

Protecting Our Water Environment



Metropolitan Water Reclamation District of Greater Chicago

**RESEARCH AND DEVELOPMENT
DEPARTMENT**

REPORT NO. 2000-5

*STUDY OF ZINC CONCENTRATIONS IN
CALUMET WATER RECLAMATION PLANT DIGESTER DRAW*

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**STUDY OF ZINC CONCENTRATIONS IN
CALUMET WATER RECLAMATION PLANT DIGESTER DRAW**

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TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	ii
LIST OF FIGURES	v
ACKNOWLEDGMENT	vi
DISCLAIMER	vi
SUMMARY AND CONCLUSIONS	vii
INTRODUCTION	1
METHODOLOGY	5
Interceptor Samples	5
Flow Measurements	9
Industrial Waste Monitoring Data	9
RESULTS	10
Calumet WRP Raw Sewage and Final Effluent Zinc Data	10
Calumet WRP Digester Draw Zinc Data	10
Calumet WRP Interceptor Zinc Data	13
Known Industrial Waste Discharges	19
Zinc Mass Balance	22
1998 South Park Interceptor Sampling	25
1999 Zinc Data	28
APPENDIX I - Interim Report on Zinc Concentrations in Calumet WRP Digested Sludge Dated June 1998	AI-1
INTRODUCTION	AI-2
METHODOLOGY	AI-8

TABLE OF CONTENTS (Continued)

	<u>Page</u>
RESULTS	AI-15
ZINC MASS BALANCE	AI-37
1998 WORK	AI-42
SUMMARY	AI-43

LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
1	Average Monthly Zinc Concentration and Loading in the Calumet WRP Raw Sewage and Final Effluent During 1998	11
2	Average Monthly Zinc Concentration and Loading in the Calumet WRP Digester Draw During 1998	12
3	Estimated Calumet WRP Interceptor Zinc Loadings in 1998	20
4	Zinc Loading to the Calumet WRP from Industries Identified as Discharging More Than 100 lbs of Zinc/Yr.	21
5	Mass Balance of Zinc at the Calumet WRP - 1998	23
6	Zinc Concentrations in Various Sewers Tributary to the South Park Interceptors in August and November 1998	27
7	Calumet WRP Digester Draw Zinc Data - 1999	30

APPENDIX TABLES

1	Average Yearly Zinc Concentration and Loading in the Calumet WRP Raw Sewage Since Inception of the Part 503 Rule	AI-6
2	Average Monthly Zinc Concentration and Loading in the Calumet WRP Raw Sewage and Final Effluent During 1997	AI-16
3	Average Monthly Zinc Concentration and Loading in the Calumet Digester Draw Sludge During 1997	AI-17
4	Calumet WRP Interceptor Zinc Concentrations	AI-24
5	Calumet WRP Interceptor Zinc Loadings	AI-26
6	Zinc Concentrations Measured in Calumet WRP Process Recycle Streams	AI-30

LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
7	Zinc Loading to the Calumet Water Reclamation Plant From Industries Identified as Discharging More Than 100 Pounds Per Year of Zinc	AI-32
8	TARP Pumpback Zinc Concentration and Loading During 1997	AI-36
9	Mass Balance of Zinc at the Calumet WRP July Through December 1997	AI-38
10	Mass Balance of Sources of Zinc Entering the Calumet WRP	AI-40

LIST OF FIGURES

<u>Figure No.</u>		<u>Page No.</u>
1	Location of South Park Interceptor and Laterals Sampling Stations	7
2	South Park Interceptor Zinc Concentrations	15
3	Blue Island Interceptor Zinc Concentrations	16
4	Harvey Interceptor Zinc Concentrations	17
5	Low Level Interceptor Zinc Concentrations	18
6	Trend of Zinc Concentration in Calumet WRP Digester Feed and Draw Sludge During 1998	28

APPENDIX FIGURES

1	Trend of Zinc Concentration in Calumet Digester Draw Sludge Since Inception of the Part 503 Rule	AI-4
2	South Facility Area	AI-9
3	Calumet WRP Sewage Flow Schematic and Sampling Locations	AI-11
4	Calumet WRP Location Plan	AI-13
5	South Park Interceptor Zinc Concentrations	AI-19
6	Blue Island Interceptor Zinc Concentrations	AI-20
7	Harvey Interceptor Zinc Concentrations	AI-21
8	Low Level Interceptor Zinc Concentrations	AI-22
9	Calumet WRP Zinc Loading vs. Rainfall	AI-34

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Thanks are also due to Ms. Karen Vallos for typing the report.

DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

SUMMARY AND CONCLUSIONS

In late 1996 and early 1997 the concentration of zinc in the anaerobically digested sludge (digester draw) of the Calumet Water Reclamation Plant (WRP) was observed to increase, such that compliance with the United States Environmental Protection Agency (USEPA) Part 503 Rule was becoming a concern.

Based upon this observation, the Research and Development (R&D) Department undertook a detailed investigation to determine the possible causes for the elevated levels of zinc at the Calumet WRP. During 1997 and 1998, the following course of action was followed:

1. Review historical raw sewage and digester draw data from the Calumet WRP and other WRPs as needed.
2. Review laboratory analytical procedures.
3. Review the industrial waste monitoring database, and the current industrial waste sampling program.
4. Intensify industrial waste monitoring efforts.
5. Initiate new sampling programs in the four main interceptors serving the Calumet WRP.
6. Initiate new sampling programs in local sewers serving the Calumet WRP.
7. Study Calumet WRP recycle streams and other plant processes.

8. Examine non-point sources of zinc.
9. Attempt to develop a mass balance for zinc at the Calumet WRP.

In June 1998, an interim report on the project, describing the 1997 work, was prepared. The main findings of that report were as follows:

1. Zinc concentrations in Calumet WRP digester draw began to increase in late 1996. The exact cause of this was unknown.
2. The Calumet WRP was receiving a disproportionately high loading of zinc when compared to the North Side WRP which receives a similar volume of daily flow.
3. Based upon data from special samplers installed in the four main interceptors feeding the Calumet WRP, it is estimated that the average amount of zinc which entered the Calumet WRP in 1997 was 541 lbs/day.
4. It was possible to identify the sources of approximately 418 lbs/day (77.3 percent) of the influent zinc in 1997. The largest sources were:
 - a. Commercial and household - 166.7 lbs/day
 - b. Municipal drinking water supply - 142.3 lbs/day

- c. Known industries - 66.7 lbs/day
- d. TARP pumpback - 41.3 lbs/day
- 5. One hundred twenty-three lbs/day (22.7 percent) of the influent zinc has not been accounted for.
- 6. An examination of the interceptor sampling data indicated that the Harvey and Low Level interceptors were receiving "spike" inputs of zinc from unknown point sources.
- 7. As of December 1997, zinc concentrations in the Calumet WRP digester draw were still higher than desired Target Level (1691 mg/kg) established by the District.

In 1998, work intensified on the interceptor, local sewer, and industrial waste sampling programs in an attempt to locate any additional zinc dischargers. In addition, Calumet WRP operating data and zinc concentrations in the incoming sewage and digester draw were monitored as in 1997. During the course of the year, the frequency of zinc "spikes" in the Harvey and Low Level interceptors decreased considerably, but an increased frequency of zinc "spikes" were observed in the South Park interceptor. Although zinc concentration in the raw sewage and digester draw were decreasing on average, when compared against 1997 values, zinc concentrations in individual digester draw samples were still exceeding the Target Level as late as September 1998.

Based upon data collected in the intensified interceptor and local sewer sampling, two previously unidentified industrial dischargers were discovered to be discharging large quantities of zinc to the South Park interceptor. Enforcement actions were initiated in late 1998 to reduce these zinc discharges, and zinc concentrations in the digester draw at the Calumet WRP have been below the Target Level for all of 1999, averaging 1077 mg/kg.

This report describes the 1998 work on the project, as well as recapping some of the 1997 work. As of December 1999, all special sampling has ended, and we have returned to a standard monitoring routine for the zinc at the Calumet WRP.

It is suggested that anyone interested in getting a detailed understanding of the various investigations conducted as part of this study should first read the entire interim report contained in Appendix I prior to reading the main body of this report.

INTRODUCTION

On February 19, 1993, a final regulation entitled "The Standards for the Use or Disposal of Sewage Sludge" was published in the *Federal Register*. This regulation, commonly referred to as the Part 503 Rule, establishes requirements for the final use and disposal of biosolids. The Part 503 Rule establishes specific risk-based pollutant limits for various heavy metals found in biosolids. Biosolids that meet the most stringent requirements for metals and pathogens are classified as Exceptional Quality (EQ) biosolids, and are considered suitable for virtually unregulated use.

The Metropolitan Water Reclamation District of Greater Chicago (District) has established an organizational policy to have its final biosolids product quality as EQ biosolids. The R&D and M&O Departments continuously monitor biosolids quality to ensure that EQ requirements are met. In late 1996 and early 1997, it was observed that the concentration of zinc in the digester draw of the Calumet WRP was increasing, and approaching the previously established Target Level, thereby causing concern. Work conducted at the District, since the inception of the Part 503 Rule, resulted in the establishment of Target Levels for metals concentration in the digester draw from each WRP that will ensure that the final biosolids product meets Part 503 alternate pollutant limits (APL). For zinc, the APL for the final biosolids product is 2800 mg/kg

dry weight. The District has established a Target Level of 1691 mg/kg for zinc in the Calumet WRP digester draw to ensure that the APL of 2800 mg of zinc/kg in the final biosolids product is met. The 1997 average zinc concentration in the Calumet WRP digester draw was 1758 mg/kg.

Based upon the observation of the rising trend in the digester draw zinc concentration, the M&O Department requested that the R&D Department undertake a detailed investigation of the elevated concentrations of zinc at the Calumet WRP.

In June 1998, the R&D Department prepared a report entitled "Interim Report on Zinc Concentrations in Calumet WRP Digested Sludge" (Interim Report). That report presented a detailed account of the methodology employed in the analysis of zinc loadings and sources of zinc at the Calumet WRP during 1997. It also reviewed raw sewage, final effluent, and digester draw zinc data for the period of 1992 through 1997. The report concluded that during 1997 an estimated 541 lbs/day of zinc was entering the Calumet WRP. It also concluded that approximately 142.3 lbs of zinc/day came from the domestic drinking water, 66.7 lbs/day came from known industries, 41.3 lbs/day came from Tunnel and Reservoir Plan (TARP) pumpback, 1.0 lb/day came from external plant recycles, and 166.7 lbs/day came from commercial and household sources. The source of the remaining 123 lbs/day was unknown.

The entire Interim Report is attached in Appendix I.

Since zinc concentrates in the sewage solids, the concentration of zinc in the final biosolids product, on a dry weight basis, will be proportional to the concentration of zinc in the raw sewage. Thus, even a ten percent reduction in the zinc loadings to the Calumet WRP would be significant as the resultant zinc concentration in the digester draw would then be expected to meet the District's Target Level. For this reason, a continuing effort was made in 1998 to identify the unknown sources of zinc in the Calumet WRP service area, and to determine if reductions in these sources, or in the known sources, is possible. Specifically, additional industrial waste sampling was conducted throughout the Calumet WRP service area to identify additional point sources of zinc. The IWD also sampled smaller local sewers that feed the main interceptors in an attempt to isolate the areas that are contributing large loadings of zinc to the system. Attempts were also made to verify the estimated flows in the four main interceptors, so that a better mass balance on zinc could be calculated.

The purpose of this report is to present the new data collected in 1998, in conjunction with some of the data presented in the previous Interim Report, and document in a final report the R&D Department's effort in bringing the zinc content at the Calumet WRP under control.

In 1999, work shifted to more of a routine monitoring effort, and a small amount of 1999 zinc data is also presented

to illustrate the current status of zinc concentrations at the Calumet WRP.

METHODOLOGY

A detailed description of the Calumet WRP service area, major interceptors that carry the raw sewage flow to the Calumet WRP, types of samples collected in 1997 for the determination of zinc concentrations, and the analytical methodology used is presented in the Interim Report attached as Appendix I.

The same types of samples collected in 1997 were also collected in 1998. However, sampling of the interceptor sewers and some of the lateral sewers discharging into these interceptors was intensified in 1998 to better quantify the industrial sources of zinc.

Interceptor Samples

As indicated in the Interim Report (Appendix I), the IWD installed special 24-hour composite samplers in the four main interceptors serving the Calumet WRP on June 18, 1997. In addition, based upon data collected in 1998 (which is presented in this report), it became clear that the largest contribution of zinc to the Calumet WRP was coming from the South Park interceptor. Therefore, it was decided to install a series of automatic samplers at various locations on the South Park interceptor in an attempt to isolate point source inputs of zinc. As additional samples were collected, the automatic samplers were repositioned into smaller and smaller areas to narrow the search for unaccounted inputs of zinc.

The first set of automatic samplers were installed in January 1998 at the following locations (Figure 1):

1. Station Cl-3 located at the District's 95th Street Pump Station. The sampler at this station collected samples from an area from Interstate-94 east to the Pump Station and south to about 112th Street.
2. Station Cl-4 located in the woods near the 95th Street Pumping Station. The sampler at this station collected samples from the area east of the Calumet River.

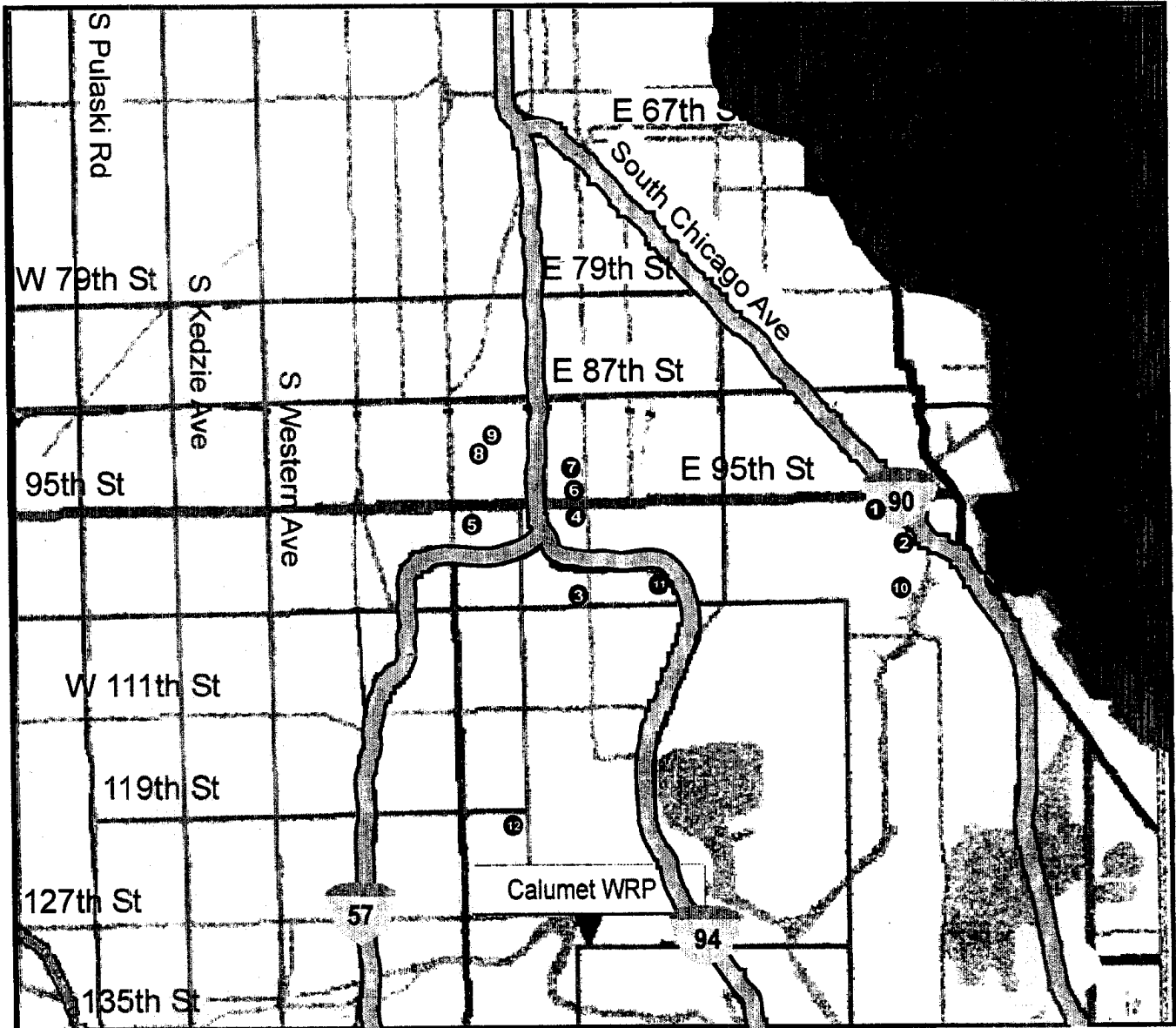
Based upon results from this first set of automatic samplers, a second set of automatic samplers were installed in July, August, and September 1998 at the following locations:

1. Station Cl-2 located at 102nd and Martin Luther King Dr. The sampler at this station collected samples from the area to the north and west of 102nd and Martin Luther King Dr.
2. Site Cl-2-L1 located at 97th and Calumet. This site isolated a 7'6" x 8'4" city sewer that services a large area to the west and north.
3. Site Cl-2-L2 located at 96th and Halsted. This site isolated two industries.

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FIGURE 1

LOCATION OF SOUTH PARK INTERCEPTOR AND LATERALS
SAMPLING STATIONS



Key:

- | | |
|---------------------|----------------------|
| 1 - Station C1-3 | 7 - Station C1-2-3 |
| 2 - Station C1-4 | 8 - Station C1-2-JA |
| 3 - Station C1-2 | 9 - Station C1-2-RE |
| 4 - Station C1-2-L1 | 10 - Station C1-3-LA |
| 5 - Station C1-2-L2 | 11 - Station C1-3-D |
| 6 - Station C1-2-1 | 12 - Station C1-1 |

4. Site Cl-2-1 located at 94th and Martin Luther King Dr. This site isolated two 3½' sewers that service an area to the west and north of this point.
5. Site Cl-2-3 located in Tuley Park. This site isolated an area north and east of this point.
6. Site Cl-2-JA located in a small city sewer outside an industry.
7. Site Cl-2-RE located in a city sewer outside another industry.
8. Site Cl-3-LA located at 99th and Manistee. This site isolated a large industrial discharger.
9. Site Cl-3-D located at 104th Street and Martin Luther King Dr. This site isolated all flows downstream of the 95th Street Pump Station.

Based upon data collected from the above sites, a final automatic sampler was installed at the end of September 1998 at the following location:

1. Site Cl-1 located at 125th and Wentworth. This site isolated an area to the west and north of 100th Street.

Sampling at all of the above sites continued for periods as short as three months to longer than a year, depending on the results.

Flow Measurements

During 1998, the Engineering and M&O Departments made numerous efforts to install, calibrate, and maintain flow meters in the four main interceptors entering the Calumet WRP (Locations 1A, 2A, 3A, and 4A in Figure 4 in Appendix I). It was hoped that this flow data, in conjunction with the chemical data, could be used to better estimate the actual zinc loading to the Calumet WRP.

Due to a variety of technical and logistical problems, it was not possible to successfully use these four flow meters, and thus no verified flow measurements for the four interceptors were made in 1998.

Industrial Waste Monitoring Data

The IWD conducts an extensive industrial waste monitoring program involving daily, weekly, monthly, and annual sampling at various industries depending upon their size and wastewater characteristics. Sampling results from 1993 through 1998 were reviewed to assess the amount of zinc discharged by industries in the Calumet WRP service area.

RESULTS

Calumet WRP Raw Sewage and Final Effluent Zinc Data

Table 1 presents 1998 monthly averages of Calumet WRP raw sewage and final effluent zinc concentrations and loadings. As can be seen, raw sewage zinc concentrations averaged 0.279 mg/L for 1998, equating to an average daily loading of 627 lbs/day. This figure includes TARP pumpback flows and internal plant recycles. Zinc concentration in the final effluent averaged 0.072 mg/L in 1998, which is equivalent to 171 lbs/day.

For comparison purposes, in 1997 raw sewage zinc concentrations averaged 0.493 mg/l, equating to an average daily loading of 1034 lbs/day. Thus, zinc loadings to the Calumet WRP decreased by approximately 40 percent from 1997 to 1998, as measured using the raw sewage sampler.

Calumet WRP Digester Draw Zinc Data

Table 2 presents 1998 monthly averages of zinc concentrations and mass (lbs/day) in the digester draw leaving the Calumet WRP digesters. As can be seen, the zinc concentration for 1998 averaged 1432 mg/kg dry weight, and equates to 228 lbs/day of zinc leaving the Calumet WRP in the anaerobically digested sludge.

As a check on this number, the average zinc loading in the digester feed for 1998 was 236 lbs/day.

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TABLE 1

AVERAGE MONTHLY ZINC CONCENTRATION AND LOADING IN THE CALUMET WRP
RAW SEWAGE AND FINAL EFFLUENT DURING 1998

Date	Daily Flow MGD	Calumet Raw Sewage		Calumet Final Outfall	
		mg Zn/L	lbs Zn/day	mg Zn/L	lbs Zn/day
January 1998	314	0.230	613	0.101	255
February 1998	306	0.207	528	0.099	242
March 1998	364	0.191	555	0.086	264
April 1998	343	0.241	678	0.085	243
May 1998	298	0.279	667	0.062	151
June 1998	281	0.441	1020	0.080	191
July 1998	234	0.418	822	0.077	149
August 1998	254	0.355	737	0.060	132
September 1998	228	0.201	378	0.047	88
October 1998	231	0.364	714	0.062	120
November 1998	238	0.205	405	0.056	113
December 1998	237	0.204	403	0.055	106
Mean	277	0.279	627	0.072	171

11

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 2

AVERAGE MONTHLY ZINC CONCENTRATION AND LOADING IN THE
CALUMET WRP DIGESTER DRAW SLUDGE DURING 1998

Date	Total Dry Tons Sludge Solids	Zinc Concentration mg Zn/dry Kg	Zinc Loading lbs Zn/day
January 1998	2091	1759	237
February 1998	2213	1459	231
March 1998	1791	1369	158
April 1998	2369	1306	206
May 1998	2689	1399	243
June 1998	2767	1394	257
July 1998	3102	1489	298
August 1998	2412	1820	283
September 1998	2398	1722	275
October 1998	2606	1319	222
November 1998	2268	1128	171
December 1998	2359	1016	155
Mean	2422	1432	228

For comparison purposes, the 1997 average zinc concentration in the digester draw was 1758 mg/kg, equating to 325 lbs/day of zinc leaving the Calumet WRP in 1997. Thus, zinc concentrations in the digester draw decreased by approximately 19 percent from 1997 to 1998.

As previously stated, the Part 503 Rule APL for zinc is 2800 mg/kg, which applies to the final sludge product. Based upon previous work, the District has set a Target Level of 1691 mg of zinc/kg in the digester draw at the Calumet WRP, as a goal to ensure that the final sludge product will meet the APL. As Table 2 indicates, Calumet WRP digester draw was below the 1691 mg/kg Target Level in 9 out of 12 months in 1998, and the yearly average for 1998 was also below the Target Level. This contrasts to 1997 when for only 6 out of 12 months the zinc concentrations were below the Target Level, and the yearly average exceeded the Target Level.

Calumet WRP Interceptor Zinc Data

As previously stated, in an effort to determine which parts of the Calumet WRP service area were contributing the most zinc to the raw sewage, the IWD installed and maintained 24-hour composite samplers in the four main interceptors entering the Calumet WRP. These samplers were positioned upstream of the introduction of TARP pumpback and plant recycles

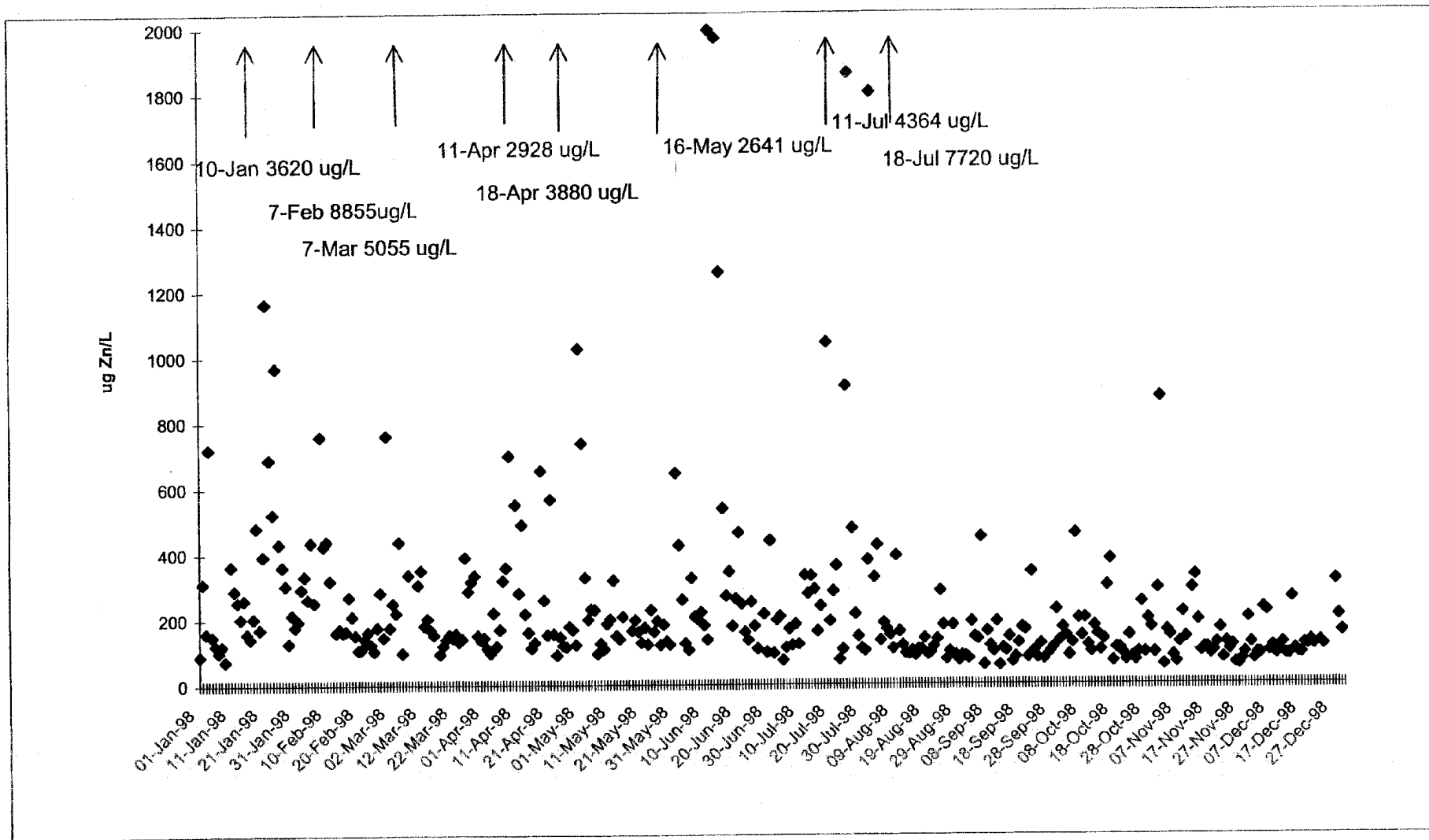
into the raw sewage, and thus are considered to more accurately represent the raw sewage entering the Calumet WRP on a daily basis.

Sample collection began on June 18, 1997, and continued throughout 1998. Figures 2 through 5 present the results of the 1998 sampling program for the South Park, Blue Island, Harvey, and Low Level interceptors, respectively. Each figure presents daily values for zinc concentration in the respective interceptors. As can be seen, zinc concentrations in the South Park interceptor were mostly in the 0.1-0.6 mg/L range. However, numerous values higher than 0.6 mg/l are evident. The Blue Island interceptor had the majority of data points in the 0.1-0.3 mg/L range for zinc. The Harvey interceptor had the majority of data points in the 0.1-0.6 mg/l range, with a few values higher than 0.6 mg/l occurring in October and November 1998. The Low Level interceptor had the majority of data points in the 0.1-0.4 mg/l range, with only three values above 0.6 mg/l.

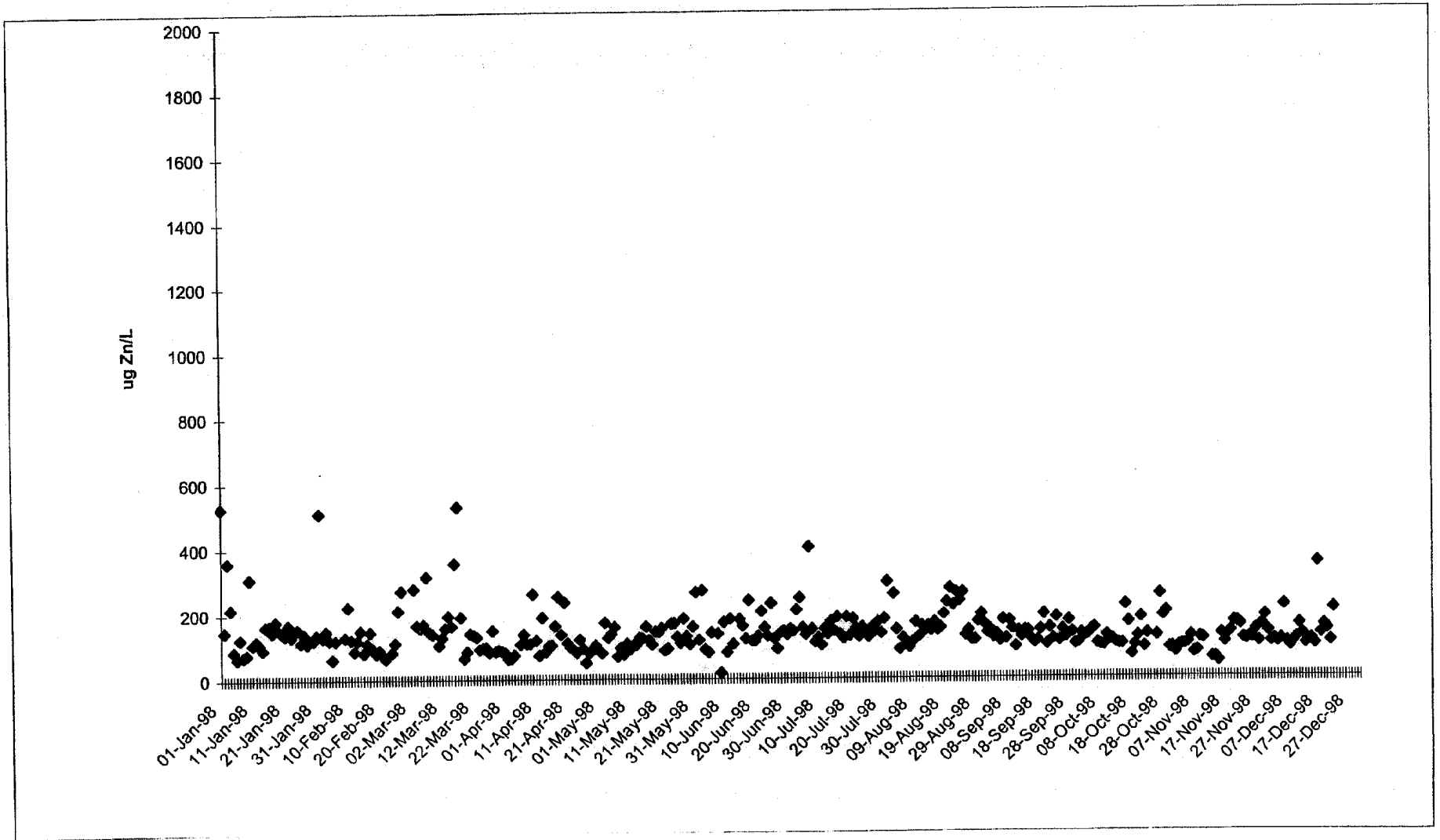
A comparison of the South Park interceptor data (Figure 2) with the other three interceptors (Figures 3 through 5) clearly indicates that the South Park interceptor was receiving "spike" inputs of zinc, well above expected background levels, in 1998.

Although attempts to measure the actual sewage flows in each interceptor, on a daily basis, were unsuccessful during 1998, the M&O Department previously made estimates of the

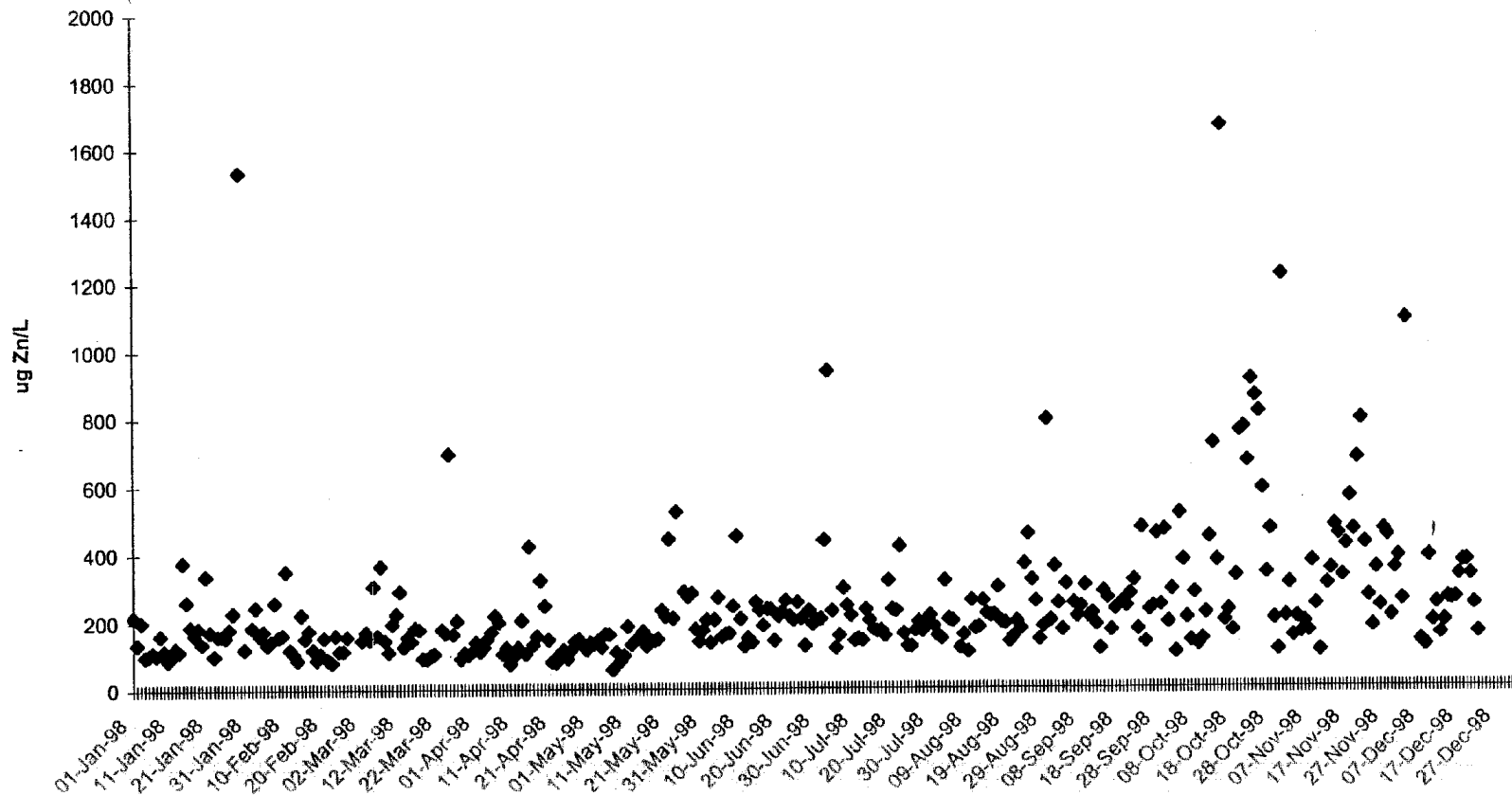
Metropolitan Water Reclamation District Of Greater Chicago
Figure 2
South Park Interceptor Zinc Concentrations



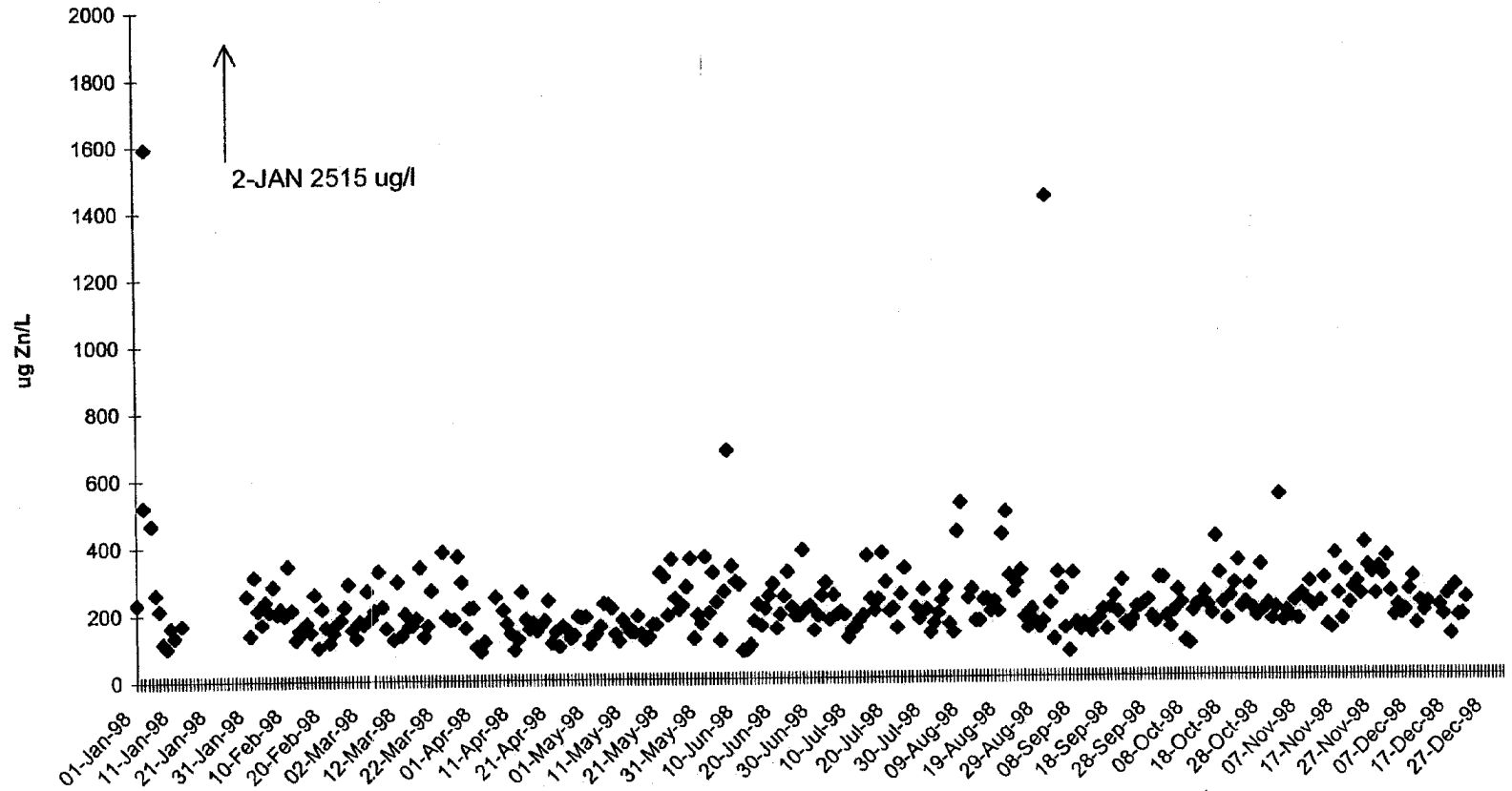
Metropolitan Water Reclamation District Of Greater Chicago
Figure 3
Blue Island Interceptor Zinc Concentrations



Metropolitan Water Reclamation District Of Greater Chicago
Figure 4
Harvey Interceptor Zinc Concentrations



Metropolitan Water Reclamation District Of Greater Chicago
Figure 5
Low Level Interceptor Zinc Concentrations



percentage of total WRP flow carried by each interceptor. Using these estimated percentages and the actual daily zinc concentrations measured in each interceptor as it enters the Calumet WRP, it is possible to estimate the zinc loading in lbs/day, carried in each of the four interceptors. This data is presented in Table 3. The total estimated zinc loading for 1998 is thus 491 lbs/day. For comparison purposes, the estimated zinc loading from the 1997 interceptor data was 500 lbs/day. However, if one takes the 1998 data for the same six-month period for which the 1997 data were collected, the 1998 zinc loading was 386 lbs/day, representing a 23 percent decrease from the same period in 1997.

As can be seen, the South Park interceptor carried almost 60 percent of the total zinc loading to the Calumet WRP in 1998. This, along with the evidence of zinc "spikes" in Figure 2, is why so much effort was placed on additional sampling along the length of the South Park interceptor.

Known Industrial Waste Discharges

The District's IWD conducts an intensive monitoring program of industrial waste dischargers in Cook County. Table 4 presents yearly data for 1993 through 1998 of the largest known zinc dischargers in the Calumet WRP service area. As can be seen, total zinc discharged for 1998 was 19,403 pounds, which is equivalent to 53.1 lbs of zinc/day, based upon 365

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

ESTIMATED CALUMET WRP INTERCEPTOR
ZINC LOADINGS IN 1998

Interceptor	Zinc (lbs/day)		
	Min.	Mean	Max.
South Park	39	294	6309
Blue Island	13	78	281
Harvey	20	55	64
Low Level	14	64	655
Total		491	

Note: Only days on which samples from all four interceptors were collected are used in the calculations.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

ZINC LOADING TO THE CALUMET WRP FROM INDUSTRIES IDENTIFIED
AS DISCHARGING MORE THAN 100 LBS OF ZINC/YR

User No.	Industrial User	1993 Zinc Loading (pounds)	1994 Zinc Loading (pounds)	1995 Zinc Loading (pounds)	1996 Zinc Loading (pounds)	1997 Zinc Loading (pounds)	1998 Zinc Loading (pounds)
11031	Riverdale Plating	632	678	705	784	703	912
13603	Chicago Specialties Inc.	1,258	853	609	1,045	637	492
12253	Acme Steel - Riverdale	8,644	3,278	126	260	5,777	3,664
11535	Allied Tube and Conduit	1,261	2,889	1,601	3,229	2,318	1,408
10208	LTV Steel Company	1,132	1,101	523	998	524	676
24943	F S C Paper Corp.	11,834	7,757	9,081	8,304	6,301	4,295
13389	Ford Motor Company	2,218	1,446	1,086	842	579	566
13330	Chicago Finished Metals	556	348	59	33	32	25
14999	Allwaste Tank Cleaning	150	210	315	113	146	43
12114	CID Recycling & Disposal	66	85	167	156	132	101
11058	Carl Buddig Foods	219	137	175	188	150	229
10142	Clean Harbors Services	1,064	455	886	1,157	549	603
13228	Dynagel Inc.	330	162	132	151	348	158
13434	General Mills	146	172	502	467	199	NA
10210	Sherwin Williams	77	56	272	382	64	NA
10918	Witco Chemical	117	108	59	116	119	41
13513	Ashland Chemical	NA	NA	NA	NA	156	68
24955	JLM Chemical	NA	NA	NA	NA	316	532
10182	PVS Chemicals	NA	NA	NA	NA	3,056	2,888
13468	Clark Refining	NA	NA	NA	NA	545	818
12254	Acme Steel - Chicago Plant	NA	NA	NA	NA	801	1,231
25044	Wisconsin Tissue Mills	NA	NA	NA	NA	788	570
10988	Andrew Corporation	NA	NA	NA	NA	111	83
	TOTALS:	29,704	19,735	16,298	18,225	24,351	19,403

NA = No analysis.

days per year. This is approximately a 20 percent decrease from 1997.

There are numerous smaller industrial dischargers of zinc (<100 lbs/year), but they do not add significantly to the total amount of industrial zinc discharged.

Zinc Mass Balance

In the Interim Report contained in Appendix I an attempt was made to develop a mass balance for zinc entering and leaving the Calumet WRP in 1997. This mass balance concluded that out of a total of 541 lbs of zinc/day entering the Calumet WRP, the source(s) of 123 lbs/day was unknown. This led to the recommendation to intensify interceptor sampling in 1998 to try to locate unknown sources of zinc.

Using the same methodology as described in the Interim Report, an attempt was made to develop a zinc mass balance for 1998.

Table 5 presents the results of the 1998 mass balance. There are two estimates for the amount of zinc entering the Calumet WRP. The first is derived from the raw sewage composite sample multiplied by the total raw sewage flow. This value is 627 lbs/day (Table 1, column 4). The second is based upon the sum of the TARP pumpback zinc loading, which is calculated from a measured flow and a measured zinc concentration, and the interceptor loading, which is calculated from an estimated flow and a measured zinc concentration. This total

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

MASS BALANCE OF ZINC AT THE CALUMET WRP - 1998

Raw Sewage Composite Sample* lbs Zinc/day	TARP Pumpback lbs Zinc/day	Four Main Interceptors lbs Zinc/day	Final Effluent lbs Zinc/day	Digester Draw lbs Zinc/day
627	50	491	171	228

*Includes TARP pumpback and plant recycles.

zinc loading is 541 lbs/day (Table 5, columns 2 and 3). We believe that this latter calculation is more representative of the actual loading to the Calumet WRP, as will be discussed later.

The amount of zinc leaving the Calumet WRP can be approximated as the zinc in the final effluent and the zinc in the digester draw. This value is 399 lbs/day (Table 1, column 6 and Table 2, column 4).

Based upon discussions with various R&D and M&O Department personnel, it is believed that final effluent and digester draw data are the most representative and reliable of those mentioned. Therefore, it is concluded that if 399 lbs of zinc/day is leaving the Calumet WRP via the final effluent and digester draw, approximately 399 lbs of zinc/day should be entering the Calumet WRP. From this it is postulated that the interceptor and TARP sampling is giving a better representation of the zinc loading to the Calumet WRP than the raw sewage composite sampler, and that the zinc loading to the Calumet WRP for 1998 should average somewhere between 399 and 541 lbs/day. It is believed that some of the discrepancy in these two numbers is due to the fact that only estimates and not actual flow rates are available for each of the four interceptors on a daily basis.

1998 South Park Interceptor Sampling

As stated previously, zinc concentration data from the South Park interceptor indicated that "spikes" of zinc were being discharged somewhere in the service area of this interceptor. In addition, an examination of the zinc loading data to the Calumet WRP continued to indicate that some unknown point source(s) of zinc might exist in the Calumet WRP service area. Thus, beginning in July 1998, the IWD placed numerous automatic samplers at various upstream points along the South Park interceptor in an attempt to isolate the location of these possible zinc discharges. The IWD utilized 1998 data from local and interceptor sewer studies throughout the Calumet WRP service area to focus inspection and sampling efforts on industrial users of zinc in their processes. Samples obtained in August and November 1998 revealed elevated levels of zinc in the northern trunk line of the South Park Interceptor. Table 6 presents an example of the type of data collected during these special sewer sampling studies. It is clear how differences in zinc concentrations can be used to isolate areas of suspected zinc discharges as some sampling stations exhibited unexpectedly high zinc concentrations. As a result, the IWD commenced regular monitoring of the local sewers downstream of an industrial metal finishing company (located upstream of station C1-3-LA) and began dedicating sampling of the wastewater discharge from another company which formulates

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6

ZINC CONCENTRATIONS IN VARIOUS SEWERS TRIBUTARY TO THE
SOUTH PARK INTERCEPTOR IN AUGUST AND NOVEMBER 1998

Day of Sampling	Sampling Station			
	Cl-3-D	Cl-2-RE	Cl-2-JA	Cl-3-LA
	----- (Zinc, mg/l) -----			
1	0.33	0.15	7.0	5.4
2	0.25	0.11	0.1	3.8
3	0.27	2.32	2.9	2.2
4	0.22	0.04	13.8	0.9
5	0.15	0.09	4.0	1.0
6	0.18	0.42	13.5	2.3
7	0.18	0.12	5.6	13.4
8	0.75	0.07	4.9	8.5
9	0.26	0.07	12.1	2.5
10	0.25	0.05	16.6	10.6
11	0.37	0.21	23.2	5.6
12	0.26	0.04	28.7	4.5
13	0.24	0.09	15.1	19.5
14	0.22	0.17	12.8	3.7
15	0.26	0.09	12.7	5.0

*Sampling dates not the same at all stations.

industrial cleaning products (located upstream of Station C1-2-JA). Prior to the intensive interceptor sampling program, these two companies had not been thought to be significant dischargers of zinc.

Since this discovery, the IWD has been meeting with both companies to discuss and improve their waste handling and disposal procedures.

1999 Zinc Data

As indicated in Figure 6, zinc concentrations in the Calumet WRP digester draw have been below the Target Level since September 1998. With IWD efforts, this trend has continued in 1999.

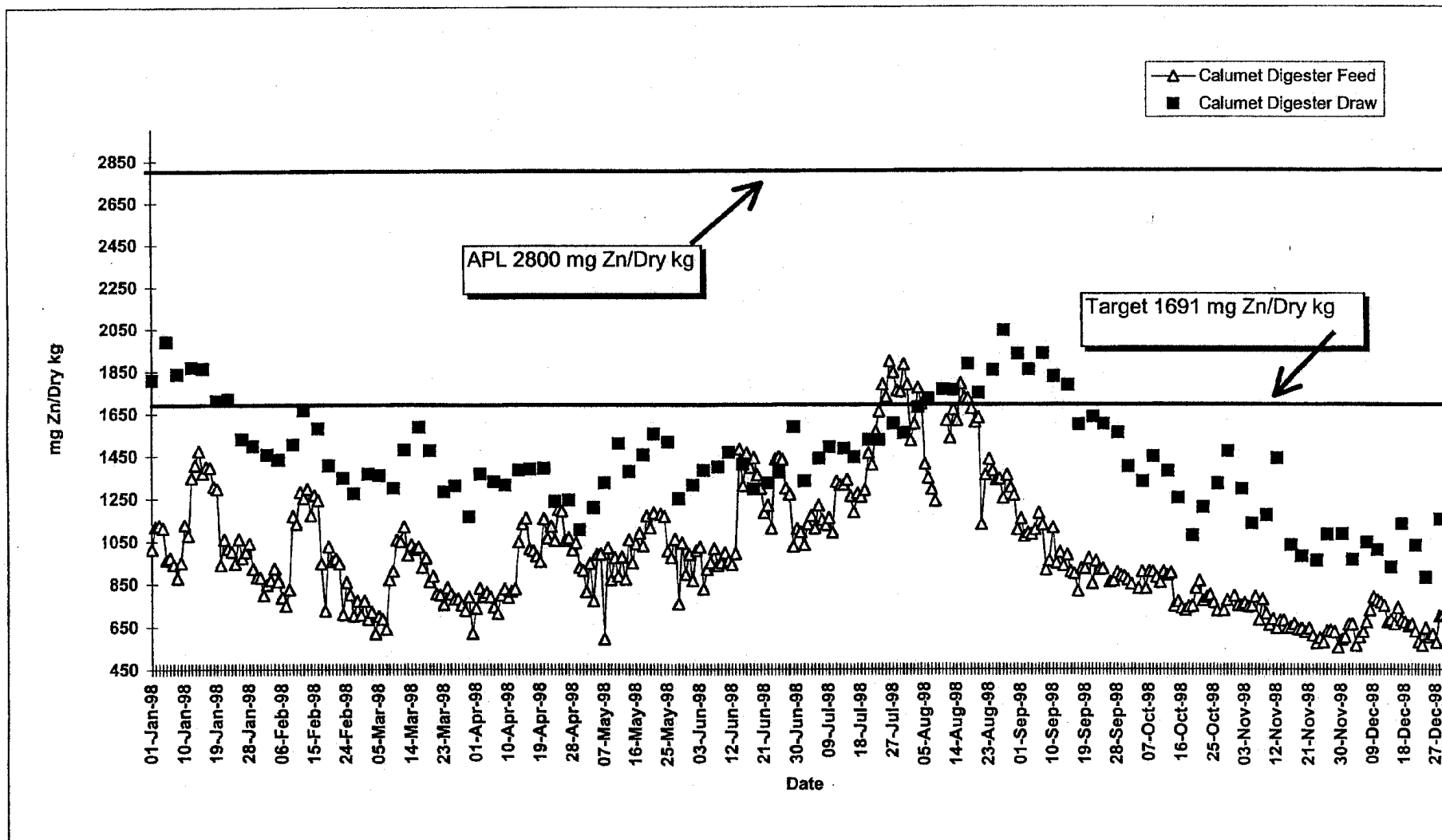
Table 7 presents weekly Calumet WRP digester draw zinc data for 1999. As can be seen, there have been no exceedances of the zinc Target Level during 1999, with the mean zinc concentration being 1077 mg/kg. This is a 25 percent decrease from the 1998 mean value of 1432 mg/kg.

As of December 1999, all special interceptor sampling in the Calumet WRP service area has ended, and only routine monitoring and sampling continues. Should problems arise in the future, more intensive monitoring efforts will be resumed.

Metropolitan Water Reclamation District Of Greater Chicago

Figure 6

Trend Of Zinc Concentration In Calumet WRP Digester Feed And Draw Sludge During 1998



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7

CALUMET WRP DIGESTER DRAW ZINC DATA - 1999

Week of	Zn (mg/kg, dry weight)
January 4, 1999	877
January 11, 1999	942
January 18, 1999	952
January 25, 1999	1054
February 1, 1999	1047
February 8, 1999	943
February 15, 1999	980
February 22, 1999	1139
March 1, 1999	1051
March 8, 1999	1002
March 15, 1999	1387
March 22, 1999	1185
March 29, 1999	1124
April 5, 1999	1072
April 12, 1999	1019
April 19, 1999	1076
April 26, 1999	1058
May 3, 1999	1056
May 10, 1999	986
May 17, 1999	929
May 24, 1999	940
May 31, 1999	932
June 7, 1999	947
June 14, 1999	793
June 21, 1999	938
June 28, 1999	1138
July 5, 1999	1134
July 12, 1999	1137
July 19, 1999	1164
July 26, 1999	998
August 2, 1999	1057
August 9, 1999	1355
August 16, 1999	1530
August 23, 1999	1132
August 30, 1999	1154
September 6, 1999	1145
September 20, 1999	1092
October 4, 1999	1160
October 18, 1999	1068
November 1, 1999	1222

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7 (Continued)

CALUMET WRP DIGESTER DRAW ZINC DATA - 1999

Week of	Zn (mg/kg, dry weight)
November 15, 1999	1118
December 6, 1999	1073
December 20, 1999	1186
1999 Mean	1077

APPENDIX I

INTERIM REPORT ON ZINC CONCENTRATIONS
IN CALUMET WRP DIGESTED SLUDGE,
DATED JUNE 1998

INTERIM REPORT ON ZINC CONCENTRATIONS
IN CALUMET WRP DIGESTED SLUDGE

By

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INTRODUCTION

USEPA Part 503 Regulations

The Clean Water Act Amendments of 1987 required that the USEPA establish standards which adequately protect public health and the environment from any reasonably anticipated adverse effects from the use or disposal of sewage sludge. On February 19, 1993, a final regulation entitled "The Standards for the Use or Disposal of Sewage Sludge" was published in the Federal Register. This regulation, commonly referred to as the Part 503 Rule, establishes requirements for the final use and disposal of sewage sludge. The Part 503 Rule establishes specific risk-based pollutant limits for various heavy metals found in sewage sludge. Sludges that meet the most stringent requirements are classified as Exceptional Quality (EQ) Sludge and are considered suitable for virtually unregulated use.

The Metropolitan Water Reclamation District of Greater Chicago (District) has established an organizational policy to have its final sludge product qualify as EQ sludge. The Research and Development (R&D) and Maintenance and Operations (M&O) Departments continuously monitor sludge quality to ensure that EQ requirements are met. In late 1996 and early 1997 it was observed that the concentration of zinc in the Calumet Water Reclamation Plant (WRP) digester draw sludge was increasing, such that it was approaching previously agreed

upon Target Levels for concern. Work conducted at the District since the inception of the Part 503 Rule, has resulted in the establishment of Target Levels for metals concentration in the digester draw sludge from each WRP that will ensure that the final sludge product meets Part 503 alternate pollutant limits (APL). For zinc, the USEPA APL for the final sludge product is 2800 mg/kg dry weight. The District-established Target Level for zinc in the Calumet WRP digester draw is 1691 mg/kg.

Based upon the observation of the rising trend in the digester draw zinc concentration, the M&O Department requested that the R&D Department undertake a detailed investigation of the elevated levels of zinc at the Calumet WRP. This report presents the work conducted during 1997, and describes the plans for 1998.

Historical Zinc Trends at the Calumet WRP

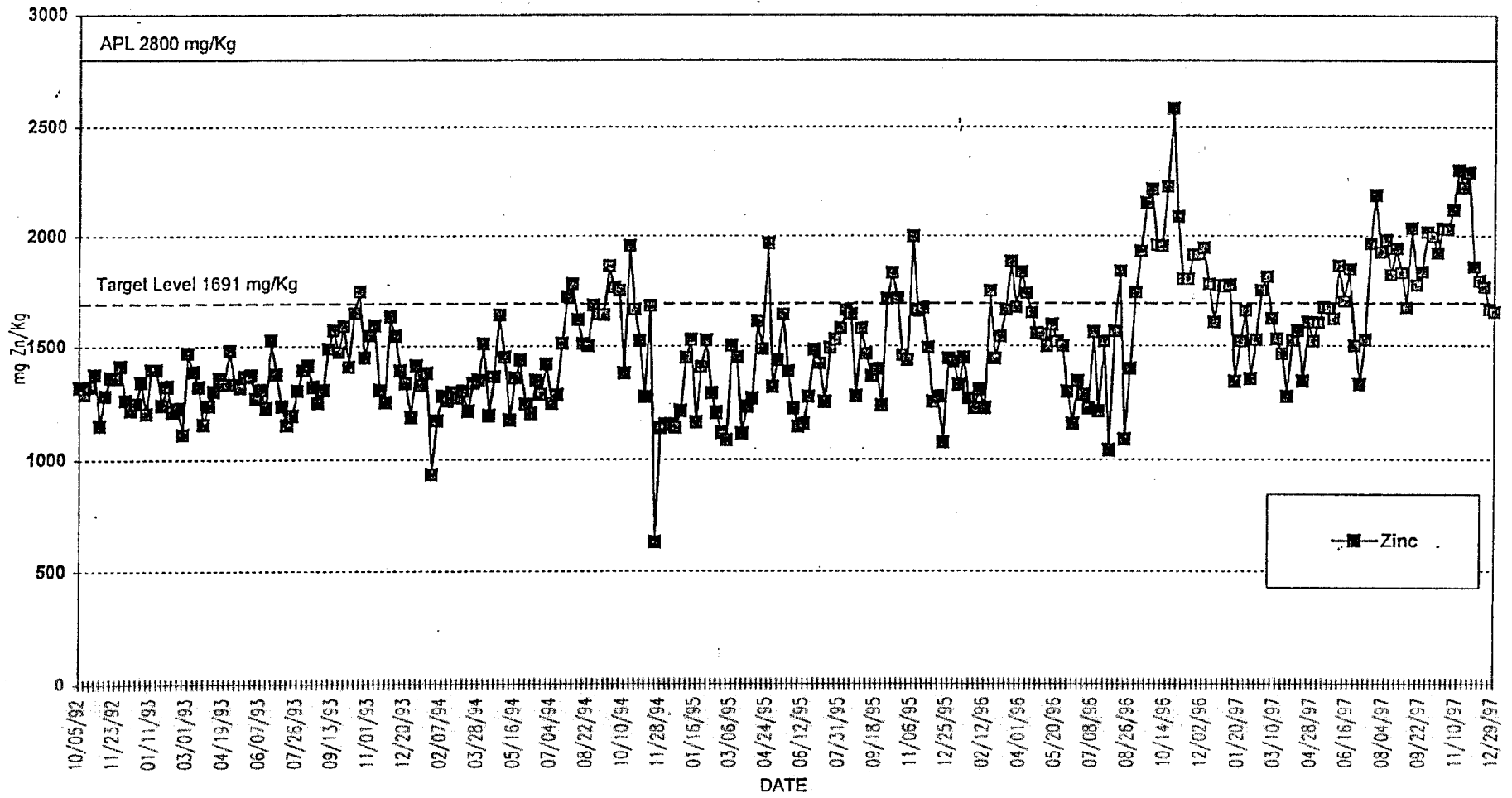
The Part 503 Rule applies to the final sludge product produced by the District. However, as there can be a lag time of many years from the time that sludge is generated at a WRP to the time that it is ready for ultimate disposal, it is necessary to assess the quality of the current sludge production on a continuous basis.

Figure 1 is a graph of five years of data on the concentration of zinc in the digester draw at the Calumet WRP. As can be seen, the yearly range of zinc concentrations has been

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 1

TREND OF ZINC CONCENTRATION IN CALUMET DIGESTER DRAW SLUDGE SINCE INCEPTION OF THE PART 503 RULE



increasing in recent years, and the number of samples exceeding the Target Level of 1691 mg/kg has increased significantly since late 1996, and even more so in 1997. For comparison purposes the 1997 average zinc concentration in the digester draw from the Stickney WRP was 874 mg/kg, approximately half the Calumet WRP level of 1756 mg/kg.

It is well documented that zinc entering a WRP in the raw sewage will preferentially concentrate in the sludge solids. Thus, to explain the increase in zinc levels in the digester draw, it is logical to look at zinc concentrations entering the Calumet WRP in the raw sewage. Table 1 presents yearly averages of raw sewage zinc concentrations and loadings from 1992 through 1997 at the Calumet WRP. As can be seen, a large increase in the amount of zinc entering the WRP occurred in 1996 and 1997. In 1997 approximately 1000 lbs/day of zinc was entering the Calumet WRP based upon the raw sewage zinc concentration and flow. This is almost five times the amount of zinc which enters the North Side WRP, which processes a similar volume of daily flow.

With this information in hand, in mid-1997 the R&D Department began an intensive study to determine zinc loadings to the Calumet WRP.

Description of R&D Department Studies

In mid-1997 various sections in the R&D Department were mobilized to investigate the zinc problem at the Calumet WRP.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 1

AVERAGE YEARLY ZINC CONCENTRATION AND LOADING IN THE
CALUMET WRP RAW SEWAGE SINCE INCEPTION OF THE PART 503 RULE

Date	Flow (MGD)	Raw Sewage	
		mg Zn/L	lbs Zn/day
1992	251	0.292	634
1993	308	0.253	651
1994	262	0.285	623
1995	270	0.243	524
1996	277	0.382	865
1997	255	0.493	1034

Input was solicited from the M&O Department, and numerous meetings were held to exchange information. The following course of action was agreed upon.

1. Review historical raw sewage and sludge data from the Calumet WRP and other WRPs as needed.
2. Review laboratory analytical procedures.
3. Review the industrial waste monitoring database, and the current industrial waste sampling program.
4. Intensify industrial waste monitoring efforts.
5. Initiate new sampling programs in the four main interceptors serving the Calumet WRP.
6. Study Calumet WRP recycle streams and other plant processes.
7. Examine non-point sources of zinc.
8. Attempt to develop a mass balance for zinc at the Calumet WRP.

METHODOLOGY

Description of Calumet WRP Service Area

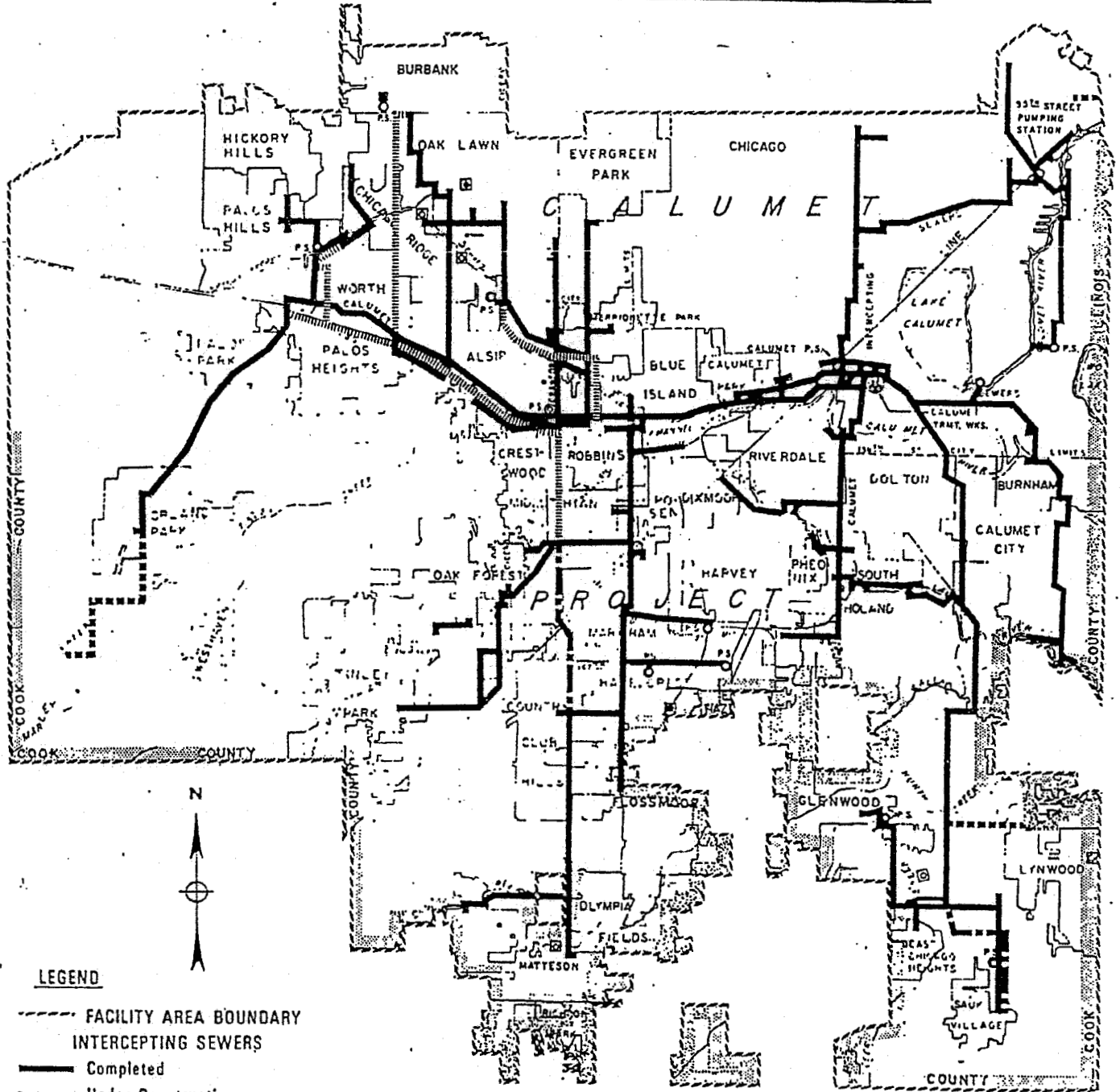
The Calumet WRP is a 354 MGD conventional activated sludge treatment plant serving the south side of the city of Chicago and south suburban Cook County. The service area is approximately 300 square miles with a service population of approximately 1,000,000 people. Figure 2 is a map of the Calumet WRP service area. The service area includes combined as well as separate sewer systems and a significant amount of heavy industry. The general boundaries of the service area are all of Chicago south of 87th Street, plus all of south and southwest suburban Cook County, except Lemont and Chicago Heights.

Four main interceptors convey wastewater flow to the Calumet WRP. They are:

1. South Park Interceptor - Conveys an estimated 46 percent of the total flow. Drains general area of Chicago north and east of the Calumet WRP to 87th Street.
2. Blue Island Interceptor - Conveys an estimated 28 percent of the total flow. Drains extensive area west and southwest of the Calumet WRP.
3. Harvey Interceptor - Conveys an estimated 12 percent of the total flow. Sewer runs along Indiana Avenue and drains area south of the WRP.

FIGURE 2

SOUTH FACILITY AREA



LEGEND

- FACILITY AREA BOUNDARY
- INTERCEPTING SEWERS
- Completed
- - - Under Construction
- Proposed - Near Future
- ||||| Future Proposed
- PUMPING STATIONS
- Existing
- ⊙ Proposed
- SEWAGE TREATMENT WORKS
- ⊗ Existing
- RETENTION RESERVOIRS
- ⊠ Existing
- ⊡ Proposed

THE METROPOLITAN SANITARY DISTRICT
OF GREATER CHICAGO

ENGINEERING DEPARTMENT

4. Low Level Interceptor - Conveys an estimated 14 percent of the total flow. Drains area south-east of the WRP to Cook County line.

In addition, the Calumet WRP receives pumpback flow from the Calumet TARP system.

Description of Sampling Points

RAW SEWAGE

Raw sewage samples are 24-hour composites collected at four points at the influent end of the grit chambers (Figure 3). The north and south samples are combined in the laboratory and analyzed as a single composite raw sewage sample.

TARP PUMPBACK

TARP pumpback flows are manually sampled each shift at the North Fine Screen House (Figure 3), and combined into a 24-hour composite for analysis. TARP pumpback flow is included in the north raw sewage sample.

FINAL EFFLUENT

The final effluent sample is a 24-hour composite collected at the final outfall conduit from the Calumet WRP.

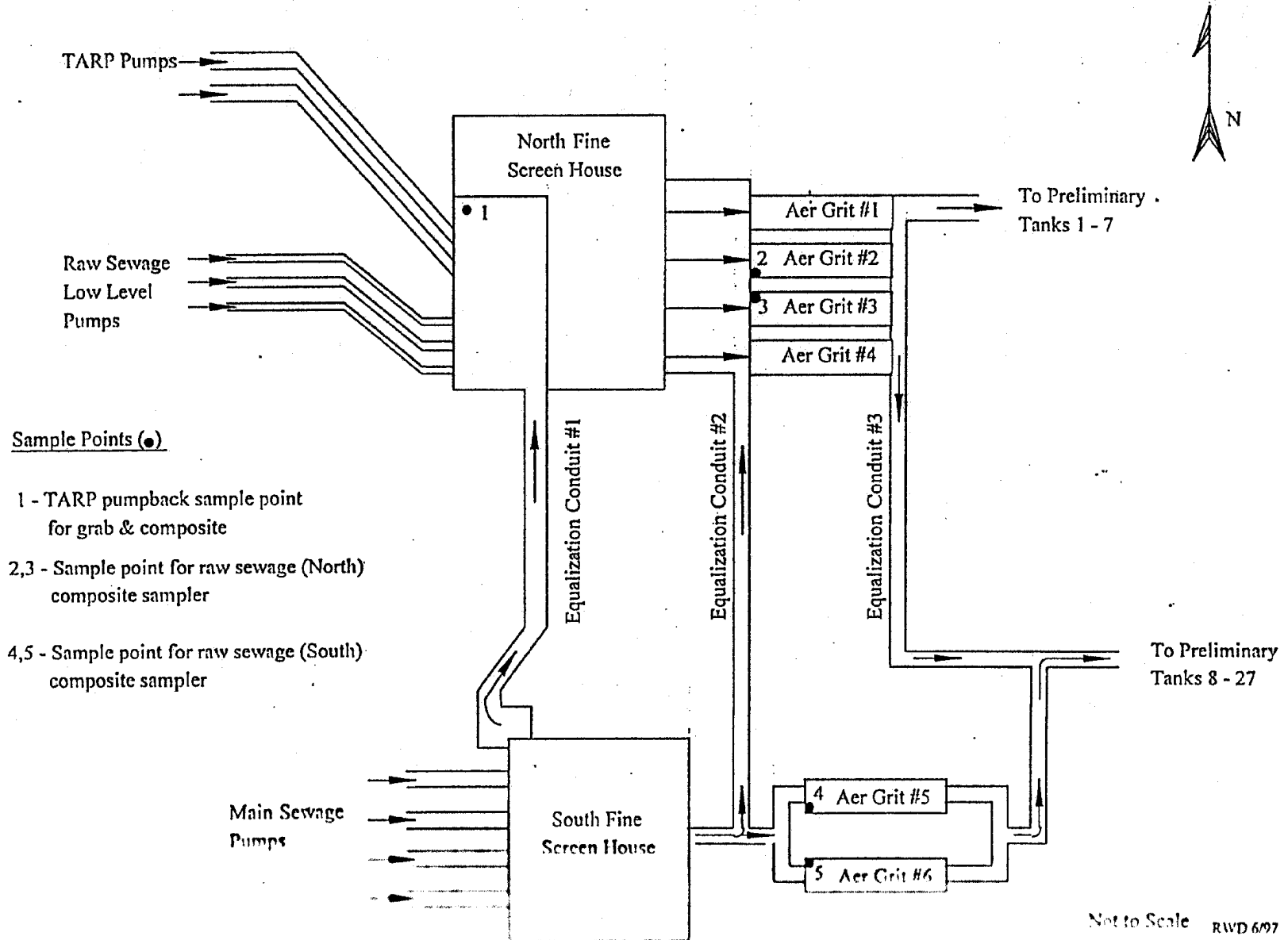
DIGESTER DRAW

The digester draw sample is a daily composite of digesters 1-8 for the period up to October 20, 1997. After October 20, 1997, four new digesters were put in service, and the digester operation was modified to a two-step process. Thus,

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 3

CALUMET WRP SEWAGE FLOW SCHEMATIC AND SAMPLING LOCATIONS



AI-11
10

after October 20, 1997, the digester draw sample was a daily composite of digesters 9-12.

RECYCLE SAMPLES

Recycle samples were representative grab samples taken on selected days as shown later in this report.

INTERCEPTOR SAMPLES

On June 18, 1997, the Industrial Waste Division installed special 24-hour composite samplers in the four main interceptors entering the Calumet WRP. This allowed the raw sewage to be sampled without the influence of TARP pumpback flows or process recycles. It also allowed the zinc concentrations coming from each of the four subparts of the Calumet WRP service area to be isolated. The sampling locations for each interceptor are shown in Figure 4.

ANALYTICAL MEHTODOLOGY

Samples were analyzed for zinc and other metals at the R&D laboratory at the Calumet WRP using Standard Methods for the Examination of Water and Wastewater, 18th Edition, procedures and appropriate Quality Assurance/Quality Control (QA/QC) protocols.

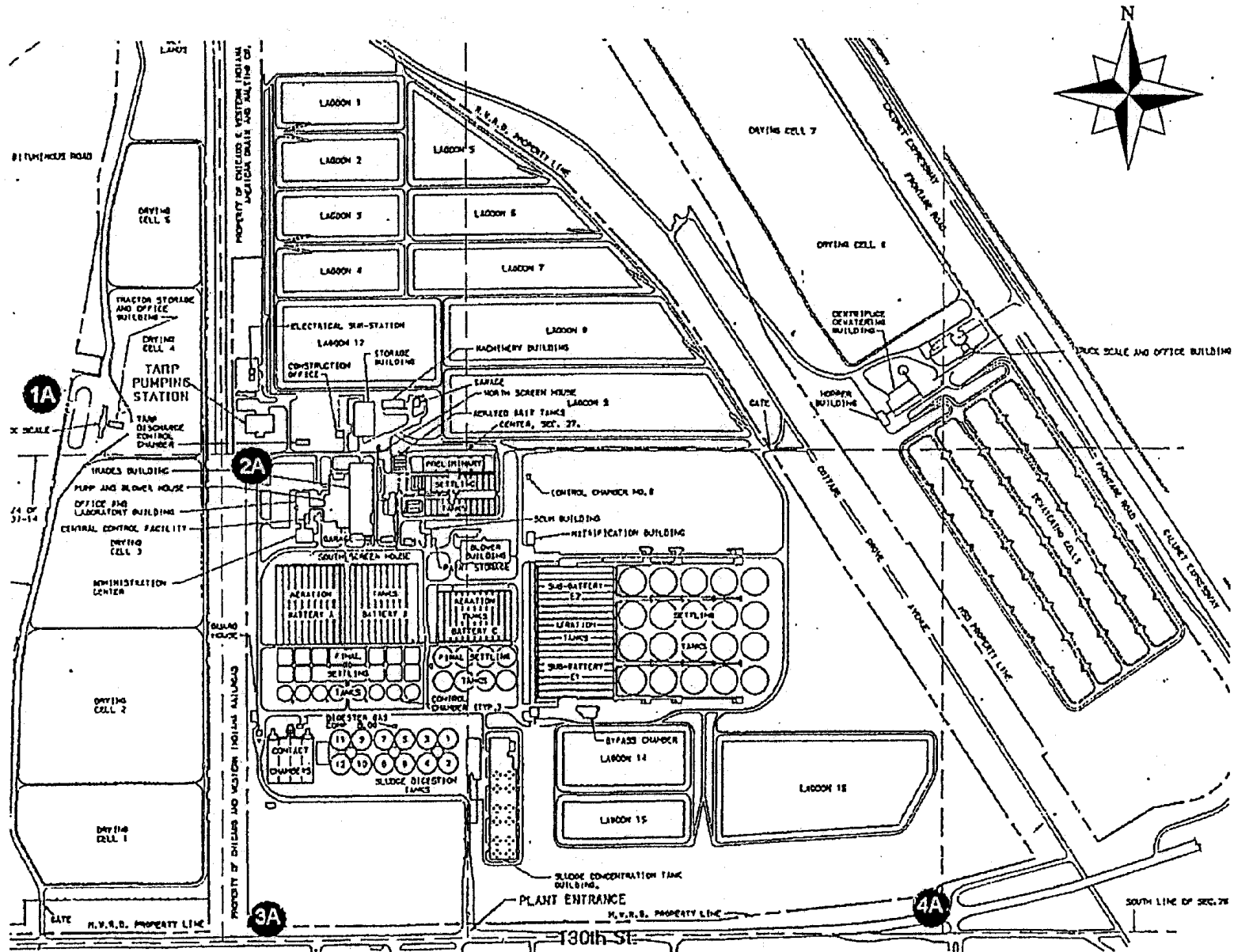
INDUSTRIAL WASTE MONITORING DATA

The Industrial Waste Division conducts an extensive industrial waste monitoring program involving daily, weekly, monthly, and annual sampling at various industries depending

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 4

CALUMET WRP LOCATION PLAN



Note: 1A = South Park Interceptor
 2A = Blue Island Interceptor
 3A = Harvey Interceptor
 4A = Low Level Interceptor

AI-13

12

upon their size and wastewater characteristics. Sampling results from 1993 through 1997 were reviewed to assess the amount of zinc discharged by industries in the Calumet WRP service area.

RESULTS

Calumet WRP Raw Sewage and Final Effluent Zinc Data

Table 2 presents 1997 monthly averages of Calumet WRP raw sewage and final effluent zinc concentrations and loadings. As can be seen, raw sewage zinc concentrations averaged 0.493 mg/L for 1997 equating to an average daily loading of 1034 lbs/day. This figure includes TARP pumpback flows and internal plant recycles. Zinc concentration in the final effluent averaged 0.100 mg/L in 1997 which is equivalent to 234 lbs/day.

In comparison, zinc in the North Side WRP raw sewage averaged 0.10 mg/L in 1997, while zinc in the West Side and Southwest raw at the Stickney WRP averaged 0.14 mg/L and 0.35 mg/L, respectively. These values also include TARP pumpback and internal recycles where applicable.

Calumet WRP Digester Draw Zinc Data

Table 3 presents 1997 monthly averages of zinc concentrations and loading in the digester draw produced at the Calumet WRP. As can be seen, the zinc concentration for 1997 averaged 1758 mg/kg dry weight, and equates to 325 lbs/day of zinc leaving the Calumet WRP in the anaerobically digested sludge.

As a check on this number, the average zinc loading in the digester feed for June through December 1997 was 327 lbs/day. No samples were analyzed for zinc prior to June 1997.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 2

AVERAGE MONTHLY ZINC CONCENTRATION AND LOADING IN THE CALUMET WRP
RAW SEWAGE AND FINAL EFFLUENT DURING 1997

Date	Daily Flow MGD	Calumet Raw Sewage		Calumet Final Effluent	
		mg Zn/L	lbs Zn/day	mg Zn/L	lbs Zn/day
January 1997	253	0.732	1538	0.128	264
February 1997	328	0.553	1415	0.149	383
March 1997	308	0.405	1005	0.101	252
April 1997	253	0.442	948	0.105	221
May 1997	232	0.353	675	0.098	188
June 1997	272	0.485	1064	0.098	214
July 1997	240	0.796	1645	0.089	179
August 1997	253	0.483	994	0.065	133
September 1997	229	0.414	786	0.078	146
October 1997	214	0.475	807	0.091	161
November 1997	228	0.362	687	0.107	201
December 1997	253	0.412	840	0.098	200
Mean	255	0.493	1034	0.100	234

AI-16

15

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

AVERAGE MONTHLY ZINC CONCENTRATION AND LOADING
IN THE CALUMET DIGESTER DRAW SLUDGE DURING 1997

Date	Total Dry Tons Sludge Solids	Zinc Concentration mg Zn/dry Kg	Zinc Loading lbs Zn/day
January 1997	3268	1573	332
February 1997	2612	1609	300
March 1997	3263	1481	312
April 1997	2990	1508	301
May 1997	3179	1641	337
June 1997	2664	1646	292
July 1997	3555	1899	436
August 1997	2922	1893	357
September 1997	2985	1865	371
October 1997	2254	2002	291
November 1997	2173	2232	313
December 1997	2268	1744	255
Mean	2844	1758	325

Note: The average zinc loading in the digester feed for June through December 1997 was 327 lbs/day. No samples were analyzed for zinc prior to June 1997.

As previously stated, the Part 503 Rule APL for zinc is 2800 mg/kg, which applies to the final sludge product. Based upon previous work, the District has set a Target Level of 1691 mg/kg of zinc in the digester draw at the Calumet WRP, as a goal to ensure that the final sludge product will meet the APL.

As it is well documented that heavy metals in the raw sewage concentrate in the sludge solids, it is clear that in order to reduce the zinc concentration in the digester draw, the zinc concentration in the raw sewage must be reduced.

Calumet WRP Interceptor Zinc Data

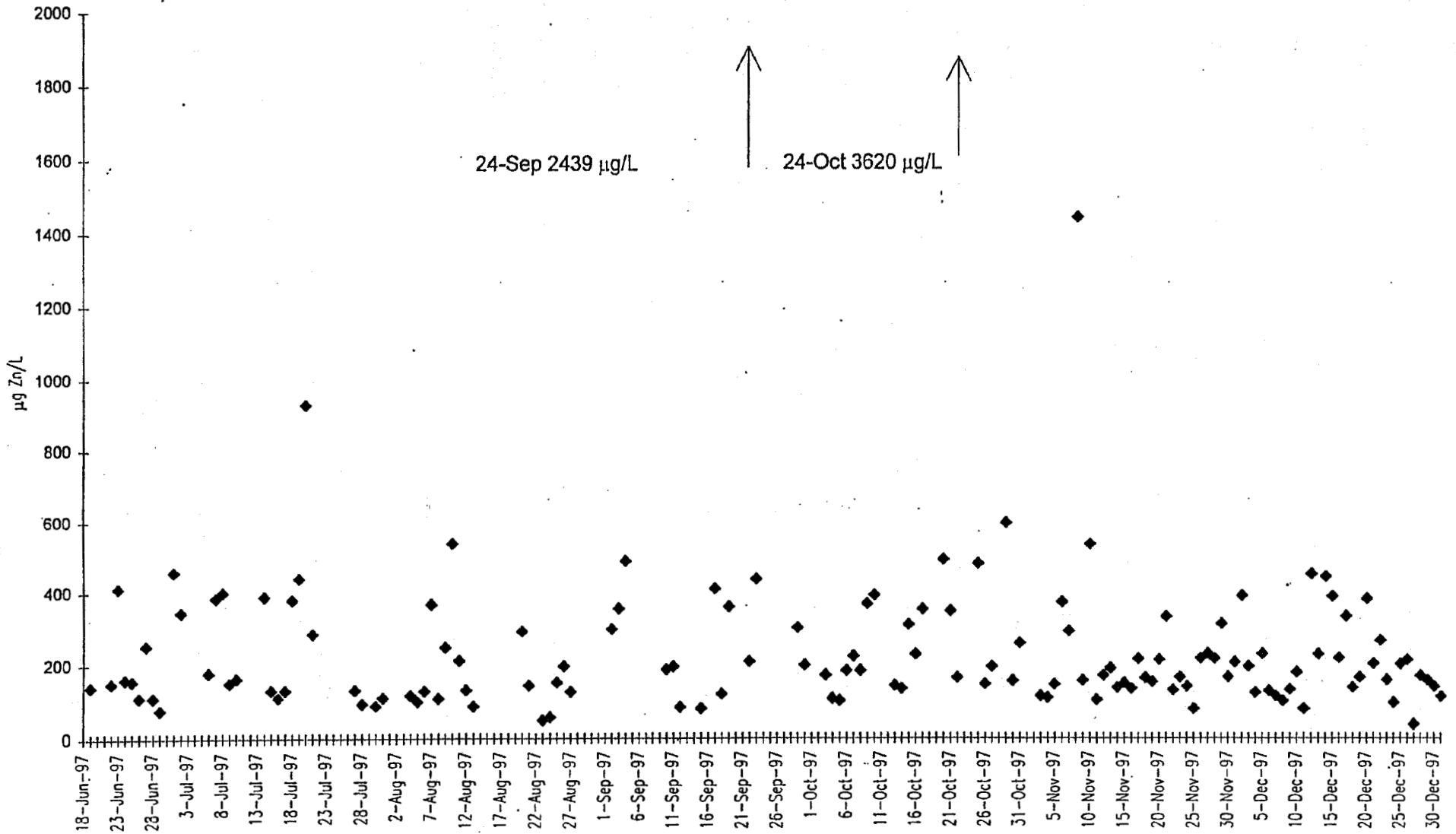
As previously stated, in an effort to determine which parts of the Calumet WRP service area were contributing the most zinc to the raw sewage, the Industrial Waste Division installed and maintained 24-hour composite samplers in the four main interceptors entering the Calumet WRP. These samplers were positioned upstream of the introduction of TARP pumpback and plant recycles into the raw sewage, and thus are considered to more accurately represent the raw sewage entering the Calumet WRP on a daily basis.

Sample collection began on June 18, 1997 and continued throughout 1997 and into 1998. Figures 5 through 8 present the results of the 1997 sampling program for the South Park, Blue Island, Harvey, and Low Level interceptors, respectively. Each figure presents daily values for zinc concentration in

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 5

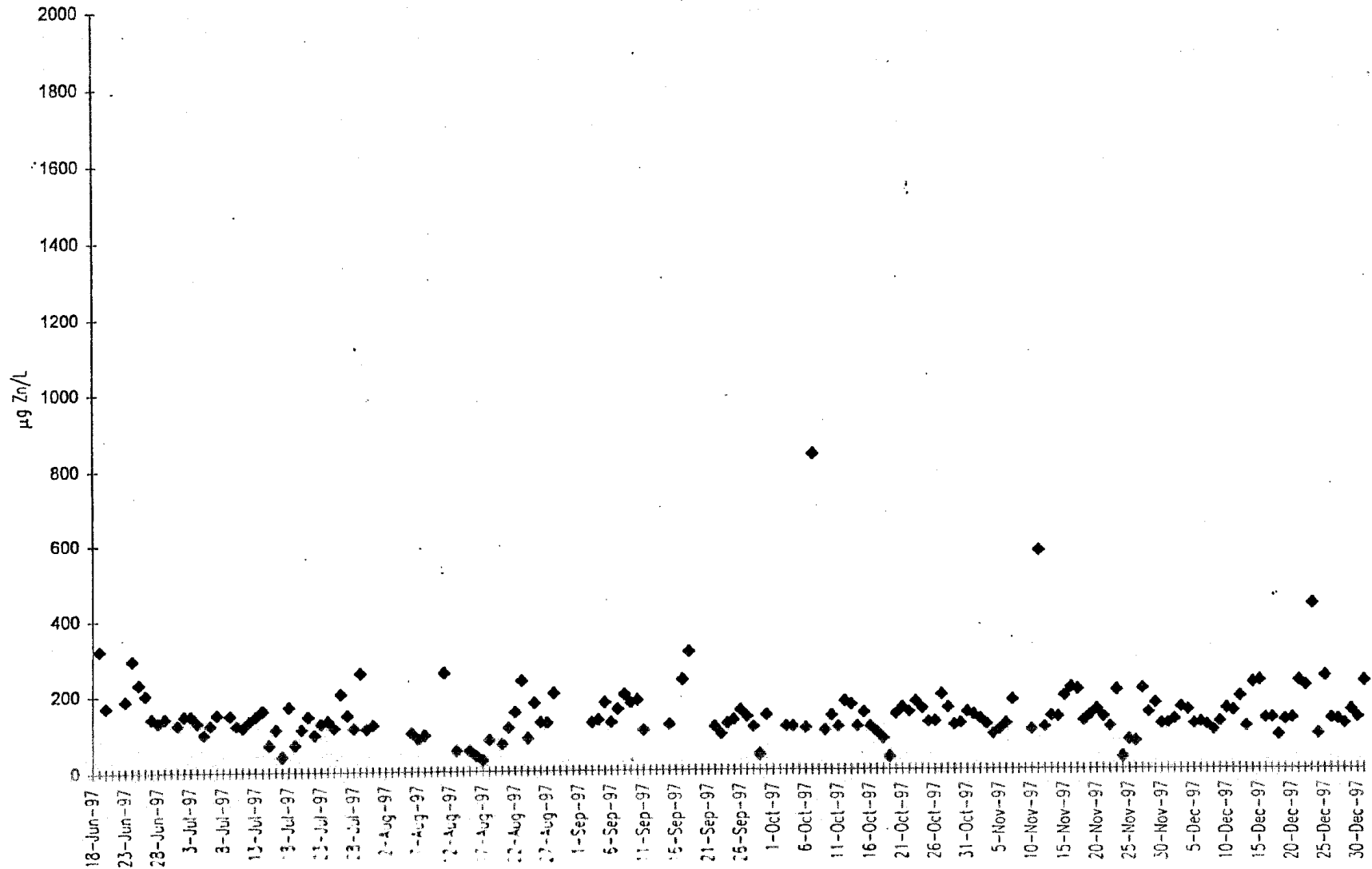
SOUTH PARK INTERCEPTOR ZINC CONCENTRATIONS



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 6

BLUE ISLAND INTERCEPTOR ZINC CONCENTRATIONS



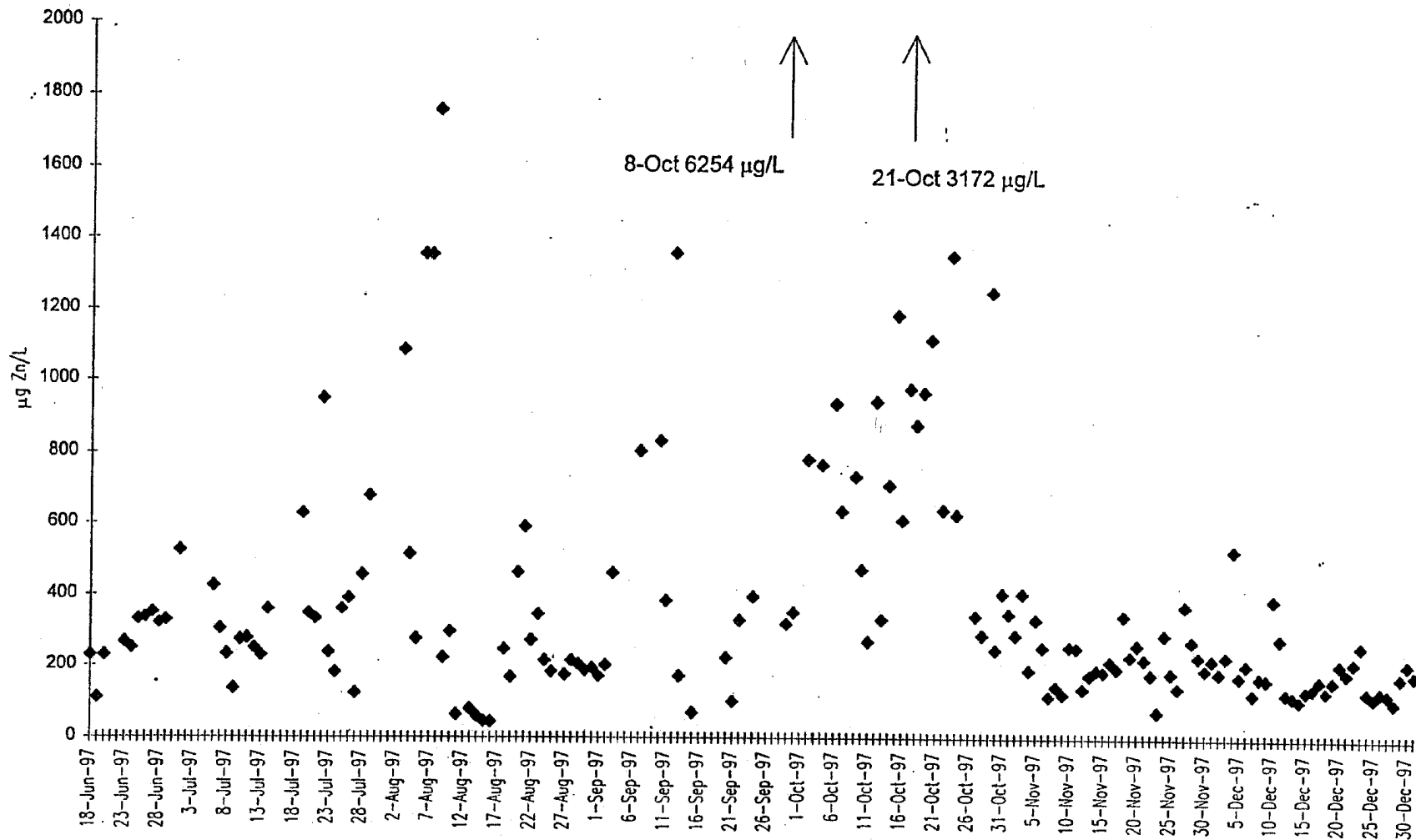
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AI-20

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 7

HARVEY INTERCEPTOR ZINC CONCENTRATIONS

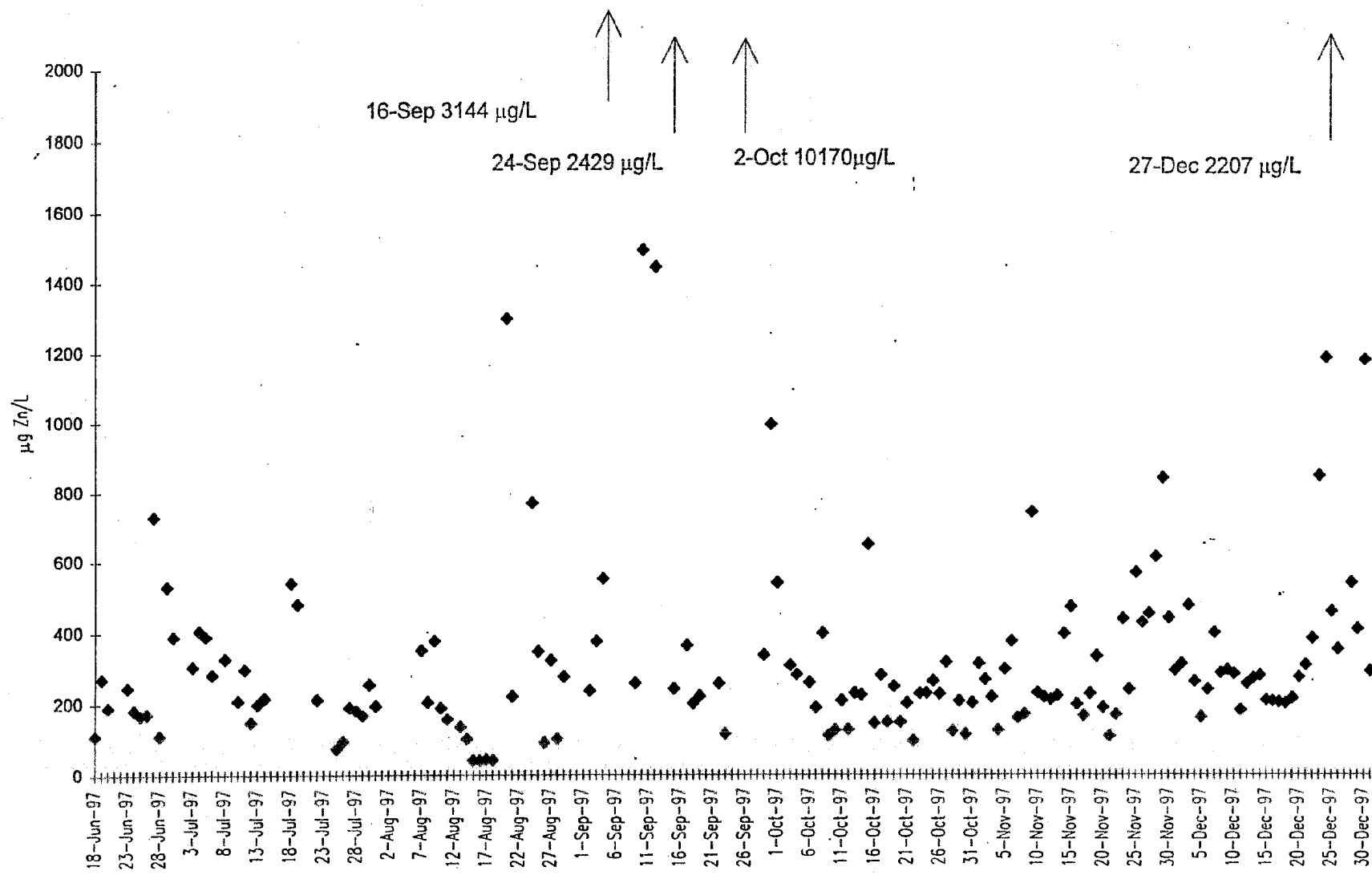


AI-21
20

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 8

LOW LEVEL INTERCEPTOR ZINC CONCENTRATIONS



AI-22
21

the respective interceptors. As can be seen, zinc concentrations in the South Park interceptor were mostly in the 0.1-0.4 mg/L range, with three values above 1.0 mg/L over the 6-month sampling period. The Blue Island interceptor had the majority of data points in the 0.1-0.2 mg/L range for zinc. No values were above 1.0 mg/L. The Harvey and Low Level interceptors both show considerable scatter in the data, with zinc concentrations above 0.5 mg/L on numerous days, and many values above 1.0 mg/L.

A comparison of the Blue Island interceptor data (Figure 6) with the Harvey interceptor data (Figure 7) clearly indicates that the Harvey interceptor is receiving "spike" inputs of zinc well above expected background levels. The same can be said for the Low Level interceptor (Figure 8). The patterns exhibited in Figures 7 and 8 are indicative of periodic discharges of zinc from unknown point sources.

A tabulated summary of the interceptor data is presented in Table 4. The Harvey and Low Level interceptors clearly have the highest zinc concentrations.

No daily sewage flow measurements are made in the individual interceptors. However, as previously mentioned, the M&O Department has made estimates of the percentage of total WRP flow carried by each of the four interceptors. Using these estimated flows and the actual zinc concentration data, it is possible to estimate the zinc loading in lbs/day carried

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

CALUMET WRP INTERCEPTOR ZINC CONCENTRATIONS

Month	Statistic	South Park mg Zn/L	Blue Island mg Zn/L	Harvey mg Zn/L	Low Level mg Zn/L
June 1997	Average	0.174	0.202	0.275	0.281
	Minimum	0.075	0.130	0.110	0.110
	Maximum	0.412	0.320	0.350	0.730
July 1997	Average	0.279	0.129	0.367	0.258
	Minimum	0.088	0.040	0.124	0.074
	Maximum	0.930	0.258	0.950	0.540
August 1997	Average	0.180	0.116	0.408	0.269
	Minimum	0.048	0.029	0.044	0.041
	Maximum	0.540	0.258	1.758	1.301
September 1997	Average	0.413	0.148	0.413	0.791
	Minimum	0.080	0.040	0.071	0.114
	Maximum	2.439	0.312	1.358	3.144
October 1997	Average	0.409	0.158	1.036	0.566
	Minimum	0.102	0.032	0.249	0.094
	Maximum	3.620	0.839	6.254	10.170
November 1997	Average	0.245	0.153	0.228	0.328
	Minimum	0.079	0.031	0.075	0.108
	Maximum	1.448	0.581	0.408	0.841
December 1997	Average	0.208	0.160	0.188	0.435
	Minimum	0.036	0.087	0.104	0.161
	Maximum	0.457	0.439	0.530	2.207
Overall Average		0.272	0.152	0.416	0.418

in each of the four interceptors. The data are presented in Table 5. Only days on which samples from all four interceptors were collected are shown in Table 5. As can be seen, the South Park interceptor carries approximately 50 percent of the zinc loading to the Calumet WRP. For the July through December 1997 period for which data are available, the total zinc loading to the Calumet WRP from the four interceptors averaged 500 lbs/day.

Other Calumet WRP Zinc Data

In an attempt to verify that no internal sources were contributing zinc to the sludge at the Calumet WRP, a number of special samples were collected for analysis. In addition, laboratory QA/QC procedures were reviewed.

FERRIC CHLORIDE (FeCl_3)

The Calumet WRP adds FeCl_3 to the sludge solids for chemical conditioning and odor control. As the FeCl_3 is an industrial grade chemical, there was some concern that it could contain high levels of zinc.

Special grab samples of the FeCl_3 used at the Calumet WRP were collected and analyzed for zinc. Only trace amounts of zinc were detected, and these amounts were similar to the manufacturer's specifications. Thus, FeCl_3 is not adding zinc to the sludge.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

CALUMET WRP INTERCEPTOR ZINC LOADINGS

Date	South Park Zinc (lbs)	Blue Island Zinc (lbs)	Harvey Zinc (lbs)	Low Level Zinc (lbs)	Zinc Total 4 Interceptors (lbs)
07/03/97	123	63	105	88	379
07/08/97	332	169	99	87	687
07/10/97	102	49	48	42	241
07/11/97	1,936	61	27	70	2,093
07/14/97	261	61	45	48	414
07/15/97	109	54	50	44	257
07/22/97	442	53	84	65	645
07/27/97	146	94	100	70	409
07/28/97	61	48	78	39	226
07/29/97	159	91	41	41	332
07/30/97	48	44	89	56	236
07/31/97	67	45	132	39	283
08/07/97	282	38	51	79	450
08/08/97	328	46	262	65	701
08/11/97	320	176	36	65	598
08/13/97	80	29	16	38	164
08/20/97	217	32	49	352	649
08/21/97	105	51	32	51	238
08/24/97	646	45	57	209	956
08/25/97	428	260	59	71	818
08/26/97	115	56	38	23	232
08/27/97	95	66	34	69	263
09/03/97	251	51	32	76	410
09/04/97	351	58	36	117	561
09/15/97	62	56	35	45	198
09/17/97	571	181	28	154	934
09/22/97	172	62	51	137	422
09/23/97	356	46	22	29	453
09/24/97	1,673	38	55	795	2,561
09/29/97	215	23	59	70	367
09/30/97	178	78	82	275	613
10/04/97	81	55	136	63	335
10/06/97	117	41	158	48	363
10/07/97	145	355	138	39	676

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5 (Continued)

CALUMET WRP INTERCEPTOR ZINC LOADINGS

Date	South Park Zinc (lbs)	Blue Island Zinc (lbs)	Harvey Zinc (lbs)	Low Level Zinc (lbs)	Zinc Total 4 Interceptors (lbs)
10/09/97	259	28	125	26	437
10/10/97	396	73	111	36	616
10/13/97	139	94	96	66	394
10/14/97	90	42	106	39	278
10/15/97	189	50	151	92	483
10/16/97	164	49	116	31	359
10/17/97	252	31	213	69	565
10/20/97	294	60	209	31	594
10/21/97	293	79	638	48	1,059
10/22/97	93	56	89	16	254
10/24/97	2,654	69	126	52	2,901
10/27/97	193	97	83	93	467
10/29/97	456	267	146	51	920
10/30/97	109	54	46	26	236
10/31/97	213	75	87	51	426
11/03/97	102	64	95	61	322
11/04/97	78	40	35	28	180
11/05/97	94	40	56	60	250
11/06/97	292	56	52	91	491
11/07/97	213	81	23	36	353
11/10/97	418	49	52	56	575
11/11/97	70	239	45	46	399
11/12/97	132	52	28	51	263
11/13/97	144	64	35	52	295
11/14/97	119	72	43	107	342
11/15/97	157	124	51	154	486
11/16/97	101	98	42	46	288
11/17/97	159	94	38	38	328
11/18/97	135	63	74	58	330
11/19/97	113	64	44	76	297
11/20/97	188	84	60	51	382
11/21/97	280	70	49	28	426
11/22/97	98	51	35	39	224
11/23/97	129	99	15	106	349

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5 (Continued)

CALUMET WRP INTERCEPTOR ZINC LOADINGS

Date	South Park Zinc (lbs)	Blue Island Zinc (lbs)	Harvey Zinc (lbs)	Low Level Zinc (lbs)	Zinc Total 4 Interceptors (lbs)
11/24/97	106	14	57	56	232
11/25/97	58	33	35	130	256
11/26/97	169	33	29	103	334
11/27/97	178	99	75	108	460
11/28/97	188	78	62	165	493
11/29/97	348	116	66	288	818
11/30/97	140	60	43	115	359
12/01/97	175	61	49	77	362
12/02/97	310	63	38	77	488
12/03/97	158	79	48	119	405
12/04/97	104	79	116	68	367
12/05/97	190	58	37	41	327
12/06/97	105	60	44	61	271
12/07/97	83	50	24	90	247
12/12/97	444	114	33	78	668
12/14/97	350	108	22	68	548
12/15/97	329	119	30	55	532
12/16/97	180	66	31	53	330
12/17/97	279	67	35	53	434
12/18/97	108	41	28	49	225
12/19/97	137	64	35	55	291
12/20/97	312	65	44	69	491
12/21/97	171	119	41	81	411
12/22/97	278	138	58	123	597
12/23/97	137	230	59	227	652
12/24/97	115	179	42	446	782
12/25/97	253	68	38	178	538
12/26/97	198	74	32	101	406
12/27/97	34	73	31	645	783
12/28/97	153	64	24	152	393
12/29/97	149	88	43	121	401
12/30/97	122	71	48	320	561
12/31/97	102	126	43	81	352
Average	252.94	79.84	69.48	98.22	500.49

PROCESS RECYCLES

A variety of special samples were collected in order to assess the zinc content of internal and external WRP recycles. The main recycles were considered to be gravity concentration tank supernatant, centrifuge centrate, and lagoon supernatant. Analysis of these samples (Table 6) indicated that zinc concentrations were in the 0.1-0.6 mg/L range. However, due to the relatively low estimated flow from these recycles, the total zinc loading is only 11.9 lbs/day. This is not a large amount of zinc relative to the total loading.

LABORATORY QA/QC PROCEDURES

In order to verify that the reported zinc data were accurate, laboratory data files and operating procedures were reviewed. In addition, special check samples and duplicates were analyzed at the Calumet WRP laboratory and the Stickney WRP laboratory.

It was determined that all QA/QC measures were rigidly followed, consistent with the established procedures.

Check standards were always within acceptable limits. Also, no new instruments were utilized for zinc analysis from mid-1992 to the present.

Thus, the laboratory data accurately represent the reported zinc concentrations.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6

ZINC CONCENTRATIONS MEASURED IN CALUMET WRP
PROCESS RECYCLE STREAMS

Process Recycle	Date	Zinc Concentration, mg/L
Lagoon Draw-Off ¹		
No. 7	4/15/97	0.3
No. 8	4/15/97	0.3
No. 8	12/19/97	0.1
No. 9	12/19/97	0.4
No. 14	1/15/97	0.4
No. 14	4/15/97	0.6
No. 14	12/19/97	0.5
No. 15	12/19/97	0.4
No. 15	12/19/97	0.2
No. 17	12/19/97	0.7
	Average	0.39
Gravity Concentrate Supernatant ²		
	1/15/97	0.3
	4/21/97	0.6
	12/9/97	0.1
	12/10/97	0.2
	Average	0.30
Centrate ³		
	4/15/97	0.2
	4/21/97	0.1
	12/9/97	0.3
	12/10/97	0.1
	Average	0.18

¹Estimated flow = 0.16 MGD.

²Estimated flow = 4.03 MGD.

³Estimated flow = 0.88 MGD.

Industrial Waste Discharges

The Industrial Waste Division conducts an intensive monitoring program of industrial waste dischargers in Cook County. Table 7 presents yearly data for 1993 through 1997 of the largest known zinc dischargers in the Calumet WRP service area. As can be seen, total zinc discharged for 1997 was 24,351 pounds, which is equivalent to 66.7 lbs of zinc/day, based upon 365 days per year.

There are numerous smaller industrial dischargers of zinc (<100 lbs/year), but they do not add significantly to the total amount of industrial zinc discharged.

Nonindustrial Sources of Zinc

DRINKING WATER

The city of Chicago's south side Cheltenham Water Filtration Plant supplies drinking water to a large part of the Calumet WRP service area. Their routine monitoring data indicate that zinc concentrations in the drinking water supply are below their analytical detection limit (<0.013 mg/L). Taking the 1997 average daily flow of 255 MGD for the Calumet WRP, this translates to a maximum contribution of 27.6 lbs/day of zinc from the city of Chicago drinking water supply.

There are five communities in the Calumet WRP service area which receive drinking water from the Hammond, Indiana water treatment plant. The Hammond plant adds zinc orthophosphate to their water as a corrosion inhibitor. Based upon

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7

ZINC LOADING TO THE CALUMET WATER RECLAMATION PLANT FROM INDUSTRIES
IDENTIFIED AS DISCHARGING MORE THAN 100 POUNDS PER YEAR OF ZINC

Industrial User	1993 Zinc Loading ¹ (Pounds)	1994 Zinc Loading (Pounds)	1995 Zinc Loading (Pounds)	1996 Zinc Loading (Pounds)	1997 Zinc Loading (Pounds)
Riverdale Plating	632	678	705	784	703
Chicago Specialties Inc.	1,258	853	609	1,045	637
Acme Steel - Riverdale	8,644	3,278	126	260	5,777
Allied Tube and Conduit	1,261	2,889	1,601	3,229	2,318
LTV Steel Company	1,132	1,101	523	998	524
F S C Paper Corporation	11,834	7,757	9,081	8,304	6,301
Ford Motor Company	2,218	1,446	1,086	842	579
Chicago Finished Metals	556	348	59	33	32
Allwaste Tank Cleaning	150	210	315	113	146
CID	66	85	167	156	132
Carl Budding Foods	219	137	175	188	150
Clean Harbors	1,064	455	886	1,157	549
Dynagel	330	162	132	151	348
General Mills	146	172	502	467	199
Sherwin Williams	77	56	272	382	64
Witco Chemical	117	108	59	116	119
Ashland Chemical	NA ²	NA	NA	NA	156
JLM Chemical	NA	NA	NA	NA	316
PVS Chemicals	NA	NA	NA	NA	3,056
Clark Refininig	NA	NA	NA	NA	545
Acme Steel - Chicago Plant	NA	NA	NA	NA	801
Wisconsin Tissue Mills	NA	NA	NA	NA	788
Andrew Corporation	NA	NA	NA	NA	111
Total	29,704	19,735	16,298	18,225	24,351

¹Loadings for 1993 were based on all available District sampling data and total plant flow. Flow splits, where applicable, were based on District records. Starting in 1994, loadings were limited to regulated operation discharge sampling data and flow.

²NA = Data not available.

discussions with the Hammond plant, we have determined that 1.27 mg zinc/L is being added to the drinking water, and that the five communities use an average of 10.83 MGD of drinking water. Some of this zinc deposits on the water mains. However, the maximum zinc contribution to the Calumet WRP from the drinking water from these five communities could be as high as 114.7 lbs/day, which is a significant amount of zinc.

Rainfall/Runoff

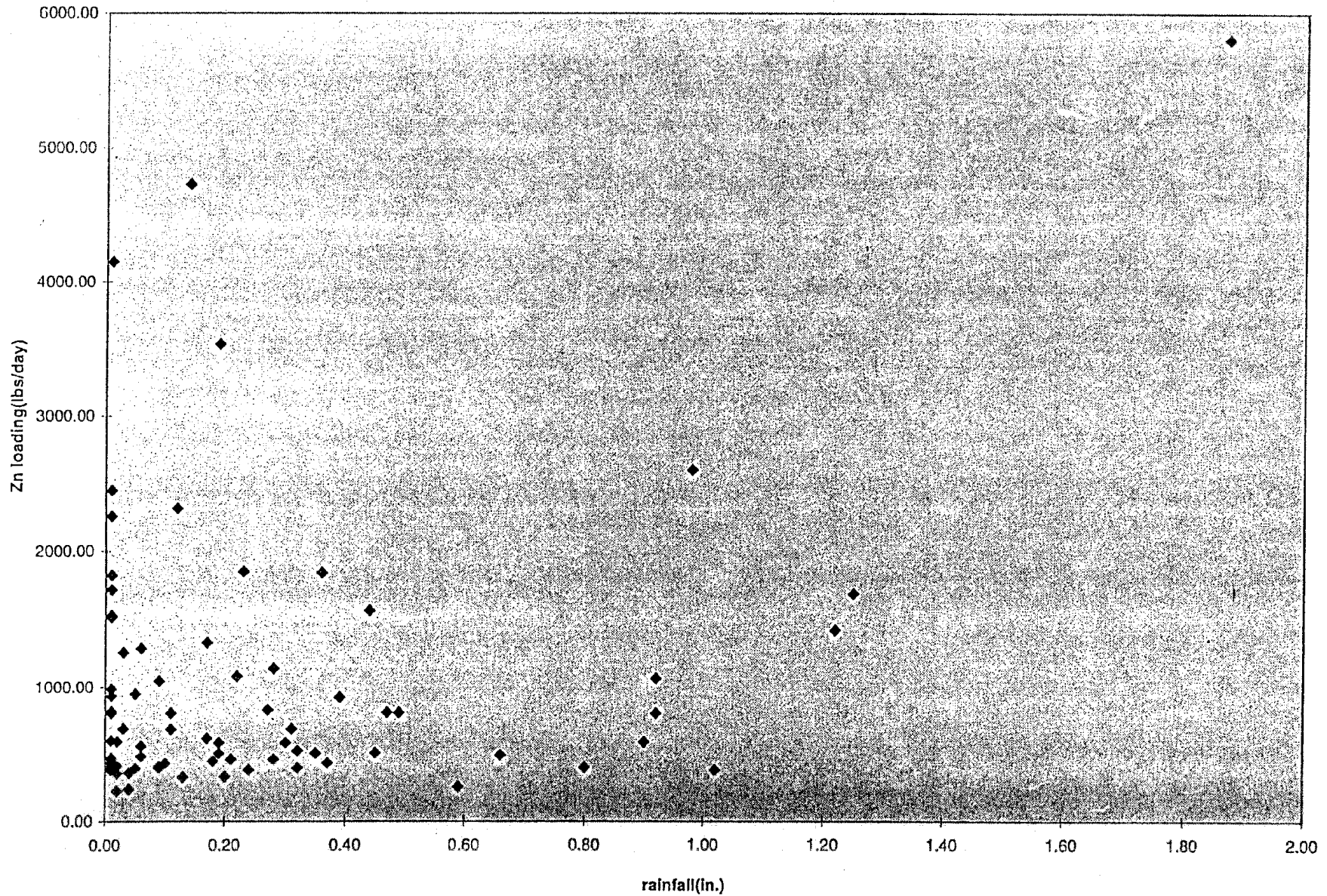
Part of the Calumet WRP service area is a combined sewer area. This means that runoff from rainfall enters the sewer system. As the flows increase during a rain event, the combined sewer overflows are diverted to the Calumet TARP system. Thus, there is a non-point source contribution of zinc to the Calumet WRP during and after rain events. The magnitude of this non-point source contribution was assessed in two ways. First, the relationship between the daily zinc loading and daily rainfall at the Calumet WRP was examined. Secondly, TARP pumpback data was examined.

Figure 9 is a graph of zinc loading versus rainfall during 1997 at the Calumet WRP. Rainfall values come from the Calumet WRP rain gauge. Zinc loadings were calculated from the raw sewage samples and the measured raw sewage flow rate. With the exception of the one extremely high zinc loading value which occurred after a two inch rain, there is no clear correlation between zinc loading and rainfall.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 9

CALUMET WRP ZINC LOADING VS. RAINFALL



TARP pumpback data for 1997 is presented in Table 8. As can be seen, the 1997 average zinc concentration in the TARP pumpback was 0.314 mg/L. As shown previously (Table 2), the 1997 average zinc concentration in the Calumet WRP raw sewage was 0.493 mg/L. Thus, the TARP pumpback does not appear to be contributing a disproportionate amount of zinc to the Calumet WRP.

It should be noted that the TARP pumpback flow is included in the sample collected by the Calumet WRP raw sewage sampler located in the North Screen House.

Based on the above data, it does not appear that non-point source runoff after rainfall is adding a disproportionate amount of zinc to the Calumet WRP.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 8

TARP PUMPBACK ZINC CONCENTRATION AND LOADING
DURING 1997

Date	Flow MGD	Concentration (mg Zn/L)	Loading (lbs Zn/day)
January 1997	23.26	0.365	65
February 1997	23.66	0.227	54
March 1997	42.26	0.379	84
April 1997	16.12	0.251	28
May 1997	13.33	0.358	35
June 1997	34.62	0.163	43
July 1997	22.63	0.274	41
August 1997	29.42	0.305	37
September 1997	17.69	1.024	111
October 1997	15.04	0.180	26
November 1997	17.84	0.134	17
December 1997	21.26	0.106	16
Mean	23.10	0.314	46

ZINC MASS BALANCE

In an attempt to put the previously described zinc data in perspective, and gain some insight into sources of zinc entering the Calumet WRP, an attempt was made to develop a mass balance for zinc entering and leaving the Calumet WRP. An attempt was also made to balance the known sources of zinc entering the Calumet WRP with the measured amount of zinc entering the Calumet WRP.

Table 9 presents the results of the first mass balance. There are two estimates for the amount of zinc entering the Calumet WRP. The first is derived from the raw sewage composite sample multiplied by the total raw sewage flow. This value is 960 lbs/day. The second is based upon the sum of the TARP pumpback zinc loading, which is calculated from a measured flow and a measured zinc concentration, and the interceptor loading, which is calculated from an estimated flow and a measured zinc concentration. This total zinc loading is 541 lbs/day. We believe that this latter calculation is more representative of the actual loading to the Calumet WRP, as will be discussed later.

The amount of zinc leaving the Calumet WRP is the sum of the zinc in the final effluent and the zinc in the digester draw. This value is 507 lbs/day.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9

MASS BALANCE OF ZINC AT THE CALUMET WRP
JULY THROUGH DECEMBER 1997

Raw Sewage Composite Sample* lbs Zinc/day	TARP Pumpback lbs Zinc/day	Four Main Interceptors lbs Zinc/day	Final Effluent lbs Zinc/day	Digester Draw lbs Zinc/day
960	41	500	170	337

*Includes TARP pumpback and plant recycles.

Based upon discussions with various R&D and M&O Department personnel, it is believed that final effluent and digester draw data are the most representative and reliable of those mentioned. Therefore, it is concluded that if 514 lbs of zinc/day is leaving the Calumet WRP, approximately 514 lbs of zinc/day of zinc should be entering the Calumet WRP. From this it is postulated that the interceptor and TARP sampling is giving a better representation of the zinc loading to the Calumet WRP than the raw sewage composite sampler, and that the zinc loading to the Calumet WRP for the July through December 1997 period averaged 541 lbs/day.

Using this assumption, Table 10 presents a breakdown of the identified sources of this 541 lbs/day of zinc. The 166.7 lbs/day of zinc attributed to commercial and household sources is based upon an estimate from data collected at the North Side WRP. The North Side WRP is similar in size to the Calumet WRP, and serves a large urban area. The estimate is derived by taking the average zinc loading in the North Side WRP raw sewage and subtracting the zinc contribution from city of Chicago water and the zinc contribution from known industrial discharges in the North Side WRP service area. The remaining zinc is assumed to represent the large background level of zinc due to the use of household products, small commercial discharges, and street runoff of tire particles and automobile rust, all of which contain zinc. Assuming that this estimate of the commercial and household contribution is reasonable,

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 10

MASS BALANCE OF SOURCES OF ZINC
ENTERING THE CALUMET WRP

Source	lbs of Zinc/day
Estimated total WRP loading from four interceptors and TARP	541
City of Chicago Water	27.6
Hammond, Indiana Water	114.7
TARP Pumpback	41.3
Known Industries	66.7
External Plant Recycles ¹	1.0
Commercial and Household Contribution ²	166.7
Subtotal	418
Zinc unaccounted for = 541-418 = 123	

¹Lagoon supernatant and centrifuge centrate.

²Estimated from North Side WRP data (see text).

known sources account for 418 lbs/day of zinc. This leaves 123 lbs/day or 22.7 percent of the influent zinc unaccounted for. It is our current hypothesis that this zinc comes from large unidentified point source dischargers. As described later in this report, work is continuing in 1998 to isolate and identify all point source discharges of zinc in the Calumet WRP service area.

1998 WORK

During 1998, work is continuing in the following areas:

1. Additional industrial waste sampling is taking place throughout the Calumet WRP service area to identify additional point sources of zinc. In addition, the Industrial Waste Division is sampling smaller local sewers that feed the main interceptors in an attempt to isolate the areas that are contributing large loadings of zinc to the system.
2. Attempts are being made to verify the estimated flows in the four main interceptors, so that a better mass balance of zinc can be calculated.

SUMMARY

In late 1996 and early 1997 it became apparent that the zinc concentration in the Calumet WRP digester draw was increasing such that it was jeopardizing the ability of the Calumet WRP to produce a final sludge product which would meet the USEPA Part 503 Rule APL for zinc.

Based upon this observation the R&D Department, in conjunction with the M&O Department, began an investigation of the sources and loadings of zinc entering the Calumet WRP. This investigation determined that an estimated 541 lbs/day of zinc is entering the Calumet WRP. This is over twice the amount of zinc that enters the North Side WRP which has a similar average daily flow.

Since zinc concentrates in the sludge solids, the concentration of zinc in the final sludge product, on a dry weight basis, will be proportional to the concentration of zinc in the raw sewage. Thus, it is important to determine the various sources of zinc entering the Calumet WRP.

Based upon the available data, it is estimated that approximately 142.3 lbs of zinc/day come from the domestic drinking water, 66.7 lbs/day come from known industries, 41.3 lbs/day come from TARP pumpback, 1.0 lb/day comes from external plant recycles, and 166.7 lbs/day come from commercial and household sources. The source of the remaining 123 lbs/day is unknown.

A comparison of the raw sewage zinc loading at the Calumet WRP with that of the North Side WRP indicates that the Calumet WRP is receiving a higher zinc loading than would be expected for a WRP of its size.

The District has established a Target Level of 1691 mg of zinc/kg in the Calumet WRP as the concentration required to ensure that the USEPA APL of 2800 mg/kg for zinc in the final sludge product is met. The 1997 average zinc concentration in the Calumet WRP digester draw was 1758 mg/kg. Thus, even a ten percent reduction in the current zinc concentration in the digester draw would be significant. Therefore, a continuing effort should be made to identify the unknown sources of zinc in the Calumet WRP service area, and to determine if reductions in these sources, or in the known sources, is possible.