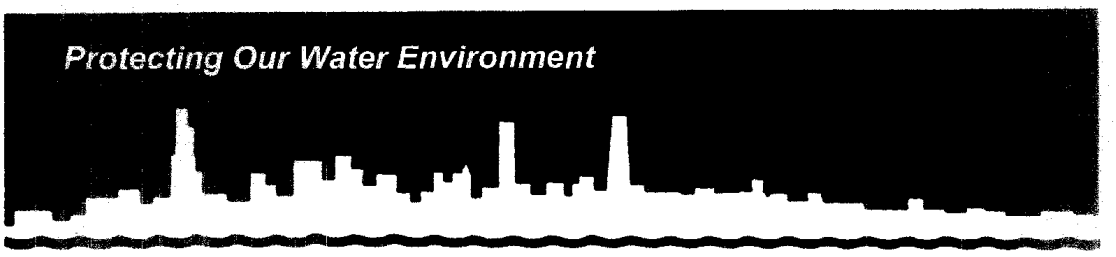

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 02-2

EVALUATION OF ODOR POTENTIAL OF CENTRIFUGE CAKE DURING AIR-DRYING OPERATIONS

February 2002

Metropolitan Water Reclamation District of Greater Chicago

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EVALUATION OF ODOR POTENTIAL OF CENTRIFUGE CAKE DURING AIR-DRYING OPERATIONS

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

ACKNOWLEDGMENTS

The authors wish to acknowledge the contributions of Mr. William Robinson, Research Scientist II (retired), who coordinated and oversaw this project in its initial years. Also acknowledged are Messrs. John Szafoni, Tom Minarik, and Saeed Farooqui, and Ms. Tiffiany Tate, Laboratory Technicians in the Wastewater Treatment Research Section who carried out the sampling and data collection for this project.

The assistance of Messrs. Norman Rose and Booker Washington and their staff of the Analytical Laboratories Division in providing the analytical support is also acknowledged.

The assistance of Mr. Zainul Abedin, Associate Biostatistician, in performing the statistical evaluation of the data is greatly appreciated.

The authors also acknowledge the assistance of the Maintenance and Operations Department staff at the Stony Island Drying Site for providing the necessary operational information.

Particular thanks are due Ms. Laura Franklin for her diligence in typing and proofreading the manuscript of this report.

The authors also thank Ms. Margo Neniskis of Science Communications International for her review and constructive comments as technical editor.

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

The majority of the centrifuge cake produced at the Stickney Water Reclamation Plant (WRP) is aged in lagoons for 18 to 36 months before it is air-dried on paved drying cells. The construction of the McCook Retention Reservoir will reduce the amount of lagoon capacity in the future. The Maintenance and Operations (M&O) Department was concerned about the potential unavailability of lagoon space for aging the centrifuge cake. It requested the Research and Development (R&D) Department to determine whether centrifuge cake without the lagoon-aging could be air dried at the LASMA/HASMA drying areas without an increase in odors.

Presently, some centrifuge cake without lagooning is dried at the Stony Island Drying Area. The air-drying of centrifuge cake is usually conducted from May through October and it generally requires approximately three to six weeks to reach a cake solids of 60 percent or greater.

To offset the variability in the properties of centrifuge cake and weather conditions, this study was conducted over three drying seasons, 1997, 1998, and 1999. In this study, the lagooned centrifuge cake, which has been lagooned for 18 months, is referred to as "aged" cake. Centrifuge cake

without the lagoon aging is referred to as "unaged" or "fresh" cake.

Batches of aged cake and fresh cake were simultaneously dried in drying cells at the Stony Island Drying Area, and the odor potential was monitored during the drying cycles. Three random samples of each type of cake being dried were collected in five-gallon pails from the given cells at a frequency of once a week during each drying cycle. The odor potential of the headspace air in the pails over the cake sample was determined by an odor panel using a forced-choice triangle procedure and expressed as an ED_{50} value. Portions of the samples were analyzed for ammonia-N (NH_4-N), total Kjeldahl nitrogen (TKN), total solids, and total volatile solids to characterize the centrifuge cake.

Statistical comparisons of the ED_{50} values of the fresh cake and the aged cake were carried out. These comparisons included all matched sets of data (paired data) by the date of sampling of the ED_{50} values of the individual samples and the averages of the three random daily grab samples. Statistically, no significant difference between the ED_{50} mean values of the fresh cake and of the aged cake was found.

The fresh cake ED_{50} showed a much greater variability in comparison to the variability of aged cake data. The ED_{50}

values of the fresh cake with a mean of 125 (range of 9 to 970) had a standard deviation of 133 as compared to the aged cake ED_{50} values with a mean of 96 (range of 14 to 328) and a standard deviation of 68. The majority of the samples had an ED_{50} of less than 200 (86 percent of the fresh cake and 93 percent of the aged cake).

The data were also sorted into different groups of percent solids and compared with respect to their ED_{50} values. Both types of centrifuge cake showed a decrease in ED_{50} values as the cakes were dried to higher percent solids. For the fresh cake with total solids less than 30 percent, an average ED_{50} value of 160 was observed, while an average value of 99 was observed for the same cake dried to 60 percent total solids. For the aged cake having total solids less than 30 percent, the average ED_{50} value was 93 as compared to 69 for the same cake dried to 60 percent total solids.

The percent total solids, volatile solids, ammonia nitrogen, and TKN data were used to correlate with odor potential (ED_{50}). No correlation was obtained between ED_{50} and percent total solids and volatile solids, ammonia nitrogen, and TKN for both the types of cakes.

The following conclusions are drawn from this study:

1. Comparison of the overall mean ED_{50} values of the aged and fresh cakes showed that there was no statistical difference between them, suggesting that the odor potential of the two types of cakes during drying would be similar.
2. The fresh cake showed greater variability in ED_{50} values than the aged cake.
3. Although there was no statistical difference in the ED_{50} values of fresh and aged cakes, the greater variability in the fresh cake suggests a greater possibility for higher odor levels to occur when drying fresh cake as compared to aged cake.
4. The drying of centrifuge cake decreases the odor, as measured by ED_{50} values, with a 38 percent decrease observed for fresh cake and a 26 percent decrease for aged cake when dried from less than 30 percent solids to greater than 60 percent solids.
5. For the most part during 1997 through 1999, the ED_{50} values have been observed to be under 200. This was observed regardless of type of cake,

and suggests a relatively low odor potential of the cakes that were studied.

6. Air-drying of centrifuge cake that is lagoon-aged less than 18 months due to future reductions in lagoon capacity should not produce any greater potential for odors during the drying process than for 18-month lagoon-aged cake.

It should be noted, however, that an 18-month lagoon-aging period for centrifuge cake is required for the proposed Class A PFRP codified operation, and for the use of the centrifuge cake as final landfill cover under Illinois Pollution Control Board AS 95-4.

INTRODUCTION

Experience at the Metropolitan Water Reclamation District of Greater Chicago (District) has shown that the odor potential of centrifuge dewatered anaerobically digested sludge is minimized by aging it in lagoons before it is air-dried on paved drying cells. The District believes that the reduction in odor potential is mainly due to further stabilizing of the organic matter in the centrifuge cake over a long detention time (18 to 36 months) in lagoons.

The District's M&O Department modified the sludge drying train for a portion of the centrifuge cake in 1997. Under this change, the centrifuge dewatered sludge is directly air-dried without stabilizing the cake in the lagoons. A modification in the sludge treatment train may have a bearing on odor potential of the centrifuge cake. The odor impact of the proposed change in the sludge treatment train prompted a study which was initiated during 1997. The objective of the study was to evaluate and compare odor potential of the aged centrifuge cake and the fresh centrifuge cake during the air-drying operation.

METHODOLOGY

Sludge Processing

All of the sludge for this study originated at the Stickney WRP, where the anaerobically digested sludge was centrifuged and then either placed into lagoons for aging or shipped directly to the Stony Island Drying Area. The anaerobically digested sludge is conditioned with cationic polymer and mechanically dewatered in high-solids centrifuges to a cake having a solids content of approximately 24 to 28 percent. For the purpose of this study, the centrifuge cake follows one of two process pathways:

1. Aged cake: Centrifuge cake is transported and placed in aging lagoons at the LASMA site, where it is retained for 18 months for further stabilization and dewatering. The aged lagooned sludge is then air-dried in batches on paved drying cells to approximately 60 percent solids content.
2. Fresh cake: The centrifuge cake is shipped directly to the drying cells, where it undergoes a similar air-drying process.

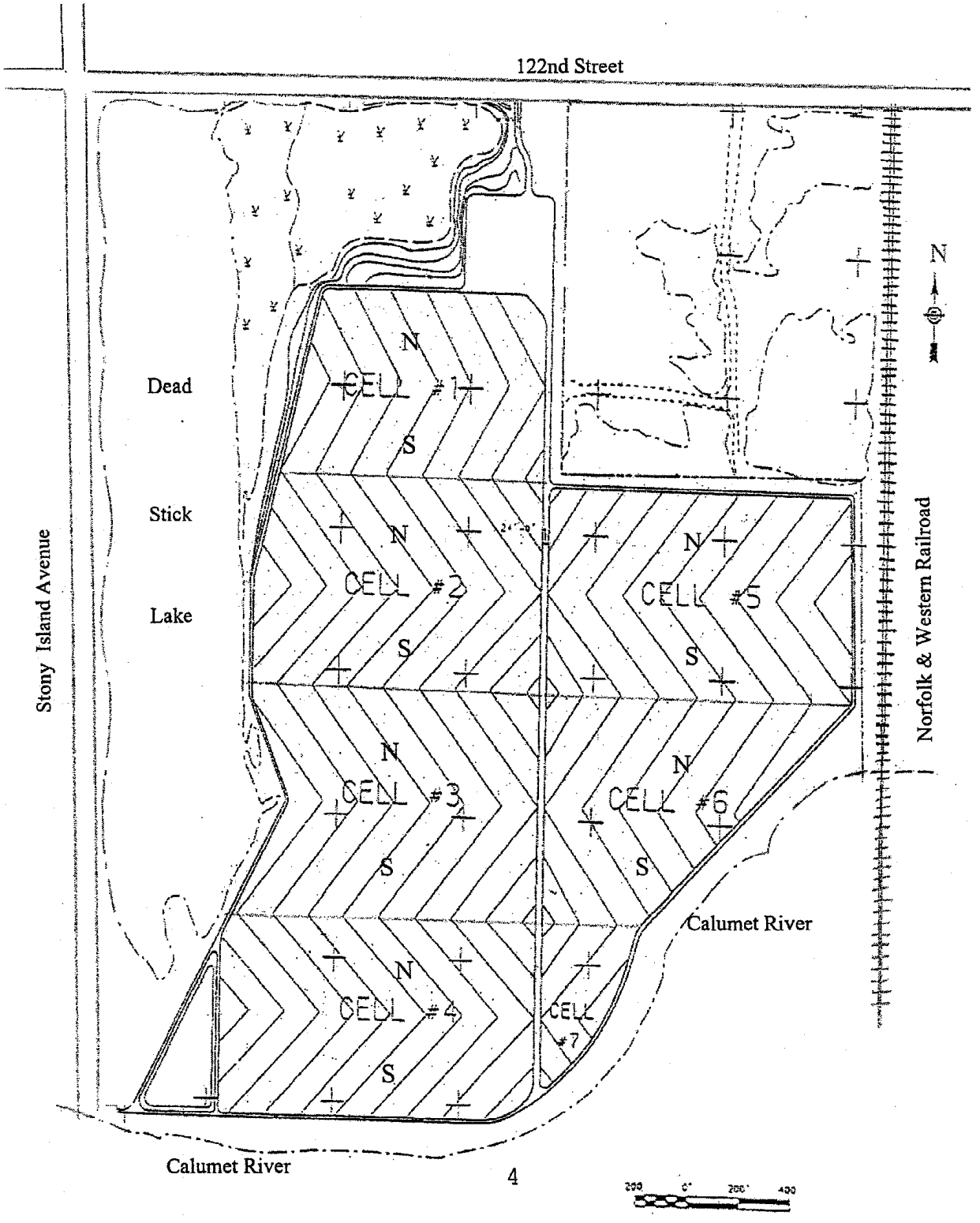
The air-drying operations are generally conducted from May through October. Application to each drying cell is no more than 410 dry tons per acre, and the centrifuge cake is applied on the drying cell no more than 18 inches deep. The air drying operations which were monitored during this study are for the Stony Island Drying area. The layout of the various drying cells is shown in Figure 1.

The centrifuge cake is held on the paved drying cells until approximately 60 percent total solids (TS) is achieved. In many instances, per need of either drying space or dried cake material for final use, the cake is removed before it is dried to 60 percent total solids. Also, the dried cake may not achieve 60 percent total solids due to rainfall and other weather related conditions. Depending upon the weather, the drying period is typically between three to five weeks, although in this study, drying times as short as seven days or as long as 90 days were reported. During the drying period, the centrifuge cake is turned, aerated, and agitated approximately three times a week using a tractor with a horizontal auger or tiller.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 1

DRYING CELLS AT STONY ISLAND DRYING AREA



Sampling and Analytical Methodology

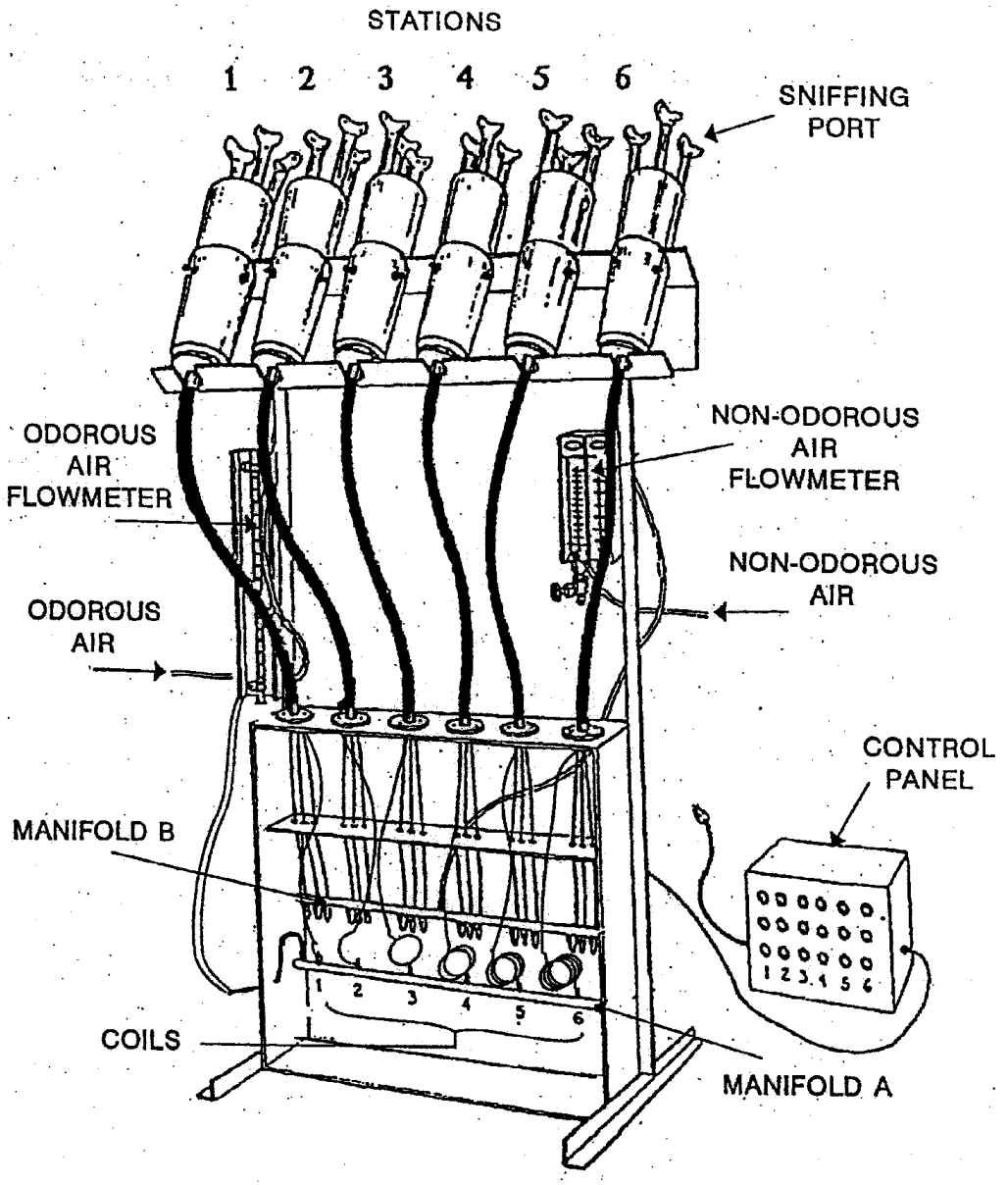
Samples of the centrifuge cake being dried were collected once per week from three locations selected randomly in a given drying cell. A five-gallon bucket was filled approximately three-quarters full, sealed, and transported to the Lue-Hing Research and Development (R&D) Complex in Stickney. A portion of each sample was then taken for analysis of four elements: NH_4-N, TKN, TS, and total volatile solids (TVS) (Standard Methods, 1995).

The odor potential of the headspace air was determined using a panel of six to eight sniffers recruited from the employees of the Lue-Hing R&D Complex in Stickney. Each sniffer followed a forced-choice triangle procedure using a dynamic (in-flow) dilution olfactometer (IIT Research Institute, Model 103) shown in Figure 2. This system uses carbon-filtered ambient air to produce a series of dilutions of the headspace sample being tested. The clean air and the sample are mixed for presentation at the sniff cups. Each dilution is presented to the panelist by means of three identical sniff cups. Two of the cups have only carbon-filtered air, while the third has the diluted odorous air. Panelists are asked to choose which of the cups has an odor. The panelists must choose a cup whether or not an odor is discerned. The detection

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 2

DYNAMIC FORCED-CHOICE TRIANGLE OLFACTOMETER



Manufactured by: IIT Research Institute - Model 103

threshold represents the dosage of odorant necessary for 50 percent of the panel to detect a difference between the odorous air and the odor-free air. This is the point at which the panelist correctly selects the cup which contains the odorous sample. All odor measurements are expressed as an average value termed ED_{50}. This term denotes Effective Dosage at the 50 percent level. It is that dilution at which 50 percent of the panel would detect the odor of the undiluted sample, and 50 percent would not. The dilution may also be denoted by a dilution-to-threshold ratio. For example, an ED_{50} of 100 means that the volume unit of the odorous air must be diluted with 100 volume units of nonodorous air to reach the panel threshold ED_{50}.

Statistical Methods

The following parametric and non-parametric analyses were performed on the data, following methods published in Nonparametric Statistical Inference (1992) and Statistical Analysis of Nonnormal Data (1995). Analysis of variance, an exact and approximate t tests, and a Wilcoxon rank-sum test were used for determining significant probability values. Common statistics such as range, averages, standard deviation, and correlation coefficients were also determined.

RESULTS

Batches of aged cake and fresh cake were monitored as they were being dried on the drying cells. Table 1 summarizes the various groups in terms of drying cell, dates which cake was applied, last day of sampling towards end of drying period, and the duration of the drying period. The drying duration in this study varied depending upon the time of the year. The longest times occur at the end of the year when sludge is placed in the drying cells at the end of October and November and remains into the following year.

As previously mentioned, not all of the batches of sludge were dried to 60 percent solids. A review of rainfall data for each of the sludge fill and drying time periods shown in Table 1 reveals that in 1998 and 1999 rainfall events played a significant role in wetting the dried cake of some of the batches being dried. As a result, the final cake solids were substantially lower than 60 percent. Also, the material placed on the drying cells in October of each year was left over the winter into the following year. The batches affected by rainfall and/or drying temperature are those with a last day of drying of September 8, 1998, October 13, 1998, December 15, 1998, August 10, 1999, and December 21, 1999.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 1

SCHEDULE OF CENTRIFUGE CAKE DRYING CYCLES - 1997 THROUGH 1999

Type of Sludge Cake	Drying Cell Address	Sludge Fill Dates	Last Day of Drying[1]	Drying Duration Days[2]	Initial Percent Solids[3]	Final Percent Solids[3]
Fresh Cake	2 North	8/11-13/97	10/7/97	48	23.28	56.57
	1 North	6/6-11/98	7/8/98	29	26.37	48.63
	2 North	7/9-14/98	7/21/98	7	34.28	60.52
	2 North	7/24-29/98	8/18/98	20	26.37	52.69
	2 North	8/26-29/98	9/8/98	7	38.79	40.93
	4 South	9/19-25/98	10/13/98	21	33.05	39.97
	4 South	10/16-24/98	12/15/98	55	43.62	30.87
	4 South	6/19-23/99	7/13/99	21	30.69	67.29
	4 South	7/17-21/99	8/10/99	20	27.30	23.75
	3 North	8/18-21/99	9/14/99	27	47.30	53.90
	4 North	9/21-23/99	12/21/99	90	25.57	28.85
Aged Cake	6 North	8/9-13/97	10/7/97	48	21.35	54.20
	6 North	6/15-18/98	7/8/98	22	25.69	52.17
	5 North	7/27-30/98	8/25/98	27	24.96	51.80
	3 North	9/18-21/98	10/13/98	21	27.80	46.63
	5 North	10/16-27/98	12/15/98	55	25.90	30.83
	5 South	10/12-14/99	12/21/99	69	36.66	50.76

[1]The last day of drying is the last day of sampling before the dried cake is removed from the drying cell. It may not always be the last day of drying.

[2]Drying duration is counted from the last day of fill to the last day of drying.

[3]Samples may not always be collected on the first and last day of drying to determine initial and final percent solids.

In addition to the fresh cake and aged cake, there were several other modified types of cake which were studied. These included underaged cake, i.e., cake which had not been lagooned for the full 18 months, stockpiled fresh cake and aged cake, and winterized cake, i.e., fresh cake which was applied at start of winter season and kept on the drying cells until the following spring. Details on modified cakes are presented under "Supplemental Studies."

The statistics of field and analytical data collected over three years from 1997 through 1999 are summarized in Table 2, by year, for each of the observed parameters. The table shows a total of 2,659 observations. Of these, 528 observations pertained to total solids, 534 were to percent total volatile solids, 532 were to ammonia nitrogen, 531 were to Kjeldahl nitrogen, and 534 were to odor potential, or ED_{50}. Table 3 shows the summary of the same data by the type of cake. This table shows that 929 observations were made on fresh cake over three years, while 600 observations were made on aged cake, and the remaining 1,130 observations on other types of cake.

For all three years, the average ED_{50} value is 112, with a maximum of 970 and a minimum of 9. This wide range of ED_{50} data shows a highly variable pattern in odor observations.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 2

SUMMARY OF DATA BY YEAR - 1997-1999

Year	Parameter	%TS	%TVS	NH_4-N (mg/L)	TKN (mg/L)	ED_{50}
1997	Minimum	21.35	30.68	40	7663	9
	Maximum	79.22	48.38	5314	27879	263
	Average	56.84	41.23	2034	16922	75
	n	86	86	84	84	86
1998	Minimum	20.05	16.88	46	2621	14
	Maximum	72.54	63.32	4345	25373	970
	Average	40.17	46.49	1331	12706	116
	n	214	214	214	214	214
1999	Minimum	19.39	21.90	300	1756	12
	Maximum	94.72	64.67	23038	30433	581
	Average	45.89	42.66	2529	13076	122
	n	228	234	234	233	234
1997-1999	Minimum	19.39	16.88	40	1756	9
	Maximum	94.72	64.67	23038	30433	970
	Average	45.36	43.96	1969	13535	112
	n	528	534	532	531	534

Abbreviations:
%TS = percent total solids.
%TVS = percent total volatile solids.
NH_4-N = ammonia nitrogen, mg/L.
TKN = total Kjeldahl nitrogen, mg/L.
ED_{50} = olfactory value, measured as effective dosage at the 50 percent level.
n = number of values.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

SUMMARY OF DATA BY TYPE OF CAKE 1997 - 1999

Type of Cake	Parameter	%TS	%TVS	NH_4-N, mg/L	TKN, mg/L	ED_{50}	Total Number by Type
Fresh Cake	Minimum	20	28	115	2193	9	
	Maximum	89	56	23038	26012	970	
	Average	41	47	1972	13454	127	
	n	184	187	186	185	187	929
Aged Cake	Minimum	20	27	115	4026	14	
	Maximum	95	65	3588	27141	328	
	Average	43	42	1739	12586	99	
	n	118	121	120	120	121	600
1997-1999 Both Types	Minimum	20	27	115	2193	9	
	Maximum	95	65	23038	27141	970	
	Average	42	45	1880	13112	116	
	n	302	308	306	305	308	1529
Others	Minimum	19	17	40	1756	14	
	Maximum	86	63	17461	30433	523	
	Average	50	43	2088	14106	106	
	n	226	226	226	226	226	1130
1997-1999 Both Types And Others	Minimum	19	17	40	1756	9	
	Maximum	95	65	23038	30433	970	
	Average	45	44	1969	13535	112	
	n	528	534	532	531	534	2659

NOTE: "Others" includes winterized, fresh stockpile, aged cake stockpile, and underaged cake data. Fresh cake data do not include winterized cake data.
n = number of values.

Table 2 also shows a slight increase in a yearly average value of ED_{50}, beginning in 1997, but this may be because of the relatively few samples collected in 1997.

For all three years of data, the average ED_{50} value for fresh cake (127) is approximately 28 percent higher than that of aged cake (99). Table 3 also shows that the variability in ED_{50} observations is much higher in fresh cake, as compared to aged cake data.

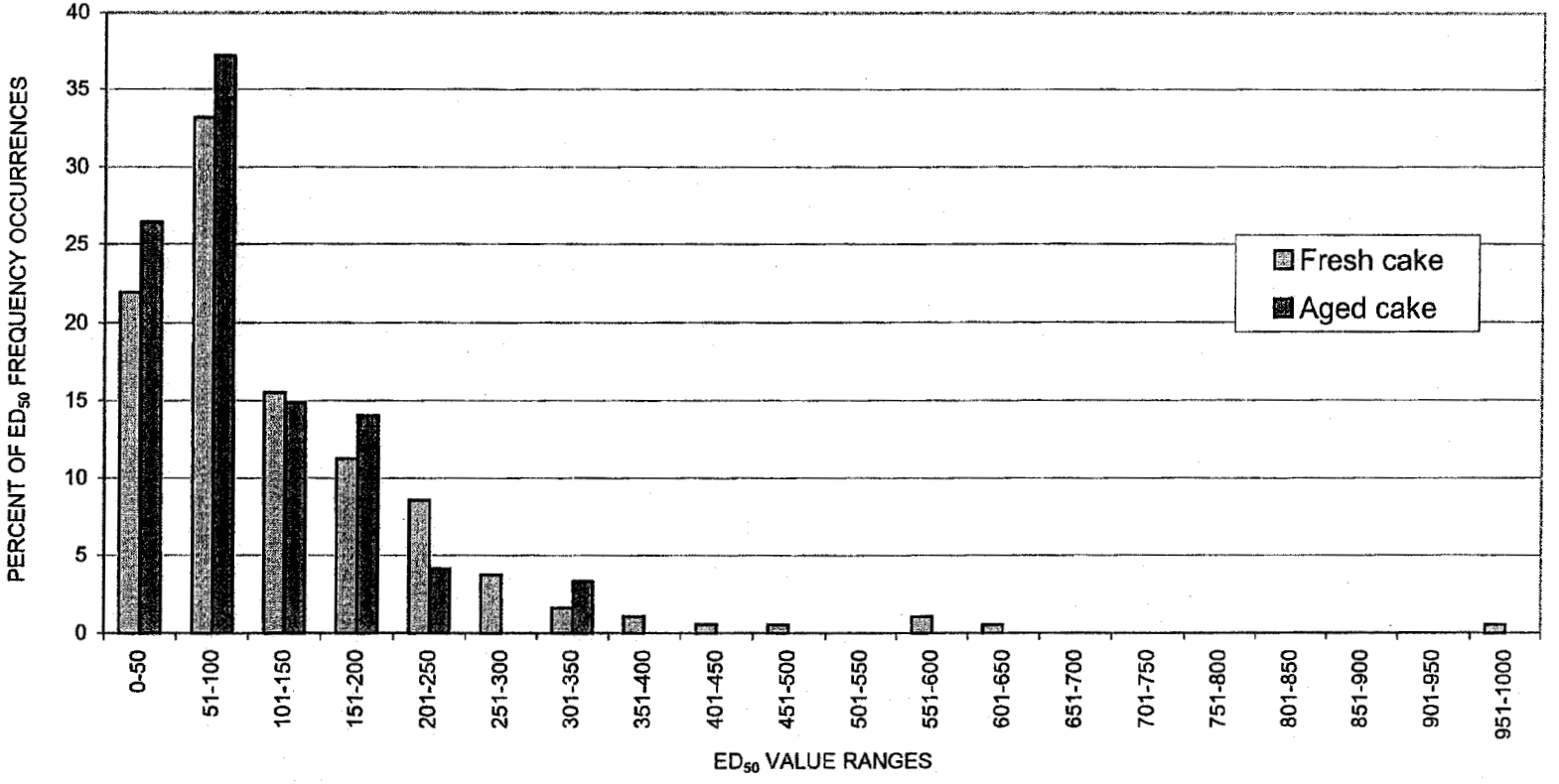
All data as observed and recorded are presented by year 1997, 1998, and 1999 in Appendix AI, Tables AI-1 through AI-4, AI-5 through AI-8, and AI-9 through AI-12, respectively. These tables show the values for percent total solids, total volatile solids, ammonia nitrogen, total Kjeldahl nitrogen, and ED_{50} for each observation.

Figure 3 is a histogram showing the frequency distribution of the ED_{50} observations for both the fresh and aged cake data. It may be noted that the distributions follow similar patterns, except that the fresh cake has a number of ED_{50} values higher than 350. Ninety-two percent of the ED_{50} values were less than 200 for the aged cake, while 86 percent of the fresh cake values were less than 200. Although an ED_{50} value of 200 is an arbitrary cutoff point, previous experience at

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 3

FREQUENCY DISTRIBUTION OF ED_{50} FOR FRESH AND AGED CAKE DATA



the District indicates that ED_{50} values less than 300 are relatively inoffensive to the general public.

In order to determine whether a statistically significant difference exists between the ED_{50} means of fresh cake and aged cake, two data sets matched by dates of sampling (paired data) were created and examined. The first data set is the original data set matched by dates of sampling, containing the individual sample values, a total of 534 ED_{50} observations on fresh and aged cake. The second data set is the strata average of the first data set and has 153 observations. That is, the second set is generated taking averages of the individual samples collected on a given date. These samples are known as strata samples and the average is termed strata average in this report when discussed in a statistical parlance. Both the paired data sets are presented in Appendix AI, Tables AI-13 and AI-14.

Both the paired data sets, consisting of individual values and the strata average values, were first tested for normality to see if the data sets came from normal population. Based on the test results, the parametric or non-parametric tests were performed. If the data came from a normal population then for testing the equality of two population means is done by using z test or t test, known as parametric analysis

of variance. If the data is not found normal (i.e. significantly different from normality) then non-parametric analysis of variance is performed using Wilcoxon rank-sum test.

The large sample theory for normality is applicable for both the paired data sets because the sample size for each type of cake in both the data sets is greater than 30.

If the data come from normal population or large sample theory holds, then t test (also known as exact t test) for comparing equality of mean ED_{50} values of both cakes is performed if equality in variance is found to be equal as determined by the f test. If the f test shows that equality in variance between the two cakes is significant then an approximate t test is performed. The z test is also appropriate for large sample cases like this one (the sample size is greater than 32 in both cakes), but it is not shown here because the significant probabilities due to the z test and the t test are equal. The Wilcoxon rank-sum test is performed when data did not come from normal population.

Regardless of normality found in the database, as a routine statistical approach to support the conclusions, both parametric and non-parametric tests were performed and the significant probability values were selected to determine whether the ED_{50} means of both cakes are different. The

significant probability for testing equality of two means will be due to t test (exact or approximate t test) if the data came from normal population otherwise the significant probability will be due to Wilcoxon rank-sum test if the population is neither normal nor large sample theory is applicable.

Both the paired data sets were examined as explained above. The test results are shown as summary statistics in Tables 4 through 7. Table 4 contains the summary statistics, and Table 5 contains information about the tests and results of the original data set. Similarly, Table 6 contains the summary statistics, and Table 7 contains information about tests and results of the strata average data set.

The testing of equality of ED_{50} means shows that the differences in the ED_{50} means of the fresh cake and aged cake are highly insignificant. In the case where individual values are matched by date, the significant probability is about 0.345 which is highly significant, indicating that odor potential of both aged and fresh cakes is no different (Table 5). The same statistical inference is corroborated from the strata average data set because the testing using the strata average data matched by dates shows that the two means are not different (Table 7; $p = 0.237$). A slight decrease in probability value

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

SUMMARY STATISTICS ON ORIGINAL DATA SET - MATCHED BY DATES

Parameter Studied	Total Obs.	Fresh Obs.	Aged Obs.	Fresh Avg.	Aged Avg.	Fresh Std. Dev.	Aged Std. Dev.
ED_{50}	254	127	127	125.3	96.1	133.1	68.4
TKN	250	125	125	14168.8	12498.7	4277.1	4500.7
NH_4-N	252	126	126	1459.1	1774.4	647.7	735.4
TS	248	124	124	38.9	42.1	11.4	17.6
TVS	254	127	127	47.8	41.7	3.0	6.2

Obs. = Observations.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

STATISTICAL TEST RESULTS ON ORIGINAL DATA SET - MATCHED BY DATES

Parameter Studied	Normal Sig. Prob.	F Test Sig. Prob.	DF of t	t Test Sig. Prob.	Wilcoxon Sig. Prob.	Appropriate Sig. Prob.
ED_{50}	0.000	0.000	188.3	0.029	0.345	0.345
TKN	0.006	0.286	248.0	0.003	0.001	0.001
NH_4-N	0.000	0.078	250.0	0.000	0.000	0.000
TS	0.000	0.000	210.7	0.095	0.861	0.861
TVS	0.000	0.000	180.8	0.000	0.000	0.000

Sig. Prob. = Significant probability.
DF of t = Degrees of freedom of t test.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6

SUMMARY STATISTICS ON STRATA AVERAGE DATA SET - MATCHED BY DATES

Parameter Studied	Total Obs.	Fresh Obs.	Aged Obs.	Fresh Avg.	Aged Avg.	Fresh Std. Dev.	Aged Std. Dev.
ED_{50}	66	33	33	139.8	105.6	97.9	58.0
TKN	64	32	32	13575.6	12167.2	3608.1	4281.7
NH_4-N	64	32	32	1491.1	1742.9	610.2	711.4
TS	64	32	32	36.8	40.6	8.6	17.9
TVS	66	33	33	48.2	42.9	2.4	5.3

Obs. = Observations.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7

STATISTICAL TEST RESULTS ON STRATA AVERAGE DATA SET - MATCHED BY DATES

Parameter Studied	Normal Sig. Prob.	F Test Sig. Prob.	DF of t	t Test Sig. Prob.	Wilcoxon Sig. Prob.	Appropriate Sig. Prob.
ED_{50}	0.000	0.002	52.0	0.091	0.237	0.237
TKN	0.509	0.173	62.0	0.160	0.055	0.160
NH_4-N	0.014	0.199	62.0	0.134	0.158	0.158
TS	0.000	0.000	44.7	0.292	0.920	0.920
TVS	0.000	0.000	44.5	0.000	0.000	0.000

Sig. Prob. = Significant probability.
DF of t = Degrees of freedom of t test.

in case of strata average data set has no statistical significance; however, it indicates that the variation in the data is minimized when the strata average data set is used for testing two means.

Another characteristic feature of this data set lies in its variability of observations. As shown previously in Tables 2 and 3, the fresh cake ED_{50} showed a much greater variability than the aged cake data. As can be seen in Table 4, the ED_{50} values of the fresh cake with a mean of 125 had a standard deviation of 133, as compared to the aged cake ED_{50} values with a mean of 96 and a standard deviation of 68. In contrast, the other parameters showed approximately similar variabilities for fresh cake and aged cake.

The three individual daily values were also averaged (strata average), and the overall mean and standard deviations computed. Table 6 presents the statistics for the strata average data matched by dates. While the variability of ED_{50} is not as great as with the individual values, the fresh cake still shows greater variability than the aged cake as measured by the standard deviation.

DISCUSSION

Scatter plot diagrams showing the measure of odor intensity, ED_{50}, on the X-axis, and each given sludge cake parameter (percent TS, percent TVS, NH_4-N, and TKN), were examined to determine a general trend or a possible relationship in each cake group.

In all, 28 scatter plots were prepared. While the figures chosen to be in this report do not show a conclusive trend, it is important to note that most of the observation on ED_{50} were below 200 regardless of type of cake and sludge parameters. Another point is that regardless of cake type no consistent trend or significant relationship was found between ED_{50} and any other parameters.

ED_{50} and Nitrogen

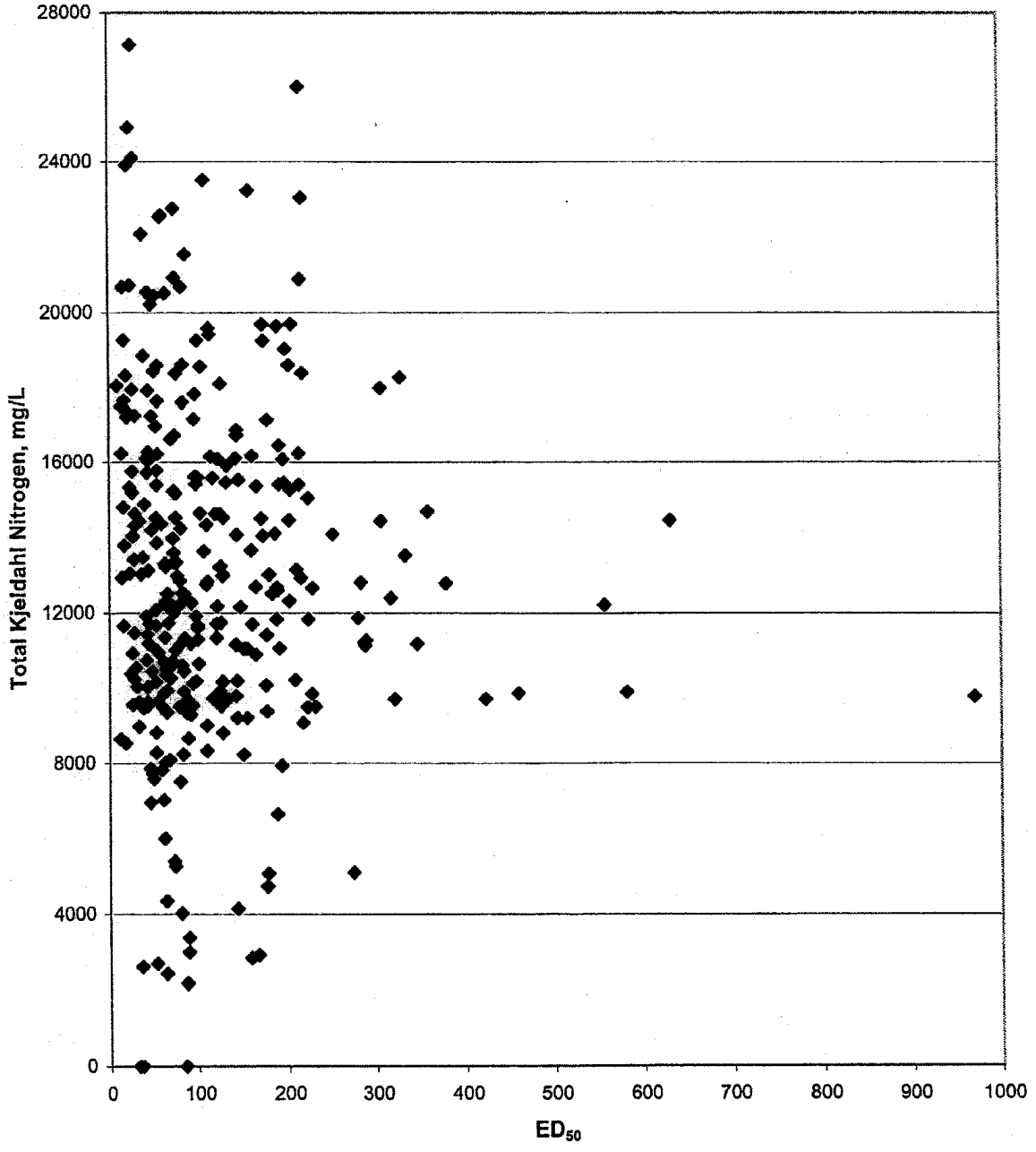
Figure 4 shows a scatter plot between ED_{50} and TKN for all data. There is no discernible trend between ED_{50} and TKN. As can be seen, ED_{50} values remained under 200 for most periods in three years regardless of TKN concentration.

Figure 5 is a plot of ED_{50} and ammonia, and does not show an apparent or clear trend between odor potential and ammonia levels when both types of cake data are combined.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 4

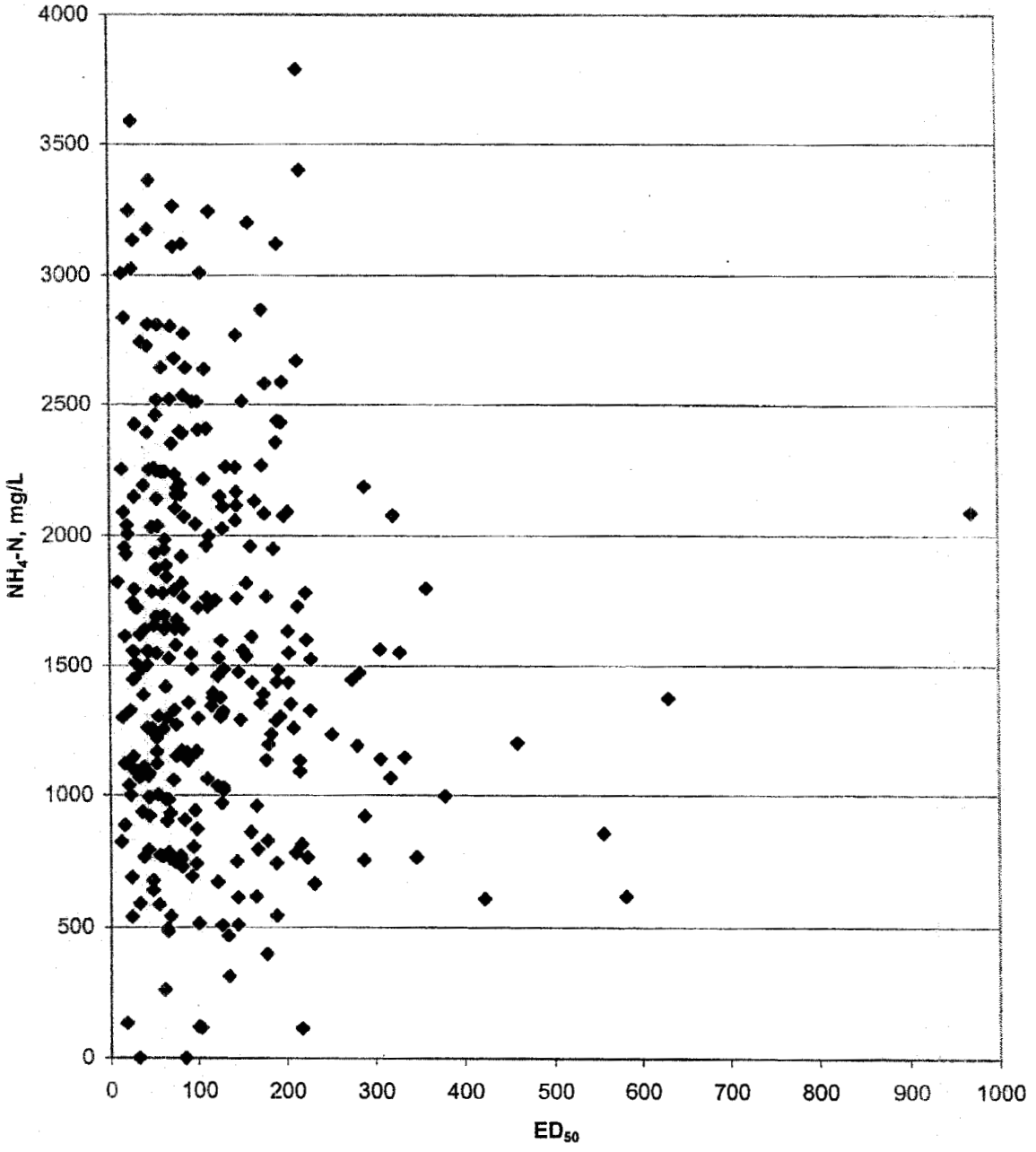
SCATTER PLOT FOR FRESH AND AGED CAKE COMBINED DATA (1997-1999): ED_{50} VS. TOTAL KJELDAHL NITROGEN



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 5

SCATTER PLOT FOR FRESH AND AGED CAKE COMBINED DATA (1997-1999): ED_{50} VS. NH_4-N



Since all the data did not show a clear trend as a function of ED_{50}, the similar scatter plots were prepared to find a trend in each data group separately. Figure 6 shows a wide range of ammonia values for aged centrifuge cake. The majority of the odor levels were found to be less than 200. Figure 7 shows similarly a wide range of ammonia values for fresh cake, and no apparent trend. Again, odor levels were found to be at relatively low levels.

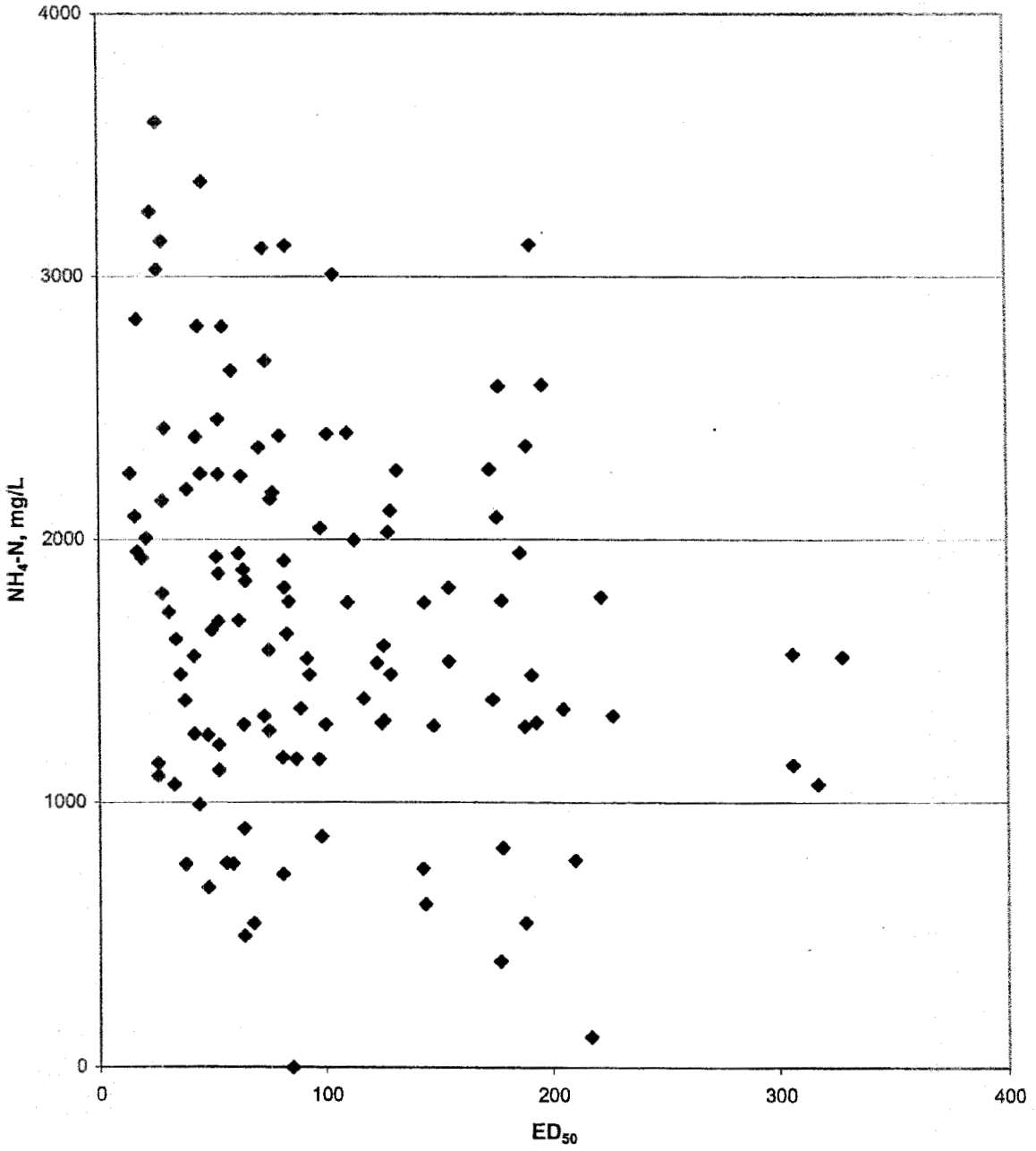
Since all the data did not show a clear trend as a function of ED_{50}, scatter plots were also prepared for the individual drying cycles of the different types of centrifuge cake.

When plotted linearly, the ED_{50} values sometimes varied inversely in response to variations in ammonia concentrations. As for example, Figure 8, which includes aged cake data over the period of October 12 through December 21, 1999, shows that ED_{50} increases with a decrease in ammonia concentration. This contradicts the assumption that while sludge is being dried in drying cells, volatilization of ammonia from the sludge would give off odor, and as a result, the ED_{50} levels would be expected to increase with higher ammonia levels. However, Figure 9, which shows aged cake data over the period of July 28 through August 25, 1998, exemplifies the anticipated trend

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 6

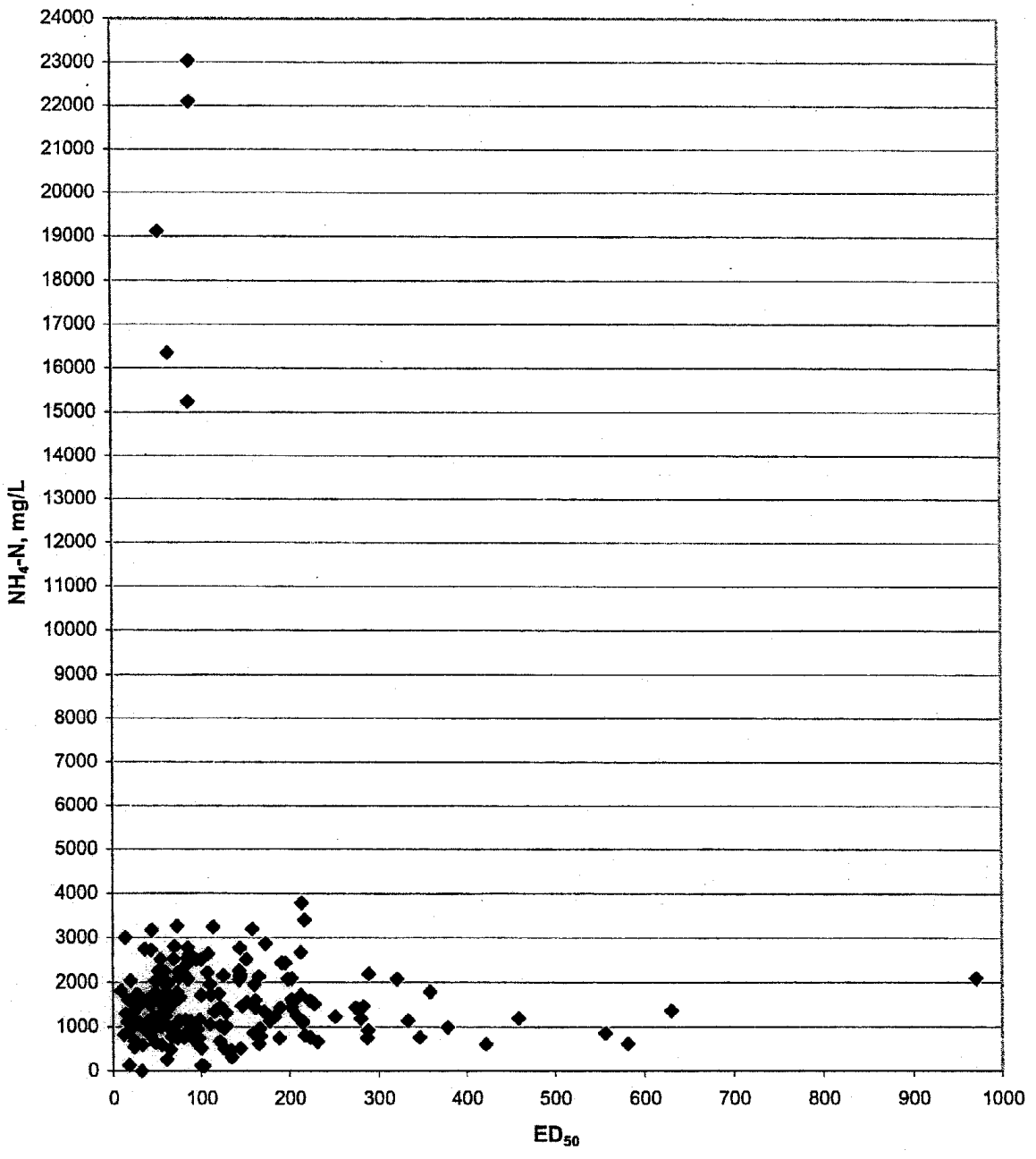
SCATTER PLOT FOR AGED CAKE DATA (1997-1999): ED_{50} VS. NH_4-N



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 7

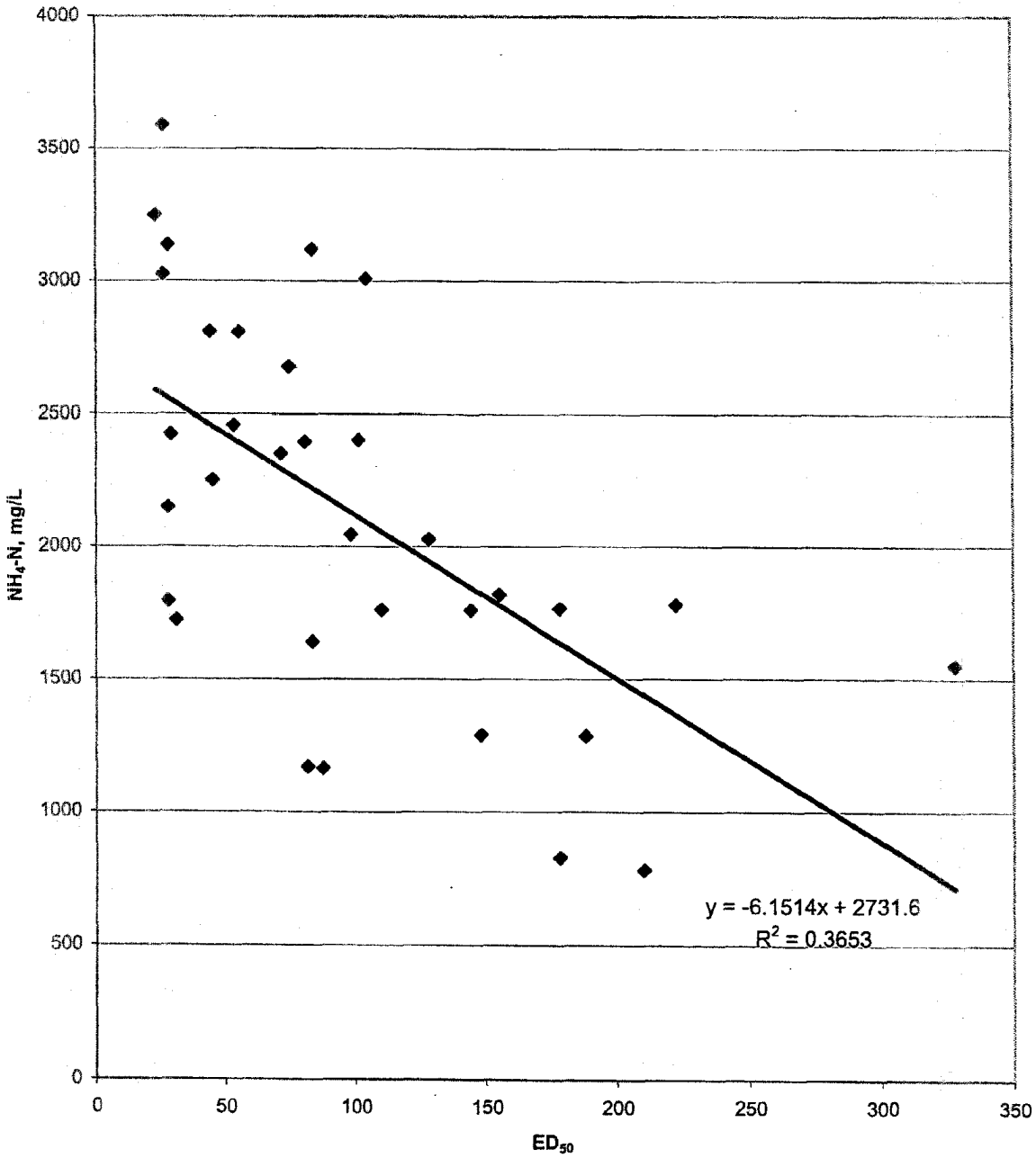
SCATTER PLOT FOR FRESH CAKE DATA (1997-1999): ED_{50} VS. NH_4-N



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 8

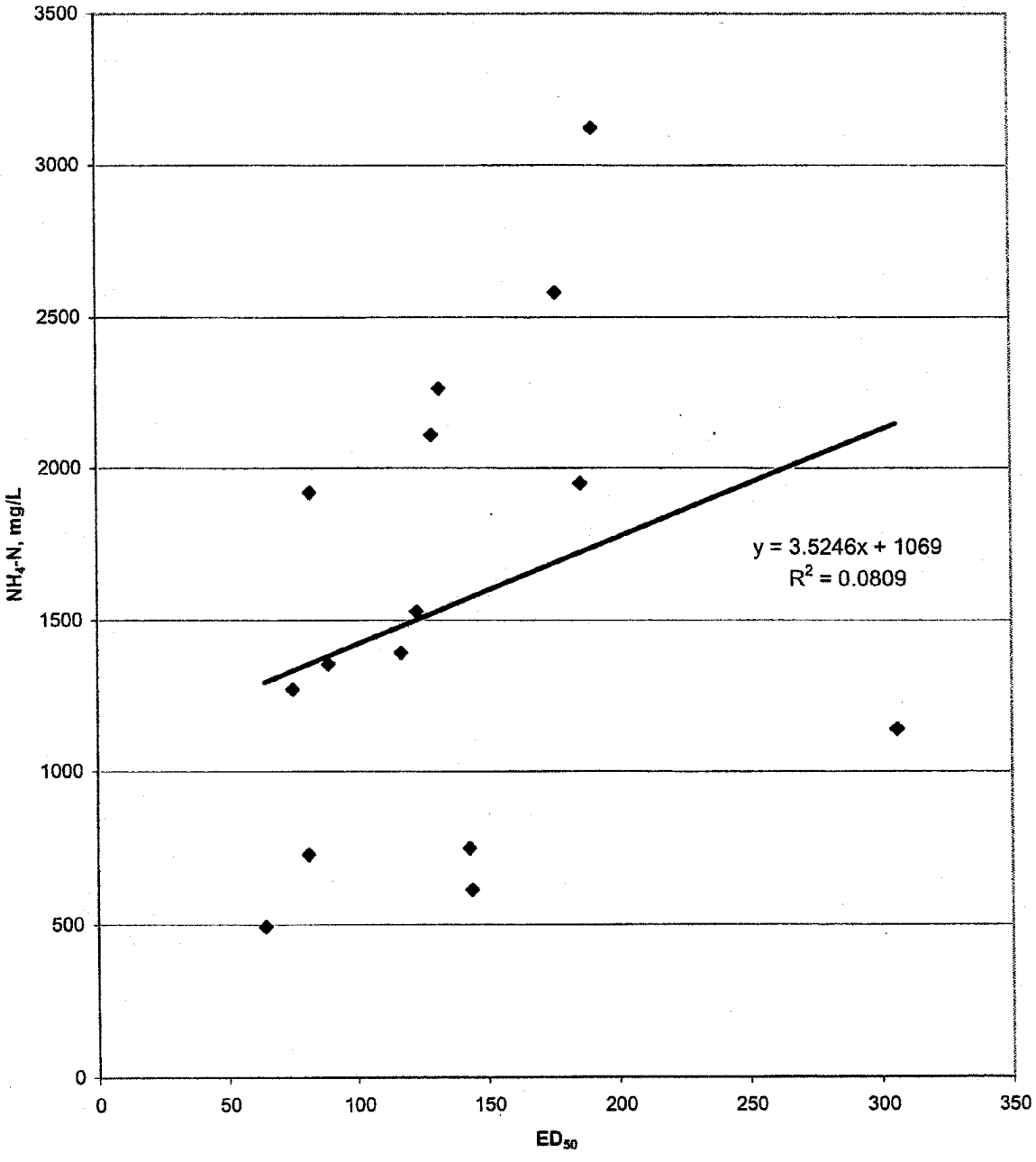
SCATTER PLOT FOR AGED CAKE, DRYING CELL 5 SOUTH, FOR THE PERIOD OF 10/12/99 - 12/21/99: ED_{50} VS. NH_4-N



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 9

SCATTER PLOT FOR AGED CAKE, DRYING CELL 5 NORTH, FOR THE PERIOD OF 7/28/98 - 8/25/98: ED_{50} VS. NH_4-N



that with an increase in ammonia concentration, the ED_{50} levels showed an increase.

ED_{50} and Solids

Figure 10 is a plot of ED_{50} and percent total volatile solids and shows that all cake types had total volatile solids generally between 40 and 50 percent with ED_{50} values under 200 for most of the time over the three years.

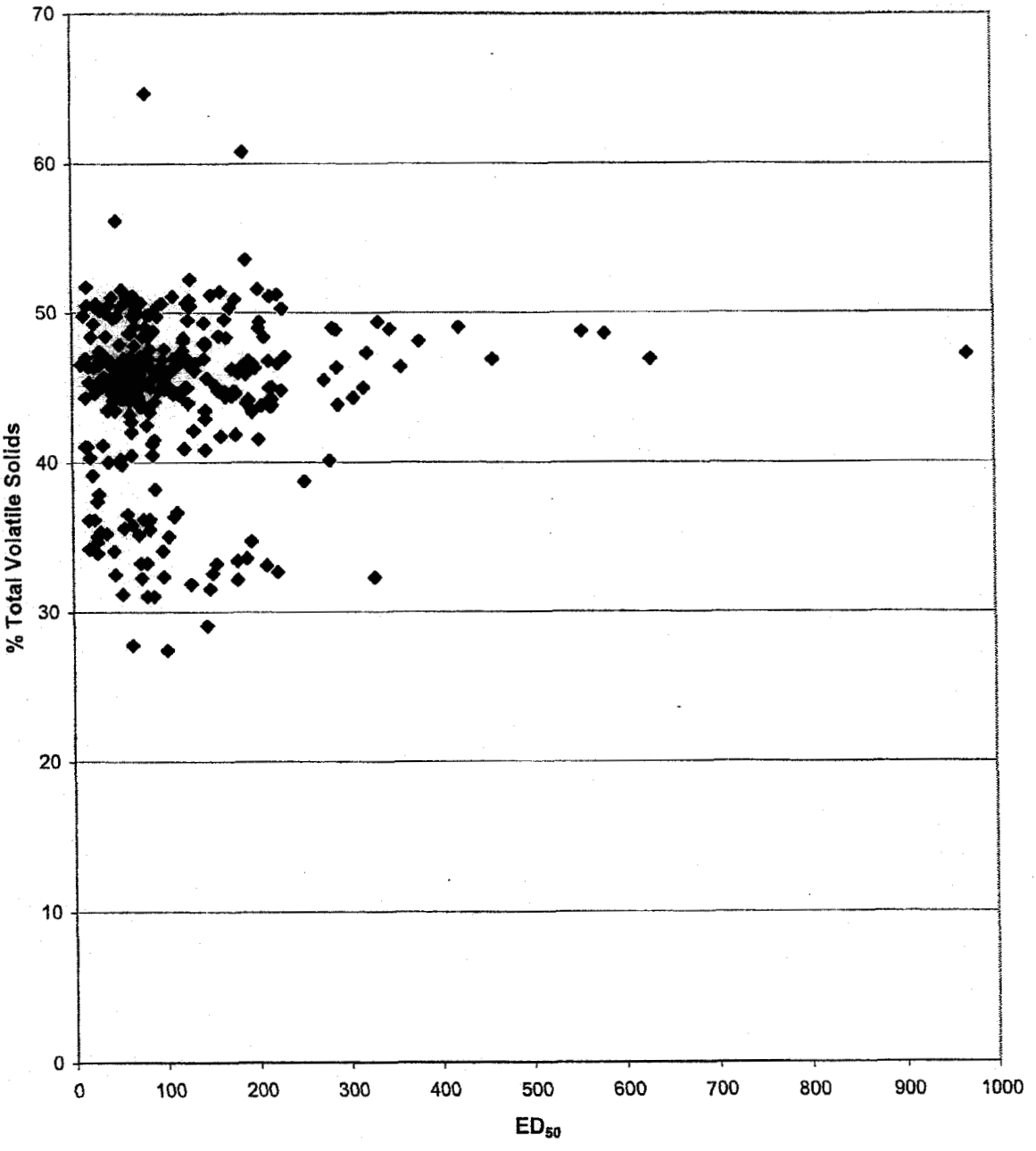
Figure 11, which is plot of ED_{50} and percent total solids, shows that the cake solids at the beginning of the drying process were always higher than 20 percent and were dried up to greater than 60 percent total solids. There is a slight indication of lower odor potential with higher percent total solids.

As the sludge is dried, the percent total solids value increases. Usually, the drier the solids, the less odors are emitted, or the lower the ED_{50} values. No consistent trend was observed between ED_{50} levels and percent total solids in either cake type for the individual drying plots. The ED_{50} decreased with sludge drying in some cases as shown in Figure 12, while it increased in other cases as shown in Figure 13. A similar contradictory relationship between ED_{50} and percent total solids was sometimes found for fresh cake also.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 10

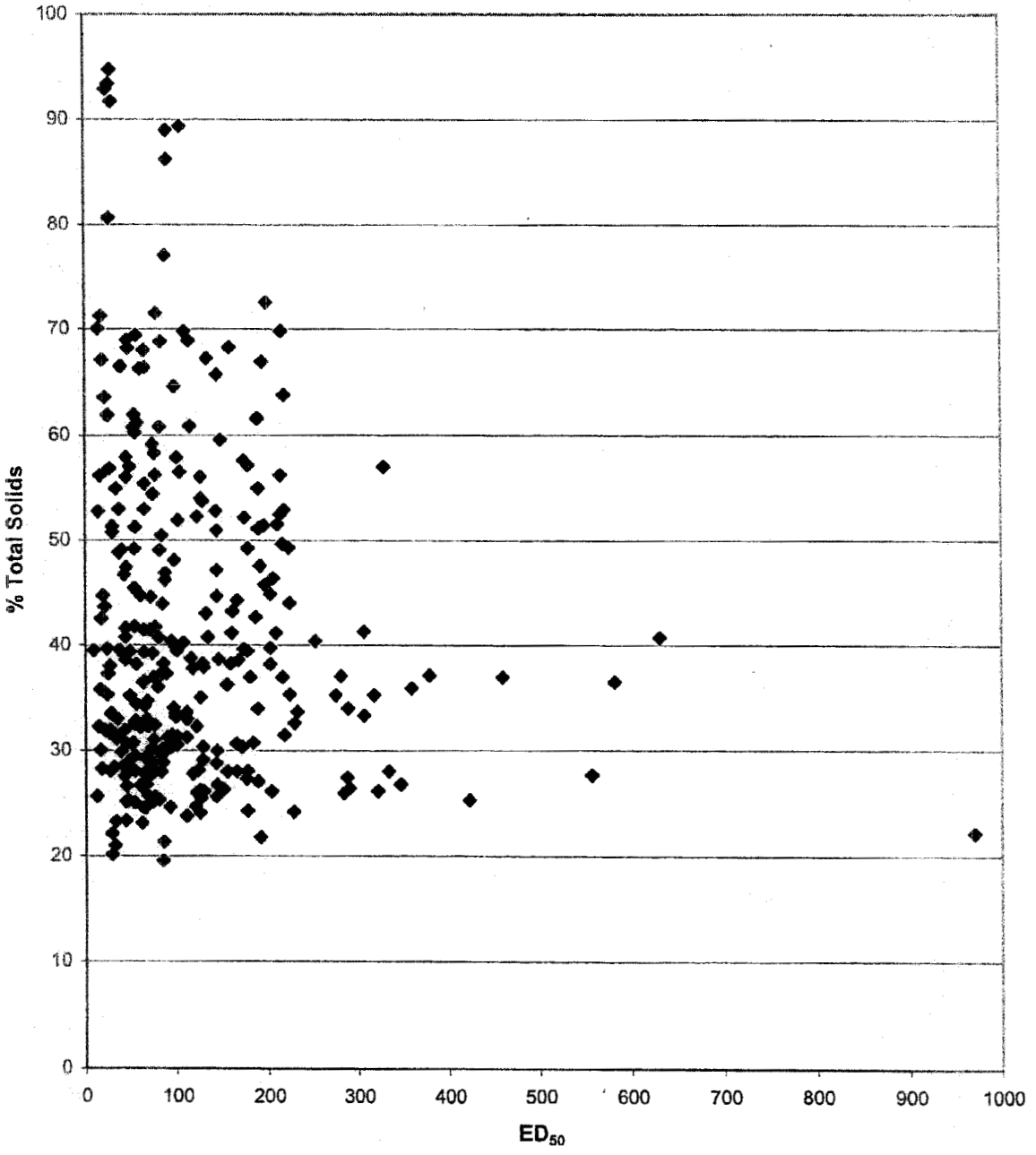
SCATTER PLOT FOR FRESH CAKE AND AGED DATA COMBINED (1997-1999): ED_{50} VS. PERCENT TOTAL VOLATILE SOLIDS



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 11

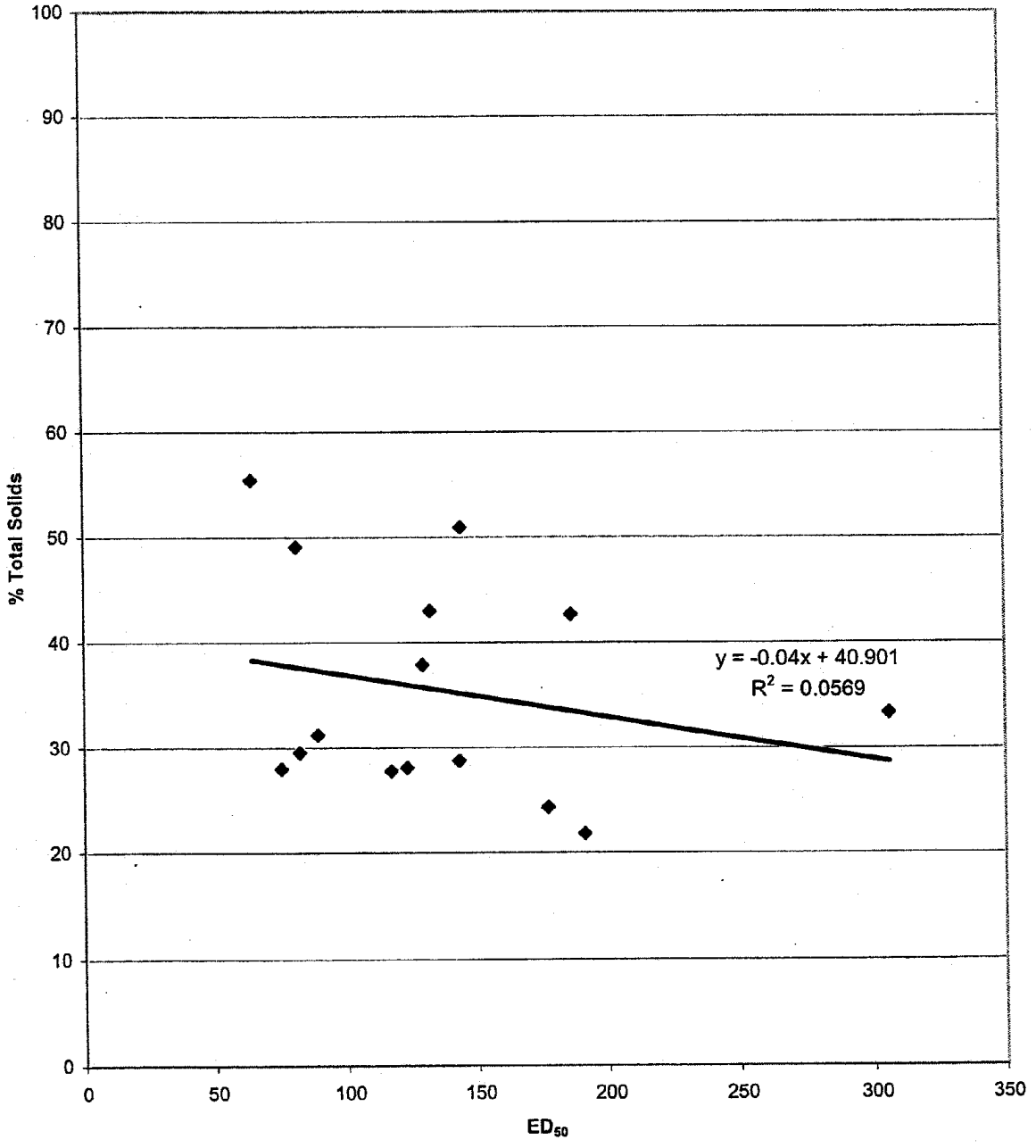
SCATTER PLOT FOR FRESH AND AGED CAKE DATA COMBINED (1997-1999): ED_{50} VS. PERCENT TOTAL SOLIDS



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 12

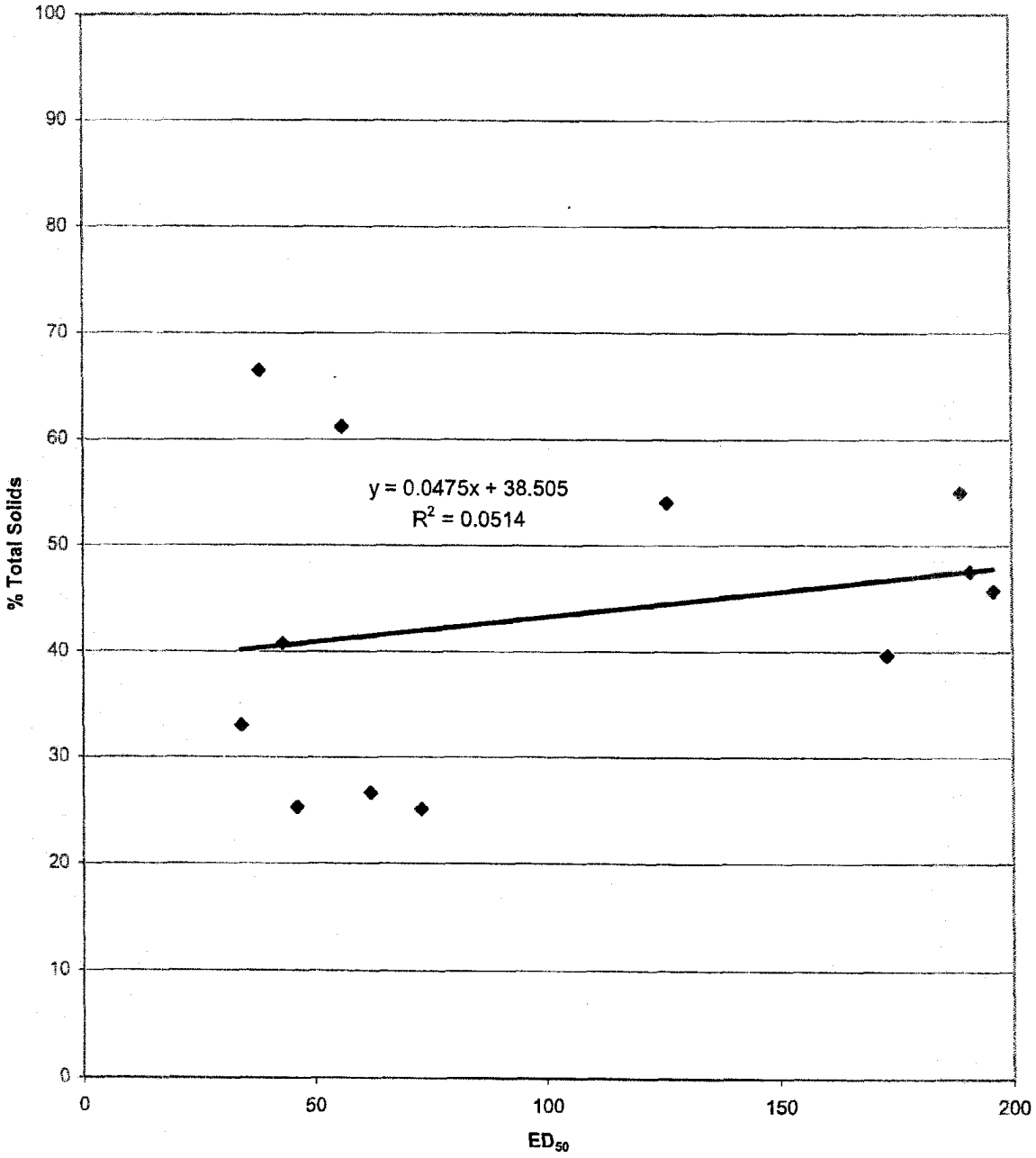
SCATTER PLOT FOR AGED CAKE, DRYING CELL 5 NORTH, FOR THE PERIOD OF 7/28/98 - 8/25/98: ED_{50} VS. PERCENT TOTAL SOLIDS



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 13

SCATTER PLOT FOR AGED CAKE, DRYING CELL 6 NORTH, FOR THE PERIOD OF 6/16/98 - 7/18/98: ED_{50} VS. PERCENT TOTAL SOLIDS



We have sought to explain the inconsistency of data measures in adjacent drying cells at different times. Since all the drying cells are physically located in the same surroundings, similar meteorological factors operate upon all drying cells. The difference in drying behavior in two drying cells may be attributed to several factors such as different composition of cake material being received in different cells over the fill time period. Perhaps a difference in composition causes degradation of cake material much differently over time and releases different compounds at different times in different concentrations. These all may contribute to highly erratic and variable observations in ED_{50}, leading to a major cause of the contradiction in the relationships discussed above.

Comparison of Different Ranges of Percent Dryness

When the centrifuge cake is spread over the drying cells, it gradually loses moisture, and we examined odor potential as the cake is drying. This was accomplished by sorting the complete data set collected over three years into four classes of moisture groups, and each one of them was then sub-sorted into the two cake type groups. The selection of moisture groups was based on the fact that centrifuge cake has a percent total

solids value of about 25 to 30 percent and the dried cake has approximately 60 percent or greater. For purposes of this study, the four moisture groups selected were 30 percent total solids or less, 30 to 45 percent, 45 to 60 percent, and 60 percent total solids and above.

The average and range of values for ED_{50} and other measured sludge parameters for each of the percent total solids levels are shown in Tables 8, 9, and 10 for the combined data, fresh cake, and the aged cake, respectively.

A review of Table 9 shows that as the fresh cake is dried more, its average ED_{50} values decreases by about 44 percent from 160 to 99. The drying also reduces the spread in ED_{50} values above 45 percent total solids. The aged cake does not show a firm trend like the fresh cake. However, average ED_{50} values for the aged cake (Table 10) dropped 26 percent from the beginning levels during the drying process. Part of this is due to the relatively low ED_{50} (average 93) at the initial drying.

Both the aged and fresh cakes are dried from 26 percent total solids to nearly 70 percent total solids in the air-drying operation. Aged cake has an average of 5 percent less volatile solids content than that of fresh cake during the entire drying process. In both cakes, average TKN values

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 8

SUMMARY STATISTICS FOR FRESH AND AGED CAKE COMBINED DATA AT DIFFERENT PERCENT CAKE SOLIDS

Solids Range		%TS	%TVS	NH_4-N mg/L	NH_4-N mg/Kg	TKN mg/L	TKN mg/kg	ED_{50}
30 Percent or Less	Maximum	29.97	51.16	3362		16724		970
	Minimum	19.58	31.05	260		4733		12
	Average	26.35	46.20	1552	5890	10884	41305	128
	n	78	78	76		76		78
30 to 45 Percent	Maximum	44.87	60.79	2803		22577		630
	Minimum	30.04	27.74	115		2621		9
	Average	36.45	45.82	1407	3860	12572	34491	122
	n	125	125	125		125		125
45 to 60 Percent	Maximum	59.60	56.19	3264		22748		328
	Minimum	45.40	27.42	115		4026		14
	Average	52.47	41.91	1701	3242	15021	28628	114
	n	58	58	58		57		58
60 Percent or Greater	Maximum	94.72	64.67	3788		27141		217
	Minimum	60.24	32.51	134		7861		14
	Average	70.91	42.39	2099	2960	17629	24861	86
	n	43	49	49		49		49

n = number of values.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9

SUMMARY STATISTICS FOR FRESH CAKE DATA AT DIFFERENT PERCENT CAKE SOLIDS

Solids Range		%TS	%TVS	NH_4-N mg/L	NH_4-N mg/Kg	TKN mg/L	TKN mg/kg	ED_{50}
30 Percent or Less	Maximum	29.97	51.16	2727		16724		970
	Minimum	19.58	31.05	260		7020		12
	Average	26.48	47.64	1395	5268	11356	42885	160
	n	41	41	40		40		41
30 to 45 Percent	Maximum	44.87	51.76	2803		22577		630
	Minimum	30.04	27.74	312		2621		9
	Average	36.59	46.98	1333	3643	12969	35444	129
	n	90	90	90		90		90
45 to 60 Percent	Maximum	58.32	56.19	3264		22748		217
	Minimum	46.71	40.49	115		9520		29
	Average	52.68	45.61	1812	3439	16479	31281	106
	n	31	31	31		30		31
60 Percent or Greater	Maximum	89	51.43	3788		26012		217
	Minimum	60.24	38.24	134		7861		14
	Average	68.61	45.23	2031	2960	18244	26591	99
	n	24	27	27		27		27

n = number of values.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 10

SUMMARY STATISTICS FOR AGED CAKE DATA AT DIFFERENT PERCENT CAKE SOLIDS

Solids Range		%TS	%TVS	NH_4-N mg/L	NH_4-N mg/Kg	TKN mg/L	TKN mg/kg	ED_{50}
30 Percent or Less	Maximum	29.86	50.73	3362		16082		227
	Minimum	20.14	34.23	399		4733		17
	Average	26.20	44.61	1727	6591	10359	39538	93
	n	37	37	36		36		37
30 to 45 Percent	Maximum	44.72	60.79	2678		18321		317
	Minimum	30.15	29.08	115		5261		19
	Average	36.10	42.84	1599	4429	11552	32000	105
	n	35	35	35		35		35
45 to 60 Percent	Maximum	59.60	46.54	2587		20677		328
	Minimum	45.40	27.42	493		4026		14
	Average	52.22	37.67	1573	3012	13400	25661	124
	n	27	27	27		27		27
60 Percent or Greater	Maximum	94.72	64.67	3588		27141		193
	Minimum	60.72	32.51	766		7935		17
	Average	73.81	38.90	2182	2956	16874	22861	69
	n	19	22	22		22		22

n = number of values.

increased by 40 to 60 percent with drying. Average ammonia values also showed increases by 26 percent to over 46 percent. When the ammonia and TKN concentrations are expressed on a dry weight basis (mg/Kg), they both show a decrease with drying. The average TKN of the fresh cake decreased from 42,885 mg/Kg at 26.48 percent solids to 26,591 mg/Kg at 68.61 percent solids. The average ammonia nitrogen also showed a decrease from 5,268 mg/Kg at 26.48 percent solids to 2,960 mg/Kg at 68.61 percent solids. Similarly, the TKN and ammonia nitrogen for the aged cake decreased with drying.

Comparison of the fresh cake ED_{50} (Table 9) with the aged cake ED_{50} (Table 10) shows that at 30 percent total solids or less the fresh cake had a higher average ED_{50} (160) than the aged cake (93). At 60 percent total solids or greater, the average ED_{50} values were 99 and 69 for the fresh cake and aged cake, respectively.

Comparison of the Variability of ED_{50} Values in Fresh and Aged Cake

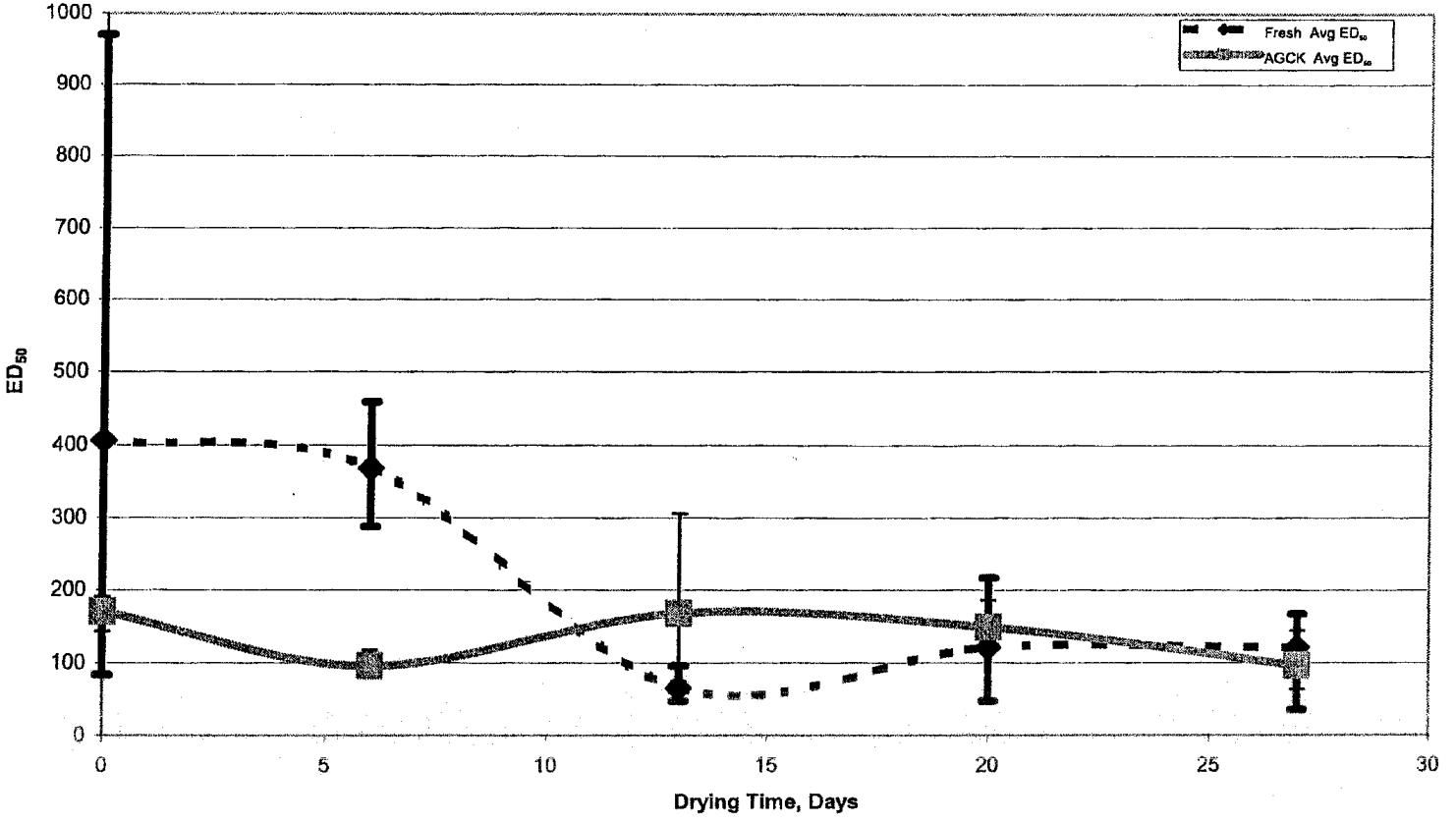
Odor measured as ED_{50} for different types of cakes were compared against drying time and plotted as high and low type charts to show the variability in three measurements made on the same day. These charts show the highest, lowest, and average daily measurements over a given drying period. Figures

14 and 15 show the comparative trends for fresh and aged cake for ED_{50} during two different drying cycles. Figure 14 shows that ED_{50} values decrease for both types of cakes as the cake is dried. The fresh cake shows a pronounced decrease in comparison to the aged cake. In contrast, Figure 15 shows that neither cake follows a systematic trend with respect to ED_{50} as the cake is dried. Both fresh and aged cake have high variability in most of the measurements, although the fresh cake shows a greater variability in the three daily samples than the aged cake.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 14

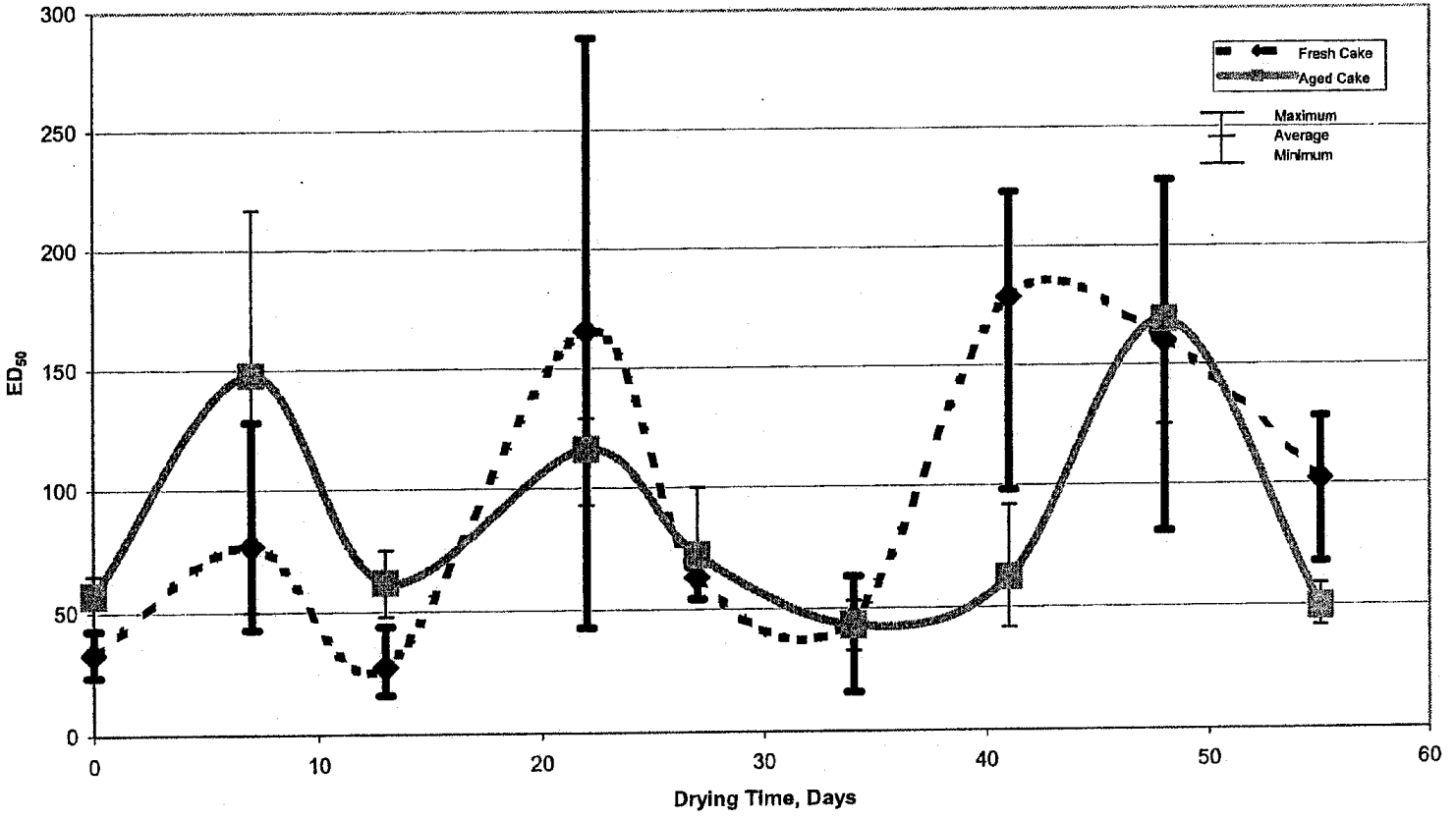
CHANGES IN ED_{50} OVER TIME FOR FILL DATES 7/24-29/98 FOR DRYING CELL 2 NORTH - FRESH CAKE AND DRYING CELL 5 NORTH - AGED CAKE



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 15

CHANGES IN ED_{50} OVER TIME FOR FILL DATES 10/16-24/98 FOR DRYING CELL 4 SOUTH - FRESH CAKE AND DRYING CELL 5 NORTH - AGED CAKE



SUPPLEMENTAL STUDIES

In addition to the major comparisons of this study of fresh versus aged cake, four other supplemental studies were attempted. These included measurement of the same parameters (i.e., NH_4-N, percent TS, percent TVS, TKN, and ED_{50}) for other types of centrifuge cakes which were underaged cake, stockpiled fresh and aged cake, and winterized fresh cake. All data were examined together with the fresh and aged cake data with and without the stockpile data. Of the total 2,659 total data points, 1,185 observations pertained to the supplemental studies.

Aged cake and fresh cake have been well defined throughout this report. "Underaged cake" was sludge that had less than 18 months of detention time in lagoons. "Stockpile cake" is cake that has been dried to approximately 60 percent total solids in a drying cell and pushed into a pile awaiting final disposal. "Winterized cake" is applied on the drying cells just before winter and remains there throughout all the winter months, and drying is completed in the spring, before it is hauled away for disposal. All cake types were considered for possible sources of odor and evaluated separately to assess odor potential.

None of the analyses performed in the supplemental studies showed a conclusive trend for increased odor potential of underaged, winterized, or stockpile cake. Regardless of cake group, no consistent trend or possible relationship was found between ED_{50} and any other parameters. Therefore, these data findings are not included in this report.

Raw data and data summaries for 1997 through 1999 from the supplemental studies may be found in Appendix II.

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Deshpande, J. V., A. P. Gore, and A. Shanubhogue, Statistical Analysis of Nonnormal Data, John Wiley & Sons, New York, 1995.

Gibbons, Jean Dickinson, and Subhabrata Chakraborti, Non-parametric Statistical Inference, 3rd edition, revised and expanded, Marcel Dekker Inc., New York, 1992.

Standard Methods for the Examination of Water and Wastewater, 19th Edition, APHA, AWWA, WEF, 1995.

APPENDIX AI

FRESH AND AGED CAKE DATA FOR 1997, 1998, AND 1999

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1

RAW FRESH CAKE DATA FOR THE YEAR OF 1997

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
8/19/97	24CK 2N	23.28	44.99	N/A	N/A	32
8/26/97	24CK 2N-A	30.77	47.88	2258	18432	51
8/26/97	24CK 2N-B	31.97	48.38	2039	17215	20
8/26/97	24CK 2N-C	29.97	47.97	2167	16724	144
9/2/97	24CK 2N-A	33.41	47.09	1449	13415	28
9/2/97	24CK 2N-B	33.53	46.61	1552	14020	27
9/2/97	24CK 2N-C	32.26	46.93	1299	12933	14
9/8/97	24CK 2N-A	42.51	46.35	1614	19271	17
9/8/97	24CK 2N-B	44.71	46.08	1779	22577	60
9/8/97	24CK 2N-C	39.54	46.51	1822	18051	9
9/15/97	24CK 2N-A	58.32	46.70	2104	20930	75
9/15/97	24CK 2N-B	57.95	46.28	1554	20552	44
9/15/97	24CK 2N-C	69.78	46.22	2636	23510	108
9/22/97	24CK 2N-A	46.71	45.00	1502	16106	42
9/22/97	24CK 2N-B	50.78	45.43	1508	17256	29
9/22/97	24CK 2N-C	47.42	45.62	921	16037	44
9/30/97	24CK 2N-A	61.87	44.58	689	20727	24
9/30/97	24CK 2N-B	69.40	44.17	1302	9658	55
9/30/97	24CK 2N-C	68.20	43.44	1250	7861	46
10/7/97	24CK 2N-A	39.66	46.30	1325	15322	23
10/7/97	24CK 2N-B	66.49	45.09	1109	22083	38
10/7/97	24CK 2N-C	63.56	45.12	1038	23903	21
	COUNT	22	22	21	21	22
	MINIMUM	23.28	43.44	689.00	7861.00	9.00
	MAXIMUM	69.78	48.38	2636.00	23903.00	144.00
	AVERAGE	47.37	46.03	1567.48	17456.33	43.23

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2

AVERAGE FRESH CAKE DATA FOR THE YEAR OF 1997

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
8/19/97	24CK 2N	23.28	44.99	N/A	N/A	32
8/26/97	24CK 2N	30.90	48.08	2155	17457	72
9/2/97	24CK 2N	33.07	46.88	1433	13456	23
9/8/97	24CK 2N	42.25	46.31	1738	19966	29
9/15/97	24CK 2N	62.02	46.40	2098	21664	76
9/22/97	24CK 2N	48.30	45.35	1310	16466	38
9/30/97	24CK 2N	66.49	44.06	1080	12749	42
10/7/97	24CK 2N	56.57	45.50	1157	20436	27
	COUNT	8	8	7	7	8
	MINIMUM	23.28	44.06	1080.33	12748.67	23.00
	MAXIMUM	66.49	48.08	2154.67	21664.00	75.67
	AVERAGE	45.36	45.95	1567.48	17456.33	42.29

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3

RAW AGED CAKE DATA FOR THE YEAR OF 1997

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
8/19/97	AGCK 6N	21.35	46.30	N/A	N/A	85
8/26/97	AGCK 6N-A	23.81	44.54	2408	12757	110
8/26/97	AGCK 6N-B	28.27	34.23	2837	13787	17
8/26/97	AGCK 6N-C	26.73	36.53	2642	14352	59
9/2/97	AGCK 6N-A	29.86	43.48	1385	9477	38
9/2/97	AGCK 6N-B	31.62	34.69	1148	9557	26
9/2/97	AGCK 6N-C	27.74	35.80	1886	13223	64
9/8/97	AGCK 6N-A	44.72	40.33	1930	18321	19
9/8/97	AGCK 6N-B	56.21	41.04	2089	20677	16
9/8/97	AGCK 6N-C	43.67	39.16	2005	17350	21
9/15/97	AGCK 6N-A	71.26	36.15	1954	17646	17
9/15/97	AGCK 6N-B	68.90	36.68	1998	19586	113
9/15/97	AGCK 6N-C	68.83	36.07	1818	20691	82
9/22/97	AGCK 6N-A	52.96	35.25	1485	13032	36
9/22/97	AGCK 6N-B	56.87	33.95	1099	10936	26
9/22/97	AGCK 6N-C	59.17	33.27	1326	13581	73
9/30/97	AGCK 6N-A	66.91	34.75	1302	7935	193
9/30/97	AGCK 6N-B	64.60	34.09	1163	17827	97
9/30/97	AGCK 6N-C	56.28	36.19	2155	18381	76
10/7/97	AGCK 6N-A	52.77	41.07	2253	17496	14
10/7/97	AGCK 6N-B	60.72	40.21	1934	20452	52
10/7/97	AGCK 6N-C	49.10	40.05	2192	18859	39
	COUNT	22	22	21	21	22
	MINIMUM	21.35	33.27	1099.00	7935.00	14.00
	MAXIMUM	71.26	46.30	2837.00	20691.00	193.00
	AVERAGE	48.29	37.90	1857.57	15520.14	57.86

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-4

AVERAGE AGED CAKE DATA FOR THE YEAR OF 1997

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
8/19/97	AGCK 6N	21.35	46.30	N/A	N/A	85
8/26/97	AGCK 6N	26.27	38.43	2629	13632	62
9/2/97	AGCK 6N	29.74	37.99	1473	10752	43
9/8/97	AGCK 6N	48.20	40.18	2008	18783	19
9/15/97	AGCK 6N	69.66	36.30	1923	19308	71
9/22/97	AGCK 6N	56.33	34.16	1303	12516	45
9/30/97	AGCK 6N	62.60	35.01	1540	14714	122
10/7/97	AGCK 6N	54.20	40.44	2126	18936	35
COUNT		8	8	7	7	8
MINIMUM		21.35	34.16	1303.33	10752.33	18.67
MAXIMUM		69.66	46.30	2629.00	19307.67	122.00
AVERAGE		46.04	38.60	1857.57	15520.14	60.13

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5

RAW FRESH CAKE DATA FOR THE YEAR OF 1998

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
5/26/98	24CK 1N-A	67.23	46.12	468	15919	133
5/26/98	24CK 1N-B	56.53	45.77	115	14638	103
5/26/98	24CK 1N-C	67.10	45.34	134	8525	18
6/2/98	24CK 1N-A	72.54	46.28	2076	19033	198
6/2/98	24CK 1N-B	66.35	46.65	1652	20517	64
6/2/98	24CK 1N-C	57.91	47.55	119	19265	100
6/9/98	24CK 1N-A	23.15	48.60	260	7020	61
6/9/98	24CK 1N-B	30.19	44.35	1058	13973	72
6/9/98	24CK 1N-C	25.76	49.05	762	11741	67
6/16/98	24CK 1N-A	24.68	47.44	1753	14613	120
6/16/98	24CK 1N-B	37.81	47.22	1374	15580	117
6/16/98	24CK 1N-C	24.11	46.80	1377	13206	125
6/23/98	24CK 1N-A	32.98	46.23	1727	12830	111
6/23/98	24CK 1N-B	38.68	45.61	1475	15526	146
6/23/98	24CK 1N-C	34.42	46.93	2037	17638	55
6/30/98	24CK 1N-A	50.46	46.92	2391	17602	83
6/30/98	24CK 1N-B	52.79	46.91	2261	16111	143
6/30/98	24CK 1N-C	56.23	46.76	1729	15399	213
7/8/98	24CK 1N-A	41.79	44.39	1167	16970	53
7/8/98	24CK 1N-B	49.67	43.72	1092	20887	215
7/8/98	24CK 1N-C	54.42	43.69	2233	22748	74
7/14/98	24CK 2N-A	39.22	46.50	746	13341	73
7/14/98	24CK 2N-B	31.35	44.88	514	11679	100
7/14/98	24CK 2N-C	32.28	48.08	671	11345	121
7/21/98	24CK 2N-A	60.24	44.71	2516	15779	54
7/21/98	24CK 2N-B	70.07	44.30	3007	16232	14
7/21/98	24CK 2N-C	51.24	45.59	2141	15391	54
7/28/98	24CK 2N-A	28.87	49.87	906	12494	84
7/28/98	24CK 2N-B	28.01	49.54	617	10897	165
7/28/98	24CK 2N-C	22.22	47.20	2089	9787	970
8/4/98	24CK 2N-A	36.97	46.87	1202	9878	459
8/4/98	24CK 2N-B	34.01	46.31	922	11145	288
8/4/98	24CK 2N-C	35.94	46.35	1798	14685	358
8/11/98	24CK 2N-A	35.22	46.47	641	17249	48
8/11/98	24CK 2N-B	38.22	46.31	586	16214	55
8/11/98	24CK 2N-C	34.07	46.33	941	17163	96
8/18/98	24CK 2N-A	57.05	56.19	1785	20227	48
8/18/98	24CK 2N-B	52.90	43.78	814	18385	217
8/18/98	24CK 2N-C	48.11	45.02	740	15610	97
8/25/98	24CK 2N-A	39.55	48.42	936	2621	36
8/25/98	24CK 2N-B	38.58	48.31	794	2925	167

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5 (Continued)

RAW FRESH CAKE DATA FOR THE YEAR OF 1998

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
8/25/98	24CK 2N-C	38.25	48.43	861	2847	159
9/1/98	24CK 2N-A	41.17	48.35	1259	10222	208
9/1/98	24CK 2N-B	36.48	48.57	1641	10698	62
9/1/98	24CK 2N-C	37.34	48.76	1133	9702	88
9/8/98	24CK 2N-A	40.77	46.61	312	9717	134
9/8/98	24CK 2N-B	41.61	46.43	792	9647	43
9/8/98	24CK 2N-C	40.40	46.28	2509	9538	94
9/22/98	24CK 4S-A	29.44	49.78	483	9349	65
9/22/98	24CK 4S-B	36.05	49.05	770	9506	79
9/22/98	24CK 4S-C	33.67	47.02	667	9516	231
9/29/98	24CK 4S-A	51.33	47.40	1725	14305	29
9/29/98	24CK 4S-B	56.07	49.50	970	9520	126
9/29/98	24CK 4S-C	44.87	48.96	1435	12325	202
10/8/98	24CK 4S-A	41.19	44.69	1959	13650	160
10/8/98	24CK 4S-B	40.24	44.95	2216	13630	107
10/8/98	24CK 4S-C	39.76	41.56	2091	14456	202
10/13/98	24CK 4S-A	40.74	46.88	1374	14445	630
10/13/98	24CK 4S-B	40.42	38.75	1234	14074	251
10/13/98	24CK 4S-C	38.75	46.49	1343	16154	115
10/20/98	24CK 4S-A	38.62	44.55	992	10033	43
10/20/98	24CK 4S-B	54.94	41.16	590	9632	33
10/20/98	24CK 4S-C	37.30	45.12	539	10388	24
10/27/98	24CK 4S-A	26.58	50.97	1253	9480	60
10/27/98	24CK 4S-B	25.16	51.04	1073	9532	43
10/27/98	24CK 4S-C	30.32	50.40	1019	8809	128
11/3/98	24CK 4S-A	30.04	50.48	1120	14793	16
11/3/98	24CK 4S-B	35.29	49.25	1000	13046	23
11/3/98	24CK 4S-C	26.62	49.62	1083	13123	44
11/12/98	24CK 4S-A	26.44	43.84	2188	11283	289
11/12/98	24CK 4S-B	30.66	44.73	2131	12690	165
11/12/98	24CK 4S-C	23.36	46.50	2727	11441	43
11/17/98	24CK 4S-A	27.55	50.18	2518	10270	69
11/17/98	24CK 4S-B	26.74	51.16	781	12170	66
11/17/98	24CK 4S-C	32.81	51.56	1002	13850	54
11/24/98	24CK 4S-A	35.82	51.76	886	11659	16
11/24/98	24CK 4S-B	36.58	50.79	984	13299	63
11/24/98	24CK 4S-C	66.24	51.18	2242	22532	59
12/1/98	24CK 4S-A	33.53	50.62	1170	15416	98
12/1/98	24CK 4S-B	36.97	51.12	1133	12934	215
12/1/98	24CK 4S-C	44.02	51.24	1601	15041	223
12/8/98	24CK 4S-A	37.23	49.85	2157	14229	81

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5 (Continued)

RAW FRESH CAKE DATA FOR THE YEAR OF 1998

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
12/8/98	24CK 4S-B	32.59	50.29	1525	12664	228
12/8/98	24CK 4S-C	30.31	50.33	1354	14493	171
12/15/98	24CK 4S-A	32.27	45.45	931	10545	68
12/15/98	24CK 4S-B	29.08	50.88	1323	10159	128
12/15/98	24CK 4S-C	31.25	51.10	1062	9001	110
	COUNT	87	87	87	87	87
	MINIMUM	22.22	38.75	115.02	2621.10	14.00
	MAXIMUM	72.54	56.19	3006.80	22748.00	970.00
	AVERAGE	39.84	47.44	1296.28	13087.36	130.11

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6

AVERAGE FRESH CAKE DATA FOR THE YEAR OF 1998

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
5/26/98	24CK 1N	63.62	45.74	239	13027	85
6/2/98	24CK 1N	65.60	46.83	1282	19605	121
6/9/98	24CK 1N	26.37	47.33	693	10911	67
6/16/98	24CK 1N	28.87	47.15	1501	14466	121
6/23/98	24CK 1N	35.36	46.26	1746	15331	104
6/30/98	24CK 1N	53.16	46.86	2127	16371	146
7/8/98	24CK 1N	48.63	43.93	1497	20202	114
7/14/98	24CK 2N	34.28	46.49	644	12122	98
7/21/98	24CK 2N	60.52	44.87	2554	15801	41
7/28/98	24CK 2N	26.37	48.87	1204	11059	406
8/4/98	24CK 2N	35.64	46.51	1307	11903	368
8/11/98	24CK 2N	35.84	46.37	723	16875	66
8/18/98	24CK 2N	52.69	48.33	1113	18074	121
8/25/98	24CK 2N	38.79	48.39	864	2798	121
9/1/98	24CK 2N	38.33	48.56	1344	10207	119
9/8/98	24CK 2N	40.93	46.44	1205	9634	90
9/22/98	24CK 4S	33.05	48.62	640	9457	125
9/29/98	24CK 4S	50.76	48.62	1377	12050	119
10/8/98	24CK 4S	40.40	43.73	2089	13912	156
10/13/98	24CK 4S	39.97	44.04	1317	14891	332
10/20/98	24CK 4S	43.62	43.61	707	10018	33
10/27/98	24CK 4S	27.35	50.80	1115	9274	77
11/3/98	24CK 4S	30.65	49.78	1068	13654	28
11/12/98	24CK 4S	26.82	45.02	2348	11805	166
11/17/98	24CK 4S	29.03	50.97	1434	12097	63
11/24/98	24CK 4S	46.21	51.24	1370	15830	46
12/1/98	24CK 4S	38.17	50.99	1301	14464	179
12/8/98	24CK 4S	33.38	50.16	1679	13795	160
12/15/98	24CK 4S	30.87	49.14	1105	9902	102
COUNT		29	29	29	29	29
MINIMUM		26.37	43.61	238.72	2797.53	27.67
MAXIMUM		65.60	51.24	2554.43	20201.67	406.33
AVERAGE		39.84	47.44	1296.28	13087.36	130.11

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-7

RAW AGED CAKE DATA FOR THE YEAR OF 1998

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
9/22/98	AGCK 3N-A	28.28	45.97	542	8084	68
9/22/98	AGCK 3N-B	27.08	45.88	545	6644	188
9/22/98	AGCK 3N-C	28.03	44.56	399	4733	177
9/29/98	AGCK 3N-A	43.93	47.53	1763	10457	84
9/29/98	AGCK 3N-B	71.49	47.10	2181	12978	77
9/29/98	AGCK 3N-C	68.00	47.02	2243	12286	63
10/8/98	AGCK 3N-A	34.21	42.02	902	10357	64
10/8/98	AGCK 3N-B	35.27	44.97	1067	12400	317
10/8/98	AGCK 3N-C	33.21	46.84	871	10189	98
10/13/98	AGCK 3N-A	41.32	44.28	1562	17985	306
10/13/98	AGCK 3N-B	52.18	44.68	1390	19257	174
10/13/98	AGCK 3N-C	46.38	43.79	1352	19705	205
7/28/98	AGCK 5N-A	28.78	49.34	749	11171	143
7/28/98	AGCK 5N-B	21.79	46.79	3122	11067	191
7/28/98	AGCK 5N-C	24.30	41.85	2582	9382	177
8/4/98	AGCK 5N-A	27.79	44.47	1393	9730	117
8/4/98	AGCK 5N-B	29.57	43.59	1920	10608	82
8/4/98	AGCK 5N-C	31.23	44.03	1355	8658	89
8/11/98	AGCK 5N-A	28.12	44.98	1530	16082	123
8/11/98	AGCK 5N-B	33.31	44.29	1140	14434	306
8/11/98	AGCK 5N-C	28.01	45.27	1271	14515	75
8/18/98	AGCK 5N-A	43.01	42.13	2263	15451	132
8/18/98	AGCK 5N-B	42.66	60.79	1950	14100	186
8/18/98	AGCK 5N-C	37.90	52.26	2110	12999	129
8/25/98	AGCK 5N-A	55.41	42.74	493	4348	64
8/25/98	AGCK 5N-B	50.93	42.93	614	4138	144
8/25/98	AGCK 5N-C	49.06	42.50	729	4026	81
10/20/98	AGCK 5N-A	28.04	44.16	1688	8281	53
10/20/98	AGCK 5N-B	24.60	44.68	1843	9939	65
10/20/98	AGCK 5N-C	25.06	45.10	2250	8809	53
10/27/98	AGCK 5N-A	30.60	44.69	1655	7580	50
10/27/98	AGCK 5N-B	27.32	44.72	2084	10086	176
10/27/98	AGCK 5N-C	31.47	44.20	115	9077	217
11/3/98	AGCK 5N-A	25.62	45.02	1578	11011	75
11/3/98	AGCK 5N-B	24.61	43.19	1692	9882	62
11/3/98	AGCK 5N-C	29.10	44.64	1254	10459	48
11/12/98	AGCK 5N-A	30.26	50.42	1486	12265	93
11/12/98	AGCK 5N-B	25.48	50.73	1310	13234	126
11/12/98	AGCK 5N-C	26.13	50.47	1486	14518	129
11/17/98	AGCK 5N-A	45.40	44.26	1219	10165	53
11/17/98	AGCK 5N-B	29.27	45.95	1295	10527	64

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-7 (Continued)

RAW AGED CAKE DATA FOR THE YEAR OF 1998

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
11/17/98	AGCK 5N-C	33.25	45.67	1295	11300	100
11/24/98	AGCK 5N-A	30.62	46.58	991	11199	44
11/24/98	AGCK 5N-B	31.11	47.22	1067	8978	33
11/24/98	AGCK 5N-C	32.49	46.49	1121	11024	53
12/1/98	AGCK 5N-A	27.57	45.62	1556	11925	42
12/1/98	AGCK 5N-B	32.63	45.36	1871	11665	53
12/1/98	AGCK 5N-C	30.57	45.73	1546	11189	92
12/8/98	AGCK 5N-A	28.01	45.11	1536	11059	155
12/8/98	AGCK 5N-B	24.22	44.79	1327	9850	227
12/8/98	AGCK 5N-C	26.20	44.97	1300	9913	125
12/15/98	AGCK 5N-A	28.36	45.95	677	7724	48
12/15/98	AGCK 5N-B	31.91	46.72	1259	10751	42
12/15/98	AGCK 5N-C	32.22	46.60	768	7819	59
6/16/98	AGCK 6N-A	26.65	44.04	1947	5997	62
6/16/98	AGCK 6N-B	25.13	44.02	3110	5398	73
6/16/98	AGCK 6N-C	25.29	44.17	3362	6947	46
6/23/98	AGCK 6N-A	61.19	45.25	771	10944	56
6/23/98	AGCK 6N-B	66.45	45.45	766	13467	38
6/23/98	AGCK 6N-C	32.98	45.70	1619	14425	34
6/30/98	AGCK 6N-A	45.75	46.54	2587	15450	196
6/30/98	AGCK 6N-B	40.77	46.30	2393	15722	43
6/30/98	AGCK 6N-C	39.64	46.21	2268	14041	173
7/8/98	AGCK 6N-A	47.54	44.08	1483	16453	191
7/8/98	AGCK 6N-B	54.00	43.94	1596	18097	126
7/8/98	AGCK 6N-C	54.98	43.93	2357	19646	189
	COUNT	66	66	66	66	66
	MINIMUM	21.79	41.85	115.42	4025.60	33.00
	MAXIMUM	71.49	60.79	3362.10	19705.00	317.00
	AVERAGE	35.66	45.63	1508.61	11251.48	112.48

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-8

AVERAGE AGED CAKE DATA FOR THE YEAR OF 1998

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
9/22/98	AGCK 3N	27.80	45.47	495	6487	144
9/29/98	AGCK 3N	61.14	47.22	2062	11907	75
10/8/98	AGCK 3N	34.23	44.61	947	10982	160
10/13/98	AGCK 3N	46.63	44.25	1435	18982	228
7/28/98	AGCK 5N	24.96	45.99	2151	10540	170
8/4/98	AGCK 5N	29.53	44.03	1556	9665	96
8/11/98	AGCK 5N	29.81	44.85	1314	15010	168
8/18/98	AGCK 5N	41.19	51.73	2108	14183	149
8/25/98	AGCK 5N	51.80	42.72	612	4170	96
10/20/98	AGCK 5N	25.90	44.65	1927	9009	57
10/27/98	AGCK 5N	29.80	44.54	1285	8914	148
11/3/98	AGCK 5N	26.44	44.28	1508	10451	62
11/12/98	AGCK 5N	27.29	50.54	1427	13339	116
11/17/98	AGCK 5N	35.97	45.29	1270	10664	72
11/24/98	AGCK 5N	31.41	46.76	1060	10400	43
12/1/98	AGCK 5N	30.26	45.57	1658	11593	62
12/8/98	AGCK 5N	26.14	44.96	1388	10274	169
12/15/98	AGCK 5N	30.83	46.42	901	8765	50
6/16/98	AGCK 6N	25.69	44.08	2806	6114	60
6/23/98	AGCK 6N	53.54	45.47	1052	12945	43
6/30/98	AGCK 6N	42.05	46.35	2416	15071	137
7/8/98	AGCK 6N	52.17	43.98	1812	18065	169
	COUNT	22	22	22	22	22
	MINIMUM	24.96	42.72	495.15	4170.30	42.67
	MAXIMUM	61.14	51.73	2806.37	18982.33	228.33
	AVERAGE	35.66	45.63	1508.61	11251.48	112.48

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-9

RAW FRESH CAKE DATA FOR THE YEAR OF 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
6/22/99	24CK 4S-A	28.05	46.50	1556	14031	26
6/22/99	24CK 4S-B	31.02	47.11	1642	16721	74
6/22/99	24CK 4S-C	33.00	46.93	1962	14328	110
6/29/99	24CK 4S-A	28.81	45.59	1790	12004	73
6/29/99	24CK 4S-B	30.53	45.46	1723	11609	100
6/29/99	24CK 4S-C	29.74	44.93	2073	12498	85
7/6/99	24CK 4S-A	54.43	45.81	3264	15227	73
7/6/99	24CK 4S-B	39.48	45.61	2509	15588	100
7/6/99	24CK 4S-C	38.25	45.45	2775	11334	85
7/13/99	24CK 4S-A	68.29	44.79	3202	23228	158
7/13/99	24CK 4S-B	63.77	44.99	3402	23044	217
7/13/99	24CK 4S-C	69.82	44.94	3788	26012	214
7/20/99	24CK 4S-A	27.44	48.84	755	11233	287
7/20/99	24CK 4S-B	27.67	48.73	856	12225	556
7/20/99	24CK 4S-C	26.79	48.88	766	11193	346
7/27/99	24CK 4S-A	35.27	45.46	1445	5104	274
7/27/99	24CK 4S-B	30.73	46.36	1235	12516	183
7/27/99	24CK 4S-C	36.98	45.94	1197	13016	180
8/3/99	24CK 4S-A	56.05	44.12	3175	17916	44
8/3/99	24CK 4S-B	60.88	44.58	3244	19425	114
8/3/99	24CK 4S-C	57.62	44.39	2868	19695	173
8/10/99	24CK 4S-A	25.35	31.05	2197	7515	80
8/10/99	24CK 4S-B	19.58	43.37	2534	9916	84
8/10/99	24CK 4S-C	26.33	32.59	2511	8228	151
8/17/99	24CK 3N-A	52.47	44.10	2669	16238	213
8/17/99	24CK 3N-B	47.15	43.44	2769	16872	144
8/17/99	24CK 3N-C	51.21	44.17	2439	15405	191
8/24/99	24CK 3N-A	51.41	43.39	2433	16079	195
8/24/99	24CK 3N-B	39.36	44.48	1985	11362	63
8/24/99	24CK 3N-C	51.14	53.61	1437	12602	189
8/31/99	24CK 3N-A	41.45	27.74	1417	8023	63
8/31/99	24CK 3N-B	52.27	40.92	1459	12179	122
8/31/99	24CK 3N-C	65.70	40.84	2115	14059	144
9/7/99	24CK 3N-A	77.01	41.25	2641	21550	87
9/7/99	24CK 3N-B	89.00	41.50	2999	23038	89
9/7/99	24CK 3N-C	86.24	38.24	3383	22103	89
9/14/99	24CK 3N-A	61.88	39.85	2703	19121	53
9/14/99	24CK 3N-B	52.96	40.49	2442	16345	64
9/14/99	24CK 3N-C	46.86	40.50	2193	15225	87
9/21/99	24CK 4S-A	26.75	47.83	510	9204	144
9/21/99	24CK 4S-B	24.65	49.76	693	9286	92

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-9 (Continued)

RAW FRESH CAKE DATA FOR THE YEAR OF 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
9/21/99	24CK 4S-C	25.32	49.02	610	9722	422
9/28/99	24CK 4S-A	44.26	44.35	960	15355	166
9/28/99	24CK 4S-B	43.25	41.76	1612	16170	161
9/28/99	24CK 4S-C	37.09	40.14	1192	11874	280
10/5/99	24CK 4S-A	38.25	46.43	1031	12981	128
10/5/99	24CK 4S-B	35.06	46.85	507	11743	126
10/5/99	24CK 4S-C	33.98	46.45	743	11836	188
10/12/99	24CK 4N-A	31.48	44.78	803	10128	94
10/12/99	24CK 4N-B	37.01	46.44	757	12847	80
10/12/99	24CK 4N-C	35.31	46.59	766	11841	223
10/19/99	24CK 4N-A	26.01	48.29	1036	11715	121
10/19/99	24CK 4N-B	27.96	48.36	1162	12522	82
10/19/99	24CK 4N-C	33.00	45.16	982	12509	66
10/26/99	24CK 4N-A	28.39	50.14	1092	10549	30
10/26/99	24CK 4N-B	41.76	48.37	1676	13336	76
10/26/99	24CK 4N-C	39.45	50.92	1135	11425	177
11/2/99	24CK 4N-A	41.45	49.84	2803	16621	70
11/2/99	24CK 4N-B	39.40	49.76	2033	14194	48
11/2/99	24CK 4N-C	48.82	49.99	2743	NA	36
11/16/99	24CK 4N-A	NA	50.67	2150	14612	125
11/16/99	24CK 4N-B	NA	51.43	1434	11704	161
11/16/99	24CK 4N-C	NA	51.23	1558	11059	151
11/23/99	24CK 4N-A	38.04	50.60	1445	15188	26
11/23/99	24CK 4N-B	38.22	51.60	1632	18599	202
11/23/99	24CK 4N-C	32.42	50.69	1150	15161	75
11/30/99	24CK 4N-A	28.48	50.55	1639	14869	40
11/30/99	24CK 4N-B	31.94	50.33	1744	15755	26
11/30/99	24CK 4N-C	29.53	50.43	1547	14511	53
12/7/99	24CK 4N-A	25.98	48.99	1473	12818	283
12/7/99	24CK 4N-B	26.14	49.40	1549	15263	203
12/7/99	24CK 4N-C	28.03	49.37	1146	13525	333
12/14/99	24CK 4N-A	37.13	48.08	998	12791	378
12/14/99	24CK 4N-B	25.67	49.80	823	8640	12
12/14/99	24CK 4N-C	36.52	48.58	618	9907	581
12/21/99	24CK 4N-A	26.18	47.30	2077	9710	321
12/21/99	24CK 4N-B	25.65	47.94	2058	9789	143
12/21/99	24CK 4N-C	34.73	47.77	1527	12293	67
	COUNT	75	78	78	77	78
	MINIMUM	19.58	27.74	506.87	5103.80	12.00
	MAXIMUM	89.00	53.61	3788.40	26012.00	581.00
	AVERAGE	40.20	45.94	1781.60	13842.32	148.33

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-10

AVERAGE FRESH CAKE DATA FOR THE YEAR OF 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
6/22/99	24CK 4S	30.69	46.85	1720	15027	70
6/29/99	24CK 4S	29.69	45.33	1862	12037	86
7/6/99	24CK 4S	44.05	45.62	2849	14050	86
7/13/99	24CK 4S	67.29	44.91	3464	24095	196
7/20/99	24CK 4S	27.30	48.82	792	11550	396
7/27/99	24CK 4S	34.33	45.92	1292	10212	212
8/3/99	24CK 4S	58.18	44.36	3096	19012	110
8/10/99	24CK 4S	23.75	35.67	2414	8553	105
8/17/99	24CK 3N	50.28	43.90	2626	16172	183
8/24/99	24CK 3N	47.30	47.16	1952	13348	149
8/31/99	24CK 3N	53.14	36.50	1664	11420	110
9/7/99	24CK 3N	84.08	40.33	9310	15927	88
9/14/99	24CK 3N	53.90	40.28	2446	16897	68
9/21/99	24CK 4S	25.57	48.87	604	9404	219
9/28/99	24CK 4S	41.53	42.08	1255	14466	202
10/5/99	24CK 4S	35.76	46.45	743	11836	188
10/12/99	24CK 4N	34.60	45.94	775	11605	132
10/19/99	24CK 4N	28.99	47.27	1060	12249	90
10/26/99	24CK 4N	36.53	49.81	1301	11770	94
11/2/99	24CK 4N	43.22	49.86	2526	15408	51
11/16/99	24CK 4N	N/A	51.11	1714	12458	146
11/23/99	24CK 4N	36.23	50.96	1409	16316	101
11/30/99	24CK 4N	29.98	50.44	1643	15045	40
12/7/99	24CK 4N	26.72	49.25	1389	13869	273
12/14/99	24CK 4N	33.11	48.82	813	10446	324
12/21/99	24CK 4N	28.85	47.67	1887	10597	177
	COUNT	25	26	26	26	26
	MINIMUM	23.75	35.67	604.22	8552.97	39.67
	MAXIMUM	84.08	51.11	9310.00	24094.67	396.33
	AVERAGE	40.20	45.93	2023.37	13606.47	149.90

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-11

RAW AGED CAKE DATA FOR THE YEAR OF 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
10/12/99	AGCK 5S-A	46.21	31.06	1164	9348	87
10/12/99	AGCK 5S-B	33.61	36.39	1761	8331	110
10/12/99	AGCK 5S-C	30.15	36.21	1641	8237	83
10/19/99	AGCK 5S-A	36.26	33.23	1818	9205	155
10/19/99	AGCK 5S-B	44.66	29.08	1760	10195	144
10/19/99	AGCK 5S-C	39.89	32.39	2044	11915	98
10/26/99	AGCK 5S-A	40.74	33.29	2397	11171	80
10/26/99	AGCK 5S-B	36.98	32.28	2678	5261	74
10/26/99	AGCK 5S-C	51.93	27.42	2404	10662	101
11/2/99	AGCK 5S-A	44.58	35.17	2352	10727	71
11/2/99	AGCK 5S-B	68.95	32.51	2252	11719	45
11/2/99	AGCK 5S-C	49.17	31.19	2459	12086	53
11/9/99	AGCK 5S-A	80.65	35.04	3025	17950	26
11/9/99	AGCK 5S-B	89.35	35.06	3009	18563	104
11/9/99	AGCK 5S-C	91.71	35.36	2426	14621	29
11/16/99	AGCK 5S-A	NA	34.07	2811	16282	44
11/16/99	AGCK 5S-B	NA	35.61	2809	18586	55
11/16/99	AGCK 5S-C	NA	35.53	3120	18608	83
11/23/99	AGCK 5S-A	92.88	36.18	3248	24916	23
11/23/99	AGCK 5S-B	93.37	37.40	3588	27141	26
11/23/99	AGCK 5S-C	94.72	37.89	3136	24098	28
11/30/99	AGCK 5S-A	22.14	46.46	2149	11479	28
11/30/99	AGCK 5S-B	20.14	46.42	1794	10246	28
11/30/99	AGCK 5S-C	21.01	46.75	1723	10041	31
12/7/99	AGCK 5S-A	57.17	33.45	828	17141	178
12/7/99	AGCK 5S-B	57.05	32.31	1552	18269	328
12/7/99	AGCK 5S-C	51.53	33.14	782	13142	210
12/14/99	AGCK 5S-A	61.56	33.62	1287	12676	188
12/14/99	AGCK 5S-B	60.81	64.67	1170	12255	81
12/14/99	AGCK 5S-C	59.60	31.55	1290	12164	148
12/21/99	AGCK 5S-A	49.24	32.17	1766	5075	178
12/21/99	AGCK 5S-B	53.75	31.89	2027	10180	128
12/21/99	AGCK 5S-C	49.29	32.70	1781	9495	222
	COUNT	30	33	33	33	33
	MINIMUM	20.14	27.42	782.10	5074.83	23.00
	MAXIMUM	94.72	64.67	3588.30	27141.00	328.00
	AVERAGE	54.30	35.68	2122.64	13387.45	99.00

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-12

AVERAGE AGED CAKE DATA FOR THE YEAR OF 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
10/12/99	AGCK 5S-A	36.66	34.55	1522	8639	93
10/19/99	AGCK 5S-C	40.27	31.57	1874	10438	132
10/26/99	AGCK 5S-A	43.22	31.00	2493	9031	85
11/2/99	AGCK 5S-C	54.23	32.96	2354	11511	56
11/9/99	AGCK 5S-A	87.24	35.15	2820	17045	53
11/16/99	AGCK 5S-C	NA	35.07	2913	17825	61
11/23/99	AGCK 5S-A	93.66	37.16	3324	25385	26
11/30/99	AGCK 5S-C	21.10	46.54	1888	10589	29
12/7/99	AGCK 5S-A	55.25	32.97	1054	16184	239
12/14/99	AGCK 5S-C	60.66	43.28	1249	12365	139
12/21/99	AGCK 5S-A	50.76	32.25	1858	8250	176
	COUNT	10	11	11	11	11
	MINIMUM	21.10	31.00	1054.11	8250.04	25.67
	MAXIMUM	93.66	46.54	3323.80	25385.00	238.67
	AVERAGE	54.30	35.68	2122.64	13387.45	99.00

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-13

RAW FRESH AND AGED CAKE DATA, SORTED AND MATCHED BY DATE OF SAMPLING (PAIRED RAW DATA)

Date	Fresh Cake	Aged Cake
8/19/97	32	85
8/26/97	51	110
8/26/97	20	17
8/26/97	144	59
9/2/97	28	38
9/2/97	27	26
9/2/97	14	64
9/8/97	17	19
9/8/97	60	16
9/8/97	09	21
9/15/97	75	17
9/15/97	44	113
9/15/97	108	82
9/22/97	42	36
9/22/97	29	26
9/22/97	44	73
9/30/97	24	193
9/30/97	55	97
9/30/97	46	76
10/7/97	23	14
10/7/97	38	52
10/7/97	21	39
6/16/98	120	62
6/16/98	117	73
6/16/98	125	46
6/16/98	132	46
6/16/98	113	46
6/16/98	38	46
6/23/98	111	56
6/23/98	146	38
6/23/98	55	34
6/23/98	88	34
6/23/98	81	34

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-13 (Continued)

RAW FRESH AND AGED CAKE DATA, SORTED AND MATCHED BY DATE OF SAMPLING (PAIRED RAW DATA)

Date	Fresh Cake	Aged Cake
6/23/98	422	34
6/30/98	83	196
6/30/98	143	43
6/30/98	213	173
7/8/98	53	191
7/8/98	215	126
7/8/98	74	189
7/28/98	84	143
7/28/98	165	191
7/28/98	970	177
8/4/98	459	117
8/4/98	288	82
8/4/98	358	89
8/11/98	48	123
8/11/98	55	306
8/11/98	96	75
8/18/98	48	132
8/18/98	217	186
8/18/98	97	129
8/25/98	36	64
8/25/98	167	144
8/25/98	159	81
9/22/98	65	68
9/22/98	79	188
9/22/98	231	177
9/29/98	29	84
9/29/98	126	77
9/29/98	202	63
10/8/98	160	64
10/8/98	107	317
10/8/98	202	98
10/13/98	630	306
10/13/98	251	174

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-13 (Continued)

RAW FRESH AND AGED CAKE DATA, SORTED AND MATCHED BY DATE OF SAMPLING (PAIRED RAW DATA)

Date	Fresh Cake	Aged Cake
10/13/98	115	205
10/20/98	43	53
10/20/98	33	65
10/20/98	24	53
10/27/98	60	50
10/27/98	43	176
10/27/98	128	217
11/3/98	16	75
11/3/98	23	62
11/3/98	44	48
11/12/98	289	93
11/12/98	165	126
11/12/98	43	129
11/17/98	69	53
11/17/98	66	64
11/17/98	54	100
11/24/98	16	44
11/24/98	63	33
11/24/98	59	53
12/1/98	98	42
12/1/98	215	53
12/1/98	223	92
12/8/98	81	155
12/8/98	228	227
12/8/98	171	125
12/15/98	68	48
12/15/98	128	42
12/15/98	110	59
10/12/99	94	87
10/12/99	80	110
10/12/99	223	83
10/19/99	121	155
10/19/99	82	144

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-13 (Continued)

RAW FRESH AND AGED CAKE DATA, SORTED AND MATCHED BY DATE OF SAMPLING (PAIRED RAW DATA)

Date	Fresh Cake	Aged Cake
10/19/99	66	98
10/26/99	30	80
10/26/99	76	74
10/26/99	177	101
11/2/99	70	71
11/2/99	48	45
11/2/99	36	53
11/9/99	74	26
11/9/99	63	104
11/9/99	213	29
11/16/99	125	44
11/16/99	161	55
11/16/99	151	83
11/23/99	26	23
11/23/99	202	26
11/23/99	75	28
11/30/99	40	28
11/30/99	26	28
11/30/99	53	31
12/7/99	283	178
12/7/99	203	328
12/7/99	333	210
12/14/99	378	188
12/14/99	12	81
12/14/99	581	148
12/21/99	321	178
12/21/99	143	128
12/21/99	67	222

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-14

AVERAGES OF RAW FRESH AND AGED CAKE DATA, SORTED AND MATCHED BY DATE OF SAMPLING (PAIRED DATA AVERAGES)

Date	Fresh Cake	Aged Cake
8/19/97	32.0	85.0
8/26/97	71.7	62.0
6/16/98	107.5	60.3
6/23/98	150.5	42.7
6/30/98	146.3	137.3
7/8/98	114.0	168.7
7/28/98	406.3	170.3
8/4/98	368.3	96.0
8/11/98	66.3	168.0
8/18/98	120.7	149.0
8/25/98	120.7	96.3
9/22/98	125.0	144.3
9/29/98	119.0	74.7
10/8/98	156.3	159.7
10/13/98	332.0	228.3
10/20/98	33.3	57.0
10/27/98	77.0	147.7
11/3/98	27.7	61.7
11/12/98	165.7	116.0
11/17/98	63.0	72.3
11/24/98	46.0	43.3
12/1/98	178.7	62.3
12/8/98	160.0	169.0
12/15/98	102.0	49.7
10/26/99	94.3	85.0
11/2/99	51.3	56.3
11/9/99	116.7	53.0
11/16/99	145.7	60.7
11/23/99	101.0	25.7
11/30/99	39.7	29.0
12/7/99	273.0	238.7
12/14/99	323.7	139.0
12/21/99	177.0	176.0

APPENDIX AII

SUPPLEMENTAL CAKE DATA

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-1

RAW STOCKPILE DATA FOR THE YEARS OF 1997 THROUGH 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
9/2/97	24SP 2N-D	61.78	44.15	2100	9177	29
9/8/97	24SP 2N-D	70.09	42.66	3373	27879	35
9/15/97	24SP 2N-D	74.99	44.89	4810	23843	82
9/22/97	24SP 2N-D	63.53	42.00	4726	18918	106
9/30/97	24SP 2N-D	72.50	43.67	5314	7663	245
10/7/97	24SP 2N-D	66.22	44.31	773	23784	64
10/14/97	24SP 2N-A	71.95	42.85	2540	26376	141
10/14/97	24SP 2N-B	77.02	42.71	1943	20650	144
10/14/97	24SP 2N-C	74.35	43.41	3851	27316	112
10/21/97	24SP 2N-A	77.39	36.16	4590	15727	74
10/21/97	24SP 2N-B	77.02	34.37	1792	8601	263
10/21/97	24SP 2N-C	71.40	35.16	1775	11331	201
10/28/97	24SP 2N-A	56.33	44.00	1788	20073	132
10/28/97	24SP 2N-B	63.60	44.25	1788	20532	97
10/28/97	24SP 2N-C	54.38	44.30	885	20471	52
11/4/97	24SP 2N-A	62.63	45.18	4869	22623	60
11/4/97	24SP 2N-B	64.59	36.00	398	16379	36
11/4/97	24SP 2N-C	62.50	44.65	5025	24890	164
11/10/97	24SP 2N-A	59.22	46.13	5025	16516	104
11/10/97	24SP 2N-B	63.20	45.08	3918	15272	94
11/10/97	24SP 2N-C	59.98	44.67	4689	17521	72
9/2/97	AGSP 6N-D	63.02	38.24	908	8372	85
9/8/97	AGSP 6N-D	79.22	35.96	883	21943	44
9/15/97	AGSP 6N-D	70.32	39.64	3158	18542	70
9/22/97	AGSP 6N-D	65.18	35.53	1660	15840	69
9/30/97	AGSP 6N-D	64.52	30.68	1415	16760	37
10/7/97	AGSP 6N-D	62.78	35.54	2065	20302	54
10/14/97	AGSP 6N-A	70.22	39.60	2879	22533	72
10/14/97	AGSP 6N-B	72.73	37.15	2886	24045	247
10/14/97	AGSP 6N-C	74.39	38.40	2551	19643	155
10/21/97	AGSP 6N-A	69.94	43.22	2550	11019	88
10/21/97	AGSP 6N-B	69.54	43.55	1726	8733	100
10/21/97	AGSP 6N-C	74.30	43.28	2091	8865	183
10/28/97	AGSP 6N-A	49.62	41.61	1980	19023	52
10/28/97	AGSP 6N-B	59.80	39.30	2483	22080	153
10/28/97	AGSP 6N-C	49.31	40.83	1415	18988	43
11/4/97	AGSP 5N-A	61.42	38.93	1392	15707	85
11/4/97	AGSP 5N-B	57.97	38.13	104	13084	66
11/4/97	AGSP 5N-C	65.49	36.28	80	13077	202
11/10/97	AGSP 5N-A	68.98	34.54	448	8630	36
11/10/97	AGSP 5N-B	58.87	37.82	40	13038	28

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-1 (Continued)

RAW STOCKPILE DATA FOR THE YEARS OF 1997 THROUGH 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
11/10/97	AGSP 5N-C	71.42	40.00	281	13186	48
9/15/98	24SP 2N-A	61.81	46.57	529	14376	213
9/15/98	24SP 2N-B	54.70	47.17	980	13982	194
9/15/98	24SP 2N-C	54.43	47.39	495	15486	287
9/1/98	AGSP 5N-A	60.75	44.15	1409	11424	110
9/1/98	AGSP 5N-B	60.62	44.03	923	13584	250
9/1/98	AGSP 5N-C	58.52	44.05	783	9236	251
9/8/98	AGSP 5N-A	24.64	46.73	1812	6983	62
9/8/98	AGSP 5N-B	22.61	46.30	1385	7574	37
9/8/98	AGSP 5N-C	24.84	46.80	2033	7697	92
9/15/98	AGSP 5N-A	68.81	44.97	2229	12150	141
9/15/98	AGSP 5N-B	71.44	41.70	4345	19729	68
9/15/98	AGSP 5N-C	72.26	43.73	4306	19470	472
7/14/98	AGSP 6N-A	65.06	44.96	1541	19896	72
7/14/98	AGSP 6N-B	56.82	44.91	1067	14311	83
7/14/98	AGSP 6N-C	59.59	44.68	1162	3659	88
7/21/98	AGSP 6N-A	67.73	45.51	1814	6872	205
7/21/98	AGSP 6N-B	70.53	45.25	1713	12728	422
7/21/98	AGSP 6N-C	63.98	44.98	1372	10219	158
11/9/99	24SP 4N-A	56.50	49.59	4196	22583	74
11/9/99	24SP 4N-B	57.34	49.67	3324	19996	63
11/9/99	24SP 4N-C	49.40	49.84	3204	17819	213
	COUNT	63	63	63	63	63
	MINIMUM	22.61	30.68	40.00	3659.00	28.00
	MAXIMUM	79.22	49.84	5314.00	27879.00	472.00
	AVERAGE	62.95	42.25	2215.70	16011.51	123.48

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-2

AVERAGE STOCKPILE DATA FOR THE YEARS OF 1997 THROUGH 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
9/2/97	24SP 2N	61.78	44.15	2100	9177	29
9/8/97	24SP 2N	70.09	42.66	3373	27879	35
9/15/97	24SP 2N	74.99	44.89	4810	23843	82
9/22/97	24SP 2N	63.53	42.00	4726	18918	106
9/30/97	24SP 2N	72.50	43.67	5314	7663	245
10/7/97	24SP 2N	66.22	44.31	773	23784	64
10/14/97	24SP 2N	74.44	42.99	2778	24781	132
10/21/97	24SP 2N	75.27	35.23	2719	11886	179
10/28/97	24SP 2N	58.10	44.18	1487	20359	94
11/4/97	24SP 2N	63.24	41.94	3431	21297	87
11/10/97	24SP 2N	60.80	45.29	4544	16436	90
9/2/97	AGSP 6N	62.07	38.24	908	8372	85
9/8/97	AGSP 6N	79.22	35.96	883	21943	44
9/15/97	AGSP 6N	70.32	39.64	3158	18542	70
9/22/97	AGSP 6N	65.18	35.53	1660	15840	69
9/30/97	AGSP 6N	64.52	30.68	1415	16760	37
10/7/97	AGSP 6N	62.78	35.54	2065	20302	54
10/14/97	AGSP 6N	72.45	38.38	2772	22074	158
10/21/97	AGSP 6N	71.26	43.35	2122	9539	124
10/28/97	AGSP 6N	52.91	40.58	1959	20030	83
11/4/97	AGSP 5N	61.63	37.78	525	13956	118
11/10/97	AGSP 5N	66.42	37.45	256	11618	37
9/15/98	24SP 2N	56.98	47.04	668	14615	231
9/1/98	AGSP 5N	59.96	44.08	1038	11415	204
9/8/98	AGSP 5N	24.03	46.61	1743	7418	64
9/15/98	AGSP 5N	70.84	43.47	3627	17116	227
7/14/98	AGSP 6N	60.49	44.85	1257	12622	81
7/21/98	AGSP 6N	67.41	45.25	1633	9940	262
11/9/99	24SP 4N	54.41	49.70	3575	20133	117
COUNT		29	29	29	29	29
MINIMUM		24.03	30.68	256.33	7417.80	29.00
MAXIMUM		79.22	49.70	5314.00	27879.00	261.67
AVERAGE		64.27	41.57	2321.37	16491.63	110.56

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-3

RAW UNDERAGED CAKE DATA FOR THE YEARS OF 1997 THROUGH 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
6/22/99	UA AGCK 5S-A	19.39	48.96	3417	10533	48
6/22/99	UA AGCK 5S-B	19.70	47.00	2941	10043	29
6/22/99	UA AGCK 5S-C	19.40	48.27	3401	11758	100
6/29/99	UA AGCK 5S-A	38.49	43.88	1676	14295	65
6/29/99	UA AGCK 5S-B	37.73	44.21	2511	18119	64
6/29/99	UA AGCK 5S-C	41.73	43.94	1588	13038	60
7/6/99	UA AGCK 5S-A	33.64	47.18	2448	12971	65
7/6/99	UA AGCK 5S-B	55.87	47.49	3336	13051	64
7/6/99	UA AGCK 5S-C	29.13	47.49	2170	11173	60
7/13/99	UA AGCK 5S-A	83.26	46.42	3800	27399	115
7/13/99	UA AGCK 5S-B	83.47	47.00	3976	25894	54
7/13/99	UA AGCK 5S-C	82.17	46.81	4845	30433	97
7/20/99	UA AGCK 6N-A	24.96	44.80	2684	10660	256
7/20/99	UA AGCK 6N-B	35.17	35.95	2247	11244	386
7/20/99	UA AGCK 6N-C	25.21	43.11	2226	10634	499
7/27/99	UA AGCK 6N-A	32.00	43.84	1700	11364	61
7/27/99	UA AGCK 6N-B	33.55	49.41	1379	11195	108
7/27/99	UA AGCK 6N-C	36.73	52.36	1486	13017	88
8/3/99	UA AGCK 6N-A	56.71	43.86	1993	14417	28
8/3/99	UA AGCK 6N-B	57.34	43.98	2571	18894	74
8/3/99	UA AGCK 6N-C	61.14	43.15	2343	14892	55
8/10/99	UA AGCK 6N-A	67.19	42.45	3177	18895	141
8/10/99	UA AGCK 6N-B	73.73	44.84	3497	21982	48
8/10/99	UA AGCK 6N-C	73.66	43.56	3924	26600	186
8/17/99	UA AGCK 6N-A	59.10	43.01	1392	16444	89
8/17/99	UA AGCK 6N-B	61.34	43.33	1687	16630	120
8/17/99	UA AGCK 6N-C	59.58	43.69	1568	16455	121
8/24/99	UA AGCK 6N-A	34.11	51.76	1449	8447	103
8/24/99	UA AGCK 6N-B	36.32	55.53	1570	7802	87
8/24/99	UA AGCK 6N-C	40.40	61.23	1619	7347	186
8/31/99	UA AGCK 6N-A	35.42	26.60	1443	7797	65
8/31/99	UA AGCK 6N-B	34.93	39.67	1809	11515	63
8/31/99	UA AGCK 6N-C	35.32	21.90	2184	9000	63
9/7/99	UA AGCK 6N-A	49.14	27.74	17461	2293	32
9/7/99	UA AGCK 6N-B	39.47	32.22	11416	2102	36
9/7/99	UA AGCK 6N-C	53.27	33.70	10546	1756	97
9/14/99	UA AGCK 6N-A	40.29	32.50	11272	2337	64
9/14/99	UA AGCK 6N-B	47.28	28.13	12650	2217	129
9/14/99	UA AGCK 6N-C	48.10	31.10	13820	2231	155
9/21/99	UA AGCK 3N-A	36.43	26.89	2134	8707	149
9/21/99	UA AGCK 3N-B	41.18	22.37	2083	8611	83

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-3 (Continued)

RAW UNDERAGED CAKE DATA FOR THE YEARS OF 1997 THROUGH 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
9/21/99	UA AGCK 3N-C	44.10	26.89	2140	8444	321
9/28/99	UA AGCK 3N-A	50.01	38.24	1268	11261	15
9/28/99	UA AGCK 3N-B	52.00	22.41	1700	9606	226
9/28/99	UA AGCK 3N-C	49.14	23.87	1436	7724	321
10/5/99	UA AGCK 3N-A	46.92	24.83	1381	9405	171
10/5/99	UA AGCK 3N-B	44.15	25.34	1262	8537	369
10/5/99	UA AGCK 3N-C	47.37	25.20	1168	9425	178
10/12/99	UA AGCK 3N-A	47.95	27.13	795	11785	68
10/12/99	UA AGCK 3N-B	50.27	26.61	973	10263	68
10/12/99	UA AGCK 3N-C	55.22	26.05	1292	10403	144
10/19/99	UA AGCK 3N-A	62.63	33.10	1346	13940	48
10/19/99	UA AGCK 3N-B	67.82	35.21	1555	16502	144
10/19/99	UA AGCK 3N-C	66.53	35.22	1906	16974	54
	COUNT	54	54	54	54	54
	MINIMUM	19.39	21.90	795.09	1755.70	15.00
	MAXIMUM	83.47	61.23	17461.00	30433.00	499.00
	AVERAGE	47.35	38.55	3326.99	12193.72	120.74

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-4

AVERAGE UNDERAGED CAKE DATA FOR THE YEARS OF 1997 THROUGH 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
6/22/99	UA AGCK 5S	19.50	48.08	3253	10778	59
6/29/99	UA AGCK 5S	39.32	44.01	1925	15151	63
7/6/99	UA AGCK 5S	39.55	47.39	2651	12398	63
7/13/99	UA AGCK 5S	82.97	46.74	4207	27909	89
7/20/99	UA AGCK 6N	28.45	41.29	2385	10846	380
7/27/99	UA AGCK 6N	34.09	48.54	1521	11859	86
8/3/99	UA AGCK 6N	58.40	43.66	2302	16068	52
8/10/99	UA AGCK 6N	71.53	43.62	3532	22492	125
8/17/99	UA AGCK 6N	60.01	43.34	1549	16510	110
8/24/99	UA AGCK 6N	36.94	56.17	1546	7865	125
8/31/99	UA AGCK 6N	35.22	29.39	1812	9437	64
9/7/99	UA AGCK 6N	47.29	31.22	13141	2050	55
9/14/99	UA AGCK 6N	45.22	30.58	12581	2262	116
9/21/99	UA AGCK 3N	40.57	25.38	2119	8588	184
9/28/99	UA AGCK 3N	50.38	28.17	1468	9530	187
10/5/99	UA AGCK 3N	46.15	25.12	1271	9122	239
10/12/99	UA AGCK 3N	51.15	26.60	1020	10817	93
10/19/99	UA AGCK 3N	65.66	34.51	1602	15805	82
COUNT		18	18	18	18	18
MINIMUM		19.50	25.12	1019.99	2050.27	52.33
MAXIMUM		82.97	56.17	13141.00	27908.67	380.33
AVERAGE		47.35	38.55	3326.99	12193.72	120.74

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-5

RAW WINTERIZED CAKE DATA FOR THE YEARS OF 1997 THROUGH 1999

DATE	SAMPLE	%TS	%TVS	NH3-N, mg/L	TKN, mg/L	ED50
4/23/98	24CK 1N-A	45.75	43.00	1535	14601	78
4/23/98	24CK 1N-B	51.99	41.94	2562	14889	16
4/28/98	24CK 1N-A	35.71	47.28	136	11821	25
4/28/98	24CK 1N-B	35.25	47.50	395	12158	54
4/28/98	24CK 1N-C	34.70	47.26	440	11568	95
5/5/98	24CK 1N-A	32.33	46.34	141	11195	28
5/5/98	24CK 1N-B	34.93	45.35	169	12127	23
5/5/98	24CK 1N-C	34.55	45.67	46	11938	48
5/12/98	24CK 1N-A	41.28	47.29	171	13852	36
5/12/98	24CK 1N-B	35.20	46.03	1033	11710	62
5/12/98	24CK 1N-C	32.25	47.94	1096	11303	21
5/19/98	24CK 1N-A	56.54	46.55	324	18303	58
5/19/98	24CK 1N-B	64.76	46.34	588	20269	42
5/19/98	24CK 1N-C	44.53	45.26	469	16943	16
4/23/98	24CK 1S-A	32.05	45.95	713	10906	71
4/23/98	24CK 1S-B	20.05	16.88	1351	11529	24
4/28/98	24CK 1S-A	24.90	49.36	1756	13030	24
4/28/98	24CK 1S-B	26.17	49.20	1795	11891	53
4/28/98	24CK 1S-C	28.11	47.83	1146	11280	48
5/5/98	24CK 1S-A	26.18	48.28	808	11352	43
5/5/98	24CK 1S-B	24.93	48.28	1537	12127	42
5/5/98	24CK 1S-C	26.51	48.00	1167	10965	74
5/12/98	24CK 1S-A	26.41	49.09	1283	12286	15
5/12/98	24CK 1S-B	37.00	46.80	310	12079	54
5/12/98	24CK 1S-C	44.63	41.44	1327	13132	48
5/19/98	24CK 1S-A	40.30	45.39	1990	15910	73
5/19/98	24CK 1S-B	51.46	46.42	1123	14490	31
5/19/98	24CK 1S-C	32.76	48.63	1756	14750	43
5/26/98	24CK 1S-A	53.57	47.63	1057	11836	32
5/26/98	24CK 1S-B	56.03	46.23	1193	15681	68
5/26/98	24CK 1S-C	70.21	46.16	1016	15331	59
6/2/98	24CK 1S-A	58.65	48.33	753	18828	32
6/2/98	24CK 1S-B	57.14	48.52	986	20749	80
6/2/98	24CK 1S-C	64.75	47.61	1077	22022	178
6/9/98	24CK 1S-A	45.71	48.01	597	14363	76
6/9/98	24CK 1S-B	38.73	47.68	477	13430	92
6/9/98	24CK 1S-C	39.57	48.39	453	12240	99
6/16/98	24CK 1S-A	51.13	47.07	210	17116	132
6/16/98	24CK 1S-B	55.10	63.32	1081	25373	113
6/16/98	24CK 1S-C	54.65	47.34	781	24865	38
6/23/98	24CK 1S-A	29.79	45.10	2282	13985	88

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-5 (Continued)

RAW WINTERIZED CAKE DATA FOR THE YEARS OF 1997 THROUGH 1999

6/23/98	24CK 1S-B	31.57	44.75	1495	10799	81
6/23/98	24CK 1S-C	29.83	45.21	1907	13423	422
4/6/99	24CK 2N-A	30.55	47.59	2496	11325	33
4/6/99	24CK 2N-B	28.96	47.30	2014	11149	74
4/6/99	24CK 2N-C	43.92	46.84	2012	10820	64
4/6/99	24CK 4N-A	39.90	45.52	1499	11373	55
4/6/99	24CK 4N-B	35.14	46.78	1789	12114	83
4/6/99	24CK 4N-C	33.75	47.32	2903	13398	75
4/13/99	24CK 2N-A	35.96	46.98	1678	9421	36
4/13/99	24CK 2N-B	39.00	45.64	1815	12015	43
4/13/99	24CK 2N-C	48.75	46.06	1772	10339	31
4/13/99	24CK 4N-A	34.15	47.83	2211	10346	55
4/13/99	24CK 4N-B	35.49	46.79	2012	8914	95
4/13/99	24CK 4N-C	30.87	45.46	1820	9181	104
4/20/99	24CK 2N-A	35.62	45.72	891	8817	148
4/20/99	24CK 2N-B	36.36	46.02	411	8598	73
4/20/99	24CK 2N-C	32.36	45.87	1533	10229	84
4/20/99	24CK 4N-A	32.92	45.78	330	9659	60
4/20/99	24CK 4N-B	27.54	50.59	847	8944	48
4/20/99	24CK 4N-C	32.79	45.70	1169	9547	72
4/27/99	24CK 2N-A	38.79	45.99	1228	10763	59
4/27/99	24CK 2N-B	41.74	45.97	1404	12471	196
4/27/99	24CK 2N-C	37.40	46.43	1263	10274	54
4/27/99	24CK 4N-A	32.80	49.77	923	9464	43
4/27/99	24CK 4N-B	37.10	49.57	1055	12154	58
4/27/99	24CK 4N-C	32.96	49.61	1328	11290	108
5/4/99	24CK 2N-A	44.63	43.10	1410	16022	14
5/4/99	24CK 2N-B	34.92	44.77	4470	20110	43
5/4/99	24CK 2N-C	85.74	45.60	2520	16682	31
5/4/99	24CK 4N-A	44.13	44.60	2483	16792	188
5/4/99	24CK 4N-B	39.69	45.16	2285	12132	236
5/4/99	24CK 4N-C	34.84	46.01	1655	13223	171
5/11/99	24CK 2N-A	58.40	45.34	1837	13667	38
5/11/99	24CK 2N-B	79.26	45.87	2111	14371	51
5/11/99	24CK 2N-C	54.65	46.17	2658	15131	36
5/11/99	24CK 4N-A	76.04	47.14	3018	21228	68
5/11/99	24CK 4N-B	71.04	44.90	2680	20124	56
5/11/99	24CK 4N-C	70.29	45.30	3001	19703	53
5/18/99	24CK 2N-A	51.26	45.04	1584	15513	28
5/18/99	24CK 2N-B	46.51	45.24	2008	18104	40
5/18/99	24CK 2N-C	47.40	42.72	300	8803	63
5/18/99	24CK 4N-A	48.77	44.42	1339	8221	523

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-5 (Continued)

RAW WINTERIZED CAKE DATA FOR THE YEARS OF 1997 THROUGH 1999

5/18/99	24CK 4N-B	44.59	47.08	1172	20621	59
5/18/99	24CK 4N-C	51.44	46.25	1512	14860	148
5/25/99	24CK 2N-A	47.62	44.35	1925	14696	75
5/25/99	24CK 2N-B	55.50	44.23	1895	15636	64
5/25/99	24CK 2N-C	52.53	42.40	625	12517	63
5/25/99	24CK 4N-A	36.32	45.34	1120	11615	75
5/25/99	24CK 4N-B	51.15	43.47	1840	14748	59
5/25/99	24CK 4N-C	41.95	43.68	830	13468	100
6/1/99	24CK 2N-A	61.20	40.69	1894	20428	68
6/1/99	24CK 2N-B	61.18	41.37	2238	20717	36
6/1/99	24CK 2N-C	63.30	41.72	2231	19074	120
6/1/99	24CK 4N-A	69.79	40.33	861	20039	171
6/1/99	24CK 4N-B	71.08	39.94	854	20750	108
6/1/99	24CK 4N-C	70.61	40.22	740	21456	127
6/8/99	24CK 2N-A	33.83	51.49	1700	13077	94
6/8/99	24CK 2N-B	27.80	48.52	1610	11007	111
6/8/99	24CK 2N-C	28.88	47.52	1373	11060	358
6/8/99	24CK 4N-A	67.37	45.95	1365	16183	113
6/8/99	24CK 4N-B	69.96	45.78	2013	18863	250
6/8/99	24CK 4N-C	78.03	45.92	2193	17106	223
6/15/99	24CK 2N-A	32.46	42.81	1811	10788	160
6/15/99	24CK 2N-B	32.73	42.60	1511	9680	171
6/15/99	24CK 2N-C	33.67	42.67	2258	13853	81
6/15/99	24CK 4N-A	51.25	43.20	1103	12720	306
6/15/99	24CK 4N-B	56.03	44.03	480	13536	164
6/15/99	24CK 4N-C	65.61	40.77	1292	11467	104
	COUNT	109	109	109	109	109
	MINIMUM	20.05	16.88	46.01	8220.90	14.00
	MAXIMUM	85.74	63.32	4469.90	25373.00	523.00
	AVERAGE	44.55	45.76	1401.21	13952.66	88.38

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-6

AVERAGE WINTERIZED CAKE DATA FOR THE YEARS OF 1997 THROUGH 1999

4/23/98	24CK 1N	48.87	42.47	2049	14745	47
4/28/98	24CK 1N	35.22	47.35	324	11849	58
5/5/98	24CK 1N	33.94	45.79	118	11753	33
5/12/98	24CK 1N	36.24	47.09	767	12288	40
5/19/98	24CK 1N	55.28	46.05	460	18505	39
4/23/98	24CK 1S	25.67	37.40	1273	11822	40
4/28/98	24CK 1S	27.14	48.52	1470	11586	51
5/5/98	24CK 1S	25.87	48.19	1171	11481	53
5/12/98	24CK 1S	36.01	45.78	973	12499	39
5/19/98	24CK 1S	41.51	46.81	1623	15050	49
5/26/98	24CK 1S	59.94	46.67	1089	14283	53
6/2/98	24CK 1S	60.18	48.15	939	20533	97
6/9/98	24CK 1S	41.34	48.03	509	13344	89
6/16/98	24CK 1S	53.63	52.58	691	22451	94
6/23/98	24CK 1S	30.40	45.02	1894	12736	197
4/6/99	24CK 2N	34.48	47.24	2174	11098	57
4/6/99	24CK 4N	36.26	46.54	2063	12295	71
4/13/99	24CK 2N	41.24	46.23	1755	10592	37
4/13/99	24CK 4N	33.50	46.69	2014	9480	85
4/20/99	24CK 2N	34.78	45.87	945	9215	102
4/20/99	24CK 4N	31.08	47.36	782	9383	60
4/27/99	24CK 2N	39.31	46.13	1298	11169	103
4/27/99	24CK 4N	34.29	49.65	1102	10969	70
5/4/99	24CK 2N	55.10	44.49	2800	17605	29
5/4/99	24CK 4N	39.55	45.26	2141	14049	198
5/11/99	24CK 2N	64.10	45.79	2202	14390	42
5/11/99	24CK 4N	72.46	45.78	2900	20352	59
5/18/99	24CK 2N	48.39	44.33	1297	14140	44
5/18/99	24CK 4N	48.27	45.92	1341	14567	243
5/25/99	24CK 2N	51.88	43.66	1482	14283	67
5/25/99	24CK 4N	43.14	44.16	1263	13277	78
6/1/99	24CK 2N	61.89	41.26	2121	20073	75
6/1/99	24CK 4N	70.49	40.16	818	20748	135
6/8/99	24CK 2N	30.17	49.18	1561	11715	188
6/8/99	24CK 4N	71.79	45.88	1857	17384	195
6/15/99	24CK 2N	32.95	42.69	1860	11440	137
6/15/99	24CK 4N	57.63	42.67	959	12574	191
	COUNT	37	37	37	37	37
	MINIMUM	25.67	37.40	118.47	9214.80	29.33
	MAXIMUM	72.46	52.58	2899.53	22451.33	243.33
	AVERAGE	44.43	45.75	1407.67	13938.47	87.66