ICR Treatment Study Summary Report

Evaluation of GAC Technology Using the Rapid Small-Scale Column Test for Compliance with the Information Collection Rule

Conducted during the period of April 1998 through February 1999

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AB Jewell Water Plant, #542

Attachments: 1 diskette containing the *Data Collection Spreadsheets*
1 diskette containing the *Treatment Study Summary Report Spreadsheets*
1 diskette containing the *ICR Treatment Summary Report*

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I. Conclusions and Recommendations-

The 70% breakthrough times for all analytes were very close to twice as long for the 20 minute EBCT's as compared to the 10 minute so the overall design of the test was successful. All of the influent THM's were below the 80 ug/L Stage 1 level and all of the 70% breakthrough concentrations for both 10 and 20 minute EBCT's were below the 60 ug/L Stage 2 level. This indicates that GAC treatment should be quite effective in meeting Stages 1 and 2. For HAA5 the influent concentrations were below the Stage 2 concentration of 30 ug/L. The highest GAC-treated concentration was about 15. This shows that GAC treatment might not be necessary to meet even the Stage 2 requirement. Removal of TOC and TOX was shown to be equally effective compared to THM and HAA removal. The time vs. concentration plots for TOX were jagged and irregular in comparison to the smoother curves for the other three analytes. This owes undoubtedly to the more difficult nature of the analysis.

In conclusion, use of advanced GAC treatment at the AB Jewell WTP could be used to control DBP's well below even the Stage 2 concentrations. The study shows it to be technically feasible and probably economically feasible, although it has not been studied at any length.

II. Background Information

A. Treatment Plant Description

Treatment Plant Schematic: See Figure 1. The sample was collected after the filter in front of the treated water clearwell. Chlorinators were turned off before sample collection and residual chlorine was measured to ensure that no residual was present.

Treatment Plant Design Information: Table 1a contains the full-scale plant unit process design information; Table 1 b contains the Bench-scale unit process information.

Table 1a: Treatment Plant Design Information

Rapid Mix
Type of Mixer: MV
Baffling Type: AV
Liquid Volume(gal): 6,940
Mean Velocity Gradient(sec-1): 200

Coagulant Addition: Alum
Coagulant Dose(mg/L): 25
Coagulant Addition: Cat-Floc
Coagulant Dose(mg/L): 2.5
Acid Addition: Sulfuric Acid
Acid Dose(mg/L): 35

Flocculation
Type of Mixer: ME
Liquid Volume(gal): 2,268,884
Short Circuiting Factor:
Baffling Type: SP

Stage Sequence Number: 1
Stage Mean Velocity Gradient(sec-1): 40
Stage Liquid Volume(gal): 961,306

Stage Sequence Number: 2
Stage Mean Velocity Gradient(sec-1): 20
Stage Liquid Volume(gal): 835,096

Stage Sequence Number: 3
Stage Mean Velocity Gradient(sec-1): 10
Stage Liquid Volume (gal): 872,482

Sedimentation
Surface Area(ft2): 124,640
Liquid Volume(gal): 13,052,301
Baffling Type: AV
Short Circuiting Factor:
Plate Settler Surface Area(ft2):
Plate Settler Brand Name:
Tube Settler Surface Area(ft2):
Tube Settler Brand Name:

Filtration
Surface Area(ft2): 21,120
Liquid Volume(gal): 524,160
Total Media Depth(in): 45
Depth of GAC(in): 33
Media Type: GACS
Type of Activated Carbon: OT
Minimum Water Depth to Top of Media(in): 4.0
Depth From Top of Media to top of Backwash Trough(in): 3.9

Disinfection
Chemical Type: Chlorine gas
Measured as: Cl2
Dose Rate(mg/L): 4.0

Clear Well
Surface Area(ft2): 105,340
Liquid Volume(gal): 10,000.000
Baffling Type: SP
Short Circuiting Factor:
Covered Indicator Code: Y

Treatment challenges facing plant:

The obvious challenge is to produce water which will surpass the stricter DBP regulations to come in the future. Current standards are being met without advanced treatment. Based upon recent THM analyses the plant is unlikely to meet the 80 mg/L Stage 1 requirement without advanced treatment. Also based upon recent results, HAA's should not be a problem in Stage 1 but will require advanced treatment when the Stage 2 standards take effect.

A. Tabular summary of source and finished water quality: Tables 2a and 2b contain the summary of source and finished water quality provided by the water treatment plant.

III. Materials and Methods

A. Pretreatment Processes to the Advanced Treatment Process

Schematics of pretreatment processes: Figure 1 outlines the full-scale process used in the plant prior to the sampling point.

Design Data: See Figure 2. Bench-scale cartridge filtration was performed at the laboratory prior to the RSSCT. Table summarizes the details concerning the filter.

B. Advanced Treatment Process Information

A schematic for the process equipment used for the RSSCT is shown in Figure 3. This schematic shows only one unit, but two identical units were used during the study. This allowed for the simultaneous evaluation of two EBCTs using the same influent water. In most runs during this study, however, they were not started at the exact same time, resulting in two data sets for the influent water. The ICR Manual for Bench and Pilot-scale Studies was used as a guide in the set-up of the apparatus.

In general, the procedures outlined in the ICR Manual for Bench and Pilot-scale Studies were followed. In order to ensure that no TOC was leaching from our apparatus into the sample, reagent water was passed through the entire system and checked for TOC. Also, the aliquot containers were checked for TOC leaching and/or absorption. Only stainless steel and teflon tubing were used in the apparatus to minimize contamination. The columns were carefully packed according to procedures in the manual.

Fortunately, headloss buildup was not a significant problem during the study. A slight agitation of the top layer of carbon was effective when it was needed.

C. Experimental Design

Table 3 describes the experimental design used in the study. Seasonal variability was examined as the primary variable at EBCT 10 and 20.

D. Analytical Methods

Table 4 lists the analytical methods and MRLs used for the study. There were no deviations from the QA/QC procedures outlined in the DBP/ICR Analytical Methods Manual.

All analytical services were performed at Environmental Health Laboratories.

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III. Results and Discussion

A. Problems Encountered

During the 1st quarter, a batch of feed water became contaminated with a high concentration of TOC. The source of this contamination was traced to an individual aliquot of water. The first data set was discarded and a new run performed with a fresh aliquot.

Total Organic Halide (TOX) results during the study were generally erratic as several results did not follow the trend of SDS THM and HAA in the effluent water. Also, high percent differences were observed for some samples. The method used and the results meet the QA/QC criteria in the DBP/ICR Analytical Methods Manual.

Experimental error: During the 1st and 2nd quarters, the runs at EBCT 20 did not reach 70% TOC breakthrough due to an error in the preparation of the predicted TOC breakthrough tables. Quarter 1 had breakthrough to 68%, and quarter 2 63%. Based on complete breakthrough curves obtained during the last two quarters of the study at EBCT 20, the upper portion of the curves can be extrapolated.

B. Water Quality Data

1. The water quality of the pretreated influent is summarized in Tables 5a and 5b.
2. Table 6 contains the specific simulated distribution system (SDS) conditions for each quarter in the study. Table 5 includes a summary of the DBP data obtained at these SDS conditions in the influent water.

C. Impact of Seasonal Variability and

D. Impact of Specific Variables on Performance

Included in this final report are several Tables and Graphs that illustrate important aspects of the study. They are as follows:

1. Breakthrough curves for TOC and UV254
   Figures4-7: TOC concentration as a function of scaled operation time
   Figures 8-11: UV254 concentration as a function of scaled days
2. SDS Chlorine Dose and Residual Analysis
   Figures 12-15: Chlorine dose / residual effluent / influent vs. operation time
   Figures 16-19: Chlorine dose / residual effluent / influent vs. operation time

3. SDS Breakthrough Curves Analysis (Effluent and Influent)

Figures 20-23: SDS-THM4 for EBCT 10&20 vs. scaled operation time
Figures 24-31: Individual SDS-THMs for EBCT 10&20 vs. scaled operation time
Figures 32-35: SDS-HAA5 for EBCT 10&20 vs. scaled operation time
Figures 36-39: SDS-HAA6 for EBCT 10&20 vs. scaled operation time
Figures 40-47: Individual SDS-HAAs for EBCT 10&20 vs. scaled operation time
Figures 48-51: SDS-TOX or EBCT 10&20 vs. scaled operation time

4. SDS Influent Analysis

Figures 52-55: Influent for individual THMs vs. scaled operation time
Figures 56-63: Influent for individual HAAs vs. scaled operation time

5. SDS Temperature and pH conditions

Figures 64-67: SDS chlorination pH vs. scaled operation time
Figures 68-71: SDS chlorination temperature vs. scaled operation time

E. Cost Information and Analysis: not performed

F. Summary of Significant Results

In general, the breakthrough curves follow the predicted increase in TOC and other SDS parameters as a function of time. Note that up through 70 % breakthrough, the Stage 2 DBP criteria of THM4 < 40 ug/L and HAA5 < 30 ug/L were NOT exceeded, indicating that the plant would be compliant with this placeholder level up to 70% breakthrough.

III. QA/QC Summary

All QA/QC procedures and requirements were followed as described in the DBP/ICR Analytical Methods Manual. Note that Table 4 lists the MRLs, some of which are lower than those listed in the manual.

All results for lab duplicates and lab fortified matrices are summarized in the ICR Treatment Study Summary Report Spreadsheets, along with some miscellaneous data about the public water supply.

PE results: Environmental Health Laboratories is a certified ICR lab that participated in all ICR PE studies. The results for these studies are listed in Tables 7-10.

Calibration Procedures: The calibration procedures used during the study are consistent with the DBP/ICR Analytical Methods Manual. Tables 9.1 to 9.4 in this manual were used as guidelines for the frequency and percent recovery requirements.

During the study, some of the chemistry analyses did not meet the ICR QA/QC requirements outlined in the ICR/DBP Analytical Methods Manual. These samples were entered as not reported (NR) in the Data Collection Spreadsheets. Many of these failures were minor and in the presence of other QC in the analytical run that pass method criteria. As a result, many of these data points are included in the graphs if they seem to fit the data. The following is a summary of QA/QC failures:

Quarter 3

C8-EBCT-10 through C10-EBCT-10 and C12-EBCT-20 effluent samples were rejected for DCAA analysis only due to failure of the low-level calibration check. These samples could not be repeated due to holding time.

B1-EBCT-20, C1-EBCT-20, C2-EBCT-20, and D1-EBCT-20 were in a run with a low-biased out-of-range CCC and could not be repeated within holding time.

Quarter 4

C5-EBCT-20: pH was analyzed outside of holding time.

Figure 1- AB Jewell Water Plant

Full-Scale Treatment Plant Schematic

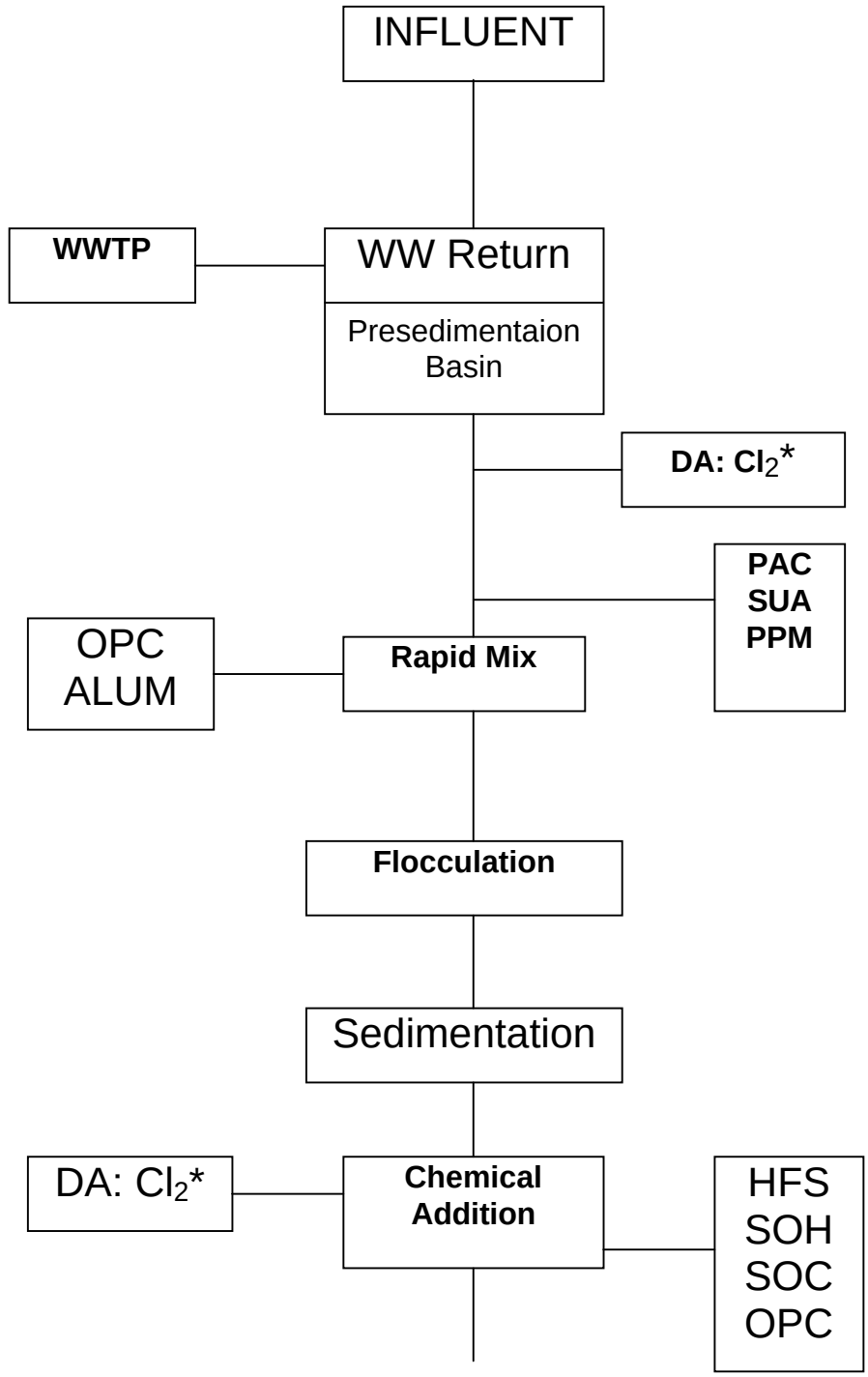
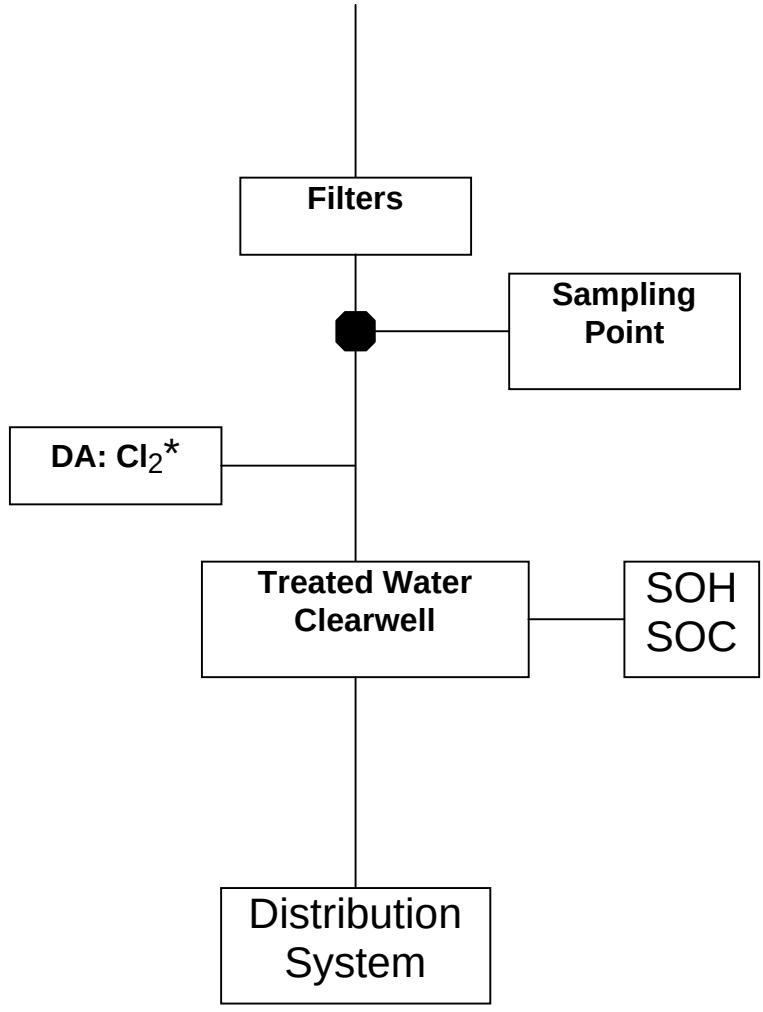

INFLUENT
WWTP
WW Return
Presedimentaion Basin
DA: Cl2*
PAC
SUA
PPM
OPC
ALUM
Rapid Mix
Flocculation
Sedimentation
DA: Cl2*
Chemical Addition
HFS
SOH
SOC
OPC

Figure 1 (cont.) - AB JEWELL WATER PLANT



***Note: Sample was taken after chlorinators had been turned off, therefore no chlorine residual was present at the time of collection.**

Figure 2 - Pretreatment Process Schematic

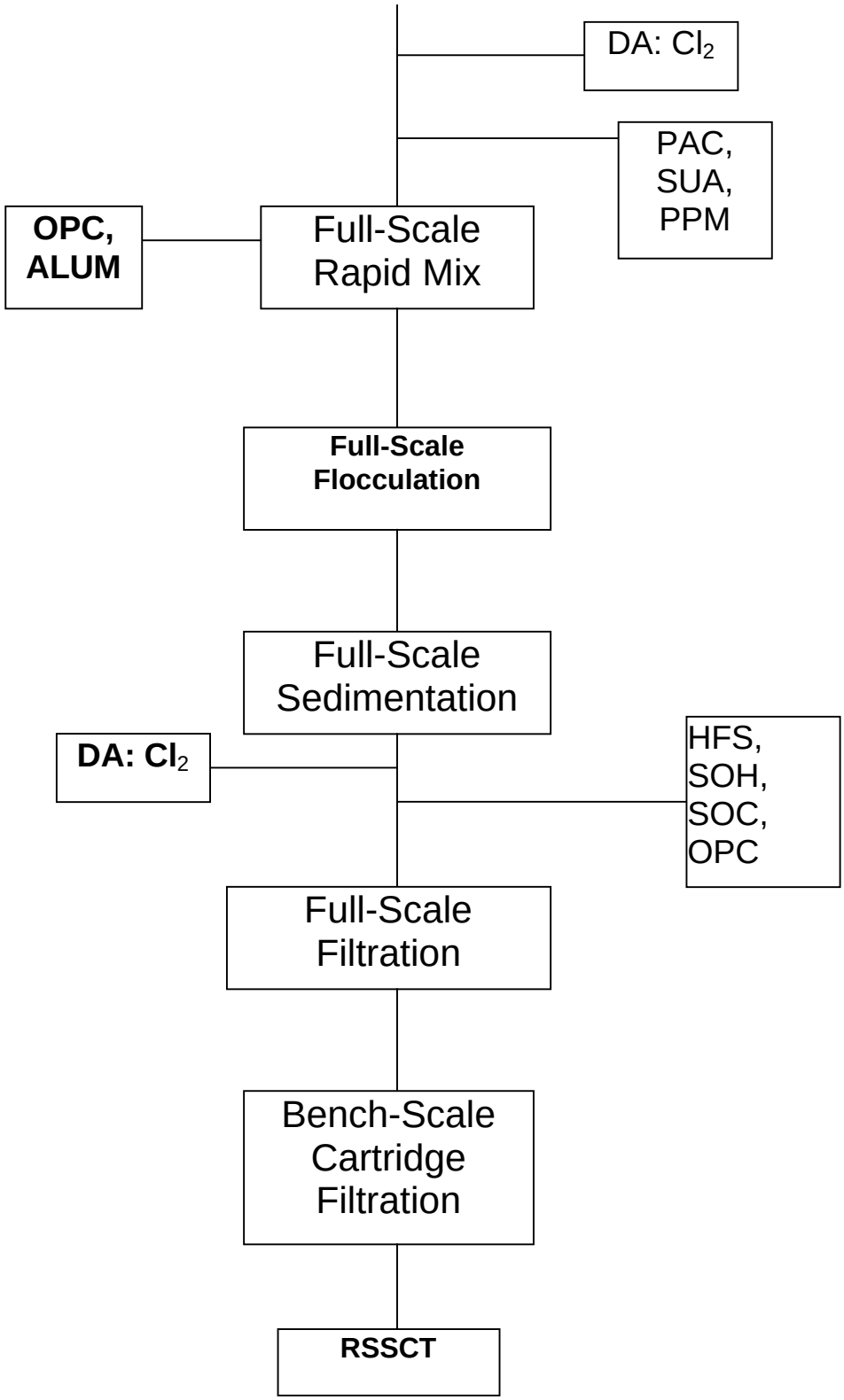


Figure 3 - RSSCT Test Apparatus Diagram

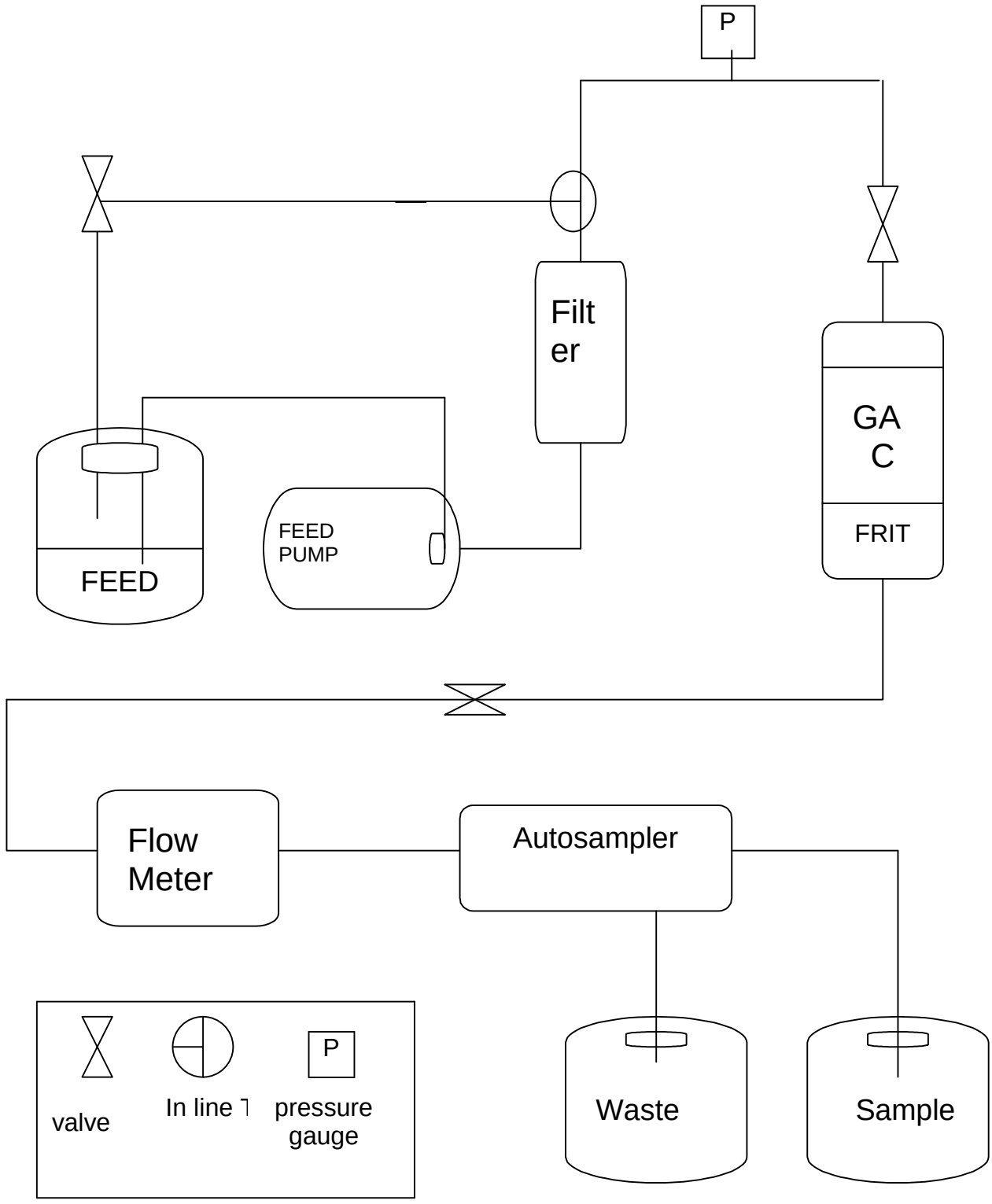


Table 1b: Bench-Scale Pretreatment Data

Unit Process	Process Description
Scale Control (Bench-Scale)	Chemical Type: NA
	Adjusted pH: NA
	Dose Rate (mg/L): NA
Cartridge Filtration (Bench-Scale)	Surface Area (ft2): 4.5
	Nominal Pore Size (mm): 1.0
	Filter Material: polypropylene
	Filter Life (gallons of processed water): NA

Table 2a: Tabular Summary of Source Water Quality

Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Maximum Yearly Value	Minimum Yearly Value
Temperature (C)	17.4	8.33	28.2	5.9
pH	7.8	0.29	8.32	7.46
Turbidity (ntu)	25.8	14.4	48.9	6.36
Alkalinity (mg/L as CaCO3)	111.9	12.1	129	83
Total Hardness (mg/L as CaCO3)	142.3	15.9	160	97
Calcium Hardness (mg/L as CaCO	106.8	11.9	120	81
TOC (mg/L)	4.05	0.68	5.62	3.1
UV254 (cm-1)	0.235	0.114	0.441	0.094
Bromide (mg/L)	72	30	152	32

A

Table 2b: Tabular Summary of Finished Water Quality

Water Quality Parameter	Average Yearly Concentration	Standard Deviation	Maximum Yearly Value	Minimum Yearly Value
Temperature (C)	18.2	8.21	29	6.5
pH	8.1	0.27	8.68	7.79
Turbidity (ntu)	0.22	0.06	0.33	0.15
TOC (mg/L)	2.23	0.19	2.57	1.92
UV254 (cm-1)	0.041	0.009	0.064	0.033
Distribution System THM4 (mg/L)	96.1	20.26	127	70.2
Distribution System HAA5 (mg/L)	37.8	9.58	59	24.4

Table 3: Experimental Design Summary For The RSSCT Stu

Season	Pretreatment	EBCT, min
Spring	Conventional filtration	10 & 20
Summer	Conventional filtration	10 & 20
Fall	Conventional filtration	10 & 20
Winter	Conventional filtration	10 & 20

Table 4: Summary of Analytical Methods and MRLs Used During The RSSCT Study

Analyte	Method	Minimum Reporting Level
Alkalinity	SM 2320 B	1.0 mg/L CaCO3
Ammonia	SM 4500-NH3 D	0.30 mg/L NH3-N
Bromide	EPA 300.0	20 mg/L
Calcium Hardness	SM 2340 B	0.25 mg/L CaCO3
Chlorine Residual	SM 4500-Cl G	0.1 mg/L
BCAA, DBAA, DCAA, MBAA, MCAA, TCAA	EPA 552.2	2.0 mg/L for MCAA 1.0 mg/L for all others
pH	SM 4500-H+	Not Applicable
TDS	SM 2510 B (TDS meter)	5.0 mg/L
Temperature	SM 2550 B	Not Applicable
CHCl3, BDCM, DBCM	EPA 524.2	1.0 mg/L for each analyte
CHBr3		
Total Hardness	SM 2340 B	0.33 mg/L CaCO3
TOC	SM 5310 C	0.50 mg/L
TOX	SM 5320 B	25.0 mg/L
Turbidity	EPA 180.1	0.05 ntu
UV254	SM 5910	0.001 cm-1

Table 5a : Average Pretreated Feed Water Quality During 4 Seasons of the RSSCT Study -10 Min EBCT

Water Quality Parameter	Units	Spring Average	Spring S.D.	Summe Average	Summe S.D.	Fall Average	Fall S.D.	Winter Average	Winter S.D.
pH	---	7.71	0.07	7.92	0.05	7.82	0.07	8.06	0.06
Temperature	^{o}C	23.0	0.00	23.0	0.00	21.3	1.53	21.0	1.00
Alkalinity	ıg/L as CaC(	113.3	2.47	116.0	7.00	114.5	4.24	119.1	0.21
Total hardness	ıg/L as CaC(	136.4	1.91	134.0	8.63	143.1	6.43	112.0	4.74
Calcium hardness	ıg/L as CaC(	102.8	1.91	102.4	6.36	109.3	7.57	88.0	2.26
Turbidity	ntu	0.36	0.04	0.40	0.03	0.16	0.07	0.18	0.02
Ammonia	mg NH_3-N /	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL
otal organic carbo	mg/L	2.67	0.29	2.87	0.12	2.55	0.13	2.03	0.08
UV_{254}	cm^{-1}	0.055	0.004	0.055	0.002	0.041	0.001	0.044	0.001
SUVA	L/(mg*m)	2.08	0.28	1.93	0.15	1.59	0.05	2.19	0.03
Bromide	mg/L	56.0	4.24	64.0	1.41	54.5	2.12	38.00	0.00
SDS-Cl_2 dose	mg/L	2.58	0.11	3.14	0.38	2.92	0.14	2.98	0.00
)S-Free Cl_2 residu	mg/L	1.23	0.35	1.32	0.30	1.60	0.12	1.62	0.05
SDS-Cl_2 demand	mg/L	1.35	0.27	1.82	0.15	1.32	0.04	1.36	0.05
S-Chlorination ter	^{o}C	13.0	0.00	26.9	0.17	27.0	0.06	11.3	0.52
DS-Chlorination p	---	8.06	0.07	8.02	0.02	8.02	0.01	8.06	0.02
DS-Incubation tim	hours	7.0	0.00	7.0	0.00	7.0	0.00	7.0	0.00
SDS-TOX	mg Cl^- /L	140.00	0.00	165.00	10.00	131.67	17.56	130.00	15.00
SDS-*CHCl3*	mg/L	28.54	2.21	30.60	4.68	25.07	4.44	22.86	0.43
SDS-*BDCM*	mg/L	17.73	0.97	16.79	1.39	16.06	1.78	12.03	0.16
SDS-*DBCM*	mg/L	6.84	0.22	7.16	0.27	8.71	0.85	4.07	0.06
SDS-*CHBr3*	mg/L	BMRL	BMRL	BMRL	BMRL	1.51	0.17	BMRL	BMRL
SDS-THM4	mg/L	53.12	3.34	54.56	6.31	51.35	7.00	38.96	0.26
SDS-*MCAA*	mg/L	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL
SDS-*DCAA*	mg/L	12.69	1.29	12.85	2.25	7.92	1.98	13.77	0.85
SDS-*TCAA*	mg/L	7.48	1.11	9.80	0.66	4.97	1.25	10.38	1.87
SDS-*MBAA*	mg/L	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL
SDS-*DBAA*	mg/L	1.67	0.14	1.60	0.55	1.85	0.29	1.08	0.10
SDS-*BCAA*	mg/L	5.44	0.58	5.45	0.72	3.83	0.65	5.40	0.33
SDS-HAA5	mg/L	21.84	2.18	24.25	2.95	14.74	3.47	24.87	2.51
SDS-HAA6	mg/L	27.84	2.42	29.70	3.67	18.57	4.12	30.27	2.84

Table 5b : Average Pretreated Feed Water Quality During 4 Seasons of the RSSCT Study -20 Min EBCT

Water Quality Parameter	Units	Spring Average	Spring S.D.	Summe Average	Summe S.D.	Fall Average	Fall S.D.	Winter Average	Winter S.D.
pH	---	7.90	0.03	7.95	0.09	7.74	0.09	8.10	0.04
Temperature	^{o}C	23.3	1.53	23.3	0.58	20.3	0.58	20.7	0.58
Alkalinity	ıg/L as CaC(	91.0	28.99	114.8	5.30	118.3	1.06	119.7	0.21
Total hardness	ıg/L as CaC(	132.5	2.83	156.0	22.49	138.4	6.58	111.8	8.70
Calcium hardness	ıg/L as CaC(	98.5	3.68	100.4	9.19	105.0	3.68	88.3	9.69
Turbidity	ntu	0.32	0.03	0.37	0.07	0.16	0.06	0.14	0.02
Ammonia	mg NH_3-N /	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL
otal organic carbo	mg/L	2.60	0.17	2.87	0.06	2.45	0.05	2.02	0.03
UV_{254}	cm^{-1}	0.056	0.002	0.055	0.002	0.040	0.003	0.044	0.002
SUVA	L/(mg*m)	2.14	0.07	1.90	0.10	1.62	0.13	2.17	0.06
Bromide	mg/L	62.5	7.78	62.0	1.41	54.5	0.71	38.50	0.71
SDS-Cl_2 dose	mg/L	2.36	0.42	3.13	0.37	2.92	0.14	3.11	0.22
)S-Free Cl_2 residu	mg/L	1.22	0.36	1.38	0.33	1.63	0.15	1.70	0.16
SDS-Cl_2 demand	mg/L	1.14	0.13	1.75	0.05	1.30	0.17	1.41	0.13
S-Chlorination ter	^{o}C	13.0	0.00	27.0	0.06	27.0	0.06	11.1	0.06
DS-Chlorination p	---	8.00	0.10	8.00	0.03	8.00	0.01	8.10	0.01
DS-Incubation tim	hours	7.0	0.00	7.0	0.00	7.0	0.00	7.0	0.00
SDS-TOX	mg Cl^- /L	135.00	15.00	160.00	8.66	130.83	31.66	102.83	28.31
SDS-*CHCl3*	mg/L	23.07	2.64	30.68	3.31	27.08	4.39	22.64	1.28
SDS-*BDCM*	mg/L	15.92	0.87	16.62	1.42	17.01	1.56	11.45	1.22
SDS-*DBCM*	mg/L	6.44	0.42	7.25	0.32	8.90	0.58	3.58	0.65
SDS-*CHBr3*	mg/L	BMRL	BMRL	BMRL	BMRL	1.54	0.07	BMRL	BMRL
SDS-THM4	mg/L	45.42	3.72	54.55	5.01	54.53	6.58	37.67	3.07
SDS-*MCAA*	mg/L	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL
SDS-*DCAA*	mg/L	12.39	2.35	13.03	1.39	7.15	0.73	12.28	1.53
SDS-*TCAA*	mg/L	7.15	2.20	10.21	2.38	3.88	0.19	11.56	1.32
SDS-*MBAA*	mg/L	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL	BMRL
SDS-*DBAA*	mg/L	1.69	0.35	1.63	0.35	1.57	0.08	1.11	BMRL
SDS-*BCAA*	mg/L	5.64	1.63	5.61	0.71	3.23	0.11	4.27	0.99
SDS-HAA5	mg/L	21.23	4.58	24.86	3.58	12.60	0.57	24.21	2.52
SDS-HAA6	mg/L	26.87	6.18	30.47	4.27	15.83	0.56	28.48	3.48

Table 6: SDS Conditions

Parameters	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
pH	-	8	8	8	8
Temperature	oC	13	27	27	11
Target residual	mg/L	1	1	1.6	1.7
Retention Time	hours	7	7	7	7

Table 7: PE Study for 1st Quarter (PE Study #6)

Parameter	Units	True Value	Measured Value	RPD
UV254	cm-1	0.101	0.09	10.89
TOC	mg/L	2.69	3.01	11.9
TOX	mg Cl- /L	135	102	24.44
Bromide	mg/L	0.059	0.056	5.08
norganic DBPs:				
ClO2-	mg/L	73.6	63	14.4
BrO3-	mg/L	16.2	17.1	5.56
ClO3-	mg/L	141	140	0.71
HAAs:				
MCAA	mg/L	9.04	7.86	13.05
MBAA	mg/L	8.1	6.84	15.56
DCAA	mg/L	18.1	16.6	8.29
TCAA	mg/L	26.2	26.8	2.29
BCAA	mg/L	11.1	8.5	23.42
DBAA	mg/L	4.97	4.36	12.27
THMs:				
CHCl3	mg/L	16.2	15.1	6.79
BDCM	mg/L	22.8	23.2	1.75
DBCM	mg/L	28.6	29.7	3.85
CHBr3	mg/L	20.2	20.2	0
HANs:				
TCAN	mg/L	-	5.97	-
DCAN	mg/L	10.9	9.02	17.25
DCP	mg/L	9	8.3	7.78
BCAN	mg/L	13	12	7.69
TCP	mg/L	8.01	6.9	13.86
DBAN	mg/L	15.9	15.2	4.4
CH	mg/L	12.2	13.8	13.11

Table 8a: PE Study for 2nd Quarter (PE Study #7)

Parameter	Units	True Value	Measured Value	RPD
UV254	cm-1	0.361	0.339	6.09
TOC	mg/L	1.22	1.29	5.74
TOX	mg Cl- /L	188	149	20.74
Inorganic DBPs:				
ClO2-	mg/L	483	449	7.04
BrO3-	mg/L	26.1	24.5	6.13
ClO3-	mg/L	375	352	6.13
HAAs:				
MCAA	mg/L	5.94	5.07	14.65
MBAA	mg/L	11.1	7.5	32.43
DCAA	mg/L	24	17.1	28.75
TCAA	mg/L	15	12.9	14
BCAA	mg/L	12.1	7.37	39.09
DBAA	mg/L	14	9.03	35.5
THMs:				
CHCl3	mg/L	17	16	5.88
BDCM	mg/L	11	11.3	2.73
DBCM	mg/L	28.1	28	0.36
CHBr3	mg/L	18.2	18.2	0
HANs:				
TCAN	mg/L	12.1	12	0.83
DCAN	mg/L	19	18.6	2.11
DCP	mg/L	5.06	5.22	3.16
BCAN	mg/L	9.1	8.69	4.51
TCP	mg/L	11.1	11.8	6.31
DBAN	mg/L	14	14.3	2.14
CH	mg/L	22.1	20.1	9.05

Table 8b: Makeup PE Study for 2nd Quarter

Parameter	Units	True Value	Measured Value	RPD
Bromide	mg/L	0.091	0.09	1.1

Table 9a: PE Study for 3rd Quarter (PE Study #8)

Parameter	Units	True Value	Measured Value	RPD
UV254	cm-1	0.072	0.066	8.33
TOC	mg/L	2.62	3.14	19.85
TOX	mg Cl- /L	80.3	62.8	21.79
Bromide	mg/L	0.325	0.296	8.92
Inorganic DBPs:				
ClO2-	mg/L	687	635	7.57
BrO3-	mg/L	13.1	12.3	6.11
ClO3-	mg/L	768	700	8.85
HAAs:				
MCAA	mg/L	13	12.6	3.08
MBAA	mg/L	16	14.3	10.63
DCAA	mg/L	14.2	12.6	11.27
TCAA	mg/L	8.03	6.76	15.82
BCAA	mg/L	5.07	4.77	5.92
DBAA	mg/L	18	17.9	0.56
HANs:				
TCAN	mg/L	6.92	5.52	20.23
DCAN	mg/L	6.16	4.51	26.79
DCP	mg/L	4.09	4.38	7.09
BCAN	mg/L	10	7.44	25.6
TCP	mg/L	2.99	3.61	20.74
DBAN	mg/L	5.07	4.52	10.85
CH	mg/L	9.08	10.6	16.74

Table 9b: Makeup PE Study for 3rd Quarter

Parameter	Units	True Value	Measured Value	RPD
THMs:				
CHCl3	mg/L	17.1	17.1	0
BDCM	mg/L	11	11	0
DBCM	mg/L	28.1	26.7	4.98
CHBr3	mg/L	18.2	18.1	0.55

Table 10: PE Study for 4th Quarter (PE Study #9)

Parameter	Units	True Value	Measured Value	RPD
UV254	cm-1	0.223	0.206	7.62
TOC	mg/L	4.19	4.25	1.43
TOX	mg Cl- /L	92.9	62.5	32.72
Bromide	mg/L	0.091	0.092	1.1
Inorganic DBPs:				
ClO2-	mg/L	167	170	1.8
BrO3-	mg/L	9.17	9.68	5.56
ClO3-	mg/L	211	209	0.95
HAAs:				
MCAA	mg/L	11.1	12.1	9.01
MBAA	mg/L	9.11	8.54	6.26
DCAA	mg/L	8.01	7.39	7.74
TCAA	mg/L	12	9.47	21.08
BCAA	mg/L	7.05	5.6	20.57
DBAA	mg/L	5	3.85	23
THMs:				
CHCl3	mg/L	32.2	32.1	0.31
BDCM	mg/L	15	14.9	0.67
DBCM	mg/L	9.1	8.73	4.07
CHBr3	mg/L	2.98	2.91	2.35
HANs:				
TCAN	mg/L	17	18.3	7.65
DCAN	mg/L	16.2	16.2	0
DCP	mg/L	8.13	9.73	19.68
BCAN	mg/L	14.1	11.5	18.44
TCP	mg/L	14.1	14.5	2.84
DBAN	mg/L	12.1	9.64	20.33
CH	mg/L	19.1	15.3	19.9

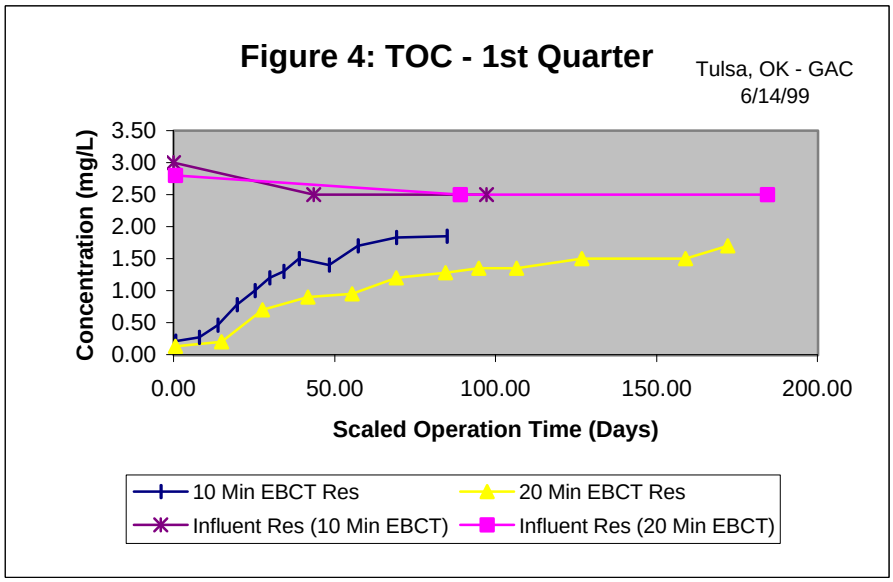


Figure 4: TOC - 1st Quarter
Tulsa, OK - GAC
6/14/99
Concentration (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT Res
20 Min EBCT Res
Influent Res (10 Min EBCT)
Influent Res (20 Min EBCT)

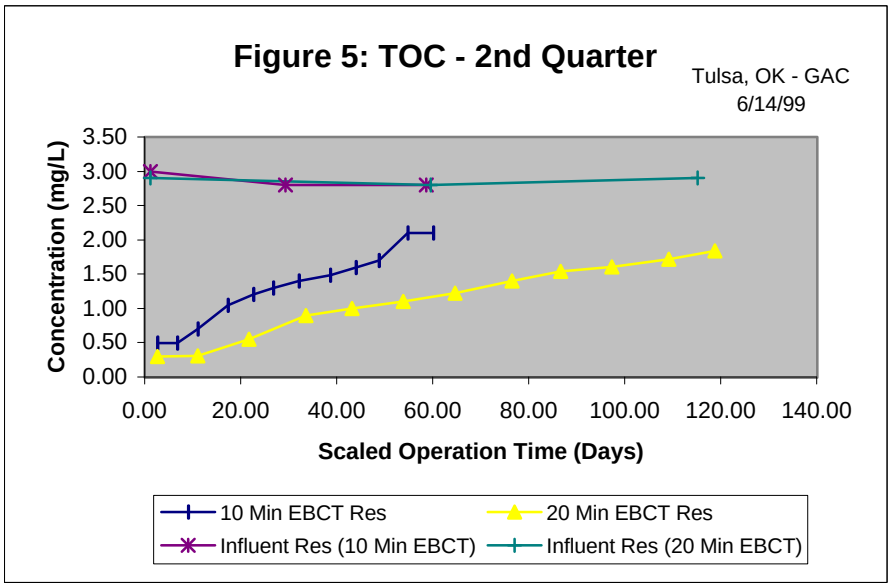


Figure 5: TOC - 2nd Quarter
Tulsa, OK - GAC
6/14/99
Concentration (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Scaled Operation Time (Days)
10 Min EBCT Res
20 Min EBCT Res
Influent Res (10 Min EBCT)
Influent Res (20 Min EBCT)

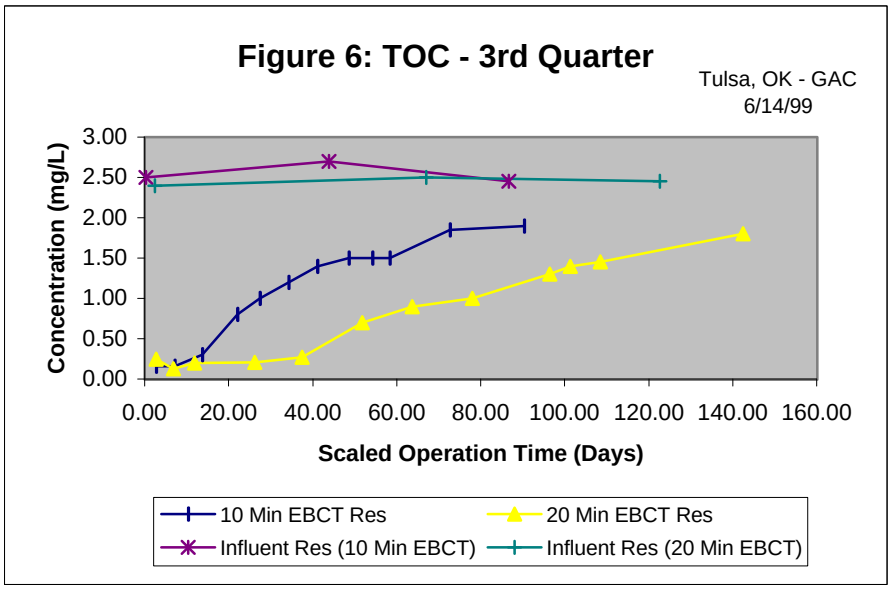


Figure 6: TOC - 3rd Quarter
Tulsa, OK - GAC
6/14/99
Concentration (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Scaled Operation Time (Days)
10 Min EBCT Res
20 Min EBCT Res
Influent Res (10 Min EBCT)
Influent Res (20 Min EBCT)

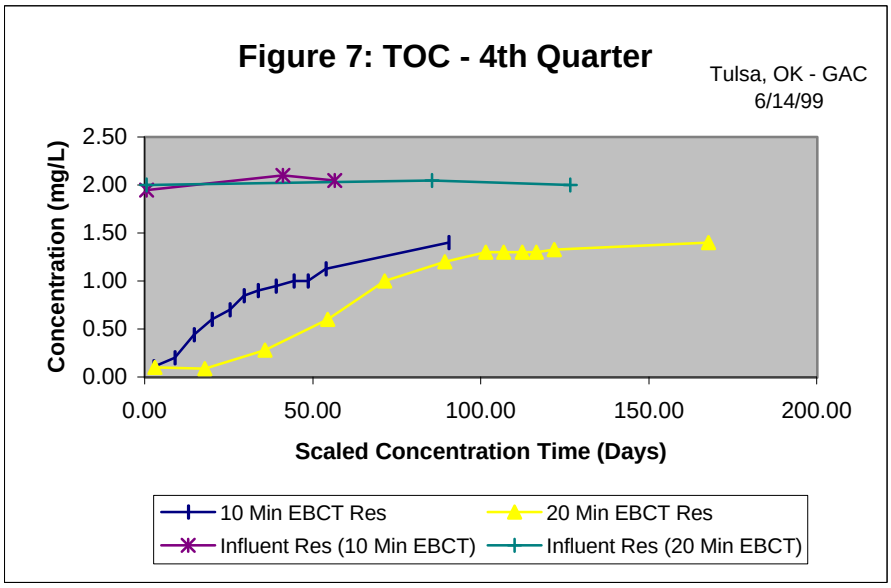


Figure 7: TOC - 4th Quarter
Tulsa, OK - GAC
6/14/99
Concentration (mg/L)
2.50
2.00
1.50
1.00
0.50
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Concentration Time (Days)
10 Min EBCT Res
20 Min EBCT Res
Influent Res (10 Min EBCT)
Influent Res (20 Min EBCT)

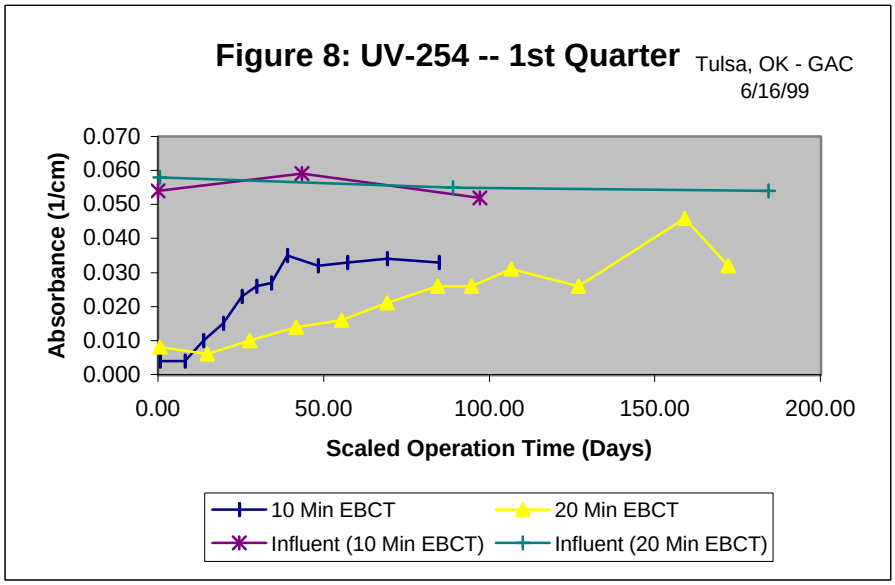


Figure 8: UV-254 -- 1st Quarter
Tulsa, OK - GAC
6/16/99
Absorbance (1/cm)
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

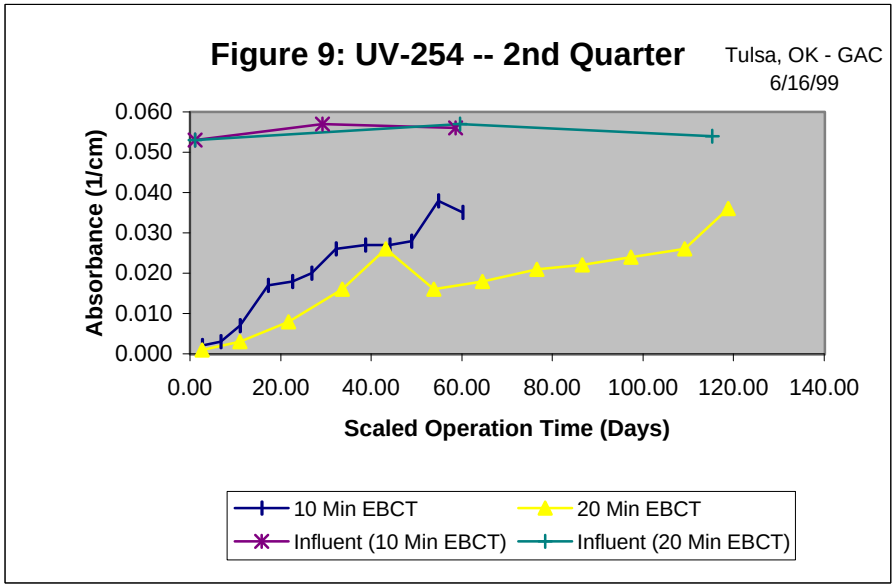


Figure 9: UV-254 -- 2nd Quarter
Tulsa, OK - GAC
6/16/99
Absorbance (1/cm)
0.060
0.050
0.040
0.030
0.020
0.010
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

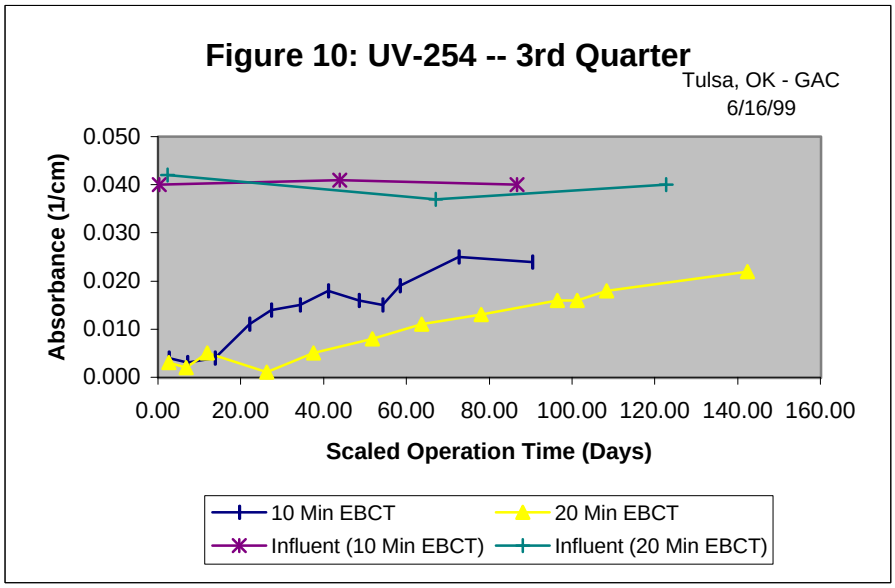


Figure 10: UV-254 -- 3rd Quarter
Tulsa, OK - GAC
6/16/99
Absorbance (1/cm)
0.050
0.040
0.030
0.020
0.010
0.000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

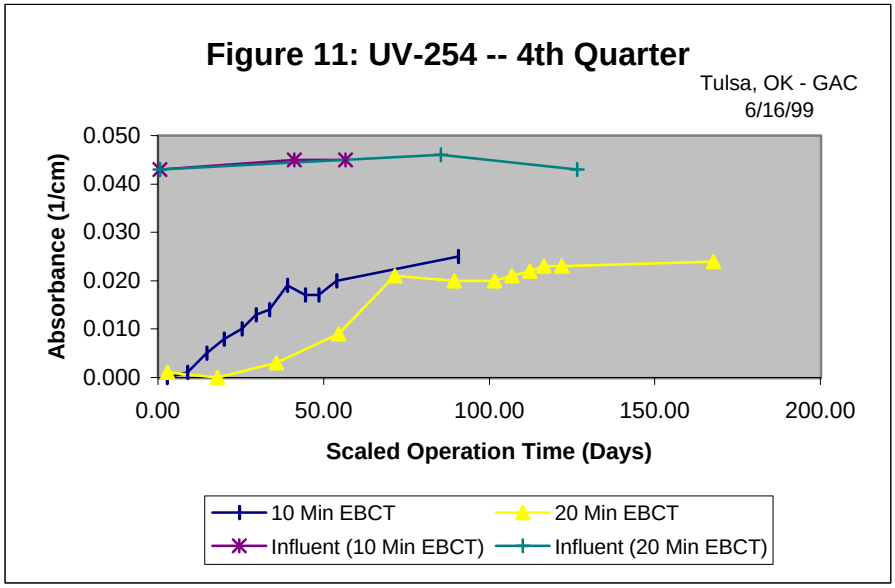


Figure 11: UV-254 -- 4th Quarter
Tulsa, OK - GAC
6/16/99
Absorbance (1/cm)
0.050
0.040
0.030
0.020
0.010
0.000
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

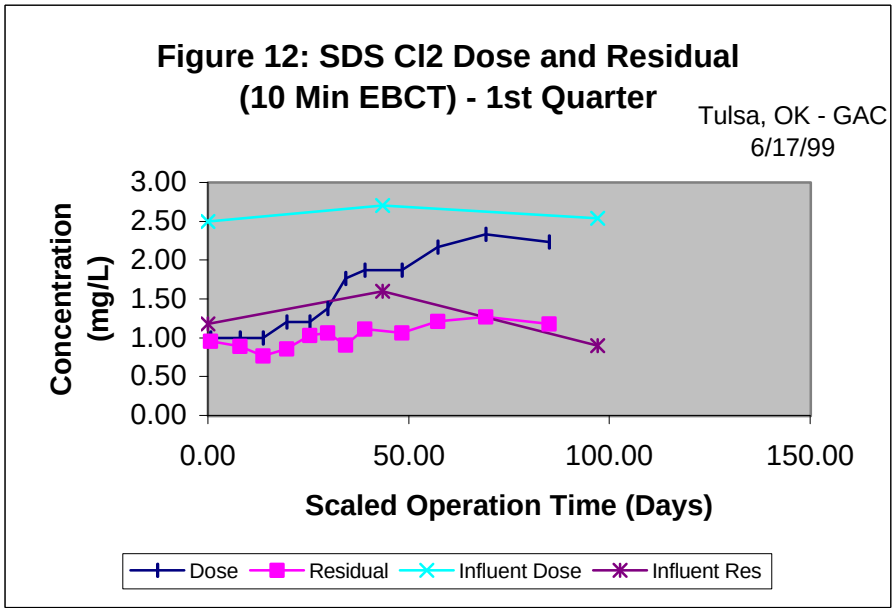


Figure 12: SDS Cl2 Dose and Residual
(10 Min EBCT) - 1st Quarter
Tulsa, OK - GAC
6/17/99
Concentration (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
50.00
100.00
150.00
Scaled Operation Time (Days)
Dose
Residual
Influent Dose
Influent Res

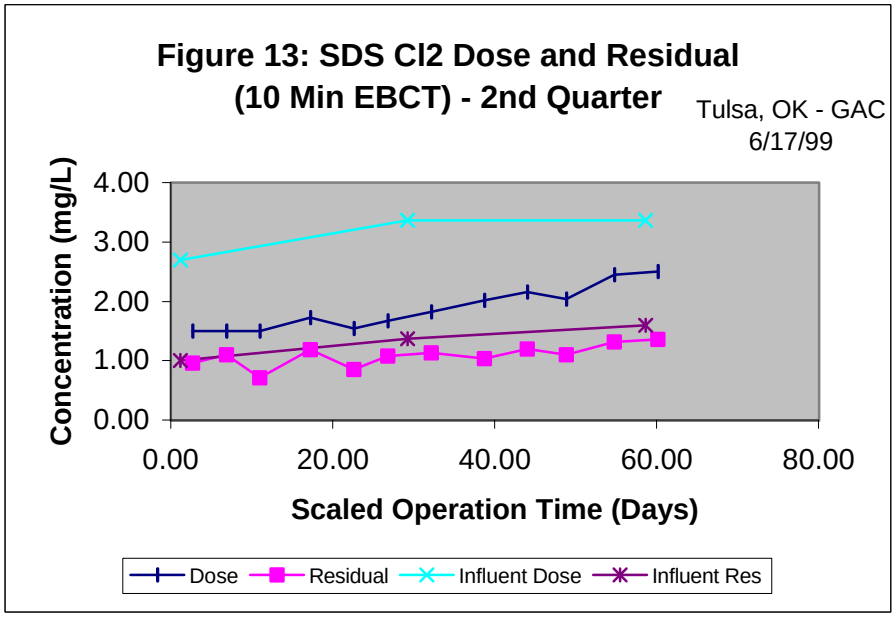


Figure 13: SDS Cl2 Dose and Residual
(10 Min EBCT) - 2nd Quarter
Tulsa, OK - GAC
6/17/99
Concentration (mg/L)
4.00
3.00
2.00
1.00
0.00
0.00
20.00
40.00
60.00
80.00
Scaled Operation Time (Days)
Dose
Residual
Influent Dose
Influent Res

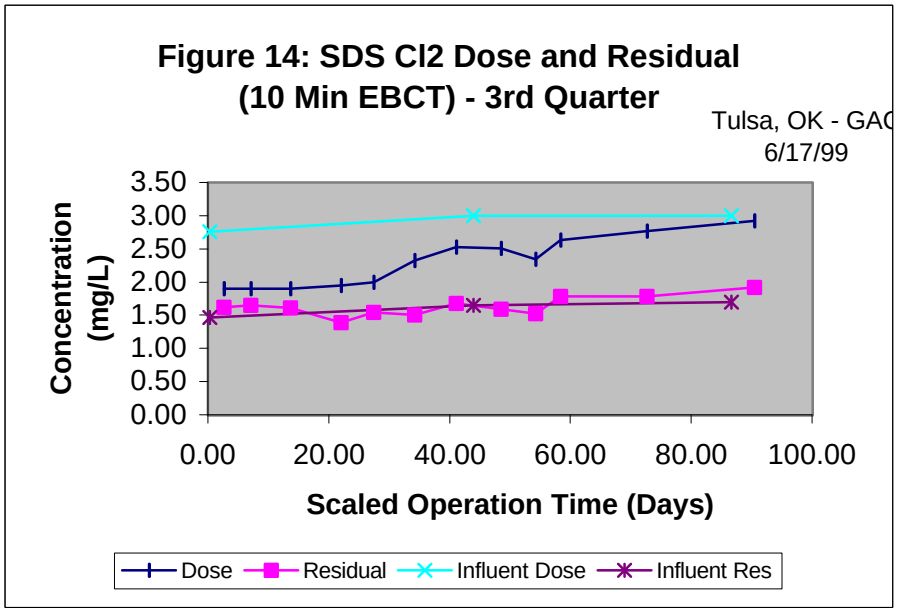


Figure 14: SDS Cl2 Dose and Residual
(10 Min EBCT) - 3rd Quarter
Tulsa, OK - GAC
6/17/99
Concentration (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Scaled Operation Time (Days)
Dose
Residual
Influent Dose
Influent Res

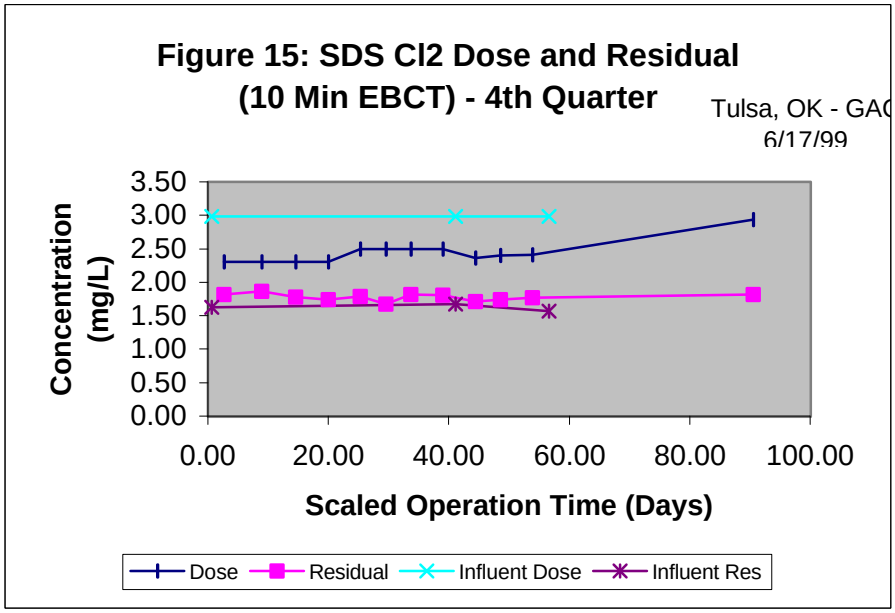


Figure 15: SDS Cl2 Dose and Residual
(10 Min EBCT) - 4th Quarter
Tulsa, OK - GAC
6/17/99
Concentration (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Scaled Operation Time (Days)
Dose
Residual
Influent Dose
Influent Res

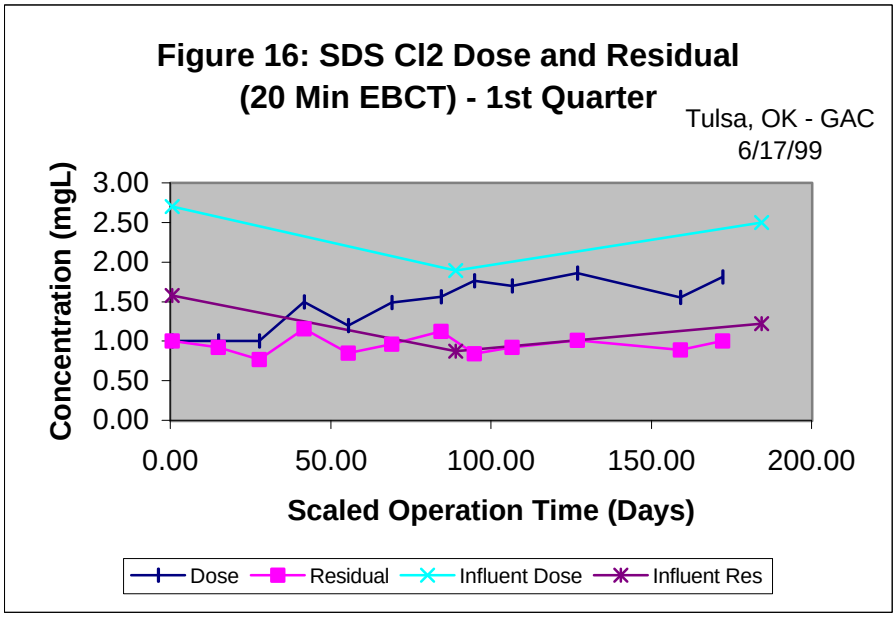


Figure 16: SDS Cl2 Dose and Residual
(20 Min EBCT) - 1st Quarter
Tulsa, OK - GAC
6/17/99
Concentration (mgL)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
Dose
Residual
Influent Dose
Influent Res

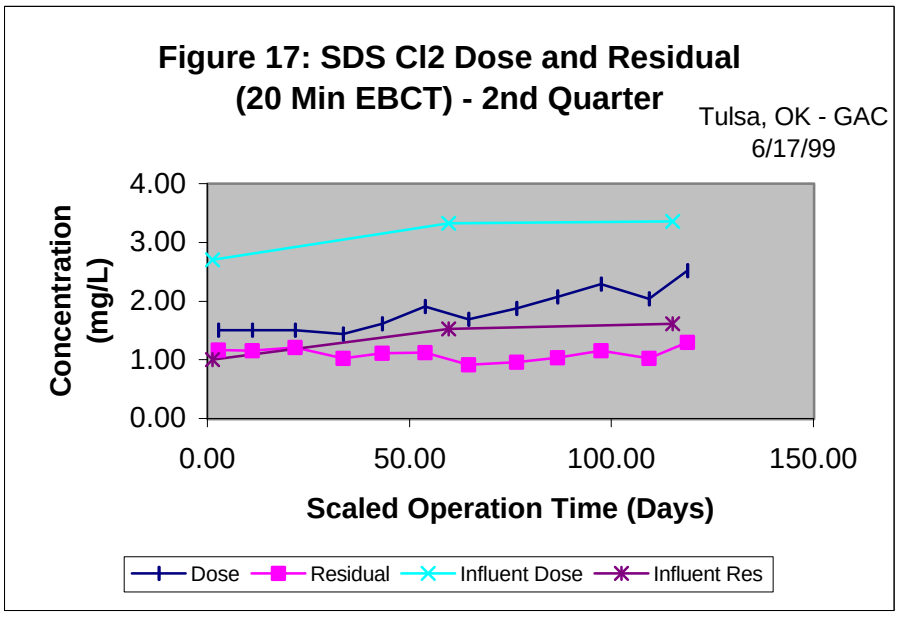


Figure 17: SDS Cl2 Dose and Residual
(20 Min EBCT) - 2nd Quarter
Tulsa, OK - GAC
6/17/99
Concentration (mg/L)
4.00
3.00
2.00
1.00
0.00
0.00
50.00
100.00
150.00
Scaled Operation Time (Days)
Dose
Residual
Influent Dose
Influent Res

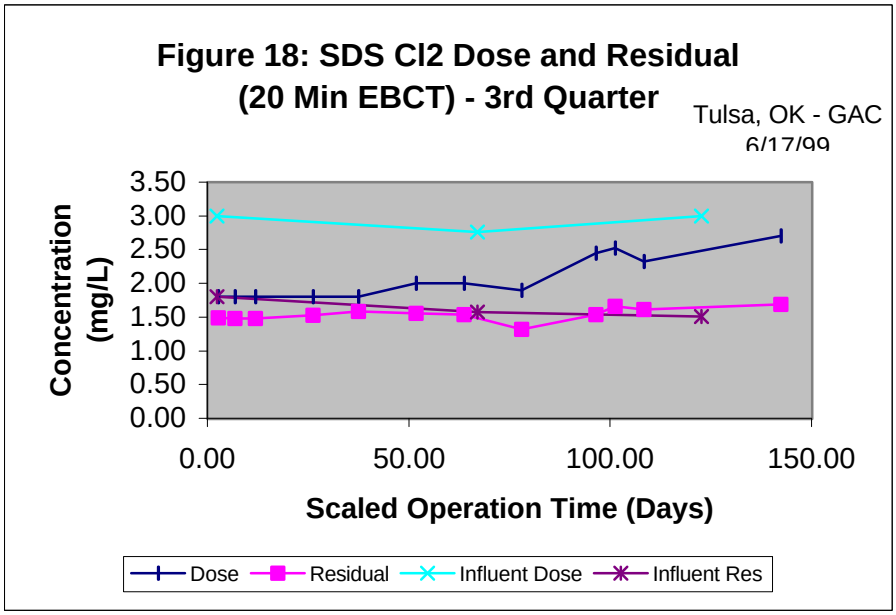


Figure 18: SDS Cl2 Dose and Residual
(20 Min EBCT) - 3rd Quarter
Tulsa, OK - GAC
6/17/99
Concentration (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
50.00
100.00
150.00
Scaled Operation Time (Days)
Dose
Residual
Influent Dose
Influent Res

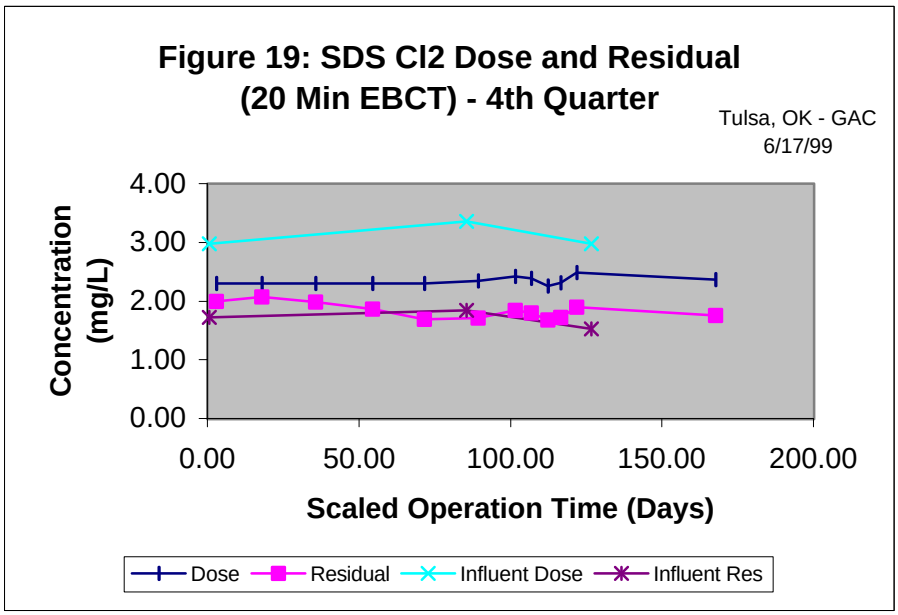


Figure 19: SDS Cl2 Dose and Residual
(20 Min EBCT) - 4th Quarter
Tulsa, OK - GAC
6/17/99
Concentration (mg/L)
4.00
3.00
2.00
1.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
Dose
Residual
Influent Dose
Influent Res

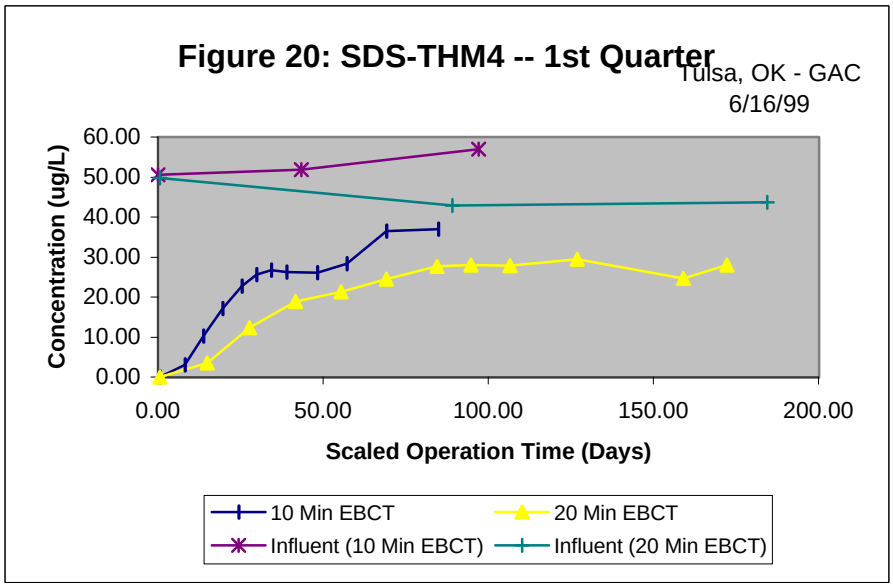


Figure 20: SDS-THM4 -- 1st Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

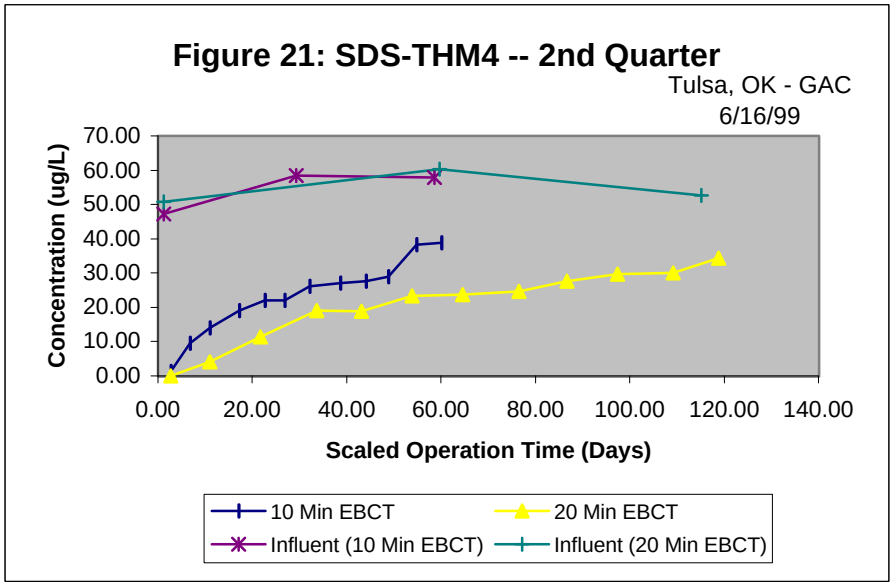


Figure 21: SDS-THM4 -- 2nd Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

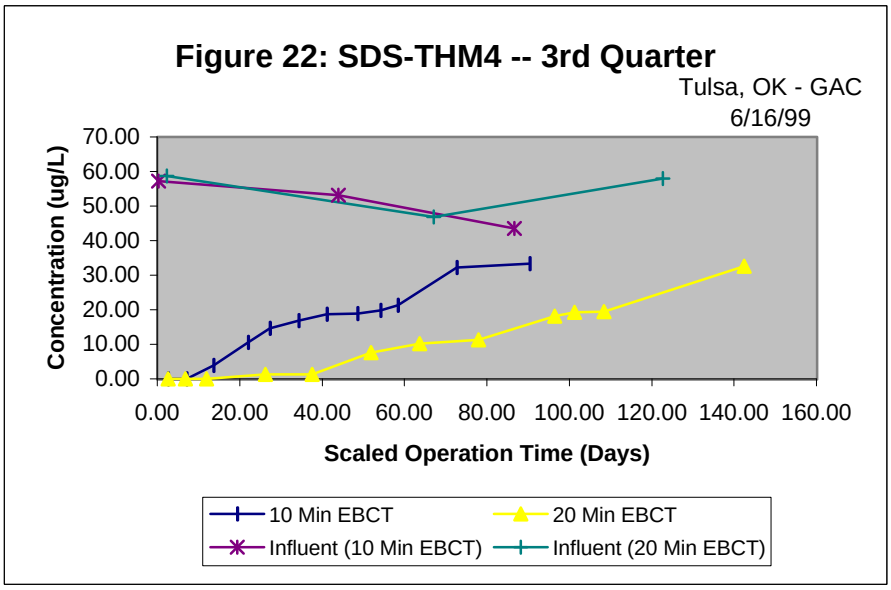


Figure 22: SDS-THM4 -- 3rd Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

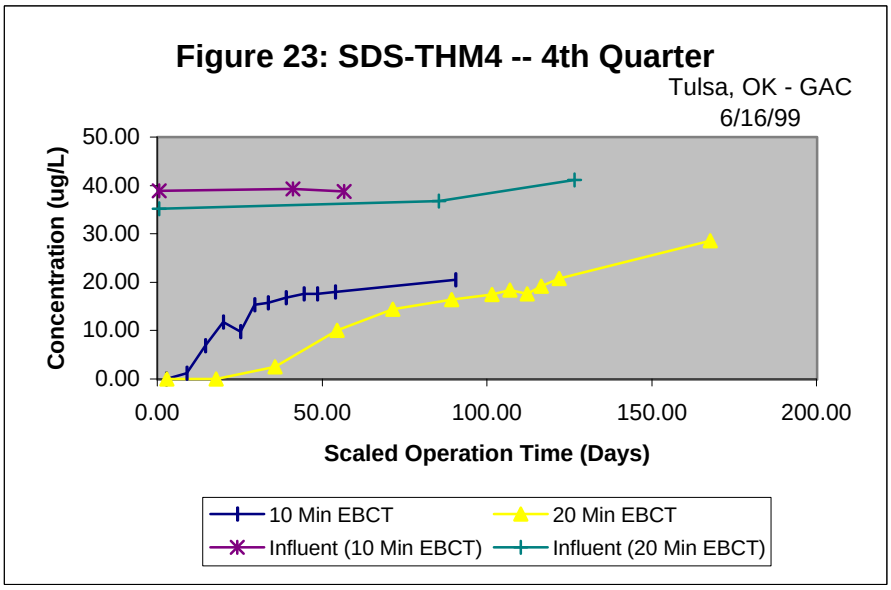


Figure 23: SDS-THM4 -- 4th Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
50.00
40.00
30.00
20.00
10.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

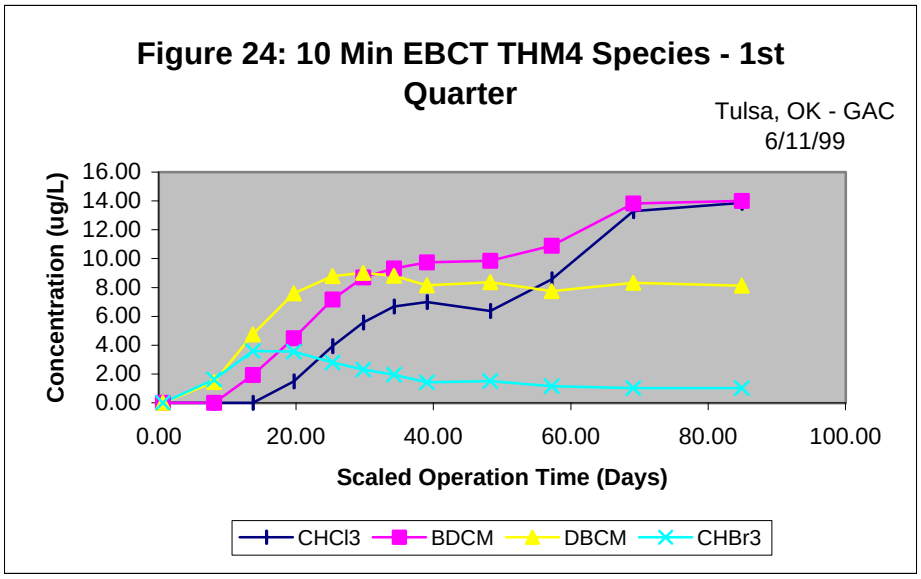


Figure 24: 10 Min EBCT THM4 Species - 1st Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Scaled Operation Time (Days)
CHCl3
BDCM
DBCM
CHBr3

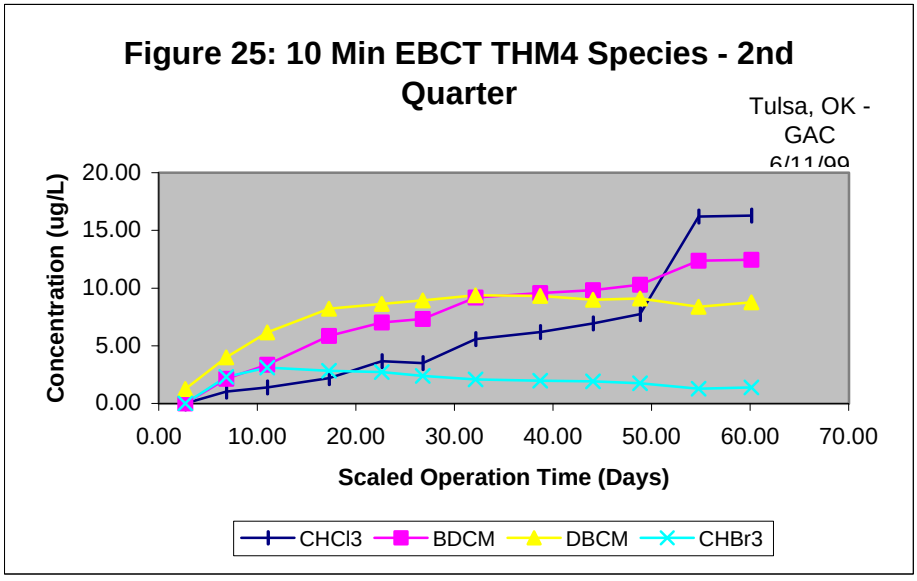


Figure 25: 10 Min EBCT THM4 Species - 2nd Quarter
Tulsa, OK - GAC
Concentration (ug/L)
20.00
15.00
10.00
5.00
0.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Scaled Operation Time (Days)
CHCl3
BDCM
DBCM
CHBr3

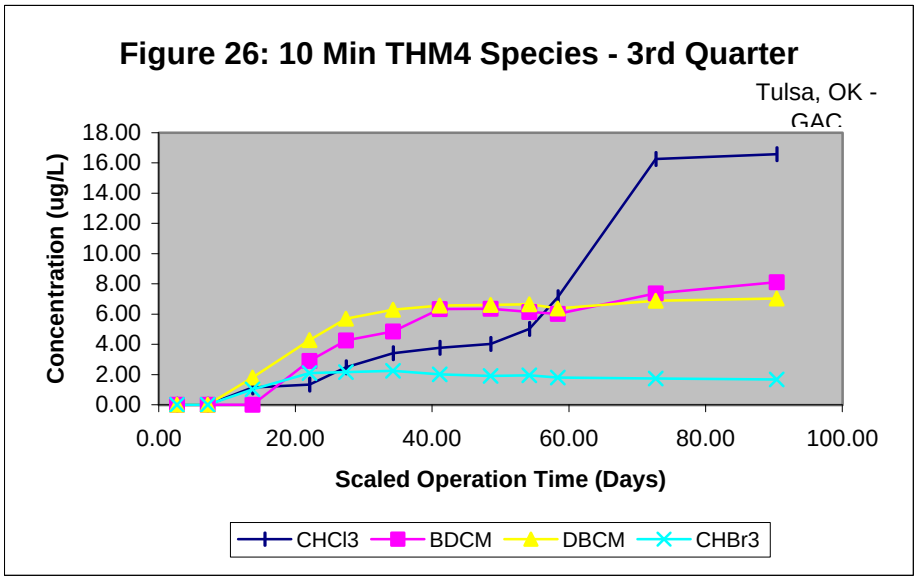


Figure 26: 10 Min THM4 Species - 3rd Quarter
Tulsa, OK - GAC
Concentration (ug/L)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Scaled Operation Time (Days)
CHCl3
BDCM
DBCM
CHBr3

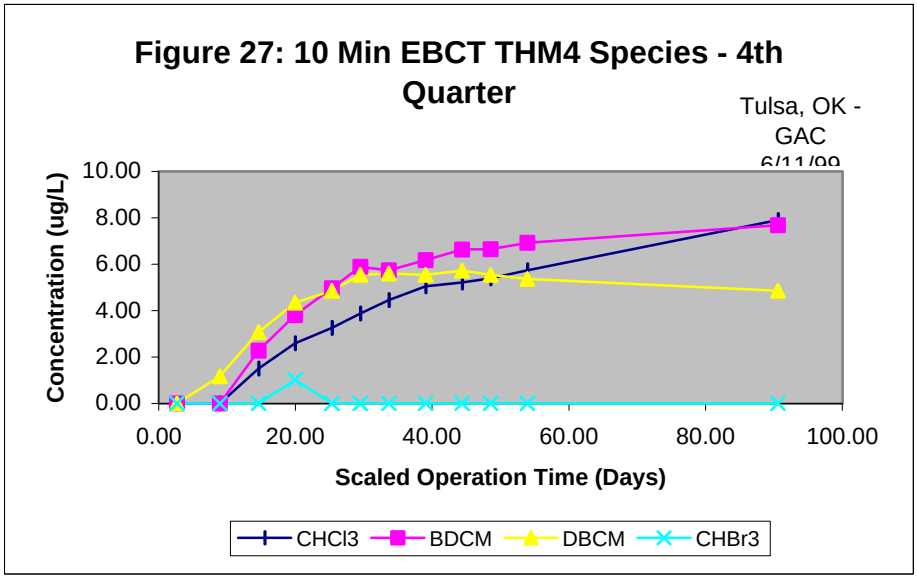


Figure 27: 10 Min EBCT THM4 Species - 4th Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Scaled Operation Time (Days)
CHCl3
BDCM
DBCM
CHBr3

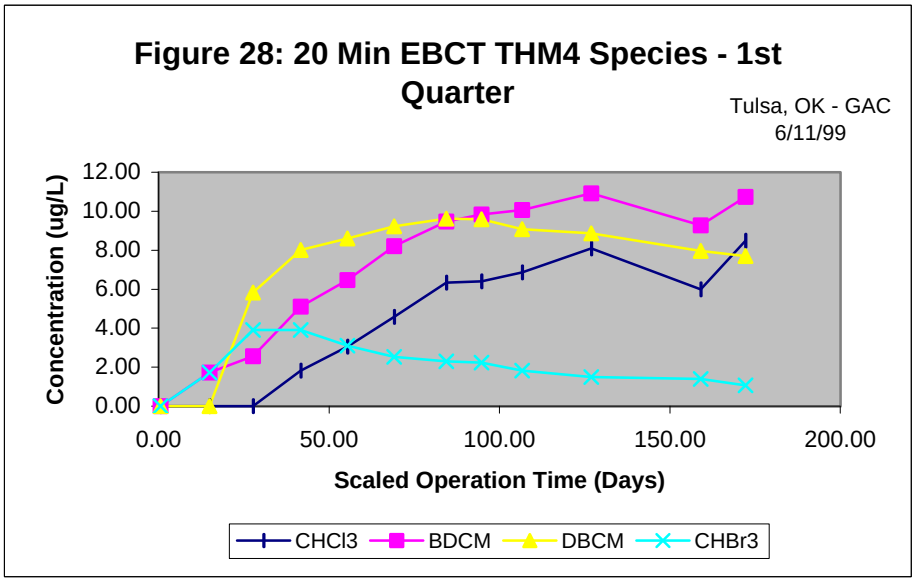


Figure 28: 20 Min EBCT THM4 Species - 1st Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
CHCl3
BDCM
DBCM
CHBr3

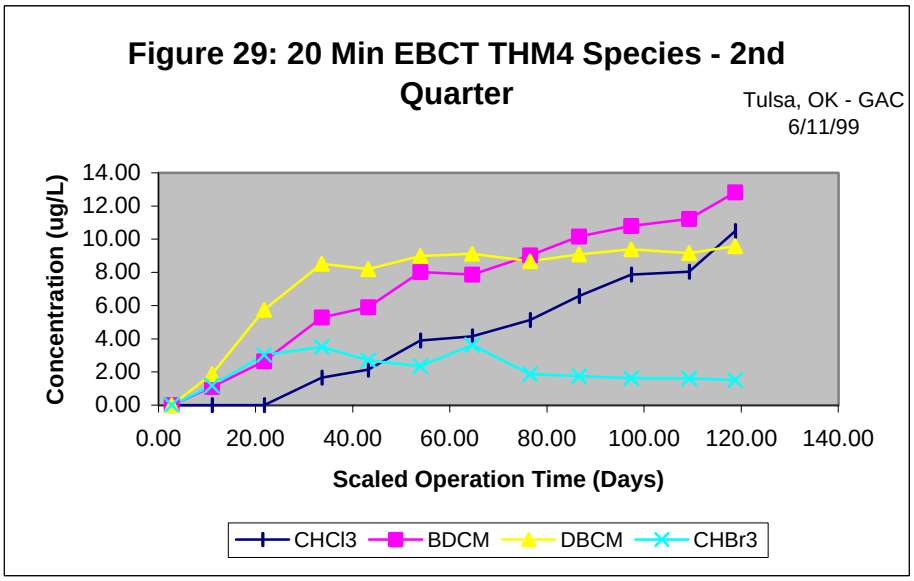


Figure 29: 20 Min EBCT THM4 Species - 2nd Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Scaled Operation Time (Days)
CHCl3
BDCM
DBCM
CHBr3

Figure 30: 20 Min EBCT THM4 Species - 3rd Quarter

Tulsa, OK - GAC
6/11/99

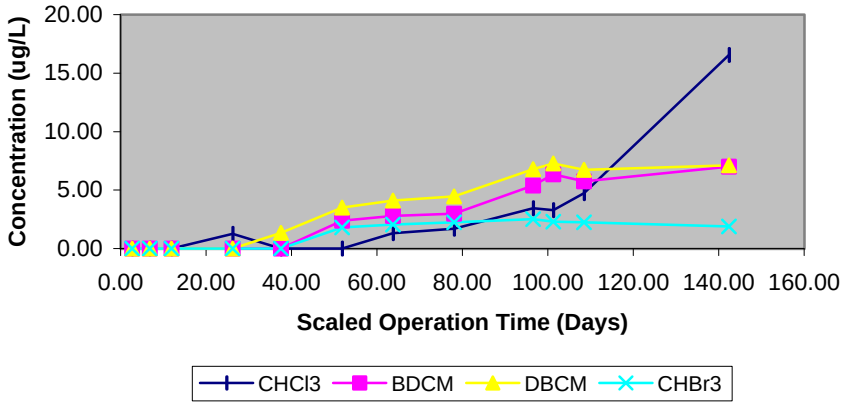
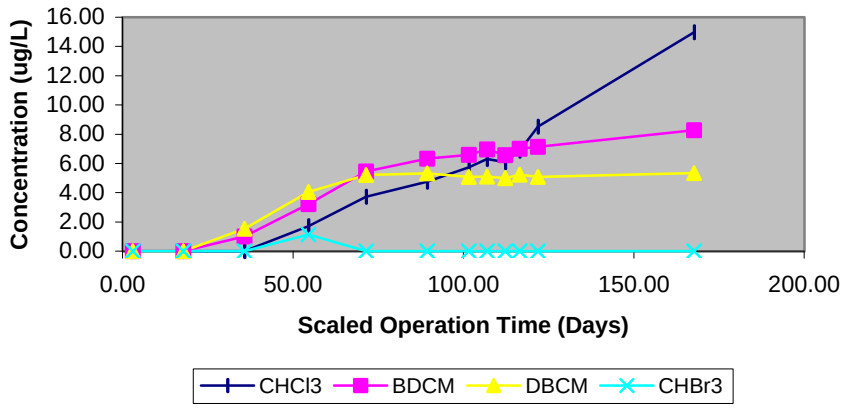


Figure 31: 20 Min EBCT THM4 Species - 4th Quarter

Tulsa, OK - GAC
6/11/99



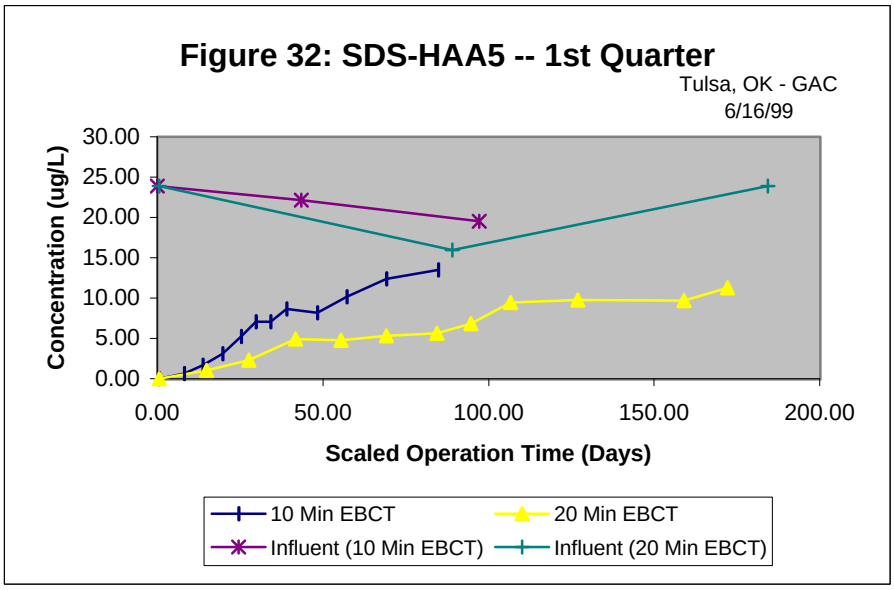


Figure 32: SDS-HAA5 -- 1st Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

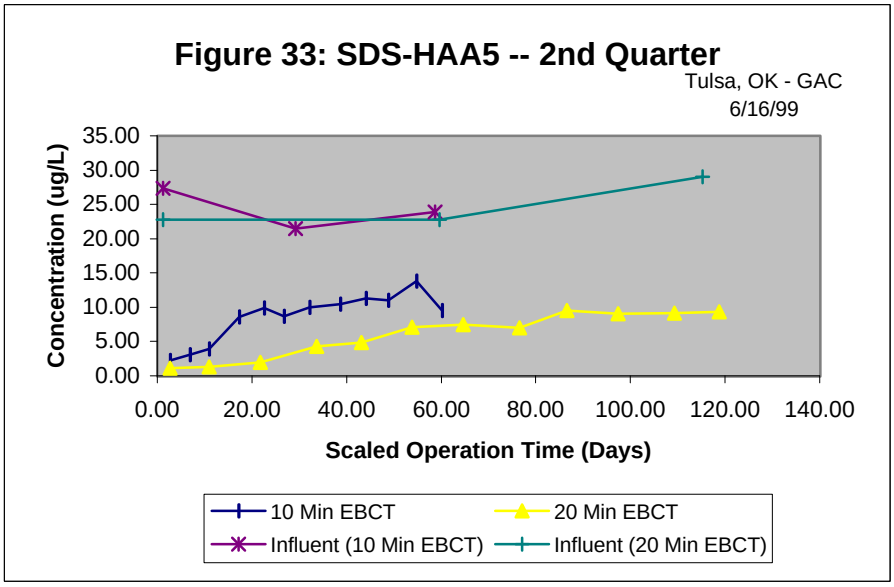


Figure 33: SDS-HAA5 -- 2nd Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

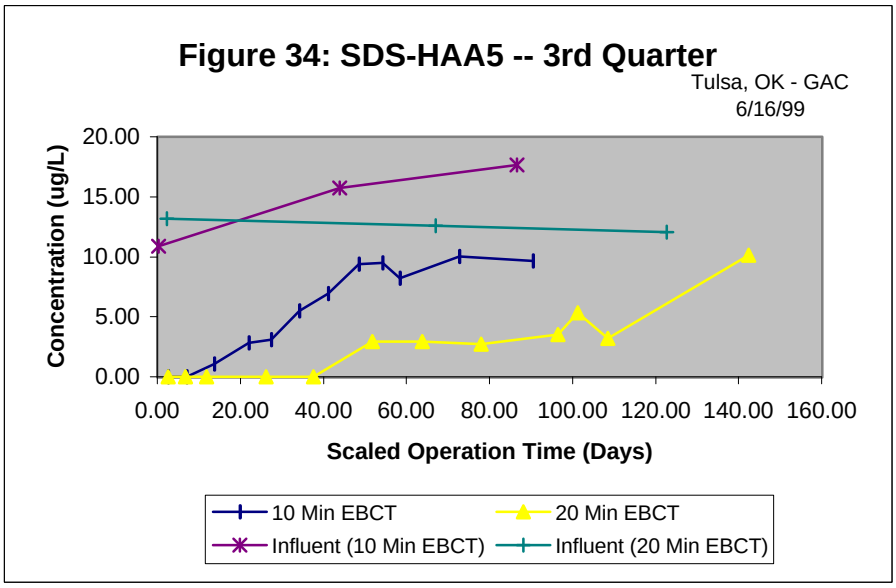


Figure 34: SDS-HAA5 -- 3rd Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

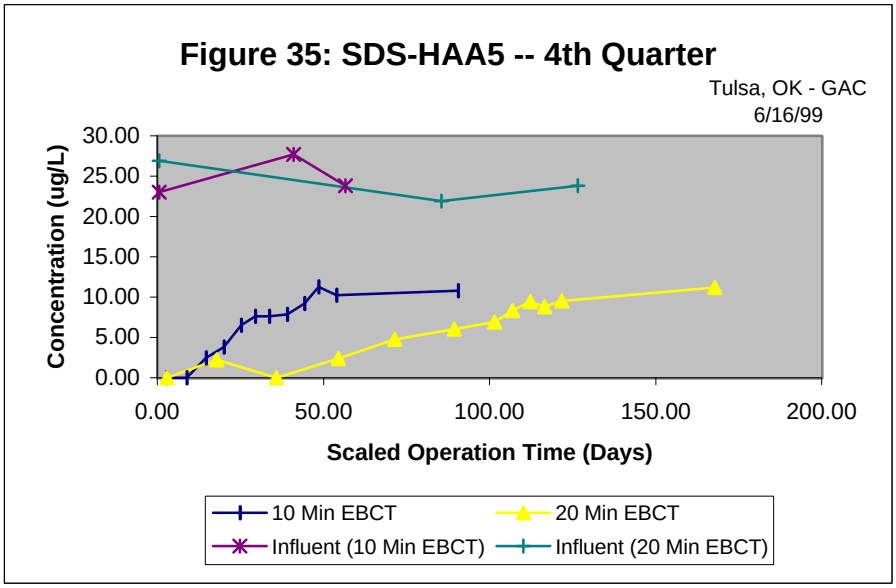


Figure 35: SDS-HAA5 -- 4th Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

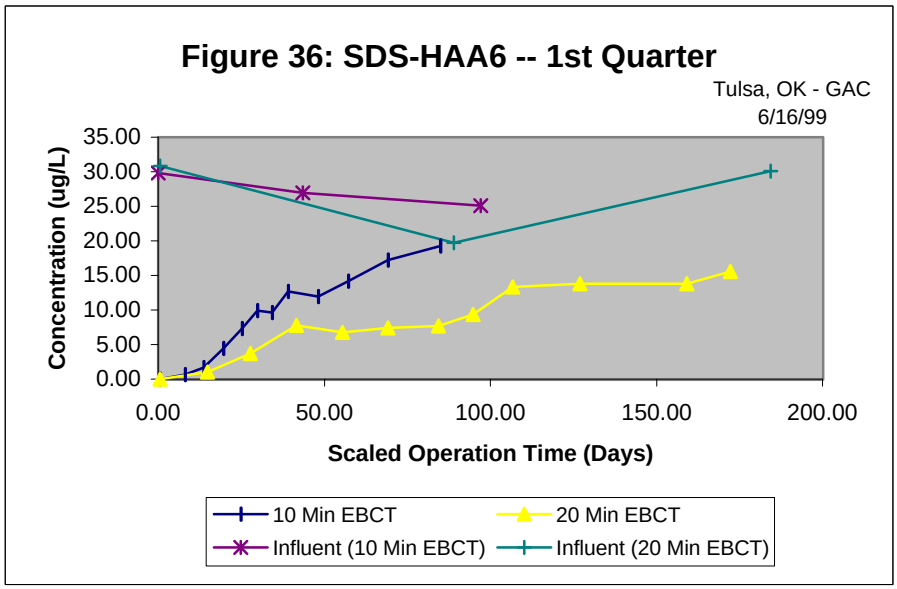


Figure 36: SDS-HAA6 -- 1st Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

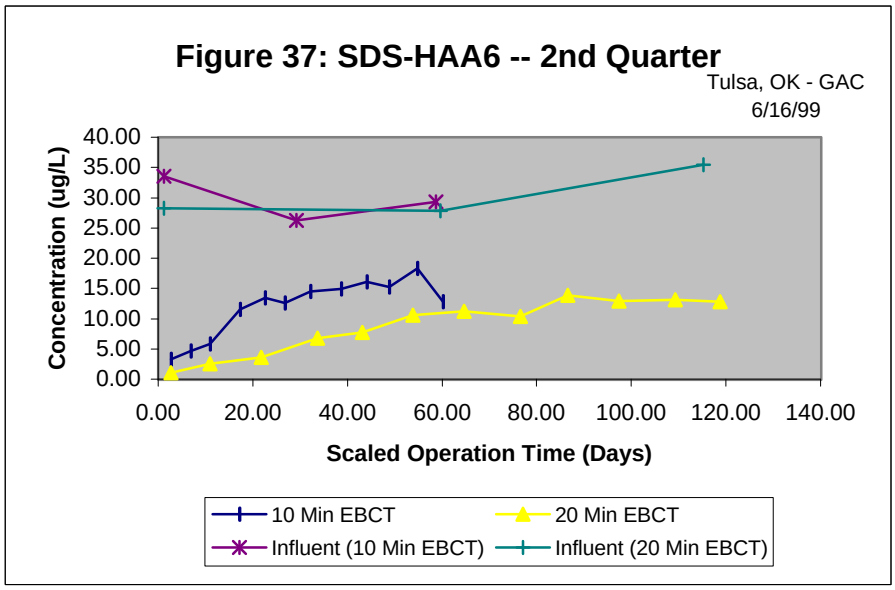


Figure 37: SDS-HAA6 -- 2nd Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

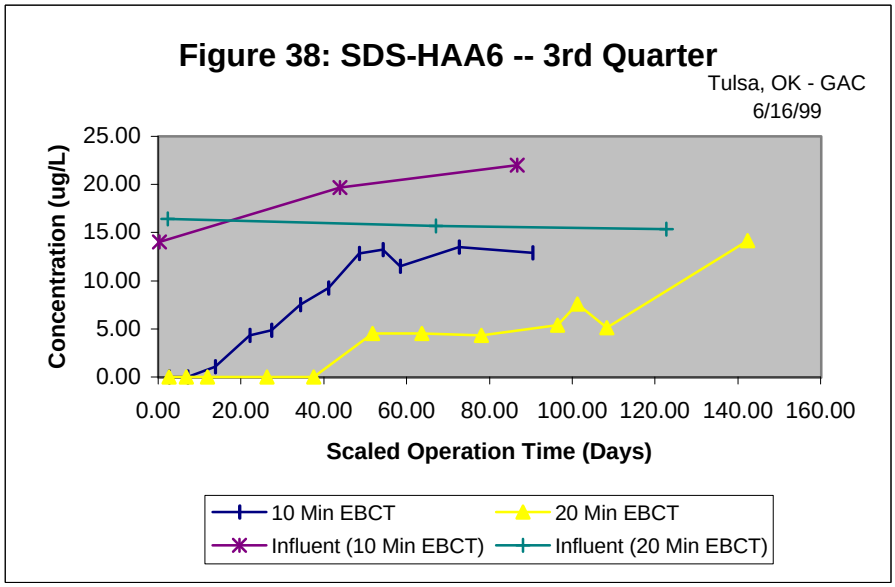


Figure 38: SDS-HAA6 -- 3rd Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

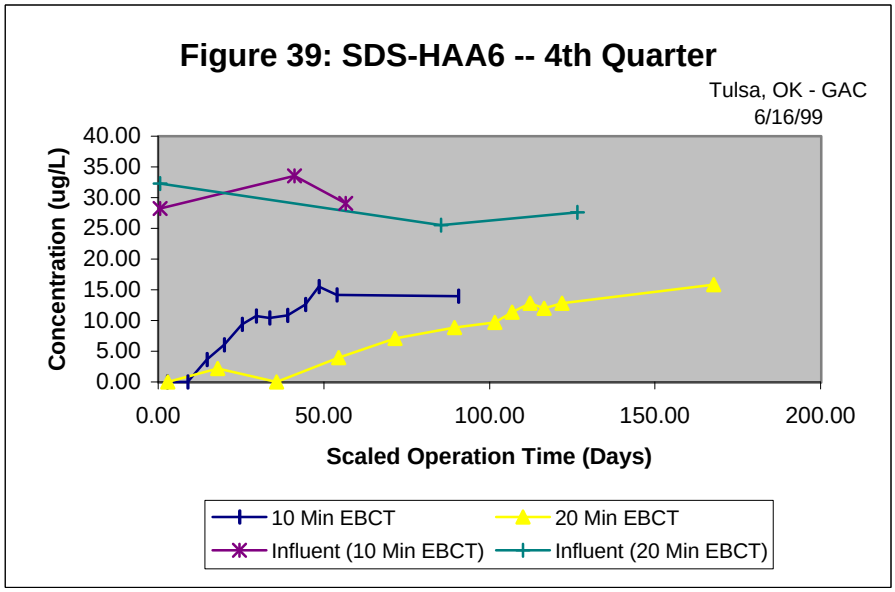


Figure 39: SDS-HAA6 -- 4th Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug/L)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

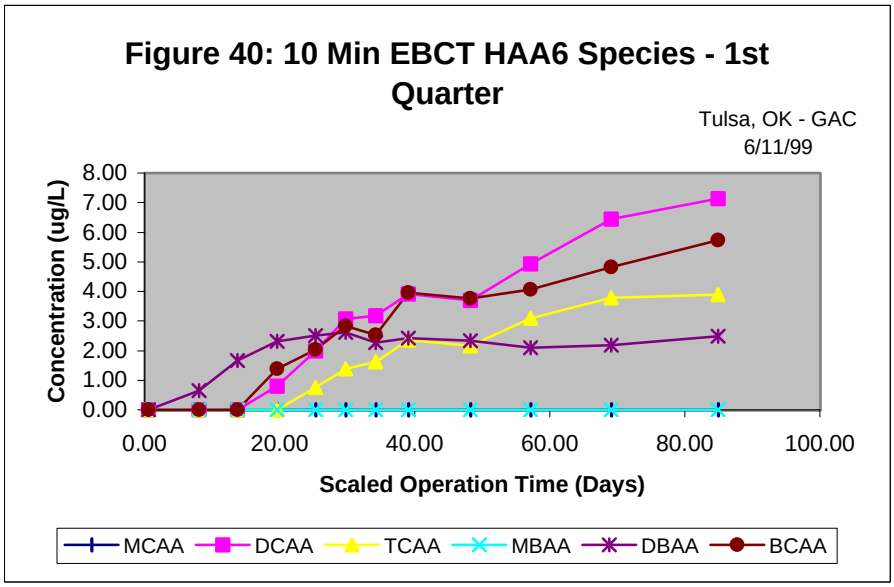


Figure 40: 10 Min EBCT HAA6 Species - 1st Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

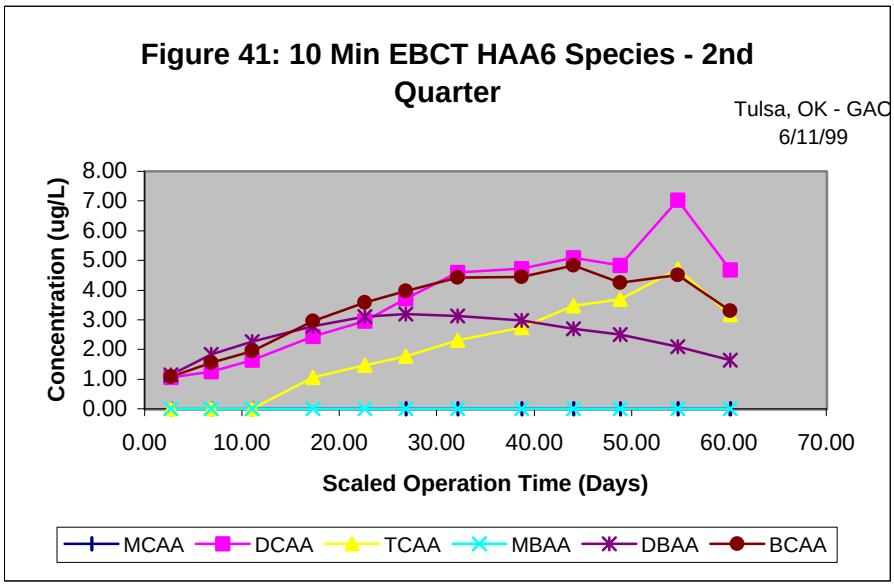


Figure 41: 10 Min EBCT HAA6 Species - 2nd Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

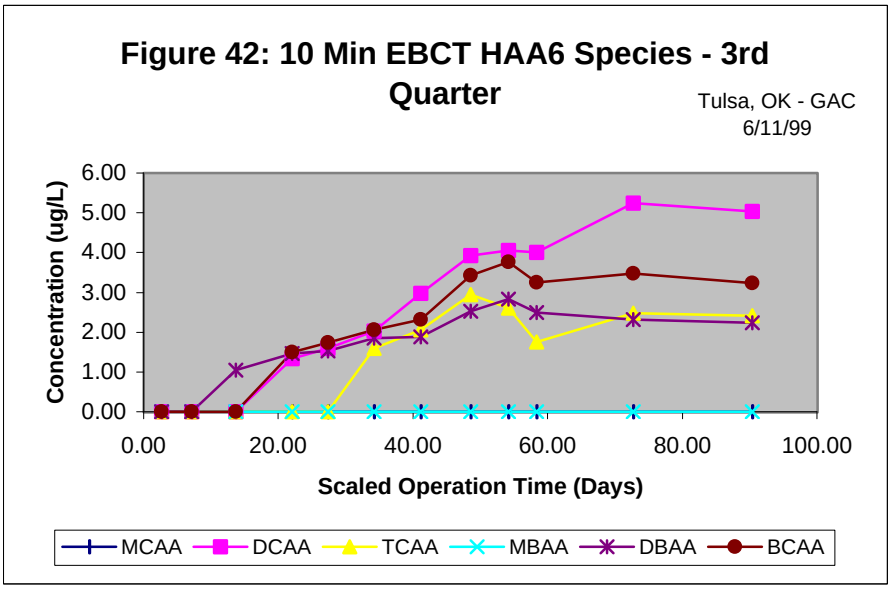


Figure 42: 10 Min EBCT HAA6 Species - 3rd Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

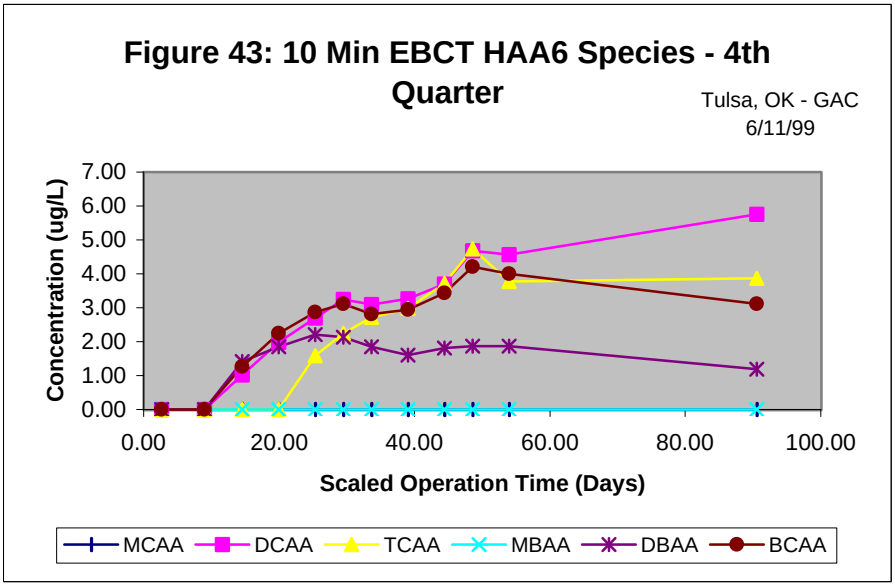


Figure 43: 10 Min EBCT HAA6 Species - 4th Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

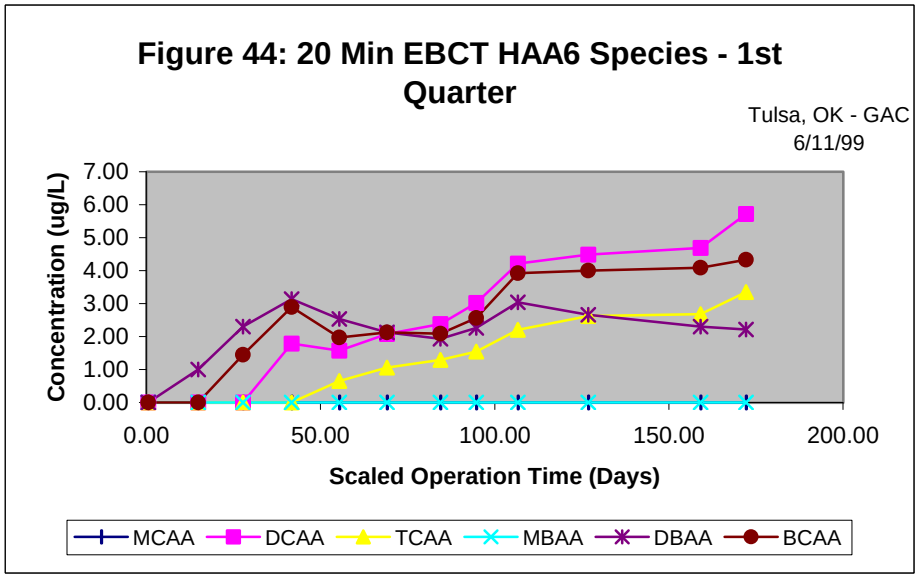


Figure 44: 20 Min EBCT HAA6 Species - 1st Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

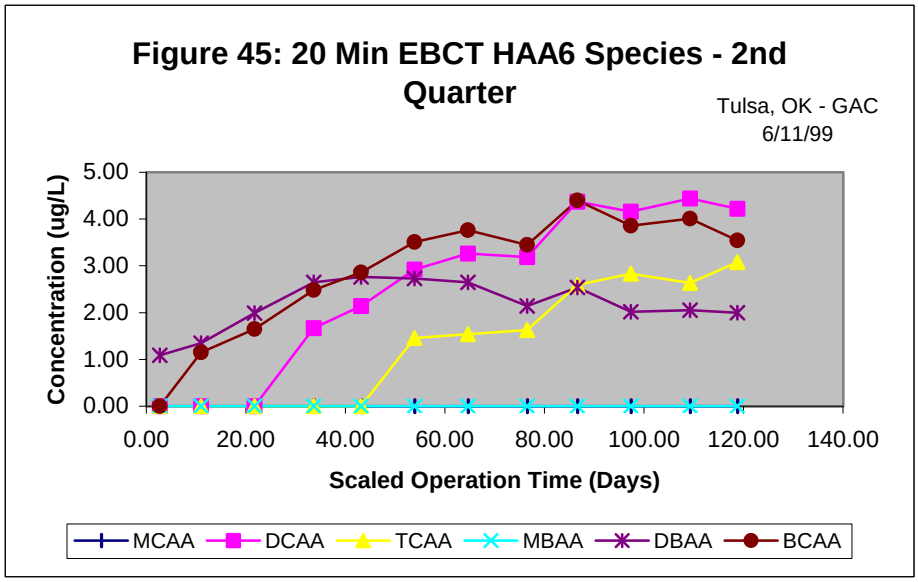


Figure 45: 20 Min EBCT HAA6 Species - 2nd Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
5.00
4.00
3.00
2.00
1.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

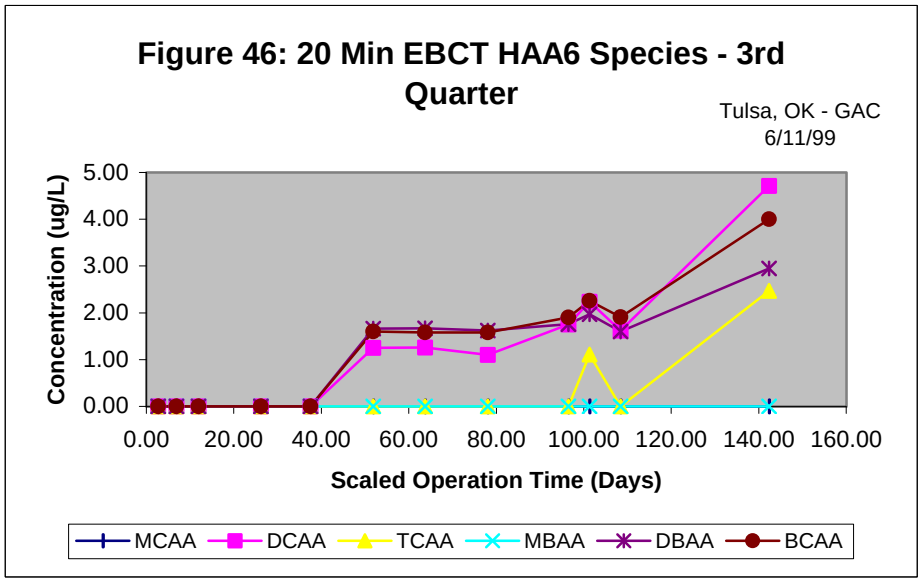


Figure 46: 20 Min EBCT HAA6 Species - 3rd Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
5.00
4.00
3.00
2.00
1.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

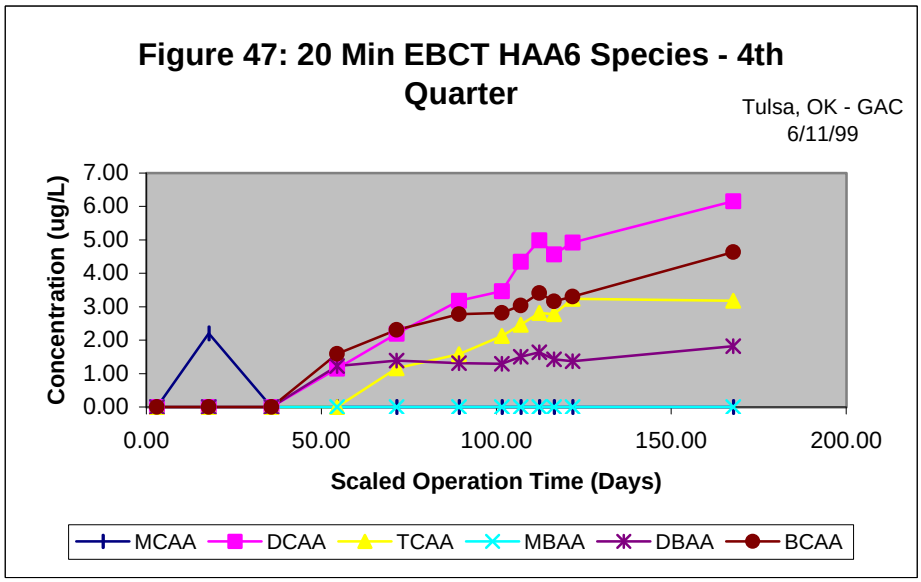


Figure 47: 20 Min EBCT HAA6 Species - 4th Quarter
Tulsa, OK - GAC
6/11/99
Concentration (ug/L)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

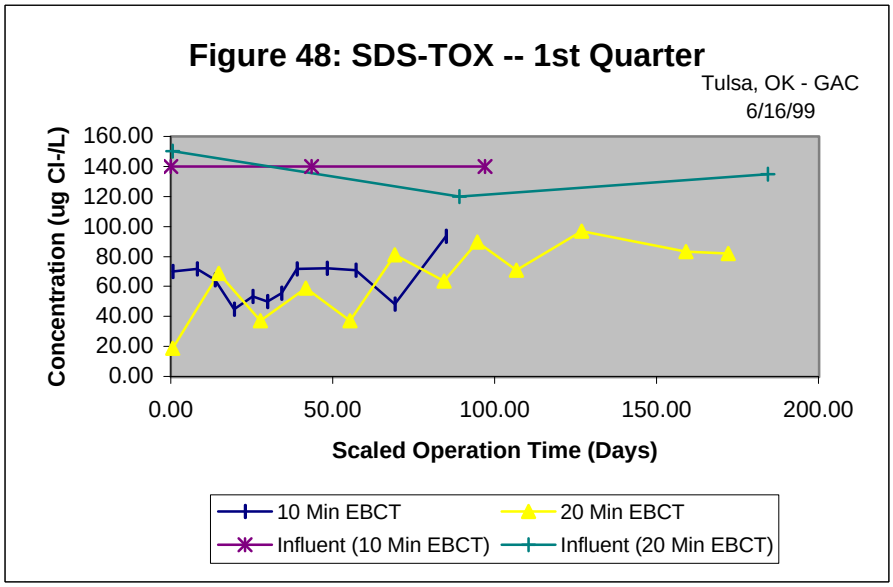


Figure 48: SDS-TOX -- 1st Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug Cl-/L)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

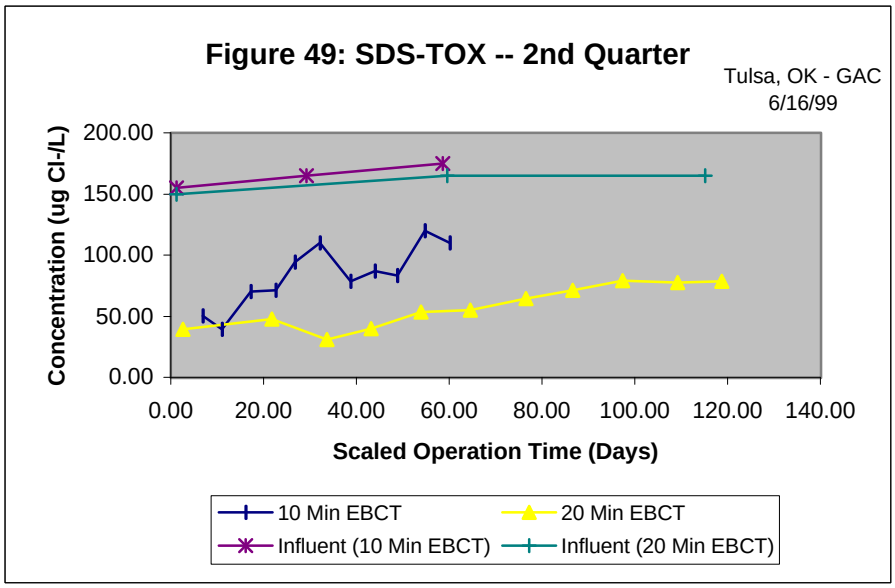


Figure 49: SDS-TOX -- 2nd Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug Cl-/L)
200.00
150.00
100.00
50.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

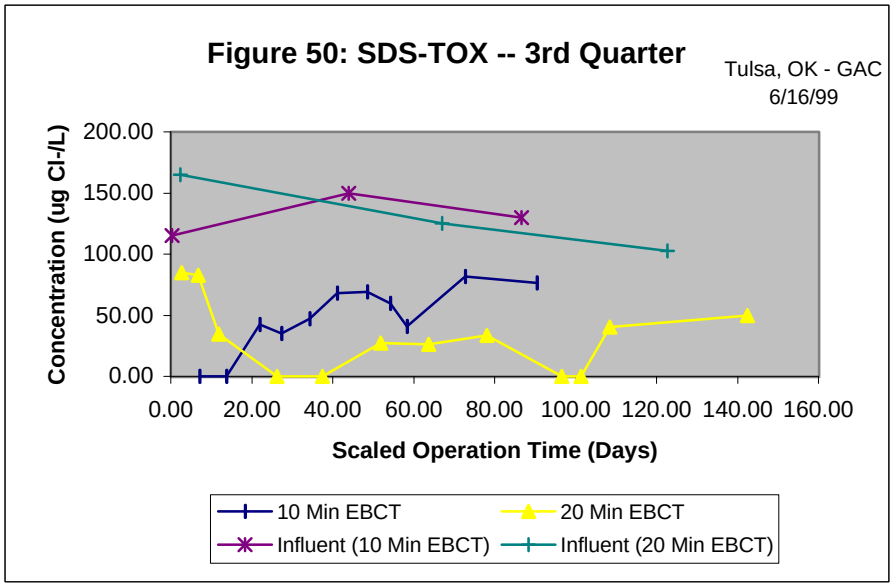


Figure 50: SDS-TOX -- 3rd Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug Cl-/L)
200.00
150.00
100.00
50.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

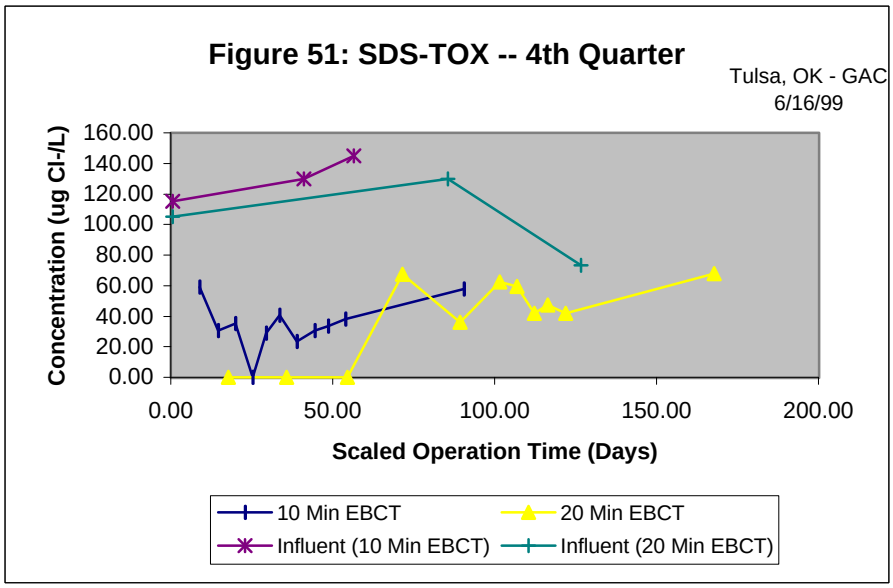


Figure 51: SDS-TOX -- 4th Quarter
Tulsa, OK - GAC
6/16/99
Concentration (ug Cl-/L)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

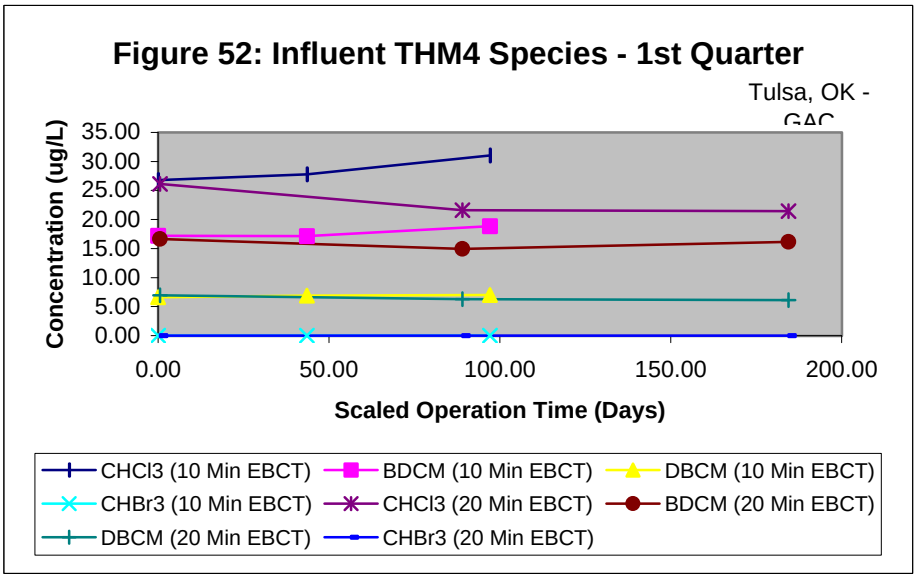


Figure 52: Influent THM4 Species - 1st Quarter
Tulsa, OK -
GAC
Concentration (ug/L)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
CHCl3 (10 Min EBCT)
BDCM (10 Min EBCT)
DBCM (10 Min EBCT)
CHBr3 (10 Min EBCT)
CHCl3 (20 Min EBCT)
BDCM (20 Min EBCT)
DBCM (20 Min EBCT)
CHBr3 (20 Min EBCT)

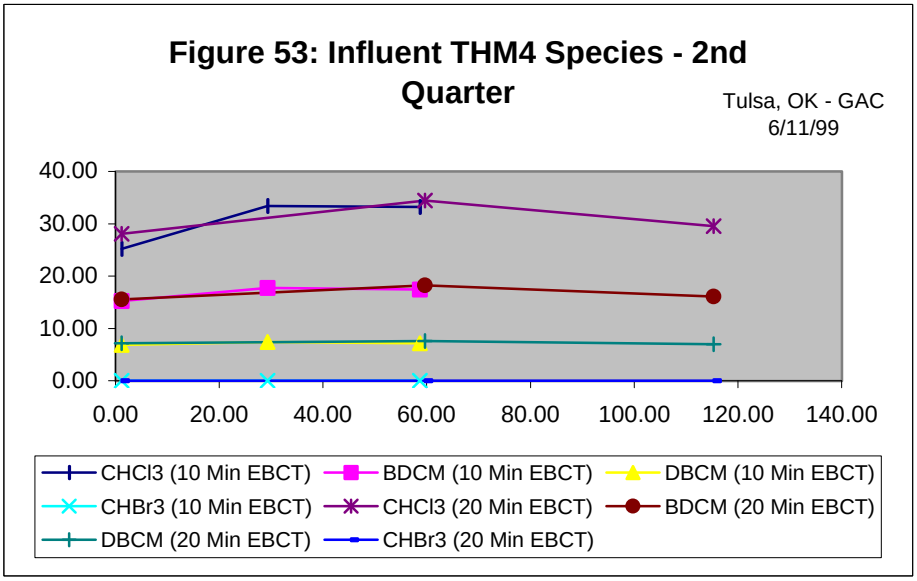


Figure 53: Influent THM4 Species - 2nd Quarter
Tulsa, OK - GAC
6/11/99
40.00
30.00
20.00
10.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
CHCl3 (10 Min EBCT)
BDCM (10 Min EBCT)
DBCM (10 Min EBCT)
CHBr3 (10 Min EBCT)
CHCl3 (20 Min EBCT)
BDCM (20 Min EBCT)
DBCM (20 Min EBCT)
CHBr3 (20 Min EBCT)

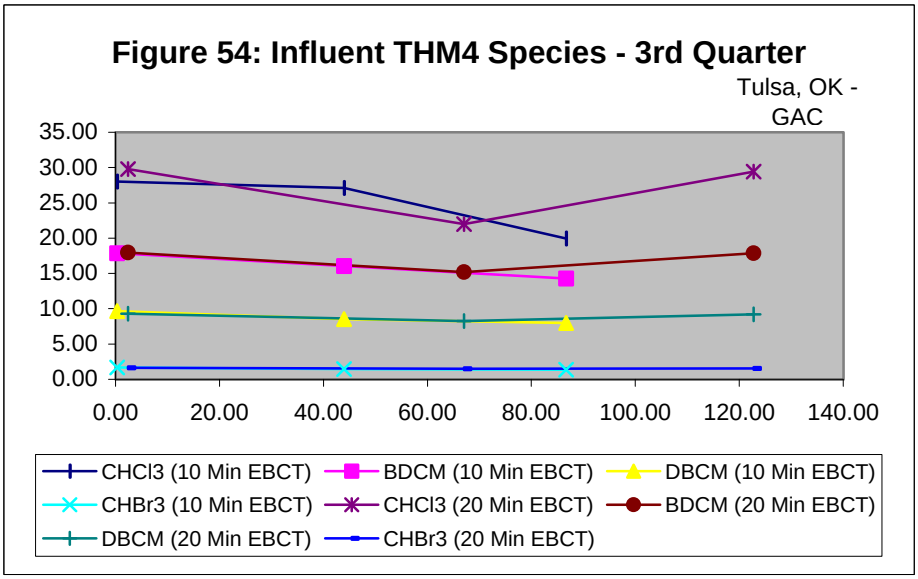


Figure 54: Influent THM4 Species - 3rd Quarter
Tulsa, OK - GAC
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
CHCl3 (10 Min EBCT)
BDCM (10 Min EBCT)
DBCM (10 Min EBCT)
CHBr3 (10 Min EBCT)
CHCl3 (20 Min EBCT)
BDCM (20 Min EBCT)
DBCM (20 Min EBCT)
CHBr3 (20 Min EBCT)

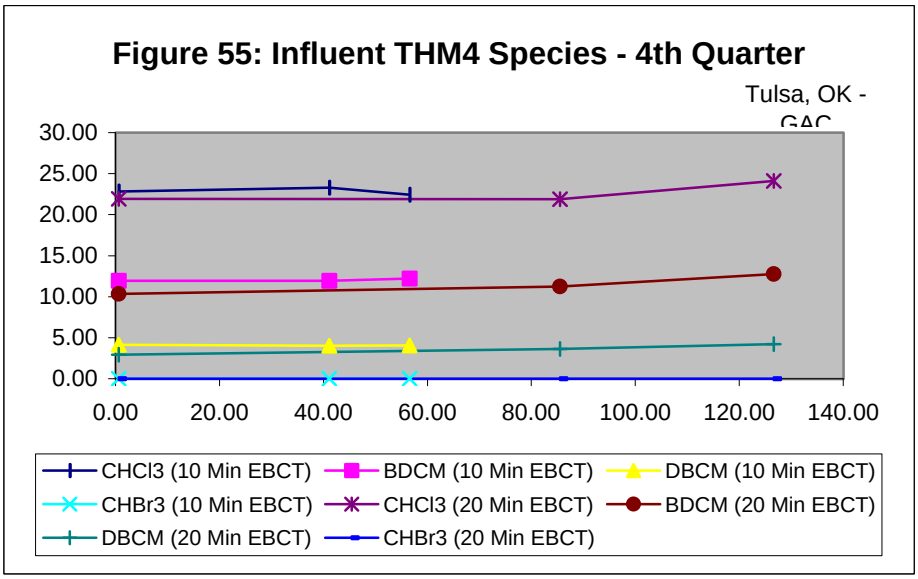


Figure 55: Influent THM4 Species - 4th Quarter
Tulsa, OK - GAC
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
CHCl3 (10 Min EBCT)
BDCM (10 Min EBCT)
DBCM (10 Min EBCT)
CHBr3 (10 Min EBCT)
CHCl3 (20 Min EBCT)
BDCM (20 Min EBCT)
DBCM (20 Min EBCT)
CHBr3 (20 Min EBCT)

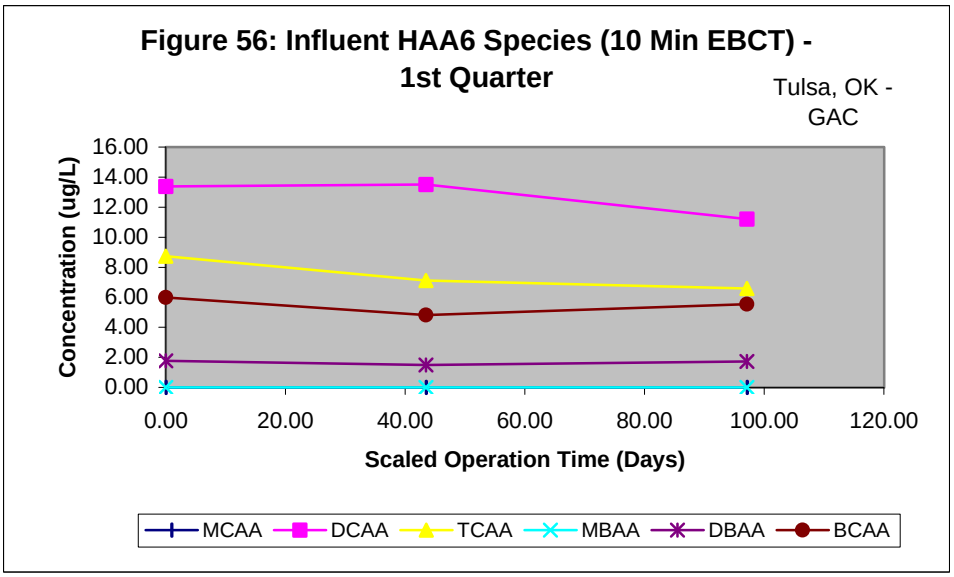


Figure 56: Influent HAA6 Species (10 Min EBCT) - 1st Quarter
Tulsa, OK - GAC
Concentration (ug/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

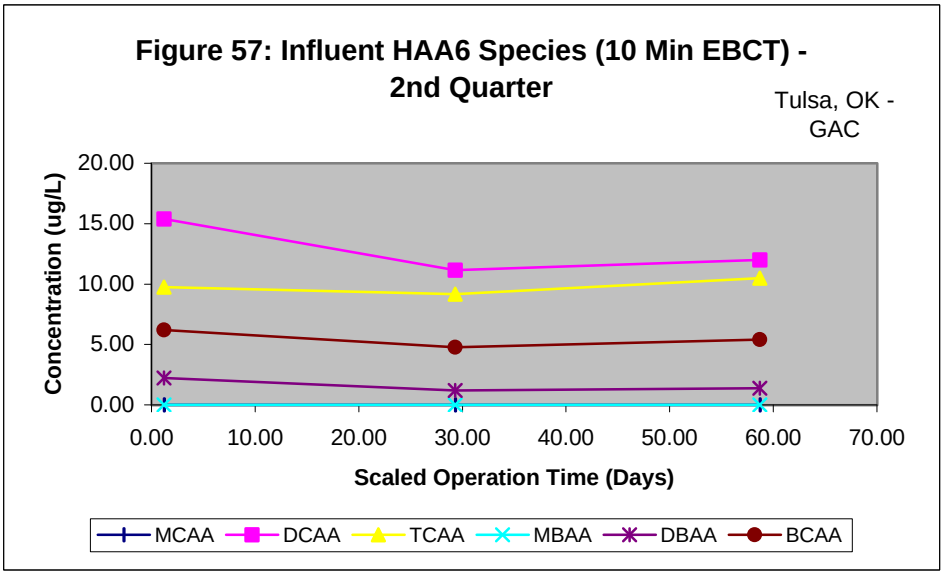


Figure 57: Influent HAA6 Species (10 Min EBCT) - 2nd Quarter
Tulsa, OK - GAC
Concentration (ug/L)
20.00
15.00
10.00
5.00
0.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

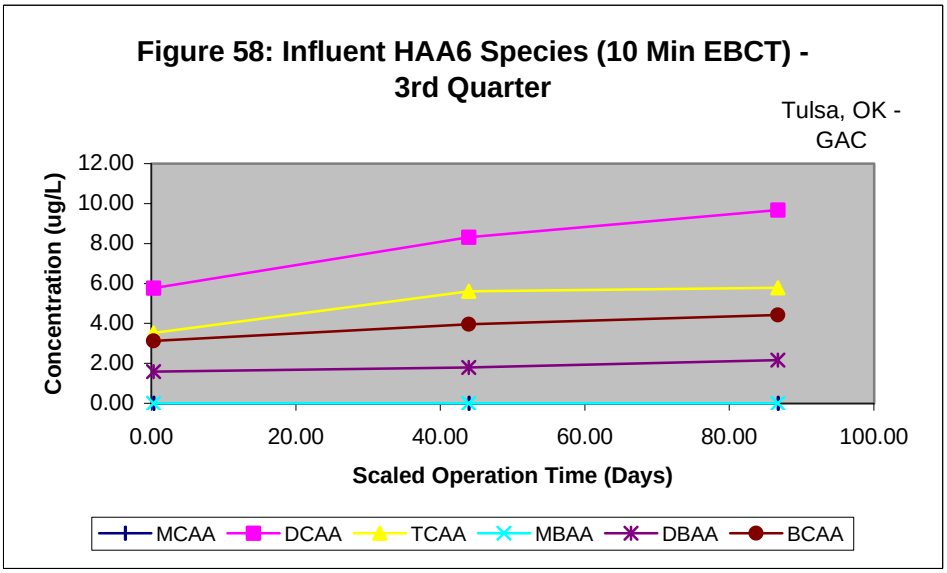


Figure 58: Influent HAA6 Species (10 Min EBCT) - 3rd Quarter
Tulsa, OK - GAC
Concentration (ug/L)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

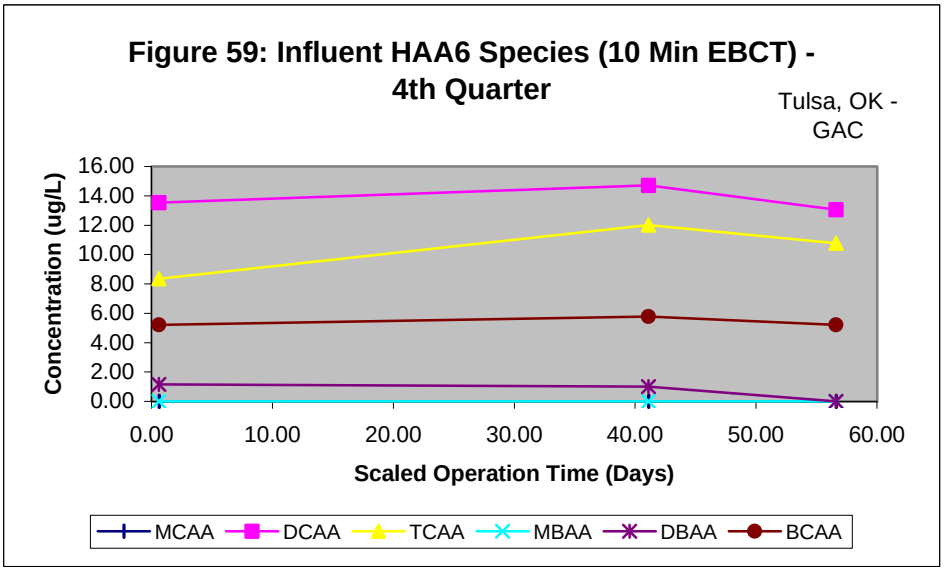


Figure 59: Influent HAA6 Species (10 Min EBCT) - 4th Quarter
Tulsa, OK - GAC
Concentration (ug/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

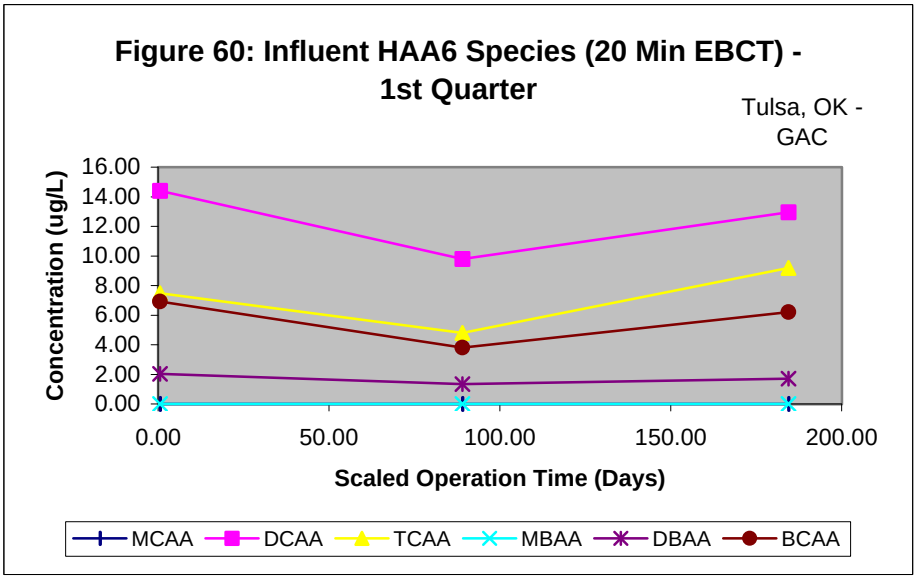


Figure 60: Influent HAA6 Species (20 Min EBCT) - 1st Quarter
Tulsa, OK - GAC
Concentration (ug/L)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

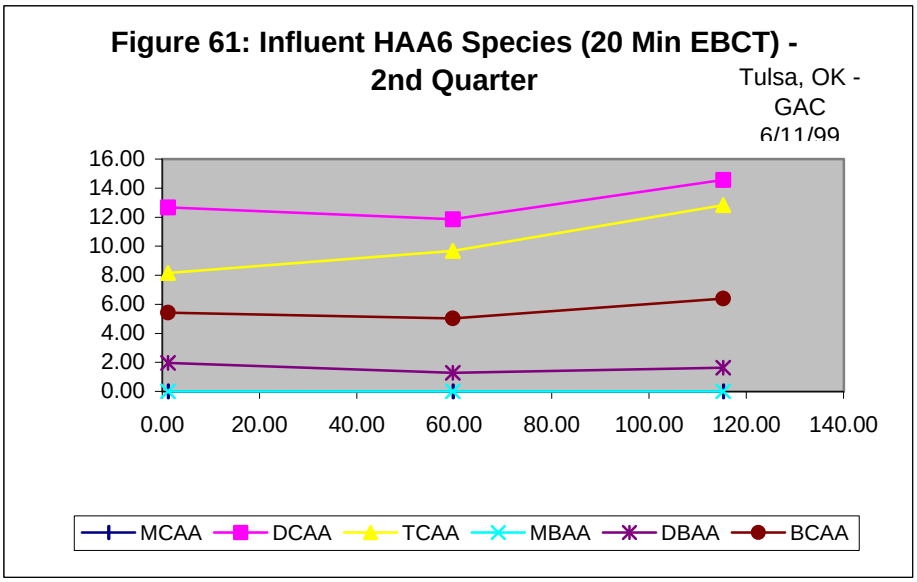


Figure 61: Influent HAA6 Species (20 Min EBCT) - 2nd Quarter
Tulsa, OK - GAC
6/11/99
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

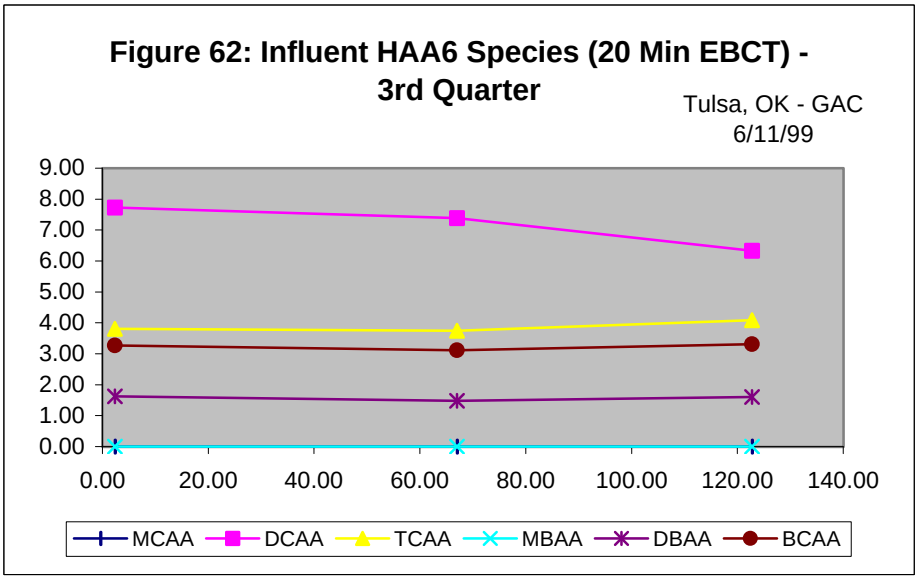


Figure 62: Influent HAA6 Species (20 Min EBCT) - 3rd Quarter
Tulsa, OK - GAC
6/11/99
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

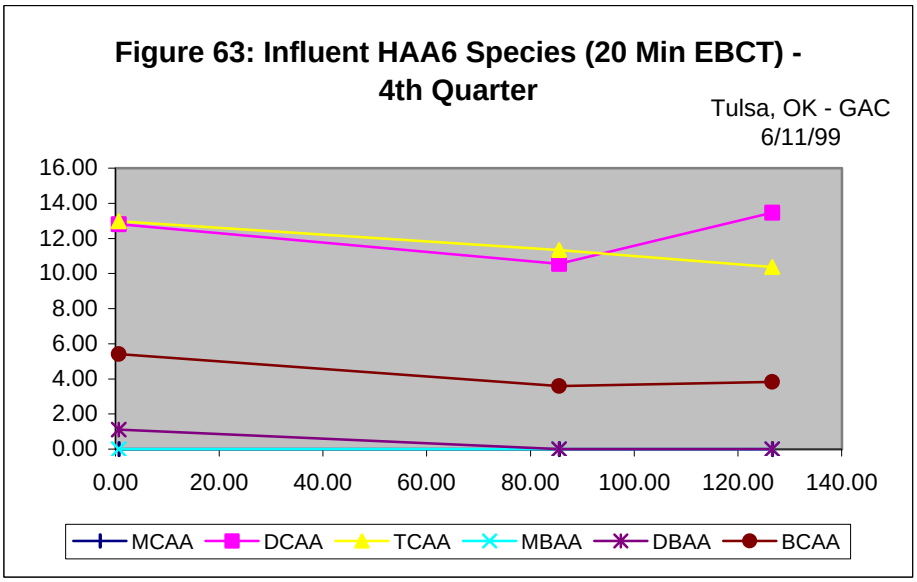


Figure 63: Influent HAA6 Species (20 Min EBCT) - 4th Quarter
Tulsa, OK - GAC
6/11/99
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
MCAA
DCAA
TCAA
MBAA
DBAA
BCAA

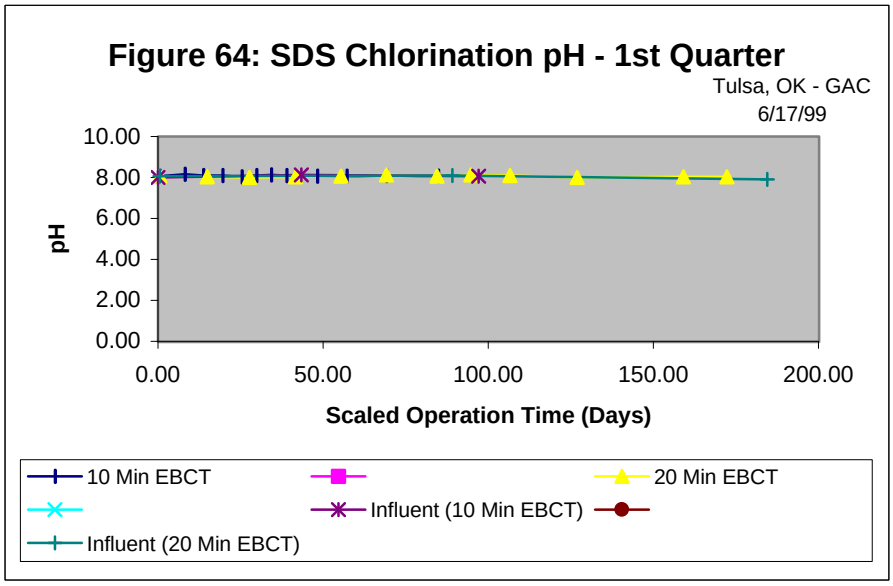


Figure 64: SDS Chlorination pH - 1st Quarter
Tulsa, OK - GAC
6/17/99
10.00
8.00
6.00
4.00
2.00
0.00
pH
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

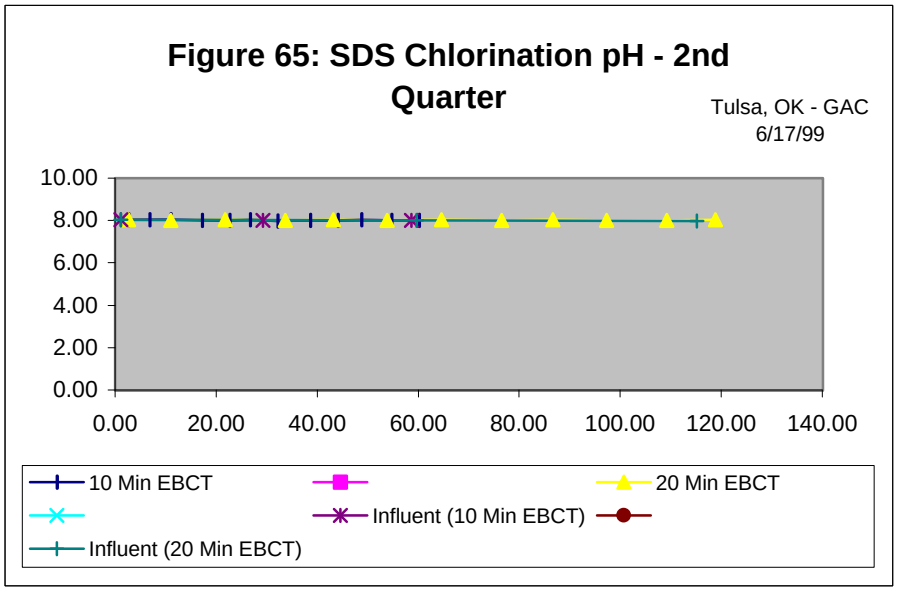


Figure 65: SDS Chlorination pH - 2nd Quarter
Tulsa, OK - GAC
6/17/99
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

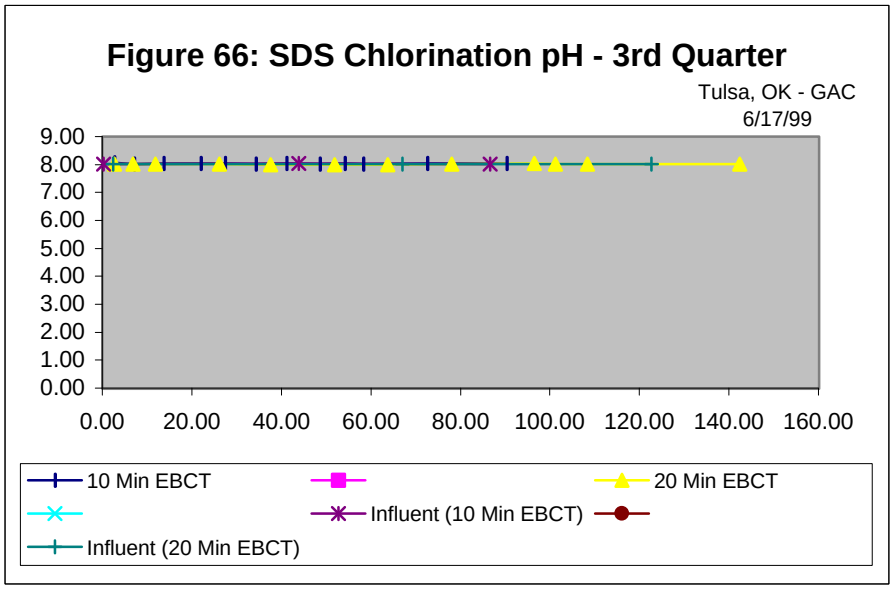


Figure 66: SDS Chlorination pH - 3rd Quarter
Tulsa, OK - GAC
6/17/99
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

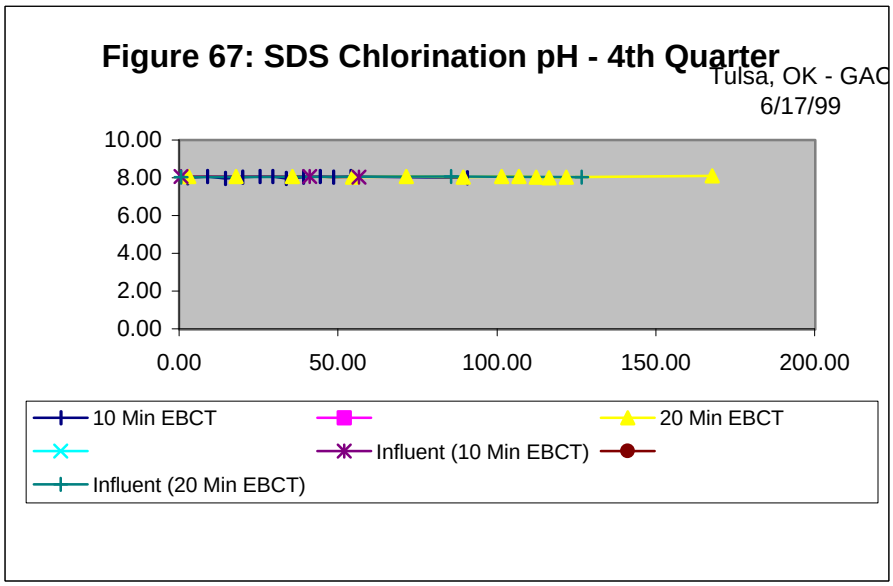


Figure 67: SDS Chlorination pH - 4th Quarter
Tulsa, OK - GAC
6/17/99
10.00
8.00
6.00
4.00
2.00
0.00
0.00
50.00
100.00
150.00
200.00
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

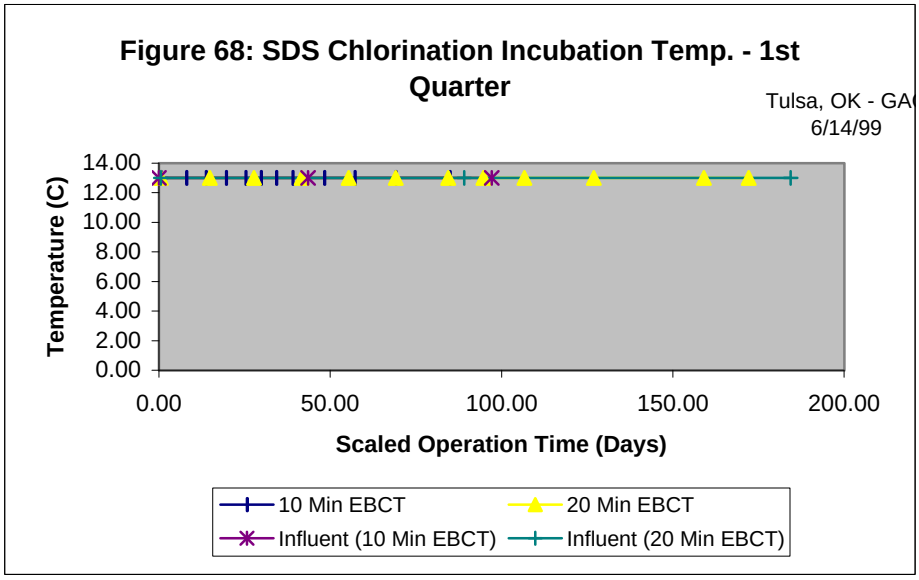


Figure 68: SDS Chlorination Incubation Temp. - 1st Quarter
Tulsa, OK - GA
6/14/99
Temperature (C)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

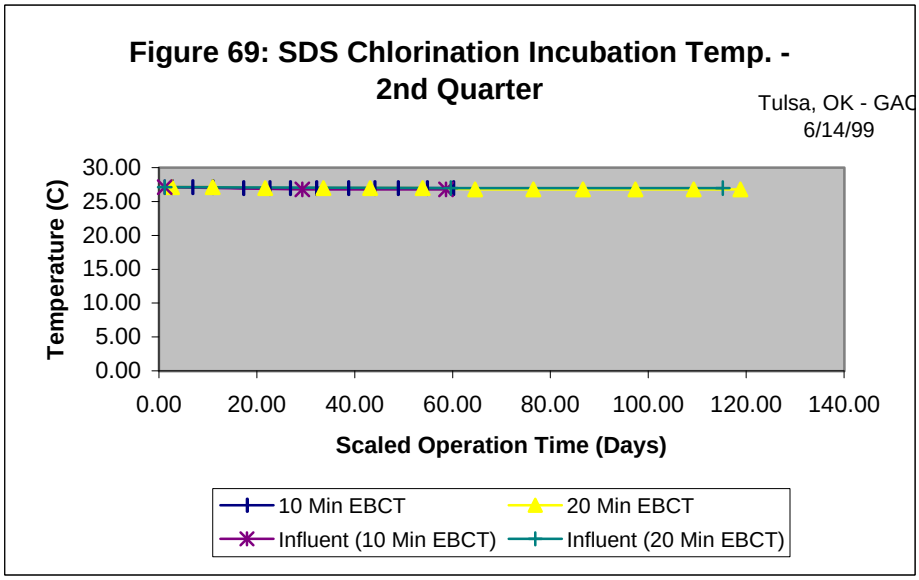


Figure 69: SDS Chlorination Incubation Temp. - 2nd Quarter
Tulsa, OK - GAC
6/14/99
Temperature (C)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

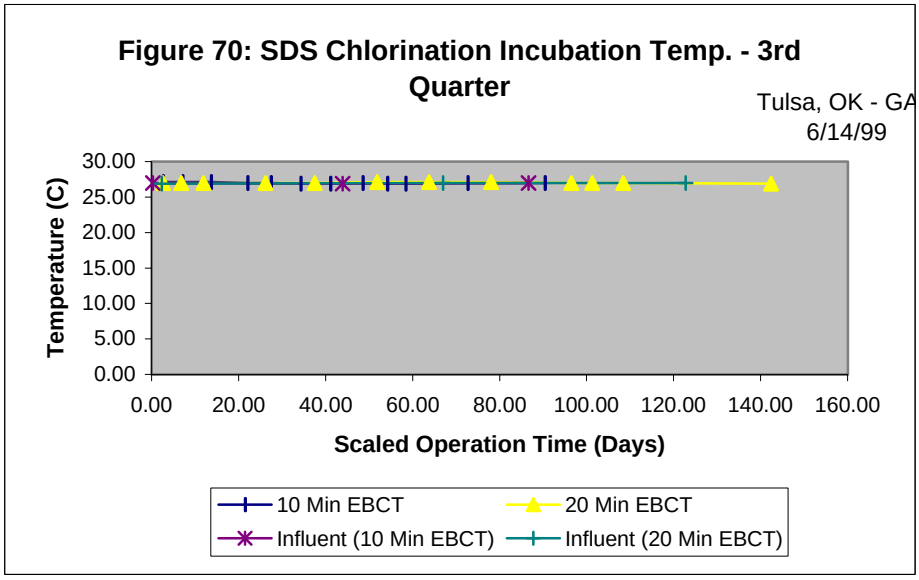


Figure 70: SDS Chlorination Incubation Temp. - 3rd Quarter
Tulsa, OK - GA
6/14/99
Temperature (C)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)

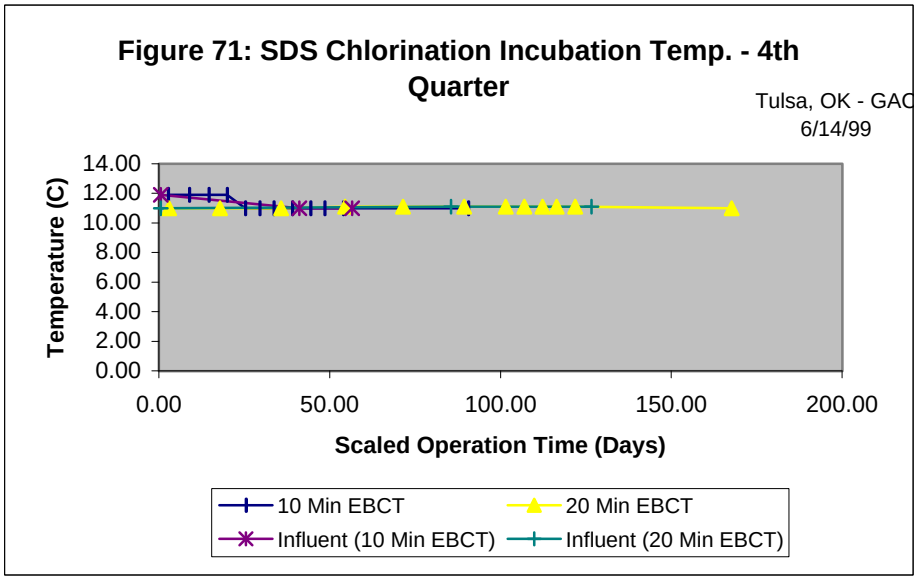


Figure 71: SDS Chlorination Incubation Temp. - 4th Quarter
Tulsa, OK - GAC
6/14/99
Temperature (C)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
50.00
100.00
150.00
200.00
Scaled Operation Time (Days)
10 Min EBCT
20 Min EBCT
Influent (10 Min EBCT)
Influent (20 Min EBCT)