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
Bachman Water Treatment Plant ICR No. 620
Elm Fork Water Treatment Plant ICR No. 619

Conducted during the period of April 13, 1998, through December 18, 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. GAC run times to breakthrough of either Stage 1 or proposed Stage 2 D/DBPR MCLs were short, with THM values normally being exceeded first. For example, run time to breakthrough of the Stage 1 THM MCL of 80 μg/L for the 10-minute GAC column was 17 days and an estimated 60 days for the 20-minute GAC columns. As expected, run time to breakthrough of the proposed Stage 2 THM MCL of 40 μg/L is even lower—less than seven days for the 10-minute GAC column and 17 days for the 20-minute GAC columns. Therefore, 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

A single study for multiple plants operating on a common source was used for the City of Dallas Bachman Water Treatment Plant and Elm Fork Water Treatment Plant. The Bachman Water Treatment Plant was selected for the GAC evaluation since this plant does not use ozone and generally produces higher disinfection byproducts. The Bachman Water Treatment Plant utilizes two-stage conventional treatment and treats water from the Elm Fork of the Trinity River. 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. Two disinfection schemes are used at the plant, depending on water temperature, to meet disinfection contact time (CT) requirements. The "warm water" process is implemented when water temperatures are above 15°C and uses chloramine for both primary and residual disinfection. For water temperatures at or below 15°C, the "cold water" process uses a short duration of free chlorine in the secondary treatment stage for primary disinfection, followed by ammonia addition and the formation of chloramine 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.

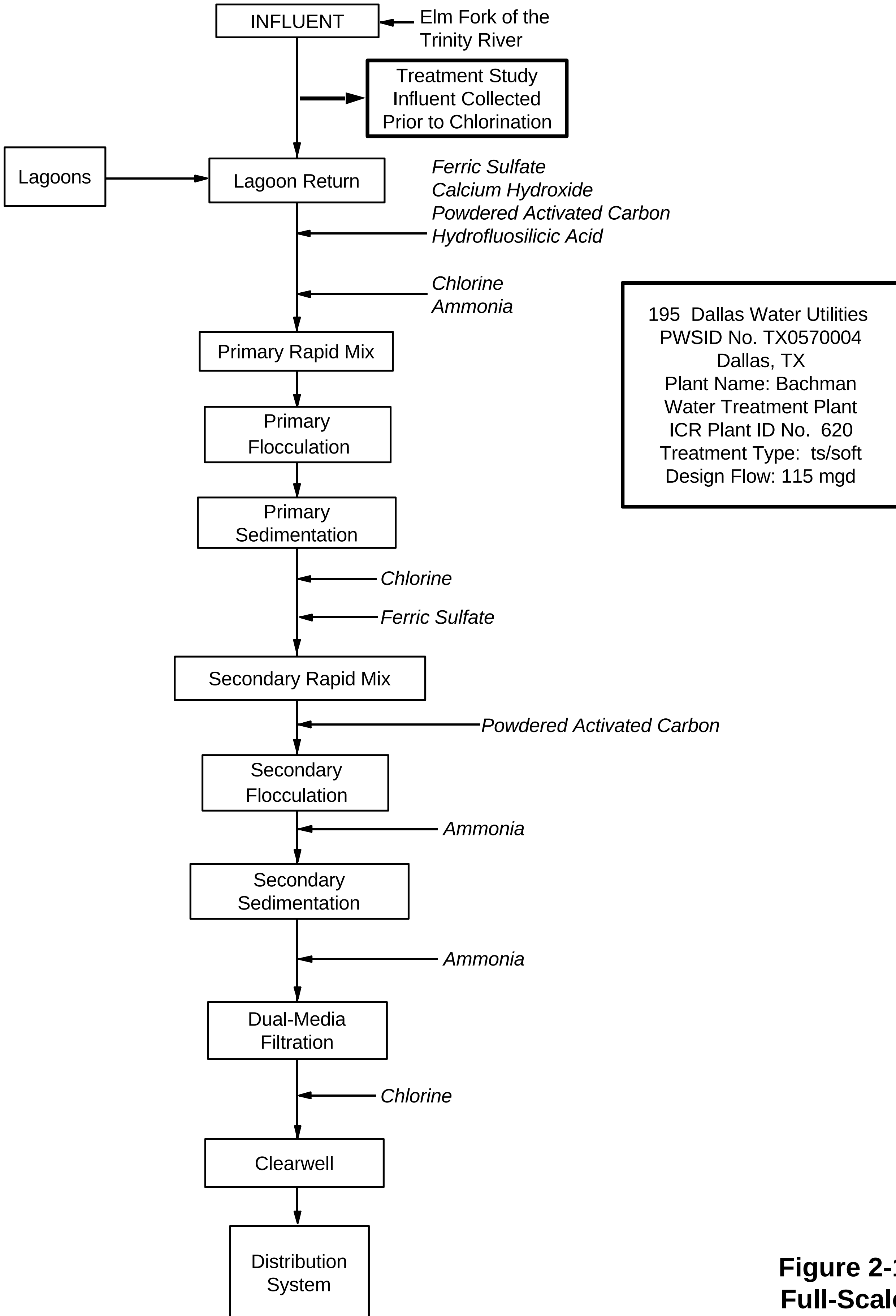


Figure 2-1
Full-Scale
Bachman WTP Schematic

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 plant is prior to the primary rapid mix basin, precluding the possibility of using water from the plant for GAC testing. Therefore, raw water was supplied to the pilot plant from the raw water pipeline, prior to any chemical addition or the lagoon return line.

The pilot plant simulated each unit process of the full-scale plant, from primary rapid mixing to filtration. However, secondary rapid mixing was not simulated due to water leakage from this module during testing start-up. 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 treated 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.

With the exception of the TOC_{in} sample for 3/30/98, which broke, samples collected on all other days showed the $TOC_{in} = TOC_{out}$. Therefore, 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 Bachman 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 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 60 mg/L and the secondary ferric dose ranged from 7 to 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 120 mg/L (as calcium hydroxide). Approximately 60 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
Bachman 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): 25 Mean Velocity Gradient (sec.$^{-1}$): 1000 @ 20 °C Coagulant Addition: Ferric Sulfate ($Fe_2(SO_4)_3$) Coagulant Dose (mg/L): 10 – 60 Lime Dose (mg/L): 0 – 120 ($Ca(OH)_2$)
Primary Flocculation (Pilot Scale)	Type of Mixer: Mechanical Liquid Volume (gal): 169 Short Circuiting Factor: 0.5 (assumed) Baffling Type: Average Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec^{-1}): 25 @ 20°C Stage Liquid Volume (gal): 56.3 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec^{-1}): 25 @ 20°C Stage Liquid Volume (gal): 56.3 Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec^{-1}): 25 @ 20°C Stage Liquid Volume (gal): 56.3
Primary Sedimentation (Pilot Scale)	Surface Area (ft^2): 3.7 Liquid Volume (gal): 92 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 Flocculation (Pilot Scale)	Type of Mixer: Mechanical Liquid Volume (gal): 169 Short Circuiting Factor: 0.5 (assumed) Baffling Type: Average Coagulant Addition: Ferric Sulfate ($Fe_2(SO_4)_3$) – Stage 1 Flocculation Coagulant Dose (mg/L): 7 – 10 Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec^{-1}): 75 @ 20°C Stage Liquid Volume (gal): 56.3 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec^{-1}): 45 @ 20°C Stage Liquid Volume (gal): 56.3 Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec^{-1}): 20 @ 20°C Stage Liquid Volume (gal): 56.3
Secondary Sedimentation (Pilot Scale)	Surface Area (ft^2): 3.7 Liquid Volume (gal): 92 Baffling Type: Poor Short Circuiting Factor: 0.3 (assumed) Tube Settler Surface Area (ft^2): 7.5 Tube Settler Brand Name: MRI (Golden, CO)
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): 25 Media Type: Sand (11”)/Anthracite (14”) Minimum Water Depth to Top of Media (ft): 7

Table 3-2
TOC Leaching Study Results for Bachman GAC Columns

Date	TOC_{in} (mg/L)	TOC_{out10} (mg/L)	TOC_{out20} (mg/L)	Std. Dev. (mg/L)
3/27/98	3.9	4.0	4.0	0.05
3/28/98	4.2	4.2	4.2	0
3/29/98	4.1	4.2	4.3	0.08
3/30/98	[1]	3.7	3.5	-
3/31/98	4.1	4.2	4.0	0.08

Notes:
[1] Sample bottle broke en route to laboratory.

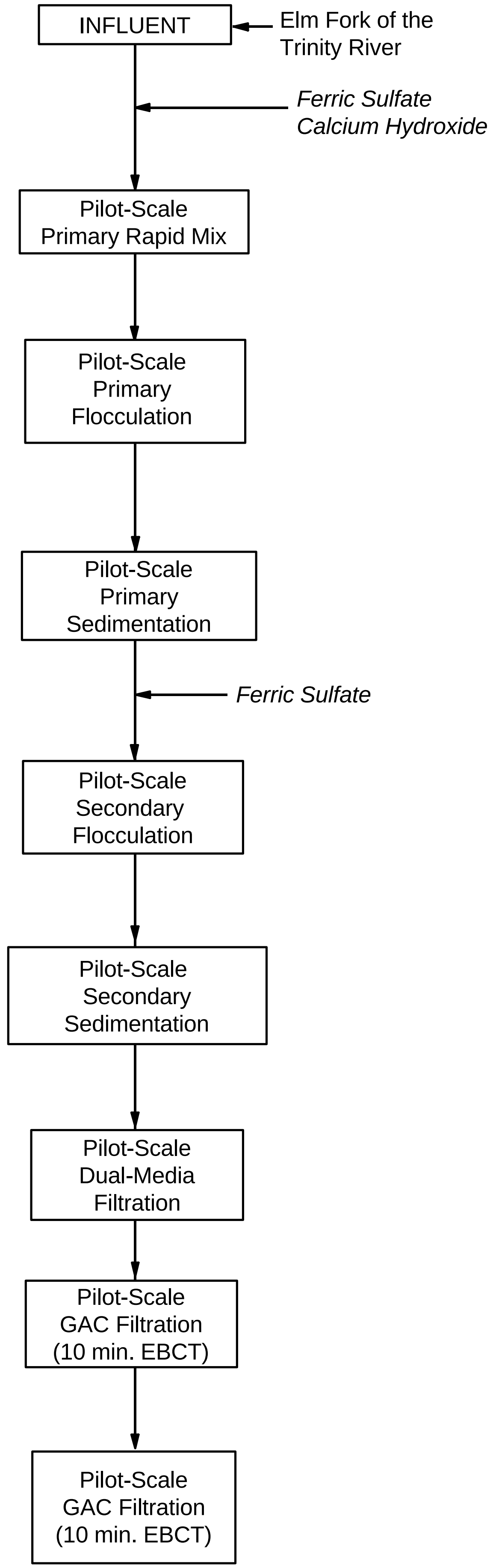
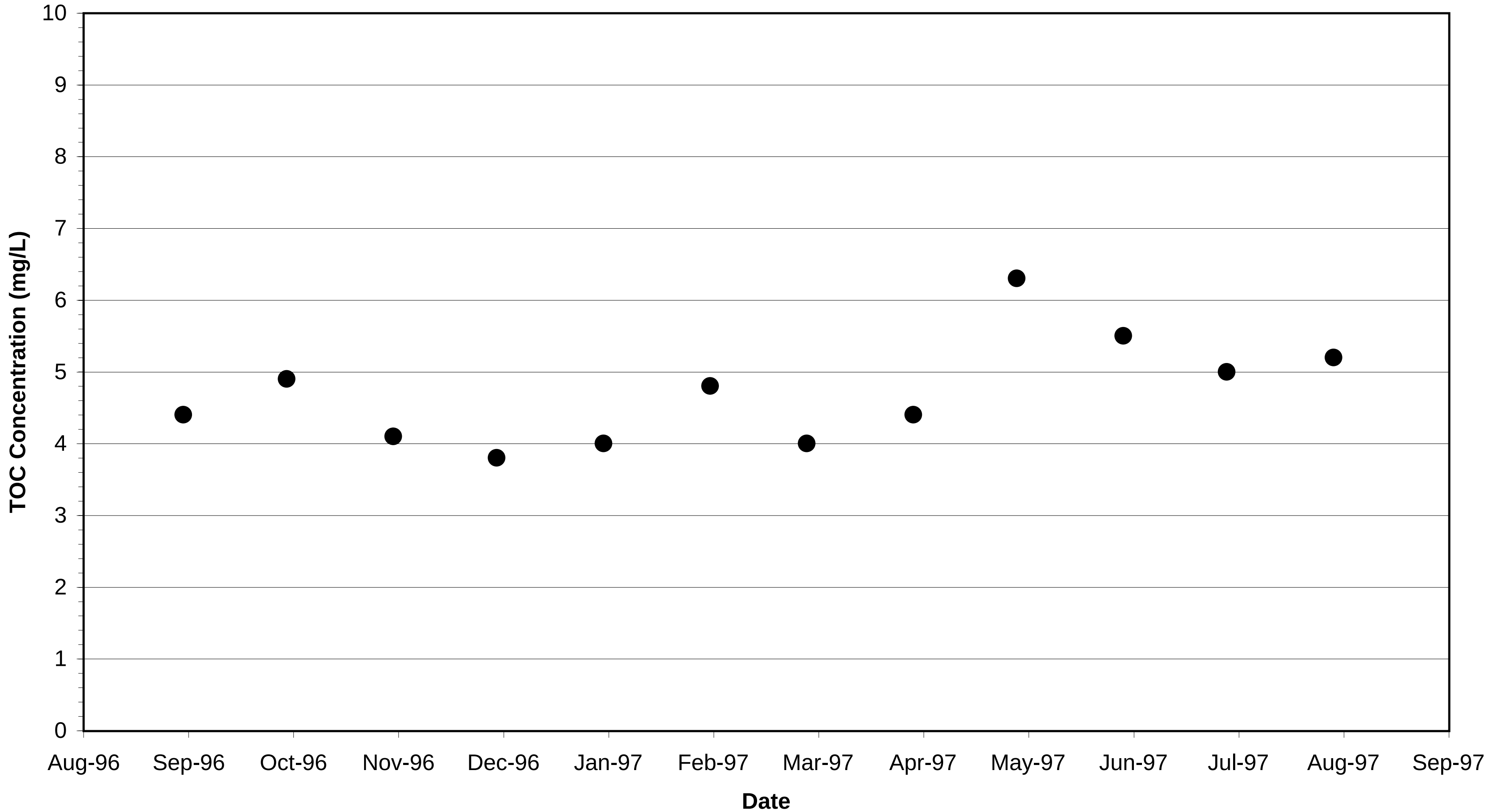


Figure 3-1
Bachman WTP
Pretreatment Schematic
Prior to GAC Filtration

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



Section 4
Results and Discussion

4.1 Problems Encountered

One noteworthy observation concerning the GAC pilot study is the shutdown of the pilot plant for a period of five days (127.5 hours) from November 16 – 21, 1998, near the end of the run. The full-scale plant went off-line during the weeks of November 1 and November 8 for maintenance work. To remain in operation, the pilot plant had to use raw water stored in the primary flocculation basins. After it was discovered that the raw water TOCs were unusually low and adversely affecting testing, the pilot plant was shut down on November 16 at 8:10 a.m., until raw water could be obtained from the normal source. Upon re-start of the pilot plant on November 21 at 4:40 p.m., the operation time was manually calculated and entered into the *Data Collection Spreadsheet*, taking downtime into account.

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 duration of 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 3.7 to 3.9 mg/L. However, 70 percent breakthrough (about 2.6 mg/L TOC) was first reached in the 10-minute GAC column after only 30 days.

The primary ferric sulfate dose was increased after the 10-minute GAC bed had expended (51 days) to investigate the effect of enhanced coagulation on extending the 20-minute GAC bed life. Had the chemical dose scheme remained constant, it is estimated the 70 percent level would have been reached in the 20-minute GAC columns in less than 100 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 also 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 seven days and the 20-minute GAC columns in 17 days. Additionally, a THM4 value of 60 μg/L was also exceeded in this same period for the 10- and 20-minute GAC columns. The 10-minute GAC column exceeded the Stage 1 MCL of 80 μg/L (with a 10 percent factor of safety) in only 17 days. It is estimated that had the chemical dose scheme remained constant, the 20-minute GAC columns would have exceeded the 80 μg/L THM4 limit in about 60 days.

Run time to HAA5 breakthrough was greater, with the 10-minute GAC column reaching the proposed Stage 2 MCL of 30 μg/L (with a 10 percent factor of safety) in 50 days. Although not currently regulated, the HAA6 value in the 10-minute GAC column reached 30 μg/L (with a 10 percent safety factor) in only 21 days. Because enhanced coagulation was evaluated after 51 days, breakthrough run times and bed volumes cannot be determined on the 10-minute GAC column for HAA5 or HAA6 limits of 60 μg/L. Likewise, breakthrough run times and bed volumes cannot be determined on the 20-minute GAC columns for HAA5 or HAA6 limits of 60 μg/L or 30 μg/L.

4.4 Summary of Significant Results

Although chemical dosages were changed after 51 days to investigate enhanced coagulation during ICR testing, influent TOCs remained fairly constant during all applicable testing for the 10-minute GAC column. Breakthrough levels for many of the parameters were reached within 50 days. Similarly, breakthrough levels for the more conservative proposed Stage 2 MCL for THM4 were reached after 7 and 17 days on the 10- and 20-minute GAC columns, respectively, before implementation of enhanced coagulation. Since THM4 levels were found to dominate, GAC would have to be replaced at THM4 breakthrough (i.e., before HAA5 breakthrough occurs). 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
Bachman Pilot Plant

Water Quality Parameter	Chemical Dose Scheme (mg/L) - Primary Ferric Sulfate/Primary Calcium Hydroxide/Secondary Ferric Sulfate									
	20/60/7	**30/40/7**	**20/40/7**	**10/40/7**	**40/40/7 [2]**	**50/40/7 [2]**	**60/40/7**	**30/0/7**	**20/0/7**	**30/80/10 [2]**
Operation time (days)	0 - 30	30 - 36	36 - 44	44 - 51	51 - 55	55 - 57	57 - 63	63 - 70	70 - 75	75 - 78
Temperature (^oC)	22.0 (2.25)	26.8	26.5 (0.71)	29.0	26.4 (1.98)	26.2 (0.26)	26.5	29.0	30.3	29.2 (0.28)
pH	8.5 (0.17)	7.9	7.9 (0.00)	8.0	7.7 (0.24)	7.5 (0.34)	7.5	6.8	7.0	7.8 (0.95)
Turbidity (NTU)	0.19 (0.03)	0.18	0.24 (0.02)	0.32	0.18 (0.04)	0.11 (0.00)	0.11	0.23	0.23	0.17 (0.13)
Alkalinity (mg/L as $CaCO_3$)	53.7 (5.61)	80.0	82.5 (3.54)	78.0	90 (5.13)	90 (3.83)	100.0	90.0	97.0	32.0
Calcium Hardness (mg/L as $CaCO_3$)	66.2 (9.75)	106.0	101.5 (0.71)	91.0	129 (5.80)	141 (3.18)	164.0	120.0	116.0	59.0
Total Hardness (mg/L as $CaCO_3$)	86.5 (12.66)	130.0	126.5 (3.5)	111.0	149 (4.99)	163 (3.01)	182.0	144.0	136.0	79.0
Bromide (ug/L)	124.2 (16.86)	160.0	155.0 (7.07)	140.0			130.0	130.0	140.0	
TOC (mg/L)	3.8 (0.08)	3.8	3.8 (0.00)	3.8			3.2	2.9	3.2	
UV_{254} (cm^{-1})	0.083 (0.004)	0.077	0.090 (0.010)	0.093			0.076	0.064	0.061	
SDS-THM4 (ug/L)	118.4 (8.62)	140.7	126.5 (15.27)	141.6			85.0	NR	NR	
SDS-HAA5 (ug/L)	36.0 (1.78)	40.2	48.90 (3.11)	56.1			44.4	NR	NR	
SDS-HAA6 (ug/L)	48.9 (2.76)	55.2	61.90 (7.35)	73.1			56.4	NR	NR	
SDS-TOX (ug Cl^-/L)	272.5 (26.30)	295.0	340.0 (0)	360.0			270.0	NR	NR	
SDS-Chlorine Demand (mg/L)	3.4 (0.08)	3.9	3.9 (0.15)	4.7			3.3	3.4	3.6	

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
Bachman Pilot Plant

Water Quality Parameter	Chemical Dose Scheme (mg/L) - Primary Ferric Sulfate/Primary Calcium Hydroxide/Secondary Ferric Sulfate									
	30/100/10 [2]	30/120/10	50/0/10 [2]	80/0/10	100/0/10 [2]	40/40/10 [2]	60/0/10	40/0/10	20/0/10	20/60/10
Operation time (days)	78 - 83	83 - 88	88 - 97	97 - 100	100 - 103	103 - 111	111 - 158	158 - 180	180 - 240	240 - 243
Temperature (^oC)	28.7 (1.06)	31.7	30.3 (1.08)	31.5	30.7 (0.95)	30.6 (2.02)	29.3 (2.22)	29.0	21.7 (3.21)	17.1
pH	9.7 (1.21)	10.6	6.9 (1.27)	6.0	5.3 (0.35)	7.4 (0.09)	6.3 (0.21)	6.5	6.8 (0.10)	8.3
Turbidity (NTU)	0.08 (0.03)	0.06	0.11 (0.04)	0.07	0.12 (0.05)	0.13 (0.03)	0.09 (0.01)	0.11	0.10 (0.01)	0.18
Alkalinity (mg/L as $CaCO_3$)	35 (4.83)	45.0	64 (11.27)	35.0	12 (1.41)	92 (4.37)	49.3 (8.02)	54.0	63.0 (10.39)	37.0
Calcium Hardness (mg/L as $CaCO_3$)	71 (8.47)	98.0	106 (9.50)	102.0	103 (1.77)	136 (3.91)	94.3 (3.50)	87.0	104.3 (4.16)	84.0
Total Hardness (mg/L as $CaCO_3$)	80 (5.94)	109.0	128 (9.13)	123.0	119 (10.39)	155 (3.94)	115.3 (3.20)	108.0	123.0 (5.29)	100.0
Bromide (ug/L)		130.0		160.0			142.5 (12.58)	150.0	121.7 (23.63)	97.0
TOC (mg/L)		2.8		2.2			2.2 (0.10)	2.7	3.0 (0.14)	2.9
UV_{254} (cm^{-1})		0.050		0.033			0.038 (0.004)	0.050	0.046 (0.010)	0.077
SDS-THM4 (ug/L)		NR		NR			76.3 (2.46)	42.3	50.2 (13.01)	54.5
SDS-HAA5 (ug/L)		NR		NR			20.0 (5.31)	26.0	21.2 (4.55)	29.8
SDS-HAA6 (ug/L)		NR		NR			27.0 (5.62)	36.0	29.0 (6.45)	36.9
SDS-TOX (ug Cl^-/L)		NR		NR			153.3 (15.28)	180.0	173.3 (37.86)	260.0
SDS-Chlorine Demand (mg/L)		4.2		3.1			3.4 (0.25)	3.4	2.9 (0.34)	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 4-2
Breakthrough Criterion for GAC ICR Testing - 10-minute EBCT
Bachman 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	7	1012	1.5	54	9	12	BMRL
SDS-THM4 =54 ug/L	7	1012	1.5	54	9	12	BMRL
SDS-THM4 =72 ug/L	17	2427	2.15	72	15	23	120
SDS-HAA5 =27 ug/L	50	7190	2.8	97	34	47	220
SDS-HAA5 =54 ug/L	NA	NA	NA	NA	NA	NA	NA
SDS-HAA6 =27 ug/L	21	3012	2.3	80	19	27	140
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
Bachman 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	17	1213	1	41	7	9	BMRL
SDS-THM4 =54 ug/L	38	2725	1.8	54	12	17	BMRL
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
Bachman Pilot Plant

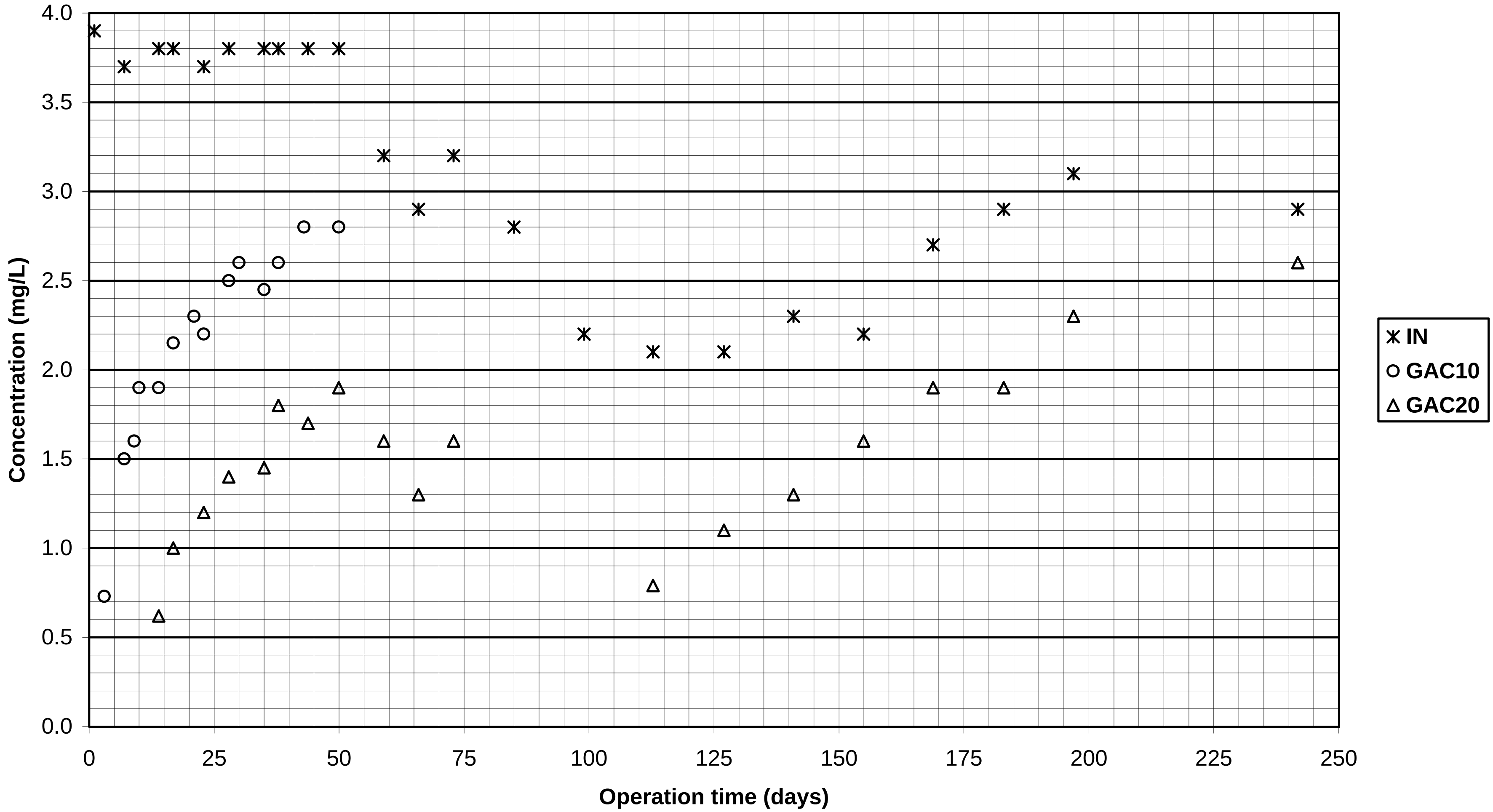


Figure 4-2
UV$_{254}$ Breakthrough Curve
Bachman Pilot Plant

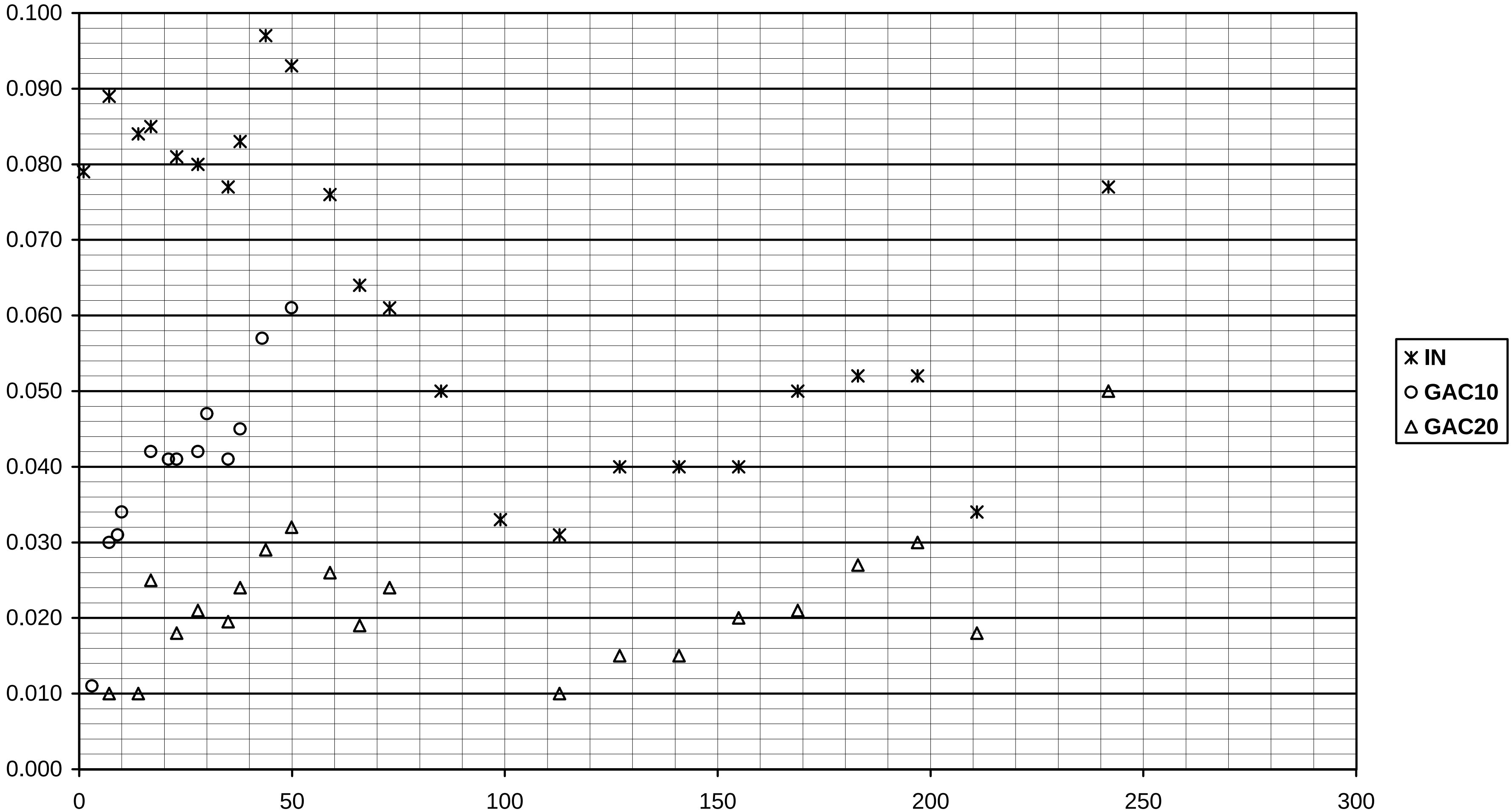


Figure 4-3
SDS-TOX Breakthrough Curve
Bachman Pilot Plant

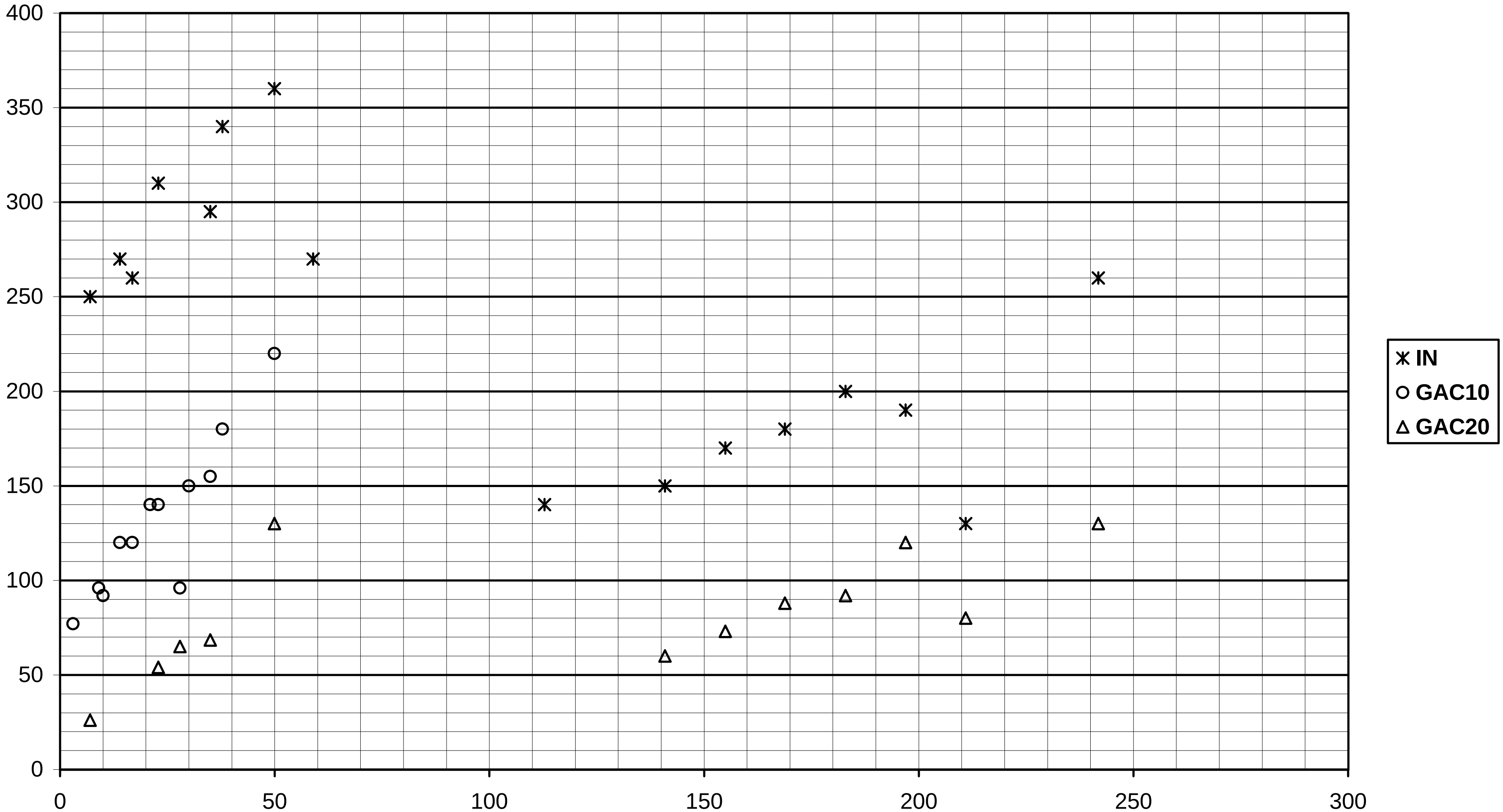


Figure 4-4
SDS-THM4 Breakthrough Curve
Bachman Pilot Plant

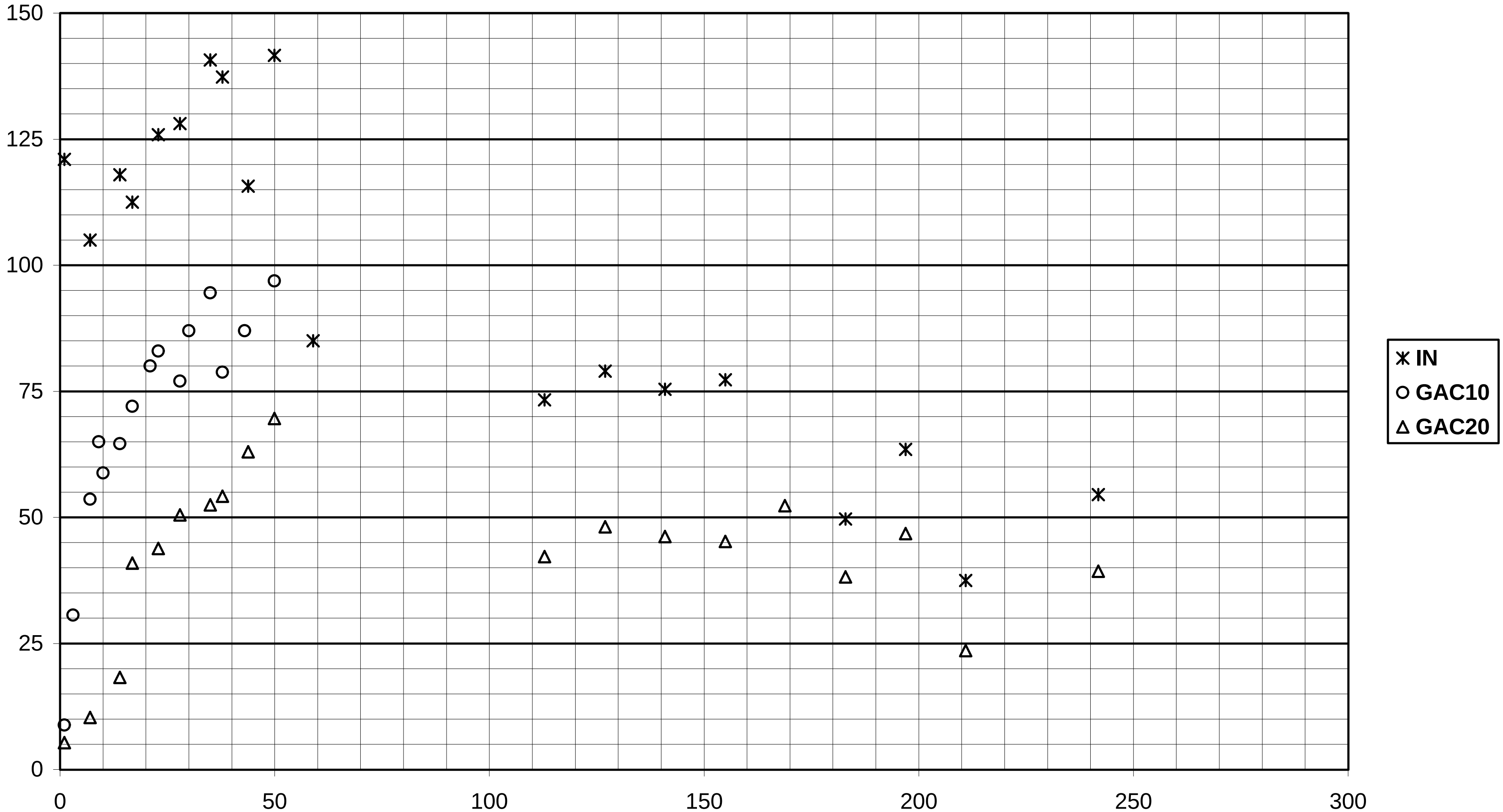


Figure 4-5
SDS-HAA5 Breakthrough Curve
Bachman Pilot Plant

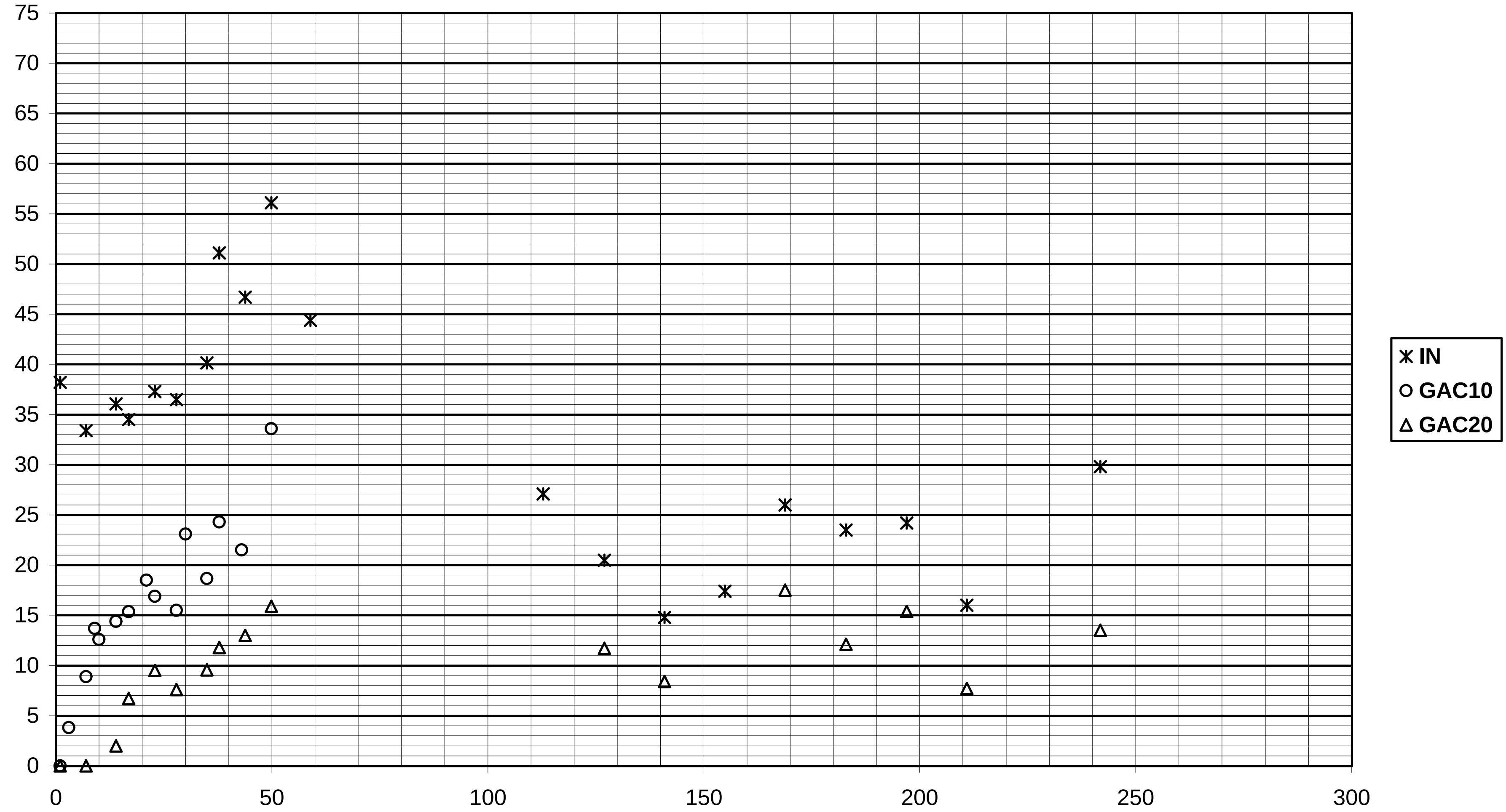
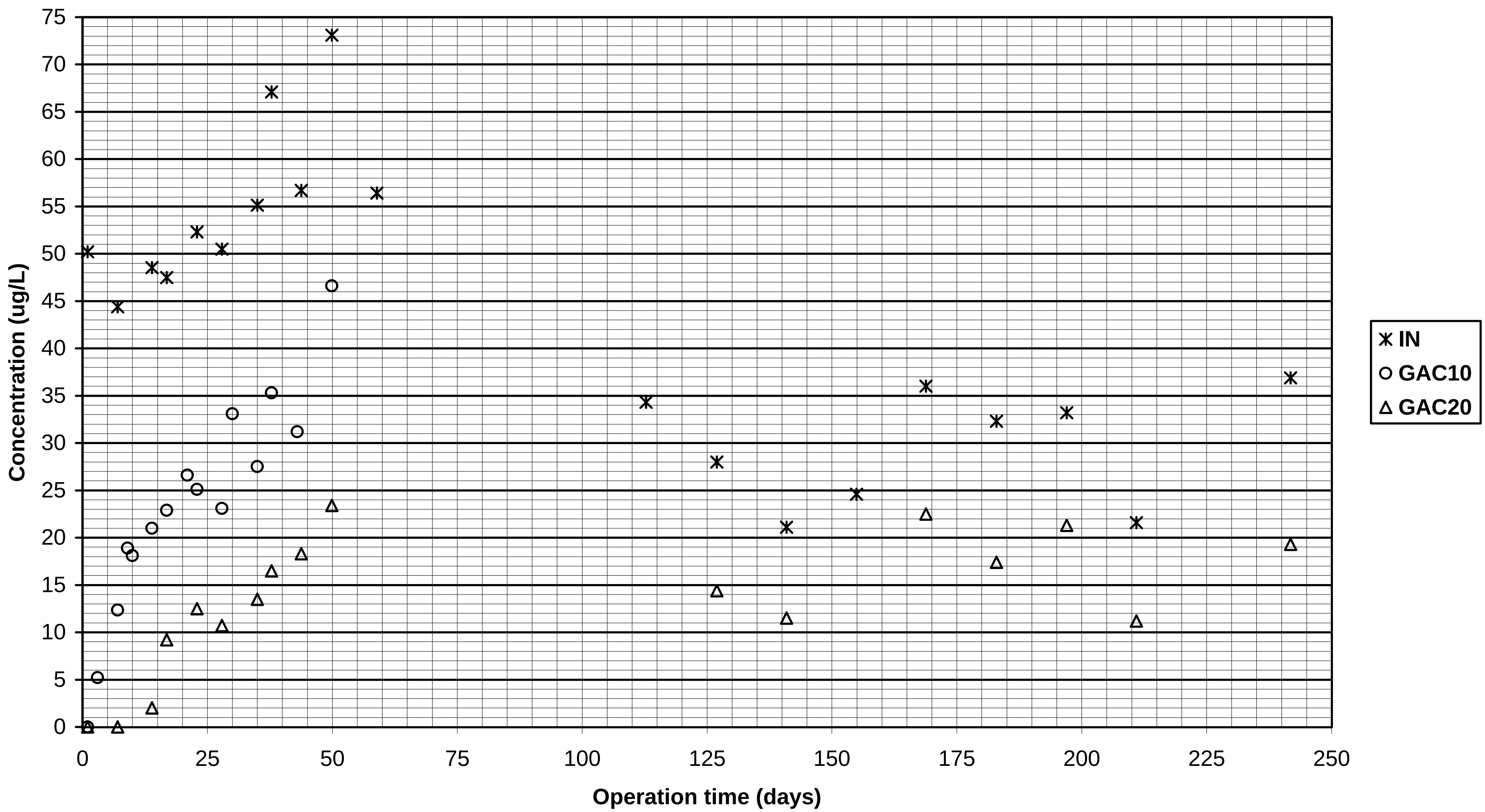


Figure 4-6
SDS-HAA6 Breakthrough Curve
Bachman Pilot Plant



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 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

Treatment Plant Name: Bachman Water Treatment Plant
ICR Treatment Plant ID: 620
Treatment Plant PWS ID:
Treatment Plant Type: TS/SOFT

State Approved Plant Capacity (MGD): 115
Historical Min. Water Temperature (deg C): 2.2
Installed Sludge Handling Capacity (DPD): 0.00
Blending Indicator: N

Water Resource Name: Elm Fork of Trinity River
Water Resource Type: Flowing stream
Intake Name: Bachman Intake
Watershed Control: N
Hydrologic Unit Code:

On River Reach Code:
Latitude (degrees, minutes, seconds): +32°50'46"
Longitude (degrees, minutes, seconds): -96°52'33"
River Reach Miles:

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
	Influent	INF	1	

Process Train Name: Bachman WTP
Process Train Category: TS/SOFT

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
1	Lagoons	Washwater Return	2	Washwater Treated: Y Coagulation/Sedimentation: N Filtration: N Disinfectant Addition: N Plain Sedimentation: Y Other Treatment: 24 hr average Water flow Returned (MGD): 5.0
3	**Chlorine gas**	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 3.00

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
4	Anhydrous ammon	Disinfectant Addition		Chemical Code: NH3A Measurement Formula: NH3 Dose Rate (mg/L): 0.50
5	Prim. Rapid Mix	Rapid Mix	4	Type of Mixer: HY Baffling Type: UN Liquid Volume (gal): 82,280 Short Circuiting Factor: Mean Velocity Gradient (sec-1): 470.0
6	Prim. Floc.	Flocculation Basin	5	Type of Mixer: ME Liquid Volume (gal): 3,023,790 Short Circuiting Factor: Baffling Type: UN Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec-1): 13 Stage Liquid Volume (gal): 1,007,930 Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec-1): 13 Stage Liquid Volume (gal): 1,007,930 Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec-1): 13

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Stage Liquid Volume (gal): 1,007,930
7	Prim. Sed.	Sedimentation	6	Surface Area (ft2): 63,131 Liquid Volume (gal): 7,291,667 Baffling Type: UN Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Tube Settler Surface Area (ft2): Tube Settler Brand Name:
8	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 2.50
9	Sec. Rapid Mix	Rapid Mix	7	Type of Mixer: ME Baffling Type: UN Liquid Volume (gal): 37,284 Short Circuiting Factor: Mean Velocity Gradient (sec-1): 750.0
10	Sec. Floc.	Flocculation Basin	8	Type of Mixer: ME Liquid Volume (gal): 3,571,750 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): 75 Stage Liquid Volume (gal): 1,190,583
				Stage Sequence Number: 2 Stage Mean Velocity Gradient (sec-1): 45 Stage Liquid Volume (gal): 1,190,583
				Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec-1): 20 Stage Liquid Volume (gal): 1,190,583
11	Anhydrous ammon	Disinfectant Addition		Chemical Code: NH3A Measurement Formula: NH3 Dose Rate (mg/L): 0.50
12	Sec. Sed.	Sedimentation	9	Surface Area (ft2): 106,564 Liquid Volume (gal): 13,020,833 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	Anhydrous ammon	Disinfectant Addition		Chemical Code: NH3A

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Measurement Formula: NH3 Dose Rate (mg/L): 0.02
14	Filtration	Filtration	10	Surface Area (ft2): 23,296 Liquid Volume (gal): 534,524 Total Media Depth (in): 25 Depth of GAC (in): Media Type: DUAL Type of Activated Carbon: Minimum Water Depth To Top of Media (ft): 3.1 Depth From Top of Media to Top of Backwash Trough (ft): 2.7
15	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: CL2 Dose Rate (mg/L): 0.10
16	Clearwell	Clearwell	11	Surface Area (ft2): 85,973 Liquid Volume (gal): 9,649,200 Minimum Liquid Volume (gal): 7,236,900 Baffling Type: UN Short Circuiting Factor: Covered Indicator Code: Y
	Finished Water	FIN	12	

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
Treatment Plant Name: Bachman Water Treatment Plant						
ICR Treatment Plant ID No: 620						
Treatment Plant Category: TS/SOFT						
Process Train Name: Bachman WTP						
Process Train Category: TS/SOFT						
1	Lagoons	Washwater Return	2			
3	Chlorine gas	Disinfectant Addition				
				Chlorine gas	CL2	3.00
4	Anhydrous ammon	Disinfectant Addition				
				Anhydrous ammonia	NH3	0.50
5	Prim. Rapid Mix	Rapid Mix	4			
				Calcium hydroxide	Ca(OH)2	46.00
				Hydrofluorosilic acid	H2SiF6	2.40
				Powdered activated carbon	PAC	3.70
				Organic polymer - coagulant aid	Poly Diallyldime Thylammonium	0.20
				Ferric sulfate	Fe2(SO4)3	28.00
6	Prim. Floc.	Flocculation Basin	5			
7	Prim. Sed.	Sedimentation	6			
8	Chlorine gas	Disinfectant Addition				
				Chlorine gas	CL2	2.50
9	Sec. Rapid Mix	Rapid Mix	7			
				Ferric sulfate	Fe2(SO4)3	14.00

Seq. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
				Organic polymer - coagulant aid	Poly Diallyldime Thylammonium	0.20
10	Sec. Floc.	Flocculation Basin	8			
				Powdered activated carbon	PAC	1.80
11	Anhydrous ammon	Disinfectant Addition				
				Anhydrous ammonia	NH3	0.50
12	Sec. Sed.	Sedimentation	9			
13	Anhydrous ammon	Disinfectant Addition				
				Anhydrous ammonia	NH3	0.02
14	Filtration	Filtration	10			
				Organic polymer - filter aid	Poly Diallydime Thylammonium	0.20
15	Chlorine gas	Disinfectant Addition				
				Chlorine gas	CL2	0.10
16	Clearwell	Clearwell	11			

__End of Report G.2 -- Final Design Plant Chemical Parameters__

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