

APPENDIX J - HAULED WASTE LOADINGS

SEPTAGE HAULER MONITORING DATA

Pollutant	Number of Detections	Number of Samples	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)	Average Concentration (mg/L)
INORGANICS					
Arsenic	144	145	0	3.5	0.141
Barium	128	128	0.002	202	5.758
Cadmium	825	1097	0.005	8.1	0.097
Chromium (T)	931	1019	0.01	34	0.49
Cobalt	16	32	< 0.003	3.45	0.406
Copper	963	971	0.01	260.9	4.835
Cyanide	575	577	0.001	1.53	0.469
Iron	464	464	0.2	2740	39.287
Lead	962	1067	< 0.025	118	1.21
Manganese	5	5	0.55	17.05	6.088
Mercury	582	703	0.0001	0.742	0.005
Nickel	813	1030	0.01	37	0.526
Silver	237	272	< 0.003	5	0.099
Tin	11	25	< 015	1	0.076
Zinc	959	967	< 0.001	444	9.971
NONCONVENTIONALS					
COD	183	183	510	117500	21247.951
ORGANICS					
Acetone	118	118	0	210	10.588
Benzene	112	112	0.005	3.1	0.062
Ethylbenzene	115	115	0.005	1.7	0.067
Isopropyl Alcohol	117	117	1	391	14.055
Methyl Alcohol	117	117	1	396	15.84
Methyl Ethyl Ketone	115	115	1	240	3.65
Methylene Chloride	115	115	0.005	2.2	0.101
Toluene	113	113	0.005	1.95	0.17
Xylene	87	87	0.005	0.72	0.051

Source: U.S. EPA's *Supplemental Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Programs*, 21W-4002, May 1991, pp. 1-27 and 1-28.

APPENDIX K - PRIORITY POLLUTANT REMOVAL EFFICIENCIES

PRIORITY POLLUTANT REMOVAL EFFICIENCIES THROUGH ACTIVATED SLUDGE TREATMENT*

Priority Pollutant	Range	Median	# of POTWs
METALS/NONMETAL INORGANICS			
Arsenic	11-78	49	12
Cadmium	25-99	64	25
Chromium	25-97	77	28
Copper	2-99	86	35
Cyanide	3-99	69	25
Lead	1-92	63	29
Mercury	1-95	62	25
Molybdenum	6-71	29	6
Nickel	2-99	40	31
Selenium	25-89	48	10
Silver	17-95	77	31
Zinc	23-99	73	35
ORGANICS			
Anthracene	29-99	67	5
Benzene	25-99	80	18
Chloroform	17-99	67	24
1,2-trans-Dichloroethylene	17-99	67	17
Ethylbenzene	25-99	86	25
Methylene chloride	2-99	62	26
Naphthalene	25-98	78	16
Phenanthrene	29-99	68	6
Phenol	3-99	90	19
Bis (2-ethylhexyl) phthalate	17-99	72	25
Butyl benzyl phthalate	25-99	67	16
Di-n-butyl phthalate	11-97	64	19
Diethyl phthalate	17-98	62	15
Pyrene	73-95	86	2
Tetrachloroethylene	15-99	80	26
Toluene	25-99	93	26
1,1,1-Trichloroethane	18-99	85	23
Trichloroethylene	20-99	89	25

Source: Region 8 POTWs and U.S. EPA's *Guidance Manual on the Development and Implementation of Local Discharger Limitations Under the Pretreatment Program*, December 1987, p. 3-56.

TRICKLING FILTER TREATMENT*	Range	Median	# of POTWs
METALS/NONMETAL INORGANICS			
Arsenic	42	42	1
Cadmium	33-96	68	10
Chromium	5-92	60	16
Copper	12-97	60	14
Cyanide	7-88	59	8
Lead	4-84	62	10
Mercury	14-80	65	13
Molybdenum	7-50	23	3
Nickel	7-72	41	13
Selenium	40-63	52	3
Silver	11-93	68	12
Zinc	14-90	63	14
ORGANICS			
Benzene	5-98	75	7
Chloroform	21-94	73	9
1,2-trans-Dichloroethylene	14-99	50	7
Ethylbenzene	45-97	80	10
Methylene chloride	5-98	70	10
Naphthalene	33-93	71	6
Phenol	50-99	84	8
Bis (2-ethylhexyl) phthalate	4-98	58	10
Butyl benzyl phthalate	25-90	60	9
Di-n-butyl phthalate	29-97	60	10
Diethyl phthalate	17-75	57	8
Tetrachloroethylene	26-99	80	10
Toluene	17-99	93	10
1,1,1-Trichloroethane	23-99	89	10
Trichloroethylene	50-99	94	10

Source: EPA Region 8 POTWs and U.S. EPA's *Guidance Manual on the Development and Implementation of Local Discharger Limitations Under the Pretreatment Program*, December 1987, p. 3-57.

LAGOON TREATMENT	Range	Mean	# of POTWs
METALS/NONMETAL INORGANICS			
Arsenic			
Cadmium			
Chromium		21	1
Copper	59-71	65	2
Lead		91	1
Mercury		95	1
Molybdenum		75	1
Nickel		42	1
Selenium		77	1
Silver		76	1
Zinc	81-86	83	2

Source: EPA Region 8 POTWs

PRIORITY POLLUTANT REMOVAL EFFICIENCIES THROUGH TERTIARY TREATMENT*

Priority Pollutant	Range	Median	# of POTWs
METALS/NONMETAL INORGANICS			
Cadmium	33-81	50	3
Chromium	22-93	72	4
Copper	8-99	85	4
Cyanide	20-93	66	4
Lead	4-86	52	3
Mercury	33-79	67	4
Nickel	4-78	17	3
Silver	27-87	62	3
Zinc	1-90	78	4
ORGANICS			
Benzene	5-67	50	2
Chloroform	16-75	53	3
1,2-trans-Dichloroethylene	50-96	83	2
Ethylbenzene	65-95	89	3
Methylene Chloride	11-96	57	4
Naphthalene	25-94	73	3
Phenol	33-98	88	4
Bis (2-ethylhexyl) phthalate	45-98	76	4
Butyl benzyl phthalate	25-94	63	4
Di-n-butyl phthalate	14-84	50	4
Diethyl phthalate	20-57	38	3
Tetrachloroethylene	67-98	91	4
Toluene	50-99	94	4
1,1,1-Trichloroethane	50-98	94	4
Trichloroethylene	50-99	93	4

Source: EPA Region 8 POTWs and U.S. EPA's *Guidance Manual on the Development and Implementation of Local Discharger Limitations Under the Pretreatment Program*, December 1987, p. 3-58.

AVERAGE POTW REMOVAL EFFICIENCIES IN THE 47-POTW DATA BASE

Priority Pollutant	Median	Mean	Number of POTWs
Barium	72.6115	72.6115	1
Cadmium	27.7778	-167.977	7
Chromium	68.1062	53.7813	10
Copper	65.100	58.462	25
Cyanide	18.1495	-2.4338	3
1,4-Dichlorobenzene	-93.6364	-93.6364	1
1,2-Trans-Dichloroethylene	85.7793	85.7793	1
Lead	45.1846	46.9904	12
Mercury	-3.1445	-3.1445	2
Nickel	33.9382	30.4551	10
Phenols	64.2493	61.0084	9
Bis (2-Ethylhexyl) Phthalate	26.3314	14.5997	7
Di-N-Butyl Phthalate	51.6304	51.6304	1
Di-N-Octyl Phthalate	78.0461	78.0461	2
Diethyl Phthalate	69.8795	44.7419	3
Silver	40.8160	46.9391	4
Trichloroethylene	96.8850	96.8850	1
Zinc	62.0314	59.0255	27

Source: U.S.EPA's *National Pretreatment Program Report to Congress*, July 1991, p. 4-28.

APPENDIX L - METHODS FOR CALCULATING REMOVAL EFFICIENCY

There are three methods of calculating removal efficiencies: average daily removal efficiency (ADRE) method, mean removal efficiency (MRE) method, and the decile approach. Each of these methods uses a set of influent and effluent values, and the concept of a daily removal efficiency (DRE). A DRE, expressed

$$DRE = 100 * \frac{(Influent - Effluent)}{Influent}$$

as a percent, is calculated as:
Where:

Influent =Either the influent concentration from a daily sample, or the influent loading (calculated by multiplying the same influent concentration by the daily flow and an 8.34 unit conversion factor)

Effluent =Either the effluent concentration from a daily sample, or the effluent loading (calculated by multiplying the same effluent concentration by the daily flow and an 8.34 unit conversion factor).

The POTW may use either concentrations for both influent and effluent, or loadings for both.

It is important to realize that the portion of the pollutant removed through a treatment process is transferred to another wastestream, typically the sludge. For conservative pollutants, such as metals, all the pollutant from the influent ends up in either the effluent or the sludge. For example, a 93% overall plant removal means that 93% of the cadmium in the influent is transferred to the sludge, while 7% remains in the effluent wastewater.

1.REVIEW OF THE DATA SET AND EXCLUSION OF CERTAIN DATA

A good first step in determining removal efficiencies is to review the data set. This review can identify any data values that are extremely high or low. If there are isolated extreme values, there are formal statistical procedures that can be applied to evaluate whether a value can be classified as an "outlier" relative to the rest of the data set. Two methods most widely used to make this determination are described in the following two paragraphs.

If the data is known to closely follow a normal distribution, then any data point that lies more than two standard deviations from the mean is considered an outlier. Consider, for example, the DRE data values from located in Table 1 of this appendix, and assume that this data is from a normal distribution. The 15 observations have a mean of 52.69 and a standard deviation of 34.65. Using this method, any data point that lies outside of the range -16.61 to 121.99, or $52.69 \pm 2*34.65$, can be considered an outlier. In this case, one value, -20.25, falls outside of the range and can be determined to be an outlier.

If the data does not closely follow a normal distribution, outliers can be determined based on the interquartile range (IQR) of the data set. First, order the data from smallest to largest and locate the data points that fall at the 25th percentile (also referred to as the first quartile or Q1), and the 75th percentile (also referred to as the third quartile or Q3). The IQR is equal to the value of the observation at Q3 minus the value of the observation at Q1. Any data point that lies more than 1.5 times this IQR below Q1, or above Q3, is considered an outlier. Again, consider the data in Table 1, but now make no assumptions about the distribution of the population from which the sample was taken. The Q1 and Q3 of this data set are located at 38.04 and 78.5 respectively. Based on these values, the IQR is equal to 40.46 (78.5 - 38.04). Any value that falls below -22.65 (38.04 - 1.5*40.46), or above 139.19 (78.5 + 1.5*40.46), can be considered an outlier. In this case, there are no values that fall outside of the range and, consequently, no values should be determined to be outliers.

Both of these methods are meant to determine any values that may be candidates for exclusion from the data set. Data exclusion should be performed only if technical justification exists to support such action (e.g., poor removals due to temporary maintenance or operational problems or known sampling problems). For example, if an examination of the data set shows that an unusually high influent value is from the same sampling day/event as an unusually high effluent value, this occurrence of corresponding extreme values should be investigated to determine if the data values can be explained by technical or operational problems not related to treatment system performance (e.g., maintenance, repair, or sampling problems). If this is the case, dropping the data pair from the data set may be appropriate.

Review of the data may also show patterns such as increasing effluent values over time. If a similar pattern is not observed for the influent values, this will generate a pattern of decreasing DREs over time. A graph or plot of DRE against sampling day/event (in order from first to most recent sample) can help identify such trends. This may alert the POTW to operational problems that should be investigated. A plot can also highlight unusually low DREs that call for further review, such as checking laboratory quality control samples to determine if blank or duplicate samples indicate anything out of the ordinary. If abnormalities are found in laboratory QA/QC (quality assurance/quality control) data, the POTW may consider excluding the affected values from the data set.

Whenever an influent sample is zero (or was reported as below the detection level and assigned a value of zero)[1], a DRE cannot be calculated regardless of the effluent value. Therefore, influent/effluent data pairs for which the influent level is zero must be removed from the data set before calculating removal efficiencies using the ADRE approach and the decile approach. However, the POTW can use these data in calculating a removal efficiency using the MRE method since the MRE method does not involve the calculation of individual DREs from each pair of influent and effluent values. If the data set contains many pairs where the influent value is zero, the POTW should use caution in deciding whether or not using these pairs is appropriate (mismatched data pairs are discussed further in the MRE section below).
A negative DRE is calculated when the effluent concentration (or loading) is higher than the influent concentration (or loading). Negative daily removals should not automatically result in data elimination since such values may be evidence of treatment system variability. Negative DREs (or for the MRE method, the influent and effluent values that would calculate as negative DREs) should be retained in the data set unless there is technical justification to remove them from the data set.

---

[1] Handling of values reported as below detection level is discussed in Chapter 6.

Example

Table 1 contains an example data set of 15 influent and effluent sample pairs for zinc. The influent and effluent concentrations have been converted to loadings using the POTW flows for the sample days. The influent and effluent concentrations may be used instead of converting to loadings. Whether loadings or concentrations are used will likely have little impact on the results of the ADRE and decile approaches. Influent and effluent flows are probably similar (if not the same) for a data pair and therefore will have little effect on the relative size of the influent and effluent values, so DREs will change little. However, converting to loadings may have a noticeable impact on the MRE method if a POTW has high variability in its flows. Since influent and effluent loadings for high flow days will increase more relative to influent and effluent loadings for low flow days, the net effect is to give greater weight to the removal rates on those days with high flows. If the POTW has high variability in its flows, it should evaluate whether its removal rates tend to go up and down in relation to flow. If so, the POTW should consider calculating an MRE using both concentrations and loadings and evaluating which is more appropriate.

Table 1. Removal Efficiency Example

Sample Day	Date	Influent Load (lbs/day)	Effluent Load (lbs/day)	DRE (%)
1	3/4/99	518.22	111.41	78.50
2	3/5/99	163.98	173.99	-6.10
3	3/6/99	110.15	97.64	11.36
4	3/7/99	1739.93	474.41	72.73
5	3/8/99	266.48	320.45	-20.25
6	4/15/99	170.48	105.15	38.32
7	5/11/99	473.16	132.67	71.96
8	5/12/99	314.19	148.96	52.59
9	5/13/99	306.68	132.69	56.73
10	5/14/99	232.57	92.63	60.17
11	5/15/99	226.52	72.60	67.95
12	6/15/99	533.25	98.87	81.46
13	7/1/99	141.43	87.63	38.04
14	7/15/99	1166.77	103.90	91.10
15	8/1/99	2301.00	97.88	95.75
Average		577.65	150.06	52.69

Review of the data shows that:

- All the influent values are greater than zero (no data exclusion needed).
- The three particularly high influent values (sample days 4, 14, and 15) all have DREs of more than 70%, so the high influent values do not appear to make the data candidates for elimination.
- There are two effluent values (sample days 4 and 5) that are significantly higher than the others. For

one, the corresponding influent value is also high and the DRE is 73%. For the other day, the DRE is negative (-20%) since the influent value is relatively low. These results are from samples taken on two consecutive days (March 7 and March 8), which may indicate that the POTW treatment system was experiencing some operational difficulties or interference at the time. The POTW should investigate the matter to determine if there are valid reasons for dropping these data from the removal calculations data set.

- There are two negative DREs (one for March 8) calculated from the influent and effluent data pairs. They occurred three days apart and may indicate temporary operational problems, so the POTW should investigate the matter (as noted above).

A plot of the data may help the POTW identify any data concerns that should be investigated. Based on the review of data for this example, it was determined that no justification exists for excluding any of the data from the data set.

2. CALCULATION OF REMOVAL EFFICIENCIES

Once the data set has been reviewed, the POTW can proceed to calculating removal efficiencies. The following sections describe each of the methods for calculating removal efficiencies and perform the calculations using the example data set in Table 1.

2.1 Average Daily Removal Efficiency (ADRE)

The ADRE is calculated by first calculating a DRE for each pair of influent and effluent values (i.e., an influent value and an effluent value from the same sampling day/event are used to calculate a DRE). This set of DREs is then averaged to determine the ADRE for a pollutant. Use of the ADRE method requires that a POTW only use data for the sampling days/events for which it has both an influent and an effluent value, and the influent value is greater than zero.

Example

For the example data set in Table 1, the ADRE is calculated as:
ADRE = [78.5+(-6.1)+11.36+72.73+(-20.25)+38.32+71.96+52.59+56.73+60.17+67.95+81.46+38.04 +91.10+95.75)]/15 = 52.69%

2.2 Mean Removal Efficiency (MRE)

The MRE is calculated by using the same formula as for the DRE (shown at the beginning of the Appendix), but instead of using individual influent and effluent values from sampling days/events, the set of influent values is first averaged to determine the average influent value and the same is done for the set of effluent values (either concentrations or loadings). These average values are then used in the DRE equation to result in the MRE for a pollutant. Unlike the ADRE method, the MRE method does not require paired influent and effluent values from the same sampling days/events. The MRE can be based on

influent and effluent sample values that are not always paired (e.g., one effluent sample is lost or destroyed, so the influent average is based on one more value than the effluent average). However, the POTW should use caution in building the data sets for calculating influent and effluent averages because if too many unpaired values are used the removal efficiencies may be meaningless since the influent data and effluent data may represent different time periods, and treatment plant conditions do vary over time.

Example

For the example data set in Table 1, the MRE is calculated as:

Average of the *influent* values = 577.65 lbs/day
Average of the *effluent* values = 150.06 lbs/day
MRE = 100*(577.65-150.06)/577.65 = 74.02%

2.3Comparison of Results from ADRE and MRE Methods

Note that the MRE (74.02%) is higher than the ADRE (52.69%). The three days with the highest influent loadings have relatively high DREs and the two negative DREs (Day 2 and Day 5) occur on days with values that are not significantly greater than the other days. In the ADRE calculation, each day/DRE is given the same weight as the others, while the MRE method gives greater weight to the days with greater loadings. This means that the high removals on the days with high influent loadings affect the MRE more than the other days do, leading to a higher MRE, while the negative values do not have as great an impact since they occur on days with less elevated influent and effluent values If each DRE were to be weighted by its proportion of the total loading, the result would be the same as with the MRE method.

Usually, the MRE and ADRE are slightly different from each other, and can be quite different (as in the example presented here). The POTW can calculate both and decide if one of the estimates is the most appropriate for use in AHL calculations. The POTW can also use the decile approach to determine representative removal efficiencies.

2.4 Decile Approach

The decile approach, unlike the above methods, considers how often the actual DRE will be above or below a specified removal rate, thereby taking into account the variability of POTW removal efficiencies over time. The decile approach involves putting the set of DREs (calculated using the formula presented at the beginning of this appendix) in order from least to greatest and then determining nine decile values. Each decile is the value below which a certain percentage of the DREs fall. For example, the first decile is the value below which 10% of the DREs fall. Similarly, the second decile is the value below which 20% of the DREs fall, on up to the ninth decile, which is the value below which 90% of the DREs fall. The fifth decile is the median and half of the DREs fall below this number. To apply the decile approach, a minimum of nine DREs are required. If exactly nine DREs are available, the nine estimated deciles are simply the nine DREs. If more then nine DREs are used, the POTW needs to calculate the nine decile estimates.

Tables 2 and 3 below illustrate use of the decile approach for the example zinc data set. The steps are:

- ***Step 1:*** Take the set of DREs and put the values in order from smallest to largest (see Table 2).

- ***Step 2:*** The entries for Column 1 are obtained by performing the two calculations. First, define the location for the first decile and then calculate the next eight multiples of that location value to determine the location for the second through ninth deciles. The first location is determined by the equation: (N+1)/10, where N = the number of data pairs/DREs used. For the example data set, N=15, so the location for the first decile is (15+1)/10 = 1.6. The location for the second decile is 2 x 1.6 = 3.2, the location for the third decile is 3 x 1.6 = 4.8, and so on up to the ninth decile of 9 x 1.6 = 14.4. (Column 1 in Table 3)

- ***Step 3:*** For each decile, take the whole number part of the value in Column 1 and place it in Column 2 (e.g., the first decile is 1.6, so the whole number part is 1; the fourth decile is 6.4, so the whole number part is 6).

- ***Step 4:*** The entries in Column 3 of Table 3 are taken from the ordered list of DREs in Table 2. The whole number values in Column 2 correspond to the entry in the ordered list in Table 2 [e.g., the whole number part for the first decile is 1, so entry 1 (-20.25%) from Table 2 is the correct value and is placed in Column 3 of Table 3; similarly, the fourth decile whole number part is 6, so value 6 (52.59%) is placed in Column 3 of Table 3 for the fourth decile].

- ***Step 5:*** Following a similar procedure as in Step 4, values for Column 4 are taken from Table 2 and place in Table 3, except that this time the values taken from Table 2 are the ones that immediately follow the Column 3 entries [e.g., for the first decile, the value placed in Column 4 is -6.10, which is value 2 (the value immediately after value 1) from Table 2; for the fourth decile, the value placed in Column 4 is 56.73, which is value 7 from Table 2].

- ***Step 6:*** Fill in Column 5 by subtracting Column 3 from Column 4 and entering the result.

- ***Step 7:*** Similar to the process for filling Column 2 (explained in Step 3) of Table 3, place the decimal part of the Column 1 entries in Column 6 of Table 3 (e.g., for the first decile, use 0.6; for the fourth decile, use 0.4).

- ***Step 8:*** Fill in Column 7 by multiplying the values in Column 5 by the values in Column 6 and entering the result.

- ***Step 9:*** Add Column 3 and Column 7 and enter the result in Column 8 of Table 3. These values are the estimated deciles.

Table 2. Set of DREs Sorted in Ascending Order

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
-20.25	-6.1	11.36	38.04	38.32	52.59	56.73	60.17	67.95	71.96	72.73	78.50	81.46	91.10	95.75

Table 3. Decile Approach for Zinc Example

Deciles	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
1st	1.6	1	-20.25	-6.10	14.15	0.6	8.490	-11.76
2nd	3.2	3	11.36	38.04	26.68	0.2	5.336	16.70
3rd	4.8	4	38.04	38.32	0.28	0.8	0.224	38.26
4th	6.4	6	52.59	56.73	4.14	0.4	1.656	54.25
5th	8.0	8	60.17	67.95	7.78	0	0.000	60.17
6th	9.6	9	67.95	71.96	4.01	0.6	2.406	70.36
7th	11.2	11	72.73	78.50	5.77	0.2	1.154	73.88
8th	12.8	12	78.50	81.46	2.96	0.8	2.368	80.87
9th	14.4	14	91.10	95.75	4.65	0.4	1.860	92.96

The main value of the decile approach is that it provides an estimate of how often a POTW is expected to exceed certain removal values, such as the ADRE and MRE. For the example, the ADRE is 53% and the MRE is calculated as 74%. If the POTW uses either one of these values, what amount of the time will its removal efficiency exceed those values? This can be estimated using the decile approach. The ADRE of 53% falls between the third and fourth deciles (38.26% and 54.25%, respectively), meaning that the actual removal efficiency is estimated to exceed the ADRE 60% to 70% of the time [(e.g., the third decile means that 30% of the time values will fall below that value (38.26% in this case)]. The MRE of 74% lies between the seventh and eight deciles (73.88% and 80.87%, respectively), so the POTW is estimated to exceed the MRE 20% to 30% of the time.

In developing local limits, appropriate removal efficiencies must be selected for calculation of AHLs for each pollutant. POTWs have often selected a pollutant's ADRE for local limits calculations. EPA recommends that POTWs consider using the decile approach or the MRE method since they better account for variabilities in removal efficiencies over time. For example, since a higher removal efficiency means more pollutant is removed to the sludge, if the POTW used the ADRE from the above example (which is likely exceeded 60% to 70% of the time) to calculate an AHL to protect sludge quality, the resulting AHL may not be adequately protective. More pollutant will likely be removed to the sludge 60% to 70% of the time, so loadings in the sludge will higher than was estimated in the AHL calculations and may lead to exceedances of sludge disposal standards.

A different approach that may address this concern is to use one decile for AHL calculations to protect sludge quality (for sludge disposal and for sludge digester inhibition for conservative pollutants) and a different decile for AHL calculations for protection against Pass Through concerns (e.g., NPDES permit limits). For example, a POTW can base its sludge quality-based AHLs on the seventh decile removal which means that greater removals to sludge and hence greater sludge loadings would be estimated to occur 30% of the time. Similarly, the POTW can use the third decile for calculating its water quality-based AHLs since lower removals (and hence higher effluent loadings) would be estimated to occur about 30% of the time. Although use of these deciles estimates that AHLs would be exceeded 30% of the time, in reality

this is not highly likely. If the entire AHL is allocated to IUs all IUs would have to discharge at their maximum allowed level to reach the AHL. Then if the removal achieved is greater than the seventh decile, more loading would go to the sludge than is provided for with the AHL. If some IUs discharge at below their allocated loadings, which is very likely at any given time, the likelihood of exceeding the allowed loading to the sludge is much lower.

3.NON-CONSERVATIVE POLLUTANTS

The above discussion of removal efficiency calculations applies to conservative pollutants (e.g., metals). However removal efficiencies for non-conservative pollutants can be used to calculate AHLs based on Pass Through criteria (e.g., biological process inhibition data, NPDES permit limits) and the guidance above can be used for non-conservative pollutants only in these cases. Conservative pollutant removal efficiencies are determined by pollutant concentrations in the POTW influent and effluent streams. The presumption applied to conservative pollutants (that removed pollutants are exclusively transferred to the POTW's sludge streams) cannot be extended to non-conservative pollutants since losses through degradation and volatilization do not contribute to pollutant loadings in sludge. Therefore, non-conservative pollutant removal efficiencies cannot be used in deriving AHLs from criteria/standards applicable to the POTW's sludge streams (e.g., digester inhibition, sludge disposal).

The equation for calculating AHLs for non-conservative pollutants, based on criteria for sludge disposal or sludge digester inhibition, is:

$$L_{INFL} = (L_{CINF}) * \frac{C_{CRIT}}{C_{SLDG}}$$

Where:

L_{INFL} = Allowable influent loading, lbs/day
L_{CINF} = POTW influent loading, lbs/d
C_{CRIT} = Sludge criteria, mg/kg dry sludge
C_{SLDG} = Existing sludge pollutant level (in sludge to disposal or to digester), mg/kg dry sludge.

The equation can be rewritten as:

$$L_{INFL} = \frac{C_{CRIT}}{\left(\frac{C_{DIG}}{L_{CINF}}\right)}$$

Where the factor C_{DIG}/L_{CINF} is a partitioning factor that relates the pollutant level in the POTW sludge (C_{DIG}) to the headworks loading of the pollutant (L_{CINF}). The partitioning factor enables calculation of an AHL (L_{INFL}) from a sludge criterion/standard (C_{CRIT}) for a non-conservative pollutant. To determine the partitioning factor for a particular pollutant, the POTW's influent and sludge must be routinely sampled for

that pollutant.

The factor C_{DIG}/L_{CINF} expresses non-conservative pollutant removals to sludge. Non-conservative pollutant removals to sludge are highly variable, and are dependent on such factors as wastewater temperature, ambient air temperature, biodegradation rates (which are temperature dependent), aeration rates, and POTW influent flow. Since non-conservative pollutant removals to sludge are highly variable, the variability in non-conservative pollutant sludge partitioning factors should be addressed in the local limits development process. The procedures and recommendations presented in this manual for addressing removal efficiency variability for conservative pollutants (e.g., the calculation of mean removals and the decile approach) can be extended to addressing variability in non-conservative pollutant sludge partitioning factors. In calculating sludge AHLs, the sludge partitioning factor should be used in place of the removal efficiency for non-conservative pollutants.

APPENDIX M - SPECIFIC GRAVITY OF SLUDGE

The allowable headworks loading (AHL) equations presented in Chapter 6 for sewage sludge disposal contain a factor for the specific gravity of sludge (sludge density). This factor accounts for differences in the density of sludge based on the percent solids of sludge to disposal. The unit conversion factor (8.34) in the same equations converts the overall units into pounds per day (lbs/day), using a specific gravity or density of sludge equal to 1 kg/l, which assumes that sludge has the same density as water. If the dewatered sludge density is different from the density of water, the unit conversion factor is not fully accurate. As the percent solids of a sludge increases, the density of the sludge increases and therefore the error introduced by the inaccurate unit conversion factor increases. To correct this inaccuracy, the numerator of the AHL equation should be multiplied by the specific gravity of the dewatered sludge (as noted in Chapter 6). If a sludge is not dewatered before disposal, the inaccuracy produced by using the unit conversion factor (8.34) without a specific gravity factor would probably not be significant.

The POTW can determine the specific gravity (density) of its sludge prior to disposal through a simple laboratory measurement. The POTW should take this measurement as part of its local limits monitoring program and average the resulting data set (e.g., 7-10 data points) to determine a representative sludge specific gravity (density) factor for use in local limits calculations. The POTW can also estimate the specific gravity of its sludge using the equations below and information on the percent solids.

For a typical wet sludge at 10% solids, the approximate density is 1.03 kg/l. For a typical dewatered sludge at 30% solids, the approximate density is 1.11 kg/l. A sludge at 50% solids may reach a density of 1.2 to 1.3 kg/l, which would result in a 20% to 30% conservative error in the calculation of an AHL if a specific gravity factor is not used. All of these values depend on the amount of volatile solids in the sludge in comparison with the amount of fixed mineral solids, which vary with percent solids, and the densities of each of these types of solids.

$$\frac{M_{WS}}{S_{WS}} = \frac{M_S}{S_S} + \frac{M_W}{S_W}$$

Where: M_{WS} = Mass of wet sludge (kg)
S_{WS} = Specific gravity of wet sludge (kg/l)
M_S = Mass of dry sludge solids (kg)
S_S = Specific gravity of sludge solids (kg/l)
M_W = Mass of water (kg)
S_W = Specific gravity of water (kg/l).

$$\frac{M_S}{S_S} = \frac{M_F}{S_F} + \frac{M_V}{S_V}$$

Where: M_F = Mass of fixed solids (kg)
S_F = Specific gravity of fixed solids (kg/l)
M_V = Mass of volatile solids (kg)
S_V = Specific gravity of volatile solids (kg/l).

The result from the second equation is used in the first equation.

Example

Sludge is 10% solids:

Assume solids consist of 33% fixed mineral solids with a specific gravity of 2.5 kg/l and 67% volatile solids with a specific gravity of 1.2 kg/l.

$$\frac{M_{WS}}{S_{WS}} = [(0.10)x\frac{M_{WS}}{1.45}] + [(0.90)x\frac{M_{WS}}{1}]$$

To determine the specific gravity of the dry sludge solids, use the second equation:
which results in S_s = 1.45 kg/l. Using this value in the first equation:

$$\frac{M_S}{S_S} = [(0.33)x\frac{M_S}{2.5}] + [(0.67)x\frac{M_S}{1.2}]$$

which yields S_{WS} = 1.03 kg/l.

APPENDIX N - SLUDGE AHL EQUATIONS USING FLOW (IN METRIC UNITS)

Some POTWs may have sludge flow data available in dry metric tons per day, rather than MGD. The AHL equations for sludge disposal in Chapter 6 can be converted to use sludge flow data in these units. Some of the equations in Chapter 6 are presented below using flows in dry metric tons per day. Use of these "dry flows" eliminates the need for the specific gravity factor in the equations.

General Sludge Equation for Conservative Pollutants

$$L_{INFL} = \frac{(C_{CRIT})(Q_{SLDG})(0.0022)}{R_{POTW}}$$

Where:

L_{INFL} = Allowable influent loading, lbs/day
C_{CRIT} = Sludge criteria, mg/kg dry sludge
Q_{SLDG} = Total sludge flow to disposal, dry metric tons per day
R_{POTW} = Removal efficiency across POTW (as decimal)
0.0022 = Unit conversion factor.

Land Application

As explained in Chapter 6, determining the land application sludge criteria for use in the general sludge equation requires that the POTW first convert 40 CFR §503 Table 2 and Table 4 sludge criteria into values in mg/kg of dry sludge units. Since Table 2 and Table 4 criteria are in Metric units (kg/ha), they must be converted into English units (lbs/acre) so that they can be used with the equations in Chapter 6 which use other English units (e.g., flow in MGD, area in acres). Table 2 and Table 4 criteria are provided in both Metric and English units in Appendix CC.

Another option is for POTWs to use the land application criteria equations in Metric units (e.g., area in hectares, flow in dry metric tons per day), thus eliminating the need to convert Table 2 and Table 4 values to English units. These equations are provided below. These equations avoid the need for a specific gravity factor since they use also use a "dry flow" for sludge.

$$C_{CRIT} = \frac{(C_{CLM})(SA)}{(SL)(Q_{LA})(0.365)}$$

Where:

C_{CRIT} = Sludge criteria, mg/kg dry sludgeC_{CUM} = Federal (Table 2 of 40 CFR 503.13) or State land application cumulative pollutant loading rate, kg/ha

SA = Site area, hectares

SL = Site life, years

Q_{LA} = Sludge flow to bulk land application at an agricultural, forest, public contact, or reclamation site, dry metric tons per day

0.365 = Unit conversion factor.

$$C_{CRIT} = \frac{C_{ANN}}{(AWSAR)(0.001)}$$

Where:

C_{CRIT} = Sludge criteria, mg/kg dry sludge

C_{ANN} = Federal (Table 4 of 40 CFR 503.13) or State land application annual pollutant loading rate, kg/ha

AWSAR = Annual whole sludge application rate, metric tons per hectare per year dry weight basis

0.001 = Unit conversion factor.

APPENDIX O - CLOSED-CUP FLASHPOINTS FOR SELECT ORGANIC COMPOUNDS

Pollutant	Closed Cup Flashpoint (°F)
Acrolein	-15
Acrylonitrile	30
Benzene	12
Chlorobenzene	82
Chloroethane (Ethyl chloride)	-58
1,1-Dichloroethane	2
1,2-Dichloroethane (Ethylene dichloride)	56
1,1-Dichloroethylene (Vinylidene chloride)	-2
Trans-1,2-Dichloroethylene, (1,2-Dichloroethylene)	36-39
1,2-Dichloropropane (Propylene dichloride)	60
Ethylbenzene	55
Toluene	40

Source: *NIOSH Pocket Guide to Chemical Hazards*, National Institute for Occupational Safety and Health, DHHS (NIOSH) Pub. No. 99-115, April 1999.

APPENDIX P - DISCHARGE SCREENING LEVELS AND HENRY'S LAW CONSTANTS FOR SELECT ORGANIC COMPOUNDS

DISCHARGE SCREENING LEVELS BASED ON EXPLOSIVITY

Pollutant	LELs(1) % volume / volume	LELs (mol/m^3)	Henry's Law Constant $(mol/m^3)/(mg/L)$	MW (g/mol)	Discharge Screening Level (mg/L)
Acrolein	2.8	1.15	8.7E-05	56.1	13163
Acrylonitrile	3.0	1.23	8.4E-05	53.1	14586
Benzene	1.2	0.49	2.9E-03	78.1	169
Chlorobenzene	1.3	0.53	1.3E-03	112.6	395
Chloroethane	3.8	1.55	7.0E-03	65.5	222
1,1-Dichloroethane	5.4	2.21	2.4E-03	99	909
1,2-Dichloroethane	6.2	2.54	4.9E-04	99	5221
1,1-Dichloroethylene	6.5	2.66	1.2E-02	97	215
Trans-1,2-Dichloroethylene	5.6	2.29	4.0E-03	97	571
1,2-Dichloropropane	3.4	1.39	1.0E-03	113	1326
Ethyl benzene	0.8	0.33	3.1E-03	106.2	106
Methyl bromide	10.0	4.09	2.7E-03	95	1521
Methyl chloride	8.1	3.31	7.4E-03	50.5	450
Methylene Chloride	13.0	5.32	1.2E-03	84.9	4307
Toluene	1.1	0.45	3.0E-03	92.1	152
1,1,2-Trichloroethane	6.0	2.45	2.6E-04	133.4	9611
1,1,1-Trichloroethane	7.5	3.07	5.2E-03	133.4	591
Trichloroethylene	8.0 (F)	3.20	3.1E-03	131.4	1029
Vinyl Chloride	3.6	1.47	1.7E-02	62.5	88

LELs assumed 25°C unless noted otherwise.

Source:

1 *Pocket Guide to Chemical Hazards*, National Institute for Occupational Safety and Health(NIOSH), DHHS, Pub. No. 99-115, April 1999.

DISCHARGE SCREENING LEVELS BASED UPON FUME TOXICITY

Pollutant	Exposure Limit (mg/m^3)	Guideline	Reference	Henry's Law Constant (mg/m^3) / (mg/L)	Discharge Screening Level (mg/L)
Acrolein	0.69	STEL	v (ACGIH)	4.9	0.141
Acrylonitrile	21.7	Ceiling	t (OSHA)	4.5	4.822
Benzene	79.8	Ceiling	t (OSHA)	228.0	0.350
Bromoform	5	PEL-TWA	t (OSHA)	22.8	0.219
Carbon tetrachloride	157.3	Ceiling	t (OSHA)	1185.0	0.133
Chlorobenzene	350	PEL-TWA	t (OSHA)	151.0	2.318
Chloroethane	2600	PEL-TWA	t (OSHA)	449.0	5.791
Chloroform	240	Ceiling	t (OSHA)	163.5	1.468
1,1-Dichloroethane	400	PEL-TWA	t (OSHA)	240.4	1.664
1,2-Dichloroethane	405	Ceiling	t (OSHA)	48.1	8.423
1,1-Dichloroethylene	79	STEL	v (ACGIH)	1202.1	0.066
Trans-1,2-Dichloroethylene	790	PEL-TWA	t (OSHA)	389.3	2.030
1,2-Dichloropropane	508	STEL	v (ACGIH)	118.5	4.288
Ethyl benzene	543	STEL	v (ACGIH)	327.0	1.661
Methyl bromide	80	Ceiling	t (OSHA)	255.5	0.313
Methyl chloride	414	Ceiling	t (OSHA)	371.6	1.114
Methylene chloride	434	Ceiling	t (OSHA)	104.8	4.141
1,1,2,2,-Tetrachlorethane	35	PEL-TWA	t (OSHA)	18.6	1.884
Tetrachloroethylene	685	STEL	v (ACGIH)	717.1	0.955
Toluene	1131	Ceiling	t (OSHA)	272.5	4.151
1,1,2-Trichloroethane	45	PEL-TWA	t (OSHA)	34.1	1.321
1,1,1-Trichloroethane	2460	STEL	v (ACGIH)	692.7	3.551
Trichloroethylene	1074	Ceiling	t (OSHA)	408.7	2.628
Vinyl Chloride	12.8	Ceiling	t (OSHA)	1048.0	0.012

v = Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices(TLVs and BEIs), ACGIH 1997.

t = 29 CFR 1900.1000, Title 29, Volume 6, Parts 1910.1000 to end, Revised July 1, 1998 Occupational Safety and Health Administration(OSHA).

HENRY'S LAW CONSTANTS EXPRESSED IN ALTERNATE UNITS

Pollutant	Henry's Law Constant(2) M/atm @298K(25°C)	Henry's Law Constant (atm m^3 / mol)	Henry's Law Constant (mol/m^3 / mg/L)	Henry's Law Constant (mg/m^3 / mg/L)
Acrolein	8.2	0.00012	0.000087	4.9
Acrylonitrile	9.15	0.00011	0.000084	4.5
Benzene	0.18	0.0056	0.0029	228
Bromoform	1.8	0.00056		23
Carbon Tetrachloride	0.034	0.029		1185
Chlorobenzene	0.27	0.0037	0.0013	151
Chloroethane	0.089	0.011	0.007	449
Chloroform	0.25	0.004		164
1,1-Dichloroethane	0.17	0.0059	0.0024	240
1,2-Dichloroethane	0.85	0.0012	0.00049	48
1,1-Dichloroethylene	0.034	0.029	0.012	1202
Trans-1,2-Dichloroethylene	0.105	0.0095	0.004	389
1,2-Dichloropropane	0.345	0.0029	0.001	119
Ethyl benzene	0.125	0.008	0.0031	327
Methyl bromide	0.16	0.0063	0.0027	256
Methyl chloride	0.11	0.0091	0.0074	372
Methylene Chloride	0.39	0.0026	0.0012	105
1,1,2,2,-Tetrachlorethane	2.2	0.00045		19
Tetrachloroethylene	0.057	0.018		717
Toluene	0.15	0.0067	0.003	273
1,1,2-Trichloroethane	1.2	0.00083	0.00026	34
1,1,1-Trichloroethane	0.059	0.017	0.0052	693
Trichloroethylene	0.1	0.01	0.0031	409
Vinyl Chloride	0.039	0.026	0.017	1048

Source: *Compilation of Henry's Law Constants for Inorganic and Organic Species of Potential Importance in Environmental Chemistry*, R. Sanders 1999(version 3); http://www.mpch-mainz.mpg.de/~sander/res/henry.html

APPENDIX Q - OSHA, ACGIH AND NIOSH EXPOSURE LEVELS

EXPOSURE LIMITS FROM VARIOUS AGENCIES FOR VOLATILE ORGANIC PRIORITY POLLUTANTS

	OSHA Exposure Limits				ACGIH				NIOSH			
Volatile Organic Compounds	**PEL/TWA ppm (mg/m3)**	**Ref.**	**Ceiling Limit ppm**	**Ref.**	**STEL ppm**	**STEL mg/m3**	**Ceiling Limit ppm (mg/m^3)**	**Ref.**	**TWA ppm (mg/m^3)**	**STEL ppm (mg/m3)**	**C ppm**	**Ref.**
Acrolein	0.1 (0.25)	t			0.3	0.69	0.1 (0.23)p	v	0.1 (0.25)	0.3 (0.8)		n
Acrylonitrile	2	n(a)	10	n(a)					1		10	n(a)
Benzene	10	t	25	t	2.5	8		v	0.1	1		n
Bromoform	0.5 (5.0)	t(a)							0.5 (5)			n(a)
Carbon Tetrachloride	10	t	25	t	10	63		v(a)		2 (12.6)		n
Chlorobenzene	75 (350)	t										
Chloroethane (Ethyl chloride)	1000 (2600)	t										
Chloroform	(C) 50 (240)	t								2 (9.78)		n
Dichloroethane, 1,1-	100 (400)	t							100 (400)			n
Dichloroethane,1,2- (Ethylene dichloride)	50	t	100	t					1 (4)	2 (8)		n
Dichloroethylene, 1,1- (Vinylidene chloride)	none	n	none	n	20	79		v(p)				
trans-Dichloroethylene,1, 2- (1,2-Dichloroethylene)	200 (790)	t							200 (790)			n
Dichloropropane,1, 2- (Propylene dichloride)	75 (350)	t			110	508		v				
Ethyl benzene	100 (435)	t			125	543		v	100 (435)	125 (545)		n
Methyl bromide	(C) 20 (80)	t(a)										
Methyl chloride	100	t	200	t	100	207		v(a)				
Methylene Chloride (Dichloromethane)	25	n	125	n								
Tetrachlorethane, 1,1,2,2-	5.0 (35)	t(a)							1 (7)			n(a)

a- designated as skin in reference

p- indicates proposed notice of intended change

* NIOSH recommends 60 minute (C) of 2ppm and 25ppm 10hour TWA (Appendix C)

C -indicates ceiling not to be exceeded

References

v- Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices(TLVs and BEIs), ACGIH 1997.

t- Occupational Safety and Health Administration(OSHA), 29 CFR 1900.1000, Title 29, Volume 6, Parts 1910.1000 to end, Revised as of July 1, 1998.

n- NIOSH Pocket Guide to Chemical Hazards, National Institute for Occupational Safety and Health, DHHS (NIOSH) Pub. No. 99-115, April 1999

d- ACGIH Documentation of the Threshold Limit Values and Biological Exposure Indices, Sixth Edition vol.1&2, 1990, 1996 supplements