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EPA

Detailed Costing Document for the Final Effluent Limitations Guidelines and Standards for the Centralized Waste Treatment Industry

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In this document, EPA presents the costs estimated for compliance with the proposed CWT effluent limitations guidelines and standards. Section 1 provides a general description of how the individual treatment technology and regulatory option costs were developed. In Sections 2 through 4, EPA describes the development of costs for each of the wastewater and sludge treatment technologies.

In Section 5, EPA presents additional compliance costs to be incurred by facilities, which are not technology specific. These additional items are retrofit costs, monitoring costs, RCRA permit modification costs, and land costs.

SECTION 1 COSTS DEVELOPMENT

1.1 Technology Costs

EPA obtained cost information for the technologies selected from the following sources:

- the data base developed from the 1991 Waste Treatment Industry (WTI) Questionnaire responses (This contained some process cost information, and was used wherever possible.),
- technical information developed for EPA rulemaking efforts such as the guidelines and standards for: the Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) category, Metal Products and Machinery (MP&M) category, and Industrial Laundries industries category,
- engineering literature,
- the CWT sampling/model facilities, and
- vendors' quotations (used extensively in estimating the cost of the various technologies).

The total costs developed by EPA include the capital costs of investment, annual O&M costs, land requirement costs, sludge disposal costs, monitoring costs, RCRA permit modification costs, and retrofit costs. Because 1989 is the base year for the WTI Questionnaire, EPA scaled all of the costs either up or down to 1989 dollars using the Engineering News Record (ENR) Construction Cost Index.

EPA based the capital costs for the technologies primarily on vendors' quotations. The standard factors used to estimate the capital costs are listed in Table 1-1. Equipment costs typically include the cost of the treatment unit and some ancillary equipment associated with that technology. Other investment costs in addition to the equipment cost include piping, instrumentation and controls, pumps, installation, engineering, delivery, and contingency.

Table 1-1. Standard Capital Cost Algorithm

Factor	Capital Cost
Equipment Cost	Technology-Specific Cost
Installation	25 to 55 percent of Equipment Cost
Piping	31 to 66 percent of Equipment Cost
Instrumentation and Controls	6 to 30 percent of Equipment Cost
Total Construction Cost	Equipment + Installation + Piping + Instrumentation and Controls
Engineering	15 percent of Total Construction Cost
Contingency	15 percent of Total Construction Cost
Total Indirect Cost	Engineering + Contingency
Total Capital Cost	Total Construction Cost + Total Indirect Cost

EPA estimated certain design parameters for costing purposes. One such parameter is the flow rate used to size many of the treatment technologies. EPA used the total daily flow in all cases, unless specifically stated. The total daily flow represents the annual flow divided by 260, the standard number of operating days for a CWT per year.

EPA derived the annual O&M costs for the various systems from vendors' information or from engineering literature, unless otherwise stated. The annual O&M costs represent the costs of maintenance, taxes and insurance, labor, energy, treatment chemicals (if needed), and residuals management (also if needed). Table 1-2 lists the standard factors EPA used to estimate the O&M costs.

Sections 2 through 4 present cost equations for capital costs, O&M costs, and land requirements for each technology and option. EPA also developed capital cost upgrade and O&M cost upgrade equations. EPA used these equations for facilities which already have the treatment technology forming the basis of the option (or some portion of the treatment technology) in-place.

Table 1-2. Standard Operation and Maintenance Cost Factor Breakdown

Factor	O&M Cost (1989 $/YR)
Maintenance	4 percent of Total Capital Cost
Taxes and Insurance	2 percent of Total Capital Cost
Labor	$30,300 to $31,200 per man-year
Electricity	$0.08 per kilowatt-hour
Chemicals:	
Lime (Calcium Hydroxide)	$57 per ton
Polymer	$3.38 per pound
Sodium Hydroxide (100 percent solution)	$560 per ton
Sodium Hydroxide (50 percent solution)	$275 per ton
Sodium Hypochlorite	$0.64 per pound
Sulfuric Acid	$80 per ton
Aries Tek Ltd Cationic Polymer	$1.34 per pound
Ferrous Sulfate	$0.09 per pound
Hydrated Lime	$0.04 per pound
Sodium Sulfide	$0.30 per pound
Residuals Management	Technology-Specific Cost
Total O&M Cost	Maintenance + Taxes and Insurance + Labor + Electricity + Chemicals + Residuals

1.2 Option Costs

EPA developed engineering costs for each of the individual treatment technologies which comprise the CWT regulatory options. These technology-specific costs are broken down into capital, O&M, and land components. To estimate the cost of an entire regulatory option, it is necessary to sum the costs of the individual treatment technologies which make up that option. In a few instances, an option consists of only one treatment technology; for those cases, the option cost is obviously equal to the technology cost. The CWT subcategory technology options are shown in Table 1-3. The treatment technologies included in each option are listed, and the subsections which contain the corresponding cost information are indicated.

EPA generally calculated the capital and O&M costs for each of the individual treatment technologies using a flowrate range of 1 gallon per day to five million gallons per day. However, the flow rate ranges recommended for use in the equations are in a smaller range and are presented for each cost equation is Sections 11.2 through 11.4 of the Development Document for the CWT Point Source Category.

Table 1-3. CWT Treatment Technology Costing Index - A Guide to the Costing Methodology Sections

Subcategory/ Option	Treatment Technology	Section
Metals 2	Selective Metals Precipitation	2.1.1
	Plate and Frame Liquid Filtration	2.2.1
	Secondary Chemical Precipitation	2.1.2
	Clarification	2.2.2
	Plate and Frame Sludge Filtration	4.1
	Filter Cake Disposal	4.2

Subcategory/ Option	Treatment Technology	Section
Metals 3	Selective Metals Precipitation	2.1.1
	Plâte and Frame Liquid Filtration	2.2.1
	Secondary Chemical Precipitation	2.1.2
	Clarification	2.2.2
	Tertiary Chemical Precipitation and pH Adjustment	2.1.3
	Clarification	2.2.2
	Plate and Frame Sludge Filtration	4.1
	Filter Cake Disposal	4.2
Metals 4	Primary Chemical Precipitation	2.1.4
	Clarification	2.2.2
	Secondary (Sulfide) Chemical Precipitation	2.1.5
	Secondary Clarification (for Direct Dischargers Only)	2.2.2
	Multi-Media Filtration	2.5
	Plate and Frame Sludge Filtration *	4.1
Metals - Cyanide Waste Pretreatment	Cyanide Destruction at Special Operating Conditions	2.6
Oils 8	Dissolved Air Flotation	2.8
Oils 8v	Dissolved Air Flotation	2.8
	Air Stripping	2.4
Oils 9	Secondary Gravity Separation	2.7
	Dissolved Air Flotation	2.8
Oils 9v	Secondary Gravity Separation	2.7
	Dissolved Air Flotation	2.8
	Air Stripping	2.4
Organics 4	Equalization	2.3
	Sequencing Batch Reactor	3.1
Organics 3	Equalization	2.3
	Sequencing Batch Reactor	3.1
	Air Stripping	2.4

* Metals Option 4 sludge filtration includes filter cake disposal.

1.2.1 Land Requirements and Costs

EPA calculated land requirements for each piece of new equipment based on the equipment dimensions. The land requirements include the total area needed for the equipment plus peripherals (pumps, controls, access areas, etc.). Additionally, EPA included a 20-foot perimeter around each unit. In the cases where adjacent tanks or pieces of equipment were required, EPA used a 20-foot perimeter for each piece of equipment, and configured the geometry to give the minimum area requirements possible. The land requirement equations for each technology are presented throughout Sections 2 to 4. EPA then multiplied the land requirements by the corresponding land costs (as detailed in 5.4) to obtain facility specific land cost estimates.

1.2.2 Operation and Maintenance Costs

EPA based O&M costs on estimated energy usage, maintenance, labor, taxes and insurance, and chemical usage cost. With the principal exception of chemical usage and labor costs, EPA calculated the O&M costs using a single methodology. This methodology is relatively consistent for each treatment technology, unless specifically noted otherwise.

EPA's energy usage costs include electricity, lighting, and controls. EPA estimated electricity requirements at 0.5 kWhr per 1,000 gallons of wastewater treated. EPA assumed lighting and controls to cost $1,000 per year and electricity cost $0.08 per kWhr. Manufacturers' recommendations form the basis of these estimates.

EPA based maintenance, taxes, and insurance on a percentage of the total capital cost as detailed in Table 1-2.

Chemical usage and labor requirements are technology specific. These costs are detailed for each specific technology according to the index given in Table 1-3.

SECTION 2 PHYSICAL/CHEMICAL WASTEWATER TREATMENT TECHNOLOGY COSTS

2.1 Chemical Precipitation

Wastewater treatment facilities widely use chemical precipitation systems to remove dissolved metals from wastewater. EPA evaluated systems that utilize sulfide, lime, and caustic as the precipitants because of their common use in CWT chemical precipitation systems and their effectiveness in removing dissolved metals.

2.1.1 Selective Metals Precipitation - Metals Option 2 and Metals Option 3

The selective metals precipitation equipment assumed by EPA for costing purposes for Metals Option 2 and Metals Option 3 consists of four mixed reaction tanks, each sized for 25 percent of the total daily flow, with pumps and treatment chemical feed systems. EPA costed for four reaction tanks to allow a facility to segregate its wastes into small batches, thereby facilitating metals recovery and avoiding interference with other incoming waste receipts. EPA assumed that these four tanks would provide adequate surge and equalization capacity for a metals subcategory CWT. EPA based costs on a four batch per day treatment schedule (that is, the sum of four batch volumes equals the facility's daily incoming waste volume).

As shown in Table 1-3, plate and frame liquid filtration follows selective metals precipitation for Metals Options 2 and 3. EPA has not presented the costing discussion for plate and frame liquid filtration in this section (consult Section 2.2.1). Likewise, EPA has presented the discussion for sludge filtration and filter cake disposal in Sections 4.1 and 4.2, respectively.

Capital and Land Costs

EPA obtained the equipment capital cost estimates for the selective metals precipitation systems from vendor quotations. These costs include the cost of the mixed reaction tanks with pumps and treatment chemical feed systems. Because only one facility in the metals subcategory has selective precipitation in-place, EPA included selective metals precipitation capital costs for all facilities (except one) for Metals Options 2 and 3. The total construction cost estimates include installation, piping and instrumentation, and controls. The total capital cost includes engineering and contingency fees at a percentage of the total construction cost (as shown in Table 1-1).

Table 2-1 presents the itemized total capital cost estimates for the selective metals precipitation treatment systems while Figure 2-1 presents the resulting cost curve. The total capital cost equation for the Metals Options 2 and 3 selective metals precipitation is:

$$\ln(Y1) = 14.461 + 0.544\ln(X) + 0.0000047(\ln(X))^2 \qquad (2\text{-}1)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-1. Total Capital Cost Estimates for Selective Metals Precipitation - Metals Options 2 and 3

Flow (MGD)	Equip.	Installation	Piping	Instrument. & Controls	Engineer. & Conting.	Total Capital Costs (1989 $)
0.000001	410	143	123	123	240	1,038
0.00001	1,433	502	430	430	839	3,634
0.001	17,554	6,144	5,266	5,266	10,269	44,499
0.01	61,428	21,500	18,429	18,429	35,936	155,721
0.1	214,966	75,238	64,490	64,490	125,755	544,938
0.5	515,951	180,583	154,785	154,785	301,831	1,307,936
1.0	752,262	263,292	225,679	225,679	440,073	1,906,983
5.0	1,805,546	631,941	541,664	541,664	1,056,245	4,577,060

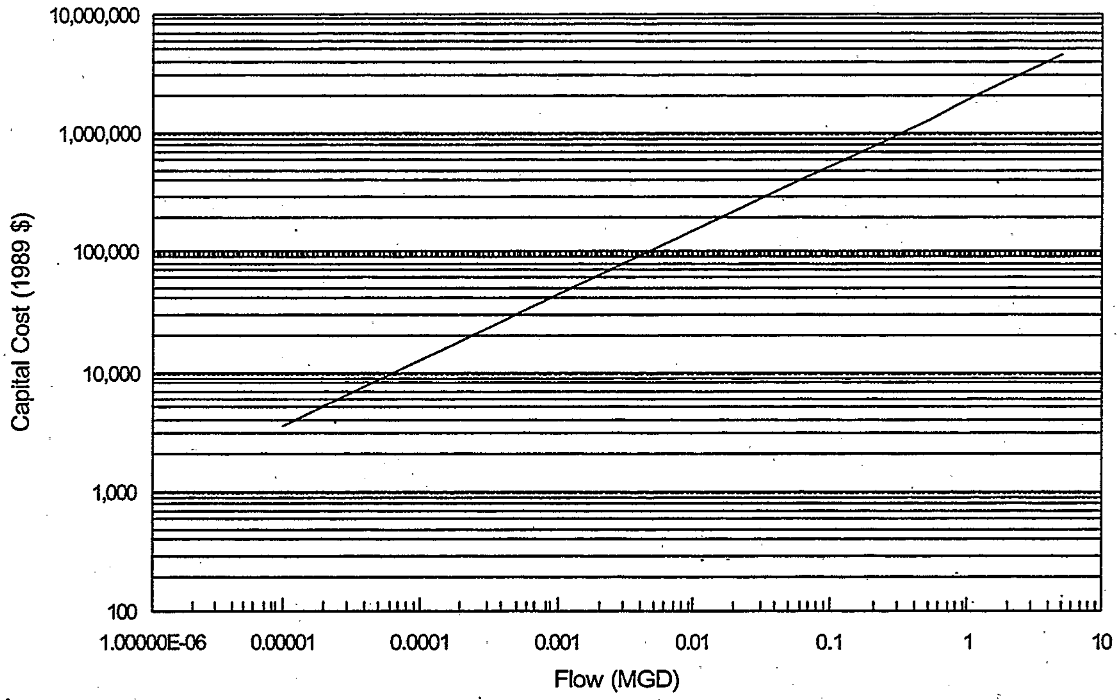

Figure 2-1. Total Capital Cost Curve for Selective Metals Precipitation - Metals Options 2 and 3

Table 2-2 presents the land requirements for the selective metal precipitation treatment systems and Figure 2-2 presents the resulting cost curve. The land requirement equation for Metals Options 2 and 3 selective metals precipitation is:

$$\mathbf{\ln(Y3) = -0.575 + 0.420\ln(X) + 0.025(\ln(X))^2} \qquad \textbf{(2-2)}$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres).

Table 2-2. Land Requirement Estimates for Selective Metals Precipitation - Metals Options 2 and 3

Flow (MGD)	Area Required (Acres)
0.016	0.1413
0.0284	0.164
0.06	0.25
0.2	0.342
0.4	0.376
1.0	0.517
2.0	0.59
3.0	0.92
4.0	1.322

Chemical Usage and Labor Requirement Costs

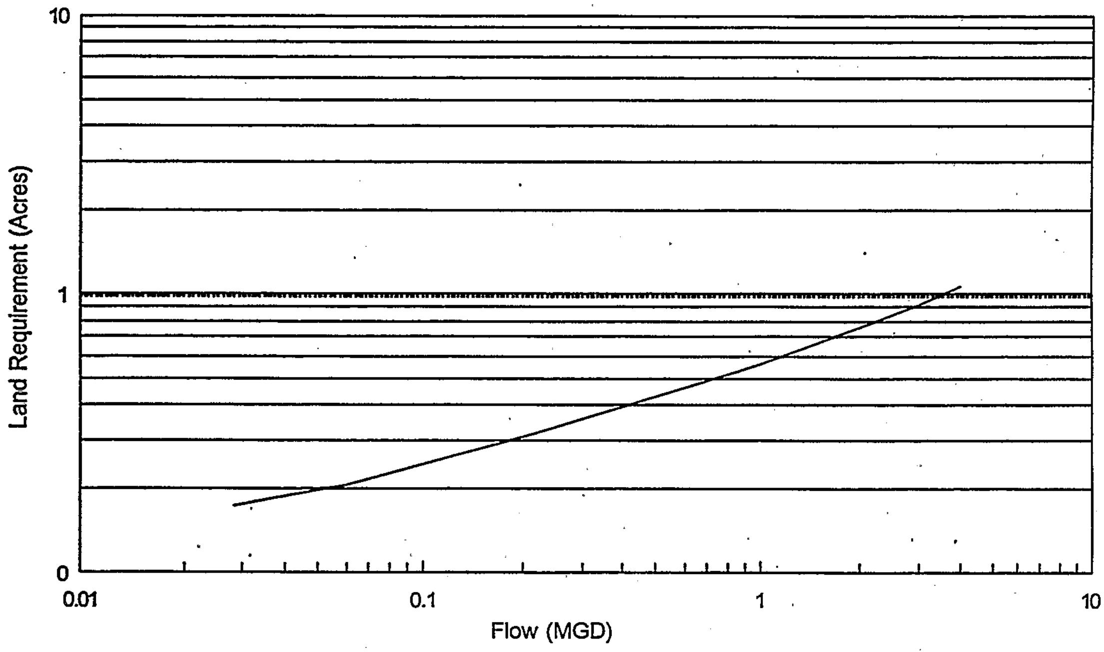

Figure 2-2. Land Requirement Curve for Selective Metals Precipitation - Metals Options 2 and 3

EPA based the labor requirements for selective metals precipitation on the model facility's operation. EPA estimated the labor cost at eight man-hours per batch (four treatment tanks per batch, two hours per treatment tank per batch).

EPA estimated selective metals precipitation chemical costs based on stoichiometric, pH adjustment, and buffer adjustment requirements. For facilities with no form of chemical precipitation in-place, EPA based the stoichiometric requirements on the amount of chemicals required to precipitate each of the metal and semi-metal pollutants of concern from the metals subcategory average raw influent concentrations to current performance levels (See Chapter 12 of the Development Document for the CWT Point Source Category for a discussion of raw influent concentrations and current loadings). The chemicals used were caustic at 40 percent of the required removals and lime at 60 percent of the required removals. (Caustic at 40 percent and lime at 60 percent add up to 100 percent of the stoichiometric requirements.) These chemical dosages reflect the operation of the selective metals precipitation model facility. Selective metals precipitation uses a relatively high percentage of caustic because the sludge resulting from caustic precipitation is amenable to metals recovery. EPA estimated the pH adjustment and buffer adjustment requirements to be 40 percent of the stoichiometric requirement. EPA added an excess of 10 percent to the pH and buffer adjustment requirements, bringing the total to 50 percent. EPA included a 10 percent excess because this is typical of the operation of the CWT facilities visited and sampled by EPA.

Table 2-3 presents the lime and caustic requirements for the selective metals precipitation for facilities with no treatment in-place. Table 2-4 presents the itemized O&M cost estimates for these facilities. Figure 2-3 presents the resulting cost curve. The O&M cost equation for the Metals Options 2 and 3 selective metals precipitation for facilities with no treatment in-place is:

$$\ln(Y2) = 15.6402 + 1.001\ln(X) + 0.04857(\ln(X))^2 \qquad (2\text{-}3)$$

where:

X = Flow Rate (MGD) and
Y2 = O&M Cost (1989 \$/YR).

Table 2-3. Lime and Caustic Requirements for Selective Metals Precipitation - Metals Options 2 and 3

Pollutant	Raw Level (mg/L)	Primary Level (mg/L)	Raw-P Level (mg/L)	Dosage Rates		Flow = 0.00001 MGD		Flow = 0.001 MGD		Flow = 0.1 MGD		Flow = 1.0 MGD	
				Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)
ALUMINUM	363.666	5.580	358.086	4.45	4.11	41.4	28.8	4,144	2,875	414,426	287,508	4,144,263	2,875,082
ANTIMONY	116.714	7.998	108.716	1.64	1.52	4.6	3.2	465	322	46,470	32,239	464,703	322,387
ARSENIC	1.790	0.084	1.706	2.67	2.47	0.1	0.1	12	8	1,185	822	11,850	8,221
BORON	153.726	31.730	121.996	11.1	10.3	35.2	24.4	3,524	2,445	352,389	244,470	3,523,885	2,444,696
CADMIUM	44.629	0.021	44.608	0.71	0.66	0.8	0.6	83	57	8,261	5,731	82,615	57,314
CHROMIUM	1186.645	0.387	1186.258	2.31	2.13	71.2	49.4	7,123	4,942	712,324	494,175	7,123,242	4,941,749
COBALT	25.809	0.254	25.555	2.04	1.88	1.4	0.9	135	94	13,540	9,393	135,400	93,934
COPPER	1736.400	0.448	1735.952	1.26	1.16	56.9	39.5	5,687	3,945	568,670	394,515	5,686,697	3,945,146
IRON	588.910	15.476	573.434	2.15	1.99	32.1	22.2	3,206	2,224	320,599	222,416	3,205,990	2,224,156
LEAD	211.044	0.392	210.652	0.77	0.71	4.2	2.9	423	294	42,327	29,364	423,269	293,643
MANGANESE	26.157	0.245	25.912	2.91	2.69	2.0	1.4	196	136	19,636	13,622	196,360	136,225
MERCURY	0.3000	0.0497	0.250	0.40	0.37	0.0	0.0	0	0	26	18	260	180
MOLYBDENUM	48.403	3.403	45.000	2.50	2.31	2.9	2.0	293	203	29,292	20,321	292,917	203,211
NICKEL	374.739	2.786	371.953	2.04	1.89	19.8	13.7	1,978	1,372	197,823	137,240	1,978,235	1,372,401
SELENIUM	0.328	0.514	0.000	2.03	1.87	0.0	0.0	0	0	0	0	0	0
SILVER	1.100	0.091	1.009	0.37	0.34	0.0	0.0	1	1	97	68	974	675
THALLIUM	0.461	0.0259	0.435	0.59	0.54	0.0	0.0	1	0	66	46	665	461
TIN	1337.900	1.026	1336.874	1.35	1.25	46.9	32.5	4,689	3,253	468,940	325,327	4,689,397	3,253,269
TITANIUM	795.600	0.239	795.361	3.34	3.09	69.1	48.0	6,913	4,796	691,305	479,593	6,913,045	4,795,925
VANADIUM	38.57	0.037	38.533	3.14	2.91	3.1	2.2	315	218	31,492	21,848	314,922	218,477
YTTRIUM	0.096	0.026	0.070	1.35	1.25	0.0	0.0	0	0	25	17	246	171
ZINC	978.16	3.9	974.260	1.22	1.13	31.0	21.5	3,102	2,152	310,199	215,201	3,101,991	2,152,007
						423	293	42,291	29,339	4,229,093	2,933,933	42,290,926	29,339,330

Table 2-4. O&M Cost Estimates for Selective Metals Precipitation - Metals Option 2 and 3

Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	Chemical Costs	Total O&M Cost (1989 $/YR)
0.000001	1,000	42	21	52,464	7	53,534
0.00001	1,000	145	73	52,464	67	53,749
0.001	1,010	1,780	890	53,900	6,651	64,231
0.01	1,104	6,229	3,114	58,964	66,512	135,923
0.1	2,040	21,798	10,899	64,504	665,117	764,358
0.5	6,200	52,317	26,159	68,684	3,325,587	3,478,947
1.0	11,400	76,279	38,140	70,564	6,651,173	6,847,556
5.0	53,000	183,082	91,541	75,136	33,255,866	33,658,625

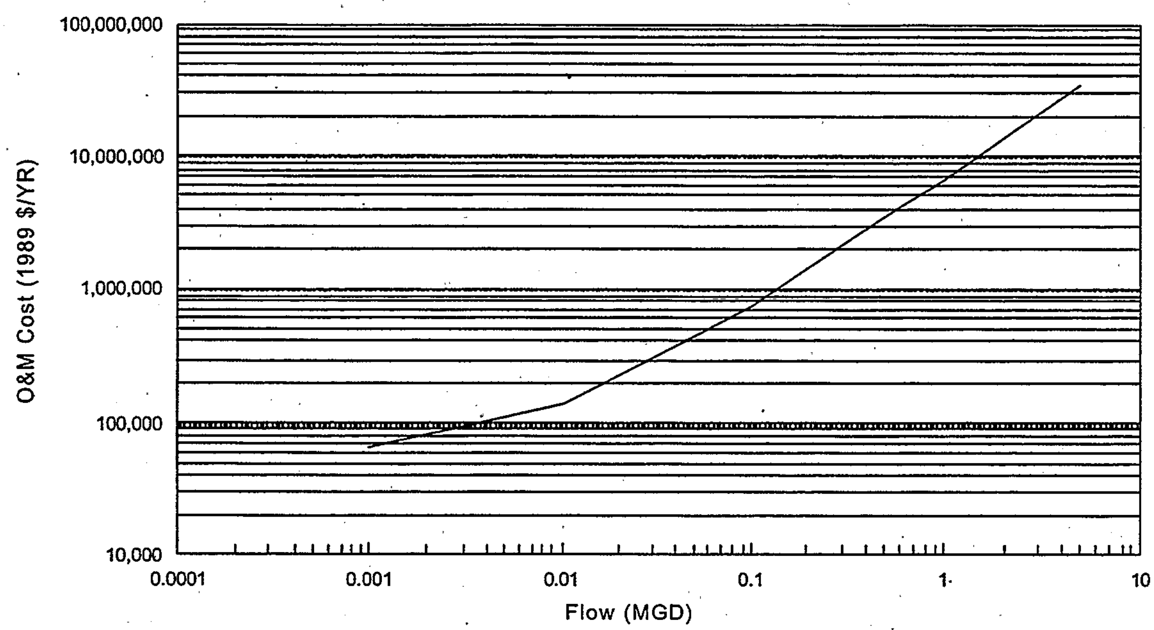

Figure 2-3. O&M Cost Curve for Selective Metals Precipitation - Metals Options 2 and 3

EPA estimated selective metals precipitation upgrade costs for facilities that currently utilize some form of chemical precipitation. Based on responses to the Waste Treatment Industry Questionnaire, EPA assumed that the in-place chemical precipitation systems use a dosage ratio of 25% caustic and 75% lime and achieve a reduction of pollutants from "raw" to "current" levels. Table 2-5 presents the chemical dosages that EPA estimates facilities currently use to treat their wastewater from "raw" to "current" levels. The selective metals precipitation upgrade would require a change in the existing dosage mix to 40% caustic and 60 % lime. Table 2-6 presents the chemical dosages required for facilities to treat their wastewaters from "raw" to "current" levels using this dosage mix. Therefore, the selective metals precipitation upgrade for facilities with in-place chemical precipitation is the increase in caustic cost (from 25 % to 40%) minus the lime credit (to decrease from 75% to 60%). Table 2-7 presents the itemized O&M cost estimates for Metals Options 2 and 3 selective metals precipitation upgrades for facilities that currently utilize some form of chemical precipitation. Figure 2-4 presents the resulting cost curve. The O&M upgrade cost equation for the Metals Options 2 and 3 is:

$$\ln(Y2) = 14.2545 + 0.8066\ln(X) + 0.04214(\ln(X))^2 \qquad (2\text{-}4)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 \$/YR).

Table 2-5. 75% Lime and 25% Caustic Credits for Selective Metals Precipitation Upgrades (Raw to Current Removals) - Metals Options 2 and 3

Pollutant	Raw Level (mg/L)	Current Level (mg/L)	Raw-C Level (mg/L)	Dosage Rates		Flow = 0.00001 MGD		Flow = 0.001 MGD		Flow = 0.1 MGD		Flow = 1.0 MGD	
				Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)
ALUMINUM	363.666	5.580	358.086	4.45	4.11	19.0	26.4	1,899	2,635	189,945	263,549	1,899,454	2,635,492
ANTIMONY	116.714	7.998	108.716	1.64	1.52	2.1	3.0	213	296	21,299	29,552	212,989	295,522
ARSENIC	1.790	0.084	1.706	2.67	2.47	0.1	0.1	5	8	543	754	5,431	7,536
BORON	153.726	31.730	121.996	11.1	10.3	16.2	22.4	1,615	2,241	161,511	224,097	1,615,114	2,240,971
CADMIUM	44.629	0.021	44.608	0.71	0.66	0.4	0.5	38	53	3,787	5,254	37,865	52,538
CHROMIUM	1186.645	0.387	1186.258	2.31	2.13	32.6	45.3	3,265	4,530	326,482	452,994	3,264,819	4,529,937
COBALT	25.809	0.254	25.555	2.04	1.88	0.6	0.9	62	86	6,206	8,611	62,058	86,106
COPPER	1736.400	0.448	1735.952	1.26	1.16	26.1	36.2	2,606	3,616	260,640	361,638	2,606,403	3,616,384
IRON	588.910	15.476	573.434	2.15	1.99	14.7	20.4	1,469	2,039	146,941	203,881	1,469,412	2,038,809
LEAD	211.044	0.393	210.651	0.77	0.71	1.9	2.7	194	269	19,400	26,917	193,997	269,171
MANGANESE	26.157	0.245	25.912	2.91	2.69	0.9	1.2	90	125	9,000	12,487	89,998	124,873
MERCURY	0.3000	0.5000	0.000	0.40	0.37	0.0	0.0	0	0	0	0	0	0
MOLYBDENUM	48.403	3.403	45.000	2.50	2.31	1.3	1.9	134	186	13,425	18,628	134,254	186,277
NICKEL	374.739	2.787	371.952	2.04	1.89	9.1	12.6	907	1,258	90,669	125,803	906,689	1,258,030
SELENIUM	0.328	0.514	0.000	2.03	1.87	0.0	0.0	0	0	0	0	0	0
SILVER	1.100	0.091	1.009	0.37	0.34	0.0	0.0	0	1	45	62	446	619
THALLIUM	0.461	0.026	0.435	0.59	0,54	0.0	0.0	0	0	30	42	305	423
TIN	1337.900	1.026	1336.874	1.35	1.25	21.5	29.8	2,149	2,982	214,931	298,216	2,149,307	2,982,163
TITANIUM	795.600	0.239	795.361	3.34	3.09	31.7	44.0	3,168	4,396	316,848	439,626	3,168,479	4,396,265
VANADIUM	38.57	0.037	38.533	3.14	2.91	1.4	2.0	144	200	14,434	20,027	144,339	200,271
YTTRIUM	0.096	0.026	0.070	1.35	1.25	0.0	0.0	0	0	11	16	113	156
ZINC	978.16	3.9	974.260	1.22	1.13	14.2	19.7	1,422	1,973	142,175	197,267	1,421,746	1,972,673
						194	269	19,383	26,894	1,938,322	2,689,422	19,383,218	26,894,216

Table 2-6. 60% Lime and 40% Caustic Requirements for Selective Metals Precipitation Upgrades (Raw to Current Removals) - Metals Options 2 and 3

Pollutant	Raw Level (mg/L)	Current Level (mg/L)	Raw-C Level (mg/L)	Dosage Rates		Flow = 0.00001 MGD		Flow = 0.001 MGD		Flow = 0.1 MGD		Flow = 1.0 MGD	
				Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)
ALUMINUM	363.666	5.580	358.086	4.45	4.11	30.4	21.1	3,039	2,108	303,913	210,839	3,039,126	2,108,394
ANTIMONY	116.714	7.998	108.716	1.64	1.52	3.4	2.4	341	236	34,078	23,642	340,782	236,417
ARSENIC	1.790	0.084	1.706	2.67	2.47	0.1	0.1	9	6	869	603	8,690	6,029
BORON	153.726	31.730	121.996	11.1	10.3	25.8	17.9	2,584	1,793	258,418	179,278	2,584,183	1,792,777
CADMIUM	44.629	0.021	44.608	0.71	0.66	0.6	0.4	61	42	6,058	4,203	60,584	42,030
CHROMIUM	1186.645	0.387	1186.258	2.31	2.13	52.2	36.2	5,224	3,624	522,371	362,395	5,223,711	3,623,949
COBALT	25.809	0.254	25.555	2.04	1.88	1.0	0.7	99	69	9,929	6,888	99,293	68,885
COPPER	1736.400	0.448	1735.952	1.26	1.16	41.7	28.9	4,170	2,893	417,024	289,311	4,170,245	2,893,107
IRON	588.910	15.476	573.434	2.15	1.99	23.5	16.3	2,351	1,631	235,106	163,105	2,351,059	1,631,047
LEAD	211.044	0.393	210.651	0.77	0.71	3.1	2.2	310	215	31,040	21,534	310,396	215,337
MANGANESE	26.157	0.245	25.912	2.91	2.69	1.4	1.0	144	100	14,400	9,990	143,997	99,898
MERCURY	0.3000	0.5000	0.000	0.40	0.37	0.0	0.0	0	0	0	0	0	0
MOLYBDENUM	48.403	3.403	45.000	2.50	2.31	2.1	1.5	215	149	21,481	14,902	214,806	149,022
NICKEL	374.739	2.787	371.952	2.04	1.89	14.5	10.1	1,451	1,006	145,070	100,642	1,450,702	1,006,424
SELENIUM	0.328	0.514	0.000	2.03	1.87	0.0	0.0	0	0	0	0	0	0
SILVER	1.100	0.091	1.009	0.37	0.34	0.0	0.0	1	0	71	50	714	495
THALLIUM	0.461	0.026	0.435	0.59	0.54	0.0	0.0	0	0	49	34	487	338
TIN	1337.900	1.026	1336.874	1.35	1.25	34.4	23.9	3,439	2,386	343,889	238,573	3,438,891	2,385,731
TITANIUM	795.600	0.239	795.361	3.34	3.09	50.7	35.2	5,070	3,517	506,957	351,701	5,069,567	3,517,012
VANADIUM	38.57	0.037	38.533	3.14	2.91	2.3	1.6	231	160	23,094	16,022	230,943	160,216
YTTRIUM	0.096	0.026	0.070	1.35	1.25	0.0	0.0	0	0	18	13	180	125
ZINC	978.16	3.9	974.260	1.22	1.13	22.7	15.8	2,275	1,578	227,479	157,814	2,274,794	1,578,138
						310	215	31,013	21,515	3,101,315	2,151,537	31,013,150	21,515,372

Table 2-7. O&M Upgrade Cost Estimates - Selective Metals Precipitation (Raw to Current Removals) - Metals Options 2 and 3

Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	Chemical Cost	Total O&M Cost (1989 $/YR)
0.000001	1,000	42	21	52,464	2	53,529
0.00001	1,000	145	73	52,464	15	53,697
0.001	1,010	1,780	890	53,900	1,445	59,025
0.01	1,104	6,229	3,114	58,964	14,458	83,869
0.05	1,520	14,950	7,475	62,784	72,291	159,020
0.1	2,040	21,798	10,899	64,504	144,582	243,823
0.5	6,200	52,317	26,159	68,684	722,909	876,269
1.0	11,400	76,279	38,140	70,564	1,445,818	1,642,201
5.0	53,000	183,082	91,541	75,136	7,229,093	7,631,852

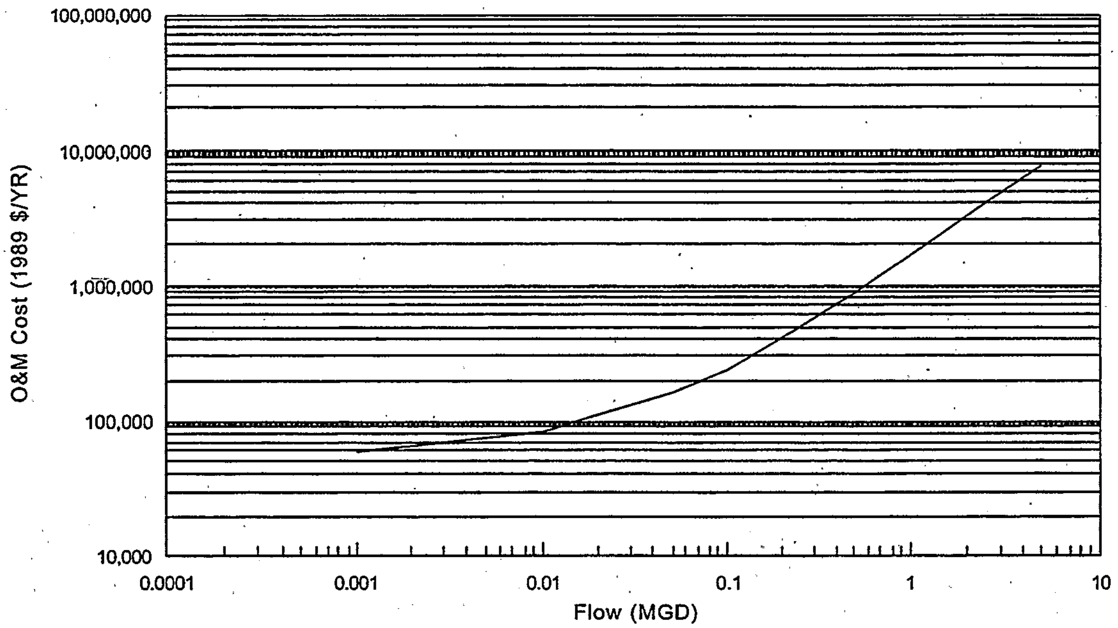

Figure 2-4. O&M Upgrade Cost Curve for Selective Metals Precipitation (Raw to Current Removals) - Metals Options 2 and 3

2.1.2 Secondary Precipitation - Metals Option 2 and Metals Option 3

The secondary precipitation system in the model technology for Metals Option 2 and Metals Option 3 follows selective metals precipitation and plate and frame liquid filtration. This secondary chemical precipitation equipment consists of a single mixed reaction tank with pumps and a treatment chemical feed system, which is sized for the full daily batch volume.

As shown in Table 1-3, clarification follows secondary chemical precipitation for Metals Options 2 and 3. The costing discussion for clarification following secondary precipitation is presented in Section 2.2.2. The discussions for sludge filtration and the associated filter cake disposal are presented in Sections 4.1, and 4.2, respectively.

Many facilities in the metals subcategory currently have chemical precipitation units in-place. For these facilities, cost upgrades may be appropriate. EPA used the following set of rules to decide whether a facility's costs should be based on a full cost equation or an upgrade equation for the secondary chemical precipitation step of Metals Options 2 and 3:

- Facilities with no chemical precipitation in-place should use the full capital and O&M costs.
- Facilities with primary chemical precipitation in-place should assume no capital costs, no land requirements, but an O&M upgrade cost for the primary step.
- Facilities with secondary chemical precipitation currently in-place should assume no capital costs, no land requirements, and no O&M costs for the secondary step.

Capital and Land Costs

For facilities that have no chemical precipitation in-place, EPA calculated capital cost estimates for the secondary precipitation treatment systems from vendor quotations.

EPA estimated the other components (i.e., piping, instrumentation and controls, etc.) of the total capital cost by applying the same factors and additional costs as detailed for selective metals precipitation (see Section 2.1.1 above).

For the facilities that have at least primary chemical precipitation in-place, EPA assumed that the capital cost for the secondary precipitation treatment system would be zero. The in-place primary chemical precipitation systems would serve as secondary precipitation systems after the installation of upstream selective metals precipitation units.

Table 2-8 presents the itemized capital cost estimates for the secondary precipitation treatment systems in Metals Options 2 and 3 while Figure 2-5 presents the resulting cost curve. The total capital cost equation for Metals Options 2 and 3 secondary precipitation is:

$$\ln(Y1) = 13.829 + 0.544\ln(X) + 0.00000496(\ln(X))^2 \qquad (2\text{-}5)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-8. Total Capital Cost Estimates for Secondary Precipitation - Metals Options 2 and 3

Flow (MGD)	Equipment Cost	Piping	Instrumentation & Controls	Installation	Engineering & Contingency	Total Capital Cost (1989 $)
0.000001	218	65	65	76	127	552
0.00001	762	229	229	267	446	1,931
0.001	9,329	2,799	2,799	3,265	5,457	23,649
0.01	32,646	9,794	9,794	11,426	19,098	82,758
0.05	78,355	23,507	23,507	27,424	45,838	198,631
0.1	114,243	34,273	34,273	39,985	66,832	289,606
0.5	274,201	82,260	82,260	95,970	160,408	695,100
1.0	399,788	119,936	119,936	139,926	233,876	1,013,462
5.0	959,554	287,866	287,866	335,844	561,339	2,432,469

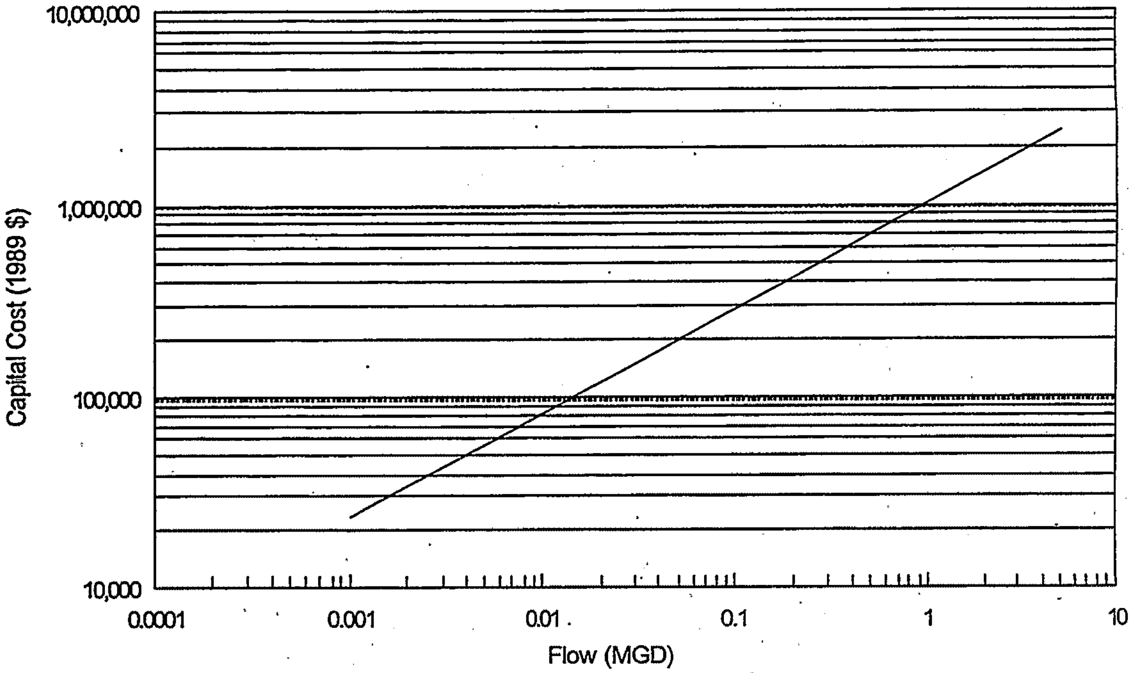

Figure 2-5. Total Capital Cost Curve for Secondary Precipitation - Metals Options 2 and 3

Table 2-9 presents the land requirements for the secondary chemical precipitation treatment systems. Figure 2-6 presents the resulting cost curve. The land requirement equation for Metals Options 2 and 3 secondary chemical precipitation is:

$$\ln(Y3) = -1.15 + 0.449\ln(X) + 0.027(\ln(X))^2 \qquad (2\text{-}6)$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres).

Table 2-9. Land Requirement Estimates for Secondary Precipitation - Metals Options 2 and 3

Flow (MGD)	Area Required (Acres)
0.0040	0.056
0.0071	0.063
0.015	0.088
0.100	0.126
0.250	0.166
0.500	0.186
1.00	0.388

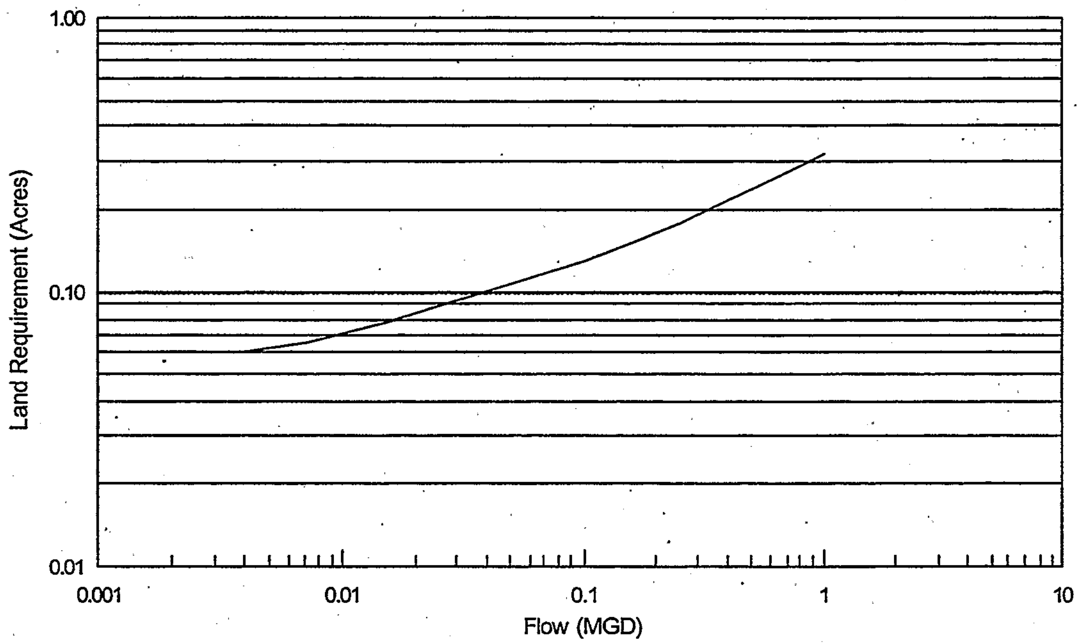

Figure 2-6. Land Requirement Curve for Secondary Precipitation - Metals Options 2 and 3

Chemical Usage and Labor Requirement Costs

EPA developed O&M cost estimates for the secondary precipitation step ofMetals Options 2 and 3 for facilities with and without chemical precipitation currently in-place. EPA assumed the labor cost to be two hours per batch, based on manufacturers' recommendations. For facilities with no chemical precipitation in-place, EPA calculated the amount of lime required to precipitate each of the metals and semi-metals from the metals subcategory current performance concentrations (achieved withthe previously explained selective metals precipitation step) to the Metals Option 2 long-term average concentrations. EPA then added a ten percent excess dosage factor and based the chemical addition costs on the required amount of lime only, which is based on the operation of the model facility for this technology.

Table 2-10 presents the lime requirements for the secondary chemical precipitation step of Metals Options 2 and 3. Table 2-11 presents the itemized annual O&M estimates for the secondary chemical precipitation units. Figure 2-7 presents the resulting cost curve. The O&M cost equation for Metals Options 2 and 3 secondary chemical precipitation is:

$$\ln(Y2) = 11.6553 + 0.48348\ln(X) + 0.02485(\ln(X))^2 \qquad (2\text{-}7)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

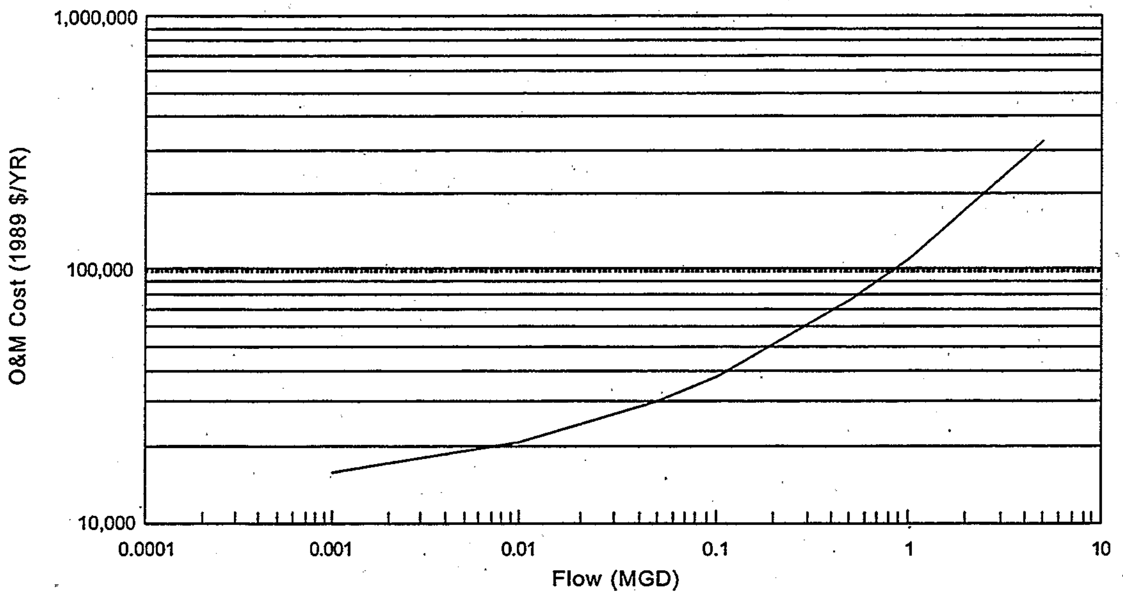

Figure 2-7. O&M Cost Curve for Secondary Precipitation - Metals Options 2 and 3

Table 2-11. O&M Cost Estimates for Secondary Precipitation - Metals Options 2 and 3

Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	Chemical Cost	Total O&M Cost (1989 $/YR)
0.000001	1,000	22	11	13,116	0	14,149
0.00001	1,000	77	39	13,116	1	14,233
0.001	1,010	946	473	13,475	21	15,925
0.01	1,104	3,310	1,655	14,741	214	21,024
0.05	1,520	7,945	3,973	15,696	1,070	30,204
0.1	2,040	11,584	5,792	16,126	2,140	37,682
0.5	6,200	27,804	13,902	17,171	10,198	75,775
1.0	11,400	40,538	20,269	17,641	21,395	111,243
5.0	53,000	97,299	48,649	18,784	106,976	324,708

Table 2-10. Lime Requirements for Secondary Precipitation - Metals Options 2 and 3

Pollutant	Current (mg/L)	Option 2 (mg/L)	Current-2 (mg/L)	Dosarge Rates	Flow = 0.00001 MGD	Flow = 0.001 MGD	Flow = 0.1 MGD	Flow = 1.0 MGD
				Lime (LBS/YR)	Lime (LBS/YR)	Lime (LBS/YR)	Lime (LBS/YR)	Lime (LBS/YR)
ALUMINUM	5.580	0.337	5.243	4.11	51.5	5,145	514,509	51,450,900
ANTIMONY	7.998	0.021	7.977	1.52	28.9	2,891	289,118	28,911,754
ARSENIC	0.084	0.018	0.066	2.47	0.4	39	3,887	388,732
BORON	31.730	8.182	23.548	10.3	576.7	57,674	5,767,444	576,744,412
CADMIUM	0.021	0.101	0.000	0.66	0.0	0	0	0
CHROMIUM	0.387	0.690	0.000	2.13	0.0	0	0	0
COBALT	0.2535	0.124	0.130	1.88	0.6	58	5,818	581,790
COPPER	0.448	0.97	0.000	1.16	0.0	0	0	0
IRON	15.476	4.134	11.342	1.99	53.8	5,377	537,677	53,767,709
LEAD	0.393	0.308	0.085	0.71	0.1	14	1,446	144,648
MANGANESE	0.245	0.061	0.184	2.69	1.2	118	11,823	1,182,287
MERCURY	0.0497	0.0010	0.049	0.37	0.0	4	429	42,853
MOLYBDENUM	3.403	0.652	2.751	2.31	15.2	1,518	151,836	15,183,641
NICKEL	2.787	1.06	1.727	1.89	7.8	779	77,882	7,788,168
SELENIUM	0.514	0.235	0.279	1.87	1.2	125	12,474	1,247,357
SILVER	0.091	0.004	0.087	0.34	0.1	7	710	71,015
THALLIUM	0.026	0.025	0.001	0.54	0.0	0	13	1,296
TIN	1.026	0.029	0.997	1.25	3.0	297	29,653	2,965,342
TITANIUM	0.239	0.004	0.235	3.09	1.7	173	17,319	1,731,913
VANADIUM	0.037	0.01	0.027	2.91	0.2	19	1,871	187,106
YTTRIUM	0.026	0.002	0.024	1.25	0.1	7	715	71,472
ZINC	3.9	0.845	3.055	1.13	8.2	825	82,476	8,247,648
					751	75,071	7,507,100	750,710,043

For facilities with chemical precipitation in-place, EPA calculated an O&M upgrade cost. In calculating the O&M upgrade cost, EPA assumed that there would be no additional costs associated with any of the components of the annual O&M cost, except for increased chemical costs. Since EPA already applied credit for chemical costs for facilities with primary precipitation in estimating the selective metals precipitation chemical costs, the chemical upgrade costs for facilities with primary precipitation are identical to facilities with no chemical precipitation in-place. Since EPA assumed that facilities with secondary precipitation would achieve the Metals Option 2 long term average concentrations with their current system and chemical additions (after installing the selective metals precipitation system), EPA assumed these facilities would not incur any additional chemical costs. In turn, EPA also assumed that facilities with secondary precipitation units in-place would incur no O&M upgrade costs.

Table 2-12 presents the itemized O&M upgrade cost estimates for the secondary chemical precipitation treatment systems. Figure 2-8 presents the resulting cost curve. The O&M upgrade cost equation for the secondary chemical precipitation systems is:

$$\ln(Y2) = 9.97021 + 1.00162\ln(X) + 0.00037(\ln(X))^2 \qquad \textbf{(2-8)}$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-12. O&M Upgrade Cost Estimates for Secondary Precipitation - Metals Options 2 and 3

Flow (MGD)	Chemical Cost	Total O&M Cost (1989 $/YR)
0.0005	11	11
0.001	21	21
0.005	107	107
0.01	214	214
0.05	1,070	1,070
0.1	2,140	2,140
0.5	10,698	10,698
1.0	21,395	21,395
5.0	106,976	106,976

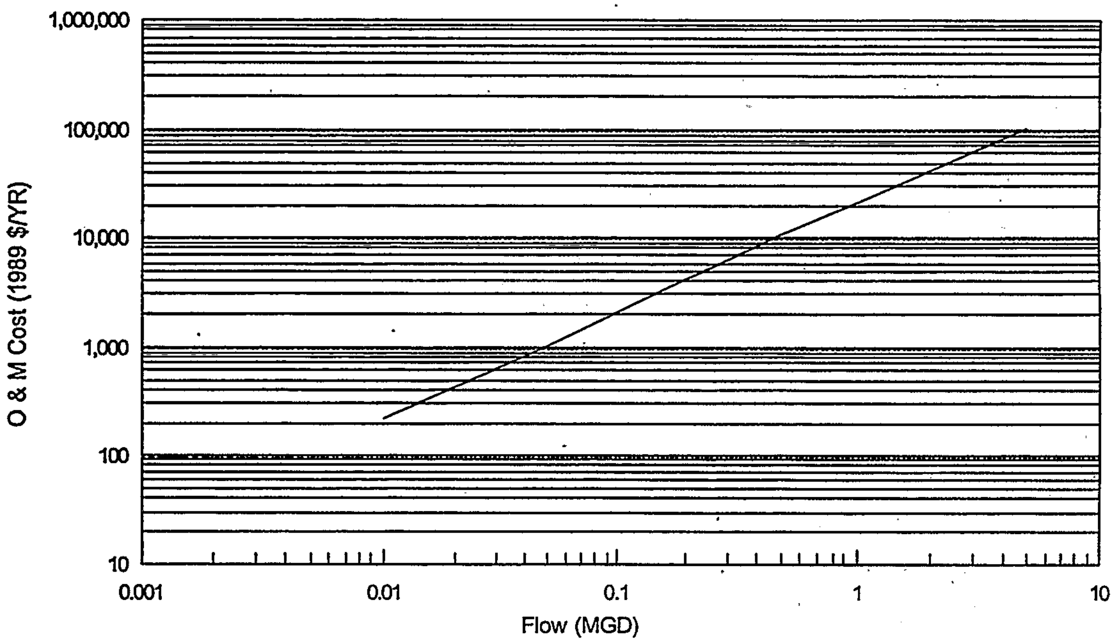

Figure 2-8. O&M Upgrade Cost Curve for Secondary Precipitation - Metals Options 2 and 3

2.1.3 Tertiary Precipitation and pH Adjustment - Metals Option 3

The tertiary chemical precipitation step for Metals Option 3 follows the secondary precipitation and clarification steps. This tertiary precipitation system consists of a rapid mix neutralization tank and a pH adjustment tank. In this step, the wastewater is fed to the rapid mix neutralization tank where lime slurry is added to raise the pH to 11.0. Effluent from the neutralization tank then flows to a clarifier for solids removal. The clarifier overflow goes to a pH adjustment tank where sulfuric acid is added to achieve the desired final pH of 9.0. This section explains the development of the cost estimates for the rapid mix neutralization tank and the pH adjustment tank. The discussions for clarification, sludge filtration, and associated filter cake disposal are presented in Sections 2.2.2, 4.1, and 4.2, respectively.

Capital and Land Costs

EPA developed the capital cost estimates for the rapid mix tank assuming continuous flow and a 15-minute detention time, which is based on the model facility's standard operation. The equipment cost includes one tank, one agitator, and one lime feed system.

EPA developed the capital cost estimates for the pH adjustment tank assuming continuous flow and a five-minute detention time, also based on the model facility's operation. The equipment cost includes one tank, one agitator, and one sulfuric acid feed system.

EPA estimated the other components (i.e., piping, instrumentation and controls, etc.) of the total capital cost for both the rapid mix and pH adjustment tank by applying the same factors and additional costs as detailed for selective metals precipitation (see Section 2.1.1 above).

The itemized capital cost estimates for the rapid mix and pH adjustment tank are presented in Tables 2-13 and 2-14, respectively. The resulting cost curves are presented as Figures 2-9 and 2-10. The total capital cost equations calculated for the rapid mix and pH adjustment tanks are presented below as Equations 2-9 and 2-10, respectively.

$$\ln(Y1) = 12.318 + 0.543\ln(X) - 0.000179(\ln(X))^2 \quad (2\text{-}9)$$

$$\ln(Y1) = 11.721 + 0.543\ln(X) + 0.000139(\ln(X))^2 \quad (2\text{-}10)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-13. Total Capital Cost Estimates for Rapid Mix Tanks - Metals Option 3

Flow (MGD)	Equipment Cost	Piping	Instrument. & Controls	Installation	Engineering & Contingency	Total Capital Cost (1989 $)
0.00001	165	49	49	58	96	417
0.0001	592	178	178	207	347	1,502
0.001	2,073	622	622	726	1,213	5,256
0.01	7,224	2,167	2,167	2,528	4,226	18,312
0.1	25,281	7,584	7,584	8,848	14,789	64,086
0.5	60,468	18,203	18,203	21,237	35,433	153,544
1.0	88,468	26,541	26,541	30,964	51,754	224,268
5.0	212,338	63,701	63,701	74,318	124,217	538,275

Table 2-14. Total Capital Cost Estimates for pH Adjustment Tanks - Metals Option 3

Flow (MGD)	Equipment Cost	Piping	Instrument & Controls	Installation	Engineering & Contingency	Total Capital Cost (1989 $)
0.00001	91	27	27	32	53	230
0.0001	326	98	98	114	191	827
0.001	1,141	342	342	399	667	2,891
0.005	2,726	818	818	954	1,595	6,901
0.01	3,974	1,192	1,192	1,391	2,325	10,074
0.05	9,329	2,799	2,799	3,265	5,458	23,640
0.1	13,907	4,172	4,172	4,867	8,135	35,253
0.5	33,379	10,014	10,014	11,683	19,581	84,851
1.0	48,667	14,600	14,600	17,033	28,470	123,370
5.0	116,808	35,042	35,042	40,883	68,333	296,108

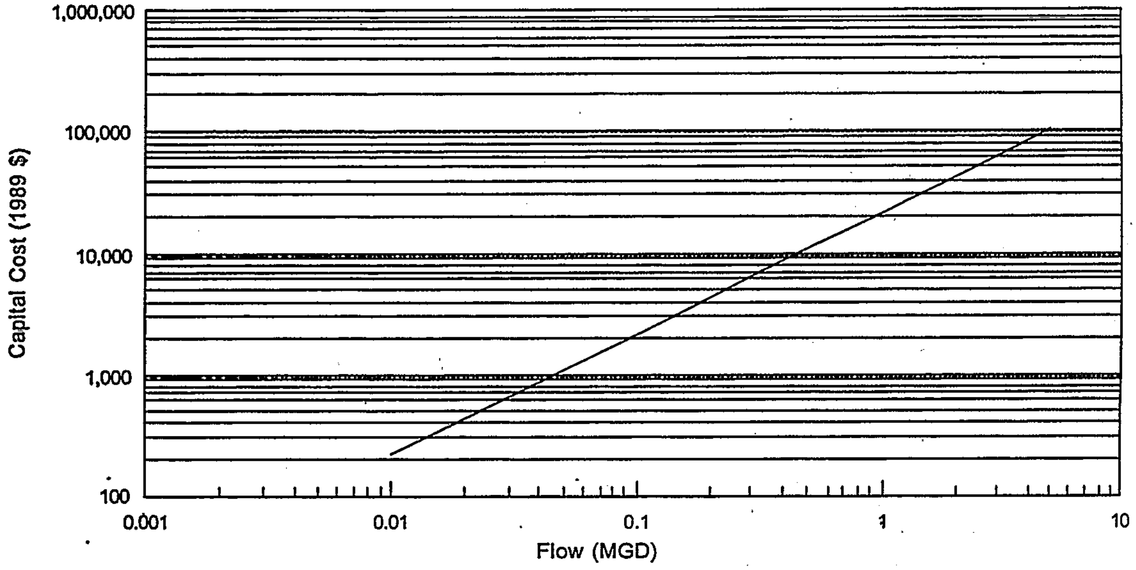

Figure 2-9. Total Capital Cost Curve for Rapid Mix Tanks - Metals Option 3

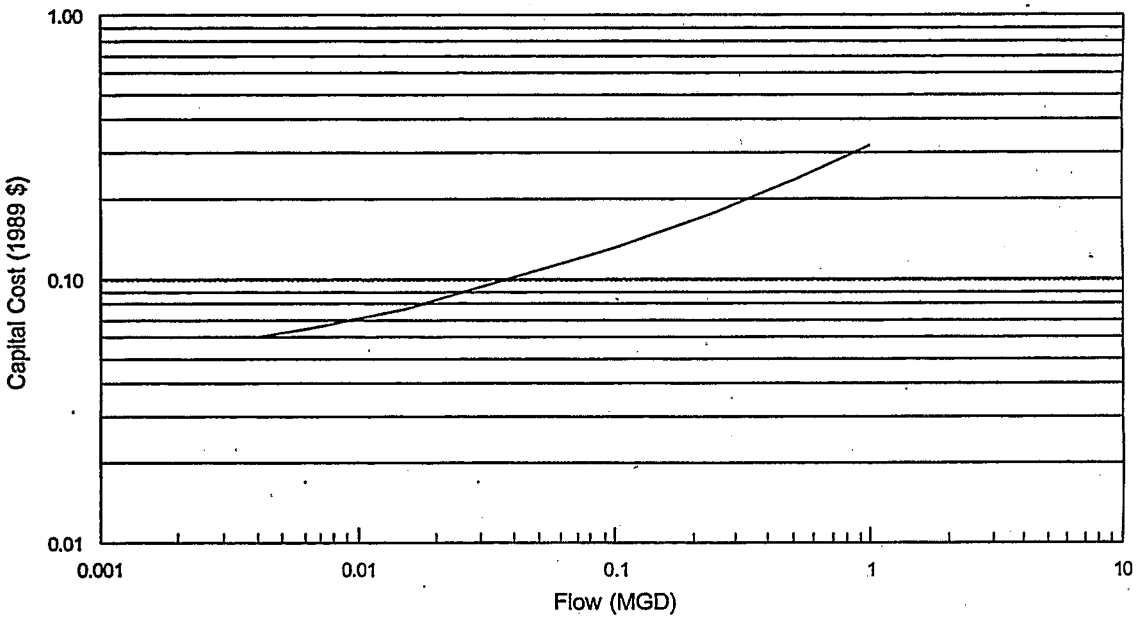

Figure 2-10. Total Capital Cost Curve for pH Adjustment Tanks - Metals Option 3

The land requirements for the rapid mix and pH adjustment tanks are presented in Table 2-15. The resulting cost curves are presented as Figures 2-11 and 2-12, respectively. The land requirement equations for the rapid mix tank and pH adjustment tank are presented below as Equations 2-11 and 2-12, respectively.

$$\ln(Y3) = -2.330 + 0.352\ln(X) + 0.019(\ln(X))^2 \tag{2-11}$$

$$\ln(Y3) = -2.67 + 0.30\ln(X) + 0.033(\ln(X))^2 \tag{2-12}$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres).

Table 2-15. Land Requirement Estimates for Tertiary Precipitation Tanks - Metals Option 3

Flow (MGD)	Rapid Mix Tank Land Requirements (Acres)	pH Adjustment Tank Land Requirements (Acres)
0.01	0.036	0.037
0.05	0.044	0.037
0.1	0.05	0.04
0.5	0.078	0.06
1.0	0.098	0.07
5.0	0.184	0.12

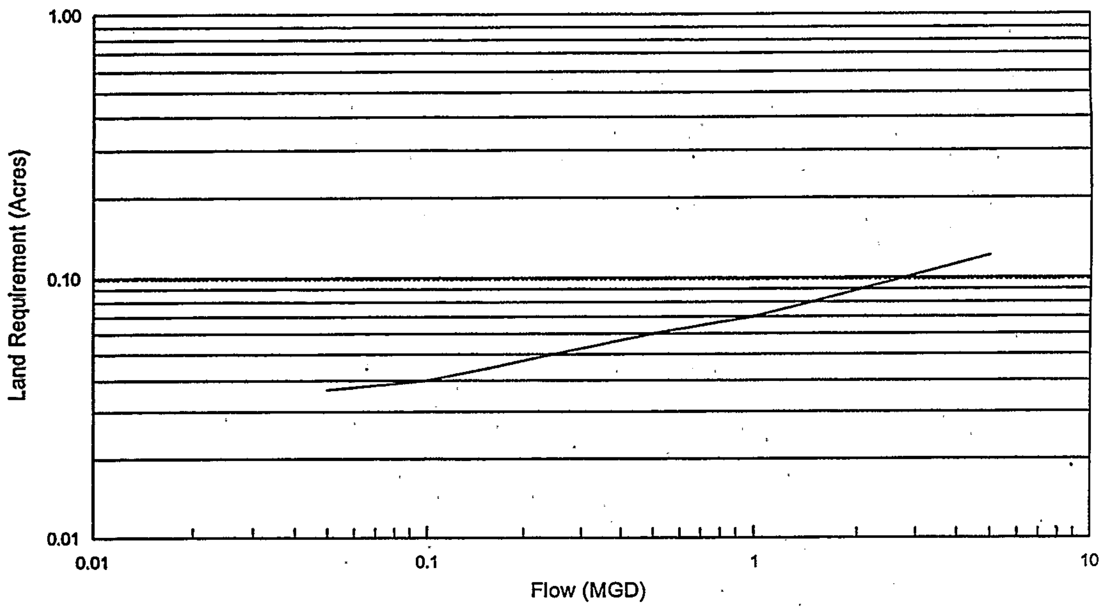

Figure 2-12. Land Requirement Curve for pH Adjustment Tanks - Metals Option 3

Chemical Usage and Labor Requirement Costs

EPA did not assign O&M costs and, in turn, chemical usage and labor requirement costs for tertiary precipitation and pH adjustment to the few facilities which have tertiary precipitation (and pH adjustment) systems in-place. For those facilities without tertiary precipitation (and pH adjustment) in-place, EPA estimated the labor requirements at one man-hour per day for the rapid mix and pH adjustment tanks. EPA based this estimate on the model facility's typical operation.

EPA estimated chemical costs for the rapid mix tank based on lime addition to achieve the stoichiometric requirements of reducing the metals and semi-metals in the wastewater from the Metals Option 2 long-term averages to the Metals Option 3 long-term averages, with a 10 percent excess. Table 2-16 presents the lime requirements for the tertiary chemical precipitation treatment systems. EPA estimated the chemical requirements for the pH adjustment tank based on the addition of sulfuric acid to lower the pH from 11.0 to 9.0, based on the model facility's operation.

The itemized O&M cost estimates for the rapid mix and pH adjustment tanks are presented in Tables 2-17 and 2-18, respectively, while the resulting cost curves are presented as Figures 2-13 and 2-14. The O&M cost equations for the rapid mix tank and pH adjustment tank are presented below as Equations 2-13 and 2-14, respectively.

$$\ln(Y2) = 9.98761 + 0.37514\ln(X) + 0.02124(\ln(X))^2 \qquad (2\text{-}13)$$

$$\ln(Y2) = 9.71626 + 0.33275\ln(X) + 0.0196(\ln(X))^2 \qquad (2\text{-}14)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-16. Lime Requirements for Tertiary Chemical Precipitation - Metals Option 3

Pollutant	Option 2 (mg/L)	Option 3 (mg/L)	Option 2-3 (mg/L)	Dosage Rates Lime (LBS/YR)	Flow = 0.001 MGD Lime (LBS/YR)	Flow = 0.01 MGD Lime (LBS/YR)	Flow = 0.1 MGD Lime (LBS/YR)	Flow = 1.0 MGD Lime (LBS/YR)
ALUMINUM	0.337	0.073	0.264	4.11	2.6	26	259	2,591
ANTIMONY	0.021	0.021	0.000	1.52	0.0	0	0	0
ARSENIC	0.018	0.011	0.007	2.47	0.0	0	4	41
BORON	8.182	66.951	0.000	10.3	0.0	0	0	0
CADMIUM	0.101	0.082	0.019	0.66	0.0	0	3	30
CHROMIUM	0.690	0.040	0.650	2.13	3.3	33	331	3,310
COBALT	0.124	0.057	0.067	1.88	0.3	3	30	301
COPPER	0.970	0.169	0.801	1.16	2.2	22	222	2,225
IRON	4.134	0.387	3.747	1.99	17.8	178	1,776	17,763
LEAD	0.308	0.055	0.253	0.71	0.4	4	43	431
MANGANESE	0.061	0.012	0.049	2.69	0.3	3	32	317
MERCURY	0.0010	0.0002	0.001	0.37	0.0	0	0	1
MOLYBDENUM	0.652	0.528	0.124	2.31	0.7	7	68	684
NICKEL	1.06	0.27	0.790	1.89	3.6	36	356	3,563
SELENIUM	0.235	0.209	0.026	1.87	0.1	1	12	116
SILVER	0.004	0.005	-0.001	0.34	(0.0)	(0)	(0)	(0)
THALLIUM	0.025	0.021	0.004	0.54	0.0	0	1	5
TIN	0.029	0.028	0.001	1.25	0.0	0	0	3
TITANIUM	0.004	0.004	0.000	3.09	0.0	0	0	0
VANADIUM	0.01	0.011	0.000	2.91	0.0	0	0	0
YTTRIUM	0.002	0.005	0.000	1.25	0.0	0	0	0
ZINC	0.845	0.206	0.639	1.13	1.7	17	173	1,725
					33	331	3,311	33,105

Table 2-17. O&M Cost Estimates for Rapid Mix Tanks - Metals Option 3

Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	Chemical Cost	Total O&M Cost (1989 $/YR)
0.00001	63	17	8	4,372	0	4,460
0.0001	63	60	30	4,372	1	4,826
0.001	63	210	105	4,492	1	4,871
0.01	69	732	366	4,914	9	6,090
0.1	128	2,563	1,282	5,375	94	9,442
0.5	388	6,142	3,071	5,724	472	15,797
1.0	713	8,971	4,485	5,880	944	20,993
5.0	3,313	21,531	10,766	6,261	4,718	46,589

Table 2-18. O&M Cost Estimates for pH Adjustment Tanks - Metals Option 3

Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	Chemical Cost	Total O&M Cost (1989 $/YR)
0.00001	21	9	5	4,372	1	4,408
0.0001	21	33	17	4,372	1	4,444
0.001	21	116	58	4,492	2	4,684
0.01	23	403	201	4,914	18	5,559
0.1	43	1,410	705	5,375	175	7,708
0.5	130	3,394	1,697	5,724	870	11,815
1.0	238	4,935	3,467	5,880	1,735	16,255
5.0	1,104	11,844	5,922	6,261	8,660	33,791

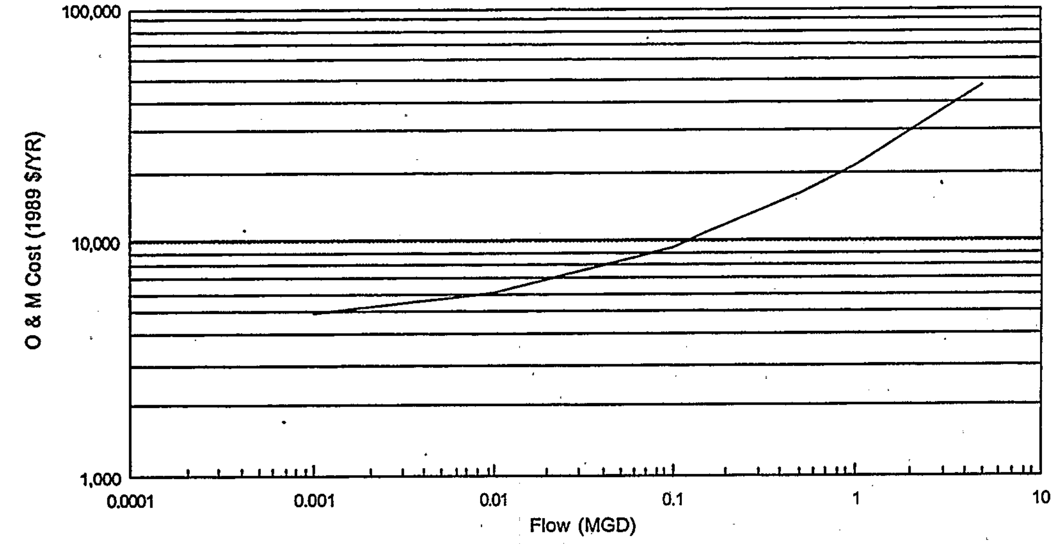

Figure 2-13. O&M Cost Curve for Rapid Mix Tanks - Metals Option 3

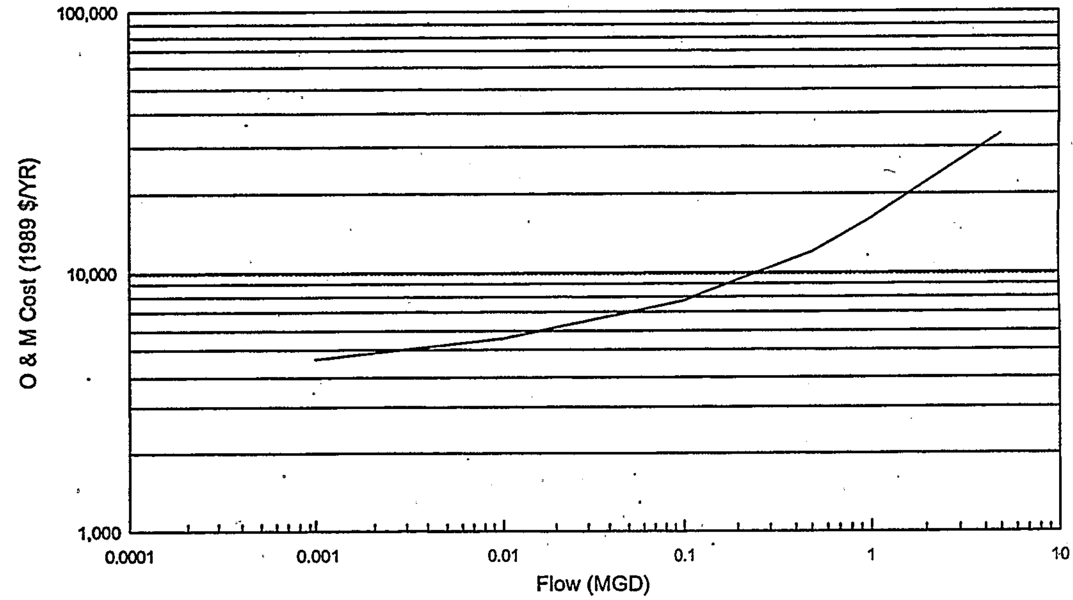

Figure 2-14. O&M Cost Curve for pH Adjustment Tanks - Metals Option 3

2.1.4 Primary Chemical Precipitation - Metals Option 4

The primary chemical precipitation system equipment for the model technology for Metals Option 4 consists of a mixed reaction tank with pumps, a treatment chemical feed system, and an unmixed wastewater holding tank. EPA designed the system to operate on a batch basis, treating one batch per day, five days per week. The average chemical precipitation batch duration reported by respondents to the WTI Questionnaire was four hours. Therefore, a one batch per day treatment schedule should provide sufficient time for the average facility to pump, treat, and test its waste. EPA also included a holding tank, equal to the daily waste volume, up to a maximum size of 5,000 gallons (equivalent to the average tank truck receipt volume throughout the industry), to allow facilities flexibility in managing waste receipts. (The Metals Option 4 model facility utilizes a holding tank.)

As shown in Table 1-3, clarification follows primary chemical precipitation for Metals Option 4. The costing discussion for clarification following primary precipitation in Metals Option 4 is presented in Section 2.2.2. The discussions for sludge filtration and the associated filter cake disposal are presented in Sections 4.1 and 4.2, respectively.

Capital and Land Costs

EPA developed total capital cost estimates for the Metals Option 4 primary chemical precipitation systems. For facilities with no chemical precipitation units in-place, the components of the chemical precipitation system included a precipitation tank with a mixer, pumps, and a feed system. In addition, EPA included a holding tank equal to the size of the precipitation tank, up to 5,000 gallons. EPA obtained these cost estimates from manufacturer's recommendations.

EPA estimated the other components (i.e., piping, instrumentation and controls, etc.) of the total capital cost for both the rapid mix and pH adjustment tank by applying the same factors and additional costs as detailed for selective metals precipitation (see Section 2.1.1 above).

For facilities that already have any chemical precipitation (treatment in-place), EPA included as capital expense only the cost of a holding tank.

The itemized primary chemical precipitation capital cost and holding tank capital cost estimates for Metals Option 4 are presented in Tables 2-19 and 2-20, respectively. The resulting cost curves are presented as Figures 2-15 and 2-16. The resulting total capital cost equations for the Metals Option 4 primary chemical precipitation and holding tank systems are presented below as Equations 2-15 and 2-16, respectively.

$$\ln(Y1) = 14.019 + 0.481\ln(X) - 0.00307(\ln(X))^2 \quad (2\text{-}15)$$

$$\ln(Y1) = 10.671 - 0.083\ln(X) - 0.032(\ln(X))^2 \quad (2\text{-}16)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-19. Total Capital Cost Estimates for Primary Chemical Precipitation - Metals Option 4

Flow (MGD)	Avg. Vendor Equipment Cost	Holding Tank	Install.	Total Construction Cost	Engineer. & Conting.	Total Capital Cost (1989 $)
0.000001	282	217	175	674	202	876
0.00001	1,030	762	627	2,419	726	3,145
0.0005	9,286	6,400	5,490	21,176	6,353	27,529
0.001	13,709	9,330	8,064	31,103	9,331	40,434
0.005	33,709	22,390	19,635	75,734	22,720	98,454
0.01	50,006	22,390	25,339	97,735	29,321	127,056
0.05	123,550	22,390	51,079	197,019	59,106	256,125
0.1	182,398	22,390	71,676	276,464	82,939	359,403
0.5	450,652	22,390	165,565	638,607	191,582	830,189
1.0	665,304	22,390	240,693	928,387	278,516	1,206,903
5.0	1,643,772	22,390	583,157	2,249,319	674,796	2,924,115

Table 2-20. Holding Tank Total Capital Cost Estimates for Chemical Precipitation - Metals Option 4

Flow (MGD)	Average Vendor Equipment Cost	Installation	Total Construction Cost	Engineering & Contingency	Total Capital Cost (1989 $)
0.000001	217	76	293	88	381
0.00001	762	267	1,029	309	1,338
0.0005	6,400	2,240	8,640	2,592	11,232
0.001	9,330	3,266	12,596	3,779	16,375
0.005	22,390	7,837	30,227	9,068	39,295

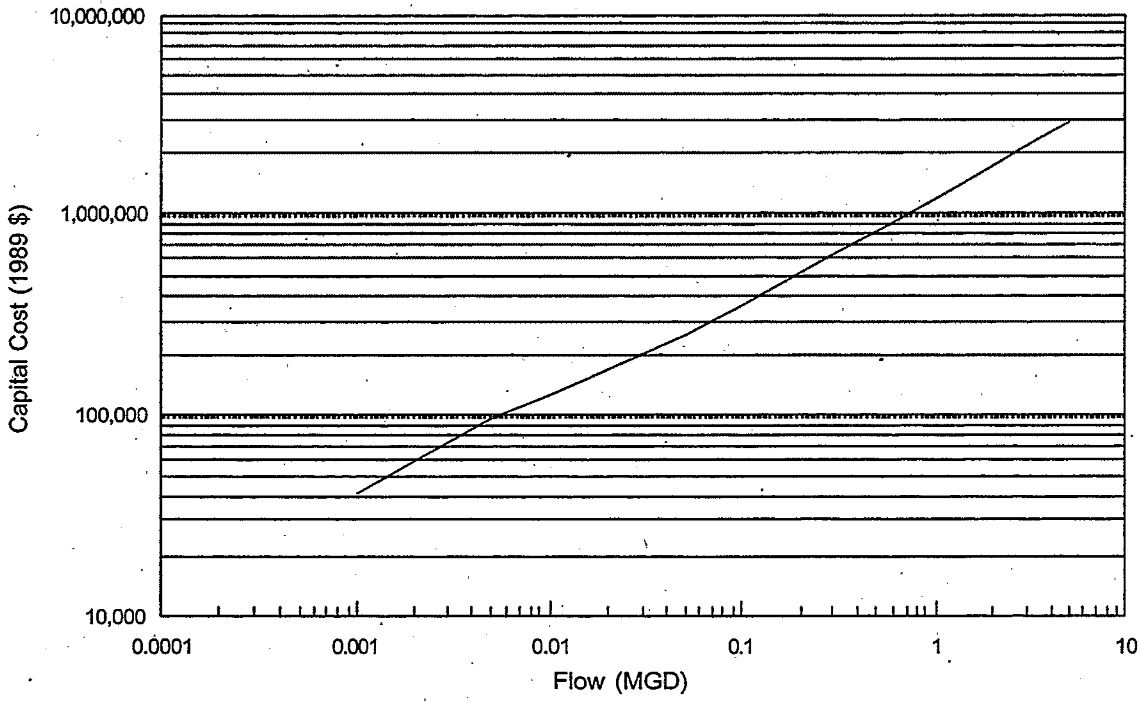

Figure 2-15. Total Capital Cost Curve for Primary Chemical Precipitation - Metals Option 4

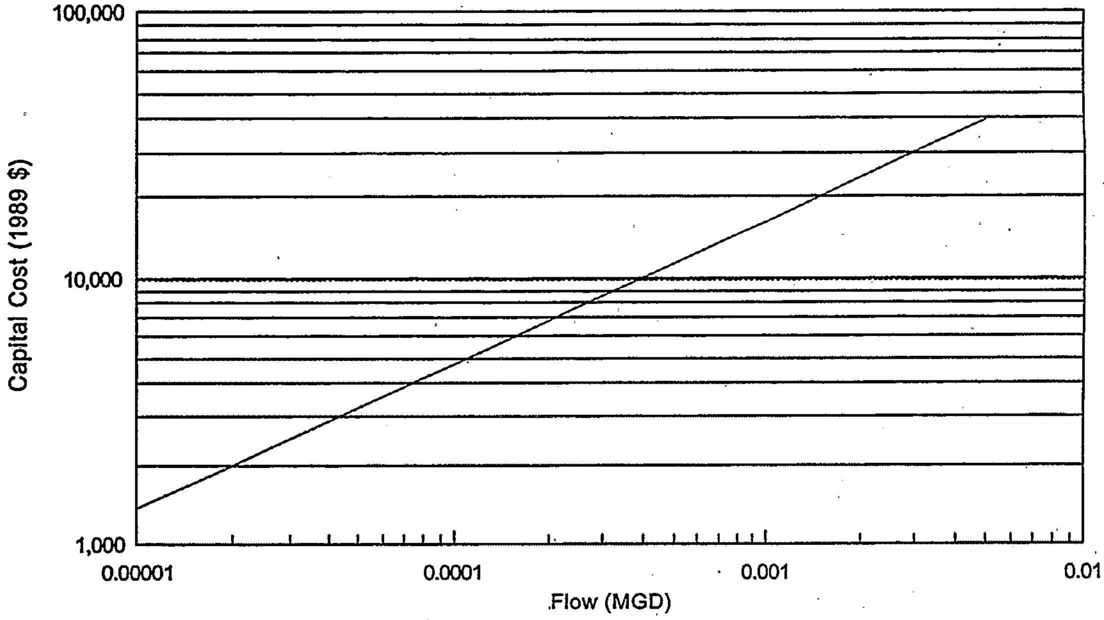

Figure 2-16. Holding Tank Total Capital Cost Curve for Primary Chemical Precipitation - Metals Option 4

The land requirements for the Metals Option 4 primary chemical precipitation and holding tank systems are presented in Table 2-21. The resulting cost curves are presented as Figures 2-17 and 2-18, respectively. The land requirement equations for the Metals Option 4 primary chemical precipitation and holding tank systems are presented below as Equations 2-17 and 2-18, respectively.

$$\ln(Y3) = -1.019 + 0.299\ln(X) + 0.015(\ln(X))^2 \quad (2\text{-}17)$$

$$\ln(Y3) = -2.866 - 0.023\ln(X) - 0.006(\ln(X))^2 \quad (2\text{-}18)$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres).

Table 2-21. Land Requirement Estimates for Chemical Precipitation - Metals Option 4

Flow (MGD)	Primary Chemical Precipitation Land Requirements (Acres)	Holding Tank Land Requirements (Acres)
0.00001	0.0791	0.0395
0.0001	0.0823	0.0410
0.001	0.0940	0.0470
0.01	0.1250	0.0574
0.05	0.1724	0.0574
0.1	0.2068	0.0574
0.5	0.2434	0.0574
1.0	0.4474	0.0574

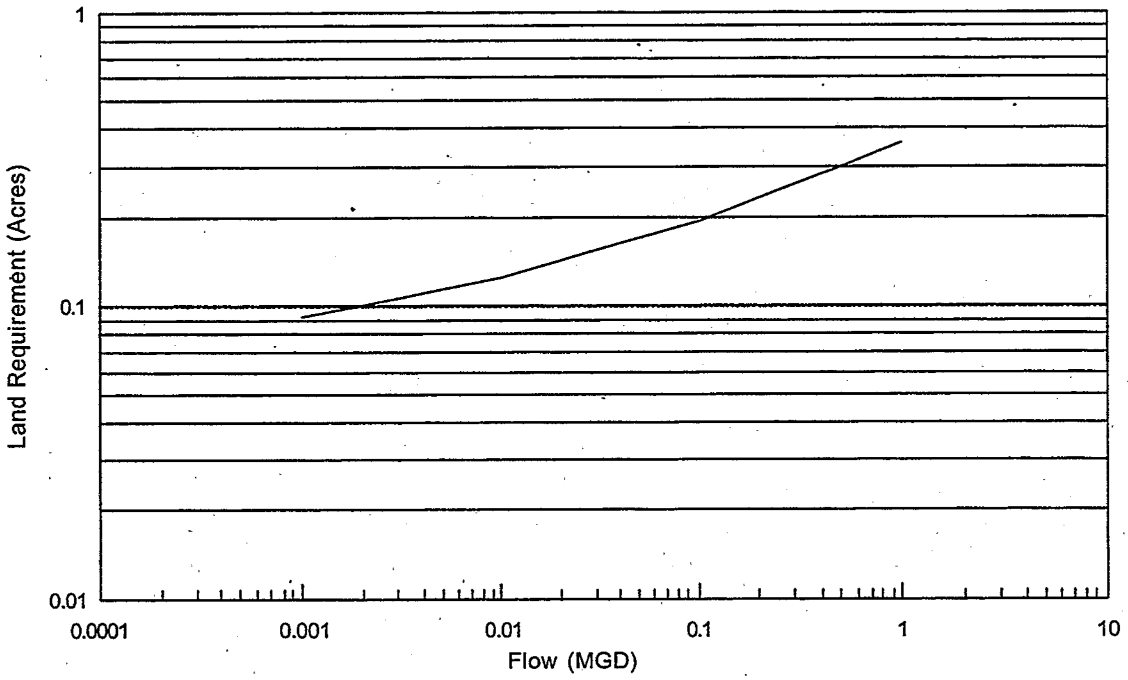

Figure 2-17. Land Requirement Curve for Primary Chemical Precipitation - Metals Option 4

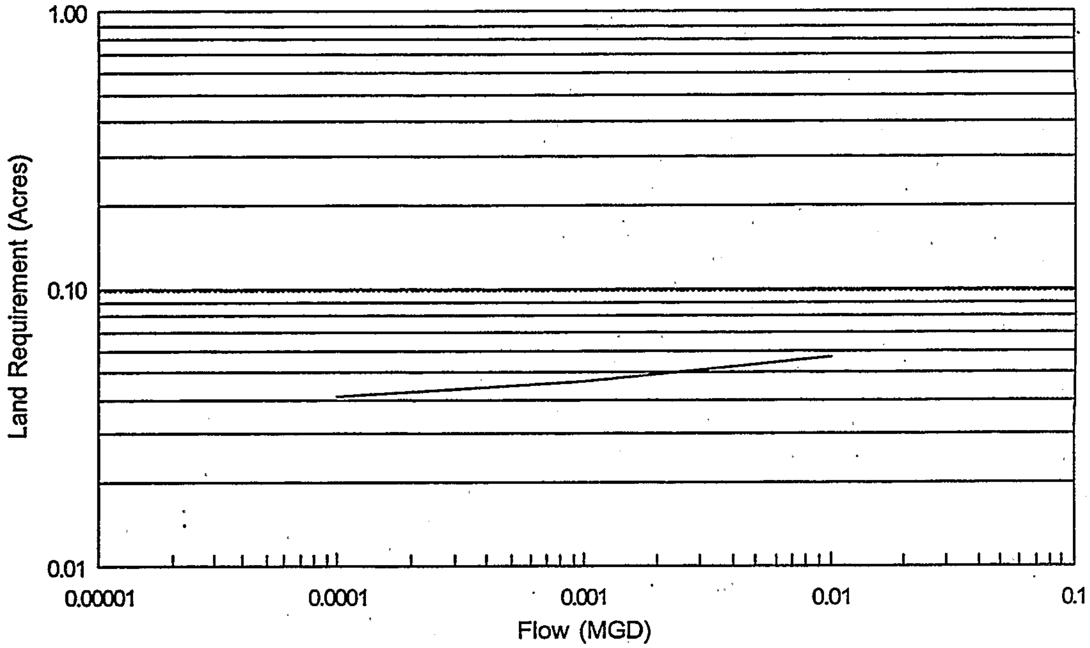

Figure 2-18. Land Requirement Curve for Holding Tank - Metals Option 4

Labor and Chemical Costs

EPA approximated the labor cost for primary chemical precipitation in Metals Option 4 at two hours per batch, one batch per day. The labor cost was estimated at $31,200 per man year. EPA based this approach on the model facility's operation.

EPA estimated chemical costs based on stoichiometric, pH adjustment, and buffer adjustment requirements. For facilities with no chemical precipitation in-place, EPA based the stoichiometric requirements on the amount of chemicals required to precipitate each of the metal and semi-metal pollutants of concern from the metals subcategory average raw influent concentrations to Metals Option 4 (Sample Point-03) concentrations. Metals Option 4, Sample Point-03 concentrations represent the sampled effluent from primary chemical precipitation at the model facility. The chemicals used were lime at 75 percent of the required removals and caustic at 25 percent of the required removals, which are based on the option facility's operation. EPA estimated the pH adjustment and buffer adjustment requirements to be 50 percent of the stoichiometric requirement, which includes a 10 percent excess of chemical dosage. Table 2-22 presents the lime and caustic requirements for the primary chemical precipitation systems for the Metals Option 4.

The itemized annual O&M cost estimates for facilities with no treatment in-place are presented in Table 2-23 and the subsequent cost curve is presented as Figure 2-19. The O&M cost equation for Metals Option 4 chemical precipitation is:

$$\ln(Y2) = 15.3534 + 1.08700\ln(X) + 0.04891(\ln(X))^2 \qquad (2\text{-}19)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

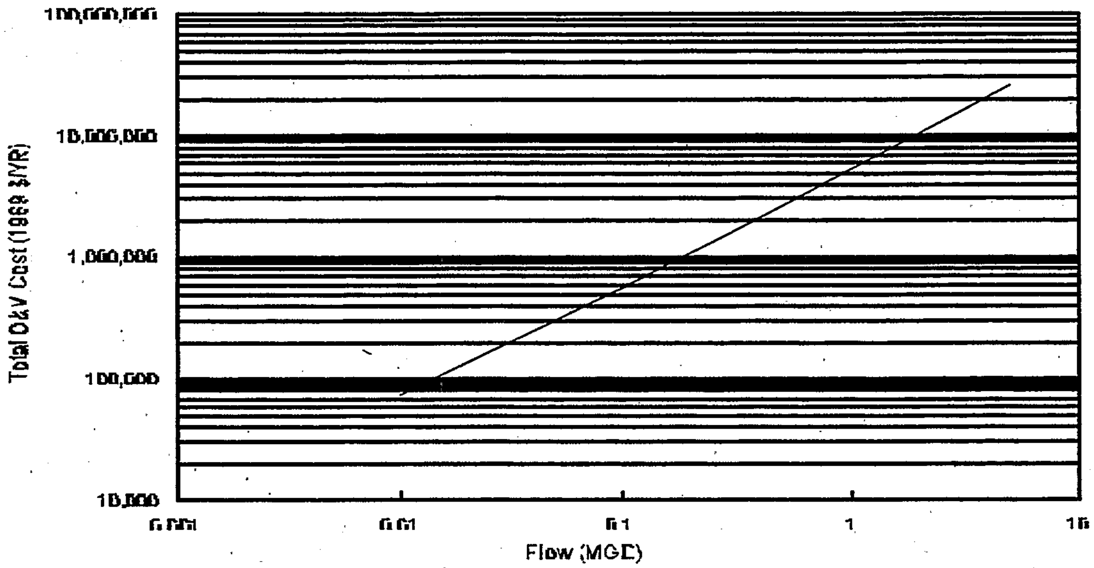

Figure 2-19. O&M Cost Curve for Primary Chemical Precipitation - Metals Option 4

Table 2-22. Lime and Caustic Requirements for Primary Chemical Precipitation Systems - Metals Option 4

Pollutant	Raw Level (mg/L)	SP03 Level (mg/L)	Raw - SP03 Level (mg/L)	Dosage Rates		Flow = 0.00001 MGD		Flow = 0.001 MGD		Flow = 0.1 MGD		Flow = 1.0 MGD	
				Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)
ALUMINUM	305.756	5.580	300.176	4.45	4.11	22	30	2,171	3,013	217,128	301,265	2,171,280	3,012,652
ANTIMONY	93.95	0.5167	93.433	1.64	1.52	2	3	250	346	24,961	34,633	249,611	346,335
ARSENIC	14.893	0.390	14.503	2.67	2.47	1	1	63	87	6,296	8,736	62,962	87,360
BORON	196.103	16.333	179.770	11.1	10.3	32	45	3,245	4,503	324,544	450,305	3,245,439	4,503,046
CADMIUM	173.590	0.501	173.089	0.71	0.66	2	3	200	278	20,035	27,799	200,352	277,988
CHROMIUM	993.460	12.537	980.923	2.31	2.13	37	51	3,681	5,108	368,141	510,795	3,681,405	5,107,950
COBALT	152.547	0.242	152.305	2.04	1.88	5	7	504	700	50,436	69,979	504,356	699,794
COPPER	1643.096	7.123	1635.973	1.26	1.16	33	46	3,349	4,647	334,949	464,742	3,349,489	4,647,416
IRIDIUM	43.802	3.283	40.519	0.83	0.77	1	1	55	76	5,485	7,611	54,851	76,105
IRON	694.378	29.533	664.845	2.15	1.99	23	32	2,323	3,223	232,316	322,338	2,323,160	3,223,385
LEAD	104.064	0.616	103.448	0.77	0.71	1	2	130	180	12,991	18,025	129,913	180,254
LITHIUM	65.501	4.03	61.471	5.76	5.33	6	8	576	799	57,611	79,936	576,115	799,359
MANGANESE	91.000	0.245	90.755	2.91	2.69	4	6	430	596	42,984	59,640	429,836	596,397
MERCURY	0.2090	0.0133	0.196	0.40	0.37	0	0	0	0	13	18	127	176
MOLYBDENUM	57.766	3.06	54.706	2.50	2.31	2	3	223	309	22,256	30,880	222,560	308,802
NICKEL	350.973	2.79	348.183	2.04	1.89	12	16	1,157	1,606	115,738	160,587	1,157,384	1,605,870
SELENIUM	0.385	0.4817	0.000	2.03	1.87	0	0	0	0	0	0	0	0
SILICON	215.607	3.650	211.957	5.70	5.27	20	27	1,966	2,727	196,553	272,718	1,965,535	2,727,180
SILVER	1.183	0.249	0.934	0.74	0.69	0	0	1	2	113	156	1,126	1,563
STRONTIUM	4.858	0.1	4.758	0.91	0.84	0	0	7	10	706	980	7,065	9,803
THALLIUM	0.461	0.02	0.441	0.59	0.54	0	0	0	1	42	58	421	584
TIN	1071.108	1.0257	1070.082	1.35	1.25	23	33	2,346	3,255	234,598	325,504	2,345,977	3,255,043
TITANIUM	630.196	0.3353	629.861	3.34	3.09	34	47	3,422	4,747	342,160	474,747	3,421,603	4,747,474
VANADIUM	36.396	0.0261	36.370	2.36	2.18	1	2	139	193	13,933	19,332	139,333	193,324
YTTRIUM	0.157	0.005	0.152	1.35	1.25	0	0	0	0	33	46	334	463
ZINC	1203.557	3.9	1199.657	1.22	1.13	24	33	2,387	3,312	238,728	331,235	2,387,277	3,312,347
ZIRCONIUM	1.085	2.71	0.000	1.32	1.22	0	0	0	0	0	0	0	0
						286	397	28,628	39,721	2,862,751	3,972,067	28,627,511	39,720,671

Table 2-23. O&M Cost Estimates for Raw TIP Chemical Precipitation - Metals Option 4

Flow (MGD)	Energy	Maintenance	Labor	Taxes & Insurance	Chemical Cost	Total O&M Cost (1989 $/YR)
0.000001	1,000	35	13,116	18	5	14,174
0.00001	1,000	126	13,116	63	51	14,356
0.001	1,010	1,617	13,475	809	5,068	21,979
0.01	1,104	5,082	14,741	2,541	50,683	74,151
0.05	1,520	10,245	15,696	5,123	253,416	286,000
0.1	2,040	14,376	16,126	7,188	506,832	546,562
0.5	6,200	33,208	17,171	16,604	2,534,161	2,607,344
1.0	11,400	48,276	17,641	24,138	5,068,322	5,169,777
5.0	53,000	116,964	18,784	58,482	25,341,609	25,588,839

For facilities which already have chemical precipitation treatment in-place, EPA estimated an O&M upgrade cost. EPA assumed that facilities with primary chemical precipitation in-place have effluent concentrations exiting the primary precipitation/solid-liquids separation system equal to the metals subcategory primary precipitation current loadings. Similarly, EPA assumed that facilities with secondary chemical precipitation in place have effluent concentrations exiting the secondary precipitation/solid-liquids separation system equal to metals subcategory secondary precipitation current loadings (see Chapter 12 of the Development Document for the CWT Point Source Category for a detailed discussion of metals subcategory primary and secondary chemical precipitation current loadings).

For the portion of the O&M upgrade equation associated with energy, maintenance, and labor, for facilities that currently have primary precipitation systems EPA calculated the percentage difference between the primary precipitation current loadings and Metals Option 4 (Sample Point-03) concentrations.

This difference is an increase of approximately two percent. Therefore, EPA calculated the energy, maintenance, and labor components of the O&M upgrade cost for facilities with primary chemical precipitation in-place at two percent of the O&M cost for facilities with no chemical precipitation in-place.

For the portion of the O&M upgrade equation associated with energy, maintenance, and labor, for facilities that currently have secondary precipitation systems EPA calculated the percentage difference between secondary precipitation current loadings and Metals Option 4 (Sample Point-03) concentrations. This difference is also an increase of approximately two percent[1]. Therefore, EPA calculated the energy, maintenance, and labor components of the O&M upgrade cost for facilities with secondary chemical precipitation in-place at two percent of the O&M cost for facilities with no chemical precipitation in-place.

For the chemical cost portion of the O&M upgrade, EPA also calculated upgrade costs depending on whether the facility had primary precipitation or secondary precipitation currently in-place. For facilities with primary precipitation, EPA calculated chemical upgrade costs based on current-to-Metals Option 4 (Sample Point-03) removals. Similarly for facilities with secondary precipitation, EPA calculated chemical upgrade costs based on secondary precipitation removals to Metals Option 4 (Sample Point -03) removals. In both cases, EPA did not include costs for pH adjustment or buffering chemicals since these chemicals should already be used in the in-place treatment system. Finally, EPA included a 10 percent excess of chemical dosage to the stoichiometric requirements of the precipitation chemicals. Tables 2-24 and 2-25 present the lime and caustic requirements for the Metals Option 4 primary chemical precipitation upgrades for facilities with primary treatment in-place and facilities with secondary treatment in-place, respectively.

[1] While pollutant concentrations resulting from secondary chemical precipitation are generally lower than those resulting from primary chemical precipitation, the percentage increase (when rounded) for primary and secondary precipitation are the same.

Table 2-24. Lime and Caustic Requirements for Primary Chemical Precipitation Upgrades - Metals Option 4 - Primary Treatment In-place

Pollutant	Primary Level (mg/L)	SP03 Level (mg/L)	Pri - SP03 Level (mg/L)	Dosage Rates		Flow = 0.001 MGD		Flow = 0.01 MGD		Flow = 0.1 MGD		Flow = 1.0 MGD	
				Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)	Caustic (LBS/YR)	Lime (LBS/YR)
ALUMINUM	28.264	5.580	22.684	4.45	4.11	120	167	1,203	1,670	12,033	16,695	120,326	166,953
ANTIMONY	4.152	0.5167	3.635	1.64	1.52	7	10	71	99	712	988	7,122	9,882
ARSENIC	0.181	0.390	0.000	2.67	2.47	0	0	0	0	0	0	0	0
BORON	35.047	16.333	18.714	11.1	10.3	248	344	2,478	3,438	24,776	34,376	247,756	343,762
CADMIUM	0.254	0.501	0.000	0.71	0.66	0	0	0	0	0	0	0	0
CHROMIUM	3.986	12.537	0.000	2.31	2.13	0	0	0	0	0	0	0	0
COBALT	0.214	0.242	0.000	2.04	1.88	0	0	0	0	0	0	0	0
COPPER	1.796	7.123	0.000	1.26	1.16	0	0	0	0	0	0	0	0
IRIDIUM	6.642	3.283	3.359	0.83	0.77	3	5	33	46	333	463	3,335	4,627
IRON	16.076	29.533	0.000	2.15	1.99	0	0	0	0	0	0	0	0
LEAD	1.909	0.616	1.293	0.77	0.71	1	2	12	17	119	165	1,191	1,652
LITHIUM	35.757	4.03	31.727	5.76	5.33	218	303	2,181	3,026	21,806	30,255	218,057	302,553
MANGANESE	1.551	0.245	1.306	2.91	2.69	5	6	45	63	454	629	4,536	6,294
MERCURY	0.0210	0.0133	0.008	0.40	0.37	0	0	0	0	0	1	4	5
MOLYBDENUM	5.833	3.06	2.773	2.50	2.31	8	11	83	115	827	1,148	8,273	11,479
NICKEL	20.083	2.79	17.293	2.04	1.89	42	58	422	585	4,215	5,849	42,154	58,489
SELENIUM	0.277	0.4817	0.000	2.03	1.87	0	0	0	0	0	0	0	0
SILICON	4.378	3.650	0.728	5.70	5.27	5	7	50	69	495	687	4,951	6,869
SILVER	0.223	0.249	0.000	0.74	0.69	0	0	0	0	0	0	0	0
STRONTIUM	5.549	0.1	5.449	0.91	0.84	6	8	59	82	593	823	5,933	8,233
THALLIUM	0.026	0.02	0.006	0.59	0.54	0	0	0	0	0	1	4	6
TIN	2.397	1.0257	1.371	1.35	1.25	2	3	22	31	220	306	2,205	3,059
TITANIUM	0.152	0.3353	0.000	3.34	3.09	0	0	0	0	0	0	0	0
VANADIUM	0.045	0.0261	0.019	2.36	2.18	0	0	1	1	5	7	53	74
YTTRIUM	0.03	0.005	0.025	1.35	1.25	0	0	0	1	4	6	40	56
ZINC	2.425	3.9	0.000	1.22	1.13	0	0	0	0	0	0	0	0
ZIRCONIUM	1.855	2.71	0.000	1.32	1.22	0	0	0	0	0	0	0	0
						666	924	6,659	9,240	66,594	92,399	665,940	923,991

EPA then combined the energy, maintenance and labor components of the O&M upgrade with the chemical portion of the O&M upgrade to develop two sets of O&M upgrade equations for the primary chemical precipitation portion of Metals Option 4.

The itemized O&M upgrade cost estimates for the facilities that currently have primary chemical precipitation in-place are presented in Table 2-26, while the O&M upgrade cost estimates for the facilities that currently have secondary chemical precipitation in-place are presented in Table 2-27. The resulting cost curves are presented as Figures 2-20 and 2-21. The O&M upgrade cost equations for the facilities that have primary and secondary chemical precipitation treatment in-place are presented below as Equations 2-20 and 2-21, respectively.

$$\ln(Y2) = 11.6203 + 1.05998\ln(X) + 0.04602(\ln(X))^2 \qquad (2\text{-}20)$$

$$\ln(Y2) = 10.9500 + 0.94821\ln(X) + 0.04306(\ln(X))^2 \qquad (2\text{-}21)$$

where:

X= Flow Rate (MGD)

Y2 = O&M Cost (1989 $/YR)

2.1.5 Secondary (Sulfide) Precipitation for Metals Option 4

The Metals Option 4 secondary sulfide precipitation system follows the primary metals precipitation/clarification step. This equipment consists of a mixed reaction tank with pumps and a treatment chemical feed system, sized for the full daily batch volume. For direct dischargers, the overflow from secondary sulfide precipitation would carry on to a clarifier and then multi-media filtration. For indirect discharges, the overflow would go immediately to the filtration unit, without clarification. Cost estimates for the clarifier are discussed in Section 2.2.2 of this document. Cost estimates for multi-media filtration are presented in Section 2.5.

Table 2-26. O&M Cost Estimates for Primary Chemical Precipitation TIP - Metals Option 4

Flow (MGD)	Energy	Maintenance	Labor	Taxes & Insurance	Chemical Cost	Total O&M Cost (1989 $/YR)
0.000001	20	1	262	8	1	292
0.00001	20	3	262	27	1	313
0.001	20	32	270	32	118	472
0.01	22	102	294	786	1,179	2,383
0.05	30	205	314	786	5,895	7,230
0.1	41	288	323	786	11,790	13,228
0.5	124	664	343	786	58,950	60,867
1.0	228	966	353	786	117,900	120,233
5.0	1,060	2,340	376	786	589,502	594,064

Table 2-27. O&M Upgrade Cost Estimates for Secondary Chemical Precipitation TIP - Metals Option 4

Flow (MGD)	Energy	Maintenance	Labor	Taxes & Insurance	Chemical Cost	Total O&M Cost (1989 $/YR)
0.000001	20	1	262	8	0	291
0.00001	20	3	262	27	1	313
0.001	20	32	270	32	44	398
0.01	22	102	294	786	439	1,643
0.05	30	205	314	786	2,196	3,531
0.1	41	288	323	786	4,392	5,830
0.5	124	664	343	786	21,959	23,876
1.0	228	966	353	786	43,918	46,251
5.0	1,060	2,340	376	786	219,588	224,150

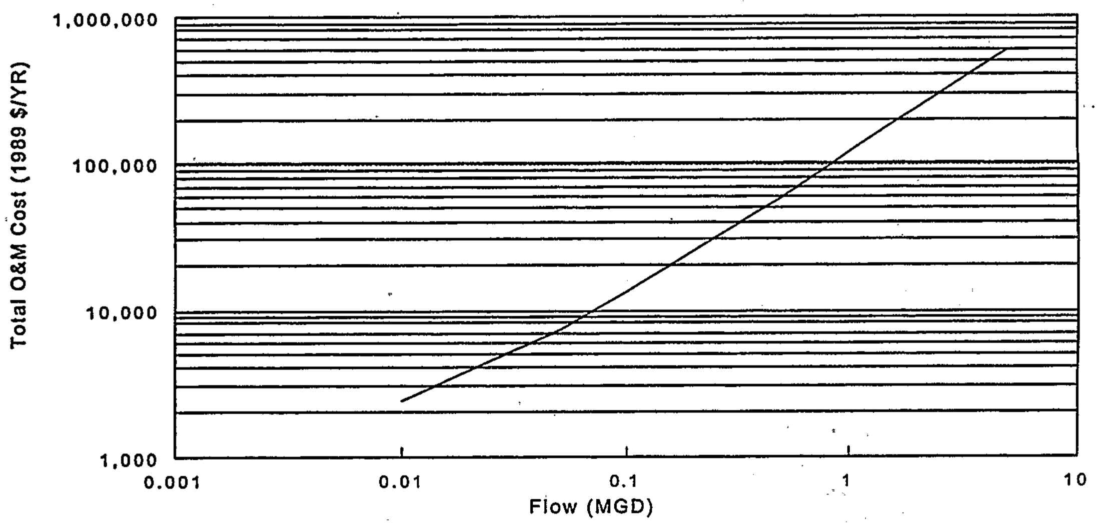

Figure 2-20. O&M Cost Curve for Primary Chemical Precipitation - Metals Option 4 - Primary Treatment In-place

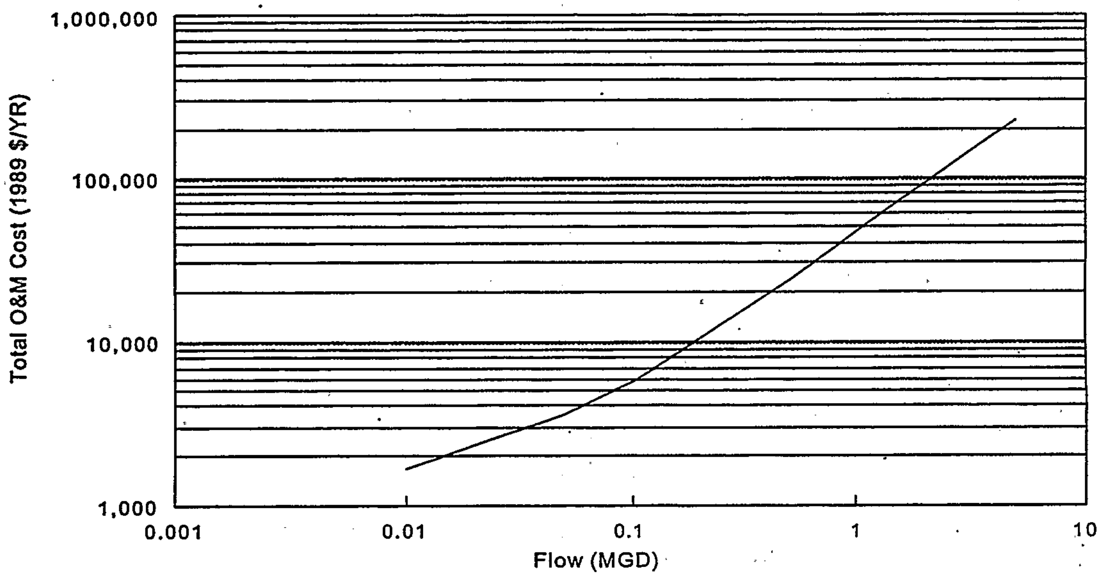

Figure 2-21. O&M Cost Curve for Primary Chemical Precipitation - Metals Option 4 - Secondary Treatment In-place

For costing purposes, EPA assumed that facilities either have secondary precipitation currently in-place and attributes no additional capital and O&M costs to these facilities, or EPA assumes that facilities do not have secondary sulfide precipitation in-place and, consequently, EPA developed costs for full O&M and capital costs. Therefore, EPA has not developed upgrade costs associated with secondary precipitation in Metals Option 4.

Capital and Land Costs

EPA developed capital cost estimates for the secondary sulfide precipitation systems in Metals Option 4 from vendor's quotes. EPA estimated the other components (i.e., piping, instrumentation, and controls, etc.) of the sulfide precipitation system by applying the same methodology, factors and additional costs as outlined for the primary chemical precipitation system for Metals Option 4 (see Section 2.1.4 above). Table 2-28 presents the itemized capital cost estimates for the secondary precipitation (sulfide precipitation) systems, while Figure 2-22 presents the resulting cost curve. The total capital cost equation for Metals Option 4 secondary (sulfide) precipitation is:

$$\ln(Y1) = 13.829 + 0.544\ln(X) + 0.00000496(\ln(X))^2 \qquad (2\text{-}22)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-28. Total Capital Cost Estimates for Secondary (Sulfide) Precipitation - Metals Option 4

Flow (MGD)	Equipment Cost	Piping	Instrumentation & Controls	Installation	Engineering & Contingency	Total Capital Cost (1989 $)
0.000001	218	65	65	76	127	551
0.00001	762	229	229	267	446	1,933
0.001	9,329	2,799	2,799	3,265	5,457	23,649
0.01	32,646	9,794	9,794	11,426	19,098	82,758
0.05	78,355	23,507	23,507	27,424	45,838	198,631
0.1	114,243	34,273	34,273	39,985	66,832	289,606
0.5	274,201	82,260	82,260	95,970	160,408	695,099
1.0	399,788	119,936	119,936	139,926	233,876	1,013,462
5.0	959,554	287,866	287,866	335,844	561,339	2,432,469

Table 2-29 presents the land requirements for the Metals Option 4 secondary (sulfide) precipitation treatment systems. The land area curve is presented as Figure 2-23. The land requirement equation for Metals Option 4 secondary (sulfide) precipitation is:

$$\ln(Y3) = -1.15 + 0.449\ln(X) + 0.027(\ln(X))^2 \qquad \textbf{(2-23)}$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres).

Table 2-29. Land Requirement Estimates for Secondary (Sulfide) Precipitation - Metals Option 4

Flow (MGD)	Area Required (Acres)
0.0040	0.056
0.0071	0.063
0.015	0.088
0.10	0.126
0.25	0.166
0.5	0.186
1.0	0.388

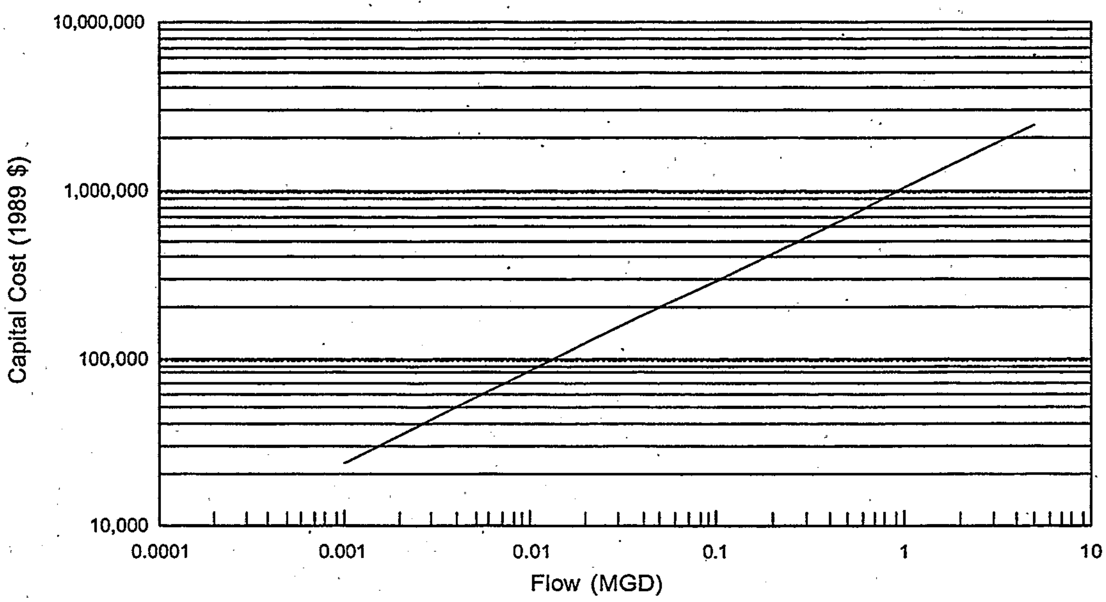

Figure 2-22. Total Capital Cost Curve for Secondary (Sulfide) Precipitation Systems - Metals Option 4

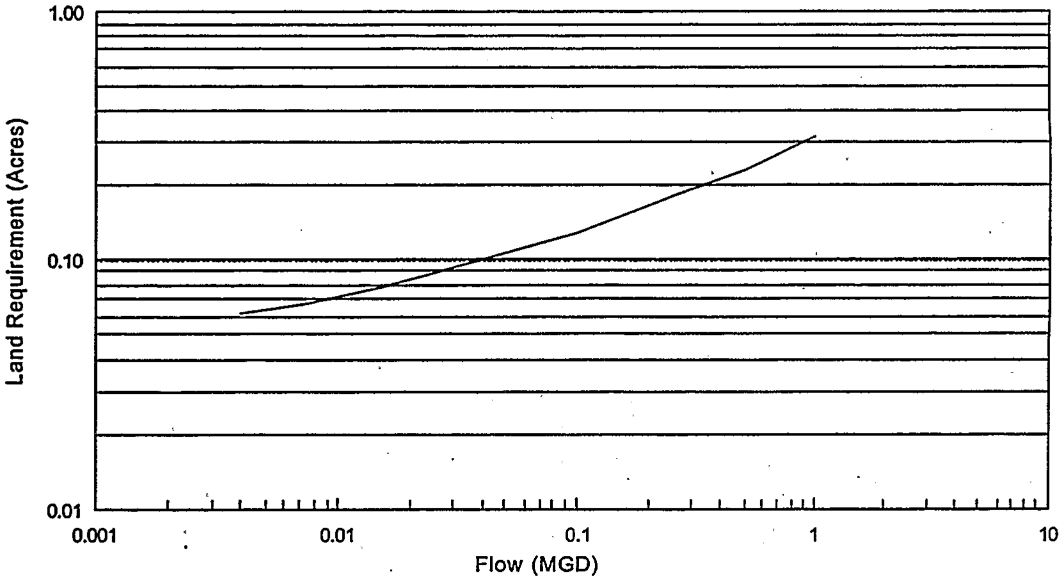

Figure 2-23. Land Requirement Curve for Secondary (Sulfide) Precipitation Systems - Metals Option 4

Labor and Chemical Costs

For facilities with no secondary precipitation systems in-place, EPA estimated the labor requirements at two hours per batch, one batch per day. EPA based this estimate on standard operation at the Metals Option 4 model facility.

For secondary sulfide precipitation in Metals Option 4, EPA did not base the chemical cost estimates on stoichiometric requirements. Instead, EPA estimated the chemical costs based on dosage rates for the addition of polymer and ferrous sulfide, obtained during the sampling of the Metals Option 4 model plant with BAT performance. Polymer was added at a rate of 0.0024 gallons per gallon of wastewater. The polymer used was the ARIES TEK LTD cationic polymer 3196 used at a rate of 16 oz of polymer per 100 gallons of water. The pricing according to the manufacturer is $1.67/lb. The ferrous sulfide slurry was added at a rate of 0.0012 gallons per gallon of wastewater. The ferrous sulfide slurry was prepared using 100 lbs of ferrous sulfate, 15 lbs of hydrated lime, 70 lbs of sodium sulfide and 500 gallons of water. According to the CWT BAT model plant, the pricing of these chemicals was as follows: $0.11/lb for ferrous sulfate, $0.044/lb for hydrated lime, and $0.38/lb for sodium sulfide. EPA assumed that the cost of water was negligible compared to the other items.

Table 2-30 presents the itemized annual O&M cost estimates for the Metals Option 4 secondary (sulfide) chemical precipitation system. The resulting cost curve is presented as Figure 2-24. The O&M cost equation for the Metals Option 4 secondary (sulfide) precipitation is:

$$\ln(Y2) = 12.076 + 0.63456\ln(X) + 0.03678(\ln(X))^2 \qquad (2\text{-}24)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-30. O&M Cost Estimates for Sulfide Precipitation Systems - Metals Option 4

Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	Chemical Cost		Total O&M Cost (1989 $/YR)
					Polymer	FeS	
0.00001	1,000	77	39	13,116	1	1	14,234
0.001	1,010	946	473	13,475	9	72	15,985
0.01	1,104	3,310	1,655	14,741	87	718	21,615
0.05	1,520	7,945	3,973	15,696	438	3,588	33,160
0.1	2,040	11,584	5,792	16,126	873	7,176	43,591
0.5	6,200	27,804	13,902	17,171	4,368	35,880	105,325
1.0	11,400	40,538	20,269	17,641	8,736	71,760	170,344
5.0	53,000	97,299	48,649	18,784	43,680	358,800	620,212

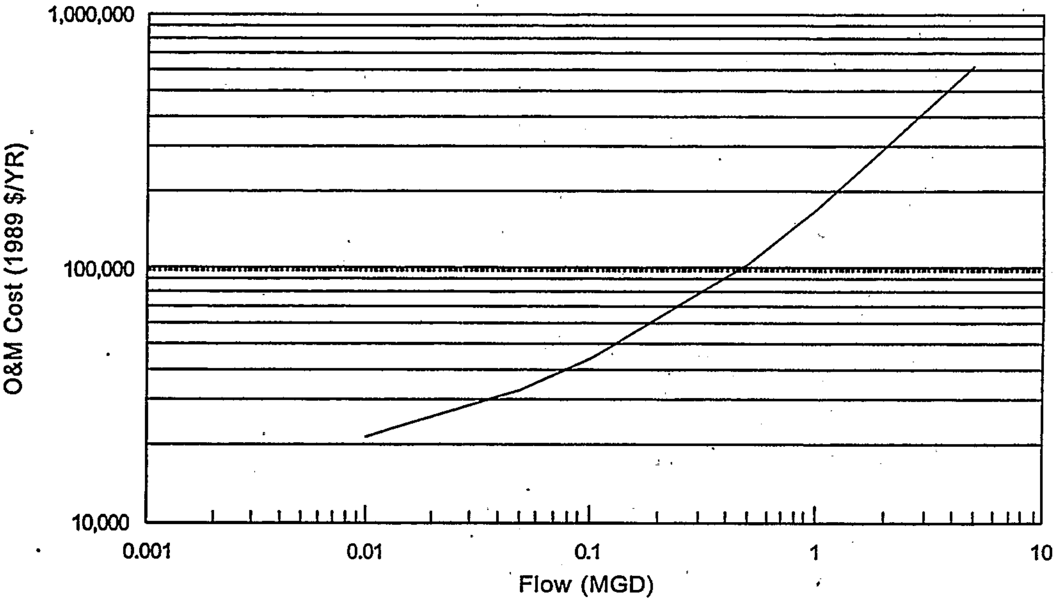

Figure 2-24. O&M Cost Curve for Secondary (Sulfide) Precipitation Systems - Metals Option 4

2.2 Plate and Frame Liquid Filtration and Clarification

Clarification systems provide continuous, low-cost separation and removal of suspended solids from water. Waste treatment facilities use clarification to remove particulates, flocculated impurities, and precipitants, often following chemical precipitation. Similarly, waste treatment facilities also use plate and frame pressure systems to remove solids from waste streams. As described in this section, these plate and frame filtration systems serve the same function as clarification and are used to remove solids following chemical precipitation from *liquid* wastestreams. The major difference between clarification systems and plate and frame liquid filtration systems is that the sludge generated by clarification generally needs to be processed further prior to landfilling, whereas, the sludge generated by plate and frame liquid filtration does not.

EPA costed facilities to include a plate and frame liquid filtration system following selective metals precipitation in Metals Options 2 and 3. The components of the plate and frame liquid filtration system include: filter plates, filter cloth, hydraulic pumps, control panel, connector pipes, and a support platform. Since EPA costed all metals facilities for selective metals precipitation systems for Metals Options 2 and 3 (except the one facility which already utilizes this technology), EPA also costed all metals facilities for plate and frame liquid filtrationsystems. Consequently, EPA did not develop any upgrade costs associated with the use of plate and frame liquid filtration, for selective metals precipitation treatment systems.

EPA also costed facilities to include a clarifier following secondary precipitation for Metals Option 2 and following both secondary and tertiary precipitation for Metals Option 3. For Metals Option 4, EPA costed facilities to include a clarifier following primary chemical precipitation and following secondary precipitation (for direct dischargers only). EPA designed and costed a single clarification system for all options and locations in the treatment train. The components of this clarification system include a clarification unit, flocculation unit, pumps, motor, foundation, and accessories.

2.2.1 Plate and Frame Liquid Filtration Following Selective Metals Precipitation - Metals Options 2 and 3

Capital and Land Costs

The plate and frame liquid filtration equipment following the selective metals precipitation step for the model technology in Metals Option 2 and 3 consists of two plate and frame liquid filtration systems. EPA assumed that each system would be used to process two batches per day for a total of four batches. EPA costed the plate and frame liquid filtration systems in this manner to allow facilities to segregate their wastes into smaller batches, thereby facilitating selective metals recovery. EPA sized each of the units to process a batch consisting of 25 percent of the daily flow and assumed that the influent to the plate and frame filtration units would consist of 96 percent liquid and four percent (40,000 mg/l) solids (based on the model facility).

Table 2-31 presents the itemized capital cost estimates for the plate and frame filtration systems following selective metals precipitation, while Figure 2-25 presents the resulting cost curve. The total capital cost equation for Metals Options 2 and 3 plate and frame filtration systems (following selective metals precipitation) is:

$$\ln(Y1) = 14.024 + 0.859\ln(X) + 0.040(\ln(X))^2 \qquad (2\text{-}25)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-31. Total Capital Cost Estimates for Plate and Frame Pressure Filtration - Metals Options 2 and 3 - Selective Metals Precipitation

Flow (MGD)	Average Vendor Equipment Cost	Installation Cost	Total Equipment & Installation Cost	Engineering & Contingency Fee	Total Capital Cost (1989 $)
0.000001	9,147	3,201	12,348	3,704	14,607
0.00001	9,147	3,201	12,348	3,704	14,607
0.0001	9,185	3,215	12,400	3,720	14,669
0.0010	12,813	4,485	17,298	5,189	20,463
0.0100	30,368	10,629	40,997	12,299	48,499
0.100	122,294	42,803	165,097	49,529	195,310
0.500	443,600	155,260	598,860	179,658	708,451
1.000	836,855	292,899	1,129,754	338,926	1,336,499

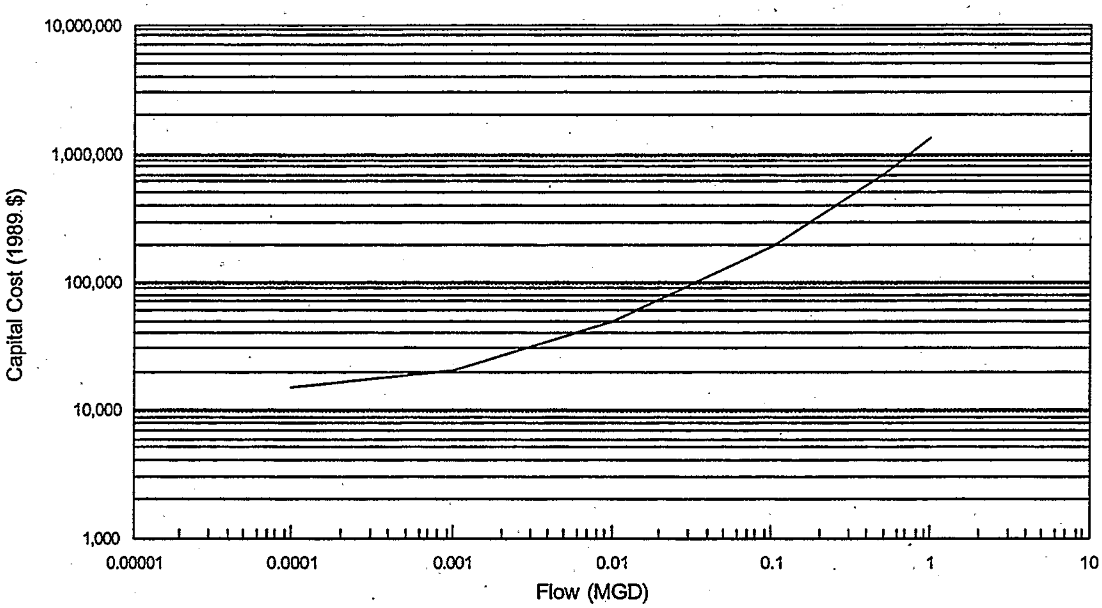

Figure 2-25. Plate and Frame Filtration (Liquid Stream) Total Capital Cost Curve for Selective Metals Precipitation - Metals Options 2 and 3

The land requirement cost curve for Metals Options 2 and 3 selective metals precipitation liquid filtration systems is presented as Figure 2-26; the subsequent equation is:

$$\ln(Y3) = -1.658 + 0.185\ln(X) + 0.009(\ln(X))^2 \qquad \textbf{(2-26)}$$

where:

X = Flow (MGD) and

Y3 = Land Requirement (Acres).

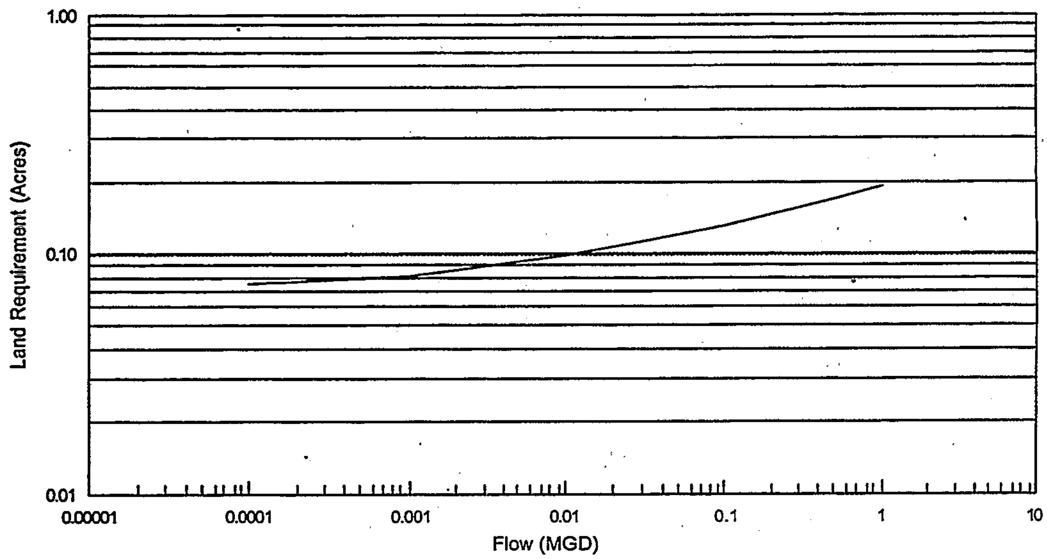

Figure 2-26. Plate and Frame Filtration (Liquid Stream) Land Requirement Curve for Selective Metals Precipitation - Metals Options 2 and 3

Chemical Usage and Labor Requirements

EPA estimated that labor requirements for plate and frame liquid filtration for Metals Options 2 and 3 would be 30 minutes per batch per filter press (based on the Metals Options 2 and 3 model facility). There are no chemicals associated with the operation of the plate and frame filtration systems. The itemized O&M cost estimates for the Metals Options 2 and 3 plate and frame filtration systems are presented in Table 2-32. The resulting cost curve is presented as Figure 2-27. The O&M equation for the Metals Options 2 and 3 selective metals precipitation plate and frame filtration systems is:

$$\ln(Y2) = 13.056 + 0.193\ln(X) + 0.00343(\ln(X))^2 \qquad (2\text{-}27)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-32. O&M Cost Estimates for Plate and Frame Pressure Filtration - Metals Options 2 and 3 - Selective Metals Precipitation

Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	O & M Cost (1989 $/YR)
0.000001	1,000	293	147	70,920	72,360
0.00001	1,000	293	147	70,920	72,360
0.0001	1,000	294	147	70,920	72,361
0.001	1,010	409	205	214,196	215,820
0.01	1,104	970	485	214,196	216,755
0.1	2,040	3,906	1,953	286,200	294,099
0.5	6,155	14,169	7,085	354,600	382,009
1.0	11,464	26,730	13,365	425,520	477,079

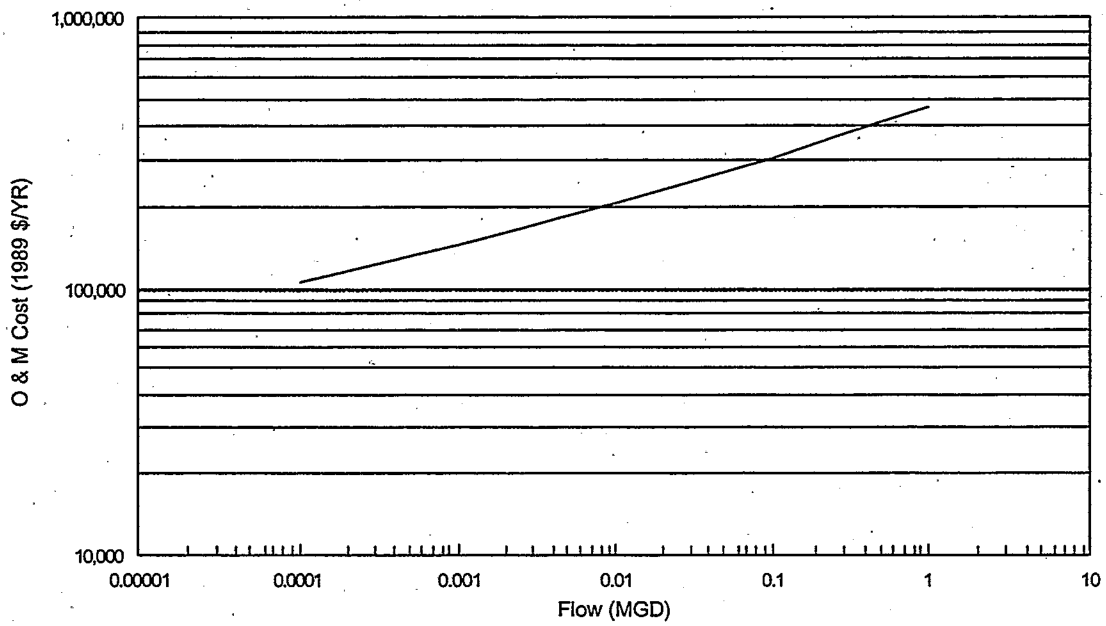

Figure 2-27. Plate and Frame Filtration (Liquid Stream) O&M Cost Curve for Selective Metals Precipitation - Metals Options 2 and 3

Even though the metal-rich sludge generated from selective metals precipitation and plate and frame liquid filtration may be recycled and re-used, EPA additionally included costs associated with disposal of these sludges in a landfill. The discussion for filter cake disposal is presented separately in Section 4.2. These disposal costs are additional O&M costs which must be added to the O&M costs calculated above to obtain the total O&M costs associated with plate and frame liquid filtration system for Metals Options 2 and 3.

2.2.2 Clarification - Metals Options 2,3, and 4

Capital and Land Costs

EPA obtained the capital cost estimate for clarification systems from vendors. EPA designed the clarification system assuming an influent total suspended solids (TSS) concentration of 40,000 mg/L (four percent solids) and an effluent TSS concentration of 200,000 mg/L (20 percent solids). In addition, EPA assumed a design overflow rate of 600 gpd/ft^2. EPA estimated the influent and effluent TSS concentrations and overflowrate based on the WTI Questionnaire response for Questionnaire ID 105. As detailed earlier, the same capital cost equation is used for all of the clarification systems for all of the Metals Options regardless of its location in the treatment train. EPA did not develop capital cost upgrades for facilities which already have clarification systems in-place. Therefore, facilities which currently have clarifiers have no land or capital costs.

EPA obtained the capital cost estimates for the clarification systems from vendors. The itemized capital cost estimates for the clarification systems are presented in Table 2-33. The resulting cost curve is presented as Figure 2-28. The total capital cost equation for the Metals Options 2, 3, and 4 clarification systems is:

$$\ln(Y1) = 11.552 + 0.409\ln(X) + 0.020(\ln(X))^2 \qquad (2\text{-}28)$$

where:

X = Flow (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-33. Total Capital Cost Estimates for Clarification Systems - Metals Options 2, 3, and 4

Vol/Day (MGD)	System Cost	Install.	Piping	Instrum. & Controls	Engineer. & Conting.	Total Capital Cost (1993 $)	Total Capital Cost (1989 $)
0.000001	6,579	2,303	1,974	1,974	3,849	16,679	15,178
0.00001	6,579	2,303	1,974	1,974	3,849	16,679	15,178
0.0001	6,579	2,303	1,974	1,974	3,849	16,679	15,178
0.001	6,971	2,440	2,091	2,091	4,078	17,671	16,081
0.01	9,547	3,341	2,864	2,864	5,585	24,201	22,023
0.05	14,550	5,093	4,365	4,365	8,512	36,885	33,565
0.1	18,358	6,425	5,507	5,507	10,739	46,536	42,348
0.5	35,466	12,413	10,640	10,640	20,748	89,907	81,815
1.0	49,563	17,347	14,869	14,869	28,994	125,642	114,334

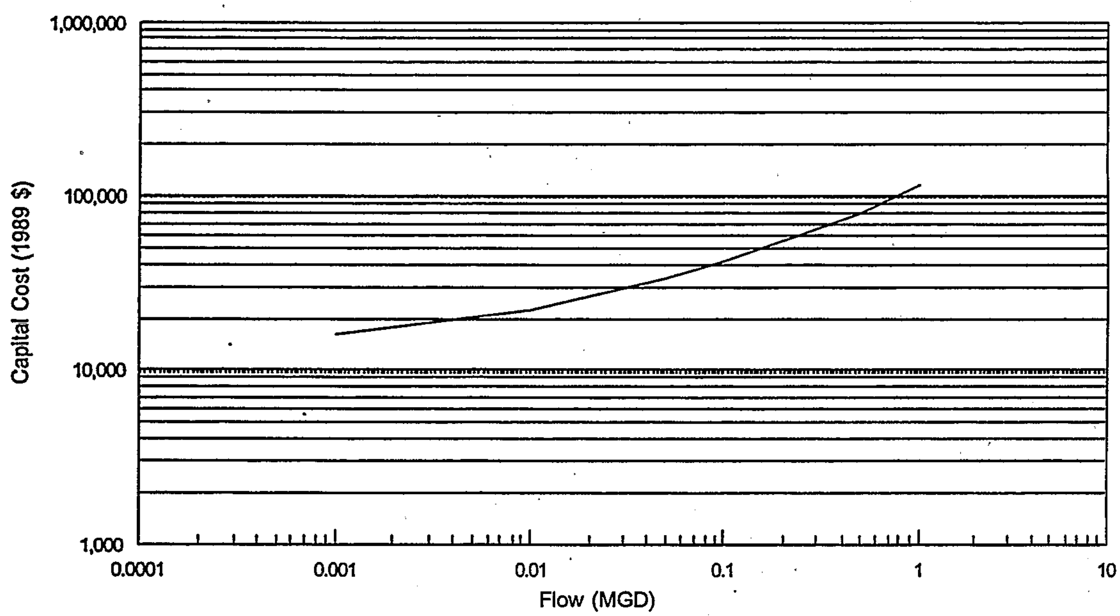

Figure 2-28. Total Capital Cost Curve for Clarification Systems - Metals Options 2, 3, and 4

Figure 2-29 presents the land requirement cost curve for the Metals Options 2, 3, and 4 clarification systems. The equation relating the flow of the clarification system with the land requirement for all Metals Options is:

$$\ln(Y3) = -1.773 + 0.513\ln(X) + 0.046(\ln(X))^2 \quad (2\text{-}29)$$

where:

X = Flow (MGD) and

Y3 = Land Requirement (Acres).

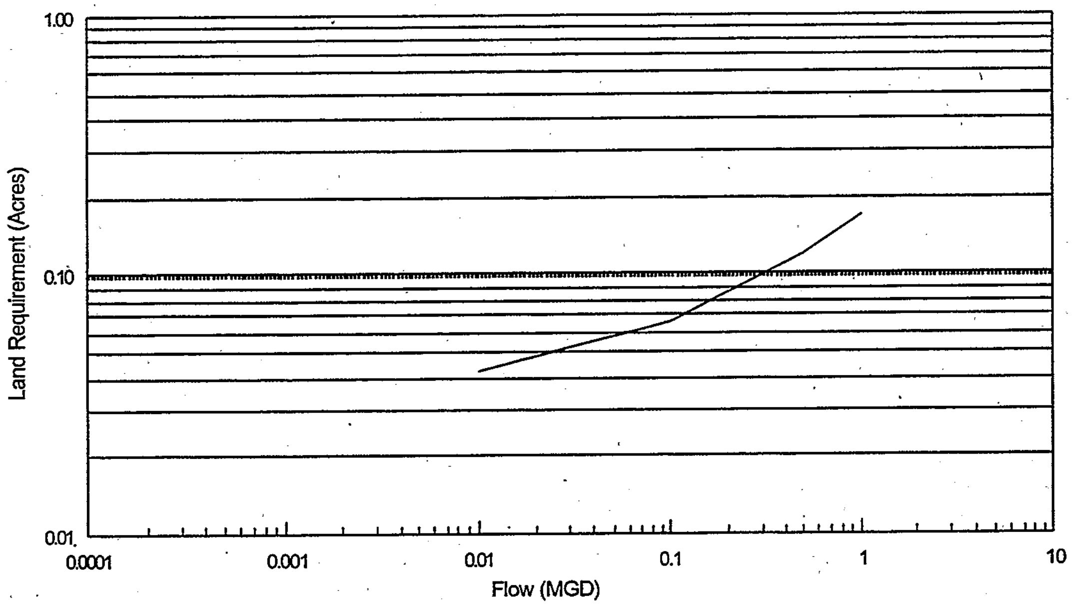

Figure 2-29. Land Requirement Curve for Clarification Systems - Metals Options 2, 3, and 4

Chemical Usage and Labor Requirements

EPA estimated the labor requirements for the clarification systems for Metals Options 2 and 3 following secondary precipitation and Metals Option 4 following primary and secondary (for direct dischargers only) precipitation at three hours per day for low-flow clarifiers and four to six hours per day for high-flow clarifiers. Based on manufacturers recommendations, EPA selected the flow cut-off between high-flow and low-flow systems to be 1,000 gallons per day. For the clarifier following tertiary precipitation in Metals Option 3 only, EPA estimated the labor requirement at one hour per day (based on the operation of the Metals Option 3 model facility). For all clarifiers for all Metals Options and treatment train locations, EPA estimated a polymer dosage rate of 2.0 mg per liter of wastewater (for the flocculation step) based on the MP&M industry cost model.

Table 2-34 presents the itemized O&M cost estimates for the Metals Options 2 and 4 clarification treatment systems, while Table 2-35 presents the itemized O&M cost estimates for the Metals Option 3 clarification systems. The resulting cost curves are presented as Figures 2-30 and 2-31. Equations 2-30 and 2-31 present the O&M cost equations for clarification systems for Metals Options 2 and 4 and Metals Option 3, respectively.

$$\ln(Y2) = 10.673 + 0.238\ln(X) + 0.013(\ln(X))^2 \qquad (2\text{-}30)$$

$$\ln(Y2) = 10.294 + 0.362\ln(X) + 0.019(\ln(X))^2 \qquad (2\text{-}31)$$

where:

X = Flow Rate (MGD),

Y2 = O&M Cost (1989 $/YR).

Table 2-34. O&M Cost Estimates for Clarification Systems - Metals Options 2 and 4

Vol/day (MGD)	Energy	Labor	Maintenance	Taxes & Insurance	Polymer Cost	Total O&M Cost (1993 $/YR)	Total O&M Cost (1989 $/YR)
0.000001	1,000	15,741	667	334	10	17,752	16,154
0.00001	1,000	15,741	667	334	10	17,752	16,154
0.0001	1,000	15,741	667	334	10	17,752	16,154
0.001	1,010	15,857	706	353	15	17,941	16,326
0.01	1,104	16,842	968	484	150	19,548	17,789
0.05	1,520	18,210	1,475	738	750	22,693	20,651
0.1	2,040	19,005	1,861	931	1,500	25,337	23,057
0.5	6,155	21,439	3,596	1,798	7,500	40,488	36,844
1.00	11,464	22,788	5,025	2,513	15,000	56,790	51,679

Table 2-35. O&M Cost Estimates for Clarification Systems - Metals Option 3

Vol/day (MGD)	Energy	Labor	Maintenance	Taxes & Insurance	Polymer Cost	Total O & M Cost (1993 $/YR)	Total O & M Cost (1989 $/YR)
0.000001	1,000	5,247	667	334	10	7,258	6,605
0.00001	1,000	5,247	667	334	10	7,258	6,605
0.0001	1,000	5,247	667	334	10	7,258	6,605
0.001	1,010	5,286	706	353	15	7,370	6,707
0.01	1,104	5,614	968	484	150	8,320	7,571
0.05	1,520	6,070	1,475	738	750	10,553	9,603
0.1	2,040	6,335	1,861	931	1,500	12,667	11,527
0.5	6,155	7,146	3,596	1,798	7,500	26,195	23,837
1.00	11,464	7,596	5,025	2,513	15,000	41,598	37,854

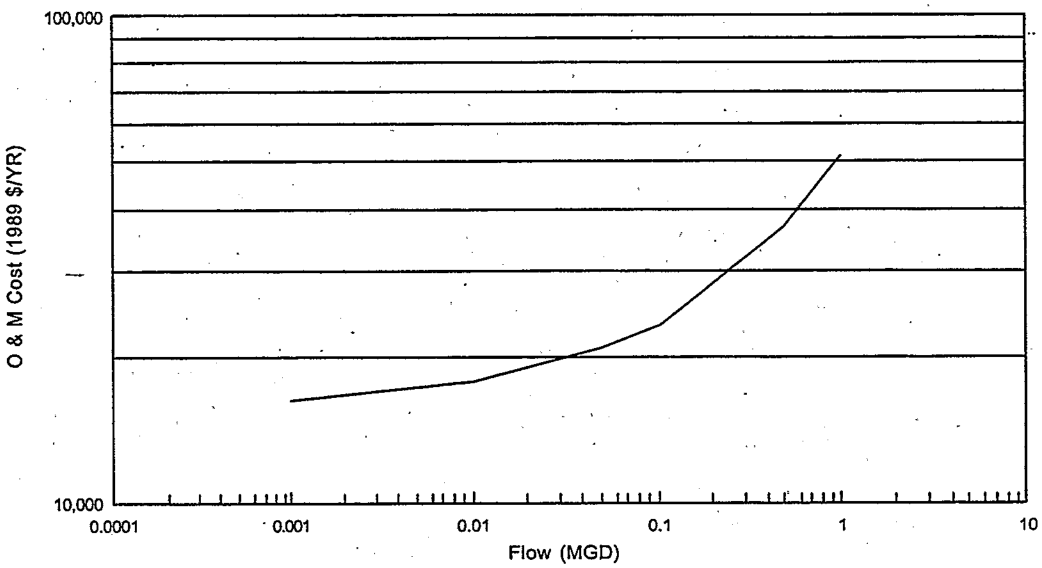

Figure 2-30. O&M Cost Curve for Clarification Systems - Metals Options 2 and 4

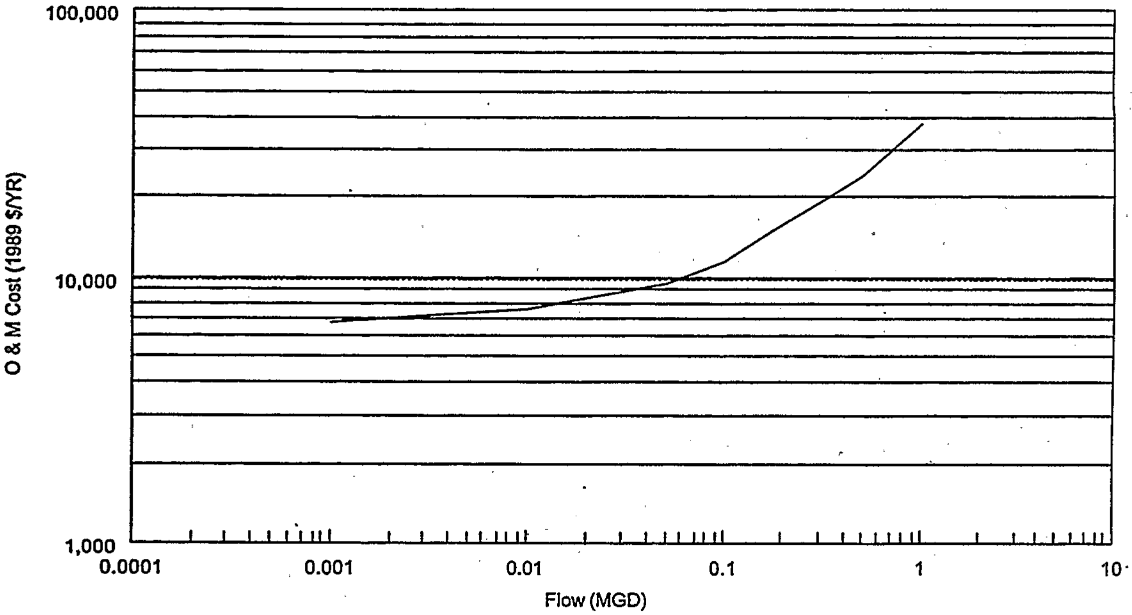

Figure 2-31. O&M Cost Curve for Clarification Systems - Metals Option 3

As shown in Table 1-3, sludge filtration follows clarification for the secondary precipitation step of Metals Options 2 and 3 and the primary and secondary (direct dischargers only) of Metals Option 4. The costing discussion and equations for sludge filtration and the associated filter cake disposal are presented in Section 4.1 and 4.2, respectively.

For facilities which already have clarification systems or plate and frame liquid filtration systems in-place for each option and location in the treatment train, EPA estimated upgrade costs. EPA assumed that clarification systems and plate and frame liquid filtration systems are equivalent. Therefore, if a facility has an in-place liquid filtration system which can serve the same purpose as a clarifier, EPA costed this facility for an upgrade only and not a new system.

For the clarification step following secondary precipitation in Metals Options 2 and 3, in order to quantify the O&M increase necessary for the O&M upgrade, EPA compared the difference between secondary precipitation current performance concentrations and the Metals Option 2 long- term averages. EPA determined facilities would need to increase their current removals by 3 percent. Therefore, for in-place clarification systems (or plate and frame liquid filtration systems) which could serve as the clarifier following secondary chemical precipitation for Metals Option 2 and 3, EPA included an O&M cost upgrade of three percent of the O&M costs for a brand new system (except for taxes, insurance, and maintenance which are a function of the capital cost).

For facilities which already have clarifiers or plate and frame liquid filtration systems in-place which could serve as the clarifier following the tertiary chemical precipitation of Metals Option 3, EPA did not estimate any O&M upgrade costs. EPA assumed the in-place technologies could perform as well as (or better) than the technology costed by EPA.

Equations 2-32 and 2-33 present the O&M upgrade cost equations for the Metals Options 2 and 3 clarification and liquid filtration systems, respectively.

$$\ln(Y2) = 7.166 + 0.238\ln(X) + 0.013(\ln(X))^2 \quad (2\text{-}32)$$

$$\ln(Y2) = 8.707 + 0.333\ln(X) + 0.012(\ln(X))^2 \quad (2\text{-}33)$$

where:

X = Flow Rate (MGD),

Y2 = O&M Cost (1989 $/YR).

Figures 2-32 and 2-33 present the cost curves for the Metals Options 2 and 3 clarification and liquid filtration O&M upgrade, respectively.

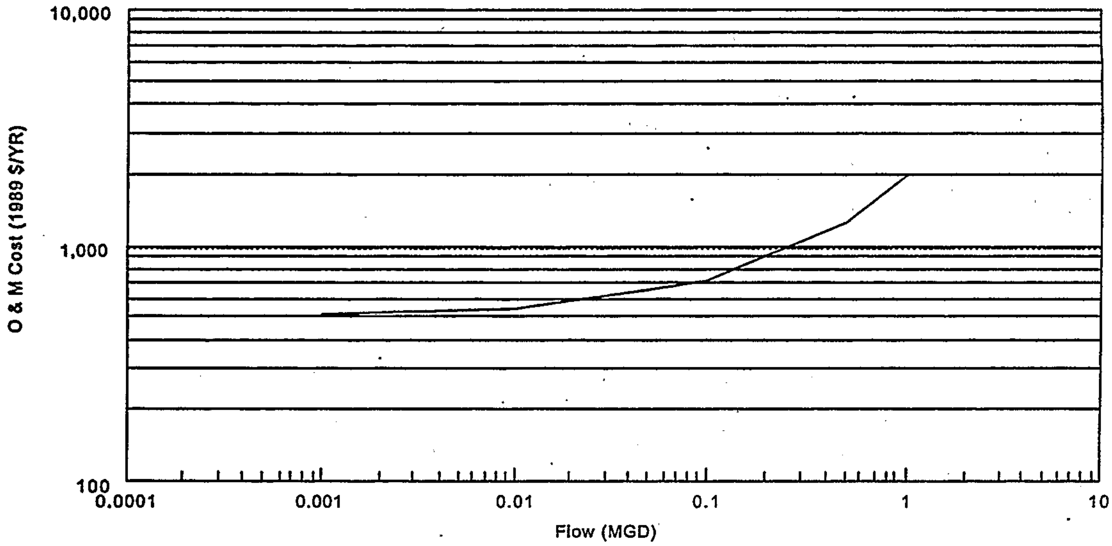

Figure 2-32. O&M Upgrade Cost Curve for Clarification Systems - Metals Options 2 and 3

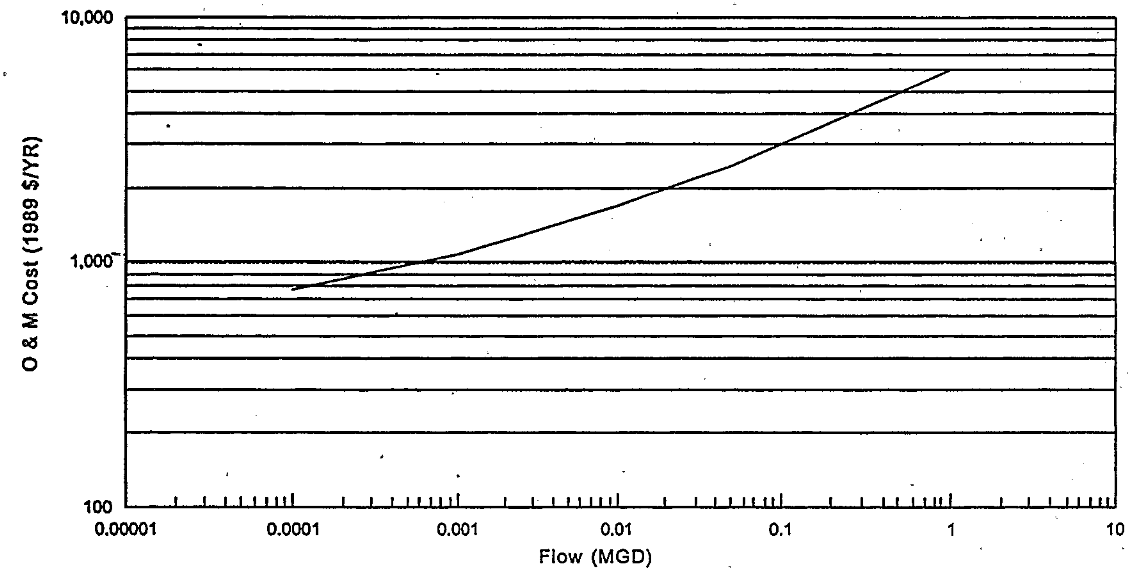

Figure 2-33. Plate and Frame Filtration (Liquid Stream) O&M Upgrade Cost Curve for Primary Chemical Precipitation - Metals Options 2 and 3

For facilities which already have clarifiers or plate and frame liquid filtration systems in-place which could serve as the clarifier following the primary chemical precipitation of Metals Option 4, EPA compared the difference between primary precipitation current loadings and the long-term averages for Metals Option 4, Sample Point 03 (Sample Point 03 follows primary precipitation and clarification at the Metals Option 4 model facility). EPA determined that facilities would need to increase their removals by 2%. Therefore, for in-place clarification systems (or plate and frame liquid filtration systems) which could serve as the clarifier following primary chemical precipitation for Metals Option 4, EPA included an O&M cost upgrade of two percent of the O&M costs for a brand new system (except for taxes, insurance, and maintenance which are a function of the capital cost).

EPA did not calculate an O&M upgrade equation for the clarification step following secondary chemical precipitation (direct dischargers only) of Metals Option 4. EPA costed all direct discharging facilities for a new clarification system following secondary chemical precipitation for Metals Option 4 since none of the direct discharging metals facilities had treatment in-place for this step.

The O&M upgrade cost equations for the Metals Option 4 clarification and liquid filtration systems are presented below as Equations 2-34 and 2-35, respectively.

$$\ln(Y2) = 6.8135 + 0.3315\ln(X) + 0.0242(\ln(X))^2 \qquad (2\text{-}34)$$

$$\ln(Y2) = 12.0242 + 1.17676\ln(X) + 0.05005(\ln(X))^2 \qquad (2\text{-}35)$$

where:

X = Flow Rate (MGD),

Y2 = O&M Cost (1989 $/YR).

2.3 Equalization

To improve treatment, facilities often need to equalize wastes by holding them in a tank. The CWT industry frequently uses equalization to minimize the variability of incoming wastes effectively.

EPA costed an equalization system which consists of a mechanical aeration basin based on responses to the WTI Questionnaire. EPA obtained the equalization cost estimates from the 1983 U.S. Army Corps of Engineers' Computer Assisted Procedure for Design and Evaluation of Wastewater Treatment Systems (CAPDET). EPA originally used this program to estimate equalization costs for the OCPSF Industry. Table 2-36 lists the default design parameters that EPA used in the CAPDET program. These default design parameters are reasonable for the CWT industry since they reflect values seen in the CWT industry. For example, the default detention time (24 hours) is appropriate since this was the median equalization detention time reported by respondents to the WTI Questionnaire.

Table 2-36. Design Parameters Used for Equalization in CAPDET Program

Aerator mixing requirements = 0.03 HP per 1,000 gallons;
Oxygen requirements = 15.0 mg/l per hour;
Dissolved oxygen in basin = 2.0 mg/l;
Depth of basin = 6.0 feet; and
Detention time = 24 hours.

EPA did not calculate capital or O&M upgrade equations for equalization. If a CWT facility currently has an equalization tank in-place, the facility received no costs associated with equalization. EPA assumed that the equalization tanks currently in-place at CWT facilities would perform as well as (or better than) the system costed by EPA.

Capital and Land Costs

The CAPDET program calculates capital costs which are "total project costs." These "total project costs" include all of the items previously listed in Table 1-1 as well as miscellaneous nonconstruction costs, 201 planning costs, technical costs, land costs, interest during construction, and laboratory costs. Therefore, to obtain capital costs for the equalization systems for this industry, EPA calculated capital costs based on total project costs minus: miscellaneous nonconstruction costs, 201 planning costs, technical costs, land costs, interest during construction, and laboratory costs.

Table 2-37 presents the total capital and land requirement estimates for the equalization systems. Figure 2-34 presents the cost curve for the total capital cost of the equalization systems, while Figure 2-35 presents the cost curve for the land requirement for the equalization systems. Equation 2-36 presents the cost equation for the total capital cost for equalization systems. Equation 2-37 presents the land requirement cost equation for the equalization systems.

$$\ln(Y1) = 12.057 + 0.433\ln(X) + 0.043(\ln(X))^2 \qquad (2\text{-}36)$$

$$\ln(Y3) = -0.912 + 1.120\ln(X) + 0.011(\ln(X))^2 \qquad (2\text{-}37)$$

where:

X = Flow Rate (MGD),

Y1 = Capital Cost (1989 $), and

Y3 = Land Requirements (Acres).

Table 2-37. Total Capital Cost, O&M Cost, and Land Requirement Estimates for Equalization Systems

Flow Rate (MGD)	Capital Cost (1989 $)	O & M Cost (1989 $/YR)	Land Requirement (acres)
0.001	59,800	33,400	0.0003
0.005	62,300	41,100	0.0015
0.01	64,200	45,400	0.003
0.05	73,200	59,100	0.015
0.10	80,680	67,600	0.03
0.50	119,100	97,500	0.15
0.75	137,900	108,700	0.34
1.0	155,100	117,900	0.46
1.5	215,900	137,900	0.69
2.0	222,200	150,200	0.92
3.0	309,600	178,100	1.38
4.0	352,900	202,200	1.84
5.0	423,500	226,900	2.30

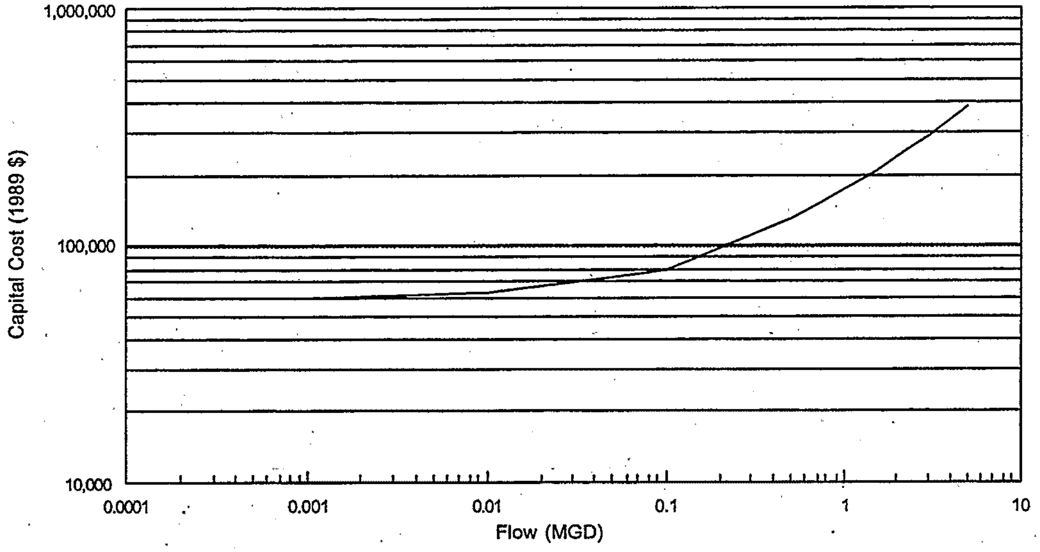

Figure 2-34. Total Capital Cost Curve for Equalization Systems

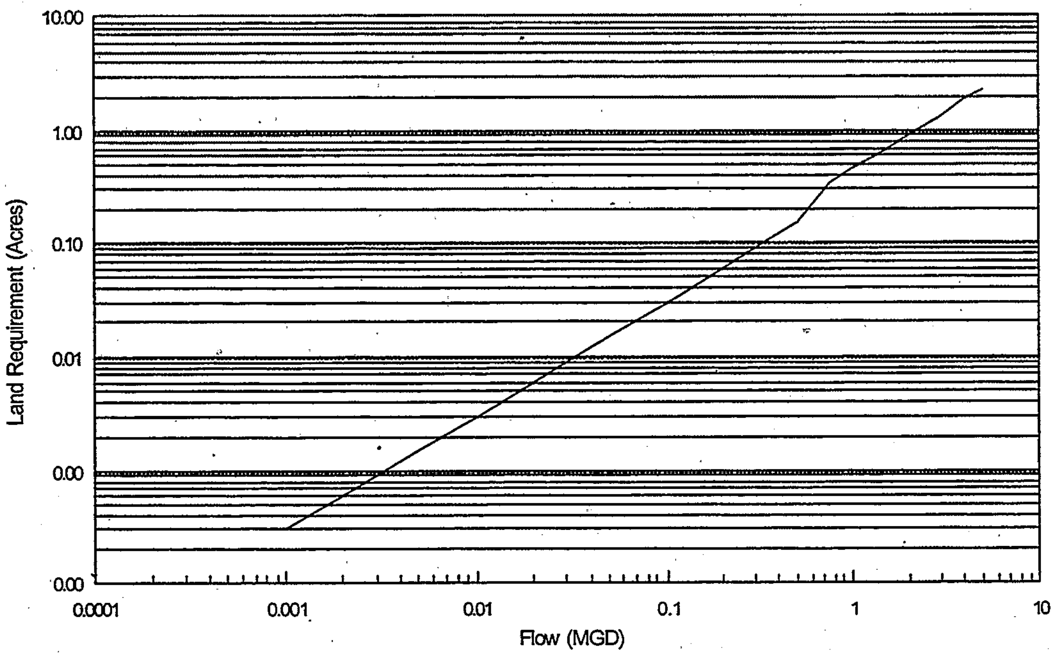

Figure 2-35. Land Requirement Curve for Equalization Systems

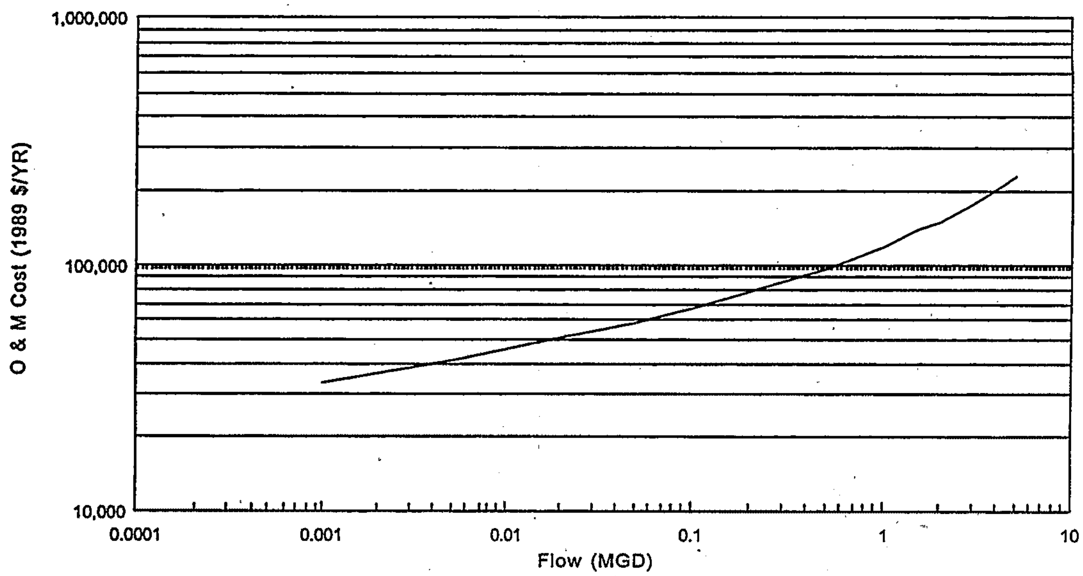

Figure 2-36. O&M Cost Curve for Equalization Systems

Operation and Maintenance Costs

EPA obtained O&M costs directly from the initial year O&M costs produced by the CAPDET program. The O&M cost estimates for equalization systems are presented in Table 2-37. Figure 2-36 presents the resulting cost curve. The O&M cost equation for the equalization systems is:

$$\mathbf{\ln(Y2) = 11.723 + 0.311\ln(X) + 0.019(\ln(X))^2} \qquad \mathbf{(2\text{-}38)}$$

where:

X = Flow Rate (MGD) and

Y2 = O & M Cost (1989 $/YR).

2.4 Air Stripping

Air stripping is an effective wastewater treatment method for removing dissolved gases and volatile compounds from wastewater streams. The technology passes high volumes of air through an agitated gas-water mixture. This promotes volatilization of compounds, and, preferably capture in air pollution control systems.

The air stripping system costed by EPA includes transfer pumps, control panels, blowers, and ancillary equipment. EPA also included catalytic oxidizers as part of the system for air pollution control purposes.

If a CWT facility currently has an air stripping system in-place, EPA did not assign the facility any costs associated with air stripping. EPA assumed that the air stripping systems currently in-place at CWT facilities would perform as well as (or better than) the system costed by EPA.

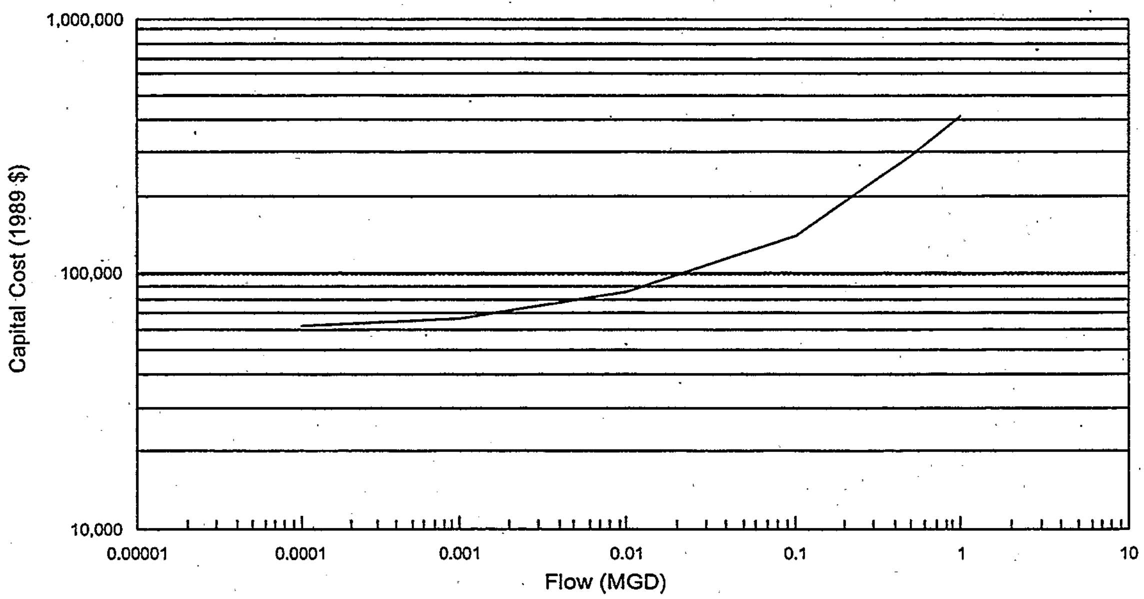

Figure 2-37. Total Capital Cost Curve for Air Stripping Systems

Capital and Land Costs

EPA's air stripping system is designed to remove pollutants with medium to high volatilities. EPA used the pollutant 1,2-dichloroethane, which has a Henry's Law Constant of 9.14 E -4 atm*L/mol, as the design basis with an influent concentration of 4,000 µg/L and an effluent concentration of 68 µg/L. EPA based these concentration on information collected on the model facility's operation. EPA used the same design basis for the air stripping systems costed for the option 8v and 9v in the oils subcategory.

EPA obtained the equipment costs from vendor quotations. Table 2-38 presents the itemized capital cost estimates for the air stripping systems. Figure 2-37 presents the resulting cost curve. The total capital cost equation for the air stripping systems is:

$$\ln(Y1) = 12.899 + 0.486\ln(X) + 0.031(\ln(X))^2 \qquad (2\text{-}39)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-38. Total Capital Cost Estimates for Air Stripping Systems

Flow (MGD)	System & Installation Cost (1989 $)	Engineering & Contingency	Total Capital Cost (1989 $)
0.0001	48,210	14,463	62,673
0.001	50,760	15,228	65,988
0.01	64,800	19,440	84,240
0.1	108,675	32,603	141,278
0.5	224,930	67,479	292,409
1.0	317,970	95,391	413,361

To develop land requirements for the air stripping and catalytic oxidizer systems, EPA used vendor data. The dimensions of the air strippers, in terms of length and width, are very small compared to the catalytic oxidizers. Figure 2-38 presents the land requirement curve for air stripping systems. The land requirement equation for the air stripping systems is:

$$\ln(Y3) = -2.207 + 0.536\ln(X) + 0.042(\ln(X))^2 \qquad \textbf{(2-40)}$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres).

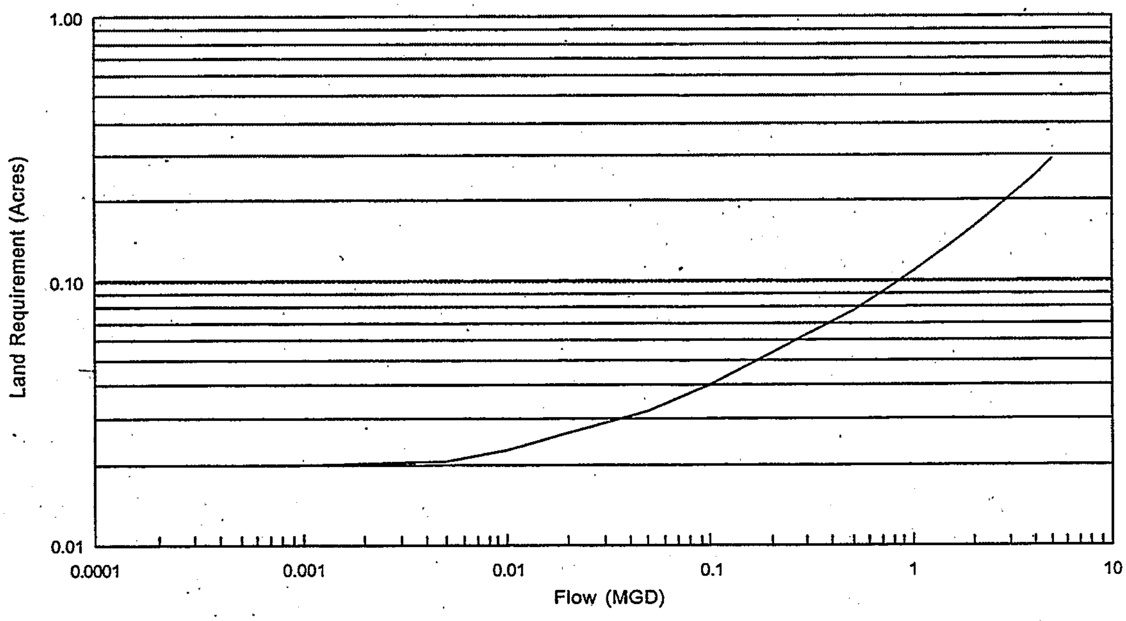

Figure 2-38. Land Requirement Curve for Air Stripping Systems

Operation and Maintenance Costs

For air stripping, O&M costs include electricity, maintenance, labor, catalyst replacement, and taxes and insurance. EPA obtained the O&M costs from the same vendor which provided the capital cost estimates.

EPA based the electricity usage for the air strippers on the amount of horsepower needed to operate the system and approximated the electricity usage for the catalytic oxidizers at 50 percent of the electricity used for the air strippers. EPA based both the horsepower requirements and the electricity requirements for the catalytic oxidizer on vendor's recommendations. EPA estimated the labor requirement for the air stripping system at three hours per day, which is based on the model facility's operation. EPA assumed that the catalyst beds in the catalytic oxidizer would require replacement every four years based on the rule of thumb (provided by the vendor) that precious metal catalysts have a lifetime of approximately four years. EPA divided the costs for replacing the spent catalysts by four to convert them to annual costs. As is the standard used by EPA for this industry, taxes and insurance were estimated at 2 percent of the total capital cost.

Table 2-39 presents the itemized O&M cost estimates for the air stripping systems. Figure 2-39 presents the resulting cost curve. The O&M cost equation for the air stripping system is:

$$\ln(Y2) = 10.865 + 0.298\ln(X) + 0.021(\ln(X))^2 \qquad (2\text{-}41)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-39. O&M Cost Estimates for Air Stripping Systems

Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	Catalyst Replacement Cost	Total O&M Cost (1992 $/YR)	Total O&M Cost (1989 $/YR)
0.0001	1,050	1,928	964	16,425	33	20,400	19,176
0.001	1,575	2,030	1,015	16,425	50	21,095	19,829
0.01	2,100	2,592	1,296	16,425	102	22,515	21,164
0.1	5,250	4,347	2,174	16,425	500	28,696	26,974
0.5	11,812	9,000	4,500	16,425	1,500	43,237	40,643
1.0	21,000	12,720	6,360	16,425	4,250	60,755	57,110

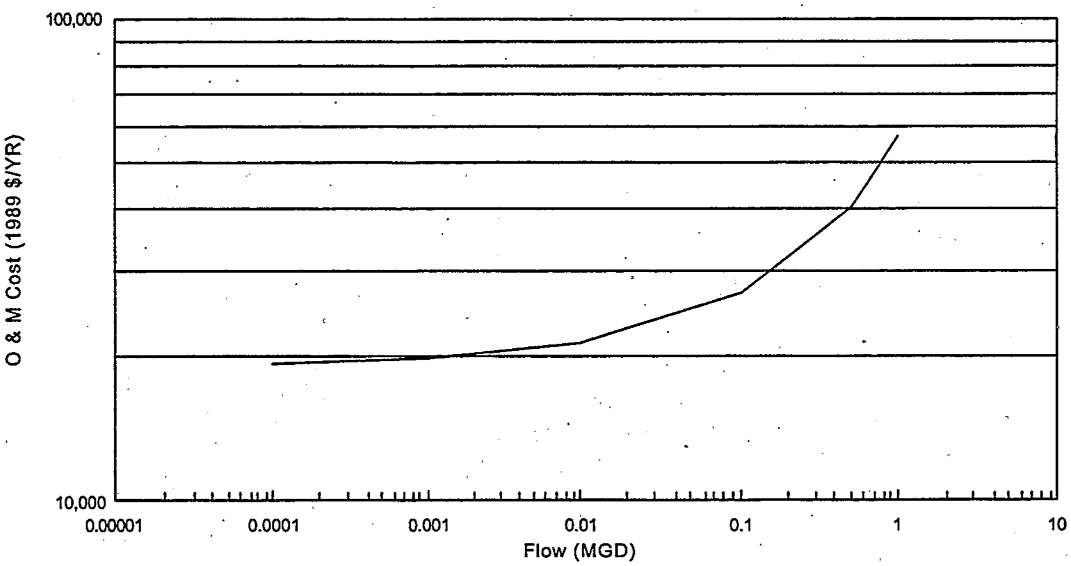

Figure 2-39. O&M Cost Curve for Air Stripping Systems

2.5 Multi-Media Filtration

Filtration is a proven technology for the removal of residual suspended solids from wastewater. The multimedia filtration system costed by EPA for this industry is a system which contains sand and anthracite coal, supported by gravel.

EPA based the design for the model multimedia filtration system on the TSS effluent long- term average concentration for Metals Option 4 -- 15 mg/L. EPA assumed that the average influent TSS concentration to the multimedia filtration system would range from 75 to 100 mg/L. EPA based the influent concentration range on vendor's recommendations on realistic TSS concentrations resulting from wastewater treatment following chemical precipitation and clarification.

EPA did not calculate capital or O&M upgrade equations for multi-media filtration. If a CWT facility currently has a multimedia filter in-place, EPA assigned the facility no costs associated with multi-media filtration. EPA assumed that the multi-media filter currently in-place at CWT facilities would perform as well as (or better than) the system costed by EPA.

Capital and Land Costs

EPA based the capital costs of multi-media filters on vendor's recommendations. Table 2-40 presents the itemized total capital cost estimates for the multi-media filtration systems. The resulting cost curve is presented as Figure 2-40. The total capital cost equation for the multi-media filtration system is:

$$\ln(Y1) = 12.0126 + 0.48025\ln(X) + 0.04623(\ln(X))^2 \qquad (2\text{-}42)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-40. Total Capital Cost Estimates for Multi-Media Filtration Systems

Flow Rate (MGD)	System Cost	Installation	Piping	Instrument. & Controls	Engineering & Contingency	Total Capital Cost (1997 $)	Total Capital Cost (1989 $)
0.01	23,500	8,225	7,050	7,050	13,748	59,573	47,198
0.05	31,000	10,850	9,300	9,300	18,135	78,585	62,261
0.50	55,000	19,250	16,500	16,500	32,175	139,425	110,463
1.0	87,000	30,450	26,100	26,100	50,895	220,545	174,732

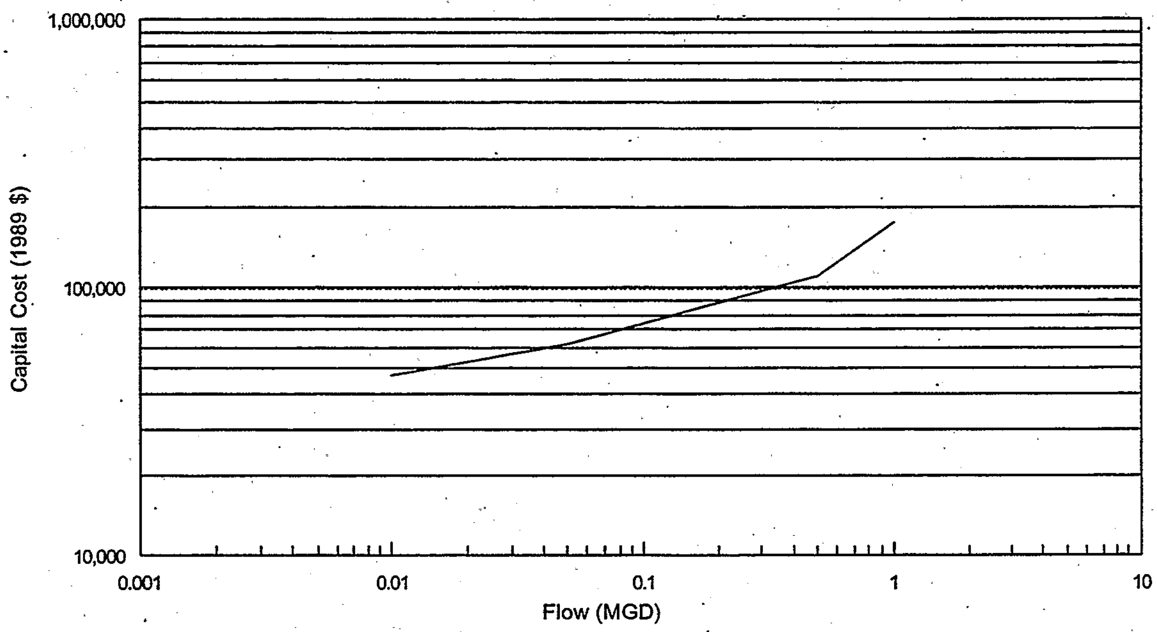

Figure 2-40. Total Capital Cost Curve for Multi-Media Filtration Systems

To develop land requirements for multi-media filtration systems, the vendor provided overall system dimensions. EPA scaled up the land dimensions to represent the total land required for the system plus peripherals (pumps, controls, access areas, etc.). Table 2-41 presents the land requirement for multi-media filtration systems. Figure 2-41 presents the resulting cost curve. The land requirement equation for the multi-media filtration system is:

$$\ln(Y3) = -2.6569 + 0.19371\ln(X) + 0.02496(\ln(X))^2 \qquad (2\text{-}43)$$

where:

X = Flow (MGD) and

Y3 = Land Requirement (Acres).

Table 2-41. Land Requirement Estimates for Multi-Media Filtration Systems

Flow Rate (MGD)	Land Requirement (Acres)
0.01	0.0485
0.05	0.0500
0.50	0.0602
1.0	0.0716

Chemical Usage and Labor Requirement Costs

EPA estimated the labor requirement for the multi-media filtration system at four hours per day, whichis based on manufacturer's recommendations. There are no chemicals associated with the operation of a multi-media filter. The itemized O&M cost estimates for the multi-media filtration systems are presented in Table 2-42. The resulting cost curve is presented as Figure 2-42. The O&M cost equation for the multi-media filtration system is:

$$\ln(Y2) = 11.5039 + 0.72458\ln(X) + 0.09535(\ln(X))^2 \quad (2\text{-}44)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-42. O&M Cost Estimates for Multi-Media Filtration Systems

Flow Rate (MGD)	Energy	Labor	Maintenance	Taxes & Insurance	Total O&M Cost (1989 $/YR)
0.01	1,600	21,900	1,888	944	26,332
0.05	1,730	21,900	2,490	1,245	27,366
0.50	31,200	21,900	4,419	2,209	59,728
1.0	70,000	21,900	6,989	3,495	102,384

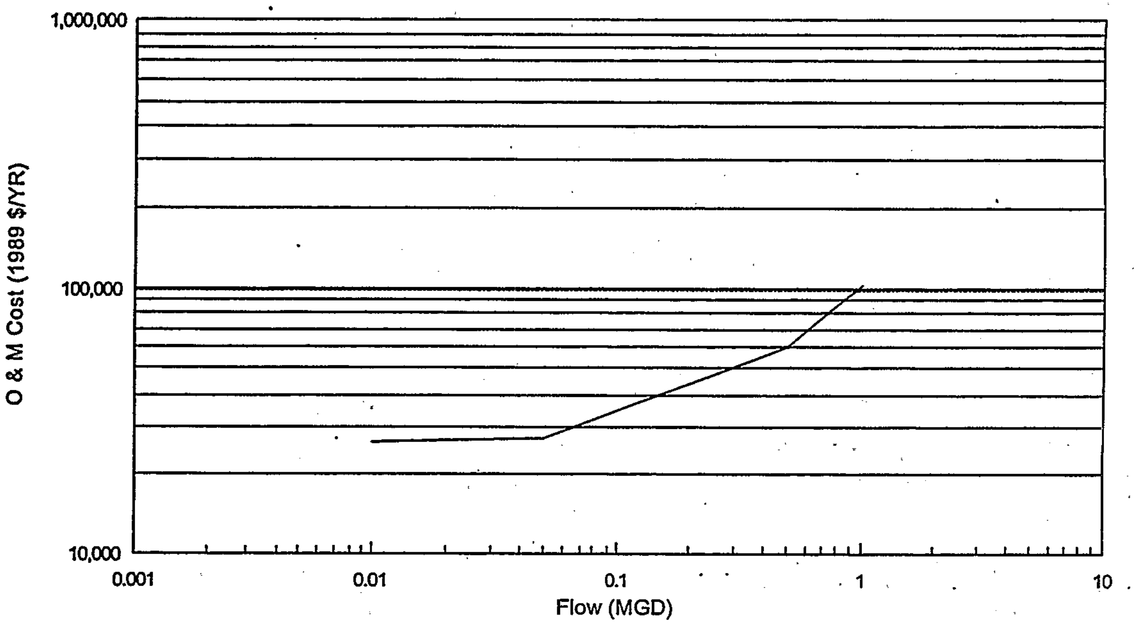

Figure 2-42. O&M Cost Curve for Multi-Media Filtration Systems

2.6 Cyanide Destruction

Many CWTs achieved required cyanide destruction by oxidation. These facilities primarily use chlorine (in either the elemental or hypochlorite form) as the oxidizing agent in this process. Oxidation of cyanide with chlorine is called alkaline chlorination.

The oxidation of cyanide waste using sodium hypochlorite is a two step process. In the first step, cyanide is oxidized to cyanate in the presence of hypochlorite, and sodium hydroxide is used to maintain a pH range of 9 to 11. The second step oxidizes cyanate to carbon dioxide and nitrogen at a controlled pH of 8.5. The amounts of sodium hypochlorite and sodium hydroxide needed to perform the oxidation are 8.5 parts and 8.0 parts per part of cyanide, respectively. At these levels, the total reduction occurs at a retention time of 16 to 20 hours. The application of heat can facilitate the more complete destruction of total cyanide.

The cyanide destruction system costed by EPA includes a two-stage reactor with a retention time of 16 hours, feed system and controls, pumps, piping, and foundation. The two-stage reactor includes a covered tank, mixer, and containment tank. EPA designed the system based on amenable and total cyanide influent concentrations of 1,548,000 μg/L and 4,633,710 μg/L, respectively and effluent concentrations of amenable and total cyanide of 276,106 μg/L and 135,661 μg/L, respectively. EPA based these influent and effluent concentrations on data collected during EPA's sampling of cyanide destruction systems.

Because the system used by the facility which forms the basis of the proposed cyanide limitation and standards uses special operation conditions, EPA assigned full capital and O&M costs to all facilities which perform cyanide destruction.

Capital and Land Costs

EPA obtained the capital costs curves for cyanide destruction systems with special operating conditions from vendor services. Table 2-43 presents the itemized total capital cost estimates for the cyanide destruction systems. Figure 2-43 presents the resulting cost curve. The total capital cost equation for cyanide destruction systems is:

$$\mathbf{ln(Y1) = 13.977 + 0.546ln(X) + 0.0033(ln(X))^{2)}} \qquad \mathbf{(2\text{-}45)}$$

where:

X = Batch Size (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-43. Total Capital Cost Estimates for Cyanide Destruction at Special Operating Conditions

Volume per Day (MGD)	System Cost	Installation	Piping	Instrument. & Controls	Total Construction Cost	Total Capital Cost (1993 $)	Total Capital Cost (1989 $)
0.000001	500	175	155	65	895	960	874
0.00001	1,850	648	574	241	3,313	3,554	3,234
0.0001	5,000	1,750	1,550	650	8,950	9,600	8,736
0.001	14,252	4,988	4,418	1,853	25,511	27,364	24,901
0.01	45,875	16,056	14,221	5,964	82,116	88,080	80,153
0.05	106,105	37,137	32,893	13,794	189,929	203,723	185,388
0.10	160,542	56,190	49,768	20,870	287,370	308,240	280,498
0.50	401,320	140,462	124,409	52,172	718,363	770,535	701,187
1.0	560,000	196,000	173,600	72,800	1,002,400	1,075,200	978,432

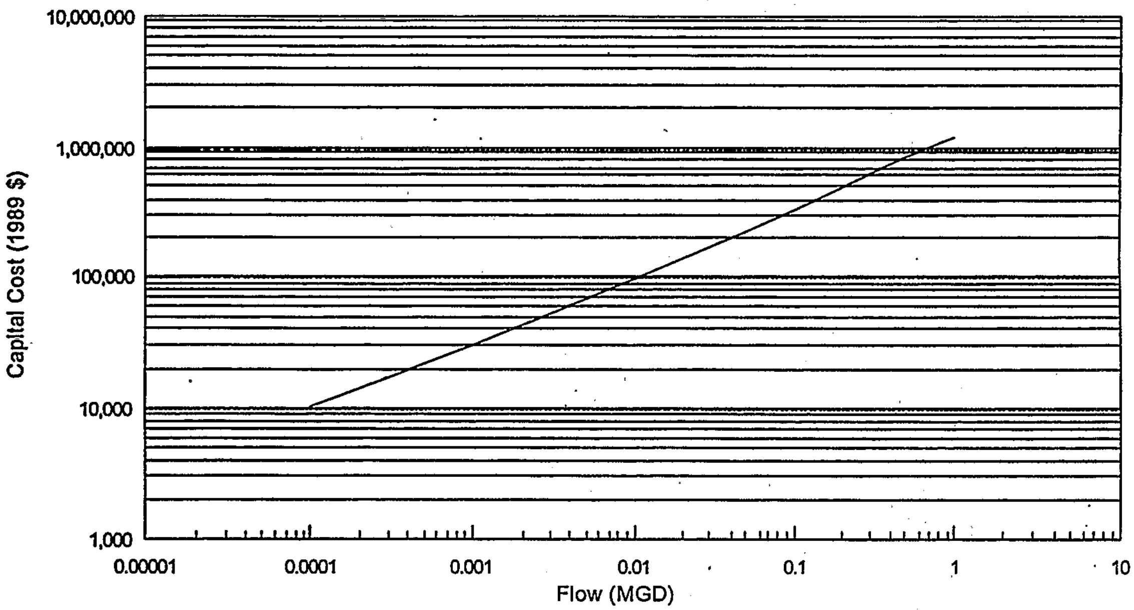

Figure 2-43. Total Capital Cost Curve for CN Destruction Systems at Special Operating Conditions

To develop land requirements for the cyanide destruction systems, EPA used the vendor data. The dimensions were scaled up to represent the total land required for the package unit plus peripherals (pumps, controls, access areas, etc.). Figure 2-44 presents the land requirement curve for the cyanide destruction system. The equation relating the flow of the cyanide destruction system with the land requirements is:

$$\ln(Y3) = -1.168 + 0.419\ln(X) + 0.021(\ln(X))^2 \quad (2\text{-}46)$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres).

Chemical Usage and Labor Requirement Costs

In estimating chemical usage and labor requirements, EPA assumed the systems would treat one batch per day. EPA based this assumption on responses to the WTI Questionnaire. Based on vendor's recommendations, EPA estimated the labor requirement for the cyanide destruction to be three hours per day. EPA determined the amount of sodium hypochlorite and sodium hydroxide required based on the stoichiometric amounts to maintain the proper pH and chlorine concentrations to facilitate the cyanide destruction as described earlier.

Table 2-44 presents the itemized O&M cost estimates for the cyanide destruction systems. Figure 2-45 presents the resulting cost curve. The O&M equation for the cyanide destruction system is:

$$\ln(Y2) = 18.237 + 1.318\ln(X) + 0.04993(\ln(X))^2 \quad (2\text{-}47)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-44. O&M Cost Estimates for Cyanide Destruction at Special Operating Conditions

Flow Rate (MGD)	Energy	Sodium Hypochlorite Cost	Sodium Hydroxide Cost	Labor	Maint.	Taxes & Ins.	Total O&M Cost (1989 $/YR)
0.00001	1,000	50	25	16,425	47	24	22
0.00001	1,000	482	225	16,425	172	86	78
0.0001	1,000	4,826	2,256	16,425	465	233	212
0.001	1,100	48,260	22,568	16,425	1,207	604	550
0.01	1,600	482,470	225,680	16,425	3,886	1,943	1,768
0.05	1,730	2,412,345	1,128,400	16,425	8,987	4,494	4,090
0.10	7,000	4,824,700	2,256,800	16,425	13,598	6,799	6,187
0.50	31,200	24,123,450	11,284,000	16,425	33,993	16,997	15,467
1.0	70,000	48,246,900	22,568,000	16,425	47,434	23,717	21,582

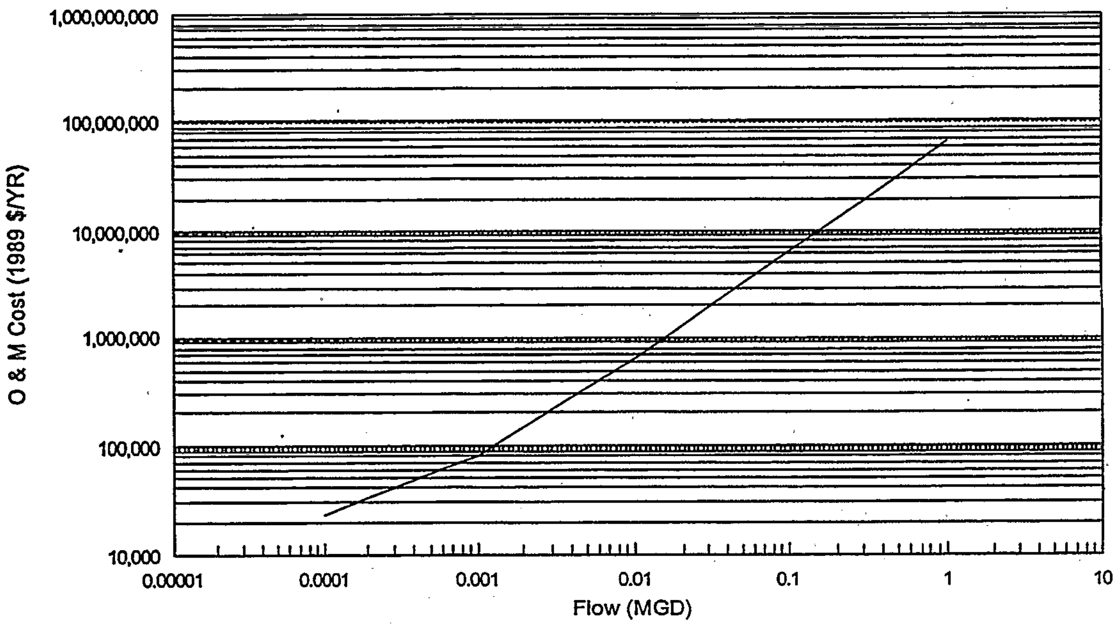

Figure 2-45. O&M Cost Curve for CN Destruction Systems at Special Operating Conditions

2.7 Secondary Gravity Separation

Secondary gravity separation systems provide additional oil and grease removal for oily wastewater. Oily wastewater, after primary gravity separation/emulsion breaking, is pumped into a series of skimming tanks where additional oil and grease removal is obtained before the wastewater enters the dissolved air flotation unit. The secondary gravity separation equipment discussed here consists of a series of three skimming tanks in series. The ancillary equipment for each tank consists of a mix tank with pumps and skimming equipment.

In estimating capital and O&M cost associated with secondary gravity separation, EPA assumed that facilities either currently have or do not have secondary gravity separation. Therefore, EPA did not develop any secondary gravity separation upgrade costs.

Capital and Land Costs

EPA obtained the capital cost estimates for the secondary gravity separation system from vendor quotes. The itemized capital cost estimates for the secondary gravity separation systems is presented in Table 2-45, while the resulting cost curve is presented as Figure 2-46.

The total capital cost equation for Oils Option 9 secondary gravity separation is:

$$\ln(Y1) = 14.3209 + 0.38774\ln(X) - 0.01793(\ln(X))^2 \qquad (2\text{-}48)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $)

Table 2-45. Total Capital Cost Estimates for Secondary Gravity Separation

Flow Rate (MGD)	Equipment Cost	Total Construction Cost	Engineer. & Conting.	Total Capital Cost (1989 $)
0.0005	19,200	25,920	7,776	33,696
0.001	27,990	37,787	11,336	49,123
0.005	67,170	90,680	27,204	117,884
0.01	97,938	132,216	39,665	171,881
0.05	235,065	317,338	95,201	412,539
0.1	342,729	462,684	138,805	601,489
0.5	822,603	1,110,514	333,154	1,443,668
1.0	1,199,364	1,619,141	485,742	2,104,883
5.0	1,378,662	1,861,194	558,358	2,419,552

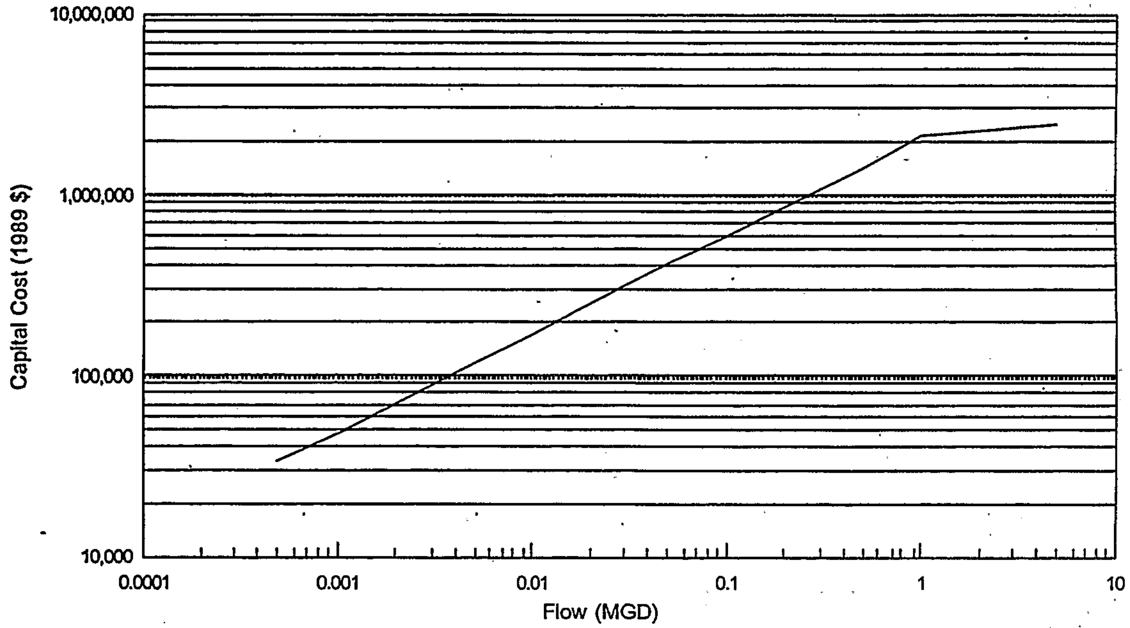

Figure 2-46. Total Capital Cost Curve for Secondary Gravity Separation

EPA calculated the land requirements for secondary gravity separation systems based on the equipment dimensions. Table 2-46 presents the land requirements for the secondary gravity separation systems. Figure 2-47 presents the resulting curve. The land requirement equation for the secondary gravity separation system is:

$$\mathbf{ln(Y3) = -0.2869 + 0.31387ln(X) + 0.01191(ln(X))^2} \qquad \textbf{(2-49)}$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres).

Table 2-46. Land Requirement Estimates for Secondary Gravity Separation

Flow Rate (MGD)	Land Requirement (Acres)
0.00001	0.097
0.0001	0.114
0.001	0.158
0.01	0.225
0.05	0.341
0.1	0.381
0.5	0.492
1.0	0.891

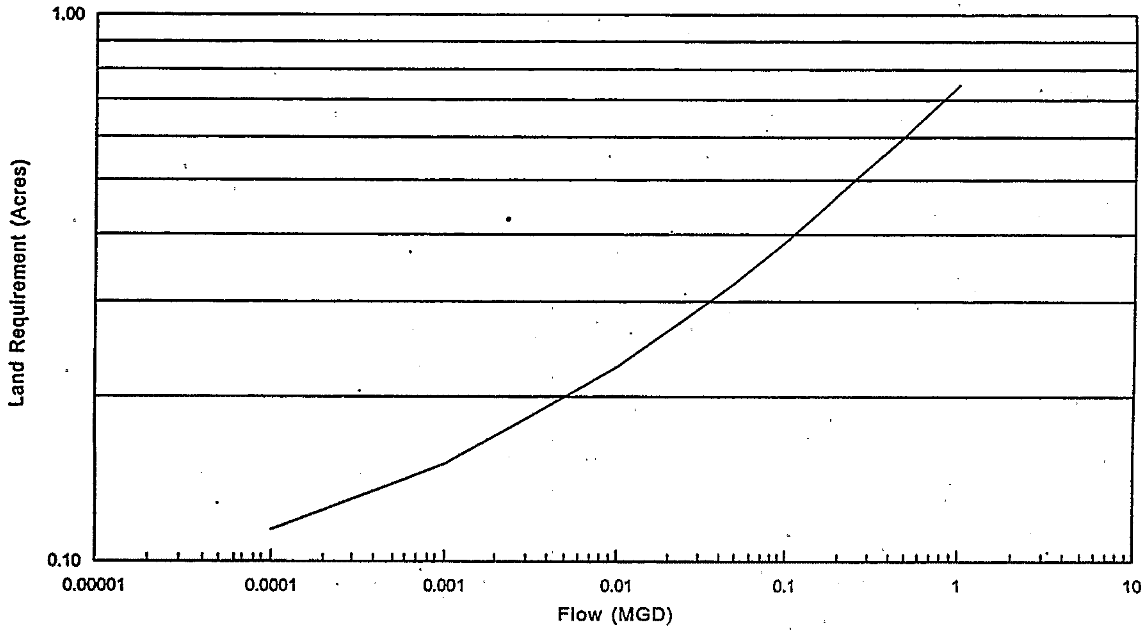

Figure 2-47. Land Requirement Curve for Secondary Gravity Separation

Chemical Usage and Labor Requirement Costs

EPA estimated the labor requirement to operate secondary gravity separation to be 3 to 9 hours per day depending on the size of the system. EPA obtained this estimate from one of the model facilities for Oils Option 9. There are no chemicals associated with the operation of the secondary gravity separation system. The itemized O&M requirements for the secondary gravity separation system is presented in Table 2-47 with the resulting cost curve presented as Figure 2-48.

The O&M Cost equation for the secondary gravity separation system is

$$\ln(Y2) = 12.0759 + 0.4401\ln(X) + 0.01544(\ln(X))^2 \qquad (2\text{-}50)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-47. O&M Cost Estimates for Secondary Gravity Separation

Flow Rate (MGD)	Maintenance	Taxes & Insurance	Energy	Labor	Total O&M Cost (1989 $/YR)
0.0005	1,348	674	3,000	11,700	16,722
0.001	1,965	982	3,030	11,700	17,677
0.005	4,715	2,358	3,180	11,700	21,953
0.01	6,875	3,438	3,312	23,400	37,025
0.05	16,502	8,251	4,560	23,400	52,713
0.1	24,060	12,030	6,120	23,400	65,610
0.5	57,747	28,874	18,600	35,100	140,321
1.0	84,195	42,098	34,200	35,100	195,593
5.0	96,782	48,391	159,000	35,100	339,273

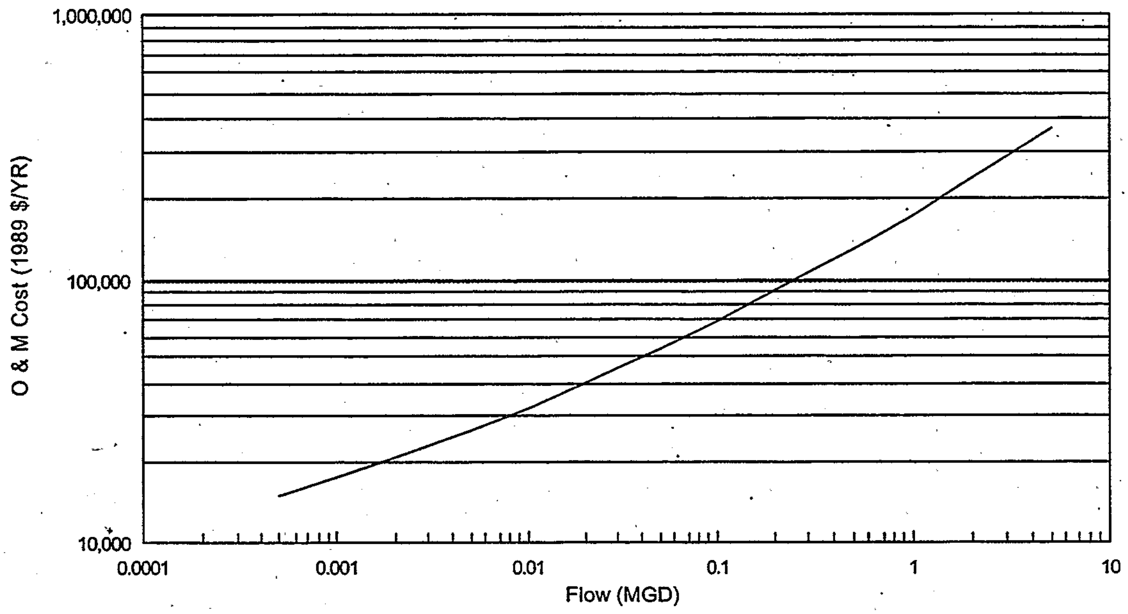

Figure 2-48. O&M Cost Curve for Secondary Gravity Separation

2.8 Dissolved Air Flotation

Flotation is the process of inducing suspended particles to rise to the surface of a tank where they can be collected and removed. Dissolved Air Flotation (DAF) is one of several flotation techniques employed in the treatment of oily wastewater. DAF is commonly used to extract free and dispersed oil and grease from oily wastewater.

Capital and Land Costs

EPA developed capital cost estimates for dissolved air flotation systems for the oils subcategory Options 8 and 9. EPA based the capital cost estimates for the DAF units on vendor's quotations. EPA assigned facilities with DAF units currently in-place no capital costs. For facilities with no DAF treatment in-place, the DAF system consists of a feed unit, a chemical addition mix tank, and a flotation tank. EPA also included a sludge filtration/dewatering unit. EPA developed capital cost estimates for a series of flow rates ranging from 25 gpm (0.036 MGD) to 1000 gpm (1.44 MGD). EPA was unable to obtain costs estimates for units with flows below 25 gallons per minute since manufacturers do not sell systems smaller than those designed for flows below 25 gallons per minute.

The current DAF system capital cost estimates include a sludge filtration/dewatering unit. For facilities which do not have a DAF unit in-place, but have other treatment systems that produce sludge (i.e. chemical precipitation and/or biological treatment), EPA assumed that the existing sludge filtration unit could accommodate the additional sludge produced by the DAF unit. For these facilities, EPA did not include sludge filtration/dewatering costs in the capital cost estimates. EPA refers to the capital cost equation for these facilities as "modified" DAF costs.

Tables 2-48 and 2-49 present the itemized capital cost estimates for the DAF and modified DAF systems, while Figures 2-49 and 2-50 present the resulting cost curves. The capital cost equations for the DAF and modified DAF treatment systems for Oils Options 8 and 9 are presented below as Equations 2-51 and 2-52, respectively.

$$\ln(Y1) = 13.9518 + 0.29445\ln(X) - 0.12049(\ln(X))^2 \quad (2\text{-}51)$$

$$\ln(Y1) = 13.509 + 0.29445\ln(X) - 0.12049(\ln(X))^2 \quad (2\text{-}52)$$

where:

X = Flow Rate (MGD)

Y1 = Total Capital Cost (1989 $)

Table 2-48. Total Capital Cost Estimates for DAF Systems

Flow MGD	DAF Unit	Feed Unit	Sludge Dewatering Unit	Shipping Cost	Total Equip. Cost	Total Construction Cost	Engineer & Conting	Total Capital Cost (1989 $)
0.036	17,067	12,560	16,502	923	47,052	91,751	27,525	119,276
0.072	34,135	16,505	28,206	1,577	80,423	156,826	47,048	203,874
0.144	73,731	36,727	61,525	3,440	175,423	342,074	102,622	444,696
1.44	209,928	99,877	172,561	9,647	492,013	959,427	287,828	1,247,255

Table 2-49. Total Capital Cost Estimates for Modified DAF Systems

Flow (MGD)	DAF Unit	Feed Unit	Shipping Cost	Total Equipment Cost	Total Construction Cost	Engineer. & Conting.	Total Capital Cost (1989 $)
0.036	17,067	12,560	593	30,220	58,928	17,678	76,606
0.072	34,135	16,505	1,013	51,653	100,723	30,217	130,940
0.144	73,731	36,727	2,209	112,667	219,701	65,910	285,611
1.44	209,928	99,877	6,196	316,001	616,202	184,861	801,063

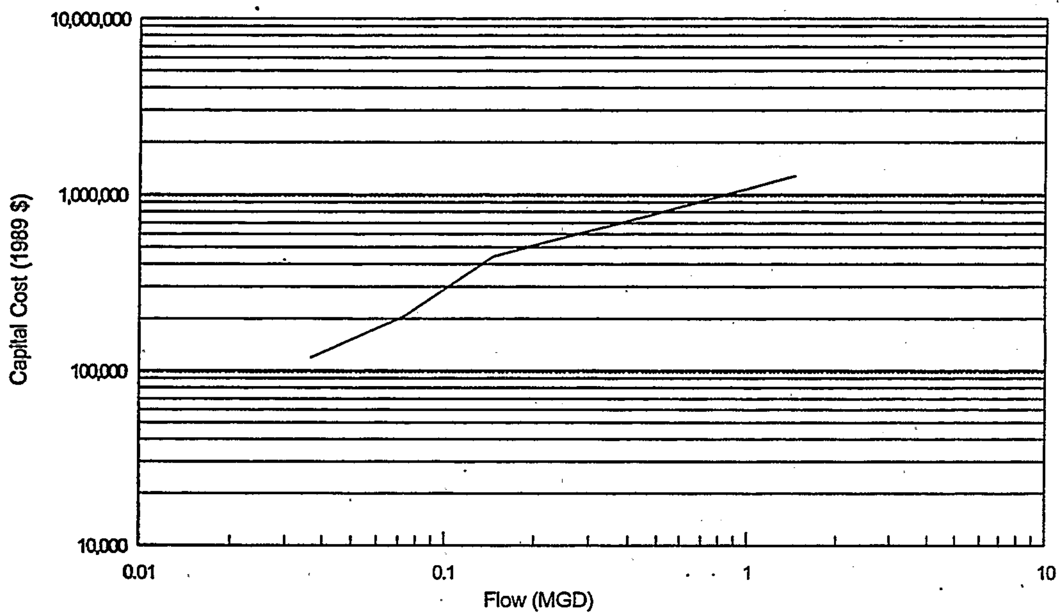

Figure 2-49. Total Capital Cost Curve for DAF Systems

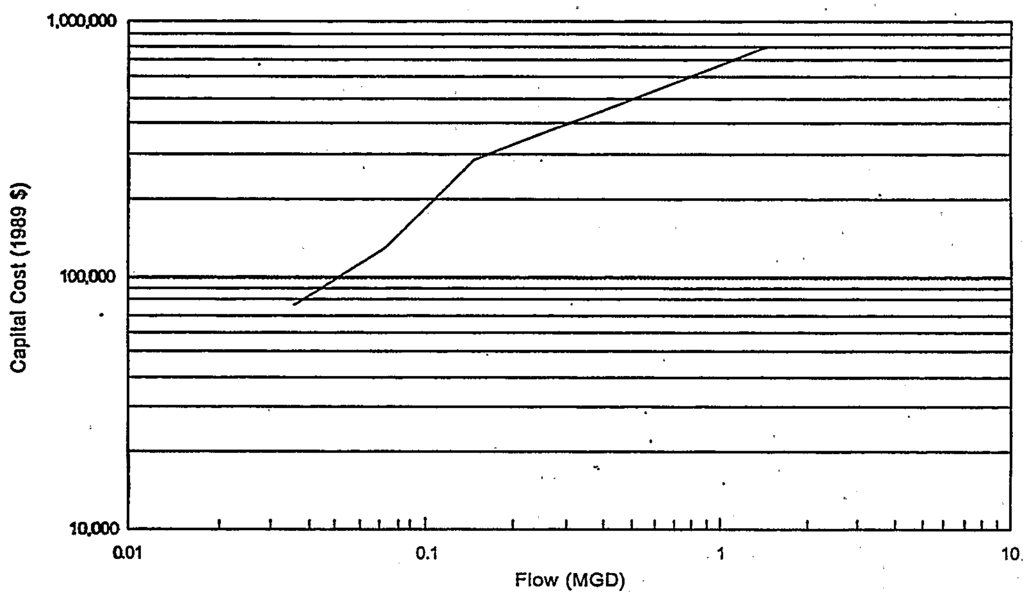

Figure 2-50. Total Capital Cost Curve for Modified DAF Systems

Because the smallest design capacity for DAF systems that EPA could obtain from vendors is 25 gpm, EPA assumed that only facilities with flow rates above 20 gpm would operate their DAF systems everyday (i.e. five days per week). More than 75 percent of the oils subcategory facilities have flow rates lower than 25 gpm. EPA assumed that these facilities could hold their wastewater and run their DAF systems from one to four days per week depending on their flow rate. Facilities that are not operating their DAF treatment systems everyday would need to install a holding tank to hold their wastewater until treatment. Therefore, for facilities which do not currently have DAF treatment in place and which have flow rates less than 20 gallons per minute, EPA additionally included costs for a holding tank. For these facilities, EPA based capital costs on a combination of DAF costs (or modified DAF costs) and holding tank costs. Table 2-50 lists the capacity of the holding tank costed for various flow rates.

Table 2-50. Holding Tank Capacity Estimates for DAF Systems

Flow Rate (GPM)	Holding Tank Capacity (gallons)
<5	7,200
5-10	14,400
10-15	21,600
15-20	28,800
>20	none

Table 2-51 presents the itemized total capital cost estimates for the holding tank systems. Figure 2-51presents the resulting cost curve. The total capital cost equation for the holding tanks is:

$$\ln(Y1) = 12.5122 - 0.15500\ln(X) - 0.05618(\ln(X))^2 \qquad (2\text{-}53)$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 $).

Table 2-51. Total Capital Cost Estimates for Holding Tank Systems

Flow (MGD)	Equipment Cost	Total Construction Cost	Engineer. & Conting.	Total Capital Cost (1989 $)
0.0005	25,600	34,560	10,368	44,928
0.001	37,310	50,382	15,115	65,497
0.005	89,560	120,906	36,272	157,178
0.01	97,938	132,216	39,665	171,881
0.05	156,710	211,559	63,468	275,027

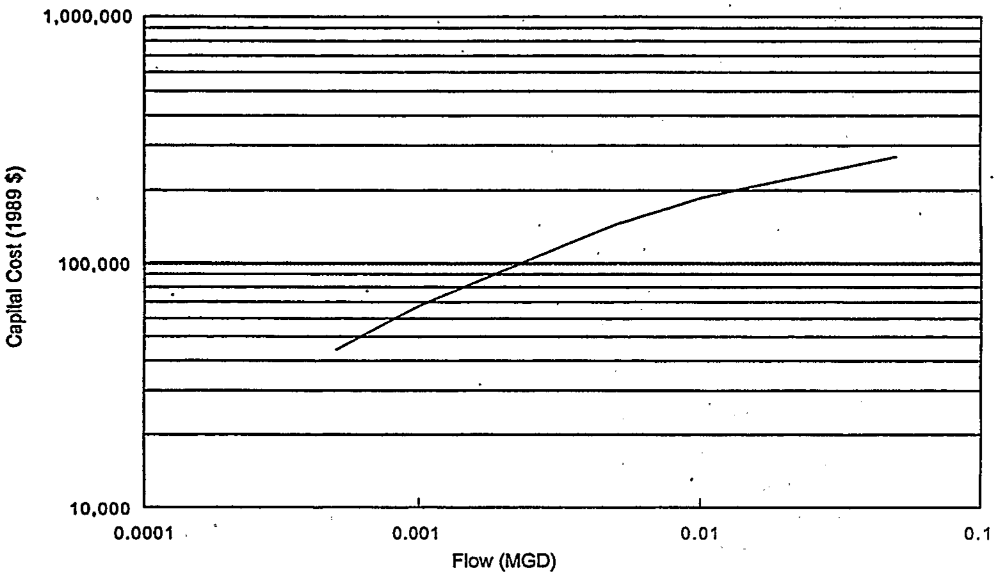

Figure 2-51. Total Capital Cost Curve for Holding Tanks

EPA estimated land requirements for the DAF and modified DAF systems. EPA assumed that the DAF and the modified DAF systems have the same land requirement. Table 2-52 presents the DAF and modified DAF land requirements, while Figure 2-52 presents the resulting cost curve. The land requirement equation for the DAF and modified DAF systems is:

$$\ln(Y3) = -0.5107 + 0.51217\ln(X) - 0.01892\,(\ln(X))^2 \qquad (2\text{-}54)$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres)

Table 2-52. Land Requirement Estimates for DAF and Modified DAF Systems

Flow (MGD)	Land Requirement (Acres)
0.036	0.090
0.072	0.132
0.144	0.212
1.44	0.720

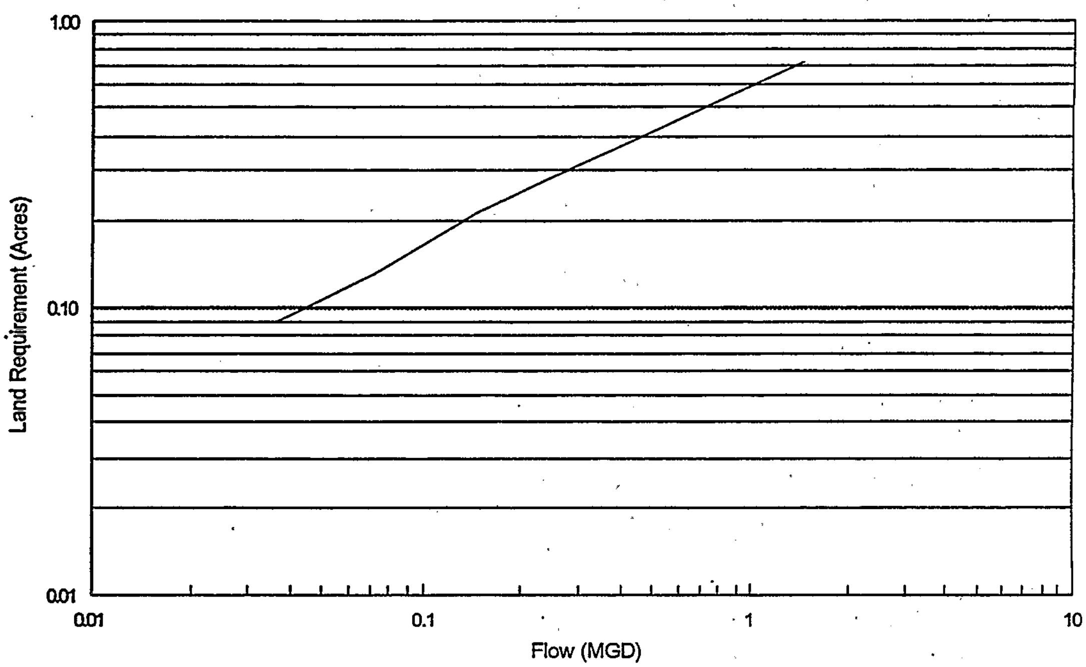

Figure. 2-52. Land Requirement Curve for DAF and Modified DAF Systems

EPA also estimated land requirements for the holding tanks. Table 2-53 presents the land requirements for the holding tank systems. The resulting cost curve is presented as Figure 2-53. The land requirement cost equation for the holding tank systems is:

$$\ln(Y3) = -1.0661 + 0.10066\ln(X) + 0.00214(\ln(X))^2 \quad \textbf{(2-55)}$$

where:

X = Flow Rate (MGD) and

Y3 = Land Requirement (Acres)

Table 2-53. Land Requirement Estimates for Holding Tank Systems

Flow (MGD)	Land Requirement (Acres)
0.0001	0.164
0.001	0.188
0.01	0.230
0.05	0.258

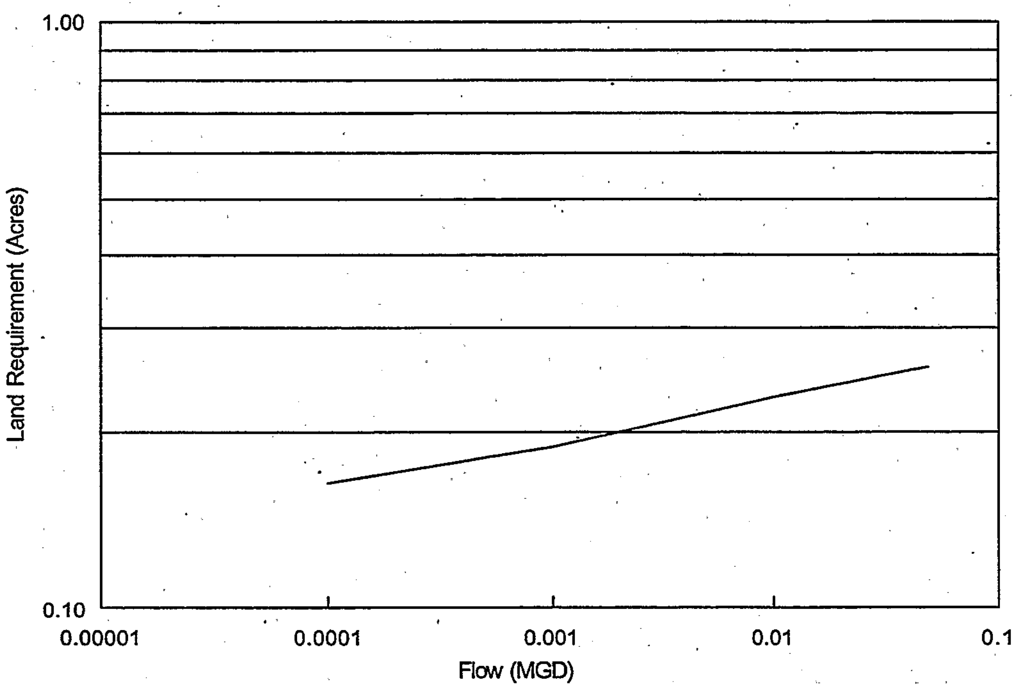

Figure 2-53. Land Requirements Curve for Holding Tanks

Chemical Usage And Labor Requirement Costs

EPA estimated the labor requirements associated with the model technology at four hours per day for the small systems to eight hours per day for the large systems, which is based on the average of the Oils Options 8 and 9 model facilities. EPA used the same labor estimate for DAF and "modified" DAF systems.

As discussed in the capital cost section, EPA has assumed that facilities with flow rates below 20 gpm will not operate the DAF daily. Therefore, for these lower flow rate facilities, EPA only included labor to operate the DAF (or "modified" DAF) systems for the days the system will be operational. Table 2-54 lists the number of days per week EPA assumed these lower flow facilities would operate their DAF systems..

Table 2-54. Labor Requirement Estimates for DAF Systems

Flow Rate (GPM)	Labor Requirements (days/week)
<5	1
5-10	2
10-15	3
15-20	4
>20	5

As detailed earlier, however, EPA also assumed that facilities with flow rates below 20 gpm, would also operate a holding tank. Therefore, for facilities with flow rates below 20 gallons per minute, EPA included additional labor to operate the holding tank.

EPA calculated chemical cost estimates for DAF and "modified" DAF systems based on additions of aluminum sulfate, caustic soda, and polymer. EPA costed for facilities to add 550 mg/L alum, 335 mg/L polymer and 1680 mg/L of NaOH. EPA also included costs for perlite addition at 0.25 lbs per lb of dry solids for sludge conditioning and sludge dewatering operations (for both the DAF and "modified" DAF systems). EPA based the chemical additions on information gathered from literature, the database for the proposed Industrial Laundries Industry guidelines and standards, and sampled facilities.

Finally, similar to the labor requirements shown in Table 2-54, EPA based chemical usage cost estimates for the DAF and modified DAF systems assuming five days per week operation for facilities with flow rates greater than 20 gpm and from one to four days per week for facilities with flow rates of 5 to 20 gpm.

Tables 2-55 and 2-56 present the itemized O&M cost estimates for the DAF and modified DAF systems with flow rates above 20 gpm. Figures 2-54 and 2-55 present the resulting cost curves. The O&M cost equations for the DAF and modified DAF systems with flow rates above 20 gpm are presented below as Equations 2-56 and 2-57, respectively.

$$\ln(Y2) = 14.5532 + 0.96495\ln(X) + 0.01219(\ln(X))^2 \qquad (2\text{-}56)$$

$$\ln(Y2) = 14.5396 + 0.97629\ln(X) + 0.01451(\ln(X))^2 \qquad (2\text{-}57)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Tables 2-57 and 2-58 present the itemized O&M Cost estimates for the DAF and modified DAF systems with flow rates of up to 20 gpm. Figures 2-56 and 2-57 present the resulting cost curves.

The O&M cost equations for the DAF and modified DAF systems with flow rates up to 20 gpm are presented below as Equations 2-58 and 2-59, respectively.

$$\ln(Y2) = 21.2446 + 4.14823\ln(X) + 0.36585(\ln(X))^2 \qquad (2\text{-}58)$$

$$\ln(Y2) = 21.2005 + 4.07449\ln(X) + 0.34557(\ln(X))^2 \qquad (2\text{-}59)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-55. O&M Cost Estimates for DAF Systems - Flow > 20 gpm

Flow (MGD)	Mainten-ance	Taxes & Insur.	Energy	Labor	Chemical Cost				Total O&M Cost (1989 $/YR)
					Alum	NaOH	Polymer	Perlite	
0.036	4,771	2,386	2,920	15,600	4,090	12,449	46,650	8,338	97,204
0.072	8,155	4,077	2,920	19,500	8,181	24,898	93,300	16,675	177,706
0.144	17,788	8,894	3,569	23,400	16,361	49,795	186,601	33,350	339,758
1.44	49,890	24,945	8,760	31,200	163,613	497,952	1,866,010	333,520	2,975,890

Table 2-56. O&M Cost Estimates for Modified DAF Systems - Flow > 20 gpm

Flow (MGD)	Mainten-ance	Taxes & Insur.	Energy	Labor	Chemical Cost				Total O&M Cost (1989 $/YR)
					Alum	NaOH	Polymer	Perlite	
0.036	3,064	1,532	2,920	15,600	4,090	12,449	46,650	8,338	94,643
0.072	5,238	2,619	2,920	19,500	8,181	24,898	93,300	16,675	173,331
0.144	11,424	5,712	3,569	23,400	16,361	49,795	186,601	33,350	330,212
1.44	32,043	16,021	8,760	31,200	163,613	497,952	1,866,010	333,520	2,949,119

Table 2-57. O&M Cost Estimates for DAF Systems - Flow ≤ 20 gpm

Flow (MGD)	Mainten-ance	Taxes & Insur.	Energy	Labor	Chemical Cost				Total O&M Cost (1989 $/YR)
					Alum	NaOH	Polymer	Perlite	
0.0072	4,771	2,386	2,920	3,120	164	498	1,866	334	16,059
0.0144	4,771	2,386	2,920	6,240	654	1,992	7,464	1,334	27,761
0.0216	4,771	2,386	2,920	9,360	1,473	4,482	16,794	3,002	45,188
0.0288	4,771	2,386	2,920	12,480	2,618	7,967	29,856	5,336	68,334

Table 2-58. O&M Cost Estimates for Modified DAF Systems - Flow ≤ 20 gpm

Flow (MGD)	Mainten-ance	Taxes & Insur.	Energy	Labor	Chemical Cost				Total O&M Cost (1989 $/YR)
					Alum	NaOH	Polymer	Perlite	
0.0072	3,064	1,532	2,920	3,120	164	498	1,866	334	13,498
0.0144	3,064	1,532	2,920	6,240	654	1,992	7,464	1,334	25,200
0.0216	3,064	1,532	2,920	9,360	1,473	4,482	16,794	3,002	42,627
0.0288	3,064	1,532	2,920	12,480	2,618	7,967	29,856	5,336	65,773

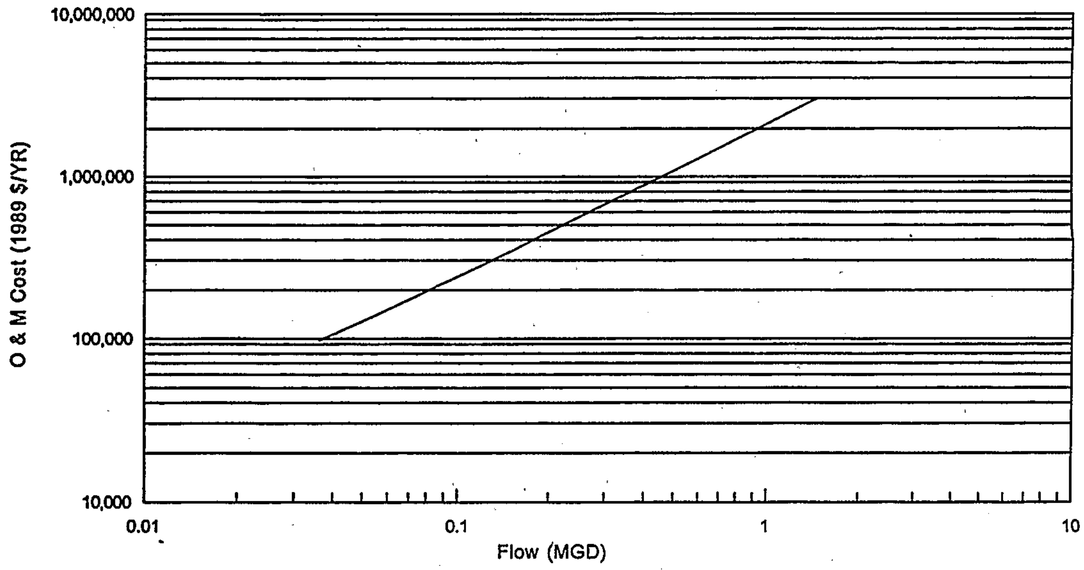

Figure 2-54. O&M Cost Curve for DAF Systems - Flow > 20 gpm

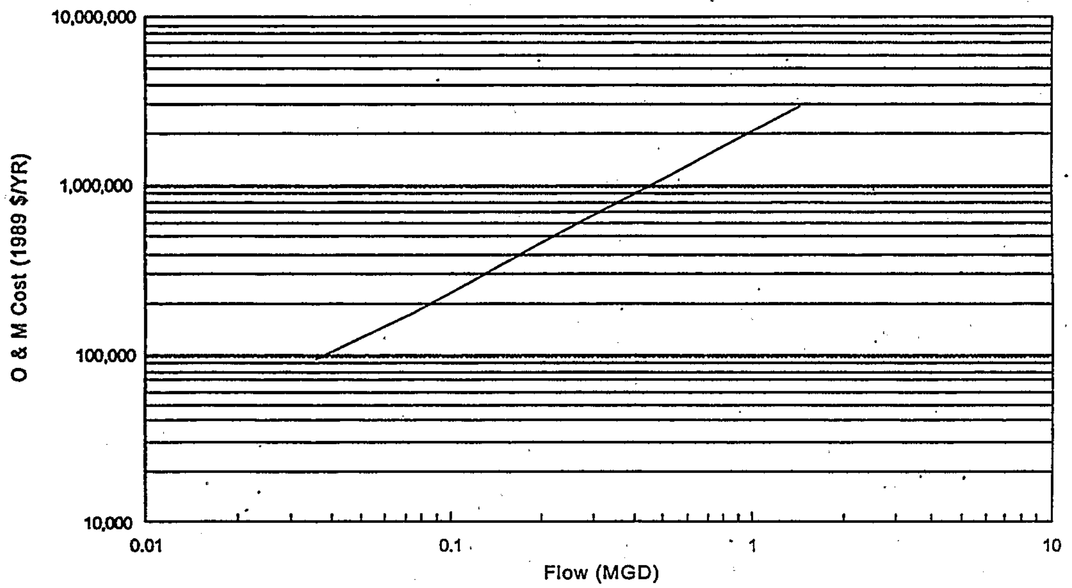

Figure 2-55. O&M Cost Curve for Modified DAF Systems - Flow > 20 gpm

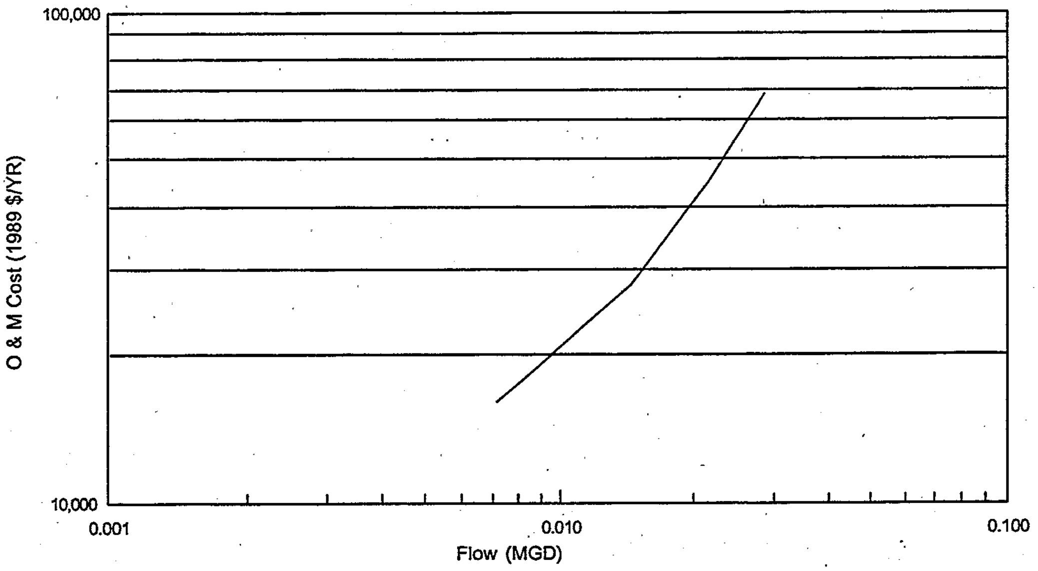

Figure 2-56. O&M Cost Curve for DAF Systems - Flow ≤ 20 gpm

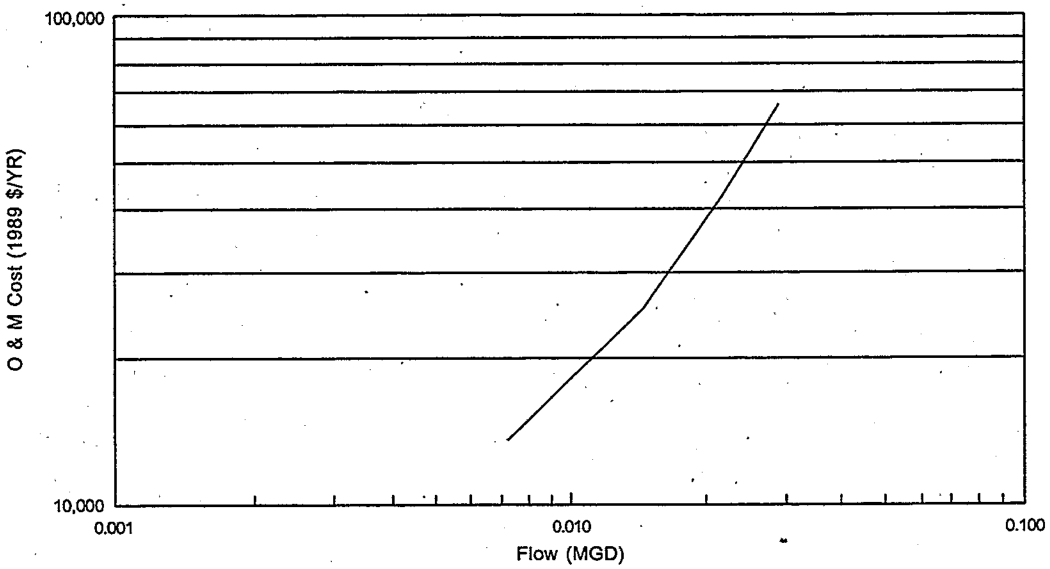

Figure 2-57. O&M Cost Curve for Modified DAF Systems - Flow ≤ 20 gpm

For
facil

ities with DAF treatment in-place, EPA estimated O&M upgrade costs. These facilities would need to improve pollutant removals from their current DAF current performance concentrations to the Oils Option 8 and Option 9 long-term averages. As detailed in Chapter 12 of the Development Document for the CWT Point Source Category, EPA does not have current performance concentration data for the majority of the oils facilities with DAF treatment in-place. EPA does, however, have seven data sets which represent effluent concentrations from emulsion breaking/gravity separation. While the pollutant concentrations in wastewater exiting emulsion breaking/gravity separation treatment are higher (in some cases, considerably higher) than the pollutant concentrations in wastewater exiting DAF treatment, EPA has, nevertheless, used the emulsion breaking/gravity separation data sets to estimate DAF upgrade costs. For each of the seven emulsion breaking/gravity separation data sets, EPA calculated the percent difference between these concentrations and the Option 8 and Option 9 long-term averages.. The median of these seven calculated percentages is 25 percent.

Therefore, EPA estimated the energy, labor, and chemical cost components of the O&M upgrade cost as 25 percent of the full O&M cost of a new system. EPA assumed that maintenance, and taxes and insurance would be zero since they are functions of the capital cost (that is, there is no capital cost for the upgrade).

EPA developed two separate O&M upgrade cost equations for facilities which currently have DAF treatment in place -- one for facilities with flow rates up to 20 gpm and one for facilities with flow rates greater than 20 gpm.

Tables 2-59 and 2-60 present the itemized O&M upgrade cost estimates for the DAF systems for facilities with flow less than or equal to 20 gpm and greater than 20 gpm, respectively. Figures 2-58 and 2-59 present the resulting cost curves. The O&M upgrade cost equations for DAF systems for facilities with flow of up to 20 gpm and greater than 20 gpm are presented below as Equations 2-60 and 2-61, respectively.

$$\ln(Y2) = 19.0459 + 3.5588\ln(X) + 0.25553(\ln(X))^2 \quad (2\text{-}60)$$

$$\ln(Y2) = 13.1281 + 0.99778\ln(X) + 0.01892(\ln(X))^2 \quad (2\text{-}61)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 2-59. O&M Upgrade Cost Estimates for DAF Systems - Flow ≤ 20 gpm

Flow (MGD)	Mainten-ance	Taxes & Insur.	Energy	Labor	Chemical Cost				Total O&M Cost (1989 $/YR)
					Alum	NaOH	Polymer	Perlite	
0.0072	0	0	730	780	41	125	467	84	2,227
0.0144	0	0	730	1,560	164	498	1,866	334	5,152
0.0216	0	0	730	2,340	368	1,121	4,199	751	9,509
0.0288	0	0	730	3,120	655	1,992	7,464	1,334	15,295

Table 2-60. O&M Upgrade Cost Estimates for DAF Systems - Flow > 20 gpm

Flow (MGD)	Mainten-ance	Taxes & Insur.	Energy	Labor	Chemical Cost				Total O&M Cost (1989 $/YR)
					Alum	NaOH	Polymer	Perlite	
0.036	0	0	730	3,900	1,023	3,112	11,663	2,085	22,513
0.072	0	0	730	4,875	2,045	6,225	23,325	4,169	41,369
0.144	0	0	892	5,850	4,090	12,449	46,650	8,338	78,269
1.44	0	0	2,190	7,800	40,903	124,488	466,503	83,380	725,264

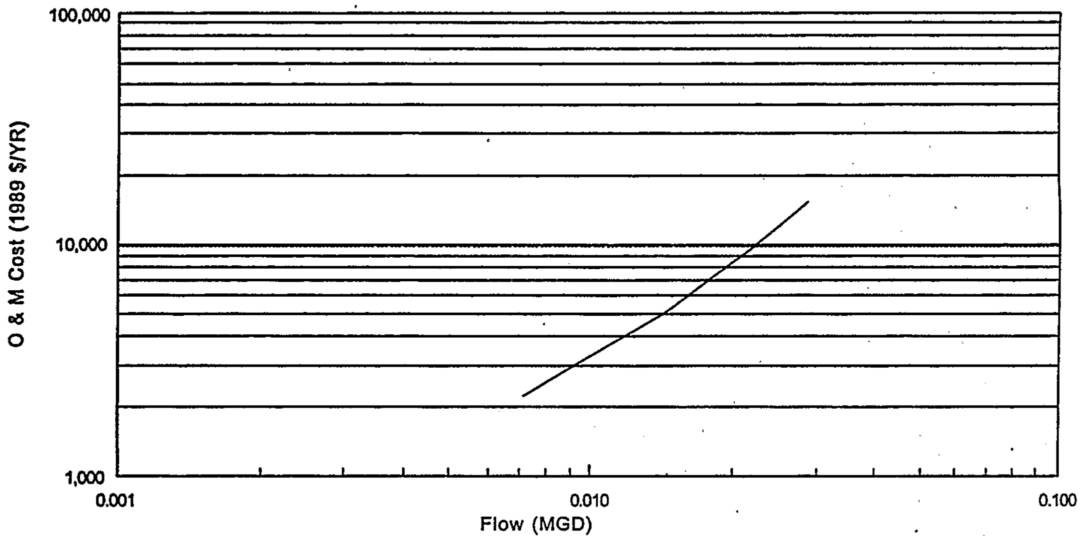

Figure 2-58. O&M Upgrade Cost Curve for DAF Systems - Flow ≤ 20 gpm

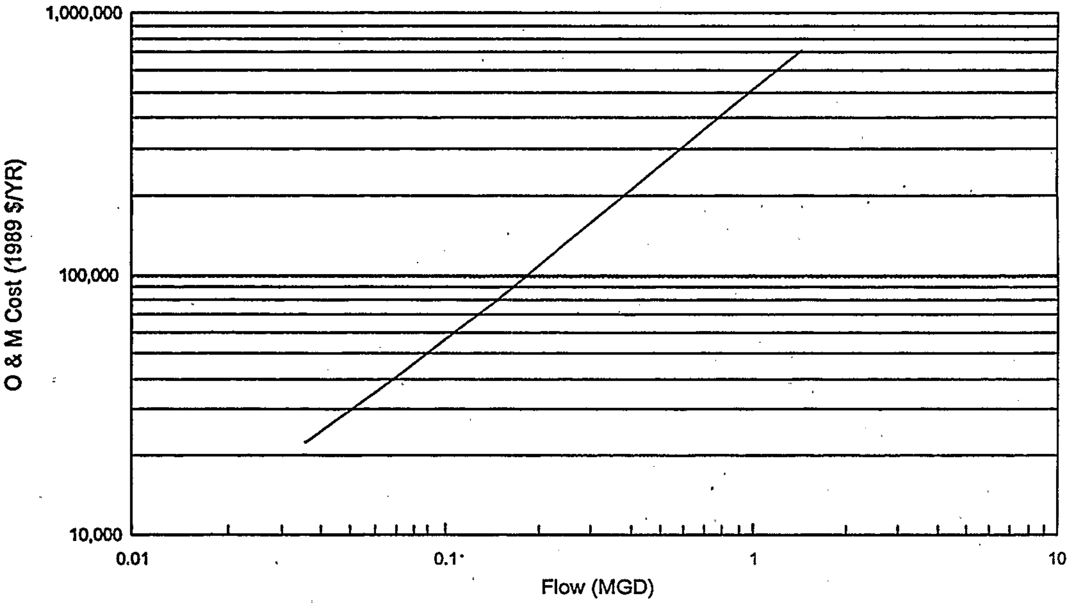

Figure 2-59. O&M Upgrade Cost Curve for DAF Systems - Flow > 20 gpm

Section 3 Biological Wastewater Treatment Technology Costs

3.1 Sequencing Batch Reactors

A sequencing batch reactor (SBR) is a suspended growth system in which wastewater is mixed with existing biological floc in an aeration basin. SBR's are unique in that a single tank acts as an equalization tank, an aeration tank, and a clarifier.

The SBR system costed by EPA for the model technology consists of a SBR tank, sludge handling equipment, feed system and controls, pumps, piping, blowers, and valves. The design parameters that EPA used for the SBR system were the average influent and effluent BOD_5, ammonia, and nitrate-nitrite concentrations. The average influent concentrations were 4800 mg/L, 995 mg/L, and 46 mg/L for BOD_5, ammonia, and nitrate-nitrite, respectively. The average effluent BOD_5, ammonia, and nitrate-nitrite concentrations used were 1,600 mg/l, 615 mg/l, and 1.0 mg/l, respectively. EPA obtained these concentrations from the sampling data at the SBR model facility. EPA assumed that all existing biological treatment systems in-place at organics subcategory facilities can meet the limitations of this proposal without incurring cost. This includes facilities which utilize any form of biological treatment -- not just SBRs. Therefore, the costs presented here only apply to facilities without biological treatment in-place. EPA did not develop SBR upgrade costs for either capital or O&M.

Although biological treatment (SBR's) systems can be used as the BAT technology throughout the United States, the design of the systems should vary due to climate conditions. Plants in colder climates should design their systems to account for lower biodegradability rates during the colder seasons. Therefore, EPA has taken these added costs into account in its costing procedures.

EPA used the National Oceanic and Atmospheric Administration (NOAA) data (1979) for determining the lowest minimum monthly average temperature (see Table 3-1). However, since water temperature cannot fall below 0°C, and rarely below 5°C, EPA established a minimum water temperature of 5°C as the minimum water temperature for the purposes of this costing procedure.

In addition, although some states have minimum temperature above 20°C, EPA has established 20°C as the highest temperature in calculating activated sludge costs. Table 3-1 presents EPA wastewater temperature values (middle column) used for each state.

EPA has costed biological treatment, which will be affected by climate conditions. Therefore, EPA has developed a cost factor that was applied to each treatment cost, depending on the location of the plant.

In order to take into account the effect of temperature in the design and cost estimation of activated sludge system upgrades, the following factor was derived:

$$\text{Temperature Correction Factor} = \left(\frac{k_B}{k_S}\right)^{0.7}$$

where k_B = Base Line k
k_S = k rate established for each State
0.7 = Cost Scale Factor

The ratio $\frac{k_B}{k_S}$ is derived from the following general equation:

$$k_S = k_B \times (\Theta)^{(T_S - T_B)}$$

where Θ = 1.07
T_B = 20°C
T_S = State Temperature

Therefore, $$\frac{k_S}{k_B} = (1.07)^{(T_S - T_B)}$$

Table 3-1. Temperatures and Temperature Cost Factors Used to Calculate Activated Sludge Costs and to Adjust Biological Treatment Upgrade Costs

State	Minimum Monthly Average Ambient Temperature (°C)[1]	Corresponding Wastewater Temperature (°C)	Cost Factor
Alabama	8	13	1.4
Alaska	-13	5	2.0
Arizona	6	11	1.5
Arkansas	4	9	1.7
California	8	13	1.4
Colorado	-6	5	2.0
Connecticut	-2	5	2.0
Delaware	0	5	2.0
Florida	16	20	1.0
Georgia	7	12	1.5
Hawaii	22	20	1.0
Idaho	-2	5	2.0
Illinois	-4	5	2.0
Indiana	-6	5	2.0
Iowa	-7	5	2.0
Kansas	-2	5	2.0
Kentucky	0	5	2.0
Louisiana	10	15	1.3
Maine	-12	5	2.0
Maryland	1	6	1.9
Massachusetts	-3	5	2.0
Michigan	-5	5	2.0
Minnesota	-13	5	2.0
Mississippi	8	13	1.4
Missouri	-1	5	2.0
Montana	-8	5	2.0
Nebraska	-6	5	2.0
Nevada	-1	5	2.0
New Hampshire	-6	5	2.0
New Jersey	0	5	2.0
New Mexico	2	7	1.8

State	Minimum Monthly Average Ambient Temperature (˚C)[1]	Corresponding Wastewater Temperature (˚C)	Cost Factor
New York	-3	5	2.0
North Carolina	6	11	1.5
North Dakota	-14	5	2.0
Ohio	-3	5	2.0
Oklahoma	3	8	1.8
Oregon	2	7	1.8
Pennsylvania	-2	5	2.0
Rhode Island	-1	5	2.0
South Carolina	8	13	1.4
South Dakota	-9	5	2.0
Tennessee	4	9	1.7
Texas	8	13	1.4
Utah	-3	5	2.0
Vermont	-8	5	2.0
Virginia	3	8	1.8
Washington	-3	5	2.0
West Virginia	0	5	2.0
Wisconsin	-8	5	2.0
Wyoming	-6	5	2.0
Puerto Rico	24	20	1.0

(1) Source of Data: National Oceanic and Atmospheric Administration, Comparison Climatic Data for the United States through 1979 (30 years of data), Environmental Data and Information Service, Asheville, North Carolina.

Thus, the temperature correction factor is:

$$\left(\frac{k_T}{k_S}\right)^{0.7} = (1.07)^{-(T_S - T_a)\,0.7}$$

Column three of Table 3-1 presents the corresponding cost factors, using this equation for each state. These factors were then used to adjust the capital and O&M of the biological treatment cost estimates.

Capital and Land Costs

EPA estimated the capital costs for the SBR systems using vendor quotes which include installation costs. Table 3-2 presents the itemized total capital cost estimates for the SBR systems. The resulting cost curve is presented as Figure 3-1. The SBR total capital cost equation is:

$$\mathbf{ln(Y1) = 15.707 + 0.512ln(X) + 0.0022(ln(X))^2} \qquad \textbf{(3-1)}$$

where:

X = Flow Rate (MGD) and

Y1 = Capital Cost (1989 \$).

Table 3-2. Total Capital Cost Estimates for Sequencing Batch Reactor Systems

Flow Rate (MGD)	System Cost	Install.	Piping	Total Constr. Cost	Engineer. & Conting.	Total Capital Cost (1993 $)	Total Capital Cost (1989 $)
0.001	100,000	35,000	54,000	189,000	40,500	229,500	206,550
0.01	360,000	126,000	194,400	680,400	145,800	826,200	743,580
0.05	635,000	222,250	342,900	1,200,150	257,175	1,457,325	1,311,592
0.10	970,000	339,500	523,800	1,833,300	392,850	2,226,150	2,003,535
0.50	2,350,000	822,500	1,269,000	4,441,500	951,750	5,393,250	4,853,925
1.0	3,200,000	1,120,000	1,728,000	6,048,000	1,296,000	7,344,000	6,609,600

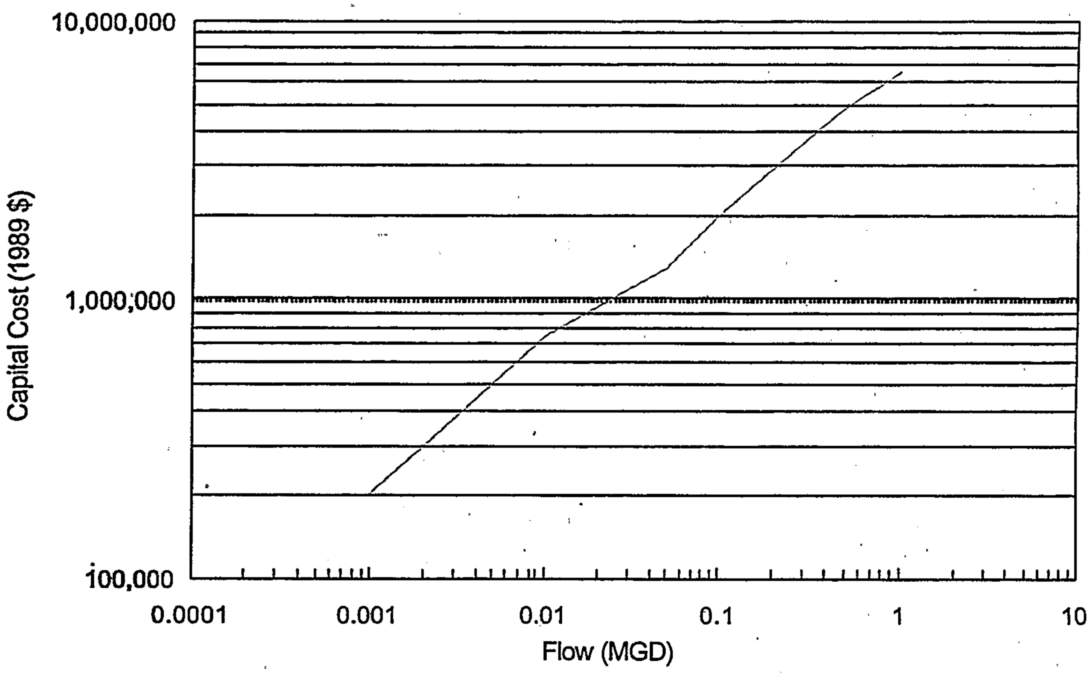

Figure 3-1. **Total** Capital Cost Curve for Sequencing Batch Reactor Systems

To develop land requirements for SBR systems, the vendor provided EPA with overall system dimensions. EPA scaled up the land dimensions to represent the total land required for the system plus peripherals (pumps, controls, access areas, etc.). The land requirement equation for the SBR systems is:

$$\ln(Y3) = -0.531 + 0.906\ln(X) + 0.072(\ln(X))^2 \quad (3\text{-}2)$$

where:

X = Flow (MGD) and

Y3 = Land Requirement (Acres).

The land requirement curve is presented as Figure 3-2.

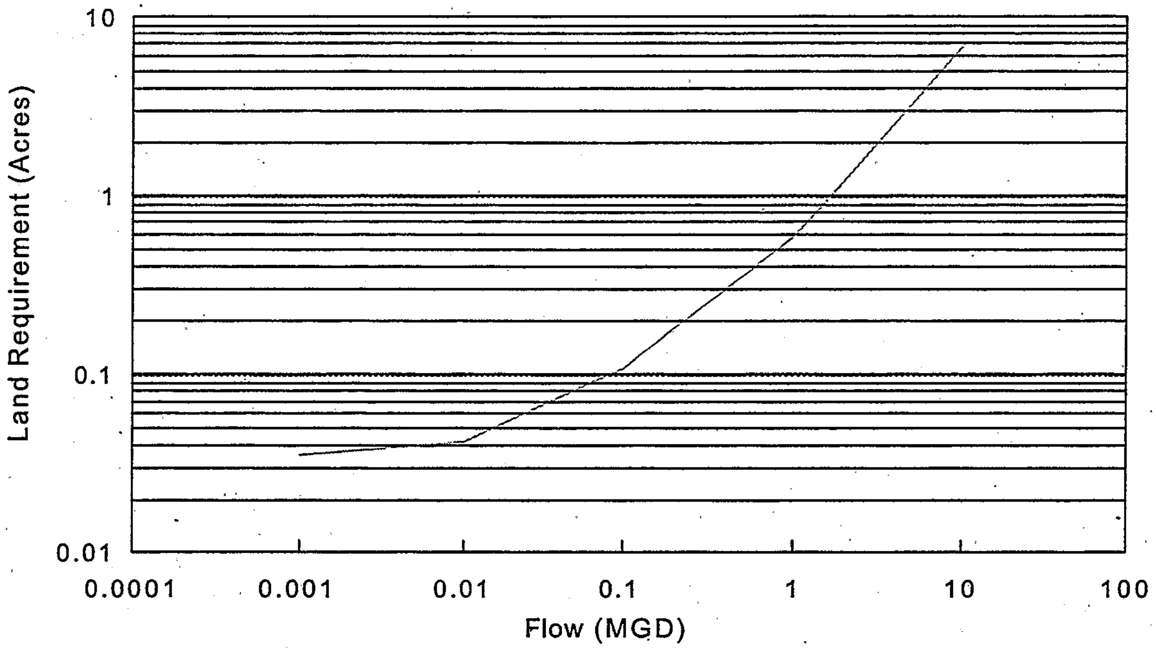

Figure 3-2. Land Requirement Curve for Sequencing Batch Reactor Systems

Operation and Maintenance Costs

The O&M costs for the SBR system include electricity, maintenance, labor, and taxes and insurance. No chemicals are utilized in the SBR system. EPA assumed the labor requirements for the SBR system to be four hours per day and based electricity costs on horsepower requirements. EPA obtained the labor and horsepower requirements from vendors. EPA estimated maintenance, taxes, and insurance using the factors detailed in Table 1-2.

Table 3-3 presents the itemized O&M cost estimates for the SBR systems. The resulting cost curve is presented as Figure 3-3. The O&M cost equation for the SBR systems is:

$$\ln(Y2) = 14.1015 + 0.81567\ln(X) + 0.03932(\ln(X))^2 \quad (3\text{-}3)$$

where:

X = Flow Rate (MGD) and

Y2 = O&M Cost (1989 $/YR).

Table 3-3. O&M Cost Estimates for Sequencing Batch Reactor Systems

Flow Rate (MGD)	Power	Labor	Maintenance	Taxes & Insurance	Chemicals	Filter Cake Disposal	Total O&M Cost (1989 $/YR)
0.001	65	14,600	8,260	4,130	2,993	770	30,818
0.01	392	14,600	29,744	14,872	6,424	7,696	73,728
0.05	1,852	29,200	52,540	26,270	12,427	38,478	160,767
0.10	3,703	29,200	80,140	40,070	17,047	76,955	247,115
0.50	18,298	58,400	194,156	97,078	38,246	384,775	790,953
1.0	36,596	58,400	264,384	132,192	55,923	769,550	1,317,045

SECTION 4 SLUDGE TREATMENT AND DISPOSAL COSTS

4.1 Plate and Frame Pressure Filtration - Sludge Stream

Pressure filtration systems are used for the removal of solids from waste streams. This section details *sludge stream* filtration which is used to treat the solids removed by the clarifiers in the Metals Options.

The pressure filtration system costed by EPA for sludge stream filtration consists of a plate and frame filtration system. The components of the plate and frame filtration system include: filter plates, filter cloth, hydraulic pumps, pneumatic booster pumps, control panel, connector pipes, and a support platform. For design purposes, EPA assumed the sludge stream to consist of 80 percent liquid and 20 percent (200,000 mg/l) solids. EPA additionally assumed the sludge stream to be 20 percent of the total volume of wastewater treated. EPA based these design parameters on CWT Questionnaire 105.

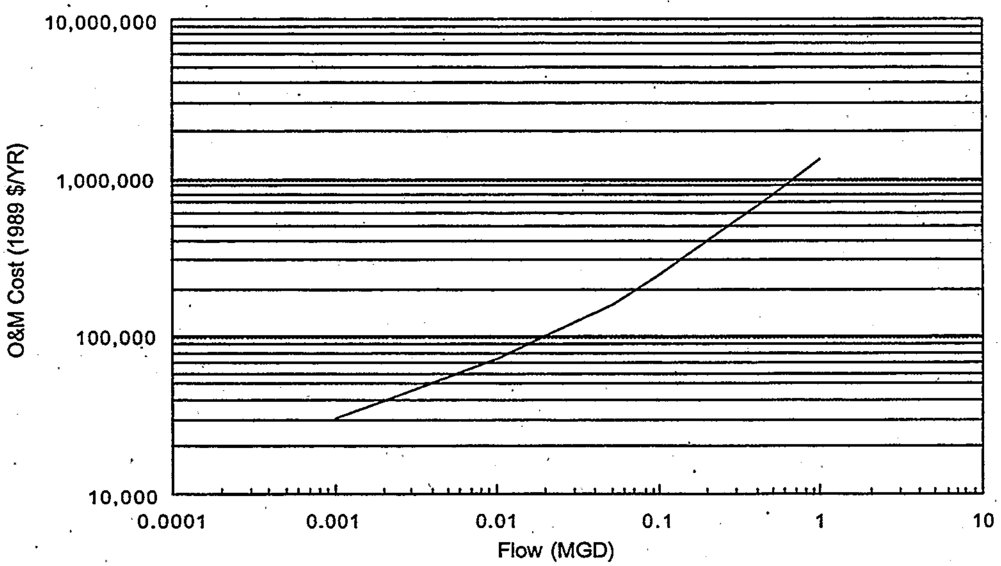

Figure 3-3. O&M Cost Curve for Sequencing Batch Reactor Systems

In costing for sludge stream treatment, if a facility does not have sludge filtration systems in-place, EPA estimated capital costs to add a plate and frame pressure filtration system to their on-site treatment train[2]. If a facility's's treatment train includes more than one clarification step in its treatment train (such as for Metals Option 3), EPA only costed the facility for a single plate and frame filtration system. EPA assumed one plate and frame filtration system could be used to process the sludge from multiple clarifiers. Likewise, if a facility already had a sludge filtration system in-place, EPA assumed that the in-place system would be sufficient and did not estimate any sludge filtration capital costs for these facilities.

Capital and Land Costs

EPA developed the capital cost equation for plate and frame sludge filtration by adding installation, engineering, and contingency costs to vendors' equipment cost estimates. EPA used the same capital cost equation for the plate and frame sludge filtration system for all of the Metals Options.

Table 4-1 presents the itemized total capital cost estimates for the plate and frame sludge filtration systems for all the Metals Options. The resulting cost curve is presented as Figure 4-1. The sludge filtration total capital cost equation for all the Metals Options is:

$$\ln(Y1) = 14.827 + 1.087\ln(X) + 0.0050(\ln(X))^2 \qquad (4\text{-}1)$$

where:

X = Flow (MGD) of Liquid Stream and

Y1 = Capital Cost (1989 $).

Table 4-1. Total Capital Cost Estimates for Plate and Frame Pressure Filtration (Sludge Stream)

[2] If a facility only had to be costed for a plate and frame pressure filtration system to process the sludge produced during the tertiary chemical precipitation and clarifications steps of metals Option 3, EPA did not cost the facility for a plate and frame pressure filtration system. Likewise, EPA assumed no O&M costs associated with the treatment of sludge from the tertiary chemical precipitation and clarification steps in Metals Option 3. EPA assumed that the total suspended solids concentration at this point is so low that sludge stream filtration is unnecessary.

Wastewater Influent Flow (MGD)	Average Vendor Equipment Cost	Install. Cost	Total Capital & Installation Cost	Engineering & Contingency Fee	Total Capital Cost (1989 $)
0.000001	6,325	2,214	8,539	2,562	10,102
0.00001	6,325	2,214	8,539	2,562	10,102
0.0001	6,482	2,269	8,751	2,625	10,352
0.001	9,897	3,464	13,361	4,008	15,806
0.01	29,474	10,316	39,790	11,937	47,072
0.05	93,960	32,886	126,846	38,054	150,059
0.10	171,183	59,914	231,097	69,329	273,388
0.50	870,475	304,666	1,175,141	352,542	1,390,192
1.00	1,939,145	678,701	2,617,846	785,354	3,096,912

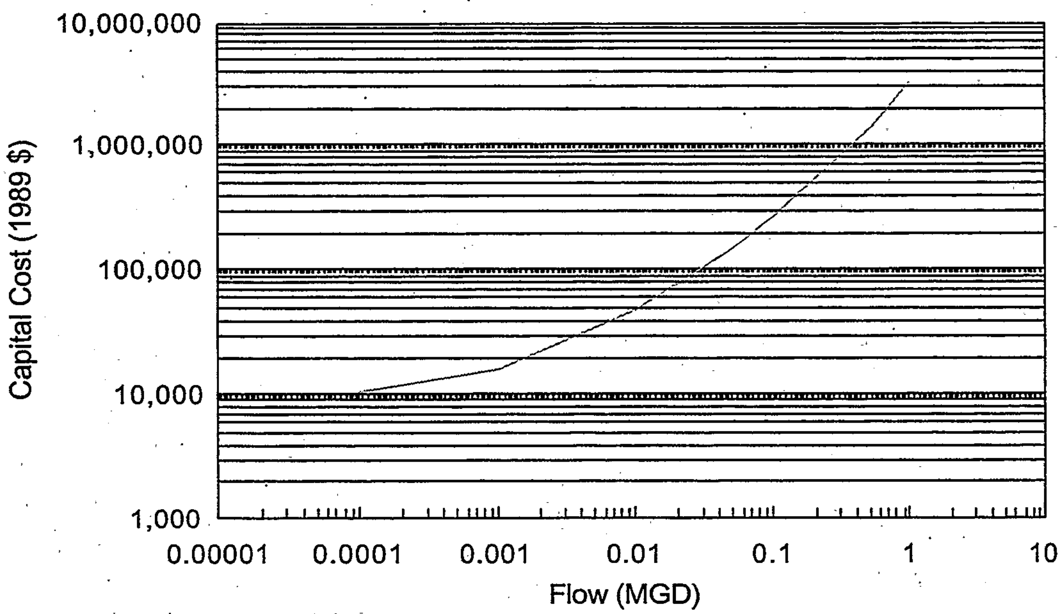

Figure 4-1. Plate and Frame Filtration (Sludge Stream) Total Capital Cost Curve - All Metals Options

EPA calculated land requirements for the plate and frame pressure filtration systems using the system dimensions plus a 20-foot perimeter. The land requirement curve is presented as Figure 4-2. The land requirement equation for all Metals Options sludge filtration is the same and is:

$$\ln(Y3) = -1.971 + 0.281\ln(X) + 0.018(\ln(X))^2 \qquad (4\text{-}2)$$

where:

X = Flow Rate (MGD) of Liquid Stream and

Y3 = Land Requirement (Acres).

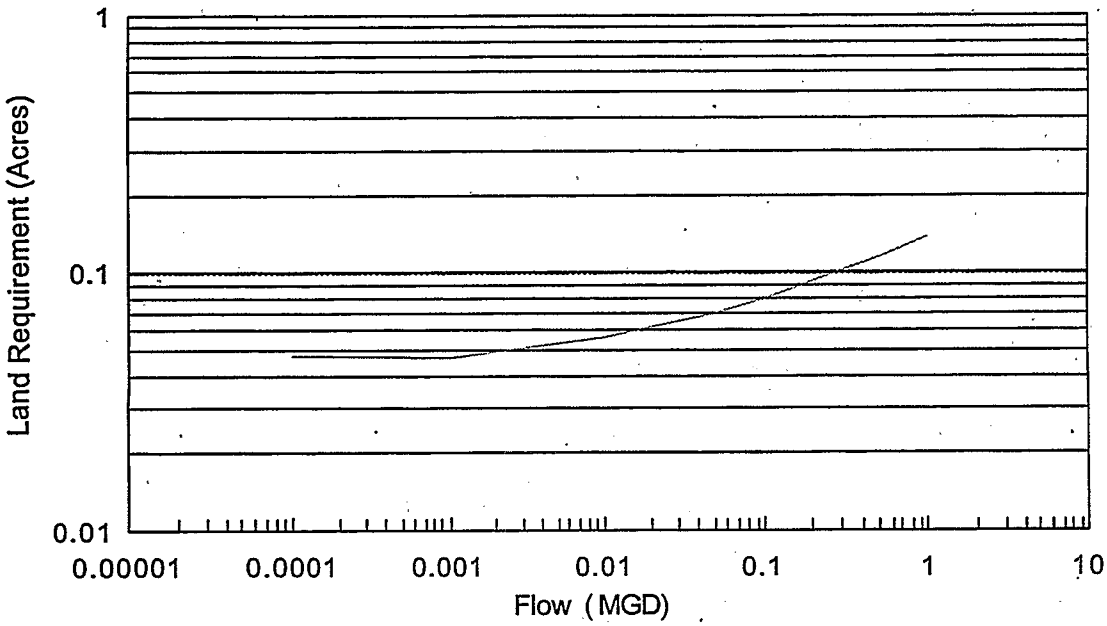

Figure 4-2. Plate and Frame Filtration (Sludge Stream) Land Requirement Curve - All Metals Options

Operation and Maintenance Costs Metals Options 2 and 3

The operation and maintenance costs for Metals Options 2 and 3 plate and frame sludge filtration consist of labor, electricity, maintenance, and taxes and insurance. EPA approximated the labor requirements for the plate and frame sludge filtration system to be thirty minutes per batch based on the Metals Options 2 and 3 model facility. Because no chemicals are used with the plate and frame sludge filtration units, EPA did not include costs for chemicals. EPA estimated electricity, maintenance, and taxes and insurance using the factors listed in Table 1-2.

Table 4-2 presents the itemized O&M cost estimates for the plate and frame sludge filtration systems for Metals Options 2 and 3. The resulting cost curve is presented as Figure 4-3. The O&M cost equation for the Metals Options 2 and 3 sludge filtration systems is:

$$\ln(Y2) = 12.239 + 0.388\ln(X) + 0.016(\ln(X))^2 \qquad (4\text{-}3)$$

where:

X = Flow Rate (MGD) of Liquid Stream and

Y2 = O&M Cost (1989 $/YR).

Table 4-2. O&M Cost Estimates for Plate and Frame Pressure Filtration - Metals Options 2 and 3 (Sludge Stream - Excluding Filter Cake Disposal Costs)

Wastewater Influent Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	O&M Cost (1989 $/YR)
0.000001	1,000	404	202	17,730	19,336
0.00001	1,000	404	202	17,730	19,336
0.0001	1,001	414	207	17,730	19,352
0.001	1,005	632	316	35,457	37,410
0.01	1,010	1,882	941	53,549	57,382
0.10	1,104	10,935	5,468	53,549	71,056
0.50	1,520	55,607	27,804	62,504	147,435
1.0	2,040	123,876	61,938	71,550	259,404

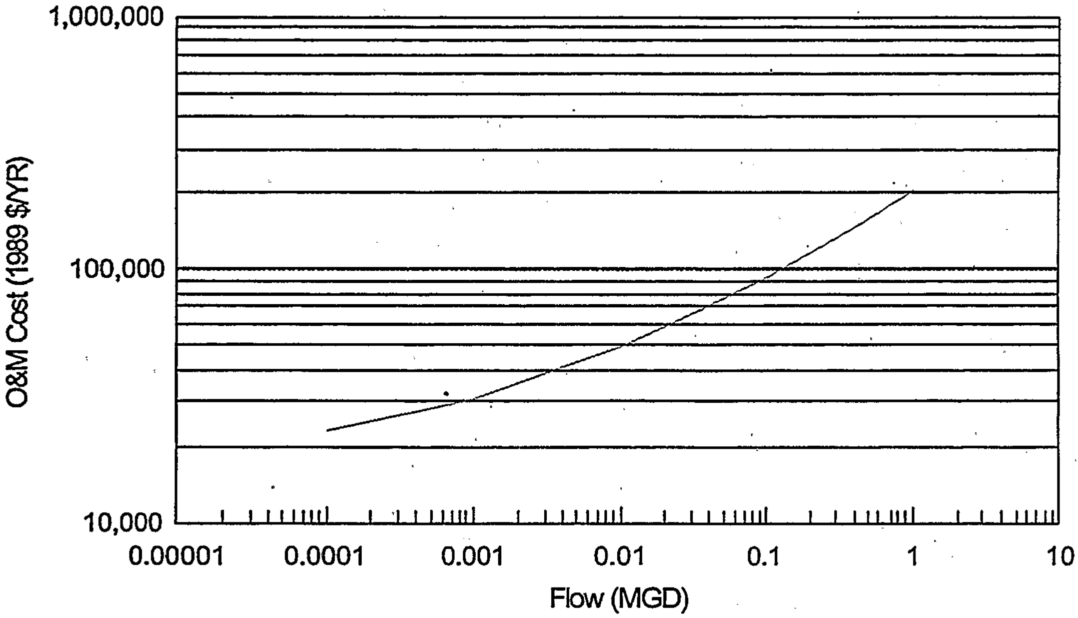

Figure 4-3. Plate and Frame Filtration (Sludge Stream) O&M Cost Curve - Metals Options 2 and 3

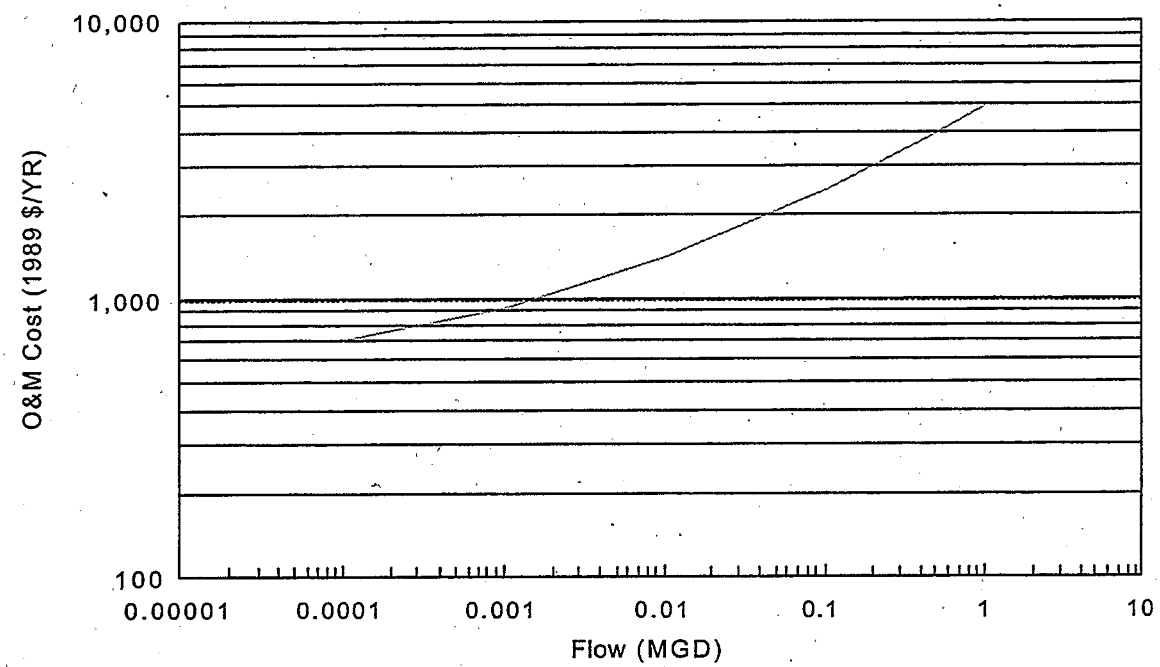

Figure 4-4. Plate and Frame Filtration (Sludge Stream) O&M Upgrade Cost Curve - Metals Options 2 and 3

For facilities which already have a sludge filtration system in-place, EPA included plate and frame filtration O&M upgrade costs. Since the sludge generated from the secondary precipitation and clarification steps in Metals Options 2 and 3 is the sludge which requires treatment for these options, these facilities would be required to improve pollutant removals from their secondary precipitation current performance concentrations to the long term averages for Metals Options 2 and 3. Therefore, EPA calculated the percent difference between secondary precipitation current performance and the Metals Options 2 and 3 long-term averages. EPA determined this percentage to be an increase of three percent.

For facilities which currently have sludge filtration systems in place, for Metals Options 2 and 3, EPA included an O&M upgrade cost which is three percent of the O&M costs of a new system (except for taxes and insurance, which are a function of the capital cost).

Table 4-3 presents the itemized O&M upgrade cost estimates for the Metals Options 2 and 3 sludge filtration systems. Figure 4-4 presents the resulting cost curve. The O&M upgrade cost equation for the Metals Options 2 and 3 sludge filtration systems is:

$$\ln(Y2) = 8.499 + 0.331\ln(X) + 0.013(\ln(X))^2 \quad (4\text{-}4)$$

where:

X = Flow Rate (MGD) of Liquid Stream and

Y2 = O&M Cost (1989 $/YR).

Table 4-3. O&M Upgrade Cost Estimates for Plate and Frame Filtration - Metals Options 2 and 3 (Sludge Stream - Excluding Filter Cake Disposal Costs)

Wastewater Influent Flow (MGD)	Energy	Maintenance	Labor	O&M Cost (1989 $ /YR)
0.000001	30	12	531	603
0.00001	30	12	531	603
0.0001	30	12	531	603
0.001	30	18	1,063	1,141
0.01	30	56	1,606	1,722
0.05	31	180	1,606	1,848
0.10	33	328	1,606	2,000
0.50	45	1,668	1,875	3,633
1.0	61	3,716	2,146	5,984

Operation and Maintenance Costs - Metals Option 4

The operation and maintenance costs for Metals Option 4 consists of labor, chemical usage, electricity, maintenance, taxes, and insurance, and filter cake disposal. The O&M plate and frame sludge filtration costing methodology for Metals Option 4 is very similar to the one discussed previously for Metals Options 2 and 3. The primary differences in the methodologies are the estimation of labor, the inclusion of filter cake disposal, and the O&M upgrade methodology.

EPA approximated the labor requirement for Metals Option 4 plate and frame sludge filtration systems at 2 to 8 hours per day depending on the size of the system. As was the case for Metals Options 2 and 3, no chemicals are used in the plate and frame sludge filtration units for Metals Option 4, and EPA estimated electricity, maintenance and taxes and insurance using the factors listed in Table 1-2. EPA also included filter cake disposal costs at $0.74 per gallon of filter cake. A detailed discussion of the basis for the filter cake disposal costs is presented in Section 4.2.

Table 4-4 presents the itemized O&M estimates for the Metals Option 4 sludge filtration systems. Figure 4-5 shows the resulting cost curve. The O&M cost equation for the Metals Option 4 sludge filtration systems is:

$$\mathbf{\ln(Y2) = 15.9321 + 1.177\ln(X) + 0.04697(\ln(X))^2} \qquad \textbf{(4-5)}$$

where:

X = Flow Rate (MGD) of Liquid Stream and

Y2 = O&M Cost (1989 $/YR).

Table 4-4. O&M Cost Estimates for Plate and Frame Pressure Filtration - Metals Option 4 (Sludge Stream - Including Filter Cake Disposal Costs)

Flow (MGD)	Energy	Maintenance	Taxes & Insurance	Labor	Filter Cake Disposal	Total O&M Cost (1989 $/YR)
0.000001	1,000	404	202	7,800	8	9,414
0.00001	1,000	404	202	7,800	77	9,483
0.0001	1,001	414	209	11,700	770	14,094
0.001	1,005	632	316	11,700	7,696	21,349
0.01	1,010	1,882	941	15,600	76,960	96,393
0.1	1,104	10,935	5,468	19,500	769,600	806,607
0.5	1,520	55,607	27,804	23,400	3,848,000	3,956,331
1.0	2,040	123,876	61,938	31,200	7,696,000	7,915,054

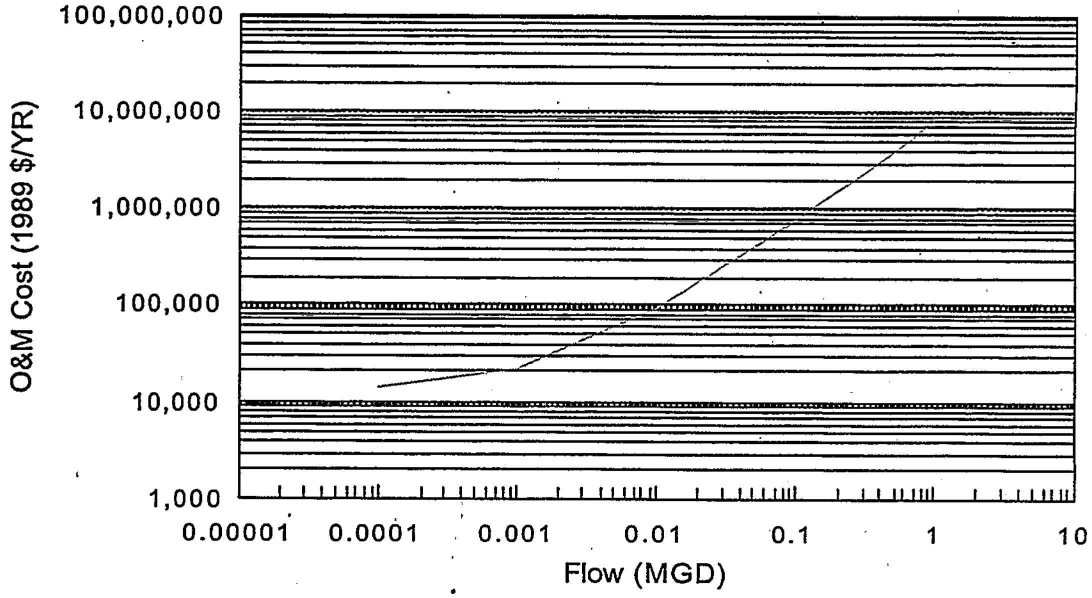

Figure 4-5. Plate and Frame Filtration (Sludge Stream) O&M Cost Curve - Metals Option 4

For facilities which already have a sludge filtration system in-place, EPA included sludge stream filtration O&M upgrade costs. For Metals Option 4, EPA included these O&M upgrade costs for processing the sludge generated from the primary precipitation and clarification steps[3]. These facilities would need to improve pollutant removals from their primary precipitation current performance concentrations to Metals Option 4 (Sample Point-03) concentrations. This sample point represents the effluent from the liquid-solids separation unit following primary chemical precipitation at the Metals Option 4 model facility. Therefore, EPA calculated the percent difference between primary precipitation current performance concentrations and Metals Option 4 (Sample Point 03) concentrations. EPA determined that there was an increase of two percent.

As such, for facilities which currently have sludge filtration systems in place, for Metals Option 4, EPA included an O&M cost upgrade of two percent of the total O&M costs (except for taxes and insurance, which are a function of the capital cost).

Table 4-5 presents the itemized O&M upgrade cost estimates for the Metals Option 4 sludge filtration systems. Figure 4-6 presents the resulting cost curve. The O&M upgrade cost equation for the Metals Option 4 sludge filtration systems is:

$$\ln(Y2) = 12.014 + 1.17846\ln(X) + 0.050(\ln(X))^2 \qquad (4\text{-}6)$$

where:

X = Flow Rate (MGD) of Liquid Stream and

Y2 = O&M Cost (1989 $/YR).

Table 4-5. O&M Upgrade Cost Estimates for Plate and Frame Filtration - Metals Option 4

[3] EPA did not include O&M upgrade costs for the sludge generated from the secondary precipitation and clarification step (direct dischargers only).

(Sludge Stream - Including Filter Cake Disposal Costs)

Wastewater Influent Flow (MGD)	Filter Cake Disposal	Energy	Maintenance	Labor	Total O&M Cost (1989 $/YR)
0.000001	1	20	8	156	185
0.00001	2	20	8	156	186
0.0001	15	20	8	234	277
0.001	154	20	13	234	421
0.01	1,539	20	38	312	1,909
0.1	15,392	22	219	390	16,023
0.5	76,960	30	1,112	468	78,570
1.0	153,920	41	2,478	624	157,063

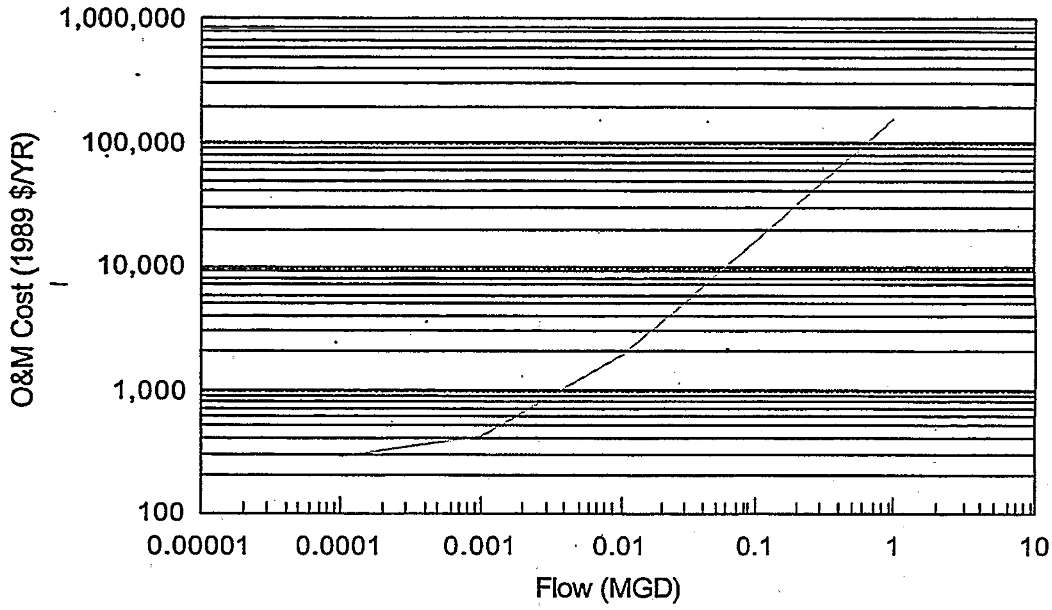

Figure 4-6. Plate and Frame Filtration (Sludge Stream) O&M Upgrade Cost Curve - Metals Option 4

4.2 Filter Cake Disposal

The liquid stream and sludge stream pressure filtration systems presented in Sections 2.2 and 4.1, respectively, generate a filter cake residual. There is an annual O&M cost that is associated with the disposal of this residual. This cost must be added to the pressure filtration equipment O&M costs to arrive at the total O&M costs for pressure filtration operation[4].

To determine the cost of transporting and disposing filter cake to an off-site facility, EPA performed an analysis on a subset of questionnaire respondents in the WTI Questionnaire response database. This subset consists of metals subcategory facilities that are direct and/or indirect dischargers and that provided information on contract haul and disposal cost to hazardous (Subtitle C) and non-hazardous (Subtitle D) landfills. From this set of responses, EPA tabulated two sets of costs -- those reported for Subtitle C contract haul and disposal and those reported for Subtitle D contract haul and disposal. the reported costs for both the Subtitle C and Subtitle D contract haul/disposal. EPA then edited this information by excluding data that was incomplete or that was not separated by RCRA classification.

EPA used the reported costs information in this data set to determine the median cost for both the Subtitle C and Subtitle D disposal options, and then calculated the weighted average of these median costs. The average was weighted to reflect the ratio of hazardous (67 percent) to nonhazardous (33 percent) waste receipts at these Metals Subcategory facilities. The final disposal cost is $0.74 per gallon of filter cake. Table 4-6 presents this analysis.

EPA calculated a single disposal cost for filter cake using both hazardous and non-hazardous landfilling costs. Certain facilities will incur costs, however, that, in reality, are higher and others will incur costs that, in reality, are lower. Thus, some low revenue metals subcategory facilities that generate non-hazardous sludge may show a higher economic burden than is representative. On the other hand, some low revenue metals subcategory facilities that generate hazardous sludge may show a lower economic

[4] Note that these costs have already been included in the O&M equation for plate and frame sludge filtration for Metals Option 4.

burden than is representative. EPA has concluded that in the end, these over- and under estimates will balance out to provide a representative cost across the industry.

EPA additionally estimated an O&M upgrade for filter cake disposal resulting from Metals Options 2 and 3 for facilities that already generate filter cake as part of their operation.

This upgrade is 3 percent of the cost of the O&M upgrade for facilities that do not already generate filter cake as a part of their operation. EPA used 3 percent because this was the same percentage calculated for plate and frame sludge filtration for these same options.

Table 4-6. CWT Metals Subcategory Filter Cake Disposal Costs

CWT QID	Filtercake Quantity (Pounds per Year)	Total Cost (1989 $ per Year)	Unit Cost (1989 $/G Filter Cake)
	Subtitle C Landfills		
022	2,632,000	250,000	0.95
072	8,834,801	835,484	0.95
080	6,389,520	711,000	1.11
089	9,456,000	602,471	0.64
100	968,000	125,964	1.30
105	13,230,000	1,164,200	0.88
255	3,030,000	530,250	1.75
257	151,650	12,450	0.82
284	5,850,000	789,000	1.35
288	297,234	36,750	1.24
294	2,628,600	390,000	1.48
449	36,000,000	2,000,000	0.56
MEDIAN			1.03
	Subtitle D Landfills		
067	15,393,486	276,160	0.18
072	440,000	24,200	0.55
119	30,410,880	361,000	0.19

132	26,378,000	158,273	0.06
133	36,960,587	780,351	0.21
135	131,451,200	2,768,225	0.21
231	80,000,000	800,000	0.10
294	56,777,760	898,560	0.16
298	2,365,740	18,800	0.08
MEDIAN			0.16
Weighted Average of Subtitle C and D Landfills Median Values			
Weighted Average ($1.03 @ 67% + $0.16 @ 33%)			0.74

Source: WTI Questionnaire Data Base
Note: Pounds = Gallons X 8.34 X Specific Gravity (SG filtercake = 1.2)

Table 4-7 presents the cost estimates for the filter cake disposal O&M and filter cake disposal O&M upgrades for Metals Options 2 and 3 systems. Figures 4-7 and 4-8 present the resulting cost curves. Equations 4-7 and 4-8 present the filter cake disposal O&M cost and O&M upgrade cost equations.

$$\mathbf{Z = 0.109169 + 7{,}695{,}499.8(X)} \qquad (4\text{-}7)$$

$$\mathbf{Z = 0.101186 + 230{,}879.8(X)} \qquad (4\text{-}8)$$

where:

X = Flow Rate (MGD) of Liquid Stream and

Z = Filter Cake Disposal Cost (1989 $/YR).

Table 4-7. Filter Cake Disposal Cost Estimates for Plate and Frame Pressure Filtration Systems - Metals Options 2 and 3

Wastewater Influent Flow (MGD)	Filter Cake Disposal Costs (1989 $/YR)	Filter Cake Upgrade Disposal Costs (1989 $/YR)
0.000001	8	1
0.00001	77	2
0.0001	770	23
0.001	7,696	231
0.01	76,960	2,309
0.05	384,800	11,544
0.10	769,600	23,088
0.50	3,848,000	115,440
1.0	7,696,000	230,880

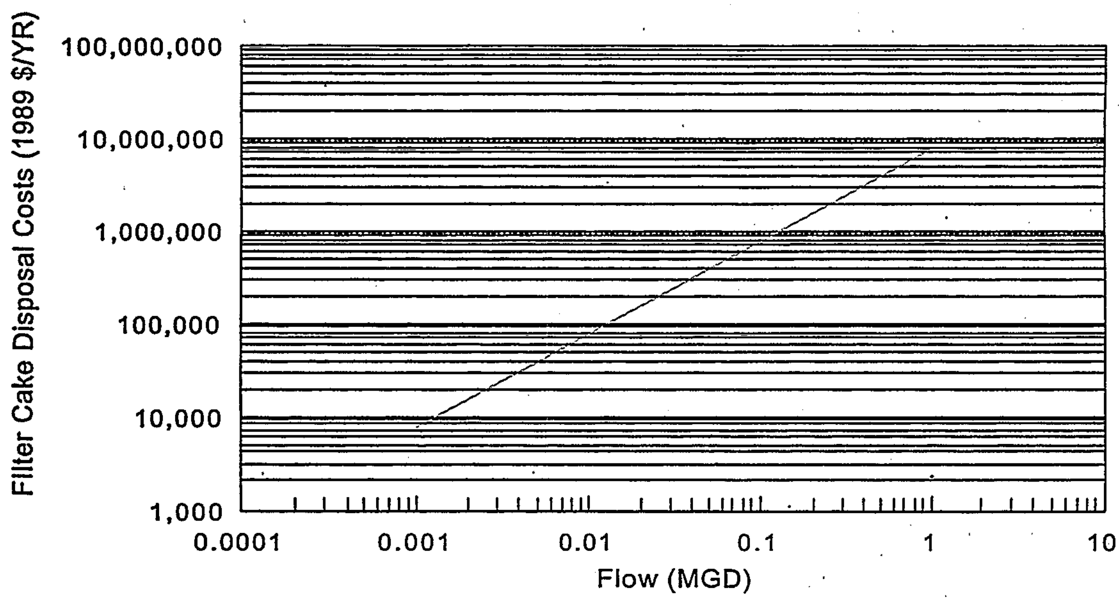

Figure 4-7. Filter Cake Disposal O&M Cost Curve for Plate and Frame Filtration Systems - Metals Options 2 and 3

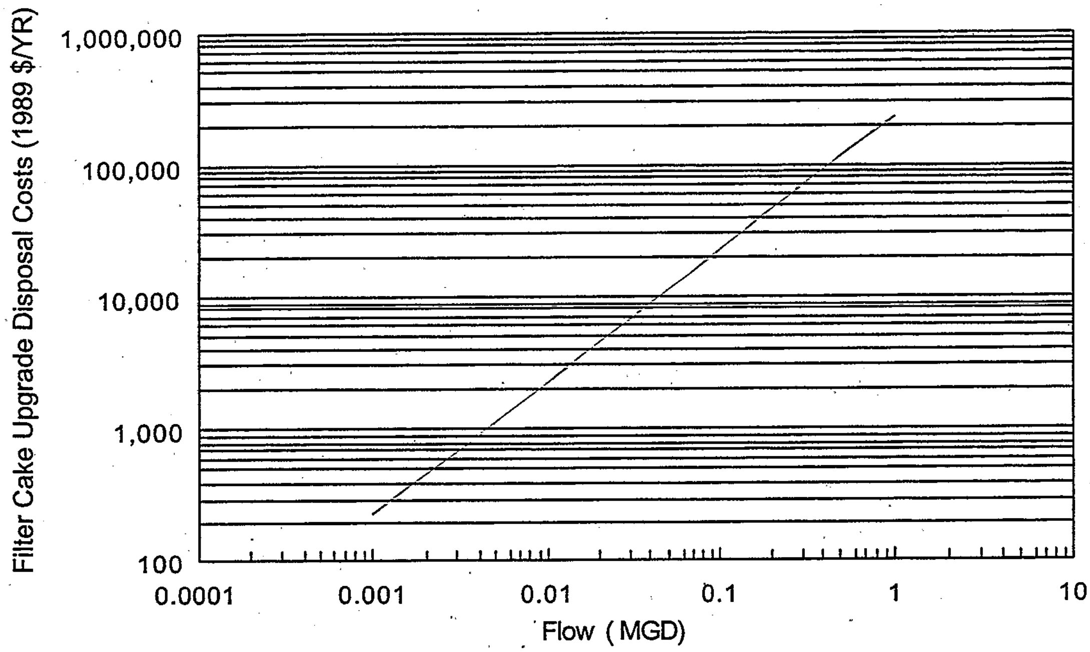

Figure 4-8. Filter Cake Disposal O&M Upgrade Cost Curve for Plate and Frame Filtration Systems - Metals Options 2 and 3

SECTION 5 ADDITIONAL COSTS

5.1 Retrofit Costs

EPA assigned costs to the CWT Industry on both an option- and facility-specific basis. The option-specific approach estimated compliance cost for a sequence of individual treatment technologies, corresponding to a particular regulatory option, for a subset of facilities defined as belonging to that regulatory subcategory. Within the costing of a specific regulatory option, EPA assigned treatment technology costs on a facility-specific basis depending upon the technologies determined to be currently in-place at the facility.

Once EPA determined that a treatment technology cost should be assigned to a particular facility, EPA considered two scenarios. The first was the installation of a new individual treatment technology as a part of a new treatment train. The full capital costs presented in Sections 2 through 4 of this document apply to this scenario. The second scenario was the installation of a new individual treatment technology which would have to be integrated into an existing in-place treatment train. For these facilities, EPA applied retrofit costs. These retrofit costs cover such items as piping and structural modifications which would be required in an existing piece of equipment to accommodate the installation of a new piece of equipment prior to or within an existing treatment train.

For all facilities which received retrofit costs, EPA added a retrofit factor of 20 percent of the total capital cost of the newly-installed or upgraded treatment technology unit that would need to be integrated into an existing treatment train. These costs are in addition to the specific treatment technology capital costs calculated with the technology specific equations described in earlier sections.

5.2 Monitoring Costs

CWT facilities that discharge process wastewater directly to a receiving stream or indirectly to a POTW will have monitoring costs. EPA regulations require both direct discharge with NPDES permits and indirect dischargers subject to categorical pretreatment standards to monitor their effluent.

EPA used the following generalizations to estimate the CWT monitoring costs:

1. EPA included analytical cost for parameters at each subcategory as follows:

- TSS, O&G, Cr+6, total CN, and full metals analyses for the metals subcategory direct dischargers, and Cr+6, total CN, and full metals analyses for the metals subcategory indirect dischargers;

- TSS, O&G, and full metals and semi-volatiles analyses for the oils subcategory option 8 and 9 direct dischargers, and full metals, and semi-volatiles for oils subcategory options 8 and 9 indirect dischargers; and

- TSS, O&G, and full metals, volatiles and semi-volatiles analyses for the oils subcategory direct dischargers, and full metals, volatiles, and semi-volatiles for oils subcategory option 8V and 9V indirect dischargers; and

- TSS, BOD_5, O&G, 6 individual metals, volatiles, and semi-volatiles analyses for the organics subcategory option 3 direct dischargers, and 6 individual metals, volatiles, and semi-volatiles analyses for the organics subcategory option 3 indirect dischargers; and

- TSS, BOD_5, O&G, 6 individual metals, and semi-volatiles analyses for the organics subcategory option 4 direct dischargers, and 6 individual metals and semi-volatiles analyses for the organics subcategory option 4 indirect dischargers.

EPA notes that these analytical costs may be overstated for the oils and the organics subcategories because EPA's final list of regulated pollutants for these subcategories do not include all of the parameters included above.

2. The monitoring frequencies are listed in Table 5-1 and are as follows:

Table 5-1. Monitoring Frequency Requirements

Parameter	Monitoring Frequency (samples/month)		
	Metals Subcategory	Oils Subcategory	Organics Subcategory
Conventionals*	20	20	20
Total Cyanide and Cr+6	20	-	-
Metals	20	4	4
Semi-Volatile Organics	-	4	4
Volatile Organics	-	4**	4**

* Conventional monitoring for direct dischargers only.

** Volatile organics monitoring for oils option 8V and 9V and organics option 3 only.

3. For facilities in multiple subcategories, EPA applied full multiple, subcategory-specific monitoring costs.

4. EPA based the monitoring costs on the number of outfalls through which process wastewater is discharged. EPA multiplied the cost for a single outfall by the number of outfalls to arrive at the total costs for a facility. For facilities for which this information is not available, EPA assumed a single outfall per facility.

5. EPA did not base monitoring costs on flow rate.

6. EPA did not include sample collection costs (labor and equipment) and sample shipping costs, and

7. The monitoring cost (based on frequency and analytical methods) are incremental to the monitoring currently being incurred by the CWT Industry. EPA applied credit to facilities for current monitoring-in-place (MIP). For facilities where actual monitoring frequencies are unknown, EPA estimated monitoring frequencies based on other subcategory facilities with known monitoring frequencies.

The cost of the analyses needed to determine compliance for the CWT pollutants are shown below in Table 5-2. EPA obtained these costs from actual quotes given by vendors and converted to 1989 dollars using the ENR's Construction Cost Index.

Table 5-2. Analytical Cost Estimates

Analyses	Cost ($1989)
BOD_5	$20
TSS	$10
O&G	$32
Cr+6	$20
Total CN	$30
Metals:	$335
Total (27 Metals)	$335
Per Metal[1]	$35
Volatile Organics (method 1624)[2]	$285
Semi-volatile Organics (method 1625)[2]	$615

1 For 10 or more metals, use the full metals analysis cost of $335.

2 There is no incremental cost per compound for methods 1624 and 1625 (although there may be a slight savings if the entire scan does not have to be reported). Use the full method cost, regardless of the actual number of constituent parameters required.

5.3 Land Costs

An important factor in the calculation of treatment technology costs is the value of the land needed for the installation of the technology. To determine the amount of land required for costing purposes, EPA calculated the land requirements for each treatment technology for the range of system sizes. EPA fit these land requirements to a curve and calculated land requirements, in acres, for every treatment system costed.

EPA then multiplied the individual land requirements by the corresponding state land cost estimates to obtain facility-specific cost estimates.

EPA used different land cost estimates for each state rather than a single nationwide average since land costs may vary widely across the country. To estimate land costs for each state, EPA obtained average land costs for suburban sites for each state from the 1990 Guide to Industrial and Real Estate Office Markets survey. EPA based these land costs on "unimproved sites" since, according to the survey, they are the most desirable. Table 5-3 presents the estimated unit land prices for the unimproved suburban sites of major cities and the averages for each state and region.

Table 5-3. Unimproved Land Costs for Suburban Areas - Region: Northeast

State	City	Land Costs ($/ft^2)		
		0 - 10 Acres	10 - 100 Acres	>100 Acres
Connecticut	Hartford	1.37	0.92	0.58
	New Haven	1.85	1.60	1.15
	State Average Cost	1.61	1.26	0.87
	Estimated State Cost/Acre($)	70,132	54,886	37,679
Maine	Portland	0.60	0.40	0.35
	State Average Cost	0.60	0.40	0.35
	Estimated State Cost/Acre($)	26,136	17,424	15,246
Massachusetts	Boston	-	2.00	1.50
	Springfield	1.45	1.10	0.75
	State Average Cost	1.45	1.55	1.13
	Estimated State Cost/Acre($)	63,162	67,518	49,005
New Hampshire	Nashua	1.50	1.15	1.00
	State Average Cost	1.50	1.15	1.00
	Estimated State Cost/Acre($)	65,340	50,094	43,560
New Jersey	Central	2.00	1.50	1.00
	Northern	4.00	3.50	2.50

Table 5-3. Unimproved Land Costs for Suburban Areas - Region: Northeast

State	City	Land Costs ($/ft²)		
		0 - 10 Acres	10 - 100 Acres	>100 Acres
	Southern	1.15	1.10	-
	State Average Cost	2.38	2.03	1.75
	Estimated State Cost/Acre($)	103,673	88,426	76,230
New York	Albany	1.20	1.00	0.40
	Buffalo	0.25	0.15	0.12
	Rochester	0.75	0.50	0.25
	Rockland/Westchester Counties	20.00	12.00	-
	Syracuse	0.40	0.35	0.25
	State Average Cost	4.52	2.80	0.26
	Estimated State Cost/Acre($)	196,891	121,968	11,180
Pennsylvania	Philadelphia	0.90	0.80	0.80
	Pittsburgh	1.00	0.60	0.35
	State Average Cost	0.95	0.70	0.58
	Estimated State Cost/Acre($)	41,382	30,492	25,047
Rhode Island		*	*	*
Vermont		*	*	*
REGIONAL	AVERAGE REGIONAL COST	1.86	1.41	0.85
—	ESTIMATED REGIONAL COST/ACRE($)	80,959	61,544	36,964

Table 5-3. Unimproved Land Costs for Suburban Areas - Region: North Central

State	City	Land Costs ($/ft^2)		
		0 - 10 Acres	10 - 100 Acres	>100 Acres
Illinois	Chicago	1.65	1.50	1.25
	Quad Cities	0.25	0.20	0.15
	State Average Cost	0.95	0.85	0.70
	Estimated State Cost/Acre($)	41,382	37,026	30,492
Indiana	Gary-Hammond	0.60	0.60	0.50
	Indianapolis	2.30	-	-
	South Bend	0.34	0.20	0.10
	Terre Haute	0.50	0.10	0.05
	State Average Cost	0.94	0.30	0.22
	Estimated State Cost/Acre($)	40,728	13,068	9,438
Iowa	Des Moines	0.30	0.25	0.20
	Quad Cities	0.25	0.20	0.15
	Sioux City	0.25	0.15	0.10
	State Average Cost	0.27	0.20	0.15
	Estimated State Cost/Acre($)	11,616	8,712	6,534
Kansas	Kansas City	-	0.20	0.20
	Wichita	0.23	0.09	0.02
	State Average Cost	0.23	0.15	0.11
	Estimated State Cost/Acre($)	10,019	6,316	4,792
Michigan	Grand Rapids	0.85	0.40	0.18
	Jackson	0.20	0.15	0.10
	State Average Cost	0.53	0.28	0.14
	Estimated State Cost/Acre($)	22,869	11,979	6,098
Minnesota	Minneapolis/ St. Paul	1.00	0.25	0.20
	State Average Cost	1.00	0.25	0.20
	Estimated State Cost/Acre($)	43,560	10,890	8,712

Table 5-3. Unimproved Land Costs for Suburban Areas - Region: North Central

State	City	Land Costs ($/ft²) 0 - 10 Acres	10 - 100 Acres	>100 Acres
Missouri	Kansas City	-	0.20	0.20
	St Louis	1.50	1.10	1.00
	State Average Cost	1.50	0.65	0.60
	Estimated State Cost/Acre($)	65,340	28,314	26,136
Ohio	Akron	0.80	0.25	0.20
	Cincinnati	0.75	0.50	0.55
	Cleveland	0.40	0.30	0.17
	Columbus	0.25	0.18	0.12
	Dayton	0.25	0.20	0.15
	State Average Cost	0.49	0.29	0.23
	Estimated State Cost/Acre($)	21,344	12,458	9,932
Nebraska	Omaha	0.70	0.60	0.40
	State Average Cost	0.70	0.60	0.40
	Estimated State Cost/Acre($)	30,492	26,136	17,424
North Dakota		*	*	*
South Dakota		*	*	*
Wisconsin	Milwaukee	0.60	0.35	0.25
	State Average Cost	0.60	0.35	0.25
	Estimated State Cost/Acre($)	26,136	15,246	10,890
REGIONAL	AVERAGE REGIONAL COST	0.72	0.89	0.30
	ESTIMATED REGIONAL COST/ACRE($)	31,407	16,988	13,068

Table 5-3. Unimproved Land Costs for Suburban Areas - Region: South

State	City	Land Costs ($/ft^2)		
		0 - 10 Acres	10 - 100 Acres	>100 Acres
Alabama	Birmingham	1.00	0.50	0.30
	Mobile	0.75	0.50	0.50
	State Average Cost	0.88	0.50	0.40
	Estimated State Cost/Acre($)	38,115	21,780	17,424
Arkansas	Fort Smith	0.75	0.60	0.50
	Little Rock	0.15	0.10	0.10
	State Average Cost	0.45	0.35	0.30
	Estimated State Cost/Acre($)	19,602	15,028	13,068
Delaware	Wilmington	1.50	1.25	1.00
	State Average Cost	1.50	1.25	1.00
	Estimated State Cost/Acre($)	65,340	54,450	43,560
Florida	Jacksonville	1.00	1.00	0.75
	Ft Lauderdale	4.50	3.50	3.50
	Lakeland	0.45	0.45	0.30
	Melbourne/ South Brevard Cty	0.80	0.80	0.80
	Miami	3.00	1.60	-
	Orlando	1.25	0.50	0.50
	Sarasota/Bradenton	0.85	0.65	0.50
	Tampa	1.75	1.25	1.25
	West Palm Beach	3.10	2.25	1.75
	State Average Cost	1.86	1.33	1.17
	Estimated State Cost/Acre($)	80,828	58,080	50,911
Georgia	Atlanta	2.00	1.75	1.25
	State Average Cost	2.00	1.75	1.25
	Estimated State Cost/Acre($)	87,120	76,230	54,450

Table 5-3. Unimproved Land Costs for Suburban Areas - Region: South

State	City	Land Costs ($/ft^2)		
		0 - 10 Acres	10 - 100 Acres	>100 Acres
Kentucky	Louisville	0.80	0.70	0.50
	State Average Cost	0.80	0.70	0.50
	Estimated State Cost/Acre($)	34,848	30,492	21,780
Louisiana	New Orleans	2.00	2.00	2.00
	Shreveport	1.00	0.50	0.30
	State Average Cost	1.50	1.25	1.15
	Estimated State Cost/Acre($)	65,340	54,450	50,094
Maryland	Baltimore	3.00	3.00	1.75
	State Average Cost	3.00	3.00	1.75
	Estimated State Cost/Acre($)	130,680	130,680	76,230
Mississippi	Jackson	0.50	0.20	0.20
	State Average Cost	0.50	0.20	0.20
	Estimated State Cost/Acre($)	21,780	8,712	8,712
North Carolina	Charlotte	0.50	0.40	0.30
	Greensboro	0.90	0.75	-
	Raleigh	1.00	1.50	1.00
	State Average Cost	0.80	0.88	0.65
	Estimated State Cost/Acre($)	34,848	38,478	28,314
Oklahoma	Oklahoma City	0.70	0.75	0.50
	Tulsa	0.50	0.50	0.40
	State Average Cost	0.60	0.63	0.45
	Estimated State Cost/Acre($)	26,136	27,225	19,602
South Carolina	Charleston	0.75	0.50	0.30
	Columbia	0.70	0.40	0.25
	Greenville	0.65	0.45	0.40
	State Average Cost	0.70	0.45	0.32
	Estimated State Cost/Acre($)	30,492	19,602	13,794

Table 5-3. Unimproved Land Costs for Suburban Areas - Region: South

State	City	Land Costs ($/ft²)		
		0 - 10 Acres	10 - 100 Acres	>100 Acres
Tennessee	Chattanooga	0.40	0.60	0.50
	Knoxville	0.45	0.25	0.15
	Memphis	1.00	0.75	0.55
	Nashville	0.80	0.50	0.50
	State Average Cost	0.66	0.43	0.35
	Estimated State Cost/Acre($)	28,859	18,513	15,246
Texas	Austin	0.75	0.60	0.50
	Corpus Christi	1.25	0.50	0.20
	Dallas	2.50	2.00	1.50
	Fort Worth	1.00	0.75	0.50
	Houston	2.50	2.00	1.00
	San Antonio	0.85	0.65	0.65
	State Average Cost	1.48	1.08	0.73
	Estimated State Cost/Acre($)	64,251	47,190	31,581
Virginia	Richmond	0.75	1.00	0.75
	Roanoke	1.25	1.00	0.75
	State Average Cost	1.00	1.00	0.75
	Estimated State Cost/Acre($)	43,560	43,560	32,670
District of Columbia	Washington	4.50	3.50	-
	State Average Cost	4.50	3.50	-
	Estimated State Cost/Acre($)	196,020	152,460	-
West Virginia		*	*	*
REGIONAL	AVERAGE REGIONAL COST	1.39	1.14	0.73
	ESTIMATED REGIONAL COST/ACRE($)	60,521	49,658	31,857

Table 5-3. Unimproved Land Costs for Suburban Areas - Region: West

State	City	Land Costs ($/ft²) 0 - 10 Acres	10 - 100 Acres	>100 Acres
Alaska		*	*	*
Arizona	Phoenix	2.25	1.50	0.75
	Tucson	1.00	0.60	0.25
	State Average Cost	1.63	1.05	0.50
	Estimated State Cost/Acre($)	70,785	45,738	21,780
California	Contra Costa	3.00	1.50	-
	Orange County	12.00	11.00	-
	San Fernando Valley	7.00	6.00	5.00
	San Gabriel Valley	7.50	4.50	-
	South Bay	18.00	18.00	18.00
	Marin & Sonoma Counties	4.00	2.50	-
	San Diego	6.00	6.00	5.00
	Stockton	1.20	0.60	0.50
	State Average Cost	7.34	6.26	7.13
	Estimated State Cost/Acre($)	319,622	272,795	310,365
Colorado	Denver	1.25	1.00	0.75
	State Average Cost	1.25	1.00	0.75
	Estimated State Cost/Acre($)	54,450	43,560	32,670
Hawaii**	Honolulu	30.00	20.00	-
	State Average Cost	30.00	20.00	-
	Estimated State Cost/Acre($)	1,306,800	871,200	-

Table 5-3. Unimproved Land Costs for Suburban Areas - Region: West

State	City	Land Costs ($/ft^2)		
		0 - 10 Acres	10 - 100 Acres	>100 Acres
Idaho		*	*	*
Montana		*	*	*
Nevada	Reno	1.25	0.75	0.50
	State Average Cost	1.25	0.75	0.50
	Estimated State Cost/Acre($)	54,450	32,670	21,780
New Mexico	Albuquerque	1.00	0.50	0.35
	State Average Cost	1.00	0.50	0.35
	Estimated State Cost/Acre($)	43,560	21,780	15,246
Oregon	Portland	2.00	1.00	0.50
	State Average Cost	2.00	1.00	0.50
	Estimated State Cost/Acre($)	87,120	43,560	21,780
Utah		*	*	*
Washington	Seattle - Eastside	4.50	3.50	-
	Spokane	0.35	0.20	0.11
	State Average Cost	2.43	1.85	0.11
	Estimated State Cost/Acre($)	105,633	80,586	4,792
Wyoming		*	*	*
REGIONAL	AVERAGE REGIONAL COST	2.41	1.77	1.41
	ESTIMATED REGIONAL COST/ACRE($)	104,980	77,101	61,233

* No data available for state, use regional average.
\- No data available for city or area indicated.
** Hawaii was not included in the regional average calculations.

The survey additionally provides land costs broken down by size ranges. These are zero to 10 acres, 10 to 100 acres, and greater than 100 acres. Since CWT facilities fall into all three size ranges (based on responses to the WTI Questionnaire), EPA averaged the three size-specific land costs for each state to arrive at the final land costs for each state. Table 5-4 presents a summary of the estimated land prices for each state.

The survey did not provide land cost estimates for Alaska, Idaho, Montana, North Dakota, Rhode Island, South Dakota, Utah, Vermont or West Virginia. For these states, EPA used regional averages of land costs. EPA determined the states comprising each region also based on the aforementioned survey since the survey categorizes the states by geographical region (northeast, north central, south, and west). In estimating the regional average costs for the western region, EPA did not include Hawaii since Hawaii's land cost is high and would have skewed the regional average.

Table 5-5 lists the land cost per acre for each state. As Table 5-5 indicates, the least expensive state is Kansas with a land cost of $7,042 per acre and the most expensive state is Hawaii with a land cost of $1,089,000 per acre.

Table 5-4. Summary of Land Costs for Unimproved Suburban Areas -

Region: Northeast

State	Land Costs per Acre ($)		
	0 - 10 Acres	10 - 100 Acres	>100 Acres
Connecticut	70,132	54,886	37,679
Maine	26,136	17,424	15,246
Massachusetts	63,162	67,518	49,005
New Hampshire	65,340	50,094	43,560
New Jersey	103,673	88,426	76,230
New York	196,891	121,968	11,180
Pennsylvania	41,382	30,492	25,047
Rhode Island	*	*	*
Vermont	*	*	*
ESTIMATED REGIONAL COST/ACRE($)	80,959	61,544	36,964

Region: North Central

Illinois	41,382	37,026	30,492
Indiana	40,728	13,068	9,438
Iowa	11,616	8,712	6,534
Kansas	10,019	6,316	4,792
Michigan	22,869	11,979	6,098
Minnesota	43,560	10,890	8,712
Missouri	65,340	28,314	26,136
New Mexico	*	*	*
Ohio	21,344	12,458	9,932
Nebraska	30,492	26,136	17,424
North Dakota	*	*	*
South Dakota	*	*	*
Wisconsin	26,136	15,246	10,890
ESTIMATED REGIONAL COST/ACRE($)	31,407	16,988	13,068\

Table 5-4 (cont.). Summary of Land Costs for Unimproved Suburban Areas -

Region: South

State	Land Costs per Acre ($)		
	0 - 10 Acres	10 - 100 Acres	>100 Acres
Alabama	38,115	21,780	17,424
Arkansas	19,602	15,028	13,068
Delaware	65,340	54,450	43,560
Florida	80,828	58,080	50,911
Georgia	87,120	76,230	54,450
Kentucky	34,848	30,492	21,780
Louisiana	65,340	54,450	50,094
Maryland	130,680	130,680	76,230
Mississippi	21,780	8,712	8,712
North Carolina	34,848	38,478	28,314
Oklahoma	26,136	27,225	19,602
South Carolina	30,492	19,602	13,794
Tennessee	28,859	18,513	15,246
Texas	64,251	47,190	31,581
Virginia	43,560	43,560	32,670
District of Columbia	196,020	152,460	-
West Virginia	*	*	*
ESTIMATED REGIONAL COST/ACRE($)	967,819.00	796,940.00	477,536.00

Table 5-4 (cont.). Summary of Land Costs for Unimproved Suburban Areas -

Region: West

State	Land Costs per Acre ($)		
	0 - 10 Acres	10 - 100 Acres	>100 Acres
Alaska	*	*	*
Arizona	70,785	45,738	21,780
California	319,622	272,795	310,365
Colorado	54,450	43,560	32,670
Hawaii**	1,306,800	871,200	*
Idaho	*	*	*
Montana	*	*	*
Nevada	54,450	32,670	21,780
New Mexico	43,560	21,780	15,246
Oregon	87,120	43,560	21,780
Utah	*	*	*
Washington	105,633	80,586	4,792
Wyoming	*	*	*
ESTIMATED REGIONAL COST/ACRE($)**	2,042,420.00	1,411,899.00	428,513.00

* No data available for state, use regional average.

** Hawaii was not included in the regional average calculations.

Table 5-5. State Land Costs for the CWT Industry

State	Land Cost per Acre (1989 $)	State	Land Cost per Acre (1989 $)
Alabama	0.00	Nebraska	24,684
Alaska*	0.00	Nevada	36,300
Arizona	0.00	New Hampshire	52,998
Arkansas	0.00	New Jersey	89,443
California	0.00	New Mexico	26,929
Colorado	0.00	New York	110,013
Connecticut	0.00	North Carolina	33,880
Delaware	0.00	North Dakota*	20,488
Florida	0.00	Ohio	14,578
Georgia	0.00	Oklahoma	24,321
Hawaii	1,089,000	Oregon	50,820
Idaho*	81,105	Pennsylvania	32,307
Illinois	36,300	Rhode Island*	59,822
Indiana	21,078	South Carolina	21,296
Iowa	8,954	South Dakota*	20,488
Kansas	7,042	Tennessee	20,873
Kentucky	29,040	Texas	47,674
Louisiana	56,628	Utah*	81,105
Maine	19,602	Vermont*	59,822
Maryland	112,530	Virginia	39,930
Massachusetts	59,895	Washington	63,670
Michigan	13,649	West Virginia*	47,345
Minnesota	21,054	Wisconsin	17,424
Mississippi	13,068	Wyoming*	81,105
Missouri	39,930	Washington DC	174,240
Montana*	81,105		

* No data available for state, use regional average.

SECTION 6 MULTIPLE WASTESTREAM SUBCATEGORY COST ESTIMATES

6.1 Implementation of a Fourth Subcategory

In the 1999 proposal, EPA proposed to establish limitations and standards for three subcategories of CWT facilities: facilities treating either metal, oily, or organic wastes and wastewater. Section VII of the proposal detailed this subcategorization scheme. See 64 FR 2300 (1999). While EPA did not propose limitations and standards for a multiple wastestream subcategory, the proposal did discuss EPA's consideration of a multiple wastestream subcategory. The proposal explained that multiple wastestream subcategory limitations, if adopted, would apply to facilities that treat wastes in more than one subcategory. EPA would establish limitations and standards for the multiple wastestream subcategory by combining pollutant limitations from the three subcategories, where relevant, and selecting the most stringent value where they overlap.

EPA's consideration of this option responded to comments to the 1995 proposal and the 1996 Notice of Data Availability. The primary reason some members of the waste treatment industry favored development of a multiple wastestream subcategory was to simplify implementation for facilities treating wastes covered by multiple subcategories. As detailed in the proposal, EPA's primary reason for not proposing (and adopting) this option was its concern that facilities that accept wastes in multiple subcategories need to provide effective treatment of all waste receipts. This concern was based on EPA's data that showed such facilities did not currently have adequate treatment-in-place. While these facilities meet their permit limitations, EPA concluded that compliance was likely achieved through co-dilution of dissimilar wastes rather than treatment. As a result, EPA determined that adoption of "multiple wastestream subcategory" limitations as described above could arguably encourage ineffective treatment.

EPA solicited comments on ways to develop a "multiple wastestream subcategory" which ensures treatment rather than dilution. The vast majority of comments on the 1999 proposal supported the establishment of a multiple wastestream subcategory for this rule, and re-iterated their concerns about implementing the three-subcategory scheme at multiple-subcategory facilities. One commenter suggested a way to implement a fourth subcategory while ensuring treatment. This commenter suggested that EPA follow the approach taken for the Pesticide Formulating, Packaging and Repackaging (PFPR) Point Source category (40 CFR Part 455). Under this approach, multiple wastestream subcategory facilities would have the option of 1) monitoring for compliance with the appropriate subcategory limitations after each treatment step or 2) monitoring for compliance with the multiple wastestream subcategory limitations at a combined discharge point and certifying that equivalent treatment to that which would be required for each subcategory waste separately is installed and properly designed, maintained, and operated. This option would eliminate the use of the combined wastestream formula or building block approach in calculating limits or standards for multiple wastestream subcategory CWT facilities (The combined wastestream formula and the building block approach are discussed in more detail in Chapter 14 of the Final Technical Development Document). Commenters suggested that an equivalent treatment system could be defined as a wastewater treatment system that is demonstrated to achieve comparable removals to the treatment system on which EPA based the limitations and standards. Ways of demonstrating equivalence might include data from recognized sources of information on pollution control, treatability tests, or self-monitoring data showing comparable removals to the applicable pollution control technology.

EPA concluded that the approaches adopted in the PFPR rule address the concerns identified earlier. EPA agreed with commenters that developing appropriate limitations on a site-specific basis for multiple wastestream facilities presents many challenges and that the use of a multiple wastestream subcategory would simplify implementation of the rule. Moreover, the limits applied to multiple wastestream treaters would be a compilation of the most stringent limits from each applicable subcategory and would generally be similar to or stricter than the limits calculated via the application of the combined wastestream formula or building block approach. Most significantly, the equivalent treatment certification requirement would address EPA's concerns that the wastes receive adequate treatment.

Therefore, EPA has established a fourth subcategory: the multiple wastestream subcategory. Section XIII.A.5.b of the preamble to the final rule details the manner in which EPA envisions the multiple wastestream subcategory will be implemented. Further, EPA is preparing a guidance manual to aid permit writers/control authorities and CWT facilities in implementing the certification process. EPA's 1999 proposal was based on establishing limitations and standards for three subcategories of CWT facilities: facilities treating either metals, oils, or organic wastes and wastewater. As detailed in the proposal, multiple wastestream subcategory limitations would be used for facilities which treat wastes in more than one subcategory, and would be established by combining pollutant limitations from all three subcategories, selecting the most stringent value where they overlap.

6.2 Methodology Used for Cost Estimates

EPA has developed cost estimates for the Multiple Wastestream Subcategory based upon data gathered and analyses performed for the original three subcategories: Metals Subcategory, Oils Subcategory, and Organics Subcategory.

Cost estimates for the Multiple Wastestream Subcategory were developed for Metals Option 4, Cyanide Option 2, Oils Option 8, and Organics Option 4. The costing methodology followed for the development of the Multiple Wastestream Subcategory cost estimates is as follows:

1. Obtain cost estimates for the oils subcategory Option 8 using the oils flowrate only.

2. Obtain cost estimates for the cyanide subsection using the cyanide flowrate only.

3. Combine oils and metals and cyanide subcategory flowrates and obtain cost estimates for the Metals Option 4. (The chemical dosages were adjusted to include the additional metals contributed by the oils subcategory effluent).

4. Combine oils, metals, cyanide, and organics flowrates and develop cost estimates for Organics Option 4.

5. The monitoring cost estimates were only developed once at the following frequency requirements:

Conventionals*	20 samples/month
Total Cyanide, CR^{+6}	20 samples/month
Metals**	20 samples/month
Semi-Volatiles	4 samples/month

* Conventional were monitored only at direct dischargers
** For the oils/organic only mix, the metals monitoring frequency is 4 samples/month

6. Plant TIP was taken into account when developing the cost estimates in the same manner as before.

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