ICR Treatment Plant Summary Report

Evaluation of GAC Technology Using Pilot-Scale Testing For Compliance with the Information Collection Rule

City of Dallas Public Water System No. TX0570004
East Side Water Treatment Plant ICR No. 618

Conducted during the period of April 13, 1998, through November 6, 1998

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Attachment: 1 diskette containing the *Data Collection Spreadsheets*, *Summary Report Spreadsheets* and the *Summary Report*

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Section 1
Conclusions and Recommendations

In concluding the ICR treatment study, GAC was not found to be an economically feasible method for the removal of disinfection byproduct precursors and subsequently the control of disinfection byproducts for this water supply. Although influent TOC concentrations were low, ranging from 2.6 to 3.1 mg/L, breakthrough levels for TOC were reached in the 10-minute GAC column in only 38 days. Breakthrough of the proposed Stage 2 THM4 MCL was reached in only 10 days in the 10-minute GAC column and is estimated to be less than 100 days for the 20-minute GAC columns. Exact breakthrough run times for other parameters such as HAA5 and HAA6 are not available due to the implementation of enhanced coagulation to extend GAC bed life. However, ICR pilot testing was conducted using only one of two water sources for the East Side WTP. This source, Lake Ray Hubbard, has a lower TOC concentration than the other source, Lake Tawakoni (i.e., 4 mg/L versus 6 mg/L). Therefore, a typical blend of source waters has a higher TOC concentration (about 5 mg/L) than the water used for pilot testing. As a result, run times to breakthrough for all parameters would be shorter for a blend of the waters. Thus, GAC would not be cost-effective for control of disinfection byproducts. Furthermore, GAC does not aid in the reduction of finished water turbidity or the removal of pathogens.

Section 2
Background Information

2.1 Plant Description

The East Side Water Treatment Plant utilizes two-stage conventional treatment and treats water from two surface water sources, Lake Ray Hubbard and Lake Tawakoni. The plant normally treats a 40%/60% blend of Lake Ray Hubbard/Lake Tawakoni water. Although the plant was classified as a two-stage softening plant under the ICR, lime is added only for pH adjustment. Therefore, no softening is achieved. The same disinfection scheme is used at the plant year round to meet disinfection contact time (CT) requirements. Chlorine is added in the raw water pipelines and then again at the raw water junction structure for primary disinfection. Ammonia is then added at the primary rapid mix to form chloramines for disinfection through the plant and for residual disinfection. A schematic of the plant is shown in Figure 2-1. Reports G.1 and G.2 from the ICR monitoring, included in Appendix A, provide plant design parameters and chemical parameters.

2.2 Source/Finished Water Quality Data

All historical source and finished water quality data is provided in the *Treatment Study Summary Report Spreadsheet* in Appendix B. The data was gathered during the monitoring portion of the ICR studies. Although plant data was collected for 18 months (July 1997 – December 1998), the *Summary Report Spreadsheet* reflects statistical summaries of data collected for 12 months (January 1998 – December 1998), since the treatment study was conducted in 1998.

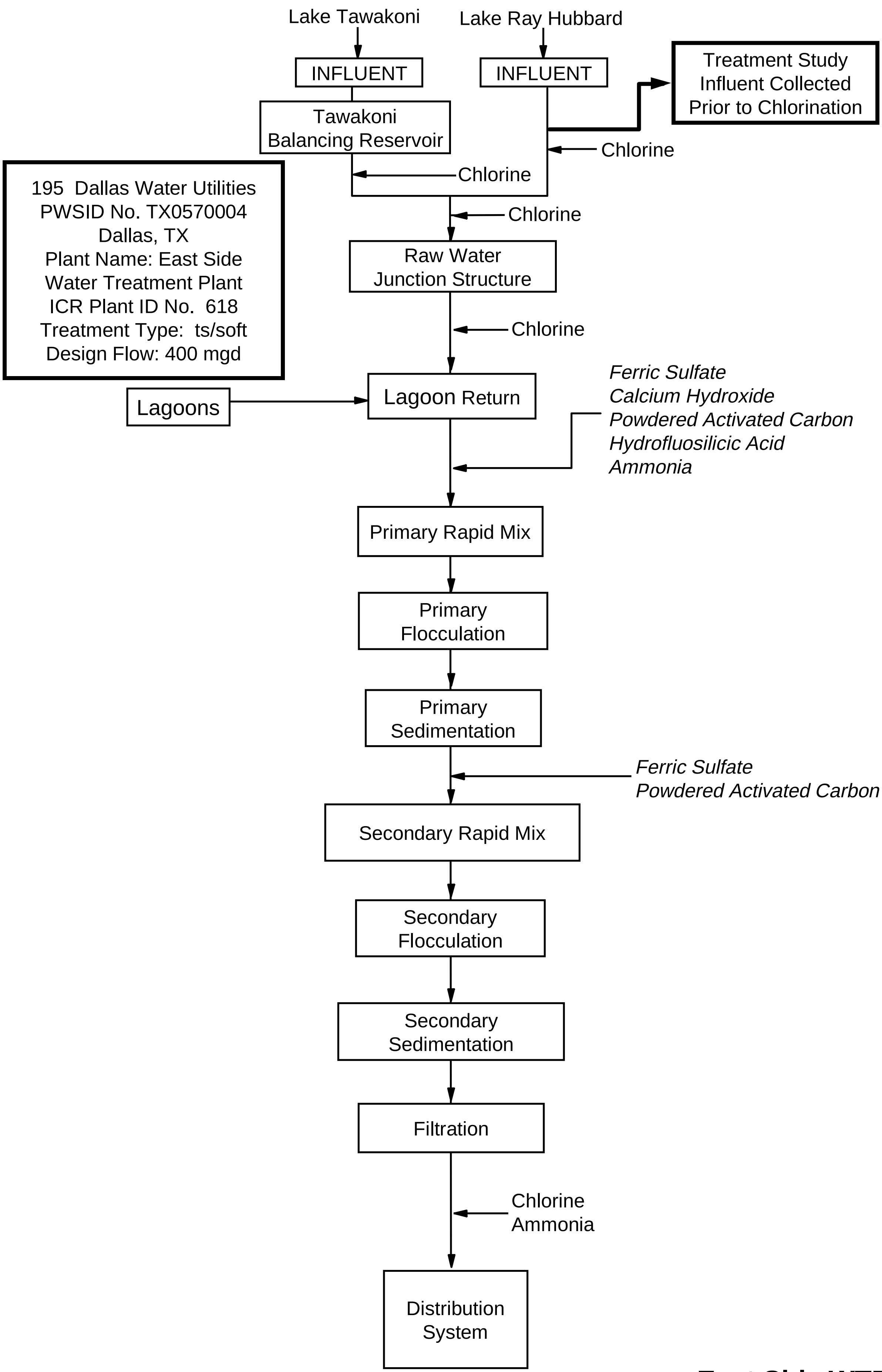

Figure 2-1
Full-Scale
East Side WTP Schematic

Section 3
Materials and Methods

3.1 Pretreatment Process

A schematic of the pretreatment pilot process used prior to the GAC pilot columns is presented in Figure 3-1. Table 3-1 lists specific design information for each pilot unit in the process. As illustrated in Figure 2-1, the first point of chlorine addition at the full-scale level is in the raw water pipelines, precluding the possibility of using water from the plant for GAC testing. Therefore, all pretreatment was accomplished at the pilot level. Since the two raw water pump stations are more than 20 miles apart, a blend of the two waters could not be tested. Historically, Lake Tawakoni has higher raw water TOC concentrations (e.g., an average of 6 mg/L for Lake Tawakoni versus an average of 4 mg/L for Lake Ray Hubbard), making that location more desirable for ICR testing. However, due to anticipated construction at the Lake Tawakoni Pump Station, ICR pilot testing was conducted at Lake Ray Hubbard (the Forney Pump Station). Raw water was supplied to the pilot plant directly from the lake.

The pilot plant simulated each unit process of the full-scale plant, from primary rapid mixing to filtration. GAC filtration followed the conventional dual-media filtration.

3.2 GAC Pilot-Scale Treatment Process

The GAC module consisted of two 4-inch-diameter plastic columns, each 10 feet in height. Each column had an empty bed contact time (EBCT) of 10 minutes, and they operated in series, thus giving a total EBCT of 20 minutes. Filtered water was pumped to the top of each column and then flowed by gravity to a clearwell tank. Flow was monitored daily to maintain the specified EBCT.

The GAC used was bituminous coal with an effective size of approximately 1.1 millimeters. GAC was supplied by Calgon Carbon Corporation in compliance with AWWA B604.

Prior to loading the columns with GAC, a test was performed to demonstrate that there had been no leaching of TOC from the GAC column material. USEPA requested that unchlorinated treated or raw water be run through the GAC columns (without any GAC) for a minimum of 340 hours and that samples of the influent TOC (TOC_{in}), effluent TOC from the first GAC column (TOC_{out10}) and effluent TOC from the second GAC column (TOC_{out20}) be taken the last five days to prove that $TOC_{in} = TOC_{out}$.

Each GAC column was flushed with unchlorinated raw water for a minimum of 10 days before the TOC sampling began. All TOC samples were collected and analyzed in accordance with the ICR Analytical Methods for TOC (Standard Method 5310C).

TOC leaching results for the GAC columns are provided in Table 3-2.

For the first three days of sampling, raw water (in lieu of treated water) was run through the columns so that the entire pilot plant would not have to run over the weekend. However, particulate matter in the raw water caused some variability in the TOC values. Additionally, a sampling error occurred on March 30, 1998, when the flow through the GAC columns switched from raw to treated water. Upon completion of the leaching study, the two columns were loaded with GAC and testing commenced on April 13, 1998.

3.3 Experimental Design

As illustrated in Figure 2-1, the East Side Water Treatment Plant adds ferric sulfate for coagulation, lime for pH adjustment, powdered activated carbon (PAC) for taste and odor control and hydrofluosilicic acid for fluoridation. At the pilot scale, ferric sulfate was also used as the coagulant in both the primary and secondary treatment stages and lime was added for pH adjustment in the primary stage. However, hydrofluosilicic acid was not added since fluoride was not being evaluated as part of the ICR treatment studies. PAC was also not applied during pilot testing since the purpose of the ICR study was to evaluate GAC for TOC reduction, not PAC.

A 12-month TOC applicability study conducted on a blend of Lake Ray Hubbard and Lake Tawakoni water from September 1996 to August 1997 for USEPA showed only minor effect of seasonal changes on TOC concentration in the raw water, as shown in Figure 3-2. Therefore, seasonal variability was determined to be insignificant and only enhanced coagulation was evaluated.

In the interest of evaluating enhanced coagulation, the ferric sulfate dose varied during the course of the study. As indicated in Table 3-1, the primary ferric dose ranged from 10 to 100 mg/L and the secondary ferric remained at 10 mg/L (all doses recorded as granular ferric sulfate). The effect of coagulant dosage on influent and effluent TOC levels and on bed life of the GAC were observed. Similarly, the lime dosage varied from 0 to 100 mg/L (as calcium hydroxide). Approximately 70 days into the study, the lime feed was discontinued to investigate the effect of pH depression on bed life extension.

3.4 Analytical Methods

All information regarding analytical methods, minimum reporting levels (MRLs) and laboratories is included in the *Treatment Study Summary Report Spreadsheet*. Each analysis was conducted in accordance with the *DBP/ICR Analytical Methods Manual*, using the most recent analytical methods. Results were reported using the most recent MRLs. MRLs for titration analyses such as alkalinity, total hardness and calcium hardness are listed at 10 mg/L $CaCO_3$ because the markings on the burets do not extend lower than 10 mL.

As required by USEPA, the following simulated distribution system (SDS) conditions with free chlorine were used for all SDS samples collected:

Incubation time:	24 hours
Incubation temperature:	ambient distribution temperature
pH:	7.8 – 9.2 (ambient)
24-hour free chlorine residual:	1.0 ($\pm$ 0.4 mg/L)

Table 3-1
Lake Ray Hubbard Pilot Plant: Summary of Pretreatment Design Data

Unit Process	Process Description
Primary Rapid Mix (Pilot Scale)	Type of Mixer: Mechanical Short Circuiting Factor: 0.1 (assumed) Baffling Type: Unbaffled – Mixed tank Liquid Volume (gal): 6 Mean Velocity Gradient ($sec.^{-1}$): 3000 @ 20 °C Coagulant Addition: Ferric Sulfate ($Fe_2(SO_4)_3$) Coagulant Dose (mg/L): 10 – 100 Lime Dose (mg/L): 0 – 100 ($Ca(OH)_2$)
Primary Flocculation (Pilot Scale)	Type of Mixer: Mechanical Liquid Volume (gal): 86 Short Circuiting Factor: 0.5 (assumed) Baffling Type: Average Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec^{-1}): 70 @ 20°C Stage Liquid Volume (gal): 28.7 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec^{-1}): 50 @ 20°C Stage Liquid Volume (gal): 28.7 Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec^{-1}): 30 @ 20°C Stage Liquid Volume (gal): 28.7
Primary Sedimentation (Pilot Scale)	Surface Area (ft^2): 3.7 Liquid Volume (gal): 90 Baffling Type: Poor Short Circuiting Factor: 0.3 (assumed) Tube Settler Surface Area (ft^2): 7.5 Tube Settler Brand Name: MRI (Golden, CO)
Secondary Rapid Mix (Pilot Scale)	Type of Mixer: Mechanical Baffling Type: Unbaffled – Mixed tank Liquid Volume (gal): 6 Mean Velocity Gradient ($sec.^{-1}$): 700 @ 20 °C Coagulant Addition: Ferric Sulfate ($Fe_2(SO_4)_3$) Coagulant Dose (mg/L): 10
Secondary Flocculation (Pilot Scale)	Type of Mixer: Mechanical Liquid Volume (gal): 86 Short Circuiting Factor: 0.5 (assumed) Baffling Type: Average Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec^{-1}): 60 @ 20°C Stage Liquid Volume (gal): 28.7 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec^{-1}): 20 @ 20°C Stage Liquid Volume (gal): 28.7 Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec^{-1}): 20 @ 20°C Stage Liquid Volume (gal): 28.7
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Dual-Media Filtration (Pilot Scale)	Inside Column Diameter (in): 4 Surface Area (ft^2): 0.087 Column Height (ft): 10 Filtration Rate (gpm/ft^2): 4 Total Media Depth (in): 26 Media Type: Sand (12")/Anthracite (14") Minimum Water Depth to Top of Media (ft): 7

Table 3-2
TOC Leaching Study Results for Lake Ray Hubbard GAC Columns

Date	TOC_{in} (mg/L)	TOC_{out10} (mg/L)	TOC_{out20} (mg/L)	Std. Dev. (mg/L)
3/27/98 [1]	3.9	3.8	4.4	0.26
3/28/98 [1]	4.5	4.2	4.6	0.17
3/29/98	4.4	4.4	4.2	0.09
3/30/98	[2]	[2]	[2]	-
3/31/98	3.3	3.1	3.3	0.09

Notes:
[1] Averages are reported for TOC values (sample and analytical duplicates) for the 27th and 28th due to higher solids content in sample. These samples were raw water (turbidity = 10 NTU).
[2] Sampling error (data not accurate).

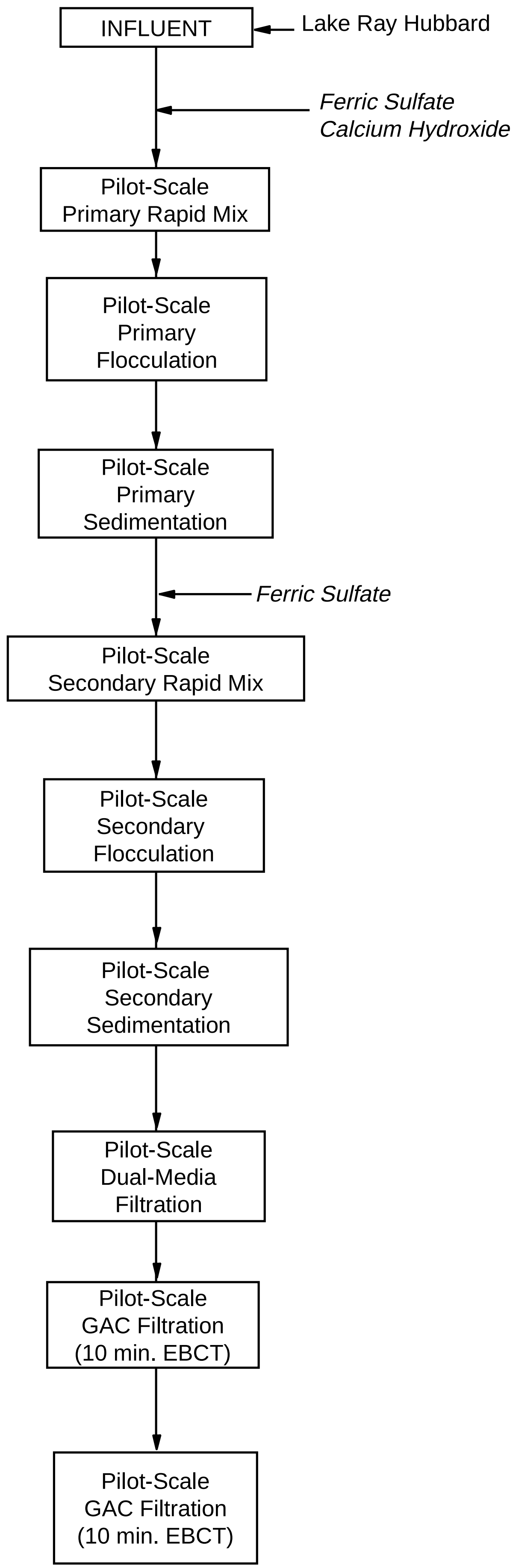
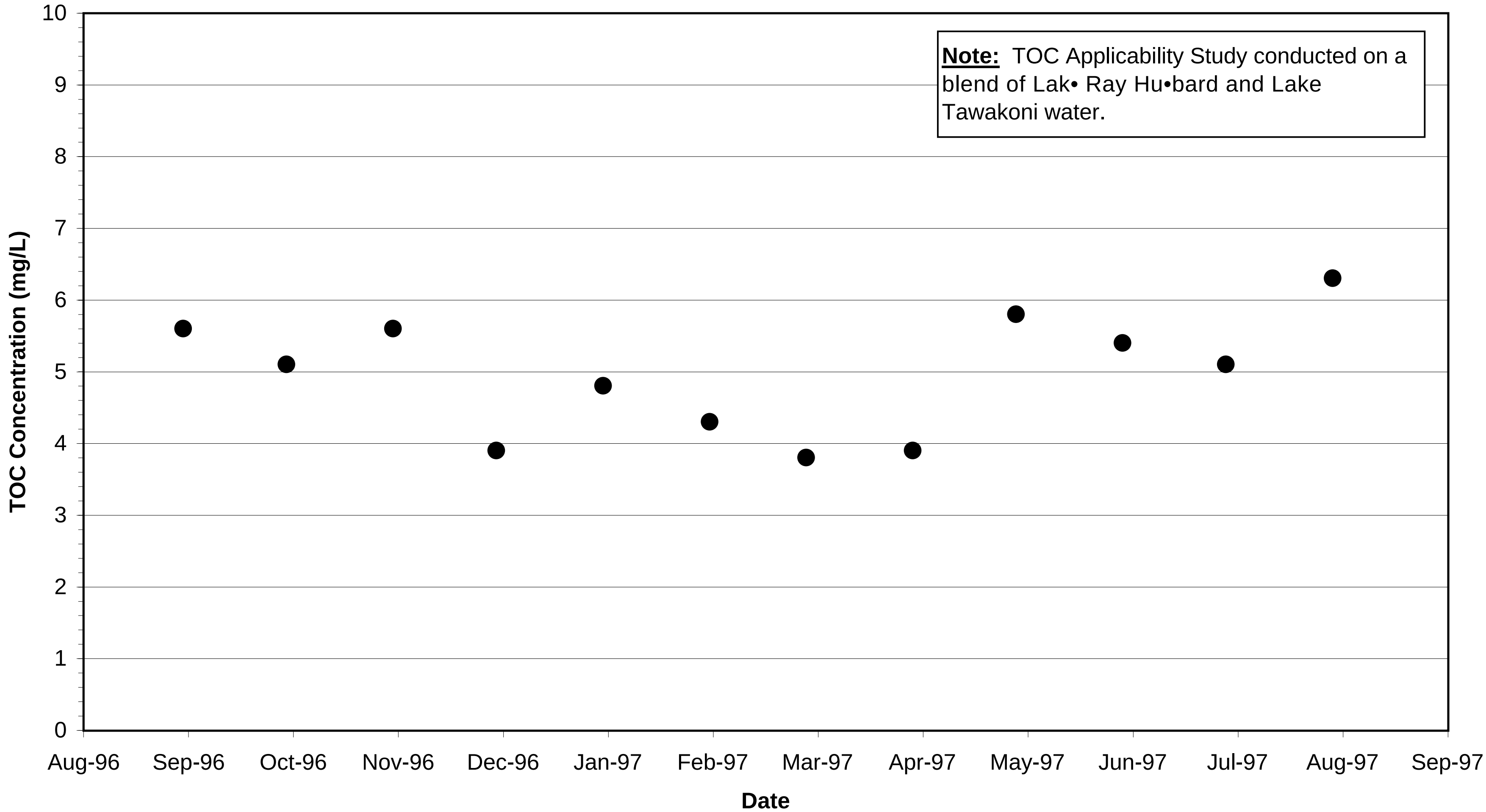


Figure 3-1
East Side WTP
Pretreatment Schematic
Prior to GAC Filtration

Figure 3-2
Raw Water TOC Concentration for East Side WTP
September 1996 - August 1997



Section 4
Results and Discussion

4.1 Problems Encountered

During the study, the headloss in the 10-minute EBCT column increased, necessitating backwash. The GAC columns were taken off-line on Wednesday, August 26, 1998, for backwashing of the 10-minute EBCT column. The backwash procedure was carefully monitored to ensure no loss of GAC media through the top of the column. Total downtime was less than one hour, so the *Data Collection Spreadsheet* was not altered to reflect this downtime in the operation time calculations.

4.2 Water Quality Data

Table 4-1 presents a summary of GAC influent water quality parameters by chemical dose scheme and operation time.

4.3 Impact of Enhanced Coagulation

The analytical results of the treatment study are recorded in the *Data Collection Spreadsheet*, provided in Appendix C. As outlined in the *ICR Manual for Bench- and Pilot-Scale Treatment Studies*, testing with GAC is to continue until either: 1) the effluent TOC concentration reaches 70 percent of the running average of the influent TOC concentration on two consecutive samples that occur a minimum of two weeks apart, or 2) 50 percent TOC breakthrough occurs and a plateau is reached in which the effluent TOC concentration does not increase over 1440 hours by more than 10 percent of the average influent TOC concentration. For both the 10-minute and 20-minute GAC columns, testing continued until 70 percent of the running average influent TOC was reached.

Breakthrough curves of concentration versus operation time (in days) are provided in Figures 4-1 through 4-6 for the various water quality parameters. It should be noted that the influent TOCs (and chemical dose schemes) remained fairly stable for the 10-minute GAC column testing. As shown on the TOC breakthrough curve in Figure 4-1, initial influent TOC levels were relatively low, ranging from 2.6 to 3.1 mg/L. However, the 70 percent level (about 1.8 mg/L) was first reached in the 10-minute GAC column after only 38 days.

The primary ferric sulfate dose was increased significantly after the 10-minute GAC bed had expended (55 days) to investigate the effect of enhanced coagulation on extending the 20-minute GAC bed life. At that time, the 20-minute GAC column effluent TOC concentration was well below the 70 percent level. However, based on the trend of the 20-minute TOC data for the first 55 days, it is estimated the 70 percent TOC level would have been reached in the 20-minute GAC columns within 125 days.

After analyzing the breakthrough curves for SDS-THM4, SDS-HAA5, and SDS-HAA6 in Figures 4-4, 4-5, and 4-6, respectively, we can determine the run time and number of bed volumes at which Stage 1 and proposed Stage 2 D/DBPR MCLs are reached. Tables 4-2 and 4-3 give both the run time and bed volumes to breakthrough for SDS-THM4, SDS-HAA5, and SDS-HAA6 for the 10- and 20-minute GAC columns, respectively. These tables list both Stage 1 and proposed Stage 2 MCLs with a 10 percent factor of safety. Additionally, a THM4 value of 54 μg/L (i.e., possible MCL = 60 μg/L) is provided for information.

As the tables show, the THM4 value exceeded the proposed Stage 2 MCL of 40 μg/L (with a 10 percent factor of safety) in the 10-minute GAC column in ten days and the 20-minute GAC columns in 129 days. However, the breakthrough run time in the 20-minute GAC column probably would have been less had enhanced coagulation not been implemented. Additionally, a THM4 value of 60 μg/L (with a 10 percent factor of safety) was exceeded in the 10-minute GAC column in 30 days. Since the chemical dose scheme changed substantially after 55 days to investigate enhanced coagulation, breakthrough run times to the Stage 1 MCL of 80 μg/L cannot be determined for the 20-minute GAC columns.

HAA5 and HAA6 levels were low, with both the 10-minute and 20-minute GAC column effluent levels remaining well below the Stage 2 MCL of 30 μg/L. Therefore, no breakthrough run times are available for HAA5 or HAA6 data.

4.4 Summary of Significant Results

Although chemical dosages were changed after 55 days to investigate enhanced coagulation during ICR testing, influent TOCs remained fairly constant during the 10-minute GAC column testing. Breakthrough levels for TOC on the 10-minute GAC column were reached after only 38 days, even with low influent TOC water feeding the column. Likewise, run time to breakthrough of the proposed Stage 2 THM4 MCL occurred after only 10 days for the 10-minute GAC column and is estimated to be less than 100 days for the 20-minute GAC columns. Due to evaluation of enhanced coagulation, exact breakthrough run times for many parameters are not available. However, it is important to note that ICR testing for East Side WTP was performed on only one of the two water sources, Lake Ray Hubbard. This water has historically had lower TOC concentrations than Lake Tawakoni water. As Figure 3-2 illustrates, a typical blend of Lake Ray Hubbard/Lake Tawakoni water has an average yearly concentration of about 5.0 mg/L TOC. Therefore, actual run times to breakthrough for East Side WTP influent would be shorter than this testing illustrates and would most likely be similar to, if not shorter than, the times found at Bachman WTP. Therefore, it is concluded that GAC would not be a cost-effective means for DBP control for this water supply.

Table 4-1
GAC Influent Average Water Quality Parameters by Chemical Dose
East Side WTP (Lake Ray Hubbard Pilot Plant)

Water Quality Parameter	Chemical Dose Scheme (mg/L) - Primary Ferric Sulfate/Primary Calcium Hydroxide/Secondary Ferric Sulfate									
	30/60/10	**40/40/10 [2]**	**30/40/10**	**20/40/10 [2]**	**10/40/10**	**50/40/10 [2]**	**60/40/10**	**30/0/10 [2]**	**20/0/10**	**30/80/10 [2]**
Operation time (days)	0 - 39	39 - 43	43 - 49	49 - 50	50 - 55	55 - 57	57 - 59	59 - 67	67 - 74	74 - 77
Temperature (^oC)	23.9 (1.51)	25.5 (0.40)	29.0	28.1	29.0	25.4 (0.18)	28.0	28.9 (1.20)	29.0	29.9 (0.79)
pH	8.4 (0.40)	7.7 (0.08)	7.5	7.9	7.7	7.5 (0.04)	7.6	6.8 (0.10)	6.4	9.4 (0.07)
Turbidity (NTU)	0.11 (0.06)	0.08 (0.01)	0.08	0.09 (0.02)	0.14	0.14 (0.06)	0.14	0.11 (0.03)	0.09	0.09 (0.03)
Alkalinity (mg/L as $CaCO_3$)	34.9 (7.20)	64 (6.30)	47.0	69.0	60.0	76 (0.0)	85.0	88 (3.69)	85.0	27 (4.90)
Calcium Hardness (mg/L as $CaCO_3$)	60.1 (12.01)	98 (10.13)	72.0	91.0	73.0	108 (4.24)	138.0	111 (3.04)	111.0	53 (4.04)
Total Hardness (mg/L as $CaCO_3$)	71.0 (11.18)	109 (7.80)	80.0	NA	83.0	119 (2.83)	149.0	123 (2.00)	119.0	64 (2.18)
Bromide (ug/L)	77.0 (2.83)		79.0		83.0		85.0		90.0	
TOC (mg/L)	2.7 (0.10)		2.8		3.1		2.4		2.7	
UV_{254} (cm^{-1})	0.053 (0.003)		0.060		0.060		0.055		0.045	
SDS-THM4 (ug/L)	75.0 (7.86)		60.8		73.9		74.9		NR	
SDS-HAA5 (ug/L)	23.4 (2.78)		27.9		32.9		27.0		NR	
SDS-HAA6 (ug/L)	30.4 (3.03)		34.9		40.8		33.8		NR	
SDS-TOX (ug Cl^-/L)	185.8 (17.44)		210.0		220.0		200.0		NR	
SDS-Chlorine Demand (mg/L)	2.3 (0.26)		2.3		2.8		2.5		2.3	

Notes:

[1] Numbers in parentheses are standard deviations.

[2] Official ICR sampling was not conducted during these testing schemes. Averages and standard deviations of daily samples are provided for information purposes.

Table 4-1 (cont.)
GAC Influent Average Water Quality Parameters by Chemical Dose
East Side WTP (Lake Ray Hubbard Pilot Plant)

Water Quality Parameter	Chemical Dose Scheme (mg/L) - Primary Ferric Sulfate/Primary Calcium Hydroxide/Secondary Ferric Sulfate									
	30/100/10	30/120/10 [2]	50/0/10	80/0/10 [2]	100/0/10	40/40/10 [2]	60/0/10	40/0/10	30/0/10 [2]	20/0/10
Operation time (days)	77 - 83	83 - 88	88 - 98	98 - 100	100 - 101	101 - 110	110 - 156	156 - 172	172 - 178	178 - 207
Temperature (^oC)	32.5	31.5 (0.81)	30.5	31 (0.04)	32.5	31.5 (1.19)	31.3 (3.79)	30.5 (2.12)	24.0 (1.17)	23.8 (0.35)
pH	10.1	10.1 (0.11)	6.3	6 (0.17)	3.8	7.1 (0.23)	5.4 (0.10)	6.5 (0.49)	6.5 (0.75)	6.8 (0.14)
Turbidity (NTU)	0.14	0.12 (0.08)	0.09	0.08 (0.00)	0.06	0.11 (0.04)	0.14 (0.12)	0.10 (0.02)	0.26 (0.12)	0.25 (0.13)
Alkalinity (mg/L as $CaCO_3$)	80.0	84 (6.80)	63.0	36 (1.41)	9.0	60 (4.63)	21.7 (5.86)	42.0 (8.49)	54 (5.81)	62.5 (6.36)
Calcium Hardness (mg/L as $CaCO_3$)	106.0	117 (7.16)	100.0	91 (2.48)	83.0	103 (6.50)	71.0 (7.21)	79.0 (7.07)	79 (1.95)	80.0 (2.83)
Total Hardness (mg/L as $CaCO_3$)	108.0	118 (6.94)	106.0	103 (0.71)	104.0	113 (4.34)	85.0 (5.29)	90.5 (6.36)	91 (1.84)	90.0 (4.24)
Bromide (ug/L)	93.5		95.0		120.0		116.7 (11.55)	125.0 (7.07)		125.0 (7.07)
TOC (mg/L)	2.3		2.4		1.8		1.8 (0.30)	2.3 (0.14)		3.1 (0.00)
UV_{254} (cm^{-1})	0.049		0.036		0.031		0.031 (0.001)	0.039 (0.008)		0.049 (0.006)
SDS-THM4 (ug/L)	NR		NR		NR		53.2 (3.89)	NR		49.2 (3.46)
SDS-HAA5 (ug/L)	NR		NR		NR		10.3 (0.49)	NR		21.4 (1.77)
SDS-HAA6 (ug/L)	NR		NR		NR		14.5 (0.71)	NR		28.7 (2.16)
SDS-TOX (ug Cl^-/L)	NR		NR		NR		110.0 (0)	NR		185.0 (7.07)
SDS-Chlorine Demand (mg/L)	2.6		2.6		2.6		2.9 (0.30)	3.5 (0.64)		4.4 (0.28)

Notes:

[1] Numbers in parentheses are standard deviations.

[2] Official ICR sampling was not conducted during these testing schemes. Averages and standard deviations of daily samples are provided for information purposes.

Table 4-2
Breakthrough Criterion for GAC ICR Testing - 10-minute EBCT
East Side WTP (Lake Ray Hubbard Pilot Plant)

Criterion	Run Time (days)	Throughput (bed volumes)	TOC (mg/L)	SDS-THM4 (mg/L)	SDS-HAA5 (mg/L)	SDS-HAA6 (mg/L)	SDS-TOX (mg Cl-/L)
SDS-THM4 =36 ug/L	10	1467	1.2	36	6	9	BMRL
SDS-THM4 =54 ug/L	30	4324	1.7	54	8	12	100
SDS-THM4 =72 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA5 =27 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA5 =54 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA6 =27 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA6 =54 ug/L	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

Table 4-3
Breakthrough Criterion for GAC ICR Testing - 20-minute EBCT
East Side WTP (Lake Ray Hubbard Pilot Plant)

Criterion	Run Time (days)	Throughput (bed volumes)	TOC (mg/L)	SDS-THM4 (mg/L)	SDS-HAA5 (mg/L)	SDS-HAA6 (mg/L)	SDS-TOX (mg Cl-/L)
SDS-THM4 =36 ug/L	129	9301	0.89	41	5	6	NR
SDS-THM4 =54 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-THM4 =72 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA5 =27 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA5 =54 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA6 =27 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA6 =54 ug/L	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

Figure 4-1
TOC Breakthrough Curve
East Side WTP (Lake Ray Hubbard Pilot Plant)

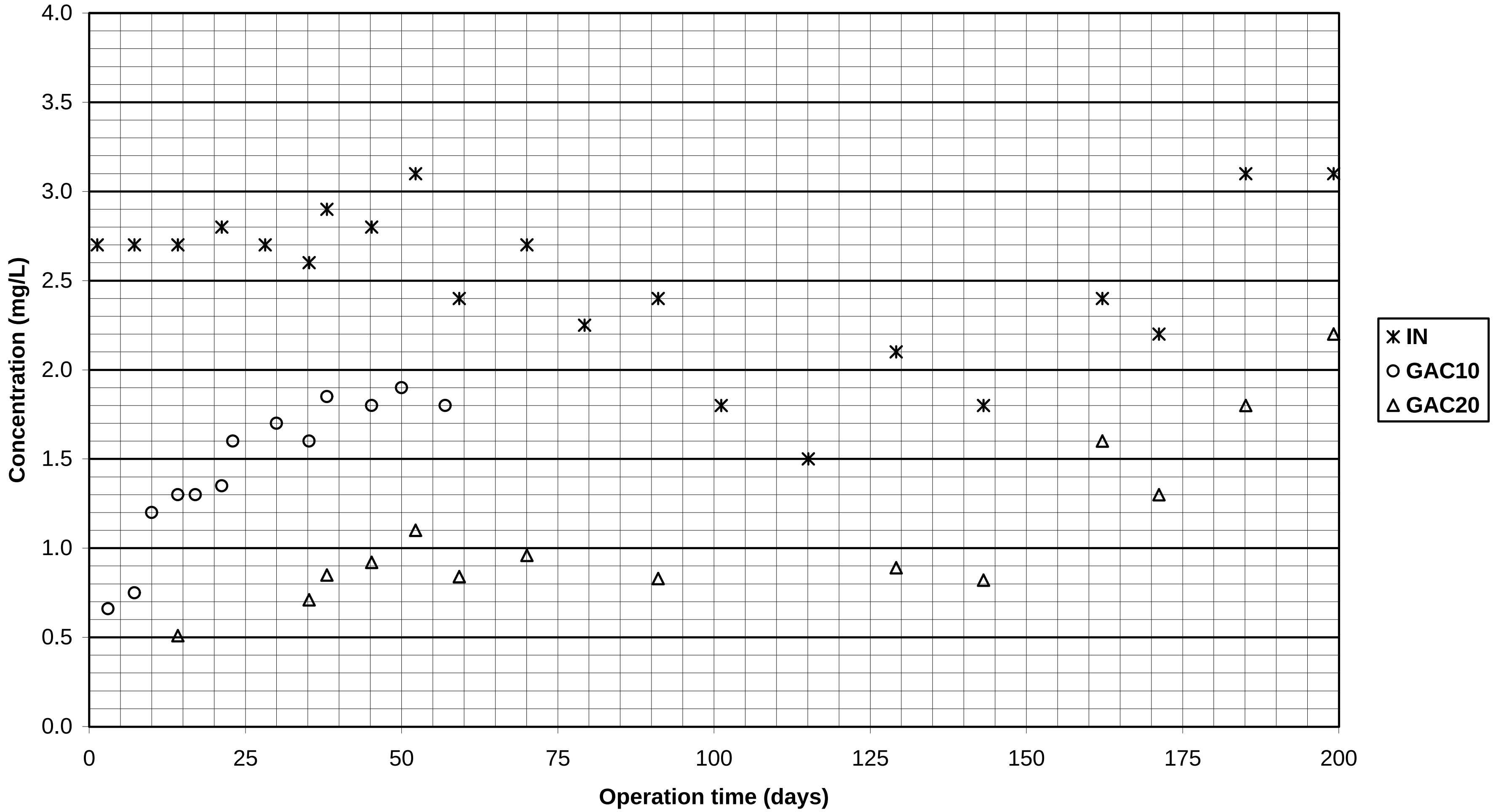


Figure 4-2
UV_{254} Breakthrough Curve
East Side WTP (Lake Ray Hubbard Pilot Plant)

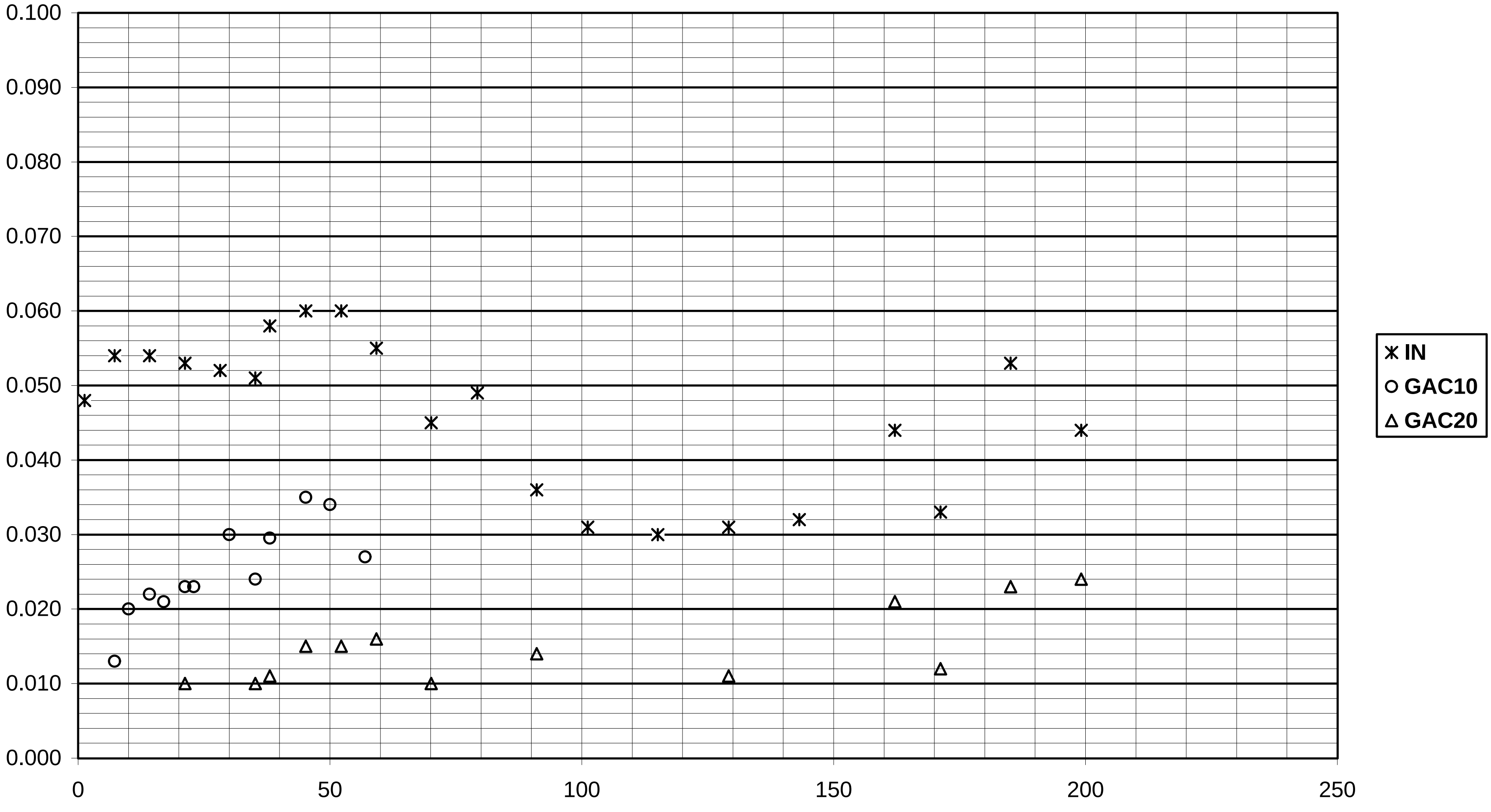


Figure 4-3
SDS-TOX Breakthrough Curve
East Side WTP (Lake Ray Hubbard Pilot Plant)

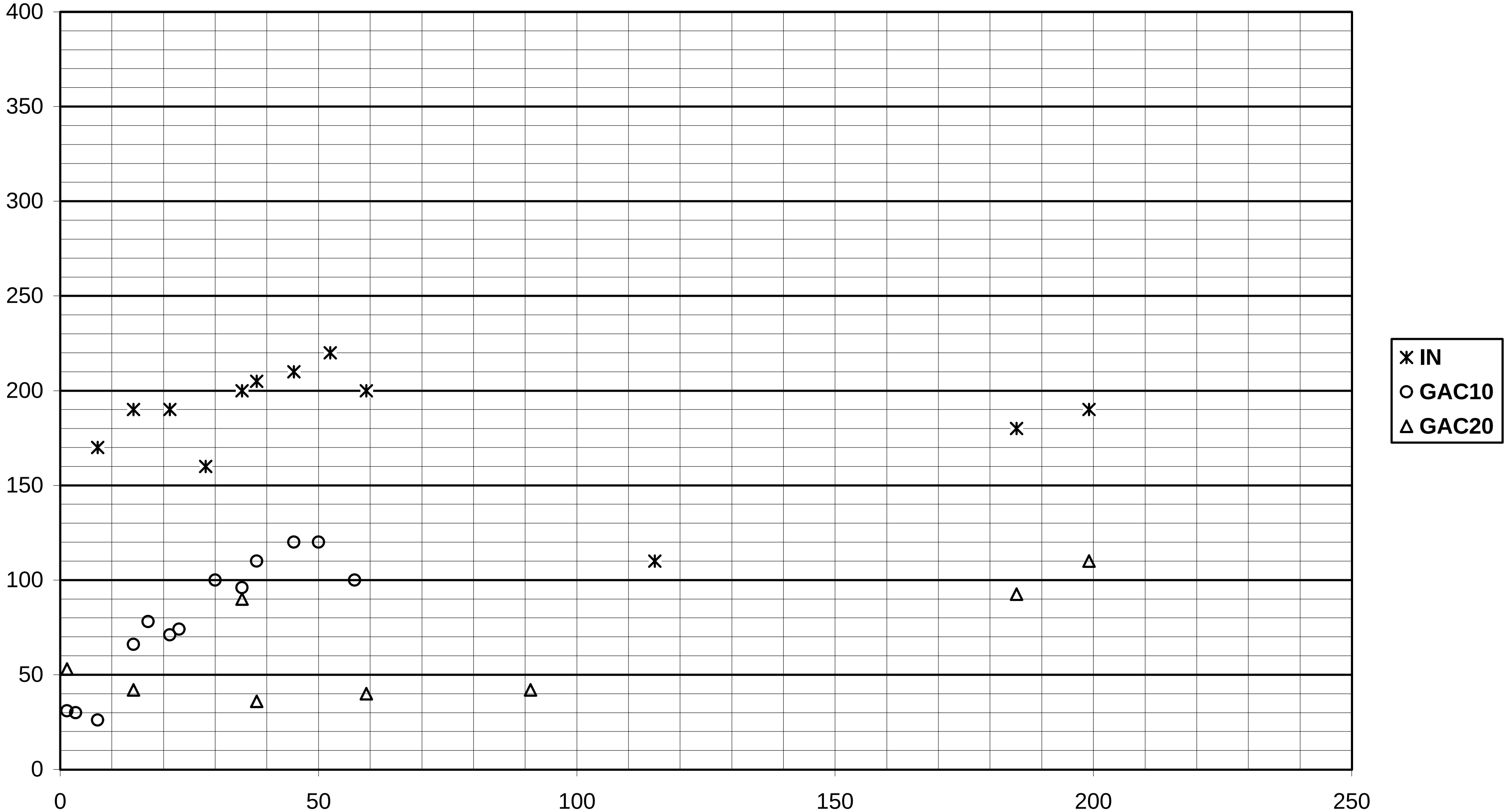


Figure 4-4
SDS-THM4 Breakthrough Curve
East Side WTP (Lake Ray Hubbard Pilot Plant)

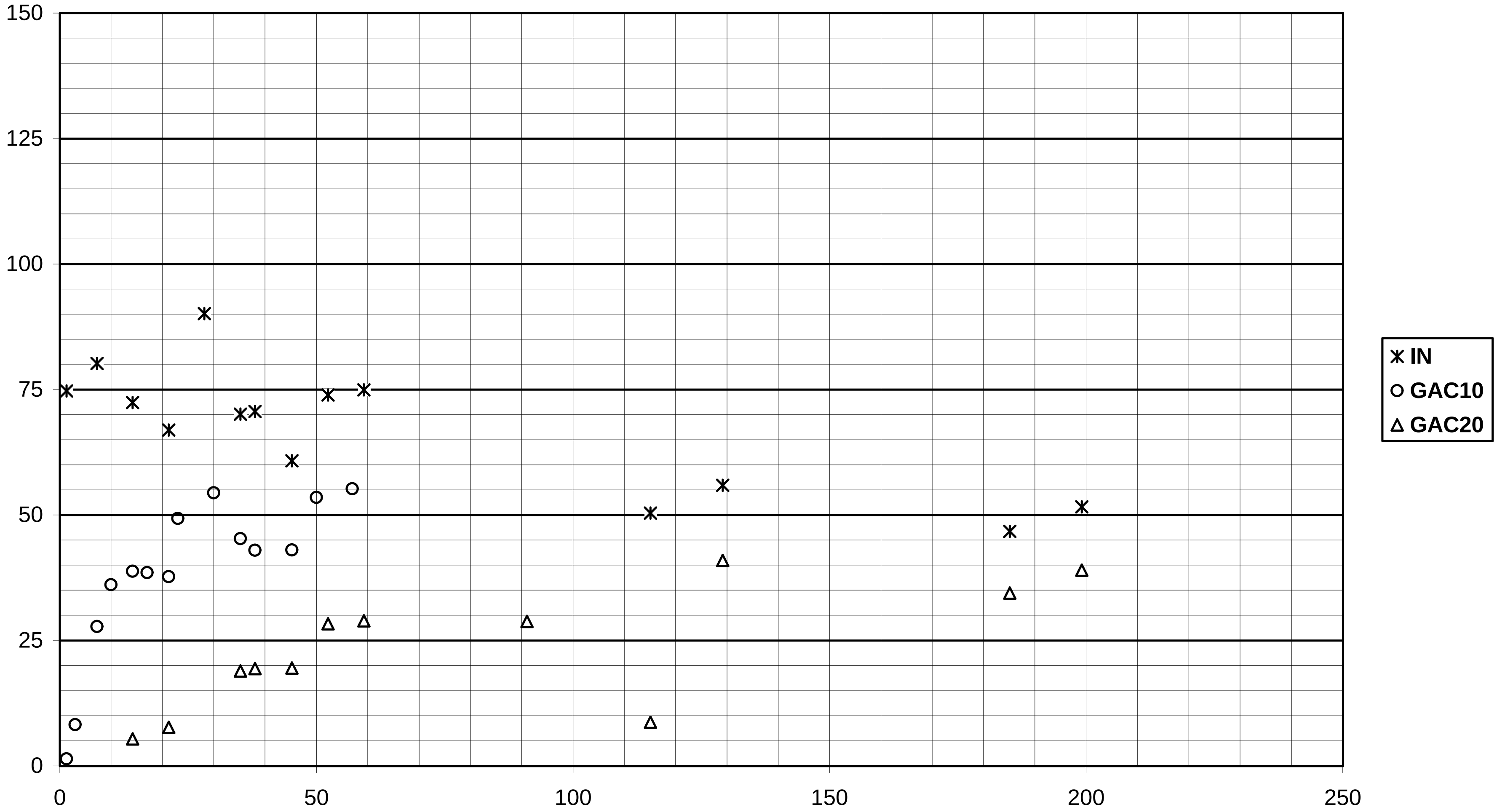


Figure 4-5
SDS-HAA5 Breakthrough Curve
East Side WTP (Lake Ray Hubbard Pilot Plant)

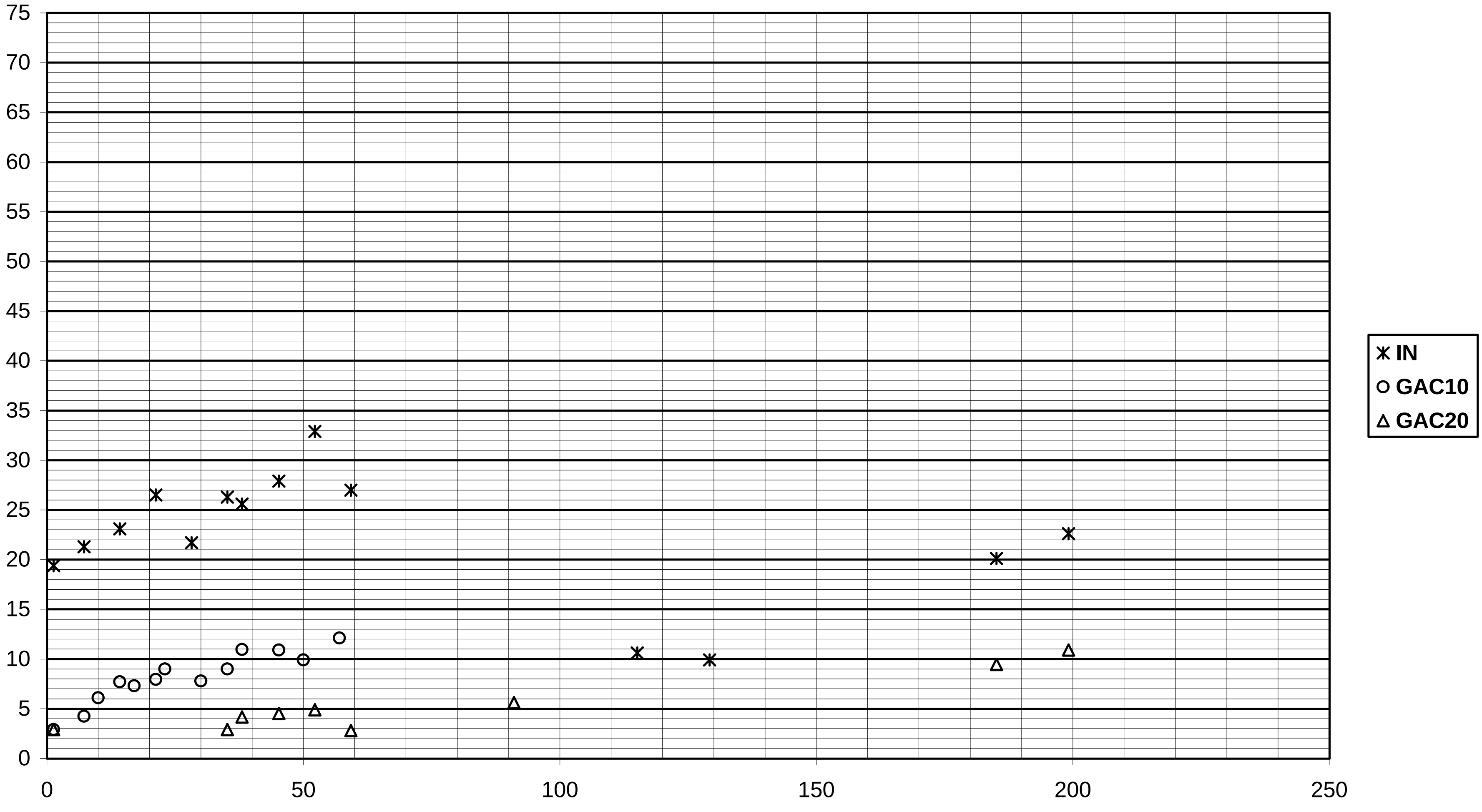
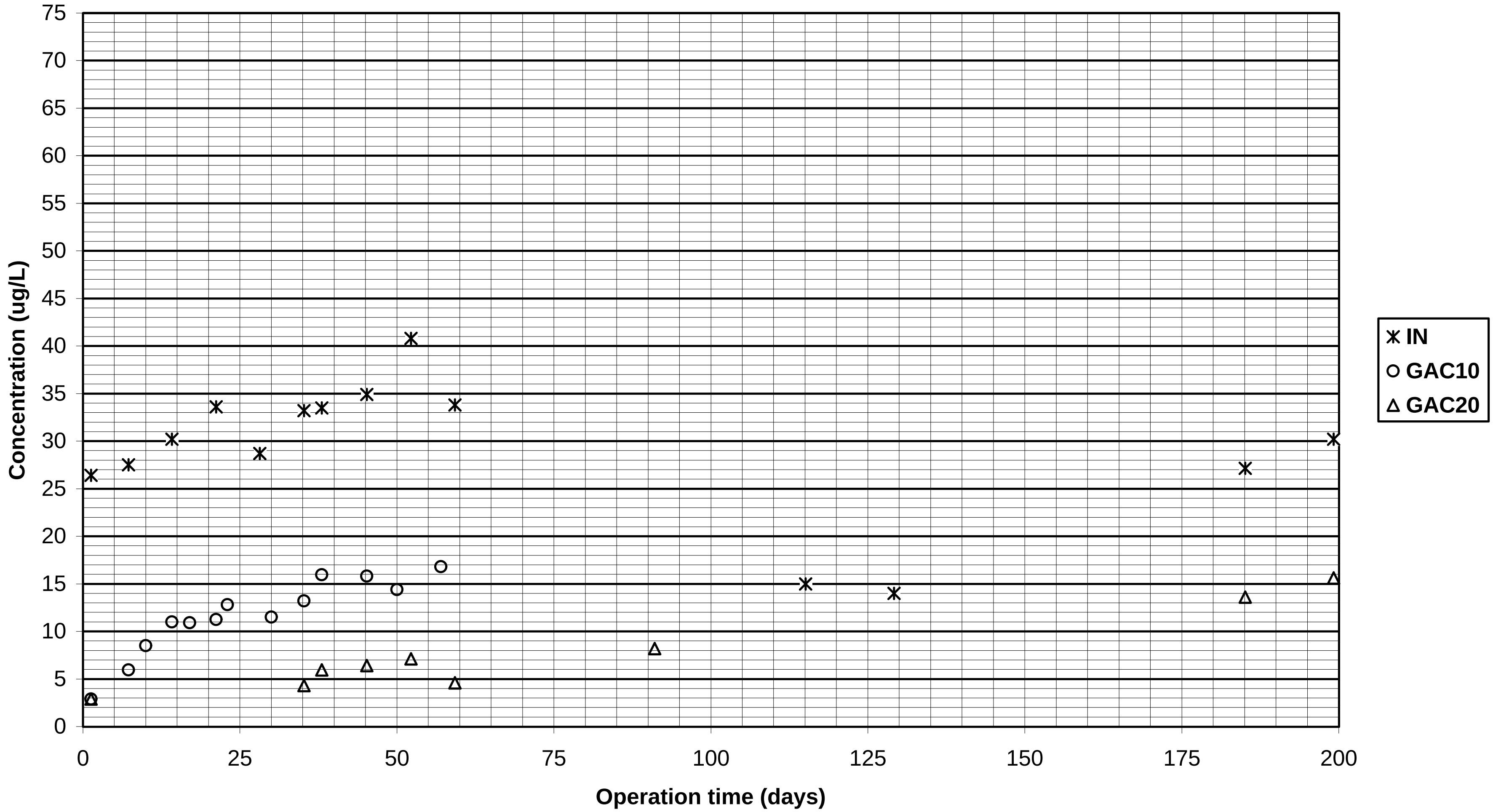


Figure 4-6
SDS-HAA6 Breakthrough Curve
East Side WTP (Lake Ray Hubbard Pilot Plant)



Section 5
QA/QC Summary

As mentioned in Section 3.4, all laboratory analyses were performed in accordance with the *DBP/ICR Analytical Methods Manual*. Two laboratories were utilized in the Dallas ICR Treatment Studies: CDM Laboratory and Environmental Health Laboratories. Information about each lab, including the specific analyses that each lab performed, is included in the *Treatment Study Summary Report Spreadsheet* in Appendix B. This spreadsheet also includes analytical methods, MRLs and all necessary QA/QC data. Statistical summaries for duplicate results, lab-fortified matrix analyses and PE studies are presented in Appendix B. Summaries of the calibration procedures for the CDM Laboratory are provided in Appendix D, and Appendix E includes this information for Environmental Health Laboratories.

Appendix A

Reports G.1 and G.2

G.1 -- Final Design Plant Parameters

Date: 6/28/99

PWS Name: Dallas Water Utilities
PWS ID: TX0570004
WIDB:
ICR Contact Person: Mr. Ted Kilpatrick

Sampling Period: Final
Design Sampling Start Date: 7/16/97
Design Sampling End Date: 12/31/98

Treatment Plant Name: East Side Water Treatment Plant
ICR Treatment Plant ID: 618
Treatment Plant PWS ID:
Treatment Plant Type: TS/SOFT

State Approved Plant Capacity (MGD): 400
Historical Min. Water Temperature (deg C): 5.0
Installed Sludge Handling Capacity (DPD): 0.00
Blending Indicator: N

Water Resource Name: Lake Ray Hubbard
Water Resource Type: Reservoir/lake
Average Residence Time (Days): 10
Intake Name: Forney Pump Station
Watershed Control: N

Hydrologic Unit Code:
River Reach:
Latitude (degrees, minutes, seconds): +32°48'26"
Longitude (degrees, minutes, seconds): -96°31'39"
River Reach Miles:

Water Resource Name: Lake Tawakoni
Water Resource Type: Reservoir/lake
Average Residence Time (Days): 10
Intake Name: Iron Bridge Pump Station
Watershed Control: N

Hydrologic Unit Code:
River Reach:
Latitude (degrees, minutes, seconds): +32°51'2"
Longitude (degrees, minutes, seconds): -96°0'21"
River Reach Miles:

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
	Influent	INF	1	
Process Train Name: East Side WTP - North Train				
Process Train Category: TS/SOFT				
1	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 1.40
2	Raw Water Junct	Other Treatment Process		Surface Area (ft2): 2,642 Liquid Volume (gal): 296,441 Short Circuiting Factor: 0.3
3	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 0.70
4	Forebay	Other Treatment Process		Surface Area (ft2): 688 Liquid Volume (gal): 118,410 Short Circuiting Factor: 0.1
5	Anhydrous ammon	Disinfectant Addition		Chemical Code: NH3A Measurement Formula: NH3 Dose Rate (mg/L): 1.00
6	Prim. Rapid Mix	Rapid Mix		Type of Mixer: HY Baffling Type: UN

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Liquid Volume (gal): 28,033 Short Circuiting Factor: Mean Velocity Gradient (sec-1): 3,000.0
7	Prim. Floc.	Flocculation Basin		Type of Mixer: ME Liquid Volume (gal): 1,611,667 Short Circuiting Factor: Baffling Type: SP Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec-1): 32 Stage Liquid Volume (gal): 537,222 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec-1): 24 Stage Liquid Volume (gal): 537,222 Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec-1): 8 Stage Liquid Volume (gal): 537,222
8	Prim. Sed.	Sedimentation		Surface Area (ft2): 86,550 Liquid Volume (gal): 11,542,333 Baffling Type: PR Short Circuiting Factor: Plate Settler Surface Area (ft2):

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Plate Settler Brand Name: Tube Settler Surface Area (ft2): Tube Settler Brand Name:
9	Sec. Rapid Mix	Rapid Mix		Type of Mixer: ME Baffling Type: UN Liquid Volume (gal): 12,233 Short Circuiting Factor: Mean Velocity Gradient (sec-1): 700.0
10	Sec. Floc.	Flocculation Basin		Type of Mixer: ME Liquid Volume (gal): 1,000,333 Short Circuiting Factor: Baffling Type: SP Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec-1): 32 Stage Liquid Volume (gal): 500,167 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec-1): 8 Stage Liquid Volume (gal): 500,167
11	Sec. Sed.	Sedimentation		Surface Area (ft2): 78,383 Liquid Volume (gal): 10,647,667 Baffling Type: PR

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Tube Settler Surface Area (ft2): Tube Settler Brand Name:
Process Train Name:	East Side WTP - South Train			
1	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 1.40
2	Raw Water Junct	Other Treatment Process	2	Surface Area (ft2): 2,642 Liquid Volume (gal): 296,441 Short Circuiting Factor: 0.3
3	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 0.70
4	Forebay	Other Treatment Process		Surface Area (ft2): 726 Liquid Volume (gal): 124,900 Short Circuiting Factor: 0.1
5	Lagoons	Washwater Return	3	Washwater Treated: Y Coagulation/Sedimentation: N Filtration: N

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Disinfectant Addition: N Plain Sedimentation: Y Other Treatment: 24 hr average Water flow Returned (MGD): 5.0
6	Anhydrous ammon	Disinfectant Addition		Chemical Code: NH3A Measurement Formula: NH3 Dose Rate (mg/L): 1.00
7	Prim. Rapid Mix	Rapid Mix	5	Type of Mixer: HY Baffling Type: UN Liquid Volume (gal): 56,067 Short Circuiting Factor: Mean Velocity Gradient (sec-1): 3,000.0
8	Prim. Floc	Flocculation Basin	6	Type of Mixer: ME Liquid Volume (gal): 3,223,333 Short Circuiting Factor: Baffling Type: SP Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec-1): 32 Stage Liquid Volume (gal): 1,074,444 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec-1): 24

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Stage Liquid Volume (gal): 1,074,444 Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec-1): 8 Stage Liquid Volume (gal): 1,074,444
9	Prim. Sed.	Sedimentation	7	Surface Area (ft2): 173,100 Liquid Volume (gal): 23,084,667 Baffling Type: PR Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Tube Settler Surface Area (ft2): Tube Settler Brand Name:
10	Sec. Rapid Mix	Rapid Mix	8	Type of Mixer: ME Baffling Type: UN Liquid Volume (gal): 24,467 Short Circuiting Factor: Mean Velocity Gradient (sec-1): 700.0
11	Sec. Floc.	Flocculation Basin	9	Type of Mixer: ME Liquid Volume (gal): 2,000,667 Short Circuiting Factor: Baffling Type: SP

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec-1): 32 Stage Liquid Volume (gal): 1,000,333
				Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec-1): 8 Stage Liquid Volume (gal): 1,000,333
12	Sec. Sed.	Sedimentation	10	Surface Area (ft2): 156,767 Liquid Volume (gal): 21,295,333 Baffling Type: PR Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Tube Settler Surface Area (ft2): Tube Settler Brand Name:
13	Filtration	Filtration	11	Surface Area (ft2): 55,488 Liquid Volume (gal): 3,443,533 Total Media Depth (in): 26 Depth of GAC (in): Media Type: DUAL Type of Activated Carbon: Minimum Water Depth To Top of Media (ft): 7.3 Depth From Top of Media to Top of Backwash Trough (ft): 3.3

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.
	Finished Water	FIN	12

G.2 -- Final Design Plant Chemical Parameters

Date: 6/28/99

PWS Name: Dallas Water Utilities
PWS ID: TX0570004
WIDB:
ICR Contact Person: Mr. Ted Kilpatrick

Sampling Period: Final
Sampling Start Date: 7/16/97
Sampling End Date: 12/31/98

Treatment Plant Name: East Side Water Treatment Plant
ICR Treatment Plant ID No: 618
Treatment Plant Category: TS/SOFT

Process Train Name: East Side WTP - North Train
Process Train Category: TS/SOFT

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
1	Chlorine gas	Disinfectant Addition				
				Chlorine gas	CL2	1.40
2	Raw Water Junct	Other Treatment Process				
3	Chlorine gas	Disinfectant Addition				
				Chlorine gas	CL2	0.70
4	Forebay	Other Treatment Process				
5	Anhydrous ammon	Disinfectant Addition				
				Anhydrous ammonia	NH3	1.00
6	Prim. Rapid Mix	Rapid Mix				

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
				Ferric sulfate	Fe2(SO4)3	46.00
				Calcium hydroxide	Ca(OH)2	51.00
				Hydrofluorosilic acid	H2SiF6	2.60
				Powdered activated carbon	PAC	0.46
7	Prim. Floc.	Flocculation Basin				
8	Prim. Sed.	Sedimentation				
9	Sec. Rapid Mix	Rapid Mix				
				Ferric sulfate	Fe2(SO4)3	23.00
				Powdered activated carbon	PAC	0.23
10	Sec. Floc.	Flocculation Basin				
11	Sec. Sed.	Sedimentation				

Process Train Name: East Side WTP - South Train
Process Train Category: TS/SOFT

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
1	Chlorine gas	Disinfectant Addition				
				Chlorine gas	CL2	1.40
2	Raw Water Junct	Other Treatment Process	2			
3	Chlorine gas	Disinfectant Addition				
				Chlorine gas	CL2	0.70
4	Forebay	Other Treatment Process				
5	Lagoons	Washwater Return	3			

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
6	Anhydrous ammon	Disinfectant Addition				
				Anhydrous ammonia	NH3	1.00
7	Prim. Rapid Mix	Rapid Mix	5			
				Ferric sulfate	Fe2(SO4)3	46.00
				Calcium hydroxide	Ca(OH)2	51.00
				Powdered activated carbon	PAC	0.46
				Hydrofluorosilic acid	H2SiF6	2.60
8	Prim. Floc	Flocculation Basin	6			
9	Prim. Sed.	Sedimentation	7			
10	Sec. Rapid Mix	Rapid Mix	8			
				Ferric sulfate	Fe2(SO4)3	23.00
				Powdered activated carbon	PAC	0.23
11	Sec. Floc.	Flocculation Basin	9			
12	Sec. Sed.	Sedimentation	10			
13	Filtration	Filtration	11			

Appendix B

Treatment Study Summary Report Spreadsheet

Appendix C

Data Collection Spreadsheet

Appendix D

Summary of Calibration Procedures
CDM Laboratory

Appendix E

Summary of Calibration Procedures
Environmental Health Laboratories