ICR Treatment Study Summary Report

Evaluation of Granular Activated Carbon Using the RSSCT for Compliance with the Information Collection Rule

Conducted during the period of May 20, 1998 through March 12, 1999

Prepared by:

Gannett Fleming, Inc.
209 Senate Avenue
Camp Hill, Pa. 17011

In July 1999

For:
Omaha Metropolitan Utilities District
PWS ID# NE3105507
1723 Harney Street
Omaha, NE 68102
Phone: 402-449-8155
Fax: 402-449-8166

Florence WTP, Plant ICR# 453

Attachments: 2 diskettes containing the *Data Collection Spreadsheets*, *Summary Report Spreadsheets* and *Summary Report*

Table of Contents

I. Conclusions and Recommendations

II. Background Information

Treatment Plant Description
- Treatment plant schematic
- Treatment plant design information
- Treatment challenges facing plant

Tabular summary of source/finished water quality **-** See *Summary Report Spreadsheet*

III. Materials and Methods

Pretreatment Processes and the GAC Adsorption Process
- Schematics of pretreatment processes and the RSSCT
- Pretreatment process description and experimental design
- RSSCT description and experimental design
- GAC preparation and standard operating procedures
- SDS procedures

Analytical Methods**-** See *Summary Report Spreadsheet*

Analytical Laboratories

IV. Results and Discussion

Problems Encountered
Water Quality Data
- Influent pH vs TOC breakthrough
- Seasonal SDS parameters
- DBP data and data analysis
- Water quality of pretreated influent

Impact of Seasonal Variability
Summary of Significant Results

V. QA/QC Summary

Appendix

- Plots of TOC vs UV_{254}

I. Conclusions and Recommendations

The full scale four quarter average TTHM and HAA6 levels for 1998 were below the Stage I MCL of 80 ug/l and 60 ug/l, respectively. However, the 1998 TTHM level of 71.3 ug/l is considerably higher than the proposed Disinfectant Byproduct (DBP) Rule-Stage II level of 40 ug/l. The 1998 HAA6 level of 26.8 ug/l is only slightly less than the proposed DBP-Rule Stage II level of 30 ug/l. TTHM reduction will be the priority DBP treatment objective.

The RSSCT demonstrated that as an overall average approximately 60% reduction of the feedwater DBP occurred for both TTHM and HAA6. Although the feedwater DBPs were lower than the distribution DBPs, the RSSCT percent reduction applied to the distribution DBPs would result in TTHM and HAA6 levels below the proposed DBP-Stage II MCL.

Based on RSSCT (Column 2) run times to 70% TOC breakthrough, full scale granular activated carbon (GAC) change-out frequency is anticipated to be approximately twice per year.

GAC should be considered a viable treatment alternative for reducing TTHM and HAA6 precursors for this supply. If in the future DBP levels must be reduced to meet new regulations (such as the proposed Stage II DBP Rule), GAC treatment is a proven alternative for reducing this supply's DBP precursors.

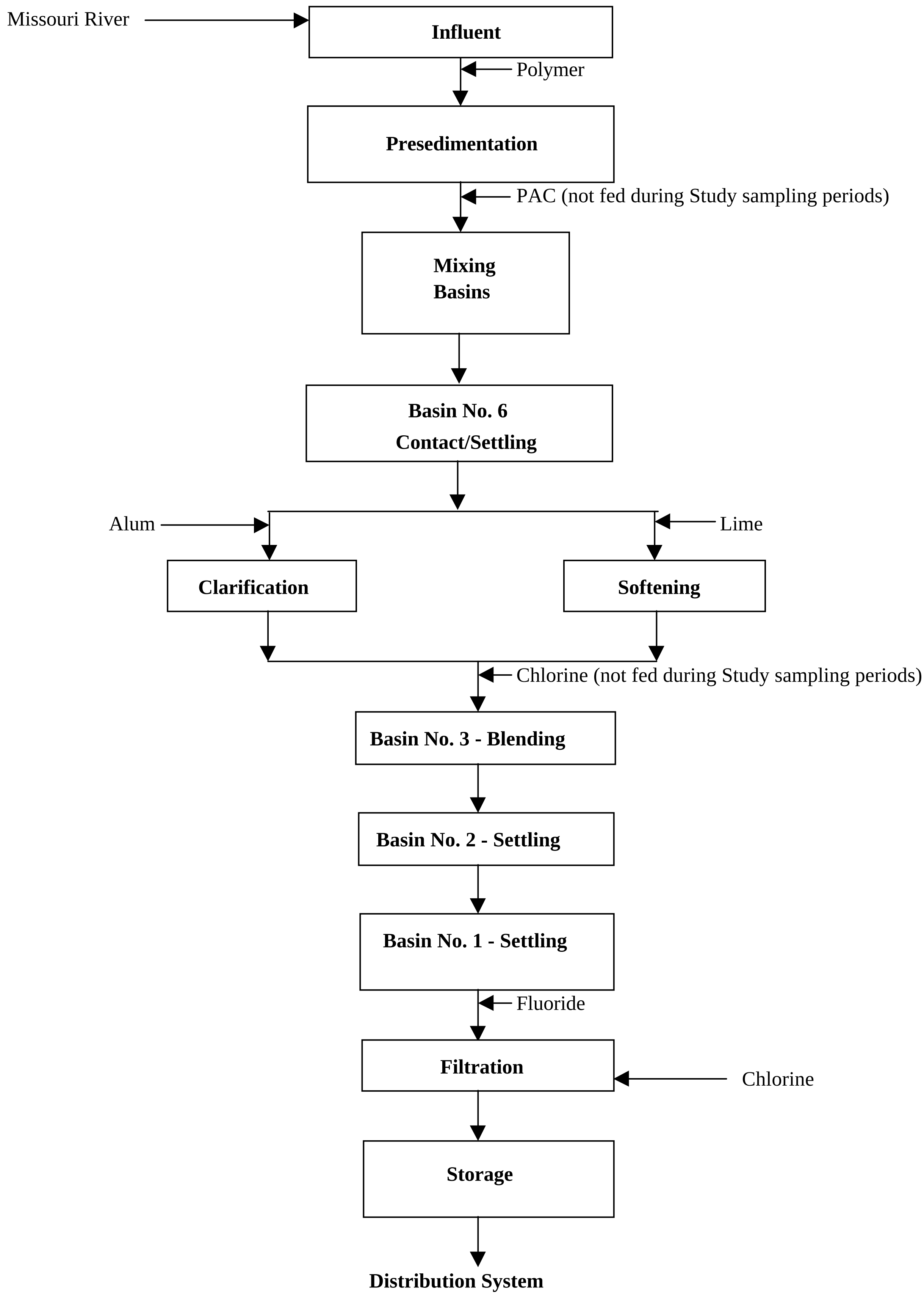
The most likely full scale location for GAC would be in contact basins following filtration, sized to provide 20 minutes empty bed contact time (EBCT). If the hydraulic gradient between the filter effluent and the clearwell has adequate differential head, new contact basins with GAC would be situated such that gravity flow would be possible from the filters to the clearwell. Otherwise the filtered water would have be pumped through GAC pressure vessels and subsequently discharged to the clearwell.

It would be preferable that all chlorination occur following the GAC adsorption process so that DBP are not formed prior to the GAC treatment.

II. **Background Information**

This section provides design data and a schematic of the full scale water treatment. In addition, there is a brief discussion of treatment challenges facing the plant.

Florence WTP
Full Scale Process Schematic



Omaha MUD
Florence WTP
Process Schematic
ICR Plant No. 453

Florence WTP
Design Plant Parameters

Table 1
Florence WTP Design Data

Unit Process	Process Description
Presedimentation	Type: Presettling Surface Area (ft2): 94,250 Liquid Volume (gal): 17,700,000 Baffling Factor: PR Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Coagulant Aid - organic polymer Coagulant Aid Dose (mg/l) - 1.0
Mixing Basins	Type: Other Treatment Process Surface Area (ft2): 24,800 Liquid Volume (gal): 1,250,000
Basin #6	Type: Sedimentation Surface Area (ft2): 96,980 Liquid Volume (gal): 16,000,000 Baffling Factor: PR Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name:
Split Treatment Upflow Clarifier Upflow Softener	 Type: Solids Contact Clarifier Brand Name: Accelator Surface Area (ft2): 45,200 Liquid Volume (gal): 4,000,000 Baffling Factor: AV Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Coagulant: Aluminum Sulfate Coagulant Dose (mg/l): 10 Type: Solids Contact Clarifier Brand Name: Accelator Surface Area (ft2): 45,200 Liquid Volume (gal): 4,000,000

Table 1
Florence WTP Design Data

Unit Process	Process Description
Upflow Softener	Baffling Factor: AV Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Alkalinity Addition: Lime Lime Dose (mg/l): 96
Combined Flow	Other Treatment Process
Disinfection	Chemical Type: Chlorine Gas Measured as: Cl_2 Dose Rate (mg/l): 2.5
Basin #3	Type: Sedimentation Surface Area (ft2): 79,464 Liquid Volume (gal): 14,000,000 Baffling Factor: PR Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name:
Basin #2	Type: Sedimentation Surface Area (ft2): 123,918 Liquid Volume (gal): 20,000,000 Baffling Factor: PR Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name:
Basin #1	Type: Sedimentation Surface Area (ft2): 126,650 Liquid Volume (gal): 20,000,000 Baffling Factor: PR Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name:
Fluoridation	Type: Other Treatment Process
Disinfection	Chemical Type: Chlorine Gas Measured as: Cl_2 Dose Rate (mg/l): 2.5
Howell Filter	Type: Filtration Surface Area (ft2): 33,600

Table 1
Florence WTP Design Data

Unit Process	**Process Description**
Howell Filter	Liquid Volume (gal): 2,000,000
	Total Media Depth (in): 30
	Depth of GAC (in):
	Media Type: Dual
	Type of Activated Carbon:
	Minimum Water Depth to Top of Media (ft): 5.3
	Depth from Top of Media to Top of Backwash Trough (ft): 2.7
Basin #7	Type: Clearwell
	Surface Area (ft2): 118,750
	Liquid Volume (gal): 24,000,000
	Minimum Liquid Volume (gal): 16,000,000
	Baffling Type: UN
	Short Circuiting Factor:
	Covered Indicator Code: Y

Treatment Challenges Facing Plant

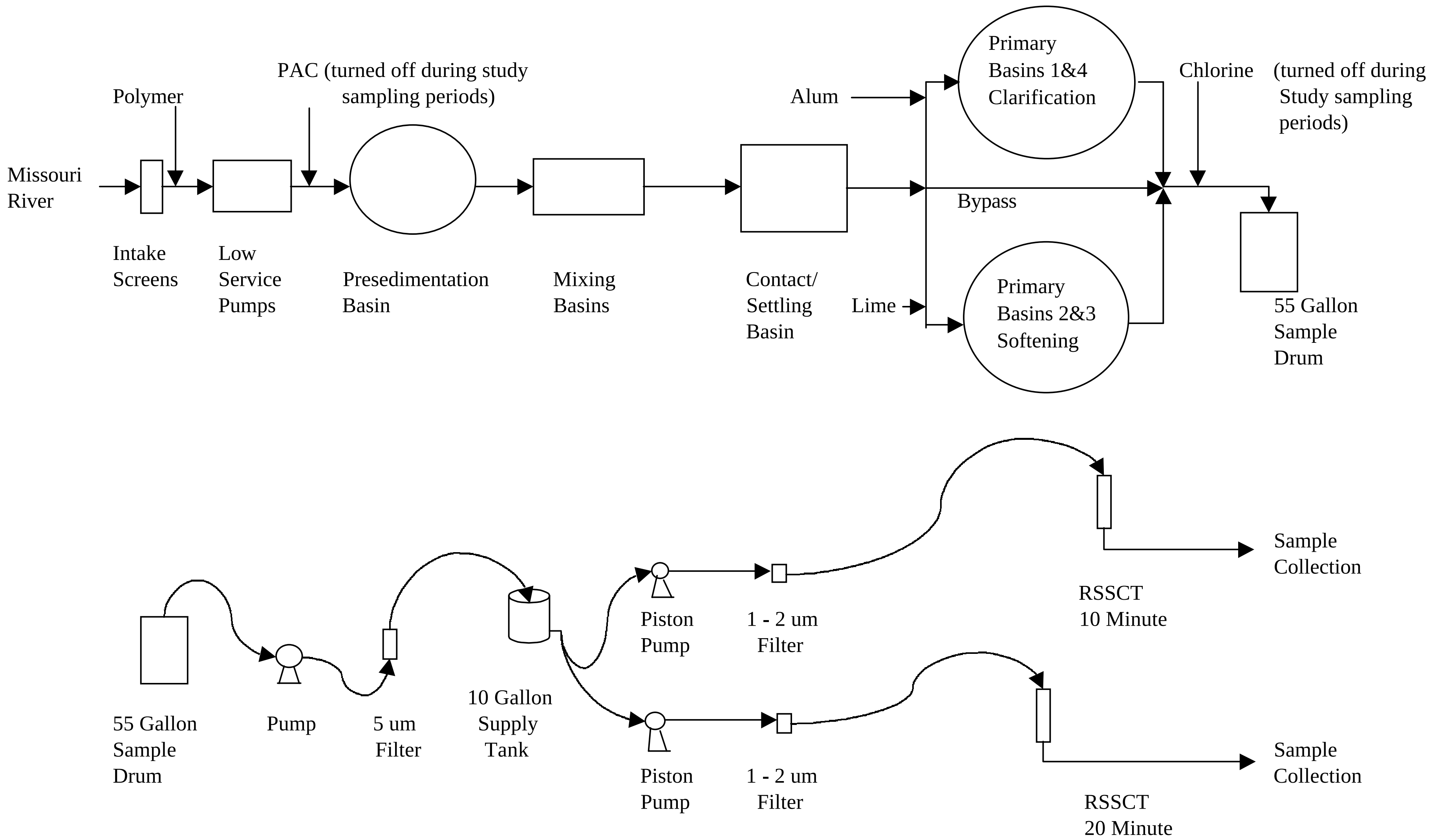
The primary DBP treatment challenge facing the plant is reducing TTHM levels. The annual average TTHM level in 1998 was 71 ug/l, which exceeds the proposed Stage II MCL for TTHMs of 60 ug/l.

Annual average HAA6 levels have been less than the proposed Stage II MCL of 40 ug/l, and therefore are not as much of a treatment priority as TTHMs.

III. **Materials and Methods**

The following section presents design information and procedures that were used to setup and conduct this RSSCT.

Florence WTP
Process Schematic
0f Full Scale and Bench-Scale
Pretreatment Processes
Followed by
RSSCT



Omaha MUD
Florence WTP
Pretreatment Process
and RSSCT Schematic
ICR Plant No. 453

Pretreatment Process and RSSCT Design

Pretreatment process description and experimental design

1. The treatment process investigated for TOC reduction was the bench-scale RSSCT using GAC

2. Treatment study sample water was collected from the blended softener/clarifier flow - chlorine feed was turned off during RSSCT sample collection

3. Sequence of pretreatment processes used in the treatment study:

Full Scale

a. Presedimentation
- Surface Area: 94,250 ft2
- Surface Loading:1.16 gpm/ft2 @ capacity
- Liquid Volume: 17,700,000 gal

b. Mixing basins
- Type: Mechanical
- DT: 11.4 minutes @ capacity
- Surface Area: 24,800 ft2
- Liquid Volume: 1,250,000 gal

Coagulant aid - polymer (1.0 mg/l)

c. Sedimentation (Basin No. 6)
- Surface Area: 96,980 ft2
- Overflow Rate: 1.13 gpm/ft2 @ capacity
- Liquid Volume: 16,000,000 gal

d. Split treatment

1) Alum coagulation (10 mg/l) followed by:
- upflow solids contact clarification (Accelator) - 1.21 gpm/ft2 @ capacity

2) Lime addition (96.0 mg/l as CaO) followed by:
- upflow solids contact softening - 1.21 gpm/ft2 @ capacity

e. Blended flow

RSSCT description and experimental design

Bench Scale

f. Cartridge filtration:
- 5.0 um nominal pore size
- Surface Area: 12 ft2
- Filter Material: Polypropylene

g. In-line Filtration:
- 1.0 to 2.0 um pore size
- Surface Area: 19.6 cm2
- Filter Material: Teflon
- Filter Life: ~ 48 hours

4. RSSCT Design

a. GAC: Calgon Filtrasorb 300 (8 x 30 mesh) ground/screened to 60x100 mesh US std, d = 0.20 mm
b. Scaling Factor: 8.0
c. Columns:
- Number: two
- Dimensions: 11 mm ID x 300 mm length
- Material: Teflon and glass (all tubing Teflon; pump heads SS)

	EBCT = 1.25 min	EBCT = 2.50 min
- GAC Depth:	106 mm	212 mm
- Flow Rate:	7.0 ml/min	7.0 ml/min

d. Seasonal Tests

Season	Pretreatment	EBCT, min
Spring	solids contact clarification/ softening/cartridge filtration	10 & 20
Summer	solids contact clarification/ softening/cartridge filtration	10 & 20
Autumn	solids contact clarification/ softening/cartridge filtration	10 & 20
Winter	solids contact clarification/ softening/cartridge filtration/ caustic soda	10 & 20

RSSCT - GAC Preparation and Standard Operating Procedures

A. Sampling GAC to Obtain a Representative Sample

Coning and Quartering Procedure

1. The total volume of the as-received GAC is taken from the original container and placed into a cone shape pile, scoop-by-scoop. Each scoop is added to the center of the pile and allowed to flow evenly in all directions.

2. The pile is then flattened from above to form a shallow cylinder of uniform thickness.

3. This cylinder of carbon is then evenly divided into pie-shaped quarters.

4. Two opposite quarters are removed.

5. The remaining two opposite quarters are piled into a cone again by taking scoops from alternate quarters.

6. Steps 2 through 5 are repeated until the desired sample size is obtained.

B. GAC Preparation

1. Representative sample of selected GAC type is ground to appropriate mesh sizes for RSSCT; grinding is performed in small batches (appropriate respiratory protection should be worn).

2. It is very important that the entire sample be ground so that it passes the upper sieve size of the desired mesh range; any GAC remaining on larger mesh should be reground.

3. After sieving, the ground GAC is washed with distilled water:
   a. Step-wise decantation in large diameter glass container
      - Pour the wash water over the ground GAC, stir the slurry until all of the GAC is wet, allow the GAC to settle for 1 to 2 minutes and then decant.
      - The amount of washing depends on the carbon-to-wash vessel volume ratio. (For ratios of 0.1 to 1.0 or less, 10 vessel volume decantations may be sufficient - care must be taken to thoroughly wash the GAC to avoid headloss buildup).

   b. An alternative method is to wash the ground GAC on the finer sieve by pouring distilled water onto the sieve while it is gently shaken to keep the GAC mixed.

4. After washing, the ground GAC is dried overnight to a constant weight at a temperature of 80 deg. C. The temperature should than be increased to 100 deg. C for 4 hours. The carbon is then weighed again and if the weight is more than 5% different than the previous weight, then drying at 100 deg. C should be continued to a constant weight. The dried GAC should be transferred to a clean bottle, capped and stored in desiccator until ready for use.

C. Ground GAC Density Determination

1. Precisely weigh about 2 grams of ground GAC and add it to a 5 to 10 ml graduated cylinder, and determine the bed volume of GAC (confirm cylinder calibration using pipettor).

2. The cylinder should be tapped by hand to assure the GAC is compacted.

3. The bed density is the GAC weight divided by the GAC bed volume.

D. RSSCT GAC Loading

1. Determine appropriate mass of ground GAC for particular column:

   Mass = bed depth x density x bed surface area

2. After weighing desired GAC mass, GAC is prewetted in an Erlenmeyer flask by adding distilled water to a level about one inch over the GAC surface.

3. The ground GAC is then deaerated by applying a vacuum for at least 15 minutes (the GAC is easier to deaerate if it is allowed to sit overnight prior to deaeration)

4. After deaertion, remove the excess water so that a ground GAC slurry exists that can be transferred into the column with a laboratory spatula.

5. The column should be filled with distilled water to a level 25% of the GAC bed depth.

6. The prewetted and deaerated GAC slurry is then packed into the column; the column should be tapped gently during the addition of the GAC slurry.

7. The GAC bed should be completely submerged during and after the packing process.

8. The integrity of the RSSCT system should be tested for leaks, air pockets or immediate headloss buildup by feeding distilled water to the system for about 10 minutes. Resolve any problems that are identified.

E. Standard Operating Procedures

1. Following GAC loading, turn the feed pump on and fill the column with distilled water; the air release valve will need to be cracked open to allow air to be purged while the column is being filled.

2. After the column has been purged of all air, close the air release valve and open the effluent.

3. Adjust the pump stroke to achieve the desired flow rate; confirm the calibration by collecting a timed effluent sample with a graduated cylinder.

4. Flow rates should be maintained to within 5% of desired flow rate; rates should be checked at least twice a day and adjusted to within this tolerance (periods of no flow exceeding 30 minutes should be accounted for by not including it in the cumulative operation time).

5. The first 20 minutes of flow should be wasted, and the first sample should be taken after 1.0 hour.

6. Flow and pressure readings should be recorded on a daily basis.

7. Significant increases in pressure suggest a need to change the prefilter and/or adjust the dampener; in severe cases the RSSCT column may need to be taken off line and the top 0.5 cm of the GAC bed stirred to break apart large lumps that form and are responsible for excessive headloss.

Florence RSSCT - SDS Procedures

Concept: Adjust samples to meet average seasonal distribution system chlorination parameters prior to analyzing for disinfectant byproducts.

Morning:

1. Start collecting each column effluent in individual gallon glass jugs to 750 ml mark-see schedule for column sampling dates.
2. Record sample date and time on Monitoring Sheet (Data Form 1) SDS Sheet and Data Form 4.
3. Measure and record pressure, flow and UV-254 for each column on Monitoring Sheet.
4. After collecting 750 ml from each column effluent, fill TOC bottles and refrigerate.
5. Check pH and titrate each remaining sample with titrant (caustic soda or sulfuric acid) to seasonal SDS pH.
6. Fill 500 ml amber glass incubation bottle (one per column effluent - no head space) with pH adjusted sample. Refrigerate.
7. Chlorine Demand Tests : (per sample) With remaining pH adjusted sample water, pour 50 ml in each of three 8 oz. bottles to perform chlorine demand tests; use volumetric pipettor to add chlorine doses to each bottle with 0.025 mg/ml stk sol'n; record doses on Chlorine Demand Sheet (Data Form 3). Hold bottles at seasonal SDS temperature for seasonal SDS incubation period.

Ml of Cl2 Stock Sol'n (0.025 mg/ml)	Cl2 Dose Equivalent (Mg/l)	Ml of Cl2 Stock Sol'n (0.025 mg/ml)	Cl2 Dose Equivalent (mg/l)	Ml of Cl2 Stock Sol'n (0.025 mg/ml)	Cl2 Dose Equivalent (mg/l)
1.0	0.6	2.0	1.2	3.0	1.8
1.2	0.8	2.2	1.4	3.2	1.9
1.4	0.9	2.4	1.5	3.4	2.0
1.6	1.0	2.6	1.6	3.6	2.1
1.8	1.1	2.8	1.7	3.8	2.2

Afternoon/Evening:

8. Check chlorine residual for each bottle (record on Data Form 3); based on these results, use chlorine dose that will produce seasonal SDS chlorine residual (chlorinate each 500 ml sample with 0.1 mg/ml stk sol'n in 1.0 liter beaker, and record time); return samples to 500 ml incubation bottles (no head space) and hold at seasonal SDS temperature for seasonal SDS incubation period.

Ml of Cl2 Stock Sol'n (0.1 mg/ml)	Cl2 Dose Equivalent (mg/l)	Ml of Cl2 Stock Sol'n (0.1 mg/ml)	Cl2 Dose Equivalent (mg/l)
1.0	0.2	6.0	1.3
2.0	0.4	7.0	1.5
3.0	0.7	8.0	1.8
4.0	0.9	9.0	2.0
5.0	1.1	10.0	2.2

9. Following SDS incubation period, fill lab sample bottles in order for each sample

   a. Two (2) 60 ml glass vials with Teflon caps for THM4

   b. One (1) 250 ml amber glass bottle with Teflon cap for TOX (add one sulfuric acid ampule to TOX bottle before filling).

   c. Two (2) 40 ml glass vials with Teflon caps for HAA6 {Note: There should be no head space in any of the sample bottles}.

   Refrigerate all samples until they can be taken to lab. Fill out Chain of Custody form.

10. With remaining sample, check and record on Data Form 4:

   a. Incubation time

   b. pH

   c. Temperature

   d. Chlorine residual

Analytical Laboratories

Laboratory	Dates of Service	Analyses Performed
Gannett Fleming Environmenta Laboratory	5/20/98 - 11/20/98	Alkalinity, Ammonia, Ca Hardness, Tot Hardness, Turbidity, Bromide, TOC, TOX, THM4, HAA6
Microbac Laboratory[(1)]	2/17/99 - 3/12/99	Alkalinity, Ammonia, Ca Hardness, Tot Hardness, Turbidity, Bromide, TOC, TOX, THM4, HAA6

(1) Gannett Fleming Environmental Laboratory was bought by Microbac Laboratory in February 1999; analysts and analytical methods did not change with change in ownership.

IV. Results and Discussion

Problems Encountered

Rapid rate of headloss development occurred across the 1 um to 2 um prefilter, requiring filter replacement at least ever other day; the headloss development also resulted in flow reductions of approximately 5 percent.

Air frequently had to be bled off the top of each column, apparently due to carbon dioxide generation occurring in feedwater as unstable water continued to precipitate calcium carbonate from the full scale softening treatment. Also, the pH, alkalinity and hardness of the softened water gradually declined as a result of calcium carbonate precipitation.

TOC results typically required a two-day turnaround, making it difficult to determine sampling frequency (UV_{254} did not track closely enough to TOC to be used as a reliable indicator for sampling frequency).

Target chlorine residuals were often difficult to achieve despite conducting chlorine demand tests and/or knowing effluent organic level trends.

The first sample of each test would typically have a TOC spike, despite wasting for approximately 45 minutes prior to sample collection.

Actual GAC depths varied from design; mass of GAC loaded was always based on the predetermined density (0.5 gram/cc) of the ground GAC, and the design empty bed volume. (see Table 2)

Water Quality Data

RSSCT Water Quality Conditions

SDS parameters used for the quarterly tests presented on Table 3 were based on average seasonal distribution system conditions as reported by Omaha MUD personnel.

No alkaline chemical was added to the feedwater during the first three quarters of testing to compensate for the pH decline that occurred due to continued softening; a relatively constant influent pH was maintained during the fourth quarter with the addition of caustic soda. Table 4 below presents the average influent pH for each column, and the days to 70 TOC percent breakthrough. The lower influent pH in the summer and autumn may have been a factor in the longer run times (Column 2) during these two seasons.

RSSCT DBP Results

Table 5 presents the average DBP levels and percent reductions. Table 6 presents the maximum DBP levels that occurred for each column effluent.

Neither Stage I MCL of the DBP Rule, or the proposed Stage II MCL of the DBP Rule were exceeded for either TTHMs or HAA6 during any of the tests. However, more importantly are the percent reductions of TTHMs and HAA6 by the RSSCT. The average distribution system TTHM and HAA6 levels for 1998 (Table 7) were higher than the RSSCT feedwater levels. Applying the RSSCT percent reductions to the distribution system TTHM and HAA6 levels results in levels of these DBPs below the proposed Stage II MCL of the DBP.

Impact of Seasonal Variability

The longest run times (Column 2) occurred in the summer and autumn, when influent TOC levels were highest.

Some of the highest SDS DBPs occurred in the autumn, reflecting higher organic levels and longer SDS contact times.

The highest average influent DBPs occurred in the spring; this was probably a factor in the relatively high column effluent DBP levels that occurred at this time.

Summary of Significant Results

The composite average of the run times for Column 2 (20 minute EBCT column) to 70% TOC breakthrough was 23.5 days; using a scaling factor of 7.4, the full-scale run time would be 174 days.

The time to 70% TOC breakthrough for Column 2 was 2.5 times to 4 times that for Column 1 (10 minute EBCT column).

A greater percentage of UV_{254} than TOC was typically removed by the GAC; therefore UV_{254} was not an accurate predictor of the level of TOC reduction.

No TTHM or HAA6 RSSCT effluent levels exceeded either the DBP Stage I or proposed Stage II MCL.

Although average seasonal distribution system conditions of chlorine residual, temperature, pH and contact time were used for RSSCT SDS criteria, the feedwater DBP levels were approximately 40 percent less than the distribution system DBP levels.

The RSSCT (Columns 1 and 2) on average reduced TTHM and HAA6 levels by greater than 50% (see Table 5).

The highest RSSCT (Columns 1 and 2) effluent TTHM and HAA6 levels were less than the feedwater DBP levels (see Table 6) with one exception, when the feedwater HAA6 level was low (winter conditions.)

Table 2
Florence WTP RSSCT
GAC Depth & EBCT

Quarter	Depth of GAC (mm)		EBCT (min)	
	Column 1	Column 2	Column 1	Column 2
1st - Spring	97	192	1.32	2.61
2nd - Summer	98	180	1.33	2.44
3rd - Autumn	94	194	1.27	2.63
4th - Winter	102	202	1.38	2.74

Table 3
Florence WTP RSSCT
Seasonal SDS Criteria

Quarter	Temp ^{o}C	pH	Incubation Time (hrs)	Chlorine Residual (mg/l)
1st - Spring	19.6	9.2	4.50	0.30
2nd - Summer	26.9	8.8	3.25	0.35
3rd - Fall	16.3	8.9	7.75	0.30
4th - Winter	13.2	9.2	13.20	0.50

Table 4
Florence WTP RSSCT
Influent pH vs TOC Breakthrough

Quarter	Parameter	Column 1	Column 2
1st - Spring	Influent pH / TOC	8.3 / 3.63	8.3 / 3.63
	70% TOC Breakthrough	8 days	19 days
2nd - Summer	Influent pH / TOC	7.8 / 3.68	7.8 / 3.68
	70% TOC Breakthrough	6.5 days	25 days
3rd - Autumn	Influent pH / TOC	8.0 / 3.53	8.0 / 3.53
	70% TOC Breakthrough	7 days	29 days
4th - Winter	Influent pH / TOC	9.0 / 3.03	9.0 / 3.03
	70% TOC Breakthrough	6 days	21 days

Table 5
Florence WTP RSSCT
Average Seasonal DBP Levels and Percent Reductions

Quarter	Influent		Column 1				Column 2			
	THM4 (µg/l)	HAA6 (µg/l)	THM4 (µg/l)	% Reduction	HAA6 (µg/l)	% Reduction	THM4 (µg/l)	% Reduction	HAA6 (µg/l)	% Reduction
1st - Spring	57.7	20.1	17.5	70	4.8	76	14.2	75	2.9	86
2nd- Summer	34.0	13.9	14.3	58	4.5	68	11.7	66	3.2	77
3rd - Autumn	45.6	15.6	19.4	57	5.5	65	17.1	63	4.6	71
4th - Winter	25.0	15.8	11.9	52	7.8	51	10.4	58	6.4	59
Average	41	16	16	59	6	65	13	65	4	73

Table 6
Florence WTP RSSCT
Maximum Seasonal DBP Levels and Percent Reductions

Quarter	Influent		Column 1				Column 2			
	THM4 (µg/l)	HAA6 (µg/l)	THM4 (µg/l)	% Reduction	HAA6 (µg/l)	% Reduction	THM4 (µg/l)	% Reduction	HAA6 (µg/l)	% Reduction
1st - Spring	57.7	20.1	32.5	44	13.2	34	30.3	47	9.1	55
2nd- Summer	34.0	13.9	21.1	38	6.8	51	24.6	28	10.8	22
3rd - Autumn	45.6	15.6	34.5	24	8.5	46	30.5	33	11.6	26
4th - Winter	25.0	15.8	25.1	0	11.7	26	21.9	12	9.6	39

Table 7
Florence RSSCT
Pretreated Feed Water Quality

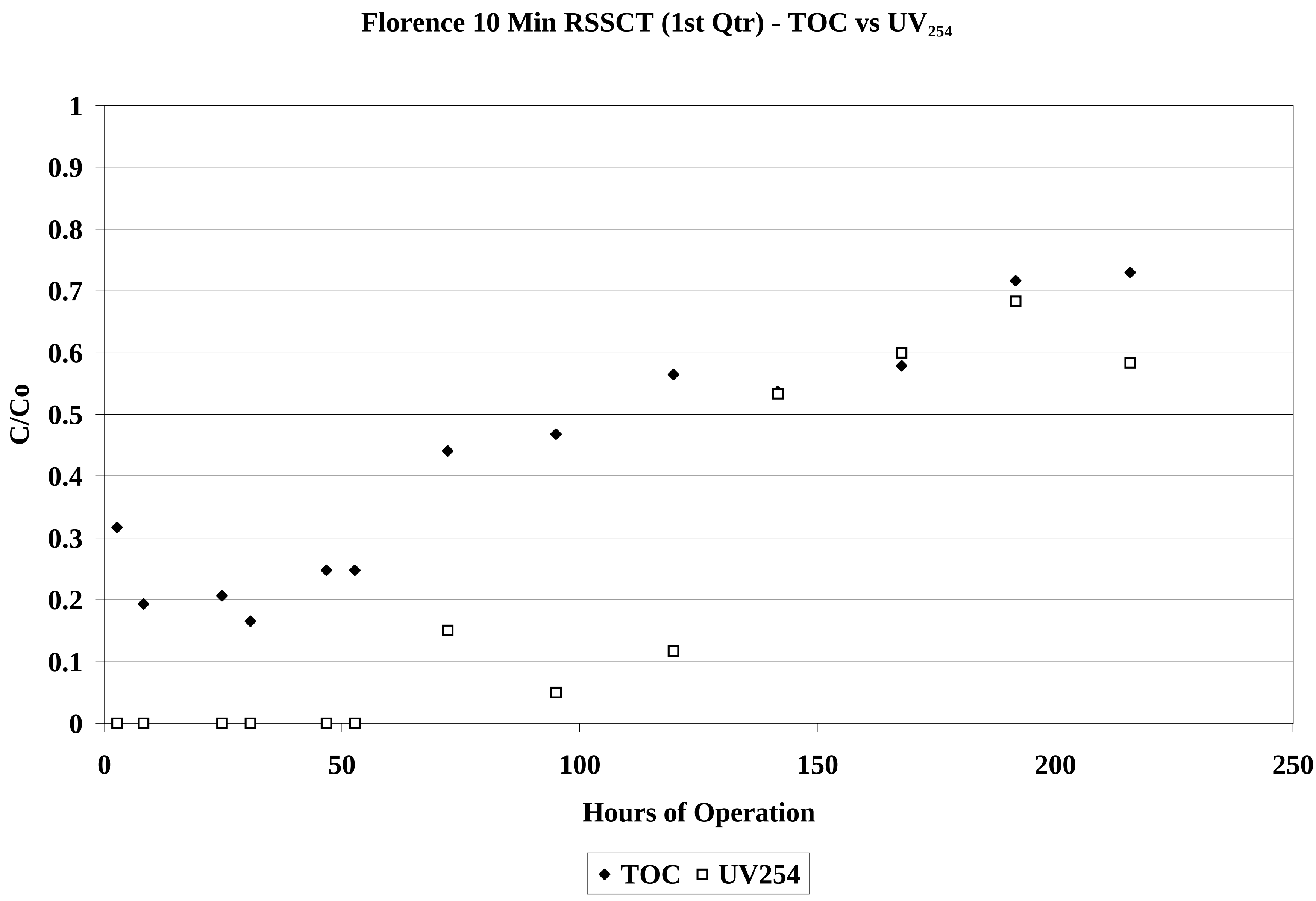
Water Quality Parameter	Spring Average (SD)	Summer Average (SD)	Autumn Average (SD)	Winter Average (SD)
Temperature (^oC)	24.3 (4.8)	22 (1.4)	21.0 (2.0)	19 (2.3)
pH	8.8 (0.0)	7.90 (3.4)	7.97 (3.16)	9.13 (1.3)
Turbidity (ntu)	1.1 (80)	0.40 (86.6)	0.17 (34.6)	0.20 (0)
Alkalinity (mg/L as $CaCO_3$)	65.5 (7.6)	55.5 (30.6)	69.5 (1.4)	41 (9.8)
Calcium Hardness (mg/L $CaCO_3$)	153 (64)	97 (2.1)	94.0 (4.3)	74 (10.8)
Total Hardness (mg/L $CaCO_3$)	200 (4.0)	160 (5.0)	166 (4.8)	140 (17.1)
Bromide (ug/L)	33.5 (3.0)	51 (7.8)	41.0 (4.9)	47 (0)
TOC (mg/L)	3.63 (18.3)	3.68 (7.0)	3.53 (14.5)	3.03 (8.5)
UV_{254} (cm^{-1})	0.06 (10.1)	0.065 (3.2)	0.06 (5.1)	0.05 (5.3)
SDS-THM4 (ug/L)	57.7 (6.3)	34 (15.1)	45.6 (1.7)	25 (1.7)
SDS-HAA5 (ug/L)	16.3 (12.6)	12.0 (33)	13.2 (16.1)	13.9 (9.4)
SDS-HAA6 (ug/L)	20.1 (27.2)	13.9 (25.4)	15.6 (14.1)	15.8 (5.6)
SDS-TOX (ug/L)	110 (45.9)	90 (40.5)	194 (26.9)	101.3 (2.4)
SDS-Chlorine Demand (mg/L)	1.44 (64.4)	1.39 (16.9)	1.4 (12.6)	1.53 (6.2)

V. QA/QC Summary

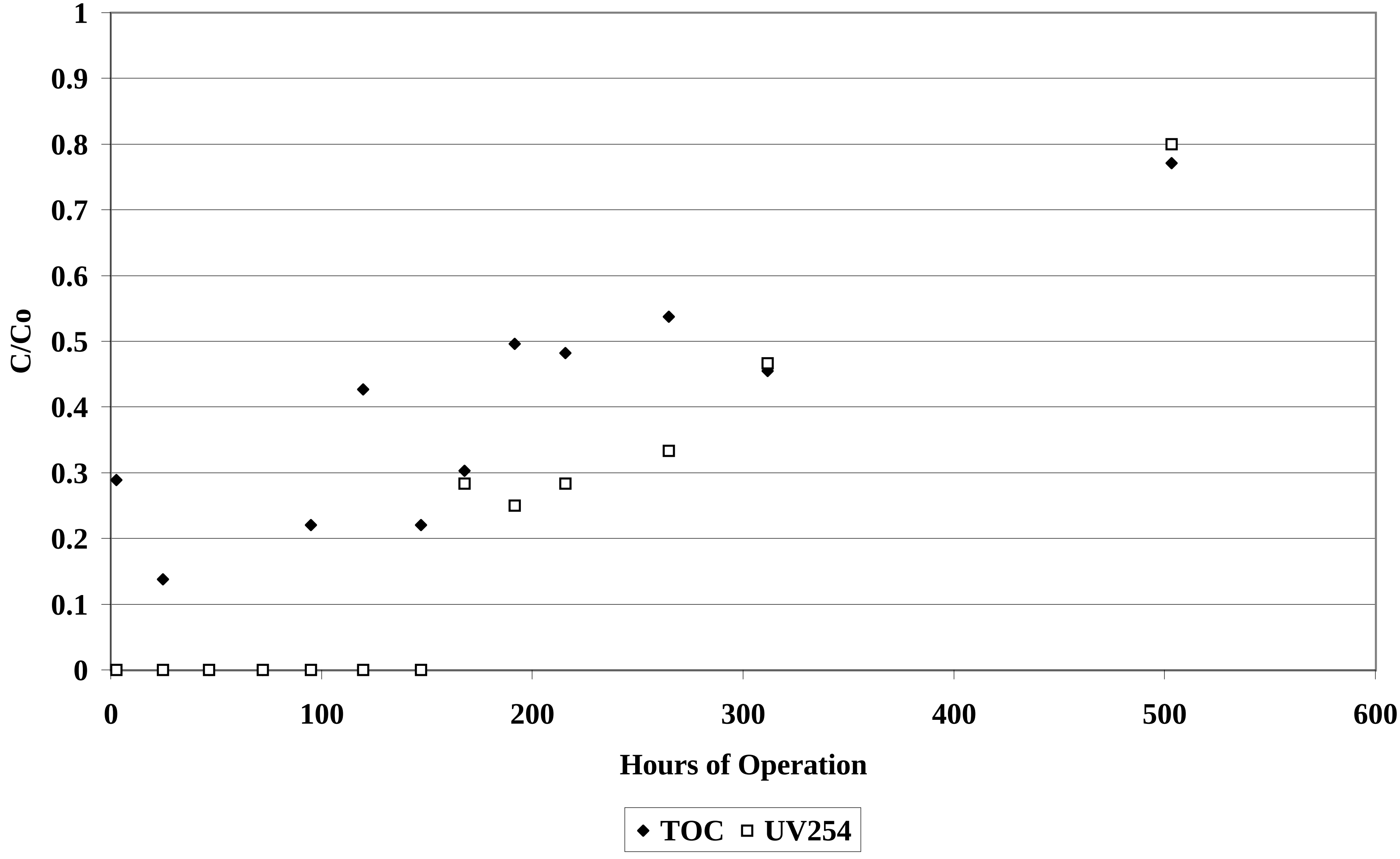
The calibration procedures in page 45 to 71 of the *EPA DBP/ICR Analytical Methods Manual* for THMs, HAAs, TOX, bromide and TOC were followed during this Study.

Appendix

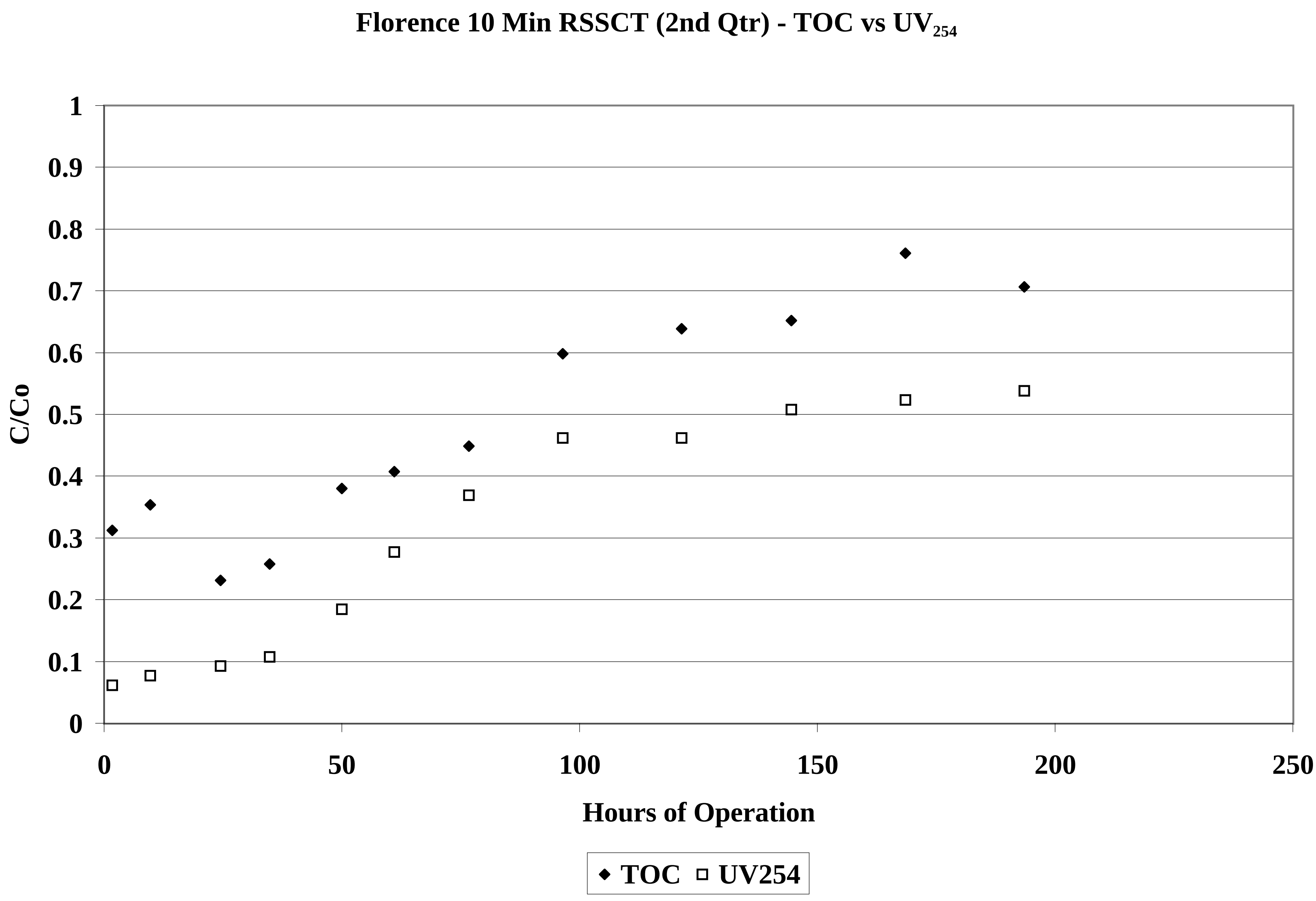
TOC vs UV_{254}
1st Quarter

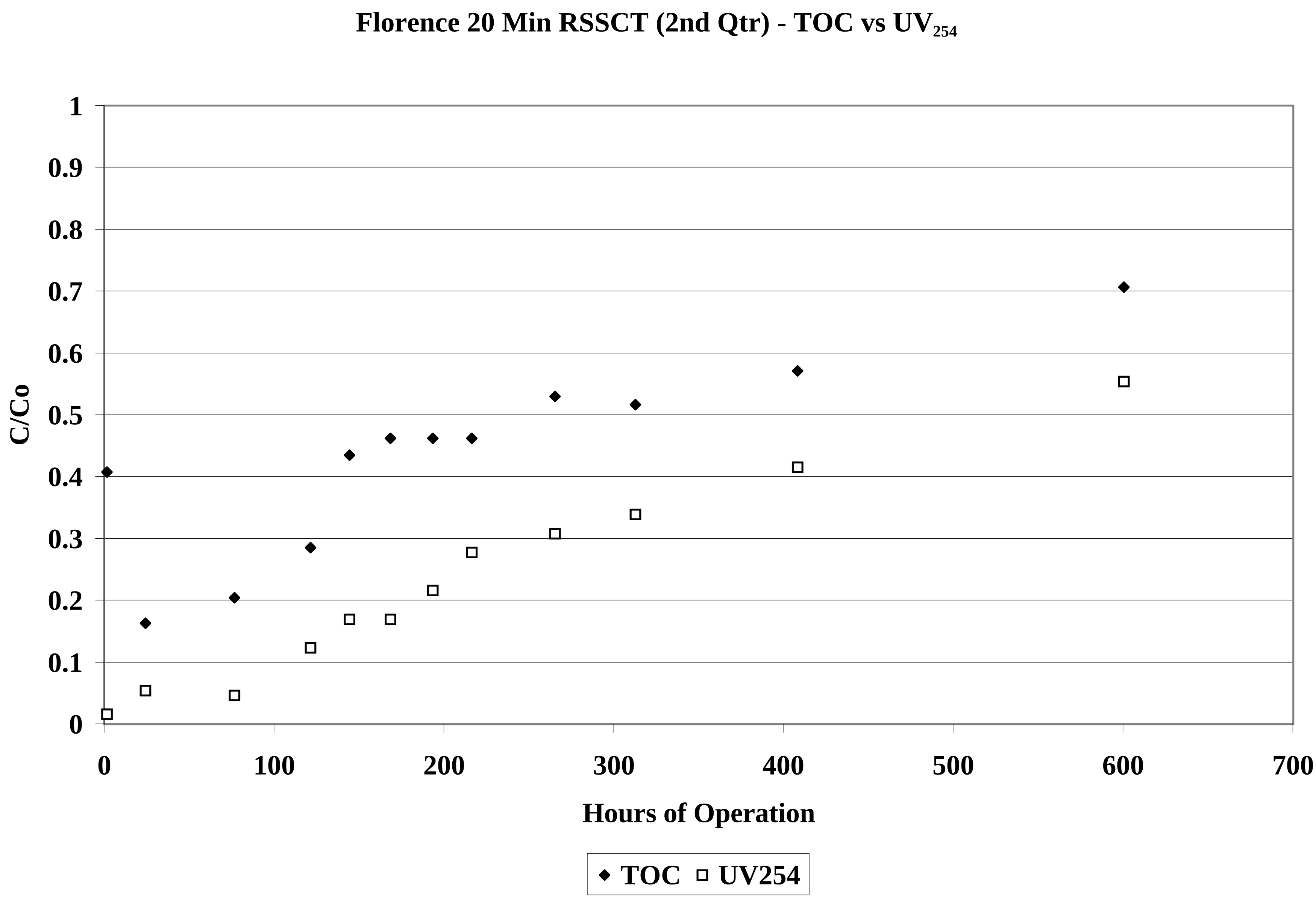

Florence 10 Min RSSCT (1st Qtr) - TOC vs UV_{254}
C/Co
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
250
Hours of Operation
TOC
UV254

Florence 20 Min RSSCT (1st Qtr) - TOC vs UV_{254}



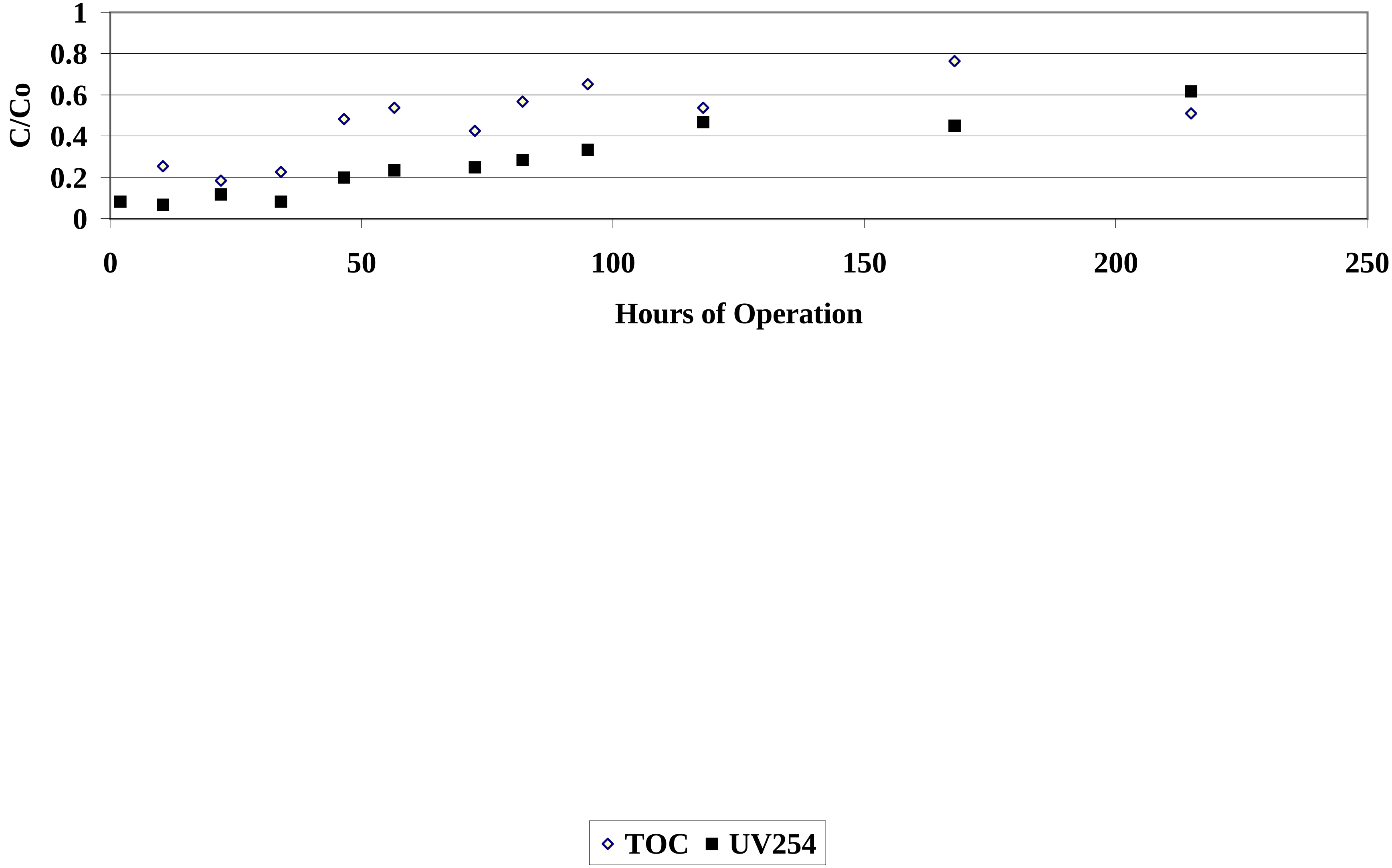
TOC vs UV_{254}
2nd Quarter

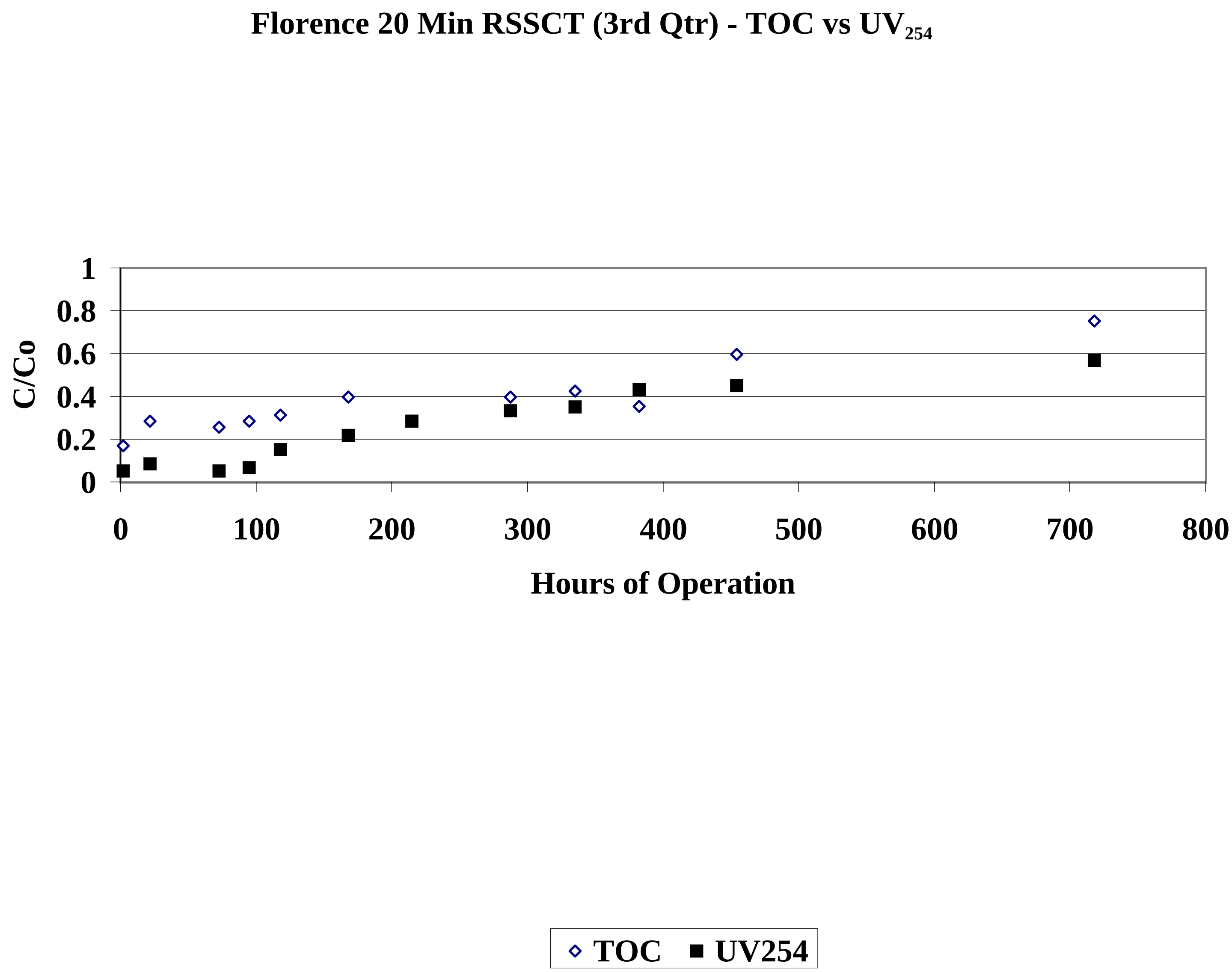

Florence 10 Min RSSCT (2nd Qtr) - TOC vs UV_{254}
C/Co
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
250
Hours of Operation
TOC
UV254


Florence 20 Min RSSCT (2nd Qtr) - TOC vs UV254
C/Co
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
100
200
300
400
500
600
700
Hours of Operation
TOC
UV254

TOC vs UV_{254}
3^{rd} Quarter

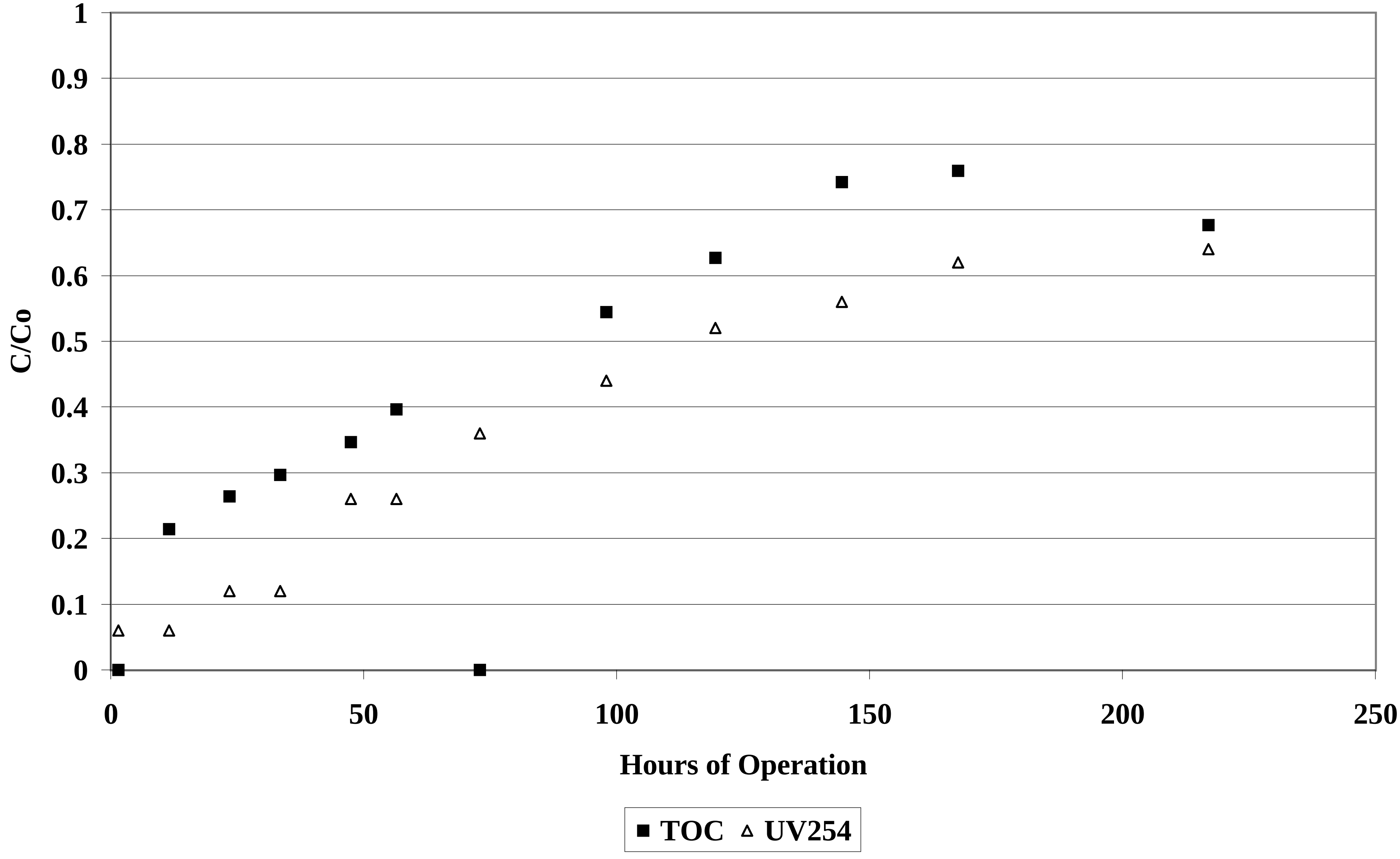
Florence 10 Min RSSCT (3rd Qtr) - TOC vs UV_{254}

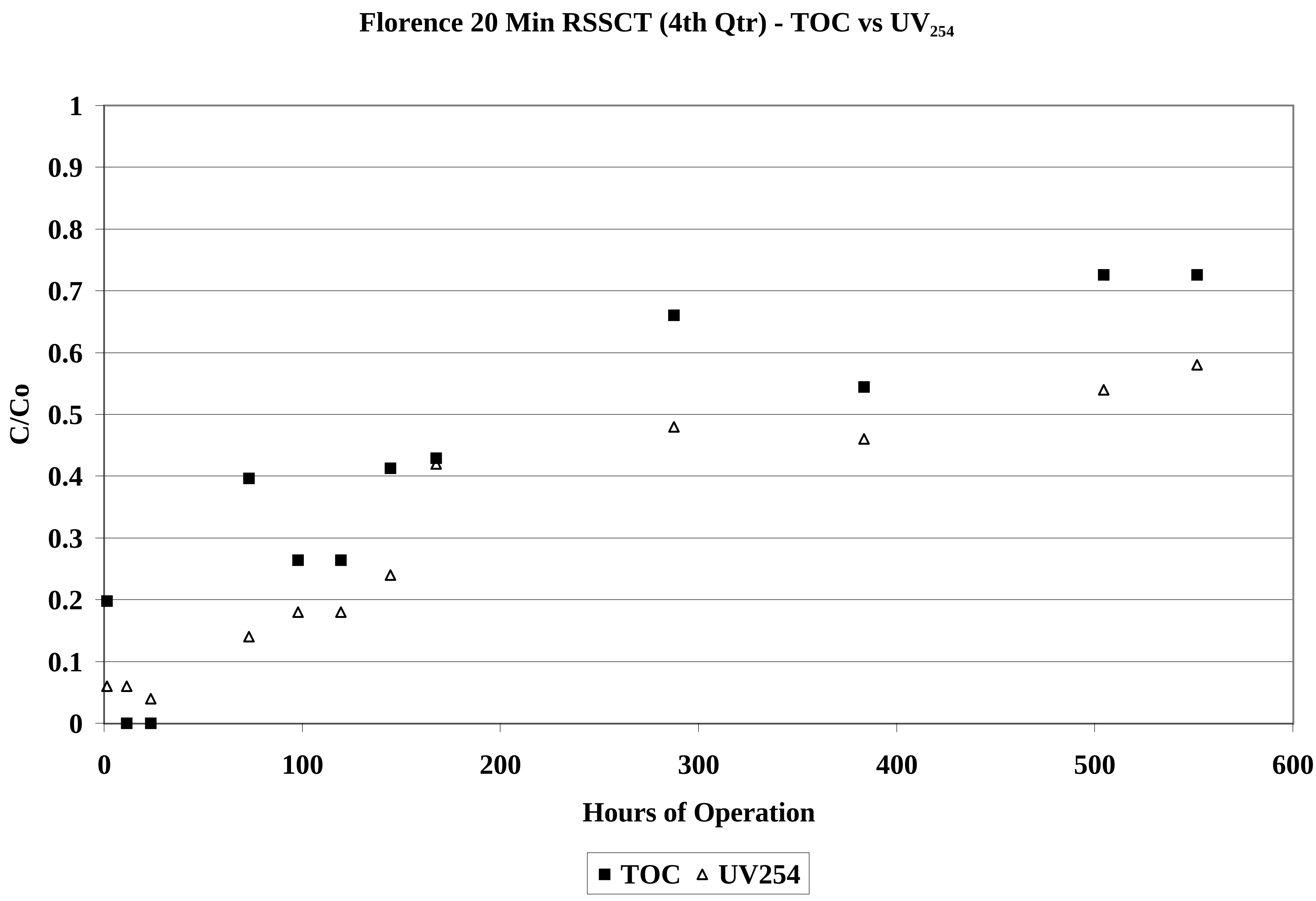



Florence 20 Min RSSCT (3rd Qtr) - TOC vs UV_{254}
C/Co
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
800
Hours of Operation
TOC
UV254

TOC vs UV_{254}
4th Quarter

Florence 10 Min RSSCT (4th Qtr) - TOC vs UV_{254}




Florence 20 Min RSSCT (4th Qtr) - TOC vs UV254
C/Co
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
100
200
300
400
500
600
Hours of Operation
TOC
UV254