ICR Treatment Study Summary Report

Evaluation of GAC Technology Using Bench–Scale Testing for Compliance with the Information Collection Rule

This study was conducted from April 21, 1998 through April 30, 1999

City Brockton Water Department, PWSID MA4201000

Silver Lake Water Filtration Plant, ICR # 402
1 Silver Lake Rt. 36
Halifax, MA 02338

Prepared by:

Camp Dresser & McKee, Inc.
10 Cambridge Center
Cambridge, MA 02142

July 1999

Table of Contents

Section 1

I Conclusions and Recommendations

The Granular Activated Carbon (GAC) Bench-Scale Study conducted for Brockton, MA using filtered water from the Silver Lake Water Treatment Plant (SLWTP) showed that a reduction in disinfection byproduct (DBP) production can be achieved over the existing filtration process. During the four quarters of testing the highest concentration of total trihalomethanes (THM4) for the plant's filtered water (source water for GAC bench-scale study) was 33.6 ug/l. The highest concentration reported for the GAC 20-minute empty bed contact time (EBCT) was 19.0 ug/l.

Although there is a 43 percent reduction in the production of THM4, the cost incurred to add GAC may not be economical for this water supply. According to the samples taken during this bench-scale study, the SLWTP does not presently have elevated levels of DBPs. This study shows that the filtered water from the SLWTP would meet the stage 2 proposed regulations for THMs (40 ug/L) and HAAs (30 ug/L). As an alternative, the plant may decide to use different chemicals for disinfection, such as chloramines, to reduce the production of DBPs in the future.

II Background

Water Quality History

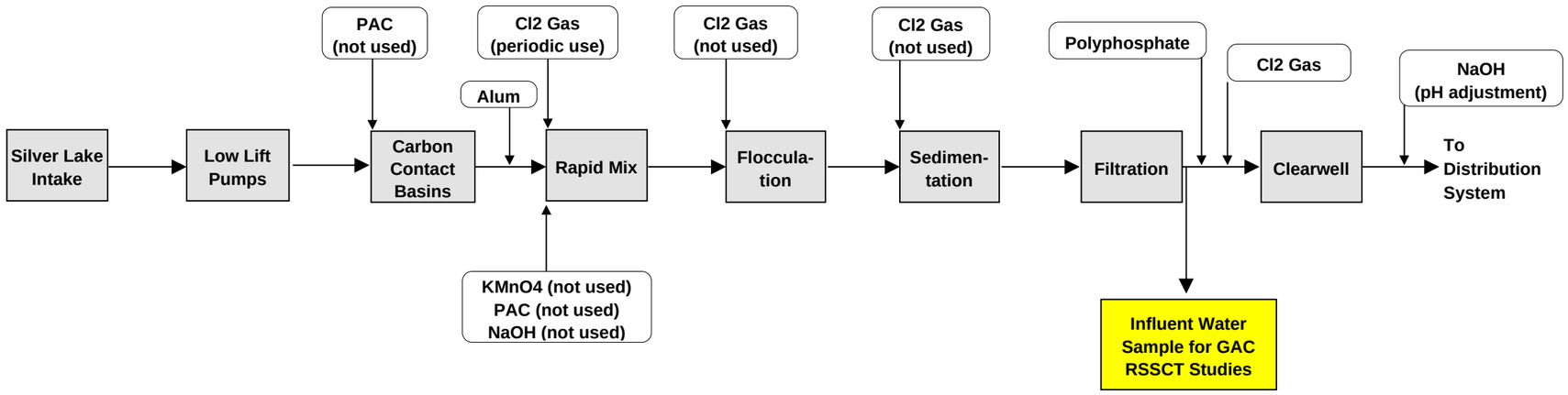
The Silver Lake Water Treatment Plant obtains its source water from Silver Lake. The lake can be characterized as being low in turbidity, color, alkalinity and organic and mineral content. The source water is relatively stable seasonally, with the most notable variations being temperature and total organic carbon levels.

The SLWTP, which employs a conventional treatment process, does an effective job of reducing particulate and organic matter. Granular activated carbon was used to replace the original anthracite/sand filter media a number of years ago. TOC reduction through the plant is approximately 30 to 40 percent. Finished water turbidity levels are consistently below 0.20 NTU, and will be readily in compliance with the Interim Enhanced Surface Water Treatment Rule (IESWTR). Both trihalomethane (THM4) and haloacetic acid (HAA5) levels will easily be able to meet the final Stage 1 D/DBP Rule levels of 80 and 60 ppb, respectively with the plant's current practice of residual disinfection by free chlorine. However, compliance with the proposed Stage 2 regulations (40 and 30 ppb, respectively) will be marginal under current treatment conditions.

Existing Treatment Plant

The Silver Lake Water Treatment Plant (SLWTP) employs a conventional treatment process as shown in Figure 1 (full-scale plant schematic). Raw water from Silver Lake is pumped into the plant to the carbon contact basins, which have the provision for applying powdered activated carbon (PAC). PAC is not currently used. After the carbon contact basins, alum is applied as the primary coagulant at approximately 10 mg/L just prior to the water entering the rapid mix basins. Chlorine (gas) can also be applied at the rapid mix basins, and is used periodically. There are also provisions to apply potassium permanganate ($KMnO_4$), PAC, and sodium hydroxide (NaOH) at the rapid mix basins, however, these chemicals are not in use at this location. After rapid mix, the water flows to the flocculation basins, which have three stages. Chlorine gas can be applied just prior to the flow entering the flocculation basins, but is not used. After flocculation, the flow enters the sedimentation basins. A chlorination point at the entry of the sedimentation basins exists, but is not used. The clarified water is then filtered through dual media filters containing 27 inches of granular activated carbon (F300) over sand for a total bed depth of 51 inches. After filtration, a corrosion inhibitor (polyphosphate) is applied followed by the application of chlorine (gas) for primary disinfection just prior to the flow entering the clearwell. After the clearwell, sodium hydroxide (NaOH) is added to adjust the pH of the finished water which is then pumped to the distribution system.

The first point of chlorine application in the full-scale plant is at the rapid mix basins (pre-chlorination). Chlorine is applied at this location periodically, and can be discontinued with proper advance notice. With the exception of this periodic use of pre-chlorination, the first point of chlorine application in the full-scale plant is immediately after the filters and prior to the clearwell. For the ICR RSSCT study, pre-chlorination was discontinued for three to four days prior to collecting the treatment study influent sample. The water for bench-scale testing was then collected at the end of this period from a location AFTER filtration but prior to the point of chlorine addition as shown on Figure 1 (full-scale plant schematic).


PAC
(not used)
Cl2 Gas
(periodic use)
Cl2 Gas
(not used)
Cl2 Gas
(not used)
Polyphosphate
Cl2 Gas
NaOH
(pH adjustment)
Alum
Silver Lake Intake
Low Lift Pumps
Carbon Contact Basins
Rapid Mix
Floccula-tion
Sedimen-tation
Filtration
Clearwell
To Distribution System
KMnO4 (not used)
PAC (not used)
NaOH (not used)
Influent Water Sample for GAC RSSCT Studies

(Figure 1)

Basic Engineering

A summary of basic engineering data can be found in ICR reports A.2 Design Plant Parameters and A.3 Design Plant Chemical Parameters in Appendix A of this document. These reports were generated as part of the ICR monitoring study conducted for the City of Brockton.

1998 Source and Finished Water Quality

A summary of the 1998 source and finished water quality parameters can be found in Tables 1 and 2. This information was taken from the 18-month monitoring under the ICR.

Table 1: **Full-Scale Source Water Quality Data**

Item	Units	Average	Std Dev	Min	Max	Count
Temperature	°C	14.61	7.16	4.10	24.30	12
pH	Unit	6.68	0.37	6.10	7.20	12
Turbidity	ntu	1.05	0.37	0.68	2.00	11
Alkalinity	mg/L as $CaCO_3$	5.9	4.3	2.0	19	12
Total Hardness	mg/L as $CaCO_3$	18	0.97	17	20	12
Calcium Hardness	mg/L as $CaCO_3$	9.92	0.67	9	11	12
TOC	mg/L	3.64	0.35	3.2	4.3	11
UV_{254}	1/cm	0.12	0.02	0.10	0.18	11
Bromide	µg/L	0.03	0.00	0.02	0.03	11

Table 2: Full-Scale Finished Water Quality Data

Item	Units	Average	Std Dev	Min	Max	Count
Temperature	C	14.63	7.44	3.5	25.3	12
pH	unit	7.35	0.30	6.8	7.86	12
Turbidity	ntu	.014	0.066	0.06	0.3	12
TOC	mg/L	2.24	0.37	1.4	2.7	12
UV_{254}	1/cm	0.037	0.008	0.010	0.042	12
SDS-THM4	µg/L	16.68	12.01	0	28.5	4
SDS-HAA5	µg/L	11.21	10.0	0	38.6	4

III Materials and Methods

Pretreatment and Design Information

Figure 1 illustrates the full-scale treatment process at the SLWTP. The sampling point for the ICR RSSCT is located after full-scale filtration but prior to chlorine addition. In months when chlorine was added prior to filtration, the plant was asked to discontinue use of chlorine for three to four days. After this time, the water was taken after filtration and used as the source water for the RSSCT.

Once enough filtered water was collected form the SLWTP, additional bench scale pretreatment was used. A cartridge filter was used when transferring the source water from the SLWTP to a reservoir for the RSSCT. An in-line filter was used for additional removal of particles once the water left the reservoir but prior to the RSSCT columns. The pretreatment equipment was not used for each of the four quarters. Table 3 lists the treatment used after full-scale filtration and during which of the four quarters it was used.

Table 3: Advanced Pretreatment for Bench-Scale GAC Study

	Quarter 1	***Quarter 2***	***Quarter 3***	***Quarter 4***
1 um pore size filter cartridge Filter material: Cellulose/Polyester Filter life: 100 gall	Not Used	**Used**	**Used**	**Used**
In-line 3um membrane filter Filter material: Filter life: 200 gall	Not Used	Not Used	**Used** – for approx. 5, 20-minute EBCT samples.	**Used**

Figure 2 shows a schematic of the RSSCT design for this study, including the advanced pretreatment mentioned above. Table 4 lists the major equipment that was used.

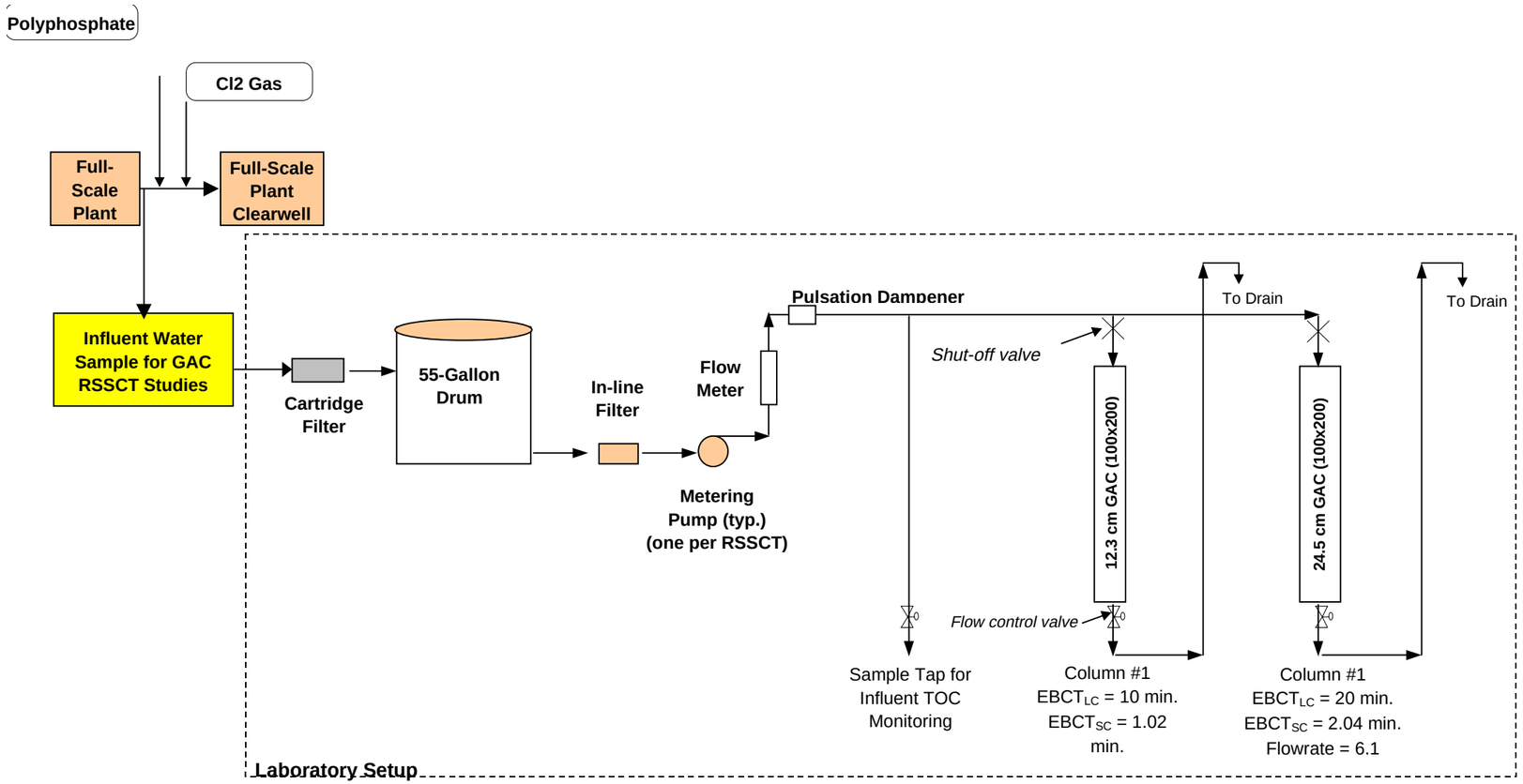
Table 4: Major Equipment for RSSCT Study

Treatment Study Influent Storage Reservoir	55-gallon drum
RSSCT Influent Pumps	Peristaltic pump
Rapid Small Scale Column	DC_{SC} = 8 mm, glass, 300 mm length with shield and cap
Flow Control Valves	Needle valves
Screens at Column Bottom (used to hold carbon in column)	(2) Coarse = 110 µm; fine = 70 µm
Miscellaneous parts and fittings	unions, elbows, tubing, nipples, reducers

Procedures

A sample of GAC was obtained from Calgon Carbon Corporation. The carbon used for the testing was ground, sieved, purified, dried, weighed, wetted, deaerated and loaded into the two columns as described in Chapter 5.0 Bench-Scale GAC Test Protocol sections 5.1 and 5.2 of the ICR manual. Each column was filled with the amount of GAC calculated for the 10-minute empty bed contact time (EBCT) and 20 minute EBCT

When headloss became a problem, the top-most layer was scraped from the carbon bed using a spatula. Extreme precaution was taken to avoid disturbing the underlying media. There were occurrences when carbon was scraped numerous times during specific quarterly runs. Information on specific problems during each quarter can be found in *Section IV Results and Discussion* of this document.



(Figure 2 ***Note: Column construction details per EPA Guidance Manual detail, Figure 5-2.*** is included as a separate file)

Tubing, fittings, and filters were changed if leaking became a problem. During these times, flow was briefly disrupted for the column that needed adjusting. The GAC remained damp during these times.

Experimental Design and Operating Parameters

Table 5 lists the initial design and operating parameters for this RSSCT. The parameters are based on an average influent TOC concentration (TOC) of 3.8 mg/L, taken from the monthly ICR monitoring results for filtered water conducted in 1997. During the bench-scale testing, an influent sample was taken prior to testing to accurately adjust each parameter.

Table 5: Initial Design Conditions

RSSCT Design and Operating Parameters	
$EBCT_{LC}$ = 10 minutes	$EBCT_{LC}$ = 20 minutes
SF = 9.82	SF = 9.82
$EBCT_{SC}$ = 1.02 minutes	$EBCT_{SC}$ = 2.04 minutes
v_{SC} = 7.23 m/hr	v_{SC} = 7.23 m/hr
l_{SC} = 12.3 cm	l_{SC} = 24.5 cm
Q_{SC} = 6.06 ml/min	Q_{SC} = 6.06 ml/min
m_{SC} = 3.08 grams	m_{SC} = 6.16 grams
t_{LC} = 53.1 days	t_{LC} = 106.3 days
t_{SC} = 5.4 days	t_{SC} = 10.8 days
V_{SC} = 47 liters	V_{SC} = 94 liters
Total influent volume = 61 liters	Total influent volume = 122 liters

The primary variable for this bench-scale study was temperature. In order to study the temperature variation, testing was done over four seasons. Table 6 lists the empty bed contact times (EBCT) and the start dates for each season.

Table 6: Experimental Design for Bench-Scale GAC study

Quarter / Season	**Pretreatment @ SLWTP**	**EBCT, min**
Quarter 1 Spring/Summer (5/7/98)	Conventional filtration (see Appendix A)	10 Minute EBCT 20 Minute EBCT
Quarter 2 Summer/Autumn (8/29/98)	Conventional filtration	10 Minute EBCT 20 Minute EBCT
Quarter 3 Autumn/Winter (11/23/98)	Conventional filtration	10 Minute EBCT 20 Minute EBCT
Quarter 4 Winter/Spring (3/29/98)	Conventional filtration	10 Minute EBCT 20 Minute EBCT

Temperature at the SLWTP ranged from as high as 24°C in the summer months to as low as 3.5°C in the winter months. Prior to each quarterly start date, one hundred gallons of filtered water was taken from the SLWTP, transported to the lab where the test was performed in tanks, and used as the influent for the study. At the plant the water temperature was tested and used as the simulated distribution system incubation temperature. Table 7 lists the SDS conditions for each of the four quarters.

Table 7: Target Conditions for SDS

	Hold Time	Hold Time pH	Temperature
Quarter 1	6	7.5	13
Quarter 2	6	7.5	20
Quarter 3	6	7.5	20 *
Quarter 4	6	7.5	10

*SDS conditions for Quarter 2 were not changed for Quarter 3.

As previously stated, the condition that varied during the four season was temperature. A laboratory error was made, however, in the third quarter when the temperature used to hold the SDS samples was established as 20 degrees Celsius. Therefore, winter conditions were not accurately simulated in this bench-scale study. However, hold time at a higher temperature would produce more conservative results. Because of turn around time for laboratory analysis, this problem was not evident until later in the study. The temperature for the fourth quarter was adjusted accordingly to simulate the winter/spring conditions.

Analytical Information

There were three laboratories used throughout the duration of the pilot study. Table 8 lists the analytes tested by each lab as well as method used and the minimum reporting level (MRL) for each method. The method and MRL used for each analyte is the same for each laboratory unless otherwise noted. Table 9 gives the full name, address and contact information for each of the four laboratories.

Table 8: List of Analytical Methods Used During GAC Pilot Study

Analyte	Method	MRL	Laboratory	Dates of Service
Alkalinity	2320 B	5 mg/l as CaCO3	CDM ALPHA	4/21/98 – 1/5/99 1/12/99 – 6/8/99
Ammonia	SM 4500-NH3-F 350.1	0.10 mg/L 0.07 mg/L	CDM ALPHA	4/21/98 – 1/5/99 1/12/99 – 6/8/99
Bromide	EPA 300A 300.0 300.0	20 µg/L 50 µg/L 50 µg/L	CDM EHL ALPHA	4/22/98 – 9/2/98 9/4/98 – 12/30/98 1/12/99 – 6/8/99
Calcium Hardness	3500 Ca D	3 mg/l	CDM ALPHA	4/21/98 – 1/5/99 1/12/99 – 6/8/99
Chlorine Residual	4500-Cl G	0.1 mg/l	CDM ALPHA	4/21/98 – 1/8/99 1/12/99 – 6/8/99
BCAA, DBAA, DCAA, MBAA, MCAA, TCAA	SM 6251B 552.2	1.0µg/L for each analyte 1.0µg/L for each analyte	CDM ALPHA	4/23/98-12/30/98 1/12/99 – 6/8/99
pH	4500-H B	Not Applicable	CDM FIELD	4/21/98 – 4/30/99
Temperature	2550 B	Not Applicable	CDM FIELD	4/21/98 – 4/30/99
CHCL3, BDCM,				

DBCM, CHBR3	EPA 551.1 551.1	1.0 µg/L for each analyte 1.0 µg/L for each analyte	CDM ALPHA	4/23/98-12/30/98 1/12/99 – 6/8/99
Total hardness	2340 B		QTPU	4/21/98 – 1/12/99
TOC	SM 5310C 415.1	0.50 mg/L 0.10 mg/L	CDM ALPHA	4/21/98 – 12/23/98 1/12/99 – 6/8/99
TOX	5320B	25 µg/L	EHL	4/21/98 – 1/12/99
Turbidity	2130 B		QTPU	4/21/98 – 1/12/99
UV 254	SM 5910 SM5910B	0.005 cm^{-1} 0.005 cm^{-1}	CDM ALPHA	4/21/98- 12/31/98 1/12/99 – 1/17/99

Table 9: Laboratory Information

	Laboratory Name	Address	Contact	Phone	Fax
CDM	Camp Dresser & McKee Laboratory (MA001)	CLOSED 1/15/99	Peter Maynard	(617) 252-8823	(617) 621-2565
EHL	Environmental Health Laboratories	110 S.Hill Street South Bend, IN 46617	Richard Radcliff	(219) 233-4777	(219) 233-8207
ALPHA	Alpha Analytical Laboratory	8 Walkup Drive Westborough, MA 01581	Jim Occhialini	(508) 898-9220	(508) 898-9193

IV Results and Discussion

Observations

The following observations and occurrences were found during the course of the bench-scale study:

1. During the first quarter RSSCT, clogging was experienced in the $EBCT_{10min}$ and $EBCT_{20min}$ columns. It is speculated that influent contained very small particles that were captured at the top of the GAC column, thus leading to a steady increase in pressure drop across the column. The test continued until the pump could no longer pump against the head. Despite failure, 70 percent breakthrough (84 days) was achieved for the $EBCT_{10min}$. About 30 percent breakthrough (106.4 days) was achieved for $EBCT_{20min}$.

   This situation was discussed with Steve Allgeier, ICR Treatment Studies Coordinator at EPA/Cincinnati. Per Steve's suggestions, the influent was filtered to remove fine particles for the next quarterly tests.

2. During the second quarter RSSCT, clogging was again experienced in the $EBCT_{10min}$ and $EBCT_{20min}$ columns despite attempts to remove fine particles by filtering the influent, as suggested by Steve Allgeier. To reduce the problem, approximately 0.5 cm of the GAC was scraped from the top of the each column to eliminate or loosen any large lumps. The dislodging of the lumps helped to unclog the columns temporarily, but pressure increase persisted.

   In this quarter, 70 percent breakthrough was achieved for the $EBCT_{10min}$ (53.3 days) and was achieved for the $EBCT_{20min}$ (123 days).

3. During the first week of the third quarter RSSCT the clogging problem arose again in the $EBCT_{10min}$ and $EBCT_{20min}$ columns. To reduce the clogging problem, a 3 µm in-line membrane

filter was installed to further remove particles from the influent. The in-line filter eliminated the clogging problem. However, on four occasions during the latter part of this third test it was noted that clogging persisted with the in-line filter in operation. At these times, approximately 0.5 cm of the GAC was scraped from the top of each column to loosen particles that had developed into large lumps.

The $EBCT_{10min}$ achieved 70 percent breakthrough at 131.3 days (14 samples). However, difficulties were encountered with the $EBCT_{20min}$. The flowrate in this column steadily declined despite efforts to dislodge lumped carbon, change column filters, change tubing and increase pump pressure. It was also noted that the effluent tubing was discolored. Mr. Allgeier suggested that algae might have formed in the column, preventing 70 percent breakthrough in the anticipated time period.

ICR requirements state that termination is achieved:

"*After the effluent TOC concentration reaches 50 percent of the average influent TOC concentration, a plateau is achieved in which the effluent TOC concentration does not increase by more than 10 percent of the average influent TOC concentration over two full-scale equivalent months for RSSCT studies."*

The $EBCT_{20min}$ reached 50 percent of the average influent concentration at 262.5 days. After this time, the effluent TOC concentration did not increase by more that 10 percent up to the last sample taken at 385.5 days. Figure 3 illustrates the results.

The time difference from the initial plateau until the final sample was 123 equivalent days. The ICR requirement stated above is for 60 equivalent days (or two months). Although 70 percent breakthrough was not achieved, ICR criteria allowed for termination.

4. The fourth quarter study proceeded with little to no difficulties. As previously stated in Table 3, both types of bench-scale pretreatment filters were used. The removal of all fine particles caused no headloss which had resulted in problems in previous quarters. In each quarter, the GAC was washed and dried exactly according to EPA procedures. Although fine particles on the carbon will create more headloss, the removal of the particles in the influent water seemed to be an important factor in this bench-scale test.

Source Water Quality
Table 10 summarizes the average influent water quality during the study. Refer to Table 5 for a list of dates for each season.

Table 10: Influent Water Quality Summary

Water Quality Parameter	Spring/Summer Average	Summer/Autumn Average	Autumn/Winter Average	Winter/Summer Average
pH	6.41	6.85	6.62	6.07
Turbidity (NTU)	0.38	0.18	0.19	BMRL
Alkalinity (mg/l)	BMRL	BMRL	BMRL	3.0
Calcium Hardness (mg/l)	9.9	9.25	9.5	10.5
Total Hardness (mg/l)	17.0	17.5	17.5	18.0
Bromide (ug/l)	27.5	27.0	31.0	BMRL
TOC (mg/l)	2.80	3.57	2.37	2.07

UV 254 (cm –1)	0.048	0.056	0.038	0.043
SDS-THM4 (ug/l)	17.37	23.20	23.2	30.9
SDS-HAA5 (ug/l)	16.37	19.10	17.37	19.1
SDS-HAA6 (ug/l)	17.80	20.80	19.17	21.7
TOX (ug/l)	167.50	230.0	270	243
Chlorine Demand (mg/l)	1.4	2.55	2.78	1.09

Note: BMRL: Below Minimum Reporting Limit

Effluent Water Quality

Graphical representations of the RSSCT results can be found at the end of this section. These graphs were generated by the EPA for the initial review of the Data Collection Sheets. Comments to the initial submittal of these sheets can be found in Section 3, along with responses from Steve Allgeier, EPA Cincinnati. Some of the graphical information will change because of corrections made in the Data Collection Sheets.

Analytes shown include TOC, UV 254, THM4, HAA6 and TOX. Also, graphs of each of the four THMs and six HAAs are shown for the respective EBCTs. Each analyte is plotted against operation time to show the breakthrough curve. As anticipated, the concentration of all parameters sampled increases with time.

Additional information concerning breakthrough and run times can be generated using the Data Collection Spreadsheets, included as a diskette with this report. As discussed with Steve Allgeier, this information was not necessary to compile for this report.

Seasonal Variation

For each season, SDS conditions were set to simulate the temperature of the water coming from the SLWTP. As noted above, the conditions were not properly established for the third quarter (Autumn/Winter).

The main seasonal variation is the TOC level of the influent. This ranged from 2.07 mg/l during the Winter/Spring study to 3.57 mg/l in the Summer/Autumn study. With varying TOC levels, the duration of the test also varies. In this experiment, it was found that the higher the TOC the faster the breakthrough. The graphs attached at the end of this section produced by the EPA illustrate these results.

V. QA/QC Summary

As stated in the *EPA HELP PACKET,* only calibration procedures are required in addition to the Treatment Summary Sheets. The calibrations for each laboratory can be found in Section 2. Also, electronic copies of the *Data Collection Sheets* and *Treatment Study Sheets* are included in Section 2.

All comments to the Data Collection Sheets have been corrected with in the sheets or have been explained as part of this report. All laboratory data has been verified and changed accordingly. Results that remain as they did for the first review of these sheets are the actual laboratory results that have been checked for error.

Section 2

Calibration Procedures

Alpha Analytical Labs
Eight Walkup Drive
Westborough, MA 01581

UV_{254}

Calibration as per Method 5910 B with DBP/ICR Analytical Methods Manual Modifications

TOC

Calibration as per Method 5310 C with DBP/ICR Analytical Methods Manual Modifications

THM

Calibration as per Method 551.1 with DBP/ICR Analytical Methods Manual Modifications

Calibration as per Method 524.2

HAA

Calibration as per Method 6251 B with DBP/ICR Analytical Methods Manual Modifications

CDM Camp Dresser & McKee Inc.

consulting engineering construction operations

Ten Cambridge Center
Cambridge, Massachusetts 02142
Tel: 617 252-8000 Fax: 617 621-2565

MEMORANDUM

To: Lisa Sorgini

From: Peter Maynard PM

Re: ICR Bench Study: Analytical Calibration Protocol

Date: 11 June 1999

Calibration for analysis of samples submitted to the CDM laboratory under ICR Bench Study programs were performed in accordance to the protocols given in the DBP/ICR Analytical Methods Manual [EPA 814-B-96-002] Section 9.0.

Environmental
Health Laboratories

110 S. Hill Street
South Bend, IN 46617-2702
(219) 233-4777
(219) 233-3272
FAX (219) 233-8207

Calibration Procedures:

EHL followed standard calibration procedures as indicated bythe Standard Methods and EPA Methods listed below:

5320B
300.0
551.1
552.2

If you have any further questions, please contact us at 1-800-332-4345.

Section 3

Responses to all EPA comments on the initial review of the Data Collection Sheets have been tracked on the sheets. The sheets are included as an electronic file within this document. Additional information requested can be found within Section 1 of this report.

Appendix A

A.2 -- Design Plant Parameters

Date: 6/10/99

PWS Name: BROCKTON WATER FILTRATION PLANT
PWS ID: MA4044000
WIDB:
ICR Contact Person: Mr. JAMES MUYLLE

Sampling Period: Design
Design Sampling Start Date: 7/23/97
Design Sampling End Date: 12/31/98

Treatment Plant Name: BROCKTON WATER FILTRATION PLANT
ICR Treatment Plant ID: 402
Treatment Plant PWS ID: MA4044000
Treatment Plant Category: CONV

State Approved Plant Capacity (MGD): 24.0
Historical Min. Water Temperature (deg C): 3.0
Installed Sludge Handling Capacity (GPD): 3,000.00
Blending Indicator: N

Water Resource Name: SILVER LAKE
Water Resource Type: Reservoir/lake
Average Residence Time (Days): 180
Intake Name: SCREEN HOUSE
Watershed Control: N

Hydrologic Unit Code:
River Reach:
Latitude (degrees, minutes, seconds): +42°1'30"
Longitude (degrees, minutes, seconds): -70°49'30"
River Reach Miles:

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
	Influent	INF	1	
Process Train Name: MAIN				
Process Train Category: CONV				
1	Carbon Contact	Other Treatment Process	2	Surface Area (ft2): 64

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Liquid Volume (gal): 20,460 Short Circuiting Factor:
2	Coagulant Addit	Other Treatment Process		Surface Area (ft2): 64 Liquid Volume (gal): 3,410 Short Circuiting Factor:
3	Chlorine gas	Disinfectant Addition		Chemical Code: CL2 Measurement Formula: Lbs. Dose Rate (mg/L): 0.00
4	Rapid Mix	Rapid Mix	4	Type of Mixer: ME Baffling Type: SP Liquid Volume (gal): 22,380 Short Circuiting Factor: 1.0 Mean Velocity Gradient (sec-1): 800.0
5	Flocculator	Flocculation Basin	5	Type of Mixer: ME Liquid Volume (gal): 504,000 Short Circuiting Factor: 0.3 Baffling Type: SP Stage Sequence Number: 1 Stage Mean Velocity Gradient (sec-1): 45 Stage Liquid Volume (gal): 84,000 Stage Sequence Number: 2

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
				Stage Mean Velocity Gradient (sec-1): 45 Stage Liquid Volume (gal): 84,000 Stage Sequence Number: 3 Stage Mean Velocity Gradient (sec-1): 45 Stage Liquid Volume (gal): 84,000 Stage Sequence Number: 4 Stage Mean Velocity Gradient (sec-1): 45 Stage Liquid Volume (gal): 84,000 Stage Sequence Number: 5 Stage Mean Velocity Gradient (sec-1): 45 Stage Liquid Volume (gal): 84,000 Stage Sequence Number: 6 Stage Mean Velocity Gradient (sec-1): 45 Stage Liquid Volume (gal): 84,000
6	Sedimentation	Sedimentation	6	Surface Area (ft2): 1,485 Liquid Volume (gal): 1,491,000 Baffling Type: SP Short Circuiting Factor: 0.5 Plate Settler Surface Area (ft2): Plate Settler Brand Name: Tube Settler Surface Area (ft2): Tube Settler Brand Name:

Seq. No.	Sample Location Name	Sample Location Type	Sample Loc. No.	
7	Filtration	Filtration	7	Surface Area (ft2): 2,850 Liquid Volume (gal): 229,500 Total Media Depth (in): 51 Depth of GAC (in): 27 Media Type: GACS Type of Activated Carbon: OT Minimum Water Depth To Top of Media (ft): 4.0 Depth From Top of Media to Top of Backwash Trough (ft): 3.0
8	Zinc Phosphate	Other Treatment Process		Surface Area (ft2): Liquid Volume (gal): Short Circuiting Factor:
9	Chlorine gas	Disinfectant Addition	10	Chemical Code: CL2 Measurement Formula: MG/L Dose Rate (mg/L): 2.70
10	Clearwell	Clearwell	9	Surface Area (ft2): 20,000 Liquid Volume (gal): 1,500,000 Minimum Liquid Volume (gal): 400,000 Baffling Type: AV Short Circuiting Factor: Covered Indicator Code: Y
	Finished Water	FIN	8	

A.3 -- Design Plant Chemical Parameters

Date: 6/10/99

PWS Name: BROCKTON WATER FILTRATION PLANT
PWS ID: MA4044000
WIDB:
ICR Contact Person: Mr. JAMES MUYLLE

Sampling Period: Design
Sampling Start Date: 7/23/97
Sampling End Date: 12/31/98

Sep. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
Treatment Plant Name: BROCKTON WATER FILTRATION PLANT						
ICR Treatment Plant ID No: 402						
Treatment Plant Category: CONV						
Process Train Name: MAIN						
Process Train Category: CONV						
1	Carbon Contact	Other Treatment Process	2			
				Powdered activated carbon	Lbs.	0.00
2	Coagulant Addit	Other Treatment Process				
				Aluminum sulfate (Alum)	AL2S04	0.00
3	Chlorine gas	Disinfectant Addition				
				Chlorine gas	Lbs.	0.00
4	Rapid Mix	Rapid Mix	4			
				Aluminum sulfate (Alum)	AL2S04	7.00
5	Flocculator	Flocculation Basin	5			
6	Sedimentation	Sedimentation	6			

Sep. No.	Sample Location Name	Sample Location Type	Sample Location Number	Chemical Name	Measurement Formula	Dose (mg/L)
7	Filtration	Filtration	7			
8	Zinc Phosphate	Other Treatment Process				
				Zinc orthophosphate	Lbs.	2.60
9	Chlorine gas	Disinfectant Addition	10			
				Chlorine gas	MG/L	2.70
10	Clearwell	Clearwell	9			
				Sodium hydroxide	NAOH	7.00

End of Report A.3 --Design Plant Chemical Parameters