THE EFFECTS OF INDUSTRIAL PRETREATMENT IN PROTECTING THE QUALITY OF SLUDGE FROM PUBLICLY OWNED TREATMENT WORKS (POTWs) LOCATED IN KENTUCKY

Kentucky Division of Water
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Pretreatment Section
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In an effort to quantify the beneficial effects of pretreatment in protecting the environment of the Commonwealth, an evaluation of the quality of sludge from various cities located in Kentucky was conducted. Sludge quality is a fairly accurate measurement of most pretreatment programs' effectiveness, as it is a record of any metal-bearing slug loads entering the treatment works and/or a record of chronic, yet continuous metal-bearing discharges which may be noncompliant with federal and local pretreatment standards.

In order to determine the effects of industrial discharges to POTWs, the background levels of metals originating from non-industrial sources (residential and small commercial areas) needed to be quantified. The easiest way to accomplish this was to evaluate the sludge quality from non-pretreatment POTW's (i.e., POTW's not receiving industrial process wastewater). The background levels will be present in all POTW's, and for the most part, the reduction of which are beyond the cities' control.

After researching the Division of Waste Management's landfarming records for the last seven (7) years, it was determined that at least 12 non-pretreatment POTW's are periodically reporting sludge quality data. This data indicates that 50% of the cities achieved compliance with Class I sludge quality, 42% with Class II quality, and 8% with Class III quality when compared with the classifications listed in Table 1. To have only one pollutant above the Class I standards placed a POTW's s sludge in a higher class.

TABLE 1 - mg/kg by weight

	Class I	Class II	Class III
Cadmium	<10	10-30	>30
Copper	<450	450-900	>900
Lead	<250	250-500	>500
Nickel	<50	50-100	>100
Zinc	<900	900-1800	>1800

Variations in sludge quality from city to city are due to many factors. Those factors which are most important are:

1. Age of sludge: The longer a sludge is accumulated and allowed to digest, the higher the metals concentrations become.

2. The type of wastewater treatment: Activated sludge treatment processes better accumulate metals than RBC's and biofilter treatment processes.

3. Whether the city accepts hauled waste: Hauled waste, such as septic waste and landfill leachate may contain concentrated amounts of metals, depending on its age and source.

4. The percentage of older houses on the POTW system: Older homes tend to have higher values of lead, copper, and zinc leaching from metal plumbing and fixtures.

5. The drinking water quality: Due to differences in the mineral and gas contents of water supplies, some waters promote the solution of metal more rapidly than others. Zinc salts are often fed at water plants to inhibit corrosion within the distribution lines. Also, intake water, depending on its source, will have trace amounts of various metals which eventually make it to the POTW.

6. Industrial contribution: Volume and type of industrial and commercial wastewater can significantly impact sludge quality.

An average of the sludge values for the 12 non-pretreatment cities are listed in Table 2. These values, as a whole, represent the lowest numbers any city (pretreatment or non-pretreatment) can achieve on a regular basis.

TABLE 2

	Average Background Values (mg/kg)
Cadmium	6.0
Chromium	34
Copper	320
Lead	110
Mercury	NA *
Nickel	33
Silver	NA *
Zinc	780

*: Not available.

Once the background level (or uncontrollable portion of a sludge's contamination) was established, a baseline was set to determine the amount of contamination due to industrial sources. The years 1984 and 1985 give a fairly accurate description of POTW sludge quality prior to the pretreatment program, since most cities finished development of their pretreatment programs in 1984 and didn't begin to fully enforce them until 1985 and beyond. By the end of 1983, there were 47 cities in Kentucky with approved pretreatment programs when Kentucky gained primacy from U.S. EPA. Today, there are 63 cities with active approved programs. Additional cities may be required to develop pretreatment programs for several reasons:

1. Direct industrial discharges connected to the sewers of previously non-pretreatment cities, due to the strict KPDES permits and Kentucky Division of Water's encouragement of regionalization.

2. New industries locating in non-pretreatment cities during the economic growth of the mid-to-late 1980's, spurred on by the location of Toyota in Georgetown.

3. The identification of indirect industrial discharges not previously identified by U.S. EPA.

Table 3 shows the average sludge concentrations for the years 1984 through 1993.

TABLE 3

SLUDGE REPORT

Year	1984 /85	'86	'87	'88	'89	'90	'91	'92	'93
#Approved Pretreatment Programs	47	53	57	59	64	66	69	62	63
#Cities Reporting	10	14	11	17	34	22	39	56	52
Cadmium (mg/kg)	9	6	8	6	7	11	6	8	7.5
Chromium (mg/kg)	180	118	149	222	120	76	109	150	102
Copper (mg/kg)	507	563	455	658	446	736	570	427	391
Lead (mg/kg)	258	156	209	105	184	129	116	141	111
Nickel (mg/kg)	97	553	63	49.6	68	61	79	131	93
Zinc (mg/kg)	1858	1896	1765	928	1066	890	966	853	805

Percent reductions in metals from 1984/85 to 1993 are listed in Table 4. These should also indicate the percent reduction in metals reaching the POTW headworks, and to a lesser degree, the percent reduction of metals reaching the receiving streams.

TABLE 4

	Percent Metals Reduction in Sludge
Cadmium	17%
Chromium	43%
Copper	23%
Lead	57%
Nickel *	71%
Zinc *	57%

*: Used the average (1984/85 & 1986) and 1993 to calculate percent reduction from 1984/85 to 1993.

There are several inherent problems with the data. These problems will affect the numbers, but there is no real way to correct them. These problems are listed below.

1. Sludge data from those cities reporting each year was used to calculate the average value. The difficulty is that the original 47 pretreatment cities were considered priority cities by U.S. EPA and would likely have higher contamination levels.

2. Data is sporadic. Until 1991, sludge reports were required at 24 month intervals.

3. Data is not weighted (i.e., cities such as Louisville, Flow = 105 MGD and Eminence, Flow = 0.22 MGD were given equal weight when calculating yearly averages for the state).

Flaws in the data are countered to some degree, though, by the following:

1. Several cities in the original 47 received considerably heavy industrial waste, such as Owensboro West and Princeton, but did not report sludge data until the late 1980's or early 1990's. By this time, most metals reduction due to enforcement of pretreatment had already taken place.

2. Many of the cities added since the original 47 now have high industrial flow due to hook-up from direct dischargers and the addition of new industries locating in Kentucky.

3. Even though the data was not weighted, large cities such as Louisville have shown reductions in metals which parallel that of the State as a whole.

Despite the flaws, the data shows a definite downward trend for all pollutants, with concentrations now approaching those of background amounts. However, small peaks were observed for most of the pollutants during the years 1987 through 1993. They are:

Cadmium in 1990
Chromium in 1988
Copper in 1988, 1990
Nickel in 1989, 1992
Zinc in 1989

These peaks are real since they were experienced by many of the cities individually. They are most likely due to one of the two reasons listed.

1. Existing direct industrial dischargers connecting to city's sewers.

2. New industries locating in the State during the 1980's economic growth.

Throughout the period from 1984 to 1993, lead and zinc concentrations continued to decrease, until the present where they are leveling off close to background concentrations.

Possibly, a better way to quantify the improvements in sludge quality from pretreatment POTWs during the study period is to tabulate the increases in Class I sludge measurements and tabulate the decreases in Class III sludge measurements. Tables 5 and 6 reflect that comparison as represented by percentages.

TABLE 5

Percentage of Pretreatment Cities Achieving Compliance with Class I Sludge Standards

Year	1984 /85	'86	'87	'88	'89	'90	'91	'92	'93	Background Cities
#Approved Programs	47	53	57	59	64	66	69	62	63	N/A
#Cities Reporting	10	14	11	17	34	22	39	56	52	12
Cadmium	80%	71%	73%	88%	85%	86%	90%	91%	92%	75%
Copper	70%	64%	64%	71%	68%	77%	67%	73%	85%	82%
Lead	70%	86%	82%	89%	88%	91%	92%	88%	98%	92%
Nickel	30%	71%	55%	71%	68%	73%	67%	61%	73%	92%
Zinc	10%	57%	45%	71%	62%	68%	64%	66%	75%	75%

TABLE 6

Percentage of Pretreatment Cities Exceeding Concentration of Class III Sludge Standards

Year	1984 /85	'86	'87	'88	'89	'90	'91	'92	'93	Background Cities
#Approved Programs	47	53	57	59	64	66	69	62	63	N/A
#Cities Reporting	10	14	11	17	34	22	39	56	52	12
Cadmium	10%	0%	9%	12%	3%	9%	3%	7%	4%	8%
Copper	10%	14%	9%	18%	3%	23%	8%	13%	8%	0%
Lead	10%	7%	9%	11%	3%	5%	0%	4%	2%	0%
Nickel	20%	29%	9%	6%	18%	9%	21%	21%	23%	0%
Zinc	30%	36%	27%	24%	18%	9%	5%	7%	2%	0%

Since only one pollutant has to exceed Class III standards before the sludge is classified as Class III, and must achieve compliance with all five Class I standards to be classified as Class I, the most important statistics gained from all this may be the percentage of pretreatment cities achieving compliance with Class I, II, and III standards. Table 7 shows those percentages for the studied period.

TABLE 7

Percentage of Pretreatment Cities Achieving Compliance with Class I, II and III Sludge Standards for All Five Pollutants

Year	1984 /85	'86	'87	'88	'89	'90	'91	'92	'93	Background Cities
#Approved Programs	47	53	57	59	64	66	69	62	63	N/A
#Cities Reporting	10	14	11	17	34	22	39	56	52	12
Class I	10%	50%	36%	53%	39%	50%	45%	41%	42%	50%
Class II	40%	14%	36%	11%	31%	25%	30%	34%	35%	42%
Class III	50%	36%	27%	37%	31%	25%	25%	25%	24%	8%

The gradual decline in Class III sludge from 1984 to 1993 indicates that many cities had sludge containing only one pollutant (nickel) meeting Class III standards. This is shown in Table 8. While improvements in other pollutants did occur, often nickel remained in the higher category. In any particular city, one industry may have achieved compliance with pretreatment standards prior to another. An example of this might be a city with two industries; one a nickel plater, the other an organic chemicals plant. The electroplater may have achieved compliance with metal finishing standards in 1987 while the organic chemicals plant achieved compliance with zinc standards in 1991. Metal finishers were targeted much earlier by EPA than organic chemical manufacturers.

The final chart, which is shown on page 10 illustrates the compliance deadlines for pretreatment standards for existing source (PSES) categorical industrial users, the more important of which fall in the period from 1985 to 1990. The compliance deadlines of the federal categories correlate fairly closely with the improvements in sludge quality.

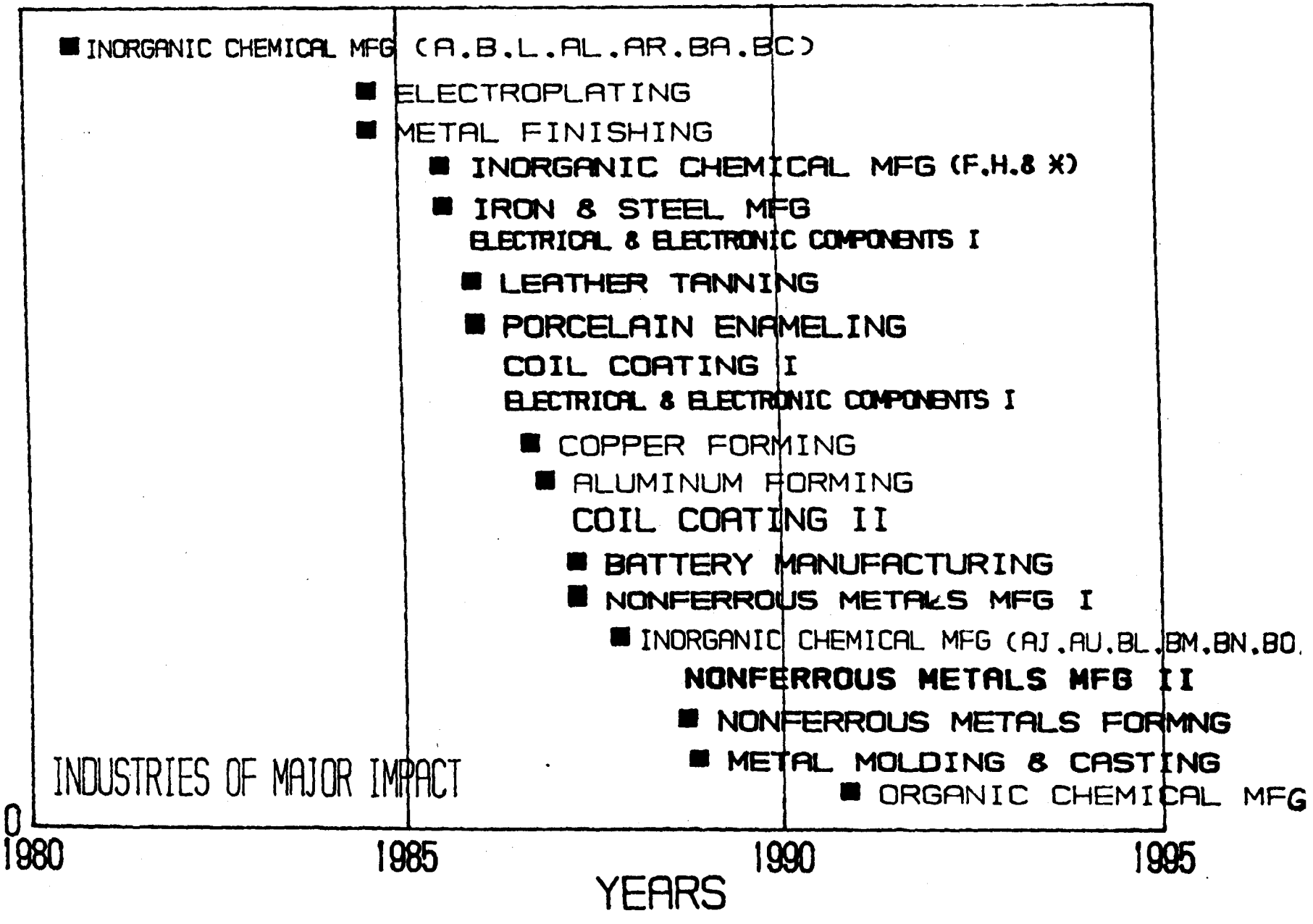
TABLE 8

Percentage of POTW's with Sludges Exceeding the Class II or III Criteria for More than One Pollutant

Year	Percent of POTWs with Class I Sludge	Percent of POTWs with Class II Sludge						Percent of POTWs with Class III Sludge					
		TOTAL	1	2	3	4	5	TOTAL	1	2	3	4	5
1984/ 1985	10%	40%	10%	20%		10%		50%	40%			10%	
1986	50%	14%	7%			7%		36%	7%	15%	7%	7%	
1987	36%	36%	9%	27%				27%		18%	9%		
1988	53%	11%	5.5%		5.5%			37%	16%	21%			
1989	39%	31%	8%	17%	3%	3%		31%	22%	6%	3%		
1990	50%	25%	12.5%	12.5%				25%	13%	8%			4%
1991	45%	30%	13%	7%	5%	5%		25%	17%	5%	3%		
1992	41%	34%	24%	8%		2%		25%	12%	8%		5%	
1993	42%	35%	22%	9%	2%	2%		24%	15%	7%	2%		
Back- Ground	50%	42%	17%	25%				8%	8%				

COMPLIANCE DEADLINES FOR INDIVIDUAL PRETREATMENT STANDARDS

FOR EXISTING SOURCE (PSES) CATEGORICAL INDUSTRIAL USERS



CONCLUSIONS:

1. As a whole, POTW sludge quality in Kentucky has continued to improve despite the fact that many industries (new sources and existing direct dischargers) have hooked up to city sewers during the past nine (9) years.

2. Most POTW's can approach background metals concentrations in sludge if pretreatment standards are enforced.

3. The adoption of new categorical pretreatment standards will not greatly improve sludge quality (with the possible exception of silver and mercury standards for hospitals, dentist offices, and printing shops). The impracticality of enforcing such standards may limit any development of such standards by U.S. EPA.

4. Enforcement of technically-based local limits and already adopted PSES and PSNS standards is the most important tool in protecting sludge quality and ultimately, water quality.

RECOMMENDATIONS:

In Kentucky the sludge give-away programs and the groundwater/surface-water monitoring requirements of sludge landfarming are directly dependent on metals concentrations in a POTW's sludge. To ensure that these programs are not detrimentally impacted with over-regulation, the following recommendations are provided, even though they go beyond the intentions of this paper.

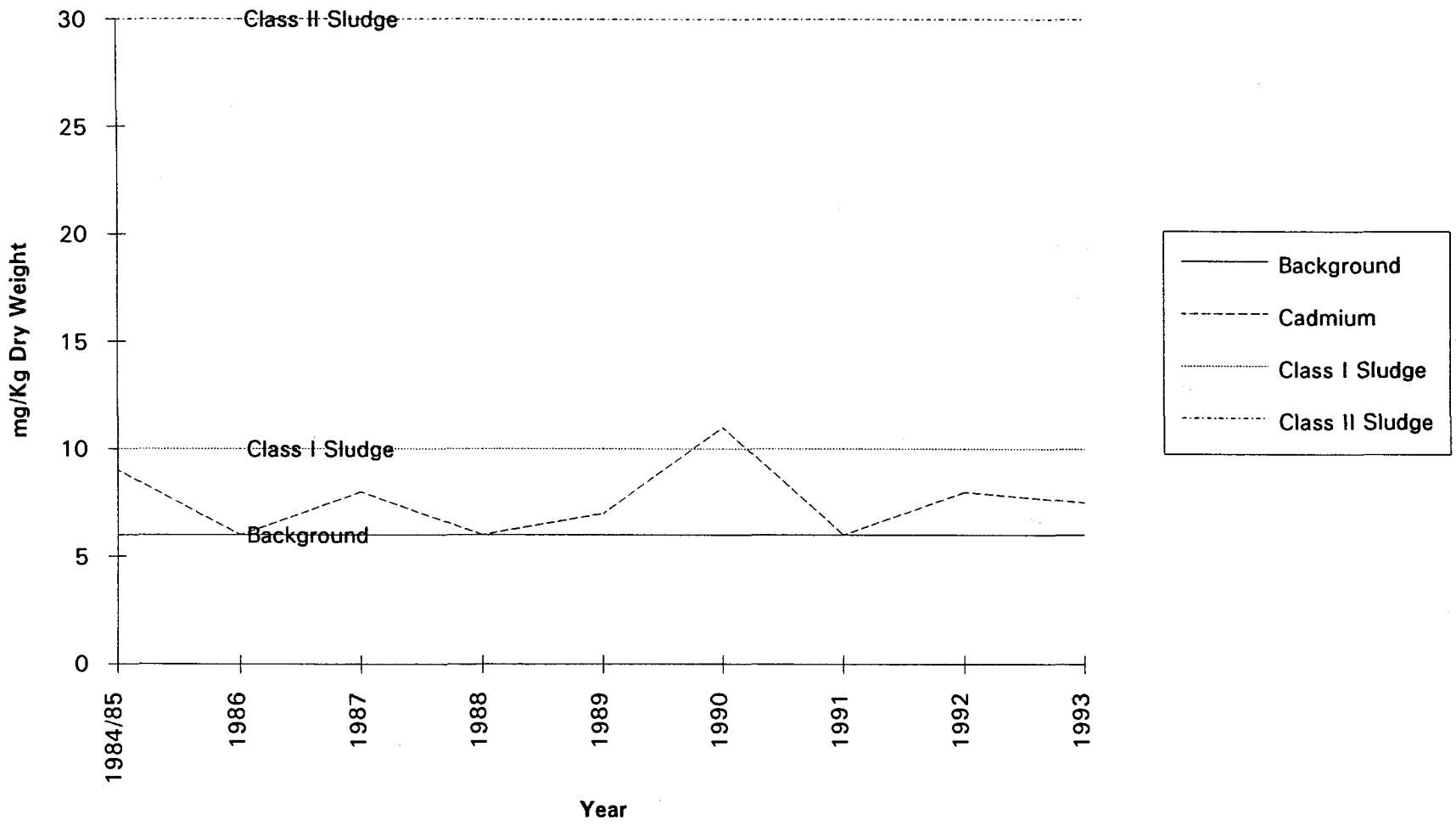
1. Because only 50% of non-pretreatment cities are able to meet Class I sludge criteria on a regular basis, the levels for this classification, at the very least, should not be lowered.

2. Since pretreatment cities:

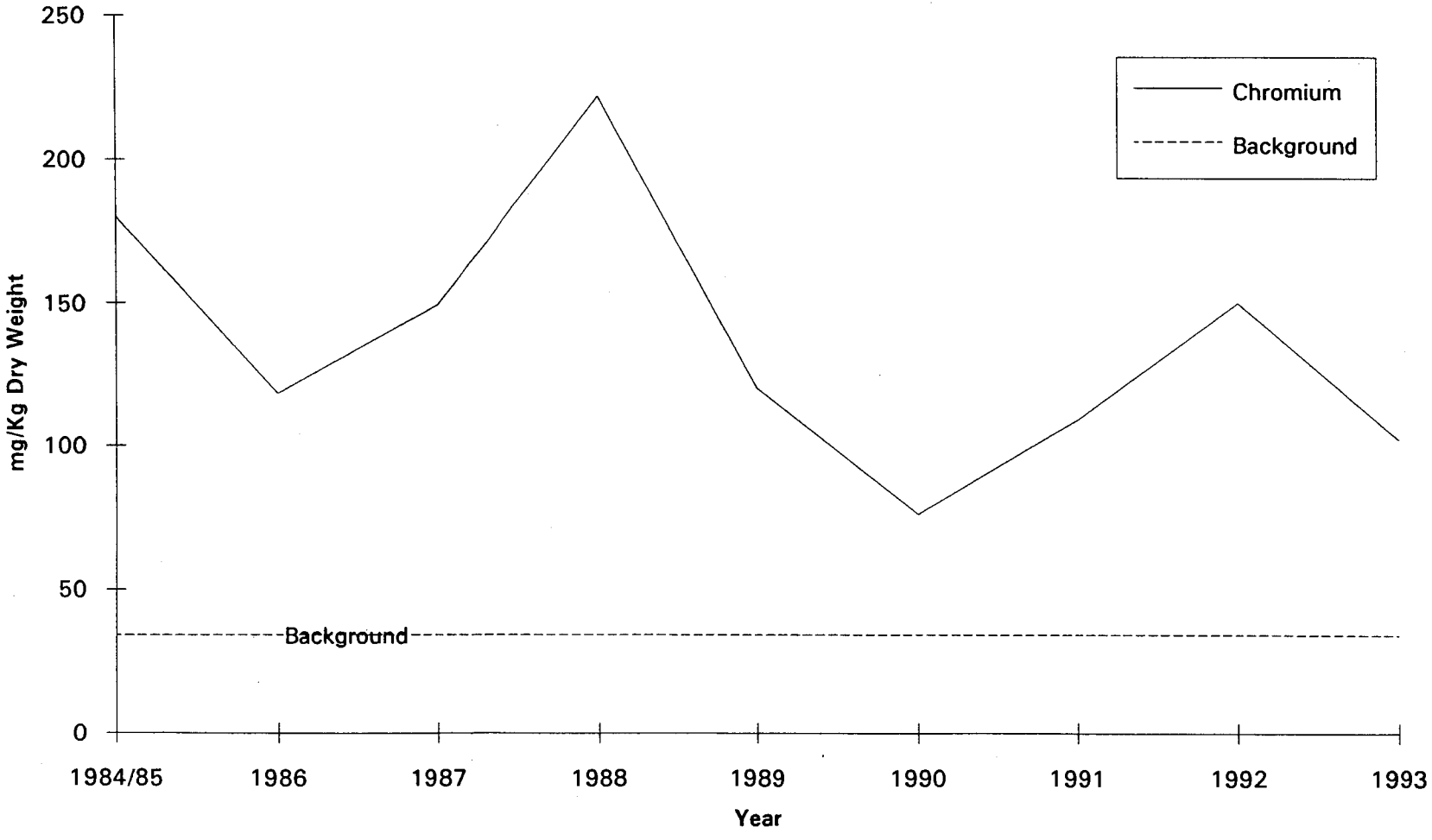
   a) are unable to obtain background levels as non-pretreatment cities can (even with effective pretreatment programs);
   b) are the largest generators of sludge (80-85%); and
   c) are the ones most likely to lose from over-regulation;

therefore, it is recommended that Class I and Class II sludge criteria be increased, where risk assessment allows for it.

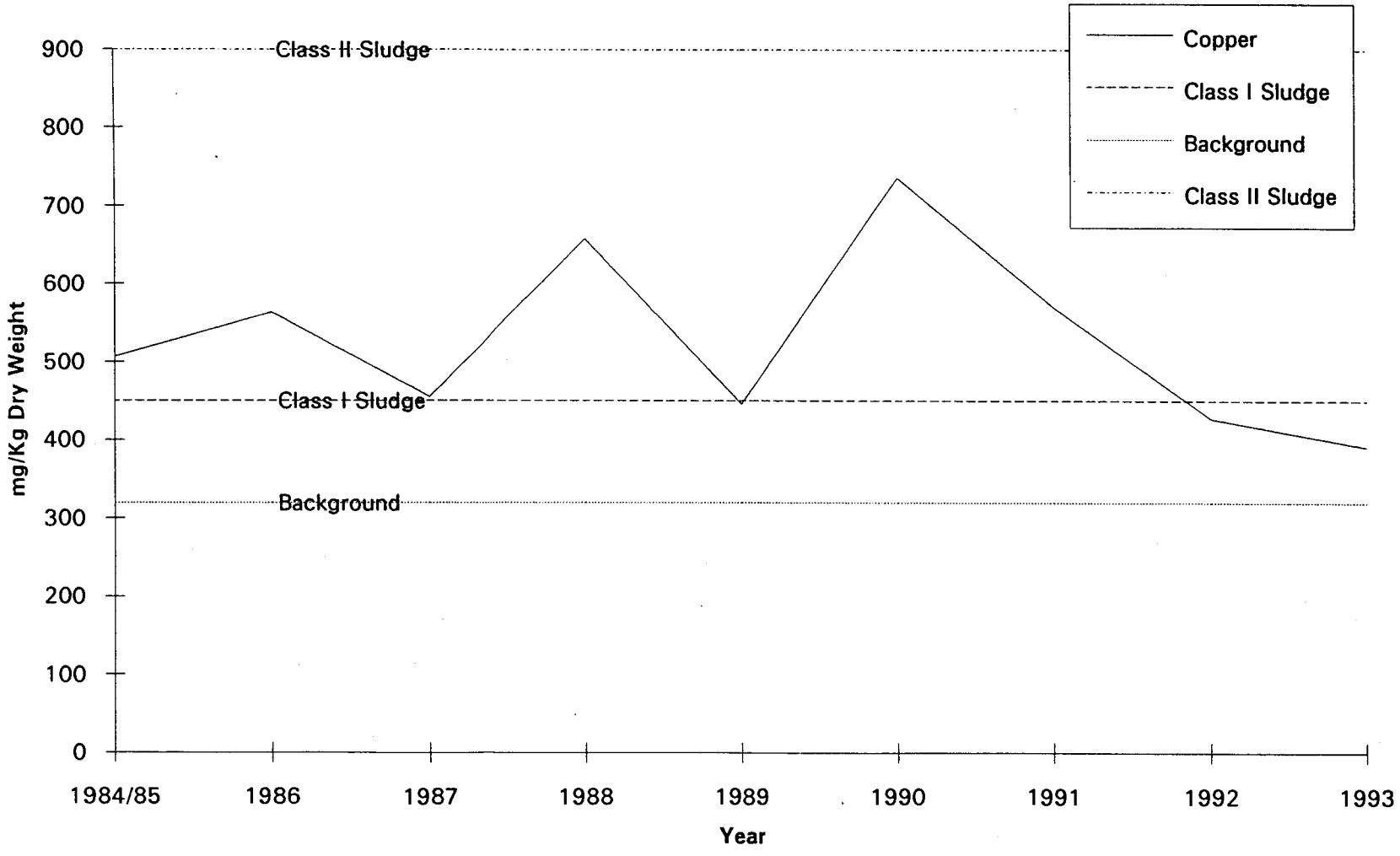
Average Cadmium Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



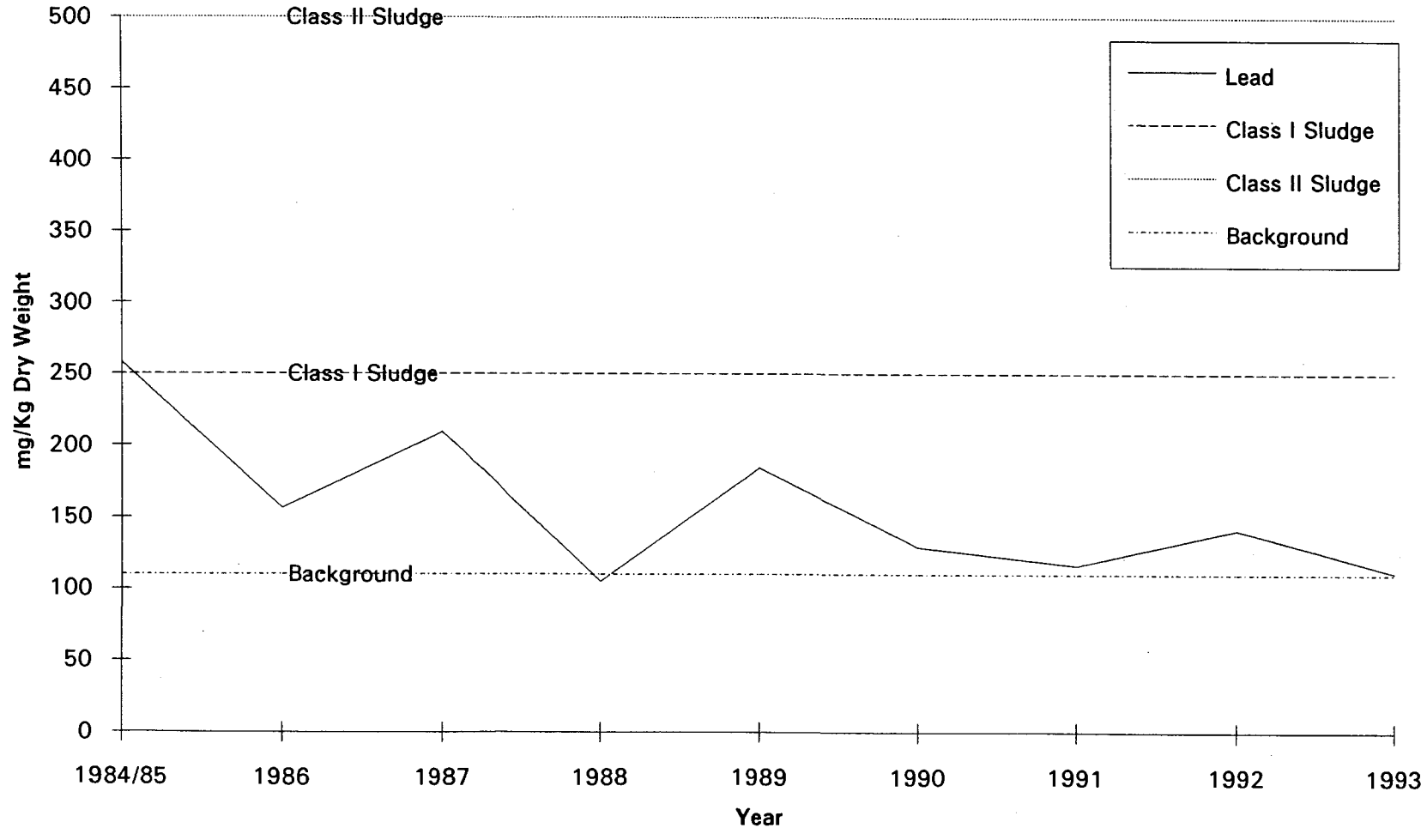
Average Chromium Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



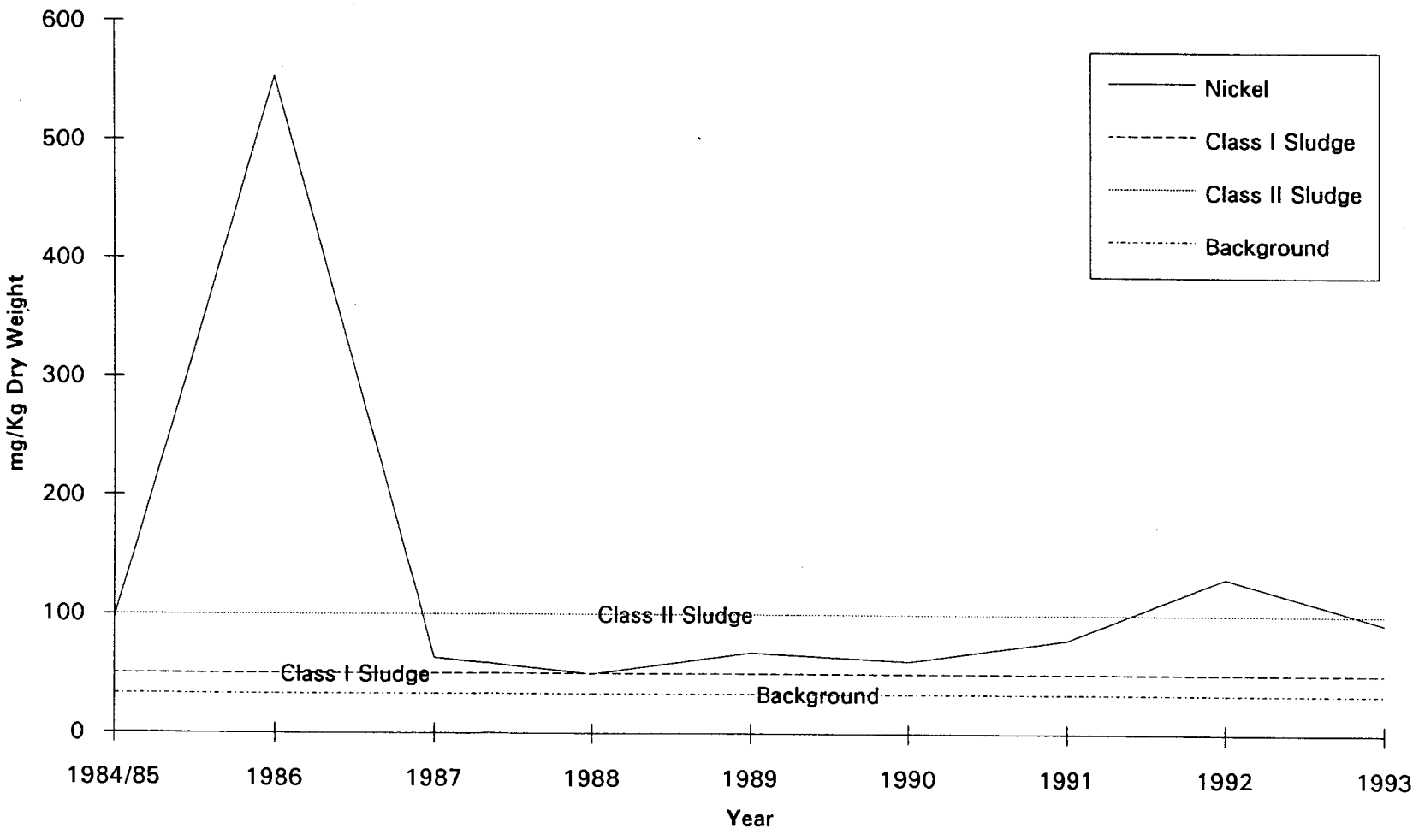
Average Copper Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



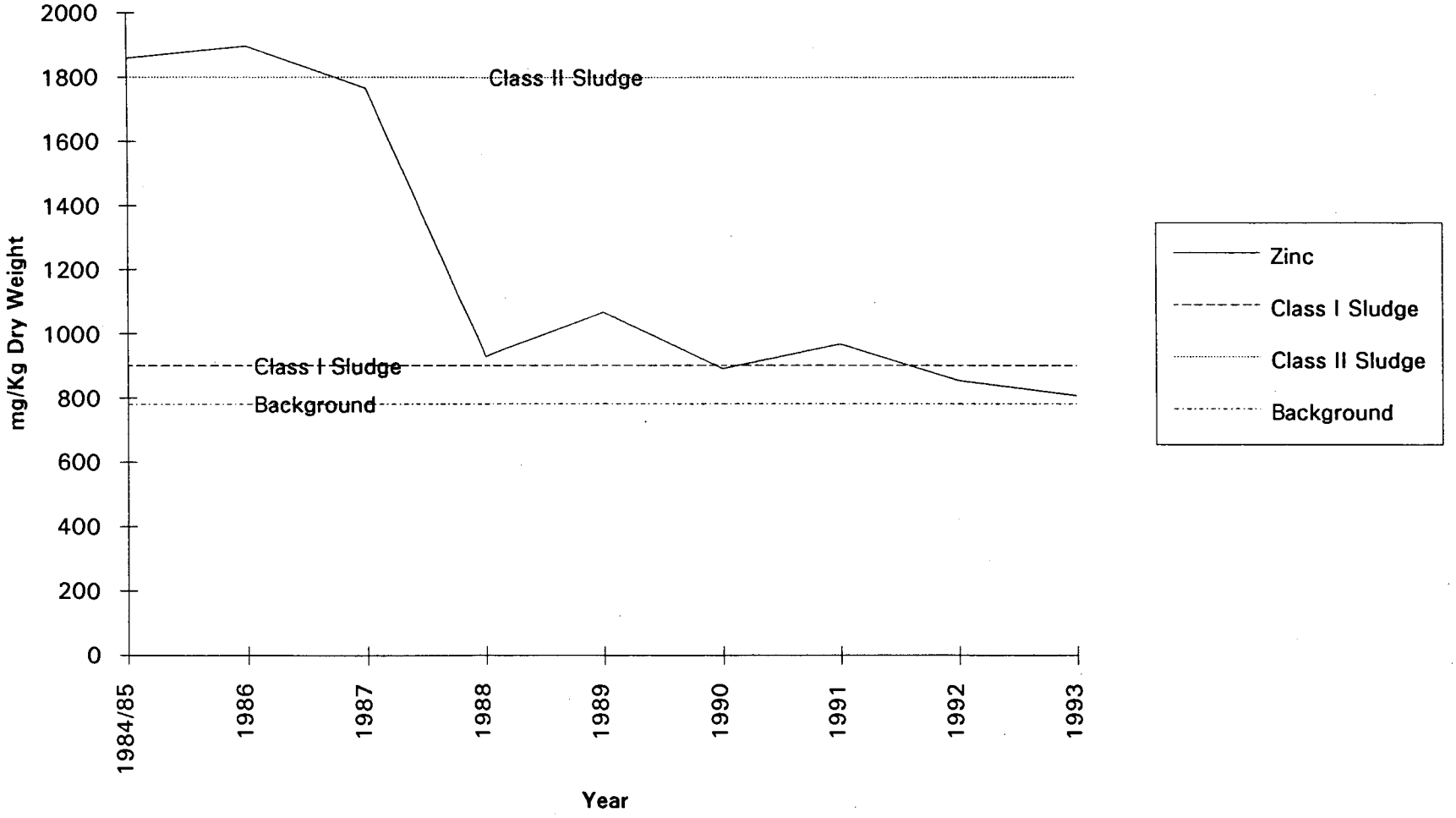
Average Lead Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



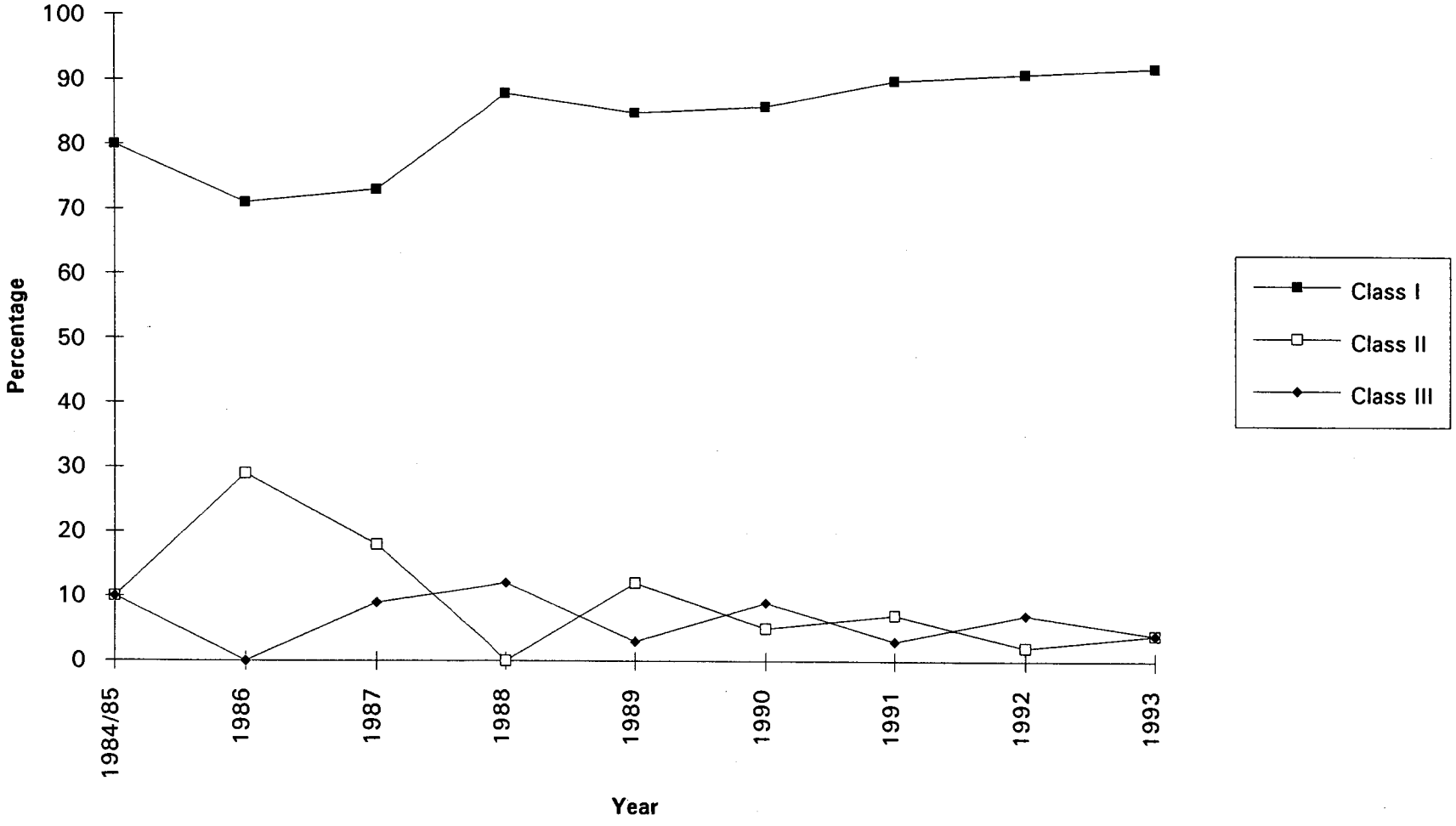
Average Nickel Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



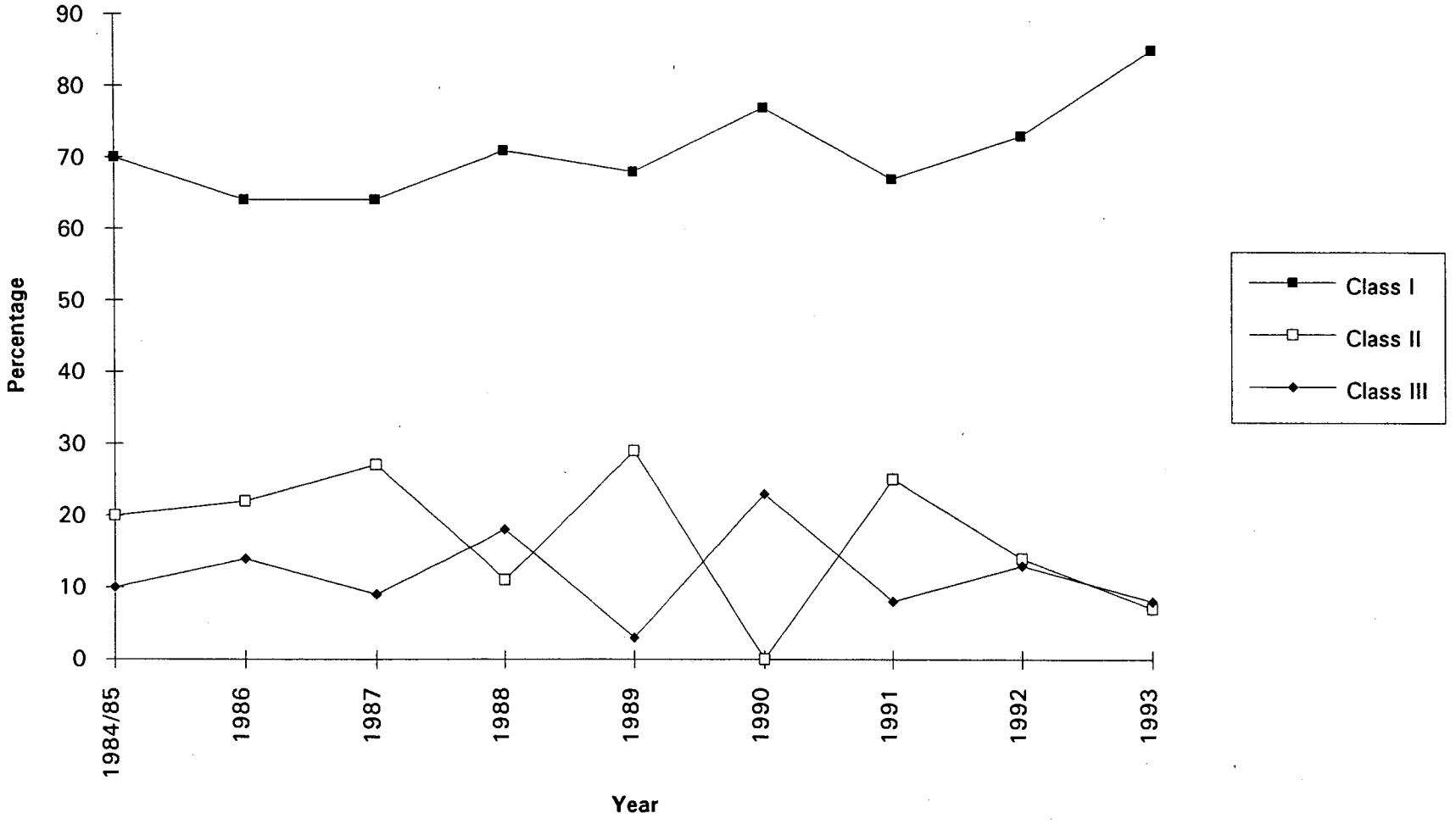
Average Zinc Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



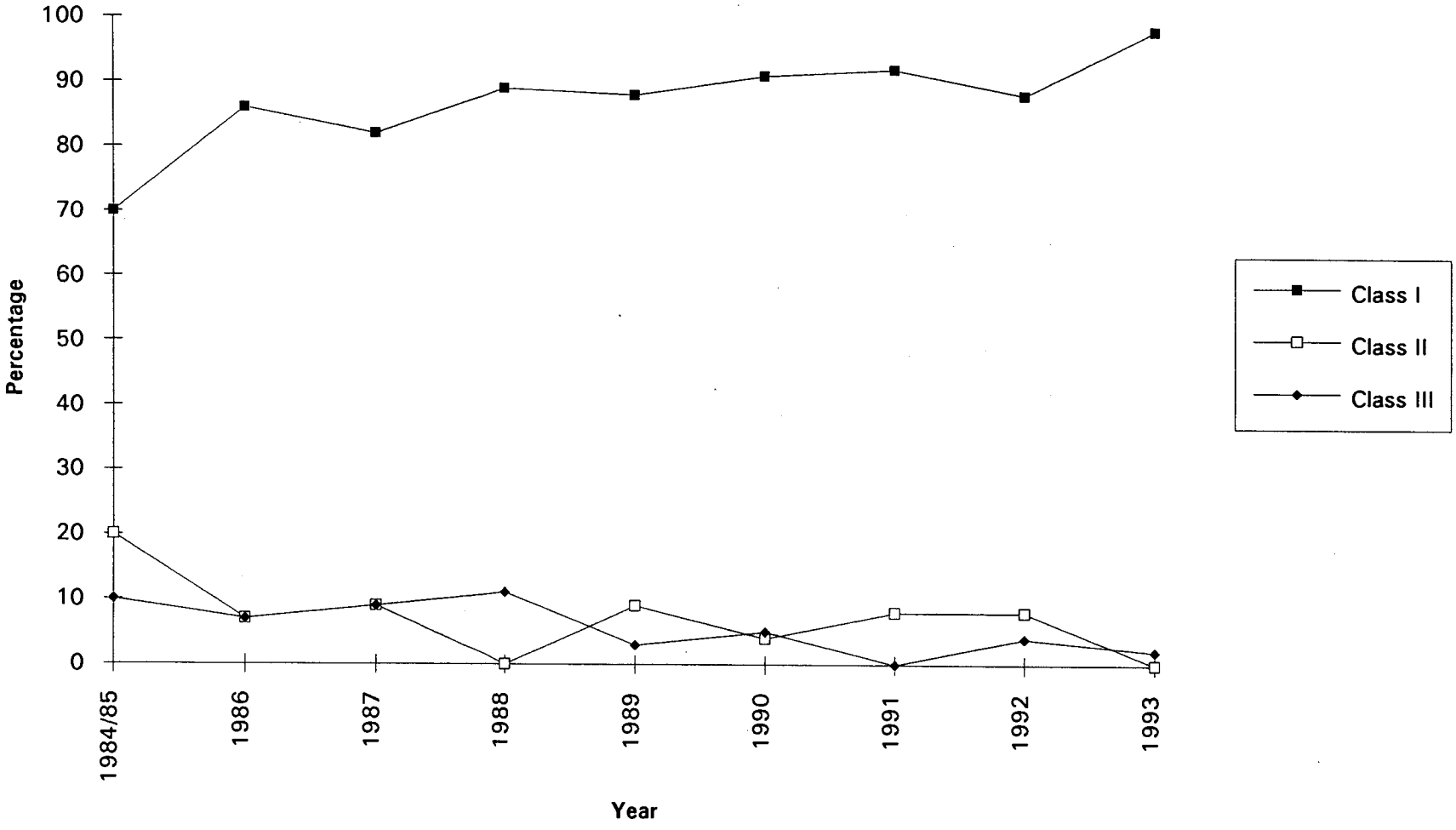
Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutant Cadmium



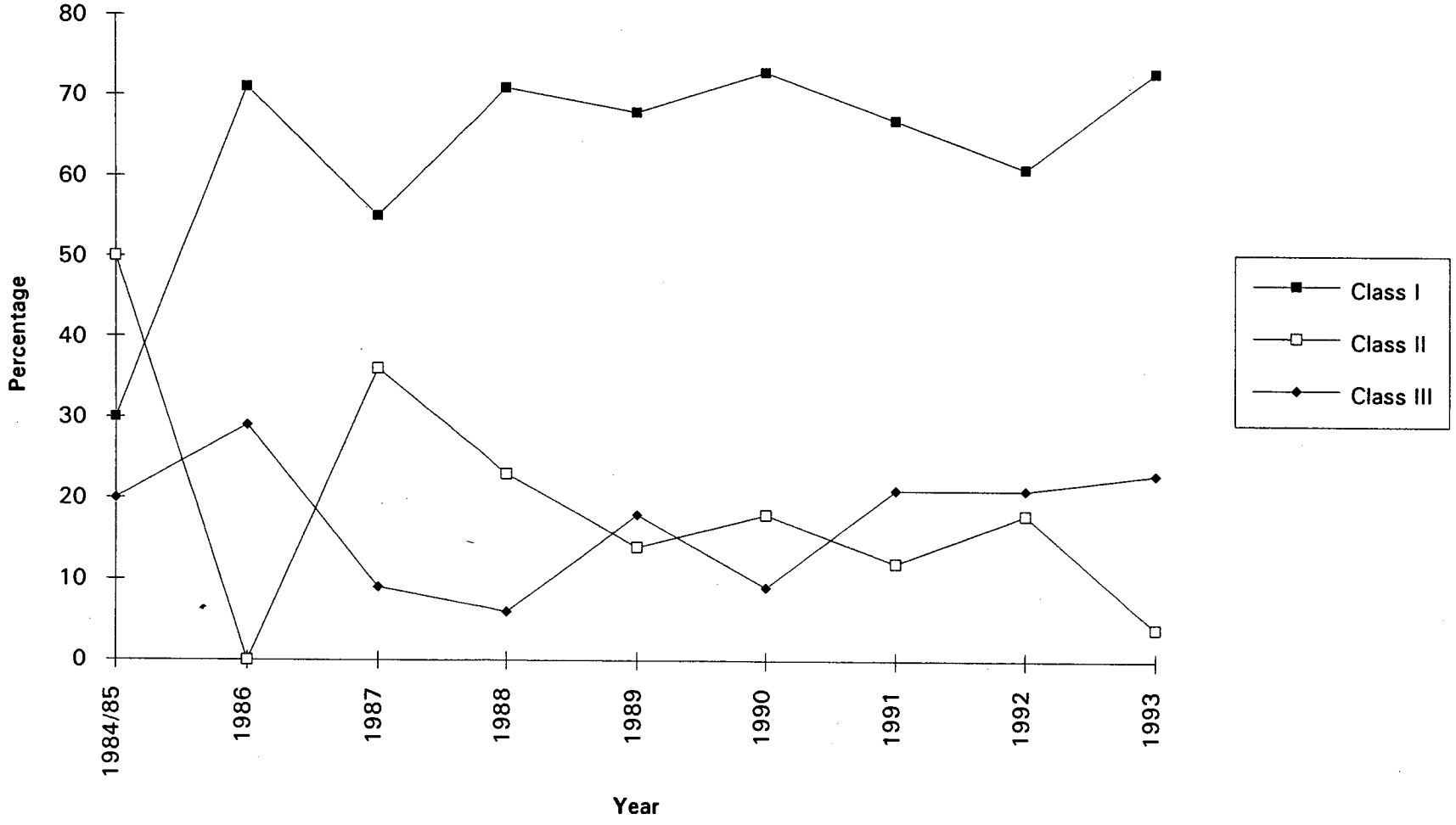
Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutant Copper



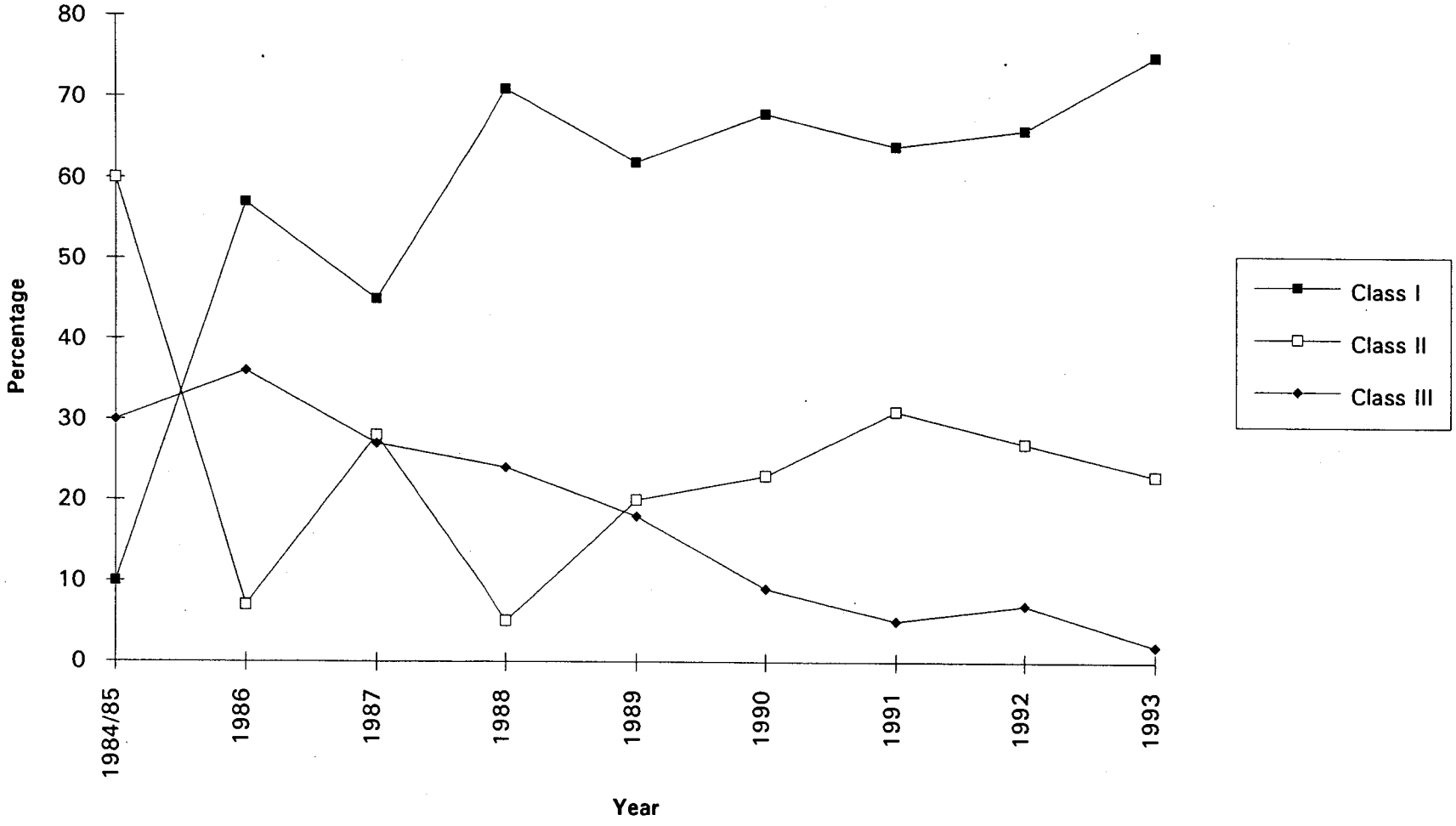
Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutant Lead



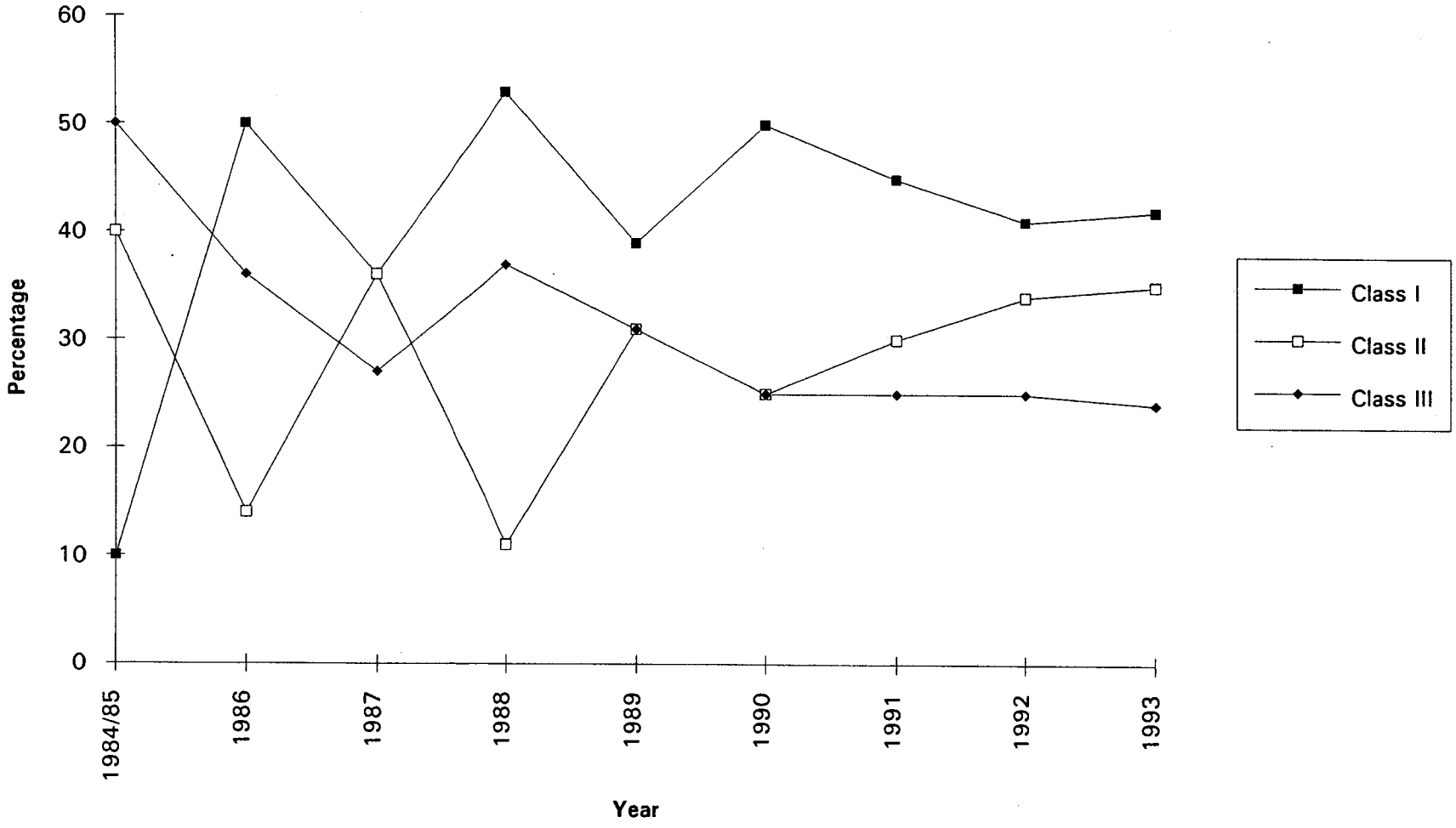
Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutant Nickel



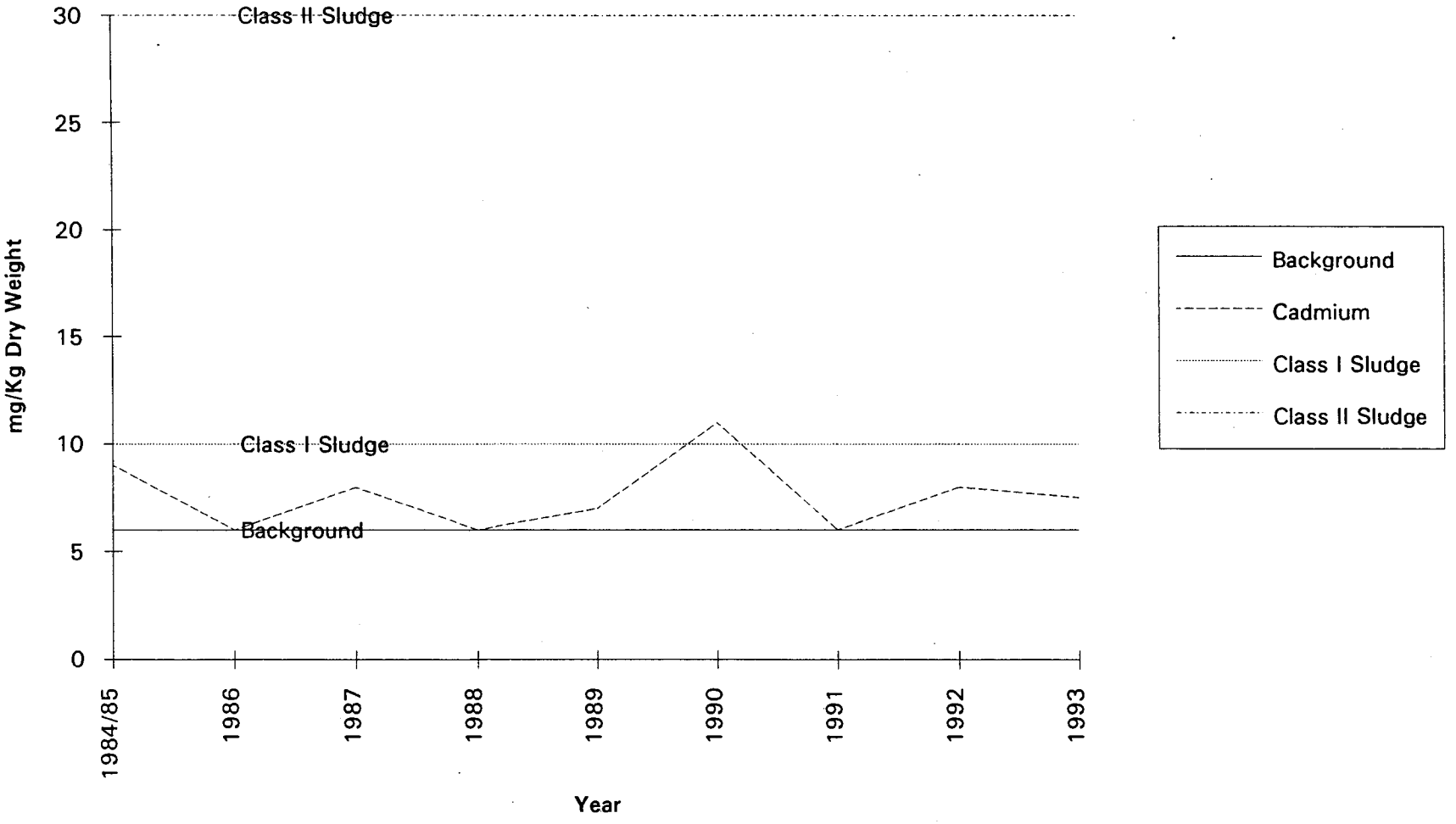
Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutant Zinc



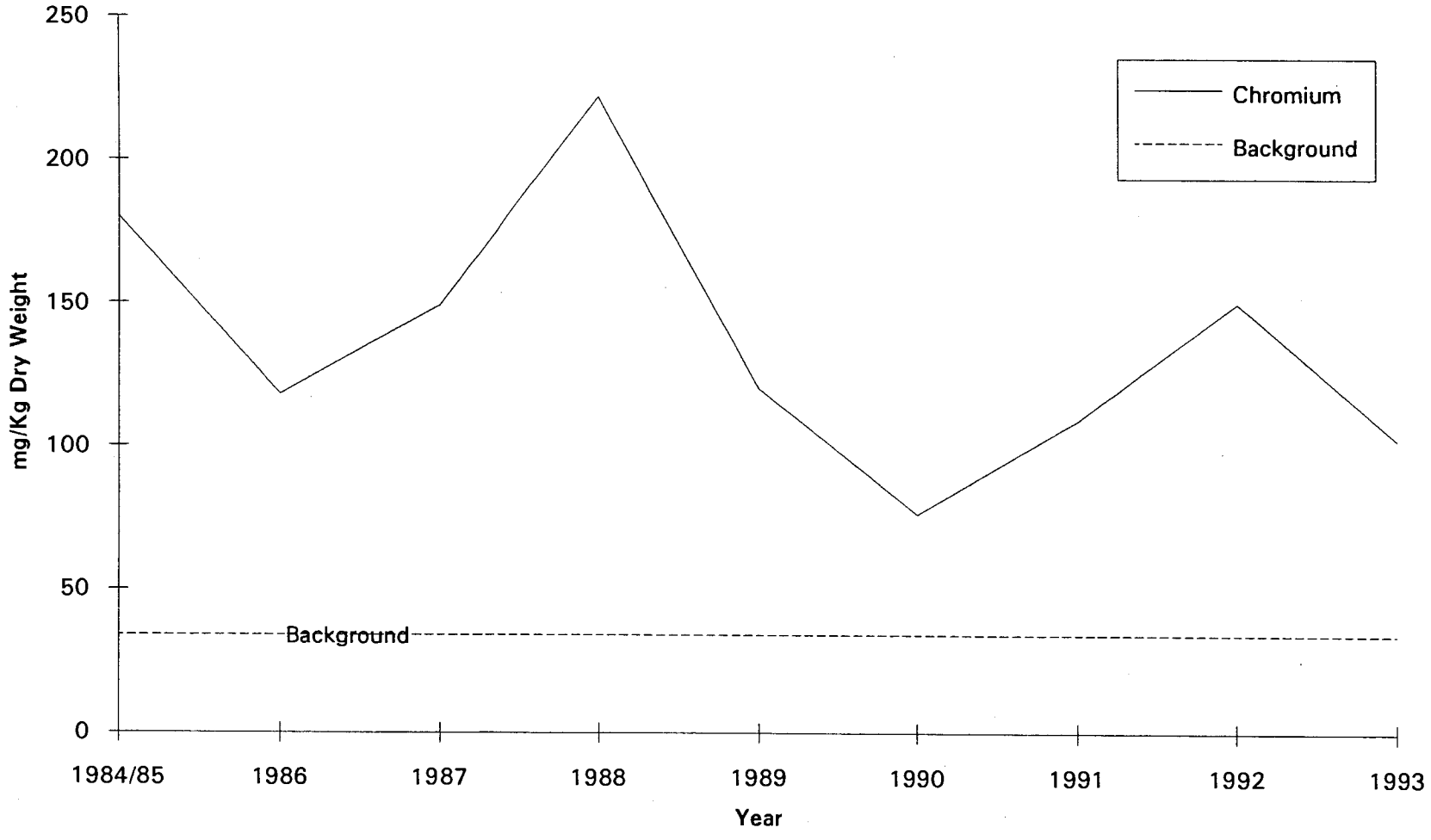
Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutants: Cadmium, Copper, Lead, Nickel And Zinc



Average Cadmium Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



Average Chromium Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



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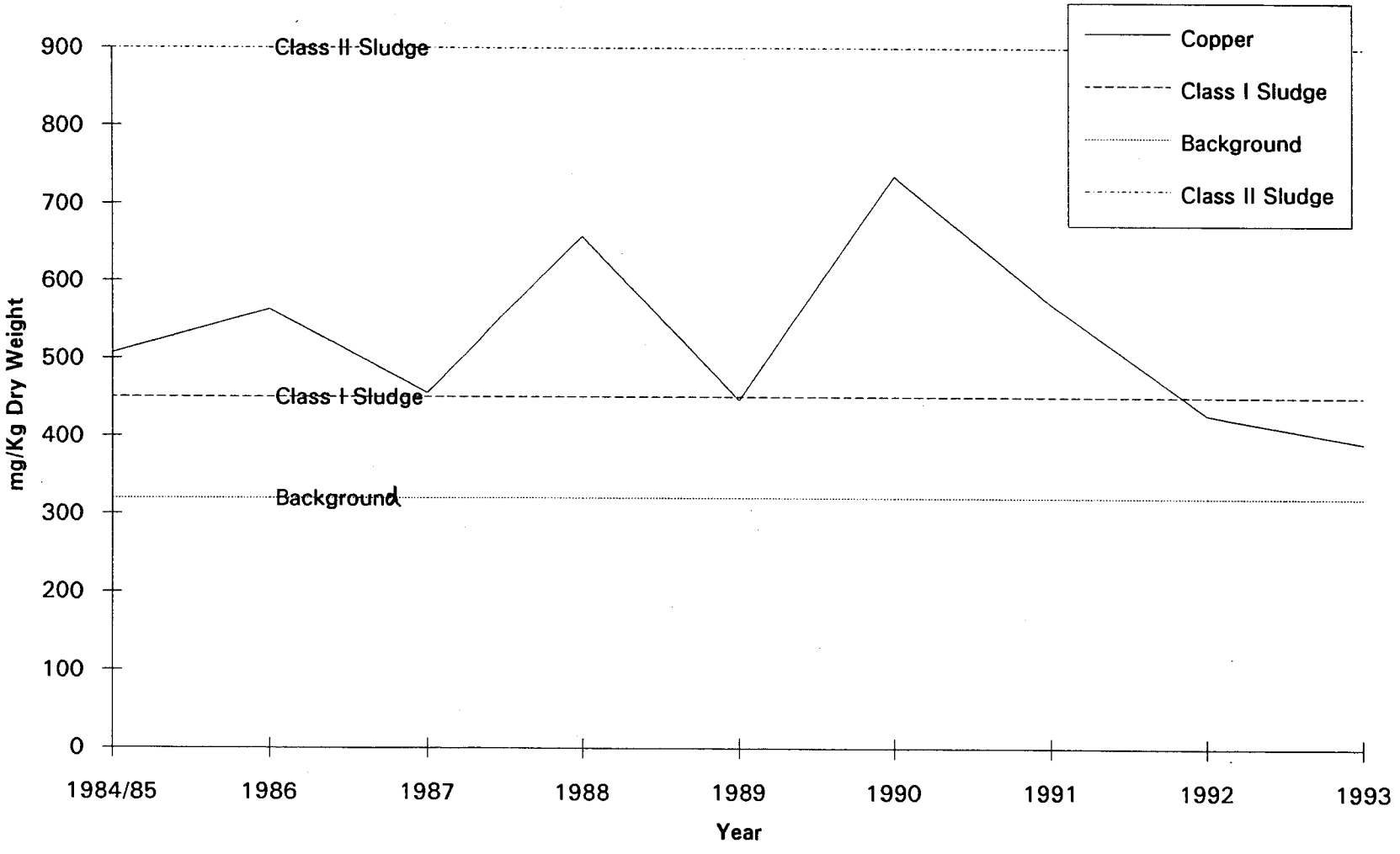
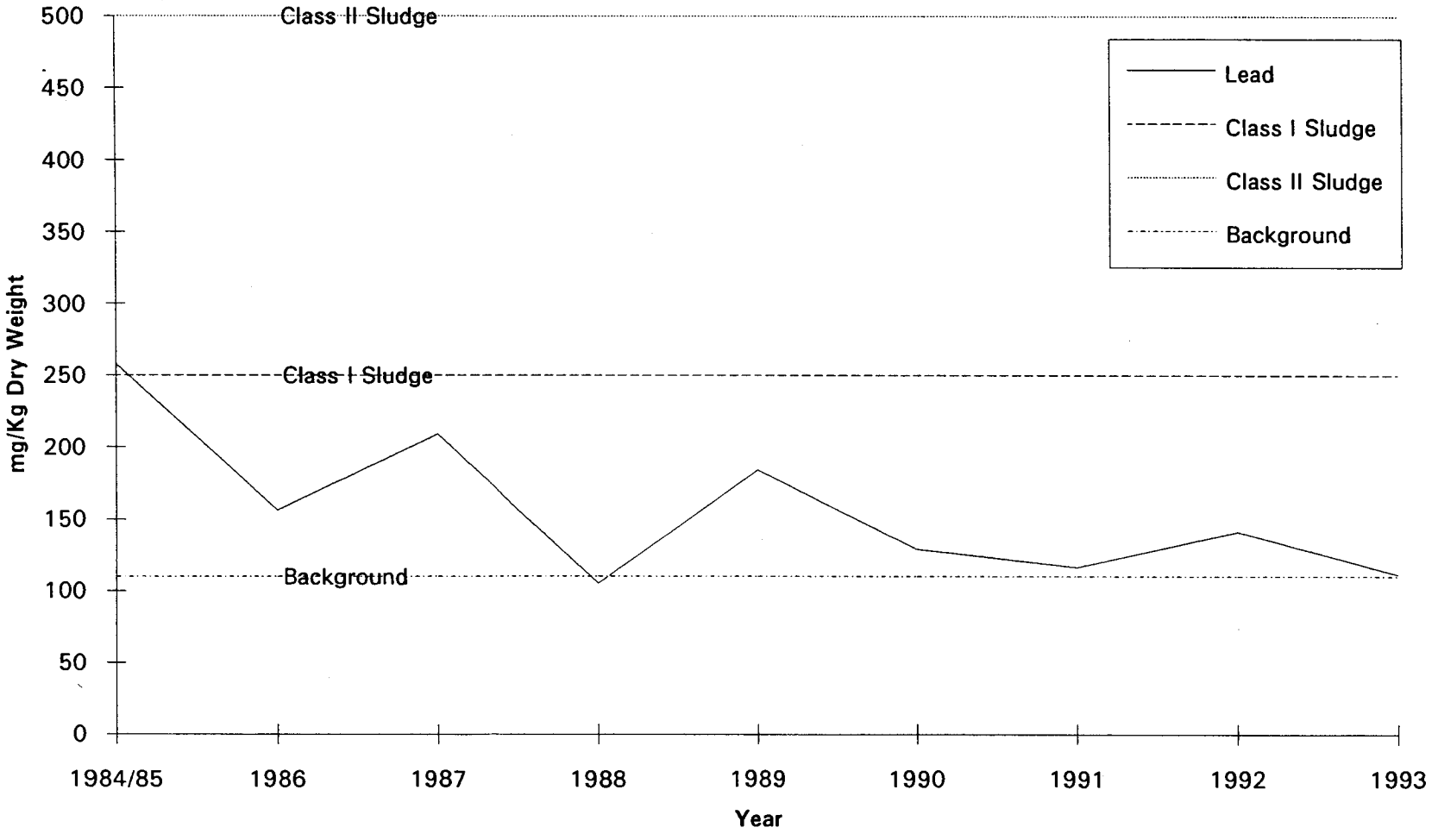
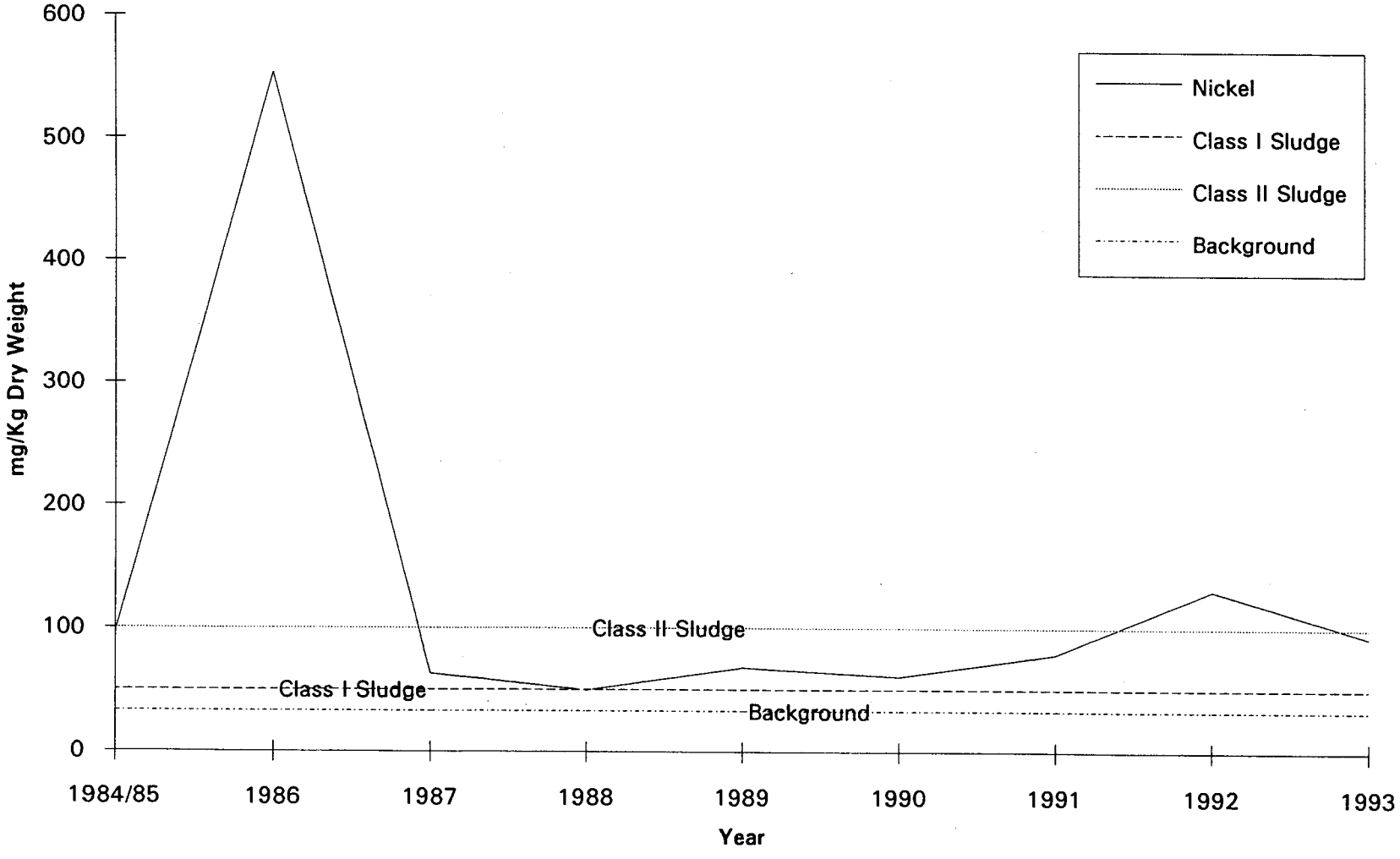


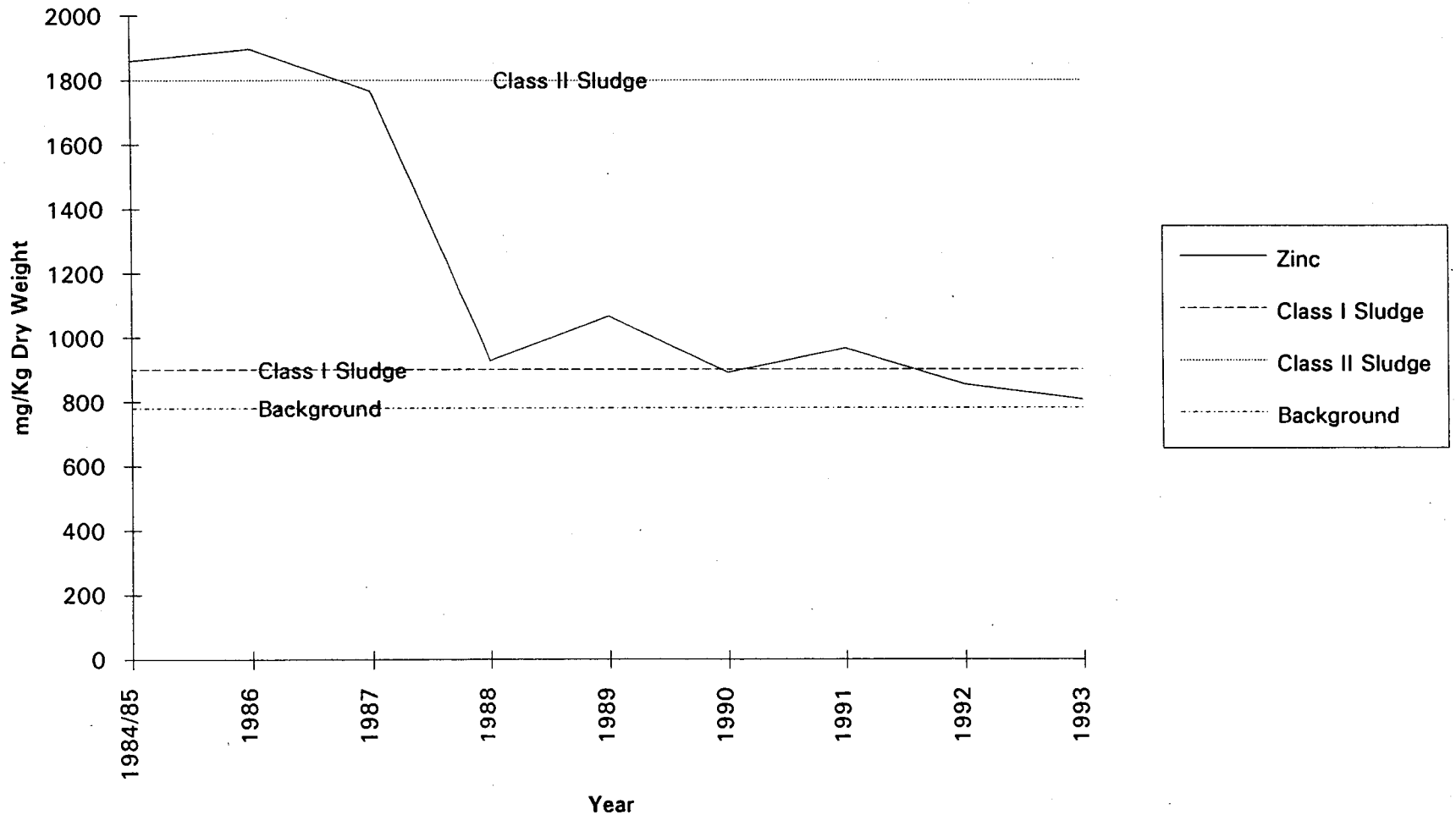
Average Lead Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



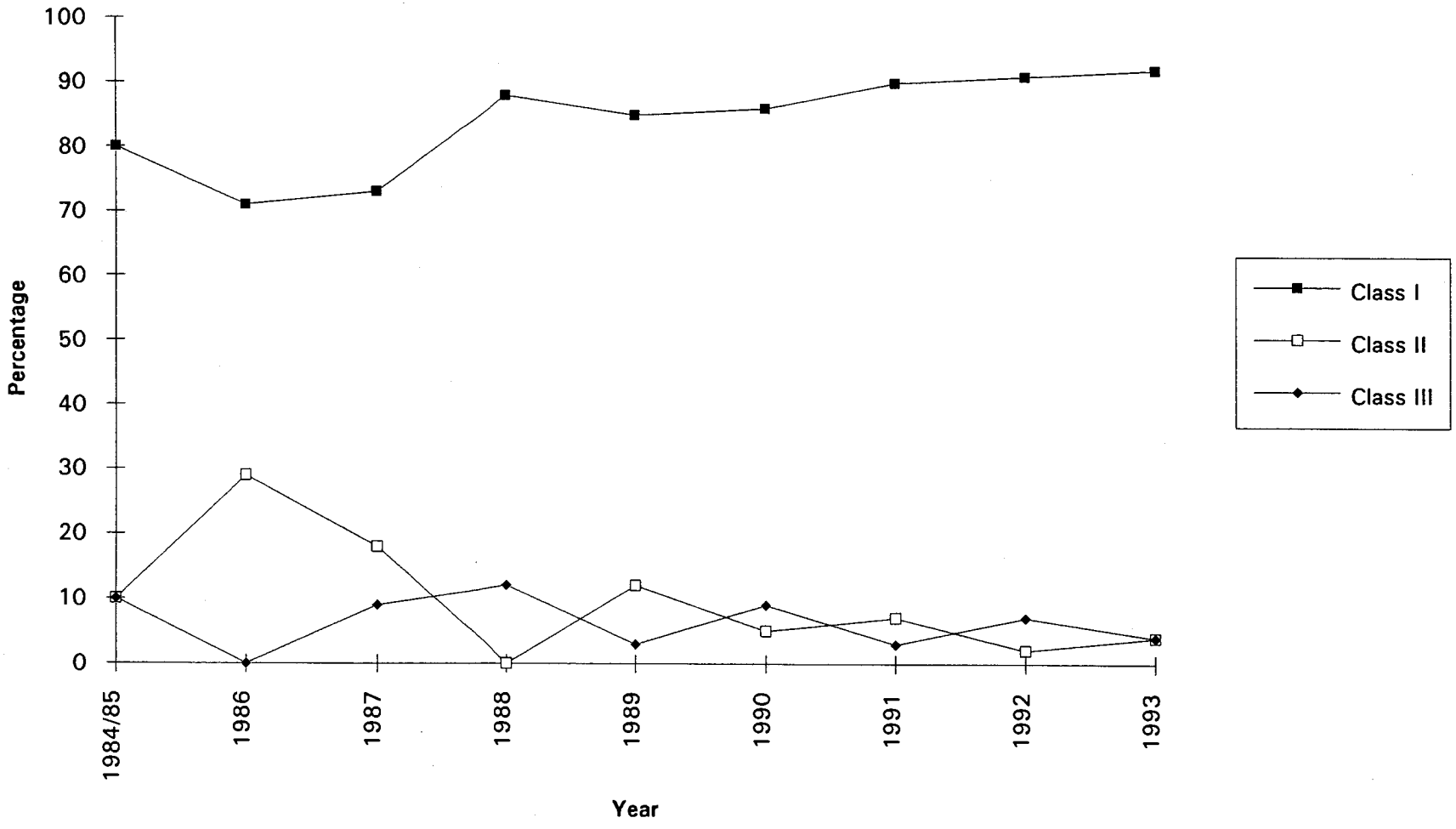
Average Nickel Concentration In Sludge For POTWs With Pretreatment Programs



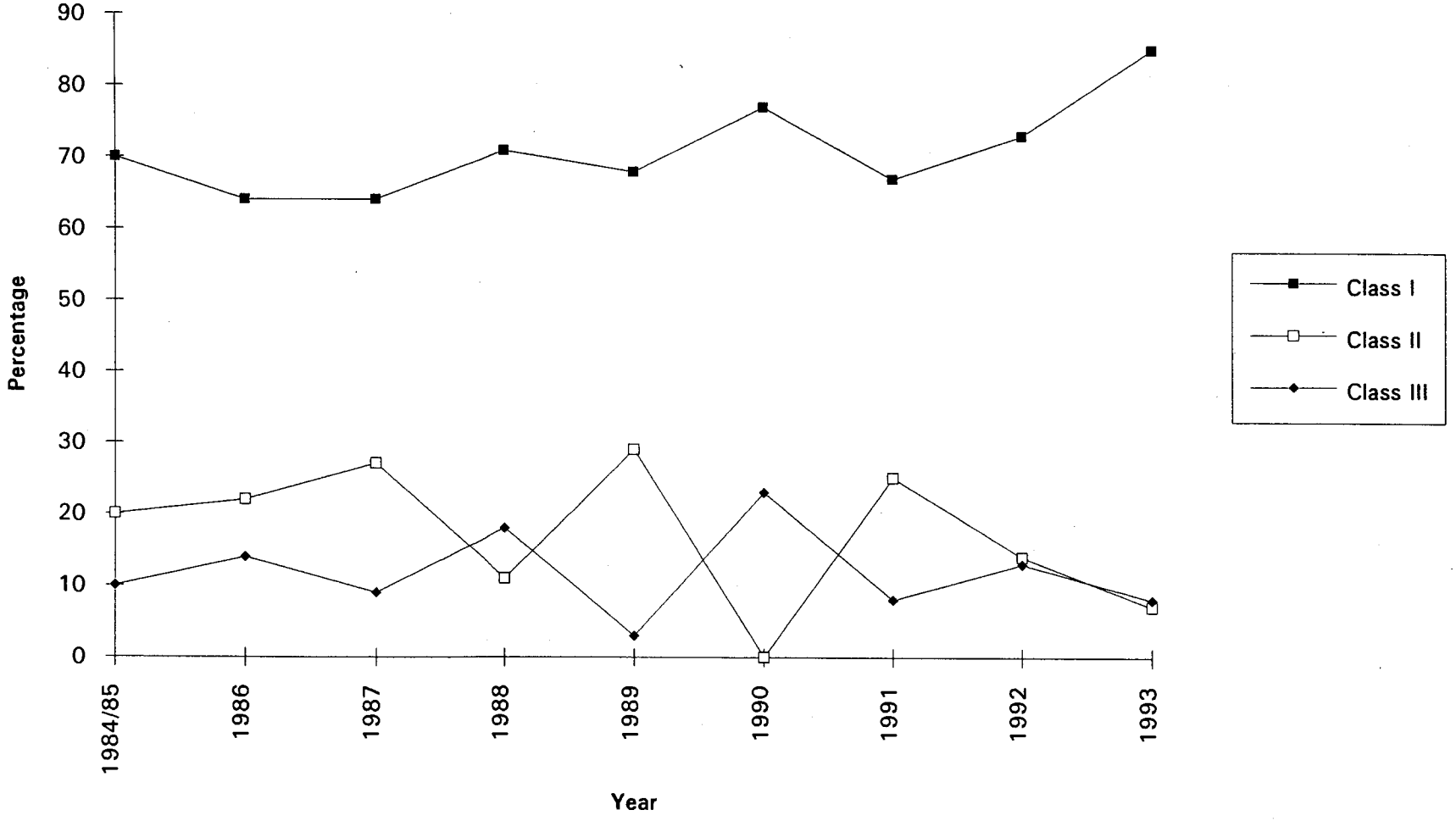
Average Zinc Concentration In Sludge For POTWs With Pretreatment Programs In Kentucky



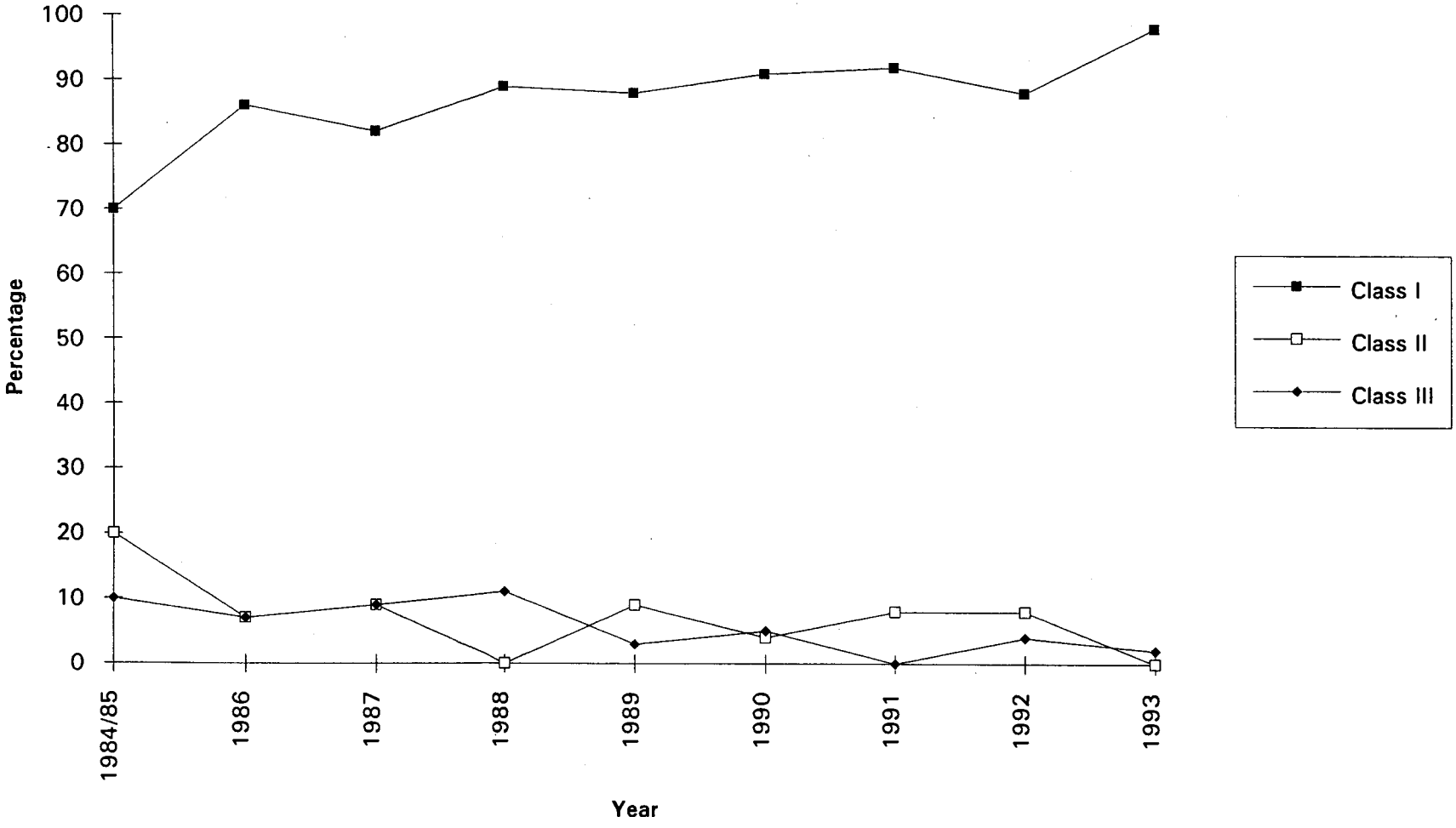
Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutant Cadmium



Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutant Copper



Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutant Lead



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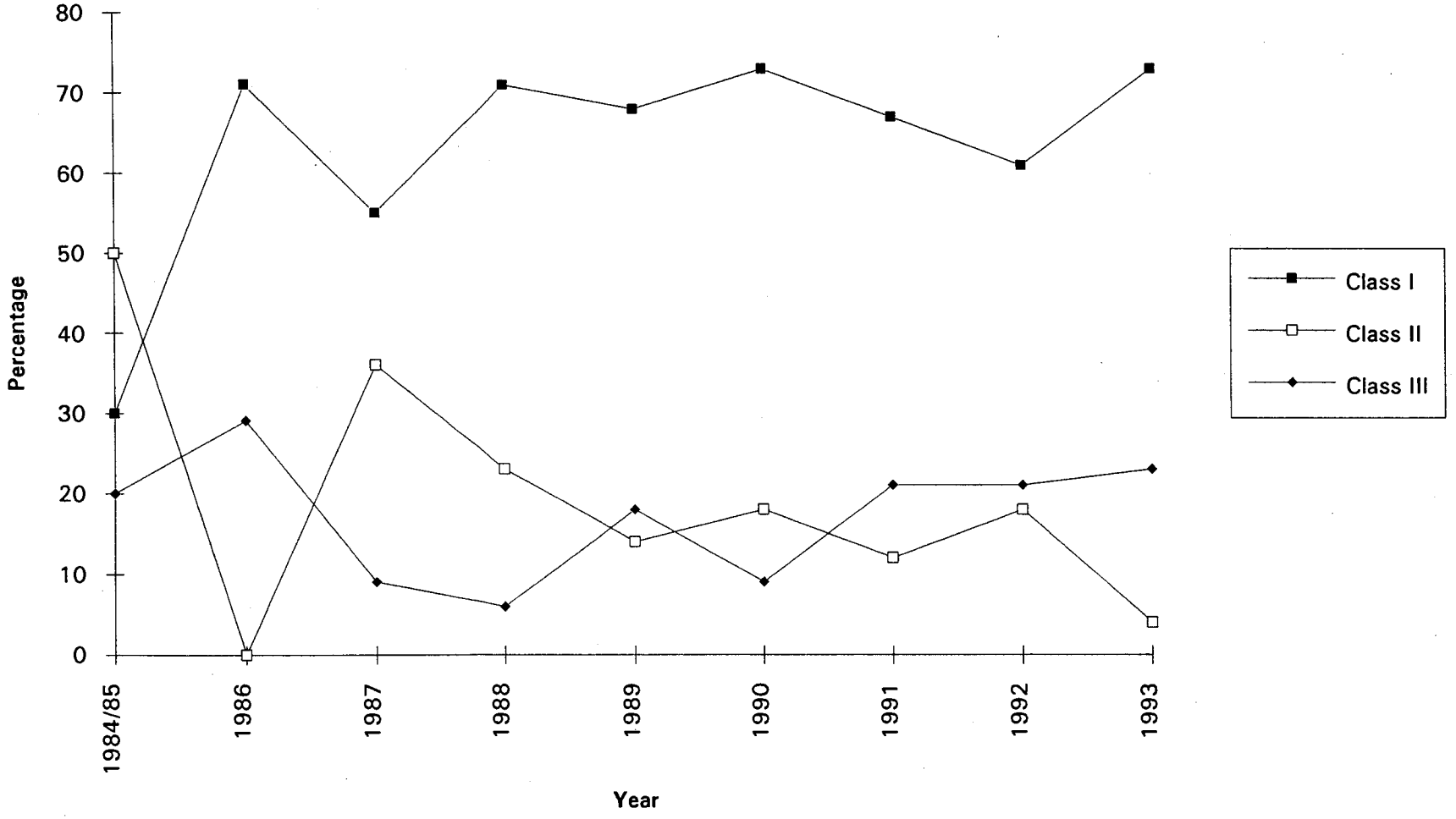

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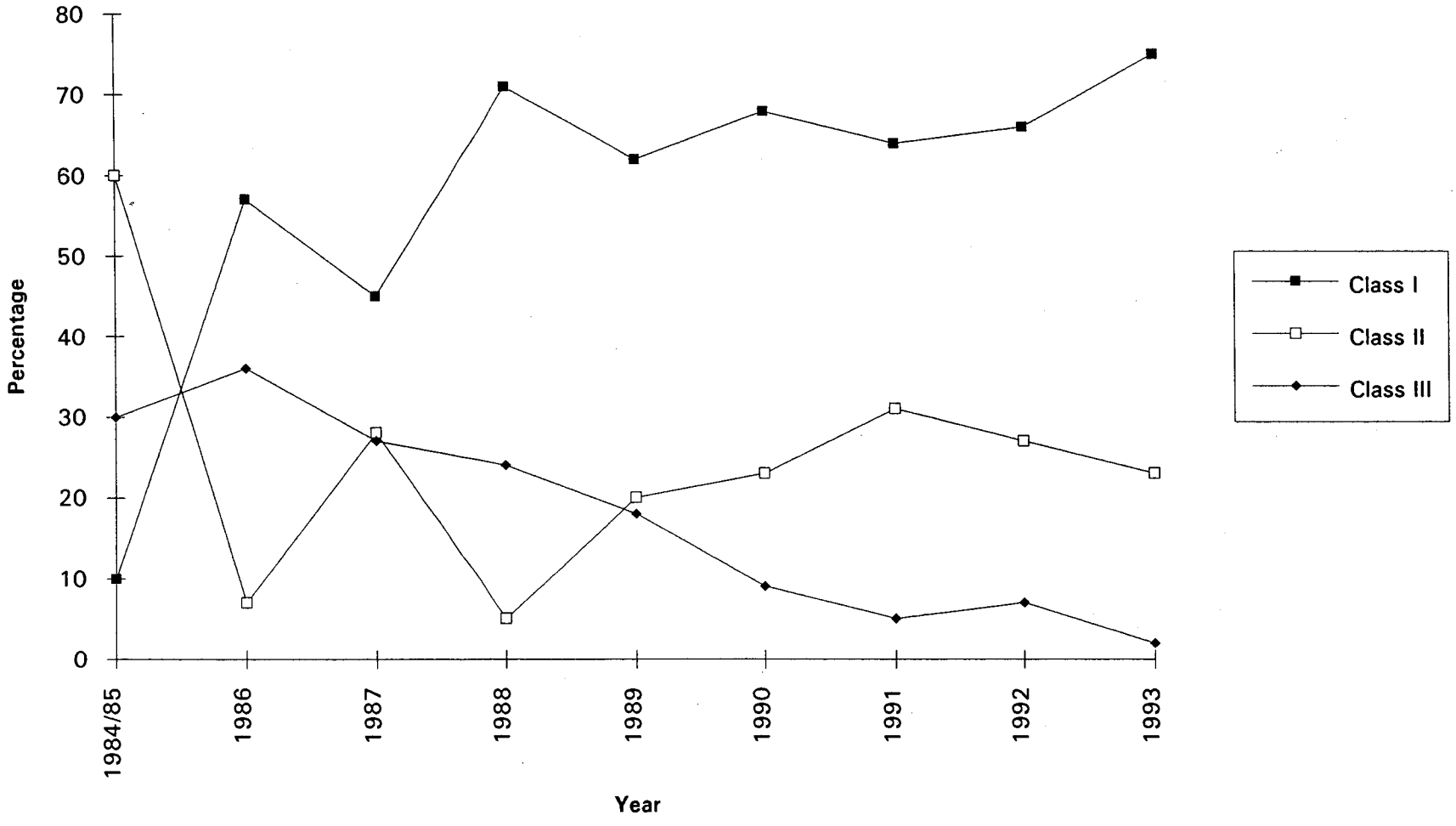

Pretreatment Programs Complying With The Various Sludge Classifications For The Pollutants: Cadmium, Copper, Lead, Nickel And Zinc