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 April 22, 1998 through April 16, 1999

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Platte River WTP, Plant ICR# 454

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

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I. Conclusions and Recommendations

The 1998 average distribution system TTHM and HAA6 levels were 49.3 ug/l and 20.8 ug/l, respectively. The HAA6 level is less than the proposed DBP Rule-Stage II MCL of 30 ug/l. The TTHM level is less than the Stage I DBP MCL of 80 ug/l, although greater than the DBP Stage II MCL of 40 ug/l. Therefore, reduction of TTHM precursors will be the priority DBP reduction objective.

Several times RSSCT TTHM levels slightly exceeded the DBP Stage II MCL before 70% TOC breakthrough.

The composite of the seasonal average run times (Column 2) to 70% TOC breakthrough was approximately 125 days full scale, using a scaling factor of 7.4. Based on these results, full scale GAC change-out frequency would be approximately three times per year.

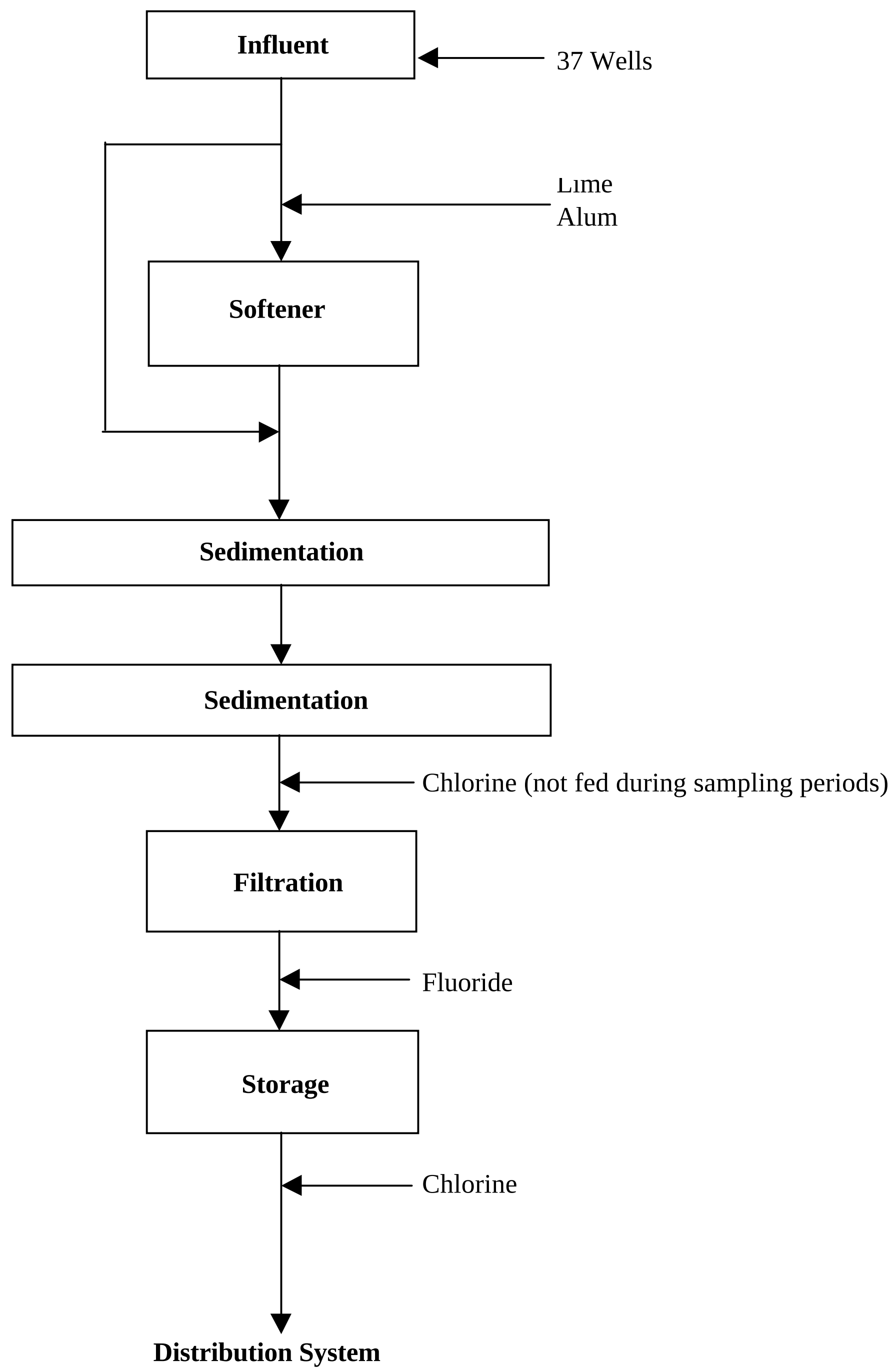
The RSSCT study results indicate that GAC would be a marginal full scale treatment process for disinfectant byproduct precursor reduction for the Platte River WTP.

If in the future the Platte River WTP has difficulty meeting new DBP regulations, treatment alternatives besides GAC should be seriously considered for DBP precursor reduction, while not total ruling out the use of GAC treatment.

II. Background Information

This section presents design data and a schematic of the Platte River WTP.

Platte River WTP
Full Scale Process Schematic



Omaha MUD
Platte River WTP
Process Schematic
ICR Plant No. 454

Platte River WTP
Design Plant Parameters

Table 1
Platte River WTP Design Data

Unit Process	Process Description
Basins 1 & 2	Type: Solids Contact Softener Brand Name: Walker Clariflow Surface Area (ft2): 16,200 Liquid Volume (gal): 2,600,000 Baffling Factor: AV Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Coagulant: Aluminum Sulfate Coagulant Dose (mg/l): 4 Alkalinity Addition: Lime Lime Dose (mg/l): 63
Basins 3 & 4	Type: Solids Contact Clarifier Brand Name: Walker Clariflow Surface Area (ft2): 16,200 Liquid Volume (gal): 2,600,000 Baffling Factor: AV Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Plate Settler Brand Name:
Basins 5 & 6	Type: Solids Contact Clarifier Brand Name: Walker Clariflow Surface Area (ft2): 16,200 Liquid Volume (gal): 2,600,000 Baffling Factor: AV Short Circuiting Factor: Plate Settler Surface Area (ft2): Plate Settler Brand Name: Plate Settler Brand Name:
Disinfection	Chemical Type: Chlorine Gas Measured as: Cl_2 Dose Rate (mg/l): 1.5

Table 1
Platte River WTP Design Data

Unit Process	Process Description
Filters 1 - 8	Type: Filtration Surface Area(ft2): 11,200 Liquid Volume (gal): 572,500 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 - Top of Media to Top of Backwash Trough (ft): 2.7 Measured as: Cl_2 Dose Rate (mg/l): 2.5
Clearwell	Type: Clearwell Surface Area (ft2): 47,614 Liquid Volume (gal): 6,000,000 Minimum Liquid Volume (gal): 1,000,000 Baffling Type: AV Short Circuiting Factor: Covered Indicator Code: Y
Disinfection	Chemical Type: Chlorine Gas Measured as: Cl2 Dose Rate (mg/l): 1.5
Fluoridation	Type: Other Treatment Process Measured as: H2SiF6 Dose (mg/l): 0.50

Treatment Challenges Facing Plant

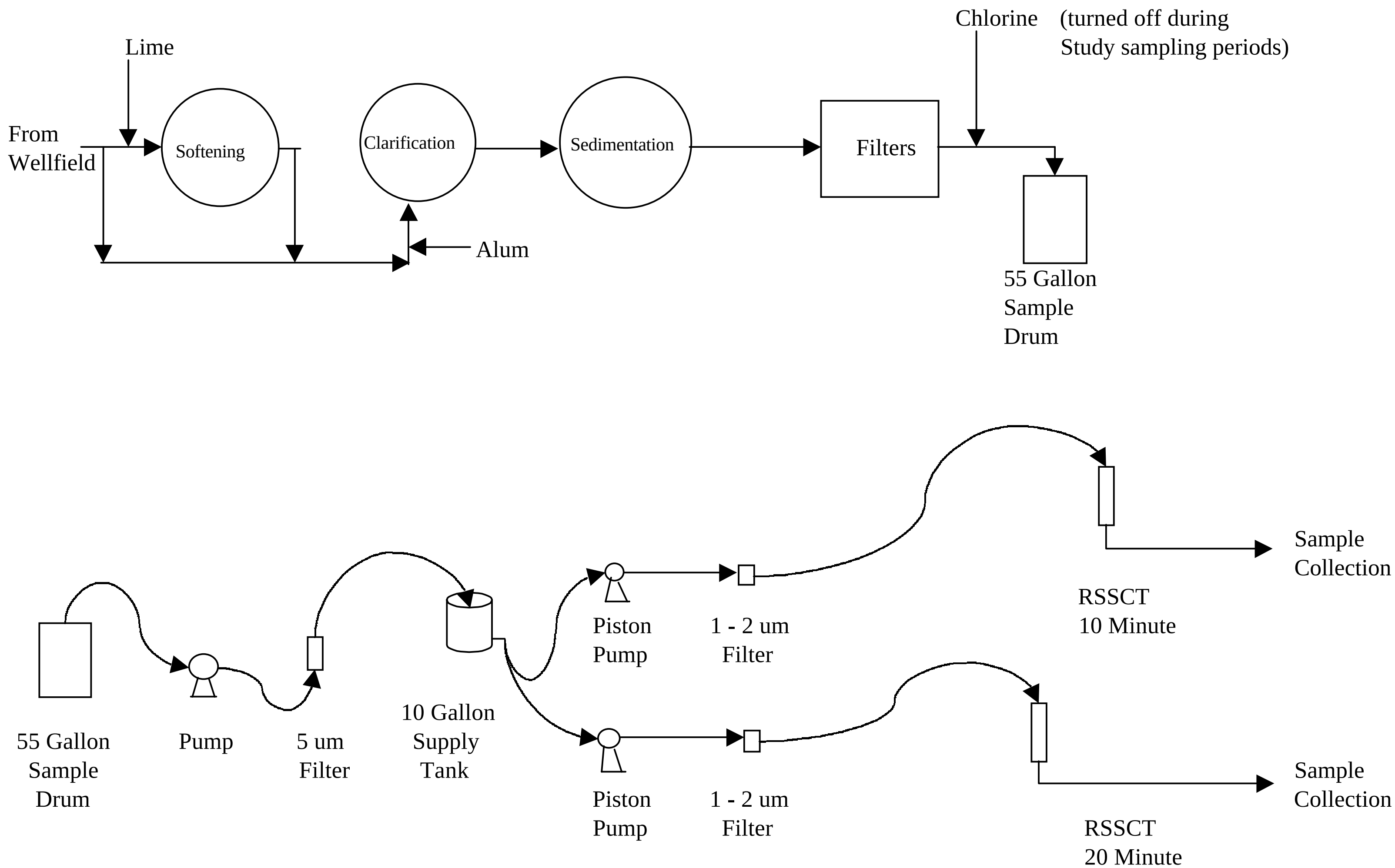
The primary DBP treatment challenge facing the plant is reducing THM levels. The annual average THM level in 1998 was 49.3 ug/l, which exceeds the proposed Stage II MCL for TTHMs of 40 ug/l.

The annual average HAA6 level in 1998 was 20.8 ug/l, below the proposed Stage II MCL of 30 ug/l; therefore treatment for HAA6 is not as much of a priority as TTHM treatment.

III. Materials and Methods

The following section presents design data and procedures for conducting this RSSCT.

Platte River WTP
Process Schematic
Of Full Scale and Bench-Scale
Pretreatment Processes
Followed by
RSSCT



Omaha MUD
Platte River WTP
Pretreatment Process
and RSSCT Schematic
ICR Plant No. 454

Platte River Water Treatment Plant
Pretreatment Process Description and Experimental Design

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

2. First chlorine feed point - solids contact clarifiers no. 5 & 6 effluent

3. Treatment study sample water will be collected from the filter effluent - chlorine feed will be turned off during RSSCT sample collection

4. Sequence of pretreatment processes to be used in the treatment study:

Full Scale

a. Split treatment
   (1) Bypass
   (2) Lime (63.0 mg/l as CaO); alum (4.0 mg/l)coagulation
      Softener (Basins No. 1 & 2) - 1.29 gpm/ft2 @ capacity
b. Solids contact clarifier (Basins No. 3 & 4) -
      2.57 gpm/ft2 @ capacity
c. Solids contact clarifier (Basins No. 5 & 6) -
      2.57 gpm/ft2 @ capacity
d. Dual media filters (1-8) - 3.72 gpm/ft2 @ capacity
      Sand with anthracite cap

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

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.

Platte River 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

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.

An attempt was made during the first quarter to depress the influent pH from around 9.0 to 7.0 with the addition of sulfuric acid; this resulted in the release of carbon dioxide and subsequent gas problems in the columns (several occurrences of gas pockets in the columns resulted in complete loss of water; GAC bed was carefully degasified with 1.0 mm diameter Teflon probe)

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 two quarters of testing to compensate for the pH decline that occurred due to continued softening; a relatively constant influent pH was maintained during the third and fourth quarters with the addition of caustic soda. Table 4 presents the average influent pH for each column, and the days to 70 TOC percent breakthrough. As can be seen from this table, there is no obvious relationship between the pH of the influent water and the adsorption capacity for TOC.

Table 5 presents the average DBP levels that occurred for each column effluent. Seasonal reductions ranged from zero up to 59 percent.

Table 6 presents the maximum DBP levels that occurred for each column.

Two TTHM data points which occurred during the spring and summer seasons slightly exceeded the proposed DBP Stage II MCL.

Impact of Seasonal Variability

The longest run time (Column 2) to 70% TOC breakthrough occurred in the autumn.

The shortest run (Column 2) to 70% TOC breakthrough occurred during the winter season testing, despite the lowest feedwater TOC.

The lowest column effluent TTHM and HAA6 levels occurred during the winter season.

The highest average effluent TTHM and HAA6 levels occurred in the summer season, despite the shortest SDS contact time.

The highest feedwater TTHM and HAA6 occurred during the summer season.

Summary of Significant Results

The TTHM levels for both columns were generally less than the proposed DBP Stage II MCL of 40 ug/l.

HAA6 precursors were evidently low; both the 1998 distribution system average HAA6 level and the RSSCT feedwater HAA6 levels were less than the proposed DBP Stage II MCL for HAA6.

UV_{254} was not an accurate predictor of TOC levels since organics that adsorb UV_{254} were more readily removed by GAC than was TOC.

Increasing the feedwater pH from around 8.0 to 9.0 appears to have had an effect on column run time and average TTHM/HAA6 precursor reduction. The feedwater pH in the winter (see Table 4) averaged 9.0; the lowest TTHM/HAA6 reduction occurred during this season (Table 5). The run time to 70% TOC breakthrough was shorter than all but the spring season.

Table 2
Platte River RSSCT
Actual GAC Depth & EBCT

Quarter	Depth of GAC (mm)		EBCT, min	
	Column 1	Column 2	Column 1	Column 2
1st - Spring	87	182	1.2	2.5
2nd - Summer	100	200	1.4	2.7
3rd - Autumn	100	192	1.4	2.6
4th - Winter	97	186	1.3	2.5

Table 3
Platte River WTP RSSCT
Influent pH vs TOC Breakthrough

Quarter	Parameter	Column 1	Column 2
1st - Spring	Influent pH / TOC	8.15 / 3.25	8.19 / 3.25
	70% TOC breakthrough	4.2 days	12 days
2nd - Summer	Influent pH / TOC	8.21 / 3.78	7.97 / 3.78
	70% TOC breakthrough	7 days	13 days
3rd - Autumn	Influent pH / TOC	8.68 / 2.96	8.68 / 2.96
	70% TOC breakthrough	6.6 days	33 days
4th - Winter	Influent pH / TOC	9.13 / 2.82	8.98 / 2.82
	70% TOC breakthrough	8 days	10 days

Table 4
Platte River WTP RSSCT
Average Seasonal SDS Criteria

Quarter	Temp. ^{o}C	pH	Incubation Time (hrs)	Chlorine Residual (mg/l)
1st - Spring	8	9.3	12.3	0.50
2nd - Summer	19	8.75	5.25	0.50
3rd - Fall	16	8.95	11.6	0.40
4th - Winter	5	9.15	9.9	0.70

Table 5
Platte River 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	43.4	13.8	24.7	43	9.7	30	18.2	58	7.4	46
2nd- Summer	48.0	17.8	19.8	59	18.4	0	24.6	49	11	38
3rd - Autumn	33.9	11.3	20.6	39	6.6	42	19.6	42	6.6	42
4th - Winter	27.8	11.9	19.7	29	7.8	34	19.9	28	6.9	42
Average	38	14	21	43	11	27	21	44	8	42

Table 6
Platte River WTP RSSCT
Maximum Seasonal DBP Levels and Percent Reductions

Quarter	Influent (avg)		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	43.4	13.8	36.8	15	20.9	0	41.2	5	10.6	23
2nd - Summer	48.0	17.8	41.0	15	24.3	0	33.3	31	15.2	15
3rd - Autumn	33.9	11.3	37.3	0	14.8	0	35.8	0	18.8	0
4th - Winter	27.8	11.9	31.0	0	9.8	18	29.7	0	12.1	0

Table 7
Platte River WTP RSSCT
Pretreated Feed Water Quality

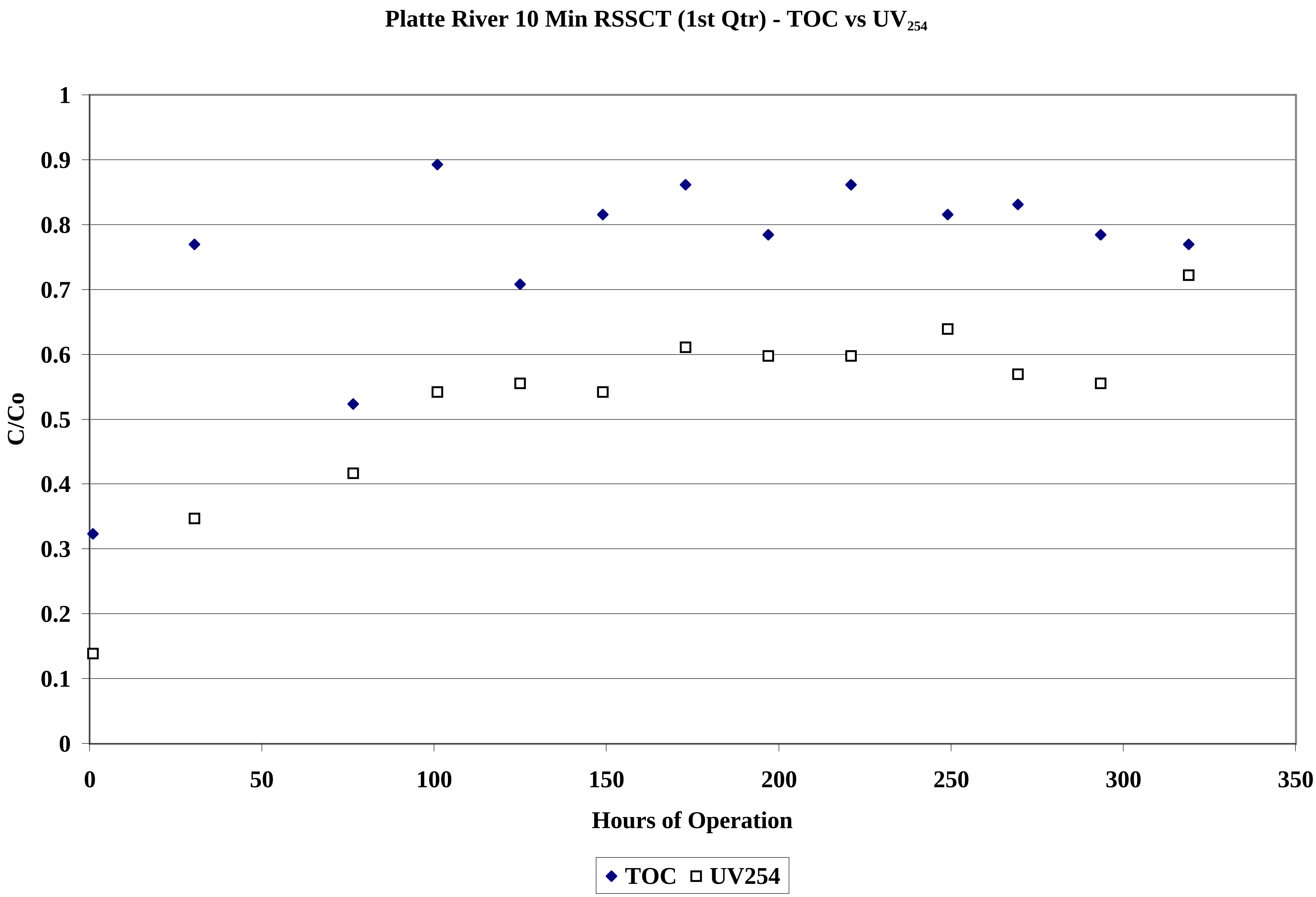
Water Quality Parameter	Spring Average (SD)	Summer Average (SD)	Autumn Average (SD)	Winter Average (SD)
Temperature (^oC)	20.6 (7.8)	22.4 (1.7)	20.5 (1.0)	20.4 (9.5)
pH	7.97 (8.2)	8.6 (4.2)	8.73 (1.8)	8.9 (3.6)
Turbidity (ntu)	0.2 (50)	0.27 (43.3)	0.17 (34.6)	0.17 (34.6)
Alkalinity (mg/L as $CaCO_3$)	124 (27.4)	120 (124)	139.5 (13.6)	133 (3)
Calcium Hardness (mg/L $CaCO_3$)	115.5 (4.3)	93 (2.2)	102 (7.8)	117 (22.2)
Total Hardness (mg/L $CaCO_3$)	182 (0.0)	138 (2.9)	157 (8.9)	163 (6.1)
Bromide (ug/L)	88.5 (7.9)	52.5 (13.3)	52.5 (24.8)	83 (4.8)
TOC (mg/L)	3.25 (7.7)	3.78 (16.6)	2.96 (17.9)	2.82 (6.2)
UV_{254} (cm^{-1})	0.072 (11.2)	0.076 (3.8)	0.049 (2.0)	0.054 (4.9)
SDS-THM4 (ug/L)	43.4 (4.5)	48.0 (13.1)	33.9 (40)	27.8 (26.6)
SDS-HAA5 (ug/L)	10.1 (46.9)	15.3 (19.0)	11.3 (37)	8.7 (44.7)
SDS-HAA6 (ug/L)	13.8 (50.2)	17.8 (25.1)	14.3 (41.6)	11.9 (50.4)
SDS-TOX (ug/L)	128.5 (12.9)	135.0 (3.1)	102.3 (6.5)	98.8 (7.8)
SDS-Chlorine Demand (mg/L)	1.06 (20.4)	1.47 (17.4)	1.2 (2.1)	1.47 (35.6)

QA/QC Summary

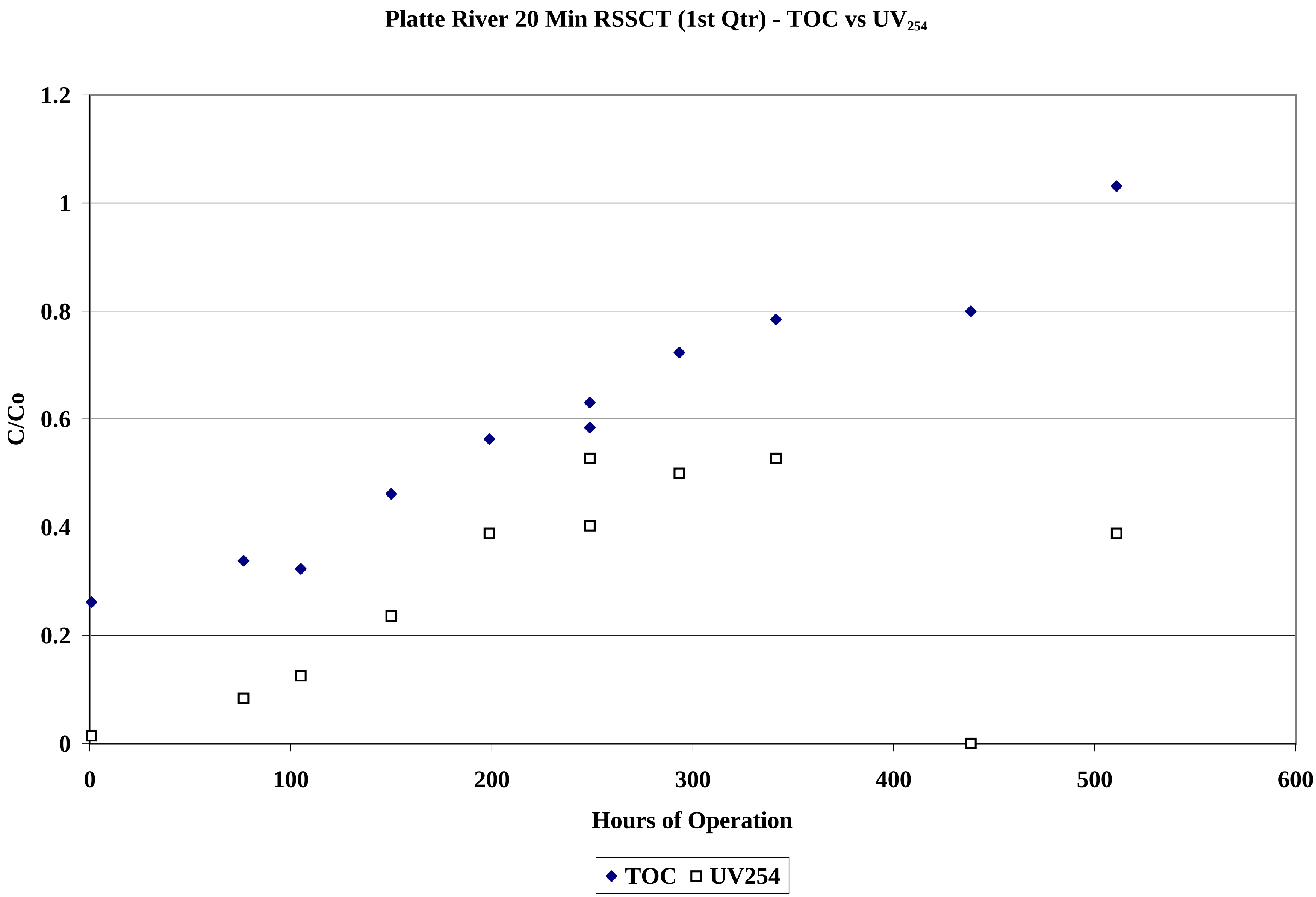
The calibration procedures in pages 45 to 71 of the DBP/ICR Analytical Methods Manual for TTHMs, HAAs, TOX, TOC, and bromide were followed during this Study.

Appendix

TOC vs UV_{254}
1^{st} Quarter

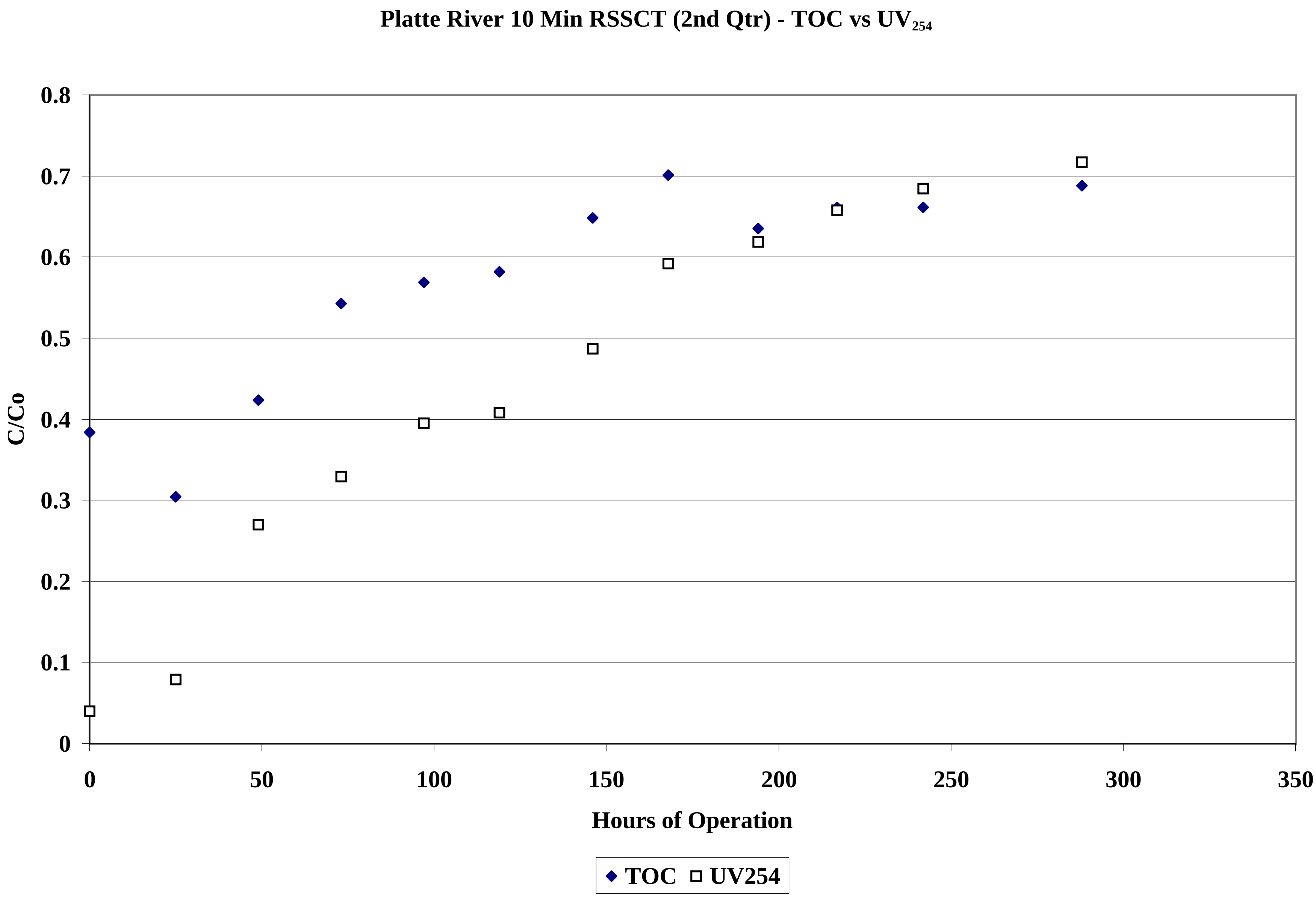


Platte River 10 Min RSSCT (1st Qtr) - TOC vs UV_{254}
C/Co
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
250
300
350
Hours of Operation
TOC
UV254

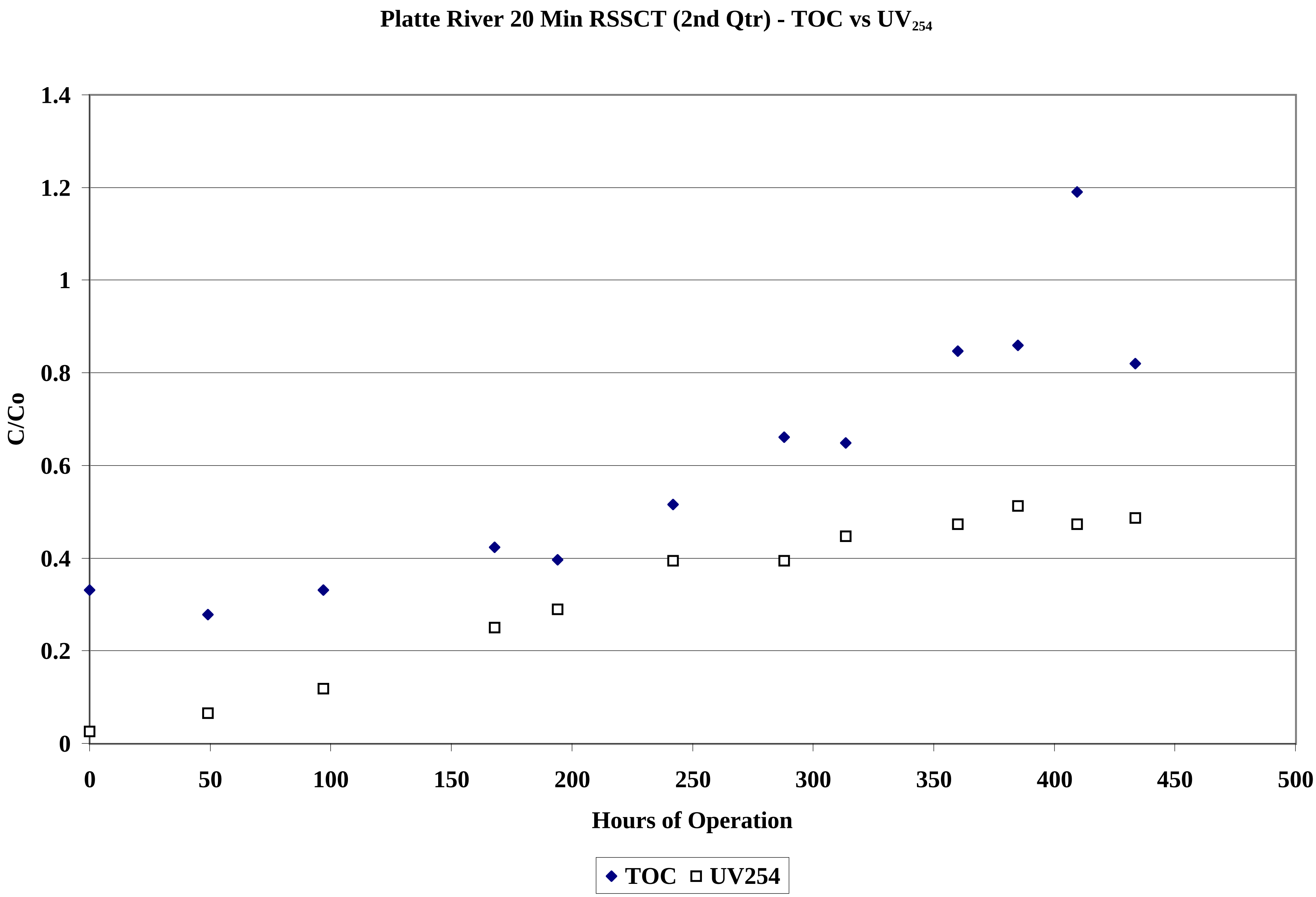


Platte River 20 Min RSSCT (1st Qtr) - TOC vs UV254
1.2
1
0.8
0.6
0.4
0.2
0
C/Co
0
100
200
300
400
500
600
Hours of Operation
TOC
UV254

TOC vs UV_{254}
2nd Quarter

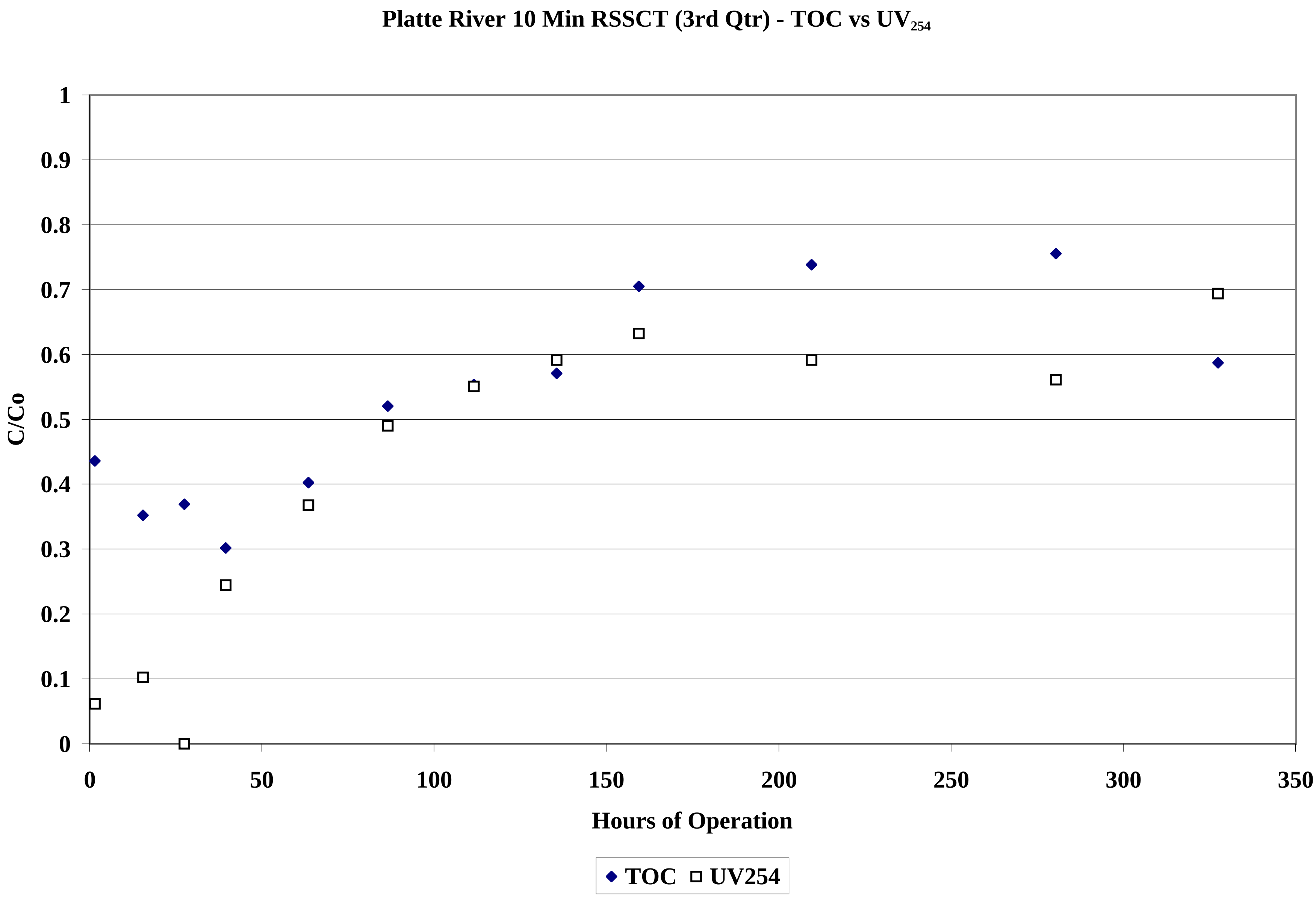


Platte River 10 Min RSSCT (2nd Qtr) - TOC vs UV254
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
C/Co
0
50
100
150
200
250
300
350
Hours of Operation
TOC
UV254

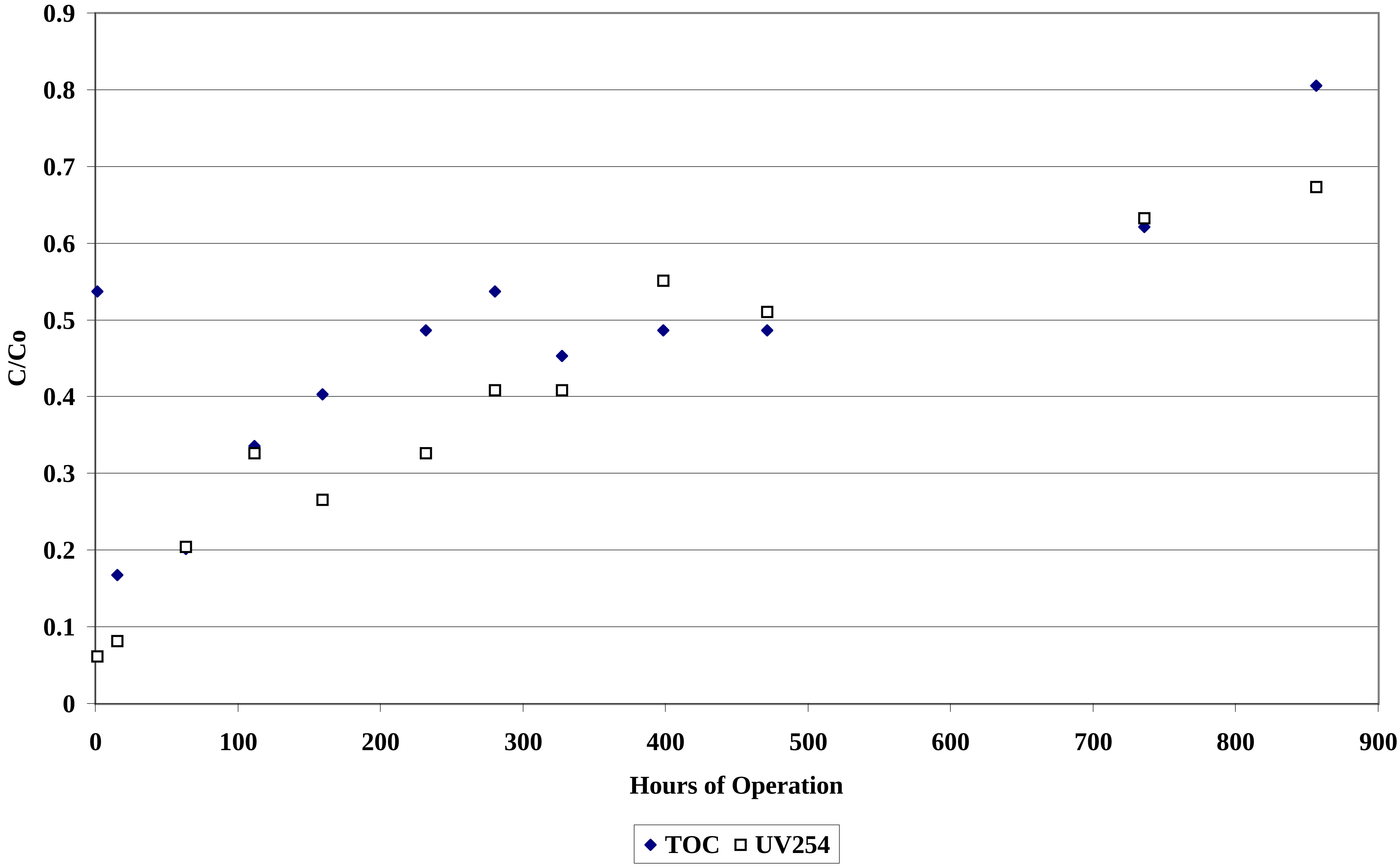


Platte River 20 Min RSSCT (2nd Qtr) - TOC vs UV_{254}
C/Co
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
400
450
500
Hours of Operation
TOC
UV254

TOC vs UV_{254}
3rd Quarter

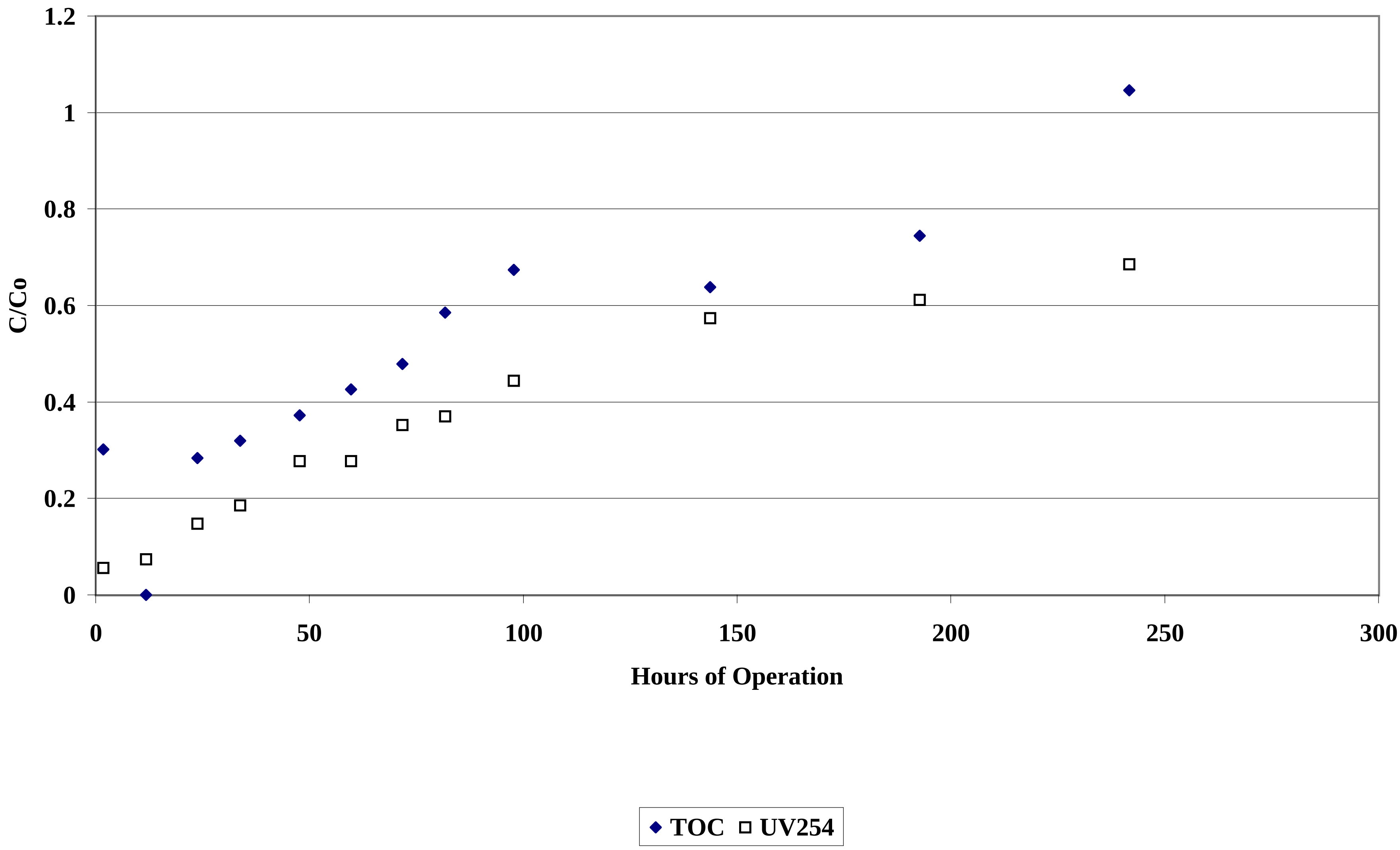

Platte River 10 Min RSSCT (3rd Qtr) - TOC vs UV254
C/Co
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
Hours of Operation
TOC
UV254

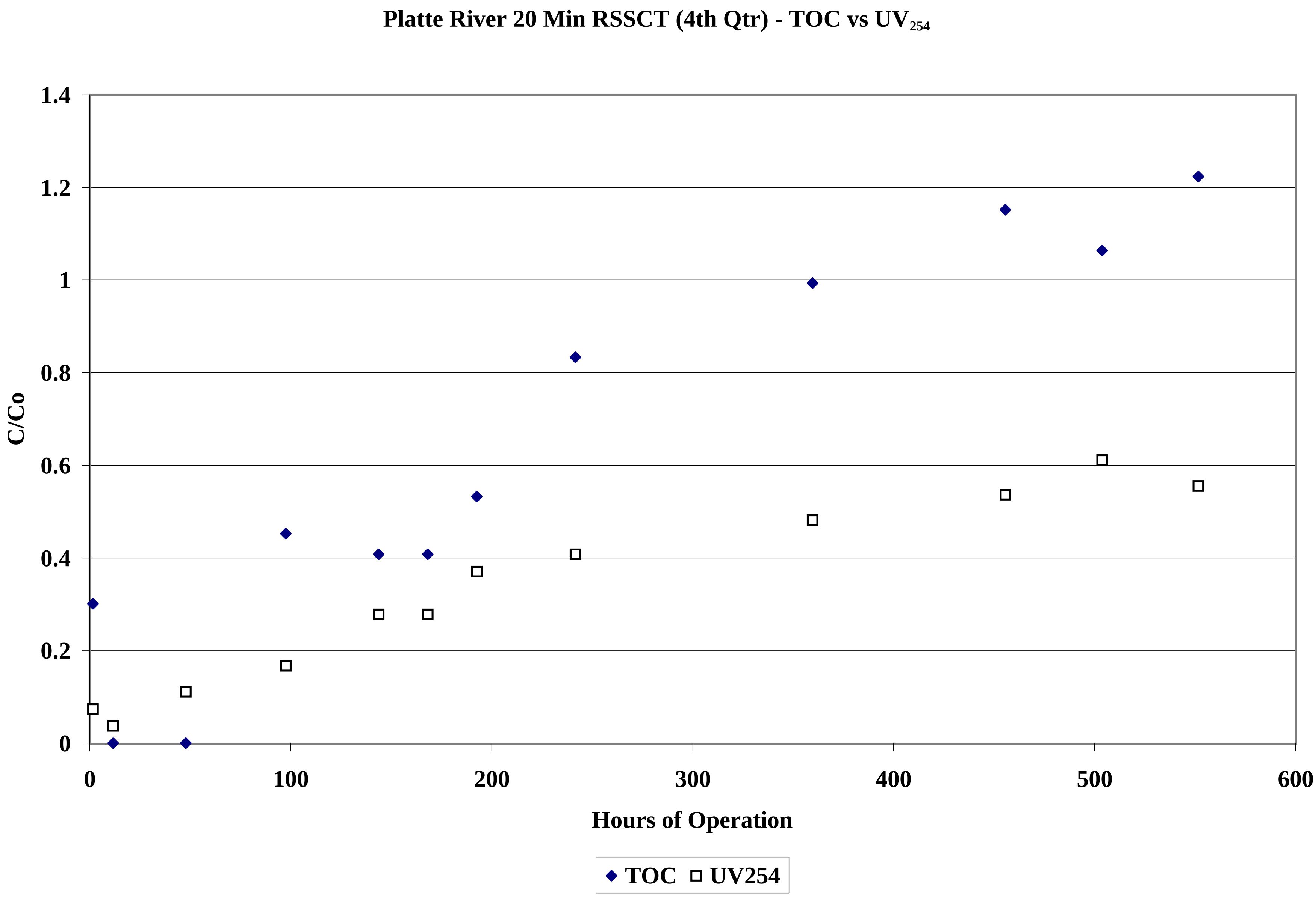
Platte River 20 Min RSSCT (3rd Qtr) - TOC vs UV_{254}



TOC vs UV_{254}
4th Quarter

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




Platte River 20 Min RSSCT (4th Qtr) - TOC vs UV254
1.4
1.2
1
0.8
0.6
0.4
0.2
0
C/Co
0
100
200
300
400
500
600
Hours of Operation
TOC
UV254